UPPER BULKLEY RIVER STEELHEAD
POPULATION MONITORING

prepared by

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FISH HABITAT IMPROVEMENT SECTION
FISH AND WILDLIFE BRANCH
MINISTRY OF ENVIRONMENT

VICTORIA, B.C.

MAY, 1983

Province of British Columbia

Ministry of Environment

Fish and Wildlife Branch
Parliament Buildings
Victoria
British Columbia
V8V 1X4

File: 0140-6
Upper Bulkley River

May 6, 1983

Mr. R. Whately
Regional Fisheries Biologist
Smithers, British Columbia

Dear Mr. Whately:

Re: Upper Bulkley River steelhead monitoring - 1982.

Enclosed are 3 copies of "Upper Bulkley River Steelhead Population Monitoring", prepared by the Fish Habitat Improvement Section. This is a very short report, basically presenting the 1982 data and a few comparisons with 1981 data. Application of the results to actual steelhead population monitoring was not included due to lack of knowledge of adult steelhead stock status. The latter is the major deficiency in our knowledge of Upper Bulkley steelhead.

Reference is made to the acid mine drainage problem associated with Equity Silver Mines Ltd. This has the potential to seriously damage the juvenile fish population of Buck Creek, the suspected major "production center" for Upper Bulkley steelhead. A recommendation to establish a "proper" impact monitoring program[1], in conjunction with Waste Management Branch, is made. Index sampling, as presently conducted for population monitoring purposes, is not detailed enough to detect deleterious effects.

The implication of this monitoring report should be brought to the attention of regional protection staff and your Manager.

Yours truly

C.D. Tredger
Biologist
Fish Habitat Improvement

G.D. Taylor
Biologist i/c
Fish Habitat Improvement Section

[1] Standard bioassays; instream live caging etc.

CDT/GDT/bc

cc: A. Tautz
D. Narver

File 0140-6
Upper Bulkley River

RECONNAISSANCE REPORT

(Fish Habitat Improvement)

PROJECT: Upper Bulkley River steelhead population monitoring.

LOCATION: Bulkley River upstream of the Morice River confluence near Houston, B.C.

MAP REFERENCE NO: 93L REGION: 6

DATE SURVEYED: August 24 and 25, 1982 MANAGEMENT UNIT: 6-8, 6-9.

PERSONS PRESENT: D. Tredger, D. Greiner, M. Lough, G. Schultze, R. Tetreau, M. O'Neill AIR PHOTO REFERENCE NO: N/A

REPORT PREPARED BY: D. Tredger REPORT DATE: April 22, 1983

PURPOSE: to monitor juvenile rainbow trout (steelhead?) densities in the Upper Bulkley River watershed.

OBSERVATIONS:

see attached

PROPOSED ACTION:

see attached

PHOTOGRAPHS ATTACHED: YES ____ NO _x_ AVAILABLE: YES _x_ NO ____

CIRCULATE TO: M. Whately, M. Lough.

SUGGESTED CONTACTS:

COMMENTS BY:

SEE ATTACHED SHEETS: YES _x_ NO ____

GDT/71/75/76

1.0 INTRODUCTION

The Upper Bulkley River, upstream of the Bulkley-Morice confluence near Houston, B.C. (Fig.1) was first assessed by the Fish Habitat Improvement Section in 1981 (Tredger, 1982). The major recommendation from the assessment was to determine present status of the steelhead population in terms of adult escapement and spawning site locations, and the relationship between resident and anadromous rainbow trout in the watershed. An adult steelhead tagging program in the Bulkley River was initiated in the fall of 1982 by Region 6 Fisheries Management, which will begin to address steelhead stock status.

On August 24 and 25, 1982 several index sites in the Upper Bulkley watershed were sampled by F.H.I.S. and Region 6 staff. This project was part of a major steelhead fry recruitment monitoring program conducted annually by Region 6 Fisheries Management. As the racial characteristics of Upper Bulkley rainbow trout stocks are unknown at this time (resident vs. anadromous), application of results to steelhead recruitment will not be attempted.

2.0 METHODS

A total of 7 index sites were sampled on August 24 and 25, 1982. Sites were chosen as those likely to have some yet to be determined importance regarding steelhead recruitment monitoring, and included Buck, McQuarrie and Richfield Creeks and the mainstem Upper Bulkley River (Fig.2). All sampling was conducted by standard F.H.I.S. methodology of fish population estimates (electrofishing) and habitat sampling (de Leeuw, 1981).

3.0 RESULTS

3.1 Physical Habitat

Physical habitat characteristics of the Upper Bulkley River system are presented and discussed in Tredger (1982). A summary of reach characteristics is included in Appendix 1. In this report only major habitat changes as monitored at sample sites will be discussed.

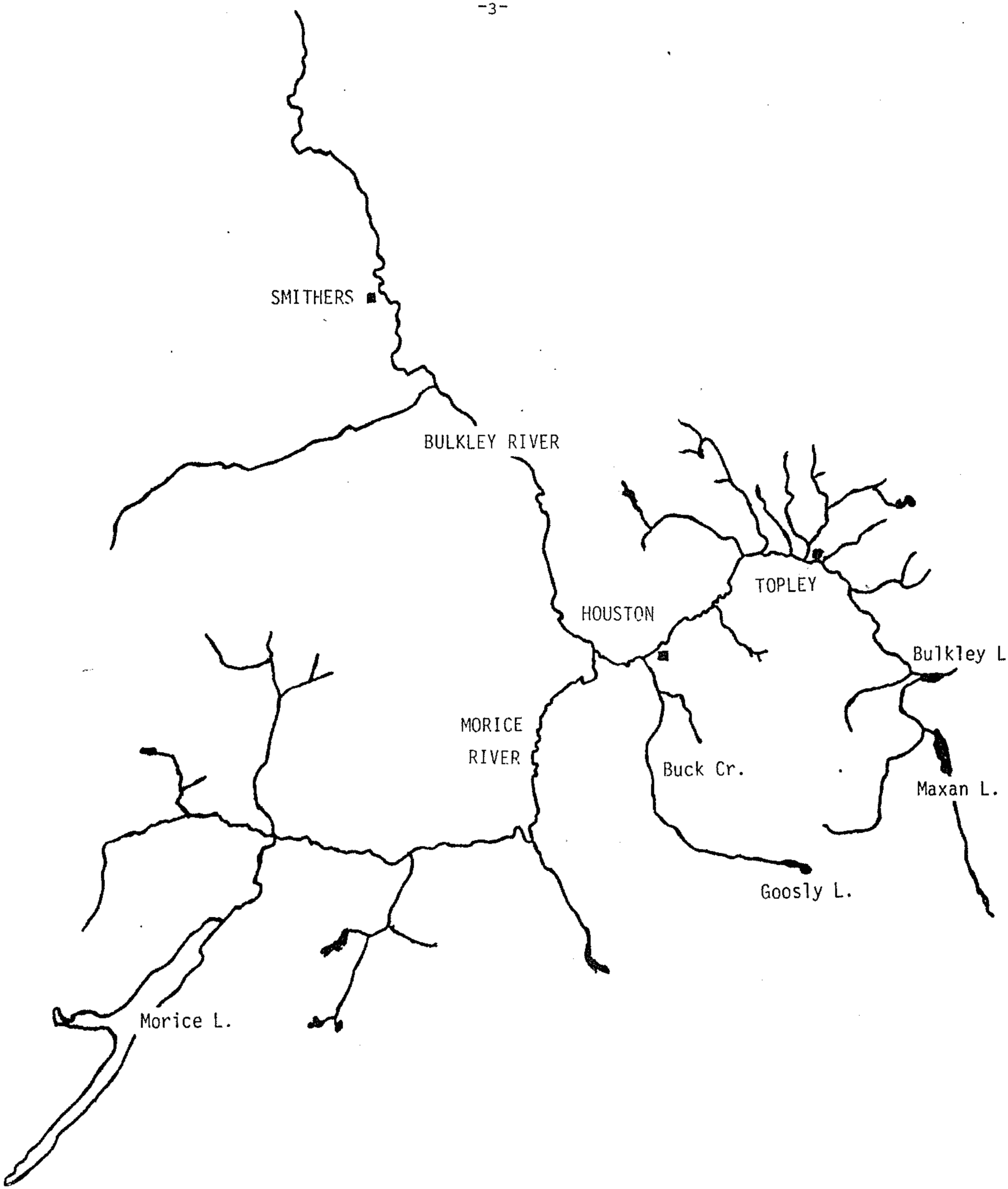

FIGURE 1. The Bulkley River watershed upstream of Smithers, B. C. Scale 1:600,000.

