KENO VALLEY STREAM SEDIMENT AND BENTHIC INVERTEBRATE MONITORING PROGRAMS, 2007

Prepared for

ACCESS
Consulting Group

by

Laberge
ENVIRONMENTAL SERVICES

March 2008

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March 31, 2008

Mr. Dan Cornett,
Access Consulting Group,
#3 Calcite 151Industrial Road
Whitehorse, Yukon.
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Dear Dan:

Re: Final Report - Keno Valley Stream Sediment and Benthic Invertebrate Monitoring Programs, 2007

Included herewith are two (2) hard copies and one unbound copy of the above report. An electronic copy, which includes all text, figures and appendices, is also included.

High levels of various metals continue to be documented in the stream sediments of the Flat Creek and Christal Creek drainages. It appears this may have impacted the health of the benthos communities at these sites, creating low populations of low diversity. Benthic invertebrate communities within the South McQuesten River and Lightning Creek watersheds were generally robust and healthy with good representation of pollution sensitive insects. Metals concentrations in the stream sediments of Lightning Creek were low, however levels were more elevated in the South McQuesten River. There is natural mineralization in this watershed as the PEL for arsenic and zinc was exceeded in the stream sediments of the upstream site at KV-1. It is suspected that these metals are not in a bioavailable form since sensitive insects were collected at all sites on the South McQuesten River.

We have enjoyed working on this project and look forward to participating on other studies at the site in the future.

Sincerely,

Bonnie Burns
Laberge Environmental Services

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1.0 INTRODUCTION

The Elsa Keno mining district was a major silver producer in Canada for 70 years, consisting of several underground and open pit silver/lead/zinc mines. Although the mill has not operated since 1989, mine drainage water has continued to flow into the environment. Lime-treated discharge from the tailings pond system, Galkeno 900 Adit, Galkeno 300 Adit, Bellkeno 600 Adit and Silver King Adit, plus untreated discharges from several other old mine openings comprise the most significant on-going source of metals burden to the receiving environment.

In 2003, the Government of Yukon assumed care and maintenance duties of the various mines, infrastructure and treatment facilities formerly known as the United Keno Hill Mines. To address the concern about potential environmental degradation to the South McQuesten River resulting from high metal-laden discharges from several abandoned mines, Laberge Environmental Services (LES) conducted an intensive sampling program targeting the receiving waters as well as the major inputs in the summer of 2003 (Laberge Environmental Services, 2004). A continuation of the receiving water monitoring program was conducted during the summer of 2004 and during low flow conditions in February 2005 (Laberge Environmental Services, 2005).

An increase in the frequency of the receiving water sampling occured from June 2005 to March 2006. During the summer season, water samples were also collected from the input sites, similar to the 2003 survey. Stream sediment samples and benthic invertebrates were collected from each of the receiving water sites during the August sampling period (Laberge Environmental Services, 2006).

Elsa Reclamation and Development Company (ERDC), a subsidiary of Alexco Resources Corp. assumed care and maintenance of the property in June 2006. On behalf of ERDC, Access Consulting Group contracted LES to conduct stream sediment and benthic invertebrate monitoring in the summer of 2007.

2.0 STUDY AREA

The Keno Valley study area is located in central Yukon, situated on the Silver Trail approximately 50 kilometres northeast of Mayo. The term "Keno Valley" is meant to describe the region encompassed by the historic Elsa/Keno mining areas and the mountains and valleys of the upper South McQuesten River in the vicinity of the small communities Elsa and Keno City. The study area lies within the Yukon Plateau North ecoregion with the terrain consisting of rolling upland plateaus and small mountain groups. The Tintina Trench traverses the ecoregion from southeast to northwest.

The ecoregion is characterized by long cold winters (mean temperature of $-20^{o}C$) and warm summers (mean temperature of $10.5^{o}C$) and extensive areas of discontinuous permafrost. Mean annual precipitation ranges from 300 mm in the major valleys up to 600 in the mountains to the northeast. Within the study area, maximum precipitation occurs in July and minimum precipitation occurs in April.

Sedge or sphagnum tussocks are common in wetlands and in black spruce stands. Extensive shrub lands occur at mid-elevations and on valley bottoms due to cold air drainage. Northern boreal forests exist at elevations up to 1500 m asl. White spruce in a matrix of dwarf willow, birch, ericaceous shrubs, and, occasionally, lodgepole pine forms extensive open forests. Black spruce, scrub willow, birch, and mosses are found on poorly drained sites. Turbic Cryosolic and Eutric Brunisolic soils predominate.

A total of 12 sampling stations were monitored in four subdrainages in the study area for sediment and benthic invertebrates (see Figure 1). The sites are located on the South McQuesten River, Christal Creek, Flat Creek and Lightning Creek (Table 1).

For the majority of the flows and inputs, the South McQuesten River is the ultimate receiving water. Two main tributaries, Christal Creek and Flat Creek, receive water affected by various sources in the Keno Valley. Lightning Creek receives inputs from the south side of Keno Hill and the north-facing slope of Sourdough Hill. Lightning Creek flows into Duncan Creek, a tributary of the Mayo River. Both the McQuesten and Mayo Rivers drain into the Stewart River.

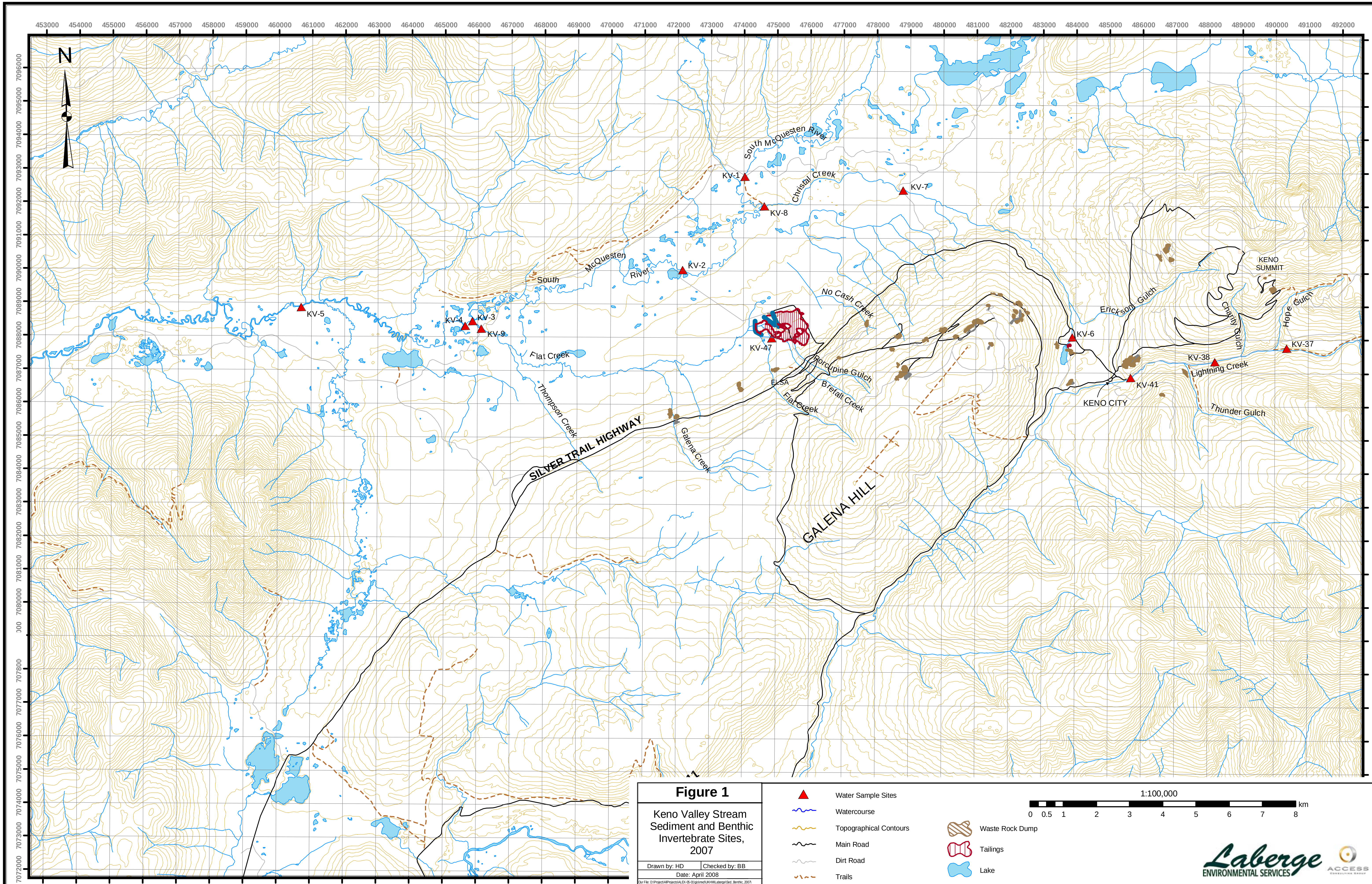


Figure 1

Keno Valley Stream Sediment and Benthic Invertebrate Sites, 2007

Table 1 SITE DESCRIPTIONS AND LOCATION

Site KV #	Site Description	UTM (NAD 83)
1	S.McQuesten River u/s Christal Creek	08 V 0474043 7092848
2	S.McQuesten River at Pumphouse Pond	08 V 0472086 7090028
3	S.McQuesten River u/s Flat Creek	08 V 0465834 7088478
4	S.McQuesten River 300 m d/s Flat Creek	08 V 0465619 7088333
5	S.McQuesten River 9 km d/s Flat Creek	08 V 0460686 7088869
6	Christal Creek @ Keno Hwy	08V 0483916 7088248
7	Christal Creek 100 m u/s Hanson Rd X-ing	08 V 0478789 7092460
8	Christal Creek @ Mouth	08 V 0474607 7091926
9	Flat Creek u/s South McQuesten River	08V 0465861 7088396
37	Lightning Creek u/s Hope Gulch	08 V 0490329 7087789
38	Lightning Creek u/s Thunder Gulch	08 V 0488198 7087330
41	Lightning Creek @ Keno u/s bridge	08 V 0485434 7086769 *

* To ensure that the benthic samplers were not tampered with during colonization, they were installed approximately 35 m upstream of the designated site.

The South McQuesten River's headwaters originate in McQuesten Lake. The uppermost site on the South McQuesten River is located approximately 2 km upstream of the mouth of Christal Creek. Four additional sites were sampled along the South McQuesten River spanning a total distance of approximately 20 km.

Christal Creek flows northwest from Christal Lake for approximately 13 km and empties into the South McQuesten River. Christal Creek receives metal-laden inputs from Galkeno 900 (lime treated), Galkeno 300 (lime treatment commenced in March 2004) and seepages (surface and groundwater) from workings on the west face of Keno Hill. Christal Lake, a long term receptor for tailings and wastewater from Galkeno 900 and Mackeno (a 1950s era development), contribute to loading as well. Three sites were sampled on Christal Creek.

Flat Creek originates on Galena Hill and flows north downslope to the broad valley below the tailings impoundment. It then flows westward 5 km through a sedge / horsetail wetland with black spruce and willows dominating the shrub/tree community (Laberge Environmental Services, 1994). The remainder of Flat Creek flows northwest mainly through mature forest to its confluence with the South McQuesten River. Flat Creek is the receiving water for mine effluent from the tailings facility and, indirectly from some of the adit discharges on Galena Hill. One site, Flat Creek at the mouth, was sampled in the current program.

Lightning Creek is situated in a steep sided valley. Three sites on Lightning Creek were sampled spanning a distance of approximately 5 km, from upstream of Hope Gulch to just upstream of the stream crossing at Keno City. Mine adit drainages from Keno 700 and the Onek decline portal located on the south side of Keno Hill, and Bellekeno 600 on the north side of Sourdough Hill, eventually report to Lightning Creek. The water quality of Thunder Gulch, a main tributary, is affected by placer mining activity, creating impacts to Lightning Creek that are not related to the Elsa/Keno mining developments.

3.0 METHODS

3.1 Water Quality

Water samples were collected at each site prior to and upstream of any other sampling activity by AGC personnel in July and September. Water samples were kept cool prior to air shipment to Bodycote Labs in Surrey, BC.

3.2 Stream Sediment Sampling

Triplicate sediment samples were collected from each site in July 2007. Sample sites were selected from areas of deposition along the stream bank, generally characterized by the finest grain size evident at the site. Samples were collected with a Teflon trowel, placed in zip-lock plastic bags, and kept cool until shipped to Bodycote Labs in Surrey, BC.

At the lab the samples were dried and screened through a 0.053 mm stainless steel sieve. The portion passing the sieve was analyzed for metals by an ICP scan. The lab used methods described in *Test Methods for Evaluating Solid Waste, Physical /Chemical Method, SW846*, 3rd Edition.

3.3 Benthic Invertebrates

3.3.1 Field Collection

Substrate samplers were used for benthic invertebrate sampling. The basket samplers were cylindrical in shape, measured 26 cm long with a diameter of 17 cm, and were constructed of galvanized wire with a 1 cm mesh. Each substrate sampler was filled with washed indigenous gravels collected from the stream bed or the bank at each sample site. The surface area provided by this 'artificial substrate' was approximately 6000 ± 1000 cm^2 (Baker 1979). Three rock filled samplers were submerged in riffle areas of the stream at each site on July 30^{th} to August 1^{st}, 2007. These samplers were left to colonize for five weeks. From September 4^{th} to 6^{th}, 2007, the artificial substrate samplers were retrieved by placing a screened bucket with a 300 micron mesh, downstream and under the basket. On shore the basket was opened in the bucket. Individual rocks were then carefully washed in the screened bucket to remove and collect all invertebrates from that sample. The debris and benthic invertebrates remaining in the bucket were placed in a one litre nalgene bottle and preserved with 10% formalin. These samples were sent to Charles Low PhD, an entomologist in Victoria, B.C. for enumeration and identification.

