QUINSAM COAL

7 South Area 5 Water Quality Effects Assessment

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QUINSAM COAL

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1. Introduction

QUINSAM COAL

1. Introduction

The Quinsam Coal Mine (QCM) is located on Vancouver Island approximately 27 km southwest of Campbell River, BC. Since 1988, Quinsam Coal Corporation (QCC), which is owned by Hillsborough Resources, has extracted coal from a number of underground mines on their coal leases located near Middle Quinsam Lake in the Quinsam River watershed, including the 2 North, 3 North, 2 South, 3 South, 4 South, 5 South and 7 South underground coal mines. QCC is proposing an expansion of underground coal workings to the south of the 7 South mine area, this proposed underground mine is referred to as 7 South Area 5 (7SA5).

Geologically, the 7SA5 mine is positioned in the Dunsmuir member of the Comox Formation. Coal will be extracted from the No. 4 Coal seam, similar to the adjacent 7 South Mine. The proposed 7SA5 mine is in an area that is structurally more complex than the previously mined areas. 7SA5 is positioned in the west-dipping, eastern limb of the Quinsam Syncline. The syncline plunges to the south and is truncated by a regional scale fault along the Iron River.

The 7SA5 mine will be accessed via a roadway driven from the southern extent of the 7 South mine, hence, new surface facilities are not required to gain access to the underground workings. Underground mining will use room and pillar mining methods to develop roadways and extract the coal. However, the pillars separating the roadways will be left in place following mine development. This feature was incorporated into the mine plan to maintain support of the roof and prevent large scale subsidence of the overlying strata.

This report is prepared in support of QCC's application to amend the current Mine Permit No. C-172 with the inclusion of the proposed 7SA5 underground mine. QCM retained Lorax Environmental Services Ltd. (Lorax) to assess groundwater conditions and predict seepage rates and geochemical mass loadings from the proposed 7SA5 underground mine to receiving waters of the Iron River and Quinsam River.

In order to achieve the overall objective of assessing the effect of the proposed mine on downstream water quality, a number of studies were undertaken and presented in this report. Chapter 2 presents the hydrogeology baseline conditions within the proposed mine area as delineated by a monitoring program initiated in 2012. The assessment of the field data was conducted jointly by Lorax and Enterprise Geoscience Services Ltd. (EGSL). Chapter 3 outlines the background groundwater chemistry at 7SA5 from the groundwater monitoring network. Chapter 4 assesses the discharge rates from the Quinsam River and Iron River using both regional data and local data collected by Lorax

on the Iron and Quinsam rivers. Chapter 5 compiles background surface water chemistry in the Quinsam River and Iron River, from a monitoring program undertaken by QCC. Chapter 6 presents the geochemical characterization program of strata in 7SA5 and develops a set of geochemical source terms for water coming into contact with the mine void. The final chapter presents the effects in water quality in the SP4 sediment pond during operational dewatering of 7SA5, downstream of 7SA5 in the Quinsam River and Iron River following closure and flooding of the underground workings and the long term cumulative effect from all of the existing and proposed mine facilities on the Quinsam River.

2. Hydrogeology

QUINSAM COAL

2. Hydrogeology

2.1 Overview

The 7 South Area 5 (7SA5) development will mine the No.4-4L coal zone hosted in the west dipping limb of the Quinsam syncline south of the Long Lake fault. The flooded 242 test mine is situated beyond the southern extent of the proposed workings. A hydrogeological study of 7SA5 was undertaken by Lorax to determine (i) anticipated groundwater inflows during mine development, (ii) seepage rates from the flooded, backfilled mine workings at closure, (iii) reflooding time for the workings and (iv) shortest travel times for mine-impacted seepage to reach the Iron River, the receiving waters for drainage from the proposed mine area.

2.1.1 Description of Program

The hydrogeological analysis was accomplished through a detailed review of exploration drilling in 7SA5 and the completion of multiple hydrogeological field investigations. The field programs included the installation of nine monitoring wells around the footprint area of the proposed 7SA5 workings to characterize baseline water quality upgradient and downgradient of the proposed workings and determine hydraulic gradients. The desktop review of exploration drilling data and the preliminary hydraulic testing results from the newly established monitoring wells indicated that the proposed 7SA5 mine area is more permeable than other areas of the mine site where Lorax has undertaken similar groundwater assessments. This prompted the undertaking of a 73-hour constant rate pumping test at 30 US GPM in a drillhole located in the southern region of the mine to more accurately determine hydraulic properties of the bulk rock mass. Additional monitoring wells were established prior to the pumping test to augment the monitoring network.

To estimate operational groundwater inflows to the mine, the drawdown from the 73-hour pumping test was used to simulate the effect of a multi-well groundwater interception system operating to reduce the head above the workings to within 10 metres or less within 100 days. This was accomplished by projecting the drawdown cone to 100 days and replicating it at additional locations to simulate the effect of a multiple pumping wells. This is based on the principle of superposition whereby drawdowns at a point in an aquifer from multiple pumping wells are additive. The superimposed drawdown curves were then re-contoured to create an aggregate drawdown ‘surface’ that could be used to calculate residual head in the footprint area of the mine.

Seepage rates from the backfilled mine void at closure were calculated using two methods. One method calculated seepage rates based on a percent net infiltration of mean annual precipitation (MAP) consistent with values derived from previous groundwater assessments across the site. The other method calculated seepage rates based on hydraulic parameters derived from the pump test, the estimated current water table surface and the proposed mine geometry. These closure seepage fluxes were then used to estimate a maximum reflooding time for the mine void. Current hydraulic gradients were used to estimate travel time for mine impacted groundwater to reach the Iron River, the nearest downstream receptor.

2.1.2 Summary of Results and Conclusions

The main findings of the 7SA5 groundwater assessment are as follows:

- The exploration borehole logs indicated that a significant number of drillholes intercepted water bearing features with airlift yields ranging from 2-60 GPM. These features more frequently occur above or at the No. 4 coal zone in the southern portion of the proposed mine area, where they may cause groundwater inflows into the development that exceed those experienced in other mine areas.
- Slug tests results from the first round of monitoring well installations indicated that the sedimentary bedrock hydraulic conductivity was approximately two orders of magnitude higher (typically 10^{-5} to 10^{-6} m/s) than that measured in other mine areas (typically 10^{-7} to 10^{-9} m/s).
- The pumping test created widespread drawdown throughout 7SA5; however limited drawdown beyond the southernmost extent of the mine may indicate that either the flooded 242 test mine or the Iron River could be hydraulically connected to the proposed mine, although this was not definitely proven with the data. Significant portions of 7SA5 are lower in elevation than the nearby Iron River.
- Analysis of the drawdown data from the pumping well and selected observation wells indicates that the bulk hydraulic conductivity of the bedrock in 7SA5 is on the order of $3x10^{-7}$ m/s, *i.e.* significantly lower than the range provided by the initial slug tests
- Superposition of '100-day' drawdown data indicated that a groundwater interception system of 5 wells pumping 30 US GPM each would be sufficient to lower the head within the proposed footprint of the mine to within 10 metres of the workings. Thus, the projected groundwater inflow to the mine in the absence of pumping is estimated to be in the range of 125-175 US GPM or 8-12 L/s when the mine is at its maximum extent. A similar pumping rate would be expected for

a network of groundwater interception wells established within the footprint of the proposed 7SA5 workings. Groundwater inflows to the mine could be greater if the southern limit of the mine is hydraulically connected to the flooded 242 test mine and/or the Iron River.

- Closure seepage rates from the flooded mine are estimated to be in in the range of 0.5-0.9 L/s or about 5-10% net infiltration of MAP as determined from Darcy flux calculations and net infiltration rates previously determined for other areas of the mine. This estimated flux appears reasonable when compared to the areally-weighted component of baseflow contributed by this groundwater catchment to the Iron River in September 2012.
- The reflooding rate to the mine will change through time in response to changing hydraulic gradients in and around the workings. At the onset of reflooding, groundwater fluxes into the mine void will be higher in response to steep hydraulic gradients; these fluxes will decline through time as heads recover. An upper bound estimate for complete reflooding of the 7SA5 mine is on the order of 20-40 years, based on the steady state flow rates anticipated from a fully flooded mine at closure. A lower bound estimate based on observations from a 4 South reflooding event; 7SA5 could reflood in as little as 1.5 years. The actual time to reflood the working is anticipated to be less than 10 years, since hydraulic gradients towards the mine void will be high even once it has flooded. Reflooding may occur more quickly if there is a hydraulic connection (*i.e.*, a fault) between the Iron River and the proposed workings.
- Once the mine refloods and pre-mining hydraulic gradients are re-established, it is estimated that mine impacted seepage may report to the Iron River in approximately 5 years.

2.2 Geological Setting

The geology of the Quinsam Coalfield has been described in detail in the main 7 South Area 5 permit amendment report prepared by Hillsborough. The salient features of this discussion, as they relate to the hydrogeology of 7SA5, are summarized below. Note that in the following discussion, directions are referenced relative to mine grid north as shown in Figure 2-1.

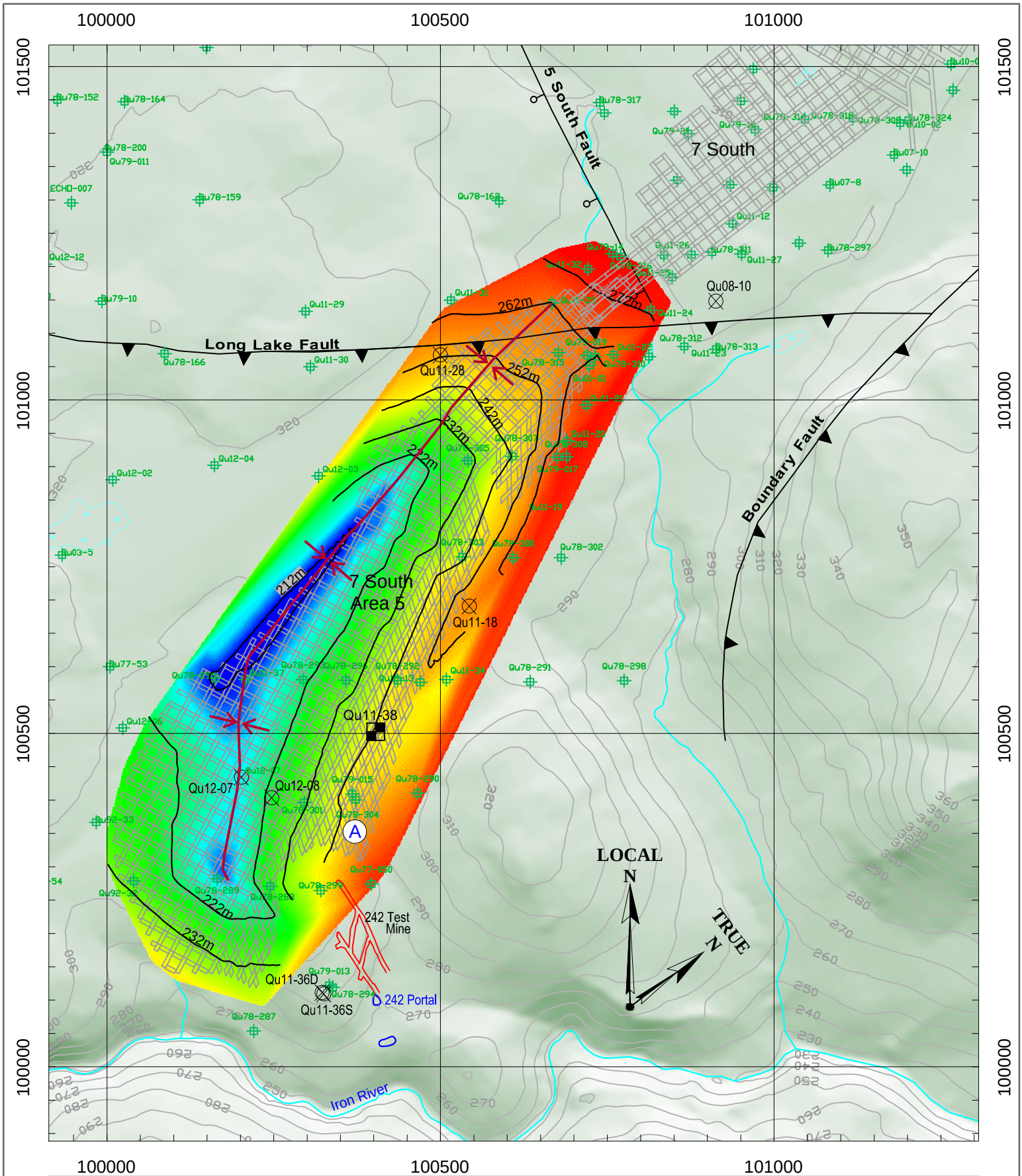
7SA5 will mine the 4-4L coal zone, hosted in the middle Dunsmuir member of the Comox formation, and will be accessed via roadways advanced southward from the main 7 South mine (Figure 2-1). In Area 5, the upper 4 seam ranges from 1.5 to 3.3 metres thickness; the middle parting ranges from 0.18 to 1.0 metres thickness and the 4L seam ranges from 1.5 to 2.5 metres thickness. The middle division of the Dunsmuir member

consists of siltstone and silty sandstones; the upper and lower divisions consist mainly of sandstone with minor interbeds of siltstone and occasional coals.

The entire Quinsam mine site is overlain by a variably thick cover of glacial, glaciofluvial and glaciomarine sediments. In 7SA5, the thickness of this unit varies from 0 to 39 metres, with an average thickness on the order of 12 metres; areas of thicker till coverage occur along the subcrop edge of the No. 5 and No. 4 coal seams and along the structurally disturbed zone extending along the trace of the Long Lake fault (Figure 2-2). The 7SA5 mining area resides almost entirely within in the west-dipping, eastern limb of the Quinsam Syncline (Figure 2-1). Within the mining footprint, the beds are generally gently dipping at less than seven degrees and flattening out to zero degrees along the axis of the syncline. At the eastern margins of the syncline (outside of the mining footprint), the beds dip more steeply at nearly 30 degrees. The syncline gently plunges to the south until it approaches the Iron River, where it is truncated by another regional scale fault.

The sedimentary sequence is separated from an emergent ridge of basement rock to the east by the Boundary Fault, the principal fault within the property. Deep seated thrusting from the south and east have caused the locally significant Long Lake strike-slip fault, which separates 7 South Area 5 from the main 7 South mine. There may be one or possibly two fault splays off the Long Lake feature that may cross-cut the 7SA5 mine plan.

In light of the structural complexity of the area that has been discussed above, logs for historic (1978, 1979, 1992) and 2011-2012 drillholes were inspected for occurrences of water bearing features. Drillers' logs from 1978 and 1979 exploration holes did not indicate water; however, it is unclear whether these features were not encountered or if they were simply not documented. The same reasoning applies to core logs of 1992 drillholes, which also did not indicate water bearing features. The 2011-2012 logs; however, do indicate water bearing features, the relevant excerpts from which have been summarized in Appendix A1. Twenty nine exploration holes were drilled in 2011 and 2012 in 7S Area 5; approximately 21 of these holes were drilled in the footprint area or immediate perimeter of the proposed Area 5 workings. Overall, 11 of these holes intersected water bearing features and had associated increases in airlift yield ranging from 2-60 imperial gallons per minute. More than half of these boreholes encountered more than one water bearing feature. The drillholes tended to intersect the water bearing features either above or below the 4-4L coal zone; one drillhole in the footprint area (QU11-35) intersected flows both above and below the coal zone. The spatial distribution of these water bearing features has been plotted in Figure 2-3. It can be seen that in the northern portion of the proposed mine, most of these features are encountered below the 4-4L coal zone, while in the southern portion of the mine, these features tend to occur



LEGEND

- Proposed Workings
- Monitoring Wells
- Pumping Wells
- Drill Holes
- Travel Time Calculation Point (A)
- No. 4 seam contours (10m)
- Syncline
- Rivers/Drainage
- Surface Elevation (10m)
- Thrust Faults
- High Angle Fault

Contour Colours

- 210m
- 220m
- 230m
- 240m
- 250m
- 260m
- 270m

DATE SAVED:	Mar 04, 2013
DRAWN BY:	GM
REVIEWED:	LLF
VERSION:	1

Coordinate System: Quinsam Mine Local Grid
Projection: Orthographic
Units: Metres

0 100 200 M

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

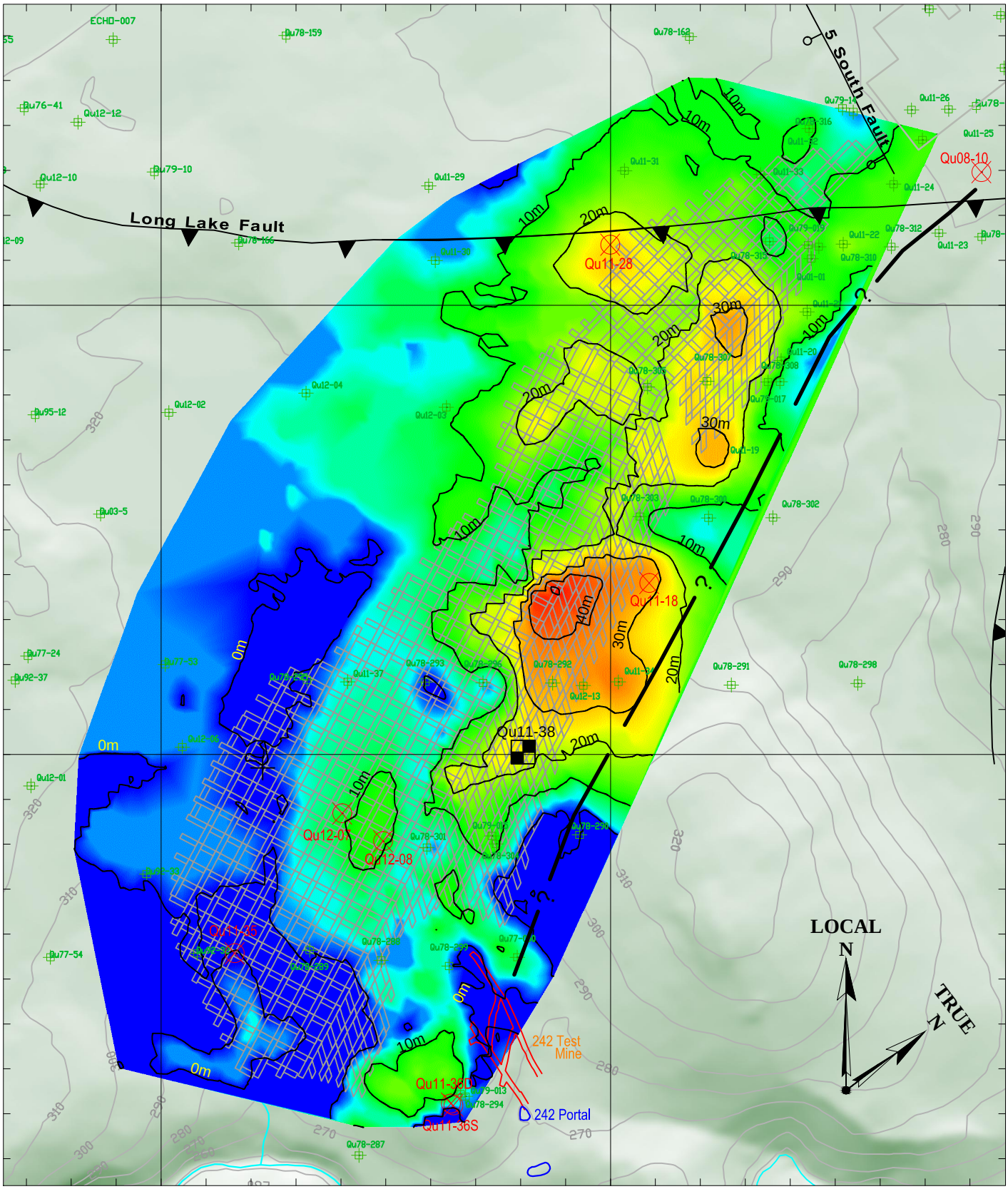
PROJECT: **Water Quality Effects Assessment: 7 South Area 5**

TITLE: **Top of No.4 Seam Elevation 7 South Area 5**

PROJECT #: **J885-7**

FIGURE: **2-1**

P:\J885 Hillsborough Resources\Drafting\AutoCAD map\Feb2013Figures\Fig 2-x_top of 4 seam_19Feb2013_GM.dwg



LEGEND

- Proposed Workings
- Monitoring Wells
- Pumping Wells
- Drill Holes
- Till Thickness (10m)
- Rivers/Drainage
- Surface Elevation (10m)
- High Angle Fault
- Thrust Fault
- Approximate Extent of 4 Seam

Contour Colours

- 0m
- 10m
- 20m
- 30m
- 40m
- 50m

DATE SAVED:	Mar 04, 2013
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REVIEWED:	LLF
VERSION:	1

Coordinate System: Quinsam Mine Local Grid
Projection: Orthographic
Units: Metres

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

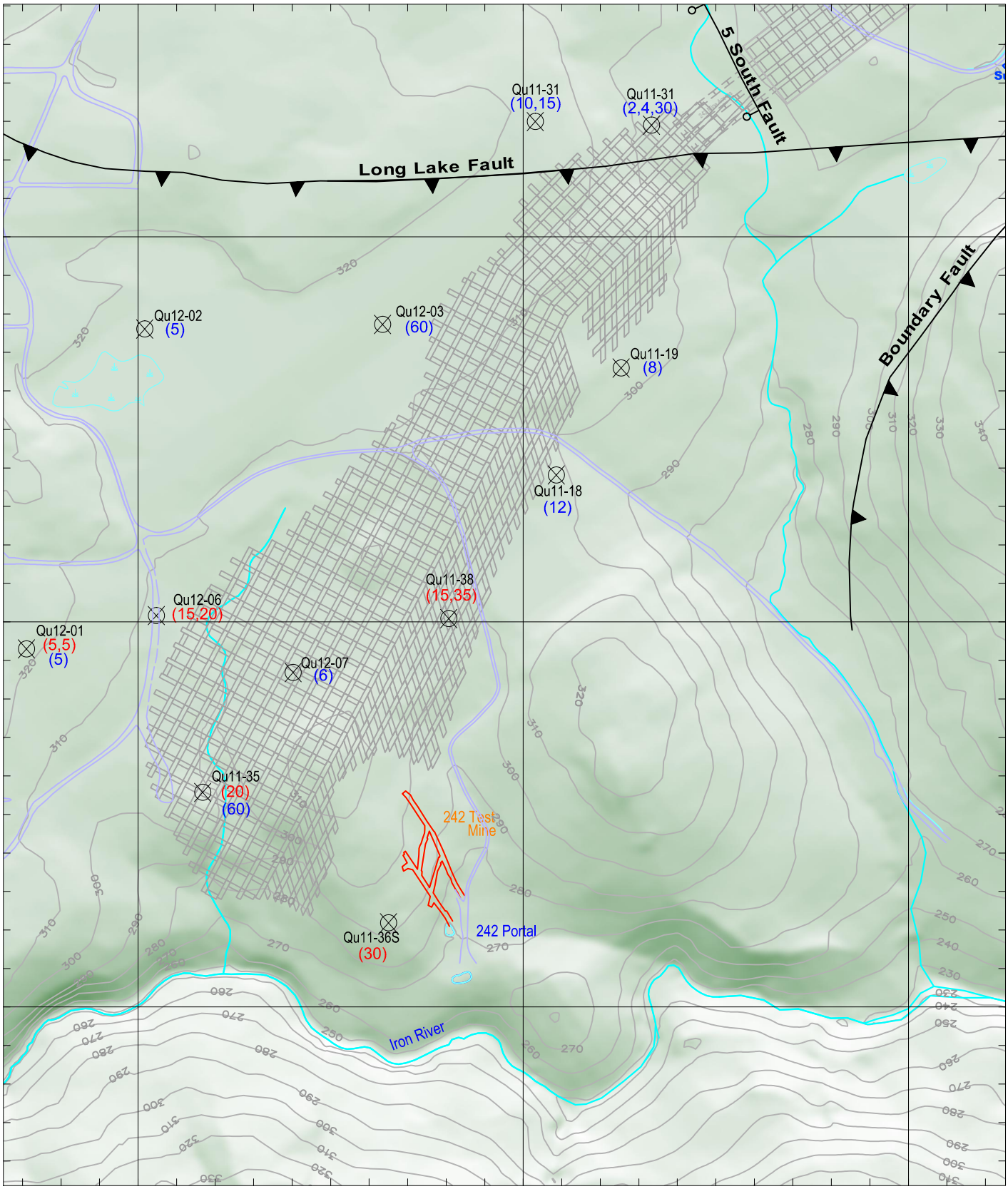
PROJECT: **Water Quality Effects Assessment: 7 South Area 5**

TITLE: **Thickness of Overburden in 7 South Area 5**

PROJECT #: **J885-7**

FIGURE: **2-2**

P:\J885 Hillsborough Resources\Drafting\AutoCAD map\Feb2013Figures\Fig 2-2_Thickness of Overburden_14Feb2013_GM.dwg



LEGEND

- Boreholes
- Workings
- Roads
- High Angle Faults
- Thrust Faults
- Surface Contours (10m)
- Rivers/Drainage
- (15,35) Airlift Yield of Multiple Fractures Above 4 Seam (GPM)
- (10,15) Airlift Yield of Multiple Fractures Below 4 Seam (GPM)

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VERSION:	1

Coordinate System: Quinsam Mine Local Grid
Projection: Orthographic
Units: Metres

0 50 100 M

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT: **Water Quality Effects Assessment: 7 South Area 5**

TITLE: **Spatial Distribution of Water Bearing Structures in 7SA5**

PROJECT #: **J885-7**

FIGURE: **2-3**

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above the coal zone. In general, there appears to be a higher probability of intersecting water bearing features in 7SA5 and the resultant flows are of higher magnitude than that observed in other mine areas.

2.3 Monitoring Network

Water levels have been collected from several monitoring wells established in former exploration holes in and around the proposed 7SA5 workings (Figure 2-4). Monitoring wells QU11-18S/D, QU11-28 and QU11-36S/D were established as baseline monitoring locations to determine vertical and horizontal hydraulic gradients across the margins of workings. These locations were also designed to characterize water quality upgradient and downgradient of the proposed workings. QU11-18D and QU11-36D were screened to intercept potential seepage pathways from the proposed mine area and incorporate high permeability fracture zones.

Wells QU12-07, QU12-08, and QU11-35 were established in October 2012 to augment the monitoring network for a multi-day pump test at QU11-38. These wells screen strata and water bearing zones in and around the No. 4 coal zone. QU11-38 was completed as a pumping well due to its central location and good reported yields. This borehole was lined with 4.5 inch PVC in order to prevent material from caving on top of the pump, but no backfill materials were emplaced to isolate specific intervals. Complete details of the monitoring well installation in 7SA5 are discussed in Appendix A2. Table 2-1 summarizes the well completion details and November 2012 water levels recorded in 7SA5. A complete record of water levels measured at these locations and open boreholes in 7SA5 is included in Appendix A3.

2.4 Baseline Groundwater Flow System

A water table contour map of 7SA5 is provided in Figure 2-4. The contours reflect March 2012 water levels measured in monitoring wells and open boreholes. QU12-07, QU12-08 and QU11-35 had not been completed as monitoring wells in March 2012, however, more recent water levels measured at these locations agree with the interpretation shown in Figure 2-4. This map also incorporates “pre-mine” water level contours from 7 South, 5 South and 4 South mine areas that have been presented in previous groundwater assessments of the site. The contours have been modified slightly from previously published versions in light of additional data from 7SA5 (Appendices I-K of Hillsborough, 2011). The water levels listed in Table 2-1 and Appendix A3 indicate that a significant downward gradient exists in Area 5 at locations QU11-18 and QU11-36. Therefore, emphasis has been given to shallower (<50 metres deep) wells and open exploration holes in construction of the water table contours.

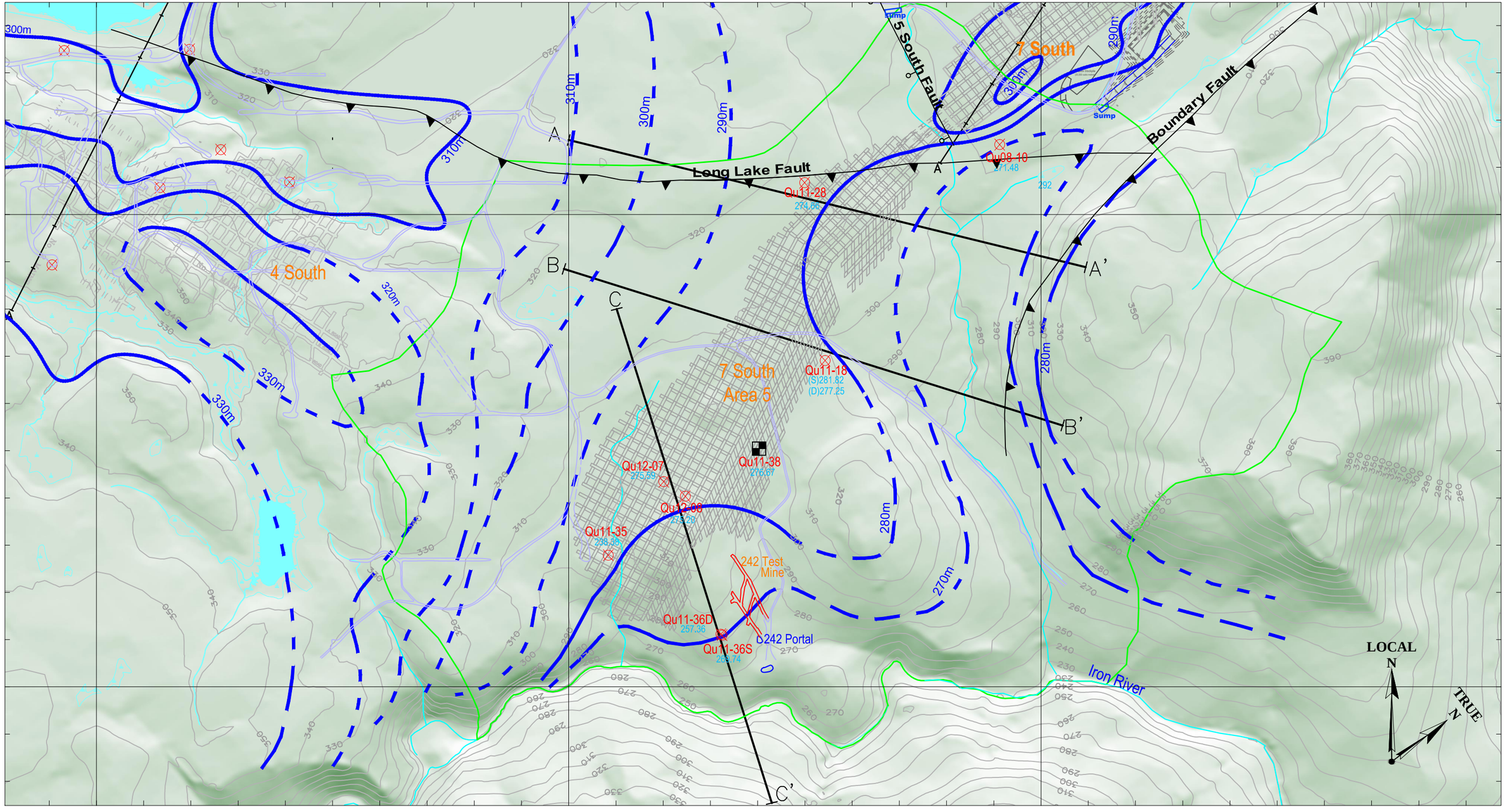
Table 2-1:
7 South Area 5 Monitoring Well Details and November 2012 Water Levels.

Sample Point	Well Completion Date	Mine Grid Co-ordinates (m)			Depth (m bTOC)[1]	Filter Pack Interval (m bgs)[1]		Screened Lithology[2]	Most Recent Water Level Date[3]	SWL (m Mine Grid)	Sampled for Water Quality[4]
		Easting	Northing	Ground Surface El.							
QU08-10	20-Apr-10	100913	101148	295.7	27.6	18.3	29.2	No. 3 Coal	19-Nov-12	271.48	x
QU11-18S	12-Dec-11	100543	100691	299.7	34.2	29.0	34.4	Till	23-Oct-12	283.58	x
QU11-18D	12-Dec-11	100543	100691	299.7	65.2	60.7	65.8	SST/Fractured SLST	19-Nov-12	277.25	x
QU11-28	14-Dec-11	100499	101067	307.1	58.0	53.3	58.5	No. 4&4L/SST	19-Nov-12	274.66	x
QU11-35	02-Oct-12	100084	100278	300.5	73.8	69.2	74.1	Fractured SST	19-Nov-12	274.87	
QU11-36S	15-Dec-11	100325	100109	286.0	42.2	38.4	43.3	Fractured SST	19-Nov-12	269.74	x
QU11-36D	20-Dec-11	100322	100111	285.9	67.2	63.1	68.3	Fractured SST	19-Nov-12	257.36	x
QU11-38	02-Oct-12	100403	100504	299.6	94.8	n/a	n/a	Various (Lined Open Hole)	19-Nov-12	276.67	x
QU12-07	05-Oct-12	100201	100434	311.4	128.1	123.1	128.6	Fractured SLST/SST	22-Nov-12	275.59	
QU12-08	05-Oct-12	100246	100403	317.0	96.9	92.0	97.5	No 4/4L Coal	24-Nov-12	275.20	

Notes:
1) bgs = below ground surface, bTOC = below top of casing
2) SST = sandstone, SLST = siltstone
3) water levels recorded in November had stabilized from pump test, except for QU11-18S
4) groundwater quality is discussed in Chapter 3.

99000 100000 101000

101000 100000



99000 100000 101000

LEGEND

- Groundwater Contours
- Groundwater Countours (inferred)
- Thrust Faults
- High Angle Fault
- Pumping Well
- Monitoring Well
- Proposed Workings
- Existing Workings
- Waterbodies
- Surface Contours (10m)
- Rivers
- Catchment Boundary
- Roads
- 222.22 Nov 2012 Water Levels (M)

DATE SAVED:	Mar 04, 2013
DRAWN BY:	GM
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VERSION:	1

Coordinate System: *Quinsam Mine Local Grid*
Projection: *Orthographic*
Units: *Metres*

0 200 400 m

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT: **Water Quality Effects Assessment: 7 South Area 5**

TITLE: **Water Table Contour Map**

PROJECT #: **J885-7**

FIGURE: **2-4**

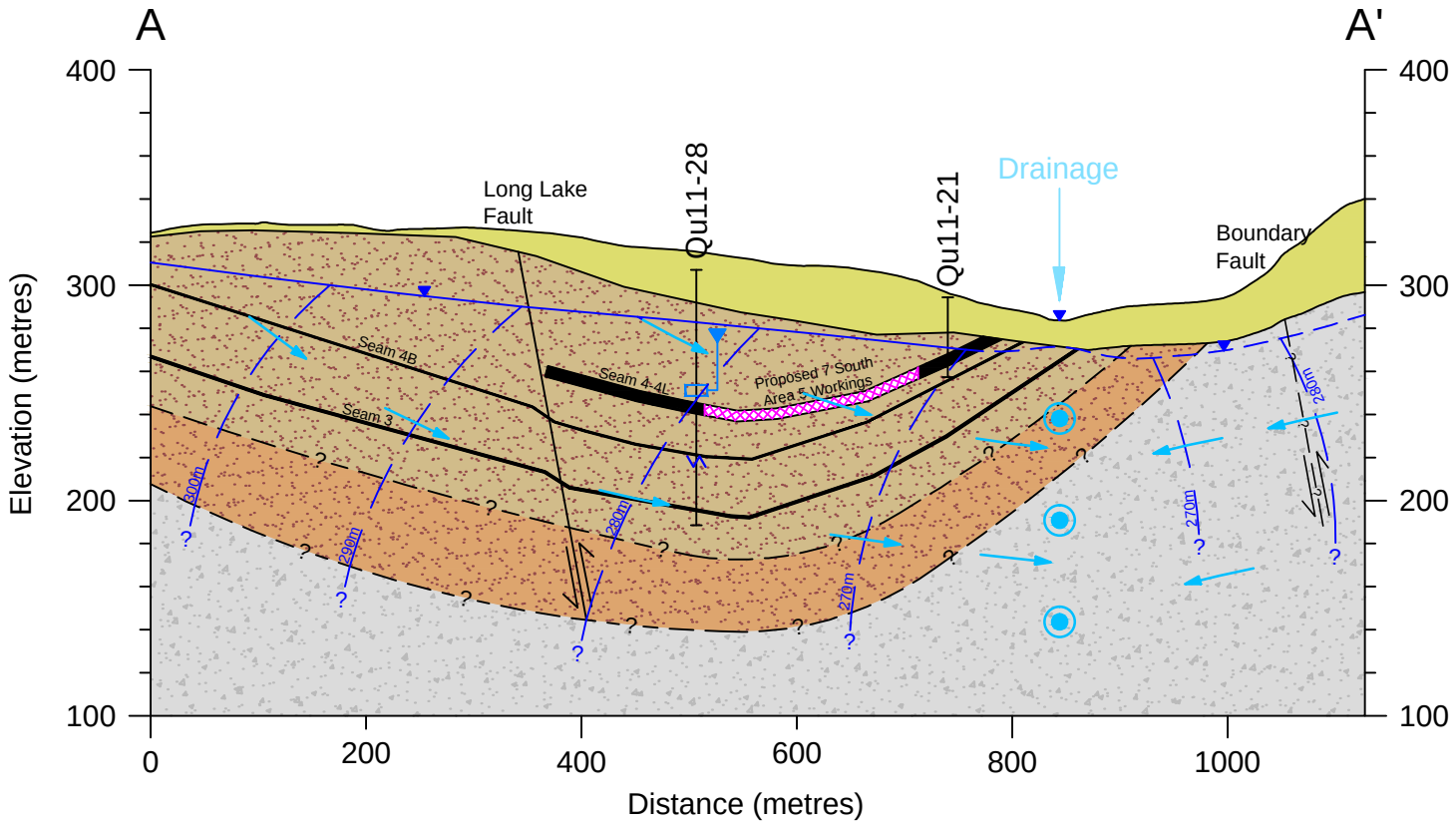
P:\J885 Hillsborough Resources\Drafting\AutoCAD map\Quinsam_fig2-5_28Jan2013.dwg

In an earlier groundwater assessment of 7 South (Appendix J of Hillsborough, 2011), it was determined that the proposed 7 South mine (Areas 1-4) occupied an area of groundwater recharge where seepage from the mine was inferred to originate solely from infiltration of precipitation and snowmelt within the footprint of the mine. The highest water levels were recorded in the southernmost portion of the mine with groundwater flow paths traveling radially from this mound. Most groundwater draining the 7 South mine footprint was inferred to drain towards the Quinsam River with the southernmost end draining towards the Iron River. The pronounced decline in hydraulic heads at the south end of the mine was attributed to the Long Lake fault, which was surmised to be a highly permeable feature that acts like a groundwater drain.

As indicated on Figure 2-4, the groundwater catchment area draining Area 5 is inferred to report entirely to the Iron River. There is uncertainty in the groundwater head potentials east of the main drainage in the vicinity of the Boundary Fault. Since no water level information is available for this area, the water table contours have been estimated to roughly follow topography. The height of land increases substantially in this area therefore the ridge to the east of the proposed mine has been treated as a groundwater divide. An alternate interpretation is that the water table contours continue to decline eastward towards the Quinsam River, with the potential for future mine impacted water reaching the Quinsam River downstream of monitoring station 7SQR. This scenario is considered to be less likely and subsequent discussion has been tailored to reflect the conditions presented in Figure 2-4.

Groundwater draining 7SA5 originates from upstream areas in the catchment as well as from infiltration of precipitation. The southern portion of Area 5 drains in a southeasterly direction towards the Iron River under gentle to moderate gradients (3-8%). Groundwater draining the middle and northern portions of Area 5 flows in a more easterly direction (~5% gradient) and then deflects southward aligned with the main surface drainage in the area. Three hydrogeological cross-sections have been constructed through the proposed Area 5 workings. Note that few drillholes intersect the Cumberland member and/or basement rock in this area; lithological contacts have been inferred based on representative thicknesses presented elsewhere (Hillsborough, 2011).

Cross-section A-A' transects the northern portion of 7SA5 (Figure 2-5). The curvature of the groundwater equipotentials reflects the downward hydraulic gradients which are inferred from QU11-18S/D, farther downgradient. The flow arrows indicate that groundwater draining the mine area has both vertical and horizontal components. In this interpretation, groundwater is shown to flow eastward from the mine area towards the drainage channel where it deflects southward (out of the page) towards the Iron River. Here, it is inferred that the water table resides in the bedrock and the till is unsaturated.



LEGEND

- Dunsmuir Sandstone
- Cumberland Member
- Igneous Basement
- Overburden
- Coal Seams
- Monitoring Well With March 2012 Water Level (Qu11-28)
- Proposed 7 South Area 5 Workings
- Groundwater Flow Path
- Fault
- Inferred Contact
- Water Table
- Inferred Water Table
- Groundwater Equipotential
- Groundwater Flow Out of Page
- Inferred Fault
- Water Bearing Fracture

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Units: Metres

0 100 200 m

2x Vertical Exaggeration

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT: 7 South Area 5 Groundwater Assessment

TITLE: Cross section A-A'

PROJECT #: J885-7

FIGURE: 2-5

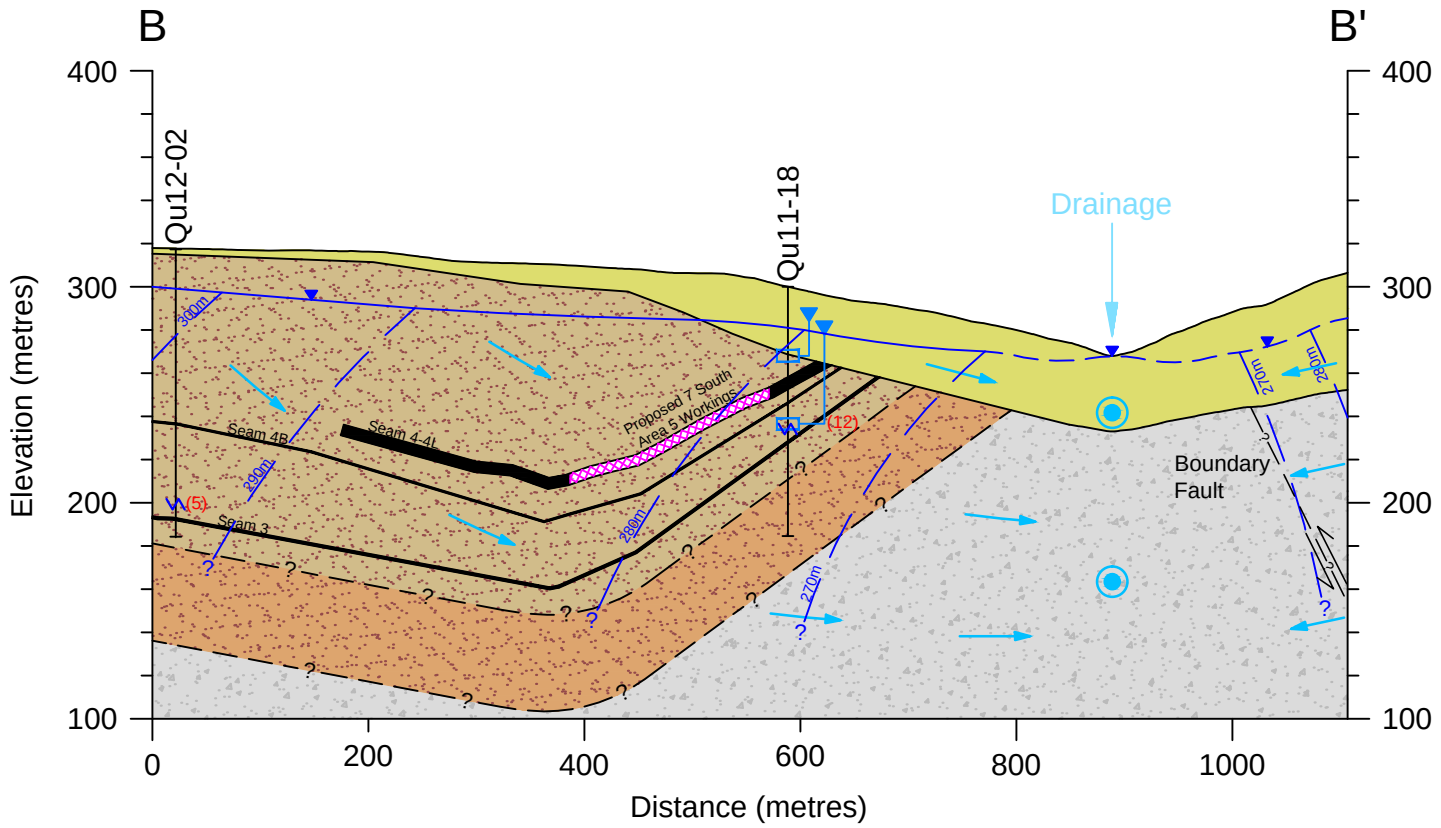
P:\J885 Hillsborough Resources\Drafting\cross sections\7 South Area 5\Cross Section A-A'_31Jan2013.dwg

In this reach, the drainage channel is inferred to be losing water to the groundwater system which is based on the on the elevation of the small wetland (~292 m) and the water level at QU08-10 (~ 275 m). The drainage may, however, cause a local mounding of the water table in this area. Groundwater draining the proposed mine workings is not expected to report to the drainage channel in its upper reach; however, this might occur farther downstream where the surface topography approaches the elevation of the mine. The Long Lake and Boundary Faults are indicated on this cross section as steeply dipping thrust faults; however, there is no drillhole data confirming the dip of the Boundary Fault.

Section B-B' (Figure 2-6) is located in the central portion of the proposed 7SA5 mine and is roughly parallel to Section A-A'. Here, the synclinal nature of the 4 seam is more pronounced. Similar to Section A-A', groundwater is inferred to flow from 7SA5 towards the drainage channel and then deflect southward (out of the page) towards the Iron River. In this area, the till is saturated as indicated by the water levels in QU11-18S/D. Water levels in QU11-18S/D indicate a strong downward gradient (20%) along the eastern margin of the proposed mine between the till and bedrock. As in Section A-A', the surface drainage is judged to be losing water to the groundwater system in this reach and groundwater draining the mine is expected to deflect downstream towards the Iron River.

Cross-section C-C' (Figure 2-7) illustrates groundwater flow paths in the southern portion of 7SA5. Along this section, the proposed mine is below the elevation of the Iron River. The water levels at QU11-36S/D indicate a strong downward gradient in the bedrock immediately upgradient of the Iron River; these gradients have ranged between 30% and 49% over a nine month period. Shallower groundwater is expected to discharge to the Iron River, however, deeper groundwater that drains the proposed workings may travel farther down the Iron River valley before reporting to the river. The strong downward gradient measured at QU11-36S/D could indicate that there is a permeable feature at depth (*i.e*. a fault) which acts as a preferential groundwater flow path. The main 7SA5 permit amendment report indicates that Quinsam syncline dies out against a regional scale fault in this area.

Note that cross-sections A-A' through C-C' have all depicted downward vertical gradients in the footprint area of 7SA5, based on water levels collected at nested wells QU11-18S/D and QU11-36S/D. The vertical gradient measured at QU11-18S/D is between till and bedrock and may overestimate the typical gradient within the bedrock as groundwater flow is often concentrated along the interface between the till and bedrock. QU11-36S and QU11-36D, which both screen bedrock, suggest even higher vertical gradients however; these wells are in close proximity to the steep Iron River valley and a



LEGEND

- Dunsmuir Sandstone
- Cumberland Member
- Igneous Basement
- Overburden
- Coal Seams
- Monitoring Well With March 2012 Water Level (Qu11-28)
- Proposed 7 South Area 5 Workings
- Groundwater Flow Path
- Fault
- Inferred Contact
- Water Table
- Inferred Water Table
- Groundwater Equipotential
- Groundwater Flow Out of Page
- Inferred Fault
- Water Bearing Fracture with air lift yield (IGPM) (12)

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VERSION:	1

Units: Metres

0 100 200m

2x Vertical Exaggeration

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT: 7 South Area 5 Groundwater Assessment

TITLE: Cross section B-B'

PROJECT #: J885-7

FIGURE: 2-6

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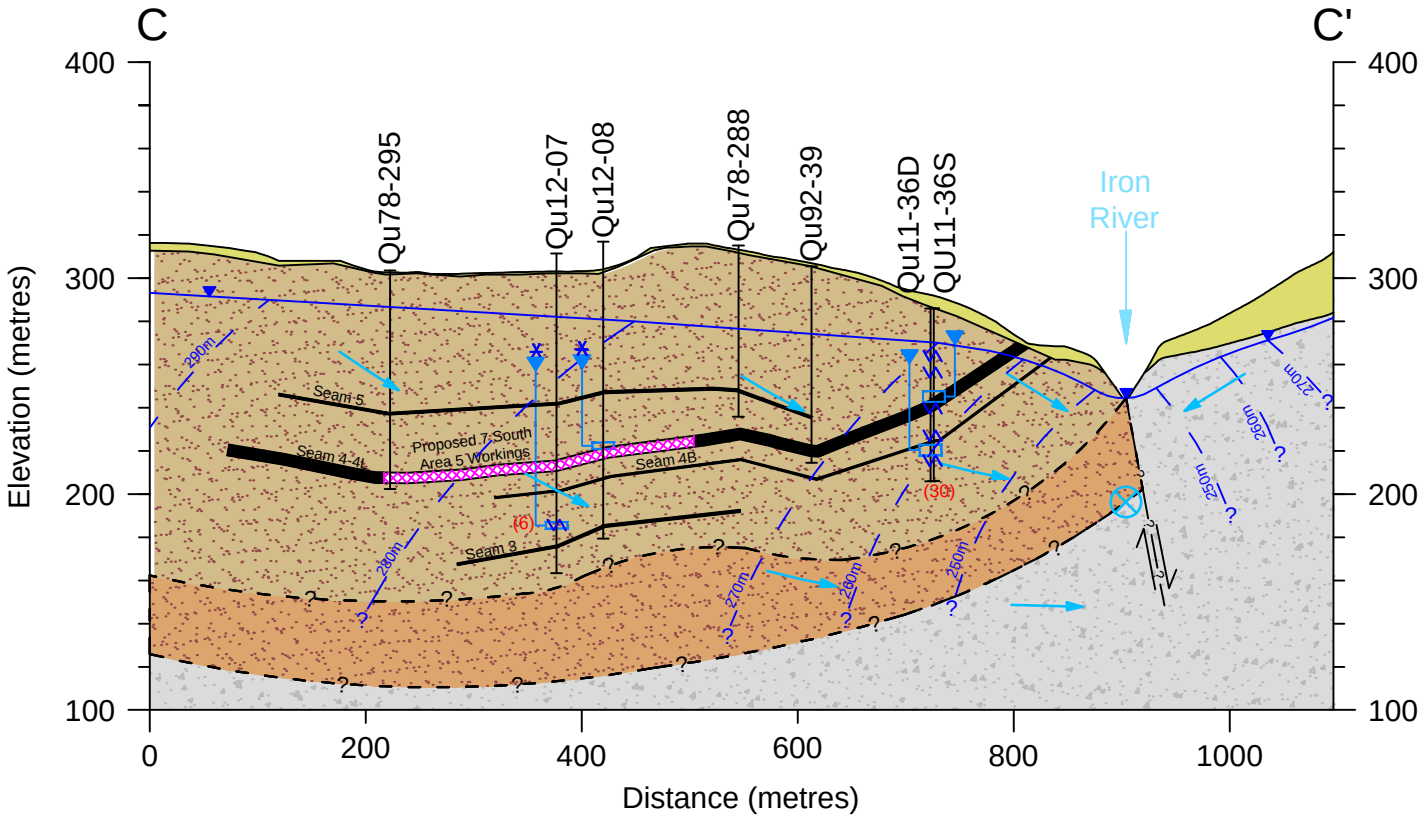

LEGEND

- Dunsmuir Sandstone
- Cumberland Member
- Igneous Basement
- Overburden
- Coal Seams
- Proposed 7 South Area 5 Workings
- Groundwater Flow Path
- Inferred Fault
- Inferred Contact
- Water Table
- Inferred Water Table
- Groundwater Equipotential
- Groundwater Flow Into Page
- (30) Airlift Yield i GPM
- Water Bearing Fracture

Monitoring Well With November 2012 Water Level — Qu11-28 — Monitoring Well With March 2012 Water Level

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Units: Metres

0 100 200 m

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT: **7 South Area 5 Groundwater Assessment**

TITLE: Cross section C-C'

PROJECT #: J885-7

FIGURE: 2-7

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possible regional fault. This would suggest that the vertical gradient here would not be representative of the entire mine footprint. A very slight upward gradient (<0.5%) exists between QU12-07 and QU12-08, however both wells screen very deep bedrock (>90 m bgs) and are not nested together. Overall, the magnitude of vertical gradients in the footprint area of 7SA5 is not well constrained.

Water level hydrographs for the 7SA5 monitoring wells are shown in Figure 2-8. The graphs do not include data collected during the pumping test (October 23rd -November 2nd, 2012). The several months of data thus far in 7SA5 indicate a seasonal variation in groundwater levels that is most pronounced at QU11-36S/D and QU08-10. QU08-10 screens the No. 3 seam north of the Long Lake fault and is highly impermeable. Given that this well screens tight material that would not drain quickly, the large (> 5 metres) seasonal fluctuation in water levels is expected. The highest water levels occurred during the spring freshet while the lowest levels occurred at the end of October 2012, approximately two weeks after the end of a prolonged dry spell.

QU11-36S and QU11-36D have experienced a seasonal variation of similar magnitude as QU08-10, or about 4.2 metres and 5.6 metres in the shallow and deep well, respectively. Unlike QU08-10, these wells screen much more permeable material (fractured sandstone). QU11-36S is screened near the elevation of Iron River, while QU11-36D is screened about 20 metres deeper (Figure 2-7). These wells did not respond during a pumping test conducted in 7SA5 and it is inferred that they may be hydraulically connected to the Iron River and/or the flooded 242 test mine workings (Appendix A7). Being located at the downgradient edge of the groundwater catchment, the large increase in water levels at QU11-36S/D through the wet season may be a result of groundwater converging at the margins of the basin, however the downward gradients suggest that there might be a permeable feature at depth that drains the deeper groundwater.

The water level records for QU11-28 and QU11-18S/D generally show a much more subdued response to seasonal recharge, with water level variations on the order of 1-2 metres over the last several months. The recent low water level at QU11-18S is most likely an artefact from the pumping test which partially dewatered the till. The limited data records at QU11-35, QU12-07 and QU11-35 indicate a water level increase of approximate 2.5 metres over the period spanning late October to late November.

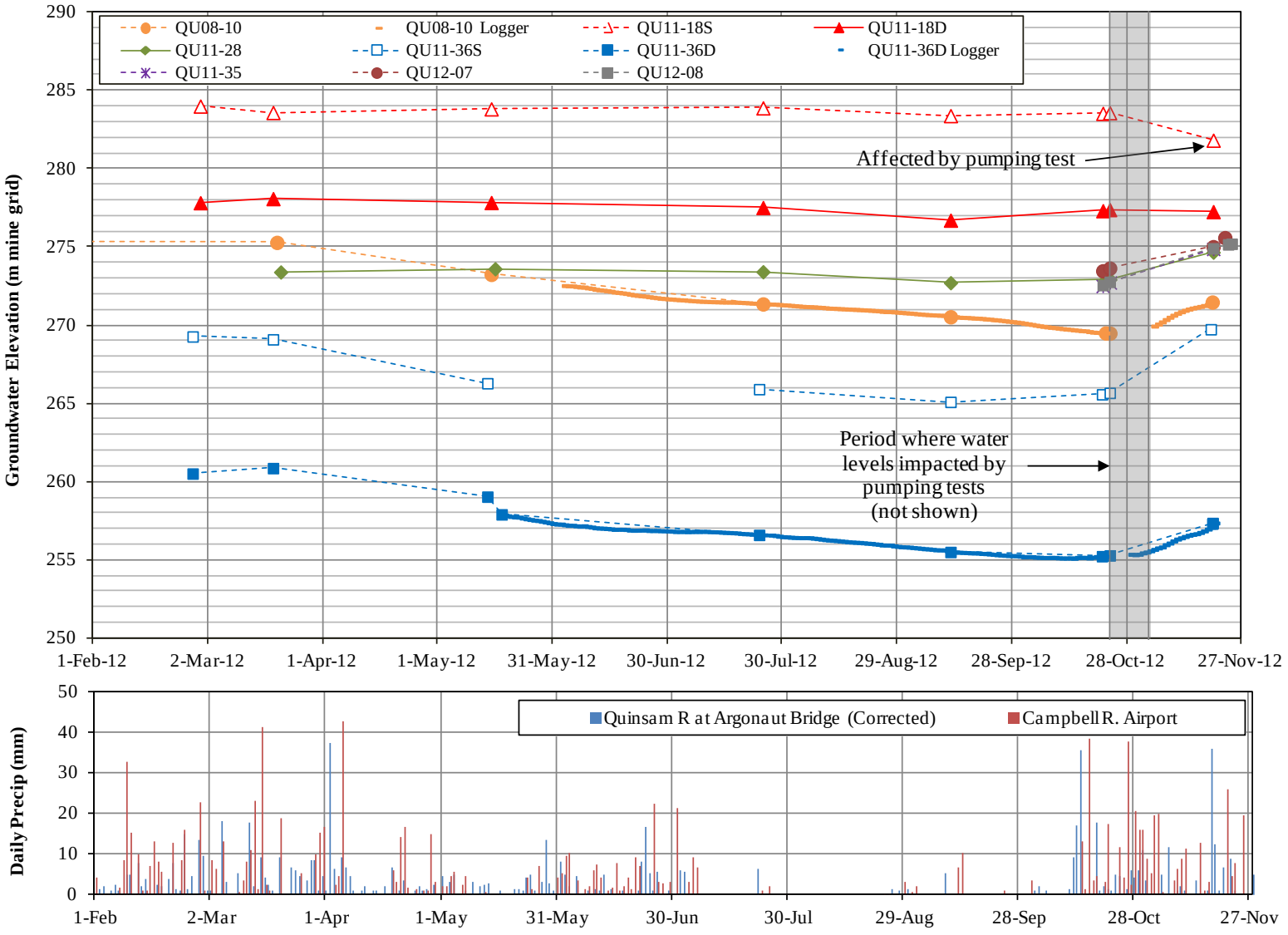


Figure 2-8: Water level hydrographs for 7SA5 monitoring wells

2.5 Groundwater Flow Estimates

2.5.1 Groundwater Inflows During Mine Development

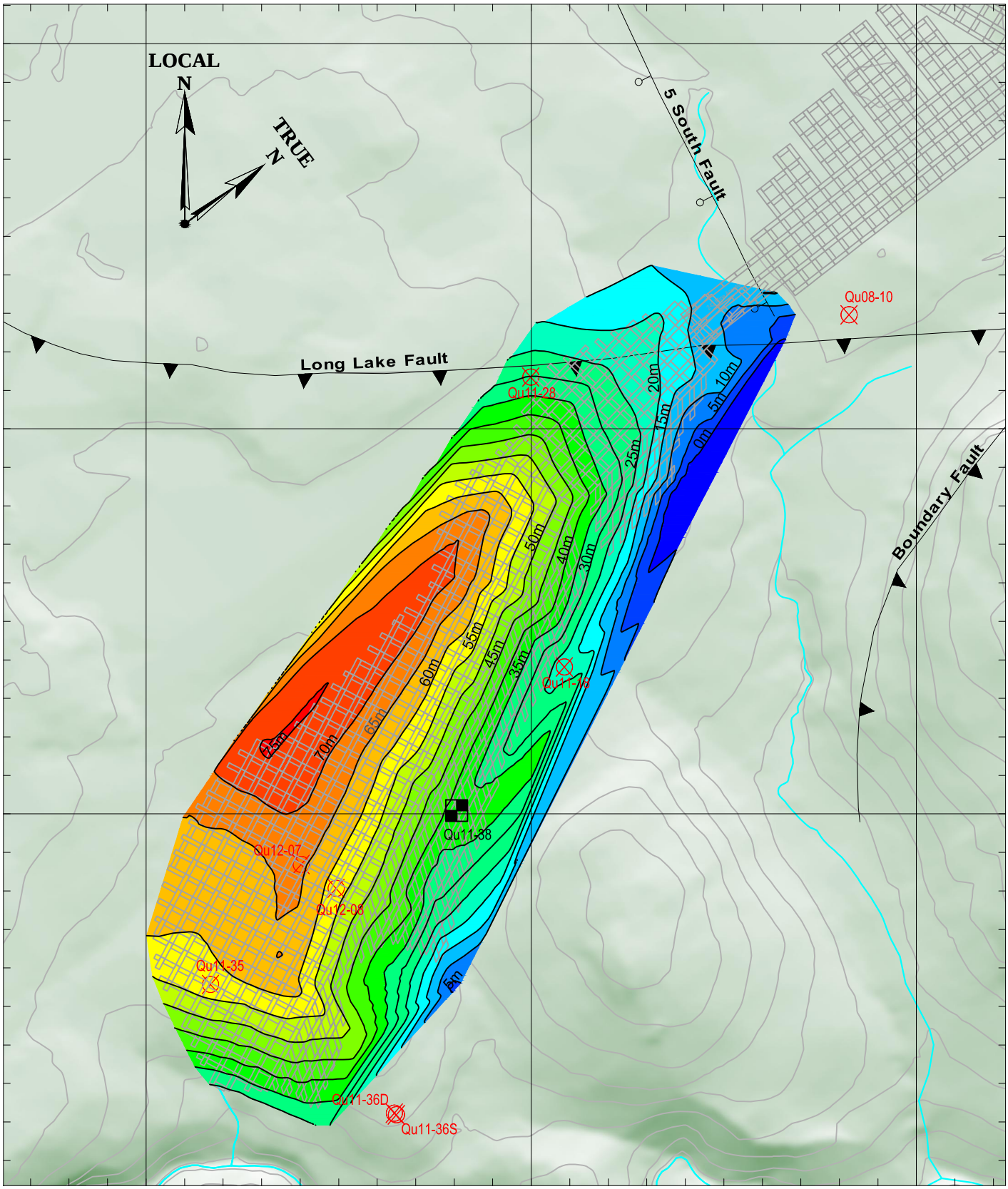
2.5.1.1 Approach

Initial slug tests on 7SA5 monitoring wells (discussed below) and the evaluation of borehole airlift yields in 2011/2012 exploration holes (Figure 2-3) indicated that 7SA5 bedrock was much more permeable than other areas of the mine site. Given that 7SA5 may be susceptible to larger groundwater inflows than other mine areas, a multi-day pump-test was undertaken to better constrain flow estimates. The drawdown from this pump test was used to predict the dewatering rates required to reduce the head to within +/- 10 metres of the elevation of the 7SA5 workings (Figure 2-9). This dewatering rate is equivalent to the amount of groundwater that may infiltrate the underground workings during development. This analysis does not take into account any potential hydraulic connection to the Iron River and/or the flooded 242 test mine which may occur through pre-existing faults. Barrier pillars between the proposed 7SA5 mine and the 242 test mine and Iron River are planned to minimize hydraulic connection to these features; however, should a connection via a significant fault exist, these inflows may be underestimated.

2.5.1.2 Slug Test Results

Slug tests were performed on all monitoring wells in 7SA5, the results of which are summarized in Table 2-2 while methods and output files are contained in Appendices A2 and A5. These values have been added to the hydraulic conductivity database (Appendix A6).

The average sedimentary bedrock hydraulic conductivity (K) in 7SA5 is approximately 7x10-6 m/s based on the slug tests at QU11-18D, QU11-35, QU11-36S/D, and QU12-07. QU08-10 was omitted from this average since it lies north of the Long Lake fault and is considered to reflect the bedrock conditions in 7 South. As is illustrated by the depth profile of bedrock K in Figure 2-10, the average hydraulic conductivity for 7SA5 sedimentary bedrock is significantly higher than the unfractured, sedimentary bedrock K determined for other areas of the mine (~$8x10^{-9}$ m/s). It should be noted, however, that in some cases the wells specifically targeted water bearing (*i.e.* higher hydraulic conductivity) features, and therefore, the 7SA5 data set may be biased high. Measurements of coal K in 7SA5 generally fall within the range of values measured elsewhere on site (Figure 2-11).



LEGEND

- Workings
- Monitoring Wells
- Pumping Wells
- Head Above 4 Seam Contours (5m)
- Rivers/Drainage
- Surface Contours (10m)
- Thrust Faults
- High Angle Faults

Contour Colours

- 0-5m
- 10-15m
- 20-25m
- 30-35m
- 40-45m
- 50-55m
- 60-65m
- 70-75m

DATE SAVED:	Feb 22, 2013
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VERSION:	1

Coordinate System: Quinsam Mine Local Grid
Projection: Orthographic
Units: Metres

0 50 100 m

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT: **Water Quality Effects Assessment: 7 South Area 5**

TITLE: Head Above Top of 4 Seam Based on March 2012 Water Levels

PROJECT #: J885-7

FIGURE: 2-9

P:\J885 Hillsborough Resources\Drafting\AutoCAD map\Feb2013Figures\Fig2-9_head above 4 seam_05Feb2013_GM.dwg

Table 2-2:
Slug test results for 7SA5 monitoring wells.

WELL ID	Screened Lithology	Hydraulic Conductivity (m/s)
QU08-10	No. 4 Coal	5.0E-09
QU11-18S	Till	1.2E-08
QU11-18D	SST/Fractured SLST	1.1E-05
QU11-28	No. 4&4L/SST	1.3E-06
QU11-35	Fractured SST	1.4E-06
QU11-36S	Fractured SST	4.2E-06
QU11-36D	Fractured SST	2.0E-05
QU12-07	Fractured SLST/SST	1.6E-05
QU12-08	No 4/4L Coal	6.5E-07

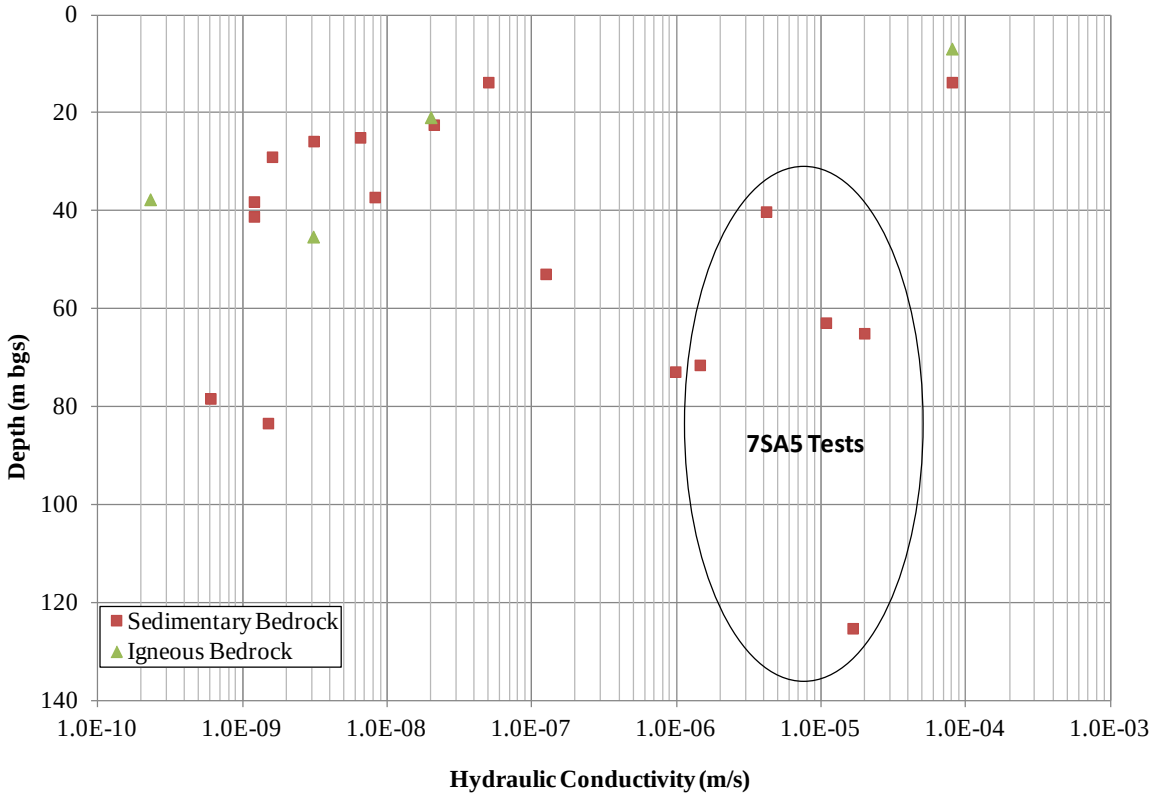


Figure 2-10: Depth profile of sedimentary bedrock hydraulic conductivity measurements at the Quinsam coal mine.

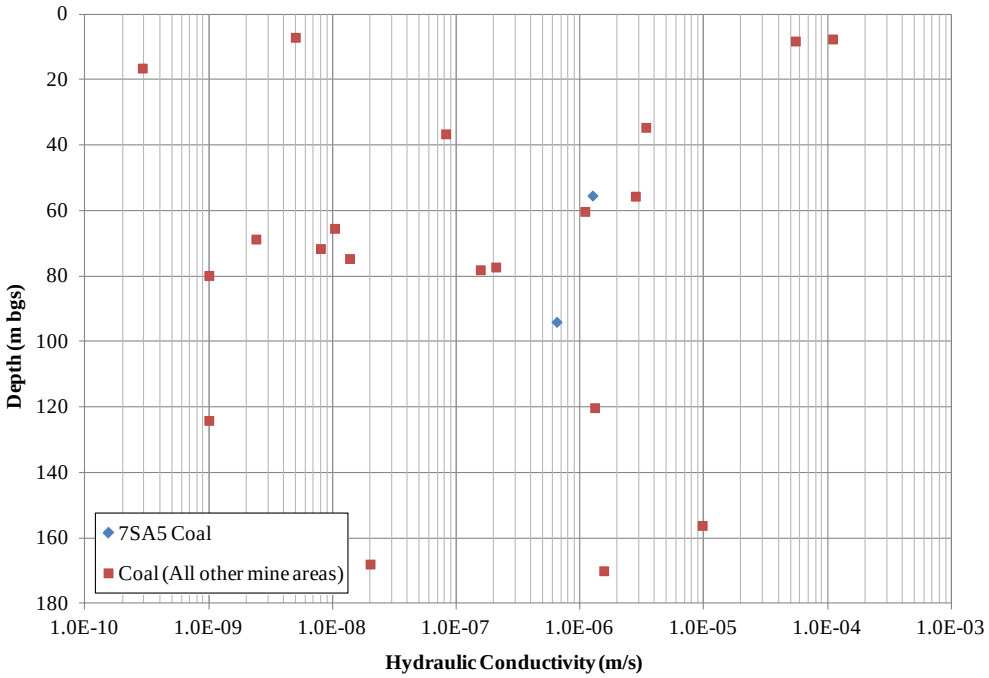


Figure 2-11: Depth profile of coal hydraulic conductivity measurements at the Quinsam coal mine.

2.5.1.3 Pump Test Results

A three-day constant rate pumping test was undertaken in 7SA5 between October 24th and 27th, 2012. Methods and detailed results of the pumping test are included in Appendix A7. QU11-38 was selected as the pumping well location for three reasons:

i. it intercepted two significant water bearing features near the elevation of the No. 4/4L coal seam - a 15 GPM feature at 39.6 m bgs (~17 metres above the No. 4 Seam) and a 35 GPM zone between 52 and 55 m bgs (1.5-4 m bove the No. 4 seam) (Appendix A4),

ii. it is located in the southern region of the proposed mine where water bearing features are commonly encountered at or above the coal seam (Figure 2-3), and

iii. it is at a significant distance (>500 metres) from the Iron River, so that potential boundary effects from the Iron River would not completely mask the influence of the test.

QU11-38 was pumped at a constant rate of 30 US GPM for 73 hours. Water levels were continuously monitored at QU11-38, all 7SA5 monitoring wells and nearby 2011-2012 exploration boreholes. The drawdowns presented in Figure 2-12 (pumping well) and Figure 2-13 (observation wells) have been corrected for background trends (Appendix A7).

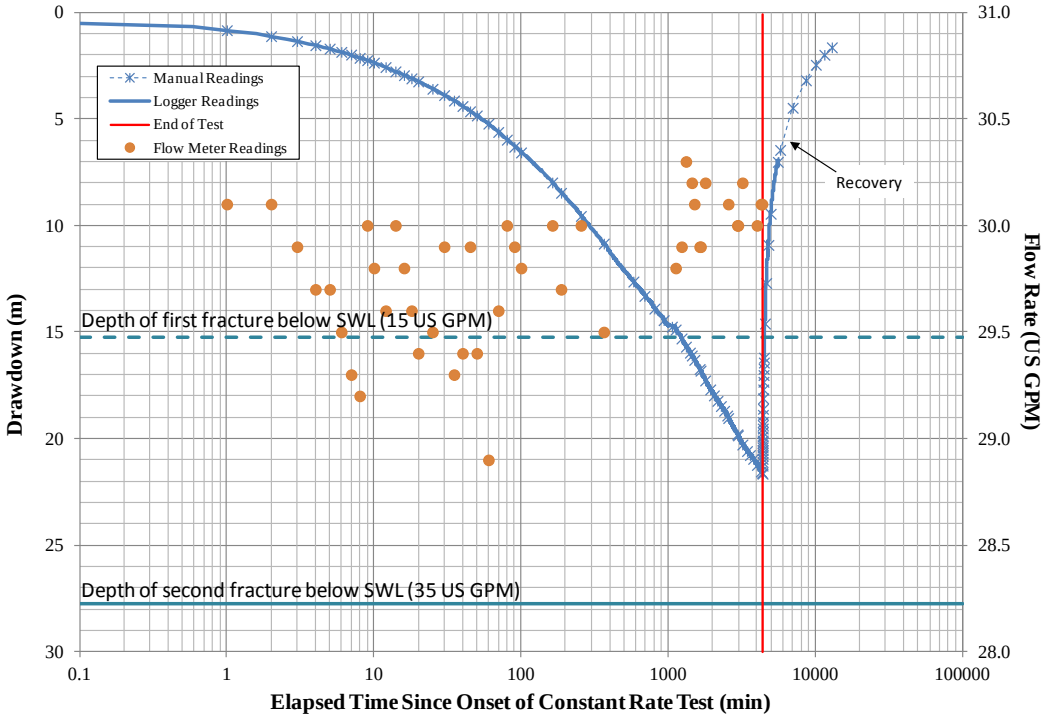


Figure 2-12: Corrected drawdown measured at QU11-38 during constant rate test.

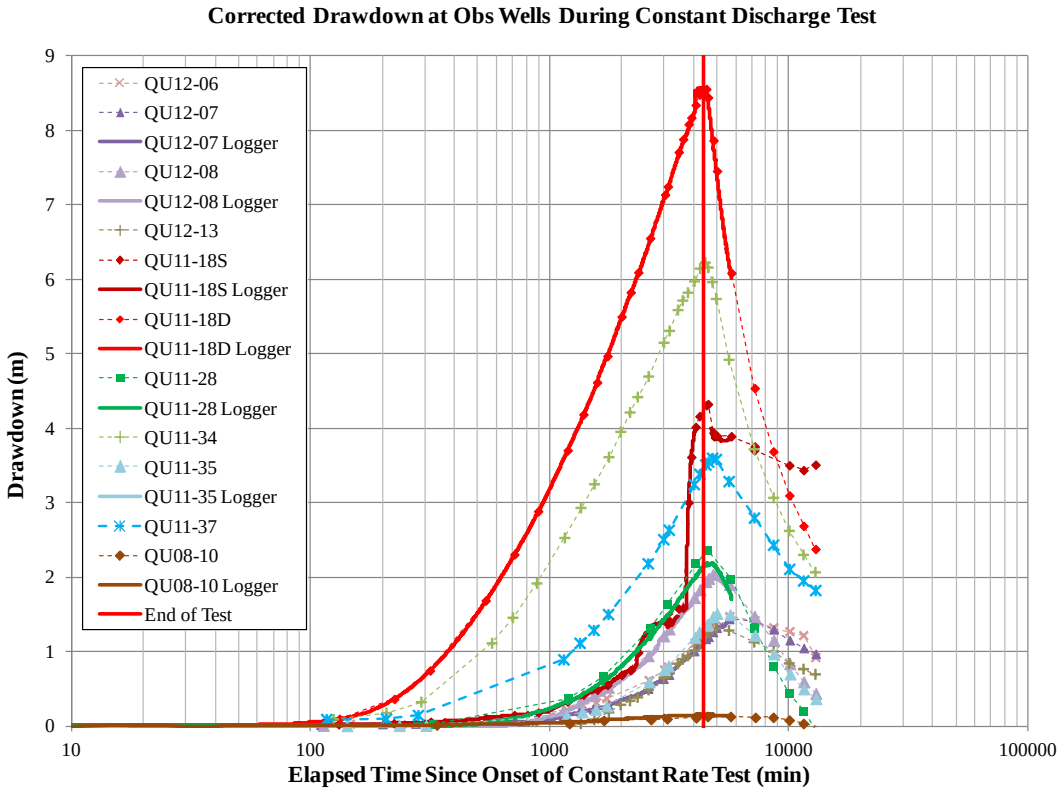


Figure 2-13: Corrected drawdown measured at observation wells and open boreholes during constant rate test.

Water quality field parameters were also continuously measured at the wellhead and water quality samples were taken after 24, 48 and 72 hours (discussed in Chapter 4). Figure 2-12 indicates that the rate of drawdown in the pumping well did not change significantly once the water level dropped below the elevation of the first fracture. This would indicate that the upper and lower fractures are connected or the upper fracture didn't dewater. Figure 2-13 illustrates that there was a widespread response to pumping throughout 7SA5 with the most significant drawdown outside of the pumping well measured at QU11-18D, about 230 m northeast of the pumping well. QU11-18S, completed in till, also had a significant response which indicates that the till was partially dewatered in this area. QU11-36S&D, on the other hand, did not experience any response to pumping and have not been included in Figure 2-13.

Maximum drawdown measurements from all monitoring locations have been tabulated in Table 2-3 and contoured in Figure 2-14. The drawdown cone is asymmetrical and is elongated along a line roughly parallel to the axis of the syncline. Based on the the response measured at QU11-28, the drawdown cone is thought to widen at the northern end of the workings as it hits the impermeable bedrock north of the Long Lake fault, drawing water from the east and west instead. The drawdown cone appears to be truncated at the southern extent of the workings due the presence of a positive (recharge) boundary, which could be the flooded 242 test mine and/or the Iron River.

The pumping test data were analysed using the Aqtesolv software to determine aquifer parameters (Appendix A7, A9). Using two different analytical solutions and a variety of boundary conditions, theoretical drawdown curves were matched to the drawdown curves of the QU11-38 and QU11-18D wells. The main outcomes of the data analysis are as follows:

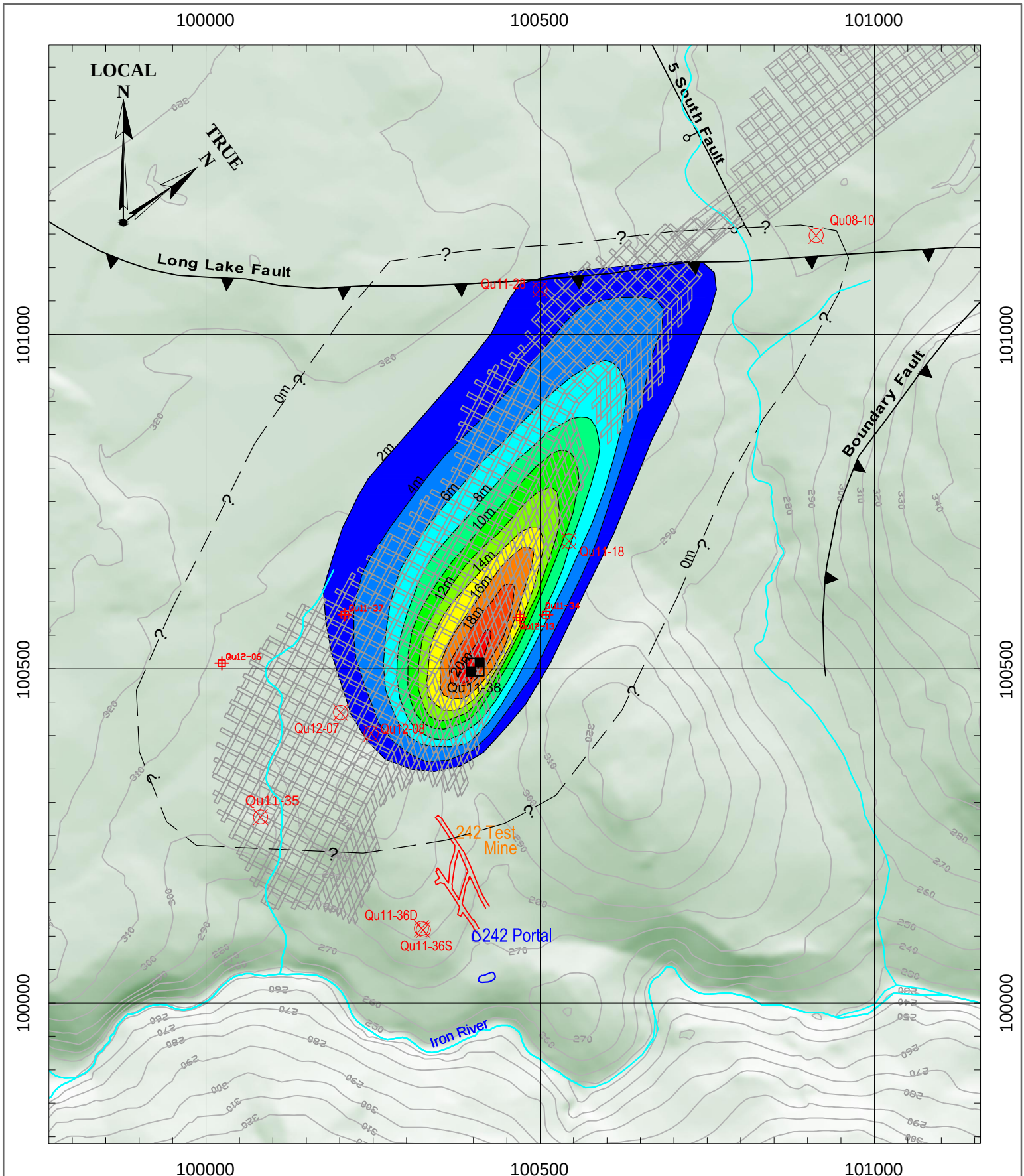
- a composite plot of the observation wells (Figure A7-11) indicated that the aquifer is not ideal (*i.e*. heterogeneous, anisotropic, and/or of finite extent),
- the drawdown derivative plot for QU11-38 neither confirms nor refutes that a constant head or recharge boundary exist in the southern area of the mine (Figure A7-12),
- the Theis solution (1935) for an ideal aquifer could not reproduce the drawdown observed in Figure 2-12 even when boundary conditions were introduced, and
- the Gringarten-Witherspoon solution (1972) for a pumping well located in a vertical fracture combined with a no flow boundary condition at the north end of the working and a constant head boundary in the south end of the workings overall produced the best fit to the drawdown curves and produced a contour plot similar to that shown in Figure 2-14 (see Figure A7-13c).

Both the Theis and Gringarten-Witherspoon solutions were relatively insensitive to no-flow boundaries introduced on the eastern and western margins of the study area, thus these boundary conditions were not used. The Gringarten-Witherspoon solution assumes that the pumping well fully penetrates the vertical fracture, which is modeled as a vertical plane. Physically, this vertical fracture would represent a more highly fractured zone centralized near the axis of the syncline. The height of the vertical fracture is thus equal to the saturated thickness of the aquifer, which in these simulations was modeled to be ~70 metres (equivalent to the thickness of the sedimentary rock sequence at QU11-38). The aquifer properties derived using the Gringarten-Witherspoon solution are summarized in Table 2-4.

Table 2-3:
Maximum drawdown (DD) measured during 3-day constant rate test at QU11-38.

WELL ID	Radius from PW (m)	Max Corrected DD (m)	Open/Slotted Interval Elev. (m mine grid)		Screened Lithology	4 Seam Interval Elev. (m mine grid)	
			Top	Bottom		Top	Bottom
QU11-38	0	21.6	274.3	204.9	open hole	242.8	241.0
QU12-13	98	1.31	265.1		open hole	?	?
QU11-34	130	6.22	261.0	229.7	open hole	240.9	238.6
QU12-08	186	2.05	225.0	219.5	No 4/4L Coal	223.6	220.9
QU11-37	210	3.59	307.4	150.6	open hole	212.4	211.6
QU12-07	214	1.44	188.3	182.8	Fractured SLST/SST	216.3	213.7
QU11-18S	234	4.32	270.8	265.3	Till	258.5	256.5
QU11-18D	234	8.55	239.1	233.9	SST/SLST	258.5	256.5
QU12-06	380	1.47	306.8	159.0	open hole	226.1	224.3
QU11-35	391	1.51	231.3	226.4	Fractured SST	223.6	221.7
QU11-28	572	2.36	253.7	248.6	No. 4&4L/SST	252.6	249.2
QU08-10	821	0.13	277.4	266.5	No. 3 Coal	N/R	N/R
QU11-36S	402	0	247.6	242.7	Fractured SST	242.3	233.9
QU11-36D	402	0	222.8	217.6	Fractured SST	242.3	233.9

Note:
1. PW = pumping well, DD = drawdown, SST = sandstone, SLST = siltstone



LEGEND

- 73 hour Drawdown Contours (2m)
- Surface Elevation (10m)
- Rivers / Drainage
- Thrust Faults
- High Angle Faults
- Proposed Workings
- Monitoring Wells
- Pumping Wells
- Open Boreholes

Contour Colours

- 2-4m
- 6-8m
- 10-12m
- 14-16m
- 18-20m

DATE SAVED:	Feb 25, 2013
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Projection: Orthographic
Units: Metres

0 50 100 M

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT: **Water Quality Effects Assessment: 7 South Area 5**

TITLE: **Corrected Drawdown at End of 73-Hour Constant Rate Pumping Test (30 USGPM)**

PROJECT #: **J885-7**

FIGURE: **2-14**

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Table 2-4:
7SA5 aquifer parameters simulated by Aqtesolv using Gringarten-Witherspoon solution.

Aquifer Parameter	Description	Units	Computed Value
K_x	Hydraulic Conductivity of Fracture	m/s	1.6×10^{-6}
K_y	Hydraulic Conductivity of Formation	m/s	2.6×10^{-7}
S_s	Specific Storage of Formation	m^{-1}	2.3×10^{-6}
L_f	Fracture Length	m	200

The computed hydraulic conductivity of the fracture is of similar magnitude to the average hydraulic conductivity measured from slug tests on 7SA5 bedrock wells (~7×10^{-6} m/s), which were generally screened across higher permeability features. The hydraulic conductivity of the bulk formation (3×10^{-7} m/s) is about ten times higher than the average hydraulic conductivity of sedimentary rock determined from other mine areas (2×10^{-8} m/s), which is consistent with 7SA5 being a more structurally disturbed area. The computed specific storage of the formation is slightly lower than the typical range (10^{-4} – 10^{-5} m^{-1}) for a fractured, cemented sandstone (L.Smith, pers. communication). Overall, the solution was sensitive to the dimensions of the fracture.

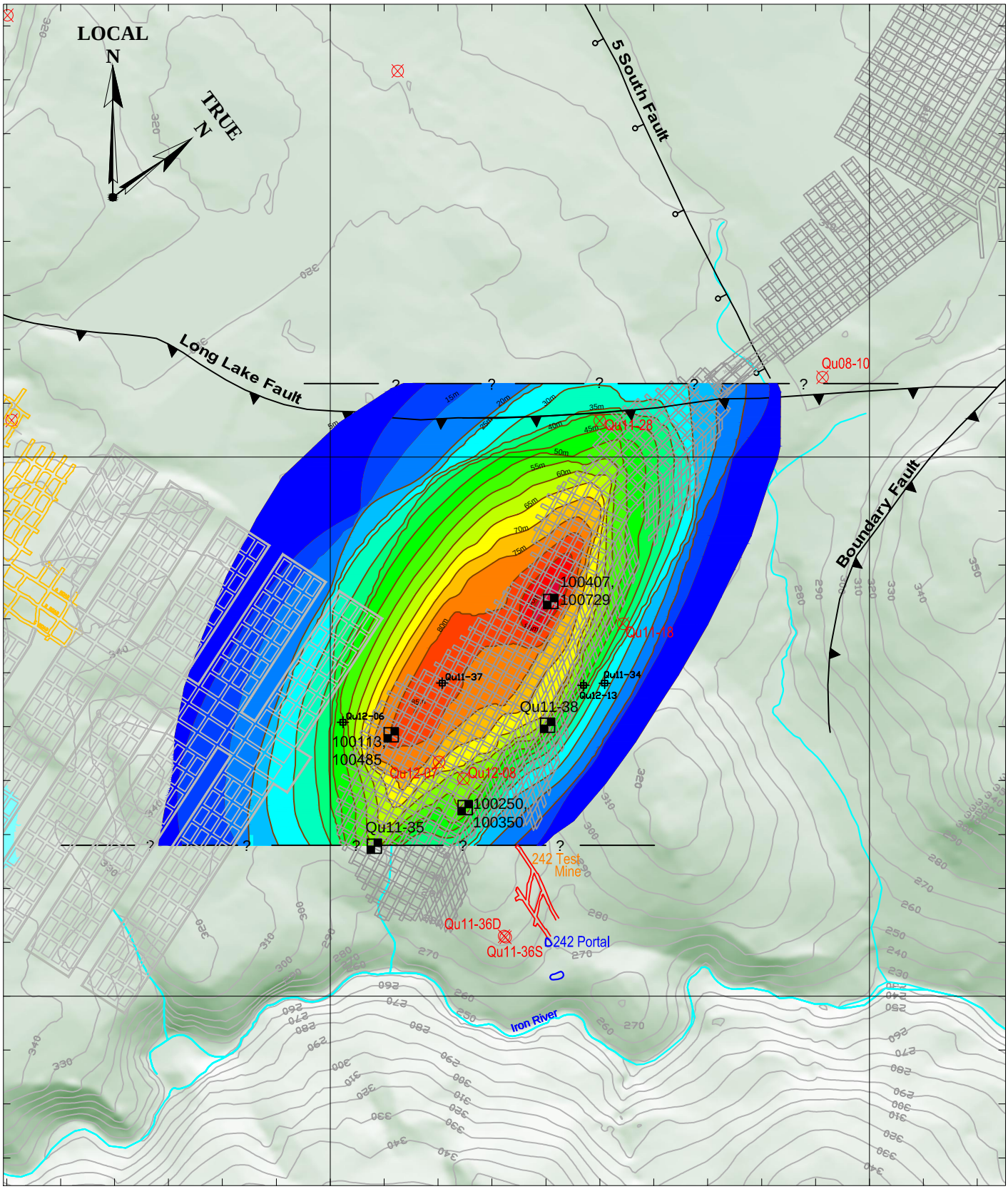
2.5.1.4 Predicted Inflows

Given the high permeability of bedrock in the 7SA5 area, it is probable that the hanging rock will dewater during mine development. As such, the approach taken for predicting potential groundwater inflows during mine development was to determine how much pumping would be required to lower the hydraulic head in the mining footprint to within +/-10 metres of the No.4 coal seam. Figure 2-9 shows the head above the No. 4 seam, based on the water level contours shown in Figure 2-4 and the structure contours for the coal zone developed by Hillsborough (Figure 2-1). To compute this pumping rate, drawdown from the 3 day pumping test at QU11-38 was extrapolated to 100 days (Table 2-5, Appendix A10). One hundred days is considered to be a reasonable timeframe for preparation of the area in advance of mining and assumes that the mining area would be fully or partially dewatered in advance of mining as high inflows of nuisance water would be undesirable during operations.

Table 2-5:
Projected drawdown in 7SA5 wells after 100 days of pumping 30 US GPM at QU11-38.

WELL ID	Radius from PW (m)	Max Corrected Drawdown (73 hours) (m)	Projected Drawdown at 100 days (m)
QU11-38	0	21.6	39
QU12-13	98	1.31	5.8
QU11-34	130	6.22	16.3
QU12-08	186	2.05	8.4
QU11-37	210	3.59	11.8
QU12-07	214	1.44	5.8
QU11-18S	234	4.32	14.5
QU11-18D	234	8.55	22.5
QU12-06	380	1.47	5.8
QU11-35	391	1.51	6.7
QU11-28	572	2.36	9.5
QU08-10	821	0.13	0.3
QU11-36S	402	0	0
QU11-36D	402	0	0

The 100-day extrapolated drawdown was contoured in the same fashion as the 73-hour test, however, some of the peripheral aspects of the drawdown cone were modified to produce a more generalized drawdown pattern less influenced by boundary conditions (Appendix A10). The generic 100-day drawdown cone was replicated to additional pumping locations to simulate the effect of a multi-well groundwater interception system. The superimposed drawdown curves were then re-contoured to create an aggregate drawdown 'surface' that approximates the effect of multiple pumping wells. This is based on the principle of superposition whereby drawdowns at a point in an aquifer from multiple pumping wells are additive. The drawdown produced from multiple pumping wells was then subtracted from the head above the No. 4 seam to produce a surface approximating the *residual* head above the No. 4 seam. The number and locations of the pumping wells were optimized to provide sufficient drawdown in the footprint of the proposed workings without over-pumping (*i.e*. limiting drawdown to less than 10 metres below the coal seam). Ultimately, it was found that 5 wells pumping 30 US GPM for 100 days would be sufficient to dewater the area above the workings. The resultant drawdown surface created by this configuration of wells is shown in Figure 2-15, the residual head over the 7SA5 workings is shown in Figure 2-16. From this analysis, it is anticipated that operational groundwater inflows into the 7SA5 workings in the absence of dewatering wells would be in range of 125-175 US GPM or 8-10 L/s.



LEGEND

- Proposed Workings
- Existing Workings
- Monitoring Wells
- Pumping Wells
- Open Boreholes
- Drawdown Contours (5m)
- Extent of Drawdown Predictions
- Rivers
- Surface Elevation
- High Angle Faults
- Thrust Faults

Contour Colours

- 5-10m
- 15-20m
- 25-30m
- 35-40m
- 45-50m
- 55-60m
- 65-70m
- 75-80m
- 85-90m

DATE SAVED:	Apr 04, 2013
DRAWN BY:	GM
REVIEWED:	LLF
VERSION:	1

Coordinate System: Quinsam Mine Local Grid
Projection: Orthographic
Units: Metres

0 100 200 M

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

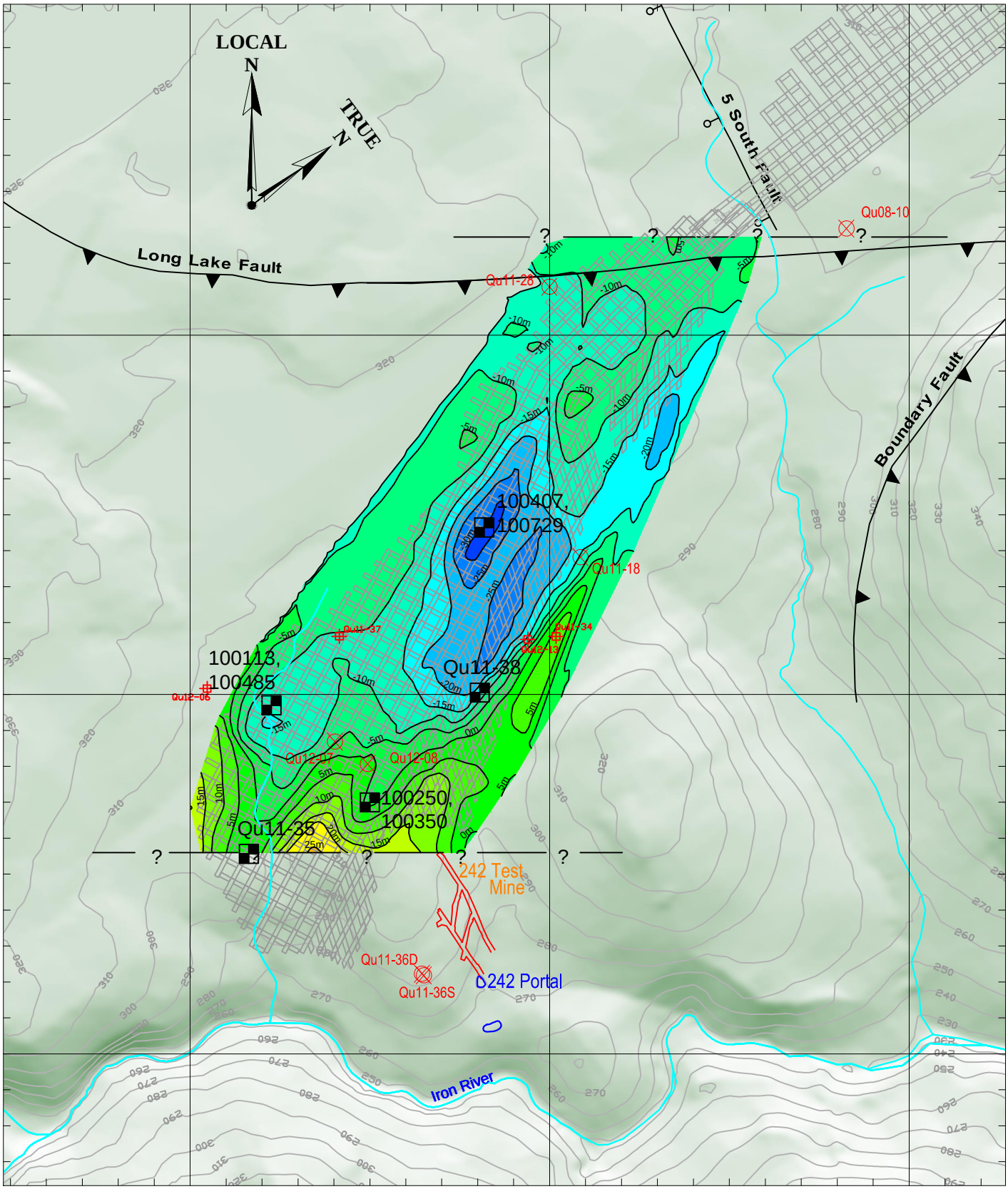
PROJECT: **Water Quality Effects Assessment: 7 South Area 5**

TITLE: **Extrapolated Drawdown For 5 Wells Pumping 100 Days at 30 US GPM Each**

PROJECT #: **J885-7**

FIGURE: **2-15**

P:\J885 Hillsborough Resources\Drafting\AutoCAD map\Feb2013Figures\Fig 2-13_drawdown combined 5 well_v2.dwg



LEGEND

- Proposed Workings
- Monitoring Wells
- Pumping Wells
- Open Borehole
- Residual Head Above 4 seam contours (5m)
- Extent of Drawdown Predictions
- Rivers
- Surface Elevation (10m)
- High Angle Faults
- Thrust Faults

Contour Colours

- (-25) - (-30)m
- (-15) - (-20)m
- (-5) - (-10)m
- 0 - 5m
- 10 - 15m
- 20 - 25m
- 30-35m

DATE SAVED:	Feb 25, 2013
DRAWN BY:	GM
REVIEWED:	LLF
VERSION:	1

Coordinate System: Quinsam Mine Local Grid
Projection: Orthographic
Units: Metres

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT: **Water Quality Effects Assessment: 7 South Area 5**

TITLE: **Residual Head Above the No. 4 Seam After 5 Wells Pumping 100 Days at 30 US GPM Each**

PROJECT #: **J885-7**

FIGURE: **2-16**

P:\J885 Hillsborough Resources\Drafting\AutoCAD map\Feb2013Figures\Fig 2-19_residual head above 4 seam_12Feb2013_GM.dwg

The method used above to determine groundwater inflows is considered to be a realistic estimation of groundwater inflows based on field observations including a three day pumping test; however, it does require some qualification. This method assumes that a similar drawdown pattern can be reproduced at any of the proposed pumping locations based on conditions encountered at QU11-38. This implies that each pumping location encounters a significant water bearing fracture/fault and similar boundary conditions to QU11-38. According to Figure 2-3 and Appendix A1, QU11-35 did encounter significant water both above and below the No. 4 seam. Similar features have not been confirmed to exist at the other pumping locations. Should less permeable rock conditions prevail, the 30 US GPM pump rate may not be sustainable and the resultant drawdown cone would be steeper and of more limited extent. Additional pumping locations would be required to achieve the desired drawdown; however, total pumping rates may not change significantly. Unidentified boundary conditions may also influence the operational inflows. In general, no flow boundaries would amplify the effects of drawdown from nearby pumping wells, and thus operational inflows would be smaller (*i.e*. less pumping wells may be required to achieve target drawdown). A constant head/recharge boundary, however, would have the opposite effect. Negligible drawdown at QU11-36S/D suggests that the flooded 242 mine or the Iron River is acting as a recharge boundary, but this was not definitively proven in the drawdown derivative plot. Due to the uncertainty over boundary conditions near the extreme southern portion of proposed workings, the 8-12 L/s operational inflow estimate is considered applicable to the mine area north of 100280 m Northing (Figure 2-15).

2.5.2 Groundwater Fluxes Through Mine Post-Development

The 7 South Area 5 will not be depillared at closure and the intention is to partially backfill the mine void with coarse coal refuse (CCR). Two approaches were taken to estimate groundwater fluxes from the flooded, backfilled mine; one based on a net precipitation infiltration rate bracketed by previous mine seepage rate estimates on the Quinsam property; the other based on a Darcy flux calculation.

2.5.2.1 Assessment of Seepage Rates from Precipitation and Infiltration

Previous groundwater assessments of other mine areas presented groundwater seepage rates as a percentage of mean annual precipitation (Hillsborough, 2011; Lorax, 2012). These seepage rates are summarized in Table 2-6. Mean annual precipitation (MAP) for the Quinsam mine site has been previously determined as 1,034 mm/yr (Lorax 2009). 'Most likely' seepage rates for the mine areas listed in Table 2-6 were calculated as Darcy fluxes and these values were in turn compared to the flux calculated by applying 100% of MAP to the mine footprint area (or in the case of Long Lake assessment, the

catchment area). 'Maximum' seepage rates were assumed to be 10% of MAP, except for the catchments feeding Long Lake, where the maximum seepage rate was calculated based on a scenario using a higher hydraulic conductivity value for the top 20 metres of bedrock ($4x10^{-7}$ m/s vs $1x10^{-7}$ m/s). Overall, the low net infiltration rates of 2-4% were deemed to be appropriate based on field observations at the site and author experience at other sites. In addition, other authors (Hodge, 1995; Foweraker, 1974) have computed recharge rates for Nanaimo Group bedrock aquifers on the Gulf Islands and found recharge rates on the order of 3-5% infiltration with the caveat that calculations were highly sensitive to aquifer storativity.

Based on these findings, groundwater seepage rates from 7 South Area 5 at closure were calculated assuming 2-10% infiltration of MAP. Using a projected mine footprint area of 28 hectares, this seepage rate corresponds to 16-80 m^3/d (0.2-0.9 L/s). Given that the bulk K of bedrock in 7SA5 is on the order of $3x10^{-7}$ m/s (as determined from the pumping test) and that this K value is similar to that assumed in the Long Lake groundwater assessment (higher K scenario), the 10% MAP value (0.9 L/s) is considered to be a reasonable approximation of groundwater infiltration at closure.

Table 2-6:
Groundwater seepage rates calculated for other mine areas expressed as net infiltration.

Mine Area	Groundwater Infiltration Area (ha)	Seepage Flux (most likely, max) (m^3/d)	Seepage Flux (most likely, max) (% of MAP)
7 South	422,250	50, 120	4%, 10%
2 North/ 3 North	3,613,948	200, 1130	2%, 10%
5 South	776,723	44, 220	2%, 10%
Long Lake (entire north and south catchments)	730,000	220, 390	3%, 10%

2.5.2.2 Calculation of Seepage Rates from Hydraulic Conductivity

Previous groundwater assessments of the Quinsam mine site have calculated groundwater seepage rates from mine areas according to Darcy's law, whereby:

$$Q=KiA$$

Q is the volumetric groundwater flux in (m^3/s), K is the hydraulic conductivity of the formation (m/s), i is the hydraulic gradient across the area in question and A is the cross-sectional area of flow. Depending on the projected groundwater flow paths, Q may be calculated as a vertical flux through the mine footprint area, or a horizontal flux along its margins or a combination of both.

Groundwater fluxes through the 7SA5 workings at closure were computed assuming horizontal flow through a cross-sectional area that takes into account the shape of syncline. There may be a vertical component through the workings, however the earlier discussion has indicated that vertical gradients are not well constrained in the mine area. The horizontal flux was computed by dividing the length of the workings roughly perpendicular to the direction of groundwater flow into two segments. Over the northern segment (length 375 m), the elevation of the coal varies between 10 and 30 metres between the upgradient (western) and downgradient (eastern) edges. Thus, the average cross-sectional thickness of flow is approximately 20 metres. Over the southern segment (length 825 metres), the elevation of the coal varies on the order of 35 metres between upgradient and downgradient edges. The hydraulic parameters and resultant fluxes computed via Darcy's law are included in Table 2-7. The total groundwater flux through the workings calculated by this method is ~41 m^3/d or 0.5 L/s. These closure groundwater fluxes have been calculated assuming that the pre-mining flow system is a reasonable proxy for conditions at closure; this assumption is valid provided that there is not a significant hydraulic connection between the mine and the Iron River.

Table 2-7:
Darcy flux estimation of mine seepage rates at closure.

Segment	Hydraulic Conductivity (m/s)	Gradient (-)	Length (m)	Thickness Normal to Flow Path (m)	Groundwater Flux (m^3/d)
1	$2.7x10^{-7}$	0.05	375	20	8
2	$2.7x10^{-7}$	0.05	825	35	32
Total					41

2.5.2.3 Comparison of Mine Seepage Rates at Closure to Iron River Baseflow

For the purposes of this assessment, the anticipated groundwater fluxes from the 7SA5 mine workings at closure are expected to be in the range of 0.5 – 0.9 L/s as determined from the Darcy flux calculation and the 10% net infiltration rate presented above. An additional means of constraining the groundwater flux from the mine area is to use baseflow measurements in the Iron River. A September 2012 spot flow measurement taken on the Iron River near the newly established hydrometric station was on the order of 45 L/s (Chapter 3). The region had experienced a prolonged dry spell over the two months prior to the measurement, and as a result, this reading is considered to be a reliable surrogate for 7Q10 flow. The estimated drainage area contributing to the Iron River at the measurement point is approximately 57 km^2 while the groundwater catchment area encompassing the 7SA5 workings is ~200 ha (2 km^2). Since this

measurement was taken late in the summer and flow remained stable at this point for the following month in the absence of precipitation, it is presumed that the streamflow is predominantly groundwater driven (*i.e*. as opposed to high elevation snow melt). If the groundwater catchment encompassing 7SA5 is about 3.5% of the total area drained by the Iron River, then the area-weighted component of baseflow attributed to the 7SA5 groundwater catchment is ~1.6 L/s. Based on the current interpretation of groundwater equipotentials () nearly half of the groundwater originating in this catchment (*i.e*. 0.8 L/s) may flow through the 7SA5 mine workings. While the flow regime in the Iron River is a focus of ongoing study, this coarse approximation of groundwater contributions agrees well with the independently determined estimation of groundwater seepage of presented above (0.5-1 L/s).

2.5.3 Time to Reflood

The projected volume of the 7SA5 workings is approximately 615,000 m^3. It is expected that the workings will initially flood at a higher rate in response to steep hydraulic gradients established between workings and surrounding areas. This rate will decline over time as the mine floods and heads recover.

A long-term reflooding rate would be similar to the steady-state flux through the workings estimated for closure (0.5-1 L/s or 43-86 m^3/d). Based on this rate, the anticipated reflooding time for mine is on the order of 20-40 years. A higher reflooding rate has been derived from a reflooding event at the 4 South mine, where pumping abruptly ended in June 2009. The average reflooding rate calculated for the six month period where water levels were allowed to recover was determined to be ~270 m^3/d, equivalent to a specific flux of ~0.004 $m^3/d/m^2$ when the footprint area of the workings was taken into account (Hillsborough, 2011). When this specific flux is applied to the entire footprint area of 7SA5 (28 ha), the resultant volumetric flux is ~1,100 m^3/d (13 L/s). This value is at the upper end of the range of pumping rates anticipated to dewater the 7SA5 workings (8-12 L/s). Using a reflooding rate of 13 L/s, the time to reflood 7SA5 would be on the order of 1.5 years.

The actual time to reflood the workings is expected to be an intermediate between the 1.5 year and the 20-40 year range presented here. Since a large portion of the mine is significantly below the water table (Figure 2-16), it is expected that a higher reflooding rate driven by steeper hydraulic gradients will prevail. Based on author experience, the actual time to reflood the workings is predicted to be less than 10 years. A major uncertainty in this prediction is the degree of connection between the Iron River and/or the flooded 242 test mine and the proposed workings. Barrier pillars will remain between the 7SA5 workings and the 242 mine and Iron River, however a significant, pre-existing

fault could expedite flooding. Directly south of the workings, the elevation of the Iron River is 240-250 metres. Within 300 metres of the river, the elevation of the proposed workings varies from 214 metres to 242 metres (Figure 2-1), which if the workings are dewatered would result in a gradient toward the mine.

2.5.4 Travel Time to the Iron River

For the purpose of estimating a minimum travel time for mine impacted seepage reaching the Iron River, the travel distance has been selected based on the closest location where the elevation of the workings is above the elevation of the river, which occurs at Point A, directly south of QU11-38 (Figure 2-1). Mine impacted water traveling from this corner of the mine may report to the Iron River, approximately 380 metres away along the groundwater flowpath. The head difference between these two locations is about 34 metres based on the pre-mining water table contour map presented in Figure 2-4. Groundwater travel time from this location can be 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 (dimensionless) and n is the effective porosity (dimensionless). The gradient based on the flowpath length and head difference discussed above is ~9%. The hydraulic conductivity of the bedrock based on interpretation of the pump test is 3×10^{-7} m/s. In previous groundwater assessments, a porosity of 0.001 was considered representative of the Dunsmuir sandstone. A study by Guimera and Carrera (2000) reviewed data from numerous tracer test experiments in bedrock and found a correlation between hydraulic conductivity and porosity values derived from first arrival times of the tracers. This data indicates porosity values ranging from 0.01 to 0.0001 for the K value derived from our pump test. Given that bedrock appears more fractured in this mine area, a higher porosity of 0.01 is assumed for the travel time calculation. The resultant travel time based on these parameters is approximately 5 years. Note that this travel time is applicable after pre-mining gradients have been established.

3. Groundwater Quality

QUINSAM COAL

3. Groundwater Quality

3.1 Overview

3.1.1 Description of Program

Selected 7 South Area 5 monitoring wells and the 242 mine portal have been sampled for water quality between one and four times since May 2010. The results have been compiled using a variety of graphical methods (piper per plot, box plots, scatter plots) to illustrate the relationship of major ion charge equivalents, redox conditions and concentrations of parameters of concern across the site and with depth.

3.1.2 Summary of Results and Conclusions

The major findings of the 7SA5 groundwater quality analysis are as follows:

- Groundwater in 7SA5 is generally circum-neutral to alkaline and is predominantly calcium bicarbonate type with no significant chloride present. Nested wells at QU11-18 and QU11-36 demonstrate increasing sodium content with depth consistent with the process of base exchange softening. Fluoride and boron concentrations also increase with depth which has been found to occur in 7 South and other Nanaimo Group aquifers. These trends suggests that deeper groundwater is older, following a longer flow path than shallow groundwater. This is consistent with flow regime described in Chapter 2.
- The 242 mine water is slightly acidic and has a calcium sulphate signature indicating that it is influenced by the oxidation of sulphide minerals. Declining sulphate levels in the portal indicate that the workings are being flushed with oxic waters; it is not clear from the timing of the sampling events whether this represents a seasonal flushing or if it is a long term trend. Trends in other parameters, including an increase in total alkalinity and a decrease or absence in reduced species (sulphide, ammonia, iron) also indicate that flushing is occurring. The 242 test mine is located in an area of broken ground where flushing of oxic recharge waters could reasonably occur.
- Field Eh readings indicate that 7SA5 groundwater becomes more reduced with depth, also suggesting that deeper groundwater is more mature. The distribution of redox sensitive species (ammonia, dissolved iron, sulphide) indicates that the shallow groundwater south of Long Lake fault is moderately reducing while the very shallow groundwater north of Long Lake fault (QU08-10) is mildly reducing. Deeper groundwater in 7SA5 varies from moderately to highly

reducing. The presence of elevated sulphide at QU11-38 indicates that the groundwater produced from the highly permeably fracture zones (which sustained the 73-hour, 30 US GPM pumping test at QU11-38) is mature and has had a sufficiently long flow path to allow highly reducing conditions to develop.

- Most parameters of concern occur at concentrations well below CSR-AW guidelines and mine permit levels, except for dissolved iron and arsenic. The 10th and 90th percentile concentrations of arsenic in the deeper wells (0.135 mg/L and 1.23 mg/L) both exceed the CSR-AW guideline while the 90th percentile concentration of iron in the deep wells (0.62 mg/L) exceeds the mine effluent permit. Iron and arsenic do not correlate well with fluoride, as was seen in 7 South groundwater, and thus are not good proxies for groundwater age in this mine area. This may suggest that iron and arsenic sulphides are not homogeneously distributed throughout the mine area.
- Concentrations of many of the parameters of concern are observed to decline with depth. These parameters include sulphate, cobalt, nickel, cadmium and aluminum. This trend, however, may be overestimated by the current data set since sulphate, cobalt, nickel and cadmium have all declined substantially at successive sampling events at QU08-10 and/or the 242 mine portal. While the decline in parameter concentrations at the 242 mine has been attributed to flushing with recharge waters, the trend at QU08-10 suggests that earlier sampling events may reflect some artefacts from the well installation. Concentrations of manganese increase with depth which is consistent with it being a redox-sensitive parameter and being remobilized from carbonate dissolution at higher partial pressures of CO_2. Copper, selenium and zinc are frequently below detection limit in 7SA5 groundwater, although zinc has been consistently measured at the 242 portal (levels have decreased through time).

3.2 Monitoring Locations

As discussed in Chapter 2, several monitoring wells have been established in 7SA5 to monitor water levels and water quality upstream and downstream of the proposed workings (Figure 2-4). Five monitoring wells were installed in December 2011 (QU11-18S/D, QU11-28 and QU11-36S/D) while QU08-10 was established in April 2010 as a part of a groundwater study supporting the 7 South permit amendment application (Hillsborough, 2011). Additional monitoring wells (QU11-35, QU12-07, QU12-08) were installed in October 2012 to augment the monitoring network for a pumping test in 7SA5, but they were not sampled for water quality. The pumping well, QU11-38, was sampled three times during the pumping test which occurred in October

2012 (Chapter 2). Table 3-1 summarizes the screened lithology, sampling frequency and other relevant observations from drilling and/or sampling. Detailed borehole logs and installation discussion are provided in Appendix A.

Most of the wells listed in Table 3-1 are moderate to fast recharging, which has been determined through sampling and confirmed by slug testing. The exceptions are QU08-10 and QU11-18S. QU08-10 lies north of the Long Lake Fault and displays very low permeability consistent with other wells screened in the 7 South mine area. QU11-18S is the only well screened in till and has a lower permeability than any of the bedrock wells in 7SA5. Table 3-1 also includes one mine pool location, the 242 mine portal. The 242 test mine was initiated in 1996, but was abandoned due to broken ground conditions. The workings are currently flooded up to the portal entrance. In late 2010, a 100 metre length of PVC was fed into the flooded workings along the conveyor belt and tubing was threaded into the PVC to allow for sampling from depth in the workings. The portal was sampled twice shortly after the pipe was deployed and then two more times thereafter.

Most of the 7SA5 monitoring wells were sampled using high flow methods (*i.e.* Hydrolift actuating Waterra tubing, or submersible pump in the case of QU11-38) except for QU08-10, which was sampled using a portable bladder pump for the last three. A peristaltic pump was used to sample the 242 mine portal at high flow rates. Field parameters were monitored at all sampling locations prior to collecting samples. Appendix B1 contains a detailed description of sampling procedures, water quality results including field parameters are tabulated in Appendix B2. The data are evaluated for quality control/quality assurance in Appendix B3. Original analytical report files from ALS Vancouver are provided in Appendix B4.

3.2.1 Major Ion Chemistry

The relationship of major ion charge equivalents is presented in a trilinear Piper plot (Figure 3-1). Overall, 7SA5 groundwater is predominantly calcium bicarbonate type with no significant chloride present. Samples from the 242 mine demonstrate a calcium sulphate signature indicating this water is influenced by the oxidation of sulphide minerals to form sulphate.

Amongst the nested wells QU11-18S/D and QU11-36S/D, there is a trend towards higher sodium content in the deeper well. QU11-18D, which has the deepest set screen amongst the 7SA5 wells (Table 3-1), transitions towards a calcium-sodium bicarbonate type water. Both wells display strong downward hydraulic gradients implying downward flow of

Table 3-1:
Location of 7 South Area 5 water quality monitoring boreholes and the coal seams intersected by borehole.

Well ID	7 South Area 5 Location	Screened Lithology[1]	Depth of Screen Below Water Level (metres)[2]	Observations	Sampling Events					
					May 2010	Jan 2011	Mar 2012	May 2012	Oct 2012	Nov 2012
QU-08-10	Northern margin of proposed workings	No. 3	0	Very slow recharge	x		x	x		x
QU11-18S	Eastern margin of proposed workings	TILL/SST interface	13	Slow recharge; samples are highly turbid (silty)			x	x		
QU11-18D		SST/SLST below No. 4	38	Fast recharge			x	x		
QU-11-28	Western margin of proposed workings	No. 4&4L/SST pyritic coal	20	Moderate recharge			x	x		
QU-11-36S	Southern margin of proposed workings	SST below No. 5	19	Fast recharge; ground was very broken and core recovery was poor			x	x		x
QU-11-36D		SST below No. 4	35	Fast recharge; also poor ground conditions			x	x		x
QU-11-38	Southeast margin of workings	SST below No. 5 to No. 3; includes 2 fracture zones (15 and 35 GPM at 39 m and 52 m bgs, respectively)	28	Open borehole with PVC liner					xxx	
242 Portal	Southern margin of proposed workings	No. 4&4L	Not available	Suspended iron in samples, has improved with time (due to settling after PVC deployment)		xx	x	x		

Notes:
1) QU11-38 is an open borehole with PVC liner and does not screen a specific interval.
2) Depth of screen is the depth of the top of the filter pack below the average water level in the well. At QU11-38, the depth is measured from the water level to the top of the 35 GPM fracture

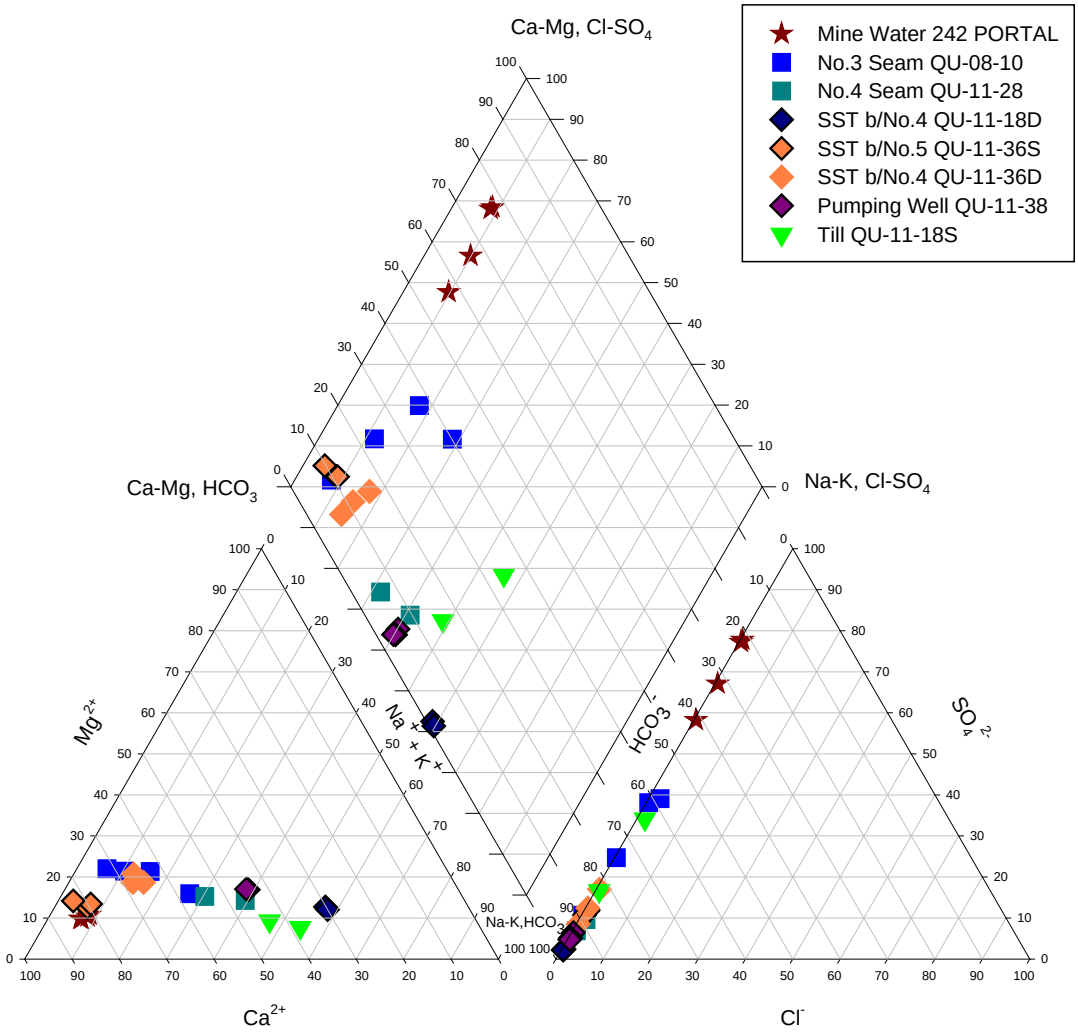


Figure 3-1: Piper plot of 7 South Area 5 groundwater.

groundwater with younger water found closer to surface and older groundwater deeper in the formation. The tendency towards higher sodium content at depth supports this observation as is consistent with base cation exchange softening that occurs along an aquifer flow path. Calcium replaces sodium on exchange sites which increases the concentration of sodium and also increases alkalinity and pH as more calcite dissolves to replenish calcium. This phenomenon has been observed elsewhere including other Nanaimo Group aquifers (Garvin, 1982; Earle and Krogh, 2004).

While the sodium signature is more pronounced in QU11-18D, QU11-18S still has a relatively high proportion of sodium compared to other sampling locations. This well is screened in an area where the till layer is particularly thick (Figure 2-2) and recharge rates are observed to be low, it is reasonable that this shallower location registers a mature groundwater signature.

QU-11-38 also shows a calcium sodium bicarbonate signature, indicating that groundwater at this location is predominantly older water. This is also confirmed by other parameters signatures (F, B, discussed below). This open hole has significant fracture flow from the sandstone overlying the No. 4 seam (Table 3-1). Thus, while this hole transects highly permeable features, the chemistry suggests that this water is a product of a longer flow path.

QU08-10 has shown a variable sulphate influence since it was initiated. Both sulphate and sodium have declined at this location since the first sampling event in 2010 (Figure 3-2). This well has very slow recharge rates and the trend in these parameters may indicate that earlier sampling events are affected by artefacts of well installation and not representative of actual changes in groundwater quality. Should this be the case, parameters should stabilize in subsequent sampling rounds.

Figure 3-1 and Figure 3-2 also indicate that sulphate is decreasing at 242 mine portal while total alkalinity (as mg/L $CaCO_3$) is increasing. Since these samples were taken at different times of the year, it may indicate a seasonal flushing of the workings with fresh recharge water, or it may suggest a longer term freshening trend in the mine pool water. This freshening of mine pool water is consistent with observations made in British and Appalachian coal mine pools (Wood *et al.*, 1998; Perry, 2001).

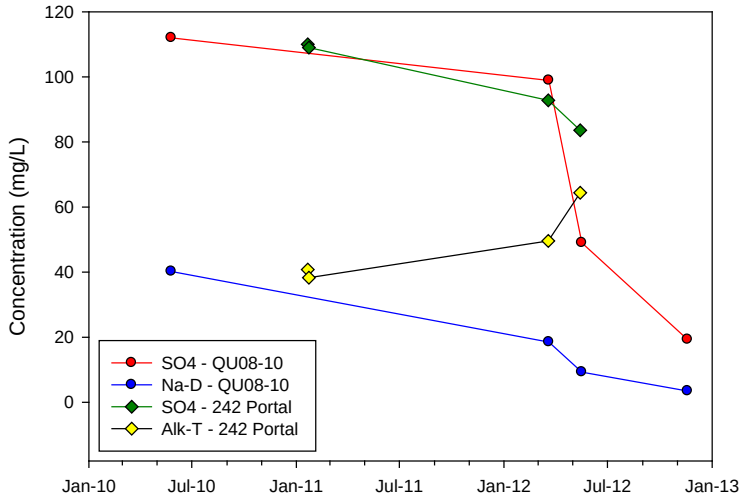


Figure 3-2: SO_4 and Na trends at QU08-10 and the 242 Mine Portal.

3.2.2 General Water Quality Characteristics

The 7SA5 groundwater chemistry can be broadly categorized into shallow water, deeper water and mine affected water based on the screen depths provided in Table 3-1. These groupings were found to be consistent with the water quality trends found in the data. QU11-18S, QU11-36S and QU08-10 have been grouped into the shallow, younger

groundwater group; QU11-18D, QU11-28, QU11-38 and QU11-36D have been grouped into the deeper, older groundwater group. The 242 mine portal has been treated separately as mine water.

The parameter concentration ranges are shown as box plots overlain with scatter plots as shown in Figure 3-3. For non-detected results the detection limit value is used for graphing and for comparison to permit and/or guideline levels. 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. The representative data set includes a total of 23 samples and the number of data points for each data set is either 22 or 23, 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 (Figure 3-4). Redox tendency has been explored through field readings of Eh (mV) and is also inferred by evaluating parameters associated with groundwater redox buffering reactions. Figure 3-4 illustrates a couple of interesting trends in the data. Groundwater in 7SA5 is generally circum-neutral to alkaline, while the 242 mine portal water is slightly acidic. The median pH of the deeper wells (7.8) is higher than the shallower wells (7.4), however there is much more spread in the shallow well data. Total alkalinity follows a similar pattern with the median of the deeper groundwater (165 mg/L $CaCO_3$) higher than the shallow groundwater (115 mg/L), and the shallow groundwater having a much larger range (80-190 mg/L). As expected, the median alkalinity of the mine pool water is much lower (44 mg/L). The tendency of the deeper groundwater to have higher pH and alkalinity is consistent with the base exchange softening process discussed in the previous section.

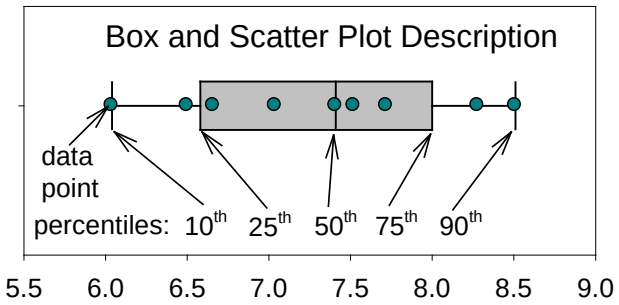


Figure 3-3: Example box plot.

More mature groundwater tends to have higher TDS than their shallower counterparts since the groundwater has had more contact time with the formation. However, this trend is not observed in the laboratory conductivity data (which serves as an analogue for TDS) for 7SA5. All three water types have median conductivity values in the range of 310 -330 µS/cm and again there is a significant spread in the shallow groundwater data. The highest conductivity recorded in the shallow groundwater is ~600 µS/cm; this was measured during the first sampling event at QU08-10. As indicated previously, the results from this sampling event at QU08-10 may be influenced by artefacts from the well installation. Overall, pH, alkalinity and conductivity values from 7SA5 groundwater fall within the range of values observed in 7 South (Hillsborough, 2011).

The final plot in Figure 3-4 shows field measured Eh readings; negative Eh readings indicate reducing conditions. The field Eh readings clearly indicate that the deeper 7SA5 groundwater is reducing; this is also confirmed by the presence of ammonia, dissolved iron and hydrogen sulphide in the deeper groundwater samples. 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) (Drever, 1998).

Figure 3-5 plots field Eh, ammonia, dissolved iron and sulphide *versus* depth of well screen below water table. The trend in field Eh *versus* depth is quite pronounced as was indicated in Figure 3-4. Ammonia was above detection levels in all monitoring locations except the 242 portal and QU11-36D (the first sampling event did record a detect, however). The highest levels of ammonia were measured at QU11-28 (0.66-0.74 mg/L), while the remaining locations were generally in the range of 0.10-0.24 mg/L. QU08-10 has low but variable amounts of ammonia, the most recent readings ranging from 0.05 to 0.086 mg/L.

Dissolved iron levels suggest some variations in groundwater redox chemistry related to the infiltration of oxic recharge waters and suphide oxidation in the unsaturated zone. Under circum-neutral oxic conditions dissolved iron is immobilized as hydrous ferric oxides, however under circum-neutral reducing conditions dissolved iron remains mobile in groundwater systems and immobilized iron can be remobilized (Drever, 1988). Dissolved iron was measured at most of the monitoring locations, except QU08-10 and the mine portal. The highest levels were recorded at QU11-36D (0.6-0.8 mg/L), while a number of wells (QU11-36S, QU11-18D, QU11-38 and QU11-18D) had levels in the 0.2-0.4 mg/L range. Even QU11-18S, screened at the till-bedrock interface, had measureable levels of iron (~0.04 mg/L).

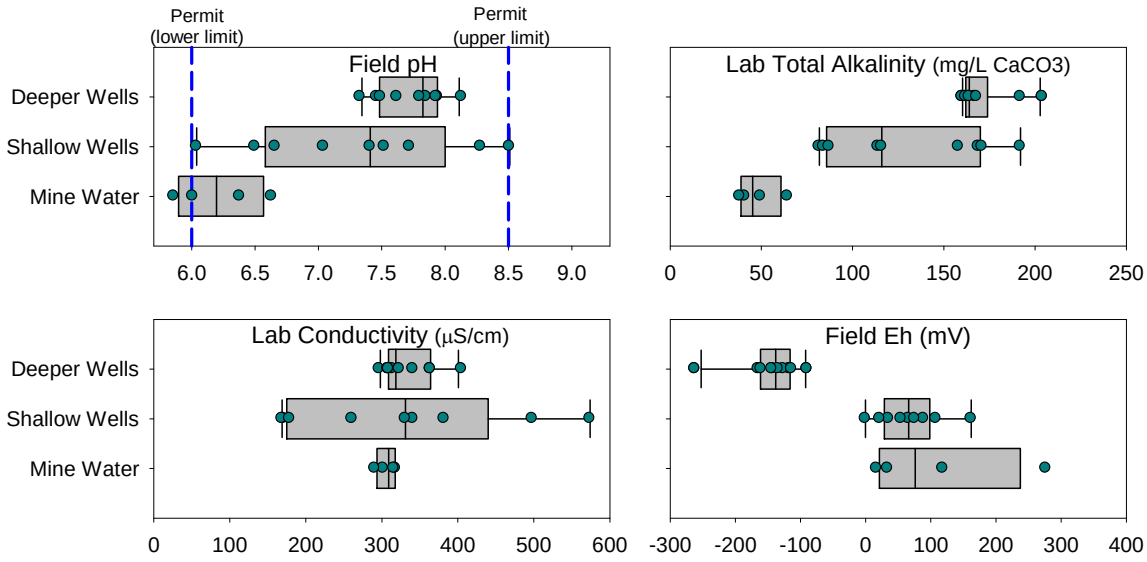


Figure 3-4: pH, alkalinity, conductivity and Eh in 7SA5 groundwater.

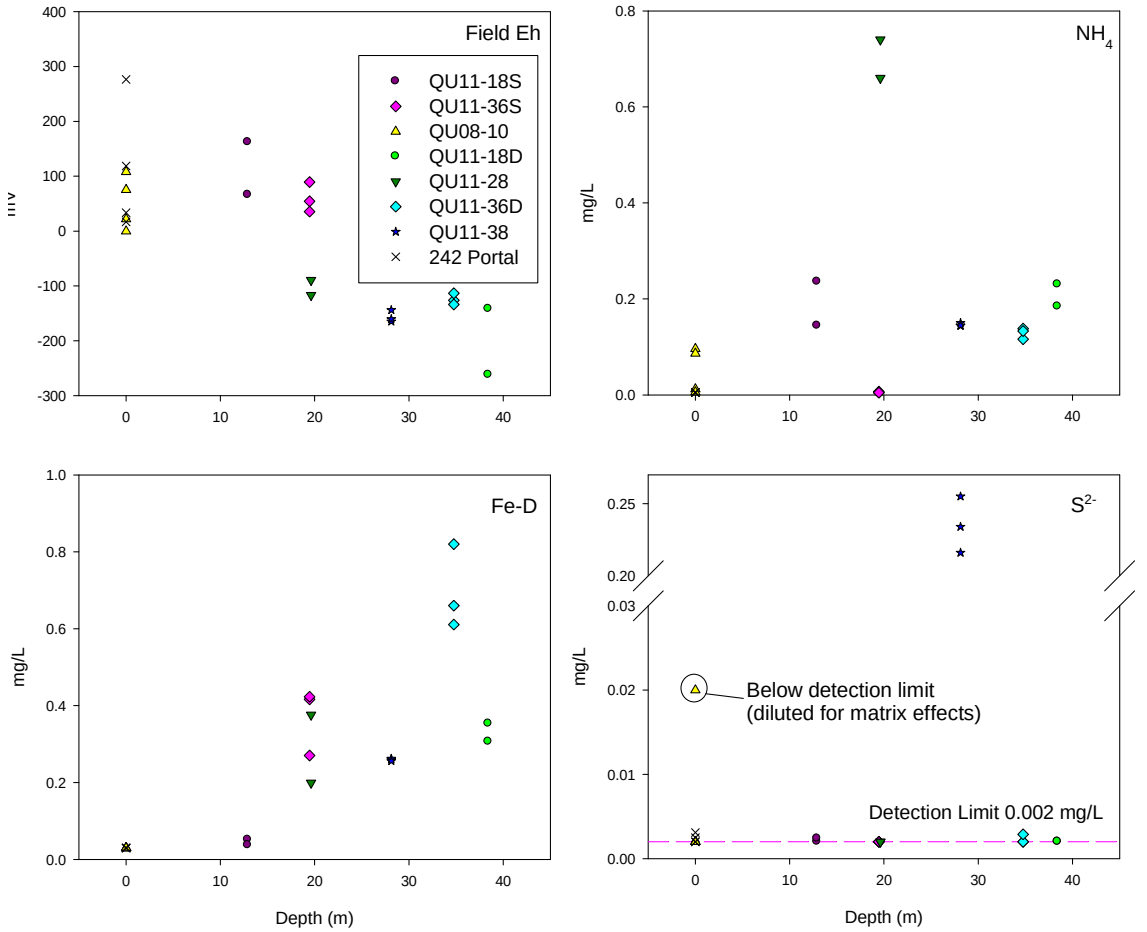


Figure 3-5: Levels of redox-sensitive parameters vs. screen depth below water table.

Most monitoring locations in 7SA5 had minimal, if any, sulphide. The main exception is QU11-38, where high levels of sulphide (0.22-0.26 mg/L) were measured during the pumping test. A couple of detects were also registered at QU11-36D, QU11-18S and the 242 mine portal.

Overall, measureable levels of any of the above species indicates that the groundwater is anoxic. The presence of sulphide (albeit, very low) in the first (January 2011) samples of the 242 mine portal water indicate that strongly reducing conditions were once present but have now become oxidized as indicated by the absence of iron, ammonia and sulphide in recent samples. This, in conjunction with a drop in sulphate and increase in alkalinity, is consistent with either a seasonal or overall freshening of the portal water with oxic recharge waters.

The consistent presence of ammonia at QU08-10 indicates that shallow groundwater immediately north of Long Lake Fault is mildly reducing. This suggests that recharge water is stripped of oxygen as it infiltrates the bedrock, which is facilitated by the extremely tight nature of the bedrock in this area (increasing contact time with the formation). Shallow groundwater south of Long Lake Fault is moderately reducing, based on the presence of dissolved iron at QU11-18S and QU11-36S. Deeper groundwater varies from moderately (QU11-28, QU11-36D) to highly (QU11-38) reducing based on the presence of dissolved iron and sulphide. It is interesting to note that while QU11-38 screens two highly productive fractures (airlift yields of 15 and 35 GPM), the groundwater has had a sufficiently long flow path to allow for both highly reducing conditions to prevail and base cation-exchange softening (reflected by higher sodium concentrations) to have occurred.

3.2.3 Parameters of Concern

The parameters of concern are F, SO_4, Al, As, B, Cd, Co, Cu, Fe, Mn, Se, and Zn, which were selected based on elevated concentrations observed in kinetic tests. The concentration ranges of the parameters of concern are shown in Figure 3-6 and are compared to QCC Effluent Permit PE-07008 limits and British Columbia Contaminated Sites Regulation Schedule 6 Aquatic Life guidelines (CSR-AW). The 10^{th} to 90^{th} percentile concentration ranges of all parameters of concern are below the CSR-AW guidelines and Permit limits, except dissolved arsenic and iron, as described below.

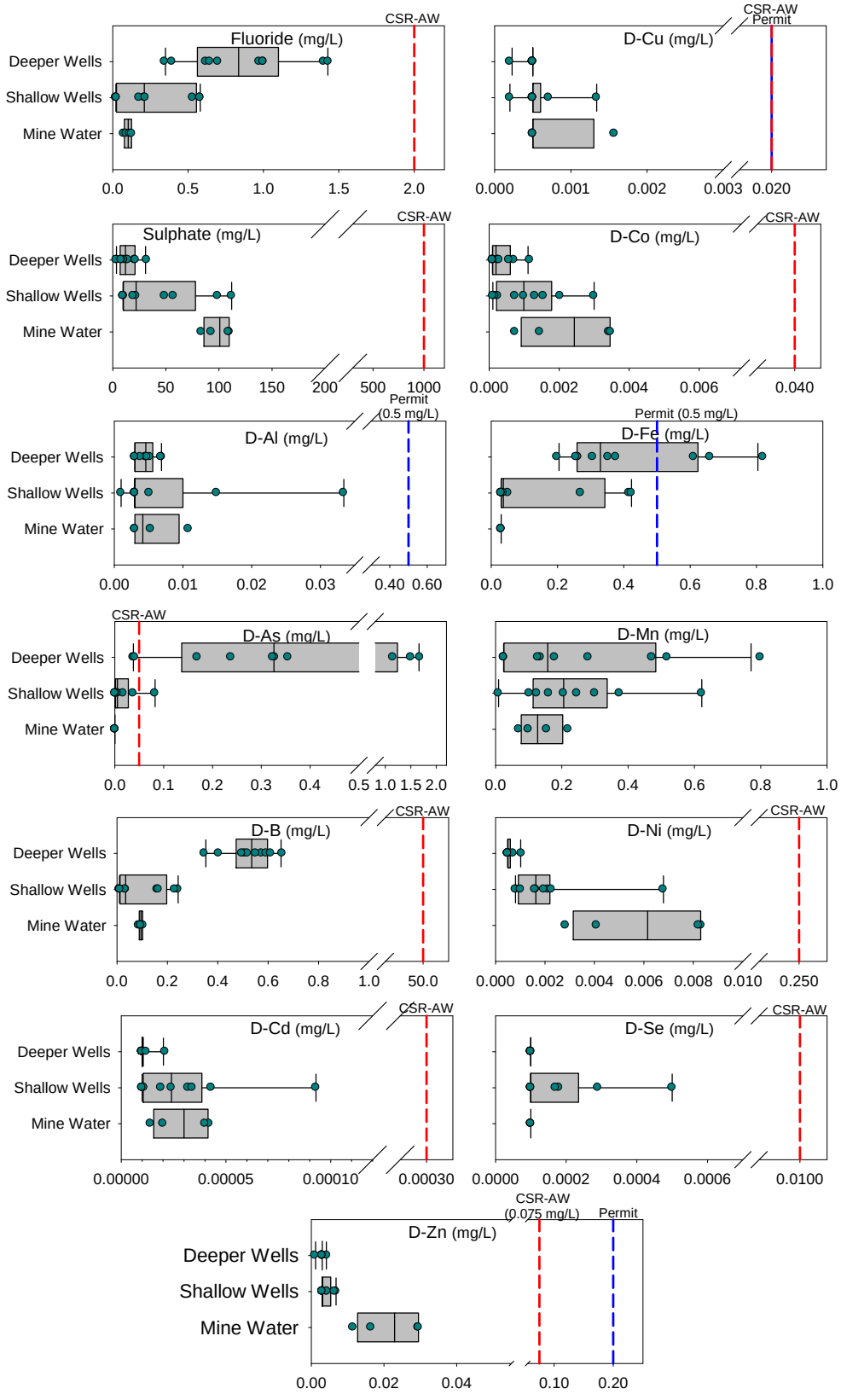


Figure 3-6: Concentration ranges (mg/L) for 7SA5 parameters of concern.

Fluoride and boron were noted to be elevated in 7 South groundwater samples (Hillsborough, 2011) and this is also observed in 7SA5 groundwater samples, especially in the deeper wells. Median concentrations for fluoride and boron in deep groundwater samples are 0.83 and 0.54 mg/L, respectively, while shallow groundwater wells report median values of 0.204 and 0.03 mg/L, respectively. Elevated fluoride and boron concentrations in groundwater have been previously observed in the Nanaimo Group sandstone and mudstone lithology (Earle and Krogh, 2006). Fluoride concentrations are generally dependent upon aquifer groundwater residence times with longer residence times leading to higher fluoride concentrations (Brunt, 2004). Fluoride is most soluble at high pH values (above 7) where calcium concentrations are low (< 75 mg/L) otherwise low solubility fluorite forms. Most of the groundwater in 7SA5, save QU08-10, has calcium concentrations below 60 mg/L, therefore, the waters with highest fluoride levels are expected to be the oldest. According to Figure 3-7, the oldest groundwater in 7SA5 is encountered at QU11-18D, followed by QU11-28 and QU11-36D. Concentrations of fluoride and boron are positively correlated in 7SA5 groundwater samples (Figure 3-7); this phenomenon has been observed in other Nanaimo Group aquifers (Earle and Krogh, 2004) and has been attributed to the process of base exchange softening.

Iron and arsenic are also elevated in 7SA5 groundwater, especially in the deeper wells. The 10^{th} and 90^{th} percentile concentrations of arsenic in the deeper wells (0.135 mg/L and 1.23 mg/L) both exceed the CSR-AW guideline. Realgar, an arsenic bearing sulphide mineral, was reported in the Nanaimo Group Haslam formation by Massey (1989) and has also been observed in Dunsmuir Sandstone at the Quinsam Mine. The 90^{th} percentile concentration of iron in the deep wells (0.62 mg/L) exceeds the mine effluent permit. In the 7 South groundwater assessment, it was found that iron and arsenic were positively correlated to fluoride, suggesting that older groundwater is higher in these parameters. This is not found to be the case in 7SA5, where the correlation of these parameters with fluoride is poor (Figure 3-8). This may suggest that arsenic and iron sulphides are not homogeneously distributed along the groundwater flow paths in 7SA5. Arsenic and dissolved iron concentrations do correlate well with each other (Figure 3-9) which suggests that the occurrence of arsenic in solution is tied to the dissolution and/or formation of hydrous ferric oxides, onto which arsenic can be sorbed.

Sulphate is generally low in 7SA5 groundwater. Sulphate shows a negative correlation with depth (Figure 3-6) with median concentrations of 11.5 and 21.6 mg/L in deep and shallow wells, and 100 mg/L at the 242 portal. There is a significant spread in the shallow well data (10^{th} and 90^{th} percentile concentrations of 10 and 77 mg/L, respectively) but this can be attributed to high initial concentrations at QU08-10, which have since dropped six-fold (Figure 3-2). Sulphate also is declining in the 242 portal (Figure 3-2), which may indicate seasonal or long-term flushing of the workings

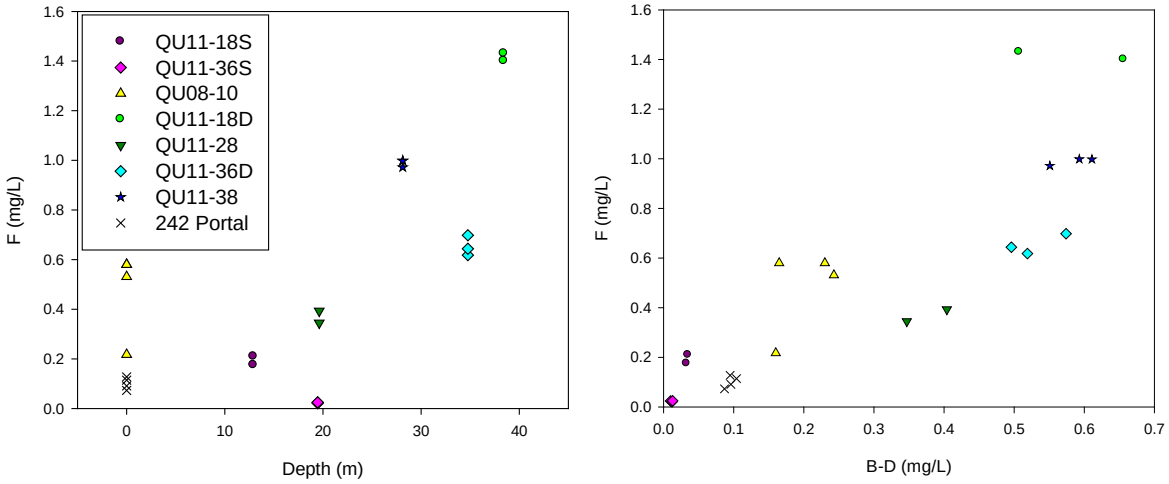


Figure 3-7: Fluoride relationship to depth and boron concentrations in 7SA5 groundwater.

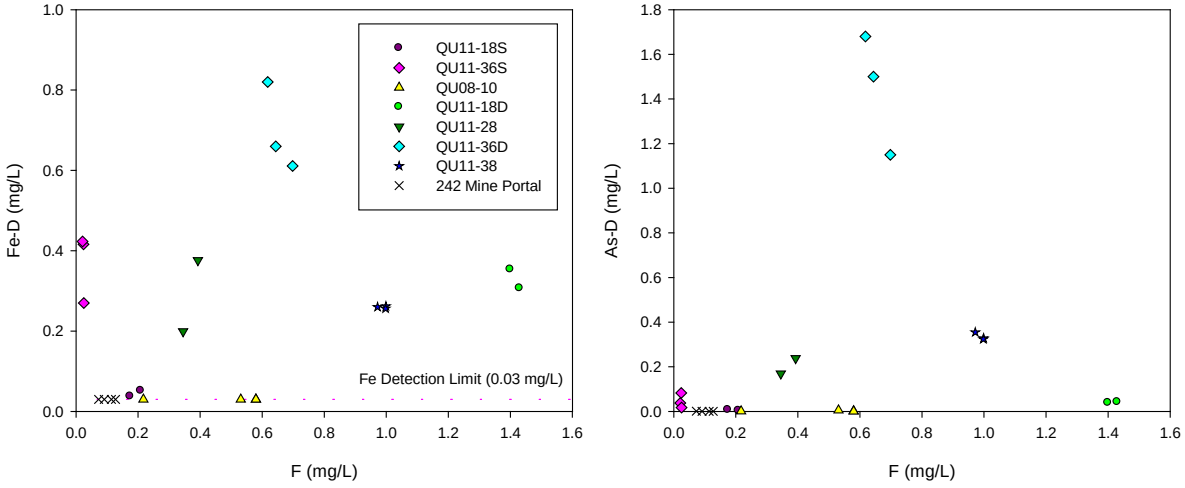


Figure 3-8: Dissolved iron and arsenic *versus* fluoride in 7SA5 groundwater.

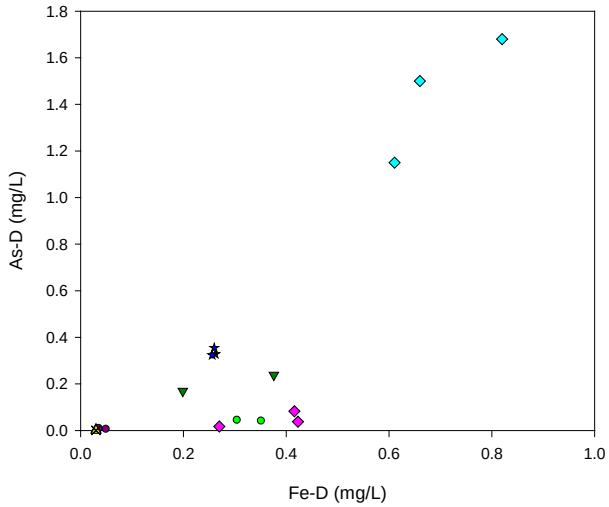


Figure 3-9: Dissolved arsenic *versus* dissolved iron in 7SA5 groundwater.

Dissolved aluminum concentrations are generally low across 7SA5 with all 90th percentile concentrations well below the 0.5 mg/L permit limit. The 90th percentile concentrations in the deep and shallow groundwater are 0.0056 mg/L and 0.01 mg/L, respectively. The higher shallow groundwater concentration can be attributed to QU11-18S, which screens the till and also has extremely high turbidity (discharge from this well is often silty). The 242 portal reports variable dissolved aluminum, ranging from below detection limit (0.003 mg/L) to 0.01 mg/L.

Dissolved manganese is variable across the site with 90th percentile concentrations highest in the deeper wells (0.48 mg/L) and decreasing in the shallow wells (0.33 mg/L) and 242 mine portal (0.20 mg/L). Manganese is a redox sensitive species with Mn-oxides tending to reduce before Fe-oxides and nitrate. Given that ammonia and dissolved iron are commonly observed in 7SA5 groundwater, the presence of manganese at concentrations exceeding those measured in 7 South is not unexpected. Higher concentrations of manganese at depth can also be correlated to the dissolution of carbonates at higher partial pressures of CO_2. Manganese at QU08-10 has declined six-fold since the first sampling event in May 2010, and has also declined in successive sampling rounds of the 242 portal.

Dissolved cobalt and nickel appear to decline with depth, however, concentrations at QU08-10 and the 242 portal have also been declining through time. The 90th percentile concentrations of cobalt in the deep and shallow groundwater are 0.00058 mg/L and 0.0018 mg/L, respectively, and 0.0034 mg/L at the portal. Cobalt is below detection limit at QU11-38. Likewise, 90th percentile concentrations of nickel are 0.0006 mg/L, 0.0022 mg/L and 0.0083 mg/L in deep groundwater, shallow groundwater and 242 portal water.

Dissolved zinc is generally very low in deeper 7SA5 groundwater, with only a single detect in the data set at QU11-18D (0.0043 mg/L). Dissolved zinc is also very low in the shallow wells, with two detects each at QU08-10 and QU11-36S with a maximum concentration less than 0.007 mg/L. Zinc is consistently elevated at the 242 mine portal with 10th and 90th percentile concentrations of 0.013 and 0.029 mg/L, but again has declined through time. All concentrations are well below the CSR AW guideline (0.075 mg/L) and permit levels (0.20 mg/L).

Dissolved cadmium is low in deeper groundwater with single detects of 0.000021 mg/L and 0.000012 mg/L at QU11-36D and QU11-38, respectively. Cadmium concentrations increase in shallow groundwater to a 90th percentile level of 0.000038 mg/L. The initial dissolved cadmium concentration measured at QU08-10 was 0.000093 mg/L, but concentrations have decreased to about half this initial level. Cadmium was also high in

the initial sampling rounds at the 242 portal (~0.00004 mg/L), but has declined in subsequent rounds. Overall, 90th percentile concentrations of dissolved cadmium are 0.000041 mg/L at the 242 portal.

Both dissolved copper and selenium are very low in 7SA5 groundwater and are below detection limit in the deeper groundwater set. Each parameter has three detects in the shallow groundwater and 242 mine water datasets. Dissolved selenium has been measured during both sampling rounds at QU11-18S (0.00018, 0.00029 mg/L) and once at QU08-10 (0.00017 mg/L). Dissolved copper has been measured once at the 242 mine portal (0.00157 mg/L) and twice at QU08-10 (0.00134 mg/L, 0.00071 mg/L).

4. Hydrology

QUINSAM COAL

4. Hydrology

4.1 Overview

Following completion of mining in the 7SA5 Mine, the mine workings are expected to flood. During this post-closure period, the flooded mine waters are expected to discharge into the Iron River. In order to assess the potential water quality effects on the Iron River, estimates of river flow are required to assess dilution and compute water quality predictions. In addition, flows in the Quinsam River downstream of the Iron River confluence are required so that the cumulative effect of 7SA5 seepage and other QCM discharges can be assessed.

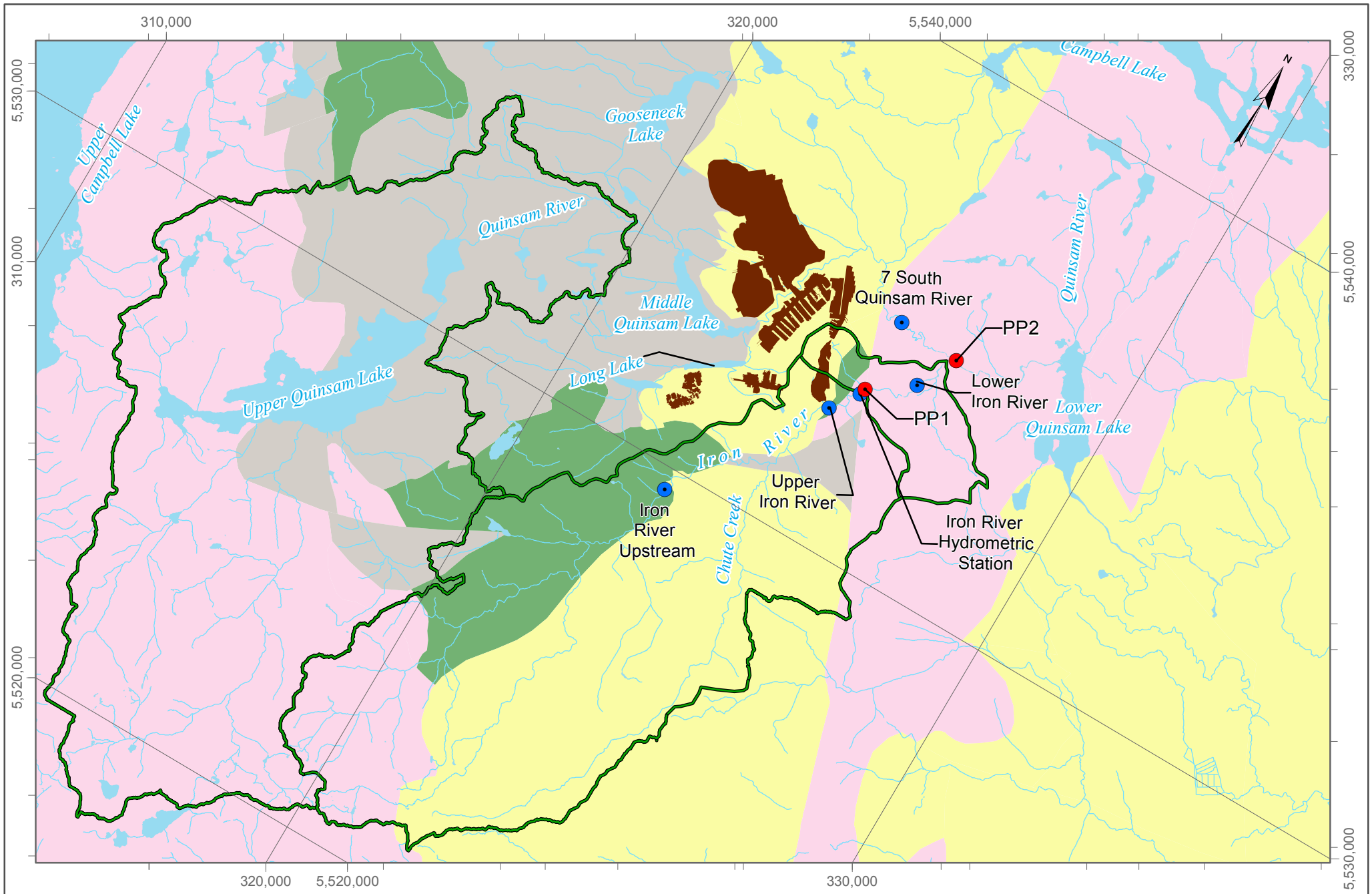
A key consideration when developing the flow estimates is that the Quinsam River flows are subject to flow diversions by BC Hydro upstream of Middle Quinsam Lake. The result of this diversion is that in the area of interest, there are distinctly different flow rates in Quinsam River than the Iron River, despite similar watershed areas.

4.1.1 Hydrologic Flow Estimate Methodology

To represent the hydrology of the Iron River in the WQEM, site- and regional flow data were inspected. Water quality will be predicted with the WQEM at two locations (see Figure 4-1; red circles): PP1, a prediction point on the Iron River downstream of the 7S Area 5 Development; and PP2, a prediction point on the Quinsam River ~100 m downstream of the Quinsam River-Iron River confluence. Watershed boundaries for the Iron River and Quinsam River at Argonaut Bridge (08HD021) are shown in this figure, as is regional geology and QCM water quality monitoring stations.

Mean monthly and 7Q10 low flow discharges were estimated for PP1 on the Iron River using the following inputs.

- A number of spot flow measurements for the Iron River (Table 4-1):
    - Spot flows were recorded for the Iron River during a watershed assessment completed in 1983 by Fisheries and Oceans Canada.
    - Spot flows were measured between May and August 2001 in a study completed by QCC that focused on development of a site-specific rating curve for the Iron River.
    - Spot flows were measured by Lorax on several occasions following July 2012 establishment of a hydrometric station downstream of the proposed 7S Area 5 development.



LEGEND

- Prediction Points
- Water Stations
- Watershed Boundaries
- Mine Workings
- Waterbodies
- Watercourses

Stratigraphic Units

- Bonanza Group
- Buttle Lake Group
- Buttle Lake Group Mount Hall Gabbro
- Island Plutobnc Suite
- Mount Washington Plutonic Suite
- Nanaimo Group
- Sicker Group
- Vancouver Group

DATE SAVED:	Mar 27, 2013
DRAWN BY:	GM
REVIEWED:	CF
VERSION:	1

Coordinate System: NAD 1983 UTM Zone 10N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter

1:100,000

0 1 2
km

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT:

J885-7: 7 South Area 5

TITLE: Regional Watersheds, Prediction Points and Stratigraphic Units Near 7 South Area 5

PROJECT #: J885-7

FIGURE: 4-1

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Table 4-1:
Spot measurements of discharge recorded on the Iron River between 1983 and 2013.

Date	Discharge (m^3/s)
01/06/1983*	1.25
21/06/1983*	0.45
19/11/1983*	5.92
23/11/1983*	2.19
2001[a]	2.10
2001[a]	1.10
2001[a]	0.42
2001[a]	0.20
25/07/2012[b]	0.19
13/09/2012[b]	0.049
07/02/2013[b]	5.3
08/02/2013[b]	2.0

* Indicates spot measurements recorded by DFO in 1983 (see Blackmun *et al.*, 1985).
[a] Indicates spot measurements recorded between May and Aug 2001. The exact dates of the measurements are not known with certainty.
[b] Indicates a spot measurement recorded while re-establishing a hydrometric station on the Iron River at the presumed point of mixing downstream of the 7S Area 5 location.

- Inspection of regional runoff and low flow relationships for Vancouver Island after Obedkoff (2003).
    - The goal of his study was to characterize the variability of streamflow parameters for Vancouver Island Rivers by an organization of hydrometric and drainage data into sub-regional hydrologic zones showing similarity.
- A regional analysis using recent Water Survey of Canada hydrometric data Figure 4-2.
    - Discharge data from the following nearby drainages were used in this assessment: Quinsam River at Argonaut Bridge; Quinsam River diversion; Tsolum River near Courtney; Tsolum River below Murex Creek; Browns River near Courtney and Oyster River below Woodhus Creek. Station identifiers, drainage characteristics and periods of record used are summarized in Table 4-2.

Mean monthly flows for PP2, located on the Quinsam River downstream of the Iron River confluence, were computed by summing estimates of flow for the Quinsam and Iron River.

- Estimated flows for the Quinsam River upstream of the Iron River were computed in a previous study (see Lorax, 2011; see Chapter 8; Figure 8-1; WD hydrometric station) and these estimates are used directly in this report to estimate flows immediately upstream of the Quinsam-Iron River confluence.
- Mean monthly flows for the Iron River at PP1 were rescaled by drainage area (*i.e.*, 58 km^2 rescaled to 63 km^2) and added to WD flows for the Quinsam River to give final PP2 discharges.

Figure 4-2: Schematic illustrating the Iron River drainage in relation to the regional drainages monitored by the Water Survey of Canada.

Table 4-2:
Summary of station data, drainage characteristics and period of record information for datasets considered in the Iron River hydrometric assessment.

Station	WSC Station Code	Lat/Long	Period of Record	Area (km^2)	Mean Elevation (m)
Oyster River below Woodhus Creek	08HD011	49°53'38" N 125°14'18" W	1997-present	306	909
Tsolum River near Courtney	08HB011	49°42'26" N 125°0'41" W	1997-present	250	331
Tsolum River below Murex Creek	08HB089	49°48'46" N 125°12'10" W	1997-present	88	551
Quinsam River at Argonaut	08HD021	49°55'53" N 125°30'33" W	1997-present	84	710
Quinsam River diversion near Campbell River	08HD026	49°56'36" N 125°30'29" W	1997-present	na	na
Browns River near Courtney	08HB025	49°41'31" N 125°4'11" W	1960-present	88	858
Iron River at Quinsam River Confluence	Na	49° 56.315'N 125° 25.038'W	Spot measurements from 1983)	63	651
Iron River at Hydrometric Station	Na	49° 55.585'N 125° 25.926'W	Spot measurements from 2001; July 2012-present (spot measurements and continuous stage data)	57	683

4.1.2 Hydrology Results Summary

A summary of the key findings of the 7SA5 hydrologic assessment are listed below.

- Like the Quinsam River hydrograph, Iron River flows are typically at their lowest during the summer (*i.e.*, June-August) and highest during autumn and winter months. In watersheds closest to the mine, only 15% of annual precipitation is realized in the June-August timeframe.
- Unlike the Quinsam River, the Iron River flows are not regulated by BC Hydro. For much of the year, the Quinsam River is diverted to the Campbell River watershed for hydro-power purposes. Owing to these diversions, observed runoff amounts and receiver flow behaviour (*i.e.*, magnitude, frequency, duration and timing of flows) of the Quinsam River differ from natural flowing watercourses near the mine (*e.g.*, Iron River, Oyster River, Browns River, Tsolum River).
- Winter flows (Nov-Mar) estimated for prediction point PP1 on the Iron River ranged from 2.5 to 4.3 m^3/s, compared to summer flows (Jun-Sep) that were as low as 0.2 m^3/s. A 7Q10 value of 0.045 m^3/s was estimated for this location.
- Winter flows estimated for prediction point PP2 on the Quinsam River ranged from 7.2 to 12.2 m^3/s, compared to summer flows that ranged from 1.1 to 3.8 m^3/s.
- As summarized in Appendix C1, summer flow conditions across much of BC were at near- or historic lows in summer 2012 owing to dry conditions which persisted from June through October. Therefore, the spot flows recorded in September as part of baseline hydrology monitoring on the Iron River are assumed to be a reliable surrogate of the 7Q10 flow for PP1.

4.2 Mean Monthly and 7Q10 Low Flows for the Iron River

4.2.1 Historical and Recent Spot Flow Measurements

Twelve spot flow measurements for the Iron River were reviewed. These data are reported in Table 4-1 noting that relevant point locations for the discharge measurements can be discerned on Figure 4-1.

Four discharge measurements were reported by Blackmun *et al*. (1985). In this DFO watershed assessment, two discharges reported for each of June and November ranged from 0.45-5.9 m^3/s. These measurements were recorded near the confluence of the Iron River-Quinsam River. The drainage area at this location was estimated to be 62 km^2, whereas the full drainage area reporting to the Quinsam River is 63 km^2.

Four flow measurements were reported by Sea-Tech (2002) between May and Aug 2001 and ranged from 0.2-2.1 m^3/s. These observations were measure on the Iron River in the vicinity of the 242 Portal (historic adit) and are deemed valuable surrogates of the low flow conditions that are typical during the summer. It was estimated that 57 km^2 of the Iron River drainage reported to the point of measurement in the Sea-Tech (2002) study.

While re-establishing the hydrometric station, discharges of 0.19 and 0.049 m^3/s were recorded on July 24 and Sept 13, 2012. Further, discharges of 5.3 and 2.0 m^3/s were recorded on Feb 7 and 8, 2013, following a small storm event. A scheduled site visit (November 28, 2012) coincided with highest stages seen since the station was instrumented, but it was not possible to safely wade the Iron River. Discharge was estimated to be 34-46 m^3/s based on visual inspection and comparison to real-time regional flow data. Like Sea-Tech (2002), the drainage area reporting to the Iron River hydrometric station was estimated to be 57 km^2. The September flow measurement was recorded during an extended regional drought, and coincided with observations of near- and record low flows across British Columbia (see Appendix C1 for 2012 flow summaries on nearby Tsolum, Oyster and Browns Rivers).

4.2.2 Regional Flow Relationships for Vancouver Island (Obedkoff, 2003)

Relevant hydrometric statistics for Vancouver Island Rivers are reported by Obedkoff (2003), a study aimed to characterize the variability of streamflow parameters through organization of hydrometric and drainage data into sub-regional hydrologic zones showing similarity. Ultimately, the regionalization approach enables more accurate estimation of discharge parameters in ungauged locations or at locations with limited period of record (*e.g.,* Iron River). The Quinsam Coal Mine is situated in Zone 28 defined by Obedkoff, an elongated hydrological region that encompasses the east portion of the Island.

Two relationships for Zone 28 are presented in Appendix B and relevant to the hydrology parameters that will be entered into the WQEM: 1) the regional relationship between runoff (mm) and elevation (m) for the region; and 2) the annual low flow curve (m^3/s) as a function of drainage area (km^2). Mean elevation for the Iron River at the recently installed hydrometric station (683 m asl; see Table 2-2) is similar to both nearby stations Quinsam River at Argonaut bridge (710 m) asl) and Tsolum River below Murex Creek (551 m asl). As per Appendix C2 – Figure C2.1, regional data are suggestive that mean annual runoff on the order of 1,200 to 1,500 mm would be reasonable for the Iron River.

The Zone 28 regional relationship between 7Q10 low flow and drainage size is illustrated in Appendix C2 (Figure C2.2). Low flow data for Zone 28 show considerable variability by drainage area and are suggestive that local factors such as topography, precipitation as snow, differences in regional GW connectivity, and occurrence of lake/wetland storage

within the drainage, drive the variability seen. Using the Zone 28 line of best fit as a predictor, an ~60 km^2 drainage returns a 7Q10 low flow on the order of 0.06 m^3/s and serves as a useful first approximation for the Iron River.

4.2.3 Inspection of Water Survey of Canada Time Series Data (1997-2010)

Nearest WSC hydrometric stations to the Iron River include: Quinsam River at Argonaut Bridge, Tsolum River below Murex Creek, Tsolum River near Courtney, Browns River near Courtney and Oyster River below Woodhus Creek. Data for the period 1997-2010 was inspected since it was recent, of reasonable duration and a timeframe in which high quality data were available for inspection at all stations (Table 4-2). All stations excepting the Quinsam River at Argonaut Bridge were assumed to be unaffected by regulation. To naturalize the hydrometric record for the Quinsam River station and allow more direct comparisons to other regional stations, the Quinsam River at Argonaut Bridge and the Quinsam Diversion time series were combined to reflect the undisturbed flow regime for that system for the 1997-2010 period of record.

4.2.3.1 Mean Annual Runoff and Annual and Mean Monthly Flow Statistics

Mean monthly flow statistics for Water Survey of Canada stations nearest to the mine are reported in Table 4-3. Mean annual discharge (MAD) ranged from 3.2-13.1 m^3/s, and once discharges were standardized by their drainage areas, mean annual runoff (MAR) depths ranged from 1,200 to 2,000 mm (Table 4-3).

Geographically, the Oyster River, Quinsam River, Tsolum at Murex are closest to the Iron River watershed (*i.e.*, within 15 km of the Iron River hydrometric station). In contrast, the Browns River near Courtney is furthest afield (roughly 32 km from the Iron River hydrometric station), and annual runoff depths in this drainage are clearly reflective of more precipitation and/or runoff efficiencies.

Table 4-3:
Summary of monthly flow statistics for drainages nearest to the Quinsam Mine.

	Discharge (m3/s)												
Station	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Avg/Total**
Tsolum River near Courtney	24.3	15.2	14.6	10.8	7.3	4.3	1.3	0.7	1.5	9.1	22.1	23.9	11.3
Tsolum River below Murex Creek	8.2	5.4	4.9	4.4	4.4	2.8	0.9	0.3	0.4	3.4	7.7	7.2	4.2
Oyster River below Woodhus Creek	20.2	9.2	12.3	14.7	20.9	15.9	7.0	2.4	2.2	12.9	22.2	17.1	13.1
Quinsam River at Argonaut Bridge (naturalized)	5.8	3.1	3.3	3.7	3.9	2.9	1.2	0.9	1.4	2.1	4.9	4.6	3.2
Browns River Near Courtney	7.9	3.8	5.1	7.1	10.9	7.6	2.4	0.8	1.1	5.4	8.9	6.4	5.6

	Runoff (mm)												
Station	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Avg/Total**
Tsolum River near Courtney	260.4	148.4	156.2	111.9	78.4	44.4	14.4	7.3	15.2	97.4	229.2	256.2	1421.1
Tsolum River below Murex Creek	250.0	149.7	148.5	129.0	134.5	82.0	27.8	9.5	11.3	104.4	225.4	218.9	1493.0
Oyster River below Woodhus Creek	176.8	73.5	107.2	124.2	183.2	134.4	61.0	21.2	18.6	112.7	187.6	149.8	1347.7
Quinsam River at Argonaut Bridge (naturalized)	186.3	90.9	105.5	113.8	123.7	88.3	38.9	28.6	43.3	68.5	151.8	145.1	1184.7
Browns River near Courtney	240.1	105.8	156.0	207.9	331.2	222.9	72.3	23.9	32.1	164.6	261.3	194.0	2009.4

4.2.3.2 Mean Monthly Flow Proportions

Monthly flow proportions for the five regional stations are reported in Table 4-4 and illustrated in Figure 4-3. Similarities and differences in these monthly flow proportions are summarized below:

- Typical of eastern Vancouver Island, flow proportions are greatest between November and March and range from 10-18% during these months.
- An exception to this is noted for the Browns and Oyster watersheds where a pronounced freshet response occurs April through June. The 'shape' of the Browns/Oyster hydrographs differs compared to the other three stations given the high elevations unique to this drainage (Figure 4-3, Table 4-2). This pattern of monthly flow is not anticipated within the Iron River watershed.
- Monthly flow proportions are lowest at all stations July through September. August flow proportions were lowest at each station in August, ranged from 0.5 to 2.4% of annual flow and averaged to 1.2% based on the five stations inspected.

Table 4-4:
Summary of monthly flow proportions for locations nearest to the Quinsam Mine.

	Flow Proportion (%)												
Station	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Avg/Total**
Tsolum River near Courtney	18.0	11.2	10.8	8.0	5.4	3.2	1.0	0.5	1.1	6.7	16.4	17.7	100.0
Tsolum River below Murex Creek	16.4	10.8	9.8	8.8	8.8	5.6	1.8	0.6	0.8	6.9	15.3	14.4	100.0
Oyster River below Woodhus Creek	12.9	5.9	7.8	9.3	13.3	10.1	4.4	1.5	1.4	8.2	14.1	10.9	100.0
Quinsam River at Argonaut Bridge (naturalized)	15.4	8.3	8.7	9.7	10.3	7.6	3.2	2.4	3.7	5.7	13.0	12.0	100.0
Browns River near Courtney	11.7	5.7	7.6	10.5	16.2	11.3	3.5	1.2	1.6	8.0	13.2	9.5	100.0

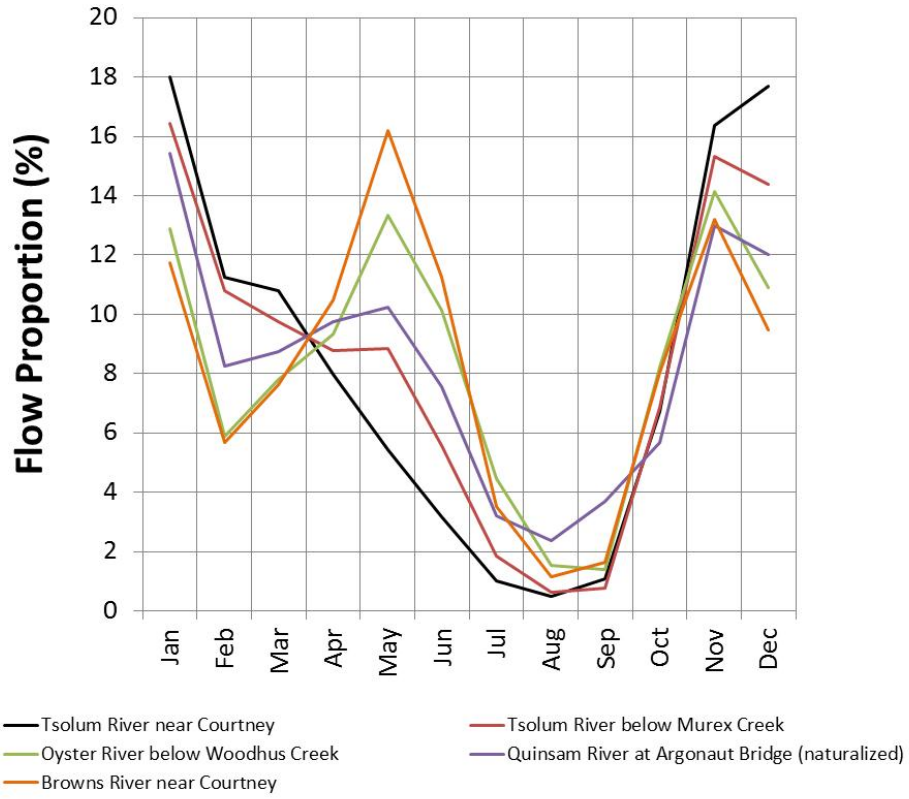


Figure 4-3: Monthly flow proportions at watersheds nearest to the Iron River for the period of record 1997-2010.

4.2.4 Iron River Hydrometric Station

Flows entered into the WQEM for PP1 on the Iron River d/s of mine influence and PP2 on the Quinsam River d/s of Iron River, were also informed by the monitoring data collected by QCC on the Iron River near the site. The Iron River hydrometric station was instrumented with a continuously reading water level recorder set in an armoured stilling well, and a metric staff gauge on July 25th, 2012.

High resolution estimates of discharge will be computed once a robust stage-discharge relation (*i.e.*, site-specific rating curve) is developed for the Iron River. In the interim, a comparison of 2012-13 water level data for Iron River to nearby rivers is shown in Figure 4-4. The comparison of stage data confirms low flow behaviour mimics patterns seen in Tsolum and Browns River. The data also confirm the September 13 spot flow recorded on the Iron River (*i.e.*, 0.049 m3/s) is reflective of the lowest flow condition recorded since re-establishment, whereas November 28, 2012 discharges were at their highest. The drainage area reporting to the hydrometric station has an estimated drainage area 57 km^2.

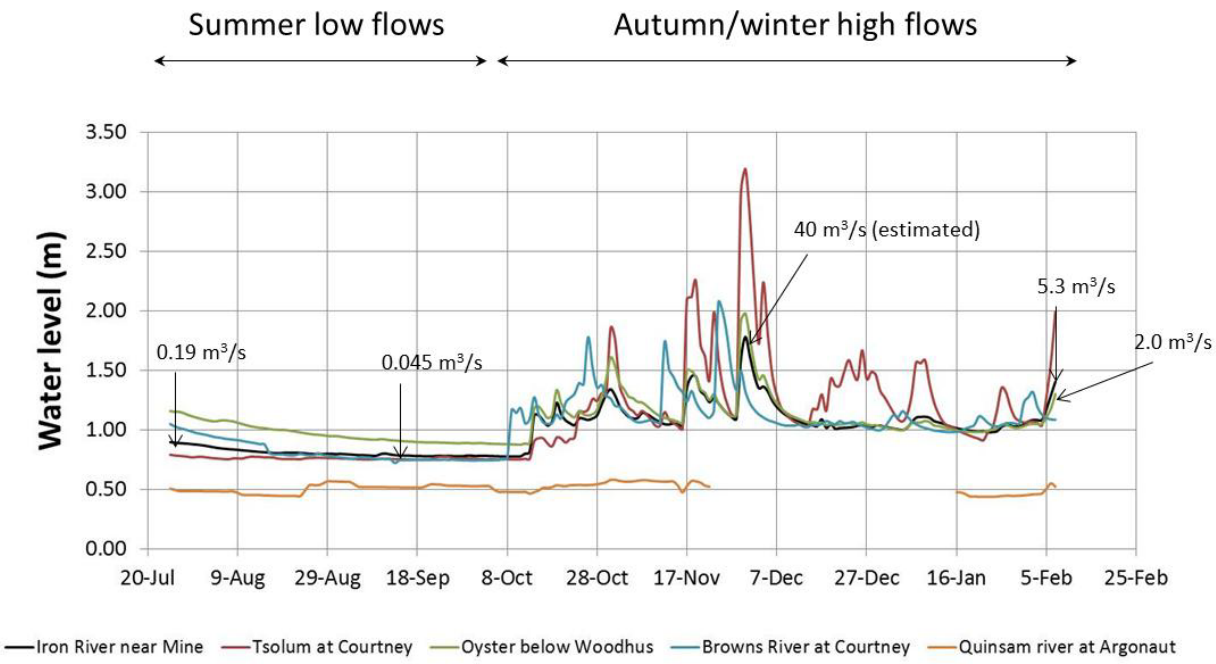


Figure 4-4: Comparison of river stages near the mine site in 2012-13. Spot flow measurements for corresponding stages on the Iron River are shown with black arrows and font.

4.3 Mean Monthly and 7Q10 Low Flows for the Quinsam River

Mean monthly flow values for prediction point PP2 on the Quinsam River were derived by summing: a synthetic dataset for the Quinsam River upstream of the Iron River confluence; and estimated flows emanating from the entire Iron River watershed. A synthetic flow series was generated for the Quinsam River u/s of the Iron River by Lorax (2011). To estimate flows for the entire Iron River watershed, monthly discharges for PP1 were rescaled to account for the difference in drainage area (*i.e.*, 63 km^2 *versus* 58 km^2).

4.4 Water Quality Effects Model Input

4.4.1 Flow Values for PP1

The assumptions used to compute mean monthly flows for PP1 are listed below:

- Mean annual runoff for the Iron River was assumed to be 1,200 mm. This value was the lowest value returned form nearest regional data and selected to be conservative.
- Based on proximity, spot flow measurements and commonalities in mean elevation and drainage area data (Table 4-2), it was assumed that Iron River monthly flow proportions (or runoff depths) would most closely resemble patterns returned for

the Tsolum River below Murex. Therefore, monthly flow patterns for the Iron River were set equal to those values.

- Iron River runoff depths were translated to units of discharge at PP1 based on a drainage area of 58 km^2.

The monthly flow proportions, runoff depths and discharges entered into the WQEM for PP1 are reported in Table 4-5.

The WQEM applies a 7Q10 low flow condition to assess worst case mixing conditions. The 7Q10 low flow calculation for the Iron River utilized data collected at regional hydrometric stations to enhance the Obedkoff (2003) low flow assessment for Zone 28 via construction of a low flow: elevation relationship (Figure 4-5). In this relationship, low flow observations are reported units of $L/s/km^2$.

There is considerable scatter in the plot, however, a conservative lower limit for 7Q10 values is evident in the data. A line of best fit enveloping these values was drawn on the figure, as was the inferred low flow value for elevation 683 m asl – the mean elevation for the Iron River watershed.

Using this approach based on nearest regional data, a flow of 0.35 $L/s/km^2$ – or 20 L/s is returned for the Iron River 7Q10 value. The spot flow measurement (49 L/s, 0.85 $L/s/km^2$) collected on the Iron River following a period of prolonged drought is also shown in Figure 4-4 (yellow triangle). A 7Q10 value of 45 L/s is proposed for inclusion in the WQEM.

Table 4-5:
Flow statistics entered into the WQEM for PP1 and PP2

	Flow Statistics												
PP1	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Avg/Total**
Flow Distribution (%)	16	11	10	8.8	8.8	5.6	1.8	0.6	0.8	6.9	15	14	100.0
Runoff Depth (mm)	197	130	117	105	106	67	22	8	9	82	184	173	1,200
Discharge at PP1 (m^3/s)*	4.3	3.1	2.5	2.4	2.3	1.5	0.5	0.2	0.2	1.8	4.1	3.7	2.2

*Discharge calculations based on estimated area of 58 km^2 for PP1

	Flow Statistics												
PP2	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Avg**
Iron River (entire drainage)*	4.6	3.3	2.8	2.6	2.5	1.6	0.5	0.2	0.2	1.9	4.5	4.1	2.4
Quinsam River at WD**	7.6	4.1	4.4	3.4	2.9	2.2	1.3	0.9	1.5	3.6	7.5	6.2	3.8
Discharge at PP2 (m^3/s)	12.2	7.4	7.2	6.0	5.4	3.8	1.8	1.1	1.7	5.5	12.0	10.3	6.2

*Discharges for the entire Iron River watershed were computed by area scaling PP1 discharges (*i.e.*, 63 km^2 vs 58 km^2).
** Flows based on Lorax (2011)

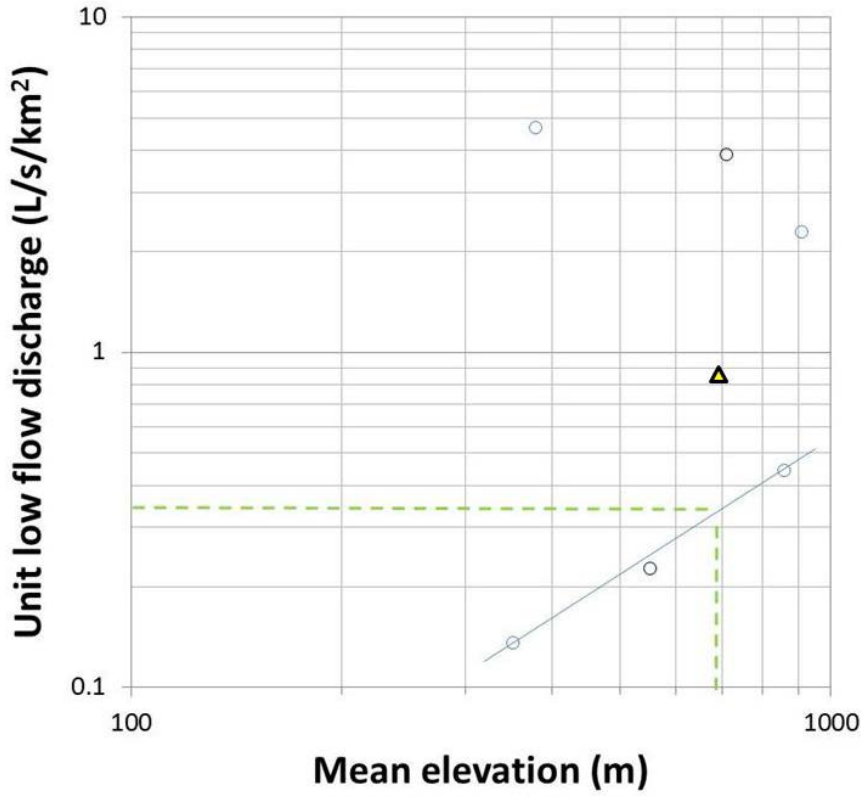


Figure 4-5: Summary of regional low flow data by elevation. Two 7Q10 values computed from regional stream flow data (black) were plotted alongside low flow data reported by Obedkoff (blue). The yellow triangle indicates the Sept 13, 2012 spot flow measured on the Iron River (mean elevation estimated to be 683 m asl). This spot flow had a value of 49 L/s or 0.85 L/s/km2 when standardized by drainage area.

