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ENVIRONMENTAL QUALITY OF RECEIVING WATERS AT UNITED KENO HILL MINES LTD. ELSA, YUKON 1990

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Environmental quality of receiving waters at United Keno Hill Mines Ltd, Elsa, Yukon

ABSTRACT

During the summer of 1990, a receiving environment monitoring study was undertaken by Environmental Protection in the streams potentially influenced by the tailings and adit drainages of United Keno Hill Mines in the Elsa/Keno area of the Yukon.

Based on the data collected from the water quality, sediments, and benthic surveys, it is apparent that Christal Creek influences the quality of the South McQuesten River. There is an increase in the metals in the water and in the sediments, downstream of the confluence of Christal Creek. Levels of most metals in water from the South McQuesten River stations remained within the recommended guidelines for the protection of aquatic life. The benthic community is altered below Christal Creek but recovers several kilometres downstream. The major source of contaminants in Christal Creek is Galkeno 900 adit, as evidenced by the water quality.

Several abandoned adits on Galena Hill seep metal-laden waters to several creeks draining this area. These creeks cross Highway No. 2 near Elsa and empty into swamps located between the highway and the South McQuesten River. The creek channels become undefined in the swamp area and there is no apparent change in water quality in the South McQuesten River where these waters would eventually seep to.

The sediment chemistry displays high levels of metals in Christal Creek and Flat Creek, with a significant increase in 1990 over 1985. Metals levels were highest in the sediments of Flat Creek, which drains the tailings area.

Benthic communities were generally diverse and dominated by Diptera and/or Plecoptera. However, it appears that the elevated levels of metals in sediments at Station 7, Flat Creek, had reduced the overall benthic habitat quality as diversity and abundance were very low at that site.

RÉSUMÉ

Durant l'été 1990, le Service de Protection de l'Environnement a conduit une étude environnementale de surveillance des eaux réceptrices influencées par les résidus miniers et le drainage des galeries d'accès de la mine United Keno Hill dans la région d'Elsa/Keno, au Yukon.

Basé sur les données recueillis de la qualité de l'eau, des sédiments et des études benthiques, il semble apparent que le ruisseau Cristal influence la qualité de l'eau de la Rivière South McQuesten. Il y a eu une augmentation des métaux dans l'eau et des sédiments en aval de la confluence avec le ruisseau Cristal. Les niveaux de la majorité des métaux dans l'eau de la rivière South McQuesten sont conforme aux lignes directrices pour la protection de la vie aquatique. La communauté benthique a été perturbée en aval du ruisseau Cristal, mais récupère plusieurs kilomètres plus loin. La source de contaminants du ruisseau Cristal est la galerie d'accès Galkeno 900, mis en évidence par la qualité de l'eau.

Plusieurs galeries d'accès abandonnées du mont Galena ruissellent vers plusieurs ruisseaux drainant cette région avec des eaux chargées de métaux. Ces ruisseaux traversent la route No.2 près d'Elsa et se déversent dans des marécages situés entre la route et la rivière South McQuesten. Le lit de ces ruisseaux se perds dans les marécages et il n'y a aucun changement dans la qualité de la de l'eau de la rivière South McQuesten où ces eaux ruissellent.

La chimie des sédiments indique des niveaux de métaux élevés dans les ruisseaux Cristal et Flat, avec une augmentation significative en 1990 en comparaison avec les niveaux de 1985. Les taux de métaux étaient plus élevés dans les sédiments du ruisseau Flat, celui-ci draine l'étang de résidus.

Les communautés benthiques étaient généralement diverses et dominés par le diptères et/où les plecoptères. Toutefois, il semble que l'élévation du niveau de métaux des sédiments à la station 7 (ruisseau Flat), a réduit la qualité globale du milieu aquatique, puisque la diversité et l'abondance des invertébrés étaient les plus basses.

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1.0 INTRODUCTION

An investigation of water quality, water quantity, stream sediments and aquatic invertebrate populations was carried out by Environmental Protection July 24 to 26 and September 19 to 21, 1990 in the South McQuesten River watershed in the vicinity of United Keno Hill Mine at Elsa, Yukon.

The purpose of the investigation was to determine if any significant impact from the tailings and adit drainages was detectable in the receiving waters, namely Flat Creek, Christal Creek and the South McQuesten River.

The information collected by this survey is compared with information from previous surveys conducted by Environmental Protection. Further comparisons are made with invertebrate information collected by private consultants in conjunction with water licence biological monitoring.

2.0 STUDY AREA

United Keno Hill Mine is located at the town of Elsa, Yukon (63°55' N, 135°30' W) approximately 450 km. by road north of Whitehorse (See Figure 1).

This area is underlain by graphitic and sericitic schist, phyllite and quartzite. The ore minerals are galena (PbS), sphalerite (ZnS), freibergite ($(Cu,Fe,Zn,Ag)_{12},(Sb,As)_4S_{13}$), and chalcopyrite ($CuFeS_2$). The gangue minerals are siderite ($FeCO_3$) and pyrite (FeS_2).

The first recorded discovery of silver-lead in the area was in 1903 on Galena Hill. Over the years this area has been mined for silver, lead, zinc, cadmium and some gold. In 1946, United Keno Hill Mine Ltd began mining and milling operations and have operated in the study area off and on until 1989.

The mine has not operated since January 6, 1989. In 1990, United Keno Hill Mines Ltd. submitted a permanent abandonment plan for the mine. At present the mine is under "care and maintenance" with some exploration ongoing.

Although there was no actual decant from the final settling pond at the time of sampling, seepage from the pond was evident in Porcupine Gulch, which flows into Flat Creek. Flat Creek joins the South McQuesten River approximately 10 km from the tailings pond decant. Christal Creek, which originates at Christal Lake 10 km east of Elsa, flows into the South McQuesten River approximately 12 km upstream of the Flat Creek confluence. Although this tributary is not directly associated with the tailings effluent, it is affected by drainage from several abandoned mine adits on the north slope of Galena Hill and the south slope of Keno Hill.

A total of 20 sampling stations were established in the study area, some of which coincide with those established in past investigations conducted by Environment Canada and by private consultants. All sites were accessed by road or by foot. Table 1 provides station descriptions. Figure 2 identifies station locations of the receiving waters and Figure 3 shows the locations of the mine area sample sites.

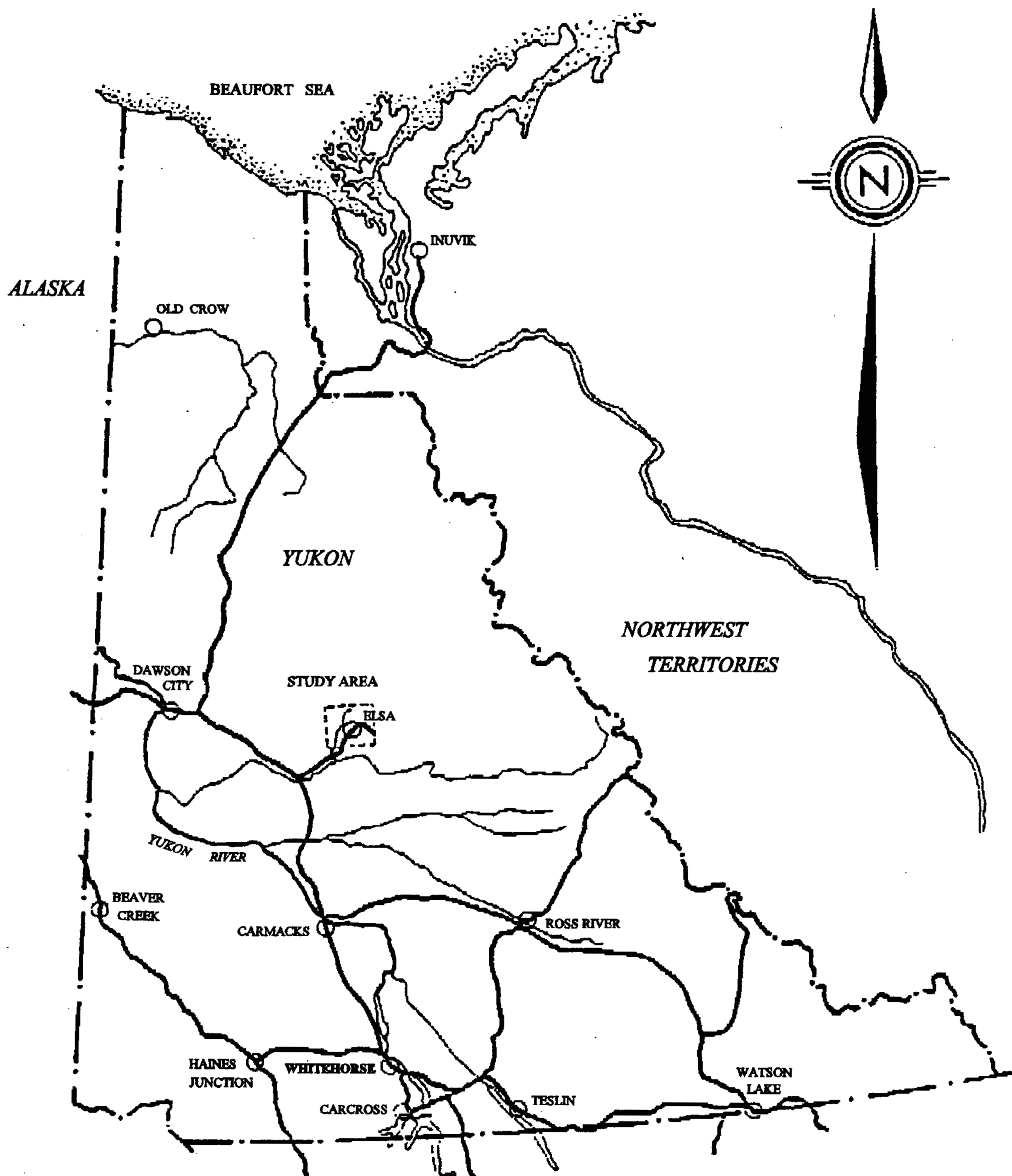


FIGURE 1 LOCATION OF STUDY AREA

TABLE 1 STATION DESCRIPTIONS

STATION	DESCRIPTION
1	Christal Creek immediately d/s of highway culvert
2*	Christal Creek immediately d/s of Hansen Lake Road bridge
3*	South McQuesten River approximately 1.5 kilometres u/s of confluence with Christal Creek
4*	South McQuesten River at domestic water supply pumphouse, approximately 6 kilometres d/s of Christal Creek confluence
6	Flat Creek approximately 70m u/s of the highway near small pumphouse
7	Flat Creek at old bridge crossing approximately 600m u/s of confluence with South McQuesten River
8	South McQuesten River approximately 15m u/s of Flat Creek confluence
9*	South McQuesten River approximately 2 kilometres d/s of Flat Creek confluence
10*	South McQuesten River approximately 9 kilometres d/s of Flat Creek confluence
11*	South McQuesten River approximately 15m u/s of Haggart Creek confluence, approximately 27 kilometres d/s of Flat Creek
12	An unnamed tributary of South McQuesten River approximately 1.5 kilometres u/s of Station 4
13	Star Creek u/s of highway
14	Sandy Creek u/s of highway
15	Galena Creek d/s of highway culvert
16	Galena Creek d/s of adit drainage
17	Porcupine diversion u/s of tailings seepage
18	Porcupine diversion d/s of tailings seepage
19	Tailings seepage into Porcupine diversion
20	No Cash 500 adit drainage u/s of highway
21	Galkeno 900 adit flow

NOTE: There is no Station 5.
* changes in location from 1985 survey as shown in Figure 2.

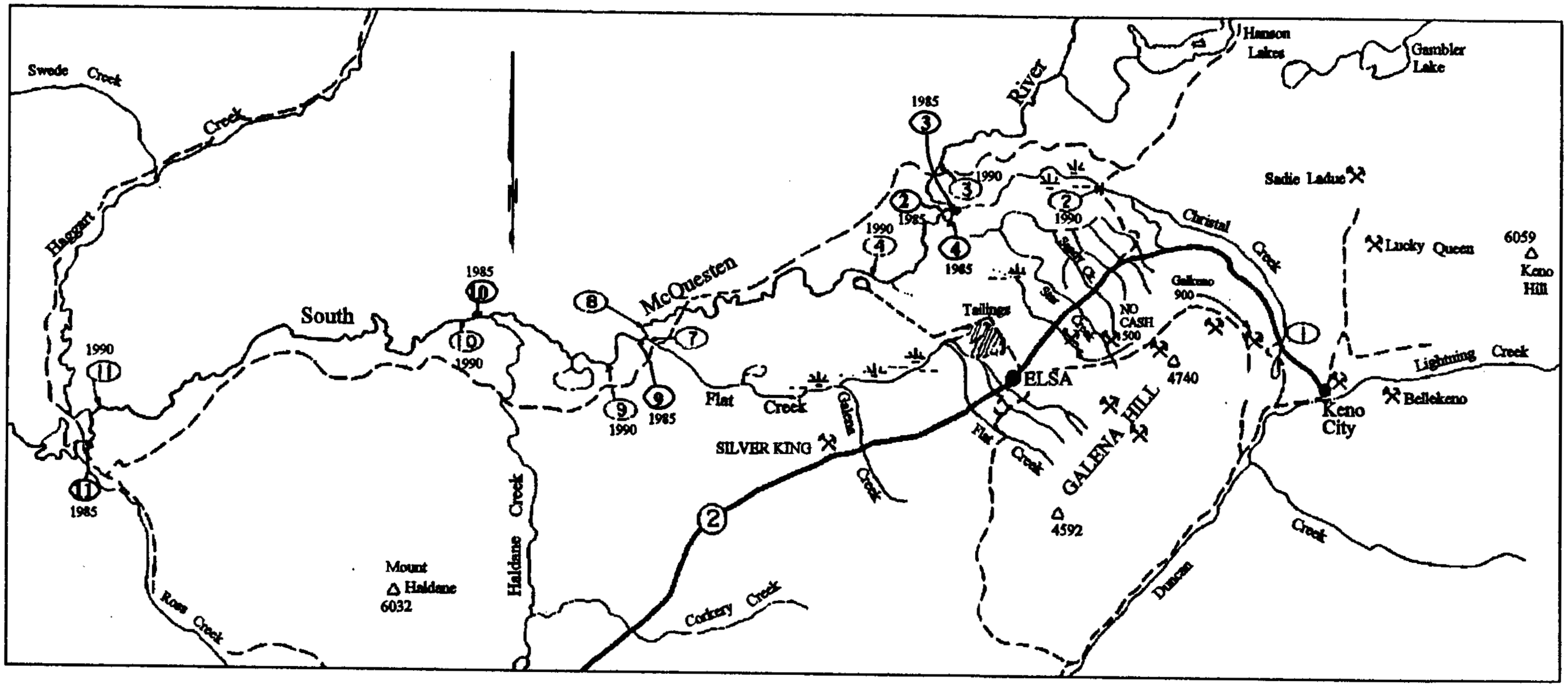
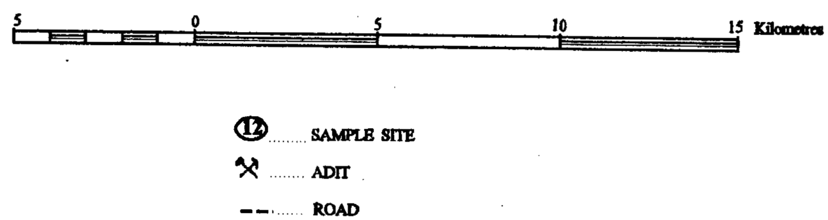


FIGURE 2 LOCATION OF RECEIVING WATERS SAMPLE STATIONS



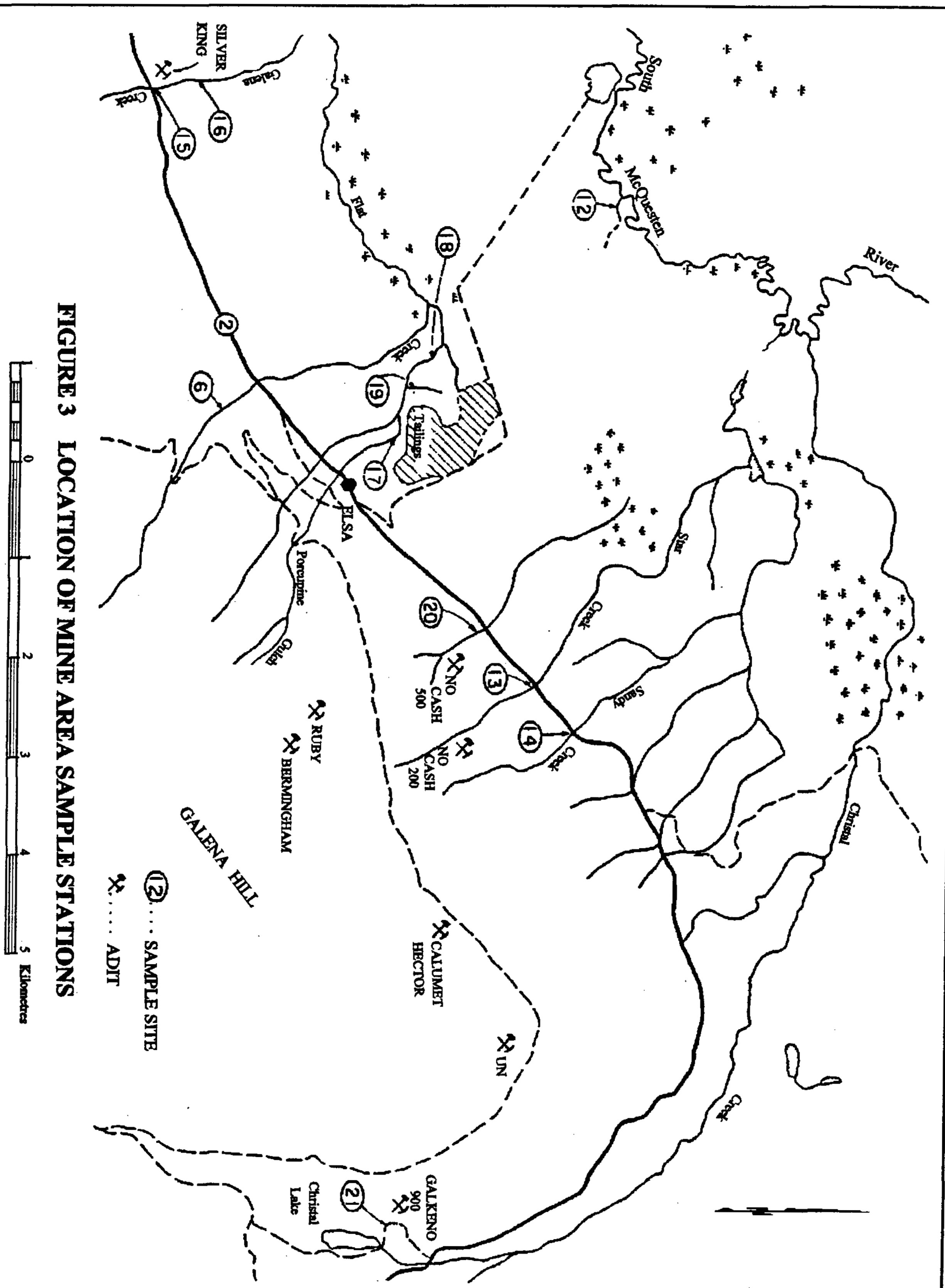


FIGURE 3 LOCATION OF MINE AREA SAMPLE STATIONS

3.0 METHODS

Surveys were conducted in the study area on two occasions: July 24 to 26, 1990 and September 19 to 21, 1990. Surveys included water quality, water quantity, sediment and benthos sampling at all locations with the exception of Stations 6 and 12 to 21, where only water quality was collected.

