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# A BASELINE SURVEY OF THE WATER QUALITY AND BIOLOGICAL CONDITIONS IN THE STREAMS OF THE HOWARD'S PASS AREA, YUKON TERRITORY

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by

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ABSTRACT

A pre-development survey of water quality and biological conditions in the streams of the Howard's Pass area was conducted in July 1980. Generally, the water chemistry parameters measured showed no anomalies. The bethnic macroinvertebrates and fish sampling results were respresentative of generally clear, unpolluted mountain streams. The high zinc concentrations in the stream sediments sampled reflected the presence of zinc ore deposits in the area.

# RÉSUMÉ

En juillet 1980 on a procédé à une analyse de la qualité de l'eau et des conditions biologiques des cours d'eau de la région non encore touchée par l'homme du col Howard. D'une manière générale, les paramètres relatifs à la composition chimique de l'eau n'ont révélé aucune anomalie. Les résultats obtenus de l'étude des macroinvertébrés bethiques et des prélèvements de poissons ontété typequers des cours d'eau de montagne limpides et non pollués.

Les fortes concentrations de zinc trouvées dans les sédiments des cours d'eau étudiés révèlent la présence de dépôts de minerai de zinc dans le sous-sol de ce secteur.

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# 1 INTRODUCTION

A survey of water quality, sediment composition and biological conditions was conducted in July 1980 in the watersheds of the Howard's Pass area (Figure 1). The purpose of the survey was to obtain baseline information on the environmental quality of streams in the area around a large lead/zinc ore body which is expected to be developed as a mine.

## 1.1 Background

The Howard's Pass area was the scene of intermittent mineral exploration activity from 1966 to 1972. In 1972 Placer Development Limited, then known as Canex Placer, staked 47 kilometers of mineral claims in the area -- 42 kilometers of which were in the Yukon and five in the Northwest Territories. Interestingly, stream sediment geochemistry originally led to the discovery of the deposit.

Further exploration and surface drilling work by Placer Development Limited led to the delineation of a mega or world class lead/zinc deposit; 14-23 million tonnes of ore of varying grades were estimated in the body. The five major mineral deposits were on the ANNIV and XY claims (Figures 2 and 3) and the zone of high grade ore runs 180 to 490 meters below surface.

During the 1980 season Placer Development Limited and its partner, U.S. Steel, carried out underground work to determine whether there were any formation problems and to bulk sample and stockpile ore for metallurgical analysis. One hundred and eighteen thousand tonnes of ore were extracted and stockpiled at Howard's Pass.

At the time of this survey, mineral exploration activity was centred at the north end of Howard's Pass (62°28'N, 129°13'W). A 14-man camp was located there at an elevation of about 1,524 meters on the upper reaches of Don Creek (Figure 3).