4.4.2 Flow Values for PP2

As outlined in Lorax (2011), to predict mean monthly flows on the Quinsam River u/s Iron River (location denoted WD in that report), mean monthly flow data for Water Survey of Canada hydrometric stations on the Quinsam River (*i.e.*, Quinsam at Argonaut; Quinsam below Lower Quinsam Lake; Quinsam at Campbell River) were plotted against drainage area to obtain a predictive relationship. 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 Quinsam River u/s Iron River based on appropriate drainage areas.

On the Quinsam River, flow: drainage area relationships were non-linear during low flow conditions (*i.e.*, Jul, Aug and Sep). Lorax (2011) concluded that flow records for summer

months at Quinsam River at Argonaut and Quinsam River below Lower Quinsam Lake were highly similar, therefore lines of best fit were drawn through their flow-drainage area data and subsequently used to compute mean monthly flows for July, August and September. The predicted monthly flows for Quinsam River u/s Iron River are reported in Table 4-5.

In addition to the computations of mean monthly flow, a 7Q10 value was computed for the Quinsam River near the mine site. 7Q10 flows for Quinsam at Argonaut and Quinsam below Lower Quinsam Lake were estimated to be 0.32 and 0.3 m3/s respectively. A value of 0.32 m3/s was used to depict a 7Q10 low flow at the WD prediction point. The monthly flow values entered into the WQEM for PP2 are reported in Table 4-5.

5. Baseline Surface Water Quality

QUINSAM COAL

5. Baseline Surface Water Quality

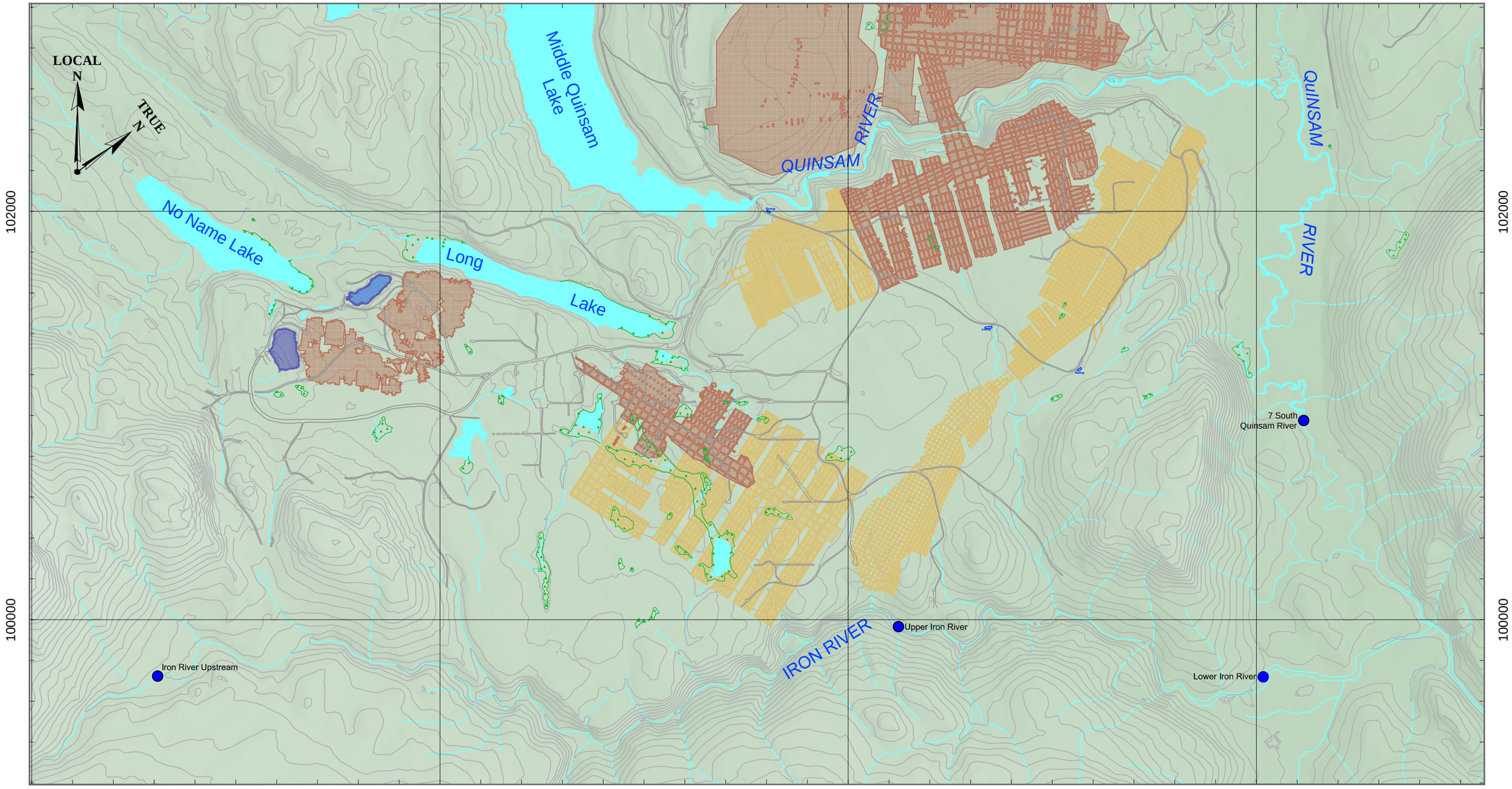
5.1 Overview

QCC currently conducts operational water quality monitoring of surface waters near the mine area, as outlined in Effluent Permit 7008. In preparation of the 7SA5 mine development, focused sampling efforts in the Quinsam and Iron Rivers were introduced in 2007 and 2008, respectively. The first component of this chapter reviews baseline and background water quality data for Iron River and Quinsam River collected from 2007 to 2012. Emphasis of this discussion is placed on the review of baseline levels of Parameters of Concern (PoC), defined as parameters that are of regional concern, or parameters for which dataset values exceeded their respective provincial water quality guidelines. The second component of this chapter presents background water quality terms developed for incorporation into the WQEM exercises.

In addition to mine-related activity, several regional historic factors have potential to influence baseline water quality in the project area. The Quinsam River watershed is subject to flow regulation due to a provincial hydroelectric station upstream of Middle Quinsam Lake, thereby altering the hydrological regime of downstream systems. Further, the Quinsam River drainage system was subject to intense logging activity in the 1950s. In recent years (2005 onwards) logging activity has been reinstated near the Quinsam Mine area, including regions within the Quinsam and Iron River catchments. This activity is notable as logging activity has potential to alter surficial drainage patterns, thereby affecting water quality in the receiving environment.

5.1.1 Baseline Water Quality Monitoring Program Description

The locations of surface water quality monitoring sites reviewed in support of the 7SA5 water quality effects assessment are shown in Table 5-1. Monitoring rationales for these stations are presented in Table 5-1. Beginning August 2007, water quality at the 7S Quinsam River station (7SQR) has been monitored on a regular basis as an indicator of cumulative mine-related effects from present QCM operations, and to characterize Quinsam River water quality prior to development of the 7 South mine (Table 5-2).



96000 98000 100000 102000

LEGEND

- Surface Water Station
- Swamp/Marsh
- Lakes
- Pits
- Elevation(10m)
- Road
- Rivers/Creeks
- Existing Mine Workings
- Proposed Mine Workings

DATE SAVED:	Jan 18, 2013
DRAWN BY:	VV
REVIEWED:	MG
VERSION:	1

Projection: *Orthographic*
Coordinate System: *Quinsam Mine Local Grid*
Units: *Metres*

1:18,000

0 200 400m

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT:

7 South Area 5 Water Quality Effects Assessment

TITLE: Surface Water Quality Monitoring Stations

PROJECT #: J885-7

FIGURE: 5-1

P:\J885 Hillsborough Resources\Drafting\J885-10\Map for Meghan\Surface WQ_Quinsam_18Jan2013.dwg

Table 5-1:
Surface water quality monitoring station rationale for Quinsam Mine 7S discharge and local surface waters.

Station	Station ID	Mine Coordinates	Rationale
Iron River Upstream	IRU	96618, 99723	Indicator of water quality in upper Iron River, upstream of all Quinsam Coal Mine-related effects; established May 2012.
Upper Iron River	UIR	100247, 99965	Indicator of water quality in upper Iron River, downstream of UIR (new) site.
Lower Iron River	LIR	102034, 99719	Indicator of water quality in lower Iron River, upstream of confluence with Quinsam River.
7 South Quinsam River	7SQR	102232, 100975	Multi-year record of Quinsam River water quality condition downstream of Middle Quinsam Lake, upstream of Iron River.

Table 5-2:
Annual water quality sampling frequency for 7SQR and Iron River stations (September 2007 to August 2012).

Year	IRU	UIR	LIR	7SQR
2007	-	-	-	2
2008	-	4	4	6
2009	-	13	13	13
2010	-	3	3	4
2011	-	-	-	14
2012	11	-	-	12
Total	11	20	20	51

Regular monitoring at two stations in Iron River (Upper Iron River, Lower Iron River) was initiated in October 2008 and carried through to November 2010 (Table 5-2). In May 2012, surface water quality monitoring in Iron River was re-established at a new site upstream of earlier locations (Iron River Upstream). The upstream location was selected over earlier sites to reflect baseline conditions above potential land disturbance that may be associated with 7S mine development.

Sampling in Iron River and Quinsam River occurred on a regular to semi-regular basis over the monitoring program. Sampling at 7SQR took place over roughly biannual or quarterly events in 2007, 2008 and 2010. In addition to biannual sampling in 2008, an additional sample set was collected October 2008. This sample set consisted of four weekly samples collected to characterize seasonal variability associated with increasing

flows. Focused monitoring (consisting of monthly to bi-monthly events) of 7SQR was introduced in 2009 and re-instated from late 2010 to present (dataset cutoff: December 12, 2012). In Iron River, sampling frequency of LIR and UIR comprised semi-annual to quarterly events in 2008 and 2010 and monthly events in 2009. The Iron River Upstream dataset (IRU) is limited to monthly or semi-monthly events from May to December 2012. The parameter list and detection limits (DLs) employed for all stations in the 7SA5 water quality program are presented in Table 5-3.

With respect to seasonal coverage, conditions for critical low flow periods (mid-summer to early autumn) have been relatively well characterized in the Iron and Quinsam River datasets. However, seasonal analysis is somewhat limited by a lack of winter sampling. For Iron River stations LIR and UIR, data for the months of January and February are absent from the dataset, while the dataset for IRU (which was established May 2012) lacks data for the months of January through to April. The 7SQR dataset demonstrates better seasonal coverage, but January and February data are limited. Overall, three or more data points exist for all months except January, for which two datapoints are available. However, the 7SQR January samples were collected over a narrow time span (January 5, 2012 and January 9, 2012). One 7SQR datapoint exists for February (February 2, 2011).

It is important to consider seasonal coverage in the dataset, as ionic parameters (*e.g.*, sulphate, conductivity) are anticipated to peak during seasonal low flow due to the greater relative contribution of groundwater to stream flow. However, parameters typically associated with TSS during high flow conditions (most notably metals, such as Al, Fe, Zn, *etc.*), are expected to increase during winter months. Because data are not available for certain winter months, it is possible the full range of parameter concentrations are not captured in the monitoring dataset. As a result, the winter data gap may affect the conservatism of background water quality terms for months with seasonal high flow (Section 5.3).

A review of baseline water quality conditions in Iron River and Quinsam River is presented in the following section (Section 5.2). This is followed by a review of background water quality term development for Quinsam River and Iron River in Section 5.3.

Table 5-3:
Water quality sample parameters and detection limits

Analyte	Symbol	Detection Limit Range	Units
Physical Parameters			
Conductivity		2.0	µS/cm
Hardness		1.0	mg $CaCO_3$/L
Total Dissolved Solids	TDS	10	mg/L
pH	pH	0.10	pH
Total Suspended Solids	TSS	1 - 4	mg/L
Major Anions			
Acidity		1.0	mg $CaCO_3$/L
Alkalinity		2.0	mg $CaCO_3$/L
Sulphate	SO_4	0.50	mg/L
Nutrient Parameters			
Ammonia Nitrogen	N-NH_4	0.02 - 0.005	mg/L
Total Kjeldahl Nitrogen	TKN	0.05 – 0.02	mg/L
Nitrate + Nitrite Nitrogen	N-NO_3	0.02 - 0.005	mg/L
Total and Dissolved Phosphate	P-PO_4	0.002	mg/L
Total and Dissolved Trace Metals			
Aluminum	Al	0.20 - 0.0010	mg/L
Antimony	Sb	0.00010 - 0.00050	mg/L
Arsenic	As	0.20 - 0.0001	mg/L
Barium	Ba	0.020 - 0.000050	mg/L
Beryllium	Be	0.0050 - 0.0001	mg/L
Bismuth	Bi	0.20 - 0.0005	mg/L
Boron	B	0.10 - 0.010	mg/L
Cadmium	Cd	0.000010 - 0.010	mg/L
Calcium	Ca	0.050 - 0.10	mg/L
Chromium	Cr	0.00050 – 0.10	mg/L
Cobalt	Co	0.00010 - 0.010	mg/L
Copper	Cu	0.00010 - 0.010	mg/L
Iron	Fe	0.0050 - 0.030	mg/L
Lead	Pb	0.000050 - 0.050	mg/L
Lithium	Li	0.0050 - 0.010	mg/L
Magnesium	Mg	0.10	mg/L
Manganese	Mn	0.00050 - 0.005	mg/L
Molybdenum	Mo	0.000050 - 0.030	mg/L
Nickel	Ni	0.00050 - 0.050	mg/L
Phosphorus	P	0.0050 - 0.30	mg/L
Potassium	K	2.0	mg/L
Selenium	Se	0.0001 – 0.20	mg/L
Silicon	Si	0.050	mg/L
Silver	Ag	0.000010 – 0.010	mg/L
Sodium	Na	0.010 - 2.0	mg/L
Strontium	Sr	0.00010 - 0.0050	mg/L
Thallium	Tl	0.000050 - 0.20	mg/L
Tin	Sn	0.00010 - 0.030	mg/L
Titanium	Ti	0.0050 - 0.01	mg/L
Uranium	U	0.000010 - 0.00020	mg/L
Vanadium	V	0.0010 - 0.030	mg/L
Zinc	Zn	0.0010 - 0.0050	mg/L

5.1.2 Water Quality Result Summary

The present analysis of baseline water quality and background water quality terms can be summarized as follows:

- Several anthropogenic factors have potential to influence baseline water quality in the project area, in addition to mine-related activity. Of note, the Quinsam River watershed is subject to flow regulation via an upstream hydroelectric station, thereby altering the hydrological regime of the receiving environment. This factor can alter normal seasonal trends for certain parameters and must be considered in environmental assessment exercises. The Iron River is not subject to this flow regulation.

- The baseline water quality analysis reviews water quality data for one station in Quinsam River (7SQR) and three stations on Iron River (Iron River Upstream (IRU); Upper Iron River (UIR); and, Lower Iron River (LIR)). For Quinsam River, the 7SQR dataset spans the time period of August 2007 to December 2012. For Iron River, the UIR and LIR datasets both range from October 2008 to November 2010, while the IRU dataset ranges from May to December, 2012.

- In general, Iron River and Quinsam River are characterized by soft to moderately hard waters. Values for conductivity, alkalinity, hardness and sulphate demonstrate seasonal fluctuations, with maxima in Iron River coinciding with low flow periods in late summer. Minima typically occur during seasonal high flow. Conversely, annual maxima at 7SQR commonly occur in late spring, which may relate to seasonal lake dynamics upstream of 7SQR or the altered hydrological regime of this system. Low values are associated with seasonal high flow, although the months in which annual minima occur vary with year.

- In general, mean concentrations of total and dissolved trace elements are low, and fall below BC provincial guidelines for the protection of freshwater aquatic life in Iron River and Quinsam River. Maximum observed elemental concentrations also fall below guidelines for the protection of wildlife and livestock, where applicable. However, on occasion Al, As, Cd, and Cu levels naturally exceed aquatic life guidelines in Iron River. Guideline exceedances in Quinsam River were observed for Al, Cd and Cu.

- For the calculation of background water quality terms in support of the WQEM, the seasonal signatures of major ions demonstrate between-station agreement for LIR and UIR. These results indicate that the datasets for LIR and UIR can be combined for water quality term development. However, the limited dataset for IRU suggests the seasonal signature at this station differs from UIR and LIR.

However, it is unclear if these differences relate to spatial variability between IRU and UIR/LIR or to differences in flow regime between sample years (*i.e.*, UIR/LIR were sampled in 2008-2010; IRU was sampled in 2012). Although the 2012 flow record supports the latter, this tenet could not be confirmed as IRU was the only Iron River station monitored in 2012. As a result, the UIR and LIR datasets, but not IRU, were combined to generate background water quality term calculations for Iron River. The 7SQR dataset was used to generate background water quality terms for Quinsam River.

- Background water quality terms for the WQEM were calculated as monthly median values, which were considered representative of background conditions. The use of monthly medians (as opposed to monthly means) avoided artifacts in the dataset caused by high DLs occasionally employed during the monitoring program.

5.2 Baseline Water Quality Results

The baseline water quality of Iron River and Quinsam River monitoring locations is reviewed in this section with respect to ion content, total suspended solids (TSS), nutrients, and elements (metals/metalloids). All data were screened against British Columbia Water Quality Guidelines for the Protection of Freshwater Aquatic Life (FWAL WQG).

In the analysis below the discussion focuses on parameters of concern (PoC), which represent parameters that are of regional concern, or parameters for which dataset values exceeded their respective FWAL WQG. Mean, median, minimum and maximum values for PoCs are shown in data summary tables below for each monitoring station in the Quinsam and Iron Rivers (Table 5-4 to Table 5-7). Time series plots for several parameters are also presented in this section to demonstrate temporal trends in water quality. Hardness-dependent guidelines shown in time series were calculated using the median water hardness calculated from the combined 7SQR and Iron River datasets (31 mg $CaCO_3$/L). All baseline water quality data are located in Appendix D.1.

Major Ions

In this section, the major ion chemistry of Iron River and Quinsam River is assessed with respect to conductivity, hardness, alkalinity, sulphate and pH. Values for these parameters are strongly influenced by the varying input of low-ionic-strength meteoric water (which dominates the seasonal signature of natural drainages during winter high flow), and higher-salinity groundwaters (which show increasing influence during summer seasonal low flow).

The Iron and Quinsam Rivers are characterized by soft to moderately hard waters, with hardness values ranging from 17 to 85 mg $CaCO_3$/L in the Iron River (Table 5-4; Table 5-5; Table 5-6) and 6 to 60 mg $CaCO_3$/L in Quinsam River (Table 5-7). On average, Iron River stations demonstrate lower conductivity (mean = 79 uS/cm) than the Quinsam River station 7SQR (mean = 112 uS/cm), but relatively comparable mean hardness (38 mg $CaCO_3$/L vs. 33 mg $CaCO_3$/L, respectively) and mean alkalinity (34 mg/L vs. 28 mg/L, respectively).

Time series for hardness, conductivity, and alkalinity in Iron River demonstrate pronounced seasonal fluctuations, with maxima at UIR, LIR and IRU coinciding with low flow periods (July – early October; Figure 5-2 to Figure 5-4). Minima for major ion parameters in Iron River typically occur during seasonal high flow (winter). Such trends in stream salinity clearly reflect varying proportions of surface runoff (lower ionic strength) and groundwater inputs (higher ionic strength) driven by the seasonal water balance.

Table 5-4:
Iron River Upstream water quality (May 2012 - December 2012).

		Dataset Statistics[a]						BC FWAL WQG[b]	
Parameter	**Units**	**Min**	**Max**	**Average**	**Median**	***n***	***n* < DL**	**30-day**	**Acute**
Physical									
Acidity (8.3)	mg/L	<0.500	1.40	0.608	<0.500	11	9	NP	NP
pH	pH Units	7.50	7.95	7.70	7.73	11	0	6.5 - 9.0	NP
Alkalinity-T	mg $CaCO_3$/L	20.0	70.9	37.9	31.9	11	0	NP	NP
Hardness-T	mg $CaCO_3$/L	19.9	83.2	39.8	30.7	11	0	NP	NP
Conductivity	uS/cm	40.1	175	84.1	67.4	11	0	NP	NP
TDS	mg/L	26.0	56.0	36.5	32.0	4	0	NP	NP
TSS	mg/L	<4.00	<4.00	4.00	<4.00	11	10	NP	NP
Nutrients and Anions									
Ammonia[c]	mg-N/L	<0.00500	0.0170	0.0122	0.0140	9	2	1.86	9.65
Nitrite+Nitrate	mg-N/L	<0.0200	0.123	0.0350	<0.0200	9	7	NP	NP
TKN	mg-N/L	0.0200	0.168	0.108	0.127	9	1	NP	NP
Phosphate-D	mg-P/L	ND	ND	ND	ND	0	ND	NP	NP
Phosphate-T	mg-P/L	ND	ND	ND	ND	0	ND	NP	NP
Sulphate	mg/L	0.900	14.7	4.54	2.76	11	218	NP	100
Metals									
Ag-D	mg/L	<0.0000200	<0.0000200	0.0000200	<0.0000200	11	11	NP	NP
Ag-T	mg/L	<0.0000200	<0.0000200	0.0000200	<0.0000200	11	11	0.000050	0.000100
Al-D	mg/L	0.00880	**0.0745**	0.0445	0.0423	11	0	0.0500	0.1000
Al-T	mg/L	0.0137	0.101	0.0565	0.0636	11	0	NP	NP
As-D	mg/L	0.000250	0.000530	0.000374	0.000370	11	0	NP	NP
As-T	mg/L	0.000200	0.000530	0.000370	0.000400	11	0	NP	0.005
Ba-D	mg/L	0.00150	0.00530	0.00287	0.00240	11	0	NP	NP
Ba-T	mg/L	0.00140	0.00550	0.00281	0.00240	11	0	1	5
B-D	mg/L	<0.0500	<0.0500	0.0500	<0.0500	11	11	NP	NP
B-T	mg/L	<0.0500	<0.0500	0.0500	<0.0500	11	11	NP	1.2
Be-D	mg/L	<0.000100	<0.000100	0.000100	<0.000100	11	11	NP	NP
Be-T	mg/L	<0.000100	<0.000100	0.000100	<0.000100	11	11	0.0053	NP
Bi-D	mg/L	<0.00100	<0.00100	0.00100	<0.00100	11	11	NP	NP
Bi-T	mg/L	<0.00100	<0.00100	0.00100	<0.00100	11	11	NP	NP
Ca-D	mg/L	7.34	29.9	15.1	12.2	11	0	NP	NP
Ca-T	mg/L	7.17	31.0	14.7	11.3	11	0	NP	NP
Cd-D	mg/L	0.0000110	0.0000320	0.0000215	0.0000230	11	0	NP	NP
Cd-T	mg/L	0.0000140	0.0000310	0.0000237	0.0000240	11	0	NP	0.000012
Co-D	mg/L	<0.000500	<0.000500	0.000500	<0.000500	11	11	NP	NP
Co-T	mg/L	<0.000500	<0.000500	0.000500	<0.000500	11	11	0.004	0.11
Cr-D	mg/L	<0.00100	<0.00100	0.00100	<0.00100	11	11	NP	NP
Cr-T	mg/L	<0.00100	<0.00100	0.00100	<0.00100	11	11	NP	0.001
Cu-D	mg/L	0.000510	0.000970	0.000769	0.000780	11	0	NP	NP
Cu-T	mg/L	0.000460	0.00121	0.000772	0.000740	11	0	0.0020	0.0049
Fe-D	mg/L	<0.00500	0.0351	0.0159	0.0146	11	3	NP	0.35
Fe-T	mg/L	0.00540	0.100	0.0336	0.0249	11	0	NP	1
Hg-D	mg/L	<0.0000020	<0.000010	0.00000855	<0.000010	11	11	NP	NP
Hg-T[d]	mg/L	<0.0000020	<0.000010	0.00000855	<0.000010	11	11	0.00001	NP

		Dataset Statistics[a]						BC FWAL WQG[b]	
Parameter	**Units**	**Min**	**Max**	**Average**	**Median**	***n***	***n* < DL**	**30-day**	**Acute**
K-D	mg/L	0.153	0.259	0.200	0.194	11	0	NP	NP
K-T	mg/L	0.139	0.273	0.197	0.210	11	0	NP	NP
Li-D	mg/L	<0.00500	<0.00500	0.00500	<0.00500	11	11	NP	NP
Li-T	mg/L	<0.00500	<0.00500	0.00500	<0.00500	11	11	0.096	0.870
Mg-D	mg/L	0.484	1.40	0.779	0.643	11	0	NP	NP
Mg-T	mg/L	0.477	1.45	0.767	0.613	11	0	NP	NP
Mn-D	mg/L	<0.00100	0.00110	0.00101	<0.00100	11	8	NP	NP
Mn-T	mg/L	<0.00100	0.00250	0.00132	0.00110	11	5	0.7401	0.8783
Mo-D	mg/L	<0.00100	<0.00100	0.00100	<0.00100	11	11	NP	NP
Mo-T	mg/L	<0.00100	0.00150	0.00105	<0.00100	11	10	1	2
Na-D	mg/L	0.641	2.12	1.07	0.871	11	0	NP	NP
Na-T	mg/L	0.561	2.24	1.01	0.823	11	0	NP	NP
Ni-D	mg/L	<0.00100	<0.00100	0.00100	<0.00100	11	11	NP	NP
Ni-T	mg/L	<0.00100	<0.00100	0.00100	<0.00100	11	11	NP	0.025
Pb-D	mg/L	<0.000200	<0.000200	0.000200	<0.000200	11	11	NP	NP
Pb-T	mg/L	<0.000200	<0.000200	0.000200	<0.000200	11	11	0.00402	0.01816
P-D	mg/L	<0.00500	0.00500	0.00500	<0.00500	11	10	NP	NP
P-T	mg/L	<0.00500	<0.00500	0.00500	<0.00500	10	10	NP	NP
Sb-D	mg/L	<0.000500	<0.000500	0.000500	<0.000500	11	11	NP	NP
Sb-T[e]	mg/L	<0.000500	<0.000500	0.000500	<0.000500	11	11	NP	0.02
Se-D	mg/L	<0.000100	0.000450	0.000233	0.000240	11	1	NP	NP
Se-T	mg/L	<0.000100	0.000390	0.000235	0.000250	11	1	NP	0.002
Si-D	mg/L	1.72	3.03	2.32	2.33	11	0	NP	NP
Si-T	mg/L	1.72	2.85	2.30	2.22	11	0	NP	NP
Sn-D	mg/L	<0.00500	<0.00500	0.00500	<0.00500	11	11	NP	NP
Sn-T	mg/L	<0.00500	<0.00500	0.00500	<0.00500	11	11	NP	NP
Sr-D	mg/L	0.0210	0.0940	0.0476	0.0417	11	0	NP	NP
Sr-T	mg/L	0.0199	0.0976	0.0462	0.0379	11	0	NP	NP
Ti-D	mg/L	<0.00500	<0.00500	0.00500	<0.00500	11	11	NP	NP
Ti-T	mg/L	<0.00500	<0.00500	0.00500	<0.00500	11	11	NP	NP
Tl-D	mg/L	<0.000050	0.0000500	0.0000500	0.0000500	11	11	NP	NP
Tl-T[f]	mg/L	<0.000050	0.0000500	0.0000500	0.0000500	11	11	0.0008	0.0003
U-D	mg/L	<0.000100	0.000130	0.000104	<0.000100	11	9	NP	NP
U-T	mg/L	<0.000100	0.000140	0.000105	<0.000100	11	9	NP	0.3
V-D	mg/L	<0.00500	<0.00500	0.00500	<0.00500	11	11	NP	NP
V-T	mg/L	<0.00500	<0.00500	0.00500	<0.00500	11	11	NP	0.006
Zn-D	mg/L	<0.00500	<0.00500	0.00500	<0.00500	11	11	NP	NP
Zn-T	mg/L	<0.00500	**0.0154**	0.00607	<0.00500	11	9	0.0075	0.0330
Zr-D	mg/L	<0.000500	0.00107	0.000552	<0.000500	11	10	NP	NP
Zr-T	mg/L	<0.000500	<0.000500	0.000500	<0.000500	11	11	NP	NP

Notes:
a. Values below the analytical detection limit were set equal to the limit for statistical calculations; ND: no data;
b. British Columbia Water Quality Guidelines for the Protection of Freshwater Aquatic Life (BC MOE, 2010); for sulphate, Cd, Cu, Pb, Mn, Ni, Ag and Zn, guidelines are calculated using the median hardness value; values that exceed the max BCWQG are shaded in grey; values that exceed the 30-day guideline are indicated in **bold font**; NP: none proposed;
c. Guidelines based on median pH and assumed temperature of 10°C.
d. Assumes methylmercury = 1.0% of total mercury;
e. Proposed Ontario guideline.
f. Site specific criteria for lower Columbia River, B.C.

Table 5-5:
Upper Iron River water quality (October 2008 - November 2010).

		Dataset Statistics[a]						BC FWAL WQG[b]	
Parameter	**Units**	**Min**	**Max**	**Average**	**Median**	***n***	***n* < DL**	**30-day**	**Acute**
Physical									
Acidity (8.3)	mg/L	1.40	1.40	1.40	1.40	1	0	NP	NP
pH	pH Units	7.41	8.23	7.85	7.86	20	0	6.5 - 9.0	NP
Alkalinity-T	mg $CaCO_3$/L	13.8	71.9	31.8	25.8	20	0	NP	NP
Hardness-T	mg $CaCO_3$/L	17.1	85.0	36.4	28.8	20	0	NP	NP
Conductivity	uS/cm	36.6	171	75.9	59.4	20	0	NP	NP
TDS	mg/L	32.0	96.0	52.1	44.5	20	0	NP	NP
TSS	mg/L	<3.00	6.00	3.22	<3.00	20	17	NP	NP
Nutrients and Anions									
Ammonia[c]	mg-N/L	<0.00500	0.0250	0.00906	<0.00500	16	15	1.34	6.98
Nitrite+Nitrate	mg-N/L	<0.00500	0.104	0.0412	0.0352	14	3	NP	NP
TKN	mg-N/L	<0.0500	0.170	0.0918	0.0845	16	2	NP	NP
Phosphate-D	mg-P/L	<0.00200	0.00410	0.00250	0.00220	15	6	NP	NP
Phosphate-T	mg-P/L	<0.00200	0.0101	0.00367	0.00280	15	2	NP	NP
Sulphate	mg/L	<0.500	10.9	3.18	1.43	20	8	128	NP
Metals									
Ag-D	mg/L	<0.0000200	<0.0100	0.000519	<0.0000200	20	20	NP	NP
Ag-T	mg/L	<0.0000200	**<0.0100**	**0.000519**	<0.0000200	20	20	0.000050	0.000100
Al-D	mg/L	0.00710	**<0.200**	**0.0608**	**0.0594**	20	1	0.0500	0.1000
Al-T	mg/L	0.0131	0.303	0.0898	0.0737	20	2	NP	NP
As-D	mg/L	<0.000500	<0.200	0.0118	0.000990	20	4	NP	NP
As-T	mg/L	0.000530	<0.200	0.0118	0.00106	20	1	NP	0.005
Ba-D	mg/L	<0.00500	<0.0200	0.0188	<0.0200	20	19	NP	NP
Ba-T	mg/L	<0.00500	<0.0200	0.0188	<0.0200	20	19	1	5
B-D	mg/L	<0.0500	<0.100	0.0975	<0.100	20	20	NP	NP
B-T	mg/L	<0.0500	<0.100	0.0975	<0.100	20	20	NP	1.2
Be-D	mg/L	<0.000100	<0.00500	0.00116	<0.00100	20	20	NP	NP
Be-T	mg/L	<0.000100	<0.00500	0.00116	<0.00100	20	20	0.0053	NP
Bi-D	mg/L	<0.00100	<0.200	0.100	<0.100	2	2	NP	NP
Bi-T	mg/L	<0.00100	<0.200	0.100	<0.100	2	2	NP	NP
Ca-D	mg/L	5.72	30.3	12.8	10.0	20	0	NP	NP
Ca-T	mg/L	5.46	28.8	12.5	10.0	20	0	NP	NP
Cd-D	mg/L	<0.0000170	<0.0100	0.000543	0.0000180	20	10	NP	NP
Cd-T	mg/L	0.0000100	<0.0100	0.000522	<0.0000170	20	11	NP	0.000011
Co-D	mg/L	<0.000300	<0.0100	0.000795	<0.000300	20	20	NP	NP
Co-T	mg/L	<0.000300	<0.0100	0.000795	<0.000300	20	20	0.004	0.11
Cr-D	mg/L	<0.00100	<0.0100	0.00145	<0.00100	20	20	NP	NP
Cr-T	mg/L	<0.00100	<0.0100	0.00145	<0.00100	20	19	NP	0.001
Cu-D	mg/L	0.000900	<0.0100	0.00180	0.00115	20	8	NP	NP
Cu-T	mg/L	<0.00100	**<0.0100**	0.00161	<0.00100	20	13	0.0020	0.0047
Fe-D	mg/L	<0.0300	0.0900	0.0448	0.0395	20	6	NP	0.35
Fe-T	mg/L	<0.0300	0.332	0.0781	0.0480	20	6	NP	1
Hg-D	mg/L	<0.0000100	<0.0000200	0.0000195	<0.0000200	19	19	NP	NP
Hg-T[d]	mg/L	<0.0000100	<0.0000200	0.0000195	<0.0000200	19	19	0.00001	NP

		Dataset Statistics[a]						BC FWAL WQG[b]	
Parameter	**Units**	**Min**	**Max**	**Average**	**Median**	***n***	***n* < DL**	**30-day**	**Acute**
K-D	mg/L	0.250	<2.00	1.91	<2.00	20	19	NP	NP
K-T	mg/L	0.260	<2.00	1.91	<2.00	20	19	NP	NP
Li-D	mg/L	<0.00500	<0.0100	0.00525	<0.00500	20	20	NP	NP
Li-T	mg/L	<0.00500	<0.0100	0.00525	<0.00500	20	20	0.096	0.870
Mg-D	mg/L	0.650	2.29	1.04	0.845	20	0	NP	NP
Mg-T	mg/L	0.650	2.21	1.03	0.915	20	0	NP	NP
Mn-D	mg/L	0.000660	<0.00500	0.00136	0.000980	20	1	NP	NP
Mn-T	mg/L	0.000820	0.0134	0.00306	0.00198	20	1	0.7317	0.8574
Mo-D	mg/L	<0.00100	<0.0300	0.00245	<0.00100	20	20	NP	NP
Mo-T	mg/L	<0.00100	<0.0300	0.00245	<0.00100	20	20	1	2
Na-D	mg/L	1.07	4.00	2.16	<2.00	20	14	NP	NP
Na-T	mg/L	1.19	4.10	2.18	<2.00	20	15	NP	NP
Ni-D	mg/L	<0.00100	<0.0500	0.00345	<0.00100	20	20	NP	NP
Ni-T	mg/L	<0.00100	<0.0500	0.00345	<0.00100	20	20	NP	0.025
Pb-D	mg/L	<0.000200	<0.0500	0.00296	<0.000500	20	20	NP	NP
Pb-T	mg/L	<0.000200	**<0.0500**	0.00296	<0.000500	20	20	0.00396	0.01674
P-D	mg/L	<0.00500	<0.300	0.152	0.152	2	2	NP	NP
P-T	mg/L	<0.00500	<0.300	0.152	0.152	2	2	NP	NP
Sb-D	mg/L	<0.000500	<0.200	0.0105	<0.000500	20	20	NP	NP
Sb-T[e]	mg/L	<0.000500	<0.200	0.0105	<0.000500	20	20	NP	0.02
Se-D	mg/L	<0.000200	<0.200	0.0109	<0.00100	20	19	NP	NP
Se-T	mg/L	<0.000200	<0.200	0.0109	<0.00100	20	19	NP	0.002
Si-D	mg/L	2.44	2.80	2.62	2.62	2	0	NP	NP
Si-T	mg/L	2.34	3.30	2.82	2.82	2	0	NP	NP
Sn-D	mg/L	<0.000500	<0.0300	0.00220	<0.000500	20	20	NP	NP
Sn-T	mg/L	<0.000500	<0.0300	0.00220	<0.000500	20	20	NP	NP
Sr-D	mg/L	0.0320	0.0368	0.0344	0.0344	2	0	NP	NP
Sr-T	mg/L	0.0360	0.0370	0.0365	0.0365	2	0	NP	NP
Ti-D	mg/L	<0.00500	<0.0100	0.00975	<0.0100	20	20	NP	NP
Ti-T	mg/L	<0.00500	0.0130	0.00990	<0.0100	20	19	NP	NP
Tl-D	mg/L	<0.0000500	<0.200	0.0102	<0.000200	20	20	NP	NP
Tl-T[f]	mg/L	<0.0000500	**<0.200**	**0.0102**	<0.000200	20	20	0.0008	0.0003
U-D	mg/L	<0.000100	<0.000200	0.000195	<0.000200	19	19	NP	NP
U-T	mg/L	<0.000100	<0.000200	0.000195	<0.000200	19	19	NP	0.3
V-D	mg/L	<0.00100	<0.0300	0.00265	<0.00100	20	20	NP	NP
V-T	mg/L	<0.00100	<0.0300	0.00266	<0.00100	20	19	NP	0.006
Zn-D	mg/L	<0.00500	<0.00500	0.00500	<0.00500	20	20	NP	NP
Zn-T	mg/L	<0.00500	<0.00500	0.00500	<0.00500	20	20	0.0075	0.0330
Zr-D	mg/L	<0.000500	<0.000500	0.000500	<0.000500	1	1	NP	NP
Zr-T	mg/L	<0.000500	<0.000500	0.000500	<0.000500	1	1	NP	NP

Notes:
a. Values below the analytical detection limit were set equal to the limit for statistical calculations; ND: no data;
b. British Columbia Water Quality Guidelines for the Protection of Freshwater Aquatic Life (BC MOE, 2010); for sulphate, Cd, Cu, Pb, Mn, Ni, Ag and Zn, guidelines are calculated using the median hardness value; values that exceed the max BCWQG are shaded in grey; values that exceed the 30-day guideline are indicated in **bold font**; NP: none proposed;
c. Guidelines based on median pH and assumed temperature of 10°C.
d. Assumes methylmercury = 1.0% of total mercury;
e. Proposed Ontario guideline.
f. Site specific criteria for lower Columbia River, B.C.

Table 5-6:
Lower Iron River water quality (October 2008 - November 2010).

		Dataset Statistics[a]						BC FWAL WQG[b]	
Parameter	**Units**	**Min**	**Max**	**Average**	**Median**	***n***	***n* < DL**	**30-day**	**Acute**
Physical									
Acidity (8.3)	mg/L	1.10	1.10	1.10	1.10	1	0	NP	NP
pH	pH Units	7.38	8.21	7.81	7.82	20	0	6.5 - 9.0	NP
Alkalinity-T	mg $CaCO_3$/L	14.5	69.3	31.8	26.0	20	0	NP	NP
Hardness-T	mg $CaCO_3$/L	17.3	84.5	36.4	28.3	20	0	NP	NP
Conductivity	uS/cm	38.0	175	77.0	60.1	20	0	NP	NP
TDS	mg/L	30.0	100	50.8	43.5	20	0	NP	NP
TSS	mg/L	<3.00	6.00	3.20	<3.00	20	18	NP	NP
Nutrients and Anions									
Ammonia[c]	mg-N/L	<0.00500	<0.0200	0.00781	<0.00500	16	16	1.59	8.25
Nitrite+Nitrate	mg-N/L	<0.00500	0.106	0.0408	0.0319	14	3	NP	NP
TKN	mg-N/L	0.0590	0.250	0.103	0.0860	16	0	NP	NP
Phosphate-D	mg-P/L	<0.00200	0.00470	0.00227	<0.00200	15	10	NP	NP
Phosphate-T	mg-P/L	<0.00200	0.0118	0.00375	0.00250	15	3	NP	NP
Sulphate	mg/L	<0.500	11.0	3.30	1.76	20	7	128	NP
Metals									
Ag-D	mg/L	<0.0000200	<0.0100	0.000519	<0.0000200	20	20	NP	NP
Ag-T	mg/L	<0.0000200	**<0.0100**	**0.000519**	<0.0000200	20	20	0.000050	0.000100
Al-D	mg/L	0.00710	**<0.200**	**0.0585**	**0.0528**	20	1	0.0500	0.1000
Al-T	mg/L	0.00730	0.314	0.0855	0.0639	20	1	NP	NP
As-D	mg/L	0.000510	<0.200	0.0123	0.00140	20	1	NP	NP
As-T	mg/L	0.000670	<0.200	0.0123	0.00143	20	1	NP	0.005
Ba-D	mg/L	<0.00500	<0.0200	0.0188	<0.0200	20	19	NP	NP
Ba-T	mg/L	<0.00500	<0.0200	0.0188	<0.0200	20	19	1	5
B-D	mg/L	<0.0500	<0.100	0.0975	<0.100	20	20	NP	NP
B-T	mg/L	<0.0500	<0.100	0.0975	<0.100	20	20	NP	1.2
Be-D	mg/L	<0.000100	<0.00500	0.00116	<0.00100	20	20	NP	NP
Be-T	mg/L	<0.000100	<0.00500	0.00116	<0.00100	20	20	0.0053	NP
Bi-D	mg/L	<0.00100	<0.200	0.100	<0.100	2	2	NP	NP
Bi-T	mg/L	<0.00100	<0.200	0.100	<0.100	2	2	NP	NP
Ca-D	mg/L	5.77	30.0	12.8	9.99	20	0	NP	NP
Ca-T	mg/L	5.62	30.4	12.6	9.97	20	0	NP	NP
Cd-D	mg/L	<0.0000170	<0.0100	0.000522	0.0000175	20	9	NP	NP
Cd-T	mg/L	<0.0000100	<0.0100	0.000518	<0.0000170	20	14	NP	0.000011
Co-D	mg/L	<00.000300	<0.0100	0.000795	<0.000300	20	20	NP	NP
Co-T	mg/L	<0.000300	<0.0100	0.000795	<0.000300	20	20	0.004	0.11
Cr-D	mg/L	<0.00100	<0.0100	0.00145	<0.00100	20	20	NP	NP
Cr-T	mg/L	<0.00100	<0.0100	0.00145	<0.00100	20	20	NP	0.001
Cu-D	mg/L	<0.000900	<0.0100	0.00159	<0.00100	20	11	NP	NP
Cu-T	mg/L	<0.00100	**<0.0100**	0.00175	<0.00100	20	13	0.0020	0.0047
Fe-D	mg/L	<0.0300	0.0900	0.0434	0.0345	20	8	NP	0.35
Fe-T	mg/L	<0.0300	0.335	0.0764	0.0470	20	7	NP	1
Hg-D	mg/L	<0.0000100	<0.0000200	0.0000195	<0.0000200	19	19	NP	NP
Hg-T[d]	mg/L	<0.0000100	<0.0000200	0.0000195	<0.0000200	19	19	0.00001	NP

		Dataset Statistics[a]						BC FWAL WQG[b]	
Parameter	**Units**	**Min**	**Max**	**Average**	**Median**	***n***	***n* < DL**	**30-day**	**Acute**
K-D	mg/L	0.230	<2.00	1.91	<2.00	20	19	NP	NP
K-T	mg/L	0.220	<2.00	1.91	<2.00	20	19	NP	NP
Li-D	mg/L	<0.00500	<0.0100	0.00525	<0.00500	20	20	NP	NP
Li-T	mg/L	<0.00500	<0.0100	0.00525	<0.00500	20	20	0.096	0.870
Mg-D	mg/L	0.650	2.32	1.08	0.870	20	0	NP	NP
Mg-T	mg/L	0.660	2.34	1.07	0.875	20	0	NP	NP
Mn-D	mg/L	0.000510	<0.00500	0.00134	0.00100	20	1	NP	NP
Mn-T	mg/L	0.000740	0.0130	0.00284	0.00154	20	1	0.7295	0.8519
Mo-D	mg/L	<0.00100	<0.0300	0.00245	<0.00100	20	20	NP	NP
Mo-T	mg/L	<0.00100	<0.0300	0.00245	<0.00100	20	20	1	2
Na-D	mg/L	1.12	5.10	2.40	<2.00	20	14	NP	NP
Na-T	mg/L	1.12	5.10	2.34	<2.00	20	14	NP	NP
Ni-D	mg/L	<0.00100	<0.0500	0.00345	<0.00100	20	20	NP	NP
Ni-T	mg/L	<0.00100	<0.0500	0.00345	<0.00100	20	20	NP	0.025
Pb-D	mg/L	<0.000200	<0.0500	0.00296	<0.000500	20	20	NP	NP
Pb-T	mg/L	<0.000200	**<0.0500**	0.00296	<0.000500	20	20	0.00395	0.01637
P-D	mg/L	<0.00500	<0.300	0.152	0.152	2	2	NP	NP
P-T	mg/L	<0.00500	<0.300	0.152	0.152	2	2	NP	NP
Sb-D	mg/L	<0.000500	<0.200	0.0105	<0.000500	20	20	NP	NP
Sb-T[e]	mg/L	<0.000500	<0.200	0.0105	<0.000500	20	19	NP	0.02
Se-D	mg/L	<0.000200	<0.200	0.0109	<0.00100	20	19	NP	NP
Se-T	mg/L	<0.000200	<0.200	0.0109	<0.00100	20	19	NP	0.002
Si-D	mg/L	2.48	2.90	2.69	2.69	2	0	NP	NP
Si-T	mg/L	2.45	2.90	2.68	2.68	2	0	NP	NP
Sn-D	mg/L	<0.000500	<0.0300	0.00220	<0.000500	20	20	NP	NP
Sn-T	mg/L	<0.000500	<0.0300	0.00220	<0.000500	20	20	NP	NP
Sr-D	mg/L	0.0320	0.0370	0.0345	0.0345	2	0	NP	NP
Sr-T	mg/L	0.0320	0.0364	0.0342	0.0342	2	0	NP	NP
Ti-D	mg/L	<0.00500	<0.0100	0.00975	<0.0100	20	20	NP	NP
Ti-T	mg/L	<0.00500	0.0120	0.00985	<0.0100	20	19	NP	NP
Tl-D	mg/L	<0.0000500	<0.200	0.0102	<0.000200	20	20	NP	NP
Tl-T[f]	mg/L	<0.0000500	**<0.200**	**0.0102**	<0.000200	20	20	0.0008	0.0003
U-D	mg/L	<0.000100	<0.000200	0.000195	<0.000200	19	19	NP	NP
U-T	mg/L	<0.000100	<0.000200	0.000195	<0.000200	19	19	NP	0.3
V-D	mg/L	<0.00100	<0.0300	0.00265	<0.00100	20	20	NP	NP
V-T	mg/L	<0.00100	<0.0300	0.00265	<0.00100	20	19	NP	0.006
Zn-D	mg/L	<0.00500	<0.00500	<0.00500	<0.00500	20	20	NP	NP
Zn-T	mg/L	<0.00500	<0.00500	<0.00500	<0.00500	20	20	0.0075	0.0330
Zr-D	mg/L	<0.000500	<0.000500	<0.000500	<0.000500	1	1	NP	NP
Zr-T	mg/L	<0.000500	<0.000500	<0.000500	<0.000500	1	1	NP	NP

Notes:
a. Values below the analytical detection limit were set equal to the limit for statistical calculations; ND: no data;
b. British Columbia Water Quality Guidelines for the Protection of Freshwater Aquatic Life (BC MOE, 2010); for sulphate, Cd, Cu, Pb, Mn, Ni, Ag and Zn, guidelines are calculated using the median hardness value; values that exceed the max BCWQG are shaded in grey; values that exceed the 30-day guideline are indicated in **bold font**; NP: none proposed;
c. Guidelines based on median pH and assumed temperature of 10°C.
d. Assumes methylmercury = 1.0% of total mercury;
e. Proposed Ontario guideline.
f. Site specific criteria for lower Columbia River, B.C.

Table 5-7:
7S Quinsam River water quality (August 2007 - December 2012).

		Dataset Statistics[a]						BC FWAL WQG[b]	
Parameter	**Units**	**Min**	**Max**	**Average**	**Median**	***n***	***n* < DL**	**30-day**	**Acute**
Physical									
Acidity (8.3)	mg/L	<0.500	0.900	0.525	<0.500	28	26	NP	NP
pH	pH Units	6.94	7.96	7.60	7.60	51	0	6.5 - 9.0	NP
Alkalinity-T	mg $CaCO_3$/L	10.3	40.5	27.5	27.9	51	0	NP	NP
Hardness-T	mg $CaCO_3$/L	6.38	60.2	33.2	33.6	51	0	NP	NP
Conductivity	uS/cm	30.2	248	112	109	51	0	NP	NP
TDS	mg/L	18.0	147	69.3	68.0	39	0	NP	NP
TSS	mg/L	<1.00	50.5	4.55	<4.00	48	42	NP	NP
Nutrients and Anions									
Ammonia[c]	mg-N/L	<0.00500	0.440	0.0305	0.0165	40	12	1.85	11.2
Nitrite+Nitrate	mg-N/L	<0.00560	0.288	0.0327	0.0200	39	15	NP	NP
TKN	mg-N/L	<0.0200	0.260	0.126	0.120	31	1	NP	NP
Phosphate-D	mg-P/L	ND	ND	ND	ND	0	ND	NP	NP
Phosphate-T	mg-P/L	ND	ND	ND	ND	0	ND	NP	NP
Sulphate	mg/L	<0.500	72.7	23.2	23.0	51	2	218	NP
Metals									
Ag-D	mg/L	<0.000020	<0.0100	0.000216	<0.000020	51	51	NP	NP
Ag-T	mg/L	<0.000020	**<0.0100**	**0.000216**	<0.000020	51	50	0.000050	0.000100
Al-D	mg/L	0.00520	**<0.200**	0.0236	0.0164	51	1	0.0500	0.1000
Al-T	mg/L	0.00820	<0.200	0.0502	0.0390	51	2	NP	NP
As-D	mg/L	<0.00010	<0.200	0.00428	0.000300	51	23	NP	NP
As-T	mg/L	<0.00010	<0.200	0.00426	0.000300	51	22	NP	0.005
Ba-D	mg/L	<0.0010	0.0260	0.0104	0.00300	51	23	NP	NP
Ba-T	mg/L	<0.0010	<0.0200	0.0100	0.00300	51	23	1	5
B-D	mg/L	<0.0500	<0.100	0.0725	<0.0500	51	51	NP	NP
B-T	mg/L	<0.0500	<0.100	0.0725	<0.0500	51	50	NP	1.2
Be-D	mg/L	<0.00010	<0.00500	0.000584	<0.000100	51	51	NP	NP
Be-T	mg/L	<0.00010	<0.00500	0.000584	<0.000100	51	51	0.0053	NP
Bi-D	mg/L	<0.0010	<0.200	0.00786	<0.00100	29	29	NP	NP
Bi-T	mg/L	<0.0010	<0.200	0.00786	<0.00100	29	29	NP	NP
Ca-D	mg/L	2.01	20.8	11.2	11.3	51	0	NP	NP
Ca-T	mg/L	1.71	19.9	11.0	11.0	51	0	NP	NP
Cd-D	mg/L	<0.0000050	<0.0100	0.000216	<0.0000170	51	38	NP	NP
Cd-T	mg/L	<0.0000050	<0.0100	0.000212	<0.0000100	51	43	NP	0.000013
Co-D	mg/L	<0.000300	<0.0100	0.000629	<0.000500	51	50	NP	NP
Co-T	mg/L	<0.000300	**<0.0100**	0.000600	<0.000500	51	51	0.004	0.11
Cr-D	mg/L	<0.00100	<0.0100	0.00118	<0.00100	51	51	NP	NP
Cr-T	mg/L	<0.00100	<0.0100	0.00118	<0.00100	51	51	NP	0.001
Cu-D	mg/L	0.000390	<0.0100	0.00119	<0.00100	51	19	NP	NP
Cu-T	mg/L	0.000500	**0.0168**	0.00146	<0.00100	51	21	0.0020	0.0052
Fe-D	mg/L	0.0249	0.224	0.0599	0.0590	51	2	NP	0.35
Fe-T	mg/L	0.0320	0.561	0.119	0.102	51	0	NP	1
Hg-D	mg/L	<0.00000200	<0.0000200	0.0000169	<0.0000200	50	50	NP	NP
Hg-T[d]	mg/L	<0.00000200	<0.0000200	0.0000169	<0.0000200	50	49	0.00001	NP

		Dataset Statistics[a]						BC FWAL WQG[b]	
Parameter	**Units**	**Min**	**Max**	**Average**	**Median**	***n***	***n* < DL**	**30-day**	**Acute**
K-D	mg/L	0.133	<2.00	1.05	0.460	51	23	NP	NP
K-T	mg/L	0.100	<2.00	1.02	0.280	51	23	NP	NP
Li-D	mg/L	<0.00500	<0.0100	0.00510	<0.00500	49	49	NP	NP
Li-T	mg/L	<0.00500	<0.0100	0.00510	<0.00500	49	49	0.096	0.870
Mg-D	mg/L	0.495	2.63	1.43	1.40	51	0	NP	NP
Mg-T	mg/L	0.514	2.54	1.42	1.42	51	0	NP	NP
Mn-D	mg/L	0.000830	0.311	0.0108	0.00461	51	1	NP	NP
Mn-T	mg/L	0.000810	0.134	0.00945	0.00700	51	0	0.7528	0.9103
Mo-D	mg/L	<0.00100	<0.0300	0.00157	<0.00100	51	51	NP	NP
Mo-T	mg/L	<0.00100	<0.0300	0.00157	<0.00100	51	51	1	2
Na-D	mg/L	1.07	24.8	9.05	8.40	51	1	NP	NP
Na-T	mg/L	0.961	24.7	9.24	8.53	51	1	NP	NP
Ni-D	mg/L	<0.00100	<0.0500	0.00196	<0.00100	51	50	NP	NP
Ni-T	mg/L	<0.00100	<0.0500	0.00204	<0.00100	51	50	NP	0.025
Pb-D	mg/L	<0.000200	<0.0500	0.00131	<0.000200	51	51	NP	NP
Pb-T	mg/L	<0.000200	**<0.0500**	0.00131	<0.000200	51	50	0.00410	0.02037
P-D	mg/L	<0.00500	<0.300	0.0156	<0.00500	28	27	NP	NP
P-T	mg/L	<0.00500	<0.300	0.0161	<0.00500	27	25	NP	NP
Sb-D	mg/L	<0.000500	<0.200	0.00441	<0.000500	51	51	NP	NP
Sb-T[e]	mg/L	<0.000500	<0.200	0.00441	<0.000500	51	51	NP	0.02
Se-D	mg/L	<0.000100	<0.200	0.00441	<0.000100	51	51	NP	NP
Se-T	mg/L	<0.000100	<0.200	0.00441	<0.000100	51	51	NP	0.002
Si-D	mg/L	1.60	4.10	2.22	2.10	29	0	NP	NP
Si-T	mg/L	1.50	3.40	2.11	2.10	29	0	NP	NP
Sn-D	mg/L	<0.000500	<0.0300	0.00373	<0.00500	51	49	NP	NP
Sn-T	mg/L	<0.000500	<0.0300	0.00355	<0.00500	51	51	NP	NP
Sr-D	mg/L	0.0115	0.0660	0.0451	0.0440	29	0	NP	NP
Sr-T	mg/L	0.0110	0.0700	0.0459	0.0463	29	0	NP	NP
Ti-D	mg/L	<0.00500	<0.0100	0.00725	<0.00500	51	51	NP	NP
Ti-T	mg/L	<0.00500	0.0120	0.00745	0.00700	51	47	NP	NP
Tl-D	mg/L	<0.0000500	<0.200	0.00404	<0.0000500	51	51	NP	NP
Tl-T[f]	mg/L	<0.0000500	**<0.200**	**0.00404**	<0.0000500	51	51	0.0008	0.0003
U-D	mg/L	<0.000100	<0.000200	0.000144	<0.000100	50	50	NP	NP
U-T	mg/L	<0.000100	<0.000200	0.000144	<0.000100	50	50	NP	0.3
V-D	mg/L	<0.00100	<0.0300	0.00433	<0.00500	51	51	NP	NP
V-T	mg/L	<0.00100	<0.0300	0.00434	<0.00500	51	50	NP	0.006
Zn-D	mg/L	<0.00500	0.0270	0.00553	<0.00500	51	48	NP	NP
Zn-T	mg/L	<0.00500	**0.0107**	0.00513	<0.00500	51	49	0.0075	0.0330
Zr-D	mg/L	<0.000500	<0.000500	0.000500	<0.000500	28	28	NP	NP
Zr-T	mg/L	<0.000500	<0.000500	0.000500	<0.000500	28	28	NP	NP

Notes:
a. Values below the analytical detection limit were set equal to the limit for statistical calculations; ND: no data;
b. British Columbia Water Quality Guidelines for the Protection of Freshwater Aquatic Life (BC MOE, 2010); for sulphate, Cd, Cu, Pb, Mn, Ni, Ag and Zn, guidelines are calculated using the median hardness value; values that exceed the max BCWQG are shaded in grey; values that exceed the 30-day guideline are indicated in **bold font**; NP: none proposed;
c. Guidelines based on median pH and assumed temperature of 10°C.
d. Assumes methylmercury = 1.0% of total mercury;
e. Proposed Ontario guideline.
f. Site specific criteria for lower Columbia River, B.C.

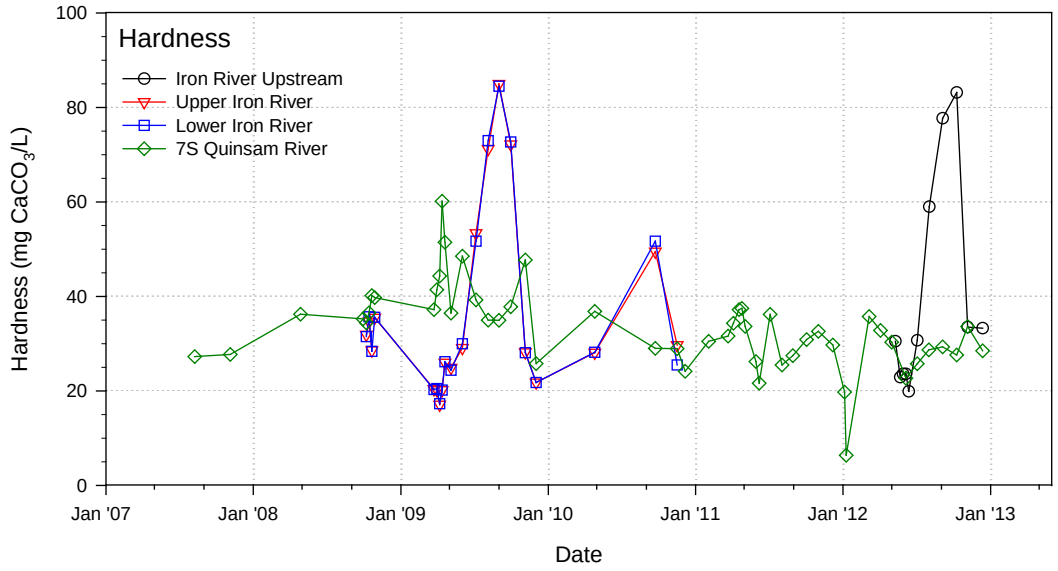


Figure 5-2: Hardness time series at surface water quality stations in Iron River and Quinsam River.

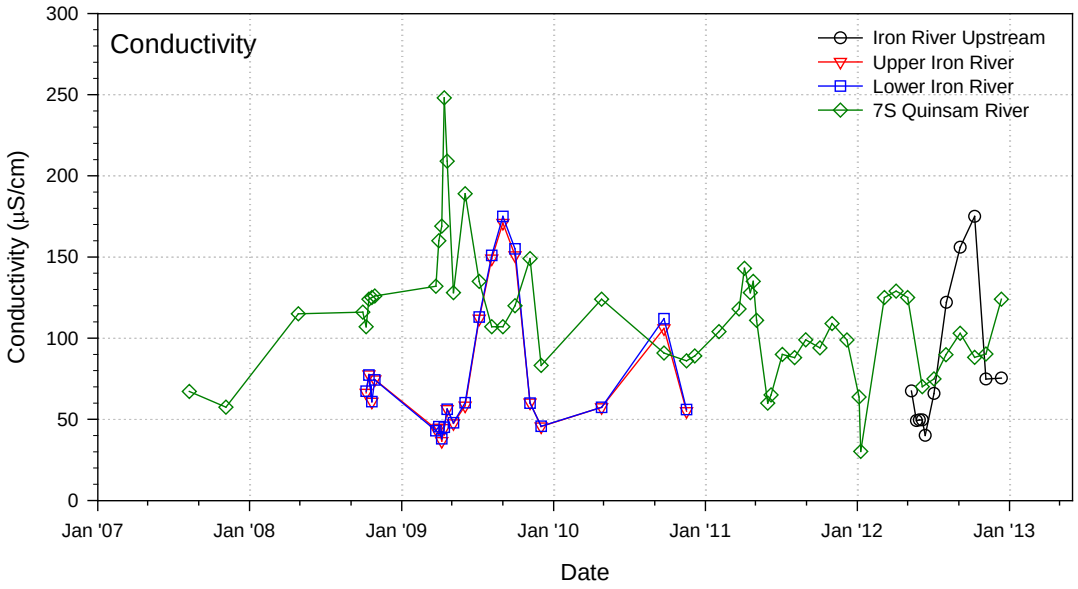


Figure 5-3: Conductivity time series at surface water quality stations in Iron River and Quinsam River.

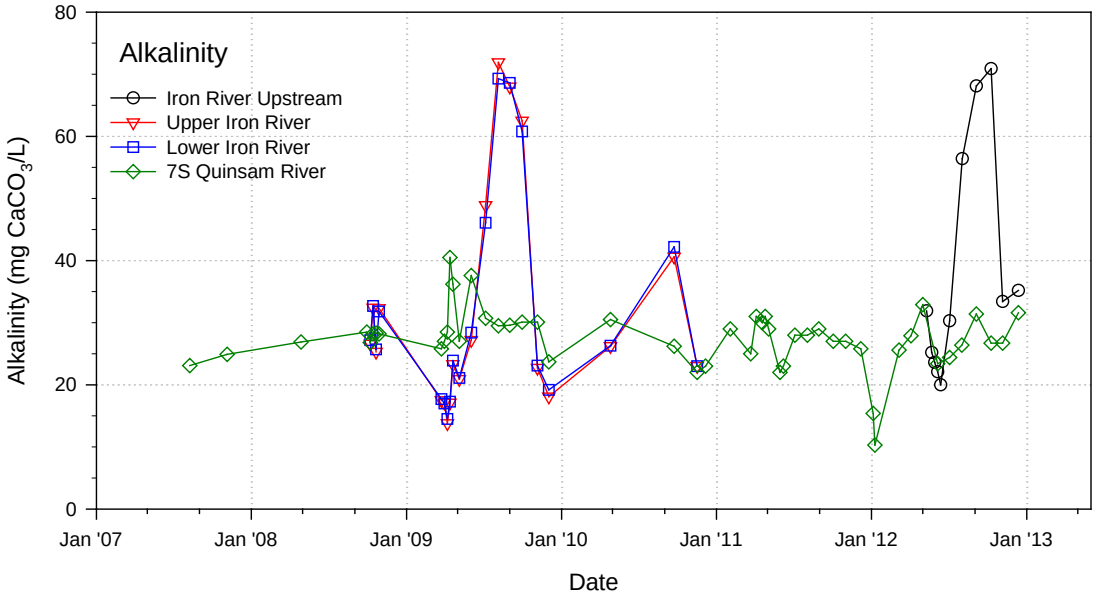


Figure 5-4: Alkalinity time series at surface water quality stations in Iron River and Quinsam River.

Conversely, seasonal trends for major ion parameters in Quinsam River are less obvious due to upstream hydrological regulation. As a result, the varying seasonal influence of meteoric water and ground water on ion time-series is not as distinct as that demonstrated for Iron River. Annual maxima at 7SQR tend to occur in spring (March-April) (Figure 5-2 to Figure 5-4). Low values are associated with seasonal high flow, although the months in which annual minima occur vary with year. This variability can be attributed to various factors, including seasonal lake dynamics upstream of 7SQR, and diversion of surface flow upstream of Middle Quinsam Lake.

Iron River pH remains relatively uniform throughout the year with values generally ranging between 7.4 and 8.2 (mean pH = 7.8; Table 5-4 to Table 5-6). pH is similar between all Iron River stations (Figure 5-5). Quinsam River exhibits slightly more acidic conditions, demonstrating pH values from 6.9 to 8.0 (mean pH = 7.6; Table 5-7). Overall, all pH values reported to date have remained within the chronic criterion range of 6.5 to 9.0.

Baseline concentrations for sulphate in Iron River are low (<15 mg/L), and exhibit a seasonal signature similar to that observed for other salinity proxies (Figure 5-6). Sulphate minima during winter flow can be attributed to the influence of low ionic strength meteoric water on stream flow, while higher values during the summer low flow period reflect an increased proportion of groundwater recharge. Sulphate values in Quinsam River are generally higher than those observed in Iron River (which partly relates to upstream QCM discharge) but remain well below the provincial guideline of

218 mg/L (mean = 23.2 mg/L). Unlike Iron River, however, seasonal maxima for this analyte typically occur in spring (March-April) comparable to that of alkalinity and hardness (above). On one occasion the sulphate concentration at 7SQR exceeded a concentration of 50 mg/L (April 2009, 72.7 mg/L). Overall, sulphate levels in both the Quinsam River and Iron River systems have remained well below their respective hardness-based FWAL WQG for the protection of aquatic life over the monitoring period (2007 – 2012).

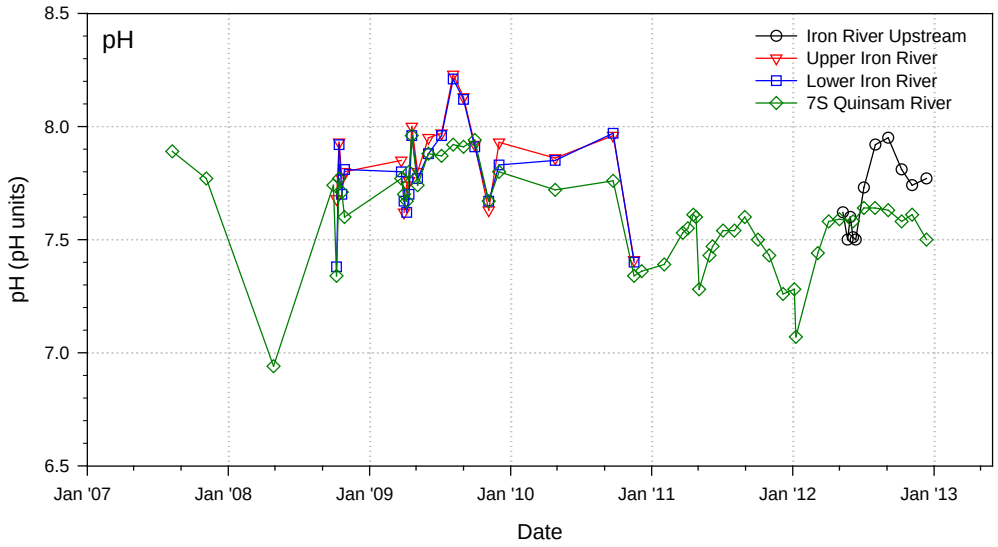


Figure 5-5: pH time series at surface water quality stations in Iron River and Quinsam River.

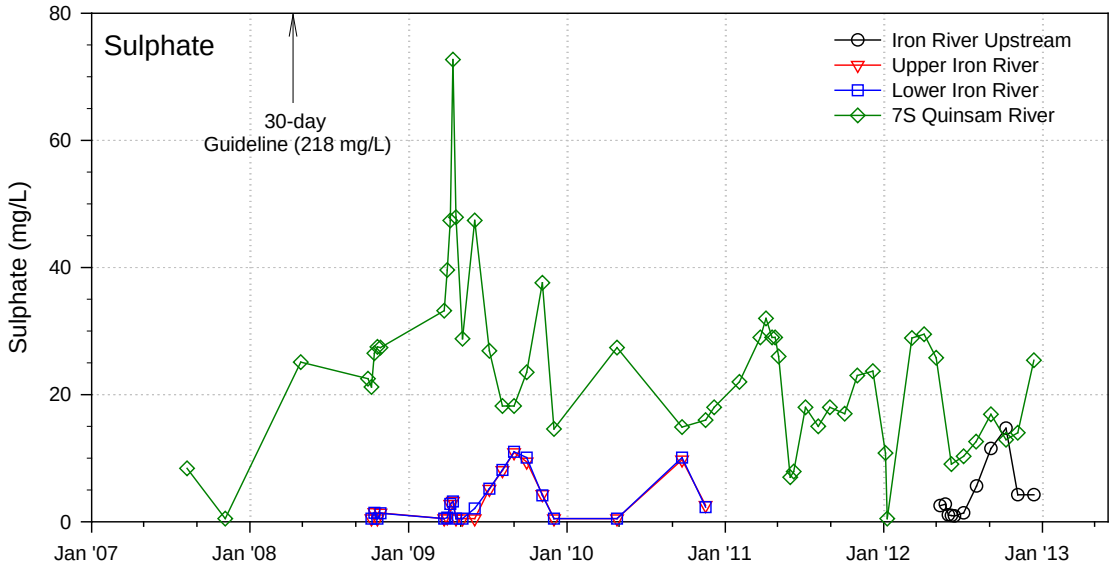


Figure 5-6: Sulphate time series at surface water quality stations in Iron River and Quinsam River. 30-day FWAL WQG based on median water hardness of 7SQR and Iron River dataset (31 mg/L $CaCO_3$/L).

Comparison of the time series profiles for major ions illustrates reasonable between-station agreement in Iron River. This is most illustrated most clearly between LIR and UIR data, collected from 2008 to 2011. Recent data at the upstream station, IRU, exhibit similar water chemistry values to downstream stations.

Total Suspended Solids

The median TSS value for UIR and LIR was <3 mg/L (2008 to 2010; Figure 5-7). Similar results were observed for IRU (median <4 mg/L; May – December, 2012). Of the entire Iron River dataset, TSS were above the DL value in only one sampling event (May 2009) in which both UIR and LIR showed values of 6.0 mg/L.

Similarly, TSS levels were near or below the DL in most 7SQR samples, but TSS levels as high as 50.5 mg/L were observed on one occasion (August 2012, 50.5 mg/L). Total suspended solids commonly increase with turbulent waters and a TSS level of 50 mg/L is not unusual in British Columbia streams during high flow events. However, the magnitude of the 7SQR value is unusual for the dataset. Rain events in late summer have potential to increase the TSS load, but Environment Canada hydrometric data for the region (Environment Canada stations 08HD021, 08HD005) indicate no major changes to flow over the days leading up to and during the August 2012 sampling event. Further, metals in the particulate fraction of the water column that would be expected to increase in association with TSS (*e.g.*, Cd, Fe, Zn, *etc*.), did not demonstrate similar increases in concentration in the same sampling event. As a result, this datum may represent a potential sampling or analytical error, but existing information does not warrant its removal from the water quality dataset. Outside of this value, TSS levels in Quinsam River samples have remained below 10 mg/L.

Nutrients

Nutrients quantified in the Iron and Quinsam River systems include nitrate+nitrite-N ($NO_3^- + NO_2^-$), ammonia-N (NH_3), and phosphate-P (PO_4^{3-}). Nitrate, nitrite and ammonia can occur in elevated concentrations in mine-related discharges due to the leaching of blasting residues (*e.g.*, ammonium nitrate/fuel oil). Ammonia and nitrate are constituents of the explosives, while nitrite is an intermediate product of the oxidation of ammonia to nitrate.

In overview, water in Iron River and Quinsam River contains relatively little nitrogen. Mean ammonia concentrations in Iron River are low (0.009 mg-N/L), with values ranging from <0.005 to 0.025 mg-N/L (Figure 5-8). Almost all values collected at UIR and LIR were below the detection limit. Despite nearby mine activity, ammonia concentrations are expected to remain low in this system due to the low persistence of ammonia in fully

oxygenated freshwaters at neutral pH. Low ammonia levels are also reported in Quinsam River (mean = 0.03 mg/L), but elevated levels are occasionally observed. For example, samples collected in October 2011 yielded ammonia levels of 0.44 mg-N/L, but remained below the 30-d freshwater guideline (1.86 mg-N/L, based on assumed pH of 7.7 and temperature of 10°C). This value was excluded from the water quality dataset and source term calculations, based on the following rationale:

- Measurements of nitrite+nitrate in the same sample were <0.02 mg/L. In fully oxygenated freshwaters at neutral pH, ammonia is expected to be converted relatively quickly to nitrate, which is more stable under these conditions. The absence of nitrate in the sample suggests that the ammonia value in this sample does not reflect true environmental conditions;
- Ammonia and nitrite+nitrate concentrations at both upstream stations, 7S and QRDS1, were low.

Similar to ammonia, nitrate+nitrite commonly occurs at low concentrations.

Table 5-4 to Table 5-6 with concentrations in Iron River ranging from <0.005 to 0.123 mg-N/L. Levels are comparable to those observed in Quinsam River, except in January 2012, when Quinsam River values ranged as high as 0.288 mg-N/L (Table 5-7). Future monitoring may require analysis of nitrite and nitrate separately, given separate provincial guidelines apply to each parameter.

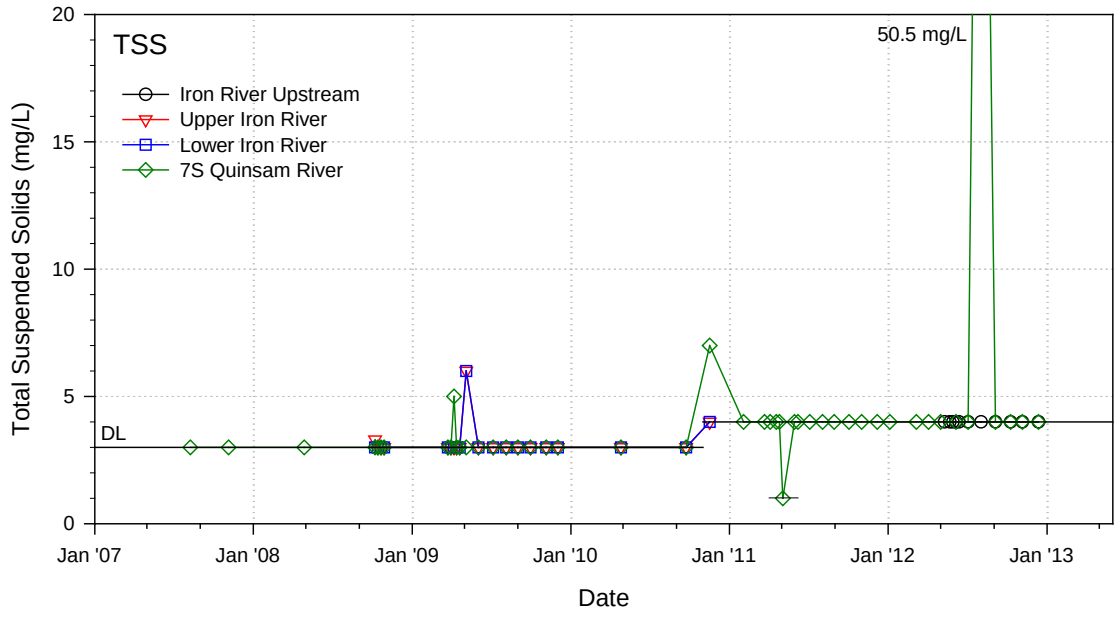


Figure 5-7: Total suspended solids time series at surface water quality stations in Iron River and Quinsam River. Solid line indicates detection limit (DL).

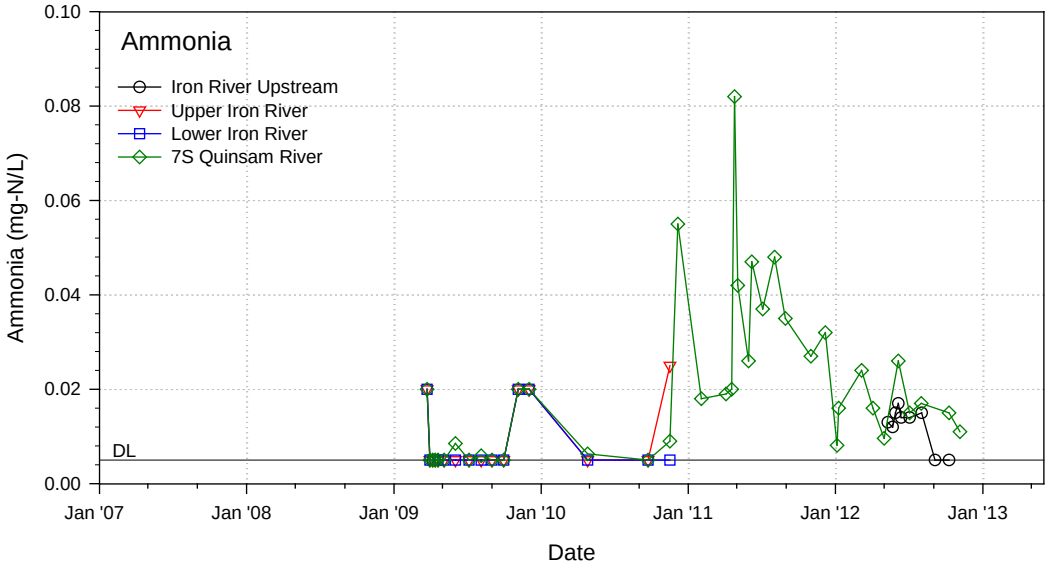


Figure 5-8: Ammonia-N time series at surface water quality stations in Iron River and Quinsam River. Solid line indicates detection limit (DL).

Total phosphate was only measured in Iron River from March 2009 to September 2010. Phosphate profiles for upper and lower stations show reasonable inter-station consistency, with total values at Iron River stations ranging from 0.0020 to 0.0118 mg-P/L (Figure 5-9). Primary productivity in freshwaters is typically limited by available phosphorus. Accordingly, measurements of phosphorus compounds in surface waters can provide an indication of trophic status (*i.e.*, productivity regime), although this metric is typically associated with lentic systems. While there are no proposed phosphate criteria for streams (including stream criteria for the protection of aquatic life or wildlife), maximum values in Iron River on one occasion exceeded the drinking water and recreation guideline of 0.01 mg/L set for lakes. This guideline is relevant, given 7SA5 waters discharged to Iron River will enter Quinsam River, which ultimately drains to Quinsam Lake.

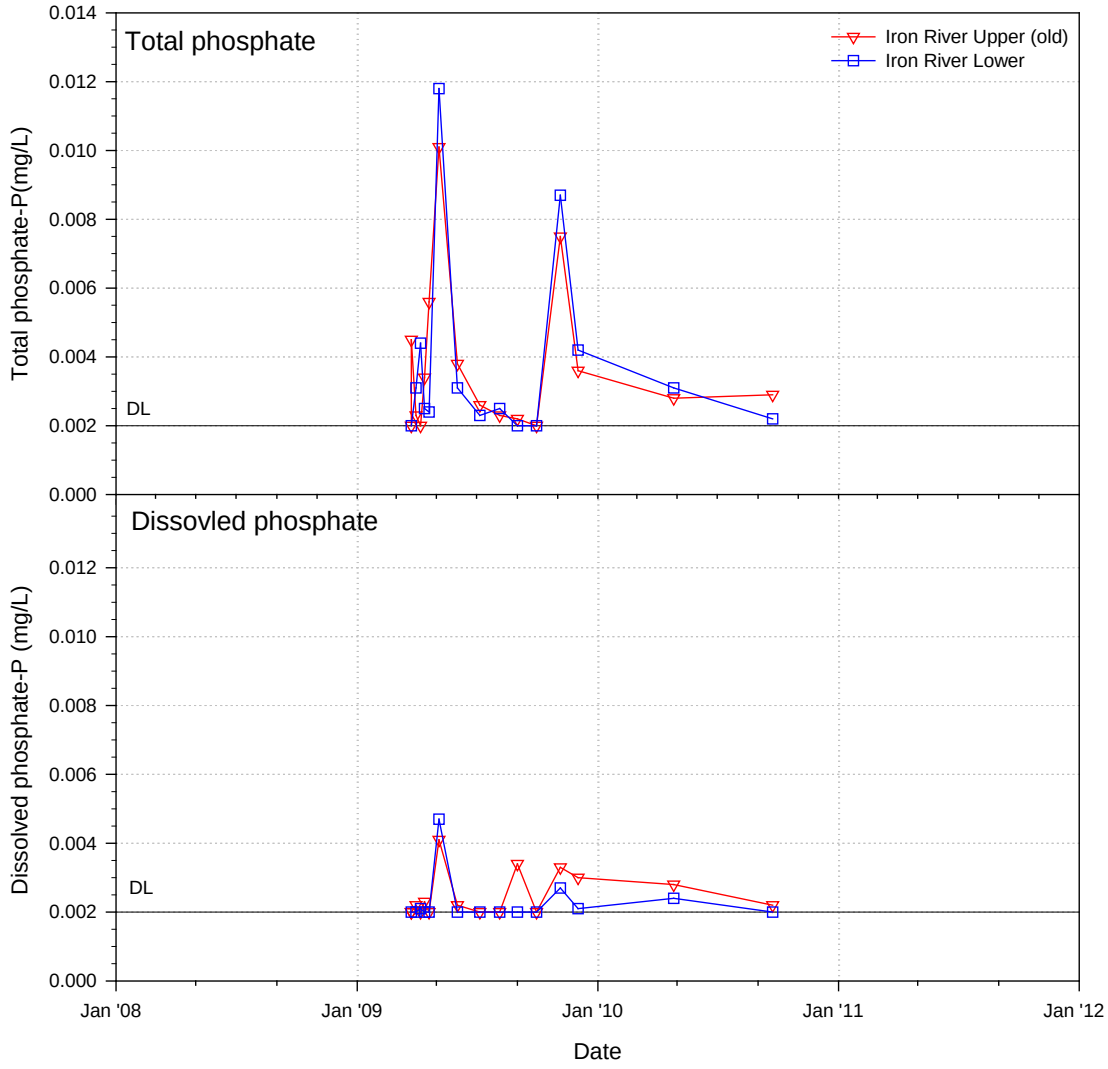


Figure 5-9: Phosphate-P time series at surface water quality stations in Iron River and Quinsam River. Solid line indicates detection limit (DL).

Trace Elements

Baseline trace element concentrations in Iron River and Quinsam River were derived from data collected from September 2007 to August 2012. In time series below, hardness dependent guidelines were calculated using the median water hardness of the combined 7SQR and Iron River dataset (31 mg $CaCO_3$/L). Quinsam and Iron River water quality data were compared to these guidelines to provide a reference point to which baseline values could be compared.

In general, mean concentrations of total and dissolved elements are low in Iron River and Quinsam River, and fall below FWAL WQG (Table 5-4 to Table 5-7, inclusive). Maximum observed elemental concentrations also fall below guidelines for the protection

of wildlife and livestock, where applicable. Certain values for Ag, Cr, Sb, and Tl are highlighted in water quality summary tables above for exceeding their respective water quality guidelines (Table 5-4 to Table 5-7). However, for these parameters highlighted values relate to unusually high DLs that were employed and not measurable concentrations. Measurable levels of Ag, Cr, Sb, and Tl in Quinsam River and Iron River water samples are below detection in almost all other measurements for which appropriate DLs were employed. With respect to parameters of concern, measureable baseline levels of Al, As (Iron River only), Cu, and Cd naturally exceeded water quality guidelines over the course of the monitoring program (Figure 5-10 to Figure 5-13). Other parameters of concern (Fe, Mn, Se, and Zn) remained below guidelines (Figure 5-14 to Figure 5-17). These parameters are discussed in greater detail below.

In general, total and dissolved Al values correlate positively with flow. Baseline Al concentrations are elevated in Iron River, with dissolved Al reaching a maximum of 0.119 mg/L in May 2009 (UIR; Figure 5-10). Dissolved values exceed the 30-d guideline annually. Dissolved values in Quinsam River (7SRQ mean = 0.024 mg/L) are lower than in Iron River (Iron River mean = 0.056 mg/L), but on occasion also exceed the 30-day guideline (*e.g.,* January 2012). The correlation between dissolved and total fractions strongly suggests that the dissolved Al fraction is governed by colloidal Al hydroxides that are able to pass through a 0.45 μm filter membrane. In sum, natural baseline levels of dissolved Al in Iron River, and to lesser extent Quinsam River, commonly approach or exceed the provincial 30-day provincial water quality guideline. These occurrences commonly take place during high flow events.

Total and dissolved As concentrations in Quinsam River are low, with values commonly near or below the detection limit (Figure 5-11). Somewhat higher concentrations were observed in Iron River over the 2008 to 2010 monitoring period at UIR and LIR. In these measurements As was present almost entirely within the dissolved fraction (Figure 5-11). During 2009 summer low flow, total As values at UIR and LIR consistently surpassed the acute water quality guideline. A similar trend was not demonstrated at IRU in recent monitoring (May 2012 to December 2012). It is unclear if dissimilarities between the UIR/LIR dataset and the IRU dataset relate to temporal differences between monitoring periods (*i.e.,* 2008-2010 vs. 2012) or spatial differences between the upstream (IRU) and downstream (UIR, LIR) sites. Note that As values for LIR are commonly greater than UIR in Figure 5-11. This pattern suggests As loading to Iron River may increase with proximity to the Quinsam River confluence, inferring the presence of a localized loading source. Ongoing monitoring at stations upstream and downstream of project-related effects in Iron River is recommended to elucidate this possibility.

Detectable levels of Cd in Iron River samples ranged from 0.00001 to 0.000084 mg/L, and 0.00001 to 0.000171 mg/L at 7SQR (Figure 5-12). However, the analysis of the Cd dataset is limited by relatively high detection limits employed over the monitoring period. For example, up to November 2010 the Cd detection limit was commonly higher than the Cd guideline (which is already low given Iron and Quinsam River water is relatively soft). As a result, Cd levels were commonly below the detection limit in several samples. Monitoring that occurred in 2012, which employed lower DLs, shows total Cd levels are higher in Iron River (IRU) compared to Quinsam River (7SQR). All IRU values for total Cd exceed the maximum Cd guideline (calculated using the median water hardness of the combined Quinsam and Iron River datasets). It should be noted that contamination is apparent in the dissolved Cd fraction of certain samples over the 2008-2012 period. Samples that demonstrate contamination include UIR (October 14, 2008; September 23, 2010; November 15, 2010) and 7SQR (November 16, 2010; December 6, 2010). While water quality guideline comparison is unaffected by these values, sample contamination must be taken into account in the calculation of background water quality terms (Section 5.3).

Values for total Cu occasionally exceed the 30-day water quality guideline (calculated using the median water hardness for the Quinsam and Iron River dataset) in both Iron River and Quinsam River (mean T-Cu = 0.00148 and 0.00146 mg/L, respectively; Figure 5-13). Of Iron River stations, Cu concentrations equaled the acute guideline at LIR on one occasion (March 3, 2009), and exceeded the 30-d guideline later that year at UIR (May 5, 2009). Similarly, at 7SQR the acute guideline was surpassed on one occasion (May 30, 2011) and the 30-d guideline was surpassed in a separate event (July 4, 2011). The former value, however, may reflect sample contamination, given dissolved levels of several metals exceeded total in this sample (*e.g.*, dissolved Co and Mn) and given low Cu levels reported at upstream stations 7S and QRDS1 over the same period. In general, comparison of the partitioning between the total and dissolved phases for these elements suggests that maxima are largely accounted for by particulate fractions (Figure 5-10, Figure 5-13).

Outside of anomalous events, concentrations of other PoC, including total Fe, Mn, Se, and Zn are typically near or below the detection limit (Figure 5-14 to Figure 5-17). Detectable values are well below water quality guidelines for the protection of aquatic life, but on occasion, unusually elevated levels of certain elements were observed. For example, certain 7SQR values for dissolved Mn (0.311 mg/L; May 2011) and dissolved Zn (0.027 mg/L; June 2011) were substantially higher than corresponding total levels. Certain 7SQR data for dissolved Cd (0.00012 mg/L, December 2010), and UIR data for dissolved Cd (0.000223 mg/L, October 2008; 0.000233 mg/L, September 2010) were

similarly elevated above total. Because the total fraction for these metals was not correspondingly elevated in samples, it can be assumed that the dissolved values reflect sample contamination or an analytical error. These data were excluded from the water quality dataset and background source term calculations. Substantially elevated levels of certain total elements (total Cu, June 2011; total Mn, October 2008) were occasionally measured in 7SQR samples. It is unclear if these data represent real environmental conditions or sampling/analytical error. As a result, these values were retained in the water quality dataset.

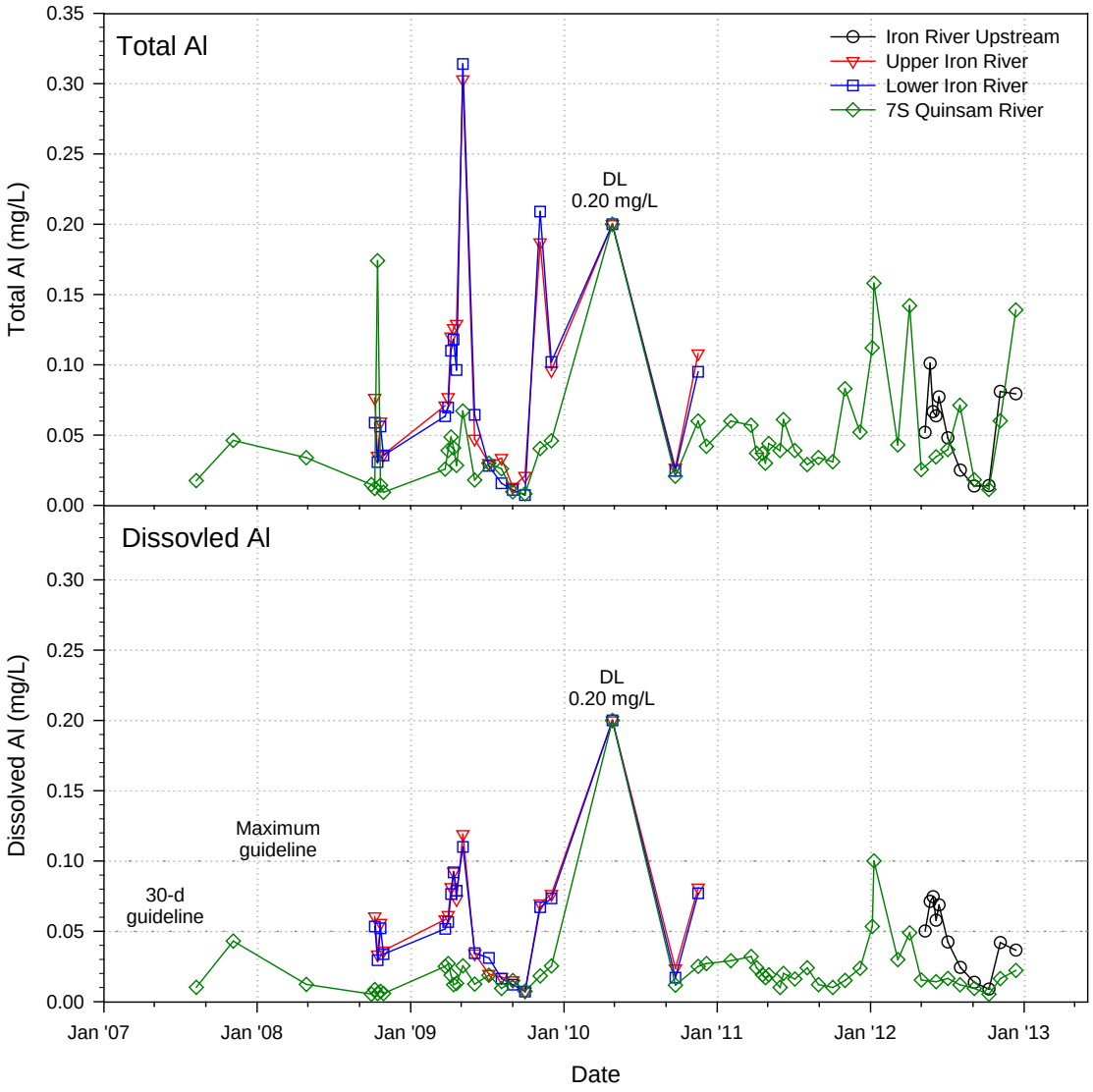


Figure 5-10: Aluminum time series at surface water quality stations in Iron River and Quinsam River. Long-dashed grey line indicates maximum FWAL WQG; short-dashed grey line indicates 30-day FWAL WQG.

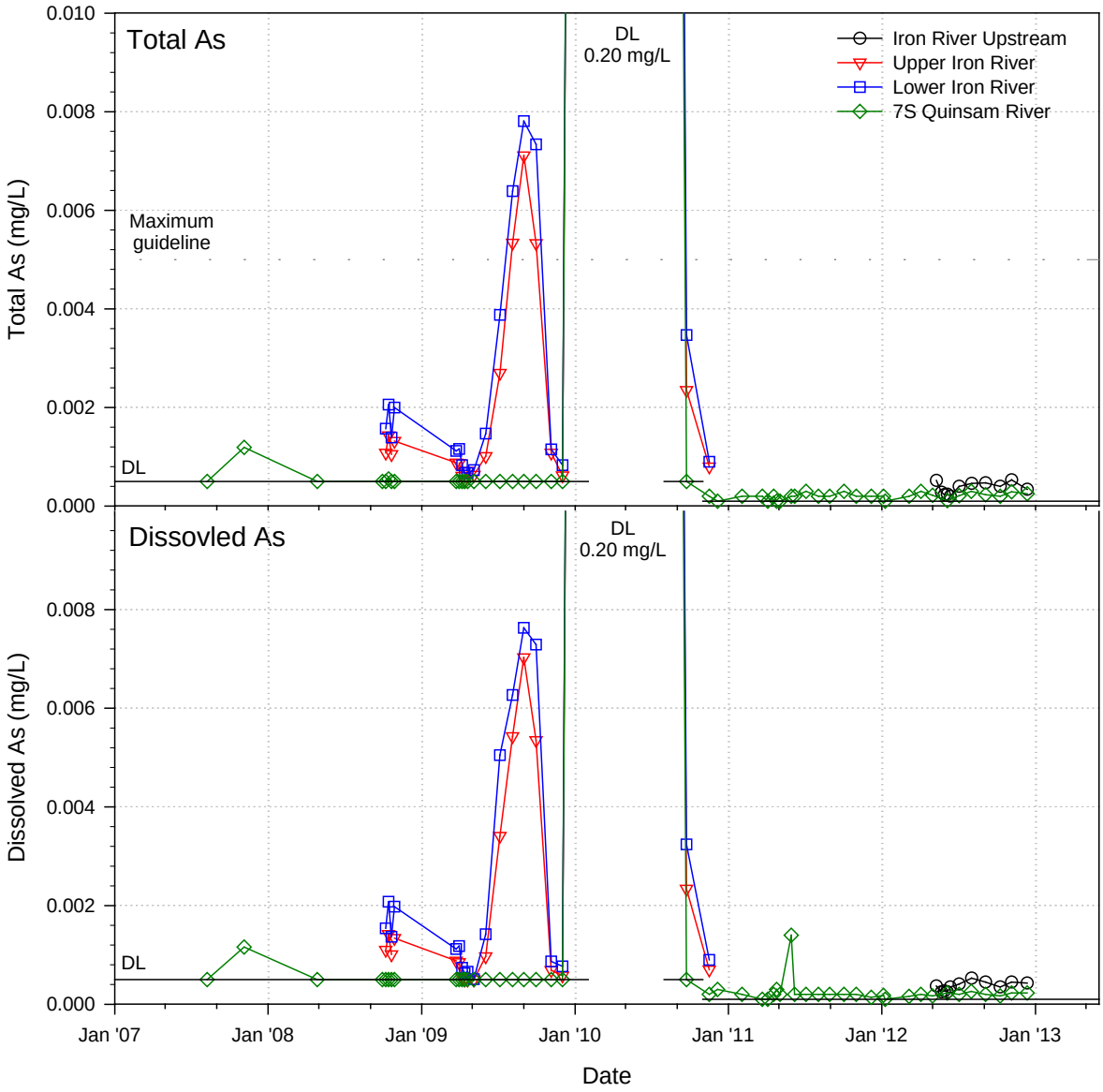


Figure 5-11: Arsenic time series at surface water quality stations in Iron River and Quinsam River. Long-dashed grey line indicates maximum FWAL WQG. Solid line indicates detection limit (DL).

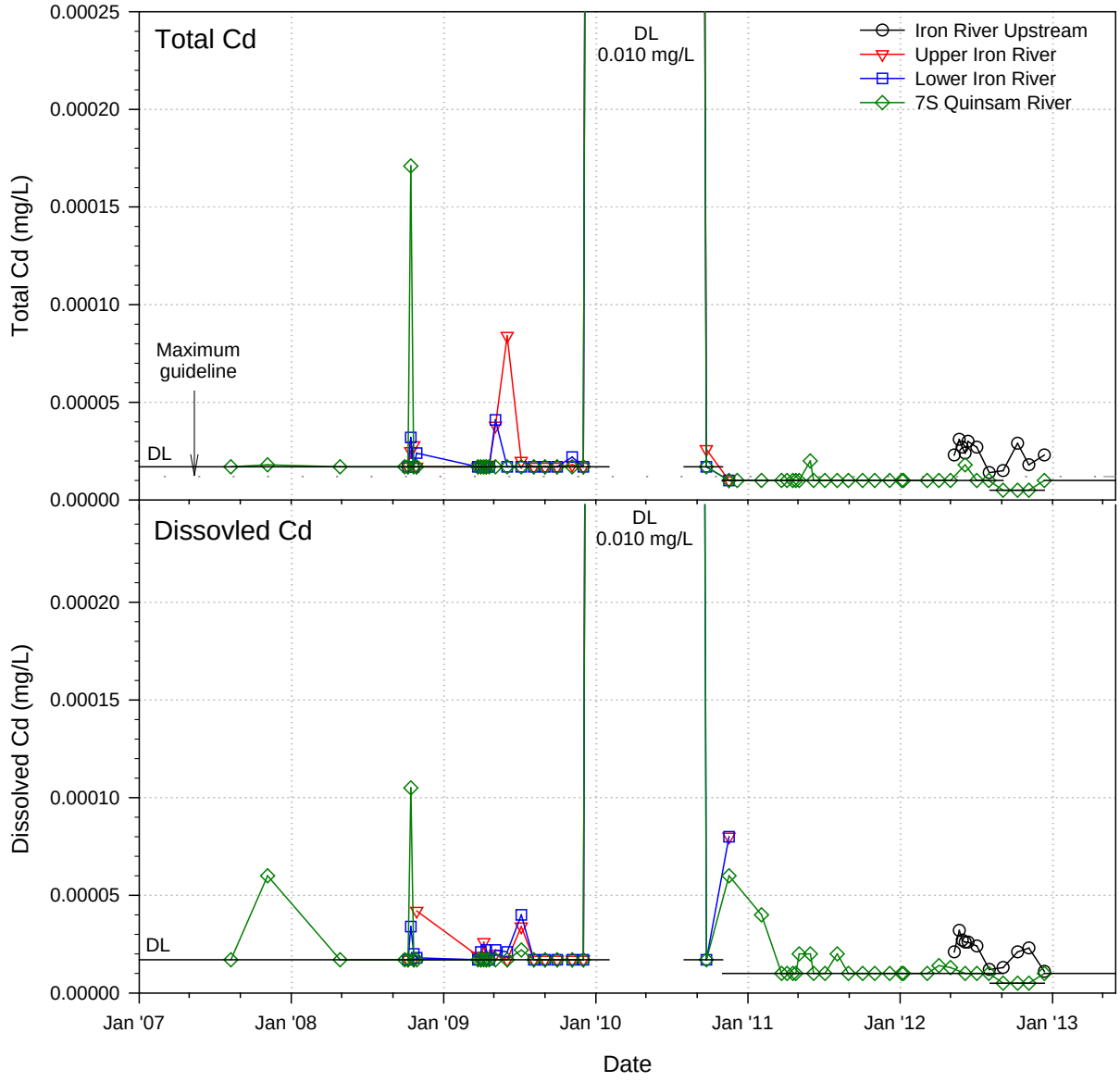


Figure 5-12: Cadmium time series at surface water quality stations in Iron River and Quinsam River. Long-dashed grey line indicates maximum FWAL WQG based on median water hardness of 7SQR and Iron River dataset (31 mg $CaCO_3$/L). Solid line indicates detection limit (DL).

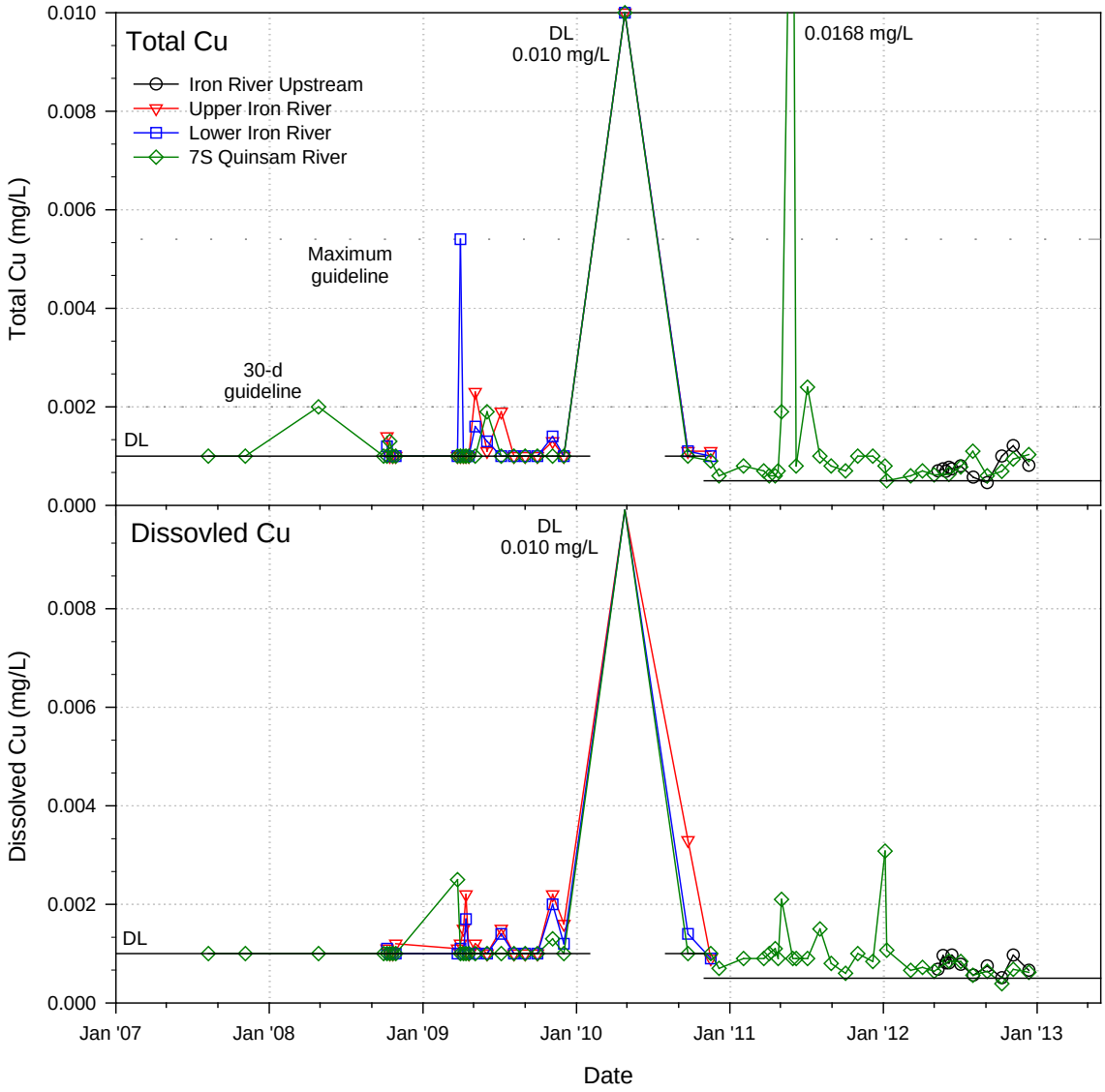


Figure 5-13: Copper time series at surface water quality stations in Iron River and Quinsam River. Long-dashed grey line indicates maximum FWAL WQG; short-dashed grey line indicates 30-day FWAL WQG based on median water hardness of 7SQR and Iron River dataset (31 mg $CaCO_3$/L). Solid line indicates detection limit (DL).

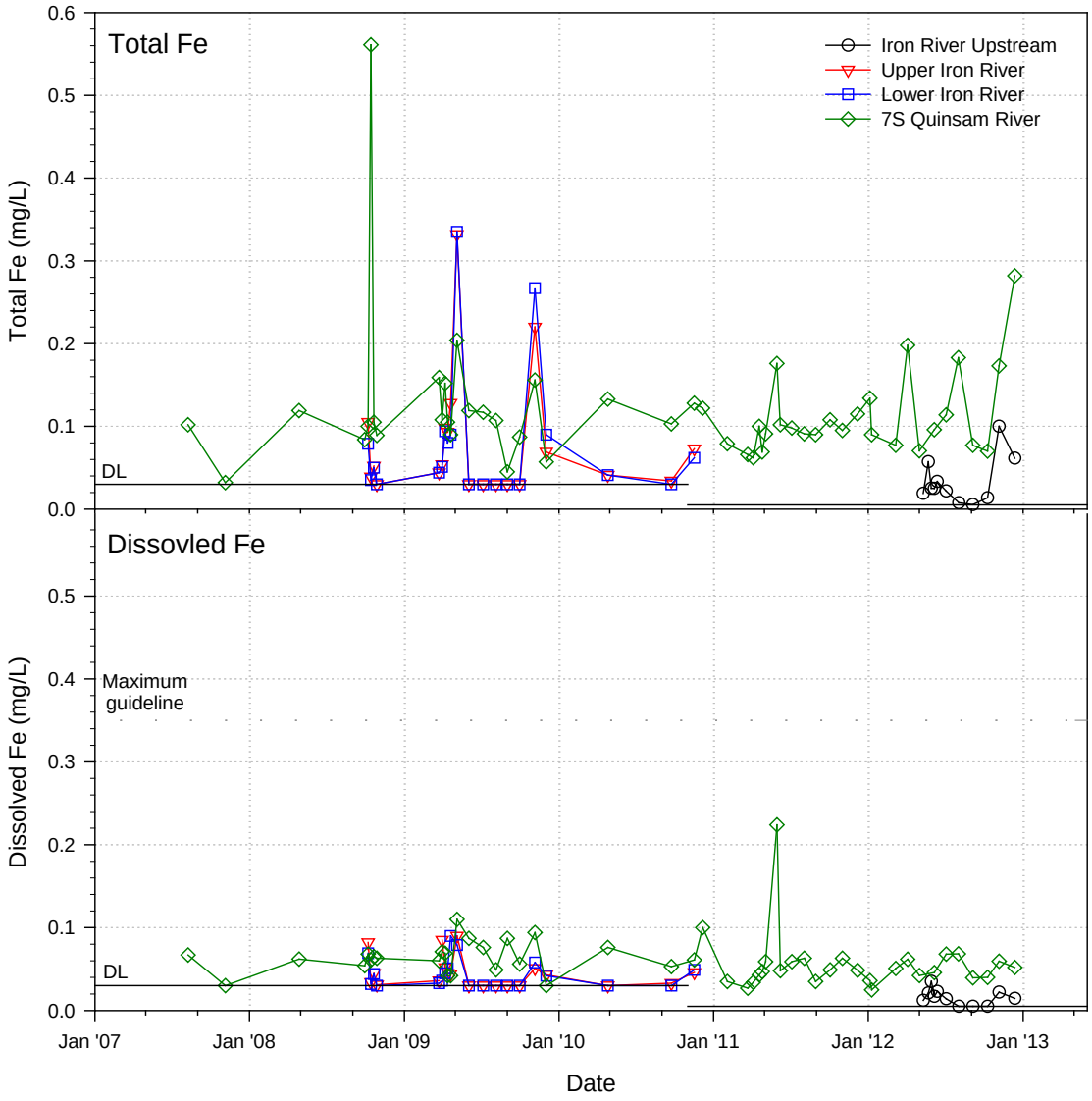


Figure 5-14: Iron time series at surface water quality stations in Iron River and Quinsam River. Long-dashed grey line indicates maximum FWAL WQG. Solid line indicates detection limit (DL).

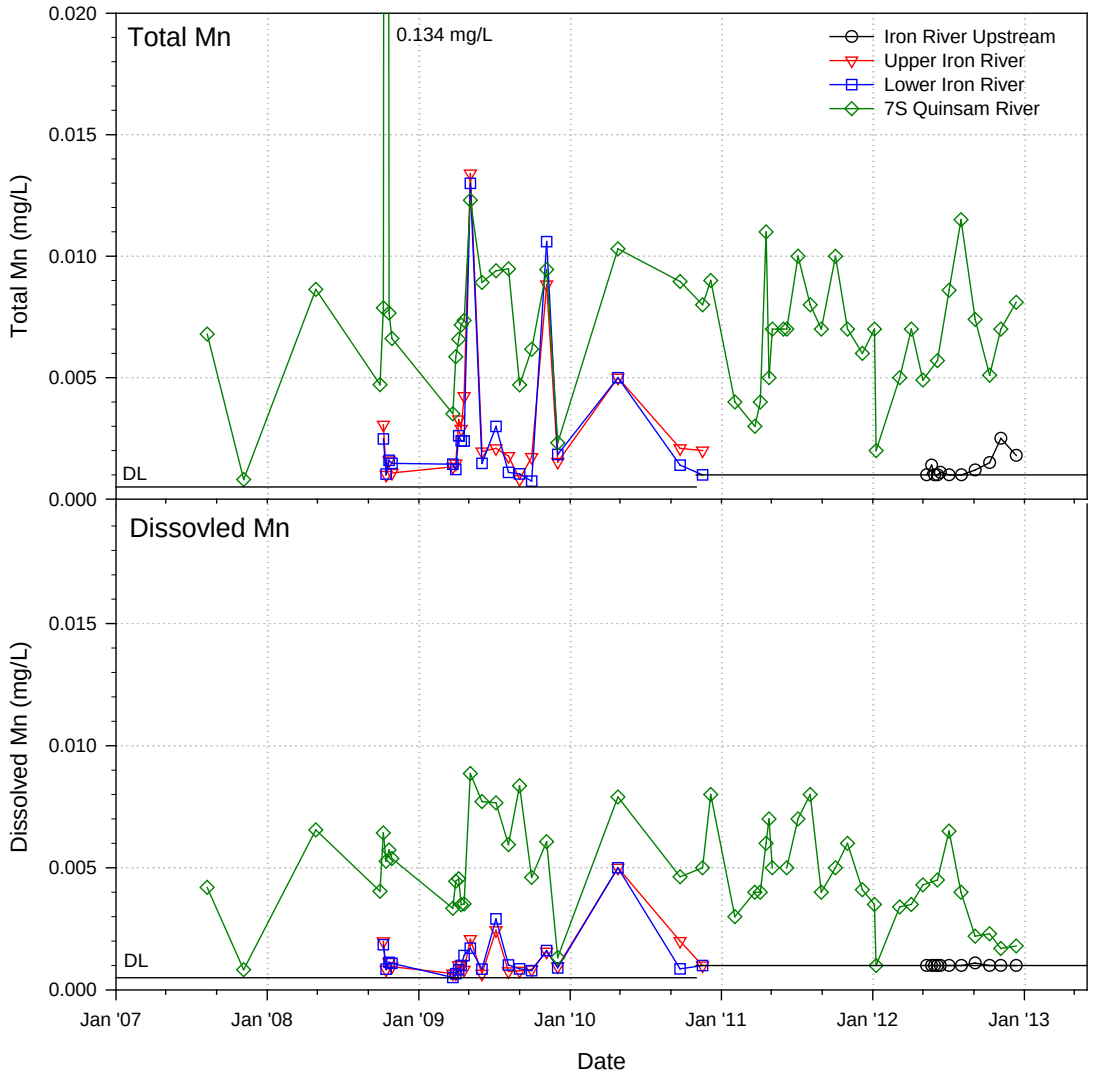


Figure 5-15: Manganese time series at surface water quality stations in Iron River and Quinsam River. Solid line indicates detection limit (DL).

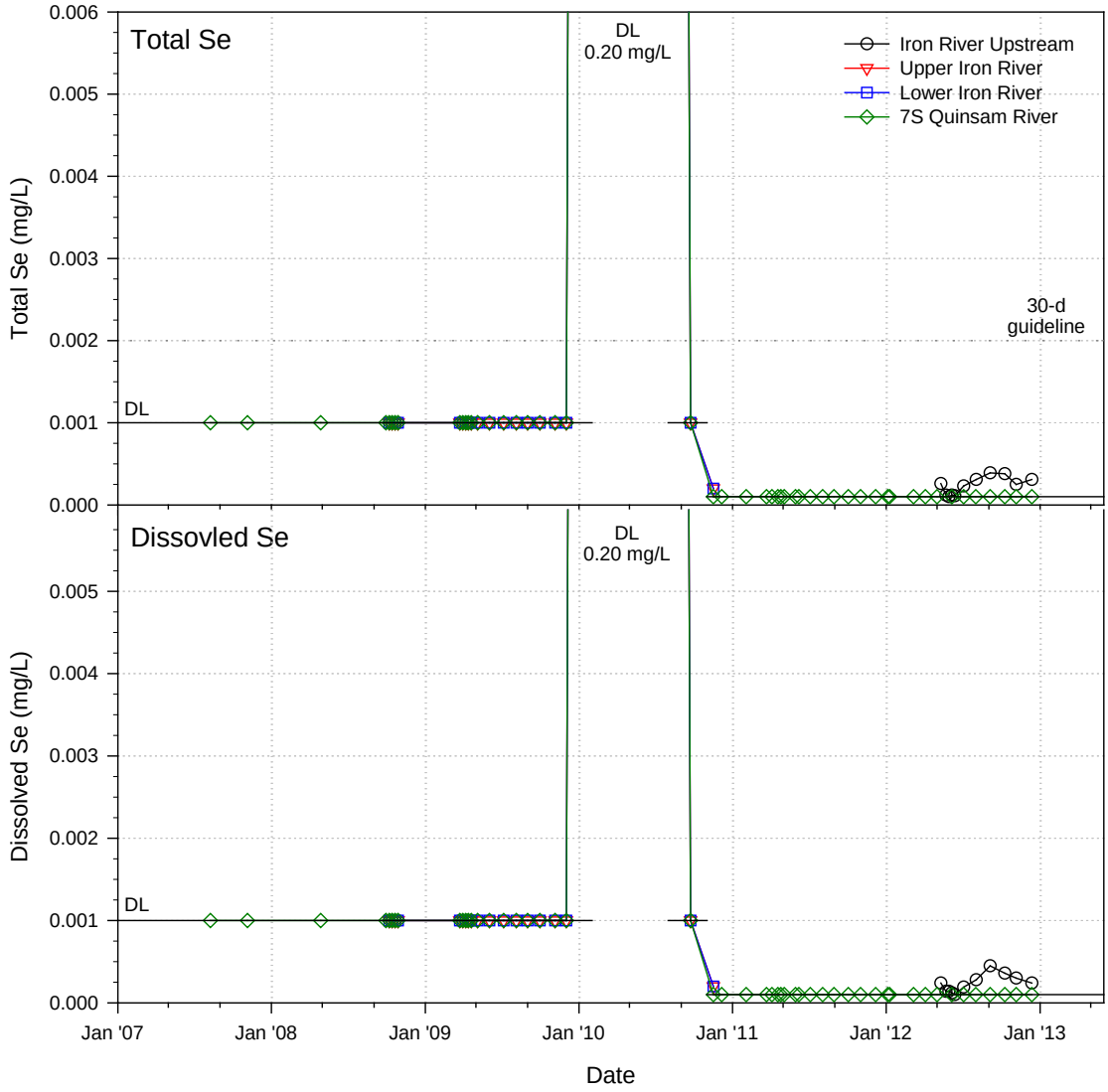


Figure 5-16: Selenium time series at surface water quality stations in Iron River and Quinsam River. Short-dashed grey line indicates 30-day FWAL WQG. Solid line indicates detection limit (DL).

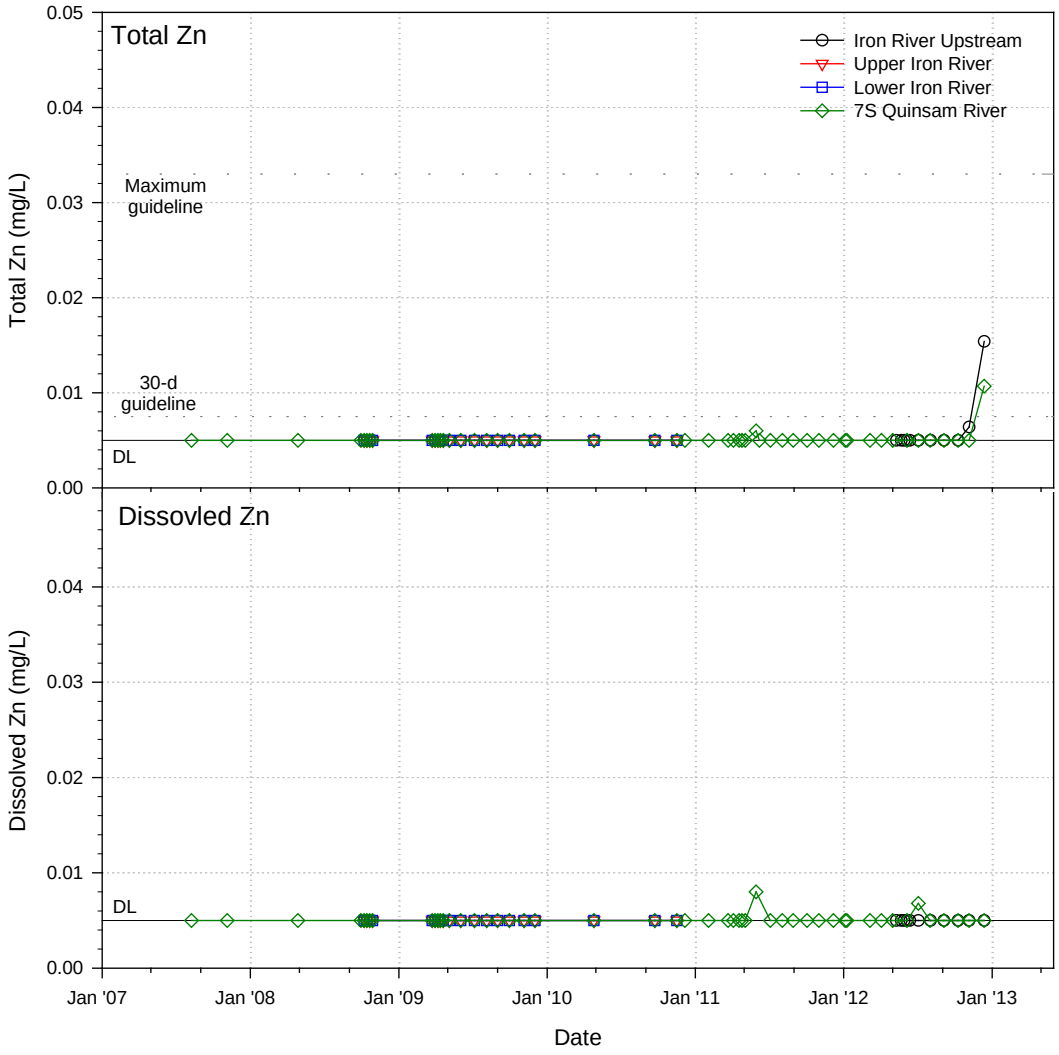


Figure 5-17: Zinc time series at surface water quality stations in Iron River and Quinsam River. Long-dashed grey line indicates maximum FWAL WQG; short-dashed grey line indicates 30-day FWAL WQG based on median water hardness of 7SQR and Iron River dataset (31 mg $CaCO_3$/L). Solid line indicates detection limit (DL).

5.3 Background Water Quality for Effects Model

5.3.1 Background Water Quality Term Generation

Background water quality terms are generated as part of the WQEM in support of the 7SA5 Mine Effects Assessment. These terms were developed using baseline chemistries from operational water quality monitoring for two areas: 1) Iron River (near the Iron River confluence with Quinsam River); and 2) Quinsam River, upstream of the Iron River confluence. This section reviews the methods employed to generate background water quality terms for these areas.

5.3.1.1 Data Selection

Quinsam River

For Quinsam River, water quality data collected at 7SQR from August 2007 to December 2012 were used to generate background water quality terms for this area. Data for stations on Quinsam River upstream of 7SQR were not included in this assessment as these data were not considered representative of conditions in Quinsam River in the vicinity of the Iron River confluence. For the purposes of assessing Quinsam River water quality effects from the 7SA5 Mine, the WQEM calculations apply 7SQR baseline water quality to a point downstream of the Iron River confluence to assess full mixing at this point. Application of 7SQR baseline water quality at this point is a conservative approach since fully mixed Iron River and Quinsam River water is expected to have substantially lower concentrations of parameters of concern than recorded at 7SQR, given low baseline metal concentrations in Iron River. Exceptions could occur for certain parameters (*e.g.*, Al) during high flow conditions as evidenced by elevated concentrations of these parameters in the Iron River.

Iron River

For Iron River, data from stations IRU and UIR were compared to data for LIR to determine whether datasets could be combined to increase the robusticity of water quality background terms. Ultimately, IRU, UIR and LIR have similar catchment areas with relatively short distances separating these monitoring sites. While there are no major sources that substantially alter the water chemistry between sites, subtle differences between catchment sizes may exist. As a result, the comparability of LIR, UIR and IRU water chemistries are reviewed below.

To more closely assess differences in water chemistry between Iron River stations, the mean monthly terms for salinity proxies (conductivity, sulphate) were compared. These parameters were selected as they can represent tracers of the water signature. The results of this analysis are shown in Figure 5-18 and Figure 5-19 for sulphate and conductivity, respectively. Data for UIR and LIR were collected from October 2008 to November 2010, while data for IRU were collected over May to December 2012. In general, monthly salinity values are remarkably similar between UIR and LIR (Figure 5-18, Figure 5-19). Given the proximity of UIR and LIR, these results are not surprising.

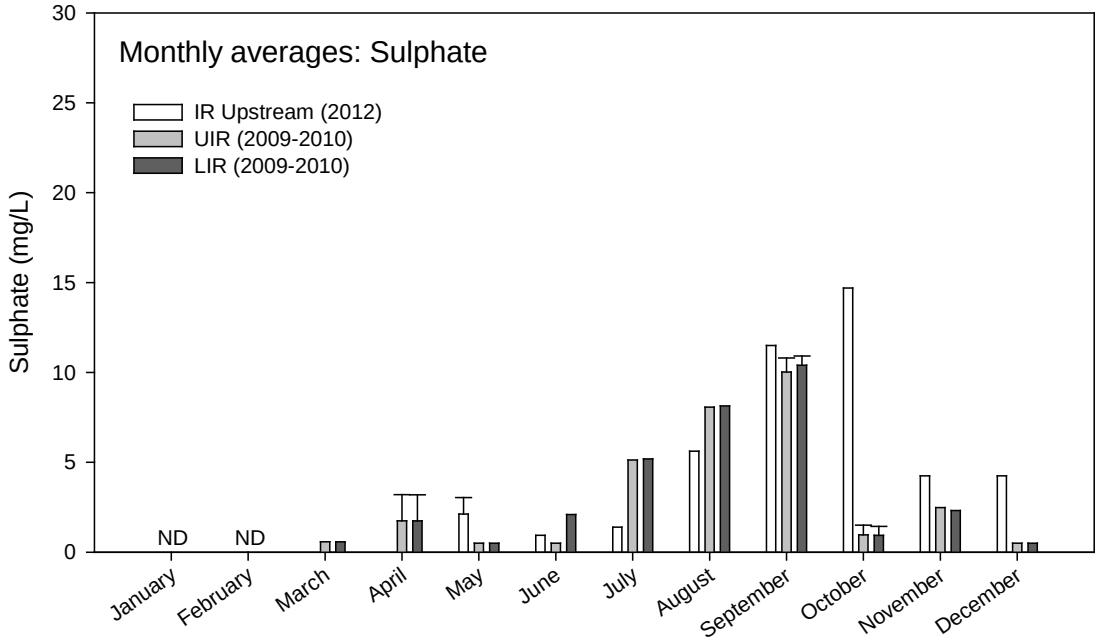


Figure 5-18: Mean monthly sulphate values in Iron River (*n* = 1-4 samples). Standard deviation shown where three or more monthly data points exist in dataset. Months for which no Iron River data exist are indicated (ND). No data for Iron River upstream for March and April.

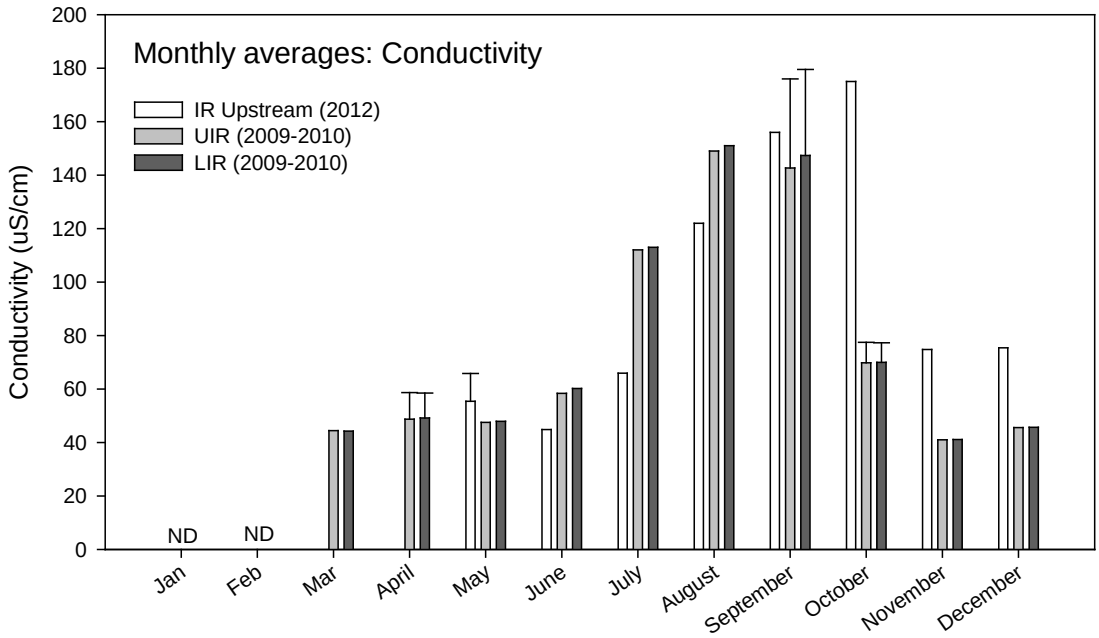


Figure 5-19: Mean monthly conductivity values in Iron River (*n* = 1-4 samples). Standard deviation shown where three or more monthly data points exist in dataset. Months for which no Iron River data exist are indicated (ND). No data for Iron River upstream for March and April.

The mean monthly results for IRU differ from LIR, most notably in the months of July and October. For example, October conductivity and sulphate values at IRU are over 2- and 15-fold greater than LIR October values, respectively. While differences may relate to spatial variation between LIR and IRU, temporal factors should also be considered. Foremost, regional flow stations on the Oyster and Tsolum Rivers indicate that higher than average flows occurred in this region in early summer 2012 (Figure 5-20, Figure 5-21, respectively). These flow data may, in part, explain lower salinity at IRU in June and July 2012 (due to increased dilution from meteoric water) compared to LIR samples from earlier years. In contrast, below average flows were observed at the Oyster and Tsolum flow stations in late summer 2012 (Figure 5-20, Figure 5-21), and fall rains occurred later than in previous years. It follows that above average salinity at IRU from October 2012 onwards may be attributed to the drier than average summer and fall observed in this region. These hydrometric data support the tenet that chemistry differences between LIR and IRU are, in part, attributable to hydrological differences between monitoring periods. However, in the absence of substantiating data for LIR or UIR from 2012, it is unclear if IRU water chemistry is suitably similar to LIR, even under different flow regimes. As a result, IRU was excluded from background water quality term calculations for Iron River.

Overall, given the similarities between monthly salinity values for UIR and LIR, these datasets were combined for the calculation of background water quality terms for the Iron River. The comparability of IRU data could not be confirmed, given substantial differences between the upstream 2012 data and the downstream data collected from 2008 to 2010. Consequently, IRU data were not used in background water quality term development.

Consideration of As loading to Iron River

Based on the above analysis, the datasets for UIR and LIR were combined for the calculation of background monthly water quality terms for Iron River. Although the datasets demonstrate considerable similarity, it is important to note that subtle differences exist between UIR and LIR water chemistries. To identify differences, the measurements of several PoCs collected at UIR and LIR on the same days were compared (Figure 5-22). The red dashed lines in Figure 5-22 represent 1:1 concentration ratios for several PoCs, while solid black lines represent the calculated regression curve for each plot. Plots for Cu and Cd are not shown, given several measurements for these elements were below the DL.

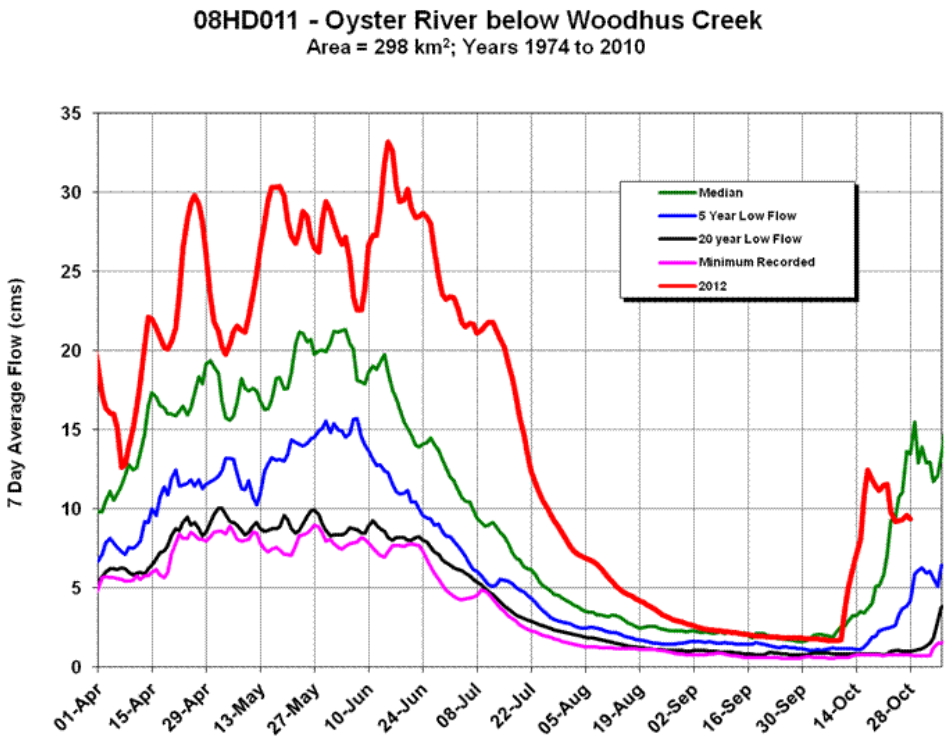


Figure 5-20: 7-day average streamflow for Oyster River below Woodhus Creek compared to historic median and low flows.

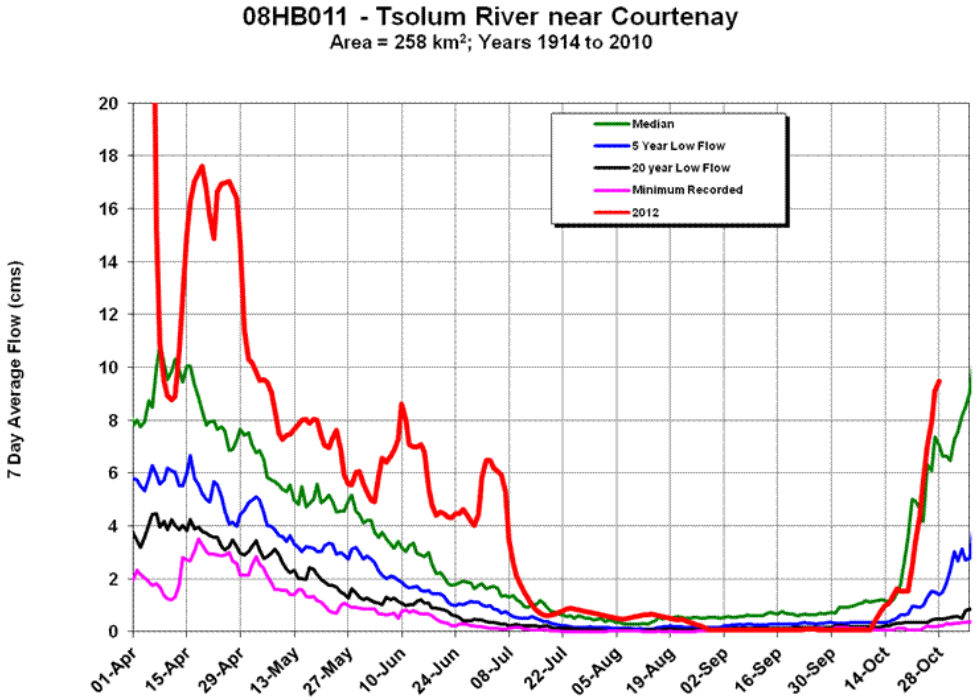


Figure 5-21: 7-day average streamflow for Tsolum River near Courtenay compared to historic median and low flows.

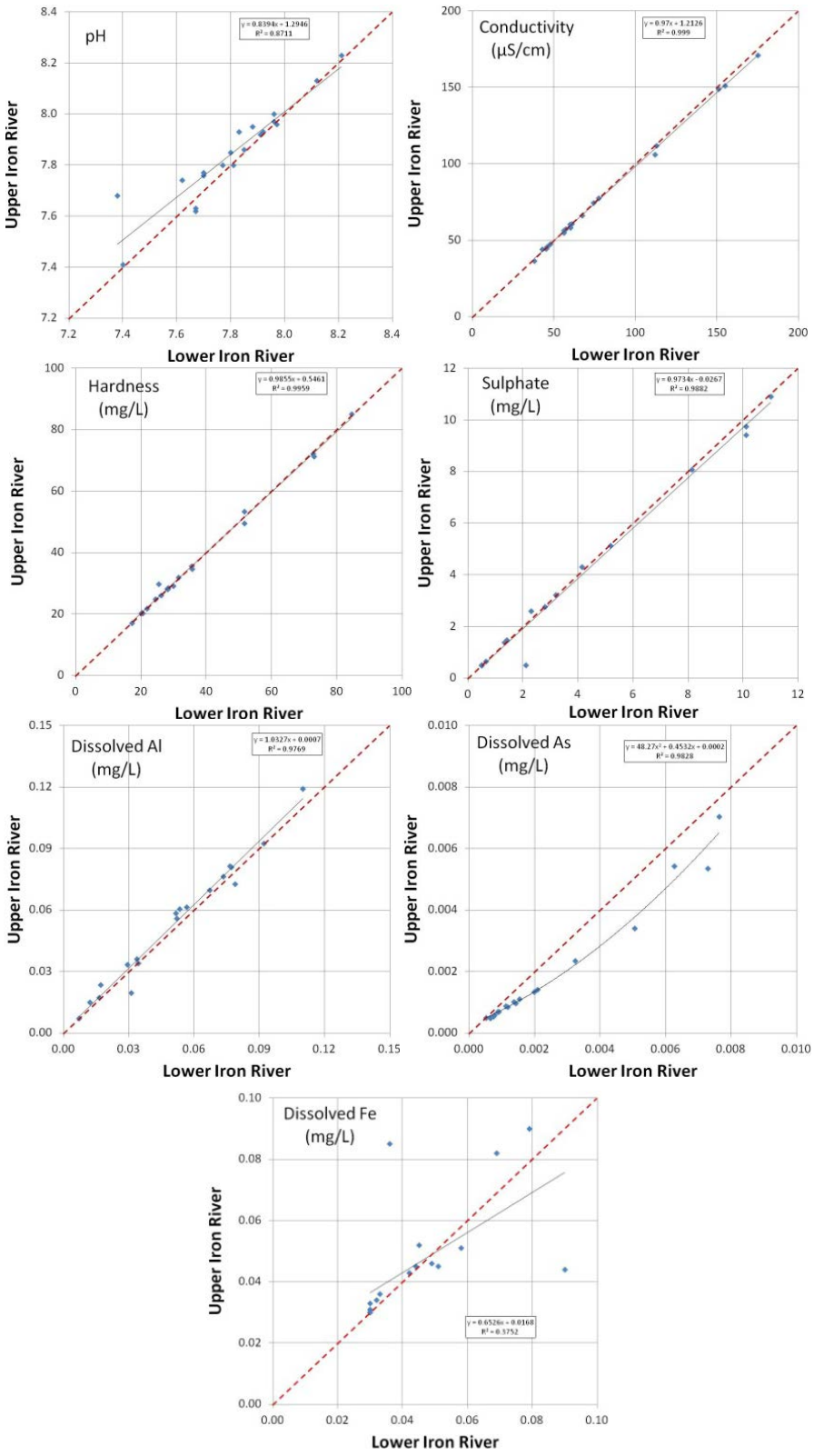


Figure 5-22: Comparison of water quality parameters at Lower Iron River and Upper Iron River for samples collected on the same day (2008 - 2010). Red dashed line represents 1:1 concentration ratio.

Overall, same-day measurements of PoCs shown in Figure 5-22 correlate positively between stations, with most parameters demonstrating close 1:1 ratios between UIR and LIR. This trend is expected, given UIR and LIR are located in similar catchments and lie within close proximity of one another. The trend for As, however, differs from other analytes. Levels of As measured at LIR are consistently higher than measurements obtained at UIR on the same day (Figure 5-22), indicating the presence of an As source in the lower region of Iron River during 2008-2010 monitoring. This observation is consistent with spatial trends shown in the time series distribution for As above (Figure 5-11), which suggest substantial As loading occurs between IRU and UIR, and to lesser extent between UIR and LIR.

The source of As in lower Iron River is attributable to two sources: 1) groundwater discharge to the Iron River; and 2) local tributaries of Iron River that drain localised regions of geologically high As concentrations. High As concentrations in groundwater adjacent to 7SA5 substantiates the tenet that groundwater discharge contributes a significant As load to the Iron River, particularly during low flow conditions. With respect to contributions from surface flows, this influence is limited to larger tributaries that sustain flows throughout the year (including seasonal low-flow periods), given the greatest increases to Iron River As levels were observed during the 2009 summer months.

It is important to highlight As as a PoC in Iron River since higher concentrations in the lower reach *versus* the upper reach of this system suggest the current water quality dataset may underestimate the background As load to the Quinsam River downstream of the Iron River confluence. Because water quality monitoring has not occurred in Quinsam River downstream of the Iron River confluence, the true magnitude and the potential effects of As loading from Iron River are unclear.

5.3.1.2 Background Water Quality Term Calculation

Monthly background water quality terms for Quinsam River and Iron River were calculated using water quality monitoring data for 7SQR, and LIR and UIR, respectively. The monthly background term for each parameter was calculated as the median of all sample measurements for each given month. The mean annual background term for each parameter was calculated as the mean of all monthly terms.

If the parameter concentration in a given sample was below the detection limit, the value for that parameter was set equal to the reported DL to maintain conservatism in estimated background terms. Detection limit values were relatively consistent over the monitoring period, but substantially higher DLs were occasionally employed. Because concentrations below the DL were set equal to the DL value, high DLs can inflate monthly water quality terms if calculated as the statistical mean of all data. By calculating the monthly median

instead, background water quality term values are more representative of typical monitoring conditions and avoid artificially high values (if means are calculated) due to anomalously high DLs.

There are indications of contamination or analytical error in the dissolved fraction of certain samples. To ensure background water quality terms were generated from real values, and not values affected by analytical artifact or contamination, total and dissolved metal fractions within each sample were compared. Only metal concentrations that equaled or exceeded the DL by a factor of five were reviewed in this analysis. Given analytical variability increases as the parameter concentration approaches the DL, this ensured that any exceedances detected were real, and not due to analytical variability. Subsequently, only dissolved metal values that exceeded the total value by 20% or more were considered indicators of contamination in this analysis. In theory, dissolved metal concentrations should be less than or equal to the total metal concentration, but all analytical methods carry some degree of imprecision. Therefore, it is possible for dissolved levels to slightly exceed total levels by the degree of imprecision of the test method. Several analytical laboratories quantify this analytical imprecision and have defined data quality objectives for metal analyses as 20% of the measured concentration for results that are more than 5-fold above the DL. This assumption indicates dissolved metal results (that are >5× DL) in a sample may be reported up to 20% higher than the total metal value due to analytical imprecision. Based on this assumption, dissolved metal values that exceeded the total value by more than 20% were excluded from monthly background term calculations.

5.3.2 Background Water Quality Term Results

Monthly background water quality terms for PoC for Lower Iron River (Table 5-8) and Quinsam River (Table 5-9) are presented below. January and February data were not available for any Iron River stations. As a result, December water quality terms for Iron River were employed for January and February as well. All background water quality terms for all parameters are located in Appendix D.2.

In the tables below, background water quality terms are compared to the BC FWAL water quality guidelines for reference. For Iron River, some monthly background terms for dissolved Al, total As and total Cd exceed their respective guidelines (Table 5-8). For dissolved Al, background water quality terms are elevated during winter and spring flows, suggesting higher values are, in part, driven by the presence of Al colloids that pass through sample filters. Conversely, total As background terms that are elevated during summer low flow are driven by the dissolved fraction, but not colloids. For Cd,

guideline exceedances can be attributed to high DLs employed over the monitoring period that exceeded the hardness-dependent guideline for Cd.

For Quinsam River water quality terms, dissolved Al only exceeds the 30-day guideline in January (Table 5-9). Half of the monthly background terms for Cd exceed the provincial water quality guideline. Similar to background water quality terms for Iron River, these exceedances can be attributed to high DLs employed over the monitoring period. Background values for all other parameters remain below the provincial water quality guidelines.

Table 5-8:
Lower Iron River background water quality for parameters of concern (October 2008 – November 2011)[1].

Parameter	Units	Mean annual	Jan[2]	Feb[2]	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	BC FWAL WQG[3]	
															30-day	Maximum
Alkalinity	mg/L	31.2	18.6	18.6	17.3	20.3	21.0	27.8	47.5	70.6	61.6	29.5	23.0	18.6	NP	NP
Conductivity	uS/cm	73.6	45.6	45.6	44.4	50.6	47.7	59.3	112	150	153	70.8	58.0	45.6	NP	NP
pH-L	pH Units	7.86	7.88	7.88	7.74	7.80	7.78	7.92	7.96	8.22	7.96	7.78	7.52	7.88	6.5-8.5	NP
TDS Lab	mg/L	49.5	37	37	32.5	39.0	44.0	40.0	68.5	88.0	84.5	48.5	38.5	37.0	NP	NP
TSS	mg/L	3.29	3	3	3.00	3.00	6.00	3.00	3.00	3.00	3.00	3.00	3.50	3.00	NP	NP
Sulphate	mg/L	2.76	0.5	0.5	0.575	1.63	0.500	1.30	5.16	8.10	10.1	0.915	3.38	0.500	218	NP
Hardness	mg $CaCO_3$/L	35.1	21.8	21.8	20.4	23.1	24.6	29.6	52.6	72.1	72.4	33.3	28.2	21.8	NP	NP
Al-D	mg/L	**0.0575**	**0.0749**	**0.0749**	**0.0575**	**0.0866**	**0.114**	0.0342	0.0253	0.0168	0.0135	0.0442	**0.0734**	**0.0749**	0.0500	0.1000
Al-T	mg/L	0.0932	0.099	0.099	0.0703	0.123	0.308	0.0558	0.0290	0.0246	0.0170	0.0461	0.148	0.0990	NP	NP
As-D	mg/L	0.00191	0.000675	0.000675	0.00100	0.000645	0.000505	0.00120	0.00329[4]	0.00585	0.00619	0.00140	0.000785	0.000675	NP	NP
As-T	mg/L	0.00196	0.000725	0.000725	0.00100	0.000690	0.000680	0.00124	0.00329	0.00586	0.00622	0.00141	0.000990	0.000725	NP	0.005
Cd-D	mg/L	0.000020	0.000017	0.000017	0.000018	0.000021	0.000021	0.000019	0.000037	0.000017	0.000017	0.000018	0.000017	0.000017	NP	NP
Cd-T	mg/L	0.000022	0.000017	0.000017	0.000017	0.000017	0.000040	0.000051	0.000019	0.000017	0.000017	0.000021	0.000014	0.000010	NP	0.000013
Co-D	mg/L	0.00031	0.00030	0.00030	0.00030	0.00030	0.00030	0.00030	0.00030	0.00030	0.00030	0.00030	0.00040	0.00030	NP	NP
Co-T	mg/L	0.00031	0.00030	0.00030	0.00030	0.00030	0.00030	0.00030	0.00030	0.00030	0.00030	0.00030	0.00040	0.00030	0.004	0.11
Cu-D	mg/L	0.0012	0.0014	0.0014	0.00110	0.00160	0.00110	0.00100	0.00145	0.00100	0.00100	0.0010	0.00145	0.00140	NP	NP
Cu-T	mg/L	0.0012	0.001	0.001	0.00100	0.00100	0.00195	0.00120	0.00145	0.00100	0.00100	0.0010	0.00120	0.00100	0.0020	0.0053
Fe-D	mg/L	0.0418	0.0425	0.0425	0.0360	0.0450	0.0845	0.0300	0.0300	0.0300	0.0300	0.0300	0.0500	0.0425	NP	0.35
Fe-T	mg/L	0.0852	0.0795	0.0795	0.0475	0.0915	0.334	0.0300	0.0300	0.0300	0.0300	0.0445	0.146	0.0795	NP	1
Pb-D	mg/L	0.00049	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00035	0.00050	NP	NP
Pb-T	mg/L	0.00049	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00035	0.00050	0.00415	0.02157
Mn-D	mg/L	0.00116	0.00093	0.00093	0.000665	0.00102	0.00190	0.000755	0.00268	0.000890	0.000850	0.00111	0.00128	0.000930	NP	NP
Mn-T	mg/L	0.00305	0.00168	0.00168	0.00138	0.00308	0.0132	0.00172	0.00254	0.00144	0.00122	0.00153	0.00542	0.00168	0.7596	0.9273
Ni-D	mg/L	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	NP	NP
Ni-T	mg/L	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	NP	0.025
Se-D	mg/L	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.00060	0.0010	NP	NP
Se-T	mg/L	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.00060	0.0010	0.002	NP
Zn-D	mg/L	0.005	0.005	0.005	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	NP	NP
Zn-T	mg/L	0.005	0.005	0.005	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0075	0.0330

[1] Monthly water quality terms calculated as median of water quality monitoring data from LIR and UIR for each month. Shaded values exceed the maximum BC water quality guideline (WQG) for the protection of fresh water aquatic life (FWAL). Bold typeface values exceed the 30-d BC FWAL WQG;
[2]No monthly data available. December water quality term used;
[3]Hardness dependent guidelines based on mean annual hardness term for Iron River Lower dataset (35.1 mg $CaCO_3$/L); a pH of 7.8 and temperature of 10°C was assumed where applicable;
[4]Dissolved As samples for July term are likely contaminated. As a result, the total As monthly water quality term for July was used as a conservative estimate of the dissolved As value for this month, given the total As fraction is largely accounted for by dissolved As (see Figure 5-11).

Table 5-9:
7S Quinsam River background water quality for parameters of concern (August 2007 – December 2012)[1].

Parameter	Units	Mean annual	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	BC FWAL WQG[2]	
															30-day	Maximum
Alkalinity	mg/L	26.2	12.8	29.0	25.7	30.5	28.0	23.4	28.0	28.0	29.6	27.6	26.7	24.8	NP	NP
Conductivity	uS/cm	99.4	47.0	104	128	139	118	70.1	90.0	89.8	107	116	90.2	94.0	NP	NP
pH-L	pH Units	7.55	7.18	7.39	7.62	7.60	7.51	7.58	7.64	7.64	7.76	7.59	7.61	7.43	6.5-8.5	NP
TDS Lab	mg/L	63.8	28.0	56.0	84.0	72.0	70.0	80.0	62.0	61.0	61.0	75.0	62.0	54.0	NP	NP
TSS	mg/L	3.75	4.00	4.00	3.50	4.00	3.50	4.00	4.00	4.00	3.00	3.00	4.00	4.00	NP	NP
Sulphate	mg/L	19.7	5.65	22.0	31.1	30.8	25.9	9.07	18.0	15.0	18.2	23.8	16.0	20.8	218	NP
Hardness	mg $CaCO_3$/L	30.5	13.1	30.5	36.5	37.4	32.0	22.7	36.2	27.5	34.9	35.5	32.6	27.1	NP	NP
Al-D	mg/L	0.0224	**0.0767**	0.0290	0.0284	0.0178	0.0172	0.0141	0.0164	0.0119	0.00830	0.00645	0.0182	0.0244	0.0500	0.1000
Al-T	mg/L	0.0462	0.135	0.0600	0.0410	0.0370	0.0415	0.0345	0.0390	0.0290	0.0148	0.0132	0.0600	0.0490	NP	NP
As-D	mg/L	0.000288	0.00014	0.000200	0.000330	0.000400	0.000200	0.000230	0.00020	0.000260	0.000500	0.000500	0.000230	0.000265	NP	NP
As-T	mg/L	0.000302	0.000150	0.000200	0.000350	0.000400	0.000210	0.000200	0.00030	0.000300	0.000500	0.000500	0.000290	0.000225	NP	0.005
Cd-D	mg/L	0.000016	0.000010	0.000040	0.000014	0.000016	0.000019	0.000010	0.000010	0.000017	0.000017	0.000017	0.000017	0.000010	NP	NP
Cd-T	mg/L	0.000013	0.000010	0.000010	0.000014	0.000014	0.000014	0.000017	0.000010	0.000010	0.000017	0.000017	0.000010	0.000010	NP	0.000012
Co-D	mg/L	0.00045	0.00050	0.00050	0.00040	0.00040	0.00050	0.00050	0.00050	0.00050	0.00030	0.00030	0.00050	0.00050	NP	NP
Co-T	mg/L	0.00045	0.00050	0.00050	0.00040	0.00040	0.00050	0.00050	0.00050	0.00050	0.00030	0.00030	0.00050	0.00050	0.004	0.11
Cu-D	mg/L	0.000953	0.00107	0.000900	0.000950	0.00100	0.000950	0.000900	0.00090	0.00100	0.00100	0.00100	0.00100	0.000770	NP	NP
Cu-T	mg/L	0.000950	0.000650	0.000800	0.000850	0.000850	0.00145	0.000800	0.0010	0.00100	0.00100	0.00100	0.00100	0.00100	0.0020	0.0049
Fe-D	mg/L	0.0526	0.0304	0.0350	0.0554	0.0450	0.0590	0.0480	0.0680	0.0630	0.0540	0.0620	0.0610	0.0502	NP	0.35
Fe-T	mg/L	0.106	0.112	0.0790	0.0925	0.102	0.134	0.102	0.114	0.102	0.0840	0.102	0.128	0.118	NP	1
Pb-D	mg/L	0.000275	0.00020	0.00020	0.00035	0.00035	0.00020	0.00020	0.00020	0.00020	0.00050	0.00050	0.00020	0.00020	NP	NP
Pb-T	mg/L	0.000275	0.00020	0.00020	0.00035	0.00035	0.00020	0.00020	0.00020	0.00020	0.00050	0.00050	0.00020	0.00020	0.00401	0.01801
Mn-D	mg/L	0.00436	0.00225	0.00300	0.00370	0.00428	0.00500	0.00500	0.00700	0.00420	0.00461	0.00532	0.00500	0.00295	NP	NP
Mn-T	mg/L	0.00660	0.00450	0.00400	0.00426	0.00708	0.00700	0.00700	0.00940	0.00800	0.00617	0.00776	0.00700	0.00705	0.7392	0.8761
Ni-D	mg/L	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	NP	NP
Ni-T	mg/L	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	NP	0.025
Se-D	mg/L	0.000325	0.00010	0.00010	0.00055	0.00055	0.00010	0.00010	0.00010	0.00010	0.0010	0.0010	0.0010	0.0010	NP	NP
Se-T	mg/L	0.000325	0.00010	0.00010	0.00055	0.00055	0.00010	0.00010	0.00010	0.00010	0.0010	0.0010	0.0010	0.0010	0.002	NP
Zn-D	mg/L	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	NP	NP
Zn-T	mg/L	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0075	0.0330

[1]Monthly water quality terms calculated as median of water quality monitoring data from 7SQR for each month. Shaded values exceed the maximum BC water quality guideline (WQG) for the protection of fresh water aquatic life (FWAL). Bold typeface values exceed the 30-d BC FWAL WQG;
[2]Hardness dependent guidelines based on mean annual hardness term for 7S Quinsam River dataset (30.5 mg $CaCO_3$/L); a pH of 7.6 and temperature of 10°C was assumed where applicable.

6. Metal Leaching / Acid Rock Drainage Characterization

QUINSAM COAL

6. Metal Leaching / Acid Rock Drainage Characterization

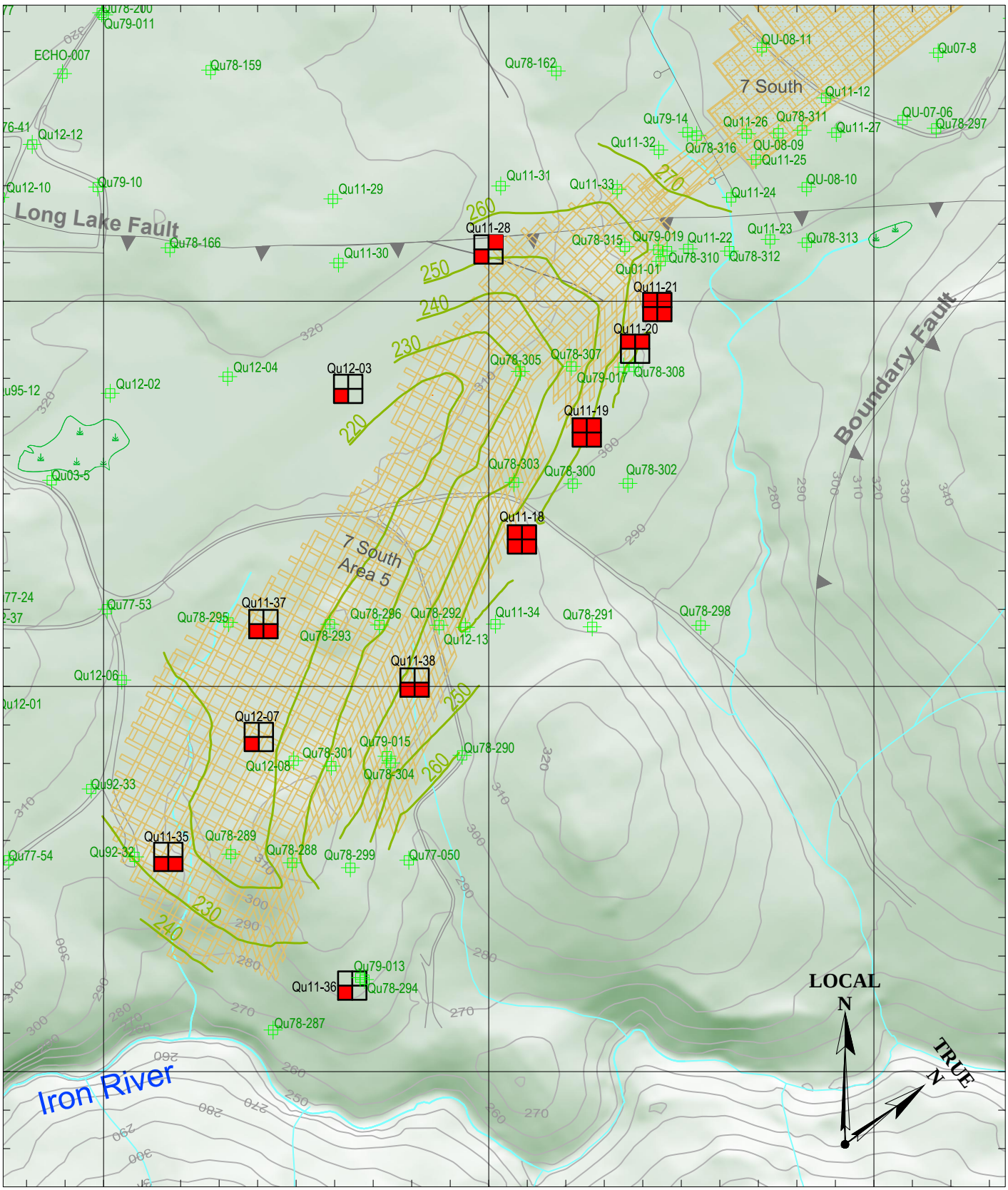
6.1 Overview

The 7SA5 mine is the southern extension of the 7 South mine and will extract coal from the same No. 4 Coal zone. The No. 4 Coal zone is comprised of the main 4 Seam and an underlying 4L Seam separated by the 4-4L parting. No. 4 Coal zone in 7SA5 is folded into a syncline and lies to the south of the Long Lake fault. The room and pillar underground mining method will extract coal from cross cutting roadways but will leave pillars in place to support the roof to prevent subsidence of the overlying strata. This mining method will restrict mine-related disturbance to the coal seam and the strata immediately adjacent to the coal seam. Similarly, mine-induced ML/ARD processes will be restricted to strata and coal exposed in the pillars and coarse coal reject (CCR) that is placed in the mine void.

This chapter outlines the baseline geochemical characteristics of the No. 4 Coal zone, the overlying strata, and the coarse coal reject (CCR) that will be produced from the washed coal. Following an overview of the baseline sample selection, result summary and methodology in Section 6.1, the acid-base accounting results are presented in Section 6.2. Section 6.3 presents the static test metal concentrations and Section 6.4 provides a comparison of the 7SA5 static test results with equivalent strata in the 7 South mine area. Time required to deplete neutralization potential from 7SA5 coal and CCR is listed in Section 6.5. Predictions of mine water chemistry are presented in Section 6.6.

6.1.1 Sample Selection

Samples for each of the hanging wall, near seam, 4 seam coal, 4L seam coal and coarse coal reject (CCR) were selected from 2011 and 2012 drill holes within the 7SA5 site of Hillsborough's Quinsam operation. Figure 6-1 presents a map 7SA5 with sampled drill hole locations, a list of sampled drill holes is presented in Table 6-1. Borehole logs with associated sample intervals and static test results are presented in Appendix E1.



LEGEND

- Proposed Mine Workings
- Elevation(10m)
- Road
- Rivers/Creeks
- 4 Seam
- Thrust Faults
- Boreholes
- Swamp/Marsh

ARD Sample
FILLED SQUARES INDICATE SAMPLING
Hanging Wall / Near Seam / Coal / CCR

DATE SAVED:	Aug 17, 2012
DRAWN BY:	VV
REVIEWED:	BM, JM
VERSION:	1

Coordinate System: Quinsam Mine Local Grid
Projection: Orthographic
Units: Metres

1:7,000

0 50 100m

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT:
7 South Area 5
ML/ARD Assessment

TITLE:
Drill Hole Locations with Sample Types

PROJECT #: J885-7

FIGURE: 6-1

P:\J885 Hillsborough Resources\Drafting\AutoCAD map\242 Mine\Quinsam_7S_Area5_ML_ARD assessment.dwg

Table 6-1:
List of drill holes sampled for rock, coal and CCR material

Drill Hole	Easting	Northing	Elevation (m)
QU11-18	324609	5533287	299
QU11-19	324549	5533437	295
QU11-20	324511	5533523	295
QU11-21	324473	5533608	294
QU11-28	324281	5533478	307
QU11-35	324664	5532672	300
QU11-36	324941	5532764	286
QU11-37	324497	5532952	308
QU11-38	324675	5533063	300
QU12-03	324318	5533223	315
QU12-07	324610	5532859	311

Sampling was focussed on the No. 4 Coal zone, hanging wall sandstone above the coal measures, near seam material and CCR. Near seam material is defined herein as material that is adjacent to the 4 and 4L coal seams. Generally, sample intervals that have been analyzed include up to 2 m of material. Therefore, the near seam samples are within 2 m of a mineable seam, this includes roof rock samples, parting samples, and footwall rock samples. Splits of raw coal, hanging wall and near seam material were sampled from drill core by Quinsam staff and sent to SGS Canada Inc. (SGS), Burnaby, British Columbia for static testing. The number of each of coal, hanging wall, near seam and CCR samples selected is presented in Table 6-2.

Table 6-2:
Units sampled for static testing

Description	Count
Hanging Wall	20
Near Seam	6
Coal	
4 Seam	15
4L Seam	7
Coarse Coal Reject	
Coarse Coal Reject	7
Total	56

CCR samples were prepared by GWIL – Birtley Coal (GWIL), Calgary, Alberta. A selection of coal intervals were selected by Quinsam staff and sent to GWIL for washability testing. Sample handling and washability testing by GWIL is completed using the following procedure:

- Each individual coal sample is air dried then crushed such that the material will pass through a 1/2" seive.
- An 1/8th split is taken to complete the head raw analysis, the remaining sample is retained to do further washability testing either as a single sample or as a portion of a composite.
- The washability procedure is initiated by either using a single coal sample or a composite sample that is screened at 28M & 60M. In the case of the samples discussed below, composite samples were used.
- The 1/2"x28M and 28Mx60M size fractions are float sank at the following specific gravities: 1.45, 1.50, 1.55, 1.60, 1.65, 1.70, 1.75. Each specific gravity fraction is then prepped and tested.

The 7 South Area 5 CCR samples are composites of coal from the 4 Seam, 4-4L parting, and the 4L Seam that have been processed as described above. A description of the composition of each of the CCR composite samples is presented in Table 6-3. Instructions on CCR composite composition were given by Quinsam staff to GWIL. Each CCR sample is comprised of the +60M material at a specific gravity cut-off point of 1.70 for all composite samples, with the exception of QU11-21 and QU11-35. Both QU11-21 and QU11-35 have a specific gravity cut-off of 1.60. CCR composite samples were shipped to SGS for ABA and metals analysis.

Table 6-3:
List of CCR samples

Drill Hole	Sample ID	Quinsam ID	Unit	Raw Weight (kg)	% Raw Comp.
QU11-18	115142				
		111801	4 Seam Coal	8.595	68%
		111802	4-4L Siltstone Parting	0.712	6%
		111803	4L Seam Coal	3.426	27%
			Total	12.733	100%
QU11-19	115361				
		111901	4 Seam Coal	10.222	72%
		111902	4-4L Siltstone Parting	0.43	3%
		111903	4L Seam Coal	3.616	25%
			Total	14.268	100%
QU11-21	115365				
		112101	4 Seam Coal	9.242	59%
		112102	4-4L Siltstone Parting	0.597	4%
		112103	4L Seam Coal	5.789	37%
			Total	15.628	100%
QU11-35	120466				
		113501	4 Seam Coal	3.578	38%
		113502	4 Seam Sandstone	1.03	11%
		113503	4 Seam Coal	4.775	51%
			Total	9.383	100%
QU11-37	120468				
		113701	4 coal	4.586	28%
		113702	4 sandstone	1.76	11%
		113703	4 coal / minor sandstones	10.236	62%
			Total	16.582	100%
QU11-38	120674				
		113801	4 coal	4.016	39%
		113802	4 Coal	0.189	2%
		113803	4-4L Ptg, sandstone	0.709	7%
		113804	4L Coal	5.275	52%
			Total	10.189	100%

6.1.2 ML /ARD Result Summary

The objective of this investigation was to provide a geochemical characterization of hanging wall, near seam, 4 seam coal, 4L seam coal and CCR material from within the 7SA5 within the Quinsam Coal property. This section presents a summary of the geochemical characteristics for samples collected for the 7SA5 mine area.

The results of this investigation are as follows:

- Hanging wall rock >2m above coal seam:
    - Total S and non-sulphate S vary by over an order of magnitude, 0.11 to 3.44 % and 0.11 to 3.40 % respectively;
    - Typically, total S and non-sulphate S decrease with increasing distance from the coal zone;
    - CaNP > siderite corrected NP, therefore Fe carbonates are prominent in hanging wall material;
    - NP is generally moderate to high, with a moderate median NP of 86.4 kg $CaCO_3$/t; and
    - NPR is typically > 2.0, with a median NPR of 7.0;
    - The high median NPR inidicates that the hanging wall material is typically non-PAG, with all samples >5 m above the coal zone are non-PAG
- Near seam waste rock:
    - Large range of total S and non-sulphate S concentration;
    - Sulphur species concentrations do not exhibit spatial trend;
    - CaNP > siderite corrected NP, therefore Fe carbonates are associated with near seam waste rock material;
    - Siderite corrected NP ranges from low to high, with a low median NP of 26.0 kg $CaCO_3$/t;
    - NPR is typically <2.0, with a median NPR of 0.9;
    - Near seam waste rock is PAG.
- 4 Seam Coal
    - Total S and sulphide S exhibit a range of concentrations that vary by an order of magnitude up to 2.8% S;
    - Sulphide S concentrations increase from the northern portion of 7SA5 to the south;

  - In general, CaNP is similar to siderite corrected NP indicating that non-Fe carbonates dominate the carbonate mineral assemblage;
  - Siderite corrected NP ranges from low to high, with a low median NP of 37.4 kg $CaCO_3$/t;
  - NPR is typically < 2.0, with a median NPR of 1.1;
  - 4 Seam coal is predominantly PAG.

- 4L Seam Coal
  - Total S and sulphide S concentrations are, generally, <1.0%. Two samples exhibit high (>1%) total and sulphide S concentrations;
  - Sulphide S concentrations increase from west to east across 7SA5;
  - CaNP is, typically, equivallent to siderite corrected NP indicating that non-Fe carbonates dominate the carbonate mineral assemblage.
  - Siderite corrected NP ranges from low to moderate, with a low median NP of 37.5 kg $CaCO_3$/t;
  - NPR is typically > 2.0, with a median NPR of 6.7;
  - 4L Seam coal is considered non-PAG.

- Coarse Coal Reject
  - The range of total S and sulphide S concentrations demonstrate a limited range relative to other material within 7SA5;
  - The median sulphide S concentration is 1.27%
  - CaNP is, generally, equivallent to siderite corrected NP;
  - Siderite corrected NP ranges from moderate to high, with a moderate median NP of 84.1 kg $CaCO_3$/t;
  - NPR is generally < 2.0, with a median NPR of 1.9;
  - Both PAG and non-PAG CCR is expected from 7SA5 and operational monitoring will be required to effectively implement the CCR management plan;
  - Up to 5% of the PAG CCR is expected to become acidic within 2 Years.

6.1.3 Static Test Methods and Rationale

Static tests are utilized as predictors for metal leaching / acid rock drainage (ML/ARD). These tests include acid-base accounting (ABA) and solid phase metals analysis. ABA involves a suite of tests including paste pH, inorganic carbon content, sulphur speciation, neutralization potential, and acid potential. The following section provides an overview of static testing.

6.1.3.1 Paste pH

On its own paste pH is not a predictor of the acid generation potential; however, the paste pH can be used as a primary indicator of the presence of existing buffering capacity. The paste pH is governed by the carbonate mineral solubility and, hence, the presence of NP. A paste is made using crushed rock material and distilled water. Distilled water typically has a pH of approximately 5. Therefore, when the paste pH values are <5, the NP present is limited or non-existent. Conversely, higher paste pH values (pH > 5) imply the presence of available NP.

6.1.3.2 Sulphur Speciation

Sulphur speciation is essential when determining the ARD potential as some sulphur species do not contribute to ARD. Sulphur may be present in mine rock as sulphide or pyritic S, sulphate S, and insoluble S. The insoluble S content is a calculated value and may represent either organic S species or incomplete digestion of sulphide S during analysis.

The potential for acid to be generated from mine rock is estimated from the acid potential (AP). Typically, ARD is the result of oxidation of sulphide bearing minerals, such as pyrite. Accordingly, the AP for mine waste material is typically calculated from the measured sulphide S content. However, when an appreciable concentration of insoluble S is present a conservative estimate of non-sulphate S is used in calculating the AP. This conservative approach assumes that the insoluble S estimate may represent an incomplete dissolution of sulphide minerals during the analytical process. Thus, non-sulphate S is a calculated value that subtracts the sulphate S content from the total S content. Non-sulphate S is used to calculate the acid potential of the 7SA5 rock strata. However, the measured sulphide S is used to calculate the acid potential of the 7SA5 coal and coarse reject samples due to the influence of organic S in the No.4 coal.

The sulphide oxidation reaction for pyrite is typically represented as (Equation 1):

$$Pyrite: \quad FeS_2 + {}^{15}\!/_{4}\, O_2 + {}^{7}\!/_{2}\, H_2O \Rightarrow Fe(OH)_3 + 2SO_4^{2-} + 4H^+$$

Thus, for each mole of sulphide-sulphur oxidized, 2 moles of acidity are produced. In the most simplistic scenario, when carbonate minerals are present the oxidation-neutralization reaction is pH-dependent. Assuming that calcium and sulphate are not lost to secondary mineral precipitation, two carbonate consumption reactions can describe this process. These reactions are represented below as Example 1 and Example 2:

(Example 1): at pH<6.3:

Pyrite (Equation 2)

$$FeS_2 + {}^{15}\!/_{4}\, O_2 + {}^{7}\!/_{2}\, H_2O + 2\left[Ca^{2+}, Mg^{2+}\right]CO_3 \longrightarrow Fe(OH)_3 + 2SO_4^{2-} + 2H_2CO_3^0 + 2\left[Ca^{2+}, Mg^{2+}\right]$$

(Example 2): at 6.3<pH<10.3:

Pyrite (Equation 3)

$$FeS_2 + {}^{15}\!/_{4}\, O_2 + {}^{7}\!/_{2}\, H_2O + 4\left[Ca^{2+}, Mg^{2+}\right]CO_3 \longrightarrow Fe(OH)_3 + 2SO_4^{2-} + 4HCO_3^- + 4\left[Ca^{2+}, Mg^{2+}\right]$$

6.1.3.3 Neutralization Potential

ML/ARD results when sulphidic mine rock is subjected to weathering processes only if there is insufficient production of neutralizing alkalinity. The neutralization potential of weathering waste material depends on the buffering capacity of the minerals that dissolve when exposed to acidic conditions. Those minerals that act to buffer acid generating reactions are typically carbonate minerals (calcite, dolomite, *etc.*). The dissolution rate of some carbonate minerals, particularly Fe-bearing carbonate, are lower than the dissolution rates of calcite and are, therefore, less effective at buffering acid generating reactions. In addition, Fe-bearing carbonates liberate Fe^{2+} during dissolution reactions, the Fe^{2+} is oxidized to Fe^{3+}, which precipitates as $Fe(OH)_3$ liberating an H^+ ion. The net capacity of a sample to neutralize acid decreases as the amount of Fe-bearing carbonate increases (Jambor *et al.*, 2002).

The 7 South Area 5 samples were analyzed for siderite corrected NP and carbonate NP (CaNP). The siderite corrected NP measurement is a non-mineral specific, relatively aggressive means of determining NP, which removes the artifacts from the incomplete hydrolysis of Fe during the measurement. Samples are treated with hydrogen peroxide to oxidize ferrous iron produced via the dissolution of Fe-bearing carbonates during the Sobek NP analysis. NP from both carbonate minerals, such as calcite and dolomite, as well as the NP of silicate and aluminosilicate minerals, which have slower dissolution rates than carbonate minerals, are measured. Therefore, in some cases a sample may exhibit an appreciable amount of NP, but if the NP is primarily available as the slower dissolving silicates and or aluminosilicates then not all of the NP measured by this method may be available with high sulphide content and reactivity.

The CaNP is calculated from the amount of inorganic carbon in the sample:

CaNP (kg $CaCO_3$/t) = Inorganic C (%) x (100.09 g/mol $CaCO_3$ / 12.01 g/mol C) x 10

Inorganic carbon is measured via coulometry. This measurement assumes that all the carbon in a sample that is evolved as CO_2 during analysis was originally present as calcium carbonate ($CaCO_3$).

6.1.3.4 Net Potential Ratio

The net potential ratio (NPR) is a measure of whether a sample will be potentially acid generating. The NPR compares the proportion of NP to acid potential (AP), and can be used over a wide range of AP and NP values. The NP used in developing the NPR for 7SA5 coal and CCR samples is the siderite corrected NP, while the AP is conservatively estimated using the sulphide S concentrations for materials such as 4 Seam coal, 4L Seam coal, and CCR. For the near seam and hanging wall materials the non-sulphate S is used to estimate AP.

The NPR is compared to criteria specified in the BC MEM regulatory guidelines (Price, 1997 and Price, 2009). The BC MEM regulatory guidelines have been utilized as acceptable criteria and are generally considered a basis for development of ML/ARD predictions. These guidelines,

Table 6-4, indicate that a sample with NPR of less than 1.0 can be, theoretically considered as potentially acid generating (PAG). For a sample with a NPR between 1.0 and 2.0 there is a possibility of becoming acid generating, given that the NP is depleted at faster rates than the rate of sulphide oxidation or that if the buffering minerals are partially unavailable. NPR values between 2.0 and 4.0 indicate a low risk of acid drainage, while NPR values greater than 4.0 have no potential of ARD. For the purposes of this investigation of 7SA5 mine rock samples with an NPR $\leq$ 2.0 are classified as PAG, while NPR > 2.0 are non-PAG.

Table 6-4:
Acid-Base Accounting (ABA) Screening Criteria (Price, 1997 and Price, 2009)

ARD Potential	Initial Screening Criteria (NPR)	Comments
Likely	< 1	Likely to be ARD generating unless sulphide minerals are unreactive.
Possibly	1 – 2	Possibly ARD generating if NP is insufficiently reactive or is depleted at a faster rate than sulphides.
Low	2 - 4	Not potentially ARD generating unless significant preferential exposure of sulphides along fracture planes, or extremely reactive sulphides in combination with insufficiently reactive NP.
None	> 4	No further ARD testing required unless materials are to be used as a source of alkalinity.

Solid Phase Metals

Solid phase metals concentrations are evaluated in order to identify metals that could potentially leach from mine waste materials should ARD occur. Metal concentrations are compared with average continental crustal abundance to yield metals that may be elevated in mine drainage. While a metal may be enriched in the solid phase relative to the crustal abundance, this does not necessarily indicate that the metal will become problematic in drainage waters. The leaching rate of metals is dependent on a series of factors in addition to solid phase concentrations. These factors include: the mineralogical associations, the geochemical stability of those minerals, and the geochemistry of the infiltrating waters. Consequently, whether a metal becomes problematic in drainage waters is dependent on the interrelationship of the variables discussed above. Solid phase metal concentrations are determined via ICP-MS metal scans on leachate derived from aqua-regia digestion of coal, hanging wall, near seam and CCR samples.

For this investigation solid phase metals results are compared with the average continental crustal abundance as presented in Price (1997). A metal is considered elevated or enriched if the metal concentration is greater than three times the average continental crustal abundance.

6.2 Acid-Base Accounting Results

The following section presents the ABA results for each of the major rock types examined in this study:

- Hanging wall waste rock (20 samples);
- Near seam waste rock (7 samples);
- 4 seam coal (15 samples);
- 4L seam coal (7 samples);
- CCR composites (7 samples).

A summary of ABA results are presented in Table 6-5 and Figure 6-2 through Figure 6-5. A cursory overview of the ABA results indicate that hanging wall, near seam, coal and CCR samples are not currently acid generating as indicated by the > 5 paste pH (Table 6-5 and Figure 6-2).

A comparison of total S with sulphide S concentrations, Figure 6-3, indicates the major sulphur species in hanging wall, near seam, coal and CCR samples is sulphide S. This is evidenced by the samples falling adjacent to the 1:1 sulphide S:total S line. As presented in Table 6-5, sulphate S and insoluble S comprise a portion of the total sulphur. Sulphate

S concentrations are typically at or near the detection limit (D.L. <0.01 %), while insoluble S concentrations range from <0.02 to 0.72 %. With respect to the hanging wall and near seam samples the elevated insoluble S concentrations represent incomplete dissolution of sulphide minerals during the analytical testing. Therefore, for the 7SA5 hanging wall and near seam materials the non-sulphate S, or the difference of the total S and sulphate S, is used to calculate acid potential (AP). With respect to the coal and CCR samples, the elevated insoluble S concentrations represent organic S, therefore for the 7SA5 coal and CCR materials the sulphide S concentrations is used to calculate AP.

Figure 6-4 presents a comparison of CaNP with siderite-corrected NP. Several samples plot above the 1:1 CaNP:siderite-corrected NP line (CaNP > siderite-corrected NP), indicating the presence of Fe-bearing carbonates, which appear to be most prevalent in the hanging wall sandstone. Consequently, the CaNP overestimates the NP available for buffering acid generating reactions and thus the siderite-corrected NP is considered the best representation of NP to be compared with the AP. Therefore, for hanging wall and near seam samples the NPR is calculated from the siderite-corrected NP and non-sulphate S content [S(T) – S (SO_4)]. For the coal and CCR samples, the NPR is calculated from the siderite corrected NP and the sulphide S content.

Table 6-5:
Minimum, maximum, and median ABA results for hanging wall, near seam, 4 Seam coal, 4L seam coal and CCR composite material from the 7 South Area 5 proposed mine

Rock Type	Paste	S(T)	$S(SO_4)$	S(S-2)	Non-Sulphate S [S(T) - $S(SO_4)$]	Insoluble S	AP	Non-Sulphate S AP	NP	CaNP	NPR
	pH	%	%	%	%	%	kg $CaCO_3$/t	kg $CaCO_3$/t	kg $CaCO_3$/t	kg $CaCO_3$/t	
Hanging Wall Waste Rock (n=20)											
Min	6.0	0.11	<0.01	0.11	0.11	<0.02	3.4	3.3	14.0	38.4	0.1
Max	8.1	3.44	0.12	3.13	3.40	0.33	97.8	106.3	252.7	331.1	39.4
Median	7.8	0.42	0.02	0.40	0.40	0.02	12.3	12.6	86.4	131.5	7.0
Near Seam (n=6)											
Min	5.5	0.70	<0.01	0.61	0.70	0.04	19.1	21.7	14.0	35.7	0.1
Max	8.2	6.49	0.20	5.70	6.29	0.59	178.1	196.6	122.7	133.0	2.9
Median	6.8	2.53	<0.01	2.22	2.49	0.25	69.4	77.7	40.1	78.8	0.9
Coal											
4 Seam (n=15)											
Min	6.4	0.26	<0.01	0.11	0.26	0.08	3.4	8.0	23.1	15.5	0.4
Max	8.4	2.78	0.04	2.28	2.74	0.72	71.3	85.6	208.5	233.1	40.4
Median	7.7	1.32	0.01	0.98	1.32	0.29	30.6	41.1	37.4	35.3	1.1
4L Seam (n=7)											
Min	5.1	0.43	<0.01	0.09	0.43	0.15	2.8	13.3	23.6	28.2	0.1
Max	8.2	8.69	0.04	8.37	8.65	0.38	261.6	270.3	65.4	93.9	12.9
Median	7.9	0.48	0.01	0.16	0.48	0.31	5.0	14.8	36.3	37.5	6.7
CCR (n=7)											
Min	6.9	0.95	<0.01	0.75	0.945	0.10	23.4	29.5	42.1	45.5	1.6
Max	7.4	2.67	0.02	2.47	2.65	0.31	77.2	82.8	153.1	144.4	2.7
Median	7.2	1.37	0.01	1.27	1.37	0.19	39.7	42.7	84.1	79.8	1.9

NP = neutralization potential
CaNP = carbonate neutralization potential = Inorganic C (%) x 100.09/12.01 x 10
NP = Siderite corrected NP
AP = acid potential = S(S-2) x 31.25 kg $CaCO_3$/t
Non-Sulphate S AP = non-sulphate S acid potential = [S(T) - $S(SO_4)$] x 31.25 kg $CaCO_3$/t
NPR = net potential ratio, for Hanging Wall and Near Seam samples NPR = NP / Non-Sulphate S AP, for Coal and CCR Samples NPR = NP / AP.

