Aquatic Resource Assessment Report for United Keno Hill Mines

Report Prepared for:

Elsa Reclamation and Development Company Ltd.
Whitehorse, YT

Report Prepared by:

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March 2009

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1.0 INTRODUCTION

1.1 Background

United Keno Hill Mines Limited and UKH Minerals Ltd. were the previous owners of the properties located on and around Galena Hill, Keno Hill, and Sourdough Hill collectively known as the Keno Hill Mining Property. For the purposes of this report these mining areas are referred to as the United Keno Hill Mines (UKHM). The UKHM area is located in north-central Yukon Territory (Figure 1.1) near the towns of Elsa and Keno and is comprised of approximately 827 mineral claims spanning the three mountains, an area of approximately 15,000 ha (about 29 km long and 8 km wide). Associated with the site are abandoned adits, buildings/structures, a tailings impoundment area and other waste material which represent a source of contaminants to the downstream watersheds (Figure 1.2).

In June 2005, Alexco Resource Corp was selected as the preferred purchaser of the UKHM assets. As required in the purchase agreement, Alexco formed a company – Elsa Reclamation and Development Company Ltd. (ERDC), to own and manage the site. ERDC is required to develop a “Reclamation Plan for the Existing State of the Mine”.

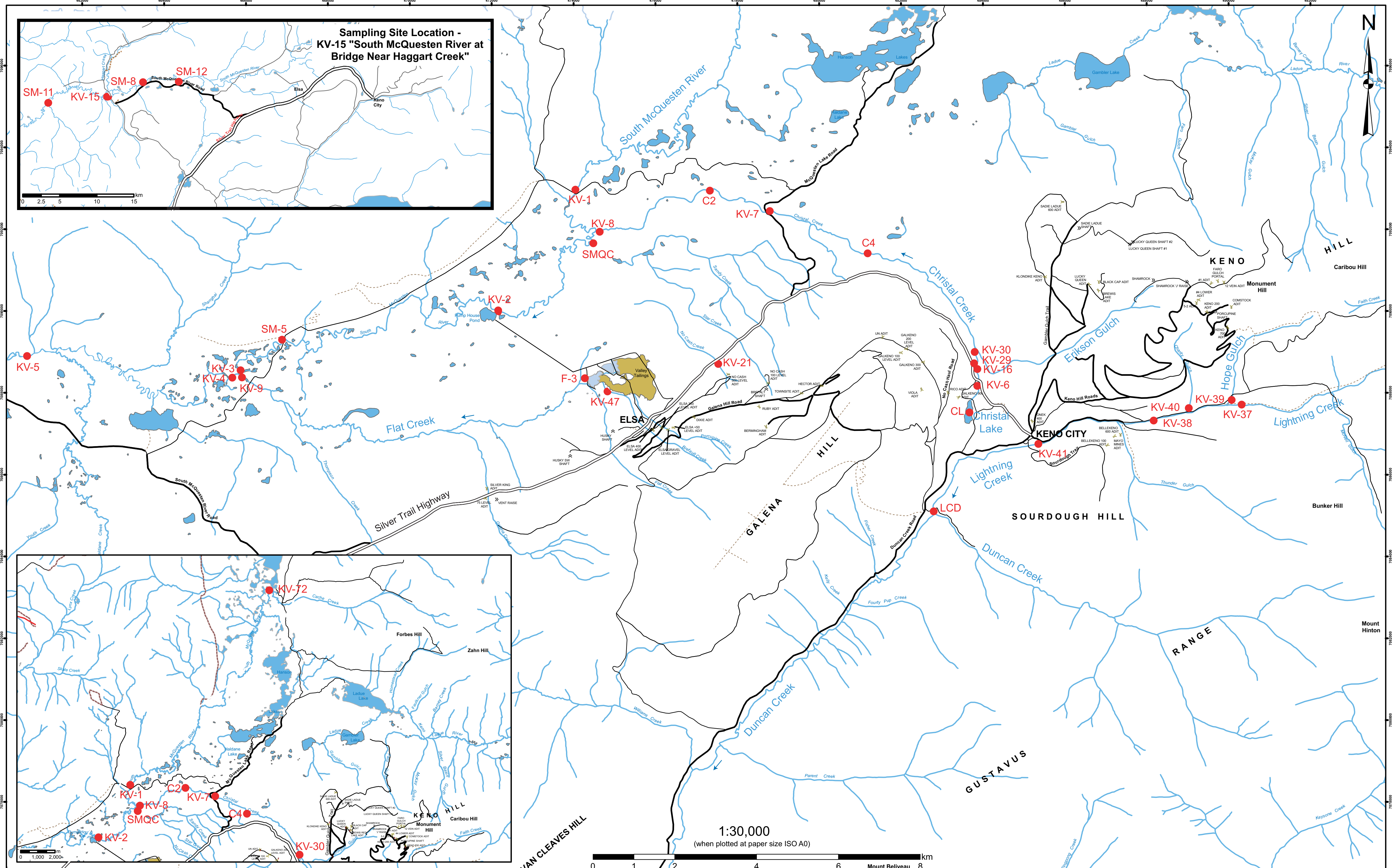
As part of the closure planning process, a water quality assessment for UKHM (Minnow 2008) was completed to evaluate current and historical water quality conditions and provide recommendations with respect to contaminants of concern. This information will support the development of water quality goals and objectives for the watersheds downstream of the mines. It is anticipated that the goals for the tributaries in the UKHM area (Lightning Creek, Christal Creek, Flat Creek) will focus on biological recovery whereas the goal for the main receiver (South McQuesten River) will focus on protection of existing resources (Figure 1.2). This will require an understanding of current biological communities and health in the drainages downstream of UKHM. While numerous chemical and biological studies of the downstream receiving environments have been undertaken in the past, the information has not previously been consolidated into one comprehensive assessment. Therefore, ERDC retained Minnow Environmental Inc. to review and assess the findings of previous studies and prepare an integrated aquatic resource assessment of the available data for the creeks and river downstream of the various UKHM sources.

Figure 1.1

Location of United Keno Hill Mines within the Yukon Territory.

Ref: 2243
Date: March 2009

Source: Access Consulting Group



Legend

Environmental Monitoring

- Sampling Station

Mine Workings

- Adit
- Shaft (to surface - connection to underground not determined)
- Valley Tailings
- Pit

Topography

- Town
- Silver Trail
- Secondary Road
- Limited-use road
- Trail
- Watercourse
- Waterbody

ALEXCO ERDC

Figure 1.2

minnow

Watercourses and Sampling Stations Assessed, United Keno Hill Mines

Ref: 2243
Date: March 2009

Source: Access Consulting Group

1.2 Study Objectives and Approach

The objective of this assessment was to provide an integrated assessment of the available biotic (fish and benthic invertebrate community) and abiotic (water and sediment) data such that current conditions within the headwaters tributaries down gradient of the mine and further downstream in the South McQuesten River are characterized.

This report, along with the Water Quality Assessment Report for United Keno Hill Mines (Minnow 2008), will serve as key supporting documents for other ERDC initiatives, such as preparation of the Closure Plan, determination of water quality goals and objectives, and the development of a long-term monitoring program.

Numerous environmental monitoring studies have been conducted in this area, by environmental consultants (Laberge Environmental Services and White Mountain Environmental Consulting) as well as the Yukon Government, Department of the Environment (Table 1.1). For the purpose of this report a sub-set of recent and historical reports dating back to 1985 were used in this assessment. Generally, the studies assessed were those which employed common stations to allow for comparison of conditions between surveys. While historical surveys were assessed to consider changes over time, the primary focus of this assessment was on the most recent biological surveys in order to characterize current conditions.

1.3 Report Organization

Section 2.0 describes the watersheds within the study area and provides an overview of mine influences and habitat characteristics of each. The results of the recent water quality assessment for UKHM (Minnow 2008) are summarized in Section 3.0. Section 4.0 provides an evaluation of current and historical sediment quality near UKHM while benthic invertebrate community health is described in Section 5.0. An assessment of current and historical fisheries data including community composition, fish condition and metal concentrations in tissues, is discussed in Section 6.0. An integrated summary is presented in Section 7.0 and recommendations in Section 8.0. References cited throughout the report are listed in Section 9.0.

Table 1.1: Environmental monitoring studies conducted at United Keno Hill Mines[a].

Author	Year	Title	Source
McLaren, R.E. and K.C. Lucas	1954	Pollution of streams in the Mayo District, Yukon Territory, December 7, 1954	From DFO Whitehorse Yukon files, unreferenced report
Environmental Protection Service	1978	Assessment of water quality and biological conditions in watersheds surrounding the United Keno Hill Mine, Elsa, Yukon, during the summers of 1974 and 1975	Fisheries and Environment Canada, Reg. Prog. Rep. 78-14
Benthel, G. and I. Soroka.	1981	Compliance evaluation of the United Keno Hill Mines Ltd. Elsa, Yukon Territory	Environment Canada, EPS. Reg. Prog. Rep. 81-23.
Northern Affairs Program	1985	United Keno Hill Mines Ltd. Information sheet for water-use application	
Yukon Territory Water Board	1985	United Keno Hill Mines Ltd. Water Licence Y1N850-O2RL	
Northern Biomes Ltd.	1986	United Keno Hill Mines Ltd., 1986 Benthic Fauna Sampling Program, Flat Creek and South McQuesten River.	Northern Biomes Ltd. 1986.
Northern Biomes Ltd.	1987	United Keno Hill Mines Ltd., 1987 Benthic Fauna Sampling Program, Flat Creek and South McQuesten River.	Northern Biomes Ltd. 1987.
Leverton and Associates.	1988	Biological Monitoring Program, United Keno Hill Mine Site.	Leverton and Associates.
Davidge, D. and G. Mackenzie-Grieve	1989	Environmental Quality of Receiving Waters at United Keno Hill Mines Ltd., Elsa Yukon	No. 89-04. Department of Environment, Environmental Protection, Pacific Region, Yukon Branch
Burns, B.E.	1990	Biological Monitoring Program at Flat Creek and South McQuesten River, Elsa Yukon, 1989	Laberge Environmental Services, 1990
Burns, B.E.	1991	Biological Monitoring Program at Flat Creek and South McQuesten River, Elsa Yukon, 1990	Laberge Environmental Services, 1991
Burns, B.E.	1992	Biological Monitoring Program at Flat Creek and South McQuesten River, Elsa Yukon, 1991	Laberge Environmental Services, 1992
Burns, B.E.	1992	Environmental quality of receiving waters at UKHM Mines Ltd. Elsa Yukon.	Regional Programing Report (draft), Dept. of Env., Env. Protection, Pacific Region, Yukon Branch
Burns, B.E.	1994	Environmental Data Compilation and Initial Monitoring at United Keno Hill Mine Area.	Laberge Environmental Services. 1994.
Environment Protection Yukon Division.	1995	Environmental Quality of Receiving Waters at United Keno Hill Mines Ltd. Elsa Yukon, 1990.	Regional Program Report No. 95-08.
Sparling, P.and M. Connor,	1995	. Fish and Fish Habitat Assessment Conducted Near Elsa, Yukon for United Keno Hill Mines August 1994 – September 1995	White Mountain Environmental Consulting
Access Mining Consultants Ltd.	1996	United Keno Hill Mine Ltd Site Characterization, Technical Appendix I – VI.	Access Mining Consultants Ltd. 1996
Burns, B.E.	1996	Biological Monitoring Survey at United Keno Hill Mine Area, 1994	Laberge Environmental Services. 1996
Environmental Services, Public Works and Government Services	2000	The Keno Valley / Dublin Gulch Environmental Baseline Assessment.	Environmental Services, Public Works and Government Services, March 2000
Burns, B.E.	2004	Receiving Water and Contaminant Pathway Monitoring in the Keno Valley, 2003. Special Projects #3.	Laberge Environmental Services. 2004.
Burns, B.E.	2005	Valley Receiving Water Monitoring Program, 2004/2005.	Laberge Environmental Services. 2005
Burns, B.E.	2006	Keno Valley Receiving Water Monitoring Program, 2005/2006. Two Volumes.	Laberge Environmental Services. 2006.
Sparling, P	2006	Fisheries Assessments Conducted in the Keno Hill Mining Area, Including Metals Analysis of Fish Tissue Samples, 2006	White Mountain Environmental Consulting
Burns, B.E.	2008	Keno Valley Stream Sediment and Benthic Invertebrate Monitoring Programs, 2007.	Laberge Environmental Services. 2008.

Shading indicates reports provided to Minnow for use in the present study.

[a] list may not be exhaustive.

2.0 DESCRIPTION OF STUDY AREA

2.1 Drainage Areas – Natural and Mine-Influenced

UKHM is located within the Stewart River watershed which is part of the Yukon River Basin. Mine drainage to the north is captured in Christal and Flat Creeks which are tributaries of the South McQuesten River (Figure 1.2). The South McQuesten River originates at McQuesten Lake and flows south-west to its confluence with the Stewart River (Burns 2008). Mine drainage to the south is captured in Lightning Creek which flows southwest into Duncan Creek before joining the Mayo River and then discharging into the Stewart River further downstream. This assessment of aquatic resources for UKHM includes the mine influenced tributaries (Lightning, Christal and Flat Creeks) as well as the South McQuesten River (Figure 1.2).

Within the South McQuesten River watershed, Christal and Flat Creeks capture most of the mine-influenced drainage. Christal Creek originates at Christal Lake which receives seepage from mine structures and contains historical deposits of tailings (Burns 2008; Sparling 2006). Downstream of Christal Lake, the creek receives seepage from mine structures located on the west side of Keno Hill and the east side of Galena Hill (Burns 2008) then flows approximately 10 km northwest before it joins the South McQuesten River downstream of McQuesten Lake.

Flat Creek receives mine effluent from the valley tailings impoundment area at its headwaters and from adits on Galena Hill which drain to Flat Creek through small tributaries located along the south side of the drainage area. Flat Creek then flows about 7 km northwest where it drains into the South McQuesten River. Since mine drainage enters Flat and Christal Creeks at their headwaters, there are no upstream locations on these creeks suitable for monitoring background (reference) conditions. One of the historical reference monitoring locations that has been used for water, sediment, and biological studies is located on the South McQuesten River upstream of the confluence of Christal and Flat Creeks (KV-1). However, recently it was observed that water quality began to deteriorate at this location suggesting a possible unidentified upstream source load (Dan Cornett, Access Consulting, pers. comm.). For the purpose of this study, data from KV-1 (up to November 2007) was used as reference data. Another station located at the headwaters of the South McQuesten River (KV-72) and upstream of mine influences has recently been added to the routine monitoring program in order to assess its use as a long term reference location for the South McQuesten watershed (Figure 1.2).

Lightning Creek, a tributary of Duncan Creek, has been subject to placer mining activity and receives drainage from mine adits on Keno and Sourdough Hills (Burns 2008). Lightning Creek upstream of Hope Gulch does not receive mine discharges and serves as an additional reference station for environmental monitoring (station KV-37; Figure 1.2).

In general, the watersheds described above were the focus of past studies although the stations sampled within watersheds often varied between studies. For the purpose of this report, stations that were closely located (e.g. typically within a few hundred meters of each other) were considered the same. A list of station identifiers used in previous studies as well as the ones used in this report is provided in Appendix Table A.1.

2.2 Habitat Characteristics

Detailed data and information describing the habitat characteristics at sampling stations were documented in the summer of 2006 (Table 2.1; Sparling 2006). This information was supplemented by habitat characteristics from other studies with particular emphasis on Sparling and Connor (1996).

Water depths at the time of the 2006 study were generally < 0.5 m in tributaries and 0.6 to 1.2 m in the South McQuesten River, with flow velocities of ≤ 1m/s at most locations, except in Lightning Creek and the mid-reaches of Christal Creek where flow velocities were slightly higher (> 1 m/s) (Sparling 2006). High flows associated with the spring freshet have generally been observed to occur in late May or June while low flows are between February and April. High flows also take place in summer and/or fall due to rainstorms that lead to significant flooding (Burns 2005).

Christal Lake, located at the headwaters of Christal Creek, is a small sub-alpine lake with a bed consisting of organic silt covered with vegetation and tailings piles at various locations around the lake (Table 2.1). Water depths in the lake are generally shallow with an estimated maximum of 3 m.

In general, Christal Creek is approximately 2 to 4 m wide characterized by mainly riffle/run habitat that includes occasional rapids, some pools and meandering reaches, and generally fine (≤ 30% sand/silt) to moderately coarse (gravel and cobble) substrate. From the headwaters of Christal Creek at Christal Lake to approximately 5 km downstream, the creek begins as a narrow (1 – 3 m) meandering channel with moderate flow velocities (0.8 m/s) before flowing through a confined valley with many pools, riffles and substrates of mainly gravel with boulder, cobble and sand (Sparling 2006; Sparling and Connor 1996). Habitat at station C4 is a high gradient, fast-flowing (> 1 m/s)

Table 2.1: Habitat characteristics recorded in June or August[a], 2006, United Keno Hill Mines, Yukon (modified from Sparling 2006) [b].

Characteristic		Lightning Creek		Christal Creek					Flat Creek	South McQueston River				
		KV41	LCD	CL	KV6	C4	KV7	KV8	KV9	KV72	KV1	KV2	KV4	KV15
Station Description	Latitude (hh mm.sss)	63 54.423 N	63 53.594 N	63 54.944 N	63 55.1739 N	63 56.8751 N	63 57.439 N	63 57.170 N	63 55.249 N	64 03.875 N	63 57.601 N	63 56.174 N	63 N	63 53.732 N
	Longitude (hh mm.sss)	135 18.205 W	135 20.739 W	135 19.926 W	135 19.4620 W	135 22.3977 W	135 25.944 W	135 31.038 W	135 41.703 W	135 21.886 W	135 31.879 W	135 34.397 W	135 W	136 01.417 W
	Elevation (feet)	3,053	2,771	-	-	2,263	-	2,099	-	2,221	2,164	-	-	-
	Length of Reach Assessed (m)	250	250	n/a	175	900	350	265	180	650	250	200	-	350
Channel Hydrology	Gradient (narrative or %)	-	-	n/a	gentle	8	-	-	< 1	-	-	-	-	-
	Average Channel Width (m)	9	5	n/a	1 m at a distance 15 m u/s of culvert 3 m d/s of culvert	3	2.8	4	3.5	22	12	17	-	32
	Average Wetted Width (m)	9	3.5	n/a	1 m at a distance 5 m us/ of culvert 2 m d/s of culvert	2.5	2.3	3.5	3.7	18	12	20	-	18
	Average Riffle Depth (m)	-	-	n/a	-	-	-	-	0.2	0.5	0.5	-	-	-
	Average Pool Depth (m)	>1.5	2.2	n/a	1	0.7	1	1.5	0.8	1.7	0.9	>2	-	>1.5
	Average Depth (m)	0.4	0.3	2 (estimate)	0.45 u/s culvert 0.15 d/s culvert	0.4	0.3 August, 0.4 June	0.4	0.3	0.7	0.6	1.2	-	0.7
	Average Velocity (m/s)	>1.5	1.3[e]	n/a	0.8 u/s culvert and pools 1 d/s culvert	>1	1	0.3	0.5	0.5	0.7	0.5	0.7	1
	General morphology	10% pool 10% riffle 80% rapid	10% pool 65% riffle 25% run	n/a	-	10% pool 70% riffle 20% run/rapid	15% pool 25% riffle 60% run	20% pool 60% glide[d] 20% run	20% pool 30% riffle 50% run	30% pool 15% riffle 55% run	15% pool 30% riffle 65% run	30% pool 10% riffle 60% run	-	10% pool 40% riffle 50% run
	Side Channels	u/s of both bridges	none	n/a	10% d/s culvert none u/s culvert	none	none	none	2 small areas	none	none	none	-	1 small
	Stream Flow Characteristics	well-defined channel within a human-made channel, consistenly fast flows d/s of bridge, plunge pools d/s culvert and old bridge	placer mine created channel, very little natural shape, flat bottom in all straight areas, one tight corner has a small deposition bar and deep corner pool, Duncan Ceek Road flattens a shallow riffle.	n/a	shifting sand, gentle meandering, some braiding d/s culvert, u/s highly meandering, small deep pools	channel flows mostly straight, occasional gentle meanders, flat bottom, occasional deep side areas	gentle meanders, channel often straight, extensive modification due to road construction, possible historic placer mining	channel confined in an open flood plain u/s of mouth, opens to series of 3 small pools at mouth	-	channel narrows becoming partially entrenched 300 d/s of lake	gentle meanders, flat-bottomed channel	mostly slow, even flows, deep riffles that do not scour substrate, wide curves and gentle meanders create large corner pools and debris traps	-	shifting channel, loose bed load and large deposition apron on one bank below confluence with Haggart Creek
Channel Bed and Bank Features	Bed Material	loosely compacted boulders in old placer mined area	well sorted, slightly compacted granular materials	organic silt with thick vegetative cover, small tailings piles at south end of lake	small gravel and sand moderately consolidated d/s culvert, fine silts and sand u/s culvert in pool, coarse consolidated substrate and some black mat u/s pool	mostly flat angular rocks tightly compacted	mostly concreted gravel and cobble, submerged bridge timbers	mostly fine with occasional cobble pockets, loosely consolidated	coarser away from mouth, moderately compacted and silted with algal growth	fine loose gravel with sandy edges near lake, coarser substrate with cobble and occasional boulders 300 m d/s	well compacted with very few smalls	highly compacted and very stable, extensive algal growth	-	loosely consolidated and shifting gravels
	Substrate (%)	10% sand 15% gravel 15% cobble 60% boulder	15% sand 40% gravel 40% cobble 5% boulder	-	10% sand/silt, 90% gravel d/s culvert, 100% fines u/s culvert in pool, 10% fines, 20% gravels, 30% cobble, 50% boulders u/s pool	10% sand 20% gravel 50% cobble 20% boulder occasional bedrock	15% sand 60% gravel 25% cobble	30% sand/silt 65% gravel 5% cobble	40% gravels 60% cobble fines in side channel	25% sand 50% gravel 20% cobble 5% boulder	10% sand (near ford) 20% gravel 50% cobble 30% boulder	30% sand 20% gravel 35% cobble 15% boulder	-	20% sand 60% gravel 20% cobble
	Bank Condition	shallow rising evenly and abruptly 0.5 to 1 m, modified by placer mining, culvert and old bridge	very even, human-made banks in placer mined area, abrupt rise of 0.5m to open flood plain	east shoreline mostly stable, west shoreline eroded, low, non-confining banks at outlet, marshy near outlet with beaver dam across entire width of lake	banks non-confining 20 m open flood plain d/s culvert, hill partially contains u/s, entrenched with abrupt 1 to 2 meter banks further up	mostly confined, occasionally entrenched, banks abrupt, rising 0.8 to >2m	confining, with >1m rise at bankful levels, open flood plain	abrupt, often undercut, rise 0.6 to 1.5 m above water line, less steep and washed from spring flooding at mouth	abrupt and confining rise 0.7 to 1.8m, open flood plain beyond	shallow, well-defined banks at McQuesten Lake outlet, entrenching 300 m d/s	old road crossing ford, banks well defined, mostly abrupt with 0.6 to 1.5m rise to open flood plain	stable and abrupt, rising 0.8 to 1.5 m above water line, 50% of bank areas undercut	-	open and exposed on one side, confined and deeper on other side
Riparian Features	Riparian Vegetation	willow, alder	willow, sedge	mature spruce, alder, birch, willow, poplar	willow and sedge	mostly alder with birch, willow, spruce	willow, spruce, alder	willow, sedge	willow, alder, spruce	mature spruce, sedge, covered flood plains	willow, alder, spruce	mature spruce, willow, alder	-	mature spruce, alder
In-stream Fish Habitat Features	Debris	few sticks	none	-	none	very few sticks and bridge timbers	some sticks and bridge timber	occasional LOD[c] and sticks	log piles and sticks	very little	occasional stick pile	stick piles	-	stick and log pile in corner
	Cover	plunge pools, perched boulders, turbulence	side banks, corner pool, light turbidity	thick aquatic vegetation	grass banks d/s of culvert, willow overhang u/s culvert and pools	perched flat rocks, cut banks, turbulence	limited, stick wads, cut banks, timber	LOD[c], small cobbles, limited amounts	LOD[c] and undercut banks	scoured banks with roots, pools, depth	boulder, cut banks, turbulence, muck	depth, sumberged sticks, cut banks	-	corner pool with debris, cut banks and depth
	Overhead Cover (%)	50	>5	n/a	15% d/s culvert 80% u/s culvert and pools	80	65	15	5	2	15	1	-	>2

[a] data collected in early September at station KV2
[a] information on all stations except station SMQ C was available in Sparling (2006)
[c] abbreviation used in Sparling (2006) possibly referring to "Large organic debris"
[d] the term "glide" is redundant with "run" and is therefore a possible data entry error in Sparling (2006)
[e] text in Sparling (2006) report indicates that velocity at LCD is < 1 m/s
Note: percentages reported for KV1 and KV6 substrate and KV1 pool, riffle, run sum to > 100%
n/a not applicable

riffle/rapid reach that flows straight with occasional meanders and pools. This reach flows over mainly gravel, cobble and boulder substrate through a steep canyon and has been subject to placer mining activity (Sparling 2006; Sparling and Connor 1996). Approximately 3 km downstream of C4, the reach at station KV-7 is straight with some meanders and moderate flows (1 m/s) (Sparling 2006) over mostly concreted gravel and cobble, while downstream at station C2, the creek flows through a wetland area that has generally well-defined banks (Sparling and Connor 1996). Station KV-8 at the mouth of Christal Creek consists of a confined channel with low average velocity (0.3 m/s) and substrate of mostly gravel with a relatively high proportion of sand/silt (30%) and some cobble (Table 2.1; Sparling 2006). Partial or complete barriers to flow and fish movement occur in Christal Creek (Sparling 2006; Sparling and Connor 1996). Several beaver dams present barriers along Christal Creek (Sparling and Connor 1996) as well as a large beaver dam in Christal Lake that controls water levels (Sparling 2006). Three barriers consisting of bridge timbers and stick jams, two of which are over a meter high, are located on Christal Creek at station C4. Christal Creek has been subject to extensive ice-damming which has been reported to persist until late spring (Sparling and Connor 1996).

Lower Flat Creek (KV-9) is characterized by riffle/pool sequences with average channel widths of approximately 3.5 m and areas dominated by either cobble/gravel or gravel/sand substrate (Table 2.1; Sparling 2006; Sparling and Connor 1996). Suitable fish habitat along Flat Creek is thought to be limited to a reach spanning approximately 400 m upstream of the mouth (Sparling 2006; Sparling and Connor 1996). Further upstream there are few cobble/gravel, riffle/pool sequences and a high proportion of bottom substrates dominated by coppery hued silt and mud which have been suggested to be old tailings (Sparling and Connor 1996). Log and stick debris found in many of the riffle areas of KV-9 in Flat Creek represent partial barriers to flow and fish movement (Sparling 2006).

Lightning Creek is wider than the other tributaries (3.5 to 9 m wetted width at time of survey) and characterized by coarse substrate including gravel, cobble and boulder and relatively fast water (> 1 m/s) in some up-stream areas, flowing as riffles and rapids (Table 2.1; Sparling 2006). Station KV-41 was noted as having turbid water at the time of the survey and also has plunge pools associated with a culvert and old bridge (Sparling 2006). Habitat at station LCD, at the confluence with Duncan Creek, includes some meanders and pools in addition to riffles and runs (Sparling 2006; Sparling and Connor 1996). The reach encompassing stations KV-41 and LCD has been largely straightened and ditched as a result of historical placer mining activity (Sparling and Connor 1996).

Among the stations assessed during the 2006 survey, average depths and velocities in the South McQuesten River were comparable to the tributaries whereas channel and wetted widths were notably greater (overall range of 12 to 32 m; Table 2.1; Sparling 2006). Channel morphology includes meandering reaches accompanied by slow moving water and sloughs, riffle/run habitat and some deep, often silted pools. At the headwaters of the South McQuesten River, in the vicinity of reference station KV-72 downstream of McQuesten Lake, a plume of chalky turbidity is apparent as Cache Creek enters the river. Further downstream bottom substrate is largely comprised of gravel and cobble with a relatively high proportion of boulder at reference station KV-1 (Sparling 2006). Downstream of Flat Creek to station KV-15, silt substrate is more common (Sparling and Connor 1996) as the river flows through a large wetland and exhibits deep, wide runs in several locations (Sparling and Connor 1996).

3.0 WATER QUALITY

3.1 Approach

Data were analysed for 20 water quality stations located on permanent surface water courses upstream (reference/background) and downstream (receiving environment) of mine-related disturbances or inputs (e.g., roads, rock piles, adits, tailings area, etc.). These stations were located on various tributaries (Lightning Creek, Christal Creek, Flat Creek and No Cash Creek) and the South McQuesten River. The database used in the assessment covered the period from 1994 to spring 2007, although some data from early years were removed for some parameters because method detection limits exceeded the water quality guidelines to which the data were being compared (Minnow 2008). Also, outliers were removed to ensure the assessment was not biased by erroneous data or rare extreme events. Data from mine-exposed areas were compared to background concentrations and water quality guidelines to identify substances and locations with elevated concentrations.

3.2 Current Water Quality

The benchmark selected for screening water quality parameters was either a summary statistic (mean ± t-value x standard deviation) of reference station KV-1 and KV-37 data or the applicable water quality guideline, whichever was higher and available. There has been some concern recently that the water quality at KV-1 began to be impacted by an unknown upstream source resulting in increased concentrations (Dan Cornett, Access Consulting, pers. comm.). Review of water quality at KV-1 indicates that metal concentrations began to rise in mid-2006 (Appendix Figure B.15) thereby possibly leveraging background values presented in the Water Quality Assessment Report (Minnow 2008) which incorporated data up to June 2007. As a result, a recommendation of the water quality assessment was that a comparative assessment of the two background stations on the South McQuesten River should be undertaken when more data at the new reference area (KV-72) are available (Minnow 2008).

Numerous parameters measured at stations within the various watersheds downstream of UKHM exceeded benchmark concentrations in at least 10% of samples (Table 3.1). However, a much smaller set of parameters and locations had concentrations above benchmarks at a high frequency (at least 50% of samples or median value) and/or magnitude (Table 3.2). These parameters, identified as potential contaminants of concern (PCOCs), included: aluminum, arsenic, cadmium, chromium, copper, iron, lead,

Table 3.1: Parameters exceeding both background concentrations and water quality guideline (if available) in more than 10% of samples collected at each location. Parameters in bold exceeded highest benchmark (background or guideline) in more than 50% of samples (i.e. median value exceeded both benchmarks) [1,2,3].

Watercourse	Station	Parameter
Lightning Creek	**KV39**	**As**, **Cd**, Pb, **NO_2**, **Zn**
	KV40	NO_2, **Se**, S
	KV38	Ag
	KV41	Al, As, Cr, Fe, Pb, NO_2, Si, Ag, TSS, Zn
Christal Creek	**KV6**	As, **Cd**, Ca, Conductivity, Hardness, Fe, **Pb**, Mg, Mn, NO_2, Se, Si, Ag, **SO_4**, S, TSS, U, **Zn**
	KV16	As, **Cd**, Ca, Cr, Conductivity, Hardness, Fe, Pb, Mg, Mn, **NO_2**, **P**, Se, Si, Ag, Sr, **SO_4**, S, U, **Zn**
	KV29	Alk-T, Al, As, **Cd**, Ca, Cr, Co, Conductivity, Cu, Hardness, Fe, Pb, Mg, **Mn**, **NO_2**, P, Si, Ag, Sr, **SO_4**, S, TDS, TSS, U, V, **Zn**
	KV30	Al, As, **Cd**, Ca, Cr, Conductivity, Hardness, Fe, Pb, Mg, Mn, **NO_2**, P, Si, Ag, Sr, **SO_4**, S, TDS, TSS, U, **Zn**
	KV7	As, **Cd**, Ca, Cr, Conductivity, Hardness, Fe, Pb, Mg, NO_2, Si, Ag, **SO_4**, S, TSS, **Zn**
	KV8	**Cd**, Ca, Conductivity, Hardness, Fe, Pb, Mg, NO_2, P, Si, Ag, Sr, **SO_4**, S, **Zn**
No Cash Creek	**KV21**	**Al**, **Cd**, Ca, **Cr**, **Cu**, Hardness, Fe, **Pb**, Mg, **Mn**, **NO_2**, S, **Zn**
Flat Creek	**KV47**	Al, As, HCO_3, **Cd**, Ca, Cr, Conductivity, Hardness, **Fe**, Pb, Mg, Mn, Si, **Ag**, Sr, S, TDS, TSS, **Zn**
	KV9	HCO_3, Ca, Cd, Conductivity, Hardness, Fe, Pb, Mg, Ag, **SO_4**, S, Zn
South McQuesten River	**KV2**	Conductivity, Fe, Ag
	KV3	Ag
	KV4	Conductivity, Fe, Pb, Ag, Zn
	KV5	Conductivity, P, Ag
	KV15	As, Conductivity, Fe, Ag, TSS

□ parameters for which 50% or more of samples were below the method detection limit but above the guideline value

[1] 17 parameters were screened against only background or guideline since both were not available

[2] pH and total alkalinity (Alk-T) were screened for >10% of samples that were below benchmarks.

[3] CN and Hg were not included due to small sample sizes

Table 3.2: Locations where parameter concentrations exceeded both background levels and guideline (if available) in 50% or more of samples (i.e. median value exceeded). Highlight indicates median values exceeded benchmark(s) by a factor of two or more. Sample sizes (n) shown in parentheses for each parameter/location [1].

Watercourse	Station	Aluminum	Arsenic	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Nitrite	Phosphorus	Selenium	Silver	Sulphate	Zinc
Lightning Creek	KV39		√ (2)	√ (2)						√ (2)					√ (2)
	KV40											√ (1)			
	KV38														
	KV41														
Christal Creek	KV6			√ (36)				√ (35)						√ (21)	√ (81)
	KV16			√ (35)						√ (3)	√ (16)			√ (19)	√ (42)
	KV29			√ (35)					√ (40)	√ (4)				√ (22)	√ (42)
	KV30			√ (34)						√ (3)				√ (19)	√ (41)
	KV7			√ (37)										√ (20)	√ (79)
	KV8			√ (34)										√ (20)	√ (40)
No Cash Creek	KV21	√ (2)		√ (1)	√ (1)	√ (1)		√ (1)	√ (2)	√ (1)					√ (2)
Flat Creek	KV47			√ (3)			√ (14)						√ (2)		√ (16)
	KV9													√ (6)	
South McQuesten River	KV2														
	KV3														
	KV4														
	KV5														
	KV15														

√ median exceeded background and / or guideline

(#) sample size

[1] 4 parameters (ammonia, beryllium, nitrate and nitrite) were screened only against guideline since a background benchmark was not available

manganese, nitrite, selenium, silver, sulphate and zinc (Appendix B). These generally occurred in the tributary stations located immediately downstream of mine sources (Christal Creek, Lightning Creek, Flat Creek and No Cash Creek; Figure 1.2). Due to insufficient data and/or adequate analytical method detection limits at some or all stations, risks to aquatic biota related to aluminum, arsenic, chromium, copper, cyanide, manganese, mercury, nitrite, phosphorus, selenium and silver could not be definitively determined; however, the data suggested that the spatial extent and/or magnitude of any influence from these parameters was likely limited. Additional data need to be collected to determine if these parameters should be considered COCs at UKHM (Minnow 2008).

Based on the above, lead, sulphate, cadmium and zinc were retained as preliminary COCs and examined further. Lead was identified as mainly in the particulate form and therefore of low bioavailability, and concentrations of sulphate downstream of mine sources were below levels associated with toxic responses among aquatic biota; hence, lead and sulphate were eliminated as COCs. The final stages of the water quality assessment identified cadmium and zinc as key COCs in water at UKHM, with highest and most frequent elevations evident in Christal Creek (Minnow 2008). Since 1994 concentrations of zinc in Christal Creek have generally decreased and there is evidence of a similar trend for cadmium from mid-2004 to 2007 (Minnow 2008). While cadmium and zinc concentrations in tributaries downstream of UKHM may cause toxicity to some species, concentrations in the South McQuesten River are currently below levels of concern.

4.0 SEDIMENT QUALITY

4.1 Approach

Sediment quality near the UKHM was evaluated using the results of studies conducted in 1985 (Davidge and MacKenzie-Grieve 1989), 1994 (Burns 1996), 2004 (Burns 2005) and 2007 (Burns 2008). Metal concentration data for sediments sampled from reference and mine-exposed stations located along three tributaries (Lightning Creek, Christal Creek and Flat Creek) and the South McQuesten River were compiled and summarized to allow comparisons against applicable sediment quality guidelines and to assess sediment quality spatially and temporally.

Some study-to-study variability has occurred in terms of sampling station locations, laboratory methods/instrumentation, as well as the parameters reported. Triplicate samples were collected in 2004 and 2007 at each station using a trowel, whereas a single composite sample from each station was taken by trowel in 1994, and triplicate samples collected in 1985 were either taken by scoop shovel (slow flowing areas) or corer (fast-flowing waters). In addition, 1985 sediment samples were frozen prior to analysis while samples from other years were kept cool but not frozen. Furthermore, samples taken in 1994, 2004, and 2007 were (presumably) oven-dried before analysis, samples taken in 1985 were freeze-dried (D. Davidge, personal communication). Lastly, only the portion of the dried sediments passing through a 0.15mm sieve was analyzed in 1985 and 1994, whereas a sieve size of 0.053 mm was used in 2004 and 2007.

Sediment metal chemistry data from each study were compiled and mean sediment metal values were calculated (except in 1994 when there was no replication) for each metal and sampling station. Spatial comparisons with respect to mine influences, an assessment of temporal patterns, and comparisons to applicable federal and provincial sediment quality guidelines were undertaken. Guidelines considered included, in order of preference, the Probable Effect Level (PEL) of the Canadian Council of Ministers of the Environment (CCME 1999), British Columbia Sediment Quality Guidelines (PEL if available; BCMOE 2006) and the Severe Effect Levels (SEL) defined by the Ontario Ministry of Environment (OMOE 1993; Appendix Table C.1). PELs are described as the concentration of a contaminant in sediment above which “significant and immediate hazards to exposed organisms” (CCME 1995, p. 19) are likely to occur. Ontario SELs are similarly defined as concentrations above which the health of the majority of benthic species may be impaired. However, these guidelines apply to whole (bulk) sediments, so comparisons to data for selected fractions of sediment (e.g., the fine fraction concentrations reported for previous sediment analyses at UKHM) must be interpreted with caution.

4.2 Sediment Quality

In 2007, arsenic concentrations in fine-grained sediments exceeded the PEL at all stations, but only slightly so at reference station KV1, whereas the mean arsenic concentration at reference station KV37 on Lightning Creek was more than 6 times the PEL (Table 4.1). Arsenic concentrations in the fine fraction of sediment samples collected at mine-exposed stations were as much as 34 times the PEL (KV9).

Concentrations of other metals measured in sediments from reference stations KV1 and KV37, as well as mine-exposed station KV41 (Lightning Creek) were low relative to guidelines and the other stations. Sediment metal concentrations were generally highest at KV9 on Flat Creek, although concentrations of cadmium, lead, and zinc were well above sediment quality guidelines in the fine fraction of the sediments analyzed from most mine-exposed stations, including stations in the South McQuesten River downstream of mine inputs.

