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KENO VALLEY RECEIVING WATER MONITORING PROGRAM, 2004/2005

Prepared for

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1.0 INTRODUCTION

1.1 Background

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. The current study represents a continuation of the receiving water monitoring program during the summer of 2004 and during low flow conditions in February 2005.

1.2 Scope of Work

Long term monitoring of receiving water is meant to capture any special or temporal trends in effects on the aquatic ecosystem downstream of the mining areas. The tasks for the 2004/2005 season included the following:

- Collect water quality samples from various sties during open water and low flow conditions.
- Conduct spot flow measurements at all water quality sites.
- Install a new sensor/data logger at Christal Creek, KV-7, to maintain a continuous record.
- Install two new sensor/data loggers at KV-9, Flat Creek upstream of the S. McQuesten River, and at KV-41, Lightning Creek at Keno, to record stream flow variation and allow for more confident study area hydrologic modeling.
- Collect stream sediment samples from each site during the open water season.

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 13 sampling stations were monitored in three subdrainages in the study area (see Figure 1). The sites were located on the South McQuesten River, Christal Creek, Flat Creek and Lightning Creek, and are described in Table 1. Several of these sites have been sampled since the 1970s and have had several site designations over time. The various site designations are also included in 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.

Table 1 SITE NUMBERING AND LOCATION

KV #	LES Site #	UKHM[1] Site #	UKHM[2] Site #	Site Description	UTM (NAD 83)
1	LES 01	S-21	UK1	S.McQuesten River u/s Christal Creek	08 V 0474043 7092848
2	LES 02	S-10	UK2	S.McQuesten River at Pumphouse Pond	08 V 0472086 7090028
3	LES 03	S-26	UK5	S.McQuesten River u/s Flat Creek	08 V 0465834 7088478
4	LES 04	S-11	UK3	S.McQuesten River 300 m d/s Flat Creek	08 V 0465619 7088333
5	LES 05			S.McQuesten River 9 km d/s Flat Creek	08 V 0460686 7088869
				S. McQuesten R. Bridge near Haggart Cr	08V 0449694 7085723
6	LES 06	S-18	UK6	Christal Creek @ Keno Hwy	08 V 0483892 7088111
7	LES 07	S-19	UK7	Christal Creek 100 m u/s Hanson Rd X-ing	08 V 0478789 7092460
8	LES 07B	S-27	UK8	Christal Creek @ Mouth	08 V 0474607 7091926
9	LES 09	S-9	UK9	Flat Creek u/s South McQuesten River	08V 0465861 7088396
37	LES 37		UK11	Lightning Creek u/s Hope Gulch	08 V 0490329 7087789
38	Stn 38			Lightning Creek u/s Thunder Gulch	08 V 0487480 7087239
41	LES 41		UK12	Lightning Creek @ Keno u/s bridge	08 V 0485434 7086769
[1]	Water Licence # QZ94-002				
[2]	Water Licence # QZ96-001				

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. Five additional sites were sampled along the South McQuesten River spanning a total distance of approximately 55 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 on Lightning Creek that are not related to the Elsa/Keno mining developments.

3.0 METHODS

Open water season sampling was conducted from July 29th to 31st, 2004. Water samples and triplicate sediment samples were collected from each of the 13 sites. Continuous water level data loggers were installed at three of the sites.

Low flow water quality monitoring was conducted from Feb 25th to 28th, 2005. Water samples were collected from all of the sites except for the South McQuesten River at the bridge near Haggart Creek. Diagnostics and data retrieval was done at all three data logger sites.

3.1 Water Quality

Water samples were collected at each site prior to and upstream of any other sampling activity. In-situ measurements of conductivity and temperature were determined with an Orion conductivity meter model 126. Dissolved oxygen readings were obtained using an Orion oxygen meter model 820 and pH measurements were taken using an Accumet Portable AP61 pH meter.

Samples for routine analysis such as alkalinity, anions, and nutrients, were collected in new one litre plastic bottles. Samples to be analyzed for total and dissolved metals were collected in new 250 mL plastic bottles. Filtering of dissolved metals samples was done at the end of each day at the lab house in Elsa using sterile 0.45 micron in-line filters and new 60mL syringes. All samples to be analyzed for metals were preserved using nitric acid vials supplied by NWL. All samples were kept cool, shipped by air in coolers to Vancouver, BC and analyzed by Norwest Labs in Surrey, BC.

3.2 Hydrology

Instantaneous discharge (spot flow) measurements were taken at all sites during the July 2004 sampling event using a "Price" meter and wading rod. An area with a uniform cross section was chosen and the velocity and depth were measured using either a AA Price or Price mini meter. Ten or more readings were taken across the profile of the stream. Total discharge was calculated as the sum of these individual discharges.

During the July visit, the gauged stations at KV-9, Flat Creek at mouth and KV-41, Lightning Creek just upstream of the Keno City Bridge, were grubbed out, refurbished and outfitted with PT2X water level sensors/dataloggers. The gauge site at KV-7, Christal Creek 200 m upstream of the Hanson Lake Road Crossing, was grubbed out and refurbished. The Chart Pac and sensor were replaced with a PT2X system.