3.1 Water Quality

In situ water quality measurements included temperature, conductivity, pH and dissolved oxygen. Temperature and conductivity were measured with a YSI Model 33 Temperature-Conductivity-Salinity Field Meter, pH was measured using a Hach Chemical pH meter, and dissolved oxygen was measured with a YSI Model 57 Dissolved Oxygen Field Meter. The latter was calibrated using the water saturated air method as described in the YSI Manual. Readings were corrected for temperature, elevation and salinity. Percent saturation was calculated from oxygen saturation tables derived from APHA et al (1981). A full description of field equipment and measurements is given in Appendix I, Table 1.

Water quality samples included a 2 litre plastic bottle for nutrients and physical measurements, a 125 mL plastic bottle for total and extractable metals and a 125 mL plastic bottle for dissolved metals. This last sample was filtered in the field prior to preservation. Sample collection, preservation and analysis methods are shown in Appendix I, Table 1.

The parameters analyzed in each nutrient sample are as follows:

- pH
- conductivity
- colour
- turbidity
- non-filterable residue
- total alkalinity
- filterable residue
- total phosphorus
- nitrites
- nitrite + nitrate
- ammonia
- sulphate
- chloride

The following parameters were analyzed in each of the dissolved, total and extractable metals sample:

aluminium (Al)	copper (Cu)	selenium (Se)
antimony (Sb)	iron (Fe)	silicon (Si)
arsenic (As)	lead (Pb)	silver (Ag)
boron (B)	magnesium (Mg)	sodium (Na)
barium (Ba)	manganese (Mn)	strontium (Sr)
beryllium (Be)	molybdenum (Mo)	tin (Sn)
cadmium (Cd)	nickel (Ni)	titanium (Ti)
calcium (Ca)	phosphorus (P)	vanadium (V)
chromium (Cr)	potassium (K)	zinc (Zn)
cobalt (Co)		

The analyses were completed at the Environmental Protection Laboratory, 4195 Marine Drive, West Vancouver, B.C.

3.2 Water Quantity

Stream flow was measured at selected stations using a Marsh McBirney Electromagnetic Flow Meter. Eleven or more velocity readings, in centimetres per second, were taken across the width of each South McQuesten River Station. On the narrower Christal and Flat Creek Stations five or more readings were taken. Stream flows were calculated by dividing the width of the stream into equal blocks, according to the number of readings taken, then the area of each block was determined (water depth X block width). This area was then multiplied by the stream velocity for each block giving a cubic meter per second value (m^3/sec). All block flows were added together to arrive at a total discharge value.

Flows could not be measured at any of the South McQuesten River sites in September due to high water. The Mayo district had received over 250% of their normal precipitation totals for the month of September (Yukon Weather Centre, 1990).

3.3 Sediments

Sediment samples were collected in triplicate during the July sampling. A teflon scoop shovel was used to collect the samples. The samples were placed in paper geochemical sampling bags, packaged in plastic bags and then frozen within 48 hours of collection. A description of sediment collection, preparation and analysis methods is given in Appendix I, Table 2.

Each sample was analyzed for particle size composition and the following metals:

aluminium (Al)	iron (Fe)	silicon (Si)
arsenic (As)	lead (Pb)	silver (Ag)
barium (Ba)	magnesium (Mg)	sodium (Na)
beryllium (Be)	manganese (Mn)	strontium (Sr)
cadmium (Cd)	mercury (Hg)	tin (Sn)
calcium (Ca)	molybdenum (Mo)	titanium (Ti)
chromium (Cr)	nickel (Ni)	vanadium (V)
cobalt (Co)	phosphorus(P)	zinc (Zn)
copper (Cu)	potassium(K)	

Particle size analysis was carried out by the Water Survey of Canada Laboratory in New Westminister, B.C. The sediment samples were analyzed for metals at the Environmental Protection Laboratory, 4195 Marine Drive, West Vancouver, B.C.

3.4 Bottom Fauna

Benthic invertebrate sampling was conducted using artificial substrate samplers. The samplers were cylindrical wire baskets (maximum volume = 0.0057 cubic meters) filled with local substrate material ranging from 2 cm to 6 cm in size. The material was hand cleaned to remove organic debris and invertebrates. Three samplers per site were placed in the stream where in situ measurements, water and sediment samples were collected, on July 24 to 26, 1990. The samplers were left to be colonised for a period of approximately 8 weeks. On September 19 to 21, 1990 the baskets were retrieved and immediately placed into a Wildco wash bucket with 0.5 mm mesh bottom. The bucket was held downstream during retrieval of the sampler in order to capture any escaping organisms. Rock and large wood debris was hand scrubbed in the wash bucket to remove invertebrates and then discarded. Invertebrates and fine debris from each basket were combined into a composite sample for each station. A 10% formalin solution was used to preserve the samples until sorting could be carried out.

In the Whitehorse Environmental Protection lab, bottom fauna were removed from the other material and placed in a labelled vial containing 70% methanol. These vials were sent to Dr. Charles Low, a consulting Invertebrate Biologist in Victoria, B.C., for identification and enumeration of the invertebrates.

3.5 Laboratory Quality Control

Systematic error and sample contamination during analysis at the Environment Protection Laboratory are minimised through duplicate analysis, procedural blanks and the use of standard reference materials. Internal lab quality control is carried out routinely in all water and sediment analysis before results are released.

At the Whitehorse lab, prior to shipping out the invertebrates, the retained debris was randomly re-sorted to ensure all organisms had been removed.

4.0 RESULTS AND DISCUSSION

4.1 Water Quality

In situ measurement, nutrients and metals (dissolved, extractable and total) results for both sample periods are presented in Appendix II, Tables 1 and 2. Criteria recommended for drinking water and aquatic life are presented in Appendix I, Table 4.

In September, an additional seven stations were sampled to assist in determining possible sources of contaminants to the receiving waters of the study area.

Galena Creek (Stations 15 and 16) flows directly into Flat Creek. Stations 17 to 19 eventually flow or seep into Flat Creek. No Cash 500 adit (Station 20) flows across the highway into the swamp area. From the examination of airphotos (flown in 1987), no defined stream channels could be determined draining the swamp area. The waters either seep overland or underground to eventually enter Christal Creek and/or the South McQuesten River. In June 1991, a small creek was observed flowing into the South McQuesten River just downstream of the confluence with Christal Creek, by EP field staff. Water quality samples were collected and the results indicated clean water (Vic Enns, Personal communication). Stations 13 and 14 have the same fate as Station 20. Galkeno 900 adit (Station 21) flows into Christal Lake which is drained by Christal Creek.

These sites will not be discussed parameter by parameter (although all the data is included in Appendix II) but only as applicable where discussing the various receiving stations' water quality.

Station 12, which is a small unnamed tributary of South McQuesten River approximately 1.5 km upstream of Station 4, was sampled in July and also in September as a possible source of overland drainage from the tailings area. There were very low levels of metals and the only anomaly was elevated levels of barium. The highest level of barium (0.119 mg/L) for the study area was recorded here. This is well below the recommended limit of 0.5 mg/L for the protection of aquatic life.

4.1.1 Temperature

In situ temperature readings reflected the seasonal changes. Generally, the South McQuesten River was warmer than the tributaries.

4.1.2 pH

In July, pH measurements were determined in the field. In September, the pH meter malfunctioned and samples for pH were analyzed in the Vancouver lab. All of the waters tested were slightly alkaline. This is characteristic of the area (Environmental Protection Service, 1978).

4.1.3 Conductivity

Conductivity was determined in the field as well as in the Vancouver lab. For ease of interpretation, the in situ measurements were used as there was a significant increase in the conductivity values by the time they were read in the lab. Conductivity levels were generally high throughout. September values were lower than July values. The levels in the South McQuesten River were fairly consistent from upstream to downstream. In July conductivity was approximately 250 μmhos/cm and in September it was approximately 175 μmhos/cm. The tributaries had higher conductivity values.

A very high value of conductivity (1290 μmhos/cm) was recorded, during the september survey, at Galkeno 900 adit(station 21) and this is reflected in Christal Creek at Stations 1 and 2. High conductivity values, 468 to 850 μmhos/cm, occurred at Stations 15 to 19 and this could be influencing the high value at Station 7, Flat Creek. Upstream on Flat Creek, Station 6, the conductivity was approximately 100 μmhos/cm lower.

4.1.4 Dissolved Oxygen

All samples were well oxygenated ranging from 8.9 mg/L to 11.9 mg/L. Oxygen concentrations were at or near saturation although saturation levels were lower in September. The oxygen levels encountered in the study would not be limiting to aquatic life.

4.1.5 Colour

Colour values were generally low; 5 or 10 during July and 10 to 20 during September. Higher colour values were recorded at Station 13 in July and Station 19 in September.

4.1.6 Turbidity

Turbidity was low, 1 FTU or less, throughout the study area except at Stations 15, 40, 25 and 10 where the values were 15, 40, 25 and 10, respectively.

4.1.7 Alkalinity

Alkalinity values were similar between sampling periods. The tributaries had higher levels than the South McQuesten River.

4.1.8 Hardness

Hardness values generally reflected the conductivity levels due to concentrations of dissolved ions. There was little difference between total hardness and Ca+Mg hardness, indicating that the hardness levels were mainly attributed to the calcium and magnesium levels. The waters throughout the system are hard (121 to 180 mg/L as $CaCO_3$) to very hard (more than 180 mg/L as $CaCO_3$). The highest hardness value of 1190 mg/L as $CaCO_3$ occurred at Galkeno 900 adit (station 21) during the September, 1990 survey.

4.1.9 Sulphate

Sulphate levels were low in the South McQuesten River, 32 to 58 mg/L, but greatly elevated in the tributaries and adit flows. This is a result of oxidation of the sulphide rock associated with the ore bodies. The highest sulphate concentration was recorded at Galkeno 900, adit with a reading of 1090 mg/L.

4.1.10 Chlorides

Chlorides were generally low throughout, ranging from 0.5 mg/L in the South McQuesten River (Station 3) to 11.7 mg/L in the tailings seepage at Station 19.

4.1.11 Phosphorus

Total phosphorus values were low throughout the study area with one elevated level of 0.99mg/L at the tailings seepage (Station 19).

4.1.12 Ammonia

Ammonia is not considered a problem in the study area and all receiving waters were well below the guideline for the protection of aquatic life.

4.1.13 Filterable Residue

Filterable residue levels generally reflected the conductivity values.

4.1.14 Non-filterable Residue

NFR values were below the detection limit in the receiving waters but were elevated at Station 13 in July and Station 19 in September.

4.1.15 Metals - Dissolved, Extractable and Total

The following metals were not detected in the receiving waters (Stations 1 to 11): beryllium (Be), cobalt (Co), potassium (K), molybdenum (Mo), nickel (Ni), phosphorus (P), antimony (Sb), and vanadium (V).

Boron (B), barium (Ba), chromium (Cr), copper (Cu), sodium (Na), silicon (Si) and strontium (Sr) were detected in the receiving waters but were below the recommended maximum levels for drinking water and protection of aquatic life.

Silver (Ag) was detected in all the samples. The September values were not considered since results from 14 of the 21 samples reported Total Ag was less than Dissolved Ag. This suggested the dissolved metals samples were probably contaminated from the field filtering procedures. Only one sample (station 6) displayed the above trend during the July sampling. The guideline for the protection of aquatic life is 0.0001 mg/L and although all stations exceeded this level the recorded values were very low.

Aluminium (Al) was usually below detection at most stations. The guideline of 0.1 mg/L was exceeded in September in the total metals sample at Stations 3, 4, 8 and 9. Levels were nonetheless very low. The tailings seepage (Station 19) had an elevated level of 1.35 mg/L Aluminum but it was not detected in Flat Creek at Station 7.

Arsenic (As) was detected in July at Stations 3, 8 and 10. The recommended guideline for aquatic life is 0.05 mg/L. This was exceeded at all three sites although the highest concentration recorded was 0.07 mg/L.

Calcium (Ca) and magnesium (Mg) are components of the measure of hardness and their values reflect the hardness levels at the stations. Higher calcium and magnesium values could indicate influence from groundwater at those sites.

There was very little iron (Fe) in the dissolved state. A guideline of 0.3 mg/l total iron has been recommended for the protection of aquatic life. This was exceeded at the downstream site on the South McQuesten River at Station 11 in July. Iron values consistently increased as one progressed downstream on the South McQuesten River. Flat Creek at Station 7 had lower iron levels than in the river. Elevated levels of iron were recorded in the adit drainages and the tailings seepage. Iron is typically high in acid mine drainage (McNeely et al, 1979a). Orange staining was observed at some of these discharges. This indicates that iron hydroxides are precipitating from the water as the oxygen content (aeration) increases (Babb et al, 1985).

Manganese (Mn) seldom reaches concentrations of 1.0 mg/L in natural surface waters (CCREM 1987) and all the stations on the South McQuesten River were well below this. However, Christal Creek and the adit drainages had highly elevated levels, most of which were in the dissolved state. Galkeno 900 adit flow (Station 21) had a total concentration of 68.9 mg/L, contributing to the high levels recorded in Christal Creek. Stations 13 and 20 also had elevated levels (9.2 mg/L and 32.1 mg/L respectively) but there appears to be little impact on the South McQuesten River where eventually these waters would drain into. Manganese is often associated with subsurface and acid mine waters (McNeely et al, 1979b).

In surface waters divalent manganese will be rapidly oxidised to manganese dioxide which will then undergo sedimentation when the waters contain high dissolved oxygen and are slightly alkaline (Stumm and Morgan, 1970). This could be the case experienced in the study area as there are elevated manganese levels in the sediments at Station 1, 2, 4 and 7 (see Section 4.3.2). So, although there are very low levels of manganese in the water at Stations 4 and 7, manganese seems to be precipitating out and settling in these areas.

The toxicity of cadmium (Cd), copper (Cu), and lead (Pb) varies with hardness, and different guidelines are recommended depending on the hardness of the water. As mentioned previously all the water in the study area was hard or very hard. The guidelines for these various metals were under the hardness category of >120 mg/L $CaCO_3$.

For the protection of aquatic life a guideline of 0.0013 mg/L of cadmium has been recommended. This was exceeded both in July and September at Stations 1, 2 and 7. All cadmium levels in the South McQuesten River were very low. The highest total cadmium value of 0.193 mg/L was recorded in July at Station 13, the corresponding dissolved cadmium value being 0.112 mg/L.

A guideline of 0.004 mg/L of copper has been set to protect aquatic life. Dissolved copper values were all higher than the extractable and total values and therefore were disregarded as contaminated. This guideline was not exceeded by total copper measurements at any of the receiving stations. The highest concentration of copper (0.132 mg/L) occurred at Station 13 in July.

A lead concentration of 0.004 mg/L has been established as the recommended guideline for the support of aquatic life. This value was exceeded at Flat Creek (Station 7) in July and at Stations 1, 2, 7, 8, 9, 10 and 11 in September. The South McQuesten River Stations were slightly over the guideline. There were elevated levels of lead in the tailings area, Stations 16 to 19, at No Cash adit (Station 20) and at Station 13.

A guideline of 0.03 mg/L of zinc has been recommended for the protection of aquatic life. Values were generally low in the South McQuesten River but all total zinc concentrations exceeded this guideline in July. The guideline was exceeded in the South McQuesten River at one site only in September, Station 3, the upstream site. The guideline was exceeded on all occasions at the Christal

Creek sites. Of the remaining sites, the guideline was met in July at Station 12 and in September at Stations 6, 12 and 15.

Zinc was very high at the adit drainage sites (Stations 13, 14, 20 and 21) but surprisingly low at the tailings seepage sites (Stations 17 to 19). The high concentrations of zinc found in the adit seep waters were associated with high concentrations of manganese and sulphate. High concentrations of sulphate increases the zinc carrying capacity and favours the solution phase. As the concentration of sulphate goes down the carrying capacity will correspondingly go down and zinc will enter the particulate phase (Babb et al, 1985). Sulphate levels decrease downstream on Christal Creek (Appendix II), but the concentration of zinc in the sediments is greater downstream at Station 2 than at Station 1 (See Section 4.3.2).

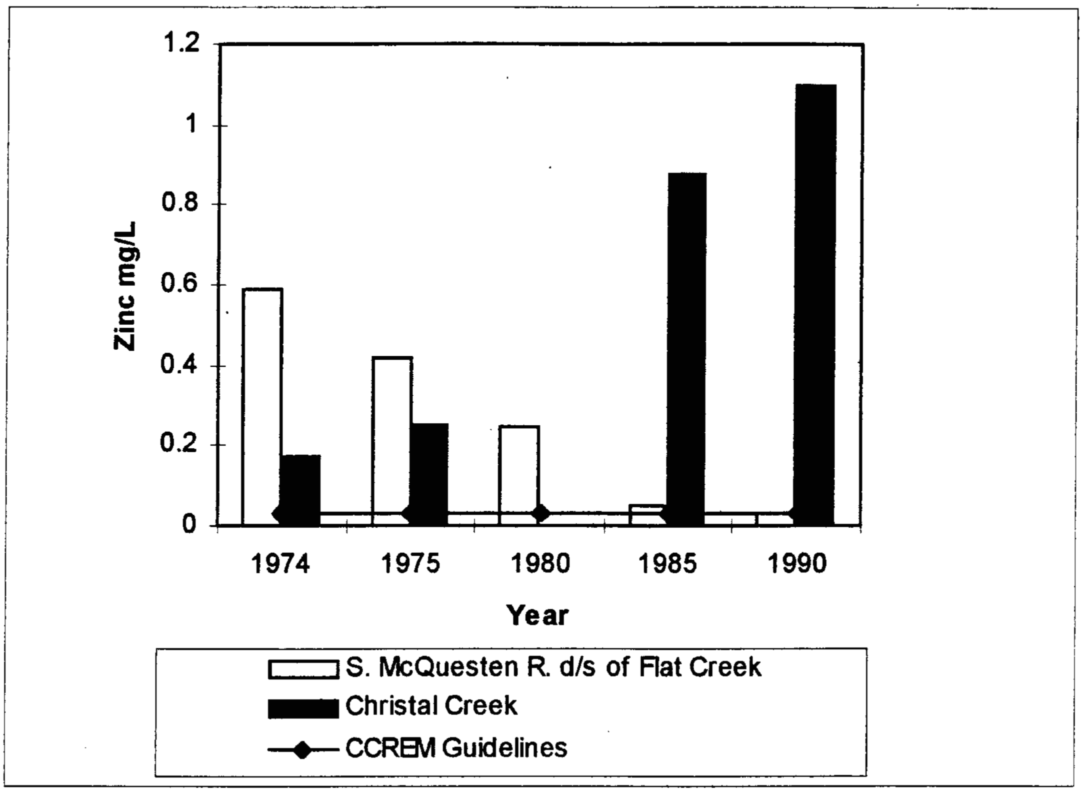
Table 2 presents historical data of zinc levels over the years reported in previous studies for Stations 1, 7, 8 and 9. Generally, zinc levels have increased at Christal Creek at Station 1, and decreased in the South McQuesten River downstream from Flat Creek at Station 9. This data has been summarised per year and is presented in Figure 4.

TABLE 2 HISTORICAL COMPARISON OF ZINC LEVELS IN WATER (mg/L)

Station	Description	EPS July 1974	EPS June 1975	EPS July 1975	EPS August 1980	EP July 1985	EP August 1985	EP July 1990	BURNS August 1990	EP Sept 1990
1	Christal Creek d/s of highway culvert	0.17	0.23	0.22		0.93	0.825	1.18		1.01
7	Flat Creek at old bridge crossing	0.73	0.77	0.6	0.349	0.23	0.215	0.076	0.112	0.217
8	S. McQuesten River u/s of Flat Creek	0.02		0.07	0.055	0.02	0.028	0.015	0.019	0.05
9	S. McQuesten River d/s of Flat Creek	0.59	0.74	0.09	0.244	0.029	0.065	0.013	0.024	0.055

Note: All zinc values are exctractable except Burns 1990, which is total.