Comparison to sediment data from previous years did not indicate any consistent increasing or decreasing trends (Appendix Tables C.2 to C.5), although this may be partly attributable to differences in sampling methods or analysis among studies (Section 4.1). Elevations in sediment levels of arsenic, cadmium, lead and zinc were also evident at mine-exposed stations sampled in previous years (Appendix Tables C.3 to C.5). As observed in 2007, sediment metal concentrations were generally highest in Flat Creek (KV9) in 1994, but concentrations observed in 2004 were generally highest in Christal Creek, particularly at Station KV6 (Figure 4.1).

As metal concentrations and particle size distributions in whole sediments collected near UKHM have not been analyzed, the significance of elevated metal levels in the fine fraction of sediments with respect to potential effects on biota cannot be determined without an understanding of the proportion of fines within the sediment. For example, if the fines represent a small portion of the total (bulk) sediment then the effects of the metal concentrations are likely less than would be suggested based on comparison to sediment quality guidelines (which are based on whole/bulk sediments). Such analyses should be done to determine the relevance of future sediment monitoring for assessing ecological health and tracking conditions over time in the drainages downstream of UKHM.

Table 4.1: Mean concentrations of selected metals in sediment exceeding applicable guidelines, United Keno Hill Mines, Yukon, 2007 [a, e].

Parameter	Units	MDL[b]	Selected Sediment Quality Guidelines[c]		Lightning Creek			Christal Creek			Flat Creek	South McQuesten River				
			Guideline	Value	KV37	KV38	KV41	KV6	KV7	KV8	KV9	KV1	KV2	KV3	KV4	KV5
Arsenic	ug/g	0.2	CCME	17	115	433	63	284	35	190	586	18.8	235	130	180	124
Cadmium	ug/g	0.05	CCME	3.5	2.7	31.2	3.4	28.2	3.7	24.8	57.1	3.3	18	14	17.0	12
Iron	ug/g	1	BCMOE	43,766	27,633	34,833	26,000	27,133	20,367	34,600	75,533	17,533	28,267	25,467	31,800	30,000
Lead	ug/g	0.3	CCME	91.3	40.0	642	82.2	954	56.4	498	6,290	13.9	707	423	985	271
Manganese	ug/g	0.3	OMOE	1,100	708	2,167	650	3,277	758	3,140	< 0.3[d]	754	3,600	3,117	4,303	4,290
Mercury	ug/g	0.003	BCMOE	0.486	0.08	0.23	0.055	0.1	0.068	0.14	0.589	0.054	0.109	0.09	0.173	0.11
Nickel	ug/g	0.1	BCMOE	75	30	42.3	30.4	27.9	22.6	44.1	32	74.0	92.2	69.4	66.8	133
Selenium	ug/g	0.3	BCMOE	2	1.4	2	0.8	2.5	1	3.6	11.0	1.2	3	2.5	3.5	3.4
Zinc	ug/g	0.5	CCME	315	125	1,637	247	1,483	404	2,067	3,143	512	1,410	1,054	1,333	1,400

[a] Reported by Burns (2008)

[b] MDL = method detection limit

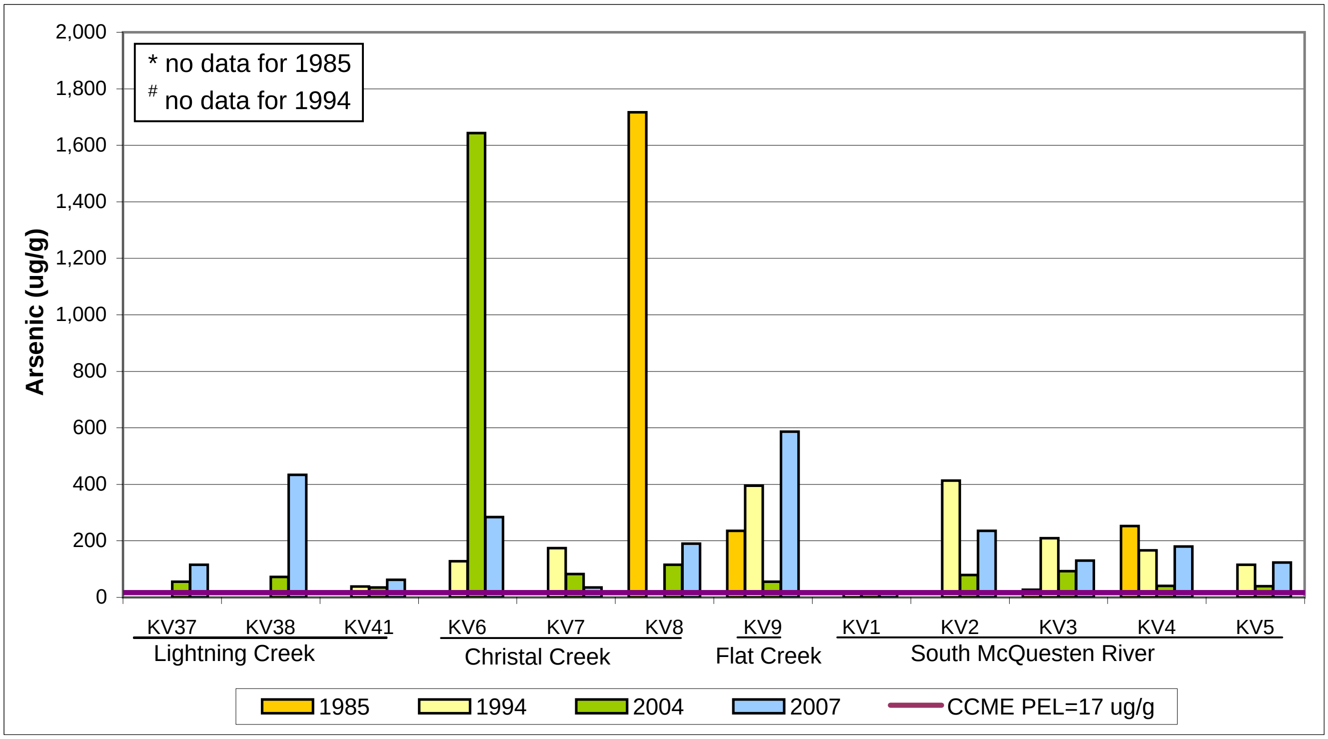
[c] see Table C.1 for explanatory footnotes

[d] concentration considerably lower then all other values and therefore considered suspect

[e] values represent means of three replicate samples

Note: concentrations measured using very fine-sized sediment (i.e. fraction passing through a 0.053 mm sieve)

Shading indicates selected benchmark and measured values exceeding benchmark.



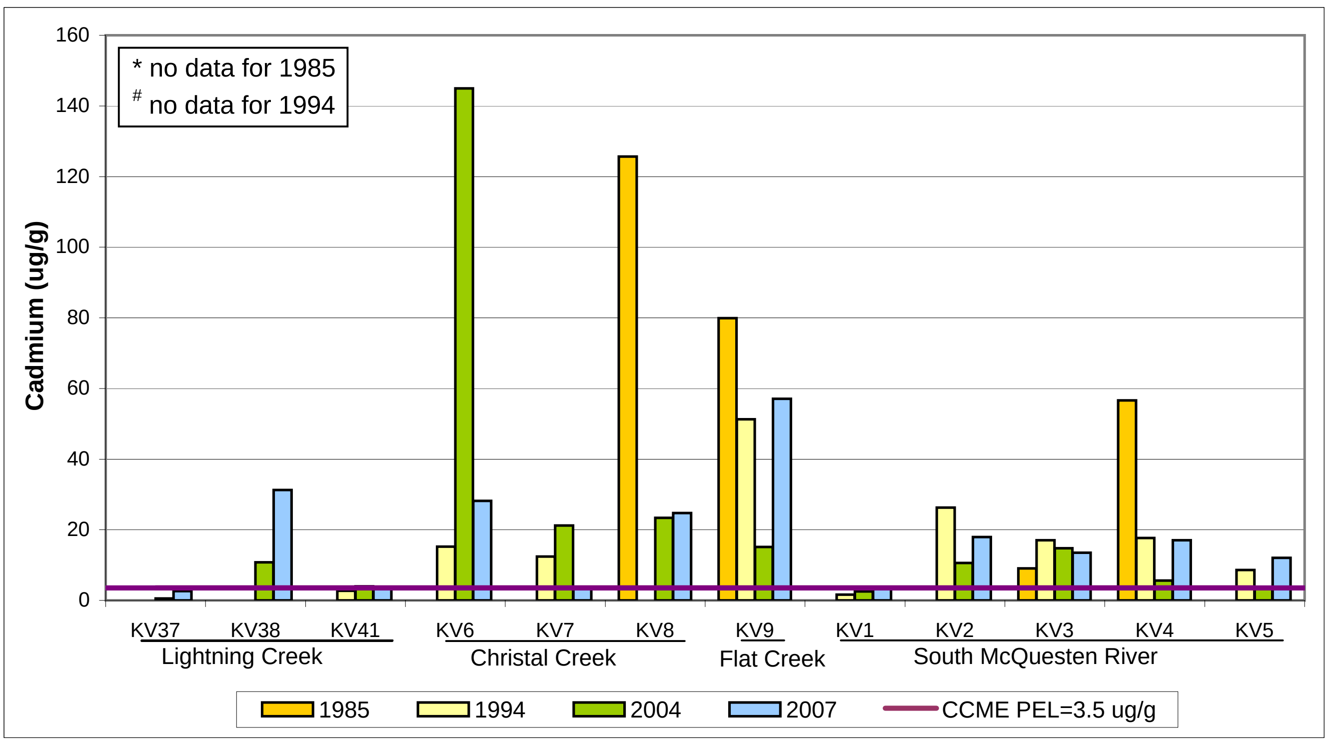
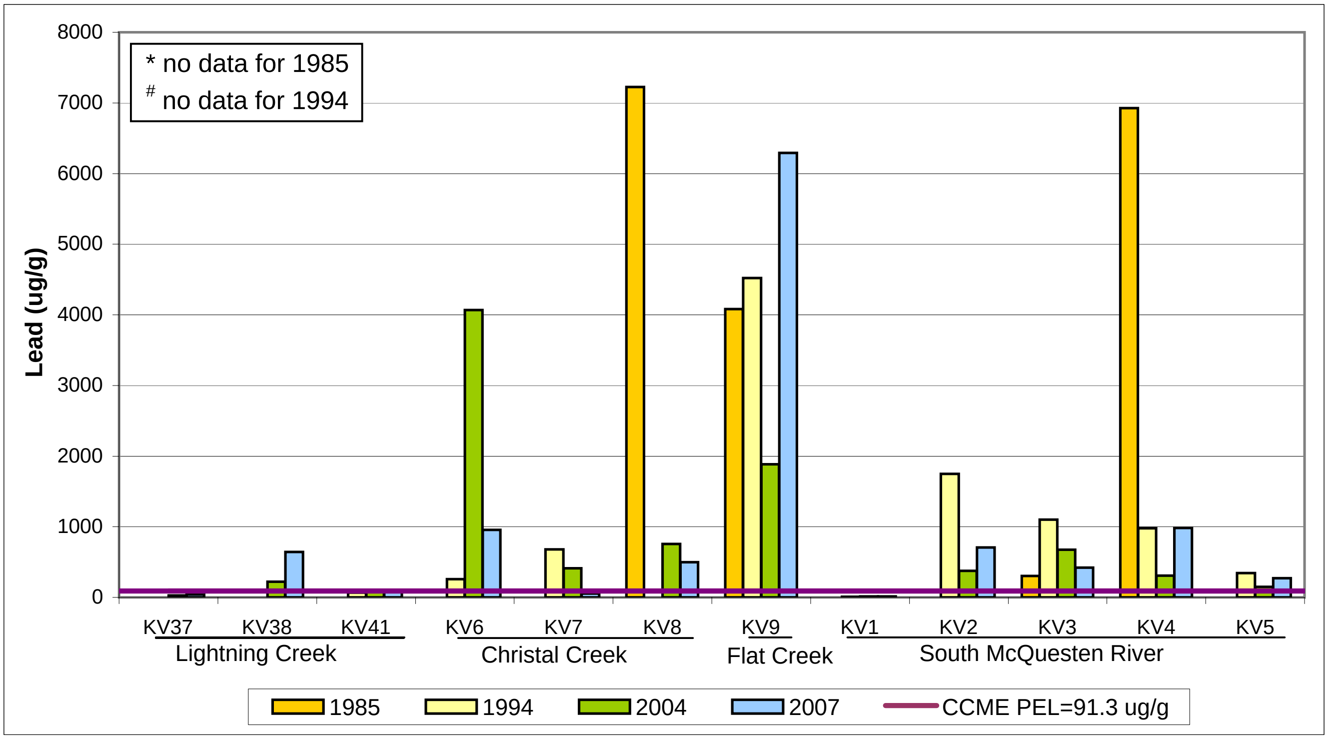


Figure 4.1: Concentrations of metals in fine fraction of sediments near United Keno Hill Mine, 1985 - 2007.



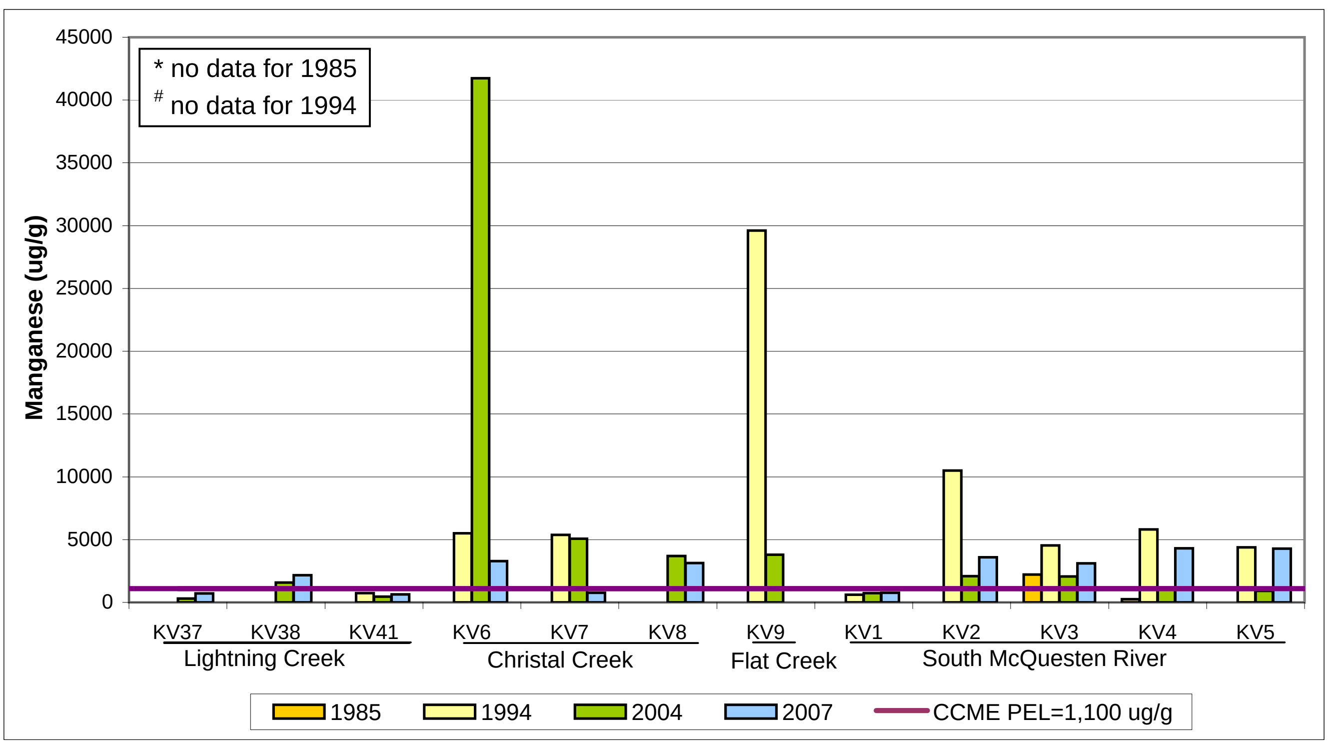


Figure 4.1: Concentrations of metals in fine fraction of sediments near United Keno Hill Mine, 1985 - 2007.

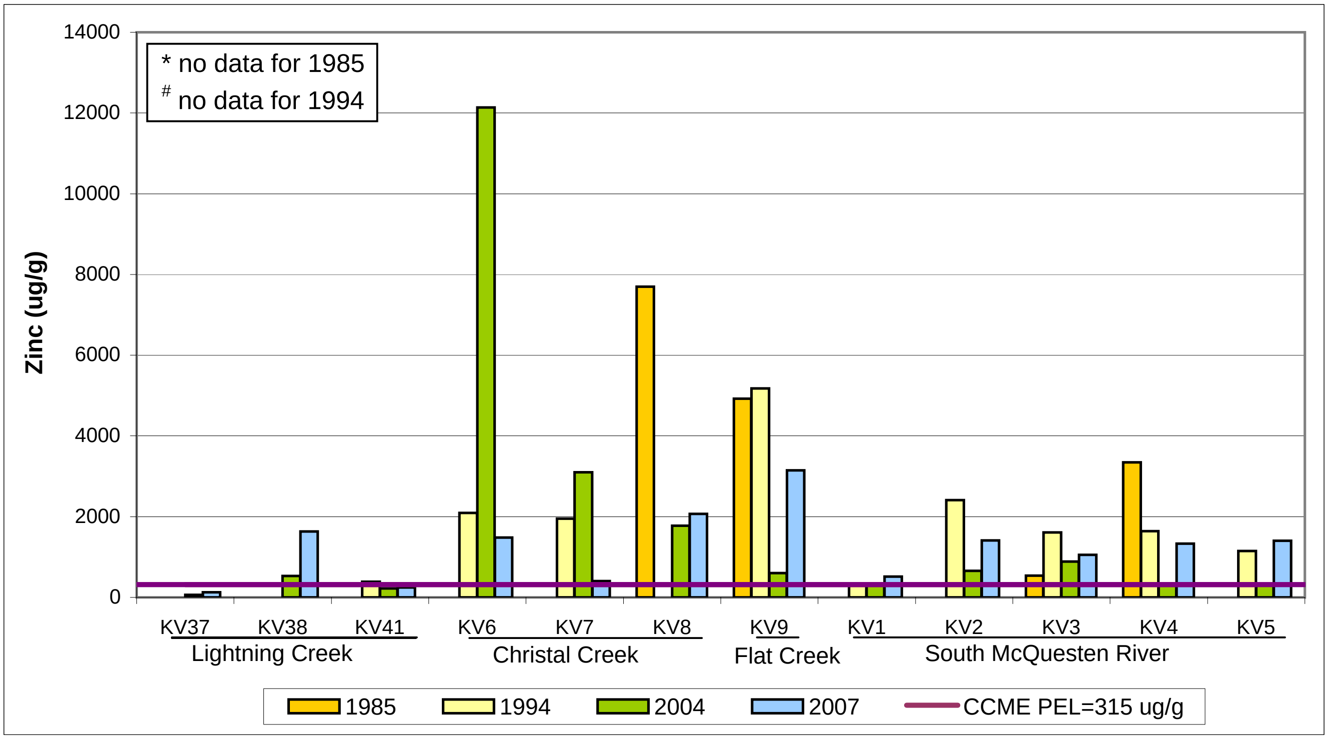


Figure 4.1: Concentrations of metals in fine fraction of sediments near United Keno Hill Mine, 1985 - 2007.

5.0 BENTHIC COMMUNITY

5.1 Approach

Benthic community data from 2007 (Burns 2008) were evaluated and compared to data from previous studies conducted in 1994 (Burns 1996), and 1985 (Davidge and Mackenzie-Grieve 1989). All three surveys were based on artificial substrates (rock baskets) deployed for approximately six weeks in mid-summer. Benthic invertebrates retained by a 500 um (1985) or 300 um (1994 and 2007) sieve were identified to the lowest practical level, which was species, genus, or higher taxonomic classifications, depending upon the degree of precision permitted by available taxonomic keys and the experience of the taxonomist.

The benthic communities at each station were summarized on the basis of various commonly used metrics, including abundance, number of taxa, and relative abundance of major taxon groups (abundance as a percentage of total individuals in the sample). At times, in comparing stations or areas, it was necessary to collapse some taxa to a higher level of organization in order to avoid biasing comparisons of stations or areas. Unidentifiable immature stages of a genus, if numerous, were sometimes proportionally attributed to species within the same genus identified at that or nearby stations. Pupae, in contrast, cannot be attributed proportionally to known taxa, since pupae found in a sample represent only that subset of the known taxa that are at the emergence stage of their life cycle. Consequently, pupae are not counted as a member of a taxon in summary metrics.

A large number of water chemistry variables (pH, hardness, nutrient, and metal concentrations) were measured at benthic macroinvertebrate sampling stations over a 3-year period (mid-2004 to mid-2007 water quality data provided by Access and Burns 2008). It is not possible to reliably determine the associations between a large suite of benthic metrics and a large set of supporting measures (water chemistry, sediment chemistry, etc.) due to the increased probability of declaring false positive relationships. To reduce the number of correlations and minimize false associations between supporting measures and benthic metrics, Principal Components Analysis (PCA) of $\log_{10}(x + 1)$ metals concentrations was used to reduce the median values (mid 2004 – mid 2007) of the 18 commonly measured water chemistry variables to a reduced suite of four PCA variables (PCA axes). However, since the number of stations was small relative to the number of variables, the PCA results must still be viewed with some caution.

Potential relationships between benthic metrics and water chemistry were examined using Pearson correlations calculated between the PCA (3-year median water chemistry) results and the suite of benthic community metrics. Owing to the large number of tested correlations, a Bonferroni-type correction was also applied, to minimize the risk of falsely declaring relationships.

5.2 Benthic Communities

Organism abundance often decreases in environments exposed to toxic effluents, but organic enrichment effluents (i.e., high in nutrients) can cause increases in abundance to high levels before declining in response to anoxia or smothering. Mean abundances were lowest in lower Christal (KV7, KV8) and Flat (KV9) Creeks (Figure 5.1a). Mean abundances were highest at KV5 in the South McQuesten River and KV6 in upper Christal Creek.

The number of benthic taxa per station is a simple and robust expression of benthic community diversity. Community diversity, and by extension, number of taxa, tends to decline in areas exposed to toxic concentrations of contaminants and may either increase (at low levels) or decrease (at high levels) in areas exposed to enriching effluent discharge. Number of benthic taxa had lowest mean value at KV7, KV8 and KV6, all located on Christal Creek (Figure 5.1b). Flat Creek station KV9, receiving drainage from the Valley Tailings management area was also characterized by low numbers of taxa. Stations on Lightning Creek (KV37, KV38, KV41) tended to have moderate to high numbers of taxa. All areas of the South McQuesten River had moderate to high numbers of taxa.

In many situations, abundance increases or decreases in a correlated manner with number of taxa, which was observed at UKHM benthic sampling stations (Figure 5.2a). The few samples from 1985 tended to have both low abundance and low number of taxa compared to more recent years, possibly reflecting different methods for sample collection or analysis rather than environmental differences. Samples from 1994 and 2007 showed similar patterns of variation in abundance and number of taxa, with samples at station KV5 in the South McQuesten River (1994) exhibiting maximal abundance. Samples at station KV5 and KV4 in both 1994 and 2007 generally showed high abundance and number of taxa, whereas stations KV7, KV8 (Christal Creek) and KV9 (Flat Creek) had lowest values of both metrics (Figure 5.2a).

Dominant taxa included both chironomid (non-biting midge) larvae, and representatives of the “sensitive” EPT (Ephemeroptera, Plecoptera, Trichoptera) orders (Figure 5.1c,d).

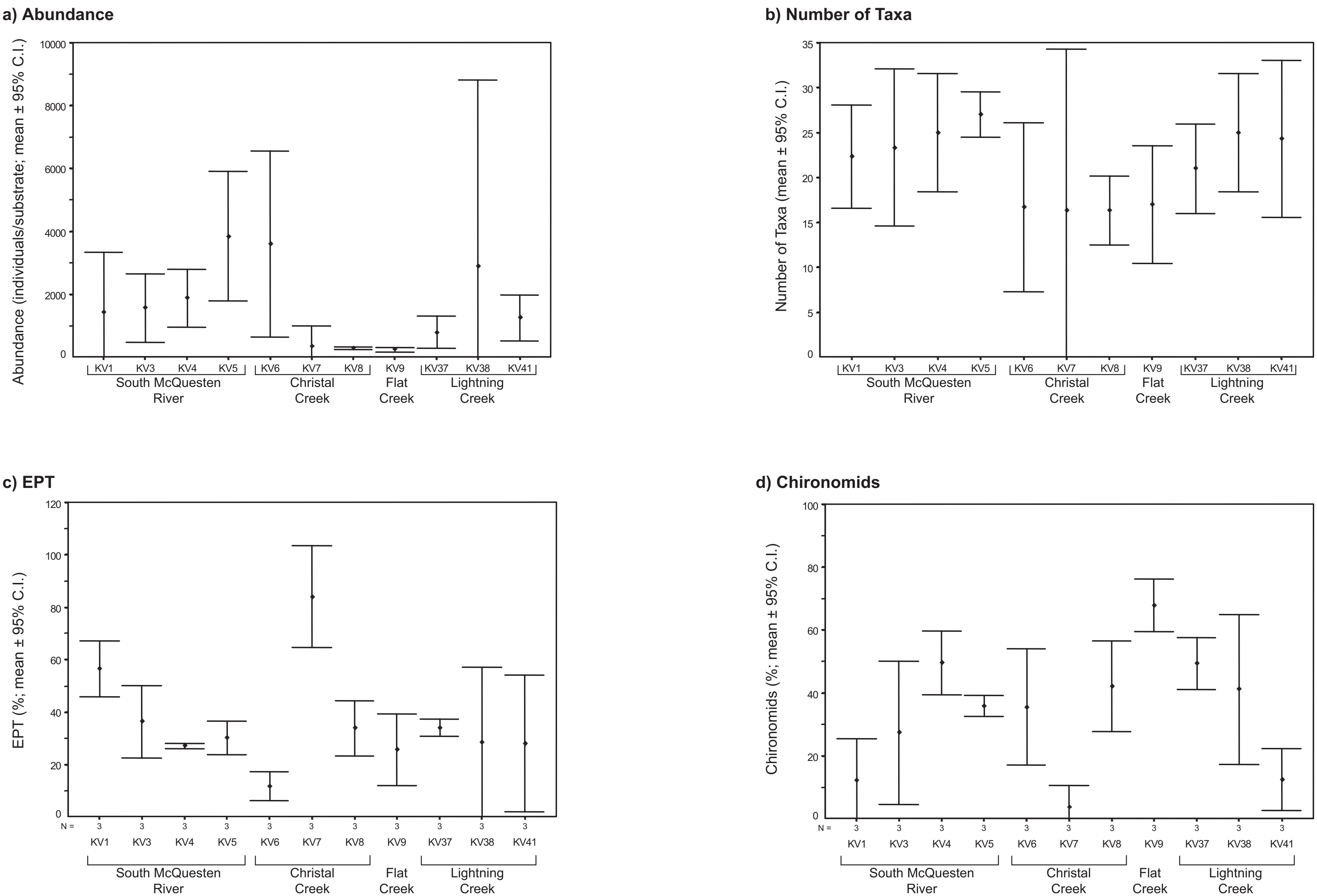


Figure 5.1: Mean benthic invertebrate community metrics by station. Values shown are mean ± 95% confidence intervals (n=3 for each station). United Keno Hill, 2007.

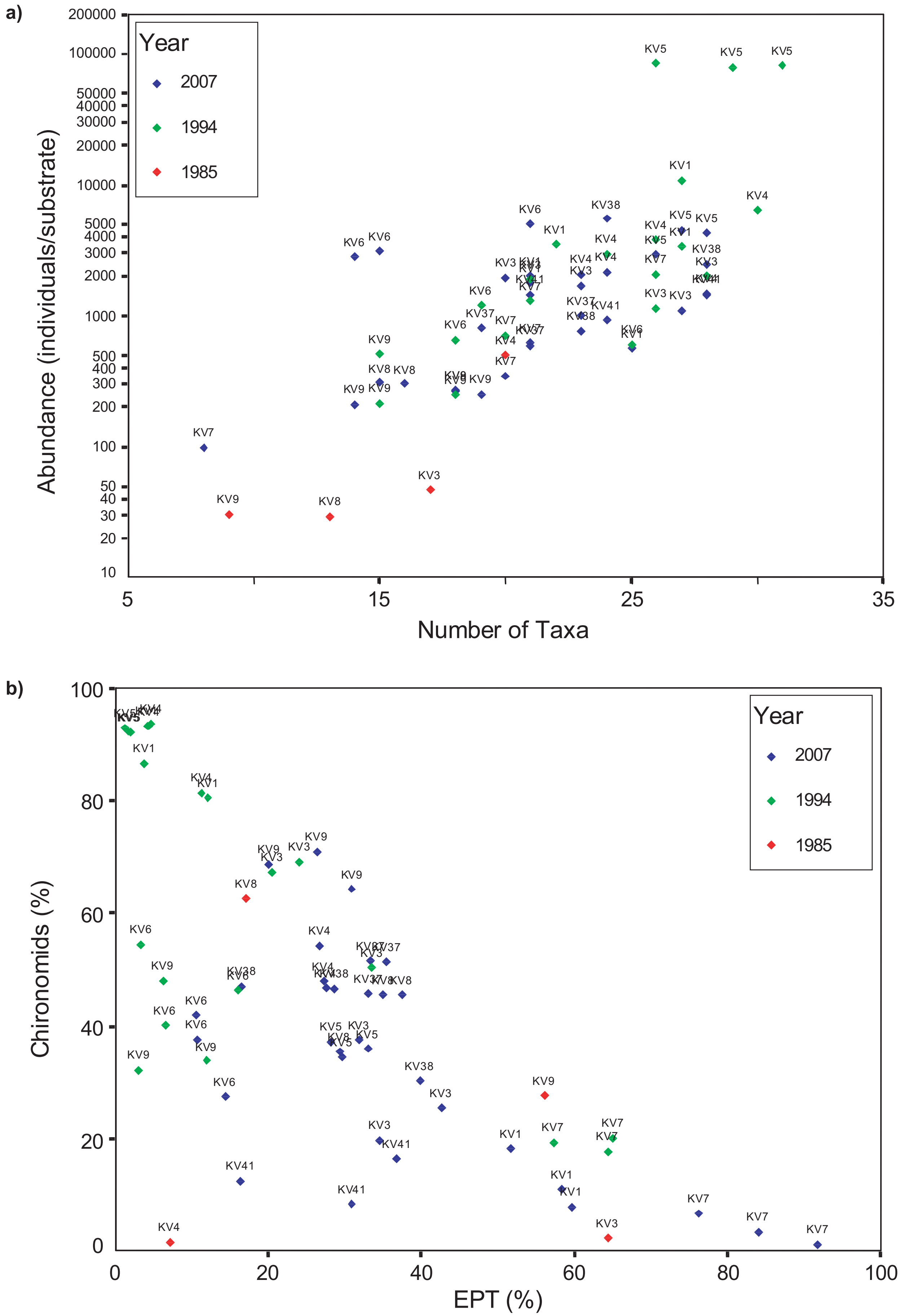


Figure 5.2: Comparisons of benthic community metrics at individual stations sampled in 1985, 1994 and 2007: a) number of taxa versus density, and b) % EPT versus % chironomids.

In 2007, samples at station KV6, in the outflow from Christal Lake, had the lowest average percent EPT, whereas KV7 further downstream had the greatest average percent EPT (Figure 5.1c; Appendix Table D.2). Chironomids were found at the lowest overall average percent in KV7 samples in 2007, and reached maximum average abundance in KV9 samples in Flat Creek just upstream of its confluence with the South McQuesten River (Figure 5.1d).

Although chironomids encompass a large number of species, with a wide range of effluent tolerance, a high percentage of this group when compared to that of the EPT group can indicate environmental stress or different (more depositional) habitat. At UKHM monitoring stations, the association between these two major taxon groups can be seen in the scatterplot of Figure 5.2b. Samples at station KV7 on Christal Creek in both 1994 and 2007 showed consistently high percent EPT and correspondingly low percent chironomids. Interestingly, KV1 samples on the South McQuesten River had low percent EPT (and high percent chironomids) in 1994, but showed the reverse of this in 2007, suggesting a dramatic change in these communities.

5.3 Potential Relationship to Mine Influences

As noted above, water quality data were summarized by Principal Components Analysis (PCA). The first four PCA axes accounted for over 93% of the overall variance in the water quality dataset (Table 5.1). The first axis, PC-1, explained the greatest amount of variation (47.2%), and separated areas with highest water concentrations of chiefly mine-related variables such as sulphate, cadmium, manganese, uranium, hardness, zinc, and conductivity (stations KV6, KV7, KV8) from other areas (Figure 5.3). All other stations had lower PC-1 scores, particularly those on Lightning Creek (KV37, KV38, KV41) indicating lower concentrations of the previous list of variables and higher relative concentrations of aluminum and total suspended solids. PC-2, explaining 21.3% of the total variance, primarily contrasted stations with higher alkalinity and strontium levels (station KV9 on Flat Creek and South McQuesten stations KV1, 3, 4, 5) against those characterized by higher total suspended solids, arsenic, nitrite, and selenium concentrations (most notably KV41 and KV6; Figure 5.3, Table 5.1). PC Axes 3 and 4 explained lower amounts of variance. PC-3 explained variability between some metals (copper, aluminum, iron) and nitrite, and PC-4 primarily separated KV9 from other stations based upon higher lead concentrations measured at this station.

Bivariate Pearson's correlations were calculated between PCA axes (representing 3-year median water chemistry results) and the suite of benthic metrics. Correlations

Table 5.1: PCA of median values (mid 2004 - mid 2007) for water quality parameters.

	Water Quality PC-1 (47.2%)	Water Quality PC-2 (21.3%)	Water Quality PC-3 (16.3%)	Water Quality PC-4 (8.4%)
log10 (1+Hardness (as CaCO3 in mg/L) 3-y Median)	0.907	-0.346	0.217	0.046
log10 (1+Total Suspended Solids (mg/L) 3-y Median)	-0.321	0.773	0.387	0.175
log10 (1+Alkalinity-Total (as CaCO3 in mg/L) 3-y Median)	0.730	-0.519	0.373	0.157
log10 (1+Nitrite (mg/L) 3-y Median)	0.488	0.720	-0.320	-0.097
log10 (1+Sulphate*-Dissolved (mg/L) 3-y Median)	0.975	-0.098	0.074	0.098
log10 (1+Aluminum-Total (mg/L) 3-y Median)	-0.330	0.443	0.806	-0.011
log10 (1+Arsenic-Total (mg/L) 3-y Median)	0.008	0.754	-0.159	0.426
log10 (1+Cadmium-Total (mg/L) 3-y Median)	0.933	0.230	-0.200	-0.027
log10 (1+Copper-Total (mg/L) 3-y Median)	-0.146	-0.280	0.916	0.085
log10 (1+Iron-Total (mg/L) 3-y Median)	0.024	0.635	0.762	0.003
log10 (1+Lead-Total (mg/L) 3-y Median)	0.582	0.216	0.060	0.747
log10 (1+Manganese-Total (mg/L) 3-y Median)	0.925	0.212	-0.035	-0.029
log10 (1+Selenium-Total (mg/L) 3-y Median)	0.623	0.703	-0.025	-0.291
log10 (1+Strontium-Total (mg/L) 3-y Median)	0.796	-0.465	0.343	-0.060
log10 (1+Uranium-Total (mg/L) 3-y Median)	0.919	0.236	-0.156	0.049
log10 (1+Zinc-Total (mg/L) 3-y Median)	0.905	0.154	-0.154	-0.217
log10 (1+Conductivity (uS/cm) 3-y Median)	0.902	-0.307	0.203	0.152
pH (pH units) 3-y Median	0.391	0.217	0.377	-0.724

Indicates strong positive weighting on axis. (green)
Indicates strong negative weighting on axis. (pink)

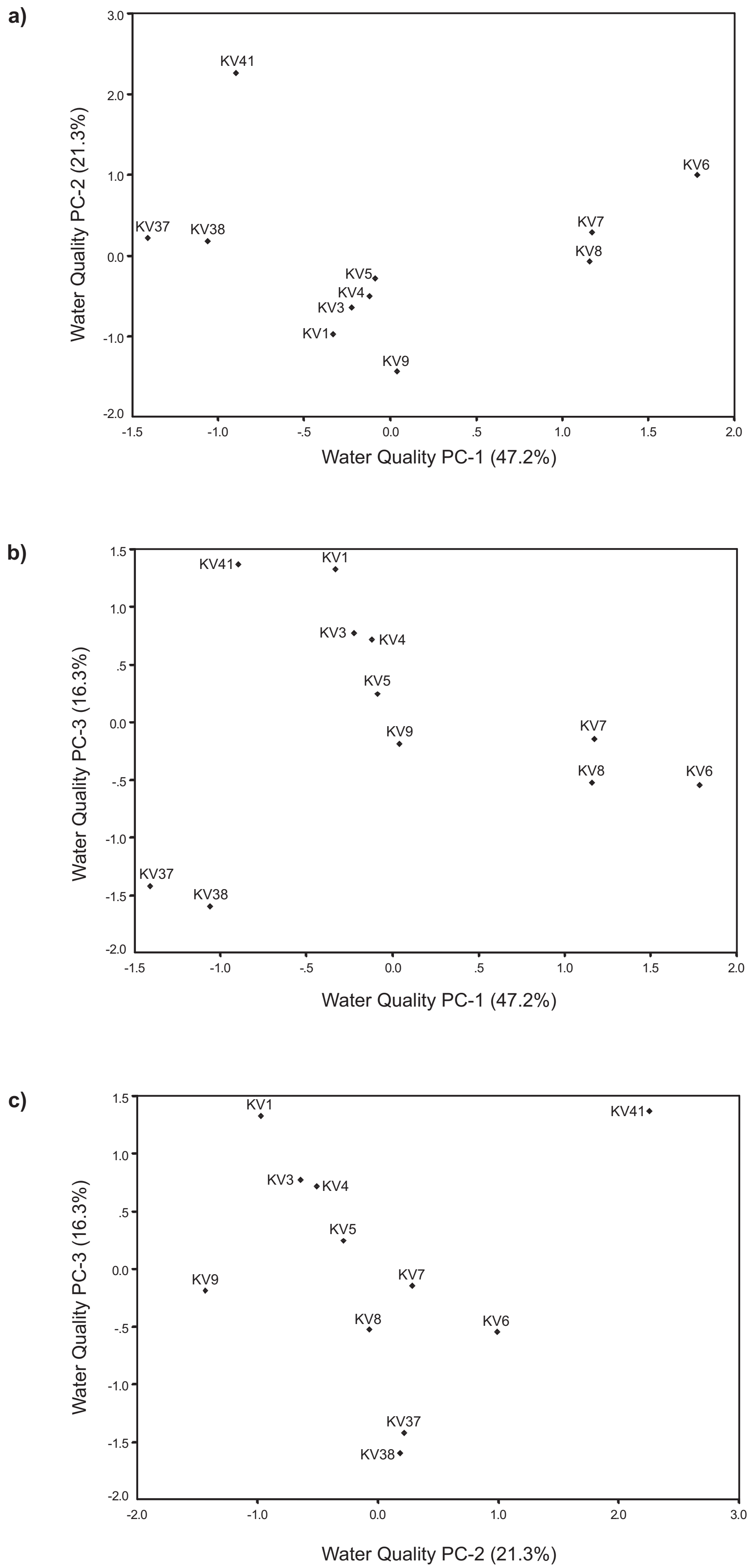


Figure 5.3: Water quality at United Keno Hill Mines stations based on PCA of median values from mid-2004 to mid-2007.

included all 11 stations. The primary correlation of interest was found to occur between the number of benthic taxa and PC-1 (Table 5.2, Figure 5.4a). Although the data are somewhat clumped, which may inflate the correlation, it was apparent that low number of taxa coincided with high values of PC-1 scores (high sulphate, cadmium, manganese, uranium, hardness, zinc, conductivity) associated with the Christal Creek stations KV6, KV7, and KV8, and to a lesser extent station KV9 on Flat Creek. A significant correlation between PC-2 and relative hydracarina (water mite) abundance does not appear to be meaningful because it was based on high values of these variables at a single station (KV41) rather than a continuous relationship.