3.3.2 Laboratory Analysis

All samples were washed through two screens with mesh sizes 1 millimetre and 180 microns. All of the organisms retained by the coarse screen were counted and identified, whereas the organisms on the 180 micron screen were subsampled as necessary. A Folsom plankton splitter was used for the subsampling. (The fraction that was counted and identified is indicated underneath the sample number in Appendix C.) The majority of the benthos was identified to the genus level.

4.0 RESULTS AND DISCUSSION

No water samples were collected, and the benthic baskets were not sampled during the September visit at KV-2, the South McQuesten River near the pumphouse pond. Upon arrival at the site it was noted that the rope attaching the samplers to shore was broken and the samplers had been disturbed and displaced from their initial placement. Immediately adjacent to the sample site a fresh moose calf kill was observed. A bloody skull and jawbone was at the access point to the creek and a short distance away lay an abundant pile of moose hair. It was deemed too dangerous to remain in the area for the couple of hours necessary to complete the requisite sampling. On-site personnel had issued warnings that a bear had been seen trailing a cow moose and her calf over the course of the previous couple of days.

A new site had to be established for KV-38, Lightning Creek upstream of Thunder Gulch in 2005. Originally this site was located just upstream of the bridge crossing Lightning Creek at Thunder Gulch. Placer work had cleared and destroyed this site, consequently it was re-established approximately 700 m upstream during the July 2005 visit. Placer work has continued in this valley since 2005, and initially it appeared that access to KV38 and KV37 was not feasible during the July 2007 visit. However, after consulting with the placer miner it was determined that a cat trail had been pushed upslope and around the new workings. The 2005 established site of KV38 had remained undisturbed upstream of the increased activity to the Lightning Creek valley. Photographs of some of the sites are presented in Appendix A.

4.1 Water Quality

For the majority of the flows and inputs, the South McQuesten River is the ultimate receiving water. Two main tributaries, Christal Creek and Flat Creek, receive contaminants from various sources in the Keno Valley. Lightning Creek receives inputs from the south side of Keno Hill and the north facing slope of Sourdough Hill. Lightning Creek flows into Duncan Creek, a tributary of the Mayo River. Both the McQuesten and Mayo Rivers drain into the Stewart River.

Details of the water quality for July and September are included with the monthly water quality reports prepared by ACG. Several parameters have been examined here to aid in the interpretation of the benthic data (Table 2). Dissolved metals data were examined in Table 2, as metals in this state are more likely to be bioavailable to aquatic life. The data were compared to the applicable CCME (1999) guidelines for the protection of freshwater aquatic life. The cells containing data that exceeded the CCME guidelines have been shaded.

All waters were near neutral to slightly alkaline. Most of the waters sampled were clear although the flow was turbid on both occasions at KV-41, Lightning Creek near the bridge.

The guideline for arsenic was exceeded only at KV-6 and KV-41. Cadmium has a very conservative guideline, which was exceeded at all sites, with the exception of KV-37 during September. The guideline for copper was slightly exceeded in the South McQuesten River sites only. Copper was not detected in the Christal or Lightning drainages. All sites met the guideline for iron. The concentration of lead slightly exceeded the guideline at KV-9 in July, and at KV-5 and KV-41 in September. The guideline for zinc was exceeded at all of the sites with the exception of KV-37 and KV-38, both on Lightning Creek. The guideline was grossly exceeded in the total and dissolved samples in September at KV-41. The concentrations are more than two orders of magnitude greater than the concentrations documented in July. After a review of some past data at KV-41, the September data definitely appears anomalous. The complete set of the data collected during September 2007 (monthlies and quarterlies) was also examined (see September monthly report prepared by ACG). It appears that the data for the samples KV-41 and KV-42 (Belle Keno) had been interchanged. The dissolved and total zinc concentrations recorded at KV-42 were 0.027 and 0.059 mg/L respectively. These concentrations correlate well with previously collected zinc data reported at KV-41, whereas these values (at KV-41 in September 2007) were typical of the Belle Keno discharge. In addition, the lab measured a conductivity value of 1,473 uS/cm in the KV-41 sample and only 135 uS/cm in KV-42 (see the analytic report in the Sept. monthly report, ACG). The high conductivity is more reflective of adit flow than surface water, further corroborating the fact that the results presented for KV-41 are likely incorrect.

Zinc was identified in the 2003 survey as the major contaminant of concern in the Keno Valley study area. Figure 2 is the graphical representation of dissolved zinc concentrations at the sites in July and September. Concentrations in the South McQuesten River were highest at the background site, KV-1 and gradually decreased progressively downstream. The September data was similar or slightly higher than the July results. Significantly higher concentrations were documented in the Christal Creek drainage. Concentrations were greater in September at KV-7 and KV-8 (the dissolved metals sample from KV-6 from the September set of samples was lost by

TABLE 2 SELECTED WATER QUALITY, JULY AND SEPTEMBER 2007

Site #	Date	pH	Temperature °C (in-situ)	Conductivity µS/cm	Discharge m3/s	T-Alkalinity mg/L	TSS mg/L	Sulfate mg/L	Arsenic Total mg/L	Cadmium Dissolved mg/L	Copper Dissolved mg/L	Iron Dissolved mg/L	Lead Dissolved mg/L	Zinc Dissolved mg/L	Zinc Total mg/L
KV-1	31-Jul-07	8.02	17.0	320	nm	89	4	70	0.0014	0.00084	0.006	0.07	0.0023	0.087	0.185
KV-1	5-Sep-07	7.68	10.4	971	nm				0.0014	0.00072	0.005	0.04	0.0002	0.088	0.126
KV-2	30-Jul-07	8.09	18.0	822	nm	100	4	71	0.002	0.00061	0.005	0.04	0.0001	0.069	0.16
No samples were collected in September															
KV-3	31-Jul-07	8.27	16.0	324	nm	102	<2	72	0.0021	0.00054	0.005	0.06	0.0005	0.058	0.126
KV-3	6-Sep-07	8.04	8.3	338	nm				0.0023	0.00055	0.004	0.05	0.0004	0.068	0.105
KV-4	31-Jul-07	8.25	16.5	345	7.028	110	2	76	0.0023	0.00054	0.004	0.05	0.0004	0.055	0.108
KV-4	6-Sep-07	8.09	8.2	437	nm				0.0022	0.00054	0.003	0.05	0.0004	0.063	0.09
KV-5	31-Jul-07	8.30	16.5	336	nm	110	<2	67	0.004	0.0004	0.004	0.08	0.0005	0.044	0.1
KV-5	6-Sep-07	8.22	8.4	455	nm				0.0036	0.00039	0.004	0.1	0.0019	0.05	0.061
KV-6	30-Jul-07	7.42	14.5	1727	0.110	114	4	247	0.0051	0.00206	<0.001	0.03	0.0009	0.291	0.316
KV-6	5-Sep-07	7.33	5.3	1712	0.06063				0.0032	Dissolved metals sample missing					0.263
KV-7	31-Jul-07	8.26	7.5	576	0.202	136	12	189	0.0032	0.0008	<0.001	0.03	0.0002	0.15	0.183
KV-7	5-Sep-07	8.27	4.3	736	0.1892				0.0029	0.00082	<0.001	0.06	0.0004	0.188	0.203
KV-8	31-Jul-07	8.25	9.2	540	0.169	137	7	185	0.004	0.00094	<0.001	0.06	0.0007	0.147	0.159
KV-8	5-Sep-07	7.98	4.1	777	0.20028				0.0039	0.00109	<0.001	0.08	0.0006	0.213	0.229
KV-9	31-Jul-07	7.73	12.0	516	0.217	185	<2	113	0.0038	0.00036	0.002	0.04	0.0014	0.035	0.041
KV-9	6-Sep-07	7.57	6.4	1717	0.1662				0.0042	0.0003	0.002	0.04	0.0007	0.034	0.046
KV-37	1-Aug-07	7.83	6.5	152	0.337	31	6	39	0.0027	0.00002	<0.001	0.04	0.0008	0.008	0.003
KV-37	4-Sep-07	7.42	4	223	nm				0.0026	0.00001	<0.001	0.01	0.0001	0.005	0.006
KV-38	1-Aug-07	7.32	6.0	171	0.407	36	<2	45	0.0025	0.00022	<0.001	0.02	0.0002	0.024	0.024
KV-38	4-Sep-07	7.16	4.1	524	nm				0.0026	0.00019	<0.001	0.01	0.0001	0.022	0.025
KV-41	30-Jul-07	8.16	9.5	181	0.695	42	31	43	0.0072	0.00009	<0.001	0.03	0.0001	0.014	0.048
KV-41	4-Sep-07	7.18	4.8	1473	nm				0.0242	0.00404	<0.001	0.1	0.0031	7.16	6.96
Method Detection Limit									0.0002	0.00001	0.001	0.01	0.0001	0.001	0.001
CCME Guideline for Freshwater Aquatic Life									0.005	0.000017	0.002	0.30	0.001	0.030	0.030

the lab). Zinc concentrations at Flat Creek were slightly over the CCME guideline but were lower than any of the sites on the South McQuesten River. With the exception of the anomalous reading of zinc reported in September at KV-41, the sites on Lightning Creek had the lowest concentrations of zinc in the water column, in the study area. The reported zinc concentration for KV-42 have also be graphed in Figure for September, for comparison purposes.

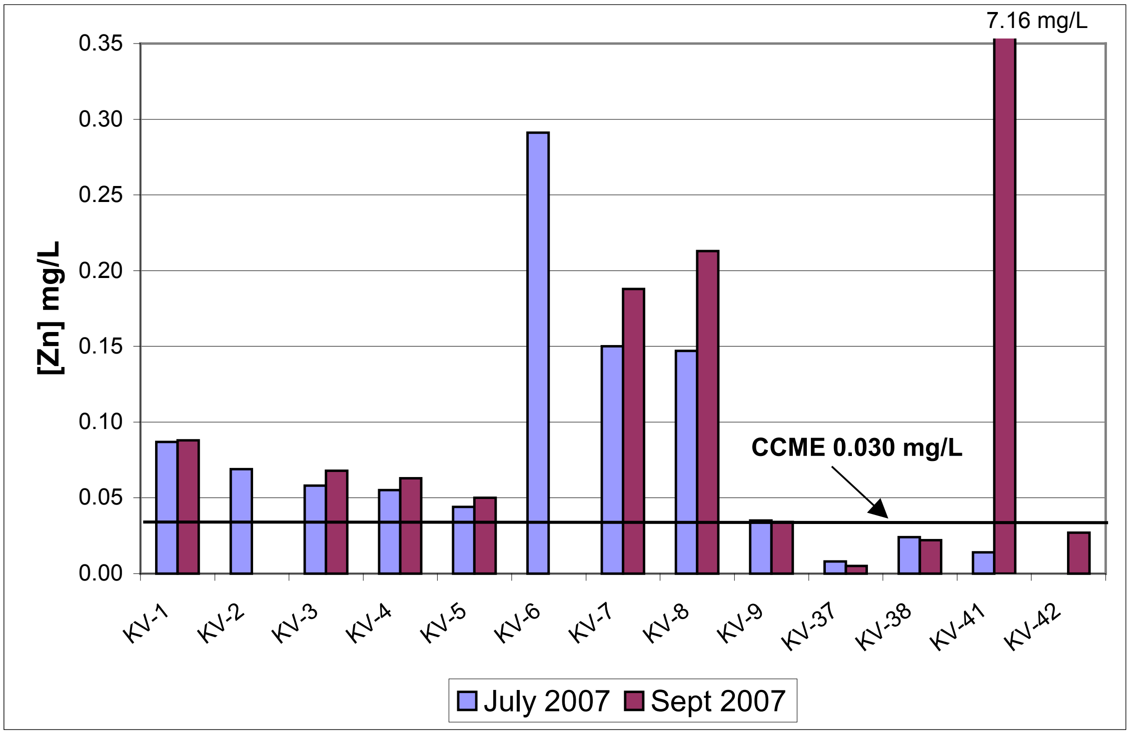


Figure 2 Dissolved Zinc Concentrations, July and September, 2007

4.2 Stream Sediment Analysis

4.2.1 Data from the July 2007 Survey

The results for the stream sediment analysis are presented in Appendix B. Six of the 32 metals analyzed were examined in detail because they may be found in the ore bodies, can be toxic to aquatic organisms at high concentrations and have sediment quality guidelines available for comparison. The means of the triplicates for each of these metals were tabulated and compared to the CCME (1999) interim freshwater sediment quality guidelines (ISQG) and to the probable effects level (PEL) (Table 3, Figure 3). Generally concentrations greater than the PEL have a 50% incidence of creating adverse biological effects.

