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An assessment of Fish Resources in the Area surrounding the Keno Hill Mine Complex

2006

Prepared for

Frank Patch
Type II Project Manager
Assessment and Abandoned Mines
Government of Yukon

Prepared by;
WHITE MOUNTAIN ENVIRONMENTAL CONSULTING
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EXECUTIVE SUMMARY

In an effort to assist in assessing potential environmental degradation of the aquatic ecosystem in the area potentially affected by the historic mining near Elsa and Keno, Yukon, evaluations of fish utilization, habitat quality and metal content in fish flesh were conducted during 2006. Previous investigations are limited to a single course of study conducted during 1995 and as such trends in the levels of metals in fish tissue and fish utilization remain unknown.

Fish habitats throughout the study area have seen changes since 1995 and fish utilization was lower in most areas than in 1995. The South McQuesten River, upstream of Haggart Creek continues to provide habitat for a variety of fish species including but not limited to; Arctic grayling, slimy sculpin, burbot, northern pike, long nose suckers, Arctic lamprey and round whitefish. Downstream of the confluence with Haggart Creek species utilization becomes more diverse with the presence of juvenile and spawning populations of Chinook salmon, utilization by all other fish species found in the South McQuesten also increases.

Utilization of Christal Creek was, as in 1995, very low for all species; some colonization of the lower reaches adjacent to the South McQuesten River by slimy sculpin occurs during the summer months, however very few fish were thought to be year round residents. The exceptions to this include a small population of Arctic grayling in the mid section of the creek and significant populations of slimy sculpin near the outlet of Christal Lake and in Christal Lake. Anecdotal references indicate that Christal Creek did have populations of adult Arctic grayling as recently as 1979. No grayling were recorded near or in Christal Lake during 1995 or 2006.

Flat Creek provides small stream fish habitats limited to the lower 800 meters of the creek. Some over-wintering of adult slimy sculpin may occur a short distance upstream from the South McQuesten River.

Habitats in Lightning Creek have been subject to placer mining influences and are generally of poor quality. Limited utilization by Arctic grayling occurs in the fast flowing reaches with populations of sub adults and adults moving into placer created turbidity. The lower reaches of Lightning Creek, near Duncan Creek support populations of Arctic grayling, slimy sculpin and adult round whitefish, these fish likely winter in the stronger flows downstream of Duncan Creek.

Utilization of the South McQuesten River by chinook salmon was again determined to end at Haggart Creek. Adult salmon were observed in August to turn back down river at the Haggart Creek confluence. No juvenile chinook salmon were recorded in the South McQuesten River upstream of the confluence with Haggart Creek. This is consistent with investigations conducted in 1991 and 1995.

Metal levels, particularly of zinc, in fish tissue are extraordinarily high in most of the mining affected waters. In contrast to other mining affected fish populations in the Yukon the sculpins from the Keno area have elevated zinc levels as much as twice as high as from tailings discharge areas near Faro, Yukon.

1.0 INTRODUCTION

The following report presents data collected during the open water season of 2006 on fish habitat, fish utilization and metal content of fish flesh from waters influenced by mining operations in the Keno Hill area near Elsa, Yukon.

Detailed information regarding fish habitat, fish utilization and metal content of fish flesh in waters influenced by mining in the Keno Valley area has not been collected since 1995. The information collected in 1994, '95 stands as the only other comprehensive study of fish resources of this area, a limited amount of pre 1994 information for the study area exists. The 1995 fisheries investigations were conducted by White Mountain Environmental Consulting (WMEC) for United Keno Hill Mines (UKHM).

The 1995 investigations consisted of spring, summer and fall evaluations of fish utilization, an assessment of fish habitats and the collection of fish flesh and livers for metal content analysis. For comparative purposes, a re-evaluation of most aspects of the 1995 investigations was completed. Certain aspects of the '95 program of study were modified for this investigation in order to provide a more complete watershed over view and to update and standardize data collection techniques. Sample sites and methods used in 2006 to assess fish habitat and fish utilization were as similar as possible to those used during the previous investigation. The 2006 assessments were conducted during three separate field investigations during spring, summer, and fall.

Concerns with mine effluent in the Elsa-Keno Hill area effecting fish date back to 1961 when UKHM's tailing pond at the head of Flat Creek washed out during spring freshet. The ensuing contaminated slug of water entered the South McQuesten River via Flat Creek and caused a large die-off of resident fish species (DFO unpublished correspondence 1961-64).

An assessment of the water quality and biological conditions in watersheds surrounding the UKHM property was conducted during the summers of 1974 and 1975 by the Environmental Protection Service (EPS), Yukon branch. As a part of that study test fishing was done in Flat Creek, Christal Creek and the South McQuesten River with an electro-fisher and barrier nets. Samples of fish tissue and liver were obtained and tested for concentrations of copper, zinc, and lead. The results of these tests are unknown.

During August 1980 the Environmental Protection Service conducted a monitoring study of the effluent discharge from UKHM to determine the state of compliance with the Federal Metal Liquid Effluent Guidelines. In Situ bioassays were conducted to demonstrate the effect of treated mine effluent on Arctic grayling, after exposing the fish to the effluent and receiving streams for 96 hours and finding no fatalities the report concluded the streams and effluent exhibited no acute toxicity at the time of the study.

2.0 STUDY AREA

The principal areas of study for this investigation were drainages influenced by historic and current mining activities. These included Christal Lake, Christal Creek, Flat Creek, the South McQuesten River and Lightning Creek (figure 1). A significant amount of information relating to water quality has been collected from many of the sites and an excellent description of the ecological context of the study area and water quality results can be found in Burns 2006.

Sampling locations for this investigation were similar to those used in 1995. Previously assigned site names were used for sample locations at sites that corresponded to long term monitoring sites. Descriptive site names were applied to all other sample locations (Table 1). The sites sampled are as follows:

- Christal Lake at both, the south end of the lake and at the outlet of the lake to Christal Creek (north end).

- Christal Creek at specific sites from the outlet of the lake to the confluence with the South McQuesten River. Sites sampled were at the Keno road crossing (KV 18 or KV 6), at a pool area approximately 2 km downstream of the lake near an abandoned bridge (C4), at the McQuesten Road crossing (KV 7) and at the outlet to South McQuesten River (KV 8).

- Flat Creek at the confluence with the South McQuesten River in a reach that extends upstream for several hundred meters (KV 9).

- The South McQuesten River at specific sites between McQuesten Lake and Haggart Creek. The principle areas being; at the lake outlet, upstream of Christal Creek (KV 1) and downstream of the outlets of Christal Creek (SMQ C) and Flat Creek (KV 4), below Elsa at the tailings dump and water intake site (KV 2) and just below the confluence of Haggart Creek.

- Lightning Creek at two locations between the Keno town site and the confluence with Duncan Creek.

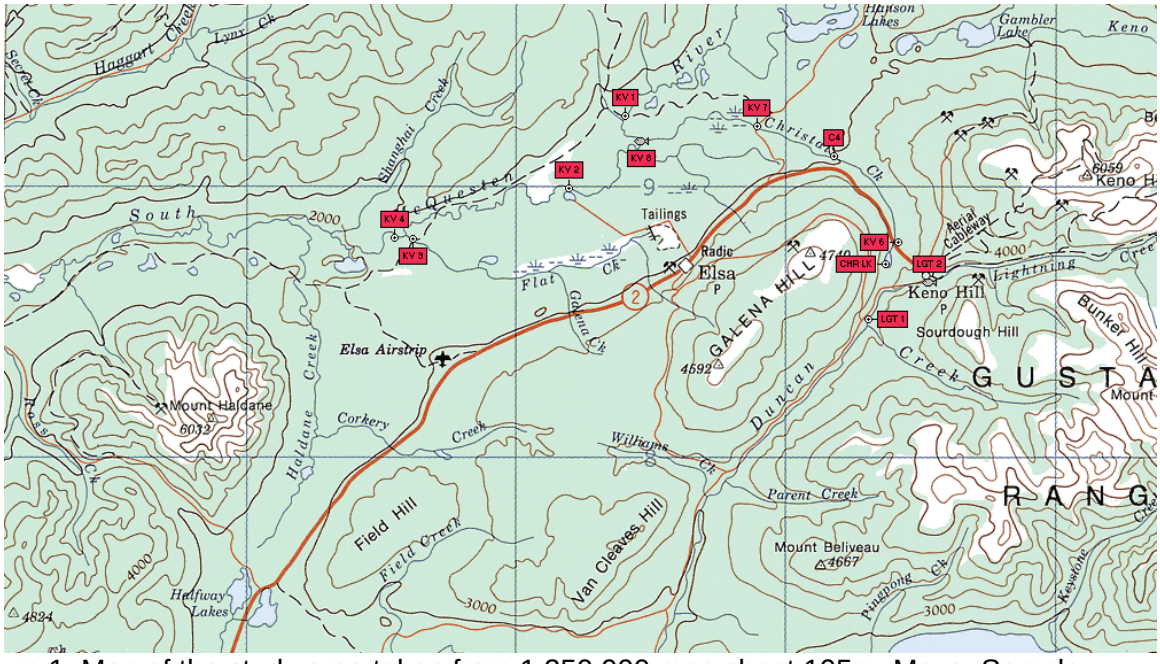

Figure 1: Map of the study area taken from 1:250,000 map sheet 105m, Mayo. Sample sites not shown on this map are South McQuesten River at McQuesten Lake and South McQuesten river downstream of Haggart Creek.