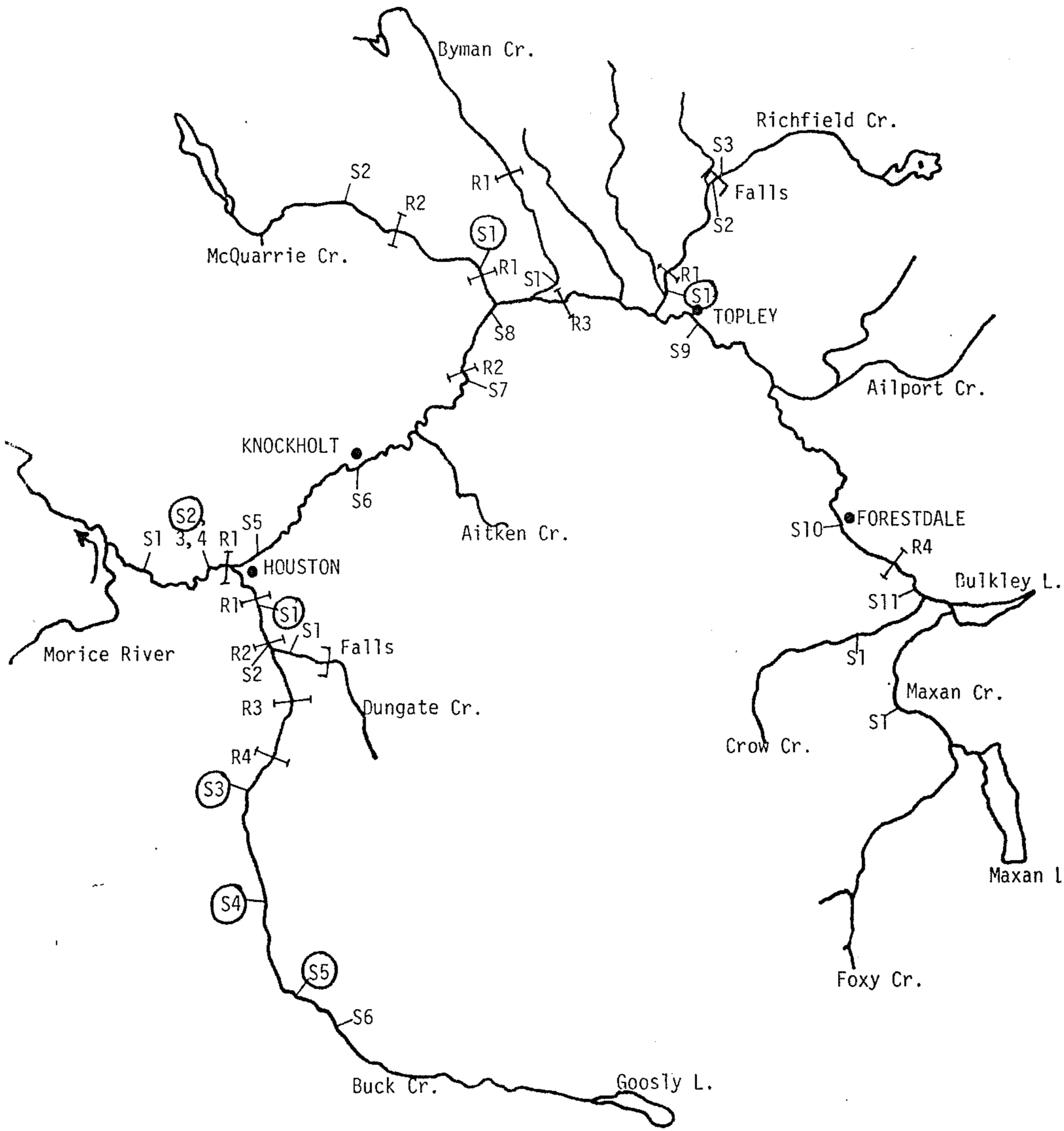

FIGURE 2. The Upper Bulkley River system, indicating reach breaks (R1) and sample sites (S1). The 1982 index sites are circled (S1).

Stream discharge

Stream discharge, as estimated at the 7 index sites, is summarized in Table 1. Discharge was very similar in the Bulkley River at Houston

Table 1. Estimated stream discharge at Upper Bulkley River index sites, 1981 and 1982.

Stream		Estimated Discharge/m^3/s (c.f.s.)	
		Sept. 1, 1981	Aug. 25, 1982
Bulkley River at Houston		1.60 (57 cfs)	1.60 (57 cfs)
Buck Creek	lower (S1,3)	0.46 (16 cfs)	0.40 (14 cfs)
	upper (S5)	0.25 (9 cfs)	0.30 (10 cfs)
McQuarrie Creek	lower	0.075(2.7 cfs)	0.20 (7.1 cfs)
Richfield Creek	lower	0.20 (7.1 cfs)	0.35 (12.4 cfs)

and lower Buck Creek in both years. Upper Buck Creek, McQuarrie Creek and Richfield Creek had somewhat higher flows in 1982.

Habitat sampling

The overall similarity in stream discharge estimates suggests that habitat characteristics should be similar in 1981 and 1982. A brief summary of "index reach" habitat is given in Table 2, with complete sampling data included in Appendix 2. Values presented in Table 2 are not directly comparable, as in most cases the 1981 results represent an average of many sites per reach, while the 1982 results represent index sites only. For this reason detailed comparisons will not be made at this time.

3.2 Fish Population Estimates

Fish population estimate results at 7 index sites in the Upper Bulkley watershed are included in Appendix 3. Analysis in this report will be restricted to juvenile rainbow trout.

Rainbow trout densities

A summary of juvenile rainbow trout densities at 7 index sites in the Upper Bulkley watershed is given in Table 3. Mean fry density was 0.25 fry/m^2 less in 1982 than in 1981. This mean difference was not

Table 2. Summary of Upper Bulkley "index stream" habitat characteristics in 1981 and 1982.

Stream and Reach		Year	Discharge (m^3/s)	Wetted Width (m)	Pool/Riffle/Glide Ratio	Mean Depth
Upper Bulkley	Reach 1	1981	1.60	16	35/ 9/56	62
		1982	1.60	12.8	6/ 3/91	67
Buck Creek	Reach 2	1981	0.46	10.8	21/ 0/79	28
		1982	0.40	14.5	16/76/ 8	41
Buck Creek	Reach 5	1981	0.25	9.4	15/18/67	37
		1982	0.30	6.7	5/53/41	23
McQuarrie Cr.	Reach 2	1981	0.075	2.3	18/34/48	12
		1982	0.20	6.2	18/57/25	14
Richfield Cr.	Reach 1	1981	0.20	6.5	9/60/31	31
		1982	0.35	5.1	5/62/33	21

Table 3. Juvenile rainbow trout density (no./m^2) at 7 index sample sites in the Upper Bulkley River, 1981 and 1982.

Sample Site		0+		1+		≥2+	
		1981	1982	1981	1982	1981	1982
Upper Bulkley	2	0	0.08	0.16	0.13	0.01	0.04
Buck Creek	1	0.13	0.17	0.06	0.07	0.01	0.02
	3	0.63	0.14	0.03	0.05	0.01	0.01
	4	0.18	0.18	0.41	0.09	0.14	0.16
	5	0.09	0.18	0.25	0.11	0.11	0
McQuarrie Cr.	1	1.89	0.89	0.54	0.26	0.06	0.06
Richfield Cr.	1	0.96	0.47	0.19	0.14	0.05	0.06
Mean Difference 1981-1982		-0.25		-0.11		-0.01	
(paired t - test, t_α = .05, 6 D.F. = 2.45)		t=1.60(6 D.F.) NS		t=2.16(6 D.F.) NS		t=0.32(6 D.F.) NS	

significant statistically. The major decreases occurred in Richfield and McQuarrie Creeks, where densities were roughly halved. In Buck Creek slight increases in fry density occurred at Sites 1 and 5, while a major decrease occurred at Site 3. Fry were present in the Upper Bulkley (below Buck Creek) in 1982, where they were not found in 1981.

Yearling (1+) density was 0.11 fish/m^2 less in 1982 than in 1981, but again the difference was not significant. At most sites yearling density was roughly equal, with relatively large decreases occurring in upper Buck Creek (Sites 4 and 5) and McQuarrie Creek. The two year old (2+) parr density was roughly equal in 1981 and 1982. One relatively large decrease was noted at Site 5 in Buck Creek.

Rainbow trout size

Cumulative length-frequency and length-weight data is included in Appendix 4. A summary of 1981 and 1982 juvenile rainbow trout size (fork length) is given in Table 4.

Table 4. Summary of juvenile rainbow trout fork length (mean and range) sampled in the Upper Bulkley River watershed, 1981 and 1982.

Age Group	Year	N	Fork Length (mm)	
			Mean	Range
0+	1981	505	46.4	28 - 69
	1982	167	43.5	30 - 57
1+	1981	242	85.3	66 - 112
	1982	73	83.2	61 - 103
2+	1981	59	121.4	104 - 157
	1982	26	113.9	97 - 128
3+	1981	7	148	134 - 165
	1982	1	169	

Only minor differences in fork length were apparent between 1981 and 1982 in the 0+ and 1+ age groups. The 1982 mean 2+ size was 7.5 mm (6%) smaller than 1981.

A condition factor of 8.38×10^{-6} was calculated from length-weight data collected at Buck and McQuarrie Creeks in 1982. No comparable weight data was collected in 1981.

