OGILVIE JOINT VENTURE

JASON PROPERTY

1982 ENVIRONMENTAL PROGRAMMES

WATSON LAKE AND MAYO DISTRICTS

YUKON TERRITORY

NTS 105-O-1 NIDDERY LAKE

RECEIVED
27 JAN 1983
MINING RECORDER
WATSON LAKE, Y.T.
I.A. & N.D.

Report Date:
January, 1983
Report No.: 4-83

Glenn R. Brown
ABERFORD RESOURCES LTD.
Calgary, Alberta

This report has [illegible] d by
the Geolo[illegible]
under [illegible] artz
Mi[illegible]
rep[illegible] on wo[illegible] amount
of $ 13,400 —

P. Watson

for Regional M[illegible], Exp[illegible] tion and
Geolo[illegible]ical Services for Commissioner
of Yukon Territory.

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A) INTRODUCTION

The environmental programmes associated with the Jason property were initiated because exploration work became sufficiently successful that it seemed likely that a mine could be developed on site. The results were expected to form part of environmental submissions to the Regional Environmental Review Committee of the Department of Indian and Northern Affairs. The exploration aspects are summarized below (the text is from "Ogilvie Joint Venture 1982 Exploration Programme", In-House Report No. 3-83) and the environmental programmes are detailed in Part 'E'.

Since its discovery in 1974, continuous exploration efforts on the Jason property have resulted in the discovery of three Pb-Zn-Ag-(Ba) zones of mineralization. The property is located in the eastern part of the Yukon Territory, at Latitude 63°10'N and Longitude 130°10'W on NTS map sheet 105-0-1 (Figure 1). The property can be reached via the North Canol Road or by regularly scheduled Trans North Airlines flights landing at the MacPass gravel runway. The closest settlement, Ross River, is established 230 kilometres south of Jason along the North Canol Road (Figure 1).

The Jason property covers part of the Selwyn Mountains and straddles the South Macmillan River near Macmillan Pass. Elevations on the property range from about 1160 metres to over 2000 metres. The relief is variable; subdued and swampy in the Macmillan River valley but rugged and steep on the higher ground. Outcrop is good along ridges but is generally poor in the valley bottoms.

B) CLAIMS

A total of 283 claims straddling the Mayo and Watson Lake Mining District boundaries make up the Jason property. A list of claims recorded in each district follows (Table II and III).

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FIGURE 1

ABERFORD RESOURCES LTD.

PROPERTY LOCATION

JASON PROJECT, YUKON

DATE	SCALE	NTS	DRAWING NO.
APRIL, 1982	1: 1,584,000	106 E	A-1744

KBB

TABLE I

LIST OF MINERAL CLAIMS
JASON PROPERTY
MAYO DISTRICT

No.	Claim	Record No.	Record Date	In Good Standing*
14	ACE 1-14	YA7470-YA7483	Oct. 26/76	Dec. 31/2000
3	15-17	YA7484-YA7486	"	"
3	22-24	YA7487-YA7489	"	"
2	31-32	YA7490-YA7491	"	"
3	36-38	YA7492-YA7494	"	"
1	Jason 189FR	YA 15148	June 1/77	Dec. 31/97
1	190FR	YA 15149	"	"
1	191FR	YA 15150	"	"
22	198FR-219FR	YA 38265-YA38286	Sept. 18/78	Dec. 31/95
3	220FR-222FR	YA38287-YA38289	"	"
18	223FR-240FR	YA41288-YA41305	Oct. 5/79	Dec. 31/92
4	1-4	Y96192-Y96195	Aug. 20/74	Dec. 31/2002
12	7-18	Y96198-Y96209	"	Dec. 31/2005
1	21	Y96212	"	"
1	22	Y96213	"	"
4	23-26	Y96214-Y96217	"	"
4	27-30	Y96218-Y96221	"	"
4	45-48	Y97986-Y97989	July 23/75	Dec. 31/2002
6	49-54	Y98244-Y98249	Aug. 8/75	"
7	55-61	Y98250-Y98256	"	Dec. 31/2004
1	62	Y98257	"	Dec. 31/2002
1	63	Y98258	"	Dec. 31/2004
2	64-65	Y98259-Y98260	"	Dec. 31/2002
3	66-68	Y98261-Y98263	"	Dec. 31/2000
2	69-70	Y98264-Y98265	"	Dec. 31/96
2	71-72	Y98266-Y98267	"	"
5	73-77	Y98268-Y98272	"	Dec. 31/2002
1	78	Y98273	"	Dec. 31/2004
1	79	Y98274	"	Dec. 31/2002
1	80	Y98275	"	Dec. 31/2004
1	81	Y98276	"	Dec. 31/2002
1	82	Y98277	"	Dec. 31/2004
1	35	Y96224	Aug. 20/74	Dec. 31/2005
1	36	Y96225	"	Dec. 31/2002
1	37	Y96226	"	Dec. 31/2005
1	38	Y96227	"	Dec. 31/2002
10	93-102	Y98278-Y98287	Aug. 8/75	Dec. 31/2000
2	103-104	Y98288-Y98289	"	Dec. 31/96
3	105-107	Y98290-Y98292	"	Dec. 31/2000
6	108-113	Y98293-Y98298	"	Dec. 31/2000
1	114	Y98299	"	Dec. 31/2002
6	117-122	Y98300-Y98305	"	Dec. 31/2000
6	125-130	Y98306-Y98311	"	Dec. 31/2002
1	141	Y98312	"	Dec. 31/2000

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TABLE I (Continued)
List of Claims,
Jason Property,
Watson Lake District

No.	Claim	Record No.	Record Date	In Good Standing*
1	Jason 142	Y98313	Aug. 8/75	Dec. 31/2003
1	143	Y98314	"	Dec. 31/2000
1	144	Y98315	"	Dec. 31/2003
1	145	Y98316	"	Dec. 31/2000
1	146	Y98317	"	Dec. 31/2003
1	147	Y98318	"	Dec. 31/2000
1	148	Y98319	"	Dec. 31/2003
1	149	Y98320	"	"
5	150-154	Y98321-Y98325	"	"
2	155-156	Y98326-Y98327	"	Dec. 31/2000
1	157	Y98328	"	Dec. 31/2002
1	158	Y98329	"	Dec. 31/2000
2	159-160	Y98330-Y98331	"	"

Total Claims 193 Mayo Mining District
90 Watson Lake Mining District
283 x 51.65 = 14,616.95 Acres

* As of December 31, 1982

TABLE II

LIST OF CLAIMS
JASON PROPERTY
WATSON LAKE DISTRICT

No.	Claim	Record No.	Record Date	In Good Standing*
3	Mike 8-10	YA11545-YA11547	Oct. 26/76	Dec. 31/84
4	Ace 18-21	YA11526-YA11529	"	"
6	Ace 25-30	YA11530-YA11535	"	"
3	Ace 33-35	YA11536-YA11538	"	"
2	Ace 39-40	YA11539-YA11540	"	"
3	Jason 90-92	Y84512-Y84514	Aug. 7/75	"
2	Jason 115-116	Y84515-Y84516	"	"
2	Jason 123-124	Y84517-Y84518	"	"
4	Jason 131-134	Y84519-Y84522	"	Dec. 31/88
1	Jason 135	Y94471	"	Dec. 31/84
1	Jason 137	Y84525	"	Dec. 31/88
16	Jason 161-176	Y93952-Y93967	Nov. 12/75	Dec. 31/86
2	Mike 1-2	YA24-YA25	June 11/76	Dec. 31/87
1	Mike 3	YA805	Aug. 30/76	Dec. 31/84
4	Mike 4-7	YA11541-YA11544	Oct. 26/76	"
5	Jason 177Fr.- 181Fr.	YA20135-YA20139	June 1/77	Dec. 31/85
1	Jason 182Fr.	YA20140	June 1/77	Dec. 31/83
6	Jason 183Fr.- 188Fr.	YA20141-YA20146	June 1/77	Dec. 31/85
3	Jason 192-194 Fr.	YA35586-YA35588	Sept. 25/78	Dec. 31/83
2	Jason 195-196 Fr.	YA35589-YA35590	"	Dec. 31/83
1	Jason 197 Fr.	YA35591	"	Dec. 31/83
2	Jason 33-34	Y83274-Y83275	Aug. 23/74	Dec. 31/88
4	Jason 41-44	Y83276-Y83279	Aug. 23/74	Dec. 31/88
5	Jason 84-88	Y84530,84507-Y84510	Aug. 7/75	"
1	Jason 89	Y84511	"	Dec. 31/84
2	Jason 19-20	Y96210-Y916211	Aug. 20/74	Dec. 31/89
2	Jason 31-32	Y96222-Y96223	"	"
2	Jason 39-40	Y96228-Y96229	"	"

90 Claims Total Watson Lake Mining Division

* As of December 31, 1982


LEGEND
LOCATION TARGETED 1981
IP 230 DENOTES IRON POST SET WITH TAGGED TRAVERSE NUMBER (McELHANNEY ASSOCIATES)
L.P DENOTES LOCATION POST
T.H. 233 DENOTES TAGGED TRAVERSE HUB, HUBS ARE 8" SPIKES OR WOODEN HUBS
(60 SW, 15 NW) DENOTES GRID LINE LOCATIONS
D.H. 34 DENOTES DIAMOND DRILL HOLE
48 DENOTES PREVIOUSLY SURVEYED LOCATION LINE POINT NUMBER (HOSFORD, IMPEY & WELTER LIMITED)
HW 1, HW 6 DENOTES CONTROL STATIONS
Fr. DENOTES FRACTIONAL MINERAL CLAIM
B/L DENOTES BASELINE
WT. DENOTES WITNESS
D.H.1 – D.H.7 DRILLED IN 1975
D.H.8 – D.H.20 DRILLED IN 1976
D.H.21 – D.H.26 DRILLED IN 1977
D.H.27 – D.H.43 DRILLED IN 1978
D.H.44 – D.H.52 DRILLED IN 1979
D.H. 53 – D.H. 67 DRILLED IN 1980
D.H. 68 – D.H. 85 DRILLED IN 1981
EXPIRY YEAR
1982
1983
1984
1985
1986
1987
1988
1989
1992
1995 – 1997
2000 – 2005
NOTE: ALL CLAIMS HAVE COMMON EXPIRY DATE OF DEC. 31.
MAYO MINING DISTRICT
WATSON LAKE MINING DISTRICT
HUDSON BAY MINING AND SMELTING CO. LTD.
TOM CLAIMS
COMINCO NIDD 361 CLAIMS
NIDD 359
CANOL ROAD
OGILVIE JOINT VENTURE
MINERAL CLAIMS
JASON PROPERTY
MACMILLAN PASS AREA (N.T.S. 105 O-1)
MAYO AND WATSON LAKE MINING DISTRICTS, YUKON TERRITORY
SCALE IN METERS
ABERFORD RESOURCES LTD.
DECEMBER 1982
09 : 422

C) HISTORY AND PREVIOUS WORK

The Jason property, which is about 45 kilometres square in area, hosts stratiform massive sulphide and bedded barite Pb-Zn-Ag deposits which are localized in an Upper Devonian shale-turbidite basin near Macmillan Pass. It shares this basin with the geologically similar Tom deposit which is located about 6 kilometres to the east.

Work on the Jason property was initiated in 1974 by the Ogilvie Joint Venture as a result of geological and geochemical studies in and around the Tom property.

Under the direction of Clyde Smith, extensive geological, geochemical and geophysical surveys combined with diamond drilling, led to the discovery in 1974 of the Main Zone and in 1978 of the South Zone. To the end of 1978, a total of 7,340 metres of diamond drilling had been completed.

The property was optioned to Pan Ocean Oil Ltd. (now Aberford Resources Ltd.) in August of 1979. Under its direction, a further 1,934 metres of diamond drilling was carried out in addition to expansion of the grid from 49.2 kilometres to 146.1 kilometres. The entire grid was tested by soil geochemistry and a gravity survey. The last hole drilled in 1979 intersected the South Zone at depth below the initial discovery holes of 1978. Diamond drill hole 79-51A intersected a 4.1 metre true thickness of sulphides which graded 2.6% Pb, 6.9% Zn and .4 oz/ton Ag.

In 1980, much of the 4,953 metres of drilling were used to better define the South Zone. The best intersection occurred in diamond drill hole 80-56B where a 20.0 metre true width of massive sulphides grading 25.78% Pb, 5.98% Zn and 12.0 oz/ton Ag was encountered. As a secondary

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objective, gravity and soil geochemical anomalies were systematically tested. This led to the discovery of high grade massive sulphides in the End Zone.

The primary objective of the 1981 field programme was to increase grade and tonnage estimates in the Main, South and End Zones to the point where underground exploration could be justified. The programme was largely successful as it increased the total reserves by 23% and greatly enhanced the definition of the Main and South Zones.

D) 1982 DRILL PROGRAMME SUMMARY

The 1982 programme was designed as an extension of last year's exploration effort to define the geometry of the mineralized zones and increase the known reserves. In 1982, only the South Zone was drilled. Drilling started on August 14 with two drill rigs operated by Heath and Sherwood Drilling of Toronto and was completed by November 1. Four drill holes and one wedged hole were drilled for a total of 2,866.64 metres. The programme was successful as four holes intersected good grade mineralization.

E) ENVIRONMENTAL PROGRAMMES SUMMARY

The environmental programs began on a serious basis in 1980, following discussions with Department of Indian and Northern Affairs staff in Whitehorse. These programmes were continued through 1981 and 1982.

Five different environmental programmes were supported by the Jason Project in 1982. They were:

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- completion of a study of the fishery resources of the property
- completion of vegetation mapping of the property
- continuation of water chemistry sampling on the property
- continuation of studies of land reclamation techniques on the property
- continued support for Yukon Territorial Government wildlife studies in the Macmillan Pass region

The costs of these projects incurred in 1982, listed in Appenix I, total $43,180.00.

The fisheries study was executed for Aberford by Monenco Consultants Limited. The final report is included as Appendix III.

The vegetation mapping, as well as the field work for the water sampling program and the reclamation study, was executed by in-house staff. The water and soil chemistry analysis was carried out by Chemex Laboratories. The results of their work are assembled in Appendix II. In-house reports are not yet complete.

The Yukon Territorial Government continued wildlife studies in the region of the Macmillan Pass mineral properties and Aberford has continued to provide a share of the industry support for those studies. The Yukon Territory Government have not yet forwarded copies of results of their 1982 studies.

STATEMENT OF QUALIFICATIONS

GLENN R. BROWN

I, Glenn R. Brown, of Calgary, Alberta hereby certify that:

1) I am a Biologist residing at 118 Ninth Street, N.W., Calgary, Alberta and am currently employed by Aberford Resources Ltd. of 300 Fifth Avenue, S.W., Calgary, Alberta.

2) I graduated from the University of Illinois in 1980 with an M.Sc. in Biology and have practiced my profession since that time.

3) I am a member in good standing of the Alberta Society of Professional Biologists.

4) I designed and executed, or supervised, the field work carried out by Aberford Resources Ltd. which forms the basis for the environmental work described in this report.

Date: January 24th, 1983

Glenn R. Brown

A P P E N D I X   I

EXHIBIT 'A'

STATEMENT OF EXPENDITURES

This is Exhibit 'A', attached to and formerly part of that certain Application for a Certificate of Work of Jacques R. Dumouchel dated the 21st day of December, 1982.

The following is a detailed statement of expenditures for the period of January 1st, 1981 to December 31st, 1982, inclusive.

EXHIBIT 'A'

1982 JASON ENVIRONMENTAL EXPENDITURES

Support for In-House Studies					
Water Chemistry Analysis					$8,313.00
Soil Chemistry Analysis					320.00
Seeds and Fertilizer					98.00
Plant Press and Supplies					75.00
Thermometers and Rain Gauges					178.00
Travel Expenses					
Plane Fares				$1,306.00	
Vehicle Rental				820.00	
Hotel Costs				140.00	2,267.00
Miscellaneous Expenses					759.00
SUBTOTAL					$3,378.00
Staff Time					
W. J. Stephen	9 days x $250/day	Jan.1 - July 8		$2,250.00	
G. R. Brown	85 days x $200/day	Jan.1 - Dec. 30		17,000.00	
J. Pearson	7 days x $85/day	May 24 - Sept. 30		595.00	
A. Clark	3 days x $50/day	August		150.00	$19,995.00
Field Support Cost					
G. R. Brown	40 days x $30/day	May 30 - Sept. 30		$1,200.00	
J. Pearson	7 days x $30/day	May 24 - Sept. 30		210.00	
A. Clark	3 days x $30/day	August		90.00	$1,500.00
IN-HOUSE EXPENSES TOTAL					$31,685.00
Contracted Studies					
Yukon Territorial Government: 1982 MacMillan Pass Regional Study (from April 1 0 Dec. 30)					$6,166.00
Monenco Fisheries Study (Jan 1 to July 31)					3,510.00
CONTRACTED STUDIES TOTAL					$9,676.00
GRAND TOTAL					$43,180.00

<u>Cost Distribution:</u>

This work applies to all claims on the Jason Property.

Total Claims:	193	Mayo Mining District
	90	Watson Lake Mining District
	283	Claims

Expenditures per claim: $43,180.00 ÷ 283 Claims = $152.58 per claim.

A P P E N D I X   I I

WATER AND SOIL CHEMISTRY RESULTS

CHEMEX

CALGARY 2021 - 41 AVE. N.E. CALGARY, CANADA T2E 6P2
TELEPHONE (403) 276-9627 TELEX 038-25541

EDMONTON 8764 - 50TH AVE. EDMONTON, CANADA T6E 5K8
TELEPHONE (403) 465-9877

CERTIFICATE OF ANALYSIS

• MINERAL • GAS • WATER • OIL • SOILS • VEGETATION • ENVIRONMENTAL ANALYSIS

ABERFORD RESOURCES LTD

AUGUST 6, 1982
DATE

WATER ANALYSIS

RECEIVED JUNE 29, 1982

PROJECT NO. 82 0036 5 2375

PARAMETERS	TOTAL	HESS T.A. JUNE 13	DISS
CALCIUM		12.7	
MAGNESIUM		2.1	
CHLORIDE		<0.5	
SULFATE		20.2	
T. ALKALINITY		20.	
PH		7.30	
CONDUCTANCE		80.9	
COLOUR		5	
TURBIDITY		32.	
T. DISSOLVED SOLIDS		55.0	
T. SUSPENDED SOLIDS		16.	
ACIDITY		1.0	
NITRATE-NITRITE		.028	
TOTAL PHOSPHOROUS		0.181	
CADMIUM	0.001		<0.001
COPPER	0.007		0.001
IRON	4.5		.03
ZINC	0.050		0.035
LEAD	0.017		<0.002
BARIUM	.50		.07
T. HARDNESS		40.3	
S. REACTIVE PHOSPHATE (OPO_4)		0.005	
S. ORGANIC PHOSPHATE		0.036	
S. ORGANIC CARBON		1.2	
T. KJELDAHL NITROGEN		.55	
AMMONIA		<.01	

CERTIFIED BY

CHEMEX

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CERTIFICATE OF ANALYSIS

• MINERAL • GAS • WATER • OIL • SOILS • VEGETATION • ENVIRONMENTAL ANALYSIS

ABERFORD RESOURCES LTD

WATER ANALYSIS

RECEIVED JUNE 29, 1982

DATE AUGUST 6, 1982

PROJECT NO. 82 0036 5 2375

PARAMETERS		HESS T.B. JUNE 13	
CALCIUM		11.9	
MAGNESIUM		2.0	
CHLORIDE		<0.5	
SULFATE		18.3	
T. ALKALINITY		18.4	
PH		7.41	
CONDUCTANCE		72.6	
COLOUR		5	
TURBIDITY		25.	
T. DISSOLVED SOLIDS		50.0	
T. SUSPENDED SOLIDS		14.	
ACIDITY		2.0	
NITRATE-NITRITE		.023	
TOTAL PHOSPHOROUS	TOTAL	0.148	DISS
CADMIUM	0.001		<0.001
COPPER	0.006		0.001
IRON	2.3		.04
ZINC	0.071		0.034
LEAD	0.014		<0.002
BARIUM	.28		.05
T. HARDNESS		37.9	
S. REACTIVE PHOSPHATE (OPO_4)		0.007	
S. ORGANIC PHOSPHATE		.027	
S. ORGANIC CARBON		1.0	
T. KJELDAHL NITROGEN		.85	
AMMONIA		<.01	

CTA MEMBER CANADIAN TESTING ASSOCIATION

CERTIFIED BY [signature]

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ABERFORD RESOURCES LTD

WATER ANALYSIS

RECEIVED JUNE 29, 1982

DATE AUGUST 6, 1982

PROJECT NO. 82 0036 5 2375

PARAMETERS		BRIDGE A JUNE 13	
CALCIUM		11.9	
MAGNESIUM		1.7	
CHLORIDE		<0.5	
SULFATE		24.9	
T. ALKALINITY		9.6	
PH		7.14	
CONDUCTANCE		75.0	
COLOUR		10	
TURBIDITY		24.	
T. DISSOLVED SOLIDS		51.0	
T. SUSPENDED SOLIDS		20.	
ACIDITY		2.0	
NITRATE-NITRITE		.019	
TOTAL PHOSPHOROUS	TOTAL	0.200	DISS
CADMIUM	0.002		0.001
COPPER	0.014		<0.001
IRON	6.9		.15
ZINC	0.21		0.16
LEAD	0.025		<0.002
BARIUM	2.06		.06
T. HARDNESS		36.7	
S. REACTIVE PHOSPHATE (OPO_4)		<0.003	
S. ORGANIC PHOSPHATE		.048	
S. ORGANIC CARBON		0.6	
T. KJELDAHL NITROGEN		.40	
AMMONIA		<.01	

