Environment Canada
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Pacific Region
Yukon Branch

A BIOLOGICAL AND WATER QUALITY ASSESSMENT AT A PLACER MINE ON BARLOW CREEK, YUKON TERRITORY

Regional Program Report 84-16

by

I. K. Soroka and G. Mackenzie-Grieve

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ABSTRACT

An assessment of water quality and biological conditions was carried out at a placer gold mine on Barlow Creek from June to September 1982. The water quality, sediment and bottom fauna characteristics were investigated at four sample stations.

Water quality parameters were influenced by the placer mining activity. During periods of sluicing activity downstream stations showed elevated levels for suspended sediments (NFR), settleable solids, filterable residue (FR), turbidity, extractable heavy metals, phosphorous and nitrites. Dissolved oxygen was slightly lower at downstream stations compared to an upstream control station.

The sediment composition of the stream bottom was seen to vary considerably from station to station and at the control station during the season. At downstream stations the sediment composition was significantly higher in percentage of fines (fine sands and silt) on sluicing days. These fines tended to be re-suspended and moved downstream during periods of non-sluicing or higher flows so that the stream bottom composition appears to recover to a composition typical of the natural stream over time. In general, there was an increase in levels of sediment metals at downstream stations during the season which reflected the general increase of fine sediments, especially during periods of sluicing activity.

Bottom fauna types, numbers and diversity were determined for each station during the season. Diversity indices were variable during the season and comparison of the control station with downstream stations shows a general overall decrease in numbers and diversity index values at downstream stations. The dominant groups in terms of abundance were the Ephemeroptera, Diptera and Plecoptera whose numbers varied in response to seasonal change and habitat alterations.

RÉSUMÉ

De juin à septembre 1982, on a procédé à une analyse de la qualité de l'eau et des conditions biologiques de la rivière Barlow, à l'emplacement d'un gisement aurifère alluvial. On a analysé la qualité de l'eau, les caractéristiques des sédiments et de la faune profonde à quatre points différents d'échangillonnage.

L'activité minière a eu un effet sur les paramètres de la qualité de l'eau. Durant les périodes de lavage du minerai on a relevé une grande turbidité dans les stations situées en aval, une proportion élevée de sédiments en suspension (résidus non filtrables), de solides en voie de sédimentation, de résidus filtrables, de métaux lourds extractibles, de phosphore et de nitrites. Dans les stations situées en aval on a relevé une proportion d'oxygène dissous légèrement inférieure à celle relevée dans une station située en amont.

On a constaté que durant la saison la composition des sédiments prélevés au fond du cours d'eau variait considérablement d'une station à l'autre, y compris la station de contrôle, Dans les stations situées en aval, la composition des sédiments comprenait un pourcentage sensiblement plus élevé de fins (sable fin et vase) les jours de lavage du minerai. Durant les périodes sans lavage ou les périodes de hautes eaux, ces fins étaient remis en suspension et transportés vers l'aval, ce qui redonnait progressivement au fond du cours d'eau sa composition naturelle. En règles générale, pendant la saison, on a constaté un accroissement de la proportion des métaux dans les sédiments aux stations situées en aval, ce qui correspondait à une plus grande accumulation des sédiments fins, en particulier durant les périodes de lavage du minerai.

Durant la saison, on a évalué pour chaque station les types, nombre et diversité de la faune profonde. Pendant ce même temps on a relevé des variations dans l'indice de diversité; en comparant les résultats de la station de contrôle et des stations situées en aval, on a constaté une diminution générale en nombre et en diversité dans les stations situées en aval. En importance numérique les groupes dominants étaient les éphéméroptères, les diptères et les plécoptères dont le nombre variait selon les changements saisonniers et les modifications de l'habitat.

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1 INTRODUCTION

A study of water quality, sediment composition and bottom fauna, was conducted on six different dates between June and September, 1982. This study was carried out, by the Environmental Protection Service - Yukon Branch, in the watershed of Barlow Creek in the Stewart River area (see Figure 1). The purpose of the study was to gather information on the quality of the stream and to enable the Environmental Protection Service to evaluate any impact to the receiving waters from placer mining operations.

1.1 Background

The Stewart River was one of the first areas in the Yukon to attract gold miners. Gold was discovered in paying quantities from its bars for many years beginning in 1883 with production reachings it peak between 1885 and 1887 (Bostock, 1957). In 1895 coarse gold was first discovered on tributary streams of the Stewart River, and in 1897 the first placer claims were staked on Clear Creek, the creek to which Barlow Creek is a tributary (Queenstake, 1982). From that time up to the 1940's, hand mining was the only form of mining that took place on Clear Creek and a number of its tributaries including Squaw Creek, Barlow Creek and Zinc Creek. According to records of the Mining Recorder for Barlow Creek, 104 claims were staked by Syndicate Lyonnais du Klondike from 1901 to 1903. In 1912 many five year placer mining grants were issued to individuals working single claims.

With the increase in gold prices in 1973, Clear Creek and the majority of its tributaries, including Barlow Creek, were staked by various individuals and companies. In 1981, two new operations were initiated on Barlow Creek and Zinc Creek. Dawson Mining Equipment, one of the larger companies on Zinc Creek, undertook an intensive mining program in 1981 but was not active in 1982 (Maxwell, J. Pers. Comm.). In 1982 there was some small scale testing activity approximately 6 km upstream of the study area on Zinc Creek. The operation on Barlow Creek where the study area is located was begun in 1981 and has the potential for a lengthy operation in that 66 claims were held by the operators.

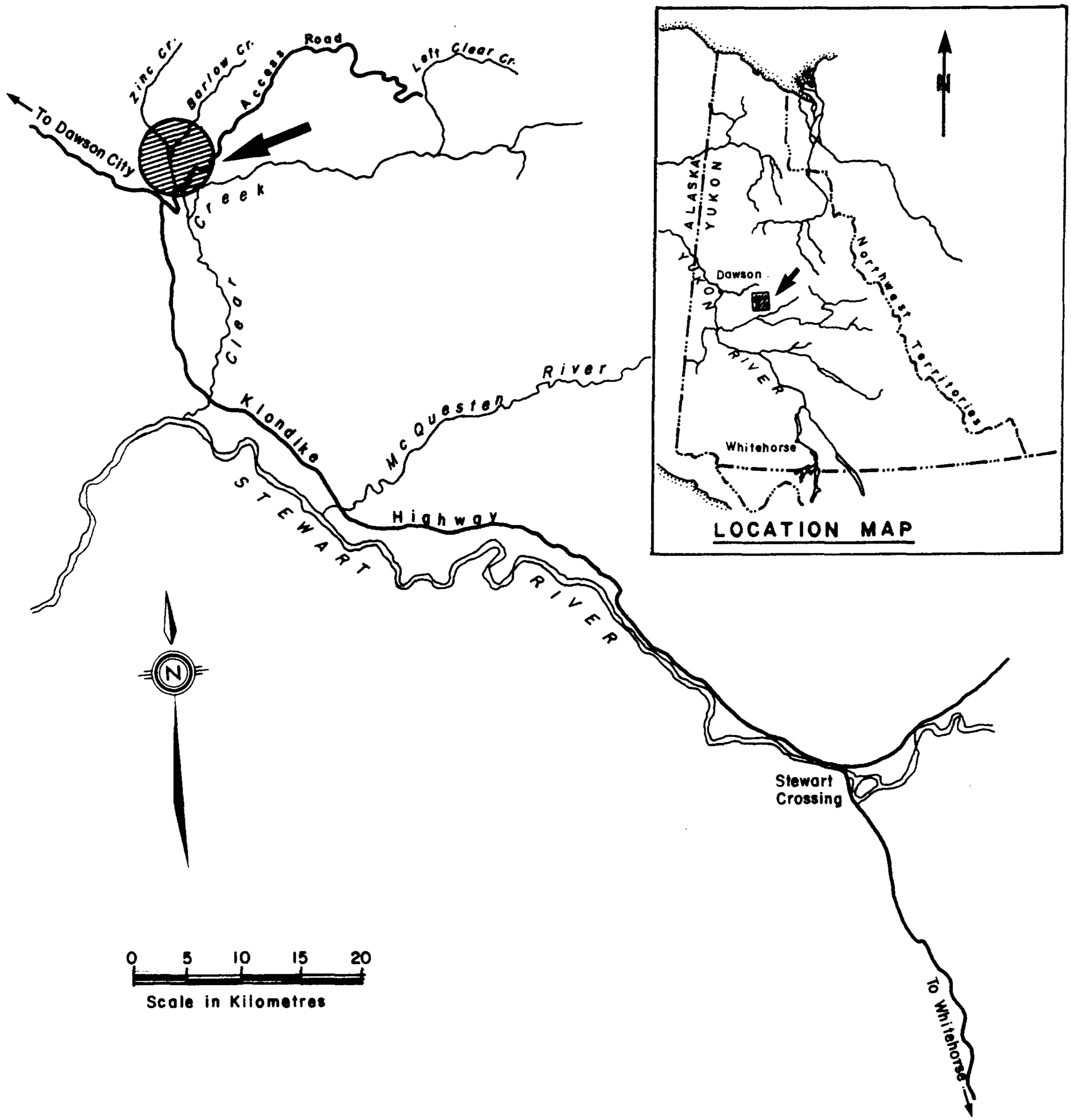

FIGURE I LOCATION OF BARLOW CREEK STUDY AREA

2 STUDY AREA

The study area lies approximately 400 km northwest of Whitehorse and 100 km southeast of Dawson City (see Figure 1). The property has easy access via a 4 km secondary road which leaves the Klondike Highway at km 610. Barlow Creek is one of many small creeks in the area that flows into Clear Creek which in turn is one of the main tributaries of the Stewart River. This network of creek and river valleys is surrounded and separated by uplands which characterize the Stewart Plateau, a subdivision of the Yukon Plateau. This plateau rises steeply along the north-east side of the Tintina Valley south of the McQuesten River (Bostock, 1948).

The current study site is located on the lower reach of Barlow Creek with elevations ranging from 555 m to 580 m. Sample stations were selected to include an upstream control station which would be unaffected by mining activity; a station to measure mine effluent and two downstream stations (see Figure 2). The sample sites are described in Table 1 and illustrated in photographs, Figures 3 to 9.

2.1 Description

Mining at Barlow Creek during the study period involved mechanically stripping the overburden, stock piling the pay dirt and gradually feeding it through the mine's processing plant. The volume of dirt stripped for 1982 was 40,000 m^3 with approximately 300 hours of sluicing between the months of July and September (DIAND, 1982). The processing plant on the site contained two trommell drums for classification of material, a stacker with a conveyor belt that carried away oversized waste rock, and a series of sluice boxes to gather gold. The concentrate from the process plant is further concentrated and cleaned in series of smaller riffles and specialized concentrator devices in a gold room. Other pieces of equipment on the site consist of a D8 cat and backhoe for digging and feeding the process plant. The water source for the mining operation was pumped directly from the Barlow Creek diversion through a 15 cm pipe at an approximate rate of 2300 L/min (500 IGPM). Barlow Creek was diverted to the northeast side

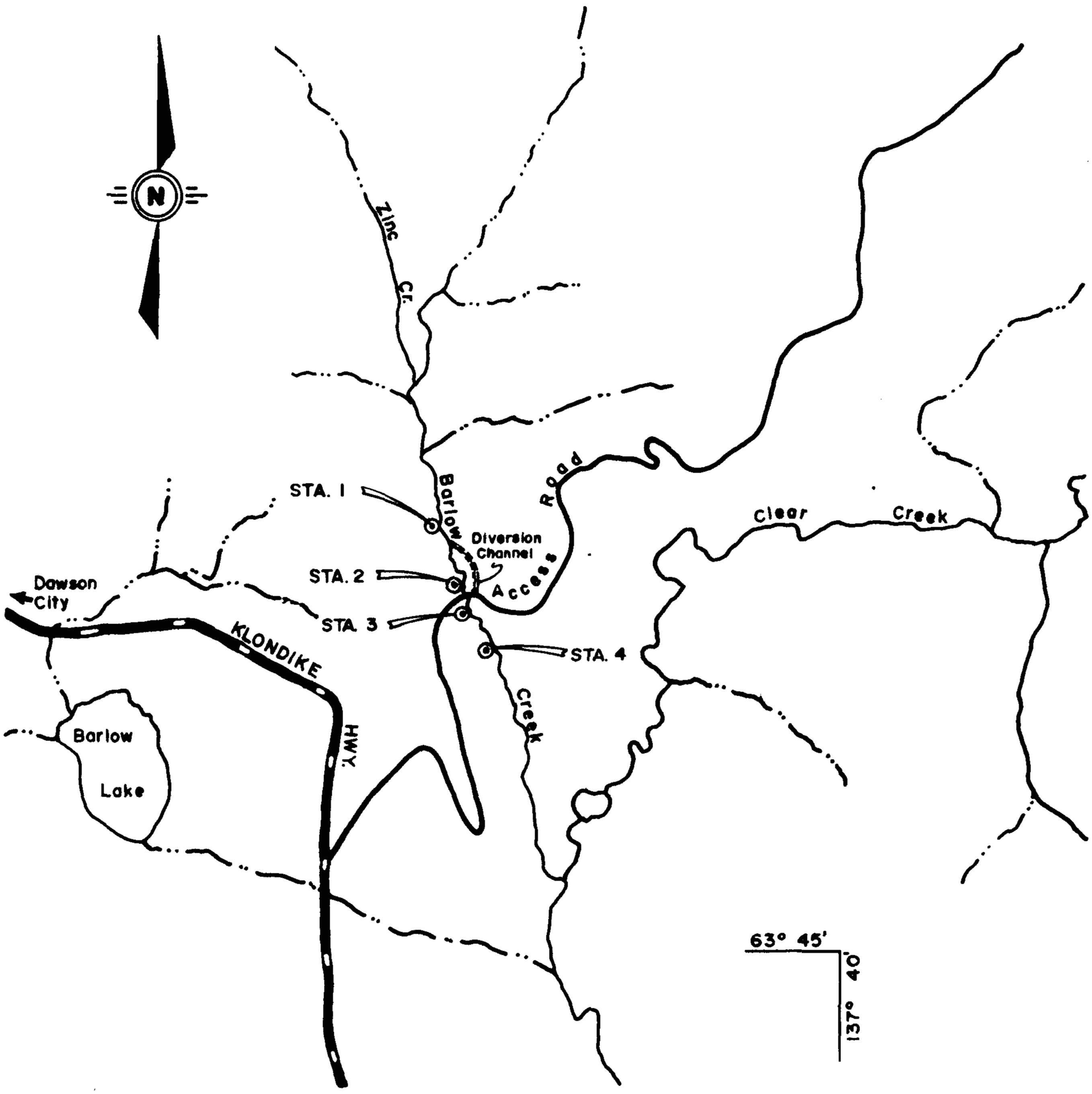

FIGURE 2 — BARLOW CREEK STUDY AREA SHOWING SAMPLE STATIONS

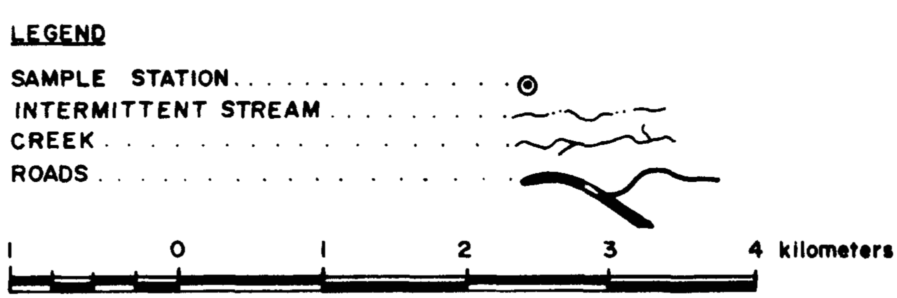

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TABLE 1 DESCRIPTION OF SAMPLE SITES IN THE BARLOW CREEK STUDY AREA

STATION	LOCATION	STREAM BOTTOM	REMARKS
1	63°46'N 137°39'W on Barlow Creek 0.75 km upstream from the mining operation and 3 km upstream of its confluence with Clear Creek. Elevation 580 m (1900 ft.)	Large cobbles, coarse gravel and some sand. 90% gravel was discarded from sediment sample.	Stable banks. Vegetation consists of black spruce, buckbrush, grasses and moss. Occassional gravel bar in the stream bed. Attempted electrofishing and found no fish. 0% shade.
2	63°46'N 137°39'W. Mine tailings effluent near the operation, 5 m (33 ft.) above its confluence with Barlow Creek. Elevation 565 m (1850 ft).	Mainly large boulders and cobbles.	Constructed effluent channel from settling pond. 0% shade.
3	63°46'N 137°39'W. 50 m (164 ft.) downstream of the confluence of the mine tailings effluent (Station 2) and Barlow Creek. Elevation 560 m (1837 ft.).	Cobbles, small pebbles and fine silt.	Stable banks. Vegetation consists of willows and grasses. Gravel bar near sampling location. Water was too shallow for electrofishing. 0% shade.
4	63°45'N 137°39' . 150m (492 ft.) downstream of station 3 on Barlow Creek. Elevation 555 m (1821 ft.).	Mainly small cobbles and gravel. Gravel cemented together and sediment. 90% gravel was discarded from sediment sample.	Stable banks. Stream channel is narrow which results in high flow during rain periods and sluicing. Attempted electrofishing but found no fish. 30% shade.

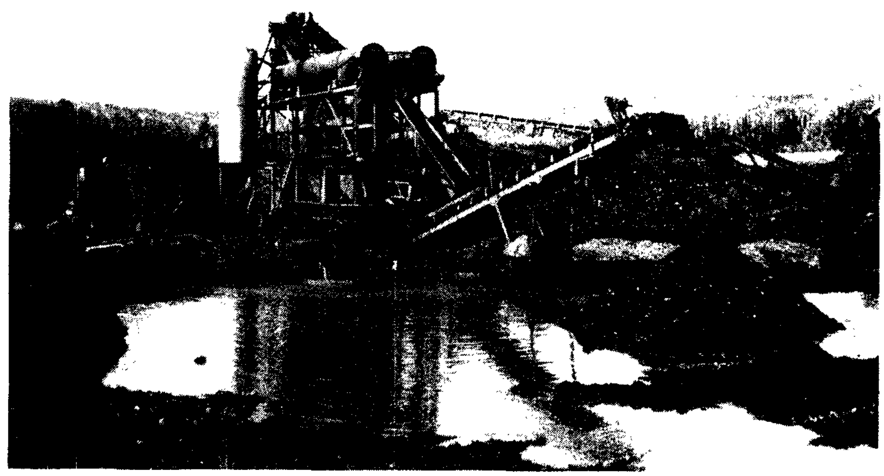

FIGURE 3 THE PROCESS PLANT AT BARLOW CREEK CONSISTS OF TWO TROMMELS, A STACKER AND A SERIES OF SLUICES. NOTE THE PILE OF WASTE ROCK BELOW THE STACKER.

FIGURE 4 BARLOW CREEK CONTROL STATION 1 LOCATED UPSTREAM OF THE MINING OPERATION.

FIGURE 5   STATION 2 IS LOCATED IN THE EFFLUENT CHANNEL 5 METRES ABOVE ITS CONFLUENCE WITH A DIVERTED SEGMENT OF BARLOW CREEK.

FIGURE 6 STATION 3 IS LOCATED 10 METRES DOWNSTREAM OF THE CLEAR CREEK ROAD BRIDGE.

FIGURE 7 STATION 4 IS LOCATED 150 METRES DOWNSTREAM OF STATION 3. HIGHER FLOWS ARE EVIDENT DURING ACTIVE SLUICING. CIRCULAR BENTHIC SAMPLER IN THE FOREGROUND.