4.0 DISCUSSION

Rainbow fry population monitoring

Rainbow trout fry densities were generally lower in 1982 compared to 1981. Relatively major density decrease occurred at 3 of 7 sites only (McQuarrie, Richfield and upper Buck Creeks). Other sites were roughly equal in both years.

As steelhead recruitment sites are unknown in the Upper Bulkley system, fry densities cannot be related to steelhead escapement. This information will serve as valuable background information when further knowledge of the adult steelhead population is gained.

Effects of an acid spill at Equity Mines Ltd.

A major acid spill occurred at Equity Silver Mines Ltd., located in the headwaters of Buck Creek, in November of 1981 (108 metric tons (11,000 gallons) of sulphuric acid). This was a major "event" in a continuing problem of acid mine drainage. Regional Waste Management Branch is monitoring the situation (Appendix 5). Of major concern is the effects (lethal and sub-lethal) of acid mine drainage on the fish population of Buck Creek. Sampling conducted by this project was not in great enough detail to detect any effects (or lack of effects) of the spill. Fish densities were generally lower throughout Buck Creek in 1982. The uppermost site in 1982 had higher fry population density, lower 1+ density and was devoid of 2+ parr. These results are viewed as natural variation rather than pollution effects. Without catastrophic effects, the impacts of Equity Mines on the Buck Creek fish population could only be detected with a detailed and designed monitoring program.

5.0 RECOMMENDATIONS

As was the case with the 1981 assessment, no resolution of steelhead stock status in the Upper Bulkley River system can be made at this time. This remains the most important question in understanding fish production in the Upper Bulkley system. What we must know is numbers of adult steelhead using the Upper Bulkley system for spawning, which areas are used, and what is the resident trout: steelhead split in rearing populations. This knowledge might allow the high production levels of particularly Buck and McQuarrie Creeks (and other areas) to be understood, and perhaps equated to potential enhanced steelhead production.

The Equity Silver Mines Ltd. acid drainage problem must be addressed in terms of effects on the Buck Creek fish population. A "proper" impact monitoring program should be established in conjunction with Waste Management Branch.

ACKNOWLEDGEMENTS

Thanks are extended to participants in the field program, D. Greiner, M. Lough, G. Schultze, R. Tetreau and M. O'Neill. D. Greiner conducted the initial field data analysis. The manuscript was edited by G.D. Taylor and typed by June Lum.

REFERENCES

de Leeuw, A.D. 1981. A British Columbia fish habitat and population stream inventory system. Unpubl. MS., Fish and Wildlife Branch, Ministry of Environment, Victoria, B.C.

Tredger, C.D. 1982. Upper Bulkley River reconnaissance with reference to juvenile steelhead carrying capacity. Unpubl. MS., Fish and Wildlife Branch, Ministry of Environment, Victoria, B.C.

APPENDIX 1. Summary of reach habitat characteristics of the Upper Bulkley River system (from Tredger 1982).

TABLE 2.--Summary of reach habitat characteristics of the Upper Bulkley River system.

STREAM	REACH	LENGTH (m)	GRADIENT (%)	AREA (m^2)	MEAN WIDTH (m)	GENERAL	P/R/G RATIO	COVER TYPE (%)		MAJOR SUBSTRATES
Bulkley R.	1	8,900	0.5	143,900	16	irregular meander, moderate gradient	35/ 9/56	B, L, OV	(0.7)	F, SG, LG (C, B)
	2	23,000	0.1	347,700	15	meandering, with oxbows, very low gradient	64/ 6/30	L, OV, C, B, IV	(1.0)	F, SG, LG
	3	8,000	0.4	75,700	9.5	irregular, moderate gradient	15/32/53	L, C, OV	(1.0)	F, SG, LG (C)
	4	25,200	0.25	174,106	7	meandering, with oxbows, very low gradient	37/ 1/62	OV, L, C	(3.5)	F, SG, LG
	5	5,200	0.1	34,200	6.5	meandering, very low gradient, originates from Bulkley Lk.	22/ 8/70	L , C, OV	(7.1)	F, SG, LG
Buck Cr.	1	2,500	0.6	23,600	9.5	unconfined with wide gravel channel	not sampled, similar to Buck Creek Reach 3			
	2	2,200	0.7	23,800	10.8	confined canyon	21/ 0/79	B, OV, C	(1.7)	C, LG, B
	3	3,800	1.6	35,900	9.5	unconfined with wide gravel channel	0/45/55	B (L, OV)	(2.0)	F, C, LG
	4	2,000	1.5	21,600	10.8	confined canyon	not sampled, similar to Buck Creek Reach 2			
	5	38,500	0.2	362,700	9.4	unconfined, irregular meander	15/18/67	B, OV, L	(3.2)	LG, SG, F
Dungate Cr.	1	2,100	5.1	7,600	3.6	high gradient, entrenched, probable falls	0/83/17	B, OV	(30.7)	SG, LG, C, B
McQuarrie Cr.	1	1,600	4.7	3,600	2.2	moderate gradient, channelized	not sampled			
	2	6,600	2.5	15,000	2.3	entrenched in steep valley, some canyon areas	18/34/48	OV, L, C	(15.2)	LG, SG, C
	3	6,000	3.0	13,600	2.3	headed by McQuarrie Lake	not sampled			
Byman Cr.	1	5,600	2.7	16,800	3	channelized at lower end	0/49/51	OV, B	(7.8)	C, B, LG
	2	10,300	2.8	30,900	3	small stream, lake headed	not sampled			
Richfield Cr.	1	2,300	2.0	14,900	6.5	meandering through valley bottom	8/12/80	OV, B, C	(8.6)	C, LG, F
	2	6,300	2.7	27,600	4.4	entrenched in deep canyon, high falls at top of reach	9/60/31	B, OV, L	(6.2)	LG, C, SG
Crow Cr.	1	14,500	2.0	41,400	2.9	small stream through forest	45/25/30	L, OV	(21.3)	SG, F, C
Maxan Cr.	1	12,500	0.5	146,700	11.7	lake headed (Maxan Lake)	9/18/74	L, OV	(6)	LG, SG, F, C

APPENDIX 2. Habitat sampling data from Upper Bulkley River index sites, 1982.

Upper Bulkley Region 6

RICHFIELD CREEK August 25, 1982

REACH 1

													Average for Reach						
													POOLS		GLIDES		RIFFLES		MEAN
													$\bar{x}$	%	$\bar{x}$	%	$\bar{x}$	%	
Habitat Class	G	R	G	P	R	G	R	G					P		G		R		
Length	9.4	3.8	20	6	25	15	8	12					6	6	Σ56.4 $\bar{x}$19.1	56.9	Σ36.8 $\bar{x}$12.3	37.1	
Wetted width	7.8	8.0	4	4	3	6	8	6					4		5.6		4.6		5.1
Channel width	12	12	12	12	10	9	10	10					12		10.8		10.2		
Area	73.3	30.4	80	24	75	90	64	72					24	4.7	Σ315.3 $\bar{x}$78.8	62	Σ169.4 $\bar{x}$56.5	33.3	
Mean depth	.2	.1	.4	.3	.15	.2	.1	.25					.3		0.26		0.12		0.21
Velocity	.3	1.2	.3	~0	1	.4	1	.5					~0		0.37		1.04		
Log cover	.5	0	2	5	0	2	.3	.5					5		Σ5 $\bar{x}$1.25		Σ.3 $\bar{x}$.1		
Boulder cover	.5	.5	.3	0	.1	.2	.1	.1					0		Σ1.1 $\bar{x}$.28		Σ.7 $\bar{x}$.23		
Instream veg.	0	0	0	0	0	0	0	0					0		0		0		
Overstream veg.	7	2	3	0	.3	1	1	0					0		Σ11 $\bar{x}$2.8		Σ3.3 $\bar{x}$1.1		
Cutbanks	0	0	1.3	1	.2	0	0	3					1		Σ4.3 $\bar{x}$1.1		Σ0.2 $\bar{x}$0.1		
Total cover	8	2.5	6.6	6	.6	3.2	1.4	3.6					6	25	Σ21.4 $\bar{x}$5.4	6.9	Σ4.5 $\bar{x}$1.5	2.7	
Turbidity	clr	→	→	→	→	→	→	→					clr		clr		clr		
Gradient %	<1	2	~0	~0	2	<1	2	~0					~0		~.5		2		
Fines	30	12	10	60	10	40	10	30					60		27.8		10.4		
Small gravel	20	12	20	20	30	20	10	30					20		22.3		19.2		
Large gravel	20	42	30	10	30	20	35	20					10		22.5		34		
Cobble	20	22	30	10	25	15	35	10					10		18.8		28.2		
Boulder	10	12	10	0	5	5	10	10					0		8.6		8.2		
Bedrock	0	0	0	0	0	0	0	0					0		0		0		
Compaction	low	→	→	→	→	→	→	→					low		low		low		