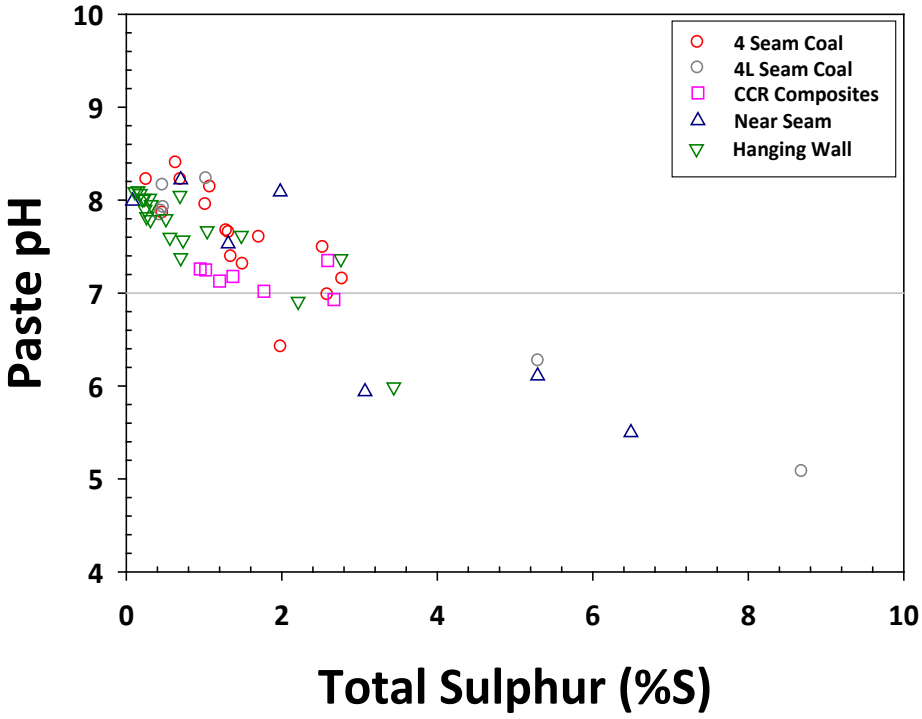


Figure 6-2: Total S *versus* paste pH

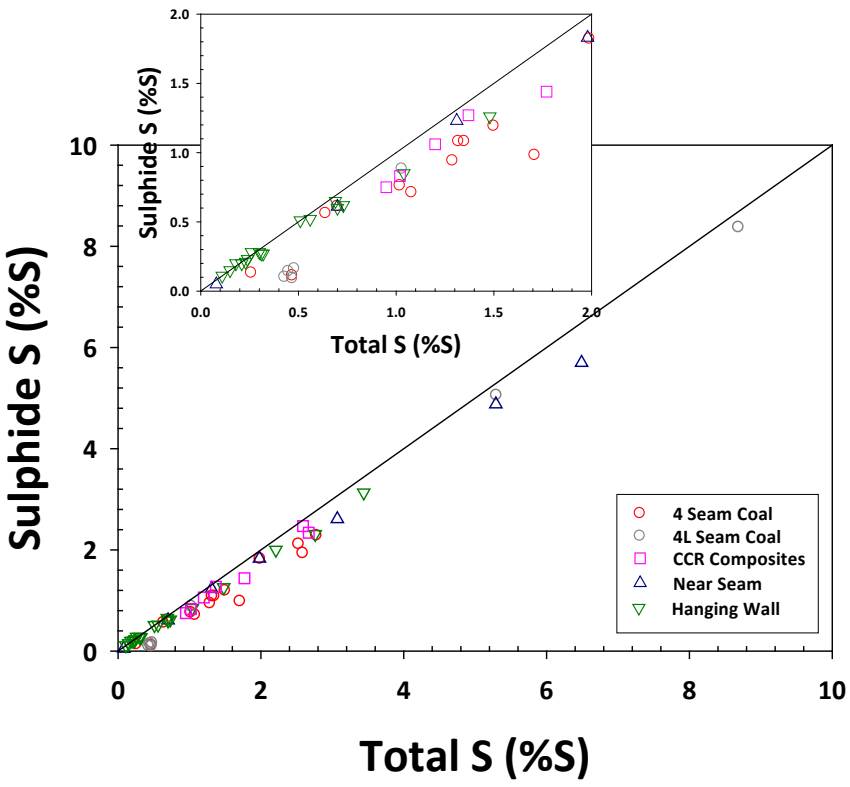


Figure 6-3: Total S *versus* sulphide S

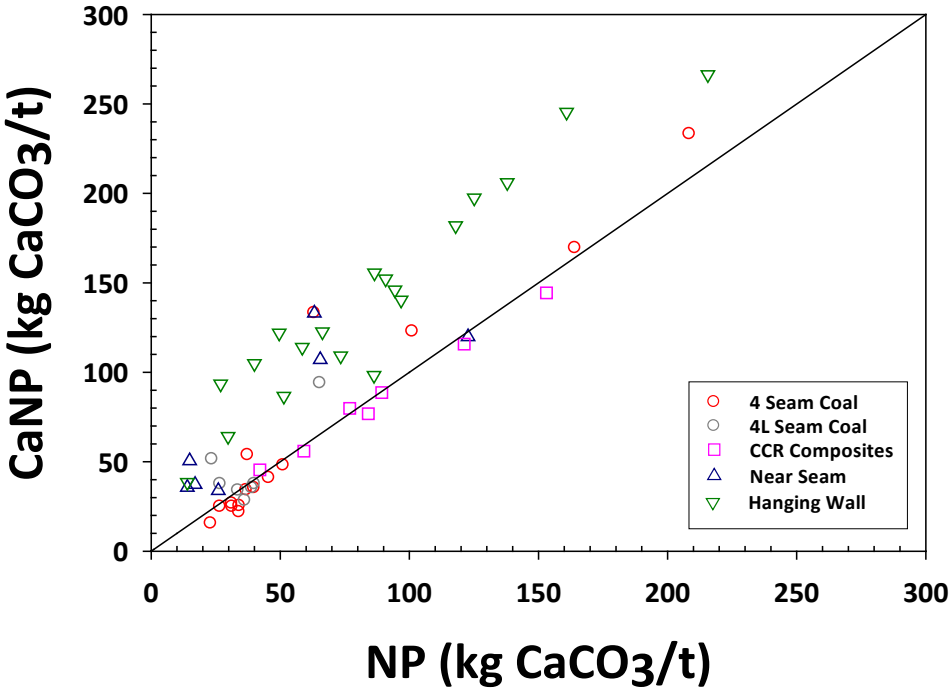


Figure 6-4: Siderite corrected NP *versus* carbonate NP

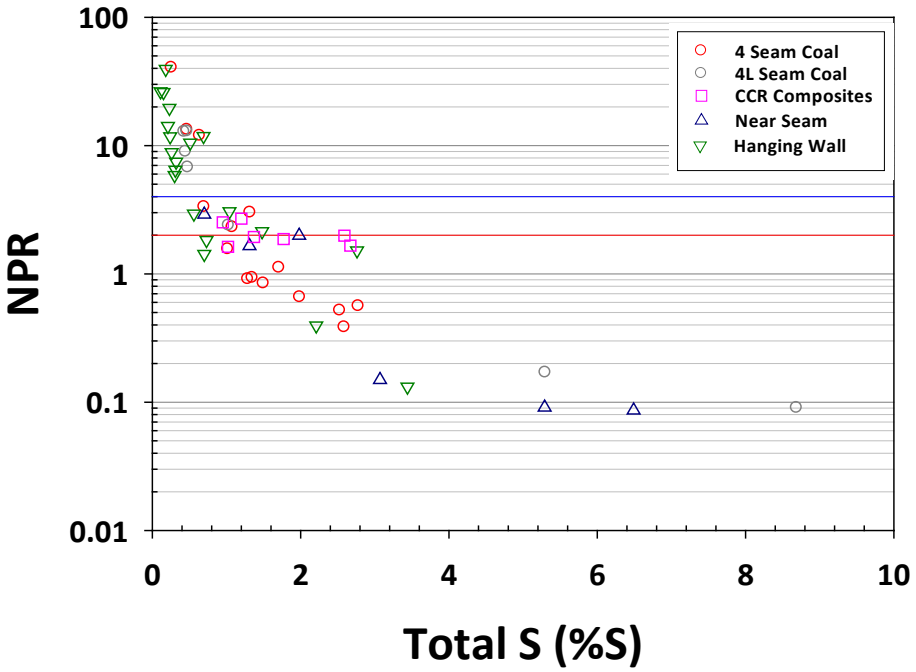
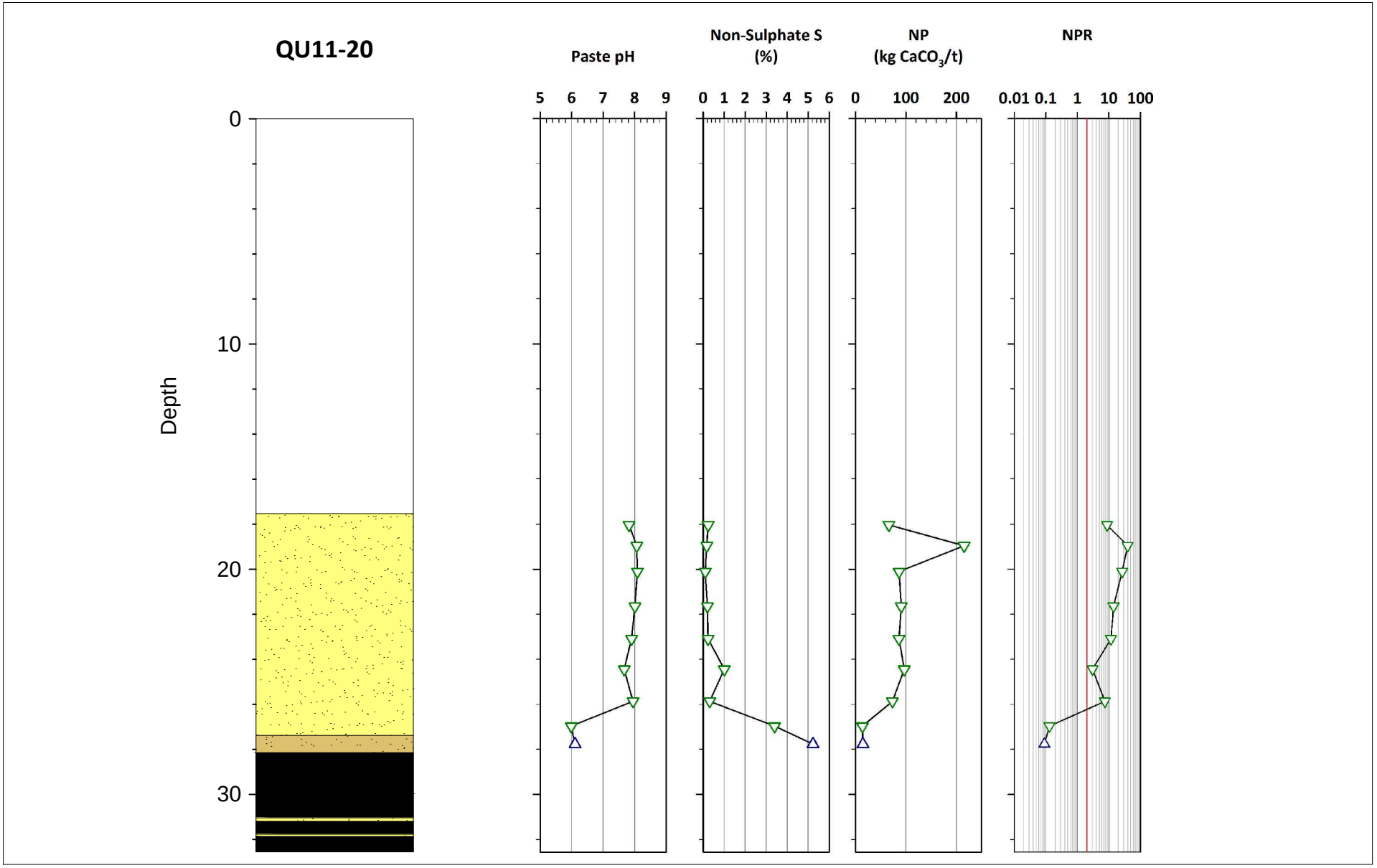


Figure 6-5: Net potential ratio (For CCR Composites and 4 and 4L Seam samples NPR = NP/AP, where AP = S(2-) x 31.25 kg $CaCO_3$/t. For Near Seam and Hanging Wall samples AP = [S(T) – $S(SO_4)$] x 31.25 kg $CaCO_3$/t) *versus* Total S.

6.2.1 Hanging Wall Waste Rock

The hanging wall waste rock material consists of sandstones and mudstones. The paste pH values range from 6.0 to 8.1 (Table 6-5 and Figure 6-2), indicating hanging wall material currently has sufficient NP available. The samples with the lowest paste pH have the highest sulphur contents (Figure 6-2). The total S concentrations range from 0.11 to 3.44 %, with median total S concentrations of 0.42 % (Table 6-5). Sulphide S and sulphate S concentrations range from 0.11 to 3.13 % and <0.01 to 0.12 %, respectively. As presented in Figure 6-3, total S in hanging wall samples is generally comprised of sulphide S, however insoluble S concentrations range from <0.02 to 0.33 %. Non-sulphate S concentrations range from 0.11 to 3.40 %, with a median of 0.40 %. Siderite corrected NP and CaNP range from 14.0 to 252.7 kg $CaCO_3$/t and 38.4 to 331.1 kg $CaCO_3$/t, respectively. Consistently higher CaNP than siderite-corrected NP in the hanging wall material indicate that Fe-carbonates are prominent (Figure 6-4). The median siderite-corrected NP for the hanging wall waste rock samples of 86.4 kg $CaCO_3$/t. Hanging wall waste rock samples exhibit NPR (NP/Non-Sulphate SAP) that ranges from 0.1 to 39.4, with a median NPR of 7.0 (Table 6-5 and Figure 6-5). Therefore, based on the median NPR the hanging wall material is considered non-PAG.

While generally being non-PAG, 5 samples of the 20 samples exhibit low NPR (<2.0). These samples are typically nearer the coal zone, within 2 to 5 m. Figure 6-6 presents an example of the drill hole profiles with hanging wall samples. Of note, as presented in drill hole profiles presented in Figure 6-6 and Appendix E1, hanging wall samples exhibit an increase in non-sulphate S content adjacent to the coal zone. As a result the NPR of hanging wall material nearer to the coal zone is typically lower than further away from the coal zone. These near (within 2 to 5 m) coal zone hanging wall samples are typically PAG.



Geology:

- N/A
- Breccia
- Coal
- Coal/Sandstone
- Coal/Siltstone
- Sandstone/Siltstone
- Conglomerate
- Lime
- Mudstone/Sandstone
- Mudstone
- Sandstone
- Siltstone/Sandstone
- Siltstone

Sample Location:

- Hanging Wall
- Near Seam
- 4 Seam Coal
- 4L Seam Coal

DATE SAVED:	Aug 07, 2012
DRAWN BY:	VV
REVIEWED:	JM
VERSION:	2

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT: **7 South Area 5 ML/ARD Assessment**

TITLE: Stratigraphy of Borehole QU11-20 with ABA Results

PROJECT #: J885-7

FIGURE:

P:\J885 Hillsborough Resources\Drafting\Stratigraphic models\7 South Area 5\Start Model_ver2_Aug2012.dwg

6.2.2 Near Seam Waste Rock

Near seam strata within 2 m of the coal seam consist of sandstones, coaly sandstones, siltstones and silty sandstones. The near seam sample selection is summarized in Section 6.1.1, above.

The paste pH values range from 5.5 to 8.2 (Table 6-5 and Figure 6-2), indicating that the near seam samples currently have NP available. As with the hanging wall samples, the near seam samples with the lowest paste pH have the highest sulphide S contents (Figure 6-2). The total S concentrations range from 0.70 to 6.49 %, with median total S concentrations of 2.53 % (Table 6-5). A single sample has total S content < 1.0 %, the remaining near seam samples have total S concentrations > 1.0 % and for the most part >2.0 %. The higher total S contents are not associated with a specific lithology. Sulphide S and sulphate S concentrations range from 0.61 to 5.70 % and <0.01 to 0.20 %, respectively. Insoluble S content ranges from 0.04 to 0.59 %. An appreciable amount of the sulphur content is represented by insoluble S. Therefore, so as to account for the potential sources of AP, non-sulphate S is considered for the near seam waste rock. Non-sulphate S concentrations range from 0.70 to 6.29 %, with a median of 2.49 %. Siderite corrected NP and CaNP range from 14.0 to 122.7 kg $CaCO_3$/t and 35.7 to 133.0 kg $CaCO_3$/t, respectively. Similar to the hanging wall waste rock samples, the near seam waste rock samples exhibit higher CaNP than siderite-corrected NP indicate that Fe-carbonates are associated with near seam material (Figure 6-4). The median siderite-corrected NP for the hanging wall waste rock samples of 26.0 kg $CaCO_3$/t. NPR for near seam samples range from 0.1 to 2.9, with a median NPR of 0.9. Therefore, the near seam material is generally considered PAG.

6.2.3 Coal Material

The mineable seam associated with the 7SA5 underground development are the 4 Seam and the 4L Seam.

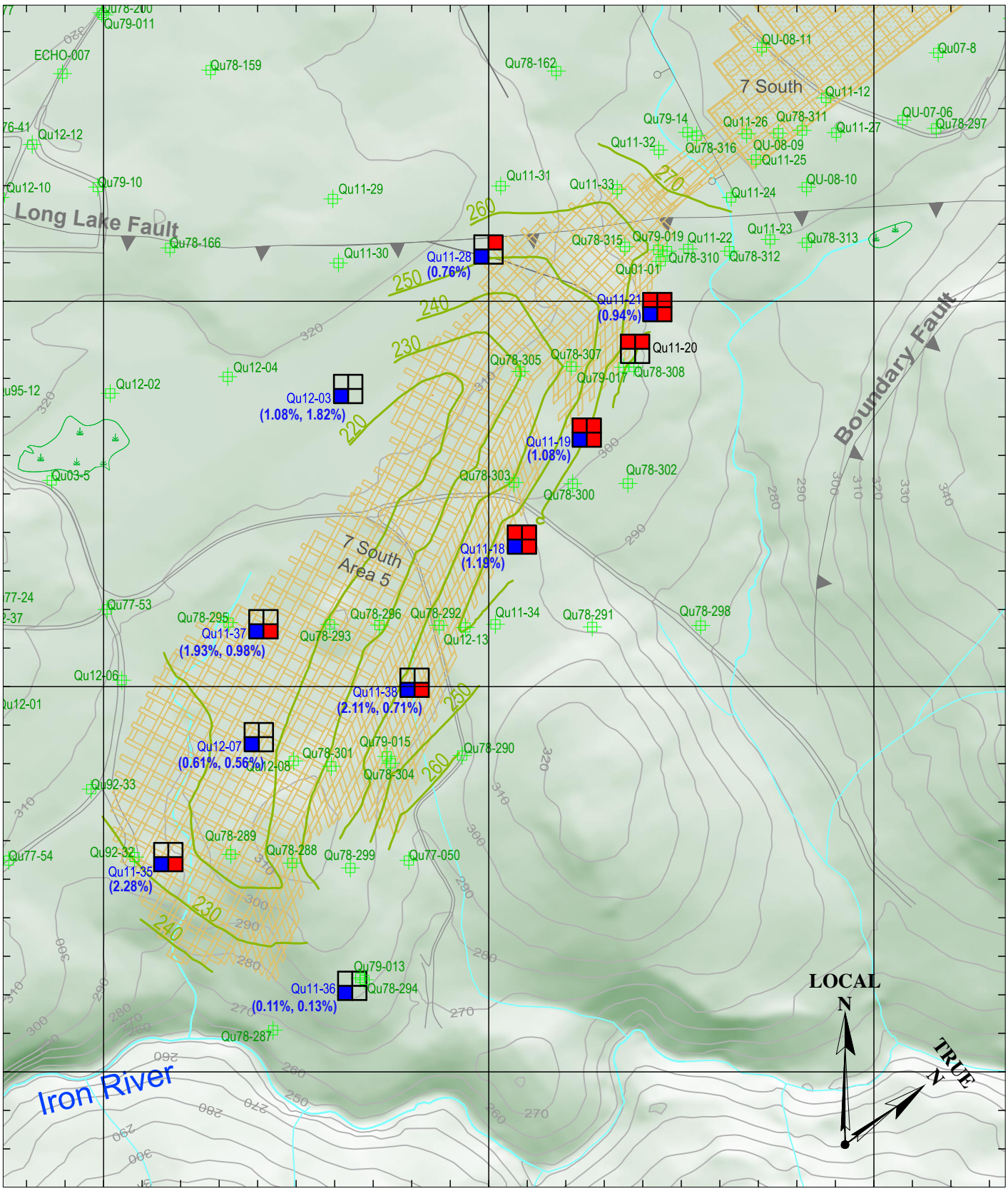
6.2.3.1 4 Seam Coal

The 4 seam coal exhibits paste pH ranging from 6.4 to 8.4, with a median paste pH of 7.7 (Table 6-5 and Figure 6-2). Paste pH decreases with increasing sulphur content as presented in Figure 6-2. The total S concentrations range from 0.26 to 2.78 %, with median total S concentrations of 1.32 % (Table 6-5). Sulphide S and sulphate S concentrations range from 0.11 to 2.28 % and <0.01 to 0.04 %, respectively. The calculated insoluble S content ranges from 0.08 to 0.72 %. A spatial distribution of sulphide S concentrations for 4 seam coal is presented in Figure 6-7. Sulphide S concentrations generally increase from the northern portion of 7 South Area 5 to the

southern portion (Figure 6-7). Siderite corrected NP and CaNP range from 23.1 to 208.5 kg $CaCO_3$/t and 15.5 to 233.1 kg $CaCO_3$/t, respectively. The median siderite-corrected NP for the 4 seam coal is 37.4 kg $CaCO_3$/t. NPR for 4 seam coal samples range from 0.4 to 40.4, with a median NPR of 1.1. Therefore, the majority of the 4 seam coal is expected to be PAG.

6.2.3.2 4L Seam Coal

The 4L seam coal exhibits paste pH ranging from 5.1 to 8.2, median paste pH of 7.9 (Table 6-5 and Figure 6-2). As with the 4 seam coal, the 4L seam coal paste pH levels decrease with increasing sulphur content (Figure 6-2). The total S concentrations range from 0.43 to 8.69 %, with a median concentration of 0.48 % (Table 6-5). Sulphide S and sulphate S concentrations range from 0.09 to 8.37 % and <0.01 to 0.04 %, respectively. Insoluble S content ranges from 0.15 to 0.38. A spatial distribution of sulphide S concentrations for 4L seam coal is presented in Figure 6-8. Sulphide S concentrations for 4L seam coal generally increase from the eastern portion of 7 South Area 5 to the western portion (Figure 6-8). Siderite corrected NP and CaNP range from 23.6 to 65.4 kg $CaCO_3$/t and 28.2 to 93.9 kg $CaCO_3$/t, respectively. The median siderite-corrected NP for 4L Seam samples is 37.5 kg $CaCO_3$/t. The 4L seam coal samples exhibit NPR ranging from 0.1 to 12.9, with a median NPR of 6.7. Therefore, the 4L seam coal material is expected to be predominately non-PAG. However, there are zones within 7SA5 that contain a high sulphur content that will produce a PAG material, similar to that observed in the 7 South mine area.



LEGEND

- Proposed Mine Workings
- Elevation(10m)
- Road
- Rivers/Creeks
- 4 Seam
- Thrust Faults
- Boreholes
- Swamp/Marsh

ARD Sample
FILLED SQUARES INDICATE SAMPLING
Hanging Wall / Near Seam / 4 Seam Coal / CCR

DATE SAVED:	Aug 17, 2012
DRAWN BY:	VV
REVIEWED:	BM, JM
VERSION:	1

Coordinate System: Quinsam Mine Local Grid
Projection: Orthographic
Units: Metres

1:7,000

0 50 100m

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT: **7 South Area 5 ML/ARD Assessment**

TITLE: Spatial Distribution of Sulphide S for 4 Seam Coal

PROJECT #: J885-7

FIGURE: 6-7

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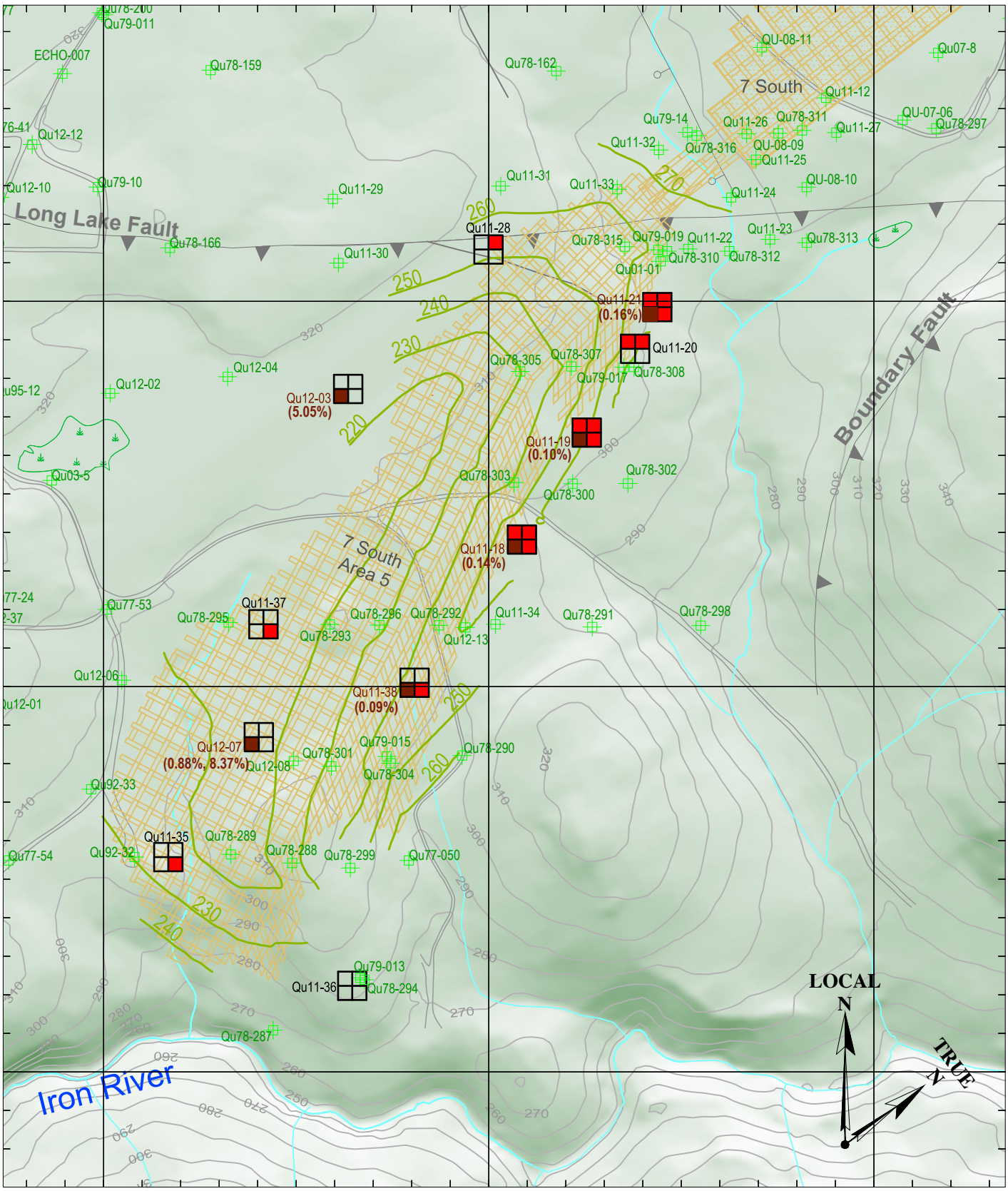

LEGEND

- Proposed Mine Workings
- Elevation(10m)
- Road
- Rivers/Creeks
- 4 Seam
- Thrust Faults
- Boreholes
- Swamp/Marsh

ARD Sample
FILLED SQUARES INDICATE SAMPLING
Hanging Wall / Near Seam / 4L Seam Coal / CCR

DATE SAVED:	Aug 17, 2012
DRAWN BY:	VV
REVIEWED:	BM, JM
VERSION:	1

Coordinate System: Quinsam Mine Local Grid
Projection: Orthographic
Units: Metres

1:7,000

0 50 100m

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT: **7 South Area 5 ML/ARD Assessment**

TITLE: Spatial Distribution of Sulphide S for 4L Seam Coal

PROJECT #: J885-7

FIGURE: 6-8

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6.2.4 CCR Material

As discussed in Section 6.1.1, the CCR samples are composites samples that include sink material from 4 seam, the 4-4L parting and 4L seam, with the exception of samples QU11-35/120466 and QU11-37/120468, which do not contain 4L seam material. This section provides an overview of the range of ABA results for CCR.

The paste pH for the CCR samples range from 6.9 to 7.4 and a median paste pH of 7.2 (Table 6-5 and Figure 6-2). Total S concentrations range from 0.95 to 2.67 %, with median total S concentrations of 1.37 % (Table 6-5). Sulphide S and sulphate S concentrations range from 0.75 to 2.47 % and <0.01 to 0.02 %, respectively. An appreciable amount of the sulphur content is represented by insoluble S, concentrations ranging from 0.10 to 0.31 %. Generally, the insoluble S content for CCR material is considered to be in the form of organic S. Siderite corrected NP and CaNP range from 42.1 to 153.1 kg $CaCO_3$/t and 45.5 to 144.4 kg $CaCO_3$/t, respectively. The median siderite-corrected NP for CCR samples is 84.1 kg $CaCO_3$/t. The CCR material analyzed exhibits a NPR range from 1.6 to 2.7, with a median NPR of 1.9. Therefore, both PAG and non-PAG CCR is expected to be produced from 7SA5. Operational monitoring will be required to identify PAG and non-PAG CCR and determine the appropriate storage location for the CCR as per the CCR management plan.

6.3 Solid Phase Metals

As discussed in Section 6.1.3.5, solid phase metals concentrations are used to evaluate mine waste material to identify metals that could potentially leach in drainage from mine waste rock dumps and or stockpiles. In this section metal concentrations are compared with average continental crustal abundance, those metals that are elevated at concentrations greater than 3 times the average continental crustal abundance will be discussed. Table 6-6 presents the range of solid phase metal concentrations and median values for each of the hanging wall waste rock, near seam waste rock, 4 seam and 4L seam coal, 4 seam and 4L seam CCR. Those values that are elevated with respect to the average continental crustal abundance are shaded in grey. A complete list of metal concentrations is presented in Appendix E3.

Table 6-6:
Solid Phase Metal Results:
Minimum, Maximum, Median Values For 7SA5 samples

Rock Type	As	Bi	Cd	Co	Cr	Cu	Hg	Mo	Ni	Pb	Sb	Se	Zn
	ppm	ppm	ppm	ppm	ppm	ppm	ppb	ppm	ppm	ppm	ppm	ppm	ppm
Hanging Wall (n=20)													
Min	**12.50**	**0.040**	0.030	7.1	46.6	10.69	<5	0.11	10	2.09	0.09	<0.1	30.2
Max	**74.10**	**0.17**	0.41	37	93.9	47.72	19	1.65	53.8	6.31	0.37	**0.2**	191
Median	**31.75**	**0.075**	0.055	9.8	58.5	13.995	2.5	0.33	14	3.53	0.13	0.08	40.6
Near Seam (n=6)													
Min	**28.90**	**0.090**	0.050	11	10.3	13.97	<5	0.24	15.8	2.66	0.12	<0.1	41.6
Max	**192.7**	**0.15**	0.14	20	100	56.47	73	2.62	37.8	6.67	**0.76**	**0.5**	74.9
Median	**56.80**	**0.11**	0.080	14	50.6	17.97	10	0.92	20.6	5.25	0.2	0.05	53.2
Coal													
4 Seam (n=15)													
Min	**22.20**	0.020	0.030	1.7	4.7	11.27	<5	0.16	2.5	1.56	0.05	<0.1	3.4
Max	**1026**	**0.15**	0.110	17	183	48.76	126	**32.89**	25.2	4.78	**161.36**	**0.6**	87.7
Median	**88.20**	**0.05**	0.06	4	30.1	16.55	86	0.84	9.5	2.5	0.16	0.1	11.8
4L Seam (n=7)													
Min	**7.000**	**0.030**	0.020	2	12.9	16.69	<5	0.27	2.8	1.41	0.05	<0.1	5.7
Max	**204.0**	**0.090**	0.13	22	101	64.85	47	2.56	33.5	4.59	**1.04**	**0.7**	77.3
Median	**28.60**	**0.070**	0.050	7	30.9	39.63	15	0.99	7	1.82	0.14	0.1	14.9
CCR (n=7)													
Min	**28.00**	**0.050**	0.040	1.6	13.5	14.39	79	0.41	2.2	2.6	0.07	<0.1	10.8
Max	**428.7**	**0.11**	0.140	7	82.3	74.82	169	**6.76**	11.9	7.05	**81.03**	**0.6**	52.8
Median	**87.00**	**0.080**	0.1	4.6	36.4	27.2	104	0.73	8.7	4.62	0.1	**0.3**	19.3
Average Continental Crustal Abundance													
	1.800	0.0085	0.15	25	102	60.00	85	1.2	84.0	14.0	0.20	0.05	70.0

Note: Cells that are shaded are >3 times the average crustal abundance

Each of the hanging wall, near seam, 4 seam coal, 4L seam coal, and CCR samples exhibit elevated As concentrations, while the majority of samples exhibit elevated Bi concentrations. Select hanging wall waste rock, near seam waste rock, 4 seam and 4L seam coal, and CCR samples have Se concentrations that are enriched relative to average crustal abundances. The median Se concentration for CCR material is elevated 6 times over the average continental crustal abundance. Select near seam, 4 Seam coal, 4L Seam coal, and CCR samples exhibit elevated Sb concentrations. Mo concentrations are enriched relative to average crustal abundance for select 4 Seam coal and CCR samples. Metals that are typically elevated in mine drainage (Cd, Cu, Cr, Ni, and Pb) are not observed to be elevated in hanging wall waste rock, near seam waste rock, 4 seam and 4L seam coal, 4 seam and 4L seam CCR samples. Additionally, while Hg concentrations are generally greater than the detection limit, none of the samples analyzed have Hg concentrations that are considered elevated or enriched.

6.4 Correlation of 7SA5 and 7 South Mine Strata

The following section compares the median results for ABA and metals for the 7SA5 near seam / parting, 4 Seam CCR, and 4L Seam CCR material categories with equivalent materials from the 7 South Mine area. Summary tables of the 7SA5 minimum, maximum and median ABA and metals are presented for each material category. Median values in the tables that are 2 times greater than the 7 South Mine median values have been shaded red and are considered relatively elevated. Those median values that are ½ of the 7 South Mine median values have been shaded green.

6.4.1 Near Seam/Parting

Near seam / parting samples from 7SA5 have been compared with near seam / parting samples from the 7 South Mine area (Table 6-7). Parting samples from 7SA5 represent the 4-4L parting, while 7 South Mine samples represent 5-4 Seam parting and 4-4L parting.

The ABA results exhibit median total S that is elevated with respect to the 7 South samples. The median NP for 7SA5 is similar to 7 South Mine, while the median NPR is low relative to the 7 South. The 7 South near seam / parting material was classified as non-PAG (Lorax 2012), however the 7SA5 near seam / parting material is PAG.

Median concentrations for each of Au, Cr, Fe, Mn, and Tl are elevated relative to the 7 South Mine samples. Median concentrations of Ag, Cu, Sr, and Ti concentrations are deplete.

In generally, the 7SA5 near seam / parting material is PAG, and, therefore, has the potential of developing acidic drainage. Parting material from the 7 South mine area is also considered PAG. While the median solid phase metal concentrations for Au, Cr, Fe, Mn, and Tl are elevated. Metals concentrations for the 7SA5 near seam / parting material are largely similar to that of the 7 South mine area.

Table 6-7:
Minimum, Maximum and Median ABA and Metals Values for Near Seam/Parting Samples.

Parameter	Units	MIN	MEDIAN	MAX	COUNT
Paste pH	**s.u.**	5.5	6.8	8.2	6
Total S	**%**	0.70	2.5	6.5	6
NP	**kg $CaCO_3$/t**	14.0	40.1	123	6
NPR		0.1	0.9	2.9	6
Ag	**ppb**	13	15	48	6
Al	**%**	0.36	0.39	0.47	6
As	**ppm**	29	68	193	6
Au	**ppb**	<0.20	0.75	11	6
B	**ppm**	<20	20	20	6
Ba	**ppm**	9.3	14	27	6
Bi	**ppm**	0.090	0.10	0.15	6
Ca	**%**	0.20	1.2	4.0	6
Cd	**ppm**	0.050	0.075	0.12	6
Co	**ppm**	11	15	20	6
Cr	**ppm**	42	62	100	6
Cu	**ppm**	14	16	56	6
Fe	**%**	2.9	4.5	6.0	6
Hg	**ppb**	<5.0	23	73	6
La	**ppm**	1.0	3.4	6.6	6
Mg	**%**	0.28	0.37	0.40	6
Mn	**ppm**	256	511	974	6
Mo	**ppm**	0.24	0.71	2.6	6
Na	**%**	0.003	0.004	0.006	6
Ni	**ppm**	16	19	35	6
Pb	**ppm**	4.3	5.3	6.7	6
Sb	**ppm**	0.12	0.32	0.76	6
Sc	**ppm**	5.9	9.1	19	6
Se	**ppm**	0.10	0.10	0.50	6
Sr	**ppm**	9.2	19	29	6
Th	**ppm**	0.80	1.1	1.5	6
Ti	**%**	0.0010	0.0025	0.0080	6
Tl	**ppm**	0.020	0.15	0.33	6
U	**ppm**	0.30	0.30	0.40	6
V	**ppm**	48	68	113	6
Zn	**ppm**	42	52	75	6

NOTE: Total S = Total Sulphur
NP = Neutralization Potential
NPR = Net potential ration = NP / TAP = NP / (Total S x 31.25 kg $CaCO_3$/t)
Shaded Red Cells are > 2 times the median concentration observed at 7 South
Shaded Green Cells are < ½ the median concentrations observed at 7 South

6.4.2 Coal Material

This section compares the 4 Seam and 4L Seam coal from 7SA5 with a single composite sample from 7 South. The 7 South coal sample is a composite of raw coal from the 4 Seam and 4L Seam.

6.4.2.1 4 Seam Coal

The 7SA5 4 Seam Coal has been compared with a composite 4 and 4L Seam Coal sample from the 7 South Mine area (92050). A summary table of minimum, maximum and median ABA and metals are presented in Table 6-8 for 7SA5 4 Seam Coal.

The ABA results exhibit median total S, NP and NPR that are relatively similar to the 7 South coal composite sample. 7SA5 4 Seam Coal median metal concentrations for Ba, Cu, Mg, and Se are less than ½ the metal concentrations of the 7 South composite coal sample. None of the median metal concentrations for 7SA5 4 Seam Coal are > 2 times metal concentrations of the 7 South Mine composite coal sample.

In general, the 4 Seam coal is PAG. Relative to the 7 South mine are 4-4L coal composite, the 7SA5 4 Seam coal is similarly acid generating and, generally, has similar median metal concentrations.

6.4.2.2 4L Seam Coal

Similar to the 7SA5 4 Seam Coal, the 7SA5 4L Seam Coal has been compared with a composite 4-4L Seam Coal sample from the 7 South Mine area (92050). A summary table of minimum, maximum and median ABA and metals are presented in Table 6-9 for 7SA5 4L Seam Coal.

The ABA results exhibit median total S that is < ½ the concentration of the 7 South coal composite sample, while NP is relatively similar to the 7 South coal composite sample. The NPR, relative to the 7 South coal composite sample, is 2 times greater. The 4L Coal Seam is generally non-PAG.

7SA5 4L Seam Coal median metal concentrations for As, Fe, Hg, and Se are less than ½ the metal concentrations of the 7 South Mine composite coal sample. None of the median metal concentrations for 7SA5 4L Seam Coal are > 2 times metal concentrations of the 7 South Mine composite coal sample.

In general, the 4L Seam coal is non-PAG. Relative to the 7 South Mine are 4-4L coal composite, the 7SA5 4L coal has a lower acid generating potential, but similar median metal concentrations.

Table 6-8:
Minimum, Maximum and Median ABA and Metals Values for 4 Seam Coal.

Parameter	Units	MIN	MEDIAN	MAX	COUNT
Paste pH	**s.u.**	6.4	7.7	8.4	15
Total S	**%**	0.26	1.3	2.8	15
NP	**kg $CaCO_3$/t**	23.1	37.4	209	15
NPR		0.3	0.7	20.2	15
Ag	**ppb**	10	21	35	15
Al	**%**	0.080	0.13	0.41	15
As	**ppm**	22	88	1026	15
Au	**ppb**	<0.20	0.20	2.6	15
B	**ppm**	<20	138	185	15
Ba	**ppm**	7.5	12	33	15
Bi	**ppm**	0.020	0.050	0.15	15
Ca	**%**	0.79	1.5	7.6	15
Cd	**ppm**	0.030	0.060	0.11	15
Co	**ppm**	1.7	4.3	17	15
Cr	**ppm**	4.7	30	183	15
Cu	**ppm**	11	17	49	15
Fe	**%**	0.24	1.2	5.2	15
Hg	**ppb**	<5.0	86	126	15
La	**ppm**	0.80	2.4	5.9	15
Mg	**%**	0.010	0.030	0.42	15
Mn	**ppm**	42.0	115	1384	15
Mo	**ppm**	0.16	0.84	33	15
Na	**%**	0.004	0.009	0.02	15
Ni	**ppm**	2.5	9.5	25	15
Pb	**ppm**	1.6	2.5	4.8	15
Sb	**ppm**	0.050	0.16	161	15
Sc	**ppm**	1.9	3.7	12	15
Se	**ppm**	0.10	0.10	0.60	15
Sr	**ppm**	20	37	186	15
Th	**ppm**	0.20	0.40	1.1	15
Ti	**%**	0.0010	0.023	0.033	15
Tl	**ppm**	0.020	0.020	0.11	15
U	**ppm**	0.20	0.30	0.50	15
V	**ppm**	19	53	104	15
Zn	**ppm**	3.4	12	88	15

NOTE: Total S = Total Sulphur
NP = Neutralization Potential
NPR = Net potential ration = NP / TAP = NP / (Total S x 31.25 kg $CaCO_3$/t)
Shaded Red Cells are > 2 times the median concentration observed at 7 South
Shaded Green Cells are < ½ the median concentrations observed at 7 South

Table 6-9:
Minimum, Maximum and Median ABA and Metals Values for 4L Seam Coal.

Parameter	Units	MIN	MEDIAN	MAX	COUNT
Paste pH	**s.u.**	5.1	7.9	8.2	7
Total S	**%**	0.43	0.5	8.7	7
NP	**kg $CaCO_3$/t**	23.6	36.3	65.4	7
NPR		0.1	2.2	3.0	7
Ag	**ppb**	16	25	41	7
Al	**%**	0.10	0.18	0.44	7
As	**ppm**	7.0	29	204	7
Au	**ppb**	<0.20	0.20	1.1	7
B	**ppm**	<20	113	141	7
Ba	**ppm**	7.7	19	33	7
Bi	**ppm**	0.030	0.070	0.090	7
Ca	**%**	0.31	1.6	2.0	7
Cd	**ppm**	0.020	0.050	0.13	7
Co	**ppm**	2.1	7.2	22	7
Cr	**ppm**	13	31	101	7
Cu	**ppm**	17	40	65	7
Fe	**%**	0.16	0.3	9.5	7
Hg	**ppb**	<5.0	15	47	7
La	**ppm**	1.0	2.5	3.8	7
Mg	**%**	0.020	0.060	0.39	7
Mn	**ppm**	42.0	61	555	7
Mo	**ppm**	0.27	0.99	2.6	7
Na	**%**	0.005	0.01	0.01	7
Ni	**ppm**	2.8	7	34	7
Pb	**ppm**	1.4	1.8	4.6	7
Sb	**ppm**	0.050	0.14	1.0	7
Sc	**ppm**	2.2	6	13	7
Se	**ppm**	0.10	0.10	0.70	7
Sr	**ppm**	12	54	91	7
Th	**ppm**	0.30	0.50	1.5	7
Ti	**%**	0.0020	0.024	0.036	7
Tl	**ppm**	0.020	0.020	0.54	7
U	**ppm**	0.20	0.30	0.50	7
V	**ppm**	33	80	116	7
Zn	**ppm**	5.7	15	77	7

NOTE: Total S = Total Sulphur
NP = Neutralization Potential
NPR = Net potential ration = NP / TAP = NP / (Total S x 31.25 kg $CaCO_3$/t)
Shaded Red Cells are > 2 times the median concentration observed at 7 South
Shaded Green Cells are < ½ the median concentrations observed at 7 South

6.4.3 CCR Material

The 7SA5 CCR composite samples have been compared with CCR composite samples from the 7 South Mine area. A summary table of minimum, maximum and median ABA and metals are presented in Table 6-10 for 7SA5 CCR composite samples. A description of the composite samples was presented above in Section 6.1.1.

The ABA results for 7SA5 CCR exhibit lower median total S concentration and similar NP relative to the 7 South CCR. The median NPR for 7SA5 is therefore > 2 times the NPR of the CCR from 7 South. While the median NPR is greater than 7 South Mine CCR samples, the 7SA5 CCR is, similarly, classified as PAG.

7SA5 CCR median concentrations for Co, Sb, and Tl are less than ½ the metal concentrations of the 7 South CCR. The median concentration for Th in 7SA5 CCR is > 2 times the metal concentration for 7 South Mine CCR sample.

In general, the ABA and metal characteristics of the 7SA5 CCR composite material and the 7 South Mine CCR composite material are similar (Table 6-10). Notably, sulphur content is lower and NPR values are higher for the 7SA5 CCR samples than for the 7 South samples. This suggests that a greater amount of non-PAG CCR may be derived from this mine area.

Table 6-10:
Minimum, Maximum and Median ABA and Metals Values for 7SA5 CCR.

Parameter	Units	MIN	MEDIAN	MAX	COUNT
Paste pH	**s.u.**	6.9	7.2	7.4	7
Total S	**%**	0.95	1.4	2.7	7
NP	**kg $CaCO_3$/t**	42.1	84.1	153	7
NPR		1.3	1.8	2.4	7
Ag	**ppb**	21	35	70	7
Al	**%**	0.24	0.36	0.47	7
As	**ppm**	28.0	87	429	7
Au	**ppb**	<0.20	0.4	0.7	7
B	**ppm**	<20	25	39	7
Ba	**ppm**	14	26	41	7
Bi	**ppm**	0.050	0.080	0.11	7
Ca	**%**	1.6	3.3	5.9	7
Cd	**ppm**	0.040	0.10	0.14	7
Co	**ppm**	1.6	4.6	7	7
Cr	**ppm**	14	36	82	7
Cu	**ppm**	14	27	75	7
Fe	**%**	1.1	1.5	2.4	7
Hg	**ppb**	79.0	104	169	7
La	**ppm**	2.6	3.9	6.2	7
Mg	**%**	0.030	0.080	0.12	7
Mn	**ppm**	100	155	408	7
Mo	**ppm**	0.41	0.73	6.8	7
Na	**%**	0.006	0.007	0.01	7
Ni	**ppm**	2.2	8.7	12	7
Pb	**ppm**	2.6	4.6	7.1	7
Sb	**ppm**	0.070	0.10	81.0	7
Sc	**ppm**	4	6	7	7
Se	**ppm**	<0.1	0.30	0.60	7
Sr	**ppm**	32	90	230	7
Th	**ppm**	1.10	2.50	3.7	7
Ti	**%**	0.0090	0.013	0.023	7
Tl	**ppm**	<0.020	0.030	0.38	7
U	**ppm**	0.20	0.50	0.70	7
V	**ppm**	24	32	57	7
Zn	**ppm**	11	19	53	7

NOTE: Total S = Total Sulphur
NP = Neutralization Potential
NPR = Net potential ration = NP / TAP = NP / (Total S x 31.25 kg $CaCO_3$/t)
Shaded Red Cells are > 2 times the median concentration observed at 7 South
Shaded Green Cells are < ½ the median concentrations observed at 7 South

6.5 NP And Sulphide S Depletion

Projections of NP and sulphide S depletion for both 7SA5 CCR and coal have been calculated. The following sections describe the method for calculation and present depletion rates based on the range of NP and sulphide S values for 7SA5 CCR and coal.

6.5.1 CCR Material

For 7SA5 CCR the NP depletion and sulphide S were calculated based on the NP consumption rates and AP production rates from kinetic testing of a 4U CCR, Col 2, and 4L CCR, Col 3 (Table 6-11). Col 2 leachate remained neutral for the duration of testing, while Col 3 generated acidic leachate after cycle 53. The NP remaining when the Col 3 sample became acidic was calculated to be 14.5 $kgCaCO_3/t$ from the cumulative metal release rates. This amount of NP that is projected to be unavailable NP for all 4 Seam CCR samples and is applied to the NP depletion time calculations discussed below. For the purposes of calculating the average NP consumption rate and AP production rate the average CMR and sulphate production rates from cycle 53 to 175 were considered for Col 2, while only the final 5 cycles of neutral conditions were considered for Col 3 (Cycles 48 to 53). Table 6-111 also compares the static geochemistry of the Col 2 and Col 3 samples with the median 4 Seam and 4L seam static geochemistry.

Table 6-11:
Comparison of Static Geochemistry for 4 Seam CCR Kinetic Tests (Col 2 and Col 3) and the Median 7SA5 CCR Results

		7 South Mine CCR		7SA5 CCR
	Units	**Col 2[a]**	**Col 3[b]**	**Median Results**
Initial Total S	%S	4.03	2.82	1.40
Initial Sulphide S	%S	2.90	2.32	1.27
Initial NP	$kgCaCO_3/t$	84.9	24.3	84.1
Initial NPR (NP/SAP)		0.9	0.3	2.1
Available NP	$kgCaCO_3/t$	75.1	14.5	74.3
NPR based on available NP (Available NP/SAP)		0.8	0.2	1.9
Leachate pH	s.u.	7.6	7.4	n/a
Sulphate Production Rate	mg/kg/wk	225.4	286	n/a
CMR	ratio	1.0	1.1	n/a
AP Production Rate	$kgCaCO_3/t/wk$	0.23	0.30	n/a
NP Consumption Rate	$kgCaCO_3/t/wk$	0.25	0.32	n/a

[a.] Leachate pH, Sulphate Production Rate, CMR, AP Production Rate and NP Consumption Rate represent the average from cycle 53 to termination
[b.] Leachate pH, Sulphate Production Rate, CMR, AP Production Rate and NP Consumption Rate represent the average for the final 5 cycles before going acid at cycle 53

Table 6-12 and Figure 6-9 presents the projected time to NP depletion for 7SA5 CCR for the range of measured NP in the baseline static characterization data. Presented are the Min, Max, and 5th through 95th percentile NP values with the time to depletion of NP. Available NP is calculated by subtracting the unavailable NP (14.5 $kgCaCO_3/t$) as calculated from Col 3 from the measured NP. As the 7SA5 CCR presented in this report are composites of 4 Seam and 4L Seam CCR a lower and upper estimate for NP depletion have been presented using the rates measured from Col 3 and Col 2, respectively. The calculated NP depletion times presented in Table 6-12 apply only to PAG CCR where the NP is expected to be consumed prior to the complete oxidation of the contained sulphide minerals. It is important to note that the baseline 7SA5 CCR sample results (Table 6-5) indicate that up to 50% of the 4 Seam CCR derived from 7SA5 will not be PAG.

For the median NP, 84.1 kg $CaCO_3/t$, the time to NP depletion for PAG 7SA5 CCR material is expected to range from 214 to 283 weeks or roughly 4 to 5 years. Conversely, if the NP of a given CCR sample is near the 25th percentile, 52 $kgCaCO_3/t$, the time to NP depletion is predicted to be 3 to 4 years.

Table 6-12:
Estimates of NP and Sulphide S Depletion for CCR from 7SA5.

	NP[1]	Available NP[2]	Time to NP Depletion	
			Using Col 3[3]	Using Col 2[4]
	$kgCaCO_3/t$	$kgCaCO_3/t$	Weeks	Weeks
Min	42.1	27.6	85	112
P5	47.2	32.7	101	133
P10	52.3	37.8	116	154
P25	68.0	53.5	165	218
P50	84.1	69.6	214	283
P75	105.3	90.8	279	370
P90	134.0	119.5	368	486
P95	143.5	129.0	397	525
Max	153.1	138.6	427	564

1. Min, Max, and 5th through 95th Percentile NP for 7SA5 CCR samples
2. Available NP = NP - NP Remaining in Col 3 after 53 cycles, prior to going acidic
3. Time to NP Depletion = Available NP / NP Consumption Rate for Column 3
4. Time to NP Depletion = Available NP / NP Consumption Rate for Column 2

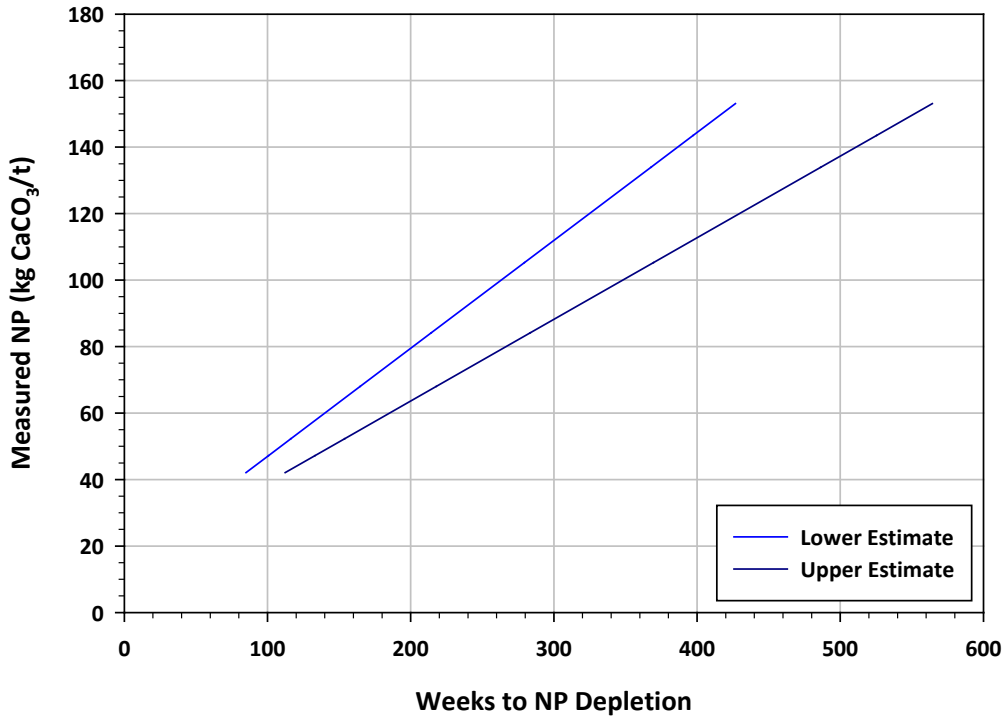


Figure 6-9: Measured NP *versus* weeks to NP depletion for 7SA5 CCR.

6.5.2 Coal Material

NP depletion times for 7SA5 coal were calculated based on the NP consumption rates and acid production rates from unsaturated column kinetic testing of a 4-4L composite coal sample, Col 1. Kinetic test data for the 4-4L composite sample indicated that sulphate production rates and metal leach rates remained consistent from cycle 80 to cycle 175. Therefore to calculate an average NP consumption rate and acid production rate the average CMR and sulphate production rates from cycle 80 to cycle 175 were considered (Table 6-13). Table 6-13 also compares the static geochemistry of the coal kinetic test sample (Col 1) with the median results for 4 Seam and 4L Seam from 7SA5.

Table 6-13:
Comparison of Static Geochemistry for
Coal Kinetic Test Sample (Col 1) and Median 7SA5 4 and 4 L Coal

		7 South Coal	7SA5 Coal	
	Units	**Col 1 (4U/4L Composite)[a]**	**4 Seam**	**4L Seam**
Initial Total S	%S	2.17	1.32	0.48
Initial Sulphide S	%S	1.27	0.98	0.16
Initial NP	$kgCaCO_3/t$	36.3	37.4	36.3
Initial NPR (NP/SAP)		0.9	1.1	6.7
Available NP	$kgCaCO_3/t$	26.5	27.6	26.5
NPR based on available NP (Available NP/SAP)		0.7	0.9	5.3
Leachate pH	s.u.	7.7	n/a	n/a
Sulphate Production Rate	mg/kg/wk	85.4	n/a	n/a
CMR	ratio	1.2	n/a	n/a
AP Production Rate	$kgCaCO_3/t/wk$	0.09	n/a	n/a
NP Consumption Rate	$kgCaCO_3/t/wk$	0.10	n/a	n/a

a. Leachate pH, Sulphate Production Rate, CMR, AP Production Rate and NP Consumption Rate represent the average from cycle 80 to 175

Table 6-14 and Figure 6-10 present the time to NP depletion for PAG components of the 4 Seam and 4L Seam coal. Presented are the Min, Max, and 5th through 95th percentile NP values and sulphide S concentrations with the time to depletion of NP. Available NP is estimated by subtracting the unavailable NP (14.5 $kgCaCO_3/t$) calculated in Col 3 from the measured NP. This estimation of unavailable NP is conservative for 4 Seam coal as documented by the ongoing Col 1 test that continues to release pH-neutral leachate although the remaining NP is calculated to be near 14 $kgCaCO_3/t$ (Lorax, 2012). For the median NP, 37.4 kg $CaCO_3/t$, the time to NP depletion is estimated to be over 4 years. Conversely, if the NP of a given coal sample is 25.6 $kgCaCO_3/t$ the time for NP depletion is estimated to be 2 years.

Table 6-14:
Estimates of NP Depletion for
4 Seam and 4L Seam Coal from 7SA5

	NP[1] $kgCaCO_3/t$	Available NP[2] $kgCaCO_3$/tonne	Time to NP Depletion Using Col 1[3] Weeks
4 Seam			
Min	23.1	8.6	84
P5	25.6	11.1	109
P10	28.5	14.0	137
P25	32.8	18.3	178
P50	37.4	22.9	224
P75	57.2	42.7	417
P90	139.0	124.5	1216
P95	177.5	163.0	1591
Max	208.5	194.0	1894
4L Seam			
Min	23.6	9.1	89
P5	24.6	10.1	98
P10	25.5	11.0	108
P25	30.3	15.8	154
P50	36.3	21.8	213
P75	39.6	25.1	245
P90	50.2	35.7	348
P95	57.8	43.3	423
Max	65.4	50.9	497

1. Min, Max, and 5th through 95th Percentile NP for 7SA5 Coal samples
2. Available NP = NP - NP Remaining in Col 1 from cycle 53 onward
3. Time to NP Depletion = Available NP / NP Consumption Rate for Column 1

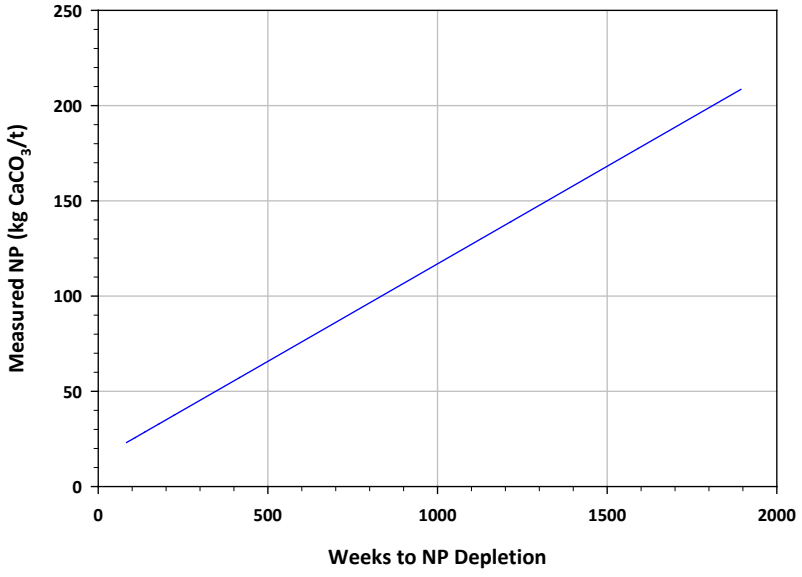


Figure 6-9: Measured NP *versus* weeks to NP depletion for 7SA5 4 Seam and 4L Seam Coal.

6.6 Geochemical Source Terms for Mine Void Water

Geochemical source terms for the 7SA5 mine water have been estimated for several scenarios that may occur in the 7SA5 mine during operation and post-closure. During operations the mine will be dewatered and the mine walls and coarse reject stored in the mine will be exposed to air, which will allow for the oxidation of sulphide minerals and progression of standard ML/ARD reactions. In the post-closure period, the mine will flood, which will restrict ARD reactions in the closed mine workings but will transfer stored metals and acidity from precipitates to the flooded mine pool. The basis for developing source terms and the predicted mine water source terms for each of the scenarios are discussed in the following sections.

Estimates of the 7SA5 mine water chemistry are derived from background groundwater chemistry, the 4 Seam saturated column test leachate data and also from measured water chemistry from the mature 4 South mine pool and baseline groundwater quality in the 7SA5 area. As discussed in Section 6.4, the coal and near seam (roof) strata that will be exposed in the 7SA5 mine walls are geochemically similar to equivalent strata in the 7 South mine area. Due to this similarity, the 7SA5 geochemical source terms have been developed using a similar approach to that used for the 7 South mine area (Lorax, 2011), but have been updated to include the most recent kinetic test and mine water chemistry data.

6.6.1 Operational Dewatering Water Quality

During mine operations, dewatering of 7SA5 will be necessary to provide dry working conditions. Dewatering pumps could be placed in wells adjacent to the mine workings or in sumps directly within the mine void. The location where groundwater is intercepted by the pumping system (*i.e.* dewatering wells or mine sump) will affect the quality of the water due to geochemical reactions within the mine void. In addition, placement of coarse reject from the 4South mine could significantly influence mine chemistry. The expected water chemistry for three separate dewatering conditions is presented in Table 6-15.

Operations Scenario 1 - Dewatering Well Water Quality

Water management may include the interception of groundwater before it enters the mine void. Pumping from dewatering wells adjacent to the mine workings will produce water with chemistry similar to the background water chemistry that has been in contact with the coal seams and aquifer matrix.

Water quality for this pumping configuration from external boreholes is estimated from the average baseline groundwater quality measured during a pump test from borehole QU11-38, which is located in the central portion of 7SA5.

Operations Scenario 2 - Mine Sump Water Quality with 4South Mine Coarse Reject

Coarse reject from 4 South will be placed in the 7SA5 mine void once the 7SA5 coal extraction is completed. Groundwater coming into contact with the mine walls and the 4 South coarse reject will be influenced by ML/ARD reactions and take on a geochemical signature influenced strongly by the 4 South coarse reject due to its PAG characteristics.

Mine water quality following the placement of the coarse reject is estimated from the median leachate concentrations from the 4 South coarse reject leach pad during the final phase of monitoring once metal release rates were observed to stabilize.

Table 6-15
Operational and Post-Closure Mine Water Quality (mg/L)

	Post Closure			Operations		
	Scenario 1 Acidic CCR before flooding	**Scenario 2 CCR not acidic before flooding**	**Scenario 3 Long Term WQ**	**Scenario 1 Dewatering Wells**	**Scenario 2 Mine Void with 4S CCR**	**Scenario 3 Mine Void without 4S CCR**
pH	6.47	7.58	7.48	8.35	2.29	7.70
SO_4	2070	1210	19	9	2510	723
Al	0.038	0.022	0.0049	0.003	39.7	3.01
As	0.286	0.269	0.204	0.336	2.00	0.027
B	1.75	0.78	0.38	0.59	0.12	0.190
Cd	0.00037	0.00017	0.00001	0.00001	0.0014	0.00019
Co	0.551	0.026	0.0009	0.0001	0.202	0.099
Cu	0.019	0.001	0.001	0.001	2.04	0.012
Fe	262.400	1.610	0.288	0.259	741	7.9
Pb	0.0076	0.0002	0.0001	0.0001	0.0025	0.001
Mn	5.981	2.460	0.659	0.025	5.620	2.86
Ni	0.640	0.060	0.001	0.001	0.460	0.186
Se	0.009	0.003	0.0001	0.0001	0.0050	0.0026
Zn	0.120	0.072	0.003	0.003	0.733	0.113

Operations Scenario 3 - Mine Sump Water Quality without Coarse Reject

Where the 4 Seam is present at a thickness of < 1.5 meters, both the 4 and 4L Seams will be removed concurrently. Where the 4 Seam is present in a significant thickness, mining of the 7SA5 will occur through development of the 4 Seam coal on entering a gallery followed by development of the 4L seam coal on exiting a gallery. Subsequent to mining both the 4 and 4L coal measures, exposures of the hanging wall, footwall, 4 Seam coal, 4L Seam coal and partings will be available to oxidation and leaching. Initially, there will be adequate NP to maintain alkaline conditions in the mine. However, portions of the exposed PAG coal strata on the roof, walls and floor of the mine will start to become acidic if exposure times exceed 2 years. Under these conditions, metals and acidity will be stored on the mine walls in the form of secondary oxide and sulphate minerals but a portion of the metals and acidity produced by sulphide oxidation will be rinsed from the walls and released directly to the waters flowing into the mine. Initially, under the pH neutral condition mine water chemistry will be similar to Scenario 1. However, the influence of ML/ARD reactions will become more pronounced with increased exposure time and the metal concentrations will increase in the mine water.

Water quality for dewatering from sumps within the mine workings is estimated from the existing 7 South portal sump water quality monitoring data. The 7 South portal pit sump receives water pumped from the 7 South underground mine as well as runoff water from the exposed 7 South portal pit walls, which are partially acidic. The predicted values reported for Scenario 3 are the 90^{th} percentile values from the monitoring period extending from June 2012 to January 2013.

6.6.2 Post-closure Mine Water Quality

The post-closure mine water chemistry is estimated for three different closure scenarios. During the post-closure period, the underground mine workings will be completely flooded. Scenario 1 is essentially a worst case scenario where the mine workings and 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 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 range water chemistry for post-closure conditions is presented in Table 6-15.

Post-closure Scenario 1 – Worst Case – Acidic Conditions Prior to Flooding

The worst case water quality in 7SA5 would be realized if the mine workings were left exposed for an extended period of time and acidic conditions developed within the mine workings before they are flooded. Under flooded conditions, oxygen transfer from the atmosphere to the mine void will be severely restricted and acid generation via sulphide oxidation essentially stops. However, the secondary minerals formed during exposure are highly to moderately soluble and would dissolve when the mine workings are allowed to flood thereby releasing stored metals and generating acidity. It has been noted that the acidic juvenile mine pool waters typically evolve over time in flooded coal mines. Acidic juvenile underground coal mine waters that contain elevated concentrations of dissolved Fe and Al evolve to mature waters that are strongly reduced, pH neutral, alkaline with high sodium, iron and sulphate concentrations. Consistent with the literature, mine water maturation has been observed at Quinsam in the 4 South Mine.

Estimates of water quality are made by selecting the maximum concentration observed in 4 Seam CCR saturated columns and direct measurements of mine pool water from the 4 South mine void.

Post-closure Scenario 2 – Expected Case – pH Neutral Conditions Prior to Flooding

The mine planning and coarse reject management will restrict the development of acidic conditions in the mine. Under pH-neutral conditions, metal accumulation rates will be reduced due to a slower rate of sulphide oxidation. Although at a slower rate, oxidation products will accumulate and, similar to the acidic case in Scenario 1, these oxidation products will solubilise and be released to the mine pool when the mine void is flooded.

Estimates of water quality are made using the greatest value from the 95^{th} percentile concentrations from the 4 Seam coarse reject saturated columns and the average baseline groundwater quality measured from borehole QU11-28, which was screened in 4 Seam.

Post-closure Scenario 3 – Long Term

In the long term the influence of groundwater water recharge contributes to the maturation of mine pool chemistry. Recharging waters contribute alkalinity loads to the mine pool and in instances where high rates of recharge are expected, groundwater can be the major factor controlling the maturation of mine pool chemistry. The influence of recharging waters can also result in the stratification of the mine pool with the upper portion of the mine pool taking on a chemical signature similar to the less mineralized recharging waters. In these cases the lower portion of the mine pool can retain a mineralized signature with high dissolved iron and sulphate content.

Estimates of long term water quality for portions of the mine pool that are connected to the recharging groundwater system are made using the greatest value from the median concentrations from the 4 Seam coarse reject saturated columns and the average baseline groundwater quality measured from borehole QU11-28.

7. Water Quality Effects Model

QUINSAM COAL

7. Water Quality Effects Model

7.1 Overview

Water quality modeling has been undertaken to assess water quality during operations and post-closure. During operational dewatering of the 7SA5 mine, predicted concentrations in water discharged from the authorized SP4 sediment pond are presented in Section 7.2. Section 7.3 outlines the predicted post-closure concentrations in the Iron River and Quinsam River from the 7SA5 mine seepage once the mine is allowed to flood. In addition, a cumulative effects model has been prepared assessing the predicted long-term concentrations for the Quinsam River, which account for post-closure conditions for all of the existing Quinsam mine areas (Section 7.4).

7.2 Operational Discharge Loading Assessment

The operational loading assessment presented in this section of the report aims to quantify future changes in SP4 water quality assuming a portion of the estimated groundwater inflow to 7 South Area 5 is directed to the sediment pond. A description of the loading model and available data sources follows in Sections 7.1.1, 7.1.2 and 7.1.3, noting that the operational loading assessment focuses on two operational periods - 2015 and 2018 that express the range of expected discharge volumes from the mine. Water quality predictions for a future SP4 were screened to current permit limits for the sediment pond and are reported in Section 7.1.4. As per the Quinsam Coal Mine discharge authorization, the following permit limits were applied in the loading assessment (Table 7-1).

Table 7-1:
SP4 Permit Limits.

Parameter	Value*
Al	0.5 mg/L
Cu	0.02 mg/L
Fe	0.3 mg/L
Pb	0.05 mg/L
Zn	0.1 mg/L

(* as dissolved metals)

Expected mining advance by year and associated groundwater inflow to the 7SA5 mine void are summarized by Figure 7-1 and Table 7-2. Reproduced from the QCC operational water management plan, these data show an expected increase in groundwater inflow from 0.95 L/s (mid-2014) to 12.0 L/s by end of 2018. These produced water

volumes may be managed within the existing underground (*e.g.*, 7S Area 2 or 5 North Underground, see Table 7-2. Alternatively, they may be directed via the surface tailings storage facility and tailings injection before discharge via Sediment Pond 4 (SP4).

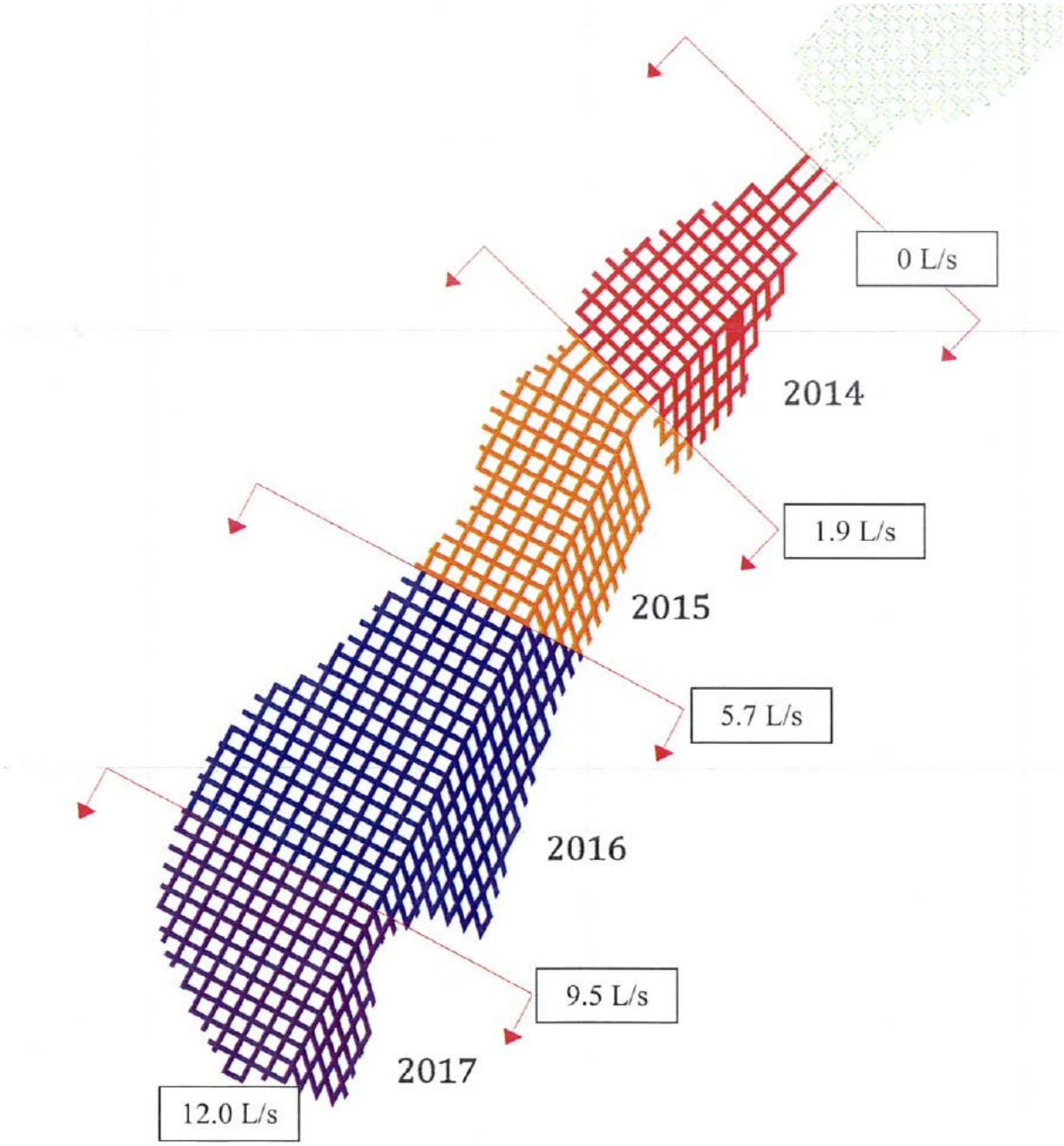


Figure 7-1: Predicted groundwater inflow rates and mining advance for 7 South Area 5.

Table 7-2:
Operational Water Balance for 7 South Area 5.

Component of Operational Water Balance	2014	2015	2016	2017	2018	Total
Days with exposed workings (n)	275	365	365	365	365	---
Average inflow rate (L/s)	0.95	3.8	7.6	10.8	12.0	---
Pumping quantity (m^3)	22,600	119,800	239,700	340,600	378,400	1,101,100
Pumping discharge (m^3)						
7S Area 2 (m^3)	14,500	30,000	32,200	2,100	---	78,800
5-South Underground (m^3)	8,100	89,800	207,500	338,500	378,400	1,022,300

7.2.1 Operational Loading Model Methodology

SP4 water quality changes owing to the addition of mine void waters from 7S Area 5 were estimated with a mass loading model. Future SP4 concentrations were computed per the equation:

$$C_f = (C_p \cdot V_p + C_g \cdot V_g)/(V_p + V_g)$$

where C_f is the future concentration at SP4, C_p and V_p are current values for concentration and volume representing SP4, and C_g and V_g are estimated future values for concentration and volume representing groundwater from the 7S Area 5 mine void. Flows used to represent SP4 prior to 7S Area 5 advancement are presented in Section 7.1.2.1 below. In the loading model, dissolved metal concentrations representing the mine void water were mixed with total and dissolved metal concentrations representing SP4 (see Section 7.1.2.3 for more detail). Further, predicted concentrations at SP4 are tabled in Section 7.1.3 for the following four scenarios:

- Scenario 3a. 2015, 10% of groundwater inflow to 7S Area 5 directed to SP4;
- Scenario 3b. 2015, 30% of groundwater inflow to 7S Area 5 directed to SP4;
- Scenario 3c. 2018, 10% of groundwater inflow to 7S Area 5 directed to SP4;
- Scenario 3d. 2018, 30% of groundwater inflow to 7S Area 5 directed to SP4;

The range of 7SA5 dewatering volumes entered into the loading model for the scenarios (10% to 30%) are the expected volumes of groundwater that will be directed to sediment pond SP4 and not be entrained in the tailings pore water underground or evaporate from the tailings pond or 2N mine sump. Together, these scenarios envelope the range of future water management and resultant water quality conditions for SP4 during the development of 7SA5.

An example calculation is presented below using the January sulphate water quality prediction for Scenario 3a, component flows and chemistries entered into the loading model included:

C_p = 528 mg/L (refer to month of January in Table 7-4 introduced later in this section)

V_p = 0.15 m^3/s or 401,760 m^3 per month

C_g = 723 mg/L (refer to Table 6-15)

V_g = 0.00038 m^3/s or 1,018 m^3 per month (refer to Section 7.1.2.2; 10% of 3.8 L/s)

Since,

$$C_f = (C_p \cdot V_p + C_g \cdot V_g)/(V_p + V_g)$$

C_f = (723 · 1,018 + 528 · 401,760) / (1,018 + 401,760)

C_f = 528.493 or 528 mg/L SO_4

7.2.2 Derivation of Model Input

7.2.2.1 Sediment Pond SP4 Discharge Rates

Monthly discharge measurements for SP4 were provided by Quinsam Coal Corporation (see Table 7-3 and Figure 7-2), and were based on daily measurements of discharge recorded at the pond. The period of record for the data provided covered January 2010 through December 2012, however, only SP4 discharge data for the 2012 calendar year was entered into the operational loading model.

Table 7-3:
SP4 Flows Prior to 7 South Area 5 Advancement.

	Discharge (m^3/s)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
2010	0.188	0.148	0.100	0.123	0.068	0.032	0.017	0.023	0.030	0.036	0.064	0.147	0.081
2011	0.151	0.164	0.146	0.121	0.070	0.085	0.045	0.040	0.024	0.053	0.093	0.104	0.091
2012	0.150	0.154	0.165	0.143	0.062	0.040	0.073	0.063	0.070	0.063	0.148	0.183	0.109
Average	0.163	0.155	0.137	0.129	0.066	0.052	0.045	0.042	0.041	0.051	0.102	0.144	0.094

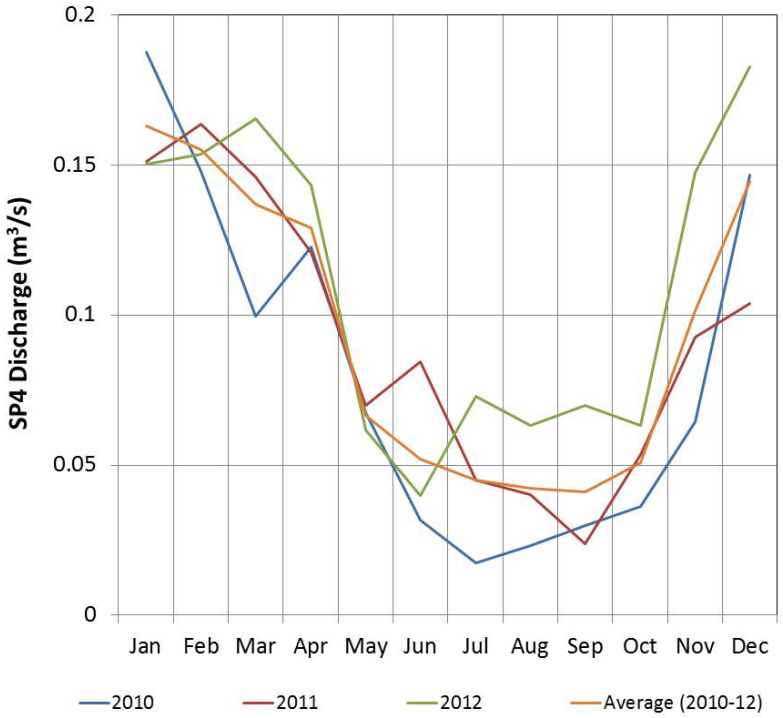


Figure 7-2: Sediment Pond 4 (SP4) monthly discharges for period of record 2010-12.

Monthly SP4 discharge values entered into the loading model were based on 2012 measurements because these flows account for both the effects of 2N/3N mine water displaced by tailings disposal in 2N/3N mines and groundwater regular dewatering from 2N/3N mines. Tailings disposal will continue during operational phases of 7S Area 5, and therefore 2012 discharges are viewed as the best surrogate for discharge from SP4 during 7SA5 mine dewatering period through to the end of 2018.

The rationale for using 2012 discharge measurements was supported by local climate data that indicate 2010 precipitation was very high (wet) (*e.g.*, 1,900 mm/yr at Campbell River compared to a 30-year normal value of ~1,450 mm/yr), whereas 2011 and 2012 precipitation was 1,400 and 1,650 mm/yr and more normal. Based on precipitation depths alone, the expectation is that SP4 discharges would be greatest in 2010. However, 2012 monthly discharges at SP4 typically exceeded those measured in 2010 and 2011, which is attributed to active waste and water management on site.

7.2.2.2 7S Area 5 Dewatering Rates

The 7SA5 dewatering volumes expected to discharge to SP4 during 2015 and 2018 were obtained from the Quinsam Coal Mine operational water management plan (see

Table 7-2 and Figure 7-1). Specifically, it was assumed that 10 and 30% of the groundwater inflow (*i.e.*, 10 and 30% of 3.9 L/s for 2015; 10 and 30% of 12 L/s at end of 2018) would be directed to SP4 for surface discharge. Of the scenarios considered in the loading assessment, Section 7.1.3 results are bracketed by the 2015, 10% Scenario (*i.e.*, Scenario 3a - best water quality is returned be the loading model) and the 2018, 30% Scenario (*i.e.*, Scenario 3d - worst water quality is returned by the loading model).

7.2.2.3 7SA5 Geochemical Source Terms and SP4 Background Concentrations

Geochemical source terms from the 7SA5 mine void were derived for sixteen parameters as described in Section 6.6. Source terms input into the operational loading model described in this chapter are those from Operations-Scenario 3 that assumes concentrations from mine water that has only come into contact with mine workings in the absence of stowed coarse reject. In addition, the risk of elevated As concentrations in the SP4 discharge were assessed using the observed background concentrations listed for Operations-Scenario 1 (Table 6-15). The geochemical source terms entered into the operational loading model were assumed constant each month of the year. Further, the geochemical source terms applied to 7S Area 5 groundwater inflows were assumed to be the same for the 2015 and 2018.

The average monthly background concentrations for SP4 that were entered into the loading model are presented in Table 7-4. Although no background concentration exceeded a permit limit for the sediment pond, some monthly values approach the British Columbia fresh water aquatic life guidelines for receiving waters.

For example, Cd-T exceeded the BC FWAL maximum guideline for Oct (Cd-T source term value was 0.00011 mg/L). Monthly sulphate values were also notably high and ranged from 500 to 850 mg/L over the year. SP4 hardness values ranged between 300 and 400 mg/L $CaCO_3$.

As shown in Table 7-4, Fe-D concentrations were below the permit limit value of 0.3 mg/L every month of the year. pH of the pond in the during operation of 7SA5 (*i.e.*, 2015, 2018) is expected to remain alkaline to pH neutral. Therefore, the expectation is that future Fe-D values will remain low, as currently observed and iron loading to SP4 will continue to be primarily in the form of Fe-T.

Average monthly background concentrations in the SP4 pond (*i.e.*, conditions prior to the advancement of 7S Area 5) used in the loading model were derived from water quality monitoring data from 2010 to 2012. A review of this data revealed the following trends and signatures.

pH and Sulphate

In comparison to total and dissolved metal data, there were considerably more data at SP4 for these two parameters. Between 8 and 16 data points per month were averaged together to yield pond source terms for pH and sulphate.

For the period of record, pH typically varied between 7.9 and 8.3 (pH units) whereas sulphate ranges from 400 mg/L (Jan, Feb and Mar) to 1,000 mg/L (Sept, Oct) within SP4. Time series for pH and sulphate shown in Figure 7-3 and Figure 7-4 give indication of recent inter- and intra-annual variability at SP4.

Iron Species

Given the pH of the sediment pond, the expectation is that ferric hydroxide ($Fe(OH)_3$) species will predominate and will report as total Fe rather than a dissolved fraction (Brownlow, 1996). Therefore, it is fully expected that SP4 Fe-D concentrations will be similar to current values in 2015 and 2018.

Total and Dissolved Metals

Monthly source terms were produced for Al-T, Al-D, As-T, B-T, Cd-T, Co-T, Cu-T, Fe-T, Fe-D, Pb-T, Mn-T, Ni-T, Se-T, Zn-T, Ca-T and Mg-T. Monthly measurements from 2010 to 2012 were averaged to define source terms for Al-T, B-T, Fe-T, Mn-T, Ca-T and Mg-T (see Figure 7-5 and Figure 7-6 for representative examples of data quality and quantity). Due to lower sample frequency compared to pH and sulphate, there were less data available to compute monthly source terms for these parameters. However, with the exception of February (n=1), there were still typically 2-4 measurements available to define a monthly source term.

For a portion of 2010, method detection limits were poor for the following parameters: Al-D, As-T, Cd-T, Cu-T, Fe-D, Ni-T, Pb-T, Se-T and Zn-T (see Figure 7-7; data for Cu-T, Pb-T and Se-T shown). Therefore, the monthly source terms computed for these parameters excluded affected measurements from 2010.

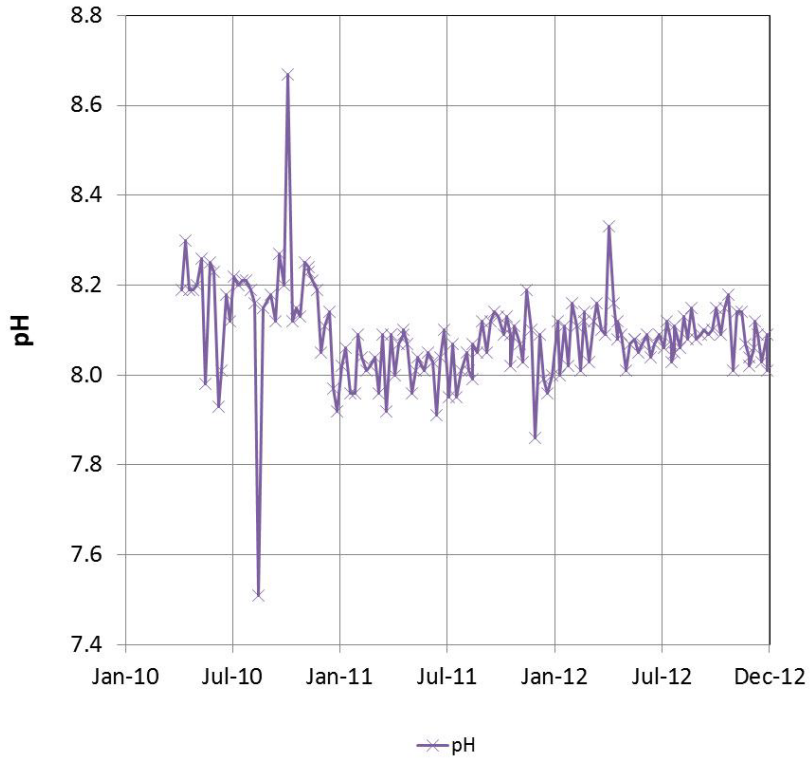


Figure 7-3: SP4 time series for pH (2010 to 2012).

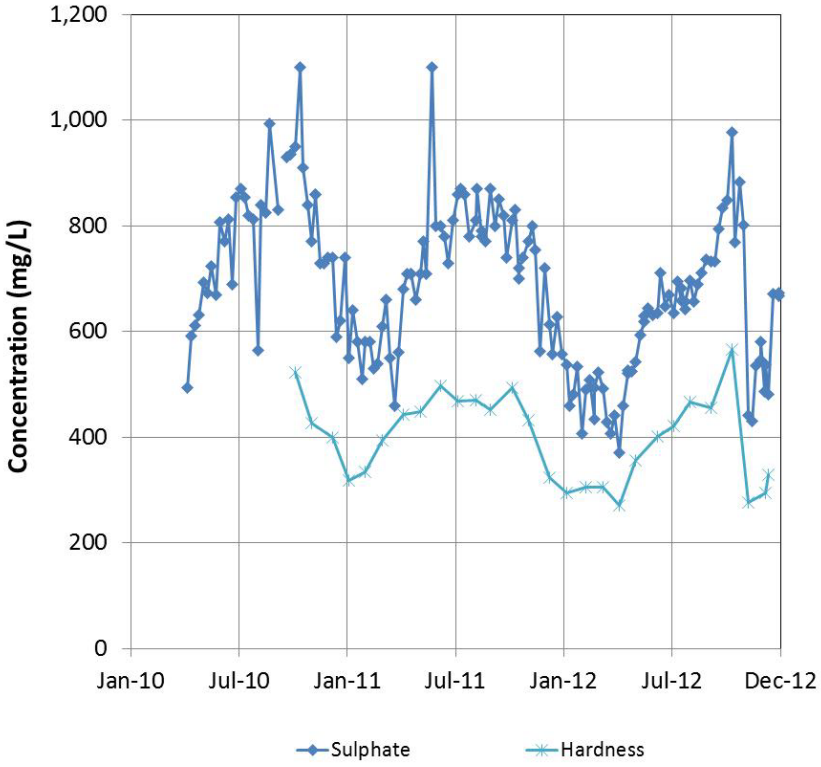


Figure 7-4: SP4 time series for sulphate and hardness (2010 to 2012).

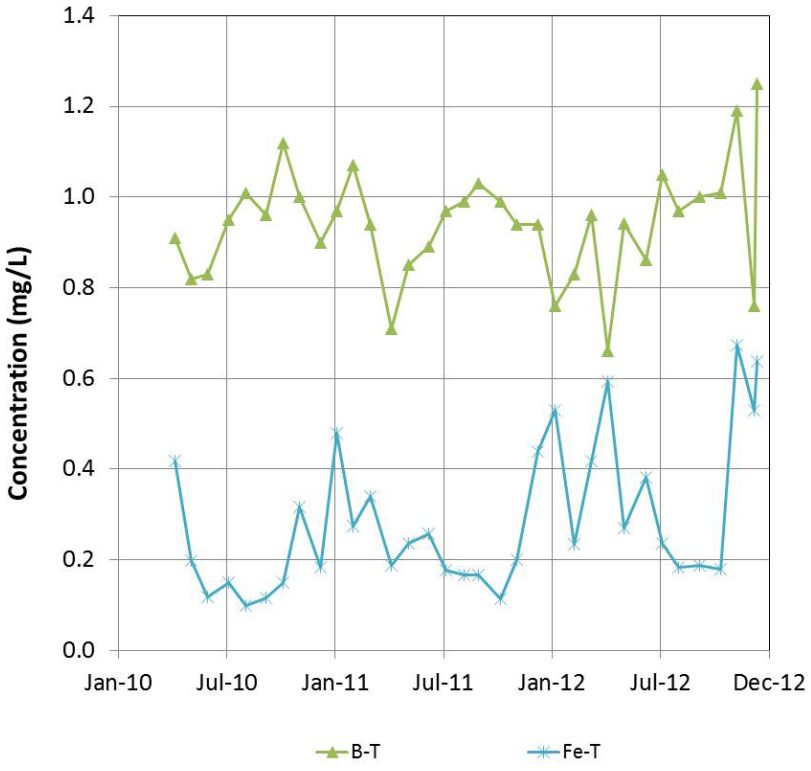


Figure 7-5: SP4 time series for boron and total iron (2010 to 2012).

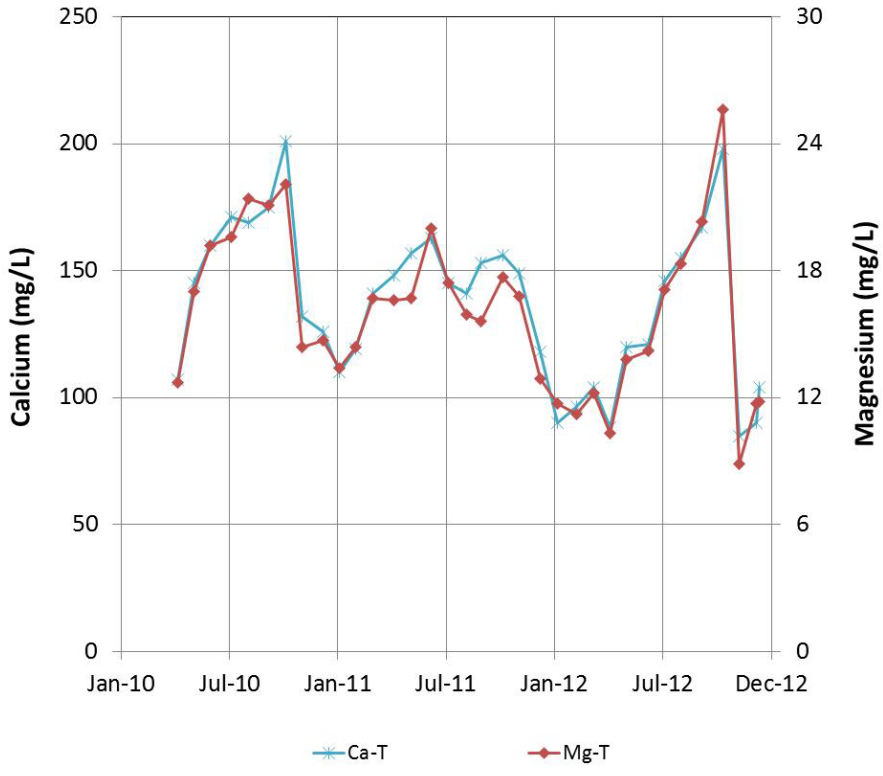


Figure 7-6: SP4 time series for calcium and magnesium (2010 to 2012).

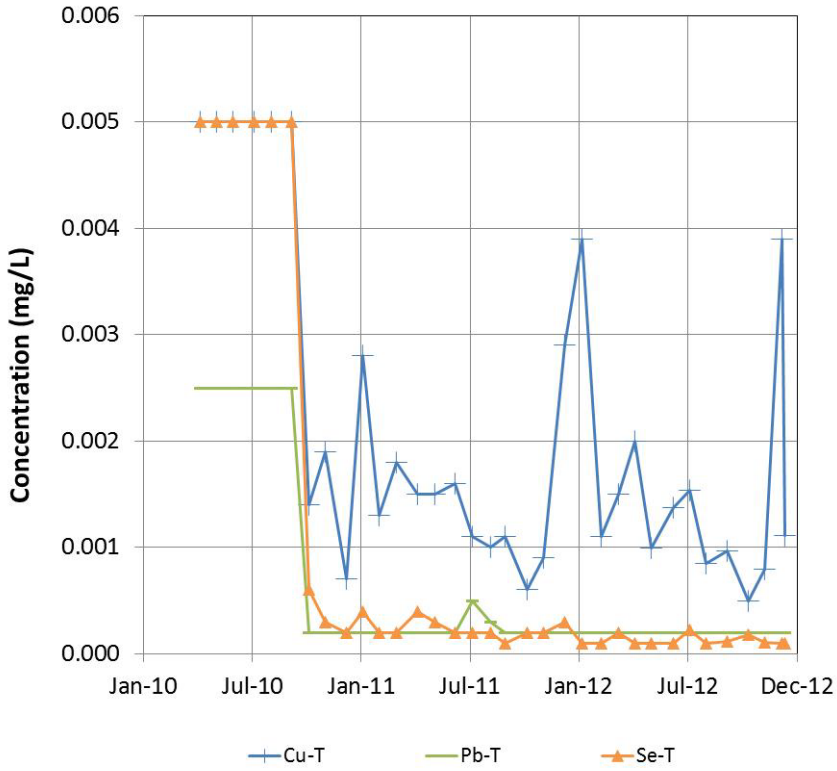


Figure 7-7: SP4 time series for Cu-T, Pb-T and Se-T (2010 to 2012).

Table 7-4:
Monthly source terms values used to represent SP4 prior to 7S Area 5 advancement.

	Concentration (mg/L - except pH)											
Parameter	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
pH	8.05	8.06	8.06	8.14	8.08	8.05	8.09	8.05	8.13	8.15	8.11	8.04
SO_4	**528**	**512**	**512**	**586**	**707**	**743**	**764**	**774**	**751**	**849**	**677**	**612**
Al-T	0.11	0.05	0.09	0.16	0.05	0.06	0.06	0.03	0.06	0.03	0.05	0.10
Al-D	0.019	0.024	0.011	0.016	0.005	0.014	0.007	0.007	0.003	0.012	0.006	0.015
As-T	0.0017	0.0018	0.0018	0.0015	0.0012	0.0011	0.0013	0.0011	0.0010	0.0009	0.0035	0.0027
B-T	0.93	0.83	0.95	0.76	0.86	0.88	0.99	1.00	0.98	1.04	1.04	0.96
Cd-T	0.000030	0.000020	0.000015	0.000020	0.000027	0.000044	0.000013	0.000023	0.000010	**0.000110**	0.000028	0.000018
Co-T	0.00223	0.00070	0.00110	0.00160	0.00160	0.00115	0.00065	0.00050	0.00050	0.00053	0.00050	0.00132
Cu-T	0.0027	0.0011	0.0017	0.0018	0.0012	0.0015	0.0013	0.0010	0.0010	0.0008	0.0012	0.0022
Fe-T	0.43	0.24	0.38	0.40	0.21	0.32	0.19	0.15	0.15	0.15	0.40	0.45
Fe-D	0.013	0.092	0.007	0.008	0.120	0.007	0.005	0.008	0.007	0.017	0.012	0.012
Pb-T	0.00020	0.00020	0.00020	0.00020	0.00020	0.00020	0.00035	0.00023	0.00020	0.00020	0.00020	0.00020
Mn-T	0.10	0.05	0.09	0.07	0.07	0.08	0.05	0.04	0.04	0.03	0.05	0.08
Ni-T	0.0053	0.0020	0.0035	0.0050	0.0051	0.0047	0.0026	0.0020	0.0017	0.0025	0.0019	0.0039
Se-T	0.00023	0.00010	0.00020	0.00025	0.00020	0.00015	0.00021	0.00013	0.00012	0.00033	0.00020	0.00018
Zn-T	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Ca-T	106	96	123	114	146	142	154	155	171	185	122	110
Mg-T	13	11	14	13	17	17	18	18	21	22	13	13

Notes:
Pink shaded values indicate an exceedance to a BC FWAL 30-day guideline. Bolded values indicate and exceedance to a BC FWAL maximum guideline. In the table, sulphate is screened to a value of 100 mg/L. Owing to high hardness values in SP4 (300-400 mg/L) the hardness-dependent sulphate guideline indicates site-specific testing is required prior to usage).

7.2.3 Results

7.2.3.1 Predicted SP4 Concentrations for Scenarios 3a and 3b

Results for Scenarios 3a and 3b are summarized in Table 7-5 and Table 7-6Table 7-8. Results are also summarized for a select number of parameters in Figure 7-8 and Figure 7-9.

Scenarios 3a and 3b (*i.e.*, 2015, 10 and 30% of groundwater inflow to SP4) returned no permit limit exceedances at SP4. For Scenario 5, the loading model predicted Fe-D would exceed the SP4 permit limit value of 0.3 mg/L between May and October. However, given the neutral pH of the SP4 discharge, the modelled Fe-D loads are expected to be present primarily in the total Fe fraction due to precipitation as ferric hydroxides.

Figure 7-8 summarizes 2015 model results for Al-D and As-T. Predicted Al-D concentrations showed no exceedances to the SP4 permit limit of 0.5 mg/L. Loading model results for As-T are shown in Figure 7-8 (lower plot). They show no exceedances to the BC maximum guideline (0.005 mg/L), although the modeled concentrations increase above the current background SP4 concentrations. This is most noticeable between June and October that coincides with the period of time when pond discharges are at their lowest. There is no permit limit for arsenic.

Figure 7-9 summarizes 2015 model results for Co-T and Fe-T, which illustrate Co-T concentrations are estimated to be elevated above background concentrations for both scenarios. Like Co-T, results for Fe-T are estimated to be elevated to current conditions at SP4 (Figure 7-9 (lower plot)), but all estimates plot below the BC freshwater aquatic life maximum guideline for receiving waters of 1.0 mg/L.

7.2.3.2 Predicted SP4 Concentrations for Scenarios 3c and 3d

Results for Scenarios 3c, and 3d are summarized in Table 7-7 and Table 7-8. Scenario 3c (*i.e.*, 2018, 10% of groundwater inflow to SP4) returned no permit limit exceedances. Scenario 3d (2018, 30% of groundwater inflow to SP4) predicted Fe-D concentrations exceeding permit guideline for the months May through October. However, actual Fe-D concentrations are expected to remain similar to historic background concentrations below the permit limit value of 0.3 mg/L (see discussion of pH control in previous section).

Figure 7-10 summarizes 2018 model results for Al-D and As-T. As shown in Figure 7-10 (upper plot), Al-D returned a single permit limit exceedance for the 2018 scenarios (*i.e.*, occurs during 2018, 100% groundwater inflow scenario). Loading model results for As-T are shown in Figure 7-10 (lower plot) and illustrate that predicted concentrations increase

above current background SP4 concentrations – particularly between June and October when pond discharges are at their lowest.

Figure 7-11 summarizes 2018 model results for Co-T and Fe-T. As shown in Figure 7-11 (upper plot), Co-T concentrations are predicted to increase above background concentrations for all scenarios. Further, estimates exceed the BC 30-day guideline (0.004 mg/L) for several months of year under Scenario 3d (2018, 30% of groundwater inflow diverted to SP4). Like Co-T, results for Fe-T are estimated to increase above background conditions at SP4 (Figure 7-11 (lower plot). Fe-T estimates are predicted to remain below the BC maximum guideline value of 1.0 mg/L for Scenarios 3c and 3d (10%, 30% groundwater inflow).

7.2.3.3 Effect of Elevated 7SA5 Arsenic Concentrations at SP4

Baseline groundwater chemistry and kinetic testing indicates that elevated arsenic concentrations may leach from the strata adjacent to the 7 South coal measures. To evaluate this risk on water discharging to the SP4 sediment pond an arsenic source concentration of 0.336 mg/L was input into the SP4 operational loading model. This arsenic source concentration is consistent with 7SA5 baseline groundwater arsenic concentrations presented for Operations-Scenario 1 source terms in Table 6-15.

The results of the loading assessment are presented in Figure 7-12. The results indicate that during the early years of mine development when dewatering rates from 7SA5 are on the order of 1 L/s, As concentrations will remain at or below 0.010 mg/L in the SP4 sediment pond discharge. However, under the higher dewatering rates expected during the later years of 7SA5 mine development concentrations at SP4 approaching 0.030 mg/L are possible.

Table 7-5:
Scenario 3a, 2015 – 10% of 3.8 L/s discharged to SP4.

	Concentration (mg/L - except pH)											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
pH	8.05	8.06	8.06	8.14	8.08	8.05	8.09	8.05	8.13	8.15	8.11	8.04
SO_4	528	513	513	586	707	742	764	773	751	848	677	612
Al-T	0.121	0.056	0.092	0.163	0.063	0.089	0.079	0.045	0.072	0.047	0.056	0.109
Al-D	0.027	0.031	0.018	0.024	0.024	0.042	0.022	0.025	0.019	0.030	0.013	0.021
As-T	0.0018	0.0019	0.0019	0.0016	0.0013	0.0013	0.0014	0.0013	0.0012	0.0011	0.0035	0.0027
B-T	0.93	0.83	0.95	0.76	0.86	0.87	0.99	0.99	0.98	1.03	1.04	0.96
Cd-T	0.000030	0.000020	0.000015	0.000020	0.000028	0.000045	0.000013	0.000024	0.000011	0.000111	0.000029	0.000019
Co-T	0.0025	0.0009	0.0013	0.0019	0.0022	0.0021	0.0012	0.0011	0.0010	0.0011	0.0008	0.0015
Cu-T	0.0027	0.0011	0.0017	0.0018	0.0013	0.0016	0.0014	0.0010	0.0010	0.0009	0.0012	0.0022
Fe-T	0.45	0.25	0.40	0.42	0.25	0.39	0.23	0.20	0.19	0.19	0.42	0.46
Fe-D	0.033	0.111	0.025	0.029	0.167	0.081	0.046	0.055	0.050	0.064	0.032	0.029
Pb-T	0.000203	0.000202	0.000202	0.000203	0.000206	0.00021	0.000354	0.000239	0.000205	0.000206	0.000203	0.000202
Mn-T	0.102	0.061	0.094	0.075	0.086	0.103	0.066	0.054	0.055	0.049	0.057	0.087
Ni-T	0.0058	0.0025	0.0039	0.0055	0.0062	0.0064	0.0035	0.0031	0.0027	0.0036	0.0024	0.0043
Se-T	0.00024	0.00011	0.00021	0.00026	0.00021	0.00017	0.00022	0.00015	0.00013	0.00034	0.00021	0.00018
Zn-T	0.0053	0.0053	0.0052	0.0053	0.0057	0.0060	0.0056	0.0056	0.0056	0.0056	0.0053	0.0052

Pink shaded values indicate a permit limit exceedance

Table 7-6:
Scenario 3b, 2015 – 30% of 3.8 L/s discharged to SP4.

	Concentration (mg/L - except pH)											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
pH	8.05	8.06	8.06	8.14	8.08	8.04	8.08	8.05	8.13	8.14	8.11	8.04
SO_4	529	514	514	587	708	742	763	773	751	846	677	612
Al-T	0.136	0.071	0.105	0.178	0.099	0.143	0.109	0.080	0.104	0.082	0.071	0.121
Al-D	0.041	0.046	0.032	0.040	0.060	0.097	0.053	0.060	0.051	0.065	0.029	0.034
As-T	0.0019	0.0020	0.0020	0.0017	0.0016	0.0018	0.0017	0.0016	0.0014	0.0014	0.0037	0.0028
B-T	0.93	0.83	0.94	0.76	0.85	0.86	0.98	0.99	0.97	1.02	1.04	0.96
Cd-T	0.000031	0.000021	0.000016	0.000021	0.000030	0.000047	0.000015	0.000026	0.000013	0.000112	0.000030	0.000019
Co-T	0.0030	0.0014	0.0018	0.0024	0.0034	0.0039	0.0022	0.0022	0.0021	0.0023	0.0013	0.0019
Cu-T	0.0027	0.0012	0.0017	0.0018	0.0014	0.0018	0.0015	0.0012	0.0011	0.0010	0.0013	0.0022
Fe-T	0.48	0.29	0.43	0.46	0.35	0.53	0.31	0.29	0.28	0.28	0.45	0.49
Fe-D	0.073	0.149	0.061	0.070	0.261	0.226	0.127	0.147	0.134	0.156	0.072	0.061
Pb-T	0.000208	0.000207	0.000207	0.000208	0.000218	0.000228	0.000363	0.000251	0.000216	0.000218	0.000208	0.000206
Mn-T	0.116	0.075	0.106	0.089	0.119	0.154	0.095	0.087	0.085	0.082	0.072	0.098
Ni-T	0.0067	0.0034	0.0048	0.0064	0.0083	0.0098	0.0054	0.0053	0.0047	0.0057	0.0033	0.0050
Se-T	0.00025	0.00012	0.00022	0.00027	0.00024	0.00022	0.00025	0.00018	0.00016	0.00037	0.00022	0.00019
Zn-T	0.0058	0.0058	0.0057	0.0059	0.0070	0.0080	0.0067	0.0069	0.0067	0.0069	0.0058	0.0057

Pink shaded values indicate a permit limit exceedance

Table 7-7:
Scenario 3c, 2018 – 10% of 12 L/s Discharged to SP4.

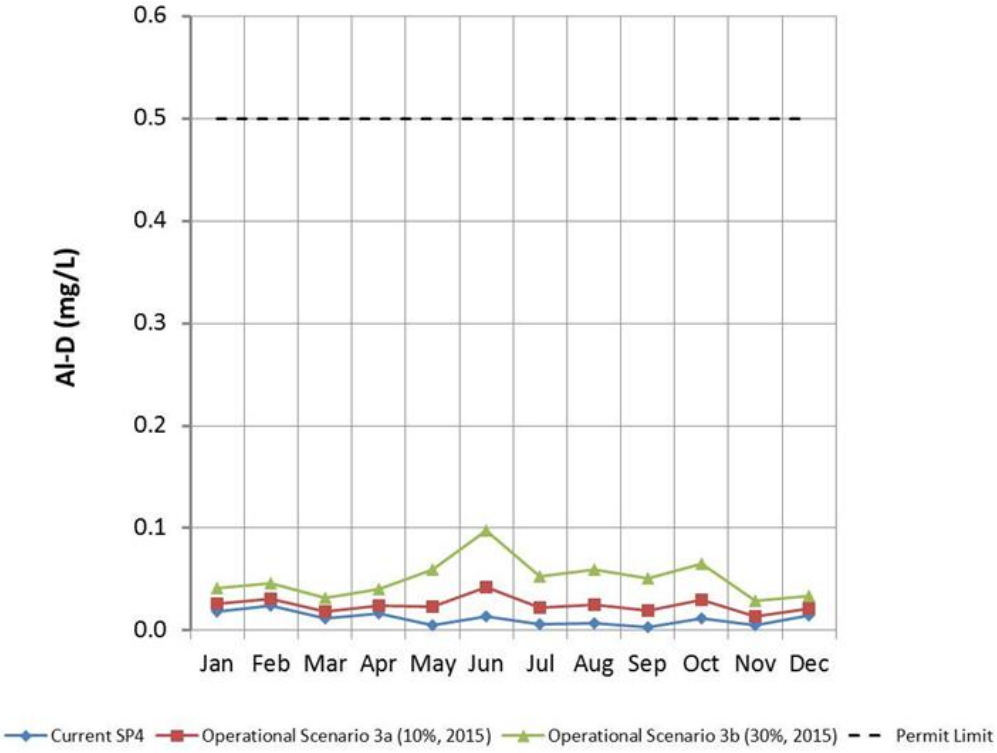
	Concentration (mg/L - except pH)											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
pH	8.05	8.06	8.06	8.14	8.08	8.04	8.08	8.05	8.13	8.14	8.11	8.04
SO_4	530	514	514	587	708	742	763	773	751	846	677	612
Al-T	0.137	0.072	0.106	0.179	0.102	0.147	0.111	0.082	0.106	0.084	0.073	0.122
Al-D	0.043	0.047	0.033	0.041	0.062	0.102	0.055	0.063	0.054	0.068	0.030	0.035
As-T	0.0019	0.0020	0.0020	0.0017	0.0017	0.0018	0.0017	0.0016	0.0015	0.0014	0.0037	0.0028
B-T	0.93	0.83	0.94	0.76	0.85	0.86	0.98	0.98	0.97	1.02	1.04	0.96
Cd-T	0.000031	0.000021	0.000016	0.000021	0.000030	0.000048	0.000015	0.000026	0.000013	0.000112	0.000030	0.000019
Co-T	0.0030	0.0015	0.0018	0.0024	0.0035	0.0040	0.0022	0.0023	0.0022	0.0024	0.0013	0.0020
Cu-T	0.0027	0.0012	0.0017	0.0018	0.0014	0.0018	0.0015	0.0012	0.0012	0.0010	0.0013	0.0022
Fe-T	0.49	0.29	0.43	0.46	0.35	0.54	0.31	0.30	0.28	0.29	0.46	0.50
Fe-D	0.076	0.152	0.064	0.073	0.268	0.238	0.133	0.154	0.141	0.164	0.075	0.064
Pb-T	0.000208	0.000208	0.000207	0.000208	0.000219	0.00023	0.000364	0.000252	0.000217	0.000219	0.000208	0.000207
Mn-T	0.117	0.076	0.107	0.090	0.122	0.158	0.097	0.090	0.088	0.085	0.073	0.099
Ni-T	0.0068	0.0034	0.0048	0.0065	0.0085	0.0100	0.0055	0.0054	0.0048	0.0059	0.0034	0.0051
Se-T	0.00025	0.00012	0.00022	0.00027	0.00025	0.00022	0.00025	0.00018	0.00016	0.00037	0.00022	0.00019
Zn-T	0.0059	0.0058	0.0058	0.0059	0.0071	0.0082	0.0067	0.0070	0.0068	0.0070	0.0059	0.0057

Pink shaded values indicate a permit limit exceedance

Table 7-8:
Scenario 3d, 2018 – 30% of 12 L/s Discharged to SP4.

	Concentration (mg/L - except pH)											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
pH	8.04	8.05	8.06	8.13	8.06	8.02	8.07	8.03	8.11	8.13	8.10	8.03
SO_4	533	517	517	589	708	741	762	771	750	842	678	614
Al-T	0.182	0.117	0.147	0.226	0.209	0.305	0.202	0.187	0.201	0.189	0.119	0.159
Al-D	0.089	0.092	0.075	0.090	0.171	0.262	0.148	0.168	0.150	0.174	0.077	0.073
As-T	0.0023	0.0024	0.0023	0.0021	0.0026	0.0032	0.0025	0.0025	0.0023	0.0023	0.0040	0.0031
B-T	0.92	0.82	0.93	0.75	0.82	0.82	0.95	0.96	0.94	0.99	1.02	0.95
Cd-T	0.000034	0.000024	0.000019	0.000024	0.000036	0.000055	0.000021	0.000032	0.000019	0.000114	0.000032	0.000021
Co-T	0.0045	0.0030	0.0032	0.0040	0.0070	0.0093	0.0053	0.0058	0.0053	0.0059	0.0029	0.0032
Cu-T	0.0029	0.0013	0.0019	0.0020	0.0018	0.0023	0.0018	0.0016	0.0015	0.0014	0.0015	0.0023
Fe-T	0.60	0.41	0.54	0.58	0.63	0.95	0.55	0.57	0.53	0.57	0.58	0.59
Fe-D	0.198	0.271	0.175	0.201	0.549	0.661	0.377	0.432	0.394	0.442	0.200	0.165
Pb-T	0.000224	0.000223	0.000222	0.000225	0.000256	0.000284	0.000391	0.000286	0.00025	0.000255	0.000224	0.00022
Mn-T	0.160	0.118	0.147	0.136	0.223	0.308	0.184	0.189	0.178	0.184	0.117	0.135
Ni-T	0.0096	0.0062	0.0074	0.0094	0.0150	0.0197	0.0112	0.0119	0.0107	0.0124	0.0063	0.0074
Se-T	0.00029	0.00016	0.00025	0.00031	0.00033	0.00035	0.00032	0.00026	0.00024	0.00045	0.00026	0.00022
Zn-T	0.0075	0.0075	0.0073	0.0076	0.0110	0.0139	0.0101	0.0108	0.0103	0.0108	0.0076	0.0071

Pink shaded values indicate a permit limit exceedance



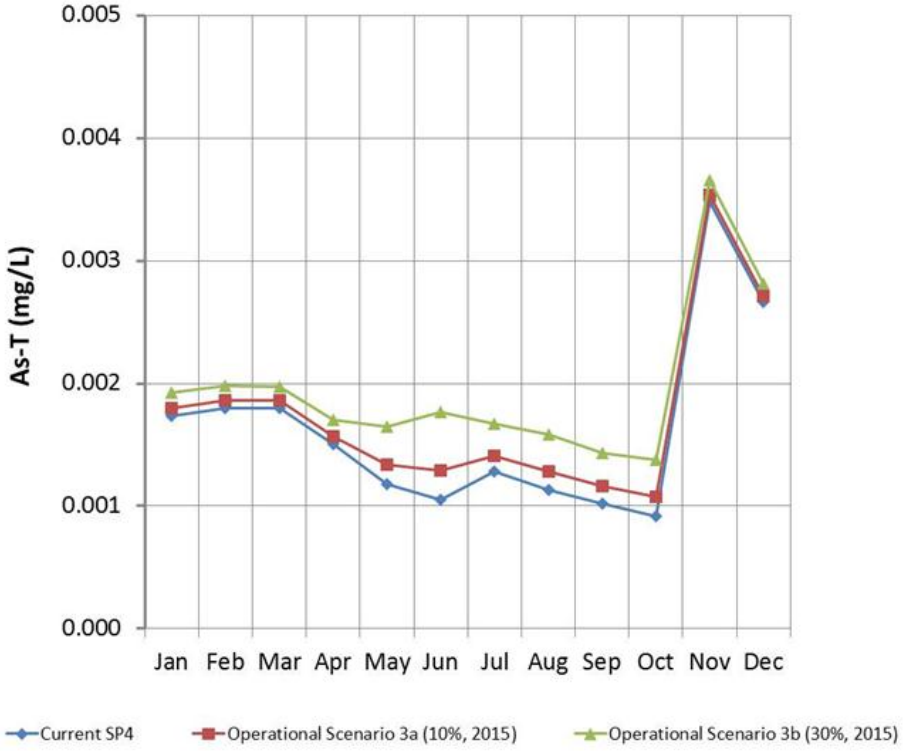
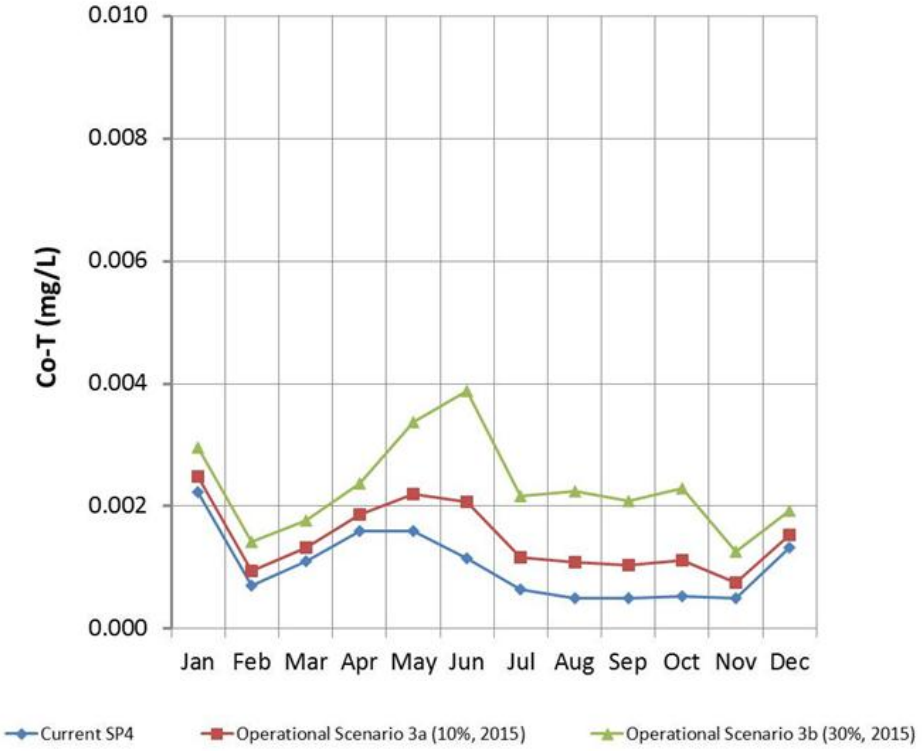


Figure 7-8: Predicted Al-D and As-T concentrations for Scenarios 3a and 3b under projected 2015 Dewatering Rates.



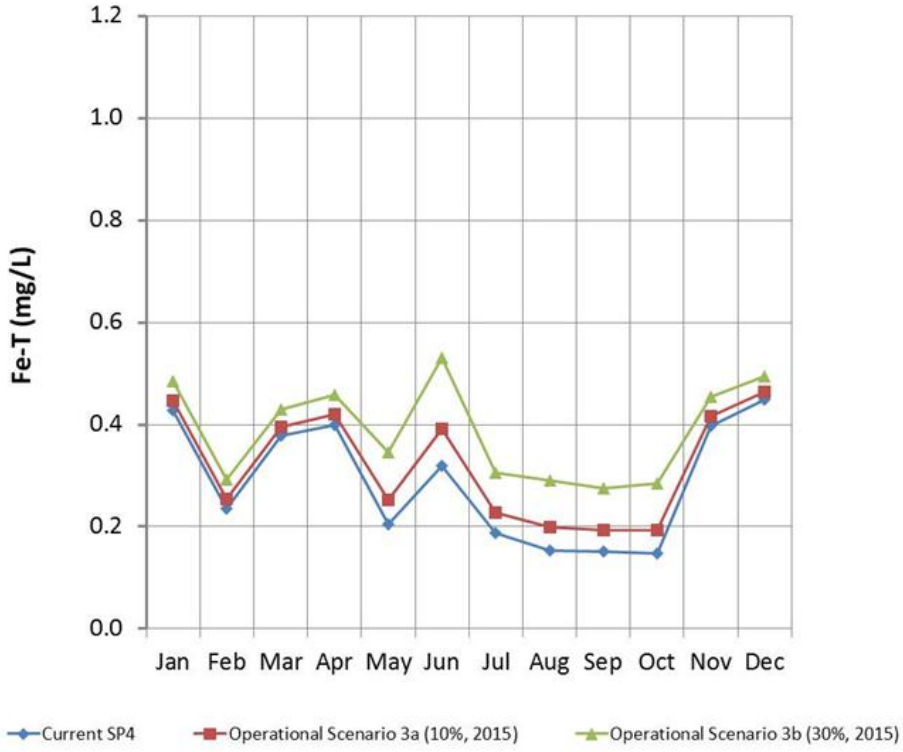
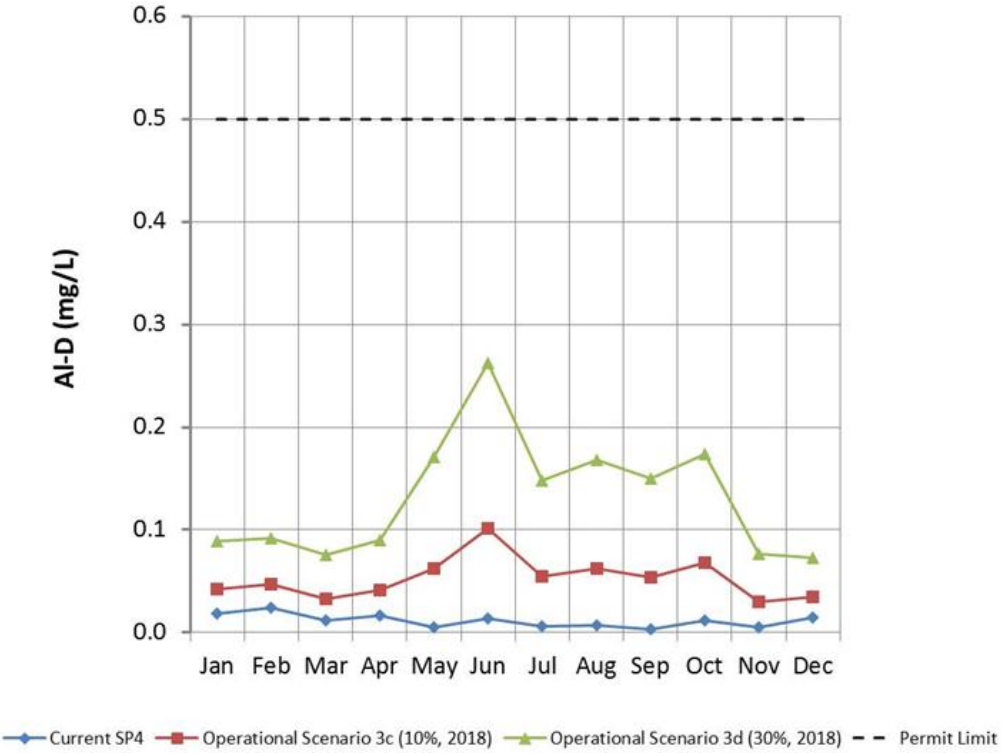


Figure 7-9: Predicted Co-D and Fe-T concentrations for Scenarios 3a and 3b under projected 2015 Dewatering Rates.



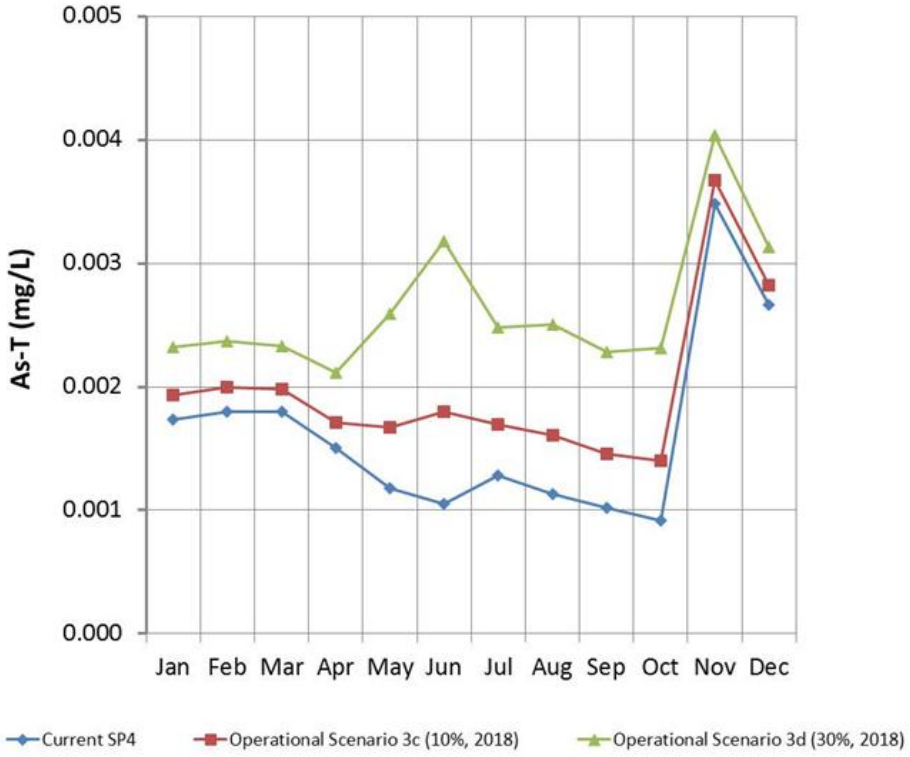
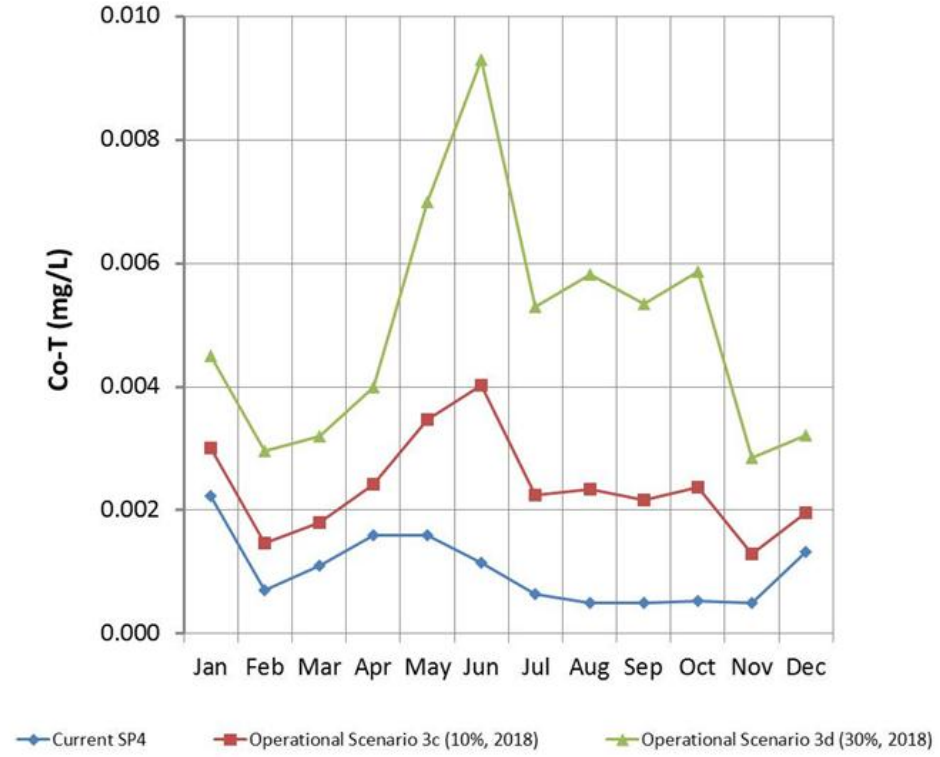


Figure 7-10: Predicted Al-D and As-T concentrations for Scenarios 3c and 3d under projected 2018 Dewatering Rates.



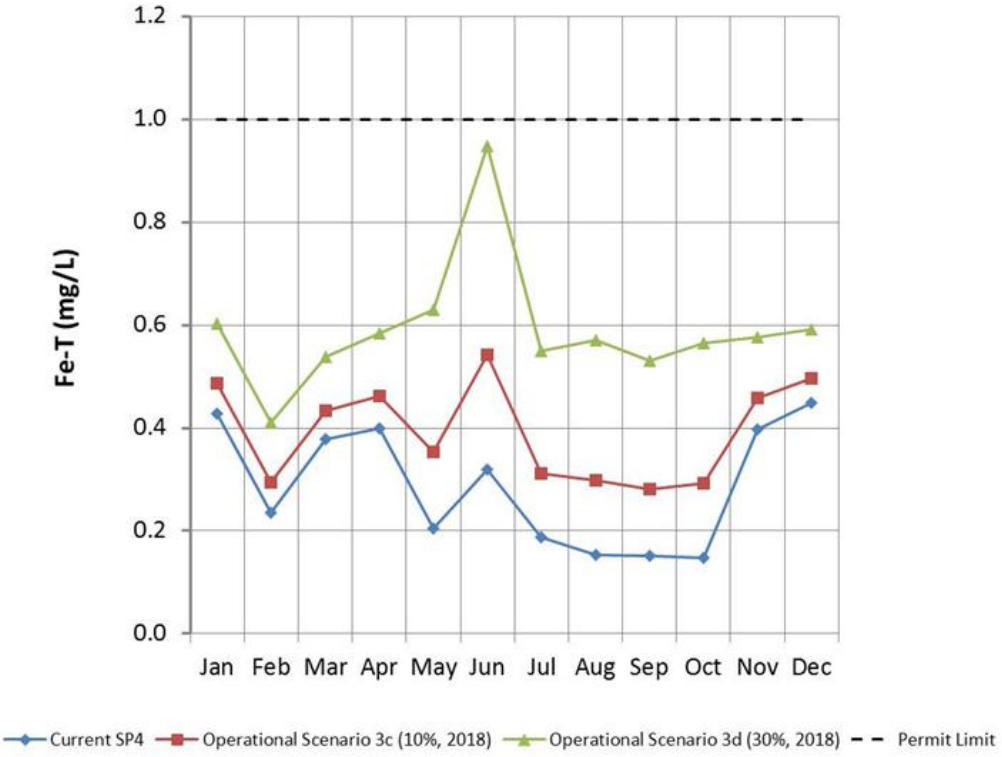
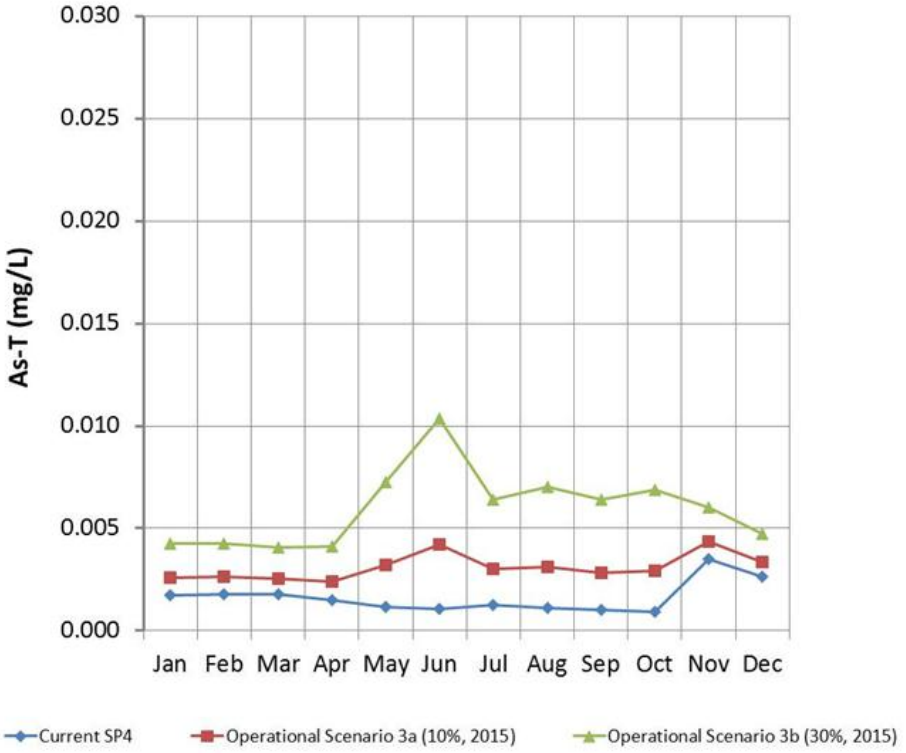


Figure 7-11: Predicted Co-T and Fe-T concentrations for Scenarios 3c and 3d under projected 2018 Dewatering Rates.



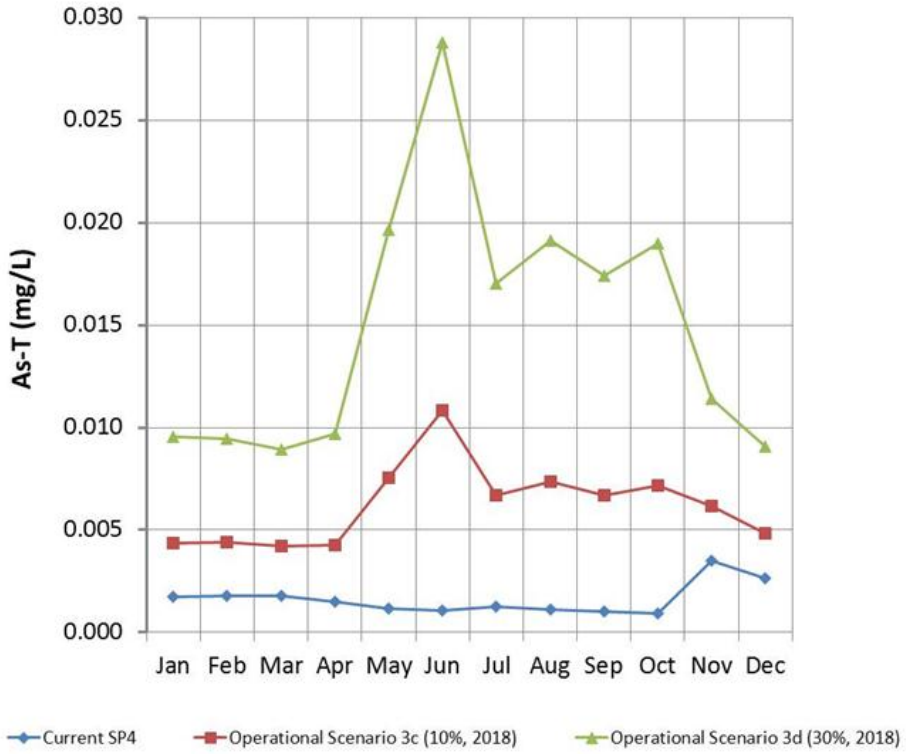


Figure 7-12: Predicted As-T concentrations for Elevated As concentrations from 7SA5 Mine Dewatering.

7.3 Post-Closure Loading Balance Model

7.3.1 Methodology and Input Sources

Post-closure water quality effects are predicted in the Iron River and Quinsam River with a mass loading model at PP1 and PP2, respectively (see Figure 4-1). This model accounts for all post-closure flows and chemical loads (*i.e.*, metals and major ions) seeping from the 7SA5 mine workings, as well as for water quality and runoff volumes from principal affected receivers (*i.e.*, Iron and Quinsam Rivers). The model is referred to as the 7SA5 Water Quality Effect Model (WQEM) in this report.

Predictions of water quality in the Iron and Quinsam Rivers were computed as per the equation:

$$C_{Final} = \frac{C_s V_s + C_n V_n}{V_s + V_n}$$

where C_{Final} is the estimated concentration at the prediction point, C_s and V_s are values for concentration and volume representing 'source load', and C_n and V_n are values for concentration and volumes representing 'non-source load'. In the WQEM, dissolved metal concentrations representing geochemistry ('source flow') are mixed with total metal concentrations representing receiver water quality condition to give a resultant total metal prediction. These predicted water quality concentrations are screened against relevant chronic and acute water quality guidelines, and the aquatic effects described.

An underpinning assumption of the WQEM is that chemical constituents behave in a conservative manner and that mass is not lost through secondary processes. For this assessment, the water balances and water quality source terms were assembled on a monthly time step, and the WQEM was run respecting the time step of those inputs. Furthermore, the WQEM was configured such that source loads would report instantaneously to the model prediction sites (on a monthly basis), with no storage or delay in the model.

The components that are input to the 7SA5 WQEM were developed and discussed in the preceding chapters. Component flows, chemistries and their connections within the 7SA5 WQEM are depicted in Figure 7-13. Each component flow and chemistry of the WQEM is described in detail in Table 7-9 and discussed briefly below. Source flow concentrations (C_s) were predicted for three post-closure scenarios – each scenario having different assumptions and geochemical inputs. The scenarios are listed below and the specifics of each scenario are described in Section 6.6.

- Scenario 1 represents worst case conditions (mine workings and the coarse reject become acidic prior to flooding).
- Scenario 2 represents expected conditions (PAG coarse reject is placed in the mine void and flooded prior to the onset of acidic conditions from the coarse reject).
- Scenario 3 represents the expected long term conditions from the flooded mine containing coarse reject.

Volumetric discharge or source flows (V_s) from the 7SA5 mine are estimated for both the operational and post-closure periods. Operational dewatering rates are discussed in Section 2.5.1 with loading model results presented in Section 7.1. With respect to post-closure, seepage estimates through the mine workings that will discharge to the Iron River are discussed in Section 2.5.2. Further, average monthly background concentrations in the Iron River and Quinsam River receiving waters (C_n) are compiled in Section 5.3 and average monthly discharge in the two rivers (V_n) is discussed in Section 4.3. In this section of the report, technical details of the WQEM are presented along with sample calculations and final water quality predictions for PP1 and PP2.

7.3.2 Water Quality Effects Model Architecture

The calculation of downstream water quality from the proposed 7SA5 mine is slightly different at the prediction point on the Iron River (PP1) than on the Quinsam River (PP2). As per Figure 7-13, water quality concentrations are computed at PP1 with the following formula:

$$\mathbf{[PP1] = (C_{GW}V_{GW} + C_{IR1}V_{IR1}) / (V_{GW} + V_{IR1})}$$

where the product of $C_{GW}V_{GW}$ represents the chemical loading from the 7S Area 5 underground post-closure, the product of $C_{IR1}V_{IR1}$ represents background chemical loading on the Iron River at PP1, and $V_{GW} + V_{IR1}$ represents total flow at PP1. The division of source and non-source loads by total volume returns a water quality concentration. The WQEM was configured to compute all predicted concentrations in units of mg/L.

Water quality concentrations were computed at PP2 with the following formula:

$$\mathbf{[PP2] = (C_{IR2}V_{IR2} + C_{QR1}V_{QR1} + C_{7SP}V_{7SP}) / (V_{IR2} + V_{QR1} + V_{7SP})}$$

where the product of CIR2VIR2 represents the chemical loading for the entire Iron River drainage (including the 7SA5 load), the product of CQR1VQR1 represents background

chemical loading on the Quinsam River immediately upstream of the Iron River confluence, and the product $C_{7SP}V_{7SP}$ represents worst case loading from the 7S sediment pond. The sum of terms $V_{IR2} + V_{QR1} + V_{7SP}$ represents total flow at PP2. Note that water quality predictions were computed for PP2 with and without consideration of the future load from 7S sediment pond. A general conclusion is that effects of the 7S sediment pond are hard to discern at PP2. The volumes and worst case predicted water quality concentrations for the 7S sediment pond are presented in Appendix F (see Tables 2 and 5).

7.3.2.1 Sample calculation for PP1

To compute the January sulphate water quality prediction for Scenario 1, component flows and chemistries entered into the WQEM included:

C_{GW} = 2,070 mg/L (refer to Table 6-15)

V_{GW} = 0.9 L/s or 2,411 m^3 per month (refer to Sections 2.1.2 and 2.5.2)

C_{IR1} = 0.5 mg/L (refer to month of January in Table 5-8)

V_{IR1} = 4.3 m^3/s or 11,445,077 m^3 per month

Since,

$$[PP1] = (C_{GW}V_{GW} + C_{IR1}V_{IR1}) / (V_{GW} + V_{IR1})$$

$$[PP1] = (2,070 \cdot 2,411 + 0.5 \cdot 11,445,077) / (2,411 + 11,445,077)$$

$$[PP1] = 0.9 \text{ mg/L } SO_4$$

7.3.2.2 Sample calculation for PP2

To compute the January sulphate water quality prediction for Scenario 1, component flows and chemistries entered into the WQEM included the following:

C_{IR2} This term is derived in the WQEM by mixing PP1 flow and chemistry (see Section 7.1.3 above) with background WQ for the Iron River and assumed flow between PP1 and the Iron-Quinsam confluence (*i.e.*, 5 km^2 of drainage - 986,645 m^3 for month of January).

$$= (0.9 \cdot 11,447,488 + 0.5 \cdot 986,645) / (11,447,488 + 986,645)$$

$$= 0.87 \text{ mg/L}$$

V_{IR2} = 4.6 m^3/s or 12,431,722 m^3 per month (see Table 4-5)

C_{QR1} = 5.65 mg/L (see Table 5-9)

V_{QR1} = 7.6 m^3/s or 20,355,840 m^3 per month (see Table 4-5)

C_{7SP} = 139 mg/L (see Table 5 (lower) – Lorax (2012))

V_{7SP} = 3,611 m^3 for the month of January (see Table 2 – Lorax (2012))

$[PP2] = (C_{IR2}V_{IR2} + C_{QR1}V_{QR1} + C_{7SP}V_{7SP}) / (V_{IR2} + V_{QR1} + V_{7SP})$

$[PP2] = (0.87 \cdot 12{,}431{,}722 + 5.65 \cdot 20{,}355{,}840 + 139 \cdot 23{,}930)/(12{,}431{,}722 + 20{,}355{,}840 + 23{,}930)$

$[PP2] = 3.9$ mg/L SO_4

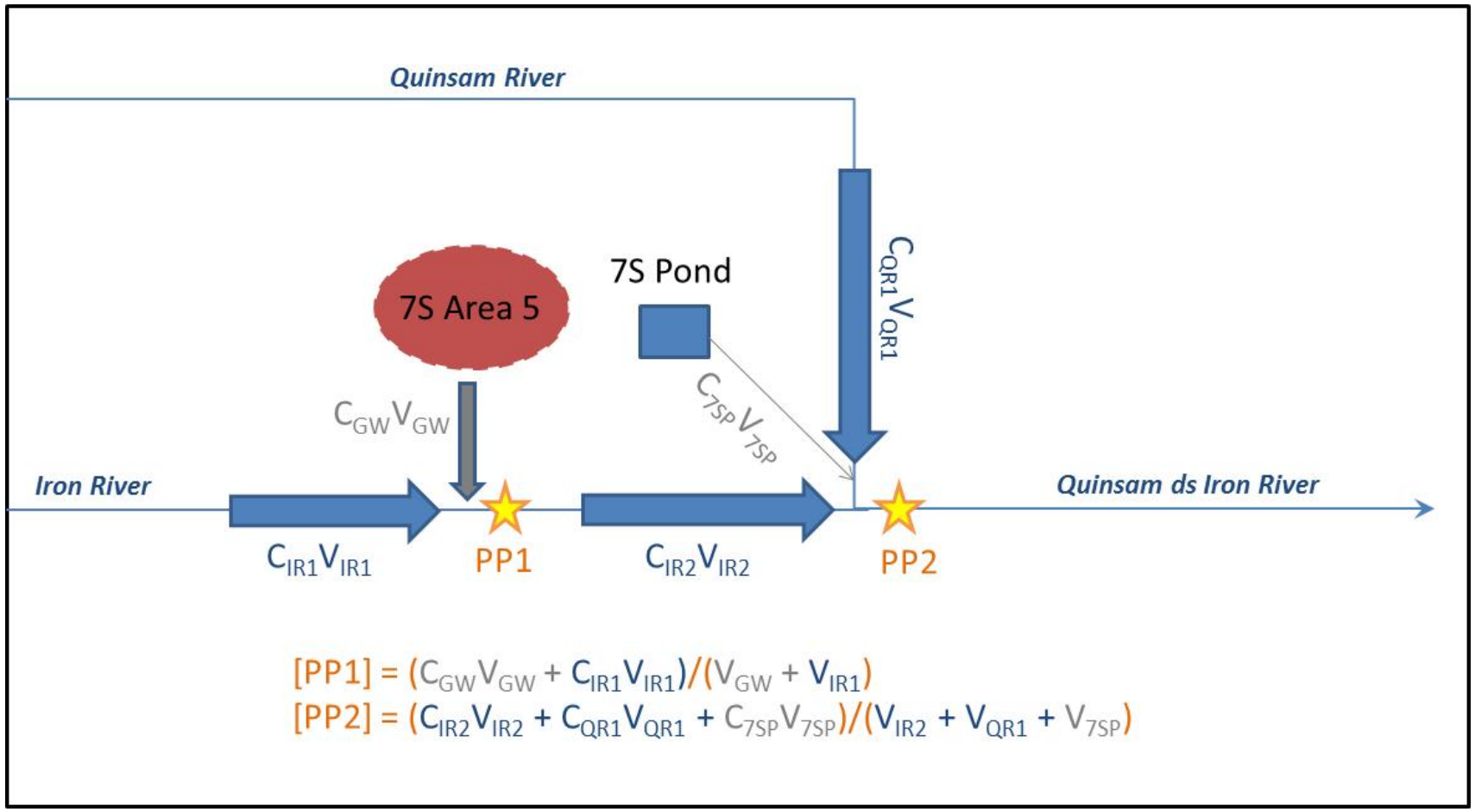


Figure 7-13: Post-closure schematic illustrating the layout of the 7S Area5 Water Quality Effects Model.

Table 7-9:
Description of the 7S Area5 Water Quality Effects Model.

Model Components	General Description	Chapter Reference
C_{IR1}	Median monthly values from Upper Iron River (UIR) and Lower Iron River Lower (LIR) monitoring sites represent C_{IR1} values entered into the WQEM. Period of record at UIR and LIR was 2008-2010, and August values were used to represent water quality for low flow (7Q10) predictions.	Ambient data and methodology to compute monthly C_{IR1} values are described in Chapter 5 (see Section 5.3).
V_{IR1}	Monthly and low flow values entered into the WQEM for V_{IR1} were based on regional analysis and site-specific hydrometric data collection for the Iron River.	V_{IR1} flows are described in Chapter 4 (see Section 4.4.1).
C_{GW}	Three sets of geochemical source terms (*i.e.*, Scenarios 1, 2 and 3) were entered into the WQEM for post-closure scenarios. In contrast to surface water quality source terms, geochemical source terms were the same for each month of the year.	Source data and methods used to compute post-closure geochemical source terms are presented in Chapter 6 (see Section 6.6).
V_{GW}	Post-closure mine flows were estimated through review of exploration drilling in 7SA5 and the completion of multiple hydrogeological field investigations. The field program included the installation of eight monitoring wells around the footprint area of the proposed 7SA5 workings and a 73-hour constant rate pumping test at an exploration hole along the southeastern margin of the proposed workings.	V_{GW} flows entered into the WQEM were 0.9 L/s for all Closure scenarios modelled. See Chapter 2 (Sections 2.1.2 and 2.5.2) for technical details associated with this rate of GW flow.
C_{IR2}	C_{IR2} water quality is computed by the WQEM. PP1 flows and chemistry are mixed with background flows and chemistry assumed to report to the Iron River between PP1 and the Iron-Quinsam River confluence. Monthly averaged values from Upper Iron River (UIR) and Lower Iron River (LIR) monitoring sites were used to represent background water quality downstream of PP1. August values for CI_{R2} were used to represent background water quality in low flow (7Q10) predictions.	Background water quality terms entered into the WQEM are described in Chapter 5 (see Section 5.3).
V_{IR2}	Monthly and low flows entered into the WQEM are based on regional analysis and hydrometric data collection for the Iron River. Note that in the WQEM, V_{IR2} is comprised of two component parts: 1) the flows assumed to report to PP1; and 2) background flow assumed to report to the Iron River downstream of PP1 and upstream of the Iron-Quinsam River confluence. The total area of the Iron River drainage was estimated to be 63 km^2, whereas the drainage area between PP1 and the confluence was estimated to be 5 km^2.	V_{IR2} flows are described in Chapter 4 (see Section 4.4.1).
C_{7SP}	Worst case water quality predictions for the 7S sediment pond were entered into the WQEM to represent future loadings from this facility.	The monthly source terms entered into the WQEM to represent C_{7SP} are described in Appendix F-1 (see Table 5 (lower)).
V_{7SP}	Flow terms representing 7S sediment pond discharge were entered into the WQEM to represent V_{7SP}.	The monthly flow terms entered into the WQEM are described in Appendix F-1 (see Table 2).
C_{QR1}	Median monthly values for the 7S Quinsam River (7SQR) monitoring site were used to compute source terms for C_{IR1}. Period of record used was 2007-2012 and August values were used to represent background water quality in low flow (7Q10) predictions.	Water quality data and methods used to compute terms entered into the WQEM for C_{QR1} are presented in Chapter 5 (see Section 5.3).
V_{QR1}	Monthly and low flows entered into the WQEM are based on hydrometric data collected by the Water Survey of Canada for period of record 1997-2010. Data from the following locations was used in the definition of V_{QR1} flow values: Quinsam River at Argonaut Bridge (08HD021); Quinsam River below Lower Quinsam Lake (08HD027); and Quinsam River at Campbell River (08HD005).	V_{QR1} flows are described in Lorax (2011) and Chapter 4 (see Section 4.4.2).

7.3.3 Water Quality Prediction Results

The results of water quality effects modelling for Iron River and Quinsam River prediction points PP1 and PP2, respectively, under different mine scenarios are presented in this section. The most sensitive users of Iron River and Quinsam River water within the residual project area will be aquatic biota. As a result, water quality predictions were compared to British Columbia Ministry of the Environment (MOE) Water Quality Guidelines for the Protection of Aquatic Life (BC WQGs) as a means to identify potential effects in the receiving environment.

In the following sections, water quality predictions for operational and post-closure mine conditions are discussed, with a focus on sulphate, Al, As, Cd, Co, and Fe, the primary parameters of environmental concern associated with mine development. Predicted concentrations are presented in both tables and time-series plots.

Tabular summaries of annual water quality predictions for Iron River (PP1) and Quinsam River (PP2) post mine closure are presented in Table 7-10 and Table 7-11 respectively. Data are shown for the yearly average and the 7-day low flow (7Q10; *i.e.*, the week during which peak environmental concentrations are predicted). All data for all mine phases and flow scenarios are presented in Appendix F.2.

Table 7-10:
Prediction Point 1 (Iron River) mean annual and 7Q10 water quality predictions for Scenarios 1, 2 and 3 at post-closure

Parameter	Units	Scenario 1		Scenario 2		Scenario 3		[2]BC WQG	
		Mean annual	[1]7Q10	Mean annual	[1]7Q10	Mean annual	[1]7Q10	Maximum WQG	30-day mean WQG
Hardness	mg $CaCO_3$/L	36.9	112	35.9	95.7	34.4	71.9	NP	NP
Sulphate	mg/L	5.33	48.5	4.26	31.7	2.78	8.32	NP	128
Al-D	mg/L	**0.058**	0.017	**0.058**	0.017	**0.058**	0.017	0.1000	0.0500
As-T	mg/L	0.00231	0.0114	0.00229	0.0110	0.00221	0.00974	0.005	NP
B-T	mg/L	0.100	0.132	0.099	0.113	0.098	0.105	1.2	NP
Cd-T	mg/L	0.000022	0.000024	0.000022	0.000020	0.000022	0.000017	0.000013	NP
Ca-T	mg/L	12.9	38.3	12.6	33.3	12.1	25.5	NP	NP
Co-T	mg/L	0.0009	**0.0111**	0.0003	0.0008	0.0003	0.0003	0.110	0.004
Cu-T	mg/L	0.00117	0.00135	0.00115	0.00100	0.00115	0.00099	0.0052	0.0020
Fe-D	mg/L	0.368	5.17	0.044	0.061	0.042	0.035	0.35	NP
Fe-T	mg/L	0.411	5.17	0.087	0.061	0.086	0.035	1	NP
Pb-T	mg/L	0.000496	0.000640	0.000487	0.000495	0.000487	0.000491	0.0210	0.00413
Mg-T	mg/L	1.13	4.02	1.07	3.09	1.01	2.02	NP	NP
Mn-T	mg/L	0.0105	0.119	0.00610	0.0496	0.00386	0.0143	0.9191	0.7564
Ni-T	mg/L	0.00179	0.0135	0.00107	0.00216	0.00100	0.000996	0.025	NP
Se-T	mg/L	0.00098	0.00116	0.00097	0.00104	0.00097	0.00098	NP	0.002
Zn-T	mg/L	0.00514	0.00725	0.00508	0.00631	0.00500	0.00497	0.0330	0.0075

Notes:
Values represent total (*T*) concentrations unless otherwise indicated with *D* (dissolved). **Bold** values exceed 30-day mean British Columbia water quality guidelines (WQGs). Shaded values exceed maximum WQGs. Mean annual predictions were calculated as the mean of monthly predicted values.
[1]7-day low flow.
[2]Water quality guidelines shown are British Columbia freshwater guidelines for the protection of aquatic life. Hardness dependent guidelines are calculated using mean annual hardness predicted for Scenario 3 (34.4 mg/L).

Table 7-11:
Prediction Point 2 (Quinsam River) mean annual and 7Q10 water quality predictions for Scenarios 1, 2 and 3 at post-closure

Parameter	Units	Scenario 1		Scenario 2		Scenario 3		[2]BC WQG	
		Mean annual	[1]7Q10	Mean annual	[1]7Q10	Mean annual	[1]7Q10	Maximum WQG	30-day mean WQG
Hardness	mg $CaCO_3$/L	30.9	39.3	30.7	37.3	30.3	34.3	NP	NP
Sulphate	mg/L	13.8	19.2	13.6	17.1	13.3	14.2	NP	218
Al-D	mg/L	0.037	0.013	0.037	0.013	0.037	0.013	0.1000	0.0500
As-T	mg/L	0.0008	0.0017	0.0008	0.0017	0.0008	0.0015	0.005	NP
B-T	mg/L	0.0761	0.0608	0.0758	0.0585	0.0757	0.0575	1.2	NP
Cd-T	mg/L	0.000016	0.000012	0.000016	0.000011	0.000016	0.000011	0.000012	NP
Ca-T	mg/L	10.4	13.2	10.3	12.6	10.2	11.6	NP	NP
Co-T	mg/L	0.0005	0.0018	0.0004	0.0005	0.0004	0.0005	0.110	0.004
Cu-T	mg/L	0.00103	0.00105	0.00103	0.00100	0.00103	0.00100	0.0048	0.0020
Fe-D	mg/L	0.117	0.697	0.0505	0.0624	0.0502	0.0592	0.35	NP
Fe-T	mg/L	0.169	0.731	0.103	0.096	0.102	0.093	1	NP
Pb-T	mg/L	0.000356	0.000258	0.000354	0.000240	0.000354	0.000239	0.0179	0.00401
Mg-T	mg/L	1.20	1.53	1.18	1.41	1.17	1.28	NP	NP
Mn-T	mg/L	0.0071	0.0217	0.0062	0.0131	0.0057	0.0088	0.8793	0.7383
Ni-T	mg/L	0.00116	0.00256	0.00102	0.00115	0.00100	0.00100	0.025	NP
Se-T	mg/L	0.00057	0.00025	0.00056	0.00023	0.00056	0.00022	NP	0.002
Zn-T	mg/L	0.00503	0.00528	0.00502	0.00516	0.00500	0.00500	0.0330	0.0075

Notes:
Values represent total (*T*) concentrations unless otherwise indicated with *D* (dissolved). **Bold** values exceed 30-day mean British Columbia water quality guidelines (WQGs). Shaded values exceed maximum WQGs. Mean annual predictions were calculated as the mean of monthly predicted values.
[1]7-day (winter) low flow.
[2]Water quality guidelines shown are British Columbia freshwater guidelines for the protection of aquatic life. Hardness dependent guidelines are calculated using mean annual hardness predicted for Scenario 3 (30.3 mg/L).

Time series profiles of monthly model output for parameters of primary environmental interest (sulphate, Al, As, Cd, Co, and Fe) for various flow conditions and mine phases are illustrated in Figure 7-14 to Figure 7-27. Modelled results are compared to average monthly background concentrations in the Iron River at PP1 and the Quinsam River at PP2. Background concentrations at PP1 were derived using the combined datasets of monitoring stations LIR and UIR. Background concentrations at PP2 were calculated as the proportional chemical load from Iron River mixed with the proportional chemical

load from Quinsam River, via 7SQR. The predicted annual average concentration was calculated as the mean of all monthly predictions.

7.3.3.1 Water Quality Prediction Results - Post-closure

Source terms for the 7SA5 mine water were estimated for several scenarios that may occur in the 7SA5 mine during operation and post-closure. In the post-closure period, the mine will flood, which will restrict ARD reactions in the closed mine workings but will transfer stored metals and acidity from precipitates to the flooded mine pool. Three different closure scenarios are assessed:

- Scenario 1 represents worst case conditions (mine workings and the coarse reject become acidic prior to flooding);
- Scenario 2 represents expected conditions (PAG coarse reject is placed in the mine void and flooded prior to the onset of acidic conditions from the coarse reject); and
- Scenario 3 represents the expected long term conditions from the coarse reject.

Water quality predictions are reviewed below as part of the 7SA5 water quality effects assessment for Iron River and Quinsam River.

General Observations

Based on the results of the receiving environment water quality predictions, the following general observations can be made:

- The greatest effect on downstream water quality is predicted to occur under Scenario 1, as expected. In contrast, Scenarios 2 and 3 show values that are typically much lower and commonly reflect background levels;
- The highest predicted concentrations for parameters demonstrating mine influence (*e.g.*, sulphate, As, Cd, Co, Fe) occur in the 7-day low flow (representing extreme summer low-flow conditions) under the worst-case mine conditions (Scenario 1);
- Water quality parameters that demonstrate mine-influence are predicted to remain well below BC WQG levels in Iron River under most mine and flow conditions modelled. Exceptions to this trend include:
    - As: Total As exceeds its guideline in all modelled scenarios during months of summer low (August, September) and the 7Q10. It is important to note that background levels of As for these time-points naturally exceed the BC WQG guideline, but mine-influence is predicted to further increase As levels in Iron River above the WQG;

- Co: Total Co exceeds the 30-day guideline only under 7Q10 conditions in Scenario 1, but not the maximum WQG – the screening value assumed appropriate for this infrequent and acute flow condition. Total Co levels are predicted to marginally increase above background in Scenarios 2 and 3;
- Fe: Dissolved Fe is predicted to exceed its criterion during months of summer low (July, August, September) and the 7Q10 in Scenario 1. However, dissolved Fe discharging from the groundwater system into the fully oxygenated Iron River will precipitate and the dissolved concentrations are expected to remain similar to background concentrations. In Scenarios 2 and 3, the model predicts that dissolved Fe will remain below guideline levels. However, predicted increases in total Fe levels are driven predominantly by the dissolved Fe load; as a result, total Fe is predicted to exceed the total Fe guideline during months of summer low flow (August, September) and the 7Q10 in Scenario 1, but remain near background levels in Scenarios 2 and 3;

- Similar to Iron River, water quality parameters that demonstrate mine-influence are predicted to remain well below BC WQG levels in Quinsam River under most flow and mine conditions modelled. Additionally, the dilution afforded by Quinsam River results in lower predicted levels of most parameters at PP2 in comparison to PP1. The only parameter that the model predicts to increase above WQGs in Quinsam River is dissolved Fe, which exceeds the guideline under worst-case, low flow conditions (Scenario 1 7Q10). As mentioned previously, reduced Fe loads from the groundwater system will in large part precipitate and report only to the total metal fraction. Thus, dissolved Fe is not expected to exceed guidelines at PP2; and
- Concentrations of dissolved Al and total Cd in Iron River and Quinsam River are predicted to exceed BC WQGs during high flow conditions. However, predicted levels are wholly driven by background water chemistry, and not mine-influence.

Sulphate

As a tracer of mine-influenced waters, the assessment of sulphate is useful for the identification of mine-related changes in the aquatic receiving environment. During the post-closure period, predicted mean monthly sulphate concentrations at PP1 range from 0.50 to 19.4 mg/L (Figure 7-14). For comparison, Iron River monthly background values (representing the combined datasets of UIR and LIR) range from <0.5 to 10.1 mg/L. Predicted sulphate levels in Iron River remain well below the hardness-based sulphate

WQG of 128 mg/L. For all scenarios and flow conditions at PP1, maxima are predicted to occur during months of summer low flow (August, September) while minimum values occur during the winter high-flow periods (December, January, February). Predictions for each modelling scenario are discussion separately below.

In the worst case scenario (Scenario 1), sulphate concentrations range from 0.9 mg/L up to 19.4 mg/L, with a mean annual value of 5.3 mg/L (Table 7-10). Predicted sulphate levels increase to 48.5 mg/L under 7Q10 conditions. Sulphate predictions under expected post-closure conditions (Scenario 2) show a similar pattern to that of worst case conditions, although with a lower magnitude of mine-related effect (Figure 7-14). In Scenario 2, monthly (post-closure) values for the mean flow year range from 0.75 mg/L to 15.3 mg/L, with an overall yearly average of 4.3 mg/L (Figure 7-14). Peak 7-day low-flow values for the mean year equate to 31.7 mg/L. Under long term conditions (Scenario 3), mine workings are not expected to contribute sulphate to Iron River, such that predicted values shown in Figure 7-14 are driven exclusively by background levels.

Mean monthly sulphate concentrations predicted for PP2 under post-closure conditions range from approximately 3.7 to 19.6 mg/L (Figure 7-15). Background PP2 concentrations (representing the proportionally mixed water chemistry of lower Iron River and 7SQR in Quinsam River) range from 3.7 to 19.3 mg/L. Similar to predictions generated for PP1, sulphate levels in Quinsam River downstream of mine-related influence are predicted to remain well below the BC WQG for sulphate (218 mg/L).

For Scenario 1, sulphate levels at PP2 are predicted to remain below 20 mg/L, with monthly averages ranging from 3.9 to 19.6 mg/L (Figure 7-15). Under 7Q10 conditions, sulphate is expected to increase up to 19.2 mg/L (Table 7-11). As observed for PP1, predicted sulphate values at PP2 under expected conditions (Scenario 2) are slightly lower than those for worst case (Scenario 1). Predicted monthly values range from 3.8 to 19.5 mg/L (annual average = 13.6 mg/L), with peak values occurring in March due to background (Figure 7-15). A maximum value of 17.1 mg/L is predicted for the 7-day low flow period (Table 7-11). Under long term conditions (Scenario 3), mine-related waters are expected to exert minimal influence at PP2. A slight increase in sulphate concentrations may occur under 7Q10 conditions, but levels are not expected to exceed 20 mg/L.

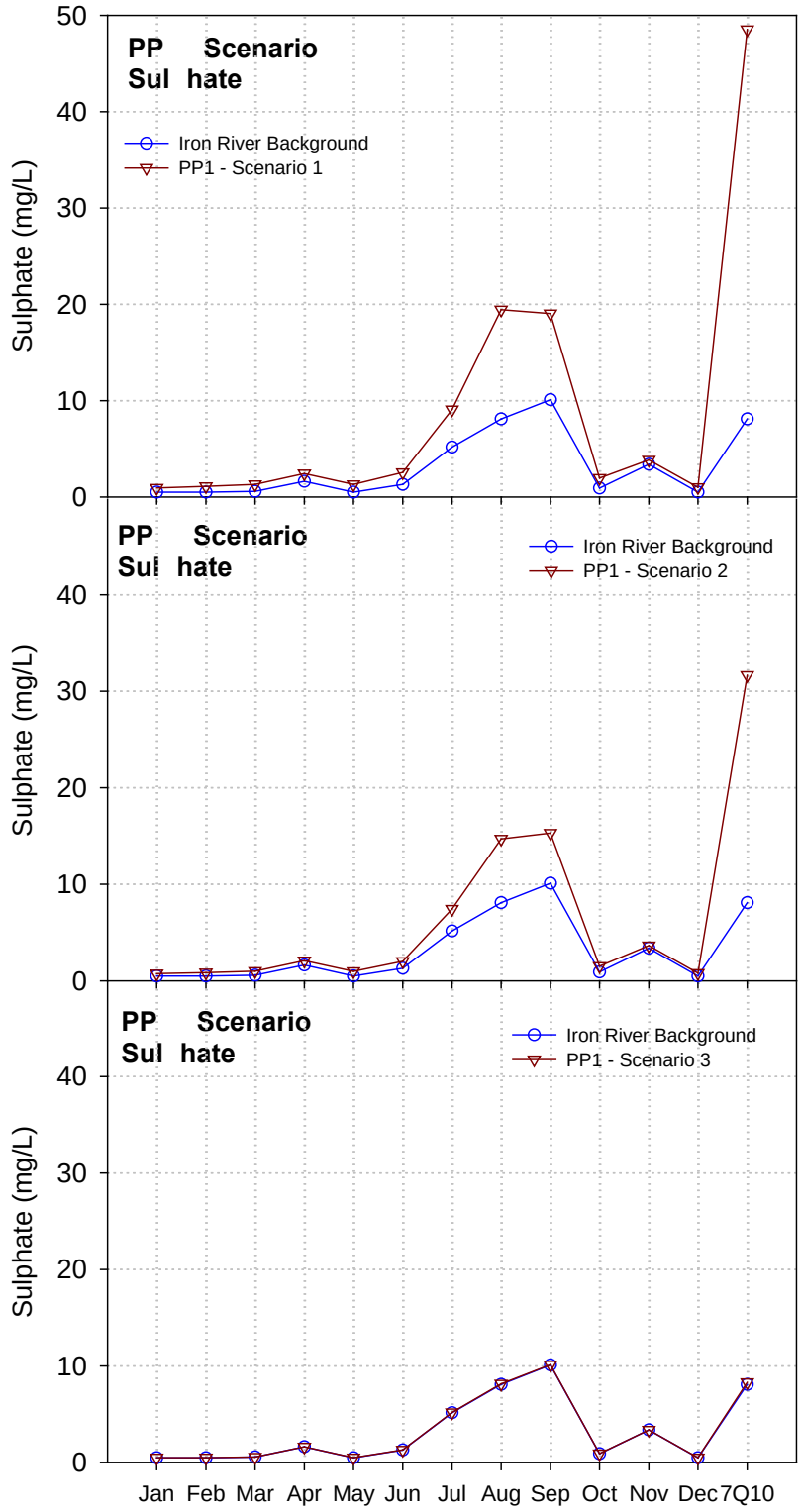


Figure 7-14: Sulphate mean monthly and 7Q10 water quality predictions for Prediction Point 1 (Iron River) in post-closure mine phase under closure scenarios 1, 2, and 3 (maroon triangles). Background monthly source terms for sulphate in Iron River are shown (blue circles).

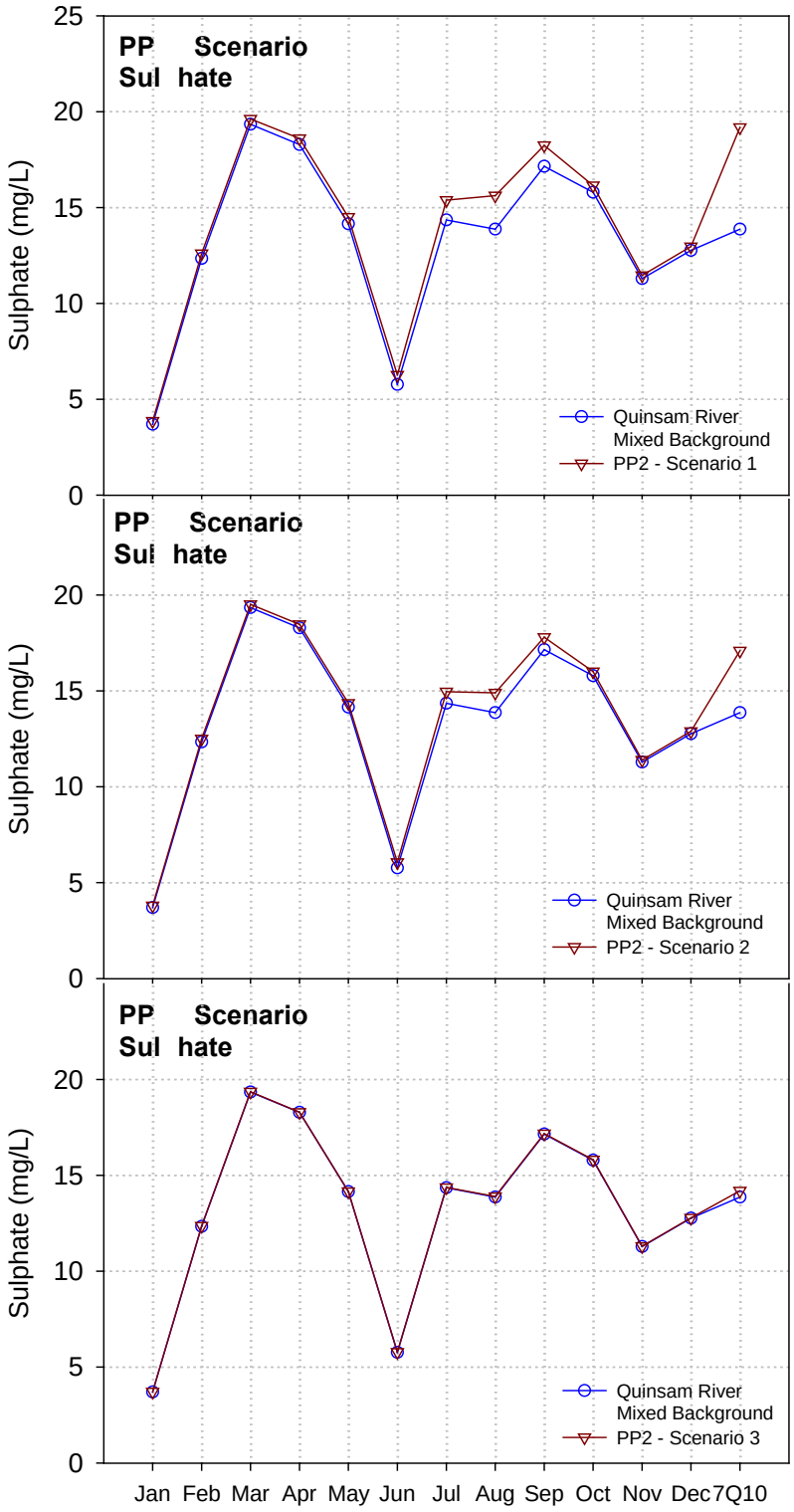


Figure 7-15: Sulphate mean monthly and 7Q10 water quality predictions for Prediction Point 2 (Quinsam River) in post-closure mine phase under closure scenarios 1, 2, and 3 (maroon triangles). Background monthly source terms for sulphate in Quinsam River (mixed) are shown (blue circles).

Dissolved Aluminum

Under post-closure conditions, mine-related influence on dissolved Al concentrations in Iron River at PP1 is negligible under all modelled scenarios (Figure 7-16). Predicted mean monthly concentrations at PP1 range from 0.013 to 0.114 mg/L, matching background values. For all mine phases and flow conditions in Iron River, minima are predicted during summer low-flow periods (August-September) while maximum values occur during the spring (May) and winter (December-February) high-flow periods. In all scenarios for PP1, 7Q10 values fall below 0.02 mg/L. Predicted values for dissolved Al exceed the 30-day BC WQG in all scenarios for seven months of the year. Of these months, the maximum BC WQG is exceeded in one month (May). Exceedances are attributed exclusively to the background water quality.

Similar to PP1, mine-related influence on dissolved Al concentrations is predicted to be minimal in Quinsam River (PP2) under all modelled scenarios (Figure 7-17). Expected mean monthly concentrations at PP2 range from 0.009 to 0.076 mg/L (Figure 7-17), equal to background values. Minima for all mine phases and flow conditions occur during summer low-flow periods (August-September) while maximum values occur during the spring (May) and winter (December) high-flow periods. Values for the 7-day low flow period remain less than 0.02 mg/L Table 7-11. At PP2, the 30-day WQG for dissolved Al is exceeded in January and May under all modelled scenarios, but exeedances are due to elevated levels of background dissolved Al rather than mine influence. As a result, Al is not considered a parameter of concern in the 7SA5 assessment given: 1) naturally elevated background levels of dissolved Al in Iron River and Quinsam River, and 2) the absence of a mine-related effect on dissolved Al levels under all modelled scenarios.

Total Arsenic

At post-closure, predicted monthly total As concentrations at PP1 range from 0.00076 to 0.0074 mg/L (Figure 7-18). Background monthly values for Iron River are slightly lower, ranging from 0.0007 to 0.0062 mg/L. In general, predicted total As levels in Iron River exceed the BC WQG (0.005 mg/L) during summer low flow under all mine scenarios. However, exceedances are largely driven by background conditions. For all mine phases and flow conditions at PP1, minima are predicted during winter high flow conditions (December to February) while maximum values occur during the summer low-flow periods (August-September).

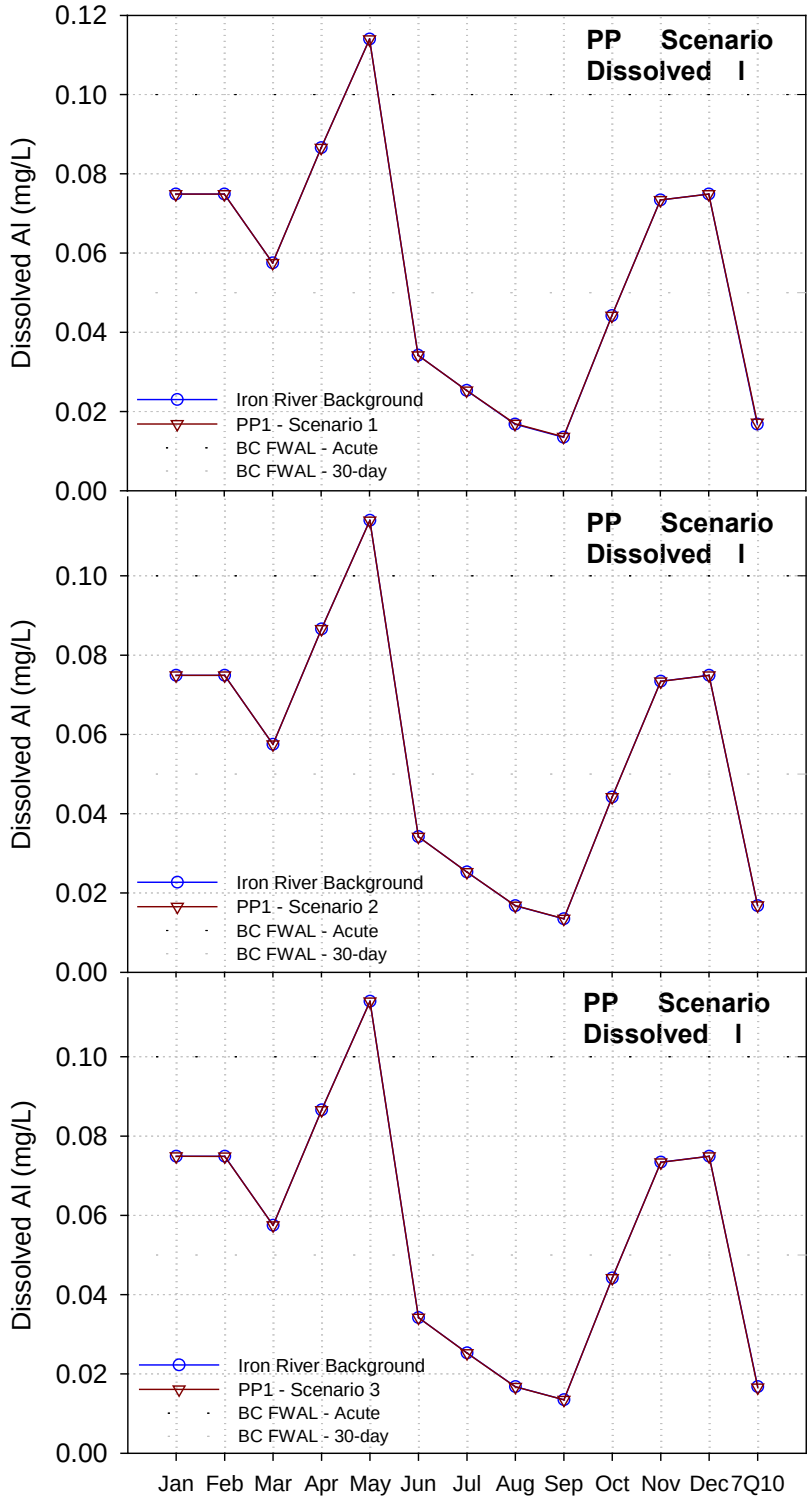


Figure 7-16: Dissolved aluminum mean monthly and 7Q10 water quality predictions for Prediction Point 1 (Iron River) in post-closure mine phase under closure scenarios 1, 2, and 3 (maroon triangles). Background monthly source terms for dissolved aluminum in Iron River are shown (blue circles).

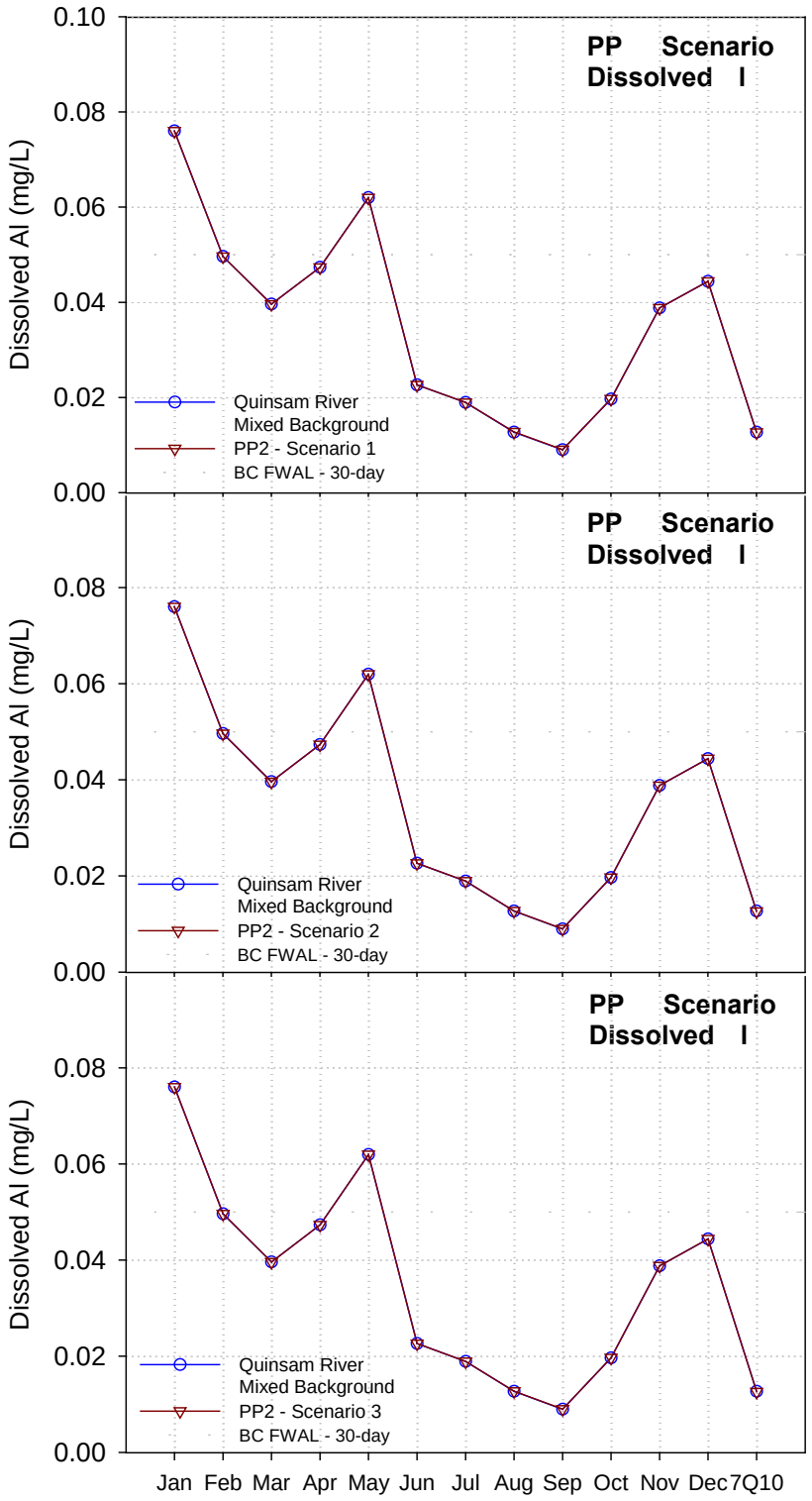


Figure 7-17: Dissolved aluminum mean monthly and 7Q10 water quality predictions for Prediction Point 2 (Quinsam River) in post-closure mine phase under closure scenarios 1, 2, and 3 (maroon triangles). Background monthly source terms for dissolved aluminum in Quinsam River (mixed) are shown (blue circles).

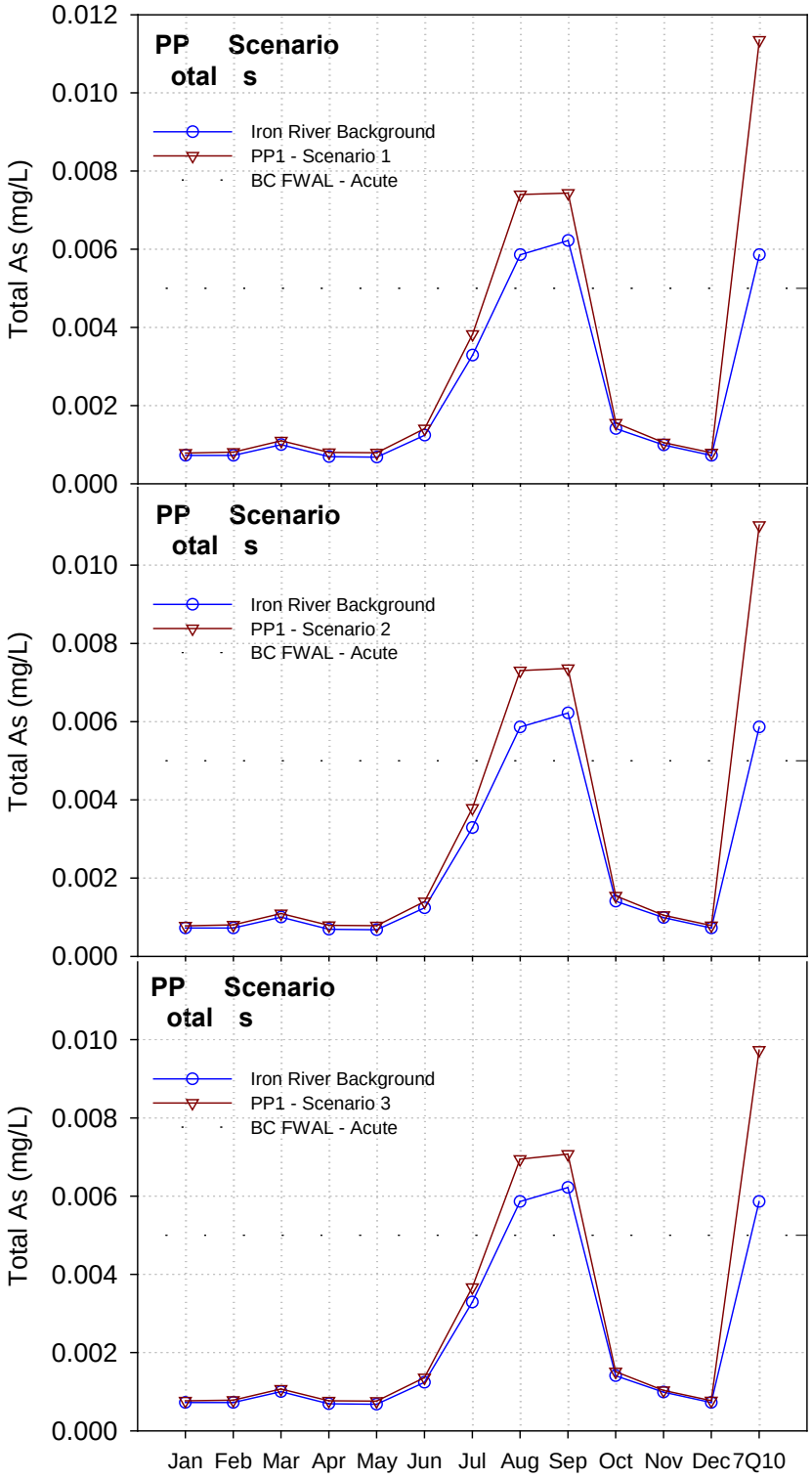


Figure 7-18: Total arsenic mean monthly and 7Q10 water quality predictions for Prediction Point 1 (Iron River) in post-closure mine phase under closure scenarios 1, 2, and 3 (maroon triangles). Background monthly source terms for total arsenic in Iron River are shown (blue circles).

In the worst case scenario (Scenario 1), total As concentrations at PP1 range from 0.0008 up to 0.0074 mg/L, with a mean annual value of 0.0023 mg/L (Table 7-10). Predicted total As levels increase to 0.0114 mg/L under 7Q10 conditions. Note that the magnitude of predicted mine-related increases at PP1 are small and represent changes to background As values that are already in exceedance of the BC WQG (Figure 7-18). For example, the predicted maximum change in mean monthly As equates to an increase of 0.0015 mg/L above background levels (August, Scenario 1). For the Scenario 1 7Q10, this change increases to 0.0055 mg/L above background.

Total As concentrations under expected post-closure conditions (Scenario 2) show a pattern similar to that observed for worst case conditions at PP1 (Figure 7-18). In Scenario 2, monthly values for the mean flow year range from 0.00078 mg/L to 0.00736 mg/L, with an overall yearly average of 0.00229 mg/L (Table 7-10). 7-day low-flow values for expected conditions (0.0110 mg/L) are similar to worst-case (above). Under long term conditions (Scenario 3), a trend similar to that of Scenarios 1 and 2 is expected at PP1, although a mine-related effect is less evident. Mean monthly values for Scenario 3 range from 0.00076 mg/L to 0.00708 mg/L, with an overall yearly average of 0.00221 mg/L (Table 7-10). The 7Q10 value for this scenario is lower than that predicted for Scenarios 1 or 2, with an estimated value of 0.0097 mg/L. Ultimately, total As in Iron River is governed by elevated background concentrations; however, measureable effects to water quality downstream of mine-influence are predicted with respect to As levels, especially under low flow conditions.

