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CONSERVATION AND PROTECTION
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PACIFIC AND YUKON REGION
NORTH VANCOUVER, B.C.

1987 CINOLA PROJECT BASELINE STUDIES

Regional Program Report No. 90 - 01

BY

G. DERKSEN

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ABSTRACT

A monitoring program was conducted in September/October 1987 to further establish the baseline conditions of water and sediment quality in streams adjacent to a proposed gold mine. The sediment results are discussed in the context of trend monitoring considerations.

RESUME

Un programme de surveillance a été mené en september/october 1987 pour mieux évaluer les conditions de base de la qualité de l'eau et des sédiments dans les cours d'eau adjacents à la mine d'or projettée. Les résultats des analyses de sédiments sont discutées dans le contexte d'une surveillance des tendances des données.

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1.0 INTRODUCTION

In June 1988, City Resources (Canada) Limited submitted a Stage II Report to the Provincial Mine Development Steering Committee (City Resources, 1988). The report outlined the proposed development of an open pit gold mine (Cinola Gold Project) on Graham Island, Queen Charlotte Islands, British Columbia. The mine would be located within the Yakoun River drainage which has significant fishery resources (Brown and Musgrave, 1979).

As part of a Cinola Gold Project pre-development data collection program, Environment Canada (Environmental Protection), undertook a monitoring program in September 1987. The program focused on further establishing baseline conditions of sediment quality from which to assess any potential changes in sediment quality resulting from mining activity. In addition, two sediment sampling techniques were used in order to evaluate differences in collection methodology. Surface water samples were also collected to characterize the study streams.

2.0 STUDY AREA

The Yakoun River drains an area of approximately 477 square kilometers. The Yakoun River flows in a northerly direction and drains into Masset Inlet near Port Clements, B.C. (Figure 1).

The tributary streams that could be potentially impacted most by the Cinola Project include Barbie Creek and Florence Creek (Figure 1). Barbie Creek drains the area surrounding the ore body (open pit) and is proposed to receive various mine related discharges (settling ponds, treated acid mine water). Upper Florence Creek has been identified as the location for the tailings impoundment. Barbie Creek drains into the Yakoun River approximately 29km upstream of Yakoun Bay. Florence Creek drains into the Yakoun Bay estuary.

2.1 Sample Sites

2.1.1 **Surface Water**. Water samples were collected on October 2,1987 from sites (1,2,4,6) as described in earlier surveys (Derksen 1983, Derksen 1985a). Sample sites are shown on Figure 1.

2.1.2 **Sediment**. Sediment samples were collected from three sites on Barbie Creek on September 30, 1987. Two of the Barbie Creek sites (B1 and B3) were located per earlier surveys (Derksen 1985). A new site (soft sediment) was sampled at the downstream end of the Barbie Creek wetland (B4) approximately 15 meters upstream of the Branch 40 road crossing (Figure 2). Two sites were sampled on Florence Creek on October 1, 1987. One site was located per earlier surveys (F1) and an additional site (F2) was sampled further upstream (approximately 200 meters downstream of the Branch 4 bridge crossing). The two sites (sampled on October 1, 1987) on the Yakoun River (Y1 and Y2) were located per previous surveys. Sample sites are shown on Figure 2.

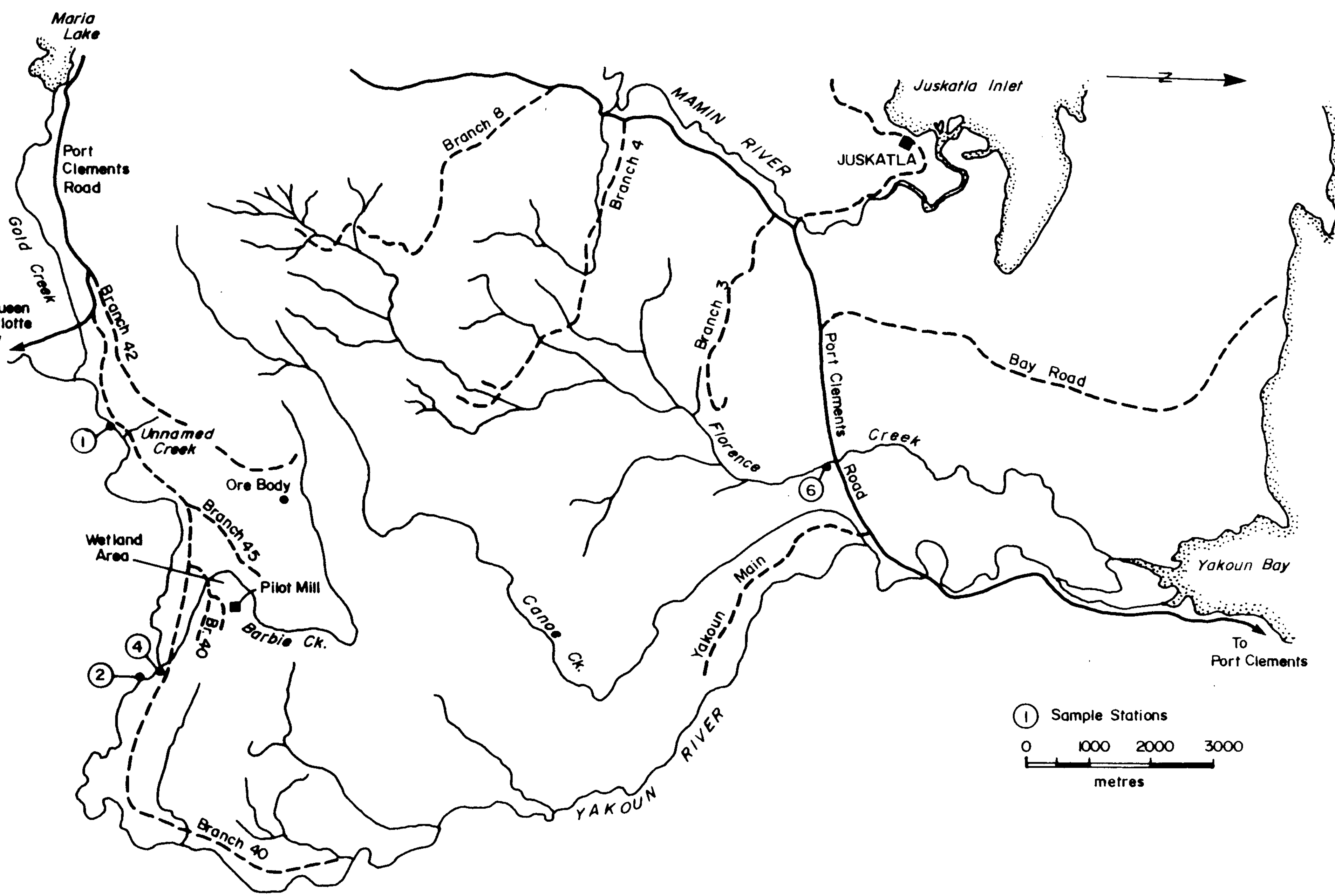

FIGURE 1. Yakoun River and Surface Water Sample Sites - 1987.