In summary, the benthic community within Christal Creek and Flat Creek has shown impairment through reduced abundance and number of taxa relative to the other watercourses sampled in the area. The benthic communities within the South McQuesten River and Lightning Creek had higher numbers of taxa and abundance suggesting limited impairment at these locations. Correlation analysis indicate a relationship between the number of taxa and water PC-1, suggesting that the number of taxa decrease in response to increases in sulphate, cadmium, manganese, uranium, hardness, zinc and conductivity consistent with conditions observed in Christal and Flat Creeks.

Table 5.2: Correlations between water quality summary variables (PC scores based on median concentration of mid 2004 - mid 2007) and benthic community metrics for 2007.

		Water Quality PC-1 (47.2%)	Water Quality PC-2 (21.3%)	Water Quality PC-3 (16.3%)	Water Quality PC-4 (8.4%)
Density (individuals/substrate) Mean	Pearson Correlation	0.034	0.183	-0.065	0.004
	p-value (2-tailed)	0.92012	0.59044	0.84974	0.99011
Number of Taxa Mean	Pearson Correlation	-0.692	0.053	0.304	-0.182
	p-value (2-tailed)	0.01834	0.87759	0.36267	0.59165
EPT (%) Mean	Pearson Correlation	0.122	-0.153	0.174	-0.555
	p-value (2-tailed)	0.72096	0.65421	0.60939	0.07622
Chironomids (%) Mean	Pearson Correlation	-0.134	-0.437	-0.484	0.506
	p-value (2-tailed)	0.69421	0.17846	0.13178	0.11223
Hydracarina (%) Mean	Pearson Correlation	-0.542	0.657	0.371	0.128
(water mites)	p-value (2-tailed)	0.08534	0.02813	0.26172	0.70676
Ephemeroptera (%) Mean	Pearson Correlation	-0.127	-0.405	0.552	-0.396
(mayflies)	p-value (2-tailed)	0.71027	0.21647	0.07803	0.22757
Plecoptera (%) Mean	Pearson Correlation	0.178	0.116	-0.350	-0.235
(stoneflies)	p-value (2-tailed)	0.60047	0.73498	0.29107	0.48633
Trichoptera (%) Mean	Pearson Correlation	0.363	0.264	0.319	-0.371
(cadisflies)	p-value (2-tailed)	0.27296	0.43297	0.33846	0.26067
Simuliids (%) Mean	Pearson Correlation	0.531	0.028	-0.010	-0.029
(blackflies)	p-value (2-tailed)	0.09311	0.93458	0.97568	0.93348

(grey) $p < 0.05$

(green) $p < 0.00139$ ($p = 0.05$ adjusted for 36 simultaneous tests)

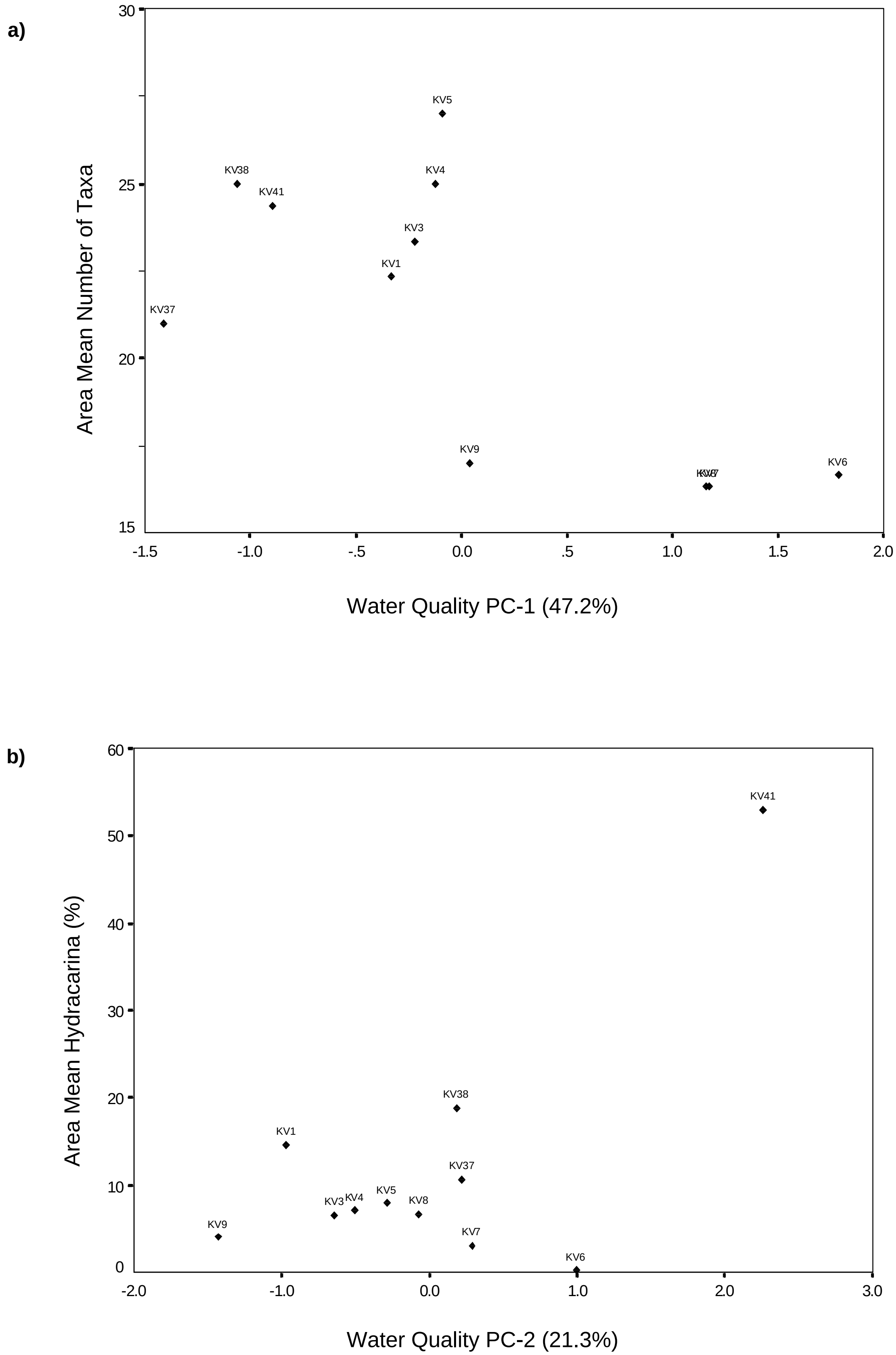


Figure 5.4: Correlations between water quality (summarized by PCA) and benthic community characteristics that were statistically significant at the unadjusted p-value of 0.05.

6.0 FISH SURVEY

6.1 Approach

Fish community composition, fish health and fish tissue metal concentrations collected in 2006 (Sparling 2006) were evaluated and compared to 1994/1995 data (Sparling and Connor 1996). Seasonal timing of the fish survey included spring (May-June), summer (July-August) and/or autumn (September) sampling during these historical studies. However, seasonal differences for each of the above fish survey components were not analyzed in this review. As for previous study components, data were available from mine-exposed Lightning, Christal and Flat Creeks, as well as the South McQuesten River downstream (mine-exposed) and upstream (reference) of UKHM operations.

Fish were collected using a variety of techniques, including backpack electrofishing, minnow trapping, angling, gill netting and/or seine netting. Backpack electrofishing and minnow trapping were the primary collection methods employed during the 2006 study and therefore findings associated with these collection measures served as the focus for the current fish community evaluation. At each sampling location, backpack electrofishing was conducted by a three man crew (electrofisher operator and two netters/recorders). Stopnet barriers were only used during the 2006 summer survey at creek stations, whereas electrofishing was completed on 'open' stations (i.e., no stopnet barriers) in the South McQuesten River and at creek stations during the fall and spring 2006 surveys. Regardless of whether stopnets were used, all sampling was completed using a single pass removal technique. At the conclusion of each electrofishing pass, captured fish were identified, enumerated and then released. In 2006, fish captured by seine were retained for tissue sampling while methods used to capture fish for metal analyses were not specified in 1994/1995. Fishing effort (i.e., electrofishing seconds) was then recorded to allow calculation of semi-quantitative estimates of relative fish abundance. Standard 'Gee' minnow traps (¼" galvanized mesh) baited with salmon roe (and/or dog kibble) were deployed as bottom, overnight sets at each sampling area. Information collected for each minnow trap set included set duration (based on deployment and retrieval date and time) and the type and number of fish captured. Fish community characteristics were summarized and compared according to species presence-absence and/or relative abundance, depending on data source. Semi-quantitative estimates of relative fish abundance were compared through analysis of electrofishing catch-per-unit-effort (CPUE), which was calculated as the total catch of each fish species per minute of electrofishing effort.

Slimy sculpin (*Cottus cognatus*) and Arctic grayling (*Thymallus arcticus*) were typically targeted for any tissue metals analysis during historical studies, and therefore only results associated with these species are considered in the current analysis. In general, attempts were made to collect at least five adult specimens of each species (i.e., fork length >80 mm and >200 mm for slimy sculpin and Arctic grayling, respectively) from each sampled station. However, success rates in reaching this target were variable and in some cases, fish size objectives were not met necessitating the analysis of composite tissue samples. For all sacrificed fish, length and/or fresh weight measurements were also typically collected. Slimy sculpin were generally collected as whole body tissue samples whereas Arctic grayling tissues were collected as muscle tissue, liver tissue and/or whole-body samples. Because the most consistently collected tissue for Arctic grayling was skinless, boneless muscle, this report focussed on this tissue type for this species. Fish tissue samples were analyzed for total metals typically using Inductively-Coupled Plasma (ICP) emission spectrometry techniques, with total mercury analysis conducted only during the 1994-1995 study. All tissue metal results were expressed in μg/g wet weight units in the current analysis, which for 1994-1995 data required conversion from reported dry weight metal concentrations using a percent moisture content of 78% as determined from the same study.

Fish tissue metal concentrations were evaluated in relation to potential influences from UKHM. Metals in whole body and/or edible muscle tissues were also compared to relevant human and/or wildlife consumption benchmarks (Table 6.1). Benchmarks for human consumption were derived utilizing published tolerable daily intake (TDI) values for various metals (Health Canada 1995 and IRIS 2006), potential mean daily fish consumption quantities for representative regional peoples (e.g., First Nations; Receuver *et al*. 1998; SENES 2006) and representative body mass values for human toddlers, children and adults (16.5 kg, 32.9 kg and 70.7 kg, respectively; Richardson 1997). These benchmarks represent the tissue concentrations considered protective of long-term human health while taking age into consideration. For this report, the most conservative human consumption benchmark (toddler) was selected for screening purposes (Table 6.1). Tissue metal benchmarks for piscivorous wildlife represented the dietary metal concentration that results in a dose equivalent to the NOAEL (No Observed Adverse Effect Level; Sample *et al*. 1996). The benchmark values utilized were representative of the most sensitive piscivorous wildlife species, which was either river otter (*Lutra canadensis*) or belted kingfisher (*Ceryle alcyon*; Table 6.1).

Table 6.1: Fish tissue metal concentration consumption benchmarks (mg/kg) for humans and piscivorous (fish-eating) wildlife

Parameter	Tolerable Daily Intake (mg/kg.day)[a]	Human Consumer[b]			Piscivorous Wildlife Consumer[c]
		Toddler	Child	Adult	
Arsenic	0.0003 [d]	0.20	0.56	1.0	0.28
Barium	0.016 [e]	10	30	52	
Beryllium	0.002 [d]	1	4	7	
Cadmium	0.0008 [d]	0.5	1.5	2.6	3.90
Chromium	0.001 [d]	0.7	1.9	3.3	
Copper	0.03 [d]	20	56	98	61.8
Lead	0.0036 [d]	2.4	6.8	11.8	4.9
Manganese	0.1402 [d]	92	264	459	358
Mercury	0.0001 [d]	0.07	0.19	0.33	0.45
Molybdenum	0.005 [d]	3.3	9.4	16.4	
Nickel	0.0013 [e]	0.9	2.4	4.3	
Selenium	0.005 [d]	3.3	9.4	16.4	
Strontium	0.6 [d]	393	1,128	1,964	
Uranium	0.0006 [e]	0.4	1.1	2.0	
Zinc	0.3 [d]	196	564	982	650

[a] Where values were reported by both IRIS (2006) and Health Canada (1995), the lowest value was used for benchmark

[b] Benchmarks for human consumers based on mean consumption rate of 16.5 g, 17.5 g and 21.6 g of fish muscle tissue per day for toddler (10.8 kg), child (32.9 kg) and adult (70.7 kg), respectively (SENES 2006).

[c] Most conservative food metal concentration resulting in a dose equivalent to the NOAEL (Sample et al. 1996)

[d] IRIS (2006).

[e] Health Canada (1995)

Shaded value indicates benchmark used for data comparisons.

6.2 Fish Community

In total, seven fish species were found in water bodies near UKHM during the 2006 study (Table 6.2). Slimy sculpin and Arctic grayling were generally the most widely encountered species, both spatially (Table 6.2) and in terms of relative abundance (i.e., highest densities relative to other fish; Table 6.3). Each of these fish species was observed in the three mine-exposed tributaries as well as downstream and upstream of the confluence of each respective creek in the South McQuesten River (Table 6.2). The presence of juvenile Arctic grayling in most watersheds (Table 6.2) indicates suitable rearing habitat and suggests spawning also occurs in the same watercourses. Although round whitefish (*Prosopium cylindraceum*), Chinook salmon (*Oncorhyncus tshawytsha*), northern pike (*Esox lucius*), burbot (*Lota lota*) and Arctic lamprey (*Lampetra japonica*) were also collected in the study area, relative abundance of each of these species was low throughout the study area (Table 6.2).

Fish community comparisons between mine-exposed areas and reference areas located upstream of mine influence on the South McQuesten River (Stations KV1 and KV72) showed no clear differences in overall fish species diversity between respective watercourses (Table 6.2). In addition, average relative fish abundance at all mine-exposed creeks and downstream areas of the South McQuesten River were similar to or higher than at the reference area (Table 6.3). Spatially, no clear differences in either species diversity or relative abundance were observed with distance from mine sources in individual watercourses, with the exception of lower fish diversity in Christal Creek at areas closest to the mine. For instance, only a single species (slimy sculpin at KV6 and Arctic grayling at C4) or no fish (Station KV7) were observed in some areas of Christal Creek compared to five species at areas closest to the creek mouth (Station KV8; Table 6.2). Possibly beaver dams, other barriers along Christal Creek and a high gradient at station C4 (Section 2.2) limit fish distribution. Overall, it is unclear whether decreased fish diversity throughout much of Christal Creek and Flat Creek compared to downstream reaches (stations KV8 and KV9, respectively) is related to physical habitat conditions or source area exposure.

Temporal comparisons between the 2006 and 1994-1995 studies indicated some minor differences in fish species diversity and/or relative abundance within some watercourses. Fish species diversity was slightly higher in Christal Creek in 2006 (round whitefish and northern pike absent in earlier study), although relative fish abundance tended to be slightly lower compared to 1994-1995 (Table 6.3 compared to Appendix Table E.3). Fish species diversity of both mine-exposed and reference areas in the

Table 6.2: Fish presence-absence by station based on electrofishing and minnow trapping catch data, United Keno Hill Mines, 2006[a].

Watershed	Station	Arctic grayling		round whitefish[b]	chinook salmon[b]	slimy sculpin[b]	northern pike[b]	burbot[b]	Arctic lamprey[b]
		juvenile	adult	-	-	-	-	-	-
Lightning Creek	KV41		X[c]	X					
	LCD		X			X			
Christal Creek	CL					X			
	KV6					X			
	C4	X	X						
	KV7								
	KV8	X	X	X		X	X	X	
Flat Creek	KV9	X				X	X	X	
South McQuesten River	KV72		X			X	X		
	KV1	X				X			X
	SMQ C	X				X		X	X
	KV2	X				X			
	KV3					X			X
	KV4	X				X			
	KV15	X	X		X	X	X		

[a] prepared using data from Sparling (2006)

[b] life stage of specimens (e.g., adult versus juvenile) was not consistently reported

[c] Sparling (2006) data tables report "sub-adults" while "juveniles" are mentioned in the text

"adult" includes individuals identified as sub-adults

Table 6.3: Mean electrofishing catch per unit effort (number of fish per minute), United Keno Hill Mines, 2006[a].

Watershed	Station	n	Arctic grayling	slimy sculpin	northern pike	burbot	round whitefish	Arctic lamprey
Lightning Creek	KV41	3	1.84	0	0	0	0.03	0
	LCD	1	0.18	2.82	0	0	0	0
Christal Creek	KV6	3	0	9.37	0	0	0	0
	C4	3	0.43	0	0	0	0	0
	KV7	3	0	0	0	0	0	0
	KV8	3	0.50	0.85	0	0.01	0.03	0
Flat Creek	KV9	3	0.06	2.43	0.04	0.07	0	0
South McQuesten River	KV72	1	0.10	0.49	0.10	0	0	0
	KV1	3	0.22	2.81	0	0	0	0.06
	SMQ C	1	0.09	2.48	0	0.14	0	0.09
	KV2	1	0.06	4.75	0	0	0	0
	KV3	2	0	3.70	0	0	0	0.05
	KV4	1	0.23	5.63	0	0	0	0
	KV15	1	0.16	3.29	0.05	0	0	0

[a] prepared using data from Sparling (2006)

South McQuesten River was slightly lower in 2006 compared to 1994-1995 (longnose sucker absent in 2006). Relative abundance also appeared to be somewhat lower in 2006 compared to 1995-95 at the South McQuesten River reference area, but no large or consistent patterns were evident between surveys for mine-exposed tributaries or downstream areas of the South McQuesten River. Because no important differences in fish species diversity or relative abundance were observed at study watercourses between studies, any apparent changes in these endpoints were likely associated with natural or sampling variability as opposed to any changes in mine-related influences over time.

6.3 Fish Health

In 2006, slimy sculpin at mine-exposed areas appeared to have lower body weight relative to length (i.e., reduced condition) compared to those from reference Station KV72 (Figure 6.1). However, sample sizes were extremely small at all areas sampled (i.e., three to eight fish), a limited number of stations were sampled and no age determinations were conducted to determine if such differences in condition were related to size-at-age differences. In addition, weight data was very limited for the 1994-1995 study. Therefore, no definitive conclusions regarding fish health among areas and time periods could be drawn from the available information.

6.4 Metal Concentrations in Tissues

Fish tissues have been analyzed historically to assess whether fish tissue quality has been influenced by each mine site. This assessment also provides an interpretation of the significance of observed metal concentrations to the health of human and/or wildlife consumers of targeted fish species. As slimy sculpin are generally not consumed by humans, assessment of the significance of tissue metal concentrations for human consumers was conducted using only Arctic grayling muscle tissue data. Similar limitations were not applicable for wildlife consumers.

In slimy sculpin collected in 2006, whole body arsenic and lead concentrations were the only metals consistently elevated in samples collected at all mine-exposed areas relative to reference (Stations KV1 and KV72; Figure 6.2). Of these metals, mean whole body arsenic concentrations were well above the wildlife consumption benchmark of 0.28 mg/kg at all mine-exposed areas, whereas mean whole body lead concentrations exceeded the wildlife consumption benchmark (of 4.9 mg/kg) only at the most upstream station in Christal Creek (Station KV6) and at Flat Creek (KV9; Figure 6.2).

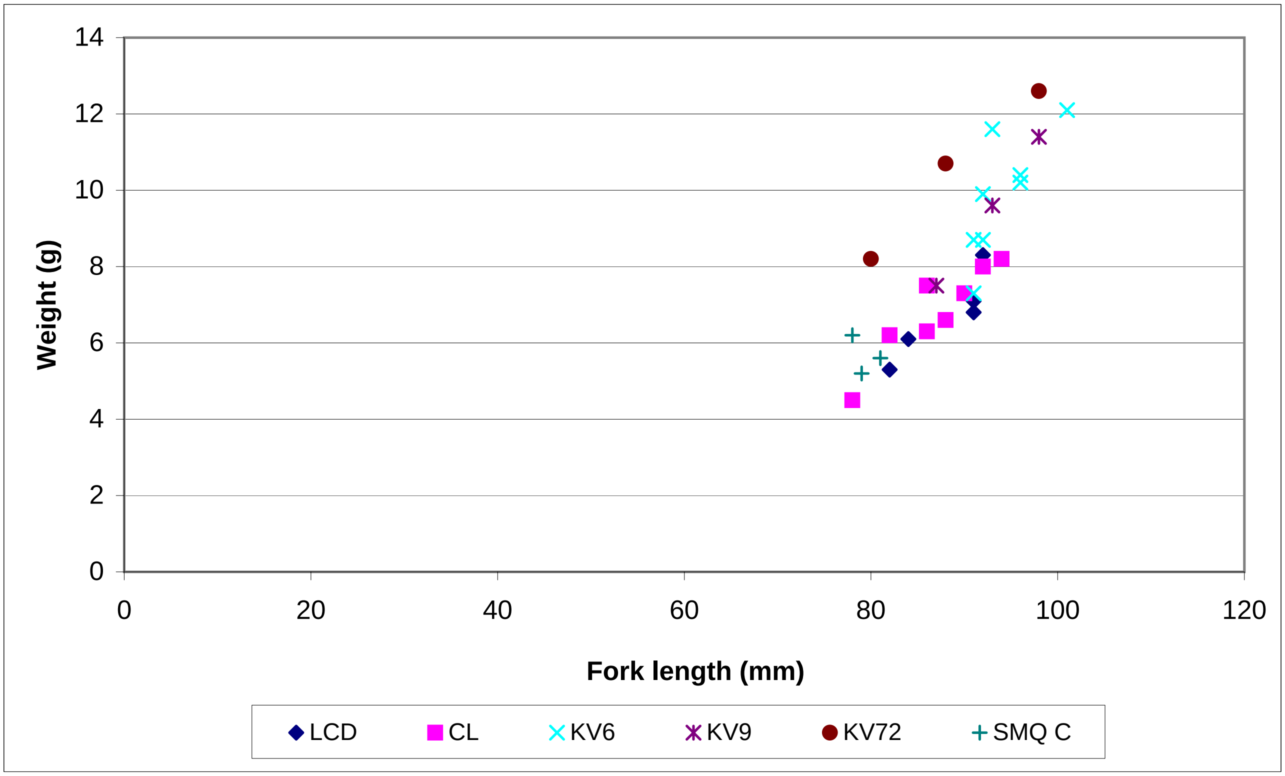
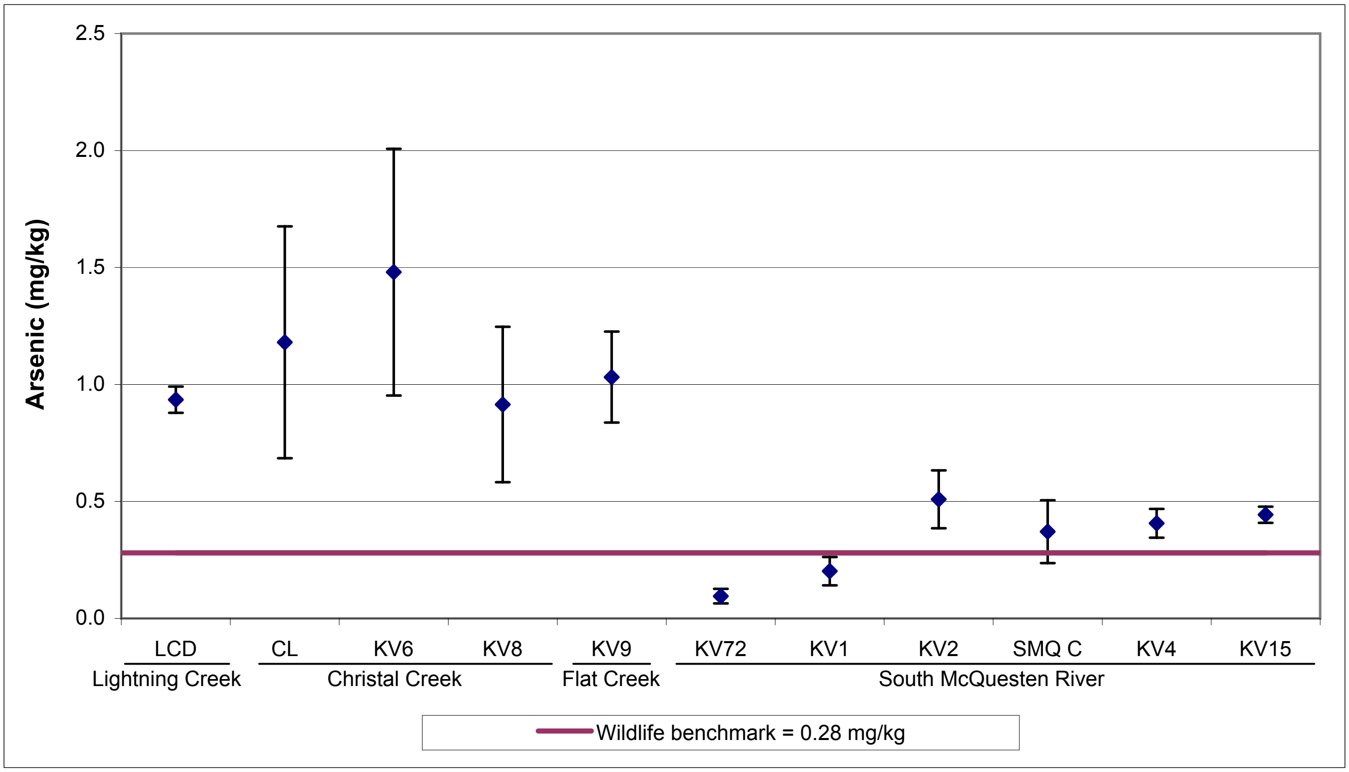


Figure 6.1: Weight vs fork length of slimy sculpin captured by seining, United Keno Hill Mines, 2006.



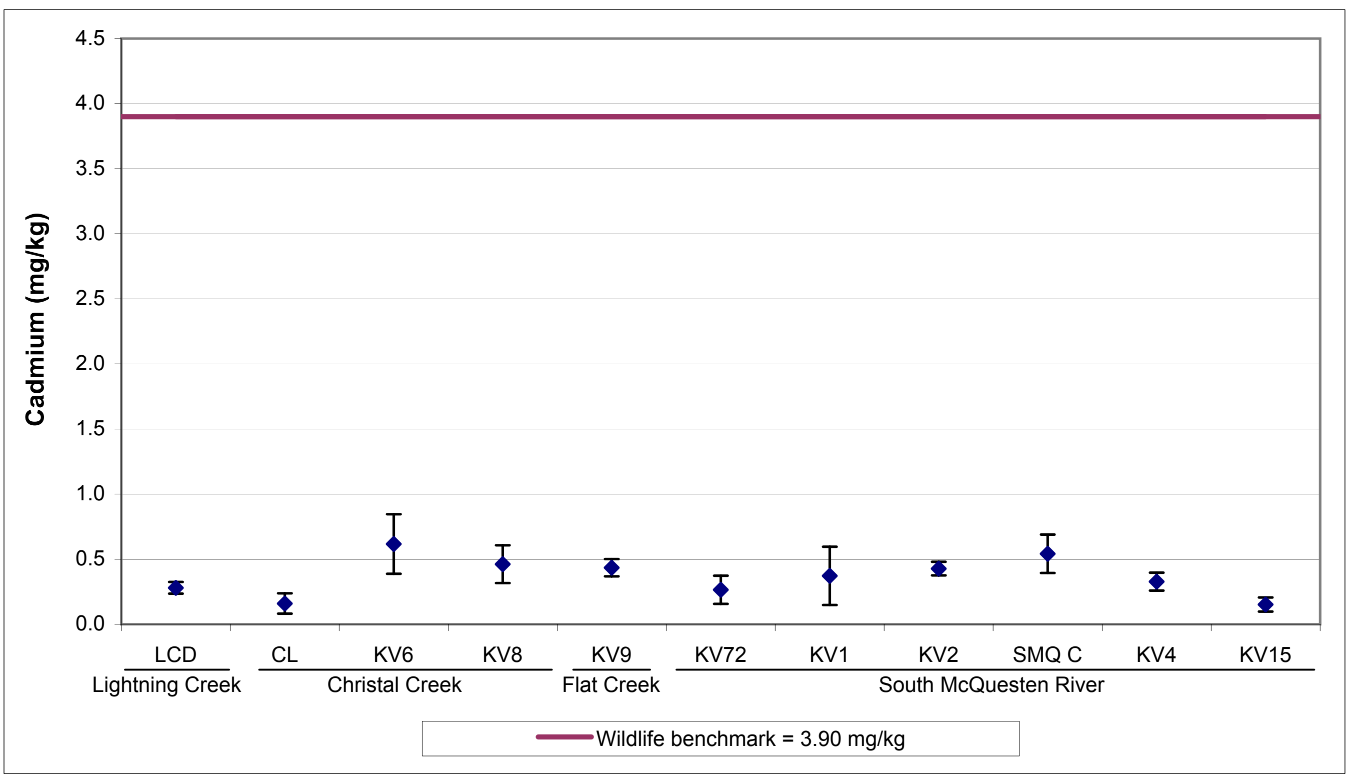
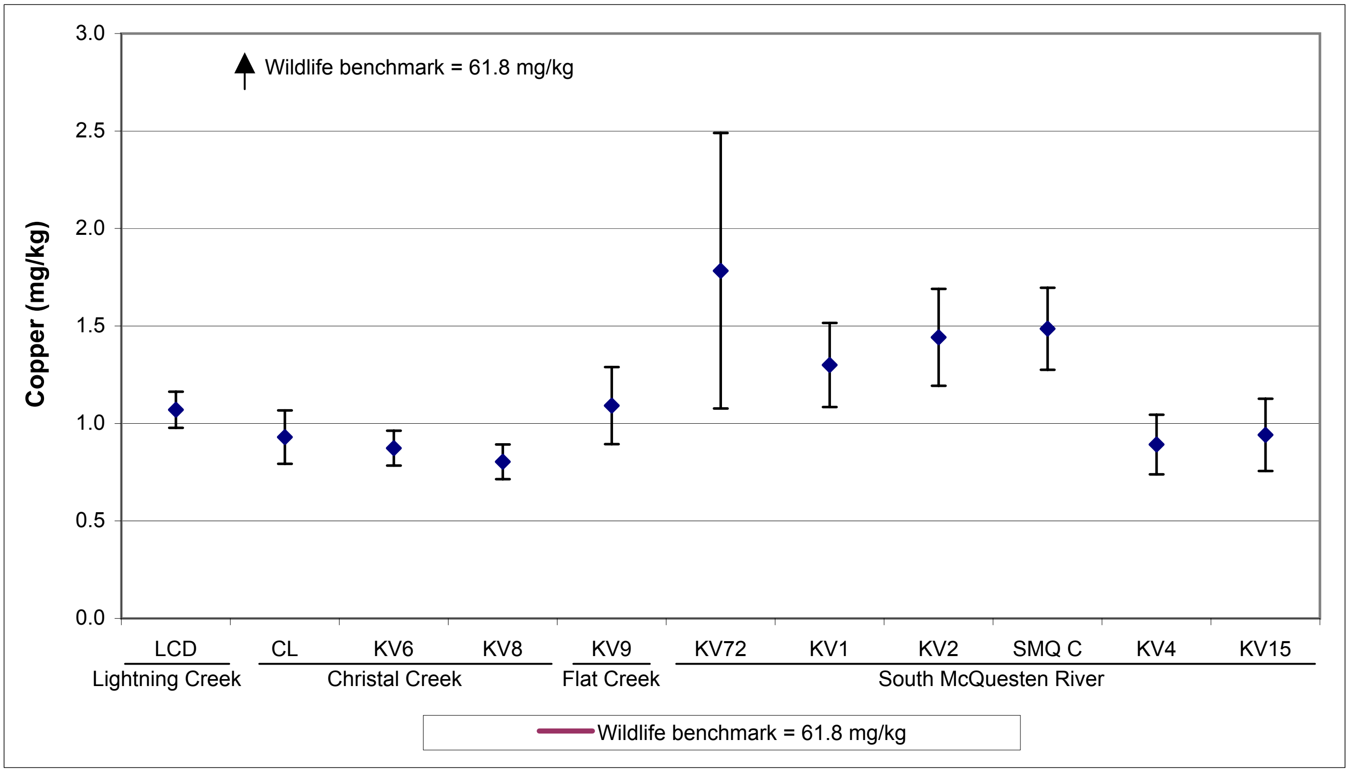


Figure 6.2: Whole body metal concentrations in slimy sculpin (± 95% confidence interval) relative to wildlife consumption benchmarks



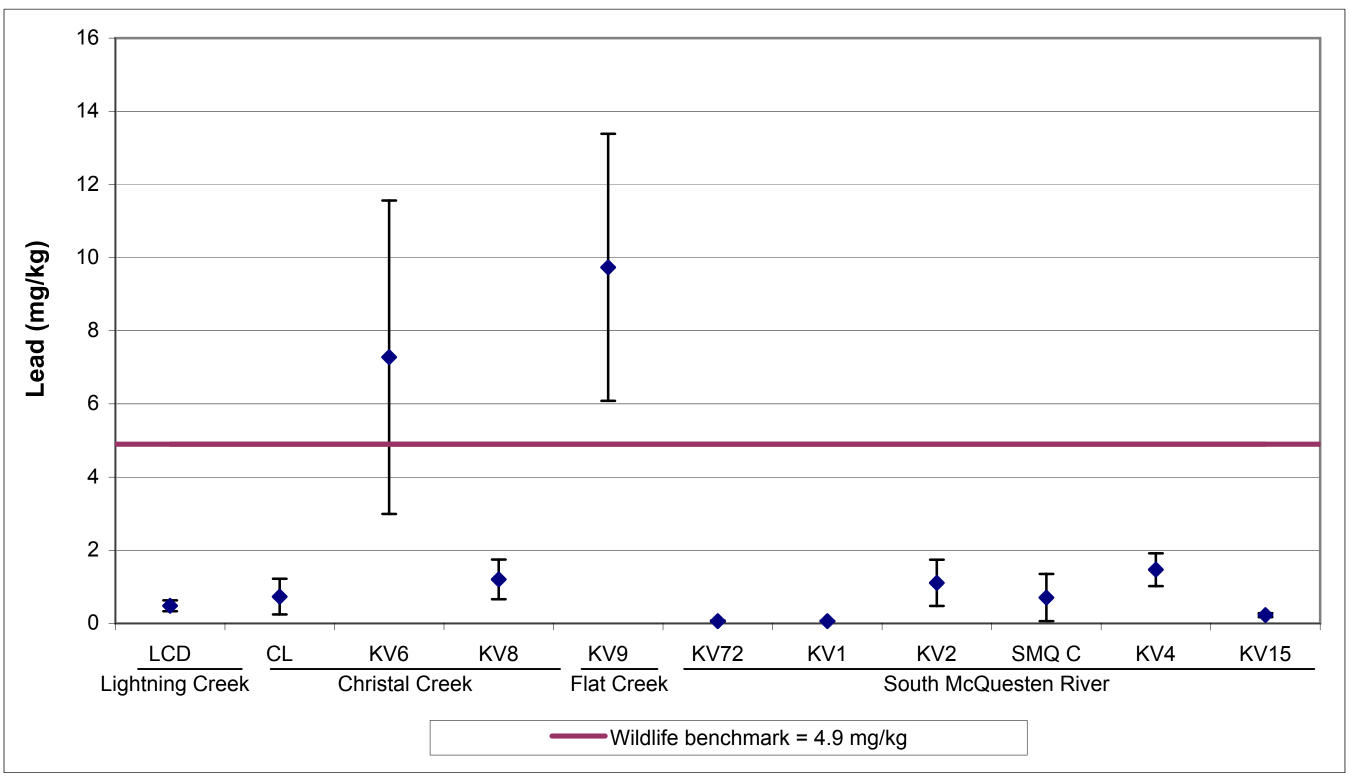
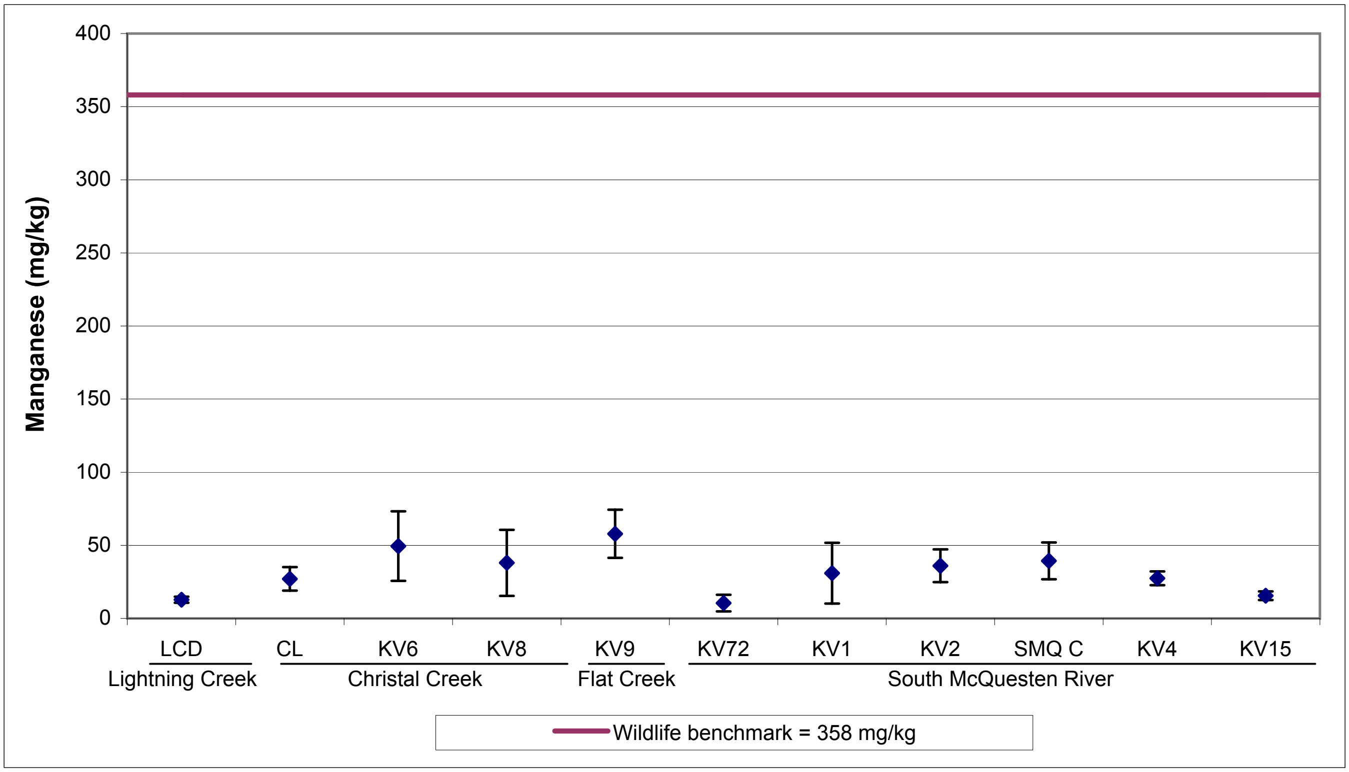


Figure 6.2: Whole body metal concentrations in slimy sculpin (± 95% confidence interval) relative to wildlife consumption benchmarks



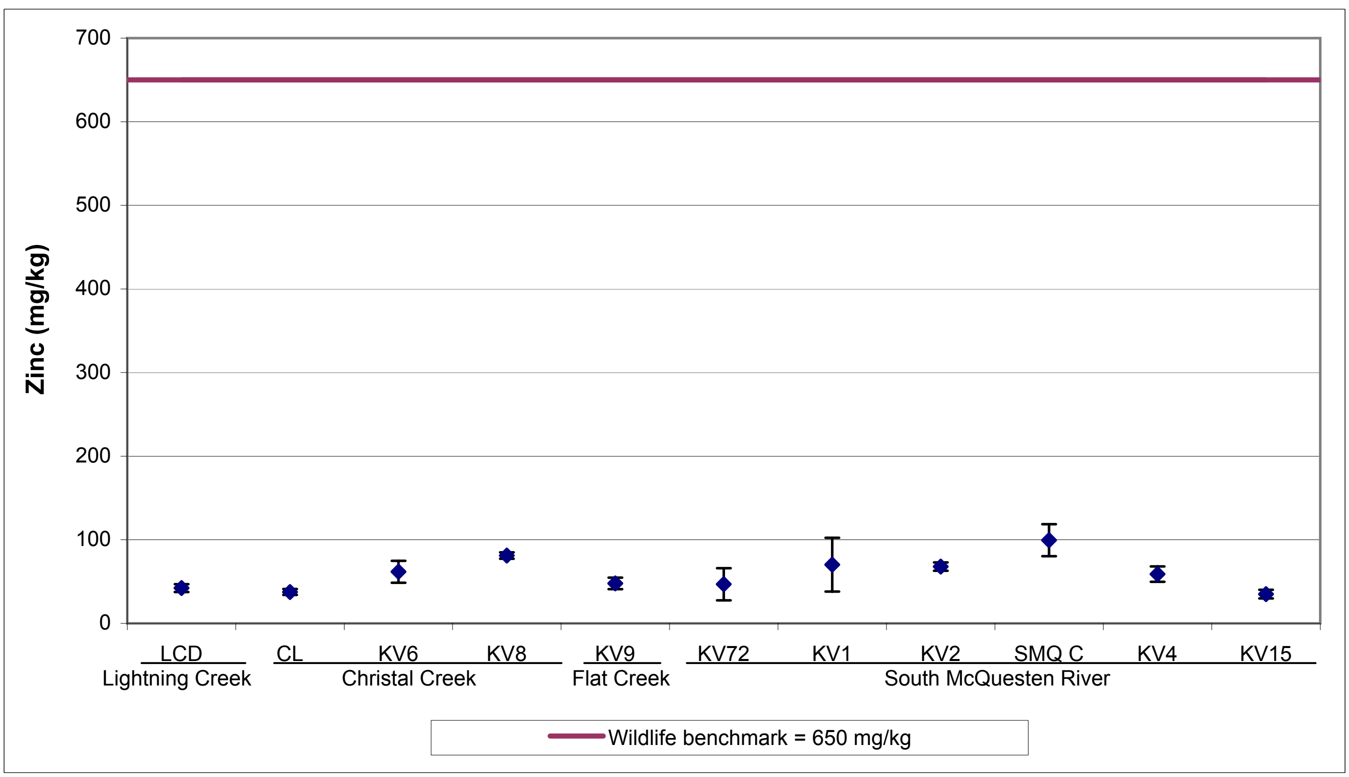


Figure 6.2: Whole body metal concentrations in slimy sculpin (± 95% confidence interval) relative to wildlife consumption benchmarks

Average Arctic grayling muscle tissue metal concentrations were well below the most conservative human consumption benchmarks in both Lightning (station LCD) and Christal Creeks (station C4) in 2006 (Table 6.4), although a single muscle sample from Lightning Creek exceeded the toddler and wildlife consumption benchmark for arsenic (Appendix Table E.5). In addition, all mean whole body metal concentrations were below respective wildlife consumption benchmarks at these areas. Where data from 1994-95 were available for the same areas sampled in 2006, a similar pattern of slimy sculpin and Arctic grayling tissue concentrations were observed, with no consistent increases or decreases in most metal concentrations evident since 1994-1995 (Appendix Tables E.5-E.10). However, mean zinc concentrations in Arctic grayling muscle and in whole body slimy sculpin were generally lower in 2006 than in 1994 – 1995 in Christal Creek (stations C4 and KV6, respectively; Table 6.4; Appendix Tables E.7, E.10 – E.11).