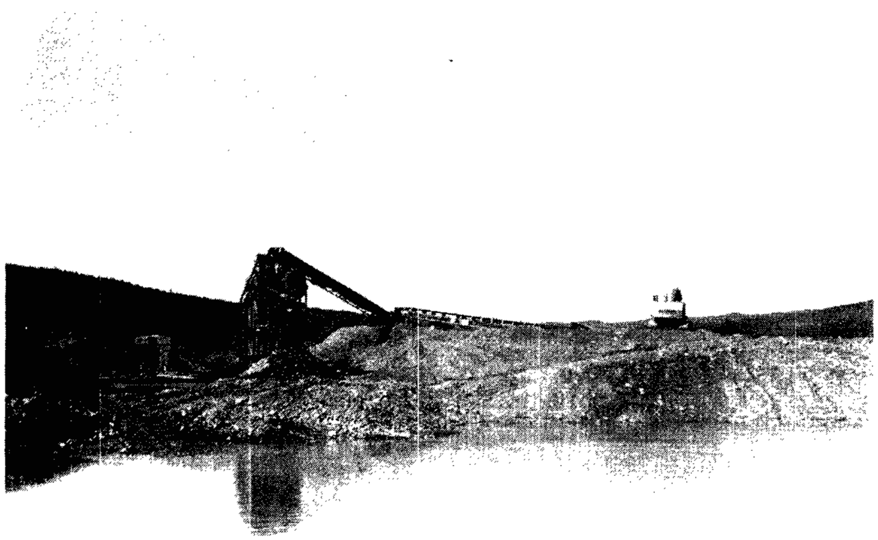

FIGURE 8 BARLOW CREEK PLACER MINING OPERATION. THE SETTLING POND IS LOCATED IN THE FOREGROUND.

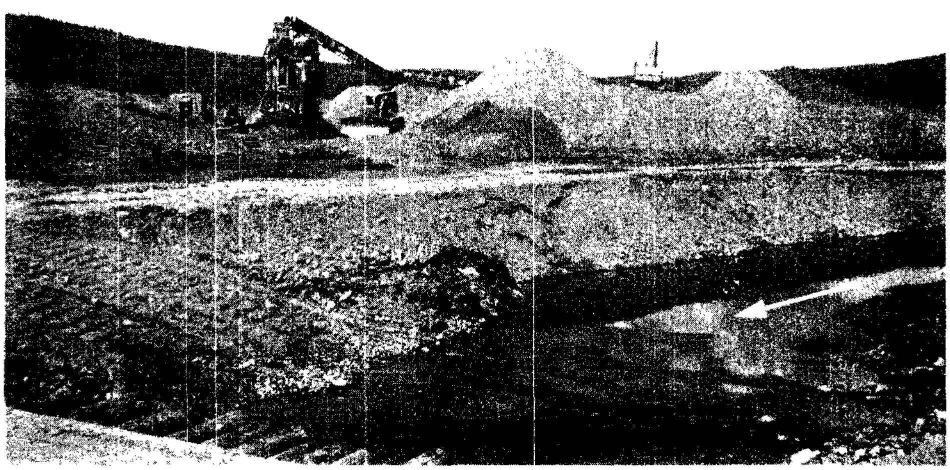

FIGURE 9 BARLOW CREEK MINING OPERATION, WITH SETTLING POND IN CENTRE AND DIVERSION CHANNEL IN THE LOWER RIGHT HAND CORNER.

of the valley, re-entering the original channel below the settling pond. Water from the sluicing operation was discharged into settling ponds and tailings were pushed up to higher ground with future plans for restoration and revegetation.

The current camp and mining operation at Barlow Creek operated under a Water Use Authorization issued under the Northern Inland Waters Act. Water requirement for the camp was estimated at 2300 L/day (500 IGPD) and 5500 L/min (1200 IGPM) for the mining operation.

During the 1982 season, mining and testing activities were carried out at two small mining operations in the Barlow Creek drainage upstream of the study area. One operation with an estimated water requirement less than 2300 L/min. took place on the upper end of Barlow Creek on the Red Rooster tributary. This consisted of a relatively small testing program involving some stripping and trenching. Any waste water resulting from the testing program was discharged into a large hole rather than into the creek, thus preventing any disturbance. The second operation occurred 6 km upstream on Zinc Creek and basically involved some hand mining with an estimated water requirement of 700 L/min. for an approximate total of 15 hours of sluicing. Any significant influence arising downstream however, may be linked to mining activity and disturbance on Zinc Creek from the previous year (J. Maxwell, Pers. Comm.).

2.2 Mineralization Description

Yukon Group rocks of the Proterozoic age underlay the Barlow and Clear Creek watershed. This Group is primarily composed of quartzite grits, shales and bands of limestone. A major structural feature found in this area is the Tintina trench which is crossed by Clear Creek between Barlow Creek and the Stewart River (Queenstake, 1982). The terrain can be described as highly weathered with colluvial slopes and V-shaped, narrow, restricted valleys. Colluvial placer deposits are developed on terrain where active down-slope movement of superficial materials is occurring, generally over a weathered bedrock surface, and commonly associated with local primary lode sources.

Factors such as slope angle or gradient, thickness and type of slope material, size and specific gravity of heavy minerals, coefficient of friction and seasonal frost all affect extent and grade of colluvial placer deposits (Boyle, 1979). It is also important to note that gold associated with colluvial deposits tends to be coarser near the primary source.

3 METHODS

Access to the area was by truck and each station was sampled six times. The sampling dates were June 26, July 8, July 19, August 9, September 1 and September 22, 1982.

3.1 Water Quality

Water samples were collected and preserved as described in Appendix I, Table 1 at each of Stations 1, 3 and 4. At Station 2, the tailings pond effluent stream, samples were collected for non-filterable residue (NFR) only.

Temperature, conductivity and pH were measured in the field using a Yellow Springs Instrument direct-reading salinity-conductivity-temperature meter and Model 296 Radiometer pH meter. Stream discharge (flow) was measured by using a Price-type current meter. Dissolved oxygen was analyzed using the Winkler's Azide modification method. Settleable solids were collected as grab samples and analyzed in the E.P.S. Whitehorse Lab within 2-4 days. Non-filterable residues were collected in duplicate. One sample was analyzed within 3 days in the Whitehorse Lab and the second sample was sent to the E.P.S. Vancouver Lab. All other analyses were performed by Laboratory Services, Environmental Protection Service, 4195 Marine Drive, West Vancouver, B.C. These included turbidity, colour, total hardness, filterable residue (FR), total alkalinity, total phosphates, nitrates, nitrites, ammonia, sulfate, chloride and the following extractable metals:

Aluminum (Al)	Copper (Cu)	Selenium (Se)
Antimony (Sb)	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)	Potassium (K)	Zinc (Zn)

The percent dissolved oxygen (% DO) saturation was calculated by first determining the dissolved oxygen saturation concentration (S') from the formula:

$$S' = S \frac{P}{760} \quad \text{(APHA et al 1975)}$$

where S' = dissolved oxygen (DO) saturation concentration at the in situ temperature and atmospheric pressure

S = dissolved oxygen (DO) saturation concentration at sea level for in situ temperature

P = atmospheric pressure in mm of mercury (mm Hg) at site elevation

The percent dissolved oxygen saturation was obtained by using the ratio of field dissolved oxygen and S' in the following formula:

$$\frac{\text{Field DO}}{S'} \times 100 = \%\ \text{DO Saturation}$$

where Field DO = Dissolved Oxygen concentration measured in the field

3.2 Sediments

Sediment samples were collected at the same time as water samples at Stations 1, 3 and 4. Sediment samples were collected on all dates except June 26 and at Station 4 on July 8 and 19. Sediments were not collected at Station 2 as this was strictly a settling pond effluent station in a constructed channel. Three replicate sediment samples were collected at each site using an aluminum shovel to scoop the samples into labelled Whirlpack bags. A description of sediment collection, preparation and analysis methods is given in Appendix I, Table 2. All sediment samples were shipped to Vancouver by air for analysis at Laboratory Services, Environmental Protection Service, West

Vancouver, British Columbia. Each of the three sediment samples collected at each station were analyzed for particle size and the following leachable metals:

Aluminum (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)	

3.3 Bottom Fauna

Bottom fauna was sampled at three Barlow Creek sampling stations. Station 2 was located in the constructed effluent channel from the settling pond and was not suitable as a station for bottom fauna collection. Samples were collected at the same time as water and sediment samples on the six sampling dates. Three replicate samples were collected at each site using a 30 cm x 30 cm surber sampler (900 cm^2 or 1 ft^2) with a mesh size of 0.76 mm. Bottom fauna samples at Station 4 on July 8 and July 19, 1982, however, were not collected because high water conditions made it impossible to obtain a representative bottom sample. Bottom fauna collection, preservation and identification methods are given in Appendix 1, Table 3.

Diversity indices were calculated from the bottom fauna data collected, using the formula described by Pielou (1975) as follows:

$$\text{Species Diversity } (H') = -\sum_{i=1}^{g} (P_i \log_{10} P_i)$$

where $P_i = n_i/N$

n_i = total number of individuals in the ith genus in one sample

N = total number of individuals identified to genus level in one sample

g = total number of genera in one sample

The use of individuals identified to genus level instead of to species level results in slightly lower diversity indices (H') values (Hughes, 1978). The omission of bottom fauna that cannot be identified to genus or species will affect the validity of diversity on a comparative level, as the entire population failed to be represented.

3.4 Fish

Electrofishing of the creek at Stations 1, 3 and 4 was conducted on July 8, 1982. This was done to determine if fish were present and, if so, to obtain tissue samples for metal analysis. No fish were present. Notes were made on whether sample streams appeared suitable for fish habitat.

4 RESULTS AND DISCUSSION

The results for the different parameters measured are generally seen to be greatly influenced by mining, particularly sluicing activity at the mine site. Sluicing was occurring during the sampling periods on July 19 and August 9, but had ceased for a few hours on September 22. There was no sluicing activity on any of the remaining sample dates.

4.1 Water Quality

Table 4 in Appendix I lists the accepted water quality criteria for drinking water and aquatic life with the appropriate reference sources. The water quality results are presented in their entirety in Appendix II whereas the following results and discussion with accompanying graphs concentrate on those parameters considered particularly important to water quality and affected by the placer mining activity.

4.1.1 Heavy Metals.

As illustrated in Figures 10 and 11, the following heavy metals, with the exception of mercury, are significantly affected downstream on Barlow Creek by placer mining activity:

Arsenic (As)	Manganese (Mn)
Copper (Cu)	Nickel (Ni)
Iron (Fe)	Lead (Pb)
Mercury (Hg)	Zinc (Zn)

Water analysis for extractable heavy metals reveals significant increases due to sluicing on July 19 and August 9. Downstream at Stations 3 and 4 arsenic levels ranged from <0.0005 mg/L to 0.0043 mg/L. Although values during sluicing periods increased 5 to 10 times from the upstream levels, they were still within the recommended limits of 0.05 mg/L/(total) for drinking water and aquatic life.

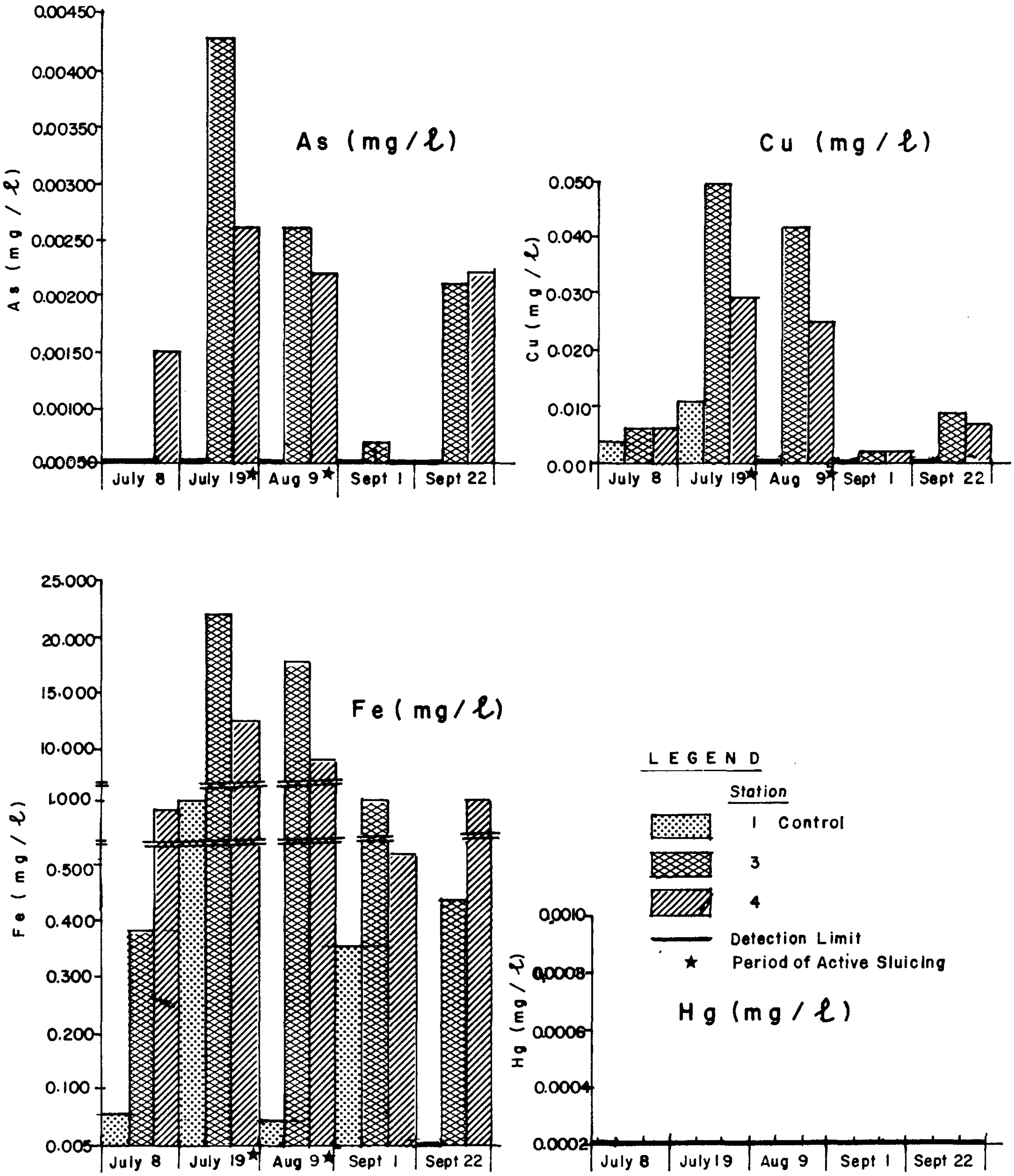

FIGURE 10 HEAVY METALS IN WATER
(Origin of Y-axis equals Detection Limit) - 1982

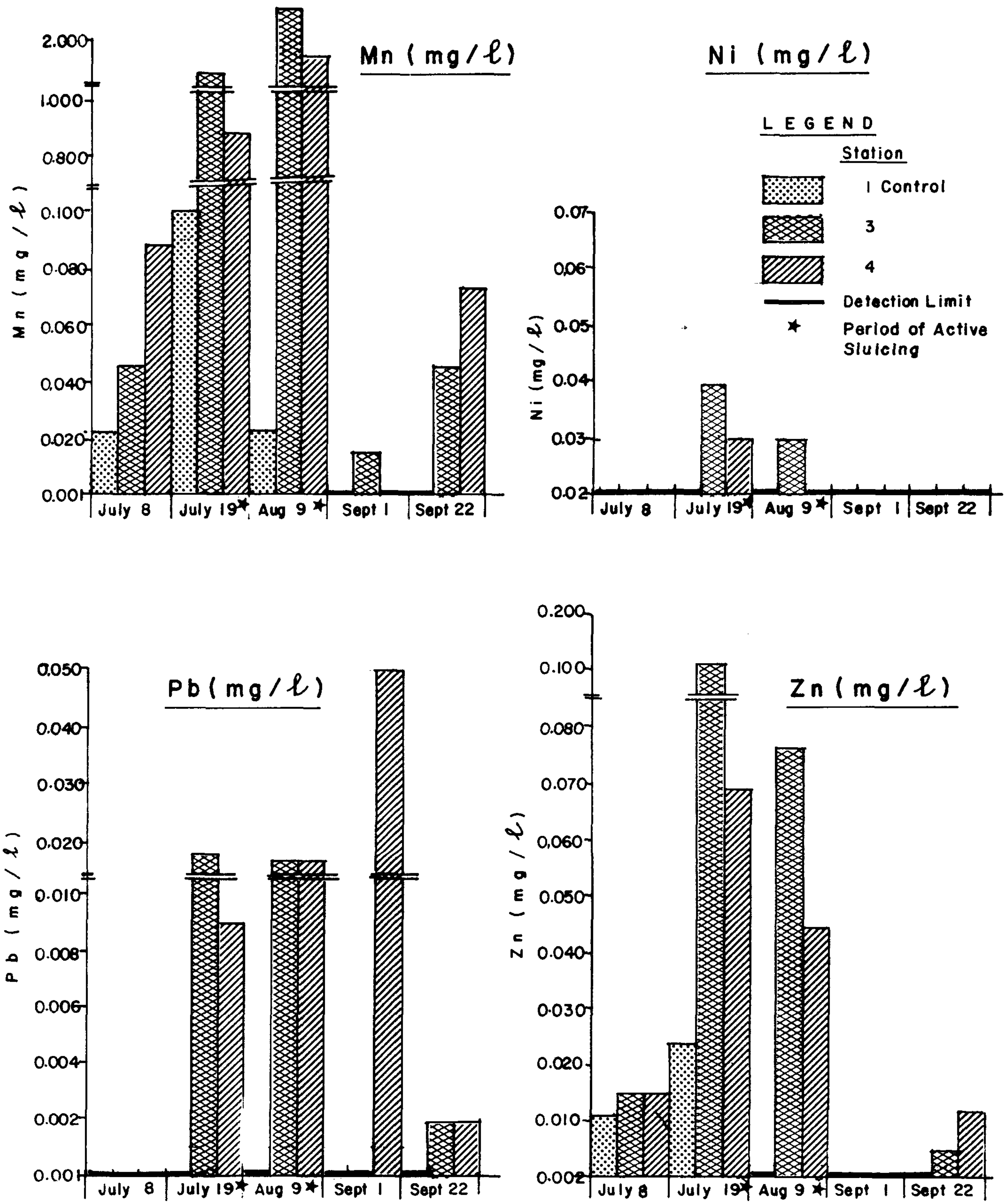

FIGURE 11 HEAVY METALS IN WATER
(Origin of Y-axis equals Detection Limit) - 1982

Copper levels increased as a result of mining and on both sluicing dates were above the recommended levels for aquatic life; 0.050 mg/L and 0.030 mg/L at Stations 3 and 4 on July 19, and 0.042 mg/L and 0.025 mg/L at Stations 3 and 4 on August 9. Copper also slightly exceeded recommended levels for aquatic life at downstream stations on July 8; 0.006 mg/L at Stations 3 and 4, and on September 22; 0.009 mg/L at Station 3 and 0.007 mg/L at Station 4. At Station 1 (control station), a level of 0.011 mg/L was found on July 19. This level may have been caused by upstream testing and sluicing activity.

Iron levels exceeded recommended limits for drinking water and aquatic life at all downstream stations throughout the sampling period and at the control (Station 1) on two occasions. The highest values found were 22.9 mg/L and 12.6 mg/L at Stations 3 and 4 on July 19 and 17.4 mg/L and 8.74 mg/L at Stations 3 and 4 on August 9. Elevated values for iron may be attributed to mining activity upstream on Barlow Creek or on the property itself.

Mercury levels were all below the detection limit of 0.0002 mg/L and therefore do not pose a problem.

Levels for manganese were found to be significantly increased at both downstream stations on July 19 and August 9. Values of 1.47 mg/L and 0.874 mg/L at Stations 3 and 4 exceeded the recommended limits for drinking water and aquatic life, as did values of 2.60 mg/L and 1.80 mg/L found at Stations 3 and 4 on August 9. Elevated levels of manganese that exceeded limits for aquatic life and drinking water were also noted at Station 1 on July 19.

Nickel levels only slightly exceeded recommended limits for aquatic life at Stations 3 and 4 on July 19 with values of 0.04 mg/L and 0.03 mg/L, and at Station 3 on August 9 with a value of 0.03 mg/L. All other values for nickel were below the 0.02 mg/L detection limit.

All levels for lead were within drinking water limits at all locations; however, some exceeded recommended limits for aquatic life. Values of 0.017 mg/L and 0.009 mg/L were found at Stations 3 and 4 on July 19 and 0.016 mg/L for Stations 3 and 4 on August 9. These levels were noted to be approximately 20 times greater than at upstream stations. An anomalous level of 0.050 mg/L also occurred at Station 4 on September 1. Possible error or contamination to the sample collection might explain this elevated level.