In contrast to PP1, mean monthly total As concentrations predicted for PP2 are low, ranging from 0.00038 to 0.0015 mg/L (Figure 7-19). Predicted PP2 concentrations are similar to background levels at PP2, which range from 0.00037 to 0.00124 mg/L. As a result, total As levels in Quinsam River downstream of mine-related influence are predicted to remain well below the BC WQG for total As. With respect to modelled mine scenarios, predicted As concentrations at PP2 are similar between Scenarios 1 (range = 0.00039 to 0.00145 mg/L), 2 (range = 0.00039 to 0.00144 mg/L), and 3 (range = 0.00038 to 0.00138 mg/L) (Figure 7-19). In all scenarios, annual maxima coincide with seasonal low flow (August) and annual minima occur during seasonal high flow (December to February), as determined by background water quality. The maximum predicted value for the 7-day low flow period ranges from 0.0017 mg/L in Scenario 1 to 0.0015 mg/L in Scenario 3 (Table 7-11)

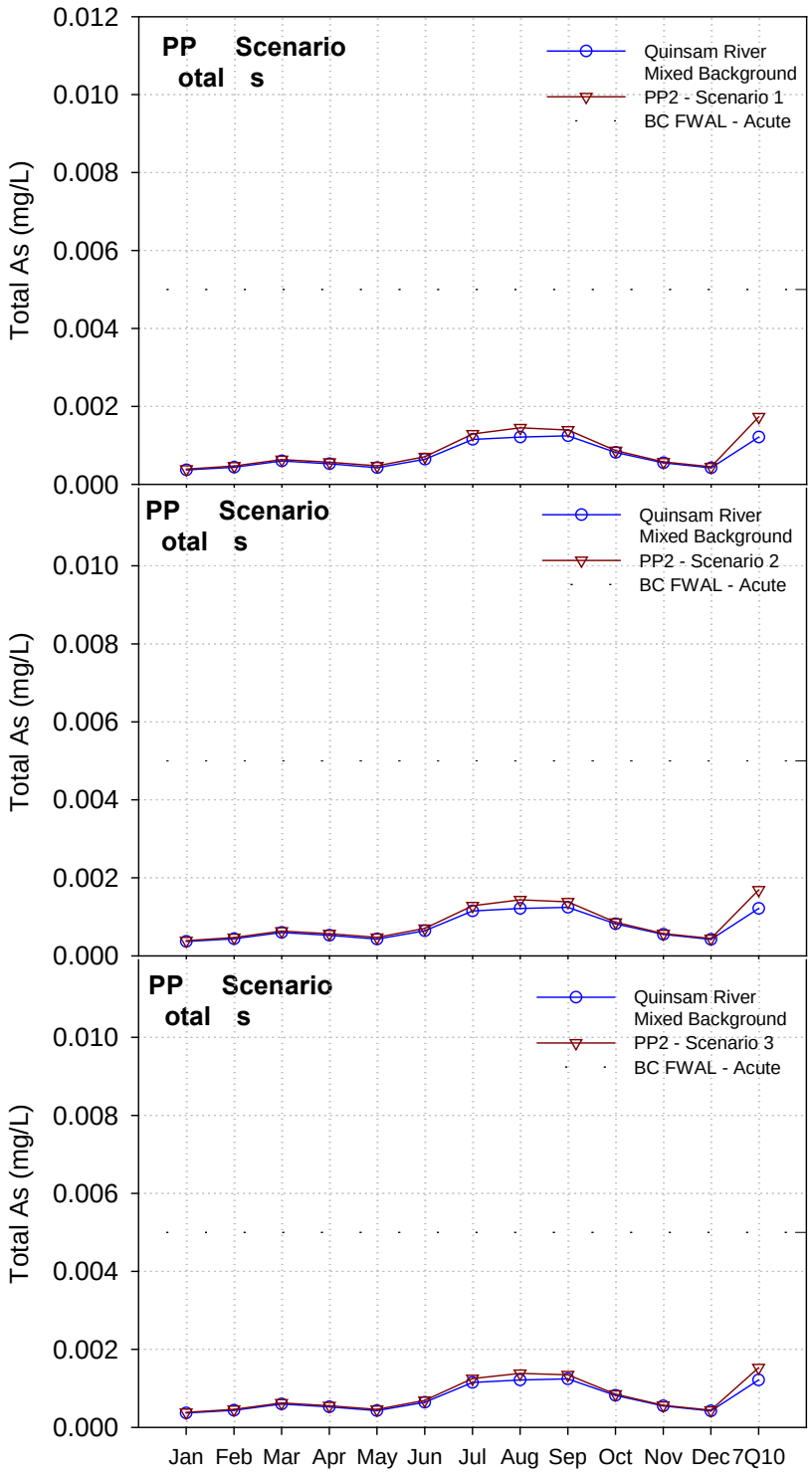


Figure 7-19: Total arsenic mean monthly and 7Q10 water quality predictions for Prediction Point 2 (Quinsam River) in post-closure mine phase under closure scenarios 1, 2, and 3 (maroon triangles). Background monthly source terms for total arsenic in Quinsam River (mixed) are shown (blue circles).

In consideration of risk to aquatic biota in Iron River, the CCME As guideline for the protection of freshwater aquatic life, from which the BC WQG is derived, is based on the sensitivity of a species of chlorophytic phytoplankton (*Scenedesmus obliquus*). This species has been shown to exhibit a toxic response at an As concentration of 0.050 mg/L (CCME, 1999). The CCME guideline for As (0.005 mg/L) is derived by multiplying the 0.050 mg/L toxicity value for *S. obliquus* by a safety factor of 0.1. To provide context, the next most sensitive species in the As toxicological database used by CCME are also phytoplankton (*Ochromonas vallesiaca, Melosira granulate*), both of which have shown effects at As concentrations of 0.075 mg/L. These species are planktonic, and typically inhabit regions of lentic habitat.

Despite elevated levels of As predicted for PP1, the risk of As toxicity to aquatic biota in Iron River is considered low for several reasons. Foremost, planktonic chlorophytes that are sensitive to As are unlikely to inhabit lower Iron River, which demonstrates extensive lotic habitat. For perspective, the next most-sensitive species in the CCME dataset for As toxicity (after *M. granulate* and *O. vallesiaca*) is the copepod *Cyclops vernalis*, which demonstrates sensitivity to As at concentrations of 0.320 mg/L. Further, post-closure As levels at PP1 are predicted to increase up to 0.011 mg/L during worst-case, extreme low flow conditions (Scenario 1 7Q10). Under these conditions, the maximum predicted As value remains well below levels reported to cause toxicity in the most sensitive species tested in the toxicological dataset. As a result, the predicted As levels at PP1 are not expected to cause adverse effects to aquatic biota that inhabit lower Iron River.

In contrast to Iron River, it is highly likely that such planktonic species exist in the Quinsam River system, given Quinsam River is bound by lentic habitat upstream (Middle Quinsam Lake) and downstream (Quinsam Lake) of PP2. However, mine-influenced waters are not predicted to increase As levels at PP2 above the BC WQG in any of the post-closure scenarios modelled. As a result, adverse effects to aquatic organisms are not expected at PP2.

Total Cadmium

Post-closure water quality predictions for total Cd at PP1 are shown in Figure 7-20, alongside the hardness-dependent BC WQG for total Cd (calculated from the predicted hardness under each respective scenario). At post-closure, predicted mean monthly total Cd concentrations at PP1 range from approximately 0.000014 to 0.000051 mg/L (Figure 7-20). Note that total Cd levels were below measureable levels in several water quality samples collected in Iron River during background monitoring. Values measured below the DL were set equal to the DL value for statistical purposes. The calculated total Cd WQG subsequently falls below the DL value for several months during seasonal high

flow (January to April, December) at PP1, during which water hardness is low. For PP2, the calculated WQG falls below the DL for the month of January. Overall, the model output shows wide-spread exceedances of the BC guideline in Iron River (Figure 7-20), but exceedances are drive by background conditions.

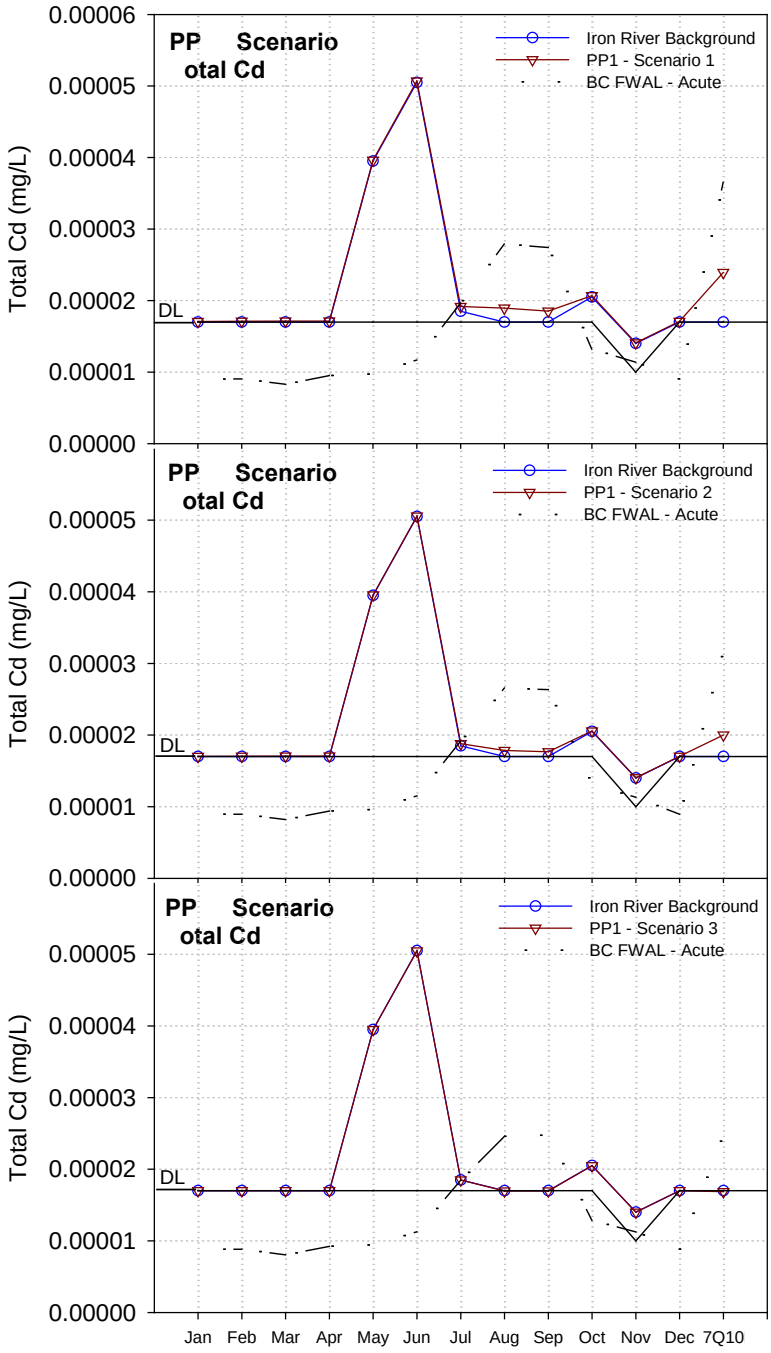


Figure 7-20: Total cadmium mean monthly and 7Q10 water quality predictions for Prediction Point 1 (Iron River) in post-closure mine phase under closure scenarios 1, 2, and 3 (maroon triangles). Background monthly source terms for total cadmium in Iron River are shown (blue circles).

In Scenario 1, the range in monthly total Cd concentrations predicted for PP1 (0.000014 to 0.000051 mg/L) is attributed to background levels (Figure 7-20). Cadmium levels are predicted to increase above background during the months of July, August and September, coincident with seasonal low flow. However, during these months hardness is predicted to correspondingly increase, such that mean monthly predictions for total Cd for July to September remain below the BC WQG during these months. A similar effect is demonstrated under 7Q10 conditions, in which the predicted Cd level (0.000024 mg/L) falls below the hardness-based WQG value of 0.000037 (Table 7-10).

Total Cd predictions under expected post-closure conditions (Scenario 2) show a similar pattern to that of worst case conditions at PP1, although with a lower magnitude of mine-related effect during low flow conditions (Figure 7-21). Similar to Scenario 1, the range of monthly values for Scenario 2 is driven by background, ranging from 0.000014 mg/L to 0.000051 mg/L, with an overall yearly average of 0.000022 mg/L (Table 7-11). Measurable increases above background conditions are only predicted for the months of August (0.000018 mg/L) and September (0.000018 mg/L), and under 7-day low-flow conditions (0.000020 mg/L). During these periods, however, predicted levels remain below the BC WQG. Under long term conditions (Scenario 3), mine workings are not expected to discharge measureable levels of Cd to Iron River. Instead, predicted values for this scenario are driven exclusively by background levels (Figure 7-20).

Mean monthly total Cd concentrations predicted for PP2 under post-closure conditions are similarly driven by background water quality, with values ranging from approximately 0.000011 to 0.000031 mg/L (Figure 7-21). Total Cd levels in Quinsam River downstream of mine-related influence are predicted to exceed the calculated BC WQG during several months of the year.

In Scenario 1, Cd levels at PP2 are expected to marginally increase above background levels during the months of July, November and for the 7Q10. However, these increases occur within the precision of analytical measurement. As discussed above, water hardness is predicted to correspondingly increase during low flow, such that predicted values remain below the BC WQG under these conditions. Under expected mine conditions (Scenario 2) and long term conditions (Scenario 3) in post-closure, mine-related effects to total Cd concentrations at PP2 are negligible (Figure 7-21).

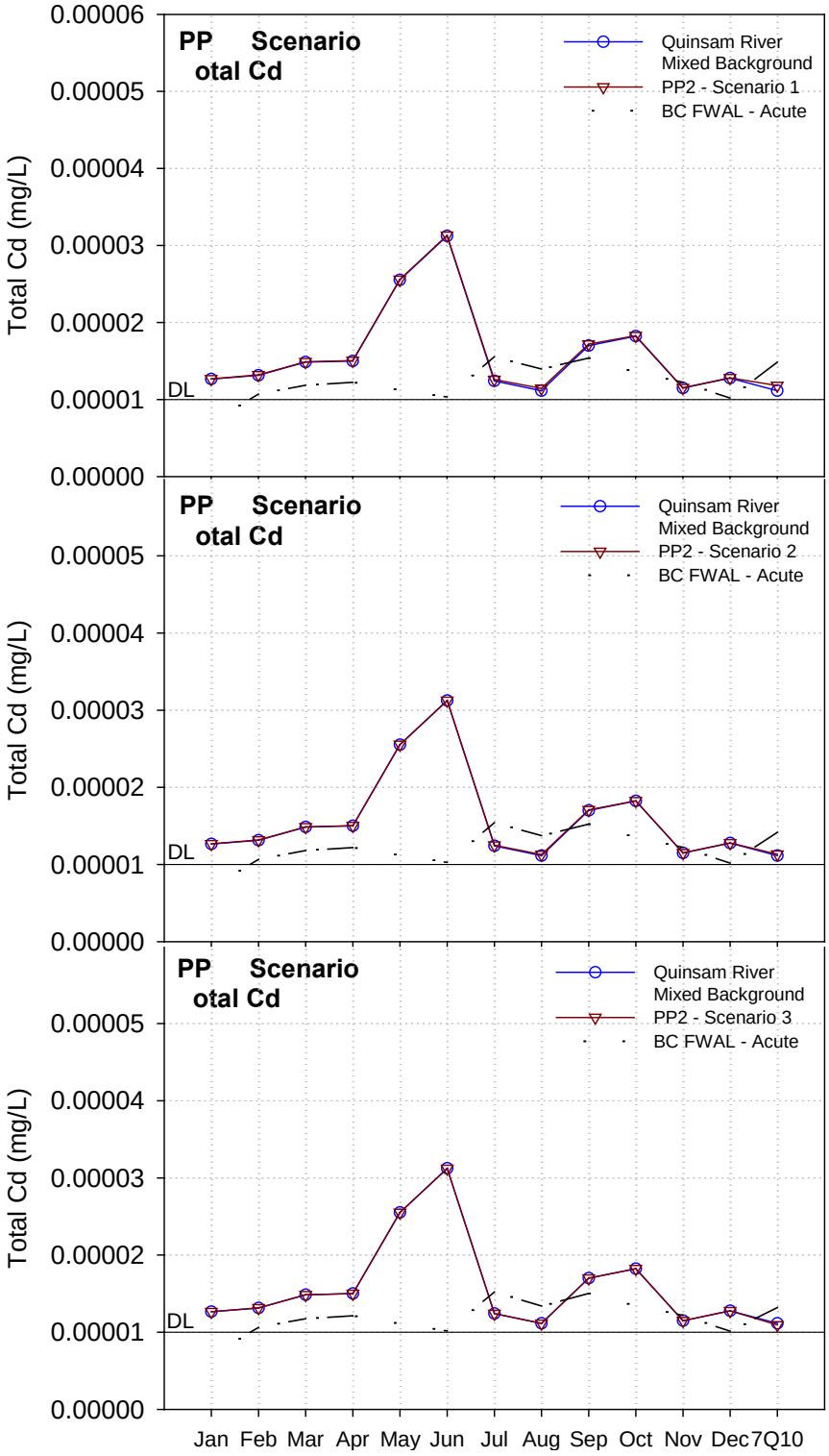


Figure 7-21: Total cadmium mean monthly and 7Q10 water quality predictions for Prediction Point 2 (Quinsam River) in post-closure mine phase under closure scenarios 1, 2, and 3 (maroon triangles). Background monthly source terms for total cadmium in Quinsam River (mixed) are shown (blue circles).

Mine-related influence on Cd levels in Iron River and Quinsam River is not expected to have adverse effects on aquatic biota in these systems, given predicted concentrations are attributed to background levels. Additionally, the BC working guideline for Cd is based on toxicity data for cladocerans (water fleas), which are planktonic crustaceans. In this regard, cladocerans are not predicted to be present in lotic habitat that comprises the lower Iron River system, such that the generic WQG will likely be overprotective for this system. Although consideration of planktonic species is relevant at PP2, given this reach is bordered by lentic habitat upstream (Middle Quinsam Lake) and downstream (Quinsam Lake), 7SA5 influence on Cd levels at PP2 is expected to be minimal.

Total Cobalt

At post-closure, predicted mean monthly total Co concentrations at PP1 range from approximately 0.00030 to 0.00333 mg/L (Figure 7-22). For comparison, Iron River monthly background values (representing the combined datasets of UIR and LIR) range from 0.00030 to 0.00040 mg/L. Overall, predicted monthly Co levels in Iron River remain below the 30-day WQG of 0.004 mg/L, but levels may exceed the 30-day guideline under extreme low flow conditions. Co levels are not predicted to exceed the maximum WQG, a screening value most appropriate for 7Q10 flow. For all mine phases and flow conditions at PP1, minima are predicted during winter months (December-January) while maximum values occur during the summer low flow period (August-September). Results of modelled mine scenarios are reviewed individually below.

In the worst case scenario (Scenario 1), monthly Co concentrations for PP1 fall below the BC WQG, ranging from 0.00042 up to 0.00333 mg/L (Figure 7-22). A mean annual value of 0.00099 mg/L is expected (Table 7-10). However, levels are predicted to increase to 0.0110 mg/L under 7Q10 conditions, more than doubling the 30-day WQG. Total Co predictions under expected conditions (Scenario 2) show a pattern similar to that of worst case conditions, although with a lower magnitude of mine-related effect (Figure 7-22). In Scenario 2, mean monthly (post-closure) values range from 0.00031 mg/L to 0.00044 mg/L, with an overall yearly average of 0.00034 mg/L (Table 7-10). In this scenario, peak 7-day low-flow values (0.0008 mg/L) fall well below the 30-day WQG. Under long term conditions (Scenario 3), mine workings do not contribute Co to Iron River, such that predicted values shown in Figure 7-22 are driven exclusively by background levels.

Mean monthly total Co concentrations predicted for PP2 under post-closure conditions range from 0.00030 to 0.000927 mg/L (Figure 7-23). Background PP2 concentrations (representing the proportionally mixed water chemistry of lower Iron River and 7SQR in Quinsam River) range from 0.00030 to 0.00047 mg/L. For Scenario 1, Co levels at PP2

are predicted to remain below 0.001 mg/L under mean monthly conditions, with monthly averages ranging from 0.00039 to 0.000927 mg/L. During 7-day low flow, the concentration of total Co is expected to increase up to 0.0018 mg/L.

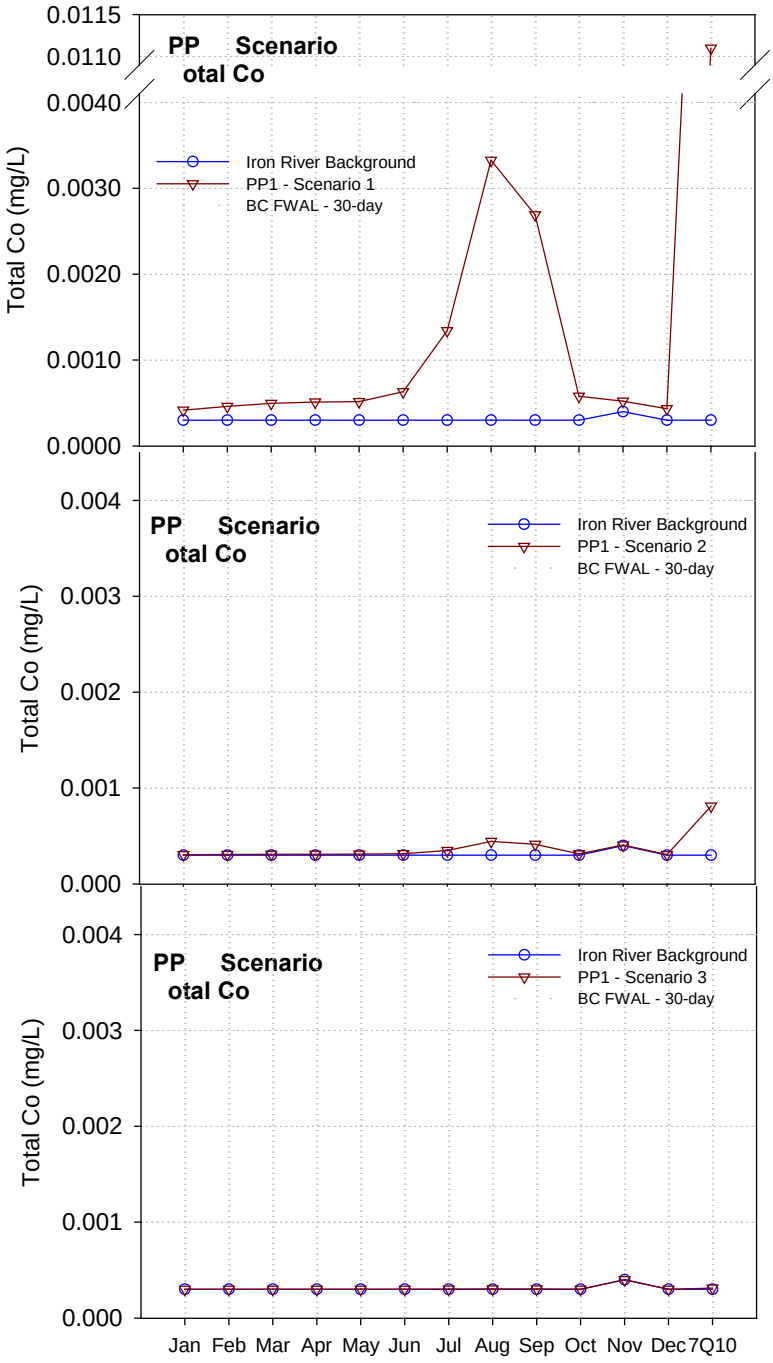


Figure 7-22: Total cobalt mean monthly and 7Q10 water quality predictions for Prediction Point 1 (Iron River) in post-closure mine phase under closure scenarios 1, 2, and 3 (maroon triangles). Background monthly source terms for total cobalt in Iron River are shown (blue circles).

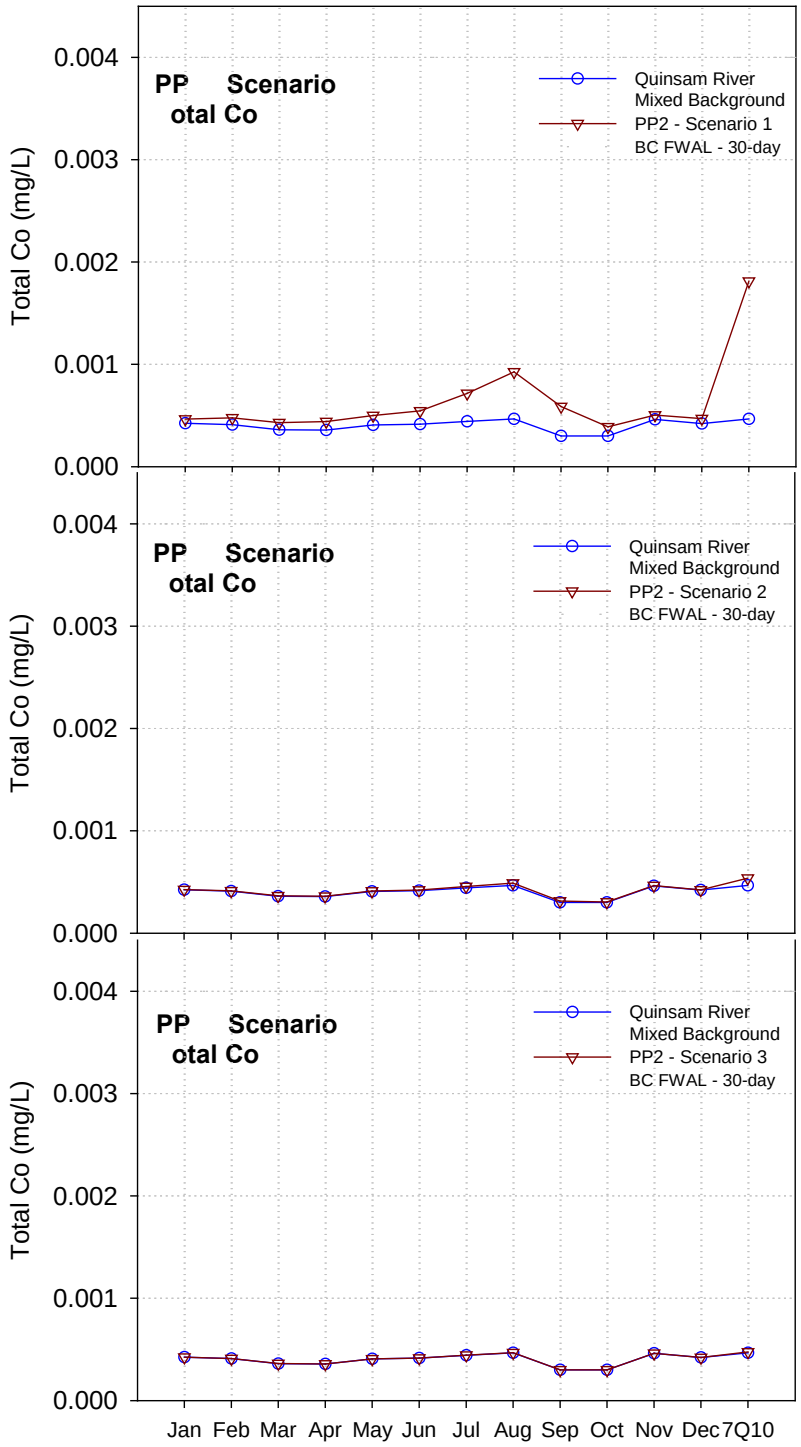


Figure 7-23: Total cobalt mean monthly and 7Q10 water quality predictions for Prediction Point 2 (Quinsam River) in post-closure mine phase under closure scenarios 1, 2, and 3 (maroon triangles). Background monthly source terms for total cobalt in Quinsam River (mixed) are shown (blue circles).

Under expected conditions (Scenario 2) and long term conditions (Scenario 3) the effect of mine-influenced waters on mean monthly and low flow Co levels is negligible. Overall, total Co levels in Quinsam River downstream of mine-related influence are predicted to remain well below the 30-day BC WQG for cobalt (0.004 mg/L). As a result, predicted values in these scenarios are not expected to increase from background.

In consideration of risk to aquatic biota in Iron River, the derivation of the BC WQG for Co found caldocerans (water fleas) were the most sensitive freshwater species. The BC WQG was calculated as the geometric mean of four separate Lowest Observed Effect Concentrations (LOECs) for *Daphnia magna* and *Ceriodaphnia dubia*, with the application of a safety factor of 0.5. Note that a LOEC of 3.3 µg/L for *C. dubia* was included in the calculation, even though this value is considered an outlier (MOE 2004). The Co WQG was given an interim status because the toxicity data set used to develop the guideline did not meet minimum requirements for full guideline derivation (MOE 2012). Because clarocerans are planktonic crustaceans, these organisms are likely absent from lotic habitat within Iron River, such that the generic WQG may be overprotective for this system.

Although the risk of Co toxicity to aquatic organisms at PP1 increases under worst-case, extreme low flow conditions (Scenario 1 7Q10), adverse effects related to 7SA5 development are not expected at this time. This assumption is based on the interim status of the current Co WQG, the low likelihood of planktonic crustaceans inhabiting lower Iron River, and the constrained conditions under which Co is predicted to exceed the 30-day WQG. Predicted Co concentrations remain below the 30-day WQG under all conditions at PP2, such that risk of Co toxicity in Quinsam River is low.

Total and Dissolved Iron

Water quality predictions were generated for both dissolved and total Fe at PP1 and PP2. Given BC WQGs exist for both dissolved and total Fe, predictions for each are reviewed separately below.

Dissolved Iron

During the post-closure period, predicted levels of dissolved Fe in Iron River and Quinsam River typically fall below the BC WQG (0.35 mg/L). However, guideline exceedances are expected under worst-case, low flow conditions. Background concentrations of dissolved Fe are relatively consistent throughout the year.

Under Scenario 1, the mass loading model predicts dissolved Fe concentrations at PP1 range from 0.0977 up to 1.472 mg/L (Figure 7-24), with a mean annual value of

0.368 mg/L (Table 7-10). For comparison, Iron River monthly background values (representing the combined datasets of UIR and LIR) range from 0.030 to 0.085 mg/L. Under worst-case conditions (Scenario 1), predicted monthly values for July, August and September exceed the BC WQG for dissolved Fe, coincident with seasonal low flow conditions (Figure 7-24). The model predicts dissolved Fe levels will increase to 5.17 mg/L under 7Q10 conditions, exceeding the BC WQG by a factor of 14. However, the measured dissolved Fe concentration in the Iron River is expected to be much lower than the loading model predicts due to geochemical contrasts between the Iron River and mine-influenced groundwater that introduces the dissolved Fe to the river. Groundwater in contact with the 7SA5 mine workings are moderately to strongly reducing. These conditions allow Fe to be mobile in the groundwater system in a reduced form (dissolved ferrous Fe). In contrast, background water chemistry suggests Iron River waters are well oxygenated – a tenet supported by the stream morphology of this system, which includes a moderately steep gradient, and a continuing series of riffles, cascades and bolder gardens that promote turbulent flow. Under the pH-neutral, oxygenated conditions present in the Iron River, dissolved Fe discharging from the groundwater system will rapidly precipitate in the oxygenated river water as a ferric hydroxide and will become part of the suspended load that is measured in the total Fe fraction rather the dissolved.

In contrast to Scenario 1, mine-influenced waters are predicted to have an immeasurable effect on dissolved Fe levels under expected (Scenario 2) and long term (Scenario 3) conditions in Quinsam River for post-closure. A small increase (up to 0.062 mg/L, from background levels of 0.058 mg/L) is predicted under 7-day low flow conditions in Scenario 2, but this difference falls close to the precision level of the model.

Mean monthly dissolved Fe concentrations predicted for PP2 range from approximately 0.035 to 0.277 mg/L (Figure 7-25). Note that background PP2 concentrations range from 0.035 to 0.071 mg/L. In general, mean monthly levels of dissolved Fe in Quinsam River are predicted to fall below the BC WQG. For Scenario 1 at PP2, mean monthly dissolved Fe levels remain below the BC WQG, with monthly averages ranging from 0.054 to 0.277 mg/L (Figure 7-25). Annual maxima occur in August, coinciding with seasonal low flow, while minima occur during winter high flow. Under 7-day low flow conditions, dissolved Fe levels are expected to increase up to 0.697 mg/L, approximately double the BC WQG (Table 7-11). As observed for PP1, predicted dissolved Fe values at PP2 under for Scenario 2 and Scenario 3 are much lower. In both scenarios, mine-influenced waters are anticipated to have minimal effect on Quinsam River water quality with respect to dissolved Fe.

Based on the above analysis, Fe is a potential parameter of concern in the 7SA5 water quality assessment with respect to Iron River water quality. Water quality modelling

results indicate that both total and dissolved Fe WQGs will be exceeded under worst case conditions. However, actual dissolved Fe levels in the receiving environment are expected to be much lower than levels predicted in water quality modelling. Given the dissolved Fe load (via groundwater) will largely precipitate out of solution once it enters the well-oxygenated, circum-neutral environment at PP1, the effects assessment of Fe focuses on the total Fe fraction (below).

Total Iron

During the post-closure period, predicted mean monthly total Fe concentrations at PP1 range from approximately 0.030 to 1.472 mg/L (Figure 7-26). In contrast, monthly background values for total Fe in Iron River (representing the combined datasets of UIR and LIR) range from 0.030 to 0.334 mg/L. In general, predicted total Fe levels in Iron River fall below the BC WQG for total Fe (1 mg/L), but guideline exceedances are expected for worst-case, low flow conditions.

For Scenario 1, predicted total Fe concentrations at PP1 range from 0.135 up to 1.472 mg/L, with a mean annual value of 0.411 mg/L (Table 7-10). In this scenario, the BC WQG for total Fe is exceeded in the months of August and September during seasonal low flow conditions. Under extreme low flow conditions (7Q10) predicted total Fe levels increase to 5.17 mg/L, exceeding the BC WQG by a factor of approximately 5. Increases of similar magnitude are predicted for dissolved Fe for the months of August and September, and for 7Q10 conditions (below), indicating increases in the total Fe fraction are driven exclusively by mine-related discharge during this time. In contrast, total Fe predictions under expected (Scenario 2) and long term (Scenario 3) conditions at PP1 show no effect from mine-influenced waters.

Mean monthly total Fe concentrations predicted for PP2 under post-closure conditions range from approximately 0.071 to 0.309 mg/L (Table 7-11). For comparison, background PP2 concentrations (representing the proportionally mixed water chemistry of lower Iron River and 7SQR in Quinsam River) range from 0.071 to 0.227 mg/L. Under worst-case conditions (Scenario 1), total Fe levels at PP2 are predicted to remain below the BC WQG, with monthly averages ranging from 0.108 to 0.309 mg/L (Figure 7-27). The mean monthly maximum value occurs in August, while annual minima occur during seasonal high flow conditions (December, January, and February). Under 7Q10 conditions, total Fe is expected to increase (up to 0.731 mg/L), but remain below the BC WQG for total Fe. As observed for PP1, predicted total Fe values at PP2 under expected (Scenario 2) and long term (Scenario 3) conditions are driven by Quinsam River background water chemistry. Mine-influenced water is predicted to have minimal effect on PP2 water quality in either of these scenarios.

Regarding effects to aquatic biota in Iron River, the BC WQG for total Fe considers indirect effects of Fe precipitates on aquatic habitat and species displacement, rather than direct effects of Fe toxicity typically associated with the dissolved fraction (MOE 2008). However, several environmental variables influence both the relative proportion of total and dissolved Fe (and subsequently the bioavailability of Fe) and the risk of adverse effects associated with the particulate Fe fraction. Based on these considerations, a guideline value of 1.0 mg/L was selected as a safe upper limit for sensitive species, which are identified as fish eggs and early life stages. However, MOE (2008) suggests that, "there is also some evidence that in many circumstances 1 mg/L might be overprotective".

Biological monitoring has shown the [absence/presence] of [fish/fish habitat/redds] in Iron River As a result, water quality modelling for PP1 indicates that under worst-case, extreme low-flow conditions (Scenario 1 7Q10), sensitive life stages (fish eggs, alevins) may incur adverse effects at PP1 related to total Fe. However, outside of these conditions, the relative risk of Fe toxicity to sensitive species or life stages Iron River is considered low. At PP2, total Fe is expected to remain below the BC WQG under all conditions and is not considered a parameter of concern in Quinsam River.

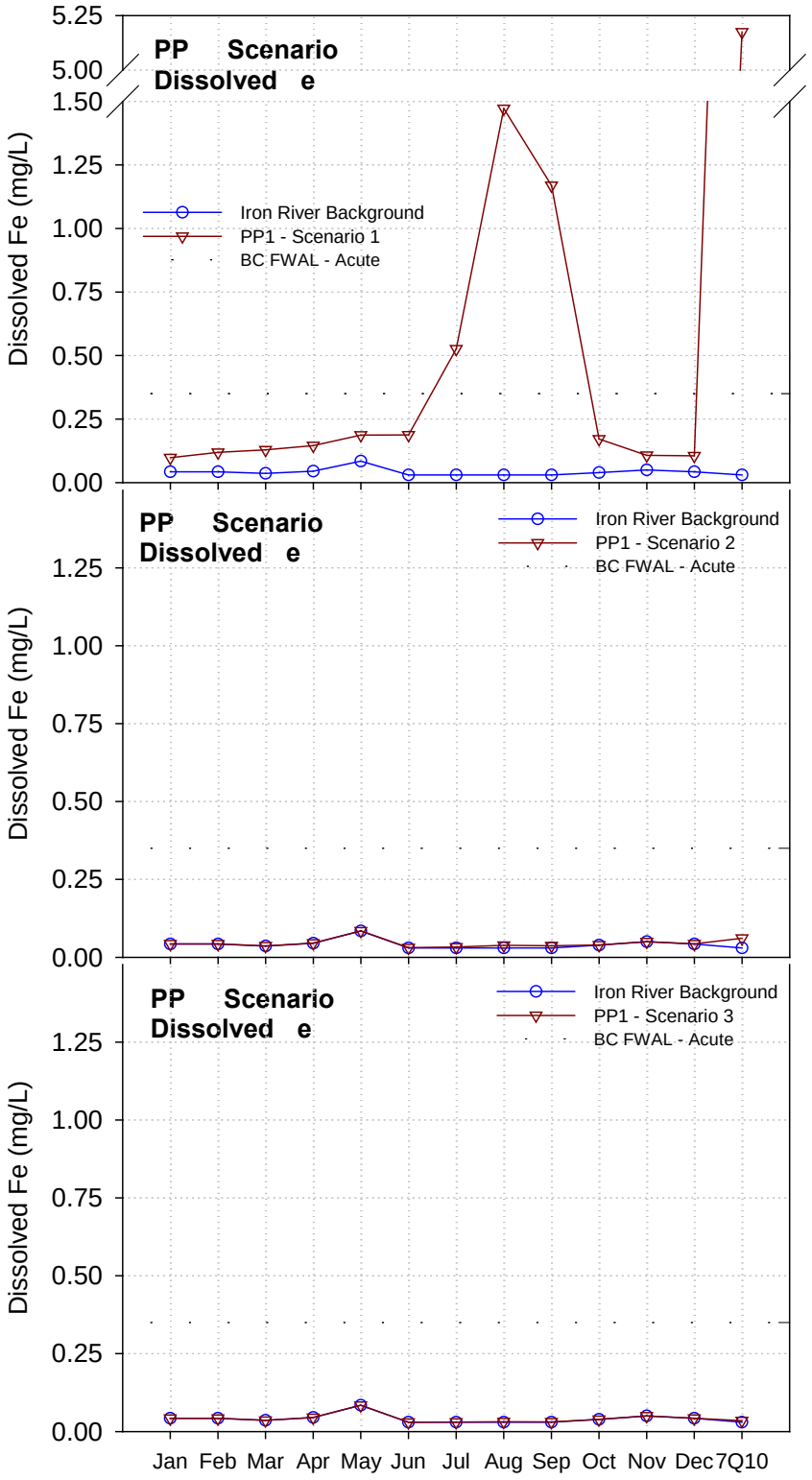


Figure 7-24: Dissolved iron mean monthly and 7Q10 water quality predictions for Prediction Point 1 (Iron River) in post-closure mine phase under closure scenarios 1, 2, and 3 (maroon triangles). Background monthly source terms for dissolved iron in Iron River are shown (blue circles).

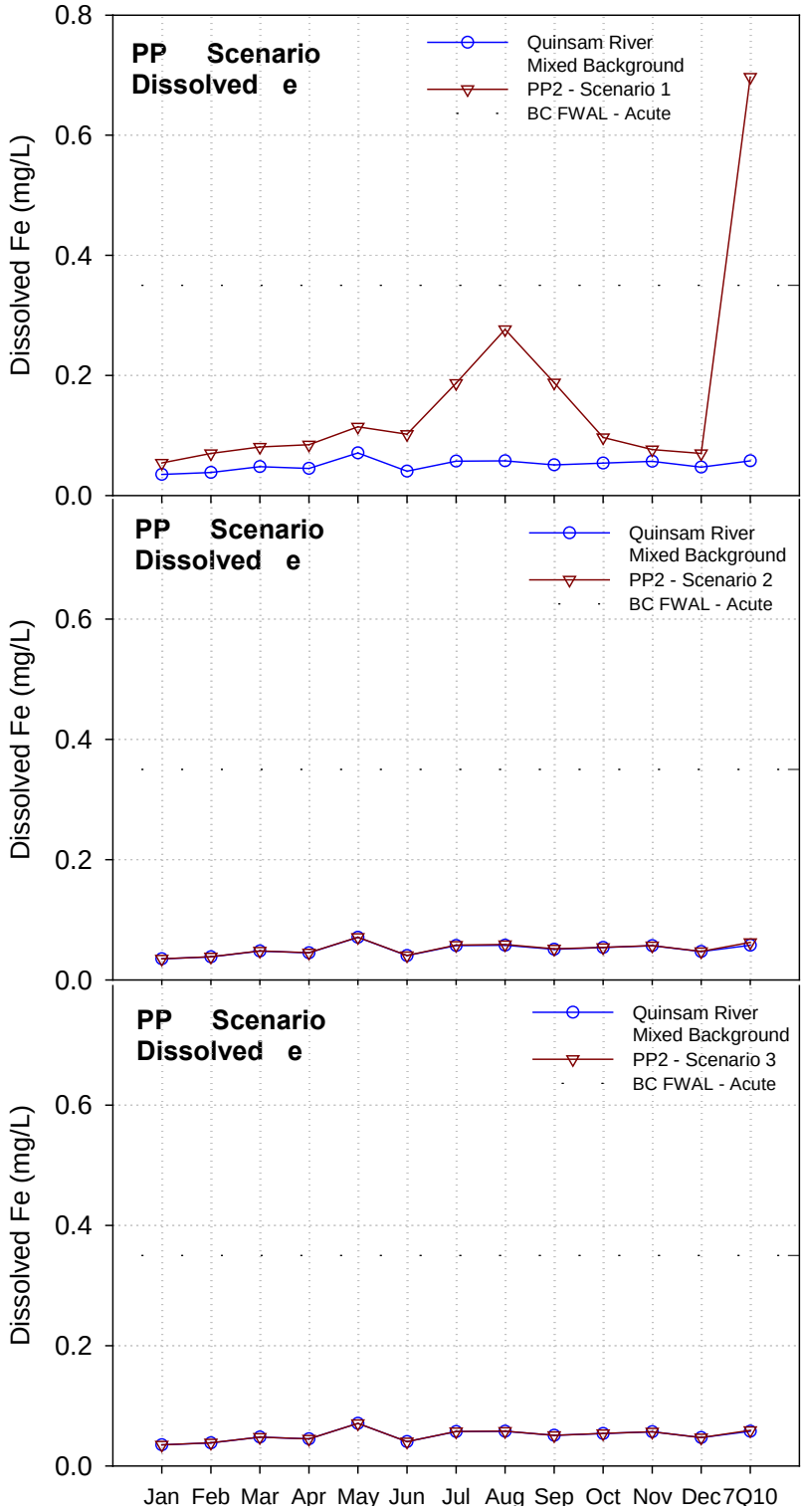


Figure 7-25: Dissolved iron mean monthly and 7Q10 water quality predictions for Prediction Point 2 (Quinsam River) in post-closure mine phase under closure scenarios 1, 2, and 3 (maroon triangles). Background monthly source terms for dissolved iron in Quinsam River (mixed) are shown (blue circles).

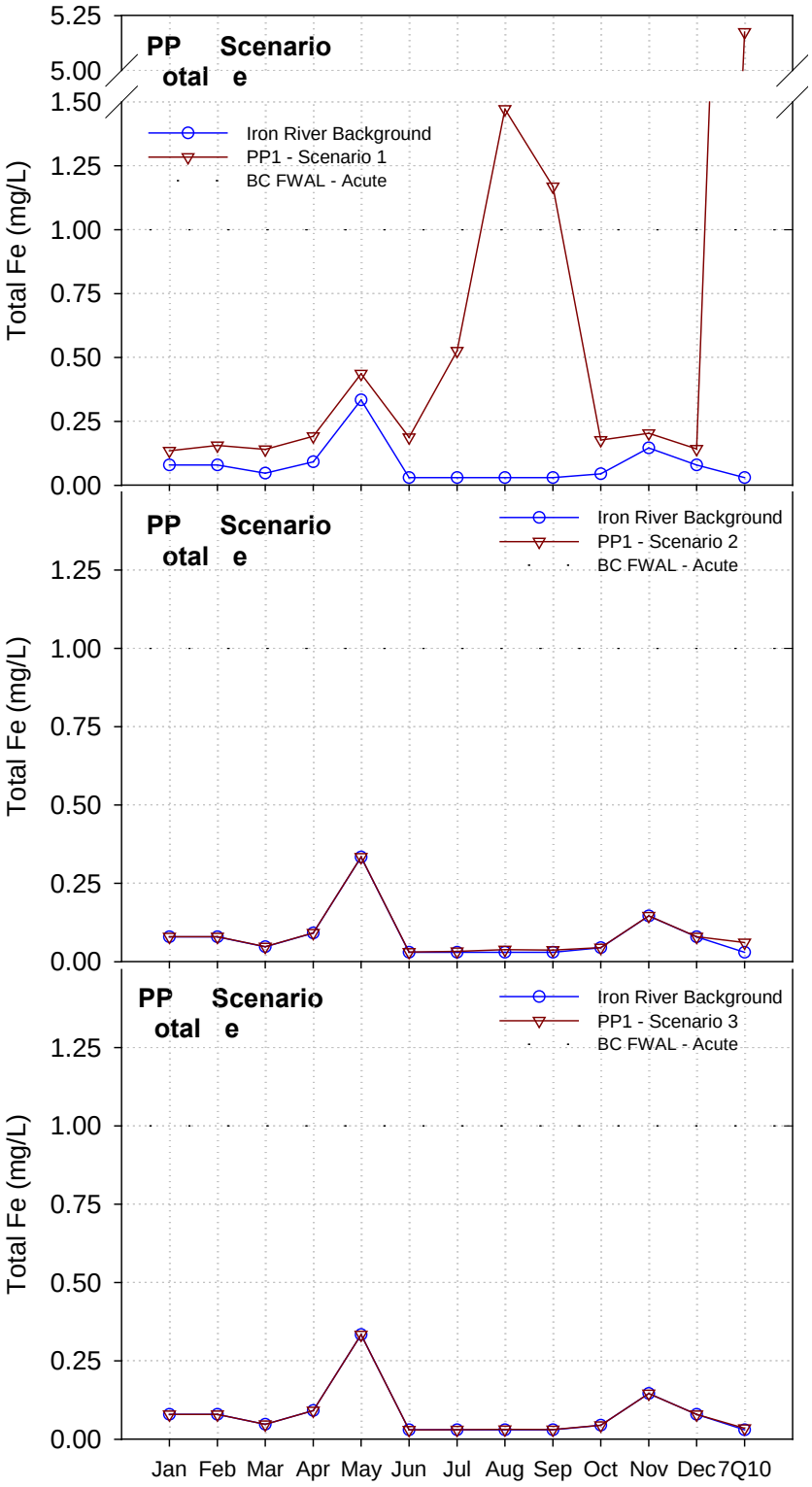


Figure 7-26: Total iron mean monthly and 7Q10 water quality predictions for Prediction Point 1 (Iron River) in post-closure mine phase under closure scenarios 1, 2, and 3 (maroon triangles). Background monthly source terms for total iron in Iron River are shown (blue circles).

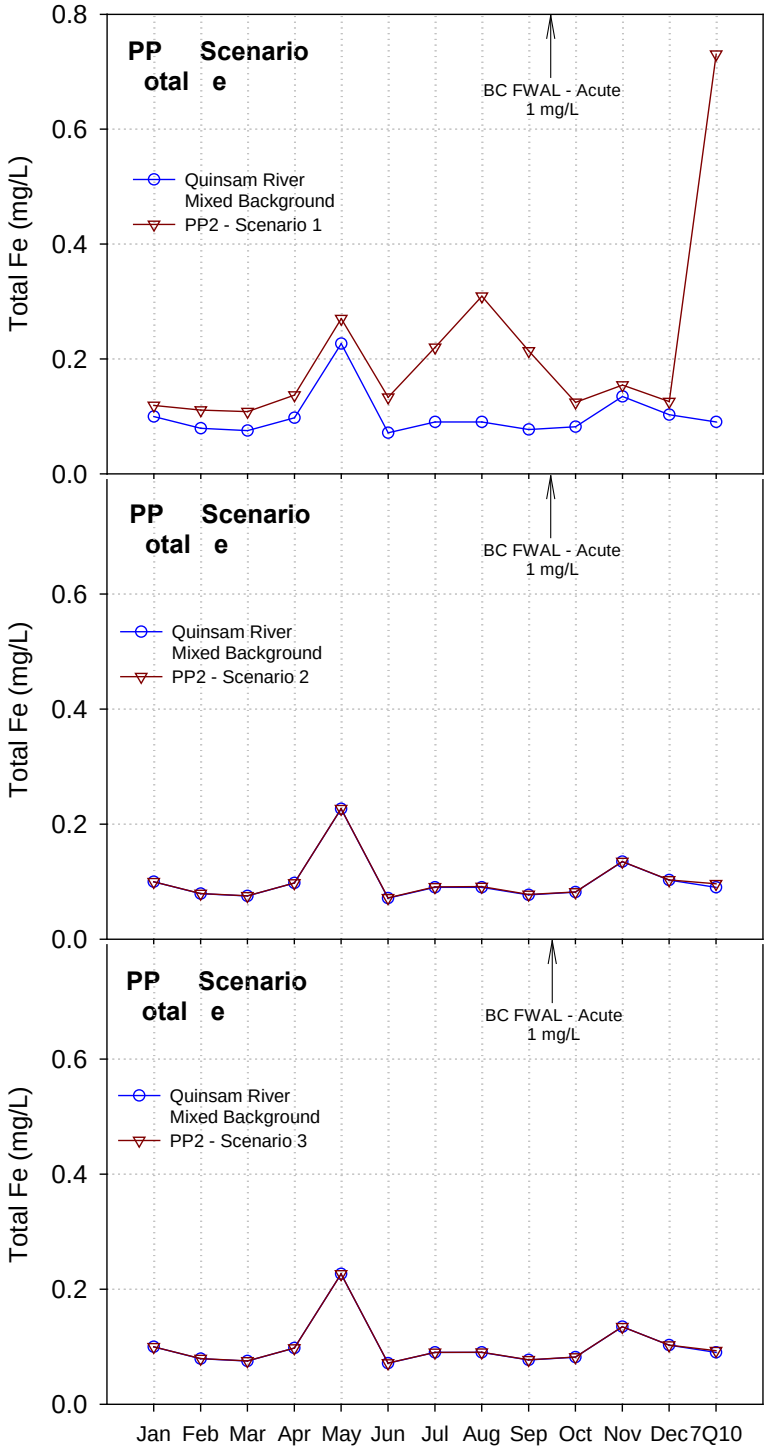


Figure 7-27: Total iron mean monthly and 7Q10 water quality predictions for Prediction Point 2 (Quinsam River) in post-closure mine phase under closure scenarios 1, 2, and 3 (maroon triangles). Background monthly source terms for sulphate in Quinsam River (mixed) are shown (blue circles).

7.4 Cumulative Effects on Quinsam River Post Closure

A cumulative effects water quality model has been updated to assess cumulative effects to water quality in the Quinsam River downstream of the Iron River confluence. In 2011, Lorax modeled the cumulative effects of the then-proposed 7 South mine in combination with other mining activities on water quality in Quinsam River for post-closure conditions. The model was updated in 2012 to include the impact of seepage from 88 Panel. In both model versions, cumulative effects were predicted at the downstream monitoring point 7SQR and assumed instantaneous, concurrent loading from all mine areas under post-closure seepage conditions. The model also assumed conservative mixing of the loads and did not consider geochemical controls on parameter concentrations. The cumulative effects model has now been updated to reflect loading from the 7SA5 development under post-closure conditions. Briefly, this required the following modifications:

- computation of loading estimates from 7SA5 at closure, assuming CCR backfill;
- selection of a new, downstream prediction point on the Quinsam River (PP2) to incorporate loading from 7SA5 to the Iron River; and
- modeling of 'background' water quality in the Quinsam River at PP2 to reflect cessation of pumping from the 2 North/ 5 South underground and the interception and treatment of 2 South/3 South underground water.

These modifications are discussed in more detail below and aspects of the model unchanged from its previous version are also summarized. The reader is referred to Appendix M of Hillsborough (2011) for a detailed description of the original cumulative effects model built in 2011.

7.4.1 Methods

The mine-related effects in the Quinsam River were assessed through the following steps:

- selection of a modeling point on the Quinsam River downstream of the Iron River confluence that receives all mine-related loads including those from 7SA5;
- adjusting background Quinsam River water quality to account for cessation of underground mine dewatering;
- generation of mine area-specific loading rates; and
- prediction of water quality resulting from the cumulative effects of mining disturbances.

7.4.1.1 Modeling Location for Cumulative Effects Analysis

The assessment of cumulative effects on the Quinsam River extends from Middle Quinsam Lake to downstream of the confluence of the Iron River with the Quinsam River at PP2. It is expected that all groundwater seepage from the flooded 2 North, 3 North, 5 South, 7 South and 7SA5 underground mines under post-closure conditions will have entered the Quinsam River by this point.

The background geochemical load at PP2 has been constructed using water quality and flows measured at 7SQR and Iron River. The derivation of monthly flows for PP2 is outlined in Chapter 4. Monthly concentrations of parameters of concern at PP2 have been modeled by assuming conservative mixing of water from the Iron River (using the 2008-2010 data set from Iron River Upper and Lower stations (Table 5-8)) and Quinsam River at 7SQR. Note that the previous cumulative effects modeled 7SQR concentrations after those measured at WB since the data set at 7SQR was not as comprehensive and incorporated higher detection limits. Continued monitoring using lower detection limits has allowed the calculation of average monthly water quality at 7SQR using values from 2007-2012. Note that Al and Cu concentrations derived from this data set are slightly higher than those values that were inferred previously from the WB data set. The background geochemical load at PP2 is thus calculated according to the equation:

$$Load_{PP2} = \left(C_{IR} \cdot V_{IR} + C_{7SQR} \cdot V_{QR}\right) * \frac{1000}{days\ in\ month}$$

where:

$Load_{PP2}$ = monthly chemical load at point PP2 on the Quinsam River (kg/d)

V_{IR} = monthly flow for the entire Iron River drainage reporting at the confluence with the Quinsam River (m^3) (Table 4-5)

C_{IR} = monthly average concentrations measured in the Iron River (mg/L) (Table 5-8)

V_{QR} = monthly flow in Quinsam River at station WD (m^3) (Table 4-5)

C_{IR} = monthly average concentrations in the Quinsam River at station 7SQR (Table 5-9)

The background geochemical load at PP2 is tabulated in Appendix G1.

7.4.1.2 Adjustment of Background Water Quality at PP2

The background geochemical load calculated for PP2 in the previous section reflects current conditions where water from the 2 North, 3 North and 5 South underground mines is actively pumped to SP4 for discharge into the Quinsam River. It also reflects current loading from the 2 South/ 3 South underground mines via the Long Lake Seep. At

closure, underground discharge to SP4 will cease and flow from the Long Lake Seep is also assumed to stop entirely as water will be pumped from the 2 South/3 South underground into a biocell treatment system (which came online in late 2011). There will be discharge of biocell effluent to SP4 at closure. Thus, the background geochemical load at PP2 needs to be adjusted for closure conditions by removing the loads from the Long Lake seep and underground pumping to SP4 and adding the load from biocell treatment system, as per the following equation:

$$Adjusted\ Load_{PP2} = Current\ Load_{PP2} - Load_{UG} - Load_{LLS} + Load_{Biocell}$$

where:

$Load_{PP2}$ = Average monthly load in Quinsam River at PP2 (kg/day)

$Load_{UG}$ = Average monthly load from underground pumping to SP4 (kg/day)

$Load_{LLS}$= Average monthly load from the Long Lake Seep (kg/day)

$Load_{Biocell}$= Average monthly load to SP4 from the biocell treatment system (kg/day)

The removal of the load from underground pumping to SP4 has been discussed previously in Lorax 2011(b). Underground pumping rates are not directly measured and are back-calculated from SP4 flows (measured at station WD) by assuming 20% runoff from the surrounding catchment (Appendix G2). The flows used in the previous analysis have been updated to include more recent precipitation and WD flow measurements (from 2006 up to March 2013). In some cases, precipitation from the site rain gauge was not available and values measured at the Campbell River airport were used instead and scaled according to Lorax (2009). The underground water quality is represented by median water quality measured at the 2 North underground sumps between 2006 and 2010 (Hillsborough, 2011). Concentrations for only selected parameters of concern could be calculated (Table 7-12) since most parameters were frequently measured below detection limit.

Table 7-12:
Median Concentrations of dissolved SO_4, Al, Fe and Mn from 2 North Mine Water.

Parameter	Concentration (mg/L)
SO_4	235
Al-d	0.025
Fe-d	0.030
Mn-d	0.062

The load from underground pumping to SP4 is calculated by multiplying the monthly average pumping rates by the average concentrations in Table 7-12; results are tabulated in Appendix G1.

Average monthly loads from the Long Lake Seep were calculated in a groundwater assessment of Long Lake (Lorax, 2012a). These loads have been tabulated in Appendix G1. It is assumed that when the biocell treatment system is brought completely online, flow from the Long Lake Seep will stop but loading from the treatment system itself will have to be added to SP4 (and thus to background water quality at PP2). This load has been quantified by assuming that the treatment system will discharge at an average daily rate equivalent to the average daily flow at the Long Lake Seep (~1050 m^3/d) (calculated using a partially synthetic data set for the 2002-2010 period of record). The parameter concentrations associated with this have been estimated by averaging the water quality measured during 11 sampling events at SP-EFF (treatment system settling pond effluent) since November 2012. Where parameter concentrations were measured below detection limit, the detection limit was used for the calculation. Average water quality measured at SP-EFF is presented in Table 7-13; the resultant chemical load to SP4 is tabulated in Appendix G1.

Table 7-13:
Average Concentrations of Parameters of Concern at SP-EFF (Nov 2012- March 2013).

Parameter	Concentration (mg/L)
SO_4-D	225.9
Al-T	0.16
As-T	0.0096
B-T	0.396
Cd-T	3.7E-05
Co-T	0.00499
Cu-T	0.0026
Fe-T	7.90
Mn-T	3.32
Ni-T	0.0040
Se-T	0.00012
Zn-T	0.00991

Appendix G1 contains the final adjusted background parameter loads. The loads have been expressed as concentrations (as a function of the flow at PP2) and plotted in Figure 7-28 and Figure 7-29 to show the relative impact of the load adjustments on the

background water quality. For the most part, the adjustment to the background concentrations at PP2 is minor except for sulphate, which declines noticeably due to cessation of pumping from the underground, and manganese, which increases substantially due to inputs from the biocell treatment system.

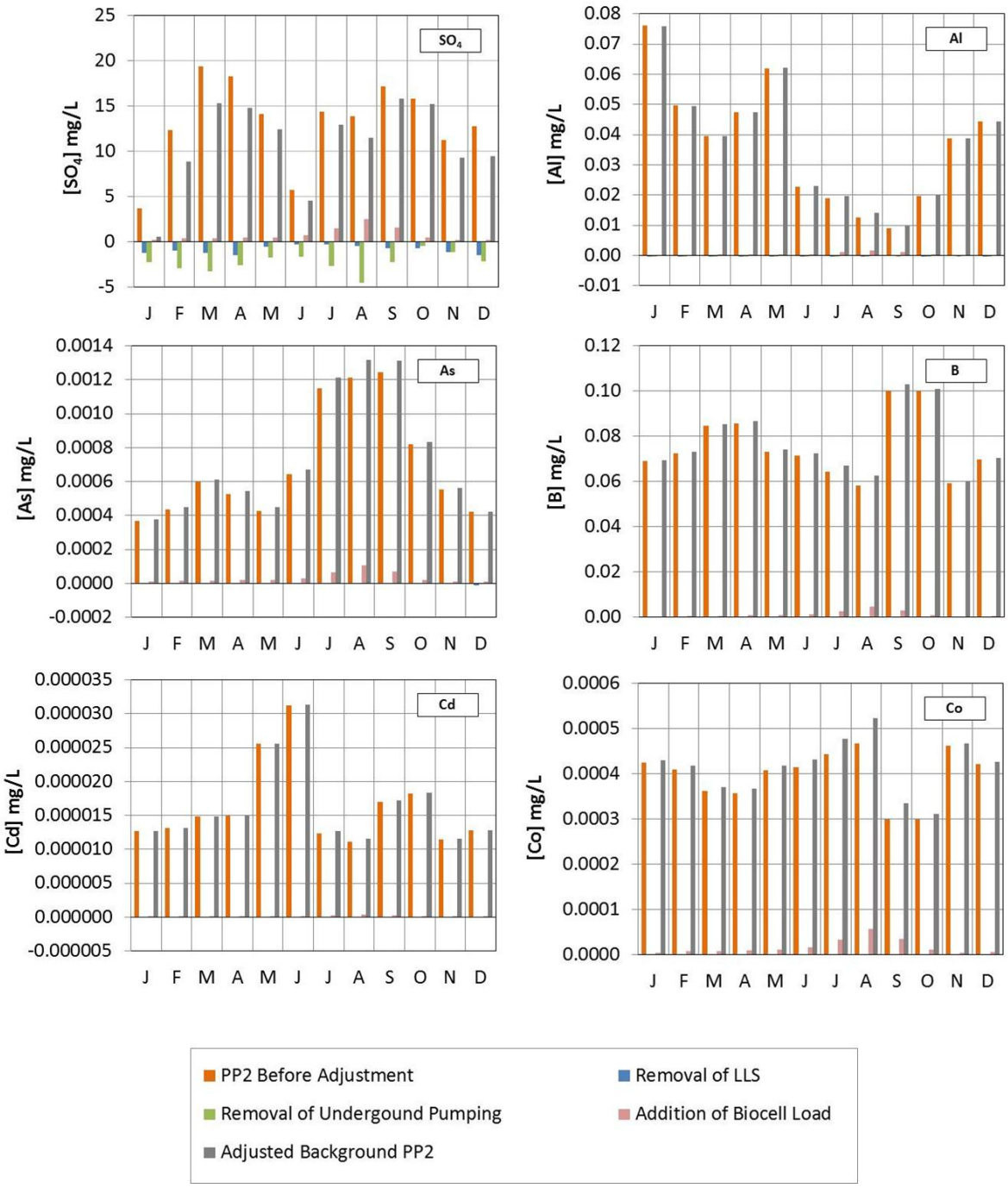


Figure 7-28: Adjustment of background POC concentrations (mg/L) at PP2.

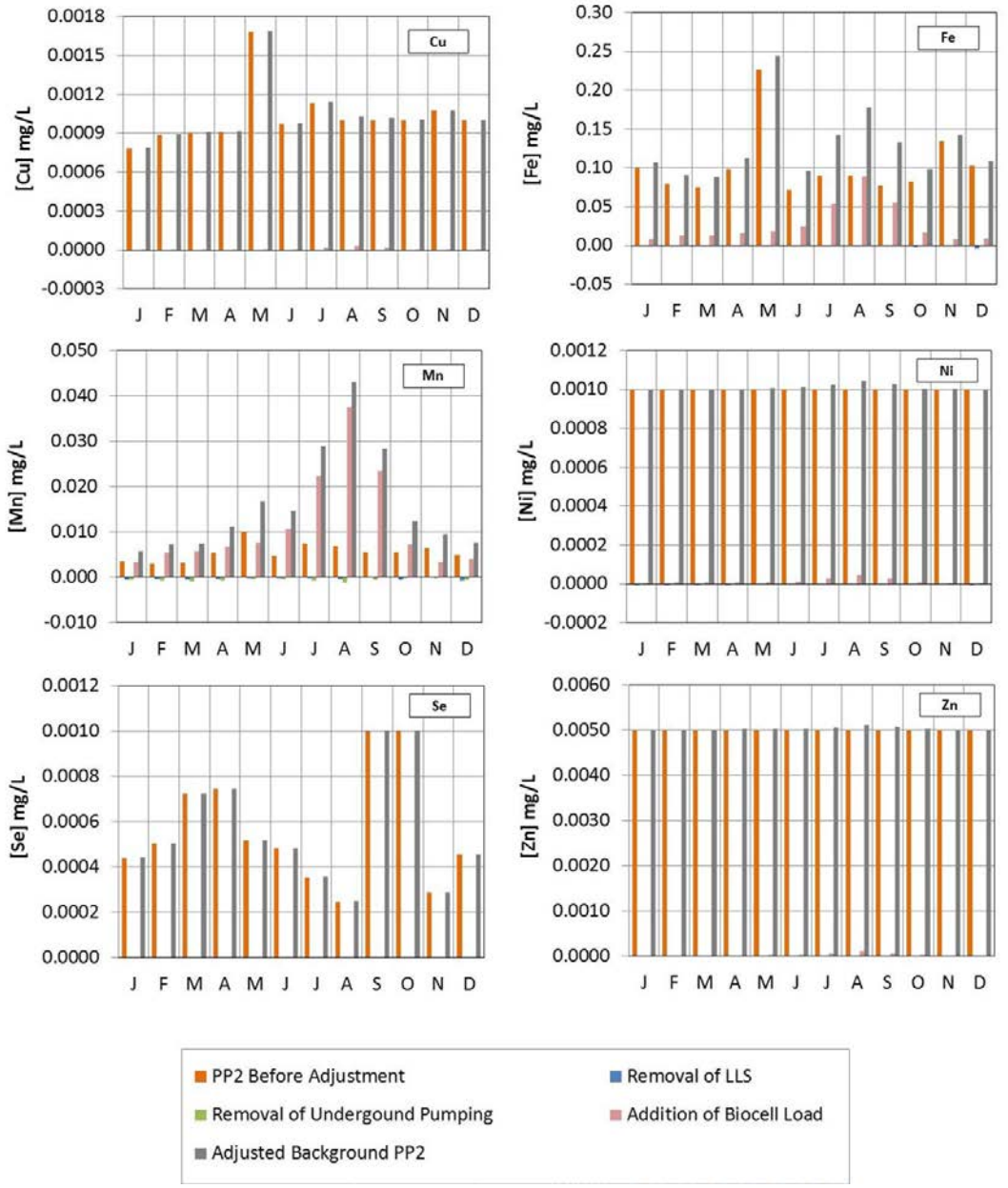


Figure 7-29: Adjustment of background POC concentrations (mg/L) at PP2.

7.4.1.3 Mine Loading Rates

Loading rates for the various mine areas at closure have been developed in numerous studies summarized in Table 7-14. The cumulative effects model takes into consideration two loading scenarios: expected and worst case concentrations under flooded conditions from each of the mine areas in units of kg/day. Both the expected and worst case scenarios include source terms for the stowage of coarse reject and tailings for areas

where QCC has proposed to store these materials. The scenarios are summarized in Table 7-14. The loading rates in kg/d for the expected and worst case from each mine area (including 7SA5) are tabulated in Appendix G3. For this analysis, it is assumed that the 7Q10 low flow period occurs in August and consequently, the mine loading rates calculated for August are used for the 7Q10 period.

Table 7-14:
Expected and Worst Case Loading Scenarios Incorporated into the Quinsam River Cumulative Effects Assessment.

Source of Loading	Description*	Reference
2N/3N Mine Seepage	Expected Case: Scenario 2 - Tailings Stored in Mine Void (Expected source term concentrations and groundwater fluxes). Table 7-1	Hillsborough (2011) Appendix K
	Worst Case: Scenario 2 - Tailings Stored in Mine Void (Higher than expected source term concentrations and groundwater flows). Table 7-1	
5S Mine Seepage	Expected Case: Scenario 2 - CCR Stored in Mine Void (Expected source term concentrations and groundwater fluxes) Table 7-2	Hillsborough (2011) Appendix K
	Worst Case: Scenario 2 - 7S CCR Stored in River Barrier Pillar (Higher than expected source term concentrations and groundwater flows) Table 7-2	
7S Sediment Pond	Expected Case: Loadings utilized were based on Expected Case Sediment Pond contributions only.	Hillsborough (2011) Appendix L
	Worst Case: Worst Case loading rates from the Sediment Pond only.	
7S Mine Seepage	Expected Case: Scenario 2 - Non-Acidic (Expected) Conditions with CCR Storage (Median Based on groundwater fluxes derived from K database). Table 9-2	Hillsborough (2011) Appendix J
	Worst Case: Scenario 1 - Acidic Conditions with CCR Storage (Upper Bound Based on groundwater fluxes derived as of 10% MAP). Table 9-1	
4S Mine Seepage	Expected Case: Scenario 2 - Flooded Workings with CCR (Median groundwater flux – sum of Long Lake and Quinsam River loadings). Table 7-2	Hillsborough (2011) Appendix I
	Worst Case: Scenario 2 - Flooded Workings with CCR (90^{th} Percentile groundwater flux – sum of Long Lake and Quinsam River loadings). Table 7-2	
2S PAG Storage	Average seepage rates for 2S seepage to Long Lake and 2S Pit seepage to 3S pit were used for both the Expected and Worst Case at 2S PAG Storage. In addition to this:	Hillsborough (2011) Appendix G
	Expected Case: Average monthly overflow from 2S pit to 3S pit was used.	
	Worst Case: Maximum monthly overflow from the 2S to 3S pit was used.	
88 Panel Seepage	Expected Case: Expected groundwater fluxes and expected chemistry for mine void (net neutral). Table 3	Lorax (2012b)
	Worst Case: Worst case groundwater fluxes and worst case chemistry for mine void (net neutral). Table 3	
7SA5 Mine Seepage	CCR stored in Mine Void. The upper limit of the range of closure groundwater seepage rates (0.9 L/s) is used for both scenarios. In addition to this:	This report
	Expected Case: Scenario 3 - expected long term conditions from the flooded mine containing coarse reject	
	Worst Case: Scenario 1 - worst case conditions (mine workings and CCR become acidic prior to flooding).	

*Description lists table in the original report referenced that discusses derivation of loading term

7.4.2 Results

The predicted cumulative effect of mine loading at closure is depicted graphically in Figure 7-30 through Figure 7-33 for the parameters of concern. The load from each mine area has been computed as an incremental change in concentration at PP2; the full height of the stacked bars represents the cumulative concentration or effect on water quality for the specified time period. The incremental and aggregate concentrations are tabulated in Appendix G4. As per previously published versions of this model (Hillsborough, 2011; Lorax 2012b), the computed concentrations assume (i) complete mixing of mine loads with background flow and (ii) conservative behaviour of parameters (*i.e*. no secondary mineral precipitation that may reduce concentrations in the river). The predicted concentrations at PP2 are compared to British Columbia Water Quality Guidelines for the protection of freshwater aquatic life (FWAL). Hardness dependent guidelines were calculated using background monthly average hardness values calculated for the PP2 site.

Overall, concentrations of most parameters of concern are below applicable guidelines under expected conditions. Dissolved aluminum exceeds the chronic guideline in January and May and total cadmium exceeds the acute guideline most times of the year except for July, August, November and during the 7Q10 low flow period. These parameters, however, are elevated in the background water quality and mine related loads account for less than 2% of the aggregate concentrations at most times of the year. As expected, the relative contribution of mine seepage on aggregate concentrations is highest during the 7Q10 low flow period, with mine seepage overall accounting for less than 30% of aggregate concentrations for most parameters. This relative contribution from mine seepage is higher for sulphate (37%) and arsenic (59%).

Under worst case conditions, arsenic levels are predicted to exceed the acute guideline (0.005 mg/L) during the 7Q10 low flow period. Over 40% of the arsenic concentration (0.0072 mg/L) can be attributed to seepage from the 2 North mine. Cadmium, whose background concentration exceeds the acute guideline during most times of the year, is predicted to exceed the guideline additionally in the 7Q10 and August low flow periods. As noted in the baseline water quality results (Section 5.2) the estimated background concentrations are largely due to the effect of the analytical detection on the calculated concentrations. Cobalt also nudges above the chronic guideline (0.0044 vs 0.004 mg/L) during the 7Q10 period; this is mostly due to loading from 7SA5 and 5 South underground (contributing 31% and 25% of the total concentration, respectively).

Of all parameters, iron shows the most dramatic increase under worst case conditions (note log scale), with concentrations increasing from 50% (November) to nearly 500% (August) over background levels. During the 7Q10 low flow period, concentrations

increase 13-fold over background levels. Most of the concentration increase is due to loading from 7 South, 7SA5 and 4 South. Worst case iron concentrations exceed the dissolved acute guideline (0.35 mg/L) in May, July-September and 7Q10 flow periods, while the total acute guideline (1 mg/L) is exceeded in the 7Q10 and August low flow periods. The loading model does not account for secondary mineral precipitation that is expected to transform the majority of the dissolved iron from solution to ferric hydroxides in the solid phase. Thus, iron loading to the Quinsam River will not remain in the dissolved phase and will be carried as suspended solids or deposited in the river sediments.

It should be stressed that worst case conditions reflect either poor waste management practices (*i.e*. CCR +/- mine void walls become acidic prior to flooding (7 South and 7 South Area 5)) or represent extremes in the water quality or groundwater data set. The mine has committed to assist reflooding of mine voids where needed to minimize oxidation of workings and mine waste.

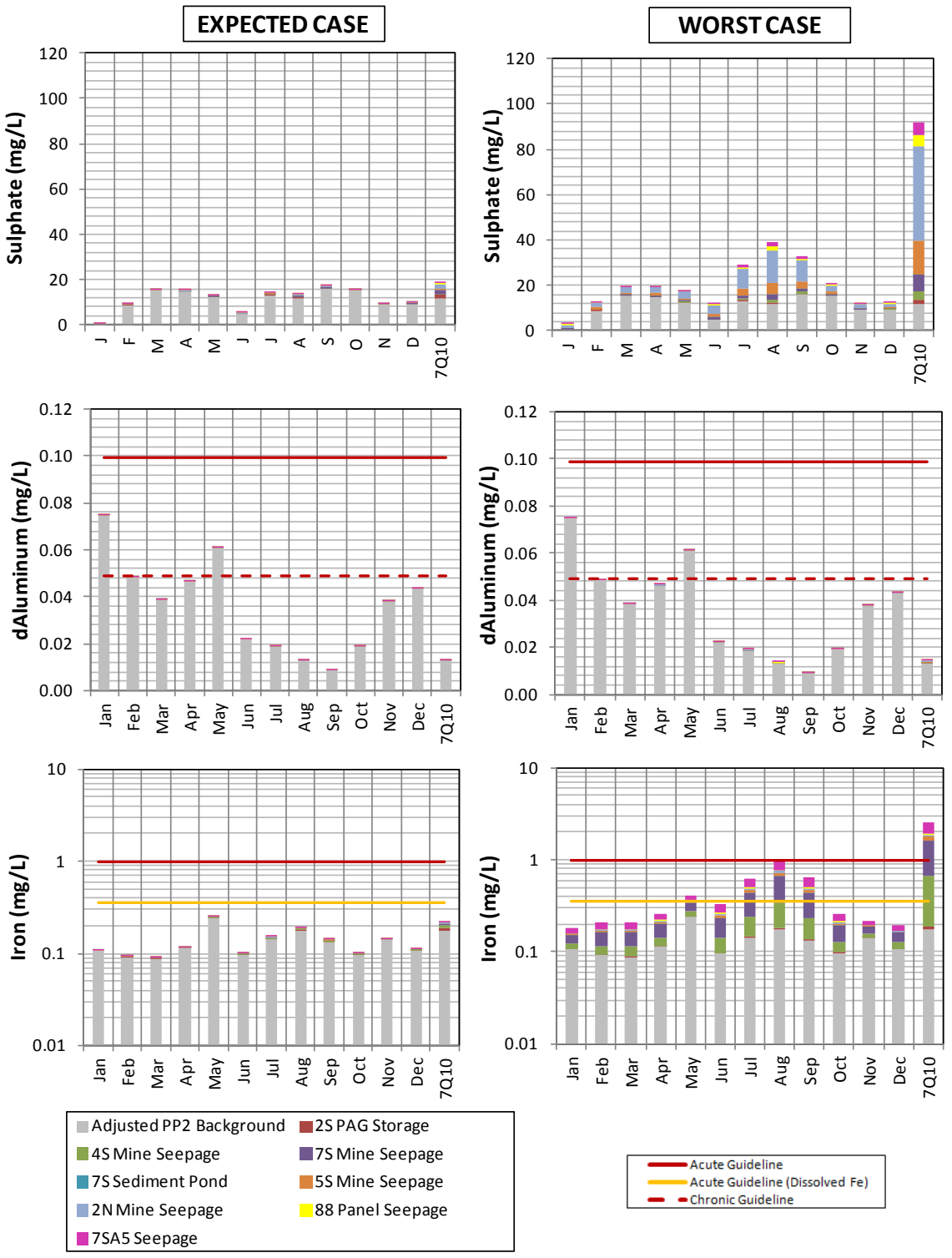


Figure 7-30: Predicted Cumulative Concentrations of Sulphate, Dissolved Aluminum and Iron at PP2.

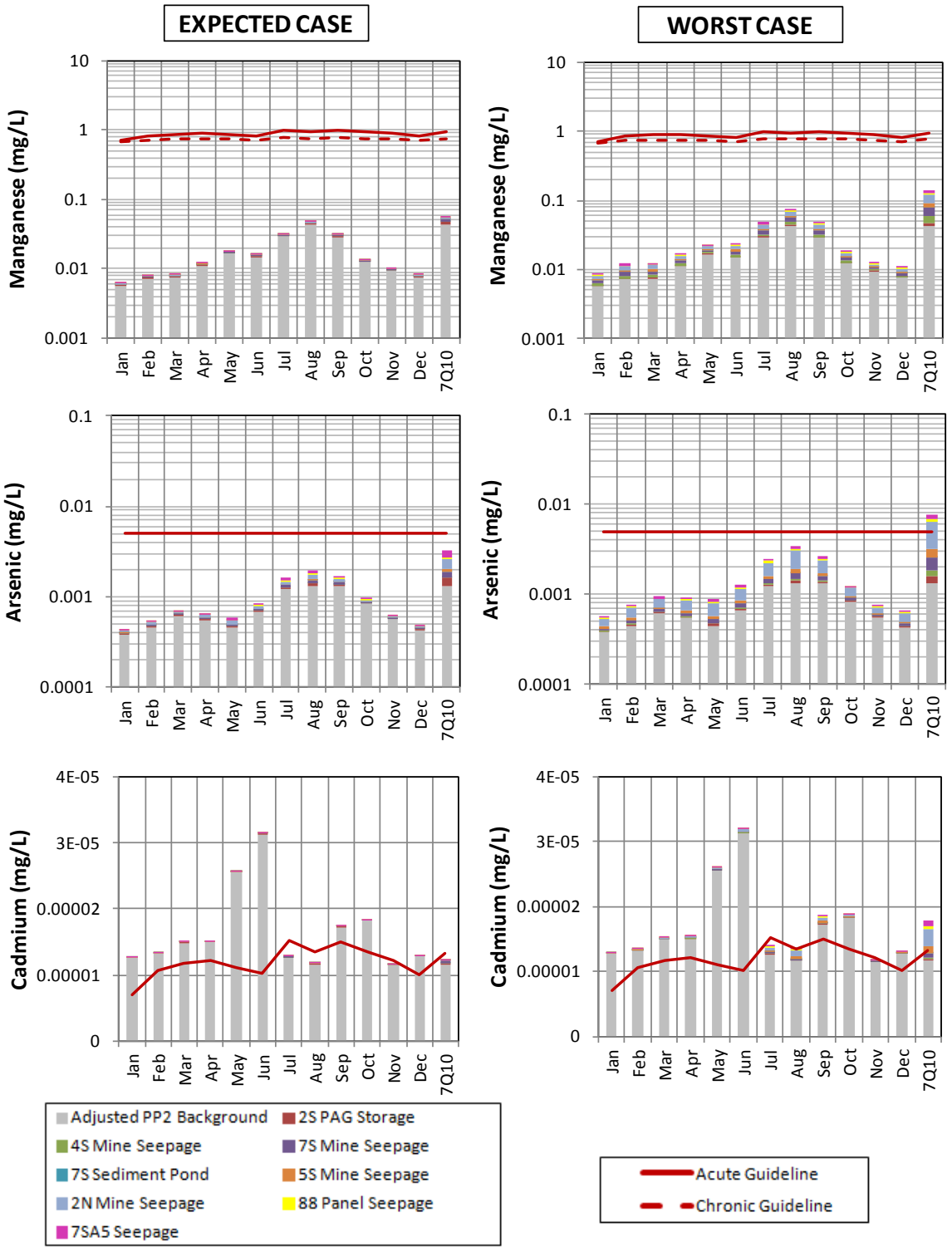


Figure 7-31: Predicted Cumulative Concentrations of Manganese, Arsenic and Cadmium at PP2.

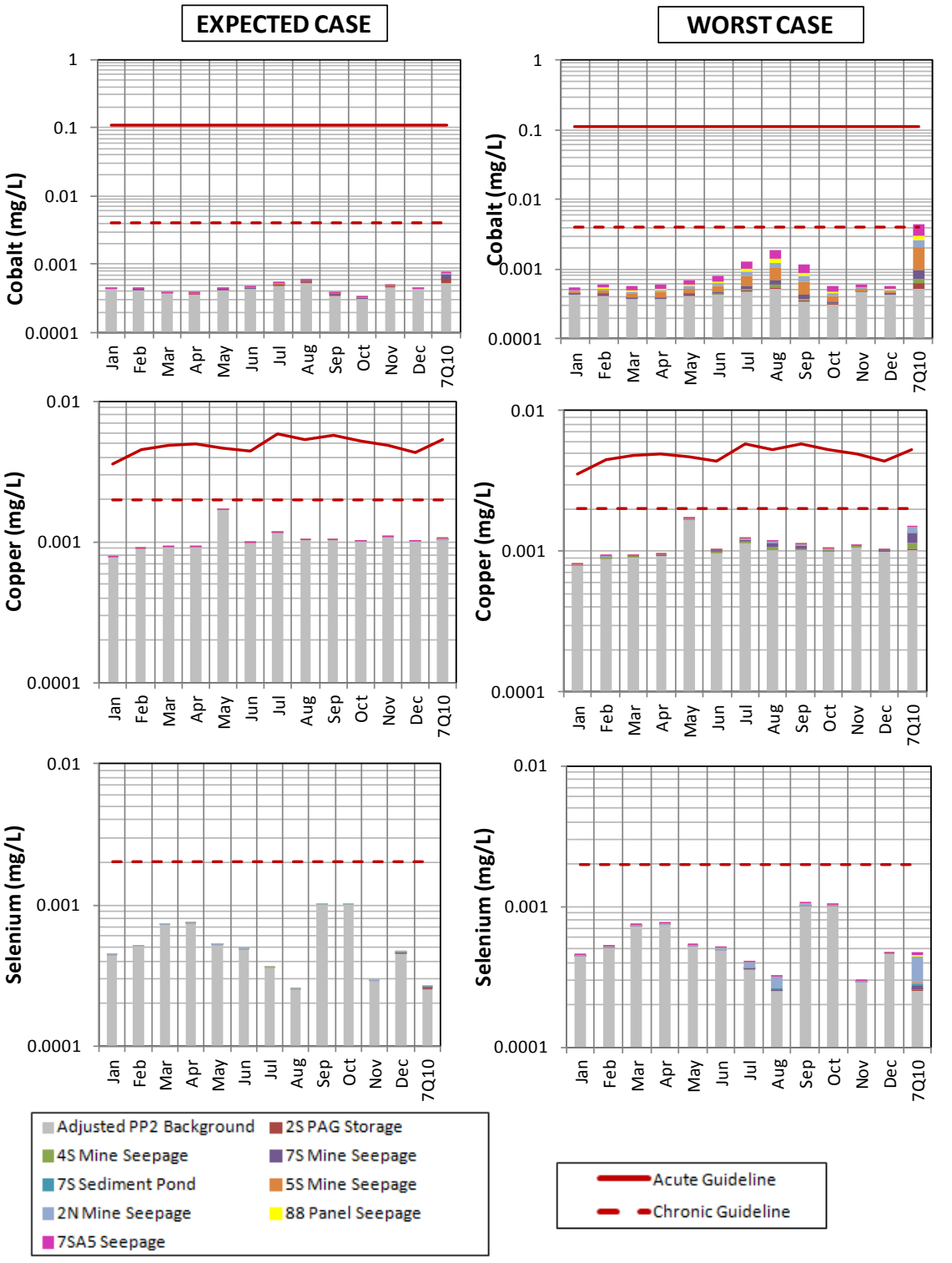


Figure 7-32: Predicted Cumulative Concentrations of Cobalt, Copper and Selenium at PP2.

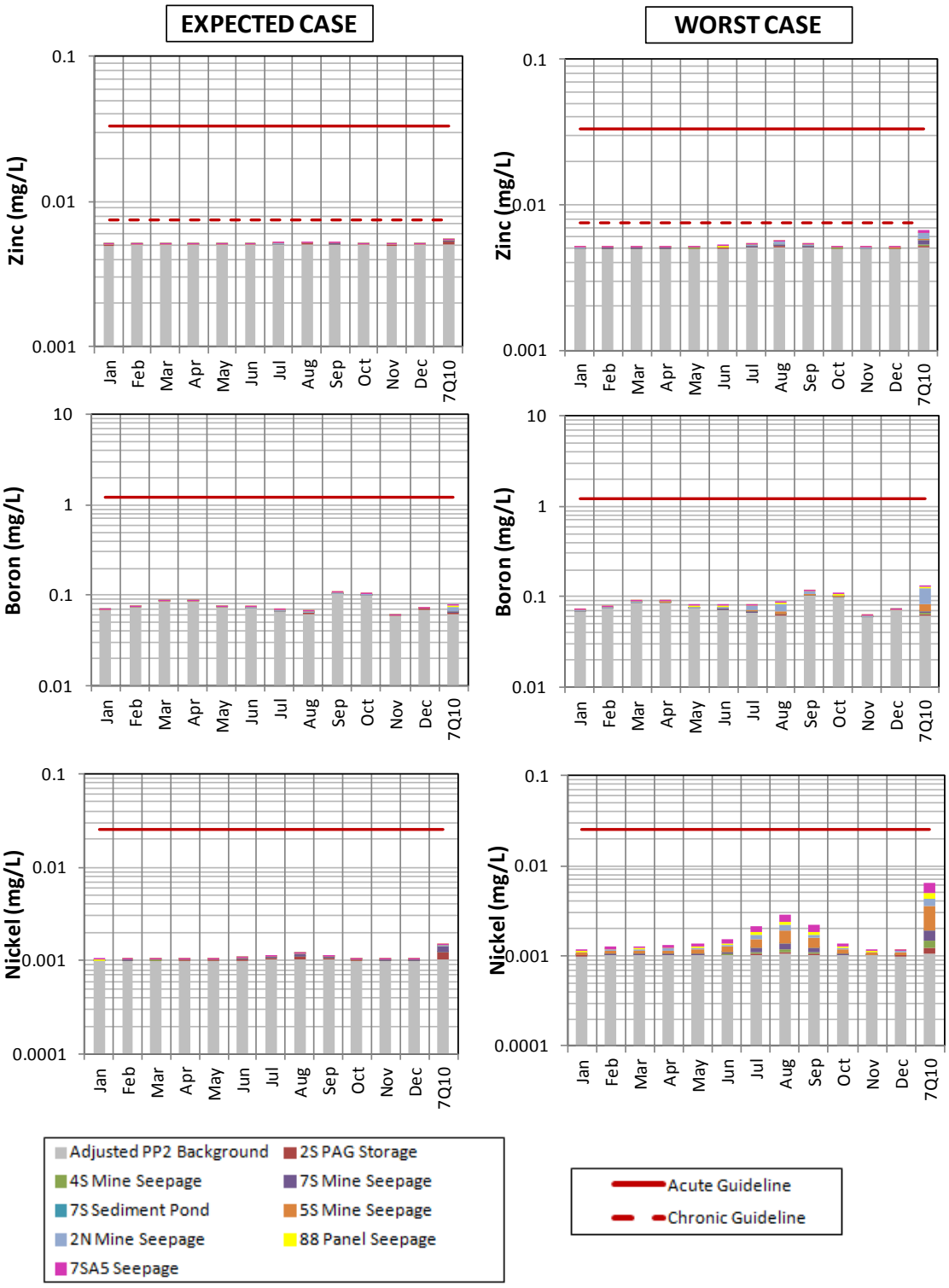


Figure 7-33: Predicted Cumulative Concentrations of Zinc, Boron and Nickel at PP2.

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Appendices

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Appendix A
Physical Groundwater Data

APPENDIX A1 WATER BEARING FEATURES IN 7SA5

APPENDIX A2 GROUNDWATER FIELD INVESTIGATION

APPENDIX A3 WATER LEVEL DATA

APPENDIX A4 WELL INSTALLATION LOGS

APPENDIX A5 SLUG TEST ANALYSES

APPENDIX A6 HYDRAULIC CONDUCTIVITY DATABASE

APPENDIX A7 7SA5 PUMPING TEST

APPENDIX A8 PUMPING TEST RAW DATA (PSP)

APPENDIX A9 PUMPING TEST ANALYSIS (AQTESOLV)

APPENDIX A10 PUMPING TEST PROJECTIONS

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APPENDIX A1 WATER BEARING FEATURES IN 7SA5

DH ID	Ground Surface (m)	Till Depth (m)	4 Seam Interval (m bgs)		Top of Cumberland (m bgs)	Top of Benson (m)	Top of Basement (m)	Total Depth (m)	Bedrock Interval (m mine grid)		Fault/Water Bearing Intervals (m bgs)		Fault/Water Bearing Intervals (elevation)		Unit	Description
11-18	299.711	34.4	41.19	43.19	79.25	105.74	NR	115.21			37.09	37.54	262.621	262.171	Fault in Sandstone	Fault Zone in Sandstone; The fault zone is quite broken, but the pieces are still in their original location, they fit together. There is oxidation along three fracture planes at 60 degrees, with the broken core in between. The fractures are lined with rusty clays, and none of the oxidation has leached into the host rock, i.e.. very little waterflow. The sandstone is as above, medium grained, medium grey, intact and uniform, ~10% of the sands are black lithic fragments. The bottom contact is one of the fracture planes at 60 degrees. The unit above and below are unfractured, unaffected outside of the fracture planes.
											38.15	38.71	261.561	261.001	Sandstone	Sandstone; Only ~10cm recovered, pyritic grey clays with sandstone rubble, a possible fault zone, with lots of lost core, the core tube jammed (probably on the fault above) and then this probably ground away.
											65.532	67.056	234.179	232.655	Siltstone	Medium grey siltstone with trace coal fragments. Picked up 12 gpm at 216'.
											79.248	80.772	220.463	218.939	Fault in Siltstone	Fault zone, 70% medium grey siltstone, 20% medium brown siltstone, 5% calcite fragments, 5 % coal fragments.
											80.772	82.296	218.939	217.415	Fault in Siltstone	Fault zone, 70% medium grey siltstone, 20% medium brown siltstone, 5% calcite fragments, 5 % coal fragments.
											82.3	82.44	217.411	217.271	Fault in Siltstone	Fault Zone in Siltstone; Medium greyish brown siltstone. This is the bottom of the fault zone, which was noted when drilling, starting at 79.25m. The interval is granular rubble and clays.
											85.57	92.16	214.141	207.551	Siltstone	Siltstone; Commonly broken unit, with a few fractures at 45 degrees, with waxy surfaces. There is rooty coal randomly throughout, less than the above coaly siltstone. The unit is medium grey coloured, and hard. There are some short 10-15cm sections that are broken up and rubbly with minor granular clays within the fragments. Below 86.8m, there is little to no coal anymore. Between 88-88.5m, there are a few fractures or breaks at 40-45 degrees. The unit is often broken. At 290.6m, there is a 10cm section of hardened bioturbated siltstone, alike 85.35-85.57m. Between 291.5-291.8m, there is a broken rubbly fault zone at 38 degrees. There is a thin 1.5cm coal seam within the fault zone at 15 degrees, bedding likely. After this fault, the unit is quite hard, but is still broken every ~5-10cm. At 91.90m, there is a 1/2cm calcite filled fracture at 43 degrees. The bottom contact is sharp at 21 degrees.
											94.68	98.48	205.031	201.231	Siltstone	Siltstone Interbeds; Interbeds of slightly different coloured siltstone, with sharp planar contacts at 30-35 degrees, a medium and a slightly darker grey colour. The interbeds are ~15-25cm's thick. The unit is intact, but still often broken. At 94.25m, there is an 8cm fault zone, filled with rubble and clays, the bottom is calcite layered at 16 degrees. The unit has a few fractures, planar, between 30-45 degrees. Below 97.23m, the unit is intact. The bottom contact is sharp at 22 degrees, not intact.
											104.04	105.74	195.671	193.971	Siltstone	Siltstone interbeds; Interbeds of dark green and dark grey siltstone, with a short 10-15cm rubbly fault zone, at 40 degrees, consistently, 1/<30cm. In the top 20cm , there are some coal spars, rooty. There are rare calcite veinlets at 35 degrees. The bottom contact is at 25 degrees.
											105.57	111.9	194.141	187.811	Siltstone	Siltstone Interbeds; Slightly maroon hematitic siltstone, and dark green siltstones. The unit is solid until 111m, then slightly broken up. There an 18cm fault zone at 43 degrees at 111.65m, with granular rubble within, clays and muds. Some of the interbeds have distinct sharp steep contacts at 45-50 degrees. The bottom contact is sharp at 45 degrees.
11-19	295.817	32	37.78	39.8	69.65	NR	NR	94.18			43.46	44.02	252.357	251.797	Sandstone	Sandstone; Tight fine grained medium grey sandstone with faint brown bioturbations, round halos and elongate rounded blebs, hollow in the middle; ophiomorpha? There are also minor blebs with dusty interstitial pyrite. Mid interval, there is a rubble zone, water? The bottom contact is sharp, erosional
											46.23	47.31	249.587	248.507	Sandstone	Sandstone; Dirty medium grained medium grey, tight, hard. After 46.45m, there is a slight orange coloured overprint, carbonate alteration, strong fizz. At 46.41m, there is a sharp fracture at 60 degrees. The bottom contact is sharp at 19 degrees.
											65.1	68.4	230.717	227.417	Coal and Mudstone	Fault Zone Through Coal and Muds; Very soft gooey coaly muds and coal and rock fragments. A possible fault plane is at 41 degrees. 8 gpm of water was picked up in this fault.
											69.65	76	226.167	219.817	Cumberland?	Mudstone; Hard mudstone with calcareous zones of harder muds that are a beige brown, the rest is medium to dark grey. Below 70.7m, the unit is quite faulted, broken, just muds and rubble remain. Fractures through the unit are at 45 degrees, 1/25-40cm.
											82.57	91.93	213.247	203.887	Mudstone	Mudstone; This unit is much alike 76.0m. At 82.85m, there is a 6cm silty coal band at 30 degrees. Between 85.7-86.3m, there is a small fault zone, with numerous parallel faults at 36 degrees, followed by a 15cm rubbly zone. There are 2 different common beds in this unit, dark grey and dark brownish grey. Faint bedding planes are noted, steep at 60-70 degrees. At 86.7m, there is a 25cm calcite healed fault zone at 60 degrees, calcite at the top and bottom. Between 88.4-88.9m, there is just rubble, clays, and a few competent small pieces of mudstone, one with a fracture plane at 80 degrees. There is some coaly rubble in this zone. Between 88.85-89.51m, the rock is very soft and pockmarked. From 89.92-90.03m, there is a band of lighter brown harder mudstone, with gradationally contact, but sub-horizontal. Again at 90.63-90.73m. Between 90.03-90.63m, the unit is soft and pockmarked . The bottom contact is sharp at 36 degrees.
11-20	294.933	14	28.07	29.97	NR	NR	NR	36.42								
11-21	294.091		25.62	27.65				36.45								
11-22	289.339	19.81	covered (4B and 3)		NR	NR	NR	58.85			38.79	39.05	250.549	250.289	Fault zone in Sandstone	Healed Fault Zone; Bluish grey coloured hard silicified unit, formerly sandstone, cooked, and intruded and healed by quartz and calcite. Some little veinlets are slightly orange, appears like oxidation. The bottom contact is broken.
											51.65	56.85	237.689	232.489	Siltstone	Siltstone and thin coal interbeds; Unit of coaly siltstone and mudstone, with thin coal seams with abundant permineralised calcite within them. The siltstone beds are medium and dark g4rey to dull black coloured. At 54.05m, three is a 12cm fault zone at 45 degrees, filled with muddy coaly gouge. (EOH @ 56.85m)
11-23	292.273	8.99	vered (3 seam only)		NR	NR	NR	22.25			18.92	19.6	273.353	272.673	Siltstone	Siltstone; Light to medium grey siltstone, with dark dull black silt sections and minor calcite rich coal seams at 20-30 degrees. The bottom contact is a fault plane at 70 degrees.
											19.6	19.8	272.673	272.473	Siltstone	Fault Zone in waxy siltstone; Siltstone rubble underneath a fault plane at 70 degrees. Calcite fragments noted in the bottom.
											20.79	22.25	271.483	270.023	Siltstone and Mudstone	Siltstone and Mudstone interbeds; Broken pieces of hard carbonate altered siltstone with soft pockmarked mudstone.
11-24	293.228	14.94	covered (4B and 3)		NR	NR	NR	46.18								No fault zones reported
11-28	307.088	28.04	54.53	57.85	NR	NR	NR	118.57			47.244	48.768	259.844	258.32	Sandstone	90% sandstone, medium to dark brown, fine grained. 10% calcite, fault zone?
											48.768	50.292	258.32	256.796	Sandstone	60% sandstone, fine grained, dirty grey. 30% dark dirty silty fine grained sands. 10% calcite, fault zone?
											58.65	59.11	248.438	247.978	Sandstone	Sandstone; Medium grey, fine to medium grained, with a 1cm calcite vein, a fault at 58.75m, at ~10 degrees, not intact, with multiple thin calcite veinlets below at 10-20 degrees, to 58.93m.
											73.152	74.676	233.936	232.412	Sandstone	Sandstone and quartz, 85% fine grained dark bluish grey, with ~15% quartz. Fault?
											89.0016	89.0016	218.0864	218.0864	Fault Zone	Fracture zone, making water, quartz breccia, crackle breccia through siltstone
11-29	322.713	1.22	62.78	63.2	NR	NR	NR	120.55								No fault zones reported; chip log not available
11-30	322.44	3.35	56.388	56.998	NR	NR	NR	107.14								No fault zones reported.
11-31	308.859	15.24	36.576	39.624	NR	NR	NR	81.38			56.388	57.912	252.471	250.947	Fault Zone/ Sandstone	Small fault zone, 60% sandstone, light grey, medium grained, 30% sandstone fine grained, medium dull grey, 10% calcite fragments. Picked up 10 gpm water.
											60.96	62.484	247.899	246.375	Fault Zone/ Sandstone	Fault Zone, 50% medium brown fine to medium grained poorly sorted sandstone, 30% medium grey medium grained sandstone, 10% chert and siltstone fragments.
											65.532	67.056	243.327	241.803	Fault Zone/ Sandstone	85% fine grained, medium grey sandstone 10% dark browny grey sandstone, medium grained. 5% quartz fragments. Fault Zone, picked up 15-20gpm
											101.56	101.7	207.299	207.159	Fault Zone in Siltstone	Fault Zone in Siltstone; Small fault zone, in light to medium grey siltstone, with abundant calcite fragments. Fault at 51 degrees.
11-32																
11-33	295.301	11.28	33.74	35.32	NR	NR	NR	71.48			12.192	13.716	283.109	281.585	Flt in sandstone	70% sandstone, medium grained, medium brown 30% chert and siltstone, small fault zone?
											47.244	47.5488	248.057	247.7522	Coal	4B Coal, dirty bone coal. Picked up 2 gpm of water.
											59.436	60.96	235.865	234.341	Sandstone	50% is fine grained, slightly silty and with trace coaly laminae 50% is fine grained, medium grey. Picked up 3-4 gpm of water.
											60.96	61.2648	234.341	234.0362	Calcite (FAULT)	Large calcite fragments, likely a fairly significant fault, picked up 30 gpm of water.
											62.484	64.008	232.817	231.293	Sandstone	Dirty brown, with calcite fragments and trace coal, likely a small fault.
											65.5	67.4	229.801	227.901	Flt in sandstone	Fault Zone in Sandstone; The sandstone is fine grained, light to medium grey, broken up, fracture, and cemented with calcite. The fault is actually at 66.75m, at 60 degrees, and planar.
11-34	299.985	39.01	59.1	61.36	NR	NR	NR	70.26	260.975	229.725	54.9	59.3	245.085	240.685	Siltstone	Siltstone; Medium to dark greyish brown, bedding at 35 degrees, broken often on bedding. After 56.5m, the unit is becoming coaly, laminae every ~10-15cm, associated with minor pyrite. At 57.8m, there is a 6cm rubbly zone, the core is completely broken up, a small fault along bedding. At 57.95m, there is a ~15cm section that is sandy, interstitial. The bottom 8cm is very soft dark grey mud. Broken crumbly bottom contact.
11-35	300.466	0.61	76.82	78.72	NR	131.09	139.48	157.94			6.096	7.62	294.37	292.846	Sandstone/ Fault	60% as above 40% light and medium orange brown fine grained sandstone, with trace realgar. Slightly oxidised. A fault, confirmed by a cave in on the E-Log.

DH ID	Ground Surface (m)	Till Depth (m)	4 Seam Interval (m bgs)		Top of Cumberland (m bgs)	Top of Benson (m)	Top of Basement (m)	Total Depth (m)	Bedrock Interval (m mine grid)		Fault/Water Bearing Intervals (m bgs)		Fault/Water Bearing Intervals (elevation)		Unit	Description
											71.48	72.4	228.986	228.066	Sandstone	Sandstone; Fine to medium grained, slightly pinkish grey, calcareous, with planar calcite veinlets steep and flat. Trace pebble sized lithics. Basal contact is a steep fracture at 70 degrees with calcite fill, making 20 gallons per minute of water.
											121.93	122.03	178.536	178.436	Breccia	Clast Supported Breccia; Angular clasts from 2-3cm sized, tightly packed with minimal medium brown mudstone matrix. Clasts consist of light to medium grey limestone and medium brown sandstone fragments. In this unit, 60 gallons per minute of water was picked up when drilling.
											122.44	122.98	178.026	177.486	Sandstone	Sandstone; Gritty, fine to medium grained, soft, with trace rooty coal and silts in the top 20cm. Hairline dendritic calcite veinlets throughout with trace to minor orange realgar. There are 2 planar veinlets at the top at 76 degrees. The bottom 4cm is a sandstone cemented breccia, the top of a fault contact, intact, sharp at 12 degrees.
											154.26	155.65	146.206	144.816	Rhyolite	Rhyolite; Leucocratic, but different from above, slightly darker, with a faint green colour, as well as disseminated amphiboles throughout in minor amounts. It is commonly broken at 12 degrees. Hairline calcite veinlets as well as minor amounts of fracture are at 75 degrees, and have disseminated clusters of fine grained pyrite along them. This unit appears to be lacking the argentite/chalcocite disseminations. The unit is much more commonly broken then above.
											155.82	157.94	144.646	142.526	Rhyolite	Rhyolite; Leucocratic, slightly darker, with a faint green colour, as well as disseminated amphiboles throughout in minor amounts. It is commonly broken on fractures at 62 degrees, planar. Hairline calcite veinlets as well as minor amounts of fracture are at 75 degrees, and have disseminated clusters of fine grained pyrite along them. This unit appears to be lacking the argentite/chalcocite disseminations. The unit is commonly broken.
11-36	285.891	8.84	43.62	52	NR	79.86	NR	80.01			10.668	12.192	275.223	273.699	Sandstone	Strongly oxidised, must be a fracture zone, dark browny orange, fine grained.
											12.192	13.716	273.699	272.175	Sandstone	Strongly oxidised, must be a fracture zone, dark browny orange, fine grained.
											33.55	35.5	252.341	250.391	Sandstone	Sandstone; Medium grey, medium grained, often broken up, with 1/2cm strong oxidation halos around breaks and fractures. Minor pyritic gouge is coating some rubble at the top of the unit, a possible fault contact. After 36.42m, the entire unit is broken, up ~75% is moderately to intensely oxidised orange. Rubbly bottom contact.
											37.19	42.27	248.701	243.621	Sandstone	Sandstone; Coarse, medium grey and light brown, moderately oxidised throughout with fractures at 55 and 70 degrees. After 38.5m, medium to dark grey. The unit is intensely broken throughout, commonly fractured. After 40.08m, there are slightly sinuous silt spars, sub horizontal. Bedding is <15 degrees. Sharp erosional basal contact.
											42.31	43.28	243.581	242.611	Sandstone	Dirty Sandstone; Fine to medium grained, dirty grey, with minor interstitial silts as well as 2 pyritic silt bands 6cm wide mid interval, rubbly, broken zones, erosional contact. The bottom contact is sharp but broken. Final airlift yield 30 gpm (M. Storey)
11-37	308.041	0.61	95.62	96.46	NR	NR	NR	157.43	307.431	150.611	105.156	106.68	202.885	201.361	Fault in Sandstone	Possibly fault, ~5% quartz, 95% dark grey to black hard fine grained sandstone.
											141.84	142.75	166.201	165.291	Mudstone	Mudstone; Dark brown, with minor pockmarks, minor blebs of sandstone, burrows, with bedding at 5-10 degrees, and moderate amounts of pyrite as rings around some burrows. There is one fracture at the top at 65 degrees. At the base is a broken rubbly contact, small fault structure.
11-38	299.579	25.3	56.82	58.57	NR	NR	NR	94.64	274.279	204.939	39.62		259.959		Sandstone	Somewhere around 130', 15 gpm of water was picked up.
											52.12	55.25	247.459	244.329	Sandstone	Sandstone; Slightly immature medium grained medium grey sandstone with abundant small intervals with disseminated black lithics within the sands. Throughout the unit are fracture zones at 60 degrees, often lined with black graphitic clays. The water increased from 15 to 50 gallons per minute in one of these fracture zones.
											85.95	88.32	213.629	211.259	Sandstone	Coaly Mudstone; Medium to dark brownish black, soft, with multiple hairline to 1cm coal laminae. The unit is often broken, with bedding at the top at 22 degrees, and the basal contact at 14 degrees.
12-01	319.033	1.52	81.6	81.98	NR	NR	NR	148.29			60.96	62.484	258.073	256.549	Coaly Siltstone	90% dark brown siltstone 10% coal, likely 5 seam ***Picked up 5 gpm of water***
											77.724	79.248	241.309	239.785	Sandstone/ Siltstone	50% sandstone as above 40% sandy siltstone as above 10% dark grey to black siltstone ***Increased water flow to ~10 gpm***
											89.916	91.44	229.117	227.593	Sandstone	As above, the sandstone is light grey. ***Up to ~15 gpm of water, not sure the source***
12-02	317.367	0.91	NR	NR	NR	NR	NR	133.05			115.82	124.37	201.547	192.997	Fracture in Sandstone	Sandstone; Fine to medium grained, medium grey, with very common banding usually <2cm thick, 1/5cm, at 13 degrees, and then steepens to 28 degrees after ~120m. At 118.1m, there is a fracture at 68 degrees, open, rough surfaced, and is making 5 gpm of water. The unit is massive, broken every ~50cm's. The bands are made up of interstitial material, and are darker grey, likely silts and ash. Below 122.5m, the banding contains dusty pyrite as well, especially after 123.5m. At 124.27m, there is a ~10cm section that is a very dirty sandstone, with minor coal spars, rich with pyrite, localised organics.
12-03	315.452	8.53	84.99	86.66	NR	NR	NR	156.31			134.87	146.2	180.582	169.252		Sandstone; Fine grained, laminated and banded commonly at 14 degrees every 3-10cm. Between 134.9-137.5m, there are numerous fractures at 35-50 degrees, often filled with calcite. At 145.42m, there is a 7cm zone of calcite, silt and trace coal at 18 degrees. Other than the faulted zones, the unit is solid and intact. The bottom of the fracture zone has 2 fractures at 75 degrees. Some of the fracture surfaces are polished. 60 gpm of water was picked up at this depth. At 136.2m, there are coal rip up clasts in the sandstone. After 137.8m the unit is intact and solid, there are no more laminae, just bands of darker grey material due to interstitial silts, seasonal? The banding is at 22 degrees. At 140.57m, there are 2 steep angled hairline calcite veinlets. At 142.1m, and 143.4m, there are 2 open rough surfaced fractures at 70 degrees. Any of these zones is providing ~60gpm of water. The basal contact is noted by the start of coaly laminae.
12-04	319.002	4.27	eroded		NR	NR	NR	136.86			64.008	65.532	254.994	253.47	Sandstone/ Coal/ Fault	50% dirty coaly sandstone, fine grained. 50% sandy coal, 5 seam. Trace oxidised orange sandstone fragments, fault?
12-06	307.441	0.61	81.39	83.11	NR	NR	NR	148.44	306.831	159.001	10.668	12.192	296.773	295.249	Sandstone/Coal/ Fault	70% sandstone as above. 20% silty coal, dark grey 10% quartz fragments, fault, some large quartz fragments up to 4cm.
											74.676	76.2	232.765	231.241	Sandstone	Medium grey, fine grained, uniform. Picked up 15gpm of water at 252'.
											79.06	81.16	228.381	226.281	Sandstone	Sandstone; Dirty in the top 100cm, with interstitial silts, and minor rounded 2cm silt halos, bioturbations. The lower half of the unit is strongly fractured with steep angled fractures at 70 degrees, a fracture every 5-10cm, fault zone. The drillers reported picking up 20 gallons per minute of water at this depth. The basal contact is sharp, planar and at 5 degrees.
											139.15	140	168.291	167.441	Siltstone	3R-3 Parting, Coaly Siltstone; Bedding at 5 degrees. Thin broken rubbly sections of coaly siltstone. One fracture is at 55 degrees. Sharp basal contact at 5 degrees. The hole is making up to 50 gallons per minute of water here, there are a few waxy polished surface near the bottom.
											143.09	145.61	164.351	161.831	Mudstone	Mud Band; Coaly, very soft but intact. Almost gouge, beds are steep at 45 degrees, but basal contact is intact and sharp at 8 degrees.
12-07	311.414	0.61	95.12	97.72	NR	NR	NR	147.98			10.668	12.192	300.746	299.222	Flt in Sandstone	70% sandstone, meidum to dark grey, medium grained, 30% calcite fragments and veinlets in the sandstone. Minor oxidised fragments, fault, but no cave in noted on the e-log.
											12.192	13.716	299.222	297.698	Fault in Sandstone	70% sandstone, meidum to dark grey, medium grained, 30% calcite fragments and veinlets in the sandstone. Minor oxidised fragments, fault, with an associated cave in noted in the e-log
											13.716	15.24	297.698	296.174	Flt in sandstone/ Sandstone	30% as above, with calcite fragments and veinlets within sandstone 70% fine to medium grained, light grey sandstone
											111.252	112.776	200.162	198.638	Sandstone	80% sandstone, hard, angular, dark brownish grey 20% orange and white calcite and coal, fault? Cave in?
											123.444	124.968	187.97	186.446	Siltstone	Medium grey brown, trace orange calcite, mninor fault?
											124.968	126.492	186.446	184.922	Siltstone / Fault	As above, slightly sandy, plus noted drop in the rods, a fault? Cave in? Picked up 6gpm of water.
12-08	316.974	0.61	93.41	96.05	NR	NR	NR	137.62			112.776	114.3	204.198	202.674	Siltstone	At ~373', notable drops while drilling, fault. Dark grey siltstone.
12-09	324.765	1.22	33.52	38.1	NR	NR	NR	93.42								No fault zones reported
12-10	324.765	0.61	18.12	18.38	NR	NR	NR	64.92			11.22	12.1	313.545	312.665	Fault	Fault; Cave in noted on e-log, calcite fragments noted in drill cuttings, no water picked up.
											13.716	15.24	311.049	309.525	Sandstone/ Fault	40% fine grained medium grey sandstone 40% medium to dark grey carby sandstone 20% quartz fragments, Fault
12-12																Hole not cored and chips currently not logged. Driller's report does not indicate water.
12-13																Hole not cored and chips currently not logged. Driller's report does not indicate water.

	Hole is located outside of immediate perimeter of 7SA5
	Fault zone is located above 4 Seam
	Fault zone is located below 4 Seam
	Fault zone is water bearing
NR	Not recovered

APPENDIX A2 GROUNDWATER FIELD INVESTIGATION

Appendix A2. Hydrogeological Field Investigations

Lorax undertook multiple field investigations in 7 South Area 5 in 2011 and 2012 to establish baseline monitoring locations and later to expand the monitoring network to optimize coverage for a multi-day pump test. This appendix summarizes monitoring well installations and associated slug tests; details of the pump test are discussed in Appendix A7.

A2.1 Monitoring Well Installations

In December of 2011, Lorax undertook a hydrogeological field investigation in 7 South Area 5 to establish groundwater monitoring wells in existing 2011 exploration boreholes. These locations were chosen to assess groundwater conditions upstream and downstream of the proposed mine. Drillwell Enterprises of Duncan, BC, was contracted for the exploration drilling, supervised by QCC, and the monitoring well installations, supervised by Lorax. The original exploration holes were advanced using both open hole and wireline coring techniques and were logged for lithology by N. Bazowski of QCC.

Monitoring wells were established in boreholes QU11-18, QU11-28 and QU11-36. Two nested monitoring wells were completed in the QU11-18 borehole; shallow and deep wells were installed in two separate boreholes at location QU11-36 due to issues with caving. Since the original QU11-36 borehole caved to 88 feet, it had to been reamed out and the PVC installed through the core pipe. An additional hole was drilled for the deep monitoring well installation. All wells were completed with threaded, machine slotted PVC of diameter specified in Table A2-1. Slotted intervals were backfilled with filter sand and 20 foot Bentonite Pel-Plug seals were established above (and below, where required) the filter pack. Alternating intervals of pea gravel (20 ft) and Bentonite Pel-Plug (3 ft) were used to backfill the holes to desired depths. Borehole logs showing lithology and well completion details are provided in Appendix A4. Note that QU08-10 was completed in the spring of 2010 as a part of the field program characterizing the hydrogeological conditions in the proposed 7 South mine.

A second suite of wells was established in October 2012 to augment the monitoring network in advance of a pump test in 7 South Area 5. These wells were established in existing exploration holes (QU11-35, QU12-07, QU12-08) and screening intervals were designed to target either the No. 4 Seam and/or water bearing features stratigraphically close to the No. 4 Seam. These wells were also installed by Drillwell under supervision of Lorax. Unlike the previous installations, an attempt was made tremie the bentonite

however, the tremie line clogged and eventually broke down hole before a shallower installation could be attempted at QU12-07. The deep installation at QU12-07; however, is sound. As a result, the shallower well that was intended to be nested in QU12-07 was completed in QU12-08 instead (without using a tremie line for the bentonite). Installation details are included in Table 0-1; well installation logs are provided in Appendix A4.

In addition to the monitoring wells, a liner was also installed in QU11-38, the pumping location for the subsequent pump test (Table 0-1). Twenty foot sections of 4.5-inch diameter PVC (SDR 21-Sch 40) with glued bell joints (secured with 0.5-inch screws) were lowered downhole using the wireline on the drill rig. The bottom 146 feet (44.5 meters) were hand slotted using a skill saw, with approximately 40 6-inch (vertical) incisions along each 20 foot section of pipe. The pipe became hung up in the lower, cored portion of the hole and currently the bottom of the pipe resides about 3 meters above the bottom of the hole. No backfill materials or end cap were used.

A2.2 Hydraulic Testing

All of the monitoring wells, except QU11-38, were slug tested. QU11-28 and QU11-18S/D were slug tested after some degree of well development had occurred; the others were tested prior to any well development. All of the wells (except QU08-10, which was slug tested in 2010) were reasonably permeable did not require corrections for background trends, etc. The slug test data were analysed using the software Aqtesolv Pro v. 4.5; the output of which is provided in Appendix A5 and summarized in Table 0-2. The hydraulic conductivity values derived from 7 South Area 5 pump test have been added to the site-wide hydraulic conductivity database (Appendix A6) that has been developed through supporting studies for the 7 South permit amendment (Hillsborough, 2011).

Table A2-1:
Summary of Well Installations in 7 South Area 5

Well ID	Mine Area	Well Install Date	Mine Grid Co-ordinates				Well Dia. (in)	Depth (m BTOC)	Slotted Interval (m bgs)		Filter Pack Interval (m bgs)		Screened Lithology[1]	SWL[2] (m Mine Grid)
			Easting (m)	Northing (m)	Ground El. (m)	PVCEl. (m)								
QU08-10	7S	20-Apr-10	100913	101148	295.7	296.2	2	27.6	19.7	27.1	18.3	29.2	No. 3 Coal	271.48
QU11-18S	7SA5	12-Dec-11	100543	100691	299.7	299.9	1.5	34.2	31.0	34.1	29.0	34.4	Till	281.82
QU11-18D	7SA5	12-Dec-11	100543	100691	299.7	299.9	2	65.2	62.0	65.0	60.7	65.8	SST/Fractured SLST	277.25
QU11-28	7SA5	14-Dec-11	100499	101067	307.1	307.5	2	58.0	54.5	57.5	53.3	58.5	No. 4&4L/SST	274.66
QU11-35	7SA5	02-Oct-12	100084	100278	300.5	301.1	2	73.8	70.7	73.8	69.2	74.1	Fractured SST	274.87
QU11-36S	7SA5	15-Dec-11	100325	100109	286.0	286.3	1.5	42.2	38.9	41.9	38.4	43.3	Fractured SST	269.74
QU11-36D	7SA5	20-Dec-11	100322	100111	285.9	286.1	2	67.2	63.9	66.9	63.1	68.3	Fractured SST	257.36
QU11-38	7SA5	02-Oct-12	100403	100504	299.6	299.8	4.5	94.8	46.9	91.4	n/a	n/a	n/a	276.67
QU12-07	7SA5	05-Oct-12	100201	100434	311.4	312.0	2	128.1	124.4	127.4	123.1	128.6	Fractured SLST/SST	275.59
QU12-08	7SA5	05-Oct-12	100246	100403	317.0	317.4	1.5	96.9	93.1	96.2	92.0	97.5	No 4/4L Coal	275.20

[1] SST=Sandstone, SLST=Siltstone, MDST=Mudstone
[2] SWL measured Nov 19-24, 2012

Table A2-2:
Hydraulic Testing Results for Long Lake Monitoring Wells

Well ID	Screened Lithology[1]	Aquifer Type	Analytical Method[2]	Hydraulic Conductivity (m/s)		
				Test 1	Test 2	Geo. Mean
QU08-10	No. 4 Coal	Confined	Hv	5.0E-09		5.0E-09
QU11-18S	Till	Unconfined	BR	1.2E-08		1.2E-08
QU11-18D	SST/Fractured SLST	Confined	CBP	9.1E-06	1.3E-05	1.1E-05
QU11-28	No. 4&4L/SST	Confined	CBP	1.3E-06		1.3E-06
QU11-35	Fractured SST	Confined	Hv/CBP	1.5E-06	1.4E-06	1.4E-06
QU11-36S	Fractured SST	Confined	CBP	3.6E-06	4.8E-06	4.2E-06
QU11-36D	Fractured SST	Confined	CBP	1.4E-05	2.9E-05	2.0E-05
QU12-07	Fractured SLST/SST	Confined	Hv	1.6E-05	1.7E-05	1.6E-05
QU12-08	No 4/4L Coal	Confined	Hv	6.5E-07		6.5E-07

[1] SST=Sandstone, SLST=Siltstone, MDST=Mudstone
[2] BR=Bouwer, H. and R.C. Rice (1976); CBP=Cooper, Bredehoeft and Papadopulos (1967); Hv = Hvorslev (1951)

APPENDIX A3 WATER LEVEL DATA

WELL ID	QU11-18S			QU11-18D			QU11-28			QU11-34			QU11-35		
Mining Area	7SA5			7SA5			7SA5			7SA5			7SA5		
Mine Grid Easting (m)	100542.84			100542.84			100499.43			100508.45			100083.51		
Mine Grid Northing (m)	100690.81			100690.81			101067.24			100580.01			100277.99		
Steel Elevation (m mine grid)	299.94			299.94			307.55			300.16			301.06		
Ground Surface (m mine grid)	299.71			299.71			307.09			299.99			300.47		
Water Level Measurment Pt.	PVC			PVC			PVC			Steel			PVC		
Total Depth (m)	34.24			65.20			57.61			71.48			73.80		
Steel Casing Stickup (m ags)	0.225			0.225			0.460			0.175			0.595		
PVC Stickup (m BTOSteel)	0.07			0.07			0.045						0.065		
PVC Casing Stickup (m ags)	0.155			0.155			0.415						0.530		
	DATE	**DTW (m)**	**WLE Mine Grid**	**DATE**	**DTW**	**WLE Mine Grid**	**DATE**	**DTW**	**WLE Mine Grid**	**DATE**	**DTW**	**WLE Mine Grid**	**DATE**	**DTW**	**WLE Mine Grid**
	29/02/12	15.867	284.00	29/02/12	22.042	277.82	21/03/12	34.105	273.40	21/10/12 16:00	20.078	280.08	12/09/12	31.805	269.19
	19/03/12	16.278	283.59	19/03/12	21.78	278.09	16/05/12	33.898	273.61	23/10/12 14:35	19.987	280.17	01/10/12	31.97	269.03
	15/05/12	16.047	283.82	15/05/12	22.031	277.84	25/07/12	34.09	273.41	24/10/12 8:12	20.218	279.94	21/10/12 18:23	28.493	272.50
	25/07/12	15.982	283.88	25/07/12	22.352	277.51	12/09/12	34.79	272.71	24/10/12 15:05	20.292	279.87	23/10/12 15:08	28.27	272.73
	12/09/12	16.477	283.39	12/09/12	23.157	276.71	22/10/12 11:45	34.585	272.92	24/10/12 16:28	20.375	279.79	24/10/12 8:55	28.202	272.79
	21/10/12 18:55	16.333	283.53	21/10/12 18:56	22.554	277.31	23/10/12 15:30	34.579	272.92	24/10/12 17:51	20.518	279.64	24/10/12 15:22	28.153	272.84
	23/10/12 14:00	16.29	283.58	23/10/12 14:00	22.482	277.38	24/10/12 12:03	34.594	272.91	24/10/12 22:35	21.299	278.86	24/10/12 16:55	28.148	272.85
	24/10/12 8:40	16.285	283.58	24/10/12 8:38	22.828	277.04	24/10/12 18:27	34.611	272.89	25/10/12 0:43	21.638	278.52	24/10/12 18:04	28.143	272.85
	24/10/12 12:13	16.293	283.57	24/10/12 9:12	22.835	277.03	25/10/12 8:59	34.95	272.55	25/10/12 3:46	22.093	278.07	25/10/12 8:34	28.202	272.79
	24/10/12 15:11	16.306	283.56	24/10/12 12:11	22.84	277.03	25/10/12 16:53	35.236	272.27	25/10/12 8:18	22.695	277.47	25/10/12 11:47	28.237	272.76
	24/10/12 16:43	16.319	283.55	24/10/12 15:12	22.926	276.94	26/10/12 9:01	35.866	271.64	25/10/12 11:33	23.092	277.07	25/10/12 14:58	28.256	272.74
	24/10/12 18:18	16.337	283.53	24/10/12 16:44	23.19	276.68	26/10/12 16:48	36.19	271.31	25/10/12 14:41	23.404	276.76	25/10/12 17:48	28.287	272.71
	24/10/12 22:00	16.383	283.48	24/10/12 18:16	23.57	276.30	27/10/12 9:07	36.722	270.78	25/10/12 18:32	23.76	276.40	26/10/12 8:28	28.537	272.46
	25/10/12 0:51	16.42	283.45	24/10/12 22:00	24.504	275.36	27/10/12 17:00	36.903	270.60	25/10/12 22:06	24.093	276.07	26/10/12 15:23	28.669	272.33
	25/10/12 3:54	16.449	283.42	25/10/12 0:52	25.118	274.75	28/10/12 12:26	36.497	271.01	26/10/12 1:11	24.347	275.81	26/10/12 17:16	28.707	272.29
	25/10/12 8:47	16.594	283.27	25/10/12 3:55	25.693	274.17	29/10/12 13:05	35.82	271.68	26/10/12 3:58	24.548	275.61	27/10/12 8:30	29.015	271.98
	25/10/12 12:03	16.682	283.18	25/10/12 8:49	26.503	273.36	30/10/12 12:26	35.3	272.20	26/10/12 8:16	24.816	275.34	27/10/12 11:18	29.075	271.92
	25/10/12 15:21	16.746	283.12	25/10/12 12:04	26.98	272.89	31/10/12 12:21	34.91	272.59	26/10/12 15:10	25.256	274.90	27/10/12 16:28	29.138	271.86
	25/10/12 18:03	16.807	283.06	25/10/12 15:19	27.405	272.46	01/11/12 13:31	34.66	272.84	26/10/12 17:55	25.41	274.75	27/10/12 17:21	29.148	271.85
	25/10/12 22:18	16.94	282.93	25/10/12 18:04	27.753	272.11	02/11/12 12:28	34.41	273.09	26/10/12 22:25	25.681	274.48	27/10/12 21:24	29.232	271.76
	26/10/12 1:20	17.002	282.86	25/10/12 22:19	28.275	271.59	19/11/12 15:05	32.84	274.66	27/10/12 1:06	25.803	274.36	28/10/12 0:24	29.256	271.74
	26/10/12 4:06	17.235	282.63	26/10/12 1:22	28.598	271.27				27/10/12 4:11	25.903	274.26	28/10/12 11:43	29.185	271.81
	26/10/12 8:51	17.558	282.31	26/10/12 4:08	28.861	271.01				27/10/12 8:18	26.047	274.11	29/10/12 13:25	28.78	272.22
	26/10/12 15:37	17.642	282.22	26/10/12 8:51	29.312	270.55				27/10/12 11:59	26.211	273.95	30/10/12 13:20	28.41	272.59
	26/10/12 16:59	17.666	282.20	26/10/12 15:38	29.885	269.98				27/10/12 15:46	26.285	273.88	31/10/12 13:34	28.02	272.98
	26/10/12 22:43	17.804	282.06	26/10/12 17:00	29.992	269.87				27/10/12 17:43	26.214	273.95	01/11/12 13:31	27.7	273.30
	27/10/12 1:14	17.812	282.05	26/10/12 22:44	30.445	269.42				27/10/12 21:00	26.013	274.15	02/11/12 13:24	27.45	273.55
	27/10/12 4:30	19.225	280.64	27/10/12 1:16	30.614	269.25				28/10/12 0:01	25.78	274.38	19/11/12 15:25	26.126	274.87
	27/10/12 6:10	19.833	280.03	27/10/12 4:32	30.809	269.06				28/10/12 10:48	24.942	275.22			
	27/10/12 8:57	20.234	279.63	27/10/12 6:13	30.895	268.97				29/10/12 12:30	23.69	276.47			
	27/10/12 11:32	20.376	279.49	27/10/12 8:59	31.06	268.81				30/10/12 13:12	22.99	277.17			
	27/10/12 16:17	20.519	279.35	27/10/12 11:31	31.195	268.67				31/10/12 12:44	22.5	277.66			
	27/10/12 17:32	20.533	279.33	27/10/12 16:19	31.262	268.60				01/11/12 13:08	22.13	278.03			
	27/10/12 21:40	20.144	279.72	27/10/12 17:34	31.148	268.72				02/11/12 12:34	21.85	278.31			
	28/10/12 0:22	20.099	279.77	27/10/12 21:43	30.563	269.30				20/11/12 14:30	20.218	279.94			
	28/10/12 12:45	20.082	279.78	28/10/12 0:29	30.147	269.72									
	29/10/12 13:00	19.92	279.95	28/10/12 12:53	28.758	271.11									
	29/10/12 12:34	19.87	280.00	29/10/12 13:00	27.17	272.70									
	31/10/12 12:31	19.62	280.25	30/10/12 12:35	26.28	273.59									
	01/11/12 12:54	19.53	280.34	31/10/12 12:33	25.65	274.22									
	02/11/12 12:28	19.58	280.29	01/11/12 12:54	25.2	274.67									
	19/11/12 15:10	18.048	281.82	02/11/12 12:28	24.85	275.02									
				19/11/12 15:10	22.612	277.25447									

WELL ID	QU11-36S			QU11-36D			QU11-37			QU12-06			QU12-07		
Mining Area	7SA5			7SA5			7SA5			7SA5			7SA5		
Mine Grid Easting (m)	100324.93			100322.46			100207.24			100023.33			100200.99		
Mine Grid Northing (m)	100109.43			100111.42			100580.13			100507.52			100433.66		
Steel Elevation (m mine grid)	286.36			286.20			308.04			307.95			312.15		
Ground Surface (m mine grid)	286.03			285.89			308.04			307.44			311.41		
Water Level Measurment Pt.	PVC			PVC			Steel			Steel			PVC		
Total Depth (m)	42.20			67.15			157.43			148.44			128.07		
Steel Casing Stickup (m ags)	0.330			0.308			0			0.51			0.74		
PVC Stickup (m BTOSteel)	0.052			0.084									0.145		
PVC Casing Stickup (m ags)	0.278			0.224									0.595		
	DATE	**DTW**	**WLE Mine Grid**	**DATE**	**DTW**	**WLE Mine Grid**	**DATE**	**DTW**	**WLE Mine Grid**	**DATE**	**DTW**	**WLE Mine Grid**	**DATE**	**DTW**	**WLE Mine Grid**
	27/02/12	17.032	269.28	27/02/12	25.597	260.52	19/03/12	34.12	273.92	19/03/12	35.72	272.23	19/03/12	39.4	272.61
	19/03/12	17.215	269.09	19/03/12	25.25	260.86	21/10/12 16:15	31.704	276.34	21/10/12 18:00	30.696	277.25	12/09/12	41.413	270.60
	14/05/12	20.02	266.29	14/05/12	27.073	259.04	23/10/12 14:10	31.257	276.78	23/10/12 15:03	30.383	277.57	21/10/12 18:37	38.535	273.47
	24/07/12	20.398	265.91	17/05/12	28.205	257.91	24/10/12 8:19	31.142	276.90	24/10/12 8:55	30.304	277.65	23/10/12 14:13	38.365	273.64
	12/09/12	21.212	265.10	24/07/12	29.517	256.60	24/10/12 14:57	31.163	276.88	24/10/12 15:27	30.282	277.67	24/10/12 8:23	38.315	273.69
	21/10/12 14:05	20.727	265.58	12/09/12	30.608	255.51	24/10/12 16:28	31.155	276.89	24/10/12 17:00	30.264	277.69	24/10/12 14:50	38.292	273.72
	23/10/12 14:43	20.634	265.67	21/10/12 14:05	30.879	255.24	24/10/12 17:43	31.19	276.85	24/10/12 18:10	30.267	277.68	24/10/12 16:20	38.296	273.71
	24/10/12 12:25	20.538	265.77	23/10/12 14:44	30.829	255.29	25/10/12 8:08	31.797	276.24	25/10/12 8:39	30.347	277.60	24/10/12 17:35	38.298	273.71
	24/10/12 15:35	20.491	265.82	24/10/12 12:22	30.837	255.28	25/10/12 11:22	31.987	276.05	25/10/12 11:53	30.4	277.55	25/10/12 7:58	38.349	273.66
	24/10/12 17:07	20.478	265.83	24/10/12 15:37	30.82	255.29	25/10/12 14:33	32.13	275.91	25/10/12 15:11	30.404	277.55	25/10/12 11:13	38.397	273.61
	24/10/12 18:52	20.453	265.86	24/10/12 17:09	30.818	255.30	25/10/12 18:24	32.305	275.74	25/10/12 17:55	30.442	277.51	25/10/12 14:19	38.412	273.60
	24/10/12 22:10	20.414	265.89	24/10/12 18:54	30.823	255.29	26/10/12 8:07	32.853	275.19	26/10/12 8:28	30.584	277.37	25/10/12 18:16	38.451	273.56
	25/10/12 1:04	20.373	265.94	24/10/12 22:11	30.831	255.28	26/10/12 15:02	33.11	274.93	26/10/12 15:29	30.675	277.27	26/10/12 7:58	38.617	273.39
	25/10/12 4:04	20.334	265.97	25/10/12 1:04	30.825	255.29	26/10/12 17:46	33.21	274.83	26/10/12 17:22	30.7	277.25	26/10/12 14:52	38.723	273.29
	25/10/12 9:23	20.274	266.03	25/10/12 4:06	30.81	255.30	27/10/12 8:10	33.683	274.36	27/10/12 8:36	30.916	277.03	26/10/12 17:36	38.767	273.24
	25/10/12 12:13	20.246	266.06	25/10/12 9:25	30.826	255.29	27/10/12 11:51	33.785	274.26	27/10/12 11:24	30.962	276.99	27/10/12 8:02	39.028	272.98
	25/10/12 15:52	20.192	266.12	25/10/12 12:16	30.826	255.29	27/10/12 16:05	33.868	274.17	27/10/12 16:32	31.003	276.95	27/10/12 11:43	39.115	272.89
	25/10/12 22:28	20.134	266.17	25/10/12 15:54	30.8	255.31	27/10/12 18:03	33.89	274.15	27/10/12 17:26	31.027	276.92	27/10/12 15:55	39.161	272.85
	26/10/12 1:30	20.099	266.21	25/10/12 22:30	30.802	255.31	27/10/12 21:04	33.91	274.13	27/10/12 21:20	31.09	276.86	27/10/12 17:53	39.181	272.83
	26/10/12 4:16	20.073	266.24	26/10/12 1:33	30.784	255.33	28/10/12 0:04	33.865	274.18	28/10/12 0:01	31.121	276.83	27/10/12 21:10	39.234	272.77
	26/10/12 8:42	20.048	266.26	26/10/12 4:18	30.756	255.36	28/10/12 10:54	33.463	274.58	28/10/12 11:35	31.086	276.86	28/10/12 0:08	39.279	272.73
	26/10/12 15:45	20.01	266.30	26/10/12 8:44	30.757	255.36	29/10/12 12:51	32.72	275.32	29/10/12 13:30	30.85	277.10	28/10/12 10:58	39.354	272.65
	26/10/12 18:02	20.004	266.30	26/10/12 15:47	30.734	255.38	30/10/12 13:06	32.12	275.92	30/10/12 13:25	30.59	277.36	29/10/12 12:35	39.22	272.79
	26/10/12 22:34	19.987	266.32	26/10/12 18:05	30.727	255.39	31/10/12 13:19	31.56	276.48	31/10/12 13:36	30.37	277.58	30/10/12 12:58	39.02	272.99
	27/10/12 1:24	19.977	266.33	26/10/12 22:36	30.747	255.37	01/11/12 13:24	31.17	276.87	01/11/12 13:35	30.15	277.80	31/10/12 13:07	38.78	273.23
	27/10/12 4:18	19.975	266.33	27/10/12 1:26	30.735	255.38	02/11/12 13:08	30.81	277.23	02/11/12 13:18	29.69	278.26	01/11/12 13:17	38.58	273.43
	27/10/12 8:49	19.935	266.37	27/10/12 4:20	30.711	255.40	19/11/12 14:30	28.377	279.66	19/11/12 15:20	28.16	279.79	02/11/12 12:59	38.41	273.60
	27/10/12 16:40	19.886	266.42	27/10/12 8:51	30.697	255.42							19/11/12	36.995	275.01
	27/10/12 18:13	19.877	266.43	27/10/12 16:43	30.653	255.46							22/11/12 16:00	36.417	275.59
	27/10/12 21:32	19.827	266.48	27/10/12 18:15	30.643	255.47									
	28/10/12 0:36	19.865	266.44	27/10/12 21:34	30.615	255.50									
	28/10/12 10:11	19.857	266.45	28/10/12 0:38	30.659	255.46									
	29/10/12 12:20	19.74	266.57	28/10/12 10:19	30.717	255.40									
	30/10/12 12:41	19.56	266.75	29/10/12 12:20	30.74	255.37									
	31/10/12 12:55	19.18	267.13	30/10/12 12:44	30.73	255.38									
	01/11/12 13:00	18.71	267.60	31/10/12 12:52	30.65	255.46									
	02/11/12 12:44	18.58	267.73	01/11/12 12:59	30.6	255.51									
	19/11/12 0:00	16.57	269.74	02/11/12 12:42	30.52	255.59									
				19/11/12 9:40	28.795	257.32									
				19/11/12 12:00	28.755	257.36									

WELL ID	**QU12-08**			**QU12-13**			**QU-08-10**			**QU-11-01**		
Mining Area	7SA5			7SA5			7-South			4-South		
Mine Grid Easting (m)	100246.48			100469.38			100912.64					
Mine Grid Northing (m)	100402.70			100575.92			101148.12					
Steel Elevation (m mine grid)	317.51			302.06			295.72			331.23		
Ground Surface (m mine grid)	316.97			302.06						331.14		
Water Level Measurment Pt.	PVC			Steel			PVC			PVC		
Total Depth (m)	96.90						30.90			88.50		
Steel Casing Stickup (m ags)	0.534						0.54			0.09		
PVC Stickup (m BTOSteel)	0.06						0.08			0.148		
PVC Casing Stickup (m ags)	0.474			0.199			0.460			-0.058		
	DATE	**DTW**	**WLE Mine Grid**	**DATE**	**DTW**	**WLE Mine Grid**	**DATE**	**DTW**	**WLE Mine Grid**	**DATE**	**DTW**	**WLE Mine Grid**
	19/03/12	43.7	273.75	3/19/2012	28.18	273.88	27/04/10	22.01	274.17	19/01/11	26.51	304.57
	21/10/12 18:43	44.89	272.56	21/10/12 15:55	29.247	272.81	13/07/10	24.16	272.02	09/02/11	26.32	304.76
	23/10/12 14:22	44.68	272.77	23/10/12 14:33	29.185	272.88	02/12/10	23.57	272.61	21/02/11	24.405	306.68
	24/10/12 8:27	44.597	272.85	24/10/12 8:10	29.19	272.87	09/02/11	20.72	275.46	13/06/11	27.41	303.67
	24/10/12 14:53	44.542	272.91	24/10/12 15:03	29.096	272.97	20/03/12	20.89	275.29	03/10/11	27.556	303.53
	24/10/12 16:24	44.517	272.93	24/10/12 16:34	29.06	273.00	15/05/12	22.933	273.25	18/05/12	27.82	303.26
	24/10/12 17:38	44.506	272.94	24/10/12 17:49	29.043	273.02	17/05/12	25.6	#N/A	23/10/12 9:05	28.257	302.83
	25/10/12 8:03	44.667	272.78	24/10/12 22:32	29.019	273.04	25/07/12	24.823	271.36	28/10/12 13:30	27.654	303.43
	25/10/12 11:17	44.758	272.69	25/10/12 0:41	29.033	273.03	12/09/12	25.643	270.54	20/11/12	26.325	304.76
	25/10/12 14:25	44.829	272.62	25/10/12 3:43	29.033	273.03	22/10/12	26.676	269.50	24/11/12	26.187	304.90
	25/10/12 18:19	44.922	272.53	25/10/12 8:13	29.115	272.95	23/10/12	26.688	269.49			
	26/10/12 8:01	45.279	272.17	25/10/12 11:31	29.185	272.88	24/10/12	26.722	269.46			
	26/10/12 14:56	45.512	271.94	25/10/12 14:39	29.234	272.83	24/10/12	26.726	269.45			
	26/10/12 17:40	45.592	271.86	25/10/12 18:30	29.325	272.74	25/10/12	26.719	269.46			
	27/10/12 8:05	45.944	271.50	25/10/12 22:03	29.423	272.64	25/10/12	26.746	269.43			
	27/10/12 11:46	46.033	271.42	26/10/12 1:09	29.472	272.59	26/10/12	26.729	269.45			
	27/10/12 16:00	46.121	271.33	26/10/12 3:55	29.515	272.55	26/10/12	26.726	269.45			
	27/10/12 17:58	46.155	271.29	26/10/12 8:13	29.61	272.45	27/10/12	26.71	269.47			
	27/10/12 21:12	46.193	271.26	26/10/12 15:08	29.767	272.29	27/10/12	26.713	269.47			
	28/10/12 0:11	46.19	271.26	26/10/12 17:53	29.823	272.24	28/10/12	26.679	269.50			
	28/10/12 11:11	45.99	271.46	26/10/12 22:22	29.943	272.12	29/10/12	26.62	269.56			
	29/10/12 12:40	45.44	272.01	27/10/12 1:04	30	272.06	30/10/12	26.58	269.60			
	30/10/12 13:02	45	272.45	27/10/12 4:09	30.041	272.02	31/10/12	26.5	269.68			
	31/10/12 13:11	44.57	272.88	27/10/12 8:15	30.108	271.95	01/11/12	26.41	269.77			
	01/11/12 13:21	44.21	273.24	27/10/12 11:57	30.187	271.87	02/11/12	26.33	269.85			
	02/11/12 13:06	43.94	273.51	27/10/12 15:44	30.285	271.78	19/11/12	24.703	271.48			
	19/11/12 14:41	42.54	274.91	27/10/12 17:41	30.338	271.72						
	23/11/12 13:00	42.286	275.16	27/10/12 20:56	30.366	271.70						
	24/11/12 11:25	42.248	275.20	28/10/12 0:00	30.385	271.68						
				28/10/12 10:45	30.34	271.72						
				29/10/12 12:30	30.15	271.91						
				30/10/12 13:14	29.99	272.07						
				31/10/12 12:38	29.8	272.26						
				01/11/12 13:11	29.69	272.37						
				02/11/12 12:30	29.59	272.47						
				19/11/12 14:30	28.193	273.87						

Well ID	QU11-38
Mining Area	7SA5
Mine Grid Easting (m)	100402.86
Mine Grid Northing (m)	100503.65
Steel Elevation (m mine grid)	299.779
Ground Surface (m mine grid)	299.579
Water Level Measurment Pt.	Steel
Total Depth (m)	94.78
Steel Casing Stickup (m ags)	0.20
PVC Stickup (m BTOSteel)	
PVC Casing Stickup (m ags)	

DATE	DTW	WLE Mine Grid	DATE	DTW	WLE Mine Grid	DATE	DTW	WLE Mine Grid
19/03/12	23.53	276.25	25/10/12 7:44	39.397	260.38	27/10/12 14:50	42.042	257.74
12/09/12	24.83	274.95	25/10/12 9:33	39.81	259.97	27/10/12 15:00	41.683	258.10
02/10/12	25.08	274.70	25/10/12 11:00	40.192	259.59	27/10/12 15:10	41.368	258.41
21/10/12 15:40	24.267	275.51	25/10/12 12:25	40.468	259.31	27/10/12 15:20	41.068	258.71
22/10/12 9:12	24.215	275.56	25/10/12 13:07	40.6	259.18	27/10/12 15:30	40.78	259.00
22/10/12 16:09	24.133	275.65	25/10/12 14:05	40.802	258.98	27/10/12 15:40	40.552	259.23
23/10/12 16:50	24.102	275.68	25/10/12 16:16	41.224	258.55	27/10/12 16:50	38.945	260.83
23/10/12 17:43	24.107	275.67	25/10/12 16:40	41.3	258.48	27/10/12 18:22	37.04	262.74
24/10/12 9:07	24.735	275.04	25/10/12 18:45	41.752	258.03	27/10/12 20:53	35.245	264.53
24/10/12 13:01	25.41	274.37	25/10/12 21:13	42.167	257.61	27/10/12 23:55	33.773	266.01
24/10/12 13:02	25.69	274.09	25/10/12 23:05	42.44	257.34	28/10/12 9:42	31.31	268.47
24/10/12 13:03	25.923	273.86	26/10/12 1:03	42.692	257.09	28/10/12 13:10	30.74	269.04
24/10/12 13:04	26.115	273.66	26/10/12 3:02	42.93	256.85	29/10/12 10:00	28.7	271.08
24/10/12 13:05	26.275	273.50	26/10/12 5:02	43.145	256.63	30/10/12 12:50	27.33	272.45
24/10/12 13:06	26.425	273.35	26/10/12 7:02	43.362	256.42	31/10/12 13:00	26.53	273.25
24/10/12 13:07	26.552	273.23	26/10/12 7:40	43.482	256.30	01/11/12 13:06	25.99	273.79
24/10/12 13:08	26.705	273.07	26/10/12 14:10	44.224	255.55	02/11/12 12:52	25.57	274.21
24/10/12 13:09	26.817	272.96	26/10/12 14:40	44.271	255.51	19/11/12	23.108	276.67
24/10/12 13:10	26.932	272.85	26/10/12 18:12	44.689	255.09			
24/10/12 13:12	27.138	272.64	26/10/12 22:14	44.984	254.79			
24/10/12 13:14	27.34	272.44	27/10/12 0:55	45.165	254.61			
24/10/12 13:16	27.52	272.26	27/10/12 4:03	45.333	254.45			
24/10/12 13:18	27.667	272.11	27/10/12 7:49	45.608	254.17			
24/10/12 13:20	27.81	271.97	27/10/12 12:06	45.898	253.88			
24/10/12 13:25	28.157	271.62	27/10/12 13:24	45.96	253.82			
24/10/12 13:30	28.453	271.33	27/10/12 14:00	45.999	253.78			
24/10/12 13:35	28.708	271.07	27/10/12 14:01	45.62	254.16			
24/10/12 13:40	28.965	270.81	27/10/12 14:02	45.455	254.32			
24/10/12 13:45	29.21	270.57	27/10/12 14:03	45.303	254.48			
24/10/12 13:50	29.407	270.37	27/10/12 14:04	45.152	254.63			
24/10/12 14:00	29.79	269.99	27/10/12 14:05	45.02	254.76			
24/10/12 14:10	30.18	269.60	27/10/12 14:06	44.89	254.89			
24/10/12 14:20	30.542	269.24	27/10/12 14:07	44.768	255.01			
24/10/12 14:30	30.875	268.90	27/10/12 14:08	44.66	255.12			
24/10/12 14:40	31.138	268.64	27/10/12 14:09	44.543	255.24			
24/10/12 15:43	32.545	267.23	27/10/12 14:10	44.443	255.34			
24/10/12 16:07	33.029	266.75	27/10/12 14:12	44.243	255.54			
24/10/12 17:15	34.11	265.67	27/10/12 14:14	44.05	255.73			
24/10/12 19:05	35.403	264.38	27/10/12 14:16	43.88	255.90			
24/10/12 22:40	37.173	262.61	27/10/12 14:18	43.72	256.06			
25/10/12 0:30	37.842	261.94	27/10/12 14:20	43.57	256.21			
25/10/12 2:26	38.432	261.35	27/10/12 14:25	43.235	256.54			
25/10/12 4:32	38.968	260.81	27/10/12 14:30	42.952	256.83			
25/10/12 6:40	39.266	260.51	27/10/12 14:40	42.458	257.32			

APPENDIX A4 WELL INSTALLATION LOGS

LORAX ENVIRONMENTAL

Borehole Log of QU11-18

HILLSBOROUGH
Resources Limited

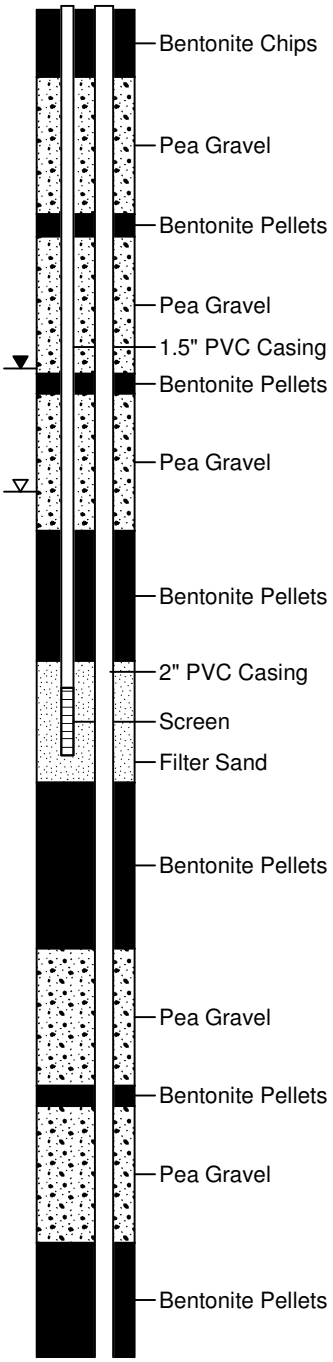
Quinsam Coal Corporation
Project #: J885-7

Date Drilled	: August 2011	Mine Grid Northing (m)	: 100690.81
Date Installed	: Dec 12, 2011	Mine Grid Easting (m)	: 100542.84
Hole Diameter	: 150 mm/ 85 mm core	Logged By	: N. Bazowski (QCC)
Drilling Method	: Air Rotary w/ wireline coring	Surveyed By	: QCC
Drilling Company	: Drillwell Enterprises	Installed By	: M. Storey (Lorax)

Water Levels
- QU11-18S: 283.59 m (Mar 19, 2012)
- QU11-18D: 278.09 m (Mar 19, 2012)

Well1: MW11-18S PVC Stickup 0.16m
Well2: MW11-18D PVC Stickup 0.16m
Elev.: 299.71 m (ground surface)

Depth (m)	Elev. (m asl) 299.71	Cored Interval	GRAPHIC	DESCRIPTION
0	299			TILL (not logged)
5	294			
10	289			
15	284			
20	279			
25	274			
30	269			
35	264			Drilled with casing, not logged
				SANDSTONE, grey, fine to medium grained Fault zone 37.2-37.7 m with fractures infilled with rusty clays, little water flow inferred
40	259			
				Coal (4 Seam) with some calcite, few surfaces display powdery orange mineral (realgar) in minor amounts
45	254			SILTSTONE
				COAL (4L Seam), dirty dull to bright clean, pyrite noted in limited intervals
				SILTSTONE, medium grey
50	249			
				COAL (4B Seam)
55	244			SILTSTONE, medium grey
60				



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Borehole Log of QU11-18

HILLSBOROUGH Resources Limited

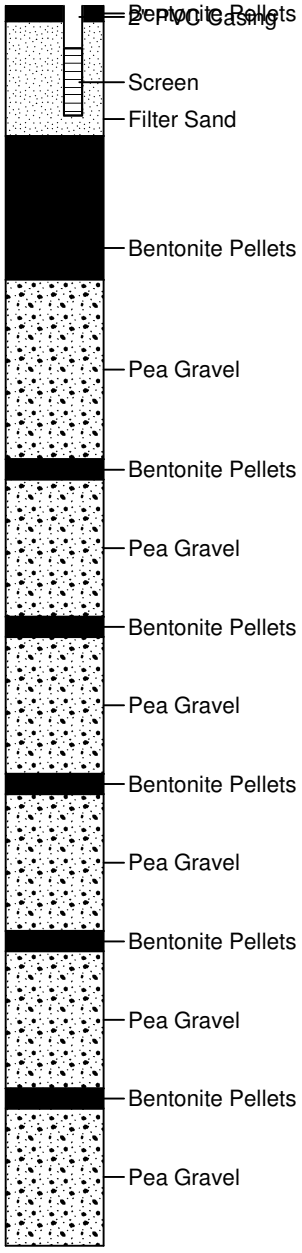
Quinsam Coal Corporation
Project #: J885-7

Date Drilled	: August 2011	Mine Grid Northing (m)	: 100690.81
Date Installed	: Dec 12, 2011	Mine Grid Easting (m)	: 100542.84
Hole Diameter	: 150 mm/ 85 mm core	Logged By	: N. Bazowski (QCC)
Drilling Method	: Air Rotary w/ wireline coring	Surveyed By	: QCC
Drilling Company	: Drillwell Enterprises	Installed By	: M. Storey (Lorax)

Water Levels
- QU11-18S: 283.59 m (Mar 19, 2012)
- QU11-18D: 278.09 m (Mar 19, 2012)

Well1: MW11-18S PVC Stickup 0.16m
Well2: MW11-18D PVC Stickup 0.16m
Elev.: 299.71 m (ground surface)

Depth (m)	Elev. (m asl) 299.71	DESCRIPTION
60	239	
		SANDSTONE, medium grey, fine grained, tight
65	234	SILSTONE, medium to dark grey, trace coal Airlift yield increased 12 GPM at 65.8 m
70	229	COAL (3 Zone)
75	224	Discrepancy between geophysical log and chip log
80	219	SILTSTONE, mostly grey interbedded with some brown, 5% calcite, 5% coal, fault zone
85	214	SILTSTONE, fractures noted 88-88.5 m and 94.3 m
90	209	
95	204	
100	199	SANDSTONE, greenish grey, fine to medium grained
		CONGLOMERATE
105	194	SILSTONE, with minor mudstone, some fractures
		BENSON CONGLOMERATE, both clast and matrix supported
110	189	SILSTONE, hematitic and dark green, 20 cm fault zone at 111.7 m
		CONGLOMERATE
115	184	EOH 115.2 m.
120		



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LORAX ENVIRONMENTAL

Borehole Log of QU11-28

HILLSBOROUGH Resources Limited

Quinsam Coal Corporation
Project #: J885-7

Date Drilled	: October 2011	Mine Grid Northing (m)	: 101067.24
Date Installed	: Dec 14, 2011	Mine Grid Easting (m)	: 100499.43
Hole Diameter	: 150 mm/ 85 mm core	Logged By	: N. Bazowski (QCC)
Drilling Method	: Air rotary w/ wireline coring	Surveyed By	: QCC
Drilling Company	: Drillwell Enterprises	Installed By	: M. Storey (Lorax)

Water Levels
▼ QU11-28: 273.40 m (Mar 21, 2012)
▽

Well: MW11-28 PVC Stickup m
Elev.: 307.09 m (ground surface)

Depth (m)	Elev. (m asl) 307.09	Cored Interval	GRAPHIC	DESCRIPTION
0	307			
5	305			TILL (not logged)
10	300			
15	295			
20	290			
25	285			
30	280			
35	275			SANDSTONE, medium grey, tight, hard
40	270			COAL (5 Seam)
45	265			SANDSTONE, brown grey to greenish grey, fine to medium grained, calcite (fracture infilling?) 48.8-50.3 m
50	260			
55	255			COAL
60	250			SILTSTONE, grey, with sandstone interbeds, minor coal
				SANDSTONE, medium grey, medium grained
				COAL (4 Seam), pyritic 54.7-54.8 m
				SANDSTONE, medium grey
				COAL (4L Seam), pyritic 55.9-56.0m, 56.1-56.5 m
				SANDSTONE, fine to medium grained, fault at 58.75 m

Bentonite Chips
Pea Gravel
Bentonite Pellets
Pea Gravel
Bentonite Pellets
Pea Gravel
Bentonite Pellets
Pea Gravel
Bentonite Pellets
2" PVC Casing
Pea Gravel
Bentonite Pellets
Pea Gravel
Bentonite Pellets
Pea Gravel
Bentonite Pellets
Filter Sand
Screen
Bentonite Pellets

LORAX ENVIRONMENTAL

Borehole Log of QU11-28

HILLSBOROUGH Resources Limited

Quinsam Coal Corporation
Project #: J885-7

Date Drilled	: October 2011	Mine Grid Northing (m)	: 101067.24
Date Installed	: Dec 14, 2011	Mine Grid Easting (m)	: 100499.43
Hole Diameter	: 150 mm/ 85 mm core	Logged By	: N. Bazowski (QCC)
Drilling Method	: Air rotary w/ wireline coring	Surveyed By	: QCC
Drilling Company	: Drillwell Enterprises	Installed By	: M. Storey (Lorax)

Water Levels
▼ QU11-28: 273.40 m (Mar 21, 2012)
▽

Well: MW11-28 PVC Stickup m
Elev.: 307.09 m (ground surface)

Depth (m)	Elev. (m asl) 307.09	DESCRIPTION
60	245	COAL
		SILTSTONE to SILTY SANDSTONE
65		SANDSTONE, fine to medium grained
	240	
70		
	235	CONGLOMERATE
		SANDSTONE, fine grained
75		
	230	
80		COAL (4B Seam)
		SILTSTONE, medium brown
	225	SANDSTONE, very fine to fine grained, grey to brown grey
85		
	220	SILTSTONE
90		Brecciated water bearing fault zone at 88.3-89 m
	215	SANDSTONE, mostly fine grained, 4 cm band of semi-massive pyrite and coal at base (104.9 m)
95		
	210	
100		
	205	
105		COAL (3R Seam), moderate platy pyrite 105.2-105.3 m
	200	MUDSTONE, brown, coaly at 105.9 m, 106.5-107 m
110		COAL (3 Seam)
	195	MUDSTONE, coaly, with minor siltstone and sandstone beds
		COAL (inferred 3L Seam)
115		MUDSTONE, coaly
	190	SANDSTONE, grey, fine grained, massive
120		EOH at 118.57 m

Bentonite Pellets
Pea Gravel
Bentonite Pellets
Pea Gravel
Bentonite Pellets
Pea Gravel
Bentonite Pellets
Pea Gravel
Bentonite Pellets
Pea Gravel
Bentonite Pellets
Pea Gravel
Bentonite Pellets
Pea Gravel

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Borehole Log of QU11-36D

HILLSBOROUGH Resources Limited

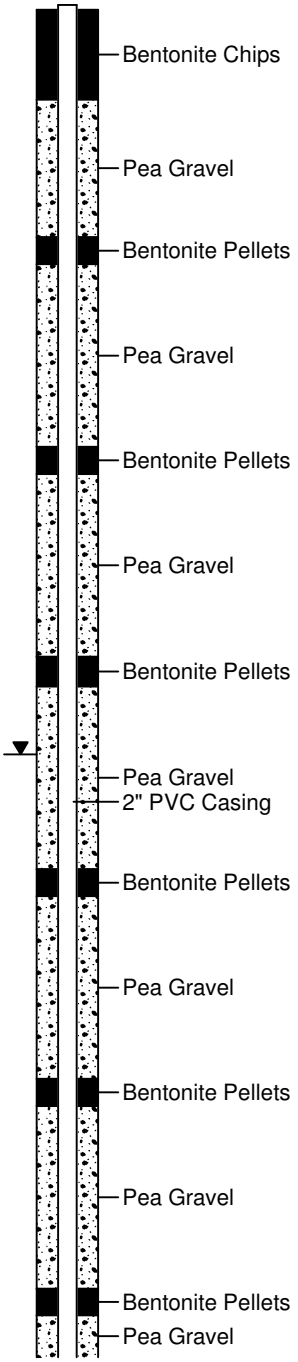
Quinsam Coal Corporation
Project #: J885-7

Date Drilled	: December 2011	Mine Grid Northing (m)	: 100111.42
Date Installed	: Dec 20, 2011	Mine Grid Easting (m)	: 100322.46
Hole Diameter	: 150 mm/ 85 mm core	Logged By	: N. Bazowski (QCC)
Drilling Method	: Air Rotary w/ wireline coring	Surveyed By	: QCC
Drilling Company	: Drillwell Enterprises	Installed By	: M. Storey (Lorax)

Water Levels
▼ QU11-36D: Water level 260.86 m (Mar 19, 2012)
▽

Well: MW11-36D PVC Stickup 0.22 m
Elev.: 285.89 m (ground surface)

Depth (m)	Elev. (m asl) 285.89	Cored Interval	GRAPHIC	DESCRIPTION
0	285			TILL (not logged)
5	280			
10	275			BR (drilled)
15	270			
20	265			
				COAL (5 Seam)
25	260			BR
30	255			SANDSTONE, medium to coarse grained, fractured with oxidation surfaces throughout Possible fault at ~33.6 m
35	250			
40	245			
45				SANDSTONE, fine to medium grained, with overlying pyritic SILSTONE (top 5 cm)



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Borehole Log of QU11-36D

LORAX ENVIRONMENTAL

HILLSBOROUGH Resources Limited

Quinsam Coal Corporation
Project #: J885-7

Date Drilled	: December 2011	Mine Grid Northing (m)	: 100111.42
Date Installed	: Dec 20, 2011	Mine Grid Easting (m)	: 100322.46
Hole Diameter	: 150 mm/ 85 mm core	Logged By	: N. Bazowski (QCC)
Drilling Method	: Air Rotary w/ wireline coring	Surveyed By	: QCC
Drilling Company	: Drillwell Enterprises	Installed By	: M. Storey (Lorax)

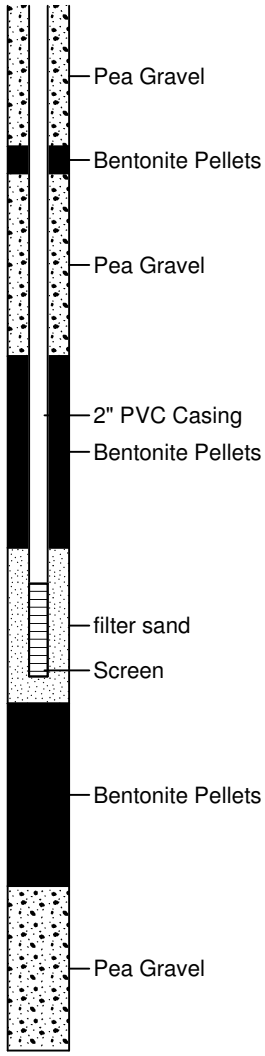
Water Levels

▼ QU11-36D: Water level 260.86 m (Mar 19, 2012)

▽

Well: MW11-36D PVC Stickup 0.22 m
Elev.: 285.89 m (ground surface)

Depth (m)	Elev. (m asl) 285.89	Cored Interval	GRAPHIC	DESCRIPTION
45	240			
50	235			SANDSTONE
				COAL (4L Seam)
				BR (drilled)
55	230			
60	225			COAL (4B Seam)
				BR (drilled)
65	220			
70	215			
75	210			
80	205			BENSON CONGLOMERATE
				EOH 80.0 m
85	200			
90				



LORAX ENVIRONMENTAL

Borehole Log of QU11-36S

HILLSBOROUGH Resources Limited

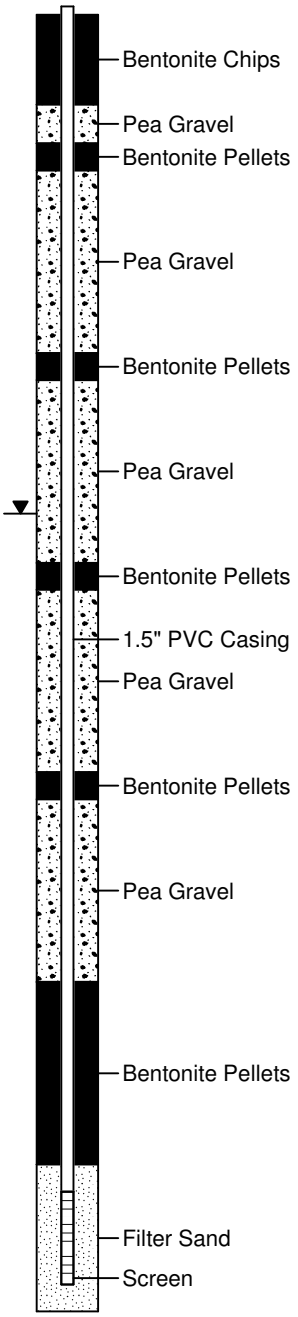
Quinsam Coal Corporation
Project #: J885-7

Date Drilled	: December 2011	Mine Grid Northing (m)	: 100109.43
Date Installed	: Dec 15, 2011	Mine Grid Easting (m)	: 100324.93
Hole Diameter	: 150 mm	Logged By	: N. Bazowski (QCC)
Drilling Method	: Air Rotary	Surveyed By	: QCC
Drilling Company	: Drillwell Enterprises	Installed By	: M. Storey (Lorax)

Water Levels
▼ QU11-36S: 269.09 m (Mar 19, 2012)
▽

Well: MW11-36S PVC Stickup 0.28 m
Elev.: 286.03 m (ground surface)

Depth (m)	Elev. (m asl) 286.03	Cored Interval	GRAPHIC	DESCRIPTION
0	285			Lithology descriptions from QU11-36D TILL (not logged)
5	280			
10	275			Bedrock (drilled)
15	270			
20	265			COAL (5 Seam)
				BR
25	260			
30	255			SANDSTONE, medium to coarse grained, fractured with oxidation surfaces throughout. Possible fault at ~33.6 m
35	250			
40	245			
45				SANDSTONE, fine to medium grained, with overlying pyritic SILSTONE (top 5 cm) EOH 43.2 m. Final airlift yield 30 GPM.



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LORAX ENVIRONMENTAL

Borehole Log of Pumping Well QU11-38

HILLSBOROUGH
Resources Limited

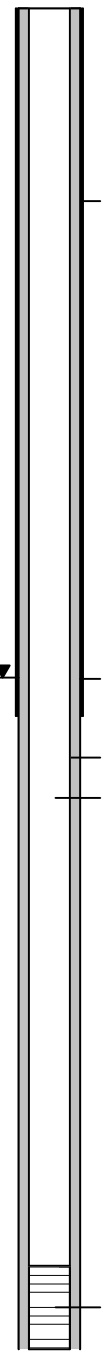
Quinsam Coal Corporation
Project #: J885-7

Date Drilled	: December 2011	Mine Grid Northing (m)	: 100503.65
Date Installed	: October 2, 2012	Mine Grid Easting (m)	: 100402.86
Hole Diameter	: 150 mm/ 140 mm core	Logged By	: N. Bazowski (QCC)
Drilling Method	: Air rotary w/ wireline coring	Surveyed By	: QCC
Drilling Company	: Drillwell Enterprises	Installed By	: L. Findlater

Water Levels
▼ QU11-38: ~274.25 m (25.08 m BTOC) Oct 2, 2012.
▽

Well: QU11-38 Steel & PVC Stickup ~0.25 m
Elev.: 299.579 m (ground surface)

Depth (m)	Elev. (m asl) 299.579	Cored Interval	GRAPHIC	DESCRIPTION
0				TILL (not logged)
5	295			
10	290			
15	285			
20	280			
25	275			SANDSTONE, medium grey, fine-medium grained, hard,
30	270			
35	265			COAL (5 Seam)
				SILTSTONE, dark greyish brown (5-5L Parting)
				COAL (5L)
40	260			SANDSTONE, fine-medium grained, minor coal bed at ~38.1m.
				Borehole yield increases to 15 gpm at 39.6 m.
				SANDSTONE, minor coal beds at 41.1 m and 44.2 m.
45	255			
50	250			



6" Steel surface casing
No backfill materials used
4.5" Crestline PVC SDR 21-Sch 40
Glued bell joints c/w 0.5" screws
Slots (hand machined)

10-10-2012 P:\J885 Hillsborough Resources\885-7 242 Mine\Borehole Logs\2012 Pump Test Installs\Installation Logs\QU11-38.bc

LORAX ENVIRONMENTAL

Borehole Log of Pumping Well QU11-38

HILLSBOROUGH Resources Limited

Quinsam Coal Corporation
Project #: J885-7

Date Drilled	: December 2011	Mine Grid Northing (m)	: 100503.65
Date Installed	: October 2, 2012	Mine Grid Easting (m)	: 100402.86
Hole Diameter	: 150 mm/ 140 mm core	Logged By	: N. Bazowski (QCC)
Drilling Method	: Air rotary w/ wireline coring	Surveyed By	: QCC
Drilling Company	: Drillwell Enterprises	Installed By	: L. Findlater

Water Levels

▼ QU11-38: ~274.25 m (25.08 m BTOC) Oct 2, 2012.

▽

Well: QU11-38 Steel & PVC Stickup ~0.25 m
Elev.: 299.579 m (ground surface)

Depth (m)	Elev. (m asl) 299.579	Cored Interval	GRAPHIC	DESCRIPTION
50				
				SANDSTONE, fracture zone 52.1-55.3 m, borehole yield increases to 50 gpm.
55	245			
				COAL (4 Seam)
				COAL (4L Seam)
60	240			
				Coaly SILTSTONE, SANDSTONE, MUDSTONE
65	235			
				COAL (4B Seam)
				SANDSTONE, dark grey and medium brown, very fine grained
70	230			
				SILTSTONE, dark grey to black, coaly
				SANDSTONE, silty
75	225			
				SANDSTONE, medium to dark grey, coaly lamina after 80.8 m
80	220			
85	215			Coal (3R Seam)
				SILTSTONE and MUDSTONE, coaly.
				COAL (3 Seam)
90	210			SILTSTONE (3-3L Parting)
				COAL (3L Seam)
95	205			
				EOH 94.6 m.
100	200			

No backfill materials used

Slots (hand machined)

No backfill materials used

PVC hung up, not on bottom of hole

10-10-2012 P:\J885 Hillsborough Resources\885-7 242 Mine\Borehole Logs\2012 Pump Test Installs\Installation Logs\QU11-38.bc

Lorax Environmental Services Ltd.
2289 Burrard Street
Vancouver, BC, Canada, V6J 3H9
Phone: +1 (604) 688-7173
Fax: +1 (604) 688-7175
www.lorax.ca

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 – 20 / 0 – 6		Overburden/ Glacial Till	0.0	Pea Gravel 0.0m-3.0m; Cement Grout 3.0m-17.37m	
22 – 58 / 6.5 – 16		Sandstone	21.3	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
61–117		Sandstone		10/20 Filter Sand 18.29m-29.2m	
20		Coal Seam 4 (Upper)	65.4		
22		Sandstone	71.9		GW Elevation: 273.38m (May 17, 2010)
24		Coal Seam 4 (Lower)		Screen 19.51m-27.0m	
26					
28		Sandstone	86.6	Bentonite Chips	
30				10/20 Filter Sand	
32			101.0	Bentonite Chips 29.2m-30.8m	
34				EOH	

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

Borehole Log of QU11-35

LORAX ENVIRONMENTAL

HILLSBOROUGH Resources Limited

Quinsam Coal Corporation
Project #: J885-7

Date Drilled	: December 2011	Mine Grid Northing (m)	: 100277.99
Date Installed	: Oct 1-2, 2012	Mine Grid Easting (m)	: 100083.51
Hole Diameter	: 150 mm/ 140 mm core	Logged By	: N. Bazowski (QCC)
Drilling Method	: Air rotary w/ wireline coring	Surveyed By	: QCC
Drilling Company	: Drillwell Enterprises	Installed By	: L. Findlater

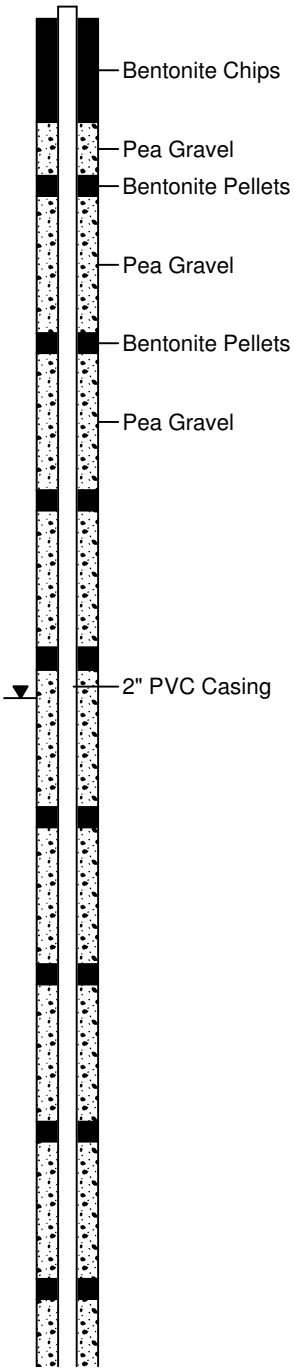
Water Levels

▼ QU11-35: 269.67 m (30.79 m bgs) Oct 3, 2012.

▽

Well: QU11-35 PVC Stickup 0.53 m
Elev.: 300.466 m (ground surface)

Depth (m)	Elev. (m asl) 300.466	Cored Interval	GRAPHIC	DESCRIPTION
0	300			TILL (not logged)
				SANDSTONE, medium grey, fine grained. Realgar noted in the 3-4.5 m interval and 6-7.6 m interval.
5	295			
10	290			SILTSTONE, dark grey
				CONGLOMERATE, mix of sandstone, chert and silts, trace oxidized surfaces
15	285			SANDSTONE, light to dark grey, fine to medium grained.
				CONGLOMERATE, cherty with minor sandstone and siltstone
20	280			SANDSTONE, brown to grey, fine to medium grained
25	275			
30	270			
35	265			
40	260			
45	255			
50	250			SILTSTONE, dark grey, coaly
				COAL (5 Seam)
55	245			SANDSTONE, brown to medium grey, fine to medium grained
60				



LORAX ENVIRONMENTAL

Borehole Log of QU11-35

HILLSBOROUGH Resources Limited

Quinsam Coal Corporation
Project #: J885-7

Date Drilled	: December 2011	Mine Grid Northing (m)	: 100277.99
Date Installed	: Oct 1-2, 2012	Mine Grid Easting (m)	: 100083.51
Hole Diameter	: 150 mm/ 140 mm core	Logged By	: N. Bazowski (QCC)
Drilling Method	: Air rotary w/ wireline coring	Surveyed By	: QCC
Drilling Company	: Drillwell Enterprises	Installed By	: L. Findlater

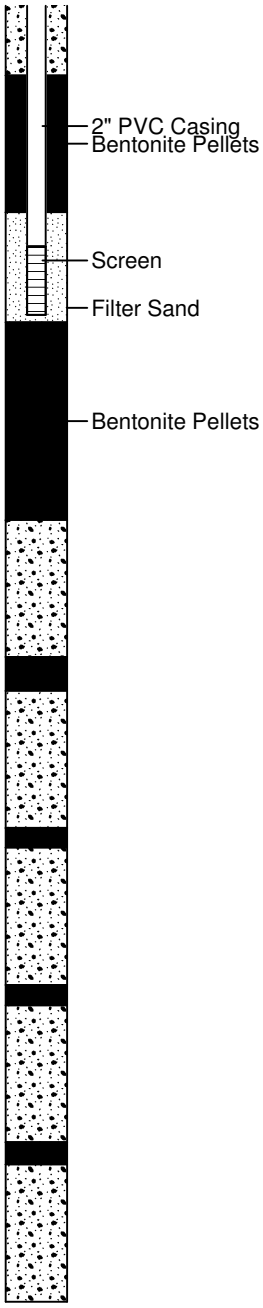
Water Levels

▼ QU11-35: 269.67 m (30.79 m bgs) Oct 3, 2012.

▽

Well: QU11-35 PVC Stickup 0.53 m
Elev.: 300.466 m (ground surface)

Depth (m)	Elev. (m asl) 300.466	Cored Interval	GRAPHIC	DESCRIPTION
60	240			
65	235			SANDSTONE, light to medium grey, medium to coarse grained, trace magnetite (?)
70	230			SANDSTONE, pinkish grey to medium grey, fine to medium grained. Fracture producing 20 gpm at 72.4m.
75	225			Calcite veining with associated realgar at 75.28 m.
				COAL (4 Seam)
				SANDSTONE, medium brown grey, fine to medium grained
80	220			COAL (4L Seam)
				SANDSTONE interbedded with coaly SILTSTONE
				SANDSTONE, brown grey to dark grey, fine grained
85	215			
90	210			COAL, (4B Seam)
				SANDSTONE interbedded with SILTSTONE
95	205			SANDSTONE, medium to dark grey, very fine to fine grained
100	200			
105	195			SILTSTONE
				SANDSTONE, interbedded light and dark silty grey, fine grained
110	190			SANDSTONE, light and medium grey, fine to medium grained
115	185			
				COAL (3R Seam)
120				COAL (3 Seam)



12-12-2012 P:\J885 Hillsborough Resources\885-7 242 Mine\Borehole Logs\2012 Pump Test Installs\Installation Logs\QU11-35.bc

Borehole Log of QU11-35

LORAX ENVIRONMENTAL

HILLSBOROUGH Resources Limited

Quinsam Coal Corporation
Project #: J885-7

Date Drilled	: December 2011	Mine Grid Northing (m)	: 100277.99
Date Installed	: Oct 1-2, 2012	Mine Grid Easting (m)	: 100083.51
Hole Diameter	: 150 mm/ 140 mm core	Logged By	: N. Bazowski (QCC)
Drilling Method	: Air rotary w/ wireline coring	Surveyed By	: QCC
Drilling Company	: Drillwell Enterprises	Installed By	: L. Findlater

Water Levels
▼ QU11-35: 269.67 m (30.79 m bgs) Oct 3, 2012.
▽

Well: QU11-35 PVC Stickup 0.53 m
Elev.: 300.466 m (ground surface)

Depth (m)	Elev. (m asl) 300.466	Cored Interval	GRAPHIC	DESCRIPTION
120	180			MUDSTONE, coaly (3L Seam), medium and dark brown
				BRECCIA, clast supported, airlift yield increases 60 gpm
125	175			MUDSTONE, coaly
				SILSTONE
				SANDSTONE, grey, fine grained, trace realgar at 124.7 m
130	170			LIMESTONE, light to medium grey
				SANDSTONE, medium to coarse grained, minor disseminated realgar at 130 m.
				CONGLOMERATE, metamorphosed
135	165			BRECCIA, metamorphosed
				SILTSTONE, metamorphosed
140	160			VOLCANICS
145	155			RHYOLITE
				QUARTZ VEIN
150	150			RHYOLITE
155	145			
				EOH at 157.95 m.
160	140			
165	135			
170	130			
175	125			
180				

12-12-2012 P:\J885 Hillsborough Resources\885-7 242 Mine\Borehole Logs\2012 Pump Test Installs\Installation Logs\QU11-35.bc

Borehole Log of QU11-35

LORAX ENVIRONMENTAL

HILLSBOROUGH Resources Limited

Quinsam Coal Corporation
Project #: J885-7

Date Drilled	: December 2011	Mine Grid Northing (m)	: 100277.99
Date Installed	: Oct 1-2, 2012	Mine Grid Easting (m)	: 100083.51
Hole Diameter	: 150 mm/ 140 mm core	Logged By	: N. Bazowski (QCC)
Drilling Method	: Air rotary w/ wireline coring	Surveyed By	: QCC
Drilling Company	: Drillwell Enterprises	Installed By	: L. Findlater

Water Levels

▼ QU11-35: 269.67 m (30.79 m bgs) Oct 3, 2012.

▽

Well: QU11-35 PVC Stickup 0.53 m
Elev.: 300.466 m (ground surface)

Depth (m)	Elev. (m asl) 300.466	Cored Interval	GRAPHIC	DESCRIPTION
0	300			TILL (not logged)
				SANDSTONE, medium grey, fine grained. Realgar noted in the 3-4.5 m interval and 6-7.6 m interval.
5	295			
10	290			SILTSTONE, dark grey
				CONGLOMERATE, mix of sandstone, chert and silts, trace oxidized surfaces
15	285			SANDSTONE, light to dark grey, fine to medium grained.
				CONGLOMERATE, cherty with minor sandstone and siltstone
20	280			SANDSTONE, brown to grey, fine to medium grained
25	275			
30	270			
35	265			
40	260			
45	255			
50	250			SILTSTONE, dark grey, coaly
				COAL (5 Seam)
55	245			SANDSTONE, brown to medium grey, fine to medium grained
60				

2" PVC Casing

12-12-2012 P:\J885 Hillsborough Resources\885-7 242 Mine\Borehole Logs\2012 Pump Test Installs\Installation Logs\QU11-35Part2.bc

LORAX ENVIRONMENTAL

Borehole Log of QU11-35

HILLSBOROUGH Resources Limited

Quinsam Coal Corporation
Project #: J885-7

Date Drilled	: December 2011	Mine Grid Northing (m)	: 100277.99
Date Installed	: Oct 1-2, 2012	Mine Grid Easting (m)	: 100083.51
Hole Diameter	: 150 mm/ 140 mm core	Logged By	: N. Bazowski (QCC)
Drilling Method	: Air rotary w/ wireline coring	Surveyed By	: QCC
Drilling Company	: Drillwell Enterprises	Installed By	: L. Findlater

Water Levels

▼ QU11-35: 269.67 m (30.79 m bgs) Oct 3, 2012.

▽

Well: QU11-35 PVC Stickup 0.53 m
Elev.: 300.466 m (ground surface)

Depth (m)	Elev. (m asl) 300.466	Cored Interval	GRAPHIC	DESCRIPTION
60	240			
65	235			SANDSTONE, light to medium grey, medium to coarse grained, trace magnetite (?)
70	230			SANDSTONE, pinkish grey to medium grey, fine to medium grained.
75	225			Fracture producing 20 gpm at 72.4m.
				Calcite veining with associated realgar at 75.28 m.
				COAL (4 Seam)
80	220			SANDSTONE, medium brown grey, fine to medium grained
				COAL (4L Seam)
				SANDSTONE interbedded with coaly SILTSTONE
85	215			SANDSTONE, brown grey to dark grey, fine grained
90	210			COAL, (4B Seam)
				SANDSTONE interbedded with SILTSTONE
95	205			SANDSTONE, medium to dark grey, very fine to fine grained
100	200			
105	195			SILTSTONE
				SANDSTONE, interbedded light and dark silty grey, fine grained
110	190			SANDSTONE, light and medium grey, fine to medium grained
115	185			
				COAL (3R Seam)
120				COAL (3 Seam)

2" PVC Casing

Screen

Pea Gravel

Bentonite Pellets

Pea Gravel

12-12-2012 P:\J885 Hillsborough Resources\885-7 242 Mine\Borehole Logs\2012 Pump Test Installs\Installation Logs\QU11-35Part2.bc

Borehole Log of QU11-35

LORAX ENVIRONMENTAL

HILLSBOROUGH Resources Limited

Quinsam Coal Corporation
Project #: J885-7

Date Drilled	: December 2011	Mine Grid Northing (m)	: 100277.99
Date Installed	: Oct 1-2, 2012	Mine Grid Easting (m)	: 100083.51
Hole Diameter	: 150 mm/ 140 mm core	Logged By	: N. Bazowski (QCC)
Drilling Method	: Air rotary w/ wireline coring	Surveyed By	: QCC
Drilling Company	: Drillwell Enterprises	Installed By	: L. Findlater

Water Levels
▼ QU11-35: 269.67 m (30.79 m bgs) Oct 3, 2012.
▽

Well: QU11-35 PVC Stickup 0.53 m
Elev.: 300.466 m (ground surface)

Depth (m)	Elev. (m asl) 300.466	Cored Interval	GRAPHIC	DESCRIPTION
120	180			MUDSTONE, coaly (3L Seam), medium and dark brown
				BRECCIA, clast supported, airlift yield increases 60 gpm
125	175			MUDSTONE, coaly
				SILSTONE
				SANDSTONE, grey, fine grained, trace realgar at 124.7 m
130	170			LIMESTONE, light to medium grey
				SANDSTONE, medium to coarse grained, minor disseminated realgar at 130 m.
				CONGLOMERATE, metamorphosed
135	165			BRECCIA, metamorphosed
				SILTSTONE, metamorphosed
140	160			VOLCANICS
145	155			RHYOLITE
				QUARTZ VEIN
150	150			RHYOLITE
155	145			
160	140			EOH at 157.95 m.
165	135			
170	130			
175	125			
180				

Pea Gravel
Bentonite Pellets
Pea Gravel
Bentonite Pellets
Pea Gravel
Bentonite Pellets
Pea Gravel
Bentonite Pellets
Pea Gravel

12-12-2012 P:\J885 Hillsborough Resources\885-7 242 Mine\Borehole Logs\2012 Pump Test Installs\Installation Logs\QU11-35Part2.bc

LORAX ENVIRONMENTAL

Borehole Log of QU12-07

HILLSBOROUGH Resources Limited

Quinsam Coal Corporation
Project #: J885-7

Date Drilled	: January 2012	Mine Grid Northing (m)	: 100433.66
Date Installed	: Oct 4-5, 2012	Mine Grid Easting (m)	: 100200.99
Hole Diameter	: 150 mm/ 140 mm core	Logged By	: N. Bazowski (QCC)
Drilling Method	: Air rotary w/ wireline coring	Surveyed By	: QCC
Drilling Company	: Drillwell Enterprises	Installed By	: L. Findlater

Water Levels

▼ QU12-07: ~272 m (~38.5 m bgs) Oct 4, 2012.

▽

Well: QU12-07 PVC Stickup ## m
Elev.: 311.4 m (ground surface).

Depth (m)	Elev. (m asl) 311.4	Cored Interval	GRAPHIC	DESCRIPTION
0	310			TILL (not logged)
				SANDSTONE, grey, very fine to fine grained
5	305			
10	300			SANDSTONE, faulted, minor oxidation and calcite veining
15	295			NOT LOGGED
20	290			
25	285			
30	280			
35	275			
40	270			
45	265			
50	260			
55	255			
60	250			
65	245			
70	240			COAL (5 Seam)
				COAL (5L Seam)
75				

Filter Sand
Bentonite Chips
Pea Gravel
Bentonite Pellets
Pea Gravel
Bentonite Pellets
2" PVC Casing broken and left down hole
Pea Gravel
Bentonite Pellets
Pea Gravel

10-10-2012 P:\J885 Hillsborough Resources\885-7 242 Mine\Borehole Logs\2012 Pump Test Installs\Installation Logs\QU12-07.bc

LORAX ENVIRONMENTAL

Borehole Log of QU12-07

HILLSBOROUGH Resources Limited

Quinsam Coal Corporation
Project #: J885-7

Date Drilled	: January 2012	Mine Grid Northing (m)	: 100433.66
Date Installed	: Oct 4-5, 2012	Mine Grid Easting (m)	: 100200.99
Hole Diameter	: 150 mm/ 140 mm core	Logged By	: N. Bazowski (QCC)
Drilling Method	: Air rotary w/ wireline coring	Surveyed By	: QCC
Drilling Company	: Drillwell Enterprises	Installed By	: L. Findlater

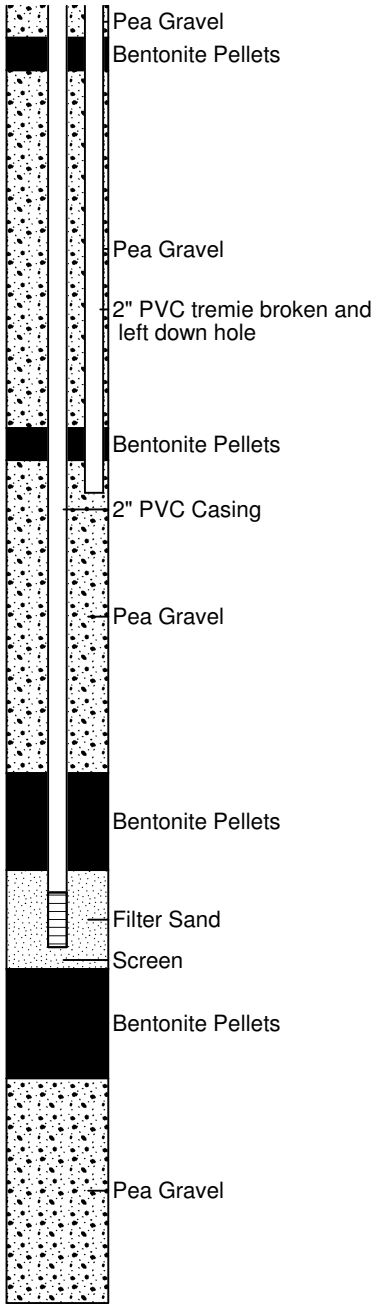
Water Levels

▼ QU12-07: ~272 m (~38.5 m bgs) Oct 4, 2012.