During the late February 2005 low flow monitoring event, discharges were measured at KV-7, KV-9, and KV-41 using the salt slug injection method.

3.3 Stream Sediment Sampling

Triplicate sediment samples were collected from each site in July 2004. 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 frozen. The samples were later packed with ice packs and shipped to Norwest 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.

4.0 RESULTS AND DISCUSSION

Good efforts were made in 2004 to clear and grub out the sample sites. Access trails to all sites were partly grubbed out during 2004 and appropriate signage was posted at each sampling station. More work is required to allow reliable access to Flat Creek at KV-9 and Christal Creek at KV-7 and KV-8. Photographs of some of the sites are presented in Appendix A.

4.1 Water Quality

4.1.1 Water Quality Results for the Current Study

From July 29th to 31st, 2004, 13 sites were sampled in the Keno Valley, and 12 sites were sampled from February 25th to 28th, 2005. 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.

The analytical lab sheets for both sampling periods are included in Appendix B. A summary of the data has been prepared in Table 2. The same parameters were examined as during the 2003 study (Laberge Environmental Services, 2004) and are displayed in the same format. The data were compared to the CCME (1999) guidelines for the protection of freshwater aquatic life. The cells containing data that exceeded the CCME guidelines are highlighted in yellow.

The data was then analyzed according the CCME Water Quality Index. For each sample, the number of yellow cells was counted to give a number that could range from 0 to 7. This value is displayed in the column labeled ‘Index’. The sites with a high index value indicate that more guidelines were exceeded than sites with a low index, and thus are potentially more contaminated. This approach does not differentiate between samples that barely exceed the guideline than those that grossly exceed the guideline. For the sites investigated in the study area, the majority of the parameters that were exceeded had fairly low concentrations.

All waters were near neutral to slightly alkaline. Most of the waters sampled were clear. There were notable suspended solids in the summer only; at the South McQuesten River bridge near Haggart Creek, at Christal Creek u/s of the Hanson Lake Bridge and at Lightning Creek u/s of the Keno City Bridge. Conductivity, hardness and alkalinity were all considerably higher in the South McQuesten, Christal and Flat drainages than in Lightning Creek. Sulphate levels were substantially higher in Christal and Flat Creeks than in the drainages of the South McQuesten River and Lightning Creek.

The highest concentrations of metals occurred in the Christal Creek drainage. KV-6, Christal Creek upstream of the Keno Highway had an index of 5, the highest in the study area. Metal concentrations were generally lower in the February samples. Cadmium has a very conservative guideline, which was exceeded at all sites except for KV-37, Lightning Creek upstream of Hope Gulch. This site had an index of 0 and appears to lie outside of the mineralized zone of the region. The guideline for copper was slightly exceeded in the South McQuesten River during July 2004. All sites met the guideline for iron. The concentration of lead at KV-6, Christal Creek u/s of the Keno Highway, slightly exceeded the guideline during July 2004. The guideline for arsenic was slightly exceeded in three samples during July, twice in Christal Creek and once in Lightning Creek. The guideline for zinc was also exceeded frequently, including sites in the South McQuesten River. A tend towards an overall decrease in concentrations of zinc has been observed in concurrent monitoring from July 2004 to February 2005 (Access Consulting Group).

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 total and dissolved zinc concentrations at the sites in July 2004 and in February 2005. It is evident that zinc concentrations are much greater in Christal Creek than at the other sites.

4.1.2 Comparisons of Annual Summer Water Quality

The water sampling program conducted in the summer of 2003 encompassed all of the sample sites as the current study, with the exception of the site at the South McQuesten River bridge near Haggart Creek. The two sets of data have been summarized in Table 3. Flows were higher during the 2004 sampling period.

The lab used a higher method detection limit in 2003 for several of the parameters. This made comparisons of some of those "non-detected" parameters difficult as values lower than the 2003 detection limit were reported in 2004. This was the case for arsenic, cadmium and lead. Arsenic was not detected in any of the samples in 2003 when the detection limit used was 0.02 mg/L. In 2004 arsenic was detected in all of the samples and concentrations ranged from 0.0022 to 0.0092 mg/L. For the sites where cadmium was detected in both years, concentrations were higher in 2004. Lead was not detected in any of the samples in 2003, but the detection limit was greater than the CCME guideline. Lead values were low at all of the sites in 2004 and the CCME guideline was exceeded at KV-6 only. Iron concentrations were low but were higher in 2004 than in 2003.

