

no water quality data; Rose Creek
- very vague report Benthic
Inw

007501

**BIOLOGICAL MONITORING
PROGRAM
- CURRAGH MINESITE -**

Prepared For:

CURRAGH RESOURCES LTD.

Prepared by:

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CHAPTER ONE

INTRODUCTION

1.0 Preamble

Pursuant to the Northern Inland Waters Act and Regulations of the Yukon Territorial Water Board, Curragh Resources Ltd. is required to conduct a benthic fauna sampling monitoring program every second year. Results of this sampling program will be used to assess the downstream effects of runoff from tailings ponds.

1.1 Study Objectives

Under the terms and conditions of maintaining a Yukon Territorial Water License, a benthic fauna sampling program must be undertaken. This benthic fauna sampling program must meet standards set by the Yukon Territorial Water Board. The Yukon Territorial Water Board recommends that three replicate benthic samples be collected from five different sampling locations. These samples are to be collected using artificial substrate samplers and each sampler must remain in situ for a duration of five weeks prior to sample collection. The benthic organisms are then to be collected, identified and enumerated.

1.2 Location of Study Area

The study area is located at approximately 62° 20' N, 133° 25' W, in the central part of the Yukon Territory (refer to Figure 1). The mine tailings drain into Rose Creek, which flows into Anvil Creek and eventually into the Pelly River.

The sampling stations are located (refer to Figure 2):

- 1) on the South Fork of Rose Creek, above the confluence of the North Fork;
- 2) in the mixing zone downstream of the intersection of the Rose Creek diversion channel and the outlet of the tailings pond;
- 3) Rose Creek, about half-way between the tailings pond outlet and Anvil Creek
- 4) Rose Creek, just above Anvil Creek; and
- 5) Anvil Creek, just below the confluence with Rose Creek.