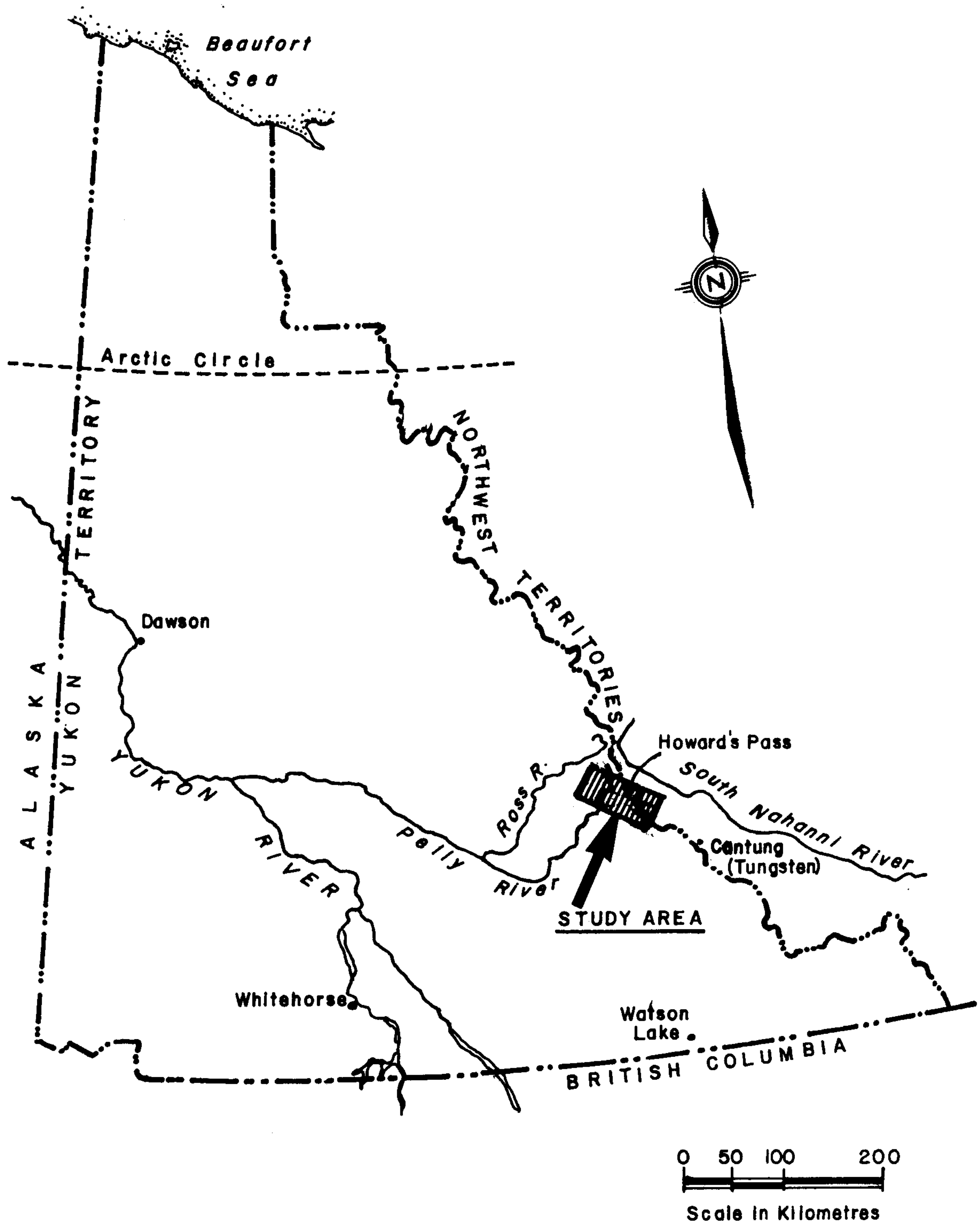


FIGURE I LOCATION OF HOWARD'S PASS

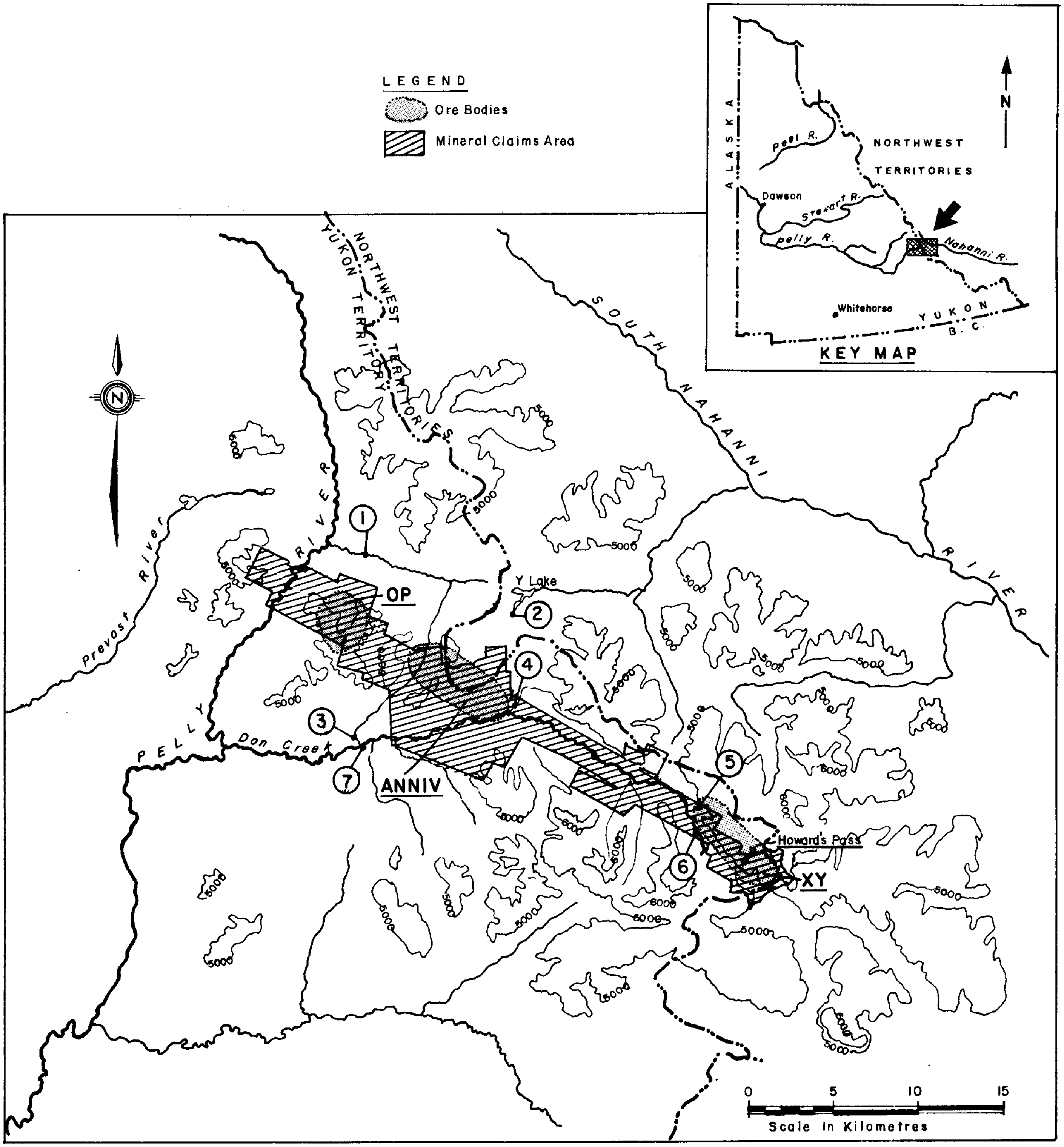


FIGURE 4 STUDY AREA SHOWING STREAMS, MINERAL CLAIMS AND SAMPLE STATIONS

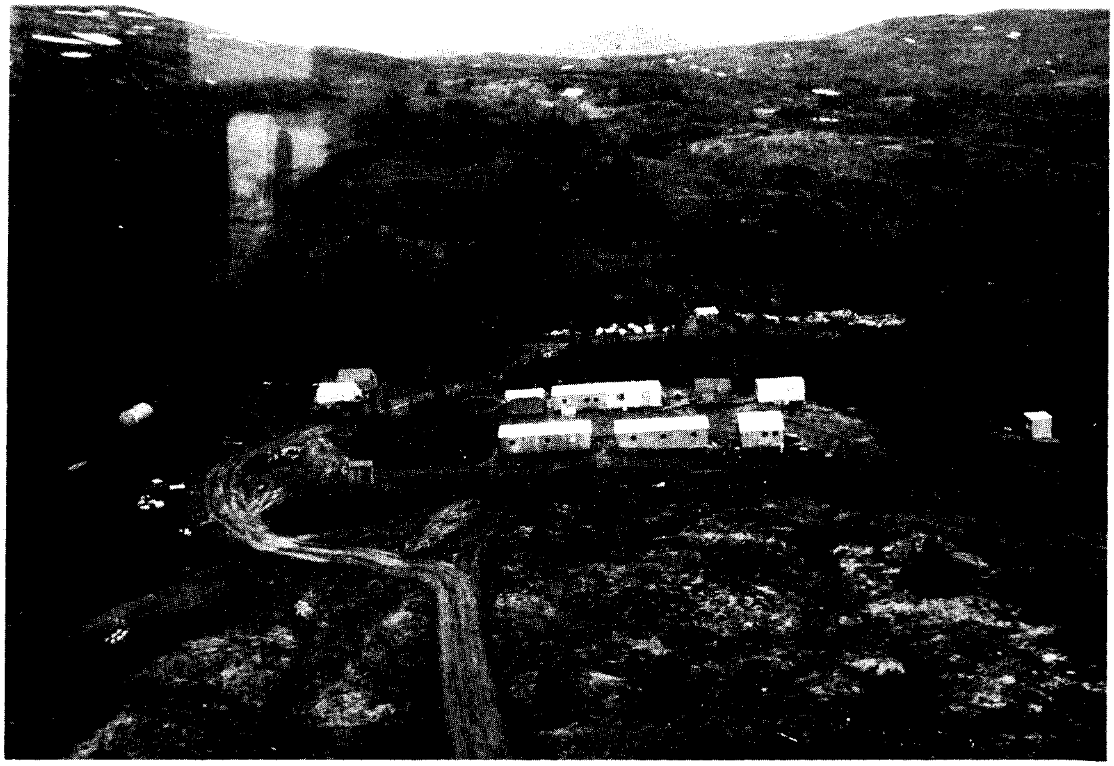

FIGURE 2 PLACER DEVELOPMENT LIMITED'S ANNIV CLAIM AT HOWARD'S PASS.

FIGURE 3 PLACER DEVELOPMENT LIMITED'S XY CLAIM AT HOWARD'S PASS. THE CAMP CAN BE SEEN ABOVE DON CREEK. THE MINE ADIT IS BELOW THE CAMP, ACROSS THE CREEK, AND THE AIRSTRIP IS IN THE BACKGROUND AT THE CREST OF THE PASS.

If the results of the 1980 season's exploration work proves extraction to be feasible, Placer Development Limited will establish an underground mine and undertake a five year underground drilling program. Developments associated with such a drilling program would be a 20-man camp at Howard's Pass and a milling plant. Plans are to establish a mill of two to five thousand tonnes per day capacity on either the South Nahanni River or the Pelly River by 1985.

An access road to Howard's Pass from Cantung was built with government assistance in 1977. In 1979 it was upgraded to permit large scale movement of equipment and supplies onto the claims site. Plans are to make the road an all-weather road by 1981. Placer Development Limited anticipates that a haul road running west to the North Canol or the Robert Campbell Highway will also be built.

Placer Development Limited has been operating under a water use authorization to date but is expected to apply for a water licence in 1981.

Environmental impact assessment is scheduled to begin in 1983 and feasibility studies for development of the mine will be undertaken in 1984-85.

Lack of energy and transportation are major infrastructural impediments to development of the mine, however, it is felt that eventually there will be a large-scale, long-life mine at Howard's Pass.

## 2 STUDY AREA

The study area was located in the vicinity of Howard's Pass which is in the Selwyn Mountains, approximately 266 kilometers north of the town of Watson Lake (Figure 1). It incorporated three contiguous blocks of mineral claims belonging to Placer Development Limited, and the streams draining them (Figure 4). The claims, named ANNIV, XY and OP, extend from Howard's Pass northwest along the Yukon-Northwest Territories border to a point about halfway between the Pelly and Prevost Rivers.

Tributaries to two distinct watersheds, the Pelly River and the South Nahanni River, were included in the study area. The majority of the sampling stations were located on streams flowing into the Pelly River because that was where the impacts of mining were expected to be the greatest.

Samples were taken at seven sites, the locations of which are shown in Figure 4. A description of the sample sites is provided in Table 1 and the photographs in Figures 5-13 illustrate their settings.

TABLE 1 DESCRIPTION OF SAMPLE SITES AT HOWARD'S PASS

| STATION | LOCATION | STREAM BOTTOM | REMARKS |
|---|---|---|---|
| 1 | 62°38'N 129°40'W. Unnamed stream collecting drainage from the N side of the OP claim and draining into the Pelly River. | Cobbles, coarse gravel and some fine gravel. | Appeared to be a productive stream - fish caught here. |
| 2 | 62°36'N 129°29'W. Unnamed stream draining N & E sides of ANNIV claim and emptying into Y Lake just inside NWT border. | Pebbles and coarse sand; iron oxide stained; unstable bottom. | Slow-moving, deep, narrow creek running through a floating fen into the south end of Y Lake. |
| 3 | 62°32'N 129°39'W. Unnamed stream draining W side of ANNIV claim just above confluence with Don Creek. | Cobbles, coarse gravel and some fine gravel. | |
| 4 | 62°33'N 129°28'W. Unnamed stream draining area between ANNIV claim and height of land between ANNIV and XY claims. Just above confluence with Don Creek. | Cobbles, coarse and fine gravel. | Appeared to be productive stream, particularly at its confluence with Don Creek where several fish were caught. Approximately 180 meters upstream of confluence on Don Creek was a waterfall which, upon inspection, appeared to be a barrier to fish movements (Figure 13). |

TABLE 1 DESCRIPTION OF SAMPLE SITES AT HOWARD'S PASS

| STATION | LOCATION | STREAM BOTTOM | REMARKS |
|---|---|---|---|
| 5 | 62°30'N 129°17'W. Unnamed stream draining part of west side of XY claim about 11 meters above confluence with Don Creek. | Boulders, cobbles and coarse gravel. | Narrow, fast-flowing stream heavily overhung with willows. |
| 6 | 62°29'N 129°17'W. Don Creek about 4 kilometers below XY claim and exploration camp. | Boulders, cobbles, coarse and fine gravel. | Productive looking stream but site was above waterfall which would be a barrier to fish. |
| 7 | 62°32'N 129°38'W. Don Creek just above confluence with stream where site #3 was located. | Coarse and fine gravel. | Appeared to be a productive area based on the number of fish caught. |

FIGURE 5. AERIAL VIEW OF SAMPLE STATION 1 LOCATED BELOW THE OP CLAIM.

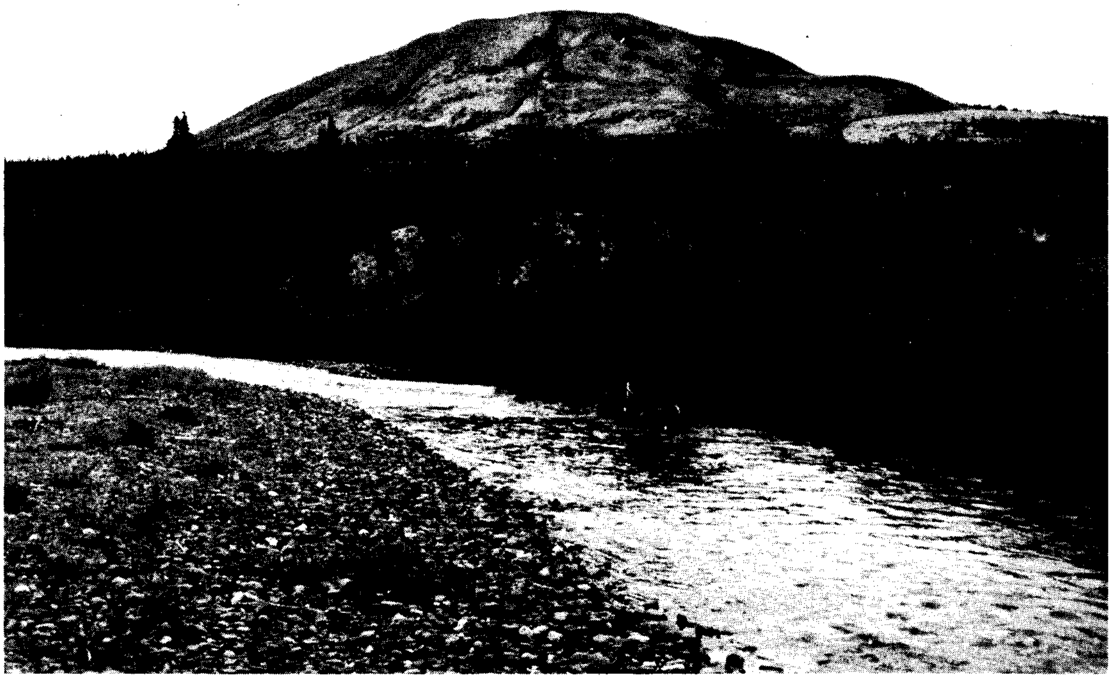

FIGURE 6 CLOSE-UP OF SAMPLE STATION 1 SHOWING COMPOSITION OF STREAM BANKS AND BOTTOM AND WILLOW/BIRCH RIPARIAN COMMUNITY.