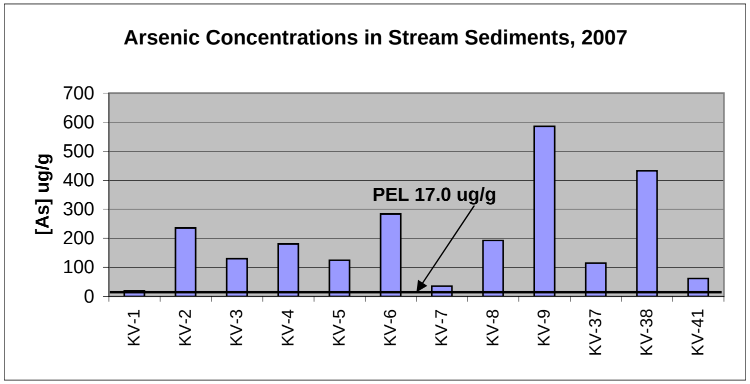
TABLE 3 SUMMARY OF STREAM SEDIMENT METAL CONCENTRATIONS, 2007

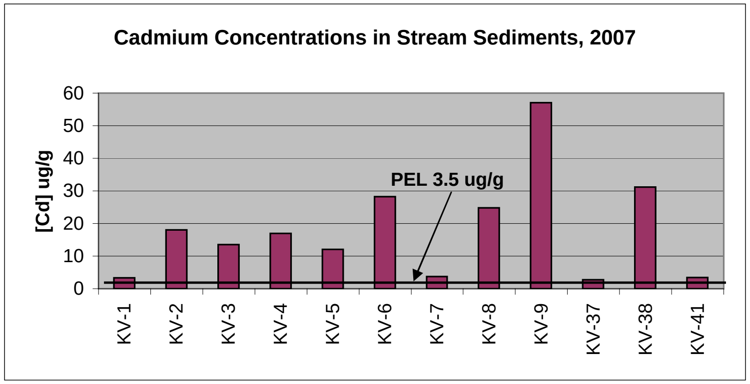
STATION	MEAN CONCENTRATION (ug/g)					
NUMBER	ARSENIC	CADMIUM	COPPER	LEAD	MERCURY	ZINC
KV-1	***18.8*** (2.9)	*3.3* (0.8)	25.4 (5.6)	13.9 (9.1)	0.05 (0.01)	***512*** (97)
KV-2	***235*** (45)	***18.0*** (1.0)	*49.5* (5.7)	***707*** (8.72)	0.11 (0.02)	***1410*** (82)
KV-3	***130*** (24)	***13.5*** (2.5)	*41.5* (2.5)	***423*** (65)	0.09 (0.003)	***1054*** (62)
KC-4	***180*** (28)	***17.0*** (1.7)	*59.0* (4.1)	***985*** (201)	0.17 (0.01)	***1333*** (131)
KV-5	***124*** (37)	***12.1*** (4.4)	*54.3* (18)	***271*** (66)	0.11 (0.04)	***1400*** (497)
KV-6	***284*** (11)	***28.2*** (7.2)	*41.3* (7.1)	***954*** (39)	0.10 (0.01)	***1483*** (365)
KV-7	***35*** (2)	***3.7*** (0.4)	26.6 (2.5)	*56* (5.5)	0.07 (0.0.01)	***404*** (51)
KV-8	***190*** (32)	***24.8*** (5.2)	*63.0* (3.5)	***498*** (122)	0.15 (0.0.01)	***2067*** (442)
KV-9	***586*** (62)	***57.1*** (10.4)	*193.7* (45)	***6290*** (1192)	***0.59*** (0.03)	***3143*** (610)
KV-37	***115*** (67)	*2.7* (1.1)	*41.6* (5.1)	*40.0* (5.0)	0.08 (0.01)	125 (5.5)
KV-38	***433*** (81)	***31.2*** (2.8)	*56.0* (3.1)	***682*** (87)	*0.23* (0.01)	***1637*** (137)
KV-41	***62*** (27)	*3.4* (1.6)	33.8 (9.0)	*82* (38)	0.06 (0.02)	*247* (96)
ISQG	5.9	0.6	35.7	35.0	0.17	123
PEL	17.0	3.5	197.0	91.3	0.486	315

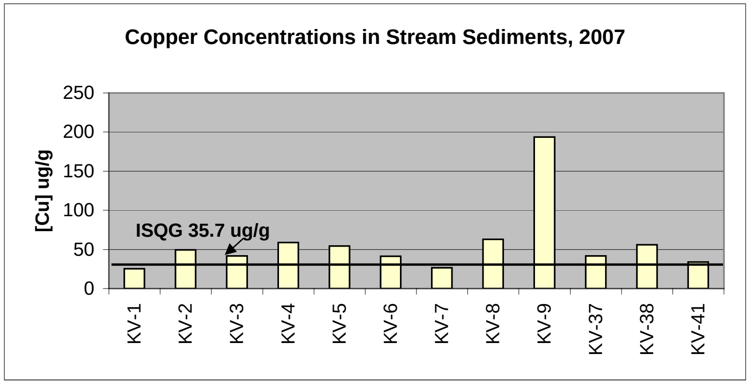
Note: (standard deviation for that data set)
ISQG = Interim freshwater Sediment Quality Guidelines (exceedences italicized)
PEL = Probable Effects Level (exceedences italicized and in bold)

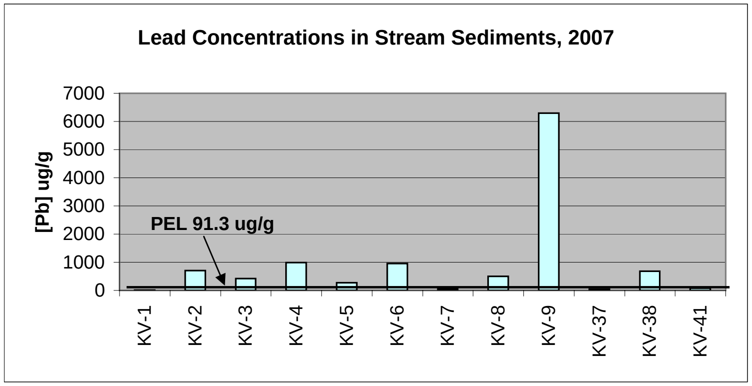
The stream sediments at KV-9, Flat Creek u/s South McQuesten River, had the highest mean concentrations of all the examined metals. Flat Creek has been the receiving water for effluent from the tailings facility for the past few decades. The mean concentrations of arsenic were high and exceeded the PEL at all sites. The ISQG guideline for cadmium was exceeded at KV-1, KV-37 and KV-41, with the PEL for cadmium exceeded at the remaining sites. All sites met the PEL for concentrations of copper in the stream sediments, however, only the sediments at KV-1, KV-7 and KV-41 met the ISQG guideline. The ISQG for lead was met in the stream sediments at KV-1 only. The ISQG was exceeded at KV-7, KV-37 and KV-41 and the PEL for lead was significantly exceeded at the other sites. Concentrations of mercury in the stream sediments were relatively low throughout. The ISQG was exceeded at KV-38, and the PEL was exceeded at KV-9. The concentration of zinc in the stream sediments at KV-37 was the only site to meet the ISQG guideline. The stream sediments at KV-41 exceeded the ISQG with the other sites greatly exceeding the PEL for zinc.

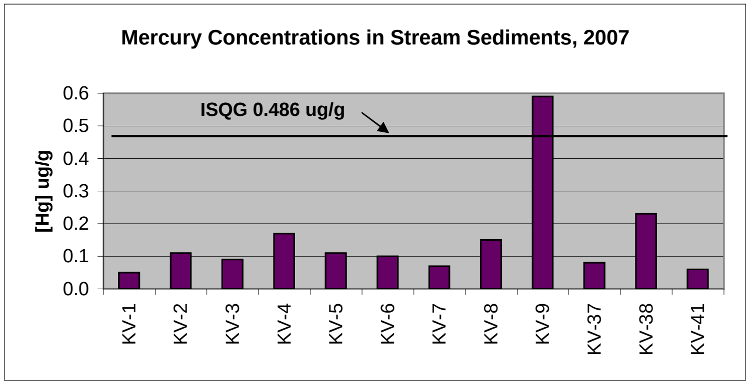
Figure 3 CONCENTRATIONS OF METALS IN THE STREAM SEDIMENTS AT EACH SITE, JULY 2007

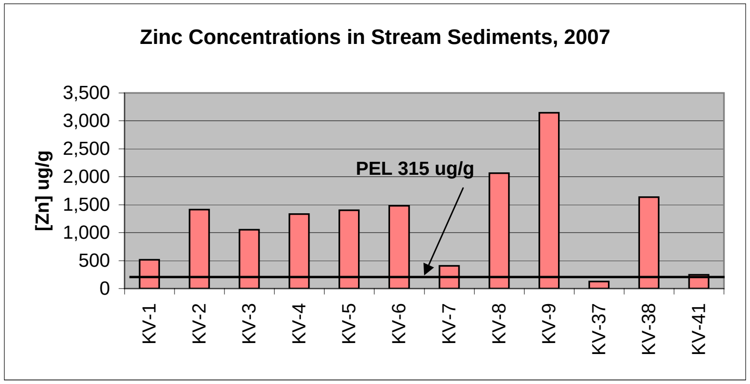












The concentration of metals in the stream sediments at KV-6 and KV-8 were relatively similar, however concentrations at KV-7, located midway between these sites, were considerably lower. Concentrations of the sediments at KV-7 were actually quite similar to the sediments at the upstream site on the South McQuesten River, KV-1. The standard deviation for the triplicate samples at KV-7 was low indicating that representative samples were collected here (Table 3).

There does appear to be some impact to the sediment quality of the South McQuesten River downstream of the confluences of Christal and Flat Creeks for each of the metals, as documented by slight increases at sites KV-2 and KV-4 respectively.

Within the Lightning Creek drainage, the highest concentrations were documented at KV-38, upstream of Thunder Gulch. This site is located 1.8 km downstream of Hope Gulch, which has documented high concentrations of water borne metals (Laberge, 2006). Metal levels in the stream sediments downstream at KV-41 were very similar to the upstream site, KV-37, indicating very little overall impact to Lightning Creek.

4.2.2 Comparison with past Sediment Surveys

Stream sediments have been collected at several of these sites over the past 20 years; in 1985 (Davidge and Mackenzie-Grieve, 1989), in 1990 (Environmental Protection, 1995), in 1994 by consultants for UKHM, in 1997 (Laberge Environmental Services, 1997), in 2004 (Laberge Environmental Services, 2005) and in 2005 (Laberge Environmental Services, 2005). The data for metals where the PEL was exceeded have been compared to the present study in Table 4 and have been graphed in Figure 4.

Recent data only (2004, 2005 and 2007) exists for sites KV-5, KV-6, KV-37, KV-38 and KV-41. Typically the highest concentration of metals in 2004 and 2005 occurred in the stream sediments at KV-6, Christal Creek u/s of the Keno Highway. In 2007, metal concentrations decreased considerably and were very low in the sediments at KV-6. In 2007, the highest concentrations of all metals occurred in the stream sediments at Flat Creek, KV-9. Prior to 2004 (before sediment samples were analyzed at KV-6), the highest concentrations of the metals occurred in the sediments at KV-9 and at KV-8.

TABLE 4 COMPARISONS OF METALS IN STREAM SEDIMENTS OVER TIME

METAL	YEAR	KV-1	KV-2	KV-3	KV-4	KV-5	KV-6	KV-7	KV-8	KV-9	KV-37	KV-38	KV-41
ARSENIC (mg/kg)	1985	<8	99	102	132				1,010	319			
	1990	27	333	150	197			263		396			
	1994	18	413	210	166			174		395			
	1997	25	220	111	117			224	587	222			
	2004	21	79	93	41	40	1,623	83	116	55	56	72	35
	2005	17	282	113	167	45	1,387	185	516	396	100	501	51
	2007	19	235	130	180	124	284	35	190	586	115	433	62
CADMIUM (mg/kg)	1985	0.6	14	29	63				96	104			
	1990	6	37	21	21			54		131			
	1994	2	26	17	19			12		51			
	1997	3	48	18	18			20	70	29			
	2004	3	11	15	6	4	145	21	23	15	1	11	4
	2005	2	44	13	16	3	130	41	68	42	1	46	3
	2007	3.3	18	13.5	17	12	28	3.7	24.8	57.1	3	31	3
LEAD (mg/kg)	1985	24	463	877	3,720				4,040	5,060			
	1990	22	1,069	791	1,110			1,088		4,580			
	1994	10	1,750	1,100	980			680		4,520			
	1997	16	1,397	717	930			1,469	2,697	4,637			
	2004	12	377	677	310	150	4,067	413	755	1,883	27	223	77
	2005	16	1,217	475	1,188	117	7,700	902	2,350	6,667	39	1,172	72
	2007	13.9	707	423	985	271	954	56	496	6290	40	682	82
ZINC (mg/kg)	1985	169	1,060	1,830	3,380				6,100	6,530			
	1990	212	2,423	1,220	1,490			10,400		9,247			
	1994	310	2,410	1,610	1,640			1,950		5,180			
	1997	486	3,950	1,540	1,487			2,217	6,237	2,090			
	2004	303	659	885	342	323	12,140	3,130	1,773	605	62	535	226
	2005	385	2,432	1,010	1,170	307	8,337	4,710	4,943	2,477	104	3,503	228
	2007	512	1410	1054	1333	1,400	1,483	404	2067	3143	125	1,637	247

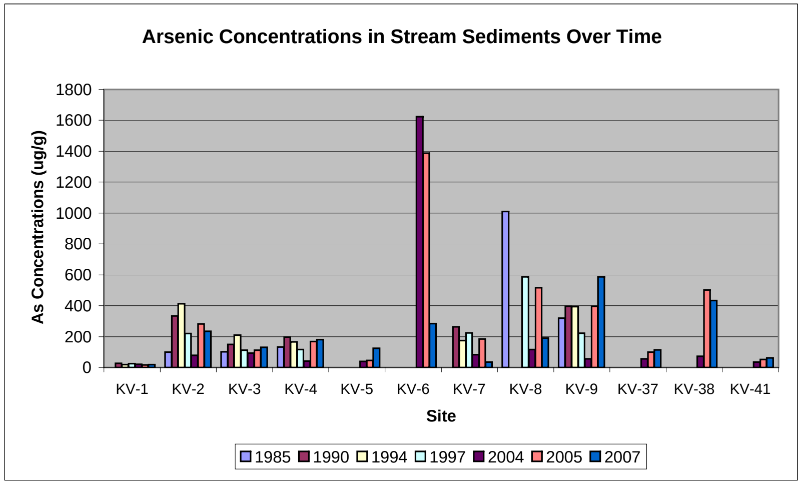
Note: Values for 1985, 1990, 1997,2004, 2005 and 2007 are the mean for triplicate samples, the values for 1994 are for one composite sample.

