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ECCLES CREEK INVERTEBRATE STUDIES AND ROCK DISSOLUTION EXPERIMENTS

Prepared for:

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1.0 INTRODUCTION

Eccles Creek below Skyline Mine has experienced a decline in biological activity over the past several years. An initial set of samples collected in the summer and fall of 1990 showed a pattern of impacted stream community below the mine discharge point and extending downstream 6,500 feet. Additional studies were conducted in the fall of 1991 to determine whether the pattern has persisted and if so to identify a possible cause. This report represents a summary of the findings to date and provides several hypotheses as to the possible causes for the observed distribution of aquatic organisms.

2.0 ECCLES CREEK STUDIES

In June and September, 1990 and October 1991, a set of stream invertebrate samples were collected at 5 sites along Eccles Creek, 1 site in Clear Creek and several tributaries to the stream (Figure 2-1). Samples were identified and counted in the laboratory to the lowest possible classification. The results of this investigation can be seen in Figure 2-2. See Appendix 1 for invertebrate identification and counts for each site and each date.

All sample dates showed the same pattern. The mean number of individuals/m^2 and the total number of taxa were significantly lower below the mine site compared to the site directly above the mine. Sites farther downstream had fewer individuals and taxa than above the mine, but were similar to the Clear Creek Site. The zone of impact appeared to extend down to Clear Creek with maximum impacts occurring 6,500 feet downstream from the mine. A Community Tolerance Quotient (CTQ) was calculated for each site (Winget and Mangum, 1979, Biotic Condition Index: Integrated Biological, Physical, and Chemical Stream Parameters For Management, U.S. Forest Service). This value reflects the sensitivity of the taxa present to environmental stress, in particular to sulfates, alkalinity, substrate size and stream gradient (Figure 2-3). A higher value indicates greater tolerance to environmental stress (less sensitive taxa). The CTQ above the mine was lower than any of the other sites, suggesting that more sensitive taxa are able to survive at that site. The CTQ value was highest directly below the mine, and decreased going downstream indicating that the sensitive species have been replaced by more tolerant ones. Clear Creek had a value similar to Eccles Creek above the confluence.

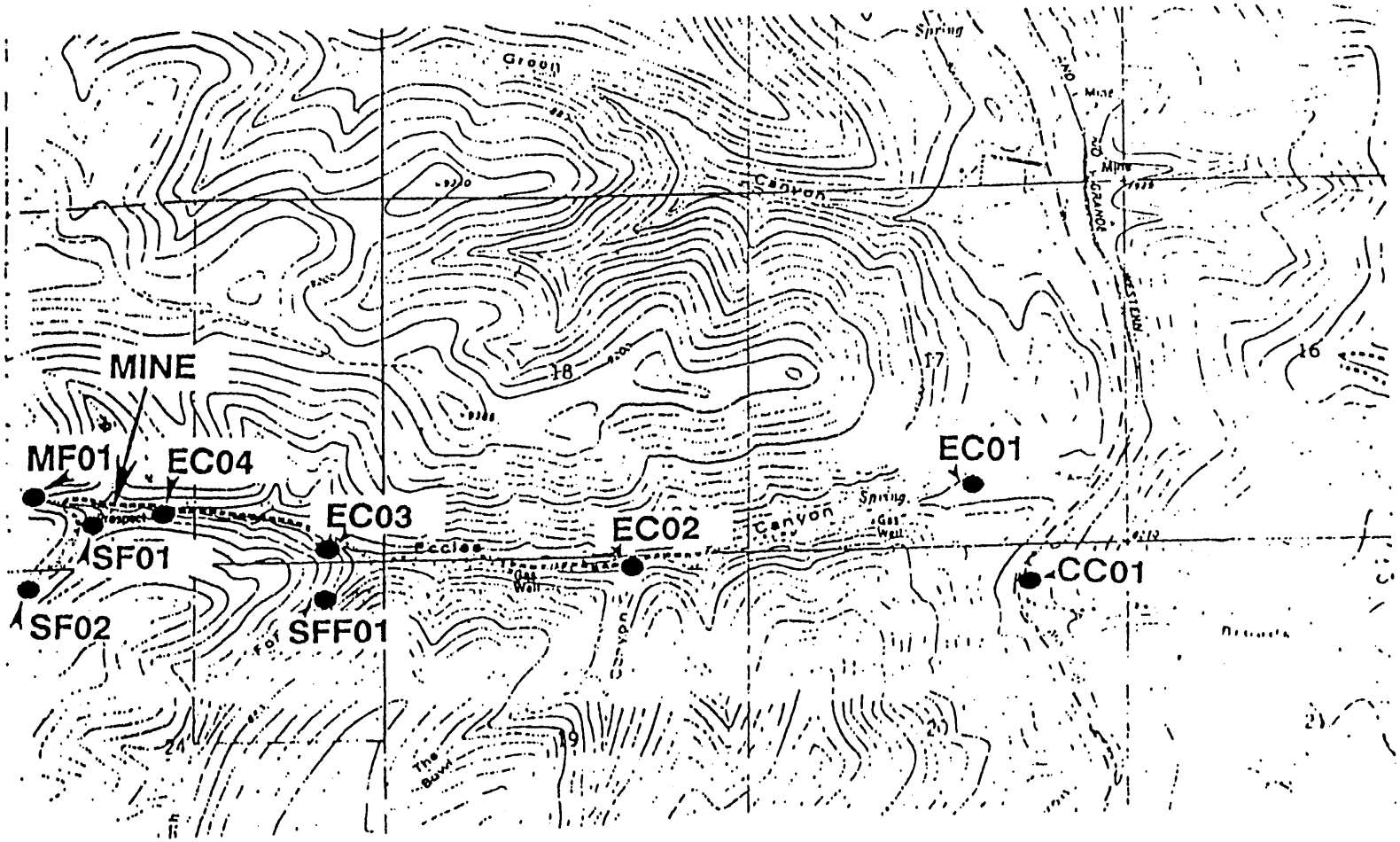

FIGURE 2-1. The location of sample sites in Eccles Creek above and below the Skyline Mine. Samples sites on tributaries are also noted

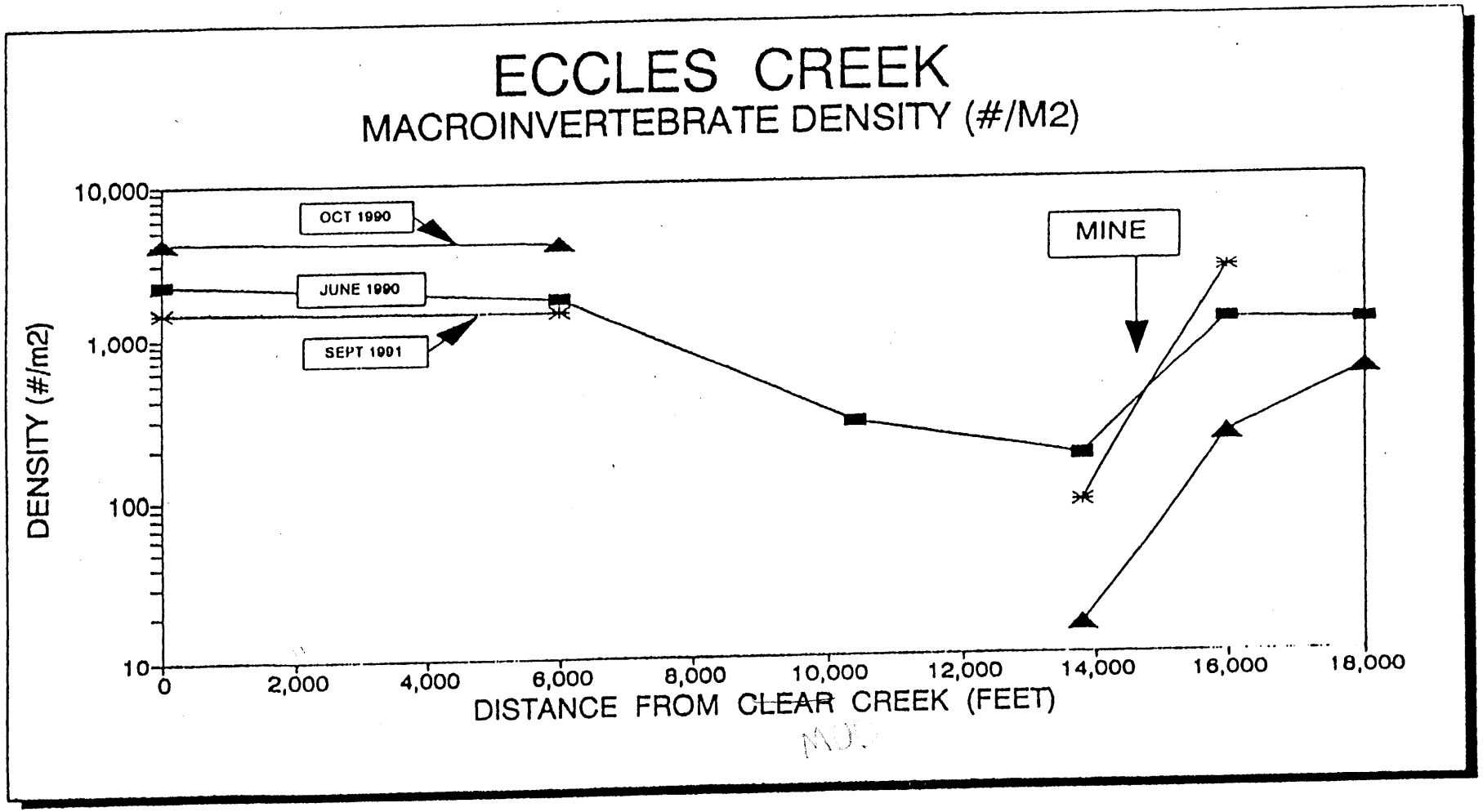

FIGURE 2-2. The spatial distribution of macroinvertebrate densities above and below the Skyline Mine. Data are for June and October, 1990 and September 1991.