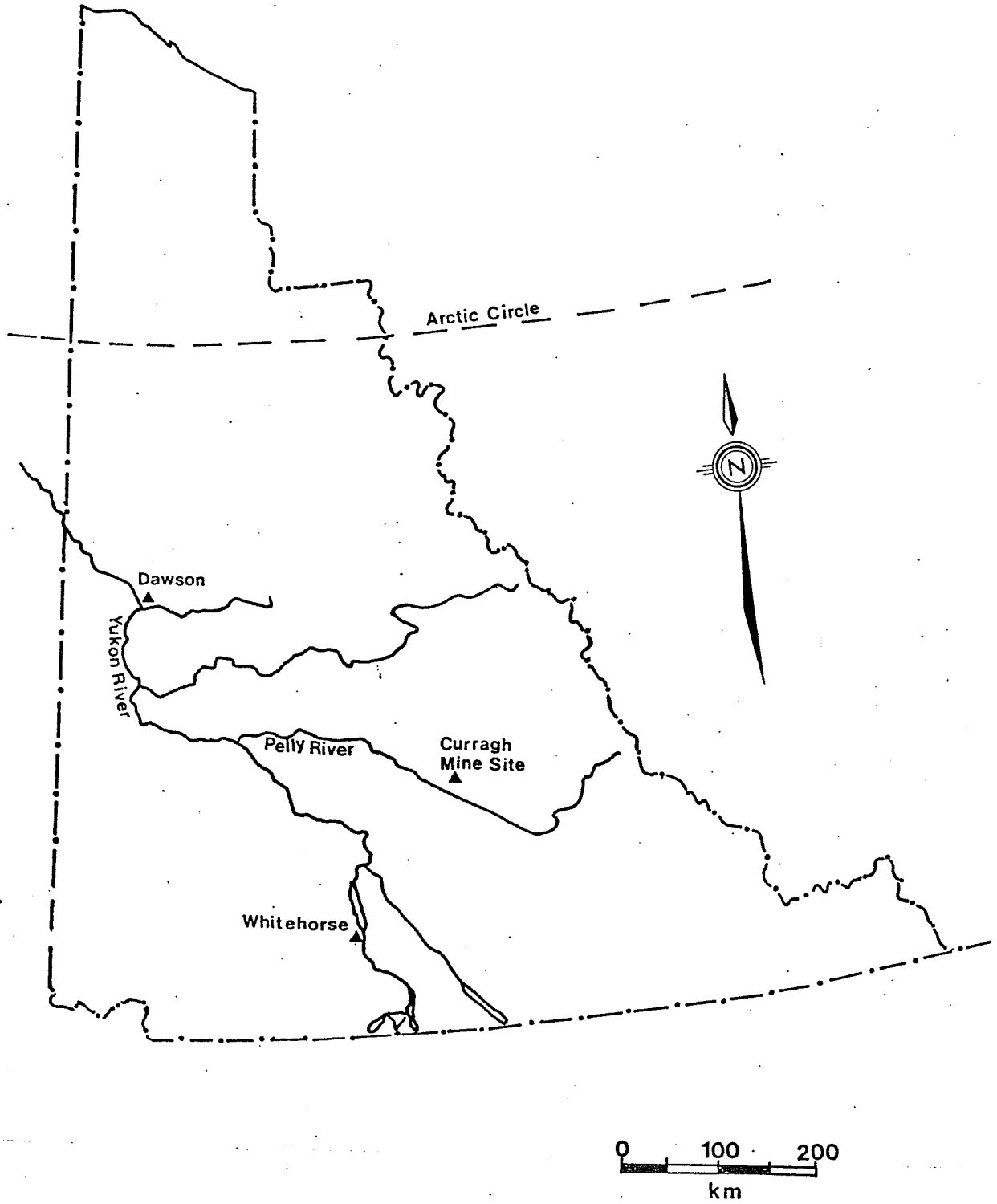


FIGURE 1 - Location of Curragh Mine Site,
Yukon Territory

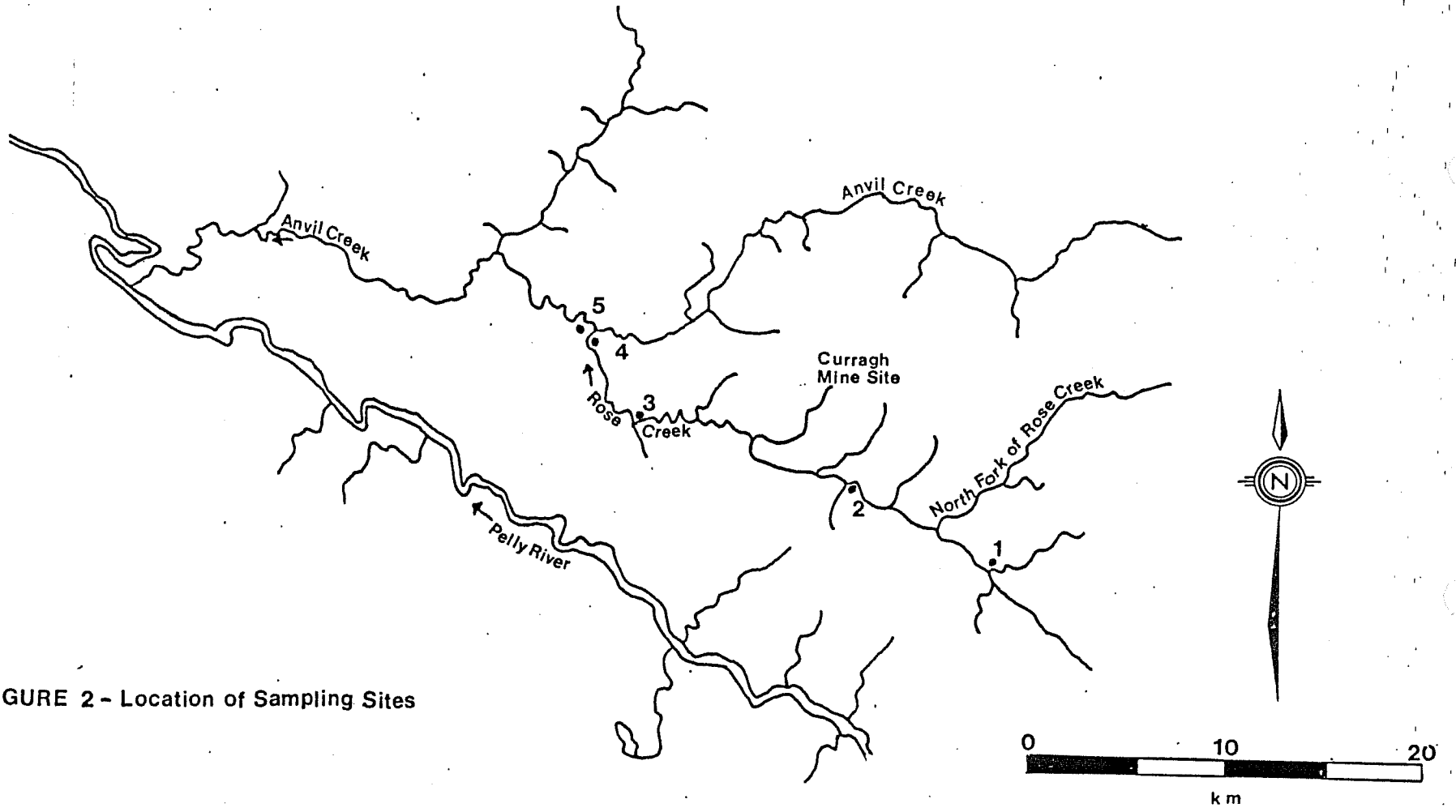


FIGURE 2 - Location of Sampling Sites

CHAPTER TWO

METHODOLOGY

2.0 Sampling Procedure

The sampling was conducted in accordance with the guidelines set out by the Yukon Territorial Water Board and the Environmental Protection Service.

2.1 Benthic Sampling

Benthic sampling was conducted using artificial substrate samplers. The sampling apparatus consisted of a cylindrical-shaped, open wire basket, approximately 25.5 cm long and 16.5 cm in diameter. Each substrate sampler sampled a total surface area of approximately 0.435 m². All substrate samplers were filled with cobble-sized rocks collected near the sample sites. Three replicate samplers were placed at each of the five sampling sites and left for a period of five weeks. Benthic sampling at four of the five sites, commenced on July 14, 1986 and concluded on August 27, 1986. Samples at Site 1 were lost sometime during this period. New samplers were installed at Site 1 on August 27, 1986 and removed October 5, 1986.

Benthic samplers were all placed in regions of laminar flow. Sample S-1 was submerged in approximately 30 cm of water where Rose Creek flows into the reservoir (see Figure 2). Sample S-2 was located immediately downstream of the confluence of the outlet of the tailings pond and the Rose Creek diversion channel, in approximately 30 cm of water (see Figure 2). Sample S-3 was

collected midway between the tailings pond outlet and the confluence of Rose Creek and Anvil Creek (see Figure 2). Sample S-4 was taken on Rose Creek, approximately 25 m upstream of the confluence of Rose Creek and Anvil Creek (see Figure 2). The final sample location, S-5, was in Anvil Creek, approximately 50 m downstream of the confluence of Rose Creek and Anvil Creek (see Figure 2).