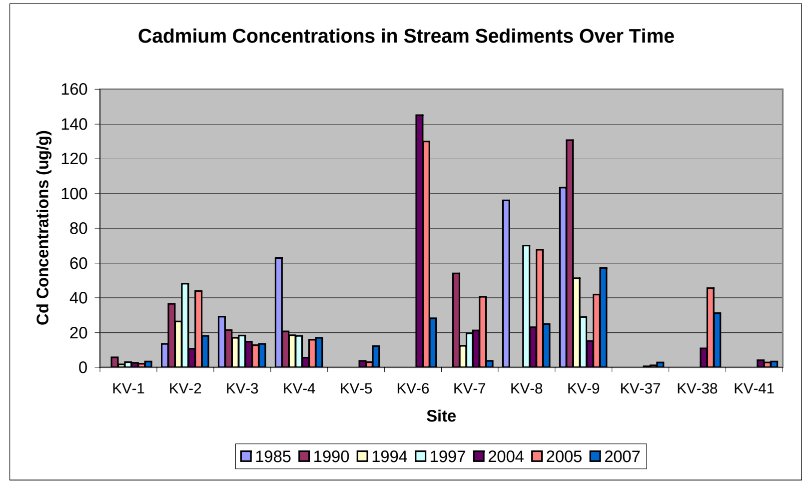
Overall, metal concentrations have been greater in the sediments of the Flat and Christal drainages than the South McQuesten and Lightning drainages. There appears to be little change in the concentrations of metals in the sediments at KV-1, KV-37 and KV-41 over time. Metals have fluctuated over time at the other sites, notably at KV-6 and KV-7.

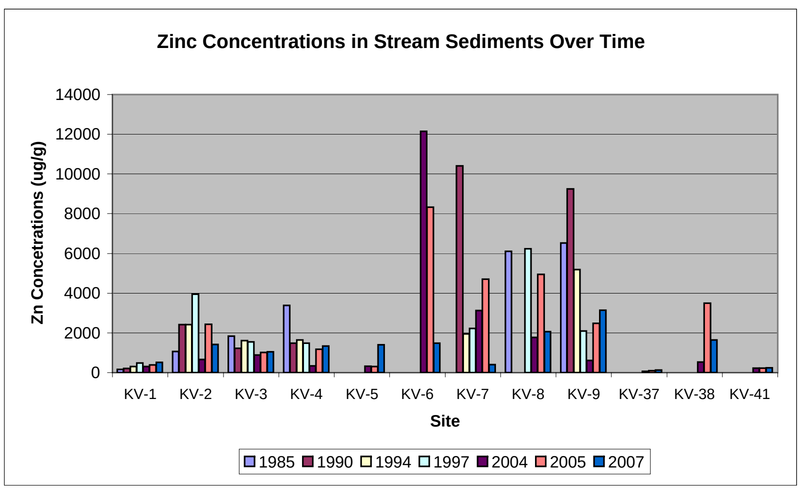
Typically, concentrations were higher in the sediments during the 1990s than during the first decade of 2000. The lowest concentrations tended to occur in 2004.

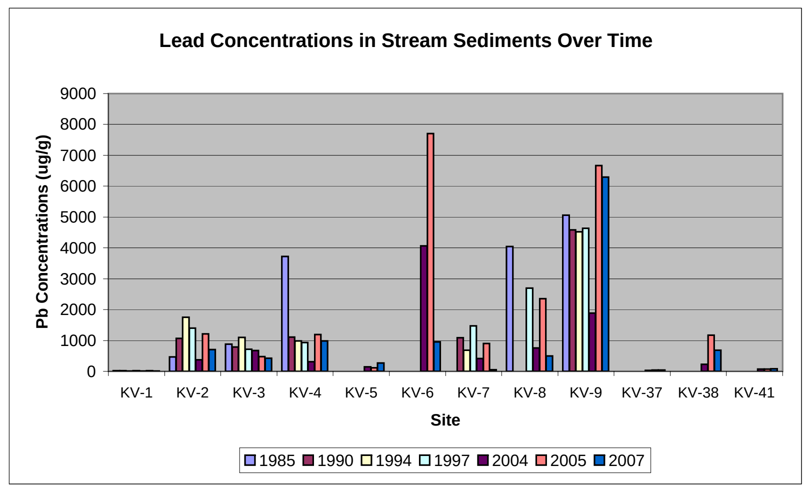
Metals in sediment can be difficult to interpret since levels can vary widely as a function of natural mineralization of local soils in a given watershed. Annual sediment monitoring should continue to determine if bedload materials are being transported downstream from point sources on Christal and Flat Creeks.

FIGURE 4 METAL CONCENTRATIONS IN STREAM SEDIMENTS OVER TIME









4.3 Benthic Invertebrates

To fully assess the environmental quality of the various drainages, benthic invertebrate monitoring was conducted in the summer of 2007. The aquatic environment provides the medium for many or all life stages of numerous species of benthic invertebrates. The quality of this medium will determine the abundance, variety, and presence or absence of various pollution sensitive organisms. The substrate provides habitat for benthic organisms and contaminated stream sediments can have substantial effects on biological activity. Concentrations of many metals were well above the PEL guideline for the protection of aquatic life. To determine if these high concentrations are bioavailable and compromising aquatic life, benthic invertebrate sampling was undertaken.

4.3.1 Results of the 2007 Survey

Five phyla were found in the study area: Arthropoda, Mollusca, Annelida, Nematoda and Cnidaria. A total of 54,609 individual invertebrates, representing 98 different taxonomic groups, were identified within these phyla. These data are presented in Appendix C. One slimy sculpin was inadvertently captured and preserved in one of the samples at KV-8. Slimy sculpins were also discovered when washing the rocks and released; another one at KV-8 and two at KV-9. The benthic baskets at KV-37 and KV-39 were covered with a great deal of leaf litter. Due to the high sediment load at KV-41, considerable amounts of silt had been deposited in and on the benthic samplers.

4.3.1.1 Abundance and Taxonomic Richness

Triplicate samples for benthic invertebrates were collected at each site with attempts made to collect samples representative of that site. The number of organisms of the triplicates was summed to give a total abundance value for that site. The abundance values ranged from a low of 718 individuals at KV-9 (Flat Creek u/s S. McQuesten R) to 11,555 individuals at KV-5, S. McQuesten River 9 km d/s Flat Creek (Table 5).

As a measure of community diversity, the number of taxonomic groups identified from species to phylum at each site was tallied. The diversity ranged from 30 different taxonomic groups identified at KV-6, Christal Creek u/s Keno Road, to 49 different taxonomic groups identified at KV-5 and

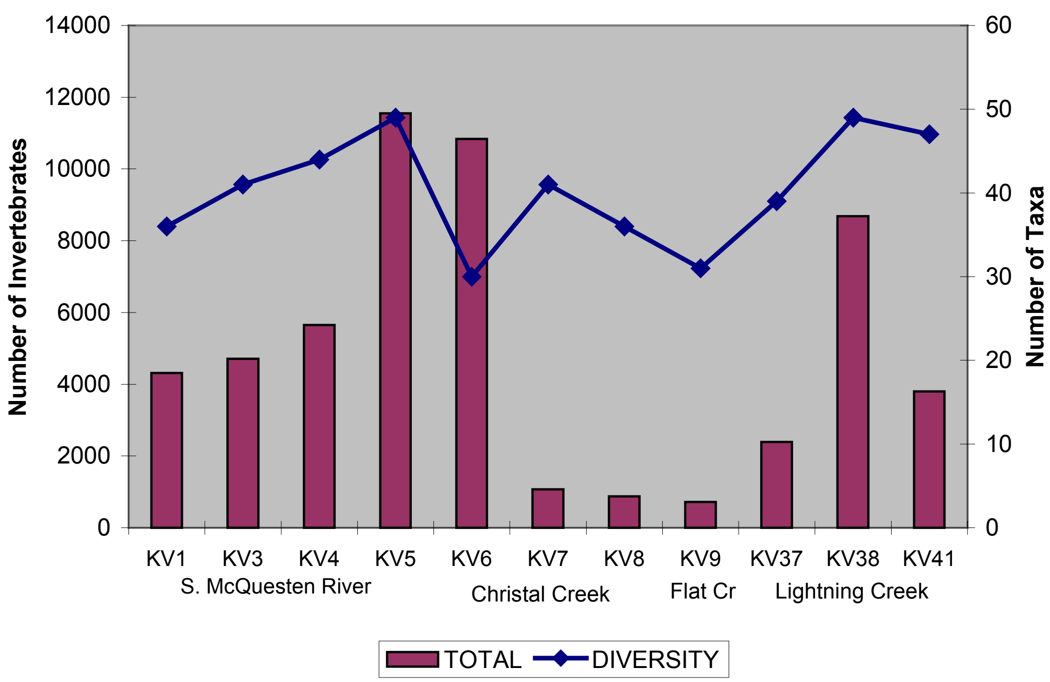
KV-38 (Lightning Creek u/s Thunder Gulch). To further characterize the taxonomic wealth of each community, the diversity was related to the population size using the formula: (Diversity –1) divided by the natural log of the population. This method showed that the community at KV-7, Christal Creek u/s of the Hanson Road, had the greatest diversity with a richness index of 5.7. The lowest index was documented at KV-6, confirming this community to be the least diverse of the sites in the study area. Population numbers and diversity are displayed in Figure 5.

Many variables contribute to invertebrate productivity, such as water temperature, air temperature, rainfall, canopy cover, substrate type and size, stream depth and velocity, as well as water and sediment quality. The life cycles of various organisms can dictate population size if an emergence is captured during the time of sampling.

TABLE 5 BENTHIC INVERTEBRATE DATA, 2007

WATERSHED	SITE #	TOTAL	DIVERSITY	TAXONOMIC RICHNESS INDEX
South McQuesten River	KV1	4,316	36	4.2
	KV3	4,713	41	4.7
	KV4	5,648	44	5.0
	KV5	11,555	49	5.1
Christal Creek	KV6	10,837	30	3.1
	KV7	1,070	41	5.7
	KV8	876	36	5.2
Flat Creek	KV9	718	31	4.6
Lightning Creek	KV37	2,392	39	4.9
	KV38	8,684	49	5.3
	KV41	3,800	47	5.6

Figure 5 BENTHIC DATA PER WATERSHED



4.3.1.2 Distribution

The composition of the benthos communities was displayed as a percentage of the major taxonomic groups for each station (Table 6). Based on this, taxa were classified with respect to their dominance within the community (Table 7).

TABLE 6 THE COMPOSITION (%) OF DIFFERENT TAXONOMIC GROUPS AT EACH STATION

TAXONOMIC GROUP	KV1	KV3	KV4	KV5	KV6	KV7	KV8	KV9	KV37	KV38	KV41
Ephemeroptera (mayflies)	50.5	14.1	9.5	21.9	0.5	7.8	2.1	1.0	3.8	2.8	2.8
Plecoptera (stoneflies)	3.6	19.0	14.1	3.1	9.7	58.4	26.4	23.0	28.9	18.3	18.1
Trichoptera (caddisflies)	3.8	2.3	3.4	4.9	2.1	15.3	4.8	1.5	1.2	0.8	6.6
Diptera (true flies)	27.7	56.5	63.8	60.8	86.4	14.1	57.4	69.9	55.5	59.4	18.3
Hydracarina (water mites)	12.9	6.6	7.0	8.3	0.2	2.6	6.8	4.3	10.3	18.4	52.4
Other *	1.4	1.5	2.2	1.1	0.2	1.8	2.4	0.2	0.2	0.3	1.7

* Other includes one or more of the following taxonomic groups:

Homoptera	Oligochaeta	Colembola	Gastropoda
Nematoda	Copepoda	Coleoptera	
Cnidaria	Aranae	Hymenoptera	

TABLE 7 TAXONOMIC DISTRIBUTION OF BENTHIC INVERTEBRATES					
SITE	**LOCATION**	**DOMINANT** (≥25%)	**SUBDOMINANT** (10% το 24.9%)	**COMMON** (1.0% το 9.9%)	**RARE** (0.1% το 0.9%)
KV-1	South McQuesten River upstream Christal Creek	Ephemeroptera Diptera	Hydracarina	Trichoptera Plecoptera Other	
KV-3	South McQuesten R upstream Flat Creek	Diptera	Plecoptera Ephemeroptera	Hydracarina Trichoptera Other	
KV-4	South McQuesten R downstream Flat Cr	Diptera	Plecoptera	Ephemeroptera Hydracarina Trichoptera Other	
KV-5	South McQuesten River 9 km downstream Flat Cr	Diptera	Ephemeroptera	Hydracarina Trichoptera Plecoptera Other	
KV-6	Christal Creek ustream Keno Highway	Diptera		Plecoptera Trichoptera	Ephemeroptera Hydracarina Other
KV-7	Chirstal Creek u/s Hanson Road x-ing	Plecoptera	Trichoptera Diptera	Ephemeroptera Hydracarina Other	
KV-8	Christal Creek near mouth	Diptera Plecoptera		Hydracarina Trichoptera Other Ephemeroptera	
KV-9	Flat Creek near mouth	Diptera	Plecoptera	Hydracarina Trichoptera Ephemeroptera	Other
KV-37	Lightning Cr u/s Hope Gulch	Diptera Plecoptera	Hydracarina	Ephemeroptera Trichoptera	Other
KV-38	Lightning Cr u/s Thunder Gulch	Diptera	Plecoptera Hydracarina	Ephemeroptera	Trichoptera Other
KV-41	Lightning Creek at Keno	Hydracarina	Diptera Plecoptera	Trichoptera Ephemeroptera Other	

Diptera (true flies) was the dominant or co-dominant group at most of the sites. Plecoptera (stoneflies) dominated the community at KV-7, and Hydracarina (water mites) dominated the population at KV-41.

Diptera is often the dominant order of aquatic communities. Dipterans are one of the most abundant insect orders, comprising more aquatic families than any other aquatic insect order (Clifford, 1991). Many dipterans can have several generations per year, even in the north, further increasing the likelihood of their collection at sites. Plecoptera was fairly abundant throughout the study area. It shared dominance at KV-8 and KV-37, and was frequently subdominant at the other sites. Hydracarina was relatively abundant in the Lightning Creek watershed where it was a subdominant group at KV-37 and KV-38. It was also subdominant at KV-1.

The dominant single taxon collected throughout the study area was *Simulium sp.* larvae (blackflies), a Dipteran, representing 21.23% of the total number of invertebrates collected (Appendix D). This was followed closely by Chironomidae juveniles, also of the order Diptera, with 21.20 %.