Zinc was detected at all sites for both sampling periods. Higher concentrations were generally recorded in 2004 and the data for total and dissolved zinc have been graphed in Figure 3. There were two exceptions to this. Concentrations of total zinc were much greater at KV-41 in 2003 than in 2004, however the dissolved values were lower. Concentrations were higher in 2003 at KV-6 in both the total and dissolved phases. In 2003 this site was sampled downstream of the road crossing at the old gauge site. In 2004 it was sampled upstream of the Keno Highway to coincide with site number ACG-WQ-5 of the Galkeno 300 monthly monitoring program. This location is upstream of a diversion ditch situated to collect seepages from the Galkeno area. Zinc concentrations decreased downstream in Christal Creek in 2003, but concentrations increased at the mouth in 2004. It appears that Christal Creek is still showing lingering effects from the treated fugitive flow from Galkeno 300. Concentrations at the mouth, KV-8, in 2004 are approximately double of those documented in 2003. This has resulted in a slight impact to the South McQuesten River where zinc exceeded the CCME guideline at the sites downstream of Christal Creek in both the dissolved and total phases. The water quality had recovered at KV-5 where concentrations were similar to those at the background site, KV-1.

4.2 Hydrology

The study area streams usually present peak flow in late May or June and low flow between February and April. Significant flood events occur due to rainstorms in the summer and/or fall, such as the peak that can be seen in mid August, 2003 at KV-7, Christal Creek at the Hanson Lake Road. Mining companies, government agencies and consultants have collected stream

flow data sporadically since the 1970s. Stream flow variation and extreme event forecasts were most recently compiled by Access Mining Consultants Ltd for the UKHM water licence application in 1997. At that time, a form of regional analysis was done, augmented with various partial records and instantaneous discharge measurements. The results were reproduced in *The Keno Valley / Dublin Gulch Environmental Baseline Assessment*, by Environmental Services, Public Works and Government Services, March 2000. By comparing Water Survey of Canada median elevations and mean annual runoff (MAR), a correlation was established for the Keno Valley area. Seasonal runoff distribution was predicted for several sub basins in the study area. The results compared favourably with the instantaneous discharge measurements.

As part of the current study, instantaneous discharge measurements were made at water sample sites, and water level recording gauges were installed at three of the sites. The most frequent measurements were made in the Christal Creek drainage as part of the Galkeno 300 Fugitive Flow and Receiving Water Monitoring programs (ACG). Preliminary rating curves were established for the three sites.

Results of instantaneous discharge measurements are included in Table 2 with the water quality data. Basin characteristics are presented in Table 4. A brief discussion of the gauged sites follows.

Table 4 Basin Characteristics for the Gauged Sites

Station	**Drainage Area (km^2)**	**Median Elevation (m)**	**MAR (mm)**
KV-7 Christal Cr @ Hanson Lake Road	43.5	870	230
KV-41 Lightning @ Keno City	58.5	N/A	N/A
KV-9 Flat Cr u/s South McQuesten River	31.2	700	170
MAR = mean annual runoff			

4.2.1 KV-7 Christal Creek Upstream of Hanson Lake Road

First established in the 1980s, this was inspected and re-surveyed in 2003 when the staff gauge was found to be in good condition. The recorder shelter was in poor condition, but sufficed to house a Chart Pac datalogger connected to a Bourdon sensor (LES equipment). The site was grubbed out, surveyed and refurbished in July 2004. The trail needs work to allow access by ATV. Christal Creek at the Hanson Lake road crossing is the only site with anything like a continuous stage record. Partial records were obtained in the mid 1990s. The LES Chart Pac data logger and Bourdon pressure transducer were installed in early August, 2003 and operated until November 18th, 2003 when it failed due to a power supply fault. The Chart Pac was reinstalled on March 23, 2004 and was replaced with a new PT2X system on July 30, 2004, which provided continuous record to the most recent download of February 27th, 2005. Flow variation over the period of record is illustrated in the discharge curve shown in Figure 4. Christal Creek experienced a rainfall event flood around the 18th of August, 2003, when the creek overtopped its banks and presented a very high discharge. A bank full flood was also measured on May 20, 2004 at 1.996 m^3/sec, providing a good range of data for the preliminary rating curve shown in Figure 5. The preliminary rating curve has been updated using the frequent data collected under the Galkeno 300 Fugitive Flow Investigation.

Low flow has been monitored using the salt slug injection method, and tends to be in the order of 0.10 to 0.15 m^3/sec. Some caution should be used in interpreting the Christal Creek discharge curve for the late winter of 2005. The apparent water level has been affected by a frozen stick dam just below the gauge causing an exaggerated gauge height. Also, overflow ice conditions can cause false high readings from transducers.