Zinc was also present at levels which exceeded recommended limits for both drinking water and aquatic life. These values were 0.111 mg/L and 0.069 mg/l at Stations 3 and 4 on July 19 and 0.076 mg/L and 0.044 mg/L at Stations 3 and 4 on August 9. Other heavy metals that appeared to increase as a result of mining activity included Aluminum (Al), Cobalt (C), Chromium (Cr) and Magnesium (Mg). These values may be found in Appendix II.

Heavy metals present in the water were clearly more abundant on dates when sluicing was occurring at the time of sampling as shown in Figures 10 and 11. These elevated levels corresponded with higher suspended sediment (NFR) values for the same dates which is expected because the metals are typically associated with fine grained material that makes up suspended sediments (Paski, Pers. Comm., 1982). It is seen in the above results and from Figures 10 and 11 that levels for copper, iron and manganese at Station 1 on July 19 in particular were higher than on other sample dates and exceeded the recommended levels for aquatic life (Cu, Fe, Mn) and drinking water (Fe, Mn). It is suggested that this increase in extractable metals at Station 1 on July 19 is due to placer testing activities on upstream tributaries to Barlow Creek or the prolonged rainfall which would increase natural erosion into the stream.

4.1.2 Suspended Sediments (Non-Filterable Residue - NFR).

All suspended sediments were collected by grab sample and analyzed at the EPS Whitehorse laboratory two to four days after collection. Duplicate samples were also analyzed at the EPS laboratory in Vancouver as a cross reference for quality control, and corresponded very closely with the results of the EPS Whitehorse laboratory. The results presented in Appendix II are those determined in the Whitehorse laboratory.

Suspended sediments can be defined as any particulate matter suspended in water and that is retained by a 0.45 micron filter or a filter of defined pore size. The term is also synonymous with non-filterable residue (NFR). Suspended sediments are comprised of sand, silt, clay and detritus, and are usually the major cause of concern in water with regard to a placer mining operation. Griffiths and Walton (1978) summarize the direct and indirect effects of sediment on fish. The direct effects are: (1) mortality of adult fish as a result of mechanical and abrasive damage; (2) impairment of reproduction, growth and survival; and (3) increase of disease within a population. The indirect effects result from: (1) habitat modifications, (2) alterations in food sources and other biotic relationships, and (3) reduction of visibility.

Good discussions of the effects and potential effects of suspended sediments on fish, the aquatic habitat and bottom invertebrates have been presented by Pickral (1981), Griffiths and Walton (1978), Cordone and Kelley (1961), and Rosenberg and Snow (1975).

Water quality with regard to suspended sediments in the upper reaches of Barlow Creek appears relatively undisturbed and indicates low levels of less than 5 mg/L of suspended sediments on most sample dates (see Figure 12). On July 19, however, Station 1 exhibited a suspended sediment level of 47 mg/L. This could have been attributed to some testing work from upstream operations on Zinc Creek or the Little Rooster tributary of Barlow Creek or as a result of rainfall which increased natural erosion into the stream. Very high values for suspended sediments were found at downstream stations, Stations 3 and 4, on the two sluicing dates, July 19 and August 9. Suspended sediments on July 19 measured as high as 6990 mg/L, 1008 mg/L and 570 mg/L at Station 2 (tailings pond effluent), Station 3 and Station 4 respectively; and 4530 mg/L, 984 mg/L and 2065 mg/L at Stations 2, 3 and 4 respectively on August 9. During sampling times on September 1, active sluicing was not occurring and the suspended sediment levels at downstream stations all exhibited greatly reduced values as compared to sluicing times. The suspended sediment levels on September 22 at Stations 3 and 4 were 211 mg/L and 142 mg/L respectively. Sluicing activity had ceased for several hours on September 22 when suspended sediments were collected at Stations 3 and 4 and found to be slightly

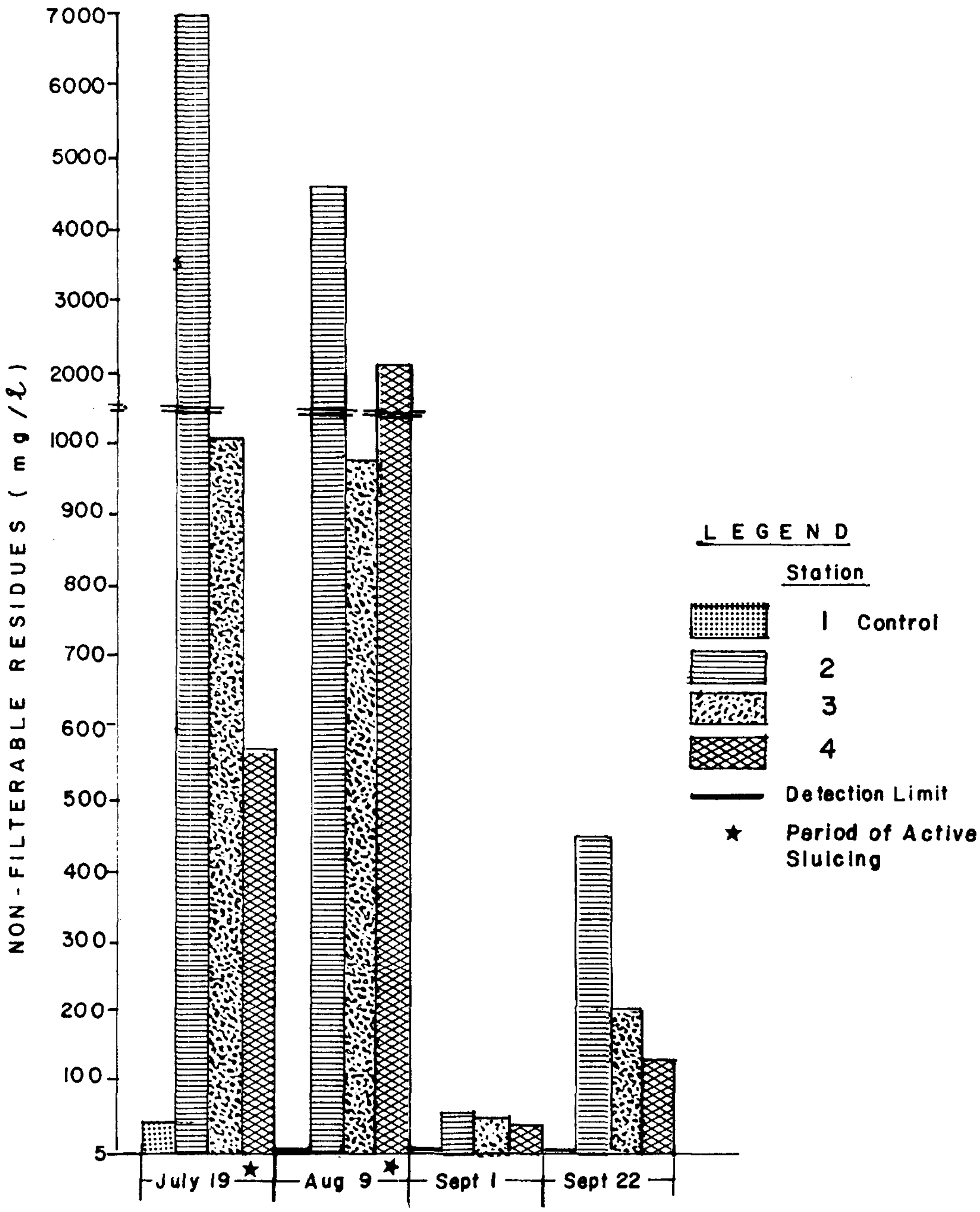

FIGURE 12 NON-FILTERABLE RESIDUE
(Origin of Y-axis equals Detection Limit)

elevated (211 mg/L and 142 mg/L respectively). Effluent had time to settle in the tailings pond, which explains the observed results.

Suspended sediment levels influence or may influence other water quality parameters such as turbidity, colour, settleable solids and dissolved oxygen. These parameters and others are described in the following section.

4.1.3 Other Water Quality Parameters.

The results for other water quality parameters that were noticeably different between upstream and downstream stations and probably influenced by placer mining are provided below. The values for these parameters, in many cases, exceeded drinking water standards or recommended levels for aquatic life. The parameters include dissolved oxygen, settleable solids, turbidity, colour, total hardness, phosphorus, nitrite (NO_2-N) and ammonia (NH_3-N). Results for these and other parameters are provided in Appendix II.

(a) Flow. Flow measurements provide only an approximation of flow in that there were variations in recorded flow rates between stations on the creek. The flow data in Appendix II indicates input to the stream between upstream and downstream stations based on average flows. The average flow rate (m^3/s) at Station 3 is greater than at Station 4 suggesting that some of the flow is diverted from the stream channel to an underground aquifer or channel between Station 3 and 4 or that there are significant errors in the flow measurements. The range of flows at Station 1 varied from 0.1 m^3/s to 0.7 m^3/s with the peak of 0.7 m^3/s occurring on July 19 which followed a period of prolonged rainfall. This period of highwater would probably contribute to the elevated levels of suspended sediments (NFR) and certain metals noted at Station 1 on July 19.

(b) Temperature. The results show a general increase between Station 1 and Station 4. The general downstream increase from 7°C at Station 1 to 9°C at Stations 3 and 4 on July 19, and 9°C at

Station 1 to 11°C at Stations 3 and 4 on August 9 may be caused by the fact that the operation had a storage pond to provide adequate water for prolonged sluicing and because during sluicing there was a high percentage of sluicing water recirculated. The greatest temperature difference between upstream and downstream stations occurred in mid-season when the warming of the ponded water would be greatest, whereas at the beginning and end of the season the upstream and downstream temperature differences were less.

(c) Dissolved Oxygen (DO). Slight decreases in dissolved oxygen were noted at all downstream stations as compared to the Station 1 control. The DO levels were between 0.1 mg/L to 1.1 mg/L lower at downstream stations than respective upstream stations, which generally did not pose a significant decrease. However small, this reduction may have been caused by surface and organic material introduced into the water from sluicing and runoff which may create an oxygen demand. The DO levels remained well above minimum levels recommended for aquatic life. The percent saturation for DO, which is directly related to the actual concentration, is used as the reference standard for this parameter. Dissolved oxygen saturation did not meet the drinking water standard at any of the downstream stations except on July 8, which corresponds with the fact that mining activity did not influence those stations until after that date. Except for July 8, the percent DO saturation was less than 100% at the control station throughout the entire operating season. This could be due to placer activity on upstream tributaries to Barlow Creek or groundwater influencing the stream during the latter parts of the season. Under the conditions present in this stream reach, the decrease in percent DO saturation is not great although it was detectable on sluicing dates.

(d) Turbidity. Increased turbidity generally exists in water when an increased surface area of silt and clay particles reflect more light than would larger sand particles (Taekema 1983). Because turbidity is directly related, though not necessarily linear, with suspended sediments it was found, as expected, to be greatly elevated at downstream stations on July 19 and August 9. Values as high as 800 FTU (Formazin Turbidity Units) and 600 FTU occurred at Stations 3 and 4 respectively on July 19, and 1280 FTU and 1200 FTU at Stations 3 and 4 on August 9. Significantly elevated turbidity levels of 180 FTU and 95.0 FTU were also demonstrated at Stations 3 and 4 during the last sampling date of the season, September 22, which occurred immediately after sluicing had ceased for the day. These values compare with levels less than 0.1 FTU to 2.9 FTU at the Station 1 control. Other downstream values during non-sluicing times range between 10.0 and 30.0 FTU, indicating turbidity resulting from non-point sources along the stream in the vicinity of the operation.

(e) Settleable Solids. Settleable solids are commonly defined as "any particulate matter in suspension that will settle out of suspension in a standard unit of time" (Department of Environment, 1979). Settleable solids were elevated on one sampling date, July 19. Values ranged from 0.9 mL/L at Station 3 and 0.2 mL/L at Station 4. Values at Stations 3 and 4 on August 9 were both less than 0.1 mL/L. All other values for settleable solids at the control and downstream at Stations 3 and 4 were less than 0.1 mL/L.

(f) Colour. Colour exceeded recommended levels for drinking water by demonstrating values greater than 100 colour units at Stations 3 and 4 on July 19. On this date, however, a value of 65 colour units was found at the control (Station 1). It is possible that this elevated level was caused from testing and mining activity upstream although naturally high flows existed at the time. A colour level of 20 colour units occurred at Station 3 on September

1. Colour measurements at Stations 3 and 4 were not analyzed for August 9 due to high turbidity interferences. High values for colour may be due to increased concentrations of organic matter introduced to water from the stripping process.

(g) Hardness. Relatively high levels of total hardness were noted throughout the sampling period. Values ranged from 66.4 - 124 mg/L as $CaCO_3$ at Station 1 to 94.0 - 214 mg/L as $CaCO_3$ at downstream stations. Levels of 195 and 130 mg/L as $CaCO_3$ occurred at Stations 3 and 4 on July 19 and 214 and 150 mg/L as $CaCO_3$ on September 1. These results clearly exceeded the recommended levels of 80-100 mg/L for drinking water.

(h) Phosphorus (as PO_4). Excessive amounts of phosphates in streams may cause algal blooms and odours that are detrimental to fish. To avoid nuisance concentrations of algae, average total phosphorus concentrations should not exceed 0.020 mg/L (Ontario Ministry of Environment, 1978). This level however was exceeded at Stations 3 and 4 on three sampling dates. These were 0.920 mg/L and 0.510 mg/L on July 19, 1.05 mg/L and 1.00 mg/L on August 9 and 0.225 mg/L and 0.145 mg/L on September 22. One other slightly elevated level that may have been significant was 0.057 mg/L found at Station 1 on July 19. Other values at the control station ranged between <0.005 - 0.008 mg/L and between 0.020 - 0.033 mg/L at Stations 3 and 4 during nonsluicing times.

(i) Nitrites. Nitrite measurements exceeded the recommended drinking water standard of 0.001 mg/L at most downstream stations and at the control station on July 19. These levels ranged from 0.007 mg/L to 0.037 mg/L. The detection limit for nitrite (0.005 mg/L) is greater than the recommended drinking water limit. All Station 1 samples except on July 19, Station 4 on September 1 and Stations 3 and 4 on September 22 were all less than the detection limit.

(j) Ammonia. Levels for ammonia were all found to be within recommended limits for drinking water and aquatic life. Calculations taken from APHA et al (1975) were used on ammonia levels to determine the percentage of un-ionized ammonia. Levels of un-ionized ammonia that exceed the 0.02 mg/L recommended level for aquatic life indicates excess concentration of metabolic products in the water which may result in stress to aquatic organisms.

(k) Conductivity, pH, filterable residues, sulphates, nitrates and alkalinity were all within recommended levels for drinking water and aquatic life.

4.2 Sediments

Sediment samples were collected at Stations 1, 3 and 4 on each of the sampling dates and subsequently analyzed for particle size composition and leachable metals. No sediment samples were collected at Station 2, or at Station 4 on July 8 and 19. When analyzing and discussing the results of sediment analysis it is necessary to be aware of the variability that can occur among replicate samples due to natural variations in stream bottom composition. Despite the limitation on interpretation the data shows the effects of sluicing on sediment composition and sediment chemistry at downstream stations compared to the control, and this can be related to the effectiveness of the settling ponds.

4.2.1 Sediment Particle Size Analysis.

Results of the sediment particle size analysis are given in Appendix III, Table 1. Illustrations of particle size in terms of mean percent composition can be found in Figures 13 and 14.

Increased levels of silts and clays occurred downstream of the mining activity throughout the operating season. Especially high concentrations of silts and fine sands were found at Station 3 on two sampling dates when sluicing occurred (July 19 and August 9). During