CTA MEMBER CANADIAN TESTING ASSOCIATION

CERTIFIED BY ____________

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CERTIFICATE OF ANALYSIS

• MINERAL • GAS • WATER • OIL • SOILS • VEGETATION • ENVIRONMENTAL ANALYSIS

ABERFORD RESOURCES LTD

WATER ANALYSIS

RECEIVED JUNE 29, 1982

DATE AUGUST 6, 1982

PROJECT NO. 82 0036 5 2375

PARAMETERS		BRIDGE B JUNE 13	
CALCIUM		16.4	
MAGNESIUM		3.2	
CHLORIDE		0.65	
SULFATE		35.5	
T. ALKALINITY		15.2	
PH		7.22	
CONDUCTANCE		108.	
COLOUR		10	
TURBIDITY		19.	
T. DISSOLVED SOLIDS		72.0	
T. SUSPENDED SOLIDS		18.	
ACIDITY		2.0	
NITRATE-NITRITE		.045	
TOTAL PHOSPHOROUS	TOTAL	0.22	DISS
CADMIUM	0.002		0.001
COPPER	0.013		<0.001
IRON	4.8		.11
ZINC	0.18		0.16
LEAD	0.012		<0.002
BARIUM	1.36		.06
T. HARDNESS		54.1	
S. REACTIVE PHOSPHATE (OPO_4)		<0.003	
S. ORGANIC PHOSPHATE		.053	
S. ORGANIC CARBON		0.7	
T. KJELDAHL NITROGEN		.30	
AMMONIA		<.01	

CTA MEMBER CANADIAN TESTING ASSOCIATION

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CHEMEX

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• MINERAL • GAS • WATER • OIL • SOILS • VEGETATION • ENVIRONMENTAL ANALYSIS

ABERFORD RESOURCES LTD

WATER ANALYSIS

RECEIVED JUNE 29, 1982

DATE AUGUST 6, 1982

PROJECT NO. 82 0036 5 2375

PARAMETERS	TOTAL	BRIDGE A JUNE 20	DISS
CALCIUM		14.6	
MAGNESIUM		2.5	
CHLORIDE		0.7	
SULFATE		29.5	
T. ALKALINITY		17.2	
PH		7.43	
CONDUCTANCE		104.	
COLOUR		10.	
TURBIDITY		15.	
T. DISSOLVED SOLIDS		69.0	
T. SUSPENDED SOLIDS		12.	
ACIDITY		2.0	
NITRATE-NITRITE		.033	
TOTAL PHOSPHOROUS		0.157	
CADMIUM	0.001		0.001
COPPER	0.013		<0.001
IRON	4.9		.04
ZINC	0.18		0.12
LEAD	0.017		<0.002
BARIUM	1.68		.05
T. HARDNESS		36.7	
S. REACTIVE PHOSPHATE (OPO_4)		<0.003	
S. ORGANIC PHOSPHATE		.033	
S. ORGANIC CARBON		0.6	
T. KJELDAHL NITROGEN		.10	
AMMONIA		<.01	

CTA MEMBER CANADIAN TESTING ASSOCIATION

CERTIFIED BY ______

CHEMEX

CALGARY 2021 - 41 AVE. N.E. CALGARY, CANADA T2E 6P2
TELEPHONE (403) 276-9627 TELEX 038-25541

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CERTIFICATE OF ANALYSIS

• MINERAL • GAS • WATER • OIL • SOILS • VEGETATION • ENVIRONMENTAL ANALYSIS

ABERFORD RESOURCES LTD

WATER ANALYSIS

RECEIVED JUNE 29, 1982

DATE AUGUST 6, 1982

PROJECT NO. 82 0036 5 2375

PARAMETERS	TOTAL	BRIDGE B JUNE 20	DISS
CALCIUM		14.6	
MAGNESIUM		2.5	
CHLORIDE		<0.5	
SULFATE		30.0	
T. ALKALINITY		17.2	
PH		7.42	
CONDUCTANCE		133.	
COLOUR		10.	
TURBIDITY		17.	
T. DISSOLVED SOLIDS		88.0	
T. SUSPENDED SOLIDS		16.	
ACIDITY		2.0	
NITRATE-NITRITE		.034	
TOTAL PHOSPHOROUS		0.153	
CADMIUM	0.001		0.001
COPPER	0.015		<0.001
IRON	6.4		.03
ZINC	0.14		0.12
LEAD	0.021		<0.002
BARIUM	2.04		.05
T. HARDNESS		46.7	
S. REACTIVE PHOSPHATE (OPO_4)		<0.003	
S. ORGANIC PHOSPHATE		.031	
S. ORGANIC CARBON		0.6	
T. KJELDAHL NITROGEN		.10	
AMMONIA		<.01	

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ABERFORD RESOURCES LTD

WATER ANALYSIS

RECEIVED JUNE 29, 1982

DATE AUGUST 6, 1982

PROJECT NO. 82 0036 5 2375

PARAMETERS		HESS T.A. JUNE 20	
CALCIUM		10.8	
MAGNESIUM		1.9	
CHLORIDE		20.5	
SULFATE		18.5	
T. ALKALINITY		15.6	
PH		7.41	
CONDUCTANCE		74.	
COLOUR		5.	
TURBIDITY		5.5	
T. DISSOLVED SOLIDS		50.0	
T. SUSPENDED SOLIDS		2.4	
ACIDITY		2.0	
NITRATE-NITRITE		.025	
TOTAL PHOSPHOROUS	TOTAL	0.051	DISS
CADMIUM	0.001		<0.001
COPPER	0.005		<0.001
IRON	.88		.03
ZINC	0.057		0.045
LEAD	0.010		<0.002
BARIUM	.35		.03
T. HARDNESS		34.7	
S. REACTIVE PHOSPHATE (OPO_4)		<0.003	
S. ORGANIC PHOSPHATE		.013	
S. ORGANIC CARBON		0.7	
T. KJELDAHL NITROGEN		.05	
AMMONIA		.02	

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ABERFORD RESOURCES LTD

WATER ANALYSIS

RECEIVED JUNE 29, 1982

DATE AUGUST 6, 1982

PROJECT NO. 82 0036 5 2375

PARAMETERS	HESS T.B.	JUNE 20	
CALCIUM		9.0	
MAGNESIUM		1.5	
CHLORIDE		0.60	
SULFATE		16.0	
T. ALKALINITY		15.6	
PH		7.20	
CONDUCTANCE		79.	
COLOUR		5.	
TURBIDITY		6.5	
T. DISSOLVED SOLIDS		52.0	
T. SUSPENDED SOLIDS		3.0	
ACIDITY		3.0	
NITRATE-NITRITE		.018	
TOTAL PHOSPHOROUS	TOTAL	0.057	DISS
CADMIUM	0.001		<0.001
COPPER	0.004		<0.001
IRON	1.45		.03
ZINC	0.061		0.042
LEAD	0.006		<0.002
BARIUM	.18		.02
T. HARDNESS		28.6	
S. REACTIVE PHOSPHATE (OPO_4)		<0.003	
S. ORGANIC PHOSPHATE		.016	
S. ORGANIC CARBON		0.6	
T. KJELDAHL NITROGEN		.05	
AMMONIA		.01	

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CERTIFICATE OF ANALYSIS

• MINERAL • GAS • WATER • OIL • SOILS • VEGETATION • ENVIRONMENTAL ANALYSIS

PAN OCEAN LTD.
JASON PROJECT
SAMPLE DATE: JULY 4
LAB. NO.: 414-1,8

DATE SEPT. 29/82
PROJECT NO. 82-36-5-2492

HESS T. A (8)	HESS T. B (8)	PARAMETERS	BRIDGE A (1)	BRIDGE B (1)
7.41	7.40	PH	7.29	6.86
0	0	COLOUR (PT CO UNITS)	0	0
1	1	ACIDITY (PPM AS CACO3)	2	2
28.8	30.0	SULPHATE (PPM)	46.6	47.4
.56	.72	TURBIDITY (JTU)	3	5
122	120	CONDUCTIVITY (UMHOS/CM)	164	160
11.7	3.5	CALCIUM (PPM)	15.2	14.8
11.8	3.6	MAGNESIUM (PPM)	4.9	4.8
<0.1	<0.1	CHLORIDE (PPM)	0.2	0.1
20.8	20.8	TOTAL ALKALINITY (PPM AS CACO3)	96.0	16.8
80.	80.0	TOTAL DISSOLVED SOLIDS (MG/L)	110.	107.
<1.0	<1.0	TOTAL SUSPENDED SOLIDS (MG/L)	<1.0	<1.0
<.01	<.01	AMMONIA-NITROGEN (PPM N)	<.01	<.01
0.30	0.25	TOTAL KJELDAHL NITROGEN (PPM N)	0.08	0.18
0.014	0.018	NITRATE-NITRITE AS N(PPM N)	0.037	0.038
0.008	0.009	TOTAL PHOSPHORUS (PPM P)	0.028	0.030
<0.003	<0.003	SOLUBLE REACTIVE PHOSPHATE (PPM P)	<0.003	<0.003
*	*	SOLUBLE ORGANIC PHOSPHATE (PPM P)	*	*
<.2	<.2	SOLUBLE ORGANIC CARBON (PPM)	<.2	<.2
0.51	0.59	ALUMINUM - TOTAL (PPM)	1.96	1.53
0.04	0.04	IONIC (PPM)	0.02	0.06
<0.001	<0.001	CADMIUM - TOTAL (PPM)	<0.001	<0.001
<0.001	<0.001	IONIC (PPM)	<0.001	<0.001
0.10	0.08	BARIUM - TOTAL (PPM)	0.05	0.05
0.08	0.08	IONIC (PPM)	0.05	0.05
0.010	0.010	COPPER - TOTAL (PPM)	0.011	0.028
0.001	0.001	IONIC (PPM)	0.001	<0.001
0.15	0.19	IRON - TOTAL (PPM)	1.90	1.60
<.01	<.01	IONIC (PPM)	<.01	<.01
0.008	0.023	LEAD - TOTAL (PPM)	0.012	0.004
<0.002	<0.002	IONIC (PPM)	<0.002	<0.002
0.084	0.082	ZINC - TOTAL (PPM)	0.18	0.20
0.072	0.072	IONIC (PPM)	0.18	0.18

* ANALYSIS WAS NOT DONE IMMEDIATELY MAKING RESULT QUESTIONABLE.

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PAN OCEAN LTD.
JASON PROJECT
SAMPLE DATE: JULY 11
LAB. NO.: 414-2,9

SEPT. 29/82
DATE
82-36-5-2492
PROJECT NO.

HESS T. A	9	HESS T. B	PARAMETERS		BRIDGE A	2	BRIDGE B
7.28		7.04	PH		7.04		7.10
0		0	COLOUR (PT CO UNITS)		0		0
2		2	ACIDITY (PPM AS CACO3)		2		2
30.3		31.2	SULPHATE (PPM)		42.7		42.7
0.64		1.2	TURBIDITY (JTU)		5.8		7.6
119		116	CONDUCTIVITY (UMHOS/CM)		152		154
11.3		11.5	CALCIUM (PPM)		14.0		13.9
3.5		3.6	MAGNESIUM (PPM)		4.4		4.4
0.1		<0.1	CHLORIDE (PPM)		0.2		<0.1
17.6		17.6	TOTAL ALKALINITY (PPM AS CACO3)		14.4		15.2
75.0		76.0	TOTAL DISSOLVED SOLIDS (MG/L)		100.		105.
<1.0		<1.0	TOTAL SUSPENDED SOLIDS (MG/L)		<1.0		<1.0
<.01		<.01	AMMONIA-NITROGEN (PPM N)		<.01		<.01
.28		0.28	TOTAL KJELDAHL NITROGEN (PPM N)		0.10		0.08
0.018		0.018	NITRATE-NITRITE AS N(PPM N)		0.038		0.038
0.008		0.009	TOTAL PHOSPHORUS (PPM P)		0.063		0.062
<0.003		<0.003	SOLUBLE REACTIVE PHOSPHATE (PPM P)		<0.003		<0.003
*		*	SOLUBLE ORGANIC PHOSPHATE (PPM P)		*		*
<.2		<.2	SOLUBLE ORGANIC CARBON (PPM)		.3		.2
0.80		0.78	ALUMINUM	- TOTAL (PPM)	1.80		1.68
0.04		0.04		IONIC (PPM)	0.02		0.04
<0.001		<0.001	CADMIUM	- TOTAL (PPM)	0.001		0.001
<0.001		<0.001		IONIC (PPM)	<0.001		<0.001
0.10		0.10	BARIUM	- TOTAL (PPM)	0.03		0.03
0.05		0.05		IONIC (PPM)	0.03		0.03
0.012		0.008	COPPER	- TOTAL (PPM)	0.016		0.014
0.001		0.001		IONIC (PPM)	0.001		<0.001
0.30		0.20	IRON	- TOTAL (PPM)	1.42		1.93
<.01		<.01		IONIC (PPM)	<.01		<.01
0.022		0.018	LEAD	- TOTAL (PPM)	0.006		0.028
<0.002		<0.002		IONIC (PPM)	<0.002		<0.002
0.088		0.088	ZINC	- TOTAL (PPM)	0.20		0.20
0.080		0.076		IONIC (PPM)	0.19		0.20

* ANALYSIS WAS NOT DONE IMMEDIATELY
MAKING RESULT QUESTIONABLE.

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PAN OCEAN LTD.
JASON PROJECT
SAMPLE DATE: JULY 18
LAB. NO.: 414-3,10

DATE SEPT. 29/82

PROJECT NO. 82-36-5-2492

HESS T. 10 A	HESS T. 10 B	PARAMETERS	BRIDGE 3 A	BRIDGE 3 B
7.33	7.30	PH	7.34	7.10
0	0	COLOUR (PT CO UNITS)	0	0
1	1	ACIDITY (PPM AS CACO3)	2	2
33.8	34.4	SULPHATE (PPM)	48.3	47.4
0.52	0.62	TURBIDITY (JTU)	5.6	9.0
135	134	CONDUCTIVITY (UMHOS/CM)	168	154
12.4	13.1	CALCIUM (PPM)	15.3	15.5
3.9	4.1	MAGNESIUM (PPM)	4.8	4.8
0.15	<0.1	CHLORIDE (PPM)	0.2	<0.1
17.6	20.0	TOTAL ALKALINITY (PPM AS CACO3)	16.8	16.0
90.0	90.0	TOTAL DISSOLVED SOLIDS (MG/L)	112.	105.
<1.0	<1.0	TOTAL SUSPENDED SOLIDS (MG/L)	<1.0	<1.0
<.01	<.01	AMMONIA-NITROGEN (PPM N)	<.01	<.01
0.30	0.15	TOTAL KJELDAHL NITROGEN (PPM N)	0.15	0.10
0.030	0.031	NITRATE-NITRITE AS N(PPM N)	0.045	.042
0.008	0.010	TOTAL PHOSPHORUS (PPM P)	0.069	0.071
<0.003	<0.003	SOLUBLE REACTIVE PHOSPHATE (PPM P)	<0.003	<0.003
*	*	SOLUBLE ORGANIC PHOSPHATE (PPM P)	*	*
<.2	<.2	SOLUBLE ORGANIC CARBON (PPM)	.2	<.2
0.52	0.51	ALUMINUM - TOTAL (PPM)	1.92	1.93
0.04	0.04	IONIC (PPM)	0.03	0.04
<0.001	<0.001	CADMIUM - TOTAL (PPM)	<0.001	0.001
<0.001	<0.001	IONIC (PPM)	<0.001	<0.001
0.12	0.10	BARIUM - TOTAL (PPM)	0.04	0.05
0.04	0.04	IONIC (PPM)	0.04	0.04
0.009	0.009	COPPER - TOTAL (PPM)	0.015	0.014
0.001	0.003	IONIC (PPM)	<0.001	<0.001
0.23	0.33	IRON - TOTAL (PPM)	1.87	1.73
<.01	<.01	IONIC (PPM)	<.01	<.01
0.018	0.014	LEAD - TOTAL (PPM)	0.016	0.012
<0.002	<0.002	IONIC (PPM)	<0.002	<0.002
0.10	0.096	ZINC - TOTAL (PPM)	0.21	0.24
0.082	0.086	IONIC (PPM)	0.21	0.22

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PAN OCEAN LTD.
JASON PROJECT
SAMPLE DATE: JULY 25
LAB. NO.: 414-4,11

DATE SEPT. 29/82
PROJECT NO. 82-36-5-2492

HESS T. 11 A	HESS T. 11 B	PARAMETERS	BRIDGE 4 A	BRIDGE 4 B
7.67	7.78	PH	7.27	7.12
0	0	COLOUR (PT CO UNITS)	0	0
1	1	ACIDITY (PPM AS CACO3)	2	2
38.1	37.6	SULPHATE (PPM)	64.	64.
0.52	0.56	TURBIDITY (JTU)	3.2	4.9
170	162	CONDUCTIVITY (UMHOS/CM)	215	201
17.6	18.3	CALCIUM (PPM)	20.8	20.7
5.3	5.4	MAGNESIUM (PPM)	6.6	6.6
0.1	<0.1	CHLORIDE (PPM)	0.2	0.15
32.8	31.2	TOTAL ALKALINITY (PPM AS CACO3)	17.6	17.6
115.	104.	TOTAL DISSOLVED SOLIDS (MG/L)	138.	140.
<1.0	<1.0	TOTAL SUSPENDED SOLIDS (MG/L)	<1.0	<1.0
.01	<.01	AMMONIA-NITROGEN (PPM N)	<.01	<.01
.30	0.35	TOTAL KJELDAHL NITROGEN (PPM N)	0.05	0.08
0.010	0.014	NITRATE-NITRITE AS N(PPM N)	0.034	0.038
0.006	0.008	TOTAL PHOSPHORUS (PPM P)	0.023	0.024
0.003	<0.003	SOLUBLE REACTIVE PHOSPHATE (PPM P)	<0.003	<0.003
*	*	SOLUBLE ORGANIC PHOSPHATE (PPM P)	*	*
<.2	<.2	SOLUBLE ORGANIC CARBON (PPM)	<.2	.3
0.61	0.67	ALUMINUM - TOTAL (PPM)	1.87	2.20
0.05	0.05	IONIC (PPM)	0.02	0.02
<0.001	<0.001	CADMIUM - TOTAL (PPM)	0.003	0.003
<0.001	<0.001	IONIC (PPM)	<0.001	<0.001
0.10	0.06	BARIUM - TOTAL (PPM)	0.05	0.05
0.05	0.04	IONIC (PPM)	0.04	0.05
0.011	0.016	COPPER - TOTAL (PPM)	0.010	0.011
0.002	0.001	IONIC (PPM)	0.001	<0.001
0.45	0.46	IRON - TOTAL (PPM)	1.33	1.92
<.01	<.01	IONIC (PPM)	<.01	<.01
0.002	0.008	LEAD - TOTAL (PPM)	<0.002	0.008
<0.002	<0.002	IONIC (PPM)	<0.002	<0.002
0.10	0.10	ZINC - TOTAL (PPM)	0.30	0.31
0.092	0.080	IONIC (PPM)	0.30	0.31

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PAN OCEAN LTD.
JASON PROJECT
SAMPLE DATE: JULY 27
LAB. NO.: 414-5,12

DATE SEPT. 29/82

PROJECT NO. 82-36-5-2492

HESS T. 12 A	HESS T. 12 B	PARAMETERS	BRIDGE 5 A	BRIDGE 5 B
7.02	7.09	PH	7.45	7.32
0	0	COLOUR (PT CO UNITS)	0	0
2	2	ACIDITY (PPM AS CACO3)	1	1
26.8	26.4	SULPHATE (PPM)	39.4	40.7
0.55	0.79	TURBIDITY (JTU)	3.5	5.6
111	110	CONDUCTIVITY (UMHOS/CM)	159.	142.
11.1	10.8	CALCIUM (PPM)	14.0	13.8
3.1	3.2	MAGNESIUM (PPM)	4.5	4.2
0.15	<0.1	CHLORIDE (PPM)	0.2	<0.1
17.6	18.4	TOTAL ALKALINITY (PPM AS CACO3)	17.6	17.6
78.0	76.0	TOTAL DISSOLVED SOLIDS (MG/L)	100.	92.0
<1.0	<1.0	TOTAL SUSPENDED SOLIDS (MG/L)	<1.0	<1.0
0.05	<.01	AMMONIA-NITROGEN (PPM N)	<.01	0.02
0.48	0.45	TOTAL KJELDAHL NITROGEN (PPM N)	0.08	0.10
0.016	0.026	NITRATE-NITRITE AS N(PPM N)	0.039	0.036
0.011	0.019	TOTAL PHOSPHORUS (PPM P)	0.035	0.037
0.003	0.003	SOLUBLE REACTIVE PHOSPHATE (PPM P)	<0.003	<0.003
*	*	SOLUBLE ORGANIC PHOSPHATE (PPM P)	*	*
<.2	<.2	SOLUBLE ORGANIC CARBON (PPM)	<.2	0.3
0.83	0.61	ALUMINUM - TOTAL (PPM)	1.30	1.27
0.05	0.05	IONIC (PPM)	0.02	0.03
<0.001	<0.001	CADMIUM - TOTAL (PPM)	0.001	<0.001
<0,001	<0.001	IONIC (PPM)	<0.001	<0.001
0.10	0.07	BARIUM - TOTAL (PPM)	0.04	0.04
0.03	0.02	IONIC (PPM)	0.04	0.04
0.010	0.016	COPPER - TOTAL (PPM)	0.010	0.007
<0.001	<0.001	IONIC (PPM)	<0.001	0.004
0.12	0.12	IRON - TOTAL (PPM)	1.44	1.44
<.01	<.01	IONIC (PPM)	<.01	<.01
0.007	0.019	LEAD - TOTAL (PPM)	0.008	0.002
<0.002	<0.002	IONIC (PPM)	<0.002	<0.002
0.066	0.070	ZINC - TOTAL (PPM)	0.17	0.18
0.058	0.062	IONIC (PPM)	0.15	0.15