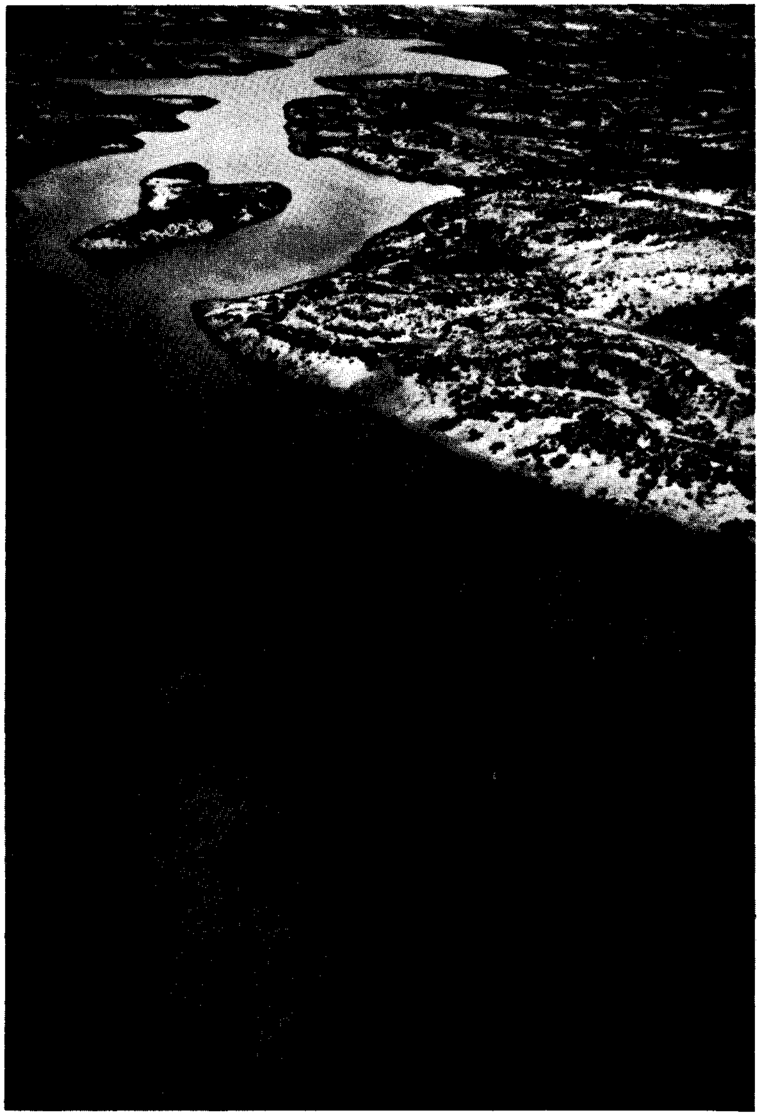

FIGURE 7 AERIAL VIEW OF SAMPLE STATION 2 LOCATED ON A STREAM RUNNING THROUGH A FLOATING FEN INTO Y LAKE.

FIGURE 8 AERIAL VIEW OF SAMPLE STATIONS 3 AND 7. STATION 3 IS ON A STREAM DRAINING THE ANNIV CLAIM AND 7 IS ON DON CREEK.

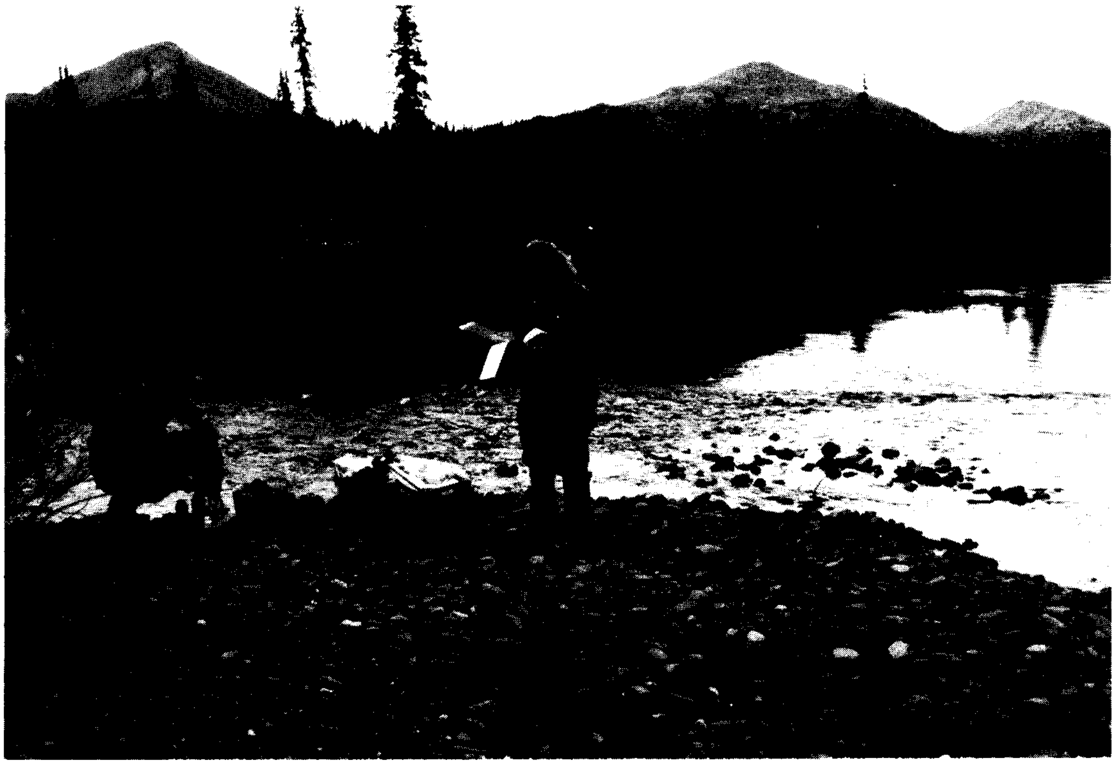

FIGURE 9 CLOSE-UP OF CONFLUENCE OF STREAMS WHERE STATIONS 3 AND 7 ARE LOCATED, SHOWING COARSE SAND/GRAVEL BANKS AND STREAM BOTTOM AND WILLOW/BIRCH RIPARIAN COMMUNITY.

FIGURE 10 AERIAL VIEW OF SAMPLE STATION 4.

FIGURE 11 AERIAL VIEW OF SAMPLE STATIONS 5 AND 6 LOCATED APPROXIMATELY 4 KILOMETERS DOWNSTREAM FROM XY CLAIM.

FIGURE 12 CLOSE-UP OF SAMPLE STATION 6. ACCESS TO ALL THE SAMPLE STATIONS WAS BY HELICOPTER.

FIGURE 13 WATERFALL WHICH IS A BARRIER TO FISH MOVEMENT ON DON CREEK.

# 3 METHODS

Access to the sample sites was by helicopter. Each site was sampled once, on July 17, 1980.

## 3.1 Water Quality

Two parameters were measured in the field at each site: temperature, with a standard centigrade thermometer, and pH, with a Model 296 Radiometer pH meter.

Water samples were collected and preserved at each site for later chemical analysis in the laboratory. Samples were collected for analysis of conductivity, nutrients, filterable and non-filterable residues, alkalinity, hardness, dissolved oxygen, total organic and total inorganic carbon, and the following extractable metals:

| | | |
|---|---|---|
| Aluminum (Al) | Iron (Fe) | Selenium (Se) |
| Antimony (Sb) | Lead (Pb) | Silver (Ag) |
| Arsenic (As) | Magnesium (Mg) | Sodium (Na) |
| Barium (Ba) | 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) | |

The sampling, preservation and storage procedures followed were those described in the Environment Canada Pollution Sampling Handbook (1979) and summarized in Table 2.

As laboratory facilities in Whitehorse were not adequate for chemical analysis of the water samples, with the exception of dissolved oxygen, they were sent to the Environmental Protection Service Regional Laboratory in West Vancouver. Table 2 summarizes the analytical procedures used at the Regional Laboratory and the procedure for dissolved oxygen used at the EPS Laboratory in Whitehorse.

TABLE 2 COLLECTION, PRESERVATION AND ANALYTICAL PROCEDURES USED IN WATER QUALITY ANALYSIS

| PARAMETER | DETECTION LIMIT WHERE APPLICABLE (mg/l) | COLLECTION AND PRESERVATION PROCEDURE[1] | ANALYTICAL PROCEDURE[2] |
|---|---|---|---|
| Dissolved Oxygen | 1.0 | Duplicate samples collected in 300 ml glass BOD bottles. Preserved with 2 ml $MnSO_4$ and 2 ml alkali-iodide-azide solution and shaken 15 times | Iodometric Azide Modification Winkler Titration Method |
| pH | | Small aliquots of sample taken and read soon after collection. No preservative | Potentiometric |
| Conductivity | 0.2 umhos/cm | In situ measurement and laboratory measurement. No preservative | Conductivity Cell |
| Ammonia ($NH_3$-N) | 0.0050 | Single samples collected in 2 litre linear polyethylene containers. No preservative. Stored at 4°C. | Phenol hypochlorite-colorimetric-automated |
| Colour | 5 (units) | Same sample as $NH_3$ | Platinum-Cobalt Comparison |
| Turbidity | 1.0 (FTU) | Same sample as $NH_3$ | Nephelometric Turbidity |
| Non-Filterable Residue | 5 | Same sample as $NH_3$ | Filtration, drying and weighing |
| Filterable Residue | 5 | Same sample as $NH_3$ | Filtration, drying and weighing |

TABLE 2 COLLECTION, PRESERVATION AND ANALYTICAL PROCEDURES USED IN WATER QUALITY ANALYSIS (continued)

| PARAMETER | DETECTION LIMIT WHERE APPLICABLE (mg/l) | COLLECTION AND PRESERVATION PROCEDURE[1] | ANALYTICAL PROCEDURE[2] |
|---|---|---|---|
| Total Alkalinity | 1.0 mg/l as $CaCO_3$ | Same sample as $NH_3$ | Potentiometric Titration |
| Total $PO_4$ | 0.0050 | Same sample as $NH_3$ | Acid per-sulfate, Autoclave digestion |
| Nitrite ($NO_2$) | 0.0050 | Same sample as $NH_3$ | Cadmium-copper reduction-colorimetric |
| Nitrate ($NO_3$) | 0.010 | Same sample as $NH_3$ | Cadmium-copper reduction-colorimetric |
| Sulfate ($SO_4$) | 1.0 | Same sample as $NH_3$ | Barium chloranilate - UV spectrophotometric |
| Chloride (Cl) | 0.50 | Same sample as $NH_3$ | Thiocyanate-combined reagent-colorimetric |
| Silica (Si) | 0.5 | Same sample as $NH_3$ | Ascorbic acid reduction - colorimetric |
| Total Organic Carbon (TOC) | 1.0 | Single samples collected in 100 ml glass jars. No preservation. Stored at 4°C. | Carbon Infra-red analyzer |
| Total Inorganic Carbon (TIC) | 1.0 | Same sample as TOC. | |
| Mercury (Total) | 0.00020 | Single samples collected in 200 ml linear polyethylene bottles. Preserved with 10 ml 5% nitric dichromate solution | Open Flameless System for Hg-AAS determination |