Figure 4: KV-7 Christal Creek at Hanson Lake Road Discharge Curve 2003-2005

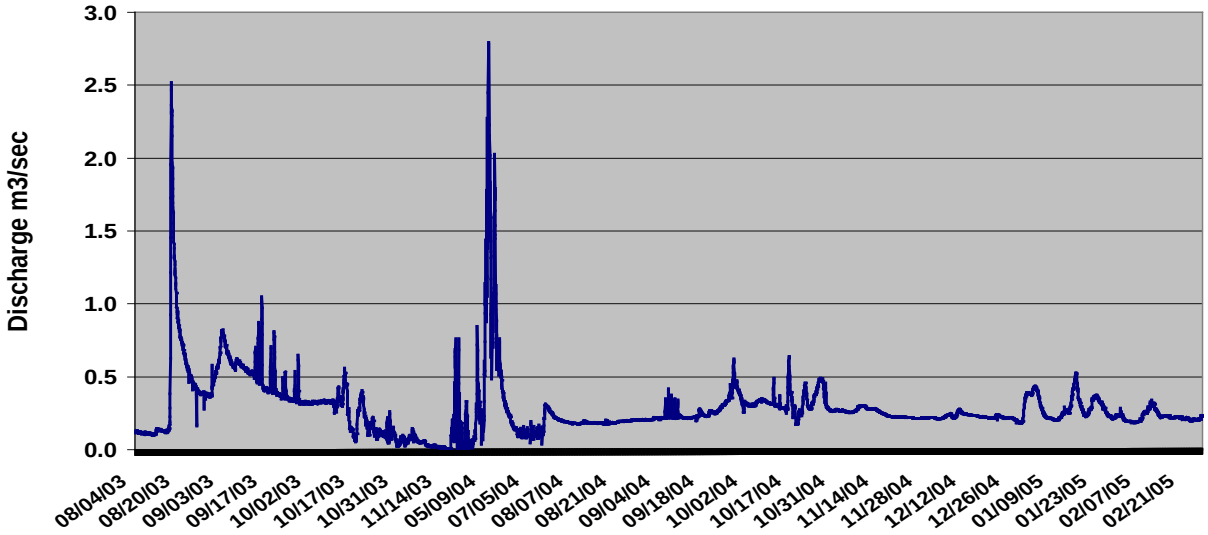
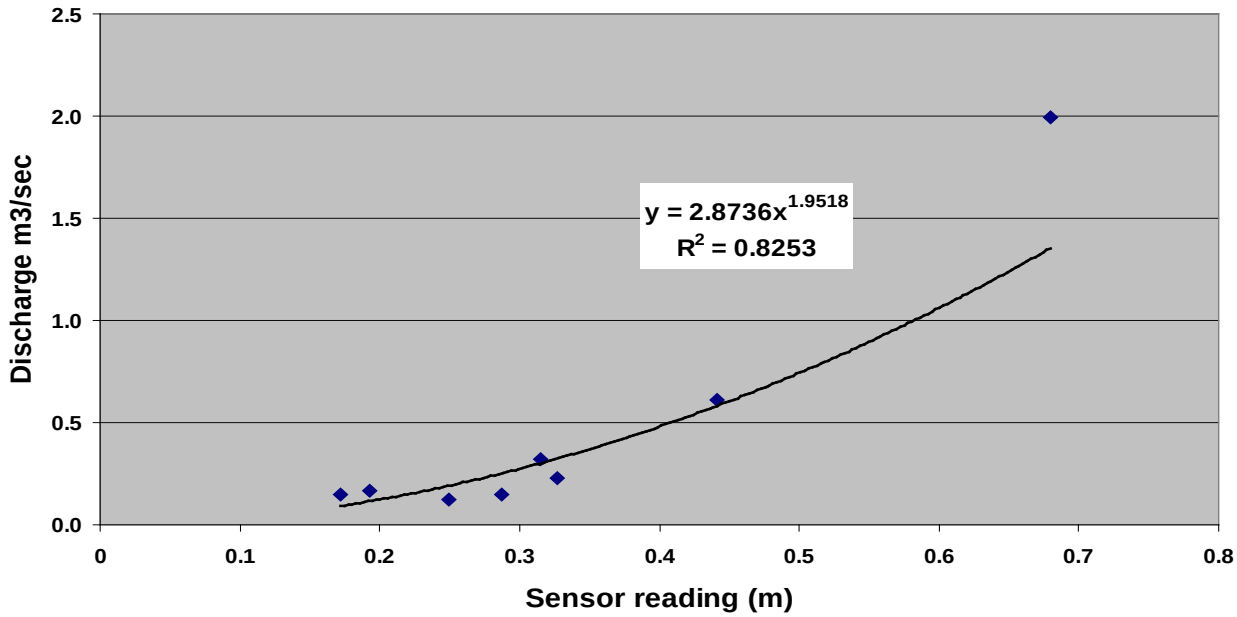


Figure 5: Preliminary Rating Curve 2005
KV-7 Christal Creek at Hanson Lake Road



4.2.2 KV-9 Flat Creek upstream South McQuesten River

A staff gauge was installed initially at the Shanghai Road Crossing in 1994, but this location proved to be unreliable. A new installation was completed near the mouth of Flat Creek in 1996. In 2003 the gauge was found to be in good condition. The site was grubbed out and the access trail improved, although it still needs work. On July 30, 2004 a PT2X system was installed at the staff gauge and recorded stage from July 30, 2004 to the latest download on February 26, 2005. Figure 6 shows the discharge of Flat Creek to February 26, 2005.