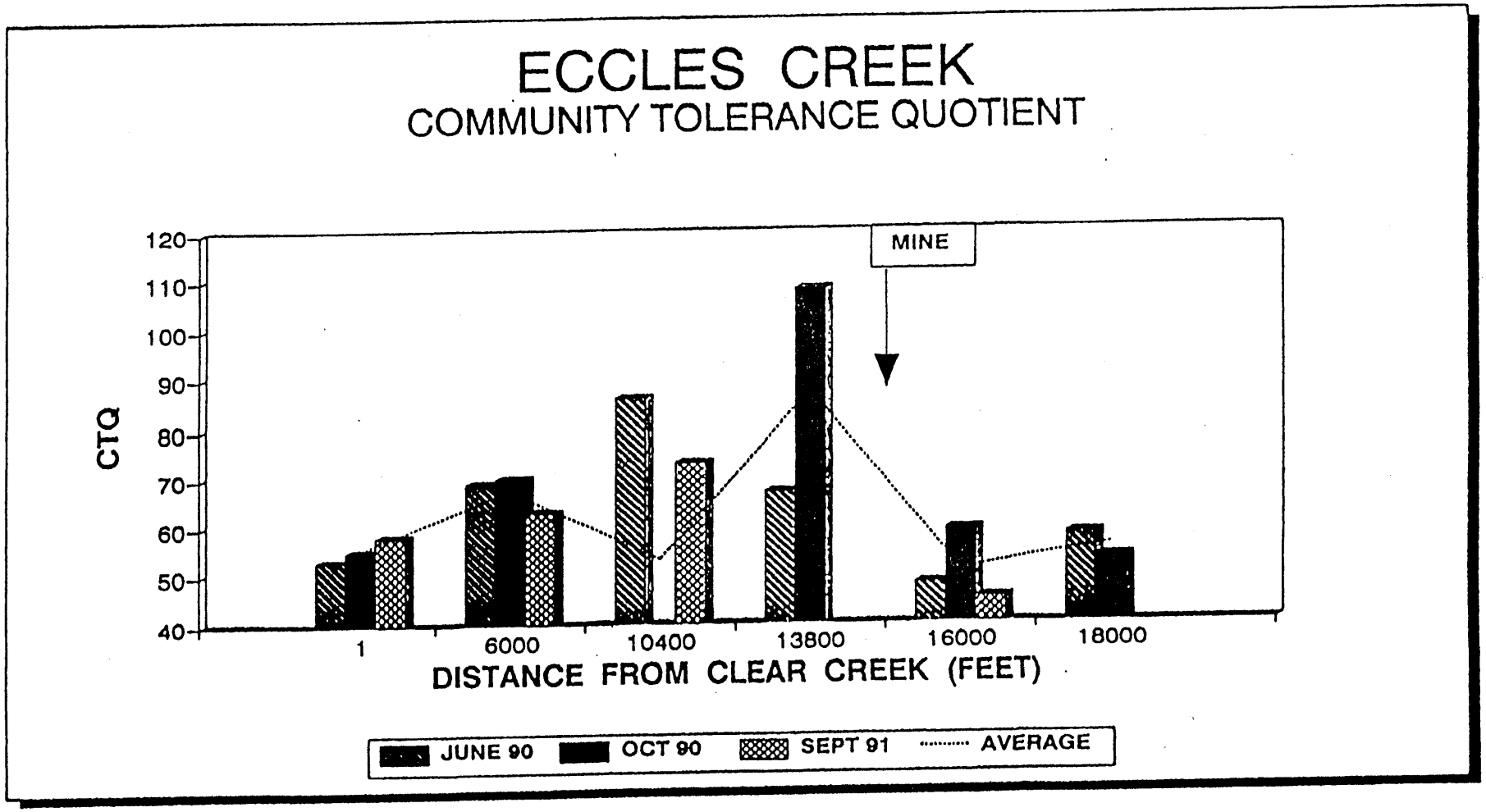

FIGURE 2-3. The Community Tolerance Quotient for macroinvertebrates collected at 6 stations in Eccles above and below the Skyline mine. High values indicate the presence of only tolerant species while low values are indications of the presence of environmentally sensitive macroinvertebrates species.

Aquatic plants (periphyton) were sampled as part of this investigation in triplicate in June 1990. Periphyton biomass can be seen in Figure 2-4. The spatial distribution of periphyton was very similar to that of the stream insects. Samples collected above the mine had significantly higher biomass levels than those immediately below the site.

In order to determine if the quality of water discharged from the mine was having a direct toxic effect on the stream biota, two sets of in situ bioassays were conducted in October, 1991 to assess short term toxicity effects. Mesh cages surrounding rock filled baskets and containing a known number of insect larvae were placed in the stream at the sample sites. After 4 days (96 hr), the cages were retrieved and living and dead animals were counted.

Results from the bioassays are shown in Table 2-1. Two different genera of insects were used to evaluate animals with different environmental tolerances. All animals survived well at all sites. In general animals that died appeared to have been crushed, possibly when the cages were being handled. This suggests that the stream water below the Skyline mine is not acutely toxic to stream invertebrates.

Because there was no evidence of acute toxicity in the instream bioassays, the differences observed in invertebrate abundance and tolerance suggest either chronic toxicity or physical rather than chemical effects. During the June, 1990 investigation, bed sediments were collected at each sample location. A comparison between the size fractions in ~~Clear~~ Mud Creek and Eccles Creek at its confluence (EC01) indicate no difference (Figure 2-5). However, a comparison of the sediment sizes within Eccles Creek (Figure 2-6) and specifically above and below the mine (Figure 2-7) indicate significant differences in the medium size particles. Those stations immediately below the mine and 4,000 feet downstream had significantly larger amounts of sediments in the 2 mm to 0.5 mm range. These medium to small sands made up 15-20% of the total sediment below the mine while above only 5% of the total was represented in this fraction (Figure 2-8).

medium - engineering
medium to very coarse - geology

The streambed directly below the mine is extremely embedded and our observations indicate very different sediment transport loads occurring at the different sites. The bioassay cages at the site below the mine were filled with sediment after only 4 days of incubation. Decreasing amounts of sediment had collected

TABLE 2-1. The results of the in situ macroinvertebrate bioassay conducted in Eccles Creek.

ASSAYS CONDUCTED WITH CERATOPSYCHE sp. (9/24/91 - 9/28/91)

LOCATION	NUMBER IN BASKET		
	Initial	Final	
		Live	Dead
Eccles Creek at Clear Creek (EC01)	20	9	0
	20	15	1
Eccles Creek above Whiskey Creek (EC02)	20	20	0
	20	13	1
Eccles Creek below mine (EC04)	20	11	0
	20	18	0
South Fork Eccles Creek above mine (SF01)	20	8	0
	20	8	3*
Clear Creek above Eccles Creek (CC01)	20	12	2*
	20	15	0

ASSAYS CONDUCTED WITH PTERONARCYS sp. (10/5/91 - 10/9/91)

LOCATION	NUMBER IN BASKET		
	Initial	Final	
		Live	Dead
Eccles Creek at Clear Creek (EC01)	10	10	0
	19	10	0
Eccles Creek below mine (EC02)	10	9	0
	10	10	0
South Fork Eccles Creek above mine (EC04)	10	10	0
	10	5	5*
Clear Creek above Eccles Creek (SF01)	9	9	0
	10	10	0