Table 1: Sample numbering and locations for 2006 investigations with previous site names, sampling dates and site location.

SITE	DATES SAMPLED	SITE NUMBER	PREVIOUS LABEL	Latitude Longitude
Flat Creek outlet	June 3, Aug 1, Sept. 21	KV 9	F1	63° 56.174 N 135° 34.397 E
Christal Lake	June, Aug, Sept	CL	CL	63° 54.944 N 135° 19.926 E
Christal Creek, @ Keno Rd	June 6, Aug 4, Sept 22	KV 6	KV 18 C 5	63° 55.1739 N 135° 19.4620 E
Christal Creek @ Polly Claims	June 5, Aug 5, Sept 20	C 4	C 4	63° 56.8791 N 135° 22.3977 E
Christal Creek @ Hanson Rd	June 4, Aug 4, Sept 19	KV 7	C 3	63° 57.439 N 135° 25.944 E
Christal Creek @ outlet	June 5, Aug 3, Sept 19	KV 8	C 1	63° 57.170 N 135° 31.038 E
S. McQuesten @lake outlet	Aug 4, Sept 18	SMQ 1		64° 03.875 N 135° 21.886 E
S McQuesten u/s Christal	June 5, Aug 3, Sept 19	KV 1		63° 57.601 N 135° 31.879 E
S. McQuesten d/s Christal	Sept. 19	SMQ C		63° 57.032 N 135° 34.397 E
S. McQuesten @ Elsa water	Sept. 2	KV 2		63° 56.174 N 135° 34.397 E
S. McQuesten d/s Flat	June 3, Aug 1, Sept 21	KV 4		63° 55.202 N 135° 41.964 E
S. McQuesten d/s Haggart	June 3, Aug 1, Sept 21	SMQ H		63° 53.732 N 136° 01.417 E
Lightning Ck @ Keno camp ground	June 7, Aug 4, Sept 19	LgT K		63° 54.423 N 135° 18.205 E
Lightning Ck u/s Duncan	June 7, Aug 4, Sept 19	LgT D		63° 53.594 N 135° 20.739 E

3.0 METHODS

Prior to initiating field activities a license to collect fisheries information was obtained through the Federal Department of Fisheries and Oceans, Whitehorse. The investigations were conducted under the authority of License to Collect Fish No. 06-14.

Fish habitat and utilization was assessed during onsite visits during all three seasons; however the primary habitat assessments were conducted during summer months when water levels were low. A hand held GPS was used to document observation locations and elevations. A laser range finder was used to measure distances within each reach. Habitat evaluations throughout the study area included assessments of creek width (wet and dry), water depth, velocity (floating object technique), bank stability, bottom substrates, available cover and riparian vegetation. Photographs (digital) representative of each reach and unique features of the channel were taken to provide a record for long term monitoring of habitat stability. A general description of physical habitats at each site has been provided in Appendix 1.

Fish utilization and distribution was assessed with a variety of techniques to ensure capture of all species present. Crew members wore polarized sunglasses at all times to assist in fish viewing and all visual observations were recorded.

Minnow trapping was conducted with “Gee type” minnow traps (¼” mesh). Traps were baited with salmon roe (Yukon River origin) suspended in the trap in a perforated plastic bag. Traps were set in all habitat types for an overnight period with the total time of set ranging from 16 to 40 hours. A simple site description was recorded for each trap set and velocities at each location were visually estimated. This style of minnow trapping has previously been shown to be highly effective for the capture of juvenile chinook salmon (jcs).

Electro-fishing was conducted with a Smith-Route POW, type 12A back pack, battery powered electro-fisher. The operator was accompanied by two crew members with dip nets. Fish utilization within the tributary creeks (Christal, Flat and Lightning) were assessed by electro-fishing with a block net during the summer evaluations. Block nets (1/8” rochel weave) were installed in the creek 100 meters apart at sites evaluated in 1994. Electro-fishing was conducted without block nets at all other sites and during the spring and fall investigations. Effort, measured in seconds of shocking time, varied between the reaches due to complexity of habitats and the number of fish encountered. Electro-fishing results have been presented as number of fish per 100 seconds of shock time.

Seining was conducted with a 5 meter long pole seine with 1/8" mesh rochel netting. Seining was restricted to depths of less than 1.5 meters and to locations with suitable bottom and bank structure. Seining was used as a tool to denote fish presence and for the collection of metal sample specimens. Due to the variability of seining, catch per unit of effort has not assessed and only general comparisons of catches have been made.

Angling was conducted with light spin casting gear with a variety of small lures and flies. Effort was recorded as minutes fished.

Small mesh monofilament gill nets (1″ and 2″) were set in Christal Lake during the August investigation. Gillnets were not used at any other location.

Temperatures were recorded at all sample stations during each sample period using a digital electronic thermometer (± 0.1°C). Temperatures were recorded into a field note book with all other pertinent information and observations from each sample site.

All fish captured were identified as to species and recorded; a sub-sample of the fish captured was measured (live) for fork length (+/- 1 mm). All fish captured were handled delicately to allow for live release except for those sacrificed for metal content analysis.

All information collected was recorded on data sheets specific to the individual techniques employed or into a field book. The information was downloaded to a computer format at the completion of each field investigation.

3 1 Metal Sample Collection

A maximum of 5 specimens each of Arctic grayling and slimy sculpin from representative areas were sacrificed for tissue samples for heavy metal analysis during fall investigations.

A maximum of 5 Arctic grayling and 5 slimy sculpins samples were collected from each site for analysis of metals in tissue. Sample collections for metals analysis were conducted primarily during the fall field session.

Arctic Grayling with a fork length >200 mm were selected for tissue sampling and sculpins 80 mm or longer were selected when possible. At sites where less than 5 sculpins over 80 mm in length were caught, a composite sample of 2 or more individual sculpins was utilized.

Specimens collected for metal sample analysis were placed into labeled zip loc baggies immediately after capture. The collected specimens were sampled later in a controlled environment. For sacrificed Arctic grayling, internal and external observations of fish health, sex and maturity, diet, fork length and round weight was recorded. From each grayling a sample of approximately 50 grams for metal content analysis was taken from the caudal area and placed in separate labeled bags. Stomach contents were analyzed at the time of sampling.

For slimy sculpins sacrificed, the total length and round weight for each specimen was recorded, including the individuals from composite samples. Each sculpin sample was bagged and labeled separately; each composite sample was bagged and labeled as a single sample.

The prepared samples were shipped to ALS Environmental Laboratories for analysis of metal content in the fish flesh. Metal content was measured using atomic absorption/fluorescence spectrometry, inductively coupled plasma-mass spectrometry and /or inductively coupled plasma-optical emission spectrophotometry.

4.0 RESULTS

Fish habitats remain stable and similar to conditions observed in 1994, ’95 at most sample locations, the exceptions being Christal and Lightning Creeks. Christal Creek has undergone two significant physical changes since the 1995 investigation. At site C4 an old bridge that was an obstruction to fish passage had a new channel cut around the obstruction sometime during the past 12 years. Additionally during the 1995 investigation a mat of consolidated bitumen like materials was in evidence through the entire length of Christal Creek. The only remnants of the mat observed during 2006 were upstream of site KV 6 at the Keno Road crossing; no traces of the material were visible at the sites further downstream. Both of these changes in the creek indicate that a significant flood event occurred in the intervening 12 years between sampling.

Lightning Creek has undergone significant channel changes in the past 12 years as a result of placer mining. The location of the sample site used in 1995 was no longer available for sampling as the creek channel had recently been altered by miners and active mining was occurring adjacent to the old site. Two new sample locations were selected further downstream to provide variation in habitat types.

Most of the samples for metals analysis were collected during the fall sample period, a few had been archived from the summer sampling period. At this time very few Arctic grayling remained in the South McQuesten, Flat or Christal Creeks. Arctic grayling had remained in the placer mine influenced waters of Lightning Creek during September. It

was presumed that most of the Arctic grayling at the other locations had moved into winter habitats either in small lakes or deep pools within the river. The result was that only two sets of five Arctic grayling samples for metal analysis were collected. These were from Christal Creek in a small area known to over-winter grayling and Lightning Creek. A complete set of sculpin samples were obtained from most locations.

4.1 CHRISTAL LAKE

Christal Lake, a small sub-alpine lake remains physically very similar to the condition observed in 1995 with extensive thick vegetation over an organic silt bottom. The lake has consistent shallow depths with the deepest water being less than 3 meters. Small amounts of active shoreline erosion occur on the east shore below Galena Hill. The erosion may be the result of permafrost melting or unstable lake levels, erosion along this shoreline was observed in 1995.