TABLE 2 COLLECTION, PRESERVATION AND ANALYTICAL PROCEDURES USED IN WATER QUALITY ANALYSIS (continued)

| PARAMETER | DETECTION LIMIT WHERE APPLICABLE (mg/l) | COLLECTION AND PRESERVATION PROCEDURE[1] | ANALYTICAL PROCEDURE[2] |
|---|---|---|---|
| Extractable Metals: | | Single samples collected in 200 ml linear polyethylene bottles. Preserved to a pH <1.5 using 2.0 ml concentrated $HNO_3$ | Inductively Coupled Argon Plasma (ICAP) combined with Optical Emission Spectrometer (OES) |
| Al | 0.090 | | |
| As | 0.15 | | |
| Ba | 0.0030 | | |
| Ca | 0.025 | | |
| Co | 0.015 | | |
| Cr | 0.015 | | |
| Fe | 0.01 | | |
| K | 0.010 | | |
| Mg | 0.025 | | |
| Mn | 0.0040 | | |
| Mo | 0.15 | | |
| Na | 0.030 | | |
| Ni | 0.080 | | |
| Sb | 0.080 | | |
| Se | 0.15 | | |
| Sn | 0.20 | | |
| Sr | 0.0040 | | |
| Ti | 0.0085 | | |
| V | 0.050 | | |
| Zn | 0.020 | | |
| Ag | 0.030 | | Flame Atomic Absorption |
| Cd | 0.0010 | | Flameless Atomic Absorption |
| Cu | 0.010 | | Flameless Atomic Absorption |
| Pb | 0.0010 | | Flameless Atomic Absorption |

TABLE 2 COLLECTION, PRESERVATION AND ANALYTICAL PROCEDURES USED IN WATER QUALITY ANALYSIS (continued)

| PARAMETER | DETECTION LIMIT WHERE APPLICABLE (mg/l) | COLLECTION AND PRESERVATION PROCEDURE[1] | ANALYTICAL PROCEDURE[2] |
|---|---|---|---|
| Hardness | 0.03 mg/l $CaCO_3$ | Same sample as metals | The sum of the ICAP results for Mg x 4.116 and Ca x 2.497 as mg/l $CaCO_3$ |
| Potassium K (extractable) | 0.010 | Same sample as metals | Flame Atomic Emission Spectrophotometry |

1 As described in Environment Canada (1976)

2 As described in Department of Environment (1979)

## 3.2 Sediments

Three sediment samples were collected at each sample site. A small aluminum shovel was used to scoop up the sediment samples which were then put in labelled Whirl-pak bags and packed on ice. The samples were sent out to the Environmental Protection Service Regional Laboratory in West Vancouver for analysis. A portion of each sample was freeze-dried and passed through a stainless steel sieve, mesh size 150 um, and then analyzed for metals using the aqua regia leach method and the ICAP method as described in Department of Environment (1979). The concentrations are presented as dry weight. The sediments were analyzed for the following metals:

| | | |
|---|---|---|
| Aluminum (Al) | Lead (Pb) | Sodium (Na) |
| Barium (Ba) | Magnesium (Mg) | Strontium (Sr) |
| Cadmium (Cd) | Manganese (Mn) | Tin (Sn) |
| Calcium (Ca) | Molybdenum (Mo) | Titanium (Ti) |
| Chromium (Cr) | Nickel (Ni) | Vanadium (V) |
| Copper (Cu) | Phosphorus (P) | Zinc (Zn) |
| Iron (Fe) | Silicon (Si) | |

## 3.3 Benthic Macroinvertebrates

Macroinvertebrate populations were sampled at all sites. Three samples were taken per site, using a 30 cm by 30 cm Surber Sampler (total area 900 $cm^2$) with a mesh size of one millimeter. The samples were put in separate, labelled glass collection jars and preserved with 10% formalin.

The organisms were sorted from the sample detritus at the EPS laboratory in Whitehorse and preserved in 70% methanol. The samples were then shipped to Nanaimo to Dr. Charles Low, a consulting entomologist, for identification and enumeration.

To statistically evaluate the invertebrate data collected, indices of diversity and evenness were calculated using the formulae described by Pielou (1975):

(a) Species Diversity

$$(H') = -\sum(Pi \log Pi)$$

where: Pi = ni/N

ni = total number of individuals in the ith species

N = the total number of individuals sampled

(b) Evenness

$$(J') = \frac{-\sum(Pi \log Pi)}{\log s}$$

where: s = total number of species sampled

J (max) = 1

For the purposes of this report, s = genera instead of species and, therefore: ni = the total number of individuals in the ith genera.

## 3.4 Fish

Fish were collected at Stations 1, 4 and 7. No attempt was made to collect fish at Stations 2, 3, 5 and 6 since Stations 5 and 6 were deemed inaccessible to fish because of a waterfall downstream on Don Creek and Stations 2 and 3 presented difficulties to sampling.

The objective of the fish collection was to obtain fish tissue samples for metals analysis rather than to assess abundance or diversity of fish.

Initially, electro-shocking was tried, using a Smith-Root Type VIII Electro-fisher, but this proved unproductive because of problems with the electro-fisher. Angling was done instead.

Dorsal muscle tissue was removed from the fish collected at Stations 1 and 4, placed in Whirl-Pak bags, frozen and sent to the Environmental Protection Service Regional Laboratory in West Vancouver for analysis. Metals were analysed by emission spectrograph following acid digestion of the tissues. Mercury was analysed separately using the cold vapour technique for atomic absorption spectrophotometry.

# 4 RESULTS AND DISCUSSION

## 4.1 Water Quality

Generally, the water quality parameters analyzed showed no anomalies (Appendix I).

Only two parameters exceeded recommended levels: conductivity and alkalinity. The high conductivity readings follow from the high alkalinity readings as high levels of salts increase conductivity. The acceptable upper limit of conductivity for the support of fish populations is 500 umhos/cm (Environment Canada 1976). Station 5 exceeded this amount with a value of 518 umhos/cm. The remainder of the stations were around 200 umhos/cm. The acceptable range for aquatic life for alkalinity is 100 mg/l as $CaCO_3$ with a pH of 7 to 8 (Environment Canada 1976). Stations 2, 4 and 5 had values over 100 mg/l with Station 5 having the highest value of 174 mg/l as $CaCO_3$. Alkalinity is used as a measure of the capacity of natural waters to neutralize acidic or caustic wastes while maintaining a pH suitable for biological activity. The existing pH's of the stations indicate that the waters were around the neutral range (7.5 to 8.5) so the high total alkalinity results were not a problem.

The remainder of the water quality parameters measured were either below detection levels (see Table 2) or below the recommended limits for a public drinking water supply.

Some of the parameters tested have different recommended levels for domestic water than for water quality for aquatic life because biomagnification of those particular parameters occurs in the food chain. The recommended limit for cadmium for drinking water is 0.01 mg/l and for aquatic life is 0.0002 mg/l (Reeder et al 1979). The detection limit for cadmium in this study was 0.0010 mg/l. This limit was exceeded at Station 6 with a value of 0.0014 mg/l. The biological half-life for cadmium has been estimated at 10 to 30 years (Eriberg et al 1974, p.88), therefore, it will accumulate in the body.

The recommended limit for chromium in domestic water is 0.1 mg/l and for aquatic life it is 0.04 mg/l (Taylor et al 1979). The results for all stations were below the detection limit of 0.015 mg/l.

The recommended levels for mercury are 0.001 mg/l in a public drinking water supply, 0.0001 mg/l in waters where fish are caught for consumption and 0.0002 mg/l in waters where fish are not consumed (Reeder et al 1979). All results were below the detection limit of 0.0002 mg/l.

For nickel, the recommended levels are 0.25 mg/l for domestic water, 0.025 mg/l for aquatic life in soft water and 0.25 mg/l for aquatic life in hard water (>150 mg/l $CaCO_3$)(Taylor et al 1979). Studies indicate that nickel does not biomagnify through the food chain but its toxicity increases as the hardness decreases. Also an increase of pH decreases the toxicity of nickel as it is less soluble at high pH values. The results for nickel were below the detection limit of 0.08 mg/l and, as the waters of the Howard's Pass area are hard, this is within the acceptable limits.

Taylor et al (1980) has recommended a level of 0.05 mg/l silver for a public drinking water supply and 0.0001 mg/l silver for aquatic life. Silver has no known function in the body and is considered a contaminant. Very minute quantities of silver are highly toxic to primitive life forms. The lower limit of detection for silver in the process used was 0.030 mg/l. This is well above the recommended level for aquatic life but is suitable for drinking water. All stations sampled were below this detection limit.

Arsenic is another metal for which the detection limit exceeds the recommended limit. Demayo et al (1979) has recommended that arsenic concentrations should be no greater than 0.05 mg/l in a public water supply and for aquatic life. All stations were below the detection limit of this study of 0.15 mg/l.

## 4.2 Sediments

There appeared to be nothing unusual in the results of the analysis of metals in the sediment (Appendix II). The zinc concentrations were high compared to those found in other Yukon streams (Burns 1980). These high concentrations confirm the presence of zinc ore deposits in the area. The average concentration of lead in soils is 10 mg/kg dry weight (Demayo et al 1980). All the stations were above this average which would be expected in the area of a major lead/zinc deposit.

## 4.3 Benthic Macroinvertebrates

A taxonomic list of the benthic macroinvertebrates collected at Howard's Pass is shown in Table 3 and Appendix III presents the macroinvertebrate data collected. Table 4 summarizes which macroinvertebrates were collected at each station. Station 2 had the greatest number of taxonomic groups represented, 26, and Station 5 had the smallest number, 15. Station 2 also yielded the greatest number of individual specimens, 364. Only four of the taxonomic groups found were collected at all seven stations: *Nemoura* (Zapada) sp., *Cinygmula* sp., *Cricotopus* sp. and Chironomidae.

Diversity and evenness values were calculated (Table 5) to assist future assessment of the impact that a lead/zinc mine would have on the watersheds of the Howard's Pass area. Diversity is a calculated value which 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. High diversity is characteristic of relatively undisturbed, unpolluted waters. Low diversity is often associated with disturbed, stressed or polluted waters.