Table 6.4: Summary statistics for concentrations of metals in Arctic grayling muscle (mg/kg wet weight) collected in August and September, United Keno Hill Mines, 2006[a].

Parameter	Toddler benchmark[b]	Wildlife benchmark[b]	Lightning Creek (station LCD)				Christal Creek (station C4)			
			n	mean	Standard Deviation	95% Confidence Limit	n	mean	Standard Deviation	95% Confidence Limit
Aluminum			5	12.34	20.53	17.994	5	3.64	2.35	2.062
Antimony			5	< 0.011	0.002	0.002	5	< 0.010	0	-
Arsenic	0.20	0.28	5	0.164	0.154	0.135	5	0.1286	0.030	0.027
Barium	10		5	1.21	0.880	0.772	5	0.57	0.130	0.114
Beryllium	1		5	< 0.10	0	-	5	< 0.10	0	-
Bismuth			5	< 0.10	0	-	5	< 0.10	0	-
Cadmium	0.5	3.90	5	0.0443	0.043	0.038	5	0.0582	0.016	0.014
Calcium			5	7440	4,139	3628	5	5954	1,331	1167
Chromium	0.7		5	< 0.11	0.013	0.012	5	< 0.10	0	-
Cobalt			5	0.069	0.053	0.047	5	0.035	0.012	0.011
Copper	20	61.8	5	0.528	0.232	0.203	5	0.499	0.076	0.067
Lead	2.4	4.9	5	0.135	0.155	0.136	5	0.130	0.069	0.061
Lithium			5	< 0.10	0	-	5	< 0.10	0	-
Magnesium			5	314	118.71	104	5	302	27.48	24
Manganese	92	358	5	3.59	3.07	2.688	5	6.24	2.89	2.531
Molybdenum	3.3		5	< 0.010	0	-	5	< 0.010	0	-
Nickel	0.9		5	< 0.10	0	-	5	< 0.10	0	-
Selenium	3.3		5	1.68	0.64	0.557	5	0.97	0.21	0.181
Strontium	393		5	6.86	3.63	3.184	5	4.66	1.07	0.936
Thallium			5	< 0.010	0	-	5	< 0.010	0	-
Tin			5	< 0.050	0	-	5	< 0.050	0	-
Uranium	0.4		5	< 0.0029	0.0021	0.002	5	< 0.0020	0	-
Vanadium			5	< 0.10	0.0089	0.008	5	< 0.10	0	-
Zinc	196	650	5	18.51	8.56	7.500	5	21.02	4.20	3.680

toddler benchmark exceeded

toddler and wildlife benchmarks exceeded

[a] prepared using data from Sparling (2006)

[b] see Table 6.1 for sources

7.0 SUMMARY

In general, studies used for the Aquatic Resource Assessment were those which employed common stations to allow for comparison of conditions between surveys. Data from these reports related to water and sediment chemistry, benthic invertebrate communities, and fisheries were compiled and evaluated to characterize current conditions relative to historical conditions and relevant environmental quality guidelines or benchmarks.

The study area that was considered included Christal, Flat and Lightning Creeks as well as the South McQuesten River. Christal and Flat Creeks, which capture most of the mine-influenced drainage from UKHM, drain northwest into the South McQuesten River. Lightning Creek, a tributary of the Mayo River via Duncan Creek, also receives mine drainage (adits on Keno and Sourdough Hills). Portions of Christal and Lightning Creeks have been affected by placer mining.

A previous analysis of water quality identified cadmium and zinc as key contaminants of concern in waters downstream of UKHM. Concentrations of these substances are at levels that are potentially toxic to aquatic biota in portions of the tributaries receiving mine drainage (particularly Christal Creek). However, contaminant levels in the South McQuesten River are currently below levels of concern.

Sediment quality data from 2006 showed that arsenic levels are consistently elevated in the fine fraction of sediments (<0.15mm) at all areas downstream of UKHM, including the South McQuesten River. Concentrations of up to 34 times the Probable Effect Levels of the Canadian Sediment Quality Guidelines have been observed. Fine sediment concentrations of cadmium, lead, and zinc were also elevated at most mine-exposed stations relative to both reference area concentrations and sediment quality guidelines. However, the guidelines are based on concentrations measured in whole sediment samples (not just the fine fraction), so potential risks to benthic biota cannot be ascertained from the available data. No consistent patterns were observed in sediment concentrations over time, although the evaluation was confounded by differences in methods for sampling and analysis.

Benthic invertebrate communities in lower Christal and Flat Creeks were characterized by relatively low abundance and number of taxa compared to reference and other, mine-exposed areas. Correlation analysis suggested that reduced number of taxa may be related to elevated water concentrations of mine-related variables such as major ions (e.g., sulphate, hardness, conductivity), cadmium, and zinc.

The fish communities of the tributaries and South McQuesten River are dominated by Arctic grayling and slimy sculpin. The presence of both adult and juvenile Arctic grayling in most watercourses indicates availability of suitable spawning and rearing habitats. Portions of Christal Creek showed limited fish diversity and densities, particularly at KV7 where no fish were found in 2006. Although some differences in diversity or density were evident in comparison to a previous study (1994-95), no large and consistent patterns were evident in mine-exposed areas that would suggest that conditions had either improved or degraded over time.

Whole body analysis of slimy sculpin showed levels of arsenic in excess of reference sediment concentrations and wildlife consumption benchmarks at most areas downstream of UKHM, particularly in Christal and Flat Creeks. These observations are consistent with elevations in sediment arsenic and lead levels observed in the same areas. Metal concentrations in Arctic grayling muscle were less than human or wildlife consumption benchmarks in almost all samples from all areas. Overall, no consistent increases or decreases were evident over time based on comparison of data from 2006 to data from 1994-95.

8.0 RECOMMENDATIONS

The following recommendations should be considered in the context of future monitoring programs:

1. Expand on the habitat characterization by Sparling (2006), presented in Table 2.1, to ensure consistent information is available among areas where benthic and fish communities are typically assessed.

2. Review monitoring station locations to ensure that each station provides unique information relative to source loads.

3. Analyze particle size and chemistry of whole sediment samples collected in reference and mine-exposed areas to determine if metal concentrations, particularly arsenic, are high enough to potentially affected biota.

4. Evaluate the sample collection methods and the sampling design that have been used in past assessments of benthic community health to identify opportunities for improvement. For example, changes to the sampling design are recommended to allow for statistical comparison of conditions in mine-exposed versus reference areas and thus allow for quantification of changes over time. Specific design options should be developed and evaluated as part of the long-term monitoring design.

5. Once the long-term monitoring program is established, standard operating procedures (SOPs) should be developed.

6. Evaluate sites that could serve as additional reference areas in future surveys to enhance evaluation of mine-exposed areas through improved understanding of reference conditions and variability.

7. Consider replacing potentially impacted KV-1 with the new reference area KV-72 by conducting a comparative assessment of the two stations when more data at KV-72 are available.

8. Collect more detailed fish health data during fisheries assessments and also measure major organ weights (e.g., gonads, livers) and fish age for any specimens that are sacrificed for tissue analysis.

9.0 REFERENCES

BCMOE (British Columbia Ministry of Environment). 2006. British Columbia Approved Water Quality Guidelines (Criteria), 2006 Edition. Updated August 2006.

Burns, B., 1996. Biological Monitoring Survey at United Keno Hill Mine Area, 1994. Laberge Environmental Services, Whitehorse, YT, 1996.

Burns, B., 2005. Keno Valley Receiving Water Monitoring Program, 2004/2005. Laberge Environmental Services, Whitehorse, YT, March 2005.

Burns, B., 2008. Keno Valley Stream Sediment and Benthic Invertebrate Monitoring Programs, 2007. Laberge Environmental Services, Whitehorse, YT. March 2008.

CCME (Canadian Council of Ministers of the Environment). 1995. Protocol for the Derivation of Canadian Sediment Quality Guidelines for the Protection of Aquatic Life. CCME EPC-98E. Prepared by Environment Canada, Guidelines Division, Technical Secretariat of the CCME Task Group on Water Quality Guidelines, Ottawa.

CCME (Canadian Council of Ministers of the Environment). 1999. Canadian Environmental Quality Guidelines. 1999 (plus updates), Canadian Council of Ministers of the Environment, Winnipeg

Davidge, D. and G. Mackenzie-Grieve, 1989. Environmental Quality of Receiving Waters at United Keno Hill Mines Ltd., Elsa Yukon. Regional Program Report No. 89-04. Department of Environment, Environmental Protection, Pacific Region, Yukon Branch. September 1989.

Health Canada. 1995. Investigating Human Exposure to Contaminants in the Environment: A Handbook for Exposure Calculations. Minister of Supply and Services Canada. Cat. No. H49-96/1-1995E.

IRIS (Integrated Risk Information System). 2006. U.S. Environmental Protection Agency. http://www.epa.gov/iris. Accessed March 27, 2006.

Minnow Environmental Inc., 2008. Water Quality Assessment Report for United Keno Hill Mines. Prepared for Elsa Reclamation and Development Company, Whitehorse, YT, July 2008.

OMOE (Ontario Ministry of the Environment), 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario, 1993

Receveur, O., N. Kassi, H.N. Chan, P.B. Berti, H.V. Kuhnlien. 1998. Yukon First Nations' Assessment of Dietary Benefit/Risk. Centre for Indigenous Peoples' Nutrition and Environment (CINE). McGill University. Ste-Anne-de-Bellevue, Quebec, May.

Richardson, G.M. 1997. Compendium of Canadian Human Exposure Factors for Risk Assessment. O'Connor Associates Environmental Inc.

Sample, B.E., D.M. Opresko and G.W. Suter II. 1996. Toxicological Benchmarks For Wildlife: 1996 Revision. United States Department of Energy, Oak Ridge National Laboratory. ES/ER/TM-86/R3. June 1996.

Senes Consultants Limited. 2006. Anvil Range Mine Tier 2 Ecological and Human Health Risk Assessment of Remediation Scenarios. Prepared for Deloitte and Touche Inc., Interim Receiver of Anvil Range Mining Corporation. April 2006.

Sparling, P., 2006. Fisheries Assessments Conducted in the Keno Hill Mining Area, Including Metals Analysis of Fish Tissue Samples, 2006. White Mountain Environmental Consulting, Whitehorse, YT. January 2006.

Sparling, P.and M. Connor, 1996. Fish and Fish Habitat Assessment Conducted Near Elsa, Yukon for United Keno Hill Mines August 1994 – September 1995. White Mountain Environmental Consulting, Whitehorse, YT, December 1995.

APPENDIX A

SAMPLING STATIONS

Table A.1: Station identifications used in the present and previous studies.

Watershed	Sediment quality					Benthic invertebrate community				Water quality		Fisheries		
	1985 station ID[1]	1994 station ID[2]	2004 station ID[3]	2007 station ID[4]	Present study station ID	1985 station ID[1]	1994 station ID[2]	2007 station ID[4]	Present study station ID	2004 - 2007 station ID[4,5]	Present study station ID	1994-1995 station ID[6]	2006 station ID[7]	Present study station ID
Lightning Creek			KV37	KV37	KV37			KV37	KV37	KV37	KV37			
										KV39				
										KV40				
			KV38	KV38	KV38			KV38	KV38	KV38	KV38			
			KV41	KV41	KV41			KV41	KV41	KV41	KV41		LgT K	KV41
													LgT D	LCD
												LC		LC
Christal Creek												CL	CL	CL
		6	KV6	KV6	KV6		6	KV6	KV6	KV6	KV6	C5	KV6	KV6
										KV16				
										KV29				
										KV30				
												C4	C4	C4
		7	KV7	KV7	KV7		7	KV7	KV7	KV7	KV7	C3	KV7	KV7
												C2		C2
	2		KV8	KV8	KV8	2					KV8	C1	KV8	KV8
No Cash Creek										KV21				
Flat Creek										KV47				
												F3		F3
	7		KV9	KV9	KV9	7	9	KV9	KV9	KV9	KV9	F1	KV9	KV9
South McQuesten River												SML	SMQ1	KV72
			KV1	KV1	KV1		1	KV1	KV1	KV1	KV1	SM2	KV1	KV1
												SM3	SMQC	SMQ C
			KV2	KV2	KV2					KV2		SM4	KV2	KV2
												SM5		SM5
	8		KV3	KV3	KV3	8	3	KV3	KV3	KV3	KV3	SM6		KV3
	9		KV4	KV4	KV4	9	4	KV4	KV4	KV4	KV4	SM7	KV4	KV4
			KV5	KV5	KV5		5	KV5	KV5	KV5	KV5	SM13		KV5
												SM12		SM12
												SM8		SM8
										KV15		SM9&SM10	SMQ H	KV15
												SM11		SM11

[1] Davidge and Mackenzie-Grieve (1989)
[2] Burns (1996)
[3] Burns (2005)
[4] Burns (2008)
[5] Minnow (2008)
[6] Sparling and Connor (1996)
[7] Sparling (2006)

APPENDIX B

WATER QUALITY DATA

Table B.1: Aluminum (mg/L) Summary Statistics for Receiving Environment Stations, 1994-2007.

Station	% < DL, > CWQG	% > DL, > CWQG	% >Background, >CWQG	n	mean	median	stdev	min	max	n <MDL
KV39	0	0	0	2	0.013	0.013	0.008	0.008	0.02	0
KV40	0	0	0	2	0.009	0.009	0.001	0.008	0.01	1
KV38	0	0	0	10	0.022	0.011	0.027	0.005	0.09	4
KV41	0	43	29	14	0.390	0.087	0.543	0.019	1.80	0
KV6	0	24	2	46	0.089	0.019	0.158	0.005	0.76	12
KV16	0	39	10	41	0.218	0.070	0.361	0.005	1.55	4
KV29	0	51	27	41	1.156	0.111	2.859	0.007	15.3	3
KV30	0	45	18	40	0.331	0.070	0.532	0.008	2.15	1
KV7	0	20	5	41	0.096	0.029	0.190	0.008	0.87	4
KV8	0	22	0	37	0.074	0.014	0.126	0.005	0.61	7
KV21	0	100	50	2	5.092	5.092	6.941	0.184	10.0	0
KV47	0	67	33	9	0.518	0.490	0.468	0.009	1.28	1
KV9	0	0	0	16	0.013	0.010	0.009	0.005	0.03	7
KV2	0	31	0	36	0.088	0.048	0.099	0.010	0.39	3
KV3	0	35	0	20	0.086	0.065	0.079	0.010	0.32	0
KV4	0	36	0	14	0.080	0.085	0.058	0.006	0.18	0
KV5	0	18	0	28	0.062	0.035	0.081	0.005	0.40	0
KV15	0	8	0	13	0.049	0.021	0.051	0.005	0.18	1

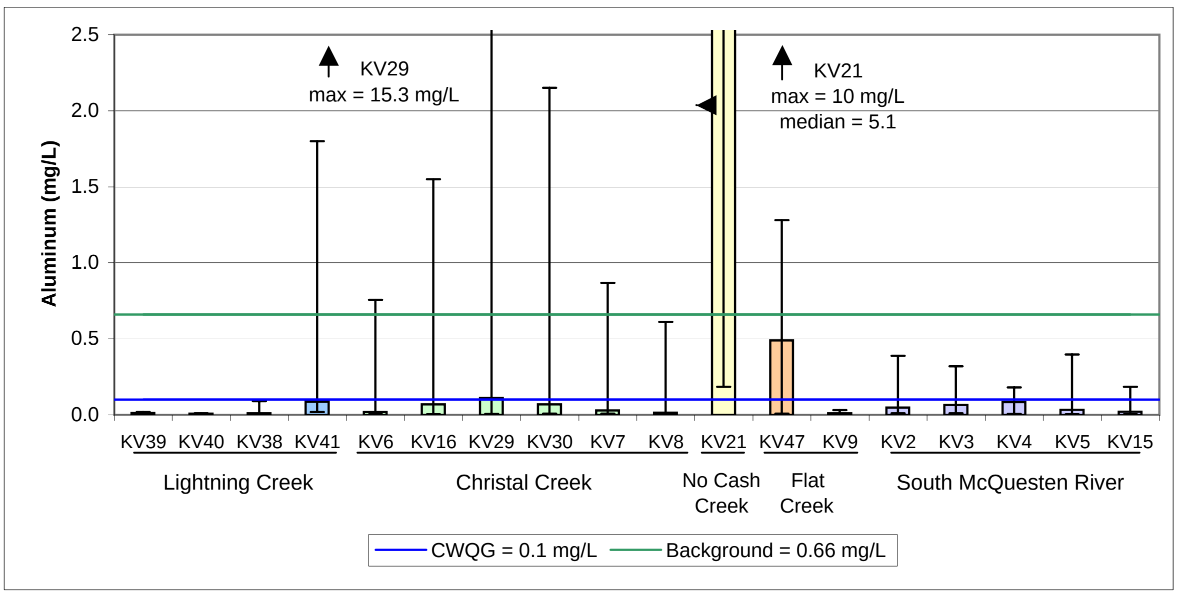


Figure B.1: Aluminum (mg/L) Median Values with Minimum and Maximum for Receiving Environment Stations, 1994 - 2007.

Table B.2: Arsenic (mg/L) Summary Statistics for Receiving Environment Stations, July 20, 2004-2007.

Station	% < DL, > CWQG	% > DL, > CWQG	% >Background, >CWQG	n	mean	median	stdev	min	max	n<MDL
KV39	0	100	100	2	0.00918	0.00918	0.0001	0.0091	0.0093	0
KV40	0	0	0	1	0.0009	0.0009	-	0.0009	0.0009	0
KV38	0	0	0	9	0.00287	0.0029	0.0006	0.002	0.0039	0
KV41	0	30	30	10	0.00796	0.00294	0.0105	0.002	0.029	0
KV6	0	31	31	35	0.00535	0.0033	0.0051	0.0002	0.0261	1
KV16	0	29	29	34	0.00451	0.00345	0.0037	0.0004	0.0198	1
KV29	0	26	26	34	0.00504	0.001	0.0118	0.0002	0.0668	2
KV30	0	32	32	34	0.00473	0.00325	0.004	0.0002	0.0196	1
KV7	0	14	14	36	0.00341	0.002	0.0035	0.0002	0.015	2
KV8	0	6	6	33	0.00292	0.0026	0.0019	0.0014	0.0114	1
KV21	0	0	0	1	0.0048	0.0048	-	0.0048	0.0048	0
KV47	0	67	67	3	0.00693	0.0051	0.0059	0.0022	0.0135	0
KV9	0	0	0	11	0.00201	0.002	0.0013	0.0006	0.0037	0
KV2	0	0	0	25	0.00171	0.0017	0.0003	0.001	0.0023	0
KV3	0	0	0	11	0.00214	0.0021	0.0003	0.0017	0.0027	0
KV4	0	0	0	10	0.00213	0.00205	0.0004	0.0017	0.0031	0
KV5	0	5	5	21	0.00359	0.0035	0.0008	0.0027	0.0063	0
KV15	0	33	33	12	0.00719	0.00435	0.0073	0.0019	0.0232	0

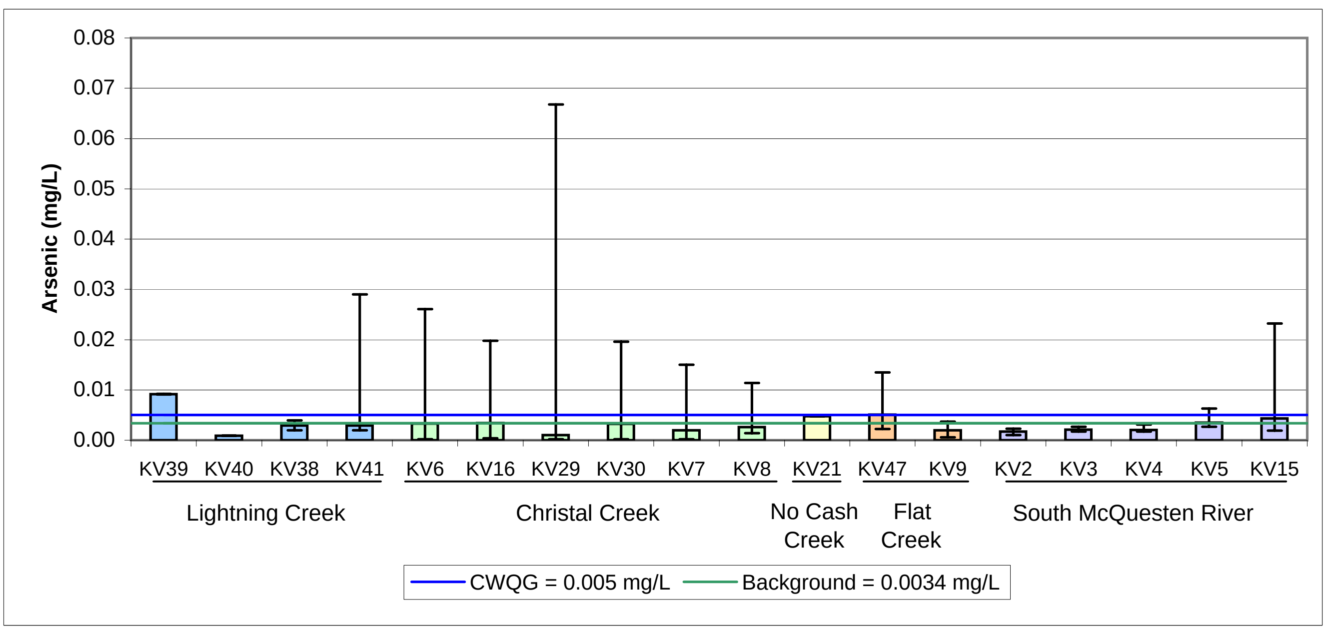


Figure B.2: Arsenic (mg/L) Median Values with Minimum and Maximum for Receiving Environment Stations, July 20, 2004 - 2007.

Table B.3: Cadmium (mg/L) Summary Statistics for Receiving Environment Stations, July 20, 2004-2007.

Station	% < DL, > CWGQ	% > DL, > CWGQ	% >Background, >CWQG	n	mean	median	stdev	min	max	n <MDL
KV39	0	100	100	2	0.00377	0.00377	0.00037	0.00350	0.00403	0
KV40	0	0	0	1	0.00004	0.00004	0.00000	0.00004	0.00004	0
KV38	0	100	0	9	0.00024	0.00020	0.00014	0.00008	0.00048	0
KV41	0	90	0	10	0.00020	0.00016	0.00012	0.00004	0.00042	0
KV6	0	100	92	36	0.00185	0.00159	0.00128	0.00008	0.00527	0
KV16	0	100	100	35	0.00239	0.00146	0.00420	0.00071	0.02600	0
KV29	0	100	100	35	0.01570	0.00634	0.02396	0.00229	0.11900	0
KV30	0	100	100	34	0.00206	0.00153	0.00148	0.00065	0.00689	0
KV7	0	100	81	37	0.00144	0.00113	0.00101	0.00046	0.00430	0
KV8	0	100	97	34	0.00154	0.00130	0.00080	0.00060	0.00340	0
KV21	0	100	100	1	0.04780	0.04780	0.00000	0.04780	0.04780	0
KV47	0	100	100	3	0.00247	0.00255	0.00045	0.00198	0.00287	0
KV9	0	100	18	11	0.00036	0.00036	0.00020	0.00014	0.00069	0
KV2	4	96	0	25	0.00020	0.00018	0.00009	0.00009	0.00040	0
KV3	0	100	8	12	0.00029	0.00025	0.00024	0.00013	0.00100	0
KV4	0	100	9	11	0.00033	0.00027	0.00020	0.00013	0.00080	0
KV5	4	86	0	21	0.00015	0.00015	0.00007	0.00003	0.00034	0
KV15	0	58	0	12	0.00009	0.00008	0.00007	0.00002	0.00023	0

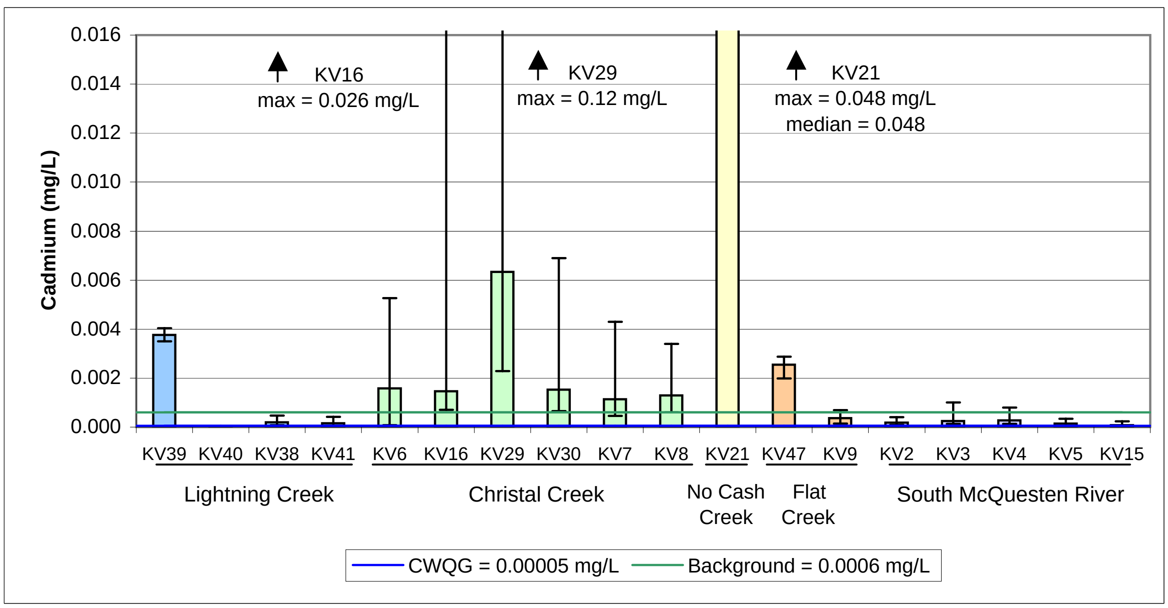


Figure B.3: Cadmium (mg/L) Median Values with Minimum and Maximum for Receiving Environment Stations, July 20, 2004 - 2007.

Table B.4: Chromium (mg/L) Summary Statistics for Receiving Environment Stations, July 20, 2004-2007.

Station	% < DL, > CWQG	% > DL, > CWQG	% >Background, >CWQG	n	mean	median	stdev	min	max	n <MDL
KV39	0	0	0	2	0.0005	0.0005	0.00000	0.0005	0.0005	2
KV40	0	0	0	1	0.0005	0.0005	-	0.0005	0.0005	1
KV38	0	0	0	8	0.0005	0.0005	0	0.0005	0.0005	8
KV41	0	30	30	10	0.00107	0.0005	0.00109	0.0005	0.0038	5
KV6	0	8	8	36	0.00071	0.0005	0.00037	0.0005	0.002	22
KV16	0	19	19	36	0.00105	0.0005	0.00172	0.0005	0.0106	26
KV29	0	30	30	33	0.00139	0.0005	0.00166	0.0005	0.0065	20
KV30	0	15	15	33	0.00077	0.0005	0.00051	0.0005	0.0028	23
KV7	0	11	11	35	0.00074	0.0005	0.00053	0.0005	0.0026	27
KV8	0	6	6	33	0.00069	0.0005	0.00041	0.0005	0.0022	24
KV21	0	100	100	1	0.0024	0.0024	0.00000	0.0024	0.0024	0
KV47	0	33	33	3	0.00113	0.00089	0.00078	0.0005	0.002	1
KV9	0	0	0	11	0.00051	0.0005	3E-05	0.0005	0.0006	10
KV2	0	0	0	25	0.00053	0.0005	0.00011	0.0005	0.001	24
KV3	0	0	0	12	0.00059	0.0005	0.00019	0.0005	0.001	11
KV4	0	0	0	11	0.00055	0.0005	0.00015	0.0005	0.001	11
KV5	0	0	0	21	0.00051	0.0005	0.00014	0.0001	0.001	20
KV15	0	8	8	12	0.00056	0.0005	0.0002	0.0005	0.0012	11

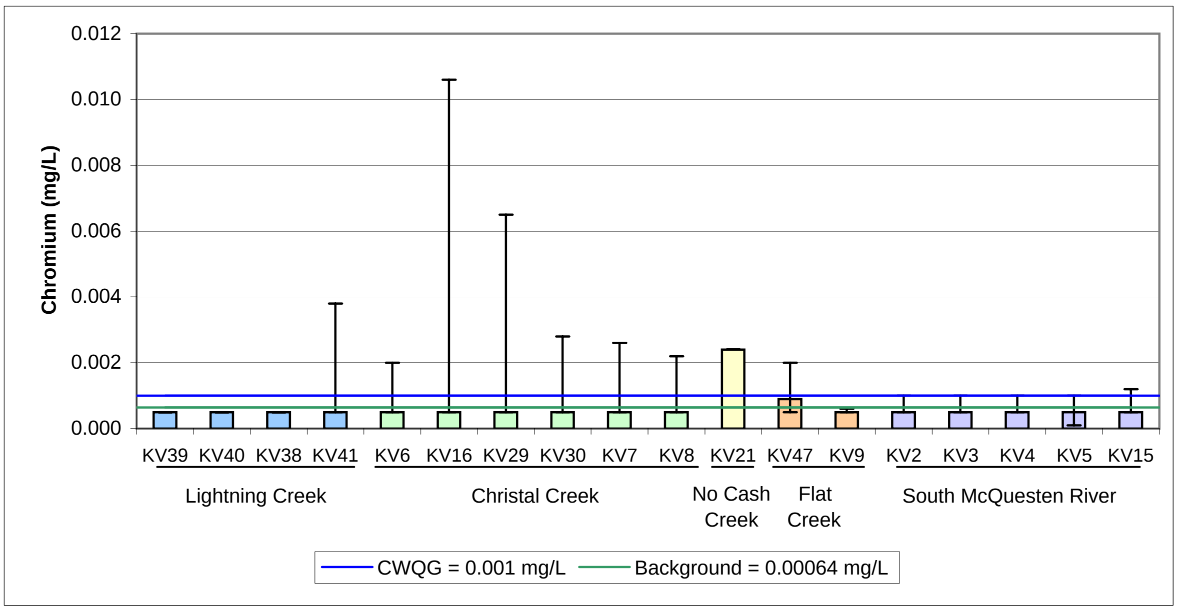


Figure B.4: Chromium (mg/L) Median Values with Minimum and Maximum for Receiving Environment Stations, July 20, 2004 - 2007.

Table B.5: Copper (mg/L) Summary Statistics for Receiving Environment Stations, July 20, 2004-2007.

Station	% < DL, > CWQG	% > DL, > CWQG	% >Background, >CWQG	n	mean	median	stdev	min	max	n <MDL
KV39	0	0	0	2	0.0016	0.0016	0.0008	0.0010	0.0021	1
KV40	0	0	0	1	0.0010	0.0010	-	0.0010	0.0010	1
KV38	11	0	0	9	0.0015	0.0010	0.0013	0.0010	0.0050	7
KV41	0	30	10	10	0.0026	0.0010	0.0025	0.0010	0.0080	4
KV6	0	9	0	35	0.0018	0.0010	0.0013	0.0010	0.0070	19
KV16	0	9	0	34	0.0018	0.0010	0.0012	0.0010	0.0060	16
KV29	0	36	12	33	0.0042	0.0020	0.0049	0.0010	0.0250	2
KV30	0	21	3	33	0.0021	0.0010	0.0017	0.0010	0.0080	15
KV7	0	20	3	35	0.0021	0.0010	0.0020	0.0010	0.0100	16
KV8	0	15	0	33	0.0021	0.0010	0.0016	0.0010	0.0070	12
KV21	0	100	100	1	0.0080	0.0080	-	0.0080	0.0080	0
KV47	0	67	0	3	0.0038	0.0040	0.0027	0.0010	0.0064	1
KV9	0	18	0	11	0.0021	0.0010	0.0018	0.0010	0.0070	1
KV2	0	4	0	25	0.0017	0.0010	0.0009	0.0010	0.0040	7
KV3	0	0	8	12	0.0028	0.0015	0.0025	0.0010	0.0090	5
KV4	0	18	0	11	0.0021	0.0020	0.0013	0.0010	0.0050	3
KV5	0	5	0	20	0.0020	0.0020	0.0009	0.0010	0.0040	5
KV15	0	0	0	12	0.0014	0.0010	0.0007	0.0010	0.0030	3

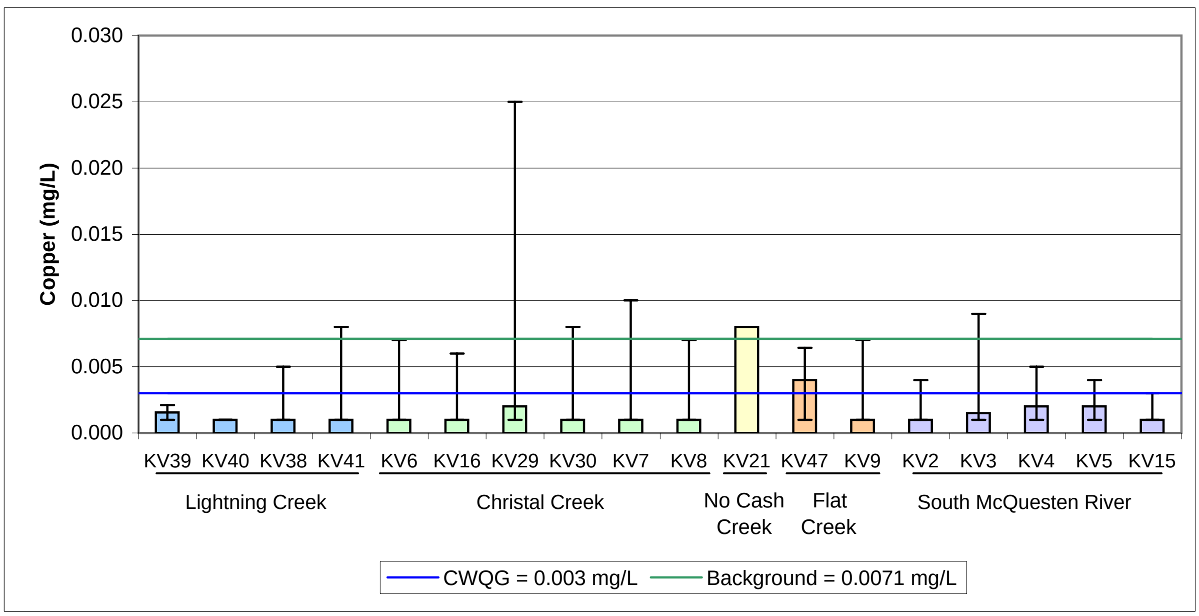


Figure B.5: Copper (mg/L) Median Values with Minimum and Maximum for Receiving Environment Stations, July 20, 2004 - 2007.