FIGURE 4 HISTORICAL COMPARISON OF ZINC LEVELS AT CHRISTAL CREEK AND THE SOUTH MCQUESTEN RIVER



4.2 Water Quantity

Flow measurements were taken when possible during both visits at Stations 1, 2, 3, 4, 7, 8, 9, 10 and 11. This data is presented in Table 3. Flows had increased considerably by the September sampling and no flow measurements could be taken at any of the sites on the South McQuesten River due to high water.

TABLE 3 WATER FLOW MEASUREMENTS

Station	MEAN DEPTH (m)		STREAM WIDTH (m)		MEAN VELOCITY (m/sec)		DISCHARGE (m^3/sec)	
	July	Sept	July	Sept	July	Sept	July	Sept
1	0.10	0.11	1.4	1.55	0.37	0.45	0.06	0.09
2	0.10	0.2	2.3	1.8	0.21	0.46	0.08	0.24
3	0.33		11.5		0.49		2.20	
4	0.46		10.0		0.39		2.17	
7	0.08	0.29	1.4	1.8	0.23	0.46	0.03	0.30
8	0.39		17.5		0.23		1.93	
9	0.27		10.0		0.72		2.34	
10	0.28		13.6		0.54		2.56	
11	0.58		13.0		0.34		3.03	

4.3 <u>Stream Sediments</u>

4.3.1 Particle Size Distribution

Particle size distribution (%) results are presented in Appendix III Table 1. In general, the sediment samples were composed chiefly of material in the >2.0 mm size range, ranging from 64.5% at Station 1 (Christal Creek) to 83.6% at Station 11 (S. McQuesten River).

Station 1, Christal Creek just downstream of Christal Lake, had the greatest percentage of silt (2.9) of all the stations. It also had the highest amount of sands (grain size 0.063 to 1.0 mm).

The overall trend for the South McQuesten River was that the further downstream from the confluence with Christal Creek, the coarser the composition of the sediment.

Flat Creek sediments also, were comprised mainly of coarse sand and gravels.

4.3.2 Sediment Metal Analysis

The metals results are presented in Appendix III Table 2. Of the metals analysed, cobalt, molybdenum and tin were not detected. Of the metals detected cadmium, copper, manganese, lead and zinc are discussed in further detail in this section. Sediment sampling was conducted in 1985 (Davidge and Mackenzie-Grieve, 1989) and comparisons have been made between this data and the 1990 data for the above selected metals (see Table 4). Stations 2, 3, 4, 9, 10 and 11 were re-located from that used in 1985 to take advantage of the existing access. Differences in sediment chemistry for these sites between 1985 and 1990 may be explained by this change.

TABLE 4 COMPARISONS OF METALS IN SEDIMENTS FROM 1985 AND 1990

STATION NUMBER	1985 Cd (mg/kg)	1990 Cd (mg/kg)	1985 Cu (mg/kg)	1990 Cu (mg/kg)	1985 Mn (mg/kg)	1990 Mn (mg/kg)	1985 Pb (mg/kg)	1990 Pb (mg/kg)	1985 Zn (mg/kg)	1990 Zn (mg/kg)
1	12.5	32.2	43.1	39.6	2087	32133	149	<86	2323	8967
*2	96.3	53.9	93.4	50.5	133	36933	4040	**1088	6097	10400
*3	<0.7	5.7	23.9	22.3	497	1018	24	22	169	212
*4	13.5	36.5	35.4	46.3	2550	19800	463	1069	1058	2423
7	103.5	130.7	161.3	171.3	<0.2	**45233	5063	4580	6533	9247
8	29.1	21.4	35.8	40.1	2353	4947	877	791	1830	1220
*9	62.8	20.6	116.6	51.7	<209	6180	3723	1110	3380	1490
*10	8.9	17.0	50.6	48.2	2620	5087	242	493	642	1082
*11	0.8	34.5	28.2	31.3	628	1697	52	**180	116	316

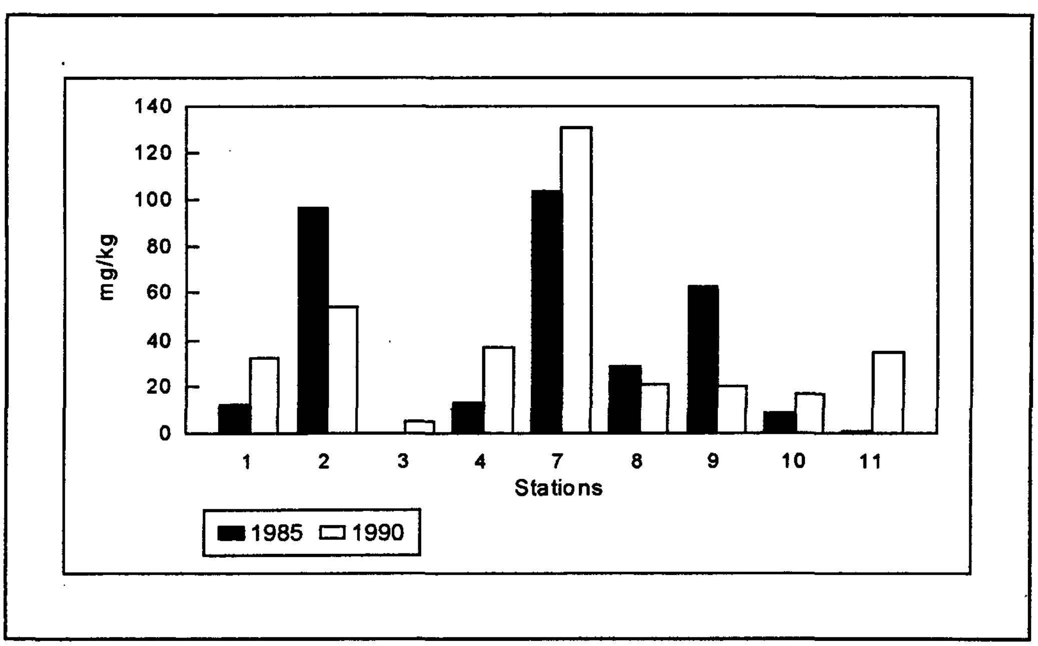
Note: All values are the mean for triplicate samples.
* Exact Locations differ between 1985 and 1990.
** Significant differences ($p < 0.05$) between the two sampling surveys.

Cadmium, copper, manganese, lead and zinc were elevated in the sediments of the two streams draining the UKHM mining area (Christal Creek and Flat Creek) in 1985 and 1990. Except for copper, all the metals had higher concentrations in 1990 than in 1985 at the far downstream sites (Stations 10 and 11) on the South McQuesten River. The historical comparison of zinc shown on Table 2 indicates that increases in metal loading from the site may be responsible for higher metal concentrations in the sediments as the bedload gradually moves downstream.

Christal Creek showed an impact on the South McQuesten River sediments. The background station (Station 3) had very low metals values, but the levels were significantly higher at Station 4, downstream of Christal Creek. Flat Creek also exhibited an impact on the South McQuesten River sediments as levels were lower upstream than downstream. The influence of Flat Creek on South McQuesten sediments was less than that of Christal Creek, especially in 1990.

Cadmium levels were elevated in Christal Creek and in Flat Creek, although Flat Creek appeared to have no impact on the South McQuesten River sediments. There were increased levels of cadmium in 1990 at Station 11, the site furthest downstream on the South McQuesten River (See Figure 5). The average cadmium concentration at this site was 34.5 mg/kg. The average concentration of cadmium in the earth's crust is 0.2 mg/kg (Taylor, 1964). Cadmium is commonly found associated with zinc sulphide ore, particularly sphalerite, which is a common mineral in the study area.

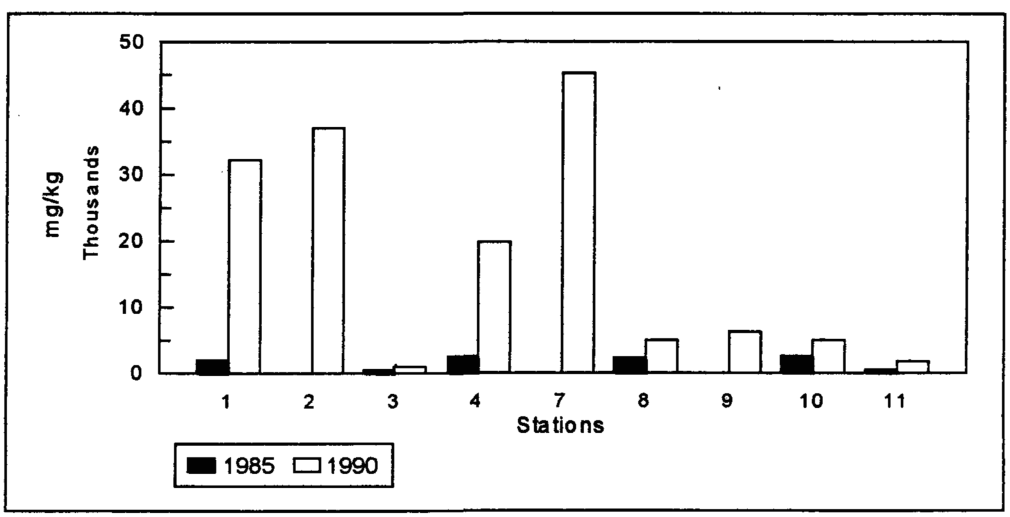
FIGURE 5 SEDIMENT CADMIUM DATA FOR 1985 AND 1990



Copper results were very similar for both years with the exception of the South McQuesten River just downstream of Flat Creek (Station 9) which was twice as high in 1985 as in 1990. This may be partly explained by the relocation of Station 9 further downstream of the confluence of Flat Creek in 1990.

Manganese levels were greatly elevated in 1990 at Flat Creek (Station 7). Although all the stations seem to show elevated manganese levels in 1990, the values were not significantly different (p>0.05) than the concentrations reported in 1985. Manganese is often present in zinc minerals and the same trend was observed with the zinc levels in the sediments.

FIGURE 6 SEDIMENT MANGANESE DATA FOR 1985 AND 1990



Significant Diference at Station 7 (p<0.05)

Lead levels were significantly lower in 1990 than in 1985 at Station 2 while being significantly higher at station 11 (See Table 4).

As previously mentioned, the concentrations of zinc in the sediments followed the same trend as for manganese. It would be expected that sediments of rivers draining mineralized areas would have elevated zinc levels. Sediments remove about 70% of water-borne zinc from rivers (Taylor, 1980).

Several factors influence exchanges across the sediment-water interface. Although metals may be bound in sediment, physical or chemical changes such as a lowering of pH, could place them into solution making them available to aquatic life (Forstner, 1989).

4.4 Stream Benthic Fauna

Appendix IV, Table 1 shows the taxonomic list of the bottom fauna collected in the study area. Appendix IV, Table 2, shows the distribution of the invertebrates identified in the samples.

Invertebrates were keyed to species where possible, or to genus or family level only, if full identification was not possible. However, some invertebrates could only be keyed to the phylum level, such as nematodes. Genera or species shown in brackets indicate that the identification was tentative.

4.4.1 Taxonomic Features

A total of six phyla were found in the study area: arthropoda, nematoda, platyhelminthes, annelida, coelenterata, and mollusca. These phyla represent 161 different taxonomic groups, most of which were identified to the genus or species level. The vast majority of the invertebrates collected were of the Class Insecta (94.5%). A total of 16,580 individuals was collected from the nine stations sampled.

The greatest number of individuals (6876) was found at Station 3 on the South McQuesten River, which acts as a control station for this study as it is upstream of the mine influenced tributaries.

The lowest abundance (166) occurred at Station 7, Flat Creek, which is the station that receives the greatest influence from the tailings pond decant and seepages.

Taxonomic richness was determined for each site. All taxonomic groups were included from species up to phylum, with the presence of a taxon representing one count. Therefore if there were 16 different taxonomic groups in one sample, the taxonomic richness would be 16. The taxonomic richness ranged from a low of 24 at Station 7, Flat Creek, to a high of 82 at Station 11, the South McQuesten River 27 km downstream from Flat Creek. The summarized data is shown in Table 5.

The percent composition of the different orders was calculated for each station and based on this the dominant order for each site was determined. An order was considered dominant if it formed 25% or more of the total invertebrates at that station. Some sites had two dominant orders. These data are also presented in Table 5. Diptera was the dominant or co-dominant order at each of the stations except for Station 7, Flat Creek, where Homoptera was the dominant order. Homoptera are terrestrial and the family Aphididae, which was in abundance here, are aphids. There is a great deal of overhanging vegetation at the Flat Creek site and the aphids probably fell into the stream during the retrieval process. The dominant aquatic order was Plecoptera, with the genus Nemoura forming the majority. Nemoura has been shown to exhibit adaptation to various pollutants (Wiederholm, 1984). Plecoptera was also the dominant or co-dominant order at Stations 1,2,4 and 8.

FIGURE 7 STATION LOCATIONS FOR TABLE 5

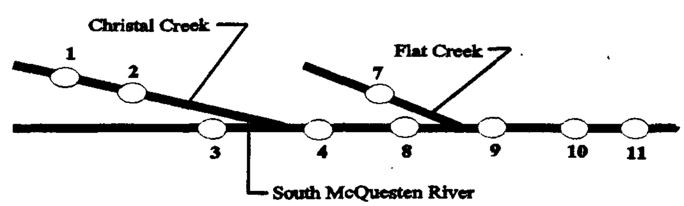


TABLE 5 SUMMARY OF ABUNDANCE, TAXANOMIC RICHNESS AND DOMINANCE

Station	1	2	3	4	7	8	9	10	11
Abundance (#/volume or surface)	496	1464	6876	706	166	285	755	2525	3307
Taxonomic Richness	41	30	62	48	24	41	42	51	82
Dominant Order (%)	D 40.7%	D 48.1%	D 86.6%	P 38.5%	H 46.4%	D 28.4%	D 58.8%	D 79.6%	D 56.8%
Subdominant Order %	P 34.7%	P 39.1%		D 27.5%	P 31.3%	P 26.3%			

D = Diptera P = Plectora H = Homoptera

4.4.2 Tributary Stations

Diptera and Plecoptera were the dominant orders at Christal Creek, Station 1. Simulidae (Black flies) was the dominant family within the order Diptera. Simulidae was also the dominant family in 1975 and 1985. The habitat is ideal for the larvae at this location as it is shallow and the current is swift. There were high levels of zinc in the water sampled on both dates, well over the recommended guideline for the protection of aquatic life. However, the most tolerant benthic organisms to heavy metals, have been found to be insect larvae (Spear, 1981).

At Christal Creek (Station 2), abundance had increased approximately three times but the taxanomic richness had decreased. Simulium was also one of the dominant genera.

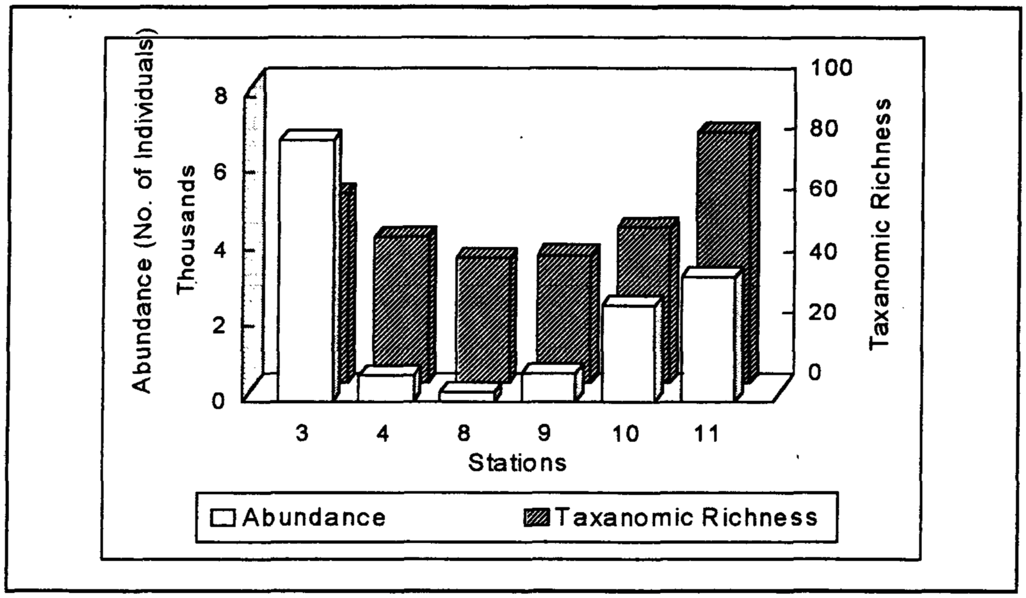
Flat Creek, Station 7, had the lowest population and taxonomic richness of all the sites sampled. Zinc levels exceeded the recommended guideline at this site, ranging from 0.069 to 0.254 mg/L. Toxicity of zinc increases in the presence of other metals often producing an additive or synergistic effect (Taylor and DeMayo 1980, Nriagu, 1980). Lead levels were above the recommended guideline (CCREM, 1987) except for dissolved lead, both in July and September. However, both copper and cadmium levels were below the recommended limit. As levels of metals in the sediments were greater here than at any of the other stations (Appendix III, Table 2), this could have contributed to the low abundance and diversity of the benthic community.

4.4.3 South McQuesten River Stations

Abundance and taxonomic richness values for the stations on the South McQuesten River were plotted (See Figure 8). It appears from this graph that both abundance and diversity decrease after the confluence with Christal Creek. The sites start to recover downstream of Flat Creek and continue to improve downstream to Station 11. Due to high water in September some difficulty was encountered in retrieving the baskets from Stations 10 and 11. It is believed that some organisms were lost in this process and although abundance had continually increased downstream of Flat Creek, it can be assumed that there would be even greater abundance at Stations 10 and 11 than recorded. Generally, the downstream site Station 11 was similar in abundance and taxanomic richness to the upstream site Station 3, although species composition was different.

Diptera was the dominant order at all the sites. No one particular family displayed dominance but several taxa within the order Diptera were well represented at each station.

FIGURE 8 ABUNDANCE AND TAXANOMIC RICHNESS SOUTH MCQUESTEN RIVER STATIONS



The study area has been the subject of eight studies from 1975 to 1990. This historic data is summarised in Table 6.

TABLE 6 HISTORIC SUMMARY OF BENTHIC ANALYSES FOR STATIONS 1,3,7,8 AND 9

Study & Year	EPS 1975	EPS 1985	N.BIOMES 1986	N. BIOMES 1987	Leverton 1988	Burns 1989	Burns 1990	EPS 1990
STATION 1								
Total # of individuals	197	655						496
Total taxa	16	31						41
Dominance and %	D 77.7	D 74.2						D
								P
STATION 3								
Total # of Individuals	357	683						6876
Total taxa	21	26						62
Dominance and %	D 81.8	D 76.3						D
STATION 7								
Total # of individuals	8	95	3343	1976	282	33	143	166
Total taxa	5	14	22	26	20	10	12	24
Dominance and %	D 62.5	D 42.1	D 80.7	P 59.4	D 50.3	D	P	H
		P 41.1		D 36.2	P 42.2	D		P
STATION 8								
Total # of individuals	1129	140	1370	1955	551	996	3516	285
Total taxa	24	20	46	43	36	39	55	41
Dominance and %	D 87.9	D 32.9	D 67.9	D 74.4	D 44.5	D	D	D
		P 25.7				P		P
Station 9								
Total # of individuals	4390	1492	2056	775	740	636	841	755
Total taxa	15	25	34	37	35	20	45	42
Dominance and %	D 98.5	D 92.8	D 64.1	D 46.5	D 40.6	P	D	D
			E 21.2	E 22.2	E 27.7			

Note: Total # of individuals data has been normalized to provide equivalent units.
D = Diptera
P = Plectopera
H = Homoptera
E = Ephermoptera

Invertebrate abundance has fluctuated over the years and this variance can be attributed to many factors such as climate, flow, life cycles of various organisms, timing and methods of sampling etc. At Station 9 the population decreased to approximately 800 individuals in 1987 and remained in that general range for the next three years until 1990. There has been a shift in dominance from Diptera to Diptera and Ephemoptera for several years and then back to Diptera. In general, most of the stations throughout the years were dominated by Dipterans. Species composition within the order Diptera was different between years.