* Animals appeared crushed

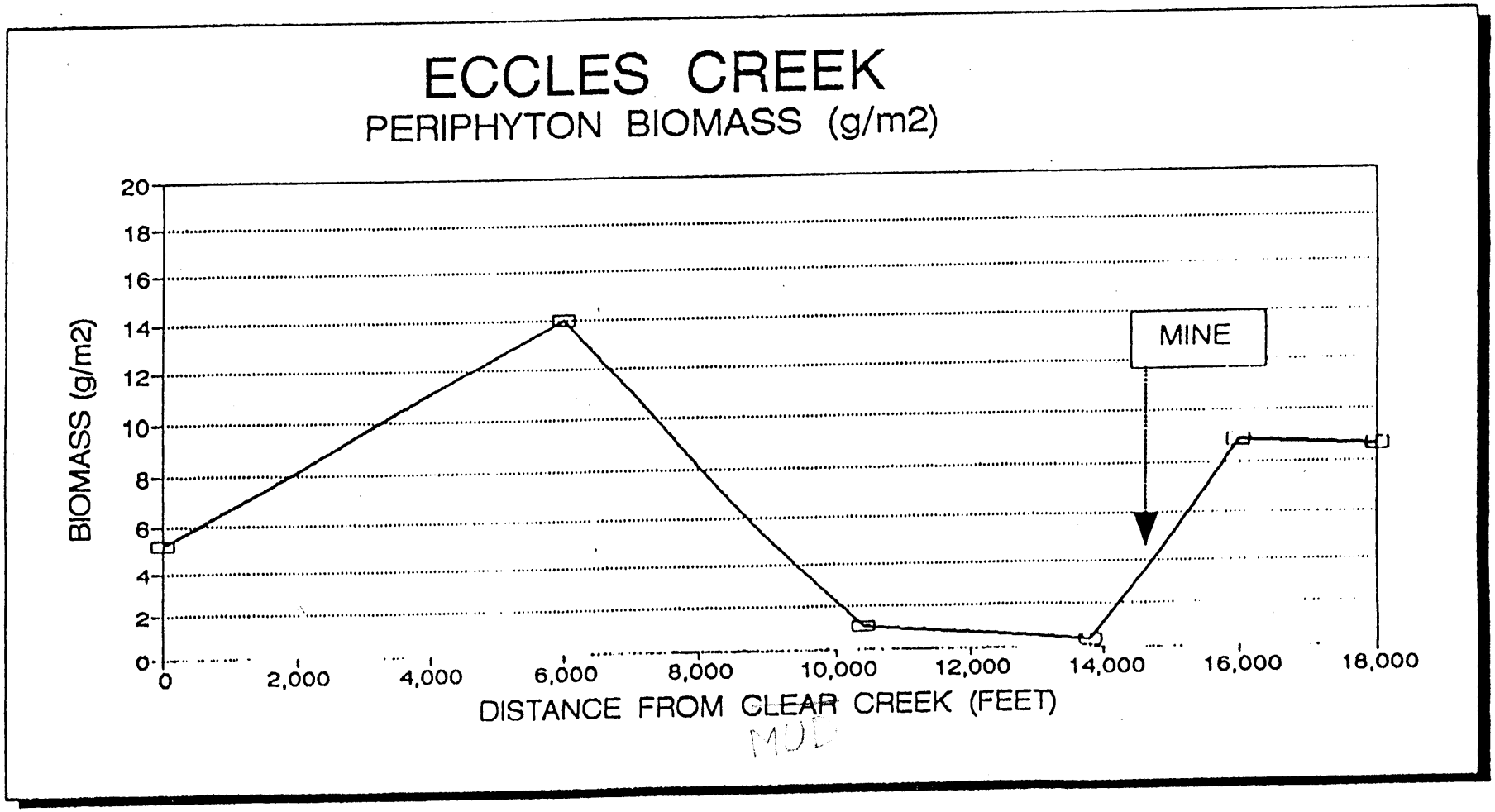

FIGURE 2-4. The spatial distribution of periphyton biomass above and below the Skyline Mine. Data are from June, 1990.

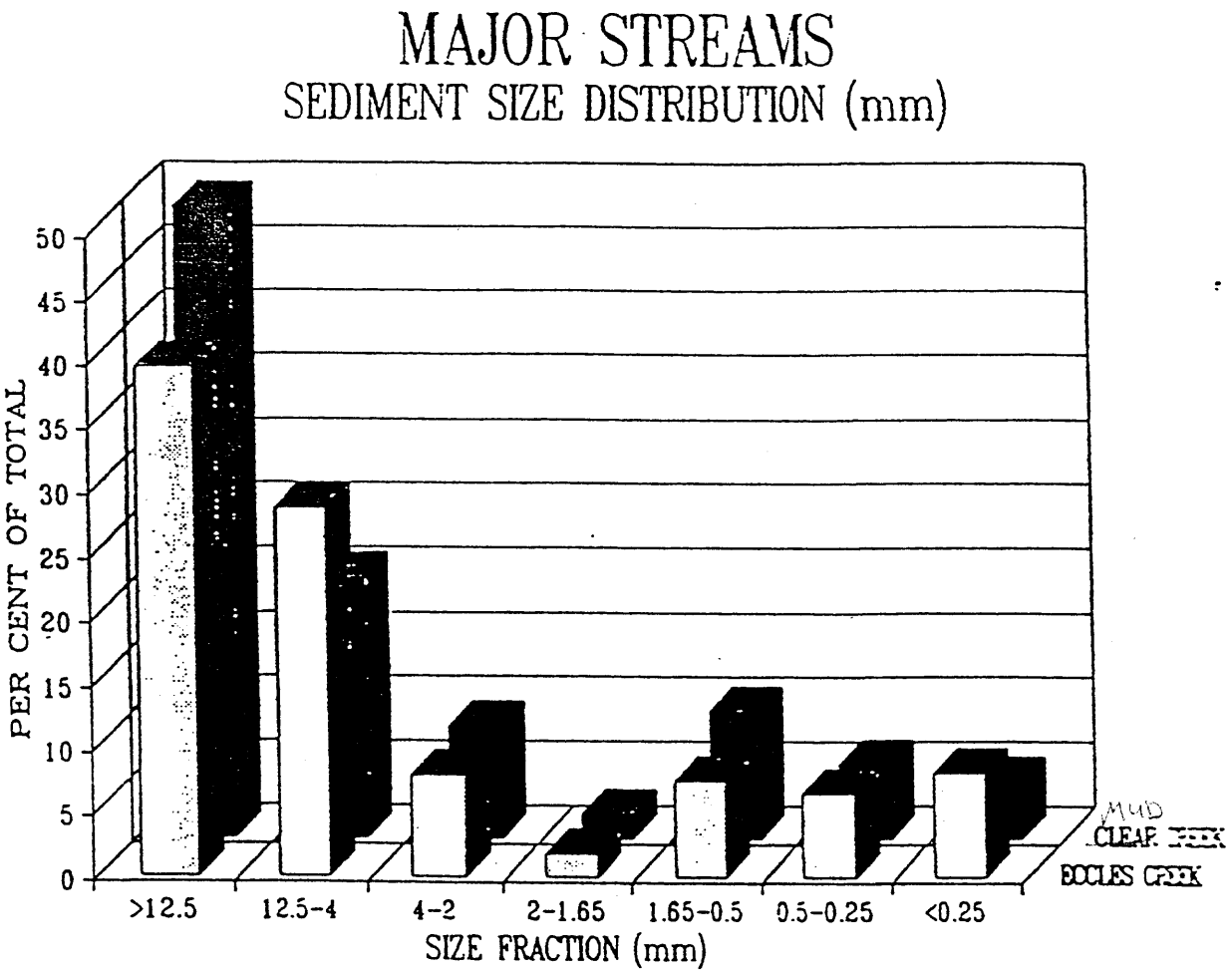

FIGURE 2-5. The size distributions of bed sediments in ~~Clear~~ MUD Creek (CC01) and Eccles Creek (EC01) near the confluence with ~~Clear~~ MUD Creek.

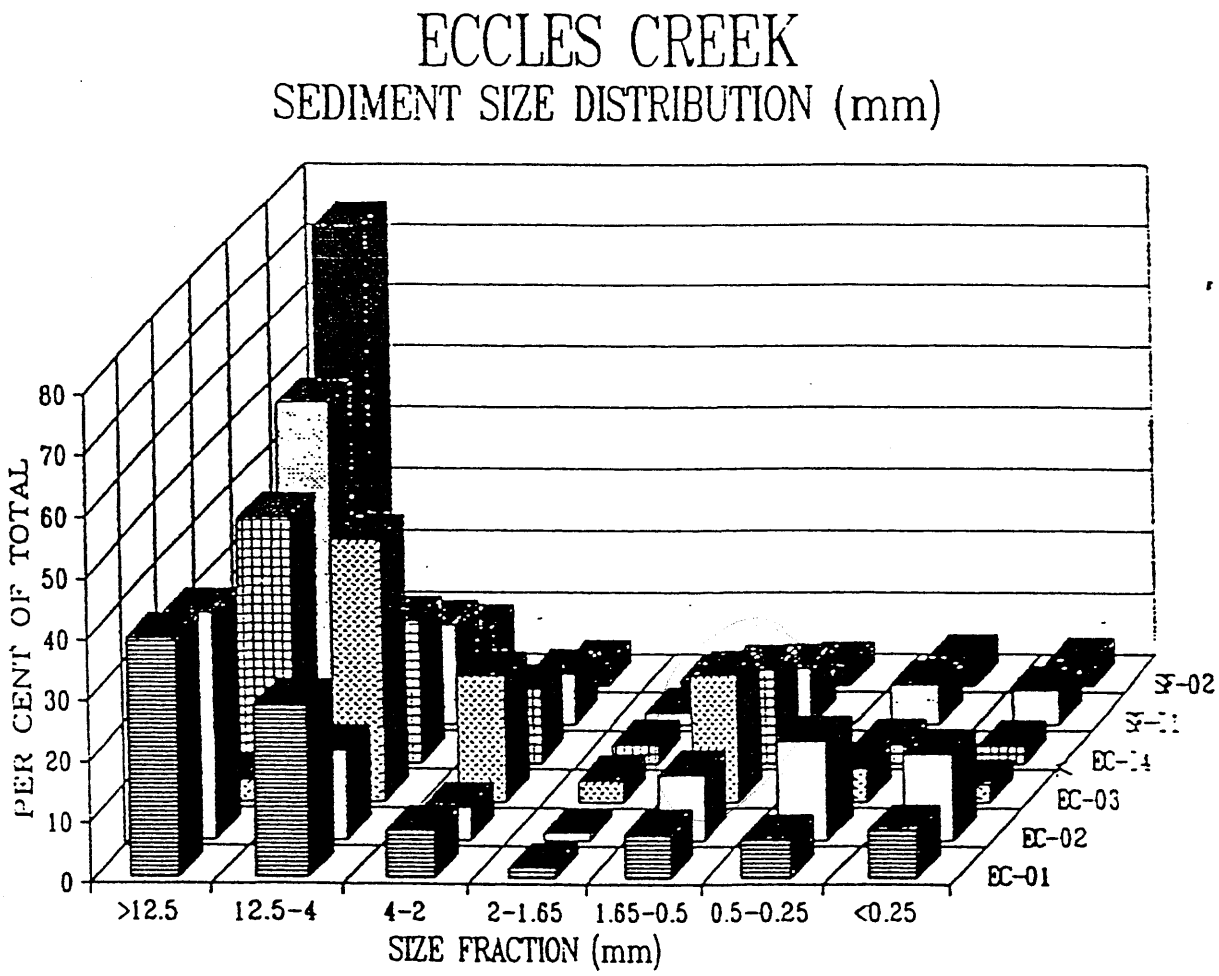

FIGURE 2-6. The size distributions of bed sediments in the Eccles Creek stations.

