

FOR REFERENCE

**DO NOT REMOVE FROM
LIBRARY**

**A Biological Survey
of the Watershed
Adjacent to a Proposed
Mine Site Near
Houston, B.C.**

A BIOLOGICAL SURVEY OF THE WATERSHED ADJACENT
TO A PROPOSED MINE SITE NEAR HOUSTON B.C.

by

R. Hallam and R. Kussat

Canada

Department of the Environment

Environmental Protection Service

Pacific Region

Vancouver, B.C.

Report Number EPS 5 - PR - 74 - 4

February, 1974

LIBRARY
ENVIRONMENT CANADA
CONSERVATION AND PROTECTION
PACIFIC REGION

ENVIRONMENTAL PROTECTION SERVICE REPORT SERIES

Surveillance reports present the results of monitoring programs carried out by the Environmental Protection Service. These reports will usually be published on a regular basis.

Other categories in the EPS series include such groups as Regulation, Codes and Protocols, Policy and Planning, Technical Appraisal, Technology Development, Surveillance and Reprints of Published Papers.

Inquiries pertaining to Environmental Protection Service Reports should be directed to the Environmental Protection Service, Department of the Environment, 1090 West Pender Street, Vancouver 1, B.C. or to the Environmental Protection Service, Ottawa K1A 0H3, Ontario.

LIBRARY
DEPT. OF THE ENVIRONMENT
ENVIRONMENTAL PROTECTION SERVICE
PACIFIC REGION

TABLE OF CONTENTS

	Page
List of Tables - - - - -	ii
List of Figures - - - - -	ii

* * * * *

1. Introduction	1
2. Materials and Methods	4
2.1. General	4
2.2. Physical Parameters	4
2.3. Water Chemistry	7
2.4. Stream Biology	7
3. Results and Discussion	10
3.1. Physical Parameters	10
3.2. Water Chemistry	14
3.3. Stream Biology	18
4. Summary	28
5. Acknowledgements	31
References	32
Appendix I	34

* * * * *

LIST OF TABLES

	Page
1. Monitoring Sites	6
2. Stream Clarity	11
3. Heavy Metal Analyses of Streams	16, 17
4. Benthic Invertebrates - Summer/73	20, 21
5. Benthic Invertebrates - Fall/73	22, 23
6. Diversity Indices for Macroinvertebrates	26
7. Pesticide Analyses of Fish from Sites 10 & 11	29
8. Heavy Metal Analyses of Fish from Sites 10 & 11	30

* * * * *

LIST OF FIGURES

	Page
1. Location Map of Proposed Mine Site	2
2. Location Map of Sample Sites	5
3. Water Temperatures	13
4. Stream Flow	14
5. Dissolved Oxygen and pH Values	18
6. Macroinvertebrates -- Percentage Distribution of Groups I, II, and III	25

* * * * *

LIBRARY
DEPT. OF THE ENVIRONMENT
ENVIRONMENTAL PROTECTION SERVICE
PACIFIC REGION

1. INTRODUCTION

In June of 1973 Equity Mining Capital Ltd. informed Environment Canada that exploration was in progress on a recently discovered ore body in north central British Columbia. Development is scheduled to commence in late 1975.

The Habitat Protection Unit of Fisheries Operations and the Environmental Protection Service are concerned with the possible effects of this development on the environment. A joint comprehensive pre-production survey of the watershed adjacent to the mine site was carried out. This report is a summary of the results of the physical, chemical and biological sampling undertaken in July and October 1973. It should provide a substantial baseline to which future environmental effects of the mining activity may be related.

The proposed development site, known as the "Goosly Property", is situated some 20 miles southeast of Houston B.C., near Goosly Lake in an area of heavily treed, rolling hills (see Figure 1). Past logging and Recreational activities in the area appear to have had no longterm detrimental effects on the aquatic environment.

The Goosly Property straddles the high point between two watersheds and encompasses a variety of small streams. Several of these run northerly into the Foxy Creek basin and others run southerly toward Goosly Lake. The mine-mill complex will be located within the

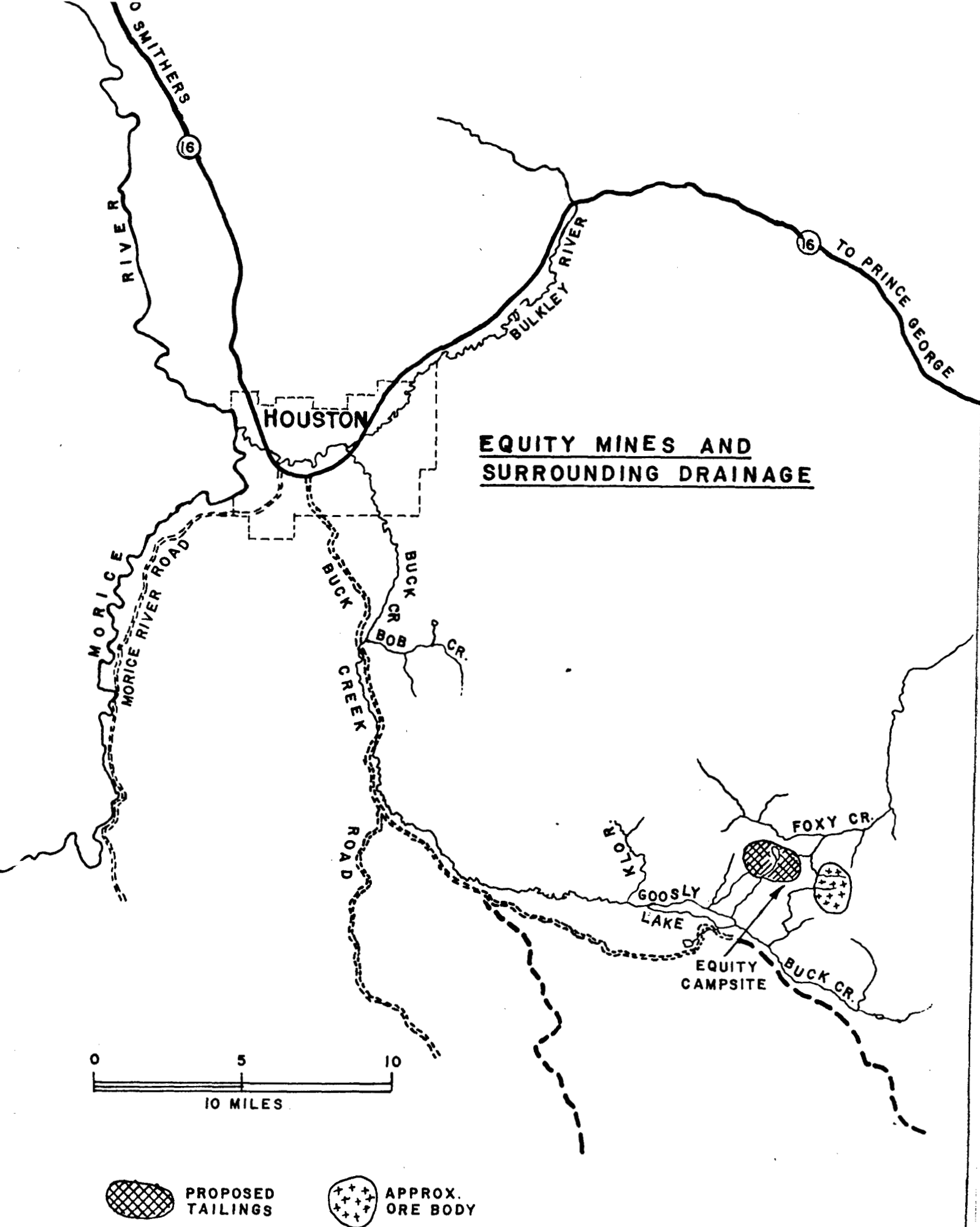


FIGURE 1.