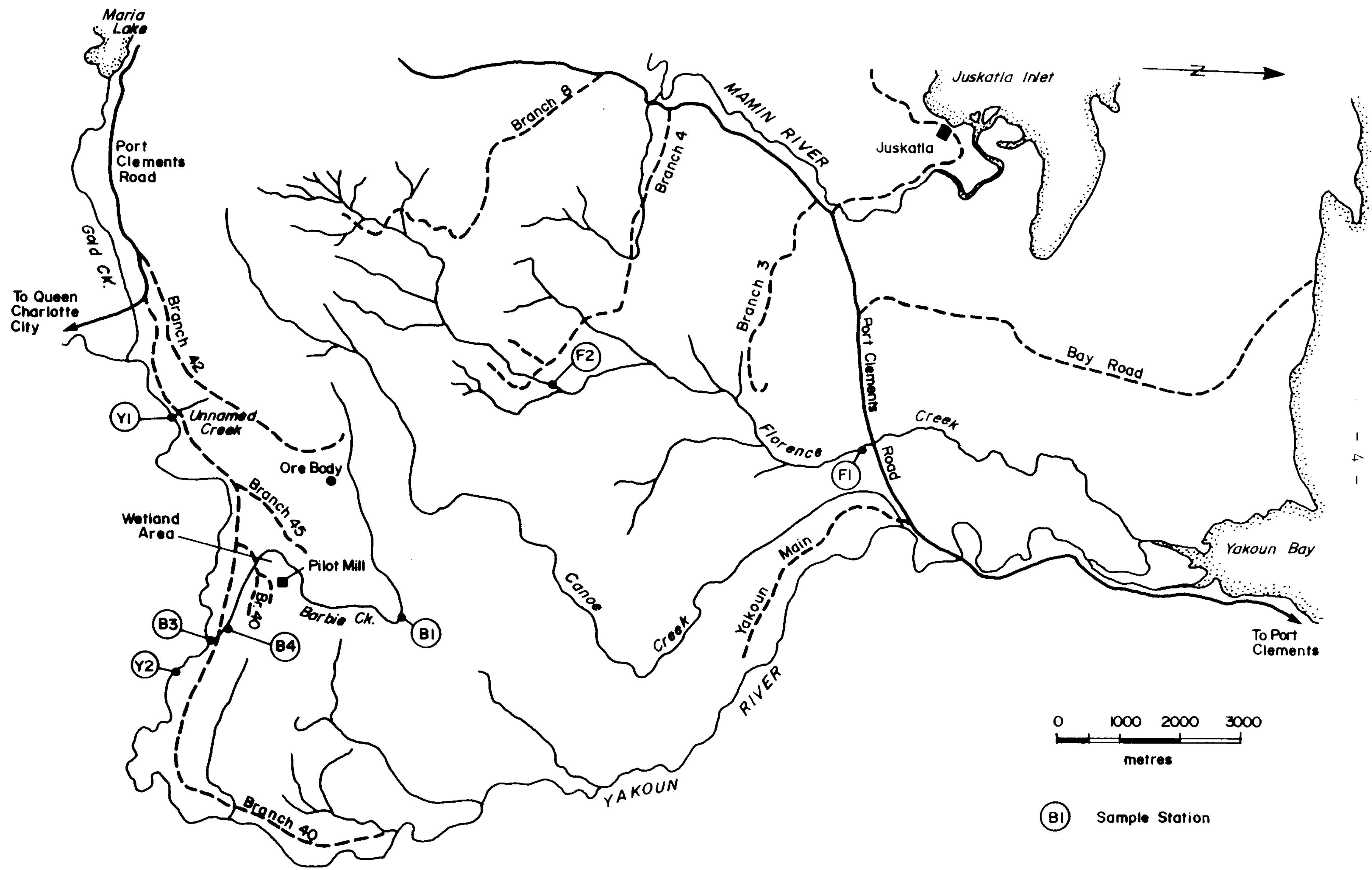

FIGURE 2 : Yakoun River and Sediment Sample Sites - 1987.

3.0 MATERIALS AND METHODS

3.1 Surface Water Quality

Grab samples were collected in clean sample bottles and treated as described in Table 1. Triplicate samples were collected in all cases except for phosphorus. Distilled water blanks were also collected for metal analysis quality assurance.

Dissolved total phosphorus samples were filtered through 0.45um distilled water soaked and rinsed cellulose acetate membrane filters. Dissolved metal samples were filtered through 0.45um cellulose nitrate membrane filters. Phosphorus samples were filtered immediately in the field. Metal samples were filtered into clean sample bottles within six hours of collection.

Samples were shipped in coolers with ice to the Environment Canada, West Vancouver Chemistry Laboratory.

Analytical methods are summarized in Table 2 (Environment Canada, 1989).

3.2 Sediment

Sediment samples at stations B1,B2,F1,F2,Y1, and Y2 were collected with a stainless steel syringe per earlier surveys. In addition, for comparative purposes, at stations B1 and F1 samples were also collected with a 3.5mm ID acrylic core tube. At station B4 (soft sediment, wetland area) only the core tube was used and a wooden dowl with a rubber bung fixed to the end of it was used to extrude the sample.