Substrate collected from each of the samplers was stored in a 70% solution of ethanol. Suspended materials were sieved through a No. 10 (158 μ) mesh net. Each sample was labelled, preserved in formalin and sent to an invertebrate biologist for analysis.

2.2 Benthic Analysis

Benthic samples were analyzed by Dr. Charles Low. Dr. Low identified and enumerated each of the replicate samples from the five different sampling sites. Samples were identified as to species wherever possible (see to Appendix A). Analysis of Dr. Low's findings are presented in Chapter 3.

CHAPTER THREE

RESULTS AND DISCUSSION

3.0 Invertebrates Collected

A total of fourteen different taxonomic orders of benthic invertebrates were collected from the five sample sites. A number of zooplankton species were also collected; however, these are not included in the calculations since they are not considered benthic fauna. Table 1 provides results of the total number of taxonomic orders collected and the relative abundance of each order. Details of each individual benthic and zooplankton species collected is presented in Appendix A.

3.1 Taxonomic Range

Based on percent composition, taxa were classified with respect to their dominance within the benthic community (McCart et al., 1977). Results of this analysis are presented in Table 2. Information within Table 2 allows for an overall impression of the benthic community composition in the study area.

Station S-1 at the entrance to the reservoir is dominated by mayflies (Ephemeroptera), stoneflies (Plecoptera) and flies (Diptera). Caddisflies (Trichoptera) also appear to be common at station S-1. All other taxa are either rare or incidental.