Q = .35 m^3/s 12.4 cfs

Upper Bulkley Region 6
Buck Creek Aug. 24 1982
Reach 2

													Average for Reach						
													POOLS		GLIDES		RIFFLES		MEAN
													$\bar{x}$	%	$\bar{x}$	%	$\bar{x}$	%	
Habitat Class	R	G	R	G	R	P							P		G		R		
Length	14.5	27	200	10	15	50							50	15.8	Σ37 $\bar{x}$18.5	11.7	Σ229.5 $\bar{x}$76.5	72.5	
Wetted width	13	10	15	8	15	15							15		9.5		14.9		14.5
Channel width	16	16	16	16	16	16							16		16		16		
Area	188.5	270	3000	80	225	750							750	16.6	Σ350 $\bar{x}$175	7.8	Σ3435 $\bar{x}$1329	75.6	
Mean depth	.25	.35	.25	.35	.15	1.2							1.2		.35		0.24		.41
Velocity	.2	.2	—	—	—	—							—		~.2		~.2		
Log cover	0	0	0	0	0	5							5		0		0		
Boulder cover	20	3	1500	2	10	0							0		Σ5 $\bar{x}$2.5		Σ1530 $\bar{x}$510		
Instream veg.	0	0	0	0	0	0							0		0		0		
Overstream veg.	1	1	200	0	0	0							0		Σ1 $\bar{x}$.5		Σ201 $\bar{x}$67		
Cutbanks	0	.5	0	0	0	0							0		Σ.5 $\bar{x}$.25		0		
Total cover	21	4.5	1700	2	10	5							5	0.7	Σ6.5 3.25	1.9	Σ1731 $\bar{x}$577	50.7	
Turbidity	c/r	c/r	c/r	c/r	c/r	c/r							c/r		c/r		c/r		
Gradient	—	—	1.5	—	—	—							—		—		~1.5		
Fines	17	35	17	15	21	35							35		30.4		17.3		
Small gravel	17	10	17	15	16	5							5		11.1		16.9		
Large gravel	17	25	17	10	16	5							5		21.6		16.9		
Cobble	22	20	22	10	26	10							10		17.7		22.3		
Boulder	27	10	27	10	21	5							5		10		26.6		
Bedrock	0	0	0	40	0	40							40		9.1		0		
Compaction	low	low	low	low	low	low							low		low		low		

$\bar{x}$ Q ~ .42 m^3/s 14.8 cfs

Upper Bulkley — Region 6

BULKLEY RIVER MAINSTEM — Aug. 24 1982

REACH 1

													Average for Reach						
													POOLS		GLIDES		RIFFLES		MEAN
													$\bar{x}$	%	$\bar{x}$	%	$\bar{x}$	%	
Habitat Class	R	G	R	G	P	G							P		G		R		
Length	18	100	2	300	30	50							30	6	Σ450 $\bar{x}$150	90	Σ20 $\bar{x}$10	4	
Wetted width	9	15	12	12	12	15							12		13		9.3		12.8
Channel width	30	20	20	35	35	20							35		30		29		
Area	162	1500	24	3600	360	750							360	5.6	Σ5850 $\bar{x}$1950	91.5	Σ186 $\bar{x}$93	2.9	
Mean depth	.3	.4	.3	.6	2	1							2		0.6		0.3		.67
Velocity	1	.3	.4	.1	.05	.01							.05		.14		0.9		
Log cover	0	0	0	2	2	.5							2		Σ2.5 $\bar{x}$.83		0		
Boulder cover	2	4	0	4	0	0							0		Σ8 $\bar{x}$2.7		Σ2 $\bar{x}$1		
Instream veg.	0	0	0	0	0	0							0		0		0		
Overstream veg.	0	0	0	0	0	0							0		0		0		
Cutbanks	0	0	0	0	0	0							0		0		0		
Total cover	2	4	0	6	2	.5							2	.6	Σ10.5 $\bar{x}$3.5	.2	Σ2 $\bar{x}$1	1.1	
Turbidity	clr	clr	clr	clr	clr	clr							clr		clr		clr		
Gradient	2	1	1.5	1	.5	.5							.5		.83		1.8		
Fines	5	40	10	50	60	90							60		52.6		5.6		
Small gravel	20	20	30	30	20	5							20		24.2		21.3		
Large gravel	40	20	40	15	20	5							20		15		40		
Cobble	30	15	20	3	0	0							0		5.7		28.7		
Boulder	5	5	0	2	0	0							0		2.5		4.4		
Bedrock	0	0	0	0	0	0							0		0		0		
Compaction	low	low	low	low	low	low							low		low		low		

$\bar{x}$ Q = 1.6 m^3/s (57 cfs)

Upper Bulkley Region 6

McQUARRIE CREEK Aug. 24, 1982

REACH 2

													Average for Reach						
													POOLS		GLIDES		RIFFLES		MEAN
													x̄	%	x̄	%	x̄	%	
Habitat Class	P	R	G	R	G	P							P		G		R		
Length	15	49	46	27	3	7							Σ22 / x̄11	15	Σ49 / x̄24.5	33.3	Σ76 / x̄38	51.7	
Wetted width	7	7.5	4.5	5	5	7.5							7.2		4.5		6.6		6.2
Channel width	15	22	29	13	13	15							15		28		18.8		
Area	105	367.5	207	135	15	52.5							Σ157.5 / x̄78.8	17.9	Σ222 / x̄111	25.2	Σ502.5 / x̄251.3	56.9	
Mean depth	.25	.1	.14	.1	.12	.3							.27		.14		.1		0.14
Velocity	—	.6	.5	—	—	—							—		~.5		~.6		
Log cover	.3	0	0	0	0	1							Σ1.3 / x̄.65		0		0		
Boulder cover	.1	4.5	2	1.4	.1	.2							Σ.3 / x̄.15		Σ2.1 / x̄1.1		Σ5.9 / x̄3		
Instream veg.	0	0	0	0	0	0							0		0		0		
Overstream veg.	.1	0	.3	0	0	3							Σ3.1 / x̄1.6		Σ.3 / x̄.15		0		
Cutbanks	.3	0	0	.4	0	0							Σ.3 / x̄.15		0		Σ.4 / x̄.2		
Total cover	.8	4.5	2.3	1.8	.1	4.2							Σ5 / x̄2.5	3.2	Σ2.4 / x̄1.2	1.1	Σ6.3 / x̄3.2	1.3	
Turbidity	clr	clr	clr	clr	clr	clr							clr		clr		clr		
Gradient	—	—	—	—	—	—							—		—		—		
Fines	30	5	10	5	15	35							31.7		10.4		5		
Small gravel	25	10	25	15	40	25							25		26		11.3		
Large gravel	10	30	30	35	20	25							15		29.3		31.3		
Cobble	10	40	25	25	15	10							10		24.3		36		
Boulder	25	15	10	20	10	5							18.3		10		16.3		
Bedrock	0	0	0	0	0	0							0		0		0		
Compaction	low	low	low	low	low	low							low		low		low		

x̄Q ~.2 m³/s 7.1 cfs

Upper Bulkley | Region 6 | Page 1 of 2

Buck Creek | Aug. 24 1982

Reach 5

Habitat Class	G	R	G	R	G	R	G	R	G	G	R	G	R	G	R	R	G	G
Length	21.3	21	10	25	35	18	4	5.2	2.8	12	5	35	100	20	10	3	9	20
Wetted width	4.3	4	5	10	6	5	5	5.5	4.8	5	9	6	8	10	4	4	6	4
Channel width	12	14	10	12	11	16	18	·18	18	18	18	18	18	15	15	15	15	20
Area	91.59	84	50	250	210	90	20	28.6	13.4	60	45	210	800	200	40	12	54	80
Mean depth	.1	.1	.1	.1	.3	.1	.25	.1	.2	.25	.15	.2	.15	.2	.2	.15	.5	.35
Velocity	.1	.2	—	—	—	—	.6	1.2	.8	.8	1	.7	1	.5	1.5	.5	—	.25
Log cover	0	0	0	.5	.5	0	.1	0	0	2	0	0	.1	1	0	0	0	.5
Boulder cover	0	0	0	.5	.5	0	.1	.1	0	0	.5	.1	4	1	0	0	0	0
Instream veg.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.2
Overstream veg.	0	0	1	1.5	1	.5	0	0	0	0	0	0	3	4	0	0	0	0
Cutbanks	0	0	0	0	0	0	0	0	1	.5	0	0	0	.2	0	.1	.1	0
Total cover	0	0	1	2.5	2	.5	.2	.1	1	2.5	.5	.1	7.1	6.2	0	.1	.1	.7
Turbidity	clr	clr	clr	clr	clr	clr	clr	clr	clr	clr	clr	clr	clr	clr	clr	clr	clr	clr
Gradient	—	.5	—	—	—	—	1	2	1	1	2	1	1.5	1	1.5	—	—	—
Fines	25	10	10	10	15	15	20	25	10	30	20	10	10	10	10	2	40	40
Small gravel	40	25	30	25	25	35	30	20	20	20	20	20	20	10	20	40	15	30
Large gravel	35	35	40	45	45	30	30	30	30	20	30	30	20	40	40	38	30	25
Cobble	0	25	20	15	10	20	15	20	40	30	20	30	25	20	20	20	10	5
Boulder	0	5	0	5	5	0	5	5	0	0	10	10	25	20	10	0	5	0
Bedrock	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Compaction	low	low	low	low	low	low	low	low	low	low	low	low	low	low	low	low	low	low