It is difficult to interpret the McQuesten data collected under the terms of the water licence, as there was no station upstream of Christal Creek, which is a major source of zinc enrichment to the South McQuesten River. Neither the 1975 nor the 1985 EP data display clear trends in abundance and diversity at the three South McQuesten stations.

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APPENDIX I

COLLECTION, PRESERVATION, ANALYSIS OR IDENTIFICATION METHODS AND WATER QUALITY CRITERIA

APPENDIX 1 TABLE 1 WATER SAMPLE COLLECTION, PRESERVATION AND ANALYSIS METHODS

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE	ANALYTICAL PROCEDURE	METHOD SECTION
Temperature	0.1°C	In situ temperature reading.	YSI Conductivity and Temperature Meter. Model 33.	
Flow		In situ flow measurements using a Price-type current meter.	Cross-section of the stream was measured and the velocity of flow was calculated using the standard Price-type current meter method.	
Dissolved Oxygen	1.00 mg/L	In situ measurement. The instrument was calibrated in the field under wanter-saturated air condition.	YSI Dissolved Oxygen meter(in situ) Orion model 701 pH meter & Orion O_2 electrode (laboratory)	
pH	0.1 pH units	Small aliquots of sample were taken and read soon after collection. No preservative. Instrument was calirated using 7.0 buffering solution.	Potentiometric	080
Conductivity	0.2 umhos/cm	In situ measurement. Laboratory measurement, specific conductivity at 25+C. No preservative. The measurement was taken from the same sample as NH_3 below.	YSI Conductivity meter model 33 (in situ).Radiometer conductivity meter (CDM2D(laboratory).	044
Colour	5 (colour units)	Same sample as NH_3.	Platinum-cobalt visual comparison	040
Turbidity	0.1 (FTU)	Same sample as NH_3 .	Nephelometric turbidity	130
Non-Filterable Residue (NFR)	5.0 mg/L	Same sample as NH_3 .	Filtration, drying and weighing of filtrate	104
Filterable Residue (FR)	10.0 mg/L	Same sample as NH_3 .	Filtration, drying and weighing of filtrate.	100
Total Alkalinity	1.0 mg/L as $CaCO_3$	Same sample as NH_3 .	Potentiometric titration	006

APPENDIX 1 TABLE 1 WATER SAMPLE COLLECTION, PRESERVATION AND ANALYSIS METHODS

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE	ANALYTICAL PROCEDURE	METHOD SECTION
Ammonia NH_3-N	0.005 mg/L	Single samples collected in 2 litre linear polyethylene containers. Each container was rinsed 3 times with sample before it was filled. No preservatives. Stored at 4°C.	Phenol hypochlorimetric-automated	058
Nitrate NO_2-N	0.005 mg/L	Same sample as NH_3.	Diazotization-colorimetric-automated	070
Nitrate NO_3-N	0.005 mg/L	Same sample as NH_3.	Cadmium-copper reduction-colorimetric-automated	072
Total Phosphate T PO_4-P	0.002 mg/L	Same sample as NH_3.	Ascorbic acid-persulphate, automated autoclave digestion	086
Sulphate SO_4	1 mg/L	Same sample as NH_3.	Automated methylthymol-blue colorimetric	122
Chloride Cl	0.5 mg/L	Same sample as NH_3.	Thiocyanate-combined reagent-colorimetric	024

APPENDIX 1 TABLE 1 WATER SAMPLE COLLECTION, PRESERVATION AND ANALYSIS METHODS

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE	ANALYTICAL PROCEDURE	METHOD SECTION
Extractable/Total Dissolved Metals	mg/L	**Total/Extractable metals** collected in 125 mL linear polyethylene bottles. Each bottle was rinsed 3 times with sample before filling. Preserved to a pH <1.5 using 1.0 mL concentrated HNO_3.	Inductively Coupled Agron Plasma	210/220
Ag	0.01			
Al	0.05			
As	0.05			
B	0.01			
Ba	0.001			
Be	0.001	**Dissolved metals** were collected in 125 mL linear polyethelene bottles rinsed 3 times with sample before filling. Filtered in field using 0.45 um cellulose nitrate filters. Preserved to pH <1.5 using 1.0 mL concentrated HNO_3.		203
Ca	0.1			
Cd	0.005			
Co	0.005			
Cr	0.005			
Cu	0.005			
Fe	0.005			
Mg	0.10			
Mn	0.001			
Mo	0.01			
Na	0.1			
Ni	0.02			
Pb	0.05			
Sb	0.05			
Se	0.05			
Si	0.05			
Sn	0.05			
Sr	0.001			
Ti	0.002			
V	0.01			
Zn	0.002			

APPENDIX 1 TABLE 1 WATER SAMPLE COLLECTION, PRESERVATION AND ANALYSIS METHODS

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE	ANALYTICAL PROCEDURE	METHOD SECTION
Cd	0.001	Same sample as metals.	<u>Graphite Furnace-Atomic Absorption Spectrometry</u>	330
Cu	0.0005	Same sample as metals.		
Pb	0.0005	Same sample as metals.		
Ag	0.0005	Same sample as metals.	<u>Graphite Furnace-Atomic Absorption Spectrometry</u>	330
Total Hardness	0.03 mg/L	Same sample as metals.		

Ca/Mg Hardness = 4.116Mg + 2.497Ca

[1] As described in Environment Canada (1976).
[2] As described in Department of Environment (1979).

APPENDIX 1 TABLE 2 SEDIMENT COLLECTION, PREPARATION AND ANALYSIS METHODS

PARAMETER	PREPARATION	ANALYSIS	METHODS CODE[1]
All Parameters	Creek and River Stations: Sediment samples were collected using a Teflon scoop to scoop stream sediments into sample bag. Three samples were collected at each station and placed in geochemical paper sample bags. Each sample is then sealed in plastic bags and frozen or keep cool within 24 hours.		231
Metals Al, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Mg, Hg, K Mn, Mo, Na, Ni, P, Pb, Sb, Si, Sn, Sr, Ti, V, Zn	Sample was oven-dried at 40°C to remove water. Sample was sieved through a size 100 mesh (.15mm) stainless steel sieve. The portion passing through was analyzed for leachable metals.		236/238/ 242
	Sample was leached with HCl and HNO_3. The sample was heated for 3 hours.	Inductively Coupled Argon Plasma (ICAP)	320
As	Same as other metals.	Hydride Generation ICAP	350
Ag	Same as other metals.	Flame Atomic Absorption	330
Particle Size	Sample was oven-dried.	Standard Sieving Operation	078

[1] Department of Environment, Department of Fisheries and Oceans, Laboratory Manual, Environmental Protection Service, Fisheries and Marine Service (1979).

APPENDIX 1 TABLE 3 BOTTOM FAUNA COLLECTION, PRESERVATION AND IDENTIFICATION METHODS

FIELD COLLECTION, SAMPLING PROCEDURES AND PRESERVATION	LABORATORY PROCEDURES	IDENTIFICATION AND ENUMERATION
Artificial Substrate Sampler: Stream benthic invertebrtaes were collected using cylindrical wire baskets (17 cm dia x 25 cm) filled with local stream bed rock material at each station. The stream bed material ranged from 2 to 6 cm in diameter. Rocks were lightly scrubbed by hand and placed into the baskets until full. Three samples were placed at each station, tethered to shore using polypropylene rope and were allowed to colonize for about 57 days. When the samples were retrieved they were quickly placed into a Wildco wash bucket with a 0.5 mm mesh bottom. All rock material was hand washed in the bucket to remove invertebrates.	Bottom fauna was sorted from other material and placed in a vial containing 70% methanol.	Bottom fauna samples were sent to Dr. C. Low, a Consulting Invertebrate Biologist, Nanaimo, B.C. for identification to genus and species if possible and enumeration of sample.

APPENDIX 1 TABLE 4 WATER QUALITY CRITERIA FOR DRINKING WATER AND AQUATIC LIFE

SUBSTANCE	RECOMMENDED LEVEL (S) FOR DRINKING WATER	REFERENCE(S)	RECOMMENDED LEVEL(S) FOR AQUATIC LIFE	REFERENCE(S)
Physical				
Colour (TCU)	<15	1		
Temperature (°C)	15			
Odour and taste	If offensive	1		
Turbidity NTU	<5	1		
Coliform-Total	10	1	recreational water Total	
(count/100mL)			500-1000/100mL	9
fecal coliform	0	1	200 /100mL	9
Chemical				
*Alkalinity mg/L	Not considered a public			
(Total)	health problem	4	>20	3
*Aluminum (Al) mg/L	Not considered a public		0.1 at pH >6.5	
	health problem	7		5
Ammonia total	0.5	4	2.2 at pH 6.5 temp 10°C	
(NH3-N)mg/L			1.37 at ph 8.0 temp 10°C	10
Antimony (Sb) mg/L				
Arsenic (As)	0.05	1	<0.05	10
total mg/L			5.0	7
Barium (Ba) mg/L	1.0	1		
Boron (B) mg/L	5.0	1	0.0002 for hardness 0-60mg/L $CaCO_3$	
*Cadmium (Cd)	0.005	1	0.0008 for hardness 60-120mg/L $CaCO_3$	
total mg/L			0.0013 for hardness 120-180mg/L $CaCO_3$	
			0.0018 for hardness >180mg/L $CaCO_3$	10
Calcium (Ca)mg/L	75-200	7		
Chloride (Cl)mg/L	<250 aesthetic objectives	1	0.02 to protect fish	
**Chromium (Cr)	0.05	1	0.002 to protect aquatic life	
total mg/L				10
Cobalt (Co)mg/L				
Conductivity @ 25°C (umhos/cm)	Depends on dissolved salts	7	150-500	6

APPENDIX 1 TABLE 4 WATER QUALITY CRITERIA FOR DRINKING WATER AND AQUATIC LIFE

SUBSTANCE	RECOMMENDED LEVEL(S) FOR DRINKING WATER	REFERENCES(S)	RECOMMENDED LEVEL(S) FOR AQUATIC LIFE	REFERENCE
*Copper (Cu) total mg/L	<1.0 aesthetic objective	1	0.002 at hardness 0-120mg/L $CaCo_3$ 0.004 at hardness 120-180mg/L $CaCO_3$ 0.006 at hardness >180mg/L $CaCO_3$	
Cyanide (CN) mg/L	0.2	1	0.005 (free)	10
Dissolved oxygen (% saturation)	Near 100%	4	>5.0mg/L	10
Fluoride (F)mg/L	1.5	1	1.5	7
Hardness (Total) as mg/L CaCO3	80-100	1		
Iron (Fe) total mg/L	<0.3 aesthetic objective	1	0.3	10
Lead (Pb) total mg/L	0.05	1	0.001 at hardness 0-60mg/L $CaCO_3$ 0.002 at hardness 60-120mg/L $CaCO_3$ 0.004 at hardness 120-180mg/L $CaCO_3$ 0.007 at hardness >180mg/L $CaCO_3$	10
Magnesium (Mg)mg/L	50	4		
Manganese (Mn)mg/L	<0.05 aesthetic objective	1	1.0	7
Mercury (Hg) total mg/L	0.001	1	0.0001	10
Molybdenum (Mo)mg/L				
Nickel (Ni) total mg/L	0.25	2	0.025 at hardness 0-60mg/L $CaCO_3$ 0.065 at hardness 60-120mg/L $CaCO_3$ 0.11 at hardness 120-180mg/L $CaCO_3$ 0.15 at hardness >180mg/L $CaCO_3$	10
Nitrate (NO3-N)mg/L	10	1		
Nitrite (NO2-N)mg/L	1.0	1	0.06	10
pH units	6.5-8.5	1	6.5-9.0	
Phosphate (PO4)mg/L	0.2	8		
*Phosphorus (P)mg/L (Total)			0.020 to prevent algae	5
Potasium (K) mg/L				
Residue: Filterable mg/L (Total dissolved solids)	<500 aesthetic objective	4	70-400 with a maximum of 2000	6
Residue: Non-Filterable (mg/L) (TSS)			increase of 10mg/L with bkgd<100mg/L increase of 10% above bkgd with bkgd >100.0mg/L	8 10

APPENDIX 1 TABLE 4 WATER QUALITY CRITERIA FOR DRINKING WATER AND AQUATIC LIFE

SUBSTANCE	RECOMMENDED LEVEL(S) FOR DRINKING WATER	REFERENCES(S)	RECOMMENDED LEVEL(S) FOR AQUATIC LIFE	REFERENCE
**Selenium (Se) total mg/L	0.01	1	0.001	10
Silica (Si)mg/L				
*Silver (Ag) total mg/L		1	0.0001	10
Sodium (Na)mg/L		1		
Strontium (Sr)mg/L	10	1		
Sulphate (SO^4)mg/L	500	1		
Tin (Sn)mg/L	Not present in natural waters	7		
Titanium (Ti)mg/L				
Total Inorganic Carbon (TIC)				
Total Organic Carbon (TOC)	5.0	5		
Uranium mg/L	0.02	1		10
Vanadium (V)				
Zinc (Zn)mg/L	<5.0 aesthetic objective	1	0.03	10

* Use graphite furnace for the lab detection limit to be less than the recommended levels.
** Lab detection limit > recommended levels.

REFERENCES:

1. Health & Welfare Canada. 1987. Guidelines for Canadian Drinking Water Quality 1987. Supply and Services, Canada.

2. Inland Waters Directorate. 1980. Guidelines for Surface Water Quality, Vol. 1 Inorganic Chemical Substances. Environment Canada, Ottawa.

3. Thurston, R.V., R.C. Russo, C.M. Fetteroff Jr., T.A. Edsall, and Y.M. Barber Jr. (Eds.). 1979. A Review of the EPA Book: Quality Criteria for Water. Water Quality Section, American Fisheries Society, Bethesda, MD, 313p.

APPENDIX I   TABLE 4   WATER QUALITY CRITERIA FOR DRINKING WATER AND AQUATIC LIFE

SUBSTANCE	RECOMMENDED LEVEL(S) FOR DRINKING WATER	REFERENCES(S)	RECOMMENDED LEVEL(S) FOR AQUATIC LIFE	REFERENCE

4. Anonymous 1977. Guidelines for Establishing Water Quality Objectives for the Territorial Waters of the Yukon and Northwest Territories. Report of the *Working Group* on Water Quality Objectives to the Chairman, Water Boards, Yukon and Northwest Territories.

5. Ontario Ministry of the Environment. 1978. Water Management - Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment.

6. Environment Canada, 1976. Pollution Sampling Handbook. Pacific Region Laboratory Services, Fisheries Operations and Environmental Protection Service, West Vancouver, B.C.

7. California State Water Resources Control Board. 1963. Water Quality Criteria. Publication No. 3-A Second Edition by McKee and Wolf.

8. Inland Waters Directorate. 1979. Water Quality Source Book a Guide to Water Quality Parameters. Environment Canada, Water Quality Branch, Ottawa, Canada.

9. Health and Welfare Canada, 1983. Guidelines for Canadian Recreational Water Quality. Supply and Services Canada.

10. CCREM. 1987. Canadian Water Quality Guidelines. Task Force on Water Quality Guidelines of the Canadian Council of Resource and Environment Ministers. Ottawa.

APPENDIX II

WATER QUALITY DATA

APPENDIX II TABLE 1 WATER QUALITY DATA FOR JULY, 1990

STATION	SAMPLE DATE	TEMP (C)	pH INSITU	pH LAB	IN SITU COND. (umhos/cm)	LAB COND. (umhos/cm)	DISSOLVED OXYGEN (mg/L)	% DISSOLVED OXYGEN SATURATION	COLOR (REL. U.)	TURB. (FTU)	TOTAL ALK. (asCaCO3) (mg/L)	(Diss.) HARDNESS (asCaCO3) (mg/L)	(Diss.) TOTAL HARDNESS (mg/L)	(Extr.) HARDNESS (asCaCO3) (mg/L)	(Extr.) TOTAL HARDNESS (mg/L)	SULFATE (mg/L)	CHLORIDE (mg/L)
1	24-Jul-90	9.9	7.72	n/a	590	882	10.4	103	5	0.6	113	488	495	479	486	351.0	1.0
2	24-Jul-90	11.0	8.16	n/a	490	687	10.1	98	5	0.4	132	353	354	351	353	240.0	0.6
3	24-Jul-90	17.4	8.27	n/a	222	272	9.1	101	10	0.2	94	128	128	130	131	38.0	0.7
4	25-Jul-90	14.9	8.04	n/a	233	319	8.9	94	10	0.2	106	153	.154	148	148	51.7	0.7
6	26-Jul-90	7.5	8.00	n/a	278	466	10.6	99	<5	0.1	200	240	240	237	238	53.6	0.4
7	25-Jul-90	12.5	8.11	n/a	480	658	9.3	94	10	0.4	192	351	351	346	347	153.0	2.9
8	25-Jul-90	17.5	8.22	n/a	239	306	n/a	n/a	10	0.3	109	158	159	151	152	53.6	0.7
9	25-Jul-90	17.0	8.19	n/a	253	315	9.1	101	5	0.3	111	158	158	154	154	56.4	0.7
10	26-Jul-90	14.5	8.21	n/a	242	321	9.3	98	10	0.2	117	161	161	158	158	54.7	0.7
11	26-Jul-90	13.5	8.04	n/a	258	327	9.1	94	10	0.5	131	169	170	168	169	50.4	0.8
12	25-Jul-90	n/a	7.74	n/a	354	477	n/a	n/a	<5	0.2	185	244	244	236	236	70.2	0.6
13	26-Jul-90	7.5	8.00	n/a	278	1200	10.6	99	160	40.0	160	710	745	698	779	563.0	0.8
14	26-Jul-90	3.5	7.74	n/a	325	629	9.7	82	<5	0.2	88	296	297	287	288	221.0	0.7