Buck Creek drainage area. Disruption of the topography will necessitate diversion of some of its tributaries and may cause physical, chemical and biological changes in some streams. Buck Creek drainage, encompasses approximately 210 square miles, and flows into the Bulkley River System which provides spawning beds for Coho, Pink, Spring, Sockeye, Chum salmon and steelhead trout.

The mine will be an open pit operation with an initial production rate of 3,000 tons of silver, copper, gold and antimony ore per day. This production rate is expected to increase to 6,000 tpd by 1980. At this rate the projected life of the mine will be approximately 20 years. The overburden, wastes, and low grade ore are expected to be placed somewhere in the Foxy Creek drainage area. Reports from B.C. Research on the leaching and bacterial oxidation of core samples, one of which was designated waste rock, proved to be a potential source of acidic mine drainage and therefore an ecological hazard (Hawley 1972_a).

Wright Engineers are presently engaged in a pilot plant study of the extractive metallurgy, and early indications point to two processes. Grinding and flotation for copper, silver and gold and a leaching plant for antimony. Both processes will incorporate one or more toxic agents such as NaCN (Hawley 1972_b).

Process water will be drawn from Goosly Lake. A 1,600,000 gal/day water licence has been applied for and the possibility of supernatant recycling is under investigation. This represents

about 1/10 of Goosly Lake outflow and the affects of this reduction are not yet known.

The tailings disposal area will in all probability eliminate a small unnamed lake west of the mine and will be located in either the Foxy Creek or Buck Creek drainage.

2. MATERIALS AND METHODS

2.1. General:

Sampling was conducted on July 14 and October 13, 1973. Eleven sampling sites were selected to monitor the major streams that could be affected by the mine operation (see Figure 2). Each station was chosen for similar bottom substrate, water depth, its strategic position and accessibility. Stations were marked with red spray paint on nearby trees and rocks.

All sites were typified by shallow fast-running water with large aggregate bottom substrate interdispersed with sandy patches. Little or no aquatic vegetation was present. Most sites are easily accessible from existing logging roads. Table 1 provides a brief explanation of each site.

2.2. Physical Parameters:

At each site an estimate of the volume of water flow, relative

SAMPLE SITES SURROUNDING
PROPOSED MINE

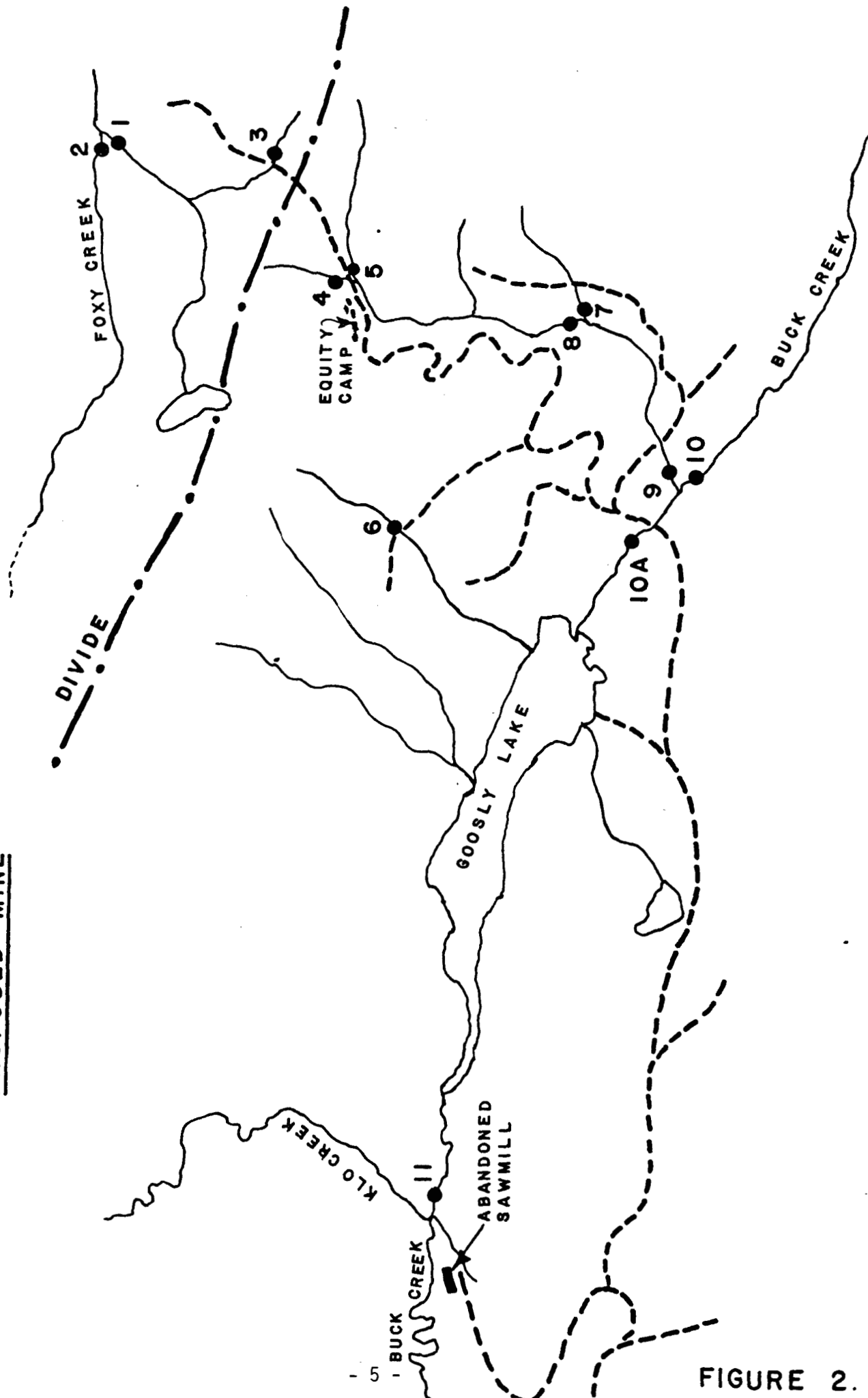


FIGURE 2.

TABLE 1: Sample Sites Established In 1973 To Monitor The Effects Of Equity Mines.

Site Number	Location	Use
1,2,3	Foxy Creek Drainage	Serve as monitors to the seepage from overburden and possibly the tailings.
4,5,7,8,9	Buck Creek Drainage	Expected to monitor the drainage from the mine and mill sites.
6	Unnamed Creek which drains into the north side of Goosly Lake	Expected to intercept most of the seepage from the tailings impoundment.
10	Buck Creek prior to influence of tributary draining Mine site.	Serves as a control and should not be affected by the mine and mill sites.
10A	Buck Creek downstream from tributary draining mine site.	Found to be the most appropriate site to seine for fish.
11	Buck Creek, Upstream from entrance of Flo Creek.	Serves to monitor changes in Goosly Lake water quality.

visual clarity of the water, and temperature was recorded.

2.3. Water Chemistry:

- (a) A litre of water was taken from each site, preserved with 5 ml of concentrated HNO_3 (Standard Methods, 1971) and delivered to the Environment Canada Water Quality Laboratory at West Vancouver for total heavy metal analyses.
- (b) The pH in the summer survey was taken with pH paper. Because these results were believed spurious a "pH Hach Kit" was used in the fall.
- (c) Dissolved oxygen (D.O.) was measured at each site during the fall survey with a Hach Kit.

2.4. Stream Biology:

2.4.1. Benthic Invertebrates --

A circular sampler that covers an area of one square foot was used to acquire three invertebrate samples at each site. The samples were placed in jars with a 5% solution of formalin. These samples were sorted, classified and enumerated at the Environment Canada Biology Laboratory in North Vancouver. Identification was achieved using a Wild M5 Stereo Microscope and the following biological keys; Pennak, 1953; Ward and Whipple, 1959; and Usinger, 1968.