▽

Well: QU12-07 PVC Stickup ## m
Elev.: 311.4 m (ground surface).

Depth (m)	Elev. (m asl) 311.4	Cored Interval	GRAPHIC	DESCRIPTION
75	235			
80	230			SANDSTONE, grey, fine to medium grained, silty and coaly at base (20 cm).
85	225			
90	220			
95	215			COAL (4 Seam)
				SANDSTONE
100	210			COAL (4L Seam)
				SILTSTONE and dirty SANDSTONE
				SANDSTONE, brown grey to dark grey, fine grained
105	205			CONGLOMERATE
				SANDSTONE, fine to medium grained
110	200			COAL (4B Seam)
				SANDSTONE, fine grained
115	195			Orange and white calcite in the 111.25-112.78m range (potential fault)
				SILTSTONE, medium brown, slightly sandy
120	190			SANDSTONE interbedded with SILTSTONE
				SILTSTONE, medium brown
125	185			Fault around 125-126.5 m, borehole yield increased 6 gpm
				SANDSTONE, browny grey and grey, fine grained
130	180			
135	175			COAL (3R/3 Seams)
				SILTSTONE, coaly
140	170			SILSTONE, coaly (3L Seam)
				SILTSTONE interbedded with SANDSTONE and GRITSTONE
145	165			MUDSTONE, dark brown, coaly
150				EOH at 147.98 m



10-10-2012 P:\J885 Hillsborough Resources\885-7 242 Mine\Borehole Logs\2012 Pump Test Installs\Installation Logs\QU12-07.bc

LORAX ENVIRONMENTAL

Borehole Log of QU12-08

HILLSBOROUGH Resources Limited

Quinsam Coal Corporation
Project #: J885-7

Date Drilled	: January 2012	Mine Grid Northing (m)	: 100402.70
Date Installed	: Oct 5, 2012	Mine Grid Easting (m)	: 100246.48
Hole Diameter	: 150 mm/ 140 mm core	Logged By	: N. Bazowski (QCC)
Drilling Method	: Air rotary w/ wireline coring	Surveyed By	: QCC
Drilling Company	: Drillwell Enterprises	Installed By	: L. Findlater

Water Levels

▼ QU12-08: ~ 271 m (~ 46 m bgs) Oct 5, 2012.

▽

Well: QU12-08 PVC Stickup ## m
Elev.: 316.97 m (ground surface).

Depth (m)	Elev. (m asl) 316.97	Cored Interval	GRAPHIC	DESCRIPTION
0	316.97			TILL (not logged)
5	315			SANDSTONE, slightly oxidized
10	310			SANDSTONE, grey, fine grained, interbedded with SILTSTONE
15	305			SANDSTONE, fine to medium grained, often silty, with minor coal seams up to ~32 meters
20	300			
25	295			
30	290			
35	285			
40	280			
45	275			
50	270			
55	265			
60	260			
65	255			
70	250			COAL (5 Seam)

Pea Gravel
Bentonite Chips
Pea Gravel
Bentonite Pellets
Pea Gravel
Bentonite Pellets
1.5" PVC Casing
Pea Gravel
Bentonite Pellets
Pea Gravel
Bentonite Pellets
Pea Gravel

10-11-2012 P:\J885 Hillsborough Resources\885-7 242 Mine\Borehole Logs\2012 Pump Test Installs\Installation Logs\QU12-08.bc

LORAX ENVIRONMENTAL

Borehole Log of QU12-08

HILLSBOROUGH Resources Limited

Quinsam Coal Corporation
Project #: J885-7

Date Drilled	: January 2012	Mine Grid Northing (m)	: 100402.70
Date Installed	: Oct 5, 2012	Mine Grid Easting (m)	: 100246.48
Hole Diameter	: 150 mm/ 140 mm core	Logged By	: N. Bazowski (QCC)
Drilling Method	: Air rotary w/ wireline coring	Surveyed By	: QCC
Drilling Company	: Drillwell Enterprises	Installed By	: L. Findlater

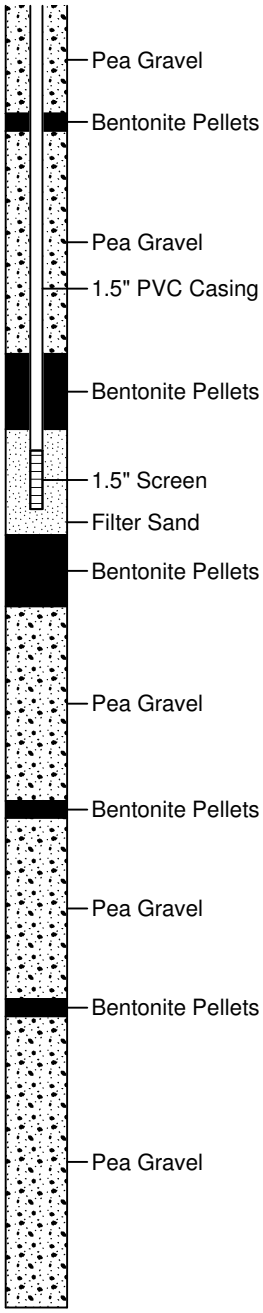
Water Levels

▼ QU12-08: ~ 271 m (~ 46 m bgs) Oct 5, 2012.

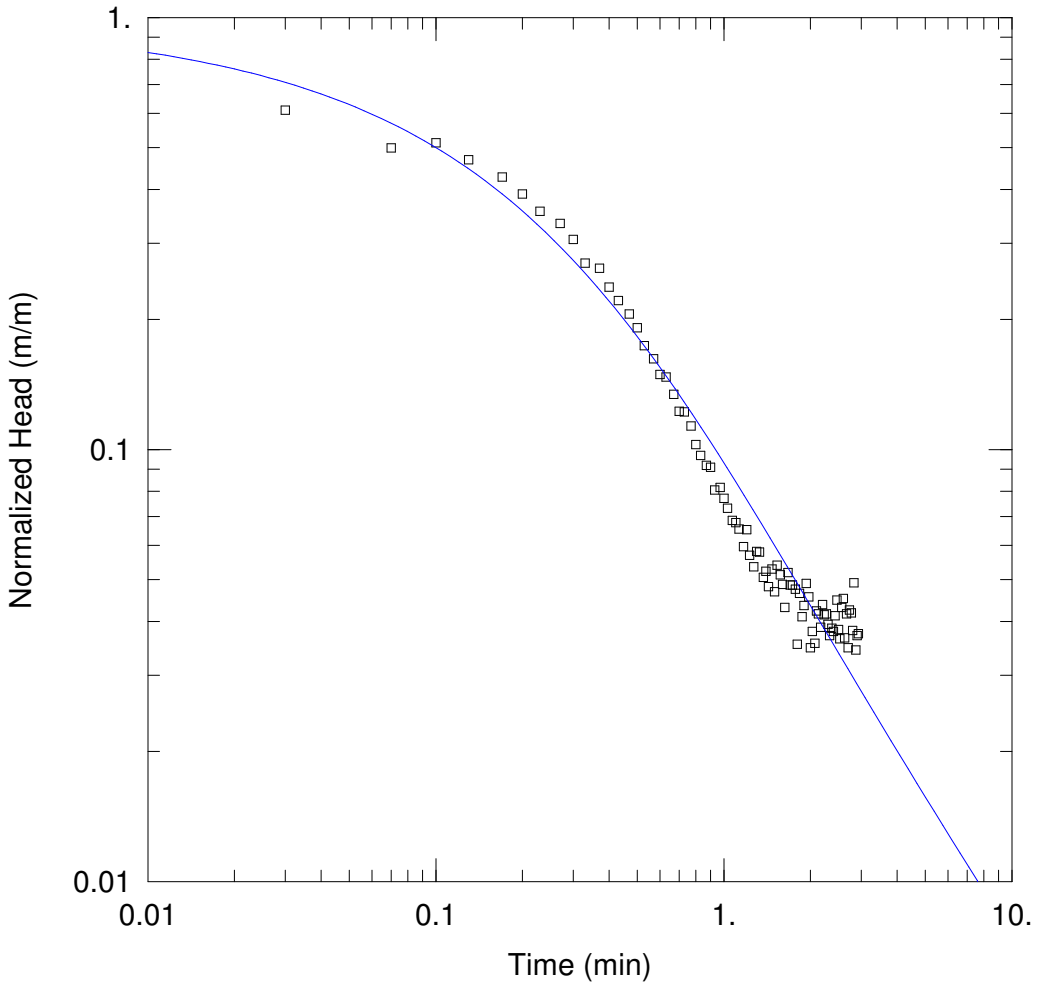
▽

Well: QU12-08 PVC Stickup ## m
Elev.: 316.97 m (ground surface).

Depth (m)	Elev. (m asl) 316.97	Cored Interval	GRAPHIC	DESCRIPTION
70	245			SANDSTONE, fine to medium grained, coaly
75	240			SANDSTONE, brown to grey, fine to medium grained
80	235			
85	230			
90	225			
95	220			COAL (4 Seam)
				COAL (4L Seam)
				SANDSTONE interbedded with SILTSTONE
100	215			SANDSTONE, grey, fine grained
105	210			COAL (4B Seam)
				SILTSTONE, dark brown, coaly
110	205			SANDSTONE, brown to grey, fine grained
				SILTSTONE, dark grey Fault noted at 113.7 m (water not reported)
115	200			SANDSTONE, brown to grey, fine to very fine grained
120	195			SILTSTONE, grey to brown
125	190			
130	185			COAL (3R Seam). Core lost over 3R to 3L interval.
				COAL (3 Seam)
				Not logged (lost core)
				COAL (3L Seam)
135				SILTSTONE interbedded with GRITSTONE and MUDSTONE
140	180			EOH at 137.62 m



APPENDIX A5 SLUG TEST ANALYSES



WELL TEST ANALYSIS

Data Set: P:\...\QU11-18D FH CBP.aqt
Date: 12/13/12 Time: 10:42:26

PROJECT INFORMATION

Company: Lorax
Client: Quinsam Coal
Project: J885-7
Location: 242 Mine

AQUIFER DATA

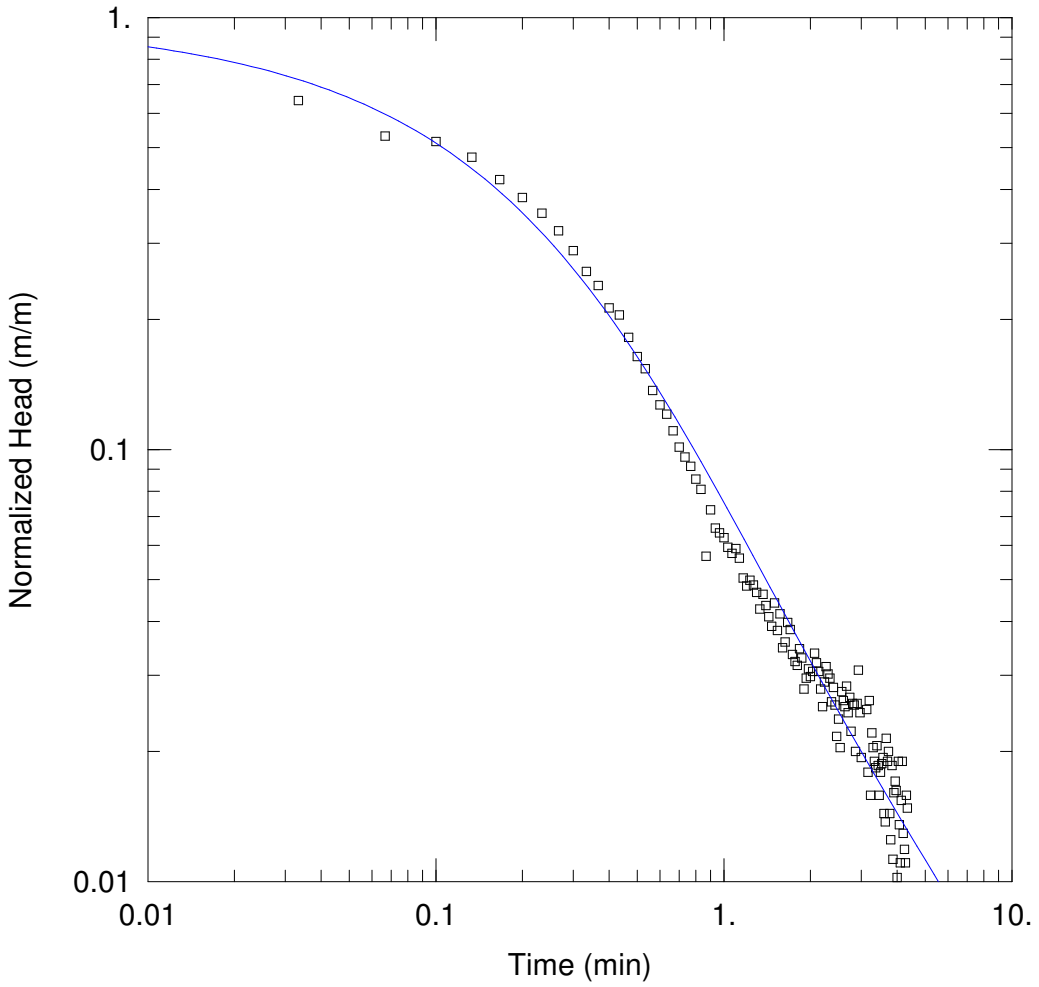
Saturated Thickness: 4.4 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (QU11-18D)

Initial Displacement: 0.48 m
Total Well Penetration Depth: 4.4 m
Casing Radius: 0.026 m
Static Water Column Height: 43.16 m
Screen Length: 4.4 m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Bredehoeft-Papadopulos
T = 3.996E-5 m^2/sec
S = 0.01707



WELL TEST ANALYSIS

Data Set: P:\...\QU11-18D RH CBP.aqt
Date: 12/13/12 Time: 10:43:31

PROJECT INFORMATION

Company: Lorax
Client: Quinsam Coal
Project: J885-7
Location: 242 Mine

AQUIFER DATA

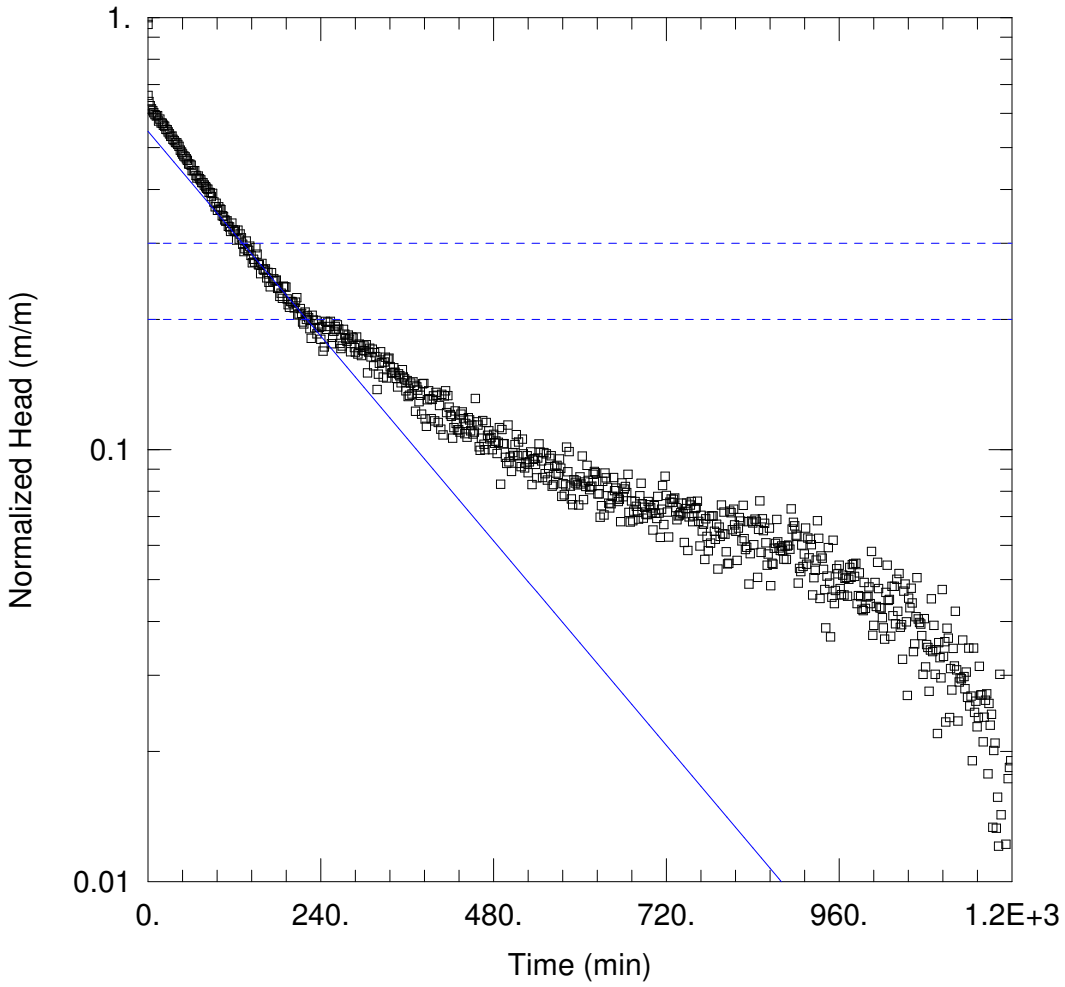
Saturated Thickness: 4.4 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (QU11-18D)

Initial Displacement: 0.48 m
Total Well Penetration Depth: 4.4 m
Casing Radius: 0.026 m
Static Water Column Height: 43.16 m
Screen Length: 4.4 m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Bredehoeft-Papadopulos
T = 5.626E-5 m^2/sec
S = 0.006439



WELL TEST ANALYSIS

Data Set: P:\J885 Hillsborough Resources\885-7 242 Mine\Slug Tests\Aqtesolv Files\QU11-18S FH.aqt
Date: 12/13/12 Time: 10:39:59

PROJECT INFORMATION

Company: Lorax
Client: Quinsam Coal
Project: J885-7
Location: 242 Mine

AQUIFER DATA

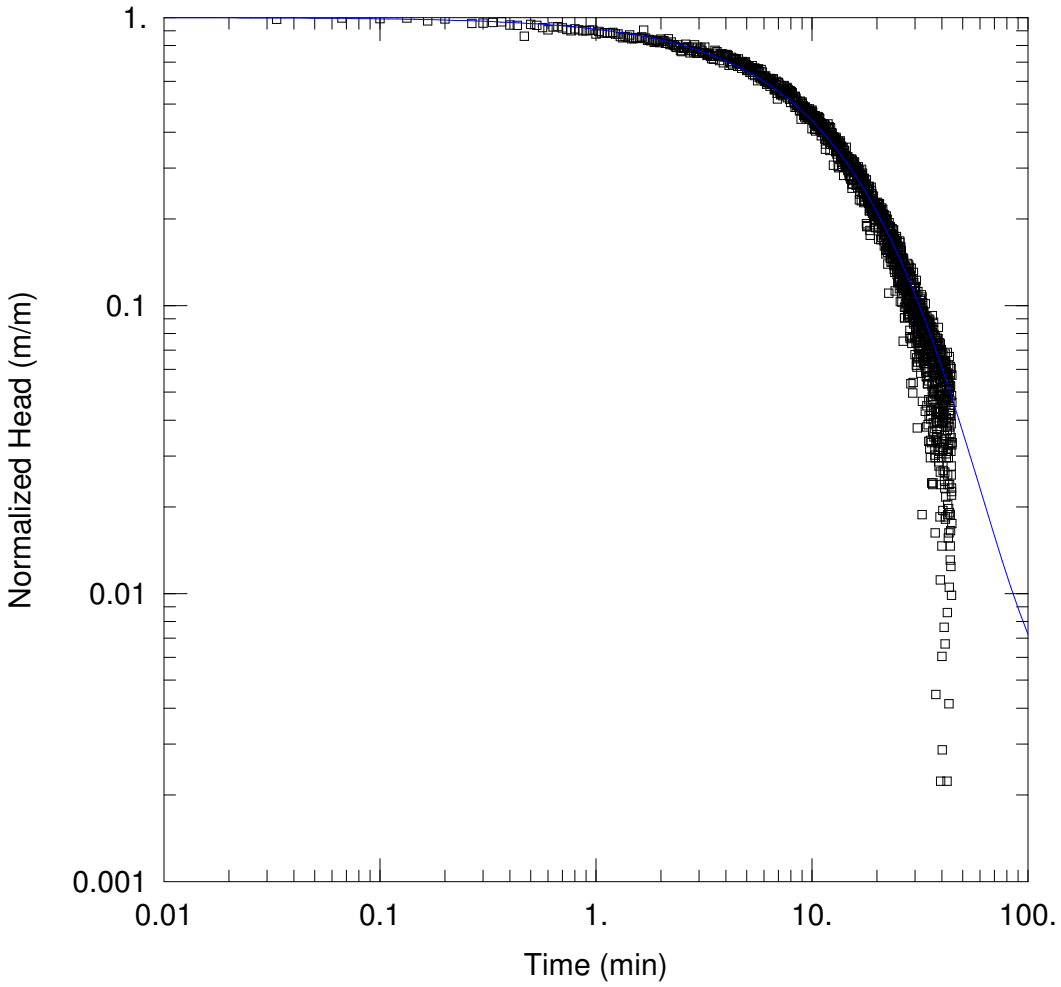
Saturated Thickness: 16.3 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (QU11-18S)

Initial Displacement: 0.82 m
Total Well Penetration Depth: 16.3 m
Casing Radius: 0.02 m
Static Water Column Height: 16.3 m
Screen Length: 5.2 m
Well Radius: 0.0762 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 1.152E-8 m/sec
y0 = 0.4469 m



WELL TEST ANALYSIS

Data Set: P:\...\QU11-28 FH CBP.aqt
Date: 12/13/12 Time: 11:30:57

PROJECT INFORMATION

Company: Lorax
Client: Quinsam Coal
Project: J885-7
Location: 242 Mine

AQUIFER DATA

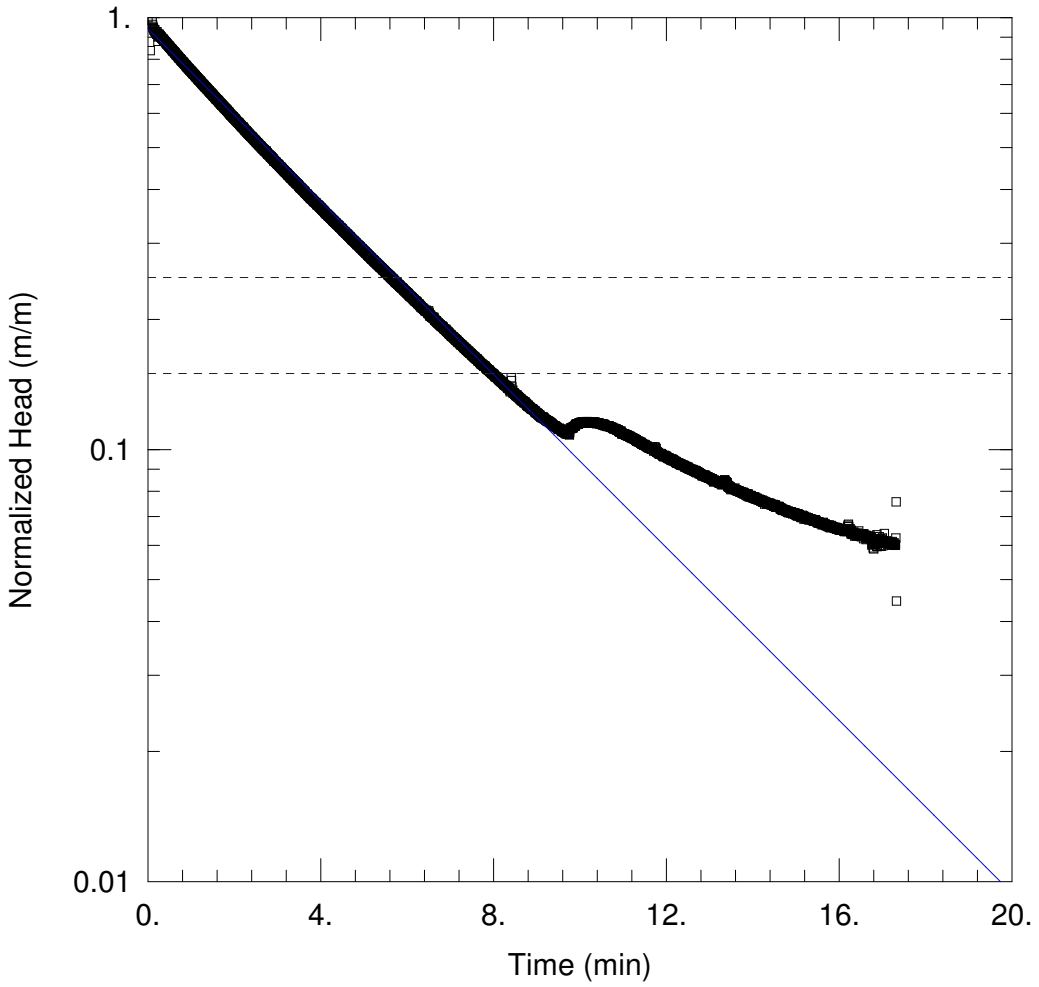
Saturated Thickness: 4.2 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (QU11-28)

Initial Displacement: 0.3142 m
Total Well Penetration Depth: 4.2 m
Casing Radius: 0.026 m
Static Water Column Height: 23.85 m
Screen Length: 4.2 m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Bredehoeft-Papadopulos
T = 5.289E-6 m^2/sec
S = 1.0E-10



WELL TEST ANALYSIS

Data Set: P:\J885 Hillsborough Resources\885-7 242 Mine\Slug Tests\Aqtesolv Files\QU11-35 FH.aqt
Date: 12/13/12 Time: 10:50:28

PROJECT INFORMATION

Company: Lorax
Client: Quinsam Coal
Project: J885-7
Location: Hillsborough Permitting

AQUIFER DATA

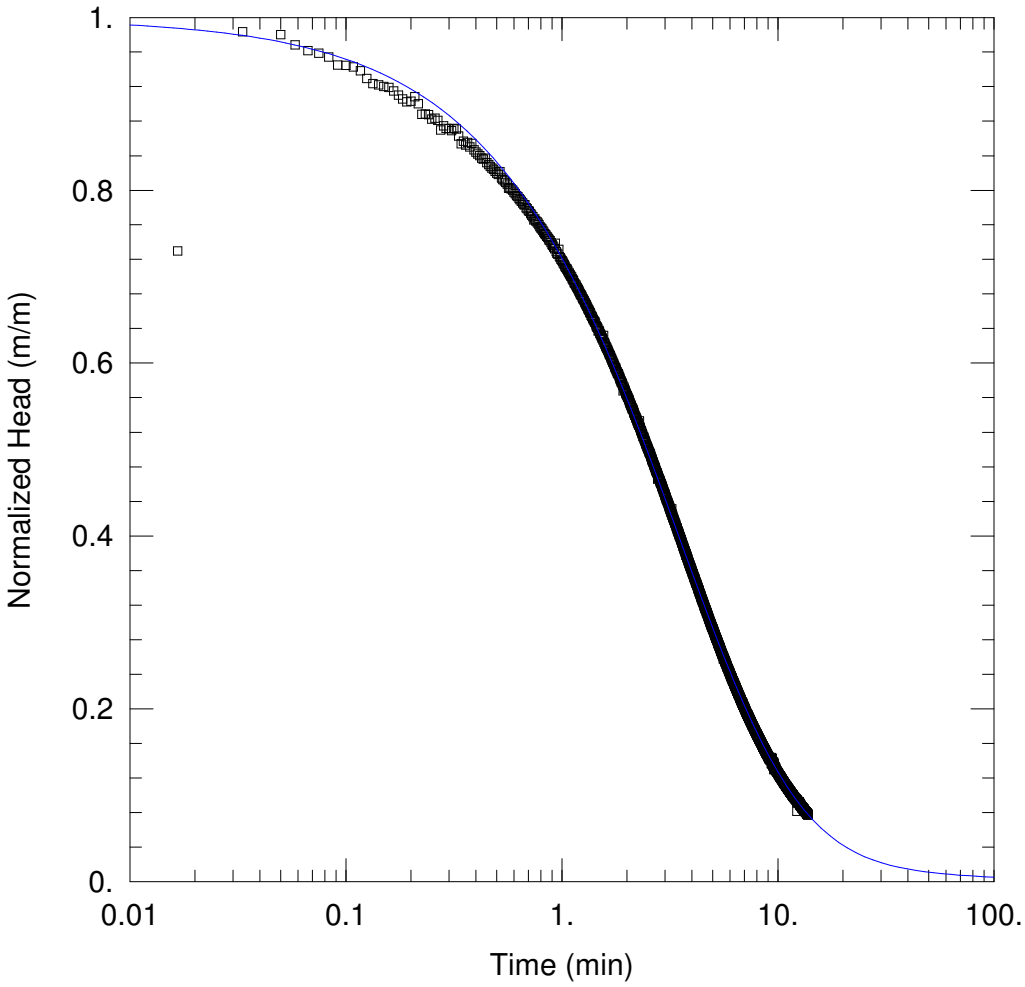
Saturated Thickness: 4.56 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (QU11-35)

Initial Displacement: 0.72 m
Total Well Penetration Depth: 42.72 m
Casing Radius: 0.026 m
Static Water Column Height: 42.23 m
Screen Length: 4.56 m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev
K = 1.507E-6 m/sec
y0 = 0.6783 m



WELL TEST ANALYSIS

Data Set: P:\...\QU11-35 RH CBP.aqt
Date: 12/13/12 Time: 10:52:09

PROJECT INFORMATION

Company: Lorax
Client: Quinsam Coal
Project: J885-7
Location: Hillsborough Permitting

AQUIFER DATA

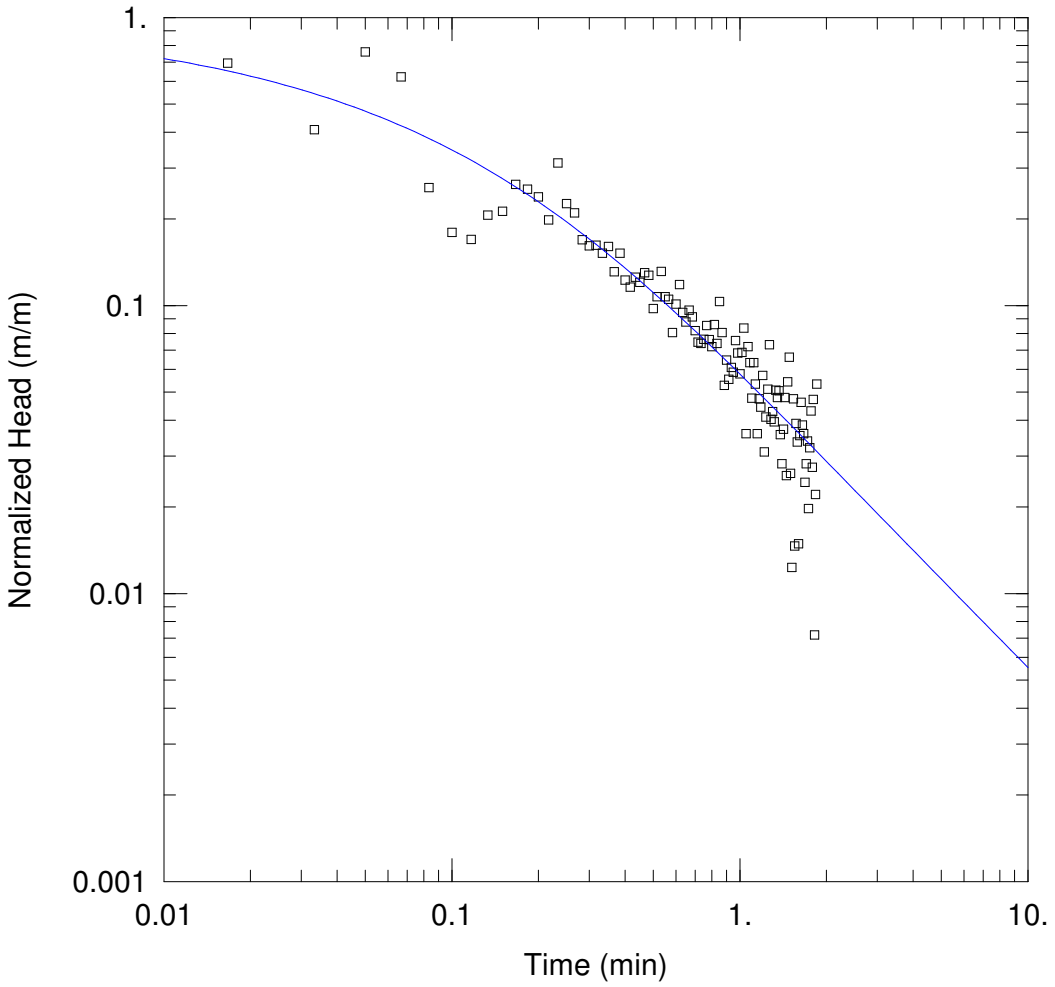
Saturated Thickness: 4.56 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (QU11-35)

Initial Displacement: 0.75 m
Total Well Penetration Depth: 42.72 m
Casing Radius: 0.026 m
Static Water Column Height: 42.23 m
Screen Length: 4.56 m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Bredehoeft-Papadopulos
T = 6.347E-6 m^2/sec
S = 7.52E-5



WELL TEST ANALYSIS

Data Set: P:\...\QU11-36D FH CBP.aqt
Date: 12/13/12 Time: 10:56:00

PROJECT INFORMATION

Company: Lorax
Client: Quinsam Coal
Project: J885-7
Location: 242 Mine

AQUIFER DATA

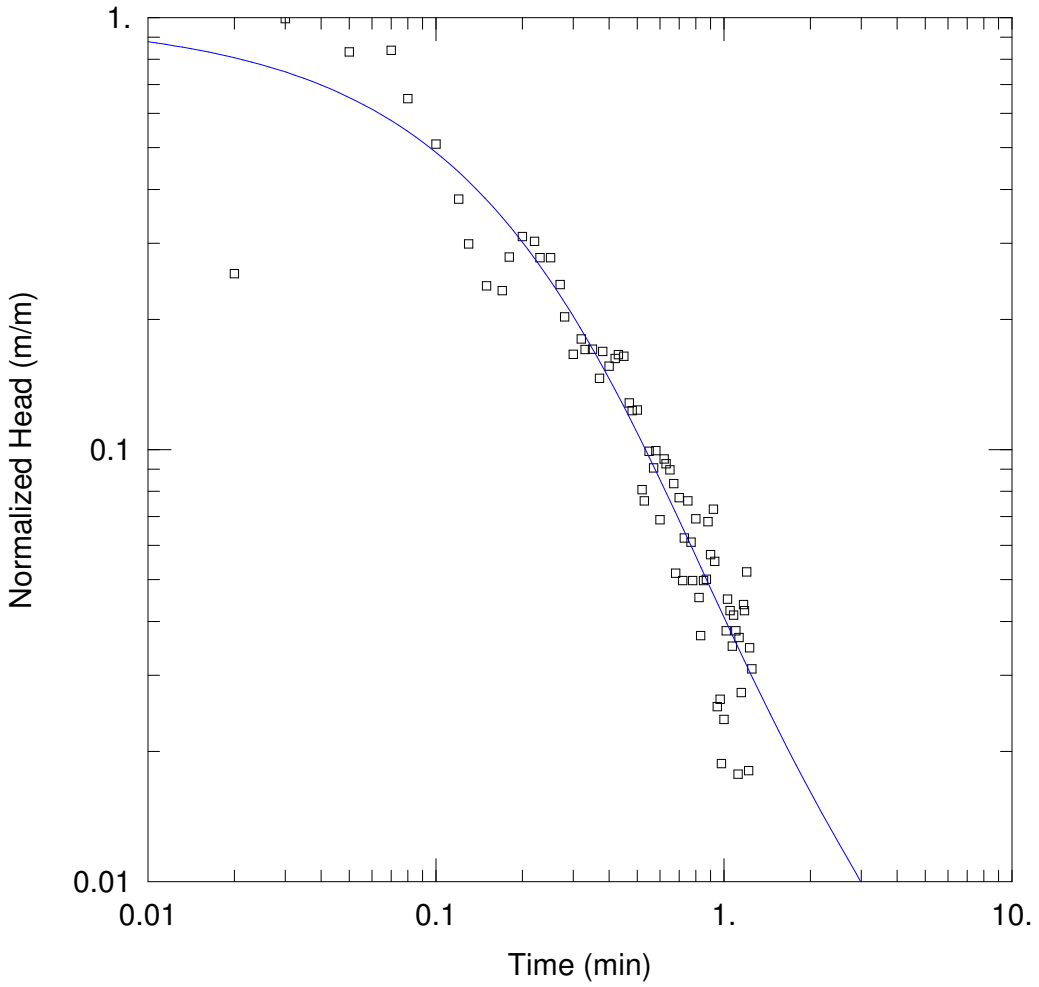
Saturated Thickness: 3.8 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (QU11-36D)

Initial Displacement: 0.39 m
Total Well Penetration Depth: 3.8 m
Casing Radius: 0.026 m
Static Water Column Height: 41.55 m
Screen Length: 3.8 m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Bredehoeft-Papadopulos
T = 5.206E-5 m^2/sec
S = 0.04952



WELL TEST ANALYSIS

Data Set: P:\...\QU11-36D RH CBP.aqt
Date: 12/13/12 Time: 10:59:27

PROJECT INFORMATION

Company: Lorax
Client: Quinsam Coal
Project: J885-7
Location: 242 Mine

AQUIFER DATA

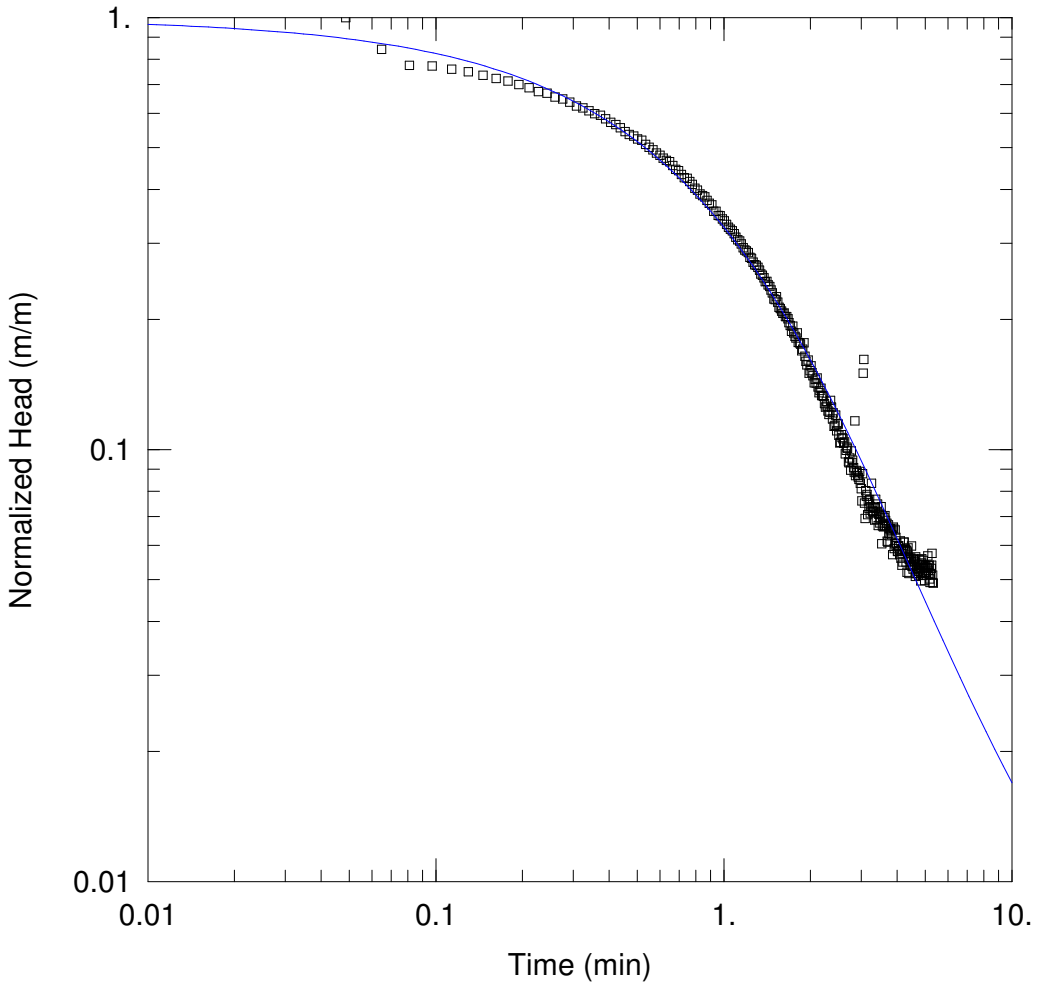
Saturated Thickness: 3.8 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (QU11-36D)

Initial Displacement: 0.3 m
Total Well Penetration Depth: 3.8 m
Casing Radius: 0.026 m
Static Water Column Height: 41.55 m
Screen Length: 3.8 m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Bredehoeft-Papadopulos
T = 0.000109 m^2/sec
S = 0.0008379



WELL TEST ANALYSIS

Data Set: P:\...\QU11-36S FH CBP.aqt
Date: 12/13/12 Time: 11:03:26

PROJECT INFORMATION

Company: Lorax
Client: Quinsam Coal
Project: J885-7
Location: 242 Mine

AQUIFER DATA

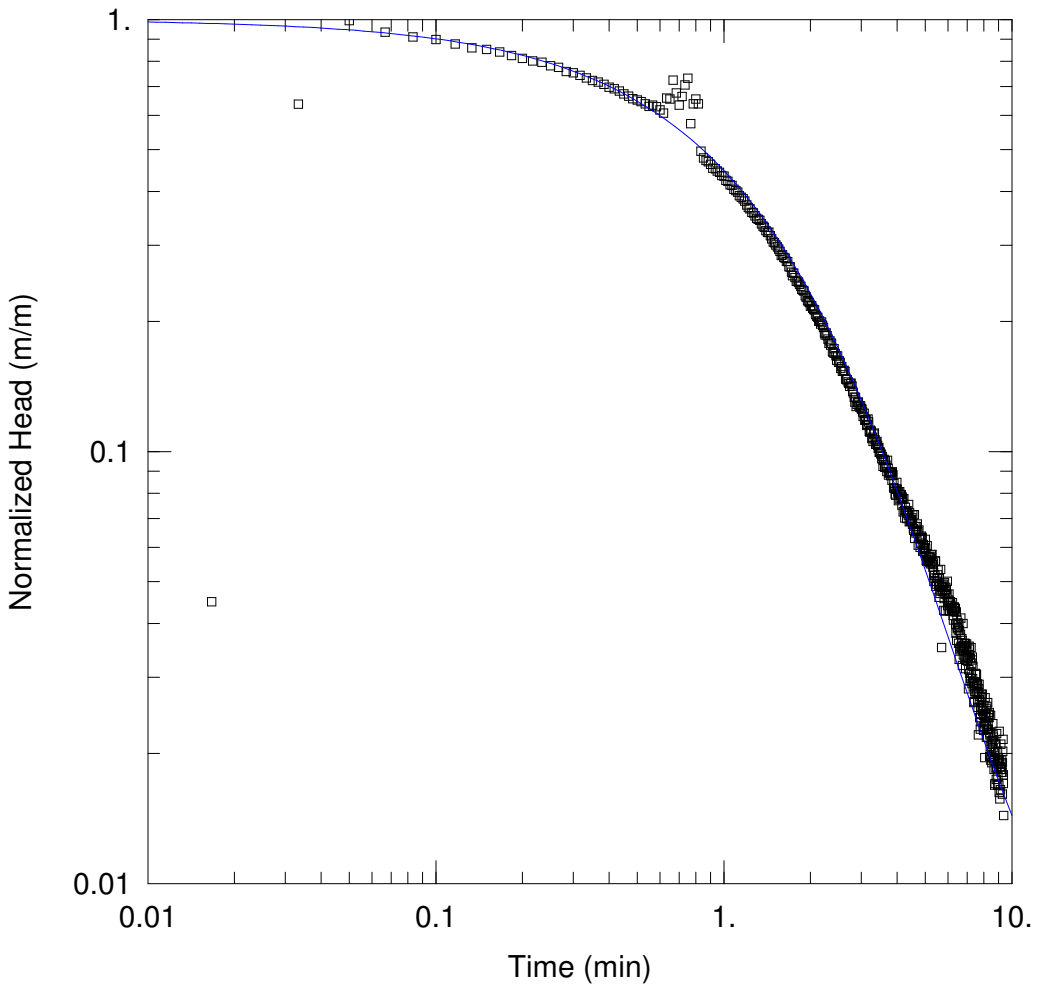
Saturated Thickness: 3.5 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (QU11-36S)

Initial Displacement: 0.76 m
Total Well Penetration Depth: 3.5 m
Casing Radius: 0.02 m
Static Water Column Height: 25.16 m
Screen Length: 3.5 m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Bredehoeft-Papadopulos
T = 1.254E-5 m^2/sec
S = 0.0003325



WELL TEST ANALYSIS

Data Set: P:\...\QU11-36S RH CBP.aqt
Date: 12/13/12 Time: 11:05:53

PROJECT INFORMATION

Company: Lorax
Client: Quinsam Coal
Project: J885-7
Location: 242 Mine

AQUIFER DATA

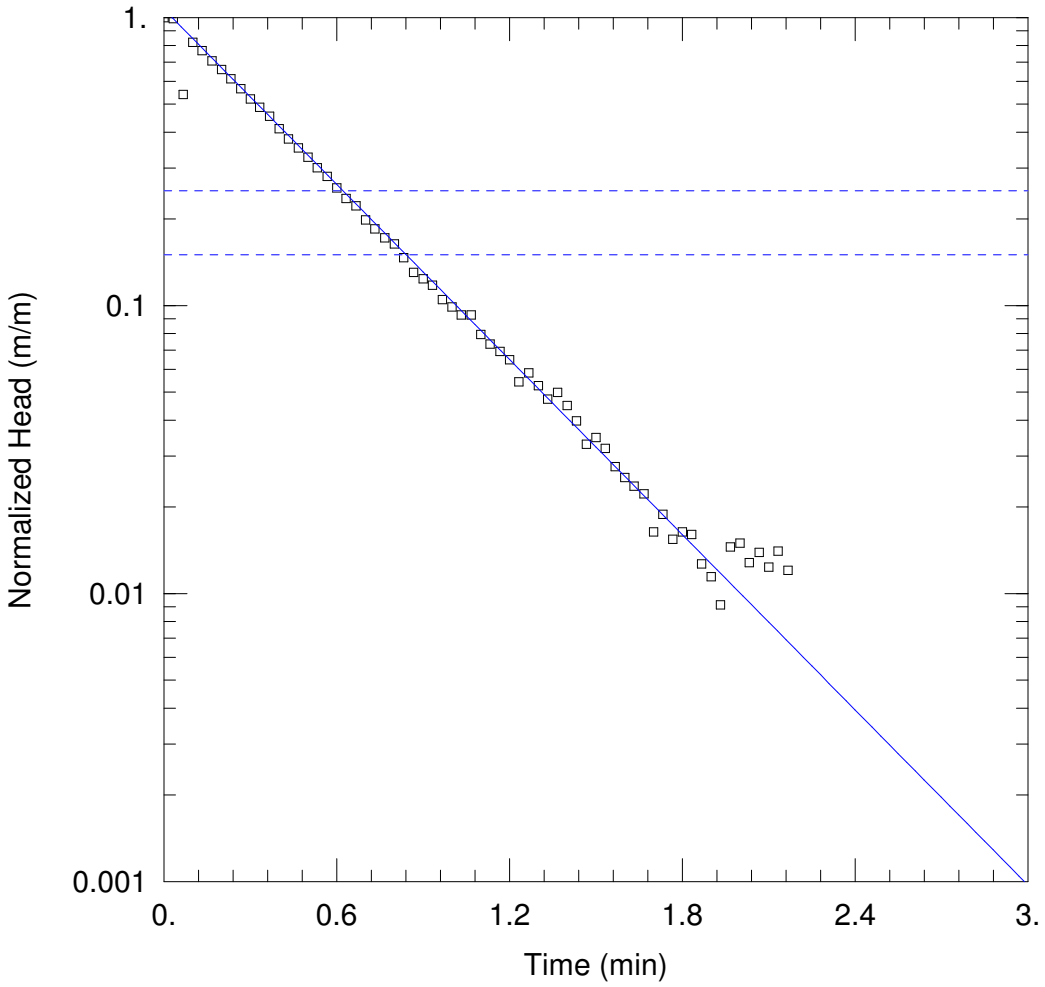
Saturated Thickness: 3.5 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (QU11-36S)

Initial Displacement: 0.75 m
Total Well Penetration Depth: 3.5 m
Casing Radius: 0.02 m
Static Water Column Height: 25.16 m
Screen Length: 3.5 m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Bredehoeft-Papadopulos
T = 1.689E-5 m^2/sec
S = 8.684E-7



WELL TEST ANALYSIS

Data Set: P:\...\QU12-07 FH Hv.aqt
Date: 12/13/12 Time: 11:09:31

PROJECT INFORMATION

Company: Lorax
Client: Quinsam Coal
Project: J885-7
Location: Hillsborough Permitting
Test Well: QU12-07

AQUIFER DATA

Saturated Thickness: 4.3 m Anisotropy Ratio (Kz/Kr): 1.

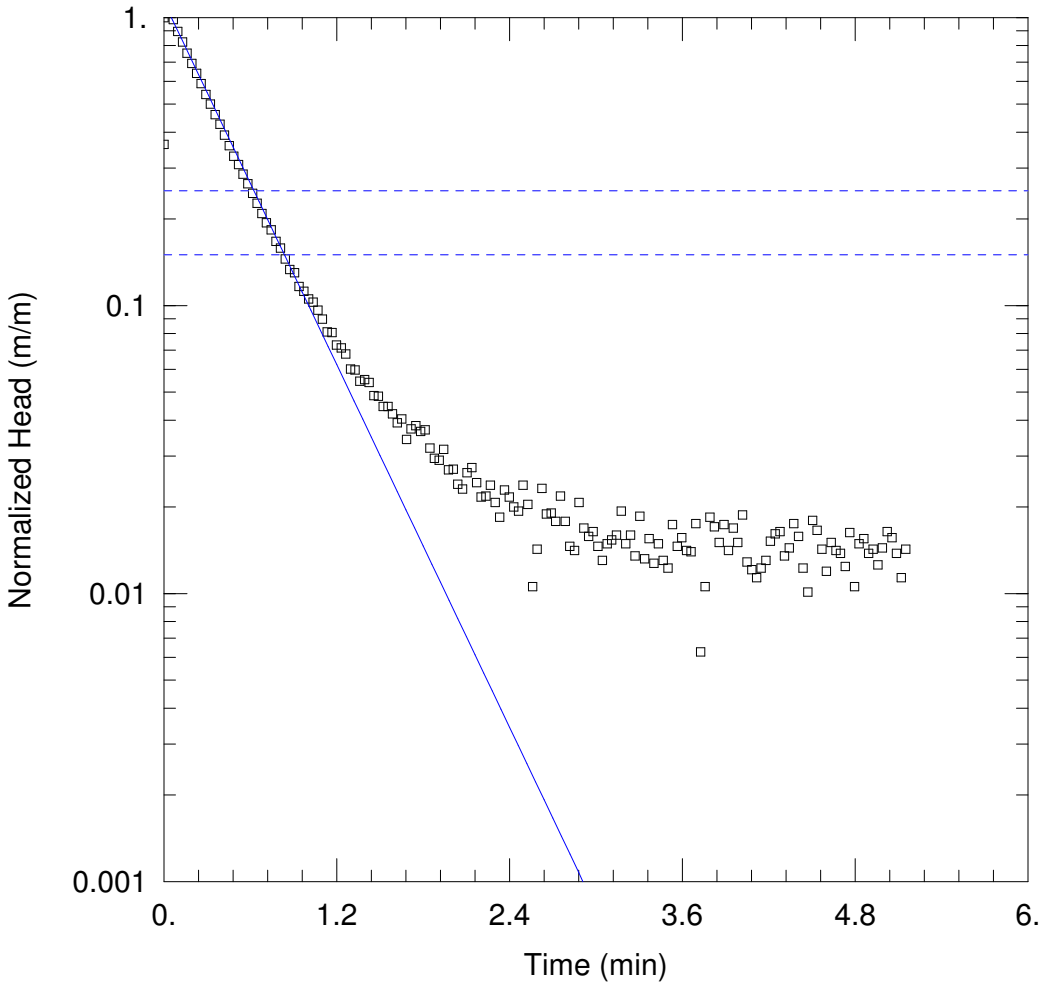
WELL DATA (QU12-07)

Initial Displacement: 0.65 m
Total Well Penetration Depth: 4.3 m
Casing Radius: 0.026 m
Static Water Column Height: 91.11 m
Screen Length: 4.3 m
Well Radius: 0.075 m

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev

K = 1.62E-5 m/sec y0 = 0.6938 m



WELL TEST ANALYSIS

Data Set: P:\...\QU12-07 RH Hv.aqt
Date: 12/13/12 Time: 11:10:58

PROJECT INFORMATION

Company: Lorax
Client: Quinsam Coal
Project: J885-7
Location: Hillsborough Permitting
Test Well: QU12-07

AQUIFER DATA

Saturated Thickness: 4.3 m Anisotropy Ratio (Kz/Kr): 1.

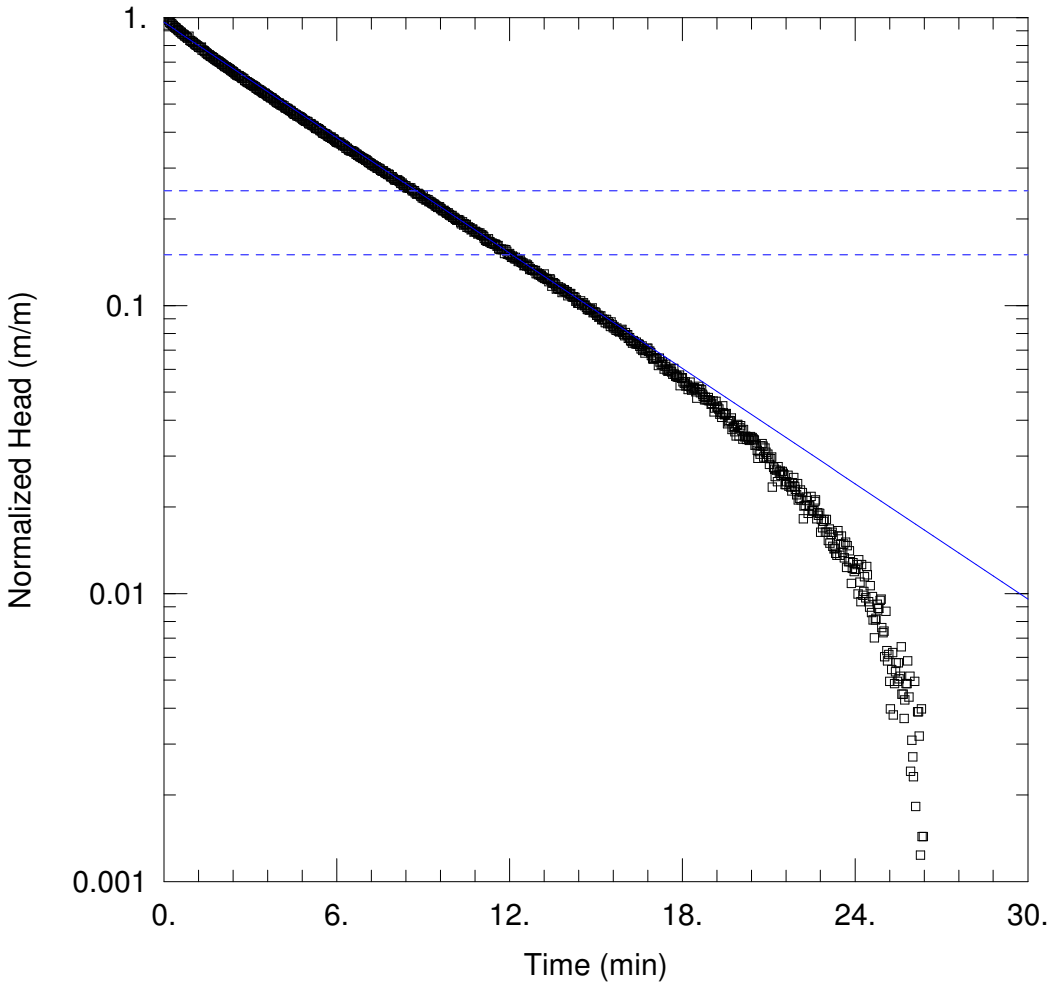
WELL DATA (QU12-07)

Initial Displacement: 0.65 m
Total Well Penetration Depth: 4.3 m
Casing Radius: 0.026 m
Static Water Column Height: 91.11 m
Screen Length: 4.3 m
Well Radius: 0.075 m

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev

K = 1.677E-5 m/sec y0 = 0.7358 m



WELL TEST ANALYSIS

Data Set: P:\J885 Hillsborough Resources\885-7 242 Mine\Slug Tests\Aqtesolv Files\QU12-08 FH.aqt
Date: 12/13/12 Time: 11:14:15

PROJECT INFORMATION

Company: Lorax
Client: Quinsam Coal
Project: J885-7
Location: Hillsborough Permitting
Test Well: QU12-08

AQUIFER DATA

Saturated Thickness: 4.2 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (QU12-08)

Initial Displacement: 1.02 m
Total Well Penetration Depth: 4.2 m
Casing Radius: 0.02 m
Static Water Column Height: 54.61 m
Screen Length: 4.2 m
Well Radius: 0.075 m

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev
K = 6.464E-7 m/sec
y0 = 0.9817 m

APPENDIX A6 HYDRAULIC CONDUCTIVITY DATABASE

Table A6-1 Hydraulic Conductivity of Bedrock and Till

Borehole ID	Mine Area	Lithology	Interval Top (ft)	Interval Bottom (ft)	Interval Midpoint (m bgs)	Measured K (m/s)	Assumed K (m/s)	Test Type	Analytical Method	Source
P2N-09-01	2N	Till+Sand	40	50	13.7	6.5E-06	6.5E-06	Slug Test	n/a	EGSL 2009 Field Investigation
P2N-09-02	2N	Till	70	80	22.9	2.2E-06	2.2E-06	Slug Test	n/a	EGSL 2009 Field Investigation
QU11-18S	7S Area 5	Till	95	112	31.5	1.2E-08	1.2E-08	Slug Test	Bouwer and Rice	Lorax 2011/12 Winter Field Investigation
QU08-13B	7S	Till-Sandstone	77	87	25.0	5.2E-06	5.2E-06	Slug Test	Hvorslev	Lorax May 2010 Field Investigation
BH10-04	2S	Mudstone/Siltstone	13	19	4.9	7E-08	7E-08	Slug Test	n/a	Golder 2S Pit Geotech Assessment
BH10-03	2S	Mudstone/Siltstone	15	21	5.5	3E-06	3E-06	Slug Test	n/a	Golder 2S Pit Geotech Assessment
n/a	4S	Sandstone	40	50	13.7	-	5.0E-08	Large scale deH20	n/a	Lorax 2011 4 South Report
QU10-09S	4S	Fractured Sandstone	41	49	13.7	7.9E-05	8E-05	Slug Test	Hvorslev	Lorax Fall 2010 Field Investigation
QU08-05	7S	Sandstone	62	102	25.0	6.5E-09	6.5E-09	Slug Test	Hvorslev	Lorax May 2010 Field Investigation
QU11-18D	7S Area 5	Fractured Sandstone	199	213	62.8	1.1E-05	1.1E-05	Slug Test	Cooper et al	Lorax 2011/12 Winter Field Investigation
QU11-35	7S Area 5	Fractured Sandstone	227	242	71.5	1.4E-06	1.4E-06	Slug Test	Cooper et al	Lorax Fall 2012 Field Investigation
QU11-36S	7S Area 5	Fractured Sandstone	126	138	40.2	4.2E-06	4.2E-06	Slug Test	Cooper et al	Lorax 2011/12 Winter Field Investigation
QU11-36D	7S Area 5	Fractured Sandstone*	207	220	65.0	2.0E-05	2.0E-05	Slug Test	Cooper et al	Lorax 2011/12 Winter Field Investigation
QU12-07	7S Area 5	Fractured Sandstone/Siltstone	404	418	125.3	1.6E-05	1.6E-05	Slug Test	Hvorslev	Lorax Fall 2012 Field Investigation
MW11-08S	LL / 2S	Sandstone	67	80	22.4	2.1E-08	2.1E-08	Slug Test	Bouwer and Rice	Lorax Fall 2011 Field Investigation
QU11-02M	LL / 4S	Siltstone	78	91	25.8	3.1E-09	3.1E-09	Slug Test	Cooper et al	Lorax Fall 2010 Field Investigation
QU11-09	RBP	Sandstone	80	110	29.0	<8E-09	1.6E-09	Packer - Lugeon	Thiem	Lorax Fall 2010 Field Investigation
QU10-07S	4S	Sandstone	109	135	37.2	8.2E-09	8.2E-09	Slug Test	Cooper Green	Lorax Fall 2010 Field Investigation
QU11-09	RBP	Sandstone	110	140	38.1	<6E-09	1.2E-09	Packer - Lugeon	Thiem	Lorax Fall 2010 Field Investigation
QU11-05	RBP	Sandstone	120	150	41.1	<6E-09	1.2E-09	Packer - Lugeon	Thiem	Lorax Fall 2010 Field Investigation
MW11-08M	LL / 2S	Sandstone	167	180	52.9	1.2E-07	1.2E-07	Slug Test	Cooper et al	Lorax Fall 2011 Field Investigation
QU10-07	4S	Sandstone	234	244	72.8	9.8E-07	9.8E-07	Packer - Lugeon	Thiem	Lorax Fall 2010 Field Investigation
QU11-05	RBP	Sandstone	242	272	78.3	<3E-09	6.0E-10	Packer - Lugeon	Thiem	Lorax Fall 2010 Field Investigation
QU10-08	4S	Sandstone	267	280	83.4	<7.5E-09	1.5E-09	Packer - Lugeon	Thiem	Lorax Fall 2010 Field Investigation
MW11-09S	LL / Quarry	Fractured Diorite	16	29	6.9		8.0E-05	inferred from QU10-09S		Lorax Fall 2011 Field Investigation
MW11-09M	LL / Quarry	Diorite	62	75	20.9	2.0E-08	2.0E-08	Slug Test	Hvorslev	Lorax Fall 2011 Field Investigation
QU11-02D	LL / 4S	Karmutsen Volcanics	117	130	37.6	2.3E-10	2.3E-10	Slug Test	Hvorslev	Lorax Fall 2010 Field Investigation
MW11-07M	LL / 2S	Volcanic/Intrusive (?)	142	155	45.3	3.1E-09	3.1E-09	Slug Test	Cooper et al	Lorax Fall 2011 Field Investigation

Notes:

n/a: Not available

Table A6-2 Hydraulic Conductivity of Coal

Borehole ID	Mine Area	Test Type	Lithology[1]	Interval Top (ft)	Interval Bottom (ft)	Interval Mid Point (m bgs)	Interval Thickness (m)	T (m^2/s)	K (m/s)	Analytical Method	Source
QU08-08B	7S	Slug Test	No. 5 + SST	26	28	8	0.5	2.6E-05	5.5E-05	Hvorslev	Lorax May 2010 Field Investigation
QU07-05	7S	Bail down recovery test	No. 4+No. 5				6.1	8.0E-07	1.0E-07	Theis	Golder, 2009
QU07-07	7S	Bail down recovery test	No. 4+No. 5				13.3	4.0E-05	3.0E-06	Theis	Golder, 2009
QU08-05	7S	Bail down recovery test	No. 4+No. 5				5.7	1.0E-07	2.0E-08	Theis	Golder, 2009
QU08-08A	7S	Slug Test	No. 4 + MST/SLST	52	56	16	1.4	4.0E-10	2.9E-10	Hvorslev	Lorax May 2010 Field Investigation
QU08-10	7S	Slug Test	No. 4 + SST+ MST	20	27	7	2.3	1.1E-08	5.0E-09	Hvorslev	Lorax May 2010 Field Investigation
QU08-13A	7S	Slug Test	No. 4 + SST+ MST	23	26	8	0.9	9.8E-05	1.1E-04	Hvorslev	Lorax May 2010 Field Investigation
QU07-08	7S	Bail down recovery test	No. 4				4.8	5.0E-07	1.0E-07	Theis	Golder, 2009
QU08-07	7S	Bail down recovery test	No. 4				3.7	2.0E-07	5.0E-08	Theis	Golder, 2009
QU09-01	7S	Bail down recovery test	No. 4				4.4	1.0E-07	3.0E-08	Theis	Golder, 2009
QU11-28	7S Area 5	Slug Test	No. 4 + No. 4L	175	189	55	4.4	5.3E-06	1.3E-06	Cooper et al	Lorax 2011/12 Winter Field Investigation
QU12-08	7S Area 5	Slug Test	No. 4 + No. 4L	302	315	94	4.4	2.8E-06	6.5E-07	Hvorslev	Lorax Fall 2012 Field Investigation
QU10-11	2N	Packer-Lugeon	SST + No. 4B	220	250	72	9.1	7.3E-08	8.0E-09	Thiem	Lorax May 2010 Field Investigation
QU10-10S	2N	Slug Test	No. 4/SST	187	209	60	6.9	7.5E-06	1.1E-06	Bouwer-Rice	Lorax Fall 2010 Field Investigation
QU08-21G-S	2N	Slug Test	No. 4/SST	242	265	77	7.0	1.5E-06	2.1E-07	Bouwer-Rice	Lorax Fall 2010 Field Investigation
QU11-14D	Quinsam N	Slug Test	No. 4	383	406	120	7.0	9.2E-06	1.3E-06	Cooper et al	Lorax Fall 2011 Field Investigation
QU10-07	4S	Packer-Lugeon	No. 3 + SST	207	244	69	11.3	1.0E-06	2.4E-09	Thiem	Lorax Fall 2010 Field Investigation
QU10-07D	4S	Slug Test	No. 3/MDST	205	225	65	6.2	6.5E-08	1.0E-08	Cooper-Green	Lorax Fall 2010 Field Investigation
QU10-08	4S	Packer-Lugeon	SST +No. 3 + SST	210	280	75	21.3	2.9E-07	1.4E-08	Thiem	Lorax Fall 2010 Field Investigation
QU10-08D	4S	Slug Test	No. 3	245	268	78	7.2	1.1E-06	1.6E-07	Cooper et al	Lorax Fall 2010 Field Investigation
QU10-09D	4S	Slug Test	No. 3/SST	102	125	35	7.0	2.4E-05	3.4E-06	Bouwer-Rice	Lorax Fall 2010 Field Investigation
QU10-09	4S	Packer-Lugeon	SST + No. 3 + MDST	100	140	37	12.2	1.0E-06	8.2E-08	Thiem	Lorax Fall 2010 Field Investigation
QU10-09	4S	Packer-Lugeon	SST +No. 2 + SLST	140	225	56	25.9	3.0E-05	2.8E-06	Thiem	Lorax Fall 2010 Field Investigation
QU10-10D	2N	Slug Test	No. 1/MDST	537	566	168	8.7	1.7E-07	2.0E-08	Hvorslev	Lorax Fall 2010 Field Investigation
QU10-11D	2N	Slug Test	No. 1/MDST	491	534	156	13.1	1.3E-04	9.7E-06	Cooper-Green	Lorax Fall 2010 Field Investigation
QU08-21G-D	2N	Slug Test	No. 1	536	580	170	13.4	2.1E-05	1.6E-06	Cooper-Green	Lorax Fall 2010 Field Investigation
QU11-05M	RBP	Slug Test	No. 1	392	423	124	9.6	9.6E-09	1.0E-09	Hvorslev	Lorax Fall 2010 Field Investigation
QU11-09D	RBP	Slug Test	No. 1	248	276	80	8.5	8.5E-09	1.0E-09	Hvorslev	Lorax Fall 2010 Field Investigation
P1-4-2 (P1-1C)	5S	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

APPENDIX A7 7SA5 PUMPING TEST

Appendix A7. 7SA5 Pumping Test

A7.1 Background

An initial review of borehole airlift yields (Appendix A1) and slug test data (Appendix A5) indicated that bedrock in 7 South Area 5 contained high permeability features (fractures) which could potentially create water management issues during mining. A multi-day pump test was recommended to ascertain whether these features represented localized areas of high permeability with limited storage or a broader region of interconnected faulting and fracturing that may or may not be connected to boundaries such as the Iron River, flooded 242 test mine and/or wetlands.

Lorax reviewed the existing exploration borehole data to determine which borehole would be the most suitable pumping well location. QU11-38 was selected because (i) it intersected a high permeability feature, producing 35 US GPM, immediately above the No. 4 Coal zone and (ii) it is located in the southern portion of the proposed mine where these types of features are more likely to occur above the No. 4 Seam and present a water management issue. A PVC liner was installed in QU11-38 to prevent any material from caving in on top of the pump. Additional monitoring wells were established at QU12-07, QU12-08 and QU11-35 to monitor water level responses in the 4 Seam and fractured areas above and below the 4 Seam at intermediate distances from the pumping well. Details of the well installations are discussed in Appendix A2 and borehole logs are provided in Appendix A4.

A7.2 Methods

Precision Services and Pumps (PSP) of Abbotsford, BC, was contracted to perform a step test and three day constant discharge test at QU11-38. The pump tests occurred between October 23rd and 27th, 2012, under supervision of L. Findlater, P.Geo. of Lorax. The step test was performed to determine a sustainable pump rate for the constant discharge test. The timing and pumping rates employed during the step and constant discharge tests are summarized in Table 7-1.

A Grundfos 460 Volt, 10 horsepower pump with 3 phase motor (Model 40S100-30) was used for both step and constant rate tests (Figure 7-1). This pump model has 30 stages and is rated 40 US GPM for head up to 613 feet. The pump was lowered on steel riser pipe such that the intake resided ~71.5 metres below ground surface; about 48 metres below the static water level and about 19 metres below the main fracture zone producing 35 US GPM. Flow rates were measured at surface by an Endress Hauser PROMAG 50

Table A7-1:
Summary of Pumping Tests Undertaken at QU11-38.

Test Type	Start/Stop Time	Duration	Pumping Rate (US GPM)
Step Test	Start: October 23, 2012 17:44 Stop: October 23, 2012 19:40	Step 1: 30 minutes Step 2: 30 minutes Step 3: 30 minutes Step 4: 26 minutes	Step 1: 11 Step 2: 20 Step 3: 30 Step 4: 40
Constant Discharge Test	Start: October 24, 2012 13:00 Stop: October 27, 2012 14:00	73 hours	30

Figure A7-1: Grundfos 40S100-30 pump used in step drawdown and constant head tests. Entire pump length is approximately 2.25 metres.

electromagnetic flow meter (Figure 7-2) which is accurate to within +/- 0.5%. Two analog pressure gauges were also plumbed into the well head assembly to monitor back pressure on the pump and on the layflat; a sampling port was also plumbed in which allowed for continuous monitoring of field parameters at the well head with YSI 556 multiparameter probe (Figure 7-2). Three inch layflat rated to 80 psi was used for the discharge line, which was run for 2800 metres along exploration roads ultimately terminating at the 4 South portal (Figure 7-3). A discharge pipe with orifice plate and manometer was assembled at the end of the discharge line (Figure 7-4). The flows employed during the pump tests; however, were just below the range of those which could be accurately measured with the manometer using the smallest size of orifice plate available.

Water levels were monitored across the study area both manually and using Solinst leveloggers programmed to record pressure readings at half minute to five minute intervals. The loggers were deployed at the pumping well QU11-38, and monitoring wells QU11-18S/D, QU11-36S/D, QU12-07, QU12-08, QU11-35, QU11-28 and QU08-10. A logger was also deployed at QU11-01, an open borehole that accesses the 4 South mine pool. Manual water levels were also taken at selected open boreholes including QU12-13, QU11-34, QU11-37 and QU12-06. Rounds of initial manual water levels were taken at all observation points prior the step and the constant discharge tests and throughout the constant discharge test (Appendix A3).

A step test was conducted on October 23rd to determine a sustainable pumping rate for the constant discharge test. QU11-38 was pumped for four 30 minute intervals at increasing pump rates: 11, 20, 30 and 40 US GPM. (Note from this point forward, it can be assumed that all flow rate measurements are in US GPM). Water level and pump rates measured by PSP during the step test are included in Appendix A8. The last pumping step ended prematurely (26 minutes) when the layflat line ruptured at the well head due to high back pressures. Later, PSP inspected the discharge line and found a couple of segments where the line had coiled up on itself which had impeded the flow and created the large back pressure.

The constant discharge test at QU11-38 was initiated on October 24th, 2012, approximately 18 hours after completion of the step drawdown test. The target pumping rate of 30 GPM was achieved within the first minute of the pumping test and remained essentially constant (to within +/- 1 gpm) for the remainder of the test with some slight adjustments on the variable flow drive and at the flow valve. The orifice started flowing approximately 90 minutes into the constant rate test. Initially, the flow at the orifice as

Figure A7-2: Pump test configuration at surface.

Figure A7-3: Discharge at 4 South portal.

Figure A7-4: Discharge line orifice and manometer.

measured on the manometer was in the 30 GPM range (water would occasionally breach the barb of the manometer, which at its minimum point measures ~33 gpm). Later on, flow at the orifice was noted to be in the range of 22-24 GPM despite the flow rate measured at the well head remaining constant at 30 GPM. After several hours, a minor leak (1-2 GPM) was noted on the layflat line along the 7SA5 access road near where the road forks to go down towards QU11-18S/D. Mid-day on October 26th, a new, larger leak (about 5 GPM) was noted on the layflat line where it crossed the access road to QU12-06 and QU11-35 (Figure 7-5). Near the end of the dayshift on October 26th, back pressure on the layflat line had declined by about 10 psi; while the flow rate measured at the well head remained unchanged (30 GPM). During the night shift of October 26th-27th, flow at the orifice had all but stopped. PSP inspected the layflat line along the 4 South exploration roads at daybreak on October 27th and found that line had sprung several leaks and estimated their total flow to be 19 GPM. None of these leaks were directly discharging into any watercourses on the site. It is believed that the pumping rate during the constant rate test remained constant at 30 GPM and that the discrepancy in flow measured at the orifice was due to leaks and stretching of the layflat.

Figure A7-5: Leak observed in layflat line October 26th, 2012. Approximate flow is 5 US GPM.

A7.3 Results and Discussion

A7.3.1 Background Water Level Trends

Water level elevations for the pumping well (QU11-38), observation wells and open boreholes in 7 South Area 5 are plotted in Figure 7-6 along with precipitation measured at the Campbell River Airport and at Environment Canada's monitoring station on the Quinsam River (at the Argonaut bridge). Refer to Figure 2-4 in the main report for well locations. Two rounds of manual water levels taken prior to the step test indicated that water levels were rising around the study area due to the onset of wet weather in mid-October. Water levels for the pumping well and most of the observation wells were corrected by removing the background rate of head increase based on these two rounds of measurements. QU11-28 and QU08-10 were similarly adjusted however using water levels taken before the step test and six days after the end of the constant discharge test.

The water level trends shown at QU11-36S/D are distinct from other observation wells in the area as the water levels continued to climb throughout the duration of the constant discharge test. Water levels at QU11-36S/D have been plotted separately in Figure 7-7 to

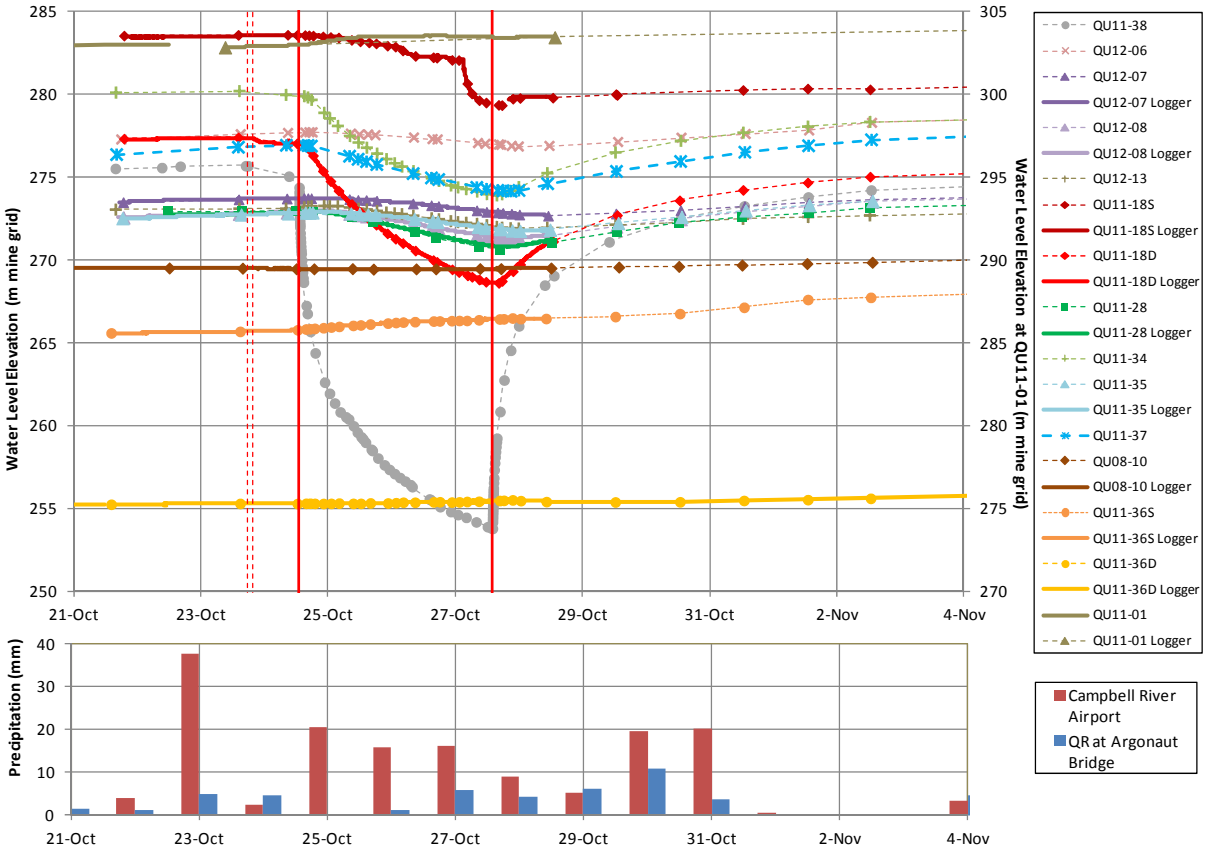


Figure A7-6: Water level elevations in 7 South Area 5 monitoring wells and open boreholes during step and constant rate pumping tests.

illustrate the trend more clearly. Figure 7-7 also includes head above the logger deployed at the Iron River hydrometric station and at QU11-35, approximately 290 metres northwest from QU11-36S/D. The water level trends at QU11-36S/D are distinctly different than that shown by QU11-35, which is of similar distance to the Iron River (240 metres versus 175 metres). QU11-35 did show a clear response to pumping during the constant rate test. QU11-36S/D however, appears to be trending in connection with the Iron River, which rose sharply in mid-October. QU11-36S is screened approximately at the elevation of the Iron River and shows the largest increase, about 0.6 metres over the test duration. QU11-36D is screened about 20 meters deeper than the river elevation, and shows a more subdued response (0.1 metre increase). The flooded 242 test mine workings may also play a role in dampening the response of QU11-36S/D to the pump test. For the purposes of analysing drawdown from constant discharge test, QU11-36S/D is considered to have not shown a response to pumping and is not included in subsequent analyses.

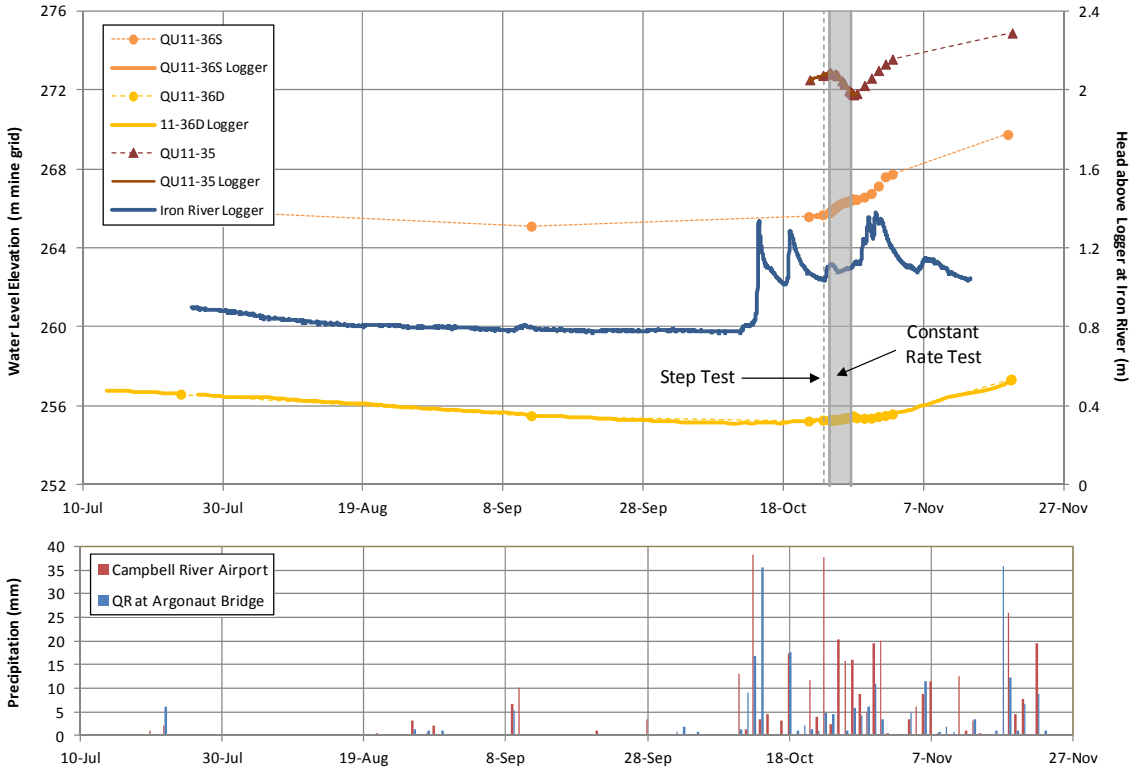


Figure A7-7: Water level hydrographs for QU11-35, QU11-36S/D and Iron River

A7.3.2 Step Test

The drawdown data from the step test is shown in Figure 7-8. By the end of the test (116 minutes) the water level in the well had drawn down 7.4 metres. Extrapolation of the 30 GPM drawdown segment to longer time frames suggested that this pump rate would be sustainable for the constant rate discharge test which was initiated the following afternoon.

A7.3.3 Constant Discharge Test

Corrected drawdown data measured at the pumping well, QU11-38, and observation wells and open boreholes is shown in Figure 7-9 and Figure 7-10 respectively. The maximum drawdown measured at the end of the constant rate test is contoured in Figure 2-13 of the main report. As shown, drawdown was widespread throughout the test area and the resultant drawdown cone was elongated along a line roughly parallel to

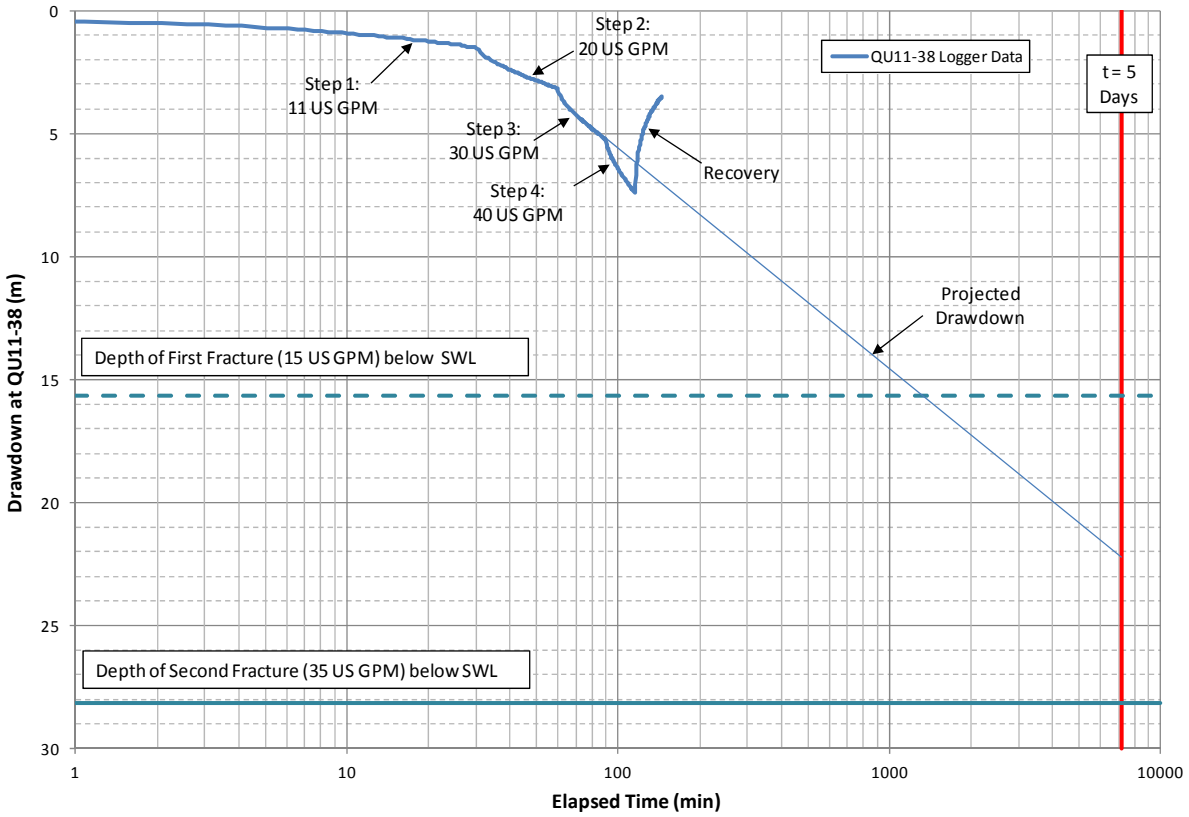


Figure A7-8: Drawdown measured at QU11-38 during step drawdown test October 23, 2012.

the axis of the syncline. The final drawdown in the pumping well, QU11-38, was 21.6 metres. The largest response outside of the pumping well was measured at QU11-18D (8.55 metres), about 230 metres northwest of the pumping well. Wells QU12-07, QU12-08, approximately 215 and 190 metres southwest of QU11-38, respectively, had a more subdued response to pumping (2 metres or less of drawdown). The drawdown contours in Figure 2-13 take into account the response measured at open exploration holes; however, this data should be viewed with some caution. Since these holes are not screened at specific intervals, they represent an average drawdown measured across the drilled section. Leakage past the surface casing or inflows from areas not influenced by the test may have buffered the response at these locations.

Aquifer parameters such as hydraulic conductivity (or transmissivity) and storage can be estimated from pumping test data using analytical solutions. There are numerous analytical solutions available for the interpretation of pumping test data which are specific to the type of aquifer (confined, unconfined, leaky) and whether the aquifer is consolidated (i.e. bedrock) or unconsolidated. These solutions can be modified to take

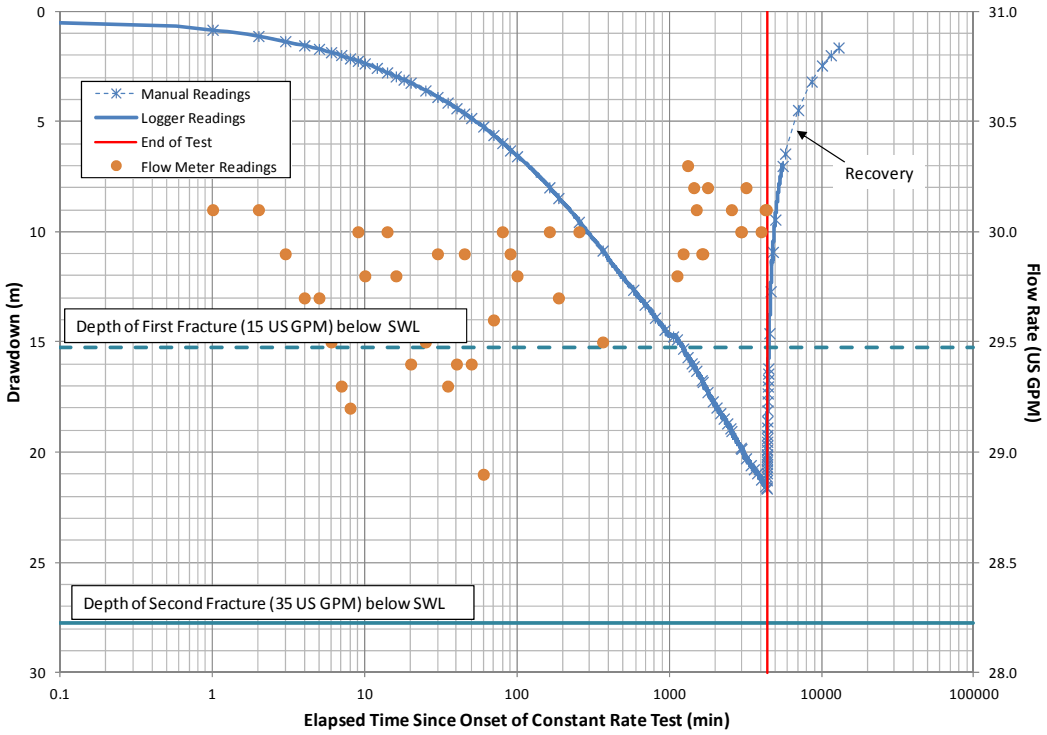


Figure A7-9: Corrected drawdown and pump rates measured at QU11-38 during constant rate pumping test (October 24-27, 2012)

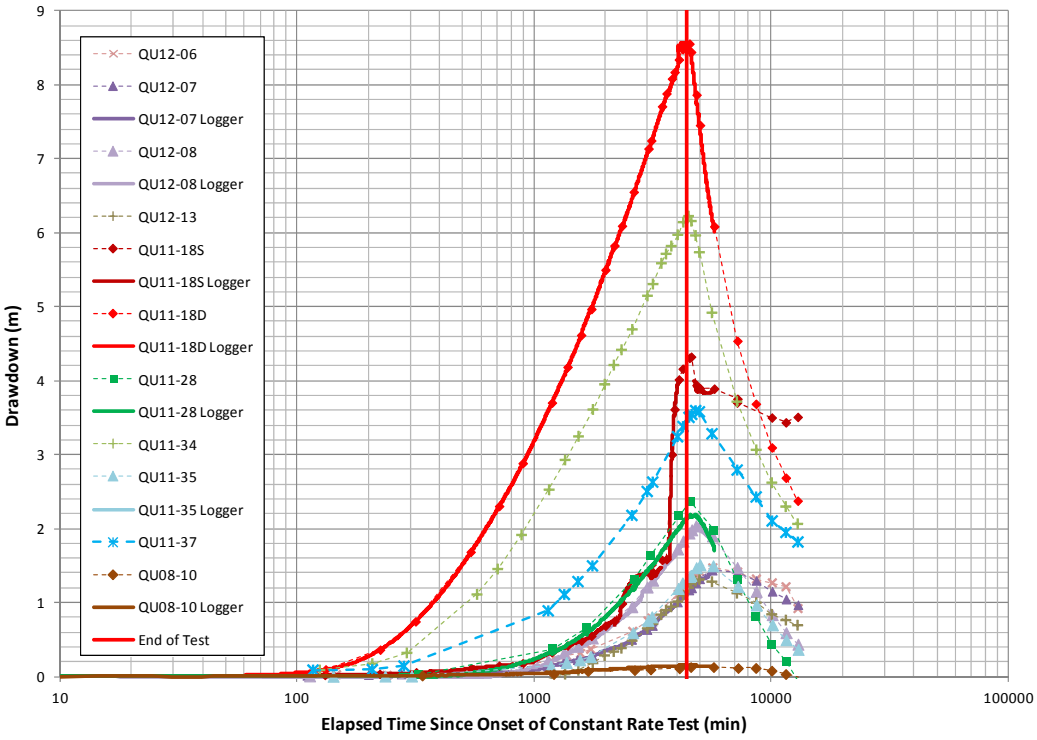


Figure A7-10: Corrected drawdown measured at observation wells during constant rate pump test at QU11-38 (October 24-27, 2012)

into account simplistic boundary conditions (such as a recharge or impermeable feature). Each of these solutions has underlying assumptions (i.e. the aquifer is of infinite extent, the well is fully penetrating, the pump rates are constant, etc.) which need to be considered. The process of selecting the appropriate analytical solution is incumbent upon field observations from drilling and scrutiny of the well response data.

Figure 7-11 is composite plot of the observation well drawdown data. The x-axis is t/r^2, or elapsed time divided by the square of the radial distance from the pumping well (in min/m^2). In an ideal confined aquifer all observation well data should plot on the same line; deviations from this indicate that the aquifer is heterogeneous, there is a directionality to the aquifer parameters and/or the aquifer is influenced by boundaries. The data indicate that one or all of these conditions are applicable to the test data from QU11-38. What is known with reasonable certainty is that 7 South Area is bound to the north and east by the Long Lake and Boundary Faults. Slug tests in 7 South (QU08-10, QU08-08A, QU08-05) indicate that the bedrock north of the Long

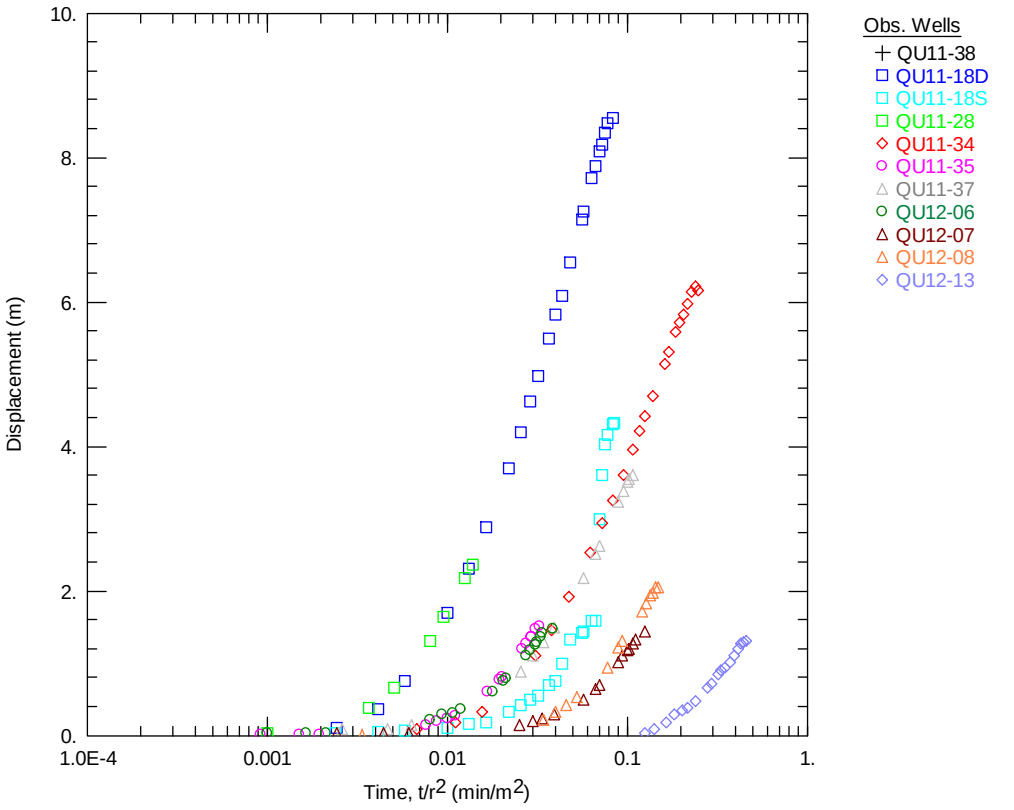


Figure A7-11: Composite plot of observation well drawdown data from constant rate pump test.

Lake Fault is quite impermeable. While less is known about the bedrock east of the Boundary Fault (basement igneous rock), it is inferred to be less permeable than the sedimentary sequences occurring in 7 South Area 5. The negligible drawdown observed in the south end of the mine at QU11-36S/D may suggest that a recharge boundary is present, likely the Iron River and/or the flooded 242 test mine. It is also possible that the stress field that created the syncline may have increased permeability parallel to the axis of the syncline (by creating joints parallel to the syncline axis). Finally, discrete fractures, such as those described in the borehole log of QU11-38 are also thought to influence the test.

In light of the above observations, the pumping test data were analysed using two different analytical solutions: the Theis method (1935) for confined, homogeneous, isotropic aquifers and the Gringarten-Witherspoon method (1972) for confined aquifers with vertical, uniform fractures. The data were analysed using AQTESOLV Pro (version 4.5), licensed to Lorax. Appendix A9 contains output from some of the simulations carried out with AQTESOLV. Each solution was applied to the data first without using boundary conditions to see if a reasonable match could be obtained to the observed data. The solutions were then applied using boundary conditions to improve fit. AQTESOLV employs an automatic curve matching routine which performs nonlinear weighted least-squares parameter estimation. To assist in simulation convergence, only observation data from the pumping well and QU11-18D were used for curve matching.

Overall, it was found that the Theis solution underpredicted late-time drawdown in the pumping well and observations wells and overpredicted early time drawdown (Run T4). When viewed as a composite plot, the simulated drawdown curves all fall on a single line which contradicts the observed data. Boundary conditions were introduced in subsequent Theis simulations in an effort to improve the shape and magnitude of the simulated drawdown curves. The model domain was simulated as a rectangle, with the average location of the Iron River along the y-axis (left hand side of page), a no flow boundary at x=1180 m (right hand side, representing Long Lake Fault), a no flow boundary along the x-axis representing roughly the Boundary fault, and another no flow boundary along the western margin (x=480 m) representing an arbitrary transition into lower permeability sedimentary bedrock (Run TB7). Overall, these simulations did improve the magnitude of the simulated drawdown, however, the timing of the drawdown remained poor. Also, the introduction of boundaries did not create the spread in the data observed in the composite plot. A few sensitivity runs indicated that calculated transmissivity and storage values were relatively insensitive to the position of the western and eastern no-flow boundaries.

The next set of simulations introduced a vertical fracture at QU11-38 using the Gringarten-Witherspoon (1972) method. An analytical solution for fracture flow was selected for three reasons: (i) the borehole log of QU11-38 indicated that the hole intercepted two water bearing fracture zones (Appendix A4), (ii) a log-log plot of drawdown versus time demonstrates an early straight line portion of slope approaching 0.5 indicating parallel, horizontal flow perpendicular to fracture (Figure 7-12) (Kruseman and de Ridder, 1994), and (iii) the data demonstrate an early time constant difference between the derivative and drawdown curves corresponding to a multiplying factor of two which indicates that a fracture dominates the early flow regime (Figure 7-12) (Renard et al, 2009). The derivative is the change in drawdown at a well with respect to log time (Bourdet, 1989).

The Gringarten-Witherspoon (1972) solution assumes that the fracture is vertical and is fully penetrated by the pumping well. The method computes the fracture length (L_f), the hydraulic conductivity along the fracture (K_x, AQTESOLV assumes that the fracture is parallel to the x-axis), the hydraulic conductivity of the formation perpendicular to the fracture (K_y) (given as the ratio K_y/K_x) and specific storage (S_s) of the formation. The

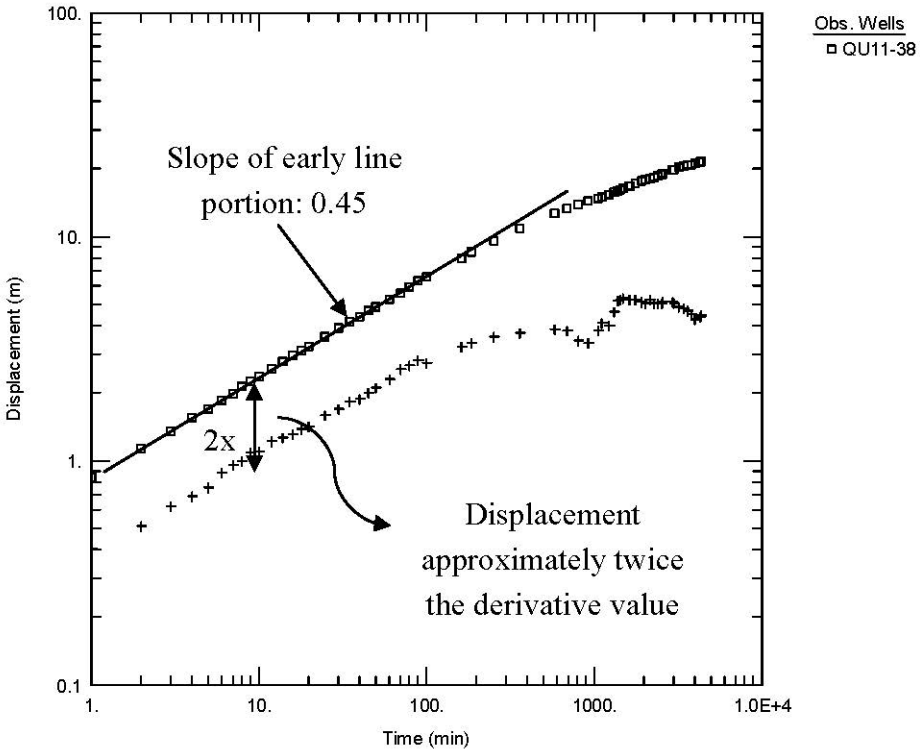
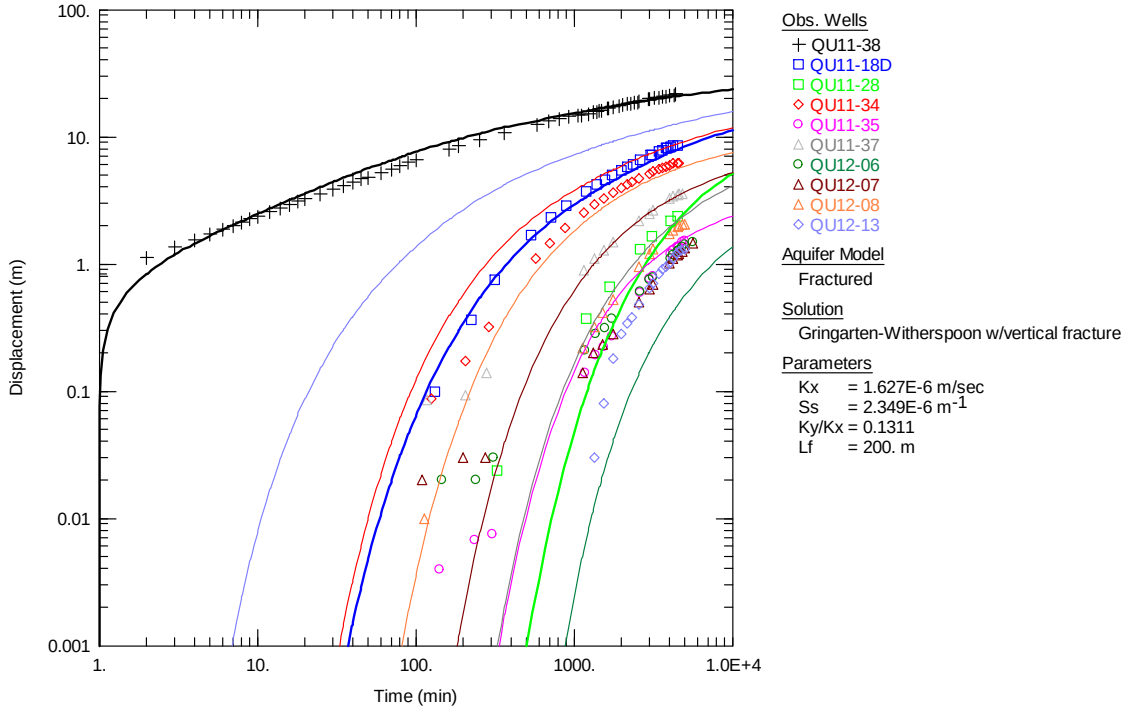


Figure A7-12:Log-log plot of drawdown (square) and drawdown derivative (cross) at QU11-38.

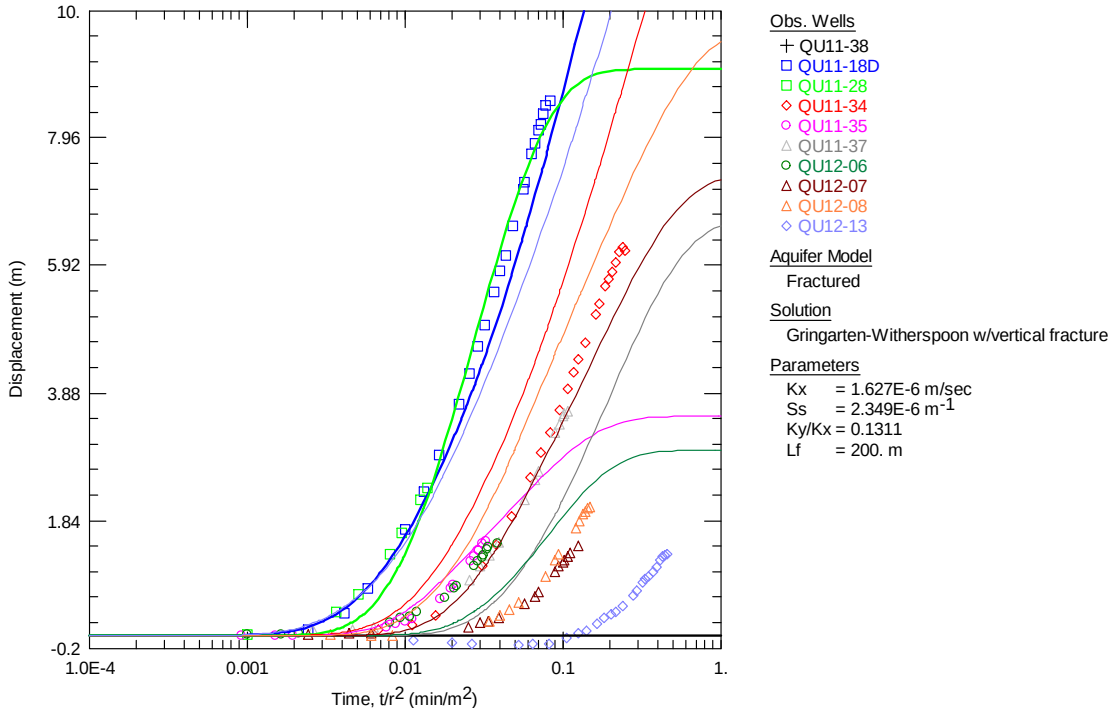
fracture, simulated as a plane, is assumed to have zero storage. Various simulations manipulating boundary conditions and fracture length were carried out (Appendix A9). These simulations produced distinctive drawdown contours, however computed values of K_x, K_y, S_s and L_f were reasonably similar between all but one simulation. Unlike the Theis simulations, the composite plots of the Gringarten-Witherspoon simulations show a separation in the curves, reflecting the heterogeneity in the aquifer introduced by the fracture. Based on the goodness-of-fit to the QU11-38 drawdown curve, the general shape of the drawdown contour plot and goodness-of-fit to observation well data in the composite plots, run GWB5 is considered the best representation of the groundwater system in the area of drawdown influenced during the pumping test. This simulation has a constant head boundary condition at x=0 m (representing the Iron River) and a no flow boundary at x=1180 m (representing the Long Lake Fault). No flow boundaries on the east and west margins did not improve fit or significantly change the computed parameters. The computed parameters are summarized in Table 7-2; output from AQTESOLV is shown in Figure 7-13.

Table A7-2:
7SA5 aquifer parameters simulated by Aqtesolv using Gringarten-Witherspoon solution

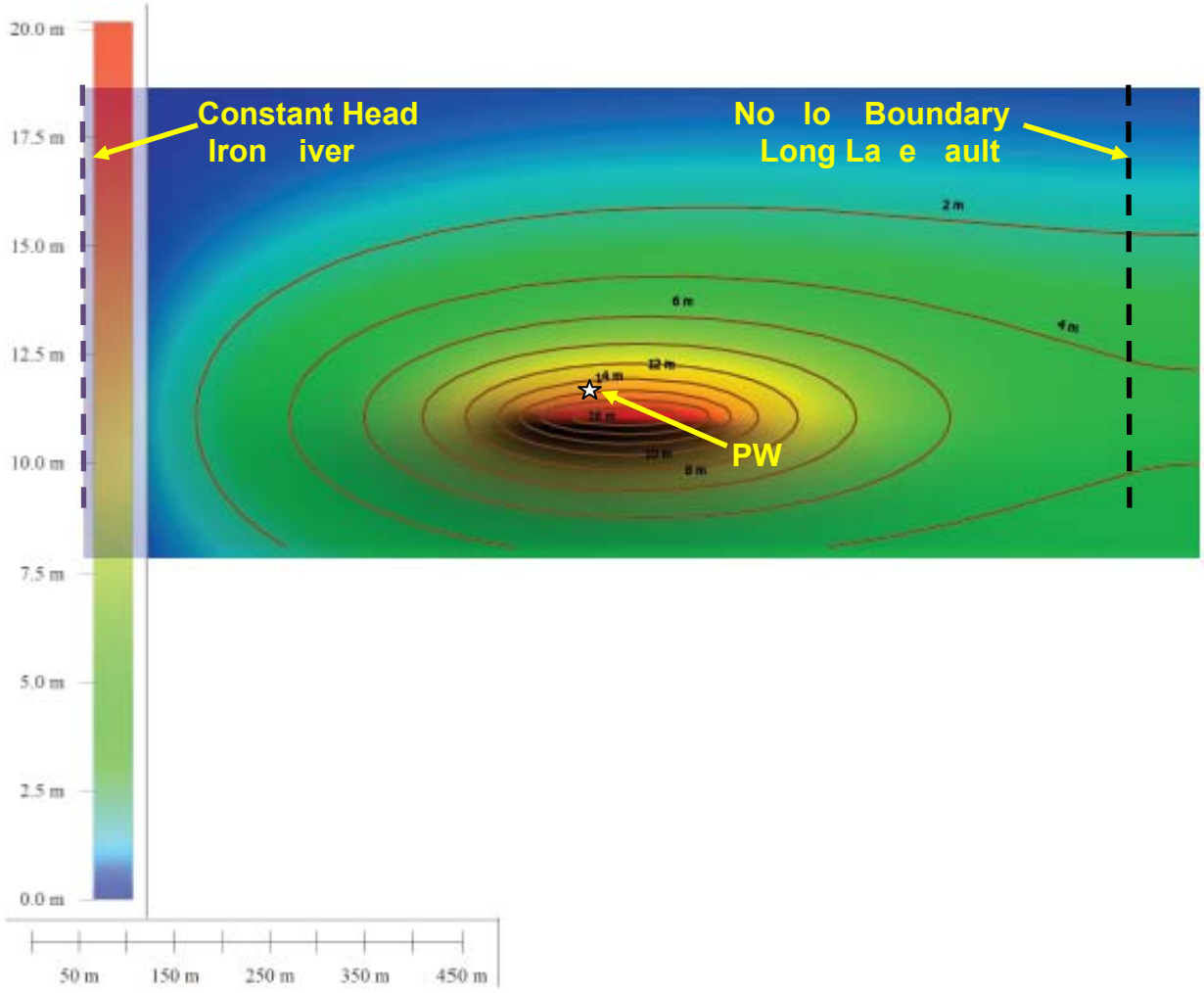
Aquifer Parameter	Description	Units	Computed Value
K_x	Hydraulic Conductivity of Fracture	m/s	1.6×10^{-6}
K_y	Hydraulic Conductivity of Formation	m/s	2.6×10^{-7}
S_s	Specific Storage	m^{-1}	2.3×10^{-6}
L_f	Fracture Length	m	200



a) Time-drawdown plot



b) Composite plot



(a) Plan view of drawdown contours

Figure A7-13:Simulated drawdown results from AQTESOLV (Run GWB5).

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Bourdet, D., Ayoub, J.A. and Y.M. Pirard, 1989. Use of pressure derivative in well-test interpretation, SPE Formation Evaluation, June 1989, pp. 293-302.

Gringarten, A.C. and P.A. Witherspoon, 1972. A method of analyzing pump test data from fractured aquifers, Int. Soc. Rock Mechanics and Int. Assoc. Eng. Geol., Proc. Symp. Rock Mechanics, Stuttgart, vol. 3-B, pp. 1-9.

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Theis, C.V., 1935. The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using groundwater storage, Am. Geophys. Union Trans., vol. 16, pp. 519-524.

APPENDIX A8 PUMPING TEST RAW DATA (PSP)

WELL I.D.	QU11-38				DATE	23 OCTOBER 2012	
DEPTH	94.787 M				PROJ. NO.	8339	
DIAMETER	4.5 IN.				PUMP SET	70 M	
PACKER	N/A				ORIFICE	4 IN. X 2 IN.	
DRILLER	DRILL WELL				DISCH. L	2800 M	
ENGINEER	LAURA FINDLATER				TEST DATUM	+29.5 CM	
TIME	ELAPSED TIME MIN.	DEPTH TO WATER METER	ORIFICE RATE USGPM	DRAWDOWN FEET	PSI	REMARKS	FLOWMETER
						S EP #	
:	0	24.144				STATIC	
	0.5	24.600	10.0		20		
	1	24.630	11.0				
	1.5	24.660	11.3		20		
	2	24.720	18.8				
	2.5	24.745	11.1		20		
	3	24.795	10.9			SLIGHT VALVE UP	
	3.5	24.840	11.1		20		
	4	24.860	10.9				
	4.5	24.885	11.1		20	SLIGHT VALVE UP	
18:05	5	24.923	11.1				
	6	24.950	10.9		20		
	7	24.980	11.0				
	8	24.995	10.9		20		
	9	25.010	11.0			SLIGHT VALVE UP	
18:10	10	25.060	11.0		20		
	12	25.093	11.3			SLIGHT VALVE UP	
	14	25.144	10.8		20	SLIGHT VALVE UP	
	16	25.206	10.9			SMALL VFD UP	
	18	25.334	10.9		20		
18:20	20	25.384	10.8				
	25	25.510	10.8		20		
18:30	30	25.618	11.3				
						S EP #	
	30.5	25.735	14.8		80	VALVE UP	
	31	25.880	20.3				
	31.5	25.930	20.2		80		
	32	25.990	20.0				
	32.5	26.046	19.6		80	SLIGHT VALVE UP	
	33	26.081	20.2				
	33.5	26.124	20.0		80		
	34	26.150	20.0				
	34.5	26.175	20.0		80		
18:35	35	26.200	20.2				
	36	26.270	20.3		80		
	37	26.338	20.2				
	38	26.401	20.1		80		
	39	26.462	20.0				
18:40	40	26.537	20.5		80		
	42	26.591	20.5				
	44	26.730	20.5		80		
	46	26.825	20.4				
	48	26.905	20.1		80		
18:50	50	26.973	20.0				
	55	27.143	19.9		80	SLIGHT VALVE UP	
19:00	60	27.310	20.0				

WELL I.D.	QU11-38				DATE	23 OCTOBER 2012	
DEPTH	94.787 M				PROJ. NO.	8339	
DIAMETER	4.5 IN.				PUMP SET	70 M	
PACKER	N/A				ORIFICE	4 IN. X 2 IN.	
DRILLER	DRILL WELL				DISCH. L	2800 M	
ENGINEER	LAURA FINDLATER				TEST DATUM	+29.5 CM	
TIME	ELAPSED TIME MIN.	DEPTH TO WATER METER	ORIFICE RATE USGPM	DRAWDOWN FEET	PSI	REMARKS	FLOWMETER
						S EP #	
	60.5	27.578	30.2		60	VALVE UP	
	61	27.625	30.1				
	61.5	27.725	30.0		60		
	62	27.736	29.9				
	62.5	27.785	29.8		60		
	63	27.835	29.7			SLIGHT VALVE UP	
	63.5	27.905	30.1		60		
	64	27.930	29.9				
	64.5	27.978	29.8		60		
19:05	65	28.031	29.7				
	66	28.105	29.6		60		
	67	28.178	30.1		58	SLIGHT VALVE UP	
	68	28.255	30.1		58		
	69	28.397	29.8		58		
19:10	70	28.404	29.8		59		
	72	28.520	29.5		60	SLIGHT VALVE UP	
	74	28.647	29.9		60		
	76	28.753	29.9		58		
	78	28.867	29.5		60	SLIGHT VALVE UP	
19:20	80	28.968	29.9		60		
	85	29.185	30.0		58	SLIGHT VALVE UP	
19:30	90	29.420	30.0		58		
						S EP #	
	90.5	29.665	40.1		50	VALVE UP	
	91	29.740	40.1				
	91.5	29.783	40.1		50		
	92	29.847	40.1				
	92.5	29.888	40.1		50		
	93	29.969	39.9				
	93.5	30.014	40.0		50		
	94	30.062	39.9				
	94.5	30.125	39.9		50		
19:35	95	30.164	39.7				
	96	30.258	39.7		50		
	97	30.365	40.5				
	98	30.470	40.3		50		
	99	30.520	40.2				
19:40	100	30.623	40.2		50		
	102	30.746	40.1				
	104	30.923	40.0		50		
	106	31.021	39.8				
	108	31.133	39.7		50	SMALL VFD UP	
19:50	110	31.258	40.3				
	115	31.458	40.2		50		
20:00	120					LAYFLAT BLEW OFF	
						END TEST	

WELL I.D.	QUI1-38	DATE	24 OCTOBER 2012
DEPTH	94.787 M	PROJ. NO.	8339
DIAMETER	4.5 IN.	PUMP SET	70 M
PACKER	N/A	ORIFICE	4 IN. X 2 IN.
DRILLER	DRILL WELL	DISCH. L	2800 M
ENGINEER	LAURA FINDLATER	TEST DATUM	+29.5 CM

TIME	ELAPSED TIME MIN.	DEPTH TO WATER METER	ORIFICE RATE USGPM	DRAWDOWN FEET	PSI	REMARKS	FLOWMETER
:	0	24.67				**S IC**	
	0.5	25.091	30.0			LAYFLAT 2/3 FULL	
	1	25.240			90	USING FLOW METER	30.8
	1.5	25.426	30.0				30.7
	2	25.562			96		30.2
	2.5	25.669	30.0				30.1
	3	25.765			96	0 PSI BACK PRESSURE	30.1
	3.5	25.930	30.0				29.9
	4	26.108			96		29.7
	4.5	26.233	30.0			5 PSI BACK PRESSURE	29.4
13:05	5	26.327			96	SLIGHT VALVE UP TO MAINTAIL FLOW	29.7
	6	26.470	30.0				29.5
	7	26.628			96	10 PSI BACK PRESSURE	29.3
	8	26.768	30.0				
	9	26.864			96	VALVE UP FROM 29.4 TO 30.1	30.0
13:10	10	26.970	30.0				29.8
	12	27.268			96	23.5 PSI BACK PRESSURE	29.4
	14	27.398	30.0				30.0
	16	27.563			96		30.0
	18	27.714	30.0			25 PSI BACK PRESSURE	29.6
13:20	20	27.843			96		30.0
	25	28.209	30.0				29.7
13:30	30	28.496			96	30 PSI BACK PRESSURE	29.8
	35	28.758	30.0			SMALL VALVE UP TO MAINTAIN FLOW	29.3
13:40	40	29.010			96	45 PSI BACK PRESSURE	29.5
	45	29.254	30.0			SMALL VALVE UP TO MAINTAIN FLOW	30.0
13:50	50	29.448			96	50 PSI BACK PRESSURE ON LAYFLAT	29.8
	55	29.673	30.0		86	SMALL VALVE UP TO MAINTAIN FLOW	29.7
14:00	60	29.831				55 PSI BACK PRESSURE ON LAYFLAT	28.9
14:10	70	30.228	30.0		86	WATER TEMP 180º F	29.6
14:20	80					HELPING LAURA / CHECKING LAYFLAT	
14:30	90		30.0			WATER AT ORIFICE	
14:40	100	31.180					29.8
14:50	110	31.429	30.0		86	60 PSI BACK PRESSURE ON LAYFLAT	29.7
15:00	120	31.672					29.7
15:20	140	32.121	30.0		86	60 PSI BACK PRESSURE ON LAYFLAT	29.5
15:40	160	32.528				SMALL VALVE UP TO MAINTAIN FLOW	29.4
16:08	188	33.096	30.0		84	WATER AT ORIFICE	29.6
16:20	200	33.294					30.0
16:40	220	33.605	30.0		84	55 PSI BACK PRESSURE ON LAYFLAT	29.5
17:10	250	34.043				SMALL VALVE UP TO MAINTAIN FLOW	30.0
17:40	280	34.489	30.0		84		30.0
18:30	330	35.091					29.7
19:20	380	35.593	30.0		84	SMALL VFD UP	29.5
20:10	430	36.158			84		30.0
21:00	480	36.574	30.0		82	SHIFT CHANGE	29.8
21:50	530	36.918			84		29.5
22:45	585	37.276	30.0		83	SMALL VALVE UP TO MAINTAIN FLOW	29.6
23:30	630					CHECKING LAYFLAT & ORIFICE	
0:25	685	37.869	30.0		83	**ct**	29.5
1:11	731	38.089				65 PSI BACK PRESSURE ON LAYFLAT	29.2
2:00	780	38.313	30.0		83	SMALL VALVE UP TO MAINTAIN FLOW	29.7
2:50	830	38.599			82	63 PSI BACK PRESSURE ON LAYFLAT	29.5
3:40	880	38.797	30.0			SMALL VALVE UP TO MAINTAIN FLOW	29.3
4:30	930	38.999			82	SMALL VALVE UP TO MAINTAIN FLOW	29.8
5:20	980	39.245	30.0		81	64 PSI BACK PRESSURE ON LAYFLAT	29.5
6:10	1030	39.308			80		29.5

WELL I.D.	QUI1-38	DATE	24 OCTOBER 2012
DEPTH	94.787 M	PROJ. NO.	8339
DIAMETER	4.5 IN.	PUMP SET	70 M
PACKER	N/A	ORIFICE	4 IN. X 2 IN.
DRILLER	DRILL WELL	DISCH. L	2800 M
ENGINEER	LAURA FINDLATER	TEST DATUM	+29.5 CM

TIME	ELAPSED TIME MIN.	DEPTH TO WATER METER	ORIFICE RATE USGPM	DRAWDOWN FEET	PSI	REMARKS	FLOWMETER
7:00	1080	39.345	30.0		80	SMALL VALVE UP TO MAINTAIN FLOW	29.3
7:50	1130	39.468			80	68 PSI BACK PRESSURE ON LAYFLAT	29.8
8:40	1180		30.0			CHECKING LAYFLAT & ORIFICE	30.0
9:30	1230	39.873			80	WATER TEMP 180º F	30.0
10:20	1280	40.072	30.0		78		30.4
11:10	1330	40.257				64 PSI BACK PRESSURE ON LAYFLAT	30.3
12:00	1380	40.421	30.0		78		30.3
12:50	1430	40.587				WATER SAMPLES TAKEN AT 13:00	30.2
13:00	1440	40.620	30.0		78	64 PSI BACK PRESSURE ON LAYFLAT	30.2
13:40	1480					CHECKING LAYFLAT & ORIFICE	
14:35	1535	40.937	30.0		78		30.2
15:23	1583	41.105				WATER CLEAR, SULFUR SMELL	30.1
16:10	1630	41.250	30.0		78	TOTAL 45593.0 USGPM	29.9
17:00	1680					CHECKING LAYFLAT	
17:50	1730	41.650	30.0		78	60 PSI BACK PRESSURE ON LAYFLAT	30.3
18:43	1783	41.774				WEATHER CLEAR & SUNNY	30.2
19:30	1830		30.0		75	BRIEFING & SHIFT CHANGE	
20:20	1880	42.065					30.1
21:10	1930	42.197	30.0		75	WATER 181º F	30.0
22:00	1980	42.326					30.1
22:50	2030	42.446	30.0		75		29.9
23:40	2080	42.563			74	55 PSI BACK PRESSURE ON LAYFLAT	29.9
0:30	2130	42.667	30.0			**ct**	29.9
1:20	2180	42.807			75		29.8
2:10	2230	42.867	30.0				29.8
3:00	2280	42.958			74		29.7
3:50	2330	43.049	30.0		75	SMALL VALVE UP TO MAINTAIN FLOW	29.6
4:40	2380	43.151			74	55 PSI BACK PRESSURE ON LAYFLAT	29.7
5:30	2430	43.242	30.0		74		29.7
6:20	2480	43.333			74	SMALL VALVE UP TO MAINTAIN FLOW	29.6
7:10	2530	43.419	30.0			59 PSI BACK PRESSURE ON LAYFLAT	29.6
8:02	2582	43.582			74	SHIFT CHANGE AT 7:00	30.2
8:50	2630	43.688	30.0				30.2
9:40	2680	43.797			74		30.0
10:30	2730	43.886	30.0				29.9
11:20	2780	44.015			74	VFD UP AND VALVE DOWN	29.9
12:10	2830	44.056	30.0		90	SMALL VALVE UP TO MAINTAIN FLOW	30.1
13:00	2880	44.148					30.1
13:50	2930	44.222	30.0		90	VFD UP	30.0
14:40	2980	44.311				55 PSI BACK PRESSURE ON LAYFLAT	30.0
15:30	3030	44.401	30.0		90	SMALL VFD UP	30.1
16:20	3080	44.492					30.0
17:10	3130	44.726	30.0		90		31.5
18:00	3180	44.707				PSI BACK PRESSURE ON LAYFLAT TO	30.1
18:50	3230	44.774	30.0		90	50 PSI FROM 60 PSI	30.2
19:40	3280	44.836			89	VALVE DOWN	30.1
20:30	3330	44.901	30.0				30.0
21:20	3380	44.958			89	47.5 PSI BACK PRESSURE ON LAYFLAT	29.9
22:10	3430	45.023	30.0				29.9
23:00	3480	45.084			89		30.0
23:50	3530	45.136	30.0				29.9
0:40	3580	45.190			89	**ct**	29.9
1:34	3634	45.243	30.0				29.8
2:40	3700	45.307			89		29.7
3:10	3730	45.333	30.0			47.5 PSI BACK PRESSURE ON LAYFLAT	29.7
4:00	3780	45.372			89	LEAK AT ORIFICE 10 USGPM	29.7
4:50	3830	45.403	30.0		89	SMALL VALVE UP TO MAINTAIN FLOW	29.7
5:40	3880	45.506			88	47.5 PSI BACK PRESSURE ON LAYFLAT	30.1
6:30	3930	45.560	30.0				30.1

WELL I.D.	QUI1-38	DATE	24 OCTOBER 2012
DEPTH	94.787 M	PROJ. NO.	8339
DIAMETER	4.5 IN.	PUMP SET	70 M
PACKER	N/A	ORIFICE	4 IN. X 2 IN.
DRILLER	DRILL WELL	DISCH. L	2800 M
ENGINEER	LAURA FINDLATER	TEST DATUM	+29.5 CM

TIME	ELAPSED TIME MIN.	DEPTH TO WATER METER	ORIFICE RATE USGPM	DRAWDOWN FEET	PSI	REMARKS	FLOWMETER
7:20	3980	45.620			88	TOTAL 121,680 USGPM	30.1
8:10	4030		30.0			CHECKING LAYFLAT, LEAKS AT ORIFICE	30.0
9:00	4080	45.735			88	FIRST LEAK = 5 USGPM	30.0
9:50	4130	45.785	30.0		88	SECOND LEAK = 8 USGPM	30.0
10:40	4180	45.835			90	THIRD LEAK = 3 USGPM / SMALL VFD UP	30.1
11:30	4230	45.906	30.0		90	FOURTH LEAK = 3 USGPM	30.1
12:20	4280	45.952			88	TOTAL 19 USGPM LEAKING	30.1
13:10	4330	45.987	30.0			WATER SAMPLES TAKEN AT 13:10	30.1
14:00	4380	46.000			88	TOTAL 129,231 USGPM, SHUT DOWN	30.0
						EC VE	
	4380.5	45.709	0				
	4381	45.628					
	4381.5	45.545	0				
	4382	45.483					
	4382.5	45.395	0				
	4383	45.325					
	4383.5	45.264	0				
	4384	45.202					
	4384.5	45.123	0				
14:05	4385	45.073					
	4386	44.921	0				
	4387	44.792					
	4388	44.700	0				
	4389	44.581					
14:10	4390	44.473	0				
	4392	44.283					
	4394	44.081	0				
	4396	43.922					
	4398	43.770	0				
14:20	4400	43.612					
	4405	43.273	0				
14:30	4410	42.994					
	4415	42.741	0				
14:40	4420	42.495					
	4425	42.286	0				
14:50	4430	42.038					
	4435	41.876	0				
15:00	4440	41.742					
15:10	4450		0			DISCONNECTING LAYFLAT	
15:20	4460						
15:30	4470		0			DISCONNECTING LAYFLAT	
15:40	4480						
16:00	4500		0			DISCONNECTING LAYFLAT	
16:34	4534	39.342					
16:40	4540	39.266	0				
17:00	4560	38.604					
17:30	4590	38.001	0				
18:00	4620	38.445					
18:50	4670	36.654	0				
19:40	4720	36.018					
20:30	4770	35.495	0				
21:20	4820					CHECKING SURROUNDING WELLS	
22:10	4870	34.554	0				
23:00	4920	34.174					
23:50	4970	33.826	0				
0:40	5020	33.500				END RECOVERY	

APPENDIX A9 PUMPING TEST ANALYSIS (AQTESOLV)

Aqtesolv Run Log

Run ID			T4	TB7	GW5	GW6	GWB1	GWB2	GWB3	GWB4	GWB5	GWB6
Boundaries			none	3 No Flow, 1 Constant Head	none	none	3 No Flow, 1 Constant Head	3 No Flow, 1 Constant Head	3 No Flow, 1 Constant Head	1 CH	1 CH, 1 NF (north)	1 CH, 2 NF (north and east)
Method			Theis	Theis	GW 1972	GW 1972	GW 1972	GW 1972	GW 1972	GW 1972	GW 1972	GW 1972
Fit Target			QU11-38, QU 11-18D									
Spatial Representation			new co-ords with x-axis parallel to axis of syncline									
File name			QU11-38 Manual DD with OBS new co-ords.aqt				QU11-38 Manual DD with OBS new co-ords GWB.aqt					
West Margin			n/a	Y=480	n/a	n/a	Y=480	Y=480	Y=480	n/a	n/a	n/a
East Margin			n/a	Y=0	n/a	n/a	Y=0	Y=0	Y=-250	n/a	n/a	Y=0
Kx	**m/s**	Hydraulic Conductivity (K) along fracture plane			2.3E-06	5.8E-07	1.1E-06	1.2E-06	8.5E-07	1.6E-06	1.6E-06	1.6E-06
Ky/Kx	**(-)**				0.118	1	0.5341	0.2492	0.466	0.131	0.131	0.136
Ky	**m/s**	K perpendicular to fracture plane			2.7E-07	5.8E-07	6E-07	3E-07	4.0E-07	2.1E-07	2.1E-07	2.2E-07
Ss	**m^{-1}**	Specific storage	2.4E-07	6.E-07	2.8E-06	9.3E-07	2.E-06	2.E-06	1.5E-06	2.4E-06	2.3E-06	2.5E-06
S	**(-)**	Storage	1.7E-05	4.0E-05	1.98E-04	6.5E-05	1E-04	2E-04	1E-04	2E-04	2E-04	2E-04
T	**m^2/s**	Transmissivity	2.2E-04	2.6E-04								
K	**m/s**	Hydraulic Conductivity	3.2E-06	3.6E-06								
Lf	**m**	Fracture length	n/a	n/a	100	200	100	200	200	200	200	200
b	**m**	Aquifer thickness	70.23	70.23	70.23	70.23	70.23	70.23	70.23	70.23	70.23	70.23
Covergence			converged		converged with relaxation of criteria							

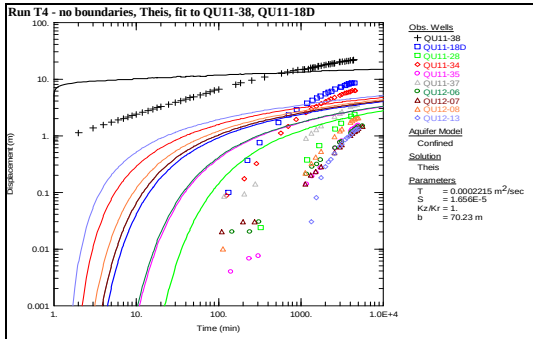
Notes

GW = Gringarten Witherspoon method for vertical, highly permeably fracture; confined aquifer

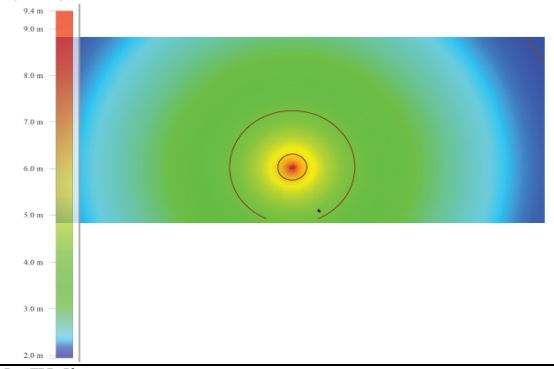
Values are calculated assuming b=70.23 m

Values are fixed

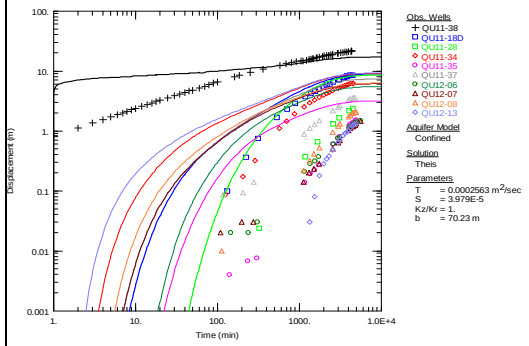
Run T4 - no boundaries, Theis, fit to QU11-38, QU11-18D



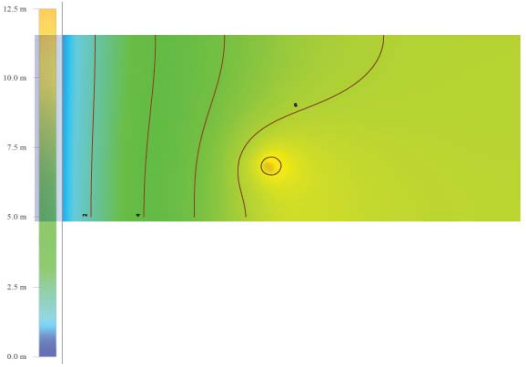
Run T4 Plan



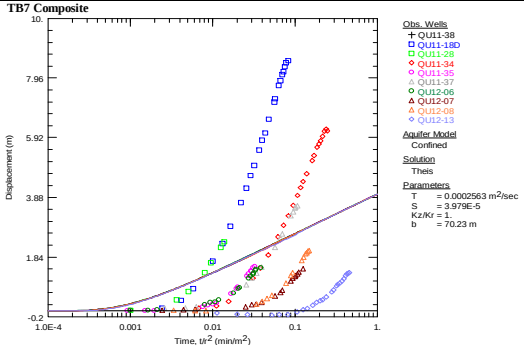
Run TB7 - Curves (1CH, 3NF, Theis)



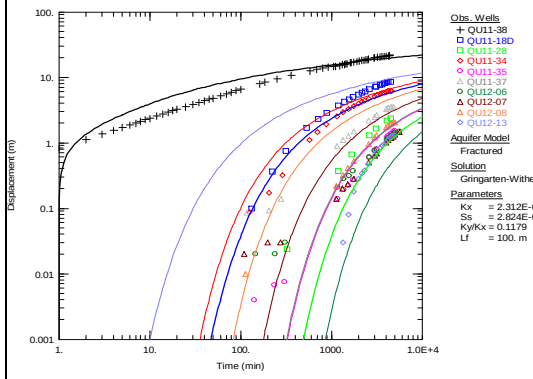
Run TB7 - Plan



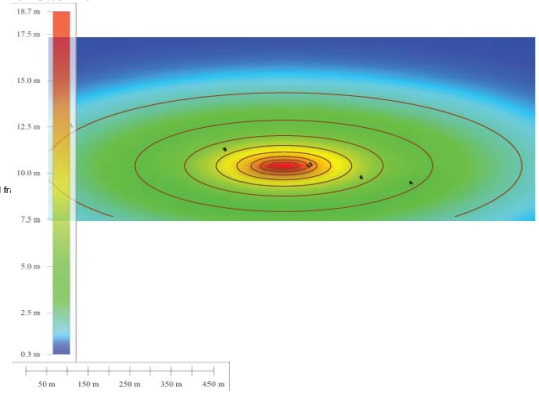
TB7 Composite



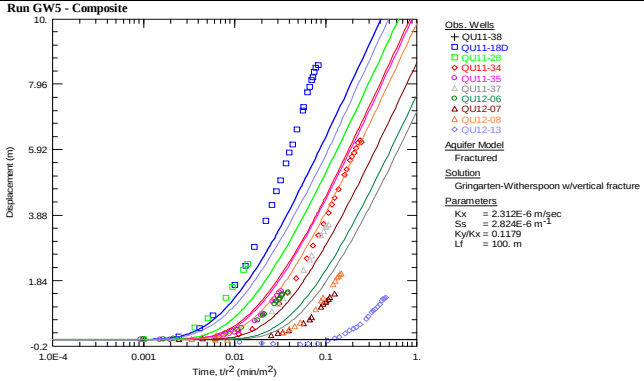
Run GW5 - no boundaries, Gringarten Witherspoon, fit to QU11-38, QU11-18D



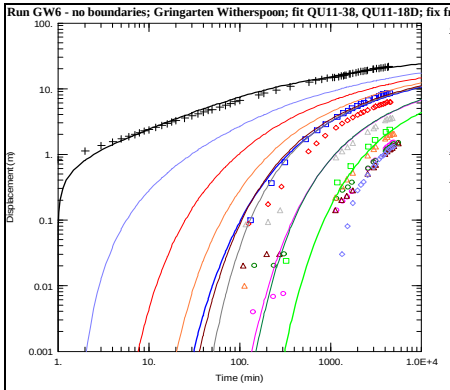
Run GW5 - Plan



Run GW5 - Composite



Run GW6 - no boundaries; Gringarten Witherspoon; fit QU11-38, QU11-18D; fix fracture length 200 m

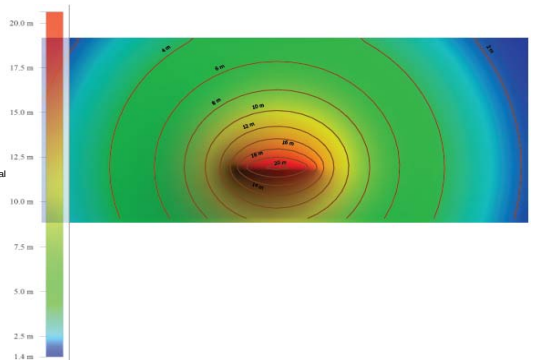


Obs. Wells
- QU11-38
- QU11-18D
- QU11-28
- QU11-34
- QU11-35
- QU11-37
- QU12-06
- QU12-07
- QU12-08
- QU12-13

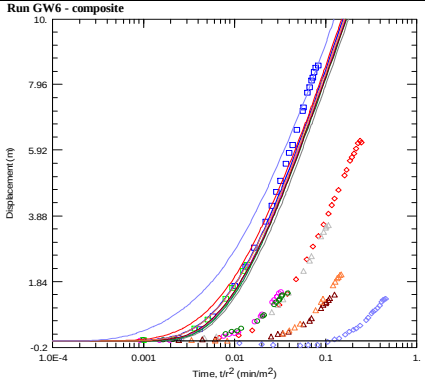
Aquifer Model
Fractured

Solution
Gringarten-Witherspoon w/vertical

Parameters
Kx = 5.777E-7 m/sec
Ss = 9.291E-7 m^{-1}
Ky/Kx = 1.
Lf = 200. m



Run GW6 - composite



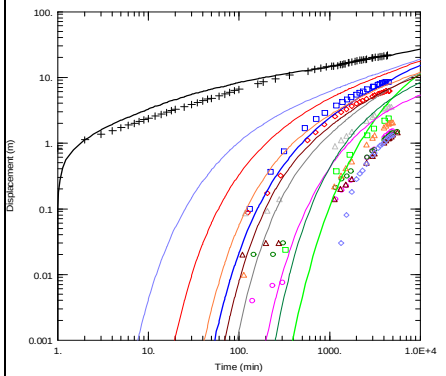
Obs. Wells
- QU11-38
- QU11-18D
- QU11-28
- QU11-34
- QU11-35
- QU11-37
- QU12-06
- QU12-07
- QU12-08
- QU12-13

Aquifer Model
Fractured

Solution
Gringarten-Witherspoon w/vertical fracture

Parameters
Kx = 5.777E-7 m/sec
Ss = 9.291E-7 m^{-1}
Ky/Kx = 1.
Lf = 200. m

Run GWB1 - 1CH, 3NF, Gringarten-Witherspoon



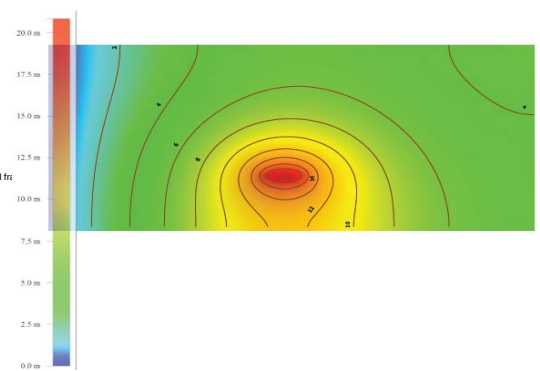
Obs. Wells
- QU11-38
- QU11-18D
- QU11-28
- QU11-34
- QU11-35
- QU11-37
- QU12-06
- QU12-07
- QU12-08
- QU12-13

Aquifer Model
Fractured

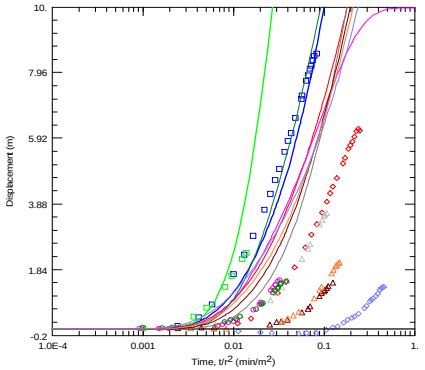
Solution
Gringarten-Witherspoon w/vertical fra

Parameters
Kx = 1.126E-6 m/sec
Ss = 1.842E-6 m^{-1}
Ky/Kx = 0.5431
Lf = 100. m

Run GWB1 - Plan



Run GWB1 - Composite



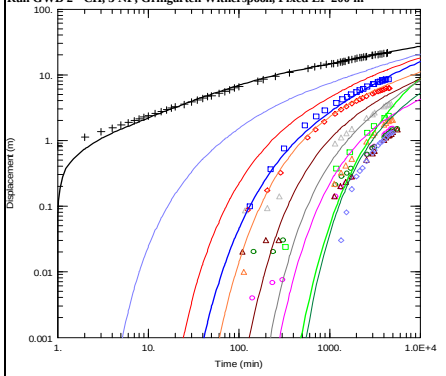
Obs. Wells
- QU11-38
- QU11-18D
- QU11-28
- QU11-34
- QU11-35
- QU11-37
- QU12-06
- QU12-07
- QU12-08
- QU12-13

Aquifer Model
Fractured

Solution
Gringarten-Witherspoon w/vertical fracture

Parameters
Kx = 1.126E-6 m/sec
Ss = 1.842E-6 m^{-1}
Ky/Kx = 0.5431
Lf = 100. m

Run GWB 2 - CH, 3 NF, Gringarten Witherspoon, Fixed LF 200 m



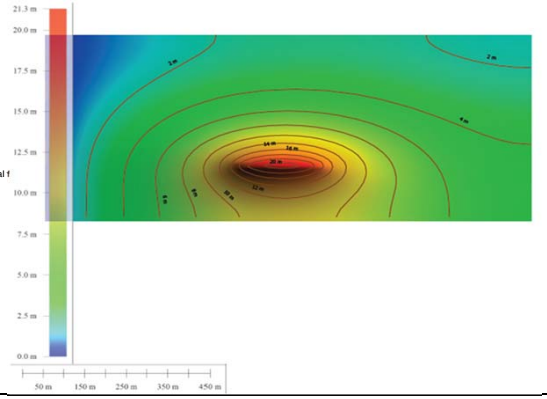
Obs. Wells
- QU11-38
- QU11-18D
- QU11-28
- QU11-34
- QU11-35
- QU11-37
- QU12-06
- QU12-07
- QU12-08
- QU12-13

Aquifer Model
Fractured

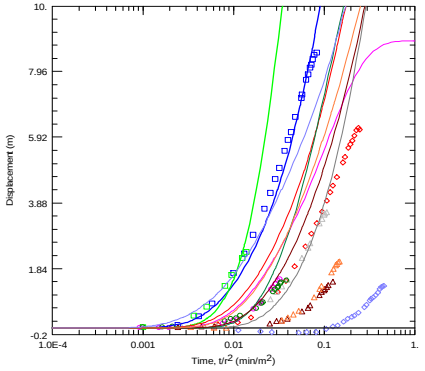
Solution
Gringarten-Witherspoon w/vertical f

Parameters
Kx = 1.177E-6 m/sec
Ss = 2.162E-6 m^{-1}
Ky/Kx = 0.2492
Lf = 200. m

Run GWB2 - Plan



GWB2 - Composite



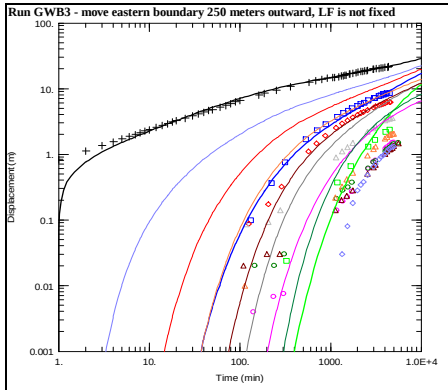
Obs. Wells
- QU11-38
- QU11-18D
- QU11-28
- QU11-34
- QU11-35
- QU11-37
- QU12-06
- QU12-07
- QU12-08
- QU12-13

Aquifer Model
Fractured

Solution
Gringarten-Witherspoon w/vertical fracture

Parameters
Kx = 1.177E-6 m/sec
Ss = 2.162E-6 m^{-1}
Ky/Kx = 0.2492
Lf = 200. m

Run GWB3 - move eastern boundary 250 meters outward, LF is not fixed



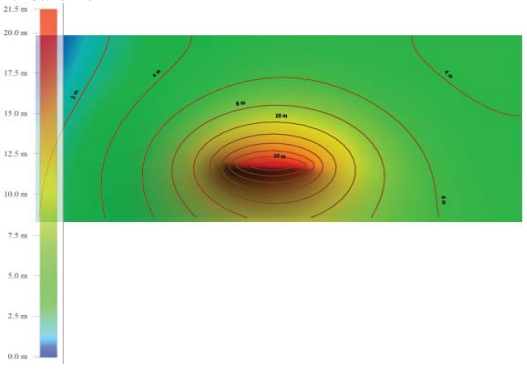
Obs. Wells
- QU11-38
- QU11-18D
- QU11-28
- QU11-34
- QU11-35
- QU11-37
- QU12-06
- QU12-07
- QU12-08
- QU12-13

Aquifer Model
Fractured

Solution
Gringarten-Witherspoon w/vertical fi

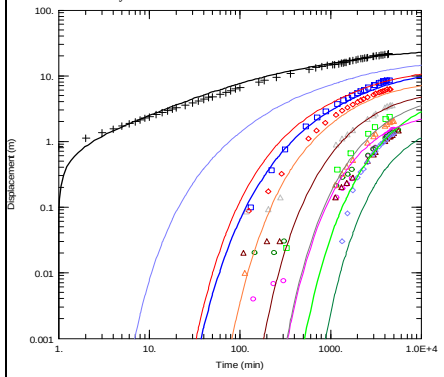
Parameters
Kx = 8.489E-7 m/sec
Ss = 1.529E-6 m^{-1}
Ky/Kx = 0.466
Lf = 200. m

Run GWB3 - Plan



Run GWB3 - Composite

Run GWB4 - CH only



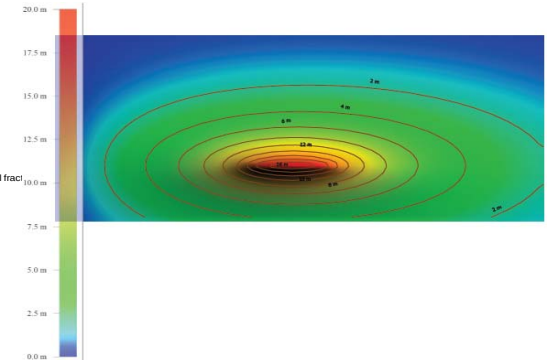
Obs. Wells
- QU11-38
- QU11-18D
- QU11-28
- QU11-34
- QU11-35
- QU11-37
- QU12-06
- QU12-07
- QU12-08
- QU12-13

Aquifer Model
Fractured

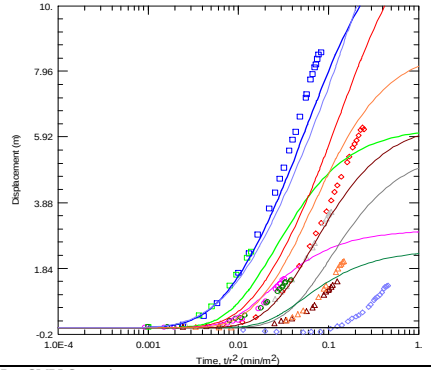
Solution
Gringarten-Witherspoon w/vertical fracl

Parameters
Kx = 1.625E-6 m/sec
Ss = 2.35E-6 m^{-1}
Ky/Kx = 0.1307
Lf = 200. m

Run GWB4 - Plan



Run GWB4-Composite



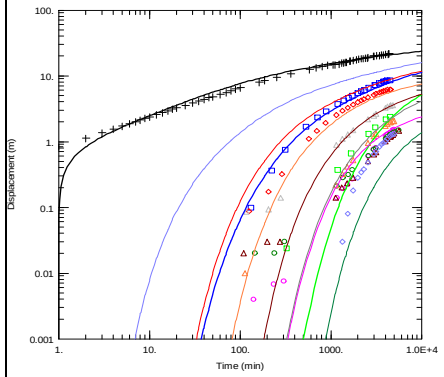
Obs. Wells
- QU11-38
- QU11-18D
- QU11-28
- QU11-34
- QU11-35
- QU11-37
- QU12-06
- QU12-07
- QU12-08
- QU12-13

Aquifer Model
Fractured

Solution
Gringarten-Witherspoon w/vertical fracture

Parameters
Kx = 1.625E-6 m/sec
Ss = 2.35E-6 m^{-1}
Ky/Kx = 0.1307
Lf = 200. m

Run GWB5 - 1CH, 1NF (north)



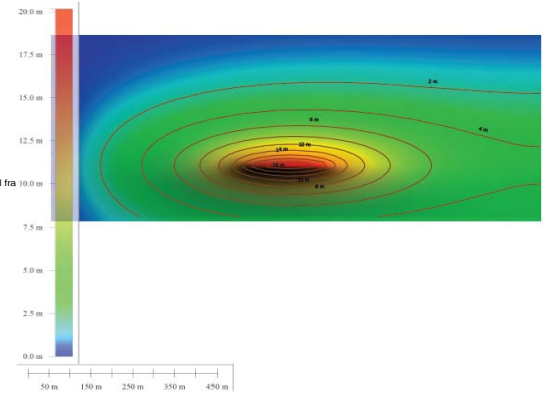
Obs. Wells
- QU11-38
- QU11-18D
- QU11-28
- QU11-34
- QU11-35
- QU11-37
- QU12-06
- QU12-07
- QU12-08
- QU12-13

Aquifer Model
Fractured

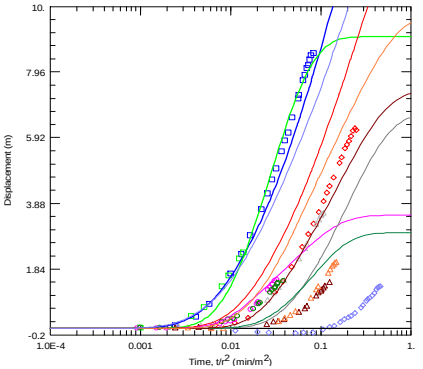
Solution
Gringarten-Witherspoon w/vertical fra

Parameters
Kx = 1.627E-6 m/sec
Ss = 2.349E-6 m^{-1}
Ky/Kx = 0.1311
Lf = 200. m

Run GWB5 Plan



Run GWB5 Composite



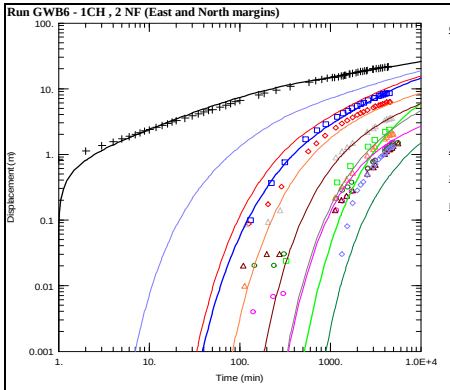
Obs. Wells
- QU11-38
- QU11-18D
- QU11-28
- QU11-34
- QU11-35
- QU11-37
- QU12-06
- QU12-07
- QU12-08
- QU12-13

Aquifer Model
Fractured

Solution
Gringarten-Witherspoon w/vertical fracture

Parameters
Kx = 1.627E-6 m/sec
Ss = 2.349E-6 m^{-1}
Ky/Kx = 0.1311
Lf = 200. m

Run GWB6 - 1CH , 2 NF (East and North margins)



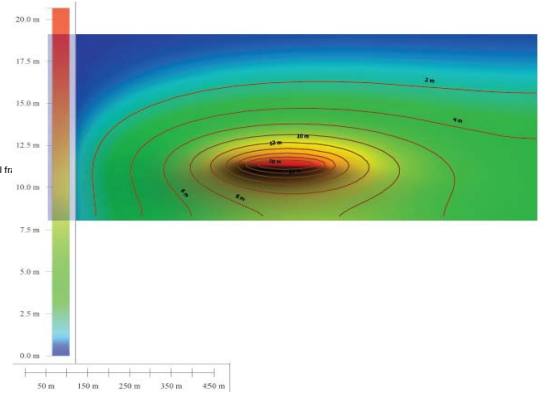
Obs. Wells
- QU11-38
- QU11-18D
- QU11-28
- QU11-34
- QU11-35
- QU11-37
- QU12-06
- QU12-07
- QU12-08
- QU12-13

Aquifer Model
Fractured

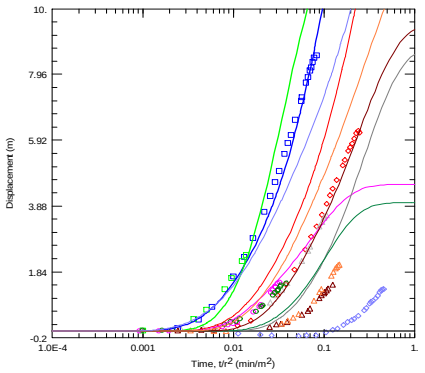
Solution
Gringarten-Witherspoon w/vertical fra

Parameters
Kx = 1.626E-6 m/sec
Ss = 2.462E-6 m^{-1}
Ky/Kx = 0.1355
Lf = 200. m

Run GWB6 - plan



Run GWB6 Composite Plot



Obs. Wells
- QU11-38
- QU11-18D
- QU11-28
- QU11-34
- QU11-35
- QU11-37
- QU12-06
- QU12-07
- QU12-08
- QU12-13

Aquifer Model
Fractured

Solution
Gringarten-Witherspoon w/vertical fracture

Parameters
Kx = 1.626E-6 m/sec
Ss = 2.462E-6 m^{-1}
Ky/Kx = 0.1355
Lf = 200. m

APPENDIX A10 PUMPING TEST PROJECTIONS

Appendix A10. Pumping Test Projection

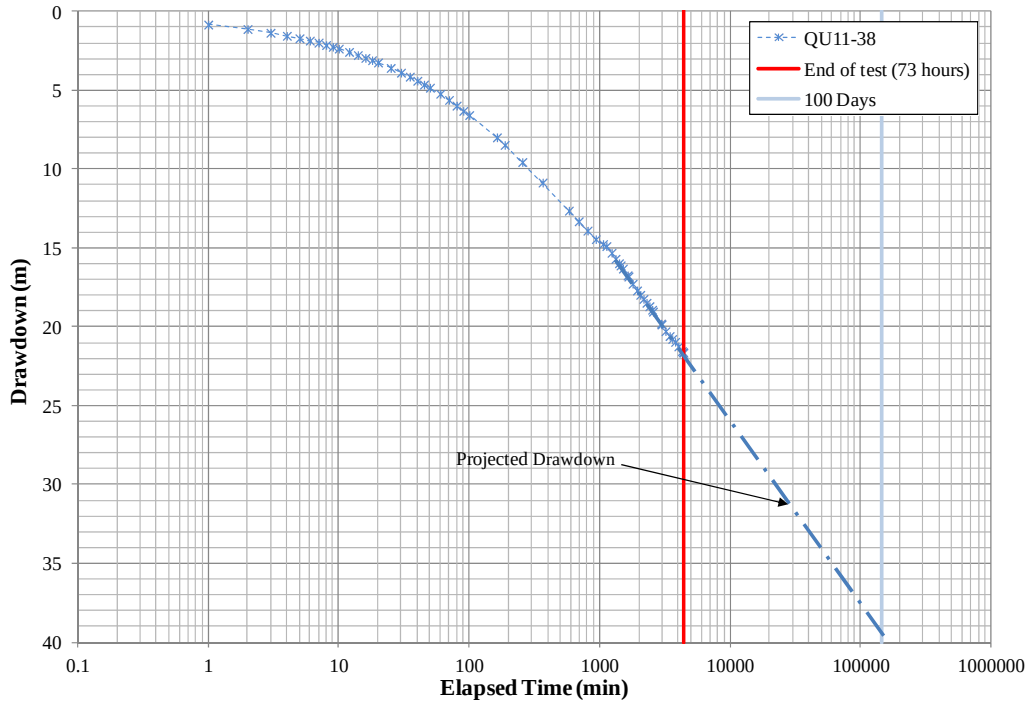


Figure A10-1: Drawdown at QU11-38 extrapolated to 100 days.

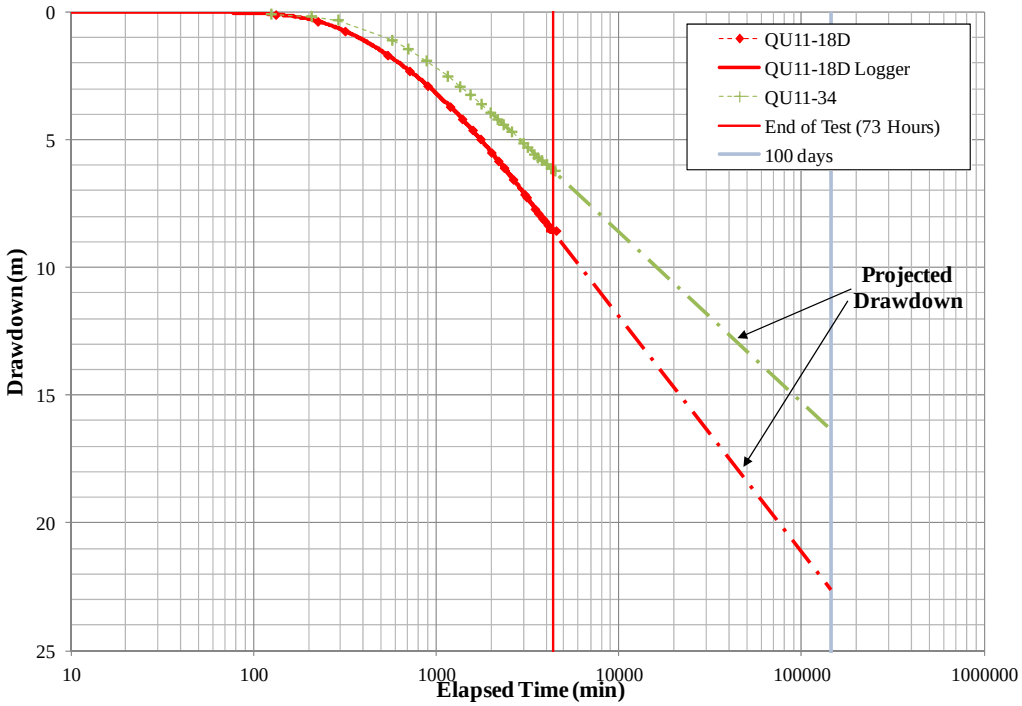


Figure A10-2: Drawdown at QU11-18D and QU11-34 extrapolated to 100 days.

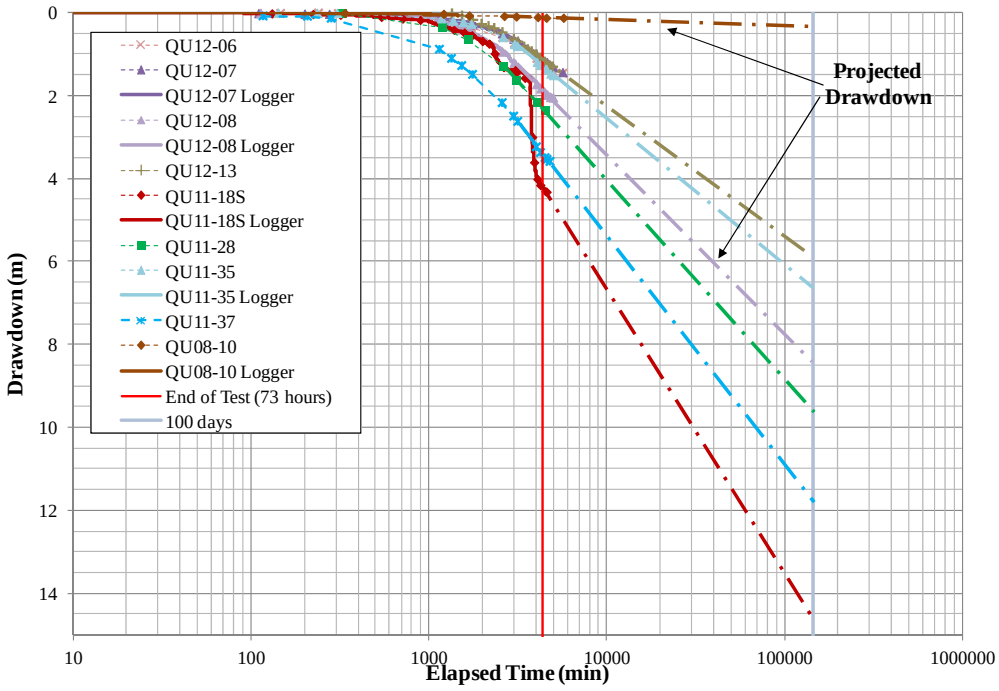
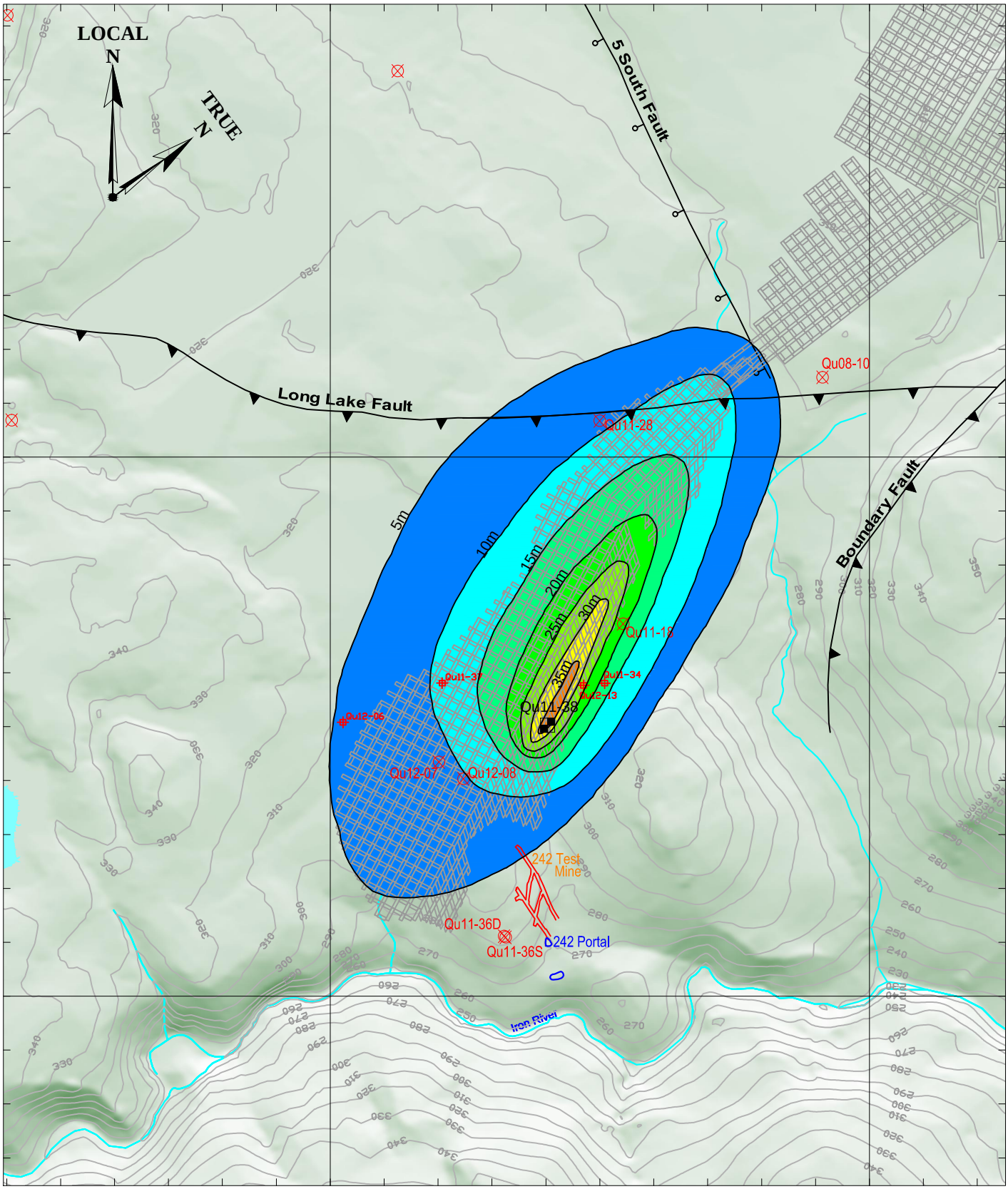


Figure A10-3: Drawdown at remaining 7SA5 observation points extrapolated to 100 days.



LEGEND

- Proposed Workings
- Monitoring Wells
- Pumping Wells
- Open Boreholes
- Drawdown Contours (5m)
- Rivers/Drainage
- Surface Elevation (10m)
- High Angle Faults
- Thrust Faults

Contour Colours

- 5-10m
- 10-15m
- 15-20m
- 20-25m
- 25-30m
- 30-35m
- >35m

DATE SAVED:	Feb 25, 2013
DRAWN BY:	GM
REVIEWED:	LLF
VERSION:	1

Coordinate System: Quinsam Mine Local Grid
Projection: Orthographic
Units: Metres

0 100 200 M

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT: **Water Quality Effects Assessment: 7 South Area 5**

TITLE: **Generalized Extrapolated Drawdown After 100 Days (30 US GPM)**

PROJECT #: **J885-7**

FIGURE: **A10-4**

P:\J885 Hillsborough Resources\Drafting\AutoCAD map\Feb2013Figures\Fig A10-4_drawdown 11-38_gm.dwg

Appendix B
Groundwater Quality

APPENDIX B1 GROUNDWATER SAMPLING

APPENDIX B2 GROUNDWATER QUALITY RESULTS

APPENDIX B3 GROUNDWATER QUALITY QA/QC

QUINSAM COAL

APPENDIX B1 GROUNDWATER SAMPLING

Appendix B1. Groundwater Sampling

This appendix summarizes the methodology used in the collection of 7 South Area 5 groundwater samples. Groundwater quality samples have been taken from monitoring six monitoring wells, an open borehole used as the pumping well for a multi-day pump test and the old 242 test mine. Details of the various sampling rounds are summarized in Table B-1.

The majority of locations were sampled using conventional high flow methods since well recharge rates were sufficiently high (Table B-1). This method consists of using a Hydrolift to actuate Waterra tubing fitted with a footvalve. Wells were typically purged at least three casing volumes prior to sampling, however some were sample earlier since the water table in the well remained stable. Stabilization of the water level indicates that all water being pumped from the well is formation water, as long as the footvalve is in the screened area. In all cases, field parameters were continuously monitored and sampling occurred once field parameters had stabilized. Wells QU11-18S/D and QU11-28 were developed via Hydrolift shortly after installation in December 2011. Between 300 and 500 litres were purged at each location to remove artefacts from drilling and well installation. QU11-36S/D were developed immediately prior to the first sampling event in February/March 2012.

QU08-10, which was completed as a monitoring well in April 2010, was initially sampled using the Hydrolift method a month later. Borehole development was limited and a minimal amount of water was purged during sampling due to extremely low recharge rates. Subsequent sampling events at this well utilized a portable bladder pump which is suited to low flow sampling. Bladder pumps operate by repeating a refill-discharge cycle, whereby compressed air is used to squeeze an internal (in this case, disposable) bladder, followed by a period when the pressure is released, allowing water to fill the bladder via hydrostratic pressure. Ultimately, water is forced up through a discharge line to surface. When low flow sampling, a sample can be collected once drawdown and field parameters stabilize, which typically occurs well before three casing volumes are purged. QU08-10, however, posed a particular challenge in that the screened formation is so impermeable that the water level does not even stabilize after purging several hours at a very low flow rate (<60 mL/min). As a result, this well was sampled once field parameters were reasonably stable without the water level stabilizing.

In order to sample the old 242 test mine pool, approximately 100 meters of 1.5 inch PVC lined with 0.5 inch OD HDPE tubing was run into the mine along the conveyor entry. A shorter length of 0.25 inch OD tubing was in turn threaded into the 0.5 tubing and then

coupled to a peristaltic pump at surface (Figure B1-1). The tubing was purged using a peristaltic pump until the turbidity improved (*i.e*. less suspended iron) and field parameters stabilized.

QU11-38 is unique in that it was sampled approximately 24, 48 and 72 hours into a 73 hour, 30 US GPM pumping test in October 2012. Details of this pump test are provided in Appendix A7. A 30-stage, 10 horsepower submersible Grundfos pump was deployed in this borehole, which is lined with a PVC liner but not backfilled to isolate a specific interval (Appendix A4). Water quality samples were collected from a sampling port plumbed into the well head assembly. A YSI multi-parameter probe was coupled to the sampling port using silicon tubing and was programmed to continuously log field parameters throughout the duration of the pumping test. The field parameters measured during this pumping test are tabulated and shown graphically in Appendix B3.

A YSI 556 or Pro model was used to monitor field parameters (*i.e.*, pH, conductivity, temperature, dissolved oxygen and oxidation reduction potential) during all sampling events. Field parameters 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) and dissolved organic carbon (DOC). A 0.45 micron filter was used to collect dissolved metals and DOC samples. All subsamples (save general chemistry/anions) were preserved in the field and submitted to ALS Environmental in Burnaby, BC, for analysis. Summarized water quality results for 7SA5 are included in Appendix B2. Quality control and quality assurance of the results are discussed in Appendix B3, while complete laboratory reports are provided in Appendix B4.

Table B-1:
7 South Area 5 Groundwater Sampling Summary

Well	Completion Date	Sampling Date	Sampling Event Purged Volume (L)	Sampling Event Purged Casing Vol.	Sampling Method	pH	Temp (^{o}C)	EC (uS/cm)	DO (mg/L)	ORP (mV)	Alkalinity (mg/L $CaCO_3$)	Comments
QU11-18S	12-Dec-11	1-Mar-12	105	4.5	H	7.72	4.1	0.346	8.66	162	114	grey, slight-mod. turbid
		16-May-12	80	3.4	H	8.28	7.9	0.258	3.03	65.9	126	grey, slight-mod. turbid
QU11-18D	12-Dec-11	29-Feb-12	270	2.9	H	7.85	6.03	0.309	5.92	-142.1	174	slight turbid, frothy
		15-May-12	367	4.0	H	8.13	7.6	0.298	--	-262.1	165	clear, slight effervescence
QU11-38		25-OCT-12	165434	129	S	--	7.5	--	0.17	-144	--	clear, slight effervescence, smells eggy
		26-OCT-12	335984	263	S	--	7.6	--	0.08	-164.7	--	clear, slight effervescence, smells eggy
		27-OCT-12	492890	386	S	--	7.6	--	0.19	-160.3	--	clear, slight effervescence, smells eggy
QU11-36S	15-Dec-11	28-Feb-12	320	9.9	H	6.66	5.94	0.175	1.37	54.5	96	brown, mod. turbid
		14-May-12	236	8.4	H	6.5	7.8	0.165	--	35.4	90	orange-brown, slight-mod turbid
		19-Nov-12	270	8.2	H	6.04	6.87	179	--	89.3	93	orange-brown, slightly turbid
QU11-36D	20-Dec-11	2-Mar-12	360	4.1	H	7.49	6.43	0.372	0.45	-126.2	162	clear, collect duplicate PW1
		15-May-12	290	3.5	H	7.62	8	0.344	--	-133.9	165	clear, slight effervescence
		19-Nov-12	240	2.9	H	7.33	6.99	324	0.89	-113.2	174	clear, slight effervescence, water level had stabilized
QU11-28	14-Dec-11	21-Mar-12	110	2.2	H	7.46	6.41	0.405	0.38	-89.6	219	slightly frothy, some dark flecks (silt) at end of purging
		17-May-12	268	5.2	H	7.8	7.63	0.37	2.34	-116.9	195	clear, collect duplicate PW5
QU08-10	20-Apr-10	26-May-10	40	3.4	H	7.04	8.17	594	0.81	108	--	n/a
		20-Mar-12	32	2.2	BP	7.41	4.63	0.524	0.27	-0.2	162	clear, parameters and WL had not stabilized
		17-May-12	15	1.6	BP	7.52	9.6	0.4	--	75.4	171	clear, ORP and WL had not stabilized
		19-Nov-12	9	1.5	BP	8.51	7.64	331	--	21.8	--	clear, WL had not stabilized
242 Portal	n/a	21-Jan-11	26	n/a	P	5.86	2.85	321	3.88	276.6	51	colloidal iron sludge was drawn through the tube during purge and sampling, repeat sampling with a longer purge
		23-Jan-11	140		P	6.01	3.94	306	5.62	33.7	45	colloidal iron particles still drawn through the tube during purge and sampling (significantly less than with the first sampling)
		3-Mar-12	85		P	6.38	5.25	0.3	3.01	118.6	60	clear with some suspended Fe particles, used 0.2um filter
		14-May-12	58		P	6.63	8.6	0.281	2.47	16.9	72	clear with some suspended Fe particles, collect two dissolved metals samples - main sample filtered through 0.45 micron (incl. DOC); 242 Portal_2 DM sample filtered with 0.2 micron filter

n/a not applicable
1. H = Hydrolift, BP = portable bladder pump, S= submersible pump, P = peristaltic pump

Figure B1-1: Sampling at the 242 Mine Portal (March, 2012).