Five composite sediment samples were collected at each site for metal and volatile residue analyses (<0.15mm fraction). The syringe samples were treated per earlier surveys except that the samples were left to settle overnight in the 2L polyethylene sample bottle rather than one hour settling in an Imhoff cone. Samples were placed in Kraft sediment bags and were kept cold

TABLE 1: SURFACE WATER SAMPLE CONTAINERS AND TREATMENT

ANALYSIS	SAMPLE BOTTLE & PRESERVATION
Immediates	
alkalinity acidity pH	- 200ml poly, cold
chloride sulfate residue(non-filterable) (total volatile) (total residue)	- 1000ml poly, cold
total organic carbon	- 100ml glass, cold
nitrogen(ammonia) (nitrite/nitrate)	- 200ml poly, cold
phosphorus (total) (dissolved)	- 60ml glass - 60ml glass
Metals	
(total and dissolved)	- 100ml acid washed poly, 0.5ml nitric acid
mercury (total)	- 100ml acid washed poly, 5ml potassium dichromate - nitric acid

TABLE 2: SURFACE WATER SAMPLE ANALYTICAL METHODS

PARAMETER (detection limit)	METHOD
Immediates	
alkalinity(1mg/L)	- Potentiometric titration with sulfric acid to pH 4.5.
acidity(1mg/L)	- Potentiometric titration with standard alkali to pH 8.3.
pH(0.1)	- Potentiometric, pH meter.
chloride(0.05mg/L)	- Colourimetric, mercuric thiocyanate-ferric nitrate combined reagent.
sulfate(1mg/L)	- Colourimetric, methylthymol blue.
residues(5mg/L)	
(non-filterable)	- Gravimetric,Whatman GFC filtered and dried at 105C for one hour.
(total volatile)	- Gravimetric, evaporated at 75C overnight and then dried at 105C for one hour, loss on ignition at 550C.
(total)	- Gravimetric, evaporated at 75C overnight and then dried at 105C for one hour.
total organic carbon(1mg/L)	- Combustion, infra-red.
phosphorus(2ug/L)	- total and dissolved. Colourimetric persulphate-autoclave digest, molybdate-ascorbic acid reduction.
nitrogen	- ammonia(5ug/L). Colourimetric, phenolhypochlorite.
	- nitrite/nitrate(5ug/L). Colourimetric, cadium/copper reduction.

metals(total and dissolved). Total metal samples (except mercury) are autoclave digested with 3:1 nitric: hydrochloric acid for two hours. Mercury samples are oxidized by the addition of 2:1 sulfuric:nitric acid, 3% potassium persulfate and heated for one hour at 105 C.

- Ag(0.1ug/L)	graphite furnace atomic absorption
- Cd(0.1ug/L)	graphite furnace atomic absorption
- Cu(0.5ug/L)	graphite furnace atomic absorption
- Pb(0.5ug/L)	graphite furnace atomic absorption
- As(0.5ug/L)	ICP emission spectrometry-hydride
- Se(0.5ug/L)	ICP emission spectrometry-hydride
- Al(0.05mg/L)	ICP emission spectrometry
- Ca(0.1mg/L)	ICP emission spectrometry
- Fe(5ug/L)	ICP emission spectrometry
- Mg(0.1mg/L)	ICP emission spectrometry
- Mn(1ug/L)	ICP emission spectrometry
- Si(0.05mg/L)	ICP emission spectrometry
- Zn(2ug/L)	ICP emission spectrometry
- Hg(0.05ug/L)	cold vapour atomic absorption
- hardness(mg/L)	- calculated from dissolved metal sample

during transit and then frozen until preparation for analysis.

Sediment sample analyses and analytical methods are summarized in Table 3. The samples were analyzed at the Environment Canada, West Vancouver Laboratory. The sediment samples in this study were digested using a microwave oven procedure whereas previously, a hot block digestion was used. Millward and Kluckner, 1989 reported that there was a significant time saving using the microwave procedure and that there were no significant differences in the results from the two procedures. Sediment reference samples NBS 1645 and NBS 1646 were used to determine metal recovery.

TABLE 3: SEDIMENT ANALYSES AND ANALYTICAL METHODS

Volatile Residue - Sample is oven dried at 90 C overnight, oven dried at 103 C for one hour and then muffled at 550 C for one hour.
- Gravimetric analysis.

Metals - Samples are oven dried at 40 C, sieved to <0.15mm. and then rolled to homogenize. The sample is then weighted (0.3g) into a Teflon digestion vessel and digested with 4.5ml HNO_3 and 1.5ml HCl and 1ml deionized water in a microwave oven (720 joules/sec) for 15 minutes. The sample is cooled, volumized, and settled overnight. The decant is analyzed.

- Ag(2ug/g)*,	ICP emission spectrometry
- Al(8ug/g),	ICP emission spectrometry
- As(8ug/g),	ICP emission spectrometry
- Ba(0.2ug/g),	ICP emission spectrometry
- Ca(20ug/g),	ICP emission spectrometry
- Cd(0.8ug/g),	ICP emission spectrometry
- Cr(0.8ug/g),	ICP emission spectrometry
- Cu(0.8ug/g),	ICP emission spectrometry
- Fe(8ug/g),	ICP emission spectrometry
- Hg(0.008ug/g),	cold vapour atomic absorption
- Mg(20ug/g),	ICP emission spectrometry
- Mn(0.2ug/g),	ICP emission spectrometry
- Ni(3ug/g),	ICP emission spectrometry
- Pb(8ug/g),	ICP emission spectrometry
- Si(8ug/g),	ICP emission spectrometry
- V(2ug/g),	ICP emission spectrometry
- Zn(0.3ug/g),	ICP emission spectrometry

* detection limit for 0.3g dried sample

4.0 RESULTS

4.1 Surface Water Quality

Water quality results for non metal and metal fractions are reported in Appendix A(i) and Appendix A(ii) respectively.

4.2 Sediment Quality

The sediment quality results are reported in Appendix B(i) (non metals) and Appendix B(ii) (metals). The reference sediment results are reported in Appendix B(iii).

5.0 DISCUSSION

5.1 Sediment Trend Monitoring

5.1.1 Sample Size Considerations. The sediment data collected in this study and from an earlier study represents a baseline for future comparisons. As examples, mercury and copper levels have been assessed to estimate sample size requirements. Analysis of variance were followed by multiple comparisons using Tukey's test (Zar, 1984). In this case, due to unequal sample sizes, the statistical program uses the harmonic mean. All tests for significance were made at the 95% level.

As shown in Figure 3, for the same station, significant differences in metal content can occur between samples collected on different months and between samples collected on the same month but different years. For example, Barbie Creek mean copper levels in September 1982 were significantly lower than on February 1983 and September 1987 (Figure 3b).

For future impact assessment studies, 'contamination' might be defined as increases in sediment levels that are statistically significantly greater than baseline levels (assuming the baseline estimate adequately reflects the population variance). The number of samples required to measure a specified increase in mean metal content (e.g. copper) can be estimated (Table 4). In order to measure a two standard deviation increase in mean sediment copper levels, in the order of 5-6 samples are required. However, in order to detect a one standard deviation increase, then an estimated 13 samples would be required.