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CTA MEMBER CANADIAN TESTING ASSOCIATION

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PAN OCEAN LTD.
JASON PROJECT
SAMPLE DATE: AUG. 1
LAB. NO.: 414-6,13

DATE SEPT. 29/82

PROJECT NO. 82-36-5-2492

HESS T. 13 A	HESS T. 13 B	PARAMETERS	BRIDGE 6 A	BRIDGE 6 B
7.18	7.19	PH	7.40	7.14
0	0	COLOUR (PT CO UNITS)	0	0
2	2	ACIDITY (PPM AS CACO3)	1	2
35.4	38.1	SULPHATE (PPM)	64.	60.
0.92	0.94	TURBIDITY (JTU)	7.2	7.0
140	147	CONDUCTIVITY (UMHOS/CM)	207	191
13.2	14.8	CALCIUM (PPM)	20.8	19.0
4.0	4.7	MAGNESIUM (PPM)	6.6	6.2
0.1	<0.1	CHLORIDE (PPM)	<0.1	<0.1
19.6	22.4	TOTAL ALKALINITY (PPM AS CACO3)	17.6	16.8
95.0	102.	TOTAL DISSOLVED SOLIDS (MG/L)	140.	125.
<1.0	<1.0	TOTAL SUSPENDED SOLIDS (MG/L)	<1.0	<1.0
.02	<.01	AMMONIA-NITROGEN (PPM N)	<.01	0.02
.43	0.70	TOTAL KJELDAHL NITROGEN (PPM N)	0.10	0.28
0.016	0.024	NITRATE-NITRITE AS N(PPM N)	0.030	0.027
0.009	0.010	TOTAL PHOSPHORUS (PPM P)	0.033	0.034
<0.003	<0.003	SOLUBLE REACTIVE PHOSPHATE (PPM P)	<0.003	<0.003
*	*	SOLUBLE ORGANIC PHOSPHATE (PPM P)	*	*
<.2	<.2	SOLUBLE ORGANIC CARBON (PPM)	<.2	<.2
0.47	0.70	ALUMINUM - TOTAL (PPM)	2.53	2.71
0.05	0.04	IONIC (PPM)	0.06	0.06
0.002	0.002	CADMIUM - TOTAL (PPM)	0.001	0.003
<0.001	<0.001	IONIC (PPM)	0.001	0.001
0.06	0.05	BARIUM - TOTAL (PPM)	0.04	0.04
0.03	0.04	IONIC (PPM)	0.04	0.04
0.012	0.010	COPPER - TOTAL (PPM)	0.020	0.016
0.002	0.002	IONIC (PPM)	0.001	0.001
0.56	0.43	IRON - TOTAL (PPM)	3.00	2.69
<.01	<.01	IONIC (PPM)	<.01	<.01
0.018	0.022	LEAD - TOTAL (PPM)	0.003	0.007
0.005	<0.002	IONIC (PPM)	<.002	<0.002
0.11	0.11	ZINC - TOTAL (PPM)	0.37	0.34
0.090	0.10	IONIC (PPM)	0.31	0.30

* ANALYSIS WAS NOT DONE IMMEDIATELY MAKING RESULT QUESTIONABLE.

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CERTIFICATE OF ANALYSIS

• MINERAL • GAS • WATER • OIL • SOILS • VEGETATION • ENVIRONMENTAL ANALYSIS

PAN OCEAN LTD.
JASON PROJECT
SAMPLE DATE: AUG 17,16
LAB. NO.: 414-7,14

DATE SEPT. 29/82

PROJECT NO. 82-36-5-2492

HESS T. 14 A	HESS T. 14 B	PARAMETERS	BRIDGE 7 A	BRIDGE 7 B
7.58	7.58	PH	6.90	6.86
0	0	COLOUR (PT CO UNITS)	0	0
1	1	ACIDITY (PPM AS CACO3)	2	2
42.1	41.4	SULPHATE (PPM)	71.5	71.5
0.16	0.59	TURBIDITY (JTU)	8.7	14
200	182	CONDUCTIVITY (UMHOS/CM)	228	214
19.7	19.5	CALCIUM (PPM)	20.7	21.2
6.3	6.3	MAGNESIUM (PPM)	7.0	6.8
0.1	0.1	CHLORIDE (PPM)	0.1	0.1
36.0	37.6	TOTAL ALKALINITY (PPM AS CACO3)	12.0	12.8
135.	124.	TOTAL DISSOLVED SOLIDS (MG/L)	155.	145.
<1.0	<1.0	TOTAL SUSPENDED SOLIDS (MG/L)	14	26
<.01	INTERFERENCE	AMMONIA-NITROGEN (PPM N)	0.03	0.03
.63	0.50	TOTAL KJELDAHL NITROGEN (PPM N)	0.20	0.25
0.004	<.003	NITRATE-NITRITE AS N(PPM N)	0.033	0.034
0.004	0.007	TOTAL PHOSPHORUS (PPM P)	0.017	0.032
<0.003	<0.003	SOLUBLE REACTIVE PHOSPHATE (PPM P)	<0.003	<0.003
*	*	SOLUBLE ORGANIC PHOSPHATE (PPM P)	*	*
<.2	<.2	SOLUBLE ORGANIC CARBON (PPM)	<.2	0.8
0.63	0.48	ALUMINUM – TOTAL (PPM)	2.26	0.84
0.08	0.09	IONIC (PPM)	0.04	0.05
0.002	0.006	CADMIUM – TOTAL (PPM)	0.003	0.005
<0.001	<0.001	IONIC (PPM)	0.003	0.005
0.06	0.05	BARIUM – TOTAL (PPM)	0.04	0.04
0.05	0.04	IONIC (PPM)	0.04	0.04
0.011	0.014	COPPER – TOTAL (PPM)	0.012	0.040
0.001	<0.001	IONIC (PPM)	0.004	0.005
0.56	0.50	IRON – TOTAL (PPM)	2.22	2.49
<.01	<.01	IONIC (PPM)	<.01	<.01
0.032	0.018	LEAD – TOTAL (PPM)	0.002	0.008
0.006	<0.002	IONIC (PPM)	<0.002	0.003
0.11	0.094	ZINC – TOTAL (PPM)	0.38	0.38
0.072	0.068	IONIC (PPM)	0.38	0.38

* ANALYSIS WAS NOT DONE IMMEDIATELY MAKING RESULT QUESTIONABLE.

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DATE ~~SEPT.~~ Oct. 29/82

PROJECT NO. 82-36-5-2492

PAN OCEAN LTD.
JASON PROJECT
SAMPLE DATE: Aug. 21
LAB. NO.: 514

HESS T. 1 A	HESS T. 1 B	PARAMETERS	BRIDGE 2 A	BRIDGE 2 B
7.66	7.67	PH	6.82	6.82
<5	<5	COLOUR (PT CO UNITS)	<5	10
2.0	2.0	ACIDITY (PPM AS CACO3)	3.2	3.2
44.0	43.5	SULPHATE (PPM)	77.	78.5
.56	.66	TURBIDITY (JTU)	5.8	6.4
205	205	CONDUCTIVITY (UMHOS/CM)	232	231
20.2	20.0	CALCIUM (PPM)	21.1	22.0
7.3	7.1	MAGNESIUM (PPM)	7.9	8.2
<0.1	0.45	CHLORIDE (PPM)	0.1	<0.1
40	40	TOTAL ALKALINITY (PPM AS CACO3)	14.4	13.6
140.	140.	TOTAL DISSOLVED SOLIDS (MG/L)	155.	155.
0.4	<0.4	TOTAL SUSPENDED SOLIDS (MG/L)	8.0	8.4
.02	.04	AMMONIA-NITROGEN (PPM N)	.05	.05
.32	.32	TOTAL KJELDAHL NITROGEN (PPM N)	.44	.44
<.003	<.003	NITRATE-NITRITE AS N(PPM N)	.040	.049
0.007	0.011	TOTAL PHOSPHORUS (PPM P)	0.015	0.017
0.003	0.008	SOLUBLE REACTIVE PHOSPHATE (PPM P)	0.003	0.004
<0.003	<0.003	SOLUBLE ORGANIC PHOSPHATE (PPM P)	.006	.006
1.2	0.7	SOLUBLE ORGANIC CARBON (PPM)	0.5	<.2
1.00	1.84	ALUMINUM - TOTAL (PPM)	3.40	3.80
0.06	0.05	IONIC (PPM)	0.03	0.03
0.002	0.003	CADMIUM - TOTAL (PPM)	0.005	0.006
0.002	0.003	IONIC (PPM)	0.004	.004
0.04	0.03	BARIUM - TOTAL (PPM)	0.04	0.12
0.03	0.03	IONIC (PPM)	0.04	0.10
0.017	0.036	COPPER - TOTAL (PPM)	0.011	0.012
0.001	0.001	IONIC (PPM)	0.002	.002
0.87	2.00	IRON - TOTAL (PPM)	2.03	2.20
<.01	<.01	IONIC (PPM)	<.01	<.01
0.004	0.007	LEAD - TOTAL (PPM)	0.011	0.005
<0.002	<0.002	IONIC (PPM)	<0.002	<0.002
0.12	0.18	ZINC - TOTAL (PPM)	0.25	0.29
0.077	0.087	IONIC (PPM)	0.23	0.23

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PAN OCEAN LTD.
JASON PROJECT
SAMPLE DATE:
LAB. NO.:

DATE SEPT. 29/82

PROJECT NO. 82-36-5-2492

HESS T. 3 A	HESS T. 3 B	PARAMETERS	BRIDGE 4 A	BRIDGE 4 B
7.33	7.36	PH	6.79	6.76
<5	<5	COLOUR (PT CO UNITS)	5	<5
2.0	2.0	ACIDITY (PPM AS CACO3)	3.2	3.2
58.5	57	SULPHATE (PPM)	85.	85.
8.2	7.8	TURBIDITY (JTU)	5.8	5.8
198	197	CONDUCTIVITY (UMHOS/CM)	251	253
18.6	23.8	CALCIUM (PPM)	23.7	23.3
6.9	7.0	MAGNESIUM (PPM)	8.9	9.0
<0.1	0.15	CHLORIDE (PPM)	0.40	<0.1
20.8	21.6	TOTAL ALKALINITY (PPM AS CACO3)	15.2	15.2
135.	133.	TOTAL DISSOLVED SOLIDS (MG/L)	160.	165.
5.6	6.4	TOTAL SUSPENDED SOLIDS (MG/L)	8.0	7.2
.04	.05	AMMONIA-NITROGEN (PPM N)	.04	.04
.32	.28	TOTAL KJELDAHL NITROGEN (PPM N)	.32	.32
.070	.036	NITRATE-NITRITE AS N(PPM N)	.014	.011
0.009	0.006	TOTAL PHOSPHORUS (PPM P)	0.020	0.022
<0.003	<0.003	SOLUBLE REACTIVE PHOSPHATE (PPM P)	0.003	0.004
.006	.004	SOLUBLE ORGANIC PHOSPHATE (PPM P)	0.009	.008
.8	.9	SOLUBLE ORGANIC CARBON (PPM)	.6	1.1
	4.50	ALUMINUM - TOTAL (PPM)	4.40	4.00
0.54	0.32	IONIC (PPM)	0.25	0.25
	0.004	CADMIUM - TOTAL (PPM)	0.005	0.005
0.002	0.002	IONIC (PPM)	0.004	0.005
N/S	0.17	BARIUM - TOTAL (PPM)	0.02	0.07
0.03	0.15	IONIC (PPM)	0.02	0.06
	0.011	COPPER - TOTAL (PPM)	0.011	0.010
0.002	0.002	IONIC (PPM)	0.002	0.002
N/S	0.51	IRON - TOTAL (PPM)	2.46	2.41
0.03	0.01	IONIC (PPM)	0.47	0.42
	0.023	LEAD - TOTAL (PPM)	0.013	0.008
0.003	<0.002	IONIC (PPM)	<0.002	<0.002
	0.095	ZINC - TOTAL (PPM)	0.47	0.47
0.11	0.10	IONIC (PPM)	.43	.43

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ABERFORD RESOURCES LTD.

DATE NOVEMBER 30, 1982

PROJECT NO. 82 036-5-2830

SAMPLE	PH	EC (USCM-1)	NA (PPM)	CA (PPM)	MG (PPM)	HCO3 (PPM)	SO4 (PPM)	CL (PPM)
TRENCH #1	5.9	30.9	10	4	<1	15.3	1.0	3.2
ROAD #1	5.1	82.5	8	2	<1	9.76	2.0	3.2
TRENCH #2	5.4	82.5	8	4	<1	19.5	1.0	3.2
ROAD #2	5.1	61.9	8	2	<1	19.5	1.0	3.2

SAMPLE	N (LB/ACRE 6")	P (LB/ACRE 6")	K(LB/ACRE 6")
TRENCH #1	11	10	96
ROAD #1	3.0	6	96
TRENCH #2	8	9	48
ROAD #2	12	6	48

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APPENDIX III

AQUATIC STUDIES AT MACMILLAN PASS, YUKON TERRITORY

BY: MONENCO CONSULTANTS LIMITED

(See Attached)

AQUATIC STUDIES AT MACMILLAN PASS YUKON TERRITORY

091422

FOR

PAN OCEAN OIL LTD.

Monenco Consultants Limited
900 One Palliser Square
125 - 9 Avenue S.E.
Calgary, Alberta
T2G OP6

monenco consultants limited

900 ONE PALLISER SQUARE, 125 - 9th AVENUE S.E.
CALGARY, ALBERTA, CANADA T2G 0P6

Telephone: (403) 263-1680 Telex: 038-22636

15 January 1982
P00 7867-5

Pan Ocean Oil Ltd.
300 Fifth Avenue S.W.
Calgary, Alberta
T2P 3C4

Attention: Dr. W.J. Stephen
Environmental Co-ordinator

Gentlemen:

We are pleased to present our final report on the baseline aquatic studies carried out at your Jason property this year.

We have enjoyed working with you on this project, and we look forward to working with you in the future.

Yours truly,

S.W. Behie, Ph.D., P.Eng.
Manager
Environmental Division

PREFACE

This report was carried out for Pan Ocean Oil Ltd. by Monenco Consultants Limited, Calgary, Alberta. The study was carried out under the direction of Dr. P.A. Neame. Mr. G.D. Szabo supervised the field studies and was responsible for the habitat descriptions and fish population studies. Dr. D.M. Trotter assisted in data interpretation and report preparation. Sediment and fish tissue analyses were carried out by Monenco Analytical Laboratories under the direction of Dr. J. Dean. Taxonomic determinations were made by Mr. R. Green (periphyton) and Ms. M.K. Ryan (benthos). Water chemistry sampling and laboratory analyses were carried out in a separate study by others, with the data presented to Monenco for inclusion in this report.

EXECUTIVE SUMMARY

Monenco Consultants Limited conducted a baseline environmental survey of Pan Ocean Oil Ltd.'s Jason property at Macmillan Pass, Yukon Territory during June, August, and October 1981. The study emphasized the description of stream habitat in the area and investigated the fish, benthic macroinvertebrate, and periphyton communities in the South Macmillan River and other smaller streams. Chemical determination of trace elements in the river bed sediment was also carried out. Pan Ocean Oil Ltd. supplied laboratory analyses of the water from the South Macmillan River and its tributaries as well as from the various tributaries of the Hess River draining the Jason Property.

The techniques used for the stream habitat assessment were developed by the British Columbia Ministry of the Environment and are also used by the Yukon Territorial government. The procedure results in a biophysical characterization of the streams indicating the fish community present and various paramenters which are related to the suitablity of the stream as fish habitat, such as slope of the stream, substrate type, and channel width. The fish community was sampled by electroshocking and the invertebrate benthic community was sampled by Surber and artificial substrate samplers. Attached algae from rock surfaces were also collected.

The tributary streams on the Jason Property are typical of headwater streams, having steep gradients, high water velocities, large-sized substrate materials and few areas of slower, deeper water (pool habitat). Associated with this physical setting was an extremely variable chemical environment including a creek affected by mine drainage (Rust Creek), and two naturally acidic drainages (Tom Creek and Orange Creek), all of which have high concentrations of certain metals, as well as alkaline streams containing low levels of dissolved

components. The South Macmillan River in the area of the Jason property is a moderate-sized, meandering river, with greater amounts of pool habitat, which on the basis of its physical characteristics should be suitable as fish habitat.

Both the density of individuals and the diversity of species within the benthic macroinvertebrate communities of the South Macmillan River and Hess tributary were found to be low. A significant decrease in density occurred in the area of the South Macmillan River immediately downstream of Rust and Tom Creeks.

The attached algal community, or periphyton, was found to be low in both diversity and density in the South Macmillan River and Hess tributary. As with the benthic invertebrate community, a decrease in density was observed in the area of the South Macmillan River downstream from Rust and Tom Creeks.

The fish community was found to be composed of one species (Arctic grayling) with only 27 specimens collected during the entire sampling program. The various physical characteristics of these fish showed them to be similar to other populations in the Yukon.

The aquatic biological systems of both the South Macmillan River and the Hess River tributary have a naturally low biological productivity, exemplified by few individuals and few species occurring within each group of organisms present. Man-made impacts, such as those due to road construction and mining, only tend to exacerbate this situation in certain locations.

The major potential impacts of mining on the aquatic environment include increased turbidity due to surface disturbance and elevated acidity and trace metal concentrations due to the release of mine water. These impacts are briefly discussed with reference to the relevant literature. Potential impacts are divided into exploration and construction, mining and abandonment phases.

Recommendations for further aquatic studies are also presented. On the basis of their scientific and managerial value, the most immediately useful studies would be:

- an improved water quality sampling program;
- further studies of benthic invertebrates;
- a study of the assimilative capacity of wetlands in the South Macmillan River floodplain for the possible reception of mine effluents.

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CONTENTS (Cont'd)

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INTRODUCTION

PART ONE - INTRODUCTION

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PART TWO

METHODS

PART TWO - METHODS

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PLATES

2.1 AQUATIC HABITAT ASSESSMENT

The methods employed to assess stream habitat quality in the Macmillan Pass area are those developed by the British Columbia Ministry of the Environment, Aquatic Studies Branch (Chamberlin 1980a). These techniques were used to maintain consistency with the Yukon government, which uses the British Columbia method of data collection. This work was done in consultation with the Ecological Land Survey of the Yukon Territorial Government, to be consistent with a regional fisheries study that they were conducting in west central Yukon in 1981.

The British Columbia aquatic assessment technique is a stream survey procedure which considers both the physical and biological characteristics of streams. The aquatic survey technique is designed to "provide a basic core of data from which inferences can be made about the dominant physical and biological processes in a river" (Chamberlin 1980a).

The "reach" is the basic sampling unit of the aquatic survey. Reaches are sections of stream that exhibit internally consistent physical characteristics, which, as a whole, differ from those found in other reaches. Reaches are usually delineated on the basis of discharge, slope, and substrate.

Reaches were mapped during an initial low level helicopter survey in June 1981. Reach boundaries were delineated by following each fluvial system at a low altitude and speed. Reach data were entered on "reach data cards" in the manner prescribed by Belford and Chamberlin (1980), using the aquatic survey terminology described in Chamberlin (1980b). A sample "reach data card" is given in Appendix A along with descriptors of the parameters for which data were collected.

Stream habitat characteristics within the study area were then summarized in two formats: (1) an aquatic biophysical map, summarizing information collected in the area and (2) detailed descriptions of the individual reaches including reach data and photographs.

Two types of information are presented on the aquatic biophysical map:

- a reach symbol which summarizes selected fish, channel and substrate information for each reach, and
- symbols describing important site specific stream features.

Reach symbols characterize an entire reach and thus represent average values. The parameters used are those which are most suitable for describing stream attributes relevant to fish production. For example, fish food production is directly related to substrate type.