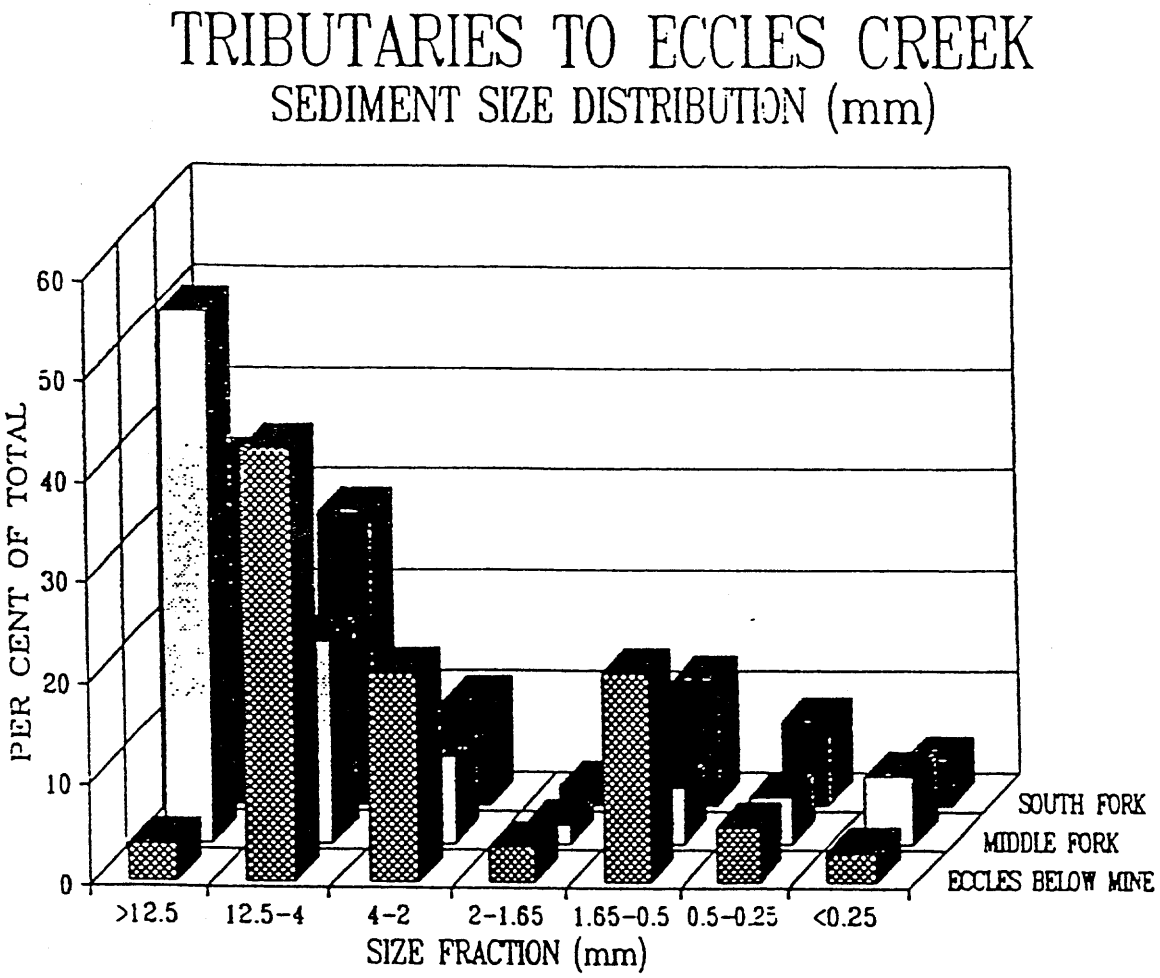

FIGURE 2-7. The size distributions of bed sediments above and below Skyline Mine. The middle and south forks are above the mine.

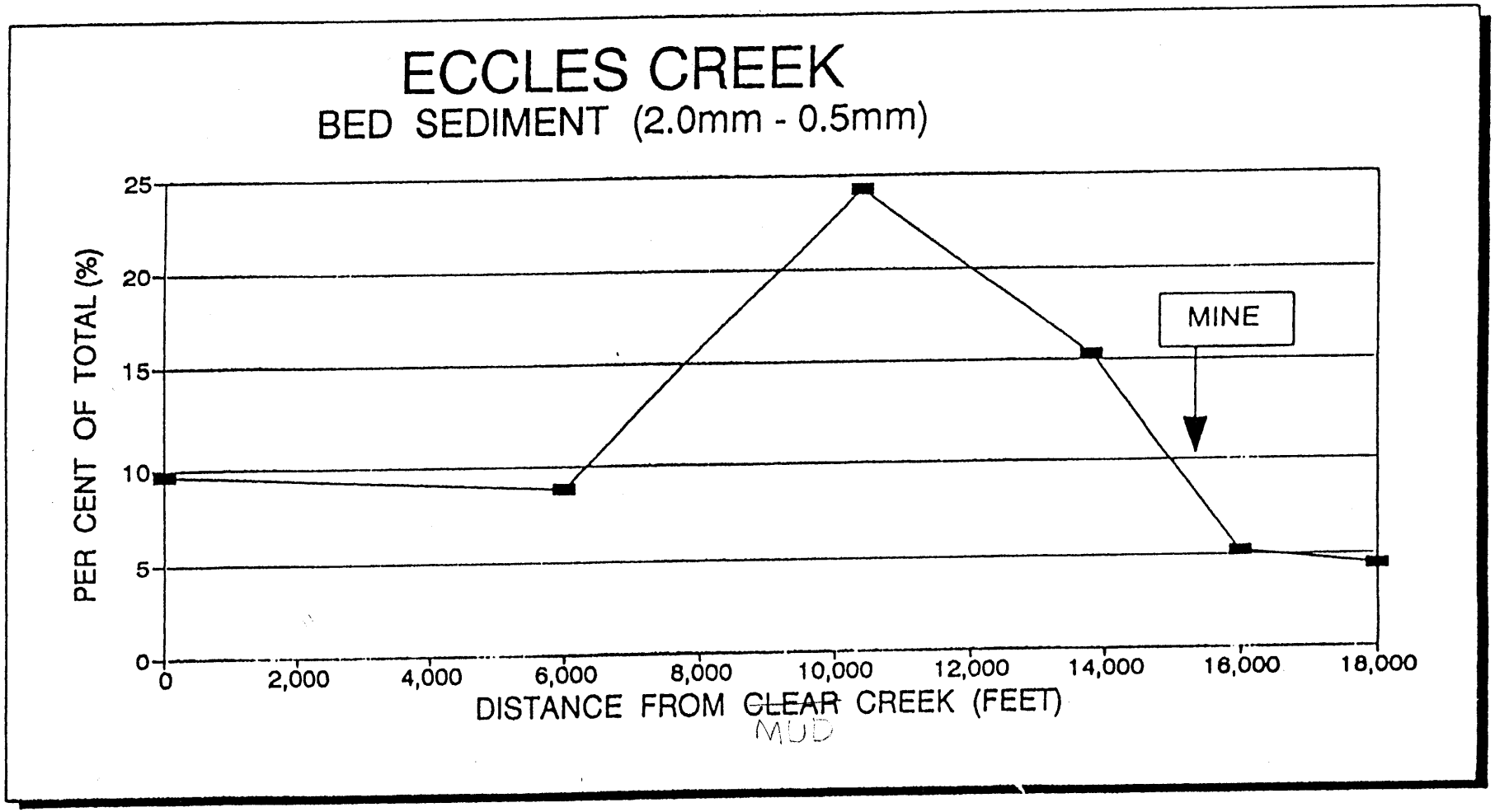

FIGURE 2-8. The % of the total sediment in the size range of 2 mm to 0.5 mm at each station sampled in Eccles Creek. Note the location of the mine 15,500 feet above the confluence with Clear Creek.

MUD

in the downstream cages, and the site above the mine had very little sediment within the cages at the conclusion of the study. To evaluate this, sediment traps were buried in the streambeds at sites above and below the mine and in Clear Creek. The 2 traps below the mine could not be located 1 week later and apparently had washed out or were covered with sediment.