APPENDIX II TABLE 1 WATER QUALITY DATA FOR JULY, 1990

STATION	TOTAL P (mg/L)	NITRITE (mg/L)	NITRITE+ NITRATE (mg/L)	AMMONIA (mg/L)	FR (mg/L)	NFR (mg/L)	ICP Diss. Ag (mg/L)	GF Diss. Ag (mg/L)	ICP Diss. Al (mg/L)	ICP Diss. As (mg/L)	ICP Diss. B (mg/L)	ICP Diss. Ba (mg/L)	ICP Diss. Be (mg/L)	ICP Diss. Ca (mg/L)	ICP Diss. Cd (mg/L)	GF Diss. Cd (mg/L)	ICP Diss. Co (mg/L)	ICP Diss. Cr (mg/L)	ICP Diss. Cu (mg/L)	GF Diss. Cu (mg/L)	ICP Diss. Fe (mg/L)
1	0.005	<0.002	0.095	0.012	710	<10	<0.01	0.0004	<0.05	<0.05	<0.01	0.061	<0.001	156.0	<0.005	0.0024	<0.005	<0.005	<0.005	0.0056	0.009
2	<0.002	<0.002	0.046	0.003	490	<10	<0.01	0.0004	<0.05	<0.05	<0.01	0.042	<0.001	109.0	<0.005	0.0013	<0.005	<0.005	<0.005	0.0025	0.006
3	0.003	<0.002	0.012	0.014	180	<10	<0.01	0.0003	<0.05	<0.05	<0.01	0.045	<0.001	33.8	<0.005	0.0004	<0.005	<0.005	<0.005	0.0024	0.035
4	0.002	<0.002	0.021	0.013	210	<10	<0.01	0.0004	<0.05	<0.05	<0.01	0.058	<0.001	41.4	<0.005	0.0003	<0.005	<0.005	<0.005	0.0026	0.035
6	0.004	<0.002	0.079	<0.002	290	<10	<0.01	0.0008	<0.05	<0.05	<0.01	0.084	<0.001	74.8	<0.005	0.0016	<0.005	<0.005	<0.005	0.0028	0.005
7	<0.002	<0.002	0.055	0.014	480	<10	<0.01	0.0002	<0.05	<0.05	<0.01	0.031	<0.001	98.4	<0.005	0.0009	<0.005	<0.005	<0.005	0.0047	0.006
8	0.002	<0.002	0.010	0.002	220	<10	<0.01	0.0005	<0.05	0.06	<0.01	0.061	<0.001	43.1	<0.005	0.0003	<0.005	<0.005	<0.005	0.0024	0.046
9	0.002	<0.002	0.008	0.003	240	<10	<0.01	0.0005	<0.05	<0.05	<0.01	0.061	<0.001	42.9	<0.005	0.0003	<0.005	<0.005	<0.005	0.0019	0.043
10	0.002	<0.002	0.011	0.010	220	<10	<0.01	0.0006	<0.05	0.06	<0.01	0.063	<0.001	43.7	<0.005	0.0005	<0.005	<0.005	<0.005	0.0019	0.042
11	0.002	<0.002	<0.002	0.005	230	<10	<0.01	0.0006	<0.05	<0.05	<0.01	0.079	<0.001	46.4	<0.005	0.0010	<0.005	<0.005	<0.005	0.0020	0.048
12	<0.002	<0.002	0.150	0.005	310	<10	<0.01	0.0007	<0.05	<0.05	<0.01	0.118	<0.001	65.3	<0.005	0.0003	<0.005	<0.005	<0.005	0.0012	0.009
13	0.039	<0.002	0.031	0.050	1120	60	<0.01	0.0004	<0.05	<0.05	<0.01	0.012	<0.001	236.0	0.112	<-----	0.010	<0.005	<0.005	0.0049	0.008
14	0.004	<0.002	0.396	0.005	440	10	<0.01	0.0004	<0.05	<0.05	0.02	0.024	<0.001	88.5	<0.005	0.0014	<0.005	<0.005	<0.005	0.0040	0.007

APPENDIX II TABLE 1 WATER QUALITY DATA FOR JULY, 1990

STATION	ICP Diss. K (mg/L)	ICP Diss. Mg (mg/L)	ICP Diss. Mn (mg/L)	ICP Diss. Mo (mg/L)	ICP Diss. Na (mg/L)	ICP Diss. Ni (mg/L)	ICP Diss. P (mg/L)	ICP Diss. Pb (mg/L)	GF Diss. Pb (mg/L)	ICP Diss. Sb (mg/L)	ICP Diss. Se (mg/L)	ICP Diss. Si (mg/L)	ICP Diss. Sn (mg/L)	ICP Diss. Sr (mg/L)	ICP Diss. Ti (mg/L)	ICP Diss. V (mg/L)	ICP Diss. Zn (mg/L)	ICP Extr. Ag (mg/L)	GF Extr. Ag (mg/L)	ICP Extr. Al (mg/L)	ICP Extr. As (mg/L)
1	<2	23.8	2.850	<0.01	1.6	<0.02	<0.1	<0.05	0.0023	<0.05	<0.05	3.49	<0.05	0.253	<0.002	<0.01	1.100	<0.01	0.0003	<0.05	<0.05
2	<2	19.6	0.362	<0.01	1.4	<0.02	<0.1	<0.05	0.0020	<0.05	<0.05	3.23	<0.05	0.215	<0.002	<0.01	0.266	<0.01	0.0004	<0.05	<0.05
3	<2	10.5	0.004	<0.01	1.4	<0.02	<0.1	<0.05	0.0011	<0.05	<0.05	1.62	<0.05	0.164	<0.002	<0.01	0.014	<0.01	0.0003	<0.05	0.07
4	<2	12.2	0.031	<0.01	1.5	<0.02	<0.1	<0.05	0.0015	<0.05	<0.05	1.89	<0.05	0.165	<0.002	<0.01	0.021	<0.01	0.0004	<0.05	<0.05
6	<2	12.8	<0.001	<0.01	1.0	<0.02	<0.1	<0.05	0.0021	<0.05	<0.05	3.01	<0.05	0.339	<0.002	<0.01	0.067	<0.01	0.0008	0.06	<0.05
7	<2	25.5	0.014	<0.01	5.6	<0.02	<0.1	<0.05	0.0030	<0.05	<0.05	2.32	<0.05	0.219	<0.002	<0.01	0.069	<0.01	0.0002	<0.05	<0.05
8	<2	12.3	0.043	<0.01	1.5	<0.02	<0.1	<0.05	0.0016	<0.05	<0.05	1.89	<0.05	0.166	<0.002	<0.01	0.013	<0.01	0.0005	<0.05	<0.05
9	<2	12.3	0.040	<0.01	1.6	<0.02	<0.1	<0.05	0.0013	<0.05	<0.05	1.86	<0.05	0.167	<0.002	<0.01	0.016	<0.01	0.0005	<0.05	<0.05
10	<2	12.6	0.037	<0.01	1.8	<0.02	<0.1	<0.05	0.0011	<0.05	<0.05	1.92	<0.05	0.174	<0.002	<0.01	0.021	<0.01	0.0006	<0.05	<0.05
11	<2	13.0	0.049	<0.01	2.0	<0.02	<0.1	<0.05	0.0014	<0.05	<0.05	2.26	<0.05	0.185	<0.002	<0.01	0.027	<0.01	0.0007	<0.05	<0.05
12	<2	19.7	0.010	<0.01	1.2	<0.02	<0.1	<0.05	0.0021	<0.05	<0.05	2.71	<0.05	0.127	<0.002	<0.01	0.007	<0.01	0.0006	<0.05	<0.05
13	<2	29.4	13.000	<0.01	1.5	0.07	<0.1	<0.05	0.0027	<0.05	<0.05	2.89	<0.05	0.304	<0.002	<0.01	6.810	<0.01	0.0015	0.57	0.08
14	<2	18.2	0.005	<0.01	2.4	<0.02	<0.1	<0.05	0.0020	<0.05	<0.05	3.55	<0.05	0.146	<0.002	<0.01	0.416	<0.01	0.0004	0.05	<0.05

APPENDIX II TABLE 1 WATER QUALITY DATA FOR JULY, 1990

STATION	ICP Extr. B (mg/L)	ICP Extr. Ba (mg/L)	ICP Extr. Be (mg/L)	ICP Extr. Ca (mg/L)	ICP Extr. Cd (mg/L)	GF Extr. Cd (mg/L)	ICP Extr. Co (mg/L)	ICP Extr. Cr (mg/L)	ICP Extr. Cu (mg/L)	GF Extr. Cu (mg/L)	ICP Extr. Fe (mg/L)	ICP Extr. K (mg/L)	ICP Extr. Mg (mg/L)	ICP Extr. Mn (mg/L)	ICP Extr. Mo (mg/L)	ICP Extr. Na (mg/L)	ICP Extr. Ni (mg/L)	ICP Extr. P (mg/L)	ICP Extr. Pb (mg/L)	GF Extr. Pb (mg/L)	ICP Extr. Sb (mg/L)
1	<0.01	0.059	<0.001	153.0	<0.005	0.0047	<0.005	<0.005	<0.005	<0.0005	0.206	<2	23.4	2.780	<0.01	1.5	<0.02	<0.1	<0.05	0.0026	<0.05
2	<0.01	0.042	<0.001	108.0	<0.005	0.0019	<0.005	<0.005	<0.005	<0.0005	0.082	<2	19.7	0.367	<0.01	1.4	<0.02	<0.1	<0.05	0.0013	<0.05
3	<0.01	0.047	<0.001	34.5	<0.005	<0.0001	<0.005	<0.005	<0.005	0.0008	0.115	<2	10.7	0.025	<0.01	1.4	<0.02	<0.1	<0.05	0.0006	<0.05
4	<0.01	0.058	<0.001	39.6	<0.005	0.0004	<0.005	<0.005	<0.005	0.0013	0.114	<2	11.9	0.041	<0.01	1.5	<0.02	<0.1	<0.05	0.0036	<0.05
6	<0.01	0.087	<0.001	73.5	<0.005	<0.0001	<0.005	0.006	<0.005	0.0009	0.109	<2	13.0	0.005	<0.01	1.0	<0.02	<0.1	<0.05	0.0033	<0.05
7	<0.01	0.030	<0.001	96.7	<0.005	0.0009	<0.005	0.006	<0.005	0.0025	0.100	<2	25.5	0.016	<0.01	5.7	<0.02	<0.1	<0.05	0.0119	<0.05
8	<0.01	0.062	<0.001	40.5	<0.005	0.0003	<0.005	<0.005	<0.005	0.0011	0.151	<2	12.2	0.050	<0.01	1.6	<0.02	<0.1	<0.05	0.0027	<0.05
9	<0.01	0.063	<0.001	41.4	<0.005	0.0002	<0.005	<0.005	<0.005	0.0007	0.150	<2	12.2	0.049	<0.01	1.6	<0.02	<0.1	<0.05	0.0019	<0.05
10	<0.01	0.064	<0.001	42.4	<0.005	0.0003	<0.005	<0.005	<0.005	0.0007	0.163	<2	12.6	0.044	<0.01	1.8	<0.02	<0.1	<0.05	0.0019	<0.05
11	<0.01	0.081	<0.001	45.7	<0.005	0.0002	<0.005	<0.005	<0.005	<0.0005	0.336	<2	13.0	0.058	<0.01	2.1	<0.02	<0.1	<0.05	0.0031	<0.05
12	<0.01	0.116	<0.001	62.4	<0.005	<0.0001	<0.005	<0.005	<0.005	<0.0005	0.075	<2	19.4	0.010	<0.01	1.3	<0.02	<0.1	<0.05	0.0014	<0.05
13	<0.01	0.012	<0.001	230.0	0.183	<------	0.021	<0.005	0.124	<------	12.600	<2	29.8	13.000	<0.01	1.5	0.09	<0.1	0.06	0.0998	<0.05
14	0.01	0.025	<0.001	85.0	<0.005	0.0011	<0.005	<0.005	<0.005	0.0022	0.140	<2	18.1	0.025	<0.01	2.4	<0.02	<0.1	<0.05	0.0022	<0.05

APPENDIX II TABLE 1 WATER QUALITY DATA FOR JULY, 1990

STATION	ICP Extr. Se (mg/L)	ICP Extr. Si (mg/L)	ICP Extr. Sn (mg/L)	ICP Extr. Sr (mg/L)	ICP Extr. Ti (mg/L)	ICP Extr. V (mg/L)	ICP Extr. Zn (mg/L)	ICP Total Ag (mg/L)	GF Total Ag (mg/L)	ICP Total Al (mg/L)	ICP Total As (mg/L)	ICP Total B (mg/L)	ICP Total Ba (mg/L)	ICP Total Be (mg/L)	ICP Total Ca (mg/L)	ICP Total Cd (mg/L)	GF Total Cd (mg/L)	ICP Total Co (mg/L)	ICP Total Cr (mg/L)	ICP Total Cu (mg/L)	GF Total Cu (mg/L)
1	<0.05	3.37	<0.05	0.243	<0.002	<0.01	1.180	<0.01	0.0005	<0.05	<0.05	0.01	0.060	<0.001	162.0	<0.005	0.0025	<0.005	0.007	<0.005	0.0008
2	<0.05	3.17	<0.05	0.215	<0.002	<0.01	0.290	<0.01	0.0006	<0.05	<0.05	0.03	0.044	<0.001	113.0	<0.005	0.0010	<0.005	0.011	<0.005	0.0010
3	<0.05	1.63	<0.05	0.163	<0.002	<0.01	0.003	<0.01	0.0005	<0.05	<0.05	0.03	0.052	<0.001	34.1	<0.005	0.0001	<0.005	<0.005	<0.005	0.0013
4	<0.05	1.81	<0.05	0.161	<0.002	<0.01	0.019	<0.01	0.0006	0.10	<0.05	0.02	0.061	<0.001	44.2	<0.005	0.0002	<0.005	0.007	<0.005	0.0025
6	<0.05	3.06	<0.05	0.338	<0.002	<0.01	0.004	<0.01	0.0006	0.34	<0.05	<0.01	0.090	<0.001	75.5	<0.005	<0.0001	<0.005	0.007	<0.005	0.0025
7	<0.05	2.26	<0.05	0.219	<0.002	<0.01	0.076	<0.01	0.0005	0.07	<0.05	0.02	0.032	<0.001	100.0	<0.005	0.0007	<0.005	0.009	<0.005	0.0029
8	<0.05	1.81	<0.05	0.167	<0.002	<0.01	0.015	<0.01	0.0006	0.09	<0.05	0.01	0.063	<0.001	44.2	<0.005	0.0002	<0.005	0.009	<0.005	0.0019
9	<0.05	1.81	<0.05	0.166	<0.002	<0.01	0.013	<0.01	0.0006	<0.05	<0.05	0.01	0.064	<0.001	44.0	<0.005	0.0001	<0.005	0.006	<0.005	0.0012
10	<0.05	1.89	<0.05	0.173	<0.002	<0.01	0.011	<0.01	0.0006	<0.05	<0.05	<0.01	0.066	<0.001	44.8	<0.005	0.0002	<0.005	0.007	<0.005	0.0030
11	<0.05	2.25	<0.05	0.185	<0.002	<0.01	0.009	<0.01	0.0006	<0.05	<0.05	<0.01	0.083	<0.001	48.4	<0.005	<0.0001	<0.005	0.008	<0.005	0.0016
12	<0.05	2.61	<0.05	0.124	<0.002	<0.01	<0.002	<0.01	0.0007	<0.05	<0.05	<0.01	0.119	<0.001	64.0	<0.005	<0.0001	<0.005	<0.005	<0.005	<0.0006
13	<0.05	3.59	<0.05	0.308	<0.002	<0.01	20.500	<0.01	0.0015	0.72	0.13	0.03	0.016	<0.001	254.0	0.193	<------	0.069	0.006	0.132	<------
14	<0.05	3.53	<0.05	0.144	<0.002	<0.01	0.434	<0.01	0.0006	0.33	<0.05	0.03	0.030	<0.001	92.3	<0.005	0.0009	<0.005	0.012	<0.005	0.0031

APPENDIX II TABLE 1 WATER QUALITY DATA FOR JULY, 1990

STATION	ICP Total Fe (mg/L)	ICP Total K (mg/L)	ICP Total Mg (mg/L)	ICP Total Mn (mg/L)	ICP Total Mo (mg/L)	ICP Total Na (mg/L)	ICP Total Ni (mg/L)	ICP Total P (mg/L)	ICP Total Pb (mg/L)	GF Total Pb (mg/L)	ICP Total Sb (mg/L)	ICP Total Se (mg/L)	ICP Total Si (mg/L)	ICP Total Sn (mg/L)	ICP Total Sr (mg/L)	ICP Total Ti (mg/L)	ICP Total V (mg/L)	ICP Total Zn (mg/L)
1	0.222	<2	24.5	2.940	<0.01	1.4	<0.02	<0.1	<0.05	0.0035	<0.05	<0.05	3.41	0.06	0.254	<0.002	<0.01	1.530
2	0.096	3	20.2	0.375	<0.01	1.3	<0.02	<0.1	<0.05	0.0010	<0.05	<0.05	3.14	<0.05	0.214	<0.002	<0.01	0.366
3	0.128	<2	10.8	0.025	<0.01	1.3	<0.02	<0.1	<0.05	<0.0006	<0.05	<0.05	1.62	<0.05	0.165	<0.002	<0.01	0.036
4	0.148	<2	12.3	0.042	<0.01	1.5	<0.02	<0.1	<0.05	0.0034	<0.05	<0.05	1.92	<0.05	0.165	<0.002	<0.01	0.016
6	0.286	<2	13.4	0.006	<0.01	1.0	<0.02	<0.1	<0.05	0.0044	<0.05	<0.05	3.44	<0.05	0.339	<0.002	<0.01	0.040
7	0.137	<2	26.3	0.016	<0.01	5.5	<0.02	<0.1	<0.05	0.0126	<0.05	<0.05	2.33	0.05	0.220	<0.002	<0.01	0.087
8	0.180	<2	12.3	0.051	<0.01	1.5	<0.02	<0.1	<0.05	0.0025	<0.05	<0.05	1.84	<0.05	0.167	<0.002	<0.01	0.013
9	0.163	<2	12.5	0.049	<0.01	1.5	<0.02	<0.1	<0.05	0.0023	<0.05	<0.05	1.79	<0.05	0.168	<0.002	<0.01	0.010
10	0.193	<2	13.0	0.045	<0.01	1.8	<0.02	<0.1	<0.05	0.0025	<0.05	<0.05	1.91	<0.05	0.176	<0.002	<0.01	0.006
11	0.357	<2	13.4	0.059	<0.01	2.0	<0.02	<0.1	<0.05	0.0040	<0.05	<0.05	2.28	<0.05	0.189	<0.002	<0.01	0.003
12	0.092	<2	20.3	0.011	<0.01	1.3	<0.02	<0.1	<0.05	0.0014	<0.05	<0.05	2.67	<0.05	0.126	<0.002	<0.01	<0.002
13	12.800	<2	31.4	13.500	<0.01	1.4	0.10	<0.1	0.08	0.0990	<0.05	<0.05	3.77	<0.05	0.310	<0.002	<0.01	27.200
14	0.326	<2	18.9	0.026	<0.01	2.4	<0.02	<0.1	<0.05	0.0032	<0.05	<0.05	3.97	<0.05	0.149	<0.002	<0.01	0.564