Table B.6: Iron (mg/L) Summary Statistics for Receiving Environment Stations, 1994-2007.

Station	% < DL, > CWQG	% > DL, > CWQG	% >Background, >CWQG	n	mean	median	stdev	min	max	n <MDL
KV39	0	0	0	2	0.07	0.07	0.05	0.030	0.10	2
KV40	0	0	0	2	0.05	0.05	0.07	0.003	0.10	1
KV38	10	0	0	10	0.14	0.10	0.13	0.028	0.50	8
KV41	0	53	41	17	0.99	0.49	1.37	0.068	4.60	3
KV6	0	37	19	79	0.48	0.20	0.65	0.010	3.50	4
KV16	0	45	21	42	0.63	0.30	1.00	0.019	6.00	4
KV29	0	41	35	37	1.81	0.30	3.81	0.100	20.3	10
KV30	0	53	33	40	0.82	0.36	1.00	0.100	4.20	2
KV7	0	25	16	77	0.34	0.20	0.46	0.010	2.34	8
KV8	0	27	12	41	0.30	0.12	0.34	0.033	1.38	7
KV21	0	100	50	2	0.56	0.56	0.34	0.322	0.80	0
KV47	0	79	71	14	1.38	1.18	0.94	0.137	3.33	0
KV9	0	22	17	23	0.30	0.14	0.34	0.049	1.00	7
KV2	0	23	17	47	0.31	0.20	0.30	0.010	1.03	0
KV3	0	9	5	22	0.24	0.20	0.13	0.092	0.75	1
KV4	0	29	13	45	0.32	0.20	0.29	0.010	1.00	0
KV5	0	7	4	28	0.23	0.20	0.13	0.024	0.80	0
KV15	0	40	13	15	0.44	0.30	0.34	0.198	1.40	0

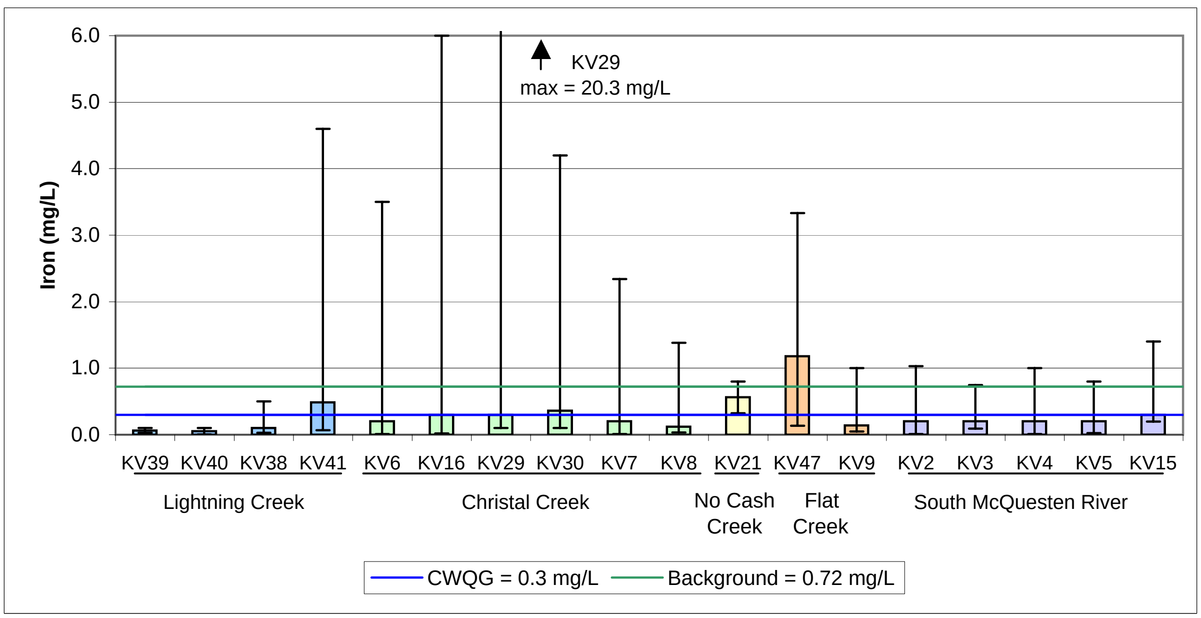


Figure B.6: Iron (mg/L) Median Values with Minimum and Maximum for Receiving Environment Stations, 1994 - 2007.

Table B.7: Lead (mg/L) Summary Statistics for Receiving Environment Stations, July 20, 2004-2007.

Station	% < DL, > CWQG	% > DL, > CWQG	% >Background, >CWQG	n	mean	median	stdev	min	max	n <MDL
KV39	0	50	50	2	0.00352	0.00352	0.00144	0.0025	0.00454	0
KV40	0	0	0	1	0.0001	0.0001	-	0.0001	0.0001	0
KV38	0	0	0	9	0.0008	0.0005	0.0006	0.0003	0.0019	1
KV41	0	30	30	10	0.0062	0.0017	0.0101	0.0005	0.0316	0
KV6	0	60	60	35	0.01489	0.0049	0.02413	0.0005	0.12	0
KV16	0	44	44	34	0.00508	0.00385	0.00512	0.0003	0.0268	0
KV29	0	26	26	34	0.00338	0.00115	0.00485	0.0001	0.0203	2
KV30	0	42	42	33	0.00537	0.0036	0.00486	0.0004	0.0246	0
KV7	0	14	14	35	0.00372	0.0015	0.00635	0.0004	0.024	1
KV8	0	23	23	31	0.00256	0.0017	0.00197	0.0006	0.0068	0
KV21	0	100	100	1	0.0052	0.0052	-	0.0052	0.0052	0
KV47	0	33	33	3	0.0451	0.0037	0.0735	0.0017	0.1300	0
KV9	0	45	45	11	0.0074	0.0033	0.0096	0.0009	0.0333	0
KV2	0	8	8	25	0.00127	0.0007	0.0013	0.0003	0.0049	0
KV3	0	9	9	11	0.00181	0.0013	0.00172	0.0009	0.00694	0
KV4	0	20	20	10	0.00399	0.00175	0.007	0.0006	0.0237	0
KV5	0	10	10	21	0.0018	0.0013	0.00168	0.0004	0.008	0
KV15	0	8	8	12	0.00148	0.00105	0.00137	0.0002	0.0049	0

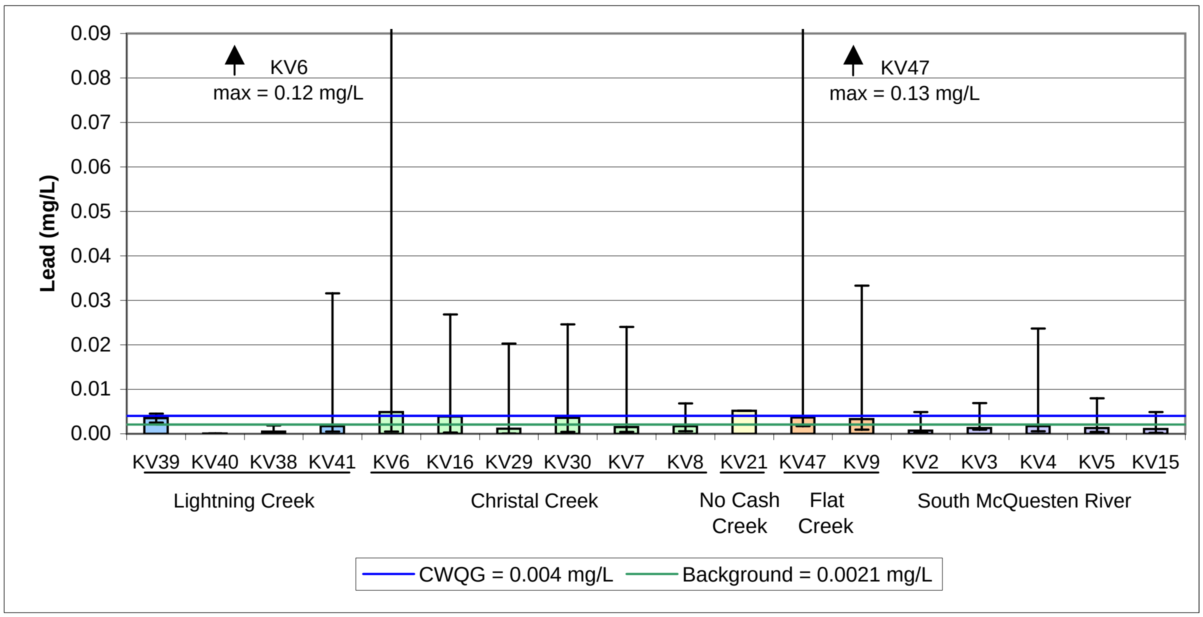


Figure B.7: Lead (mg/L) Median Values with Minimum and Maximum for Receiving Environment Stations, July 20, 2004 - 2007.

Table B.8: Manganese (mg/L) Summary Statistics for Receiving Environment Stations, 1994-2007.

Station	% < DL, > BCWQG	% > DL, > BCWQG	% >Background, >BCWQG	n	mean	median	stdev	min	max	n <MDL
KV39	0	0	0	2	0.01	0.01	0.00	0.01	0.01	1
KV40	0	0	0	2	0.00	0.00	0.00	0.00	0.01	0
KV38	0	0	0	10	0.01	0.01	0.01	0.01	0.02	6
KV41	0	0	0	17	0.05	0.02	0.06	0.00	0.22	0
KV6	0	16	16	80	0.77	0.56	0.61	0.01	2.60	0
KV16	0	20	20	41	1.36	0.72	1.95	0.23	9.27	0
KV29	0	53	53	40	14	1.61	25	0.01	101	0
KV30	0	31	31	39	1.56	0.92	1.75	0.29	7.65	0
KV7	0	0	0	75	0.29	0.24	0.22	0.01	0.92	0
KV8	0	0	0	40	0.20	0.26	0.25	0.07	1.28	0
KV21	0	100	100	2	3.20	3.20	1.16	2.38	4.02	0
KV47	0	43	43	14	1.34	1.11	0.78	0.52	3.00	0
KV9	0	0	0	23	0.06	0.05	0.03	0.01	0.15	0
KV2	0	0	0	45	0.08	0.07	0.04	0.04	0.20	0
KV3	0	0	0	19	0.07	0.07	0.02	0.04	0.12	0
KV4	0	0	0	44	0.10	0.09	0.06	0.03	0.34	0
KV5	0	0	0	26	0.07	0.07	0.03	0.00	0.13	0
KV15	0	0	0	15	0.08	0.08	0.05	0.01	0.19	0

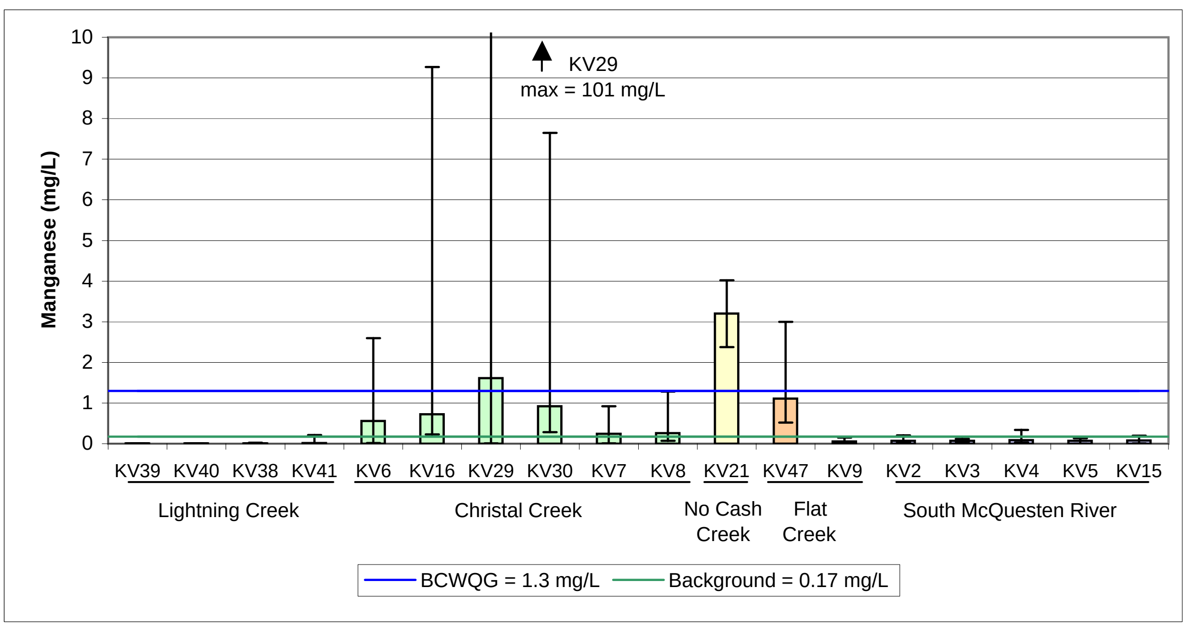


Figure B.8: Manganese (mg/L) Median Values with Minimum and Maximum for Receiving Environment Stations, 1994 - 2007.

Table B.9: Nitrite (mg/L) Summary Statistics for Receiving Environment Stations, 1994-2007.

Station	% < DL, > CWQG	% > DL, > CWQG	n	mean	median	stdev	min	max	n <MDL
KV39	0	50	2	0.138	0.138	0.124	0.050	0.226	0
KV40	-	-	0	-	-	-	-	-	-
KV38	0	0	3	0.043	0.040	0.015	0.030	0.059	1
KV41	0	20	5	0.028	0.030	0.025	0.002	0.063	1
KV6	0	29	7	0.045	0.050	0.044	0.002	0.120	0
KV16	0	67	3	0.077	0.080	0.035	0.040	0.110	0
KV29	0	75	4	0.565	0.210	0.828	0.040	1.800	0
KV30	0	67	3	0.087	0.090	0.045	0.040	0.130	0
KV7	0	38	8	0.060	0.050	0.067	0.002	0.200	2
KV8	0	0	4	0.040	0.036	0.024	0.005	0.060	0
KV21	0	100	1	0.070	0.070	-	0.070	0.070	0
KV47	0	0	5	0.030	0.029	0.026	0.002	0.060	0
KV9	0	0	8	0.023	0.018	0.023	0.002	0.060	7
KV2	0	0	7	0.020	0.030	0.016	0.002	0.040	5
KV3	0	0	7	0.013	0.005	0.013	0.002	0.030	6
KV4	0	0	7	0.017	0.008	0.016	0.002	0.040	4
KV5	0	0	5	0.030	0.030	0.018	0.002	0.050	1
KV15	0	0	1	0.030	0.030	-	0.030	0.030	0

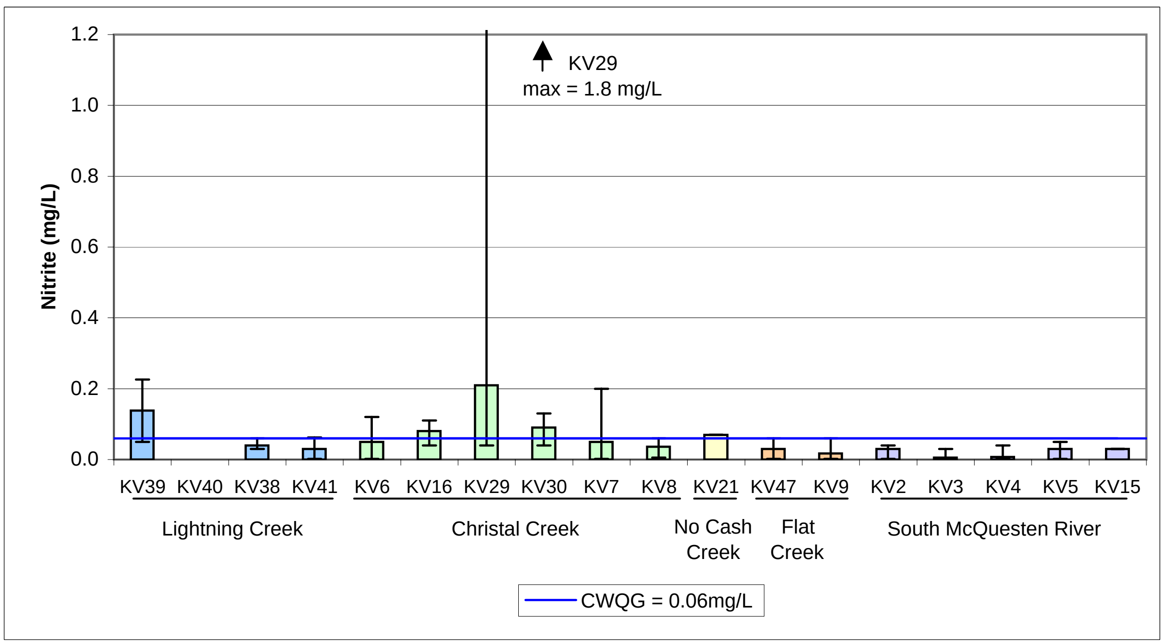


Figure B.9: Nitrite (mg/L) Median Values with Minimum and Maximum for Receiving Environment Stations, 1994 - 2007.

Table B.10: Phosphorus (mg/L) Summary Statistics for Receiving Environment Stations, 1994-2007.

Station	% < DL, > PWQO	% > DL, > PWQO	% >Background, >PWQO	n	mean	median	stdev	min	max	N <MDL
KV39	-	-	-	0	-	-	-	-	-	0
KV40	100	0	0	1	0.06	0.06	-	0.06	0.06	1
KV38	100	0	0	1	0.06	0.06	-	0.06	0.06	1
KV41	33	67	0	3	0.05	0.06	0.02	0.03	0.07	1
KV6	77	15	0	13	0.06	0.06	0.01	0.05	0.08	10
KV16	25	75	63	16	0.41	0.45	0.33	0.06	1.20	4
KV29	44	56	44	9	0.43	0.16	0.51	0.06	1.34	4
KV30	29	71	14	7	0.22	0.12	0.32	0.06	0.94	2
KV7	30	60	0	10	0.08	0.07	0.04	0.03	0.18	4
KV8	67	33	17	6	0.11	0.06	0.10	0.06	0.31	4
KV21	100	0	0	1	0.06	0.06	-	0.06	0.06	2
KV47	33	67	0	6	0.07	0.06	0.01	0.06	0.09	2
KV9	86	0	0	7	0.05	0.06	0.01	0.03	0.06	7
KV2	50	40	0	10	0.07	0.06	0.02	0.03	0.12	6
KV3	60	20	0	5	0.06	0.06	0.02	0.03	0.07	4
KV4	40	40	0	5	0.07	0.06	0.04	0.03	0.14	3
KV5	60	40	20	5	0.10	0.06	0.09	0.06	0.27	3
KV15	100	100	0	2	0.06	0.06	0	0.06	0.06	2

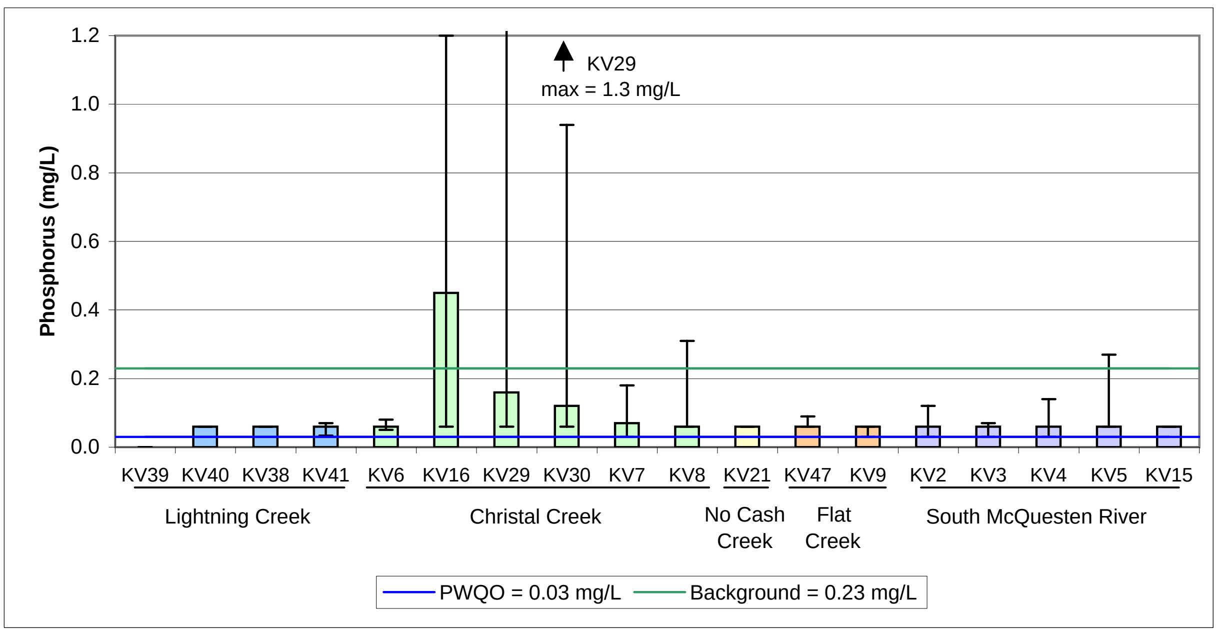


Figure B.10: Phosphorus (mg/L) Median Values with Minimum and Maximum for Receiving Environment Stations, 1994 - 2007.

Table B.11: Selenium (mg/L) Summary Statistics for Receiving Environment Stations, July 20, 2004 - 2007.

Station	% < DL, > CWQG	% > DL, > CWQG	% >Background, >CWQG	n	mean	median	stdev	min	max	n <MDL
KV39	0	0	0	2	0.0009	0.0009	0.0002	0.0007	0.0010	1
KV40	0	100	100	1	0.0014	0.0014	-	0.0014	0.0014	0
KV38	0	0	0	9	0.0007	0.0006	0.0002	0.0005	0.0010	2
KV41	0	0	0	10	0.0008	0.0008	0.0002	0.0004	0.0010	1
KV6	0	20	20	35	0.0009	0.0009	0.0004	0.0003	0.0030	1
KV16	0	14	14	35	0.0008	0.0007	0.0003	0.0004	0.0019	1
KV29	0	9	9	33	0.0006	0.0004	0.0004	0.0002	0.0023	8
KV30	0	9	9	33	0.0008	0.0008	0.0002	0.0004	0.0012	1
KV7	0	9	9	35	0.0007	0.0007	0.0002	0.0003	0.0013	2
KV8	0	9	9	32	0.0007	0.0007	0.0002	0.0003	0.0012	1
KV21	0	0	0	1	0.0009	0.0009	-	0.0009	0.0009	0
KV47	0	0	0	3	0.0007	0.0007	0.0004	0.0003	0.0010	1
KV9	0	0	0	11	0.0003	0.0002	0.0002	0.0002	0.0010	3
KV2	0	0	0	25	0.0005	0.0005	0.0001	0.0002	0.0006	2
KV3	0	0	0	11	0.0005	0.0005	0.0002	0.0002	0.0010	1
KV4	0	0	0	10	0.0005	0.0005	0.0002	0.0003	0.0010	1
KV5	0	0	0	21	0.0004	0.0004	0.0001	0.0002	0.0007	2
KV15	0	0	0	12	0.0003	0.0003	0.0001	0.0002	0.0005	3

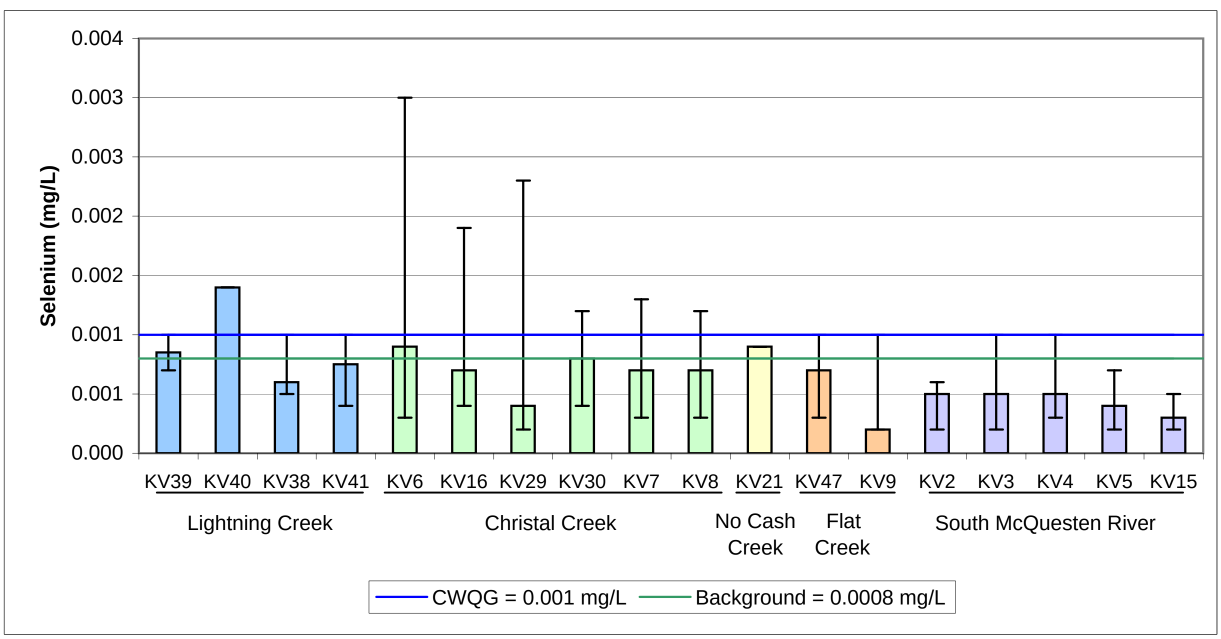


Figure B.11: Selenium (mg/L) Median Values with Minimum and Maximum for Receiving Environment Stations, July 20, 2004 - 2007.

Table B.12: Silver (mg/L) Summary Statistics for Receiving Environment Stations, July 20, 2004 - 2007.

Station	% < DL, > CWQG	% > DL, > CWQG	% >Background, >CWQG	n	mean	median	stdev	min	max	n<MDL
KV39	0	0	0	2	0.0001	0.0001	0.0000	0.0000	0.0001	1
KV40	0	0	0	1	0.0001	0.0001	-	0.0001	0.0001	1
KV38	0	13	13	8	0.0001	0.0001	4.8E-05	0.000022	0.0002	6
KV41	0	30	30	10	0.00021	0.0001	0.00025	0.000059	0.0009	6
KV6	0	32	32	34	0.0003	0.0001	0.00046	0.0001	0.0019	21
KV16	0	19	19	32	0.00014	0.0001	0.00013	0.0001	0.0008	24
KV29	0	24	24	29	0.00016	0.0001	0.00014	0.0001	0.0007	19
KV30	0	23	23	31	0.00014	0.0001	0.0001	0.0001	0.0005	21
KV7	0	26	26	34	0.00015	0.0001	0.00011	0.0001	0.0005	24
KV8	0	23	23	31	0.00014	0.0001	9.2E-05	0.0001	0.0005	19
KV21	0	0	0	1	0.0001	0.0001	-	0.0001	0.0001	1
KV47	0	50	50	2	0.00112	0.00112	0.00144	0.0001	0.00214	1
KV9	0	18	18	11	0.00012	0.0001	3.8E-05	0.0001	0.0002	7
KV2	0	16	16	25	0.00016	0.0001	0.00017	0.0001	0.0008	16
KV3	0	20	20	10	0.00014	0.0001	9.7E-05	0.000099	0.0004	6
KV4	0	20	20	10	0.00014	0.0001	7.5E-05	0.0001	0.0003	7
KV5	0	14	14	21	0.00015	0.0001	0.00018	0.0001	0.0009	16
KV15	0	17	17	12	0.00013	0.0001	6.2E-05	0.0001	0.0003	9

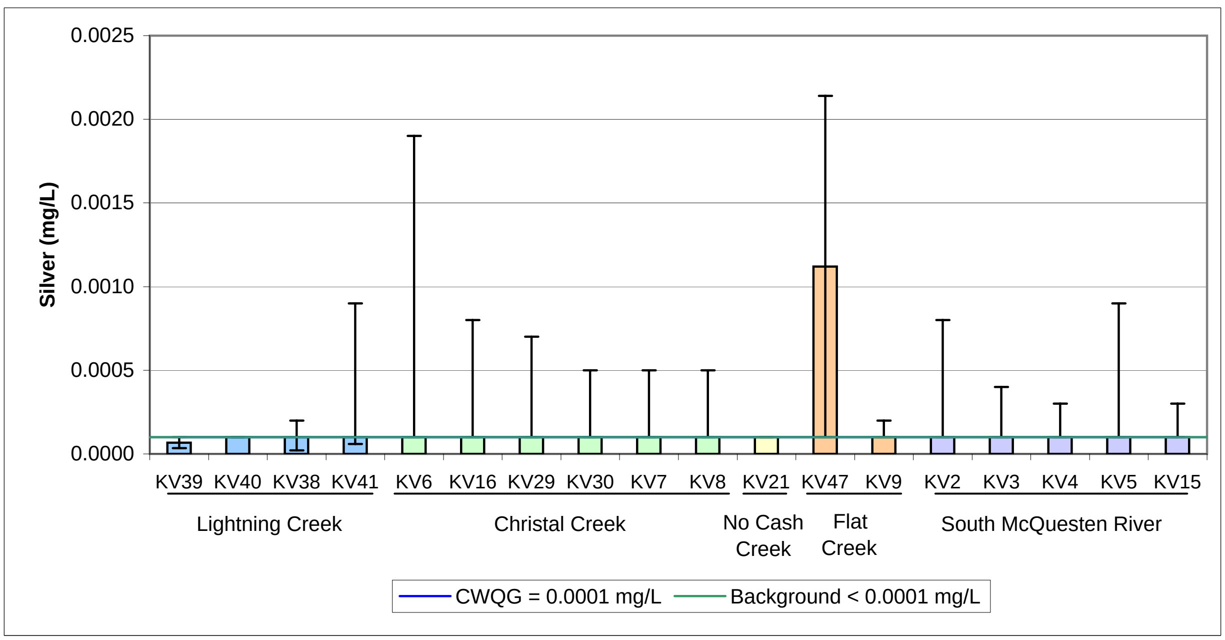


Figure B.12: Silver (mg/L) Median Values with Minimum and Maximum for Receiving Environment Stations, July 20, 2004 - 2007.

Table B.13: Sulphate (mg/L) Summary Statistics for Receiving Environment Stations, July 20, 2004-2007.

Station	% < DL, > BCWQG	% > DL, > BCWQG	% >Background, >BCWQG	n	mean	median	stdev	min	max	n <MDL
KV39	0	100	0	1	57	57	-	57	57	0
KV40	-	-	-	-	-	-	-	-	-	-
KV38	0	0	0	5	34	36	6	25	43	0
KV41	0	40	0	5	42	50	14	22	54	0
KV6	0	100	86	21	256	281	79	73	334	0
KV16	0	100	100	19	333	320	149	150	900	0
KV29	0	100	100	22	931	905	154	540	1250	0
KV30	0	100	100	19	337	342	71	159	457	0
KV7	0	100	95	20	240	252	57	105	340	0
KV8	0	90	85	20	214	239	76	50	310	1
KV21	-	-	-	-	-	-	-	-	-	-
KV47	0	100	0	1	59	59	-	59	59	0
KV9	0	83	67	6	126	139	51	42	190	0
KV2	0	90	0	21	78	84	21	26	104	0
KV3	0	86	0	7	78	93	27	27	104	0
KV4	0	83	0	6	79	83	24	38	104	0
KV5	0	82	6	17	75	79	23	22	110	0
KV15	0	75	0	8	63	64	26	22	100	0

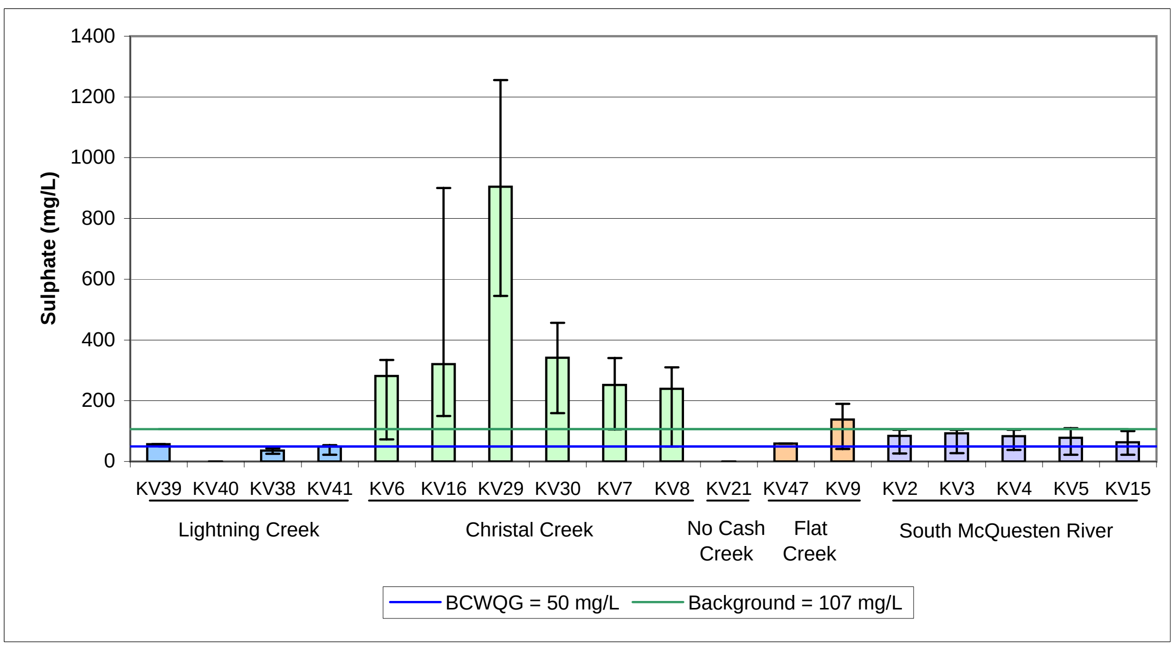


Figure B.13: Sulphate (mg/L) Median Values with Minimum and Maximum for Receiving Environment Stations, July 20, 2004 - 2007.

Table B.14: Zinc (mg/L) Summary Statistics for Receiving Environment Stations, 1994-2007.

Station	% < DL, > CWQG	% > DL, > CWQG	% >Background, >CWQG	n	mean	median	stdev	min	max	n <MDL
KV39	0	100	100	2	0.32	0.32	0.065	0.271	0.36	0
KV40	0	0	0	2	0.01	0.01	0.004	0.003	0.01	0
KV38	0	30	0	10	0.03	0.03	0.013	0.014	0.05	0
KV41	0	47	11	19	0.05	0.03	0.068	0.004	0.28	0
KV6	0	91	78	81	0.33	0.26	0.275	0.001	1.75	0
KV16	0	100	95	42	0.81	0.29	1.305	0.135	5.41	0
KV29	0	100	100	42	11.7	4.31	17.78	0.658	65.5	0
KV30	0	100	95	41	1.02	0.42	1.413	0.111	5.79	0
KV7	0	100	85	79	0.34	0.27	0.238	0.048	1.31	0
KV8	0	100	98	40	0.42	0.32	0.341	0.118	1.86	0
KV21	0	100	100	2	3.95	3.95	1.146	3.140	4.76	0
KV47	0	94	94	16	0.25	0.24	0.116	0.003	0.44	0
KV9	0	78	19	27	0.09	0.05	0.084	0.020	0.30	0
KV2	0	72	6	50	0.06	0.04	0.057	0.010	0.36	0
KV3	0	75	4	24	0.05	0.04	0.036	0.016	0.19	0
KV4	0	74	11	46	0.07	0.04	0.063	0.010	0.29	0
KV5	0	45	0	29	0.03	0.03	0.015	0.010	0.07	0
KV15	0	25	0	16	0.02	0.02	0.017	0.003	0.06	0

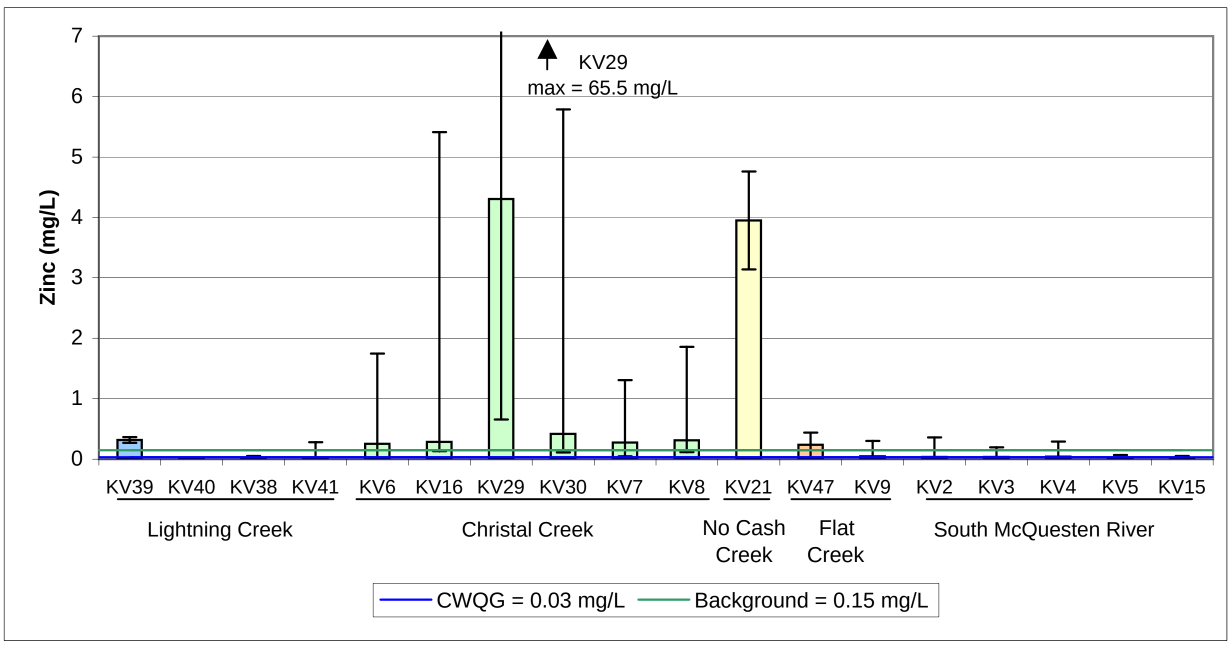


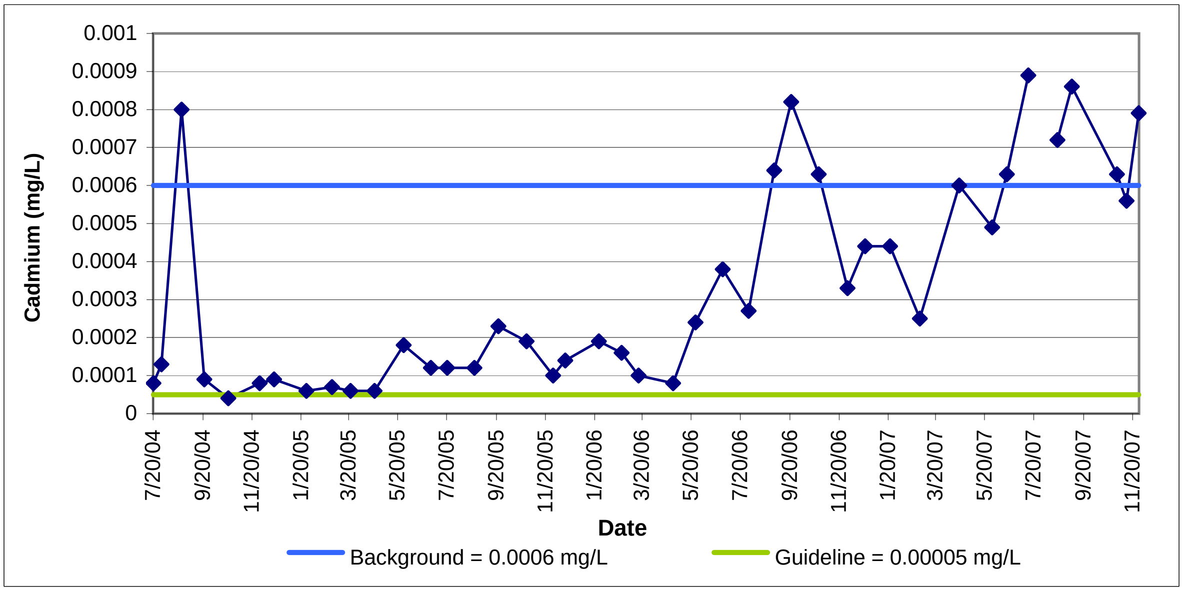
Figure B.14: Zinc (mg/L) Median Values with Minimum and Maximum for Receiving Environment Stations, 1994 - 2007.