The invertebrate data was subjected to two different analyses:

- (a) organisms were placed into groups with respect to their sensitivity to pollution in accordance with MacKenthun's (1969) standards. Mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) for example, categorize clean waters, while conversely sludgeworms can tolerate a large amount of pollution.
- (b) The Wilhm and Dorris (1968) measure of diversity (\bar{d}), which relates benthic communities to water quality was also applied. The formula which was first derived by Margalef (1956) from information theory and expanded by Wilhm and Dorris (1968) is presented below:

$$\bar{d} = \sum_{i=1}^s \frac{n_i}{n} \log_2 \frac{n_i}{n}$$

Where \bar{d} = diversity per sample

n_i = total number of individuals per taxon

n = total number of individuals per sample

s = total number of taxa

This index is a numerical value which represents the relative "variety of life" in the sample

by relating the number of individuals in each taxon to the total number of taxa.

Diversity indices have been used in the past (Wilhm 1968, Cole 1973). These researchers feel that values of less than 1 from the Wilhm diversity index (\bar{d}) are obtained in areas of heavy pollution and values above 3 in areas of clean and highly productive waters.

2.4.2. Phytoplankton --

A one litre bottle of water from each station was preserved with "lugol" for a qualitative record of algal species. These samples were also identified at the Environment Canada Fresh Water Biology Laboratory in North Vancouver with the aid of a Wild M40 inverted microscope and several Biological keys: Prescott 1962, Prescott 1970, Patrick and Reimer 1966.

2.4.3. Vertebrates --

Fish were seined at all stations with 10 ft², 1/4 inch mesh net but were found only at sites 10 and 11 (Buck Creek). The fish were identified and divided into two equivalent samples. Sample 1 was wrapped in tin foil and frozen, then sent to the British Columbia Department of Agriculture Pesticide Laboratory for pesticide analysis. Sample 2 was frozen in plastic bags and sent to the Environment

Canada Water Quality Laboratory for heavy metal analyses.

3. RESULTS AND DISCUSSION

3.1. Physical Parameters:

Although generally not directly toxic, physical parameters such as turbidity, temperature and flow rates often influence the quality of the aquatic environment and the natural biota as much as chemical pollutants. When the tailings from a mining operation are discharged directly into the environment, the receiving waters may suffer vast changes in these physical characteristics.

Table 2 summarizes the observed clarity of the water at each station during the summer and fall surveys. On July 14th all streams were clear. Melting snow near the camp on October 13th carried a large amount of silt that increased the turbidity of the water drastically. This turbidity was observed as far south as site 8. Site 7 was also clouded with silt from melting snow on a recently logged area which this particular stream drains.

Heavy silting can be deleterious to macro-invertebrate and fish populations. Most molluscs require solid surfaces on

TABLE 2: Stream Clarity For Summer And Fall/73.

Sample Site	July 14/73	October 13/73
1	clear	clear
2	clear	clear
3	clear	clear
4	clear	turbid
5	clear	turbid
6	clear	clear
7	clear	discoloured
8	clear	discoloured
9	clear	clear
10	clear	clear
11	clear	discoloured

which to attach. Mayfly populations abandon areas subjected to scouring by fine sand particles. Silting reduces the number of sheltered crevices which many benthic organisms seek out and often results in the "silting-over" and possible asphyxiation of developing fish eggs. Gross siltation can cause physical damage to fish gill membranes resulting in reduced gaseous exchange and behavioral abnormalities. Direct entry of tailings into the watershed would undoubtedly result in deleterious effects on the fisheries resource and would therefore not be acceptable.

Water temperatures are depicted in Figure 3, they averaged 8°C more in the summer than in the fall. During the fall visit, the ground at higher altitudes was covered with snow and many of the streams had shore ice, consequently water temperatures there approached freezing. But at lower altitudes, where the streams converge (e.g. sites 8, 9, 10, and 11), the air was warmer and the water temperatures were a few degrees higher.

Temperature plays an important part in stream ecology. Periodism and Circadian rhythms of the many aquatic organisms are dependant on natural seasonal changes in temperature. Fecundity rates, the number of generations per year, biomass production and the species present are also related to the prevailing temperatures. Life sustaining dissolved oxygen,

although not usually a problem associated with mine effluents, is directly related to temperature.

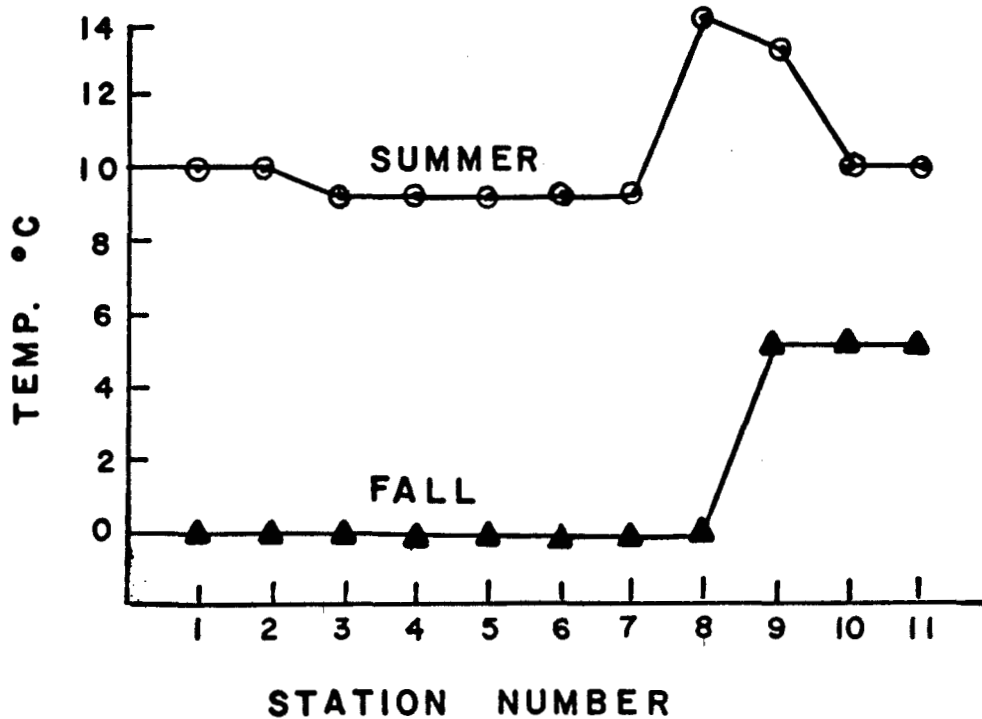


FIG. 3: Water Temperatures For July 14th and October 13th, 1973.

Trout, the dominant species in Buck Creek, are very sensitive to increases in temperature and cannot sustain ambient temperatures above 25°C for long periods (Hynes, 1970). Of course in any of these factors, lethal levels do not have to be reached, before detrimental behavioural and physiological changes occur.

Figure 4 depicts the difference between summer and fall flow rates at each sample site. As a general rule, flow rates of these streams reach their maximum in the early summer after spring rains and melting snow. Minimum flow rates can be expected in the mid-winter.