TABLE 3 TAXONOMIC LIST OF THE BENTHIC MACROINVERTEBRATES COLLECTED AT HOWARD'S PASS

| | | |
|---|---|---|
| | Phylum: | Platyhelminthes |
| 1. | Class: | Turbellaria |
| 2. | Phylum: | Nematoda |
| | Phylum: | Annelida |
| | Class: | Oligochaeta |
| | Order: | Plesiopora |
| 3. | Family: | Enchytraeidae |
| | Family: | Tubificidae |
| 4. | | *Phallodrillus* sp. |
| 5. | | *Rhyacodrilus* sp. |
| | Order: | Prosopora |
| | Family: | Lumbriculidae |
| 6. | | *Kincaidiana hexatheca* |
| | Phylum: | Arthropoda |
| | Class: | Crustacea |
| | Order: | Cladocera |
| | Family: | Chydoridae |
| 7. | | *Eurycercus lamellatus* |
| | Class: | Arachnoidea |
| 8. | Order: | Acari undet. |

TABLE 3 TAXONOMIC LIST OF THE BENTHIC MACROINVERTEBRATES COLLECTED AT HOWARD'S PASS (continued)

| | | |
|---|---|---|
| | Class: | Insecta |
| | Order: | Plecoptera |
| | Family: | Chloroperlidae |
| 9. | | Alloperla sp. |
| | Family: | Perlodidae |
| 10. | | Arcynopteryx sp. |
| 11. | | Isoperla sp. |
| | Family: | Nemouridae |
| 12. | | Nemoura (Amphinemoura) sp. |
| 13. | | Nemoura (Zapada) sp. |
| 14. | Order: | Ephemeroptera |
| | Family: | Baetidae |
| 15. | | Ameletus sp. |
| 16. | | Baetis sp. |
| 17. | | Ephemerella flavilinea |
| 18. | | Ephemerella levis |
| 19. | | Ephemerella proserpina |
| | Family: | Heptageniidae |
| 20. | | Cinygmula sp. |
| 21. | | Epeorus sp. |
| 22. | | Rithrogena sp. |
| 23. | Order: | Hemiptera |
| 24. | Family: | Cicadellidae |

TABLE 3 TAXONOMIC LIST OF THE BENTHIC MACROINVERTEBRATES COLLECTED AT HOWARD'S PASS (continued)

| | | |
|---|---|---|
| | Order: | Trichoptera |
| | Family: | Rhyacophilidae |
| 25. | | *Agapetus* sp. |
| 26. | | *Rhyacophila angelita* |
| 27. | | *Rhyacophila tucula* |
| | Family: | Limnephilidae |
| 28. | | *Drusinus* sp. |
| 29. | Order: | Lepidoptera |
| | Order: | Coleoptera |
| | Family: | Dytiscidae |
| 30. | | *Dytiscus* sp. |
| 31. | Order: | Diptera |
| | Family: | Tipulidae |
| 32. | | *Eripotera* sp. |
| 33. | | *Pedicia* sp. |
| 34. | | *Tipula* sp. |
| 35. | Family: | Simulidae |
| | Family: | Tendipedidae |
| 36. | | *Corynoneura* sp. |
| 37. | | *Polypedilum* sp. |
| | Family: | Diamesinae |
| 38. | | *Diamesa* sp. |

TABLE 3 TAXONOMIC LIST OF THE BENTHIC MACROINVERTEBRATES COLLECTED AT HOWARD'S PASS (continued)

| | | |
|---|---|---|
| 39. | Family: | Chironomidae |
| 40. | | <u>Cardiocladius</u> sp. |
| 41. | | <u>Chironomus</u> sp. |
| 42. | | <u>Cricotopus</u> sp. |
| 43. | | <u>Diplocladius</u> sp. |
| 44. | | <u>Eukiefferiella</u> sp. |
| 45. | | <u>Heterotrissocladius</u> sp. |
| 46. | | <u>Micropsectra</u> sp. |
| 47. | | <u>Orthocladius</u> sp. |
| 48. | | <u>Procladius</u> sp. |
| 49. | | <u>Smitta</u> sp. |
| | Family: | Empididae |
| 50. | | <u>Hemerodromia</u> sp. |
| 51. | | <u>Wiedemannia</u> sp. |
| | | |
| 52. | Order: | Hymenoptera |
| | | |
| | Order: | Homoptera |
| 53. | Family: | Aphididae (terr.) |
| | | |
| | Phylum: | Mullusca |
| | Class: | Gastropoda |
| | Order: | Ctenobranchiata |
| | Family: | Amnicolidae |
| 54. | | <u>Hydrobia</u> sp. |

TABLE 4 BENTHIC MACROINVERTEBRATES COLLECTED AT EACH STATION

| | | STATIONS | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | TAXONOMIC GROUP | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1. | Turbellaria | x | | x | | | x | x |
| 2. | Nematoda | | x | | x | | | |
| 3. | Enchytraeidae | | x | | | | | |
| 4. | *Phallodrillus* sp. | | x | | | | | |
| 5. | *Rhyacodrilus* sp. | | x | | | | | |
| 6. | *Kincaidiana hexatheca* | | x | x | x | | | x |
| 7. | *Eurycercus lamellatus* | | x | | | | | |
| 8. | Acari undet. | x | x | x | | | | |
| 9. | *Alloperla* sp. | x | | x | x | x | x | x |
| 10. | *Arcynopteryx* sp. | | | x | x | | | |
| 11. | *Isoperla* sp. | | | | x | | | |
| 12. | *Nemoura* (Amphinemoura) sp. | x | | | | | | |
| 13. | *Nemoura* (Zapada) sp. | x | x | x | x | x | x | x |
| 14. | Ephemeroptera | | | x | | | x | |
| 15. | *Ameletus* sp. | x | x | | | x | x | x |
| 16. | *Baetis* sp. | x | | x | x | x | x | x |
| 17. | *Ephemerella flavilinea* | x | | | | | | |
| 18. | *Ephemerella levis* | | | | | | | x |
| 19. | *Ephemerella proserpina* | | | | | | | x |
| 20. | *Cinygmula* sp. | x | x | x | x | x | x | x |
| 21. | *Epeorus* sp. | x | | x | x | | x | |
| 22. | Rithrogena | x | | x | | | | |
| 23. | Hemiptera | | | | | x | | |
| 24. | Cicadellidae | | | | x | | | |
| 25. | *Agapetus* sp. | x | | | | | | |
| 26. | *Rhyacophila angelita* | | | x | | | | |
| 27. | *Rhyacophila tucula* | | x | x | | | | x |

TABLE 4 BENTHIC MACROINVERTEBRATES COLLECTED AT EACH STATION

| TAXONOMIC GROUP | STATIONS 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 28. *Drusinus* sp. | | | | | | x | x |
| 29. Lepidoptera, terr. larvae | | | | | x | | |
| 30. *Dytiscus* sp. | | x | | | | | |
| 31. Diptera, adult | x | x | x | x | x | | |
| 32. *Eripotera* sp. | x | x | | | x | | x |
| 33. *Pedicia* sp. | | x | | | | x | x |
| 34. *Tipula* sp. | | | x | | | | |
| 35. Simulidae, larvae | x | | | | | | x |
| 36. *Corynoneura* sp. | | | | x | | | |
| 37. *Polypedilum* sp. | | x | | | | | x |
| 38. *Diamesa* sp. | | | | | x | x | |
| 39. Chironomidae, pupae | x | x | x | x | x | x | x |
| 40. *Cardiocladius* sp. | | x | x | x | | | |
| 41. *Chironomus* sp. | | x | | | | | |
| 42. *Cricotopus* sp. | x | x | x | x | x | x | x |
| 43. *Diplocladius* sp. | | x | | x | | | |
| 44. *Eukiefferella* sp. | x | x | | | | | x |
| 45. *Heterotrissocladius* sp. | x | x | x | | x | x | x |
| 46. *Micropsectra* sp. | x | x | | | | | x |
| 47. *Orthocladius* sp. | | | | | | x | |
| 48. *Procladius* sp. | | x | | | | | x |
| 49. *Smitta* sp. | | x | | | | | |
| 50. Hemerodromia | | | | | | x | |
| 51. *Wiedemannia* sp. | | | | | x | x | |
| 52. Hymenoptera, adult | x | | | | | | |
| 53. Aphididae (terr.) | | | x | x | x | x | |
| 54. *Hydrobia* sp. | | | | x | | | |
| TOTAL: | 21 | 26 | 20 | 18 | 15 | 18 | 21 |

TABLE 5 SUMMARY OF DIVERSITY AND EVENNESS INDICES

| STATION NUMBER | | DIVERSITY | EVENNESS |
|---|---|---|---|
| 1 | a | 0.68 | 0.63 |
| | b | 0.55 | 0.61 |
| | c | 0.77 | 0.85 |
| 2 | a | 0.69 | 0.89 |
| | b | 0.52 | 0.40 |
| | c | 0.66 | 0.66 |
| 3 | a | 0.60 | 0.56 |
| | b | 0.83 | 0.83 |
| | c | 0.72 | 0.80 |
| 4 | a | 0.72 | 0.69 |
| | b | 0.71 | 0.75 |
| | c | 0.60 | 0.63 |
| 5 | a | 0.80 | 0.94 |
| | b | 0.75 | 0.78 |
| | c | 0.68 | 0.87 |
| 6 | a | 0.89 | 0.93 |
| | b | 0.62 | 0.73 |
| | c | 0.85 | 0.89 |
| 7 | a | 0.74 | 0.71 |
| | b | 0.52 | 0.58 |
| | c | 0.92 | 0.85 |

The diversity index (H'), which summarizes information on the numbers and kinds of organisms present, has been widely accepted as an indication of water quality (Wilhm and Dorris 1968). Generally, diversity values greater than 3.0 (in $\log_2$ or 0.90 in $\log_{10}$) are found in unpolluted, productive waters while heavily polluted waters have values of less than 1.0 (in $\log_2$ or 0.30 in $\log_{10}$). In this study diversity values are slightly lower than would be expected in pristine mountain streams. This may be attributable to the fact that genus rather than species diversity was calculated. In addition, streams may tend to be slightly less productive in alpine settings in northern environments than in southern Canada and the United States where the standards were determined. The diversity indices in this study are comparable to those found in other unpolluted alpine streams in Yukon (Burns 1980).

Pielou's (1975) evenness value (J) ranges from 0, where only one taxon is present, to a maximum of 1.0, where each taxon has equal representation. In natural healthy populations evenness ranges from 0.5 to 0.8. Mean evenness values for the seven sample locations range from 0.65 at Station 2 to 0.86 at Station 5. The values indicate a fairly even distribution of individuals in the taxa.

## 4.4 Fish

The objective of the fish sampling was to obtain fish tissue samples for metals analysis rather than to assess the abundance and diversity of fish. However, the fact that grayling (*Thymallus arcticus*) were easily caught at Stations 1, 4 and 7 is useful information. Station 4 appeared to be a very productive grayling area with a total of eight mature grayling caught and released in 30 minutes. Three immature grayling were caught at Station 7 and one adult grayling was caught at Station 1.