The preliminary rating curve is presented in Figure 7. Caution should be used in interpreting the October data because the sensor may have recorded some flooding due to overflow ice conditions. The latter part of the curve is also suspect because the sensor was apparently reporting high readings in extremely cold weather. It is very likely that the discharge remained in the order of 0.02 m^3/sec from late December 2004 to late February 2005. The discharge on February 26th was 0.028 m^3/sec and likely represents the low flow condition.

Figure 6: KV-9 Flat Creek U/S South McQuesten Discharge Curve 2004-2005

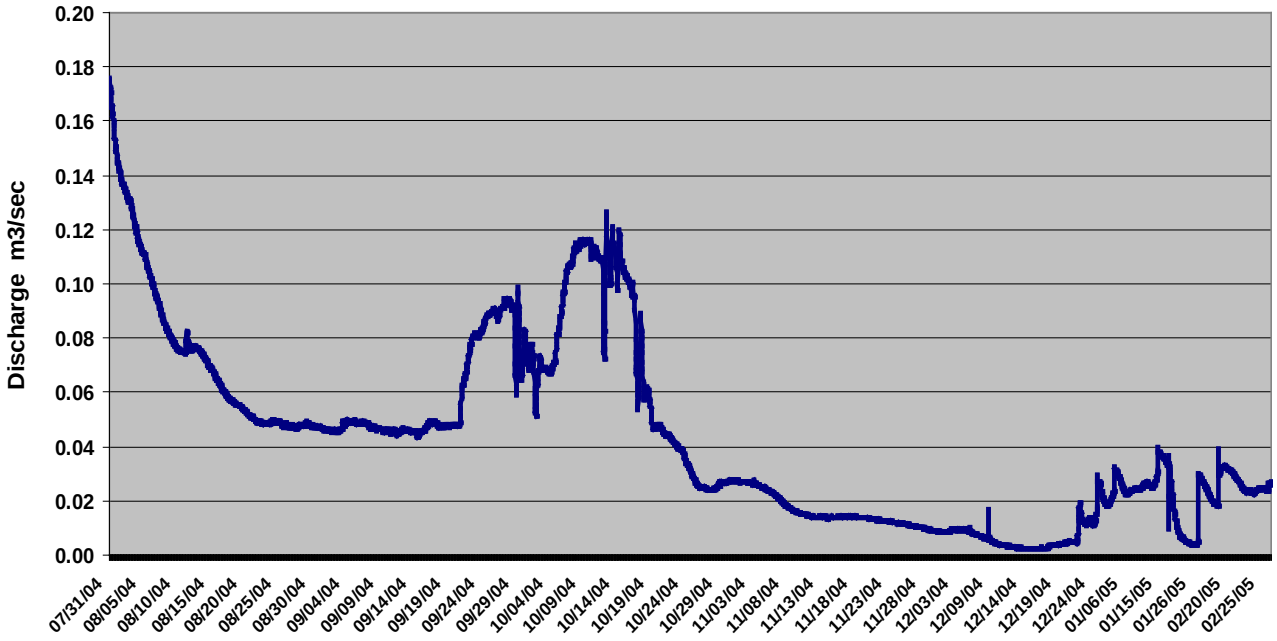
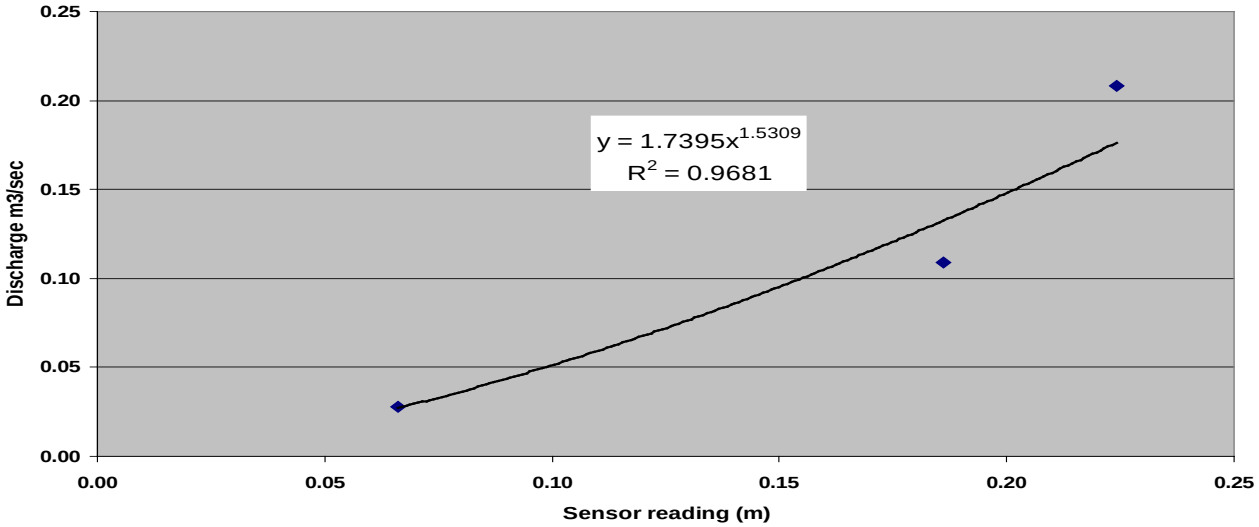