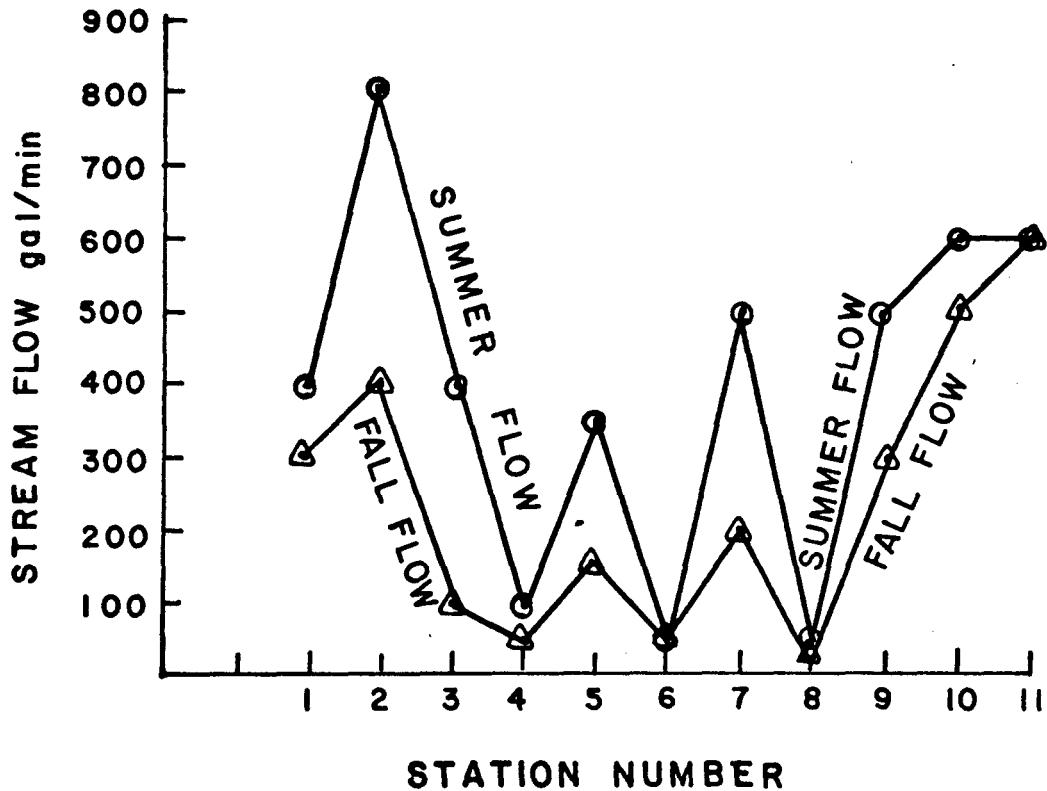


FIG. 4: Stream Flow For July 14th and October 13th, 1973.

3.2. Water Chemistry:

A summary of the heavy metal content of the water sampled

during the Summer and Fall surveys is given in Table 3. These provide an effective index to which future water quality changes may be related.

Except for two stations near the camp, heavy metal levels were found to be below the acceptable limites specified by Todd (1970). Higher than normal values of Cu, Zn and Fe at sample sites 4 and 5 are probably due to the camp activity. These samples contained a significant amount of suspended solids which were subject to leaching by the nitric acid preservative, and may have contained a considerable amount of contamination from a portable core sample grinder less than 100 feet from each of these sample sites. The excess ground rock from this operation was thrown outside the door on melting snow where it could leach into the stream.

pH values in the streams sampled are considered normal and within the acceptable range of 6.0 to 9.0 (Todd, 1970).

Dissolved oxygen levels were found, at most sample sites, to be above 90% saturation.

pH and Dissolved Oxygen levels for July 14/73 and Oct. 13/73 are presented in Figure 5.

TABLE 3: Heavy Metal Analysis for July 14th and October 13th, 1973.

Metal	Date (1973)	Sample Site No.										
		1	2	3	4	5	6	7	8	9	10	11
Cu	July 14	.01	<0.01	<0.01	.01	0.01	<0.01	.01	.02	.04	.01	<0.01
	Oct. 13	<0.03	<0.03	<0.03	0.55	0.04	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Pb	July 14	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
	Oct. 13	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Zn	July 14	<0.01	<0.01	.03	<.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01
	Oct. 13	<0.06	<0.06	0.07	0.77	0.07	<0.06	0.05	<0.06	<0.06	<0.06	<0.06
Fe	July 14	.76	.24	.92	.52	.40	.62	.36	---	.33	.96	.61
	Oct. 13	0.21	0.14	2.50	57.0	2.90	0.11	0.71	1.30	0.47	0.89	0.30
Ni	July 14	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
	Oct. 13	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Mo	July 14	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
	Oct. 13	---	---	---	---	---	---	---	---	---	---	---
Cd	July 14	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
	Oct. 13	---	---	---	---	---	---	---	---	---	---	---
Ca	July 14	38.0	19.0	3.8	3.2	28.0	9.8	17.0	8.1	15.0	12.0	8.6
	Oct. 13	18.0	3.9	51.0	10.0	31.0	10.0	24.0	12.0	22.0	13.0	8.3

All values expressed as mg/l unless otherwise indicated.

TABLE 3: Continued --

Metal	Date (1973)	Sample Site No.										
		1	2	3	4	5	6	7	8	9	10	11
Mg	July 14	5.1	6.0	3.1	2.3	7.9	6.0	7.7	3.6	7.4	8.2	7.1
	Oct. 13	3.50	1.50	4.80	4.40	6.50	3.20	6.30	3.80	6.50	5.00	3.40
Mn	July 14	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
	Oct. 13	---	---	---	---	---	---	---	---	---	---	---
Cr	July 14	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Oct. 13	---	---	---	---	---	---	---	---	---	---	---
Ag	July 14	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
	Oct. 13	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Sb	July 14	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
	Oct. 13	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Hg	July 14	<0.8 µg/l	<0.8 µg/l	<0.8 µg/l	<0.8 µg/l	<0.8 µg/l	<0.8 µg/l	<0.8 µg/l	<0.8 µg/l	<0.8 µg/l	<0.8 µg/l	<0.8 µg/l
	Oct. 13	<0.8 µg/l	<0.8 µg/l	<0.8 µg/l	<0.8 µg/l	<0.8 µg/l	<0.8 µg/l	<0.8 µg/l	<0.8 µg/l	<0.8 µg/l	<0.8 µg/l	<0.8 µg/l
As	July 14 Oct. 13	Nitric Acid interferes with As test.										

All values expressed as mg/l unless otherwise indicated.

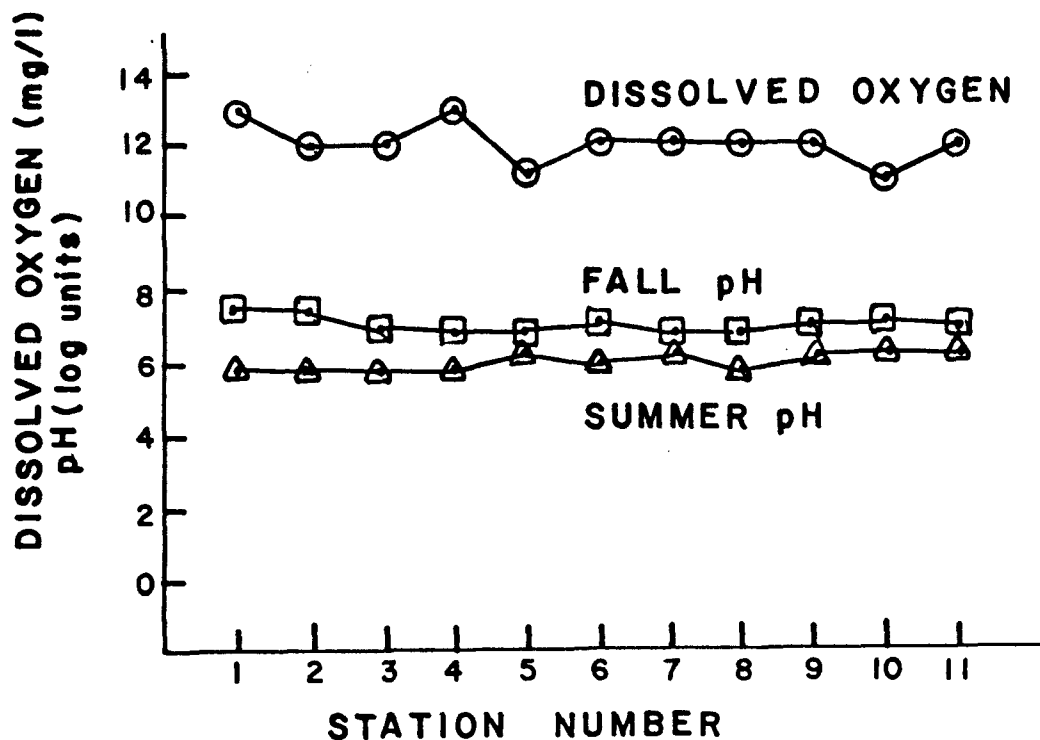


FIG. 5: pH and Dissolved Oxygen Levels For July 14th and October 13th, 1973.