Biophysical stream characteristics used in reach symbols are arranged in the following format:

Fish Species Present

Channel Width (m)	Valley Flat: Channel Ratio	Slope %	Substrate Materials			
			Fines	Gravel	Larges	Bedrock

where:

Channel Width = Distance between rooted vegetation

Valley Flat/Channel Ratio = Ratio between width of valley flat and width of channel, coded as: A(0-2), B(2-5), C(5-10), D(10+) or E (not applicable)

Slope = Elevation gain/reach length, as an average for the reach

Substrate Materials = % to nearest 10% of:

Fines - 0-2 mm

Gravel - 2-64 mm

Larges - Greater than 64 mm

Bedrock - consolidated material

Example:

	Rb	Ch		(Co)		
9	B	1.5	2	3	4	1

Fish Present: Rainbow trout, chinook, coho (probable occurrance)

Channel: Width 9 m, valley flat to channel ratio from 2-5, average reach slope 1.5%

Substrate: 20% fines, 30% gravel, 40% larges, 10% bedrock

In addition to the symbols that identify the reaches and their characteristics, the map also provides the numerical codes for watershed subdivisions occurring in the study area. These codes are also used in Appendix B. The hierarchical watershed coding system used in the area follows the methods described in Shera and Grant (1980). Tributaries are numbered sequentially, going upstream on the mainstream. An eight level code represented by a 21-digit number is used for reconnaissance (1:50,000) mapping (Shera and Grant 1980). To be compatible with other Yukon aquatic studies, we used the watershed code numbers which were derived by the Department of Renewable Resources, Yukon Territory.

No habitat evaluations took place in the few small lakes or ponds or in the wetlands situated in the study area.

2.2 PHYSICAL AND CHEMICAL FEATURES

221 WATER CHEMISTRY

In situ water quality parameters (temperature, dissolved oxygen, and conductivity) were measured with a mercury thermometer and Y.S.I. meters. Laboratory water quality data were provided by Pan Ocean Oil Ltd. Water quality and biological sampling sites are identified in Plate 2-1.

222 SEDIMENT AND TISSUE CHEMISTRY

Samples of sediment were taken with a small shovel and placed in a zip-lock bag for shipment to Monenco Analytical Laboratories. One whole fish specimen was collected and frozen for shipment to the laboratory for metal analysis.

Known amounts of sediment were digested in a nitric-perchloric-hydrofluoric acid solution and evaporated to dryness. A small amount of hydrochloric acid dissolved the residue which was then diluted with distilled water. The quantities of metals in solution were measured by atomic absorption analysis.

Ten grams of muscle tissue of the fish was digested in a nitric-perchloric acid solution overnight at room temperature. The solution was then evaporated to dryness, solubilized with hydrochloric acid, diluted with distilled water and analyzed by atomic absorption.

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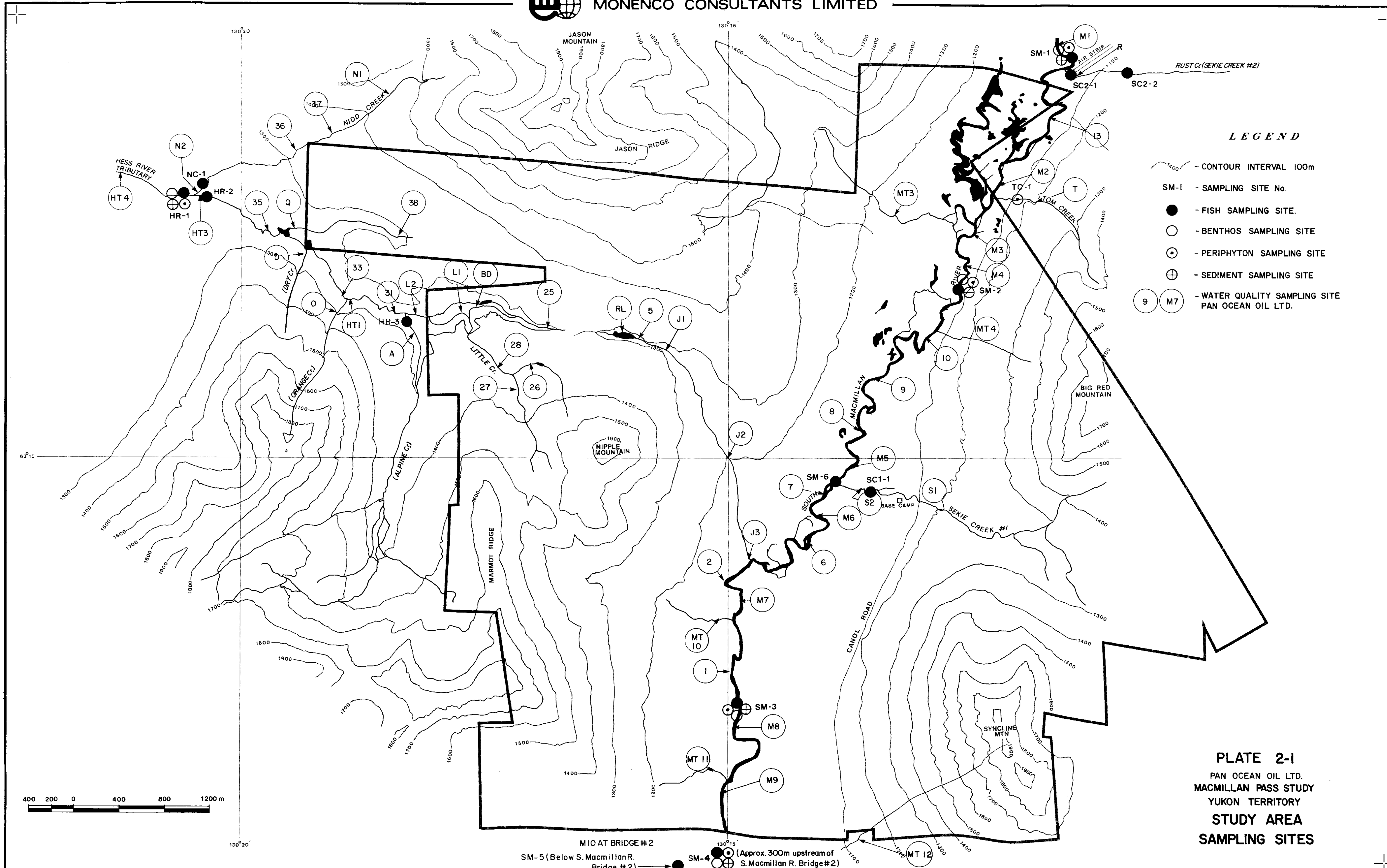

PLATE 2-1
PAN OCEAN OIL LTD.
MACMILLAN PASS STUDY
YUKON TERRITORY
STUDY AREA
SAMPLING SITES

2.3 BIOLOGICAL FEATURES

231 PERIPHYTON

Samples of the attached algal community were collected using a modified syringe fitted with a brush, which was used to clean a defined area (5 cm^2) of the surface of a rock selected arbitrarily from the stream bed. Three samples (total 15 cm^2) were collected from each rock and pooled for analysis. Three separate 15 cm^2 samples were collected at each station.

Samples were analyzed according to the method of Utermohl (1958). Whole water samples preserved with Lugol's solution were thoroughly agitated and a subsample was allowed to settle in a settling chamber. The subsamples ranged in volume from 1.0 to 10 ml and settling time was based upon three hours per cm of chamber height. A inverted microscope equipped with phase contrast illumination was used for identification and enumeration of the phytoplankton.

Cell numbers were converted to volumes by using the average dimensions of the algae (Findenegg 1969). The calculated cell volumes were then converted to biomass values by assuming a specific gravity of 1.

Identifications were based mainly upon the works of Bourrelly (1957, 1966, 1968, 1970), Cleve-Euler (1951-1955), Croasdale (1973), Desikachary (1959), Hilliard (1966, 1967), Hilliard and Asmund (1963), Hustedt (1927-1964), Foged (1974), Lowe (1975), Lune (1962), Hygaard (1977), Prescott (1962), Patrick and Reimer (1966, 1975), Skuja (1948, 1964), Sreenivasa and Duthie (1975), Whitford and Schumacher (1973), and Willen (1963).

232 BENTHIC INVERTEBRATES

Benthic macroinvertebrates in the South Macmillan and Hess tributary were sampled by two methods. Three Surber samples (each sampling 0.09 m^2 or 1 sq. ft.) were taken at each site. In addition, artificial substrate samplers consisting of metal cylinders filled with stones from the streambed were also used at the same sites. These samplers have a sampling area of approximately 54 cm^2 and a volume of approximately 1,350 cm^3. The samplers were installed in June and retrieved in October, and the Surber samples were collected in October. Benthic macroinvertebrate samples were preserved in 10% formalin.

References used for the taxonomic identification of invertebrates from Surber and artificial substrate samplers as well as the fish stomach contents were Agriculture Canada (1981), Baumann et al. (1977), Dosdall and Lemkuhl (1979), Jewett, (1959), Lemkuhl (1979), Merritt and Cummins (1978), Pennak (1978), Ward and Whipple (1959), and Wiggins (1977).

233 FISH POPULATIONS

Sampling for fish distribution and composition was undertaken in the field using a Smith Root Type VII backpack electrofisher. Three hundred metre (300 m) sections of stream were routinely sampled except where stream gradient or accessibility made shocking of such long sections impractical. No population estimates were made.

When it was feasible, a barrier net was placed at the lower end of the stream section and shocking was done in the downstream direction. The successful use of a barrier net was limited to sampling in Nidd Creek, Tom Creek, and the Hess River tributary below Nidd Creek. At other locations, high stream gradients or flows prevented the placement of the net. In these instances, electroshocking was performed in an upstream direction. The South Macmillan River was sampled in June, August, and October. Other streams were visited in June and August only.

Fish specimens were weighed and measured in the field using a portable spring scale and a fish measuring board. Scale samples were removed for later aging of fish in the laboratory and all fish were visually examined for their reproductive condition. A single fish specimen was retained for heavy metal analyses. Stomach samples were retained and preserved in the field for later determination of organisms utilized for food.

A swim survey using a snorkel and wetsuit was undertaken in the South Macmillan River in August to verify the presence or absence of fish in the river.

PART THREE

BASELINE ENVIRONMENTAL STUDY RESULTS

PART THREE - BASELINE ENVIRONMENTAL STUDY RESULTS

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FIGURES

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3.1 AQUATIC HABITAT ASSESSMENT

311 INTRODUCTION

The results of the aquatic habitat assessment undertaken in 1981 are presented in this section. A biophysical stream survey map (Plate 3-1) illustrates the basic reach divisions, reach data, site specific stream features and the watershed code numbers for the area. Detailed reach data and photographs for reaches identified on the map are found in Appendix B.

312 RESULTS OF THE AQUATIC HABITAT ASSESSMENT

All major fluvial (stream) habitats on and immediately outside the Jason property were investigated. The South Macmillan River is the longest and largest system in the study area. The Hess River tributary, its headwaters partially on the property, was the next largest stream. All other streams were tributaries to these two systems. Most of the other tributaries in the area are short, sometimes intermittent meltwater streams having only one or two reaches, often characterized by a steep mountainside reach and a more gently sloping, less turbulent, valley bottom reach (i.e., Sekie Creek).

The South Macmillan River has two distinct reach types on the property. Reach 21 has a steeper gradient and straighter channel than reach 22, and is characterized by numerous small cascades and rapids. Pools are smaller and fewer than in reach 22, and the substrate has a larger component of boulder-sized material. In contrast, reach 22 is less turbulent, more meandering, and has larger pools. Gravel substrate is abundant and appears suitable for fish spawning. A third reach, 20a, is similar to reach 22 in physical structure. The "a"

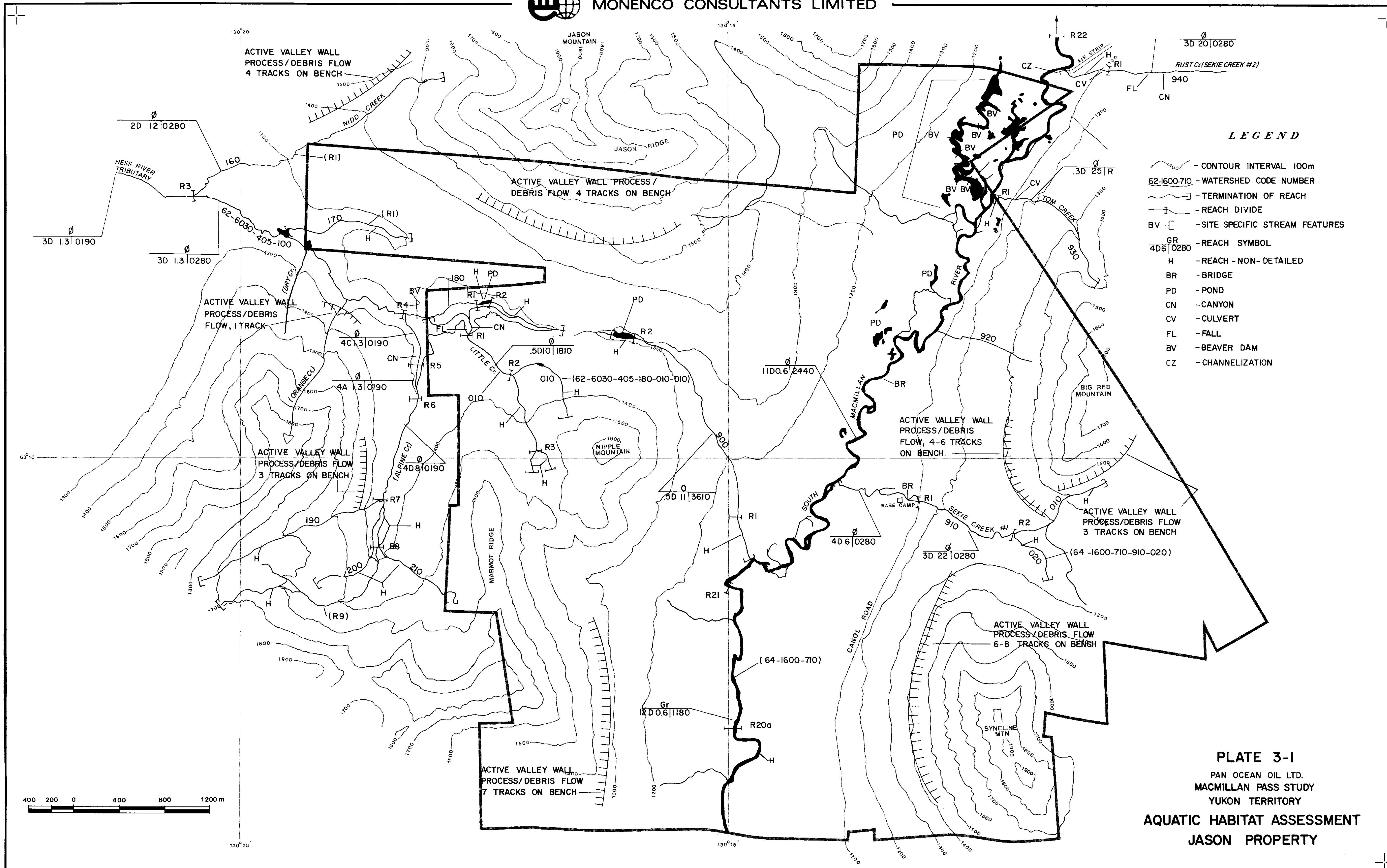


PLATE 3-1
PAN OCEAN OIL LTD.
MACMILLAN PASS STUDY
YUKON TERRITORY
AQUATIC HABITAT ASSESSMENT
JASON PROPERTY

designation was necessary to accommodate this additional reach which was not identified by the Yukon Ecological Land Survey due to differences in the scale of their mapping.

Gradients in the streams were often too great to provide fish holding water (pools) or to permit easy upstream fish movements. The South Macmillan River and Hess River tributary had the lowest calculated slopes, 0.6 and 1.3% respectively. Slopes greater than 20% (in mountainside reaches) were not uncommon.

High stream gradients prevent the deposition of any significant amounts of finer substrate materials which are important as benthic invertebrate habitat and as spawning habitat for fish. In almost all reaches, the substrate was composed of gravel, cobble and boulder-sized material. Substrate material in the Hess River tributary was almost exclusively boulder sized rocks. Reach R22 of the South Macmillan River had the greatest accumulation of finer substrate materials.

The greatest percentage of fluvial habitat in the study area was characterized by riffles, rapids, and cascades. Riffle areas are essential for successful salmonid repreduction and provide habitat for the most important food items used by salmonids. Pools are equally important for providing cover and resting areas for fish. Some salmonids spend as much as 95 percent of the time in pools (Thompson 1974, Hooper 1973). A 1:1 riffle:pool ratio is usually considered optimum for fish production.

Except for reaches 21 and 22, pools were non-existent in most stream reaches examined. Reach R22 of the South Macmillan River had the greatest percentage of pools and the most suitable riffle:pool ratio in the area. However, the absence of fish in the reach suggests there may be other limiting factors, such as water quality or lack of food.

In north-temperate climates, overwintering areas are critical to the survival of fish. These areas must have sufficient depth so as not to freeze to the bottom, and a food source that occasionally can support large concentrations of fish. Deep pools are often sought out by fish for overwintering. Other than some of the deeper pools noted in reach R22 of the South Macmillan River, no suitable overwintering fish habitat was observed in the study area.

Water level fluctuations were noted in streams throughout the sampling period, with the highest levels coinciding with the spring freshet. In general, lateral channel movement in the streams examined was low, as evidenced by the lush growth of riparian vegetation (mostly understory and ground cover) and the lack of major active erosion points. Some active bank erosion due to undercutting was observed in the South Macmillan River in reach R22, upstream and downstream of the airstrip.

Stream turbidity was variable throughout the property and was influenced by exploratory mining activity in the area. Throughout the year, the South Macmillan River remained moderately turbid even upstream of developments. Natural erosion in this stream and occasional man-made disturbances contributed to periodic high turbidity.

313 SUMMARY

The South Macmillan River and Hess River tributary were the largest streams in the study area. The South Macmillan River had two distinct reach types: one with a steeper gradient, straighter channel and many cascades and rapids, and the other more meandering with larger pools. Other tributary streams had steep gradients which would limit fish access. Tributary stream habitat was characterized by abundant riffles, rapids and cascades, with pools being non-existent in most reaches of these streams. No suitable overwintering fish habitat was observed other than some of the deeper pools found in reach R22 of the South Macmillan River.

3.2 PHYSICAL-CHEMICAL FEATURES

321 WATER CHEMISTRY

.1 Introduction

The dissolved and suspended substances in the waters of the project area, which collectively constitute the water chemistry, are a major force determining the nature of the resident aquatic biological communities. These substances determine not only the relative productivity of the various components in the aquatic system but also their ability to resist environmental change.

.2 Results

Table 3-1 presents the water chemistry data collected on site during the June survey. All dissolved oxygen concentrations were above 100 percent saturation due primarily to the turbulent nature of the streams. Conductivity was highest in Rust Creek. The largest variation in water temperature (4°C) was observed within approximately one hour between the highest and lowest sampling sites on the South Macmillan River (Table 3.1).

The results of the water analyses of samples from the South Macmillan River and its tributaries are presented in Tables 3-2, 3-3 and 3-4. The sampling station numbers are arranged from the most upstream site (top of the table) to the most downstream (bottom of the table) with tributary data (designated by 'T') positioned between the river data corresponding to the entrance of the tributary. Tables 3-5, 3-6 and 3-7 present the analysis of samples from the Hess River tributaries, in the same manner as Tables 3-2 to 3-4. Plate 2-1 shows the locations of the sampling sites.