Figure 7: KV-9 Flat Creek U/S South McQuesten Preliminary Rating Curve 2005



4.2.3 KV-41 Lightning Creek at Keno City

This gauge site was first installed in 1994, and was destroyed by aufice and flooding in 1995, and refurbished in 1996. In 2003 the gauge was found to be in good condition, was cleared and grubbed out, and was surveyed relative to bench marks. In July 2004, a PT2X sensor and datalogger was installed at the staff gauge. Figure 8 shows the discharge in Lightning Creek from July 2004 to February 2005. The preliminary rating curve is shown in Figure 9. Although some spikes can be seen on the curve, these are likely the result of temporary flooding due to overflow ice conditions. Lightning Creek likely presented a gradual decline in discharge throughout the period with diurnal fluctuations and some minor peaks resulting from local rainfall events. The discharge of 0.063 m^3/sec measured on February 27, 2005 likely represents the low flow condition.

Figure 8: KV-41 Lightning Creek at Keno City
Discharge Curve 2004-2005

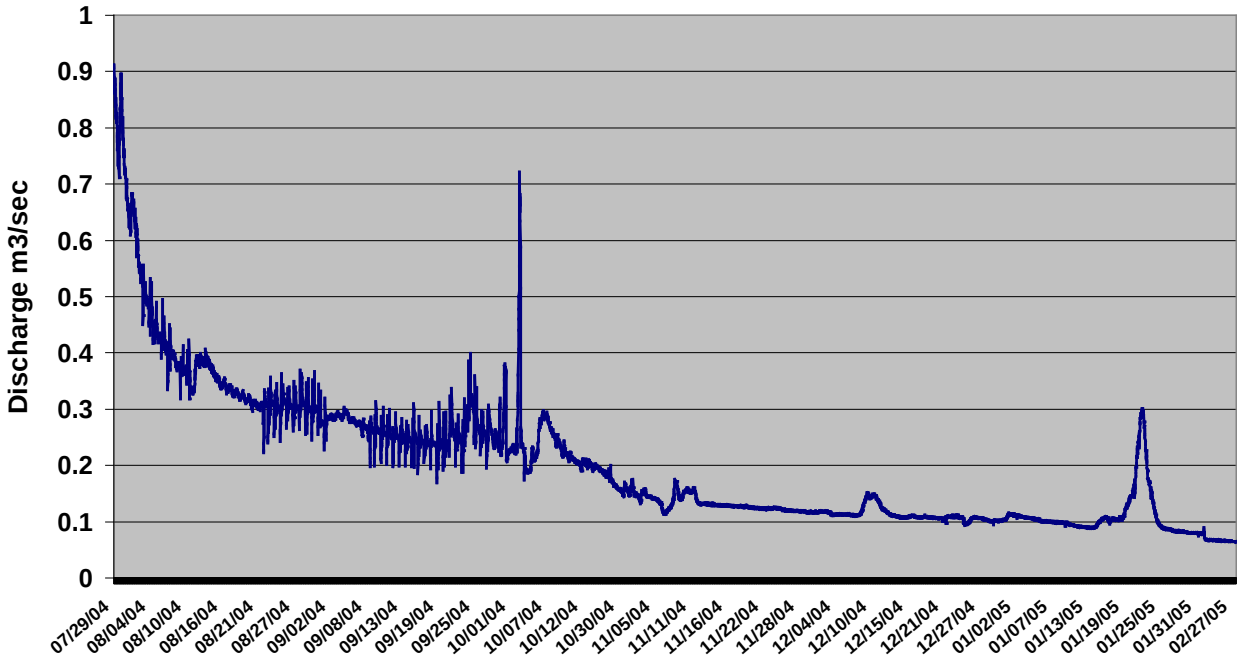
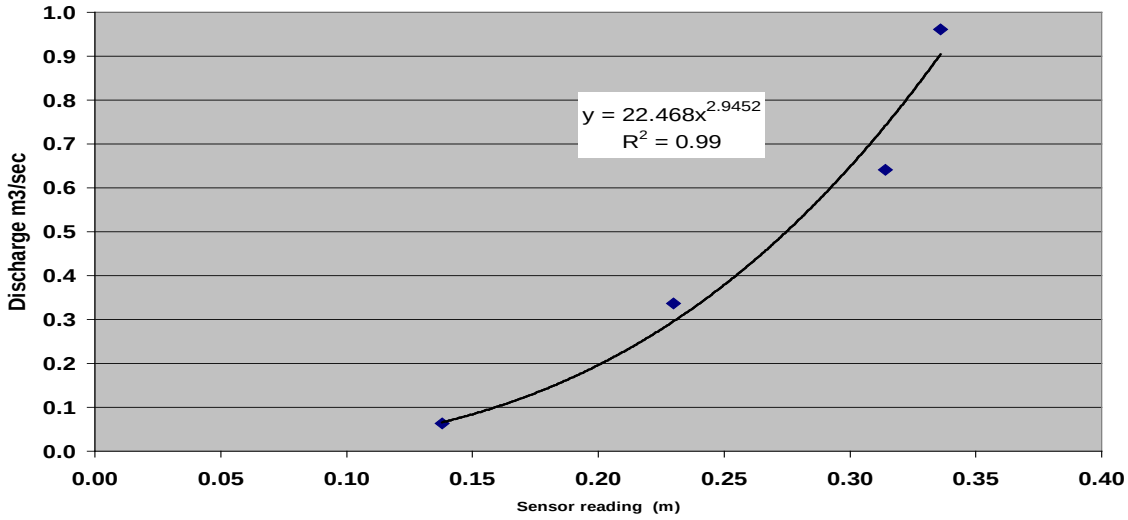