Beaver dams at the outlet of the lake control water levels in the lake. During the summer of 2006 the beaver dam crossed the entire north end of the lake and was active and maintained creating a 1.3 meter head.

An old tailings pile exists immediately downstream of the beaver dam on the north east corner of the lake (photo 1). The tailings originated from a mill that operated on the east side of Christal Lake from 1956 to 1958. Tailings are also visible at the north end of the lake, in the lake; these were dumped on the ice during spring when the mill was in operation (photo 2). The tailings within the lake are at present stable. The tailings below the beaver dam are at risk of being washed into Christal Creek if the beaver breaches on the east side.

Both gillnetting and minnow trapping were conducted in Christal Lake during 2006, and as in 1995 the only species of fish found in Christal Lake were slimy sculpin. The minnow traps set in Christal Lake produced the highest catch per unit of effort of any of the sample sites with an average of 4.85 sculpins per trap per 24 hour period (table 2). An extraordinarily large beaver was observed in Christal Lake feeding on aquatic vegetation.

Photo 1: The beaver dam at the outflow of Christal Lake during September, 2006. The non-vegetated area in the background is tailings from the late 1950's that will be eroded in the event the beaver dam fails.

Photo 2: Tailings, visible as red, deposited into Christal Lake during the late 1950's are still visible at the north end of the lake. June 2006.

4.2 CHRISTAL CREEK, SITE KV 6

Site KV 6 is located at the Keno Road crossing of Christal Creek. Habitats in this study reach have been modified by the road crossing, a pool created on the upstream side of the road bed (photo 3) and alterations to winter flow through the culvert have created unnatural habitats to the native creek habitats downstream of the road. Remnants of the black mat that had been common throughout Christal Creek in 1995 were observed only

as small patches upstream of the culvert and pools. This material has been washed form all other areas of the creek investigated during 2006 and was not observed at any other site.

Slimy sculpin were the only fish species recorded at this site in both 2006 and 1995, and were relatively abundant during all sampling periods. During 2006, large adults were common throughout the creek both upstream and downstream of the road bed and sculpin fry were very common in the pool upstream of the road (tables 2 and 3). Minnow trap results from this site had the second highest catches next to Christal Lake in the study area with summer catches of an average of 2.19 sculpin per trap per 24 hour period.

Anecdotal reports from long time residents indicate that adult Arctic grayling were present in significant numbers and were easily angled on either side of the road as recently as 1978. Arctic grayling were not recorded in 1995 and were not positively recorded during the 2006 investigations although a small fish thought to be a juvenile grayling was observed in the pool upstream of the road, the fish was not caught nor positively identified.

Photo 3: The shallow pool upstream of the Keno Road crossing at site KV 6 during August, 2006.

4.3 CHRISTAL CREEK: SITE C4

Fish habitat at site C 4, located at the site of the old “Polly Claims”, 4.7 km downstream of Christal Lake, has a history of modification by both placer and hard rock mining. Two significant habitat changes have occurred at this site in the past 12 years; a mat of consolidated fine black material observed in 1995 has disappeared from this site and a new channel around a barrier to fish passage has been created.

Bridges across the creek, built in the 1960's and now collapsed have created a series of barriers to fish movement. The lower barrier observed in 1995, no fish were recorded upstream of this barrier in 1995 (Sparling and Connor 1995) and the pools below have changed at some time between 1995 and 2006. The creek has cut a new channel around the old barrier and the pools down stream of the old barrier have filled in (photo 4). The pools were suspected as having provided over winter habitat for a small group of Artic grayling in 1995.

A series of three other barriers, all upstream of the washed out barrier remain in place. The first, approximately 230 meters upstream from the original barrier, a small stick jam created over old bridge timbers has created a partial barrier that acts as a barrier during low water, Arctic grayling were recorded above this barrier in 2006. No fish were captured upstream of the second and third extant barriers, separated by 30 meters, and located a further 370 meters upstream of the washed out barrier. Both of these barriers likely limit fish migration during all seasons (photo 5). Arctic grayling were the only fish found in this reach during the 2006 investigations (Tables 2 and 3) and although moderately common they were not as common as and more widely dispersed than in 1995.

Photo 4: Christal Creek site C4 during June of 2006 at the site of the 1995 barrier. During the 1995 investigations the creek flowed on the right side of the photo over a 1.5 meter barrier. The flowing channel on the left has been cut some time since 1995.

Photo 5: Intact barriers on Christal Creek during August of 2006, at the upstream end of site C 4. A second barrier is visible in the background and both are higher than 1 meter. No Arctic grayling were recorded upstream of this barrier in 2006.

4.4 CHRISTAL CREEK: SITE KV 7

Site KV 7 at the Hanson Lake Road crossing has also had all remnants of the fine black mats that were apparent in 1995 removed. This site has very limited fish cover and mostly fine substrates (photo 6). Conductivity at this site was high (>700 ms/sec) during all three sampling periods in 2006 and no fish were recorded. The high conductivity did limit the effectiveness of electro-fishing. The only fish recorded at this site during 1995 was a single Arctic grayling juvenile.

Photo 6: Christal Creek at site KV 7 during August of 2006.

4.5 CHRISTAL CREEK: SITE KV 8

Christal Creek at site KV 8 was investigated from the confluence with the South McQuesten River upstream for a distance of 265 meters. Within this reach the creek flows in a narrow, deep and confined channel before opening into a series of pools for extending 50 meters before entering the South McQuesten River (photo 7). The site has good, but small fish habitats that were very lightly utilized. During August and September, 2006 small slimy and occasional juvenile Arctic grayling, sub-adult burbot were recorded (tables 2 and 3). A group of six adult Arctic grayling were observed but not captured, in the lower pool during the August investigation. No fish were recorded at this site during spring evaluations, however water levels were high fishing was difficult.

During 1995 juvenile Arctic grayling, burbot, slimy sculpins and a single adult grayling were recorded at this site during summer and fall investigations and no fish were recorded in this reach during spring investigations Sparling and Connor 1995). Juvenile Arctic grayling were much more common in 1995 than in 2006.

Photo 7: Site KV 8, Christal Creek flows as a narrow and confined channel before entering a series of pools 50 meters upstream of the South McQuesten River, August 2006.

4.6 FLAT CREEK SITE KV 9

The only reaches of Flat Creek investigated during 2006 were the outlet near the South McQuesten River (photos 8 and 9) and at the old Shangai Road crossing 400 meters upstream of the river. Investigations in 1995 clearly showed that little fish habitat exists upstream of these locations (Sparling and Connor 1995). Habitats within Flat Creek remain similar to those encountered during 1995. This reach has cobble gravel substrates in pool riffle sequences punctuated with partial log and stick jams that have built up in many of the riffle areas. Two small pools near the mouth have depths > 1

meter. During August the conductivity of Flat Creek was 630 ms/sec while the South McQuesten was 360 ms/sec.

Fish utilization of Flat Creek has historically been low, the EPS 1974 investigations report low fish numbers as did the 1995 investigation (Sparling and Connor 1995). During 2006 no fish were captured with minnow traps during spring investigations and only a few slimy sculpin were captured during August (table 2). Electro-fishing showed the lower reach of the creek colonized over the summer months with slimy sculpin and occasional burbot sub adults, grayling juveniles and northern pike juveniles (table 3). By the September sampling period very few sculpin remained in the lowest reach and no other species were present. Adult sculpin were recorded near the Shangai Road during all sample periods indicating that some over-winter habitat for adult sculpin does exist further away from the river.

Catches recorded during 2006 in Flat Creek were similar to those of 1995 except the numbers of juvenile Arctic grayling recorded were significantly lower during 2006.

Photo 8: Lower Flat Creek, showing water staff gauge, 90 meters upstream of the South McQuesten River. This reach was the lower 60 meters of the block net fish survey 100 meter reach.


Photo 9: Flat Creek as it enters the South McQuesten River, August 2006.

4.7 LIGHTNING CREEK, SITES LgT K and LgT D

Habitat conditions in Lightning Creek are subject to active placer mining. The sample site used during the 1995 investigations was in an active mining zone during 2006 and new sites away from the active mining were selected for the 2006 investigations. The two sites selected offer different habitat types. Site LgT K flows adjacent to the town of Keno camp grounds and spans the reach crossed by an active road (culvert) and the abandoned bridge 300 meters downstream (photo 10). Site LgT D is located immediately upstream of the confluence with Duncan Creek (photo 11) and is forded by the Duncan Creek Road. Both sites have been placer mined in the past and have man made channels.

Habitats have stabilized at both sites. Site LgT K consists of fast flowing rapids over highly compacted boulders with plunge pools associated with both the culvert and the old bridge. A collection pool upstream of the culvert creates the widest section of the reach. The lower reach, site LgT D has a much slower flow with gravel substrates.

Both sites differed in fish species composition. Site LgT K had only Arctic grayling, both adults and juveniles during June, August and September. Site LgT D had a greater diversity of speciation with slimy sculpins, round whitefish and Arctic grayling common during both August and September. Fishing at site LgT D was not conducted during the spring investigation due to high water.