Station S-2 is located just below the confluence of the Rose Creek diversion channel and the outlet of the tailings pond. This station is dominated by midges (Chironomid) and stoneflies

(Plecoptera). Also commonly found are mayflies (Ephemeroptera), flies (Diptera), caddisflies (Trichoptera) and oligochaetes. Pennak (1978) indicates that members of the oligochaetes can be used as "pollution indicators" if they are present in the 10 - 60% composition category. If so, it indicates areas of oxygen saturation and settling ponds. However, in S-2 oligochaetes are common but only make up 1.13% of the community. Rare or incidental taxa including mites (Acari), roundworms (Nematoda) and cicadas (Homoptera) are incidental taxa.

Station S-3 is located midway between the tailings ponds and the confluence of Rose Creek and Anvil Creek. This station is dominated by midges (Chironomid) with stoneflies (Plecoptera) as subdominants. Commonly found are mayflies (Ephemeroptera), caddisflies (Trichoptera), flies (Diptera) and mites (Acari). The oligochaetes were only rarely found, while the roundworms (Nematodes) and cicadas (Homoptera) become incidental taxa.

Station S-4, on Rose Creek, just above the confluence of Rose Creek and Anvil Creek is dominated by stoneflies (Plecoptera) and midges (Chironomid). The mayflies (Ephemeroptera) become the subdominants. Commonly found are the caddisflies (Trichoptera) and flies (Diptera). All other taxa are either rare or incidental.

Station S-5, located on Anvil Creek downstream of the confluence of Rose Creek and Anvil Creek, is dominated by stoneflies (Plecoptera) and midges (Chironomid) with mayflies (Ephemeroptera) as subdominants. The caddisflies (Trichoptera), flies (Diptera) and mites (Acari) are commonly found. The remaining taxa are either rare or incidental.

3.2 Species Diversity

The Shannon Weaver Diversity Index (Shannon and Weaver, 1949) was used to calculate species diversity. The precise formula used is taken from Lloyd et al. (1968) where diversity (d') is:

$$d' = \frac{c (N \log_{10} N - (\sum ni \times \log_{10} ni))}{N}$$

$c = 3.321928$

$N =$ total number of individuals

$ni =$ number of individuals of the i th species

The species diversity of the the five sampling locations is presented in Table 3. Table 3 is based on the following:

- d' is dependent on the number of species (i.e. richness and distribution of individuals among species i.e. evenness);
- therefore d' increases with increases in the above;
- d' is proportional to the uncertainty of identification of a randomly selected individual from the population;
- d' is 0 when all individuals are of the same species, d' is at a maximum when each species has the same number of individuals;
- in unstressed streams d' ranges from 1 to 4; and
- in polluted streams d' is usually less than 1 (Wilm, 1970).

Table 3 indicates that Station S-4 on Rose Creek, just above the confluence with Anvil Creek has the highest diversity. Stations S-1, on Rose Creek where it flows into the reservoir and Station S-5, on Anvil Creek below the confluence of Rose Creek and Anvil Creek have approximately the same species diversity. Station S-2, below the confluence of the tailings pond and the diversion channel and Station S-3, on Rose Creek, midway between the tailings pond and Anvil Creek, have the lowest species diversity, with Station S-3 being the lowest.

3.3 Standing Crop

The standing crop measures the instantaneous quantity of individuals and is therefore a good measure of overall productivity. The standing crop estimates are influenced by a number of independent variables such as time of year, rate of flow and water depth. Table 4 indicates the standing crop for each of the sample areas. In the unstressed site, Station S-1, the standing crop is $360.0 / m^2$. Where the tailings pond and the Rose Creek diversion channel meet, Station S-2, the standing crop has increased to $2092.1 / m^2$, or almost a six fold increase in production. As samples were taken further down Rose Creek, the production continues to rise. At Station S-3, midway between the tailings pond and Anvil Creek, the standing crop is $2490.2 / m^2$. At Station S-4, located on Rose Creek just upstream of the confluence with Anvil Creek, the standing crop is $4535.0 / m^2$. Finally downstream of the confluence of the two creeks, the standing crop reduces to $3686.7 / m^2$. At all stations, with the exception of Station S-1, the majority of the standing crop consists of midges (Chironomid) and stoneflies (Plecoptera). Station S-1 has the majority of the standing crop consisting of mayflies (Ephemeroptera) and stoneflies (Plecoptera).