Figure 9: KV-41 Preliminary Rating Curve 2005



4.3 Stream Sediment Analysis

4.3.1 Data from the 2004 Survey

The results for the stream sediment analysis are presented in Appendix C. Six of the 31 metals analyzed were examined in detail, because of their potential toxicity to aquatic systems. 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 5). Generally concentrations greater than the PEL have a 50% incidence of creating adverse biological effects. Note that guidelines have yet to be developed for selenium.

TABLE 5

SUMMARY OF STREAM SEDIMENT METAL CONCENTRATIONS, 2004

STATION NUMBER	MEAN CONCENTRATION (ug/g)					
	ARSENIC	CADMIUM	COPPER	LEAD	SELENIUM	ZINC
KV-1	***21.2***	*2.5*	17.5	11.7	0.72	*303*
KV-2	***78.8***	***10.6***	22.2	***377***	0.81	***659***
KV-3	***93.3***	***14.8***	28.5	***677***	0.85	***885***
KC-4	***40.5***	***5.6***	27.2	***310***	0.50	***342***
KV-5	***39.8***	***3.6***	14.0	***150***	<0.10	***323***
KV-6	***1,643***	***145***	*83.3*	***4,067***	<0.10	***12,140***
KV-7	***83.1***	***21.2***	23.3	***413***	<0.10	***3,130***
KV-8	***116.0***	***23.4***	22.9	***755***	0.22	***1,773***
KV-9	***55.2***	***15.1***	35.6	***1,883***	<0.10	***605***
KV-37	***55.9***	0.5	19.7	27.2	0.29	62
KV-38	***72.2***	***10.8***	28.6	***223***	<0.10	***535***
KV-41	***35.4***	***4.0***	21.7	*76.7*	<0.10	*226*
ISQG	5.9	0.6	35.7	35.0		123
PEL	17.0	3.5	197.0	91.3		315

Note: ISQG = Interim freshwater Sediment Quality Guidelines (exceedences italicized)
PEL = Probable Effects Level (exceedences italicized and in bold)

The mean concentrations of arsenic were high and exceeded the PEL at all sites. The ISQG guideline for cadmium was met at KV-37 and exceeded at KV-41. The PEL for lead was exceeded at the rest of the sites. The ISQG for zinc was met at KV-37 and exceeded at KV-1 and KV-41. The concentrations of zinc in the sediments at the other 10 sites exceeded the PEL, significantly at the sites on Christal Creek.

Low concentrations of selenium were detected in the sediments at half of the sites. Environment Protection (Whitehorse) maintains a database on metal concentrations in stream sediments throughout the Yukon. Of 605 detectable levels, the mean for selenium was 2.5 ug/g, ranging from 0.1 to 38.8 ug/g. The concentrations documented in the Keno Valley study area were well below the Yukon mean.

To further interpret the sediment data, each parameter has been graphed (Figure 10). Concentrations of all the metals were considerably greater in the sediments at KV-6, Christal Creek upstream of the Keno Highway, than at the other sites. Christal Creek at KV-6 lies downstream of the old tailings from the old Mackeno mill, and drains Christal Lake, a long term receptor for wastewater from Galkeno 900.

High concentrations of lead were also evident at KV-9, Flat Creek at the mouth, which has been the receiving water for effluent from the tailings facility for the past few decades. The South McQuesten River appears to be impacted by these sources of lead. Although concentrations in the stream sediments decrease downstream on the South McQuesten River, levels at KV-5 (9 km d/s of Flat Creek) are greater than the PEL and are much higher than background levels at KV-1.

Selenium appears to be a naturally occurring element in the stream sediments of the South McQuesten River, as it was notable by its absence in Flat Creek and most of the sites on Christal and Lightning Creeks.

An extremely high concentration of zinc was documented at KV-6, reflecting the influence of the old tailings deposited in this area. Concentrations decreased down Christal Creek. There appears to be a slight spatial impact to the receiving environmental of the South McQuesten River, however zinc is naturally present in this watershed and concentrations downstream at KV-5 are very similar to the background level at KV-1.