Photo 10: Lightning Creek site LgT K. Electro-fishing below the abandoned bridge at the downstream end of the Keno campgrounds, June 2006.

Photo 11: Lightning Creek looking upstream from the Duncan Creek Road ford during September, 2006.

4.8 SOUTH McQUESTEN RIVER

Five sites on the South McQuesten River were sampled. Habitat assessments were less detailed than in the tributaries however habitats do vary slightly at each of the locations. The sites were primarily sampled for fish utilization and for the collection of fish for metal analysis samples. The sites sampled were spread from McQuesten Lake to downstream of Haggart Creek in order to provide an understanding of background levels of metals and covered strategic locations such as downstream of the outlets of Flat and Christal Creeks.

The South McQuesten River, within the study reach flows as a meandering mountain river with several different flow regimes. The most predominant regimes being gravel/cobble bottomed riffles interspersed with glide areas and occasional deep, often silted pools. Old meander scrolls have created sloughs along much of the river and provide slack water habitats.

The upper most site sampled, at the outlet from McQuesten Lake, has a small tributary, Cache Creek, entering from the east. This creek has developed a chalky turbidity in the last 2 years and creates a visible plume as it enters the otherwise clear waters of the South McQuesten River (photo 12).

Arctic grayling captured during the June sampling period were assessed for state of maturity and the timing of the spawn. Samples collected from the South McQuesten River near the Haggart Creek confluence on June 3, 2006 had recently completed spawning and the date of spawning was calculated to be on or near May 27, at least 10 days later than calculated in 1995.

Chinook salmon were observed near the confluence with Haggart Creek on July 31, 2006. The salmon were observed to swim up to the mix water zone and turn back swimming 300 meters into well mixed water before turning back upstream. The salmon were observed to follow this pattern at least four times before turning downstream and not returning. A short visual assessment of Haggart Creek upstream of the confluence was conducted the following day and no salmon were observed. It was assumed that the salmon had moved downstream in the South McQuesten River.

More detailed and informed assessment of jcs habitat potential upstream of Haggart Creek in the South McQuesten river suggests that habitats for rearing jcs are limited and not as common as previously thought.

Fish utilization of the South McQuesten was in general, found to be much greater downstream of the confluence of Haggart Creek both in terms of the number of fish captured and in species diversity than upstream of the confluence. No chinook salmon juveniles were recorded upstream of the confluence with Haggart Creek, however they were recorded downstream of the confluence (photo 13).

Photo 12: Cache Creek entering the South McQuesten River just downstream from the outlet of McQuesten Lake. The turbid plume from Cache Creek was clearly visible during August, 2006.

Photo 13: the confluence of the South McQuesten River (right) and Haggart Creek as seen from the Haggart Creek bridge in June, 2006.

5.0 Metal Content in Fish Flesh

For the purpose of simplifying the data for this report seven key metals of a total of 24 sampled for have six have been selected to create comparative tables. The metals discussed in this paper include Arsenic, Cadmium, Copper, Lead, Manganese, Nickel and Zinc. A complete listing of all metals sampled for has been presented in appendix 2.

During the 1995 sampling period fish flesh samples were taken from Christal Creek at the Keno Road crossing, site KV 6, and from the outlet area of Flat Creek, site KV 9. As

in 1995 the highest concentrations of metals found were at site KV 18. This site also had the greatest variation in metal concentrations and the highest levels of zinc recorded during 2006. The highest zinc levels of 2006 were half of those from the highest level recorded in 1995 (Table 1). In general metal levels from sculpins taken in Christal Creek near the lake outlet have slightly lower levels of metals than those from 1995.

Significant differences in all metal concentrations from 2006 were found in lake resident sculpin as opposed to those taken from below the outlet from the Galkeeno adits, with the lake residents showing much lower levels than the creek residents. This is particularly true for cadmium (Tables 1 and 4).

Sculpin samples from site KV 18 at the Keno Road crossing were taken during both August and September. The samples from August had consistently higher metal levels than those taken during September particularly arsenic and lead (Table 4). The timing of metals uptake and subsequent excretion is poorly understood, however it has been assumed in the past that metals continually bioaccumulate in fish and that ingested metals remain in the fish; however it has also been noted, particularly with Arctic grayling, that metal content of the flesh will quickly equalize with the ambient metal content of surrounding waters as fish are semi-permeable membranes.

New sample collection from South McQuesten River at 5 locations starting from just below.

No fish samples for metal content were taken from the McQuesten River during the 1995 sampling; however slimy sculpin samples from six different locations on the South McQuesten River from McQuesten Lake to below the confluence with Haggart Creek were taken in 2006. The analysis of these samples clearly indicates that background levels of most metals in fish are elevated even above Christal Creek (Tables 2 and 3). Samples taken from immediately downstream of Christal Creek had the highest levels of most metals found in fish flesh within the study area. Metal content in fish flesh was high upstream of Christal Creek. Metal analysis clearly shows that concentrations of metals in fish are lower downstream of the confluence with Haggart Creek.

Slimy sculpin from Lightning Creek (Table 5) had elevated levels of zinc and moderately elevated levels of most other metals, however zinc levels were lower than those from other areas sampled other than below Haggart Creek on the South McQuesten River.

Metal analysis of Arctic grayling show higher levels of most metals form grayling taken from Lightning Creek than those in Christal Creek (Table 6). The levels of zinc from both locations are higher than background levels from other areas of the Yukon. Arctic grayling samples for metal analysis of Arctic grayling from 1995 were liver samples and therefore do not compare well with the 2006 flesh samples.

6.0 RECOMMENDATIONS

Metal concentrations in fish flesh from the study were considerably higher than found in other areas of the Yukon affected by hard rock mining (table 10). strongly recommend that in order to create a meaningful data set that trends can be determined from that annual sampling occur for metal analysis. We know enough about the distribution of fish

in the study are. It would be wise to monitor habitat impacts and changes on Christal Creek, the barriers, the tailings and the continuing inputs from the Galkeeno inputs.

With regards to the barriers to fish passage on Christal Creek, great care should be exercised prior to any program to remove the barriers. The two large barriers have both developed a significant collection of stream sediments behind them; in essence they have become sediment traps. Removal of the barriers would allow the materials trapped behind the barriers to re-enter the aquatic system and potentially enter the South McQuesten River. It would be prudent to assess the nature of the trapped sediments prior to any remedial measures designed to remove the barriers.

A far more pressing issue with Christal Creek relates to the presence of the tailings immediately downstream of the current and active beaver dam at the outlet of the lake. It is not unlikely that a breach in the beaver dam will occur on the east side of the lake creating a surge flow that could easily impact the tailings, creating a new flush of tailings into Christal Creek.

Table 2: A summary of Minnow trapping results from all sample stations. Catches are presented as the average number of fish caught per trap per 24 hour period.

Sample site	**Date**	**s. sculpin**	**A.grayling**	**burbot**	**RWF**	**NP**	**jcs**	**JCS +1**	
CL	Sept	4.85	0.00	0.00			0.00	0.00	
KV 6	June	1.42	0.00	0.00			0.00	0.00	
	August	2.19	0.00	0.00	0.00	0.00	0.00	0.00	
C4	August	0	0	0	0	0	0	0	
KV 7	June	0	0	0			0	0	
	August	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
KV 8	June	0	0	0			0	0	
	August	0.00	0.04	0.04	0.00	0.08	0.00	0.00	
Flat KV 9	June	0	0	0			0	0	
	August	0.15	0.00	0.00	0.00	0.00	0.00	0.00	
LgT K	June	0	0	0	0	0	0	0	
	August	0	0	0	0	0	0	0	
LgT D	June	0	0	0	0	0	0	0	
	August	0.47	0.00	0.00	0.00	0.00	0.00	0.00	
SMQ									
KV 1	June	0.25	0	0			0	0	
	August	0.10	0.00	0.00	0.00	0.00	0.00	0.00	
SMQ C	June								high water
	August	0	0	0	0	0	0	0	
KV4	August	0	0	0	0	0	0	0	
D/S Haggart	August	0.31	0.11	0.00	0.00	0.00	0.11	0.00	
Haggart	August	0.00	0.00	0.00	0.16	0.00	0.16	0.00	

Table 3 : Summary of electro-fishing results from investigations conducted during 2006 in the Keno Hill mining area.

