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

MINNOVA SEDIMENT STUDY
1990

Regional Program Report: 91-05

by

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DECEMBER 1994

ABSTRACT

A monitoring program was conducted in May 1990 to determine the sediment quality of Johnson Creek which receives treated mine effluent from the Minnova copper/lead/zinc/silver mine. The basic pattern of metal distribution was similar to that of the 1988 baseline data.

RÉSUMÉ

Un programme de surveillance a été mené en mai 1990 pour déterminer la qualité des sédiments du ruisseau Johnson. Ce ruisseau reçois l'effluent traité de la mine de cuivre/plomb/zinc/argent Minnova. Le patron de base de la distribution des métaux en 1990 était similaire à celle de l'étude de base mené en 1988.

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1.0 INTRODUCTION

The Minnova Inc. copper/lead/zinc/silver mine started development of its open pit on February 1989 and began processing ore in May 1989. The mine is located in the central interior of British Columbia (Figure 1), northeast of Kamloops, adjacent to Johnson Creek which drains into Sinmax Creek. Sinmax Creek supports both sockeye and coho salmon and is an important kokanee salmon spawning stream (Brown et al., 1979). Johnson Creek has an impassable falls approximately 400 metres upstream of its confluence with Sinmax Creek.

A seasonal flow-paced discharge of treated tailings pond supernatant is permitted (B.C. Environment Permit PE 8147) over the period April to November, inclusive. A second discharge from the waste rock dump runoff retention pond occurs on an ongoing basis (Figure 1).

Environment Canada conducted a baseline sediment quality survey of Johnson Creek in May 1988 (Derksen, 1990a). Treated effluent was discharged over the period October 17, 1989 to November 30, 1989. This report presents sediment quality data collected May 30, 1990, after the first year of operation.