Cadmium is geochemically similar to zinc and the concentrations of cadmium in the stream sediments followed the same trend as concentrations of zinc.

With the exception of KV-6, the copper concentrations were fairly similar throughout the study area.

4.3.2 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, and in 1997 (Laberge Environmental Services, 1997). These data have been compared to the present study in Table 6 and have been graphed in Figure 11.

Overall, this data set appears to present a distinct trend towards lower metal concentrations in the stream sediments. Concentrations in 2004 were significantly lower than in previous studies. For several parameters the lowest concentrations documented to date were noted at most of the sites. This trend can only be verified by repeated sampling.

Concentrations of all the metals were fairly low at the upstream site, KV-1. Concentrations of the metals appear stabilized at KV-3 and except for in 1985, there appears to be little influence on the South McQuesten sediments downstream of Flat Creek.

Concentrations were generally the highest in the sediments at KV-9 (Flat Creek) but decreased dramatically in 2004. Levels of zinc, arsenic and cadmium were actually lower in the sediments in Flat Creek than in Christal Creek in 2004.

The Galkeno 300 Fugitive flow has impacted the water quality of Christal Creek since late 2003 (ACG) but does not appear to have compromised the quality of the substrate habitat at the downstream sites (KV-7 and KV-9) at this time. The sediment chemistry of Christal Creek has significantly improved at all of the sites since last analyzed in 1997.

5.0 CONCLUSIONS

It appears that Christal Creek is still recovering from the impacts of the treated Galkeno 300 fugitive flow. This has resulted in some spatial impact to the South McQuesten River where the CCME guideline for waterborne zinc was exceeded at the downstream sites in both the total and dissolved phases. However, the upstream site KV-1 also exceeded the guideline in July 2004 (total sample only).

Concentrations of total and dissolved metals were generally lower in February 2005 than in July 2004. There appears to be a general decline in the concentrations over time in the receiving sites as treatment continues at Galkeno 300 (ACG). The current study only includes two sampling events, mid summer 2004 and low flow 2005. In the interim, many samples have been collected as part of the Care and Maintenance, and Galkeno 300 Fugitive Flow Investigation programs. When viewed in its entirety, the data set appears to present a trend towards declining metals concentrations in the receiving waters. It should be noted that there have been periodic spikes in metals concentrations over this time period, particularly at the sites close to Galkeno 300. Overall, concentrations were considerably lower back in August 2003 prior to the fugitive flow of Galkeno 300 creating any impacts.

The sensors and data loggers installed in July 2004 are successfully collecting data, allowing discharge curves to be developed for KV-7, Christal Creek upstream Hanson Road, KV-9, Flat Creek upstream South McQuesten River and KV-41, Lightning Creek upstream Keno bridge. Preliminary rating curves will become refined with more measurements. Hopefully the hydrometric data will contribute to a more reliable mass balance and water quality model over time.

The sediment quality appears to have improved significantly over time at the receiving sites. This trend can only be verified through repeat sampling.

6.0 RECOMMENDATIONS

A general recommendation is to follow through with a full blown multi disciplinary aquatic effects monitoring program. Such a program would include fish and fish habitat assessment, benthic invertebrate monitoring, in addition to basic water quality, hydrometric and sediment monitoring.

Monitoring of the receiving water quality should continue on a regular basis. Overall, water quality has shown improvement since lime treatment began at Galkeno 300 in March 2004, but regular monitoring will ensure that this trend persists.

The assessment of the stream sediment characteristics indicates that the quality has improved favourably since the last sampling event conducted in 1997. Annual monitoring of the sediments should be conducted to assess the potential transport of particulate and precipitated zinc resulting from the fugitive flow from Galkeno 300.

The substrate provides habitat for benthic organisms and contaminated stream sediments can have substantial effects on biological activity. Although metal concentrations have decreased in the sediments, several parameters continue to have concentrations 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 should be undertaken annually. The last biological monitoring program was conducted by LES over ten years ago in 1994.

To fully assess the health and productivity of the receiving waters a fisheries study should be undertaken. White Mountain Environmental Consulting conducted an in-depth fish resources study in the Keno Valley in 1994. Fish habitat was assessed and the utilization of this habitat was monitored. Fish tissue samples were also collected for metal analysis. A similar study is recommended for 2005. The increased zinc loading experienced by Christal Creek and the South McQuesten River over the past year could have an impact on the fisheries. Grayling spawn in the South McQuesten River and rear in Christal Creek, as far upstream as the Hanson Lake bridge (WMEC, 1995). The South McQuesten River is also home for salmon spawners.

7.0 REFERENCES

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APPENDIX A

PHOTOGRAPHS

APPENDIX B

WATER QUALITY
ANALYTICAL RESULTS FOR WORKORDERS:
323984 – JULY 2004
366463 – FEB 2005
366415 – FEB 2005

APPENDIX C

SEDIMENT GEOCHEMISTRY
ANALYTICAL RESULTS FOR WORKORDER 361274