Site	Date	effort secs	S. Sculpin	A. grayling	burbot	RWF	NP	jcs	A. lamprey	comment
smq us flat	06/04	125	6							
KV 9	06/04	125	8							1st 20 m
KV 9	06/04	420	12 ad 1 fry		1		1			100 m block site
shanghai rd flat	06/04	247	0	0	0	0	0	0	0	high water
KV 7	06/04	480	0	0	0	0	0	0	0	
smq us chris ol	06/05	314	5	2 juv	0	0	0	0	1	shore only
KV 8	06/05	510	2	0	0	0	0	0	0	
C4	06/05	941	0	0	0	0	0	0	0	
C4 d/s	08/05	265	0	0	0	0	0	0	0	
C4 u/s	08/05	432		2 juv. 3 adult 12 sub ad						
KV 6 ds culv	06/06	158	5 ad 2 juv	0	0	0	0	0	0	
KV 6 us culv	06/06	120	4 ad 2 juv	0	0	0	0	0	0	
KV 6 us pool	06/06	195	6 ad 5 juv	0	0	0	0	0	0	
Light us	06/07	497	0	7 ad	0	0	0	0	0	ag in culv pool
KV 9	08/01	166	11	1 juv	0	0	0	0	0	1st 50 m
KV 9 block 1	08/01	1,075	46 ad 4 fry	2 juv	1 juv 1 sub a		1 juv			miss 25 ss
smq us flat	08/01	610	46 ad	0	0	0	0	0	1	
shangia rd flat	08/01	180	8 ad	0	0	0	0	0	0	
smq us chris	08/03	208	9 ad	1 juv	0	0	0	0	0	
chris block	08/03	698	17 ad	6 ad 10 juv	0	1 juv	0	0	0	poor els high cond
KV 7	08/04	633	0	0	0	0	0	0	0	
KV 18 ds culv	08/04	230	19 ad 2 fry							
KV 18 us culv	08/04	276	33 ad	0	0	0		0	0	obs small fish likely ag juv in pond
light ds	08/04	340	16 ad	1 sub ad	0	0	0	0	0	
light us	08/05	563	0	4 ad 16 sub ad	0	0		0	shrew	all fish near culv
light camp gr	08/05	96	0	2 ad 2 sub a	0	1 ad	0	0	0	
C4	08/05	265	0	0	0	0	0	0	0	
smq lk ol	09/19	616	5	1 sub ad	0	0	1 juv	0	0	
KV 1	09/18	629	51 ad	0	0	0	0	0	0	

Table 3 continued

Site	Date	effort secs	S. Sculpin	A. grayling	burbot	RWF	NP	jcs	A. lamprey	comment
KV 8	09/18	1,384	20 juv & adult	3 juv	1 sub ad	0	0	0	0	
smq ds chris	09/18	1,330	55 juv & adult	2 juv	3 sub ad	0	0	0	2	
KV 7	09/19	680	0	0	0	0	0	0	0	
light camp	09/19	265	0	11 sub ad	0	0	0	0	0	
C4 ds barrier	09/20	540	0	3 sub ad	0	0	0	0	0	
C4 us barier	09/20	153	0	0	0	0	0	0	0	
C4 ds old barrier	09/20	81	0	0	0	0	0	0	0	
smq ds hagg	09/21	1,112	61 ad, sub a	1 suba 2 juv	0	0	1 sub ad	0	0	
smq ds flat	09/21	788	74 ad sub ad	3 juv	0	0	0	0	0	
flat block site	09/21	690	37 small	1 juv	0	0	0	0	0	no nets
flat at Shangai	09/21	261	7 ad	0	1 sub ad	0	0	0	0	
KV 2	09/21	972	77 small	1 juv	0	0	0	0	0	
KV 18 ds culv	09/22	157	17 ad	0	0	0	0	0	0	
KV 18 us culv	09/22	380	51 ad >100 fry							

Table 4: Comparative metal content for key metals (expressed as ug/g) from data from 1995 and 2006 sampling for slimy sculpin from Flat and Christal Creeks. The average metal concentrations for all fish sampled in the given year have been recorded with the range of concentrations given below each average. * Cadm = cadmium, ** Mang = Manganese

Site	Arsenic	Cadm*	Copper	Lead	Mang.**	Nickel	Zinc
Christl Ck KV 6 '95	avg 1.38 0.51-3.95	avg 0.24 0.07-1.03	avg 0.72 0.44-1.34	avg 2.46 0.18-14.91	avg 107.11 8.40-188.16	avg 0.41 0.10-1.10	avg 87.99 41.35-187.06
Christl Ck KV 6 '06	avg 1.480 0.54-2.99	avg 0.617 0.35-1.26	avg 0.873 0.58-0.92	avg 7.276 1.21-19.0	avg 49.48 14.2-118.0	avg 0.3 0.18-0.47	avg 61.75 36.7=89.0
Christl Lk outlet '06	avg 1.390 0.74-2.84	avg 0.226 0.19-0.36	avg 1.037 0.85-1.28	avg 1.070 0.58-2.20	avg 32.26 18.6-46.5	avg 0.137 <0.1-0.16	avg 39.66 33.0-44.8
Christl Lk west end '06	avg 0.831 0.45-1.40	avg 0.048 0.36-0.55	avg 0.751 0.65-0.87	avg 0.17 0.10-0.23	avg 18.4 11.5-46.5	avg 0.16 <0.1-0.16	avg 34.07 32.1-36.2
Flat Ck '95	avg 1.43 0.66-3.47	avg 0.34 0.18-0.59	avg 1.61 1.06-3.47	avg 11.17 3.09-29.39	avg 51.74 16.91-127.7	avg 0.19 0.15-0.24	avg 56.01 37.76-76.69
Flat Ck '06	avg 1.031	avg 0.434	avg 1.092	avg 9.734	avg 57.9	avg 0.12	avg 47.86

Table 5: Metal concentration averages for key metal concentrations (expressed as ug/g) from slimy sculpin taken during September, 2006 from six sites on the South McQuesten River between McQuesten Lake outlet and below the confluence of Haggart Creek.

Site	Arsenic	Cadm*	Copper	Lead	Mang.**	Nickel	Zinc
MQ lk	1.390	0.226	1.037	1.070	32.26	0.137	39.66
KV 1	0.202	0.371	1.300	0.062	30.93	0.663	70.20
SMQ C	0.371	0.541	1.486	0.706	39.40	1.078	99.54
KV 2	0.509	0.427	1.442	1.108	35.98	1.022	67.96
KV 4	0.407	0.327	0.892	1.468	27.44	0.318	58.9
d/s Haggart	0.443	0.152	0.802	0.226	15.5	0.175	34.98

* Cadm = cadmium, ** Mang = Manganese

Table 6: Summary of key metal concentrations (expressed as ug/g) from Slimy Sculpin from South McQuesten River, 2006.

Site	Arsenic	Cadm.*	Copper	Lead	Mang.*	Nickel	Zinc
SMQ L	0.072	0.328	2.30	0.079	15.5	1.39	62.1
2	0.088	0.311	1.96	0.059	10.6	0.92	49.9
3	0.126	0.126	1.09	0.045	5.44	0.28	28.4
KV1 1	0.146	0.160	1.20	0.070	13.3	0.42	39.2
KV1 2	0.252	0.553	1.18	0.062	49.9	0.82	95.0
KV1 3	0.208	0.401	1.52	0.054	29.6	0.75	76.4
SMQ C							
l 1	0.193	0.402	1.16	0.430	28.1	0.52	108
2	0.281	0.321	1.35	0.279	32.3	0.62	73.2
3	0.418	0.637	1.76	0.362	64.3	1.88	87.7
4	0.598	0.707	1.66	2.02	37.0	1.40	131
5	0.364	0.639	1.50	0.437	35.3	0.97	97.8
SMQ KV2							
KV2 1	0.664	0.452	1.62	1.25	35.5	1.08	65.9
KV2 2	0.649	0.503	1.52	2.31	52.0	1.24	75.5
KV2 3	0.344	0.349	1.25	0.592	24.2	0.87	61.0
KV2 4	0.461	0.388	1.06	0.633	22.9	0.69	65.9
KV2 5	0.428	0.443	1.76	0.756	45.3	1.23	71.5
SMQ KV 4							
KV4 1	0.296	0.263	0.797	2.28	19.6	0.23	64.1
KV4 2	0.412	0.289	0.777	1.34	25.4	0.21`	43.3
KV4 3	0.399	0.265	0.737	1.62	29.1	0.27	54.2
KV4 4	0.486	0.440	1.01	1.09	34.3	0.45	70.2
KV4 5	0.441	0.379	1.14	1.01	28.8	0.43	62.7
SMQ H	0.506	0.253	1.17	0.315	21.4	0.21	41.8
2	0.444	0.0886	0.681	0.182	13.1	0.13	27.0
3	0.400	0.134	0.778	0.171	13.7	<0.10	38.9
4	0.443	0.127	1.12	0.261	14.5	0.19	35.6
5	0.424	0.156	0.261	0.199	14.8	0.17	31.6

* Cadm = cadmium, ** Mang = Manganese, SMQ = South McQuesten River

Table 7: Summary of key metal concentrations (expressed as ug/g) from slimy sculpin from Christal Lake and Christal Creek, 2006.