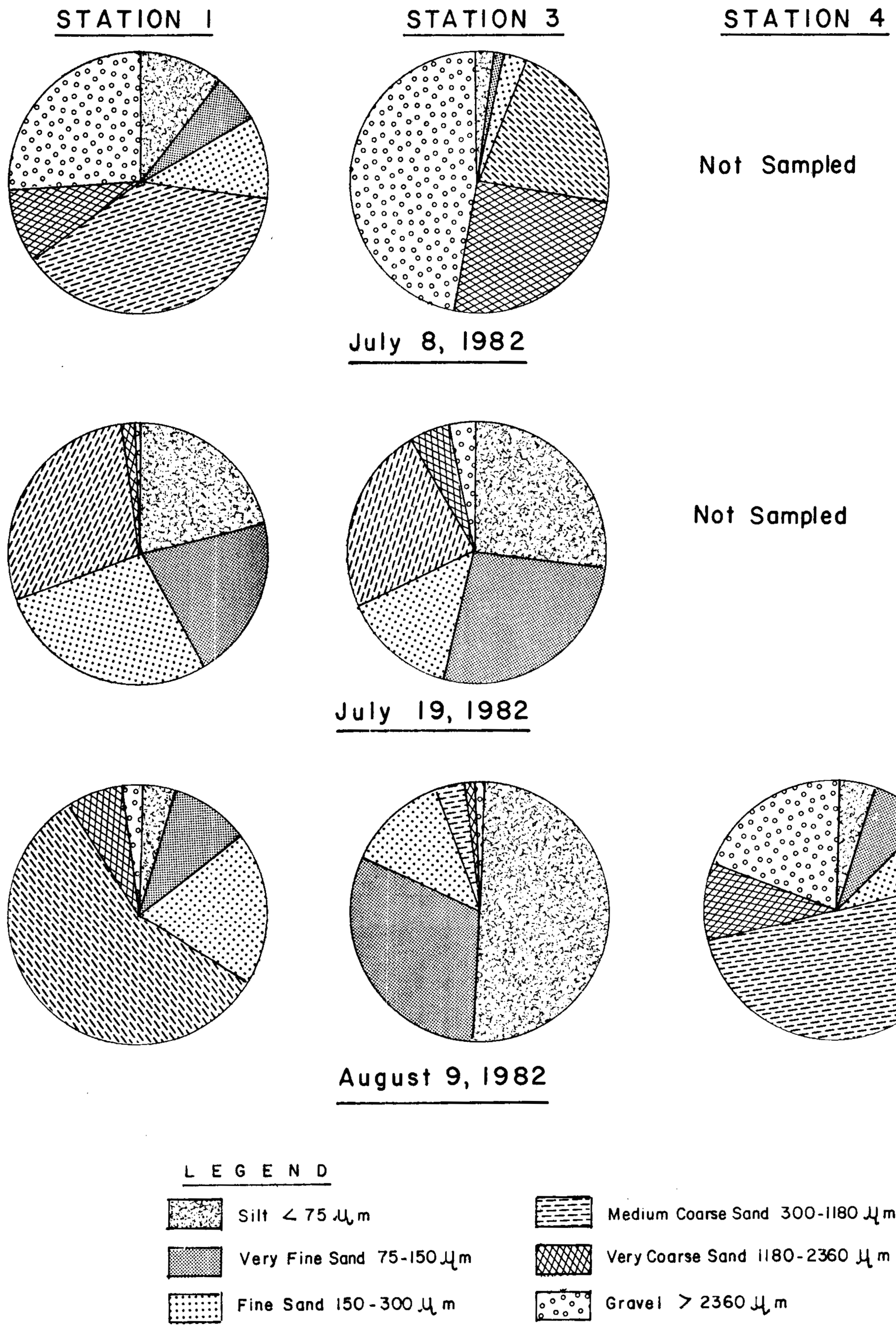

FIGURE 13 SEDIMENT PARTICLE SIZE ANALYSIS - MEAN PERCENT COMPOSITION

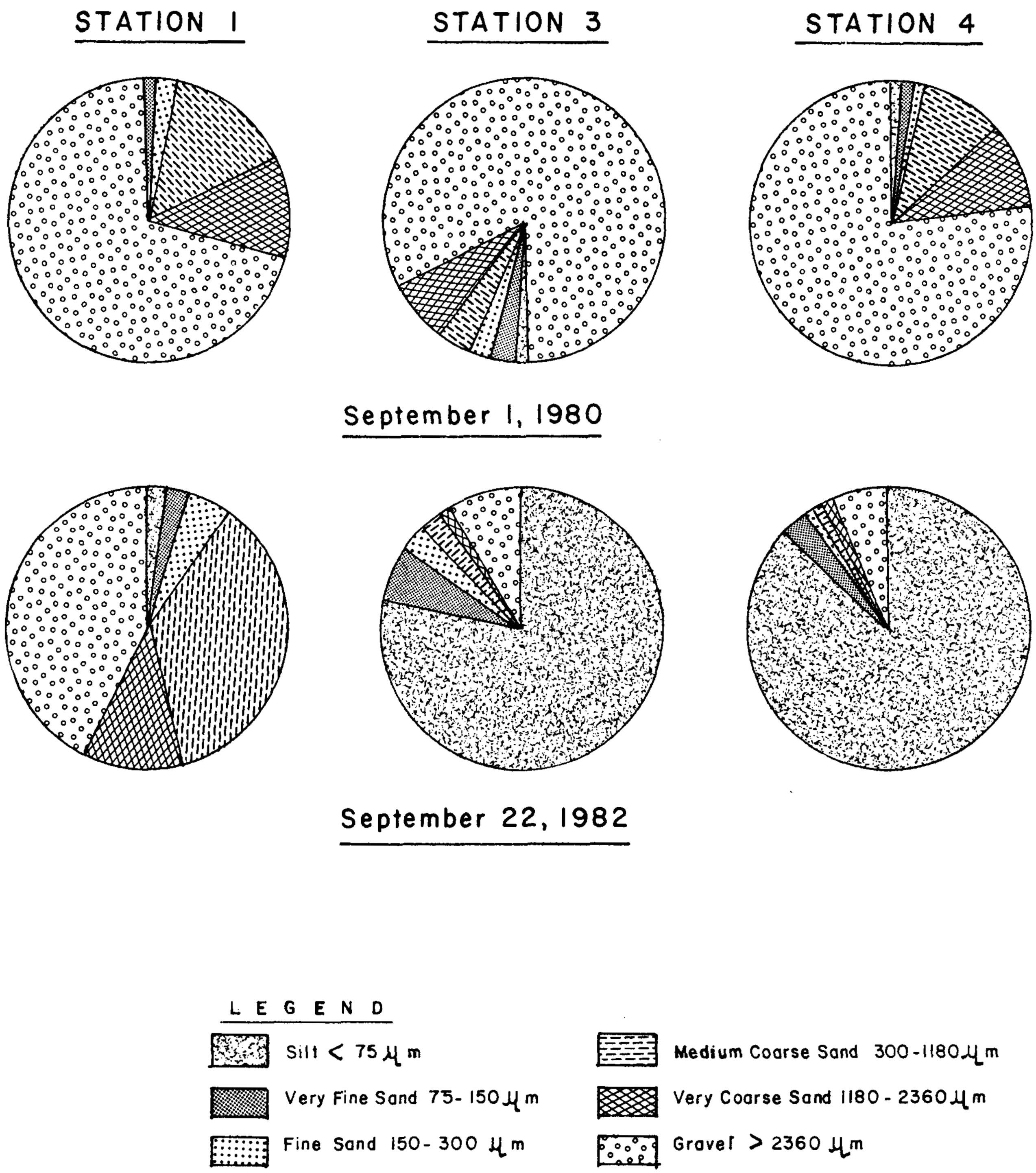

FIGURE 14 SEDIMENT PARTICLE SIZE ANALYSIS - MEAN PERCENT COMPOSITION

these two periods percent composition of silts and fine sands (75 um to 350 um) ranged from 67.4% to 97% downstream at Station 3, but only 19.4% at Station 4 on August 9. Eighty percent of the sediment collected at Station 4 on August 9 ranged in size from medium coarse sand to gravel (300 um to >2360 um). Due to the deep and narrow channel at Station 4 and an increase in discharge during sluicing, a "flushing out" process may have occurred to explain this state of recovery to the stream bed. Sediment at Stations 3 and 4 on September 1 consisted mostly of gravel which ranged in size >2360 um, 96.1% and 97.6% respectively. Sluicing had ceased for a period during this time and provided enough time for fine particles to be resuspended and transported further downstream allowing the stream bed in the study area to return to a more natural composition for the area.

Interesting sediment samples were collected at Stations 3 and 4 on September 22 where 89.6% to 93.5% of the sediment gathered was considered fine and ranged in size from 75 - 300 um. Sluicing was estimated at 300 hours between June and September and a thrust in sluicing activity at the end of the season may explain the large increase of fine sediments found downstream on this date. Also, sluicing had ceased just prior to sampling on this date so it is unlikely that there had been sufficient time for the stream to resuspend and move sediments further downstream. The flow rate was also declining later in the season and the stream was less able to resuspend the sediments.

4.2.2 Sediment Metal Concentrations.

The concentration of metals analyzed in the portion of the sediment that was smaller than 150 um are given in Appendix III, Table 2 for all stations sampled. Sediments at Station 4 on July 8 and 19 were not collected due to high water and the inability to obtain a representative sample. A list of mean values for sediment metal concentrations is found in Table 2.

Generally there appears to be some variability in the heavy metal results from the sediment sampled throughout the operating season. A mean value of 5.5 mg/kg was found at Station 3 on July 8 and

TABLE 2 BARLOW CREEK MEAN VALUES FOR SEDIMENT METAL CONCENTRATIONS
(All mean concentrations given in mg/kg dry weight unless otherwise noted)

DATE:	July 8, 1982			July 19, 1982			August 09, 1982			September 1, 1982			September 22, 1982		
STATIONS:	1	3	4	1	3	4	1	3	4	1	3	4	1	3	4
Ag	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Al	7880	9900	9090	7213	7027	9053	11133	12267	9757	11400	12600	12967	12200	15200	14267
As	5.2	5.5	5.0	5.5	4.3	5.9	6.4	6.0	5.8	7.6	8.5	8.4	7.7	16.2	16.6
B	6.1	7.2	3.9	3.1	5.5	4.7	11.5	10.0	8.2	6.4	11.1	9.7	---	---	---
Ba	91.5	123	107	76.4	78.9	106	108	151	106	97.9	128	131	113	132	134
Be	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.3	0.3	0.3
Ca	2707	3060	3237	2730	2577	2893	3807	4080	3440	4147	4040	4123	4507	3430	3563
Cd	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Co	7.9	7.8	6.4	6.5	6.6	9.3	10.6	12.4	12.6	9.9	11.3	13.2	11.6	11.9	10.4
Cr	19.6	21.6	22.1	17.1	16.0	19.3	25.1	24.3	21.3	22.3	24.6	28.4	28.1	25.3	24.3
Cu	20.4	20.5	19.5	17.5	16.1	19.5	22.7	22.4	18.4	23.8	24.3	24.0	23.1	34.2	29.6
Fe	15933	19667	17433	14733	14000	17467	21400	21267	18733	25667	25700	25633	24200	28633	25967
Hg	0.10	0.06	0.12	0.15	0.15	0.14	0.11	0.15	0.15	0.14	0.03	0.09	0.10	0.11	0.12
K	359	584	503	385	363	557	999	978	755	1267	1517	1740	1090	1670	1563
Mg	3347	3860	3513	3060	2943	3620	3977	4357	3520	4200	4333	4397	4137	5260	4817
Mn	514	976	516	394	373	457	618	634	447	602	650	688	753	582	587
Mo	<0.8	<0.8	<0.8	2.2	1.6	2.5	3.0	2.4	2.3	4.7	5.3	5.1	10.7	13.5	12.8
Na	90	123	120	90	93	100	137	163	120	137	147	173	133	173	163
Ni	18	20	16	15	14	19	20	21	19	21	23	24	20	22	20
P	608	590	660	704	652	642	629	649	659	745	678	670	756	693	655
Pb	7	6	5	7	5	7	8	9	8	8	10	11	9	16	13
Si	2900	3007	2960	2400	2300	2580	3827	3687	3227	3847	3763	3083	3543	3830	3637
Sn	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Sr	18.5	22.5	22.0	16.0	15.7	19.0	28.2	31.2	23.7	29.3	29.1	30.2	34.3	28.2	28.7
Ti	215	355	465	275	239	290	883	672	686	1213	1048	1108	1307	894	844
V	19	24	24	19	18	23	32	33	28	35	37	38	35	38	27
Zn	49.8	55.9	49.3	44.4	43.3	50.6	55.2	60.3	49.0	59.7	62.4	62.3	57.1	91.5	82.4

between 16.2 mg/kg and 16.6 mg/kg at Stations 3 and 4 on September 22; all of which were considered to be within normal limits. Manganese and zinc decreased slightly during the two sluicing periods as compared to the other sampling dates. Mean values for manganese ranged from 373 mg/kg to 976 mg/kg; a normal level for manganese is in the area of 1000 mg/kg (Paski, 1982). Mean values for zinc were also found to decrease during sluicing with a value of 43.3 mg/kg at Station 3 on July 19 and 60.3 mg/kg and 49.0 mg/kg at Stations 3 and 4 on August 9. After this period zinc levels gradually increased to mean values of 62.4 mg/kg and 62.3 mg/kg at Stations 3 and 4 on September 1 and 91.5 mg/kg and 82.4 mg/kg at Stations 3 and 4 on September 22. With other heavy metals such as copper, iron, mercury, nickel and lead, mean values increased over the operating season (see Figures 15 and 16).

A mean value of 16.1 mg/kg for copper was found at Station 3 on July 19, and 22.4 mg/kg and 18.4 mg/kg at Stations 3 and 4 on August 9. By the end of the season values had increased slightly to 34.2 mg/kg and 29.6 mg/kg at Stations 3 and 4 on September 22. Mean values for copper found at the control sites varied little from the downstream stations. Mean values for iron were found to generally increase over the summer. A mean value of 14000 mg/kg was found at Station 3 on July 19 and 21267 mg/kg and 18733 mg/kg at Stations 3 and 4 on August 9. Values for mercury were most elevated during sluicing and declined in sediments toward the end of the summer. A level of 0.15 mg/kg was found at Station 3 on July 19 and 0.15 mg/kg each at Stations 3 and 4 on August 9. Mercury levels ranged between 0.03 mg/kg and 0.15 mg/kg. These concentrations are similar to other placer mining streams in Yukon Territory (Mathers et al 1981). Nickel and lead both rose gradually over the duration of the operating season although they remained within normal levels.

It was difficult to draw any firm conclusions due to the sample variability found for the heavy metals at Barlow Creek. Some metals decreased during sluicing periods and recovered by the end of the summer, while others gradually increased over the summer and suddenly escalated at the end of the season. The latter event was likely the result of a build up of sediment due to a concentrated

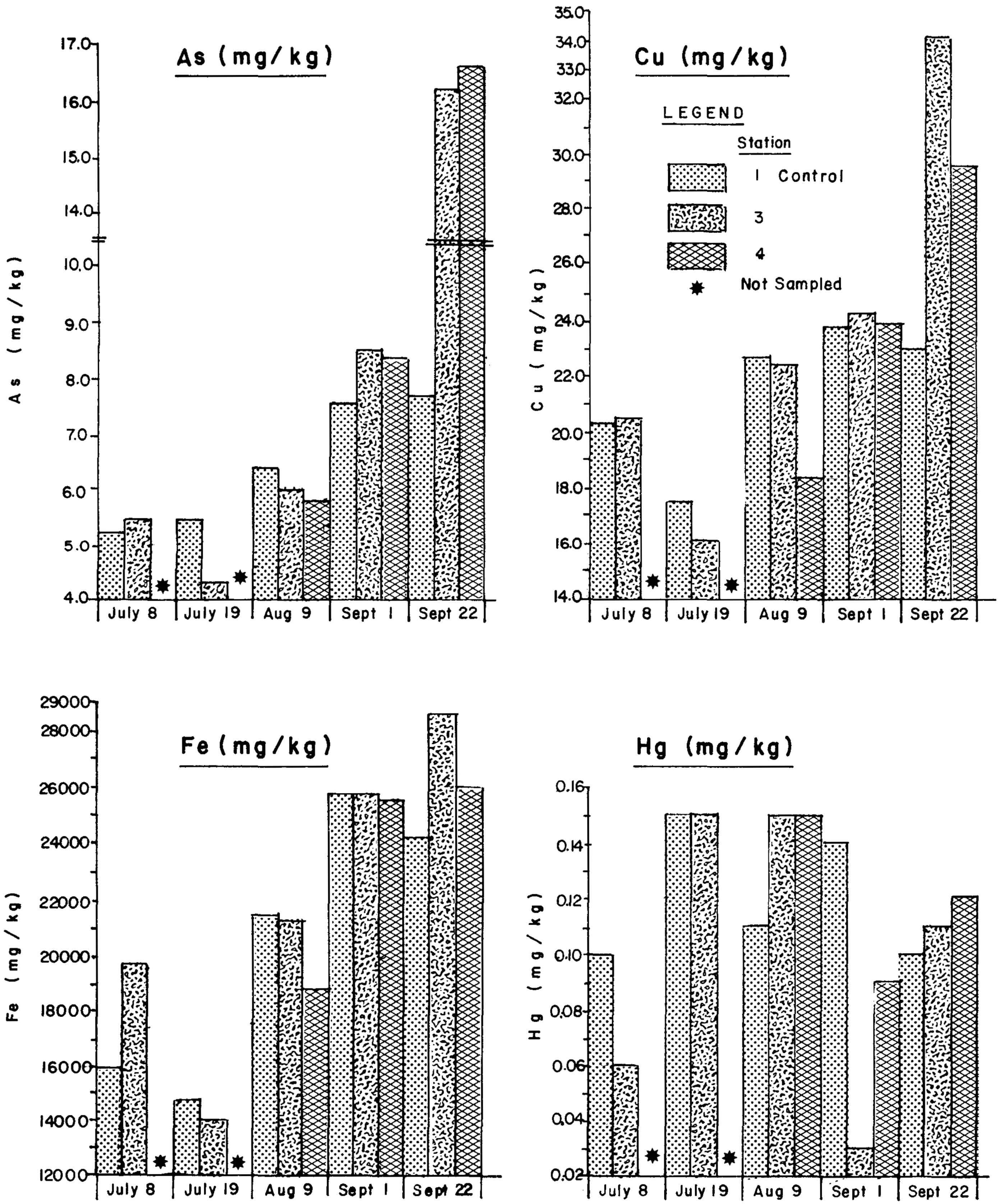

FIGURE 15 MEAN HEAVY METALS IN SEDIMENT

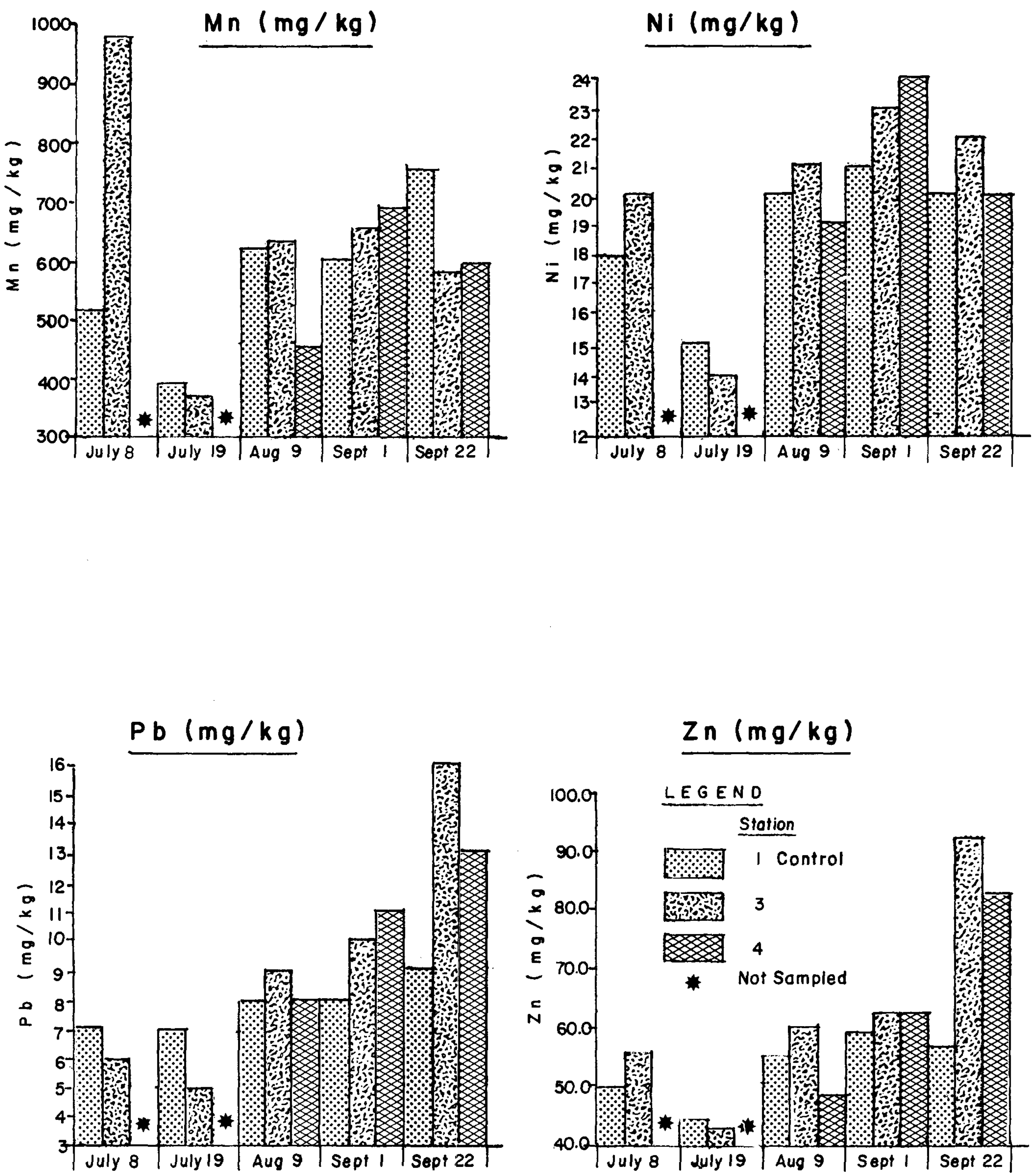

FIGURE 16 MEAN HEAVY METALS IN SEDIMENT

sluicing period which took place near the end of the season. Sluicing was estimated by the operator as 300 hours between June and September.

Although most of the heavy metals increased, all were considered to be within normal values for stream sediment (Paski, 1982). The build up of fine sediments, thus the increase in heavy metal concentrations, might suggest that the retention time of the settling pond was less effective at settling the heavier metal bearing sediments at the end of the operating season than at the beginning.

4.3 Bottom Fauna

4.3.1 Bottom Fauna Numbers and Diversity Indices.

A summary of Barlow Creek bottom fauna numbers and diversity indices is given in Table 3. Stations 1, 3 and 4 were the only stations where bottom fauna were collected. Station 2 (settling pond effluent) was unsuitable for collection. Appendix IV, Table 1 lists the bottom fauna taxonomic groups as in Pennak (1978), found in Barlow Creek. Appendix IV, Table 2 lists the numbers of individuals in each taxonomic group and the diversity index for each sample.