Recommendations

Sediment transport in Eccles Creek should be further evaluated. If invertebrates are limited by heavy sedimentation or a severely embedded substrate, a means of reducing suspended sediments may resolve the problem of reduced invertebrate and periphyton abundance and diversity near the mine site. A chemical gradient does exist along Eccles Creek due to discharges from the mine, however, and it is believed that this chemical gradient will persist for a few years longer (see following section). In September when the bioassay cages were placed, conductivity was highest immediately below the mine, and lowest immediately above the mine (Table 2-2). This pattern has been observed in past data as well. Although the bioassay results indicate no acute toxicity, chronic toxicity tests may help demonstrate whether a longer term chemical impact is occurring. The simplest method for sorting out physical vs. chemical causes will be to place invertebrate baskets at each site and monitor colonization rates concurrent with sedimentation rates. It may also be beneficial to physically disturb the bottom substrate in Eccles Creek below the mine during a high flow period. This would allow natural flushing to occur, would eliminate the embedded nature of the substrate, and clean the substrate of medium sized sands. This should allow new colonization of invertebrates to occur. This activity could be experimentally tried in a short reach, with the resulting substrate quality and invertebrate community being monitored for success.

3.0 ROCK DUST DISSOLUTION EXPERIMENTS

Skyline's #3 mine (2 North Mains area) is currently discharging water with high TDS (average 2.18 g/l) and high sulfate (average 1.0 g/l) concentrations. Sulfate bearing rockdust containing gypsum was used

TABLE 2-2. Eccles Creek conductivities and temperatures measured at the conclusion of the macroinvertebrate in situ bioassay.

LOCATION	CONDUCTIVITY (umhos/cm)	TEMPERATURE (C)
Eccles Creek at ~~Clear~~ Mud Creek (EC01)	1000	12
Eccles Creek above Whiskey Creek (EC02)	1050	13
Eccles Creek below mine (EC04)	1125	12
South Fork Eccles Creek above mine (SF01)	320	9
Clear Creek above Eccles Creek (CC01)	500	9

in this mine area which is now being inundated with ground water. This study was conducted to determine the total potential yield of TDS and sulfate from this area of the mine, and to predict how long these elevated concentrations may occur in discharge water.

3.1 Dissolution Experiments

A series of dissolution experiments was conducted to determine the potential yield of TDS from this mine area. Ground water that discharges into the mine was used as dilution water. A carefully measured amount of rockdust was added to 1 liter of water, stirred for 1 hour (contact time) then filtered. TDS and sulfate were measured in the filtrate and the remaining rockdust was returned to the beaker with 1 liter of fresh dilution water. This process was repeated until the TDS and sulfate in the filtrate fell to background concentrations originally measured the dilution water.

Figures 3-1 and 3-2 show results from these experiments. At the lower initial rockdust concentration (10 g/l) the first solution produced water with very high TDS and sulfate concentrations which fell rapidly to background concentrations by the third dilution. At higher initial rockdust concentrations, TDS remained at approximately 2.25 g/l through a series of dilutions, then fell to background concentrations within 2 to 3 dilutions. Higher initial rockdust concentrations resulted in a longer series of dilutions before the concentrations were reduced.

Sulfate concentrations behaved differently than TDS in the filtrate. At the lowest initial rockdust concentration, the highest sulfate concentration was observed in the first dilution, and concentrations dropped in subsequent dilutions. At higher rockdust concentrations, sulfate concentration actually increased over the first several dilutions. At the highest rockdust concentration (50 g/l), a saturated concentration of 2.5 mg/l sulfate was reached. The inconsistent responses of the solutions, depending on initial rockdust concentration, may be due to interactions between calcite and sulfate in the solution.

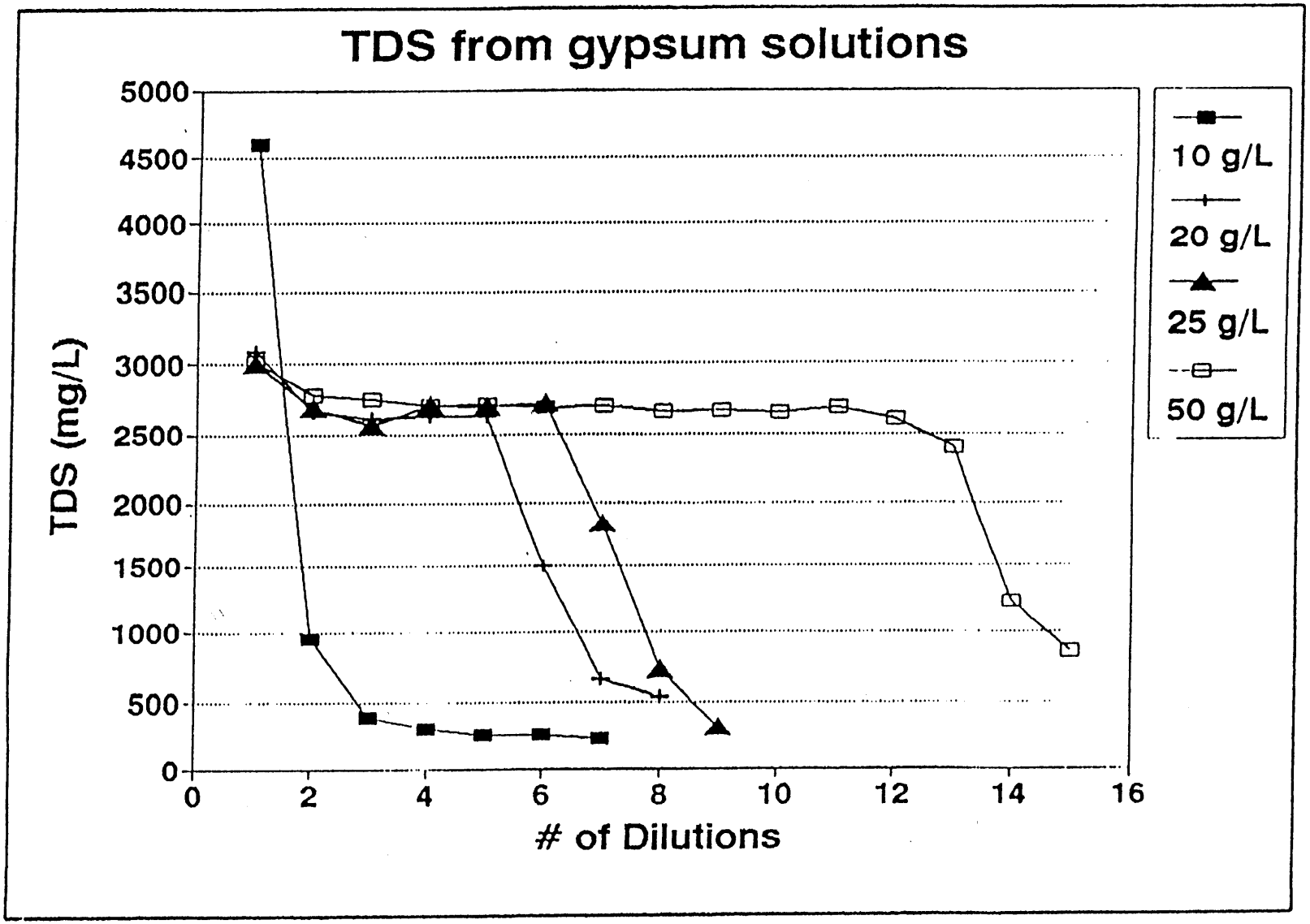

FIGURE 3-1. The concentration of TDS (mg/l) after sequential #'s of dilutions. Each curve represents a different initial concentration of gypsum solutions.