APPENDIX II TABLE 2 WATER QUALITY FOR SEPTEMBER, 1990

STATION	SAMPLE DATE	TEMP (C)	pH INSITU	pH LAB	IN SITU COND. (umhos/cm)	LAB COND. (umhos/cm)	DISSOLVED OXYGEN (mg/L)	%DISSOLVED OXYGEN SATURATION	COLOR (REL. U.)	TURB. (FTU)	TOTAL ALK. (asCaCO3) (mg/L)	(DISS.) HARDNESS (asCaCO3) (mg/L)	(DISS.) TOTAL HARDNESS (mg/L)	(EXTR.) HARDNESS (asCaCO3) (mg/L)	(EXTR.) TOTAL HARDNESS (mg/L)	SULFATE (mg/L)
1	20-Sep-90	6.0	n/a	8.0	460	750	10.5	88.4	10	1.0	101	369	373	389	394	287.0
2	20-Sep-90	2.2	n/a	8.1	302	569	11.9	86.3	15	0.4	118	271	273	277	279	159.0
3	20-Sep-90	6.8	n/a	8.1	168	269	10.8	88.4	15	0.2	89	128	129	130	131	41.3
4	20-Sep-90	7.2	n/a	8.1	150	298	n/a	n/a	15	0.3	95	140	140	142	142	53.7
6	21-Sep-90	2.2	n/a	8.3	197	361	n/a	n/a	15	0.2	157	174	175	171	172	32.2
7	19-Sep-90	4.5	n/a	8.1	270	473	11.7	89.4	25	0.4	136	226	227	231	232	110.0
8	19-Sep-90	6.2	n/a	8.1	185	305	10.7	85.6	20	0.3	95	143	144	143	144	55.7
9	19-Sep-90	6.2	n/a	8.0	189	320	10.7	85.6	15	0.3	99	147	147	149	150	58.0
10	19-Sep-90	6.0	n/a	8.1	180	311	10.6	84.8	20	0.3	103	147	148	147	148	54.7
11	19-Sep-90	5.1	n/a	8.1	162	317	10.7	83.5	20	0.3	107	149	150	148	149	54.3
12	21-Sep-90	4.2	n/a	8.2	265	486	n/a	n/a	<5	0.4	182	231	232	234	234	69.7
13	20-Sep-90	3.2	n/a	7.9	470	822	n/a	n/a	<5	15.0	115	404	434	410	449	294.0
14	20-Sep-90	2.8	n/a	7.7	259	466	n/a	n/a	15	0.3	57	223	229	223	229	166.0
15	21-Sep-90	n/a	n/a	8.2	n/a	267	n/a	n/a	40	0.2	110	130	131	127	127	30.4
16	21-Sep-90	3.1	n/a	7.9	172	322	n/a	n/a	50	3.0	106	153	155	159	164	53.8
17	21-Sep-90	4.1	n/a	8.2	580	986	n/a	n/a	<5	0.2	217	514	515	512	514	351.0
18	21-Sep-90	2.9	n/a	7.9	468	838	n/a	n/a	10	0.9	171	443	447	450	456	302.0
19	21-Sep-90	2.9	n/a	7.1	850	1500	n/a	n/a	80	40.0	355	676	723	655	743	443.0
20	21-Sep-90	n/a	n/a	8.0	n/a	1560	n/a	n/a	5	25.0	287	669	723	698	759	495.0
21	20-Sep-90	5.0	n/a	7.4	1290	2540	n/a	n/a	<5	10.0	151	1150	1280	1190	1330	1090.0

APPENDIX II TABLE 2 WATER QUALITY FOR SEPTEMBER, 1990

STATION	CHLORIDE (mg/L)	TOTAL P (mg/L)	NITRITE (mg/L)	NITRITE+ NITRATE (mg/L)	AMMONIA (mg/L)	FR (mg/L)	NFR (mg/L)	ICP Diss. Ag (mg/L)	GF Diss. Ag (mg/L)	ICP Diss. Al (mg/L)	ICP Diss. As (mg/L)	ICP Diss. B (mg/L)	ICP Diss. Ba (mg/L)	ICP Diss. Be (mg/L)	ICP Diss. Ca (mg/L)	ICP Diss. Cd (mg/L)
1	1	0.006	<0.002	0.112	0.005	570	<10	<0.01	0.0009	<0.05	<0.05	<0.01	0.045	<0.001	117.0	<0.005
2	1	0.004	<0.002	0.120	<0.002	430	<10	<0.01	0.0013*	<0.05	<0.05	<0.01	0.032	<0.001	81.8	<0.005
3	0.5	0.005	<0.002	0.030	0.006	181	<10	<0.01	0.0009	<0.05	<0.05	<0.01	0.040	<0.001	34.3	<0.005
4	0.6	0.004	<0.002	0.034	0.014	190	<10	<0.01	0.0011*	<0.05	<0.05	<0.01	0.043	<0.001	38.0	<0.005
6	0.6	0.002	<0.002	0.158	0.003	230	<10	<0.01	0.0015*	<0.05	<0.05	<0.01	0.059	<0.001	54.5	<0.005
7	2.5	0.003	<0.002	0.036	0.007	330	<10	<0.01	0.0012	<0.05	<0.05	<0.01	0.022	<0.001	61.3	<0.005
8	0.6	0.004	<0.002	0.037	0.007	198	<9	<0.01	0.0013*	0.05	<0.05	<0.01	0.045	<0.001	38.9	<0.005
9	0.7	0.004	<0.002	0.036	0.009	210	<9	<0.01	0.0013*	<0.05	<0.05	<0.01	0.046	<0.001	39.6	<0.005
10	0.8	0.004	<0.002	0.036	0.008	200	<9	<0.01	0.0012*	<0.05	<0.05	<0.01	0.047	<0.001	40.1	<0.005
11	0.8	0.004	<0.002	0.035	0.007	200	<9	<0.01	0.0014*	<0.05	<0.05	<0.01	0.053	<0.001	40.7	<0.005
12	0.8	0.003	<0.002	0.238	0.012	274	<10	<0.01	0.0013*	<0.05	<0.05	<0.01	0.110	<0.001	61.4	<0.005
13	0.8	0.008	<0.002	0.201	0.015	639	11	<0.01	0.0008*	<0.05	<0.05	<0.01	0.017	<0.001	129.0	0.114
14	0.9	0.012	<0.002	0.340	0.005	344	20	<0.01	0.0011*	<0.05	<0.05	0.01	0.023	<0.001	65.8	0.011
15	0.6	0.006	<0.002	0.046	0.008	190	<10	<0.01	0.0013*	<0.05	<0.05	<0.01	0.055	<0.001	36.0	<0.005
16	0.7	0.012	<0.002	0.049	0.017	220	<9	<0.01	0.0012	<0.05	<0.05	<0.01	0.050	<0.001	42.3	<0.005
17	9.8	0.004	<0.002	0.517	0.043	750	<10	<0.01	0.0008	<0.05	<0.05	0.01	0.031	<0.001	162.0	0.007
18	4.9	0.006	0.005	0.163	0.291	660	<10	<0.01	0.0008*	<0.05	<0.05	<0.01	0.052	<0.001	128.0	<0.005
19	11.7	0.099	0.003	0.025	6.810	1000	140	<0.01	0.0007	<0.05	<0.05	<0.01	0.450	<0.001	189.0	0.006
20	10.5	0.017	0.002	0.037	0.492	1120	20	<0.01	0.0006*	<0.05	<0.05	<0.01	0.053	<0.001	189.0	0.042
21	0.9	0.013	<0.002	<0.002	0.092	2170	10	<0.01	0.0016*	<0.05	0.16	<0.01	0.014	<0.001	393.0	0.020

Note: * Indictes GF Tot. Ag < GF Diss. Ag

APPENDIX II TABLE 2 WATER QUALITY FOR SEPTEMBER, 1990

STATION	GF Diss. Cd (mg/L)	ICP Diss. Co (mg/L)	ICP Diss. Cr (mg/L)	ICP Diss. Cu (mg/L)	GF Diss. Cu (mg/L)	ICP Diss. Fe (mg/L)	ICP Diss. K (mg/L)	ICP Diss. Mg (mg/L)	ICP Diss. Mn (mg/L)	ICP Diss. Mo (mg/L)	ICP Diss. Na (mg/L)	ICP Diss. Ni (mg/L)	ICP Diss. P (mg/L)	ICP Diss. Pb (mg/L)	GF Diss. Pb (mg/L)	ICP Diss. Sb (mg/L)
1	0.0035	<0.005	<0.005	<0.005	0.0016	0.033	<2	18.6	1.41	<0.01	1.3	<0.02	<0.1	<0.05	0.0022	<0.05
2	0.0018	<0.005	<0.005	<0.005	0.0016	0.031	<2	16.2	0.33	<0.01	1.2	<0.02	<0.1	<0.05	0.0019	<0.05
3	0.0002	<0.005	<0.005	<0.005	0.0018	0.036	<2	10.3	0.02	<0.01	1.2	<0.02	<0.1	<0.05	0.0008	<0.05
4	0.0003	<0.005	<0.005	<0.005	0.0019	0.034	<2	10.8	0.03	<0.01	1.2	<0.02	<0.1	<0.05	0.0011	<0.05
6	<0.0001	<0.005	<0.005	<0.005	0.0018	0.008	<2	9.3	0.00	<0.01	0.8	<0.02	<0.1	<0.05	0.0008	<0.05
7	0.0014	<0.005	<0.005	<0.005	0.0052	0.044	<2	17.7	0.07	<0.01	2.4	<0.02	<0.1	<0.05	0.0046	<0.05
8	0.0003	<0.005	<0.005	<0.005	0.0035	0.078	<2	11.2	0.04	<0.01	1.1	<0.02	<0.1	<0.05	0.0016	<0.05
9	0.0004	<0.005	<0.005	<0.005	0.0026	0.048	<2	11.6	0.04	<0.01	1.3	<0.02	<0.1	<0.05	0.0021	<0.05
10	0.0003	<0.005	<0.005	<0.005	0.0028	0.070	<2	11.5	0.03	<0.01	1.4	<0.02	<0.1	<0.05	0.0019	<0.05
11	0.0001	<0.005	<0.005	<0.005	0.0025	0.089	<2	11.6	0.03	<0.01	1.4	<0.02	<0.1	<0.05	0.0019	<0.05
12	0.0001	<0.005	<0.005	<0.005	0.0011	0.011	<2	18.9	0.02	<0.01	1.2	<0.02	<0.1	<0.05	0.0012	<0.05
13	<----	0.008	<0.005	0.007	0.0084	<0.005	<2	19.8	8.86	<0.01	1.6	0.05	<0.1	<0.05	0.0017	<0.05
14	0.0098	<0.005	<0.005	<0.005	0.0033	0.019	<2	14.3	1.22	<0.01	2.1	<0.02	<0.1	<0.05	0.0015	<0.05
15	0.0002	<0.005	<0.005	<0.005	0.0025	0.038	<2	9.8	0.01	<0.01	0.7	<0.02	<0.1	<0.05	0.0016	<0.05
16	0.0021	0.005	<0.005	0.010	0.0106	0.804	<2	11.6	0.24	<0.01	0.8	<0.02	<0.1	<0.05	0.0065*	<0.05
17	0.0053	<0.005	<0.005	<0.005	0.0030	0.008	<2	26.6	0.01	<0.01	5.6	<0.02	<0.1	<0.05	0.0204	<0.05
18	0.003	<0.005	<0.005	<0.005	0.0021	0.025	<2	30.0	2.05	<0.01	3.0	<0.02	<0.1	<0.05	0.0025	<0.05
19	0.0002	0.107	<0.005	<0.005	0.0022	18.600	3	49.7	6.53	<0.01	25.0	<0.02	<0.1	<0.05	0.0010	<0.05
20	<----	0.009	<0.005	0.009	0.0128	0.127	<2	48.1	24.80	<0.01	9.5	0.03	<0.1	<0.05	0.0047	<0.05
21	<----	0.104	<0.005	<0.005	0.0093	4.480	<2	40.7	41.60	<0.01	1.9	0.39	<0.1	<0.05	0.0010	<0.05

Note: * Indictes GF Tot. Pb < GF Diss. Pb

APPENDIX II TABLE 2 WATER QUALITY FOR SEPTEMBER, 1990

STATION	ICP Diss. Se (mg/L)	ICP Diss. Si (mg/L)	ICP Diss. Sn (mg/L)	ICP Diss. Sr (mg/L)	ICP Diss. Ti (mg/L)	ICP Diss. V (mg/L)	ICP Diss. Zn (mg/L)	ICP Extr. Ag (mg/L)	GF Extr. Ag (mg/L)	ICP Extr. Al (mg/L)	ICP Extr. As (mg/L)	ICP Extr. B (mg/L)	ICP Extr. Ba (mg/L)	ICP Extr. Be (mg/L)	ICP Extr. Ca (mg/L)	ICP Extr. Cd (mg/L)
1	<0.05	3.15	<0.05	0.183	<0.002	<0.01	0.922	<0.01	0.0007	<0.05	<0.05	<0.01	0.049	<0.001	123.0	<0.005
2	<0.05	2.76	<0.05	0.160	<0.002	<0.01	0.445	<0.01	0.0012	<0.05	<0.05	<0.01	0.035	<0.001	83.2	<0.005
3	<0.05	1.83	<0.05	0.142	<0.002	<0.01	0.022	<0.01	0.0010	0.08	<0.05	<0.01	0.043	<0.001	34.6	<0.005
4	<0.05	1.91	<0.05	0.141	<0.002	<0.01	0.038	<0.01	0.0012	0.07	<0.05	<0.01	0.046	<0.001	38.2	<0.005
6	<0.05	2.50	<0.05	0.247	<0.002	<0.01	0.009	<0.01	0.0014	<0.05	<0.05	<0.01	0.062	<0.001	53.1	<0.005
7	<0.05	2.63	<0.05	0.144	<0.002	<0.01	0.199	<0.01	0.0013	<0.05	<0.05	<0.01	0.023	<0.001	62.7	<0.005
8	<0.05	2.08	<0.05	0.142	<0.002	<0.01	0.050	<0.01	0.0012	0.05	<0.05	<0.01	0.049	<0.001	38.7	<0.005
9	<0.05	2.02	<0.05	0.145	<0.002	<0.01	0.045	<0.01	0.0012	0.05	<0.05	<0.01	0.048	<0.001	40.3	<0.005
10	<0.05	2.15	<0.05	0.153	<0.002	<0.01	0.033	<0.01	0.0013	<0.05	<0.05	<0.01	0.049	<0.001	39.8	<0.005
11	<0.05	2.23	<0.05	0.153	<0.002	<0.01	0.025	<0.01	0.0014	<0.05	<0.05	<0.01	0.055	<0.001	40.2	<0.005
12	<0.05	2.78	<0.05	0.117	<0.002	<0.01	0.003	<0.01	0.0011	<0.05	<0.05	<0.01	0.116	<0.001	61.4	<0.005
13	<0.05	3.02	<0.05	0.193	<0.002	<0.01	8.660	<0.01	0.0009	0.21	<0.05	<0.01	0.017	<0.001	131.0	0.132
14	<0.05	3.38	<0.05	0.109	<0.002	<0.01	2.120	<0.01	0.0010	<0.05	<0.05	<0.01	0.024	<0.001	65.6	0.007
15	<0.05	2.71	<0.05	0.119	<0.002	<0.01	0.010	<0.01	0.0013	<0.05	<0.05	<0.01	0.057	<0.001	34.4	<0.005
16	<0.05	2.96	<0.05	0.125	<0.002	<0.01	0.137	<0.01	0.0012	0.10	<0.05	0.01	0.054	<0.001	43.8	<0.005
17	<0.05	4.65	<0.05	0.210	<0.002	<0.01	0.354	<0.01	0.0014	<0.05	<0.05	<0.01	0.033	<0.001	160.0	<0.005
18	<0.05	3.09	<0.05	0.298	<0.002	<0.01	0.381	<0.01	0.0006	<0.05	<0.05	<0.01	0.057	<0.001	128.0	<0.005
19	<0.05	9.08	<0.05	0.561	0.002	<0.01	0.151	<0.01	0.0017	0.41	0.11	<0.01	0.600	<0.001	180.0	0.006
20	<0.05	4.83	<0.05	0.343	<0.002	<0.01	5.030	<0.01	0.0007	<0.05	<0.05	0.01	0.059	<0.001	194.0	0.052
21	<0.05	4.26	<0.05	0.438	<0.002	<0.01	33.200	0.01	0.0017	<0.05	0.21	<0.01	0.014	<0.001	407.0	0.025

APPENDIX II TABLE 2 WATER QUALITY FOR SEPTEMBER, 1990

STATION	GF Extr. Cd (mg/L)	ICP Extr. Co (mg/L)	ICP Extr. Cr (mg/L)	ICP Extr. Cu (mg/L)	GF Extr. Cu (mg/L)	ICP Extr. Fe (mg/L)	ICP Extr. K (mg/L)	ICP Extr. Mg (mg/L)	ICP Extr. Mn (mg/L)	ICP Extr. Mo (mg/L)	ICP Extr. Na (mg/L)	ICP Extr. Ni (mg/L)	ICP Extr. P (mg/L)	ICP Extr. Pb (mg/L)	GF Extr. Pb (mg/L)	ICP Extr. Sb (mg/L)	ICP Extr. Se (mg/L)
1	0.0042	<0.005	<0.005	<0.005	0.0011	0.283	<2	19.9	1.520	<0.01	1.3	<0.02	<0.1	<0.05	0.0122	<0.05	<0.05
2	0.0024	<0.005	<0.005	<0.005	0.0008	0.107	<2	16.8	0.347	<0.01	1.2	<0.02	<0.1	<0.05	0.0040	<0.05	<0.05
3	0.0001	<0.005	<0.005	<0.005	0.0012	0.116	<2	10.6	0.024	<0.01	1.1	<0.02	<0.1	<0.05	0.0008	<0.05	<0.05
4	0.0004	<0.005	0.005	<0.005	0.0012	0.122	<2	11.2	0.043	<0.01	1.2	<0.02	<0.1	<0.05	0.0027	<0.05	<0.05
6	0.0001	<0.005	<0.005	<0.005	0.0010	0.040	<2	9.4	0.001	<0.01	0.8	<0.02	<0.1	<0.05	0.0007	<0.05	<0.05
7	0.0015	<0.005	<0.005	<0.005	0.0023	0.127	<2	18.2	0.090	<0.01	2.4	<0.02	<0.1	<0.05	0.0160	<0.05	<0.05
8	0.0003	<0.005	<0.005	<0.005	0.0018	0.131	<2	11.4	0.043	<0.01	1.2	<0.02	<0.1	<0.05	0.0041	<0.05	<0.05
9	0.0004	<0.005	<0.005	<0.005	0.0012	0.132	<2	11.8	0.046	<0.01	1.3	<0.02	<0.1	<0.05	0.0045	<0.05	<0.05
10	0.0003	<0.005	0.005	<0.005	0.0013	0.176	<2	11.6	0.046	<0.01	1.3	<0.02	<0.1	<0.05	0.0044	<0.05	<0.05
11	0.0001	<0.005	<0.005	<0.005	0.0016	0.241	<2	11.6	0.040	<0.01	1.4	<0.02	<0.1	<0.05	0.0039	<0.05	<0.05
12	0.0001	<0.005	<0.005	<0.005	0.0005	0.079	<2	19.5	0.022	<0.01	1.2	<0.02	<0.1	<0.05	0.0009	<0.05	<0.05
13	<----	0.024	<0.005	0.069	<----	3.030	<2	20.1	9.100	<0.01	1.5	0.04	<0.1	<0.05	0.0559	<0.05	<0.05
14	0.0097	<0.005	0.005	<0.005	0.0015	0.038	<2	14.5	1.230	<0.01	2.0	<0.02	<0.1	<0.05	<0.0005	<0.05	<0.05
15	0.0001	<0.005	<0.005	<0.005	0.0015	0.043	<2	9.9	0.004	<0.01	0.8	<0.02	<0.1	<0.05	0.0017	<0.05	<0.05
16	0.0024	0.009	<0.005	0.018	0.0172	1.650	<2	12.1	0.253	<0.01	0.9	<0.02	<0.1	<0.05	0.0033	<0.05	<0.05
17	0.0061	<0.005	<0.005	<0.005	0.0031	0.475	<2	27.4	0.194	<0.01	6.0	<0.02	<0.1	0.15	0.1890	<0.05	<0.05
18	0.0043	<0.005	<0.005	<0.005	0.0019	0.796	<2	31.3	2.180	<0.01	3.1	<0.02	<0.1	<0.05	0.0380	<0.05	<0.05
19	0.0020	0.217	<0.005	<0.005	0.0048	40.900	<2	49.6	6.450	<0.01	26.6	<0.02	0.1	<0.05	0.1080	<0.05	<0.05
20	<----	0.032	<0.005	<0.005	0.0041	3.530	<2	51.5	25.300	<0.01	10.4	0.02	<0.1	<0.05	0.0279	<0.05	<0.05
21	<----	0.110	<0.005	<0.005	0.0104	5.150	<2	42.6	42.200	<0.01	1.9	0.41	0.1	<0.05	0.0028	<0.05	<0.05