APPENDIX B2 GROUNDWATER QUALITY RESULTS

Sample ID		Mine Water 242 PORTAL	Mine Water 242 PORTAL	Mine Water 242 PORTAL	Mine Water 242 PORTAL	No.4 QU08-10	No.4 QU08-11	No.4 QU08-12	No.4 QU08-13	Till QU11-18S	Till QU11-18S	SST QU11-18D	SST QU11-18D	No.4 QU11-28	No.4 QU11-28
Date Sampled		21-Jan-11	23-Jan-11	19-Mar-12	14-May-12	26-May-10	20-Mar-12	17-May-12	19-NOV-12	02-Mar-12	16-May-12	29-Feb-12	15-May-12	21-Mar-12	17-May-12
Time Sampled		16:45	16:13	15:00	16:00	14:00	14:00	14:00	17:00	10:30	13:00	13:00	17:45	17:00	15:15
ALS Sample ID		L973238-2	L973239-2	L1126875-1	L1148808-2	L891772-4	L1126875-2	L1149837-2	L1241567-3	L1120238-4	L1149837-1	L1120238-2	L1148808-3	L1126875-5	L1149837-3
Matrix		Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
Area		242	242	242	242	242/7S	242/7S	242/7S	242/7S	7S A5	7S A5	7S A5	7S A5	7S A5	7S A5
Sampled by		Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax
Physical Tests															
Colour, True	CU					13.8									
Field Conductivity	uS/cm	321	306	300	281	594	524	400	533	346	258	309	298	405	370
Conductivity	uS/cm	318	316	302	291	574	498	382	331	341	261	314	297	405	364
Hardness (as CaCO3)	mg/L	159	151	141	136	250	234	203	154	80.1	72.7	72.9	71.8	138	148
Field pH	pH	5.86	6.01	6.38	6.63	7.04	7.41	7.52	8.51	7.72	8.28	7.85	8.13	7.46	7.8
pH	pH	6.97	7.02	7.50	7.71	7.34	8.14	8.11	8.22	8.21	8.22	8.31	8.37	8.19	8.15
Field Eh	eV	276.6	33.7	118.60	16.9	108.0	-0.20	75.4	21.8	162	65.9	-142.1	-262.1	-89.60	-116.9
Field Temperature	C	2.85	3.94	5.25	8.6	8.17	4.63	9.6	7.64	4.1	7.9	6.03	7.6	6.41	7.63
Total Suspended Solids	mg/L	38.0	12.0	7.3	3.3	224	6.7	37.5	28	1020	3270	76.7	49.3	201	8.8
Total Dissolved Solids	mg/L	197	204	192	182	387	319	230	202	232	183	193	157	244	214
Turbidity	NTU	107	33.9	11.5	2.69	191	12.4	14.2	34.1	972	4000	17.5	9.87	87.1	3.6
Anions and Nutrients															
Acidity (as CaCO3) (pH 8.3)	mg/L	11.4	10.2	7.2	5.7		3.7	3.3	1.1	1.5	1.1	*1*	*1*	2.9	3.1
Field Alkalinity, Total (as CaCO3)	mg/L	51	45	60.0	72		162	171	276	114	126	174	165	219.0	195
Alkalinity, Total (as CaCO3)	mg/L	40.8	38.3	49.6	64.4	192	169	158	171	114	116	167	162	204	192
Ammonia as N	mg/L	*0.005*	*0.005*	*0.005*	*0.005*	0.012	0.0960	0.0864	0.0058	0.144	0.236	0.230	0.184	0.74	0.66
Bromide (Br)	mg/L	*0.05*	*0.05*	*0.05*	*0.05*	*0.05*	*0.05*	*0.05*	*0.05*	0.064	*0.05*	*0.05*	*0.05*	*0.05*	*0.05*
Chloride (Cl)	mg/L	*0.5*	*0.5*	0.66	0.54	5.28	1.18	0.74	0.6	2.23	0.88	0.73	0.63	2.64	1.39
Fluoride (F)	mg/L	0.073	0.091	0.114	0.127	0.217	0.531	0.58	0.58	0.209	0.175	1.40	1.43	0.345	0.393
Nitrate (as N)	mg/L	0.0106	0.0103	0.0127	0.0135	0.0113	*0.005*	*0.005*	0.27	*0.005*	*0.005*	*0.005*	*0.005*	*0.005*	*0.005*
Nitrite (as N)	mg/L	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	0.0049	0.0028	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*
Total Kjeldahl Nitrogen	mg/L	0.098							0.08						
Total Nitrogen	mg/L	*0.05*	*0.05*	*0.05*	*0.05*		*0.05*	0.05	0.353	0.410	0.9	0.140	0.1	0.826	0.63
Field Dissolved Oxygen mg/L	mg/L			3.01	2.47		0.27			8.66	3.03	5.92		0.380	2.34
Ortho Phosphate as P	mg/L			*0.001*	*0.001*	0.0159	0.0177	0.0181			0.0226		0.023	0.0084	0.0047
Total Dissolved Phosphate As P	mg/L	*0.002*	*0.002*	*0.002*	*0.002*		0.0187	0.021	0.0181	0.0402	0.031	0.0147	0.0262	0.0079	*0.002*
Total Phosphate as P	mg/L	0.0213	0.0060	0.0039	*0.002*	0.227	0.0486	0.0568	0.0484	0.684	2.45	0.0519	0.0607	0.126	0.0398
Sulfate (SO4)	mg/L	110	109	92.8	83.6	112	98.9	49	19.3	57.1	22	3.96	3.45	20.8	13.5
Sulphide as S	mg/L	0.0031	0.0025	*0.002*	*0.002*	*0.02*	*0.002*	*0.002*	*0.002*	*0.002*	0.0024	*0.002*	*0.002*	*0.002*	*0.002*
Dissolved Metal Species															
Iron, Dissolved Ferrous		*0.02*	*0.02*												
Iron, Dissolved Ferric		*0.05*	*0.05*												
Iron, Dissolved Total		*0.03*	*0.03*												
Organic / Inorganic Carbon															
Dissolved Organic Carbon	mg/L	0.59	0.67	2.01	2.04		5.01	1.64	1.51	3.71	6.84	1.06	2.14	4.75	2.58
Total Organic Carbon	mg/L	2.32	1.32	0.70	1.15	8.22	2.48	1.59	1.1	13.8	32	1.21	1.95	7.58	2.78

Sample ID		Mine Water 242 PORTAL	Mine Water 242 PORTAL	Mine Water 242 PORTAL	Mine Water 242 PORTAL	No.4 QU08-10	No.4 QU08-11	No.4 QU08-12	No.4 QU08-13	Till QU11-18S	Till QU11-18S	SST QU11-18D	SST QU11-18D	No.4 QU11-28	No.4 QU11-28
Date Sampled		21-Jan-11	23-Jan-11	19-Mar-12	14-May-12	26-May-10	20-Mar-12	17-May-12	19-NOV-12	02-Mar-12	16-May-12	29-Feb-12	15-May-12	21-Mar-12	17-May-12
Time Sampled		16:45	16:13	15:00	16:00	14:00	14:00	14:00	17:00	10:30	13:00	13:00	17:45	17:00	15:15
ALS Sample ID		L973238-2	L973239-2	L1126875-1	L1148808-2	L891772-4	L1126875-2	L1149837-2	L1241567-3	L1120238-4	L1149837-1	L1120238-2	L1148808-3	L1126875-5	L1149837-3
Matrix		Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
Area		242	242	242	242	242/7S	242/7S	242/7S	242/7S	7S A5	7S A5	7S A5	7S A5	7S A5	7S A5
Sampled by		Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax
Total Metals															
Aluminum (Al)-Total	mg/L	0.921	0.351	0.121	0.0436	2.97	0.194	0.446	0.621	31.4	35.1	0.916	0.933	2.28	0.275
Antimony (Sb)-Total	mg/L	0.00109	0.00048	0.00029	0.0003	0.00044	0.00017	0.00017	0.00017	0.00040	0.0004	*0.0001*	*0.0001*	*0.0001*	*0.0001*
Arsenic (As)-Total	mg/L	0.342	0.120	0.0362	0.0167	0.00809	0.00518	0.00247	0.00193	0.0192	0.0408	0.0362	0.0428	0.163	0.242
Barium (Ba)-Total	mg/L	0.0741	0.0644	0.0587	0.0546	0.116	0.104	0.0999	0.132	0.215	0.412	0.172	0.165	0.242	0.319
Beryllium (Be)-Total	mg/L	*0.0005*	*0.0005*	*0.0001*	*0.0001*	*0.0005*	*0.0001*	*0.0001*	*0.0001*	0.00088	0.00198	*0.0001*	*0.0001*	0.00026	*0.0001*
Bismuth (Bi)-Total	mg/L	*0.0005*	*0.0005*	*0.0005*	*0.0005*	*0.0005*	*0.0005*	*0.0005*	*0.0005*	*0.0005*	*0.001*	*0.0005*	*0.0005*	*0.0005*	*0.0005*
Boron (B)-Total	mg/L	0.095	0.097	0.111	0.101	0.164	0.249	0.247	0.197	0.049	0.047	0.636	0.566	0.361	0.416
Cadmium (Cd)-Total	mg/L	0.000078	0.000054	0.000028	0.000018	0.000276	0.000029	0.000045	0.000052	0.000400	0.000982	0.000013	0.000016	0.000095	*0.00001*
Calcium (Ca)-Total	mg/L	53.6	52.0	50.8	48.1	75.3	68.8	63.7	49	46.9	74.9	22.1	20.3	48.4	46.3
Chromium (Cr)-Total	mg/L	0.00076	0.00032	*0.0002*	0.00013	0.00250	*0.0004*	0.00052	0.00089	0.0304	0.0366	0.00098	0.00098	0.00155	0.00015
Cobalt (Co)-Total	mg/L	0.00515	0.00521	0.00267	0.00133	0.0117	0.00284	0.00154	0.00222	0.0209	0.0315	0.00098	0.00093	0.00287	0.00076
Copper (Cu)-Total	mg/L	0.00965	0.00603	0.00231	0.00094	0.00855	0.00091	0.00126	0.00392	0.0977	0.165	0.00421	0.00269	0.0141	*0.0005*
Iron (Fe)-Total	mg/L	16.7	6.24	1.96	0.802	6.33	0.490	0.887	1.85	42.2	53.1	1.60	1.19	2.95	0.492
Lead (Pb)-Total	mg/L	0.000435	0.000163	0.000075	*0.00005*	0.00218	0.000233	0.00029	0.000669	0.00791	0.017	0.000654	0.000626	0.00233	0.000115
Lithium (Li)-Total	mg/L	0.0089	0.0086	0.0110	0.00937	*0.005*	0.00100	0.001	0.00145	0.0101	0.0117	0.0202	0.0179	0.0248	0.033
Magnesium (Mg)-Total	mg/L	3.91	3.79	4.09	3.89	13.6	14.0	12.1	9.51	16.6	21	5.84	5.1	9.33	8.12
Manganese (Mn)-Total	mg/L	0.304	0.238	0.160	0.1	0.846	0.417	0.326	0.0838	1.01	1.59	0.198	0.149	0.907	0.534
Mercury (Hg)-Total	mg/L	*0.00001*	*0.00001*	*0.00001*	*0.00001*		*0.00001*	*0.00001*	*0.00001*	0.000032	0.000145	*0.00001*	*0.00001*	*0.00001*	*0.00001*
Molybdenum (Mo)-Total	mg/L	0.00131	0.000574	0.000367	0.000285	0.00346	0.00419	0.0026	0.000722	0.00468	0.00237	0.00148	0.00159	0.00170	0.000944
Nickel (Ni)-Total	mg/L	0.0101	0.00966	0.00525	0.00326	0.0119	0.00294	0.00248	0.00414	0.0284	0.0404	0.00165	0.0012	0.00293	0.0006
Phosphorus (P)-Total	mg/L	*0.3*	*0.3*	*0.3*	*0.3*	*0.3*	*0.3*	*0.3*	*0.3*	0.66	1.54	*0.3*	*0.3*	*0.3*	*0.3*
Potassium (K)-Total	mg/L	*2*	*2*	*2*	*2*	3.6	2.8	2.7	2.3	3.7	4.1	2.3	2.2	2.7	2.6
Selenium (Se)-Total	mg/L	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0005*	*0.0001*	*0.0001*	0.00017	0.00059	0.0005	*0.0001*	*0.0001*	*0.0001*	*0.0001*
Silicon (Si)-Total	mg/L	4.42	3.68	3.52	3.2	11.9	3.96	5.09	4.88	53.6	55.8	7.32	7.46	12.2	6.68
Silver (Ag)-Total	mg/L	*0.00001*	*0.00001*	*0.00001*	*0.00001*	0.000039	*0.00001*	*0.00001*	0.000013	0.000101	0.000081	*0.00001*	*0.00001*	*0.00001*	*0.00001*
Sodium (Na)-Total	mg/L	4.1	4.0	4.8	4.5	40.1	17.9	9.6	3.8	44.0	31.9	42.0	41	39.2	29.4
Strontium (Sr)-Total	mg/L	0.104	0.0987	0.124	0.105	0.318	0.546	0.427	0.371	0.256	0.355	0.345	0.276	0.533	0.456
Thallium (Tl)-Total	mg/L	0.00032	0.00033	0.000257	0.000196	*0.0001*	0.000039	0.00004	0.000035	0.000324	0.000587	0.000014	0.000016	0.000063	0.000012
Tin (Sn)-Total	mg/L	*0.0001*	*0.0001*	*0.0001*	*0.0001*	0.00025	*0.0001*	0.0001	0.00012	0.00055	0.00158	*0.0001*	0.00022	0.00074	*0.0001*
Titanium (Ti)-Total	mg/L	0.012	*0.01*	*0.01*	*0.01*	0.095	0.012	0.029	0.028	1.84	1.35	0.051	0.038	0.126	*0.01*
Uranium (U)-Total	mg/L	0.000156	0.000059	0.000019	*0.00001*	0.00615	0.00260	0.00164	0.000695	0.00347	0.00449	0.000307	0.000288	0.00135	0.000468
Vanadium (V)-Total	mg/L	0.0024	*0.001*	*0.001*	*0.001*	0.0068	*0.001*	0.0013	0.0022	0.103	0.132	0.0029	0.002	0.0076	*0.001*
Zinc (Zn)-Total	mg/L	0.0576	0.0393	0.0213	0.0139	0.0120	0.0030	0.0036	0.0043	0.0738	0.109	0.0053	0.0056	0.0125	*0.003*

Sample ID		**Mine Water 242 PORTAL**	**Mine Water 242 PORTAL**	**Mine Water 242 PORTAL**	**Mine Water 242 PORTAL**	**No.4 QU08-10**	**No.4 QU08-11**	**No.4 QU08-12**	**No.4 QU08-13**	**Till QU11-18S**	**Till QU11-18S**	**SST QU11-18D**	**SST QU11-18D**	**No.4 QU11-28**	**No.4 QU11-28**
Date Sampled		21-Jan-11	23-Jan-11	19-Mar-12	14-May-12	26-May-10	20-Mar-12	17-May-12	19-NOV-12	02-Mar-12	16-May-12	29-Feb-12	15-May-12	21-Mar-12	17-May-12
Time Sampled		16:45	16:13	15:00	16:00	14:00	14:00	14:00	17:00	10:30	13:00	13:00	17:45	17:00	15:15
ALS Sample ID		L973238-2	L973239-2	L1126875-1	L1148808-2	L891772-4	L1126875-2	L1149837-2	L1241567-3	L1120238-4	L1149837-1	L1120238-2	L1148808-3	L1126875-5	L1149837-3
Matrix		Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
Area		242	242	242	242	242/7S	242/7S	242/7S	242/7S	7S A5	7S A5	7S A5	7S A5	7S A5	7S A5
Sampled by		Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax
Dissolved Metals															
Aluminum (Al)-Dissolved	mg/L	*0.003*	0.0108	0.0053	*0.003*	0.0051	*0.003*	*0.003*	*0.003*	0.0149	0.0334	0.0069	0.0068	0.0052	0.0046
Antimony (Sb)-Dissolved	mg/L	0.00012	0.00014	0.00016	0.00016	0.00036	0.00017	0.00013	0.00011	0.00036	0.00029	*0.0001*	*0.0001*	*0.0001*	*0.0001*
Arsenic (As)-Dissolved	mg/L	0.00071	0.00040	0.00042	0.00033	0.00126	0.00528	0.00161	0.00056	0.00231	0.00625	0.0378	0.0412	0.169	0.238
Barium (Ba)-Dissolved	mg/L	0.0666	0.0616	0.0555	0.055	0.0612	0.100	0.0906	0.106	0.0207	0.0208	0.169	0.168	0.214	0.312
Beryllium (Be)-Dissolved	mg/L	*0.0005*	*0.0005*	*0.0001*	*0.0001*	*0.0005*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*
Bismuth (Bi)-Dissolved	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*	*0.0005*
Boron (B)-Dissolved	mg/L	0.087	0.096	0.104	0.095	0.160	0.243	0.23	0.165	0.035	0.033	0.656	0.507	0.347	0.404
Cadmium (Cd)-Dissolved	mg/L	0.000042	0.000040	0.000020	0.000014	0.000093	0.000019	0.000034	0.000043	*0.00001*	0.000011	*0.00001*	*0.00001*	*0.00001*	*0.00001*
Calcium (Ca)-Dissolved	mg/L	57.0	54.0	49.7	49.6	78.1	69.9	61.9	47.1	26.7	24	20.5	19	42.2	46.3
Chromium (Cr)-Dissolved	mg/L	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0005*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*
Cobalt (Co)-Dissolved	mg/L	0.00342	0.00347	0.00145	0.00074	0.00300	0.00203	0.00099	0.00011	0.00025	0.00017	0.00026	0.00013	0.00116	0.00071
Copper (Cu)-Dissolved	mg/L	*0.0005*	0.00157	*0.0005*	*0.0005*	0.00134	*0.0005*	*0.0005*	0.00071	*0.0005*	*0.0005*	*0.0005*	*0.0005*	*0.0005*	*0.0005*
Iron (Fe)-Dissolved	mg/L	*0.03*	*0.03*	*0.03*	*0.03*	*0.03*	*0.03*	*0.03*	*0.03*	0.051	0.037	0.353	0.306	0.199	0.376
Lead (Pb)-Dissolved	mg/L	*0.00005*	*0.00005*	*0.00005*	*0.00005*	0.000068	*0.00005*	*0.00005*	*0.00005*	*0.00005*	*0.00005*	*0.00005*	*0.00005*	*0.00005*	*0.00005*
Lithium (Li)-Dissolved	mg/L	0.0088	0.0086	0.0111	0.00986	*0.005*	0.00101	0.00073	0.00069	*0.0005*	*0.0005*	0.0209	0.0171	0.0238	0.0333
Magnesium (Mg)-Dissolved	mg/L	4.08	3.89	4.03	3.83	13.2	14.4	11.8	8.79	3.27	3.1	5.25	4.63	7.90	7.89
Manganese (Mn)-Dissolved	mg/L	0.219	0.155	0.0993	0.0704	0.622	0.374	0.3	0.00943	0.206	0.125	0.179	0.136	0.799	0.518
Mercury (Hg)-Dissolved	mg/L	*0.00001*	*0.00001*	*0.00001*	*0.00001*		*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*
Molybdenum (Mo)-Dissolved	mg/L	0.000096	0.000102	0.000156	0.000192	0.00313	0.00432	0.00239	0.000633	0.00543	0.00373	0.00154	0.00147	0.00175	0.000858
Nickel (Ni)-Dissolved	mg/L	0.00832	0.00821	0.00409	0.00283	0.00679	0.00227	0.0016	0.00196	0.00084	0.00081	*0.0005*	*0.0005*	0.00105	0.00052
Phosphorus (P)-Dissolved	mg/L	*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*
Potassium (K)-Dissolved	mg/L	*2*	*2*	*2*	*2*	3.2	2.9	2.6	2.2	*2*	*2*	2.3	2.1	2.4	2.5
Selenium (Se)-Dissolved	mg/L	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0005*	*0.0001*	*0.0001*	0.00017	0.00029	0.00018	*0.0001*	*0.0001*	*0.0001*	*0.0001*
Silicon (Si)-Dissolved	mg/L	3.57	3.38	3.33	3.08	5.16	3.71	3.71	3.85	2.91	3.09	5.61	5.18	5.09	5.52
Silver (Ag)-Dissolved	mg/L	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*
Sodium (Na)-Dissolved	mg/L	4.2	4.1	4.7	4.5	40.2	18.5	9.3	3.5	42.6	28.5	43.2	40.8	39.8	28.2
Strontium (Sr)-Dissolved	mg/L	0.105	0.101	0.122	0.101	0.298	0.529	0.396	0.355	0.152	0.126	0.337	0.249	0.494	0.438
Thallium (Tl)-Dissolved	mg/L	0.00028	0.00033	0.000259	0.000172	*0.0001*	0.000036	0.00003	0.000023	0.000029	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*
Tin (Sn)-Dissolved	mg/L	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	0.00011	*0.0001*
Titanium (Ti)-Dissolved	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*	*0.01*	*0.01*
Uranium (U)-Dissolved	mg/L	*0.00001*	*0.00001*	*0.00001*	*0.00001*	0.00524	0.00251	0.00151	0.000614	0.00228	0.0017	0.000142	0.00009	0.000884	0.000416
Vanadium (V)-Dissolved	mg/L	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	0.0016	0.0034	*0.001*	*0.001*	*0.001*	*0.001*
Zinc (Zn)-Dissolved	mg/L	0.0294	0.0295	0.0164	0.0115	0.0043	*0.003*	*0.003*	0.0064	*0.003*	*0.003*	*0.003*	0.0043	*0.003*	*0.003*

Results in red italics are greater than number indicated.
Results in blue italics are below the detection limit indicated.

Sample ID		**frSST QU11-36S**	**frSST QU11-36S**	**frSST QU11-36S**	**frSST QU11-36D**	**frSST QU11-36D**	**frSST QU11-36D**	**frSST QU11-38**	**frSST QU11-39**	**frSST QU11-40**	**Guideline and Permit Limits**	**CSR notes**			
Date Sampled		28-Feb-12	14-May-12	19-NOV-12	02-Mar-12	15-May-12	19-NOV-12	25-OCT-12	26-OCT-12	27-OCT-12	Effluent Permit PE-07008 [a]	BC CSR-AW [b, f]		BC WQG-AL [c, d, e, f]	BC WQG-AL [c, d, e, f]
Time Sampled		15:00	15:30	12:30	16:00	13:00	16:30	13:15	14:15	13:15		CSR-AW (freshwater)[2]		30 day	Max
ALS Sample ID		L1120238-1	L1148808-1	L1240539-3	L1120238-5	L1148808-4	L1240539-4	L1230464-1	L1230464-2	L1230464-3					
Matrix		Water	Water	Water	Water	Water	Water	Water	Water	Water					
Area		7S A5	7S A5	7S A5	7S A5	7S A5	7S A5	7S A5	7S A5	7S A5					
Sampled by		Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax					
Physical Tests															
Colour, True	CU														
Field Conductivity	uS/cm	175	165	179	372	344	324	605	611	614					
Conductivity	uS/cm	171	169	179	364	341	323	309	308	309					
Hardness (as CaCO3)	mg/L	92	88.6	96.5	171	173	163	109	110	110					
Field pH	pH	6.66	6.50	6.04	7.49	7.62	7.33	7.94	7.94	7.93	6.0 - 8.5			6.5-9	NP
pH	pH	7.44	7.62	7.70	8.18	8.21	8.3	8.38	8.33	8.35	6.0 - 8.5			6.5-9	NP
Field Eh	eV	54.5	35.4	89.3	-126.2	-133.9	-113.2	-144	-165	-160					
Field Temperature	C	5.94	7.80	6.87	6.43	8.00	6.99	7.5	7.6	7.6					
Total Suspended Solids	mg/L	857	372	97.3	38	122	4.7	*3*	*3*	*3*					
Total Dissolved Solids	mg/L	140	109	111	206	184	190	189	176	184					
Turbidity	NTU	1390	455	172	23.8	55.7	8.86	26.6	11.9	12.3					
Anions and Nutrients															
Acidity (as CaCO3) (pH 8.3)	mg/L	4.4	7.5	5.0	1.7	2	*1*	*1*	*1*	*1*					
Field Alkalinity, Total (as CaCO3)	mg/L	96	90	93.0	162	165	174								
Alkalinity, Total (as CaCO3)	mg/L	81.8	84.2	87.2	164	160	163	162	164	168				NP	10
Ammonia as N	mg/L	0.0067	*0.005*	*0.005*	0.138	0.116	0.133	0.150	0.144	0.145	1.0	11.3	h	1.85	12.7
Bromide (Br)	mg/L	*0.05*	*0.05*	*0.05*	0.062	*0.05*	*0.05*	*0.050*	*0.050*	*0.050*					
Chloride (Cl)	mg/L	0.57	0.6	0.53	1.08	0.79	0.65	0.690	0.750	0.780		1500		150	600
Fluoride (F)	mg/L	0.024	0.021	0.025	0.618	0.644	0.698	0.972	0.999	0.998		2	i	NP	0.2
Nitrate (as N)	mg/L	*0.005*	*0.005*	0.0144	*0.005*	*0.005*	*0.005*	*0.005*	*0.005*	*0.005*		400		3	32.8
Nitrite (as N)	mg/L	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*		0.2	k	0.02	0.06
Total Kjeldahl Nitrogen	mg/L														
Total Nitrogen	mg/L	0.06	*0.05*	*0.05*	0.06	0.12	0.08	0.13	0.14	0.15					
Field Dissolved Oxygen mg/L	mg/L	1.37			0.45		0.89	0.17	0.08	0.19					
Ortho Phosphate as P	mg/L		*0.001*			0.0051		0.0062	0.0046	0.0046	0.03				
Total Dissolved Phosphate As P	mg/L	0.0021	*0.002*	*0.002*	0.0147	0.0171	0.0118	0.0111	0.0117	0.0081	0.03				
Total Phosphate as P	mg/L	0.296	0.165	0.055	0.0986	0.086	0.0335	0.0271	0.0194	0.0219	0.03				
Sulfate (SO4)	mg/L	9.7	10.5	9.66	31.9	21.5	14.4	10.6	8.53	7.96		1000		50	100
Sulphide as S	mg/L	*0.002*	*0.002*	*0.002*	*0.002*	*0.002*	0.0029	0.234	0.255	0.216		0.02			0.002
Dissolved Metal Species															
Iron, Dissolved Ferrous															
Iron, Dissolved Ferric															
Iron, Dissolved Total															
Organic / Inorganic Carbon															
Dissolved Organic Carbon	mg/L	0.51	1.41	*0.5*	0.91	1.63	*0.5*	0.82	1.09	0.89					
Total Organic Carbon	mg/L	9.97	4.73	1.58	0.95	2.48	0.57	0.86	0.71	0.81					

Sample ID		**frSST QU11-36S**	**frSST QU11-36S**	**frSST QU11-36S**	**frSST QU11-36D**	**frSST QU11-36D**	**frSST QU11-36D**	**frSST QU11-38**	**frSST QU11-39**	**frSST QU11-40**	**Guideline and Permit Limits**	**CSR notes**		
Date Sampled		28-Feb-12	14-May-12	19-NOV-12	02-Mar-12	15-May-12	19-NOV-12	25-OCT-12	26-OCT-12	27-OCT-12	Effluent Permit PE-07008 [a]	BC CSR-AW [b, f]	BC WQG-AL [c, d, e, f]	BC WQG-AL [c, d, e, f]
Time Sampled		15:00	15:30	12:30	16:00	13:00	16:30	13:15	14:15	13:15		CSR-AW (freshwater)[2]	30 day	Max
ALS Sample ID		L1120238-1	L1148808-1	L1240539-3	L1120238-5	L1148808-4	L1240539-4	L1230464-1	L1230464-2	L1230464-3				
Matrix		Water	Water	Water	Water	Water	Water	Water	Water	Water				
Area		7S A5	7S A5	7S A5	7S A5	7S A5	7S A5	7S A5	7S A5	7S A5				
Sampled by		Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax				
Total Metals														
Aluminum (Al)-Total	mg/L	13.8	10.1	3.47	0.675	2.97	0.233	1.04	0.217	0.212				
Antimony (Sb)-Total	mg/L	0.0138	0.0132	0.0119	0.00049	0.00085	0.0004	*0.0001*	*0.0001*	*0.0001*			NP	0.02
Arsenic (As)-Total	mg/L	0.503	0.378	0.274	1.59	1.45	1.19	0.348	0.319	0.313			NP	0.005
Barium (Ba)-Total	mg/L	0.306	0.209	0.141	0.129	0.134	0.125	0.135	0.130	0.132			1	5
Beryllium (Be)-Total	mg/L	0.00078	0.00039	0.00014	*0.0001*	0.00018	*0.0001*	*0.0001*	*0.0001*	*0.0001*			0.0053	NP
Bismuth (Bi)-Total	mg/L	*0.0005*	*0.0005*	*0.0005*	*0.0005*	*0.0005*	*0.0005*	*0.0005*	*0.0005*	*0.0005*				
Boron (B)-Total	mg/L	0.023	0.021	0.020	0.519	0.566	0.598	0.536	0.588	0.604			NP	1.2
Cadmium (Cd)-Total	mg/L	0.00051	0.000319	0.000124	0.000027	0.000082	*0.00001*	*0.00001*	*0.00001*	*0.00001*			NP	0.000017
Calcium (Ca)-Total	mg/L	34	31.8	32.9	51.9	52.4	50.6	30.4	30.6	32.0			NP	4
Chromium (Cr)-Total	mg/L	0.0191	0.00911	0.00363	0.0005	0.00231	0.00019	0.00126	0.00029	0.00029			NP	0.001
Cobalt (Co)-Total	mg/L	0.0284	0.016	0.00504	0.00109	0.00209	0.00022	0.00033	*0.0001*	*0.0001*			0.004	0.11
Copper (Cu)-Total	mg/L	0.0543	0.0269	0.00882	0.00147	0.00787	0.00079	0.00121	*0.0005*	0.00085			0.002	0.006
Iron (Fe)-Total	mg/L	42.4	26.7	11.2	1.5	3.13	0.796	0.669	0.392	0.384			NP	1
Lead (Pb)-Total	mg/L	0.00838	0.00385	0.00131	0.000291	0.00128	0.000082	0.000167	*0.00005*	0.000064			0.004	0.03
Lithium (Li)-Total	mg/L	0.0238	0.0128	0.00790	0.0493	0.0499	0.0512	0.0331	0.0338	0.0344			0.096	0.87
Magnesium (Mg)-Total	mg/L	7.01	4.97	3.81	9.11	10.2	9.74	7.14	7.22	7.44				
Manganese (Mn)-Total	mg/L	0.509	0.306	0.176	0.471	0.313	0.136	0.0291	0.0259	0.0257			0.8	1
Mercury (Hg)-Total	mg/L	0.000129	0.0001	0.000023	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*			0.00002	NP
Molybdenum (Mo)-Total	mg/L	0.00123	0.000575	0.00100	0.0355	0.0284	0.0168	0.00244	0.00164	0.00137			1	2
Nickel (Ni)-Total	mg/L	0.0355	0.0199	0.00679	0.0011	0.00222	*0.0005*	0.00130	*0.0005*	*0.0005*			NP	0.025
Phosphorus (P)-Total	mg/L	*0.3*	*0.3*	*0.05*	*0.3*	*0.3*	*0.05*	*0.3*	*0.3*	*0.3*				
Potassium (K)-Total	mg/L	2.5	*2*	0.58	*2*	*2*	0.99	*2*	*2*	*2*			NP	373
Selenium (Se)-Total	mg/L	*0.0001*	0.0001	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*			0.002	NP
Silicon (Si)-Total	mg/L	43.4	18.5	8.53	5.81	11.8	5.34	5.76	4.40	4.46				
Silver (Ag)-Total	mg/L	0.000231	0.000058	0.000022	0.000019	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*			0.00005	0.0001
Sodium (Na)-Total	mg/L	2.3	*2*	1.32	12.9	11.2	10.7	29.3	29.9	30.4				
Strontium (Sr)-Total	mg/L	0.0519	0.0396	0.0404	0.375	0.408	0.409	0.317	0.334	0.348				
Thallium (Tl)-Total	mg/L	0.000181	0.000118	0.000051	0.000016	0.000046	*0.00001*	*0.00001*	*0.00001*	*0.00001*			0.0008	0.0003
Tin (Sn)-Total	mg/L	*0.0001*	0.0002	*0.0001*	*0.0001*	0.00027	*0.0001*	*0.0001*	*0.0001*	*0.0001*				
Titanium (Ti)-Total	mg/L	1.34	0.454	0.136	0.035	0.119	*0.01*	0.068	0.014	0.014			NP	2
Uranium (U)-Total	mg/L	0.00175	0.0009	0.000342	0.000638	0.000572	0.000149	0.000026	0.000011	*0.00001*			NP	0.3
Vanadium (V)-Total	mg/L	0.119	0.0531	0.0208	0.0015	0.0052	*0.001*	0.0029	*0.001*	*0.001*			NP	0.006
Zinc (Zn)-Total	mg/L	0.0608	0.0445	0.0197	0.0042	0.0106	*0.003*	0.0047	*0.003*	*0.003*			0.0075	0.033

Sample ID		**frSST QU11-36S**	**frSST QU11-36S**	**frSST QU11-36S**	**frSST QU11-36D**	**frSST QU11-36D**	**frSST QU11-36D**	**frSST QU11-38**	**frSST QU11-39**	**frSST QU11-40**	**Guideline and Permit Limits**	**CSR notes**			
Date Sampled		28-Feb-12	14-May-12	19-NOV-12	02-Mar-12	15-May-12	19-NOV-12	25-OCT-12	26-OCT-12	27-OCT-12	Effluent Permit PE-07008 [a]	BC CSR-AW [b, f]		BC WQG-AL [c, d, e, f]	BC WQG-AL [c, d, e, f]
Time Sampled		15:00	15:30	12:30	16:00	13:00	16:30	13:15	14:15	13:15		CSR-AW (freshwater)[2]		30 day	Max
ALS Sample ID		L1120238-1	L1148808-1	L1240539-3	L1120238-5	L1148808-4	L1240539-4	L1230464-1	L1230464-2	L1230464-3					
Matrix		Water	Water	Water	Water	Water	Water	Water	Water	Water					
Area		7S A5	7S A5	7S A5	7S A5	7S A5	7S A5	7S A5	7S A5	7S A5					
Sampled by		Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax	Lorax					
Dissolved Metals															
Aluminum (Al)-Dissolved	mg/L	*0.003*	*0.003*	*0.001*	0.0046	0.0048	0.0038	*0.003*	*0.003*	*0.003*	0.5			0.05	0.1
Antimony (Sb)-Dissolved	mg/L	0.00696	0.00467	0.00334	*0.0001*	0.00025	0.00027	*0.0001*	*0.0001*	*0.0001*		0.2		NP	0.02
Arsenic (As)-Dissolved	mg/L	0.0824	0.0377	0.0173	1.68	1.5	1.15	0.355	0.328	0.324		0.05		NP	0.005
Barium (Ba)-Dissolved	mg/L	0.0981	0.1	0.107	0.13	0.129	0.126	0.141	0.137	0.137		10		1	5
Beryllium (Be)-Dissolved	mg/L	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*		0.053		0.0053	NP
Bismuth (Bi)-Dissolved	mg/L	*0.0005*	*0.0005*	*0.0005*	*0.0005*	*0.0005*	*0.0005*	*0.0005*	*0.0005*	*0.0005*					
Boron (B)-Dissolved	mg/L	0.01	0.012	0.013	0.519	0.496	0.574	0.551	0.593	0.611		50		NP	1.2
Cadmium (Cd)-Dissolved	mg/L	*0.00001*	0.000024	0.000032	*0.00001*	0.000021	*0.00001*	*0.00001*	*0.00001*	0.000012		0.0003		NP	0.000017
Calcium (Ca)-Dissolved	mg/L	31.9	30.3	33.0	53.2	52.8	49.8	31.6	31.9	32.0				NP	4
Chromium (Cr)-Dissolved	mg/L	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*		0.01		NP	0.001
Cobalt (Co)-Dissolved	mg/L	0.00131	0.00155	0.00074	0.00057	0.00029	0.00011	*0.0001*	*0.0001*	*0.0001*		0.04		0.004	0.11
Copper (Cu)-Dissolved	mg/L	*0.0005*	*0.0005*	*0.0002*	*0.0005*	*0.0005*	*0.0002*	*0.0005*	*0.0005*	*0.0005*	0.02	0.02	i	0.002	0.006
Iron (Fe)-Dissolved	mg/L	0.416	0.423	0.270	0.82	0.66	0.611	0.260	0.262	0.256	0.5			NP	0.35
Lead (Pb)-Dissolved	mg/L	*0.00005*	*0.00005*	*0.00005*	*0.00005*	*0.00005*	*0.00005*	*0.00005*	*0.00005*	*0.00005*	0.05	0.04	i	0.004	0.03
Lithium (Li)-Dissolved	mg/L	0.0053	0.00447	0.00462	0.0504	0.0467	0.0534	0.0347	0.0357	0.0363				0.096	0.87
Magnesium (Mg)-Dissolved	mg/L	3.03	3.11	3.44	9.2	8.82	9.4	7.33	7.38	7.41					
Manganese (Mn)-Dissolved	mg/L	0.246	0.161	0.102	0.472	0.28	0.128	0.0256	0.0249	0.0251				0.8	1
Mercury (Hg)-Dissolved	mg/L	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*		0.001		0.00002	NP
Molybdenum (Mo)-Dissolved	mg/L	0.000279	0.000203	0.000166	0.0364	0.0269	0.0162	0.00241	0.00165	0.00137		10		1	2
Nickel (Ni)-Dissolved	mg/L	0.00163	0.00213	0.00102	0.00056	*0.0005*	*0.0005*	0.00072	*0.0005*	*0.0005*		0.25	i	NP	0.025
Phosphorus (P)-Dissolved	mg/L	*0.3*	*0.3*	*0.05*	*0.3*	*0.3*	*0.05*	*0.3*	*0.3*	*0.3*					
Potassium (K)-Dissolved	mg/L	*2*	*2*	0.21	*2*	*2*	0.95	*2*	*2*	*2*				NP	373
Selenium (Se)-Dissolved	mg/L	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*		0.01		0.002	NP
Silicon (Si)-Dissolved	mg/L	2.95	2.96	2.87	4.1	4.25	4.57	4.25	4.18	4.15					
Silver (Ag)-Dissolved	mg/L	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*		0.0005	i	0.00005	0.0001
Sodium (Na)-Dissolved	mg/L	2	*2*	1.33	13.5	10.9	10.3	30.3	30.8	30.3					
Strontium (Sr)-Dissolved	mg/L	0.0366	0.0317	0.0354	0.388	0.362	0.388	0.334	0.342	0.349					
Thallium (Tl)-Dissolved	mg/L	*0.00001*	*0.00001*	0.000010	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*	*0.00001*		0.003		0.0008	0.0003
Tin (Sn)-Dissolved	mg/L	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*					
Titanium (Ti)-Dissolved	mg/L	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*		1		NP	2
Uranium (U)-Dissolved	mg/L	0.00005	0.000031	0.000032	0.000574	0.00026	0.000122	0.000013	*0.00001*	*0.00001*		3		NP	0.3
Vanadium (V)-Dissolved	mg/L	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*				NP	0.006
Zinc (Zn)-Dissolved	mg/L	*0.003*	0.0068	0.0043	*0.003*	*0.003*	*0.001*	*0.003*	*0.003*	*0.003*	0.2	0.075	i	0.0075	0.033

Results in red italics are greater than number indicated.
Results in blue italics are below the detection limit indicated.

APPENDIX B3 GROUNDWATER QUALITY QA/QC

Appendix B3. Groundwater Quality QA/QC

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.

Laboratory quality control data indicate good precision, accuracy and contamination control in the laboratory test procedures. The field blank data (Table B3-1) indicates good contamination control with values below the detection limit. The field replicates indicate good precision and sample homogeneity although the field replicates typically each have at least one parameter with a relative percent difference (RPD) greater than 50% (Table B3-1). The parameters with high RPDs include T-Ag (both QU11-36D replicates), bromide, sulphide and T-Al (QU11-14D replicate) and T-Se and T-Ag (QU11-38 replicate).

The water quality consistency was evaluated for the 242 mine portal 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 B3-2). Two or more samples were collected at the 242 Portal, QU08-10, QU11-18S, QU11-18D, QU11-28, QU11-36S, QU11-36D and QU11-38. The highest variability in repeat sampling rounds was observed at QU08-10 where over half of the parameters exceeded 50% RSD. The variability observed in the 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. The remaining wells and the 242 Portal have between approximately 25% and 35% of parameters exceeding 50% RSD or 50% RPD.

The most consistent groundwater water quality was observed at wells QU11-18D and QU11-38 with most parameters at these locations below 50% RPD or 50% RSD. The samples from QU11-38 were collected on three consecutive days during a 73-hour constant rate pumping test at this location, with a duplicate collected on the third day. Field parameters were monitored continuously throughout the pump test and showed rapid stabilization after the onset of pumping (Figure B3-1, Table B3-3).

It should be noted that consecutive samples with variations in total suspended solids (TSS) 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 the 242 Portal (ranging from 3.3 to 38 mg/L), QU08-10 (ranging from 6.7 to 224 mg/L), QU11-18S (ranging from 1020 to 3270 mg/L), QU11-28 (ranging from 8.8 to 201 mg/L), QU11-36S (ranging from 97.3 to 857 mg/L) and QU11-36D (ranging from 4.7 to 122 mg/L).

The January 2011 sampling events at the 242 Portal occurred shortly after the PVC sampling conduit was emplaced (Appendix B1), which disturbed iron hydroxides that had settled along the conveyor belt. The improvement of TSS (from 38 to 3.3 mg/L) at this location is likely due to these precipitates settling out of suspension. As a result of improvement in TSS through time, the 242 Portal shows a decreasing trend for some total metals including aluminum (from 0.921 to 0.0436 mg/L), arsenic (from 0.342 to 0.0167 mg/L) and iron (16.7 to 0.802 mg/L). The decrease in total arsenic is attributed to the decrease in total iron, as arsenic is known to sorb onto ferrous iron. Some dissolved metals (cobalt, copper, manganese, zinc) have also dropped through time at the 242 Portal which has been attributed to the flushing of the mine with oxic recharge waters (Chapter 3).

QU11-18S is screened in till and is also slow to recharge. Water collected during purging is usually silty and the low recharge rates inhibit extensive well development. This has contributed to high and variable levels of TSS at this location. QU11-36S shows a trend of decreasing TSS and several total metals. Parameters displaying this trend include TSS (from 857 to 97.3 mg/L), T-Cr (from 0.0191 to 0.00363 mg/L), T-Fe (from 42.4 to 11.2 mg/L), T-Pb (from 0.00838 to 0.00131 mg/L) and D-As (from 0.0824 to 0.0173 mg/L). This trend in water quality may be attributed to increased well development with each sampling round. QU11-36D does not display this same trend. The TSS at QU11-36D is highest in the May 2012 sample. This is associated with several elevated total metals (e.g., T-Al, T-Fe, T-Pb and T-Zn).

Groundwater collected at QU08-10 appears to be influenced by artefacts of well installation. This is an extremely tight well and recharge is slow; as a consequence less than 2 well volumes were purged prior to the initial sample collection in May 2010. This initial sample was collected using a hydrolift, while subsequent samples were collected using a bladder pump. The initial sample has several parameters that are elevated relative to other QU08-10 samples, including chloride (5.28 mg/L), TOC (8.22 mg/L), T-Al (2.97 mg/L), T-Cd (0.000276 mg/L), T-Co (0.0117 mg/L), T-Fe (6.33 mg/L) and T-Pb (0.00218 mg/L). In addition, the initial QU08-10 has a lower pH (7.34) relative to later samples (range: 8.11 to 8.22). The possibility of well installation artefacts on the water

quality of the May 2010 QU08-10 sample should be considered when reviewing the water quality of this well.

Overall, the water quality data from the 242 Portal and the wells in this area are considered to be representative of the groundwater water quality in the 7 South Area 5, with the exception of the early data from QU08-10. 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 B3-1:
Water Quality Results for Field Replicates and Field Blanks

Sample ID	**Units**	**Field Blank**	**Field Replicate (QU-11-36D)**			**Field Replicate (QU-11-14D)**			**Field Replicate (QU-11-28)**			**Field Replicate (QU-11-38)**			**Field Replicate (QU-11-36D)**		
Date Sampled		22-NOV-12	02-Mar-12	02-Mar-12	RPD [1]	21-Mar-12	21-Mar-12	RPD [1]	17-May-12	17-May-12	RPD [1]	27-Oct-12	27-Oct-12	RPD [1]	19-Nov-12	19-Nov-12	RPD [1]
Physical Tests																	
Conductivity	uS/cm	*2*	364	365	0%	1740	1750	1%	364	364	0%	309	302	2%	323	322	0%
Hardness (as CaCO3)	mg/L	*0.5*	171	171	0%	213	213	0%	148	146	1%	110	110	0%	163	157	4%
pH	pH	5.49	8.18	8.19	0%	8.10	8.10	0%	8.15	8.13	0%	8.35	8.31	0%	8.3	8.29	0%
Total Suspended Solids	mg/L	*3*	38.0	40.0	5%	3.3	4.0	19%	8.8	8.2	7%	*3*	*3*	0%	4.7	4.3	9%
Total Dissolved Solids	mg/L	*10*	206	212	3%	929	924	1%	214	206	4%	184	185	1%	190	186	2%
Turbidity	NTU	*0.1*	23.8	23.5	1%	27.2	25.3	7%	3.60	3.41	5%	12.3	9.98	21%	8.86	9.26	4%
Anions and Nutrients																	
Acidity (as CaCO3)	mg/L	2.1	1.7	1.7	0%	5.8	5.7	2%	3.1	3.3	6%	*1*	*1*	0%	*1*	*1*	0%
Alkalinity, Total (as CaCO3)	mg/L	*2*	164	163	1%	300	297	1%	192	188	2%	168	165	2%	163	165	1%
Ammonia, Total (as N)	mg/L	*0.005*	0.138	0.145	5%	4.76	4.69	1%	0.66	0.585	12%	0.145	0.145	0%	0.133	0.13	2%
Bromide (Br)	mg/L	*0.05*	0.062	*0.05*	21%	3.4	*1*	109%	*0.05*	*0.05*	0%	*0.050*	*0.050*	0%	*0.05*	*0.05*	0%
Chloride (Cl)	mg/L	*0.5*	1.08	1.08	0%	381	384	1%	1.39	1.39	0%	0.780	0.770	1%	0.65	0.65	0%
Fluoride (F)	mg/L	*0.02*	0.618	0.619	0%	0.94	0.94	0%	0.393	0.393	0%	0.998	0.995	0%	0.698	0.698	0%
Nitrate (as N)	mg/L	*0.005*	*0.005*	*0.005*	0%	*0.1*	*0.1*	0%	*0.005*	*0.005*	0%	*0.005*	*0.005*	0%	*0.005*	*0.005*	0%
Nitrite (as N)	mg/L	*0.001*	0.001	*0.001*	0%	*0.02*	*0.02*	0%	*0.001*	*0.001*	0%	*0.001*	*0.001*	0%	*0.001*	*0.001*	0%
Total Nitrogen	mg/L	*0.05*	0.060	0.050	18%	5.79	5.70	2%	0.630	0.680	8%	0.1500	0.1300	14%	0.08	0.05	46%
Orthophosphate-Dissolved (as P)	mg/L	*0.001*				*0.001*	0.0010	0%	0.0047	0.0043	9%	0.0046	0.0043				
Phosphorus (P)-Total Dissolved	mg/L	*0.002*	0.0147	0.0153	4%	0.0023	0.0021	9%	*0.002*	*0.002*	0%	0.0081	0.0094	15%	0.0118	0.0123	4%
Phosphorus (P)-Total	mg/L	*0.002*	0.0986	0.0928	6%	0.0728	0.0748	3%	0.0398	0.0375	6%	0.0219	0.0186	16%	0.0335	0.0374	11%
Sulfate (SO4)	mg/L	*0.5*	31.9	31.9	0%	*10*	*10*	0%	13.5	13.5	0%	7.96	7.95	0%	14.4	14.3	1%
Sulphide as S	mg/L	*0.002*	*0.002*	*0.002*	0%	0.0024	0.0077	105%	*0.002*	*0.002*	0%	0.216	0.202	7%	0.0029	*0.002*	37%
Organic / Inorganic Carbon																	
Dissolved Organic Carbon	mg/L	*0.5*	0.91	0.73	22%	7.53	7.14	5%	2.58	2.58	0%	0.89	0.75	17%	*0.5*	*0.5*	0%
Total Organic Carbon	mg/L	*0.5*	0.95	0.96	1%	5.36	5.36	0%	2.78	2.60	7%	0.81	0.82	1%	0.57	0.67	16%
Total Metals																	
Aluminum (Al)-Total	mg/L	*0.003*	0.675	0.672	0%	0.180	0.0856	71%	0.275	0.267	3%	0.212	0.257	19%	0.233	0.221	5%
Antimony (Sb)-Total	mg/L	*0.0001*	0.00049	0.00050	2%	*0.0002*	*0.0002*	0%	*0.0001*	*0.0001*	0%	*0.0001*	*0.0001*	0%	0.0004	0.0004	0%
Arsenic (As)-Total	mg/L	*0.0001*	1.59	1.63	2%	0.0645	0.0629	3%	0.242	0.244	1%	0.313	0.319	2%	1.19	1.25	5%
Barium (Ba)-Total	mg/L	*0.00005*	0.129	0.130	1%	0.753	0.730	3%	0.319	0.322	1%	0.132	0.134	2%	0.125	0.13	4%
Beryllium (Be)-Total	mg/L	*0.0001*	*0.0001*	*0.0001*	0%	*0.0002*	*0.0002*	0%	*0.0001*	*0.0001*	0%	*0.0001*	*0.0001*	0%	*0.0001*	*0.0001*	0%
Bismuth (Bi)-Total	mg/L	*0.0005*	*0.0005*	*0.0005*	0%	*0.001*	*0.001*	0%	*0.0005*	*0.0005*	0%	*0.0005*	*0.0005*	0%	*0.0005*	*0.0005*	0%
Boron (B)-Total	mg/L	*0.01*	0.519	0.522	1%	2.06	2.12	3%	0.416	0.422	1%	0.604	0.605	0%	0.598	0.616	3%
Cadmium (Cd)-Total	mg/L	*0.00001*	0.000027	0.000023	16%	*0.00002*	*0.00002*	0%	*0.00001*	*0.00001*	0%	*0.00001*	*0.00001*	0%	*0.00001*	*0.00001*	0%
Calcium (Ca)-Total	mg/L	*0.05*	51.9	52.4	1%	61.2	59.9	2%	46.3	47.1	2%	32.0	30.9	3%	50.6	49.9	1%
Chromium (Cr)-Total	mg/L	*0.0001*	0.00050	0.00051	2%	*0.0006*	*0.0004*	40%	0.00015	0.00014	7%	0.00029	0.00031	7%	0.00019	0.0002	5%
Cobalt (Co)-Total	mg/L	*0.0001*	0.00109	0.00112	3%	0.00277	0.00271	2%	0.00076	0.00079	4%	*0.0001*	*0.0001*	0%	0.00022	0.00023	4%
Copper (Cu)-Total	mg/L	*0.0005*	0.00147	0.00138	6%	*0.001*	*0.001*	0%	*0.0005*	*0.0005*	0%	0.00085	0.00074	14%	0.00079	0.00084	6%
Iron (Fe)-Total	mg/L	*0.03*	1.50	1.52	1%	2.68	2.63	2%	0.492	0.489	1%	0.384	0.384	0%	0.796	0.763	4%
Lead (Pb)-Total	mg/L	*0.00005*	0.000291	0.000299	3%	*0.0001*	*0.0001*	0%	0.000115	0.000124	8%	0.000064	0.000080	22%	0.000082	0.000111	30%
Lithium (Li)-Total	mg/L	*0.0005*	0.0493	0.0496	1%	0.100	0.103	3%	0.0330	0.0338	2%	0.0344	0.0345	0%	0.0512	0.0537	5%
Magnesium (Mg)-Total	mg/L	*0.1*	9.11	9.24	1%	14.7	14.3	3%	8.12	8.29	2%	7.44	7.25	3%	9.74	9.43	3%
Manganese (Mn)-Total	mg/L	*0.00005*	0.471	0.476	1%	1.02	1.00	2%	0.534	0.538	1%	0.0257	0.0265	3%	0.136	0.137	1%
Mercury (Hg)-Total	mg/L	*0.00001*	*0.00001*	*0.00001*	0%	*0.00001*	*0.00001*	0%	*0.00001*	*0.00001*	0%	*0.00001*	*0.00001*	0%	*0.00001*	*0.00001*	0%
Molybdenum (Mo)-Total	mg/L	*0.00005*	0.0355	0.0360	1%	0.00137	0.00134	2%	0.000944	0.000940	0%	0.00137	0.00145	6%	0.0168	0.0169	1%
Nickel (Ni)-Total	mg/L	*0.0005*	0.00110	0.00113	3%	0.0030	0.0029	3%	0.00060	0.00059	2%	*0.0005*	*0.0005*	0%	*0.0005*	*0.0005*	0%

Sample ID	Units	Field Blank	Field Replicate (QU-11-36D)			Field Replicate (QU-11-14D)			Field Replicate (QU-11-28)			Field Replicate (QU-11-38)			Field Replicate (QU-11-36D)		
Date Sampled		22-NOV-12	02-Mar-12	02-Mar-12	RPD [1]	21-Mar-12	21-Mar-12	RPD [1]	17-May-12	17-May-12	RPD [1]	27-Oct-12	27-Oct-12	RPD [1]	19-Nov-12	19-Nov-12	RPD [1]
Phosphorus (P)-Total	mg/L	*0.3*	*0.3*	*0.3*	0%	*0.3*	*0.3*	0%	*0.3*	*0.3*	0%	*0.3*	*0.3*	0%	*0.05*	*0.05*	0%
Potassium (K)-Total	mg/L	*2*	*2*	*2*	0%	6.0	5.8	3%	2.6	2.6	0%	*2*	*2*	0%	0.99	0.97	2%
Selenium (Se)-Total	mg/L	*0.0001*	*0.0001*	*0.0001*	0%	*0.0002*	*0.0002*	0%	*0.0001*	*0.0001*	0%	*0.0001*	0.00022	75%	*0.0001*	0.00011	10%
Silicon (Si)-Total	mg/L	*0.05*	5.81	5.79	0%	5.78	5.67	2%	6.68	6.66	0%	4.46	4.46	0%	5.34	5.16	3%
Silver (Ag)-Total	mg/L	*0.00001*	0.000019	*0.00001*	62%	*0.00002*	*0.00002*	0%	*0.00001*	*0.00001*	0%	*0.00001*	0.000283	186%	*0.00001*	0.000416	191%
Sodium (Na)-Total	mg/L	*2*	12.9	13.2	2%	269	262	3%	29.4	29.9	2%	30.4	29.8	2%	10.7	11.2	5%
Strontium (Sr)-Total	mg/L	*0.0002*	0.375	0.382	2%	1.12	1.12	0%	0.456	0.469	3%	0.348	0.358	3%	0.409	0.424	4%
Thallium (Tl)-Total	mg/L	*0.00001*	0.000016	0.000012	29%	0.000046	0.000051	10%	0.000012	0.000010	18%	*0.00001*	*0.00001*	0%	*0.00001*	*0.00001*	0%
Tin (Sn)-Total	mg/L	*0.0001*	*0.0001*	*0.0001*	0%	0.00051	0.00046	10%	*0.0001*	*0.0001*	0%	*0.0001*	*0.0001*	0%	*0.0001*	*0.0001*	0%
Titanium (Ti)-Total	mg/L	*0.01*	0.035	0.036	3%	*0.01*	*0.01*	0%	*0.01*	0.011	10%	0.014	0.019	30%	*0.01*	*0.01*	0%
Uranium (U)-Total	mg/L	*0.00001*	0.000638	0.000646	1%	0.00118	0.00118	0%	0.000468	0.000469	0%	*0.00001*	0.000012	18%	0.000149	0.000146	2%
Vanadium (V)-Total	mg/L	*0.001*	0.0015	0.0014	7%	*0.002*	*0.002*	0%	*0.001*	*0.001*	0%	*0.001*	*0.001*	0%	*0.001*	*0.001*	0%
Zinc (Zn)-Total	mg/L	*0.003*	0.0042	0.0038	10%	*0.006*	*0.006*	0%	*0.003*	*0.003*	0%	*0.003*	*0.003*	0%	*0.003*	*0.003*	0%
Dissolved Metals																	
Aluminum (Al)-Dissolved	mg/L	*0.003*	0.0046	0.0044	4%	*0.006*	*0.006*	0%	0.0046	0.0046	0%	*0.003*	*0.003*	0%	0.0038	0.006	45%
Antimony (Sb)-Dissolved	mg/L	*0.0001*	*0.0001*	*0.0001*	0%	*0.0002*	*0.0002*	0%	*0.0001*	*0.0001*	0%	*0.0001*	*0.0001*	0%	0.00027	0.00029	7%
Arsenic (As)-Dissolved	mg/L	*0.0001*	1.68	1.71	2%	0.0731	0.0739	1%	0.238	0.240	1%	0.324	0.325	0%	1.15	1.31	13%
Barium (Ba)-Dissolved	mg/L	*0.00005*	0.130	0.131	1%	0.691	0.686	1%	0.312	0.317	2%	0.137	0.141	3%	0.126	0.132	5%
Beryllium (Be)-Dissolved	mg/L	*0.0001*	*0.0001*	*0.0001*	0%	*0.0002*	*0.0002*	0%	*0.0001*	*0.0001*	0%	*0.0001*	*0.0001*	0%	*0.0001*	*0.0001*	0%
Bismuth (Bi)-Dissolved	mg/L	*0.0005*	*0.0005*	*0.0005*	0%	*0.001*	*0.001*	0%	*0.0005*	*0.0005*	0%	*0.0005*	*0.0005*	0%	*0.0005*	*0.0005*	0%
Boron (B)-Dissolved	mg/L	*0.01*	0.519	0.517	0%	1.70	1.65	3%	0.404	0.406	0%	0.611	0.573	6%	0.574	0.599	4%
Cadmium (Cd)-Dissolved	mg/L	*0.00001*	*0.00001*	*0.00001*	0%	*0.00002*	*0.00002*	0%	*0.00001*	*0.00001*	0%	0.000012	*0.00001*	18%	*0.00001*	*0.00001*	0%
Calcium (Ca)-Dissolved	mg/L	*0.05*	53.2	53.2	0%	59.0	58.5	1%	46.3	45.4	2%	32.0	31.9	0%	49.8	47.9	4%
Chromium (Cr)-Dissolved	mg/L	*0.0001*	*0.0001*	*0.0001*	0%	0.00029	0.00028	4%	*0.0001*	*0.0001*	0%	*0.0001*	*0.0001*	0%	*0.0001*	*0.0001*	0%
Cobalt (Co)-Dissolved	mg/L	*0.0001*	0.00057	0.00059	3%	0.00282	0.00292	3%	0.00071	0.00070	1%	*0.0001*	*0.0001*	0%	0.00011	0.00012	9%
Copper (Cu)-Dissolved	mg/L	*0.0005*	*0.0005*	*0.0005*	0%	*0.001*	*0.001*	0%	*0.0005*	*0.0005*	0%	*0.0005*	*0.0005*	0%	*0.0002*	*0.0002*	0%
Iron (Fe)-Dissolved	mg/L	*0.03*	0.820	0.824	0%	3.44	3.51	2%	0.376	0.370	2%	0.256	0.256	0%	0.611	0.577	6%
Lead (Pb)-Dissolved	mg/L	*0.00005*	*0.00005*	*0.00005*	0%	*0.0001*	*0.0001*	0%	*0.00005*	*0.00005*	0%	*0.00005*	*0.00005*	0%	*0.00005*	*0.00005*	0%
Lithium (Li)-Dissolved	mg/L	*0.0005*	0.0504	0.0505	0%	0.0844	0.0810	4%	0.0333	0.0337	1%	0.0363	0.0342	6%	0.0534	0.0542	1%
Magnesium (Mg)-Dissolved	mg/L	*0.1*	9.20	9.26	1%	16.0	16.2	1%	7.89	7.80	1%	7.41	7.39	0%	9.4	8.97	5%
Manganese (Mn)-Dissolved	mg/L	*0.00005*	0.472	0.484	3%	1.01	1.02	1%	0.518	0.514	1%	0.0251	0.0256	2%	0.128	0.145	12%
Mercury (Hg)-Dissolved	mg/L	*0.00001*	*0.00001*	*0.00001*	0%	*0.00001*	*0.00001*	0%	*0.00001*	*0.00001*	0%	*0.00001*	*0.00001*	0%	*0.00001*	*0.00001*	0%
Molybdenum (Mo)-Dissolved	mg/L	*0.00005*	0.0364	0.0367	1%	0.00138	0.00133	4%	0.000858	0.000870	1%	0.00137	0.00133	3%	0.0162	0.0162	0%
Nickel (Ni)-Dissolved	mg/L	*0.0005*	0.00056	0.00052	7%	0.0023	0.0025	8%	0.00052	0.00051	2%	*0.0005*	*0.0005*	0%	*0.0005*	*0.0005*	0%
Phosphorus (P)-Dissolved	mg/L	*0.3*	*0.3*	*0.3*	0%	*0.3*	*0.3*	0%	*0.3*	*0.3*	0%	*0.3*	*0.3*	0%	*0.05*	*0.05*	0%
Potassium (K)-Dissolved	mg/L	*2*	*2*	*2*	0%	5.4	5.4	0%	2.5	2.5	0%	*2*	*2*	0%	0.95	0.89	7%
Selenium (Se)-Dissolved	mg/L	*0.0001*	*0.0001*	*0.0001*	0%	*0.0002*	*0.0002*	0%	*0.0001*	*0.0001*	0%	*0.0001*	0.00016	46%	*0.0001*	*0.0001*	0%
Silicon (Si)-Dissolved	mg/L	*0.05*	4.10	4.10	0%	6.44	6.58	2%	5.52	5.44	1%	4.15	4.18	1%	4.57	4.4	4%
Silver (Ag)-Dissolved	mg/L	*0.00001*	*0.00001*	*0.00001*	0%	*0.00002*	*0.00002*	0%	*0.00001*	*0.00001*	0%	*0.00001*	*0.00001*	0%	*0.00001*	*0.00001*	0%
Sodium (Na)-Dissolved	mg/L	*2*	13.5	13.6	1%	215	211	2%	28.2	27.9	1%	30.3	30.5	1%	10.3	11.6	12%
Strontium (Sr)-Dissolved	mg/L	*0.0002*	0.388	0.384	1%	0.991	0.939	5%	0.438	0.438	0%	0.349	0.336	4%	0.388	0.403	4%
Thallium (Tl)-Dissolved	mg/L	*0.00001*	*0.00001*	*0.00001*	0%	*0.00002*	*0.00002*	0%	*0.00001*	*0.00001*	0%	*0.00001*	*0.00001*	0%	*0.00001*	*0.00001*	0%
Tin (Sn)-Dissolved	mg/L	*0.0001*	*0.0001*	*0.0001*	0%	*0.0002*	*0.0002*	0%	*0.0001*	*0.0001*	0%	*0.0001*	*0.0001*	0%	*0.0001*	*0.0001*	0%
Titanium (Ti)-Dissolved	mg/L	*0.01*	*0.01*	*0.01*	0%	*0.01*	*0.01*	0%	*0.01*	*0.01*	0%	*0.01*	*0.01*	0%	*0.01*	*0.01*	0%
Uranium (U)-Dissolved	mg/L	*0.00001*	0.000574	0.000577	1%	0.00115	0.00112	3%	0.000416	0.000403	3%	*0.00001*	*0.00001*	0%	0.000122	0.000125	2%
Vanadium (V)-Dissolved	mg/L	*0.001*	*0.001*	*0.001*	0%	*0.002*	*0.002*	0%	*0.001*	*0.001*	0%	*0.001*	*0.001*	0%	*0.001*	*0.001*	0%
Zinc (Zn)-Dissolved	mg/L	*0.003*	*0.003*	*0.003*	0%	*0.006*	*0.006*	0%	*0.003*	*0.003*	0%	*0.003*	*0.003*	0%	*0.001*	*0.001*	0%

Results in blue italics are below the detection limit indicated.
1 RPD = Relative Percent Difference = 100 * | (result 1 - result 2) / average (result 1, result 2) |. Dissimilar results (>50% difference) are shaded.

Table B3-2: Relative percent difference and relative standard deviation between sampling events at 7SA5

Sample ID		242 PORTAL										QU08-10										QU11-18S					QU11-18D				
Date Sampled		21-Jan-11	23-Jan-11	19-Mar-12	14-May-12							26-May-10	20-Mar-12	17-May-12	19-NOV-12							02-Mar-12	16-May-12				29-Feb-12	15-May-12			
Time Sampled		16:45	16:13	15:00	16:00							14:00	14:00	14:00	17:00							10:30	13:00				13:00	17:45			
ALS Sample ID		L973238-2	L973239-2	L1126875-1	L1148808-2							L891772-4	L1126875-2	L1149837-2	L1241567-3							L1120238-4	L1149837-1				L1120238-2	L1148808-3			
Matrix		Water	Water	Water	Water							Water	Water	Water	Water							Water	Water				Water	Water			
Area		242	242	242	242							242/7S	242/7S	242/7S	242/7S							7S A5	7S A5				7S A5	7S A5			
Sampled by		Lorax	Lorax	Lorax	Lorax	n	Max	Min	Mean	S	%RSD[1]	Lorax	Lorax	Lorax	Lorax	n	Max	Min	Mean	S	%RSD[1]	Lorax	Lorax	n	Mean	RPD[2]	Lorax	Lorax	n	Mean	RPD[2]
Rock type												No. 4/SST	No. 4/SST	No. 4/SST	No. 4/SST							TILL	TILL				SST/SLST	SST/SLST			
Physical Tests																															
Colour, True	CU											13.8				1															
Field Conductivity	uS/cm	321	306	300	281	4	321	281	302.0	16.6	5%	594	524	400	533	4	594	400	512.8	81.3	16%	346	258	2	302.0	29%	309	298	2	303.5	4%
Conductivity	uS/cm	318	316	302	291	4	318	291	306.8	12.7	4%	574	498	382	331	4	574	331	446.3	110.2	25%	341	261	2	301.0	27%	314	297	2	305.5	6%
Hardness (as $CaCO_3$)	mg/L	159	151	141	136	4	159	136	146.8	10.3	7%	250	234	203	154	4	250	154	210.3	42.3	20%	80.1	72.7	2	76.4	10%	72.9	71.8	2	72.4	2%
Field pH	pH	5.86	6.01	6.38	6.63	4	6.63	5.86	6.220	0.350	6%	7.04	7.41	7.52	8.51	4	8.51	7.04	7.620	0.628	8%	7.72	8.28	2	8.000	7%	7.85	8.13	2	7.990	4%
pH	pH	6.97	7.02	7.50	7.71	4	7.71	6.97	7.300	0.363	5%	7.34	8.14	8.11	8.22	4	8.22	7.34	7.953	0.411	5%	8.21	8.22	2	8.215	0%	8.31	8.37	2	8.340	1%
Field Eh	eV	276.6	33.7	118.60	16.9	4	276.6	16.9	111.5	118.8	107%	108.0	-0.20	75.4	21.8	4	108	-0.2	51.3	49.4	96%	162	65.9	2	114.0	84%	-142.1	-262.1	2	-202.1	59%
Field Temperature	C	2.85	3.94	5.25	8.6	4	8.60	2.85	5.160	2.494	48%	8.17	4.63	9.6	7.64	4	9.6	4.63	7.510	2.091	28%	4.1	7.9	2	6.000	63%	6.03	7.6	2	6.815	23%
Total Suspended Solids	mg/L	38.0	12.0	7.3	3.3	4	38	3.3	15.15	15.643	103%	224	6.7	37.5	28	4	224	6.7	74.05	100.793	136%	1020	3270	2	2145	105%	76.7	49.3	2	63	43%
Total Dissolved Solids	mg/L	197	204	192	182	4	204	182	193.8	9.3	5%	387	319	230	202	4	387	202	284.5	84.6	30%	232	183	2	207.5	24%	193	157	2	175.0	21%
Turbidity	NTU	107	33.9	11.5	2.69	4	107	2.69	38.77	47.34	122%	191	12.4	14.2	34.1	4	191	12.4	62.93	85.95	137%	972	4000	2	2486.00	122%	17.5	9.87	2	13.69	56%
																								0							
Anions and Nutrients																								0							
Acidity (as $CaCO_3$) (pH 8.3)	mg/L	11.4	10.2	7.2	5.7	4	11.4	5.7	8.63	2.63	31%		3.7	3.3	1.1	3	3.7	1.1	2.70	1.40	52%	1.5	1.1	2	1.30	31%	*1*	*1*	2	1.00	n/a
Field Alkalinity, Total (as $CaCO_3$)	mg/L	51	45	60.0	72	4	72	45	57.0	11.7	21%		162	171	276	3	276	162	203.0	63.4	31%	114	126	2	120.0	10%	174	165	2	169.5	5%
Alkalinity, Total (as $CaCO_3$)	mg/L	40.8	38.3	49.6	64.4	4	64.4	38.3	48.28	11.79	24%	192	169	158	171	4	192	158	172.50	14.20	8%	114	116	2	115.00	2%	167	162	2	164.50	3%
Ammonia as N	mg/L	*0.005*	*0.005*	*0.005*	*0.005*	4	0.005	0.005	0.0050	0.0000	n/a	0.012	0.0960	0.0864	0.0058	4	0.096	0.0058	0.0501	0.0477	95%	0.144	0.236	2	0.1900	48%	0.230	0.184	2	0.2070	22%
Bromide (Br)	mg/L	*0.05*	*0.05*	*0.05*	*0.05*	4	0.05	0.05	0.050	0.000	n/a	*0.05*	*0.05*	*0.05*	*0.05*	4	0.05	0.05	0.050	0.000	n/a	0.064	*0.05*	2	0.057	25%	*0.05*	*0.05*	2	0.050	n/a
Chloride (Cl)	mg/L	*0.5*	*0.5*	0.66	0.54	4	0.66	0.5	0.550	0.076	14%	5.28	1.18	0.74	0.6	4	5.28	0.6	1.950	2.234	115%	2.23	0.88	2	1.555	87%	0.73	0.63	2	0.680	15%
Fluoride (F)	mg/L	0.073	0.091	0.114	0.127	4	0.127	0.073	0.1013	0.0240	24%	0.217	0.531	0.58	0.58	4	0.58	0.217	0.4770	0.1749	37%	0.209	0.175	2	0.1920	18%	1.40	1.43	2	1.4150	2%
Nitrate (as N)	mg/L	0.0106	0.0103	0.0127	0.0135	4	0.0135	0.0103	0.01178	0.00157	13%	0.0113	*0.005*	*0.005*	0.27	4	0.27	0.005	0.07283	0.13148	181%	*0.005*	*0.005*	2	0.00500	n/a	*0.005*	*0.005*	2	0.00500	n/a
Nitrite (as N)	mg/L	*0.001*	*0.001*	*0.001*	*0.001*	4	0.001	0.001	0.0010	0.0000	n/a	*0.001*	*0.001*	0.0049	0.0028	4	0.0049	0.001	0.0024	0.0019	77%	*0.001*	*0.001*	2	0.0010	n/a	*0.001*	*0.001*	2	0.0010	n/a
Total Kjeldahl Nitrogen	mg/L	0.098				1	0.098	0.098	0.098						0.08	1	0.08	0.08	0.08												
Total Nitrogen	mg/L	*0.05*	*0.05*	*0.05*	*0.05*	4	0.05	0.05	0.050	0.000	n/a		*0.05*	0.05	0.353	3	0.353	0.05	0.151	0.175	116%	0.410	0.9	2	0.655	75%	0.140	0.1	2	0.120	33%
Field Dissolved Oxygen mg/L	mg/L			3.01	2.47	2	3.01	2.47	2.740	0.382	14%		0.27			1	0.27	0.27	0.270		0%	8.66	3.03	2	5.845	96%	5.92		1		
Ortho Phosphate as P	mg/L			*0.001*	*0.001*	2	0.001	0.001	0.0010	0.0000	n/a	0.0159	0.0177	0.0181		3	0.0181	0.0159	0.0172	0.0012	7%		0.0226	1	0.0226	100%		0.023	1	0.0230	100%
Total Dissolved Phosphate As P	mg/L	*0.002*	*0.002*	*0.002*	*0.002*	4	0.002	0.002	0.0020	0.0000	n/a		0.0187	0.021	0.0181	3	0.021	0.0181	0.0193	0.0015	8%	0.0402	0.031	2	0.0356	26%	0.0147	0.0262	2	0.0205	56%
Total Phosphate as P	mg/L	0.0213	0.0060	0.0039	*0.002*	4	0.0213	0.002	0.00830	0.00882	106%	0.227	0.0486	0.0568	0.0484	4	0.227	0.0484	0.09520	0.08795	92%	0.684	2.45	2	1.56700	113%	0.0519	0.0607	2	0.05630	16%
Sulfate (SO_4)	mg/L	110	109	92.8	83.6	4	110	83.6	98.85	12.865	13%	112	98.9	49	19.3	4	112	19.3	69.8	43.25	62%	57.1	22	2	39.55	89%	3.96	3.45	2	3.705	14%
Sulphide as S	mg/L	0.0031	0.0025	*0.002*	*0.002*	4	0.0031	0.002	0.00240	0.00052	22%	*0.02*	*0.002*	*0.002*	*0.002*	4	0.02	0.002	0.00650	0.00900	n/a	*0.002*	0.0024	2	0.00220	18%	*0.002*	*0.002*	2	0.00200	n/a
Dissolved Metal Species																															
Iron, Dissolved Ferrous		*0.02*	*0.02*			2	0.02	0.02	0.020	0.000	n/a																				
Iron, Dissolved Ferric		*0.05*	*0.05*			2	0.05	0.05	0.050	0.000	n/a																				
Iron, Dissolved Total		*0.03*	*0.03*			2	0.03	0.03	0.030	0.000	n/a																				
Organic / Inorganic Carbon																															
Dissolved Organic Carbon	mg/L	0.59	0.67	2.01	2.04	4	2.04	0.59	1.328	0.806	61%		5.01	1.64	1.51	3	5.01	1.51	2.720	1.984	73%	3.71	6.84	2	5.275	59%	1.06	2.14	2	1.600	68%
Total Organic Carbon	mg/L	2.32	1.32	0.70	1.15	4	2.32	0.7	1.373	0.684	50%	8.22	2.48	1.59	1.1	4	8.22	1.1	3.348	3.298	99%	13.8	32	2	22.900	79%	1.21	1.95	2	1.580	47%
Total Metals																															
Aluminum (Al)-Total	mg/L	0.921	0.351	0.121	0.0436	4	0.921	0.0436	0.3592	0.3967	110%	2.97	0.194	0.446	0.621	4	2.97	0.194	1.0578	1.2868	122%	31.4	35.1	2	33.2500	11%	0.916	0.933	2	0.9245	2%
Antimony (Sb)-Total	mg/L	0.00109	0.00048	0.00029	0.0003	4	0.00109	0.00029	0.000540	0.000377	70%	0.00044	0.00017	0.00017	0.00017	4	0.00044	0.00017	0.000238	0.000135	57%	0.00040	0.0004	2	0.000400	0%	*0.0001*	*0.0001*	2	0.000100	n/a
Arsenic (As)-Total	mg/L	0.342	0.120	0.0362	0.0167	4	0.342	0.0167	0.1287	0.1491	116%	0.00809	0.00518	0.00247	0.00193	4	0.00809	0.00193	0.0044	0.0028	64%	0.0192	0.0408	2	0.0300	72%	0.0362	0.0428	2	0.0395	17%
Barium (Ba)-Total	mg/L	0.0741	0.0644	0.0587	0.0546	4	0.0741	0.0546	0.06295	0.00845	13%	0.116	0.104	0.0999	0.132	4	0.132	0.0999	0.11298	0.01441	13%	0.215	0.412	2	0.31350	63%	0.172	0.165	2	0.16850	4%
Beryllium (Be)-Total	mg/L	*0.0005*	*0.0005*	*0.0001*	*0.0001*	4	0.0005	0.0001	0.00030	0.00023	n/a	*0.0005*	*0.0001*	*0.0001*	*0.0001*	4	0.0005	0.0001	0.00020	0.00020	n/a	0.00088	0.00198	2	0.00143	77%	*0.0001*	*0.0001*	2	0.00010	n/a
Bismuth (Bi)-Total	mg/L	*0.0005*	*0.0005*	*0.0005*	*0.0005*	4	0.0005	0.0005	0.00050	0.00000	n/a	*0.0005*	*0.0005*	*0.0005*	*0.0005*	4	0.0005	0.0005	0.00050	0.00000	n/a	*0.0005*	*0.001*	2	0.00075	n/a	*0.0005*	*0.0005*	2	0.00050	n/a
Boron (B)-Total	mg/L	0.095	0.097	0.111	0.101	4	0.111	0.095	0.1010	0.0071	7%	0.164	0.249	0.247	0.197	4	0.249	0.164	0.2143	0.0412	19%	0.049	0.047	2	0.0480	4%	0.636	0.566	2	0.6010	12%
Cadmium (Cd)-Total	mg/L	0.000078	0.000054	0.000028	0.000018	4	0.000078	0.000018	0.0000445	0.0000270	61%	0.000276	0.000029	0.000045	0.000052	4	0.000276	0.000029	0.0001005	0.0001174	117%	0.000400	0.000982	2	0.0006910	84%	0.000013	0.000016	2	0.0000145	21%
Calcium (Ca)-Total	mg/L	53.6	52.0	50.8	48.1	4	53.6	48.1	51.13	2.32	5%	75.3	68.8	63.7	49	4	75.3	49	64.20	11.19	17%	46.9	74.9	2	60.90	46%	22.1	20.3	2	21.20	8%
Chromium (Cr)-Total	mg/L	0.00076	0.00032	*0.0002*	0.00013	4	0.00076	0.00013	0.000353	0.000283	80%	0.00250	*0.0004*	0.00052	0.00089	4	0.0025	0.0004	0.001078	0.000971	90%	0.0304	0.0366	2	0.033500	19%	0.00098	0.00098	2	0.000980	0%
Cobalt (Co)-Total	mg/L	0.00515	0.00521	0.00267	0.00133	4	0.00521	0.00133	0.003590	0.001916	53%	0.0117	0.00284	0.00154	0.00222	4	0.0117	0.00154	0.004575	0.004780	104%	0.0209	0.0315	2	0.026200	40%	0.00098	0.00093	2	0.000955	5%
Copper (Cu)-Total	mg/L	0.00965	0.00603	0.00231	0.00094	4	0.00965	0.00094	0.00473	0.00392	83%	0.00855	0.00091	0.00126	0.00392	4	0.00855	0.00091	0.00366	0.00353	96%	0.0977	0.165	2	0.13135	51%	0.00421	0.00269	2	0.00345	44%
Iron (Fe)-Total	mg/L	16.7	6.24	1.96	0.802	4	16.7	0.802	6.426	7.238	113%	6.33	0.490	0.887	1.85	4	6.33	0.49	2.389	2.689	113%	42.2	53.1	2	47.650	23%	1.60	1.19	2	1.395	29%
Lead (Pb)-Total	mg/L	0.000435	0.000163	0.000075	*0.00005*	4	0.000435	0.00005	0.000181	0.000176	98%	0.00218	0.000233	0.00029	0.000669	4	0.00218	0.000233	0.000843	0.000912	108%	0.00791	0.017	2	0.012455	73%	0.000654	0.000626	2	0.000640	4%
Lithium (Li)-Total	mg/L	0.0089	0.0086	0.0110	0.00937	4	0.011	0.0086	0.00947	0.00107	11%	*0.005*	0.00100	0.001	0.00145	4	0.005	0.001	0.00211	0.00194	92%	0.0101	0.0117	2	0.01090	15%	0.0202	0.0179	2	0.01905	12%
Magnesium (Mg)-Total	mg/L	3.91	3.79	4.09	3.89	4	4.09	3.79	3.920	0.125	3%	13.6	14.0	12.1	9.51	4	14	9.51	12.303	2.033	17%	16.6	21	2	18.800	23%	5.84	5.1	2	5.470	14%
Manganese (Mn)-Total	mg/L	0.304	0.238	0.160	0.1	4	0.304	0.1	0.2005	0.0892	44%	0.846	0.417	0.326	0.0838	4	0.846	0.0838	0.4182	0.3180	76%	1.01	1.59	2	1.3000	45%	0.198	0.149	2	0.1735	28%
Mercury (Hg)-Total	mg/L	*0.00001*	*0.00001*	*0.00001*	*0.00001*	4	0.00001	0.00001	0.000010	0.000000	n/a		*0.00001*	*0.00001*	*0.00001*	3	0.00001	0.00001	0.000010	0.000000	n/a	0.000032	0.000145	2	0.000089	128%	*0.00001*	*0.00001*	2	0.000010	n/a
Molybdenum (Mo)-Total	mg/L	0.00131	0.000574	0.000367	0.000285	4	0.00131	0.000285	0.0006340	0.0004668	74%	0.00346	0.00419	0.0026	0.000722	4	0.00419	0.000722	0.0027430	0.0014959	55%	0.00468	0.00237	2	0.0035250	66%	0.00148	0.00159	2	0.0015350	7%
Nickel (Ni)-Total	mg/L	0.0101	0.00966	0.00525	0.00326	4	0.0101	0.00326	0.007068	0.003352	47%	0.0119	0.00294	0.00248	0.00414	4	0.0119	0.00248	0.005365	0.004413	82%	0.0284	0.0404	2	0.034400	35%	0.00165	0.0012	2	0.001425	32%
Phosphorus (P)-Total	mg/L	*0.3*	*0.3*	*0.3*	*0.3*	4	0.3	0.3	0.30	0.00	n/a	*0.3*	*0.3*	*0.3*	*0.3*	4	0.3	0.3	0.30	0.00	n/a	0.66	1.54	2	1.10	80%	*0.3*	*0.3*	2	0.30	n/a
Potassium (K)-Total	mg/L	*2*	*2*	*2*	*2*	4	2	2	2.0	0.0	n/a	3.6	2.8	2.7	2.3	4	3.6	2.3	2.9	0.5	19%	3.7	4.1	2	3.9	10%	2.3	2.2	2	2.3	4%
Selenium (Se)-Total	mg/L	*0.0001*	*0.0001*	*0.0001*	*0.0001*	4	0.0001	0.0001	0.00010	0.00000	n/a	*0.0005*	*0.0001*	*0.0001*	0.00017	4	0.0005	0.0001	0.00022	0.00019	88%	0.00059	0.0005	2	0.00055	17%	*0.0001*	*0.0001*	2	0.00010	n/a
Silicon (Si)-Total	mg/L	4.42	3.68	3.52	3.2	4	4.42	3.2	3.705	0.517	14%	11.9	3.96	5.09	4.88	4	11.9	3.96	6.458	3.661	57%	53.6	55.8	2	54.700	4%	7.32	7.46	2	7.390	2%
Silver (Ag)-Total	mg/L	*0.00001*	*0.00001*	*0.00001*	*0.00001*	4	0.00001	0.00001	0.000010	0.000000	n/a	0.000039	*0.00001*	*0.00001*	0.000013	4	0.000039	0.00001	0.000018	0.000014	78%	0.000101	0.000081	2	0.000091	22%	*0.00001*	*0.00001*	2	0.000010	n/a
Sodium (Na)-Total	mg/L	4.1	4.0	4.8	4.5	4	4.8	4	4.35	0.37	8%	40.1	17.9	9.6	3.8	4	40.1	3.8	17.85	15.92	89%	44.0	31.9	2	37.95	32%	42.0	41	2	41.50	2%
Strontium (Sr)-Total	mg/L	0.104	0.0987	0.124	0.105	4	0.124	0.0987	0.1079	0.0111	10%	0.318	0.546	0.427	0.371	4	0.546	0.318	0.4155	0.0977	24%	0.256	0.355	2	0.3055	32%	0.345	0.276	2	0.3105	22%
Thallium (Tl)-Total	mg/L	0.00032	0.00033	0.000257	0.000196	4	0.00033	0.000196	0.000276	0.000062	23%	*0.0001*	0.000039	0.00004	0.000035	4	0.0001	0.000035	0.000054	0.000031	58%	0.000324	0.000587	2	0.000456	58%	0.000014	0.000016	2	0.000015	13%
Tin (Sn)-Total	mg/L	*0.0001*	*0.0001*	*0.0001*	*0.0001*	4	0.0001	0.0001	0.00010	0.00000	n/a	0.00025	*0.0001*	0.0001	0.00012	4	0.00025	0.0001	0.00014	0.00007	51%	0.00055	0.00158	2	0.00107	97%	*0.0001*	0.00022	2	0.00016	75%
Titanium (Ti)-Total	mg/L	0.012	*0.01*	*0.01*	*0.01*	4	0.012	0.01	0.0105	0.0010	10%	0.095	0.012	0.029	0.028	4	0.095	0.012	0.0410	0.0368	90%	1.84	1.35	2	1.5950	31%	0.051	0.038	2	0.0445	29%
Uranium (U)-Total	mg/L	0.000156	0.000059	0.000019	*0.00001*	4	0.000156	0.00001	0.0000610	0.0000668	110%	0.00615	0.00260	0.00164	0.000695	4	0.00615	0.000695	0.0027713	0.0023830	86%	0.00347	0.00449	2	0.0039800	26%	0.000307	0.000288	2	0.0002975	6%
Vanadium (V)-Total	mg/L	0.0024	*0.001*	*0.001*	*0.001*	4	0.0024	0.001	0.00135	0.00070	52%	0.0068	*0.001*	0.0013	0.0022	4	0.0068	0.001	0.00283	0.00270	96%	0.103	0.132	2	0.11750	25%	0.0029	0.002	2	0.00245	37%
Zinc (Zn)-Total	mg/L	0.0576	0.0393	0.0213	0.0139	4	0.0576	0.0139	0.03303	0.01955	59%	0.0120	0.0030	0.0036	0.0043	4	0.012	0.003	0.00573	0.00422	74%	0.0738	0.109	2	0.09140	39%	0.0053	0.0056	2	0.00545	6%

Table B3-2: Relative percent difference and relative standard deviation between sampling events at 7SA5

Sample ID		242 PORTAL										QU08-10										QU11-18S					QU11-18D				
Date Sampled		21-Jan-11	23-Jan-11	19-Mar-12	14-May-12							26-May-10	20-Mar-12	17-May-12	19-NOV-12							02-Mar-12	16-May-12				29-Feb-12	15-May-12			
Time Sampled		16:45	16:13	15:00	16:00							14:00	14:00	14:00	17:00							10:30	13:00				13:00	17:45			
ALS Sample ID		L973238-2	L973239-2	L1126875-1	L1148808-2							L891772-4	L1126875-2	L1149837-2	L1241567-3							L1120238-4	L1149837-1				L1120238-2	L1148808-3			
Matrix		Water	Water	Water	Water							Water	Water	Water	Water							Water	Water				Water	Water			
Area		242	242	242	242							242/7S	242/7S	242/7S	242/7S							7S A5	7S A5				7S A5	7S A5			
Sampled by		Lorax	Lorax	Lorax	Lorax	n	Max	Min	Mean	S	%RSD[1]	Lorax	Lorax	Lorax	Lorax	n	Max	Min	Mean	S	%RSD[1]	Lorax	Lorax	n	Mean	RPD[2]	Lorax	Lorax	n	Mean	RPD[2]
Dissolved Metals																															
Aluminum (Al)-Dissolved	mg/L	*0.003*	0.0108	0.0053	*0.003*	4	0.0108	0.003	0.0055	0.0037	67%	0.0051	*0.003*	*0.003*	*0.003*	4	0.0051	0.003	0.0035	0.0011	30%	0.0149	0.0334	2	0.0242	77%	0.0069	0.0068	2	0.0069	1%
Antimony (Sb)-Dissolved	mg/L	0.00012	0.00014	0.00016	0.00016	4	0.00016	0.00012	0.000145	0.000019	13%	0.00036	0.00017	0.00013	0.00011	4	0.00036	0.00011	0.000193	0.000114	59%	0.00036	0.00029	2	0.000325	22%	*0.0001*	*0.0001*	2	0.000100	n/a
Arsenic (As)-Dissolved	mg/L	0.00071	0.00040	0.00042	0.00033	4	0.00071	0.00033	0.0005	0.0002	36%	0.00126	0.00528	0.00161	0.00056	4	0.00528	0.00056	0.0022	0.0021	97%	0.00231	0.00625	2	0.0043	92%	0.0378	0.0412	2	0.0395	9%
Barium (Ba)-Dissolved	mg/L	0.0666	0.0616	0.0555	0.055	4	0.0666	0.055	0.05968	0.00551	9%	0.0612	0.100	0.0906	0.106	4	0.106	0.0612	0.08945	0.01987	22%	0.0207	0.0208	2	0.02075	0%	0.169	0.168	2	0.16850	1%
Beryllium (Be)-Dissolved	mg/L	*0.0005*	*0.0005*	*0.0001*	*0.0001*	4	0.0005	0.0001	0.00030	0.00023	n/a	*0.0005*	*0.0001*	*0.0001*	*0.0001*	4	0.0005	0.0001	0.00020	0.00020	n/a	*0.0001*	*0.0001*	2	0.00010	n/a	*0.0001*	*0.0001*	2	0.00010	n/a
Bismuth (Bi)-Dissolved	mg/L	*0.0005*	*0.0005*	*0.0005*	*0.0005*	4	0.0005	0.0005	0.00050	0.00000	n/a	*0.0005*	*0.0005*	*0.0005*	*0.0005*	4	0.0005	0.0005	0.00050	0.00000	n/a	*0.0005*	*0.0005*	2	0.00050	n/a	*0.0005*	*0.0005*	2	0.00050	n/a
Boron (B)-Dissolved	mg/L	0.087	0.096	0.104	0.095	4	0.104	0.087	0.0955	0.0070	7%	0.160	0.243	0.23	0.165	4	0.243	0.16	0.1995	0.0431	22%	0.035	0.033	2	0.0340	6%	0.656	0.507	2	0.5815	26%
Cadmium (Cd)-Dissolved	mg/L	0.000042	0.000040	0.000020	0.000014	4	0.000042	0.000014	0.0000290	0.0000141	49%	0.000093	0.000019	0.000034	0.000043	4	0.000093	0.000019	0.0000473	0.0000321	68%	*0.00001*	0.000011	2	0.0000105	10%	*0.00001*	*0.00001*	2	0.0000100	n/a
Calcium (Ca)-Dissolved	mg/L	57.0	54.0	49.7	49.6	4	57	49.6	52.58	3.59	7%	78.1	69.9	61.9	47.1	4	78.1	47.1	64.25	13.21	21%	26.7	24	2	25.35	11%	20.5	19	2	19.75	8%
Chromium (Cr)-Dissolved	mg/L	*0.0001*	*0.0001*	*0.0001*	*0.0001*	4	0.0001	0.0001	0.000100	0.000000	n/a	*0.0005*	*0.0001*	*0.0001*	*0.0001*	4	0.0005	0.0001	0.000200	0.000200	n/a	*0.0001*	*0.0001*	2	0.000100	n/a	*0.0001*	*0.0001*	2	0.000100	n/a
Cobalt (Co)-Dissolved	mg/L	0.00342	0.00347	0.00145	0.00074	4	0.00347	0.00074	0.002270	0.001388	61%	0.00300	0.00203	0.00099	0.00011	4	0.003	0.00011	0.001533	0.001254	82%	0.00025	0.00017	2	0.000210	38%	0.00026	0.00013	2	0.000195	67%
Copper (Cu)-Dissolved	mg/L	*0.0005*	0.00157	*0.0005*	*0.0005*	4	0.00157	0.0005	0.00077	0.00054	70%	0.00134	*0.0005*	*0.0005*	0.00071	4	0.00134	0.0005	0.00076	0.00040	52%	*0.0005*	*0.0005*	2	0.00050	n/a	*0.0005*	*0.0005*	2	0.00050	n/a
Iron (Fe)-Dissolved	mg/L	*0.03*	*0.03*	*0.03*	*0.03*	4	0.03	0.03	0.030	0.000	n/a	*0.03*	*0.03*	*0.03*	*0.03*	4	0.03	0.03	0.030	0.000	n/a	0.051	0.037	2	0.044	32%	0.353	0.306	2	0.330	14%
Lead (Pb)-Dissolved	mg/L	*0.00005*	*0.00005*	*0.00005*	*0.00005*	4	0.00005	0.00005	0.000050	0.000000	n/a	0.000068	*0.00005*	*0.00005*	*0.00005*	4	0.000068	0.00005	0.000055	0.000009	17%	*0.00005*	*0.00005*	2	0.000050	n/a	*0.00005*	*0.00005*	2	0.000050	n/a
Lithium (Li)-Dissolved	mg/L	0.0088	0.0086	0.0111	0.00986	4	0.0111	0.0086	0.00959	0.00115	12%	*0.005*	0.00101	0.00073	0.00069	4	0.005	0.00069	0.00186	0.00210	113%	*0.0005*	*0.0005*	2	0.00050	n/a	0.0209	0.0171	2	0.01900	20%
Magnesium (Mg)-Dissolved	mg/L	4.08	3.89	4.03	3.83	4	4.08	3.83	3.958	0.117	3%	13.2	14.4	11.8	8.79	4	14.4	8.79	12.048	2.418	20%	3.27	3.1	2	3.185	5%	5.25	4.63	2	4.940	13%
Manganese (Mn)-Dissolved	mg/L	0.219	0.155	0.0993	0.0704	4	0.219	0.0704	0.1359	0.0656	48%	0.622	0.374	0.3	0.00943	4	0.622	0.00943	0.3264	0.2522	77%	0.206	0.125	2	0.1655	49%	0.179	0.136	2	0.1575	27%
Mercury (Hg)-Dissolved	mg/L	*0.00001*	*0.00001*	*0.00001*	*0.00001*	4	0.00001	0.00001	0.000010	0.000000	n/a		*0.00001*	*0.00001*	*0.00001*	3	0.00001	0.00001	0.000010	0.000000	n/a	*0.00001*	*0.00001*	2	0.000010	n/a	*0.00001*	*0.00001*	2	0.000010	n/a
Molybdenum (Mo)-Dissolved	mg/L	0.000096	0.000102	0.000156	0.000192	4	0.000192	0.000096	0.0001365	0.0000458	34%	0.00313	0.00432	0.00239	0.000633	4	0.00432	0.000633	0.0026183	0.0015439	59%	0.00543	0.00373	2	0.0045800	37%	0.00154	0.00147	2	0.0015050	5%
Nickel (Ni)-Dissolved	mg/L	0.00832	0.00821	0.00409	0.00283	4	0.00832	0.00283	0.005863	0.002822	48%	0.00679	0.00227	0.0016	0.00196	4	0.00679	0.0016	0.003155	0.002439	77%	0.00084	0.00081	2	0.000825	4%	*0.0005*	*0.0005*	2	0.000500	n/a
Phosphorus (P)-Dissolved	mg/L	*0.3*	*0.3*	*0.3*	*0.3*	4	0.3	0.3	0.30	0.00	n/a	*0.3*	*0.3*	*0.3*	*0.3*	4	0.3	0.3	0.30	0.00	n/a	*0.3*	*0.3*	2	0.30	n/a	*0.3*	*0.3*	2	0.30	n/a
Potassium (K)-Dissolved	mg/L	*2*	*2*	*2*	*2*	4	2	2	2.0	0.0	n/a	3.2	2.9	2.6	2.2	4	3.2	2.2	2.7	0.4	16%	*2*	*2*	2	2.0	n/a	2.3	2.1	2	2.2	9%
Selenium (Se)-Dissolved	mg/L	*0.0001*	*0.0001*	*0.0001*	*0.0001*	4	0.0001	0.0001	0.00010	0.00000	n/a	*0.0005*	*0.0001*	*0.0001*	0.00017	4	0.0005	0.0001	0.00022	0.00019	88%	0.00029	0.00018	2	0.00024	47%	*0.0001*	*0.0001*	2	0.00010	n/a
Silicon (Si)-Dissolved	mg/L	3.57	3.38	3.33	3.08	4	3.57	3.08	3.340	0.202	6%	5.16	3.71	3.71	3.85	4	5.16	3.71	4.108	0.705	17%	2.91	3.09	2	3.000	6%	5.61	5.18	2	5.395	8%
Silver (Ag)-Dissolved	mg/L	*0.00001*	*0.00001*	*0.00001*	*0.00001*	4	0.00001	0.00001	0.000010	0.000000	n/a	*0.00001*	*0.00001*	*0.00001*	*0.00001*	4	0.00001	0.00001	0.000010	0.000000	n/a	*0.00001*	*0.00001*	2	0.000010	n/a	*0.00001*	*0.00001*	2	0.000010	n/a
Sodium (Na)-Dissolved	mg/L	4.2	4.1	4.7	4.5	4	4.7	4.1	4.38	0.28	6%	40.2	18.5	9.3	3.5	4	40.2	3.5	17.88	16.11	90%	42.6	28.5	2	35.55	40%	43.2	40.8	2	42.00	6%
Strontium (Sr)-Dissolved	mg/L	0.105	0.101	0.122	0.101	4	0.122	0.101	0.1073	0.0100	9%	0.298	0.529	0.396	0.355	4	0.529	0.298	0.3945	0.0983	25%	0.152	0.126	2	0.1390	19%	0.337	0.249	2	0.2930	30%
Thallium (Tl)-Dissolved	mg/L	0.00028	0.00033	0.000259	0.000172	4	0.00033	0.000172	0.000260	0.000066	25%	*0.0001*	0.000036	0.00003	0.000023	4	0.0001	0.000023	0.000047	0.000036	75%	0.000029	*0.00001*	2	0.000020	97%	*0.00001*	*0.00001*	2	0.000010	n/a
Tin (Sn)-Dissolved	mg/L	*0.0001*	*0.0001*	*0.0001*	*0.0001*	4	0.0001	0.0001	0.00010	0.00000	n/a	*0.0001*	*0.0001*	*0.0001*	*0.0001*	4	0.0001	0.0001	0.00010	0.00000	n/a	*0.0001*	*0.0001*	2	0.00010	n/a	*0.0001*	*0.0001*	2	0.00010	n/a
Titanium (Ti)-Dissolved	mg/L	*0.01*	*0.01*	*0.01*	*0.01*	4	0.01	0.01	0.010	0.000	n/a	*0.01*	*0.01*	*0.01*	*0.01*	4	0.01	0.01	0.010	0.000	n/a	*0.01*	*0.01*	2	0.010	n/a	*0.01*	*0.01*	2	0.010	n/a
Uranium (U)-Dissolved	mg/L	*0.00001*	*0.00001*	*0.00001*	*0.00001*	4	0.00001	0.00001	0.000010	0.000000	n/a	0.00524	0.00251	0.00151	0.000614	4	0.00524	0.000614	0.002469	0.002003	81%	0.00228	0.0017	2	0.001990	29%	0.000142	0.00009	2	0.000116	45%
Vanadium (V)-Dissolved	mg/L	*0.001*	*0.001*	*0.001*	*0.001*	4	0.001	0.001	0.0010	0.0000	n/a	*0.001*	*0.001*	*0.001*	*0.001*	4	0.001	0.001	0.0010	0.0000	n/a	0.0016	0.0034	2	0.0025	72%	*0.001*	*0.001*	2	0.0010	n/a
Zinc (Zn)-Dissolved	mg/L	0.0294	0.0295	0.0164	0.0115	4	0.0295	0.0115	0.02170	0.00917	42%	0.0043	*0.003*	*0.003*	0.0064	4	0.0064	0.003	0.00418	0.00160	38%	*0.003*	*0.003*	2	0.00300	n/a	*0.003*	0.0043	2	0.00365	36%

Results in red italics are greater than number indicated.
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) |
n/a = not applicable, all values are below the detection limit

Table B3-2: Relative percent difference and relative standard deviation between sampling events at 7SA5

		QU11-28					QU11-36S									QU11-36D									QU11-38								
Date Sampled		21-Mar-12	17-May-12				28-Feb-12	14-May-12	19-Nov-12							02-Mar-12	15-May-12	19-Nov-12							25-Oct-12	26-Oct-12	27-Oct-12						
Time Sampled		17:00	15:15				15:00	15:30	12:30							16:00	13:00	16:30							13:15	14:15	13:15						
ALS Sample ID		L1126875-5	L1149837-3				L1120238-1	L1148808-1	L1240539-3							L1120238-5	L1148808-4	L1240539-4							L1230464-1	L1230464-2	L1230464-3						
Matrix		Water	Water				Water	Water	Water							Water	Water	Water							Water	Water	Water						
Area		7SA5	7SA5				7SA5	7SA5	7SA5							7SA5	7SA5	7SA5							7SA5	7SA5	7SA5						
Sampled by		Lorax	Lorax	**n**	**Mean**	**RPD[2]**	Lorax	Lorax	Lorax	**n**	**Max**	**Min**	**Mean**	**s**	**RSD[1]**	Lorax	Lorax	Lorax	**n**	**Max**	**Min**	**Mean**	**S**	**RSD[1]**	Lorax	Lorax	Lorax	**n**	**Max**	**Min**	**Mean**	**S**	**RSD[1]**
Rock type		No. 4&4L/SST	No. 4&4L/SST				SST?	SST?	SST?							SST	SST																
Physical Tests																																
Colour, True	CU																															
Field Conductivity	uS/cm	405	370	2	387.5	9%	175	165	179	3	179	165	173.0	7.2	4%	372	344	324	3	372	324	346.7	24.1	7%	605	611	614	3	614	605	610.0	4.6	1%
Conductivity	uS/cm	405	364	2	384.5	11%	171	169	179	3	179	169	173.0	5.3	3%	364	341	323	3	364	323	342.7	20.6	6%	309	308	309	3	309	308	308.7	0.6	0%
Hardness (as $CaCO_3$)	mg/L	138	148	2	143.0	7%	92	88.6	96.5	3	96.5	88.6	92.4	4.0	4%	171	173	163	3	173	163	169.0	5.3	3%	109	110	110	3	110	109	109.7	0.6	1%
Field pH	pH	7.46	7.8	2	7.630	4%	6.66	6.50	6.04	3	6.66	6.04	6.400	0.322	5%	7.49	7.62	7.33	3	7.62	7.33	7.480	0.145	2%	7.94	7.94	7.93	3	7.94	7.93	7.937	0.006	0%
pH	pH	8.19	8.15	2	8.170	0%	7.44	7.62	7.70	3	7.7	7.44	7.587	0.133	2%	8.18	8.21	8.3	3	8.3	8.18	8.230	0.062	1%	8.38	8.33	8.35	3	8.38	8.33	8.353	0.025	0%
Field Eh	eV	-89.60	-116.9	2	-103.3	26%	54.5	35.4	89.3	3	89.3	35.4	59.7	27.3	46%	-126.2	-133.9	-113.2	3	-113.2	-133.9	-124.4	10.5	-8%	-144	-165	-160	3	-144	-164.7	-156.3	10.9	-7%
Field Temperature	C	6.41	7.63	2	7.020	17%	5.94	7.80	6.87	3	7.8	5.94	6.870	0.930	14%	6.43	8.00	6.99	3	8	6.43	7.140	0.796	11%	7.5	7.6	7.6	3	7.6	7.5	7.567	0.058	1%
Total Suspended Solids	mg/L	201	8.8	2	104.9	183%	857	372	97.3	3	857	97.3	442.1	385	87%	38	122	4.7	3	122	4.7	54.9	60.4	110%	*3*	*3*	*3*	3	3	3	3	0.0	n/a
Total Dissolved Solids	mg/L	244	214	2	229.0	13%	140	109	111	3	140	109	120.0	17.3	14%	206	184	190	3	206	184	193.3	11.4	6%	189	176	184	3	189	176	183.0	6.6	4%
Turbidity	NTU	87.1	3.6	2	45.35	184%	1390	455	172	3	1390	172	672.33	637.42	95%	23.8	55.7	8.86	3	55.7	8.86	29.45	23.93	81%	26.6	11.9	12.3	3	26.6	11.9	16.93	8.37	49%
Anions and Nutrients																																
Acidity (as $CaCO_3$) (pH 8.3)	mg/L	2.9	3.1	2	3.00	7%	4.4	7.5	5.0	3	7.5	4.4	5.63	1.64	29%	1.7	2	*1*	3	2	1	1.57	0.51	33%	*1*	*1*	*1*	3	1	1	1.00	0.00	n/a
Field Alkalinity, Total (as $CaCO_3$)	mg/L	219.0	195	2	207.0	12%	96	90	93.0	3	96	90	93.0	3.0	3%	162	165	174	3	174	162	167.0	6.2	4%				0					
Alkalinity, Total (as $CaCO_3$)	mg/L	204	192	2	198.00	6%	81.8	84.2	87.2	3	87.2	81.8	84.40	2.71	3%	164	160	163	3	164	160	162.33	2.08	1%	162	164	168	3	168	162	164.67	3.06	2%
Ammonia as N	mg/L	0.74	0.66	2	0.7000	11%	0.0067	*0.005*	*0.005*	3	0.0067	0.005	0.0056	0.0010	18%	0.138	0.116	0.133	3	0.138	0.116	0.1290	0.0115	9%	0.150	0.144	0.145	3	0.15	0.144	0.1463	0.0032	2%
Bromide (Br)	mg/L	*0.05*	*0.05*	2	0.050	n/a	*0.05*	*0.05*	*0.05*	3	0.05	0.05	0.050	0.000	n/a	0.062	*0.05*	*0.05*	3	0.062	0.05	0.054	0.007	13%	*0.050*	*0.050*	*0.050*	3	0.05	0.05	0.050	0.000	n/a
Chloride (Cl)	mg/L	2.64	1.39	2	2.015	62%	0.57	0.6	0.53	3	0.6	0.53	0.567	0.035	6%	1.08	0.79	0.65	3	1.08	0.65	0.840	0.219	26%	0.690	0.750	0.780	3	0.78	0.69	0.740	0.046	6%
Fluoride (F)	mg/L	0.345	0.393	2	0.3690	13%	0.024	0.021	0.025	3	0.025	0.021	0.0233	0.0021	9%	0.618	0.644	0.698	3	0.698	0.618	0.6533	0.0408	6%	0.972	0.999	0.998	3	0.999	0.972	0.9897	0.0153	2%
Nitrate (as N)	mg/L	*0.005*	*0.005*	2	0.00500	n/a	*0.005*	*0.005*	0.0144	3	0.0144	0.005	0.00813	0.00543	67%	*0.005*	*0.005*	*0.005*	3	0.005	0.005	0.00500	0.00000	n/a	*0.005*	*0.005*	*0.005*	3	0.005	0.005	0.00500	0.00000	n/a
Nitrite (as N)	mg/L	*0.001*	*0.001*	2	0.0010	n/a	*0.001*	*0.001*	*0.001*	3	0.001	0.001	0.0010	0.0000	n/a	*0.001*	*0.001*	*0.001*	3	0.001	0.001	0.0010	0.0000	n/a	*0.001*	*0.001*	*0.001*	3	0.001	0.001	0.0010	0.0000	n/a
Total Kjeldahl Nitrogen	mg/L																															
Total Nitrogen	mg/L	0.826	0.63	2	0.728	27%	0.06	*0.05*	*0.05*	3	0.06	0.05	0.053	0.006	11%	0.06	0.12	0.08	3	0.12	0.06	0.087	0.031	35%	0.13	0.14	0.15	3	0.15	0.13	0.140	0.010	7%
Field Dissolved Oxygen mg/L	mg/L	0.380	2.34	2	1.360	144%	1.37			1	1.37	1.37	1.370		n/a	0.45		0.89	2	0.89	0.45	0.670	0.311	46%	0.17	0.08	0.19	3	0.19	0.08	0.147	0.059	40%
Ortho Phosphate as P	mg/L	0.0084	0.0047	2	0.0066	56%		*0.001*		1	0.001	0.001	0.0010		n/a		0.0051		1	0.0051	0.0051	0.0051			0.0062	0.0046	0.0046	3	0.0062	0.0046	0.0051	0.001	18%
Total Dissolved Phosphate As P	mg/L	0.0079	*0.002*	2	0.0050	119%	0.0021	*0.002*	*0.002*	3	0.0021	0.002	0.0020	0.0001	3%	0.0147	0.0171	0.0118	3	0.0171	0.0118	0.0145	0.0027	18%	0.0111	0.0117	0.0081	3	0.0117	0.0081	0.0103	0.0019	19%
Total Phosphate as P	mg/L	0.126	0.0398	2	0.08290	104%	0.296	0.165	0.055	3	0.296	0.055	0.1720	0.1207	70%	0.0986	0.086	0.0335	3	0.0986	0.0335	0.0727	0.0345	47%	0.0271	0.0194	0.0219	3	0.0271	0.0194	0.0228	0.0039	17%
Sulfate (SO_4)	mg/L	20.8	13.5	2	17.15	43%	9.7	10.5	9.66	3	10.5	9.66	9.953	0.474	5%	31.9	21.5	14.4	3	31.9	14.4	22.600	8.802	39%	10.6	8.53	7.96	3	10.6	7.96	9.030	1.389	15%
Sulphide as S	mg/L	*0.002*	*0.002*	2	0.00200	n/a	*0.002*	*0.002*	*0.002*	3	0.002	0.002	0.00200	0.00000	n/a	*0.002*	*0.002*	0.0029	3	0.0029	0.002	0.00230	0.00052	23%	0.234	0.255	0.216	3	0.255	0.216	0.23500	0.01952	8%
Dissolved Metal Species																																
Iron, Dissolved Ferrous																																
Iron, Dissolved Ferric																																
Iron, Dissolved Total																																
Organic / Inorganic Carbon																																
Dissolved Organic Carbon	mg/L	4.75	2.58	2	3.665	59%	0.51	1.41	*0.5*	3	1.41	0.5	0.807	0.523	65%	0.91	1.63	*0.5*	3	1.63	0.5	1.013	0.572	56%	0.82	1.09	0.89	3	1.09	0.82	0.933	0.140	15%
Total Organic Carbon	mg/L	7.58	2.78	2	5.180	93%	9.97	4.73	1.58	3	9.97	1.58	5.427	4.238	78%	0.95	2.48	0.57	3	2.48	0.57	1.333	1.011	76%	0.86	0.71	0.81	3	0.86	0.71	0.793	0.076	10%
Total Metals																																
Aluminum (Al)-Total	mg/L	2.28	0.275	2	1.2775	157%	13.8	10.1	3.47	3	13.8	3.47	9.1233	5.2338	57%	0.675	2.97	0.233	3	2.97	0.233	1.2927	1.4693	114%	1.04	0.217	0.212	3	1.04	0.212	0.4897	0.4766	97%
Antimony (Sb)-Total	mg/L	*0.0001*	*0.0001*	2	0.000100	n/a	0.0138	0.0132	0.0119	3	0.0138	0.0119	0.012967	0.000971	7%	0.00049	0.00085	0.0004	3	0.00085	0.0004	0.000580	0.000238	41%	*0.0001*	*0.0001*	*0.0001*	3	0.0001	0.0001	0.000100	0.0000	n/a
Arsenic (As)-Total	mg/L	0.163	0.242	2	0.2025	39%	0.503	0.378	0.274	3	0.503	0.274	0.3850	0.1147	30%	1.59	1.45	1.19	3	1.59	1.19	1.4100	0.2030	14%	0.348	0.319	0.313	3	0.348	0.313	0.3267	0.0187	6%
Barium (Ba)-Total	mg/L	0.242	0.319	2	0.28050	27%	0.306	0.209	0.141	3	0.306	0.141	0.21867	0.08292	38%	0.129	0.134	0.125	3	0.134	0.125	0.12933	0.00451	3%	0.135	0.130	0.132	3	0.135	0.13	0.13233	0.00252	2%
Beryllium (Be)-Total	mg/L	0.00026	*0.0001*	2	0.00018	89%	0.00078	0.00039	0.00014	3	0.00078	0.00014	0.00044	0.00032	74%	*0.0001*	0.00018	*0.0001*	3	0.00018	0.0001	0.00013	0.00005	36%	*0.0001*	*0.0001*	*0.0001*	3	0.0001	0.0001	0.00010	0.00000	n/a
Bismuth (Bi)-Total	mg/L	*0.0005*	*0.0005*	2	0.00050	n/a	*0.0005*	*0.0005*	*0.0005*	3	0.0005	0.0005	0.00050	0.00000	n/a	*0.0005*	*0.0005*	*0.0005*	3	0.0005	0.0005	0.00050	0.00000	n/a	*0.0005*	*0.0005*	*0.0005*	3	0.0005	0.0005	0.00050	0.00000	n/a
Boron (B)-Total	mg/L	0.361	0.416	2	0.3885	14%	0.023	0.021	0.020	3	0.023	0.02	0.0213	0.0015	7%	0.519	0.566	0.598	3	0.598	0.519	0.5610	0.0397	7%	0.536	0.588	0.604	3	0.604	0.536	0.5760	0.0356	6%
Cadmium (Cd)-Total	mg/L	0.000095	*0.00001*	2	0.0000525	162%	0.00051	0.000319	0.000124	3	0.00051	0.000124	0.0003177	0.0001930	61%	0.000027	0.000082	*0.00001*	3	0.000082	0.00001	0.0000397	0.0000376	95%	*0.00001*	*0.00001*	*0.00001*	3	0.00001	0.00001	0.0000100	0.00000	n/a
Calcium (Ca)-Total	mg/L	48.4	46.3	2	47.35	4%	34	31.8	32.9	3	34	31.8	32.90	1.10	3%	51.9	52.4	50.6	3	52.4	50.6	51.63	0.93	2%	30.4	30.6	32.0	3	32	30.4	31.00	0.87	3%
Chromium (Cr)-Total	mg/L	0.00155	0.00015	2	0.000850	165%	0.0191	0.00911	0.00363	3	0.0191	0.00363	0.010613	0.007844	74%	0.0005	0.00231	0.00019	3	0.00231	0.00019	0.001000	0.001145	115%	0.00126	0.00029	0.00029	3	0.00126	0.00029	0.000613	0.000560	91%
Cobalt (Co)-Total	mg/L	0.00287	0.00076	2	0.001815	116%	0.0284	0.016	0.00504	3	0.0284	0.00504	0.016480	0.011687	71%	0.00109	0.00209	0.00022	3	0.00209	0.00022	0.001133	0.000936	83%	0.00033	*0.0001*	*0.0001*	3	0.00033	0.0001	0.000177	0.000133	75%
Copper (Cu)-Total	mg/L	0.0141	*0.0005*	2	0.00730	186%	0.0543	0.0269	0.00882	3	0.0543	0.00882	0.03001	0.02290	76%	0.00147	0.00787	0.00079	3	0.00787	0.00079	0.00338	0.00391	116%	0.00121	*0.0005*	0.00085	3	0.00121	0.0005	0.00085	0.00036	42%
Iron (Fe)-Total	mg/L	2.95	0.492	2	1.721	143%	42.4	26.7	11.2	3	42.4	11.2	26.767	15.600	58%	1.5	3.13	0.796	3	3.13	0.796	1.809	1.197	66%	0.669	0.392	0.384	3	0.669	0.384	0.482	0.162	34%
Lead (Pb)-Total	mg/L	0.00233	0.000115	2	0.001223	181%	0.00838	0.00385	0.00131	3	0.00838	0.00131	0.004513	0.003581	79%	0.000291	0.00128	0.000082	3	0.00128	0.000082	0.000551	0.000640	116%	0.000167	*0.00005*	0.000064	3	0.000167	0.00005	0.000094	0.000064	68%
Lithium (Li)-Total	mg/L	0.0248	0.033	2	0.02890	28%	0.0238	0.0128	0.00790	3	0.0238	0.0079	0.01483	0.00814	55%	0.0493	0.0499	0.0512	3	0.0512	0.0493	0.05013	0.00097	2%	0.0331	0.0338	0.0344	3	0.0344	0.0331	0.03377	0.00065	2%
Magnesium (Mg)-Total	mg/L	9.33	8.12	2	8.725	14%	7.01	4.97	3.81	3	7.01	3.81	5.263	1.620	31%	9.11	10.2	9.74	3	10.2	9.11	9.683	0.547	6%	7.14	7.22	7.44	3	7.44	7.14	7.267	0.155	2%
Manganese (Mn)-Total	mg/L	0.907	0.534	2	0.7205	52%	0.509	0.306	0.176	3	0.509	0.176	0.3303	0.1678	51%	0.471	0.313	0.136	3	0.471	0.136	0.3067	0.1676	55%	0.0291	0.0259	0.0257	3	0.0291	0.0257	0.0269	0.0019	7%
Mercury (Hg)-Total	mg/L	*0.00001*	*0.00001*	2	0.000010	n/a	0.000129	0.0001	0.000023	3	0.000129	0.000023	0.000084	0.000055	65%	*0.00001*	*0.00001*	*0.00001*	3	0.00001	0.00001	0.000010	0.000000	n/a	*0.00001*	*0.00001*	*0.00001*	3	0.00001	0.00001	0.000010	0.000000	n/a
Molybdenum (Mo)-Total	mg/L	0.00170	0.000944	2	0.0013220	57%	0.00123	0.000575	0.00100	3	0.00123	0.000575	0.0009350	0.0003323	36%	0.0355	0.0284	0.0168	3	0.0355	0.0168	0.0269000	0.0094398	35%	0.00244	0.00164	0.00137	3	0.00244	0.00137	0.0018167	0.0005564	31%
Nickel (Ni)-Total	mg/L	0.00293	0.0006	2	0.001765	132%	0.0355	0.0199	0.00679	3	0.0355	0.00679	0.020730	0.014373	69%	0.0011	0.00222	*0.0005*	3	0.00222	0.0005	0.001273	0.000873	69%	0.00130	*0.0005*	*0.0005*	3	0.0013	0.0005	0.000767	0.000462	60%
Phosphorus (P)-Total	mg/L	*0.3*	*0.3*	2	0.30	n/a	*0.3*	*0.3*	*0.05*	3	0.3	0.05	0.22	0.14	n/a	*0.3*	*0.3*	*0.05*	3	0.3	0.05	0.22	0.14	n/a	*0.3*	*0.3*	*0.3*	3	0.3	0.3	0.30	0.00	n/a
Potassium (K)-Total	mg/L	2.7	2.6	2	2.7	4%	2.5	*2*	0.58	3	2.5	0.58	1.7	1.0	59%	*2*	*2*	0.99	3	2	0.99	1.7	0.6	35%	*2*	*2*	*2*	3	2	2	2.0	0.0	n/a
Selenium (Se)-Total	mg/L	*0.0001*	*0.0001*	2	0.00010	n/a	*0.0001*	0.0001	*0.0001*	3	0.0001	0.0001	0.00010	0.00000	0%	*0.0001*	*0.0001*	*0.0001*	3	0.0001	0.0001	0.00010	0.00000	n/a	*0.0001*	*0.0001*	*0.0001*	3	0.0001	0.0001	0.00010	0.00000	n/a
Silicon (Si)-Total	mg/L	12.2	6.68	2	9.440	58%	43.4	18.5	8.53	3	43.4	8.53	23.477	17.960	77%	5.81	11.8	5.34	3	11.8	5.34	7.650	3.602	47%	5.76	4.40	4.46	3	5.76	4.4	4.873	0.768	16%
Silver (Ag)-Total	mg/L	*0.00001*	*0.00001*	2	0.000010	n/a	0.000231	0.000058	0.000022	3	0.000231	0.000022	0.000104	0.000112	108%	0.000019	*0.00001*	*0.00001*	3	0.000019	0.00001	0.000013	0.000005	40%	*0.00001*	*0.00001*	*0.00001*	3	0.00001	0.00001	0.000010	0.000000	n/a
Sodium (Na)-Total	mg/L	39.2	29.4	2	34.30	29%	2.3	*2*	1.32	3	2.3	1.32	1.87	0.50	27%	12.9	11.2	10.7	3	12.9	10.7	11.60	1.15	10%	29.3	29.9	30.4	3	30.4	29.3	29.87	0.55	2%
Strontium (Sr)-Total	mg/L	0.533	0.456	2	0.4945	16%	0.0519	0.0396	0.0404	3	0.0519	0.0396	0.0440	0.0069	16%	0.375	0.408	0.409	3	0.409	0.375	0.3973	0.0193	5%	0.317	0.334	0.348	3	0.348	0.317	0.3330	0.0155	5%
Thallium (Tl)-Total	mg/L	0.000063	0.000012	2	0.000038	136%	0.000181	0.000118	0.000051	3	0.000181	0.000051	0.000117	0.000065	56%	0.000016	0.000046	*0.00001*	3	0.000046	0.00001	0.000024	0.000019	80%	*0.00001*	*0.00001*	*0.00001*	3	0.00001	0.00001	0.000010	0.000000	n/a
Tin (Sn)-Total	mg/L	0.00074	*0.0001*	2	0.00042	152%	*0.0001*	0.0002	*0.0001*	3	0.0002	0.0001	0.00013	0.00006	43%	*0.0001*	0.00027	*0.0001*	3	0.00027	0.0001	0.00016	0.00010	63%	*0.0001*	*0.0001*	*0.0001*	3	0.0001	0.0001	0.00010	0.00000	n/a
Titanium (Ti)-Total	mg/L	0.126	*0.01*	2	0.0680	171%	1.34	0.454	0.136	3	1.34	0.136	0.6433	0.6239	97%	0.035	0.119	*0.01*	3	0.119	0.01	0.0547	0.0571	104%	0.068	0.014	0.014	3	0.068	0.014	0.0320	0.0312	97%
Uranium (U)-Total	mg/L	0.00135	0.000468	2	0.0009090	97%	0.00175	0.0009	0.000342	3	0.00175	0.000342	0.0009973	0.0007090	71%	0.000638	0.000572	0.000149	3	0.000638	0.000149	0.0004530	0.0002653	59%	0.000026	0.000011	*0.00001*	3	0.000026	0.00001	0.0000157	0.0000090	57%
Vanadium (V)-Total	mg/L	0.0076	*0.001*	2	0.00430	153%	0.119	0.0531	0.0208	3	0.119	0.0208	0.06430	0.05005	78%	0.0015	0.0052	*0.001*	3	0.0052	0.001	0.00257	0.00229	89%	0.0029	*0.001*	*0.001*	3	0.0029	0.001	0.00163	0.00110	67%
Zinc (Zn)-Total	mg/L	0.0125	*0.003*	2	0.00775	123%	0.0608	0.0445	0.0197	3	0.0608	0.0197	0.04167	0.02070	50%	0.0042	0.0106	*0.003*	3	0.0106	0.003	0.00593	0.00409	69%	0.0047	*0.003*	*0.003*	3	0.0047	0.003	0.00357	0.00098	28%

Table B3-2: Relative percent difference and relative standard deviation between sampling events at 7SA5

		QU11-28					QU11-36S									QU11-36D									QU11-38								
Date Sampled		21-Mar-12	17-May-12				28-Feb-12	14-May-12	19-Nov-12							02-Mar-12	15-May-12	19-Nov-12							25-Oct-12	26-Oct-12	27-Oct-12						
Time Sampled		17:00	15:15				15:00	15:30	12:30							16:00	13:00	16:30							13:15	14:15	13:15						
ALS Sample ID		L1126875-5	L1149837-3				L1120238-1	L1148808-1	L1240539-3							L1120238-5	L1148808-4	L1240539-4							L1230464-1	L1230464-2	L1230464-3						
Matrix		Water	Water				Water	Water	Water							Water	Water	Water							Water	Water	Water						
Area		7S A5	7S A5				7S A5	7S A5	7S A5							7S A5	7S A5	7S A5							7S A5	7S A5	7S A5						
Sampled by		Lorax	Lorax	**n**	**Mean**	**RPD[2]**	Lorax	Lorax	Lorax	**n**	**Max**	**Min**	**Mean**	**s**	**RSD[1]**	Lorax	Lorax	Lorax	**n**	**Max**	**Min**	**Mean**	**S**	**RSD[1]**	Lorax	Lorax	Lorax	**n**	**Max**	**Min**	**Mean**	**S**	**RSD[1]**
Dissolved Metals																																
Aluminum (Al)-Dissolved	mg/L	0.0052	0.0046	2	0.0049	12%	*0.003*	*0.003*	*0.001*	3	0.003	0.001	0.0023	0.0012	n/a	0.0046	0.0048	0.0038	3	0.0048	0.0038	0.0044	0.0005	12%	*0.003*	*0.003*	*0.003*	3	0.003	0.003	0.0030	0.0000	n/a
Antimony (Sb)-Dissolved	mg/L	*0.0001*	*0.0001*	2	0.000100	n/a	0.00696	0.00467	0.00334	3	0.00696	0.00334	0.004990	0.001831	37%	*0.0001*	0.00025	0.00027	3	0.00027	0.0001	0.000207	0.000093	45%	*0.0001*	*0.0001*	*0.0001*	3	0.0001	0.0001	0.0001	0.000100	n/a
Arsenic (As)-Dissolved	mg/L	0.169	0.238	2	0.2035	34%	0.0824	0.0377	0.0173	3	0.0824	0.0173	0.0458	0.0333	73%	1.68	1.5	1.15	3	1.68	1.15	1.4433	0.2695	19%	0.355	0.328	0.324	3	0.355	0.324	0.3357	0.0169	5%
Barium (Ba)-Dissolved	mg/L	0.214	0.312	2	0.26300	37%	0.0981	0.1	0.107	3	0.107	0.0981	0.10170	0.00469	5%	0.13	0.129	0.126	3	0.13	0.126	0.12833	0.00208	2%	0.141	0.137	0.137	3	0.141	0.137	0.13833	0.00231	2%
Beryllium (Be)-Dissolved	mg/L	*0.0001*	*0.0001*	2	0.00010	n/a	*0.0001*	*0.0001*	*0.0001*	3	0.0001	0.0001	0.00010	0.00000	n/a	*0.0001*	*0.0001*	*0.0001*	3	0.0001	0.0001	0.00010	0.00000	n/a	*0.0001*	*0.0001*	*0.0001*	3	0.0001	0.0001	0.00010	0.00000	n/a
Bismuth (Bi)-Dissolved	mg/L	*0.0005*	*0.0005*	2	0.00050	n/a	*0.0005*	*0.0005*	*0.0005*	3	0.0005	0.0005	0.00050	0.00000	n/a	*0.0005*	*0.0005*	*0.0005*	3	0.0005	0.0005	0.00050	0.00000	n/a	*0.0005*	*0.0005*	*0.0005*	3	0.0005	0.0005	0.00050	0.00000	n/a
Boron (B)-Dissolved	mg/L	0.347	0.404	2	0.3755	15%	0.01	0.012	0.013	3	0.013	0.01	0.0117	0.0015	13%	0.519	0.496	0.574	3	0.574	0.496	0.5297	0.0401	8%	0.551	0.593	0.611	3	0.611	0.551	0.5850	0.0308	5%
Cadmium (Cd)-Dissolved	mg/L	*0.00001*	*0.00001*	2	0.0000100	n/a	*0.00001*	0.000024	0.000032	3	0.000032	0.00001	0.0000220	0.0000111	51%	*0.00001*	0.000021	*0.00001*	3	0.000021	0.00001	0.0000137	0.0000064	46%	*0.00001*	*0.00001*	0.000012	3	0.000012	0.00001	0.0000107	0.0000012	11%
Calcium (Ca)-Dissolved	mg/L	42.2	46.3	2	44.25	9%	31.9	30.3	33.0	3	33	30.3	31.73	1.36	4%	53.2	52.8	49.8	3	53.2	49.8	51.93	1.86	4%	31.6	31.9	32.0	3	32	31.6	31.83	0.21	1%
Chromium (Cr)-Dissolved	mg/L	*0.0001*	*0.0001*	2	0.000100	n/a	*0.0001*	*0.0001*	*0.0001*	3	0.0001	0.0001	0.000100	0.000000	n/a	*0.0001*	*0.0001*	*0.0001*	3	0.0001	0.0001	0.000100	0.000000	n/a	*0.0001*	*0.0001*	*0.0001*	3	0.0001	0.0001	0.000100	0.000000	n/a
Cobalt (Co)-Dissolved	mg/L	0.00116	0.00071	2	0.000935	48%	0.00131	0.00155	0.00074	3	0.00155	0.00074	0.001200	0.000416	35%	0.00057	0.00029	0.00011	3	0.00057	0.00011	0.000323	0.000232	72%	*0.0001*	*0.0001*	*0.0001*	3	0.0001	0.0001	0.000100	0.000000	n/a
Copper (Cu)-Dissolved	mg/L	*0.0005*	*0.0005*	2	0.00050	n/a	*0.0005*	*0.0005*	*0.0002*	3	0.0005	0.0002	0.00040	0.00017	n/a	*0.0005*	*0.0005*	*0.0002*	3	0.0005	0.0002	0.00040	0.00017	n/a	*0.0005*	*0.0005*	*0.0005*	3	0.0005	0.0005	0.00050	0.00000	n/a
Iron (Fe)-Dissolved	mg/L	0.199	0.376	2	0.288	62%	0.416	0.423	0.270	3	0.423	0.27	0.370	0.086	23%	0.82	0.66	0.611	3	0.82	0.611	0.697	0.109	16%	0.260	0.262	0.256	3	0.262	0.256	0.259	0.003	1%
Lead (Pb)-Dissolved	mg/L	*0.00005*	*0.00005*	2	0.000050	n/a	*0.00005*	*0.00005*	*0.00005*	3	0.00005	0.00005	0.000050	0.000000	n/a	*0.00005*	*0.00005*	*0.00005*	3	0.00005	0.00005	0.000050	0.000000	n/a	*0.00005*	*0.00005*	*0.00005*	3	0.00005	0.00005	0.000050	0.000000	n/a
Lithium (Li)-Dissolved	mg/L	0.0238	0.0333	2	0.02855	33%	0.0053	0.00447	0.00462	3	0.0053	0.00447	0.00480	0.00044	9%	0.0504	0.0467	0.0534	3	0.0534	0.0467	0.05017	0.00336	7%	0.0347	0.0357	0.0363	3	0.0363	0.0347	0.03557	0.00081	2%
Magnesium (Mg)-Dissolved	mg/L	7.90	7.89	2	7.895	0%	3.03	3.11	3.44	3	3.44	3.03	3.193	0.217	7%	9.2	8.82	9.4	3	9.4	8.82	9.140	0.295	3%	7.33	7.38	7.41	3	7.41	7.33	7.373	0.040	1%
Manganese (Mn)-Dissolved	mg/L	0.799	0.518	2	0.6585	43%	0.246	0.161	0.102	3	0.246	0.102	0.1697	0.0724	43%	0.472	0.28	0.128	3	0.472	0.128	0.2933	0.1724	59%	0.0256	0.0249	0.0251	3	0.0256	0.0249	0.0252	0.0004	1%
Mercury (Hg)-Dissolved	mg/L	*0.00001*	*0.00001*	2	0.000010	n/a	*0.00001*	*0.00001*	*0.00001*	3	0.00001	0.00001	0.000010	0.000000	n/a	*0.00001*	*0.00001*	*0.00001*	3	0.00001	0.00001	0.000010	0.000000	n/a	*0.00001*	*0.00001*	*0.00001*	3	0.00001	0.00001	0.000010	0.000000	n/a
Molybdenum (Mo)-Dissolved	mg/L	0.00175	0.000858	2	0.0013040	68%	0.000279	0.000203	0.000166	3	0.000279	0.000166	0.0002160	0.0000576	27%	0.0364	0.0269	0.0162	3	0.0364	0.0162	0.0265000	0.0101059	38%	0.00241	0.00165	0.00137	3	0.00241	0.00137	0.0018100	0.0005381	30%
Nickel (Ni)-Dissolved	mg/L	0.00105	0.00052	2	0.000785	68%	0.00163	0.00213	0.00102	3	0.00213	0.00102	0.001593	0.000556	35%	0.00056	*0.0005*	*0.0005*	3	0.00056	0.0005	0.000520	0.000035	7%	0.00072	*0.0005*	*0.0005*	3	0.00072	0.0005	0.000573	0.000127	22%
Phosphorus (P)-Dissolved	mg/L	*0.3*	*0.3*	2	0.30	n/a	*0.3*	*0.3*	*0.05*	3	0.3	0.05	0.22	0.14	n/a	*0.3*	*0.3*	*0.05*	3	0.3	0.05	0.22	0.14	n/a	*0.3*	*0.3*	*0.3*	3	0.3	0.3	0.30	0.00	n/a
Potassium (K)-Dissolved	mg/L	2.4	2.5	2	2.5	4%	*2*	*2*	0.21	3	2	0.21	1.4	1.0	74%	*2*	*2*	0.95	3	2	0.95	1.7	0.6	37%	*2*	*2*	*2*	3	2	2	2.0	0.0	n/a
Selenium (Se)-Dissolved	mg/L	*0.0001*	*0.0001*	2	0.00010	n/a	*0.0001*	*0.0001*	*0.0001*	3	0.0001	0.0001	0.00010	0.00000	n/a	*0.0001*	*0.0001*	*0.0001*	3	0.0001	0.0001	0.00010	0.00000	n/a	*0.0001*	*0.0001*	*0.0001*	3	0.0001	0.0001	0.00010	0.00000	n/a
Silicon (Si)-Dissolved	mg/L	5.09	5.52	2	5.305	8%	2.95	2.96	2.87	3	2.96	2.87	2.927	0.049	2%	4.1	4.25	4.57	3	4.57	4.1	4.307	0.240	6%	4.25	4.18	4.15	3	4.25	4.15	4.193	0.051	1%
Silver (Ag)-Dissolved	mg/L	*0.00001*	*0.00001*	2	0.000010	n/a	*0.00001*	*0.00001*	*0.00001*	3	0.00001	0.00001	0.000010	0.000000	n/a	*0.00001*	*0.00001*	*0.00001*	3	0.00001	0.00001	0.000010	0.000000	n/a	*0.00001*	*0.00001*	*0.00001*	3	0.00001	0.00001	0.000010	0.000000	n/a
Sodium (Na)-Dissolved	mg/L	39.8	28.2	2	34.00	34%	2	*2*	1.33	3	2	1.33	1.78	0.39	22%	13.5	10.9	10.3	3	13.5	10.3	11.57	1.70	15%	30.3	30.8	30.3	3	30.8	30.3	30.47	0.29	1%
Strontium (Sr)-Dissolved	mg/L	0.494	0.438	2	0.4660	12%	0.0366	0.0317	0.0354	3	0.0366	0.0317	0.0346	0.0026	7%	0.388	0.362	0.388	3	0.388	0.362	0.3793	0.0150	4%	0.334	0.342	0.349	3	0.349	0.334	0.3417	0.0075	2%
Thallium (Tl)-Dissolved	mg/L	*0.00001*	*0.00001*	2	0.000010	n/a	*0.00001*	*0.00001*	0.000010	3	0.00001	0.00001	0.000010	0.000000	0%	*0.00001*	*0.00001*	*0.00001*	3	0.00001	0.00001	0.000010	0.000000	n/a	*0.00001*	*0.00001*	*0.00001*	3	0.00001	0.00001	0.000010	0.000000	n/a
Tin (Sn)-Dissolved	mg/L	0.00011	*0.0001*	2	0.00011	10%	*0.0001*	*0.0001*	*0.0001*	3	0.0001	0.0001	0.00010	0.00000	n/a	*0.0001*	*0.0001*	*0.0001*	3	0.0001	0.0001	0.00010	0.00000	n/a	*0.0001*	*0.0001*	*0.0001*	3	0.0001	0.0001	0.00010	0.00000	n/a
Titanium (Ti)-Dissolved	mg/L	*0.01*	*0.01*	2	0.010	n/a	*0.01*	*0.01*	*0.01*	3	0.01	0.01	0.010	0.000	n/a	*0.01*	*0.01*	*0.01*	3	0.01	0.01	0.010	0.000	n/a	*0.01*	*0.01*	*0.01*	3	0.01	0.01	0.010	0.000	n/a
Uranium (U)-Dissolved	mg/L	0.000884	0.000416	2	0.000650	72%	0.00005	0.000031	0.000032	3	0.00005	0.000031	0.000038	0.000011	28%	0.000574	0.00026	0.000122	3	0.000574	0.000122	0.000319	0.000232	73%	0.000013	*0.00001*	*0.00001*	3	0.000013	0.00001	0.000011	0.000002	16%
Vanadium (V)-Dissolved	mg/L	*0.001*	*0.001*	2	0.0010	n/a	*0.001*	*0.001*	*0.001*	3	0.001	0.001	0.0010	0.0000	n/a	*0.001*	*0.001*	*0.001*	3	0.001	0.001	0.0010	0.0000	n/a	*0.001*	*0.001*	*0.001*	3	0.001	0.001	0.0010	0.0000	n/a
Zinc (Zn)-Dissolved	mg/L	*0.003*	*0.003*	2	0.00300	n/a	*0.003*	0.0068	0.0043	3	0.0068	0.003	0.00470	0.00193	41%	*0.003*	*0.003*	*0.001*	3	0.003	0.001	0.00233	0.00115	n/a	*0.003*	*0.003*	*0.003*	3	0.003	0.003	0.00300	0.00000	n/a

Results in red italics are greater than number indicated.
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) |
n/a = not applicable, all values are below the detection limit

Table B3-3:
Water quality field parameters measured during October 2012 constant rate pumping test at QU11-38

Time	Elapsed Time (min)	Conductivity (mS/cm)	Specific Conductance (uS/cm)	Dissolved Oxygen (mg/L)	ORP_1 (mV)	pH_1 (Units)	Temperature (C)
24/10/2012 14:39	99.8	0.397	599	0.64	43.6	6.89	7.3
24/10/2012 15:09	129.9	0.398	602	0.25	-62.8	7.8	7.3
24/10/2012 15:39	159.9	0.399	603	0.2	-118.5	7.85	7.3
24/10/2012 16:09	189.9	0.401	607	0.22	-116.5	7.88	7.2
24/10/2012 16:39	219.9	0.4	608	0.24	-121.7	7.89	7.1
24/10/2012 17:09	249.9	0.404	614	0.29	-128.5	7.89	7.1
24/10/2012 17:39	279.9	0.4	610	0.31	-119.8	7.9	7
24/10/2012 18:09	309.9	0.401	611	0.31	-120	7.9	7
24/10/2012 18:39	339.9	0.401	613	0.34	-125.4	7.9	6.9
24/10/2012 19:09	369.9	0.401	614	0.35	-129.5	7.91	6.9
24/10/2012 19:39	399.9	0.4	612	0.37	-126.6	7.91	6.9
24/10/2012 20:09	429.9	0.401	613	0.39	-116.3	7.92	6.9
24/10/2012 20:39	459.9	0.401	613	0.44	-126.8	7.92	6.9
24/10/2012 21:09	489.9	0.399	613	0.51	-128	7.91	6.8
24/10/2012 21:39	519.9	0.396	610	0.3	-128.4	7.92	6.7
24/10/2012 22:09	549.9	0.397	612	0.67	-124.9	7.92	6.6
24/10/2012 22:39	579.9	0.392	611	0.89	-120	7.92	6.3
24/10/2012 23:09	609.9	0.391	612	1.22	-113.6	7.92	6.1
24/10/2012 23:39	639.9	0.391	612	0.87	-120.4	7.93	6.1
25/10/2012 0:09	669.9	0.39	614	1.1	-120.8	7.93	5.9
25/10/2012 0:39	699.9	0.39	610	0.86	-120.5	7.93	6.1
25/10/2012 1:09	729.9	0.39	610	1.05	-116.3	7.92	6.1
25/10/2012 1:39	759.9	0.389	609	1.14	-109.9	7.92	6
25/10/2012 2:09	789.9	0.39	611	1.02	-111	7.93	6
25/10/2012 2:39	819.9	0.388	610	1.32	-119.6	7.93	6
25/10/2012 3:09	849.9	0.389	610	0.87	-125.5	7.93	6
25/10/2012 3:39	879.9	0.389	610	1.33	-116	7.93	6
25/10/2012 4:09	909.9	0.389	609	0.7	-125.6	7.94	6
25/10/2012 4:39	939.9	0.388	611	1.45	-123.3	7.93	5.9
25/10/2012 5:09	969.9	0.387	609	1.19	-123.8	7.94	5.9
25/10/2012 5:39	999.9	0.388	611	1.39	-124.9	7.94	5.9
25/10/2012 6:09	1029.9	0.386	609	1.38	-118.7	7.93	5.8
25/10/2012 6:39	1059.9	0.385	609	1.71	-106.2	7.94	5.7
25/10/2012 7:09	1089.9	0.384	609	1.59	-126.3	7.94	5.7
25/10/2012 7:39	1119.9	0.378	613	1.26	-117.5	7.93	4.9
25/10/2012 8:09	1149.9	0.396	603	0.26	-137.4	7.95	7

Time	Elapsed Time (min)	Conductivity (mS/cm)	Specific Conductance (uS/cm)	Dissolved Oxygen (mg/L)	ORP_1 (mV)	pH_1 (Units)	Temperature (C)
25/10/2012 8:39	1179.9	0.395	607	0.35	-140.5	7.94	6.7
25/10/2012 9:09	1209.9	0.397	609	0.3	-129	7.93	6.8
25/10/2012 9:39	1239.9	0.398	609	0.29	-140.5	7.94	6.8
25/10/2012 10:09	1269.9	0.398	608	0.36	-142	7.93	6.9
25/10/2012 10:39	1299.9	0.403	611	0.32	-139.4	7.94	7.1
25/10/2012 11:09	1329.9	0.401	609	0.33	-143.1	7.93	7.1
25/10/2012 11:39	1359.9	0.398	602	0.33	-139.6	7.94	7.2
25/10/2012 12:09	1389.9	0.402	607	0.34	-135	7.94	7.3
25/10/2012 12:39	1419.9	0.403	608	0.41	-134.6	7.94	7.4
25/10/2012 13:09	1449.9	0.406	609	0.09	-141.6	7.93	7.6
25/10/2012 13:39	1479.9	0.405	607	0.09	-139.2	7.94	7.6
25/10/2012 14:09	1509.9	0.403	605	0.19	-148	7.94	7.5
25/10/2012 14:39	1539.9	0.405	608	0.22	-143.8	7.94	7.5
25/10/2012 15:09	1569.9	0.402	605	0.17	-144	7.94	7.5
25/10/2012 15:39	1599.9	0.404	608	0.22	-144.6	7.94	7.4
25/10/2012 16:09	1629.9	0.405	610	0.26	-129.4	7.94	7.4
25/10/2012 16:39	1659.9	0.404	609	0.24	-145.8	7.94	7.4
25/10/2012 17:09	1689.9	0.404	609	0.28	-138.5	7.94	7.3
25/10/2012 17:39	1719.9	0.404	610	0.31	-136.9	7.94	7.3
25/10/2012 18:09	1749.9	0.404	605	0.19	-132.9	7.92	7.6
25/10/2012 18:39	1779.9	0.406	608	0.01	-152	7.95	7.6
25/10/2012 18:56	1796.5	0.405	607	0.03	-214.7	8.37	7.6
25/10/2012 21:56	1976.5	0.404	606	0.06	-156.7	7.94	7.6
26/10/2012 0:56	2156.5	0.404	606	0.09	-156.9	7.94	7.6
26/10/2012 3:56	2336.5	0.405	608	0.11	-152	7.94	7.5
26/10/2012 6:56	2516.5	0.405	608	0.12	-156.5	7.94	7.5
26/10/2012 9:56	2696.5	0.404	608	0.15	-161.8	7.94	7.5
26/10/2012 12:56	2876.5	0.405	606	0.14	-150.8	7.94	7.6
26/10/2012 15:56	3056.5	0.408	611	0.08	-164.7	7.94	7.6
26/10/2012 18:56	3236.5	0.407	610	0.14	-163.7	7.94	7.6
26/10/2012 21:56	3416.5	0.407	611	0.16	-162.8	7.94	7.5
27/10/2012 0:56	3596.5	0.408	611	0.16	-163.2	7.94	7.6
27/10/2012 3:56	3776.5	0.404	605	0.17	-161.8	7.93	7.6
27/10/2012 6:56	3956.5	0.409	613	0.17	-161.6	7.94	7.5
27/10/2012 9:56	4136.5	0.408	612	0.18	-160.6	7.93	7.6
27/10/2012 12:06	4266.0		614	0.18	-160.3	7.93	7.6
27/10/2012 13:24	4344.0		613	0.19	-160	7.94	7.6

Batteries changed in YSI.

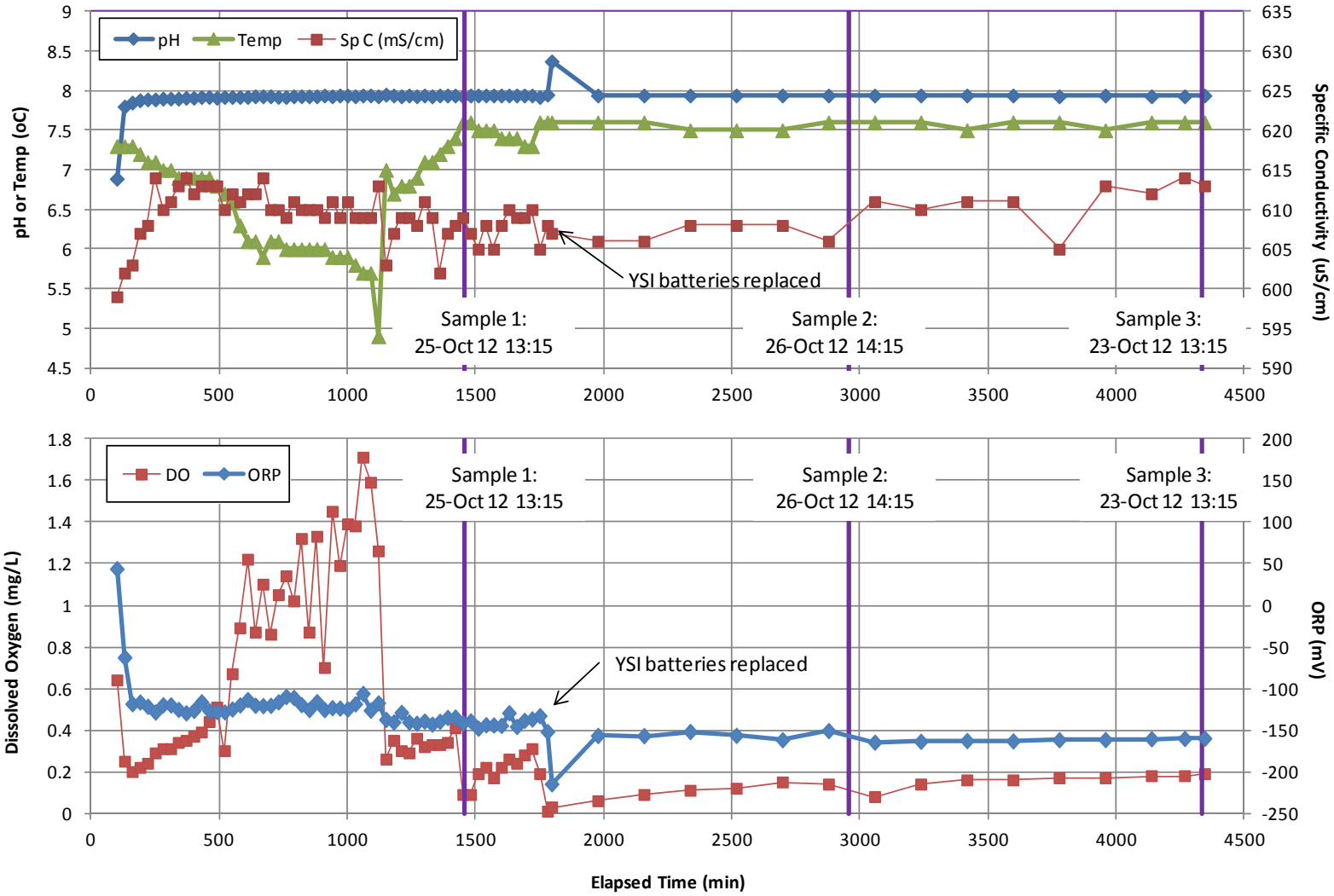


Figure B3-1: Time trends of field parameters measured on QU11-38 discharge during constant rate pumping test (October, 2012).

Appendix C
Hydrology

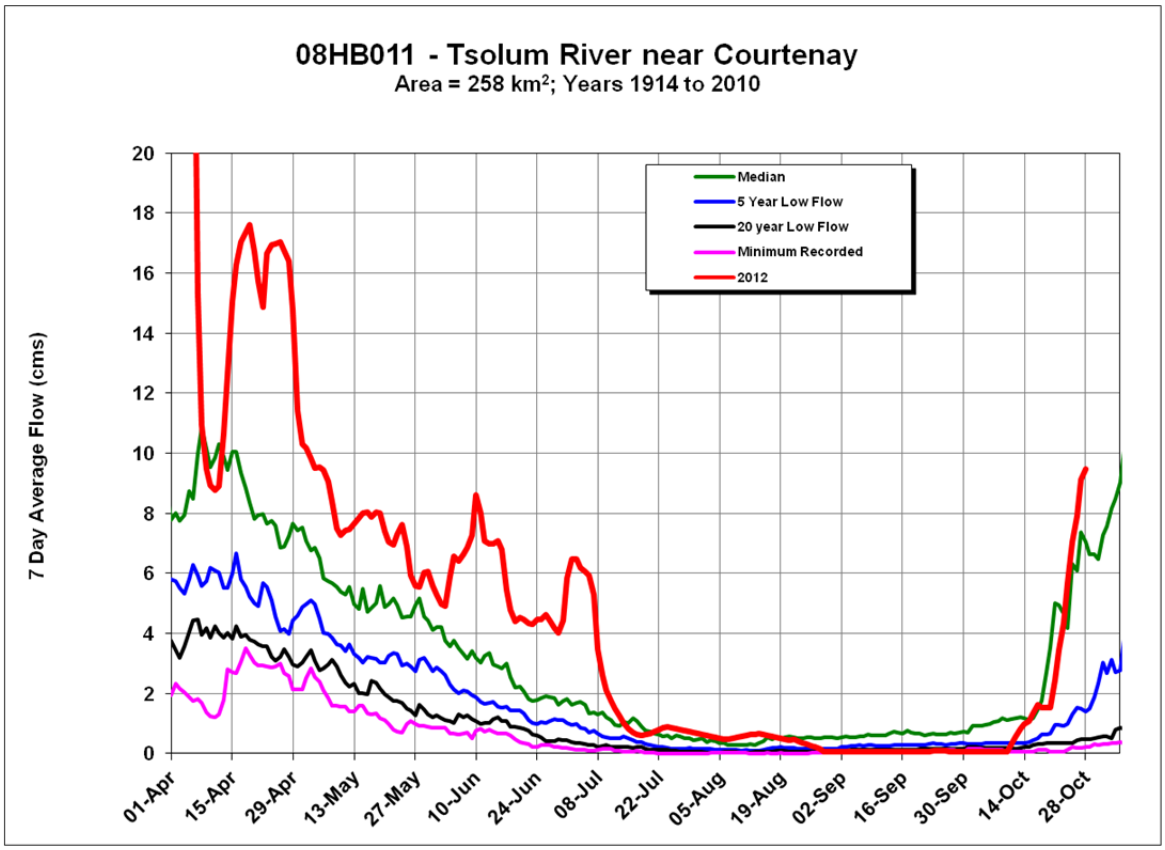
APPENDIX C1 SUMMARY OF REGIONAL HYDROMETRIC STATISTICS FOR ZONE 28 AFTER OBEDKOFF (2003)

APPENDIX C2 DEPICTION OF WATER YEAR 2012 – MEASURED VS. LONG-TERM FLOW STATISTICS

QUINSAM COAL

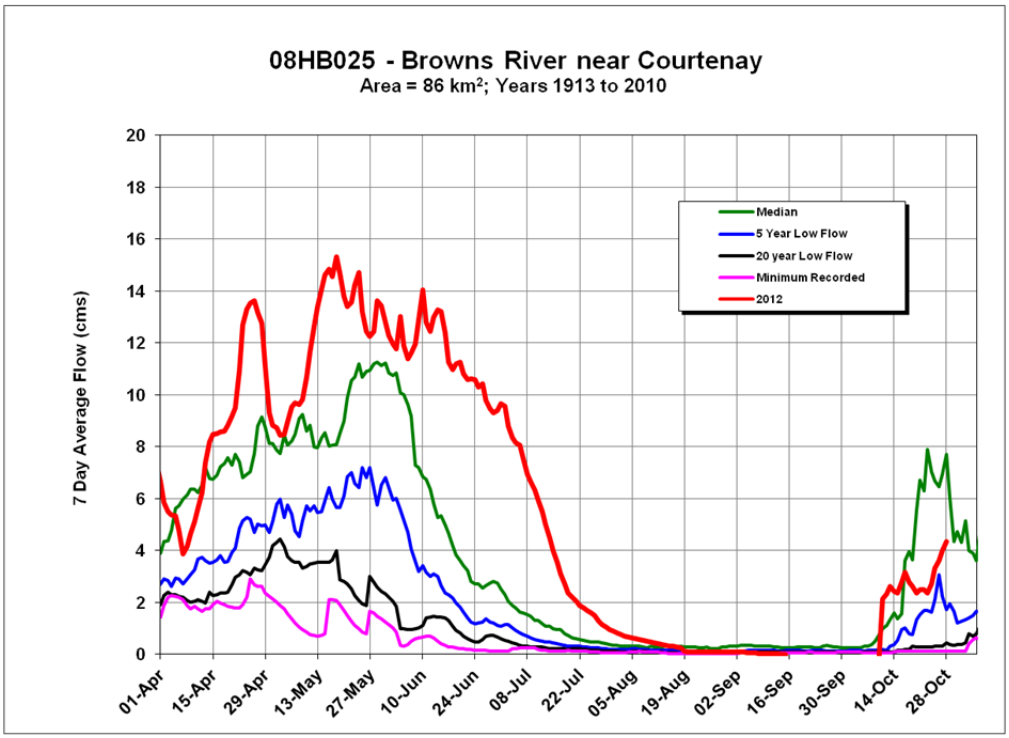
APPENDIX C1 SUMMARY OF REGIONAL HYDROMETRIC STATISTICS FOR ZONE 28 AFTER OBEDKOFF (2003)

Appendix C1. Depiction of Water Year 2012 – Measured vs. Long-term Flow Statistics



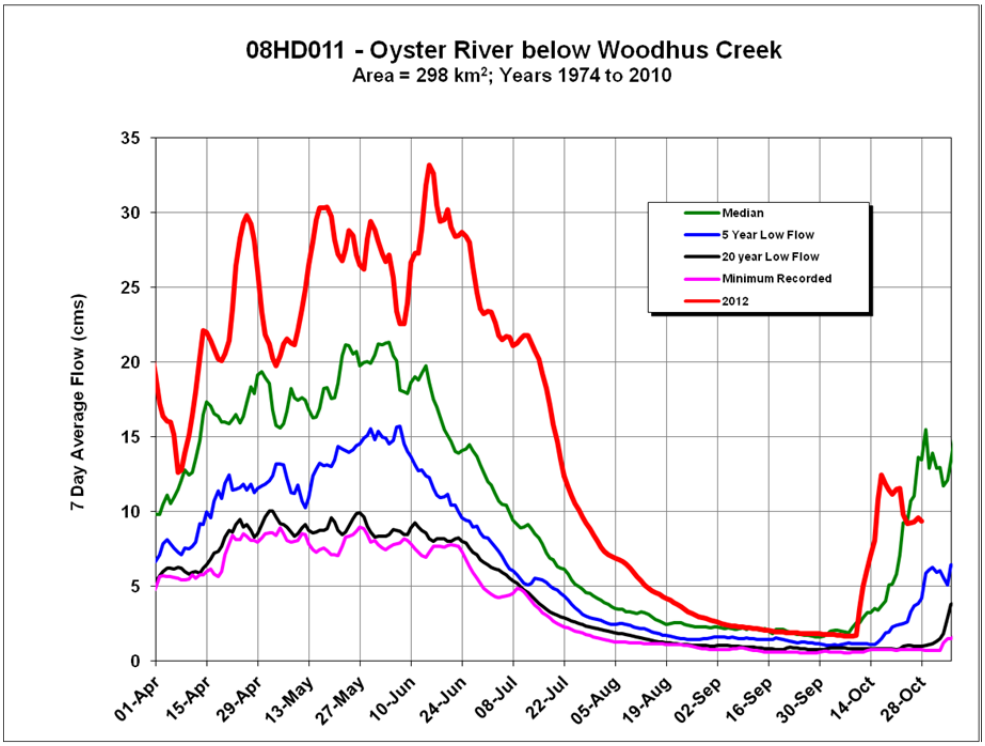
C1-1: Tsolum River near Courtney (Summary produced by BC Ministry of Environment)

http://bcrfc.env.gov.bc.ca/bulletins/watersupply/7DayPercentMedian2012.htm



C1-2: Browns River near Courtney (Summary produced by BC Ministry of Environment)

http://bcrfc.env.gov.bc.ca/bulletins/watersupply/7DayPercentMedian2012.htm



C1-3: Oyster River below Woodhus (Summary produced by BC Ministry of Environment)

http://bcrfc.env.gov.bc.ca/bulletins/watersupply/7DayPercentMedian2012.htm

Appendix C2. Summary of Regional Hydrometric Statistics for Zone 28 after Obedkoff (2003)

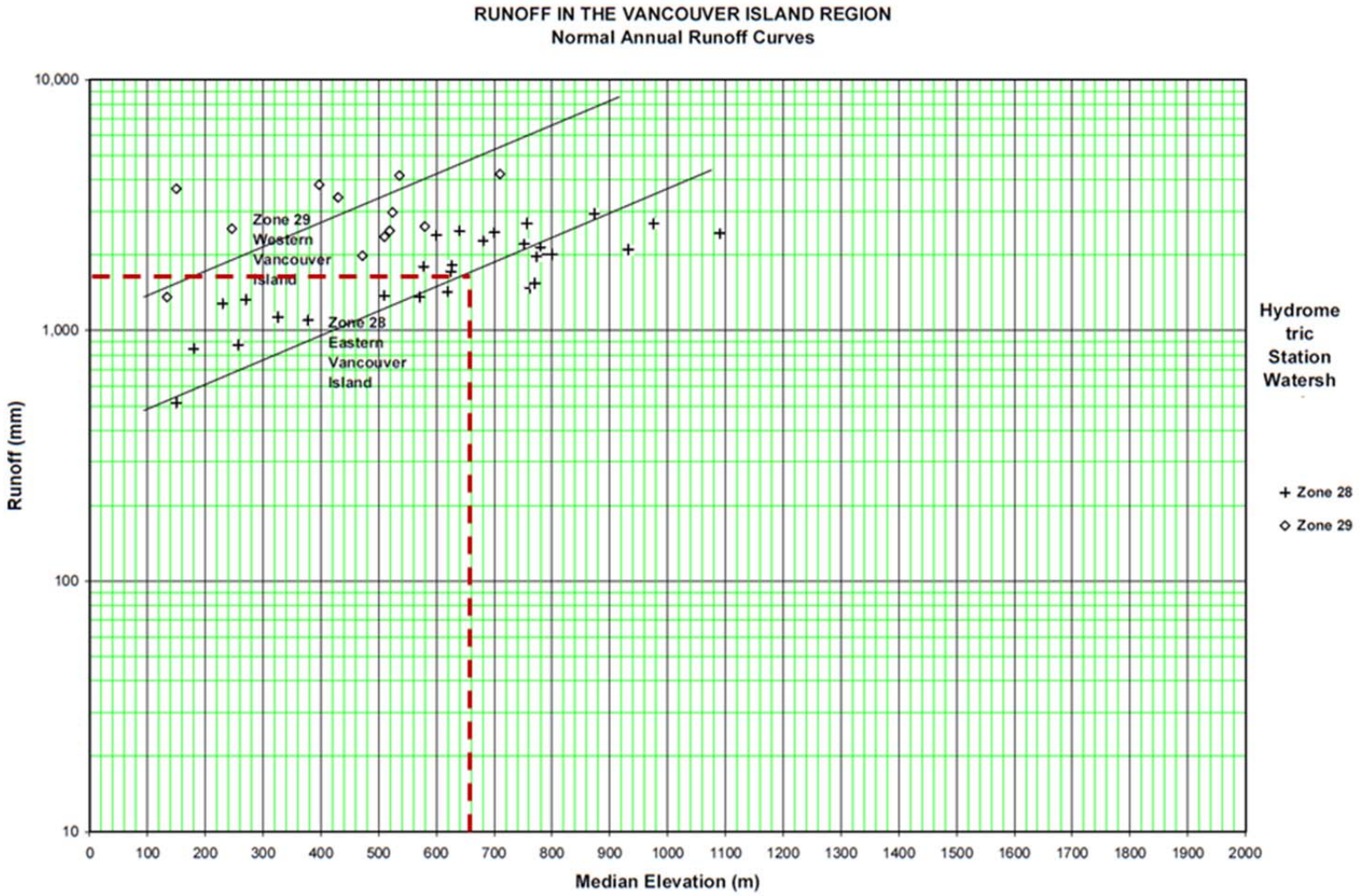


Figure C2-1: Relationship between annual runoff and elevation for Zone 28 (Eastern Vancouver Island) after Obedkoff (2003).

APPENDIX C2 DEPICTION OF WATER YEAR 2012 – MEASURED VS. LONG-TERM FLOW STATISTICS

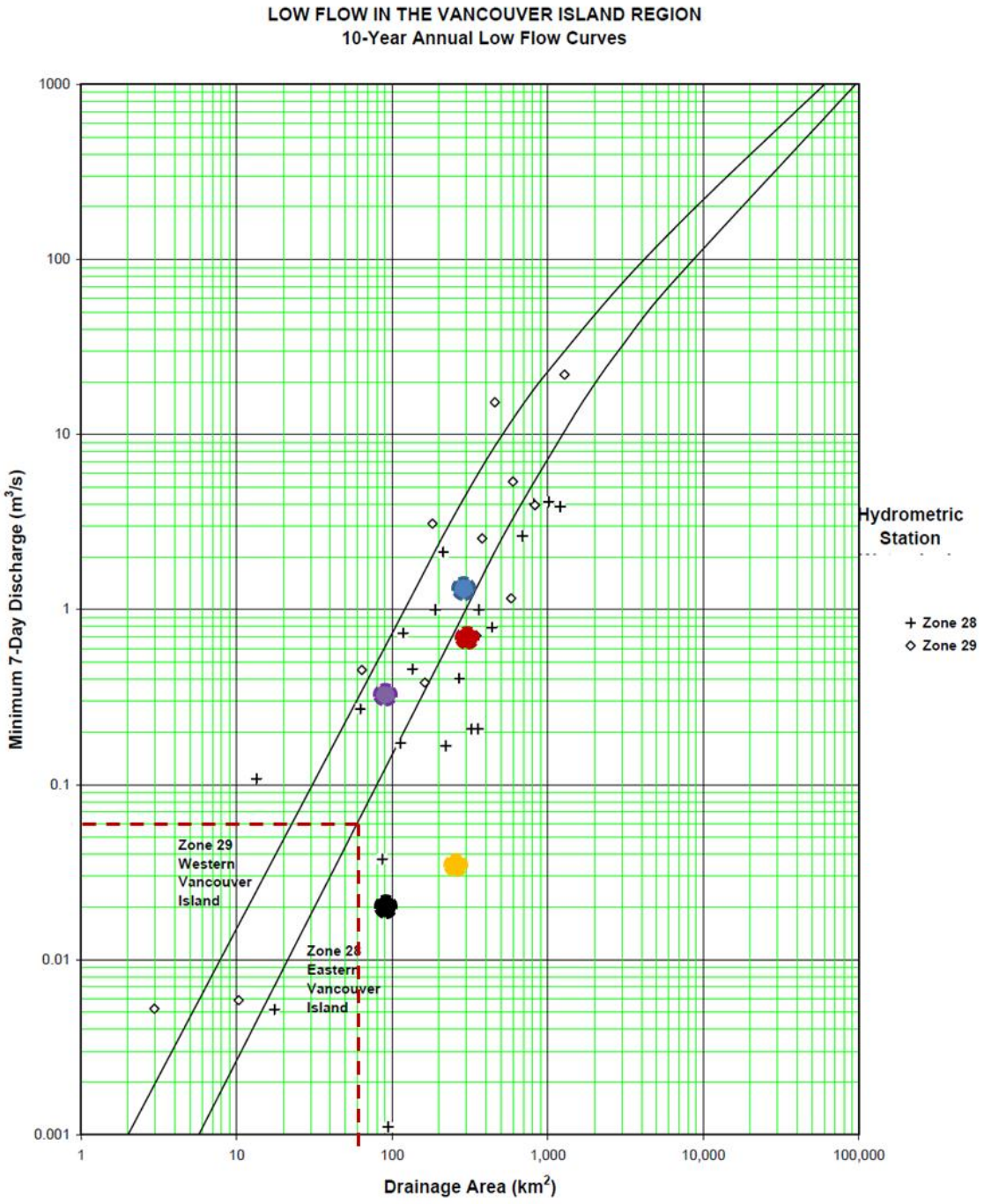


Figure C2-2: Relationship between 7Q10 low flow and drainage area for Zone 28 (Eastern Vancouver Island) after Obedkoff (2003). The blue, red and yellow circles indicate observations computed by Obedkoff for Quinsam River at Campbell River, Oyster River below Woodhus Creek and Tsolum River near Courtney. The purple and black circles indicate observations computed for Quinsam River at Argonaut Bridge and Tsolum River below Murex Creek based on data from 1997-2010.

Table C2-1:
Hydrometric statistics for Hydrologic Zone 28 after Obedkoff (2003).