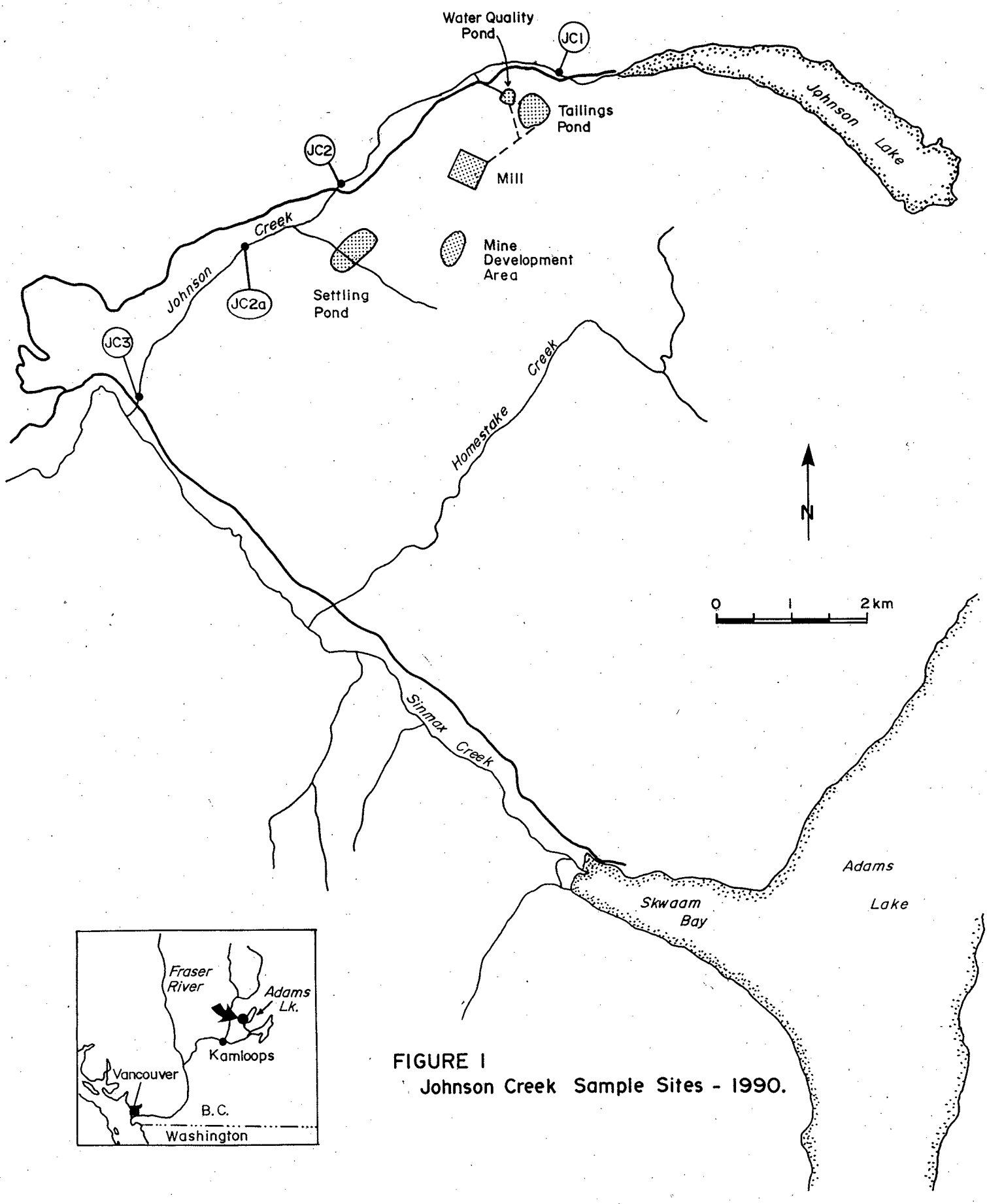


FIGURE 1
Johnson Creek Sample Sites - 1990.

2.0 STUDY AREA

Johnson Creek flows into Sinmax Creek which drains an area of approximately 130 square kilometres. Sinmax Creek discharges into Skwaam Bay of Adams Lake (Figure 1).

2.1 Sediment Sample Sites

Sediment samples were collected at four sites on Johnson Creek. Two sites (JC1 and JC3) were sampled in the 1988 baseline survey. Site JC2 was relocated closer to the treated effluent discharge tributary compared to 1988 (at staff gauge S2 approximately 200 m downstream of tributary). A new site (JC2a) was sampled at the lower staff gauge (S4), approximately 200 m downstream of the waste rock settling pond discharge tributary (Figure 1).

3.0 MATERIALS AND METHODS

3.1 Sediment

Sediment samples were collected with a stainless steel syringe sampler (Derksen, 1985).

Five sediment samples (composites of three syringe samples per 2 L sample bottle) were collected at each site for metal and volatile residue analyses (<0.15 mm fraction). The syringe samples were left to settle overnight in 2 L polyethylene sample bottles. Samples were transferred into Kraft sediment bags, kept cold during transit, and then frozen until preparation for anlysis.

Sediment sample analyses and analytical methods are summarized in Table 1. The samples were analyzed at the Environment Canada, West Vancouver Laboratory. The sediment samples in this study were digested using a microwave oven procedure (Millward and Kluckner, 1989). Sediment reference samples NBS 1646, NBS 2704, and MESS-1 were used to determine metal recovery.

TABLE 1: SEDIMENT ANALYSES AND ANALYTICAL METHODS

PARAMETER (Detection Limit)	METHOD
Volatile Residue	- Sample was 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 <0.15 mm, and then rolled to homogenise. The sample is then weighed (0.3 g) into a Teflon digestion vessel and digested with 4.5 ml HNO_3, 1.5 ml HCl and 1 ml deionized water in a microwave oven (720 joules/sec) for 15 minutes. The sample is cooled, volumized, and settled overnight. The decant is analysed.	
Ag (2 μg/g)*	- ICP emission spectrometry
Ag (0.02 μg/g)	- graphite furnace atomic absorption**
Al (8 μg/g)	- ICP emission spectrometry
As (8 μg/g)	- ICP emission spectrometry
Ba (0.2 μg/g)	- ICP emission spectrometry
Ca (20 μg/g)	- ICP emission spectrometry
Cd (0.8 μg/g)	- ICP emission spectrometry
Cd (0.02 μg/g)	- graphite furnace atomic absorption**
Cr (0.8 μg/g)	- ICP emission spectrometry
Cu (0.8 μg/g)	- ICP emission spectrometry
Fe (8 μg/g)	- ICP emission spectrometry
Hg (0.008 μg/g)	- cold vapour atomic absorption
Mg (20 μg/g)	- ICP emission spectrometry
Mn (0.2 μg/g)	- ICP emission spectrometry
Ni (3 μg/g)	- ICP emission spectrometry
Pb (8 μg/g)	- ICP emission spectrometry
Pb (0.08 μg/g)	- graphite furnace atomic absorption**
Si (8 μg/g)	- ICP emission spectrometry
V (2 μg/g)	- ICP emission spectrometry
Zn (0.3 μg/g)	- ICP emission spectrometry

* detection limit for 0.3 g dried sample
** GFAA analysis if concentration ≤2x ICP detection

4.0 RESULTS AND DISCUSSION

4.1 Sediment Quality

The sediment quality results are reported in Appendix I(a) (non-metals) and Appendix I(b) (metals). The reference sediment results are listed in Appendix I(c).