Plecoptera (stoneflies), Ephemeroptera (mayflies) and Trichoptera (caddisflies) are sensitive to most types of pollution (Rosenberg and Resh, 1993). Lehmkuhl (1979) has identified several groups within these insect orders that have a very low tolerance to chemical pollution and thus can be used as indicator organisms. Fourteen taxa (eight taxa within Plecoptera, four taxa within Ephemeroptera and two taxa within Trichoptera) were identified in the Keno Valley study area (Table 8).

TABLE 8

Presence (+) and Absence (-) of Sensitive Taxa in the Keno Valley Study Area, 2007

	S. McQuesten River				**Christal Creek**			**Flat Cr**	**Lightning Creek**		
Sensitive Taxa	KV-1	KV-3	KV-4	KV-5	KV-6	KV-7	KV-8	KV-9	KV-37	KV-38	KV-41
Plecoptera											
Nemouridae	+	+	+	+	+	+	+	+	+	+	+
Perlodidae	-	-	-	-	+	+	+	+	+	+	+
Capniidae	+	+	+	+	+	+	+	+	+	+	+
Taeniopterigidae	-	-	-	+	+	+	+	+	+	+	+
Leuctridae	-	-	-	-	-	-	-	-	-	-	+
Chloroperlidae	-	+	+	+	-	-	-	+	+	+	+
Perlidae	+	+	+	+	+	+	-	-	-	-	-
Pteronarcyidae	+	+	+	+	-	-	-	-	-	-	-
Ephemeroptera											
Epeorus	-	-	-	-	-	-	-	-	+	+	+
Ephemerellidae	+	+	+	+	-	-	-	+	+	+	+
Rhithrogena	-	-	-	+	-	-	-	-	+	+	-
Paraleptophlebia	+	+	+	+	-	-	-	-	-	-	-
Trichoptera											
Rhyacophilidae	+	+	+	+	+	+	+	+	+	+	+
Brachycentridae	+	+	+	+	-	-	+	+	-	-	+
Total # of sensitive taxa:	8	9	9	11	6	6	6	8	9	9	10

After Lehmkuhl (1979)

The community on the South McQuesten River 9 km d/s of Flat Creek, KV-5, had the greatest number of sensitive taxa present with 11 out of the possible 14. The sites on Christal Creek, KV-6, KV-7 and KV-8, had the lowest number with six sensitive taxa present. There was no representation from any of the sensitive Ephemeroptera groups at any of the Christal Creek sites. There were eight sensitive taxa identified at the upstream site on the South McQuesten River, KV-1 and at Flat Creek, KV-9. The sites on Lightning Creek had good representation with 9 or 10 sensitive groups present.

It would appear that the high concentrations of metals documented in the water column and the stream sediments in the Christal Creek are impacting the health of the benthos communities at these sites. Several metals exceeded the CCME guidelines for the protection of freshwater biota at this sites. In addition, the concentrations of several metals in the stream sediments were well above the PEL and it is evident that some adverse effects are occurring. Metal concentrations in the stream sediments at KV-9, Flat Creek were the highest in the study area. Although a couple more sensitive taxa were documented here, the population was depressed and the diversity was low. The high concentration of metals in the sediments at KV-9 could be compromising the benthic community in this reach.

The communities within the South McQuesten River watershed appear healthy and robust. Concentrations of water borne metals were generally fairly low, however zinc and cadmium slightly exceeded the CCME guidelines at most of the South McQuesten River sites. The concentrations of metals in the stream sediments were considerably lower than those documented in Christal and Flat Creeks, however there were occasions where the PEL was exceeded (arsenic, cadmium, lead and zinc). The high number of sensitive taxa recorded at all of the sites on the South McQuesten River would tend to indicate that the metals are probably not in a bioavailable form.

The communities on Lightning Creek had diverse and very high populations with good representation of sensitive taxa. Water quality and stream sediment concentrations were relatively similar to those of the South McQuesten River, and do not appear to be causing any adverse effects to the benthos communities.

4.3.2 Comparisons with Past Studies

Benthic invertebrate samples have been collected sporadically from several sites, dating back to 1975. Environmental Protection Service carried out biological monitoring in the study area in 1975, 1985 and 1990. As a requirement under license number Y1N85-02RI, benthic fauna sampling was conducted annually at four sites, between 1986 and 1990. In 1994, Laberge Environmental Services completed a biological monitoring program in the Keno Valley study area. All of these studies used “artificial” substrate samplers with a colonization period of five to six weeks, and triplicates were done per site. As the same methodology was employed throughout, legitimate comparisons can be undertaken.
Very few sites were sampled on each occasion. These were tabulated along with the infrequently

sampled upstream sites (Table 9). Abundance at these sites was graphed in Figure 6.

There is a data gap for several years for the upstream sites, KV-1 and KV-6. Only KV-1 (South McQuesten River u/s of Christal Creek) represents a true background site. Populations were very low here in the first years of sampling but were far greater in recent years. It is not known why populations were so depressed in 1975 and 1985. Populations at Flat Creek (KV-9) and South McQuesten River d/s of Flat Creek (KV-4) were depressed during the latter years of operation of the mine (operations ceased in 1989). Populations at both sites appear to have recovered somewhat in 1994 and 2005. Populations fluctuated at South McQuesten River u/s of Flat Creek (KV-3) over time with higher populations documented during the recent surveys. Populations increased significantly in Christal Creek near the Keno highway (KV-6) in recent studies as well.

Diversity has fluctuated at the sites. The communities on the South McQuesten River generally are more diverse than those on Christal and Flat Creeks. The diversity of the communities at KV-3 and KV-4 has been relatively uniform in recent years.

Diptera has usually been the dominant order at all of the sites over time. Plecoptera shared dominance at KV-3, South McQuesten River u/s Flat Creek, on several occasions. There has been a shift in recent studies at KV-1 where Ephemeroptera has also been dominant. The community at Flat Creek at the mouth, KV-9, saw the greatest shift in dominance over the years. Homoptera (true bugs) and Oligochaeta (aquatic earthworms) have shared dominance here during some of the surveys. Based on the numbers, diversity and the composition of the community, Flat Creek is the most impacted site of those examined in Table 9.

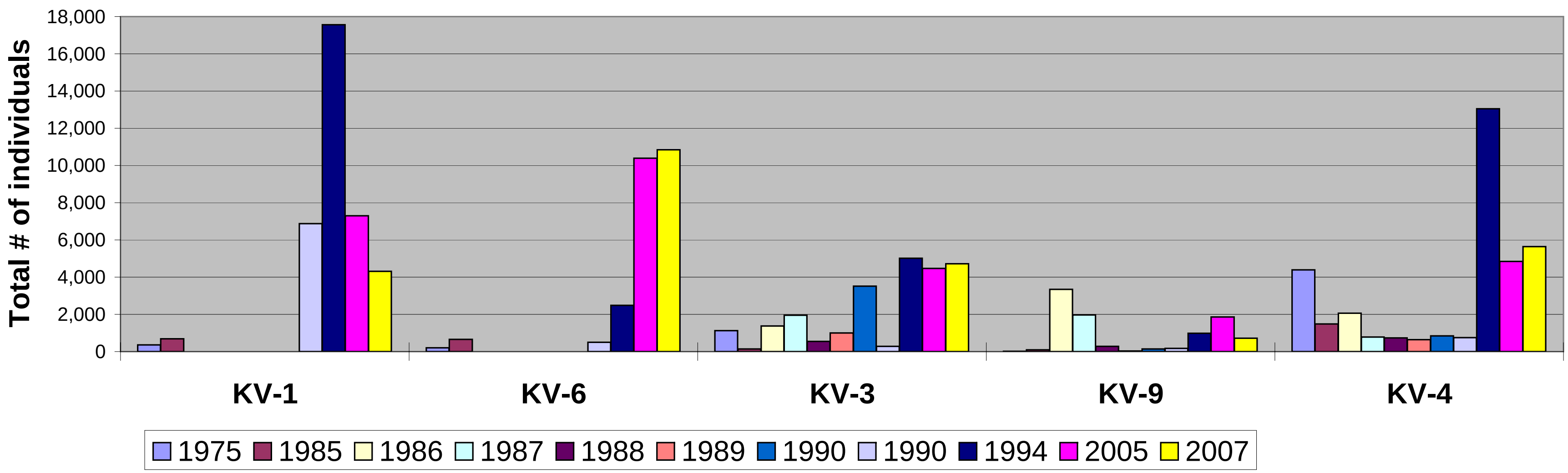
In summary with the limited data available, it appears that benthic populations were negatively affected during the years of mine operation, and have significantly recovered since. Without corresponding data from the background site (KV-1) during this time period it can not be stated definitively if this was a result of mining, or if natural regional conditions caused the depressed populations.

TABLE 9 HISTORICAL BENTHIC DATA FOR SELECTED SITES IN THE KENO VALLEY STUDY AREA

STUDY	YEAR	S. McQuesten R. u/s Christal KV-1			Christal Cr at Keno Rd X-ing KV-6			S. McQuesten R u/s Flat Cr KV-3			Flat Cr u/s S. McQuesten R KV-9			S. McQuesten R d/s Flat Cr KV-4		
Study	Year	Total # of individuals	Total taxa	Dominance and %	Total # of individuals	Total taxa	Dominance and %	Total # of individuals	Total taxa	Dominance and %	Total # of individuals	Total taxa	Dominance and %	Total # of individuals	Total taxa	Dominance and %
EPS	1975	357	21	D 81.8	197	16	D 77.7	1129	24	D 87.9	8	5	D 62.5	4390	15	D 98.5
EPS	1985	683	26	D 76.3	655	31	D 74.2	140	20	D 32.9, P 25.7	95	14	D 42.1, P41.1	1492	25	D 92.8
N. BIOMES	1986							1370	46	D 67.9	3343	22	D 80.7	2056	34	D 64.1
N. BIOMES	1987							1955	43	D 74.4	1976	26	P 59.4, D 36.2	775	37	D 46.5
Leverton	1988							551	36	D 44.5	282	20	D 50.3 P 42.2	740	35	D 40.6, E 27.7
Burns	1989							996	39	D 43.9, P 28.0	33	10	D 51.5	636	20	P 75.6
Burns	1990							3516	55	D 89.4	143	12	P 72.7	841	45	D 71.2
EPS	1990	6876	62	D 86.6	496	41	D 40.7, P 34.7	285	41	D 28.4, P 26.3	166	24	H 46.4, P 31.3	755	42	D 58.8
LES	1994	17557	46	D 89.6	2478	46	D 48.3, O 36.3	5016	40	D 67.5	991	36	O 53.7, D 36.6	13053	48	D 89.9
LES	2005	7290	56	D 59.7, E 27.4	10391	28	D 89.0	4464	44	D 64.8	1856	44	P 50.4, D 39.6	4838	57	D 58.7
LES	2007	4316	36	E 50.5, D 27.7	10837	30	D 86.4	4713	41	D 56.5	718	31	D 69.9	5648	44	D 63.8

D = Diptera E = Ephemeroptera P = Plecoptera O = Oligochaeta H = Homoptera

FIGURE 6 Benthos Abundance Over Time at Selected Sites



5.0 SUMMARY

The CCME guidelines for cadmium and zinc were exceeded in all drainages, and were also exceeded at the background site KV-1. The South McQuesten River appears to have naturally high levels of copper, which also exceeded the guideline, including the upstream site, KV-1. Copper was detected in Flat Creek but not in the Christal and Lightning drainages. Although a very high concentration of zinc was reported in the September samples from KV-41, it is strongly suspected that this was due to a labelling mix up with sample KV-42, Belle Keno.

Concentrations of arsenic, cadmium, lead and zinc were high in the stream sediments at most of the sites throughout the study area, usually exceeding the PEL, including at the background site, KV-1. The highest concentrations of the metals were documented at Flat Creek, KV-9, during the 2007 study. Over time, metal concentrations have been greater in the sediments of the Flat and Christal drainages than the South McQuesten and Lightning drainages. There appears to be little change in the concentrations of metals in the sediments at KV-1, KV-37 and KV-41.

Benthic invertebrate populations were robust and healthy in the South McQuesten River and Lightning Creek drainages. There was good representation from the groups of insects that are known to be sensitive to chemical pollution, indicating healthy environments in these areas. There was a very high population at Christal Creek u/s of Keno Hwy, KV-6, however the community was the least diverse of those studied. Populations at the other two sites on Christal Creek and at Flat Creek, KV-9, were depressed. It appears that the high concentrations of metals in the stream sediments at Flat and Christal Creeks are negatively impacting the health of the benthos communities located on these drainages.

6.0 REFERENCES

Baker, S.A. 1979. *Environmental Quality of Rose Creek as affected by Cyprus Anvil Mining Corp. Ltd. (Survey data from 1974, 75, and 76).* EPS, Regional Program Report No. 79-25.

Burns, B.E. 1990. *Biological Monitoring Program at Flat Creek and South McQuesten River, Elsa Yukon, 1989.* Prepared for United Keno Hill Mines Ltd.

Burns, B.E. 1991. *Biological Monitoring Program at Flat Creek and South McQuesten River, Elsa Yukon, 1990.* Prepared for United Keno Hill Mines Ltd.

Burns, B.E. 1992. *Biological Monitoring Program at Flat Creek and South McQuesten River, Elsa Yukon, 1991.* Prepared for United Keno Hill Mines Ltd.

Canadian Council of Ministers of the Environment (CCME). 1999. *Canadian Environmental Guidelines.* Task Force of Water Quality Guidelines. Ottawa, Canada.

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.

Environmental Protection Service. 1978. *Environmental Quality of Receiving Waters at United Keno Hill Mines Ltd., Elsa, Yukon*. Env. Prot, Regional Program Report. No. 79-14. 26p.

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.

Laberge Environmental Services. 1994. *Environmental Data Compilation and Initial Monitoring at United Keno Hill Mine Area.* Prepared for United Keno Hill Mines.