5.1.2 Sample Method Considerations

To determine whether different sample methods might result in different estimates of sediment metal levels, both syringe and core tube samples were collected at two sites. As shown in Figure 4, significant differences in mean estimates of sediment quality can result from different sample methods. The

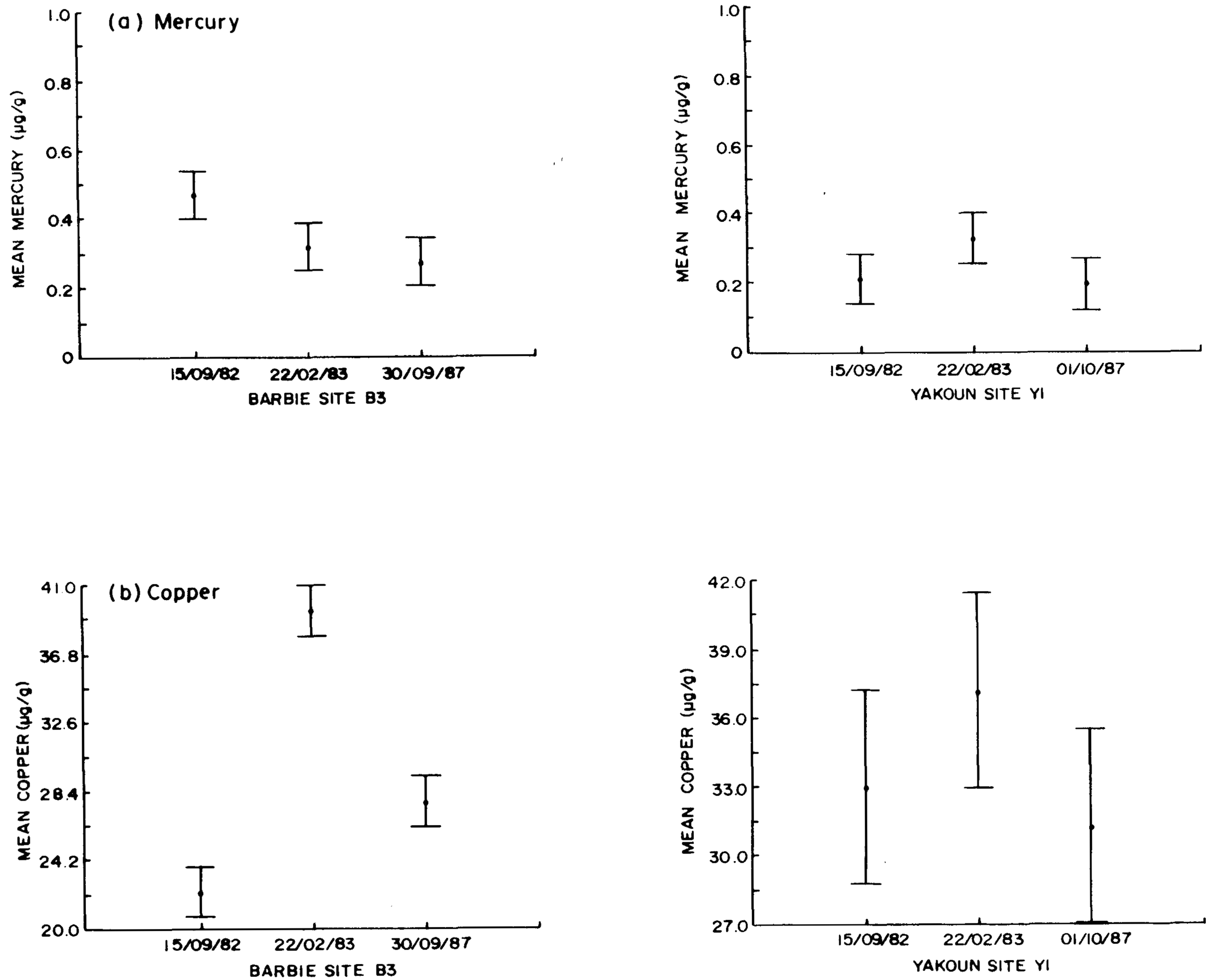

FIGURE 3: Barbie Creek and Yakoun River - Tukey's Multiple Comparison for (a) Mean Mercury and (b) Mean Copper Concentrations for Syringe Samples.

TABLE 4: ESTIMATED SAMPLE SIZE TO MEASURE A SPECIFIED LEVEL OF CHANGE IN BARBIE CREEK (B3) SEDIMENT COPPER CONCENTRATIONS

Background Information	Percent Chance	Specified Change	Estimated n*
mean = 30.3 ugCu/g sd = 7.5	(i) 90%	15 ugCu/g	5-6
var = 56.7 n = 14	(ii) 90%	7.5 ugCu/g	13

* Estimation of required n to test Ho: U = Uo, p=0.05 (Zar,1984 pg. 110)

higher mercury, copper, and aluminium levels in the syringe samples can be attributed to the higher organic content of those samples (Table 5). Barbie Creek and the Yakoun River to a lesser degree are both highly organic in nature (Appendix A(i)). Copper, mercury, and aluminium form stable complexes with humic (organic) material (Petersen, 1987). Maintaining continuity in sample methods is an important factor in trend assessments.