Diversity index values were calculated (Table 3) to assist further assessment of the impact that a placer mining operation could have on Barlow Creek. The diversity index is used to express the "richness" of a community, represented by the number of different taxonomic groups (genera in this case). Communities of high diversity are characterized by large numbers of species with no single species overwhelmingly abundant. Communities of low diversity contain few species, some of which are represented in disproportionately high numbers. Generally diversity values greater than 0.90 (in $\log_{10}$ or 3.0 in $\log_2$) are found in unpolluted, productive waters while heavily polluted waters have values less than 0.30 (in $\log_{10}$ or 1.0 in $\log_2$)" (Wihlm and Dorris, 1968). The diversity indices in this study fall within a comparable range to those found in other Yukon streams subjected to placer mining such as Clear Creek (Burns, 1980). Bottom fauna populations (number per m^2) generally have been found to be quite low, possibly due to cold climate of the study area and

TABLE 3 SUMMARY OF BARLOW CREEK BOTTOM FAUNA AND DIVERSITY INDICES

DATE 1982	STATION	DIVERSITY (H^1)	NUMBER PER FT.^{2} (0.093m^2)	CALCULATED NUMBER PER M^2	STATION	DIVERSITY (H^1)	NUMBER PER FT.^{2} (0.093m^2)	CALCULATED NUMBER PER M^2	STATION	DIVERSITY (H^1)	NUMBER PER FT.^{2} (0.093m^2)	CALCULATED NUMBER PER M^2
June 26	1 - 1	0.57	73	785	3 - 1	0.20	6	65	4 - 1	0.48	4	43
	1 - 2	0.70	80	861	3 - 2	0.47	8	86	4 - 2	0.27	17	183
	1 - 3	----	--	----	3 - 3	----	-	--	4 - 3	----	--	---
July 08	1 - 1	0.67	300	3228	3 - 1	0.60	6	65	4 - 1	*	*	*
	1 - 2	0.60	408	4390	3 - 2	0.20	6	65	4 - 2	*	*	*
	1 - 3	0.61	193	2077	3 - 3	0.47	8	86	4 - 3	*	*	*
July 10	1 - 1	0.73	9	97	3 - 1	0.00	2	22	4 - 1	*	*	*
	1 - 2	0.41	5	54	3 - 2	0.08	58	624	4 - 2	*	*	*
	1 - 3	0.52	20	215	3 - 3	0.00	18	194	4 - 3	*	*	*
Aug. 09	1 - 1	0.28	24	258	3 - 1	0.78	27	291	4 - 1	0.00	1	11
	1 - 2	0.44	42	452	3 - 2	0.28	3	32	4 - 2	0.00	7	75
	1 - 3	0.56	62	667	3 - 3	0.56	26	280	4 - 3	0.00	2	22
Sept 01	1 - 1	0.70	41	441	3 - 1	0.84	27	291	4 - 1	0.66	24	258
	1 - 2	0.70	27	291	3 - 2	0.94	29	312	4 - 2	0.75	23	247
	1 - 3	0.66	35	377	3 - 3	0.73	12	129	4 - 3	0.48	8	86
Sept 22	1 - 1	0.74	26	280	3 - 1	0.70	17	183	4 - 1	0.42	32	344
	1 - 2	0.78	42	452	3 - 2	0.55	22	237	4 - 2	0.30	5	54
	1 - 3	0.89	69	742	3 - 3	0.70	24	258	4 - 3	0.50	30	323

*- Bottom fauna not collected due to highwater conditions.

disturbance from an operation upstream. The bottom fauna standing crop appears low as a result, thus affecting the potential as a food source for fish in this type of habitat.

Diversity (H') values taken over six sampling periods for Station 1 (control) ranged from 0.28 to 0.89 and actual numbers of individuals collected by Surber sampler ranged from 5 to 408 (per 0.093 m^2 or 1.0 ft^2). On July 19 diversity ranged between 0.41 and 0.73 at Station 1, and between 0 and 0.08 at Station 3. Benthic samples were not collected at Station 4 on July 19 due to high water conditions precluding obtaining benthic samples. Total numbers of individuals ranged from 5 to 20 at Station 1 and from 2 to 58 at Station 3. On August 9 diversity ranged between 0.28 and 0.56 at Station 1, 0.28 to 0.78 at Station 3 and zero at Station 4. Total numbers collected at this date ranged from 24 to 62 at Station 1, 3 to 27 at Station 3 and 1 to 7 at Station 4.

Significant variation in terms of diversities and total number of individuals were found at Station 1 on July 19 and Stations 1, 3 and 4 on August 9. Low numbers of individuals at Station 1 may have been the result of some mining disturbance six kilometers upstream on Zinc Creek. At Station 4 on August 9 benthic invertebrates were greatly reduced. These lower levels are considered to be due to sampling variability rather than impact from mining activity since there was not a corresponding reduction at Station 3. The three most abundant orders of bottom fauna found in terms of numbers of individuals were Ephemeroptera, Diptera and Plecoptera, which are further discussed in the following section.

4.3.2 Three Most Abundant Orders Found in Barlow Creek.

A list of the three most abundant orders and the component taxa found in Barlow Creek is given in Table 4. The numbers found and percent abundance based on the totals for these three orders is shown in Table 5. These values represent the numbers obtained in three replicate samples (0.279 m^2 or 3 ft^2) at each station. Graphs illustrating actual abundance and percent abundance for the three orders can be found in Figures 17, 18 and 19.

TABLE 4 THREE MOST ABUNDANT ORDERS AND THEIR TAXONOMIC GROUPS FOUND IN BARLOW CREEK

Ephemeroptera:	_Ameletus_ sp.	_Epeorus_ sp.
	Baetis sp.	
	Cinygmula sp.	
Diptera:	Chironomidae adult	_Orthocladius_ sp.
	Chironomidae pupae	_Diamesa_ sp.
	Brillia sp.	_Monodiamesa_ sp.
	Cardiocladius sp.	_Pseudodiamesa_ sp.
	Cricotopus sp.	Culicidae
	Diplocladius sp.	_Chelifera_ sp.
	Epoicocladius sp.	_Prosimulium_ sp.
	Eukiefferiella sp.	_Metacnephia_ sp.
	Heterotrissocladius sp.	_Erioptera_ sp.
		Tipula sp.
Plecoptera:	Subimago	_Arcynopteryx_ sp.
	Capnia sp.	_Cultus_ sp.
	Alloperla sp.	_Megarcys_ sp.
	Utaperla sp.	_Skwala_ sp.
	Podmosta sp.	Unid. dam.

TABLE 5 BARLOW CREEK BOTTOM FAUNA DATA - NUMBERS AND PERCENT CALCULATED FOR THE THREE MOST ABUNDANT ORDERS

SAMPLE DATE		June 26, 1982		July 8, 1982		July 19, 1982		August 9, 1982		September 1, 1982		September 22, 1982	
STATION		Total Number	Per-centage	Total Number	Per-centage	Total Number	Per-centage	Total Number	Per-centage	Total Number	Per-centage	Total Number	Per-centage
1	E	53	88	87	86	25	78	16	80	15	20	6	6
	D	7	12	11	11	7	22	4	20	59	79	79	73
	P	0	0	3	3	0	0	0	0	1	1	23	21
	Tot	60		101		32		20		75		108	
3	E	13	100	17	81	1	50	44	78	11	17	2	3
	D	0	0	4	19	1	50	10	18	37	59	52	85
	P	0	0	0	0	0	0	2	4	15	24	7	12
	Tot	13		21		2		56		63		61	
4	E	10	91	*	*	*	*	1	50	3	12	0	0
	D	1	9	*	*	*	*	0	0	18	72	55	92
	P	0	0	*	*	*	*	1	50	4	16	5	8
	Tot	11		*	*	*	*	2		25		60	

E - Ephemeroptera D - Diptera P - Plecoptera

* - Bottom fauna not sampled due to high water conditions.

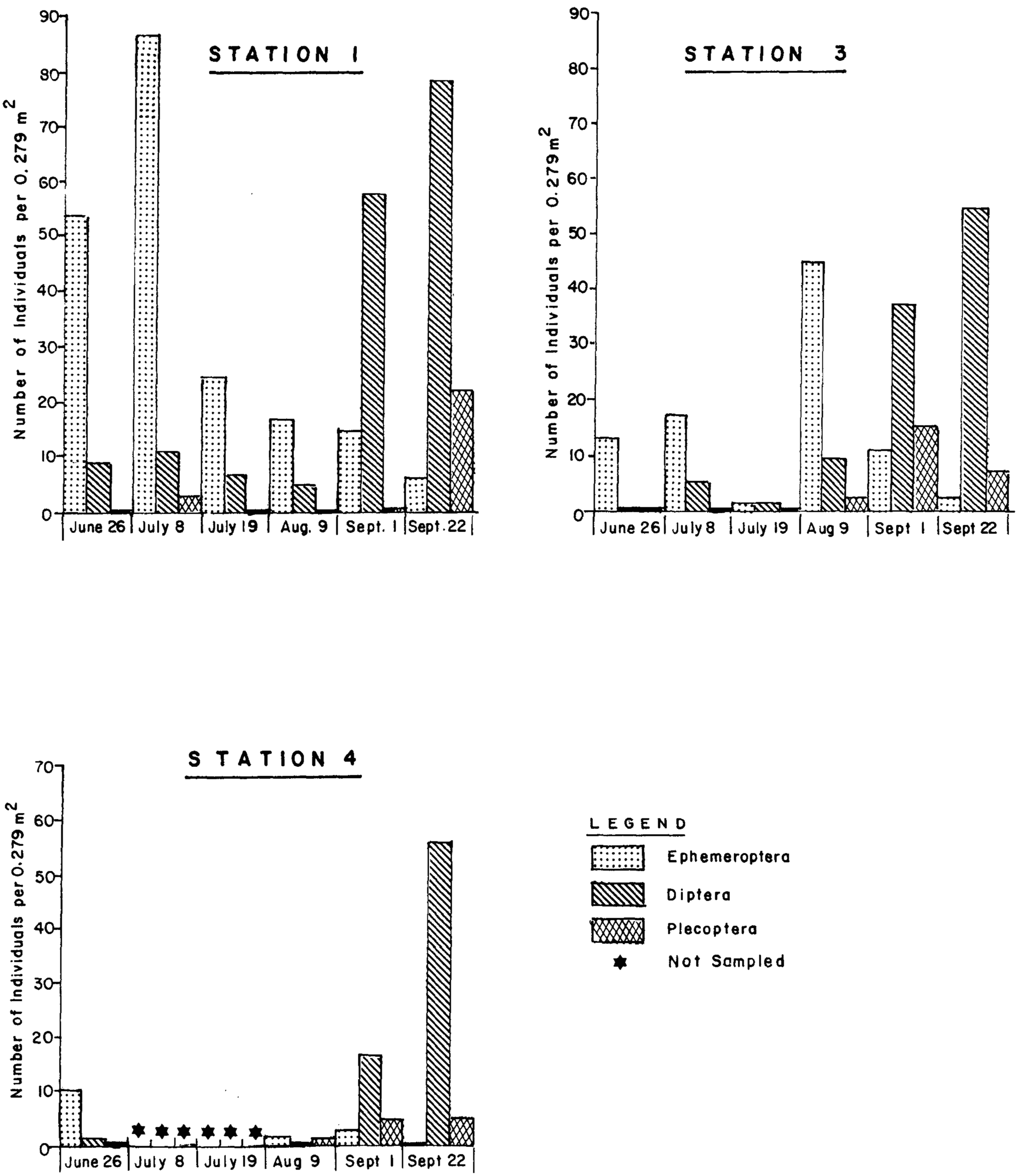

FIGURE 17 BOTTOM FAUNA DATA - ABUNDANCE

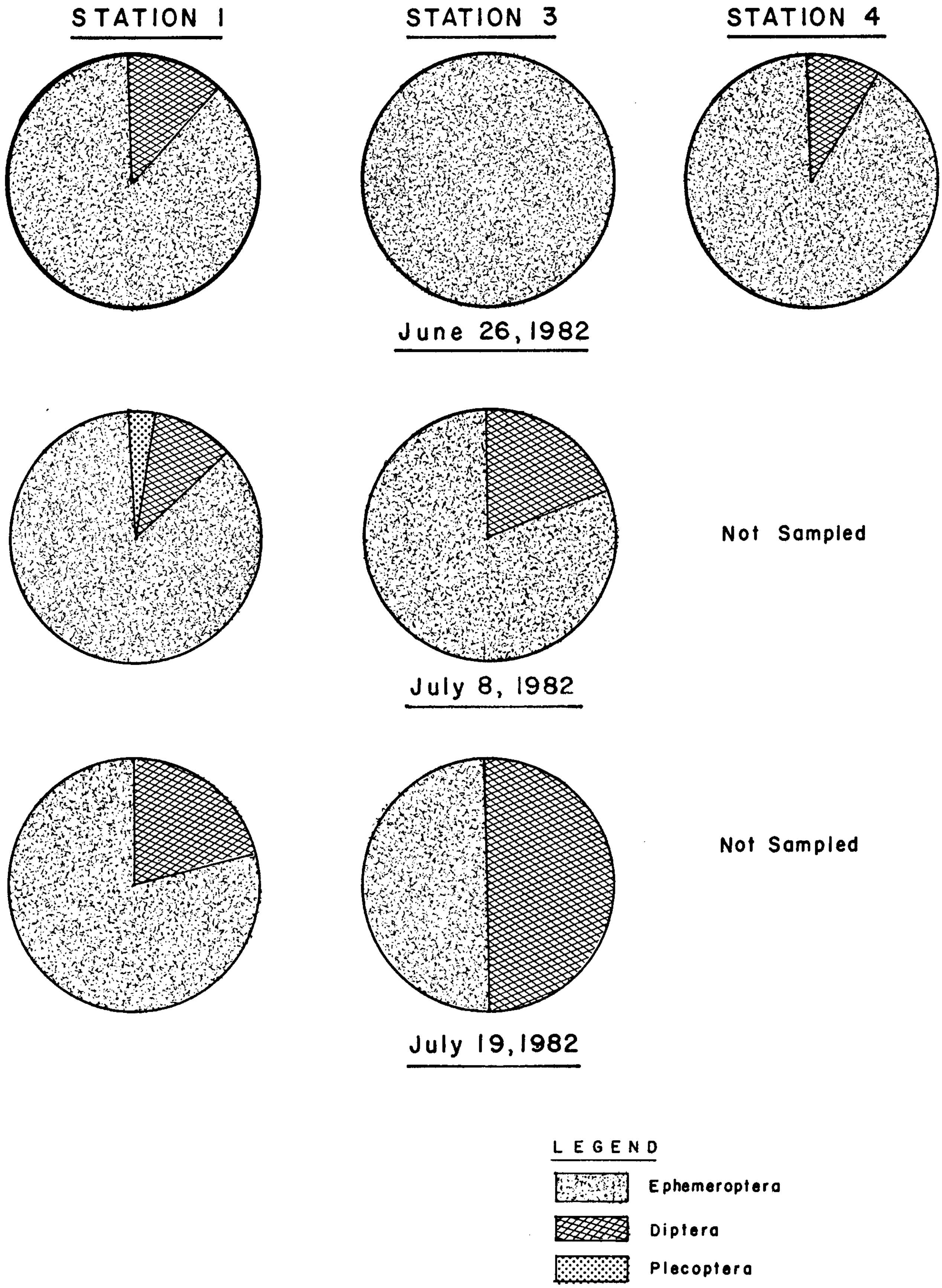

FIGURE 18 BOTTOM FAUNA DATA – PERCENT ABUNDANCE

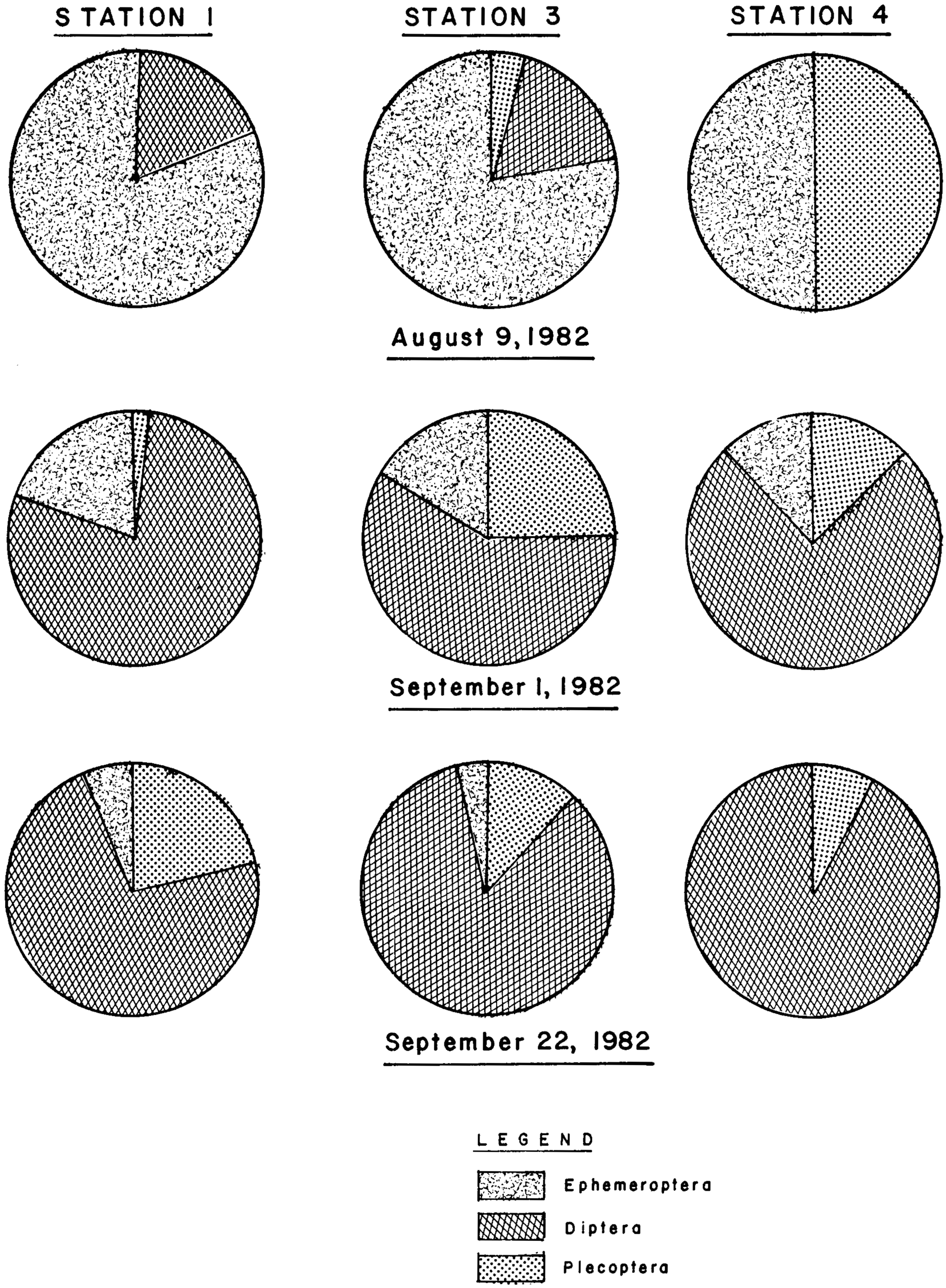

FIGURE 19 BOTTOM FAUNA DATA - PERCENT ABUNDANCE

Because of their sensitivity to low levels (10 - 15 mg/L) of suspended sediments (Rosenberg and Snow, 1977), the invertebrate populations are important as monitoring agents of environmental changes resulting from siltation. Increased levels of suspended sediments may fill interstices in the gravel substrate, thereby reducing the exchange of oxygenated water crucial to the survival of macro-invertebrates. In addition to this, increased sedimentation can change substrate composition, which may correspondingly change the community structure more suitable to the new habitat. A change in benthic habitat as a result of sedimentation usually results in a decline in important fish food organisms (Trichoptera, Ephemeroptera, Plecoptera) and the replacement with more tolerant species such as Chironomidae and Oligochaeta (Griffiths and Walton, 1978).

The three most abundant orders were chosen to determine if any general observations could be made with regard to their numbers as related to sluicing or non-sluicing conditions, or seasonal trends influenced by sluicing. Eighty-seven individuals of the order Ephemeroptera were found at Station 1 on July 8, representing 86% of the three orders. Numbers of individuals declined to 25 on July 19 and 16 on August 9, but still represented 78% and 80% respectively of the three most abundant orders. This reduction in population continued to the end of the summer. Seasonal succession of emergence could be a significant factor to this decline according to Usinger (1956). Conversely, individuals from the order Diptera increased in numbers at Station 1 on September 1 and 22 where mean sediment composition consisted of 91.7% and 97% medium coarse sand to gravel (300->2360 um).

Abundance of Ephemeroptera was similar at Station 3 on June 26 and July 8 with individuals numbering 13 and 17 respectively. Mean sediment composition for July 8 only consisted of 7.8% silt and fine sand. Numbers, however, were reduced to 1 individual on July 19 where sediment was composed of 67.4% fine sand and silt, and increased to 44 on August 9 where substrate was comprised of 97% fine sand and silt. Numbers of Ephemeroptera on the two sluicing dates were quite inconsistant with each other. Ninety-seven percent fine sand and silt on August 9 did not provide a habitat where one would expect to see an increase of Ephemeroptera. This cleanwater invertebrate group is known for its inability to survive high sediment levels (Langer, 1980). All of this might lead to the conclusion that a significant degree of variability existed in the collection of the sediment samples. The last two sampling periods in September show a reduction of Ephemeroptera which may be linked to a natural seasonal decline due to colder water temperatures. Ephemeroptera at Station 4 numbered ten or less throughout the sampling period.