The sediment data collected in this study were compared to the 1988 baseline data for Johnson Creek (Table 2). Tests for significant differences in metal content between stations and years were not made. Derksen (1990b) demonstrated that the annual variability in sediment metal levels can be quite large. Several years of baseline data would be required to adequately detect subtle changes in sediment metal content at any single station. The results for copper, lead, and zinc are shown in Figure 2, Figure 3, and Figure 4, respectively. For Johnson Creek, a general pattern of higher metal levels at the upstream site (JC1) and the lower site (JC3) was evident in both 1988 and 1990.

The reference sediment recoveries for MESS-1 (Cu, Pb, and Zn) in 1988 and 1990 are shown in Figure 5. The mean recovery for lead and zinc was similar for both years. Mean copper recovery was higher in 1990.

4.2 Future Monitoring

The sediment quality of Johnson Creek should be re-evaluated prior to mine closure in order to determine possible impacts from mine discharges.

TABLE 2: 1988 AND 1990 SEDIMENT QUALITY SUMMARY - JOHNSON CREEK

SITE	MEAN CONCENTRATION (µg/g)											
	Ag		Cd		Cu		Hg		Pb		Zn	
	1988	1990	1988	1990	1988	1990	1988	1990	1988	1990	1988	1990
JC1	0.08	<2	0.23	0.10	39.8	33.4	0.034	0.026	10.4	13.7	128	106
JC2	0.07	<2	0.08	0.05	24.3	36.4	0.024	0.014	5.2	9.6	109	80.5
JC2a	-	<2	-	0.08	-	28.0	-	0.020	-	9.7	-	113
JC3	0.07	<2	0.24	0.15	52.5	48.8	0.154	0.066	28.0	33.3	155	148