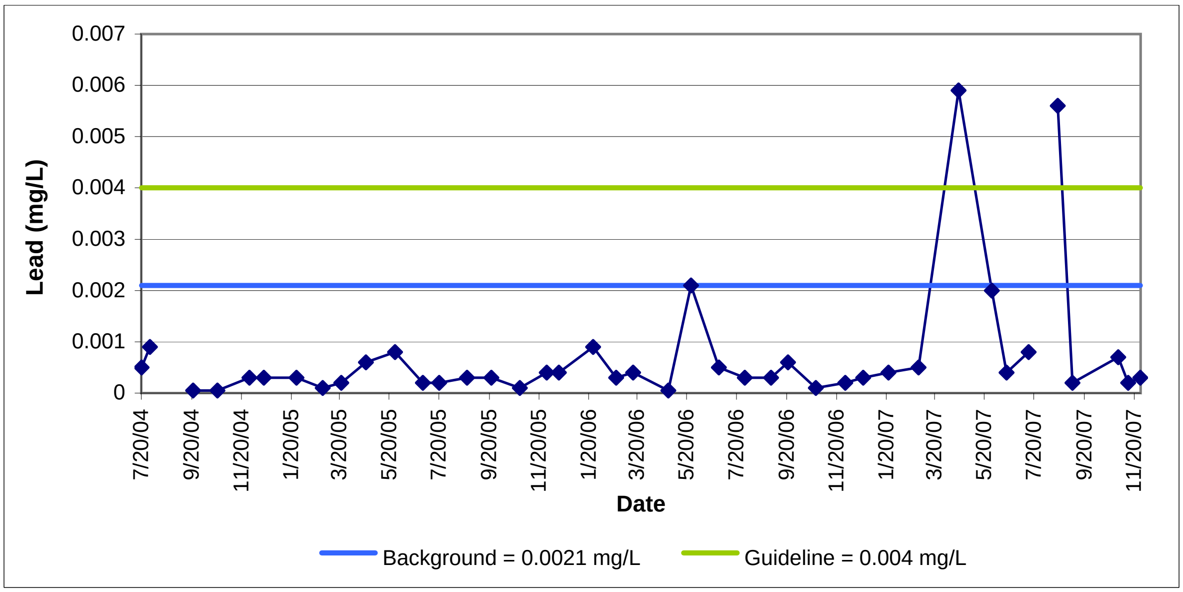
Table B.15: Water quality medians (mid-2004 - mid-2007) used in PCA, United Keno Hill Mines[a].

Watershed	Station	Alkalinity-Total (as CaCO3)	Aluminum-Total	Arsenic-Total	Cadmium-Total	Conductivity	Copper-Total	Hardness (as CaCO3)	Iron-Total	Lead-Total
	Units	mg/L	mg/L	mg/L	mg/L	uS/cm	mg/L	mg/L	mg/L	mg/L
Lightning Creek	KV37	30	0.021	0.0029	0.000005	129.5	0.0005	53.0	0.05	0.0002
	KV38	36	0.011	0.0027	0.0002	155	0.0005	66.5	0.05	0.0005
	KV41	46	0.28	0.004	0.00023	197	0.0024	76	0.5	0.0030
Christal Creek	KV6	130	0.025	0.0037	0.00158	686	0.0010	416	0.2	0.0055
	KV7	144	0.032	0.0021	0.0011	625	0.0010	390	0.2	0.0016
	KV8	146	0.017	0.0026	0.0013	680	0.0010	392	0.1	0.0020
Flat Creek	KV9	194	0.01	0.0024	0.0004	615	0.0020	302	0.05	0.0045
South McQuesten River	KV1	120	0.153	0.0014	0.00021	377	0.0035	204	0.2	0.0003
	KV3	118	0.097	0.0021	0.00025	319	0.0026	237	0.2	0.0013
	KV4	130	0.0896	0.0022	0.00028	417	0.0020	216	0.2	0.0020
	KV5	140	0.034	0.0035	0.00016	429	0.0020	212	0.2	0.0014

Watershed	Station	Manganese-Total	Nitrite	pH	Selenium-Total	Strontium-Total	Sulphate*-Dissolved	Total Suspended Solids	Uranium-Total	Zinc-Total
	Units	mg/L	mg/L	pH units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Lightning Creek	KV37	0.009	0.026	7.67	0.0004	0.060	23.0	2.0	0.0003	0.003
	KV38	0.0025	0.045	7.62	0.0005	0.078	35.8	1	0.0003	0.025
	KV41	0.044	0.050	7.73	0.0007	0.086	46.5	17.2	0.0005	0.031
Christal Creek	KV6	0.456	0.060	7.80	0.0009	0.226	281	1	0.0051	0.218
	KV7	0.273	0.060	7.84	0.0008	0.243	245	2	0.0027	0.227
	KV8	0.180	0.050	7.82	0.0007	0.241	230	1	0.0025	0.287
Flat Creek	KV9	0.065	0.015	7.45	0.0002	0.212	138	1	0.0010	0.043
South McQuesten River	KV1	0.098	0.015	7.79	0.0004	0.223	71.5	1.0	0.0008	0.048
	KV3	0.083	0.016	7.80	0.0005	0.207	82.3	1	0.0008	0.047
	KV4	0.078	0.015	7.88	0.0005	0.201	76.0	1.5	0.0008	0.058
	KV5	0.077	0.040	7.81	0.0004	0.227	77.5	1	0.0008	0.036

[a] prepared using data from Minnow (2008) and Burns (2008).





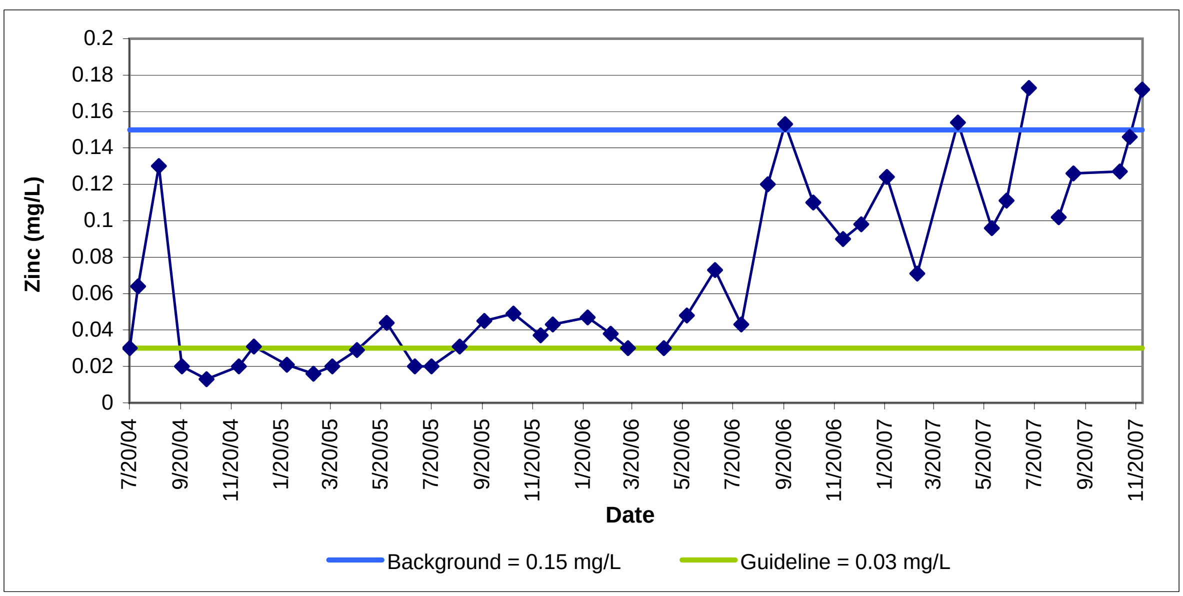


Figure B.15: Concentrations of cadmium, lead and zinc at station KV-1, United Keno Hill Mines, mid-2004 - 2007.

APPENDIX C

SEDIMENT QUALITY

Table C.1: Guidelines selected for evaluating sediment quality at United Keno Hill Mines

Parameter	Units	Sediment Quality Guidelines					
		Canadian[a]		British Columbia[b]		Ontario[e]	
		ISQG[c]	PEL[d]	ISQG[c]	PEL[d]	LEL[f]	SEL[g]
Aluminum	ug/g						
Antimony	ug/g						
Arsenic	ug/g	5.9	17	5.9	17	6	33
Barium	ug/g						
Beryllium	ug/g						
Bismuth	ug/g						
Cadmium	ug/g	0.6	3.5	0.6	3.5	0.6	10
Calcium	ug/g						
Chromium	ug/g	37.3	90	37.3	90	26	110
Cobalt	ug/g						
Copper	ug/g	35.7	197	35.7	197	16	110
Iron	ug/g			21,200	43,766	20,000	40,000
Lead	ug/g	35.0	91.3	35	91	31	250
Lithium	ug/g						
Magnesium	ug/g						
Manganese	ug/g					460	1,100
Mercury	ug/g			0.170	0.486	0.2	2
Molybdenum	ug/g						
Nickel	ug/g			16	75	16	75
Phosphorus	ug/g					600	2,000
Potassium	ug/g						
Selenium	ug/g			2[f]			
Silicon	ug/g						
Silver	ug/g						
Sodium	ug/g						
Strontium	ug/g						
Sulfur	ug/g						
Thallium	ug/g						
Thorium	ug/g						
Tin	ug/g						
Titanium	ug/g						
Uranium	ug/g						
Vanadium	ug/g						
Zinc	ug/g	123	315	123	315	120	820
Zirconium	ug/g						
pH	pH units						

[a] CCME (1999)

[b] BCMOE (2006)

[c] Interim sediment quality guideline

[d] Probable effect level

[e] OMOE (1993)

[f] Lethal effect level.

[g] Severe effect level.

Shading indicates value used in evaluating measured sediment concentrations at United Keno Hill.

Table C.2: Sediment quality data for stations near United Keno Hill Mines, Yukon, 2007[a,e].

Parameter	Units	MDL[b]	Selected Sediment Quality Guidelines[c]		Lightning Creek			Christal Creek			Flat Creek	South McQuesten River				
			Guideline	Value	KV37	KV38	KV41	KV6	KV7	KV8	KV9	KV1	KV2	KV3	KV4	KV5
Aluminum	ug/g	1			12,533	9,023	8,693	9,410	7,253	11,200	7,323	8,050	8,770	8,140	9,557	12,733
Antimony	ug/g	0.5			0.6	14	0.7	14.8	< 0.5	6	150	< 0.5	15.3	15.6	32.3	6
Arsenic	ug/g	0.2	CCME	17	115	433	63	284	35	190	586	18.8	235	130	180	124
Barium	ug/g	0.03			232	160	186	251	226	301	342	133	155	163	195	247
Beryllium	ug/g	0.01			0.3	0.23	0.3	0.3	0.2	0.38	0.32	0.24	0.29	0.26	0.32	0.44
Bismuth	ug/g	0.5			2.7	4.0	2.2	2.9	1.9	3.4	8.5	1.4	2.6	2.6	3.0	3
Cadmium	ug/g	0.05	CCME	3.5	2.7	31.2	3.4	28.2	3.7	24.8	57.1	3.3	18	14	17.0	12
Calcium	ug/g	2			3,560	5,113	3,837	5,760	15,500	14,433	8,237	7,217	8,910	11,100	9,183	12,417
Chromium	ug/g	0.04	CCME	90	22.0	37.8	23	16.7	13.2	21	15.8	12.5	18	14.3	15.8	19.6
Cobalt	ug/g	0.05			11.0	13.4	10.4	10.5	7.49	13.8	10.1	19.5	24	18.2	20.1	35
Copper	ug/g	0.05	CCME	197	42	56	33.8	41.3	26.6	63.0	194	25.4	49.5	41.5	59.0	54.3
Iron	ug/g	1	BCMOE	43,766	27,633	34,833	26,000	27,133	20,367	34,600	75,533	17,533	28,267	25,467	31,800	30,000
Lead	ug/g	0.3	CCME	91.3	40.0	642	82.2	954	56.4	498	6,290	13.9	707	423	985	271
Lithium	ug/g	0.1			19.3	13.9	13.0	15.1	13	20	12	13.1	14.1	13.6	15.2	20
Magnesium	ug/g	1			3,993	5,013	3,913	4,167	6,910	6,650	5,150	4,467	5,180	5,313	5,727	7,037
Manganese	ug/g	0.3	OMOE	1,100	708	2,167	650	3,277	758	3,140	< 0.3[d]	754	3,600	3,117	4,303	4,290
Mercury	ug/g	0.003	BCMOE	0.486	0.08	0.23	0.055	0.1	0.068	0.14	0.589	0.054	0.109	0.09	0.173	0.11
Molybdenum	ug/g	0.05			1.4	5	1.7	0.7	1	1.6	0.2	0.63	1.5	0.7	0.7	1.1
Nickel	ug/g	0.1	BCMOE	75	30	42.3	30.4	27.9	22.6	44.1	32	74.0	92.2	69.4	66.8	133
Phosphorus	ug/g	0.5	OMOE	2,000	1,100	1,070	991	1,053	988	1,007	755	1,020	1,093	1,040	1,047	1,029
Potassium	ug/g	5			350	270	360	397	387	567	475	410	464	437	527	693
Selenium	ug/g	0.3	BCMOE	2	1.4	2	0.8	2.5	1	3.6	11.0	1.2	3	2.5	3.5	3.4
Silicon	ug/g	1			315	311	355	312	263	265	314	139	175	104	251	141
Silver	ug/g	0.2			0.8	15.0	1.9	12.2	0.8	7.1	16.0	0.3	11.8	7	16.2	4.4
Sodium	ug/g	1			43	43	59	67	83	80	81	73	84	95	79	88
Strontium	ug/g	0.02			19.9	21.2	18.6	23.5	40.0	42.0	29	29.7	39	32.8	26.1	44.3
Sulfur	ug/g															
Thallium	ug/g	0.3			0.5	3.0	0.4	5.6	0.4	4.9	46	1.0	6.4	5	7.6	6.3
Thorium	ug/g															
Tin	ug/g	0.2			0.3	7.2	3	0.9	0.2	0.6	9.1	0.2	1.6	1	1.7	0.7
Titanium	ug/g	0.05			44	79	135	72	107	73	38	105	105	104	95	83
Uranium	ug/g															
Vanadium	ug/g	0.1			30	26	29	26	22	31	22	20	22	21	25	26
Zinc	ug/g	0.1	CCME	315	125	1,637	247	1,483	404	2,067	3,143	512	1,410	1,054	1,333	1,400
Zirconium	ug/g	0.05			1	2.0	3	2.2	3	3.5	2.2	2.2	2.6	2.3	2.6	3.0

[a] Reported by Burns (2008)

[b] MDL - method detection limit

[c] see Table C.1 for explanatory footnotes

[d] concentration considerably lower then all other values and therefore considered suspect

[e] values represent means of three replicate samples

Note: concentrations measured using very fine-sized sediment (i.e. fraction passing through a 0.053 mm sieve)

Shading indicates measured values exceeding benchmark.

Table C.3: Sediment quality data for stations near United Keno Hill Mines, Yukon, 2004[a,d].

Parameter	Units	MDL[b]	Selected Sediment Quality Guidelines[c]		Lightning Creek			Christal Creek			Flat Creek	South McQuesten River				
			Guideline	Value	KV37	KV38	KV41	KV6	KV7	KV8	KV9	KV1	KV2	KV3	KV4	KV5
Aluminum	ug/g	5			11,300	5,877	5,853	7,573	5,810	6,800	4,100	9,187	9,133	10,967	14,557	7,930
Antimony	ug/g	0.2			2.00	9	4.83	87	11	15.5	23.0	0.8	13	15.4	9.3	5.86
Arsenic	ug/g	0.2	CCME	17	55.9	72	35.4	1,643	83	116	55.2	21.2	78.8	93.3	40.5	40
Barium	ug/g	1			168	87	88.3	89.1	263	174	238	183	151	195	370	139
Beryllium	ug/g	0.1			0.2	0	0.1	< 0.5	0.14	0.2	0.1	0.19	0.2	0.2	0.27	0.15
Bismuth	ug/g	0.5			0.2	0	< 0.2	< 2	0.33	0.3	0.3	0.36	0.3	0.36	0.43	0.33
Cadmium	ug/g	0.01	CCME	3.5	0.54	11	4.0	145	21.2	23.4	15	2.52	10.6	14.8	5.6	3.6
Calcium	ug/g	200			2,887	3,657	2,700	11,067	15,867	6,713	3,953	10,547	9,153	12,100	35,827	7,073
Chromium	ug/g	0.5	CCME	90	14.5	8	11.8	11	9.5	10	8.24	11.3	12.1	11.8	16.5	10.7
Cobalt	ug/g	0.1			6.2	8	6.27	42	10.3	7.82	6.15	15.1	11.7	13.1	9.4	7.28
Copper	ug/g	1	CCME	197	19.7	29	21.7	83	23	22.9	35.6	17.5	22.2	28.5	27.2	14
Iron	ug/g	10	BCMOE	43,766	13,600	17,033	14,300	64,800	16,267	16,200	12,767	14,367	17,400	16,867	18,033	13,533
Lead	ug/g	0.1	CCME	91.3	27	223	76.7	4,067	413	755	1,883	12	377	677	310	150
Lithium	ug/g	1			10	7	6.7	8	7.6	8.4	7	9.2	8.3	8.5	12	8
Magnesium	ug/g	200			3,740	6,447	4,433	5,327	8,140	5,573	4,237	6,583	6,700	6,760	15,960	6,027
Manganese	ug/g	5	OMOE	1,100	300	1,577	471	41,733	5,063	3,683	3,797	733	2,087	2,060	1,196	909
Mercury	ug/g		BCMOE	0.486												
Molybdenum	ug/g	1			1.1	3	1.3	< 5	2.4	1.6	1	1.2	1.2	1	2	1
Nickel	ug/g	0.5	BCMOE	75	16	15	16	92.1	29.9	20.3	14.3	47	39.0	44.5	26	24.0
Phosphorus	ug/g	30	OMOE	2,000	684	434	424	505	992	711	735	768	838	907	748	636
Potassium	ug/g	400			330	223	213	677	680	407	340	693	623	917	2,267	563
Selenium	ug/g	0.2	BCMOE	2	0.3	0	< 0.10	< 1	< 0.10	0.14	< 0.10	0.72	0.57	1	0.5	0.1
Silicon	ug/g															
Silver	ug/g	0.1			0.59	1.60	1.7	9.2	4.08	6.52	9.34	0	6.35	8.12	3.4	2.13
Sodium	ug/g	400			< 200	< 200	< 200	< 200	< 200	< 200	< 200	200	200	< 200	223	207
Strontium	ug/g	1			10	8.0	7.1	29	21.7	13.5	13.5	26.7	22.8	22	38.4	16
Sulfur	ug/g															
Thallium	ug/g	0.1			0.1	0.06	0.03	0.2	0.1	0.1	0.4	0.1	0.1	0.15	0.2	0.1
Thorium	ug/g															
Tin	ug/g	1			< 0.5	1	1	< 5	1	2	1	0.87	2	1	1	1
Titanium	ug/g	0.5			88.7	112	351	143	86	97.4	86.6	198	154	155	146	145
Uranium	ug/g	0.5			1	1	1	5.1	1.1	0.92	0.44	1	0.8	1	1.2	0.53
Vanadium	ug/g	0.1			20.3	15	18.0	24	16	15.9	17.3	20.5	19.7	20.5	28.4	18
Zinc	ug/g	1	CCME	315	61.6	535	226	12,140	3,103	1,773	605	303	659	885	342	323
Zirconium	ug/g	1			1	2.4	2.1	< 5	2.1	1.9	1.2	2.6	2.2	2.3	3.5	2

[a] Reported by Burns (2005)

[b] MDL - method detection limit

[c] see Table C.1 for explanatory footnotes

[d] values represent means of three replicate samples

Note: concentrations measured using very fine-sized sediment (i.e. fraction passing through a 0.053 mm sieve)

Shading indicates measured values exceeding benchmark.

Table C.4: Sediment quality data for stations near United Keno Hill Mines, Yukon, 1994[a,d].

Parameter	Units	MDL[b,e]	Selected Sediment Quality Guidelines[c]		Lightning Creek			Christal Creek			Flat Creek	South McQuesten River				
			Guideline	Value	KV37	KV38	KV41	KV6	KV7	KV8	KV9	KV1	KV2	KV3	KV4	KV5
Aluminum	ug/g	-					13,700	8,970	8,930		9,020	9,880	6,210	12,400	9,430	10,800
Antimony	ug/g	-					4	8	16		150	< 2	5	35	41	18
Arsenic	ug/g	-	CCME	17			39	128	174		395	18	413	210	166	116
Barium	ug/g	-					223	223	298		394	185	142	262	190	253
Beryllium	ug/g	-					0.3	< 0.1	< 0.1		< 0.1	0.3	< 0.1	0.2	< 0.1	< 0.1
Bismuth	ug/g	-					<5	< 5	< 5		< 5	< 5	< 5	< 5	< 5	< 5
Cadmium	ug/g	-	CCME	3.5			2.7	15.2	12.4		51.3	1.6	26.3	17	17.7	8.6
Calcium	ug/g	-					6,230	10,800	13,900		9,060	9,450	8,910	11,000	8,690	11,200
Chromium	ug/g	-	CCME	90			26.7	16.1	15		19	16.7	12	22	15.8	16.7
Cobalt	ug/g	-					13.3	11	9.4		10.1	10.4	10.6	11.5	8.3	9.6
Copper	ug/g	-	CCME	197			43.5	34.5	27.9		116	22.4	48.4	49.4	40.9	29.2
Iron	ug/g	-	BCMOE	43,766			27,900	27,600	29,000		61,000	21,500	41,500	34,000	31,000	29,800
Lead	ug/g	-	CCME	91.3			70	260	680		4,520	10	1,750	1,100	980	344
Lithium	ug/g	-					16.8	11.5	10.6		8.7	13.5	9	13.9	11.5	12
Magnesium	ug/g	-					4,690	5,600	5,970		3,500	5,820	4,650	5,700	4,820	6,500
Manganese	ug/g	-	OMOE	1,100			739	5,500	5,380		29,600	602	10,500	4,530	5,800	4,390
Mercury	ug/g	-	BCMOE	0.486												
Molybdenum	ug/g	-					<1	< 1	< 1		< 1	3	< 1	< 1	< 1	< 1
Nickel	ug/g	-	BCMOE	75			33.7	36.3	30		36.8	36.2	33.7	41.4	28.5	47.5
Phosphorus	ug/g	-	OMOE	2,000			948	895	1,110		575	865	878	910	829	817
Potassium	ug/g	-					990	650	860		1,310	1,090	310	1,760	940	1,050
Selenium	ug/g	-	BCMOE	2			<2	< 2	< 2		< 2	< 2	< 2	< 2	< 2	< 2
Silicon	ug/g	-					283	231	243		303	206	142	218	194	193
Silver	ug/g	-					0.5	4.2	7.3		55.2	< 0.5	5.1	14.4	14.2	6
Sodium	ug/g	-					153	120	137		162	149	102	212	147	169
Strontium	ug/g	-					29	26	30		26	31	22	31	23	32
Sulfur	ug/g	-					140	1,110	1,600		2,030	570	3,350	1,600	1,340	780
Thallium	ug/g	-														
Thorium	ug/g	-					7	3	2		< 1	4	< 1	4	3	2
Tin	ug/g	-					<1	< 1	< 1		< 1	< 1	< 1	< 1	< 1	< 1
Titanium	ug/g	-					803	380	349		301	465	104	506	415	474
Uranium	ug/g	-					<5	< 5	< 5		< 5	< 5	< 5	< 5	< 5	< 5
Vanadium	ug/g	-					42	27	25		25	31	15	36	27	30
Zinc	ug/g	-	CCME	315			389	2,090	1,950		5,180	310	2,410	1,610	1,640	1,150
Zirconium	ug/g	-					8.6	5.2	4.5		0.6	6	4.8	6.9	5	4

[a] Reported by Burns (1994)

[b] MDL - method detection limit

[c] see Table C.1 for explanatory footnotes

[d] values represent one composite sample

[e] MDL values not reported in Burns (1994)

Note: concentrations measured using fine-sized sediment (i.e. fraction passing through a 0.15 mm sieve)

Shading indicates measured values exceeding benchmark.

Table C.5: Sediment quality data for stations near United Keno Hill Mines, Yukon, 1985[a,e].

Parameter	Units	MDL[b,f]	Selected Sediment Quality Guidelines[c]		Lightning Creek			Christal Creek			Flat Creek	South McQuesten River				
			Guideline	Value	KV37	KV38	KV41	KV6	KV7	KV8	KV9	KV1	KV2	KV3	KV4	KV5
Aluminum	ug/g	-								5,717	6,040			8,093	5,575	
Antimony	ug/g	-														
Arsenic	ug/g	-	CCME	17						1,717	235			27	253	
Barium	ug/g	-								148	305			221	953	
Beryllium	ug/g	-								< 2	< 0.2			< 0.2	< 0.2	
Bismuth	ug/g	-														
Cadmium	ug/g	-	CCME	3.5						126	79.9			9.1	56.7	
Calcium	ug/g	-								7,333	6,763			9,380	7,075	
Chromium	ug/g	-	CCME	90						16.7	21.1			25.0	20.8	
Cobalt	ug/g	-								6.0	13.5			9.90	11.3	
Copper	ug/g	-	CCME	197						120	127.3			28.4	150.5	
Iron	ug/g	-	BCMOE	43,766						114,333	44,033			21,600	42,800	
Lead	ug/g	-	CCME	91.3						7,227	4,083			303	6,925	
Lithium	ug/g	-														
Magnesium	ug/g	-								5,753	3,720			5,910	3,965	
Manganese	ug/g	-	OMOE	1,100						< 0.2[d]	< 0.2[d]			2,213	244	
Mercury	ug/g	-	BCMOE	0.486												
Molybdenum	ug/g	-								25.3	< 0.8			< 0.8	< 0.8	
Nickel	ug/g	-	BCMOE	75						13	46			23	36	
Phosphorus	ug/g	-	OMOE	2,000						718	481			667	556	
Potassium	ug/g	-														
Selenium	ug/g	-	BCMOE	2												
Silicon	ug/g	-								70	697			727	665	
Silver	ug/g	-														
Sodium	ug/g	-								123	157			247	155	
Strontium	ug/g	-								19.8	27.5			25.7	26.6	
Sulfur	ug/g	-														
Thallium	ug/g	-														
Thorium	ug/g	-														
Tin	ug/g	-								< 2	14			6	8	
Titanium	ug/g	-								268	346			860	381	
Uranium	ug/g	-														
Vanadium	ug/g	-								33.4	27.4			38.5	26.7	
Zinc	ug/g	-	CCME	315						7,700	4,920			536	3,345	
Zirconium	ug/g	-														

[a] Reported by Davidge and Mackenzie-Grieve (1989)
[b] MDL - method detection limit
[c] see Table C.1 for explanatory footnotes
[d] concentration considerably lower then other values and therefore considered suspect
[e] values represent means of three replicate samples
[f] MDL values not reported in Davidge and Mackenzie-Grieve (1989)
Note: concentrations measured using fine-sized sediment (i.e. fraction passing through a 0.15 mm sieve)
Shading indicates measured values exceeding benchmark.

APPENDIX D

BENTHIC INVERTEBRATE COMMUNITY

Table D.1: Benthic invertebrate data, United Keno Hill Mines (1985, 1994 and 2007). Some taxon groups were combined for analyses to ensure consistent levels of taxonomy among stations.

Source	DOE [1]	DOE [1]	DOE [1]	DOE [1]	Laberge [2]			Laberge [2]			Laberge [2]			Laberge [2]			Laberge [2]			Laberge [2]			Laberge [2]			Laberge [3]			Laberge [3]		
Year	1985	1985	1985	1985	1994			1994			1994			1994			1994			1994			1994			2007			2007		
Watershed	South McQuesten River		Christal Creek	Flat Creek	South McQuesten River												Christal Creek						Flat Creek			South McQuesten River					
Current Station ID	KV3	KV4	KV8	KV9	KV1-1	KV1-2	KV1-3	KV3-1	KV3-2	KV3-3	KV4-1	KV4-2	KV4-3	KV5-1	KV5-2	KV5-3	KV6-1	KV6-2	KV6-3	KV7-1	KV7-2	KV7-3	KV9-1	KV9-2	KV9-3	KV1-1	KV1-2	KV1-3	KV3-1	KV3-2	KV3-3
PHYLUM COELENTERATA/CNIDARIA																															
Class Hydrozoa																															
Hydra sp.					32	49	16				8	1					16	42	6									2			
PHYLUM NEMATODA		2	1							4	8			67	65	69	1	6	2					1		8		2	4	12	12
PHYLUM ANNELIDA																															
Class Oligochaeta																															
Family Enchytraeidae J																										8					
Family Enchytraeidae	1		1						2	1					64		1														
Family Naididae																															
Naididae Unid J/D																										1					
Chaetogaster sp						136	64	8	8	16	32	8	8	128	138	320	189	225	482				100	108	324						4
Nais sp										1								2													
Family Tubificidae J																											24	10	6	8	12
Family Tubificidae, unid., uv.			1																												
Tubifex sp			3																												
Class Hirudinae																															
Order Rhynchobdellida																															
Family Piscicolidae																															
Piscicola salmonsitica													1			1															
PHYLUM ARTHROPODA																															
Class Arachnida																															
Order Hydracarina																															
Hydracarina, unid J/D					137	48	128	48	88	68	64	240	32	4037	3845	4003	2	1		12			3	1							
Kawamuracarus sp														67	3																
Lebertia sp											4	16		1	192	194	1						2	2	1						
Neumannia sp					8	9								2	64															4	
Sperchon sp					19	24	16			8	25			323	256	394	2	1						1	1	8		4	2	4	
Torrenticola sp																	1	2			8	2		1	1	80	88	32	30	32	12
Unioncola sp																										160	112	72	48	136	44
Oribatei																												2			
Class Insecta																															
Order Collembola																															
Collembola Unid J																															
Hypogastrura sp																							1								
Isotomurus sp																	1														
Podura sp																															
Order Ephemeroptera																															
Family Ameletidae																															
Ameletus sp											8									3	4							2			
Family Baetidae																															
Baetis sp	8	4			190		99	271	207	261	57	107	8	466	850	794	5			1	4	4		1	1	894	1039	217	109	351	191
Family Ephemerellidae																															
Drunella flavilinia																															
Drunella doddsi																															
Ephemerella (Drunella)	4	3		1																											
Ephemerella grandis					3	3	1	4	2	3	13	2	2	11	26	37															
Ephemerella sp					22	17	30		10		2	1	14	1		2															
Ephemerellidae J																										15	2		1		
Family Heptageniidae																															
Cinygmula sp																															
Epeorus																															
Epeorus (Iron) sp																				4											
Heptagenia sp					11	4	12																								
Rhithrogena sp	5	1			102	18	76	52	9	21	18	30	15	3	68	1	1			4		4									
Family Leptophlebiidae																															
Paraleptophlebia sp					4	17	91		1	1	8	1	3	5			1									8		2	6	4	1
Order Plecoptera																															
Plecoptera, Unid, J/D					9			8	56	32	24	16	8		64	64			2	846	479	244	4	7	2						
Family Capnidae																															
Capnidae unid			7	7																											
Capnia sp					16		32	81	106	44	32	169	56	129	133	1			1	241	227	80	4	8	9	57	32	11	273	226	222
Family Chloroperlidae																															
Alloperla sp		1																													
Sweltsa Grp																													1		3
Sweltsa sp gp					1				1		1	1		2				2													
Family Leuctridae																															
Leuctra sp																															
Family Nemouridae																															

Table D.1: Benthic invertebrate data, United Keno Hill Mines (1985, 1994 and 2007). Some taxon groups were combined for analyses to ensure consistent levels of taxonomy among stations.

Source	**DOE [1]**	**DOE [1]**	**DOE [1]**	**DOE [1]**	**Laberge [2]**			**Laberge [2]**			**Laberge [2]**			**Laberge [2]**			**Laberge [2]**			**Laberge [2]**			**Laberge [2]**			**Laberge [3]**			**Laberge [3]**		
Year	**1985**	**1985**	**1985**	**1985**	**1994**			**1994**			**1994**			**1994**			**1994**			**1994**			**1994**			**2007**			**2007**		
Watershed	South McQuesten River		Christal Creek	Flat Creek	South McQuesten River												Christal Creek						Flat Creek			South McQuesten River					
Current Station ID	KV3	KV4	KV8	KV9	KV1-1	KV1-2	KV1-3	KV3-1	KV3-2	KV3-3	KV4-1	KV4-2	KV4-3	KV5-1	KV5-2	KV5-3	KV6-1	KV6-2	KV6-3	KV7-1	KV7-2	KV7-3	KV9-1	KV9-2	KV9-3	KV1-1	KV1-2	KV1-3	KV3-1	KV3-2	KV3-3
Malenka sp	4	4																													
Podmosta sp		2		32													13	10	6	4	1			1	1						
Zapada (oregonensis)		1	3																												
Zapada sp					3		20	5		1	50	31	11	94	29	160	52	19	22	99	52	28	2	4		11	26	6	36	40	80
Family Perlidae																															
Acroneuria sp	21	12																													
Classenia sabulosa						2	1	3	1			1			4	3															
Hesperoperla sp																										4	1	2	5		1
Family Perlodidae																															
Arcynopteryx (compacta)	2	4	3																												
Isoperla sp											1	1		1	1				1	2	1	3									
Megarcys sp																				3	2	4									
Skwala curvata														1																	
Skwala paralella					1						1			5	5	4	1			3	2	3	1		2						
Family Pteronarcyidae																															
Pteronarcella sp																													4		
Pteronarcella regularis	4	12			2	1		1	2	7		10	1	18	14	20															
Pteronarcys sp																										4	1	2	5		1
Pteronarcys californica					4	2	6	4	2	2	2	2	1	1	3	2															
Pteronarcys dorsata	5	10			1											1															
Family Taenioptergidae																															
Taenionema sp																				41	16	4	1								
Order Trichoptera																															
Trichoptera Unid J					9	1			1		16	8	8	1	1	1				3	9	7	1	1						2	
Trichoptera A																															
Family Brachycentridae																															
Brachycentrus sp					4		17		2	4		1		23	30	30								1		3	2	6	1	1	
Micrasema sp														2	5	4															
Family Glossosmatidae																															
Glossosoma sp																															
Family Hydropsychidae																															
Arctopsyche sp	30	36		11	8		21	21	8	4	13	25	5	142	137	140	3	1								31	57	30	16	16	12
Family Hydroptilidae																															
Hydroptila sp												9		39	50	91	1						1			8					
Hydroptilidae J																												4			
Oxyethira sp						63	24				10	1	1	3	10	8			1					2		3	1	5	2	1	17
Family Lepidostomatidae																															
Lepidostoma sp						1	1				1															3	2	1			
Family Limnephilidae																															
Clostoeca sp		1	2																												
Dicosmoecus sp									1		1										2								1		
Ecclysomyia																	1														
Grensia sp															1																
Limnephilus sp																	18	10	6												
Nemotaulius sp													1																		
Onocosmoecus sp	1																														
Family Polycentropodidae																															
Polycentropus sp																															
Family Rhyacophilidae																															
Rhyaccophila acropedes	1	1																													
Rhyacophila acropedes or vao					1									1						6	1	4	1			7	2	1	2	28	8
Rhyacophila hyalinata																															
Rhyacophila sp J/D					10		3				16	1		7	14	13				68	28	18									
Order Coleoptera																															
Ephemerella dorothea infrequens	5	12																													
Haliplidae, unid., adult		1																													
Order Diptera																															
Diptera Unid A														2			1														
Diptera L																															
Family Ceratopogonidae																															
Bezzia sp																															
Culicoides sp																															
Palpomyia sp																			1												
Family Chironomidae																															
Chironomidae unid J/D					1689	2352	8081	984	1002	416	4344	1944	1521	34686	30542	32544	93	106	288	269	96	91	84	28	140						
Chironomidae A																															
Chironomidae J																										104	138	62	220	276	533
Chironomidae P	1	3	9	6	8						8		8		7	4	4	1	1		4		1	4	1				2		
Phaenopsectra																													2		16
Thienemannimyia																										1	8	15	7	20	4
Sub Family Chironomiinae																															
Constempelina sp																							1								
Micropsectra sp	1																														

Table D.1: Benthic invertebrate data, United Keno Hill Mines (1985, 1994 and 2007). Some taxon groups were combined for analyses to ensure consistent levels of taxonomy among stations.