Individuals of the order Diptera were less than 25% in abundance at the control station on all dates except on September 1 and September 23 where they represented 79% and 73% respectively. Numbers of individuals of Station 3 remained less than ten up to and including August 9. However, at this time individuals increased to 37 on September 1, where sediment was composed of 96.1% medium coarse sand to gravel (300 to >2360 um). The number of individuals at Station 3 on September 22 also increased to 52 where sediment was composed of approximately 89.6% silt to fine sand (<300 um). Both increases to the Diptera population occurred under two different sediment conditions. On August 9, zero individuals were collected at Station 4 where sediment was composed of 79.7% coarse sand to gravel. Eighteen (72%) and 55 (92%) individuals were collected at Station 4 on September 1 and 22 respectively. Sediment composition consisted of 97.6% medium sand to gravel (300 to >2360 um) on September 1 and 93.5% fine sand to silt (<75-300 um) on September 22.

Individuals of the order Plecoptera were extremely low in numbers throughout most of the operating season, but increased slightly at the end of the summer. Because numbers were so low at the control (Station 1), it was difficult to draw any meaningful conclusions. Perhaps the significant disturbance made upstream on Zinc Creek the year previous influenced the population, as this order is dependant on abundant oxygen supply for its survival (Pennak, 1978). In any case, low populations were present at the very end of the operating season at all three stations.

In spite of the two active sluicing periods, invertebrate results are not very conclusive. However, there appears to be a slight decrease in total numbers of the three orders at Station 3 during sluicing periods (see Table 5). The order Diptera appears more tolerant as shown by the numbers at Stations 3 and 4 on September 1 and 22. These figures may suggest that Diptera individuals possess the ability to adapt more effectively to a stressed and changing environment created from sluicing activity than the more sensitive individuals belonging to the other two orders.

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APPENDICES

APPENDIX I

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

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

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE[1]	ANALYTICAL PROCEDURE	METHOD SECTION[2]
Temperature		In situ temperature reading.	Standard Centigrade Thermometer	
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.[3]	
Dissolved Oxygen	1.00 mg/L	Duplicate samples collected in 300 mL glass BOD bottles. The BOD bottles were rinsed 3 times with sample before filling. Preserved with 2 mL manganese sulphate and 2 mL alkali-iodide-azide solution and shaken 15 times. A water seal was maintained and DO analysis was done within 7 days.	Iodometric Azide Modification Winkler Titration Method	048
pH		Small aliquots of sample were taken and read soon after collection. No preservative.	Potentiometric	080
Conductivity	0.2 umhos/cm	In situ measurement. Laboratory measurement. No preservative. The measurement was taken from the same as NH_3 below.	YSI Conductivity Meter Model 33 Radiometer Conductivity Meter (CDMC) with radiometer conductivity cell.	044

APPENDIX I TABLE 1 WATER SAMPLE COLLECTION, PRESERVATION AND ANALYSIS METHODS (continued)

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE[1]	ANALYTICAL PROCEDURE	METHOD SECTION[2]
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 Hypochlorite-Colorimetric-Automated	058
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
Settleable Solids	0.1 mL/L	Same collection procedure as for NH_3.	Settleable Matter	112
Non-Filterable Residue (NFR)	5 mg/L	Same sample as NH_3.	Filtration, drying and weighing of residue on filter	104
Filterable Residue (FR)	10 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
Total Phosphate T PO_4-P	0.005 mg/L	Same sample as NH_3.	Acid-persulphate, Autoclave Digestion	086
Nitrite NO_2-N	0.005 mg/L	Same sample as NH_3.	Diazotization-Colorimetric-Automated	070

APPENDIX I TABLE 1 WATER SAMPLE COLLECTION, PRESERVATION AND ANALYSIS METHODS (continued)

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE[1]	ANALYTICAL PROCEDURE	METHOD SECTION[2]
Nitrate NO_3-N	0.01 mg/L	Same sample as NH_3.	Cadmium Copper Reduction Colorimetric Automated	072
Sulphate SO_4	1.0 mg/L	Same sample as NH_3.	Barium Chloranilate -UV Spectrophotometric	122
Chloride Cl	0.5 mg/L	Same sample as NH_3.	Thiocyanate-Combined Reagent-Colorimetric	024
Silica Total Si	0.5 mg/L	Same sample as NH_3.	Ascorbic Acid Reduction - Colorimetric	118
Mercury Total Hg	0.0002 mg/L	Single samples were collected in a 200 ml linear polyethylene bottle. Preserved with a 10 ml 5% nitric dichromate solution.	Open Flameless System for Hg-AAS Determination	211 224 284 411
Extractable Metals	mg/L	Single samples collected in 200 ml linear polyethylene bottles. Each bottle was rinsed 3 times with sample before filling. Preserved to a pH <1.5 using 2.0 ml concentrated HNO_3.	Inductively Coupled Argon Plasma (ICAP) combined with Optical Emission Spectrometer (OES)	201 592
Al	0.05			
As	0.05			
Ba	0.001			
Be	0.001			
Ca	0.1			
Cd	0.004			
Co	0.005			
Cr	0.005			
Cu	0.005			

APPENDIX I TABLE 1 WATER SAMPLE COLLECTION, PRESERVATION AND ANALYSIS METHODS (continued)

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE[1]	ANALYTICAL PROCEDURE	METHOD SECTION[2]
Extractable Metals (continued)	mg/L			
Fe	0.005			
Mg	0.10			
Mn	0.001			
Mo	0.005			
Na	0.5			
Ni	0.02			
Pb	0.04			
Sb	0.05			
Se	0.05			
Sn	0.01			
Sr	0.001			
Ti	0.002			
V	0.01			
Zn	0.005			
As	0.0005	Same sample as metals.	Hydride Generation - ICAP	
Cd	0.0005	Same as sample metals.	Graphite Atomic Absorption	Atomic
Cu	0.001	Same sample as metals.	Flameless Technique (AAS)	Absorption
Pb	0.001	Same sample as metals.		Jarrell-Ash
Zn	0.002	Same sample as metals.		850 Manual

APPENDIX I TABLE 1 WATER SAMPLE COLLECTION, PRESERVATION AND ANALYSIS METHODS (continued)

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE[1]	ANALYTICAL PROCEDURE	METHOD SECTION[2]
Ag	0.0005 mg/L	Same sample as metals.	Graphite Furnace Atomic Absorption Spectrophotometry	210 290
K	0.01 mg/L	Same sample as metals.	Flame Atomic Emission Spectrophotometry	210 423
Total Hardness	0.030 mg/L as $CaCO_3$	Same sample as metals.	The sum of the ICAP results for Mg x 4.116 and Ca x 2.497 reported as mg/L $CaCO_3$	

1 As described in Environment Canada (1976).

2 As described in Department of Environment (1979).

3 As described in the U.S. Dept. of the Interior (1975).

APPENDIX I TABLE 2 SEDIMENT COLLECTION, PREPARATION AND ANALYSIS METHODS

PARAMETER	COLLECTION/PREPARATION	ANALYSIS	METHOD CODE[1]
All Parameters	Creek Stations: Sediment samples were collected using an aluminum shovel to scoop sample into pre-labelled Kraft soil bags stored inside Whirl-Pak bags for shipping. Three samples were taken at each station. Samples were kept cool and were frozen (-19°C) as soon as possible.		
Metals (Leachable) mg/g Al 8 As 8 Ba 0.2 Be 0.2 Ca 17 Co 0.8 Cr 0.8 Fe 0.8 Mg 17 Mn 0.2 Mo 0.8	Sample was oven dried at 60°C for 24 hours to remove water and then sieved through a size 100 mesh (0.15 mm) stainless steel sieve. The portion passing through was analyzed for metals. Samples were leached with aque regia solution. Nominal detection limits (based on 3 gms sediment sample and at a final volume of 50 ml).	Inductively Coupled Argon Plasma (ICAP) Combined with Optical Emission Spectrometer (OES)	231 236 238 242

APPENDIX I TABLE 2 SEDIMENT COLLECTION, PREPARATION AND ANALYSIS METHODS (continued)

PARAMETER		PREPARATION	ANALYSIS	METHOD CODE[1]
Metals (Leachable) (continued)	mg/g			
Na	33	(Unreliable in this type of digestion)		
Ni	3			
P	8			
Si	17			
Sn	2			
Sr	0.2			
Ti	0.3			
V	2			
Zn	0.3			
Ag	0.08	Same as other metals.	Graphite Furnace Atomic Absorption Spectrophotometry	Jarrell-Ash 850 Manual
Cd	0.08	Same as other metals.		
Cu	0.2	Same as other metals.		
Pb	0.2	Same as other metals.		
K	2	Same as other metals.	Flame Atomic Emission Spectrophotometry	423
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 I TABLE 3 BOTTOM FAUNA COLLECTION, PRESERVATION AND IDENTIFICATION METHODS

FIELD COLLECTION, SAMPLING PROCEDURES AND PRESERVATION	LABORATORY PROCEDURES	IDENTIFICATION AND ENUMERATION
Surber Sampler: Creek and river samples were taken using a surber sampler with a 60 cm long net (mesh size 0.76 mm). Area sampled was 900 cm^2 (1 ft^2). Surber samples were washed into a cup at the bottom of a plankton net (0.75 mm mesh size), put in separate labelled glass jars and preserved with 10% formalin. 3 samples were taken at each station.	Bottom fauna was removed from other material in a labelled vial containing 70% methanol.	Bottom fauna was sent to Dr. C. Low, Consulting Invertebrate Biologist, Nanaimo, B. C. for identification to genus, species if possible, and enumeration.

APPENDIX I 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 Pt. Counts	15	1		
Odour and taste	0	1		
Turbidity J.T.U.	5	1		
Chemical				
Alkalinity mg/L (Total)	Not considered a public health problem	4	>20	3
Aluminum (Al) mg/L	Not considered a public health problem	7	0.1	5
Ammonia (NH_3-N) mg/L	0.5 (Total)	4	0.02 (un-ionized)	3
Antimony (Sb) mg/L				
Arsenic (As) mg/L	0.05	1	0.05	2 (total)
Barium (Ba) mg/L	1.0	1	5.0	7
Boron (Bo) mg/L	1.0	1		
Cadmium (Cd) mg/L	0.005	1	0.0002	2 (total)
Calcium (Ca) mg/L	75-200	7		
Chloride (Cl)mg/L	250	1		
Chromium (Cr) mg/L	0.05	1	0.04	2 (total)
Cobalt (Co) mg/L				
Conductivity @ 25°C (umhos/cm)	Depends on dissolved salts	7	150-500	6
Copper (Cu) mg/L	1.0	1	0.002	2 (total)
Cyanide (CN) mg/L	0.2	1	0.005	3
Dissolved oxygen (% saturation)	Near 100%	4	$\geq$5.0 mg/L	3

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

SUBSTANCE	RECOMMENDED LEVEL(S) FOR DRINKING WATER	REFERENCE(S)	RECOMMENDED LEVEL(S) FOR AQUATIC LIFE	REFERENCE(S)
Fluoride (F) mg/L	1.5	1	1.5	7
Hardness (Total) as mg/L $CaCO_3$	80-100	1		
Iron (Fe) mg/L	0.3	1	1.0	3
Lead (Pb) mg/L	0.05	1	0.005 (soft H_2O*)	2 (total)
			0.01 (hard H_2O*)	2 (total)
Magnesium (Mg) mg/L	50	4		
Manganese (Mn) mg/L	0.05	1	1.0	7
Mercury (Hg) mg/L	0.002	1	0.0001-0.0002	2 (total)
Molybdenum (Mo)				
Nickel (Ni) mg/L	0.25	2	0.025 (soft H_2O*)	2 (total)
			0.25 (hard H_2O*)	2 (total)
Nitrate (NO_3-N) mg/L	10	1		
Nitrite (NO_2-N) mg/L	0.001	1		
pH units	6.5 - 8.5	1	6.5 - 9.0	3
Phosphorus (P) mg/L (Total)			0.020 to prevent algae	5
Potassium (K) mg/L				
Residue: Filterable mg/L (Total dissolved solids)	1000	4	70 - 400 with a maximum of 2000	6
Residue: Non-Filterable (mg/L)				
Selenium (Se) mg/L	0.01	1	0.01	2 (total)
Silica (Si) mg/L				
Silver (Ag) mg/L	0.05	1	0.0001	2 (total)
Sodium (Na) mg/L	20	1		
Strontium (Sr) mg/L	10	1		
Sulphate (SO_4) mg/L	500	1		

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

SUBSTANCE	RECOMMENDED LEVEL(S) FOR DRINKING WATER	REFERENCE(S)	RECOMMENDED LEVEL(S) FOR AQUATIC LIFE	REFERENCE(S)
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		
Vanadium (V)				
Zinc (Zn) mg/L	5.0	1	0.030	5

* Soft water has a total hardness less than 95 mg/L as $CaCO_3$. Hard water has a total hardness of more than 95 mg/L as $CaCO_3$ (Reference 6).

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1. Health & Welfare Canada, <u>Guidelines for Canadian Drinking Water Quality 1978</u>, Supply and Services, Canada (1979).

2. Inland Waters Directorate, <u>Guidelines for Surface Water Quality</u>, Vol. 1, Inorganic Chemical Substances. Environment Canada, Ottawa (1979, 1980).

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

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

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

4. Anonymous, 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 Chairmen, Water Boards, Yukon and Northwest Territories, July (1977).

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

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

APPENDIX II

WATER QUALITY DATA

APPENDIX II

BARLOW PLACER STUDY
WATER QUALITY DATA

PARAMETER		STATION 1	STATION 3	STATION 4
Flow m^3/s	a	---	---	0.3
	b	0.2	0.2	0.3
	c	0.7	1.4	0.9
	d	0.3	0.4	0.2
	e	0.1	0.2	0.2
	f	0.1	0.4	0.2
Temperature (°C)	a	8	8	7
	b	10	10	11
	c	7	9	9
	d	9	11	11
	e	6	7	7
	f	4	4	4
Dissolved Oxygen (mg/L)	a	---	---	---
	b	11.7	10.8	10.6
	c	10.1	9.6	9.8
	d	10.6	10.1	10.0
	e	11.2	10.8	10.8
	f	12.0	11.9	11.8
% D.O. Saturation (%)	a	---	---	---
	b	111	96	102
	c	89	88	90
	d	98	97	96
	e	97	94	94
	f	98	97	96

Date sampled:

a) June 26, 1982
b) July 8, 1982
c) July 19, 1982*
d) August 9, 1982*
e) September 1, 1982
f) September 22, 1982

* Active Sluicing

APPENDIX II BARLOW PLACER STUDY
WATER QUALITY DATA (Continued)

PARAMETER		STATION 1	STATION 2	STATION 3	STATION 4
Settleable Solids (mL/L)	a	--	--	--	--
	b	--	--	<0.1	--
	c	<0.1	0.5	0.9	0.2
	d	<0.1	0.8	<0.1	<0.1
	e	<0.1	<0.1	<0.1	<0.1
	f	<0.1	0.4	<0.1	<0.1
Non-Filterable Residue Whitehorse Lab (mg/L)	a	--	--	--	--
	b	--	--	--	--
	c	47	6990	1008	570
	d	<5	4530	984	2065
	e	<5	60	50	40
	f	<5	452	211	142
Non-Filterable Residue Vancouver Lab (mg/L)	a	--	--	--	--
	b	7	--	20	40
	c	48	--	1160	526
	d	<5	--	110	945
	e	<5	--	75	38
	f	7	--	211	138
Filterable Residue (mg/L)	a	---	--	--	--
	b	148	--	155	163
	c	103	--	140	146
	d	131	--	190	185
	e	183	--	185	182
	f	187	--	208	189

Date sampled:

a) June 26, 1982
b) July 8, 1982
c) July 19, 1982*
d) August 9, 1982*
e) September 1, 1982
f) September 22, 1982

* Active Sluicing

APPENDIX II — BARLOW PLACER STUDY
WATER QUALITY DATA (Continued)

PARAMETER		STATION 1	STATION 2	STATION 3	STATION 4
pH In Situ	a	--	--	--	--
	b	7.8	7.4	7.8	7.7
	c	--	--	7.8	7.3
	d	8.4	7.9	8.2	7.9
	e	--	6.9	7.1	7.5
	f	8.0	7.9	7.8	--
pH Laboratory	a	--	--	--	--
	b	7.7	--	7.8	7.8
	c	6.7	--	6.7	6.7
	d	8.1	--	7.6	7.6
	e	7.6	--	7.6	7.6
	f	7.7	--	7.7	7.7
Conductivity In Situ (umhos/cm)	a	105	--	108	102
	b	135	--	140	150
	c	80	--	82	80
	d	152	--	158	157
	e	158	--	160	163
	f	143	--	162	153
Conductivity Laboratory (umhos/cm)	a	--	--	--	--
	b	214	--	213	216
	c	125	--	124	121
	d	187	--	231	239
	e	260	--	255	260
	f	270	--	270	270

Date sampled:

a) June 26, 1982
b) July 8, 1982
c) July 19, 1982*
d) August 9, 1982*
e) September 1, 1982
f) September 22, 1982

* Active Sluicing

APPENDIX II BARLOW PLACER STUDY
WATER QUALITY DATA (Continued)

PARAMETER		STATION 1	STATION 3	STATION 4
Colour (colour units)	a	--	--	--
	b	7	15	15
	c	65	>100	>100
	d	7	†	†
	e	5	20	10
	f	5	5	5
Turbidity (FTU)	a	--	--	--
	b	<0.1	10.0	13.5
	c	2.9	800	600
	d	0.1	1280	1200
	e	<0.1	30.0	10.8
	f	<0.1	180	95.0
Total Alkalinity (mg/L as $CaCO_3$)	a	--	--	--
	b	54.0	52.0	54.0
	c	34.0	34.0	34.0
	d	48.0	52.0	56.0
	e	62.0	61.0	61.0
	f	62.0	62.0	62.0
Total Hardness (mg/L as $CaCO_3$)	a	--	--	--
	b	100	99.1	106
	c	66.4	195	130
	d	110	214	150
	e	124	129	126
	f	76.6	94.0	133

Date sampled:

a) June 26, 1982
b) July 8, 1982
c) July 19, 1982*
d) August 9, 1982*
e) September 1, 1982
f) September 22, 1982

† Could not remove all turbidity from sample; therefore all colour units will be falsely high

* Active Sluicing

APPENDIX II

BARLOW PLACER STUDY
WATER QUALITY DATA (Continued)

PARAMETER		STATION 1	STATION 3	STATION 4
Total PO_4-P (mg/L)	a	---	---	---
	b	<0.005	0.020	0.030
	c	0.057	0.920	0.510
	d	<0.005	1.05	1.00
	e	0.008	0.033	0.021
	f	0.005	0.225	0.145
NO_2-N (mg/L)	a	---	---	---
	b	<0.005	0.007	0.008
	c	0.008	0.037	0.031
	d	<0.005	0.034	0.034
	e	<0.005	0.008	<0.005
	f	<0.005	<0.005	<0.005
NO_3-N (mg/L)	a	---	---	---
	b	0.07	0.05	0.05
	c	0.01	0.03	0.05
	d	0.05	0.04	0.04
	e	0.04	0.03	0.04
	f	0.09	0.11	0.10
NH_3-N † (mg/L)	a	---	---	---
	b	<0.005	0.005	0.006
	c	0.071	0.083	0.060
	d	<0.005	0.072	0.056
	e	<0.005	0.011	0.005
	f	<0.005	0.010	0.011

Date sampled:

a) June 26, 1982
b) July 8, 1982
c) July 19, 1982*
d) August 9, 1982*
e) September 1, 1982
f) September 22, 1982

† All values for un-ionized NH_3-N are less than 0.02 mg/L

* Active Sluicing

APPENDIX II BARLOW PLACER STUDY
WATER QUALITY DATA (Continued)