TABLE 3-1

Water Chemistry Parameters, MacMillan Pass Area, Jason Property, June 1981

Location	Station	Date	Time (D.S.T.)	Water Temp.	Air Temp.	Diss. Oxygen	Conductivity
			h	°C	°C	ppm	mhos
S. Macmillan R.	SM-1	1981-06-12	13:00	5.0	14.0	12.4	98
	SM-2	1981-06-12	16:00	8.0	12.1	11.0	110
	SM-3	1981-06-13	14:00	7.5	12.0	11.2	95
	SM-4	1981-06-14	14:00	9.0	16.5	10.9	94
Rust Cr.	SC2-1	1981-06-12	10:15	5.4	14.0	12.1	210
	SC2-2	1981-06-12	09:15	3.9	8.9	13.0	210
Sekie Cr. #1	SC1-1	1981-06-12	21:30	4.6	13.0	12.4	30
Hess R. Trib.	HR-1	1981-06-13	09:30	4.2	9.0	12.6	83
	HR-3	1981-06-13	13:30	3.0	9.0	13.3	-
Nidd Cr.	NC-1	1981-06-13	11:00	4.2	9.0	13.2	110

TABLE 3-2

South Macmillan River and Tributaries Water Chemistry, June 1981
(Data from Cordilleran Engineering)

	pH	Alkal- inity	Hardness	Diss. Solids	Susp. Solids	Turbidity	SO_4	PO_4	F	Total Fe	Diss. Fe	As	Cu	Pb	Zn	Cd	Cr	Mo	U	Total Hg	Ba
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
13	6.7	16	48	118	31	26	55	1	110	3800	140	2	14	4	310	4	<5	12	0.2	<.05	<100
M2	6.8	23	50	160	20	15	40	3	112	1100	70	<2	10	4	230	3	<5	8	0.2	<.05	<100
(T) T	3.0	-	46	360	60	105	215	<1	200	17900	3700	2	100	4	1200	22	<5	32	5.3	<.05	<100
M4	6.9	23	46	162	15	12	40	1	130	1100	70	<2	11	8	220	2	<5	12	0.2	<.05	<100
(T)MT4	4.6	2	18	48	<2	6	15	<1	25	50	60	<2	16	4	63	1	<5	8	0.05	<.05	<100
10	7.0	23	42	163	7	14	50	<1	120	1050	70	<2	5	12	230	2	<5	4	0.1	<.05	<100
9	6.9	21	48	142	3	12	50	<1	120	860	120	<2	5	6	240	2	<5	8	0.2	<.05	<100
M5	7.0	24	50	160	52	28	45	2	130	4920	80	2	5	12	210	2	<5	4	0.3	<.05	<100
(T) S1	5.6	3	18	30	<2	8	5	<1	35	150	130	<2	14	8	55	<1	<5	12	0.3	<.05	<100
(T) S2	5.6	4	16	20	<2	7	10	<1	35	50	50	<2	9	4	90	1	5	8	0.2	<.05	<100
7	7.1	22	42	126	10	16	45	<1	120	2230	60	<2	5	8	210	3	<5	4	1.0	<.05	<100
6	7.1	21	38	114	10	11	45	<1	110	2100	200	2	8	6	330	2	5	4	0.2	<.05	<100
(T) J1	7.6	64	48	114	<2	6	5	1	80	460	220	<2	7	4	23	<1	5	4	1.2	<.05	<100
(T) J2	7.7	60	44	124	170	120	10	2	90	2920	170	2	7	4	20	1	<5	4	1.0	<.05	100
(T) J3	7.8	66	48	114	19	26	10	1	95	440	200	2	4	4	48	<1	5	4	1.3	<.05	<100
M7	7.3	20	46	112	32	18	45	1	110	2300	40	2	5	4	160	2	<5	4	0.2	<.05	100
(T)MT10	8.0	90	64	122	<2	5	15	<1	130	50	100	<2	12	4	32	<1	10	8	3.0	<.05	150
M8	7.4	22	42	72	11	10	45	<1	100	980	40	<2	5	4	155	2	<5	4	0.1	<.05	100
(T)MT11	6.8	8	20	108	<2	5	10	<1	30	50	50	<2	5	8	7	<1	<5	4	0.4	<.05	<100
M9	7.1	22	40	74	60	26	35	2	100	2520	80	2	7	12	120	2	5	4	0.3	<.05	100
MT12	7.4	35	36	58	<2	5	10	<1	75	50	70	<2	14	8	43	2	<5	12	0.2	<.05	<100

NOTE: Sampling sites arranged from upstream to downstream; (T) designates tributaries with sampling sites arranged in similar manner

TABLE 3-3

South Macmillan River and Tributaries Water Chemistry, August 1981
(Data from Pan Ocean Oil Ltd.)

	pH	Alkal- inity	Hardness	Diss. Solids	Susp. Solids	Turbidity	SO_4	PO_4
		ppm	ppm	ppm	ppm	ppm	ppm	ppm
M1	7.5	20	76	106	14	2	26	<1
(T) R	3.1	-	84	168	142	182	113	<1
M2	7.1	12	68	86	23	10	30	<1
(T) T	2.8	-	140	458	28	90	323	<1
M3	7.1	16	76	122	20	13	38	<1
(T)MT3	8.1	50	84	94	<1	2	3	<1
M4	7.1	12	76	100	20	15	41	<1
M5	7.2	16	96	96	18	16	30	<1
(T) S1	7.1	6	36	28	2	<2	2	<1
(T) S2	7.5	8	32	12	4	<2	2	<1
M6	7.2	16	72	84	15	11	29	<1
(T) RL	5.4	10	60	32	360	100	8	<1
(T) J1	7.8	66	100	62	4	<2	2	<1
(T) J2	7.9	64	84	86	10	8	5	<1
(T) J3	8.3	126	164	214	4	2	19	<1
M7	7.3	16	76	112	15	14	27	<1
(T)MT11	7.6	12	40	60	<1	<2	6	<1
M10	7.4	16	80	96	14	10	23	<1
(T)MT12	6.9	8	20	30	1	<2	2	<1

NOTE: Sampling sites arranged from upstream to downstream; (T) designates tributaries with sampling sites arranged in similar manner

TABLE 3-3 (Cont'd)

South Macmillan River and Tributaries Water Chemistry, August 1981

	F	Total Fe	Diss. Fe	As	Cu	Pb	Zn	Cd	Cr	Mo	U	Total Hg	Ba	Mn	Sb	Sr	Ag
	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
M1	130	1,480	9	<2	5	6	100	1	<2	8	0.3	<0.05	100	54	30	90	<1
(T) R	110	29,200	960	<2	73	90	2400	16	3	150	2.5	<0.05	600	200	40	50	<1
M2	110	2,330	30	<2	6	8	210	2	<2	5	0.2	<0.05	200	72	20	90	<1
(T) T	210	27,200	6,000	<2	110	14	1,955	5	20	555	6.0	<0.05	300	180	40	30	<1
M3	110	2,720	20	<2	4	10	185	2	<2	7	0.2	<0.05	250	180	40	30	<1
(T))MT3	100	100	200	<2	6	6	11	<1	<2	395	1.0	<0.05	200	70	20	90	<1
M4	110	2,620	15	<2	4	6	210	2	<2	10	0.2	<0.05	200	8	40	100	<1
M5	110	4,150	15	<2	10	6	200	2	<2	11	0.2	<0.05	200	72	30	90	<1
(T)S1	40	350	60	<2	6	6	19	<1	<2	17	0.05	<0.05	170	72	30	90	<1
(T)S2	45	200	50	<2	5	6	13	<1	<2	27	<0.05	<0.05	180	8	20	20	<1
M6	110	2,450	20	<2	5	10	230	2	<2	9	0.1	<0.05	220	8	30	20	<1
(T)RL	130	27,000	250	<2	6	4	6	<1	<2	5	<0.05	<0.05	500	34	20	70	<1
(T)J1	90	950	180	<2	12	2	6	<1	<2	28	0.4	<0.05	200	160	20	40	<1
(T)J2	80	650	310	<2	12	8	25	<1	<2	32	0.7	<0.05	300	4	20	100	<1
(T)J3	120	620	130	<2	9	2	52	<1	<2	15	3.5	<0.05	150	10	40	100	<1
M7	120	2,950	30	<2	5	8	145	1	<2	6	0.1	<0.05	220	10	30	170	<1
(T)MT11	35	50	95	<2	4	4	7	<1	<2	16	<0.05	<0.05	150	56	20	70	<1
M10	120	4,950	25	2	4	6	110	1	<2	8	0.2	<0.05	200	4	20	50	<1
(T)MT12	30	60	100	2	5	8	4	1	<2	24	0.1	<0.05	200	48	20	80	<1

NOTE: Sampling sites arranged from upstream to downstream; (T) designates tributaries with sampling site arranged in similar manner

TABLE 3-4

South Macmillan River and Tributaries Water Chemistry, September 1981
(Data from Pan Ocean Oil Ltd.)

	pH	Acidity	Alkal-inity	Total Hardness	Ca	Mg	Conductivity	Dissolved Solids	Suspended Solids	Turbidity	Colour	SO_4	Cl	Total Phosphorus	NO_2-NO_3
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	JTU	APHA	ppm	ppm	ppm as P	ppm as N
M1	7.03	1.0	14.6	102	24.3	10.0	224	145	10	2.6	<5	55	0.2	0.019	5.4
(T)R	2.86	20.1	0	51	12.2	5	743	483	11	20.2	<5	240	0.2	0.035	0.174
M2	7.05	3.72	-*	108	27.4	9.5	283	184	9.0	6.3	<5	60	0.2	0.037	9.6
(T)T	2.66	479	0	70	10.9	10.3	1218	792	3	10.4	15	482	<0.2	0.26	2.1
M3	6.87	17.1	11.6	90	22.9	7.9	215	139	23	12	5	67	0.2	0.023	1.06
M4	4.56	2.52	0.60	106	25.5	10.3	274	178	15	25	20	6 5	0.2	0.030	9.7
M5	6.66	1.0	17.	97	24.1	9.0	212	138	26	25	10	65	0.2	0.024	1.10
(T)S1	3.68	15.0	0	17	5.3	0.9	147	95	30	7.2	10	25	<0.2	<0.003	3.1
(T)S2	5.95	2.40	2.6	19	5.4	1.3	59.7	39	4.0	1.6	5	25	0.2	0.005	0.054
M6	6.77	18.2	15.6	86	21.1	8.1	195	127	19	9.0	5	60	0.2	0.019	0.20
(T)J2	7.65	1.0	72.6	84	26.3	4.4	175	114	4.0	3.8	10	17.3	0.5	0.017	0.021
(T)MT10	7.82	1.0	126	175	52.7	10.5	317	206	4.0	3.6	20	38	0.5	0.015	0.079
M8	7.30	13.5	19.4	84	21.3	7.4	1954	127	21	8.0	<5	60	0.2	0.018	0.20
(T)MT11	6.38	1.0	5.80	43	14.0	1.9	111	72	1.0	0.48	<5	34.8	0.2	0.003	1.54
M9	7.01	16.5	18.8	83	19.9	8.1	195	127	22	8.0	5	60	0.2	0.018	0.093
M10	7.39	3.53	19.6	82	21.5	6.8	184	119	18	10	<5	55	0.2	0.017	0.056
(T)MT12	6.55	7.14	4.60	15	4.9	0.6	41.7	27	1.0	0.63	15	12.7	0.5	0.003	0.07

NOTE: Sampling sites arranged from upstream to downstream; (T) designates tributaries with sampling sites arranged in similar manner
* insufficient sample

TABLE 3-4 (Cont'd)

South Macmillan River and Tributaries Water Chemistry, September 1981
(All units are ppb)

	As	Cd	Cu	Fe	Cr	Mn	Zn	Pb	Ba	Sr	Ni	Mo	Hg	U	Sb
M1	1.6	5	6	800	<10	50	340	2	100	50	<1	<1	0.3	0.6	0.7
(T)R	6.1	34	120	32,900	<10	450	3,360	40	<100	100	430	<1	<0.1	2.2	0.6
M2	2.3	4	6	2,280	<10	70	1,200	2	200	100	<1	<1	0.3	0.5	0.6
(T)T	18.6	48	120	24,300	<10	400	2,640	2	<100	100	780	<1	<0.1	1.2	1.1
M3	1.6	5	16	2,950	30	110	430	5	<100	100	100	<1	0.2	1.0	0.9
M4	4.2	5	24	5,500	70	100	440	8	<100	100	100	<1	0.2	0.3	0.4
M5	1.3	4	13	2,820	<10	80	370	5	<100	100	100	<1	0.1	0.4	0.4
(T)S1	1.8	1	8	190	<10	50	65	<2	<100	<50	29	<1	<0.1	0.6	0.5
S2	2.5	1	9	230	<10	40	64	<2	<100	<50	33	<1	<0.1	0.6	0.4
M6	0.6	4	13	2,510	<10	100	340	<2	100	100	99	<1	<0.1	1.1	4.6
(T)J2	1.0	<1	2	520	<10	60	30	2	<100	100	11	<1	0.1	1.9	0.6
(T)MT10	1.1	2	30	140	<10	10	39	3	<100	100	38	<1	0.3	1.5	0.7
M8	0.9	4	12	2,310	<10	60	350	<2	<100	100	92	<1	0.1	0.9	0.5
(T)MT11	<0.2	<1	1	70	<10	10	14	<2	<100	50	4	<1	0.1	0.6	0.2
M9	1.6	5	13	2,200	<10	100	350	<2	<100	100	95	<1	0.1	0.8	0.5
M10	1.3	4	10	1,680	<10	60	280	<2	<100	100	80	<1	<0.1	0.5	0.5
(T)MT12	<0.2	1	1	80	<10	10	38	<2	200	<50	<1	<1	0.1	0.4	0.2

NOTE: Sampling sites arranged from upstream to downstream; (T) designates tributaries with sampling sites arranged in similar manner

TABLE 3-5

Hess River Tributaries Water Chemistry, June 1981
(Data from Cordilleran Engineering)

	pH	Alkal- inity	Hardness	Diss. Solids	Susp. Solids	Turbidity	SO_4	PO_4	F	Total Fe	Diss. Fe	As	Cu	Pb	Zn	Cd	Cr	Mo	U	Total Hg	Ba
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
26	8.0	120	76	144	2	7	5	<1	50	50	50	<2	12	16	35	1	10	8	2.0	<.05	150
27	7.7	97	64	90	4	9	5	2	50	50	80	<2	9	16	55	2	5	8	2.0	<.05	100
28	8.1	102	64	140	2	7	20	<1	45	150	220	<2	8	12	55	<1	5	8	2.0	<.05	<100
(T) 25	7.8	89	56	104	3	9	10	1	45	50	50	2	16	8	60	2	10	12	1.6	<.05	200
L2	7.9	91	64	120	9	5	10	3	75	150	140	<2	9	8	20	<1	10	8	2.0	<.05	<100
(T) A	7.2	7	30	40	2	6	25	<1	60	100	100	<2	14	8	90	1	10	8	0.3	<.05	<100
31	7.1	20	32	56	2	5	20	<1	90	100	100	<2	5	8	42	2	10	4	0.4	<.05	<100
(T) 0	4.0	2	8	20	4	5	15	<1	75	310	80	<2	34	16	150	1	10	8	0.3	<.05	<100
33	7.1	21	28	42	4	6	25	2	75	120	80	<2	9	20	62	1	10	4	0.3	<.05	<100
D	4.0	2	4	10	2	4	10	<1	85	150	160	<2	23	24	100	2	10	4	0.2	<.05	<100
(T) 38	7.6	104	80	166	2	5	25	1	110	200	220	<2	7	24	20	<1	10	12	2.0	<.05	<100
35	6.8	23	34	78	3	4	20	<1	75	50	80	<2	5	8	63	<1	10	8	0.4	<.05	<100

NOTE: Sampling sites arranged from upstream to downstream; (T) designates tributaries to main channel

Nidd Creek

(T) 37	7.6	64	54	130	2	6	30	<1	65	100	80	<2	9	12	23	<1	10	12	3.0	<.05	100
(T) 36	7.5	64	54	116	6	5	25	<1	60	50	80	<2	11	20	20	<1	5	8	3.5	<.05	<100

TABLE 3-6

Hess River Tributaries Water Chemistry, August 1981
(Data from Pan Ocean Oil Ltd.)

	pH	Alkal-inity	Hardness	Diss. Solids	Susp. Solids	Turbidity	SO_4	PO_4
		ppm	ppm	ppm	ppm	ppm	ppm	ppm
(T) BD	7.9	84	104	98	2	<2	5	<1
(T) 26	8.2	112	148	112	6	3	8	<1
(T) 27	8.1	144	168	168	1	<2	8	<1
(T) L1	8.4	132	172	150	<1	<2	11	<1
HT1	7.8	20	64	38	1	<2	16	<1
(T) O	3.6	-	64	68	6	35	37	<1
HT2	6.8	24	60	96	1	<2	16	<1
(T) Q	8.4	124	160	196	<1	<2	18	<1
HT3	7.9	24	36	178	<1	<2	18	<1
(T) N1	8.2	58	116	174	7	<2	26	<1
(T) N2	8.3	62	76	186	38	50	34	<1
HT4	8.0	30	76	124	8	<2	17	<1

NOTE: Sampling sites arranged from upstream to downstream; (T) designates tributaries to main channel

TABLE 3-6 (Cont'd)

Hess River Tributaries Water Chemistry, August 1981
(All Units are ppb)

	F	Total Fe	Diss. Fe	As	Cu	Pb	Zn	Cd	Cr	Mo	U	Total Hg	Ba	Mn	Sb	Sr	Ag
	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
(T) BD	150	400	75	<2	7	6	75	2	<2	18	0.5	<0.05	280	6	30	110	<1
(T) 26	70	150	40	<2	8	4	55	1	<2	12	2.5	<0.05	200	6	30	200	<1
(T) 27	40	100	30	<2	6	2	65	<1	<2	23	1.5	<0.05	200	6	30	180	<1
(T) L1	60	30	25	2	6	2	65	<1	<2	17	3.0	<0.05	350	6	30	230	<1
HT1	80	320	75	<2	16	4	75	<1	<2	5	0.2	<0.05	200	40	20	80	<1
(T) O	170	3800	480	<2	88	14	295	3	<2	4	0.9	<0.05	220	130	30	70	<1
HT2	110	270	35	<2	5	2	155	1	<2	4	0.2	<0.05	200	36	30	80	<1
(T) Q	110	20	35	2	8	6	18	<1	<2	6	1.5	<0.05	200	6	50	160	<1
HT3	110	20	25	2	9	10	80	1	<2	4	0.2	<0.05	240	32	40	80	<1
(T) N2	110	250	20	<2	7	8	14	<1	<2	7	3.0	<0.05	180	110	40	110	<1
(T) N2	100	1500	140	2	6	4	9	<1	<2	7	2.5	<0.05	200	70	40	120	<1
HT4	90	480	15	2	100	110	55	<1	<2	4	0.4	<0.05	200	38	20	90	<1

NOTE: Sampling sites arranged from upstream to downstream; (T) designates tributaries with sampling sites arranged in similar manner

TABLE 3-7

Hess River Tributaries Water Chemistry, September 1981

(Data from Pan Ocean Oil Ltd.)

	pH	Acidity	Alkal-inity	Total Hardness	Ca	Mg	Conductivity	Dissolved Solids	Suspended Solids	Turbidity	Colour	SO_4	Cl	Total Phosphorous	NO_2-NO_3
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	JTU	APHA	ppm	ppm	ppm as P	ppm as N
(T)BD	7.31	5.81	85.0	100	30.9	5.6	195	127	6.0	0.64	5	16.7	0.2	0.076	0.102
(T)L1	8.30	0	141	161	47.3	10.5	296	192	11	2.2	<5	20.0	0.5	0.017	0.023
HT1	7.82	2.46	45.2	79	21.0	6.5	160	104	6.0	1.0	10	35.3	0.2	0.008	0.034
(T) O	2.80	169	0	72	20.1	5.2	776	504	44	160	50	210	0.2	0.074	0.067
(T) Q	8.06	2.46	118	151	45.7	8.9	279	81	4.0	0.8	<5	33.3	0.5	0.010	0.055
HT3	7.51	<1.0	40.0	89	24.6	6.6	180	117	7.0	2.4	<5	43.3	0.2	0.009	1.71
(T)N1	7.69	<1.0	74.2	136	38.5	9.5	256	166	6.0	2.6	5	55.7	0.2	0.007	0.008
(T)N2	7.85	<1.0	70.4	131	37.0	9.4	247	160	9.0	5.2	10	50.3	0.2	0.010	1.42
HT4	7.87	<1.0	53.8	95	26.4	7.0	189	123	4.0	3.2	5	44.6	0.2	0.009	0.031

NOTE: Sampling sites arranged from upstream to downstream; (T) designates tributaries with sampling sites arranged in similar manner

TABLE 3-7 (Cont'd)

Hess River Tributaries Water Chemistry, September 1981
(All units are ppb)

	As	Cd	Cu	Fe	Cr	Mn	Zn	Pb	Ba	Sr	Ni	Mo	Hg	U	Sb
(T)BD	0.4	3	1	20	10	10	44	<2	100	100	20	1	0.1	1.0	0.6
(T)L1	0.4	3	1	40	10	10	50	<2	100	150	15	1	0.2	3.2	0.8
HT1	<0.2	3	3	220	10	30	52	< 2	100	100	18	1	0.1	1.2	0.3
(T) O	0.6	28	710	45,800	10	1,030	2,020	<2	100	100	500	1	0.1	2.9	0.8
(T) Q	<0.2	2	6	80	10	10	30	4	100	100	14	1	0.1	1.9	0.2
HT3	<0.2	3	9	440	10	40	77	< 2	100	100	29	1	0.1	1.1	0.2
(T)N1	0.4	3	2	140	10	130	100	<2	100	100	17	1	0.1	3	0.2
(T)N2	0.4	2	21	120	10	80	30	2	100	100	30	1	0.1	2.7	0.2
HT4	0.7	3	11	390	10	30	91	< 2	100	100	31	1	0.1	1.4	0.4

NOTE: Sampling sites arranged from upstream to downstream; (T) designates tributaries with sampling sites arranged in similar manner

.21 South Macmillan River Drainage

The August 1978 data presented by Art Pearson and Associates (1981) for the M1 station area on the South Macmillan showed a pH of 6.8 above the entrance of Rust Creek. This is close to June 1981 measurements downstream (below the entrance of Rust Creek) at stations 13 and M2 of pH 6.7 and 6.8 (Table 3-2).

Although other data given by Art Pearson and Associates (1981) show that Rust Creek depresses the pH of the South Macmillan River immediately below its entrance, it is apparent from data collected farther downstream (13 and M2) that mixing, dilution and/or neutralization of the Rust Creek water occurs and the pH of the river returns to higher levels.

Art Pearson and Associates (1981) also present 1980 data from the South Macmillan River immediately above and below the entrance of Rust Creek which shows a definite increase in zinc and manganese, apparently caused by Rust Creek. Boron, however, seems to have been decreased by the entrance of Rust Creek.