3.3. Stream Biology:

3.3.1. Benthic invertebrates --

Populations of invertebrates, each with their unique requirements have proven to be excellent indicators of changes in their environment. All organisms have specific tolerance ranges to many different environmental factors. Some are highly tolerant of modified conditions, others are moderately tolerant and those that cannot cope with even small environmental

changes are highly intolerant.

In pristine ecological conditions a diversified flora and fauna exists (tolerant and non-tolerant) in a highly integrated, interdependent system. Even a subtle disruption of this system may manifest itself in a large re-adjustment in the relative population proportions. For example, a change in the nutrient supply may cause reduced numbers of one species while another becomes more prominent.

Biological communities are reported to be excellent indicators of environmental stress. Community structure will adjust to stress by shifts in species diversity, density, and dominance (Smith, 1966). However, sudden changes in the biota also occur quite naturally from season to season and year to year. It must be remembered that in most communities there lies a redundancy in members at any one trophic level and this protects most species from total elimination by fluctuating seasonal changes. Therefore, biological data, biotic indices and significant changes in biological communities must be analysed by an experienced ecologist who has an understanding of the interaction of the environment and fauna.

Tables 4 and 5 represent the combined counts of three

TABLE 4: Benthic Invertebrates -- July 14, 1973.

	Sample Site Numbers										
	1	2	3	4	5	6	7	8	9	10	11
Group I (pollution tolerant).											
Oligochaeta	1	-	-	-	-	-	1	1	-	4	3
Polychaeta	-	-	-	-	-	-	1	-	-	--	--
Group II (moderately tolerant).											
Diptera											
Heleidae	42	4	13	22	7	-	-	-	5	11	164
Pelopinae	5	38	-	2	1	5	-	8	-	4	--
Tendipedidae	134	145	25	67	40	66	37	94	20	69	730
Simuliidae	3	1	-	1	-	-	-	-	-	--	3
Empididae	2	6	2	2	1	-	2	2	-	12	55
Phoridae	-	-	-	-	-	1	-	-	-	--	--
Thaumaleidae	-	-	2	-	1	-	-	-	-	--	--
Trichoceridae	-	-	1	-	-	-	-	-	-	--	--
Ceratopogonidae	-	-	-	-	-	-	-	-	15	--	--
Stratiomyiidae	-	-	-	-	-	-	-	-	-	--	19
Dolichopodidae	-	-	-	-	-	-	-	-	-	--	--
Tipulidae	-	-	-	-	-	-	-	-	-	--	--
Rhagionidae	-	-	-	-	-	-	-	-	-	--	--
Crustacea	5	4	-	-	-	-	-	-	2	27	5
Gastropoda	-	6	-	-	-	-	-	-	-	1	3
Nematoda	-	2	-	-	-	6	1	-	-	8	2
Hydrozoa	-	3	-	-	-	-	1	-	-	--	1
Arachnida, Hydracarina	-	5	16	-	1	7	-	2	6	12	2

TABLE 4: Continued --

	Sample Site Numbers										
	1	2	3	4	5	6	7	8	9	10	11
Group III (intolerant).											
Coleoptera											
Elmidae	24	30	-	-	-	-	-	-	1	2	187
Hydrophilidae	-	-	-	-	-	1	-	-	-	2	--
Diatomidae	-	-	-	-	-	-	-	-	-	--	--
Cupedidae	-	-	-	-	-	-	-	-	-	--	2
Collembola Isotomidae	-	-	1	-	-	-	-	-	-	-	--
Ephemeroptera											
Baetidae	37	19	45	1	-	31	17	-	42	20	253
Ephemereidae	1	-	-	-	-	-	1	-	3	--	--
Heptageniidae	28	31	36	18	2	35	1	-	11	4	138
Hemiptera Mesoueleidae	-	-	-	-	-	-	-	-	5	--	--
Homoptera Psyllidae	-	-	-	-	-	-	-	-	1	--	--
Lepidoptera Corydalidae	-	-	-	-	-	-	-	-	4	--	--
Plecoptera											
Perlodidae	25	11	4	2	2	16	-	-	1	18	--
Chloroperlinae	2	5	18	-	-	3	-	-	4	--	285
Nemouridae	-	1	-	-	-	-	-	-	-	--	--
Thysanoptera Thripidae	-	-	1	-	-	-	-	-	6	--	1
Trichoptera											
Hydropsychidae	4	3	-	-	1	-	-	-	-	--	--
Rhyacophilidae	1	1	3	-	-	5	2	-	-	--	--
Philopotamidae	1	13	-	-	-	-	-	-	-	--	1
Megaloptera Conydalidae	4	-	-	-	-	-	-	-	5	--	--

TABLE 5: Benthic Invertebrates -- October 12, 1973

	Sample Site Numbers										
	1	2	3	4	5	6	7	8	9	10	11
Group I (pollution tolerant).											
Oligochaeta	-	-	-	-	-	-	-	-	-	--	1
Polychaeta	-	-	-	-	-	-	-	-	-	--	--
Group II (moderately tolerant).											
Diptera											
Heleidae	3	8	-	-	-	3	-	-	3	10	8
Pelopiinae	-	-	-	-	-	-	-	-	-	--	--
Tendipedidae	17	82	9	31	3	105	3	31	3	42	249
Simuliidae	-	-	-	-	-	-	-	-	-	--	--
Empididae	-	2	-	1	1	3	1	18	36	1	--
Phoridae	-	-	-	-	-	-	-	-	3	--	--
Thaumaleidae	-	-	-	-	-	-	-	-	-	--	--
Trichoceridae	-	-	-	-	-	-	-	-	-	--	--
Ceratopogonidae	-	-	-	-	-	-	-	-	-	--	--
Stratiomyiidae	-	-	-	-	-	-	-	-	-	--	--
Dolichopodidae	2	2	-	-	-	4	-	-	6	7	--
Tipulidae	1	1	-	1	1	6	3	9	-	9	--
Rhagionidae	-	1	-	-	-	-	12	-	-	--	--
Crustacea	-	-	-	-	-	-	-	-	-	--	--
Castropoda	-	-	-	-	-	-	-	-	-	--	1
Nematoda	-	-	-	-	-	-	-	-	-	--	--
Hydrozoa	-	-	-	-	-	-	-	-	-	--	--
Arachnida, Hydracarina	-	-	-	-	-	-	-	-	-	--	--

TABLE 5: Continued --

	Sample Site Numbers										
	1	2	3	4	5	6	7	8	9	10	11
Group III (intolerant).											
Coleoptera											
Elmidae	3	4	-	-	1	-	-	-	-	--	146
Hydrophilidae	-	-	-	-	-	-	-	-	-	--	--
Diatomidae	-	-	-	-	-	-	-	-	-	--	--
Cupedidae	-	-	-	-	-	-	-	-	-	--	--
Collembola Isotomidae	-	-	-	-	-	-	-	-	-	--	--
Ephemeroptera											
Baetidae	51	58	37	1	-	9	9	-	21	204	32
Heptageniidae	21	47	22	-	-	3	3	-	24	6	6
Hemiptera Mesovelleidae	-	-	-	-	1	-	-	-	-	--	1
Homoptera Psyllidae	-	-	-	-	-	-	-	-	-	--	--
Lepidoptera Corydalidae	-	-	-	-	-	-	-	-	-	--	--
Plecoptera											
Perlidae	-	4	-	-	-	-	-	-	-	2	--
Chloroperlinae	4	15	-	-	-	-	-	-	-	--	1
Nemouridae	123	128	51	-	-	30	3	-	78	33	146
Thysanoptera Thripidae	-	-	-	-	-	-	-	-	-	--	--
Trichoptera											
Hydropsychidae	3	4	-	-	-	3	-	-	-	--	--
Rhyacophilidae	5	3	2	-	-	-	-	9	-	--	--
Philopotamidae	-	-	-	-	-	-	-	-	-	--	--
Megaloptera Condyliidae	-	-	-	-	-	-	-	-	-	--	--

invertebrate samples of the summer and fall programs. The invertebrates were identified to family and then placed into one of three groups. Group I is considered highly tolerant of polluted waters, Group II, moderately tolerant, and Group III very intolerant. Fig. 6 graphically shows the relative proportions of these three groups at each site.