TABLE 5: CORRELATION MATRIX

	Cu	Al	SVR
Hg	0.24	0.48*	0.50*
Cu		0.68*	0.56*
Al			0.70*

* p=0.05, reject hypothesis (r = 0) that variables are independent

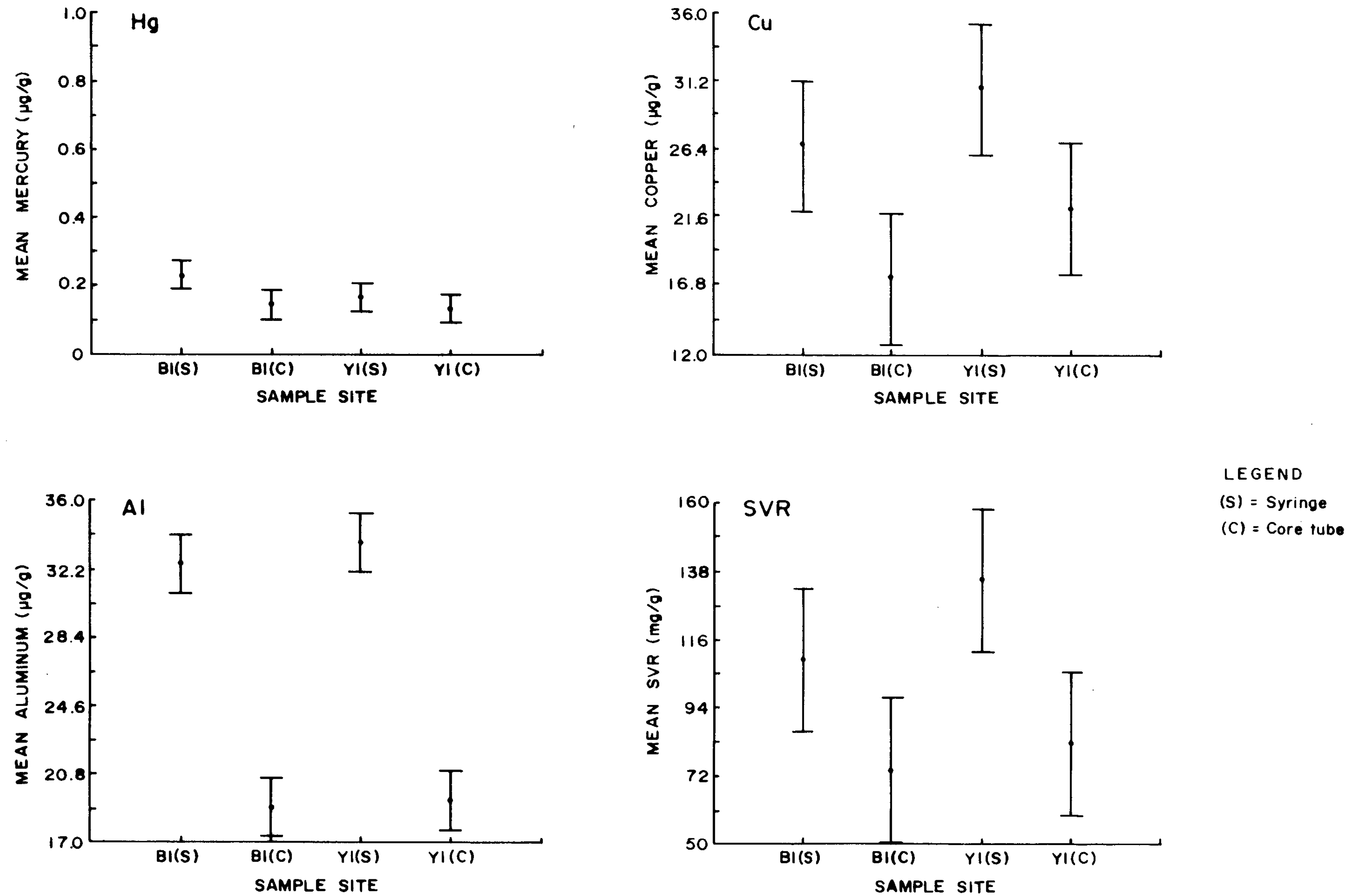

FIGURE 4. Barbie Creek and Yakoun River - Tukey's Multiple Comparison for Syringe and Core Tube Samples - Hg, Cu, Al, SVR.

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APPENDIX A – WATER QUALITY (i) NON METALS

- Acidity, Alkalinity, Hardness, pH, Sulphite and Chloride
- TOC, TR, NFR, TVR, Nitrite+Nitrate-N, Ammonia-N and total and Dissolved Phosphorus

APPENDIX A - WATER QUALITY (i) NON METALS
Date : October 2 1987

Parameter* (stn)	Barbie Creek (4)	Florence Creek (6)	Yakoun River (1)	Yakoun River (2)
Acidity	10.9	8.8	2.1	2.1
(mg/l CaC03)	10.9	8.8	2.1	2.1
	10.9	8.4	2.1	1.7
Alkalinity	3.1	4.6	10.2	11.2
(mg/l CaC03)	3.1	4.6	9.7	9.7
	3.1	4.6	9.2	10.2
Hardness(Ca&Mg)	12.4	8.26	11.6	11.8
(mg/l CaC03)	12.5	8.02	11.5	11.6
	13.0	8.37	11.6	12.0
Hardness(Total)	18.4	13.7	12.7	12.9
(mg/l CaC03)	18.5	13.2	12.7	12.8
	19.0	13.8	12.7	13.1
pH	5.4	5.6	6.9	6.9
	5.4	5.6	6.9	6.9
	5.4	5.6	6.9	6.9
Sulphate(mg/L)	15	12	10	9
	16	12	10	9
	16	13	10	9
Chloride(mg/L)	7.5	7.0	4.4	4.3
	7.7	7.1	4.4	4.4
	7.6	7.0	4.4	4.0

cont'd...

APPENDIX A - WATER QUALITY (i) NON METALS (Continued)
Date : October 2 1987

Parameter* (stn)	Barbie Creek (4)	Florence Creek (6)	Yakoun River (1)	Yakoun River (2)
TOC(mg/l)	27	31	10	10
	27	30	7	8
	23	29	11	10
TR(mg/L)	101	103	46	42
	99	102	46	46
	94	99	46	51
NFR(mg/L)	<5	<5	<5	<5
	<5	<5	<5	<5
	<5	<5	<5	<5
TVR(mg/L)	72	79	28	22
	75	81	28	28
	69	78	24	24
Nitrite+Nitrate-N	<5	<5	16	16
(ug/L)	<5	<5	16	17
	<5	<5	16	17
Ammonia-N(ug/L)	15	18	<5	<5
	21	19	5	<5
	14	19	<5	<5
TPhos. -P(ug/L)	30	26	17	13
TDPhos.-P(ug/L)	25	27	8	11

* 3 replicates except phosphorus

APPENDIX A – WATER QUALITY (ii) METALS

- Al, As, Cd, Cu, Fe, Pb, Mn, Hg, and Zn

APPENDIX A - WATER QUALITY (ii) METALS
Date : October 2 1987

Parameter*	Barbie Creek		Florence Creek		Yakoun River			
(station)	4		6		1		2	
	T	D	T	D	T	D	T	D
Al(mg/L)	0.63	0.53	0.60	0.58	0.37	0.13	0.40	0.13
	0.61	0.55	0.62	0.56	0.39	0.16	0.37	0.14
	0.66	0.54	0.67	0.58	0.39	0.13	0.38	0.14
As(ug/L)	2.0	1.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	1.9	1.4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	2.0	1.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cd(ug/L)	0.1	<0.1	-	<0.1	0.1	<0.1	0.1	<0.1
	0.1	<0.1	0.1	<0.1	0.2	<0.1	0.2	<0.1
	0.1	<0.1	0.1	<0.1	<0.1	<0.1	0.2	<0.1
Cu(ug/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Fe(mg/L)	1.89	1.42	1.30	1.16	0.44	0.19	0.48	0.19
	1.88	1.40	1.31	1.12	0.44	0.19	0.55	0.19
	1.96	1.42	1.30	1.18	0.44	0.19	0.42	0.19
Pb(ug/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	<0.5
	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.9	<0.5
Mn(mg/L)	0.230	0.221	0.046	0.043	0.023	0.009	0.026	0.012
	0.229	0.216	0.045	0.043	0.024	0.010	0.023	0.010
	0.237	0.219	0.047	0.043	0.024	0.009	0.022	0.011
Hg(ug/L)	<0.05	-	<0.05	-	<0.05	-	0.12	-
	<0.05	-	<0.05	-	<0.05	-	<0.05	-
	<0.05	-	<0.05	-	<0.05	-	<0.05	-
Zn(ug/L)	8	9	<2	2	<2	<2	4	<2
	9	9	<2	2	<2	<2	<2	<2
	7	8	<2	4	<2	<2	6	3