Laberge Environmental Services. 2004. *Receiving Water and Contaminant Pathway Monitoring in the Keno Valley, 2003*. Special Projects #3. Prepared for Nacho Nyak Dun Development Corporation.

Laberge Environmental Services. 2005. *Keno Valley Receiving Water Monitoring Program, 2004/2005.* Prepared for Access Mining Consultants Ltd.

Laberge Environmental Services. 2006. *Keno Valley Receiving Water Monitoring Program, 2005/2006.* Two Volumes. Prepared for Assessment and Abandoned Mines, Government of Yukon.

Leverton and Associates. 1988. *Biological Monitoring Program, United Keno Hill Mine Site.* Prepared for United Keno Hill Mines Ltd.

Lehmkuhl, Dennis M. 1979. *How to Know the Aquatic Insects*. University of Saskatchewan. Wm. C. Brown C. Publishers. Dubuque, Iowa.

Northern Biomes Ltd. 1986. *United Keno Hill Mines Ltd., 1986 Benthic Fauna Sampling Program, Flat Creek and South McQuesten River*. Prepared for United Keno Hill Mines Ltd., by C.L. Petkovich and E.G. Johnston.

Northern Biomes Ltd. 1987. *United Keno Hill Mines Ltd., 1987 Benthic Fauna Sampling Program, Flat Creek and South McQuesten River*. Prepared for United Keno Hill Mines Ltd., by C.L. Petkovich and C.A. McEwen.

Rosenberg, David M. and Vincent H. Resh. 1993. *Freshwater Biomonitoring and Benthic Macroinvertebrates*. Chapman & Hall Inc. New York.

APPENDIX A

PHOTOGRAPHS

KV-2, September 5th, 2007. The benthic baskets have been moved, probably by a fleeing moose. The calf kill site was on shore adjacent to the baskets.

The end of the road to KV-38 and KV-37. Note the increased ground disturbance in the Lightning Creek valley to the right.

Water was flowing very turbid at KV-41 on September 4th, 2007.

The pollution-sensitive stonefly genus *Pteronarcys,* was found at the South McQuesten sites only, September 6th, 2007.

APPENDIX B

STREAM SEDIMENT DATA, 2007

APPENDIX B **STREAM SEDIMENT METAL CONCENTRATIONS, 2007**

	Aluminum ug/g	Antimony ug/g	Arsenic ug/g	Barium ug/g	Beryllium ug/g	Bismuth ug/g	Cadmium ug/g	Calcium ug/g	Chromium ug/g	Cobalt ug/g	Copper ug/g	Iron ug/g	Lead ug/g	Lithium ug/g
Det Limit	1	0.5	0.2	0.03	0.01	0.5	0.05	2	0.04	0.05	0.05	1	0.3	0.1
KV1-A	8770	<0.5	21.7	138	0.27	1.6	4.2	7530	13	22.9	31.3	19100	24.4	14.1
KV1-B	8130	<0.5	18.9	135	0.25	1.4	3	7300	12.7	19.1	24.7	17900	7.6	13.2
KV1-C	7250	<0.5	15.9	127	0.21	1.3	2.6	6820	11.9	16.5	20.2	15600	9.7	11.9
Mean:	**8050**		**18.83**	**133.33**	**0.24**	**1.43**	**3.27**	**7217**	**12.5**	**19.5**	**25.4**	**17533**	**13.90**	**13.07**
S.D.:	**763**		**2.90**	**5.69**	**0.03**	**0.15**	**0.83**	**362**	**0.6**	**3.2**	**5.6**	**1779**	**9.15**	**1.11**
KV2-A	8450	14.2	208	155	0.27	2.4	17	8600	17	26	43.7	24600	713	13.8
KV2-B	7660	17.5	287	121	0.27	2.9	18.9	7830	15.3	12.2	49.7	31800	711	11.9
KV2-C	10200	14.3	210	190	0.33	2.5	18	10300	22	33.9	55.1	28400	697	16.7
Mean:	**8770**	**15.3**	**235.00**	**155.33**	**0.29**	**2.60**	**17.97**	**8910**	**18.1**	**24.0**	**49.5**	**28267**	**707.00**	**14.13**
S.D.:	**1300**	**1.9**	**45.04**	**34.50**	**0.03**	**0.26**	**0.95**	**1264**	**3.5**	**11.0**	**5.7**	**3602**	**8.72**	**2.42**
KV3-A	8960	13.6	114	171	0.29	2.7	13.4	11400	14.4	20.1	42.8	25300	393	14.9
KV3-B	7500	13.6	119	147	0.24	2.1	11	11600	13.8	18.6	43.2	23200	378	12.7
KV3-C	7960	19.5	157	172	0.25	2.9	16.1	10300	14.6	15.9	38.6	27900	497	13.2
Mean:	**8140**	**15.6**	**130.00**	**163.33**	**0.26**	**2.57**	**13.50**	**11100**	**14.3**	**18.2**	**41.5**	**25467**	**422.67**	**13.60**
S.D.:	**746**	**3.4**	**23.52**	**14.15**	**0.03**	**0.42**	**2.55**	**700**	**0.4**	**2.1**	**2.5**	**2354**	**64.81**	**1.15**
KV4-A	10000	34.6	186	203	0.33	2.7	18.5	9370	15.9	23.8	63.4	32500	1070	15.5
KV4-B	8830	36.8	204	187	0.29	3.1	17.4	9160	15.1	16.3	58.4	33100	1130	14.2
KV4-C	9840	25.6	149	196	0.33	3.1	15.2	9020	16.3	20.1	55.2	29800	755	15.8
Mean:	**9557**	**32.3**	**179.67**	**195.33**	**0.32**	**2.97**	**17.03**	**9183**	**15.8**	**20.1**	**59.0**	**31800**	**985.00**	**15.17**
S.D.:	**634**	**5.9**	**28.04**	**8.02**	**0.02**	**0.23**	**1.68**	**176**	**0.6**	**3.8**	**4.1**	**1758**	**201.43**	**0.85**
KV5-A	10200	7	87.7	198	0.33	2	8.74	9450	14.9	20.4	38.1	24800	234	16.5
KV5-B	15800	5.8	161	308	0.57	3.4	17	13600	26.8	58.4	73.7	36000	347	24
KV5-C	12200	5.9	122	236	0.43	2.5	10.5	14200	17.2	27	51.2	29200	231	19.4
Mean:	**12733**	**6.2**	**123.57**	**247.33**	**0.44**	**2.63**	**12.08**	**12417**	**19.6**	**35.3**	**54.3**	**30000**	**270.67**	**19.97**
S.D.:	**2838**	**0.7**	**36.68**	**55.87**	**0.12**	**0.71**	**4.35**	**2587**	**6.3**	**20.3**	**18.0**	**5643**	**66.12**	**3.78**
KV6-A	9040	15.2	292	224	0.24	2.6	23.3	5160	15.8	9.37	36.9	25300	953	14.4
KV6-B	8990	14.1	272	233	0.24	2.8	24.8	5330	15.8	9.74	37.5	25700	916	14.4
KV6-C	10200	15.2	288	297	0.3	3.2	36.4	6790	18.6	12.3	49.4	30400	994	16.6
Mean:	**9410**	**14.8**	**284.00**	**251.33**	**0.26**	**2.87**	**28.17**	**5760**	**16.7**	**10.5**	**41.3**	**27133**	**954.33**	**15.13**
S.D.:	**685**	**0.6**	**10.58**	**39.80**	**0.03**	**0.31**	**7.17**	**896**	**1.6**	**1.6**	**7.1**	**2836**	**39.02**	**1.27**
KV7-A	6890	<0.5	36.3	224	0.19	1.8	3.4	15300	12.5	7.17	24.6	19600	62.2	12.7
KV7-B	7570	<0.5	34.9	234	0.22	2.2	4.1	16100	13.8	7.89	29.4	21300	55.8	14
KV7-C	7300	<0.5	33	221	0.2	1.7	3.5	15100	13.3	7.42	25.7	20200	51.3	13.7
Mean:	**7253**		**34.73**	**226.33**	**0.20**	**1.90**	**3.67**	**15500**	**13.2**	**7.5**	**26.6**	**20367**	**56.43**	**13.47**
S.D.:	**342**		**1.66**	**6.81**	**0.02**	**0.26**	**0.38**	**529**	**0.7**	**0.4**	**2.5**	**862**	**5.48**	**0.68**
KV8-A	11700	7	225	318	0.39	3.7	30.8	14400	21.3	14.6	66.6	36800	629	21
KV8-B	10900	4	161	293	0.38	3.3	21.3	15200	20.4	13.4	62.6	33200	387	19.7
KV8-C	11000	6.5	184	292	0.37	3.2	22.2	13700	20	13.3	59.7	33800	477	19.7
Mean:	**11200**	**5.8**	**190.00**	**301.00**	**0.38**	**3.40**	**24.77**	**14433**	**20.6**	**13.8**	**63.0**	**34600**	**497.67**	**20.13**
S.D.:	**436**	**1.6**	**32.42**	**14.73**	**0.01**	**0.26**	**5.24**	**751**	**0.7**	**0.7**	**3.5**	**1929**	**122.32**	**0.75**
KV9-A	8610	159	616	397	0.37	8.9	63.4	9050	18.1	11.6	191	76600	7550	13.8
KV9-B	7640	134	515	407	0.32	7.2	62.7	8670	17.5	11.7	240	67800	6140	12.1
KV9-C	5720	156	628	221	0.26	9.4	45.1	6990	11.7	6.95	150	82200	5180	9.2
Mean:	**7323**	**149.7**	**586.33**	**341.67**	**0.32**	**8.50**	**57.07**	**8237**	**15.8**	**10.1**	**193.7**	**75533**	**6290.00**	**11.70**
S.D.:	**1471**	**13.7**	**62.07**	**104.62**	**0.06**	**1.15**	**10.37**	**1096**	**3.5**	**2.7**	**45.1**	**7259**	**1192.10**	**2.33**
KV37-A	13700	<0.5	192	271	0.37	3.2	3.9	3300	23.7	13.7	47.4	34400	41.1	20.9
KV37-B	11600	0.7	86.7	202	0.3	2.7	2.3	3190	20.5	9.21	38.3	24600	44.3	17.7
KV37-C	12300	<0.5	67.6	223	0.32	2.2	1.8	4190	21.7	9.96	39	23900	34.5	19.4
Mean:	**12533**	**0.7**	**115.43**	**232.00**	**0.33**	**2.70**	**2.67**	**3560**	**22.0**	**11.0**	**41.6**	**27633**	**39.97**	**19.33**
S.D.:	**1069**		**66.99**	**35.37**	**0.04**	**0.50**	**1.10**	**548**	**1.6**	**2.4**	**5.1**	**5871**	**5.00**	**1.60**
KV38-A	8890	15	372	143	0.23	4.5	31.1	4980	51.4	14.6	59.2	36400	610	14.4
KV38-B	8980	13.6	525	162	0.23	3.8	34.1	5170	31.6	13.2	55.8	35100	740	13.6
KV38-C	9200	13.2	403	176	0.24	3.8	28.5	5190	30.5	12.4	53	33000	576	13.8
Mean:	**9023**	**13.9**	**433.33**	**160.33**	**0.23**	**4.03**	**31.23**	**5113**	**37.8**	**13.4**	**56.0**	**34833**	**642.00**	**13.93**
S.D.:	**159**	**0.9**	**80.88**	**16.56**	**0.01**	**0.40**	**2.80**	**116**	**11.8**	**1.1**	**3.1**	**1716**	**86.56**	**0.42**
KV41-A	8040	<0.5	44.4	173	0.23	1.7	2.3	3500	16	9.19	28.6	22600	54.3	11.9
KV41-B	10100	1.1	93.1	217	0.3	3.1	5.27	4390	35.6	13.2	44.2	32700	126	15.3
KV41-C	7940	<0.5	50	168	0.23	1.9	2.6	3620	18.4	8.77	28.6	22700	66.4	11.9
Mean:	**8693**	**1.1**	**62.50**	**186.00**	**0.25**	**2.23**	**3.39**	**3837**	**23.3**	**10.4**	**33.8**	**26000**	**82.23**	**13.03**
S.D.:	**1219**		**26.65**	**26.96**	**0.04**	**0.76**	**1.64**	**483**	**10.7**	**2.4**	**9.0**	**5803**	**38.38**	**1.96**