The data in Fig. 6 indicates that in all cases groups II and III are well represented therefore it is concluded that the water is of excellent quality. Diptera especially Tendipedidae (Midges) formed the bulk of Group II, while Ephemeroptera (Mayflies) and Plecoptera (Stoneflies) formed the majority in Group III. As can be expected, in a pristine community only a few Group I organisms were obtained (stations 7, 8, 10, and 11). However, a future rise in the proportion of Group I at the expense of Group III may be indicative of a degrading environment.

The calculated values for \bar{d} for each sample site during the summer and fall surveys are presented in Table 6.

Diversity indices of the benthic communities near the "Goosly Property" averaged 2.143. These relatively

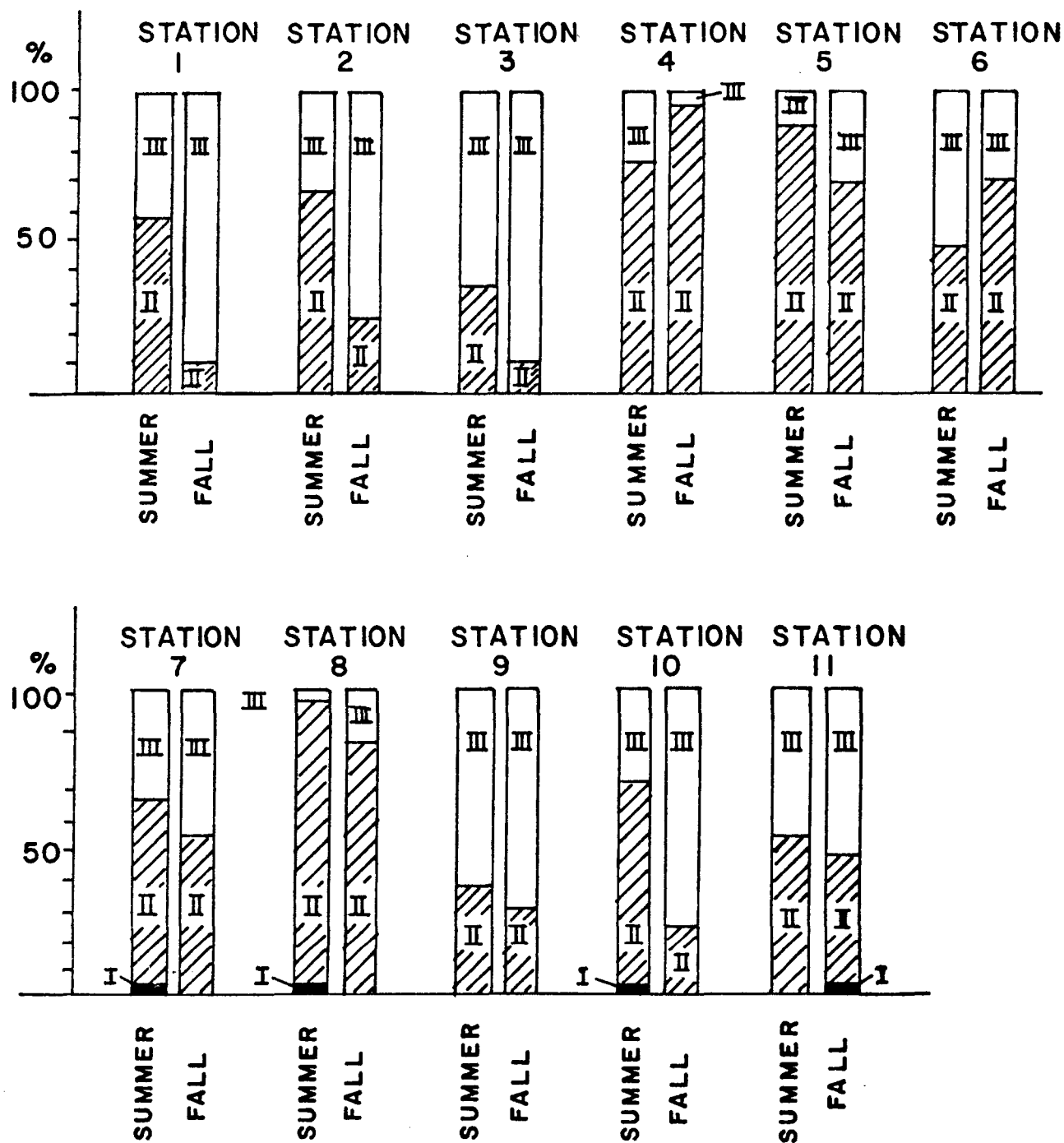


FIG. 6: THE PERCENTAGE DISTRIBUTION OF GROUPS I, II, AND III, FOR FALL AND SUMMER '73

TABLE 6: Diversity Indices For Summer And Fall/73.

Station Number	July 14/73		October 13/73	
	n	\bar{d}	n	\bar{d}
1	319	2.732	233	2.110
2	328	2.900	359	2.545
3	167	2.873	121	1.872
4	115	1.753	34	.570
5	56	1.584	7	2.128
6	176	2.578	166	1.813
7	64	1.840	34	2.424
8	107	.722	67	1.802
9	131	3.231	174	2.222
10	194	3.145	313	1.744
11	1858	2.598	591	1.963

(n) = total number of individuals per sample.

(\bar{d}) = diversity index.

low values may be attributed to the lack of accumulated nutrients in these cold northern streams. Also it has been suggested that some sensitivity of the index is lost when diversities are based on higher taxonomic categories (Egloff & Brakel, 1973).

3.3.2. Phytoplankton --

Tables in Appendix I list the species found at each site. Those without a relative population percentage may be considered to be only occasionally seen.

In all cases the majority of algae were diatoms and only occasional findings of chlorophytes, cyanophytes, crysophytes, etc. were made. Site 11, the exit to Goosly Lake, displayed the most diversity. This may be attributed in part to the warmer temperatures and additional nutrients usually found in a lake.

Phycologists believe that most species are available in all streams (if thoroughly examined) and flourish when conditions become suitable (opportunists).

Large algae blooms result from nutrient excess, changes in temperature, changes in flow and other factors which are sometimes linked with industrial discharges (Hynes 1970). During the two visits to the area no blooms were observed. This was confirmed by the

laboratory analysis because the water samples yielded so few algae that quantitative analysis was not practical.

3.3.3. Vertebrates --

The fish caught were tentatively identified as peamouth chub and rainbow trout. They averaged 10 cm. in length and the average weight was less than 50 grams. Table 8 summarizes the results of the pesticide analyses in fish tissue. None were detected.

Table 7 summarizes the results of the heavy metal analysis of fish tissue. Complete heavy metal analysis was not possible, because most analyses require more sample than was supplied. The zinc levels were relatively high and additional samples should be collected. Heavy metal concentrations in fish and the water should be kept under close surveillance after the mine starts operation.

TABLE 7: Heavy Metal Analysis of Fish
From Sites 10 and 11.

Metal	Concentration (ppm)	
	Wet	Dry
Cu	2.6	11.0
Zn	21.0	92
Cd	.34	1.5

TABLE 8: Pesticide Analysis Of Fish From
Sites 10 and 11, July 1973.

Pesticide	Concentration (ppm)
Lindane	not detected
Heptachlor	not detected
Aldrin	not detected
H. Epoxide	not detected
DDE	not detected
Dieldrin	not detected
op' DDT	not detected
DDD	not detected
DDT	not detected
Other Chlorinated Hydrocarbon Insecticides	not detected

4. SUMMARY

The mine operation will result in topographical changes which could have adverse effects on the local fishery and wildlife resources. Adequate abatement facilities and surveillance of construction and operation of the mine will be necessary if environmental damage is to be minimized.