3.4 Pollution Levels

The Shannon-Weaver Index indicates that in unstressed streams d' ranges from 1 to 4, and in polluted streams d' is usually less than 1 (Wilm, 1970). Figure 3 indicates the theoretical pollution line relative to species diversity. Stations S-2 and S-3, downstream of the tailings ponds, appear to be the most "stressed" of the five sample sites; however, the data indicates that these two stations cannot be classified as polluted by this method. Data from Stations S-1, S-4 and S-5 indicate "unstressed" aquatic environments.

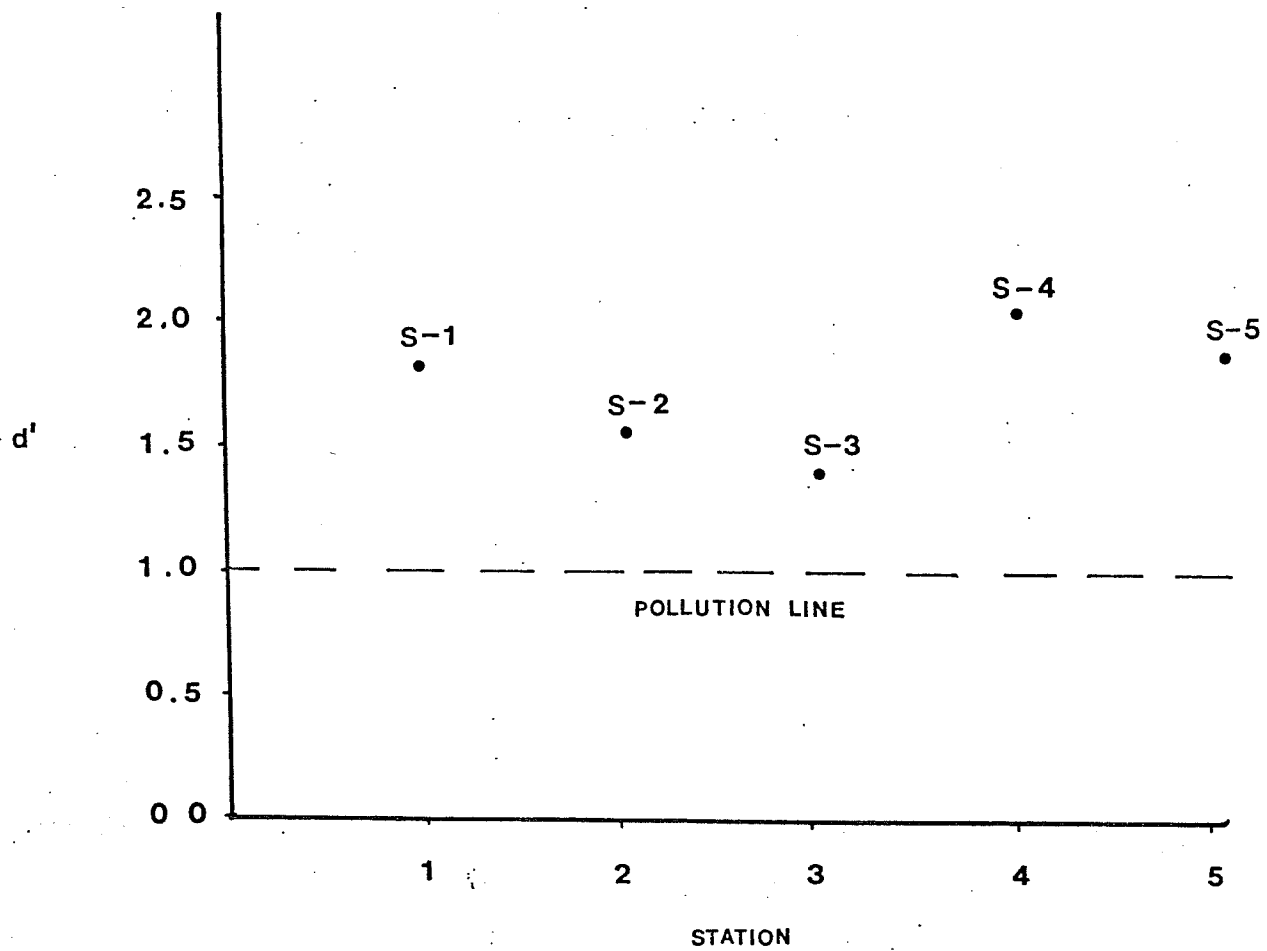


FIGURE 3 POLLUTION LINE RELATIVE TO BENTHIC SPECIES DIVERSITY

CHAPTER FOUR

CONCLUSIONS

There appears to be some impact of the tailings pond on the benthic communities of Rose Creek. This appears in the lower diversity levels and the increase in the presence of oligochaetes at S-2 when compared to all other sites. Contaminants appear to be removed by the time the water reaches S-4, as the diversity levels increase substantially and the presence of oligochaetes is reduced. Removal could be through sedimentation as well as through uptake by plants. There appears to be little effect of the tailings pond on Anvil Creek as samples above and below the confluence with Rose Creek indicate similar communities.

Station S-1 appears odd in that it has a substantially lower productivity than all the other sites. This may be related to the problems which arose in sampling at this location. When all samplers were being removed on August 27, 1986, it was discovered that the S-1 samplers were no longer in place. Once this problem was noted, new samplers were installed and removed five weeks later, on October 5, 1986. This particular time of the season is when benthic animal life usually begins to reduce in intensity and therefore most of the benthic invertebrates would have emerged. This would leave only a fraction of the community that may have been present earlier in the season. Therefore it appears that the reduction in productivity at this site is due to seasonal variation.