The results of the metal analysis of the tissue samples taken at Stations 1 and 4 are presented in Table 6. The following metals were detected in the tissues: aluminum, barium, calcium, copper,

TABLE 6 FISH TISSUE METALS AND MERCURY ANALYSIS RESULTS
(ppm - mg/kg)

| | STATION 1 | | STATION 4 | |
|---|---|---|---|---|
| PARAMETER | WET WEIGHT | DRY WEIGHT | WET WEIGHT | DRY WEIGHT |
| Al | <0.94 | <4.27 | 2.37 | 10.7 |
| As | <1.57 | <7.11 | <1.57 | <7.12 |
| Ba | 0.311 | 1.41 | 4.55 | 20.6 |
| Ca | 1210 | 5480 | 702 | 3180 |
| Cd | <0.104 | <0.474 | <0.105 | <0.474 |
| Co | <0.157 | <0.711 | <0.157 | <0.712 |
| Cu | 0.632 | 2.87 | 0.765 | 3.46 |
| Cr | 0.997 | 4.53 | 1.06 | 4.79 |
| Fe | 4.5 | 20.4 | 11.1 | 50.3 |
| Mg | 245 | 1110 | 234 | 1060 |
| Mn | 0.493 | 2.24 | 0.305 | 1.38 |
| Mo | <1.57 | <7.11 | <1.57 | <7.12 |
| Na | 488 | 2210 | 500 | 2260 |
| Ni | <0.835 | <3.79 | <0.838 | <3.8 |
| P | 2810 | 12800 | 2480 | 11200 |
| Pb | <0.835 | <3.79 | <0.838 | <3.8 |
| Sb | <0.835 | <3.79 | <0.838 | <3.8 |
| Se | <1.57 | <7.11 | <1.57 | <7.12 |
| Si | <4.18 | <19.0 | <4.19 | <19.0 |
| Sr | 1.29 | 5.86 | 0.514 | 2.33 |
| Ti | 0.0919 | 0.417 | <0.089 | <0.403 |
| V | <0.522 | <2.37 | <0.524 | <2.37 |
| Zn | 6.45 | 29.3 | 9.9 | 44.8 |
| Hg | 0.053 | 0.2386 | 0.053 | 0.2409 |

chromium, iron, magnesium, manganese, sodium, phosphorus, strontium, titanium, zinc and mercury. Of these metals, calcium, copper, iron, magnesium, manganese, phosphorus, strontium and zinc are considered essential nutrients.

Iron is required in trace amounts only but with higher concentrations present in the water, it creates detrimental effects. Iron hydroxides deposit on the gills of fish which may cause irritation and blocking of respiratory channels. Heavy precipitation can smother eggs. Strontium is necessary for bone growth but the radioactive form Sr90 is highly toxic due to its long half-life and its tendency to accumulate in flesh, bones, and scales.

Fish are relatively tolerant of chromium salts. The toxic effect of chromium is that it participates in inhibiting the respiration by inactivating enzymes which are responsible for energy production from food (NRC 1976). It has not been shown to bioaccumulate to any great degree through the food chain.

Aluminum is one of the most abundant elements and is found in soils, plants and tissues. It has not been proven to be essential and in excessive amounts will interfere with phosphorus metabolism.

There was a higher concentration of barium in the tissue from Station 4 than Station 1. This correlates with the sediment composition. Barium ions are quickly precipitated by adsorption or sedimentation. It does not accumulate within the body and is excreted fairly rapidly. Barium salts are considered to be muscle stimulants, especially for the heart.

Trace amounts of titanium are found in most animal tissue. There is no evidence that it is essential for plant or animal growth. Titanium was only detected in the tissue from Station 1.

Small amounts of mercury were detected at both stations. The form of mercury most commonly found in fish is methylmercury which accumulates in fish muscle. In the biological system, mercury is subject to biomagnification and its accumulation over time is proportional to the ambient concentration (US EPA 1973). The most sensitive stages of life are embryo, alevin and juvenile. The level of mercury in fish flesh set for human consumption is 0.5 mg/kg mercury wet weight (Reeder 1979). The concentrations from Stations 1 and 4 were well below this level. The mercury concentrations at Howard's Pass fall into the lower end of the range found in arctic grayling in other water bodies in the Yukon Territory (Baker 1979a).

The zinc concentrations at Howard's Pass were quite a bit higher (3.0 to 6.5 mg/kg) than those found in arctic grayling taken in Pelly River and Anvil Creek, Yukon (Baker 1979b).

In summation, none of the metals found in the fish tissue samples were in significantly high concentrations.

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# APPENDICES

# APPENDIX I

## WATER CHEMISTRY DATA

APPENDIX I WATER CHEMISTRY DATA

| STATION NUMBER | TEMP. °C | D.O. mg/l | % D.O. SATURATION | pH IN SITU | pH LAB | COLOUR | TURBIDITY FTU | NFR mg/l |
|---|---|---|---|---|---|---|---|---|
| 1 | 8 | 10.72 | 100 | 8.2 | 7.8 | 5 | <1.0 | <5 |
| 2 | 12 | 9.21 | 99 | 7.9 | 8.1 | 5 | <1.0 | <5 |
| 3 | 7 | 10.38 | 99 | 8.05 | 7.6 | 10 | 2.7 | <5 |
| 4 | 7 | 10.21 | 97 | 8.25 | 8.1 | 5 | <1.0 | <5 |
| 5 | 6.5 | 10.53 | 101 | 8.5 | 8.3 | 5 | <1.0 | <5 |
| 6 | 9 | 10.26 | 103 | 8.2 | 7.8 | 5 | 1.2 | <5 |
| 7 | 9 | 9.58 | 96 | 7.8 | 7.5 | 7 | 1.3 | - |

| STATION NUMBER | FR mg/l | COND. umhos/cm | TOTAL ALKALINITY | TOTAL HARDNESS | TOC | TIC | TOTAL $PO_4$-P | NITRITE $NO_2$-N |
|---|---|---|---|---|---|---|---|---|
| 1 | 107 | 181 | 67.5 | 90.3 | <1.0 | 16.0 | 0.0136 | <0.0050 |
| 2 | 164 | 286 | 140.0 | 152.0 | <1.0 | 32.0 | 0.0054 | <0.0050 |
| 3 | 100 | 151 | 43.5 | 73.1 | 1.0 | 10.0 | 0.0068 | <0.0050 |
| 4 | 167 | 286 | 130.0 | 153.0 | <1.0 | 30.0 | 0.0132 | <0.0050 |
| 5 | 337 | 518 | 174.0 | 284.0 | <1.0 | 39.0 | 0.0120 | <0.0050 |
| 6 | 148 | 236 | 61.0 | 116.0 | <1.0 | 14.0 | 0.0055 | <0.0050 |
| 7 | - | 21.0 | 71.1 | 109.0 | 1.0 | 17.0 | 0.0100 | <0.0050 |

APPENDIX I WATER CHEMISTRY DATA (continued)

| STATION NUMBER | NITRATE $NO_3$-N | AMMONIA $NH_3$-N | SULFATE $SO_4$ | CHLORIDE Cl | Ag | Al | As | Ba |
|---|---|---|---|---|---|---|---|---|
| 1 | <0.010 | <0.0050 | 19.4 | <0.50 | <0.030 | <0.09 | <0.15 | 0.105 |
| 2 | <0.010 | <0.0050 | 9.90 | <0.50 | <0.030 | <0.09 | <0.15 | 0.128 |
| 3 | <0.010 | <0.0050 | 26.4 | <0.50 | <0.030 | 0.392 | <0.15 | 0.105 |
| 4 | <0.010 | <0.0050 | 16.8 | <0.50 | <0.030 | <0.09 | <0.15 | 0.153 |
| 5 | <0.010 | <0.0050 | 98.0 | <0.50 | <0.030 | <0.09 | <0.15 | 0.0797 |
| 6 | <0.010 | <0.0050 | 50.2 | <0.50 | <0.030 | 0.257 | <0.15 | 0.109 |
| 7 | <0.010 | <0.0050 | 31.0 | 0.121 | <0.030 | 0.149 | <0.15 | 0.145 |

| STATION NUMBER | Ca | Cd | Co | Cr | Cu | Fe | Hg | K |
|---|---|---|---|---|---|---|---|---|
| 1 | 26.3 | <0.0010 | <0.015 | <0.015 | 0.0053 | 0.042 | <0.00020 | 0.243 |
| 2 | 51.6 | <0.0010 | <0.015 | <0.015 | 0.0053 | 0.142 | <0.00020 | 0.104 |
| 3 | 20.3 | <0.0010 | <0.015 | <0.015 | 0.0068 | 0.185 | <0.00020 | 0.577 |
| 4 | 49.7 | <0.0010 | <0.015 | <0.015 | 0.0037 | 0.045 | <0.00020 | 0.197 |
| 5 | 86.6 | <0.0010 | <0.015 | <0.015 | 0.0050 | 0.024 | <0.00020 | 0.478 |
| 6 | 33.3 | 0.0014 | <0.015 | <0.015 | 0.014 | 0.082 | <0.00020 | 0.323 |
| 7 | 30.8 | <0.0010 | <0.015 | <0.015 | 0.0041 | 0.222 | <0.00020 | 0.305 |

APPENDIX I WATER CHEMISTRY DATA (continued)

| STATION NUMBER | Mg | Mn | Mo | Na | Ni | Pb | Sb | Se |
|---|---|---|---|---|---|---|---|---|
| 1 | 5.97 | <0.003 | <0.15 | 0.463 | <0.08 | <0.0010 | <0.08 | <0.15 |
| 2 | 5.69 | 0.0075 | <0.15 | 0.431 | <0.08 | <0.0010 | <0.08 | <0.15 |
| 3 | 5.44 | 0.0108 | <0.15 | 0.355 | <0.08 | <0.0010 | <0.08 | <0.15 |
| 4 | 7.03 | 0.0048 | <0.15 | 0.419 | <0.08 | <0.0010 | <0.08 | <0.15 |
| 5 | 16.4 | 0.0033 | <0.15 | 0.258 | <0.08 | <0.0010 | <0.08 | <0.15 |
| 6 | 7.91 | 0.024 | <0.15 | 0.22 | <0.08 | <0.0010 | <0.08 | <0.15 |
| 7 | 7.89 | 0.0132 | <0.15 | 0.322 | <0.08 | <0.0010 | <0.08 | <0.15 |

| STATION NUMBER | Si | Sn | Sr | Ti | V | Zn |
|---|---|---|---|---|---|---|
| 1 | 2.72 | <0.2 | 0.0919 | <0.0085 | <0.05 | 0.041 |
| 2 | 2.68 | <0.2 | 0.115 | <0.0085 | <0.05 | <0.02 |
| 3 | 3.79 | <0.2 | 0.0701 | <0.0085 | <0.05 | 0.141 |
| 4 | 2.44 | <0.2 | 0.111 | <0.0085 | <0.05 | 0.031 |
| 5 | 2.17 | <0.2 | 0.105 | <0.0085 | <0.05 | 0.075 |
| 6 | 2.2 | <0.2 | 0.0797 | <0.0085 | <0.05 | 0.148 |
| 7 | 2.64 | <0.2 | 0.0906 | <0.0085 | <0.05 | 0.076 |

All units in mg/l.
Total Alkalinity and Total Hardness units are in mg/l $CaCO_3$.