APPENDIX B **STREAM SEDIMENT METAL CONCENTRATIONS, 2007**

	Magnesium ug/g	Manganese ug/g	Mercury ug/g	Molybdenum ug/g	Nickel ug/g	Phosphorus ug/g	Potassium ug/g	Selenium ug/g	Silicon ug/g	Silver ug/g	Sodium ug/g	Strontium ug/g	Thallium ug/g	Tin ug/g
Det Limit	1	0.3	0.003	0.05	0.1	0.5	5	0.3	1	0.2	1	0.02	0.3	0.2
KV1-A	4640	926	0.058	0.65	88.7	1010	440	1.2	82	0.4	74	31.1	1.2	0.3
KV1-B	4530	684	0.06	0.64	70.8	1010	410	1.4	79	<0.2	74	30.3	1	<0.2
KV1-C	4230	651	0.045	0.6	62.5	1040	380	1.1	257	0.2	71	27.8	0.7	<0.2
Mean:	**4467**	**754**	**0.054**	**0.630**	**74.0**	**1020**	**410**	**1.2**	**139**	**0.3**	**73.0**	**29.7**	**1.0**	**0.3**
S.D.:	**212**	**150**	**0.008**	**0.026**	**13.4**	**17**	**30**	**0.2**	**102**	**0.1**	**1.7**	**1.7**	**0.3**	
KV2-A	5020	3590	0.102	1.5	94.5	1020	450	3	114	10.8	83	36.7	6.4	1.9
KV2-B	4640	2670	0.127	1.2	60.2	1120	400	2.4	148	13.9	76	36	4.3	1.4
KV2-C	5880	4540	0.097	1.8	122	1140	541	3.6	264	10.7	94	45.1	8.5	1.5
Mean:	**5180**	**3600**	**0.109**	**1.500**	**92.2**	**1093**	**464**	**3.0**	**175**	**11.8**	**84.3**	**39.3**	**6.4**	**1.6**
S.D.:	**635**	**935**	**0.016**	**0.300**	**31.0**	**64**	**71**	**0.6**	**79**	**1.8**	**9.1**	**5.1**	**2.1**	**0.3**
KV3-A	5390	2880	0.089	0.72	78.3	1040	470	2.6	131	6.7	76	35.4	5	0.8
KV3-B	5300	3110	0.084	0.7	68.2	1020	400	2.3	86	6	121	32.2	5.2	1.7
KV3-C	5250	3360	0.09	0.67	61.6	1060	440	2.6	95	8.6	88	30.9	5.8	1.2
Mean:	**5313**	**3117**	**0.088**	**0.697**	**69.4**	**1040**	**437**	**2.5**	**104**	**7.1**	**95.0**	**32.8**	**5.3**	**1.2**
S.D.:	**71**	**240**	**0.003**	**0.025**	**8.4**	**20**	**35**	**0.2**	**24**	**1.3**	**23.3**	**2.3**	**0.4**	**0.5**
KV4-A	5770	4660	0.183	0.7	75.2	1070	552	3.5	272	17.8	79	26.6	8.4	1.8
KV4-B	5860	4920	0.174	0.63	52.8	1080	500	4.1	283	18.9	76	24.5	8.9	1.9
KV4-C	5550	3330	0.162	0.7	72.5	990	529	2.8	197	11.9	81	27.2	5.6	1.3
Mean:	**5727**	**4303**	**0.173**	**0.677**	**66.8**	**1047**	**527**	**3.5**	**251**	**16.2**	**78.7**	**26.1**	**7.6**	**1.7**
S.D.:	**159**	**853**	**0.011**	**0.040**	**12.2**	**49**	**26**	**0.7**	**47**	**3.8**	**2.5**	**1.4**	**1.8**	**0.3**
KV5-A	5660	2500	0.074	0.64	86	978	553	2.4	99	3.7	78	35.8	3.7	0.4
KV5-B	7260	7500	0.151	1.9	204	1040	852	4.9	60	5.9	90	52.8	10.8	1.4
KV5-C	8190	2870	0.097	0.88	110	1070	673	2.8	264	3.7	96	44.2	4.5	0.4
Mean:	**7037**	**4290**	**0.107**	**1.140**	**133.3**	**1029**	**693**	**3.4**	**141**	**4.4**	**88.0**	**44.3**	**6.3**	**0.7**
S.D.:	**1280**	**2786**	**0.040**	**0.669**	**62.4**	**47**	**150**	**1.3**	**108**	**1.3**	**9.2**	**8.5**	**3.9**	**0.6**
KV6-A	4020	2880	0.103	0.6	24.9	1060	390	2.2	317	12.4	66	22.2	4.8	0.9
KV6-B	4000	3030	0.114	0.65	25.5	1060	370	2.3	324	11.7	68	22.5	5.2	0.8
KV6-C	4480	3920	0.09	0.86	33.3	1040	430	3.1	296	12.6	66	25.9	6.7	1
Mean:	**4167**	**3277**	**0.102**	**0.703**	**27.9**	**1053**	**397**	**2.5**	**312**	**12.2**	**66.7**	**23.5**	**5.6**	**0.9**
S.D.:	**272**	**562**	**0.012**	**0.138**	**4.7**	**12**	**31**	**0.5**	**15**	**0.5**	**1.2**	**2.1**	**1.0**	**0.1**
KV7-A	6730	730	0.072	0.91	21.4	1020	360	1.4	242	1	80	39.4	0.5	<0.2
KV7-B	7020	786	0.071	1	24.1	980	410	1	312	0.7	85	41.4	0.5	0.3
KV7-C	6980	758	0.062	0.95	22.3	964	390	1.3	234	0.7	85	39.1	0.3	<0.2
Mean:	**6910**	**758**	**0.068**	**0.953**	**22.6**	**988**	**387**	**1.2**	**263**	**0.8**	**83.3**	**40.0**	**0.4**	**0.3**
S.D.:	**157**	**28**	**0.006**	**0.045**	**1.4**	**29**	**25**	**0.2**	**43**	**0.2**	**2.9**	**1.3**	**0.1**	**#DIV/0!**
KV8-A	6900	4160	0.14	1.7	46.1	1040	615	4.6	313	9.3	83	41.7	6.9	0.6
KV8-B	6510	2440	0.145	1.6	45.4	980	546	3.1	220	5.3	79	43.7	3.2	0.6
KV8-C	6540	2820	0.149	1.6	40.8	1000	541	3.2	261	6.7	79	40.6	4.5	0.6
Mean:	**6650**	**3140**	**0.145**	**1.633**	**44.1**	**1007**	**567**	**3.6**	**265**	**7.1**	**80.3**	**42.0**	**4.9**	**0.6**
S.D.:	**217**	**904**	**0.005**	**0.058**	**2.9**	**31**	**41**	**0.8**	**47**	**2.0**	**2.3**	**1.6**	**1.9**	**0.0**
KV9-A	5250	<0.3	0.596	0.2	35	833	565	10.6	293	14.6	66	32	43	9.1
KV9-B	5120	<0.3	0.552	0.2	36.6	788	509	10.3	298	13.2	126	35.6	44.9	10.2
KV9-C	5080	<0.3	0.619	<0.05	23.3	644	350	12.1	350	20.2	52	20.7	48.6	7.9
Mean:	**5150**	**#DIV/0!**	**0.589**	**0.200**	**31.6**	**755**	**475**	**11.0**	**314**	**16.0**	**81.3**	**29.4**	**45.5**	**9.1**
S.D.:	**89**	**#DIV/0!**	**0.034**	**0.000**	**7.3**	**99**	**112**	**1.0**	**32**	**3.7**	**39.3**	**7.8**	**2.8**	**1.2**
KV37-A	4260	1210	0.097	1.7	34	1190	380	1.8	346	0.8	46	20.6	0.8	0.4
KV37-B	3770	498	0.076	1.2	26.6	1060	320	1.2	303	0.9	40	17.6	<0.3	0.2
KV37-C	3950	416	0.08	1.2	28.6	1050	350	1.2	297	0.6	44	21.4	<0.3	0.3
Mean:	**3993**	**708**	**0.084**	**1.367**	**29.7**	**1100**	**350**	**1.4**	**315**	**0.8**	**43.3**	**19.9**	**0.8**	**0.3**
S.D.:	**248**	**437**	**0.011**	**0.289**	**3.8**	**78**	**30**	**0.3**	**27**	**0.2**	**3.1**	**2.0**		**0.1**
KV38-A	5780	2600	0.22	7	51.9	1100	270	2.5	293	16.6	37	20.5	3.6	14.5
KV38-B	4660	2050	0.244	3.7	38.7	1070	260	2	351	11.6	48	21.3	2.9	3.7
KV38-C	4600	1850	0.219	3.4	36.2	1040	280	1.6	290	16.7	45	21.9	2.6	3.5
Mean:	**5013**	**2167**	**0.228**	**4.700**	**42.3**	**1070**	**270**	**2.0**	**311**	**15.0**	**43.3**	**21.2**	**3.0**	**7.2**
S.D.:	**665**	**388**	**0.014**	**1.997**	**8.4**	**30**	**10**	**0.5**	**34**	**2.9**	**5.7**	**0.7**	**0.5**	**6.3**
KV41-A	3630	526	0.046	1.1	24.1	906	340	0.4	356	1.1	58	17.6	0.4	0.2
KV41-B	4510	903	0.074	2.9	42.4	1110	410	1.3	367	2.8	64	20.3	0.5	6.8
KV41-C	3600	520	0.046	1.2	24.6	958	330	0.8	341	1.7	56	17.8	0.3	0.9
Mean:	**3913**	**650**	**0.055**	**1.733**	**30.4**	**991**	**360**	**0.8**	**355**	**1.9**	**59.3**	**18.6**	**0.4**	**2.6**
S.D.:	**517**	**219**	**0.016**	**1.012**	**10.4**	**106**	**44**	**0.5**	**13**	**0.9**	**4.2**	**1.5**	**0.1**	**3.6**

APPENDIX B STREAM SEDIMENT METAL CONCENTRATIONS, 2007

	Titanium ug/g	Vanadium ug/g	Zinc ug/g	Zirconium ug/g	pH pH
Det Limit	0	0	0	0.05	0.5
KV1-A	96	21	619	2.3	7.0
KV1-B	102	21	487	2.2	7.0
KV1-C	117	20	430	2.2	7.0
Mean:	**105**	**20**	**512**	**2.2**	**7.0**
S.D.:	**11**	**1**	**97**	**0.1**	**0.0**
KV2-A	105	21	1430	2.4	7.5
KV2-B	88	20	1320	2.4	7.3
KV2-C	122	24	1480	2.9	7.4
Mean:	**105**	**22**	**1410**	**2.6**	**7.4**
S.D.:	**17**	**2**	**82**	**0.3**	**0.1**
KV3-A	94	23	1090	2.4	7.4
KV3-B	104	20	982	2.1	7.4
KV3-C	114	22	1090	2.5	7.3
Mean:	**104**	**21**	**1054**	**2.3**	**7.4**
S.D.:	**10**	**1**	**62**	**0.2**	**0.1**
KV4-A	102	25	1470	2.7	7.1
KV4-B	90	24	1320	2.5	7.2
KV4-C	94	25	1210	2.7	7.0
Mean:	**95**	**25**	**1333**	**2.6**	**7.1**
S.D.:	**6**	**1**	**131**	**0.1**	**0.1**
KV5-A	80	23	1010	2.6	7.4
KV5-B	67	30	1960	3.2	7.4
KV5-C	101	27	1230	3.2	7.5
Mean:	**83**	**26**	**1400**	**3.0**	**7.4**
S.D.:	**17**	**3**	**497**	**0.3**	**0.1**
KV6-A	86	25	1220	2.1	6.7
KV6-B	68	25	1330	2.2	6.8
KV6-C	63	29	1900	2.3	7.0
Mean:	**72**	**26**	**1483**	**2.2**	**6.8**
S.D.:	**13**	**2**	**365**	**0.1**	**0.2**
KV7-A	106	21	356	2.6	7.5
KV7-B	107	23	458	3	7.4
KV7-C	109	22	397	2.7	7.5
Mean:	**107**	**22**	**404**	**2.8**	**7.5**
S.D.:	**2**	**1**	**51**	**0.2**	**0.1**
KV8-A	82	33	2570	3.6	7.3
KV8-B	67	31	1740	3.6	7.2
KV8-C	70	31	1890	3.3	7.3
Mean:	**73**	**31**	**2067**	**3.5**	**7.3**
S.D.:	**8**	**1**	**442**	**0.2**	**0.1**
KV9-A	35	25	3380	2.5	7.3
KV9-B	44	23	3600	2.1	7.4
KV9-C	34	17	2450	1.9	7.2
Mean:	**38**	**22**	**3143**	**2.2**	**7.3**
S.D.:	**5**	**4**	**610**	**0.3**	**0.1**
KV37-A	47	34	128	1.5	6.0
KV37-B	45	29	129	1.1	5.9
KV37-C	40	28	119	1	6.6
Mean:	**44**	**30**	**125**	**1.2**	**6.2**
S.D.:	**4**	**3**	**6**	**0.3**	**0.4**
KV38-A	88	25	1730	2.9	7.1
KV38-B	70	26	1700	1.8	7.0
KV38-C	78	27	1480	1.4	7.0
Mean:	**79**	**26**	**1637**	**2.0**	**7.0**
S.D.:	**9**	**1**	**137**	**0.8**	**0.1**
KV41-A	131	27	184	3	7.0
KV41-B	138	34	358	3.7	7.2
KV41-C	137	27	200	3.1	7.1
Mean:	**135**	**29**	**247**	**3.3**	**7.1**
S.D.:	**4**	**4**	**96**	**0.4**	**0.1**