Data presented, therefore, indicates that the tailings ponds appear to have very little effect on the lower portions of Rose Creek and Anvil Creek.

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TABLE 1
COLLECTED BENTHIC INVERTEBRATES

<u>TAXA</u>	<u>TOTAL # COLLECTED</u>					<u>PERCENT COMPOSITION</u>				
	1	2	3	4	5	1	2	3	4	5
Nematoda		1.7	0.3	0.3	1.7		0.19	0.03	0.02	0.11
Aranea	0.7			0.3		0.45			0.02	
Acari	0.7	7.0	12.3	7.7	23.3	0.45	0.77	1.14	0.39	1.76
Plecoptera	44.3	240.7	236.7	752.0	715.7	28.29	26.40	21.85	38.15	44.58
Ephemeroptera	65.3	37.0	88.3	301.7	179.0	41.70	4.06	8.15	15.24	11.15
Trichoptera	2.0	24.7	64.3	189.7	68.0	1.28	2.71	5.93	9.62	4.24
Diptera	41.0	23.0	19.0	116.0	30.7	26.18	2.52	1.75	5.88	1.91
Chironomid		567.0	661.0	599.3	575.0		62.19	61.01	30.38	35.82
Hymenoptera		0.3		0.7			0.03		0.04	
Homoptera	1.3		0.3	0.3		0.83		0.03	0.02	
Coleoptera				1.7					0.09	
Lepidoptera				0.3					0.02	
Mollusca	0.3				0.3	0.19				0.02
Oligochaeta	1.0	10.3	1.3	3.0	11.7	0.64	1.13	0.12	0.15	0.73
Total Number Collected	156.6	911.7	1083.5	1973.0	1605.4					
Total Taxa Collected	9	9	9	13	9					

TABLE 2
TAXANOMIC RANGE OF BENTHIC INVERTEBRATES

<u>STATION</u>	<u>DOMINANT</u>	<u>SUBDOMINANT</u>	<u>COMMON</u>	<u>RARE</u>	<u>INCIDENTAL</u>
1	Ephemeroptera Plecoptera Diptera		Trichoptera	Homoptera Oligochaeta Aranea Acari Mollusca	
2	Chironomid Plecoptera		Ephemeroptera Diptera Trichoptera Oligochaeta	Acari Nematoda	Hymenoptera
3	Chironomid	Plecoptera	Ephemeroptera Trichoptera Diptera Acari	Oligochaeta	Nematoda Homoptera
4	Plecoptera Chironomid	Ephemeroptera	Trichoptera Diptera	Acari Oligochaeta	Coleoptera Hymenoptera Nematoda Aranea Homoptera Lepidoptera
5	Plecoptera Chironomid	Ephemeroptera	Trichoptera Diptera Acari	Oligochaeta Nematoda	Mollusca