FIGURE 2: 1988 and 1990 COMPARISON FOR MEAN COPPER - JOHNSON CREEK

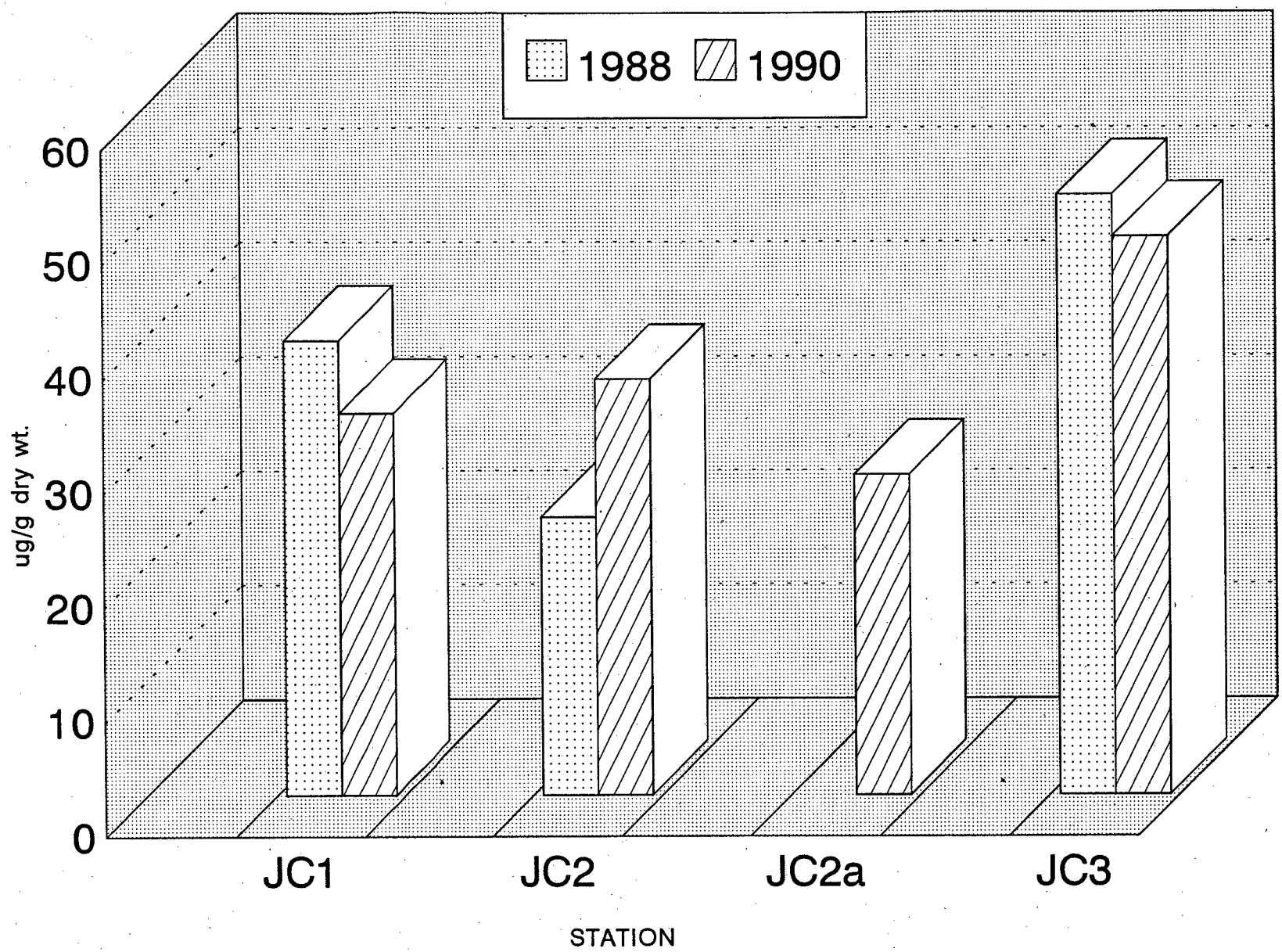


FIGURE 3: 1988 and 1990 COMPARISON FOR MEAN LEAD - JOHNSON CREEK

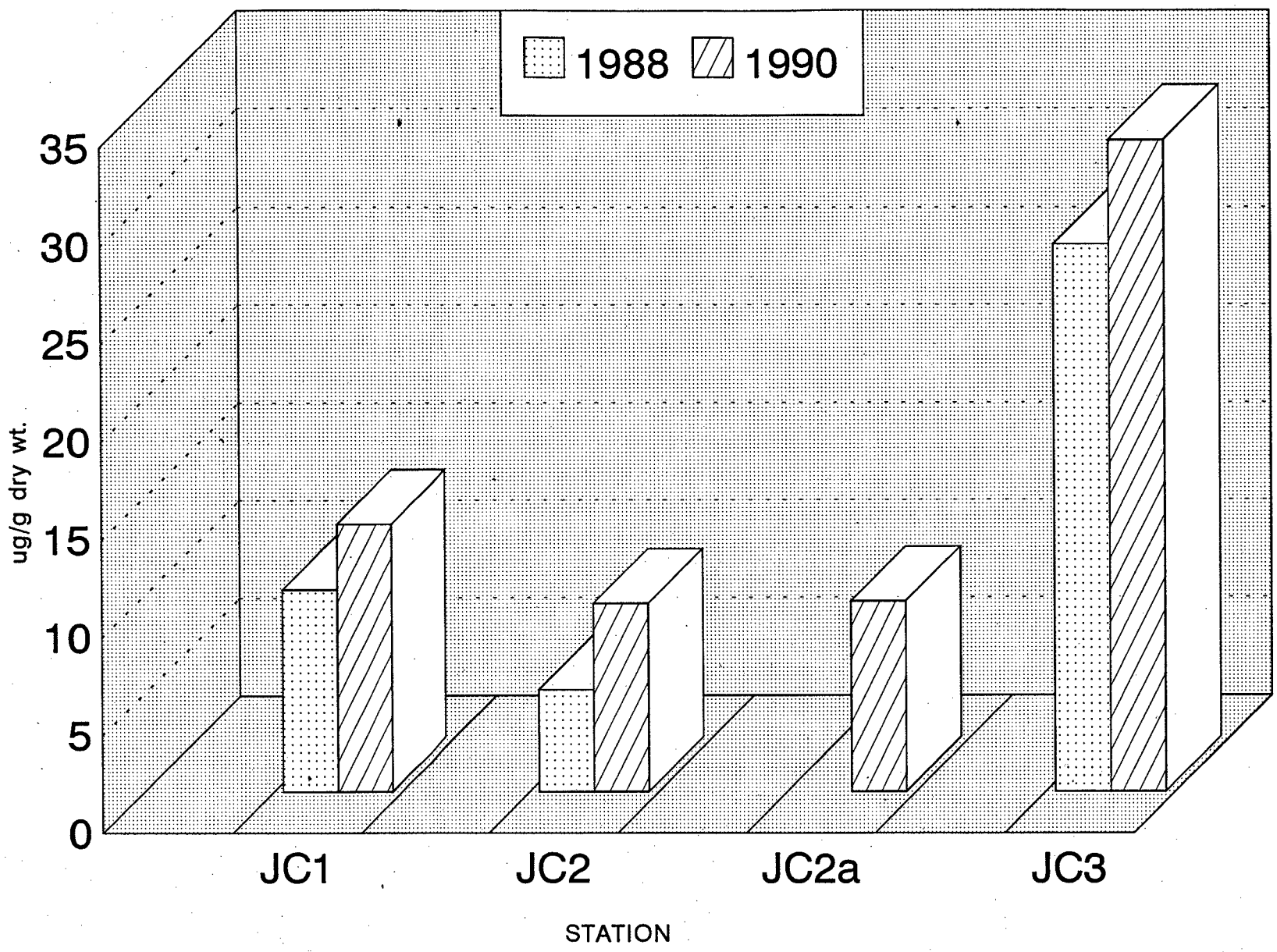


FIGURE 4: 1988 and 1990 COMPARISON FOR MEAN ZINC - JOHNSON CREEK