Site	Arsenic	Cadm.*	Copper	Lead	Mang.**	Nickel	Zinc
Christal Lk outlet							
1	1.10	0.197	0.993	0.580	37.6	0.12	41.7
2	1.21	0.256	1.28	1.19	46.5	0.16	44.8
3	0.741	0.133	1.02	0.445	18.6	<0.10	35.1
4	1.06	0.189	0.853	0.934	29.2	<0.10	33.0
5	2.84	0.355	1.04	2.20	29.4	0.13	43.7
Chris Lk west end							
6	0.447	0.0363	0.653	0.100	11.5	<0.10	32.1
7	1.12	0.0512	0.874	0.173	16.1	0.16	36.2
8	0.925	0.0554	0.727	0.237	27.6	<0.10	33.9
Christal Ck, Keno Rd							
KV18 1 Aug	1.23	0.375	1.04	3.26	31.7	0.21	48.4
KV18 2 Aug	1.32	0.636	0.876	9.93	68.3	0.24	78.6
KV18 3 Aug	1.50	0.557	0.921	6.22	44.0	0.26	54.9
KV18 4 Aug	2.99	1.26	0.917	19.0	118	0.41	81.9
KV18 5 Aug	2.05	0.924	0.883	12.8	69.7	0.26	89.0
KV18 6 Sept	1.42	0.354	0.883	2.68	26.3	0.37	46.8
KV18 7 Sept	0.542	0.548	0.583	3.11	23.6	0.18	57.7
KV18 8 Sept	0.789	0.277	0.884	1.21	14.2	0.47	36.7
Christal Ck at SMQ							
KV8 1	0.670	0.349	0.813	0.674	34.4	0.25	83.1
KV8 2	0.834	0.433	0.877	1.32	59.5	0.37	83.0
KV8 3	1.24	0.601	0.720	1.61	20.1	0.18	77.3
Flat Ck u/s SMQ							
KV9 1	0.803	0.476	0.890	12.3	63.7	0.11	50.7
KV9 2	1.02	0.478	1.20	11.4	72.0	0.12	43.6
KV9 3	1.40	0.448	1.42	14.3	74.2	<0.10	49.3
KV9 4	0.98	0.469	1.06	5.78	51.2	0.13	58.3
KV9 5	0.954	0.301	0.888	4.89	28.4	<0.10	37.4

* Cadm = cadmium, ** Mang = Manganese, SMQ = South McQuesten River

Table 8: Summary of key metal concentrations (expressed as ug/g) from slimy sculpin from Lightning Creek, 2006.

Site	Arsenic	Cadm.*	Copper	Lead	Mang.**	Nickel	Zinc
Light 1	0.855	0.348	1.00	0.308	11.5	0.22	41.8
Light 3	0.934	0.252	1.00	0.396	11.4	0.19	39.8
Light 4	0.985	0.258	1.08	0.604	12.4	0.28	38.3
Light 5	0.966	0.260	1.20	0.617	15.9	0.24	49.1

* Cadm = cadmium, ** Mang = Manganese

Table 9: Summary of key metal concentrations (expressed as ug/g) from Arctic Grayling taken from Christal Creek and Lightning Creek, 2006.

Site	**Arsenic**	**Cadm ***	**Copper**	**Lead**	**Mang ****	**Nickel**	**Zinc**
Chris Ck 1	0.092	0.0833	0.614	0.081	3.14	<0.010	17.9
Chris Ck 2	0.109	0.0514	0.513	0.053	3.94	<0.010	17.3
Chris Ck 3	0.132	0.0413	0.404	0.125	6.17	<0.010	19.5
Chris Ck 4	0.138	0.0537	0.469	0.165	7.64	<0.010	23.0
Chris Ck 5	0.172	0.0614	0.494	0.228	10.3	<0.010	27.4
Light Ck 1	0.432	0.118	0.832	0.294	8.85	<0.010	31.5
Light Ck 2	0.100	0.0497	0.617	0.315	2.81	<0.010	18.7
Light Ck 3	0.035	0.0188	0.192	<0.02	1.03	<0.010	7.66
Light Ck 4	0.130	0.0169	0.876	0.022	3.34	<0.010	16.0
Light Ck 5	0.123	0.0179	0.921	0.022	1.94	<0.010	18.7

* Cadm = cadmium, ** Mang = Manganese

Table 10: Summary of averages for key metal concentrations (expressed as ug/g) from slimy sculpin tissue collected as part of the Aquatic Life Sampling and Testing Program, conducted near Faro, Yukon during August of 2005, 2004 data is presented below for comparison (from Sparling 2006).

METAL	YEAR	R1	R2	R4	R6	V8	B1
Copper	2004	0.57	1.20	0.88	0.93	0.79	0.87
	2005	1.12	1.25	0.96	0.98	0.95	1.12
	2006	0.72	0.564	0.41	0.56	no sample	0.61
Lead	2004	0.41	0.24	0.22	0.13	0.16	0.075
	2005	0.57	1.02	0.56	<0.5	<0.5	<0.5
	2006	<0.1	<0.1	<0.1	<0.1	no sample	<0.1
Manganese	2004	28.10	31.70	30.8	30.80	6.70	9.17
	2005	24.96	38.78	47.72	26.42	7.37	8.67
	2006	16.66	19.70	36.96	8.23	no sample	11.10
Zinc	2004	53.1	39.3	57.6	41.0	55.14	31.27
	2005	30.06	51.76	49.94	39.1	45.66	26.06
	2006	33.04	49.62	44.52	27.22	no sample	23.7
Cadmium	2004	0.011	0.051	0.062	0.072	0.184	0.108
	2005	0.05	<0.05	<0.05	0.076	0.18	0.085
	2006	0.04	0.03	0.04	0.058	no sample	0.06

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LITERATURE CITED

Burns, Bonnie, 2006. *Keno Valley Receiving Water Monitoring Program, 2005 / 2006. Volume 1.* Prepared for Type II Mines, Assessment and Abandoned Mines. Prepared by Laberge Environmental Services. March 2006.

Environmental Protection Service, *Assessment of the Water quality and biological conditions in watersheds surrounding the United Keno Hill Mine, Elsa, Yukon, during the summers of 1974 and 1975*.
Fisheries and Environment Canada Reg. Prog. Rep. 78-14

Federal Government of Canada, Department of Fisheries and Oceans, Whitehorse ,Yukon. *Stream Files*.

Benthel, G. and I. Soroka. 1981., *Compliance Evaluation of United Keno Hill Mines LTD. Elsa, Yukon Territory. Environment Canada*, EPS. Reg. Prog. Rep. 81-23

Sparling P. and Connor M., 1995. *Fish and Fish Habitat Assessment Conducted Near Elsa, Yukon. Prepared For United Keno Hill Mines, August 1994-September 1995.* December, 1995.

Sparling, Paul. 2006. *Aquatic Life Sampling and Testing Program For The Anvil Range Mine Site, Rose and Vangorda Creek Watersheds, Faro, Yukon*. Conducted during August, 2006. Prepared for Delloite and Touche Inc. by White Mountain Environmental Consultants, January 2007.

APPENDIX 1
SAMPLE SITE GENERAL DESCRIPTIONS

GENERAL DESCRIPTION
Site F1

LOCATION: Flat Creek immediately upstream of the outlet to South McQuesten River

Lat / Long: 63° 55.249 N / 135° 41.703 E
Dates Sampled: 1994, 1995,
June 3, August 1, September 21, 2006

CHANNEL CHARACTERISTICS:

Surveyed Length:	180 m	Gradient:	< 1%
Average Channel Width:	3.5 m		
Average Wetted Width:	3.7 m		
Average Riffle/ Pool Depths:	0.2 and 0.8 m		
Average Depth:	0.3m (August)		
Average Velocity	0.5 m/sec		
% Pool, Riffle, Run / Glide:	20% pool	30% riffle	50% run/glide
Side Channels:	2 small areas		
Debris:	log piles and sticks		
Cover	LOD and undercut banks		
Crown Closure:	5%		
Riparian Vegetation:	willow alder spruce		

BED MATERIAL: Bed materials become coarser away from McQuesten, most moderately compacted and silted with algal growth.

Fines: sand only in side channel
Gravels: 40%
Larges: 60%

STREAM BANKS: abrupt and confining rise 0.7 to 1.8 meters with open flood plain beyond.

WATER QUALITY:

Date	pH	Temp (C)	Cond (uS/cm)	Visual color
Aug 1, '06	7.88	10.4	630	Gin

FISH SPECIES PRESENT

GENERAL DESCRIPTION

Site CL

LOCATION: Christal Creek

Lat / Long: 63° 54.944 N / 135° 19.926 E
Dates Sampled: 1994, 1995
June 7, August 2, September 22, 2006

CHANNEL CHARACTERISTICS:

Surveyed Length:	n/a
Average Channel Width:	n/a
Average Wetted Width:	n/a
Average Riffle/ Pool Depths:	n/a
Average Depth:	estimate 2 m
% Pool, Riffle, Run / Glide:	n/a
Side Channels:	n/a
Debris:	n/a
Cover	thick aquatic vegetation
Crown Closure:	
Riparian Vegetation:	mature spruce, alder, birch willow and poplar

BED MATERIAL: loon shit with thick vegetative cover as thick as 1 meter, several small tailings piles at the south end of the lake

LAKE BANKS: Mostly stable along the east shoreline, west shoreline has erosion occurring either from rising water level or permafrost deterioration. Banks at the north end of the lake (outlet area) are low and non-confining. Most of the north end of the lake consists of marsh areas. An active beaver dam crosses the entire width of the lake and created a head of 1.2 meters by September.