PARAMETER		STATION 1	STATION 3	STATION 4
SO_4	a	---	---	---
	b	62.5	55.5	54.5
	c	25.4	26.1	25.7
	d	42.0	54.0	55.0
	e	62.5	62.5	63.5
	f	66.5	71.5	72.0
Cl (mg/L)	a	---	---	---
	b	<0.5	0.5	0.5
	c	1.0	6.6	4.6
	d	<0.5	3.0	2.3
	e	0.6	0.9	0.7
	f	0.6	0.6	0.6
Ag (mg/L)	a	---	---	---
	b	<0.03	<0.03	<0.03
	c	<0.03	<0.03	<0.03
	d	<0.03	<0.03	<0.03
	e	<0.03	<0.03	<0.03
	f	<0.03	<0.03	<0.03
Al (mg/L)	a	---	---	---
	b	<0.05	0.25	0.48
	c	0.92	11.2	6.24
	d	<0.05	8.07	3.95
	e	0.24	0.60	0.36
	f	<0.05	0.42	0.96

Date sampled:

a) June 26, 1982
b) July 8, 1982
c) July 19, 1982*
d) August 9, 1982*
e) September 1, 1982
f) September 22, 1982

* Active Sluicing

APPENDIX II BARLOW PLACER STUDY
WATER QUALITY DATA (Continued)

PARAMETER		STATION 1	STATION 3	STATION 4
As (mg/L)	a	---	---	---
	b	<0.0005	<0.0005	0.0015
	c	<0.0005	0.0043	0.0026
	d	<0.0005	0.0026	0.0022
	e	<0.0005	0.00072	<0.0005
	f	<0.0005	0.0021	0.0022
Ba (mg/L)	a	---	---	---
	b	0.033	0.041	0.063
	c	0.046	0.440	0.244
	d	0.034	0.497	0.339
	e	0.042	0.057	0.048
	f	0.018	0.052	0.072
Be (mg/L)	a	---	---	---
	b	<0.001	<0.001	<0.001
	c	<0.001	<0.001	<0.001
	d	<0.001	<0.001	<0.001
	e	<0.001	<0.001	<0.001
	f	<0.001	<0.001	<0.001
Ca (mg/L)	a	---	---	---
	b	25.3	24.6	25.9
	c	14.2	19.8	16.4
	d	28.0	32.0	27.2
	e	31.4	31.5	31.4
	f	19.9	23.3	31.7

Date sampled:

a) June 26, 1982
b) July 8, 1982
c) July 19, 1982*
d) August 9, 1982*
e) September 1, 1982
f) September 22, 1982

* Active Sluicing

APPENDIX II — BARLOW PLACER STUDY
WATER QUALITY DATA (Continued)

PARAMETER		STATION 1	STATION 3	STATION 4
Cd (mg/L)	a	---	---	---
	b	<0.0005	<0.0005	<0.0005
	c	<0.0005	0.0005	<0.0005
	d	<0.0005	<0.0005	<0.0005
	e	<0.0005	<0.0005	<0.0005
	f	<0.0005	<0.0005	<0.0005
Co (mg/L)	a	---	---	---
	b	<0.005	<0.005	<0.005
	c	<0.005	0.038	0.022
	d	<0.005	0.042	0.023
	e	<0.005	<0.005	<0.005
	f	<0.005	<0.005	<0.005
Cr (mg/L)	a	---	---	---
	b	<0.005	<0.005	<0.005
	c	0.060	0.019	0.010
	d	<0.005	0.009	<0.005
	e	<0.005	<0.005	<0.005
	f	<0.005	<0.005	<0.005
Cu (mg/L)	a	---	---	---
	b	0.004	0.006	0.006
	c	0.011	0.050	0.030
	d	<0.001	0.042	0.025
	e	0.001	0.002	0.002
	f	<0.001	0.009	0.007

Date sampled:

a) June 26, 1982
b) July 8, 1982
c) July 19, 1982*
d) August 9, 1982*
e) September 1, 1982
f) September 22, 1982

* Active Sluicing

APPENDIX II BARLOW PLACER STUDY
WATER QUALITY DATA (Continued)

PARAMETER		STATION 1	STATION 3	STATION 4
Fe (mg/L)	a	---	---	---
	b	0.059	0.383	0.957
	c	1.76	22.9	12.6
	d	0.044	17.4	8.74
	e	0.345	1.05	0.560
	f	<0.005	0.429	1.48
Hg (mg/L)	a	---	---	---
	b	<0.0002	<0.0002	<0.0002
	c	<0.0002	<0.0002	<0.0002
	d	<0.0002	<0.0002	<0.0002
	e	<0.0002	<0.0002	<0.0002
	f	<0.0002	<0.0002	<0.0002
K (mg/L)	a	---	---	---
	b	0.33	0.40	0.63
	c	0.36	0.98	0.69
	d	0.36	1.10	0.72
	e	0.41	0.74	0.68
	f	0.43	1.64	1.49
Mg (mg/L)	a	---	---	---
	b	8.9	8.6	9.0
	c	5.4	9.4	7.3
	d	9.6	12.9	9.9
	e	10.7	10.9	10.7
	f	6.7	7.9	11.1

Date sampled:

a) June 26, 1982
b) July 8, 1982
c) July 19, 1982*
d) August 9, 1982*
e) September 1, 1982
f) September 22, 1982

* Active Sluicing

APPENDIX II BARLOW PLACER STUDY
WATER QUALITY DATA (Continued)

PARAMETER		STATION 1	STATION 3	STATION 4
Mn (mg/L)	a	---	---	---
	b	0.022	0.046	0.089
	c	0.139	1.47	0.874
	d	0.023	2.60	1.80
	e	<0.001	0.016	<0.001
	f	<0.001	0.046	0.074
Mo (mg/L)	a	---	---	---
	b	<0.005	<0.005	<0.005
	c	<0.005	<0.005	<0.005
	d	<0.005	<0.005	<0.005
	e	<0.005	<0.005	<0.005
	f	<0.005	<0.005	<0.005
Na (mg/L)	a	---	---	---
	b	3.0	2.9	3.0
	c	1.3	3.1	3.0
	d	3.0	3.2	2.8
	e	3.3	3.4	3.4
	f	2.3	2.6	3.4
Ni (mg/L)	a	---	---	---
	b	<0.02	<0.02	<0.02
	c	<0.02	0.04	0.03
	d	<0.02	0.03	<0.02
	e	<0.02	<0.02	<0.02
	f	<0.02	<0.02	<0.02

Date sampled:

a) June 26, 1982 d) August 9, 1982*
b) July 8, 1982 e) September 1, 1982
c) July 19, 1982* f) September 22, 1982

* Active Sluicing

APPENDIX II BARLOW PLACER STUDY
WATER QUALITY DATA (Continued)

PARAMETER		STATION 1	STATION 3	STATION 4
Pb (mg/L)	a	---	---	---
	b	<0.001	<0.001	<0.001
	c	0.001	0.017	0.009
	d	<0.001	0.016	0.016
	e	<0.001	<0.001	0.050
	f	<0.001	0.002	0.002
Sb (mg/L)	a	---	---	---
	b	<0.05	<0.05	<0.05
	c	<0.05	<0.05	<0.05
	d	<0.05	<0.05	<0.05
	e	<0.05	<0.05	<0.05
	f	<0.05	<0.05	<0.05
Se (mg/L)	a	---	---	---
	b	<0.05	<0.05	<0.05
	c	<0.05	<0.05	<0.05
	d	<0.05	<0.05	<0.05
	e	<0.05	<0.05	<0.05
	f	<0.05	<0.05	<0.05
Si (mg/L)	a	---	---	---
	b	4.2	4.4	4.3
	c	3.2	3.9	3.7
	d	3.7	4.6	4.6
	e	4.4	4.5	4.4
	f	4.5	4.6	4.5

Date sampled:

a) June 26, 1982
b) July 8, 1982
c) July 19, 1982*
d) August 9, 1982*
e) September 1, 1982
f) September 22, 1982

* Active Sluicing

APPENDIX II BARLOW PLACER STUDY
WATER QUALITY DATA (Continued)

PARAMETER		STATION 1	STATION 3	STATION 4
Sn (mg/L)	a	---	---	---
	b	<0.01	<0.01	<0.01
	c	<0.01	<0.01	<0.01
	d	<0.01	<0.01	<0.01
	e	<0.01	<0.01	<0.01
	f	<0.01	<0.01	<0.01
Sr (mg/L)	a	---	---	---
	b	0.149	0.142	0.152
	c	0.084	0.133	0.106
	d	0.167	0.208	0.172
	e	0.184	0.185	0.184
	f	0.118	0.140	0.191
Ti (mg/L)	a	---	---	---
	b	<0.002	0.005	0.010
	c	0.004	0.036	0.024
	d	<0.002	0.026	0.017
	e	<0.002	0.004	<0.002
	f	<0.002	<0.002	0.006
V (mg/L)	a	---	---	---
	b	<0.01	<0.01	<0.01
	c	<0.01	0.03	0.01
	d	<0.01	0.03	0.02
	e	<0.01	<0.01	<0.01
	f	<0.01	<0.01	<0.01

Date sampled:

a) June 26, 1982
b) July 8, 1982
c) July 19, 1982*
d) August 9, 1982*
e) September 1, 1982
f) September 22, 1982

* Active Sluicing

APPENDIX II BARLOW PLACER STUDY
WATER QUALITY DATA (Continued)

PARAMETER		STATION 1	STATION 3	STATION 4
Zn	a	---	---	---
(mg/L)	b	0.011	0.015	0.015
	c	0.024	0.111	0.069
	d	<0.002	0.076	0.044
	e	<0.002	<0.002	<0.002
	f	<0.002	0.005	0.012

Date sampled:

a) June 26, 1982
b) July 8, 1982
c) July 19, 1982*
d) August 9, 1982*
e) September 1, 1982
f) September 22, 1982

* Active Sluicing

APPENDIX III

SEDIMENT DATA

APPENDIX III TABLE 1 BARLOW CREEK SEDIMENT PARTICLE SIZE ANALYSIS - STATION 1

SAMPLE NUMBER	DATE 1982	PERCENT COMPOSITION > 2360 um Gravel	1180 - 2360 um Very Coarse Sand	300 - 1180 um Med. Coarse Sand	150 - 300 um Fine Sand	75 - 150 um Very Fine Sand	< 75 um Silt
1 - 1	June 26	---	---	---	---	---	---
	July 08	12.4	5.1	43.6	16.7	9.6	12.5
	July 19	0.0	0.2	20.3	32.9	28.7	17.8
	Aug. 09	6.8	14.3	55.8	14.3	5.3	3.5
	Sept 01	75.3	12.0	10.8	1.2	0.4	0.3
	Sept 22	58.3	11.1	23.2	3.9	2.0	1.5
1 - 2	June 26	---	---	---	---	---	---
	July 08	39.9	20.8	29.7	3.7	2.4	3.6
	July 19	0.2	1.0	53.6	30.9	10.1	4.2
	Aug. 09	0.7	4.1	57.7	23.0	9.0	5.6
	Sept 01	60.3	14.4	19.7	3.2	1.3	1.1
	Sept 22	48.3	14.6	26.7	5.3	2.6	2.5
1 - 3	June 26	---	---	---	---	---	---
	July 08	22.9	4.5	40.4	14.4	7.6	10.0
	July 19	0.5	1.9	19.1	13.2	32.6	32.7
	Aug. 09	0.6	4.1	56.5	19.7	10.8	8.3
	Sept 01	75.8	11.0	11.4	1.0	0.5	0.3
	Sept 22	26.1	14.6	52.3	3.9	1.9	1.2

MEAN PERCENT COMPOSITION

SAMPLE NUMBER	DATE 1982	Gravel	Very Coarse Sand	Med. Coarse Sand	Fine Sand	Very Fine Sand	Silt
STN. 1	June 26	---	---	---	---	---	---
	July 08	25.2	10.1	37.9	11.6	6.5	8.7
	July 19	0.2	1.0	31.0	25.7	23.8	18.3
	Aug. 09	2.7	7.5	56.6	19.0	8.4	5.8
	Sept 01	70.5	12.5	14.0	1.8	0.7	0.5
	Sept 22	44.2	13.4	34.1	4.4	2.2	1.7

APPENDIX III TABLE 1 BARLOW CREEK SEDIMENT PARTICLE SIZE ANALYSIS - STATION 3

		PERCENT COMPOSITION					
		> 2360 um	1180 - 2360 um	300 - 1180 um	150 - 300 um	75 - 150 um	< 75 um
SAMPLE NUMBER	DATE 1982	Gravel	Very Coarse Sand	Med. Coarse Sand	Fine Sand	Very Fine Sand	Silt
3 - 1	June 26	---	---	---	---	---	---
	July 08	45.8	24.5	23.3	2.2	1.4	2.8
	July 19	0.5	1.5	10.0	9.7	39.7	38.6
	Aug. 09	0.2	0.1	1.8	10.7	24.7	62.5
	Sept 01	87.2	5.7	4.0	1.1	1.1	1.0
	Sept 22	24.6	0.7	1.0	1.6	4.4	67.7
3 - 2	June 26	---	---	---	---	---	---
	July 08	43.5	22.6	23.7	2.6	2.2	5.4
	July 19	0.6	1.9	19.5	17.4	31.9	28.8
	Aug. 09	0.0	0.2	2.6	17.2	39.0	41.0
	Sept 01	88.1	3.8	3.0	1.6	1.7	1.8
	Sept 22	0.1	0.2	0.3	0.5	3.2	95.8
3 - 3	June 26	---	---	---	---	---	---
	July 08	52.5	21.3	19.8	1.9	1.4	3.2
	July 19	6.1	11.9	45.7	11.6	10.8	13.9
	Aug. 09	1.6	0.2	2.4	12.6	29.5	53.7
	Sept 01	82.8	7.8	6.1	1.4	1.6	0.4
	Sept 22	0.1	0.3	3.9	8.1	12.5	75.2

MEAN PERCENT COMPOSITION

STN. 3	June 26	---	---	---	---	---	---
	July 08	47.2	22.7	22.3	2.3	1.7	3.8
	July 19	2.4	5.1	25.1	12.9	27.4	27.1
	Aug. 09	0.60	0.1	2.3	13.5	31.1	52.4
	Sept 01	86.0	5.8	4.3	1.3	1.5	1.1
	Sept 22	8.30	0.40	1.7	3.4	6.7	79.5

APPENDIX III TABLE 1 BARLOW CREEK SEDIMENT PARTICLE SIZE ANALYSIS - STATION 4

PERCENT COMPOSITION

SAMPLE NUMBER	DATE 1982	> 2360 um Gravel	1180 - 2360 um Very Coarse Sand	300 - 1180 um Med. Coarse Sand	150 - 300 um Fine Sand	75 - 150 um Very Fine Sand	< 75 um Silt
4 - 1	June 26	---	---	---	---	---	---
	July 08	---	---	---	---	---	---
	July 19	---	---	---	---	---	---
	Aug. 09	27.7	14.5	43.0	5.8	4.5	4.4
	Sept 01	78.6	9.1	10.4	0.8	0.5	0.5
	Sept 22	0.0	0.1	0.4	0.9	3.9	94.7
4 - 2	June 26	---	---	---	---	---	---
	July 08	---	---	---	---	---	---
	July 19	---	---	---	---	---	---
	Aug. 09	13.1	10.0	57.1	10.1	5.9	3.8
	Sept 01	82.8	8.1	6.8	0.5	0.6	1.1
	Sept 22	0.2	0.2	0.3	0.8	6.9	91.6
4 - 3	June 26	---	---	---	---	---	---
	July 08	---	---	---	---	---	---
	July 19	---	---	---	---	---	---
	Aug. 09	13.3	9.4	54.1	11.5	6.6	5.2
	Sept 01	74.8	11.1	10.7	0.9	1.0	1.5
	Sept 22	17.8	0.1	0.4	1.1	2.9	77.6

MEAN PERCENT COMPOSITION

STN. 4	June 26	---	---	---	---	---	---
	July 08	---	---	---	---	---	---
	July 19	---	---	---	---	---	---
	Aug. 09	18.0	11.3	50.4	9.1	5.7	4.6
	Sept 01	78.8	9.5	9.3	0.7	0.7	1.0
	Sept 22	6.0	0.1	0.4	0.9	4.6	88.0

APPENDIX III TABLE 2 BARLOW CREEK SEDIMENT CHEMISTRY DATA - STATION 1
(All concentrations given in mg/kg dry weight unless otherwise noted)

DATE:	July 8, 1982			July 19, 1982			August 9, 1982			September 1, 1982			September 22, 1982		
STATION:	1 - 1	1 - 2	1 - 3	1 - 1	1 - 2	1 - 3	1 - 1	1 - 2	1 - 3	1 - 1	1 - 2	1 - 3	1 - 1	1 - 2	1 - 3
Ag	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Al	7370	8860	7410	7020	7240	7380	11100	10900	11400	11000	11300	11900	12300	12400.	11900
As	5.4	5.4	4.8	4.5	6.2	5.9	7.2	5.9	6.0	7.6	6.9	8.3	8.4	7.7	7.1
B	4.5	5.1	8.6	1.6	4.0	3.8	12.2	9.0	13.3	2.1	5.5	11.7	---	---	---
Ba	86.1	102	86.3	72.4	70.1	86.8	103	109	112	95.4	98.7	99.6	114	119	106
Be	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.3	0.3	0.3
Ca	2610	3040	2470	2640	2590	2960	3570	4100	3750	4150	4150	4140	4690	4670	4160
Cd	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	5.2	0.7	<0.3
Co	7.2	9.1	7.3	4.5	9.4	5.7	10.3	10.0	11.6	10.0	10.0	9.8	11.6	12.2	10.9
Cr	18.4	21.7	18.7	16.4	17.7	17.2	25.1	24.8	25.5	21.0	22.9	23.1	28.1	28.2	28.1
Cu	18.7	22.7	19.9	17.5	19.5	15.6	23.3	21.3	23.5	23.0	23.7	24.6	22.9	23.8	22.7
Fe	14900	17500	15400	14300	15500	14400	21800	20900	21500	24800	24900	27300	24300	24000	24300
Hg	0.05	0.13	0.11	0.14	0.16	0.14	0.10	0.16	0.08	0.25	0.07	0.10	0.10	0.10	0.11
K	348	411	317	374	383	398	998	970	1030	1200	1210	1390	1070	1060	1140
Mg	3110	3680	3250	2990	3230	2960	4070	3810	4050	4060	4200	4340	4090	4200	4120
Mn	451	575	515	414	418	349	653	583	619	596	585	624	734	711	813
Mo	<0.8	<0.8	1.0	2.4	2.5	1.7	3.0	3.0	2.9	4.4	5.1	4.6	<0.8	<0.8	10.7
Na	100	100	70	90	80	100	130	140	140	120	150	140	130	130	140
Ni	18	19	16	14	17	14	20	18	21	19	22	21	20	21	19
P	607	626	592	670	700	741	596	695	597	761	744	731	791	768	708
Pb	5	8	7	6	10	5	6	9	9	8	8	9	9	9	10
Si	2850	3150	2700	2340	2380	2480	3850	3950	3680	4540	3930	3070	3030	3990	3610
Sn	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Sr	17.3	21.2	16.9	15.6	14.7	17.6	26.6	29.7	28.3	28.6	29.2	30.0	35.8	35.3	31.8
Ti	216	256	172	258	257	309	865	917	867	1160	1110	1370	1450	1320	1150
V	18	21	17	18	18	21	30	33	32	34	34	36	<2	<2	35
Zn	47.3	53.7	48.3	43.3	46.3	43.5	57.4	52.7	55.5	57.8	59.2	62.2	56.3	57.2	57.7

APPENDIX III TABLE 2 BARLOW CREEK SEDIMENT CHEMISTRY DATA - STATION 3
(All concentrations given in mg/kg dry weight unless otherwise noted)