APPENDIX C

BENTHIC INVERTEBRATE DATA, 2007

	1a	1b	1c	3a	3b	3c	4a	4b	4c	5a	5b	5c	6a	6b	6c	7a	7b
Fines split to:	1/8	1/8	1/2	1/2	1/4	1/4	1/8	1/8	1/8	1/8	1/8	1/8	1/16	1/8	1/8		
PHYLUM ARTHROPODA																	
Class Insecta																	
Order Ephemeroptera																	
Ameletus sp			2				4		8							18	44
Family Baetidae																	
Baetis sp	894	1039	217	109	351	191	113	221	150	760	947	764	1	24	32	1	5
Family Heptageniidae																	
Cinygmula sp								8									
Epeorus																	
Rhithrogena sp										1		1					
Family Ephemerellidae																	
Ephemerellidae J	15	2		1				2	8	7	7						
Drunella flavilinia							6				1	1					
Family Leptophlebiidae																	
Paraleptophlebia sp	8		2	6	4	1	5	8	1	18	19						
Order Plecoptera																	
Family Capnidae																	
Capnia sp	57	32	11	273	226	222	112	124	236	82	93	41	32			85	94
Family Perlodidae																	
Megarcys sp																	
Skwala paralella													1		2		1
Family Nemouridae																	
Zapada sp	11	26	6	36	40	80	80	139	82	32	34	8	537	230	127	96	259
Family Pteronarcyidae																	
Pteronarcella sp				4			3	3	8	5	9	7					
Pteronarcys sp	4	1	2	5		1	3		1	2		1					
Family Chloroperlidae																	
Sweltsa Grp				1		3	3		1		1		1		1		19
Family Taenioptergidae																	
Taenionema sp										13	4	19	38	37	42	3	
Family Perlidae																	
Hesperoperla sp	4	1	2	5		1	3		1	2		1					
Family Leuctridae																	
Leuctra sp																	
Order Trichoptrea																	
Trichoptera Unid J					2				8				38	1		27	4
Trichoptera A																	
Family Hydropsychidae																	
Arctopsyche sp	31	57	30	16	16	12	18	16	34	54	60	81					
Family Brachycentridae																	
Brachycentrus sp	3	2	6	1	1		4	19	12	76	39	24					
Micrasema sp																	
Family Limnephilidae																	
Clostoeca sp																26	80
Dicosmoecus sp				1													
Ecclysomyia																	2
Limnephilus sp													7	1			
Family Glossosmatidae																	
Glossosoma sp																	
Family Hydroptilidae																	
Hydroptila sp	8						8	8		33	32	1					
Hydroptilidae J			4				12										
Oxyethira sp	3	1	5	2	1	17	10	10	17	1	4						1
Family Lepidostomatidae																	
Lepidostoma sp	3	2	1							6	3	6	1				
Family Polycentropodidae																	
Polycentropus sp																	
Family Rhyacophilidae																	
Rhyacophila acropedes or vao	7	2	1	2	28	8	16			90	51	3	59	2	117	7	10
Rhyacophila hyalinata																	
Order Diptera																	
Diptera Unid A								1	1		2	3	1				1
Diptera L																3	1
Family Chironomidae																	
Chironomidae A										8				1			
Chironomidae J	104	138	62	220	276	533	469	819	940	1139	1170	846	640	460	782	9	6
Chironomidae P				2							1	1	2	2	8		2
Brillia sp					1			8	9		3	17					
Cardiocladius sp						4							423	206	94		
Corynoneura sp										8							
Cricotopus sp	24	48	12	26	57	50	129	86	123	221	166	117	86	61	40	11	10
Diamesa sp		8	6	2	4	8	16	8	9	34	32	24	10	16	24		1
Eukiefferiella sp	8	16	6	14	17	16	16		40	41	35	27	171	299	335	1	1
Euryhapsis sp																1	
Phaenopsectra				2		16		8			8						
Rheotanytarsus sp				2	4		12	24		104	56	8					
Thienemanniella sp							4										
Thienemannimyia	1	8	15	7	20	4	34	32	32	16	50		26	4		1	
Family Ceratopogonidae																	

A = adult L = larvae P = pupae J = juvenile D = damaged Unid = unidentified terr = terristrial

	1a	1b	1c	3a	3b	3c	4a	4b	4c	5a	5b	5c	6a	6b	6c	7a	7b
Fines split to:	1/8	1/8	1/2	1/2	1/4	1/4	1/8	1/8	1/8	1/8	1/8	1/8	1/16	1/8	1/8		
Bezzia sp								1									
Culicoides sp							1										
Family Empididae																	
Chelifera sp		1	2	6	4	1	28	24	1	49	33	1	33	16		17	51
Hemerodromia sp																	
Weidemannia sp																	
Family Muscidae																	
Limnophora sp																	
Family Psychodidae																	
Pericoma sp													18		1	1	2
Family Simulidae																	
Cnephia L	9	2	4	2													
Prosimulium L																	
Prosimulium P																	
Simulium sp L	300	386	35	243	672	417	192	283	211	1005	994	683	2791	1373	1402	1	9
Simulium sp P			1	6	13	13	6	30	4	32	54	38	8	9	19	1	1
Family Tipulidae																	
Dicronata sp				2			4									8	5
Gonomyodes sp																	
Tipula sp												1					
Order Collembola																	
Collembola Unid J																	
Hypogastrura sp													1			1	1
Isotomurus sp											1						
Podura sp												1					
Order Homoptera																	
Aphididae (terr)	1			2		3							2	1		3	1
Cicadellidae (terr)								1									
cf Aclerdidae (terr)											1						
Order Hymenoptera A (terr)					1											1	
Order Araneae (terr)					1	1											1
Order Hydracarina																	
Hydracarina Unid J																16	
Lebertia										24	56	16					
Neumania					4						8						
Sperchon	8		4	2	4		16	8	8	88	32						1
Torrenticola sp	80	88	32	30	32	12	28	48	24	106	161	48				1	
Unioncola sp	160	112	72	48	136	44	72	80	112	129	192	88	16		8	3	3
Oribatei			2								8					1	1
Order Coleoptera																	
Hydrophiloidea L (terr)																	
Staphylinidae A (terr)																	
Class Crustacea																	
Sub Class Copepoda																	
Sub Order Cyclopoida																	
Sub Order Harpacticoida											8					1	
PHYLUM MOLLUSCA																	
Class Gastropoda																	
Fossaria sp		1	1		3	1											
Physella gyrina										1							
Valvata sincera			2														
PHYLUM ANNELIDA																	
Class Oligochaeta																	
Family Enchytraeidae J	8							8		1						2	3
Family Naididae																	
Naididae Unid J/D	1																
Chaetogaster sp						4	8		8		16						
Nais sp							4										
Family Lumbricidae (terr)															1		
Family Tubificidae J		24	10	6	8	12	12	32	16	16	16	24	3			3	
PHYLUM NEMATODA	8		2	4	12	12	8	1	24	13	28	2		2	8	1	1
PHYLUM CNIDARIA																	
Class Hydroza																	
Order Hydroida																	
Hydra sp			2										28	50	25		
Fish (vertebrate)																	
Cottus cognatus																	
TOTAL / SAMPLE	1760	1997	559	1088	1938	1687	1459	2060	2129	4217	4435	2903	4974	2795	3068	350	621
TOTAL / SITE	4316			4713			5648			11555			10837			1070	
Taxonomic Richness/sample	26	23	31	33	28	28	35	30	30	35	40	32	27	20	19	30	31
Taxonomic Richness/site	36			41			44			49			30			41	

A = adult L = larvae P = pupae J = juvenile D = damaged Unid = unidentified terr = terrestrial

	7c	8a	8b	8c	9a	9b	9c	37a	37b	37c	38a	38b	38c	41a	41b	41c		
Fines split to:												1/4	1/16	1/4	1/4	1/2		
PHYLUM ARTHROPODA																		
Class Insecta																		
Order Ephemeroptera																		
Ameletus sp	15	2							1	1		8	3	25		9	140	0.26
Family Baetidae																		
Baetis sp		10	4	2	5			8	6	19	2	15	129	7		6	6032	11.05
Family Heptageniidae																		
Cinygmula sp								3	5	7	7	30	12	18	4	11	105	0.19
Epeorus								5	5	16	4	13	4	10	4	2	63	0.12
Rhithrogena sp								6		3	1	9	8				29	0.05
Family Ephemerellidae																		
Ephemerellidae J					1		1										44	0.08
Drunella flavilinia									5	1		1		6	1	3	25	0.05
Family Leptophlebiidae																		
Paraleptophlebia sp																	72	0.13
Order Plecoptera																		
Family Capnidae																		
Capnia sp	7	16	26	16	31	23	19	3	3	7	44	111	266	126	4	28	2450	4.49
Family Perlodidae																		
Megarcys sp															2		2	0.00
Skwala paralella		6	14	8	4	2	4	1	2	10	3	6	7	3		5	79	0.14
Family Nemouridae																		
Zapada sp	56	48	34	47	25	11	4	152	249	258	224	487	431	220	121	146	4336	7.94
Family Pteronarcyidae																		
Pteronarcella sp																	39	0.07
Pteronarcys sp																	20	0.04
Family Chloroperlidae																		
Sweltsa Grp	5						2		1			2	2		1	3	46	0.08
Family Taenioptergidae																		
Taenionema sp		5	2	9	9	14	17	3		2		4	4	20	5	3	253	0.46
Family Perlidae																		
Hesperoperla sp																	20	0.04
Family Leuctridae																		
Leuctra sp																2	2	0.00
Order Trichoptrea																		
Trichoptera Unid J	6	8	6	20		1	1	1		1	5		17	6	10	6	168	0.31
Trichoptera A											1		1	3			5	0.01
Family Hydropsychidae																		
Arctopsyche sp	1	1		1										4			432	0.79
Family Brachycentridae																		
Brachycentrus sp			2			1	1										191	0.35
Micrasema sp														2			2	0.00
Family Limnephilidae																		
Clostoeca sp				1													107	0.20
Dicosmoecus sp		1															2	0.00
Ecclysomyia														1			3	0.01
Limnephilus sp																	8	0.01
Family Glossosmatidae																		
Glossosoma sp														26	32	11	69	0.13
Family Hydroptilidae																		
Hydroptila sp																	90	0.16
Hydroptilidae J						1											17	0.03
Oxyethira sp																	72	0.13
Family Lepidostomatidae																		
Lepidostoma sp																	22	0.04
Family Polycentropodidae																		
Polycentropus sp										1							1	0.00
Family Rhyacophilidae																		
Rhyacophila acropedes or vao		1	1		1	1	4	8	6	4	12	12	15	50	49	50	617	1.13
Rhyacophila hyalinata								4	1	3	2		1	1			12	0.02
Order Diptera																		
Diptera Unid A	1								1			1					12	0.02
Diptera L		1		1							6	17	1				30	0.05
Family Chironomidae																		
Chironomidae A		1		1										1			12	0.02
Chironomidae J		25	21	19	41	36	35	119	88	123	23	569	1812	1	33	19	11577	21.20
Chironomidae P		2	1	1	3	5	1	5	13	9	37	84	17	8	11	5	220	0.40
Brillia sp	1	11	39	60	1						2			4		2	158	0.29
Cardiocladius sp							1	12	129	110	18	26	5	12	14	2	1056	1.93
Corynoneura sp							1										9	0.02
Cricotopus sp		23	11	17	103	94	138	17	24	28	41	189	67	104	21	11	2155	3.95
Diamesa sp		1		1	3	2	3	106	150	234	93	229	527	92	94	29	1766	3.23
Eukiefferiella sp		43	26	26	1	2	2	4	3	7	14	41	120	8	5	9	1354	2.48
Euryhapsis sp					2	2	1							4			10	0.02
Phaenopsectra																	34	0.06
Rheotanytarsus sp		14	10	11				5	4	3	2	1	16				276	0.51
Thienemanniella sp					1												5	0.01
Thienemannimyia					3	5											258	0.47
Family Ceratopogonidae																		

A = adult L = larvae P = pupae J = juvenile D = damaged Unid = unidentified terr = terristrial

	7c	8a	8b	8c	9a	9b	9c	37a	37b	37c	38a	38b	38c	41a	41b	41c		
Fines split to:												1/4	1/16	1/4	1/4	1/2		
Bezzia sp																	1	0.00
Culicoides sp																	1	0.00
Family Empididae																		
Chelifera sp		1	2		1		1					2	13				287	0.53
Hemerodromia sp																1	1	0.00
Weidemannia sp								1			5	4	4	18	8	20	60	0.11
Family Muscidae																		
Limnophora sp							1					4					5	0.01
Family Psychodidae																		
Pericoma sp					1			4	8	6	10	20	17	50	46	25	209	0.38
Family Simulidae																		
Cnephia L																	17	0.03
Prosimulium L								7	6	14	19	87	604	4			741	1.36
Prosimulium P										1		6	5				12	0.02
Simulium sp L	5	34	55	44	6	2	3	33	14	36	14	75	278				11596	21.23
Simulium sp P			1			1					2		16				255	0.47
Family Tipulidae																		
Dicronata sp								2		1	1	14		10	13	11	71	0.13
Gonomyodes sp								1					1				2	0.00
Tipula sp											2				1		4	0.01
Order Collembola																		
Collembola Unid J															4		4	0.01
Hypogastrura sp															4		7	0.01
Isotomurus sp		1	1	1										1			5	0.01
Podura sp			2	4													7	0.01
																	0	
Order Homoptera																		
Aphididae (terr)		4		1		1		1	1		5	1	1	9	5		42	0.08
Cicadellidae (terr)			1										1				3	0.01
cf Aclerdidae (terr)																	1	0.00
Order Hymenoptera A (terr)				2													4	0.01
Order Araneae (terr)												1					4	0.01
Order Hydracarina																		
Hydracarina Unid J			40		2	2	24	24	48	56	88	168	16			8	492	0.90
Lebertia			1	1				2		1		14	16	38	86	56	311	0.57
Neumania								1				2					15	0.03
Sperchon								1	3	3	3	25	76	76	74	44	476	0.87
Torrenticola sp		1						1			8	2	32				734	1.34
Unioncola sp	2	7	6	3	1	1	1	46	28	33	67	158	919	460	761	388	4156	7.61
Oribatei				1								1				2	16	0.03
Order Coleoptera																		
Hydrophiloidea L (terr)															1		1	0.00
Staphylinidae A (terr)									1								1	0.00
Class Crustacea																		
Sub Class Copepoda																		
Sub Order Cyclopoida		1		1													2	0.00
Sub Order Harpacticoida																	9	0.02
PHYLUM MOLLUSCA																		
Class Gastropoda																		
Fossaria sp																	6	0.01
Physella gyrina																	1	0.00
Valvata sincera																	2	0.00
PHYLUM ANNELIDA																		
Class Oligochaeta																		
Family Enchytraeidae J											1	8		9	7	6	53	0.10
Family Naididae																		
Naididae Unid J/D																	1	0.00
Chaetogaster sp																	36	0.07
Nais sp																	4	0.01
Family Lumbricidae (terr)																	1	0.00
Family Tubificidae J				3							3	1	1	6	13		209	0.38
PHYLUM NEMATODA					1			2		1	1	1					132	0.24
PHYLUM CNIDARIA																		
Class Hydroza																		
Order Hydroida																		
Hydra sp																	105	0.19
Fish (vertebrate)																		
Cottus cognatus		1															1	
		269																
TOTAL / SAMPLE	99	268	306	302	246	207	265	588	805	999	770	2449	5465	1443	1434	923	54609	100.00
TOTAL / SITE		876			718			2392			8684			3800				
Taxonomic Richness/sample	10	26	23	27	22	20	22	32	27	31	35	41	38	37	30	31	98	
Taxonomic Richness/site		36			31			39			49			47				

A = adult L = larvae P = pupae J = juvenile D = damaged Unid = unidentified terr = terristrial