APPENDIX II TABLE 2 WATER QUALITY FOR SEPTEMBER, 1990

STATION	ICP Extr. Si (mg/L)	ICP Extr. Sn (mg/L)	ICP Extr. Sr (mg/L)	ICP Extr. Ti (mg/L)	ICP Extr. V (mg/L)	ICP Extr. Zn (mg/L)	ICP Tot. Ag (mg/L)	GF Tot. Ag (mg/L)	ICP Tot. Al (mg/L)	ICP Tot. As (mg/L)	ICP Tot. B (mg/L)	ICP Tot. Ba (mg/L)	ICP Tot. Be (mg/L)	ICP Tot. Ca (mg/L)	ICP Tot. Cd (mg/L)	GF Tot. Cd (mg/L)
1	3.42	<0.05	0.199	<0.002	<0.01	1.010	<0.01	0.0010	0.05	<0.05	<0.01	0.048	<0.001	121.0	<0.005	0.0046
2	2.90	<0.05	0.168	<0.002	<0.01	0.473	<0.01	0.0010	0.06	<0.05	<0.01	0.035	<0.001	83.9	<0.005	0.0027
3	1.90	<0.05	0.148	<0.002	<0.01	0.018	<0.01	0.0010	0.12	<0.05	<0.01	0.043	<0.001	34.6	<0.005	0.0002
4	1.99	<0.05	0.147	<0.002	<0.01	0.048	<0.01	0.0010	0.11	<0.05	<0.01	0.047	<0.001	38.4	<0.005	0.0004
6	2.49	<0.05	0.254	<0.002	<0.01	<0.002	<0.01	0.0010	0.11	<0.05	<0.01	0.063	<0.001	55.4	<0.005	<0.0001
7	2.68	<0.05	0.148	<0.002	<0.01	0.217	<0.01	0.0012	<0.05	<0.05	<0.01	0.023	<0.001	62.5	<0.005	0.0018
8	2.04	<0.05	0.150	<0.002	<0.01	0.050	<0.01	0.0010	0.11	<0.05	<0.01	0.049	<0.001	38.9	<0.005	0.0004
9	2.07	<0.05	0.149	<0.002	<0.01	0.055	<0.01	0.0010	0.11	<0.05	<0.01	0.049	<0.001	40.7	<0.005	0.0005
10	2.18	<0.05	0.155	<0.002	<0.01	0.042	<0.01	0.0008	0.10	<0.05	<0.01	0.050	<0.001	39.7	<0.005	0.0004
11	2.23	<0.05	0.156	<0.002	<0.01	0.032	<0.01	0.0008	<0.05	<0.05	<0.01	0.054	<0.001	40.4	<0.005	0.0003
12	2.83	<0.05	0.122	<0.002	<0.01	<0.002	<0.01	0.0010	<0.05	<0.05	<0.01	0.115	<0.001	62.8	<0.005	<0.0001
13	3.21	<0.05	0.197	<0.002	<0.01	10.400	<0.01	0.0007	0.21	<0.05	<0.01	0.017	<0.001	130.0	0.124	<----
14	3.42	<0.05	0.111	<0.002	<0.01	2.150	<0.01	0.0012	0.08	<0.05	<0.01	0.025	<0.001	65.5	0.007	0.0100
15	2.69	<0.05	0.122	<0.002	<0.01	0.004	<0.01	0.0010	<0.05	<0.05	<0.01	0.055	<0.001	37.0	<0.005	0.0002
16	3.14	<0.05	0.132	<0.002	<0.01	0.163	<0.01	0.0012	0.10	<0.05	<0.01	0.052	<0.001	44.6	<0.005	0.0025
17	4.74	<0.05	0.221	<0.002	<0.01	0.398	<0.01	0.0013	0.10	<0.05	0.01	0.033	<0.001	170.0	0.007	0.0057
18	3.21	<0.05	0.316	<0.002	<0.01	0.443	<0.01	0.0006	0.08	<0.05	<0.01	0.056	<0.001	136.0	<0.005	0.0046
19	10.10	<0.05	0.594	0.010	<0.01	0.233	<0.01	0.0010	1.35	0.08	<0.01	0.595	<0.001	192.0	0.008	0.0024
20	5.34	<0.05	0.374	<0.002	<0.01	5.640	<0.01	0.0005	<0.05	<0.05	<0.01	0.057	<0.001	210.0	0.056	<----
21	4.43	<0.05	0.464	0.003	<0.01	34.700	<0.01	0.0012	<0.05	0.15	0.02	0.015	<0.001	422.0	0.027	<----

APPENDIX II TABLE 2 WATER QUALITY FOR SEPTEMBER, 1990

STATION	ICP Tot. Co (mg/L)	ICP Tot. Cr (mg/L)	ICP Tot. Cu (mg/L)	GF Tot Cu (mg/L)	ICP Tot. Fe (mg/L)	ICP Tot. K (mg/L)	ICP Tot. Mg (mg/L)	ICP Tot. Mn (mg/L)	ICP Tot. Mo (mg/L)	ICP Tot. Na (mg/L)	ICP Tot. Ni (mg/L)	ICP Tot. P (mg/L)	ICP Tot. Pb (mg/L)	GF Tot Pb (mg/L)	ICP Tot. Sb (mg/L)	ICP Tot. Se (mg/L)
1	<0.005	0.006	<0.005	0.0015	0.303	<2	19.8	1.530	<0.01	1.3	<0.02	<0.1	<0.05	0.0130	<0.05	<0.05
2	<0.005	0.006	<0.005	0.0009	0.131	<2	17.1	0.356	<0.01	1.2	<0.02	<0.1	<0.05	0.0044	<0.05	<0.05
3	<0.005	<0.005	<0.005	0.0027	0.149	<2	10.7	0.024	<0.01	1.2	<0.02	<0.1	<0.05	0.0010	<0.05	<0.05
4	<0.005	0.006	<0.005	0.0012	0.172	<2	11.4	0.045	<0.01	1.2	<0.02	<0.1	<0.05	0.0021	<0.05	<0.05
6	<0.005	<0.005	<0.005	0.0009	0.099	<2	9.7	0.003	<0.01	0.8	<0.02	<0.1	<0.05	0.0009	<0.05	0.06
7	<0.005	<0.005	<0.005	0.0022	0.150	<2	18.3	0.090	<0.01	2.5	<0.02	<0.1	<0.05	0.0161	<0.05	<0.05
8	<0.005	<0.005	<0.005	0.0016	0.164	<2	11.6	0.044	<0.01	1.2	<0.02	<0.1	<0.05	0.0038	<0.05	<0.05
9	<0.005	<0.005	<0.005	0.0012	0.181	<2	12.0	0.047	<0.01	1.3	<0.02	<0.1	<0.05	0.0042	<0.05	<0.05
10	<0.005	<0.005	<0.005	0.0010	0.214	<2	11.7	0.047	<0.01	1.3	<0.02	<0.1	<0.05	0.0047	<0.05	<0.05
11	<0.005	0.005	0.013	0.0011	0.275	<2	11.7	0.041	<0.01	1.4	<0.02	<0.1	<0.05	0.0041	<0.05	<0.05
12	<0.005	<0.005	<0.005	<0.0006	0.095	<2	20.0	0.024	<0.01	1.2	<0.02	<0.1	<0.05	0.0012	<0.05	<0.05
13	0.025	<0.005	0.066	<---	3.000	<2	20.3	9.210	<0.01	1.5	0.05	<0.1	<0.05	0.0564	<0.05	<0.05
14	<0.005	<0.005	<0.005	0.0022	0.069	<2	14.7	1.250	<0.01	2.1	<0.02	<0.1	<0.05	0.0015	<0.05	<0.05
15	<0.005	0.007	<0.005	0.0014	0.071	<2	10.1	0.004	<0.01	0.7	<0.02	<0.1	<0.05	0.0016	<0.05	<0.05
16	0.010	<0.005	0.017	0.0177	1.640	<2	12.1	0.254	<0.01	0.8	<0.02	<0.1	<0.05	0.0025	<0.05	<0.05
17	0.006	0.007	<0.005	0.0039	0.907	<2	27.9	0.213	<0.01	5.5	<0.02	<0.1	0.18	0.1600	<0.05	0.06
18	0.005	<0.005	<0.005	0.0018	0.849	<2	32.0	2.320	<0.01	3.1	<0.02	<0.1	<0.05	0.0360	<0.05	<0.05
19	0.204	<0.005	0.006	0.0064	42.100	2	50.1	6.840	<0.01	24.0	<0.02	0.2	0.06	0.0870	<0.05	<0.05
20	0.029	0.005	<0.005	0.0028	3.650	<2	52.4	32.100	<0.01	9.6	0.03	<0.1	<0.05	0.0260	<0.05	<0.05
21	0.105	<0.005	<0.005	0.0080	5.260	<2	43.3	68.900	<0.01	1.8	0.43	0.1	<0.05	0.0023	<0.05	<0.05

APPENDIX II TABLE 2 WATER QUALITY FOR SEPTEMBER, 1990

STATION	ICP Tot. Si (mg/L)	ICP Tot. Sn (mg/L)	ICP Tot. Sr (mg/L)	ICP Tot. Ti (mg/L)	ICP Tot. V (mg/L)	ICP Tot. Zn (mg/L)
1	3.28	<0.05	0.192	<0.002	<0.01	1.140
2	2.89	<0.05	0.166	<0.002	<0.01	0.549
3	1.94	<0.05	0.145	<0.002	<0.01	0.033
4	2.07	<0.05	0.146	0.002	<0.01	0.061
6	2.63	<0.05	0.253	0.003	<0.01	0.009
7	2.63	<0.05	0.146	<0.002	<0.01	0.254
8	2.16	<0.05	0.148	<0.002	<0.01	0.063
9	2.17	<0.05	0.148	<0.002	<0.01	0.073
10	2.25	<0.05	0.152	0.002	<0.01	0.049
11	2.24	<0.05	0.152	<0.002	<0.01	0.042
12	2.82	<0.05	0.121	<0.002	<0.01	0.004
13	3.11	<0.05	0.193	<0.002	<0.01	11.800
14	3.43	<0.05	0.110	0.003	<0.01	2.450
15	2.72	<0.05	0.118	<0.002	<0.01	0.015
16	3.04	<0.05	0.127	<0.002	<0.01	0.198
17	4.81	<0.05	0.213	0.005	<0.01	0.514
18	3.30	<0.05	0.310	0.003	<0.01	0.550
19	11.90	<0.05	0.566	0.043	<0.01	0.314
20	5.27	<0.05	0.361	<0.002	<0.01	6.880
21	4.40	<0.05	0.451	<0.002	<0.01	41.400

APPENDIX III

STREAM SEDIMENTS DATA

APPENDIX III TABLE1 PERCENT PARTICLE SIZE DISTRIBUTION, JULY 24 - 26/90

STATION	SAMPLE #	% Size Range mm <0.063	0.063-0.15	0.15-0.25	0.25-0.5	0.5-1.0	1.0-2.0	>2.0	Total Weight g
1	1	0.4	0.8	1.3	4.3	9.5	18.9	81.1	236.1
	2	7.8	14.9	20.0	30.8	42.6	64.6	35.4	213.4
	3	0.4	0.8	1.5	5.2	12.3	23.1	76.9	263.7
	mean	2.9	5.5	7.6	13.4	21.5	35.5	64.5	237.7
	STD	4.3	8.1	10.7	15.0	18.4	25.3	23.3	25.2
2	4	0.3	0.7	1.4	5.1	13.3	25.4	74.6	199.0
	5	0.3	0.5	1.0	3.0	7.8	20.8	79.2	209.2
	6	0.2	0.3	0.6	2.3	7.3	16.0	84.0	251.1
	mean	0.3	0.5	1.0	3.5	9.5	20.7	79.3	219.8
	STD	0.1	0.2	0.4	1.5	3.3	4.7	4.7	27.6
3	7	1.4	2.5	3.7	6.6	9.1	16.2	83.8	177.3
	8	0.2	0.5	0.8	3.6	6.8	12.9	87.1	131.6
	9	0.8	1.6	2.6	10.5	18.3	30.5	69.5	204.8
	mean	0.8	1.5	2.4	6.9	11.4	19.9	80.1	171.2
	STD	0.6	1.0	1.5	3.5	6.1	9.4	9.4	37.0
4	10	0.4	1.1	2.7	9.4	14.3	21.5	78.5	336.7
	11	0.2	0.6	2.1	12.6	19.9	27.8	72.2	310.1
	12	0.8	2.5	6.3	26.0	41.8	50.0	50.0	272.8
	mean	0.5	1.4	3.7	16.0	25.3	33.1	66.9	306.5
	STD	0.3	1.0	2.3	8.8	14.5	15.0	15.0	32.1
7	19	0.1	0.3	0.8	4.8	11.4	19.6	80.4	244.8
	20	0.0	0.2	0.5	6.1	11.8	15.6	84.4	317.9
	21	0.0	0.2	0.4	4.8	12.4	22.1	77.9	307.8
	mean	0.0	0.2	0.6	5.2	11.9	19.1	80.9	290.2
	STD	0.1	0.1	0.2	0.8	0.5	3.3	3.3	39.6
8	22	1.2	3.6	8.4	18.7	21.8	24.4	75.6	254.1
	23	1.0	2.1	3.8	10.8	16.1	21.3	78.7	271.4
	24	0.2	0.6	1.6	7.4	14.7	23.5	76.5	297.6
	mean	0.8	2.1	4.6	12.3	17.5	23.1	76.9	274.4
	STD	0.5	1.5	3.5	5.8	3.8	1.6	1.6	21.9
9	25	0.5	1.0	1.4	3.2	9.0	15.2	84.8	286.1
	26	1.1	1.7	2.3	4.9	8.3	15.1	84.9	259.1
	27	0.4	0.9	1.5	7.6	14.9	24.1	75.9	210.4
	mean	0.7	1.2	1.7	5.2	10.7	18.1	81.9	251.9
	STD	0.4	0.4	0.5	2.2	3.6	5.2	5.2	38.4
10	28	0.2	0.4	0.7	1.7	4.5	13.0	87.0	277.1
	29	0.1	0.3	0.4	2.5	8.6	24.2	75.8	236.4
	30	0.6	1.2	2.1	6.6	16.4	32.0	68.0	271.8
	mean	0.3	0.6	1.1	3.6	9.8	23.1	76.9	261.8
	STD	0.3	0.5	0.9	2.6	6.0	9.6	9.6	22.1
11	31	0.0	0.1	1.7	7.4	15.6	25.4	74.6	182.9
	32	0.0	0.1	0.1	0.8	8.6	15.3	84.7	226.7
	33	0.0	0.0	0.1	1.0	3.4	8.6	91.4	244.9
	mean	0.0	0.1	0.6	3.1	9.2	16.4	83.6	218.2
	STD	0.0	0.1	0.9	3.8	6.1	8.5	8.5	31.9

STD = Standard Deviation

APPENDIX III TABLE 2 SEDIMENT METALS ANALYSES FOR JULY 24 - 26, 1990

STATION NUMBER	SAMPLE NUMBER	LOCATION IN STREAM	K STD. (mg/L)	Mg (mg/L)	Mg Mean (mg/L)	Mg STD. (mg/L)	Mn (mg/L)	Mn Mean (mg/L)	Mn STD. (mg/L)	Mo (mg/L)	Mo Mean (mg/L)	Mo STD. (mg/L)	Na (mg/L)	Na Mean (mg/L)	Na STD. (mg/L)	Ni (mg/L)	Ni Mean (mg/L)	Ni STD. (mg/L)	P (mg/L)
1	1	n/a	173.2	7500	6567	869.3	58400	32133	23269.4	6	<4	n/a	4560	2127	2217.4	245	137	96.9	720
	2	n/a		6420			23900			3			220			110			830
	3	n/a		5780			14100			<2			1600			57			730
2	4	n/a	1209.7	5730	7400	2235.8	46400	36933	11809.5	<2	<2	n/a	3670	5110	2678.1	140	172	95.7	770
	5	n/a		6530			23700			2			3460			97			900
	6	n/a		9940			40700			2			8200			280			720
3	7	n/a	1331.7	12200	9377	2830.0	1030	1018	108.0	<2	<2	n/a	8550	7327	3642.5	80	77	24.6	810
	8	n/a		9390			905			<2			10200			100			770
	9	n/a		6540			1120			<2			3230			51			830
4	10	LB	230.9	5550	5970	497.9	15900	19800	5273.5	<2	<2	n/a	3420	1773	1468.4	22	26	3.6	720
	11	MS		6520			25800			<2			1300			27			860
	12	RB		5840			17700			<2			600			29			910
7	19	n/a	0.0	5030	5213	208.4	39200	45233	5227.2	3	<2	n/a	5700	5227	410.4	90	97	11.0	680
	20	n/a		5440			48400			<2			5010			110			610
	21	n/a		5170			48100			2			4970			92			600
8	22	LB	577.4	5580	8467	2910.3	4750	4947	803.3	<2	<2	n/a	2740	4330	1953.0	26	46	23.5	840
	23	MS		11400			4260			<2			3740			41			980
	24	RB		8420			5830			2			6510			72			910
9	25	LB	519.6	8710	8643	1691.0	6060	6180	599.1	<2	<2	n/a	5240	4443	885.5	77	64	15.9	870
	26	MS		6920			5650			3			3490			46			910
	27	RB		10300			6830			2			4600			68			830
10	28	n/a	923.8	10900	8297	2493.4	5960	5087	860.3	7	<4	n/a	7500	4503	3105.2	120	74	40.1	880
	29	n/a		8060			5060			3			4710			56			870
	30	n/a		5930			4240			<2			1300			46			900
11	31	n/a	1101.5	5400	8713	6319.1	1310	1697	375.5	<6	<4	n/a	34500	32910	23325.7	100	140	96.1	600
	32	n/a		16000			1720			<4			55400			250			560
	33	n/a		4740			2060			3			8830			71			570

*STD. = Standard Deviation

APPENDIX III TABLE 2 SEDIMENT METALS ANALYSES FOR JULY 24 - 26, 1990

STATION NUMBER	SAMPLE NUMBER	LOCATION IN STREAM	P Mean (mg/L)	P STD. (mg/L)	Pb (mg/L)	Pb Mean (mg/L)	Pb STD. (mg/L)	Sb (mg/L)	Sb Mean (mg/L)	Sb STD. (mg/L)	Si (mg/L)	Si Mean (mg/L)	Si STD. (mg/L)	Sn (mg/L)	Sn Mean (mg/L)	Sn STD. (mg/L)	Sr (mg/L)	Sr Mean (mg/L)
1	1	n/a	760	60.8	<8	83	93.9	<8	<8	n/a	512	545	47.7	<8	<8	n/a	50.8	42.0
	2	n/a			185			<8			600			<8			38.9	
	3	n/a			65			<8			524			<8			36.3	
2	4	n/a	797	92.9	1550	1088	410.2	29	<18	n/a	633	549	73.1	<8	<8	n/a	44.9	44.6
	5	n/a			766			<8			517			<8			44.8	
	6	n/a			949			18			498			<8			44.1	
3	7	n/a	803	30.6	21	22	2.6	<8	<8	n/a	506	495	22.0	<8	<8	n/a	37.4	33.7
	8	n/a			25			<8			470			<8			33.1	
	9	n/a			20			<8			510			<8			30.5	
4	10	LB	830	98.5	798	1069	257.4	40	70	28.6	543	662	105.1	<8	<8	n/a	22.1	22.2
	11	MS			1310			97			743			<8			20.7	
	12	RB			1100			73			699			<8			23.7	
7	19	n/a	630	43.6	4400	4580	392.3	120	130	10.0	812	782	29.1	<8	<8	n/a	44.9	46.4
	20	n/a			5030			140			780			<8			50.0	
	21	n/a			4310			130			754			<8			44.2	
8	22	LB	910	70.0	611	791	165.6	26	30	7.2	541	604	80.2	<8	<8	n/a	20.8	28.4
	23	MS			937			25			576			<8			31.8	
	24	RB			825			38			694			<8			32.6	
9	25	LB	870	40.0	619	1110	573.4	32	53	27.6	657	695	33.3	<8	<8	n/a	34.5	33.1
	26	MS			970			42			712			<8			33.0	
	27	RB			1740			84			717			<8			31.8	
10	28	n/a	883	15.3	443	493	56.2	19	20	1.0	760	703	52.3	<8	<8	n/a	41.6	34.8
	29	n/a			483			20			693			<8			30.7	
	30	n/a			554			21			657			<8			32.1	
11	31	n/a	577	20.8	180	180	0.0	<30	<20	n/a	1430	1032	366.9	<30	<20	n/a	31.0	32.0
	32	n/a			180			<20			960			<20			38.3	
	33	n/a			180			<10			707			<10			26.7	