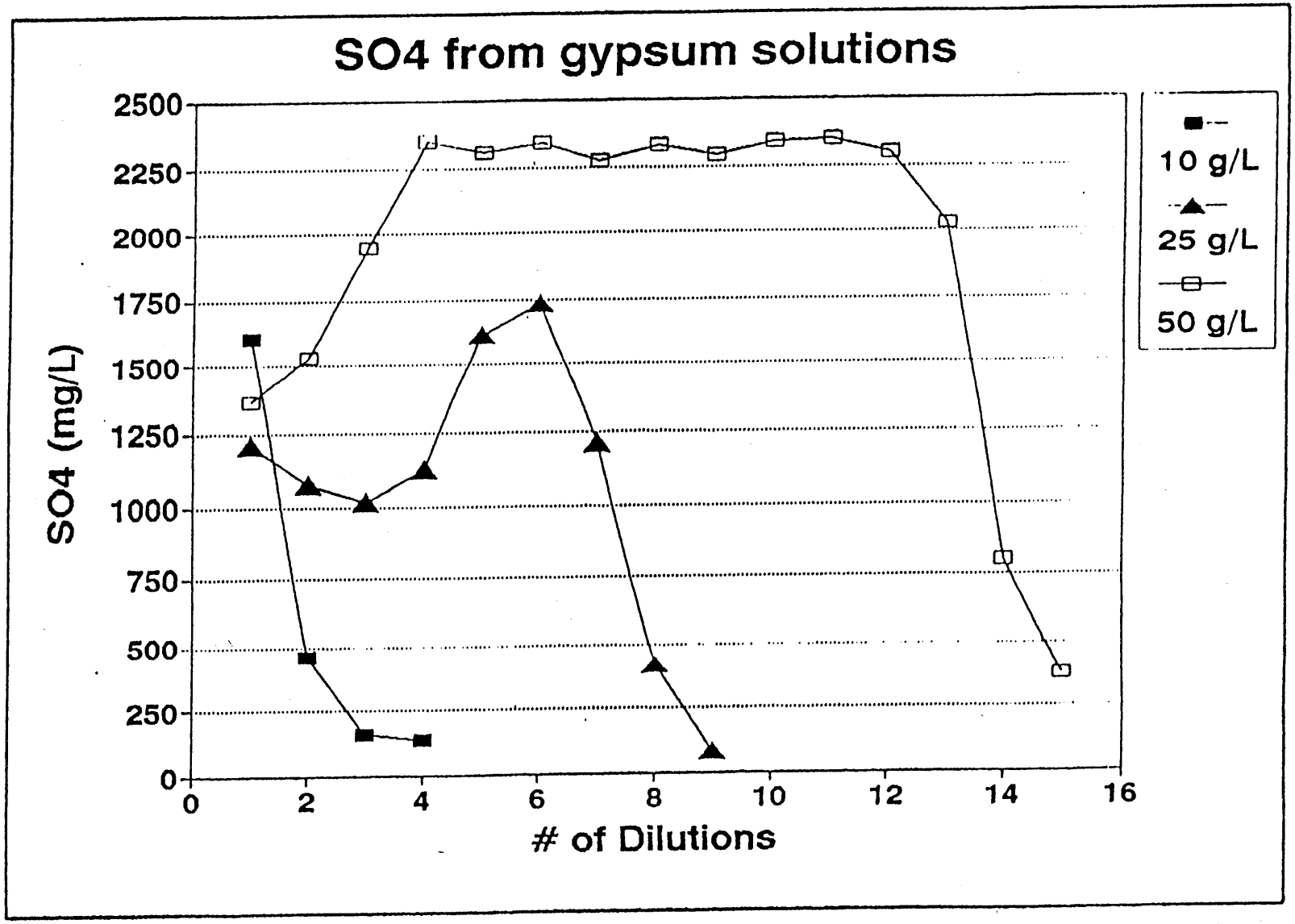

FIGURE 3-2. The concentration of Sulfate (SO_4) after sequential #'s of dilutions. Each curve represents a different initial concentration of gypsum solutions.

3.1 Discussion

Based on sulfate and TDS concentrations in the mine discharge it appears that the relative concentration of residual rock dust to mine accrual water is probably around 25 g/l. The TDS and sulfate measured in discharge water from November 1990 to December 1991 were similar to those concentrations measured in the laboratory studies in the 25 g/l. Sulfate increased from an average of 1.0 g/l to 1.7 g/l over time in the discharge water, but has since remained relatively constant at the latter concentration. TDS has remained fairly constant over the same period at 2.7 g/l. This level was attained in the laboratory studies in the 20 to 50 g/l treatments. The very high SO_4 concentration resulting from the highest rockdust concentrations is probably at a supersaturated state and would not be observed in the mine discharge.

Mass calculations of total TDS yield from the rockdust were relatively consistent throughout all these treatments. On average, 1 g of rockdust yielded 0.4 g TDS. Assuming 75 million gallons have been discharged from the mine area to date, and an average concentration of 1200 mg/l TDS in the discharge, approximately 625 tons of TDS have been discharged from the mine. Background concentrations account for approximately 94 tons of TDS. The resulting 531 tons of TDS is equivalent to approximately 1330 tons of rockdust. Skyline estimates that between 1200 and 2400 tons of rockdust were applied to this mine area. This suggests that at the very worst, half the TDS potential from this rockdust has already been discharged. The dissolution experiments also indicate that the discharge concentration will probably remain relatively constant at approximately 2 g/l until most of the TDS has been leached from the rockdust. At that point, TDS should drop fairly quickly. Sulfate should not rise above approximately 1.7 g/l and should fall as the TDS concentrations decline.

APPENDIX I

Macroinvertebrate Identification and Counts

Table 1-1. Aquatic macroinvertebrate abundance, taxa richness, diversity and environmental tolerance in Eccles Creek (EC01) for 28 September, 1991.

Taxa	Counts per sample			Number/m2		TQ
	1	2	3	Mean	Std Dev	
Oligochaeta	—	1	1	5.4	3.8	108
Ephemeroptera						
Baetidae						
Baetis	141	84	174	1078.7	301.5	72
Heptageniidae						
Epeorus	1	—	—	2.7	3.8	21
Trichoptera						
Brachycentridae						
Brachycentrus	8	15	6	78.4	31.3	24
Lepidostomatidae						
Lepidostoma	—	—	1	2.7	3.8	18
Hydropsychidae						
Arctopsyche	1			8.1	0.0	18
Ceratopsyche	37	21	23	219.0	57.7	
Rhyacophilidae						
Rhyacophila	1	2	—	8.1	6.6	18
Coleoptera						
Dryopidae						
Helichus	—	1	—	2.7	3.8	
Elmidae						
Optioservus	—	2	—	5.4	7.6	108
Diptera						
Chironomidae	5	4	4	35.1	3.8	108
Empididae						
Chelifera	—	1	1	5.4	3.8	
Stratiomyidae						
Euparyphus	1	1	—	5.4	3.8	108
Tipulidae						
Tipula	2	3	—	13.5	10.1	36
Total number	197	135	211	1468.0	267.8	
Total taxa	9	11	8			
Diversity Index	0.404	0.559	0.284	0.416	0.113	
Community Tolerance Quotient						58.1

Table 1-2. Aquatic macroinvertebrate abundance, taxa richness, diversity and environmental tolerance in Eccles Creek (EC02) for 28 September, 1991.

Taxa	Counts per sample			Number/m2		TQ
	1	2	3	Mean	Std Dev	
Oligochaeta	1	4	17	59.5	56.3	108
Ephemeroptera						
Baetidae						
Baetis	50	61	43	416.3	60.1	72
Ephemerellidae						
Drunella	2	—	—	5.4	7.6	
Plecoptera						
Perlodidae						
Isoperla	—	—	1	2.7	3.8	48
Trichoptera						
Brachycentridae						
Brachycentrus	20	25	38	224.4	61.5	24
Hydropsychidae						
Ceratopsyche	85	83	41	565.0	164.5	
Lepidostomatidae						
Lepidostoma	3	—	—	8.1	11.5	18
Limnephilidae						
Dicosmoecus	1	2	1	10.8	3.8	24
Rhyacophilidae						
Rhyacophila	1	1	1	8.1	0.0	18
Coleoptera						
Dryopidae						
Helichus	—	—	3	8.1	11.5	
Diptera						
Chironomidae	3	1	1	13.5	7.6	108
Empididae						
Hemerodromia	—	—	1	2.7	3.8	108
Stratiomyidae						
Euparyphus	3	9	10	59.5	25.1	108
Tipulidae						
Hexatoma	—	—	1	2.7	3.8	36
Tipula	4	3	3	27.0	3.8	36
Hydracarina	—	1	1	5.4	3.8	108
Total number	173	190	162	1419.3	93.4	
Total taxa	11	10	14			
Diversity Index	0.604	0.605	0.789	0.666	0.087	
Community Tolerance Quotient						62.8

Table 1-3. Aquatic macroinvertebrate abundance, taxa richness, diversity and environmental tolerance in Eccles Creek (EC03) for 28 September, 1991.

Taxa	Counts per sample			Number/m2		TQ
	1	2	3	Mean	Std Dev	
Oligochaeta	1	—	17	48.7	63.2	108
Ephemeroptera						
Baetidae						
Baetis	3	—	3	16.2	11.5	72
Plecoptera						
Nemouridae						
Zapada	—	—	1	2.7	3.8	16
Hemiptera						
Unidentified larva	—	1	—	2.7	3.8	
Trichoptera						
Brachycentridae						
Brachycentridae	1	—	—	2.7	3.8	24
Hydropsychidae						
Ceratopsyche	4	—	—	10.8	15.3	
Diptera						
Chironomidae	1	—	—	2.7	3.8	108
Empididae						
Hemerodromia	—	1	—	2.7	3.8	108
Total number	9	2	22	89.2	67.2	
Total taxa	4	2	4			
Diversity Index	0.634	0.301	0.266	0.400	0.166	
Community Tolerance Quotient						72.7

Table 1-4. Aquatic macroinvertebrate abundance, taxa richness, diversity and environmental tolerance in South Fork (SF01) for 28 September, 1991.

Taxa	Counts per sample			Number/m2		TQ
	1	2	3	Mean	Std Dev	
Ephemeroptera						
Baetidae						
Baetis	246	15	44	824.5	833.3	72
Ephemerellidae						
Drunella	—	15	3	48.7	52.6	
Heptageniidae						
Cinygmula	213	73	98	1038.1	494.4	21
Siphlonuridae						
Ameletus	10	4	6	54.1	20.2	48
Plecoptera						
Chloroperlidae						
Sweltsa	4	3	3	27.0	3.8	24
Nemouridae						
Zapada	26	15	17	156.8	38.8	16
Perlodidae						
Isoperla	13	1	—	37.8	47.9	48
Megarcys	—	1	—	2.7	3.8	24
Trichoptera						
Brachycentridae						
Brachycentrus	—	4	3	18.9	13.8	24
Hydropsychidae						
Ceratopsyche	13	1	4	48.7	41.4	108
Parapsyche	3	2	—	13.5	10.1	6
Lepidostomatidae						
Lepidostoma	1	—	—	2.7	3.8	18
Limnephilidae						
Neothremma	—	—	1	2.7	3.8	8
Rhyacophilidae						
Rhyacophila	19	9	16	119.0	34.0	18
Coleoptera						
Dryopidae						
Helichus	—	3	1	10.8	10.1	
Elmidae						
Optioservus	4	2	1	18.9	10.1	108
Diptera						
Chironomidae	—	—	1	2.7	3.8	108
Psychodidae						
Pericoma	1	—	—	2.7	3.8	36
Stratiomyidae						
Euparyphus	—	2	1	8.1	6.6	108
Tipulidae						
Dicranota	—	1	—	2.7	3.8	24
Tipula	1	1	—	5.4	3.8	36
Total number	554	152	202	2454.7	1450.8	
Total taxa	13	17	15			
Diversity Index	0.595	0.820	0.692	0.702	0.092	
Community Tolerance Quotient						45

Table 1-5. Aquatic macroinvertebrate abundance, taxa richness, diversity and environmental tolerance in Clear Creek (CC01) for 28 September, 1991.