Upper Bulkley Buck Creek Reach 5	Region 6 Aug. 24 1982										Page 2 of 2		Average for Reach						
													POOLS		GLIDES		RIFFLES		MEAN
													x̄	%	x̄	%	x̄	%	
Habitat Class	R	G	R	G	P								P		G		R		
Length	5	12	8	10	18								18	4.4	Σ91.1 x̄7.59	46.7	Σ200.2 x̄20	48.9	
Wetted width	4	4	8	8	8								8		5.9		7.2		6.7
Channel width	20	20	22	18	15								15		15.5		16.7		
Area	20	48	64	80	144								144	5.3	Σ1117 x̄93.1	41.4	Σ1433.6 x̄143.4	53.3	
Mean depth	.10	.2	.10	.35	1								1		.25		.13		.23
Velocity	.5	.25	.5	—	—								—		.47		.92		
Log cover	0	.2	0	.1	.1								.1		Σ4.4 x̄.37		Σ.6 x̄.06		
Boulder cover	0	.1	0	.2	.1								.1		Σ2 x̄.17		Σ5.1 x̄.51		
Instream veg.	0	0	.2	0	.2								.2		Σ.2 x̄.02		Σ.2 x̄.02		
Overstream veg.	0	0	0	.1	.2								.2		Σ11.1 x̄.93		Σ5 x̄.5		
Cutbanks	0	0	0	.2	1.5								1.5		Σ2 x̄.17		Σ.1 x̄.01		
Total cover	0	.3	.2	.6	2.1								2.1	1.5	Σ14.7 x̄1.23	1.3	Σ11 x̄1.1	0.8	
Turbidity	clr	clr	clr	clr	clr								clr		clr		clr		
Gradient	—	—	—	—	—								—		~1		~1.5		
Fines	5	25	5	15	15								15		18		10.6		
Small gravel	30	30	40	30	20								20		23		23.3		
Large gravel	50	30	40	40	25								25		35.3		28.4		
Cobble	15	15	15	13	30								30		16.8		21.9		
Boulder	0	0	0	2	10								10		6.9		15.8		
Bedrock	0	0	0	0	0								0		0		0		
Compaction	low	low	low	low	low								low		low		low		

x̄ Qn .3   10.5 cfs

APPENDIX 3. Fish population estimate results at Upper Bulkley River index sites, 1982.

Upper Bulkley River at Nadina Road (Houston)

DATE Aug 24/83 AREA 162 m² SITE # 2

LENGTH 18 m

SPECIES	AGE	ll-RANGE	$\bar{l}$	MEAN WEIGHT	C_1	$\hat{p}$	$\hat{n}$	TOTAL BIOMASS	No/M² DENSITY	BIOMASS DENSITY	No / lineal meter
Rbt	0+	36-54	47.00	0.90	12	0.90	13.33	12.02	0.08	0.07	0.74
	1+	77-102	89.11	6.05	19	0.90	21.11	127.33	0.13	0.79	1.17
	2+	112-128	121.17	15.05	6	0.90	6.67	100.31	0.04	0.62	0.37
								239.66	0.25	1.48	2.28
Coho	0+	64-65	64.50	3.22	2	0.90	2.22	7.16	0.01	0.04	0.12
Chin	0+	60-85	72.05	4.26	22	0.90	24.44	104.25	0.15	0.64	1.36
	1+	89-102	100.56	11.37	9	0.90	10.00	113.71	0.06	0.70	0.56
								217.96	0.21	1.34	1.92
Mw	Σ	78-235	168.67	82.44	6	0.90	6.67	549.58	0.04	3.39	0.37
Dace sp	Σ	33-98	58.66	3.04	62	0.90	68.89	209.65	0.43	1.29	3.83

HABITAT DESCRIPTION: Riffle habitat

Discharge 1.6 m³/s 56.5 cfs Gradient 2

Temperature (°C) 18°C @ 1200 HRS Turbidity Clear

Hydraulic Type	Pool	Glide	Riffle
% area			100
mean width			9.0
mean depth			0.3
% cover			1.2
cover type[1]			B
substrate[2]			F5, SG20, LG40 C30, B5

COMMENTS: Chinook redds in glide below site

[1] L log, B boulder, IV instream vegetation, OV overstream vegetation, C cutbanks

[2] F fines, SG small gravel, LG large gravel, C cobbles, B boulders, Br bedrock

Buck Creek at Powerline

DATE Aug 25/82 AREA 188.5 m^2 SITE # 1

LENGTH 14.5 m

SPECIES	AGE	ll-RANGE	$\overline{ll}$	MEAN WEIGHT	C_1	$\bar{p}$	$\bar{n}$	TOTAL BIOMASS	No/M^2 DENSITY	BIOMASS DENSITY	No / lineal metre
Rbt	0+	36-54	45.68	0.83	22	0.70	31.43	26.04	0.17	0.14	2.17
	1+	81-96	85.78	5.33	9	0.70	12.86	68.53	0.07	0.36	0.89
	2+	109-119	112.33	11.94	3	0.70	4.29	51.18	0.02	0.27	0.30
			0					145.75	0.26	0.77	3.36
Coho	0+	83	83.00	6.86	1	0.70	1.43	9.80	0.01	0.05	0.10
Chk	0+	67-82	77.17	5.14	6	0.70	8.57	44.04	0.05	0.23	0.59
Mw	E	67-132	73.67	5.51	3	0.70	4.29	23.63	0.02	0.13	0.30
Dace sp	E	23-87	68.14	4.10	21	0.70	30.00	123.11	0.16	0.65	2.07

HABITAT DESCRIPTION: Riffle habitat

Discharge Q ~ .39 m^3/s 13.8 cfs Gradient ~1.5

Temperature (°C) 17° @ 1530 HRS Turbidity Clear

Hydraulic Type	Pool	Glide	Riffle
% area			100
mean width			13.0
mean depth			0.25
% cover			11.1
cover type[1]			B, OV
substrate[2]			F17, SG17, LG17 C22, B27

COMMENTS: Mostly glide/riffle habitat except for 2 pools, riffle/glide in canyon near site. No barrier in canyon.

[1] L log, B boulder, IV instream vegetation, OV overstream vegetation, C cutbanks

[2] F fines, SG small gravel, LG large gravel, C cobbles, B boulders, Br bedrock

Buck Creek
below 1st Bridge on
Buck Flats Road

DATE Aug 25/82   AREA 91.6 m^2 SITE # 3
LENGTH 21.3 m

SPECIES	AGE	ℓ-RANGE	$\bar{\ell}$	MEAN WEIGHT	C_1	$\bar{p}$	$\bar{n}$	TOTAL BIOMASS	No/M^2 DENSITY	BIOMASS DENSITY	No / linear meter
Rbt	0+	44-55	50.25	1.08	12	0.95	12.63	13.58	0.14	0.15	0.59
	1+	77-88	83.75	4.96	4	0.95	4.21	20.89	0.05	0.23	0.20
	2+	109	109.0	10.85	1	0.95	1.05	11.42	0.01	0.12	0.05
								45.89	0.20	0.50	0.84
Dacesp	E	39-76	47.35	1.43	17	0.95	17.89	25.56	0.20	0.28	0.84

HABITAT DESCRIPTION: Glide habitat

Discharge Q = .03 m^3/s 1.06 cfs   Gradient NR

Temperature (°C)   Turbidity Clear

Hydraulic Type	Pool	Glide	Riffle
% area		100	
mean width		4.3	
mean depth		.1	
% cover		—	
cover type[1]		—	
substrate[2]		F25, SG40, LG35	

COMMENTS:

[1] L log, B boulder, IV instream vegetation, OV overstream vegetation, C cutbanks

[2] F fines, SG small gravel, LG large gravel, C cobbles, B boulders, Br bedrock

Buck Creek
at 2nd Bridge on
Buck Flats Road

DATE Aug25/82 AREA 62.04 m^2 SITE # 4

LENGTH 12 m

SPECIES	AGE	ll-RANGE	$\bar{l}$	MEAN WEIGHT	C_1	$\bar{p}$	$\bar{n}$	TOTAL BIOMASS	No/m^2 DENSITY	BIOMASS DENSITY	No / lineal metre
Rbt	0+	41-55	48.10	1.00	10	0.90	11.11	11.06	0.18	0.18	0.93
	1+	75-86	79.80	4.29	5	0.90	5.56	23.82	0.09	0.38	0.46
	2+	97-124	112.50	12.15	8	0.90	8.89	107.99	0.14	1.74	0.74
	3+	169	169.0	40.45	1	0.90	1.11	44.94	0.02	0.72	0.09
								187.81	0.43	3.12	2.22
Mw	Σ	73-76	74.67	5.62	3	0.90	3.33	18.75	0.05	0.30	0.28
Rhacesp	Σ	46-96	72.11	4.57	27	0.90	30.00	137.00	0.48	2.21	2.50