Pristine conditions were encountered in the watershed in the vicinity of the "Goosly Property". A diversified biota was recorded and indexed to facilitate future comparison. Minor environmental degradation can be detected by relating post-operational observations (chemical, physical, biological) to the established baseline. Corrective measures can then be recommended before detrimental effects become a major issue.

5. ACKNOWLEDGEMENTS

The technical assistance of Miss Linda Thorsen, Miss Jane Lee and Mr. Barry Kovish for benthos and algae identification is gratefully acknowledged. Thanks are also due to Mr. M. Jones, Senior Field Technician (E.P.S.) and Mr. W. Knapp (Fisheries Operations, N.O.B.) for their guidance and support in the field sampling program. We would also like to extend thanks to Miss Doris Loesener for the typing of this report.

REFERENCES

- COLE, R.A. 1973.
Stream Community Response to Nutrient Enrichment, Journal WPCF,
Vol. 45, No. 9, 1874-1888.
- EGLOFF, D.A. and W.H. BRAKEL 1973.
Stream Pollution and a Simplified Diversity Index. Journal WPCF.,
Vol. 45, No. 11, 2269 - 2275.
- HAWLEY, J.R. 1972 (a).
The Problem of Acid Mine Drainage in the Province of Ontario,
Ministry of the Environment, Toronto, Ontario.
- HAWLEY, J.R. 1972 (b).
Use, Characteristics and Toxicity of Mine-Mill Reagents in Ontario,
Ministry of the Environment, Toronto, Ontario.
- HYNES, H.B.N. 1970.
The Ecology of Running Waters, University of Toronto Press.
- MACKENTHUS, L.M. 1969.
The Practice of Water Pollution Biology, U.S. Department of
the Interior, Federal Water Pollution Control Administration,
Division of Technical Support.
- MARGALEF, R. 1956.
Informacion y diversidad especifica en las comunidades de
organismos. Inv. Pesquera, Vol. 3, P. 99-106. Cited in
Wilhm and Dorris (1968).
- PATRICK, R. and C.W. REIMER 1966.
The Diatoms of the United States. The Livingston Publishing Co.,
Philadelphia.
- PENNAK, R.W. 1953.
Fresh Water Invertebrates of the United States. The Ronald Press
Co., New York.
- PRESCOTT, G.W. 1962.
Algae of the Western Great Lakes Area. William C. Brown Co.,
Dubuque, Iowa.
- PRESCOTT, G.W. 1970.
How to Know the Fresh Water Algae. 2nd Ed., William C. Brown
Co., Dubuque, Iowa.

- SMITH, R.L. 1966.
Ecology and Field Biology, Harper and Row, New York.
- STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER.
13th. Ed., 1971, APHA. AWWA. WPCF.
- TODD, D.K. 1970.
The Water Encyclopedia, The Maple Press.
- USINGER, R.L. et. al. 1968.
Aquatic Insects of California, University of California Press.
- WARD, H.B. and G.C. CHANDLER 1918.
Fresh Water Biology, 2nd. Ed., John Wiley and Sons Inc., New York.
- WILHM, J.L. and T.C. DORRIS 1968.
Biological Parameters for Water Quality Criteria, Bioscience 18, 477-481.

APPENDIX I

BIOLOGICAL SAMPLING --

PHYTOPLANKTON

BIOLOGICAL SAMPLING - PHYTOPLANKTON

Sample size - 1 litre grab sample in mid stream

Sample Site #1 -

Summer
July 14/1973

Bacillariophyceae (diatoms)

- *Cocconeis placentula*
- *Fragilaria construens*
- *Fragilaria crotonensis*
- *Fragilaria vaucheriae*
- *Frustulia rhomboides*
- *Gomphonema parvulum*
- *Hannaea arcus*
- *Meridion circulare*
- *Navicula pupula*
- *Navicula* sp.
- *Nitzschia acicularis*
- *Nitzschia palea*
- *Synedra ulna*

Chlorophyceae (green)

- *Closterium* sp.

Fall
October 13/1973

Bacillariophyceae (diatoms)

- *Achnanthes minutissima*
- *Cocconeis placentula*
- *Denticula* sp.
- *Fragilaria vaucheriae*
- *Gomphonema parvulum*
- *Hannaea arcus*
- *Melosira italica*
- *Meridion circulare*
- *Navicula bacilliformis*
- *Rhizosolenia* sp.
- *Synedra ulna*
- *Tabellaria fenestrata*

Chlorophyceae (green)

- *Chlamydomonas* sp.
- *Raphidonema* sp.

Cyanophyceae (blue green)

- *Anabaena* sp.

BIOLOGICAL SAMPLING - PHYTOPLANKTON

Sample Site #2 -

Summer
July 14/1973

- Bacillariophyceae (diatoms)
- Cocconeis placentula
 - Fragilaria construens
 - Fragilaria crotonensis
 - Fragilaria vaucheriae
 - Gomphonema parvulum (on stalks)
 - Hannaea arcus
 - Melosira italica
 - Meridion circulare
 - Navicula bacilliformis
 - Synedra ulna
 - Tabellaria fenestrata (5%)

- Chlorophyceae
- Chlamydomonas sp.

- Crysophyceae (yellow green)
- Dinobryon bavaricum

- Cyanophyceae
- Nostoc sp. (5%)

Fall
October 13/1973

- Bacillariophyceae (diatoms)
- Achnanthes flexella
 - Asterionella gracillima
 - Fragilaria construens
 - Fragilaria vaucheriae
 - Fragilaria crotonensis
 - Gomphonema parvulum (on stalks)
 - Melosira italica
 - Melosira tenuissima
 - Navicula sp.
 - Nitzschia acicularis
 - Nitzschia palea
 - Navicula dicephala
 - Synedra ulna
 - Tabellaria fenestrata
 - Tabellaria flocculosa

- Cyanophyceae (blue green)
- Nostoc sp.

BIOLOGICAL SAMPLING - PHYTOPLANKTON

Sample Site #3 -

Summer
July 14/1973

- Bacillariophyceae (diatoms)
- *Achnanthes flexella*
 - *Fragilaria crotonensis*
 - *Fragilaria vaucheriae* (45%)
 - *Gomphonema parvulum*
 - *Hannaea arcus*
 - *Meridion circulare* (45%)
 - *Navicula dicephala*
 - *Stephanodiscus astrea*
 - *Tabellaria fenestrata*
- Cyanophyceae (blue green)
- *Nostoc* sp.

Fall
October 13/1973

- Bacillariophyceae (diatoms)
- *Asterionella gracillima*
 - *Cymbella turgida*
 - *Fragilaria crotonensis*
 - *Fragilaria vaucheriae*
 - *Meridion circulare*
 - *Navicula dicephala*
 - *Tabellaria fenestrata*
- Chlorophyceae (green)
- *Chlamydomonas* sp.
 - *Raphidonema* sp.

Sample Site #4 -

Summer
July 14/1973

- Bacillariophyceae
- *Cymbella turgida*
 - *Hannaea arcus* (45%)
 - *Meridion circulare*
 - *Navicula* sp.
 - *Neidium* sp.
 - *Nitzschia* sp.
 - *Tabellaria fenestrata*
 - *Tabellaria flocculosa* (45%)
- Chlorophyceae
- *Closterium* sp.

- Crysophyceae (yellow green)
- *Tribonema* sp.

Fall
October 13/1973

- Bacillariophyceae
- *Fragilaria construens*
 - *Fragilaria vaucheriae*
 - *Hannaea arcus*
 - *Navicula dicephala*
 - *Nitzschia palea*
 - *Stauroneis* sp.
 - *Tabellaria flocculosa*
- Chlorophyceae
- *Microspora* sp.