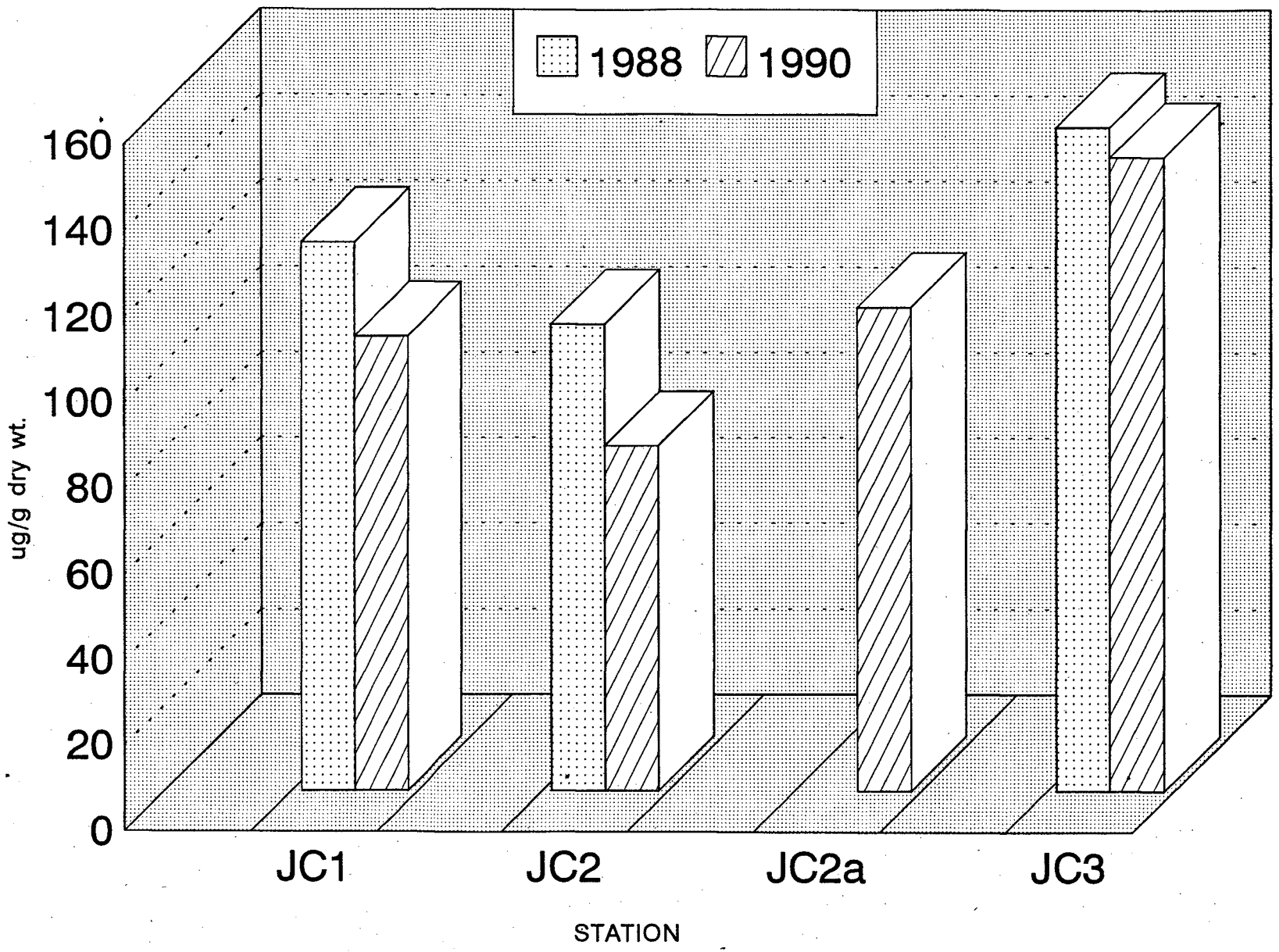
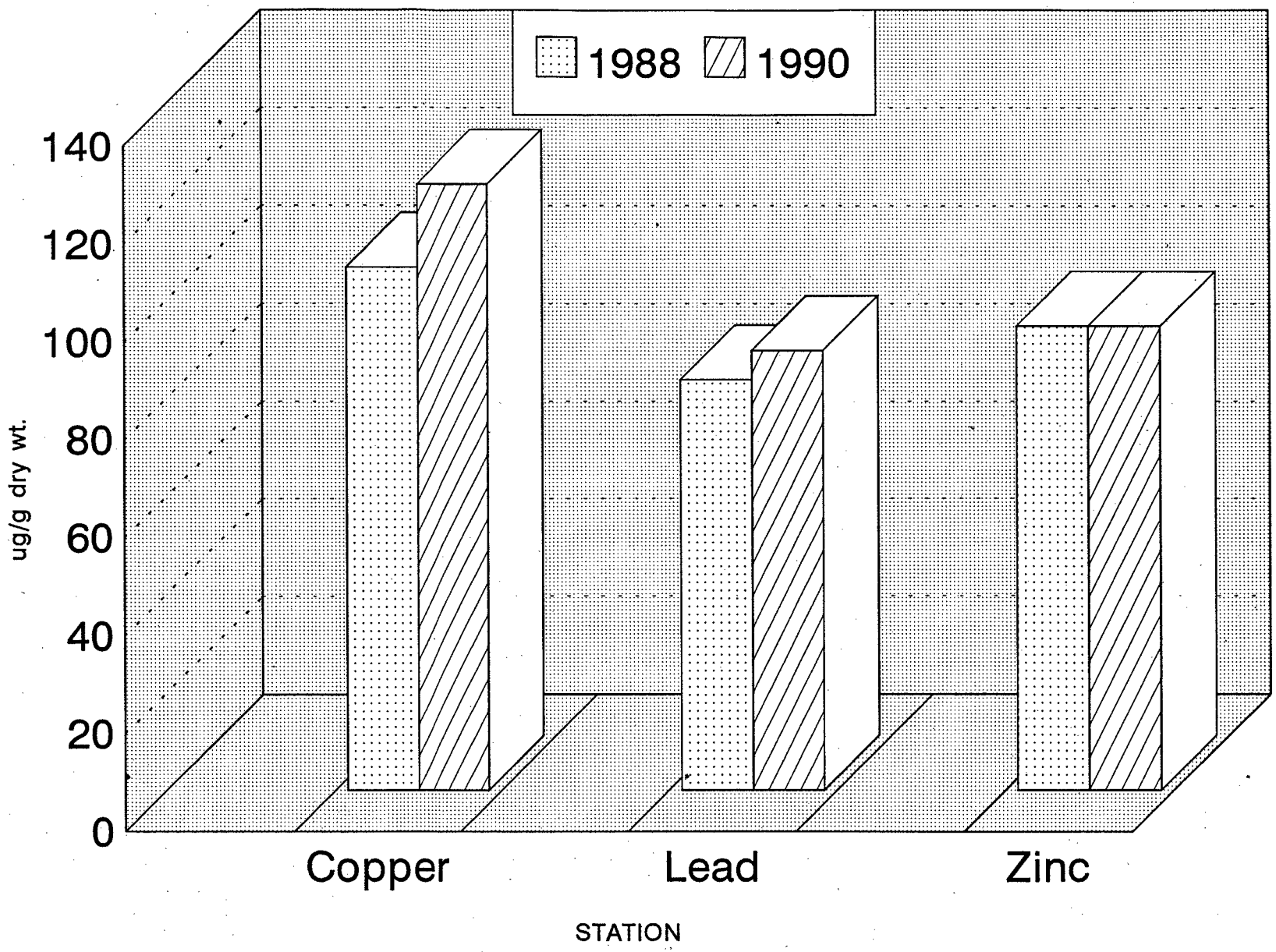


FIGURE 5: 1988 and 1990 REFERENCE SAMPLE RECOVERY FOR COPPER, LEAD, AND ZINC



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ACKNOWLEDGEMENTS

The analytical services provided by the staff of the Environment Canada, West Vancouver Laboratory are gratefully acknowledged. Thanks are extended to Isabel Booth for her help in the collection of the field samples and Amy Chu for spreadsheet compilation.