HABITAT DESCRIPTION: Glide/riffle/glide

Discharge Q ~ .40 m^3/s 14.1 cfs Gradient ~1.3

Temperature (°C) 14°C Turbidity Clear

Hydraulic Type	Pool	Glide	Riffle
% area		53.9	46.1
mean width		4.9	5.5
mean depth		0.23	0.10
% cover		1.9	0.2
cover type[1]		L, B,	B
substrate[2]		F16, SG26 LG30, C25, B3	F25, SG20, LG30, C20, B5

COMMENTS:

[1] L log, B boulder, IV instream vegetation, OV overstream vegetation, C cutbanks

[2] F fines, SG small gravel, LG large gravel, C cobbles, B boulders, Br bedrock

Buck Creek at Ferris' Property

DATE Aug 25/82 AREA 52.5 M² SITE # 5

LENGTH 12.2 M

SPECIES	AGE	II-RANGE	$\bar{l}$	MEAN WEIGHT	C_1	$\bar{p}$	$\bar{n}$	TOTAL BIOMASS	No/M² DENSITY	BIOMASS DENSITY	No / lineal mete
Rbt	0+	37-44	40.63	0.57	8	0.85	9.41	5.33	0.18	0.10	0.77
	1+	74-99	85.00	5.30	5	0.85	5.88	31.20	0.11	0.59	0.48
								36.53	0.29	0.69	1.25
Dace	≤	22-72	42.40	1.14	15	0.85	17.65	20.13	0.34	0.38	1.45

HABITAT DESCRIPTION:

Discharge Q ~ .30 m³/s 10.5 cfs Gradient N/R

Temperature (°C) 15°C Turbidity Clear

Hydraulic Type	Pool	Glide	Riffle
% area		69.3	30.7
mean width		4.0	5.35
mean depth		0.5	0.15
% cover		0.2	0.2
cover type[1]		C	C
substrate[2]		F40, SG15, LG30, C10, B5	F2, SG40, LG38, C2

COMMENTS:

[1] L log, B boulder, IV instream vegetation, OV overstream vegetation, C cutbanks

[2] F fines, SG small gravel, LG large gravel, C cobbles, B boulders, Br bedrock

M^c^Quarrie Creek DATE Aug 25/82 AREA 67.2 m² SITE # 1

LENGTH 11.1 m

SPECIES	AGE	ll-RANGE	$\bar{l}$	MEAN WEIGHT	C_1	$\bar{p}$	$\bar{n}$	TOTAL BIOMASS	No/m² DENSITY	BIOMASS DENSITY	No/lineal meter
Rbt.	0+	30-50	39.38	0.54	48	0.80	60.00	32.15	0.89	0.48	5.41
	1+	61-95	79.29	4.36	14	0.80	17.50	76.33	0.26	1.14	1.58
	2+	108-112	109.67	11.06	3	0.80	3.75	41.48	0.06	0.62	0.34
								149.96	1.21	2.24	7.33
Dace sp	Σ	57-89	66.71	3.66	7	0.80	8.75	32.05	0.13	0.48	0.79

HABITAT DESCRIPTION:

Discharge Q ~ .24 m³/s 8.47 cfs Gradient N/R

Temperature (°C) 18° C Turbidity Clear

Hydraulic Type	Pool	Glide	Riffle
% area		30.7	69.3
mean width		5.8	6.3
mean depth		0.14	0.10
% cover		3.4	6.7
cover type[1]		B, OV	B
substrate[2]		F10, SG25, LG30, C25, B10	F5, SG10, LG30, C40, B15

COMMENTS:

[1] L log, B boulder, IV instream vegetation, OV overstream vegetation, C cutbanks

[2] F fines, SG small gravel, LG large gravel, C cobbles, B boulders, Br bedrock

Richfield Creek at Highway 16 DATE Aug25/82 AREA 103.72 m² SITE # 1

LENGTH 13.2 m

SPECIES	AGE	fl-RANGE	$\bar{fl}$	MEAN WEIGHT	C_1	$\bar{p}$	$\bar{n}$	TOTAL BIOMASS	No/m² DENSITY	BIOMASS DENSITY	No/ linear meter
Rbt	0+	32-57	41.56	0.63	55	0.90	61.11	38.25	0.47	0.29	4.63
	1+	61-89	77.29	3.99	17	0.90	18.89	75.39	0.14	0.58	1.43
	2+	98-119	105.86	10.22	7	0.90	7.78	77.93	0.06	0.60	0.59
								191.57	0.67	1.47	6.65
Chk	0+	70	70.00	3.77	1	0.90	1.11	4.19	0.01	0.03	0.08
Dacesp	Σ	54-88	68.67	4.00	6	0.90	6.67	26.68	0.05	0.20	0.51

HABITAT DESCRIPTION: Glide /Riffle

Discharge Q ~ .5 m³/s 17.6cfs Gradient ~1.5

Temperature (°C) 17°C Turbidity Clear

Hydraulic Type	Pool	Glide	Riffle
% area		70.1	29.9
mean width		7.8	8.0
mean depth		0.2	0.1
% cover		7.7	2.4
cover type[1]		L, B, OV	B, OV
substrate[2]		F30, SG20, LG20 C20, B10	F10, SG10, LG40 C30, B10

COMMENTS: Green filamentous algae present throughout wetted substrate

[1] L log, B boulder, IV instream vegetation, OV overstream vegetation, C cutbanks

[2] F fines, SG small gravel, LG large gravel, C cobbles, B boulders, Br bedrock

APPENDIX 4. Length-frequency analysis and length-weight relationships from the Upper Bulkley River system, 1982.

Cumulative Length-frequency Data - Rainbow trout
Location: Upper Bulkley 1982
Date: August 24 to August 25 1982

Rbt

0+

1+

2+

MEANS

0+	43.50
1+	83.21
2+	113.88
3+	169

Cumulative Length-frequency Data
Location: Upper Bulkley 1982
Date: August 24 to August 25 1982

1 Sculpin 115mm

	Coho	Chk	Dacesp	Mw
20				
1				
2			I	
3			I	
4				
5				
6				
7				
8				
9				
30				
1				
2			II	
3				
4				
5				
6			II	
7			II	
8				
9			III	
40			II	
1			II	
2			I	
3			IIII	
4			IIII	
5				
6			II	
7				
8				
9				
50			II	
1				
2			I	
3				
4			I	
5			I	
6				
7			III	
8				
9			II	
60		I	II	
1				
2		I	I	
3		I	III	
4	I	III		
5	I	I	I	
6			I	
7		I	III	I
8		IIII	IIIII I	
9			II	
70			IIIII III	
1			III	
2		II	IIII	I
3			I	I
4			I	
5		I	II	I
6		II	II	I
7			II	
8	↑	III		I
9			II	
80		I		
1		↑		
2		IIII		
3	I 0+		I	
4		I	III	
5		II	II	
6		0+	II	
7			I	
8			I	
9		I 1+	I	
90				
1			I	
2			I	
3			I	
4		↓		
5		I	I	
6		II	II	
7				
8			I	
9				

	Coho	Chk	Dacesp	Mw
100		II		
1				
2		II		
3				
4				
5				
6				
7				
8				
9				
110				
1		I		
2				
3				
4		I		
5				
6				
7				
8				
9				
120				
1				
2				
3				I
4				
5				
6				
7				
8				
9				
130				
1				
2				I
3				
4				
5				
6				
7				
8				
9				
140				
1				
2				
3				
4				
5				
6				
7				
8				
9				
150				
1				
2				
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4				
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7				
8				
9				
160				
1				
2				
3				
4				
5				
6				
7				
8				
9				
170				
1				
2				
3				
4				
5				
6				
7				
8				
9				

	Mw			
180				
1				
2				
3				
4				
5	I			
6				
7				
8				
9	I			
190				
1				
2				
3				
4				
5				
6				
7				
8				
9				
200				
1				
2	I			
3				
4				
5				
6				
7				
8				
9				
210				
1				
2				
3				
4				
5				
6				
7				
8				
9				
220				
1				
2				
3				
4				
5				
6				
7				
8				
9				
230				
1				
2				
3				
4				
5	I			
6				
7				
8				
9				
240				
1				
2				
3				
4				
5				
6				
7				
8				
9				
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				

Length/Weight Relationships

1.	McQuarrie Creek	$r^2 = 0.95$ $a = 1.01$ $b = 8.26 \times 10^{-6}$
2.	Upper Buck Creek 2nd Bridge Crossing	$r^2 = 0.97$ $a = 2.78$ $b = 8.04 \times 10^{-6}$
3.	Combined data	$r^2 = 0.97$ $a = 1.56$ $b = 8.38 \times 10^{-6}$
	Empirical formula	$wt = 8.38 \times 10^{-6} \ \ell^3$

K-values used for Upper Bulkley 1982 population estimates

Rainbow trout	8.38×10^{-6}	ℓ^3
Coho	1.2×10^{-5}	ℓ^3
Chinook	1.1×10^{-5}	ℓ^3
Mountain whitefish	1.35×10^{-5}	ℓ^3
Sculpin	1.0×10^{-5}	ℓ^3
Dace	1.15×10^{-5}	ℓ^3

APPENDIX 5. Some correspondence regarding acid drainage problems from Equity Silver Mines Ltd. (from Habitat Management files).