# APPENDIX II

## SEDIMENT RESULTS

APPENDIX II SEDIMENT RESULTS

| STATION NUMBER | Al | Ba | Ca | Cd | Cr | Cu | Fe | Mg |
|---|---|---|---|---|---|---|---|---|
| 1 | 10537 | 993 | 5647 | 5.90 | 20.3 | 70.3 | 27767 | 2913 |
| 2 | 9777 | 403 | 8407 | 3.9 | 21.5 | 31.7 | 44333 | 4273 |
| 3 | 21267 | 4763 | 10460 | 15.6 | 36.0 | 96.8 | 33933 | 4060 |
| 4 | 8897 | 2203 | 7003 | 2.4 | 21.7 | 54.8 | 19633 | 2680 |
| 5 | 8663 | 649 | >24667 | 5.1 | 30.9 | 73.0 | 21900 | 5573 |
| 6 | 11403 | 4443 | 18067 | 11.3 | 29.9 | 99.9 | 26233 | 4250 |
| 7 | 11500 | 4830 | 9353 | 6.3 | 28.3 | 55.0 | 23333 | 3807 |

| STATION NUMBER | Mn | Mo | Na | Ni | P | Pb | Si | Sn |
|---|---|---|---|---|---|---|---|---|
| 1 | 625 | <18.3 | 65.6 | 105.3 | 1693 | 31.9 | 2603 | <24.4 |
| 2 | 272 | <18.4 | 68.1 | 46.0 | 1907 | 41.5 | 2830 | <24.5 |
| 3 | 1317 | <18.3 | 59.6 | 205.3 | 2413 | 69.1 | 4627 | <24.4 |
| 4 | 190 | <18.3 | 48.1 | 43.8 | 1717 | 51.1 | 2120 | <24.4 |
| 5 | 164 | 21.4 | 54.3 | 103.5 | 2683 | 102.3 | 2987 | <24.7 |
| 6 | 523 | <18.4 | 63.7 | 115.3 | 2583 | 286.0 | 2783 | <24.5 |
| 7 | 231 | <18.3 | 63.0 | 79.3 | 2523 | 78.2 | 2987 | <24.4 |

APPENDIX II SEDIMENT RESULTS (continued)

| STATION NUMBER | Sr | Ti | V | Zn |
|---|---|---|---|---|
| 1 | 52.0 | 62.2 | 84.0 | 822 |
| 2 | 30.4 | 55.0 | 75.3 | 485 |
| 3 | 81.5 | 75.8 | 251 | 2347 |
| 4 | 47.9 | 45.8 | 174 | 565 |
| 5 | 48.4 | 506.7 | 221 | 900 |
| 6 | 62.1 | 78.7 | 182 | 1703 |
| 7 | 72.2 | 99.6 | 212 | 905 |

All units in mg/kg.

# APPENDIX III

## BENTHIC MACROINVERTEBRATE DATA

APPENDIX III BENTHIC MACROINVERTEBRATE DATA

| | TAXONOMIC GROUP | STATION 1 a | STATION 1 b | STATION 1 c | STATION 2 a | STATION 2 b | STATION 2 c |
|---|---|---|---|---|---|---|---|
| 1. | Turbellaria | 1 | - | 2 | - | - | - |
| 2. | Nematoda | - | - | - | - | 1 | 1 |
| 3. | Enchytraeidae | - | - | - | 1 | 2 | 1 |
| 4. | Phallodrillus sp. | - | - | - | - | 1 | - |
| 5. | Rhyacodrilus sp. | - | - | - | 4 | 3 | 9 |
| 6. | Kincaidiana hexatheca | - | - | - | - | 1 | - |
| 7. | Eurycercus lamellatus | - | - | - | - | 1 | - |
| 8. | Acari undet. | - | - | 2 | 3 | 2 | - |
| 9. | Alloperla sp. | 18 | 4 | 2 | - | - | - |
| 10. | Arcynopteryx sp. | - | - | - | - | - | - |
| 11. | Isoperla sp. | - | - | - | - | - | - |
| 12. | Nemoura (Amphinemoura) sp. | 1 | - | - | - | - | - |
| 13. | Nemoura (Zapada) sp. | 1 | 1 | 2 | - | 1 | - |
| 14. | Ephemeroptera | - | - | - | - | - | - |
| 15. | Ameletus sp. | - | 2 | - | - | 1 | - |
| 16. | Baetis sp. | 1 | - | 1 | - | - | - |
| 17. | Ephemerella flavilinea | 1 | - | 2 | - | - | - |
| 18. | Ephemerella levis | - | - | - | - | - | - |
| 19. | Ephemerella proserpina | - | - | - | - | - | - |
| 20. | Cinygmula sp. | 59 | 54 | 7 | 1 | 1 | - |
| 21. | Epeorus sp. | 14 | 22 | 6 | - | - | - |
| 22. | Rithrogena | - | 1 | - | - | - | - |
| 23. | Hemiptera | - | - | - | - | - | - |
| 24. | Cicadellidae | - | - | - | - | - | - |
| 25. | Agapetus sp. | 2 | - | 1 | - | - | - |
| 26. | Rhyacophila angelita | - | - | - | - | - | - |
| 27. | Rhyacophila tucula | - | - | - | - | 1 | - |

APPENDIX III BENTHIC MACROINVERTEBRATE DATA (continued)

| TAXONOMIC GROUP | STATION 1 a | STATION 1 b | STATION 1 c | STATION 2 a | STATION 2 b | STATION 2 c |
|---|---|---|---|---|---|---|
| 28. *Drusinus* sp. | - | - | - | - | - | - |
| 29. Lepidoptera, terr. larvae | - | - | - | - | - | - |
| 30. *Dytiscus* sp. larvae | - | - | - | - | - | 1 |
| 31. Diptera, adult | - | - | 1 | - | 1 | - |
| 32. *Erioptera* sp. | 1 | - | - | - | 1 | - |
| 33. *Pedicia* sp. | - | - | - | - | 1 | - |
| 34. Tipulidae, *Tipula* sp. | - | - | - | - | - | - |
| 35. Simulidae larvae | 1 | - | 2 | - | - | - |
| 36. *Corynoneura* sp. | - | - | - | - | - | - |
| 37. *Polypedilum* sp. | - | - | - | - | 1 | 3 |
| 38. *Diamesa* sp. | - | - | - | - | - | - |
| 39. Chironomidae pupae | 9 | 2 | 4 | 2 | 2 | 9 |
| 40. *Cardiocladius* sp. | - | - | - | - | 2 | 7 |
| 41. *Chironomus* sp. | - | - | - | - | 1 | 2 |
| 42. *Cricotopus* sp. | 1 | - | - | 5 | 129 | 74 |
| 43. *Diplocladius* sp. | - | - | - | - | 2 | - |
| 44. *Eukiefferiella* sp. | 1 | - | - | 1 | 3 | - |
| 45. *Heterotrissocladius* sp. | 1 | 2 | - | - | 1 | 4 |
| 46. *Micropsectra* sp. | 30 | 8 | 10 | 7 | 13 | 5 |
| 47. *Orthocladius* sp. | - | - | - | - | - | - |
| 48. *Procladius* sp. | - | - | - | 3 | 2 | 8 |
| 49. *Smitta* sp. | - | - | - | - | 7 | 19 |
| 50. *Hemerodromia* sp. | - | - | - | - | - | - |
| 51. Empididae, *Wiedemannia* sp. | - | - | - | - | - | - |
| 52. Hymenoptera, adult | 1 | - | - | - | - | - |
| 53. Aphididae | - | - | - | - | - | - |
| 54. *Hydrobia* sp. | - | - | - | - | - | - |
| Fish eggs, undet. | - | - | - | 1 | 12 | - |

APPENDIX III BENTHIC MACROINVERTEBRATE DATA (continued)

| | STATION 1 | | | STATION 2 | | |
|---|---|---|---|---|---|---|
| TAXONOMIC GROUP | a | b | c | a | b | c |
| Column Total | 143 | 96 | 42 | 28 | 193 | 143 |
| Station Total | | 281 | | | 364 | |

APPENDIX III BENTHIC MACROINVERTEBRATE DATA (continued)

| | TAXONOMIC GROUP | STATION 3 | | | STATION 4 | | |
|---|---|---|---|---|---|---|---|
| | | a | b | c | a | b | c |
| 1. | Turbellaria | 1 | 2 | 1 | - | - | - |
| 2. | Nematoda | - | - | - | - | 1 | - |
| 3. | Enchytraeidae | - | - | - | - | - | - |
| 4. | Phallodrillus sp. | - | - | - | - | - | - |
| 5. | Rhyacodrilus sp. | - | - | - | - | - | - |
| 6. | Kincaidiana hexatheca | - | 3 | - | 4 | 5 | - |
| 7. | Eurycercus lamellatus | - | - | - | - | - | - |
| 8. | Acari undet. | 1 | - | - | - | - | - |
| 9. | Alloperla sp. | 12 | 4 | 11 | 5 | 6 | 1 |
| 10. | Arcynopteryx sp. | 4 | 1 | - | 6 | 5 | 8 |
| 11. | Isoperla sp. | - | - | - | 1 | - | - |
| 12. | Nemoura (Amphinemoura) sp. | - | - | - | - | - | - |
| 13. | Nemoura (Zapada) sp. | 85 | 16 | 13 | 7 | 4 | 1 |
| 14. | Ephemeroptera | 1 | - | - | - | - | - |
| 15. | Ameletus sp. | - | - | - | - | - | - |
| 16. | Baetis sp. | 21 | 6 | 9 | 1 | - | 1 |
| 17. | Ephemerella flavilinea | - | - | - | - | - | - |
| 18. | Ephemerella levis | - | - | - | - | - | - |
| 19. | Ephemerella proserpina | - | - | - | - | - | - |
| 20. | Cinygmula sp. | 3 | 2 | 1 | 39 | 31 | 27 |
| 21. | Epeorus sp. | 4 | 1 | 3 | 17 | 7 | 6 |
| 22. | Rithrogena | 1 | - | - | - | - | - |
| 23. | Hemiptera | - | - | - | - | - | - |
| 24. | Cicadellidae | - | - | - | - | - | 1 |
| 25. | Agapetus sp. | - | - | - | - | - | - |
| 26. | Rhyacophila angelita | 1 | 1 | 1 | - | - | - |
| 27. | Rhyacophila tucula | 1 | 2 | 1 | - | - | - |