APPENDIX I(a)

SEDIMENT QUALITY - VOLATILE RESIDUES

APPENDIX I(a):

JOHNSON CREEK SEDIMENT VOLATILE RESIDUES, 1990

(mg/g dry wt., <0.15 mm)

Site	JC1	JC2	JC2a	JC3
	63.1	35.3	76.7	82.1
	64.6	45.3	92.1	66.8
	85.1	29.2	70.4	97.2
	53.5	45.4	102	82.4
	74.8	36.3	101	77.3
Mean	68.2	38.3	88.4	81.2
SD	12.1	7.0	14.3	11.0
n	5	5	5	5
CV	18	18	16	14

APPENDIX I(b)

SEDIMENT QUALITY - METALS

APPENDIX I(b):

JOHNSON CREEK SEDIMENT METALS, 1990 - Ag, As and Cd

Ag (µg/g dry wt., <0.15 mm)

Site	JC1	JC2	JC2a	JC3
	<2	<2	<2	<2
	<2	<2	<2	<2
	<2	<2	<2	<2
	<2	<2	<2	<2
	<2	<2	<2	<2
Mean	<2	<2	<2	<2
SD	0	0	0	0
n	5	5	5	5
CV	0	0	0	0

As (µg/g dry wt., <0.15 mm)

Site	JC1	JC2	JC2a	JC3
	10	19	17	22
	21	20	21	10
	10	36	22	25
	23	28	24	17
	28	20	35	27
Mean	18	25	24	20
SD	8	7	7	7
n	5	5	5	5
CV	44	30	28	34

Cd (µg/g dry wt., <0.15 mm)

Site	JC1	JC2	JC2a	JC3
	0.10	0.06	0.07	0.18
	0.09	0.06	0.05	0.17
	0.10	0.03	0.09	0.21
	0.09	0.07	0.10	0.10
	0.10	0.05	0.10	0.10
Mean	0.10	0.05	0.08	0.15
SD	0.01	0.02	0.02	0.05
n	5	5	5	5
CV	6	28	26	33

APPENDIX I(b):

JOHNSON CREEK SEDIMENT METALS, 1990 - Cr, Cu and Hg

Cr (µg/g dry wt., <0.15 mm)

Site	JC1	JC2	JC2a	JC3
	126	186	146	236
	136	243	210	229
	212	185	313	238
	154	226	292	262
	148	212	295	272
Mean	155	210	251	247
SD	34	25	71	19
n	5	5	5	5
CV	22	12	28	7

Cu (µg/g dry wt., <0.15 mm)

Site	JC1	JC2	JC2a	JC3
	31.1	37.1	21.8	57.8
	29.3	35.2	22.7	45.9
	37.8	29.7	29.4	53
	32.6	40.4	32.3	44.3
	36.1	39.7	33.8	42.8
Mean	33.4	36.4	28	48.8
SD	3.5	4.3	5.5	6.4
n	5	5	5	5
CV	11	12	20	13

Hg (µg/g dry wt., <0.15 mm)

Site	JC1	JC2	JC2a	JC3
	0.029	0.010	0.017	0.060
	0.023	0.020	0.018	0.072
	0.028	0.009	0.018	0.062
	0.022	0.021	0.026	0.075
	0.026	0.010	0.023	0.062
Mean	0.026	0.014	0.020	0.066
SD	0.003	0.006	0.004	0.007
n	5	5	5	5
CV	12	43	19	10

APPENDIX I(b):

JOHNSON CREEK SEDIMENT METALS, 1990 - Ni, Pb, and Zn

Ni (μg/g dry wt., <0.15 mm)

Site	JC1	JC2	JC2a	JC3
	66	92	69	110
	71	110	93	110
	99	89	140	110
	80	110	130	120
	76	100	130	120
Mean	78	100	112	114
SD	13	10	30	5
n	5	5	5	5
CV	16	10	27	5

Pb (μg/g dry wt., <0.15 mm)

Site	JC1	JC2	JC2a	JC3
	12.3	11	8.1	33.1
	12.7	9.8	8.6	28.4
	15.1	8.1	9.8	35
	14.2	9.8	10.7	40.5
	14.1	9.5	11.2	29.4
Mean	13.7	9.6	9.7	33.3
SD	1.2	1.0	1.3	4.8
n	5	5	5	5
CV	8	11	14	15

Zn (μg/g dry wt., <0.15 mm)

Site	JC1	JC2	JC2a	JC3
	119	76.7	97.5	179
	104	79.1	90.4	145
	106	80.2	126	150
	99.6	83	125	131
	102	83.7	126	135
Mean	106.1	80.5	113.0	148
SD	7.6	2.9	17.6	18.9
n	5	5	5	5
CV	7	4	16	13