Source	DOE [1]	DOE [1]	DOE [1]	DOE [1]	Laberge [2]			Laberge [2]			Laberge [2]			Laberge [2]			Laberge [2]			Laberge [2]			Laberge [2]			Laberge [3]			Laberge [3]		
Year	1985	1985	1985	1985	1994			1994			1994			1994			1994			1994			1994			2007			2007		
Watershed	South McQuesten River		Christal Creek	Flat Creek	South McQuesten River												Christal Creek						Flat Creek			South McQuesten River					
Current Station ID	KV3	KV4	KV8	KV9	KV1-1	KV1-2	KV1-3	KV3-1	KV3-2	KV3-3	KV4-1	KV4-2	KV4-3	KV5-1	KV5-2	KV5-3	KV6-1	KV6-2	KV6-3	KV7-1	KV7-2	KV7-3	KV9-1	KV9-2	KV9-3	KV1-1	KV1-2	KV1-3	KV3-1	KV3-2	KV3-3
Rheotanytarsus sp					707	136	801	160	107	93	664	618	568	33834	33644	37732	19	19	30	9	4	6	1		1				2	4	
Sub Family Diamesinae																															
Diamesa sp																				1							8	6	2	4	8
Monodiamesa sp																			1												
Sub Family Orthocladiinae																															
Brillia sp			15																	2	13									1	
Cardiocladius sp		4	2											128	129	193	36	2	48	12	4	2									4
Corynoneura sp					46	160	224	24	73	10	272	40	184	64	64			2					2	2	1						
Cricotopus sp	1	6	19	13	78	72	272	16	48	8	224	89	97	838	996	844	35	40	96	11		8	6	11	4	24	48	12	26	57	50
Eukiefferiella sp					59	104	336	57	33	17	234	122	163	1286	1454	848	16	28	64	69	51	18	1	7	5	8	16	6	14	17	16
Euryhapsis sp																	2														
Heleniella sp																		2	4												
Heterotrissocladius sp		8	10	5																											
Thienemanniella sp					16	8	80	16	48		24	8	24		10					25	48	8		2	1						
Sub Family Tanypodinae																															
Procladius sp				1													1														
Thienemannimyia sp					63	152	217	40	33	26	189	213	162	3458	5048	5464	71	61	114	10	7	2	21	17	10						
Family Empididae																															
Chelifera sp					11			8	8	4		8		70	15	17				1		1	3		2		1	2	6	4	1
Clinocera sp																		1						1							
Hemerodromia sp																															
Weidemannia sp																									1						
Family Muscidae																															
Limnophora sp														1									1								
Family Psychodidae																															
Pericoma sp																				2	15	1									
Psychoda sp		1																													
Family Simulidae																															
Simulidae Unid J/D					16		16																								
Cnephia L																										9	2	4	2		
Prosimulium L																															
Prosimulium P																															
Prosimulium sp																				4	4	2									
Simulium sp L	42	1347	10	9																						300	386	35	243	672	417
Simulium sp P	1	15	1	4				3		1		1	1		1	2				1								1	6	13	13
Simulium sp					8		16	52	79	20		9		64	128	194	6		4	287	206	160	2		2						
Family Tipulidae																															
Tipulidae Unid J/D														1																	
Dicronata sp																				1									2		
Gonomyodes sp																															
Tipula sp			1	2																											
Class Crustacea																															
Sub Class Ostracoda																															
Candona sp						8				4							6	68	10												
PHYLUM MOLLUSCA																															
Class Gastropoda																															
Gastropoda unid. dam					4	15	5		3	12	1		2																		
Fossaria sp																											1	1		3	1
Fossaria modicella					8	35	20	9	18	18	4		2																		
Gyraulus parvus						5	4		1	2																					
Physa gyrina					3	7	6	1	6	1	10		4	1																	
Physella gyrina																															
Valvata sincera	1				3				23	25	9		1			1												2			
Family Lymnaeidae																															
Stagnicola (kennicotti)	2																														
Class Pelecypoda (Bivalva)																															
Pisidium sp									8		1																				

[1] Davidge and Mackenzie-Grieve (1989)
[2] Burns (1994)
[3] Burns (2008)

Table D.1: Benthic invertebrate data, United Keno Hill Mines (1985, 1994 and 2007). Some taxon groups were combined for analyses to ensure consistent levels of taxonomy among stations.

Source	**Laberge [3]**			**Laberge [3]**			**Laberge [3]**			**Laberge [3]**			**Laberge [3]**			**Laberge [3]**			**Laberge [3]**			**Laberge [3]**			**Laberge [3]**		
Year	**2007**			**2007**			**2007**			**2007**			**2007**			**2007**			**2007**			**2007**			**2007**		
Watershed	South McQuesten River						Christal Creek									Flat Creek			Lightning Creek								
Current Station ID	KV4-1	KV4-2	KV4-3	KV5-1	KV5-2	KV5-3	KV6-1	KV6-2	KV6-3	KV7-1	KV7-2	KV7-3	KV8-1	KV8-2	KV8-3	KV9-1	KV9-2	KV9-3	KV37-1	KV37-2	KV37-3	KV38-1	KV38-2	KV38-3	KV41-1	KV41-2	KV41-3
PHYLUM COELENTERATA/CNIDAR																											
Class Hydrozoa																											
Hydra sp.							28	50	25																		
PHYLUM NEMATODA	8	1	24	13	28	2		2	8	1	1					1			2		1	1	1				
PHYLUM ANNELIDA																											
Class Oligochaeta																											
Family Enchytraeidae J		8		1						2	3											1	8		9	7	6
Family Enchytraeidae																											
Family Naididae																											
Naididae Unid J/D																											
Chaetogaster sp	8		8		16																						
Nais sp	4																										
Family Tubificidae J	12	32	16	16	16	24	3			3					3							3	1	1	6	13	
Family Tubificidae, unid., uv.																											
Tubifex sp																											
Class Hirudinae																											
Order Rhynchobdellida																											
Family Piscicolidae																											
Piscicola salmonsitica																											
PHYLUM ARTHROPODA																											
Class Arachnida																											
Order Hydracarina																											
Hydracarina, unid J/D										16				40		2	2	24	24	48	56	88	168	16			8
Kawamuracarus sp																											
Lebertia sp				24	56	16								1	1				2		1		14	16	38	86	56
Neumannia sp					8														1				2				
Sperchon sp	16	8	8	88	32						1								1	3	3	3	25	76	76	74	44
Torrenticola sp	28	48	24	106	161	48				1			1						1			8	2	32			
Unioncola sp	72	80	112	129	192	88	16		8	3	3	2	7	6	3	1	1	1	46	28	33	67	158	919	460	761	388
Oribatei					8					1	1				1								1				2
Class Insecta																											
Order Collembola																											
Collembola Unid J																										4	
Hypogastrura sp							1			1	1															4	
Isotomurus sp					1								1	1	1										1		
Podura sp						1								2	4												
Order Ephemeroptera																											
Family Ameletidae																											
Ameletus sp	4		8							18	44	15	2							1	1		8	3	25		9
Family Baetidae																											
Baetis sp	113	221	150	760	947	764	1	24	32	1	5		10	4	2	5			8	6	19	2	15	129	7		6
Family Ephemerellidae																											
Drunella flavilinia	6				1	1														5	1		1		6	1	3
Drunella doddsi																											
Ephemerella (Drunella)																											
Ephemerella grandis																											
Ephemerella sp																											
Ephemerellidae J		2	8	7	7											1		1									
Family Heptageniidae																											
Cinygmula sp		8																	3	5	7	7	30	12	18	4	11
Epeorus																			5	5	16	4	13	4	10	4	2
Epeorus (Iron) sp																											
Heptagenia sp																											
Rhithrogena sp				1		1													6		3	1	9	8			
Family Leptophlebiidae																											
Paraleptophlebia sp	5	8	1	18	19																						
Order Plecoptera																											
Plecoptera, Unid, J/D																											
Family Capnidae																											
Capnidae unid																											
Capnia sp	112	124	236	82	93	41	32			85	94	7	16	26	16	31	23	19	3	3	7	44	111	266	126	4	28
Family Chloroperlidae																											
Alloperla sp																											
Sweltsa Grp	3		1		1		1		1		19	5						2		1			2	2		1	3
Sweltsa sp gp																											
Family Leuctridae																											
Leuctra sp																											2
Family Nemouridae																											

Table D.1: Benthic invertebrate data, United Keno Hill Mines (1985, 1994 and 2007). Some taxon groups were combined for analyses to ensure consistent levels of taxonomy among stations.

Source	Laberge [3]			Laberge [3]			Laberge [3]			Laberge [3]			Laberge [3]			Laberge [3]			Laberge [3]			Laberge [3]			Laberge [3]		
Year	2007			2007			2007			2007			2007			2007			2007			2007			2007		
Watershed	South McQuesten River						Christal Creek									Flat Creek			Lightning Creek								
Current Station ID	KV4-1	KV4-2	KV4-3	KV5-1	KV5-2	KV5-3	KV6-1	KV6-2	KV6-3	KV7-1	KV7-2	KV7-3	KV8-1	KV8-2	KV8-3	KV9-1	KV9-2	KV9-3	KV37-1	KV37-2	KV37-3	KV38-1	KV38-2	KV38-3	KV41-1	KV41-2	KV41-3
Malenka sp																											
Podmosta sp																											
Zapada (oregonensis)																											
Zapada sp	80	139	82	32	34	8	537	230	127	96	259	56	48	34	47	25	11	4	152	249	258	224	487	431	220	121	146
Family Perlidae																											
Acroneuria sp																											
Classenia sabulosa																											
Hesperoperla sp	3		1	2		1																					
Family Perlodidae																											
Arcynopteryx (compacta)																											
Isoperla sp																											
Megarcys sp																										2	
Skwala curvata																											
Skwala paralella							1		2		1		6	14	8	4	2	4	1	2	10	3	6	7	3		5
Family Pteronarcyidae																											
Pteronarcella sp	3	3	8	5	9	7																					
Pteronarcella regularis																											
Pteronarcys sp	3		1	2		1																					
Pteronarcys californica																											
Pteronarcys dorsata																											
Family Taenioptergidae																											
Taenionema sp				13	4	19	38	37	42	3			5	2	9	9	14	17	3		2		4	4	20	5	3
Order Trichoptera																											
Trichoptera Unid J			8				38	1		27	4	6	8	6	20		1	1	1		1	5		17	6	10	6
Trichoptera A																						1		1	3		
Family Brachycentridae																											
Brachycentrus sp	4	19	12	76	39	24								2			1	1									
Micrasema sp																									2		
Family Glossosmatidae																											
Glossosoma sp																									26	32	11
Family Hydropsychidae																											
Arctopsyche sp	18	16	34	54	60	81						1	1		1										4		
Family Hydroptilidae																											
Hydroptila sp	8	8		33	32	1																					
Hydroptilidae J	12																1										
Oxyethira sp	10	10	17	1	4						1																
Family Lepidostomatidae																											
Lepidostoma sp				6	3	6	1																				
Family Limnephilidae																											
Clostoeca sp										26	80				1												
Dicosmoecus sp													1														
Ecclysomyia											2														1		
Grensia sp																											
Limnephilus sp							7	1																			
Nemotaulius sp																											
Onocosmoecus sp																											
Family Polycentropodidae																											
Polycentropus sp																					1						
Family Rhyacophilidae																											
Rhyaccophila acropedes																											
Rhyacophila acropedes or vao	16			90	51	3	59	2	117	7	10		1	1		1	1	4	8	6	4	12	12	15	50	49	50
Rhyacophila hyalinata																			4	1	3	2		1	1		
Rhyacophila sp J/D																											
Order Coleoptera																											
Ephemerella dorothea infrequens																											
Haliplidae, unid., adult																											
Order Diptera																											
Diptera Unid A		1	1		2	3	1				1	1								1			1				
Diptera L										3	1		1		1							6	17	1			
Family Ceratopogonidae																											
Bezzia sp		1																									
Culicoides sp	1																										
Palpomyia sp																											
Family Chironomidae																											
Chironomidae unid J/D																											
Chironomidae A				8				1					1		1										1		
Chironomidae J	469	819	940	1139	1170	846	640	460	782	9	6		25	21	19	41	36	35	119	88	123	23	569	1812	1	33	19
Chironomidae P					1	1	2	2	8		2		2	1	1	3	5	1	5	13	9	37	84	17	8	11	5
Phaenopsectra		8			8																						
Thienemannimyia	34	32	32	16	50		26	4		1						3	5										
Sub Family Chironomiinae																											
Constempelina sp																											
Micropsectra sp																											

Table D.1: Benthic invertebrate data, United Keno Hill Mines (1985, 1994 and 2007). Some taxon groups were combined for analyses to ensure consistent levels of taxonomy among stations.

Source	**Laberge [3]**			**Laberge [3]**			**Laberge [3]**			**Laberge [3]**			**Laberge [3]**			**Laberge [3]**			**Laberge [3]**			**Laberge [3]**			**Laberge [3]**		
Year	**2007**			**2007**			**2007**			**2007**			**2007**			**2007**			**2007**			**2007**			**2007**		
Watershed	South McQuesten River						Christal Creek									Flat Creek			Lightning Creek								
Current Station ID	KV4-1	KV4-2	KV4-3	KV5-1	KV5-2	KV5-3	KV6-1	KV6-2	KV6-3	KV7-1	KV7-2	KV7-3	KV8-1	KV8-2	KV8-3	KV9-1	KV9-2	KV9-3	KV37-1	KV37-2	KV37-3	KV38-1	KV38-2	KV38-3	KV41-1	KV41-2	KV41-3
Rheotanytarsus sp	12	24		104	56	8							14	10	11				5	4	3	2	1	16			
Sub Family Diamesinae																											
Diamesa sp	16	8	9	34	32	24	10	16	24		1		1		1	3	2	3	106	150	234	93	229	527	92	94	29
Monodiamesa sp																											
Sub Family Orthocladiinae																											
Brillia sp		8	9		3	17						1	11	39	60	1						2			4		2
Cardiocladius sp							423	206	94									1	12	129	110	18	26	5	12	14	2
Corynoneura sp				8														1									
Cricotopus sp	129	86	123	221	166	117	86	61	40	11	10		23	11	17	103	94	138	17	24	28	41	189	67	104	21	11
Eukiefferiella sp	16		40	41	35	27	171	299	335	1	1		43	26	26	1	2	2	4	3	7	14	41	120	8	5	9
Euryhapsis sp										1						2	2	1							4		
Heleniella sp																											
Heterotrissocladius sp																											
Thienemanniella sp	4															1											
Sub Family Tanypodinae																											
Procladius sp																											
Thienemannimyia sp																											
Family Empididae																											
Chelifera sp	28	24	1	49	33	1	33	16		17	51		1	2		1		1					2	13			
Clinocera sp																											
Hemerodromia sp																											1
Weidemannia sp																			1			5	4	4	18	8	20
Family Muscidae																											
Limnophora sp																		1					4				
Family Psychodidae																											
Pericoma sp							18		1	1	2					1			4	8	6	10	20	17	50	46	25
Psychoda sp																											
Family Simulidae																											
Simulidae Unid J/D																											
Cnephia L																											
Prosimulium L																			7	6	14	19	87	604	4		
Prosimulium P																					1		6	5			
Prosimulium sp																											
Simulium sp L	192	283	211	1005	994	683	2791	1373	1402	1	9	5	34	55	44	6	2	3	33	14	36	14	75	278			
Simulium sp P	6	30	4	32	54	38	8	9	19	1	1			1			1					2		16			
Simulium sp																											
Family Tipulidae																											
Tipulidae Unid J/D																											
Dicronata sp	4									8	5								2		1	1	14		10	13	11
Gonomyodes sp																			1					1			
Tipula sp						1																2				1	
Class Crustacea																											
Sub Class Ostracoda																											
Candona sp																											
PHYLUM MOLLUSCA																											
Class Gastropoda																											
Gastropoda unid. dam																											
Fossaria sp																											
Fossaria modicella																											
Gyraulus parvus																											
Physa gyrina																											
Physella gyrina				1																							
Valvata sincera																											
Family Lymnaeidae																											
Stagnicola (kennicotti)																											
Class Pelecypoda (Bivalva)																											
Pisidium sp																											

[1] Davidge and Mackenzie-Grieve (1989)
[2] Burns (1994)
[3] Burns (2008)

Table D.2: Summary statistics for benthic community metrics at United Keno Hill Mines, 2007[a].

		n	Mean	Standard Deviation	Standard Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound	Minimum	Maximum
Density (individuals/substrate)	KV1	3	1438.333	770.767	445.002	-476.357	3353.024	559.000	1997.000
	KV3	3	1568.333	436.447	251.983	484.138	2652.529	1086.000	1936.000
	KV4	3	1881.667	367.710	212.297	968.225	2795.108	1459.000	2128.000
	KV5	3	3844.333	824.852	476.228	1795.288	5893.379	2900.000	4424.000
	KV6	3	3610.333	1186.309	684.916	663.378	6557.289	2793.000	4971.000
	KV7	3	353.667	260.108	150.174	-292.478	999.812	98.000	618.000
	KV8	3	288.000	22.869	13.204	231.190	344.810	262.000	305.000
	KV9	3	239.000	30.116	17.388	164.187	313.813	206.000	265.000
	KV37	3	796.000	206.066	118.972	284.105	1307.895	587.000	999.000
	KV38	3	2890.667	2380.357	1374.299	-3022.467	8803.800	764.000	5462.000
	KV41	3	1260.333	292.141	168.668	534.615	1986.052	923.000	1430.000
	Total	33	1651.879	1456.353	253.519	1135.478	2168.279	98.000	5462.000
Number of Taxa	KV1	3	22.333	2.309	1.333	16.596	28.070	21.000	25.000
	KV3	3	23.333	3.512	2.028	14.609	32.057	20.000	27.000
	KV4	3	25.000	2.646	1.528	18.428	31.572	23.000	28.000
	KV5	3	27.000	1.000	0.577	24.516	29.484	26.000	28.000
	KV6	3	16.667	3.786	2.186	7.262	26.071	14.000	21.000
	KV7	3	16.333	7.234	4.177	-1.637	34.304	8.000	21.000
	KV8	3	16.333	1.528	0.882	12.539	20.128	15.000	18.000
	KV9	3	17.000	2.646	1.528	10.428	23.572	14.000	19.000
	KV37	3	21.000	2.000	1.155	16.032	25.968	19.000	23.000
	KV38	3	25.000	2.646	1.528	18.428	31.572	23.000	28.000
	KV41	3	24.333	3.512	2.028	15.609	33.057	21.000	28.000
	Total	33	21.303	4.812	0.838	19.597	23.009	8.000	28.000
Hydracarina (%)	KV1	3	14.597	4.851	2.801	2.547	26.647	10.015	19.678
	KV3	3	6.595	2.958	1.708	-0.754	13.944	3.327	9.091
	KV4	3	7.109	0.734	0.423	5.287	8.931	6.608	7.951
	KV5	3	7.939	2.558	1.477	1.584	14.293	5.241	10.330
	KV6	3	0.194	0.171	0.099	-0.230	0.619	0.000	0.322
	KV7	3	2.979	2.761	1.594	-3.880	9.838	0.809	6.087
	KV8	3	6.716	7.561	4.365	-12.066	25.497	1.684	15.410
	KV9	3	4.037	4.676	2.700	-7.579	15.652	1.220	9.434
	KV37	3	10.646	1.865	1.077	6.011	15.280	9.309	12.777
	KV38	3	18.748	3.347	1.932	10.434	27.062	15.127	21.728
	KV41	3	52.863	12.215	7.052	22.521	83.206	40.140	64.496
	Total	33	12.038	14.681	2.556	6.833	17.244	0.000	64.496
EPT (%)	KV1	3	56.539	4.237	2.446	46.014	67.063	51.700	59.579
	KV3	3	36.315	5.560	3.210	22.504	50.126	31.848	42.541
	KV4	3	27.058	0.389	0.224	26.093	28.024	26.645	27.416
	KV5	3	30.198	2.554	1.474	23.854	36.541	28.083	33.035
	KV6	3	11.804	2.234	1.290	6.253	17.354	10.466	14.383
	KV7	3	84.016	7.802	4.505	64.634	103.399	76.232	91.837
	KV8	3	33.867	4.231	2.443	23.357	44.377	29.180	37.405
	KV9	3	25.703	5.465	3.155	12.127	39.279	20.000	30.894
	KV37	3	33.931	1.290	0.745	30.728	37.135	33.049	35.412
	KV38	3	28.262	11.668	6.737	-0.723	57.247	16.459	39.791
	KV41	3	27.969	10.505	6.065	1.874	54.065	16.317	36.713
	Total	33	35.969	19.229	3.347	29.151	42.788	10.466	91.837
Chironomids (%)	KV1	3	12.258	5.269	3.042	-0.832	25.347	7.789	18.068
	KV3	3	27.464	9.148	5.282	4.739	50.189	19.576	37.493
	KV4	3	49.551	4.060	2.344	39.465	59.636	46.607	54.182
	KV5	3	35.793	1.378	0.796	32.369	39.216	34.381	37.135
	KV6	3	35.558	7.454	4.303	17.041	54.074	27.318	41.832
	KV7	3	3.641	2.845	1.642	-3.426	10.708	1.020	6.667
	KV8	3	42.095	5.789	3.342	27.713	56.476	35.410	45.455
	KV9	3	67.927	3.386	1.955	59.515	76.339	64.228	70.874
	KV37	3	49.451	3.289	1.899	41.282	57.621	45.656	51.452
	KV38	3	41.204	9.614	5.551	17.321	65.088	30.105	46.943
	KV41	3	12.367	3.977	2.296	2.489	22.245	8.342	16.294
	Total	33	34.301	19.114	3.327	27.523	41.078	1.020	70.874
Simuliids (%)	KV1	3	14.717	6.614	3.819	-1.714	31.148	7.156	19.429
	KV3	3	28.015	6.496	3.750	11.878	44.151	23.112	35.382
	KV4	3	12.961	2.607	1.505	6.485	19.437	10.103	15.209
	KV5	3	24.396	0.623	0.360	22.849	25.943	23.689	24.862
	KV6	3	50.706	5.099	2.944	38.040	63.373	46.332	56.307
	KV7	3	2.433	2.369	1.368	-3.451	8.318	0.580	5.102
	KV8	3	15.384	2.737	1.580	8.586	22.182	12.977	18.361
	KV9	3	1.676	0.681	0.393	-0.015	3.366	1.132	2.439
	KV37	3	4.804	2.176	1.256	-0.601	10.210	2.494	6.814
	KV38	3	9.327	6.344	3.663	-6.431	25.086	4.581	16.532
	KV41	3	0.093	0.161	0.093	-0.308	0.494	0.000	0.280
	Total	33	14.956	14.841	2.583	9.694	20.218	0.000	56.307

[a] prepared using data from Burns (2008), Burns (2005), Burns (1996) and Davidge and Mackenzie-Grieve (1989).

APPENDIX E

FISHERIES DATA

Appendix Table E.1: Fish presence-absence by station based on electrofishing and minnow trapping catch data, United Keno Hill Mines, 1994 - 1995[a].

Watershed	Station	arctic grayling (fry)	arctic grayling	slimy sculpin	northern pike	burbot	chinook salmon	arctic lamprey	longnose sucker
Christal Creek	CL			X					
	KV6			X					
	C4		X						
	KV7	X							
	C2			X					
	KV8	X		X		X			
Flat Creek	KV9	X		X		X			
South McQuesten River	KV72				X				
	KV1	X		X		X		X	X
	SMQ C	X		X	X	X		X	X
	KV2	X		X	X	X		X	X
	SM5			X					
	KV3	X		X	X	X			
	KV4	X		X	X	X			
	SM12			X	X	X		X	
	SM8			X	X	X			
	KV15	X		X	X	X	X		X

[a] prepared using data from Sparling and Connor (1996)

Table E.2: Catch per unit effort by method, United Keno Hill Mines, 1994-95 and 2006.

Watershed	Station	Date[a]	Capture method	Units	arctic grayling	slimy sculpin	northern pike	burbot	chinook salmon	round whitefish	arctic lamprey	longnose sucker
Lightning Creek	KV41	7-Jun-06	electrofishing	# fish / minute	0.85	0	0	0	0	0	0	0
	KV41	5-Aug-06	electrofishing	# fish / minute	2.19	0	0	0	0	0.09	0	0
	KV41	19-Sep-06	electrofishing	# fish / minute	2.49	0	0	0	0	0	0	0
	LCD	4-Aug-06	electrofishing	# fish / minute	0.18	2.82	0	0	0	0	0	0
Christal Creek	KV6	Jul-95	electrofishing	# fish / minute	0	1.70	0	0	0	0	0	0
	KV6	Sep-94	electrofishing	# fish / minute	0	1.28	0	0	0	0	0	0
	KV6	6-Jun-06	electrofishing	# fish / minute	0	3.04	0	0	0	0	0	0
	KV6	4-Aug-06	electrofishing	# fish / minute	0	6.40	0	0	0	0	0	0
	KV6	22-Sep-06	electrofishing	# fish / minute	0	18.7	0	0	0	0	0	0
	C4	Jul-95	electrofishing	# fish / minute	2.54	0	0	0	0	0	0	0
	C4	Sep-94	electrofishing	# fish / minute	0	0	0	0	0	0	0	0
	C4	5-Jun-06	electrofishing	# fish / minute	0	0	0	0	0	0	0	0
	C4	5-Aug-06	electrofishing	# fish / minute	1.06	0	0	0	0	0	0	0
	C4	20-Sep-06	electrofishing	# fish / minute	0.23	0	0	0	0	0	0	0
	KV7	Sep-94	electrofishing	# fish / minute	0.06	0	0	0	0	0	0	0
	KV7	Jul-95	electrofishing	# fish / minute	0	0	0	0	0	0	0	0
	KV7	4-Jun-06	electrofishing	# fish / minute	0	0	0	0	0	0	0	0
	KV7	4-Aug-06	electrofishing	# fish / minute	0	0	0	0	0	0	0	0
	KV7	19-Sep-06	electrofishing	# fish / minute	0	0	0	0	0	0	0	0
	C2	Sep-94	electrofishing	# fish / minute	0	0.07	0	0	0	0	0	0
	C2	Jul-95	electrofishing	# fish / minute	0	0	0	0	0	0	0	0
	KV8	Sep-94	electrofishing	# fish / minute	0.47	0.23	0	0.06	0	0	0	0
	KV8	Jul-95	electrofishing	# fish / minute	7.21	0.72	0	0	0	0	0	0
	KV8	5-Jun-06	electrofishing	# fish / minute	0	0.24	0	0	0	0	0	0
	KV8	3-Aug-06	electrofishing	# fish / minute	1.38	1.46	0	0	0	0.09	0	0
	KV8	18-Sep-06	electrofishing	# fish / minute	0.13	0.87	0	0.04	0	0	0	0
Flat Creek	F3	Sep-94	electrofishing	# fish / minute	0	0	0	0	0	0	0	0
	KV9	Sep-94	electrofishing	# fish / minute	0.06	1.58	0	0	0	0	0	0
	KV9	May/June-95	electrofishing	# fish / minute	0	2.51	0	0.16	0	0	0	0
	KV9	Jul-95	electrofishing	# fish / minute	1.52	5.10	0	0	0	0	0	0
	KV9	4-Jun-06	electrofishing	# fish / minute	0	1.59	0.08	0.08	0	0	0	0
	KV9	1-Aug-06	electrofishing	# fish / minute	0.13	2.91	0.04	0.08	0	0	0	0
	KV9	21-Sep-06	electrofishing	# fish / minute	0.06	2.78	0	0.06	0	0	0	0
South McQuesten River	KV72	19-Sep-06	electrofishing	# fish / minute	0.10	0.49	0.10	0	0	0	0	0
	KV1	Sep-94	electrofishing	# fish / minute	0.44	6.51	0	0.03	0	0	0	0.72
	KV1	Jul-95	electrofishing	# fish / minute	0.52	4.66	0	0	0	0	0.10	0
	KV1	5-Jun-06	electrofishing	# fish / minute	0.38	0.96	0	0	0	0	0.19	0
	KV1	3-Aug-06	electrofishing	# fish / minute	0.29	2.60	0	0	0	0	0	0
	KV1	18-Sep-06	electrofishing	# fish / minute	0	4.86	0	0	0	0	0	0
	SMQ C	Sep-94	electrofishing	# fish / minute	0.05	4.93	0.11	0.05	0	0	0.05	0.60
	SMQ C	18-Sep-06	electrofishing	# fish / minute	0.09	2.48	0	0.14	0	0	0.09	0
	KV2	Sep-94	electrofishing	# fish / minute	0	0.59	0	0.07	0	0	0.07	0.07
	KV2	Jul-95	electrofishing	# fish / minute	0.10	2.46	0.30	0	0	0	0.05	0
	KV2	21-Sep-06	electrofishing	# fish / minute	0.06	4.75	0	0	0	0	0	0
	KV3	Sep-94	electrofishing	# fish / minute	0.06	4.17	0.06	0.06	0	0	0	0
	KV3	May/June-95	electrofishing	# fish / minute	0	4.62	0	0	0	0	0	0
	KV3	Jul-95	electrofishing	# fish / minute	0	0.65	0.65	0	0	0	0	0
	KV3	4-Jun-06	electrofishing	# fish / minute	0	2.88	0	0	0	0	0	0
	KV3	1-Aug-06	electrofishing	# fish / minute	0	4.52	0	0	0	0	0.10	0
	KV4	Sep-94	electrofishing	# fish / minute	0.21	6.02	0.07	0.07	0	0	0	0
	KV4	May/June-95	electrofishing	# fish / minute	0	2.13	0	0	0	0	0	0
	KV4	Jul-95	electrofishing	# fish / minute	0	0.84	0.42	0	0	0	0	0
	KV4	21-Sep-06	electrofishing	# fish / minute	0.23	5.63	0	0	0	0	0	0
	SM12	May/June-95	electrofishing	# fish / minute	0	6.71	0.12	0.12	0	0	1.97	0
	SM8	May/June-95	electrofishing	# fish / minute	0	27.3	0	0.20	0	0	0	0
	KV15	May/June-95	electrofishing	# fish / minute	0.26	2.66	0.09	0	0	0	0	0.60
	KV15	21-Sep-06	electrofishing	# fish / minute	0.16	3.29	0.05	0	0	0	0	0
Lightning Creek	LCD	05-Jun-06	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	LCD	3-Aug-06	minnow trapping	# fish / day	0	0.47	0	0	0	0	0	0
	KV41	06-Jun-06	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV41	2-Aug-06	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
Christal Creek	CL	10-Sep-94	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	CL	11-Sep-94	minnow trapping	# fish / day	0	0.25	0	0	0	0	0	0
	CL	12-Sep-94	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	CL	13-Sep-94	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	CL	15-Jul-95	minnow trapping	# fish / day	0	0.31	0	0	0	0	0	0
	CL	16-Jul-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	CL	22-Sep-06	minnow trapping	# fish / day	0	4.83	0	0	0	0	0	0
	KV6	19-May-95	minnow trapping	# fish / day	0	1.02	0	0	0	0	0	0
	KV6	15-Jul-95	minnow trapping	# fish / day	0	0.75	0	0	0	0	0	0
	KV6	16-Jul-95	minnow trapping	# fish / day	0	0.63	0	0	0	0	0	0
	KV6	05-Jun-06	minnow trapping	# fish / day	0	1.43	0	0	0	0	0	0
	KV6	3-Aug-06	minnow trapping	# fish / day	0	2.19	0	0	0	0	0	0
	C4	11-Sep-94	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	C4	19-May-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	C4	15-Jul-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0

Table E.2: Catch per unit effort by method, United Keno Hill Mines, 1994-95 and 2006.

Watershed	Station	Date[a]	Capture method	Units	arctic grayling	slimy sculpin	northern pike	burbot	chinook salmon	round whitefish	arctic lamprey	longnose sucker
Christal Creek	C4	16-Jul-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	C4	4-Aug-06	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV7	05-Sep-94	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV7	09-Sep-94	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV7	19-May-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV7	15-Jul-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV7	16-Jul-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV7	3-Jun-06	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV7	1-Aug-06	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	C2	15-Jul-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	C2	16-Jul-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV8	07-Sep-94	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV8	15-Jul-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV8	16-Jul-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV8	04-Jun-06	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV8	1-Aug-06	minnow trapping	# fish / day	0.04	0	0	0	0.09	0	0	0
Flat Creek	F3	17-Jul-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	F3	18-Jul-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV9	05-Sep-94	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV9	06-Sep-94	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV9	08-Sep-94	minnow trapping	# fish / day	0.17	0	0	0	0	0	0	0
	KV9	20-May-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV9	17-Jul-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV9	18-Jul-95	minnow trapping	# fish / day	0	0.39	0	0	0	0	0	0
	KV9	01-Jun-06	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV9	03-Jun-06	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV9	31-Jul-06	minnow trapping	# fish / day	0	0.16	0	0	0	0	0	0
South McQuesten River	KV72	17-Jul-95	minnow trapping	# fish / day	0	0	0	0	0.20	0	0	0
	KV72	18-Jul-95	minnow trapping	# fish / day	0	0	0	0	0.42	0	0	0
	KV1	05-Sep-94	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV1	19-May-95	minnow trapping	# fish / day	0	0.17	0	0	0	0	0	0
	KV1	16-Jul-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV1	04-Jun-06	minnow trapping	# fish / day	0	0.25	0	0	0	0	0	0
	KV1	1-Aug-06	minnow trapping	# fish / day	0	0.10	0	0	0	0	0	0
	SMQ C	16-Jul-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	SMQ C	1-Aug-06	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV2	06-Sep-94	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV2	07-Sep-94	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV2	19-May-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV2	21-May-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV2	16-Jul-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV2	17-Jul-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	SM5	05-Sep-94	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	SM5	06-Sep-94	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	SM5	15-Sep-94	minnow trapping	# fish / day	0	0.50	0	0	0	0	0	0
	SM5	20-May-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	SM5	17-Jul-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	SM5	18-Jul-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV3	05-Sep-94	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV3	06-Sep-94	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV3	20-May-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV3	17-Jul-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV3	18-Jul-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV3	31-Jul-06	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV4	05-Sep-94	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV4	06-Sep-94	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV4	20-May-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV4	20-Jul-95	minnow trapping	# fish / day	0	0	0	0	0.09	0	0	0
	KV4	31-Jul-06	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	SM12	02-Jun-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	SM8	02-Jun-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	SM8	18-Jul-95	minnow trapping	# fish / day	0	0	0	0	0.21	0	0	0
	SM8	19-Jul-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV15	20-May-95	minnow trapping	# fish / day	0	0	0	0.18	0	0	0	0
	KV15	02-Jun-95	minnow trapping	# fish / day	0	0	0	0	0	0	0	0
	KV15	19-Jul-95	minnow trapping	# fish / day	0	0	0	0	5.48	0	0	0
	KV15	20-Jul-95	minnow trapping	# fish / day	0	0	0	0	0.99	0	0	0
	KV15	31-Jul-06	minnow trapping	# fish / day	0.11	0.32	0.11	0	0	0	0	0
Lightning Creek	LC	29-Jul-95	angling	# fish/15 min.	4.55	0	0	0	0	0	0	0

Table E.2: Catch per unit effort by method, United Keno Hill Mines, 1994-95 and 2006.

Watershed	Station	Date[a]	Capture method	Units	arctic grayling	slimy sculpin	northern pike	burbot	chinook salmon	round whitefish	arctic lamprey	longnose sucker
Christal Creek	C4	9-Sep-94	angling	# fish/15 min.	2.50	0	0	0	0	0	0	0
	C2	16-Sep-94	angling	# fish/15 min.	1.50	0	0	0	0	0	0	0
	C2	22-May-95	angling	# fish/15 min.	0	0	0	0	0	0	0	0
	KV8	7-Sep-94	angling	# fish/15 min.	1.0	0	0	0	0	0	0	0
South McQuesten River	KV72	22-May-95	angling	# fish/15 min.	1.0	0	0.6	0	0	0	0	0
	KV1	5-Sep-94	angling	# fish/15 min.	0	0	0	0	0	0	0	0
	KV1	22-May-95	angling	# fish/15 min.	0	0	0	0	0	0	0	0
	KV2	6-Sep-94	angling	# fish/15 min.	0.17	0	0	0	0	0	0	0
	KV2	7-Sep-94	angling	# fish/15 min.	0.91	0	0	0	0	0	0	0
	KV2	19-May-95	angling	# fish/15 min.	0	0	0	0	0	0	0	0
	KV2	16-Jul-95	angling	# fish/15 min.	0.85	0	0.21	0	0	0	0	0
	SM5	5-Sep-94	angling	# fish/15 min.	1.50	0	0	0	0	0	0	0
	SM5	8-Sep-94	angling	# fish/15 min.	0.50	0	0	0	0	0	0	0
	SM5	23-May-95	angling	# fish/15 min.	0	0	0	0	0	0	0	0
	KV3	6-Sep-94	angling	# fish/15 min.	1	0	0	0	0	0	0	0
	KV3	20-May-95	angling	# fish/15 min.	0	0	0	0	0	0	0	0
	KV3	22-May-95	angling	# fish/15 min.	0	0	0	0	0	0	0	0
	KV4	22-May-95	angling	# fish/15 min.	0	0	0	0	0	0	0	0
	SM8	20-May-95	angling	# fish/15 min.	0.50	0	0	0	0	0	0	0
	KV15	20-May-95	angling	# fish/15 min.	0	0	0	0	0	0	0	0
	KV15	23-May-95	angling	# fish/15 min.	0	0	0	0	0	0	0	0
	KV15	18-Jul-95	angling	# fish/15 min.	1.25	0	0.63	0	0	0	0	0
Lightning Creek	LC	Sep-94	seining	# fish/m^2	0.02	0	0	0	0	0	0	0
	LC	May/June-95	seining	# fish/m^2	0.003	0	0	0	0	0	0	0
	LC	Jul-95	seining	# fish/m^2	0.01	0	0	0	0	0	0	0
Christal Creek	KV6	May/June-95	seining	# fish/m^2	0	0.17	0	0	0	0	0	0
	KV7	Sep-94	seining	# fish/m^2	0	0	0	0	0	0	0	0
	KV8	Sep-94	seining	# fish/m^2	8.2	0	0	0	0	0	0	0
Flat Creek	KV9	Sep-94	seining	# fish/m^2	0.12	0.26	0.007	0	0	0	0	0
	KV9	Jul-95	seining	# fish/m^2	0.16	0.12	0	0	0	0	0	0
South McQuesten River	KV72	May/June-95	seining	# fish/m^2	0	0.01	0	0	0	0	0	0
	KV72	Jul-95	seining	# fish/m^2	0.19	0.01	0.004	0	0	0.01	0	0
	KV1	Sep-94	seining	# fish/m^2	0.09	0.27	0	0	0	0	0	0.03
	KV1	May/June-95	seining	# fish/m^2	0	0.04	0	0	0	0.002	0	0
	KV1	Jul-95	seining	# fish/m^2	0.24	0.07	0	0	0	0	0.007	0.10
	SMQ C	Sep-94	seining	# fish/m^2	0.14	0.30	0	0	0	0.005	0	0.04
	SMQ C	May/June-95	seining	# fish/m^2	0.02	0	0	0	0	0	0.02	0
	SMQ C	Jul-95	seining	# fish/m^2	0.45	0.26	0	0	0	0.002	0.002	0.03
	KV2	Sep-94	seining	# fish/m^2	0.02	0.81	0.01	0	0	0.01	0	0
	KV2	Jul-95	seining	# fish/m^2	0.11	0.26	0.003	0	0	0	0	0.003
	KV3	Sep-94	seining	# fish/m^2	0.05	0.40	0.009	0	0	0	0	0.009
	KV3	May/June-95	seining	# fish/m^2	0	0.03	0	0	0	0	0	0
	KV3	Jul-95	seining	# fish/m^2	0.04	0.16	0.007	0	0	0	0	0
	KV4	Sep-94	seining	# fish/m^2	0.05	0.17	0	0	0	0	0	0
	KV4	Jul-95	seining	# fish/m^2	0.69	0.22	0	0	0	0.005	0	0
	KV5	Jul-95	seining	# fish/m^2	0.90	0.43	0	0	0	0.01	0	0.24
	SM12	Jul-95	seining	# fish/m^2	0.32	0.23	0.003	0.003	0	0.01	0	0
	SM8	Jul-95	seining	# fish/m^2	0.05	0.25	0.006	0	0	0	0	0.22
	KV15	May/June-95	seining	# fish/m^2	0.04	0.12	0	0	0	0.002	0	0.009
	KV15	Jul-95	seining	# fish/m^2	0.64	0.05	0	0	0.04	0.06	0	0.03
	SM11	Jul-95	seining	# fish/m^2	0.14	0.20	0	0	0.08	0.01	0	0

[a] date for minnow trapping is set date

[b] "day" for minnow trapping where multiple traps were set at a station was calculated by adding set-time/24hours togther for all traps at the station. CPUE was total number of fish captured with all traps divided by day.