Unfortunately in June 1981, no water samples were taken above the entrance of Rust Creek so that similar comparisons are not possible. However, water samples from the two stations below the entrance of Rust Creek taken in June 1981 (13 and M2) show large decreases in total and dissolved iron between these stations (Table 3-2). Smaller decreases were observed for turbidity, suspended solids, and zinc. These decreases might be expected as the distance from the source of the input increased.

The water quality data for August and September 1981, (Tables 3-3 and 3-4) had sampling sites above (M1) and below (M2) the entrance of Rust Creek. Even though the downstream sampling site is located over 1.6 km below the entrance of Rust Creek, the water analyses for August reveal increases at M2 in turbidity, suspended solids, total iron and zinc. With the exception of suspended solids, the same pattern is observed in the September analyses. Acidity and conductivity at M2 also show an increase over M1 in September.

Thus it appears that Rust Creek can influence specific water quality parameters of the South Macmillan River from its entrance to station M2, over 1.6 km downstream.

The next tributary entering the South Macmillan River is Tom Creek (Station T). The first site downstream of Tom Creek sampled in June was M4 (approximately one kilometer downstream). No influence of Tom Creek was seen in any of the parameters analyzed in the June samples. In both the August and September samples a new sampling site (M3) approximately 400 m downstream from the entrance of Tom Creek was used. Again, no pronounced differences in the concentrations of the parameters sampled between M2 and M3 could be detected in August. The possible exception was that of dissolved solids, which increased from 86 ppm at M2 to 122 ppm at M3 (Table 3-3).

In September, noticeable increases were observed at M3 in acidity, suspended solids, turbidity, copper, and nickel when compard to station M2 (Table 3-4). With the exception of suspended solids, the values of these parameters in Tom Creek were all much higher than they were in the South Macmillan River.

The 30 ppb increase in chromium at M3 over that found at M2 (<10 ppb) cannot be explained, particularly when Tom Creek contributes nothing in terms of this metal (< 10 ppb). This increase in chromium will be addressed later when discussing stations M3, M4, and M5.

The fact that the influence of Tom Creek on the South Macmillan River water chemistry appears to occur in September and not June could be attributed to reduced flow in the South Macmillan River in September compared with that in June. Over the period 1975-1979, the month of June had the highest mean monthly discharge, which may have diluted the discharge from Tom Creek to a level closer to that of the main river.

The next downstream South Macmillan River sampling site, (Station 10) was located less than 100 m downstream from the entrance of another tributary (designated MT4, see plate 2-1). With the exception of suspended solids, no differences between station M4 (located 550 m upstream from the entrance of MT4) and station 10 were observed. Suspended solid concentrations decreased by one half.

The June sampling program had three sites (stations 10, 9, and M5) along the South Macmillan River in an area not receiving any significant tributary streams. This 3.1 km section of river (from station 10 to M5) permits an examination of the normal variability of some parameters in the river (Table 3-2). Of the 21 parameters analyzed, large variations occur only in suspended solids, turbidity, and total iron. In addition, these all occur between stations 9 and M5. Suspended solid concentrations increased from 3 to 52 ppm, turbidity increased from 12 to 28 ppm and total iron increased from 860 to 4920 ppb (Table 3-2). The cause of these variations is unknown, although bridge and road construction in the area of station 9 could possibly have played a part in the observed effects at M5.

An additional sampling site (M3) on the South Macmillan River and on a downstream tributary (see Plate 2-1) designated MT3 was established in August (Table 3-3). There were no noticeable differences in any of the concentrations of the parameters between sampling stations M3 and M4 which could be attributed to the inflow of tributary MT3.

The section of the river from M4 to M5 (approximately 3.75 km) showed little variation in the water quality parameters measured (Table 3-3). The only large increase observed was in total iron (2,620 ppb at M4 to 4,150 ppb at M5). Tributary MT4 entered the South Macmillan River approximately 3 km above station M5, and was dry in August. The June sample of MT4 had 50 ppb total iron and 60 ppb dissolved iron.

The September sampling program revealed a rather unusual pattern of water quality parameter levels (see Table 3-4) between stations M3 and M5. The pH at station M4 was 4.56. This is the lowest pH recorded at any South Macmillan River sampling site for any sampling period. Associated with this low pH is a slightly higher conductivity, dissolved solids concentration, and levels of arsenic, iron, and chromium. These same parameters, at M5 are at levels equal to or lower than those observed at M3. Tributary MT3 enters the river between M3 and M4, but due to very low flow, water quality sampling was not conducted on this tributary in September. The August samples, however, (Table 3-3) showed this tributary to be basic (pH 8.1) and contain low levels of dissolved solids, arsenic, iron and chromium. In addition, previous sampling of M4 in June and August 1981 showed it to be neutral (pH 6.9 and 7.1 respectively) and to contain levels of dissolved solids, iron, arsenic, and chromium similar to these at all other river sampling sites.

One possible explanation for the observed irregularities at M4 in September is that a slug of water with distinctly different characteristics from those observed normally in the South Macmillan River was introduced at some point along the river and was travelling downstream at the time the samples were taken.

The section of the river from stations M5 to 7 receives Sekie Creek. Station 7, located approximately 100 m below the entrance of Sekie Creek seemed to indicate that dilution of the South Macmillan River constituted the only influence this creek had on the South Macmillan River. Farther downstream, between stations 7 and 6, there was little or no difference in the water quality parameters measured in June. (Table 3-2).

During the August water quality sampling, station M6 was established between stations 7 and 6, which were then abandoned. As in June, the values for all water quality parameters at the M6 area were equal to or lower than those at M5 (Table 3-3). Although the same general pattern observed in June, and August was apparent in the September samples, acidity at M6 was observed to be much higher than was found at M5. Sekie Creek, which was neutral in August was acidic in September. The pH measured at station S1 in September (3.68) would appear to be in error as there are no known discharges to this creek which could cause such a drastic reduction in pH. Station S2, 200 m downstream from S1 had a pH of 5.95 during the same sampling period. Even taking into account the acidity present in Sekie Creek it seems unlikely that the increase in acidity observed at station M6 was caused entirely by Sekie Creek. Another anomaly observed at station M6 was the ten fold increase of antimony over that observed at station M5 (Table 3-4). The levels of antimony observed in Sekie Creek were equal to those observed in the river upstream of Sekie Creek and therefore could have not been caused by this inflow. It is possible that the 10 fold increase is the result of either analytical error or data transcription.

The section of the South Macmillan River between stations 6 (or M6) and M7 receives Jason Creek. Generally, there was little difference between the parameters at station 6 and M7 in June. Suspended solids increased slightly while dissolved iron and zinc were reduced by over half. The same pattern was also present in August, except that suspended solids and dissolved iron remained unchanged between the stations. Zinc was only slightly reduced (Table 3-3).

During the September sampling regime station M7 was eliminated leaving approximately three kilometers between main river sampling locations (M6 to M8). Although this section of the South Macmillan River received both Jason Creek and a smaller tributary (MT 10) there was no substantial difference between the water quality parameters at M6 and M8 (see Table 3-4).

Only two main river sampling stations were established below M7 in June 1981. Of the 21 parameters measured during this month only suspended solids and total iron had noticeable variations. Both were reduced by over 50 percent between M7 and M8 only to increase again at M9 (Table 3-2). During the August sampling period, stations M8 and M9 were not sampled. However, there was little difference in the water quality parameters measured at stations M7 and M10. In September, samples were taken on the South Macmillan River at M8, M9, and M10 (see Plate 2-1). Of the 30 parameters measured only acidity changed (decreased) substantially between M9 and M10 (Table 3-4).

Of the nine tributaries on the South Macmillan River sampled for this study, two stand out in terms of their acidity and high levels of dissolved and suspended substances. Rust Creek, which was sampled in August and September, and Tom Creek, which was sampled in June, August and September, consistently had levels of iron, zinc, cadmium, and total dissolved solids which were substantially above concentrations of those parameters in the South Macmillan River. High levels of sulphate, copper, manganese, molybdenum, uranium, arsenic and nickel were also found at elevated concentrations in both tributaries at least once during the three sampling periods. It is important to note that while Rust Creek receives mine drainage, Tom Creek is a naturally acidic stream. By contrast the remaining seven tributaries had little in the way of elevated levels of metals or other of the parameters sampled.

The tributaries draining the area of Big Red Mountain (Rust Creek, Tom Creek, MT4, and Sekie Creek) are acid with the exception of the August measurements of alkaline pH in Sekie Creek (Table 3-3). The tributaries draining the area to the west of the South Macmillan River (MT3, Jason Creek, MT10 and MT11) are alkaline.

Both Jason Creek and MT10 have a noticeably higher alkalinity than the South Macmillan River. Other parameters in the tributaries which were observed to be occasionally high in relation to the river were suspended solids, turbidity, and iron. However, these parameters did not appear to be consistently high. The general pattern observed for the tributaries below Rust and Tom Creeks was of dissolved and suspended substances at or below concentrations observed in the river.

Station RL, the pond at the head of Jason Creek, was the only static water body sampled. It was sampled once in August (Table 3-3) and found to be acidic (pH 5.4) with the highest level of suspended solids and the second highest concentration of total iron (Rust Creek was higher) of any station sampled during August. The remaining water quality parameters were not sufficiently different from those observed at the other sampling locations in the South Macmillan basin to warrant discussion. It is interesting that the first sampling site on Jason Creek (J1, Table 3-3) had a pH (7.8), alkalinity, suspended solids, turbidity and total iron concentrations which were drastically different from the same parameters in the pond. The reasons for this are unclear.

.3 Hess River Drainage

The June 1981 sampling program began in the uppermost regions of the Hess River tributaries draining the northwest slope of Nipple Mountain and the area between it and Jason Ridge. As can be seen on Plate 2-1, station 28 (Little Creek) is located below the confluence of tributary streams sampled at locations 26 and 27. As would be expected, the water quality from all three locations showed negligible differences. Station 25 is located at the head of another tributary which eventually combines with Little Creek. Again, there are no substantial differences in the water quality parameters measured at station 25 when compared with stations 26, 27 and 28.

Stations 26 and 27 were sampled again in August 1981 and found to have higher levels of hardness and total iron when compared to June. The levels of lead were lower in August by at least a factor of four. Otherwise, the parameters measured in June and August were not greatly different. In August, station 25 was moved further downstream and designated BD. Comparisons of the water quality parameters sampled in June at station 25 and at BD in August showed only higher hardness and lower turbidity and copper in August, (Tables 3-5, 3-6, 3-7). Comparison of water quality parameters collected at the same location (BD) in September showed decreases in the concentrations at total iron, molybdenum and antimony.

Station L1 (see Plate 2-1) was established in August and sampled again September. In neither case did the water quality upstream of the sampling site produce any effects at this station. Comparison of the analyses from August and September for this station showed only an increase in suspended solids in September accompanied by a decrease in molybdenum, barium, and antimony.

Station L2, sampled only in June, was immediately upstream of the entrance of Alpine Creek (Station A). Station 31, also sampled only in June was immediately below the entrance of Alpine Creek. Of the 21 water quality parameters examined, only three were slightly higher at station 31 than at station L2 (Table 3-5). Thus, Alpine Creek exerted only a negligible influence on Little Creek. Like stations L2 and 31, Alpine Creek (Station A) was sampled only in June.

The Orange Creek sampling site (Station O) was established in June along with a sampling station (33) immediately downstream of its entrance into what is now referred to as the Hess Tributary (see Plate 2-1). Orange Creek in June was acid (pH 4.0) and contained levels of total iron, copper, and zinc which were substantially higher than anything reported at the more upstream locations. However, Orange Creek failed to influence any water quality parameter in the Hess Tributary in June (Table 3-5).

Orange Creek was sampled again in August and September and remained very acid (pH 3.6 and 2.8, respectively). The elevated levels of total iron, copper and zinc also remained a characteristic of this stream during August and September (Tables 3-6 and 3-7).

Stations HT1 and HT2 were established immediately above and approximately 500 m below the entrance of Orange Creek in August. Only the pH and zinc concentrations between HT1 and HT2 appear to be effected by Orange Creek (Table 3-6) and these changes do not appear to be substantial.

The last section of the Hess Tributary sampled in June was delineated by Stations 33 and 35 (see Table 3-5). Between these two points the main water course received two tributaries (Dry Creek or Station D and Station 38). Dry Creek was not sampled in August or September because it was dry. The only effect of these tributaries on the water quality parameters at Station 35 would seem to be a slight increase in dissolved solids, possibly from the high concentration of this parameters in the water at Station 38 (Table 3-5).

Nidd Creek was sampled in June at two locations (Stations 36 and 37). The values for all water quality parameters observed at both stations on Nidd Creek, except uranium, were within the range of values observed from the other Hess River tributaries. Uranium concentrations were only slightly elevated above the values for the other tributaries.

The section of the Hess Tributary from just above the entrance of Dry Creek (HT2) to just above the entrance of Nidd Creek (HT3) was sampled in August along with a tributary station (Q) (See

Plate 2-1 and Table 3-6). Dry Creek was not sampled during this month or in September. The only difference observed between the values for the water quality parameters at HT2 and HT3 was a large reduction in total iron and slight reduction in zinc at HT3. It is not known whether these changes could have been caused by tributary Q alone.

In September, HT2 was eliminated as a sampling site. Samples were taken, however, at HT1, O, Q, and HT3 (see Plate 2-1 and Table 3-7). Increases in the concentrations of the metals copper, iron, zinc, and nickel were observed at HT3 in relation to HT1. These are the same metals exhibiting high concentrations in Orange Creek. Thus Orange Creek may influence the water quality in the Hess River Tributary as far downstream as HT3 during the fall.

Nidd Creek was sampled at two locations in each of the three sampling periods. Comparisons of the water quality parameter values from June to August (Tables 3-5 and 3-6) showed that Nidd Creek was slightly more alkaline in August. There were also slight increases in hardness, dissolved solids, suspended solids, turbidity and fluorine, and slightly lower levels of zinc and chromium in August. A large increase in total iron was observed in August over that in June.

From August to September in Nidd Creek, both hardness and copper increased slightly. Small reductions were noted in suspended solids, total iron, lead and zinc. A large reduction in antimony was also noted during this time period. No data was available for this parameter in June.

The most downstream section of the Hess River tributary sampled in August was delineated by Stations HT3 and HT4 (see Plate 2-1). The only major tributary entering this section was Nidd Creek. Although most of the water quality parameters analyzed at HT3 and HT4 were not sufficiently different to warrant discussion, large increases were observed in total iron (24 X), copper (10 X) and lead (10 X) at HT4. While the increased iron could have possibly resulted from the input of Nidd Creek (Table 3-6), the concentrations of copper and lead in Nidd Creek were below that observed at HT3 and thus could not have contributed to the large increase observed at HT4.

The same sampling regime (HT3, Nidd Creek, and HT4) was used again in September and this time no substantial differences were found between the values of water quality parameters at HT3 and HT4. Thus Nidd Creek does not exert a consistent influence on the Hess River tributary.

.3 Comparison with Other Data

Water chemistry parameters for the years 1976, 1977 and 1978 (Beak consultants Ltd. 1980) were reviewed and compared with data in Tables 3-2 to 3-7. Although great variability existed in some parameters (e.g. suspended solids, hardness), no consistent patterns were discerned. Tom Creek (Station T) was consistently acidic with large concentrations of iron.

Table 3-8 compares the mean vaues of selected water chemistry parameters for the South Macmillan and the Hess River tributary for June 1981 with other rivers and streams in the Yukon and western British Columbia. Generally, the values for the South Macmillan and the Hess River Tributary were within the range of values found at the other locations. Only with respect to lead did the Hess River tributary appear to be higher when compared to the other sites. The South Macmillan water chemistry appears to be within the wide limits set by other rivers and streams of the area.

Naturally occurring mineral seeps will influence small drainages and produce water quality parameters similar to those encountered in effluents from active and abandoned mines. Table 3-9 compares Tom Creek (a naturally occurring drainage without man-made impacts) with the water chemistry parameters of some active and abandoned metal mines in Canada. Tom Creek exhibits values within the ranges of the effluents for five of the eleven parameters given (pH, suspended solids, acidity, iron and zinc) and approaches effluent values for an additional three parameters (sulphate, nickel and copper).

.4 Relation to Other Parameters

The relationship between the observed variations in water chemistry, the periphyton and the macroinvertebrate communities will be discussed in their appropriate sections.

TABLE 3-8

Comparison of Selected Water Chemistry Parameters from the South Macmillan and Hess River Tributary (Mean Values) with Other Rivers and Streams in the Yukon and Western British Columbia

Study Area	Date	Site	* pH	Alkal-inity	Hardness	Diss. Solids	Susp. Solids	SO_4	Cond.	Total Fe	Diss. Fe	Cu	Pb	Zn	Cd
				ppm	ppm	ppm	ppm	ppm		ppb	ppb	ppb	ppb	ppb	ppb
South Macmillan River	(June 1981)		7.0	22	45	128	23	45	99	2087	88	7.2	7.2	220	2
Hess River	(June 1981)		6.7	57	43	82	4	13	83	126	114	13	108	65	1
South McQuesten River	(July 1975)	(3)	8.1	78	110				170	340		<10	30	70	<10
	" "	(4)	8.0	73	100				133	180		<10	20	10	<10
	" "	(10)	8.1	86	120				202	210		<10	<10	90	<10
Tsichu River	(July 1975)	(3)	6.9	13	19	23	2	5	30		60	<15	<10	<5	<10
		(5)	7.7	19	43	44	1	16	55		80	<15	<10	15	<10
Pelly River	(Sept 1977)	(10N)	7.8	89	118		7.4	31	224		139	<10	<10	2	<2
	" "	(10S)	7.9	88	114		6.6	28	218		96	<10	<10	2	3
	" "	(11)	7.7	115	150		2.6	39	278		59	<10	<10	26	5
Vangorda Creek	(Sept 1977)	(1)	7.3	22	26		0.2	6.2	58		5	<10	<10	7	2
	" "	(2)	7.7	183	211		0.4	68	425		25	<10	<10	76	11
	" "	(5)	8.1	188	240		2.8	55	415		39	<10	<10	8	<2
	" "	(6)	7.7	66	71		0.8	8.7	137		83	<10	<10	5	9
	" "	(7)	8.0	99	122		0.4	30	235		15	<10	<10	12	3
	" "	(8)	8.4	137	168		2.2	40	312		18	<10	<10	12	2
Rackla River	(June 1979)	(3)	8.2	99	118	112	4.8	22	259	200		<5	<50	<5	<5
	" "	(7)	8.5	185	266	298	4.6	64	380	3100		<5	<50	<5	<5
	" "	(1)	8.2	99	120	140	0.6	16	269	100		<5	<50	<5	<5
	" "	(6)	8.2	109	131	136	8.6	19	300	300		<5	<50	<5	<5
	" "	(5)	8.1	96	112	126	28.8	15	258	500		<5	<50	<5	<5
Don Creek	(July 1980)	(6)	8.2	61	116			50	236	82		14	1	148	1.4
	" "	(7)	7.8	71	109			31	21	222		4.1	1	76	1
Victoria Creek	(Aug 1977)	(4)	7.7	64	78				90	250		<10	<20	10	<10
	" "	(5)	7.7	64	78				94	230		<10	<20	10	<10
Rose Creek	(Sept 1976)	(1)	6.9	86	92			9.5	186	240		10	5	50	2
	" "	(3)	7.9	1	139			85	400	260			10	14	0.2
	" "	(4)	7.1	149	203				763	340		2	3	50	0.2
	(Aug 1976)	(5)	7.8	92						220		10	70	90	10
Anvil Cr	(July 1976)	(6)	7.9	70	7.8				115	1600		<10	70	40	<10
	" "	(8)	7.7	63	67				110	1200		<10	20	20	<10
Pelly River	(Aug 1976)	(9)	8.1	94						2000		<10	<20	10	<10
	" "	(10)	8.1	98						190		<10	<20	10	<10
Big Creek	(Sep 1976)	(2)	7.8	74	78				100	30		<10	<20	10	<10
Wolverine Creek	(Sep 1976)	(5)	7.7	99	79				95	70		<10	<20	10	<10

South McQuesten River data from EPS 1978
Tsichu River data from Sergy et al. 1976
Pelly River (1977) data from Montreal Engineering Company, Limited 1978
Vangorda Creek data from Montreal Engineering Company, Limited 1978
Rackla River data from Monenco Consultants Pacific Ltd. 1980
Don Creek data from Archibald and Burns 1981
Victoria Creek data from EPS 1979
Rose Creek, Anvil Creek and Pelly River (1976) data from Baker 1979
Big Creek and Wolverine Creek data from Kelso et al 1977

* geometric mean for South Macmillan River pH (mean of 11), and Hess River Tributary pH (mean of 8).