* 3 replicates

APPENDIX B - SEDIMENT QUALITY (i) NON METAL

- SVR

APPENBIX B(i) - SVR

SVR (%) (<0.15mm)

	LOWER BARBIE	MIDDLE BARBIE		LOWER FLORENCE		UPPER FLORENCE	YAKOUN	
(1987)	B3(S)	B1(S)	B1(C)	F1(S)	F1(C)	F2(S)	Y1(S)	Y2(S)
SEP 30	11.5	10.2	7.5	13.1	7.1	11.2	8.7	6.6
	11.7	18.2	4.9	15.0	7.4	10.6	8.6	6.8
	10.2	9.9	10.8	13.6	10.0	13.1	10.1	6.5
	13.1	8.1	7.3	15.2	8.0	10.8	8.3	6.6
	29.4	8.5	6.6	10.9	9.0	11.9		
MEAN	15.2	11.0	7.4	13.6	8.3	11.5	8.9	6.6
SD	7.2	3.7	1.9	1.6	1.1	0.9	0.7	0.1
n	5	5	5	5	5	5	4	4
rsd(%)	47	34	26	11	13	8	8	2

	LOWER BARBIE
(1987)	B4(C)
SEP 30	39.2
	27.2
	23.6
	27.6
	28.7
MEAN	29.3
SD	5.3
n	5
rsd(%)	18

(S) = syringe sampler
(C) = core sampler

APPENDIX B - SEDIMENT QUALITY (ii) METALS

- As, Cd and Cr
- Cu and Hg
- Ni, Pb and Zn
- Al and Fe
- Ca, Mg and Mn
- Barbie Wetland Site B4

APPENDIX B(ii) - As, Cd, and Cr

ARSENIC (ug/g) (<0.15mm)

	LOWER BARBIE	MIDDLE BARBIE		LOWER FLORENCE		UPPER FLORENCE	YAKOUN	
(1987)	B3(S)	B1(S)	B1(C)	F1(S)	F1(C)	F2(S)	Y1(S)	Y2(S)
SEP 30	20	28	71	< 8	29	< 8	< 8	41
	23	30	37	< 8	21	< 8	< 8	27
	10	31	28	< 8	31	< 8	40	27
	23	10	73	< 8	22	< 8	30	35
	88	< 8	60	< 8	26	< 8		
MEAN	33	21	54	< 8	26	< 8	21	33
SD	28	10	18	0	4	0	14	6
n	5	5	5	5	5	5	4	4
rsd(%)	85	48	34	0	15	0	65	18

CADMIUM (ug/g) (<0.15mm) *

	LOWER BARBIE	MIDDLE BARBIE		LOWER FLORENCE		UPPER FLORENCE	YAKOUN	
(1987)	B3(S)	B1(S)	B1(C)	F1(S)	F1(C)	F2(S)	Y1(S)	Y2(S)
SEP 30				< 0.8				
				< 0.8				
				< 0.8				
				< 0.8				
				< 0.8				
MEAN				< 0.8				
SD				0				
n				5				
rsd(%)				0				

* values not reported(high reference sample variability),F1(S)rerun

CHROMIUM (ug/g) (<0.15mm)

	LOWER BARBIE	MIDDLE BARBIE		LOWER FLORENCE		UPPER FLORENCE	YAKOUN	
(1987)	B3(S)	B1(S)	B1(C)	F1(S)	F1(C)	F2(S)	Y1(S)	Y2(S)
SEP 30	51.6	61.9	24.5	41.8	23.3	34.7	55.4	56.9
	47.1	52.8	24.1	36.8	20.3	38.8	53.0	60.1
	50.5	65.3	24.3	39.2	21.9	41.2	50.3	64.6
	50.6	70.5	29.0	44.8	21.8	41.6	62.9	71.7
	42.9	66.9	26.8	47.0	21.3	39.5		
MEAN	48.5	63.5	25.7	41.9	21.7	39.2	55.4	63.3
SD	3.2	6.0	1.9	3.7	1.0	2.5	4.7	5.6
n	5	5	5	5	5	5	4	4
rsd(%)	7	9	7	9	4	6	8	9

(S) = syringe sampler (C) = core sampler

APPENDIX B(ii) - Cu and Hg

COPPER (ug/g) (<0.15mm)

(1987)	LOWER BARBIE B3(S)	MIDDLE BARBIE B1(S)	MIDDLE BARBIE B1(C)	LOWER FLORENCE F1(S)	LOWER FLORENCE F1(C)	UPPER FLORENCE F2(S)	YAKOUN Y1(S)	YAKOUN Y2(S)
SEP 30	27.5	27.7	19.2	36.2	20.3	38.1	33.9	29.5
	27.7	31.7	15.0	25.3	20.6	38.0	35.1	30.5
	26.2	30.7	14.0	25.6	20.2	38.3	29.4	30.0
	26.6	23.0	19.8	25.9	19.1	36.5	26.7	29.8
	30.2	19.8	18.3	39.8	30.8	35.9		
MEAN	27.6	26.6	17.3	30.6	22.2	37.4	31.3	30.0
SD	1.4	4.5	2.3	6.2	4.3	1.0	3.4	0.4
n	5	5	5	5	5	5	4	4
rsd(%)	5	17	13	20	20	3	11	1

MERCURY (ug/g) (<0.15mm)

(1987)	LOWER BARBIE B3(S)	MIDDLE BARBIE B1(S)	MIDDLE BARBIE B1(C)	LOWER FLORENCE F1(S)	LOWER FLORENCE F1(C)	UPPER FLORENCE F2(S)	YAKOUN Y1(S)	YAKOUN Y2(S)
SEP 30	0.24	0.25	0.12	0.19	0.13	0.18	0.19	0.19
	0.24	0.25	0.11	0.18	0.09	0.14	0.20	0.18
	0.21	0.25	0.23	0.17	0.19	0.19	0.19	0.21
	0.25	0.15	0.15	0.18	0.08	0.14	0.20	0.23
	0.43	0.27	0.12	0.11	0.18	0.15		
MEAN	0.27	0.23	0.15	<0.17	0.13	0.16	0.19	0.20
SD	0.08	0.04	0.04	0.03	0.04	0.02	0.01	0.02
n	5	5	5	5	5	5	4	4
rsd(%)	29	18	30	17	34	13	3	9