APPENDIX III BENTHIC MACROINVERTEBRATE DATA (continued)

| TAXONOMIC GROUP | STATION 3 a | STATION 3 b | STATION 3 c | STATION 4 a | STATION 4 b | STATION 4 c |
|---|---|---|---|---|---|---|
| 28. Drusinus sp. | - | - | - | - | - | - |
| 29. Lepidoptera, terr. larvae | - | - | - | - | - | - |
| 30. Dytiscus sp. larvae | - | - | - | - | - | - |
| 31. Diptera, adult | 1 | - | - | - | 1 | 1 |
| 32. Erioptera sp. | - | - | - | - | - | - |
| 33. Pedicia sp. | - | - | - | - | - | - |
| 34. Tipulidae, Tipula sp. | 1 | - | - | - | - | - |
| 35. Simulidae larvae | - | - | - | - | - | - |
| 36. Corynoneura sp. | - | - | - | - | - | 1 |
| 37. Polypedilum sp. | - | - | - | - | - | - |
| 38. Diamesa sp. | - | - | - | - | - | - |
| 39. Chironomidae pupae | 1 | - | - | 2 | 1 | 1 |
| 40. Cardiocladius sp. | 4 | 1 | 1 | 1 | 1 | - |
| 41. Chironomus sp. | - | - | - | - | - | - |
| 42. Cricotopus sp. | 1 | 8 | 1 | 1 | 2 | 1 |
| 43. Diplocladius sp. | - | - | - | 1 | - | 1 |
| 44. Eukiefferiella sp. | - | - | - | - | - | - |
| 45. Heterotrissocladius sp. | 1 | - | - | - | - | - |
| 46. Micropsectra sp. | - | - | - | - | - | - |
| 47. Orthocladius sp. | - | - | - | - | - | - |
| 48. Procladius sp. | - | - | - | - | - | - |
| 49. Smitta sp. | - | - | - | - | - | - |
| 50. Hemerodromia sp. | - | - | - | - | - | - |
| 51. Empididae, Wiedemannia sp. | - | - | - | - | - | - |
| 52. Hymenoptera, adult | - | - | - | - | - | - |
| 53. Aphididae | 1 | - | - | - | 1 | 1 |
| 54. Hydrobia sp. | - | - | - | - | 1 | - |
| Fish eggs, undet. | - | - | - | - | - | - |

APPENDIX III BENTHIC MACROINVERTEBRATE DATA (continued)

| | STATION 3 | | | STATION 4 | | |
|---|---|---|---|---|---|---|
| TAXONOMIC GROUP | a | b | c | a | b | c |
| Column Total | 145 | 47 | 42 | 85 | 66 | 51 |
| Station Total | | 234 | | | 202 | |

APPENDIX III BENTHIC MACROINVERTEBRATE DATA (continued)

| | TAXONOMIC GROUP | STATION 5 | | | STATION 6 | | |
|---|---|---|---|---|---|---|---|
| | | a | b | c | a | b | c |
| 1. | Turbellaria | - | - | - | - | 1 | - |
| 2. | Nematoda | - | - | - | - | - | - |
| 3. | Enchytraeidae | - | - | - | - | - | - |
| 4. | *Phallodrillus* sp. | - | - | - | - | - | - |
| 5. | *Rhyacodrilus* sp. | - | - | - | - | - | - |
| 6. | *Kincaidiana hexatheca* | - | - | - | - | - | - |
| 7. | *Eurycercus lamellatus* | - | - | - | - | - | - |
| 8. | Acari undet. | - | - | - | - | - | - |
| 9. | *Alloperla* sp. | 1 | 2 | 1 | - | 1 | 5 |
| 10. | *Arcynopteryx* sp. | - | - | - | - | - | - |
| 11. | *Isoperla* sp. | - | - | - | - | - | - |
| 12. | *Nemoura* (Amphinemoura) sp. | - | - | - | - | - | - |
| 13. | *Nemoura* (Zapada) sp. | - | 4 | 2 | 4 | 12 | - |
| 14. | Ephemeroptera | - | - | - | - | 1 | - |
| 15. | *Ameletus* sp. | 1 | 1 | - | 1 | - | 2 |
| 16. | *Baetis* sp. | 3 | 14 | 3 | 3 | 38 | 1 |
| 17. | *Ephemerella flavilinea* | - | - | - | - | - | - |
| 18. | *Ephemerella levis* | - | - | - | - | - | - |
| 19. | *Ephemerella proserpina* | - | - | - | - | - | - |
| 20. | *Cinygmula* sp. | 1 | 3 | - | 1 | 1 | - |
| 21. | *Epeorus* sp. | - | - | - | 2 | - | - |
| 22. | Rithrogena | - | - | - | - | - | - |
| 23. | Hemiptera | - | 1 | - | - | - | - |
| 24. | Cicadellidae | - | - | - | - | - | - |
| 25. | *Agapetus* sp. | - | - | - | - | - | - |
| 26. | *Rhyacophila angelita* | - | - | - | - | - | - |
| 27. | *Rhyacophila tucula* | - | - | - | - | - | - |

APPENDIX III BENTHIC MACROINVERTEBRATE DATA (continued)

| TAXONOMIC GROUP | STATION 5 a | STATION 5 b | STATION 5 c | STATION 6 a | STATION 6 b | STATION 6 c |
|---|---|---|---|---|---|---|
| 28. *Drusinus* sp. | - | - | - | 1 | - | - |
| 29. Lepidoptera, terr. larvae | 1 | - | 2 | - | - | - |
| 30. *Dytiscus* sp. larvae | - | - | - | - | - | - |
| 31. Diptera, adult | 4 | - | 2 | - | - | - |
| 32. *Erioptera* sp. | - | 1 | - | - | - | - |
| 33. *Pedicia* sp. | - | - | - | - | - | 1 |
| 34. Tipulidae, *Tipula* sp. | - | - | - | - | - | - |
| 35. Simulidae larvae | - | - | - | - | - | - |
| 36. *Corynoneura* sp. | - | - | - | - | - | - |
| 37. *Polypedilum* sp. | - | - | - | - | - | - |
| 38. *Diamesa* sp. | - | 1 | 7 | 4 | 29 | 3 |
| 39. Chironomidae pupae | 2 | - | 5 | 1 | 1 | 1 |
| 40. *Cardiocladius* sp. | - | - | - | - | - | - |
| 41. *Chironomus* sp. | - | - | - | - | - | - |
| 42. *Cricotopus* sp. | 1 | - | - | 2 | 11 | - |
| 43. *Diplocladius* sp. | - | - | - | - | - | - |
| 44. *Eukiefferiella* sp. | - | - | - | - | - | - |
| 45. *Heterotrissocladius* sp. | 1 | 1 | 3 | 1 | 2 | 5 |
| 46. *Micropsectra* sp. | - | - | - | - | - | - |
| 47. *Orthocladius* sp. | - | - | - | - | - | 1 |
| 48. *Procladius* sp. | - | - | - | - | - | - |
| 49. *Smitta* sp. | - | - | - | - | - | - |
| 50. *Hemerodromia* sp. | - | - | - | - | - | 1 |
| 51. Empididae, *Wiedemannia* sp. | 2 | 3 | 1 | - | - | 1 |
| 52. Hymenoptera, adult | - | - | - | - | - | - |
| 53. Aphididae | 5 | 3 | 3 | 2 | - | - |
| 54. *Hydrobia* sp. | - | - | - | - | - | - |
| Fish eggs, undet. | - | - | - | - | - | - |

APPENDIX III BENTHIC MACROINVERTEBRATE DATA (continued)

| | STATION 5 | | | STATION 6 | | |
|---|---|---|---|---|---|---|
| TAXONOMIC GROUP | a | b | c | a | b | c |
| Column Total | 22 | 34 | 29 | 22 | 97 | 21 |
| Station Total | | 85 | | | 140 | |

APPENDIX III BENTHIC MACROINVERTEBRATE DATA (continued)

| | TAXONOMIC GROUP | STATION 7 a | b | c |
|---|---|---|---|---|
| 1. | Turbellaria | 1 | - | 1 |
| 2. | Nematoda | - | - | - |
| 3. | Enchytraeidae | - | - | - |
| 4. | *Phallodrillus* sp. | - | - | - |
| 5. | *Rhyacodrilus* sp. | - | - | - |
| 6. | *Kincaidiana hexatheca* | 2 | - | 1 |
| 7. | *Eurycercus lamellatus* | - | - | - |
| 8. | Acari undet. | - | - | - |
| 9. | *Alloperla* sp. | 1 | - | - |
| 10. | *Arcynopteryx* sp. | - | - | - |
| 11. | *Isoperla* sp. | - | - | - |
| 12. | *Nemoura* (Amphinemoura) sp. | - | - | - |
| 13. | *Nemoura* (Zapada) sp. | 1 | 5 | 11 |
| 14. | Ephemeroptera | - | - | - |
| 15. | *Ameletus* sp. | 5 | 1 | 6 |
| 16. | *Baetis* sp. | 26 | 26 | 14 |
| 17. | *Ephemerella flavilinea* | - | - | - |
| 18. | *Ephemerella levis* | - | - | 2 |
| 19. | *Ephemerella proserpina* | - | 1 | - |
| 20. | *Cinygmula* sp. | 12 | 3 | 2 |
| 21. | *Epeorus* sp. | - | - | - |
| 22. | Rithrogena | - | - | - |
| 23. | Hemiptera | - | - | - |
| 24. | Cicadellidae | - | - | - |
| 25. | *Agapetus* sp. | - | - | - |
| 26. | *Rhyacophila angelita* | - | - | - |
| 27. | *Rhyacophila tucula* | 1 | - | - |

APPENDIX III BENTHIC MACROINVERTEBRATE DATA (continued)

| | | STATION 7 | | |
|---|---|---|---|---|
| | TAXONOMIC GROUP | a | b | c |
| 28. | *Drusinus* sp. | - | 1 | - |
| 29. | Lepidoptera, terr. larvae | - | - | - |
| 30. | *Dytiscus* sp. larvae | - | - | - |
| 31. | Diptera, adult | - | - | - |
| 32. | *Erioptera* sp. | - | - | 1 |
| 33. | *Pedicia* sp. | - | - | 1 |
| 34. | Tipulidae, *Tipula* sp. | - | - | - |
| 35. | Simulidae larvae | 1 | - | - |
| 36. | *Corynoneura* sp. | - | - | - |
| 37. | *Polypedilum* sp. | 1 | - | - |
| 38. | *Diamesa* sp. | - | - | - |
| 39. | Chironomidae pupae | - | 1 | - |
| 40. | *Cardiocladius* sp. | - | - | - |
| 41. | *Chironomus* sp. | - | - | - |
| 42. | *Cricotopus* sp. | 5 | - | 15 |
| 43. | *Diplocladius* sp. | - | - | - |
| 44. | *Eukiefferiella* sp. | 1 | - | - |
| 45. | *Heterotrissocladius* sp. | - | 1 | 3 |
| 46. | *Micropsectra* sp. | 2 | 1 | 5 |
| 47. | *Orthocladius* sp. | - | - | - |
| 48. | *Procladius* sp. | - | - | 4 |
| 49. | *Smitta* sp. | - | - | - |
| 50. | *Hemerodromia* sp. | - | - | - |
| 51. | Empididae, *Wiedemannia* sp. | - | - | - |
| 52. | Hymenoptera, adult | - | - | - |
| 53. | Aphididae | - | - | - |
| 54. | *Hydrobia* sp. | - | - | - |
| | Fish eggs, undet. | - | - | - |

APPENDIX III BENTHIC MACROINVERTEBRATE DATA (continued)

| | STATION 7 | | |
|---|---|---|---|
| TAXONOMIC GROUP | a | b | c |
| Column Total | 59 | 40 | 66 |
| Station Total | | 165 | |