*STD. = Standard Deviation

APPENDIX III TABLE 2   SEDIMENT METALS ANALYSES FOR JULY 24 - 26, 1990

STATION NUMBER	SAMPLE NUMBER	LOCATION IN STREAM	Sr STD. (mg/L)	Ti (mg/L)	Ti Mean (mg/L)	Ti STD. (mg/L)	V (mg/L)	V Mean (mg/L)	V STD. (mg/L)	Zn (mg/L)	Zn Mean (mg/L)	Zn STD. (mg/L)
1	1	n/a	7.7	265	285	17.7	10	17	5.9	17700	8967	7691.8
	2	n/a		297			21			6000		
	3	n/a		294			19			3200		
2	4	n/a	0.4	202	233	49.7	10	15	8.1	13000	10400	2946.2
	5	n/a		290			24			7200		
	6	n/a		206			10			11000		
3	7	n/a	3.5	458	446	32.7	28	27	2.3	232	212	24.4
	8	n/a		409			24			185		
	9	n/a		471			28			220		
4	10	LB	1.5	408	417	21.4	23	25	2.6	1290	2423	987.6
	11	MS		401			24			3100		
	12	RB		441			28			2880		
7	19	n/a	3.2	244	237	30.7	26	24	2.5	8840	9247	1013.2
	20	n/a		203			21			10400		
	21	n/a		263			24			8500		
8	22	LB	6.6	551	499	73.4	29	31	3.5	1240	1220	121.2
	23	MS		531			35			1090		
	24	RB		415			29			1330		
9	25	LB	1.4	429	377	82.7	28	29	1.7	1710	1490	192.9
	26	MS		421			31			1410		
	27	RB		282			28			1350		
10	28	n/a	5.9	376	415	33.6	31	30	0.6	1250	1082	154.1
	29	n/a		437			30			947		
	30	n/a		431			30			1050		
11	31	n/a	5.9	355	349	39.9	30	25	5.0	253	316	54.4
	32	n/a		306			20			350		
	33	n/a		385			24			344		

*STD. = Standard Deviation

APPENDIX IV

BOTTOM FAUNA DATA

APPENDIX IV TABLE 1 TAXANOMIC LIST OF BOTTOM FAUNA

NUMBER		INVERTEBRATE	NUMBER		INVERTEBRATE
	Phylum:	Arthropoda	46		Hydropsyche sp
	Class:	Insecta	47		Hydroptila sp
	Order:	Plecoptera	48	Family:	Leptoceridae, J/D
1		Acroneuria sp	49		Oxyethira sp
2		Arcynopteryx sp	50		Parapsyche sp
3		Capnia sp	51		Rhyacophila angelita
4		Isogenoides sp	52		Rhyacophila sp
5		Isoperla sp	53		Rhyacophila vaccua
6		Kogotus sp	54		Rhyacophila vagrita
7		Malenka sp	55		Rhyacophila (vao\acropedes)
8		Megarcys sp			
9		Nemoura sp		Order:	Diptera
10		Podmosta sp	56		Unid adult
11		Pteronarcella regularis	57		Unid larvae
12		Pteronarcys californica	58	Family:	Culicidae adult
13		Sweltsa sp group	59	Family:	Sciaridae
14		Taenionema sp	60		(Corynoptera sp?)
15		Utaperla sp	61	Family:	Ephydridae
16		Zapada sp	62		(Hydrelia sp?)
			63	Family:	Ceratopogonidae
	Order:	Ephemeroptera	64		Palpomyia sp
17		Unid. adult	65	Family:	Tipulidae
18		Ameletus sp	66		Antocha sp
19		Baetis sp	67		Dicranota sp
20		Cinygmula sp	68		Erioptera sp
21		Epeorus deceptivus	69		Hesperoconopa sp
22		Epeorus (albertae)	70		Hexatoma sp
23		Ephemerella coloradensis	71		Pedicia sp
24		Ephemerella doddsi	72		Prioncera sp
25		Ephemerella grandis	73		Rhabdomastix sp
26		Ephemerella inermis	74		Tipula sp
27		Ephemerella mollitia		Family:	Empididae
28		Ephemerella sp	75		Pupae
29		Heptagenia sp	76		Chelifera sp
30		Leptophlebia sp	77		Weidemannia sp
31		Paraleptophlebia sp		Family:	Simulidae
32		Rithrogena sp	78		Prosimulium sp
			79		Simulium sp
	Order:	Trichoptera	80		Simulium sp pupae
33		Unid pupa	81		Adult
34		Unid J/D	82		Limnophora sp
35		Agraylea		Family:	Psychodidae
36		Arctopsyche sp	83		Pericoma sp
37	Family:	Brachycentridae, J/D	84	Family:	(Syrphidae?)
38		Brachycentrus sp		Family:	Chironomidae
39		Ceraclea sp	85		Adult
40		Clostoeca sp	86		Pupae
41		Ecclisomyia sp	87		Brillia sp
42		Glossosoma sp	88		Cardiocladius sp
43		Grammataulius sp	89		Constempellina sp
44		Grensia sp	90		Corynoneura sp
45		Hesperophylax sp	91		Cricotopus sp

• non aquatic species

APPENDIX IV TABLE 1 TAXANOMIC LIST OF BOTTOM FAUNA

NUMBER		INVERTEBRATE
92		Diamesa sp
93		Eukiefferiella sp
94		Euryhapsis sp
95		Gymnometriocnemus sp
96		Micropsectra sp
97		Monopelopia sp
98		Nilotanypus sp
99		Orthocladius sp
100		Paratendipes sp
101		Phaenopsectra sp
102		Polypedilum (pentapedilum)
103		Polypedilum (Polypedilum)
104		Potthastia sp
105		Psectrocladius sp
106		Rheocricotopus sp
107		Rheotanytarsus sp
108		Thienemanniella sp
109		Thienemannimyia sp
110		Trissopelopia sp
111	Family:	Unid. orthocladiinae
	Order:	Collembola
112		Isotomurus sp
	Order	Hymenoptera
113	Family:	Formicidae
	Order:	Homoptera
114	Family:	Aphididae
115	Family:	Cicadellidae
116	Family:	Psyllidae
	Order:	Hemiptera
117	Family:	Corixidae dam
118		Callicorixa sp
	Order:	Coleoptera
119		Unid larva
120	Order:	Lepidoptera L
	Class	Arachnoidae
121	Subclass:	Arachnida
	Order:	Hydracarina
122		Unid J/D
123		Oribatei
124		Kerendowskia sp
125		Lebertia sp
126		Newmannia sp
127		Sperchon sp
128		Torrenticola sp
129		Wandesia sp
	Class:	Crustacea
130	Subclass:	Ostracoda

NUMBER		INVERTEBRATE
	Subclass:	Copepoda
131	Order:	Cyclopoida
132	Order:	Calanoida
133	Order:	Harpacticoida
	Order:	Cladocera
134		Acroperus harpae
135		Alonella sp
136		Daphnia rosea
137		Daphnia sp dam
138		Eurycercus lamellatus
139		Graptoleberus testudinaria
140		Pleuroxus trigonellus
141		Polyphemus pediculus
142		Simocephalus sp
143	Phylum:	Nematoda
	Phylum:	Platyhelminthes
	Class:	Turbellaria
	Order:	Tricladida
144		Polycelis coronata
	Phylum:	Annelida
	Class:	Oligochaeta
145	Family:	Lumbriculidae, unid J/D
146		Kincaidiana hexatheca
147	Family:	Enchytraeidae
148	Family:	Tubificidae
149	Family:	Naididae
150		Nais sp
151		Chaetogaster sp
	Class:	Hirudinea
152		Batrachobdella sp
	Phylum:	Coelenterata
	Class:	Hydrozoa
	Order:	Hydroida
153		Hydra sp
	Phylum:	Mollusca
	Class:	Pelecypoda
154	Order:	Bivalvia
155		Sphaerium sp
156		Pisidium sp
157	Class:	Gastropoda
158		Stagnicola (arctica)
159		Heliosoma sp
160		Valvata (sincera)
161		Physa sp

* non aquatic species

APPENDIX IV TABLE 2 INVERTABRATE DISTRIBUTION

Number	INVERTEBRATE	STA.1	% Tot.	STA.2	% Tot.	STA.3	% Tot.	STA.4	% Tot.	STA.7	% Tot.	STA.8	% Tot.	STA.9	% Tot.	STA.10	% Tot.	STA.11	% Tot.
1	Acroneuria sp	0	0	0	0	39	1	19	3	0	0	13	5	7	1	5	0	1	0
2	Arcynopteryx sp	12	2	8	1	0	0	0	0	0	0	0	0	0	0	0	0	8	0
3	Capnia sp	2	0	191	13	97	1	83	12	16	10	19	7	61	8	43	2	93	3
5	Isoperla sp	108	22	45	3	2	0	0	0	0	0	0	0	0	0	0	0	23	1
7	Malenka sp	2	0	0	0	299	4	157	22	1	1	22	8	95	13	175	7	130	4
9	Nemoura sp	5	1	0	0	0	0	0	0	31	19	0	0	3	0	0	0	0	0
11	Pteronarcella regularis	0	0	0	0	0	0	3	0	0	0	1	0	3	0	11	0	18	1
12	Pteronarcys californica	0	0	0	0	3	0	6	1	0	0	3	1	0	0	0	0	1	0
13	Sweltsa sp group	4	1	11	1	4	0	0	0	1	1	16	6	0	0	2	0	49	1
14	Taenionema sp	0	0	1	0	0	0	0	0	3	2	0	0	2	0	3	0	0	0
16	Zapada sp	39	8	316	22	22	0	4	1	0	0	1	0	3	0	0	0	23	1
17	Ephemeroptera Unid. adult	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	Ameletus sp	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	Baetis sp	0	0	2	0	68	1	29	4	1	1	25	9	48	6	84	3	35	1
20	Cinygmula sp	0	0	0	0	0	0	9	1	0	0	3	1	1	0	0	0	0	0
25	*Ephemerella grandis*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	10	0	2	0
27	Ephemerella mollitia	0	0	0	0	3	0	2	0	0	0	0	0	0	0	3	0	3	0
28	Ephemerella sp	0	0	0	0	2	0	1	0	0	0	0	0	5	1	1	0	6	0
29	Heptagenia sp	0	0	0	0	17	0	5	1	0	0	0	0	0	0	0	0	1	0
30	Leptophlebia sp	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
31	Paraleptophlebia sp	0	0	0	0	86	1	1	0	0	0	2	1	0	0	1	0	11	0
32	Rithrogena sp	0	0	0	0	77	1	101	14	1	1	14	5	22	3	11	0	9	0
34	Tricoptera Unid. J/D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	0
35	Agraylea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
36	Arctopsyche sp	25	5	0	0	30	0	24	3	0	0	8	3	14	2	31	1	2	0
37	Brachycentridae, J/D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
38	Brachycentrus sp	1	0	0	0	1	0	12	2	2	1	0	0	0	0	4	0	3	0
39	Ceraclea sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
40	Clostoeca sp	0	0	52	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0
41	Ecclisomyia sp	0	0	15	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0
42	Glossosoma sp	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
43	*Grammataulius sp*	0	0	0	0	0	0	0	0	5	3	0	0	0	0	0	0	0	0
45	Hesperophylax sp	0	0	4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
46	Hydropsyche sp	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0
47	Hydroptila sp	0	0	0	0	16	0	5	1	1	1	1	0	0	0	12	0	414	13
48	Leptoceridae, J/D	1	0	0	0	2	0	2	0	0	0	0	0	0	0	4	0	11	0
49	Oxyethira sp	0	0	0	0	3	0	2	0	2	1	5	2	2	0	9	0	8	0
53	Rhyacophila vaccua	13	3	29	2	6	0	1	0	0	0	0	0	1	0	1	0	0	0
55	Rhyacophila (vao\acropedes)	1	0	5	0	13	0	11	2	0	0	1	0	4	1	35	1	0	0
56	Diptera Unid. adult	1	0	2	0	5	0	2	0	1	1	4	1	15	2	1	0	0	0
57	Diptera Unid. larvae	2	0	0	0	1	0	0	0	1	1	0	0	3	0	3	0	1	0
64	Palpomyia sp	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	18	1
66	Antcha sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
71	Pedicia sp	3	1	1	0	24	0	3	0	0	0	0	0	0	0	3	0	43	1
72	Prioncera sp	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
74	Tipula sp	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
76	Chelifera sp	2	0	2	0	73	1	1	0	0	0	1	0	3	0	31	1	30	1
77	*Weidemannia sp*	0	0	1	0	2	0	0	0	0	0	1	0	0	0	0	0	1	0

Note: Numbering System Corresponds to the Yukon Invertebrate List

APPENDIX IV TABLE 2 INVERTABRATE DISTRIBUTION

Number	INVERTEBRATE	STA.1	% Tot.	STA.2	% Tot.	STA.3	% Tot.	STA.4	% Tot.	STA.7	% Tot.	STA.8	% Tot.	STA.9	% Tot.	STA.10	% Tot.	STA.11	% Tot.
78	Prosimulium sp	17	3	41	3	2	0	0	0	0	0	0	0	3	0	0	0	0	0
79	Simulium sp	93	19	425	29	36	1	28	4	8	5	10	4	281	37	65	3	1	0
80	Simulium sp pupae	4	1	1	0	0	0	8	1	0	0	0	0	41	5	16	1	0	0
82	Limnophora sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
83	Pericoma sp	4	1	16	1	2	0	0	0	0	0	0	0	0	0	1	0	7	0
84	(Syrphidae?)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
85	Chironomidae adult	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
86	Chironomidae pupae	3	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
87	Brillia sp	0	0	179	12	12	0	9	1	4	2	0	0	2	0	2	0	0	0
88	Cardiocladius sp	47	9	0	0	0	0	1	0	0	0	0	0	1	0	1	0	1	0
90	Corynoneura sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
91	Cricotopus sp	0	0	0	0	11	0	4	1	4	2	3	1	0	0	48	2	27	1
92	Diamesa sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
93	Eukiefferiella sp	14	3	12	1	110	2	19	3	1	1	1	0	10	1	201	8	62	2
96	Micropsectra sp	0	0	2	0	74	1	7	1	0	0	20	7	6	1	16	1	875	26
97	Monopelopia sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
98	Nilotanypus sp	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0
99	Orthocladius sp	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
100	Paratendipes sp	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	15	0
101	Phaenopsectra sp	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	5	0
103	Polypedilum (Polypedilum)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
104	Potthastia sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
106	Rheocricotopus sp	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
107	Rheotanytarsus sp	0	0	0	0	1055	15	58	8	0	0	24	8	9	1	1034	41	29	1
108	Thienemanniella sp	0	0	1	0	2	0	0	0	0	0	1	0	0	0	0	0	6	0
110	Trissopelopia sp	4	1	0	0	123	2	2	0	0	0	5	2	2	0	14	1	77	2
111	Orthocladiinae unid.	6	1	15	1	4404	64	51	7	2	1	11	4	65	9	572	23	671	20
112	Isotomurus sp	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	10	0
113	Formicidae	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
114	Aphididae	37	7	26	2	1	0	2	0	75	45	4	1	23	3	1	0	8	0
115	Cicadellidae	0	0	1	0	0	0	0	0	1	1	0	0	2	0	0	0	5	0
116	Psyllidae	2	0	0	0	0	0	0	0	1	1	0	0	2	0	0	0	0	0
117	Corixidae dam	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
118	Callicorixa sp	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
119	Coleoptera unid. larva	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
120	Lepidoptera L	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
121	Arachnida	0	0	0	0	0	0	0	0	1	1	0	0	2	0	0	0	0	0
122	Hydracrina unid. J/D	13	3	12	1	9	0	2	0	0	0	4	1	2	0	36	1	67	2
123	Oribatei	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	4	0
124	Kerendowskia sp	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3	0	9	0
127	Sperchon sp	4	1	0	0	9	0	0	0	0	0	2	1	0	0	0	0	1	0
128	Torrenticola sp	0	0	0	0	1	0	0	0	0	0	2	1	0	0	0	0	8	0
130	Ostracoda	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
131	Cyclopoida	0	0	0	0	1	0	0	0	2	1	1	0	0	0	0	0	25	1
132	Calanoida	0	0	0	0	1	0	0	0	0	0	0	0	2	0	1	0	0	0
133	Harpacticoida	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	5	0
134	Acroperus harpae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0
135	Alonella sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0

Note: Numbering System Corresponds to the Yukon Invertebrate List

APPENDIX IV TABLE 2 INVERTABRATE DISTRIBUTION

Number	INVERTEBRATE	STA.1	% Tot.	STA.2	% Tot.	STA.3	% Tot.	STA.4	% Tot.	STA.7	% Tot.	STA.8	% Tot.	STA.9	% Tot.	STA.10	% Tot.	STA.11	% Tot.
136	Daphnia rosea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
137	Daphnia sp dam	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3	0	1	0
138	Eurycercus lamellatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
139	Graptoleberus testudinaria	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
140	Pleuroxus trigonellus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
142	Simocephalus sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0
143	Nematoda	2	0	1	0	15	0	0	0	0	0	0	0	1	0	6	0	21	1
144	Polycelis coronata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
145	Lumbriculidae, unid J/D	8	2	1	0	2	0	1	0	1	1	0	0	0	0	0	0	62	2
147	Enchytraeidae	3	1	0	0	7	0	3	0	0	0	0	0	2	0	0	0	27	1
148	Tubificidae	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
150	Nais sp	0	0	0	0	6	0	0	0	0	0	0	0	2	0	3	0	0	0
151	Chaetogaster sp	1	0	27	2	9	0	0	0	0	0	1	0	0	0	7	0	15	0
152	Batrachobdella sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
153	Hydra sp	5	1	0	0	31	0	9	1	0	0	2	1	0	0	1	0	10	0
155	Sphaerium sp	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	11	0
156	Pisidium sp	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	8	0
157	Gastropoda	0	0	0	0	16	0	2	0	0	0	17	6	0	0	2	0	6	0
158	Stagnicola (arctica)	0	0	5	0	8	0	7	1	0	0	14	5	0	0	2	0	13	0
159	Heliosoma sp	0	0	4	0	1	0	0	0	0	0	1	0	0	0	0	0	4	0
160	Valvata (sincera)	0	0	2	0	0	0	0	0	0	0	16	6	0	0	1	0	198	6
161	Physa sp	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0

Note: Numbering System Corresponds to the Yukon Invertebrate List