Watershed		Hydro-	Median	Normal Annual		10-Year Annual Peak Flow				10-Year 7-Day Low Flow			10-Year 7-Day Low Flow		
Stream	Hydro-	logic	Elev-	Runoff			Drainage			Drainage	June-September		Drainage	Annual	
	metric	Zone	ation				Area			Area			Area		
	Station		(m)		(mm)	(m^3/s)	(km^2)	($L/s/km^2$)		(km^2)	(m^3/s)		(km^2)	(m^3/s)	
				Zone 28	Zone 29			Zone 28	Zone 29		Zone 28	Zone 29		Zone 28	Zone 29
Bings	08HA016	28	180	847		19.8	17.5	1131		17.5	0.005		17.5	0.005	
Browns	08HB025	28	800	2010		181	86.0	2105		86.0	0.039		86.0	0.038	
Chemainus	08HA001	28	625	1720		615	355	1732		355	0.208		355	0.208	
Comox Lake	Inflow	28	752	2210		-	470	-		470	-		470	-	
Cruickshank	08HB074	28	976	2670		424	213	1991		213	2.57		213	2.13	
Cusheon Lake	Inflow	28	150	515		-	8.31	-		8.31	-		8.31	-	
Dove	08HB075	28	270	1330		60.5	46.6	1298		46.6	0.000		46.6	0.001	
Elk	08HD018	28	1090	2440		175	117	1496		117	0.843		117	0.736	
Englishman	08HB002	28	571	1360		532	324	1642		324	0.218		324	0.208	
Gold	08HC001	28	757	2670		2130	1010	2109		1,010	4.29		1,010	4.13	
Jordan Reservoir	Inflow	28	640	2500		-	144	-		144	-		144	-	
Jump	08HB041	28	700	2460		117	62.2	1881		62.2	0.317		62.2	0.271	
Koksilah	08HA003	28	510	1380		281	221	1271		221	0.167		221	0.167	
Little Qualicum	08HB004	28	780	2010		138	135	1022		135	0.473		135	0.458	
Millstone	08HB032	28	257	875		51.6	94.2	548		94.2	0.002		94.2	0.001	
Nanaimo	08HB034	28	578	1800		883	684	1291		684	2.67		684	2.64	
Nile	08HB022	28	600	2400		64.9	13.4	4843		13.4	0.115		13.4	0.108	
Nimpkish	09HF005	28	681	2280		1090	815	1337		815	4.32		815	4.03	
Oyster	08HD011	28	762	1480		282	298	946		298	0.800		298	0.692	
Quinsam	08HD005	28	378	1100		132	285	463		285	1.33		285	1.33	
Salmon - ab Diversion	08HD015	28	770	1540		347	270	463		270	0.437		270	0.405	
Salmon - Memekay	08HD007	28	619	1430		433	437	991		437	0.830		437	0.793	
Salmon - Sayward	08HD006	28	627	1820		1120	1200	933		1200	4.03		1200	3.88	
Sooke Lake	Inflow	28	326	1130		-	72.6	-		72.6	-		72.6	-	
Tsable	08HB024	28	780	2150		325	113	2876		113	0.192		113	0.172	
Tsitika	08HF004	28	773	1970		721	359	2008		359	1.08		359	1.00	
Tsolum	08HB011	28	230	1280		233	258	903		258	0.035		258	0.035	
Ucona	08HC002	28	873	2930		539	189	2852		189	1.18		189	1.00	
Upper Campbell Lake	Inflow	28	932	2100		-	1170	-		1,170	-		1,170	-	

Appendix D
Surface Water Quality Data

QUINSAM COAL

Baseline Water Quality Data

Station Name	Collect Date	Acidity 8.3	Alkalinity	Conductivity	pH	TDS	TSS	NH3	NO2+NO3	TKN	PO4-D	PO4-T	Sulphate	Hardness-T	Ag-D	Ag-T	Al-D	Al-T	As-D	As-T	Ba-D	Ba-T	B-D	B-T	Be-D	Be-T
		mg/L	mg CaCO3/L	uS/cm	pH Units	mg/L	mg/L	mg-N/L	mg-N/L	mg-N/L	mg-P/L	mg-P/L	mg/L	mg CaCO3/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
Lower Iron River	07/10/2008	-	27.2	67.3	7.38	42	*<3.0*	-	-	-	-	-	*<0.50*	31.5	*<0.000020*	*<0.000020*	0.0534	0.0588	0.00154	0.00157	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Lower Iron River	14/10/2008	-	32.7	77.3	7.92	56	*<3.0*	-	-	-	-	-	1.41	35.7	*<0.000020*	*<0.000020*	0.0294	0.0308	0.00208	0.00206	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Lower Iron River	21/10/2008	-	25.7	60.9	7.70	44	*<3.0*	-	-	-	-	-	*<0.50*	28.4	*<0.000020*	*<0.000020*	0.0521	0.0561	0.00137	0.00139	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Lower Iron River	28/10/2008	-	31.8	74.3	7.81	49	*<3.0*	-	-	-	-	-	1.33	35.6	*<0.000020*	*<0.000020*	0.0337	0.0355	0.00198	0.00200	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Lower Iron River	24/03/2009	-	17.7	43.0	7.80	30	*<3.0*	*<0.020*	0.0476	0.070	*<0.0020*	*<0.0020*	*<0.50*	20.3	*<0.000020*	*<0.000020*	0.0517	0.0634	0.00112	0.00112	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Lower Iron River	31/03/2009	-	17.0	45.5	7.67	36	*<3.0*	*<0.0050*	-	0.078	*<0.0020*	0.0031	0.65	20.5	*<0.000020*	*<0.000020*	0.0566	0.0696	0.00118	0.00116	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Lower Iron River	07/04/2009	-	14.5	38.0	7.62	40	*<3.0*	*<0.0050*	0.0432	0.087	0.0021	0.0044	2.80	17.3	*<0.000020*	*<0.000020*	0.0765	0.110	0.00074	0.00083	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Lower Iron River	13/04/2009	-	17.3	45.1	7.70	33	*<3.0*	*<0.0050*	0.0807	0.087	*<0.0020*	0.0025	3.19	20.2	*<0.000020*	*<0.000020*	0.0919	0.118	0.00063	0.00067	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Lower Iron River	20/04/2009	-	23.9	56.2	7.96	41	*<3.0*	*<0.0050*	0.0557	0.084	*<0.0020*	0.0024	*<0.50*	26.2	*<0.000020*	*<0.000020*	0.0788	0.0963	0.00066	0.00067	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Lower Iron River	05/05/2009	-	21.1	47.9	7.77	43	6.0	*<0.0050*	0.0178	0.175	0.0047	0.0118	*<0.50*	24.4	*<0.000020*	*<0.000020*	0.110	0.314	0.00051	0.00073	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Lower Iron River	02/06/2009	-	28.4	60.2	7.88	44	*<3.0*	*<0.0050*	*<0.0050*	0.11	*<0.0020*	0.0031	2.10	30.0	*<0.000020*	*<0.000020*	0.0344	0.0644	0.00142	0.00147	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Lower Iron River	06/07/2009	-	46.1	113	7.96	70	*<3.0*	*<0.0050*	0.0328	0.111	*<0.0020*	0.0023	5.19	51.7	*<0.000020*	*<0.000020*	0.0310	0.0281	0.00505	0.00388	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Lower Iron River	05/08/2009	-	69.3	151	8.21	87	*<3.0*	*<0.0050*	0.106	0.076	*<0.0020*	0.0025	8.14	73.0	*<0.000020*	*<0.000020*	0.0163	0.0157	0.00627	0.00639	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Lower Iron River	01/09/2009	-	68.6	175	8.12	100	*<3.0*	*<0.0050*	0.0969	0.064	*<0.0020*	*<0.0020*	11.0	84.5	*<0.000020*	*<0.000020*	0.0120	0.0110	0.00763	0.00781	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Lower Iron River	30/09/2009	-	60.8	155	7.91	86	*<3.0*	*<0.0050*	0.0141	0.064	*<0.0020*	*<0.0020*	10.1	72.7	*<0.000020*	*<0.000020*	0.0071	0.0073	0.00729	0.00734	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Lower Iron River	05/11/2009	-	23.1	60.0	7.67	37	3.0	*<0.020*	0.0310	0.153	0.0027	0.0087	4.15	28.1	*<0.000020*	*<0.000020*	0.0671	0.209	0.00087	0.00115	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Lower Iron River	02/12/2009	-	19.2	45.7	7.83	33	*<3.0*	*<0.020*	0.0152	0.085	0.0021	0.0042	*<0.50*	21.8	*<0.000020*	*<0.000020*	0.0734	0.102	0.00077	0.00083	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Lower Iron River	26/04/2010	-	26.3	57.4	7.85	32	*<3.0*	*<0.0050*	*<0.0050*	0.102	0.0024	0.0031	*<0.50*	28.2	*<0.010*	*<0.010*	*<0.20*	*<0.20*	*<0.20*	*<0.20*	*<0.010*	*<0.010*	*<0.10*	*<0.10*	*<0.0050*	*<0.0050*
Lower Iron River	23/09/2010	-	42.2	112	7.97	69	*<3.0*	*<0.0050*	-	0.059	*<0.0020*	0.0022	10.1	51.7	*<0.000020*	*<0.000020*	0.0170	0.0245	0.00324	0.00347	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Lower Iron River	16/11/2010	1.1	23	56	7.40	44	*<4*	*<0.005*	*<0.02*	0.25	-	-	2.3	25.5	*<0.00002*	*<0.00002*	0.077	0.095	0.0009	0.0009	0.005	0.005	*<0.05*	*<0.05*	*<0.0001*	*<0.0001*
Upper Iron River	07/10/2008	-	26.6	66.3	7.68	50	3.3	-	-	-	-	-	*<0.50*	31.9	*<0.000020*	*<0.000020*	0.0605	0.0764	0.00110	0.00108	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Upper Iron River	14/10/2008	-	32.4	77.6	7.93	48	*<3.0*	-	-	-	-	-	1.48	34.7	*<0.000020*	*<0.000020*	0.0334	0.0352	0.00142	0.00143	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Upper Iron River	21/10/2008	-	25.3	60.8	7.77	46	*<3.0*	-	-	-	-	-	*<0.50*	28.6	*<0.000020*	*<0.000020*	0.0559	0.0595	0.00101	0.00105	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Upper Iron River	28/10/2008	-	32.3	74.5	7.80	77	*<3.0*	-	-	-	-	-	1.38	35.5	*<0.000020*	*<0.000020*	0.0362	0.0361	0.00134	0.00132	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Upper Iron River	24/03/2009	-	17.5	44.1	7.85	33	*<3.0*	*<0.020*	0.0428	0.086	*<0.0020*	*<0.0020*	*<0.50*	20.4	*<0.000020*	*<0.000020*	0.0584	0.0710	0.00088	0.00088	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Upper Iron River	31/03/2009	-	17.1	44.8	7.62	32	*<3.0*	*<0.0050*	-	0.076	0.0022	0.0023	0.65	20.2	*<0.000020*	*<0.000020*	0.0615	0.0769	0.00085	0.00087	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Upper Iron River	07/04/2009	-	13.8	36.6	7.74	41	*<3.0*	*<0.0050*	0.0475	0.101	*<0.0020*	0.0020	2.76	17.1	*<0.000020*	*<0.000020*	0.0813	0.120	0.00054	0.00061	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Upper Iron River	13/04/2009	-	17.1	44.6	7.76	36	*<3.0*	*<0.0050*	0.0808	0.100	0.0023	0.0034	3.23	20.2	*<0.000020*	*<0.000020*	0.0924	0.126	*<0.00050*	0.00053	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Upper Iron River	20/04/2009	-	23.3	56.3	8.00	44	*<3.0*	*<0.0050*	0.0557	0.085	*<0.0020*	0.0056	*<0.50*	26.0	*<0.000020*	*<0.000020*	0.0727	0.129	*<0.00050*	0.00071	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Upper Iron River	05/05/2009	-	20.9	47.5	7.80	45	6.0	*<0.0050*	0.0134	0.158	0.0041	0.0101	*<0.50*	24.9	*<0.000020*	*<0.000020*	0.119	0.303	*<0.00050*	0.00063	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Upper Iron River	02/06/2009	-	27.2	58.4	7.95	36	*<3.0*	*<0.0050*	*<0.0050*	0.063	0.0022	0.0038	*<0.50*	29.1	*<0.000020*	*<0.000020*	0.0341	0.0473	0.00097	0.00101	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Upper Iron River	06/07/2009	-	48.9	112	7.97	67	*<3.0*	*<0.0050*	0.0527	0.103	*<0.0020*	0.0026	5.13	53.4	*<0.000020*	*<0.000020*	0.0196	*<0.030*	0.00341	0.00270	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Upper Iron River	05/08/2009	-	71.9	149	8.23	89	*<3.0*	*<0.0050*	0.104	0.083	*<0.0020*	0.0023	8.07	71.2	*<0.000020*	*<0.000020*	0.0173	0.0336	0.00543	0.00534	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Upper Iron River	01/09/2009	-	68.0	171	8.13	96	*<3.0*	*<0.0050*	0.0896	0.055	0.0034	0.0022	10.9	85.0	*<0.000020*	*<0.000020*	0.0150	0.0131	0.00703	0.00711	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Upper Iron River	30/09/2009	-	62.5	151	7.92	83	*<3.0*	*<0.0050*	0.0179	*<0.050*	*<0.0020*	*<0.0020*	9.42	72.2	*<0.000020*	*<0.000020*	0.0071	0.0209	0.00535	0.00533	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Upper Iron River	05/11/2009	-	22.7	60.3	7.63	37	3.0	*<0.020*	0.0276	0.150	0.0033	0.0075	4.30	28.2	*<0.000020*	*<0.000020*	0.0697	0.187	0.00069	0.00108	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Upper Iron River	02/12/2009	-	18.1	45.6	7.93	41	*<3.0*	*<0.020*	0.0145	0.084	0.0030	0.0036	*<0.50*	21.8	*<0.000020*	*<0.000020*	0.0764	0.0960	0.00058	0.00062	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Upper Iron River	26/04/2010	-	26.2	57.4	7.86	38	*<3.0*	*<0.0050*	*<0.0050*	*<0.050*	0.0028	0.0028	*<0.50*	28.1	*<0.010*	*<0.010*	*<0.20*	*<0.20*	*<0.20*	*<0.20*	*<0.010*	*<0.010*	*<0.10*	*<0.10*	*<0.0050*	*<0.0050*
Upper Iron River	23/09/2010	-	40.6	106	7.96	63	*<3.0*	*<0.0050*	-	0.055	0.0022	0.0029	9.75	49.5	*<0.000020*	*<0.000020*	0.0235	0.0267	0.00234	0.00235	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
Upper Iron River	16/11/2010	1.4	23	55	7.41	40	*<4*	0.025	*<0.02*	0.17	-	-	2.6	29.7	*<0.00002*	*<0.00002*	0.081	0.108	0.0007	0.0008	0.005	0.005	*<0.05*	*<0.05*	*<0.0001*	*<0.0001*
7 South Quinsam River	09/08/2007	-	23.1	67.2	7.89	48	*<3.0*	-	-	-	-	-	8.4	27.26	*<0.000020*	*<0.000020*	0.0101	0.0176	*<0.00050*	*<0.00050*	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
7 South Quinsam River	05/11/2007	-	24.9	57.5	7.77	41	*<3.0*	-	-	-	-	-	*<0.50*	27.733	*<0.000020*	*<0.000020*	0.0430	0.0462	0.00116	0.00119	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
7 South Quinsam River	27/04/2008	-	26.9	115	6.94	72	*<3.0*	-	-	-	-	-	25.1	36.236	*<0.000020*	*<0.000020*	0.0122	0.0339	*<0.00050*	*<0.00050*	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
7 South Quinsam River	29/09/2008	-	28.5	116	7.74	-	-	-	-	-	-	-	22.5	35.236	*<0.000020*	0.000021	0.0053	0.0148	*<0.00050*	*<0.00050*	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
7 South Quinsam River	07/10/2008	-	26.8	107	7.34	47	*<3.0*	-	-	-	-	-	21.2	34.404	*<0.000020*	*<0.000020*	0.0085	0.0120	*<0.00050*	*<0.00050*	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
7 South Quinsam River	14/10/2008	-	28.2	124	7.77	75	*<3.0*	-	-	-	-	-	26.5	36.519	*<0.000020*	*<0.000020*	0.0057	0.174	*<0.00050*	0.00055	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
7 South Quinsam River	21/10/2008	-	28.3	125	7.71	76	*<3.0*	-	-	-	-	-	27.5	40.179	*<0.000020*	*<0.000020*	0.0072	0.0143	*<0.00050*	*<0.00050*	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
7 South Quinsam River	28/10/2008	-	28.2	126	7.60	88	*<3.0*	-	-	-	-	-	27.4	39.765	*<0.000020*	*<0.000020*	0.0057	0.0093	*<0.00050*	*<0.00050*	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
7 South Quinsam River	24/03/2009	-	25.8	132	7.77	84	*<3.0*	*<0.020*	0.0696	0.086	-	-	33.2	37.22	*<0.000020*	*<0.000020*	0.0250	0.0258	*<0.00050*	*<0.00050*	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
7 South Quinsam River	31/03/2009	-	27.0	160	7.70	99	*<3.0*	*<0.0050*	-	0.091	-	-	39.6	41.413	*<0.000020*	*<0.000020*	0.0270	0.0390	*<0.00050*	*<0.00050*	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
7 South Quinsam River	07/04/2009	-	28.5	169	7.67	109	5.0	*<0.0050*	0.0324	0.068	-	-	47.4	44.327	*<0.000020*	*<0.000020*	0.0187	0.0486	*<0.00050*	*<0.00050*	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
7 South Quinsam River	13/04/2009	-	40.5	248	7.80	147	*<3.0*	*<0.0050*	0.0310	0.097	-	-	72.7	60.164	*<0.000020*	*<0.000020*	0.0120	0.0409	*<0.00050*	*<0.00050*	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
7 South Quinsam River	20/04/2009	-	36.2	209	7.96	124	*<3.0*	*<0.0050*	0.0228	0.074	-	-	47.9	51.479	*<0.000020*	*<0.000020*	0.0129	0.0284	*<0.00050*	*<0.00050*	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*

Baseline Water Quality Data

Station Name	Collect Date	Acidity 8.3	Alkalinity	Conductivity	pH	TDS	TSS	NH3	NO2+NO3	TKN	PO4-D	PO4-T	Sulphate	Hardness-T	Ag-D	Ag-T	Al-D	Al-T	As-D	As-T	Ba-D	Ba-T	B-D	B-T	Be-D	Be-T
		mg/L	mg CaCO3/L	uS/cm	pH Units	mg/L	mg/L	mg-N/L	mg-N/L	mg-N/L	mg-P/L	mg-P/L	mg/L	mg CaCO3/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
7 South Quinsam River	05/05/2009	-	27.0	128	7.74	84	*<3.0*	*<0.0050*	0.0613	0.138	-	-	28.8	36.47	*<0.000020*	*<0.000020*	0.0254	0.0671	*<0.00050*	*<0.00050*	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
7 South Quinsam River	02/06/2009	-	37.6	189	7.88	126	*<3.0*	0.0085	0.0244	0.12	-	-	47.4	48.524	*<0.000020*	*<0.000020*	0.0124	0.0180	*<0.00050*	*<0.00050*	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
7 South Quinsam River	06/07/2009	-	30.7	135	7.87	80	*<3.0*	*<0.0050*	0.0169	0.138	-	-	26.9	39.265	*<0.000020*	*<0.000020*	0.0187	*<0.030*	*<0.00050*	*<0.00050*	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
7 South Quinsam River	05/08/2009	-	29.5	107	7.92	66	*<3.0*	0.0059	0.0164	0.105	-	-	18.2	34.986	*<0.000020*	*<0.000020*	0.0093	0.0260	*<0.00050*	*<0.00050*	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
7 South Quinsam River	01/09/2009	-	29.6	107	7.91	61	*<3.0*	*<0.0050*	0.0104	0.104	-	-	18.2	34.945	*<0.000020*	*<0.000020*	0.0149	0.0096	*<0.00050*	*<0.00050*	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
7 South Quinsam River	30/09/2009	-	30.1	120	7.94	72	*<3.0*	*<0.0050*	0.0056	0.099	-	-	23.5	37.81	*<0.000020*	*<0.000020*	0.0073	0.0082	*<0.00050*	*<0.00050*	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
7 South Quinsam River	05/11/2009	-	30.1	149	7.67	91	*<3.0*	*<0.020*	0.0481	0.180	-	-	37.6	47.737	*<0.000020*	*<0.000020*	0.0182	0.0404	*<0.00050*	*<0.00050*	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
7 South Quinsam River	02/12/2009	-	23.7	83.2	7.80	56	*<3.0*	*<0.020*	0.0226	0.097	-	-	14.6	25.783	*<0.000020*	*<0.000020*	0.0253	0.0459	*<0.00050*	*<0.00050*	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
7 South Quinsam River	26/04/2010	-	30.5	124	7.72	70	*<3.0*	0.0063	0.0173	0.089	-	-	27.4	36.851	*<0.010*	*<0.010*	*<0.20*	*<0.20*	*<0.20*	*<0.20*	*<0.010*	*<0.010*	*<0.10*	*<0.10*	*<0.0050*	*<0.0050*
7 South Quinsam River	23/09/2010	-	26.2	90.8	7.76	54	*<3.0*	*<0.0050*	-	0.108	-	-	14.9	29.009	*<0.000020*	*<0.000020*	0.0116	0.0207	*<0.00050*	*<0.00050*	*<0.020*	*<0.020*	*<0.10*	*<0.10*	*<0.0010*	*<0.0010*
7 South Quinsam River	16/11/2010	0.8	22	86	7.34	56	7	0.009	0.03	0.21	-	-	16	28.953	*<0.00002*	*<0.00002*	0.025	0.060	0.0002	0.0002	0.002	0.002	*<0.05*	*<0.05*	*<0.0001*	*<0.0001*
7 South Quinsam River	06/12/2010	*<0.5*	23	89	7.36	-	-	0.055	0.04	0.11	-	-	18	24.145	*<0.00002*	*<0.00002*	0.027	0.042	0.0003	0.0001	0.003	0.003	*<0.05*	*<0.05*	*<0.0001*	*<0.0001*
7 South Quinsam River	02/02/2011	0.9	29	104.00	7.39	56.00	*<4.00*	0.018	0.03	0.15	-	-	22.00	30.494	*<0.00002*	*<0.00002*	0.029	0.06	0.0002	0.0002	0.002	0.002	*<0.05*	*<0.05*	*<0.0001*	*<0.0001*
7 South Quinsam River	22/03/2011	*<0.5*	25	118	7.53	70	*<4*	-	0.03	-	-	-	29	31.621	*<0.00002*	*<0.00002*	0.032	0.057	0.0001	0.0002	0.002	0.003	*<0.05*	*<0.05*	*<0.0001*	*<0.0001*
7 South Quinsam River	04/04/2011	*<0.5*	31	143	7.55	72	*<4*	0.019	0.03	0.12	-	-	32	34.322	*<0.00002*	*<0.00002*	0.024	0.037	0.0001	0.0001	0.003	0.002	*<0.05*	*<0.05*	*<0.0001*	*<0.0001*
7 South Quinsam River	18/04/2011	*<0.5*	30	128	7.61	64	*<4*	0.020	*<0.02*	0.14	-	-	29	37.228	*<0.00002*	*<0.00002*	0.019	0.037	0.0002	0.0002	0.002	0.003	*<0.05*	*<0.05*	*<0.0001*	*<0.0001*
7 South Quinsam River	25/04/2011	*<0.5*	31	135	7.60	70	*<4*	0.082	*<0.02*	0.18	-	-	29	37.474	*<0.00002*	*<0.00002*	0.017	0.030	0.0003	0.0001	0.002	0.002	*<0.05*	*<0.05*	*<0.0001*	*<0.0001*
7 South Quinsam River	03/05/2011	*<0.5*	29	111	7.28	70	1	0.042	*<0.02*	0.26	-	-	26	33.658	*<0.00002*	*<0.00002*	0.019	0.044	0.0002	0.0001	0.002	0.002	*<0.05*	*<0.05*	*<0.0001*	*<0.0001*
7 South Quinsam River	30/05/2011	*<0.5*	22	60	7.43	44	*<4*	0.026	*<0.02*	-	-	-	7.0	26.205	*<0.00002*	*<0.00002*	0.010	0.039	0.0014	0.0002	0.026	0.002	*<0.05*	*<0.05*	*<0.0001*	*<0.0001*
7 South Quinsam River	07/06/2011	*<0.5*	23	65	7.47	34	*<4*	0.047	*<0.02*	-	-	-	7.9	21.642	*<0.00002*	*<0.00002*	0.020	0.061	0.0002	0.0002	0.001	0.001	*<0.05*	*<0.05*	*<0.0001*	*<0.0001*
7 South Quinsam River	04/07/2011	*<0.5*	28	90	7.54	44	*<4*	0.037	0.05	-	-	-	18	36.228	*<0.00002*	*<0.00002*	0.016	0.039	0.0002	0.0003	0.002	0.002	*<0.05*	0.05	*<0.0001*	*<0.0001*
7 South Quinsam River	03/08/2011	*<0.5*	28	88	7.54	58	*<4*	0.048	*<0.02*	-	-	-	15	25.498	*<0.00002*	*<0.00002*	0.024	0.029	0.0002	0.0002	0.002	0.002	*<0.05*	*<0.05*	*<0.0001*	*<0.0001*
7 South Quinsam River	30/08/2011	*<0.5*	29	99	7.60	64	*<4*	0.035	*<0.02*	-	-	-	18	27.46	*<0.00002*	*<0.00002*	0.012	0.034	0.0002	0.0002	0.002	0.002	*<0.05*	*<0.05*	*<0.0001*	*<0.0001*
7 South Quinsam River	03/10/2011	*<0.5*	27	94	7.50	54	*<4*	0.44	*<0.02*	-	-	-	17	30.871	*<0.00002*	*<0.00002*	0.010	0.031	0.0002	0.0003	0.002	0.002	*<0.05*	*<0.05*	*<0.0001*	*<0.0001*
7 South Quinsam River	01/11/2011	*<0.5*	27	109	7.43	68	*<4*	0.027	*<0.02*	-	-	-	23	32.621	*<0.00002*	*<0.00002*	0.015	0.083	0.0002	0.0002	0.002	0.002	*<0.05*	*<0.05*	*<0.0001*	*<0.0001*
7 South Quinsam River	07/12/2011	*<0.5*	25.8	98.9	7.26	52	*<4.0*	0.032	0.022	-	-	-	23.7	29.732	*<0.000020*	*<0.00002*	0.0236	0.052	0.00014	0.0002	0.0021	0.002	*<0.050*	*<0.05*	*<0.00010*	*<0.0001*
7 South Quinsam River	05/01/2012	*<0.5*	15.4	63.7	7.28	38	*<4.0*	0.0081	*<0.020*	-	-	-	10.8	19.7552	*<0.000020*	*<0.00002*	0.0534	0.112	0.00018	0.0002	0.0019	0.002	*<0.050*	*<0.05*	*<0.00010*	*<0.0001*
7 South Quinsam River	09/01/2012	*<0.5*	10.3	30.2	7.07	18	-	0.016	0.288	*<0.020*	-	-	*<0.50*	6.3824	*<0.000020*	*<0.00002*	0.100	0.158	*<0.00010*	*<0.0001*	0.0011	0.001	*<0.050*	*<0.05*	*<0.00010*	*<0.0001*
7 South Quinsam River	06/03/2012	*<0.5*	25.6	125	7.44	-	*<4.0*	0.024	0.024	0.132	-	-	28.9	35.769	*<0.000020*	*<0.00002*	0.0298	0.043	0.00016	0.0002	0.0027	0.003	*<0.050*	*<0.05*	*<0.00010*	*<0.0001*
7 South Quinsam River	03/04/2012	*<0.5*	27.9	129	7.58	-	4	0.016	0.031	0.164	-	-	29.5	32.818	*<0.000020*	*<0.00002*	0.0489	0.142	0.0002	0.0003	0.003	0.003	*<0.050*	*<0.05*	*<0.00010*	*<0.0001*
7 South Quinsam River	01/05/2012	*<0.50*	32.9	125	7.59	-	*<4.0*	0.0096	*<0.020*	0.158	-	-	25.8	30.33	*<0.000020*	*<0.000020*	0.0153	0.0254	0.00017	0.00022	0.0024	0.0025	*<0.050*	*<0.050*	*<0.00010*	*<0.00010*
7 South Quinsam River	05/06/2012	*<0.50*	23.4	70.1	7.58	-	*<4.0*	0.026	*<0.020*	0.166	-	-	9.07	22.7125	*<0.000020*	*<0.000020*	0.0141	0.0345	0.00023	0.00011	0.0016	0.0014	*<0.050*	*<0.050*	*<0.00010*	*<0.00010*
7 South Quinsam River	03/07/2012	*<0.50*	24.4	74.9	7.64	-	*<4.0*	0.015	0.023	0.157	-	-	10.3	25.764	*<0.000020*	*<0.000020*	0.0164	0.0397	0.0002	0.00021	0.0017	0.0017	*<0.050*	*<0.050*	*<0.00010*	*<0.00010*
7 South Quinsam River	01/08/2012	*<0.50*	26.4	89.8	7.64	-	50.5	0.017	*<0.020*	0.104	-	-	12.6	28.688	*<0.000020*	*<0.000020*	0.0119	0.0712	0.00026	0.0003	0.0019	0.0022	*<0.050*	*<0.050*	*<0.00010*	*<0.00010*
7 South Quinsam River	04/09/2012	*<0.50*	31.4	103	7.63	-	*<4.0*	-	-	-	-	-	16.9	29.327	*<0.000020*	*<0.000020*	0.0093	0.0182	0.00020	0.00023	0.0016	0.0019	*<0.050*	*<0.050*	*<0.00010*	*<0.00010*
7 South Quinsam River	09/10/2012	*<0.50*	26.7	88.2	7.58	-	*<4.0*	0.015	*<0.020*	0.115	-	-	12.9	27.628	*<0.000020*	*<0.000020*	0.0052	0.0113	0.00017	0.00020	0.0015	0.0017	*<0.050*	*<0.050*	*<0.00010*	*<0.00010*
7 South Quinsam River	05/11/2012	*<0.50*	26.7	90.2	7.61	-	*<4.0*	0.011	*<0.020*	0.128	-	-	14.0	33.65	*<0.000020*	*<0.000020*	0.0163	0.0601	0.00023	0.00029	0.0026	0.0029	*<0.050*	*<0.050*	*<0.00010*	*<0.00010*
7 South Quinsam River	12/12/2012	*<0.50*	31.6	124	7.50	-	4.0	-	-	-	-	-	25.4	28.491	*<0.000020*	*<0.000020*	0.0221	0.139	0.00023	0.00025	0.0025	0.0029	*<0.050*	*<0.050*	*<0.00010*	*<0.00010*
Iron River Upstream	10/05/2012	*<0.50*	31.9	67.4	7.62	56	*<4.0*	0.013	*<0.020*	0.168	-	-	2.53	30.5	*<0.000020*	*<0.000020*	0.0501	0.0519	0.00037	0.00052	0.0024	0.002	*<0.050*	*<0.050*	*<0.00010*	*<0.00010*
Iron River Upstream	22/05/2012	*<0.50*	25.2	49.2	7.5	30	*<4.0*	0.012	*<0.020*	0.12	-	-	2.76	22.9	*<0.000020*	*<0.000020*	0.0712	0.101	0.00025	0.00028	0.0018	0.0016	*<0.050*	*<0.050*	*<0.00010*	*<0.00010*
Iron River Upstream	29/05/2012	*<0.50*	23.6	49.6	7.6	26	*<4.0*	0.015	*<0.020*	0.15	-	-	1.07	23.6	*<0.000020*	*<0.000020*	0.0745	0.0666	0.00027	0.00023	0.0022	0.0015	*<0.050*	*<0.050*	*<0.00010*	*<0.00010*
Iron River Upstream	05/06/2012	*<0.50*	22.1	49.6	7.51	-	*<4.0*	0.017	0.123	*<0.020*	-	-	0.98	23.6	*<0.000020*	*<0.000020*	0.0578	0.0636	0.00025	0.00024	0.0016	0.0016	*<0.050*	*<0.050*	*<0.00010*	*<0.00010*
Iron River Upstream	12/06/2012	*<0.50*	20	40.1	7.5	34	*<4.0*	0.014	*<0.020*	0.139	-	-	0.9	19.9	*<0.000020*	*<0.000020*	0.0687	0.0771	0.00035	0.0002	0.0015	0.0014	*<0.050*	*<0.050*	*<0.00010*	*<0.00010*
Iron River Upstream	03/07/2012	0.79	30.3	65.9	7.73	-	*<4.0*	0.014	*<0.020*	0.127	-	-	1.39	30.7	*<0.000020*	*<0.000020*	0.0423	0.048	0.00041	0.0004	0.0022	0.0024	*<0.050*	*<0.050*	*<0.00010*	*<0.00010*
Iron River Upstream	02/08/2012	1.4	56.4	122	7.92	-	*<4.0*	0.015	*<0.020*	0.066	-	-	5.62	59	*<0.000020*	*<0.000020*	0.0242	0.025	0.00053	0.00046	0.0042	0.0041	*<0.050*	*<0.050*	*<0.00010*	*<0.00010*
Iron River Upstream	04/09/2012	*<0.50*	68.1	156	7.95	-	*<4.0*	*<0.0050*	0.052	0.051	-	-	11.5	77.695	*<0.000020*	*<0.000020*	0.0136	0.0137	0.00045	0.00047	0.0053	0.0052	*<0.050*	*<0.050*	*<0.00010*	*<0.00010*
Iron River Upstream	09/10/2012	*<0.50*	70.9	175	7.81	-	*<4.0*	*<0.0050*	*<0.020*	0.131	-	-	14.7	83.158	*<0.000020*	*<0.000020*	0.0088	0.0140	0.00035	0.00040	0.0051	0.0055	*<0.050*	*<0.050*	*<0.00010*	*<0.00010*
Iron River Upstream	05/11/2012	*<0.50*	33.4	74.8	7.74	-	4.0	-	-	-	-	-	4.25	33.5053	*<0.000020*	*<0.000020*	0.0419	0.0810	0.00045	0.00053	0.0026	0.0029	*<0.050*	*<0.050*	*<0.00010*	*<0.00010*
Iron River Upstream	12/12/2012	*<0.50*	35.2	75.4	7.77	-	*<4.0*	-	-	-	-	-	4.25	33.2633	*<0.000020*	*<0.000020*	0.0365	0.0793	0.00043	0.00034	0.0027	0.0027	*<0.050*	*<0.050*	*<0.00010*	*<0.00010*

Baseline Water Quality Data

Station Name	Collect Date	Bi-D	Bi-T	Ca-D	Ca-T	Cd-D	Cd-T	Co-D	Co-T	Cr-D	Cr-T	Cu-D	Cu-T	Fe-D	Fe-T	Hg-D	Hg-T	K-D	K-T	Li-D	Li-T	Mg-D	Mg-T	Mn-D	Mn-T	Mo-D	Mo-T	Na-D	Na-T
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Lower Iron River	07/10/2008	-	-	10.9	10.9	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	0.0011	0.0012	0.069	0.079	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	1.05	1.06	0.00185	0.00248	*<0.0010*	*<0.0010*	*<2.0*	*<2.0*
Lower Iron River	14/10/2008	-	-	12.5	12.5	0.000034	0.000032	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	0.032	0.035	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	1.07	1.09	0.00085	0.00103	*<0.0010*	*<0.0010*	*<2.0*	*<2.0*
Lower Iron River	21/10/2008	-	-	9.88	10.1	0.000020	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	0.044	0.050	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	0.92	0.92	0.00113	0.00160	*<0.0010*	*<0.0010*	*<2.0*	*<2.0*
Lower Iron River	28/10/2008	-	-	12.5	12.6	0.000018	0.000024	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.030*	*<0.030*	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	1.06	1.07	0.00109	0.00147	*<0.0010*	*<0.0010*	*<2.0*	*<2.0*
Lower Iron River	24/03/2009	-	-	6.89	6.36	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	0.033	0.044	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	0.76	0.73	0.00051	0.00144	*<0.0010*	*<0.0010*	*<2.0*	*<2.0*
Lower Iron River	31/03/2009	-	-	6.92	6.48	0.000021	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	0.0011	0.0054	0.036	0.051	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	0.78	0.75	0.00066	0.00122	*<0.0010*	*<0.0010*	*<2.0*	*<2.0*
Lower Iron River	07/04/2009	-	-	5.77	5.62	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	0.045	0.094	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	0.69	0.69	0.00083	0.00261	*<0.0010*	*<0.0010*	*<2.0*	*<2.0*
Lower Iron River	13/04/2009	-	-	6.98	6.69	0.000022	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	0.0017	*<0.0010*	0.051	0.080	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	0.69	0.66	0.00100	0.00240	*<0.0010*	*<0.0010*	*<2.0*	*<2.0*
Lower Iron River	20/04/2009	-	-	9.26	8.99	0.000017	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	0.090	0.090	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	0.74	0.74	0.00141	0.00239	*<0.0010*	*<0.0010*	*<2.0*	*<2.0*
Lower Iron River	05/05/2009	-	-	8.72	8.18	0.000022	0.000041	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	0.0010	0.0016	0.079	0.335	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	0.65	0.68	0.00171	0.0130	*<0.0010*	*<0.0010*	*<2.0*	*<2.0*
Lower Iron River	02/06/2009	-	-	10.7	10.2	0.000021	0.000017	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	0.0013	*<0.030*	*<0.030*	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	0.78	0.75	0.00085	0.00147	*<0.0010*	*<0.0010*	*<2.0*	*<2.0*
Lower Iron River	06/07/2009	-	-	18.4	17.9	0.000040	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	0.0014	*<0.0010*	*<0.030*	*<0.030*	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	1.40	1.38	0.00291	0.00299	*<0.0010*	*<0.0010*	2.3	2.3
Lower Iron River	05/08/2009	-	-	25.8	25.1	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.030*	*<0.030*	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	2.05	1.95	0.00102	0.00110	*<0.0010*	*<0.0010*	5.1	3.6
Lower Iron River	01/09/2009	-	-	30.0	30.4	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.030*	*<0.030*	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	2.32	2.34	0.00086	0.00104	*<0.0010*	*<0.0010*	5.1	5.1
Lower Iron River	30/09/2009	-	-	25.7	25.5	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.030*	*<0.030*	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	2.05	2.03	0.00079	0.00074	*<0.0010*	*<0.0010*	4.0	4.0
Lower Iron River	05/11/2009	-	-	9.72	9.64	0.000017	0.000022	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	0.0020	0.0014	0.058	0.267	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	0.94	0.96	0.00161	0.0106	*<0.0010*	*<0.0010*	*<2.0*	*<2.0*
Lower Iron River	02/12/2009	-	-	7.61	7.34	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	0.0012	*<0.0010*	0.042	0.090	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	0.67	0.66	0.00090	0.00184	*<0.0010*	*<0.0010*	*<2.0*	*<2.0*
Lower Iron River	26/04/2010	*<0.20*	*<0.20*	10.1	9.84	*<0.010*	*<0.010*	*<0.010*	*<0.010*	*<0.010*	*<0.010*	*<0.010*	*<0.010*	*<0.030*	0.041	-	-	*<2.0*	*<2.0*	*<0.010*	*<0.010*	0.75	0.74	*<0.0050*	*<0.0050*	*<0.030*	*<0.030*	*<2.0*	*<2.0*
Lower Iron River	23/09/2010	-	-	18.3	18.1	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	0.0014	0.0011	*<0.030*	*<0.030*	*<0.000010*	*<0.000010*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	1.45	1.45	0.00086	0.00140	*<0.0010*	*<0.0010*	2.4	2.6
Lower Iron River	16/11/2010	*<0.001*	*<0.001*	8.82	8.84	0.00008	0.00001	*<0.0005*	*<0.0005*	*<0.001*	*<0.001*	0.0009	0.0010	0.049	0.062	*<0.00002*	*<0.00002*	0.23	0.22	*<0.005*	*<0.005*	0.82	0.83	0.001	0.001	*<0.001*	*<0.001*	1.12	1.12
Upper Iron River	07/10/2008	-	-	11.1	10.6	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	0.0011	0.0014	0.082	0.105	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	1.03	0.97	0.00199	0.00306	*<0.0010*	*<0.0010*	*<2.0*	*<2.0*
Upper Iron River	14/10/2008	-	-	12.2	12.4	0.000223	0.000025	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	0.034	0.039	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	1.04	1.06	0.00083	0.00100	*<0.0010*	*<0.0010*	*<2.0*	*<2.0*
Upper Iron River	21/10/2008	-	-	10.0	9.79	*<0.000017*	0.000028	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	0.045	0.052	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	0.88	0.90	0.00114	0.00159	*<0.0010*	*<0.0010*	*<2.0*	*<2.0*
Upper Iron River	28/10/2008	-	-	12.5	12.6	0.000042	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	0.0012	*<0.0010*	0.031	*<0.030*	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	1.01	1.03	0.00095	0.00108	*<0.0010*	*<0.0010*	*<2.0*	*<2.0*
Upper Iron River	24/03/2009	-	-	6.91	6.83	0.000019	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	0.0011	*<0.0010*	0.036	0.044	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	0.75	0.76	0.00067	0.00133	*<0.0010*	*<0.0010*	*<2.0*	*<2.0*
Upper Iron River	31/03/2009	-	-	6.85	6.46	0.000017	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	0.0012	*<0.0010*	0.085	0.054	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	0.76	0.73	0.00067	0.00146	*<0.0010*	*<0.0010*	*<2.0*	*<2.0*
Upper Iron River	07/04/2009	-	-	5.72	5.46	0.000026	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	0.0015	*<0.0010*	0.052	0.098	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	0.68	0.66	0.00101	0.00328	*<0.0010*	*<0.0010*	*<2.0*	*<2.0*
Upper Iron River	13/04/2009	-	-	6.99	6.80	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	0.0022	*<0.0010*	0.045	0.093	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	0.68	0.66	0.00103	0.00289	*<0.0010*	*<0.0010*	*<2.0*	*<2.0*
Upper Iron River	20/04/2009	-	-	9.22	9.14	0.000019	0.000018	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	0.044	0.128	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	0.73	0.74	0.00082	0.00424	*<0.0010*	*<0.0010*	*<2.0*	*<2.0*
Upper Iron River	05/05/2009	-	-	8.92	8.19	0.000020	0.000038	*<0.00030*	*<0.00030*	*<0.0010*	0.0010	0.0012	0.0023	0.090	0.332	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	0.65	0.67	0.00208	0.0134	*<0.0010*	*<0.0010*	*<2.0*	*<2.0*
Upper Iron River	02/06/2009	-	-	10.4	10.1	*<0.000017*	0.000084	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	0.0011	*<0.030*	*<0.030*	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	0.74	0.71	0.00066	0.00196	*<0.0010*	*<0.0010*	*<2.0*	*<2.0*
Upper Iron River	06/07/2009	-	-	19.1	18.2	0.000034	0.000020	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	0.0015	0.0019	*<0.030*	*<0.030*	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	1.40	1.30	0.00244	0.00209	*<0.0010*	*<0.0010*	2.0	*<2.0*
Upper Iron River	05/08/2009	-	-	25.4	24.8	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.030*	*<0.030*	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	1.89	1.85	0.00076	0.00177	*<0.0010*	*<0.0010*	2.8	2.8
Upper Iron River	01/09/2009	-	-	30.3	28.8	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.030*	*<0.030*	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	2.29	2.21	0.00078	0.00082	*<0.0010*	*<0.0010*	4.0	4.1
Upper Iron River	30/09/2009	-	-	25.7	24.9	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.030*	*<0.030*	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	1.91	1.87	0.00084	0.00173	*<0.0010*	*<0.0010*	3.1	3.2
Upper Iron River	05/11/2009	-	-	9.80	10.0	*<0.000017*	0.000018	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	0.0022	0.0013	0.051	0.220	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	0.91	0.95	0.00156	0.00883	*<0.0010*	*<0.0010*	*<2.0*	*<2.0*
Upper Iron River	02/12/2009	-	-	7.66	7.70	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	0.0016	*<0.0010*	0.043	0.069	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	0.65	0.65	0.00096	0.00153	*<0.0010*	*<0.0010*	*<2.0*	*<2.0*
Upper Iron River	26/04/2010	*<0.20*	*<0.20*	10.1	9.75	*<0.010*	*<0.010*	*<0.010*	*<0.010*	*<0.010*	*<0.010*	*<0.010*	*<0.010*	*<0.030*	0.041	-	-	*<2.0*	*<2.0*	*<0.010*	*<0.010*	0.72	0.70	*<0.0050*	*<0.0050*	*<0.030*	*<0.030*	*<2.0*	*<2.0*
Upper Iron River	23/09/2010	-	-	17.6	17.0	0.000233	0.000026	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	0.0033	0.0011	0.033	0.034	*<0.000010*	*<0.000010*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	1.36	1.34	0.00200	0.00209	*<0.0010*	*<0.0010*	2.2	2.3
Upper Iron River	16/11/2010	*<0.001*	*<0.001*	8.84	10.3	0.00008	0.00001	*<0.0005*	*<0.0005*	*<0.001*	*<0.001*	0.0009	0.0011	0.046	0.073	*<0.00002*	*<0.00002*	0.25	0.26	*<0.005*	*<0.005*	0.81	0.93	0.001	0.002	*<0.001*	*<0.001*	1.07	1.19
7 South Quinsam River	09/08/2007	-	-	9.33	9.10	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	0.067	0.102	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	1.14	1.10	0.00420	0.00679	*<0.0010*	*<0.0010*	3.1	3.2
7 South Quinsam River	05/11/2007	-	-	9.69	9.65	0.000060	0.000018	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.030*	0.032	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	0.89	0.88	0.00083	0.00081	*<0.0010*	*<0.0010*	*<2.0*	*<2.0*
7 South Quinsam River	27/04/2008	-	-	12.3	12.1	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	0.0010	*<0.0020*	0.062	0.119	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	1.49	1.46	0.00655	0.00863	*<0.0010*	*<0.0010*	8.7	8.5
7 South Quinsam River	29/09/2008	-	-	11.9	11.7	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	0.054	0.084	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	1.47	1.46	0.00404	0.00471	*<0.0010*	*<0.0010*	8.3	8.2
7 South Quinsam River	07/10/2008	-	-	11.4	11.4	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	0.068	0.100	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	1.47	1.44	0.00643	0.00787	*<0.0010*	*<0.0010*	8.4	8.3
7 South Quinsam River	14/10/2008	-	-	12.8	12.0	0.000105	0.000171	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	0.0013	0.061	0.561	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	1.60	1.59	0.00527	0.134	*<0.0010*	*<0.0010*	9.8	10.5
7 South Quinsam River	21/10/2008	-	-	13.3	13.3	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	0.065	0.105	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	1.66	1.69	0.00573	0.00766	*<0.0010*	*<0.0010*	9.9	10.0
7 South Quinsam River	28/10/2008	-	-	13.2	13.2	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	0.063	0.089	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	1.65	1.65	0.00538	0.00661	*<0.0010*	*<0.0010*	9.6	9.5
7 South Quinsam River	24/03/2009	-	-	12.7	12.1	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	0.0025	*<0.0010*	0.060	0.159	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	1.74	1.70	0.00334	0.00351	*<0.0010*	*<0.0010*	12.4	12.7
7 South Quinsam River	31/03/2009	-	-	15.1	13.4	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	0.071	0.108	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	2.05	1.93	0.00445	0.00586	*<0.0010*	*<0.0010*	14.1	14.5
7 South Quinsam River	07/04/2009	-	-	15.0	14.5	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	0.069	0.152	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	2.03	1.97	0.00455	0.00658	*<0.0010*	*<0.0010*	15.5	15.5
7 South Quinsam River	13/04/2009	-	-	20.8	19.9	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	0.042	0.105	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	2.63	2.54	0.00349	0.00717	*<0.0010*	*<0.0010*	24.8	24.7
7 South Quinsam River	20/04/2009	-	-	17.8	17.0	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	0.042	0.090	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	2.23	2.19	0.00352	0.00736	*<0.0010*	*<0.0010*	20.4	20.7

Baseline Water Quality Data

Station Name	Collect Date	Bi-D	Bi-T	Ca-D	Ca-T	Cd-D	Cd-T	Co-D	Co-T	Cr-D	Cr-T	Cu-D	Cu-T	Fe-D	Fe-T	Hg-D	Hg-T	K-D	K-T	Li-D	Li-T	Mg-D	Mg-T	Mn-D	Mn-T	Mo-D	Mo-T	Na-D	Na-T
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
7 South Quinsam River	05/05/2009	-	-	12.9	11.8	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	0.110	0.204	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	1.77	1.70	0.00886	0.0123	*<0.0010*	*<0.0010*	12.3	11.7
7 South Quinsam River	02/06/2009	-	-	16.8	15.9	*<0.000017*	0.000017	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	0.0019	0.087	0.119	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	2.26	2.14	0.00771	0.00892	*<0.0010*	*<0.0010*	18.8	18.1
7 South Quinsam River	06/07/2009	-	-	13.2	13.0	0.000022	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	0.0010	*<0.0010*	0.076	0.117	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	1.66	1.65	0.00766	0.00940	*<0.0010*	*<0.0010*	11.5	11.3
7 South Quinsam River	05/08/2009	-	-	12.0	11.6	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	0.049	0.107	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	1.50	1.46	0.00595	0.00948	*<0.0010*	*<0.0010*	8.0	7.8
7 South Quinsam River	01/09/2009	-	-	11.6	11.6	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	0.087	0.045	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	1.43	1.45	0.00836	0.00470	*<0.0010*	*<0.0010*	7.6	7.7
7 South Quinsam River	30/09/2009	-	-	12.4	12.5	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	0.056	0.087	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	1.59	1.60	0.00461	0.00617	*<0.0010*	*<0.0010*	9.2	9.3
7 South Quinsam River	05/11/2009	-	-	15.7	15.7	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	0.0013	*<0.0010*	0.094	0.156	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	2.05	2.07	0.00607	0.00945	*<0.0010*	*<0.0010*	11.2	11.3
7 South Quinsam River	02/12/2009	-	-	8.45	8.46	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.030*	0.057	*<0.000020*	*<0.000020*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	1.11	1.13	0.00133	0.00232	*<0.0010*	*<0.0010*	7.1	7.2
7 South Quinsam River	26/04/2010	*<0.20*	*<0.20*	12.3	12.1	*<0.010*	*<0.010*	*<0.010*	*<0.010*	*<0.010*	*<0.010*	*<0.010*	*<0.010*	0.076	0.133	-	-	*<2.0*	*<2.0*	*<0.010*	*<0.010*	1.64	1.61	0.0079	0.0103	*<0.030*	*<0.030*	11.1	10.9
7 South Quinsam River	23/09/2010	-	-	10.1	9.57	*<0.000017*	*<0.000017*	*<0.00030*	*<0.00030*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	0.053	0.103	*<0.000010*	*<0.000010*	*<2.0*	*<2.0*	*<0.0050*	*<0.0050*	1.25	1.24	0.00463	0.00896	*<0.0010*	*<0.0010*	6.4	6.9
7 South Quinsam River	16/11/2010	*<0.001*	*<0.001*	9.45	9.40	0.00006	*<0.00001*	*<0.0005*	*<0.0005*	*<0.001*	*<0.001*	0.0010	0.0009	0.061	0.128	*<0.00002*	*<0.00002*	0.19	0.17	*<0.005*	*<0.005*	1.30	1.33	0.005	0.008	*<0.001*	*<0.001*	4.77	4.82
7 South Quinsam River	06/12/2010	*<0.001*	*<0.001*	8.97	7.69	0.00012	0.00001	*<0.0005*	*<0.0005*	*<0.001*	*<0.001*	0.0007	0.0006	0.100	0.122	*<0.00002*	*<0.00002*	0.16	0.15	*<0.005*	*<0.005*	1.30	1.20	0.008	0.009	*<0.001*	*<0.001*	5.64	5.62
7 South Quinsam River	02/02/2011	*<0.001*	*<0.001*	9.6	10.00	0.00004	*<0.00001*	*<0.0005*	*<0.0005*	*<0.001*	*<0.001*	0.0009	0.0008	0.035	0.079	*<0.00002*	*<0.00002*	0.22	0.22	*<0.005*	*<0.005*	1.26	1.34	0.003	0.004	*<0.001*	*<0.001*	9.68	10.9
7 South Quinsam River	22/03/2011	*<0.001*	*<0.001*	10.2	10.5	*<0.00001*	0.00001	*<0.0005*	*<0.0005*	*<0.001*	*<0.001*	0.0009	0.0007	0.027	0.066	*<0.00002*	*<0.00002*	0.24	0.24	*<0.005*	*<0.005*	1.35	1.31	0.004	0.003	*<0.001*	*<0.001*	10.9	10.5
7 South Quinsam River	04/04/2011	*<0.001*	*<0.001*	11.7	11.4	*<0.00001*	*<0.00001*	*<0.0005*	*<0.0005*	*<0.001*	*<0.001*	0.0010	0.0006	0.034	0.062	*<0.00002*	*<0.00002*	0.25	0.22	*<0.005*	*<0.005*	1.43	1.42	0.004	0.004	*<0.001*	*<0.001*	12.9	12.8
7 South Quinsam River	18/04/2011	*<0.001*	*<0.001*	11.8	12.3	*<0.00001*	*<0.00001*	*<0.0005*	*<0.0005*	*<0.001*	*<0.001*	0.0011	0.0006	0.043	0.100	*<0.00002*	*<0.00002*	0.26	0.22	*<0.005*	*<0.005*	1.52	1.58	0.006	0.011	*<0.001*	*<0.001*	11.5	12.0
7 South Quinsam River	25/04/2011	*<0.001*	*<0.001*	13.0	12.3	*<0.00001*	0.00001	*<0.0005*	*<0.0005*	*<0.001*	*<0.001*	0.0009	0.0007	0.047	0.069	*<0.00002*	*<0.00002*	0.23	0.23	*<0.005*	*<0.005*	1.51	1.64	0.007	0.005	*<0.001*	*<0.001*	11.8	12.6
7 South Quinsam River	03/05/2011	*<0.001*	*<0.001*	11.3	11.2	0.00002	*<0.00001*	*<0.0005*	*<0.0005*	*<0.001*	*<0.001*	0.0021	0.0019	0.059	0.091	*<0.00002*	*<0.00002*	0.46	0.46	*<0.005*	*<0.005*	1.40	1.38	0.005	0.007	*<0.001*	*<0.001*	9.71	10.2
7 South Quinsam River	30/05/2011	*<0.001*	*<0.001*	11.9	8.76	0.00002	0.00002	0.0020	*<0.0005*	*<0.001*	*<0.001*	0.0009	0.0168	0.224	0.176	*<0.00002*	*<0.00002*	1.18	0.20	*<0.005*	*<0.005*	1.15	1.05	0.311	0.007	*<0.001*	*<0.001*	1.68	2.52
7 South Quinsam River	07/06/2011	*<0.001*	*<0.001*	8.05	7.23	0.00001	*<0.00001*	*<0.0005*	*<0.0005*	*<0.001*	*<0.001*	0.0009	0.0008	0.048	0.102	*<0.00002*	*<0.00002*	0.17	0.10	-	-	1.02	0.87	0.005	0.007	*<0.001*	*<0.001*	3.27	2.52
7 South Quinsam River	04/07/2011	*<0.001*	*<0.001*	10.5	11.9	0.00001	*<0.00001*	*<0.0005*	*<0.0005*	*<0.001*	*<0.001*	0.0009	0.0024	0.059	0.098	*<0.00002*	*<0.00002*	0.23	0.28	-	-	1.23	1.58	0.007	0.010	*<0.001*	*<0.001*	7.11	14.2
7 South Quinsam River	03/08/2011	*<0.001*	*<0.001*	9.83	8.51	0.00002	*<0.00001*	*<0.0005*	*<0.0005*	*<0.001*	*<0.001*	0.0015	0.0010	0.063	0.091	*<0.00002*	*<0.00002*	0.63	0.27	*<0.005*	*<0.005*	1.17	1.03	0.008	0.008	*<0.001*	*<0.001*	6.40	6.04
7 South Quinsam River	30/08/2011	*<0.001*	*<0.001*	9.37	9.18	*<0.00001*	*<0.00001*	*<0.0005*	*<0.0005*	*<0.001*	*<0.001*	0.0008	0.0008	0.035	0.090	*<0.00002*	*<0.00002*	0.22	0.20	*<0.005*	*<0.005*	1.17	1.10	0.004	0.007	*<0.001*	*<0.001*	7.92	7.66
7 South Quinsam River	03/10/2011	*<0.001*	*<0.001*	10.5	10.2	*<0.00001*	*<0.00001*	*<0.0005*	*<0.0005*	*<0.001*	*<0.001*	0.0006	0.0007	0.049	0.108	*<0.00002*	*<0.00002*	0.21	0.21	*<0.005*	*<0.005*	1.23	1.31	0.005	0.010	*<0.001*	*<0.001*	5.72	6.13
7 South Quinsam River	01/11/2011	*<0.001*	*<0.001*	10.9	10.9	*<0.00001*	*<0.00001*	*<0.0005*	*<0.0005*	*<0.001*	*<0.001*	0.0010	0.0010	0.063	0.095	*<0.00002*	*<0.00002*	0.33	0.28	*<0.005*	*<0.005*	1.35	1.31	0.006	0.007	*<0.001*	*<0.001*	7.76	8.04
7 South Quinsam River	07/12/2011	*<0.0010*	*<0.001*	9.66	9.81	*<0.000010*	*<0.00001*	*<0.00050*	*<0.0005*	*<0.0010*	*<0.001*	0.00084	0.0010	0.0486	0.115	*<0.000020*	*<0.000020*	0.194	0.181	*<0.0050*	*<0.005*	1.28	1.27	0.0041	0.006	*<0.0010*	*<0.001*	7.61	7.52
7 South Quinsam River	05/01/2012	*<0.0010*	*<0.001*	6.26	6.39	*<0.000010*	*<0.00001*	*<0.00050*	*<0.0005*	*<0.0010*	*<0.001*	0.00308	0.0008	0.0360	0.134	*<0.000010*	*<0.000010*	0.201	0.202	*<0.0050*	*<0.005*	0.991	0.922	0.0035	0.007	*<0.0010*	*<0.001*	4.40	4.07
7 South Quinsam River	09/01/2012	*<0.0010*	*<0.001*	2.01	1.71	*<0.000010*	*<0.00001*	*<0.00050*	*<0.0005*	*<0.0010*	*<0.001*	0.00107	0.0005	0.0249	0.090	*<0.000010*	*<0.000010*	0.290	0.267	*<0.0050*	*<0.005*	0.495	0.514	*<0.0010*	0.002	*<0.0010*	*<0.001*	1.07	0.961
7 South Quinsam River	06/03/2012	*<0.0010*	*<0.001*	11.4	11.7	*<0.000010*	*<0.00001*	*<0.00050*	*<0.0005*	*<0.0010*	*<0.001*	0.00066	0.0006	0.0507	0.077	*<0.000002*	0.0000023	0.239	0.208	*<0.0050*	*<0.005*	1.58	1.59	0.0034	0.005	*<0.0010*	*<0.001*	9.69	9.80
7 South Quinsam River	03/04/2012	*<0.0010*	*<0.001*	10.4	10.7	0.000014	*<0.00001*	*<0.00050*	*<0.0005*	*<0.0010*	*<0.001*	0.00072	0.0007	0.0619	0.198	*<0.000010*	*<0.000010*	0.265	0.235	*<0.0050*	*<0.005*	1.51	1.48	0.0035	0.007	*<0.0010*	*<0.001*	12	11.7
7 South Quinsam River	01/05/2012	*<0.0010*	*<0.0010*	10.4	10	0.000013	*<0.000010*	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	0.00064	0.00062	0.0422	0.0704	*<0.000010*	*<0.000010*	0.226	0.206	*<0.0050*	*<0.0050*	1.29	1.3	0.0043	0.0049	*<0.0010*	*<0.0010*	11.6	11.7
7 South Quinsam River	05/06/2012	*<0.0010*	*<0.0010*	8.12	7.65	*<0.000010*	0.000018	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	0.00085	0.00063	0.0458	0.096	*<0.000010*	*<0.000010*	0.244	0.188	*<0.0050*	*<0.0050*	0.912	0.875	0.0045	0.0057	*<0.0010*	*<0.0010*	3.78	3.65
7 South Quinsam River	03/07/2012	*<0.0010*	*<0.0010*	8.35	8.6	*<0.000010*	*<0.000010*	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	0.00084	0.00078	0.068	0.114	*<0.000010*	*<0.000010*	0.157	0.155	*<0.0050*	*<0.0050*	0.998	1.04	0.0065	0.0086	*<0.0010*	*<0.0010*	4.13	4.18
7 South Quinsam River	01/08/2012	*<0.0010*	*<0.0010*	9.69	9.54	*<0.000010*	*<0.000010*	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	0.00056	0.0011	0.0684	0.183	*<0.000010*	*<0.000010*	0.146	0.15	*<0.0050*	*<0.0050*	1.21	1.18	0.004	0.0115	*<0.0010*	*<0.0010*	6.46	6.34
7 South Quinsam River	04/09/2012	*<0.0010*	*<0.0010*	9.41	9.73	*<0.000005*	*<0.0000050*	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	0.00064	0.00060	0.0394	0.0771	*<0.000010*	*<0.000010*	0.142	0.155	*<0.0050*	*<0.0050*	1.17	1.22	0.0022	0.0074	*<0.0010*	*<0.0010*	6.95	6.94
7 South Quinsam River	09/10/2012	*<0.0010*	*<0.0010*	8.80	9.28	*<0.0000050*	*<0.0000050*	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	0.00039	0.00069	0.0400	0.0701	*<0.0000020*	*<0.0000020*	0.133	0.135	*<0.0050*	*<0.0050*	1.07	1.08	0.0023	0.0051	*<0.0010*	*<0.0010*	6.24	6.70
7 South Quinsam River	05/11/2012	*<0.0010*	*<0.0010*	11.5	11.0	*<0.0000050*	*<0.0000050*	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	0.00068	0.00094	0.0595	0.173	*<0.0000020*	*<0.0000020*	0.208	0.215	*<0.0050*	*<0.0050*	1.47	1.50	0.0017	0.0070	*<0.0010*	*<0.0010*	8.29	8.53
7 South Quinsam River	12/12/2012	*<0.0010*	*<0.0010*	9.84	9.33	*<0.000010*	*<0.000010*	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	0.00062	0.00103	0.0519	0.282	*<0.000010*	*<0.000010*	0.227	0.243	*<0.0050*	*<0.0050*	1.30	1.26	0.0018	0.0081	*<0.0010*	*<0.0010*	12.3	12.3
Iron River Upstream	10/05/2012	*<0.0010*	*<0.0010*	12.2	11.3	0.000021	0.000023	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	0.00068	0.0007	0.0123	0.0189	*<0.000010*	*<0.000010*	0.2	0.18	*<0.0050*	*<0.0050*	0.613	0.551	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	0.79	0.684
Iron River Upstream	22/05/2012	*<0.0010*	*<0.0010*	9.45	8.35	0.000032	0.000031	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	0.00096	0.00074	0.0212	0.0571	*<0.000010*	*<0.000010*	0.181	0.139	*<0.0050*	*<0.0050*	0.527	0.494	*<0.0010*	0.0014	*<0.0010*	*<0.0010*	0.714	0.632
Iron River Upstream	29/05/2012	*<0.0010*	*<0.0010*	8.99	8.58	0.000027	0.000027	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	0.00081	0.00069	0.0351	0.0252	*<0.000010*	*<0.000010*	0.153	0.152	*<0.0050*	*<0.0050*	0.544	0.527	*<0.0010*	*<0.0010*	*<0.0010*	0.0015	0.693	0.593
Iron River Upstream	05/06/2012	*<0.0010*	*<0.0010*	8.4	8.58	0.000026	0.000024	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	0.00081	0.00077	0.017	0.0249	*<0.000010*	*<0.000010*	0.213	0.216	*<0.0050*	*<0.0050*	0.515	0.533	0.001	*<0.0010*	*<0.0010*	*<0.0010*	0.651	0.641
Iron River Upstream	12/06/2012	*<0.0010*	*<0.0010*	7.34	7.17	0.000026	0.00003	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	0.00097	0.00074	0.0231	0.0333	*<0.000010*	*<0.000010*	0.153	0.145	*<0.0050*	*<0.0050*	0.484	0.477	*<0.0010*	0.0011	*<0.0010*	*<0.0010*	0.641	0.561
Iron River Upstream	03/07/2012	*<0.0010*	*<0.0010*	11.1	11.2	0.000024	0.000027	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	0.00078	0.0008	0.0142	0.0219	*<0.000010*	*<0.000010*	0.194	0.21	*<0.0050*	*<0.0050*	0.643	0.662	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	0.871	0.823
Iron River Upstream	02/08/2012	*<0.0010*	*<0.0010*	22.8	22	0.000012	0.000014	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	0.00056	0.00057	*<0.0050*	0.0076	*<0.000010*	*<0.000010*	0.235	0.237	*<0.0050*	*<0.0050*	1.05	1.02	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	1.45	1.3
Iron River Upstream	04/09/2012	*<0.0010*	*<0.0010*	29.4	28.7	0.0000130	0.0000150	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	0.00075	0.00046	*<0.0050*	0.0054	*<0.000010*	*<0.000010*	0.259	0.273	*<0.0050*	*<0.0050*	1.38	1.45	0.0011	0.0012	*<0.0010*	*<0.0010*	1.85	1.81
Iron River Upstream	09/10/2012	*<0.0010*	*<0.0010*	29.9	31.0	0.0000210	0.0000290	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	0.00051	0.00100	*<0.0050*	0.0136	*<0.0000020*	*<0.0000020*	0.250	0.250	*<0.0050*	*<0.0050*	1.40	1.38	0.0010	0.0015	*<0.0010*	*<0.0010*	2.12	2.24
Iron River Upstream	05/11/2012	*<0.0010*	*<0.0010*	13.3	12.2	0.0000230	0.0000180	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	0.00097	0.00121	0.0221	0.100	*<0.0000020*	*<0.0000020*	0.190	0.212	*<0.0050*	*<0.0050*	0.747	0.733	*<0.0010*	0.0025	*<0.0010*	*<0.0010*	1.00	0.974
Iron River Upstream	12/12/2012	*<0.0010*	*<0.0010*	12.9	12.3	0.000011	0.000023	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	0.00066	0.00081	0.0146	0.0615	*<0.000010*	*<0.000010*	0.169	0.156	*<0.0050*	*<0.0050*	0.665	0.613	*<0.0010*	0.0018	*<0.0010*	*<0.0010*	0.948	0.866

Baseline Water Quality Data

Station Name	Collect Date	Ni-D	Ni-T	Pb-D	Pb-T	P-D	P-T	Sb-D	Sb-T	Se-D	Se-T	Si-D	Si-T	Sn-D	Sn-T	Sr-D	Sr-T	Ti-D	Ti-T	Tl-D	Tl-T	U-D	U-T	V-D	V-T	Zn-D	Zn-T	Zr-D	Zr-T
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Lower Iron River	07/10/2008	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Lower Iron River	14/10/2008	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Lower Iron River	21/10/2008	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Lower Iron River	28/10/2008	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Lower Iron River	24/03/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Lower Iron River	31/03/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Lower Iron River	07/04/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Lower Iron River	13/04/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Lower Iron River	20/04/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Lower Iron River	05/05/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	0.012	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	0.0010	*<0.0050*	*<0.0050*	-	-
Lower Iron River	02/06/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Lower Iron River	06/07/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	0.00096	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Lower Iron River	05/08/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Lower Iron River	01/09/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Lower Iron River	30/09/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Lower Iron River	05/11/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Lower Iron River	02/12/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Lower Iron River	26/04/2010	*<0.050*	*<0.050*	*<0.050*	*<0.050*	*<0.30*	*<0.30*	*<0.20*	*<0.20*	*<0.20*	*<0.20*	2.48	2.45	*<0.030*	*<0.030*	0.0370	0.0364	*<0.010*	*<0.010*	*<0.20*	*<0.20*	-	-	*<0.030*	*<0.030*	*<0.0050*	*<0.0050*	-	-
Lower Iron River	23/09/2010	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Lower Iron River	16/11/2010	*<0.001*	*<0.001*	*<0.0002*	*<0.0002*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*	0.0002	0.0002	2.9	2.9	*<0.005*	*<0.005*	0.032	0.032	*<0.005*	*<0.005*	*<0.00005*	*<0.00005*	*<0.0001*	*<0.0001*	*<0.005*	*<0.005*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*
Upper Iron River	07/10/2008	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Upper Iron River	14/10/2008	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Upper Iron River	21/10/2008	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Upper Iron River	28/10/2008	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Upper Iron River	24/03/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Upper Iron River	31/03/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Upper Iron River	07/04/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Upper Iron River	13/04/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Upper Iron River	20/04/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Upper Iron River	05/05/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	0.013	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	0.0011	*<0.0050*	*<0.0050*	-	-
Upper Iron River	02/06/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Upper Iron River	06/07/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Upper Iron River	05/08/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Upper Iron River	01/09/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Upper Iron River	30/09/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Upper Iron River	05/11/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Upper Iron River	02/12/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Upper Iron River	26/04/2010	*<0.050*	*<0.050*	*<0.050*	*<0.050*	*<0.30*	*<0.30*	*<0.20*	*<0.20*	*<0.20*	*<0.20*	2.44	2.34	*<0.030*	*<0.030*	0.0368	0.0360	*<0.010*	*<0.010*	*<0.20*	*<0.20*	-	-	*<0.030*	*<0.030*	*<0.0050*	*<0.0050*	-	-
Upper Iron River	23/09/2010	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
Upper Iron River	16/11/2010	*<0.001*	*<0.001*	*<0.0002*	*<0.0002*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*	0.0002	0.0002	2.8	3.3	*<0.005*	*<0.005*	0.032	0.037	*<0.005*	*<0.005*	*<0.00005*	*<0.00005*	*<0.0001*	*<0.0001*	*<0.005*	*<0.005*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*
7 South Quinsam River	09/08/2007	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.030*	*<0.030*	*<0.0050*	*<0.0050*	-	-
7 South Quinsam River	05/11/2007	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
7 South Quinsam River	27/04/2008	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
7 South Quinsam River	29/09/2008	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
7 South Quinsam River	07/10/2008	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
7 South Quinsam River	14/10/2008	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	0.012	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	0.0013	*<0.0050*	*<0.0050*	-	-
7 South Quinsam River	21/10/2008	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
7 South Quinsam River	28/10/2008	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
7 South Quinsam River	24/03/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
7 South Quinsam River	31/03/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
7 South Quinsam River	07/04/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
7 South Quinsam River	13/04/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
7 South Quinsam River	20/04/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-

Baseline Water Quality Data

Station Name	Collect Date	Ni-D	Ni-T	Pb-D	Pb-T	P-D	P-T	Sb-D	Sb-T	Se-D	Se-T	Si-D	Si-T	Sn-D	Sn-T	Sr-D	Sr-T	Ti-D	Ti-T	Tl-D	Tl-T	U-D	U-T	V-D	V-T	Zn-D	Zn-T	Zr-D	Zr-T
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
7 South Quinsam River	05/05/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
7 South Quinsam River	02/06/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
7 South Quinsam River	06/07/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
7 South Quinsam River	05/08/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
7 South Quinsam River	01/09/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
7 South Quinsam River	30/09/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	0.00079	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
7 South Quinsam River	05/11/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
7 South Quinsam River	02/12/2009	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
7 South Quinsam River	26/04/2010	*<0.050*	*<0.050*	*<0.050*	*<0.050*	*<0.30*	*<0.30*	*<0.20*	*<0.20*	*<0.20*	*<0.20*	2.39	2.39	*<0.030*	*<0.030*	0.0646	0.0644	*<0.010*	*<0.010*	*<0.20*	*<0.20*	-	-	*<0.030*	*<0.030*	*<0.0050*	*<0.0050*	-	-
7 South Quinsam River	23/09/2010	*<0.0010*	*<0.0010*	*<0.00050*	*<0.00050*	-	-	*<0.00050*	*<0.00050*	*<0.0010*	*<0.0010*	-	-	*<0.00050*	*<0.00050*	-	-	*<0.010*	*<0.010*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.00020*	*<0.0010*	*<0.0010*	*<0.0050*	*<0.0050*	-	-
7 South Quinsam River	16/11/2010	*<0.001*	*<0.001*	*<0.0002*	*<0.0002*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*	*<0.0001*	*<0.0001*	2.4	2.4	*<0.005*	*<0.005*	0.041	0.041	*<0.005*	*<0.005*	*<0.00005*	*<0.00005*	*<0.0001*	*<0.0001*	*<0.005*	*<0.005*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*
7 South Quinsam River	06/12/2010	*<0.001*	*<0.001*	*<0.0002*	*<0.0002*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*	*<0.0001*	*<0.0001*	2.6	2.3	*<0.005*	*<0.005*	0.041	0.040	*<0.005*	*<0.005*	*<0.00005*	*<0.00005*	*<0.0001*	*<0.0001*	*<0.005*	*<0.005*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*
7 South Quinsam River	02/02/2011	*<0.001*	*<0.001*	*<0.0002*	*<0.0002*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*	*<0.0001*	*<0.0001*	2.5	2.6	*<0.005*	*<0.005*	0.045	0.049	*<0.005*	*<0.005*	*<0.00005*	*<0.00005*	*<0.0001*	*<0.0001*	*<0.005*	*<0.005*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*
7 South Quinsam River	22/03/2011	*<0.001*	*<0.001*	*<0.0002*	*<0.0002*	-	-	*<0.0005*	*<0.0005*	*<0.0001*	*<0.0001*	2.3	2.5	*<0.005*	*<0.005*	0.055	0.061	*<0.005*	*<0.005*	*<0.00005*	*<0.00005*	*<0.0001*	*<0.0001*	*<0.005*	*<0.005*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*
7 South Quinsam River	04/04/2011	*<0.001*	*<0.001*	*<0.0002*	*<0.0002*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*	*<0.0001*	*<0.0001*	2.2	2.1	*<0.005*	*<0.005*	0.066	0.059	*<0.005*	*<0.005*	*<0.00005*	*<0.00005*	*<0.0001*	*<0.0001*	*<0.005*	*<0.005*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*
7 South Quinsam River	18/04/2011	*<0.001*	*<0.001*	*<0.0002*	*<0.0002*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*	*<0.0001*	*<0.0001*	2.1	2.1	*<0.005*	*<0.005*	0.063	0.067	*<0.005*	*<0.005*	*<0.00005*	*<0.00005*	*<0.0001*	*<0.0001*	*<0.005*	*<0.005*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*
7 South Quinsam River	25/04/2011	*<0.001*	*<0.001*	*<0.0002*	*<0.0002*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*	*<0.0001*	*<0.0001*	2.2	2.1	*<0.005*	*<0.005*	0.063	0.064	*<0.005*	*<0.005*	*<0.00005*	*<0.00005*	*<0.0001*	*<0.0001*	*<0.005*	*<0.005*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*
7 South Quinsam River	03/05/2011	*<0.001*	*<0.001*	*<0.0002*	*<0.0002*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*	*<0.0001*	*<0.0001*	1.9	1.9	*<0.005*	*<0.005*	0.057	0.057	*<0.005*	*<0.005*	*<0.00005*	*<0.00005*	*<0.0001*	*<0.0001*	*<0.005*	*<0.005*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*
7 South Quinsam River	30/05/2011	0.001	0.005	*<0.0002*	*<0.0002*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*	*<0.0001*	*<0.0001*	4.1	2.2	*<0.005*	*<0.005*	0.044	0.028	*<0.005*	*<0.005*	*<0.00005*	*<0.00005*	*<0.0001*	*<0.0001*	*<0.005*	*<0.005*	0.008	0.006	*<0.0005*	*<0.0005*
7 South Quinsam River	07/06/2011	*<0.001*	*<0.001*	*<0.0002*	*<0.0002*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*	*<0.0001*	*<0.0001*	1.8	1.7	0.014	*<0.005*	0.027	0.023	*<0.005*	*<0.005*	*<0.00005*	*<0.00005*	*<0.0001*	*<0.0001*	*<0.005*	*<0.005*	0.027	*<0.005*	*<0.0005*	*<0.0005*
7 South Quinsam River	04/07/2011	*<0.001*	*<0.001*	*<0.0002*	*<0.0002*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*	*<0.0001*	*<0.0001*	2.0	1.7	*<0.005*	*<0.005*	0.038	0.070	*<0.005*	*<0.005*	*<0.00005*	*<0.00005*	*<0.0001*	*<0.0001*	*<0.005*	*<0.005*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*
7 South Quinsam River	03/08/2011	*<0.001*	*<0.001*	*<0.0002*	0.0002	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*	*<0.0001*	*<0.0001*	1.9	1.6	*<0.005*	*<0.005*	0.039	0.038	*<0.005*	*<0.005*	*<0.00005*	*<0.00005*	*<0.0001*	*<0.0001*	*<0.005*	*<0.005*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*
7 South Quinsam River	30/08/2011	*<0.001*	*<0.001*	*<0.0002*	*<0.0002*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*	*<0.0001*	*<0.0001*	1.6	1.5	*<0.005*	*<0.005*	0.040	0.041	*<0.005*	*<0.005*	*<0.00005*	*<0.00005*	*<0.0001*	*<0.0001*	*<0.005*	*<0.005*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*
7 South Quinsam River	03/10/2011	*<0.001*	*<0.001*	*<0.0002*	*<0.0002*	*<0.005*	0.007	*<0.0005*	*<0.0005*	*<0.0001*	*<0.0001*	1.8	1.7	*<0.005*	*<0.005*	0.045	0.057	*<0.005*	*<0.005*	*<0.00005*	*<0.00005*	*<0.0001*	*<0.0001*	*<0.005*	*<0.005*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*
7 South Quinsam River	01/11/2011	*<0.001*	*<0.001*	*<0.0002*	*<0.0002*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*	*<0.0001*	*<0.0001*	2.1	2.0	*<0.005*	*<0.005*	0.048	0.047	*<0.005*	*<0.005*	*<0.00005*	*<0.00005*	*<0.0001*	*<0.0001*	*<0.005*	*<0.005*	*<0.005*	*<0.005*	*<0.0005*	*<0.0005*
7 South Quinsam River	07/12/2011	*<0.0010*	*<0.001*	*<0.00020*	*<0.0002*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.0005*	*<0.00010*	*<0.0001*	2.30	2.4	*<0.0050*	*<0.005*	0.0429	0.043	*<0.0050*	*<0.005*	*<0.000050*	*<0.00005*	*<0.00010*	*<0.0001*	*<0.0050*	*<0.005*	*<0.0050*	*<0.005*	*<0.00050*	*<0.0005*
7 South Quinsam River	05/01/2012	*<0.0010*	*<0.001*	*<0.00020*	*<0.0002*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.0005*	*<0.00010*	*<0.0001*	2.00	2.1	*<0.0050*	*<0.005*	0.0277	0.025	*<0.0050*	0.007	*<0.000050*	*<0.00005*	*<0.00010*	*<0.0001*	*<0.0050*	*<0.005*	*<0.0050*	*<0.005*	*<0.00050*	*<0.0005*
7 South Quinsam River	09/01/2012	*<0.0010*	*<0.001*	*<0.00020*	*<0.0002*	0.0070	0.0078	*<0.00050*	*<0.0005*	*<0.00010*	*<0.0001*	3.90	3.4	*<0.0050*	*<0.005*	0.0115	0.011	*<0.0050*	*<0.005*	*<0.000050*	*<0.00005*	*<0.00010*	*<0.0001*	*<0.0050*	*<0.005*	*<0.0050*	*<0.005*	*<0.00050*	*<0.0005*
7 South Quinsam River	06/03/2012	*<0.0010*	*<0.001*	*<0.00020*	*<0.0002*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.0005*	*<0.00010*	*<0.0001*	2.44	2.5	*<0.0050*	*<0.005*	0.0605	0.062	*<0.0050*	*<0.005*	*<0.000050*	*<0.00005*	*<0.00010*	*<0.0001*	*<0.0050*	*<0.005*	*<0.0050*	*<0.005*	*<0.00050*	*<0.0005*
7 South Quinsam River	03/04/2012	*<0.0010*	*<0.001*	*<0.00020*	*<0.0002*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.0005*	*<0.00010*	*<0.0001*	2.69	2.7	*<0.0050*	*<0.005*	0.063	0.064	*<0.0050*	0.008	*<0.000050*	*<0.00005*	*<0.00010*	*<0.0001*	*<0.0050*	*<0.005*	*<0.0050*	*<0.005*	*<0.00050*	*<0.0005*
7 South Quinsam River	01/05/2012	*<0.0010*	*<0.0010*	*<0.00020*	*<0.00020*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*	*<0.00010*	*<0.00010*	1.81	1.74	*<0.0050*	*<0.0050*	0.0544	0.0502	*<0.0050*	*<0.0050*	*<0.000050*	*<0.000050*	*<0.00010*	*<0.00010*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*
7 South Quinsam River	05/06/2012	*<0.0010*	*<0.0010*	*<0.00020*	*<0.00020*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*	*<0.00010*	*<0.00010*	1.69	1.7	*<0.0050*	*<0.0050*	0.027	0.0232	*<0.0050*	*<0.0050*	*<0.000050*	*<0.000050*	*<0.00010*	*<0.00010*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*
7 South Quinsam River	03/07/2012	*<0.0010*	*<0.0010*	*<0.00020*	*<0.00020*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*	*<0.00010*	*<0.00010*	1.86	1.84	*<0.0050*	*<0.0050*	0.0282	0.0313	*<0.0050*	*<0.0050*	*<0.000050*	*<0.000050*	*<0.00010*	*<0.00010*	*<0.0050*	*<0.0050*	0.0068	*<0.0050*	*<0.00050*	*<0.00050*
7 South Quinsam River	01/08/2012	*<0.0010*	*<0.0010*	*<0.00020*	*<0.00020*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*	*<0.00010*	*<0.00010*	1.88	1.82	*<0.0050*	*<0.0050*	0.0377	0.0376	*<0.0050*	*<0.0050*	*<0.000050*	*<0.000050*	*<0.00010*	*<0.00010*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*
7 South Quinsam River	04/09/2012	*<0.0010*	*<0.0010*	*<0.00020*	*<0.00020*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*	*<0.00010*	*<0.00010*	1.72	1.85	*<0.0050*	*<0.0050*	0.0363	0.0365	*<0.0050*	*<0.0050*	*<0.000050*	*<0.000050*	*<0.00010*	*<0.00010*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*
7 South Quinsam River	09/10/2012	*<0.0010*	*<0.0010*	*<0.00020*	*<0.00020*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*	*<0.00010*	*<0.00010*	1.61	1.64	*<0.0050*	*<0.0050*	0.0323	0.0344	*<0.0050*	*<0.0050*	*<0.000050*	*<0.000050*	*<0.00010*	*<0.00010*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*
7 South Quinsam River	05/11/2012	*<0.0010*	*<0.0010*	*<0.00020*	*<0.00020*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*	*<0.00010*	*<0.00010*	2.20	2.27	*<0.0050*	*<0.0050*	0.0560	0.0593	*<0.0050*	*<0.0050*	*<0.000050*	*<0.000050*	*<0.00010*	*<0.00010*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*
7 South Quinsam River	12/12/2012	*<0.0010*	*<0.0010*	*<0.00020*	*<0.00020*	*<0.0050*	-	*<0.00050*	*<0.00050*	*<0.00010*	*<0.00010*	2.26	2.33	*<0.0050*	*<0.0050*	0.0524	0.0463	*<0.0050*	0.0081	*<0.000050*	*<0.000050*	*<0.00010*	*<0.00010*	*<0.0050*	*<0.0050*	*<0.0050*	0.0107	*<0.00050*	*<0.00050*
Iron River Upstream	10/05/2012	*<0.0010*	*<0.0010*	*<0.00020*	*<0.00020*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*	0.00024	0.00026	2.21	2.18	*<0.0050*	*<0.0050*	0.0417	0.0358	*<0.0050*	*<0.0050*	*<0.000050*	*<0.000050*	*<0.00010*	*<0.00010*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*
Iron River Upstream	22/05/2012	*<0.0010*	*<0.0010*	*<0.00020*	*<0.00020*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*	0.00014	0.00012	1.89	1.72	*<0.0050*	*<0.0050*	0.0292	0.0246	*<0.0050*	*<0.0050*	*<0.000050*	*<0.000050*	*<0.00010*	*<0.00010*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*
Iron River Upstream	29/05/2012	*<0.0010*	*<0.0010*	*<0.00020*	*<0.00020*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*	0.00014	*<0.00010*	1.83	1.76	*<0.0050*	*<0.0050*	0.0264	0.0246	*<0.0050*	*<0.0050*	*<0.000050*	*<0.000050*	*<0.00010*	*<0.00010*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*
Iron River Upstream	05/06/2012	*<0.0010*	*<0.0010*	*<0.00020*	*<0.00020*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*	0.00012	0.00012	1.76	1.94	*<0.0050*	*<0.0050*	0.0255	0.025	*<0.0050*	*<0.0050*	*<0.000050*	*<0.000050*	*<0.00010*	*<0.00010*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*
Iron River Upstream	12/06/2012	*<0.0010*	*<0.0010*	*<0.00020*	*<0.00020*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*	*0.0001*	0.00011	1.72	1.73	*<0.0050*	*<0.0050*	0.021	0.0199	*<0.0050*	*<0.0050*	*<0.000050*	*<0.000050*	*<0.00010*	*<0.00010*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*
Iron River Upstream	03/07/2012	*<0.0010*	*<0.0010*	*<0.00020*	*<0.00020*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*	0.00019	0.00023	2.33	2.22	*<0.0050*	*<0.0050*	0.0357	0.0379	*<0.0050*	*<0.0050*	*<0.000050*	*<0.000050*	*<0.00010*	*<0.00010*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*
Iron River Upstream	02/08/2012	*<0.0010*	*<0.0010*	*<0.00020*	*<0.00020*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*	0.00028	0.00031	3.03	2.79	*<0.0050*	*<0.0050*	0.0719	0.0701	*<0.0050*	*<0.0050*	*<0.000050*	*<0.000050*	*<0.00010*	*<0.00010*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*
Iron River Upstream	04/09/2012	*<0.0010*	*<0.0010*	*<0.00020*	*<0.00020*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*	0.00045	0.00039	2.87	2.85	*<0.0050*	*<0.0050*	0.0909	0.0911	*<0.0050*	*<0.0050*	*<0.000050*	*<0.000050*	0.00011	0.00011	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	0.00107	*<0.00050*
Iron River Upstream	09/10/2012	*<0.0010*	*<0.0010*	*<0.00020*	*<0.00020*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*	0.00036	0.00038	2.51	2.62	*<0.0050*	*<0.0050*	0.0940	0.0976	*<0.0050*	*<0.0050*	*<0.000050*	*<0.000050*	0.00013	0.00014	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*
Iron River Upstream	05/11/2012	*<0.0010*	*<0.0010*	*<0.00020*	*<0.00020*	*<0.0050*	*<0.0050*	*<0.00050*	*<0.00050*	0.00030	0.00025	2.76	2.81	*<0.0050*	*<0.0050*	0.0429	0.0430	*<0.0050*	*<0.0050*	*<0.000050*	*<0.000050*	*<0.00010*	*<0.00010*	*<0.0050*	*<0.0050*	*<0.0050*	0.0064	*<0.00050*	*<0.00050*
Iron River Upstream	12/12/2012	*<0.0010*	*<0.0010*	*<0.00020*	*<0.00020*	0.0050	-	*<0.00050*	*<0.00050*	0.00024	0.00031	2.66	2.63	*<0.0050*	*<0.0050*	0.0447	0.0386	*<0.0050*	*<0.0050*	*<0.000050*	*<0.000050*	*<0.00010*	*<0.00010*	*<0.0050*	*<0.0050*	*<0.0050*	0.0154	*<0.00050*	*<0.00050*

Background water quality terms: Iron River - monthly median values

Parameter	Units	Mean annual	Jan[a]	Feb[a]	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Alkalinity	mg CaCO3/L	31.2	18.6	18.6	17.3	20.3	21.0	27.8	47.5	70.6	61.6	29.5	23.0	18.6
Conductivity	uS/cm	73.6	45.6	45.6	44.4	50.6	47.7	59.3	112	150	153	70.8	58.0	45.6
pH	pH Units	7.86	7.88	7.88	7.74	7.80	7.78	7.92	7.96	8.22	7.96	7.78	7.52	7.88
TDS	mg/L	49.5	37.0	37.0	32.5	39.0	44.0	40.0	68.5	88.0	84.5	48.5	38.5	37.0
TSS	mg/L	3.29	3.00	3.00	3.00	3.00	6.00	3.00	3.00	3.00	3.00	3.00	3.50	3.00
NH3	mg-N/L	0.0111	0.0200	0.0200	0.0125	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.0125[b]	0.0200	0.0200
NO2+NO3	mg-N/L	0.0352	0.0148	0.0148	0.0452	0.0516	0.0156	0.00500	0.0428	0.105	0.0538	0.0388[b]	0.0238	0.0148
TKN	mg-N/L	0.0978	0.0845	0.0845	0.0770	0.0870	0.166	0.0865	0.107	0.0795	0.0570	0.110[b]	0.162	0.0845
PO4-D	mg-P/L	0.00247	0.00255	0.00255	0.00200	0.00205	0.00440	0.00210	0.00200	0.00200	0.00200	0.0025[b]	0.00300	0.00255
PO4-T	mg-P/L	0.00421	0.00390	0.00390	0.00215	0.00295	0.0110	0.00345	0.00245	0.00240	0.00210	0.0051[b]	0.00810	0.00390
Sulphate	mg/L	2.76	0.500	0.500	0.575	1.63	0.500	1.30	5.16	8.10	10.1	0.915	3.38	0.500
Hardness-T	mg CaCO3/L	35.1	21.8	21.8	20.4	23.1	24.6	29.6	52.6	72.1	72.4	33.3	28.2	21.8
Ag-D	mg/L	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200
Ag-T	mg/L	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200
Al-D	mg/L	0.0575	0.0749	0.0749	0.0575	0.0866	0.114	0.0342	0.0253	0.0168	0.0135	0.0442	0.0734	0.0749
Al-T	mg/L	0.0932	0.0990	0.0990	0.0703	0.123	0.308	0.0558	0.0290	0.0246	0.0170	0.0461	0.148	0.0990
As-D	mg/L	0.00178	0.000675	0.000675	0.00100	0.000645	0.000505	0.00120	0.00329[c]	0.00585	0.00619	0.00140	0.000785	0.000675
As-T	mg/L	0.00196	0.000725	0.000725	0.00100	0.000690	0.000680	0.00124	0.00329	0.00586	0.00622	0.00141	0.000990	0.000725
Ba-D	mg/L	0.0194	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0125	0.0200
Ba-T	mg/L	0.0194	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0125	0.0200
B-D	mg/L	0.0979	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.0750	0.100
B-T	mg/L	0.0979	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.0750	0.100
Be-D	mg/L	0.000962	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.000550	0.00100
Be-T	mg/L	0.000962	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.000550	0.00100
Ca-D	mg/L	12.4	7.64	7.64	6.90	8.10	8.82	10.6	18.8	25.6	25.7	11.6	9.28	7.64
Ca-T	mg/L	12.1	7.52	7.52	6.47	7.90	8.18	10.2	18.0	25.0	25.2	11.6	9.82	7.52
Cd-D	mg/L	0.0000196	0.0000170	0.0000170	0.0000180	0.0000205	0.0000210	0.0000190	0.0000370	0.0000170	0.0000170	0.0000180	0.0000170	0.0000170
Cd-T	mg/L	0.0000218	0.0000170	0.0000170	0.0000170	0.0000170	0.0000395	0.0000505	0.0000185	0.0000170	0.0000170	0.0000205	0.0000140	0.0000170
Co-D	mg/L	0.000308	0.000300	0.000300	0.000300	0.000300	0.000300	0.000300	0.000300	0.000300	0.000300	0.000300	0.000400	0.000300
Co-T	mg/L	0.000308	0.000300	0.000300	0.000300	0.000300	0.000300	0.000300	0.000300	0.000300	0.000300	0.000300	0.000400	0.000300
Cr-D	mg/L	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100
Cr-T	mg/L	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100
Cu-D	mg/L	0.00124	0.00140	0.00140	0.00110	0.00160	0.00110	0.00100	0.00145	0.00100	0.00100	0.00100	0.00145	0.00140
Cu-T	mg/L	0.00115	0.00100	0.00100	0.00100	0.00100	0.00195	0.00120	0.00145	0.00100	0.00100	0.00100	0.00120	0.00100
Fe-D	mg/L	0.0418	0.0425	0.0425	0.0360	0.0450	0.0845	0.0300	0.0300	0.0300	0.0300	0.0390	0.0500	0.0425
Fe-T	mg/L	0.0852	0.0795	0.0795	0.0475	0.0915	0.334	0.0300	0.0300	0.0300	0.0300	0.0445	0.146	0.0795
Hg-D	mg/L	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200
Hg-T	mg/L	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200
K-D	mg/L	1.93	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	1.12	2.00
K-T	mg/L	1.93	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	1.13	2.00
Li-D	mg/L	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500
Li-T	mg/L	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500
Mg-D	mg/L	1.01	0.660	0.660	0.760	0.705	0.650	0.760	1.40	1.97	1.98	1.04	0.865	0.660
Mg-T	mg/L	0.998	0.655	0.655	0.740	0.695	0.675	0.730	1.34	1.90	1.95	1.04	0.940	0.655
Mn-D	mg/L	0.00116	0.000930	0.000930	0.000665	0.00102	0.00190	0.000755	0.00268	0.000890	0.000850	0.00111	0.00128	0.000930
Mn-T	mg/L	0.00305	0.00168	0.00168	0.00138	0.00308	0.0132	0.00172	0.00254	0.00144	0.00122	0.00153	0.00542	0.00168
Mo-D	mg/L	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100
Mo-T	mg/L	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100
Na-D	mg/L	2.27	2.00	2.00	2.00	2.00	2.00	2.00	2.15	3.95	3.55	2.00	1.56	2.00
Na-T	mg/L	2.21	2.00	2.00	2.00	2.00	2.00	2.00	2.15	3.20	3.60	2.00	1.60	2.00
Ni-D	mg/L	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100
Ni-T	mg/L	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100
Pb-D	mg/L	0.000488	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000350	0.000500
Pb-T	mg/L	0.000488	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000350	0.000500
Sb-D	mg/L	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500
Sb-T	mg/L	0.000519	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000730	0.000500	0.000500	0.000500	0.000500	0.000500
Se-D	mg/L	0.000967	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.000600	0.00100
Se-T	mg/L	0.000967	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.000600	0.00100
Sn-D	mg/L	0.000688	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.00275	0.000500
Sn-T	mg/L	0.000688	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.00275	0.000500
Ti-D	mg/L	0.00979	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.00750	0.0100
Ti-T	mg/L	0.0100	0.0100	0.0100	0.0100	0.0100	0.0125	0.0100	0.0100	0.0100	0.0100	0.0100	0.00750	0.0100
Tl-D	mg/L	0.000194	0.000200	0.000200	0.000200	0.000200	0.000200	0.000200	0.000200	0.000200	0.000200	0.000200	0.000125	0.000200
Tl-T	mg/L	0.000194	0.000200	0.000200	0.000200	0.000200	0.000200	0.000200	0.000200	0.000200	0.000200	0.000200	0.000125	0.000200
U-D	mg/L	0.000196	0.000200	0.000200	0.000200	0.000200	0.000200	0.000200	0.000200	0.000200	0.000200	0.000200	0.000150	0.000200
U-T	mg/L	0.000196	0.000200	0.000200	0.000200	0.000200	0.000200	0.000200	0.000200	0.000200	0.000200	0.000200	0.000150	0.000200
V-D	mg/L	0.00117	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00300	0.00100
V-T	mg/L	0.00117	0.00100	0.00100	0.00100	0.00100	0.00105	0.00100	0.00100	0.00100	0.00100	0.00100	0.00300	0.00100
Zn-D	mg/L	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500
Zn-T	mg/L	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500

[a]No monthly data available. December monthly source term used.

[b]No data available for October. Average of September and November values used.

[c]Dissolved As samples for July source term are likely contaminated. The total As monthly source term for July was used as a conservative estimate of the dissolved As value for this month.

Background water quality terms: 7S Quinsam River - monthly median values

Parameter	Units	Mean annual	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Alkalinity	mg CaCO3/L	26.2	12.8	29.0	25.7	30.5	28.0	23.4	28.0	28.0	29.6	27.6	26.7	24.8
Conductivity	uS/cm	99.4	47.0	104	128	139	118	70.1	90.0	89.8	107	116	90.2	94.0
pH	pH Units	7.55	7.18	7.39	7.62	7.60	7.51	7.58	7.64	7.64	7.76	7.59	7.61	7.43
TDS	mg/L	63.8	28.0	56.0	84.0	72.0	70.0	80.0	62.0	61.0	61.0	75.0	62.0	54.0
TSS	mg/L	3.75	4.00	4.00	3.50	4.00	3.50	4.00	4.00	4.00	3.00	3.00	4.00	4.00
NH3	mg-N/L	0.0359	0.0120	0.0180	0.0200	0.0160	0.0178	0.0260	0.0150	0.0260	0.00500	0.015	0.0155	0.0320
NO2+NO3	mg-N/L	0.0336	0.154	0.0300	0.0300	0.0300	0.0200	0.0200	0.0230	0.0200	0.00800	0.0200	0.0250	0.0226
TKN	mg-N/L	0.120	0.0200	0.150	0.0910	0.120	0.158	0.143	0.148	0.104	0.104	0.115	0.180	0.104
PO4-D	mg-P/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PO4-T	mg-P/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sulphate	mg/L	19.7	5.65	22.0	31.1	30.8	25.9	9.07	18.0	15.0	18.2	23.8	16.0	20.8
Hardness-T	mg CaCO3/L	30.5	13.1	30.5	36.5	37.4	32.0	22.7	36.2	27.5	34.9	35.5	32.6	27.1
Ag-D	mg/L	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200
Ag-T	mg/L	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200
Al-D	mg/L	0.0224	0.0767	0.0290	0.0284	0.0178	0.0172	0.0141	0.0164	0.0119	0.00830	0.00645	0.0182	0.0244
Al-T	mg/L	0.0462	0.135	0.0600	0.0410	0.0370	0.0415	0.0345	0.0390	0.0290	0.0148	0.0132	0.0600	0.0490
As-D	mg/L	0.000288	0.000140	0.000200	0.000330	0.000400	0.000200	0.000230	0.000200	0.000260	0.000500	0.000500	0.000230	0.000265
As-T	mg/L	0.000302	0.000150	0.000200	0.000350	0.000400	0.000210	0.000200	0.000300	0.000300	0.000500	0.000500	0.000290	0.000225
Ba-D	mg/L	0.00664	0.00150	0.00200	0.0114	0.0115	0.00240	0.00160	0.00200	0.00200	0.0200	0.0200	0.00260	0.00275
Ba-T	mg/L	0.00668	0.00150	0.00200	0.0115	0.0115	0.00225	0.00140	0.00200	0.00220	0.0200	0.0200	0.00290	0.00295
B-D	mg/L	0.0625	0.0500	0.0500	0.0750	0.0750	0.0500	0.0500	0.0500	0.0500	0.100	0.100	0.0500	0.0500
B-T	mg/L	0.0625	0.0500	0.0500	0.0750	0.0750	0.0500	0.0500	0.0500	0.0500	0.100	0.100	0.0500	0.0500
Be-D	mg/L	0.000325	0.000100	0.000100	0.000550	0.000550	0.000100	0.000100	0.000100	0.000100	0.00100	0.00100	0.000100	0.000100
Be-T	mg/L	0.000325	0.000100	0.000100	0.000550	0.000550	0.000100	0.000100	0.000100	0.000100	0.00100	0.00100	0.000100	0.000100
Ca-D	mg/L	10.2	4.14	9.60	12.0	12.6	11.3	8.12	10.5	9.69	11.6	12.1	10.9	9.32
Ca-T	mg/L	10.1	4.05	10.0	11.9	12.3	10.6	7.65	11.9	9.18	11.6	11.7	10.9	8.90
Cd-D	mg/L	0.0000163	0.0000100	0.0000400	0.0000135	0.0000155	0.0000185	0.0000100	0.0000100	0.0000170	0.0000170	0.0000170	0.0000170	0.0000100
Cd-T	mg/L	0.0000126	0.0000100	0.0000100	0.0000135	0.0000135	0.0000135	0.0000170	0.0000100	0.0000100	0.0000170	0.0000170	0.0000100	0.0000100
Co-D	mg/L	0.000450	0.000500	0.000500	0.000400	0.000400	0.000500	0.000500	0.000500	0.000500	0.000300	0.000300	0.000500	0.000500
Co-T	mg/L	0.000450	0.000500	0.000500	0.000400	0.000400	0.000500	0.000500	0.000500	0.000500	0.000300	0.000300	0.000500	0.000500
Cr-D	mg/L	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100
Cr-T	mg/L	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100
Cu-D	mg/L	0.000953	0.00107	0.000900	0.000950	0.00100	0.000950	0.000900	0.000900	0.00100	0.00100	0.00100	0.00100	0.000770
Cu-T	mg/L	0.000950	0.000650	0.000800	0.000850	0.000850	0.00145	0.000800	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100
Fe-D	mg/L	0.0526	0.0304	0.0350	0.0554	0.0450	0.0590	0.0480	0.0680	0.0630	0.0540	0.0620	0.0610	0.0502
Fe-T	mg/L	0.106	0.112	0.0790	0.0925	0.102	0.134	0.102	0.114	0.102	0.0840	0.102	0.128	0.118
Hg-D	mg/L	0.0000192	0.0000100	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200
Hg-T	mg/L	0.0000192	0.0000100	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200	0.0000200
K-D	mg/L	0.735	0.246	0.220	1.12	1.13	0.460	0.244	0.230	0.630	2.00	2.00	0.330	0.210
K-T	mg/L	0.688	0.234	0.220	1.12	1.12	0.333	0.188	0.280	0.270	2.00	2.00	0.280	0.212
Li-D	mg/L	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500
Li-T	mg/L	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500
Mg-D	mg/L	1.30	0.743	1.26	1.66	1.52	1.34	1.02	1.23	1.17	1.43	1.54	1.35	1.29
Mg-T	mg/L	1.31	0.718	1.34	1.64	1.61	1.34	0.875	1.58	1.10	1.45	1.52	1.33	1.23
Mn-D	mg/L	0.00436	0.00225	0.00300	0.00370	0.00428	0.00500	0.00500	0.00700	0.00420	0.00461	0.00532	0.00500	0.00295
Mn-T	mg/L	0.00660	0.00450	0.00400	0.00426	0.00708	0.00700	0.00700	0.00940	0.00800	0.00617	0.00776	0.00700	0.00705
Mo-D	mg/L	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100
Mo-T	mg/L	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100
Na-D	mg/L	8.02	2.74	9.68	11.6	12.4	10.7	3.78	7.11	6.46	7.60	9.00	7.76	7.36
Na-T	mg/L	8.50	2.52	10.9	11.6	12.7	11.0	3.65	11.3	6.34	7.70	8.90	8.04	7.36
Ni-D	mg/L	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100
Ni-T	mg/L	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100
Pb-D	mg/L	0.000275	0.000200	0.000200	0.000350	0.000350	0.000200	0.000200	0.000200	0.000200	0.000500	0.000500	0.000200	0.000200
Pb-T	mg/L	0.000275	0.000200	0.000200	0.000350	0.000350	0.000200	0.000200	0.000200	0.000200	0.000500	0.000500	0.000200	0.000200
Sb-D	mg/L	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500
Sb-T	mg/L	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500
Se-D	mg/L	0.000325	0.000100	0.000100	0.000550	0.000550	0.000100	0.000100	0.000100	0.000100	0.00100	0.00100	0.000100	0.000100
Se-T	mg/L	0.000325	0.000100	0.000100	0.000550	0.000550	0.000100	0.000100	0.000100	0.000100	0.00100	0.00100	0.000100	0.000100
Sn-D	mg/L	0.00369	0.00500	0.00500	0.00275	0.00275	0.00500	0.00275	0.00500	0.00500	0.000500	0.000500	0.00500	0.00500
Sn-T	mg/L	0.00388	0.00500	0.00500	0.00275	0.00275	0.00500	0.00500	0.00500	0.00500	0.000500	0.000500	0.00500	0.00500
Ti-D	mg/L	0.00625	0.00500	0.00500	0.00750	0.00750	0.00500	0.00500	0.00500	0.00500	0.0100	0.0100	0.00500	0.00500
Ti-T	mg/L	0.00659	0.00600	0.00500	0.00750	0.00900	0.00500	0.00500	0.00500	0.00500	0.0100	0.0100	0.00500	0.00655
Tl-D	mg/L	0.0000875	0.0000500	0.0000500	0.000125	0.000125	0.0000500	0.0000500	0.0000500	0.0000500	0.000200	0.000200	0.0000500	0.0000500
Tl-T	mg/L	0.0000875	0.0000500	0.0000500	0.000125	0.000125	0.0000500	0.0000500	0.0000500	0.0000500	0.000200	0.000200	0.0000500	0.0000500
U-D	mg/L	0.000125	0.000100	0.000100	0.000150	0.000150	0.000100	0.000100	0.000100	0.000100	0.000200	0.000200	0.000100	0.000100
U-T	mg/L	0.000125	0.000100	0.000100	0.000150	0.000150	0.000100	0.000100	0.000100	0.000100	0.000200	0.000200	0.000100	0.000100
V-D	mg/L	0.00400	0.00500	0.00500	0.00300	0.00300	0.00500	0.00500	0.00500	0.00500	0.00100	0.00100	0.00500	0.00500
V-T	mg/L	0.00401	0.00500	0.00500	0.00300	0.00300	0.00500	0.00500	0.00500	0.00500	0.00100	0.00115	0.00500	0.00500
Zn-D	mg/L	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500
Zn-T	mg/L	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500

ND = No data

Appendix E
Metal Leaching / Acid Rock Drainage

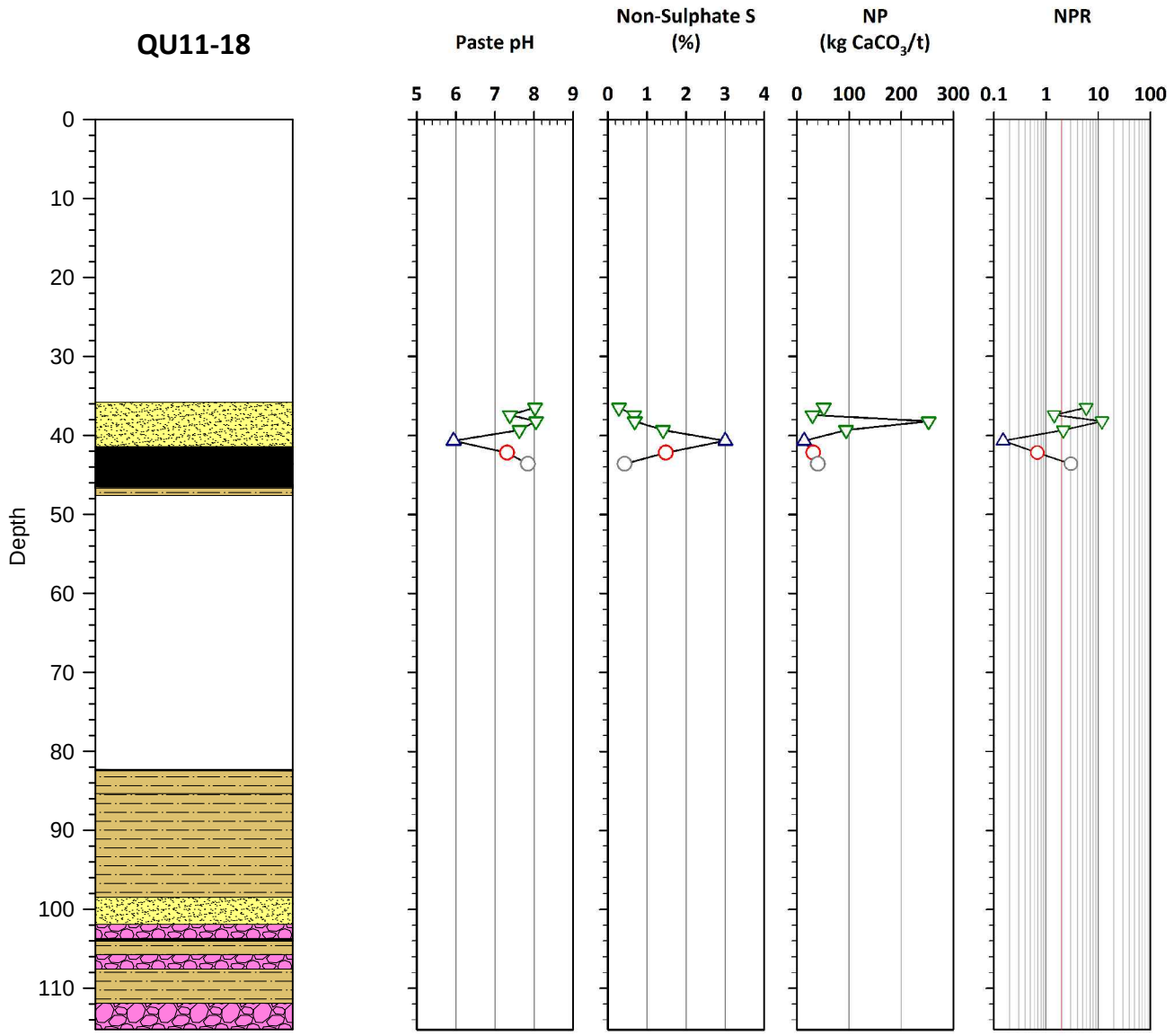
APPENDIX E1 BORE HOLE LOG PLOTS OF ML/ARD RESULTS

APPENDIX E2 ACID-BASE ACCOUNTING RESULTS APPENDIX

E3 SOLID PHASE METALS RESULTS

QUINSAM COAL

APPENDIX E1 BORE HOLE LOG PLOTS OF ML/ARD RESULTS



Geology:

- N/A
- Breccia
- Coal
- Coal/Sandstone
- Coal/Siltstone
- Sandstone/Siltstone
- Conglomerate
- Lime
- Mudstone/Sandstone
- Mudstone
- Sandstone
- Siltstone/Sandstone
- Siltstone

Sample Location:

- Hanging Wall
- Near Seam
- 4 Seam Coal
- 4L Seam Coal

DATE SAVED:	Aug 07, 2012
DRAWN BY:	VV
REVIEWED:	JM
VERSION:	2

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT: **7 South Area 5 ML/ARD Assessment**

TITLE: Stratigraphy of Borehole QU11-18 with ABA Results

PROJECT #: J885-7

FIGURE:

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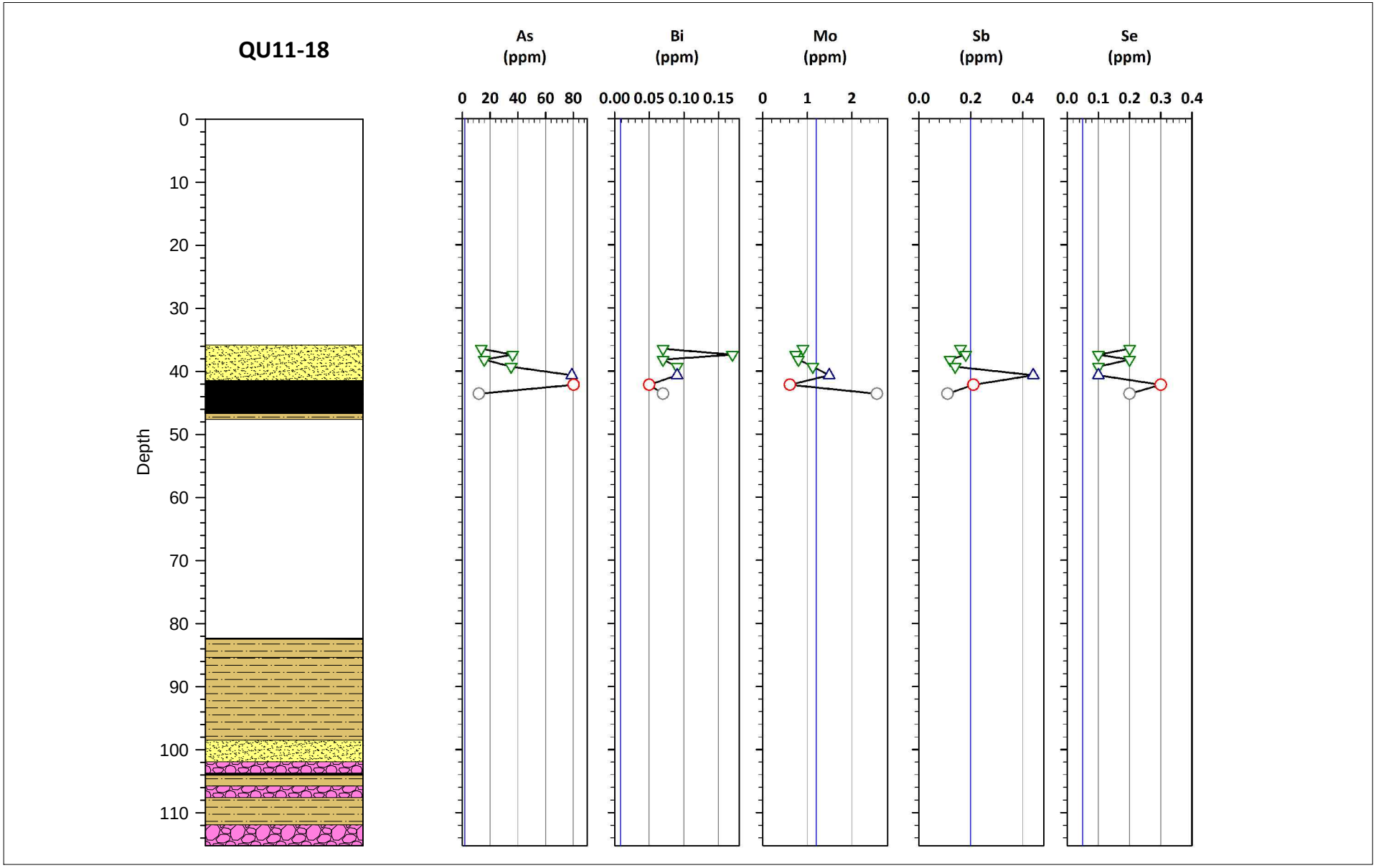

Geology:

- N/A
- Breccia
- Coal
- Coal/Sandstone
- Coal/Siltstone
- Sandstone/Siltstone
- Conglomerate
- Lime
- Mudstone/Sandstone
- Mudstone
- Sandstone
- Siltstone/Sandstone
- Siltstone

Sample Location:

- Hanging Wall
- Near Seam
- 4 Seam Coal
- 4L Seam Coal

DATE SAVED:	Aug 07, 2012
DRAWN BY:	VV
REVIEWED:	JM
VERSION:	2

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT: **7 South Area 5 ML/ARD Assessment**

TITLE: Stratigraphy of Borehole QU11-18 with Metals Concentration Results

PROJECT #: J885-7

FIGURE:

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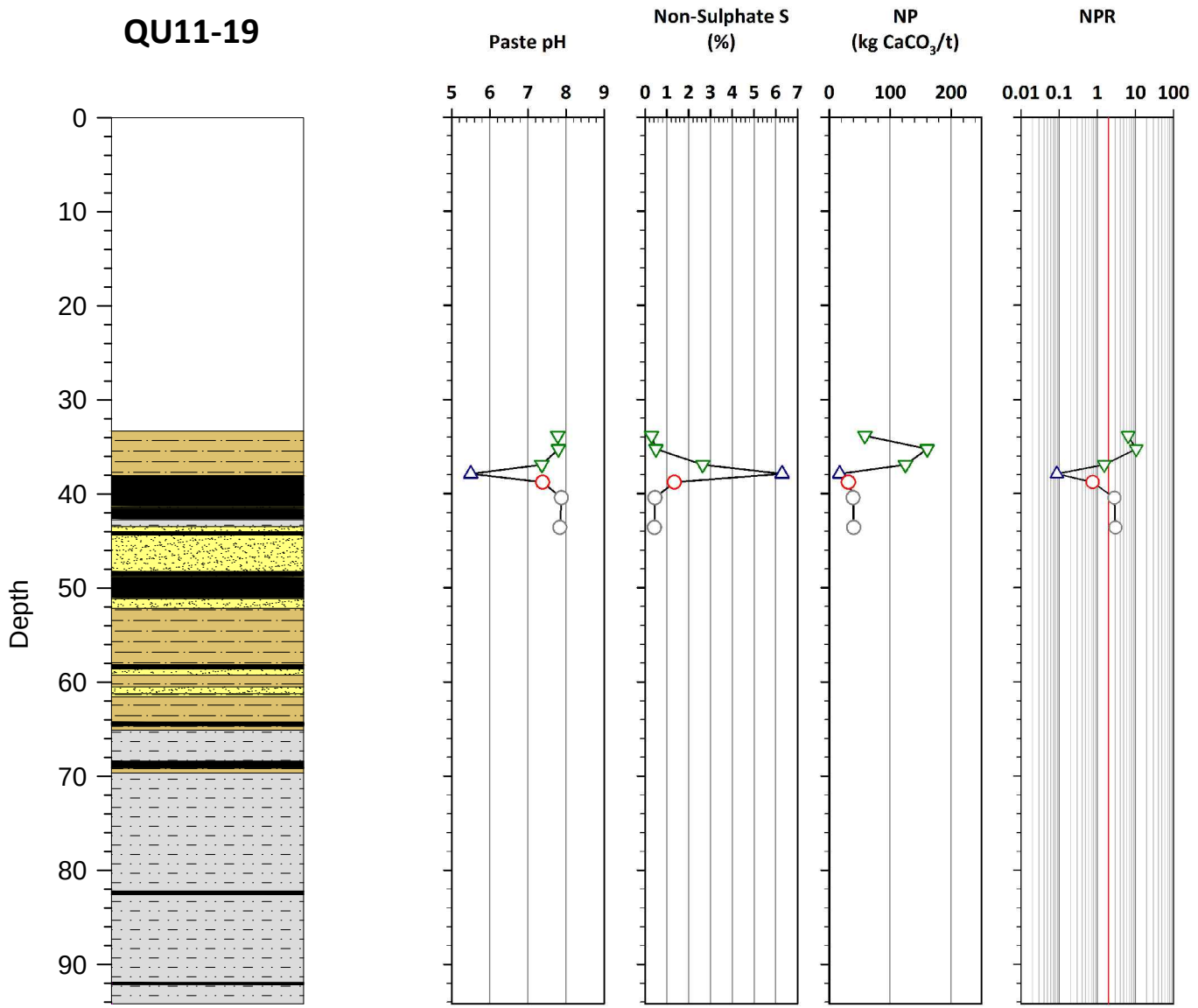

Geology:

- N/A
- Breccia
- Coal
- Coal/Sandstone
- Coal/Siltstone
- Sandstone/Siltstone
- Conglomerate
- Lime
- Mudstone/Sandstone
- Mudstone
- Sandstone
- Siltstone/Sandstone
- Siltstone

Sample Location:

- Hanging Wall
- Near Seam
- 4 Seam Coal
- 4L Seam Coal

DATE SAVED:	Aug 07, 2012
DRAWN BY:	VV
REVIEWED:	JM
VERSION:	2

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT: **7 South Area 5 ML/ARD Assessment**

TITLE: Stratigraphy of Borehole QU11-19 with ABA Results

PROJECT #: J885-7

FIGURE:

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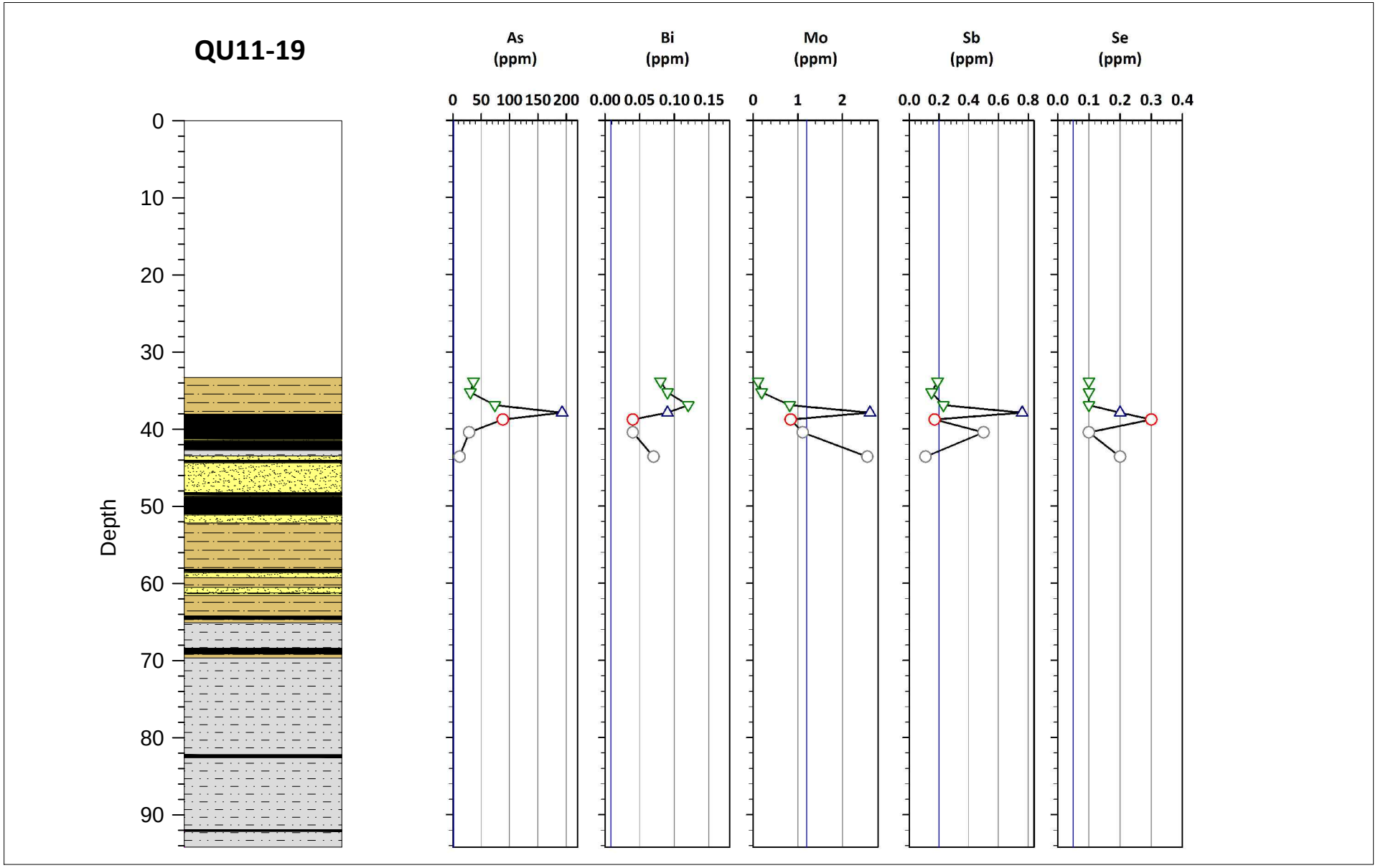


Geology:

- N/A
- Breccia
- Coal
- Coal/Sandstone
- Coal/Siltstone
- Sandstone/Siltstone
- Conglomerate
- Lime
- Mudstone/Sandstone
- Mudstone
- Sandstone
- Siltstone/Sandstone
- Siltstone

Sample Location:

- Hanging Wall
- Near Seam
- 4 Seam Coal
- 4L Seam Coal

DATE SAVED:	Aug 07, 2012
DRAWN BY:	VV
REVIEWED:	JM
VERSION:	2

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

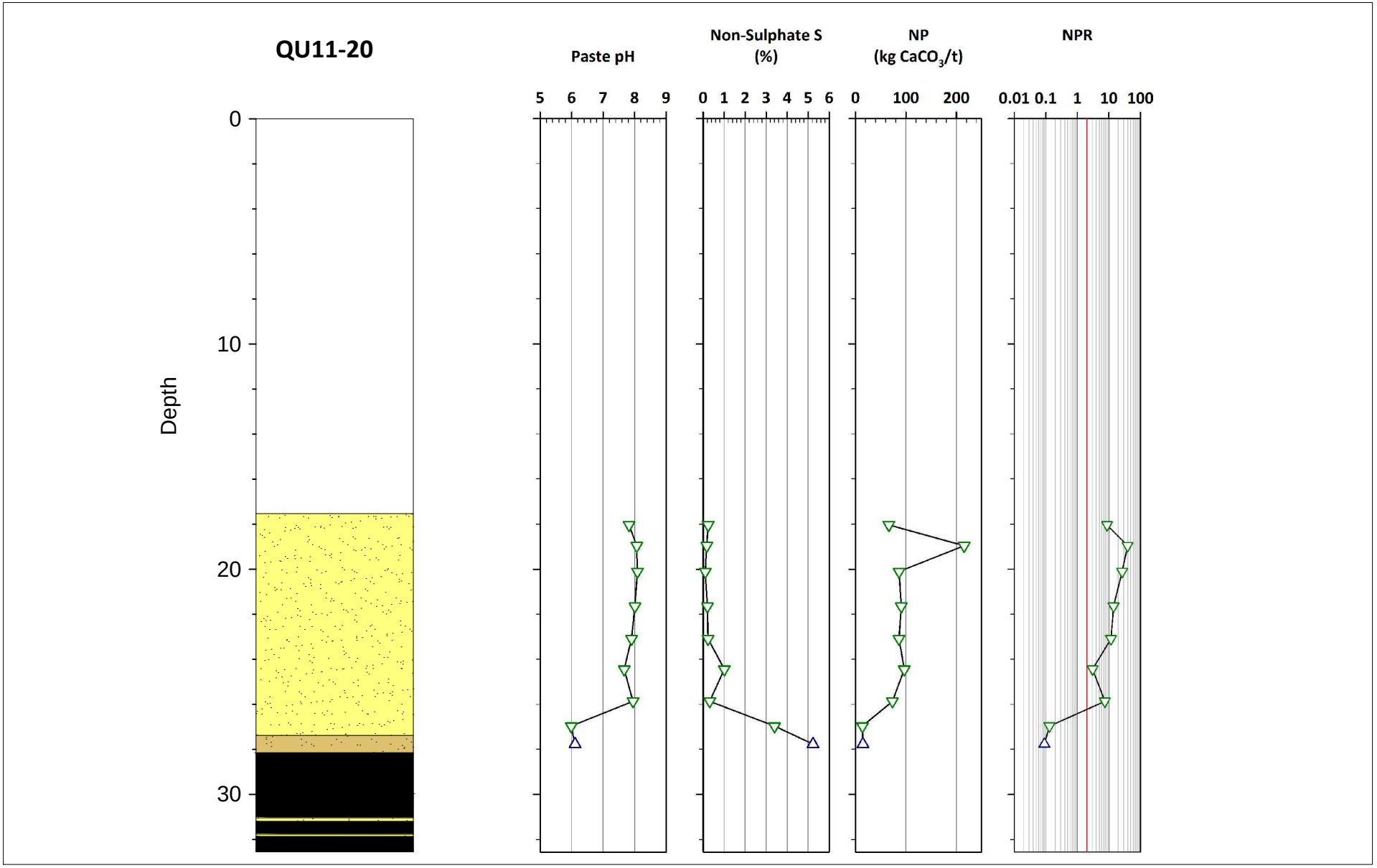
PROJECT: **7 South Area 5 ML/ARD Assessment**

TITLE: Stratigraphy of Borehole QU11-19 with Metals Concentration Results

PROJECT #: J885-7

FIGURE:

P:\J885 Hillsborough Resources\Drafting\Stratigraphic models\7 South Area 5\Start Model_ver2_Aug2012.dwg



Geology:

- N/A
- Breccia
- Coal
- Coal/Sandstone
- Coal/Siltstone
- Sandstone/Siltstone
- Conglomerate
- Lime
- Mudstone/Sandstone
- Mudstone
- Sandstone
- Siltstone/Sandstone
- Siltstone

Sample Location:

- Hanging Wall
- Near Seam
- 4 Seam Coal
- 4L Seam Coal

DATE SAVED:	Aug 07, 2012
DRAWN BY:	VV
REVIEWED:	JM
VERSION:	2

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT: **7 South Area 5 ML/ARD Assessment**

TITLE: Stratigraphy of Borehole QU11-20 with ABA Results

PROJECT #: J885-7

FIGURE:

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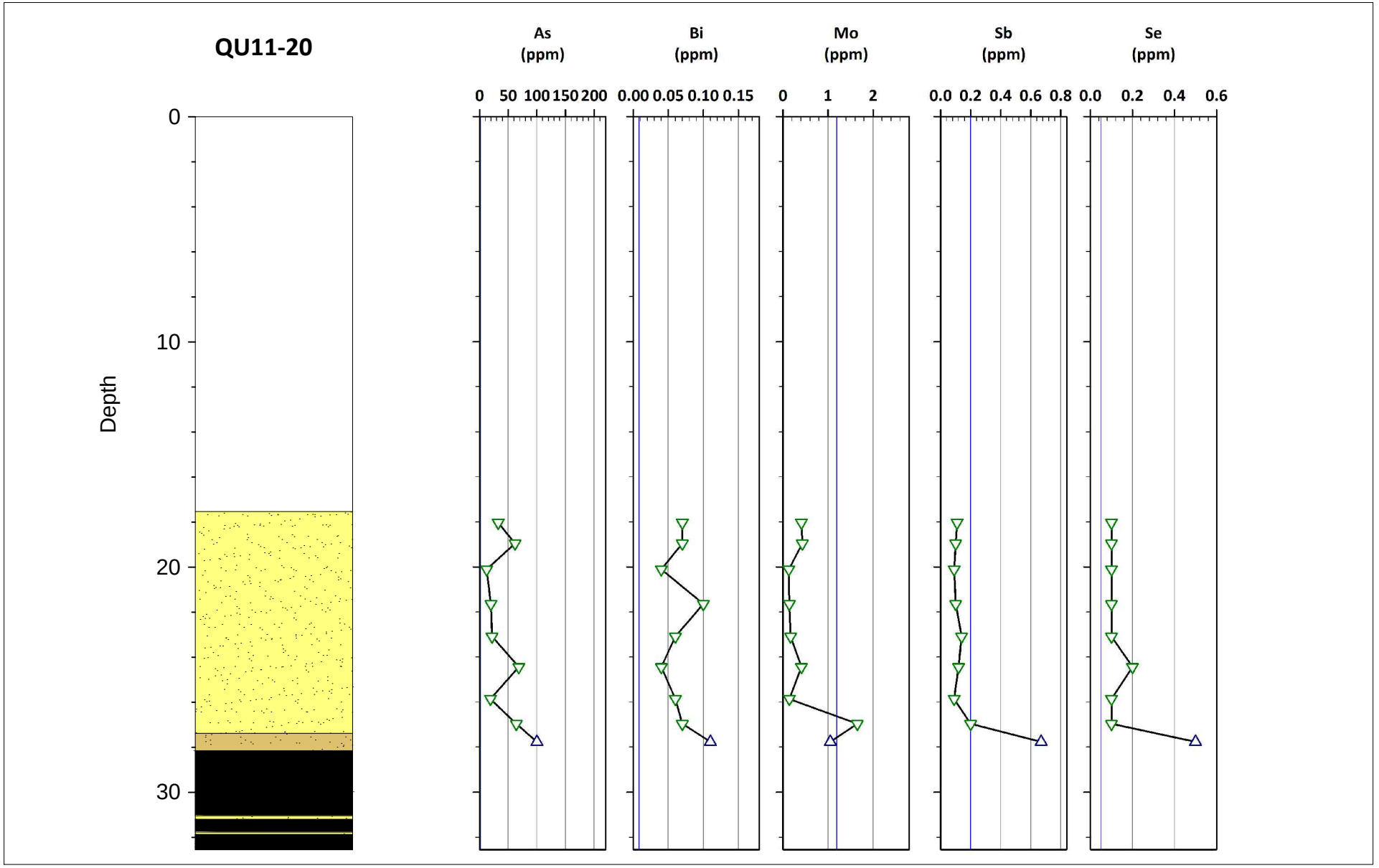

Geology:

- N/A
- Breccia
- Coal
- Coal/Sandstone
- Coal/Siltstone
- Sandstone/Siltstone
- Conglomerate
- Lime
- Mudstone/Sandstone
- Mudstone
- Sandstone
- Siltstone/Sandstone
- Siltstone

Sample Location:

- Hanging Wall
- Near Seam
- 4 Seam Coal
- 4L Seam Coal

DATE SAVED:	Aug 07, 2012
DRAWN BY:	VV
REVIEWED:	JM
VERSION:	2

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT: **7 South Area 5 ML/ARD Assessment**

TITLE: Stratigraphy of Borehole QU11-20 with Metals Concentration Results

PROJECT #: J885-7

FIGURE:

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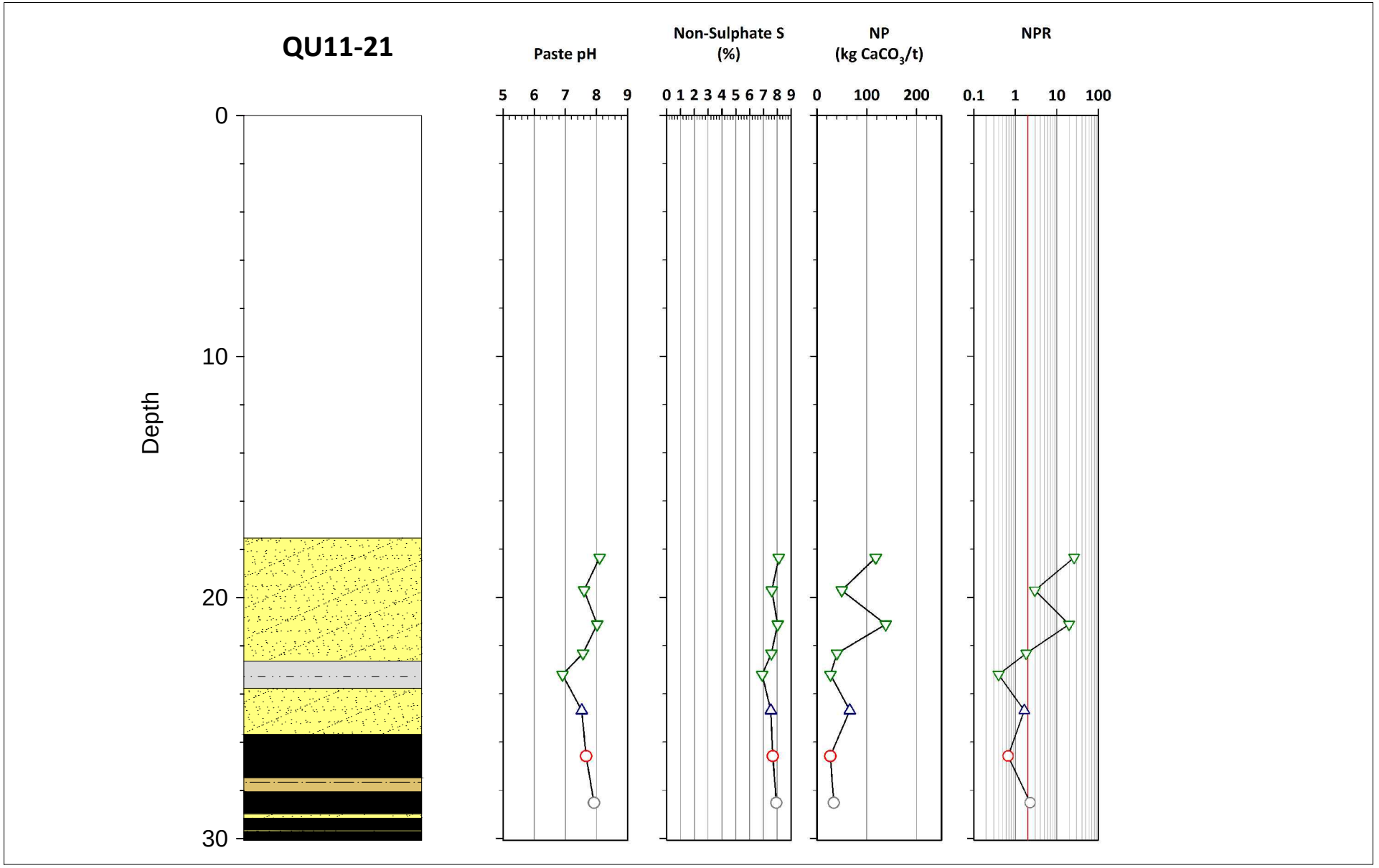

Geology:

- N/A
- Breccia
- Coal
- Coal/Sandstone
- Coal/Siltstone
- Sandstone/Siltstone
- Conglomerate
- Lime
- Mudstone/Sandstone
- Mudstone
- Sandstone
- Siltstone/Sandstone
- Siltstone

Sample Location:

- Hanging Wall
- Near Seam
- 4 Seam Coal
- 4L Seam Coal

DATE SAVED:	Aug 07, 2012
DRAWN BY:	VV
REVIEWED:	JM
VERSION:	2

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT: **7 South Area 5 ML/ARD Assessment**

TITLE: Stratigraphy of Borehole QU11-21 with ABA Results

PROJECT #: J885-7

FIGURE:

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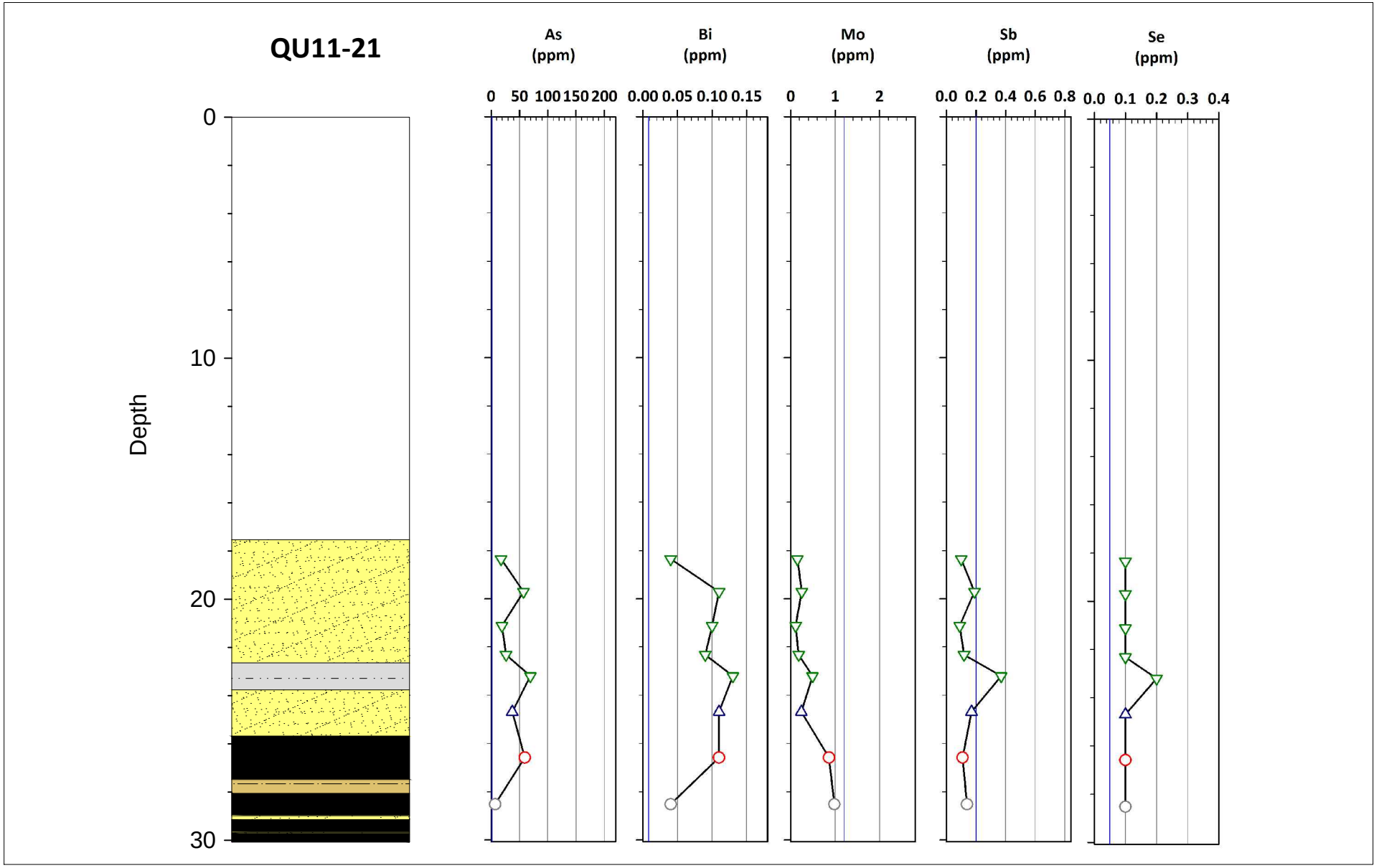


Geology:

- N/A
- Breccia
- Coal
- Coal/Sandstone
- Coal/Siltstone
- Sandstone/Siltstone
- Conglomerate
- Lime
- Mudstone/Sandstone
- Mudstone
- Sandstone
- Siltstone/Sandstone
- Siltstone

Sample Location:

- Hanging Wall
- Near Seam
- 4 Seam Coal
- 4L Seam Coal

DATE SAVED:	Aug 07, 2012
DRAWN BY:	VV
REVIEWED:	JM
VERSION:	2

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

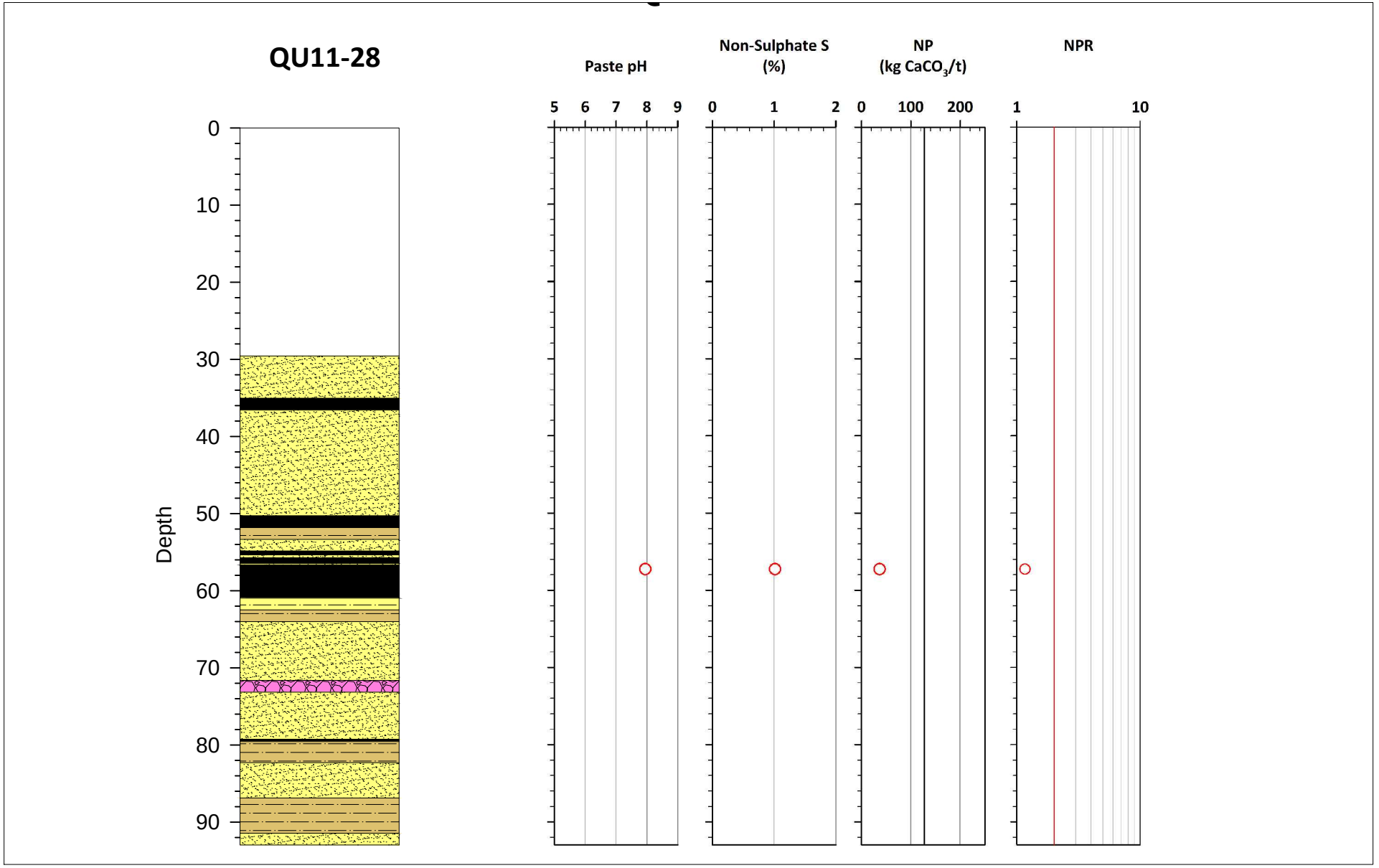
PROJECT: **7 South Area 5 ML/ARD Assessment**

TITLE: Stratigraphy of Borehole QU11-21 with Metals Concentration Results

PROJECT #: J885-7

FIGURE:

P:\J885 Hillsborough Resources\Drafting\Stratigraphic models\7 South Area 5\Start Model_ver2_Aug2012.dwg



Geology:

- N/A
- Breccia
- Coal
- Coal/Sandstone
- Coal/Siltstone
- Sandstone/Siltstone
- Conglomerate
- Lime
- Mudstone/Sandstone
- Mudstone
- Sandstone
- Siltstone/Sandstone
- Siltstone

Sample Location:

- Hanging Wall
- Near Seam
- 4 Seam Coal
- 4L Seam Coal

DATE SAVED:	Aug 07, 2012
DRAWN BY:	VV
REVIEWED:	JM
VERSION:	2

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT: **7 South Area 5 ML/ARD Assessment**

TITLE: Stratigraphy of Borehole QU11-28 with ABA Results

PROJECT #: J885-7

FIGURE:

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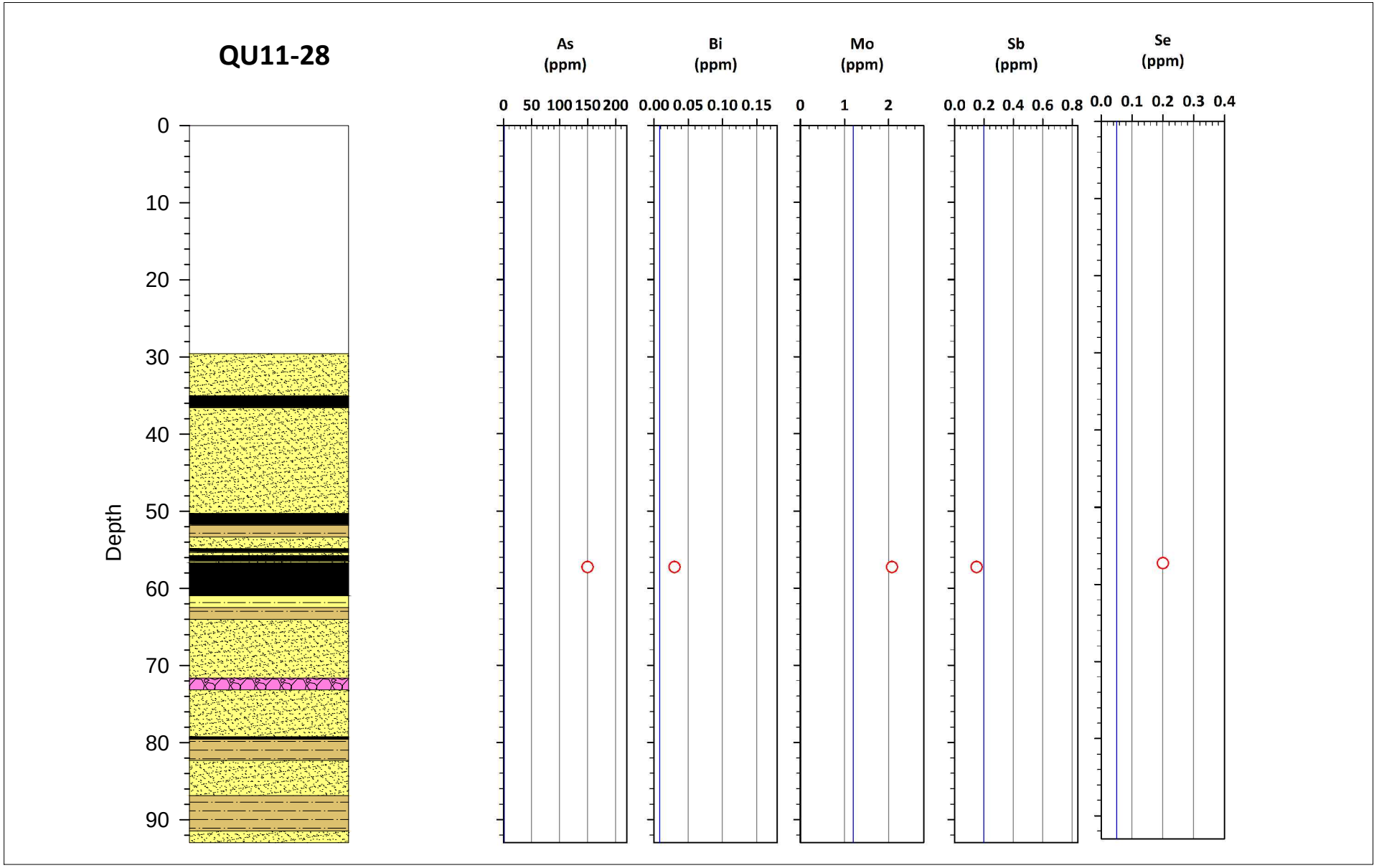

Geology:

- N/A
- Breccia
- Coal
- Coal/Sandstone
- Coal/Siltstone
- Sandstone/Siltstone
- Conglomerate
- Lime
- Mudstone/Sandstone
- Mudstone
- Sandstone
- Siltstone/Sandstone
- Siltstone

Sample Location:

- Hanging Wall
- Near Seam
- 4 Seam Coal
- 4L Seam Coal

DATE SAVED:	Aug 07, 2012
DRAWN BY:	VV
REVIEWED:	JM
VERSION:	2

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT: **7 South Area 5 ML/ARD Assessment**

TITLE: Stratigraphy of Borehole QU11-28 with Metals Concentration Results

PROJECT #: J885-7

FIGURE:

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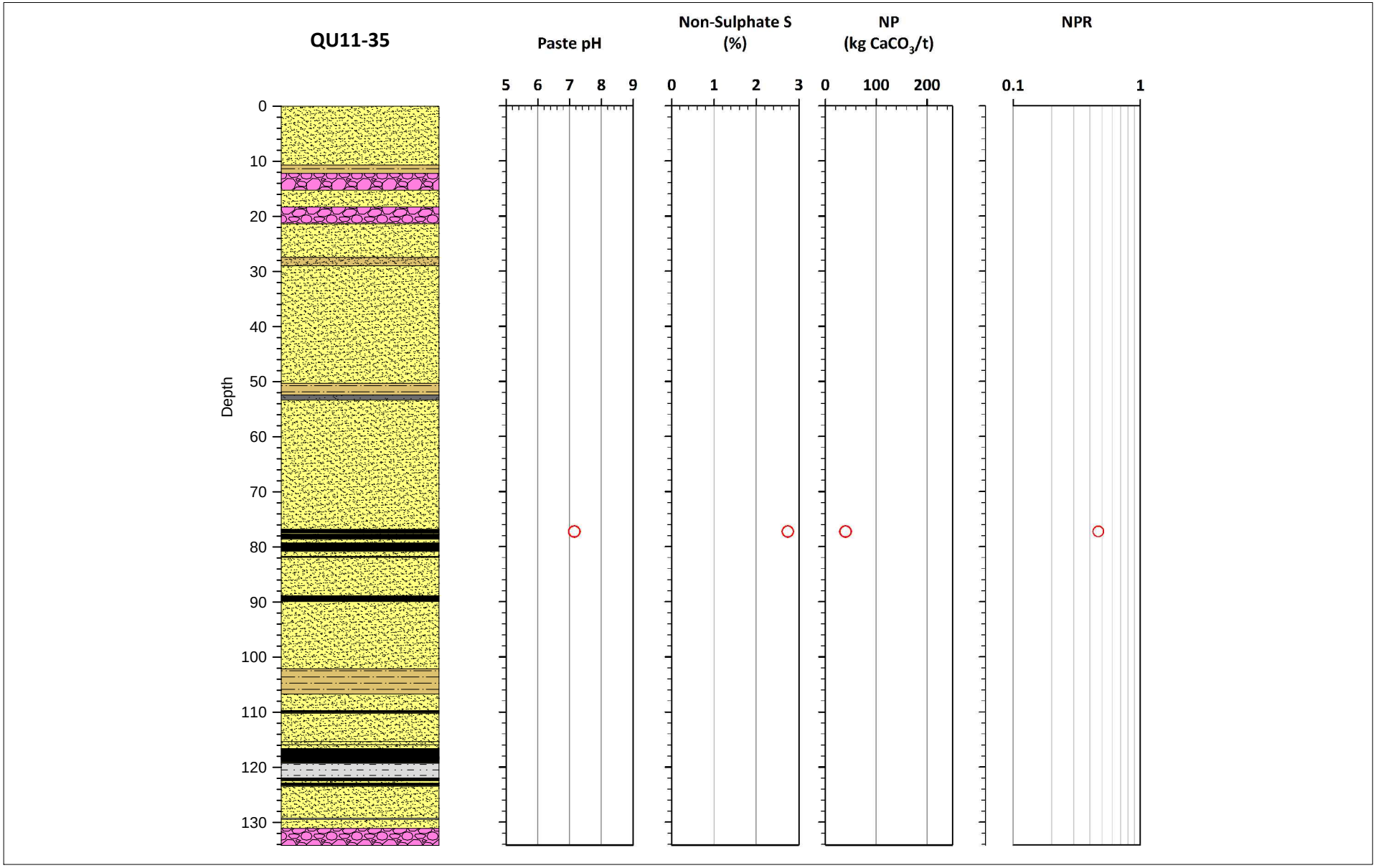

Geology:

- N/A
- Breccia
- Coal
- Coal/Sandstone
- Coal/Siltstone
- Sandstone/Siltstone
- Conglomerate
- Lime
- Mudstone/Sandstone
- Mudstone
- Sandstone
- Siltstone/Sandstone
- Siltstone

Sample Location:

- Hanging Wall
- Near Seam
- 4 Seam Coal
- 4L Seam Coal

DATE SAVED:	Aug 07, 2012
DRAWN BY:	VV
REVIEWED:	JM
VERSION:	2

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT: **7 South Area 5 ML/ARD Assessment**

TITLE: Stratigraphy of Borehole QU11-35 with ABA Results

PROJECT #: J885-7

FIGURE:

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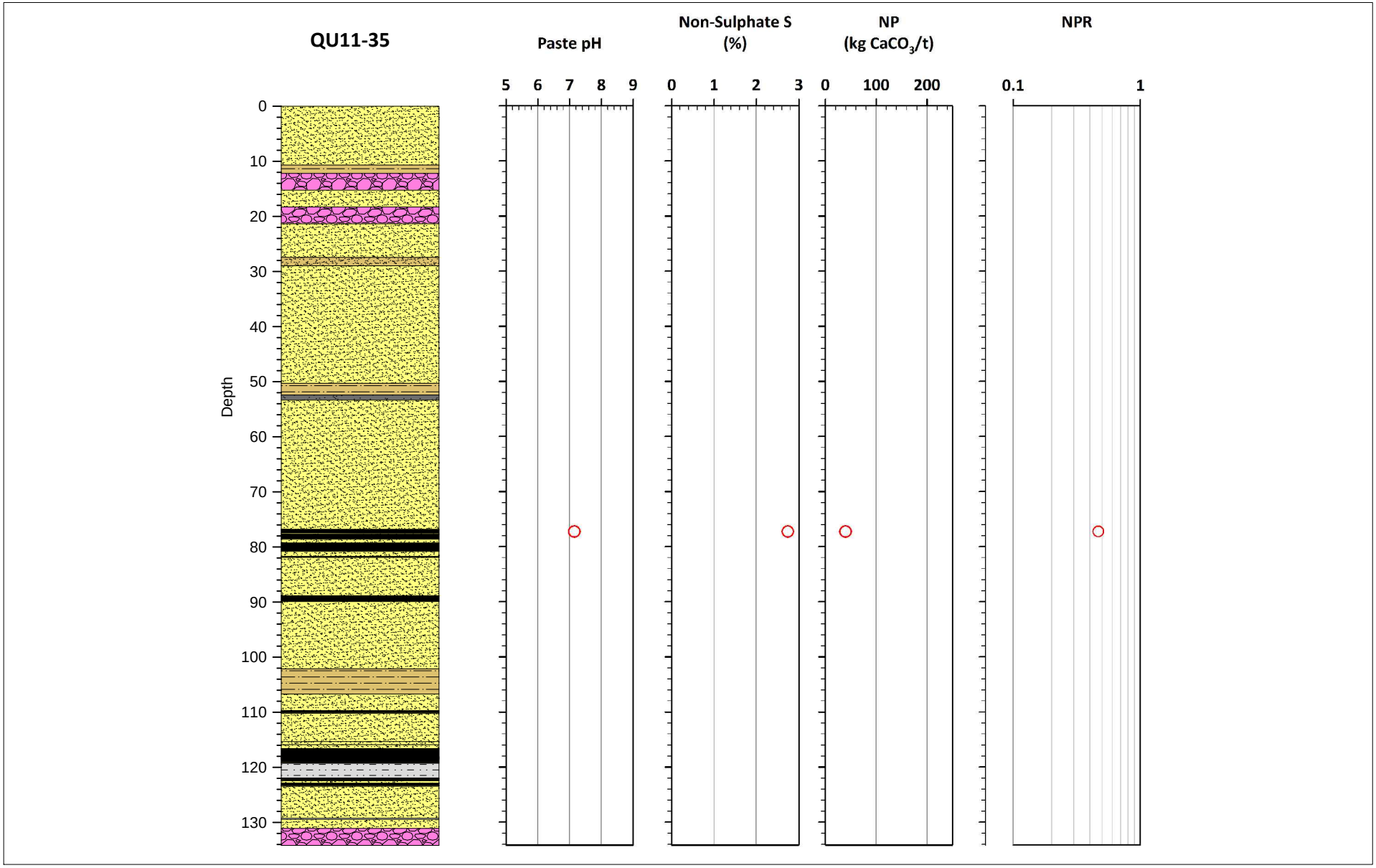

Geology:

- N/A
- Breccia
- Coal
- Coal/Sandstone
- Coal/Siltstone
- Sandstone/Siltstone
- Conglomerate
- Lime
- Mudstone/Sandstone
- Mudstone
- Sandstone
- Siltstone/Sandstone
- Siltstone

Sample Location:

- Hanging Wall
- Near Seam
- 4 Seam Coal
- 4L Seam Coal

DATE SAVED:	Aug 07, 2012
DRAWN BY:	VV
REVIEWED:	JM
VERSION:	2

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT: **7 South Area 5 ML/ARD Assessment**

TITLE: Stratigraphy of Borehole QU11-35 with Metals Conectration Results

PROJECT #: J885-7

FIGURE:

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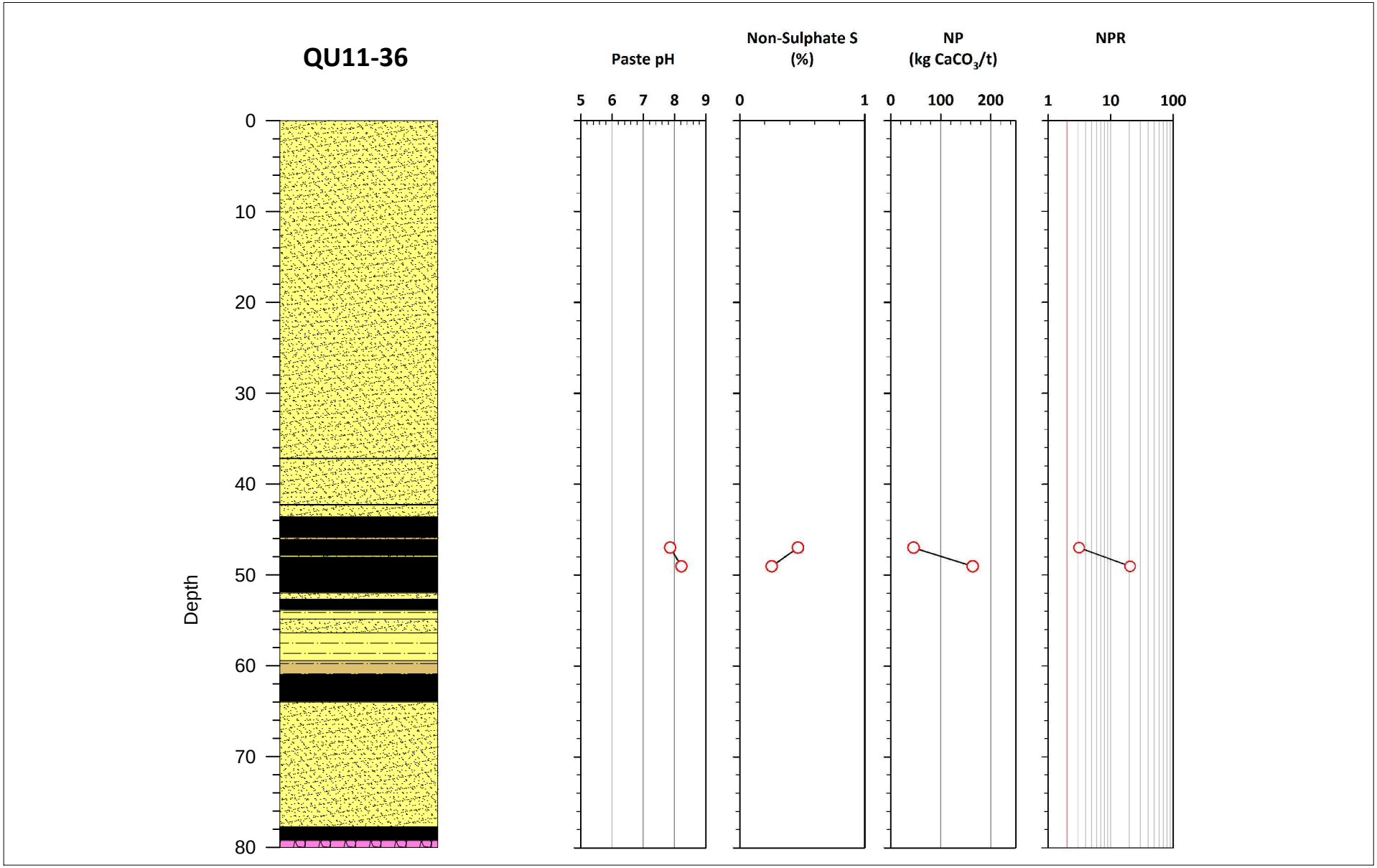

Geology:

- N/A
- Breccia
- Coal
- Coal/Sandstone
- Coal/Siltstone
- Sandstone/Siltstone
- Conglomerate
- Lime
- Mudstone/Sandstone
- Mudstone
- Sandstone
- Siltstone/Sandstone
- Siltstone

Sample Location:

- Hanging Wall
- Near Seam
- 4 Seam Coal
- 4L Seam Coal

DATE SAVED:	Aug 07, 2012
DRAWN BY:	VV
REVIEWED:	JM
VERSION:	2

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT: **7 South Area 5 ML/ARD Assessment**

TITLE: Stratigraphy of Borehole QU11-35 with ABA Results

PROJECT #: J885-7

FIGURE:

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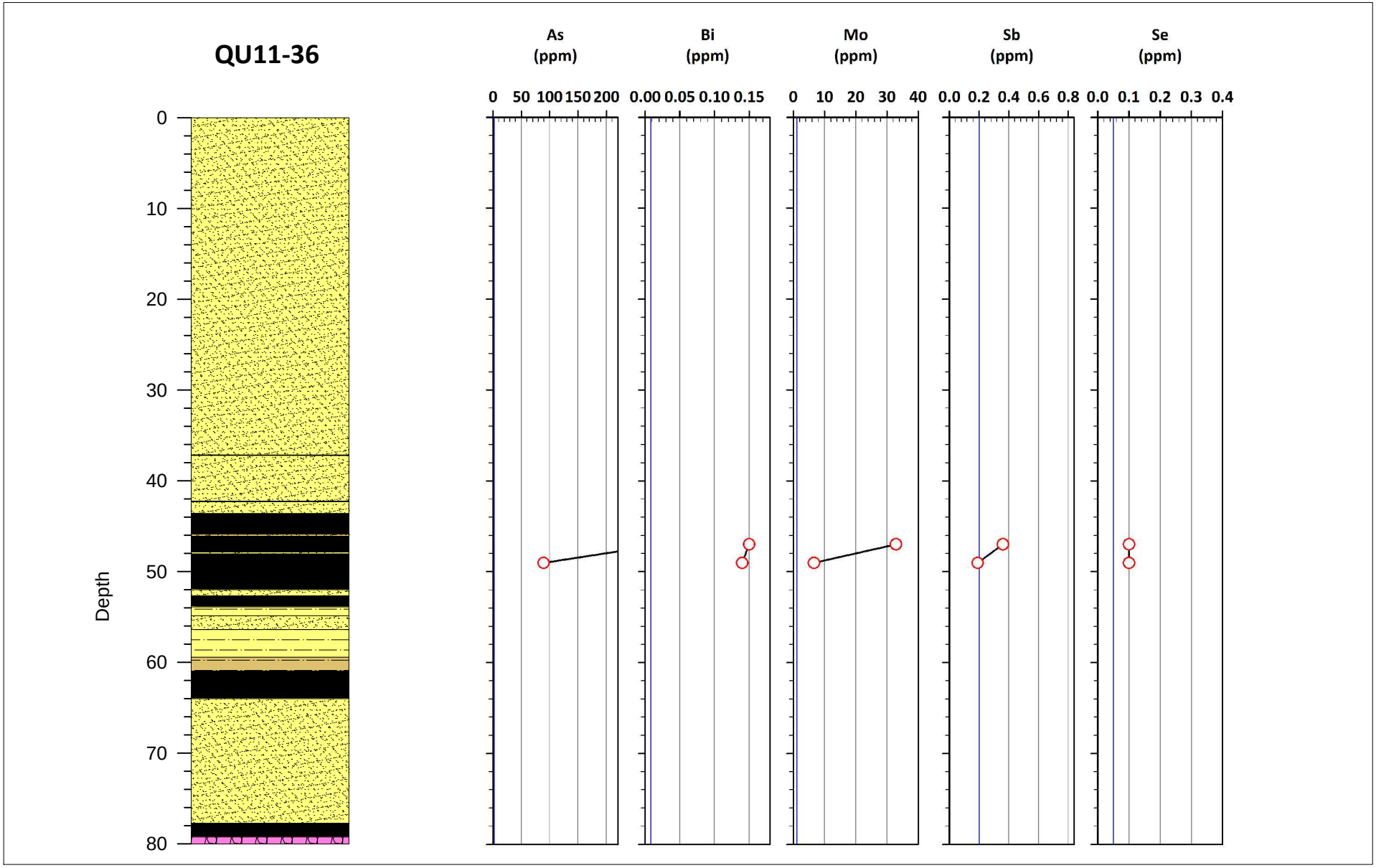

Geology:

- N/A
- Breccia
- Coal
- Coal/Sandstone
- Coal/Siltstone
- Sandstone/Siltstone
- Conglomerate
- Lime
- Mudstone/Sandstone
- Mudstone
- Sandstone
- Siltstone/Sandstone
- Siltstone

Sample Location:

- Hanging Wall
- Near Seam
- 4 Seam Coal
- 4L Seam Coal

DATE SAVED:	Aug 07, 2012
DRAWN BY:	VV
REVIEWED:	JM
VERSION:	2

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT: **7 South Area 5 ML/ARD Assessment**

TITLE: Stratigraphy of Borehole QU11-35 with Metals Concentration Results

PROJECT #: J885-7

FIGURE:

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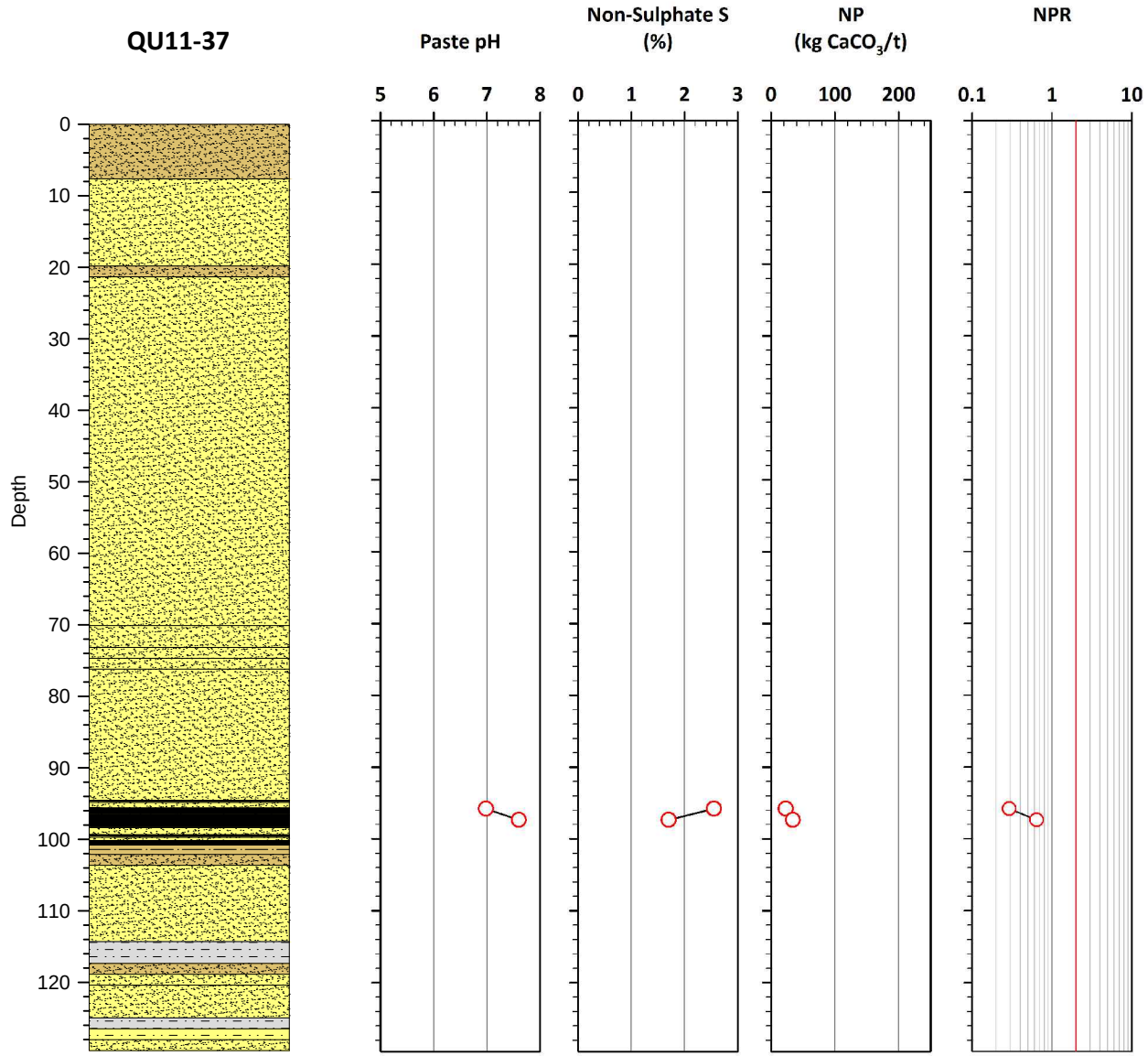

Geology:

- N/A
- Breccia
- Coal
- Coal/Sandstone
- Coal/Siltstone
- Sandstone/Siltstone
- Conglomerate
- Lime
- Mudstone/Sandstone
- Mudstone
- Sandstone
- Siltstone/Sandstone
- Siltstone

Sample Location:

- Hanging Wall
- Near Seam
- 4 Seam Coal
- 4L Seam Coal

DATE SAVED:	Aug 07, 2012
DRAWN BY:	VV
REVIEWED:	JM
VERSION:	2

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT: **7 South Area 5 ML/ARD Assessment**

TITLE: Stratigraphy of Borehole QU11-37 with ABA Results

PROJECT #: J885-7

FIGURE:

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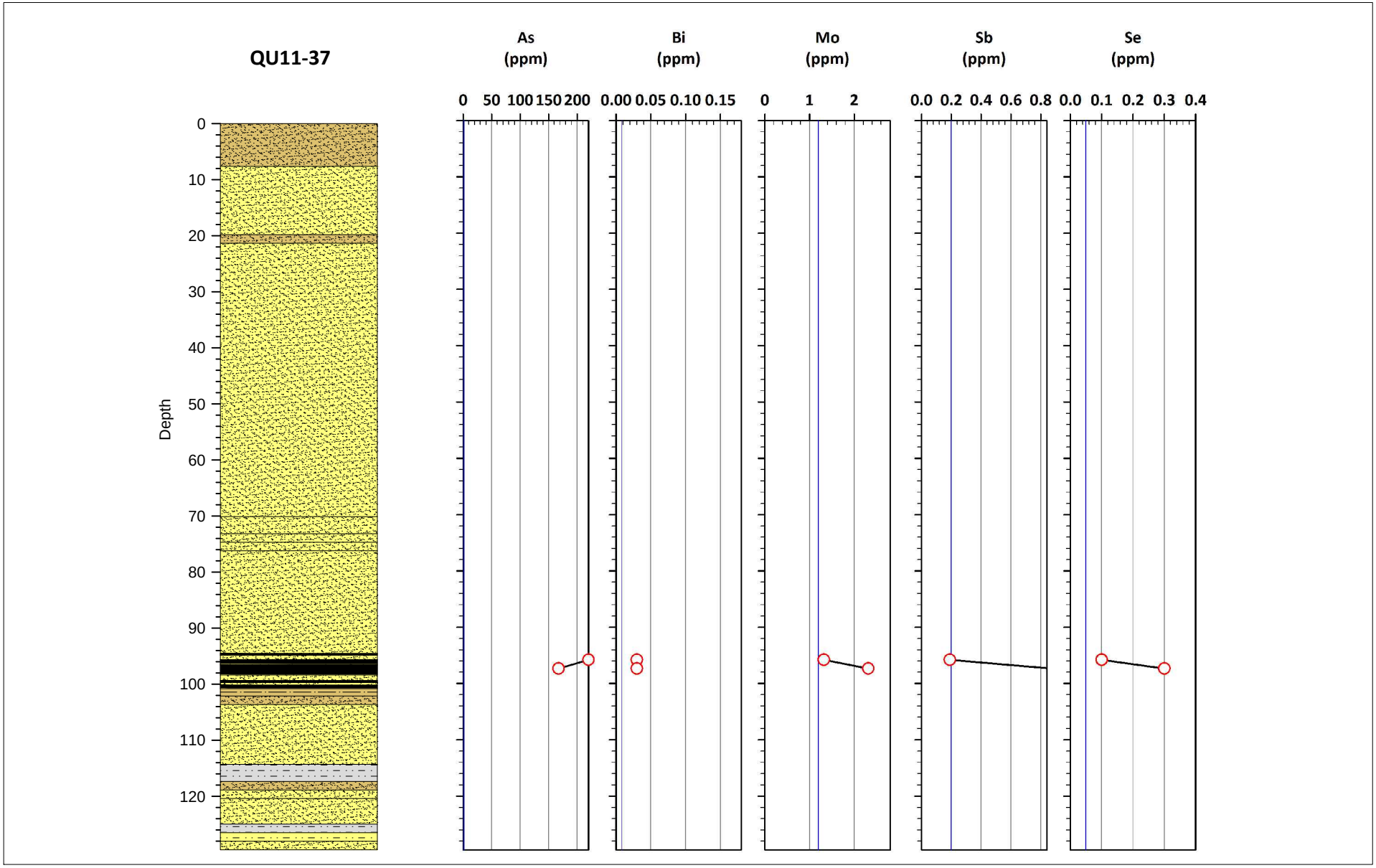


Geology:

- N/A
- Breccia
- Coal
- Coal/Sandstone
- Coal/Siltstone
- Sandstone/Siltstone
- Conglomerate
- Lime
- Mudstone/Sandstone
- Mudstone
- Sandstone
- Siltstone/Sandstone
- Siltstone

Sample Location:

- Hanging Wall
- Near Seam
- 4 Seam Coal
- 4L Seam Coal

DATE SAVED:	Aug 07, 2012
DRAWN BY:	VV
REVIEWED:	JM
VERSION:	2

CLIENT: QUINSAM COAL

LORAX ENVIRONMENTAL

PROJECT: **7 South Area 5 ML/ARD Assessment**

TITLE: Stratigraphy of Borehole QU11-37 with Metals Concentration Results

PROJECT #: J885-7

FIGURE:

P:\J885 Hillsborough Resources\Drafting\Stratigraphic models\7 South Area 5\Start Model_ver2_Aug2012.dwg

APPENDIX E2 ACID-BASE ACCOUNTING RESULTS

Sample ID				**Paste pH**	**CO2 %**	**C(T) %**	**S(T) %**	**S(SO4) %**	**S(S-2) %**	**Insoluble S %**	**Stot-SO4**
Method Code				Sobek	2A11HCl	2A Leco	2A Leco	CSA07V	CSA08D	Calc.	
LOD		From	To	0.2	0.02	0.02	0.02	0.01	0.01	#N/A	
4 Seam Coal											
120301	4 Seam Coal	84.99	85.31	7.65	5.4		1.32	<0.01	1.08	0.24	1.315
120303	4 Coal	85.79	86.66	6.42	2.36		1.99	0.02	1.82	0.15	1.97
120701	4 Seam Roof, Coaly Sandstone	94.97	95.12	8.22	5.85		0.7	<0.01	0.61	0.09	0.695
120702	4 seam coal	95.12	97.72	8.4	10.25		0.64	<0.01	0.56	0.08	0.635
QU11-18 #111801	4 Seam Coal	41.19	43.19	7.31	1.17	71.95	1.5	0.02	1.19	0.29	1.48
QU11-19 #111901	4 Seam Coal	37.78	39.8	7.39	1.09	67.05	1.35	0.01	1.08	0.26	1.34
QU11-21 #112101	4 Seam Coal	25.68	27.48	7.67	1.09	65.44	1.29	<0.01	0.94	0.35	1.285
QU11-28 #112805	4 Seam Coal	56.69	57.85	7.95	1.5	45.11	1.02	<0.01	0.76	0.26	1.015
QU11-35 #113501	4 Seam Coal	76.82	77.71	7.15	1.55	62.23	2.78	0.04	2.28	0.46	2.74
QU11-36 #113605	4 Seam Coal	46.12	47.85	7.86	1.8	69.83	0.47	<0.01	0.11	0.36	0.465
QU11-36 #113607	4 Seam Coal	48.06	50.01	8.22	7.45	23.32	0.26	<0.01	0.13	0.13	0.255
QU11-37 #113701	4 Seam Coal	95.39	96.18	6.98	0.68	55.92	2.59	0.04	1.93	0.62	2.55
QU11-37 #113703	4 Seam Coal	96.4	98.31	7.6	1.11	60.85	1.71	0.01	0.98	0.72	1.7
QU11-38 #113801	4 Seam Coal	56.88	57.61	7.49	0.96	72.64	2.53	0.03	2.11	0.39	2.5
QU11-38 #113802	4 Seam Coal	57.61	58.57	8.14	2.11	73.38	1.08	<0.01	0.71	0.37	1.075
			COUNT	15	15	11	15	15	15	15	15
			COUNT <DL	0	0	0	0	8	0	0	0
			MIN	6.42	0.68	0	0.26	<0.01	0.11	0.08	0.255
			MAX	8.4	10.25	0	2.78	0.04	2.28	0.72	2.74
			10th	7.048	1.012	#NUM!	0.538	0.005	0.302	0.106	0.533
			25th	7.35	1.1	#NUM!	0.86	0.005	0.66	0.195	0.855
			50th	7.65	1.55	#NUM!	1.32	0.005	0.98	0.29	1.315
			75th	8.045	3.88	#NUM!	1.85	0.02	1.505	0.38	1.835
			95th	8.274	8.29	#NUM!	2.647	0.04	2.161	0.65	2.607
4L Seam Coal											
120704	4L Seam Coal	98.13	98.48	8.23	4.13		1.03	<0.01	0.88	0.15	1.025
120706	4L Seam Coal	98.96	99.52	5.08	2.26		8.69	0.04	8.37	0.28	8.65
QU11-18 #111803	4L Seam Coal	43.28	43.94	7.84	1.65	64.4	0.43	<0.01	0.1	0.33	0.425
QU11-38 #113804	4L Seam Coal	58.65	59.62	8.16	1.24	72.39	0.47	<0.01	0.09	0.38	0.465
QU11-21 #112103	4L Seam Coal	28.06	28.98	7.92	1.49	61.83	0.48	<0.01	0.16	0.32	0.475
QU11-19 #111903	4L Seam Coal	39.91	40.98	7.88	1.55	59.66	0.45	<0.01	0.14	0.31	0.445
120304	4L Coal and Sandstone	90.3	92.1	6.27	1.65		5.3	0.04	5.05	0.21	5.26
			COUNT	7	7	4	7	7	7	7	7
			COUNT <DL	0	0	0	0	5	0	0	0
			MIN	5.08	1.24	0	0.43	<0.01	0.09	0.15	0.425
			MAX	8.23	4.13	0	8.69	0.04	8.37	0.38	8.65
			10th	5.794	1.39	#NUM!	0.442	0.005	0.096	0.186	0.437
			25th	7.055	1.52	#NUM!	0.46	0.005	0.12	0.245	0.455
			50th	7.88	1.65	#NUM!	0.48	0.005	0.16	0.31	0.475
			75th	8.04	1.955	#NUM!	3.165	0.0225	2.965	0.325	3.1425
			95th	8.209	3.569	#NUM!	7.673	0.04	7.374	0.365	7.633
Near Seam											
111805	4 Seam Roof-Sandstone	39.92	41.44	5.94	1.57		3.07	0.07	2.61	0.39	3
111904	Coaly Sandstone-4 Seam Roof Rock	37.73	38.05	5.5	1.64		6.49	0.2	5.7	0.59	6.29
112009	Silty sandstone-4 seam roof rock	27.38	28.15	6.11	2.22		5.29	0.06	4.88	0.35	5.23
112106	Sandstone/ trace siltstone, 4 seam roof	23.76	25.62	7.53	4.71		1.31	0.04	1.23	0.04	1.27
120701	4 Seam Roof, Coaly Sandstone	94.97	95.12	8.22	5.85		0.7	<0.01	0.61	0.09	0.695
120703	4-4L sandstone Parting	97.72	98.13	8.09	5.27		1.98	<0.01	1.83	0.15	1.975
			COUNT	6	6	0	6	6	6	6	6
			COUNT <DL	0	0	0	0	2	0	0	0
			MIN	5.5	1.57	0	0.7	<0.01	0.61	0.04	0.695
			MAX	8.22	5.85	0	6.49	0.2	5.7	0.59	6.29
			10th	5.72	1.605	#NUM!	1.005	0.005	0.92	0.065	0.9825
			25th	5.9825	1.785	#NUM!	1.4775	0.01375	1.38	0.105	1.44625
			50th	6.82	3.465	#NUM!	2.525	0.05	2.22	0.25	2.4875
			75th	7.95	5.13	#NUM!	4.735	0.0675	4.3125	0.38	4.6725
			95th	8.1875	5.705	#NUM!	6.19	0.1675	5.495	0.54	6.025

Sample ID Method Code LOD		From	To	**Paste pH** Sobek 0.2	**CO2 %** 2A11HCl 0.02	**C(T) %** 2A Leco 0.02	**S(T) %** 2A Leco 0.02	**S(SO4) %** CSA07V 0.01	**S(S-2) %** CSA08D 0.01	**Insoluble S %** Calc. #N/A	**Stot-SO4**
Hanging Wall Waste Rock											
111901	Sandstone	33.3	34.38	7.79	5.01		0.31	0.02	0.27	0.02	0.29
111902	Sandstone	34.38	36.1	7.8	10.79		0.51	0.02	0.51	<0.01	0.49
111903	Sandstone	36.1	37.73	7.37	8.68		2.76	0.12	2.31	0.33	2.64
111801	Sandstone	35.81	37.15	8.02	3.81		0.3	0.02	0.28	<0.01	0.28
111802	Fault zone in sandstone	37.15	37.7	7.38	2.82		0.7	0.03	0.6	0.07	0.67
111803	Sandstone	37.7	38.71	8.05	14.56		0.69	<0.01	0.65	0.04	0.685
111804	Sandstone	38.71	39.92	7.62	6.42		1.48	0.07	1.26	0.15	1.41
112001	Sandstone	17.53	18.53	7.82	5.39		0.26	0.02	0.28	<0.01	0.24
112002	Sandstone	18.53	19.38	8.07	11.71		0.18	<0.01	0.2	<0.01	0.175
112003	Sandstone w/ black disseminations	19.38	20.83	8.09	6.84		0.11	<0.01	0.11	<0.01	0.105
112004	Sandstone	20.83	22.46	8.01	6.69		0.21	<0.01	0.2	0.01	0.205
112005	Sandstone w/ black disseminations	22.46	23.71	7.9	4.32		0.24	<0.01	0.23	0.01	0.235
112006	Bioturbated Sandstone	23.71	25.16	7.67	6.17		1.04	0.03	0.85	0.16	1.01
112007	Sandstone	25.16	26.55	7.95	4.8		0.32	<0.01	0.27	0.05	0.315
112008	Sandstone with black interstitial material	26.55	27.38	5.99	1.69		3.44	0.04	3.13	0.27	3.4
112101	Sandstone	17.53	19.16	8.1	8		0.15	<0.01	0.15	<0.01	0.145
112102	Sandstone	19.16	20.24	7.6	5.36		0.56	0.02	0.52	0.02	0.54
112103	Sandstone	20.24	21.99	8.02	9.06		0.23	<0.01	0.21	0.02	0.225
112104	Sandstone	21.99	22.64	7.57	4.61		0.73	0.03	0.62	0.08	0.7
112105	Mudstone/Sandstone	22.64	23.76	6.91	4.11		2.21	0.03	2	0.18	2.18
			COUNT	20	20	0	20	20	20	20	20
			COUNT <DL	0	0	0	0	8	0	6	0
			MIN	5.99	1.69	0	0.11	<0.01	0.11	<0.01	0.105
			MAX	8.1	14.56	0	3.44	0.12	3.13	0.33	3.4
			10th	7.324	3.711	#NUM!	0.177	0.005	0.195	0.005	0.172
			25th	7.5925	4.5375	#NUM!	0.2375	0.005	0.225	0.005	0.2325
			50th	7.81	5.78	#NUM!	0.415	0.02	0.395	0.02	0.4025
			75th	8.02	8.17	#NUM!	0.8075	0.03	0.7	0.0975	0.7775
			95th	8.0905	11.8525	#NUM!	2.794	0.0725	2.351	0.273	2.678
CCR Composites											
115142	0.055917694	111803	0.269064635	7.13	3.9		1.2	<0.01	1.06	0.14	1.195
115361	0.03013737	111903	0.253434258	7.18	3.51		1.37	<0.01	1.27	0.1	1.365
115365	0.038200665	112103	0.370424878	7.26	2.46		0.95	<0.01	0.75	0.2	0.945
120072	0.200987612	112805	0.432556528	7.25	2		1.02	<0.01	0.83	0.19	1.015
120466	0.109772994	113503	0.508899073	6.93	5.09		2.67	0.02	2.34	0.31	2.65
120468	0.106139187	113703	0.617295863	7.02	3.38		1.77	0.02	1.44	0.31	1.75
120674	0.018549416	113803	0.069584846	7.35	6.35		2.59	<0.01	2.47	0.12	2.585
			COUNT	7	7	0	7	7	7	7	7
			COUNT <DL	0	0	0	0	5	0	0	0
			MIN	6.93	2	0	0.95	<0.01	0.75	0.1	0.945
			MAX	7.35	6.35	0	2.67	0.02	2.47	0.31	2.65
			10th	6.957	2.138	#NUM!	0.971	0.005	0.774	0.106	0.966
			25th	7.075	2.92	#NUM!	1.11	0.005	0.945	0.13	1.105
			50th	7.18	3.51	#NUM!	1.37	0.005	1.27	0.19	1.365
			75th	7.255	4.495	#NUM!	2.18	0.0125	1.89	0.255	2.1675
			95th	7.323	5.972	#NUM!	2.646	0.02	2.431	0.31	2.6305

Sample ID		**TAP**	**SAP**	**Non-SO4 AP**	**Modified NP**	**CaNP**	**NP/TAP**	**NP/SAP**	**NP/Non SO4AP**	**Fizz Test**
		kg CaCO3/t	**kg CaCO3/t**	**kg CaCO3/t**	**w/ Siderite Correction**	**kg CaCO3/t**				
Method Code		CALC	CALC	CALC	Modified/Siderite Cor.	CALC	CALC	CALC	CALC	Sobek
LOD		LORAX	LORAX	LORAX	0.5	LORAX	LORAX	LORAX	LORAX	#N/A
4 Seam Coal										
120301	4 Seam Coal	41.25	33.75	41.09375	101.2	122.809816	2.453333333	2.998518519	2.462661597	Moderate
120303	4 Coal	62.1875	56.875	61.5625	37.4	53.67243808	0.601407035	0.657582418	0.60751269	Slight
120701	4 Seam Roof, Coaly Sandstone	21.875	19.0625	21.71875	63.2	133.0439673	2.889142857	3.315409836	2.909928058	Slight
120702	4 seam coal	20	17.5	19.84375	208.5	233.1112247	10.425	11.91428571	10.50708661	Moderate
QU11-18 #111801	4 Seam Coal	46.875	37.1875	46.25	31.3	26.60879346	0.667733333	0.841680672	0.676756757	Slight
QU11-19 #111901	4 Seam Coal	42.1875	33.75	41.875	31.4	24.78938878	0.744296296	0.93037037	0.749850746	Slight
QU11-21 #112101	4 Seam Coal	40.3125	29.375	40.15625	26.7	24.78938878	0.662325581	0.90893617	0.664902724	Slight
QU11-28 #112805	4 Seam Coal	31.875	23.75	31.71875	36.9	34.11383776	1.157647059	1.553684211	1.163349754	Slight
QU11-35 #113501	4 Seam Coal	86.875	71.25	85.625	39.9	35.25096569	0.459280576	0.56	0.465985401	Slight
QU11-36 #113605	4 Seam Coal	14.6875	3.4375	14.53125	45.6	40.93660532	3.104680851	13.26545455	3.138064516	Slight
QU11-36 #113607	4 Seam Coal	8.125	4.0625	7.96875	164.2	169.4320609	20.20923077	40.41846154	20.6054902	Slight
QU11-37 #113701	4 Seam Coal	80.9375	60.3125	79.6875	23.1	15.46493979	0.285405405	0.383005181	0.289882353	Slight
QU11-37 #113703	4 Seam Coal	53.4375	30.625	53.125	34.2	25.24423995	0.64	1.116734694	0.643764706	Slight
QU11-38 #113801	4 Seam Coal	79.0625	65.9375	78.125	34.1	21.83285617	0.431304348	0.517156398	0.43648	Slight
QU11-38 #113802	4 Seam Coal	33.75	22.1875	33.59375	51.2	47.98679845	1.517037037	2.307605634	1.524093023	Slight
		15	15	15	15	15	15	15	15	-
		0	0	0	0	0	0	0	0	-
		8.125	3.4375	7.96875	23.1	15.46493979	0.285405405	0.383005181	0.289882353	-
		86.875	71.25	85.625	208.5	233.1112247	20.20923077	40.41846154	20.6054902	-
		16.8125	9.4375	16.65625	28.54	23.01546921	0.442494839	0.534293839	0.448282161	-
		26.875	20.625	26.71875	32.75	25.01681436	0.620703518	0.749631545	0.625638698	-
		41.25	30.625	41.09375	37.4	35.25096569	0.744296296	1.116734694	0.749850746	-
		57.8125	47.03125	57.34375	57.2	88.24112702	2.671238095	3.156964177	2.686294827	-
		82.71875	67.53125	81.46875	177.49	188.53581	13.36026923	21.41135664	13.53660769	-
4L Seam Coal										
120704	4L Seam Coal	32.1875	27.5	32.03125	65.4	93.92676664	2.03184466	2.378181818	2.041756098	Slight
120706	4L Seam Coal	271.5625	261.5625	270.3125	23.6	51.39818223	0.086904488	0.090227001	0.087306358	None
QU11-18 #111803	4L Seam Coal	13.4375	3.125	13.28125	40	37.52522154	2.976744186	12.8	3.011764706	Slight
QU11-38 #113804	4L Seam Coal	14.6875	2.8125	14.53125	36.3	28.20077255	2.471489362	12.90666667	2.498064516	Slight
QU11-21 #112103	4L Seam Coal	15	5	14.84375	33.7	33.88641218	2.246666667	6.74	2.270315789	Slight
QU11-19 #111903	4L Seam Coal	14.0625	4.375	13.90625	39.1	35.25096569	2.780444444	8.937142857	2.811685393	Slight
120304	4L Coal and Sandstone	165.625	157.8125	164.375	26.8	37.52522154	0.161811321	0.169821782	0.163041825	Slight
		7	7	7	7	7	7	7	7	-
		0	0	0	0	0	0	0	0	-
		13.4375	2.8125	13.28125	23.6	28.20077255	0.086904488	0.090227001	0.087306358	-
		271.5625	261.5625	270.3125	65.4	93.92676664	2.976744186	12.90666667	3.011764706	-
		13.8125	3	13.65625	25.52	31.61215633	0.131848588	0.13798387	0.132747638	-
		14.375	3.75	14.21875	30.25	34.56868893	1.09682799	1.2740018	1.102398961	-
		15	5	14.84375	36.3	37.52522154	2.246666667	6.74	2.270315789	-
		98.90625	92.65625	98.203125	39.55	44.46170189	2.625966903	10.86857143	2.654874955	-
		239.78125	230.4375	238.53125	57.78	81.16819132	2.917854264	12.87466667	2.951740912	-
Near Seam										
111805	4 Seam Roof-Sandstone	95.9375	81.5625	93.75	14	35.70581686	0.145928339	0.17164751	0.149333333	None
111904	Coaly Sandstone-4 Seam Roof Rock	202.8125	178.125	196.5625	17	37.29779596	0.083821263	0.095438596	0.086486486	Slight
112009	Silty sandstone-4 seam roof rock	165.3125	152.5	163.4375	14.9	50.48847989	0.090132325	0.097704918	0.091166348	None
112106	Sandstone/ trace siltstone, 4 seam roof	40.9375	38.4375	39.6875	65.5	107.1174506	1.6	1.704065041	1.650393701	Moderate
120701	4 Seam Roof, Coaly Sandstone	21.875	19.0625	21.71875	63.2	133.0439673	2.889142857	3.315409836	2.909928058	Slight
120703	4-4L sandstone Parting	61.875	57.1875	61.71875	122.7	119.8532833	1.983030303	2.14557377	1.988050633	Moderate
		6	6	6	6	6	6	6	6	-
		0	0	0	0	0	0	0	0	-
		21.875	19.0625	21.71875	14	35.70581686	0.083821263	0.095438596	0.086486486	-
		202.8125	178.125	196.5625	122.7	133.0439673	2.889142857	3.315409836	2.909928058	-
		31.40625	28.75	30.703125	14.45	36.50180641	0.086976794	0.096571757	0.088826417	-
		46.171875	43.125	45.1953125	15.425	40.59546694	0.104081329	0.116190566	0.105708094	-
		78.90625	69.375	77.734375	40.1	78.80296524	0.872964169	0.937856275	0.899863517	-
		147.96875	134.765625	146.015625	64.925	116.6693252	1.887272727	2.035196588	1.9036364	-
		193.4375	171.71875	188.28125	108.4	129.7462963	2.662614719	3.02295082	2.679458701	-

Sample ID		**TAP**	**SAP**	**Non-SO4 AP**	**Modified NP**	**CaNP**	**NP/TAP**	**NP/SAP**	**NP/Non SO4AP**	**Fizz Test**
		kg CaCO3/t	**kg CaCO3/t**	**kg CaCO3/t**	**w/ Siderite Correction**	**kg CaCO3/t**				
Method Code		CALC	CALC	CALC	Modified/Siderite Cor.	CALC	CALC	CALC	CALC	Sobek
LOD		LORAX	LORAX	LORAX	0.5	LORAX	LORAX	LORAX	LORAX	#N/A
Hanging Wall Waste Rock										
111901	Sandstone	9.6875	8.4375	9.0625	58.5	113.9402181	6.038709677	6.933333333	6.455172414	Slight
111902	Sandstone	15.9375	15.9375	15.3125	160.9	245.3922063	10.09568627	10.09568627	10.5077551	Moderate
111903	Sandstone	86.25	72.1875	82.5	125.1	197.4054079	1.450434783	1.732987013	1.516363636	Moderate
111801	Sandstone	9.375	8.75	8.75	51.4	86.64914792	5.482666667	5.874285714	5.874285714	Slight
111802	Fault zone in sandstone	21.875	18.75	20.9375	29.8	64.134015	1.362285714	1.589333333	1.423283582	Slight
111803	Sandstone	21.5625	20.3125	21.40625	252.7	331.1316519	11.71942029	12.44061538	11.8049635	Moderate
111804	Sandstone	46.25	39.375	44.0625	94.4	146.0072256	2.041081081	2.397460317	2.142411348	Moderate
112001	Sandstone	8.125	8.75	7.5	66.3	122.5823904	8.16	7.577142857	8.84	Slight
112002	Sandstone	5.625	6.25	5.46875	215.6	266.3153601	38.32888889	34.496	39.424	Moderate
112003	Sandstone w/ black disseminations	3.4375	3.4375	3.28125	86.5	155.5591002	25.16363636	25.16363636	26.36190476	Moderate
112004	Sandstone	6.5625	6.25	6.40625	90.8	152.1477164	13.83619048	14.528	14.17365854	Moderate
112005	Sandstone w/ black disseminations	7.5	7.1875	7.34375	86.3	98.24785276	11.50666667	12.00695652	11.75148936	Slight
112006	Bioturbated Sandstone	32.5	26.5625	31.5625	96.8	140.321586	2.978461538	3.644235294	3.066930693	Moderate
112007	Sandstone	10	8.4375	9.84375	73.4	109.1642808	7.34	8.699259259	7.456507937	Slight
112008	Sandstone with black interstitial material	107.5	97.8125	106.25	14	38.43492388	0.130232558	0.14313099	0.131764706	Slight
112101	Sandstone	4.6875	4.6875	4.53125	117.9	181.9404681	25.152	25.152	26.01931034	Moderate
112102	Sandstone	17.5	16.25	16.875	49.6	121.9001136	2.834285714	3.052307692	2.939259259	Slight
112103	Sandstone	7.1875	6.5625	7.03125	137.9	206.0475801	19.18608696	21.01333333	19.61244444	Moderate
112104	Sandstone	22.8125	19.375	21.875	40	104.8431947	1.753424658	2.064516129	1.828571429	Slight
112105	Mudstone/Sandstone	69.0625	62.5	68.125	26.9	93.47191547	0.389502262	0.4304	0.394862385	Slight
		20	20	20	20	20	20	20	20	-
		0	0	0	0	0	0	0	0	-
		3.4375	3.4375	3.28125	14	38.43492388	0.130232558	0.14313099	0.131764706	-
		107.5	97.8125	106.25	252.7	331.1316519	38.32888889	34.496	39.424	-
		5.53125	6.09375	5.375	29.51	84.39763463	1.265007369	1.47344	1.320441462	-
		7.421875	7.03125	7.265625	50.95	103.1943592	1.969166975	2.31422427	2.063951368	-
		12.96875	12.34375	12.578125	86.4	131.4519882	6.689354839	7.255238095	6.955840175	-
		25.234375	21.875	24.296875	119.7	185.806703	12.24861284	12.96246154	12.39713726	-
		87.3125	73.46875	83.6875	217.455	269.5561747	25.82189899	25.63025455	27.01500952	-
CCR Composites										
115142	0.055917694	37.5	33.125	37.34375	89.3	88.69597819	2.381333333	2.695849057	2.391297071	Moderate
115361	0.03013737	42.8125	39.6875	42.65625	76.9	79.82638037	1.79620438	1.937637795	1.802783883	Moderate
115365	0.038200665	29.6875	23.4375	29.53125	59.1	55.94669393	1.990736842	2.5216	2.001269841	Moderate
120072	0.200987612	31.875	25.9375	31.71875	42.1	45.48511702	1.320784314	1.62313253	1.32729064	Moderate
120466	0.109772994	83.4375	73.125	82.8125	121.2	115.7596228	1.45258427	1.657435897	1.46354717	Moderate
120468	0.106139187	55.3125	45	54.6875	84.1	76.86984776	1.520451977	1.868888889	1.537828571	Moderate
120674	0.018549416	80.9375	77.1875	80.78125	153.1	144.4152465	1.891583012	1.983481781	1.895241779	Moderate
		7	7	7	7	7	7	7	7	-
		0	0	0	0	0	0	0	0	-
		29.6875	23.4375	29.53125	42.1	45.48511702	1.320784314	1.62313253	1.32729064	-
		83.4375	77.1875	82.8125	153.1	144.4152465	2.381333333	2.695849057	2.391297071	-
		30.34375	24.1875	30.1875	47.2	48.62359009	1.360324301	1.63342354	1.368167599	-
		34.6875	29.53125	34.53125	68	66.40827085	1.486518124	1.763162393	1.500687871	-
		42.8125	39.6875	42.65625	84.1	79.82638037	1.79620438	1.937637795	1.802783883	-
		68.125	59.0625	67.734375	105.25	102.2278005	1.941159927	2.252540891	1.94825581	-
		82.6875	75.96875	82.203125	143.53	135.8185594	2.264154386	2.64357434	2.274288902	-

APPENDIX E3 SOLID PHASE METALS RESULTS

Sample ID Method Code LOD		From	To	Ag ppb 1F-01 2	Al % 1F-01 0.01	As ppm 1F-01 0.1	Au ppb 1F-01 0.2	B ppm 1F-01 20	Ba ppm 1F-01 0.5	Bi ppm 1F-01 0.02	Ca % 1F-01 0.01	Cd ppm 1F-01 0.01	Co ppm 1F-01 0.1	Cr ppm 1F-01 0.5	Cu ppm 1F-01 0.01	Fe % 1F-01 0.01	Ga ppm 1F-01 0.1	Hg ppb 1F-01 5
4 Seam Coal																		
120301	4 Seam Coal	84.99	85.31	18	0.35	67.8	1.5	<20	10.9	0.06	3.4	0.05	16.1	65	21.8	3.11	1.3	8
120303	4 Coal	85.79	86.66	21	0.41	41.1	2.6	<20	10.2	0.05	0.79	0.07	17.1	61.2	24.95	3.57	1.4	<5
120701	4 Seam Roof, Coaly Sandstone	94.97	95.12	17	0.36	28.9	<0.2	<20	9.3	0.09	2.01	0.08	11.4	100.4	14.41	5.16	1.3	<5
120702	4 seam coal	95.12	97.72	10	0.26	22.2	<0.2	<20	9.5	0.05	7.64	0.06	9.5	76.3	12.13	2.68	1	<5
QU11-18 #111801	4 Seam Coal	41.19	43.19	24	0.09	80.2	0.5	179	14.8	0.05	1.42	0.04	3.3	4.7	17.56	1.02	1.1	126
QU11-19 #111901	4 Seam Coal	37.78	39.8	33	0.13	88.2	<0.2	158	16.9	0.04	1.39	0.07	6	6.7	39.57	1	1.6	113
QU11-21 #112101	4 Seam Coal	25.68	27.48	35	0.16	59.6	0.3	185	16.6	0.11	1.14	0.09	7.5	6.2	48.76	0.88	2	97
QU11-28 #112805	4 Seam Coal	56.69	57.85	23	0.17	149.7	0.4	99	12.3	0.03	1.54	0.05	5.2	92.2	29.39	0.96	1.8	97
QU11-35 #113501	4 Seam Coal	76.82	77.71	25	0.08	1025.5	<0.2	133	32.6	0.03	1.74	0.08	2.9	16.2	15.01	1.99	2.2	114
QU11-36 #113605	4 Seam Coal	46.12	47.85	19	0.09	302.5	0.3	139	24.3	0.15	1.93	0.06	3.3	5.3	16.28	0.24	1.7	16
QU11-36 #113607	4 Seam Coal	48.06	50.01	29	0.35	89.3	<0.2	35	26.8	0.14	6.52	0.11	4.3	182.8	25.79	1.19	2.2	19
QU11-37 #113701	4 Seam Coal	95.39	96.18	19	0.12	219.8	<0.2	138	7.5	0.03	0.95	0.04	3.4	49.5	16.55	1.79	2.4	80
QU11-37 #113703	4 Seam Coal	96.4	98.31	22	0.11	167.4	<0.2	170	9.4	0.03	1.47	0.03	3.8	30.1	15.63	0.85	1.6	116
QU11-38 #113801	4 Seam Coal	56.88	57.61	17	0.08	129.9	<0.2	174	10.1	0.02	1.39	0.04	2.2	8.5	14.84	1.83	1.4	125
QU11-38 #113802	4 Seam Coal	57.61	58.57	18	0.11	58.3	<0.2	141	26.8	0.03	2.19	0.03	1.7	4.9	11.27	0.56	1.2	86
			COUNT	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
			COUNT <DL	0	0	0	9	4	0	0	0	0	0	0	0	0	0	3
			MIN	10	0.08	22.2	<0.2	<20	7.5	0.02	0.79	0.03	1.7	4.7	11.27	0.24	1	<5
			MAX	35	0.41	1025.5	2.6	185	32.6	0.15	7.64	0.11	17.1	182.8	48.76	5.16	2.4	126
			10th	17	0.084	33.78	0.1	10	9.34	0.03	1.026	0.034	2.48	5.06	13.042	0.676	1.14	2.5
			25th	18	0.1	58.95	0.1	22.5	9.8	0.03	1.39	0.04	3.3	6.45	14.925	0.92	1.3	12
			50th	21	0.13	88.2	0.1	138	12.3	0.05	1.54	0.06	4.3	30.1	16.55	1.19	1.6	86
			75th	24.5	0.305	158.55	0.35	164	20.6	0.075	2.1	0.075	8.5	70.65	25.37	2.335	1.9	113.5
			95th	33.6	0.375	519.4	1.83	180.8	28.54	0.143	6.856	0.096	16.4	125.12	42.327	4.047	2.26	125.3
4L Seam Coal																		
120704	4L Seam Coal	98.13	98.48	16	0.3	26.8	<0.2	<20	7.7	0.07	2.02	0.03	12.9	100.8	16.69	3.51	1	<5
120706	4L Seam Coal	98.96	99.52	41	0.37	204	<0.2	<20	32.5	0.09	0.31	0.13	19.6	53.3	48.76	9.5	2.4	47
QU11-18 #111803	4L Seam Coal	43.28	43.94	24	0.14	11.9	<0.2	113	22.9	0.07	1.64	0.09	6.4	12.9	39.63	0.27	1.5	10
QU11-38 #113804	4L Seam Coal	58.65	59.62	21	0.1	61	0.4	141	19.3	0.03	1.56	0.02	2.1	14	17.62	0.16	1.3	21
QU11-21 #112103	4L Seam Coal	28.06	28.98	35	0.18	7	<0.2	127	21.7	0.04	1.42	0.05	7.2	12.9	64.85	0.33	1.7	25
QU11-19 #111903	4L Seam Coal	39.91	40.98	25	0.17	28.6	<0.2	127	15.7	0.04	1.61	0.04	6	30.9	46.02	0.31	1.5	15
120304	4L Coal and Sandstone	90.3	92.1	25	0.44	101.9	1.1	<20	13.5	0.09	0.44	0.05	22.1	53.9	33.99	6.37	1.7	10
			COUNT	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
			COUNT <DL	0	0	0	5	3	0	0	0	0	0	0	0	0	0	1
			MIN	16	0.1	7	<0.2	<20	7.7	0.03	0.31	0.02	2.1	12.9	16.69	0.16	1	<5
			MAX	41	0.44	204	1.1	141	32.5	0.09	2.02	0.13	22.1	100.8	64.85	9.5	2.4	47
			10th	19	0.124	9.94	0.1	10	11.18	0.036	0.388	0.026	4.44	12.9	17.248	0.226	1.18	7
			25th	22.5	0.155	19.35	0.1	10	14.6	0.04	0.93	0.035	6.2	13.45	25.805	0.29	1.4	10
			50th	25	0.18	28.6	0.1	113	19.3	0.07	1.56	0.05	7.2	30.9	39.63	0.33	1.5	15
			75th	30	0.335	81.45	0.25	127	22.3	0.08	1.625	0.07	16.25	53.6	47.39	4.94	1.7	23
			95th	39.2	0.419	173.37	0.89	136.8	29.62	0.09	1.906	0.118	21.35	86.73	60.023	8.561	2.19	40.4
Near Seam																		
111805	4 Seam Roof-Sandstone	39.92	41.44	15	0.38	78.9	0.3	<20	15.5	0.09	0.26	0.05	13.7	74	14.8	3.57	1.2	36
111904	Coaly Sandstone-4 Seam Roof Rock	37.73	38.05	13	0.41	192.7	11.1	<20	13	0.09	0.4	0.06	11.1	46	13.97	5.99	1.3	54
112009	Silty sandstone-4 seam roof rock	27.38	28.15	48	0.47	100	1.5	<20	27.2	0.11	0.2	0.12	20.2	41.5	56.47	5.69	2.3	73
112106	Sandstone/ trace siltstone, 4 seam roof	23.76	25.62	15	0.4	37.2	1.2	<20	16.8	0.11	2.2	0.07	15.3	50.6	22.31	2.87	1.5	10
120701	4 Seam Roof, Coaly Sandstone	94.97	95.12	17	0.36	28.9	<0.2	<20	9.3	0.09	2.01	0.08	11.4	100.4	14.41	5.16	1.3	<5
120703	4-4L sandstone Parting	97.72	98.13	13	0.36	56.8	<0.2	<20	11.9	0.15	3.98	0.09	16.8	79.2	17.97	3.85	1.6	<5
			COUNT	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
			COUNT <DL	0	0	0	2	6	0	0	0	0	0	0	0	0	0	2
			MIN	13	0.36	28.9	<0.2	<20	9.3	0.09	0.2	0.05	11.1	41.5	13.97	2.87	1.2	<5
			MAX	48	0.47	192.7	11.1	10	27.2	0.15	3.98	0.12	20.2	100.4	56.47	5.99	2.3	73
			10th	13	0.36	33.05	0.1	10	10.6	0.09	0.23	0.055	11.25	43.75	14.19	3.22	1.25	2.5
			25th	13.5	0.365	42.1	0.15	10	12.175	0.09	0.295	0.0625	11.975	47.15	14.5075	3.64	1.3	4.375
			50th	15	0.39	67.85	0.75	10	14.25	0.1	1.205	0.075	14.5	62.3	16.385	4.505	1.4	23
			75th	16.5	0.4075	94.725	1.425	10	16.475	0.11	2.1525	0.0875	16.425	77.9	21.225	5.5575	1.575	49.5
			95th	40.25	0.455	169.525	8.7	10	24.6	0.14	3.535	0.1125	19.35	95.1	47.93	5.915	2.125	68.25