DATE:	July 8, 1982			July 19, 1982			August 09, 1982			September 1, 1982			September 22, 1982		
STATION:	3 - 1	3 - 2	3 - 3	3 - 1	3 - 2	3 - 3	3 - 1	3 - 2	3 - 3	3 - 1	3 - 2	3 - 3	3 - 1	3 - 2	3 - 3
Ag	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Al	8900	10500	10300	6620	6910	7550	12800	10900	13100	12000	13100	12700	16300	16000	13300
As	5.7	5.3	5.6	4.4	4.2	4.4	6.7	5.3	5.9	7.9	8.5	9.0	17.3	17.1	14.1
B	5.8	10.0	5.9	7.8	6.6	2.2	9.3	11.7	8.9	14.2	12.7	6.4	---	---	---
Ba	120	129	119	67.9	80.8	88.1	168	124	162	119	141	125	141	135	120
Be	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.4	0.3	<0.2
Ca	2810	3510	2860	2380	2430	2920	4420	3540	4280	3850	4200	4070	3880	3590	2820
Cd	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Co	9.2	6.2	8.1	5.1	6.6	8.1	14.2	9.6	13.3	9.5	10.7	13.7	11.5	11.8	12.3
Cr	20.1	22.7	21.9	15.4	15.4	17.3	24.7	22.2	25.9	21.7	22.9	29.2	27.4	26.7	21.7
Cu	20.8	20.1	20.7	16.6	15.5	16.1	25.1	19.6	22.5	23.7	25.1	24.1	32.2	36.6	33.7
Fe	18800	20100	20100	13700	13400	14900	22100	19400	22300	25000	26000	26100	29100	29900	26900
Hg	0.06	0.05	0.06	0.16	0.15	0.15	0.15	0.14	0.16	0.03	0.03	0.03	0.10	0.12	0.10
K	471	648	632	316	363	410	983	850	1100	1440	1530	1580	1790	1650	1570
Mg	3680	3940	3960	2900	2870	3060	4610	3930	4530	4200	4460	4340	5440	5480	4860
Mn	1120	899	910	381	362	377	696	540	665	609	687	655	589	600	558
Mo	<0.8	<0.8	<0.8	1.2	1.6	2.0	2.4	2.4	2.5	5.7	5.0	5.3	13.1	14.0	<0.8
Na	90	160	120	80	100	100	170	140	180	150	140	150	210	180	130
Ni	22	19	20	13	14	15	22	18	23	22	23	24	24	26	17
P	594	648	528	646	592	717	696	623	629	666	703	664	719	717	643
Pb	7	4	6	4	5	6	10	8	9	8	10	12	16	18	15
Si	2960	3110	2950	2030	2320	2550	3770	3480	3810	4120	4130	3040	2300	3960	5230
Sn	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	3	2	<2
Sr	20.3	25.7	21.5	14.0	15.2	17.8	32.7	26.1	33.3	27.5	30.4	29.3	32.1	29.8	22.8
Ti	210	475	380	180	220	317	626	640	751	1020	954	1170	1120	924	638
V	21	28	24	16	18	21	34	30	35	35	37	38	38	37	<2
Zn	54.5	56.4	56.7	42.3	41.9	45.6	65.8	53.2	62.0	59.8	65.8	61.7	90.0	96.5	87.9

APPENDIX III TABLE 2 BARLOW CREEK SEDIMENT CHEMISTRY DATA - STATION 4
(All concentrations given in mg/kg dry weight unless otherwise noted)

DATE:	July 8, 1982			July 19, 1982			August 09, 1982			September 01, 1982			September 22, 1982		
STATION:	4 - 1	4 - 2	4 - 3	4 - 1	4 - 2	4 - 3	4 - 1	4 - 2	4 - 3	4 - 1	4 - 2	4 - 3	4 - 1	4 - 2	4 - 3
Ag	--	--	--	--	--	--	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Al	--	--	--	--	--	--	10800	9460	9010	13200	12100	13600	12300	14700	15800
As	--	--	--	--	--	--	5.7	5.8	5.8	8.5	8.0	8.8	18.8	14.2	16.9
B	--	--	--	--	--	--	10.8	6.7	7.2	6.6	12.5	10.1	---	---	---
Ba	--	--	--	--	--	--	127	97.9	93.9	120	130	143	116	145	141
Be	--	--	--	--	--	--	< 0.2	< 0.2	< 0.2	0.2	< 0.2	0.2	< 0.2	0.3	0.3
Ca	--	--	--	--	--	--	3910	3260	3150	3820	4020	4530	3060	3730	3900
Cd	--	--	--	--	--	--	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Co	--	--	--	--	--	--	13.8	13.2	10.8	13.9	11.3	14.3	10.9	10.9	9.3
Cr	--	--	--	--	--	--	23.8	20.2	19.8	29.6	26.1	29.5	21.1	25.4	26.3
Cu	--	--	--	--	--	--	19.3	18.7	17.2	25.0	22.6	24.5	30.7	27.4	30.6
Fe	--	--	--	--	--	--	20300	18400	17500	27300	23500	26100	23900	26000	28000
Hg	--	--	--	--	--	--	0.14	0.08	0.24	0.09	0.16	0.03	0.10	0.16	0.10
K	--	--	--	--	--	--	944	672	649	1880	1460	1760	1340	1540	1810
Mg	--	--	--	--	--	--	3690	3530	3340	4570	4120	4500	4210	5030	5210
Mn	--	--	--	--	--	--	488	441	413	683	658	723	498	644	618
Mo	--	--	--	--	--	--	2.1	2.6	2.1	5.5	4.5	5.4	<0.8	12.4	13.2
Na	--	--	--	--	--	--	140	110	110	180	160	180	130	170	190
Ni	--	--	--	--	--	--	20	20	17	25	22	26	15	23	23
P	--	--	--	--	--	--	683	653	642	644	656	709	661	616	688
Pb	--	--	--	--	--	--	9	8	8	11	10	12	12	14	13
Si	--	--	--	--	--	--	3770	3040	2870	2460	4210	2580	4620	4050	2240
Sn	--	--	--	--	--	--	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Sr	--	--	--	--	--	--	28.1	22.0	21.1	28.1	29.2	33.4	24.0	30.2	31.8
Ti	--	--	--	--	--	--	911	586	561	1210	913	1200	728	784	1020
V	--	--	--	--	--	--	33	26	26	37	36	40	8	36	38
Zn	--	--	--	--	--	--	50.6	49.2	47.3	63.2	59.1	64.7	80.0	80.2	87.1

Note: Sediment samples were not collected on July 8 and 19 due to high water conditions. Unable to collect a representative sample.

APPENDIX IV

BOTTOM FAUNA DATA

APPENDIX IV TABLE 1 BOTTOM FAUNA TAXONOMIC GROUPS FOUND IN BARLOW CREEK

	Phylum:	Annelida
	Class:	Oligochaeta
	Order:	Lumbriculida
	Family:	Lumbriculidae
1.		*Kincaidiana* *hexatheca*
	Order:	Haplotaxida
2.	Family:	Enchytraeidae
	Family:	Tubificidae
3.		*Telmatodrilus* sp.
4.		*Tubifex* sp.
5.		*Ilyodrilus* sp.
6.	Class:	Hirudinae
	Phylum:	Anthropoda
	Class:	Arachnoidae
7.	Order:	Acari
8.	Order:	Arachnida
	Class:	Insecta
	Order:	Plecoptera
9.		Subimago
	Family:	Capniidae
10.		*Capnia* sp.
	Family:	Chloroperlinae
11.		*Alloperla* sp.
12.		*Utaperla* sp.
	Family:	Nemouridae

APPENDIX IV TABLE 1 BOTTOM FAUNA TAXONOMIC GROUPS FOUND IN BARLOW CREEK (Continued)

13.		*Podmosta* sp.
	Family:	Perlodidae
14.		*Arcynopteryx* sp.
15.		*Cultus* sp.
16.		*Megarcys* sp.
17.		*Skwala* sp.
18.		unid. dam.
	Order:	Ephemeroptera
	Family:	Baetidae
19.		*Ameletus* sp.
20.		*Baetis* sp.
	Family:	Heptageniidae
21.		*Cinygmula* sp.
22.		*Epeorus* sp.
	Family:	Siphlonuridae
23.		*Siphlonurus* sp.
	Order:	Trichoptera
		Limnephilidae
24.		*Clostoeca* sp.
25.		*Ecclisomya* sp.
	Order:	Diptera
	Family:	Chironomidae
26.		Chironomidae adult
27.		Chironomidae pupae
28.		*Brillia* sp.
29.		*Cardiocladius* sp.
30.		*Cricotopus* sp.
31.		*Diplocladius* sp.
32.		*Epoicocladius* sp.
33.		*Eukiefferiella* sp.
34.		*Heterotrissocladius* sp.
35.		*Orthocladius* sp.
	Subfamily:	Diamesinae

APPENDIX IV TABLE 1 BOTTOM FAUNA TAXONOMIC GROUPS FOUND IN BARLOW CREEK (Continued)

36.		_Diamesa_ sp.
37.		_Monodiamesa_ sp.
38.	Family:	_Pseudodiamesa_ sp.
39.	Family:	Culicidae
	Family:	Empididae
40.		_Chelifera_ sp.
	Family:	Simulidae
41.		_Prosimulium_ sp.
42.		_Metacnephia_ sp.
	Family:	Tipulidae
43.		_Erioptera_ sp.
44.		_Tipula_ sp.
	Order:	Homoptera
45.	Family:	Aphididae

APPENDIX IV TABLE 2 BARLOW CREEK BOTTOM FAUNA DATA - STATION 1

TAXONOMIC GROUP	June 26/82			July 8/82			July 19/82			August 9/82			Sept. 1/82			Sept. 22/82		
	1-1	1-2	1-3	1-1	1-2	1-3	1-1	1-2	1-3	1-1	1-2	1-3	1-1	1-2	1-3	1-1	1-2	1-3
2. Enchytraeidae	41	37	x	234	329	132	-	-	-	21	36	51	9	2	5	4	4	6
4. *Tubifex* sp.	-	-	x	34	42	29	-	-	1	-	-	-	5	1	6	-	8	7
5. *Ilyodrilus* sp.	8	5	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9. Plecoptera subimago	-	-	x	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
10. *Capnia* sp.	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
13. *Podmosta* sp.	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	4	7	7
14. *Arcynopteryx* sp.	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
15. *Cultus* sp.	-	-	x	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-
17. *Skwala* sp.	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-
19. *Ameletus* sp.	4	6	x	2	-	1	-	-	-	-	1	-	-	-	-	-	-	-
20. *Baetis* sp.	12	14	x	10	10	7	3	-	5	1	-	3	-	-	-	-	-	1
21. *Cinygmula* sp.	8	8	x	10	16	16	2	3	9	2	3	1	2	-	-	2	-	1
22. *Epeorus* sp.	-	1	x	4	6	5	1	1	1	-	2	3	7	4	2	-	-	2
23. *Siphlonurus* sp.	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26. Chironomidae adult	-	-	x	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
27. Chironomidae pupae	-	-	x	-	-	-	-	-	1	-	-	-	3	1	2	-	3	6
28. *Brillia* sp.	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
29. *Cardiocladius* sp.	-	-	x	-	-	-	-	-	-	-	-	-	-	3	2	1	-	2
30. *Cricotopus* sp.	-	-	x	-	1	-	-	-	1	-	-	-	8	6	-	2	2	5
32. *Epoicocladius* sp.	-	-	x	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
33. *Eukiefferiella* sp.	-	-	x	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
34. *Heterotrissocladius* sp.	-	-	x	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
35. *Orthocladius* sp.	-	-	x	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX IV TABLE 2 BARLOW CREEK BOTTOM FAUNA DATA - STATION 1

TAXONOMIC GROUP	June 26/82			July 8/82			July 19/82			August 09/82			Sept. 1/82			Sept. 22/82		
	1-1	1-2	1-3	1-1	1-2	1-3	1-1	1-2	1-3	1-1	1-2	1-3	1-1	1-2	1-3	1-1	1-2	1-3
36. Diamesa sp.	-	-	x	-	-	-	-	-	-	-	-	-	4	8	11	4	8	15
37. Monodiamesa sp.	-	-	x	2	1	-	1	-	-	-	-	-	-	-	-	-	-	-
38. Pseudodiamesa sp.	-	-	x	-	-	-	-	1	1	-	-	4	-	2	6	8	7	13
39. Culicidae adult	-	-	x	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
40. Chelifera sp.	-	7	x	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
41. Prosimulium sp.	-	-	x	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-
42. Metacnephia sp.	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
43. Erioptera sp.	-	-	x	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
44. Tipula sp.	-	-	x	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-
45. Aphididae	-	2	x	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
(T) Column Totals	73	80	x	300	408	193	9	5	20	24	42	62	41	27	35	26	42	69
(N) Total Number	32	41	x	66	79	61	9	5	17	3	6	11	27	24	27	22	34	57
(H') Diversity	0.57	0.70	x	0.67	0.60	0.61	0.73	0.41	0.52	0.28	0.44	0.56	0.70	0.70	0.66	0.74	0.78	0.89

NOTE: Column totals recorded per ft^2

X = Not sampled.

APPENDIX IV   TABLE 2   BARLOW CREEK BOTTOM FAUNA DATA - STATION 3

TAXONOMIC GROUP	June 26/82			July 9/82			July 19/82			August 9/82			Sept. 1/82			Sept. 22/82		
	3-1	3-2	3-3	3-1	3-2	3-3	3-1	3-2	3-3	3-1	3-2	3-3	3-1	3-2	3-3	3-1	3-2	3-3
1. Kincaidiana hexatheca	-	-	x	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
2. Enchytraeidae	-	1	x	-	-	-	-	-	-	-	-	-	1	1	-	-	-	1
3. Telmatrodrilus sp.	-	-	x	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
4. Tubifex sp.	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8. Arachnida	-	-	x	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10. Capnia sp.	-	-	x	-	-	-	-	-	-	2	-	-	-	-	1	1	-	-
12. Utaperla sp.	-	-	x	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
13. Podmosta sp.	-	-	x	-	-	-	-	-	-	-	-	-	-	4	-	3	-	-
16. Megarcys sp.	-	-	x	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
17. Skwala sp.	-	-	x	-	-	-	-	-	-	-	-	-	2	2	2	-	2	1
18. Unid. dam.	-	-	x	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
19. Ameletus sp.	-	2	x	-	-	1	-	-	-	2	-	1	-	-	-	-	-	-
20. Baetis sp.	1	3	x	1	-	1	-	-	-	1	-	2	3	1	-	-	-	-
21. Cinygmula sp.	5	2	x	1	5	5	-	1	-	8	-	5	1	1	1	1	-	-
22. Epeorus sp.	-	-	x	1	1	1	-	-	-	8	2	15	1	2	1	-	-	1
23. Siphlonurus sp.	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24. Cloasteca sp.	-	-	x	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
25. Ecclisomya sp.	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26. Chironomidae adult	-	-	x	2	-	-	-	-	-	-	-	-	-	-	-	-	-	1
27. Chironomidae pupae	-	-	x	-	-	-	-	-	-	-	-	-	1	-	3	-	2	2
28. Brillia sp.	-	-	x	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
29. Cardiocladius sp.	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
30. Cricotopus sp.	-	-	x	-	-	-	-	-	-	2	-	1	4	-	-	5	2	2
31. Diplocladius sp.	-	-	x	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
34. Heterotrissocladius sp.	-	-	x	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1

APPENDIX IV TABLE 2 BARLOW CREEK BOTTOM FAUNA DATA - STATION 3

TAXONOMIC GROUP	June 26/82			July 8/82			July 19/82			August 9/82			Sept. 1/82			Sept. 22/82		
	3-1	3-2	3-3	3-1	3-2	3-3	3-1	3-2	3-3	3-1	3-2	3-3	3-1	3-2	3-3	3-1	3-2	3-3
35. Orthocladius sp.	-	-	x	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-
36. Diamesa sp.	-	-	x	-	-	-	-	-	-	-	-	-	9	10	3	5	11	10
37. Monodiamesa sp.	-	-	x	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38. Pseudodiamesa sp.	-	-	x	-	-	-	-	-	-	2	-	2	1	1	1	2	4	4
39. Culicidae adult	-	-	x	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40. Chelifera sp.	-	-	x	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
42. Metacnephia sp.	-	-	x	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
44. Tipula sp.	-	-	x	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
(T) Column Totals	6	8	x	8	6	8	2	58	18	27	3	26	27	29	12	17	22	24
(N) Total Number	6	7	x	4	6	8	2	58	18	27	3	26	24	28	9	17	20	21
(H') Diversity	0.20	0.47	x	0.60	0.20	0.70	0.00	0.08	0.00	0.78	0.28	0.56	0.84	0.94	0.73	0.70	0.55	0.70

NOTE: Column totals recorded per ft^2

x = not sampled.

APPENDIX IV TABLE 2 BARLOW CREEK BOTTOM FAUNA DATA - STATION 4

TAXONOMIC GROUP	June 26/82			July 8/82			July 19/82			August 9/82			Sept. 1/82			Sept. 22/82		
	4-1	4-2	4-3	4-1	4-2	4-3	4-1	4-2	4-3	4-1	4-2	4-3	4-1	4-2	4-3	4-1	4-2	4-3
2. Enchytraeidae	1	8	x	x	x	x	x	x	x	-	7	1	14	13	1	5	-	2
4. Tubifex sp.	-	-	x	x	x	x	x	x	x	-	-	-	-	-	-	-	-	-
6. Hirudinae	-	1	x	x	x	x	x	x	x	-	-	-	-	-	-	-	-	-
7. Acari	-	-	x	x	x	x	x	x	x	-	-	-	-	1	-	-	-	-
11. Alloperla sp.	-	-	x	x	x	x	x	x	x	-	-	1	-	-	-	-	-	-
13. Podmosta sp.	-	-	x	x	x	x	x	x	x	-	-	-	-	-	2	2	-	2
15. Cultus sp.	-	-	x	x	x	x	x	x	x	-	-	-	-	-	-	-	-	-
17. Skwala sp.	-	-	x	x	x	x	x	x	x	-	-	-	-	-	2	1	-	-
19. Ameletus sp.	1	-	x	x	x	x	x	x	x	-	-	-	-	-	-	-	-	-
20. Baetis sp.	1	3	x	x	x	x	x	x	x	-	-	-	-	1	-	-	-	-
21. Cinygmula sp.	-	5	x	x	x	x	x	x	x	1	-	-	-	-	-	-	-	-
22. Epeorus sp.	-	-	x	x	x	x	x	x	x	-	-	-	1	1	-	-	-	-
23. Siphlonurus sp.	-	-	x	x	x	x	x	x	x	-	-	-	-	-	-	-	-	-
27. Chironomidae pupae	-	-	x	x	x	x	x	x	x	-	-	-	1	-	1	3	1	3
28. Brillia sp.	-	-	x	x	x	x	x	x	x	-	-	-	-	-	-	-	-	-
29. Cardiocladius sp.	-	-	x	x	x	x	x	x	x	-	-	-	-	-	-	1	-	-
30. Cricotopus sp.	-	-	x	x	x	x	x	x	x	-	-	-	-	2	-	-	-	-
34. Heterotrissocladius sp.	-	-	x	x	x	x	x	x	x	-	-	-	2	2	-	-	-	-
36. Diamesa sp.	-	-	x	x	x	x	x	x	x	-	-	-	3	-	2	17	2	14
37. Monodiamesa sp.	-	-	x	x	x	x	x	x	x	-	-	-	-	-	-	-	-	-
38. Pseudodiamesa sp.	-	-	x	x	x	x	x	x	x	-	-	-	1	-	-	3	2	7

NOTE: Bottom fauna was not collected on July 8 and 19 due to high water conditions.

APPENDIX IV TABLE 2 BARLOW CREEK BOTTOM FAUNA DATA - STATION 4

TAXONOMIC GROUP	June 26/82			July 8/82			July 19/82			August 9/82			Sept. 1/82			Sept. 22/82		
	4-1	4-2	4-3	4-1	4-2	4-3	4-1	4-2	4-3	4-1	4-2	4-3	4-1	4-2	4-3	4-1	4-2	4-3
40. Chelifera sp.	1	-	*	x	x	x	x	x	x	-	-	-	2	1	-	-	-	1
42. Metacnephia sp.	-	-	*	x	x	x	x	x	x	-	-	-	-	-	-	-	-	1
44. Tipula sp.	-	-	*	x	x	x	x	x	x	-	-	-	-	1	-	-	-	-
45. Aphididae	-	-	*	x	x	x	x	x	x	-	-	-	-	1	-	-	-	-
(T) Column Totals	4	17	*	x	x	x	x	x	x	1	7	2	24	23	8	32	5	30
(N) Total Numbers	3	8	*	x	x	x	x	x	x	0	0	1	9	8	6	24	4	25
(H') Diversity	0.48	0.29	*	x	x	x	x	x	x	0.00	0.00	0.00	0.66	0.75	0.48	0.42	0.30	0.50

NOTE: Bottom fauna was not collected on July 8 and 19 due to high water conditions.

* = not sampled