Province of British Columbia — Environment — MEMORANDUM

To:
Dave Reynolds
Regional Manager

Date:
May 11, 1982.
File: 0161
xr 0261 Equity

Re: Acid drainage, Equity Mines

Gordon and I accompanied Brian Wilkes, George Derkson (E.P.S.), and Margaret Ross (E.P.S.) to the Equity Mine site on May 4, 1982. The trip was an eye opener. We have a serious acid drainage problem already and the mine has only been operating for two years. The situation is outlined in the attached memo written by Brian Wilkes.

This is simply to inform you that I agree with Brian's judgement that the situation is serious. I suspect that present output of acid and metals is just the beginning. The long term outlook for upper Buck Creek is in my opinion grim, and the outlook further downstream is not good. The worst current problem seems to stem from about half a mile of road that was ballasted with acid generating waste rock. It must be realized that many thousands of times as much rock is planned for disposal in the waste rock dump, and all of it will presumably undergo acid generation and leaching processes similar to those now well underway in the road material. My point is that present problems are just the beginning.

Perhaps now it may be apparent why I assign such very high priority to the Consolidated Cinola proposal. At least with Equity we have many miles of relatively limited value aquatic habitat between the mine and the high value Bulkley River. In the Consolidated Cinola issue we will have no such buffer. The mine, the milling complex, the tailings ponds, and the waste rock dump would all be in the immediate vicinity of the Yakoun River.

Just for perspective, the copper levels measured in the Equity leachate are about one thousand times those necessary to kill trout.

Cheers,

A. Edie

Allan Edie

c.c. D. Smuin
Keith Moore
Gordon Mackinnon
Mike Whately
Jim Walker
Brian Wilkes

AE:sb

British Columbia Environment

MEMORANDUM

Edie 0261 Equity.

To: T. Roberts

Date: May 4, 1982

File: PE-4475

Re: Equity Mine Update to May 3, 1982

1. Mine personnel have installed the gravity feed system to the sump for collecting waste rock acid water and pumping to the tailings pond. This should have theoretically caused an elevation in pH in the water over the silt check dams at Bessemer and below the waste rock dump. However, pH at these stations remains in the 3.5 range as of April 28th.

2. Clearly, further action is necessary to elevate the pH of waters flowing into the Bessemer creek drainage. I am advised today that other sources of acid water have been discovered, for example, the crushed ore bin drainage water. Consequently, Mr. Patterson advised me today that the entire mill yard is to be ditched and the water collected will be fed to the main sump.

3. Characteristics of the water sampled below the crushed culvert (now collected by the sump) are alarming. The table below gives recent data (station 0700092):

				Mg/L		
	PH	Cu Dissolved	As Dissolved	Zn Dissolved	Fe Dissolved	Pb Dissolved
1982-3-5	3.0	67.0	4.34	41.0	570	.02
1982-3-17	2.8	90.1	9.9	46.7	813	.20
1982-4-28	2.7					
Federal Maximum allowable (mg/l)		1.0 Total Cu	0.05 Total As	5.0 Total Zn	.3 Total Fe	0.05 Total Pb

There is no doubt that water of this character would be toxic to fish and other aquatic organisms. It must be enphasized that metal levels in the water flowing into Bessemer creek are still low. However, the sustained low pH of waters flowing into Bessemer, and thence into Buck creek, signals the potential to carry dissolved metals.

If metals elevate in Bessemer creek to levels similar to waters from the crushed culvert, we will have an emergency situation on our hands. The worst case scenario is the biological death of the upper Bulkley river, along with the public health issue attendant to toxic metals levels.

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Present metals readings in Bessemer creek water are as follows (Station 0400762) to March 5, 1982:

	pH	Cu Diss.	As Diss.	Zn Diss.	Fe Diss.	Pb Diss.
1982-2-25	4.3	1.93	.005	2.23	2.65	.001
1982-3-5	4.4	1.63	.005	2.01	2.57	.005

The concern is that the pH has dropped over the past 8 weeks from the 4.5 area to the 3.5 area. During this period, no new metals analysis have been obtained due to the backlog of work at the lab. The lab must co-operate in treating these samples on a priority basis because metals levels could have skyrocketed in the past 8 weeks and we simply wouldn't know it. We must have priority analysis so we know where we stand with the past samples.

It is suggested that as pH decreases, the difference between total and dissolved levels will be negligible. Therefore, if the company could use its atomic absorption spectrometer to provide frequent, up-to-date total metals counts at the silt check dams, we would have an up to date but rough picture of the situation. The company has been concerned that samples handled in its assay lab would be subject to contamination. This problem would have to be solved.

4. The company has taken over the biomonitoring program. We still do dissolved metals because the company has no field filtering apparatus. However, as soon as this is obtained, all the chemistry & aquatic work will be carried out by the company under my supervision. Split sampling will occur regularly to check company data. It is intended to review and adjust the biomonitoring program in the fall.

5. It is apparent to me that there is a great potential for serious environmental and public health consequences as a result of the acid water problem. I recommend the following:

   A. Brief senior ministry executive on the seriousness of this business. If an emergency situation develops, or if EMA is to be used, they should be advised now that the possibility exists.

   B. Be prepared to order Equity Mines to divert all water from the silt check dams into the tailings pond. If metals levels exceed drinking water maximums in Goosly lake or Buck creek, there is no solution other than a simple prohibition of all discharge.

   C. Order the company to install standpipes in various locations below the water collection ditches for periodic sampling. An hydrologist must be consulted for locations and methods. The objective is to discover if acid is in ground water not intercepted by the ditches.

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D. Order the company to install a water recorder or staff guage in Buck Creek. This is required to construct a stage-discharge curve & obtain total discharge figures. If the station is placed below Goosly lake, the flushing rate of the lake can be accurately calculated. This information, coupled with alkalinity measurement, can give us inferences on acid tolerance in the lake.

E. Order the company to undertake several acid generation studies in the main zone ore body. The main zone contains both pyrite and pyrrhotite. According to Hawley, 1972 (The Problem of Acid Mine Drainage in the Province of Ontario, Ont. MOE) pyrrhotite is up to 80 times as reactive as pyrite. Consequently, the acid generation potential of the main zone may be greater than the south zone. This must be proved in a quantitative manner one way or another.

F. The company and ourselves should investigate methods used by other companies in preventing the escape of acid to the environment. I understand the Sullivan mine and Western mines have acid generation problems and we should be looking for a creative solution to the equity situation. The ditch system is acknowledged to be a short term stop-gap measure. So far, it looks like the use of anionic or cationic surfactants as bactericides is not a good idea, due to conflicting reports of the persistance & toxicity of these substances, plus the need for continuous dosage.

Finally, it's time to frankly raise the spectre of preventing the main ore body from being mined until the appropriate works are in place for acid water treatment. If such technology fails to be found, a political choice has to be made on whether the mine is worth the potential environmental costs.

Brian

B.D. Wilkes
Head, Environmental Section

BDW/md

c.c. D. Smuin
A. Edie
M. Whately
R. McGinn, Mines Ministry

Province of British Columbia — Ministry of Environment

MEMORANDUM

To: R. H. Ferguson, Director
Waste Management Branch

MINISTRY OF ENVIRONMENT
JUL 9 1982
PE 4475
WASTE MANAGEMENT BRANCH

Date: July 6, 1982

File #50.21
PE 4475

RE: EQUITY SILVER MINES LTD. - PE 4475

Attached is a file record of the involvement of Skeena Waste Management staff in acid spill and acid generation problem at Equity Mines near Houston. It accurately documents both conditions, and more currently identifies the role that regional staff have, and are playing in connection with Permit 4475.

This is somewhat different than the evaluation by Assistant Director Klassen of the matter in his memo to you of June 21, 1982.

D.E. Smuin
Regional Director
Skeena Region

DES/cm

cc: T. Roberts

Called Terry R. for copy of memo (not on file) RHK. 82/7/15
I believe my comments to RHF reflected EPS concerns.

DISTRIBUTION	DATE	INITIALS
RHF	27/7	
~~RHK~~		
File		

Province of British Columbia — Environment — MEMORANDUM

To: FILE

Date: June 21, 1982

File: PE-4475

SUBJECT: EQUITY SILVER - RECORD OF EVENTS

November 18, 1981 - Holding tank corroded through resulting in the spill of 11,000 gallons of concentrated H_2SO_4 into the Bessemer drainage. Our office was notified November 19th.

November 20, 1981 - Karen Diemert, engineering aid, was on the scene to take samples and check pH and conductivity of drainages in the area. In the days following the acid spill, there was an essentially continuous dialogue between our office and Equity personnel concerning clean up procedures, monitoring requirements, and monitoring results obtained by Equity. Although unable to be on site all the time, Karen received very regular progress reports. On November 20th, 9:30 A.M., Karen met with Fish and Wildlife and Water Resources people to set up a regular monitoring program.