TABLE 3-9

Chemical Composition of the Final Discharge of Some Mines
Compared to Natural Drainage at Tom Creek
Data from Clarke (1974) and Falk et al. (1973)

Mine	1	2	3	4	4	5	6	7	8	
Operation	Cu,-Zn	H_2SO_4 from FeS_2	U	U		Cu,Pb,Zn	Cu,Pb,Zn Au,Ag,	Au	Au	
Status	Active	Abandoned	Abandoned	Active	Abandoned	Active	Active	Active	Active	Tom Creek
Lime to Mill Eff.	Yes	--	--	Yes	--	Yes	Yes			
pH	3.0	2.6	2.0-2.8	6.1	2.6	6.4	5.3	7.4	8.4	3
Suspended solids (ppm)			25	5	35	18	22.7			60
Dissolved solids (ppm)		9200	13435	3095	3805	1078	1394.9			360
Hardness (ppm)		1392						3065	301	46
Acidity - $CaCO_3$ (ppm)		3800	7700	30	1940	29				54
Sulphate (ppm)	855	4050	6900	1560	2150	670	1003.5	279	290	215
Iron (total) (ppm)	11.7	1310	220-340	0.4	550	29	22.7	1.4	0	17.9
Nickel (ppm)		6.3	1.5			0				0.78
Uranium (ppm)			5.6							0.005
Zinc (ppm)	0.43	34	9.4			2.15	6.5	0.13	0.069	1.2
Copper (ppm)	0	2.45	2.2			0.22	1.1	0.2	8.3	0.1

Mines 1 to 6 are located in Ontario

Mines 7 and 8 are located in the Northwest Territories

.5 Summary

In the South Macmillan River drainage, Rust Creek and Tom Creek are consistently acidic and contain high levels of dissolved and suspended substances. These creeks have a variable influence on the South Macmillan River although the factors governing the variability are not clear. The tributaries MT4 and Sekie Creek also appear to be slightly acidic but any influence on the river was not observed. The remaining tributaries are alkaline and do not appear to input large amounts of dissolved substances to the South Macmillan River. Large variations in the levels of various water chemistry parameters occur in the river and many of these cannot be attributed to continuous tributary input. Masses or 'slugs' of water having chemical characteristics different from the ambient water chemistry and possibly originating as a man-made discharge may be one explanation of the observed variations. Localized disturbance of bank material during construction of roads and bridges is also another factor which may cause variations in the observed water chemistry.

The Hess River tributaries (with the exception of Orange Creek) sampled during this survey were somewhat less variable in the concentrations of dissolved substances as these tributaries drain a relatively small, more homogenous area in comparison to the South Macmillan drainage system.

Orange Creek is consistently acid with high levels of suspended and dissolved substances (e.g., total iron, sulphate, fluoride, zinc, manganese, and copper). Its influence on the Hess tributary is variable, but the causes of the variations or the amount of impact it has on the Hess tributary are unknown. Likewise, Nidd Creek appears to influence the Hess tributary, but the effect is not consistent.

322 SEDIMENT CHEMISTRY

.1 Introduction

The trace element composition of stream sediment can be a useful indicator of the levels of metals present in the aquatic environment. Stream sediments can also be used as a component of a monitoring program for the effects of waste discharge.

.2 Results

Of the 15 metals examined in the sediment (Table 3-10) 6 had increases of 15 percent or greater between station SM-1 and SM-2 and two had large decreases. The biggest increase observed was in lead with a 100 percent increase between SM-1 and SM-2. Copper increased 62 percent, vanadium increased 29 percent, arsenic increased 27 percent, Zn increased 16 percent, and iron increased 15 percent between stations SM-1 and SM-2. Unlike the other elements, zinc increased by 30 percent between SM-2 and SM-3. Associated with the increases of six metals between SM-1 and SM-2 was a decrease of barium (50%) and manganese (39%). The levels of these metals increased again at SM-3.

The changes in sediment chemistry observed between stations SM-1 and SM-2 must be attributable to the inflow of the tributaries. Both Tom Creek and Rust Creek had large amounts of iron, zinc, copper in water of a low pH. The mixing of Tom and Rust Creeks and the relatively neutral (pH 6.8) South Macmillan River should have caused the metals in the Tom Creek water to be lost from solution (or suspension). The deposition of the metals from Tom and Rust Creeks and other tributaries below SM-1 is the most reasonable cause of the increased metal levels in the sediment.

TABLE 3-10

Metal Concentrations of the Sediment from the South Macmillan and Hess River Tributary, October 1981

Station	Element (ppb)														
	Fe	Cd	Sr	V	Sb	Cu	Ba	Zn	Pb	Co	Mn	As	Se	Hg	Ag
SM-1	42,659	7	41	732	25	69	2897	497	40	90	346	41	≤3	0.04	≤3
SM-2	49,264	6	38	941	29	112	1452	576	80	100	210	52	3	0.04	≤3
SM-3	39,799	11	51	954	26	103	2807	746	40	102	512	43	≤3	0.01	≤3
SM-4	43,979	6	47	1031	23	79	2910	501	51	98	301	51	≤3	0.01	≤3
HR-1	40,376	12	27	1038	47	94	1929	863	33	134	850	36	≤3	0.01	≤3

* Average of three replicate analyses

.5 Summary

Chemical analyses of the substrate material on the bottom of the South Macmillan River showed increases in the metal content between SM-1 and SM-2. Station SM-2 is below the entrance of Rust and Tom Creeks which are known to contain high levels of metals. Normal chemical reactions between the tributary and the river water may result in the deposition of the metals on the bottom of the South Macmillan River.

3.3 BIOLOGICAL FEATURES OF SAMPLING SITES

331 PERIPHYTON

.1 Introduction

Attached algae or periphyton has been used in the past for both baseline aquatic studies and environmental monitoring programs as indices of spatial or temporal change in biological communities. The attached algae, or algal community, at a particular location responds to the interaction of all the many environmental variables (e.g., light, temperature, sediment, and water chemistry) to which it is exposed. Information about the environment in which the attached algal community exists is indicated by the relative abundance or density of the attached algae, the number of different kinds of organisms in the algal community (diversity) and by the known physiological responses of algae in general to variations in their environment.

.2 Results

The species of attached algae collected in three replicate samples from four stations on the South Macmillan River and one station on the Hess River tributary are presented in Tables 3-11 and 3-12. In addition, a single sample of attached algae was collected from Tom Creek by the Canol Road.

It is clear from Table 3-11 that the blue-green algae (Cyanophyta) form the numerically dominant group at all South Macmillan River stations and at the Tom Creek station. In the Hess River tributary samples, the total number of individuals of the Cyanophyta was approximately equal to the number of golden-brown algae (Chrysophyta). The diatoms (Bacillariophyta), which usually constitute the major algal

TABLE 3-11

Species Composition, Total Density (as cells/cm^2), Total Biomass (as mg/m^2) and Number of Species per Sample of the Periphyton Samples from Selected Stations in the Macmillan Pass Area, August, 1981.

Division / Species — Station / Replicate	SM-1			SM-2			SM-3			SM-4			HR-1			TC1
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
Chlorophyta																
Chlamydomonas spp.	-	-	-	-	3,000	-	-	-	-	-	-	-	-	-	-	-
Ulothrix subtillissima	23,800															
Cyanophyta																
Lyngbya aerugineo-coerulea	-	-	62,600	-	-	-	41,700	244,300	-	-	-	-	-	-	86,400	-
Oscillatoria aghardhi	-	-	-	-	-	-	49,200	146,000	-	-	-		509,400	201,000	378,300	-
Phormidium tenue	23,800	-	482,600	-	47,600	35,700	634,700	2,716,900	7,387,900	-	53,600	190,700	74,500	38,700	107,200	-
Gleocapsa aeruginosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,131,900
Chrysophyta																
Hydrurus foetidus	-	-	-	-	-	11,900	3,000	-	11,900	-	-	-	1,275,000	13,400	134,100	-
Kephyrion littorale	-	-	-	-	-	-	-	-	-	-	-	-	-	1,500	-	-
Ochromonas spp.	-	-	3,000	-	-	-	-	-	-	-	-	-	-	-	-	3,000
Pseudokephyrion striatum	-	-	-	-	-	-	-	3,000	-	-	-	-	-	-	-	-
Bacillariophyta																
Achnanthes minutissima	-	-	-	-	-	-	-	-	-	-	-	3,000	-	-	-	-
Cymbella minuta	-	-	-	700	-	-	-	-	-	-	-	-	-	-	-	-
Diatoma hiemale var. mesodon	-	-	-	-	-	-	-	14,900	-	-	-	3,000	-	-	-	-
Eunotia elegans	-	3,000	3,000	-	-	-	-	-	-	-	-	-	-	-	-	-
Hannaea arcus	-	-	-	-	-	-	700	-	-	-	-	-	3,000	-	6,000	-
Gomphonema truncatum	-	-	-	-	-	-	-	-	-	-	-	-	3,000	-	-	-
Nitzschia capitellatum	-	-	-	-	-	-	-	-	3,000	-	-	-	-	-	-	-
Synedra radians	-	-	-	-	-	-	-	-	-	-	3,000	-	-	-	-	-
Total cells/cm^2	47,600	3,000	551,200	700	50,600	47,600	729,300	3,125,100	7,402,800	-	56,600	196,700	1,864,900	254,600	712,000	1,134,900
Total biomass mg/m^2	0.003	0.009	0.009	0.0002	0.001	0.003	0.003	0.054	0.077	-	0.002	0.003	0.261	0.003	0.029	0.034
No. of species	2	1	4	1	2	2	2	5	3	-	2	3	5	4	5	2
Average cells/cm^2 for 3 replicates	200,600 cells/cm^2			33,000 cell/cm^2			3,752,400 cells/cm^2			126,700 cells/cm^2			943,800 cells/cm^2			

SM = South MacMillan River, HR = Hess River Tributary, TC = Tom Creek

TABLE 3-12

Percent Composition of the Major Groups Based Upon Total Density and Total Biomass
of the Periphyton Samples from Selected Stations in the Macmillan Pass Area, August 1981

Division	Station	SM-1			SM-2			SM-3			SM-4			HR-1			TC1
Species	Replicates	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1
								(Total Density)									
Chlorophyta		50.0	-	-	-	5.9	-	-	-	-	-	-	-	-	-	-	-
Cyanophyta		50.0	-	98.9	-	94.1	75.0	-	99.4	99.8	-	94.7	97.0	31.1	94.2	80.3	99.7
Chrysophyta		-	-	0.5	-	-	25.0	-	0.1	0.2	-	-	-	68.4	5.9	18.8	0.3
Bacillariophyta		-	100.0	0.5	100.0	-	-	-	0.5	0.1	-	5.3	3.0	0.3	-	0.8	-
								(Total Biomass)									
Chlorophyta		90.9	-	-	-	33.3	-	-	-	-	-	-	-	-	-	-	-
Cyanophyta		9.0	-	89.9	-	66.7	14.3	72.8	89.4	96.0	-	28.6	54.7	11.0	13.6	91.2	99.9
Chrysophyta		-	-	1.1	-	-	85.7	10.2	0.2	2.8	-	-	-	88.1	86.4	0.1	0.1
Bacillariophyta		-	100.0	9.1	100.0	-	-	17.0	10.4	1.2	-	71.4	45.3	0.9	-	8.8	-

SM = South MacMillan River Tributary, HR = Hess River Tributary, TC = Tom Creek division in terms of density in small streams, play a minor role in the river and streams of the project site. While low in density, the diatoms are the most diverse (seven species) of the four algal divisions present in the river.

The Hess River tributary was the only location sampled where approximately equal densities of Cyanophyta and Chrysophyta were present. Of the two species of Chrysophyta at this site, Hydrurus foetidus was by far the most dominant. This attached, filamentous alga is characteristic of fast flowing, well aerated, cold water streams (Ruttner 1963). The remaining members of the Chrysophyta found in the project area are free-swimming flagellated forms which reside among the filaments of attached algae or in the bottom boundary layer where little or no current exists.

The large amount of Gleocapsa aeruginosa (1,131,900 cells/ cm^2) found in Tom Creek is unusual given the extremely acidic environment. However, the cells of this alga exist within a heavy, gelatinous matrix so that the environment experienced by the algal cell itself is not that of the surrounding water. The extreme environmental conditions of acidity and metal concentrations prevent the development of a diverse periphyton community.

.3 Comparison With Other Data

The low density of diatoms in the current study is in marked contrast to the large number of diatoms found in the Rackla River, a tributary of the Stewart River in the central Yukon (Monenco Consultants Pacific Limited 1980) at sampling site number 7 (see Table 3-8, Section 321, for selected water quality parameters of this site). While the South Macmillan and Rackla Rivers generally had high iron concentrations, the former contained a higher level (as an average) of zinc than did the Rackla. It is probable that other factors also enter into the dissimilarities found between the two rivers. No species were found which were common to the two studies. This is not unusual given the differences in river basins and other environmental factors.

.4 Relation to Other Parameters

The dominance of the blue-green algae in the South Macmillan River is very possibly due to the relatively high levels of iron in the water. Morton and Lee (1974) have demonstrated that a shift in the dominant type of algae present (i.e., from green algae (Chlorophyta) to the blue-green algae) could be accomplished by increased iron concentrations in the range of 0.1-1.0 mg/L. Phosphorus, usually thought to be the major influence on population changes of this type, had no effect on the relative abundance of the different types of algae present. The iron concentrations present in the South Macmillan River are within the range reported to cause a shift in community dominance. In addition, Murphy et al. (1976) demonstrated that the suppression of other algae by blue-green algae appeared to be mediated by the production and excretion of an iron-selective chelator. In this latter work, the importance of iron was not its actual concentration, but its availability to algal species. The production and excretion of an iron-selective chelator by the blue-green algae made iron more available to these organisms and permitted them more favourable growing conditions than the other algae present.

Table 3-11 shows a large drop in the average total density of cells between stations SM-1 and SM-2 and this mirrors the drop in macroinvertebrate benthos found between the same stations. However, at the next station downstream (SM-3), the average total density had increased to almost four million cells/cm^2 (an increase of over 110 times the value at SM-2). This increased density is due almost entirely to the growth of the filamentous blue-green algae. This pattern of abrupt reduction (SM-2) followed by increased growth (SM-3) is what would be expected if the South Macmillan River were receiving some sort of toxic or inhibitory impact, which, with further dilution and distance downstream, would be eliminated so that conditions might even stimulate growth. The reduction in cell density at SM-4 to a level approaching that seen at SM-1 is also part of the expected pattern in that the conditions causing stimulatory growth have been diluted to a level similar to that at SM-1.

.5 Summary

Because of the large numbers of micro-habitats present in any stream which are available for algal colonization, more intensive sampling would have probably yielded more species. Given the low diversity of the samples, however, substantial increases in the numbers of species would not be expected. Even if more species were found, the pattern observed in the South Macmillan River with the present samples would not be altered. As with other types of biological communities, it is the patterns of growth and the changes in species diversity density of the individuals within the community which reflect changes in the aquatic environment and these are the patterns which can be observed among the sampling stations along the South Macmillan River.

332 BENTHIC INVERTEBRATES

.1 Introduction

Benthic macroinvertebrates have a long history of use as biological indicators of environmental conditions. Their larger size (compared to algae) has lead to a greater understanding of their taxonomy and ecology as well as their individual and community responses to environmental changes. Like periphyton, their existence on the stream bottom allows them to interact with the flowing water and the many variables in its physical and chemical properties. The benthic macroinvertebrates are also subject to variations in food supply and other variables associated with the bottom of the stream (i.e., variations in stream bed composition, slope of the stream bed, etc.). The information derived from samples of the benthic invertebrates, their relative abundance, their diversity and their known resistance or susceptibility to environmental change can be used to assess the environmental character of the stream in which they occur.

.2 Results

The results of benthic macroinvertebrate sampling with the Surber and artificial substrate samplers are summarized in Tables 3-13 and 3-14. The raw data is presented in Appendix C. While densities are generally low at all sites, there is a dramatic reduction in density observed below the entrance of Rust Creek. This reduction is also observed at the more downstream sampling stations and is present in both the Surber and artificial substrate sampler data.

Surber Samples Within the Surber samples, the greatest reduction in both density and diversity occurs in the order Plecoptera (stoneflies) which decreased from 154 at station SM-1 to 15 per square metre at SM-2. Similarly, there is a dramatic reduction in the density of midge larvae (Chironomidae) from 96 to 7 per square metre between sample stations SM-1 and SM-2. The extremely low densities continue down the South Macmillan River until at the most downstream sampling station (SM-4) only one midge larva and one caddisfly larva (Trichoptera) were found in three Surber samples (totalling eight organisms per square metre). By contrast, the Surber samples from the Hess River tributary reveal a low density, yet reasonably diverse assemblage of benthic invertebrates. Like the uppermost station on the South Macmillan, the population in the Hess River is dominated by stoneflies ($168/m^2$) and midge larvae ($139/m^2$). The trophic relationships of the organisms collected by Surber sampler are given in Table 3-15.

TABLE 3-13

Organisms in Surber Samples
Collected from Four Stations on the South MacMillan River (SM)
and One Station on the Hess River Tributary (HR)

Taxa	Stations	SM-1	SM-2	SM-3	SM-4	HR-1
Annelida						
Oligochaeta		7				4
Arthropoda						
Insecta						
Plecoptera		43	7			36
Perlodidae		11				18
Megarcys		4				11
Chloroperlidae		46		11		46
Nemouridae				4		21
Zapada		36	4			36
Taeniopterigidae		14				
Doddsia			4			
Trichoptera						
Rhyacophilidae						
Rhyacophila		4				4
Limnephilidae						
Ecclisomyia					4	4
Diptera						
Chironomidae		96	7		4	139
Tipulidae		14				4
Empididae						11
Total Density		275	22	15	8	334

Units = No/m^2, 3 samples per site

TABLE 3-14

Organisms Collected in Artificial Substrate Samplers at Four Stations on the South Macmillan River and One Station on the Hess River Tributary

Taxa	Stations	SM-1	SM-2	SM-3	SM-4	HR-1
Annelida						
Oligochaeta			2			2
Arthropoda						
Insecta						
Plecoptera						62
Perlodidae						185
Megarcys						
Chloroperlidae		93				62
Nemouridae						
Zapada		93				
Trichoptera						
Limnephilidae						
Ecclisomyia						62
Diptera		278	93		62	
Chironomidae		556	278		123	1,789
Tipulidae		93	93			185
Empididae						62
Lepidoptera			93			
Collembola						
Isotomidae			93			
Total Density		1,113	650	0	185	2,409

Units = No/m^2

Artificial Substrate Samples In contrast to the Surber samples, the artificial substrate samples (which include organisms inhabiting areas below the streambed surface) show a more dense but less diverse macroinvertebrate population. The order Diptera, especially the midge larvae, dominate at all sampling sites. Because these samples must be left in the streambed for a period of time, they are subject to exposure due to reductions in stream flow. Due to the exposure and/or loss of some artificial substrate samplers, the data from stations SM-1, SM-2 and SM-3 are based on only two samplers per site. All artificial substrate samplers at station SM-4 were relocated in August because of reduced river level. While the relocation of these samplers did not permit time periods of sampling equal to those not relocated, they were nevertheless colonized. The samplers at station SM-3 were not disturbed and yet produced no benthic organisms in October when all samplers were retrieved. The trophic relationships of the organisms collected by artificial substrate sampler are given in Table 3-16.

.3 Comparison With Other Data

In August 1978, the Environmental Protection Service (EPS) collected benthic macroinvertebrate samples from the South Macmillan River in the area of the current project (Art Pearson and Associates 1981). The most upstream site sampled by EPS (EPS3) corresponded with collection station SM-1 of the current study. Although it is not stated which type of sampling equipment was used, this study did find one mayfly (Ephemeroptera) and five stoneflies. With the exception of the midge family, there was only limited taxonomic resemblance to the collections made by Monenco. Similarities between the two data sets occur only in the low densities of individual organisms observed above Rust Creek and in the overall reduction of benthic fauna below the entrance of Rust Creek (SM-2 and EPS sampling sites 5, 6 and 9).

TABLE 3-15

Trophic Relationships of Organisms
Collected by Surber Samplers*

Taxon	Trophic Relationship
Annelida	
Oligochaeta	burrower
Arthropoda	
Insecta	
Plecoptera	
Perlodidae	
Megarcys	predator
Chloroperlidae	generally predators
Nemouridae	
Zapada	shredder
Taeniopterigidae	
Doddsia	scraper
Trichoptera	
Rhyacophilidae	
Rhyacophila	predator
Limnephilidae	
Ecclisomyia	collector-gatherer
Diptera	
Chironomidae	collector-gatherers or predators
Tipulidae	generally shredders
Empididae	generally predators

* from Merrit and Cummins 1978

TABLE 3-16

Trophic Relationships of Organisms
Collected in Artificial Substrate Samplers*

Taxon	Trophic Relationship
Annelida	
Oligochaeta	burrower
Arthropoda	
Insecta	
Plecoptera	
Perlodidae	generally predators, some scrapers
Chloroperlidae	generally predators, some scrapers
Nemouridae	
Zapada	shredder
Trichoptera	
Limnephilidae	
Ecclisomyia	collector-gatherer, some scrapers
Diptera	
Chironomidae	collector-gatherers or predators
Tipulidae	generally shredders
Empididae	generally predators
Lepidoptera	generally shredders
Collembola	
Isotomidae	collectors-gatherers (scavengers)

* from Merrit and Cummins 1978

The EPS study also sampled sites above and below the entrance of Sekie Creek (EPS11 and 12). Although the macroinvertebrate fauna at these latter two stations were similar, they differed from the sites further upstream. The absence of stoneflies and the expanded variety of midge larvae at EPS11 and 12 suggest differences in substrate. There were no EPS sampling sites equivalent to Monenco's stations SM-3 and SM-4.