CLASSIFICATION

Dominant (D)	$D \geq 25.0 \%$
Subdominant (S)	$10.0 \% \leq S < 25.0 \%$
Common (C)	$1.0 \% \leq C < 10.0 \%$
Rare (R)	$0.1 \% \leq R < 1.0 \%$
Incidental (I)	$I < 0.1 \%$

TABLE 3
BENTHIC INVERTEBRATE DIVERSITY

<u>STATION</u>	<u>DIVERSITY</u>
1	1.82
2	1.54
3	1.39
4	2.08
5	1.87

TABLE 4
STANDING CROP (# / m²)

<u>TAXA</u>	<u>STATION</u>				
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>
Nematoda		3.9	0.7	0.7	3.9
Aranea	1.6			0.7	
Acari	1.6	16.1	28.3	17.7	53.6
Plecoptera	101.8	553.3	544.2	1728.7	1645.3
Ephemeroptera	150.1	85.1	203.0	693.6	411.5
Trichoptera	4.6	56.8	147.8	436.1	156.3
Diptera	94.3	52.9	43.7	266.7	70.6
Chironomid		1303.5	1519.5	1377.7	1321.8
Hymenoptera		0.7		1.6	
Homoptera	3.0		0.7	0.7	
Coleoptera				3.9	
Lepidoptera				0.7	
Mollusca					0.7
Oligochaeta	2.3	23.7	3.0	6.9	26.9
<u>TOTAL</u>	360.0	2092.1	2490.2	4535.0	3686.7

TRAP SIZE: radius (r) = 16.5 cm; length (l) = 25.5 cm

$$\begin{aligned}
 \text{Surface Area} &= 2 \pi r^2 + 2 \pi r h \\
 &= 2 \pi (165)^2 + 2 \pi (165) (255) \text{ mm}^2 \\
 &= 171059.72 + 264365.02 \text{ mm}^2 \\
 &= 435424.74 \text{ mm}^2 \\
 &= 0.43542474 \text{ m}^2
 \end{aligned}$$

APPENDIX A

INVERTEBRATE SPECIES COLLECTED

Sample	S11	S12	S13
Aranea	2		
Acari	1		1
Plecoptera			
Zapada sp	26	23	8
Malenka sp		1	
Arcynopteryx sp	2	1	1
Sweltza Gp.	5	2	1
Capnia sp	22	31	10
Ephemeroptera			
Ephemerella flavilinea		1	1
Ephemerella attenuata			1
Cinygmula sp			1
Heptagenia sp	2		
Ameletus sp	41	46	103
Trichoptera			
Rhyacophila (hyalinata)		1	
Rhyacophila acropedes			1
Hesperophylax sp		1	
Limnephilidae, unid J/D 1		1	1
Diptera, chironomidae			
Chironomidae, unid, juv.20		14	17
Cardiocladius sp	4	1	
Cricotopus sp	4	3	3
Eukiefferiella sp	5	4	5
Tanytarsus sp	3	2	
Micropsectra sp	3	3	2
Brillia sp	3	5	10
Corynoneura sp	4		7
Dicrotendipes sp		1	
Psychodidae			
Pericoma sp	1		
Oligochaeta			
Enchytraeidae		2	
Formicidae		1	
Homoptera, adult	4		