Taxa	Counts per sample			Number/m2		TQ
	1	2	3	Mean	Std Dev	
Oligochaeta	—	1	—	2.7	3.8	108
Ephemeroptera						
Baetidae						
Baetis	—	64	69	359.6	254.8	72
Ephemerellidae						
Serratella	—	6	2	21.6	20.2	
Plecoptera						
Perlodidae						
Isoperla	—	14	5	51.4	47.0	48
Pteronarcyidae						
Pteronarcys	—	5	1	16.2	17.5	
Trichoptera						
Brachycentridae						
Brachycentrus	—	35	12	127.1	117.8	24
Hydropsychidae						
Ceratopsyche	6	80	108	524.5	349.0	
Parapsyche	2	—	—	5.4	7.6	6
Lepidostomatidae						
Lepidostoma	—	1	—	2.7	3.8	18
Coleoptera						
Dryopidae						
Helichus	—	7	3	27.0	23.3	
Elmidae						
Optioservus	1	22	26	132.5	88.9	108
Diptera						
Chironomidae	1	2	3	16.2	6.6	108
Stratiomyidae						
Euparyphus	—	1	—	2.7	3.8	108
Tipulidae						
Antocha	1	1	1	8.1		24
Dicranota	—	3	—	8.1	11.5	24
Hexatoma	—	1	—	2.7	3.8	36
Hydracarina	1	3	8	32.4	23.9	108
Total number	12	246	238	1340.9	879.7	
Total taxa	6	16	11			
Diversity Index	0.640	0.826	0.652	0.706	0.08	
Community Tolerance Quotient						60.9

Table 2-1. Aquatic macroinvertebrate abundance, taxa richness, diversity and environmental tolerance in Eccles Creek (ECO1) for October 1990.

Taxa	Counts per sample	TQ
Oligochaeta	22	108
Ephemeroptera		
Baetidae		
Baetis	63	72
Ephemerellidae		
Drunella	1	
Plecoptera		
Perlodidae		
Isoperla	6	48
Tricoptera		
Brachycentridae		
Brachycentrus	11	24
Hydropsychidae		
Ceratopsyche	109	
Rhyacophilidae		
Rhyacophila	6	18
Coleoptera		
Elmidae		
Heterlimnius	1	
Diptera		
Chiromomidae	120	108
Empididae		
Chelifera	21	
Stratiomyidae		
Caloparyphus	1	
Tipulidae		
Antocha	141	24
Tipula	4	36
Total Number	**506**	
Total taxa	**13**	
Density (number/m2)	**4104**	
Diversity Index	**1.8**	
Community Tolerance Quotient		**54.8**

Table 2-2. Aquatic macroinvertebrate abundance, taxa richness, diversity and environmental tolerance in Eccles Creek (ECC1-A) for October 1990

Taxa	Counts per sample	TQ
Oligochaeta	17	108
Ephemeroptera		
Baetidae		
Baetis	264	72
Ephemerellidae		
Drunella	2	
Plecoptera		
Perlodidae		
Isoperla	2	48
Tricoptera		
Brachycentridae		
Brachycentrus	28	24
Hydropsychidae		
Ceratopsyche	28	
Rhyacophilidae		
Rhyacophila	5	18
Diptera		
Chironomidae	4	108
Empididae		
Chelifera	1	
Stratiomyidae		
Caloparyphus	1	
Tipulidae		
Antocha	1	24
Total number	**353**	
Total taxa	**11**	
Density (number/m2)	**2863**	
Diversity Index	**1.4**	
Community Tolerance Quotient		**57.4**

Table 2-3. Aquatic macroinvertebrate abundance, taxa richness, diversity and environmental tolerance in Eccles Creek (EC02) for October 1990

Taxa	Counts per sample	TQ
Oligochaeta	21	108
Turbellaria	3	108
Ephemeroptera		
Baitidae		
Baetis	231	72
Ephemerellidae		
Drunella	1	21
Plecoptera		
Chloroperlidae		
Utaperla	1	
Nemouridae		
Zapada	8	16
Tricoptera		
Brachycentridae		
Brachycentrus	40	24
Hydropsychidae		
Ceratopsyche	114	
Hydroptilidae		
Hydroptila	1	108
Rhyacophilidae		
Rhyacophila	1	18
Coleoptera		
Elmidae		
Heterlimnius	1	
Diptera		
Chironomidae	16	108
Muscidae		
Limnophora	3	108
Simulidae		
Simulium	1	108
Stratiomyidae		
Caloparyphus	1	
Euparyphus	2	108
Tipulidae		
Hexatoma	1	36
Tipula	45	36
Total Number	491	
Total Taxa	18	
Density (number/m2)	3928	
Diversity Index	1.6	
Community Tolerance Quotient		69.9

Table 2-4. Aquatic macroinvertebrate abundance, taxa richness, diversity and environmental tolerance in Eccles Creek (EC04) for October 1990

Taxa	Counts per sample	TQ
Oligochaeta	1	108
Tricoptera		
Hydropsychidae		
Ceratopsyche	1	
Total Number	2	
Total Taxa	2	
Density (number/m2)	16	
Diversity Index	0.7	
Community Tolerance Quotient		108

Table 2-5. Aquatic macroinvertebrate abundance, taxa richness, diversity and environmental tolerance in Eccles Creek (SF01) for October 1990.

Taxa	Counts per sample	TQ
Turbellaria	1	108
Ephemeroptera		
Baetidae		
Baetis	1	72
Heptageniidae		
Cinygmula	3	21
Siphlonuridae		
Ameletus	5	48
Plecoptera		
Nemouridae		
Zapada	5	16
Tricoptera		
Limnephilidae		
Hesperophylax	1	108
Rhyacophilidae		
Rhyacophila	2	18
Diptera		
Chironomidae	1	108
Tipulidae		
Tipula	8	36
Total Number	27	
Total Taxa	9	
Density (number/m2)	216	
Diversity Index	1.9	
Community Tolerance Quotient		59.4

Table 2-6. Aquatic macroinvertebrate abundance. taxa richness, diversity and environmental tolerance in Eccles Creek (SF02) for October 1990.

Taxa	Counts per sample	TQ
Oligochaeta	1	108
Ephemeroptera		
Baetidae		
Baetis	27	72
Heptageniidae		
Cinygmula	3	21
Plecoptera		
Nemouridae		
Zapada	6	16
Tricoptera		
Hydropsychidae		
Arctopsyche	2	18
Limnephilidae		
Neothremma	2	8
Rhyacophilidae		
Rhyacophila	13	18
Coleoptera		
Elmidae		
Optioservus	2	108
Diptera		
Chironomidae	6	108
Empididae		
Chelifera	1	
Psychodidae		
Pericoma	1	
Stratiomyidae		
Caloparyphus	2	
Total Number	66	
Total Taxa	12	
Density (number/m2)	528	
Diversity Index	1.9	
Community Tolerance Quotient		53.0

Table 2-7. Aquatic macroinvertebrate abundance, taxa richness, diversity and environmental tolerance in Eccles Creek (MF01) for October 1990.

Taxa	Counts per sample	TQ
Turbellaria	6	108
Ephemeroptera		
Baetidae		
Baetis	200	72
Heptageniidae		
Cinygmula	35	21
Plecoptera		
Chloroperlidae		
Utaperla	4	
Nemouridae		
Amphinemura	39	6
Zapada	40	16
Perlodidae		
Isoperla	13	48
Skwala	1	18
Tricoptera		
Hydropsychidae		
Arctopsyche	28	18
Limnephilidae		
Dicosmoecus	1	24
Neothremma	2	8
Rhyacophilidae		
Rhyacophila	18	18
Coleoptera		
Elmidae		
Optioservus	1	108
Diptera		
Chironomidae	93	108
Empididae		
Chelifera	2	
Clinocera	2	
Psychodidae		
Pericoma	1	
Hydracarina	1	108
Terrestrial	2	
Total Number	**489**	
Total Taxa	**19**	
Density (number/m2)	**3912**	
Diversity Index	**1.9**	
Community Tolerance Quotient		**48.6**

Table 2-8. Aquatic macroinvertebrate abundance, taxa richness, diversity and environmental tolerance in Eccles Creek (CC01) for October 1990.

Taxa	Counts per sample	TQ
Turbellaria	1	108
Ephemeroptera		
Baetidae		
Baetis	26	72
Ephemerellidae		
Drunella	3	21
Ephemerella	1	48
Plecoptera		
Perlodidae		
Isoperla	4	48
Tricoptera		
Brachycentridae		
Brachycentrus	4	24
Hydropsychidae		
Ceratopsyche	25	
Coleoptera		
Elmidae		
Heterlimnius	5	
Diptera		
Chironomidae	1	108
Tipulidae		
Antocha	15	24
Hexatoma	3	36
Total Number	88	
Total Taxa	11	
Density (number/m2)	704	
Diversity Index	1.9	
Community Tolerance Quotient		54.3

Table 3-1. Aquatic macroinvertebrate abundance, taxa richness, diversity and environmental tolerance in Eccles Creek (EC01) for June 1990.