(S) = syringe sampler
(C) = core sampler

APPENDIX B(ii) - Ni, Pb, and Zn

NICKEL (ug/g) (<0.15mm)

(1987)	LOWER BARBIE B3(S)	MIDDLE BARBIE B1(S)	MIDDLE BARBIE B1(C)	LOWER FLORENCE F1(S)	LOWER FLORENCE F1(C)	UPPER FLORENCE F2(S)	YAKOUN Y1(S)	YAKOUN Y2(S)
SEP 30	26	19	8	19	9	17	26	25
	24	20	10	20	9	19	22	29
	30	18	9	18	9	20	22	30
	33	19	10	19	8	20	28	34
	34	21	10	21	9	18		
MEAN	29	19	9	19	9	19	25	30
SD	4	1	1	1	0	1	3	3
n	5	5	5	5	5	5	4	4
rsd(%)	13	5	9	5	5	6	11	11

LEAD (ug/g) (<0.15mm)

(1987)	LOWER BARBIE B3(S)	MIDDLE BARBIE B1(S)	MIDDLE BARBIE B1(C)	LOWER FLORENCE F1(S)	LOWER FLORENCE F1(C)	UPPER FLORENCE F2(S)	YAKOUN Y1(S)	YAKOUN Y2(S)
SEP 3	< 8	< 8	18	< 8	24	< 8	< 8	28
	< 8	< 8	10	< 8	19	< 8	< 8	26
	< 8	< 8	20	< 8	18	< 8	31	25
	< 8	< 8	23	< 8	19	< 8	24	22
	< 8	< 8	21	< 8	25	< 8		
MEAN	< 8	< 8	18	< 8	21	< 8	18	25
SD	0	0	4	0	3	0	10	2
n	5	5	5	5	5	5	4	4
rsd(%)	0	0	24	0	14	0	57	9

ZINC (ug/g) (<0.15mm)

(1987)	LOWER BARBIE B3(S)	MIDDLE BARBIE B1(S)	MIDDLE BARBIE B1(C)	LOWER FLORENCE F1(S)	LOWER FLORENCE F1(C)	UPPER FLORENCE F2(S)	YAKOUN Y1(S)	YAKOUN Y2(S)
SEP 30	237	182	109	82.7	125	133	220	111
	180	232	101	78.7	130	152	222	116
	176	212	106	81.2	121	168	203	119
	189	213	108	81.5	84	125	186	112
	336	142	110	82.6	77	141		
MEAN	224	196	107	81	107	144	208	115
SD	60	31	3	1	22	15	15	3
n	5	5	5	5	5	5	4	4
rsd(%)	27	16	3	2	21	10	7	3

(S) = syringe sampler (C) = core sampler

APPENDIX B(ii) - Al and Fe

ALUMINIUM (mg/g) (<0.15mm)

(1987)	LOWER BARBIE B3(S)	MIDDLE BARBIE B1(S)	MIDDLE BARBIE B1(C)	LOWER FLORENCE F1(S)	LOWER FLORENCE F1(C)	UPPER FLORENCE F2(S)	YAKOUN Y1(S)	YAKOUN Y2(S)
SEP 30	38.8	32.9	19.2	34.3	20.7	35.1	37.4	26.5
	39.4	32.8	16.3	30.8	19.8	36.5	41.8	25.5
	37.7	33.9	20.2	34.7	20.2	37.2	26.3	26.7
	38.1	34.6	19.9	35.3	18.3	35.4	24.3	26.1
	39.6	28.3	19.2	33.4	17.7	34.0		
MEAN	38.7	32.5	19.0	33.7	19.3	35.6	32.5	26.2
SD	0.7	2.2	1.4	1.6	1.1	1.1	7.4	0.5
n	5	5	5	5	5	5	4	4
rsd(%)	2	7	7	5	6	3	23	2

IRON (mg/g) (<0.15mm)

(1987)	LOWER BARBIE B3(S)	MIDDLE BARBIE B1(S)	MIDDLE BARBIE B1(C)	LOWER FLORENCE F1(S)	LOWER FLORENCE F1(C)	UPPER FLORENCE F2(S)	YAKOUN Y1(S)	YAKOUN Y2(S)
SEP 30	51.6	53.0	45.1	46.4	45.5	51.6	44.4	44.9
	54.9	50.4	30.0	52.0	45.4	52.0	42.7	45.0
	51.0	44.4	23.0	49.3	44.7	53.7	46.0	44.8
	53.6	42.8	44.1	52.3	42.5	50.3	43.4	44.6
	79.4	31.4	42.6	43.6	41.9	51.6		
MEAN	58.1	44.4	37.0	48.7	44.0	51.8	44.1	44.8
SD	10.7	7.5	8.9	3.3	1.5	1.1	1.2	0.1
n	5	5	5	5	5	5	4	4
rsd(%)	18	17	24	7	3	2	3	0

(S) = syringe sampler
(C) = core sampler

APPENDIX B(ii) - Ca, Mg and Mn

CALCIUM (mg/g) (<0.15mm)

(1987)	LOWER BARBIE B3(S)	MIDDLE BARBIE B1(S)	MIDDLE BARBIE B1(C)	LOWER FLORENCE F1(S)	LOWER FLORENCE F1(C)	UPPER FLORENCE F2(S)	YAKOUN Y1(S)	YAKOUN Y2(S)
SEP 30	7.93	6.44	4.32	5.99	3.96	7.05	8.78	6.66
	7.89	5.69	3.67	5.41	4.10	6.90	9.43	6.59
	8.02	6.60	3.60	5.90	4.03	6.93	6.36	6.65
	7.76	7.46	4.68	5.95	4.11	6.58	6.12	6.75
	5.53	6.10	4.41	5.84	3.56	6.52		
MEAN	7.43	6.46	4.14	5.82	3.95	6.80	7.67	6.66
SD	0.95	0.59	0.43	0.21	0.20	0.21	1.45	0.06
n	5	5	5	5	5	5	4	4
rsd(%)	13	9	10	4	5	3	19	1

MAGNESIUM (mg/g) (<0.15mm)