WATER QUALITY:

Date	pH	Temp (C)	Cond (uS/cm)	Visual color
Sept 22/06	7.94	4.2	850	clear, light tannin

FISH SPECIES PRESENT
Slimy sculpin

GENERAL DESCRIPTION
KV 6

LOCATION: Christal Creek at the Keno Road Crossing
Lat / Long: 63° 55.1739 N / 135° 19.4620 E
Dates Sampled: 1994, 1995
June 6, August 4 , September 22, 2006

CHANNEL CHARACTERISTICS:	175 m	Gradient:	gentle
August, 2006			
Surveyed Length:			
Average Channel Width:	3.0 m d/s culvert		15 m u/s culvert narrows to 1 m
Average Wetted Width:	2 m d/s culvert		5 m u/s culvert to 1 m
Average Riffle/ Pool Depths:	1.0 m		
Average Depth:	0.15 d/s culvert		0.45 u/s culvert
Average velocity	1.0 m/sec "	0.8 m/sec u/s pools	
% Pool, Riffle, Run / Glide:	% pool	% riffle	% run/glide
Side Channels:	10 % d/s culvert, none u/s culvert		
Debris:	none		
Cover	grass banks d/s culvert, willow overhang u/s pools		
Crown Closure:	15% d/s culvert, 80 % u/s pools		
Riparian Vegetation:	two varieties of willow and sedge		

BED MATERIAL: Downstream of the culvert has small gravels with sand edges, moderately consolidated, The pool upstream of culvert has fine silts and sands, upstream of the pool velocities increase and substrates become coarse and well consolidated and occasional patches of black mat were still visible.

Fines: 10% sand/ silt d/s culvert, 100% in pool and 10% u/s of pools
Gravels: 90 % d/s culvert, 20% upstream of pools
Larges: 30% us pools%
Boulders: 50% u/s pools

STREAM BANKS: Downstream of the culvert banks are non-confining with an open flood plain of up to 20 meters. Upstream of the culvert the pool is partial y confined by a hill to the East, upstream of the pools the channel is entrenched with abrupt banks rising 1 to 2 meters.

STREAM FLOW CHARACTERISTICS: Downstream of the culvert the channel flows through shifting sands with gentle meanders and some braiding. Upstream of the culvert the past the non-confined pool becomes highly meandering with small but deep pools.

WATER QUALITY:

Date	pH	Temp (C)	Cond (uS/cm)	Visual color
June 6/06	7.7	7.4		light tannin
Aug. 4/06	8.1	15.9	710	clear

FISH SPECIES PRESENT
Slimy sculpin

GENERAL DESCRIPTION

C 4

LOCATION: Christal Creek 2 km downstream of Christal Lake at the site of the old "Polly Claims"

Lat / Long: 63° 56.8751 N / 135°22.3977 E
Elevation: 2,263 feet
Dates Sampled: 1994, 1994
June 5, August 5, September 20, 2006

CHANNEL CHARACTERISTICS: August 2006

Surveyed Length:	900 m	Gradient:	8%	
Average Channel Width:	3.0 m			
Average Wetted Width:	2.5 m			
Average Pool Depths:	0.7 m			
Average Depth:	0.4 m			
Average velocity	>1 m/sec			
% Pool, Riffle, Run / Glide:	10% pool	70% riffle	10% run	10% rapid
Side Channels:	none			
Debris:	very few sticks and bridge timbers			
Cover	perched flat rocks, cut banks and turbulence			
Crown Closure:	80%			
Riparian Vegetation:	predominantly alder with occ. birch, willow and spruce			

BED MATERIAL: Mostly flat or angular rocks tightly compacted

Fines: 10% sand (side deposits)
Gravels: 20%
Cobble: 50%
Boulder: 20%
Bedrock: occasional

STREAM BANKS: Channel mostly confined and occasionally entrenched on left bank. Most banks abrupt rising 0.8 to >2 meters

STREAM FLOW CHARACTERISTICS: Channel flows mostly straight with occasional gentle meanders with a flat bottom and occasional deep side areas

WATER QUALITY:

Date	pH	Temp (C)	Cond (uS/cm)	Visual color
June 5, 06	8.2	4.8		light grey with tannin stain
Aug 5, 06	8.5	9.6	710	light kahki

FISH SPECIES PRESENT
Electro- fishing, minnow traps and visual observation

GENERAL DESCRIPTION

Site KV 7

LOCATION: Christal Creek at Hanson Lake Rd crossing
Lat / Long: 63° 57.439 N / 135° 25.944 E
Dates Sampled: 1994, 1995
June 4, August 4, September 19, 2006

CHANNEL CHARACTERISTICS: August, 2006

Surveyed Length:	350 m
Average Channel Width:	2.8 m
Average Wetted Width:	2.3m
Average Riffle/ Pool Depths:	1.0 m
Average Depth:	0.3 Aug, 0.4m June
Average velocity	1.0 m/sec
% Pool, Riffle, Run / Glide:	15% pool 25% riffle 60% run/glide
Side Channels:	none
Debris:	some sticks and bridge timber
Cover	limited, stick wads, cut banks, timbers
Crown Closure:	65%
Riparian Vegetation:	willow spruce and alder

BED MATERIAL: consist mostly of concreted gravel and cobbles with submerged timbers from bridge construction

Fines: 15% sand
Gravels: 60%
cobbles: 25%

STREAM BANKS: confining with over 1 m rise at bank full levels, flood plain open

STREAM FLOW CHARACTERISTICS: Stream flows with gentle meanders, channel often straight and much modified by road construction and possibly historic placer mining.

WATER QUALITY:

Date	pH	Temp (C)	Cond (uS/cm)	Visual color
June 4/06	8.1	4.2		grey
Aug. 4/06	8.5	9.4	680	light grey
Sept. 19/06	8.4	5.1	680	gin

FISH SPECIES PRESENT
Electro-fishing, minnow trapping and visual observation

GENERAL DESCRIPTION

Site KV 8

LOCATION: Christal Creek immediately upstream of the confluence with the South McQuesten River

Lat / Long: 63° 57.170 N / 135° 31.038 E
Elevation: 2,099 feet
Dates Sampled: 1994, 1995
June 5, August 3, September 19, 2006

CHANNEL CHARACTERISTICS: August 2006

Surveyed Length:	265 m		
Average Channel Width:	4 m		
Average Wetted Width:	3.5 m		
Average Pool Depths:	1.5 m		
Average Depth:	0.4		
Average velocity	0.3 m/sec		
% Pool, Riffle, Run / Glide:	20% pool	60% glide	20% run
Side Channels:	none		
Debris:	occasional LOD and sticks		
Cover	LOD, small cobbles, limited amounts		
Crown Closure:	15%		
Riparian Vegetation:	willow sedge		

BED MATERIAL: Mostly fine with occasional cobble pockets, loosely consolidated

Fines: 30% sandy silt
Gravels: 65%
Larges: 5%

STREAM BANKS: Abrupt and often undercut rise 0.6 to 1.5 meters above water line, near pools at outlet the banks become less steep and well washed from consistent spring flooding.

STREAM FLOW CHARACTERISTICS: Channel is confined in an open flood plain 50 meters upstream of river and opens to a series of 3 small pools before entering the McQuesten River.

WATER QUALITY:

Date	pH	Temp (C)	Cond (uS/cm)	Visual color
June 5/06		1.9		light grey turbidity
Aug. 3		10.4		gin
Sept. 19/06	8.37	4.2	700	gin

FISH SPECIES PRESENT
Minnow traps, electro-fishing and visual observation

GENERAL DESCRIPTION

Site SMQ LK

LOCATION:
Lat / Long: 64° 03.875 N / 135° 21.886 E
Elevation: 2,221 feet
Dates Sampled: 1995
August 4, September 18, 2006

CHANNEL CHARACTERISTICS: August, 2006

Surveyed Length:	650 m	Gradient:	
Average Channel Width:	22m		
Average Wetted Width:	18m		
Average Riffle/ Pool Depths:	riffles 0.5 m		pools 1.7 m
Average Depth:	0.7 m		
Average velocity	0.5 m/sec		
% Pool, Riffle, Run / Glide:	30% pool	15% riffle	55% run/glide
Side Channels:	none		
Debris:	very little		
Cover	scoured banks with roots, pools, depth		
Crown Closure:	2%		
Riparian Vegetation:	mature spruce, sedge covered flood plains		

BED MATERIAL: Substrates near the lake consist of fine, loose gravels with sandy edges grading to silt at shoreline. Downstream 300 meters substrates become coarser with cobbles common in areas with constricted flow and increased velocities, occasional boulders also become more common.

Fines: 25% sand
Gravels: 50%
Cobbles: 20%
Boulders: 5%

STREAM BANKS: The lake outlet has shallow banks with small hills and flood zones behind; banks are well defined with obvious sedge covered flood zones occurring on both sides. Below 300 meters from the lake the river flows into a narrowing valley and banks become entrenching.

STREAM FLOW CHARACTERISTICS: the channel narrows and becomes partially entrenched 300 meters downstream of the lake.