Sample ID Method Code LOD		From	To	Ag ppb 1F-01 2	Al % 1F-01 0.01	As ppm 1F-01 0.1	Au ppb 1F-01 0.2	B ppm 1F-01 20	Ba ppm 1F-01 0.5	Bi ppm 1F-01 0.02	Ca % 1F-01 0.01	Cd ppm 1F-01 0.01	Co ppm 1F-01 0.1	Cr ppm 1F-01 0.5	Cu ppm 1F-01 0.01	Fe % 1F-01 0.01	Ga ppm 1F-01 0.1	Hg ppb 1F-01 5
Hanging Wall Waste Rock																		
111901	Sandstone	33.3	34.38	16	0.36	36.4	2	<20	14.1	0.08	1.85	0.05	9.5	60.6	15.81	3.16	1	<5
111902	Sandstone	34.38	36.1	13	0.36	31	2.4	<20	14.3	0.09	6.03	0.06	11.1	50.2	12.61	3.94	1.2	<5
111903	Sandstone	36.1	37.73	12	0.39	74.1	1.1	<20	14.6	0.12	4.61	0.07	22.4	46.6	15.28	4.74	1.4	<5
111801	Sandstone	35.81	37.15	18	0.37	13.6	1	<20	196.1	0.07	1.71	0.05	9.6	93.9	13.08	2.14	1.1	6
111802	Fault zone in sandstone	37.15	37.7	16	0.7	36.2	0.5	<20	59.8	0.17	0.79	0.18	36.8	81.5	18.21	2.87	1.4	5
111803	Sandstone	37.7	38.71	15	0.37	15.8	<0.2	<20	21.3	0.07	10.22	0.05	9.8	75.2	12.92	3.31	1.2	8
111804	Sandstone	38.71	39.92	18	0.37	35.1	2.3	<20	20	0.09	3.5	0.07	15.9	81.9	13.98	3.84	1.3	8
112001	Sandstone	17.53	18.53	15	0.39	32.5	2	<20	17.3	0.07	2.27	0.07	9.8	71.6	15.45	3.3	1.3	<5
112002	Sandstone	18.53	19.38	14	0.34	61.9	1.4	<20	18.8	0.07	8.44	0.05	8.5	52.1	16.87	3.21	1.1	<5
112003	Sandstone w/ black disseminations	19.38	20.83	14	0.35	12.5	1.1	<20	14.5	0.04	3.12	0.03	7.1	53	10.69	2.94	1	<5
112004	Sandstone	20.83	22.46	14	0.38	19.7	1.5	<20	18.7	0.1	3.08	0.05	8.8	58.6	11.87	3.46	1.2	<5
112005	Sandstone w/ black disseminations	22.46	23.71	15	0.39	21.6	0.8	<20	14.7	0.06	1.67	0.05	9.6	59.2	14.01	2.55	1.1	<5
112006	Bioturbated Sandstone	23.71	25.16	18	0.37	68.6	0.9	<20	13.8	0.04	3.48	0.41	17.2	51.7	13.7	2.69	1	<5
112007	Sandstone	25.16	26.55	16	0.36	19.1	0.7	<20	15.1	0.06	2.46	0.03	7.8	52.5	12.41	1.9	0.9	<5
112008	Sandstone with black interstitial material	26.55	27.38	19	0.35	64.1	0.8	<20	11.2	0.07	0.21	0.04	9.2	57	12.98	4.09	1	<5
112101	Sandstone	17.53	19.16	14	0.31	17.4	0.7	<20	15.1	0.04	4.21	0.03	7.3	62.6	11.55	3.13	1	<5
112102	Sandstone	19.16	20.24	17	0.36	57	1.2	<20	17.3	0.11	1.36	0.09	20.4	58.4	18.34	4.11	1.2	5
112103	Sandstone	20.24	21.99	14	0.4	19	1	<20	52.6	0.1	4.88	0.08	9.7	47	14.92	3.17	1.4	<5
112104	Sandstone	21.99	22.64	16	0.37	26.3	1.5	<20	15.6	0.09	0.91	0.07	13.2	58.9	15.96	3.67	1.3	<5
112105	Mudstone/Sandstone	22.64	23.76	43	0.45	69.4	1	<20	26	0.13	0.55	0.11	18.2	55.5	47.72	4.77	2.2	19
			COUNT	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
			COUNT <DL	0	0	0	1	20	0	0	0	0	0	0	0	0	0	14
			MIN	12	0.31	12.5	<0.2	<20	11.2	0.04	0.21	0.03	7.1	46.6	10.69	1.9	0.9	<5
			MAX	43	0.7	74.1	2.4	10	196.1	0.17	10.22	0.41	36.8	93.9	47.72	4.77	2.2	19
			10th	13.9	0.349	15.58	0.68	10	14.07	0.04	0.766	0.03	7.75	49.88	11.838	2.509	1	2.5
			25th	14	0.36	19.075	0.8	10	14.575	0.0675	1.5925	0.05	9.1	52.4	12.8425	2.9225	1	2.5
			50th	15.5	0.37	31.75	1.05	10	16.45	0.075	2.77	0.055	9.75	58.5	13.995	3.255	1.2	2.5
			75th	17.25	0.39	58.225	1.5	10	20.325	0.1	4.31	0.0725	16.225	64.85	15.8475	3.865	1.3	5
			95th	20.2	0.4625	69.635	2.305	10	66.615	0.132	8.529	0.1915	23.12	82.5	19.809	4.7415	1.44	8.55
CCR Composites																		
115142	0.055917694	111803	0.269064635	69	0.45	38.5	<0.2	39	36.1	0.09	3.62	0.1	3.7	28.1	40.93	1.3	1.7	115
115361	0.03013737	111903	0.253434258	70	0.47	41.8	0.6	<20	36.7	0.11	3.2	0.11	6	36.4	50.98	1.48	1.8	104
115365	0.038200665	112103	0.370424878	59	0.43	28	0.3	<20	41.2	0.09	2.38	0.13	7	13.5	74.82	1.05	2.1	89
120072	0.200987612	112805	0.432556528	35	0.34	87	0.7	30	22.5	0.08	1.63	0.09	6.4	66.9	27.2	1.36	1.7	79
120466	0.109772994	113503	0.508899073	32	0.24	428.7	0.6	25	14.1	0.07	4.73	0.14	3.8	57.5	24.41	2.37	1.7	104
120468	0.106139187	113703	0.617295863	21	0.24	121.4	<0.2	<20	17.6	0.05	3.27	0.07	4.6	82.3	18.3	1.5	1.4	143
120674	0.018549416	113803	0.069584846	26	0.36	113.4	0.4	30	25.6	0.05	5.86	0.04	1.6	24.8	14.39	2.21	1.5	169
			COUNT	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
			COUNT <DL	0	0	0	2	3	0	0	0	0	0	0	0	0	0	0
			MIN	21	0.24	28	<0.2	<20	14.1	0.05	1.63	0.04	1.6	13.5	14.39	1.05	1.4	79
			MAX	70	0.47	428.7	0.7	39	41.2	0.11	5.86	0.14	7	82.3	74.82	2.37	2.1	169
			10th	22.5	0.24	31.15	0.1	10	15.15	0.05	1.855	0.049	2.23	16.89	15.563	1.125	1.43	82
			25th	29	0.29	40.15	0.2	10	20.05	0.06	2.79	0.08	3.75	26.45	21.355	1.33	1.6	96.5
			50th	35	0.36	87	0.4	25	25.6	0.08	3.27	0.1	4.6	36.4	27.2	1.48	1.7	104
			75th	64	0.44	117.4	0.6	30	36.4	0.09	4.175	0.12	6.2	62.2	45.955	1.855	1.75	129
			95th	69.7	0.464	336.51	0.67	36.3	39.85	0.104	5.521	0.137	6.82	77.68	67.668	2.322	2.01	161.2

Sample ID	K	La	Mg	Mn	Mo	Na	Ni	P	Pb	S	Sb	Sc	Se	Sr	Te	Th	Ti	Tl	U	V	W	Zn
	%	ppm	%	ppm	ppm	%	ppm	%	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm
Method Code	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01
LOD	0.01	0.5	0.01	1	0.01	0.001	0.1	0.001	0.01	0.02	0.02	0.1	0.1	0.5	0.02	0.1	0.001	0.02	0.1	2	0.1	0.1
4 Seam Coal																						
120301	0.04	2.4	0.34	626	0.16	0.007	23.1	0.001	3.59	1.32	0.12	8.8	<0.1	27.8	<0.02	0.9	0.003	0.07	0.2	89	<0.1	56.4
120303	0.05	0.8	0.42	478	0.23	0.007	25.2	<0.001	3.59	2.24	0.12	8.8	<0.1	21.8	<0.02	0.9	0.005	0.09	0.2	72	<0.1	87.7
120701	0.05	2.8	0.38	574	0.26	0.006	16.5	0.002	4.25	0.68	0.12	11.8	<0.1	24.1	0.04	0.8	0.001	<0.02	0.3	104	<0.1	49.9
120702	0.04	5.9	0.27	1384	0.24	0.004	12.8	0.003	3.11	0.61	0.1	9	<0.1	37.4	<0.02	0.9	0.001	<0.02	0.2	57	<0.1	35.3
QU11-18 #111801	<0.01	2.5	0.03	42	0.61	0.009	4.9	0.008	1.95	1.36	0.21	2.3	0.3	75.8	<0.02	0.3	0.023	<0.02	0.3	32	0.1	6.7
QU11-19 #111901	0.01	2.4	0.02	46	0.84	0.012	7.1	0.006	2.5	1.31	0.17	3.2	0.3	75.6	<0.02	0.4	0.029	<0.02	0.3	53	<0.1	9.2
QU11-21 #112101	0.02	2.1	0.02	56	0.86	0.016	8.3	0.004	2.23	1.07	0.11	4.2	0.1	59	0.03	0.3	0.033	<0.02	0.2	64	<0.1	7.6
QU11-28 #112805	0.02	3.6	0.06	123	2.08	0.009	15.5	0.002	2.07	0.89	0.15	4.5	0.2	40.3	0.02	0.5	0.023	<0.02	0.3	62	<0.1	15.2
QU11-35 #113501	<0.01	1.5	0.01	144	3.42	0.012	6	0.003	4.78	2.53	161.36	3.4	0.6	24.4	<0.02	0.4	0.02	0.11	0.3	27	<0.1	26.1
QU11-36 #113605	<0.01	1.5	0.01	115	32.89	0.004	3.3	0.003	1.72	0.15	0.36	2.4	0.1	20.4	<0.02	0.2	0.031	<0.02	0.5	41	0.4	3.4
QU11-36 #113607	0.02	3.2	0.17	689	6.62	0.005	15.5	0.002	3.45	0.16	0.19	8.5	0.1	33.2	<0.02	1.1	0.014	<0.02	0.4	102	<0.1	30.9
QU11-37 #113701	0.02	1.9	0.05	86	1.32	0.012	11.2	0.002	2.27	2.15	0.19	3.7	0.1	30.4	0.03	0.3	0.027	<0.02	0.2	36	<0.1	10.9
QU11-37 #113703	0.01	3	0.02	91	2.31	0.013	9.5	<0.001	2.81	1.15	0.87	3.4	0.3	45.8	<0.02	0.5	0.023	<0.02	0.3	41	<0.1	11.8
QU11-38 #113801	<0.01	1.4	0.02	48	0.62	0.014	2.7	<0.001	1.56	2.27	0.16	2	0.4	59	<0.02	0.2	0.023	<0.02	0.3	25	0.1	5
QU11-38 #113802	<0.01	4.4	0.02	46	0.77	0.016	2.5	0.021	2.09	0.83	0.05	1.9	<0.1	186.4	<0.02	0.3	0.022	<0.02	0.5	19	0.2	5.6
	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
	5	0	0	0	0	0	0	3	0	0	0	0	5	0	11	0	0	12	0	0	11	0
	<0.01	0.8	0.01	42	0.16	0.004	2.5	<0.001	1.56	0.15	0.05	1.9	<0.1	20.4	<0.02	0.2	0.001	<0.02	0.2	19	<0.1	3.4
	0.05	5.9	0.42	1384	32.89	0.016	25.2	0.021	4.78	2.53	161.36	11.8	0.6	186.4	0.04	1.1	0.033	0.11	0.5	104	0.4	87.7
	0.005	1.44	0.014	46	0.234	0.0044	2.94	0.0005	1.812	0.34	0.104	2.12	0.05	22.72	0.01	0.24	0.0018	0.01	0.2	25.8	0.05	5.24
	0.005	1.7	0.02	52	0.435	0.0065	5.45	0.0015	2.08	0.755	0.12	2.8	0.05	26.1	0.01	0.3	0.0095	0.01	0.2	34	0.05	7.15
	0.02	2.4	0.03	115	0.84	0.009	9.5	0.002	2.5	1.15	0.16	3.7	0.1	37.4	0.01	0.4	0.023	0.01	0.3	53	0.05	11.8
	0.03	3.1	0.22	526	2.195	0.0125	15.5	0.0035	3.52	1.755	0.2	8.65	0.3	59	0.015	0.85	0.025	0.01	0.3	68	0.075	33.1
	0.05	4.85	0.392	897.5	14.501	0.016	23.73	0.0119	4.409	2.348	49.017	9.84	0.46	108.98	0.033	0.96	0.0316	0.096	0.5	102.6	0.26	65.79
4L Seam Coal																						
120704	0.04	2.2	0.34	555	0.27	0.005	17.5	0.001	3.98	0.99	0.12	10.3	<0.1	18.9	0.03	0.8	0.002	<0.02	0.2	80	<0.1	35.8
120706	0.04	1.3	0.39	447	2.2	0.009	31.7	0.002	4.15	7.81	1.04	13.1	0.7	16.6	<0.02	1.1	0.02	0.28	0.5	116	<0.1	77.3
QU11-18 #111803	0.02	3.8	0.05	61	2.56	0.01	6.6	0.002	1.82	0.14	0.11	3.9	0.2	91.1	<0.02	0.5	0.03	<0.02	0.3	63	<0.1	11.5
QU11-38 #113804	0.01	3.3	0.02	42	0.99	0.014	2.8	0.005	1.41	0.16	0.05	2.2	0.2	84.5	<0.02	0.4	0.024	<0.02	0.4	33	0.2	5.7
QU11-21 #112103	0.02	2.5	0.06	57	0.98	0.014	6	<0.001	1.71	0.2	0.14	6	<0.1	54.3	<0.02	0.3	0.036	<0.02	0.2	92	<0.1	14.9
QU11-19 #111903	0.02	3.2	0.06	50	1.11	0.01	7	0.004	1.64	0.19	0.5	4.9	<0.1	74.7	<0.02	0.4	0.028	<0.02	0.2	68	<0.1	12.3
120304	0.05	1	0.24	423	0.72	0.007	33.5	<0.001	4.59	5.68	0.24	9.5	0.1	12.3	<0.02	1.5	0.009	0.54	0.3	106	<0.1	66.4
	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	0	0	0	0	0	0	0	2	0	0	0	0	3	0	6	0	0	5	0	0	6	0
	0.01	1	0.02	42	0.27	0.005	2.8	<0.001	1.41	0.14	0.05	2.2	<0.1	12.3	<0.02	0.3	0.002	<0.02	0.2	33	<0.1	5.7
	0.05	3.8	0.39	555	2.56	0.014	33.5	0.005	4.59	7.81	1.04	13.1	0.7	91.1	0.03	1.5	0.036	0.54	0.5	116	0.2	77.3
	0.016	1.18	0.038	46.8	0.54	0.0062	4.72	0.0005	1.548	0.152	0.086	3.22	0.05	14.88	0.01	0.36	0.0062	0.01	0.2	51	0.05	9.18
	0.02	1.75	0.055	53.5	0.85	0.008	6.3	0.00075	1.675	0.175	0.115	4.4	0.05	17.75	0.01	0.4	0.0145	0.01	0.2	65.5	0.05	11.9
	0.02	2.5	0.06	61	0.99	0.01	7	0.002	1.82	0.2	0.14	6	0.1	54.3	0.01	0.5	0.024	0.01	0.3	80	0.05	14.9
	0.04	3.25	0.29	435	1.655	0.012	24.6	0.003	4.065	3.335	0.37	9.9	0.2	79.6	0.01	0.95	0.029	0.145	0.35	99	0.05	51.1
	0.047	3.65	0.375	522.6	2.452	0.014	32.96	0.0047	4.458	7.171	0.878	12.26	0.55	89.12	0.024	1.38	0.0342	0.462	0.47	113	0.155	74.03
Near Seam																						
111805	0.05	5.6	0.29	256	1.49	0.003	18.3	0.002	5.58	3.03	0.44	5.9	<0.1	9.2	<0.02	1.5	0.002	0.22	0.4	49	<0.1	41.6
111904	0.05	1.2	0.28	448	2.62	0.003	15.8	0.001	5.32	5.89	0.76	7.6	0.2	12.9	<0.02	1.1	0.004	0.26	0.3	48	<0.1	53.2
112009	0.05	1	0.39	318	1.05	0.004	34.9	0.001	5.25	4.85	0.67	8.1	0.5	10.8	0.04	1	0.008	0.33	0.3	70	<0.1	74.9
112106	0.05	4	0.4	649	0.24	0.004	20.6	0.002	4.37	1.34	0.17	10.1	<0.1	24.6	0.02	1	0.003	0.03	0.3	66	<0.1	59.4
120701	0.05	2.8	0.38	574	0.26	0.006	16.5	0.002	4.25	0.68	0.12	11.8	<0.1	24.1	0.04	0.8	0.001	<0.02	0.3	104	<0.1	49.9
120703	0.04	6.6	0.36	974	0.37	0.004	20.6	0.002	6.67	1.86	0.2	19.1	<0.1	29.1	<0.02	1.4	0.002	0.08	0.3	113	<0.1	50.1
	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	0	0	0	0	0	0	0	0	0	0	0	0	4	0	3	0	0	1	0	0	6	0
	0.04	1	0.28	256	0.24	0.003	15.8	0.001	4.25	0.68	0.12	5.9	<0.1	9.2	<0.02	0.8	0.001	<0.02	0.3	48	<0.1	41.6
	0.05	6.6	0.4	974	2.62	0.006	34.9	0.002	6.67	5.89	0.76	19.1	0.5	29.1	0.04	1.5	0.008	0.33	0.4	113	0.05	74.9
	0.045	1.1	0.285	287	0.25	0.003	16.15	0.001	4.31	1.01	0.145	6.75	0.05	10	0.01	0.9	0.0015	0.02	0.3	48.5	0.05	45.75
	0.05	1.6	0.3075	350.5	0.2875	0.00325	16.95	0.00125	4.59	1.47	0.1775	7.725	0.05	11.325	0.01	1	0.002	0.0425	0.3	53.25	0.05	49.95
	0.05	3.4	0.37	511	0.71	0.004	19.45	0.002	5.285	2.445	0.32	9.1	0.05	18.5	0.015	1.05	0.0025	0.15	0.3	68	0.05	51.65
	0.05	5.2	0.3875	630.25	1.38	0.004	20.6	0.002	5.515	4.395	0.6125	11.375	0.1625	24.475	0.035	1.325	0.00375	0.25	0.3	95.5	0.05	57.85
	0.05	6.35	0.3975	892.75	2.3375	0.0055	31.325	0.002	6.3975	5.63	0.7375	17.275	0.425	27.975	0.04	1.475	0.007	0.3125	0.375	110.75	0.05	71.025

Sample ID	K	La	Mg	Mn	Mo	Na	Ni	P	Pb	S	Sb	Sc	Se	Sr	Te	Th	Ti	Tl	U	V	W	Zn
	%	ppm	%	ppm	ppm	%	ppm	%	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm
Method Code	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01	1F-01
LOD	0.01	0.5	0.01	1	0.01	0.001	0.1	0.001	0.01	0.02	0.02	0.1	0.1	0.5	0.02	0.1	0.001	0.02	0.1	2	0.1	0.1
Hanging Wall Waste Rock																						
111901	0.05	2.6	0.32	649	0.11	0.004	13.1	0.003	3.4	0.32	0.19	9.4	0.1	14.4	<0.02	1	0.002	<0.02	0.3	73	<0.1	47.1
111902	0.05	7.8	0.24	1123	0.19	0.004	13.9	0.005	3.53	0.57	0.15	10.4	<0.1	29.8	<0.02	1.1	0.002	<0.02	0.3	81	<0.1	39.7
111903	0.05	6.4	0.24	998	0.82	0.003	28	0.003	6.11	2.52	0.23	10	0.1	27	<0.02	1.4	0.003	0.05	0.3	76	<0.1	49.4
111801	0.05	4.6	0.32	514	0.9	0.004	12.9	0.005	3.92	0.31	0.16	7.2	0.2	16.8	<0.02	1.1	0.001	<0.02	0.3	47	<0.1	40.9
111802	0.05	5.3	0.21	734	0.74	0.006	53.8	0.007	4.46	0.69	0.18	13.2	<0.1	12.3	<0.02	1.3	0.003	0.09	0.6	81	<0.1	156
111803	0.05	10.3	0.24	1591	0.8	0.005	14.1	0.008	3.68	0.75	0.12	9.2	0.2	37.6	<0.02	1.1	0.001	<0.02	0.3	63	<0.1	37.4
111804	0.05	9.3	0.3	919	1.12	0.004	21.6	0.006	4.79	1.59	0.14	10.8	0.1	19.3	<0.02	1.5	0.002	0.02	0.4	66	<0.1	34.3
112001	0.06	3.4	0.34	486	0.41	0.005	14.2	0.002	3.07	0.32	0.11	8.8	<0.1	19.7	0.03	0.8	0.002	<0.02	0.2	76	<0.1	49.5
112002	0.06	7.8	0.23	1224	0.43	0.005	11.1	0.004	3.31	0.21	0.1	6.1	<0.1	36.3	0.03	0.9	0.001	<0.02	0.3	47	<0.1	30.7
112003	0.06	3.1	0.3	585	0.13	0.005	10	0.002	2.09	0.12	0.09	5.1	<0.1	20.1	0.03	0.6	0.001	<0.02	0.2	47	<0.1	33.1
112004	0.06	3	0.33	625	0.14	0.006	11.4	0.002	3.14	0.22	0.1	7.2	<0.1	23.6	<0.02	0.7	0.002	<0.02	0.2	70	<0.1	39
112005	0.06	1.6	0.36	415	0.17	0.004	13.9	0.001	3.53	0.27	0.14	6.7	0.1	17.1	<0.02	0.6	0.002	<0.02	0.3	62	<0.1	40.3
112006	0.05	2.8	0.28	630	0.41	0.003	21.7	0.001	4.52	1	0.12	4.9	0.2	19.5	<0.02	0.6	0.001	0.03	0.2	38	<0.1	191.4
112007	0.05	2.2	0.31	504	0.14	0.004	10	<0.001	2.66	0.32	0.09	5.5	<0.1	17	<0.02	0.8	0.002	<0.02	0.2	41	<0.1	30.2
112008	0.05	0.6	0.25	226	1.65	0.003	14.8	<0.001	4.36	3.41	0.2	4.5	<0.1	11	0.02	0.4	0.002	0.07	0.2	37	<0.1	34.4
112101	0.06	2.9	0.35	563	0.15	0.004	10.9	0.002	2.5	0.18	0.1	5.5	<0.1	25.1	<0.02	0.6	0.001	<0.02	0.3	51	<0.1	35.6
112102	0.06	2.3	0.41	447	0.25	0.006	23.3	0.002	6.31	0.59	0.19	9.5	<0.1	21.6	<0.02	0.9	0.002	<0.02	0.4	111	<0.1	58.6
112103	0.07	7.3	0.42	857	0.11	0.006	13.7	0.003	3.28	0.24	0.09	10.9	0.1	34.7	<0.02	1.3	0.002	<0.02	0.3	100	<0.1	56.8
112104	0.06	1.9	0.47	371	0.18	0.006	18.6	0.002	3.34	0.68	0.12	9.3	0.1	28.7	<0.02	0.9	0.003	<0.02	0.3	95	<0.1	65.1
112105	0.06	1.4	0.51	416	0.49	0.006	31	0.001	4.93	2.19	0.37	11.5	0.2	24	<0.02	0.8	0.005	0.1	0.3	97	<0.1	80.4
	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	0	0	0	0	0	0	0	2	0	0	0	0	10	0	16	0	0	14	0	0	20	0
	0.05	0.6	0.21	226	0.11	0.003	10	<0.001	2.09	0.12	0.09	4.5	<0.1	11	<0.02	0.4	0.001	<0.02	0.2	37	<0.1	30.2
	0.07	10.3	0.51	1591	1.65	0.006	53.8	0.008	6.31	3.41	0.37	13.2	0.2	37.6	0.03	1.5	0.005	0.1	0.6	111	0.05	191.4
	0.05	1.58	0.239	410.6	0.128	0.003	10.81	0.00095	2.644	0.207	0.09	5.08	0.05	14.19	0.01	0.6	0.001	0.01	0.2	40.7	0.05	32.86
	0.05	2.275	0.2475	476.25	0.1475	0.004	12.525	0.00175	3.245	0.2625	0.1	5.95	0.05	17.075	0.01	0.675	0.001	0.01	0.2	47	0.05	35.3
	0.055	3.05	0.315	605	0.33	0.0045	14	0.002	3.53	0.445	0.13	9	0.075	20.85	0.01	0.9	0.002	0.01	0.3	68	0.05	40.6
	0.06	6.625	0.3525	872.5	0.755	0.006	21.625	0.00425	4.475	0.8125	0.1825	10.1	0.1	27.425	0.01	1.1	0.002	0.0225	0.3	81	0.05	57.25
	0.0605	9.35	0.472	1242.35	1.1465	0.006	32.14	0.00705	6.12	2.5645	0.237	11.585	0.2	36.365	0.03	1.405	0.0031	0.0905	0.41	100.55	0.05	157.77
CCR Composites																						
115142	0.03	5	0.08	155	0.53	0.006	5.3	0.002	5.1	1.13	0.09	5.5	<0.1	97.3	0.06	2.8	0.014	0.04	0.6	33	<0.1	16.1
115361	0.03	6.2	0.08	109	0.7	0.006	9.3	0.018	6.42	1.35	0.21	6.4	0.3	164.9	0.06	3.7	0.014	0.03	0.7	32	<0.1	16.8
115365	0.03	4.6	0.11	100	0.41	0.009	8.7	0.006	4.58	0.83	0.07	7.4	0.4	90.4	<0.02	2.6	0.023	<0.02	0.5	57	<0.1	19.3
120072	0.04	3.7	0.12	222	0.75	0.007	11.9	<0.001	4.62	0.92	0.1	5.8	<0.1	40.5	<0.02	1.5	0.011	0.02	0.3	35	<0.1	36.3
120466	0.02	2.6	0.08	408	6.76	0.008	6.3	<0.001	7.05	2.6	81.03	6.6	0.6	32.2	<0.02	1.4	0.013	0.38	0.5	32	<0.1	52.8
120468	0.03	3.9	0.06	265	1.63	0.006	9.9	<0.001	3.42	1.58	9.63	5.2	0.2	46	<0.02	1.1	0.011	0.04	0.2	30	<0.1	25.9
120674	0.02	2.9	0.03	139	0.73	0.008	2.2	0.001	2.6	2.61	0.1	4	0.3	230.4	<0.02	2.5	0.009	0.02	0.5	24	<0.1	10.8
	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	0	0	0	0	0	0	0	3	0	0	0	0	2	0	5	0	0	1	0	0	7	0
	0.02	2.6	0.03	100	0.41	0.006	2.2	<0.001	2.6	0.83	0.07	4	<0.1	32.2	<0.02	1.1	0.009	<0.02	0.2	24	<0.1	10.8
	0.04	6.2	0.12	408	6.76	0.009	11.9	0.018	7.05	2.61	81.03	7.4	0.6	230.4	0.06	3.7	0.023	0.38	0.7	57	0.05	52.8
	0.02	2.69	0.039	102.7	0.446	0.006	3.13	0.0005	2.846	0.857	0.076	4.36	0.05	34.69	0.01	1.19	0.0096	0.013	0.23	25.8	0.05	12.39
	0.025	3.3	0.07	124	0.615	0.006	5.8	0.0005	4	1.025	0.095	5.35	0.125	43.25	0.01	1.45	0.011	0.02	0.4	31	0.05	16.45
	0.03	3.9	0.08	155	0.73	0.007	8.7	0.001	4.62	1.35	0.1	5.8	0.3	90.4	0.01	2.5	0.013	0.03	0.5	32	0.05	19.3
	0.03	4.8	0.095	243.5	1.19	0.008	9.6	0.004	5.76	2.09	4.92	6.5	0.35	131.1	0.035	2.7	0.014	0.04	0.55	34	0.05	31.1
	0.037	5.84	0.117	365.1	5.221	0.0087	11.3	0.0144	6.861	2.607	59.61	7.16	0.54	210.75	0.06	3.43	0.0203	0.278	0.67	50.4	0.05	47.85

Appendix F
7S Area5 Water Quality Effects Model (WQEM)

APPENDIX F1 7S SEDIMENT POND INPUTS TO THE 7S AREA5 WQEM

APPENDIX F2 7S AREA5 WQEM - RESULTS

QUINSAM COAL

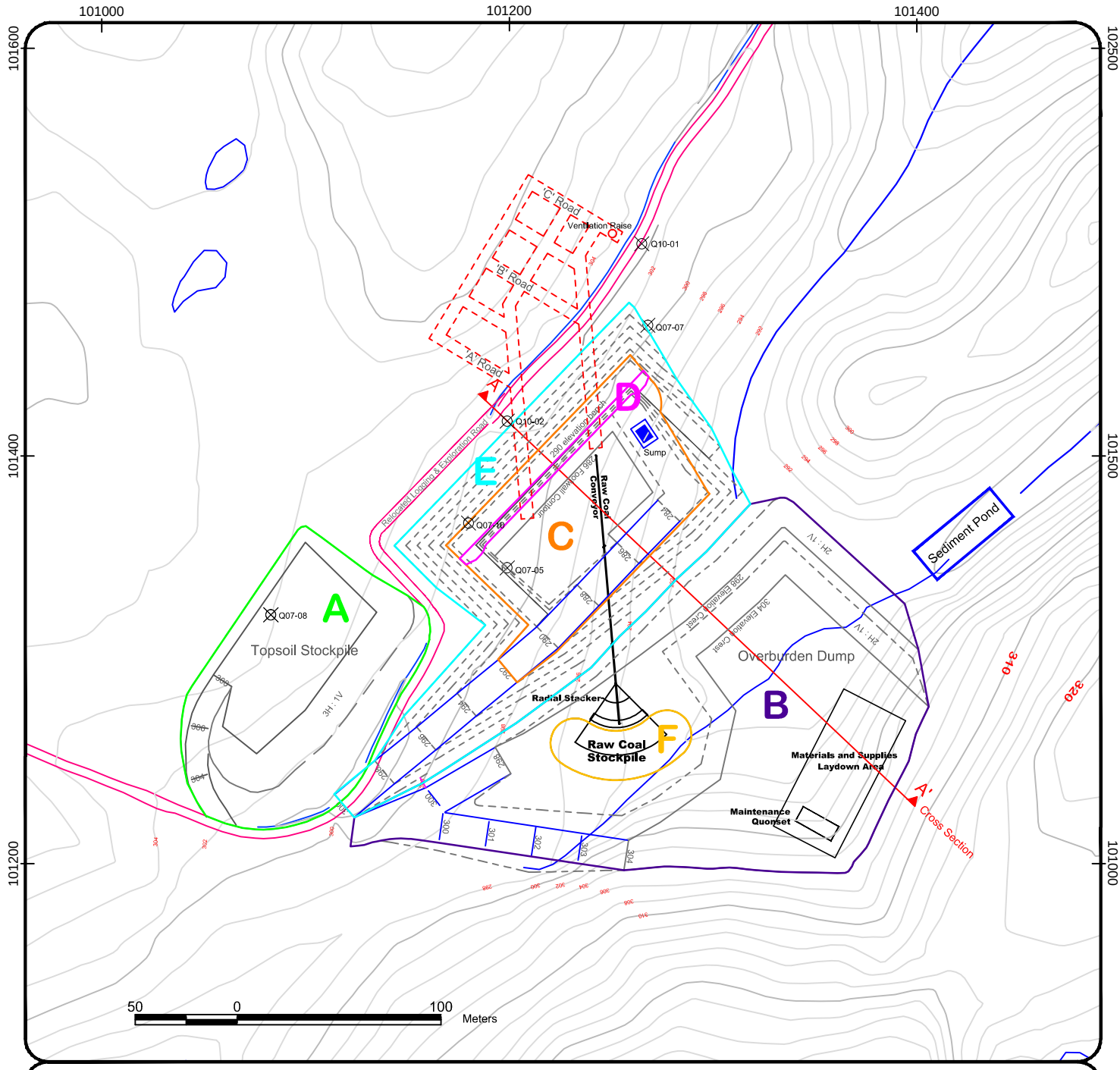
APPENDIX F1 7S SEDIMENT POND INPUTS TO THE 7S AREA5 WQEM

MEMORANDUM

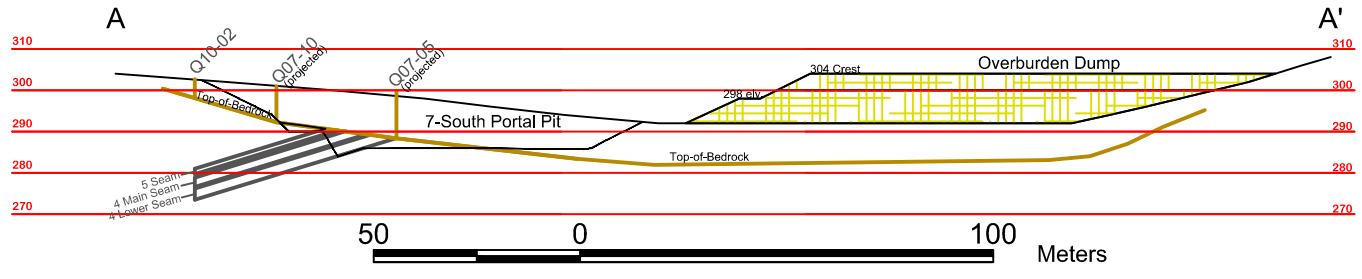
To:	**Alan Calder, Golder Associates Ltd.**	**Date: May 17, 2012**
cc:	**Gary Gould, Hillsborough Resources**	
From:	**Colin Fraser, Stephanie Simpson, Bruce Mattson**	**Project #: 885-1**
Subject:	**7 South Sediment Pond Loading Assessment**	

Quinsam Coal Corporation (QCC) and its parent company Hillsborough Resources Ltd. (Hillsborough) is proposing to develop the 7 South underground mine and extract coal from the No. 4 Coal Zone. As part of this development, a small pit will be mined to expose the No. 4 Coal and to establish portal access to the underground mine (Figure 1). Hillsborough contracted Lorax Environmental Services Ltd. (Lorax) to complete a geochemical loading assessment of the water that will discharge from the 7 South portal area at the Quinsam Mine (Lorax, 2011). The proposed 7 South portal layout consists of a topsoil stockpile (A), an overburden stockpile (B), a pit with bedrock (C), coal seam (D) and till (E) exposures, a raw coal stockpile, an in-pit sump, a sediment pond and a network of perimeter ditches (Figure 1).

The proposed water management plan for the 7 South portal advocates for the discharge of sump waters collected in the pit to the adjacent 7 South underground workings or pumping these waters into the 5 South mine workings to facilitate flooding of the exposed coal in these mines. This approach would result in only surface runoff from the raw coal and overburden stockpiles discharging to the proposed 7 South sediment pond. To evaluate the effects of the raw coal stockpile and overburden on the downstream receiving environment, a site water balance was constructed to estimate volumes and concentrations of water anticipated to report to the sediment pond. Expected and worst case estimates of sediment pond concentrations were estimated, as were concentrations of the sediment pond loadings at a proposed discharge point near the Quinsam River (7S site). This memo summarizes the assumptions, constraints and key findings of this geochemical loading assessment.



Cross Section



LORAX ENVIRONMENTAL

MINE GRID

TRUE

Projection: Mine Grid Coordiantes

Project No.	J885-1
Client	Hillsborough Resources
Date	May 6, 2011

Figure Title

7 South Portal Pit Layout

Figure Number

1

Legend

A	Topsoil Stockpile 11,667m²	D	Exposed Coal in Pit 561m²
B	Overburden Dump 27,207m²	E	Exposed Till in Pit 10,993m²
C	Exposed Bedrock in Pit 8,734m²	F	Raw Coal Stockpile 1,618m²

1. Water Balance

Water Balance Methods and Rationale

A runoff coefficient method was used to estimate monthly water volumes from the mine workings at 7 South, where monthly precipitation depths were multiplied by a facility-specific runoff coefficient and then scaled by surface area. Monthly estimates of site precipitation reported in Norwest (2009) were used to resolve the site water balance (Table 1). For the December to June period, a runoff coefficient of 0.85 was used to compute runoff from the overburden stockpile and undisturbed drainage areas, whereas 0.6 was used to compute runoff for the July to November period for these locations. In contrast, a runoff coefficient of 0.95 was used to compute runoff from the coal stock pile each month of the year. The selection of these runoff coefficients was guided by the following:

Regional runoff data collected by the Water Survey of Canada – Monthly estimates of discharge at the Water Survey of Canada (WSC) hydrology station "Quinsam River at Lower Quinsam Lake" were subtracted from those measured at a second station further down stream "Quinsam River at Campbell River" and runoff amounts computed based on the watershed area between the two stations. In comparing monthly runoff depths to monthly precipitation, monthly runoff coefficients averaged 0.80 annually and ranged from 0.7 to 1.0 between December and June. Runoff coefficients were lower (*e.g.,* 0.5 to 0.6) during summer and early autumn when evaporative stress was greatest and appreciable rainfall likely replenishes soil storage rather than produces runoff.

Local estimates of precipitation and evaporation – Mean annual precipitation (Table 1) was estimated to be 1,034 mm, and forested and clearcut evaporation near the site were estimated to be 326 and 466 mm. Clearcut evaporation was assumed to be a reasonable proxy for evaporation at the 7S facilities, and suggest approximately 700 mm per year – or 0.70 of annual precipitation – should generate surface water runoff.

Local gradients, infiltration and storage - Travel distances from the facilities to the sump and sediment pond were short and hydraulic gradients on soil stockpiles and pitwalls were steep. Exposed surfaces ((*i.e.,* coal pile, bedrock wall of pit) were reasoned to have lower infiltration and storage capacities and higher runoff coefficients than other site facilities (*e.g.,* soil storage pile, overburden soil).

Table 1:
Summary of monthly precipitation and evaporation for the mine site (reproduced from Norwest (2009)).

	Water flux (mm)			
Month	**Precipitation**	**Free water evaporation**	**Evapotranspiration (clearcut)**	**Evapotranspiration (forest cover)**
Jan	143	16	13	19
Feb	108	27	15	21
Mar	110	60	21	30
Apr	55	93	25	36
May	40	123	33	47
Jun	36	139	39	56
Jul	25	146	46	66
Aug	29	117	45	65
Sep	39	69	34	49
Oct	105	36	25	35
Nov	162	20	17	24
Dec	183	13	13	19
Annual	**1034**	**859**	**326**	**466**

Water Balance Configuration

The 7 South Surface Water Management Plan described in Golder (2011) was used to compute the site water balance. Volumes of water generated by the overburden dump and coal stockpile were assumed to report to the sediment pond, and runoff from the exposed pit and topsoil stockpile were assumed to report to the pit sump. For the purposes of this memo, it was assumed that sump waters would be pumped underground – thus having no bearing on water volumes and concentrations within the sediment pond.

Travel distances within and between mine site features were on the order of 10-100s of metres and hydraulic gradients were appreciable. Therefore, it was assumed that flows and associated chemical loads would report instantaneously to the sump or sediment pond with no storage or delay. As per Golder (2011), the design specifications for the sediment pond (Figure 1) are designated: area of 605 m^2, volume of 777 m^3 and maximum depth of 2.2 m. A floating decant structure at the sediment pond allows dewatering of the sediment pond at a rate of 5 L/s, which permits draw down of the sediment pond over a 2-3 day period.

Technical Details: Drainage to the Sediment Pond

For mine features that drain directly to the sediment pond, the following was assumed:

Overburden dump – The overburden dump contains ~150,000 m^3 of till from the pit. The footprint area of the overburden dump was estimated to be 27,207 m^2. It was assumed that the road and ramps built into this feature were comprised of material identical in composition to the overburden dump itself.

Coal stockpile – The surface area of the coal stockpile within the footprint of the overburden dump was estimated to be 1,618 m^2. Volumes of water produced at this location were assumed to report to the sediment pond.

Undisturbed catchment areas in the vicinity of mine facilities – It was assumed that runoff generated from undisturbed catchment areas was intercepted by ditches and re-directed to watercourses down-gradient of the sediment pond and pit. As such, it was assumed that naturally draining catchment areas had no influence on the water and chemical balances of the sediment pond.

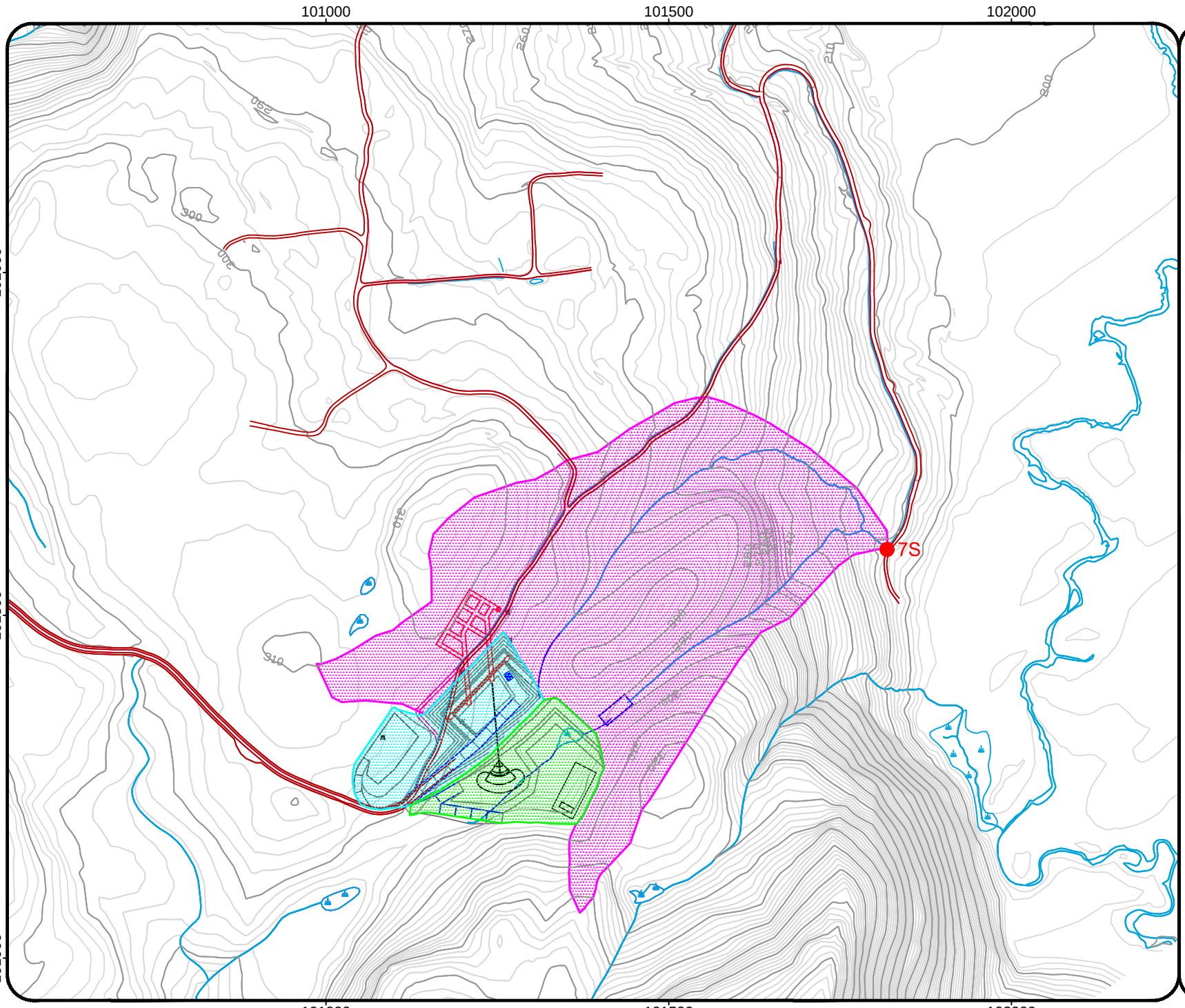
Evaporation – Water was permitted to evaporate from the sediment pond congruent with the monthly rates of free water evaporation reported in Table 1 and total pond surface area.

Undisturbed catchment areas down-gradient of the sediment pond: The drainage area reporting to the 7S water quality sampling and prediction point was estimated to be 240,702 m^2 (Figure 2). To the south and west of this drainage area, ditching forces local drainage to a SW flowing tributary (Golder, 2011).

Key Water Balance Results

The volumes of water discharging from the sediment pond and produced by the undisturbed catchment down-gradient of the sediment pond are reported in Table 2 and were used to drive the geochemical mass loading model.

Average annual discharge from the sediment pond was 25,000 m^3/year (*i.e,* 7.9 x 10^{-4} m^3/s), where monthly discharges were greatest in Nov-Dec and approximately 4,500 m^3/month. Volumes expected from the raw coal stockpile ranged from 40-300 m^3/month. Annual volume of undisturbed catchment drainage expected at the 7S location was computed to be 204,000 m^3/year and ranged from 4,000-40,000 m^3/month throughout the year.


101000
101500
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7S
Legend
7 South Surface Water Sample Location
Natural Catchment
Runoff to Sediment Pond
Runoff to Sump
Road
MINE GRID
TRUE
LORAX ENVIRONMENTAL
Meters
0
100
200
Projection: Mine Grid Coordiantes
Figure Title
Estimate of Drainage Area Providing Dilution to Sediment Pond Discharge
Figure No.
2
Project No.
J885-1
Client
Hillsborough Resources
Date
June 16, 2011

Table 2:
Estimated volumes of water discharging from the sediment pond and reporting to the 7S prediction point.

Sediment pond water balance:

		Water flux in m^3												
Unit	**Area (m^2)**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Sum**
Runoff from overburden stockpile	27,207	3,314	2,500	2,551	1,270	660	585	412	483	890	2,424	3,737	4,220	23,045
Runoff from the coal stock pile	1,618	220	166	170	84	62	55	39	45	59	161	248	281	1,590
Direct precipitation on the sediment pond	605	87	65	67	33	24	22	15	18	23	63	98	110	626
Evaporative losses from sediment pond	605	-10	-16	-36	-56	-74	-84	-88	-71	-42	-22	-12	-8	-520
Total		3,611	2,715	2,752	1,331	672	578	378	475	930	2,626	4,071	4,603	24,741

Undisturbed drainage areas reporting to the 7S location:

		Water flux in m^3												
Unit	**Area (m^2)**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Sum**
Undisturbed drainage areas	240,702	29,319	22,117	22,567	11,232	5,840	5,171	3,646	4,271	7,877	21,442	33,063	37,339	203,883

2. Geochemical Source Terms

Geochemical source terms were developed for overburden and coal stockpiles (Lorax, 2011), and were used as input to the geochemical loading model to evaluate water quality draining from the 7 South mine site during operations. Data used to develop the source terms include: surface water samples, shake flask extractions (SFE) and unsaturated laboratory columns (Table 3).

Table 3:
Geochemical Data that Provides Basis for Source Terms

Source Term	Basis for Source Terms
Sedimentation Pond	
Coal Stockpile	Leachate data from unsaturated column (Col 1)
Overburden (till) Stockpile	SFE data
Undisturbed Drainage	
Natural drainage to 7S	7S Background Water Quality Data

The rationale and assumptions behind the development of the source terms are listed below.

- SFE data provides a reasonable approximation of water soluble constituents that may be released from the overburden under oxic conditions. The SFE laboratory procedure provides near-total measures of water soluble constituents from geological samples. Under field conditions precipitation infiltrating through stockpiled material will only come into contact and rinse a portion of the particles in the pile. Thus, the range of SFE concentrations reported for overburden are expected to approximate concentrations of waters that runoff and infiltrate through the relatively small overburden stockpiles and complete rinsing of exposed bedrock strata.

- The data from unsaturated columns provides a reasonable estimate of the drainage chemistry expected from the raw coal stockpile. Coal stockpiles are projected to be on the order of 3 m in height. Thus, the range of concentrations reported from the raw coal column are expected to approximate concentrations of waters that runoff and infiltrate through the relatively small coal stockpiles and complete rinsing of exposed coal strata.

- Each stockpile mass and exposed unit produces a single drainage chemistry that is constant with time.

Expected and worst-case concentrations were developed for the raw coal and overburden soil stockpile source terms (Table 4). Expected concentrations are intended to provide a conservative

best-estimate of the median drainage chemistry expected from each material while worst-case concentrations are intended to provide an upper limit for the drainage chemistry.

Table 4:
Geochemical Source Terms

Parameter (mg/L)	*Sedimentation Pond*				*Undisturbed Drainage*	*BC WQG*	
	Till/OB Stockpile		**Coal Stockpile*** **		**7S Subwatershed**		
	expected	**worst case**	**expected**	**worst case**	**expected**	***30-day***	***max***
pH**	7.9	7.3	7.8	7.6	np	6.5-8.5	NP
Fluoride	0.09	0.12	0.6	0.6	np	NP	0.2
Dissolved Sulphate	16	29	***661***	***1799***	*0.5*	50	100
Dissolved Metals					*Total Metals*		
Aluminum	0.043	***0.12***	0.0039	0.0052	0.049	0.05	0.1
Arsenic	0.001	0.0022	0.0005	0.0042	0.0001	NP	0.005
Boron	0.034	0.06	0.59	1.53	0.05	NP	1.2
Cadmium	0.000011	0.00003	0.000034	0.00015	0.000008	NP	0.000012
Cobalt	0.000092	0.00025	0.001	***0.022***	0.0005	0.004	0.11
Copper	***0.0038***	***0.0066***	0.0005	***0.0025***	0.0005	0.002	0.005
Iron	0.036	0.14	0.008	0.022	0.019	NP	0.35
Manganese	0.013	0.023	0.06	0.52	0.001	0.74	0.87
Nickel	0.0005	0.00084	0.0024	0.042	0.001	NP	0.025
Selenium	0.0019	***0.0056***	***0.0024***	***0.014***	0.0001	0.002	NP
Zinc	0.003	0.0058	0.0015	0.0068	0.005	0.008	0.033

Notes: shaded values exceed max, bold exceed 30-day BC WQG based on hardness of 30 mg/L $CaCO_3$

* represents HW and FW bedrock in portal pit

** pH expressed in pH units, values are the 10th percentile (rathert than 90th)

*** F concentrations from coal estimated from saturated column data

Source terms derived from creek water quality data or SFE data used median values to represent the expected concentrations and 90th percentile values to represent the worst-case concentrations. Source terms for the raw coal, which were derived from leachate data of Col 1, used average values of cycles (weeks) 51 through 85 of testing to represent the expected concentrations and the 90th percentile value for all 85 cycles to represent the worst-case concentrations. The raw data is presented in Appendix B of the 7 South Groundwater Assessment Report (Lorax, 2011[2]).

Background surface water quality was collected by QCC at the 7S monitoring site. The average concentration was used as background chemistry for the undisturbed drainage area in the water quality model. Background water quality at 7S consistently had concentrations of dissolved Al measured to be near the BC WQG and as a result the expected Al concentration assigned to undisturbed drainage water is only slightly below the guideline of 0.05 mg/L. Background concentrations of total Cd are set at 0.000008 mg/L. This value was validated based on an extended set of samples collected between November 2010 and March 2012. Cd during this period of record was below the detection limit of 0.00001 mg/L in 14 of 17 samples. The laboratory was asked to reassess the Cd data with a reported detection limit of 0.000005 mg/L. An average total Cd concentration was calculated as 0.0000078 mg/L using the lower detection limit data and reporting those samples that were < 0.000005 mg/L as 0.000005 mg/L. Total copper concentrations measured at 7S were all below 0.001 mg/L for the period of record used to develop the background source term in the water quality model.

Runoff chemistry from the till overburden stockpile is expected to be similar to the background water quality prior to mixing with runoff from the undisturbed catchment in the sediment pond, however, expected case Cu and worst case concentrations of Al, Cd, Cu and Se are predicted to exceed BC WQGs. Similarly, prior to mixing, drainage from the coal stockpile is expected to be elevated for sulphate and Se in addition to Cd with respect to BC WQG. Potential worst-case conditions at the coal stockpile indicate higher concentrations for parameters of concern with sulphate, B, Cd, Co, Cu, Ni and Se exceeding the BC WQGs.

Nutrient loading associated with mining operations is typically associated with sewage and/or grey water discharge (phosphorous) and rinsing explosive residues from waste rock (nitrogen compounds). QCC has stated that no explosives would be used to remove the till overburden from the 7 South portal site or for cutting coal in the 7 South Underground Mine. Therefore, predictions for ammonia, nitrate and nitrite were not included for the 7 South sediment pond. Although a portable toilet will be installed near the 7 South portal, waste collected from the toilet will not be discharged into the 7 South sediment pond. Therefore, high levels of phosphorous loading would not be expected in the discharge to 7S.

3. Predicted Concentrations in the Sediment Pond and at the 7S Water Quality Prediction Point

Water quality was predicted at the sediment pond and 7S prediction point with a mass loading model. The mass loading model accounted for all flow and chemical loads (*i.e.*, metals and major ions) entering and exiting the sediment pond, as well as from background water quality and runoff volumes from undisturbed portions of the drainage.

Predictions of water quality in the receiving watercourse were generated via a simple mass balance approach that combined the loadings associated with source flows (*i.e.*, flows in contact with the mine site) and non-source flows (background), as per the equation:

$$C_{Final} = \frac{C_1 V_1 + C_2 V_2}{V_1 + V_2}$$

where C_{Final} is the predicted concentration in the receiving waterbody or watercourse, C_1 and V_1 are the respective values for concentration and volume of 'source flows', and C_2 and V_2 are the respective values for concentration and volumes of 'non-source flows'. An underpinning assumption of this approach is that parameters behave in a conservative manner and that no mass is lost through secondary processes. In the case of computations for the sediment pond, predicted concentrations were a function of source flows only.

The mass loading model was run on a monthly time step and the model was constructed such that all source loads would report instantaneously to the model prediction sites (on a monthly basis), with no storage or delay in the model. Mass loads were predicted for two scenarios (*i.e.*, expected and worst case) – each with different assumptions and input criteria. Total metal concentrations for the 7S site and dissolved metal concentrations for geochemical source terms were used in the mass loading computations.

Key Results

The predicted concentrations for the sediment pond are reported in Table 5, and predicted concentrations at 7S are reported in Table 6. Parameters showing exceedance to water quality guidelines have been conditionally formatted in these tables (pink).

Expected case predictions of sediment pond water quality showed exceedances to guidelines (BC WQG) for sulphate (30 day), cadmium (Max) and copper (30 day). In contrast, worst case predictions within the sediment pond showed exceedances for sulphate and a suite of dissolved metals (*i.e.*, Al, Cd, Cu and Se).

Water quality predictions at the 7S site showed no exceedances to guidelines in the expected case and a single parameter exceedance (*i.e.,* Al) under a worst case (Table 6), which was driven by the till overburden source term.

Potential Sensitivities

Runoff coefficients for the overburden stockpile and undisturbed drainage were indexed to regional discharge data, whereas the runoff coefficient for the coal stockpile was high and constant (0.95). In effect, the water balance was biased toward the presence of the coal stockpile and results can be considered conservative.

The site water balance was driven by the best available climate dataset (Norwest, 2009) for the location. Since the same precipitation distribution was applied to each facility or catchment drainage reporting to either of the sediment pond or 7S site, no one component of the water balance was directly biased in this regard. For example, an increase in precipitation would increase the load of a constituent exiting the pond, but would result in added dilution capability from the undisturbed 7S drainage areas and similar water quality predictions.

Dilution calculations were based on a catchment area of ~240,000 m2 (Table 2) - an area delineated based on high quality site topographic data. Water quality predictions at the 7S location are sensitive to the undisturbed drainage area reporting there – a larger drainage area equates to more dilution capability and vice versa. Given this sensitivity, the location of drains, culverts and roads should be designed to ensure that dilution capability at 7S is maximized and not diminished.

Table 5:
Predicted Concentration in the Sediment Pond – Expected and Worst Case

Sedimentation Pond - Expected Case - Predicted Concentrations

Parameter	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fluoride	mg/L	0.122	0.122	0.122	0.122	0.134	0.134	0.134	0.134	0.122	0.122	0.122	0.122
Dissolved Sulphate	mg/L	56.199	56.199	56.199	56.199	71.213	71.213	71.213	71.213	56.199	56.199	56.199	56.199
Aluminum	mg/L	0.041	0.041	0.041	0.041	0.040	0.040	0.040	0.040	0.041	0.041	0.041	0.041
Arsenic	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
Boron	mg/L	0.069	0.069	0.069	0.069	0.082	0.082	0.082	0.082	0.069	0.069	0.069	0.069
Cadmium	mg/L	0.000012	0.000012	0.000012	0.000012	0.000013	0.000013	0.000013	0.000013	0.000012	0.000012	0.000012	0.000012
Cobalt	mg/L	0.00015	0.00015	0.00015	0.00015	0.00017	0.00017	0.00017	0.00017	0.00015	0.00015	0.00015	0.00015
Copper	mg/L	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Iron	mg/L	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
Manganese	mg/L	0.016	0.016	0.016	0.016	0.017	0.017	0.017	0.017	0.016	0.016	0.016	0.016
Nickel	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
Selenium	mg/L	0.00193	0.00193	0.00193	0.00193	0.00194	0.00194	0.00194	0.00194	0.00193	0.00193	0.00193	0.00193
Zinc	mg/L	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003

Sedimentation Pond - Worst Case - Predicted Concentrations

Parameter	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fluoride	mg/L	0.150	0.150	0.150	0.150	0.161	0.161	0.161	0.161	0.150	0.150	0.150	0.150
Dissolved Sulphate	mg/L	139.313	139.313	139.313	139.313	180.514	180.514	180.514	180.514	139.313	139.313	139.313	139.313
Aluminum	mg/L	0.113	0.113	0.113	0.113	0.110	0.110	0.110	0.110	0.113	0.113	0.113	0.113
Arsenic	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
Boron	mg/L	0.152	0.152	0.152	0.152	0.186	0.186	0.186	0.186	0.152	0.152	0.152	0.152
Cadmium	mg/L	0.000037	0.000037	0.000037	0.000037	0.000040	0.000040	0.000040	0.000040	0.000037	0.000037	0.000037	0.000037
Cobalt	mg/L	0.00161	0.00161	0.00161	0.00161	0.00211	0.00211	0.00211	0.00211	0.00161	0.00161	0.00161	0.00161
Copper	mg/L	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
Iron	mg/L	0.133	0.133	0.133	0.133	0.130	0.130	0.130	0.130	0.133	0.133	0.133	0.133
Manganese	mg/L	0.054	0.054	0.054	0.054	0.066	0.066	0.066	0.066	0.054	0.054	0.054	0.054
Nickel	mg/L	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.003	0.003	0.003	0.003
Selenium	mg/L	0.00612	0.00612	0.00612	0.00612	0.00632	0.00632	0.00632	0.00632	0.00612	0.00612	0.00612	0.00612
Zinc	mg/L	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006

Table 6:
Predicted Concentration at the 7S Site – Mixing Volumes and Concentrations from the Sediment Pond and Undisturbed Drainage

Sedimentation Pond plus dilution from Undisturbed Catchment - Expected Case - Predicted Concentrations

Parameter	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dissolved Sulphate	mg/L	6.492	6.492	6.492	6.492	7.283	7.283	7.283	7.283	6.492	6.492	6.492	6.492
Aluminum	mg/L	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048
Arsenic	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Boron	mg/L	0.052	0.052	0.052	0.052	0.053	0.053	0.053	0.053	0.052	0.052	0.052	0.052
Cadmium	mg/L	0.000008	0.000008	0.000008	0.000008	0.000008	0.000008	0.000008	0.000008	0.000008	0.000008	0.000008	0.000008
Cobalt	mg/L	0.00046	0.00046	0.00046	0.00046	0.00047	0.00047	0.00047	0.00047	0.00046	0.00046	0.00046	0.00046
Copper	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
Iron	mg/L	0.021	0.021	0.021	0.021	0.020	0.020	0.020	0.020	0.021	0.021	0.021	0.021
Manganese	mg/L	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Nickel	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
Selenium	mg/L	0.00030	0.00030	0.00030	0.00030	0.00028	0.00028	0.00028	0.00028	0.00030	0.00030	0.00030	0.00030
Zinc	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

Sedimentation Pond plus dilution from Undisturbed Catchment - Worst Case - Predicted Concentrations

Parameter	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dissolved Sulphate	mg/L	15.433	15.433	15.433	15.433	17.768	17.768	17.768	17.768	15.433	15.433	15.433	15.433
Aluminum	mg/L	0.056	0.056	0.056	0.056	0.055	0.055	0.055	0.055	0.056	0.056	0.056	0.056
Arsenic	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Boron	mg/L	0.061	0.061	0.061	0.061	0.063	0.063	0.063	0.063	0.061	0.061	0.061	0.061
Cadmium	mg/L	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011
Cobalt	mg/L	0.00062	0.00062	0.00062	0.00062	0.00065	0.00065	0.00065	0.00065	0.00062	0.00062	0.00062	0.00062
Copper	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
Iron	mg/L	0.031	0.031	0.031	0.031	0.030	0.030	0.030	0.030	0.031	0.031	0.031	0.031
Manganese	mg/L	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
Nickel	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
Selenium	mg/L	0.00075	0.00075	0.00075	0.00075	0.00070	0.00070	0.00070	0.00070	0.00075	0.00075	0.00075	0.00075
Zinc	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

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APPENDIX F2 7S AREA5 WQEM - RESULTS

PP1 (Iron River)

Scenario 1

Parameter	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	7Q10
Sulphate	mg/L	0.936	1.10	1.31	2.42	1.31	2.54	9.06	19.4	19.0	1.96	3.83	0.998	48.5
Al-D	mg/L	0.0749	0.0749	0.0575	0.0866	0.114	0.0342	0.0253	0.0169	0.0136	0.0442	0.0734	0.0749	0.0172
As-T	mg/L	0.000785	0.000808	0.00110	0.000799	0.000792	0.00141	0.00382	0.00740	0.00743	0.00155	0.00105	0.000794	0.0114
B-T	mg/L	0.100	0.100	0.101	0.101	0.101	0.101	0.103	0.109	0.107	0.101	0.0754	0.100	0.132
Cd-T	mg/L	0.0000171	0.0000171	0.0000171	0.0000171	0.0000396	0.0000507	0.0000192	0.0000189	0.0000185	0.0000207	0.0000141	0.0000171	0.0000239
Ca-T	mg/L	7.67	7.72	6.72	8.17	8.45	10.6	19.3	28.7	28.1	11.9	9.97	7.69	38.3
Co-T	mg/L	0.000416	0.000461	0.000495	0.000510	0.000516	0.000631	0.00134	0.00333	0.00269	0.000578	0.000520	0.000432	0.0111
Cu-T	mg/L	0.00100	0.00101	0.00101	0.00101	0.00196	0.00121	0.00148	0.00110	0.00108	0.00101	0.00120	0.00100	0.00135
Fe-D	mg/L	0.0977	0.119	0.129	0.145	0.187	0.188	0.526	1.47	1.17	0.171	0.107	0.106	5.17
Fe-T	mg/L	0.135	0.156	0.141	0.192	0.437	0.188	0.526	1.47	1.17	0.177	0.203	0.143	5.17
Pb-T	mg/L	0.000501	0.000502	0.000503	0.000503	0.000503	0.000504	0.000513	0.000539	0.000531	0.000504	0.000352	0.000502	0.000640
Mg-T	mg/L	0.678	0.687	0.779	0.737	0.718	0.796	1.55	2.49	2.42	1.09	0.964	0.681	4.02
Mn-T	mg/L	0.00294	0.00343	0.00350	0.00536	0.0155	0.00532	0.0138	0.0343	0.0272	0.00454	0.00673	0.00312	0.119
Ni-T	mg/L	0.00113	0.00119	0.00123	0.00124	0.00125	0.00138	0.00221	0.00451	0.00377	0.00132	0.00114	0.00115	0.0135
Se-T	mg/L	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00102	0.00105	0.00104	0.00100	0.000602	0.00100	0.00116
Zn-T	mg/L	0.00502	0.00503	0.00504	0.00504	0.00505	0.00507	0.00522	0.00563	0.00550	0.00506	0.00503	0.00503	0.00725
Hardness	mg/L	21.9	22.1	20.0	23.4	24.1	29.8	54.5	82.0	80.2	34.3	28.9	22.0	112

Scenario 2

Parameter	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	7Q10
Sulphate	mg/L	0.755	0.853	1.00	2.09	0.973	2.03	7.44	14.7	15.3	1.52	3.64	0.791	31.7
Al-D	mg/L	0.0749	0.0749	0.0575	0.0866	0.114	0.0342	0.0253	0.0168	0.0135	0.0442	0.0734	0.0749	0.0169
As-T	mg/L	0.000781	0.000803	0.00110	0.000793	0.000785	0.00140	0.00379	0.00731	0.00736	0.00154	0.00105	0.000790	0.0110
B-T	mg/L	0.100	0.100	0.100	0.100	0.100	0.100	0.101	0.104	0.103	0.100	0.0752	0.100	0.113
Cd-T	mg/L	0.0000170	0.0000170	0.0000171	0.0000171	0.0000396	0.0000506	0.0000188	0.0000178	0.0000177	0.0000206	0.0000140	0.0000170	0.0000200
Ca-T	mg/L	7.61	7.65	6.63	8.07	8.35	10.5	18.8	27.3	27.0	11.8	9.92	7.63	33.3
Co-T	mg/L	0.000305	0.000308	0.000309	0.000310	0.000310	0.000316	0.000349	0.000443	0.000413	0.000313	0.000406	0.000306	0.000812
Cu-T	mg/L	0.00100	0.00100	0.00100	0.00100	0.00195	0.00120	0.00145	0.00100	0.00100	0.00100	0.00120	0.00100	0.00100
Fe-D	mg/L	0.0428	0.0430	0.0366	0.0456	0.0851	0.0310	0.0330	0.0387	0.0369	0.0398	0.0503	0.0429	0.0610
Fe-T	mg/L	0.0798	0.0799	0.0481	0.0921	0.334	0.0310	0.0330	0.0387	0.0369	0.0453	0.146	0.0799	0.0610
Pb-T	mg/L	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000499	0.000499	0.000500	0.000350	0.000500	0.000495
Mg-T	mg/L	0.668	0.673	0.762	0.719	0.699	0.767	1.46	2.23	2.21	1.07	0.953	0.670	3.09
Mn-T	mg/L	0.00220	0.00240	0.00225	0.00402	0.0142	0.00320	0.00719	0.0150	0.0119	0.00277	0.00596	0.00227	0.0496
Ni-T	mg/L	0.00101	0.00102	0.00102	0.00102	0.00102	0.00104	0.00111	0.00132	0.00126	0.00103	0.00101	0.00101	0.00216
Se-T	mg/L	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00101	0.00101	0.00100	0.000601	0.00100	0.00104
Zn-T	mg/L	0.00501	0.00502	0.00502	0.00503	0.00503	0.00504	0.00513	0.00537	0.00529	0.00503	0.00501	0.00502	0.00631
Hardness	mg/L	21.8	21.9	19.7	23.1	23.7	29.3	53.0	77.4	76.6	33.9	28.7	21.8	95.7

Scenario 3

Parameter	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	7Q10
Sulphate	mg/L	0.504	0.505	0.582	1.64	0.507	1.31	5.19	8.16	10.1	0.924	3.38	0.504	8.32
Al-D	mg/L	0.0749	0.0749	0.0575	0.0866	0.114	0.0342	0.0253	0.0167	0.0135	0.0442	0.0734	0.0749	0.0166
As-T	mg/L	0.000768	0.000784	0.00107	0.000768	0.000759	0.00136	0.00367	0.00695	0.00708	0.00151	0.00103	0.000774	0.00974
B-T	mg/L	0.100	0.100	0.100	0.100	0.100	0.100	0.101	0.102	0.101	0.100	0.0751	0.100	0.105
Cd-T	mg/L	0.0000170	0.0000170	0.0000170	0.0000170	0.0000395	0.0000505	0.0000185	0.0000170	0.0000170	0.0000205	0.0000140	0.0000170	0.0000169
Ca-T	mg/L	7.53	7.53	6.48	7.92	8.20	10.2	18.1	25.1	25.3	11.6	9.83	7.53	25.5
Co-T	mg/L	0.000300	0.000300	0.000300	0.000300	0.000300	0.000300	0.000301	0.000303	0.000303	0.000300	0.000400	0.000300	0.000312
Cu-T	mg/L	0.00100	0.00100	0.00100	0.00100	0.00195	0.00120	0.00145	0.000997	0.000998	0.00100	0.00120	0.00100	0.000990
Fe-D	mg/L	0.0426	0.0426	0.0361	0.0451	0.0846	0.0302	0.0305	0.0314	0.0311	0.0391	0.0501	0.0426	0.0350
Fe-T	mg/L	0.0795	0.0796	0.0476	0.0916	0.334	0.0302	0.0305	0.0314	0.0311	0.0446	0.146	0.0796	0.0350
Pb-T	mg/L	0.000500	0.000500	0.000500	0.000500	0.000500	0.000500	0.000499	0.000498	0.000498	0.000500	0.000350	0.000500	0.000491
Mg-T	mg/L	0.657	0.657	0.743	0.698	0.678	0.734	1.35	1.93	1.98	1.04	0.942	0.657	2.02
Mn-T	mg/L	0.00182	0.00187	0.00161	0.00333	0.0135	0.00211	0.00378	0.00505	0.00407	0.00186	0.00556	0.00184	0.0143
Ni-T	mg/L	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.000999	0.000999	0.00100	0.00100	0.00100	0.000996
Se-T	mg/L	0.00100	0.00100	0.00100	0.00100	0.00100	0.000999	0.000998	0.000995	0.000996	0.00100	0.000600	0.00100	0.000982
Zn-T	mg/L	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00499	0.00499	0.00500	0.00500	0.00500	0.00497
Hardness	mg/L	21.5	21.5	19.2	22.6	23.3	28.5	50.7	70.7	71.3	33.3	28.4	21.5	71.9

D: Dissolved
T: Total

PP2 (Quinsam River downstream of Iron River confluence)

Scenario 1

Parameter	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	7Q10
Sulphate	mg/L	3.86	12.6	19.6	18.6	14.5	6.27	15.4	15.6	18.2	16.1	11.5	13.0	19.2
Al-D	mg/L	0.0760	0.0496	0.0396	0.0473	0.0620	0.0226	0.0189	0.0127	0.00901	0.0197	0.0388	0.0444	0.0127
As-T	mg/L	0.000389	0.000471	0.000636	0.000568	0.000475	0.000709	0.00129	0.00145	0.00139	0.000865	0.000573	0.000448	0.00173
B-T	mg/L	0.0691	0.0727	0.0848	0.0860	0.0734	0.0716	0.0651	0.0596	0.101	0.100	0.0595	0.0700	0.0608
Cd-T	mg/L	0.0000127	0.0000132	0.0000149	0.0000151	0.0000256	0.0000313	0.0000126	0.0000115	0.0000172	0.0000183	0.0000115	0.0000128	0.0000118
Ca-T	mg/L	5.46	9.02	9.95	10.5	9.62	8.93	14.0	12.4	13.8	11.8	10.6	8.47	13.2
Co-T	mg/L	0.000465	0.000477	0.000431	0.000440	0.000499	0.000545	0.000716	0.000927	0.000588	0.000390	0.000504	0.000469	0.00181
Cu-T	mg/L	0.000785	0.000893	0.000911	0.000918	0.00168	0.000974	0.00114	0.00102	0.00101	0.00100	0.00108	0.00100	0.00105
Fe-D	mg/L	0.0543	0.0701	0.0809	0.0846	0.115	0.102	0.187	0.277	0.188	0.0966	0.0766	0.0702	0.697
Fe-T	mg/L	0.119	0.111	0.108	0.137	0.270	0.133	0.220	0.309	0.214	0.124	0.154	0.126	0.731
Pb-T	mg/L	0.000314	0.000336	0.000409	0.000415	0.000340	0.000329	0.000289	0.000255	0.000504	0.000501	0.000257	0.000319	0.000258
Mg-T	mg/L	0.711	1.06	1.32	1.24	1.06	0.846	1.58	1.34	1.59	1.38	1.20	1.02	1.53
Mn-T	mg/L	0.00388	0.00369	0.00391	0.00627	0.0109	0.00617	0.0104	0.0119	0.00865	0.00656	0.00687	0.00546	0.0217
Ni-T	mg/L	0.00105	0.00108	0.00108	0.00110	0.00111	0.00115	0.00132	0.00153	0.00133	0.00110	0.00105	0.00106	0.00256
Se-T	mg/L	0.000443	0.000506	0.000725	0.000745	0.000518	0.000485	0.000361	0.000257	0.00101	0.00100	0.000288	0.000458	0.000245
Zn-T	mg/L	0.00501	0.00501	0.00501	0.00502	0.00502	0.00503	0.00506	0.00510	0.00506	0.00502	0.00501	0.00501	0.00528
Hardness	mg/L	16.5	26.9	30.3	31.4	28.4	25.8	41.5	36.6	41.0	35.3	31.4	25.4	39.3

Scenario 2

Parameter	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	7Q10
Sulphate	mg/L	3.80	12.5	19.5	18.5	14.4	6.06	15.0	14.9	17.8	16.0	11.4	12.9	17.1
Al-D	mg/L	0.0760	0.0496	0.0396	0.0473	0.0620	0.0226	0.0189	0.0127	0.00901	0.0197	0.0388	0.0444	0.0126
As-T	mg/L	0.000388	0.000469	0.000634	0.000565	0.000472	0.000705	0.00128	0.00144	0.00138	0.000862	0.000572	0.000447	0.00169
B-T	mg/L	0.0690	0.0726	0.0847	0.0858	0.0733	0.0714	0.0646	0.0588	0.100	0.100	0.0594	0.0699	0.0585
Cd-T	mg/L	0.0000127	0.0000132	0.0000149	0.0000150	0.0000256	0.0000313	0.0000125	0.0000113	0.0000171	0.0000183	0.0000115	0.0000128	0.0000113
Ca-T	mg/L	5.44	8.99	9.91	10.5	9.58	8.87	13.9	12.2	13.7	11.8	10.6	8.45	12.6
Co-T	mg/L	0.000426	0.000413	0.000365	0.000361	0.000412	0.000421	0.000456	0.000489	0.000314	0.000304	0.000465	0.000423	0.000537
Cu-T	mg/L	0.000783	0.000891	0.000909	0.000915	0.00168	0.000970	0.00113	0.00100	0.00100	0.00100	0.00108	0.00100	0.00100
Fe-D	mg/L	0.0351	0.0386	0.0481	0.0452	0.0711	0.0407	0.0580	0.0589	0.0517	0.0542	0.0570	0.0473	0.0624
Fe-T	mg/L	0.0998	0.0794	0.0754	0.0977	0.227	0.0718	0.0909	0.0914	0.0778	0.0821	0.135	0.103	0.0962
Pb-T	mg/L	0.000314	0.000335	0.000408	0.000414	0.000339	0.000327	0.000285	0.000249	0.000500	0.000500	0.000256	0.000319	0.000240
Mg-T	mg/L	0.707	1.05	1.31	1.23	1.05	0.835	1.55	1.30	1.56	1.38	1.20	1.02	1.41
Mn-T	mg/L	0.00362	0.00326	0.00347	0.00574	0.0103	0.00534	0.00867	0.00898	0.00682	0.00599	0.00660	0.00515	0.0131
Ni-T	mg/L	0.00100	0.00101	0.00101	0.00101	0.00101	0.00101	0.00103	0.00105	0.00103	0.00101	0.00100	0.00101	0.00115
Se-T	mg/L	0.000442	0.000506	0.000724	0.000744	0.000517	0.000483	0.000358	0.000251	0.00100	0.00100	0.000288	0.000457	0.000229
Zn-T	mg/L	0.00501	0.00501	0.00501	0.00501	0.00501	0.00502	0.00503	0.00506	0.00504	0.00501	0.00501	0.00501	0.00516
Hardness	mg/L	16.5	26.8	30.2	31.3	28.2	25.6	41.1	35.9	40.6	35.1	31.3	25.3	37.3

Scenario 3

Parameter	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	7Q10
Sulphate	mg/L	3.71	12.4	19.4	18.3	14.2	5.78	14.4	13.9	17.2	15.8	11.3	12.8	14.2
Al-D	mg/L	0.0760	0.0496	0.0396	0.0473	0.0620	0.0226	0.0189	0.0127	0.00900	0.0197	0.0388	0.0444	0.0126
As-T	mg/L	0.000383	0.000461	0.000626	0.000555	0.000461	0.000690	0.00125	0.00138	0.00135	0.000852	0.000567	0.000441	0.00153
B-T	mg/L	0.0690	0.0725	0.0847	0.0858	0.0732	0.0713	0.0644	0.0585	0.100	0.100	0.0594	0.0698	0.0575
Cd-T	mg/L	0.0000127	0.0000131	0.0000149	0.0000150	0.0000255	0.0000312	0.0000124	0.0000112	0.0000170	0.0000182	0.0000115	0.0000128	0.0000109
Ca-T	mg/L	5.41	8.94	9.86	10.4	9.51	8.77	13.7	11.9	13.5	11.7	10.5	8.42	11.6
Co-T	mg/L	0.000424	0.000410	0.000362	0.000357	0.000408	0.000415	0.000444	0.000468	0.000301	0.000300	0.000463	0.000421	0.000476
Cu-T	mg/L	0.000783	0.000891	0.000908	0.000915	0.00168	0.000970	0.00113	0.00100	0.00100	0.00100	0.00108	0.00100	0.00100
Fe-D	mg/L	0.0350	0.0384	0.0480	0.0450	0.0708	0.0404	0.0573	0.0578	0.0510	0.0540	0.0569	0.0472	0.0592
Fe-T	mg/L	0.0997	0.0793	0.0752	0.0975	0.227	0.0715	0.0902	0.0903	0.0771	0.0819	0.135	0.103	0.0930
Pb-T	mg/L	0.000314	0.000335	0.000408	0.000414	0.000339	0.000327	0.000285	0.000249	0.000500	0.000500	0.000256	0.000319	0.000239
Mg-T	mg/L	0.703	1.04	1.31	1.23	1.04	0.822	1.52	1.26	1.53	1.37	1.19	1.02	1.28
Mn-T	mg/L	0.00348	0.00304	0.00324	0.00547	0.00998	0.00491	0.00778	0.00748	0.00588	0.00569	0.00647	0.00499	0.00875
Ni-T	mg/L	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100
Se-T	mg/L	0.000442	0.000505	0.000724	0.000744	0.000517	0.000483	0.000356	0.000249	0.00100	0.00100	0.000287	0.000457	0.000222
Zn-T	mg/L	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500
Hardness	mg/L	16.4	26.6	30.0	31.1	28.0	25.3	40.5	34.9	39.9	34.9	31.2	25.2	34.3

D: Dissolved
T: Total

Appendix G
Quinsam River Cumulative Effects Model

APPENDIX G1 ADJUSTMENT OF BACKGROUND WATER QUALITY AT PP2

APPENDIX G2 UNDERGROUND PUMPING RATES TO SP4

APPENDIX G3 LOADS BY MINE AREA

APPENDIX G4 AGGREGATE CONCENTRATIONS AT PP2

QUINSAM COAL

APPENDIX G1 ADJUSTMENT OF BACKGROUND WATER QUALITY AT PP2

QUINSAM RIVER AT PP2 (BACKGROUND PRIOR ADJUSTMENT)													
		Concentration mg/L											
	Units	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Volume	m3	32,787,562	18,176,365	19,167,168	15,440,724	14,454,648	9,913,704	4,864,251	2,884,415	4,469,186	14,833,681	31,018,330	27,489,407
F	mg/L												
SO4	mg/L	3.70E+00	1.23E+01	1.93E+01	1.83E+01	1.41E+01	5.77E+00	1.44E+01	1.39E+01	1.71E+01	1.58E+01	1.13E+01	1.28E+01
Metals													
Al-D	mg/L	7.60E-02	4.96E-02	3.96E-02	4.73E-02	6.20E-02	2.26E-02	1.89E-02	1.27E-02	8.98E-03	1.97E-02	3.88E-02	4.44E-02
As-T	mg/L	3.68E-04	4.36E-04	6.00E-04	5.24E-04	4.27E-04	6.42E-04	1.15E-03	1.21E-03	1.24E-03	8.18E-04	5.51E-04	4.23E-04
B-T	mg/L	6.90E-02	7.25E-02	8.46E-02	8.57E-02	7.31E-02	7.12E-02	6.42E-02	5.82E-02	1.00E-01	1.00E-01	5.93E-02	6.98E-02
Cd-T	mg/L	1.27E-05	1.31E-05	1.48E-05	1.50E-05	2.55E-05	3.12E-05	1.24E-05	1.11E-05	1.70E-05	1.82E-05	1.15E-05	1.28E-05
Co-T	mg/L	4.24E-04	4.10E-04	3.61E-04	3.57E-04	4.07E-04	4.15E-04	4.43E-04	4.67E-04	3.00E-04	3.00E-04	4.63E-04	4.21E-04
Cu-T	mg/L	7.83E-04	8.90E-04	9.08E-04	9.14E-04	1.68E-03	9.70E-04	1.13E-03	1.00E-03	1.00E-03	1.00E-03	1.07E-03	1.00E-03
Fe-T	mg/L	9.97E-02	7.92E-02	7.52E-02	9.75E-02	2.27E-01	7.14E-02	9.01E-02	9.02E-02	7.70E-02	8.19E-02	1.35E-01	1.03E-01
Mn-T	mg/L	3.43E-03	2.96E-03	3.15E-03	5.36E-03	9.87E-03	4.76E-03	7.45E-03	6.92E-03	5.53E-03	5.58E-03	6.41E-03	4.92E-03
Ni-T	mg/L	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03
Se-T	mg/L	4.41E-04	5.04E-04	7.23E-04	7.43E-04	5.16E-04	4.82E-04	3.56E-04	2.48E-04	1.00E-03	1.00E-03	2.87E-04	4.56E-04
Zn-T	mg/L	5.00E-03	5.00E-03	5.00E-03	5.00E-03	5.00E-03	5.00E-03	5.00E-03	5.00E-03	5.00E-03	5.00E-03	5.00E-03	5.00E-03
		Load (kg/d)											
	Units	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Volume	m3	32,787,562	18,176,365	19,167,168	15,440,724	14,454,648	9,913,704	4,864,251	2,884,415	4,469,186	14,833,681	31,018,330	27,489,407
F	kg/d												
SO4	kg/d	3910.53	7937.87	11959.90	9407.93	6597.36	1906.52	2251.85	1290.21	2554.39	7555.98	11672.49	11317.68
Metals													
Al-D	kg/d	80.40	31.93	24.49	24.36	28.90	7.48	2.97	1.18	1.34	9.41	40.12	39.37
As-T	kg/d	0.39	0.28	0.37	0.27	0.20	0.21	0.18	0.11	0.19	0.39	0.57	0.38
B-T	kg/d	72.93	46.63	52.33	44.13	34.10	23.54	10.08	5.42	14.90	47.85	61.35	61.89
Cd-T	kg/d	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.01
Co-T	kg/d	0.45	0.26	0.22	0.18	0.19	0.14	0.07	0.04	0.04	0.14	0.48	0.37
Cu-T	kg/d	0.83	0.57	0.56	0.47	0.78	0.32	0.18	0.09	0.15	0.48	1.11	0.89
Fe-T	kg/d	105.43	50.97	46.48	50.18	105.63	23.60	14.14	8.39	11.47	39.18	139.29	91.12
Mn-T	kg/d	3.63	1.90	1.95	2.76	4.60	1.57	1.17	0.64	0.82	2.67	6.63	4.37
Ni-T	kg/d	1.06	0.64	0.62	0.51	0.47	0.33	0.16	0.09	0.15	0.48	1.03	0.89
Se-T	kg/d	0.47	0.32	0.45	0.38	0.24	0.16	0.06	0.02	0.15	0.48	0.30	0.40
Zn-T	kg/d	5.29	3.22	3.09	2.57	2.33	1.65	0.78	0.47	0.74	2.39	5.17	4.43
LLS LOAD TO LONG LAKE - REMOVE FROM BACKGROUND													
		Concentration at Source mg/L											
Month	**Units**	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Volume	m3	62,422	34,906	56,253	46,871	18,644	7,078	3,028	3,070	7,215	20,514	64,800	59,893
SO4	mg/L	6.10E+02	4.90E+02	4.10E+02	4.70E+02	4.20E+02	3.80E+02	4.40E+02	4.25E+02	4.50E+02	4.75E+02	5.20E+02	6.60E+02
Al-D	mg/L	8.00E-03	2.20E-02	2.00E-02	3.00E-03	4.00E-03	1.50E-02	3.70E-02	6.00E-03	nd	4.50E-03	nd	4.00E-03
As-T	mg/L	6.00E-04	1.00E-03	1.10E-03	4.00E-04	7.00E-04	2.80E-03	1.10E-03	2.85E-03	nd	3.35E-03	nd	4.80E-03
B-T	mg/L												
Cd-T	mg/L	5.00E-06	5.00E-06	5.00E-06	5.00E-06	5.00E-06	5.00E-06	5.00E-06	5.00E-06	nd	5.00E-06	nd	5.00E-06
Co-T	mg/L												
Cu-T	mg/L	3.00E-04	3.00E-04	6.00E-04	2.00E-04	2.00E-04	5.00E-04	2.00E-04	2.00E-04	nd	3.00E-04	nd	1.10E-03
Fe-D	mg/L	3.80E-02	1.49E-01	5.00E-03	1.80E-02	2.30E-02	2.49E-01	5.39E-01	9.06E-01	nd	1.22E+00	nd	1.56E+00
Mn-T	mg/L	2.59E-01	2.29E-01	1.67E-01	1.16E-01	1.68E-01	2.28E-01	2.42E-01	3.34E-01	nd	3.52E-01	nd	3.42E-01
Ni-T	mg/L	3.00E-03	3.00E-03	2.00E-03	2.00E-03	1.00E-03	2.00E-03	1.00E-03	1.00E-03	nd	1.50E-03	nd	3.00E-03
Se-T	mg/L												
Zn-T	mg/L												

LLS LOAD TO LONG LAKE - REMOVE FROM BACKGROUND													
		Load (kg/d)											
Month	**Units**	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Volume	m3	62,422	34,906	56,253	46,871	18,644	7,078	3,028	3,070	7,215	20,514	64,800	59,893
SO4 (1 yr)	kg/day	1228	605	744	734	253	90	43	42	108	314	1123	1275
Al-D	kg/day	1.61E-02	2.72E-02	3.63E-02	4.69E-03	2.41E-03	3.54E-03	3.61E-03	5.94E-04		2.98E-03		7.73E-03
As-T	kg/day	1.21E-03	1.24E-03	2.00E-03	6.25E-04	4.21E-04	6.61E-04	1.07E-04	2.82E-04		2.22E-03		9.27E-03
B-T	kg/day												
Cd-T	kg/day	1.01E-05	6.18E-06	9.07E-06	7.81E-06	3.01E-06	1.18E-06	4.88E-07	4.95E-07		3.31E-06		9.66E-06
Co-T	kg/day												
Cu-T	kg/day	6.04E-04	3.71E-04	1.09E-03	3.12E-04	1.20E-04	1.18E-04	1.95E-05	1.98E-05		1.99E-04		2.13E-03
Fe-D	kg/day	7.65E-02	1.84E-01	9.07E-03	2.81E-02	1.38E-02	5.87E-02	5.27E-02	8.97E-02		8.07E-01		3.01E+00
Mn-T	kg/day	5.22E-01	2.83E-01	3.03E-01	1.81E-01	1.01E-01	5.38E-02	2.36E-02	3.31E-02		2.33E-01		6.61E-01
Ni-T	kg/day	6.04E-03	3.71E-03	3.63E-03	3.12E-03	6.01E-04	4.72E-04	9.77E-05	9.90E-05		9.93E-04		5.80E-03
Se-T	kg/day												
Zn-T	kg/day												
BIOCELL CONTRIBUTION TO SP4 - ADD TO BACKGROUND													
		Concentration at Source mg/L											
Parameter	**Units**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Volume	m3	32,650	29,754	32,650	31,597	32,650	31,597	32,650	32,650	31,597	32,650	31,597	32,650
SO4-D	mg/L	2.26E+02	2.26E+02	2.26E+02	2.26E+02	2.26E+02	2.26E+02	2.26E+02	2.26E+02	2.26E+02	2.26E+02	2.26E+02	2.26E+02
Al-T	mg/L	1.58E-01	1.58E-01	1.58E-01	1.58E-01	1.58E-01	1.58E-01	1.58E-01	1.58E-01	1.58E-01	1.58E-01	1.58E-01	1.58E-01
As-T	mg/L	9.56E-03	9.56E-03	9.56E-03	9.56E-03	9.56E-03	9.56E-03	9.56E-03	9.56E-03	9.56E-03	9.56E-03	9.56E-03	9.56E-03
B-T	mg/L	3.96E-01	3.96E-01	3.96E-01	3.96E-01	3.96E-01	3.96E-01	3.96E-01	3.96E-01	3.96E-01	3.96E-01	3.96E-01	3.96E-01
Cd-T	mg/L	3.73E-05	3.73E-05	3.73E-05	3.73E-05	3.73E-05	3.73E-05	3.73E-05	3.73E-05	3.73E-05	3.73E-05	3.73E-05	3.73E-05
Co-T	mg/L	4.99E-03	4.99E-03	4.99E-03	4.99E-03	4.99E-03	4.99E-03	4.99E-03	4.99E-03	4.99E-03	4.99E-03	4.99E-03	4.99E-03
Cu-T	mg/L	2.61E-03	2.61E-03	2.61E-03	2.61E-03	2.61E-03	2.61E-03	2.61E-03	2.61E-03	2.61E-03	2.61E-03	2.61E-03	2.61E-03
Fe-T	mg/L	7.90E+00	7.90E+00	7.90E+00	7.90E+00	7.90E+00	7.90E+00	7.90E+00	7.90E+00	7.90E+00	7.90E+00	7.90E+00	7.90E+00
Mn-T	mg/L	3.32E+00	3.32E+00	3.32E+00	3.32E+00	3.32E+00	3.32E+00	3.32E+00	3.32E+00	3.32E+00	3.32E+00	3.32E+00	3.32E+00
Ni-T	mg/L	3.98E-03	3.98E-03	3.98E-03	3.98E-03	3.98E-03	3.98E-03	3.98E-03	3.98E-03	3.98E-03	3.98E-03	3.98E-03	3.98E-03
Se-T	mg/L	1.22E-04	1.22E-04	1.22E-04	1.22E-04	1.22E-04	1.22E-04	1.22E-04	1.22E-04	1.22E-04	1.22E-04	1.22E-04	1.22E-04
Zn-T	mg/L	9.91E-03	9.91E-03	9.91E-03	9.91E-03	9.91E-03	9.91E-03	9.91E-03	9.91E-03	9.91E-03	9.91E-03	9.91E-03	9.91E-03
		Load (kg/d)											
Parameter	**Units**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Volume	m3	32,650	29,754	32,650	31,597	32,650	31,597	32,650	32,650	31,597	32,650	31,597	32,650
SO4-D	kg/d	2.38E+02	2.38E+02	2.38E+02	2.38E+02	2.38E+02	2.38E+02	2.38E+02	2.38E+02	2.38E+02	2.38E+02	2.38E+02	2.38E+02
Al-T	kg/d	1.66E-01	1.66E-01	1.66E-01	1.66E-01	1.66E-01	1.66E-01	1.66E-01	1.66E-01	1.66E-01	1.66E-01	1.66E-01	1.66E-01
As-T	kg/d	1.01E-02	1.01E-02	1.01E-02	1.01E-02	1.01E-02	1.01E-02	1.01E-02	1.01E-02	1.01E-02	1.01E-02	1.01E-02	1.01E-02
B-T	kg/d	4.17E-01	4.17E-01	4.17E-01	4.17E-01	4.17E-01	4.17E-01	4.17E-01	4.17E-01	4.17E-01	4.17E-01	4.17E-01	4.17E-01
Cd-T	kg/d	3.93E-05	3.93E-05	3.93E-05	3.93E-05	3.93E-05	3.93E-05	3.93E-05	3.93E-05	3.93E-05	3.93E-05	3.93E-05	3.93E-05
Co-T	kg/d	5.25E-03	5.25E-03	5.25E-03	5.25E-03	5.25E-03	5.25E-03	5.25E-03	5.25E-03	5.25E-03	5.25E-03	5.25E-03	5.25E-03
Cu-T	kg/d	2.75E-03	2.75E-03	2.75E-03	2.75E-03	2.75E-03	2.75E-03	2.75E-03	2.75E-03	2.75E-03	2.75E-03	2.75E-03	2.75E-03
Fe-T	kg/d	8.32E+00	8.32E+00	8.32E+00	8.32E+00	8.32E+00	8.32E+00	8.32E+00	8.32E+00	8.32E+00	8.32E+00	8.32E+00	8.32E+00
Mn-T	kg/d	3.49E+00	3.49E+00	3.49E+00	3.49E+00	3.49E+00	3.49E+00	3.49E+00	3.49E+00	3.49E+00	3.49E+00	3.49E+00	3.49E+00
Ni-T	kg/d	4.19E-03	4.19E-03	4.19E-03	4.19E-03	4.19E-03	4.19E-03	4.19E-03	4.19E-03	4.19E-03	4.19E-03	4.19E-03	4.19E-03
Se-T	kg/d	1.28E-04	1.28E-04	1.28E-04	1.28E-04	1.28E-04	1.28E-04	1.28E-04	1.28E-04	1.28E-04	1.28E-04	1.28E-04	1.28E-04
Zn-T	kg/d	1.04E-02	1.04E-02	1.04E-02	1.04E-02	1.04E-02	1.04E-02	1.04E-02	1.04E-02	1.04E-02	1.04E-02	1.04E-02	1.04E-02

2 NORTH UNDERGROUND PUMPING TO SP4 - REMOVE FROM BACKGROUND

		Concentration at Source mg/L											
Parameter	**Units**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Volume	m3	304,819	224,545	263,323	166,759	103,054	68,118	54,791	54,928	41,441	25,032	152,004	251,745
SO4-D	mg/L	235	235	235	235	235	235	235	235	235	235	235	235
Al-D	mg/L	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
Fe-D	mg/L	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
Mn-D	mg/L	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062

		Load (kg/d)											
Parameter	**Units**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Volume	m3	304,819	224,545	263,323	166,759	103,054	68,118	54,791	54,928	41,441	25,032	152,004	251,745
SO4-D	kg/d	2311	1868	1996	1306	781	534	415	416	325	190	1191	1908
Al-D	kg/d	0.25	0.20	0.21	0.14	0.08	0.06	0.04	0.04	0.03	0.02	0.13	0.20
Fe-D	kg/d	0.29	0.24	0.25	0.17	0.10	0.07	0.05	0.05	0.04	0.02	0.15	0.24
Mn-D	kg/d	0.61	0.49	0.53	0.34	0.21	0.14	0.11	0.11	0.09	0.05	0.31	0.50

ADJUSTED PP2 BACKGROUND CONCENTRATIONS

		Concentration mg/L											
	Units	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Volume	m3	32,787,562	18,176,365	19,167,168	15,440,724	14,454,648	9,913,704	4,864,251	2,884,415	4,469,186	14,833,681	31,018,330	27,489,407
SO4	mg/L	5.76E-01	8.86E+00	1.53E+01	1.48E+01	1.24E+01	4.60E+00	1.29E+01	1.15E+01	1.58E+01	1.52E+01	9.28E+00	9.44E+00
Al-D	mg/L	7.59E-02	4.95E-02	3.95E-02	4.74E-02	6.22E-02	2.30E-02	1.97E-02	1.40E-02	9.86E-03	2.00E-02	3.88E-02	4.43E-02
As-T	mg/L	3.76E-04	4.50E-04	6.13E-04	5.43E-04	4.48E-04	6.70E-04	1.21E-03	1.32E-03	1.31E-03	8.35E-04	5.61E-04	4.24E-04
B-T	mg/L	6.94E-02	7.31E-02	8.53E-02	8.65E-02	7.40E-02	7.25E-02	6.69E-02	6.27E-02	1.03E-01	1.01E-01	5.97E-02	7.03E-02
Cd-T	mg/L	1.27E-05	1.32E-05	1.49E-05	1.51E-05	2.56E-05	3.13E-05	1.27E-05	1.16E-05	1.73E-05	1.83E-05	1.15E-05	1.28E-05
Co-T	mg/L	4.29E-04	4.18E-04	3.70E-04	3.67E-04	4.19E-04	4.31E-04	4.77E-04	5.24E-04	3.35E-04	3.11E-04	4.68E-04	4.27E-04
Cu-T	mg/L	7.85E-04	8.94E-04	9.10E-04	9.19E-04	1.69E-03	9.78E-04	1.15E-03	1.03E-03	1.02E-03	1.01E-03	1.08E-03	1.00E-03
Fe-T	mg/L	1.07E-01	9.15E-02	8.82E-02	1.13E-01	2.44E-01	9.62E-02	1.42E-01	1.78E-01	1.33E-01	9.75E-02	1.43E-01	1.08E-01
Mn-T	mg/L	5.66E-03	7.18E-03	7.46E-03	1.11E-02	1.67E-02	1.47E-02	2.89E-02	4.29E-02	2.84E-02	1.23E-02	9.48E-03	7.55E-03
Ni-T	mg/L	9.98E-04	1.00E-03	1.00E-03	1.00E-03	1.01E-03	1.01E-03	1.03E-03	1.04E-03	1.03E-03	1.01E-03	1.00E-03	9.98E-04
Se-T	mg/L	4.41E-04	5.05E-04	7.24E-04	7.43E-04	5.17E-04	4.83E-04	3.57E-04	2.49E-04	1.00E-03	1.00E-03	2.87E-04	4.56E-04
Zn-T	mg/L	5.01E-03	5.02E-03	5.02E-03	5.02E-03	5.02E-03	5.03E-03	5.07E-03	5.11E-03	5.07E-03	5.02E-03	5.01E-03	5.01E-03

		Load (kg/d)											
	Units	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Volume	m3	32,787,562	18,176,365	19,167,168	15,440,724	14,454,648	9,913,704	4,864,251	2,884,415	4,469,186	14,833,681	31,018,330	27,489,407
SO4	kg/d	609.38	5702.41	9457.65	7605.23	5801.44	1521.16	2031.41	1069.63	2359.42	7289.78	9596.48	8372.03
Al-D	kg/d	80.31	31.87	24.41	24.38	28.98	7.59	3.09	1.30	1.47	9.55	40.16	39.32
As-T	kg/d	0.40	0.29	0.38	0.28	0.21	0.22	0.19	0.12	0.20	0.40	0.58	0.38
B-T	kg/d	73.35	47.05	52.74	44.54	34.52	23.96	10.49	5.83	15.31	48.27	61.76	62.31
Cd-T	kg/d	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.01
Co-T	kg/d	0.45	0.27	0.23	0.19	0.20	0.14	0.07	0.05	0.05	0.15	0.48	0.38
Cu-T	kg/d	0.83	0.57	0.56	0.47	0.79	0.32	0.18	0.10	0.15	0.48	1.11	0.89
Fe-T	kg/d	113.37	58.87	54.53	58.30	113.83	31.79	22.36	16.57	19.75	46.67	147.46	96.18
Mn-T	kg/d	5.99	4.62	4.61	5.73	7.79	4.87	4.53	3.99	4.23	5.88	9.81	6.70
Ni-T	kg/d	1.06	0.64	0.62	0.52	0.47	0.33	0.16	0.10	0.15	0.48	1.04	0.89
Se-T	kg/d	0.47	0.32	0.45	0.38	0.24	0.16	0.06	0.02	0.15	0.48	0.30	0.40
Zn-T	kg/d	5.30	3.23	3.10	2.58	2.34	1.66	0.79	0.48	0.76	2.40	5.18	4.44

APPENDIX G2 UNDERGROUND PUMPING RATES TO SP4

UNDERGROUND PUMPING VOLUME

	2006				2007				2008			
	WD Outflow (m3)	Precip (mm)	Runoff Volume (m^3)	UG Pumping Volume (m^3)	WD Outflow (m3)	Precip (mm)	Runoff Volume (m^3)	UG Pumping Volume (m^3)	WD Outflow (m3)	Precip (mm)	Runoff Volume (m^3)	UG Pumping Volume (m^3)
January	530,876	226.0	147,081	383,795	436,487	155.0	100,874	335,613	325,567	84.0	54,667	270,900
February	352,576	103.6	67,423	285,153	183,241	73.2	47,639	135,602	170,299	39.4	25,642	144,657
March	371,274	157.0	102,176	269,098	301,223	96.6	62,867	238,356	181,596	52.8	34,362	147,234
April	183,142	60.6	39,438	143,704	128,803	79.4	51,674	77,129	54,973	29.0	18,873	36,100
May	88,238	39.2	25,511	62,727	61,218	34.0	22,127	39,091	59,289	33.8	21,997	37,292
June	57,199	25.0	16,270	40,929	72,174	41.8	27,203	44,971	34,277	48.0	31,238	3,039
July	51,860	20.2	13,146	38,714	31,116	45.2	29,416	1,700	46,313	20.0	13,016	33,297
August	54,960	8.2	5,337	49,623	49,358	53.4	34,753	14,605	40,537	54.2	35,273	5,264
September	48,031	32.4	21,086	26,945	87,999	68.8	44,775	43,224	83,769	11.6	7,549	76,220
October	62,811	81.4	52,975	9,836	200,283	146.8	95,537	104,746	74,532	79.6	51,804	22,728
November	251,710	233.8	152,157	99,553	323,849	116.2	75,623	248,226	73,855	84.6	55,058	18,797
December	383,231	213.6	139,011	244,220	307,653	81.0	52,715	254,938	163,813	37.8	24,600	139,213
Total	2,435,908	1,201.0	781,611	1,654,297	2,183,404	991.4	645,203	1,538,201	1,308,820	574.8	374,080	934,740

	2009				2010				2011			
	WD Outflow (m3)	Precip (mm)	Runoff Volume (m^3)	UG Pumping Volume (m^3)	WD Outflow (m3)	Precip (mm)	Runoff Volume (m^3)	UG Pumping Volume (m^3)	WD Outflow (m3)	Precip (mm)	Runoff Volume (m^3)	UG Pumping Volume (m^3)
January	99,856	51.0	33,191	66,665	502,287	135.4	88,118	414,169	404,689	127.5	82,977	321,712
February	77,839	43.6	28,375	49,464	357,859	88.4	57,531	300,328	396,105	188.2	122,481	273,625
March	274,158	53.8	35,013	239,145	258,085	102.2	66,512	191,573	391,452	188.5	122,676	268,776
April	101,255	22.8	14,838	86,417	318,310	148.3	96,514	221,796	313,359	52.8	34,362	278,997
May	196,441	59.6	38,788	157,653	180,996	24.0	15,619	165,377	187,537	97.4	63,388	124,149
June	114,374	21.4	13,927	100,447	82,127	41.3	26,878	55,249	219,038	39.2	25,511	193,526
July	48,534	28.4	18,483	30,051	46,722	0.8	521	46,201	120,338	46.4	30,197	90,141
August	73,466	14.5	9,437	64,029	61,771	2.8	1,822	59,949	107,919	13.2	8,591	99,329
September	49,807	43.2	28,115	21,692	77,476	22.0	14,318	63,158	61,706	129.0	83,953	-22,247
October	47,002	123.0	80,048	-33,046	96,998	22.6	14,708	82,290	143,059	217.5	141,542	1,516
November	360,983	202.8	131,982	229,001	127,805	59.9	38,983	88,822	240,138	122.8	79,944	160,193
December	403,161	50.4	32,800	370,361	379,866	312.7	203,505	176,361	278,265	112.8	73,410	204,855
Total	1,846,876	714.5	464,997	1,381,879	2,490,302	960.4	625,028	1,865,274	2,863,604	1,335.3	869,033	1,994,571

	2012				2013				2006 - 2013 Average			
	WD Outflow (m3)	Precip (mm)	Runoff Volume (m^3)	UG Pumping Volume (m^3)	WD Outflow (m3)	Precip (mm)	Runoff Volume (m^3)	UG Pumping Volume (m^3)	WD Outflow (m3)	Precip (mm)	Runoff Volume (m^3)	UG Pumping Volume (m^3)
January	402,366	133.8	87,058	315,308	402,366	110.6	71,978	330,387	388,062	127.9	83,243	304,819
February	382,657	109.9	71,490	311,167	382,657	132.6	86,296	296,361	287,904	97.4	63,359	224,545
March	442,842	122.4	79,655	363,188	442,842	82.4	53,626	389,216	332,934	107.0	69,611	263,323
April	371,198	73.8	48,029	323,169					210,149	66.7	43,390	166,759
May	165,027	46.0	29,937	135,091					134,107	47.7	31,052	103,054
June	103,224	99.2	64,559	38,665					97,488	45.1	29,370	68,118
July	161,263	27.4	17,832	143,431					72,307	26.9	17,516	54,791
August	93,388	2.6	1,692	91,696					68,771	21.3	13,843	54,928
September	89,230	12.5	8,135	81,095					71,146	45.6	29,704	41,441
October	106,380	183.2	119,227	-12,846					104,438	122.0	79,406	25,032
November	330,853	171.2	111,417	219,436					244,170	141.6	92,166	152,004
December	448,283	116.8	76,013	372,269					337,753	132.2	86,008	251,745
Total	3,096,712	1,098.7	715,044	2,381,669	1,227,865	325.6	211,900	1,015,965	2,349,227	981.4	638,669	1,710,558

WD Run-off Area (m^2) 813,500
Run-off Coefficient 0.8

Precip measured at QCC Met Station
Precip measured at Campbell River Airport, reduced to 65% according to Lorax precip model

APPENDIX G3 LOADS BY MINE AREA

LOADS BY MINE AREA - VARIABLE

2S PAG Storage - Expected Case

Parameter	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SO4	kg/day	7.52E+01	6.81E+01	6.72E+01	6.30E+01	6.30E+01	6.30E+01	6.30E+01	6.30E+01	6.30E+01	6.30E+01	6.73E+01	7.21E+01
Al-D	kg/day	7.65E-03	3.74E-03	3.24E-03	4.30E-04	4.30E-04	4.30E-04	4.30E-04	4.30E-04	4.30E-04	4.30E-04	3.99E-03	7.19E-03
As-T	kg/day	1.34E-02	1.14E-02	1.11E-02	9.50E-03	9.50E-03	9.50E-03	9.50E-03	9.50E-03	9.50E-03	9.50E-03	1.12E-02	1.30E-02
B-T	kg/day	1.07E-01	7.68E-02	7.28E-02	4.90E-02	4.90E-02	4.90E-02	4.90E-02	4.90E-02	4.90E-02	4.90E-02	7.41E-02	1.01E-01
Cd-T	kg/day	1.69E-05	1.24E-05	1.18E-05	8.75E-06	8.75E-06	8.75E-06	8.75E-06	8.75E-06	8.75E-06	8.75E-06	1.26E-05	1.60E-05
Co-T	kg/day	3.55E-03	3.28E-03	3.25E-03	3.10E-03	3.10E-03	3.10E-03	3.10E-03	3.10E-03	3.10E-03	3.10E-03	3.24E-03	3.40E-03
Cu-T	kg/day	4.10E-04	2.15E-04	1.90E-04	5.00E-05	5.00E-05	5.00E-05	5.00E-05	5.00E-05	5.00E-05	5.00E-05	2.27E-04	3.87E-04
Fe-T	kg/day	3.48E-01	3.41E-01	3.41E-01	3.36E-01	3.36E-01	3.36E-01	3.36E-01	3.36E-01	3.36E-01	3.36E-01	3.41E-01	3.47E-01
Mn-T	kg/day	1.85E-01	1.63E-01	1.60E-01	1.45E-01	1.45E-01	1.45E-01	1.45E-01	1.45E-01	1.45E-01	1.45E-01	1.60E-01	1.78E-01
Ni-T	kg/day	7.20E-03	6.56E-03	6.47E-03	6.10E-03	6.10E-03	6.10E-03	6.10E-03	6.10E-03	6.10E-03	6.10E-03	6.47E-03	6.89E-03
Se-T	kg/day	5.18E-04	3.56E-04	3.35E-04	2.23E-04	2.23E-04	2.23E-04	2.23E-04	2.23E-04	2.23E-04	2.23E-04	3.63E-04	4.91E-04
Zn-T	kg/day	6.85E-03	5.51E-03	5.34E-03	4.38E-03	4.38E-03	4.38E-03	4.38E-03	4.38E-03	4.38E-03	4.38E-03	5.39E-03	6.49E-03

2S PAG Storage - Worst Case

Parameter	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SO4	kg/day	1.05E+02	7.80E+01	7.42E+01	6.30E+01	6.30E+01	6.30E+01	6.30E+01	6.30E+01	6.30E+01	6.30E+01	7.29E+01	7.68E+01
Al-D	kg/day	8.51E-03	4.13E-03	3.56E-03	4.30E-04	4.30E-04	4.30E-04	4.30E-04	4.30E-04	4.30E-04	4.30E-04	4.40E-03	7.75E-03
As-T	kg/day	1.38E-02	1.16E-02	1.13E-02	9.50E-03	9.50E-03	9.50E-03	9.50E-03	9.50E-03	9.50E-03	9.50E-03	1.14E-02	1.32E-02
B-T	kg/day	1.14E-01	7.99E-02	7.55E-02	4.90E-02	4.90E-02	4.90E-02	4.90E-02	4.90E-02	4.90E-02	4.90E-02	7.69E-02	1.05E-01
Cd-T	kg/day	2.20E-05	1.43E-05	1.32E-05	8.75E-06	8.75E-06	8.75E-06	8.75E-06	8.75E-06	8.75E-06	8.75E-06	1.39E-05	1.77E-05
Co-T	kg/day	5.18E-03	3.84E-03	3.65E-03	3.10E-03	3.10E-03	3.10E-03	3.10E-03	3.10E-03	3.10E-03	3.10E-03	3.58E-03	3.78E-03
Cu-T	kg/day	4.51E-04	2.33E-04	2.05E-04	5.00E-05	5.00E-05	5.00E-05	5.00E-05	5.00E-05	5.00E-05	5.00E-05	2.47E-04	4.13E-04
Fe-T	kg/day	3.49E-01	3.42E-01	3.41E-01	3.36E-01	3.36E-01	3.36E-01	3.36E-01	3.36E-01	3.36E-01	3.36E-01	3.41E-01	3.47E-01
Mn-T	kg/day	2.40E-01	1.78E-01	1.69E-01	1.45E-01	1.45E-01	1.45E-01	1.45E-01	1.45E-01	1.45E-01	1.45E-01	1.66E-01	1.78E-01
Ni-T	kg/day	1.03E-02	7.61E-03	7.23E-03	6.10E-03	6.10E-03	6.10E-03	6.10E-03	6.10E-03	6.10E-03	6.10E-03	7.12E-03	7.55E-03
Se-T	kg/day	6.50E-04	4.05E-04	3.73E-04	2.23E-04	2.23E-04	2.23E-04	2.23E-04	2.23E-04	2.23E-04	2.23E-04	4.01E-04	5.39E-04
Zn-T	kg/day	8.64E-03	6.04E-03	5.68E-03	4.38E-03	4.38E-03	4.38E-03	4.38E-03	4.38E-03	4.38E-03	4.38E-03	5.74E-03	6.61E-03

7S Portal-Sediment Pond - Expected Case

Parameter	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SO4	kg/day	6.41E+00	5.30E+00	4.93E+00	2.54E+00	1.42E+00	1.30E+00	8.89E-01	1.04E+00	1.78E+00	4.69E+00	7.47E+00	8.16E+00
Al-D	kg/day	4.62E-03	3.83E-03	3.56E-03	1.83E-03	7.93E-04	7.25E-04	4.95E-04	5.80E-04	1.28E-03	3.38E-03	5.39E-03	5.89E-03
As-T	kg/day	1.10E-04	9.14E-05	8.50E-05	4.37E-05	1.91E-05	1.75E-05	1.19E-05	1.40E-05	3.07E-05	8.08E-05	1.29E-04	1.41E-04
B-T	kg/day	7.83E-03	6.48E-03	6.02E-03	3.10E-03	1.63E-03	1.49E-03	1.02E-03	1.19E-03	2.17E-03	5.72E-03	9.12E-03	9.97E-03
Cd-T	kg/day	1.42E-06	1.17E-06	1.09E-06	5.61E-07	2.59E-07	2.37E-07	1.62E-07	1.90E-07	3.94E-07	1.04E-06	1.65E-06	1.81E-06
Co-T	kg/day	1.69E-05	1.40E-05	1.30E-05	6.71E-06	3.39E-06	3.10E-06	2.12E-06	2.48E-06	4.70E-06	1.24E-05	1.97E-05	2.16E-05
Cu-T	kg/day	4.10E-04	3.39E-04	3.15E-04	1.62E-04	7.03E-05	6.43E-05	4.39E-05	5.14E-05	1.14E-04	3.00E-04	4.78E-04	5.22E-04
Fe-T	kg/day	3.91E-03	3.23E-03	3.01E-03	1.55E-03	6.72E-04	6.15E-04	4.19E-04	4.91E-04	1.08E-03	2.86E-03	4.55E-03	4.97E-03
Mn-T	kg/day	1.82E-03	1.50E-03	1.40E-03	7.19E-04	3.40E-04	3.11E-04	2.12E-04	2.49E-04	5.04E-04	1.33E-03	2.12E-03	2.31E-03
Ni-T	kg/day	7.05E-05	5.84E-05	5.43E-05	2.79E-05	1.32E-05	1.21E-05	8.27E-06	9.69E-06	1.96E-05	5.16E-05	8.22E-05	8.98E-05
Se-T	kg/day	2.20E-04	1.82E-04	1.69E-04	8.72E-05	3.88E-05	3.55E-05	2.42E-05	2.84E-05	6.11E-05	1.61E-04	2.57E-04	2.80E-04
Zn-T	kg/day	3.31E-04	2.74E-04	2.55E-04	1.31E-04	5.74E-05	5.25E-05	3.58E-05	4.20E-05	9.20E-05	2.42E-04	3.86E-04	4.22E-04

7S Portal-Sediment Pond - Worst Case

Parameter	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SO4	kg/day	1.59E+01	1.31E+01	1.22E+01	6.29E+00	3.61E+00	3.30E+00	2.25E+00	2.64E+00	4.41E+00	1.16E+01	1.85E+01	2.02E+01
Al-D	kg/day	1.29E-02	1.06E-02	9.90E-03	5.09E-03	2.20E-03	2.02E-03	1.37E-03	1.61E-03	3.57E-03	9.41E-03	1.50E-02	1.64E-02
As-T	kg/day	2.65E-04	2.19E-04	2.04E-04	1.05E-04	4.74E-05	4.34E-05	2.96E-05	3.47E-05	7.36E-05	1.94E-04	3.09E-04	3.38E-04
B-T	kg/day	1.73E-02	1.43E-02	1.33E-02	6.84E-03	3.71E-03	3.40E-03	2.32E-03	2.72E-03	4.80E-03	1.26E-02	2.01E-02	2.20E-02
Cd-T	kg/day	4.27E-06	3.54E-06	3.29E-06	1.69E-06	8.05E-07	7.37E-07	5.03E-07	5.89E-07	1.19E-06	3.12E-06	4.98E-06	5.44E-06
Co-T	kg/day	1.83E-04	1.52E-04	1.41E-04	7.25E-05	4.22E-05	3.86E-05	2.64E-05	3.09E-05	5.08E-05	1.34E-04	2.13E-04	2.33E-04
Cu-T	kg/day	7.23E-04	5.99E-04	5.57E-04	2.86E-04	1.25E-04	1.14E-04	7.80E-05	9.13E-05	2.01E-04	5.29E-04	8.43E-04	9.21E-04
Fe-T	kg/day	1.51E-02	1.25E-02	1.16E-02	5.99E-03	2.60E-03	2.38E-03	1.62E-03	1.90E-03	4.20E-03	1.11E-02	1.76E-02	1.93E-02
Mn-T	kg/day	6.15E-03	5.09E-03	4.74E-03	2.44E-03	1.31E-03	1.20E-03	8.18E-04	9.58E-04	1.71E-03	4.50E-03	7.17E-03	7.84E-03
Ni-T	kg/day	3.88E-04	3.21E-04	2.99E-04	1.54E-04	8.72E-05	7.98E-05	5.45E-05	6.38E-05	1.08E-04	2.84E-04	4.52E-04	4.94E-04
Se-T	kg/day	6.98E-04	5.78E-04	5.37E-04	2.76E-04	1.26E-04	1.16E-04	7.89E-05	9.24E-05	1.94E-04	5.11E-04	8.14E-04	8.89E-04
Zn-T	kg/day	6.68E-04	5.53E-04	5.14E-04	2.65E-04	1.18E-04	1.08E-04	7.34E-05	8.60E-05	1.86E-04	4.89E-04	7.79E-04	8.51E-04

LOADS BY MINE AREA - CONSTANT

		4 South		7 South		5 South and 87 Panel		2 North		88 Panel		7SA5	
Parameter	Units	Expected Case	Worst Case	Expected Case	Worst Case	Expected Case	Worst Case	Expected Case	Worst Case	Expected Case	Worst Case	Expected Case	Worst Case
SO4	kg/day	3.30E+00	1.19E+02	6.10E+01	2.46E+02	1.89E+01	4.76E+02	5.99E+01	1.31E+03	1.01E+01	1.75E+02	1.49E+00	1.61E+02
Al-D	kg/day	3.80E-05	1.40E-03	4.20E-04	2.90E-03	9.29E-04	1.20E-02	2.72E-03	2.76E-02	4.50E-04	4.41E-03	3.81E-04	2.95E-03
As-T	kg/day	2.00E-04	7.10E-03	9.20E-03	2.30E-02	3.51E-03	1.90E-02	1.94E-02	1.02E-01	2.51E-03	1.68E-02	1.58E-02	2.22E-02
B-T	kg/day	1.20E-03	4.30E-02	4.70E-02	1.20E-01	3.37E-02	4.50E-01	2.37E-01	1.23E+00	5.47E-02	2.09E-01	2.92E-02	1.36E-01
Cd-T	kg/day	1.80E-07	6.50E-06	8.20E-06	2.00E-05	5.03E-07	4.08E-05	4.31E-06	8.19E-05	4.61E-07	1.50E-05	7.78E-07	2.88E-05
Co-T	kg/day	1.00E-04	3.70E-03	3.00E-03	7.50E-03	2.19E-04	3.54E-02	1.92E-04	1.76E-02	1.06E-04	1.30E-02	7.27E-05	4.28E-02
Cu-T	kg/day	8.90E-05	3.30E-03	4.80E-05	6.70E-03	2.38E-05	2.63E-04	2.16E-04	3.58E-03	2.31E-05	1.15E-04	3.89E-05	1.45E-03
Fe-T	kg/day	4.10E-01	1.50E+01	3.20E-01	3.10E+01	3.83E-02	4.87E+00	1.06E-01	2.83E+00	4.59E-02	1.68E+00	2.24E-02	2.04E+01
Mn-T	kg/day	9.40E-03	3.40E-01	1.40E-01	7.10E-01	6.48E-03	3.44E-01	7.76E-02	9.70E-01	3.46E-03	1.15E-01	5.12E-02	4.65E-01
Ni-T	kg/day	2.10E-04	6.90E-03	5.90E-03	1.50E-02	3.47E-04	5.09E-02	2.16E-04	2.60E-02	1.68E-04	1.88E-02	6.10E-05	4.98E-02
Se-T	kg/day	2.70E-06	9.80E-05	2.10E-04	5.30E-04	5.01E-06	3.01E-04	4.31E-05	4.98E-03	4.61E-06	8.82E-05	7.78E-06	7.23E-04
Zn-T	kg/day	1.20E-04	4.40E-03	4.30E-03	1.10E-02	3.86E-04	4.89E-03	1.29E-03	1.58E-02	1.87E-04	1.24E-03	2.57E-04	9.33E-03

APPENDIX G4 AGGREGATE CONCENTRATIONS AT PP2

CONCENTRATIONS BY PARAMETER (AS A FUNCTION OF PP2 FLOW)

Fluoride - Expected Case	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**7Q10**
Adjusted PP2 Background	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2S PAG Storage	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4S Underground Mine	3.69E-07	6.06E-07	6.31E-07	7.58E-07	8.36E-07	1.18E-06	2.49E-06	4.19E-06	2.62E-06	8.15E-07	3.77E-07	4.40E-07	1.22E-05
7S Underground Mine	2.27E-05	3.73E-05	3.88E-05	4.66E-05	5.15E-05	7.26E-05	1.53E-04	2.58E-04	1.61E-04	5.02E-05	2.32E-05	2.71E-05	7.53E-04
7S Portal-Sediment Pond	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5S Underground Mine	3.20E-05	5.25E-05	5.47E-05	6.57E-05	7.25E-05	1.02E-04	2.15E-04	3.63E-04	2.27E-04	7.07E-05	3.27E-05	3.81E-05	1.06E-03
2 North Underground Mine	1.79E-04	2.94E-04	3.06E-04	3.67E-04	4.05E-04	5.72E-04	1.20E-03	2.03E-03	1.27E-03	3.95E-04	1.83E-04	2.13E-04	5.93E-03
88 Panel	2.62E-05	4.30E-05	4.48E-05	5.38E-05	5.93E-05	8.37E-05	1.76E-04	2.97E-04	1.86E-04	5.78E-05	2.68E-05	3.12E-05	8.68E-04
7SA5 Underground	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Aggregate Concentration at PP2 - Expected Case	**2.60E-04**	**4.27E-04**	**4.45E-04**	**5.34E-04**	**5.89E-04**	**8.32E-04**	**1.75E-03**	**2.95E-03**	**1.85E-03**	**5.74E-04**	**2.66E-04**	**3.10E-04**	**8.62E-03**
Fluoride - Worst Case	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**7Q10**
Adjusted PP2 Background	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2S PAG Storage	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4S Underground Mine	1.32E-05	2.18E-05	2.26E-05	2.72E-05	3.00E-05	4.24E-05	8.92E-05	1.50E-04	9.40E-05	2.93E-05	1.35E-05	1.58E-05	4.39E-04
7S Underground Mine	1.13E-04	1.87E-04	1.94E-04	2.33E-04	2.57E-04	3.63E-04	7.65E-04	1.29E-03	8.06E-04	2.51E-04	1.16E-04	1.35E-04	3.77E-03
7S Portal-Sediment Pond	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5S Underground Mine	2.26E-04	3.72E-04	3.87E-04	4.65E-04	5.13E-04	7.24E-04	1.52E-03	2.57E-03	1.61E-03	5.00E-04	2.31E-04	2.70E-04	7.50E-03
2 North Underground Mine	9.03E-04	1.49E-03	1.55E-03	1.86E-03	2.05E-03	2.89E-03	6.09E-03	1.03E-02	6.41E-03	2.00E-03	9.24E-04	1.08E-03	3.00E-02
88 Panel	1.00E-04	1.64E-04	1.71E-04	2.06E-04	2.27E-04	3.20E-04	6.74E-04	1.14E-03	7.10E-04	2.21E-04	1.02E-04	1.19E-04	3.32E-03
7SA5 Underground	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Aggregate Concentration at PP2 - Worst Case	**1.36E-03**	**2.23E-03**	**2.32E-03**	**2.79E-03**	**3.08E-03**	**4.34E-03**	**9.14E-03**	**1.54E-02**	**9.63E-03**	**3.00E-03**	**1.39E-03**	**1.62E-03**	**4.50E-02**

Sulphate - Expected Case	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**7Q10**
Adjusted PP2 Background	5.76E-01	8.86E+00	1.53E+01	1.48E+01	1.24E+01	4.60E+00	1.29E+01	1.15E+01	1.58E+01	1.52E+01	9.28E+00	9.44E+00	1.15E+01
2S PAG Storage	7.11E-02	1.06E-01	1.09E-01	1.22E-01	1.35E-01	1.91E-01	4.02E-01	6.77E-01	4.23E-01	1.32E-01	6.50E-02	8.13E-02	1.98E+00
4S Underground Mine	3.12E-03	5.13E-03	5.34E-03	6.41E-03	7.08E-03	9.99E-03	2.10E-02	3.55E-02	2.22E-02	6.90E-03	3.19E-03	3.72E-03	1.04E-01
7S Underground Mine	5.77E-02	9.48E-02	9.87E-02	1.19E-01	1.31E-01	1.85E-01	3.89E-01	6.56E-01	4.09E-01	1.27E-01	5.90E-02	6.88E-02	1.91E+00
7S Portal-Sediment Pond	6.06E-03	8.24E-03	7.98E-03	4.93E-03	3.05E-03	3.94E-03	5.66E-03	1.12E-02	1.19E-02	9.79E-03	7.22E-03	9.20E-03	3.27E-02
5S Underground Mine	1.78E-02	2.93E-02	3.05E-02	3.66E-02	4.04E-02	5.71E-02	1.20E-01	2.03E-01	1.27E-01	3.94E-02	1.82E-02	2.13E-02	5.92E-01
2 North Underground Mine	5.67E-02	9.32E-02	9.69E-02	1.16E-01	1.29E-01	1.81E-01	3.82E-01	6.44E-01	4.02E-01	1.25E-01	5.80E-02	6.76E-02	1.88E+00
88 Panel	9.59E-03	1.58E-02	1.64E-02	1.97E-02	2.18E-02	3.07E-02	6.47E-02	1.09E-01	6.81E-02	2.12E-02	9.81E-03	1.14E-02	3.18E-01
7SA5 Underground	1.40E-03	2.31E-03	2.40E-03	2.89E-03	3.19E-03	4.49E-03	9.47E-03	1.60E-02	9.97E-03	3.10E-03	1.44E-03	1.67E-03	4.66E-02
Aggregate Concentration at PP2 - Expected Case	**8.00E-01**	**9.22E+00**	**1.57E+01**	**1.52E+01**	**1.29E+01**	**5.27E+00**	**1.43E+01**	**1.38E+01**	**1.73E+01**	**1.57E+01**	**9.50E+00**	**9.71E+00**	**1.84E+01**
Sulphate - Worst Case	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**7Q10**
Adjusted PP2 Background	5.76E-01	8.86E+00	1.53E+01	1.48E+01	1.24E+01	4.60E+00	1.29E+01	1.15E+01	1.58E+01	1.52E+01	9.28E+00	9.44E+00	1.15E+01
2S PAG Storage	9.96E-02	1.21E-01	1.20E-01	1.22E-01	1.35E-01	1.91E-01	4.02E-01	6.77E-01	4.23E-01	1.32E-01	7.05E-02	8.66E-02	1.98E+00
4S Underground Mine	1.13E-01	1.85E-01	1.92E-01	2.31E-01	2.55E-01	3.60E-01	7.58E-01	1.28E+00	7.99E-01	2.49E-01	1.15E-01	1.34E-01	3.73E+00
7S Underground Mine	2.33E-01	3.82E-01	3.98E-01	4.78E-01	5.28E-01	7.44E-01	1.57E+00	2.64E+00	1.65E+00	5.14E-01	2.38E-01	2.77E-01	7.72E+00
7S Portal-Sediment Pond	1.50E-02	2.04E-02	1.98E-02	1.22E-02	7.74E-03	9.99E-03	1.44E-02	2.84E-02	2.96E-02	2.43E-02	1.79E-02	2.28E-02	8.28E-02
5S Underground Mine	4.50E-01	7.40E-01	7.70E-01	9.24E-01	1.02E+00	1.44E+00	3.03E+00	5.11E+00	3.19E+00	9.94E-01	4.60E-01	5.37E-01	1.49E+01
2 North Underground Mine	1.24E+00	2.04E+00	2.12E+00	2.55E+00	2.81E+00	3.97E+00	8.35E+00	1.41E+01	8.80E+00	2.74E+00	1.27E+00	1.48E+00	4.11E+01
88 Panel	1.66E-01	2.73E-01	2.84E-01	3.41E-01	3.76E-01	5.31E-01	1.12E+00	1.89E+00	1.18E+00	3.67E-01	1.70E-01	1.98E-01	5.50E+00
7SA5 Underground	1.52E-01	2.50E-01	2.60E-01	3.13E-01	3.45E-01	4.87E-01	1.03E+00	1.73E+00	1.08E+00	3.36E-01	1.56E-01	1.82E-01	5.05E+00
Aggregate Concentration at PP2 - Worst Case	**3.04E+00**	**1.29E+01**	**1.95E+01**	**1.97E+01**	**1.79E+01**	**1.23E+01**	**2.92E+01**	**3.89E+01**	**3.30E+01**	**2.06E+01**	**1.18E+01**	**1.24E+01**	**9.16E+01**

dAluminum - Expected Case	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**7Q10**
Adjusted PP2 Background	7.59E-02	4.95E-02	3.95E-02	4.74E-02	6.22E-02	2.30E-02	1.97E-02	1.40E-02	9.86E-03	2.00E-02	3.88E-02	4.43E-02	1.40E-02
2S PAG Storage	7.23E-06	5.81E-06	5.23E-06	8.35E-07	9.22E-07	1.30E-06	2.74E-06	4.62E-06	2.89E-06	8.99E-07	3.86E-06	8.11E-06	1.35E-05
4S Underground Mine	3.59E-08	5.91E-08	6.15E-08	7.38E-08	8.15E-08	1.15E-07	2.42E-07	4.08E-07	2.55E-07	7.94E-08	3.68E-08	4.29E-08	1.19E-06
7S Underground Mine	3.97E-07	6.53E-07	6.79E-07	8.16E-07	9.01E-07	1.27E-06	2.68E-06	4.51E-06	2.82E-06	8.78E-07	4.06E-07	4.74E-07	1.32E-05
7S Portal-Sediment Pond	4.37E-06	5.95E-06	5.76E-06	3.56E-06	1.70E-06	2.19E-06	3.15E-06	6.23E-06	8.62E-06	7.07E-06	5.21E-06	6.64E-06	1.82E-05
5S Underground Mine	8.78E-07	1.44E-06	1.50E-06	1.80E-06	1.99E-06	2.81E-06	5.92E-06	9.98E-06	6.23E-06	1.94E-06	8.98E-07	1.05E-06	2.91E-05
2 North Underground Mine	2.57E-06	4.22E-06	4.39E-06	5.28E-06	5.83E-06	8.22E-06	1.73E-05	2.92E-05	1.82E-05	5.68E-06	2.63E-06	3.06E-06	8.52E-05
88 Panel	4.25E-07	6.99E-07	7.27E-07	8.74E-07	9.64E-07	1.36E-06	2.87E-06	4.83E-06	3.02E-06	9.40E-07	4.35E-07	5.07E-07	1.41E-05
7SA5 Underground	3.60E-07	5.92E-07	6.16E-07	7.40E-07	8.17E-07	1.15E-06	2.43E-06	4.10E-06	2.56E-06	7.96E-07	3.69E-07	4.30E-07	1.20E-05
Aggregate Concentration at PP2 - Expected Case	**7.59E-02**	**4.96E-02**	**3.95E-02**	**4.74E-02**	**6.22E-02**	**2.30E-02**	**1.97E-02**	**1.41E-02**	**9.91E-03**	**2.00E-02**	**3.89E-02**	**4.44E-02**	**1.42E-02**
dAluminum - Worst Case	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**7Q10**
Adjusted PP2 Background	7.59E-02	4.95E-02	3.95E-02	4.74E-02	6.22E-02	2.30E-02	1.97E-02	1.40E-02	9.86E-03	2.00E-02	3.88E-02	4.43E-02	1.40E-02
2S PAG Storage	8.05E-06	6.41E-06	5.77E-06	8.35E-07	9.22E-07	1.30E-06	2.74E-06	4.62E-06	2.89E-06	8.99E-07	4.26E-06	8.74E-06	1.35E-05
4S Underground Mine	1.32E-06	2.18E-06	2.26E-06	2.72E-06	3.00E-06	4.24E-06	8.92E-06	1.50E-05	9.40E-06	2.93E-06	1.35E-06	1.58E-06	4.39E-05
7S Underground Mine	2.74E-06	4.51E-06	4.69E-06	5.63E-06	6.22E-06	8.78E-06	1.85E-05	3.12E-05	1.95E-05	6.06E-06	2.80E-06	3.27E-06	9.10E-05
7S Portal-Sediment Pond	1.22E-05	1.66E-05	1.60E-05	9.90E-06	4.72E-06	6.10E-06	8.76E-06	1.73E-05	2.40E-05	1.97E-05	1.45E-05	1.85E-05	5.05E-05
5S Underground Mine	1.13E-05	1.86E-05	1.93E-05	2.32E-05	2.56E-05	3.62E-05	7.62E-05	1.28E-04	8.03E-05	2.50E-05	1.16E-05	1.35E-05	3.75E-04
2 North Underground Mine	2.61E-05	4.30E-05	4.47E-05	5.37E-05	5.93E-05	8.36E-05	1.76E-04	2.97E-04	1.86E-04	5.78E-05	2.67E-05	3.12E-05	8.67E-04
88 Panel	4.17E-06	6.85E-06	7.13E-06	8.56E-06	9.45E-06	1.33E-05	2.81E-05	4.74E-05	2.96E-05	9.21E-06	4.26E-06	4.97E-06	1.38E-04
7SA5 Underground	2.79E-06	4.59E-06	4.78E-06	5.74E-06	6.34E-06	8.94E-06	1.88E-05	3.18E-05	1.98E-05	6.18E-06	2.86E-06	3.33E-06	9.27E-05
Aggregate Concentration at PP2 - Worst Case	**7.60E-02**	**4.96E-02**	**3.96E-02**	**4.75E-02**	**6.23E-02**	**2.31E-02**	**2.00E-02**	**1.46E-02**	**1.02E-02**	**2.01E-02**	**3.89E-02**	**4.44E-02**	**1.57E-02**

CONCENTRATIONS BY PARAMETER (AS A FUNCTION OF PP2 FLOW)

Arsenic - Expected Case	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	7Q10
Adjusted PP2 Background	3.76E-04	4.50E-04	6.13E-04	5.43E-04	4.48E-04	6.70E-04	1.21E-03	1.32E-03	1.31E-03	8.35E-04	5.61E-04	4.24E-04	1.32E-03
2S PAG Storage	1.27E-05	1.76E-05	1.79E-05	1.85E-05	2.04E-05	2.87E-05	6.05E-05	1.02E-04	6.38E-05	1.99E-05	1.08E-05	1.46E-05	2.98E-04
4S Underground Mine	1.89E-07	3.11E-07	3.23E-07	3.89E-07	4.29E-07	6.05E-07	1.27E-06	2.15E-06	1.34E-06	4.18E-07	1.93E-07	2.26E-07	6.28E-06
7S Underground Mine	8.70E-06	1.43E-05	1.49E-05	1.79E-05	1.97E-05	2.78E-05	5.86E-05	9.89E-05	6.18E-05	1.92E-05	8.90E-06	1.04E-05	2.89E-04
7S Portal-Sediment Pond	1.04E-07	1.42E-07	1.38E-07	8.50E-08	4.10E-08	5.30E-08	7.61E-08	1.50E-07	2.06E-07	1.69E-07	1.24E-07	1.59E-07	4.39E-07
5S Underground Mine	3.32E-06	5.46E-06	5.68E-06	6.83E-06	7.54E-06	1.06E-05	2.24E-05	3.78E-05	2.36E-05	7.34E-06	3.40E-06	3.96E-06	1.10E-04
2 North Underground Mine	1.84E-05	3.02E-05	3.14E-05	3.77E-05	4.17E-05	5.88E-05	1.24E-04	2.09E-04	1.30E-04	4.06E-05	1.88E-05	2.19E-05	6.10E-04
88 Panel	2.38E-06	3.91E-06	4.07E-06	4.88E-06	5.39E-06	7.61E-06	1.60E-05	2.70E-05	1.69E-05	5.25E-06	2.43E-06	2.83E-06	7.89E-05
7SA5 Underground	1.50E-05	2.46E-05	2.56E-05	3.07E-05	3.39E-05	4.79E-05	1.01E-04	1.70E-04	1.06E-04	3.31E-05	1.53E-05	1.78E-05	4.97E-04
Aggregate Concentration at PP2 - Expected Case	**4.37E-04**	**5.46E-04**	**7.13E-04**	**6.60E-04**	**5.77E-04**	**8.52E-04**	**1.60E-03**	**1.97E-03**	**1.72E-03**	**9.61E-04**	**6.21E-04**	**4.96E-04**	**3.21E-03**
Arsenic - Worst Case	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**7Q10**
Adjusted PP2 Background	3.76E-04	4.50E-04	6.13E-04	5.43E-04	4.48E-04	6.70E-04	1.21E-03	1.32E-03	1.31E-03	8.35E-04	5.61E-04	4.24E-04	1.32E-03
2S PAG Storage	1.31E-05	1.80E-05	1.82E-05	1.85E-05	2.04E-05	2.87E-05	6.05E-05	1.02E-04	6.38E-05	1.99E-05	1.10E-05	1.49E-05	2.98E-04
4S Underground Mine	6.71E-06	1.10E-05	1.15E-05	1.38E-05	1.52E-05	2.15E-05	4.52E-05	7.63E-05	4.77E-05	1.48E-05	6.87E-06	8.01E-06	2.23E-04
7S Underground Mine	2.17E-05	3.57E-05	3.72E-05	4.47E-05	4.93E-05	6.96E-05	1.47E-04	2.47E-04	1.54E-04	4.81E-05	2.22E-05	2.59E-05	7.22E-04
7S Portal-Sediment Pond	2.51E-07	3.41E-07	3.30E-07	2.04E-07	1.02E-07	1.31E-07	1.89E-07	3.73E-07	4.94E-07	4.05E-07	2.99E-07	3.81E-07	1.09E-06
5S Underground Mine	1.80E-05	2.95E-05	3.07E-05	3.69E-05	4.08E-05	5.75E-05	1.21E-04	2.04E-04	1.28E-04	3.97E-05	1.84E-05	2.14E-05	5.96E-04
2 North Underground Mine	9.64E-05	1.58E-04	1.65E-04	1.98E-04	2.19E-04	3.08E-04	6.50E-04	1.10E-03	6.84E-04	2.13E-04	9.86E-05	1.15E-04	3.20E-03
88 Panel	1.58E-05	2.60E-05	2.71E-05	3.25E-05	3.59E-05	5.07E-05	1.07E-04	1.80E-04	1.12E-04	3.50E-05	1.62E-05	1.89E-05	5.26E-04
7SA5 Underground	2.10E-05	3.46E-05	3.60E-05	4.32E-05	4.77E-05	6.73E-05	1.42E-04	2.39E-04	1.49E-04	4.65E-05	2.15E-05	2.51E-05	6.98E-04
Aggregate Concentration at PP2 - Worst Case	**5.69E-04**	**7.63E-04**	**9.39E-04**	**9.31E-04**	**8.76E-04**	**1.27E-03**	**2.48E-03**	**3.46E-03**	**2.65E-03**	**1.25E-03**	**7.56E-04**	**6.53E-04**	**7.58E-03**

Boron - Expected Case	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	7Q10
Adjusted PP2 Background	6.94E-02	7.31E-02	8.53E-02	8.65E-02	7.40E-02	7.25E-02	6.69E-02	6.27E-02	1.03E-01	1.01E-01	5.97E-02	7.03E-02	6.27E-02
2S PAG Storage	1.02E-04	1.19E-04	1.18E-04	9.52E-05	1.05E-04	1.48E-04	3.12E-04	5.27E-04	3.29E-04	1.02E-04	7.16E-05	1.14E-04	1.54E-03
4S Underground Mine	1.13E-06	1.87E-06	1.94E-06	2.33E-06	2.57E-06	3.63E-06	7.65E-06	1.29E-05	8.06E-06	2.51E-06	1.16E-06	1.35E-06	3.77E-05
7S Underground Mine	4.44E-05	7.30E-05	7.60E-05	9.13E-05	1.01E-04	1.42E-04	3.00E-04	5.05E-04	3.15E-04	9.82E-05	4.55E-05	5.30E-05	1.47E-03
7S Portal-Sediment Pond	7.40E-06	1.01E-05	9.74E-06	6.02E-06	3.50E-06	4.52E-06	6.49E-06	1.28E-05	1.46E-05	1.20E-05	8.82E-06	1.12E-05	3.74E-05
5S Underground Mine	3.18E-05	5.23E-05	5.44E-05	6.54E-05	7.22E-05	1.02E-04	2.15E-04	3.62E-04	2.26E-04	7.04E-05	3.26E-05	3.80E-05	1.06E-03
2 North Underground Mine	2.24E-04	3.69E-04	3.84E-04	4.61E-04	5.09E-04	7.18E-04	1.51E-03	2.55E-03	1.59E-03	4.96E-04	2.29E-04	2.67E-04	7.44E-03
88 Panel	5.17E-05	8.49E-05	8.84E-05	1.06E-04	1.17E-04	1.65E-04	3.48E-04	5.87E-04	3.67E-04	1.14E-04	5.29E-05	6.16E-05	1.71E-03
7SA5 Underground	2.76E-05	4.54E-05	4.72E-05	5.67E-05	6.26E-05	8.84E-05	1.86E-04	3.14E-04	1.96E-04	6.10E-05	2.82E-05	3.29E-05	9.16E-04
Aggregate Concentration at PP2 - Expected Case	**6.98E-02**	**7.39E-02**	**8.61E-02**	**8.74E-02**	**7.50E-02**	**7.39E-02**	**6.98E-02**	**6.76E-02**	**1.06E-01**	**1.02E-01**	**6.02E-02**	**7.08E-02**	**7.69E-02**
Boron - Worst Case	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**7Q10**
Adjusted PP2 Background	6.94E-02	7.31E-02	8.53E-02	8.65E-02	7.40E-02	7.25E-02	6.69E-02	6.27E-02	1.03E-01	1.01E-01	5.97E-02	7.03E-02	6.27E-02
2S PAG Storage	1.08E-04	1.24E-04	1.22E-04	9.52E-05	1.05E-04	1.48E-04	3.12E-04	5.27E-04	3.29E-04	1.02E-04	7.43E-05	1.18E-04	1.54E-03
4S Underground Mine	4.07E-05	6.68E-05	6.95E-05	8.35E-05	9.22E-05	1.30E-04	2.74E-04	4.62E-04	2.89E-04	8.99E-05	4.16E-05	4.85E-05	1.35E-03
7S Underground Mine	1.13E-04	1.87E-04	1.94E-04	2.33E-04	2.57E-04	3.63E-04	7.65E-04	1.29E-03	8.06E-04	2.51E-04	1.16E-04	1.35E-04	3.77E-03
7S Portal-Sediment Pond	1.63E-05	2.22E-05	2.15E-05	1.33E-05	7.97E-06	1.03E-05	1.48E-05	2.92E-05	3.22E-05	2.64E-05	1.95E-05	2.48E-05	8.52E-05
5S Underground Mine	4.25E-04	6.99E-04	7.27E-04	8.73E-04	9.64E-04	1.36E-03	2.86E-03	4.83E-03	3.02E-03	9.39E-04	4.35E-04	5.07E-04	1.41E-02
2 North Underground Mine	1.16E-03	1.91E-03	1.99E-03	2.39E-03	2.63E-03	3.72E-03	7.83E-03	1.32E-02	8.25E-03	2.57E-03	1.19E-03	1.39E-03	3.85E-02
88 Panel	1.98E-04	3.25E-04	3.38E-04	4.06E-04	4.48E-04	6.32E-04	1.33E-03	2.25E-03	1.40E-03	4.37E-04	2.02E-04	2.36E-04	6.56E-03
7SA5 Underground	1.29E-04	2.11E-04	2.20E-04	2.64E-04	2.92E-04	4.12E-04	8.67E-04	1.46E-03	9.13E-04	2.84E-04	1.32E-04	1.53E-04	4.27E-03
Aggregate Concentration at PP2 - Worst Case	**7.15E-02**	**7.67E-02**	**8.90E-02**	**9.09E-02**	**7.88E-02**	**7.93E-02**	**8.11E-02**	**8.67E-02**	**1.18E-01**	**1.06E-01**	**6.19E-02**	**7.29E-02**	**1.33E-01**

Cadmium - Expected Case	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	7Q10
Adjusted PP2 Background	1.27E-05	1.32E-05	1.49E-05	1.51E-05	2.56E-05	3.13E-05	1.27E-05	1.16E-05	1.73E-05	1.83E-05	1.15E-05	1.28E-05	1.16E-05
2S PAG Storage	1.59E-08	1.92E-08	1.91E-08	1.70E-08	1.88E-08	2.65E-08	5.58E-08	9.40E-08	5.87E-08	1.83E-08	1.21E-08	1.80E-08	2.75E-07
4S Underground Mine	1.70E-10	2.80E-10	2.91E-10	3.50E-10	3.86E-10	5.45E-10	1.15E-09	1.93E-09	1.21E-09	3.76E-10	1.74E-10	2.03E-10	5.65E-09
7S Underground Mine	7.75E-09	1.27E-08	1.33E-08	1.59E-08	1.76E-08	2.48E-08	5.23E-08	8.81E-08	5.50E-08	1.71E-08	7.93E-09	9.25E-09	2.57E-07
7S Portal-Sediment Pond	1.34E-09	1.82E-09	1.76E-09	1.09E-09	5.56E-10	7.18E-10	1.03E-09	2.04E-09	2.64E-09	2.17E-09	1.60E-09	2.04E-09	5.95E-09
5S Underground Mine	4.75E-10	7.81E-10	8.13E-10	9.76E-10	1.08E-09	1.52E-09	3.20E-09	5.40E-09	3.37E-09	1.05E-09	4.86E-10	5.67E-10	1.58E-08
2 North Underground Mine	4.08E-09	6.70E-09	6.97E-09	8.38E-09	9.25E-09	1.30E-08	2.75E-08	4.63E-08	2.89E-08	9.01E-09	4.17E-09	4.86E-09	1.35E-07
88 Panel	4.36E-10	7.17E-10	7.46E-10	8.96E-10	9.89E-10	1.40E-09	2.94E-09	4.96E-09	3.10E-09	9.64E-10	4.46E-10	5.20E-10	1.45E-08
7SA5 Underground	7.35E-10	1.21E-09	1.26E-09	1.51E-09	1.67E-09	2.35E-09	4.96E-09	8.36E-09	5.22E-09	1.63E-09	7.52E-10	8.77E-10	2.44E-08
Aggregate Concentration at PP2 - Expected Case	**1.27E-05**	**1.32E-05**	**1.49E-05**	**1.51E-05**	**2.57E-05**	**3.14E-05**	**1.28E-05**	**1.18E-05**	**1.74E-05**	**1.84E-05**	**1.16E-05**	**1.28E-05**	**1.23E-05**
Cadmium - Worst Case	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**7Q10**
Adjusted PP2 Background	1.27E-05	1.32E-05	1.49E-05	1.51E-05	2.56E-05	3.13E-05	1.27E-05	1.16E-05	1.73E-05	1.83E-05	1.15E-05	1.28E-05	1.16E-05
2S PAG Storage	2.08E-08	2.22E-08	2.14E-08	1.70E-08	1.88E-08	2.65E-08	5.58E-08	9.40E-08	5.87E-08	1.83E-08	1.34E-08	2.00E-08	2.75E-07
4S Underground Mine	6.15E-09	1.01E-08	1.05E-08	1.26E-08	1.39E-08	1.97E-08	4.14E-08	6.99E-08	4.36E-08	1.36E-08	6.29E-09	7.33E-09	2.04E-07
7S Underground Mine	1.89E-08	3.11E-08	3.23E-08	3.89E-08	4.29E-08	6.05E-08	1.27E-07	2.15E-07	1.34E-07	4.18E-08	1.93E-08	2.26E-08	6.28E-07
7S Portal-Sediment Pond	4.04E-09	5.50E-09	5.32E-09	3.29E-09	1.73E-09	2.23E-09	3.20E-09	6.33E-09	7.96E-09	6.53E-09	4.82E-09	6.14E-09	1.85E-08
5S Underground Mine	3.85E-08	6.33E-08	6.59E-08	7.92E-08	8.74E-08	1.23E-07	2.60E-07	4.38E-07	2.74E-07	8.52E-08	3.94E-08	4.60E-08	1.28E-06
2 North Underground Mine	7.74E-08	1.27E-07	1.32E-07	1.59E-07	1.76E-07	2.48E-07	5.22E-07	8.80E-07	5.50E-07	1.71E-07	7.92E-08	9.24E-08	2.57E-06
88 Panel	1.42E-08	2.33E-08	2.42E-08	2.91E-08	3.21E-08	4.54E-08	9.55E-08	1.61E-07	1.01E-07	3.13E-08	1.45E-08	1.69E-08	4.70E-07
7SA5 Underground	2.72E-08	4.47E-08	4.65E-08	5.59E-08	6.17E-08	8.71E-08	1.83E-07	3.09E-07	1.93E-07	6.01E-08	2.78E-08	3.24E-08	9.03E-07
Aggregate Concentration at PP2 - Worst Case	**1.29E-05**	**1.35E-05**	**1.52E-05**	**1.55E-05**	**2.60E-05**	**3.20E-05**	**1.40E-05**	**1.37E-05**	**1.86E-05**	**1.87E-05**	**1.17E-05**	**1.30E-05**	**1.79E-05**

CONCENTRATIONS BY PARAMETER (AS A FUNCTION OF PP2 FLOW)

Cobalt - Expected Case	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	7Q10
Adjusted PP2 Background	4.29E-04	4.18E-04	3.70E-04	3.67E-04	4.19E-04	4.31E-04	4.77E-04	5.24E-04	3.35E-04	3.11E-04	4.68E-04	4.27E-04	5.24E-04
2S PAG Storage	3.36E-06	5.10E-06	5.25E-06	6.02E-06	6.64E-06	9.37E-06	1.97E-05	3.33E-05	2.08E-05	6.47E-06	3.14E-06	3.84E-06	9.72E-05
4S Underground Mine	9.45E-08	1.55E-07	1.62E-07	1.94E-07	2.14E-07	3.03E-07	6.37E-07	1.07E-06	6.71E-07	2.09E-07	9.67E-08	1.13E-07	3.14E-06
7S Underground Mine	2.84E-06	4.66E-06	4.85E-06	5.83E-06	6.43E-06	9.08E-06	1.91E-05	3.22E-05	2.01E-05	6.27E-06	2.90E-06	3.38E-06	9.41E-05
7S Portal-Sediment Pond	1.60E-08	2.18E-08	2.11E-08	1.30E-08	7.28E-09	9.39E-09	1.35E-08	2.67E-08	3.16E-08	2.59E-08	1.91E-08	2.43E-08	7.78E-08
5S Underground Mine	2.07E-07	3.40E-07	3.54E-07	4.25E-07	4.69E-07	6.61E-07	1.39E-06	2.35E-06	1.47E-06	4.57E-07	2.11E-07	2.46E-07	6.86E-06
2 North Underground Mine	1.81E-07	2.98E-07	3.10E-07	3.73E-07	4.12E-07	5.81E-07	1.22E-06	2.06E-06	1.29E-06	4.01E-07	1.86E-07	2.16E-07	6.02E-06
88 Panel	1.00E-07	1.65E-07	1.71E-07	2.06E-07	2.27E-07	3.20E-07	6.75E-07	1.14E-06	7.10E-07	2.21E-07	1.02E-07	1.19E-07	3.32E-06
7SA5 Underground	6.87E-08	1.13E-07	1.18E-07	1.41E-07	1.56E-07	2.20E-07	4.63E-07	7.81E-07	4.88E-07	1.52E-07	7.03E-08	8.20E-08	2.28E-06
Aggregate Concentration at PP2 - Expected Case	**4.36E-04**	**4.29E-04**	**3.81E-04**	**3.80E-04**	**4.33E-04**	**4.51E-04**	**5.20E-04**	**5.97E-04**	**3.81E-04**	**3.25E-04**	**4.74E-04**	**4.35E-04**	**7.37E-04**
Cobalt - Worst Case	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**7Q10**
Adjusted PP2 Background	4.29E-04	4.18E-04	3.70E-04	3.67E-04	4.19E-04	4.31E-04	4.77E-04	5.24E-04	3.35E-04	3.11E-04	4.68E-04	4.27E-04	5.24E-04
2S PAG Storage	4.90E-06	5.96E-06	5.90E-06	6.02E-06	6.64E-06	9.37E-06	1.97E-05	3.33E-05	2.08E-05	6.47E-06	3.47E-06	4.26E-06	9.72E-05
4S Underground Mine	3.50E-06	5.75E-06	5.98E-06	7.19E-06	7.94E-06	1.12E-05	2.36E-05	3.98E-05	2.48E-05	7.73E-06	3.58E-06	4.17E-06	1.16E-04
7S Underground Mine	7.09E-06	1.17E-05	1.21E-05	1.46E-05	1.61E-05	2.27E-05	4.78E-05	8.06E-05	5.03E-05	1.57E-05	7.25E-06	8.46E-06	2.35E-04
7S Portal-Sediment Pond	1.73E-07	2.35E-07	2.28E-07	1.41E-07	9.05E-08	1.17E-07	1.68E-07	3.32E-07	3.41E-07	2.80E-07	2.06E-07	2.63E-07	9.69E-07
5S Underground Mine	3.35E-05	5.50E-05	5.72E-05	6.88E-05	7.59E-05	1.07E-04	2.26E-04	3.80E-04	2.38E-04	7.40E-05	3.42E-05	3.99E-05	1.11E-03
2 North Underground Mine	1.66E-05	2.73E-05	2.84E-05	3.41E-05	3.76E-05	5.31E-05	1.12E-04	1.89E-04	1.18E-04	3.67E-05	1.70E-05	1.98E-05	5.51E-04
88 Panel	1.23E-05	2.03E-05	2.11E-05	2.54E-05	2.80E-05	3.95E-05	8.32E-05	1.40E-04	8.76E-05	2.73E-05	1.26E-05	1.47E-05	4.09E-04
7SA5 Underground	4.05E-05	6.66E-05	6.93E-05	8.32E-05	9.19E-05	1.30E-04	2.73E-04	4.60E-04	2.88E-04	8.95E-05	4.14E-05	4.83E-05	1.34E-03
Aggregate Concentration at PP2 - Worst Case	**5.48E-04**	**6.11E-04**	**5.70E-04**	**6.07E-04**	**6.83E-04**	**8.04E-04**	**1.26E-03**	**1.85E-03**	**1.16E-03**	**5.69E-04**	**5.88E-04**	**5.67E-04**	**4.39E-03**

Copper - Expected Case	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	7Q10
Adjusted PP2 Background	7.85E-04	8.94E-04	9.10E-04	9.19E-04	1.69E-03	9.78E-04	1.15E-03	1.03E-03	1.02E-03	1.01E-03	1.08E-03	1.00E-03	1.03E-03
2S PAG Storage	3.88E-07	3.34E-07	3.07E-07	9.71E-08	1.07E-07	1.51E-07	3.19E-07	5.37E-07	3.36E-07	1.04E-07	2.20E-07	4.36E-07	1.57E-06
4S Underground Mine	8.41E-08	1.38E-07	1.44E-07	1.73E-07	1.91E-07	2.69E-07	5.67E-07	9.57E-07	5.97E-07	1.86E-07	8.61E-08	1.00E-07	2.79E-06
7S Underground Mine	4.54E-08	7.46E-08	7.76E-08	9.33E-08	1.03E-07	1.45E-07	3.06E-07	5.16E-07	3.22E-07	1.00E-07	4.64E-08	5.41E-08	1.51E-06
7S Portal-Sediment Pond	3.87E-07	5.27E-07	5.10E-07	3.15E-07	1.51E-07	1.95E-07	2.80E-07	5.53E-07	7.64E-07	6.26E-07	4.62E-07	5.89E-07	1.61E-06
5S Underground Mine	2.25E-08	3.70E-08	3.85E-08	4.63E-08	5.11E-08	7.20E-08	1.52E-07	2.56E-07	1.60E-07	4.98E-08	2.30E-08	2.68E-08	7.47E-07
2 North Underground Mine	2.04E-07	3.35E-07	3.49E-07	4.19E-07	4.62E-07	6.52E-07	1.37E-06	2.32E-06	1.45E-06	4.51E-07	2.09E-07	2.43E-07	6.76E-06
88 Panel	2.18E-08	3.58E-08	3.73E-08	4.48E-08	4.95E-08	6.98E-08	1.47E-07	2.48E-07	1.55E-07	4.82E-08	2.23E-08	2.60E-08	7.24E-07
7SA5 Underground	3.68E-08	6.04E-08	6.29E-08	7.55E-08	8.34E-08	1.18E-07	2.48E-07	4.18E-07	2.61E-07	8.13E-08	3.76E-08	4.38E-08	1.22E-06
Aggregate Concentration at PP2 - Expected Case	**7.86E-04**	**8.95E-04**	**9.12E-04**	**9.20E-04**	**1.69E-03**	**9.80E-04**	**1.15E-03**	**1.04E-03**	**1.02E-03**	**1.01E-03**	**1.08E-03**	**1.00E-03**	**1.05E-03**
Copper - Worst Case	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**7Q10**
Adjusted PP2 Background	7.85E-04	8.94E-04	9.10E-04	9.19E-04	1.69E-03	9.78E-04	1.15E-03	1.03E-03	1.02E-03	1.01E-03	1.08E-03	1.00E-03	1.03E-03
2S PAG Storage	4.26E-07	3.63E-07	3.32E-07	9.71E-08	1.07E-07	1.51E-07	3.19E-07	5.37E-07	3.36E-07	1.04E-07	2.39E-07	4.65E-07	1.57E-06
4S Underground Mine	3.12E-06	5.13E-06	5.34E-06	6.41E-06	7.08E-06	9.99E-06	2.10E-05	3.55E-05	2.22E-05	6.90E-06	3.19E-06	3.72E-06	1.04E-04
7S Underground Mine	6.33E-06	1.04E-05	1.08E-05	1.30E-05	1.44E-05	2.03E-05	4.27E-05	7.20E-05	4.50E-05	1.40E-05	6.48E-06	7.56E-06	2.10E-04
7S Portal-Sediment Pond	6.84E-07	9.31E-07	9.00E-07	5.56E-07	2.68E-07	3.46E-07	4.97E-07	9.82E-07	1.35E-06	1.11E-06	8.15E-07	1.04E-06	2.87E-06
5S Underground Mine	2.49E-07	4.09E-07	4.25E-07	5.11E-07	5.64E-07	7.96E-07	1.68E-06	2.83E-06	1.77E-06	5.50E-07	2.54E-07	2.97E-07	8.25E-06
2 North Underground Mine	3.39E-06	5.57E-06	5.80E-06	6.96E-06	7.68E-06	1.08E-05	2.28E-05	3.85E-05	2.41E-05	7.49E-06	3.47E-06	4.04E-06	1.12E-04
88 Panel	1.09E-07	1.79E-07	1.87E-07	2.24E-07	2.48E-07	3.49E-07	7.36E-07	1.24E-06	7.75E-07	2.41E-07	1.12E-07	1.30E-07	3.62E-06
7SA5 Underground	1.37E-06	2.26E-06	2.35E-06	2.82E-06	3.11E-06	4.39E-06	9.25E-06	1.56E-05	9.75E-06	3.03E-06	1.40E-06	1.64E-06	4.56E-05
Aggregate Concentration at PP2 - Worst Case	**8.00E-04**	**9.19E-04**	**9.37E-04**	**9.50E-04**	**1.72E-03**	**1.03E-03**	**1.24E-03**	**1.20E-03**	**1.12E-03**	**1.04E-03**	**1.09E-03**	**1.02E-03**	**1.52E-03**

Iron - Expected Case	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	7Q10
Adjusted PP2 Background	1.07E-01	9.15E-02	8.82E-02	1.13E-01	2.44E-01	9.62E-02	1.42E-01	1.78E-01	1.33E-01	9.75E-02	1.43E-01	1.08E-01	1.78E-01
2S PAG Storage	3.29E-04	5.31E-04	5.51E-04	6.52E-04	7.20E-04	1.02E-03	2.14E-03	3.61E-03	2.25E-03	7.01E-04	3.30E-04	3.91E-04	1.05E-02
4S Underground Mine	3.88E-04	6.37E-04	6.63E-04	7.97E-04	8.79E-04	1.24E-03	2.61E-03	4.41E-03	2.75E-03	8.57E-04	3.97E-04	4.62E-04	1.29E-02
7S Underground Mine	3.03E-04	4.97E-04	5.18E-04	6.22E-04	6.86E-04	9.68E-04	2.04E-03	3.44E-03	2.15E-03	6.69E-04	3.09E-04	3.61E-04	1.00E-02
7S Portal-Sediment Pond	3.69E-06	5.02E-06	4.86E-06	3.00E-06	1.44E-06	1.86E-06	2.67E-06	5.28E-06	7.28E-06	5.97E-06	4.40E-06	5.61E-06	1.54E-05
5S Underground Mine	3.62E-05	5.96E-05	6.20E-05	7.45E-05	8.22E-05	1.16E-04	2.44E-04	4.12E-04	2.57E-04	8.01E-05	3.71E-05	4.32E-05	1.20E-03
2 North Underground Mine	9.99E-05	1.64E-04	1.71E-04	2.05E-04	2.27E-04	3.20E-04	6.73E-04	1.14E-03	7.09E-04	2.21E-04	1.02E-04	1.19E-04	3.31E-03
88 Panel	4.34E-05	7.13E-05	7.42E-05	8.92E-05	9.84E-05	1.39E-04	2.92E-04	4.93E-04	3.08E-04	9.59E-05	4.44E-05	5.17E-05	1.44E-03
7SA5 Underground	2.11E-05	3.47E-05	3.62E-05	4.34E-05	4.79E-05	6.77E-05	1.42E-04	2.40E-04	1.50E-04	4.67E-05	2.16E-05	2.52E-05	7.01E-04
Aggregate Concentration at PP2 - Expected Case	**1.08E-01**	**9.35E-02**	**9.03E-02**	**1.16E-01**	**2.47E-01**	**1.00E-01**	**1.51E-01**	**1.92E-01**	**1.41E-01**	**1.00E-01**	**1.44E-01**	**1.10E-01**	**2.18E-01**
Iron - Worst Case	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**7Q10**
Adjusted PP2 Background	1.07E-01	9.15E-02	8.82E-02	1.13E-01	2.44E-01	9.62E-02	1.42E-01	1.78E-01	1.33E-01	9.75E-02	1.43E-01	1.08E-01	1.78E-01
2S PAG Storage	3.30E-04	5.32E-04	5.52E-04	6.52E-04	7.20E-04	1.02E-03	2.14E-03	3.61E-03	2.25E-03	7.01E-04	3.30E-04	3.92E-04	1.05E-02
4S Underground Mine	1.42E-02	2.33E-02	2.43E-02	2.91E-02	3.22E-02	4.54E-02	9.56E-02	1.61E-01	1.01E-01	3.13E-02	1.45E-02	1.69E-02	4.71E-01
7S Underground Mine	2.93E-02	4.82E-02	5.01E-02	6.02E-02	6.65E-02	9.38E-02	1.98E-01	3.33E-01	2.08E-01	6.48E-02	3.00E-02	3.50E-02	9.73E-01
7S Portal-Sediment Pond	1.43E-05	1.95E-05	1.88E-05	1.16E-05	5.57E-06	7.19E-06	1.03E-05	2.04E-05	2.82E-05	2.31E-05	1.70E-05	2.17E-05	5.96E-05
5S Underground Mine	4.60E-03	7.56E-03	7.87E-03	9.45E-03	1.04E-02	1.47E-02	3.10E-02	5.23E-02	3.27E-02	1.02E-02	4.71E-03	5.49E-03	1.53E-01
2 North Underground Mine	2.68E-03	4.40E-03	4.58E-03	5.50E-03	6.07E-03	8.57E-03	1.81E-02	3.04E-02	1.90E-02	5.92E-03	2.74E-03	3.19E-03	8.89E-02
88 Panel	1.59E-03	2.62E-03	2.72E-03	3.27E-03	3.61E-03	5.10E-03	1.07E-02	1.81E-02	1.13E-02	3.52E-03	1.63E-03	1.90E-03	5.28E-02
7SA5 Underground	1.93E-02	3.17E-02	3.30E-02	3.96E-02	4.38E-02	6.17E-02	1.30E-01	2.19E-01	1.37E-01	4.26E-02	1.97E-02	2.30E-02	6.40E-01
Aggregate Concentration at PP2 - Worst Case	**1.79E-01**	**2.10E-01**	**2.11E-01**	**2.61E-01**	**4.07E-01**	**3.27E-01**	**6.28E-01**	**9.96E-01**	**6.44E-01**	**2.57E-01**	**2.16E-01**	**1.94E-01**	**2.57E+00**

CONCENTRATIONS BY PARAMETER (AS A FUNCTION OF PP2 FLOW)

Manganese - Expected Case	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	7Q10
Adjusted PP2 Background	5.66E-03	7.18E-03	7.46E-03	1.11E-02	1.67E-02	1.47E-02	2.89E-02	4.29E-02	2.84E-02	1.23E-02	9.48E-03	7.55E-03	4.29E-02
2S PAG Storage	1.75E-04	2.53E-04	2.58E-04	2.81E-04	3.10E-04	4.37E-04	9.21E-04	1.55E-03	9.70E-04	3.02E-04	1.55E-04	2.00E-04	4.53E-03
4S Underground Mine	8.89E-06	1.46E-05	1.52E-05	1.83E-05	2.02E-05	2.84E-05	5.99E-05	1.01E-04	6.31E-05	1.96E-05	9.09E-06	1.06E-05	2.95E-04
7S Underground Mine	1.32E-04	2.18E-04	2.26E-04	2.72E-04	3.00E-04	4.24E-04	8.92E-04	1.50E-03	9.40E-04	2.93E-04	1.35E-04	1.58E-04	4.39E-03
7S Portal-Sediment Pond	1.72E-06	2.34E-06	2.26E-06	1.40E-06	7.30E-07	9.42E-07	1.35E-06	2.67E-06	3.38E-06	2.78E-06	2.05E-06	2.61E-06	7.81E-06
5S Underground Mine	6.12E-06	1.01E-05	1.05E-05	1.26E-05	1.39E-05	1.96E-05	4.13E-05	6.96E-05	4.35E-05	1.35E-05	6.26E-06	7.30E-06	2.03E-04
2 North Underground Mine	7.34E-05	1.21E-04	1.26E-04	1.51E-04	1.66E-04	2.35E-04	4.95E-04	8.34E-04	5.21E-04	1.62E-04	7.51E-05	8.75E-05	2.44E-03
88 Panel	3.27E-06	5.38E-06	5.59E-06	6.72E-06	7.42E-06	1.05E-05	2.20E-05	3.72E-05	2.32E-05	7.23E-06	3.35E-06	3.90E-06	1.09E-04
7SA5 Underground	4.84E-05	7.96E-05	8.28E-05	9.95E-05	1.10E-04	1.55E-04	3.26E-04	5.50E-04	3.44E-04	1.07E-04	4.95E-05	5.77E-05	1.61E-03
Aggregate Concentration at PP2 - Expected Case	**6.11E-03**	**7.88E-03**	**8.18E-03**	**1.20E-02**	**1.76E-02**	**1.60E-02**	**3.16E-02**	**4.76E-02**	**3.13E-02**	**1.32E-02**	**9.92E-03**	**8.08E-03**	**5.65E-02**
Manganese - Worst Case	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**7Q10**
Adjusted PP2 Background	5.66E-03	7.18E-03	7.46E-03	1.11E-02	1.67E-02	1.47E-02	2.89E-02	4.29E-02	2.84E-02	1.23E-02	9.48E-03	7.55E-03	4.29E-02
2S PAG Storage	2.27E-04	2.77E-04	2.74E-04	2.81E-04	3.10E-04	4.37E-04	9.21E-04	1.55E-03	9.70E-04	3.02E-04	1.61E-04	2.01E-04	4.53E-03
4S Underground Mine	3.21E-04	5.28E-04	5.50E-04	6.61E-04	7.29E-04	1.03E-03	2.17E-03	3.65E-03	2.28E-03	7.11E-04	3.29E-04	3.83E-04	1.07E-02
7S Underground Mine	6.71E-04	1.10E-03	1.15E-03	1.38E-03	1.52E-03	2.15E-03	4.52E-03	7.63E-03	4.77E-03	1.48E-03	6.87E-04	8.01E-04	2.23E-02
7S Portal-Sediment Pond	5.82E-06	7.92E-06	7.66E-06	4.73E-06	2.81E-06	3.63E-06	5.21E-06	1.03E-05	1.15E-05	9.40E-06	6.94E-06	8.84E-06	3.01E-05
5S Underground Mine	3.25E-04	5.34E-04	5.56E-04	6.68E-04	7.37E-04	1.04E-03	2.19E-03	3.69E-03	2.31E-03	7.18E-04	3.32E-04	3.88E-04	1.08E-02
2 North Underground Mine	9.17E-04	1.51E-03	1.57E-03	1.88E-03	2.08E-03	2.94E-03	6.18E-03	1.04E-02	6.51E-03	2.03E-03	9.38E-04	1.09E-03	3.04E-02
88 Panel	1.08E-04	1.78E-04	1.85E-04	2.23E-04	2.46E-04	3.47E-04	7.30E-04	1.23E-03	7.69E-04	2.40E-04	1.11E-04	1.29E-04	3.60E-03
7SA5 Underground	4.40E-04	7.23E-04	7.52E-04	9.04E-04	9.97E-04	1.41E-03	2.96E-03	5.00E-03	3.12E-03	9.72E-04	4.50E-04	5.24E-04	1.46E-02
Aggregate Concentration at PP2 - Worst Case	**8.68E-03**	**1.20E-02**	**1.25E-02**	**1.71E-02**	**2.33E-02**	**2.41E-02**	**4.85E-02**	**7.61E-02**	**4.91E-02**	**1.88E-02**	**1.25E-02**	**1.11E-02**	**1.40E-01**

Nickel - Expected Case	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	7Q10
Adjusted PP2 Background	9.98E-04	1.00E-03	1.00E-03	1.00E-03	1.01E-03	1.01E-03	1.03E-03	1.04E-03	1.03E-03	1.01E-03	1.00E-03	9.98E-04	1.04E-03
2S PAG Storage	6.81E-06	1.02E-05	1.05E-05	1.19E-05	1.31E-05	1.85E-05	3.89E-05	6.56E-05	4.09E-05	1.27E-05	6.26E-06	7.77E-06	1.91E-04
4S Underground Mine	1.99E-07	3.26E-07	3.40E-07	4.08E-07	4.50E-07	6.35E-07	1.34E-06	2.26E-06	1.41E-06	4.39E-07	2.03E-07	2.37E-07	6.59E-06
7S Underground Mine	5.58E-06	9.17E-06	9.54E-06	1.15E-05	1.27E-05	1.79E-05	3.76E-05	6.34E-05	3.96E-05	1.23E-05	5.71E-06	6.65E-06	1.85E-04
7S Portal-Sediment Pond	6.67E-08	9.07E-08	8.78E-08	5.42E-08	2.84E-08	3.67E-08	5.27E-08	1.04E-07	1.31E-07	1.08E-07	7.95E-08	1.01E-07	3.04E-07
5S Underground Mine	3.28E-07	5.40E-07	5.61E-07	6.74E-07	7.44E-07	1.05E-06	2.21E-06	3.73E-06	2.33E-06	7.25E-07	3.36E-07	3.91E-07	1.09E-05
2 North Underground Mine	2.04E-07	3.35E-07	3.49E-07	4.19E-07	4.62E-07	6.52E-07	1.37E-06	2.32E-06	1.45E-06	4.51E-07	2.09E-07	2.43E-07	6.76E-06
88 Panel	1.59E-07	2.61E-07	2.72E-07	3.27E-07	3.61E-07	5.09E-07	1.07E-06	1.81E-06	1.13E-06	3.51E-07	1.63E-07	1.90E-07	5.27E-06
7SA5 Underground	5.77E-08	9.49E-08	9.87E-08	1.19E-07	1.31E-07	1.85E-07	3.89E-07	6.56E-07	4.10E-07	1.28E-07	5.90E-08	6.88E-08	1.92E-06
Aggregate Concentration at PP2 - Expected Case	**1.01E-03**	**1.02E-03**	**1.02E-03**	**1.03E-03**	**1.04E-03**	**1.05E-03**	**1.11E-03**	**1.18E-03**	**1.12E-03**	**1.03E-03**	**1.02E-03**	**1.01E-03**	**1.45E-03**
Nickel - Worst Case	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**7Q10**
Adjusted PP2 Background	9.98E-04	1.00E-03	1.00E-03	1.00E-03	1.01E-03	1.01E-03	1.03E-03	1.04E-03	1.03E-03	1.01E-03	1.00E-03	9.98E-04	1.04E-03
2S PAG Storage	9.76E-06	1.18E-05	1.17E-05	1.19E-05	1.31E-05	1.85E-05	3.89E-05	6.56E-05	4.09E-05	1.27E-05	6.88E-06	8.52E-06	1.91E-04
4S Underground Mine	6.52E-06	1.07E-05	1.12E-05	1.34E-05	1.48E-05	2.09E-05	4.40E-05	7.42E-05	4.63E-05	1.44E-05	6.67E-06	7.78E-06	2.16E-04
7S Underground Mine	1.42E-05	2.33E-05	2.43E-05	2.91E-05	3.22E-05	4.54E-05	9.56E-05	1.61E-04	1.01E-04	3.13E-05	1.45E-05	1.69E-05	4.71E-04
7S Portal-Sediment Pond	3.67E-07	4.99E-07	4.83E-07	2.99E-07	1.87E-07	2.41E-07	3.47E-07	6.85E-07	7.23E-07	5.93E-07	4.38E-07	5.58E-07	2.00E-06
5S Underground Mine	4.82E-05	7.92E-05	8.24E-05	9.90E-05	1.09E-04	1.54E-04	3.25E-04	5.47E-04	3.42E-04	1.06E-04	4.93E-05	5.74E-05	1.60E-03
2 North Underground Mine	2.46E-05	4.04E-05	4.20E-05	5.05E-05	5.58E-05	7.87E-05	1.66E-04	2.79E-04	1.75E-04	5.43E-05	2.51E-05	2.93E-05	8.16E-04
88 Panel	1.78E-05	2.92E-05	3.04E-05	3.65E-05	4.03E-05	5.68E-05	1.20E-04	2.02E-04	1.26E-04	3.92E-05	1.82E-05	2.12E-05	5.89E-04
7SA5 Underground	4.71E-05	7.73E-05	8.05E-05	9.67E-05	1.07E-04	1.51E-04	3.17E-04	5.35E-04	3.34E-04	1.04E-04	4.81E-05	5.61E-05	1.56E-03
Aggregate Concentration at PP2 - Worst Case	**1.17E-03**	**1.27E-03**	**1.28E-03**	**1.34E-03**	**1.38E-03**	**1.54E-03**	**2.13E-03**	**2.91E-03**	**2.19E-03**	**1.37E-03**	**1.17E-03**	**1.20E-03**	**6.49E-03**

Selenium - Expected Case	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	7Q10
Adjusted PP2 Background	4.41E-04	5.05E-04	7.24E-04	7.43E-04	5.17E-04	4.83E-04	3.57E-04	2.49E-04	1.00E-03	1.00E-03	2.87E-04	4.56E-04	2.49E-04
2S PAG Storage	4.89E-07	5.53E-07	5.42E-07	4.32E-07	4.77E-07	6.73E-07	1.42E-06	2.39E-06	1.49E-06	4.65E-07	3.51E-07	5.53E-07	6.98E-06
4S Underground Mine	2.55E-09	4.20E-09	4.37E-09	5.25E-09	5.79E-09	8.17E-09	1.72E-08	2.90E-08	1.81E-08	5.64E-09	2.61E-09	3.04E-09	8.47E-08
7S Underground Mine	1.99E-07	3.26E-07	3.40E-07	4.08E-07	4.50E-07	6.35E-07	1.34E-06	2.26E-06	1.41E-06	4.39E-07	2.03E-07	2.37E-07	6.59E-06
7S Portal-Sediment Pond	2.08E-07	2.83E-07	2.74E-07	1.69E-07	8.33E-08	1.08E-07	1.55E-07	3.05E-07	4.10E-07	3.36E-07	2.48E-07	3.16E-07	8.91E-07
5S Underground Mine	4.73E-09	7.78E-09	8.10E-09	9.73E-09	1.07E-08	1.51E-08	3.19E-08	5.38E-08	3.36E-08	1.05E-08	4.84E-09	5.65E-09	1.57E-07
2 North Underground Mine	4.08E-08	6.70E-08	6.97E-08	8.38E-08	9.25E-08	1.30E-07	2.75E-07	4.63E-07	2.89E-07	9.01E-08	4.17E-08	4.86E-08	1.35E-06
88 Panel	4.36E-09	7.17E-09	7.46E-09	8.96E-09	9.89E-09	1.40E-08	2.94E-08	4.96E-08	3.10E-08	9.64E-09	4.46E-09	5.20E-09	1.45E-07
7SA5 Underground	7.35E-09	1.21E-08	1.26E-08	1.51E-08	1.67E-08	2.35E-08	4.96E-08	8.36E-08	5.22E-08	1.63E-08	7.52E-09	8.77E-09	2.44E-07
Aggregate Concentration at PP2 - Worst Case	**4.42E-04**	**5.06E-04**	**7.25E-04**	**7.45E-04**	**5.18E-04**	**4.84E-04**	**3.60E-04**	**2.55E-04**	**1.00E-03**	**1.00E-03**	**2.88E-04**	**4.58E-04**	**2.66E-04**
Selenium - Worst Case	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**7Q10**
Adjusted PP2 Background	4.41E-04	5.05E-04	7.24E-04	7.43E-04	5.17E-04	4.83E-04	3.57E-04	2.49E-04	1.00E-03	1.00E-03	2.87E-04	4.56E-04	2.49E-04
2S PAG Storage	6.15E-07	6.30E-07	6.03E-07	4.32E-07	4.77E-07	6.73E-07	1.42E-06	2.39E-06	1.49E-06	4.65E-07	3.88E-07	6.07E-07	6.98E-06
4S Underground Mine	9.27E-08	1.52E-07	1.59E-07	1.90E-07	2.10E-07	2.97E-07	6.25E-07	1.05E-06	6.58E-07	2.05E-07	9.48E-08	1.11E-07	3.07E-06
7S Underground Mine	5.01E-07	8.24E-07	8.57E-07	1.03E-06	1.14E-06	1.60E-06	3.38E-06	5.70E-06	3.56E-06	1.11E-06	5.13E-07	5.98E-07	1.66E-05
7S Portal-Sediment Pond	6.60E-07	8.98E-07	8.69E-07	5.37E-07	2.71E-07	3.50E-07	5.03E-07	9.93E-07	1.30E-06	1.07E-06	7.87E-07	1.00E-06	2.90E-06
5S Underground Mine	2.85E-07	4.68E-07	4.87E-07	5.85E-07	6.46E-07	9.12E-07	1.92E-06	3.24E-06	2.02E-06	6.30E-07	2.91E-07	3.40E-07	9.45E-06
2 North Underground Mine	4.71E-06	7.74E-06	8.05E-06	9.67E-06	1.07E-05	1.51E-05	3.17E-05	5.35E-05	3.34E-05	1.04E-05	4.81E-06	5.61E-06	1.56E-04
88 Panel	8.34E-08	1.37E-07	1.43E-07	1.71E-07	1.89E-07	2.67E-07	5.62E-07	9.47E-07	5.92E-07	1.84E-07	8.53E-08	9.94E-08	2.77E-06
7SA5 Underground	6.84E-07	1.12E-06	1.17E-06	1.41E-06	1.55E-06	2.19E-06	4.61E-06	7.77E-06	4.85E-06	1.51E-06	6.99E-07	8.16E-07	2.27E-05
Aggregate Concentration at PP2 - Worst Case	**4.49E-04**	**5.17E-04**	**7.36E-04**	**7.57E-04**	**5.32E-04**	**5.04E-04**	**4.01E-04**	**3.25E-04**	**1.05E-03**	**1.02E-03**	**2.94E-04**	**4.66E-04**	**4.70E-04**

CONCENTRATIONS BY PARAMETER (AS A FUNCTION OF PP2 FLOW)

Zinc - Expected Case	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**7Q10**
Adjusted PP2 Background	5.01E-03	5.02E-03	5.02E-03	5.02E-03	5.02E-03	5.03E-03	5.07E-03	5.11E-03	5.07E-03	5.02E-03	5.01E-03	5.01E-03	5.11E-03
2S PAG Storage	6.47E-06	8.57E-06	8.64E-06	8.50E-06	9.38E-06	1.32E-05	2.79E-05	4.70E-05	2.94E-05	9.14E-06	5.21E-06	7.31E-06	1.37E-04
4S Underground Mine	1.13E-07	1.87E-07	1.94E-07	2.33E-07	2.57E-07	3.63E-07	7.65E-07	1.29E-06	8.06E-07	2.51E-07	1.16E-07	1.35E-07	3.77E-06
7S Underground Mine	4.07E-06	6.68E-06	6.95E-06	8.35E-06	9.22E-06	1.30E-05	2.74E-05	4.62E-05	2.89E-05	8.99E-06	4.16E-06	4.85E-06	1.35E-04
7S Portal-Sediment Pond	3.13E-07	4.26E-07	4.13E-07	2.55E-07	1.23E-07	1.59E-07	2.28E-07	4.51E-07	6.18E-07	5.06E-07	3.73E-07	4.76E-07	1.32E-06
5S Underground Mine	3.65E-07	5.99E-07	6.24E-07	7.49E-07	8.27E-07	1.17E-06	2.46E-06	4.15E-06	2.59E-06	8.06E-07	3.73E-07	4.35E-07	1.21E-05
2 North Underground Mine	1.22E-06	2.01E-06	2.09E-06	2.51E-06	2.77E-06	3.91E-06	8.24E-06	1.39E-05	8.68E-06	2.70E-06	1.25E-06	1.46E-06	4.06E-05
88 Panel	1.77E-07	2.90E-07	3.02E-07	3.63E-07	4.01E-07	5.65E-07	1.19E-06	2.01E-06	1.25E-06	3.90E-07	1.81E-07	2.11E-07	5.86E-06
7SA5 Underground	2.04E-07	3.35E-07	3.49E-07	4.19E-07	4.62E-07	6.52E-07	1.37E-06	2.32E-06	1.45E-06	4.51E-07	2.09E-07	2.43E-07	6.76E-06
Aggregate Concentration at PP2 - Expected Case	**5.02E-03**	**5.04E-03**	**5.04E-03**	**5.04E-03**	**5.05E-03**	**5.06E-03**	**5.14E-03**	**5.23E-03**	**5.14E-03**	**5.05E-03**	**5.02E-03**	**5.03E-03**	**5.45E-03**
Zinc - Worst Case	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**7Q10**
Adjusted PP2 Background	5.01E-03	5.02E-03	5.02E-03	5.02E-03	5.02E-03	5.03E-03	5.07E-03	5.11E-03	5.07E-03	5.02E-03	5.01E-03	5.01E-03	5.11E-03
2S PAG Storage	8.17E-06	9.38E-06	9.19E-06	8.50E-06	9.38E-06	1.32E-05	2.79E-05	4.70E-05	2.94E-05	9.14E-06	5.56E-06	7.46E-06	1.37E-04
4S Underground Mine	4.16E-06	6.84E-06	7.12E-06	8.55E-06	9.44E-06	1.33E-05	2.80E-05	4.73E-05	2.95E-05	9.20E-06	4.26E-06	4.96E-06	1.38E-04
7S Underground Mine	1.04E-05	1.71E-05	1.78E-05	2.14E-05	2.36E-05	3.33E-05	7.01E-05	1.18E-04	7.38E-05	2.30E-05	1.06E-05	1.24E-05	3.45E-04
7S Portal-Sediment Pond	6.32E-07	8.60E-07	8.32E-07	5.14E-07	2.52E-07	3.26E-07	4.68E-07	9.25E-07	1.25E-06	1.02E-06	7.53E-07	9.60E-07	2.70E-06
5S Underground Mine	4.63E-06	7.60E-06	7.91E-06	9.51E-06	1.05E-05	1.48E-05	3.12E-05	5.26E-05	3.28E-05	1.02E-05	4.73E-06	5.52E-06	1.54E-04
2 North Underground Mine	1.49E-05	2.45E-05	2.55E-05	3.06E-05	3.38E-05	4.77E-05	1.01E-04	1.70E-04	1.06E-04	3.30E-05	1.53E-05	1.78E-05	4.95E-04
88 Panel	1.18E-06	1.93E-06	2.01E-06	2.42E-06	2.67E-06	3.76E-06	7.92E-06	1.34E-05	8.34E-06	2.60E-06	1.20E-06	1.40E-06	3.90E-05
7SA5 Underground	8.82E-06	1.45E-05	1.51E-05	1.81E-05	2.00E-05	2.82E-05	5.95E-05	1.00E-04	6.26E-05	1.95E-05	9.02E-06	1.05E-05	2.93E-04
Aggregate Concentration at PP2 - Worst Case	**5.06E-03**	**5.10E-03**	**5.10E-03**	**5.12E-03**	**5.13E-03**	**5.19E-03**	**5.39E-03**	**5.66E-03**	**5.41E-03**	**5.13E-03**	**5.06E-03**	**5.07E-03**	**6.72E-03**