BIOLOGICAL SAMPLING - PHYTOPLANKTON

Sample Site #5 -

Summer
July 14/1973

Bacillariophyceae
- Asterionella gracillima
- Fragilaria crotonensis
- Fragilaria pinnata
- Fragilaria vaucheriae
- Hanaea arcue
- Meridion circulare
- Navicula decussis
- Nitzschia palea
- Synedra ulna
- Tabellaria fenestrata

Chlorophyceae
- Chlamydomonas sp.

Crysophyceae
- Dinobryon divergens

Cyanophyceae
- Nostoc sp.
- Oscillatoria sp.

Fall
October 13/1973

Bacillariophyceae
- Fragilaria crotonensis
- Fragilaria vaucheriae
- Melosira italica
- Meridion circulare
- Nitzschia acicularia
- Tabellaria fenestrata

Chlorophyceae
- Stigeoclonium sp.

BIOLOGICAL SAMPLING - PHYTOPLANKTON

Sample Site #6 -

Summer
July 14/1973

- Bacillariophyceae (diatoms)
- Asterionella gracillima
 - Cymbella turgida
 - Gomphonema parvulum
 - Meridion circulare (90%)
 - Navicula bacilliiformis
 - Navicula exigua
 - Rhoicosphenia curvata
 - Tabellaria fenestrata

- Chlorophyceae (green)
- Closterium sp.

Fall
October 13/1973

- Bacillariophyceae (diatoms)
- Cocconeis placentula
 - Fragilaria crotonensis
 - Fragilaria vaucheriae
 - Gomphonema parvulum
 - Hannaea arcus
 - Melosira distans
 - Melosira italica
 - Navicula sp.
 - Nitzschia acicularis
 - Nitzschia c.f. acuminata
 - Nitzschia palea
 - Pinnularia sp.
 - Rhizosolenia sp.
 - Rhoicosphenia curvata
 - Synedra ulna
 - Stauroneis sp.
 - Tabellaria fenestrata

- Chlorophyceae
- Chlamydomonas sp.

Sample Site #7 -

Summer
July 14/1973

- Bacillariophyceae
- Achnanthes minutissima
 - Fragilaria crotonensis
 - Fragilaria vaucheriae
 - Gomphonema olivaceum
 - Hannaea arcus
 - Navicula exigua
 - Navicula pupula
 - Nitzschia palea
 - Tabellaria fenestrata

Fall
October 13/1973

- Bacillariophyceae
- Fragilaria crotonensis
 - Gomphonema olivaceum
 - Hannaea arcus
 - Meridion circulare
 - Nitzschia holstaca (90%)
 - Rhizosolenia sp.
 - Synedra ulna
 - Tabellaria fenestrata

- Crysophyceae (yellow green)
- Tribonema sp.

BIOLOGICAL SAMPLING - PHYTOPLANKTON

Sample Site #8 -

Summer
July 14/1973

Bacillariophyceae
- Cyclotella stelligera
- Denticula sp.
- Fragilaria vaucheriae
- Epithemia sp.
- Melosira distans
- Nitzschia acicularis
- Nitzschia palea
- Pinnularia sp.
- Tabellaria fenestrata

Chlorophyceae
- filamentous green

Crysophyceae
- Dinobryon divergens
- Tribonema sp.

Fall
October 14/1973

Bacillariophyceae
- Cymbella cuspidata
- Cymbella turgida
- Fragilaria vaucheriae
- Hannaea arcus
- Melosira distans
- Melosira italica
- Meridion circulare
- Navicula exigua
- Nitzschia holsatica
- Nitzschia littoralis
- Pinnularia sp.
- Synedra ulna

Chlorophyceae
- filamentous green

BIOLOGICAL SAMPLING - PHYTOPLANKTON

Sample Site #9 -

Summer
July 14/1973

- Bacillariophyceae
- *Fragilaria vaucheriae*
 - *Hannaea arcus*
 - *Meridion circulare*
 - *Navicula pupla*
 - *Nitzschia acicularis*
 - *Nitzschia palea*
 - *Nitzschia holsatica*
 - *Synedra ulna*
 - *Tabellaria fenestrata*

Fall
October 14/1973

- Bacillariophyceae
- *Asterionella gracillima*
 - *Cymbella turgida*
 - *Fragilaria crotonensis*
 - *Fragilaria vaucheriae*
 - *Gomphonema olivaceum*
 - *Hannaea arcus*
 - *Melosira distans*
 - *Navicula* sp.
 - *Nitzschia acicularis*
 - *Rhizosolenia* sp.
 - *Synedra ulna*
 - *Tabellaria fenestrata*

- Chlorophyceae
- *Chlamydomonas* sp.

- Crysophyceae
- *Dinobryon divergens*

Sample Site #10 -

Summer
July 14/1973

- Bacillariophyceae
- *Cymbella turgida*
 - *Fragilaria construens*
 - *Fragilaria crotonensis*
 - *Fragilaria vaucheriae*
 - *Gomphonema parvulum*
 - *Navicula bacilliformis*
 - *Navicula decussis*
 - *Navicula dicephala*
 - *Neidium* sp.
 - *Nitzschia acicularis* (90%)
 - *Nitzschia palea*
 - *Nitzschia sublinearis*
 - *Synedra ulna*
 - *Tabellaria fenestrata*

- Chlorophyceae
- *Crucigenia* c.f. *tetrapedia*
 - *Cerasterias* sp.
 - *Chlamydomonas* sp.

- Crysophyceae
- *Dinobryon divergens*

Fall
October 14/1973

- Bacillariophyceae
- *Fragilaria crotonensis*
 - *Fragilaria vaucheriae*
 - *Gomphonema parvulum*
 - *Navicula dicephala*
 - *Navicula lanceolata*
 - *Nitzschia acicularis*
 - *Nitzschia palea*
 - *Synedra ulna*
 - *Tabellaria fenestrata*

- Chlorophyceae
- *Chlamydomonas* sp.
 - *Euglena* sp.

- Crysophyceae
- *Dinobryon divergens*

BIOLOGICAL SAMPLING - PHYTOPLANKTON

Sample Site #11 -

Summer
July 15/1973

Bacillariophyceae

- *Achnanthes nimutissima*
- *Achnanthes* sp.
- *Amphipleura pellucida*
- *Amphora* sp.
- *Asterionella gracillima*
- *Coconeis* sp.
- *Cymbella turgida*
- *Fragilaria construens*
- *Fragilaria crotonensis*
- *Fragilaria pinnata*
- *Fragilaria vaucheriae*
- *Melosira distans*
- *Melosira italica*
- *Melosira tenuissima*
- *Navicula* sp.
- *Nitzschia acicularis*
- *Nitzschia palea*
- *Nitzschia spectabilis*
- *Stephanodiscus niagare*
- *Synedra ulna*
- *Tabellaria fenestrata*
- *Tabellaria flocculosa*

Chlorophyceae

- *Chlamydomonas* sp.
- *Closterium* sp.

Crysophyceae

- *Dinobryon divergens*

Rhodophyceae

- *Batrachospermum* sp.

Fall
October 12/1973

Bacillariophyceae

- *Achnanthes minutissima*
- *Asterionella gracillima*
- *Coscinodiscus* sp.
- *Cyclotella stelligera*
- *Fragilaria construens*
- *Fragilaria crotonensis*
- *Fragilaria vaucheriae* (30%)
- *Epithemia* sp.
- *Melosira italica*
- *Navicula bacilliformis*
- *Navicula dicephala*
- *Nitzschia acicularis*
- *Nitzschia littoralis*
- *Pinnularia* sp.
- *Pleurosigma* sp.
- *Stephanodiscus astrea*
- *Synedra ulna*
- *Tabellaria fenestrata*
- *Nitzschia holsatica* (30%)
- *Cymbella turgida*

Chlorophyceae

- *Chlamydomonas* sp.

Crysophyceae

- *Dinobryon divergens* (30%)

Cyanophyceae

- *Anabaena* sp.

PROTOZOA - Halteria sp.