APPENDIX I(b):

JOHNSON CREEK SEDIMENT METALS, 1990 - Al, Ca, and Fe

Al (mg/g dry wt., <0.15 mm)

Site	JC1	JC2	JC2a	JC3
	18.3	16.3	12.9	18.5
	17.2	16.3	13.7	15
	20.9	17	16.9	17.5
	21.1	17.5	16.1	15.3
	19.8	17.3	18.2	15.4
Mean	19.5	16.9	15.6	16.3
SD	1.7	0.6	2.2	1.6
n	5	5	5	5
CV	9	3	14	10

Ca (mg/g dry wt., <0.15 mm)

Site	JC1	JC2	JC2a	JC3
	93.7	19.9	9.2	27.3
	87.1	19.5	10.2	27.3
	64.3	14.7	11.1	30.6
	31.1	23.3	11.5	27.9
	57.5	20.9	13.6	33.8
Mean	66.7	19.7	11.1	29.4
SD	25.0	3.1	1.6	2.8
n	5	5	5	5
CV	37	16	15	10

Fe (mg/g dry wt., <0.15 mm)

Site	JC1	JC2	JC2a	JC3
	31.1	33.1	27	42.7
	32.2	32.4	27.4	39.7
	35.6	34.6	35	39.1
	38	33.1	33.4	35.3
	34.2	33.7	36.9	35.2
Mean	34.2	33.4	31.9	38.4
SD	2.7	0.8	4.5	3.2
n	5	5	5	5
CV	8	2	14	8

APPENDIX I(b):

JOHNSON CREEK SEDIMENT METALS, 1990 - Mg and Mn

Mg (mg/g dry wt., <0.15 mm)

Site	JC1	JC2	JC2a	JC3
	12.5	13.9	8.3	15.3
	12.1	12.3	8.7	13.1
	14.2	14.2	11.4	14.4
	14.5	14.7	10.9	12.7
	13.6	14.7	12.3	12.5
Mean	13.4	14.0	10.3	13.6
SD	1.0	1.0	1.7	1.2
n	5	5	5	5
CV	8	7	17	9

Mn (mg/g dry wt., <0.15 mm)

Site	JC1	JC2	JC2a	JC3
	2.28	0.66	1	0.91
	0.88	0.57	0.55	0.88
	0.89	0.63	1.25	0.96
	0.56	0.69	1.14	0.85
	0.93	0.77	1.27	0.81
Mean	1.11	0.66	1.04	0.88
SD	0.67	0.07	0.30	0.06
n	5	5	5	5
CV	61	11	28	6

APPENDIX I(c)

SEDIMENT QUALITY - REFERENCE SEDIMENT

APPENDIX I(c):

REFERENCE SEDIMENT - NBS 1646

	Hg	Cd	Cu	Pb	Zn
	Laboratory Analysis (μg/g dry wt, <0.15 mm)				
	0.060	<0.8	15	19	124
	0.066	<0.8	16	24	121
	0.071				
Mean	0.066	<0.8	16	22	123
SD	0.006	0	1	4	2
n	3	2	2	2	2
	Certified Values (μg/g dry wt, <0.15 mm)				
	0.063	0.36	18	28.2	138
	(0.051-0.75)	(0.29-0.43)	(15-21)	(26.4-30.0)	(132-144)

REFERENCE SEDIMENT - NBS 2704

	Hg	Cd	Cu	Pb	Zn
	Laboratory Analysis (μg/g dry wt, <0.15 mm)				
	1.47	2.9	96.4	150	433
	1.46	3.1	96.5	160	457
	1.52				
Mean	1.48	3	96.5	155	445
SD	0.03	0.1	0.1	7	17
n	3	2	2	2	2
	Certified Values (μg/g dry wt, <0.15 mm)				
	1.44	3.45	98.6	161	438
	(1.37-1.51)	(3.23-3.67)	(93.6-103.6)	(144-178)	(426-450)

APPENDIX I(c):

REFERENCE SEDIMENT - MESS-1

	Hg	Cd	Cu	Pb	Zn
	Laboratory Analysis (μg/g dry wt, <0.15 mm)				
	0.218	<0.8	27.8	26	167
	0.245	<0.8	34.4	35	196
	0.160				
Mean	0.208	<0.8	31.1	30.5	182
SD	0.043	0	4.7	6.4	21
n	3	2	2	2	2
	Certified Values (μg/g dry wt, <0.15 mm)				
	0.171	0.59	25.1	34.0	191
	(0.157-0.185)	(0.49-0.69)	(21.3-28.9)	(27.9-40.1)	(174-208)