Taxa	Counts per sample		TQ
	1	2	
Oligochaeta	1	8	108
Ephemeroptera			
Baetidae			
Baetis	-	3	72
Ephemerellidae			
Drunella	-	1	
Trichoptera			
Brachycentridae			
Brachycentrus	2	29	24
Hydropsychidae			
Ceratopsyche	12	38	
Rhyacophilidae			
Rhyacophila	-	14	18
Coleoptera			
Elmidae			
Heterlimnius	-	2	
Diptera			
Chironomidae	169	19	108
Empididae			
Chelifera	6	-	
Tipulidae			
Antocha	5	11	24
Hexatoma	-	1	36
Tipula	-	1	36
Unidentified	1	-	
Total Number	**196**	**127**	
Total Taxa	**7**	**11**	
Density (number/m2)	**2212**		
Diversity Index	**1.24**		
Community Tolerance Quotient			**53.3**

Table 3-2. Aquatic macroinvertebrate abundance. taxa richness, diversity and environmental tolerance in Eccles Creek (EC02) for June 1990.

Taxa	Counts per sample		TQ
	1	2	
Oligochaeta	66	21	108
Ephemeroptera			
Ephemerellidae			
Drunela	7	2	
Trichoptera			
Brachycentridae			
Brachycentrus	1	1	24
Hydropsychidae			
Ceratopsyche	32	9	
Diptera			
Chironomidae	68	40	108
Empididae			
Chelifera	1	-	
Stratiomyidae			
Caloparyphus	1	-	
Tipulidae			
Tipula	1	-	36
Unidentified	-	1	
Total Number	**177**	**74**	
Total Taxa	**8**	**6**	
Density (number/m2)	**1719**		
Diversity Index	**1.22**		
Community Tolerance Quotient			**69**

Table 3-3. Aquatic macroinvertebrate abundance, taxa richness, diversity and environmental tolerance in Eccles Creek (EC03) for June 1990.

Taxa	Counts per sample		TQ
	1	2	
Oligochaeta	-	2	108
Ephemeroptera			
Baetidae			
Baetis	1	2	72
Ephemerellidae			
Ephemerella	-	1	48
Lepidoptera	1	-	72
Coleoptera			
Dytiscidae			
Uvarus	-	1	
Hymenoptera			
Formicidae	1	2	
Diptera			
Ceratopogonidae	-	2	108
Chironomidae	4	10	108
Unidentified	6	5	
Terrestrial	-	1	
Total Number	13	26	
Total Taxa	5	9	
Density (number/m2)	267		
Diversity Index	1.58		
Community Tolerance Quotient			86

Table 3-4. Aquatic macroinvertebrate abundance, taxa richness, diversity and environmental tolerance in Eccles Creek (EC04) for June 1990.

Taxa	Counts per sample		TQ
	1	2	
Ephemeroptera			
Baetidae			
Baetis	6	8	72
Heptageniidae			
Cinygmula	1	-	21
Orthoptera	-	1	
Diptera			
Chironomidae	-	3	108
Stratiomyidae			
Caloparyphus	-	1	
Unidentified	3	1	
Total Number	**10**	**14**	
Total Taxa	**3**	**5**	
Density (number/m2)	**164**		
Diversity Index	**1.06**		
Community Tolerance Quotient			**67**

Table 3-5. Aquatic macroinvertebrate abundance, taxa richness, diversity and environmental tolerance in Eccles Creek (SF01) for June 1990.

Taxa	Counts per sample		TQ
	1	2	
Turbellaria	-	8	108
Oligochaeta	1	-	108
Ephemeroptera			
Baetidae			
Baetis	16	5	72
Ephemerellidae			
Drunella	-	1	
Ephermerella	7	3	48
Heptageniidae			
Cinygmula	4	6	21
Plecoptera			
Nemouridae			
Zapada	1	2	16
Perlidae			
Hesperoperla	1	-	18
Perlodidae			
Isoperla	-	2	48
Trichoptera			
Hydropsychidae			
Parapsyche	4	2	6
Unidentified	-	2	
Rhycophilidae			
Rhyacophila	6	6	18
Limnephilidae			
Dicosmoecus	1	-	24
Diptera			
Chironomidae	26	58	108
Tipulidae			
Tipula	2	2	36
Unidentified	-	1	
Total Number	**69**	**98**	
Total Taxa	**11**	**13**	
Density (number/m2)	**1144**		
Diversity Index	**1.72**		
Community Tolerance Quotient			**48.5**

Table 3-6. Aquatic macroinvertebrate abundance, taxa richness, diversity and environmental tolerance in Eccles Creek (SF02) for June 1990.

Taxa	Counts per sample		TQ
	1	2	
Turbellaria	4	4	108
Oligochaeta	1	-	108
Ephemeroptera			
Baetidae			
Baetis	26	19	72
Ephemerellidae			
Drunella	-	1	
Ephemerella	1	-	48
Heptageniidae			
Cinygmula	59	17	21
Siphlonuridae			
Ameletus	1	-	48
Plecoptera			
Chloroperlidae			
Utaperla	-	1	24
Nemouridae			
Zapada	1	2	16
Trichoptera			
Hydropsychidae			
Hydropsyche	-	1	108
Limnephilidae			
Onocosmoecus	1	-	18
Rhyacophilidae			
Rhyacophila	3	2	18
Uenoidae			
Neothrema	-	1	
Coleoptera			
Elmidae			
Heterlimnius	2	1	
Diptera			
Chironomidae	-	2	108
Ptychopteridae			
Ptychoptera	2	-	
Simuliidae	1	-	108
Tipulidae			
Hexatoma	1	-	36
Ormosia	2	1	
Tipula	1	1	36
Total Number	106	53	
Total Taxa	15	13	
Density (number/m2)	1089		
Diversity Index	1.63		
Community Tolerance Quotient			58.5

Table 3-7. Aquatic macroinvertebrate abundance, taxa richness, diversity and environmental tolerance in Eccles Creek (SFF01) for June 1990.

Taxa	Counts per sample		TQ
	1	2	
Turbellaria	-	2	108
Oligochaeta	3	4	108
Ephemeroptera			
Baetidae			
Baetis	18	33	72
Ephemerellidae			
Drunella	-	9	
Ephemerella	6	-	48
Heptageniidae			
Cinygmula	19	74	21
Siphlonuridae			
Ameletus			48
Plecoptera			
Chloroperlidae			
Utaperla	3	6	24
Nemouridae			
Zapada	1	3	16
Trichoptera			
Rhyacophilidae			
Rhyacophila	6	2	18
Diptera			
Chironomidae	2	2	108
Tipulidae			
Tipula	1	-	36
Coleoptera			
Elmidae			
Heterlimnius	1	3	
Total Number	**60**	**138**	
Total Taxa	**10**	**10**	
Density (number/m2)	**1356**		
Diversity Index	**1.62**		
Community Tolerance Quotient			**55.2**

Table 3-8. Aquatic macroinvertebrate abundance, taxa richness, diversity and environmental tolerance in Eccles Creek (MF01) for June 1990.

Taxa	Counts per sample		TQ
	1	2	
Turbellaria	25	5	108
Oligochaeta	2	-	108
Ephemeroptera			
Baetidae			
Baetis	74	43	72
Ephemerellidae			
Drunella	2	3	
Heptageniidae			
Cinygmule	14	9	21
Plecoptera			
Nemouridae			
Zapada	2	2	16
Perlodidae			
Isoperla	1	5	48
Trichoptera			
Hydropsychidae			
Parapsyche	2	2	6
Rhyacophilidae			
Rhyacophila	13	9	18
Coleptera			
Unidentified	1	-	
Diptera			
Chironomidae	11	-	108
Empididae			
Chelifera	4	-	
Clinocera	2	-	
Tipulidae			
Tipula	-	1	36
Unidentifed	1	1	
Total Number	**154**	**80**	
Total Taxa	**14**	**10**	
Density (number/m2)	**1603**		
Diversity Index	**1.66**		
Community Tolerance Quotient			**54.1**

Table 3-9. Aquatic macroinvertebrate abundance, taxa richness, diversity and environmental tolerance in Eccles Creek (CC01) for June 1990.

Taxa	Counts per sample		TQ
	1	2	
Turbellaria	-	1	108
Oligochaeta	1	3	108
Ephemeroptera			
Baetidae			
Baetis	2	8	72
Ephemerellidae			
Drunella	2	19	
Ephemerella	7	6	48
Plecoptera			
Chloroperlidae			
Haploperla	1	-	24
Trichoptera			
Brachycentridae			
Brachycentrus	-	45	24
Hydropsychidae			
Ceratopsyche	2	79	
Limnephilidae			
Onocosmoecus	-	1	18
Psychoglypha	2	-	24
Coleoptera			
Elmidae			
Optioservus	-	1	108
Dytiscidae			
Desmopachria	1	-	
Unidentified	-	1	
Diptera			
Chironomidae	4	21	108
Empididae			
Chelifera	1	3	
Stratiomyidae			
Caloparyphus	-	1	
Tipulidae			
Antocha	-	3	24
Tipula	-	1	36
Hexatoma	1	5	36
Total Number	24	198	
Total Taxa	11	16	
Density (number/m2)	1521		
Diversity Index	2		
Community Tolerance Quotient			56.8