	S21	S22	S23	S31	S32	S33	S41	S42	S43	S51	S52	S53
Nematoda	1		2			1			1	1		3
Nematomorpha (Gordius sp?)	1	1										
Ostracoda		1										1
Copepoda												
Epischura sp	1											
Cyclops sp	2								1			
Harpacitoida								1				
Cladocera												
Daphnia galeata	1	1	1				1					
Bosmina longirostris	1					2						
Aranea							1					1
Acari	10	8	3	13	7	17	4	10	9	36	18	16
Plecoptera												
Skvala sp			1	1		1	1	6	11	20	1	7
Zapada sp	187	131	85	57	80	121	282	246	409	486	257	356
Malenka sp	17	15	4	5		5	6	6		8	1	3
Arcynopteryx sp	69	88	41	89	106	191	106	122	169	178	25	135
Sweltza sp.	7	9	11			2	15	2	8	19	21	14
Isoperla sp	5	2	1	2	3	5	3	3		1		1
Taenionema sp	7	8	3	4	5	3	14	10	12	10	5	
Capnia sp	6	10	11	8	7	13	205	184	406	331	147	102
Pteronarcella regularis		3				2	9	8	11	6	7	6
Ephemeroptera												
Baetis sp	24	21	11	28	37	53	91	74	96	52		32
Ephemerella doddsi				7	8	12	17	12	18	15	1	5
Ephemerella flavilinea		2	2	1	3	6		2	2	1	2	
Ephemerella (attenuata?)	3	6	5	16	4	13	59	72	102	93	18	34
Ephemerella spinifera		1				1	1		1			1
Cinygmula sp	4	12	16	5	15	32	80	57	152	200	29	38
Epeorus (I) longimanus	2	1		6	6	10	16	11	18	12		1
Ameletus sp			1				2			1		2
Rithrogena sp						2	6	5	11			
Trichoptera												
Rhyacophila acropedes		1	1	1		4		1	1	4		2
Rhyacophila vagrita	2	5	1			4	5		2	1	1	3
Hesperophylax sp	2	13	2		2				3	1	2	4
Arctopsyche sp	4			7	13	4	13		6	12	5	7
Hydropsychidae, juv.	20	5	3	52	21	61	166	115	248	133	1	26
Limnephilidae, juv/dam.	6	2	4				1	1	3			1
Brachycentrus sp		3		1								
Agapetus sp				4	7	12	4					
Ecclisomyia sp										1		
Diptera, simuliidae												
Gymnopsis sp pupa			1									
Prosimulium sp L	1	5	1		1	8	10	4	8	6		1
Prosimulium sp P		1	1	3	1	3	10	9	25	19	5	4
Simulium sp L	16	26	13	18	2	12	124	24	102	42	3	6
Simulium sp P	3	1		2	1	6	9	6	17	4	1	1
Chironomidae, adult									1			
Chironomidae pupae	36	18	9	10	15	21	8	6	13	32	9	7
Chironomidae L. unid.	35	31	7	13		14	16	66	147	249	31	118

	S21	S22	S23	S31	S32	S33	S41	S42	S43	S51	S52	S53
Diptera, chironomidae Cont.												
Cardiocladius sp	18	19	14	74	53	59	12	7	14	40	13	17
Cricotopus sp	455	321	232	365	254	483	325	164	334	467	78	109
Eukiefferiella sp	115	133	136	176	119	275	215	174	261	252	61	145
Tanytarsus sp	6	8	32	1		4	7	1	2	2	7	8
Diamesa sp	6	3	3	11	3	7	2		4			1
Micropsectra sp	2							1		1		1
Brillia sp	7	6	1		1	2	3	1	1	7	1	1
Pentaneura sp	1		8	1	1				1	12	1	1
Trichocladius sp			1									1
Corynoneura sp			1									
Psychodidae												
Pericoma sp		1				2				2	2	4
Tipulidae												
Prioncera sp			1						1			
Antocha sp	1	2							3	2		3
Tipula sp				1	1	1	1					
Empididae pupae						2				3	4	11
Hemerodromia sp	1						1	1	1	2	5	1
Chelifera sp	4	1	2	1	1	8	1		2	3	2	1
Muscidae, adult					1		1					
Lispocephala sp	5	8	11			2		1				
Unid muscidae										2		
Ceratopogonidae												
Palpomyia sp		1				1				4	2	1
Hymenoptera, adult			1					1				
Homoptera, adult								1				
Aphididae						1	1	1	2			
Coleoptera												
Psephinidae pupae							1	2	1			
Dytiscidae larva, dam.							1					
Lepidoptera, larva									1			
Gastropoda, dam, terrestrial.												1
Oligochaeta												
Nais (communis)	2	5	6									
Tubificidae, juv.						1		1				
Enchytraeidae	5	7	6	2		1	2	1	5	12	6	9