[c] prepared using data from Sparling (2006) and Sparling and Connor (1996)

Appendix Table E.3: Mean electrofishing catch per unit effort (number of fish per minute), United Keno Hill Mine, 1994 - 95[a].

Watershed	Station	n	arctic grayling	slimy sculpin	northern pike	burbot	arctic lamprey	longnose sucker
Christal Creek	KV6	2	0	1.49	0	0	0	0
	C4	2	1.27	0	0	0	0	0
	KV7	2	0.03	0	0	0	0	0
	C2	2	0	0.04	0	0	0	0
	KV8	2	3.84	0.48	0	0.03	0	0
Flat Creek	F3	1	0	0	0	0	0	0
	KV9	3	0.53	3.06	0	0.05	0	0
South McQuesten River	KV1	2	0.48	5.59	0	0.02	0.05	0.36
	SMQ C	1	0.05	4.93	0.11	0.05	0.05	0.60
	KV2	2	0.05	1.53	0.15	0.03	0.06	0.03
	KV3	3	0.02	3.14	0.23	0.02	0	0
	KV4	3	0.07	3.00	0.16	0.02	0	0
	SM12	1	0	6.71	0.12	0.12	1.97	0
	SM8	1	0	27.31	0	0.20	0	0
	KV15	1	0.26	2.66	0.09	0	0	0.60

[a] prepared using data from Sparling and Connor (1996)

Table E.4: Morphometrics for slimy sculpin captured by seine, United Keno Hill Mine, 2006[a].

Watershed	Station ID	Fish ID	Fork length (mm)	Weight (g)	Condition factor
Lightning Creek	LCD	LCD-1	91	7.1	0.94
		LCD-2	82	5.3	0.96
		LCD-3	91	6.8	0.90
		LCD-4	92	8.3	1.07
		LCD-5	84	6.1	1.03
		n	**5**	**5**	**5**
		mean	**88**	**6.7**	**1.0**
		SD	**4.6**	**1.1**	**0.1**
Christal Creek	CL	CL-1	88	6.6	0.97
		CL-2	92	8	1.03
		CL-3	86	6.3	0.99
		CL-4	78	4.5	0.95
		CL-5	82	6.2	1.12
		CL-6	86	7.5	1.18
		CL-7	94	8.2	0.99
		CL-8	90	7.3	1.00
		n	**8**	**8**	**8**
		mean	**87**	**6.8**	**1.03**
		SD	**5.2**	**1.2**	**0.08**
	KV6	KV6-1	92	8.7	1.12
		KV6-2	91	8.7	1.15
		KV6-3	96	10.2	1.15
		KV6-4	91	7.3	0.97
		KV6-5	96	10.4	1.18
		KV6-6	92	9.9	1.27
		KV6-7	101	12.1	1.17
		KV6-8	93	11.6	1.44
		n	**8**	**8**	**8**
		mean	**94**	**9.9**	**1.2**
		SD	**3.5**	**1.6**	**0.1**
Flat Creek	KV9	KV9-1	98	11.4	1.21
		KV9-2	87	7.5	1.14
		KV9-3	93	9.6	1.19
		n	**3**	**3**	**3**
		mean	**93**	**10**	**1**
		SD	**5.5**	**2.0**	**0.04**
South McQuesten River	KV72	KV72-1	98	12.6	1.34
		KV72-2	88	10.7	1.57
		KV72-3	80	8.2	1.60
		n	**3**	**3**	**3**
		mean	**89**	**10.5**	**1.5**
		SD	**9.0**	**2.2**	**0.1**
	SMQ C	SMQ C-1	81	5.6	1.05
		SMQ C-2	78	6.2	1.31
		SMQ C-3	79	5.2	1.05
		n	**3**	**3**	**3**
		mean	**79**	**5.7**	**1.1**
		SD	**2**	**0.5**	**0.1**

SD - standard deviation

[a] prepared using data from Sparling (2006)

Appendix Table E.5: Concentrations of metals in arctic grayling muscle (mg/kg wet weight) collected in August and September 2006, United Keno Hill Mines[a].

Parameter	Toddler benchmark	Wildlife benchmark	Lightning Creek					Christal Creek				
			LCD-1	LCD-2	LCD-3	LCD-4	LCD-5	C4-1	C4-2	C4-3	C4-4	C4-5
Aluminum			49.0	4.9	< 2.0	2.1	3.7	< 2.0	2.2	2.7	3.6	7.7
Antimony			0.014	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Arsenic	0.20	0.28	0.432	0.100	0.035	0.130	0.123	0.092	0.109	0.132	0.138	0.172
Barium	10		2.70	0.763	0.471	1.26	0.847	0.403	0.481	0.625	0.615	0.734
Beryllium	1		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Bismuth			< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Cadmium	0.5	3.90	0.118	0.0497	0.0188	0.0169	0.0179	0.0833	0.0514	0.0413	0.0537	0.0614
Calcium			13600	5530	2310	8220	7540	4830	4610	5940	7880	6510
Chromium	0.7		0.13	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Cobalt			0.159	0.054	< 0.020	0.046	0.067	0.022	0.033	0.026	0.042	0.052
Copper	20	61.8	0.832	0.617	0.192	0.481	0.516	0.614	0.513	0.404	0.469	0.494
Lead	2.4	4.9	0.294	0.315	< 0.020	0.022	0.022	0.081	0.053	0.125	0.165	0.228
Lithium			< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Magnesium			432	343	115	358	322	282	279	291	345	313
Manganese	92	358	8.85	2.81	1.03	3.34	1.94	3.14	3.94	6.17	7.64	10.3
Molybdenum	3.3		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Nickel	0.9		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Selenium	3.3		1.88	1.87	0.56	1.91	2.16	0.68	0.96	0.87	1.11	1.21
Strontium	393		11.7	5.01	1.96	8.06	7.56	3.19	4.53	4.38	5.11	6.11
Thallium			< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Tin			< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Uranium	0.4		0.0067	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020
Vanadium			0.12	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Zinc	196	650	31.5	18.7	7.66	16.0	18.7	17.9	17.3	19.5	23.0	27.4

toddler benchmark exceeded

toddler and wildlife benchmarks exceeded

[a] prepared using data from Sparling (2006)

Appendix Table E.6: Concentrations of metals (mg/kg wet weight[d]) in arctic grayling muscle and liver collected in the fall 1994 - 95, United Keno Hill Mines[e].

Parameter	Toddler benchmark	Wildlife benchmark	Christal Creek							Flat Creek	South McQuesten River					
			C4-1	C4-2	C4-3	C4-4	C4-5	C4-L[a]	KV7-1	KV9-1[b]	KV1-1	KV1-2	KV1-3	KV1-4	KV1-5	KV1-L[c]
			muscle	muscle	muscle	muscle	muscle	liver	whole fish	whole fish	muscle	muscle	muscle	muscle	muscle	liver
Arsenic	0.20	0.28	< 0.44	< 0.44	< 0.44	< 0.44	< 0.44	< 0.44	0.44	0.66	< 0.44	< 0.44	< 0.44	< 0.44	< 0.44	< 0.66
Cadmium	0.5	3.90	0.02	< 0.01	< 0.04	0.04	< 0.01	2.07	0.11	0.18	0.02	0.02	0.06	0.06	0.02	0.58
Chromium	0.7	-	0.22	0.22	0.22	0.40	0.20	0.09	0.15	0.20	0.18	0.20	0.22	0.22	0.20	0.11
Cobalt	-	-	0.09	< 0.02	0.07	0.09	0.04	0.29	0.04	0.04	< 0.02	0.04	0.07	0.04	0.09	0.44
Copper	20	61.8	0.35	0.40	0.35	0.22	0.31	3.87	0.84	1.06	0.42	0.48	0.53	0.59	0.55	3.08
Lead	2.4	4.9	0.22	0.22	0.22	0.44	0.22	0.22	0.44	3.08	< 0.22	< 0.22	< 0.22	0.44	< 0.22	0.88
Mercury	0.07	0.45	< 0.02	< 0.02	< 0.02	0.02	< 0.02	0.02	< 0.02	< 0.02	0.04	0.02	0.04	< 0.02	0.02	0.02
Nickel	0.9	-	0.09	0.53	0.13	0.18	0.13	0.11	0.09	0.18	0.09	0.13	0.13	0.11	0.99	0.37
Zinc	196	650	29	28	30	51	26	28	36	38	18	19	27	27	21	22

toddler benchmark exceeded

toddler and wildlife benchmarks exceeded

Note: samples consisted of one individual fish unless otherwise indicated

[a] composite sample of livers from fish C4-1 to C4-5

[b] composite of four fish

[c] composite sample of livers from fish KV1-1, KV1-2 and KV1-5

[d] dry weight values reported in Sparling and Connor (1996) converted to wet weight assuming 78% moisture and using the formula [dry weight value * 0.22].

[e] prepared using data from Sparling and Connor (1996)

Appendix Table E.7: Concentrations of metals (mg/kg wet weight) in arctic grayling muscle collected in the fall 1994 - 95, United Keno Hill Mines[a].

Parameter	Toddler benchmark	Wildlife benchmark	Christal Creek (station C4)				South McQuesten River (station KV1)			
			n	mean	Standard Deviation	95% Confidence Limit	n	mean	Standard Deviation	95% Confidence Limit
Arsenic	0.20	0.28	5	< 0.44	0	0	5	< 0.44	0	0
Cadmium	0.5	3.90	5	0.02	0.01	0.01	5	0.03	0.022	0.02
Chromium	0.7	-	5	0.25	0.08	0.07	5	0.20	0.02	0.02
Cobalt	-	-	5	0.06	0.03	0.03	5	0.05	0.03	0.02
Copper	20	61.8	5	0.33	0.07	0.06	5	0.51	0.07	0.06
Lead	2.4	4.9	5	0.26	0.10	0.09	5	0.26	0.10	0.09
Mercury	0.07	0.45	5	0.02	0	0.00	5	0.03	0.01	0.01
Nickel	0.9	-	5	0.21	0.18	0.16	5	0.29	0.39	0.34
Zinc	196	650	5	33	10	9	5	22	4.3	3.8

toddler benchmark exceeded

toddler and wildlife benchmarks exceeded

Appendix Table E.8: Concentrations of metals in slimy sculpin (mg/kg wet weight) collected in August, September and October, United Keno Hill Mines, 2006[d].

Parameter	Wildlife benchmark	Lightning Creek				Christal Lake West-end			Christal Lake Outlet					Christal Creek										
		LCD-1	LCD-3	LCD-4	LCD-5	CLW-1	CLW-2	CLW-3	CLO-1	CLO-2	CLO-3	CLO-4	CLO-5	KV6-1	KV6-2	KV6-3	KV6-4	KV6-5	KV6-6	KV6-7	KV6-8	KV8-1	KV8-2[a]	KV8-3[b]
Aluminum		44.7	46.6	81.3	55.5	19.5	29.6	11.1	21.1	30.8	16.6	19.2	30.0	22.1	16.3	41.7	39.2	32.3	53.8	3.6	148	11.0	20.7	13.3
Antimony		0.028	0.013	0.020	0.021	0.020	0.017	0.019	0.032	0.045	0.041	0.039	0.165	0.044	0.074	0.108	0.167	0.135	0.037	0.020	0.015	0.018	0.093	0.017
Arsenic	0.28	**0.855**	**0.934**	**0.985**	**0.966**	**0.447**	**1.12**	**0.925**	**1.10**	**1.21**	**0.741**	**1.06**	**2.84**	**1.23**	**1.32**	**1.50**	**2.99**	**2.05**	**1.42**	**0.542**	**0.789**	**0.67**	**0.834**	**1.24**
Barium		2.61	3.17	3.33	3.82	0.808	1.01	1.13	1.42	1.67	0.799	0.908	1.40	1.21	2.26	1.97	3.93	2.41	2.00	0.920	1.09	1.90	2.65	1.52
Beryllium		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Bismuth		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Cadmium	3.90	0.348	0.252	0.258	0.260	0.0363	0.0512	0.0554	0.197	0.256	0.133	0.189	0.355	0.375	0.636	0.557	1.26	0.924	0.354	0.548	0.277	0.349	0.433	0.601
Calcium		9360	11100	6670	10400	11400	10300	10100	8820	7880	7050	6280	8480	10400	10100	10300	14000	12700	7790	9690	5450	11400	13300	7450
Chromium		0.20	0.19	0.27	0.14	0.14	0.12	0.11	< 0.10	0.16	0.13	0.13	0.14	< 0.10	0.13	0.14	0.17	0.16	0.46	< 0.10	0.28	< 0.10	0.16	< 0.10
Cobalt		0.101	0.096	0.145	0.126	0.031	0.090	0.037	0.053	0.067	0.054	0.046	0.055	0.039	0.043	0.049	0.093	0.061	0.081	< 0.020	0.146	0.052	0.106	0.058
Copper	61.8	1.00	1.00	1.08	1.20	0.653	0.874	0.727	0.993	1.28	1.02	0.853	1.04	1.04	0.876	0.921	0.917	0.883	0.883	0.583	0.884	0.813	0.877	0.720
Lead	4.9	0.308	0.396	0.604	0.617	0.100	0.173	0.237	0.580	1.19	0.445	0.934	2.20	3.26	**9.93**	**6.22**	**19.0**	**12.8**	2.68	3.11	1.21	0.674	1.32	1.61
Lithium		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	0.11	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	0.10	0.11	< 0.10	0.17	< 0.10	0.40	< 0.10	< 0.10	< 0.10
Magnesium		344	363	314	359	346	329	336	351	310	322	282	316	361	464	351	373	385	351	431	352	354	370	327
Manganese	358	11.5	11.4	12.4	15.9	11.5	16.1	27.6	37.6	46.5	18.6	29.2	29.4	31.7	68.3	44.0	118	69.7	26.3	23.6	14.2	34.4	59.5	20.1
Molybdenum		0.022	0.022	0.027	0.027	0.019	0.020	0.02	0.018	0.028	0.022	0.017	0.025	0.039	0.037	0.030	0.035	0.042	0.044	0.019	0.021	0.018	0.022	0.019
Nickel		0.22	0.19	0.28	0.24	< 0.10	0.16	< 0.10	0.12	0.16	< 0.10	< 0.10	0.13	0.21	0.24	0.26	0.41	0.26	0.37	0.18	0.47	0.25	0.37	0.18
Selenium		2.84	2.93	2.55	2.67	0.93	0.76	1.05	1.01	1.16	1.31	1.26	1.03	1.17	0.97	1.03	0.88	0.95	0.97	0.81	1.04	1.15	1.39	1.43
Strontium		8.00	9.42	6.60	9.62	4.48	4.04	3.71	3.47	3.22	2.85	2.55	2.95	3.83	4.23	3.96	6.29	5.05	3.35	3.81	2.28	9.07	12.2	5.55
Thallium		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Tin		< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Uranium		0.0098	0.0095	0.0129	0.0121	0.0046	0.0114	0.0168	0.0095	0.0109	0.0058	0.0064	0.0171	0.0125	0.0371	0.0196	0.0635	0.0208	0.0127	0.0314	0.0045	0.0086	0.0088	0.0053
Vanadium		0.19	0.18	0.28	0.19	< 0.10	0.13	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	0.12	0.17	0.22	0.17	0.14	0.11	0.37	0.11	0.16	< 0.10
Zinc	650	41.8	39.8	38.3	49.1	32.1	36.2	33.9	41.7	44.8	35.1	33.0	43.7	48.4	78.6	54.9	81.9	89	46.8	57.7	36.7	83.1	83.0	77.3

wildlife benchmark exceeded (shaded cells, shown in bold)

Note: samples consisted of one individual fish unless otherwise indicated

[a] composite sample of three fish

[b] composite sample of four fish

[c] composite sample of two fish

[d] prepared using data from Sparling (2006)

Appendix Table E.8: Concentrations of metals in slimy sculpin (mg/kg wet weight) collected in August, September and October, United Keno Hill Mines, 2006[d].

Parameter	Wildlife benchmark	Flat Creek					South McQuesten River																	
		KV9-1	KV9-2	KV9-3	KV9-4[a]	KV9-5[a]	KV72-1	KV72-2	KV72-3	KV1-1[c]	KV1-2[a]	KV1-3[b]	KV2-1[a]	KV2-2[a]	KV2-3[a]	KV2-4[b]	KV2-5[b]	SMQ C-1	SMQ C-2	SMQ C-3	SMQ C-4[a]	SMQ C-5[b]	KV4-1	KV4-2[c]
Aluminum		38.9	17.6	22.7	13.0	9.0	29.0	28.4	13.9	13.0	20.4	22.3	47.1	42.3	12.4	12.4	33.2	14.4	18.9	40.6	51.7	21.2	5.5	5.1
Antimony		0.189	0.251	0.326	0.148	0.070	< 0.010	< 0.010	< 0.010	< 0.010	0.011	0.010	0.025	0.054	< 0.010	< 0.010	0.013	0.013	0.012	0.012	0.043	0.093	0.016	0.017
Arsenic	0.28	0.803	1.02	1.40	0.980	0.954	0.072	0.088	0.126	0.146	0.252	0.208	0.664	0.649	0.344	0.461	0.428	0.193	0.281	0.418	0.598	0.364	0.296	0.412
Barium		2.33	1.80	1.93	2.01	1.82	1.91	1.12	0.793	1.35	3.47	2.30	2.96	3.71	2.12	2.27	2.35	3.42	2.38	3.46	3.47	2.29	2.15	1.75
Beryllium		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Bismuth		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Cadmium	3.90	0.476	0.478	0.448	0.469	0.301	0.328	0.311	0.155	0.160	0.553	0.401	0.452	0.503	0.349	0.388	0.443	0.402	0.321	0.637	0.707	0.639	0.263	0.289
Calcium		9890	5730	9900	10700	9630	14700	11800	9190	10800	17000	11900	13300	14100	11400	14100	11300	19400	15400	13600	13400	14400	15700	12500
Chromium		0.15	0.13	0.12	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	0.14	< 0.10	0.15	< 0.10	< 0.10	0.14	0.17	0.16	< 0.10	0.15	0.15	< 0.10	< 0.10
Cobalt		0.034	0.030	0.029	0.036	< 0.020	0.394	0.231	0.093	0.086	0.275	0.192	0.345	0.469	0.287	0.203	0.496	0.116	0.17	0.727	0.439	0.313	0.049	0.069
Copper	61.8	0.890	1.20	1.42	1.06	0.888	2.3	1.96	1.09	1.20	1.18	1.52	1.62	1.52	1.25	1.06	1.76	1.16	1.35	1.76	1.66	1.5	0.797	0.777
Lead	4.9	12.3	11.4	14.3	5.78	4.89	0.079	0.059	0.045	0.070	0.062	0.054	1.25	2.31	0.592	0.633	0.756	0.43	0.279	0.362	2.02	0.437	2.28	1.34
Lithium		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Magnesium		286	256	297	330	325	409	387	318	350	417	366	380	374	340	402	367	438	403	375	374	389	374	320
Manganese	358	63.7	72.0	74.2	51.2	28.4	15.5	10.6	5.44	13.3	49.9	29.6	35.5	52.0	24.2	22.9	45.3	28.1	32.3	64.3	37.0	35.3	19.6	25.4
Molybdenum		0.021	0.028	0.022	0.024	0.023	0.038	0.028	0.020	0.019	0.021	0.022	0.031	0.030	0.022	0.020	0.026	0.018	0.017	0.024	0.033	0.023	0.014	0.025
Nickel		0.11	0.12	< 0.10	0.13	< 0.10	1.39	0.92	0.28	0.42	0.82	0.75	1.08	1.24	0.87	0.69	1.23	0.52	0.62	1.88	1.40	0.97	0.23	0.21
Selenium		0.45	0.46	0.41	0.88	0.55	1.36	1.42	1.13	1.13	1.03	1.15	1.29	1.35	1.12	1.17	1.20	1.43	1.23	1.75	1.66	1.40	0.91	0.89
Strontium		6.53	4.22	5.4	8.01	5.31	14.9	11.5	9.77	12.3	18.4	13.3	13.1	14.5	11.2	13.6	10.8	18.7	15.1	14.2	13.6	14.0	12.6	10.3
Thallium		0.018	0.013	0.018	0.019	0.013	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Tin		< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Uranium		0.0061	0.0037	0.0042	0.0025	0.0022	0.0077	0.0074	0.0025	0.0046	0.0077	0.0059	0.0148	0.0110	0.0049	0.0035	0.0061	0.0071	0.0057	0.0132	0.0101	0.0074	0.0038	0.0023
Vanadium		0.24	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	0.17	0.11	0.17	0.18	< 0.10	0.12	0.11	0.13	0.11	0.11	0.19	0.14	< 0.10	< 0.10
Zinc	650	50.7	43.6	49.3	58.3	37.4	62.1	49.9	28.4	39.2	95.0	76.4	65.9	75.5	61.0	65.9	71.5	108	73.2	87.7	131	97.8	64.1	43.3

wildlife benchmark exceeded

Note: samples consisted of one individual fish unless otherwise indicated

[a] composite sample of three fish

[b] composite sample of four fish

[c] composite sample of two fish

[d] prepared using data from Sparling (2006)

Appendix Table E.8: Concentrations of metals in slimy sculpin (mg/kg wet weight) collected in August, September and October, United Keno Hill Mines, 2006[d].

Parameter	Wildlife benchmark	KV4-3[c]	KV4-4[a]	KV4-5[a]	KV15-1[a]	KV15-2[a]	KV15-3[c]	KV15-4[c]	KV15-5[a]
Aluminum		20.2	8.4	7.8	16.5	13.2	9.8	14.9	14.0
Antimony		0.012	0.013	0.012	0.013	< 0.010	< 0.010	0.014	0.012
Arsenic	0.28	0.399	0.486	0.441	0.506	0.444	0.400	0.443	0.424
Barium		2.23	2.290	2.64	2.42	1.99	2.26	2.41	1.83
Beryllium		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Bismuth		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Cadmium	3.90	0.265	0.440	0.379	0.253	0.0886	0.134	0.127	0.156
Calcium		12200	13300	16100	13000	10500	13300	14700	10800
Chromium		0.16	0.14	< 0.10	< 0.10	0.12	< 0.10	0.13	0.13
Cobalt		0.088	0.122	0.094	0.071	0.044	0.049	0.075	0.059
Copper	61.8	0.737	1.01	1.14	1.17	0.681	0.778	1.12	0.960
Lead	4.9	1.62	1.09	1.01	0.315	0.182	0.171	0.261	0.199
Lithium		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Magnesium		314	370	412	366	290	355	384	331
Manganese	358	29.1	34.3	28.8	21.4	13.1	13.7	14.5	14.8
Molybdenum		0.019	0.025	0.021	0.021	0.017	0.018	0.019	0.023
Nickel		0.27	0.45	0.43	0.21	0.13	< 0.10	0.19	0.17
Selenium		0.74	1.06	1.24	2.09	2.02	1.51	3.03	1.38
Strontium		10.9	12.1	15.7	13.9	11.3	13.9	14.9	11.5
Thallium		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Tin		< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Uranium		0.0033	0.0032	0.0036	0.0036	< 0.0020	0.0029	0.0038	0.0027
Vanadium		0.14	< 0.10	0.11	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Zinc	650	54.2	70.2	62.7	41.8	27.0	38.9	35.6	31.6

(shaded) wildlife benchmark exceeded

Note: samples consisted of one individual fish unless otherwise indicated

[a] composite sample of three fish

[b] composite sample of four fish

[c] composite sample of two fish

[d] prepared using data from Sparling (2006)

Appendix Table E.9: Concentrations of metals (whole body mg/kg wet weight [c]) in slimy sculpin collected in the fall, United Keno Hill Mines, 1994 - 95 [d].

Parameter	Wildlife benchmark	Christal Creek							Flat Creek				
		CL-1	CL-2	CL-3	CL-4	KV6-1	KV6-2	C2-1	KV9-1[a]	KV9-2[a]	KV9-3[a]	KV9-4	KV9-5[b]
Arsenic	0.28	0.88	0.88	0.88	1.1	3.96	1.32	0.88	0.66	0.66	1.54	2.86	1.1
Cadmium	3.90	0.0396	0.0418	0.0704	0.066	1.0362	0.2068	0.2816	0.22	0.3256	0.3938	0.4862	0.22
Chromium	-	0.198	0.198	0.198	0.198	0.682	0.286	0.198	0.22	0.22	0.264	0.264	0.22
Cobalt	-	0.088	0.066	0.088	0.088	0.176	0.132	< 0.022	0.022	0.022	0.044	0.044	0.022
Copper	61.8	0.396	0.484	0.528	0.594	1.342	0.506	0.638	1.012	1.078	1.518	2.86	1.012
Lead	4.9	< 0.22	< 0.22	< 0.22	0.44	14.96	1.98	0.88	5.06	8.58	11.88	24.2	5.5
Mercury	0.45	< 0.022	< 0.022	< 0.022	< 0.022	< 0.022	< 0.022	< 0.022	< 0.022	< 0.022	< 0.022	< 0.022	< 0.022
Nickel	-	0.22	0.308	0.352	0.22	1.1	0.55	0.22	0.132	0.22	0.198	0.176	0.132
Zinc	650	71	69	80	75	188	72	64	43	58	57	63	41

(shaded) wildlife benchmark exceeded

Note: samples consisted of one individual fish unless otherwise indicated

[a] composite of four fish

[b] composite of seven fish

[c] dry weight values reported in Sparling and Connor (1996) converted to wet weight assuming 78% moisture and using the formula [dry weight value * 0.22].

[d] prepared using data from Sparling and Connor (1996)

Table E.10: Summary of metal concentrations in whole body slimy sculpin (mg/kg wet weight), United Keno Hill Mines, 2006 [a].

Parameter	Wildlife benchmark[b]	Lightning Creek				Christal Creek												Flat Creek			
		n	mean	Standard Deviation	95% Confidence Limit	n	mean	Standard Deviation	95% Confidence Limit	n	mean	Standard Deviation	95% Confidence Limit	n	mean	Standard Deviation	95% Confidence Limit	n	mean	Standard Deviation	95% Confidence Limit
		LCD				CL				KV6				KV8				KV9			
Aluminum		4	57.03	16.85	16.517	8	22	7.19	4.981	8	44.63	44.65	30.938	3	15.00	5.07	5.735	5	20.24	11.62	10.184
Antimony		4	0.021	0.01	0.006	8	0.05	0.05	0.034	8	0.075	0.06	0.039	3	0.043	0.04	0.049	5	0.197	0.10	0.086
Arsenic	0.28	4	0.935	0.06	0.056	8	1.18	0.71	0.495	8	1.480	0.76	0.527	3	0.915	0.29	0.332	5	1.031	0.22	0.194
Barium		4	3.23	0.50	0.489	8	1.14	0.32	0.223	8	1.97	0.97	0.672	3	2.02	0.58	0.651	5	1.98	0.21	0.188
Beryllium		4	0.1	0.00	-	8	< 0.10	0.00	-	8	0.1	0.00	0.000	3	0.1	0.00	0.000	5	0.1	0.00	-
Bismuth		4	0.1	0.00	-	8	< 0.10	0.00	-	8	0.1	0.00	0.000	3	0.1	0.00	0.000	5	0.1	0.00	-
Cadmium	3.90	4	0.280	0.05	0.045	8	0.16	0.11	0.078	8	0.616	0.33	0.228	3	0.461	0.13	0.145	5	0.434	0.08	0.066
Calcium		4	9,383	1,945	1,906	8	8789	1734.57	1,202	8	10,054	2,651	1,837	3	10,717	2,984	3,377	5	9,170	1,965	1,722
Chromium		4	0.20	0.05	0.052	8	0.13	0.02	0.013	8	0.19	0.12	0.085	3	0.12	0.03	0.039	5	0.12	0.02	0.019
Cobalt		4	0.117	0.02	0.022	8	0.05	0.02	0.013	8	0.067	0.04	0.028	3	0.072	0.03	0.033	5	0.030	0.01	0.005
Copper	61.8	4	1.070	0.09	0.093	8	0.93	0.20	0.137	8	0.873	0.13	0.089	3	0.803	0.08	0.089	5	1.092	0.23	0.197
Lead	4.9	4	0.481	0.15	0.151	8	0.73	0.70	0.488	8	7.276	6.18	4.284	3	1.201	0.48	0.542	5	9.734	4.16	3.649
Lithium		4	0.1	0.00	-	8	0.10	0.00	-	8	0.1475	0.10	0.073	3	0.10	0.00	0.000	5	0.1	0.00	-
Magnesium		4	345	22.23	21.781	8	324	22.07	15.294	8	384	42.19	29.236	3	350	21.73	24.593	5	299	30.24	26.510
Manganese	358	4	12.8	2.12	2.073	8	27	11.55	8.001	8	49.5	34.34	23.798	3	38.0	19.95	22.570	5	57.9	18.80	16.476
Molybdenum		4	0.025	0.00	0.003	8	0.02	0.00	0.003	8	0.033	0.01	0.006	3	0.020	0.00	0.002	5	0.024	0.00	0.002
Nickel		4	0.23	0.04	0.037	8	0.12	0.03	0.018	8	0.30	0.10	0.072	3	0.27	0.10	0.109	5	0.11	0.01	0.011
Selenium		4	2.75	0.17	0.167	8	1.06	0.18	0.124	8	0.98	0.11	0.075	3	1.32	0.15	0.171	5	0.55	0.19	0.168
Strontium		4	8.41	1.41	1.378	8	3.41	0.65	0.449	8	4.10	1.18	0.819	3	8.94	3.33	3.765	5	5.89	1.44	1.260
Thallium		4	0.01	0.00	-	8	< 0.010	0.00	-	8	0.01	0.00	-	3	0.01	0.00	-	5	0.0162	0.00	0.003
Tin		4	0.05	0.00	-	8	< 0.050	0.00	-	8	0.05	0.00	0.000	3	0.05	0.00	0.000	5	0.05	0.00	-
Uranium		4	0.011	0.00	0.002	8	0.01	0.005	0.003	8	0.025	0.02	0.013	3	0.008	0.00	0.002	5	0.004	0.00	0.001
Vanadium		4	0.21	0.05	0.046	8	0.10	0.01	-	8	0.18	0.09	0.061	3	0.12	0.03	0.036	5	0.13	0.06	0.055
Zinc	650	4	42.3	4.79	4.691	8	38	5.06	3.506	8	61.8	18.99	13.161	3	81.1	3.32	3.757	5	47.9	7.85	6.884

(shaded) wildlife benchmark exceeded

[a] prepared using data from Sparling (2006)

[b] see Table 6.4 for sources

Table E.10: Summary of metal concentrations in whole body slimy sculpin (mg/kg wet weight), United Keno Hill Mines, 2006 [a].

Parameter	Wildlife benchmark[b]	South McQuesten River																							
		n	mean	Standard Deviation	95% Confidence Limit	n	mean	Standard Deviation	95% Confidence Limit	n	mean	Standard Deviation	95% Confidence Limit	n	mean	Standard Deviation	95% Confidence Limit	n	mean	Standard Deviation	95% Confidence Limit	n	mean	Standard Deviation	95% Confidence Limit
		KV72				KV1				KV2				SMQ				KV4				KV15			
Aluminum		3	23.77	8.55	9.675	3	18.57	4.91	5.560	5	29.48	16.37	14.350	5	29.36	16.01	14.033	5	9.40	6.20	5.437	5	13.68	2.49	2.184
Antimony		3	0.010	0.00	0.000	3	0.010	0.00	0.001	5	0.022	0.02	0.016	5	0.035	0.04	0.031	5	0.014	0.00	0.002	5	0.012	0.00	0.002
Arsenic	0.28	3	0.095	0.03	0.031	3	0.202	0.05	0.060	5	0.509	0.14	0.124	5	0.371	0.15	0.134	5	0.407	0.07	0.062	5	0.443	0.04	0.034
Barium		3	1.27	0.57	0.650	3	2.37	1.06	1.202	5	2.68	0.66	0.576	5	3.00	0.61	0.536	5	2.21	0.32	0.280	5	2.18	0.26	0.230
Beryllium		3	0.1	0.00	0.000	3	0.1	0.00	0.000	5	0.1	0.00	-	5	0.1	0.00	-	5	0.1	0.00	-	5	0.1	0.00	-
Bismuth		3	0.1	0.00	0.000	3	0.1	0.00	0.000	5	0.1	0.00	-	5	0.1	0.00	-	5	0.1	0.00	-	5	0.1	0.00	-
Cadmium	3.90	3	0.265	0.10	0.108	3	0.371	0.20	0.224	5	0.427	0.06	0.052	5	0.541	0.17	0.148	5	0.327	0.08	0.069	5	0.152	0.06	0.054
Calcium		3	11,897	2,756	3,119	3	13,233	3,308	3,743	5	12,840	1,399	1,227	5	15,240	2,455	2,152	5	13,960	1,822	1,597	5	12,460	1,776	1,556
Chromium		3	0.10	0.00	0.000	3	0.11	0.02	0.026	5	0.12	0.02	0.022	5	0.15	0.03	0.024	5	0.12	0.03	0.025	5	0.12	0.02	0.013
Cobalt		3	0.239	0.15	0.170	3	0.184	0.09	0.107	5	0.360	0.12	0.108	5	0.353	0.24	0.214	5	0.084	0.03	0.024	5	0.060	0.01	0.012
Copper	61.8	3	1.783	0.62	0.706	3	1.300	0.19	0.216	5	1.442	0.28	0.249	5	1.486	0.24	0.210	5	0.892	0.17	0.153	5	0.942	0.21	0.185
Lead	4.9	3	0.061	0.02	0.019	3	0.062	0.01	0.009	5	1.108	0.72	0.632	5	0.706	0.74	0.646	5	1.468	0.51	0.449	5	0.226	0.06	0.053
Lithium		3	0.10	0.00	0.000	3	0.10	0.00	0.000	5	0.1	0.00	-	5	0.1	0.00	-	5	0.1	0.00	-	5	0.1	0.00	-
Magnesium		3	371	47.48	53.727	3	378	34.99	39.595	5	373	22.45	19.674	5	396	26.40	23.136	5	358	40.91	35.863	5	345	36.34	31.854
Manganese	358	3	10.5	5.03	5.693	3	30.9	18.34	20.749	5	36.0	12.78	11.204	5	39.4	14.32	12.555	5	27.4	5.42	4.746	5	15.5	3.37	2.950
Molybdenum		3	0.029	0.01	0.010	3	0.021	0.00	0.002	5	0.026	0.00	0.004	5	0.023	0.01	0.006	5	0.021	0.00	0.004	5	0.020	0.00	0.002
Nickel		3	0.86	0.56	0.630	3	0.66	0.21	0.242	5	1.02	0.24	0.209	5	1.08	0.57	0.496	5	0.32	0.11	0.100	5	0.16	0.04	0.039
Selenium		3	1.30	0.15	0.173	3	1.10	0.06	0.073	5	1.23	0.09	0.081	5	1.49	0.21	0.184	5	0.97	0.19	0.166	5	2.01	0.65	0.570
Strontium		3	12.06	2.61	2.953	3	14.67	3.27	3.702	5	12.64	1.59	1.390	5	15.12	2.08	1.819	5	12.32	2.10	1.841	5	13.10	1.61	1.408
Thallium		3	0.01	0.00	-	3	0.01	0.00	-	5	0.01	0.00	-	5	0.01	0.00	-	5	0.01	0.00	-	5	0.01	0.00	-
Tin		3	0.05	0.00	0.000	3	0.05	0.00	0.000	5	0.05	0.00	-	5	0.05	0.00	-	5	0.05	0.00	-	5	0.05	0.00	-
Uranium		3	0.006	0.00	0.003	3	0.006	0.00	0.002	5	0.008	0.00	0.004	5	0.009	0.00	0.003	5	0.003	0.00	0.001	5	0.003	0.00	0.001
Vanadium		3	0.10	0.00	0.000	3	0.13	0.04	0.043	5	0.14	0.04	0.032	5	0.14	0.03	0.029	5	0.11	0.02	0.015	5	0.10	0.00	-
Zinc	650	3	46.8	17.06	19.308	3	70.2	28.41	32.151	5	68.0	5.62	4.926	5	99.5	21.78	19.095	5	58.9	10.42	9.137	5	35.0	5.86	5.137

(shaded) wildlife benchmark exceeded

[a] prepared using data from Sparling (2006)

[b] see Table 6.4 for sources

Appendix Table E.11: Concentrations of metals (mg/kg wet weight) in whole body of slimy sculpin collected in the fall 1994 - 95, United Keno Hill Mines [a].

Parameter	Wildlife benchmark	Christal Creek								Flat Creek			
		n	mean	Standard Deviation	95% Confidence Limit	n	mean	Standard Deviation	95% Confidence Limit	n	mean	Standard Deviation	95% Confidence Limit
		CL				KV6				KV9			
Arsenic	0.28	4	0.94	0.11	0.096	2	2.64	-	-	5	1.36	0.912	0.800
Cadmium	3.90	4	0.054	0.016	0.014	2	0.6215	-	-	5	0.33	0.115	0.101
Chromium	-	4	0.198	0	0	2	0.484	-	-	5	0.24	0.024	0.021
Cobalt	-	4	0.083	0.011	0.010	2	0.154	-	-	5	0.03	0.012	0.011
Copper	61.8	4	0.501	0.083	0.073	2	0.924	-	-	5	1.50	0.791	0.694
Lead	4.9	4	0.28	0.110	0.096	2	8.47	-	-	5	11	7.8	6.9
Mercury	0.45	4	< 0.022	0	0	2	< 0.022	-	-	5	0.02	0	0
Nickel	-	4	0.28	0.07	0.058	2	0.825	-	-	5	0.17	0.039	0.034
Zinc	650	4	74	5	4	2	130	-	-	5	52	9.9	8.7

(shaded) wildlife benchmark exceeded

[a] prepared using data from Sparling and Connor (1996)