(1987)	LOWER BARBIE B3(S)	MIDDLE BARBIE B1(S)	MIDDLE BARBIE B1(C)	LOWER FLORENCE F1(S)	LOWER FLORENCE F1(C)	UPPER FLORENCE F2(S)	YAKOUN Y1(S)	YAKOUN Y2(S)
SEP 30	4.57	3.28	2.58	3.79	3.95	5.84	6.28	5.79
	4.80	3.55	3.07	4.47	3.96	6.17	6.29	5.39
	4.71	3.25	2.92	4.03	4.00	6.07	6.92	5.39
	4.61	3.65	3.04	4.28	4.20	5.76	6.36	6.02
	5.35	3.20	3.16	3.76	3.92	5.96		
MEAN	4.81	3.39	2.95	4.07	4.01	5.96	6.46	5.65
SD	0.28	0.18	0.20	0.28	0.10	0.15	0.27	0.27
n	5	5	5	5	5	5	4	4
rsd(%)	6	5	7	7	3	2	4	5

MANGANESE (mg/g) (<0.15mm)

(1987)	LOWER BARBIE B3(S)	MIDDLE BARBIE B1(S)	MIDDLE BARBIE B1(C)	LOWER FLORENCE F1(S)	LOWER FLORENCE F1(C)	UPPER FLORENCE F2(S)	YAKOUN Y1(S)	YAKOUN Y2(S)
SEP 30	3.17	1.24	2.47	2.51	1.29	1.77	1.11	1.15
	4.36	2.62	0.91	2.75	1.64	1.79	1.03	1.14
	4.36	0.67	0.41	2.58	1.85	2.45	1.09	1.14
	4.23	0.86	2.19	2.44	1.82	1.76	1.17	1.10
	4.63	0.46	2.09	1.39	1.84	2.10		
MEAN	4.15	1.17	1.61	2.33	1.69	1.97	1.10	1.13
SD	0.51	0.77	0.80	0.48	0.21	0.27	0.05	0.02
n	5	5	5	5	5	5	4	4
rsd(%)	12	66	50	21	13	14	5	2

(S) = syringe sampler (C)= core sampler

APPENDIX B(ii) - Barbie Wetland Site B4
(core samples,<0.15mm)

DATE (1987)	As (ug/g)	Cr (ug/g)	Cu (ug/g)	Hg (ug/g)	Ni (ug/g)	Pb (ug/g)	ZN (ug/g)
SEP 30	62	19.3	18.3	0.37	7	20	147
	40	22.3	16.5	0.34	10	19	246
	45	22.1	17.0	0.34	8	24	159
	33	20.7	16.0	0.34	10	10	184
	46	22.5	17.2	0.35	9	17	167
MEAN	45	21.4	17.0	0.35	9	18	181
SD	10	1.2	0.8	0.01	1	5	35
n	5	5	5	5	5	5	5
rsd(%)	21	6	5	3	13	26	19

DATE (1987)	Al (mg/g)	Fe (mg/g)	Ca (mg/g)	Mg (mg/g)	Mn (mg/g)
SEP 30	24.4	36.5	4.01	3.28	2.52
	24.5	30.5	3.38	3.84	1.80
	25.6	30.1	3.04	4.09	1.44
	24.4	29.6	3.31	3.94	1.77
	26.6	34.1	3.48	4.05	1.70
MEAN	25.1	32.2	3.44	3.84	1.85
SD	0.9	2.7	0.32	0.29	0.36
n	5	5	5	5	5
rsd(%)	3	8	9	8	20

APPENDIX B - SEDIMENT QUALITY (iii) REFERENCE SEDIMENT

- Reference Sediment NBS1645
- Reference Sediment MBS1646

APPENDIX B(iii) - REFERENCE SEDIMENT NBS 1645

METAL (ug/g)	WEST VANCOUVER LABORATORY (i)	(ii)	(iii)	mean	sd	rsd (%)
MERCURY	0.840	0.832	0.788	0.820	0.023	3
ARSENIC	77	110	90	92	14	15
CADMIUM	16.9	11.0	6.5	11.5	4.3	37
CHROMIUM (mg/g)	32.1	29.8	25.7	29.2	2.6	9
COPPER	124.0	97.3	118.0	113.1	11.4	10
LEAD	703	692	612	669	41	6
MANGANESE	705	759	701	722	26	4
NICKEL	23	24	24	24	0	2
VANADIUM	16	23	23	21	3	16
ZINC	1670	1820	1640	1710	79	5
IRON (mg/g)	118	106	104	109	6	6

METAL (ug/g)	NBS 1645 CERTIFIED VALUE (+-95%limits)		WEST VANCOUVER LABORATORY (MEAN % RECOVERY)*
MERCURY	1.1	(0.6-1.6)	75
ARSENIC			
CADMIUM	10.2	(8.7-11.7)	
COPPER	109	(90-128)	104
LEAD	714	(686-742)	
MANGANESE	785	(688-882)	
NICKEL	45.8	(42.9-48.7)	
VANADIUM	23.5	(16.6-30.4)	
ZINC	1720	(1551-1889)	99
(mg/g)			
CHROMIUM	29.6	(26.8-32.4)	99
IRON	113	(101-125)	96

* based on mean certified value

APPENDIX B(iii) - REFERENCE SEDIMENT NBS 1646

METAL (ug/g)	WEST VANCOUVER LABORATORY (i)	(ii)	(iii)	mean	sd	rsd (%)
MERCURY	0.085	0.081	0.073	0.080	0.005	6
ARSENIC	8	28	8	15	9	64
CADMIUM	2.3	1.0	0.8	1.4	0.7	49
CHROMIUM	46.7	51.0	41.0	46.2	4.1	9
COPPER	19.9	18.2	15.0	17.7	2.0	11
LEAD	20	34	8	21	11	51
MANGANESE	264	267	246	259	9	4
NICKEL	21	20	18	20	1	6
VANADIUM	54	53	49	52	2	4
ZINC	116	122	113	117	4	3

METAL (ug/g)	NBS1646 CERTIFIED VALUE	(+-95%limits)	WEST VANCOUVER LABORATORY (MEAN % RECOVERY)*
MERCURY	0.063	(0.051-0.075)	127
ARSENIC	11.6	(10.3-12.9)	
CADMIUM	0.36	(0.29-0.43)	
CHROMIUM	76	(73-79)	
COPPER	18	(15-21)	98
LEAD	28.2	(26.4-30)	
MANGANESE	375	(355-395)	
NICKEL	32	(29-35)	
VANADIUM	94	(93-95)	
ZINC	138	(132-144)	85
(mg/g)			
ALUMINIUM	62.5	(60.5-64.5)	
CALCIUM	8.3	(8-8.6)	
IRON	33.5	(32.5-34.5)	
MAGNESIUM	10.9	(10.1-11.7)	

* based on mean certified value