WATER QUALITY:

Date	pH	Temp (C)	Cond (uS/cm)	TDS (mg/l)	DO (mg/l)	Visual color

FISH SPECIES PRESENT

GENERAL DESCRIPTION

Site KV 1

LOCATION: South McQuesten River 1 km upstream of Christal Creek confluence
Lat / Long: 63° 57.601 N / 135° 31.879 E
Elevation: 2,164 feet
Dates Sampled: 1995
June 5, August 3, September 18, 2006

CHANNEL CHARACTERISTICS: August 2006

Surveyed Length:	250 m		
Average Channel Width:	12 m		
Average Wetted Width:	12 m		
Average Riffle/ Pool Depths:	riffles 0.5 m		pools 0.9 m
Average Depth:	0.6 m		
Average velocity	0.7 m/sec		
% Pool, Riffle, Run / Glide:	15% pool	30% riffle	65% run/glide
Side Channels:	none		
Debris:	occasional stick pile		
Cover	boulder, cut banks, turbulence, muck		
Crown Closure:	15%		
Riparian Vegetation:	willow alder , some spruce		

BED MATERIAL: Substrates are well compacted with very few smalls, most sorting of small materials occurs near ford site.

Fines: 10% sand mostly near ford
Gravels: 20%
Cobbles: 50%
Boulders: 30%

STREAM BANKS: Old Shangai road ford crosses river midway through reach, all other areas the banks are well defined, mostly abrupt and rise 0.6 to 1.5 meters to an open flood plain.

STREAM FLOW CHARACTERISTICS: gentle meanders with a mostly flat bottomed channel

WATER QUALITY:

Date	pH	Temp (C)	Cond (uS/cm)	Visual color

FISH SPECIES PRESENT
Artic grayling, slimy sculpin, Arctic lamprey,

GENERAL DESCRIPTION

Site KV 2

LOCATION: South McQuesten River at the Elsa water supply lake
Lat / Long: 63° 56.174 N / 135° 34.397 E
Date Sampled: 1995
September 21, 2006

CHANNEL CHARACTERISTICS: September, 2006

Surveyed Length:	200 m		
Average Channel Width:	17 m		
Average Wetted Width:	20 m		
Average Pool Depths:	> 2.0 m		
Average Depth:	1.2 m		
Average velocity	0.5 m/sec		
% Pool, Riffle, Run / Glide:	30% pool	10% riffle	60% run/glide
Side Channels:	none		
Debris:	stick piles		
Cover	depth, submerged sticks, cut banks		
Crown Closure:	10%		
Riparian Vegetation:	mature spruce with willow and alder		

BED MATERIAL: Substrates are highly compacted and very stable, most with extensive algal growth.

Fines: 30% sand, all deposition points are sand as are off channel areas
Gravels: 20%
Cobbles: 35%
Boulders: 15%

STREAM BANKS: are stable and abrupt rising 0.8 to 1.5 meters from water level and are undercut in 50% of bank areas.

STREAM FLOW CHARACTERISTICS: Flows at this site are even and mostly slow, riffles are deep and do not cause substrate scour, wide curves of gentle meanders create large corner pools and debri traps

FISH SPECIES PRESENT
Slimy sculpin,

GENERAL DESCRIPTION

Site KV 4

LOCATION: South McQuesten River downstream of Flat Creek
Lat / Long: 63° 135°
Elevation:
Site Number:
Site Description:
Date Sampled

CHANNEL CHARACTERISTICS:

Surveyed Length:	m	Gradient:	
Average Channel Width:	m		
Average Wetted Width:	m		
Average Riffle/ Pool Depths:			
Average Depth:	.		
Average velocity	0.7 m/sec		
% Pool, Riffle, Run / Glide:	% pool	% riffle	% run/glide
Side Channels:	r		
Debris:			
Cover			
Crown Closure:			
Riparian Vegetation:			

BED MATERIAL:

Fines: % sand
Gravels: %
Larges: %
Bedrock:

STREAM BANKS:

STREAM FLOW CHARACTERISTICS:

Date	Discharge (m^3/sec)

WATER QUALITY:

Date	pH	Temp (C)	Cond (uS/cm)	TDS (mg/l)	DO (mg/l)	Visual color

FISH SPECIES PRESENT

GENERAL DESCRIPTION

Site SMQ H

LOCATION: South McQuesten River downstream of the confluence with Haggart Creek
Lat / Long: 63° 53.732 N / 136° 01.417
Dates Sampled: 1991, 1994, 1995
June 3, August 1, September 21, 2006

CHANNEL CHARACTERISTICS: August, 2006

Surveyed Length:	350 m		
Average Channel Width:	32 m		
Average Wetted Width:	18 m		
Average Riffle/ Pool Depths:	>1.5 m		
Average Depth:	0.7 m		
Average velocity	1 m/sec		
% Pool, Riffle, Run / Glide:	10% pool	40% riffle	50% run/glide
Side Channels:	1 small		
Debris:	stick and log pile in corner		
Cover	corner pool with debri, cut banks and depth		
Crown Closure:	>2%		
Riparian Vegetation:	mature spruce with alder		

BED MATERIAL: loosely consolidated and shifting gravels

Fines: 20% sand
Gravels: 60%
Cobbles: 20%

STREAM BANKS: open on right and confined on left, left side is deeper and most of exposed bank on right

STREAM FLOW CHARACTERISTICS: below the confluence the channel is shifting with a loose bed load and a large deposition apron on the right bank

WATER QUALITY:

Date	site	pH	Temp (C)	Cond (uS/cm)	Visual color
Aug. 1/06	d/s Haggart	8.2	13.3	350	gin
Aug 1/06	u/s Haggart	8.3	15.2	390	gin
Aug 1/06	Haggart u/s SMQ	8.25	12.8	320	gin

FISH SPECIES PRESENT
Slimy sculpin, Arctic grayling, round whitefish,

GENERAL DESCRIPTION

Site LgT K

LOCATION: Lightning Creek adjacent to the Keno Campground
Lat / Long: 63° 54.423 N / 135° 18.205
Elevation: 3,053
Dates Sampled: June 7, August 4, September 19, 2006

CHANNEL CHARACTERISTICS: June, 2006

Surveyed Length:	250 m
Average Channel Width:	9 m
Average Wetted Width:	9 m
Average Pool Depths:	>1.5 m
Average Depth:	0.4 m
Average velocity	>1.5 m/sec
% Pool, Riffle, Run / Glide:	10% pool 10% riffle 80% rapid
Side Channels:	upstream of both bridges
Debris:	few sticks
Cover	plunge pools, perched boulders, turbulence
Crown Closure:	50%
Riparian Vegetation:	willow alder

BED MATERIAL: loosely compacted boulders in old placer mined area

Fines: 10% sand on sides only
Gravels: 15%
Cobbles: 15%%
Boulders: 60%

STREAM BANKS: banks are shallow rising evenly and abruptly o.5 to 1 meter, banks have been modified by placer mining and a culvert and an old bridge cross the creek.

STREAM FLOW CHARACTERISTICS: Channel is well defined within a man made channel, flows are consistently fast away from bridging structures. Plunge pools occur below both the culvert and the old bridge.

WATER QUALITY:

Date	pH	Temp (C)	Cond (uS/cm)	Visual color
June 6/06		3.7		light grey
Aug 4/06	8.2	10.4	205	light chalk turbidity

FISH SPECIES PRESENT
Arctic grayling

GENERAL DESCRIPTION

Site LgT D

LOCATION: Lightning Creek upstream of the confluence with Duncan Creek at the Duncan Creek Ford.
Lat / Long: 63° 53.594 N / 135° 20.739 E
Elevation: 2,771 feet
Date Sampled: June 7, August 4, September 19, 2006

CHANNEL CHARACTERISTICS: August, 2006

Surveyed Length:	250 m		
Average Channel Width:	5 m		
Average Wetted Width:	3.5 m		
Average Riffle/ Pool Depths:	2.2 m		
Average Depth:	0.3		
Average velocity	1.3 m/sec		
% Pool, Riffle, Run / Glide:	10% pool	65% riffle	25% run/glide
Side Channels:	none		
Debris:	none		
Cover	side banks, corner pool, light turbidity		
Crown Closure:	>5%		
Riparian Vegetation:	willow with sedge		

BED MATERIAL: well sorted slightly compacted granular materials

Fines: 15% sand
Gravels: 40%
Cobble: 40%
Boulder: 5%

STREAM BANKS: very even, man made banks in placer mined area with an abrupt rise of 0.5 meters to an open flood plain

STREAM FLOW CHARACTERISTICS: Placer mine created channel has very little natural shape, bottom is flat in all straight areas, one tight corner has a small deposition bar and deep corner pool. The Duncan Creek Road Fords the site and flattens a shallow riffle.

WATER QUALITY:

Date	pH	Temp (C)	Cond (uS/cm)	Visual color
June 6/06		3.5		light grey turbid
Aug. 4/06	8.2	10.0	200	light chalk

FISH SPECIES PRESENT
Arctic grayling, slimy sculpin, round whitefish