November 25, 1981 - Karen Diemert, and regional biologist, Brian Wilkes, were at the site to monitor mine drainages as well as downstream receiving waters. The above also met with Equity personnel to discuss progress as well as a planned course of action.

November 27, 1981 - Terry Roberts and Karen Diemert conducted the monitoring of 7 sample sites in the Equity Silver area.

December 7, 1981 - In a telephone conversation with Karen Diemert, mill superintendent, Gary Hawthorne, promised that a full pH profile would be done on the Bessemer system to try to determine the continued source of acidity. At this point, the waste rock dump was suspected of acid generation.

December 10, 1981 - Public hearing in Houston at the suggestion of mine manager, John Shaw. Till this point, Equity personnel had been carrying out a daily monitoring program and reporting results back to our office in Smithers.

Following is the weekly monitoring program carried out by Karen Diemert (weather permitting) till February 12th, her final official working day. Average number of sample sites visited per week was around 7.

December 10, 1981
December 17, 1981
December 31, 1981
January 18, 1982
January 26, 1982
February 4, 1982
February 12, 1982

Samples were obtained for general ions, as well as total and dissolved metals; analyses were done by the environmental lab in Vancouver.

.uary 5, 1982	- A letter addressed to Equity Silver, from Terry Roberts, outlines the requirement for plans for spill control facilities as well as an outline for a general spill control scheme for the entire plant site drainage area. Also in this letter, was discussed the apparent natural acid generation problem occurring at Equity Silver.
February 9, 1982	- At this time, construction of collection ditches and a pumping station below the Haul Road was underway with the intention of collecting the naturally generated acid seepage from the (waste rock) road base and pumping it up to the tailings pond, as a temporary measure. A concrete containment was under construction for the sulphuric acid tank and containment plans were being drawn up for the two caustic tanks.
February 22, 1982	- The collection and pumping system below the Haul Road was put into service, pumping acid water up into tankers which were emptied into the tailings pond. This resulted in a rise in the pH of Bessemer Creek from less than 4. to around 4.5.
February 25, 1982	- Waste Management and E.P.S. met with Equity Silver to discuss the acid mine drainage problem.
February 25, 1982	- Bruce Maclean and Frank Rhebergen, Waste Management personnel, obtained water samples at 8 monitoring sites.
February 25, 1982	- Second public hearing held in Houston.
March 3, 1982	- Regional Biologist, Brian Wilkes, had completed a draft proposal for a comprehensive environmental monitoring program for Equity Silver. A finalized version of this monitoring programme was presented to the Company on April 14th at the mine site.
March 5, 1982	- Bruce and Frank again obtained 8 sets of samples.
March 9, 1982	- Terry Roberts, Regional Manager, and Frank Rhebergen, Waste Management officer, met with Gary Hawthorne, Doug Fraser and John Shaw of Equity Silver to discuss the current situation, alternative courses of action, clean up, construction, and reporting requirements, etc., as well as likely biological monitoring requirements in the near future. Doug Fraser, Mine Superintendent, led a tour of the mine site to show Waste Management the construction of diversion and collection ditches, pumping stations, etc.
March 11, 1982	- Frank Rhebergen of Waste Management conducted the monitoring of 8 sample sites in the Equity area.
March 17, 1982	- Frank Rhebergen again obtained samples from 8 monitoring sites.
March 24, 1982	- Frank and Bruce obtained water samples from 9 locations as well as snow samples from 2 sites near the plant area.

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April 1, 1982 - Frank Rhebergen obtained water samples from 8 monitoring sites. In all these cases, pH and conductivity tests were performed in the Waste Management lab in Smithers upon return from the field.

April 5, 1982 - Meeting held in Smithers office; present were Terry Roberts (WMB), Brian Wilkes (WMB), Frank Rhebergen (WMB), Andy Ackerman (COS), and Terry Turnbull of Federal Fisheries. Brian presented the monitoring program which Equity Silver would be asked to undertake shortly. Current status at Equity, and possible future developments were discussed. Enforcement strategy, media involvement, groundwater studies, possible legal action, and surveillance committee were also subjects of discussion.

April 7, 1982 - Frank Rhebergen obtained water samples at 10 monitoring locations. Each week along with routine monitoring, additional grab samples were taken from various locations in an attempt to determine the sources of acid drainage. Construction progress was also inspected on a weekly basis.

April 14, 1982 - Meeting was held at Equity Silver between Waste Management staff and Equity representatives. Status report was given by Equity as well as an outline of future plans. Brian Wilkes presented the environmental monitoring program. Terry Roberts again proposed the initiation of a Surveillance Committee. A tour of the mine site was given and construction progress was inspected.

New sources of acid water were discovered in the diversion ditches along the upstream side of the Haul Road; this was brought to the attention of Bob Patterson who promised to do something to eliminate the problem. A sample of acid seepage from below the Haul Road was obtained for bacterial analysis by the E.P.S. lab.

Three water samples were obtained.

April 15, 1982 - Water samples were obtained at 10 monitoring sites, and a flow measurement was obtained at the silt check dam.

April 20, 1982 - Simultaneous monitoring of 11 sites was carried out by Waste Management and Equity Silver. Permanent monitoring locations were established and marked for the new monitoring program.

April 22, 1982 - Frank Rhebergen talked to the Environmental lab about Equity Silver's water sampling technique and the likely introduction of error in their analyses. Guidelines were given by the Environmental lab and would be passed on to Equity.

April 22, 1982 - An improved acid water collection system came into service. The system consisted of 6" and 8" gravity fed lines draining collection ditches below the Haul Road and waste rock dump, respectively, into a main sump equipped with a pumping station which directed the acid water to the tailings pond via a 10" line.

April 23, 1982 – Brian Wilkes met with Equity personnel to discuss monitoring programme details as well as the requirement for improved lab technique.

April 28, 1982 – Frank Rhebergen obtained water samples from 14 sites; simultaneous samples were obtained by Equity staff. Ditches and sumps were inspected for cave-ins and slumping tendencies; this was done on a weekly basis. Also, with the ice being gone now, flow estimates were being obtained on a weekly basis. With the collection system in operation for one week, no rise in pH was evident yet on Bessemer Creek. On this date, pH at the silt check dam was 3.3 with an approximate flow rate of 700 gal/min. Weekly grab samples continued to indicate the main source of acid water being fed into Bessemer Creek from the diversion ditches along the upstream side of the Haul Road.

May 4, 1982 – Frank Rhebergen obtained water samples from 12 sites and made a general inspection of the area. Sumps and collection lines had been constructed above the Haul Road in order to isolate from Bessemer Creek the acid water collecting in the diversion ditches. The resultant rise in pH at the silt check dam was minimal.

May 5, 1982 – Brian Wilkes and E.P.S. biologists toured the Equity Silver area and met with Equity personnel at the site.

May 11, 1982 – Frank Rhebergen obtained 19 water samples at Equity Silver. Flow had increased about 6 fold in Bessemer Creek and pH had risen to 4.4 from the 3.4 recorded one week earlier.

May 12, 1982 – Meeting with Equity Mines with representatives from E.P.S. and W.M.B. present; subjects of discussion were:

- Spill Contingency Plan
- containment facilities for acid and caustic storage tanks
- I.E.C. report on acid mine drainage
- surveillance committee
- current status of Equity's acid generation problem
- the requirement for hydrology studies
- the need for improved monitoring with faster turnaround on samples
- Reclamation plan
- collection of legal samples by E.P.S.

May 19, 1982 – Frank Rhebergen obtained 22 samples from the area surrounding Equity Silver Mines. Additional ditching had been constructed around the plant site area for the collection of acid water. A pond of acid water above the Haul Road had been pumped dry thus lowering the water table in the area and eliminating the springs of acid water in the road base which had been the main source of contamination of Bessemer Creek. Although the flow in the creek had dropped to approximately 1/7 of the previous week's flow, the pH rose from 4.4 to 5.9, the highest it had been in many months.

May 26, 1982 - Brian Wilkes and Frank Rhebergen conducted water quality study on Goosly Lake, obtaining temperature, pH, and dissolved oxygen profiles for 3 different sites on the lake. pH of Bessemer Creek at the mine was also checked and found to have improved again from 5.9 one week earlier to 6.8. Specific conductance was down to 180 µMHO/CM while earlier typical values were of the order of 2500 µMHO/CM.

June 15, 1982 - Frank Rhebergen obtained 24 water samples and made general inspection of the area. On the whole, the situation appeared to be under control with a few minor concerns requiring some attention. The pH of Bessemer Creek was still up at 6.8 while the collected acid water in the main sump had a pH of 3.0. In conclusion, the system of collection and diversion ditches, gravity fed lines, sumps and pumps appear to have isolated the acid water from the natural drainages for the short term, anyhow. At this time, it is not yet known what the long term approach will be to the acid generation problem.

Frank Rhebergen

Frank Rhebergèn, P. Eng.
Waste Management Officer

FR/ak