.4 Relation to Other Parameters

Although there is no clear and consistent relationship between water chemistry and benthic macroinvertebrate data, the large reduction in benthic macroinvertebrate density between sampling stations SM-1 and SM-2 is accompanied by an increase in the concentration of several metals in the sediment (see Section 322). This reduction in macroinvertebrate density is also associated with a reduction in the density of attached algae or periphyton. Thus, the possibility exists that a reduction in the amount of food available (as periphyton) is linked to the observed reduction in benthic macroinvertebrates. Alternatively, the increase in metal content of the sediments may produce conditions resulting in decreased density. More detailed benthic studies would be needed to distinguish between these possibilities.

.5 Summary

A large decrease in macroinvertebrate abundance was observed in the South Macmillan River downstream from SM-1 in both Surber and artificial substrate samples. In the former, the most dramatic change occurred between SM-1 and SM-2, while in the latter the most dramatic change was between SM-2 and SM-3. This was primarily due to the different areas of the streambed sampled (i.e. surface as opposed to subsurface). In comparison to one another, the surface (Surber) samples showed greater variety of species but lower abundance, while the subsurface (artificial substrate) samples were the opposite. This pattern was also present in the Hess River tributary which overall exhibited a greater abundance and number of species than did the South Macmillan River.

333 FISH POPULATIONS

.1 Introduction

Fish, by virtue of their position at or near the top of the aquatic food web and their recreational resource value, are the most frequently studied and discussed component of the aquatic system. In order to assess the fish populations in the Macmillan Pass area, field investigations were conducted during three site visits over the June to October period in 1981 (11-15 June, 17-20 August, 06-09 October).

Table 3-17 lists the fish species found in the Yukon River system. Many of these species (e.g., inconnu, *Stenodus leucicthys*, least cisco, *Coregonus sardinella*, Bering cisco, *C. laurettae*, sockeye salmon, *Oncorhynchus nerka*, coho salmon, *O. kisutch*, pink salmon, *O. gorbuscha*) are only found in the lower reaches of the river system and may be found only rarely in the Yukon Territory. Other species (e.g., round whitefish, *Prosopium cylindraceum*, pygmy whitefish, *P. coulteri*, lake trout, *Salvelinus namaycush*, Dolly Varden, *S. malma*, chinook salmon, *Oncorhynchus tshawytscha*, and chum salmon, *O. keta*) are found as far upstream as the headwaters at least part of the year. Arctic grayling, round whitefish, slimy sculpin, lake trout, and longnose sucker are known to be present in the South Macmillan River system. Chinook salmon fry and juvenile salmon have been captured in the South Macmillan River approximately 40 km below the Jason property, as have spawning adult longnose suckers (Elson 1974, Walker 1976, Barker 1979). The actual distributions of the species listed depends on a number of interacting factors such as food availability, season, habitat availability, and variations in flow.

TABLE 3-17

Fish Species of the Yukon River System*

Scientific Name	Common Name
Lampetra japonica	Arctic Lamprey
Stenodus leucicthys	Inconnu
Coregonus nasus	Broad Whitefish
C. clupeaformis	Humpback Whitefish
C. sardinella	Least Cisco
C. laurettae	Bering Cisco
Prosopium cylindraceum	Round Whitefish
P. coulteri	Pygmy Whitefish
Thymallus arcticus	Arctic Grayling
Salvelinus namaycush	Lake Trout
S. malma	Dolly Varden
S. alpinus	Arctic Char
Oncorhynchus nerka	Sockeye Salmon
O. tshawytscha	Chinook Salmon
O. keta	Chum Salmon
O. kisutch	Coho Salmon
O. gorbuscha	Pink Salmon
Esox lucius	Northern Pike
Dallia pectoralis	Blackfish
Couesius plumbeus	Lake Chub
Catostomus catostomus	Longnose Sucker
Percopsis omiscomaycus	Trout Perch
Lota lota	Burbot
Pungitius pungitius	Ninespine Stickleback
Cottus cognatus	Slimy Sculpin

* From McPhail and Lindsay 1970
Scott and Crossman 1973

.2 Results

Electroshocking at ten sampling sites (Table 3-18) in and around the project site yielded only 27 Arctic grayling (Thymallus arcticus). The age, weight, length and conditions of these fish are given in Table 3-19. All Arctic grayling were collected in the South Macmillan River at sites SM-3 and SM-5. The other eight sites either had no fish present or the fish were at such low densities that electroshocking could not determine their presence. No fish were observed during the snorkel survey undertaken in the South Macmillan River upstream of the airstrip in August. Turbidity prevented a snorkel survey downstream of this point.

Until this study, previous sampling had failed to produce any fish above Bridge #2 on the Canol Road (above SM-5) (Davies and Shepard 1981, Davies pers. comm.). The presence of Arctic grayling has now been verified to extend at least to station SM-3 on the South Macmillan River, within the boundaries of the Jason property. Arctic grayling and round whitefish are considered to be the only species likely to be found in the headwaters of the South Macmillan River (Elson 1974). Although not encountered in this study, round whitefish have a widespread distribution in northern latitude streams and rivers (Scott and Crossman 1973, McPhail and Lindsey 1970). Thus, it is possible that their presence could be verified in the upper South Macmillan River with more intensive sampling.

No fish were captured in the Hess River tributary and its tributaries draining the northwestern extent of the Jason property. No suitable fish habitat was observed in the areas sampled, but helicopter reconnaissance along the entire length of this stream revealed general habitat improvement as one proceeded downstream to the Hess River, although no fish were seen. In more favourable habitat in the Hess River tributary, Arctic grayling and Dolly Varden char have been found in low

TABLE 3-18

Electroshocking Results in the Macmillan Pass Area, Jason Property, June, August and October, 1981

Stream Designation	Station No.	Reach No.	Date	Length Shocked	Shocking Duration	Fish Species Captured	No. of Fish	C.P.U.E.[1] fish/s x 100
				mm	s			
S. Macmillan R.	SM-6	R-22	1981-06-14	100	207	Gr	1	0.5
			1981-10-09	100	315	Gr	1	0.3
S. Macmillan R.	SM-4	R-20a	1981-06-13	300	400	–	–	–
			1981-08-19	100		–	–	–
S. Macmillan R.	SM-3	R21	1981-06-13	300	184[2]	–	–	–
			1981-08-18	300	657	Gr[3]	25	3.8
			1981-10-08	50[4]	65	–	–	–
S. Macmillan R.	SM-1	R22	1981-06-12	300	178	–	–	–
			1981-08-19	300	444	–	–	–
	SM-2	R22	1981-06-12	300	231	–	–	–
			1981-08-19	300	373	–	–	–
S. Macmillan R.	SM-5	R-22a	1981-08-19	300	301	–	–	–
Rust Cr.	SC2-1	R-1	1981-06-12	300	321	–	–	–
		R-2	1981-06-12	75	183	–	–	–
Sekie Cr. #1	SC1-1	R-1	1981-06-12	300	89	–	–	–
			1981-08-19	300	308	–	–	–
Hess R. Tributary	HR-1	R-3	1981-06-13	300	282	–	–	–
			1981-08-18	120	175	–	–	–
	HR-2	R-4	1981-08-18	100	77	–	–	–
	HR-5	R-5	1981-06-13	300	164	–	–	–
Nidd Cr.	NC-1	R-1	1981-06-13	50	56	–	–	–

[1] C.P.U.E. = Catch Per Unit Effort
[2] Only one side of river shocked due to high water levels
[3] Gr = Arctic grayling
[4] Equipment malfunctions resulted in only 50 m being shocked

TABLE 3-19

Age, Weight, Fork and Total Lengths and Coefficients of Condition (K(FL) and K(TL)) of Arctic Grayling (Thymallus arcticus) Collected by Electrofishing, South Macmillan River, Yukon Territory, June, August and October 1981.

Specimen No.	Age	Sex[1]	Weight	Fork Length	Total Length[2]	K(FL)	(K(TL)
			grams	mm	mm		
1[3]	2	-	48	176	193	0.88	0.66
2	3	F	95	204	224	1.11	0.84
3	3	F	95	209	229	1.04	0.79
4	2	-	50	171	188	0.99	0.75
5	2	-	45	162	178	1.05	0.79
6	3	F	65	181	199	1.09	0.82
7	2	M	50	168	184	1.05	0.80
8	1	-	30	148	162	1.05	0.70
9	1	-	20	127	139	0.92	0.74
10	1	-	35	152	167	0.97	0.75
11	1	-	25	143	157	0.85	0.64
12	2	-	40	160	176	0.97	0.73
13	2	-	45	166	182	0.98	0.74
14	1	-	20	130	143	0.91	0.68
15	3	M	60	180	197	1.02	0.78
16	1	-	30	145	159	0.98	0.74
17	2	-	50	163	179	1.15	0.87
18	1	-	15	118	129	0.91	0.69
19	1	-	15	117	128	0.93	0.71
20	1	-	20	128	140	0.95	0.72
21	1	-	20	124	136	1.04	0.79
22	3	M	65	186	204	1.01	0.76
23	1	-	15	116	127	0.96	0.73
24	1	-	15	120	132	0.86	0.65
25	1	-	15	114	125	1.01	0.76
26	1	-	15	120	132	0.86	0.65
27[4]	1	-	17	125	137	0.87	0.66
MEAN			37.6	150.1	164.7	0.98	0.74
S.D.			23.4	28.3	31.1	0.08	0.06
RANGE			15-95	114-209	125-229	0.85-1.15	0.64-0.87

1 All fish were immature, sex could not be determined in most cases
2 Total length calculated from fork length by method of Carlander (1969)
3 Single specimen captured in June 1981
4 Single specimen captured in October 1981

numbers (Davies pers. comm.). Chinook salmon are known to spawn at the outlet of Niddery Lake, which is a short distance from the confluence of this tributary and the Hess River (Elson 1974).

The spatial distribution or zonation of fish species in streams from the headwaters to the sea has been recognized since the early 1900's (Hynes 1972). The greater downstream diversity of fish has been attributed to the greater abundance of detritus and phytoplankton, producing a greater number of trophic levels as the tributaries of a given stream grow in number and volume of flow (Lowe-McConnell 1975). It has also been suggested that habitat diversity increases downstream (Tramer and Roger 1973).

In a study of 15 river systems and their associated fish fauna, Horwitz (1978) found that the number of fish species present was correlated with the patterns of flow variability: the more constant the headwater flow, the greater the number of species. Conversely, with more variable flow, the diversity should become correspondingly lower. The monthly mean discharge (for 1975 to 1979) for the South Macmillan River at Kilometre 401 Canol Road (approximately 45 km. south of the Jason Property) varied by a factor of 55 (Environment Canada 1980). This streamflow variability, in combination with low production of fish food organisms (Section 322), probably has adverse effects on habitat utilization by the fish populations.

.21 Fish Population Characteristics - Arctic Grayling-Thymallus arcticus

General Distribution Arctic grayling are found across northwestern Canada and are an important game fish in the Yukon Territory (Scott and Crossman 1973, McPhail and Lindsey 1970). General habitat preferences include clear rivers, lakes and streams. As discussed previously, they are present in the Yukon River system and occur in the South Macmillan River as far upstream as the Jason property.

Size Distribution Arctic grayling collected in this study from the South Macmillan River ranged in size from 114 to 209 mm, with a mean size of 150 mm. The most common length frequency distribution (51.9%) was for fish less than 150 mm in length with 92.6 percent being less than 200 mm in length. Length frequency distribution is given in Table 3-20.

Age and Growth The scale method has been traditionally used for aging Arctic grayling, but recent evidence suggests that scale readings may underestimate the ages of grayling due to missing first annuli and difficulty in annulus identification in older fish (Shallock 1965, McCart *et al*. 1972, de Bruyn and McCart 1974). However, where both scales and otoliths are used for aging, similar ages are obtained until the fish approaches age seven or eight (Craig and Poulin 1975, de Bruyn and McCart 1974). Scales were considered to give an appropriate estimate of age in this study. Arctic grayling from the South Macmillan River ranged in age from one to three years, with one year old grayling being the most abundant age class encountered (Table 3-21).

The age-length relationships for grayling from the South Macmillan River compared with other populations throughout the species range is presented in Table 3-22 and Figure 3-1. The grayling encountered in this study exhibit a rate of growth that is comparable with slower growing Arctic populations but is within the range of growth observed for the species. Tripp and McCart (1974) describe the Donnelly River grayling population as one of the fastest growing populations that have been studied north of the 60th parallel in Canada and Hodgson Creek populations as the slowest growing. The South Macmillan River population falls between these two extremes.

Generally, grayling grow more rapidly in the southern portion of their range, while northern fish grow more slowly, live longer and have a maximum size smaller than those in the south (Craig and Poulin

TABLE 3-20

Fork Length Frequency Distribution of Arctic Grayling from the South Macmillan River, June, August and October, 1981

	Length Cohorts (mm)		
	100 - 149	150 - 199	200 - 249
Total No. of Fish (N = 27)	14	11	2

TABLE 3-21

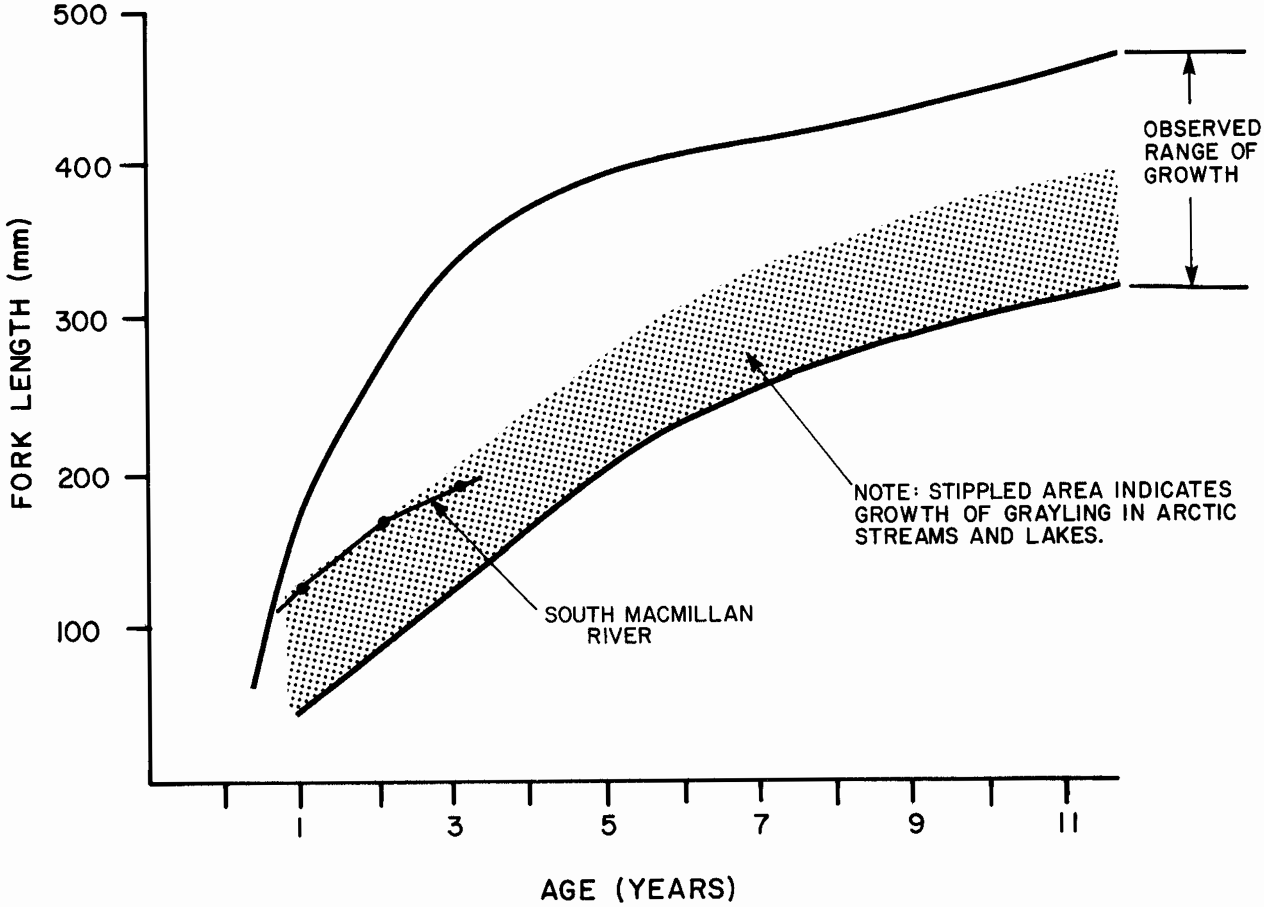
Age Frequency Distribution of Arctic Grayling from the South Macmillan River, June, August and October, 1981

	Age		
	1+	2+	3+
Total No. of Fish (N = 27)	15	7	5

TABLE 3-22

Observed Age-Length Relationships of Arctic Grayling from the South Macmillan River, 1981, Compared with Other Populations

Location (Latitude/Longitude)	Age	n	Fork Length (mm) Mean	S.D.	Range	Reference
S. Macmillan R., Yukon	1	15	128	13	114-152	This study
(63° 10'N 130° 15'W)	2	7	167	6	160-176	
	3	5	192	14	180-209	
Hodgson Cr., N.W.T.	1	5	105	13	90-122	Tripp & McCart
(63° 20'N 123° 24'W)	2	46	118	10	91-148	1974
	3	29	144	14	116-167	
Donnelly, R., N.W.T.	1	19	143	48	60-197	Tripp & McCart
(65° 05'W 128° 00'W)	2	29	225	18	106-290	1974
	3	44	267	25	222-330	
Weir Cr./Kavik R.,	1	46	98	11	84-125	Craig & Poulin
Alaska	2	30	140	19	91-182	1974
(70° 10'N 147° 00'W)	3	27	192	25	133-238	
Collins Cr., Sask.	1	4	152	7	144-160	Saskmont
(58° 05'N 103° 00'W)	2	16	246	15	216-275	Engineering
	3	2	329	28	309-349	Company Limited 1980
Red Rock Cr. & L., Mont.	1	73	208	-	-	Nelson 1954
(45° 00'N 113° 00'W)	2	78	292	-	-	
	3	160	329	-	-	



ADAPTED FROM: CRAIG & POULIN 1974

FIGURE 3-1
PAN OCEAN OIL LTD.
MACMILLAN PASS STUDY
GROWTH RATE OF ARCTIC GRAYLING FROM S. MACMILLAN R. COMPARED WITH THOSE OF OTHER POPULATIONS THROUGHOUT THE SPECIES' RANGE - 1981

1974). The slow growth rate observed for grayling in this study is consistent with the general overall low productivity of aquatic systems found in the study area.

Weight-Length Relationship The relationship between the weight and length of fish can be described in a logarithmic form using the formula:

$$\mathrm{Log}_{10} W = a + b\ (\mathrm{Log}_{10} L)$$

where:

W = weight (g)
L = fork or total length (mm)
a = Y intercept
b = regression coefficient (slope) (Ricker 1975)

The following weight-length relationship was calculated for South Macmillan River grayling ($N = 27$; $r = 0.993$):

$$\mathrm{Log}_{10} W(g) = 3.196\ \mathrm{Log}_{10} FL(mm) - 5.480.$$

A comparison of this relationship with other grayling populations (Table 3-23) at northern latitudes shows comparable weight-length relationships.

Several investigations have shown that the value of "b" will usually be near 3.0, since the weight of an object varies as the cube of its length, when shape and specific gravity are constant (Carlander 1969). Variations from this value can be affected by species specific morphological characteristics, sex, sexual maturity, age and environmental influences. This cubic relationship is maintained by South Macmillan River grayling.

TABLE 3-23

Selected Weight-Length Relationships for Arctic Grayling Throughout Their Range

Location (Latitued/Longitude)	N	r	Weight-Length Relationship	Reference
S. Macmillan R., Yukon (63° 10'N 130° 15'W	27	0.993	$Log_{10}W = 3.196\ Log_{10}FL(mm) - 5.480$	This study
Weir Cr./Kavik R., Alaska (70° 10'N 140° 00'W)	110	0.998	$Log_{10}W(g) = 3.151\ Log_{10}FL(mm) - 5.346$	Craig and Poulin 1974
Donnelly R., N.W.T. (65° 05'N 128°00'W)	73	0.997	$Log_{10}W(g) = 3.201\ Log_{10}FL(mm) - 5.387$	Tripp and McCart 1974
Grebe L., Wyoming (45° 00'N 111° 00'W)	-	-	$Log_{10}W(g) = 2.768\ Log_{10}TL(mm) - 4.525$	Carlander 1969
Collins Cr., Sask. (58° 05'N 103° 00'W)	29	0.99	$Log_{10}W(g) = 3.22\ Log_{10}FL(mm) - 5.427$	Saskmont Engineering Company Limited 1980
Great Slave L., N.W.T. (61° 00'N 114° 00'W)	325	-	$Log_{10}W(g) = 2.602\ Log_{10}FL(mm) - 3.897$	Falk and Gillman 1974

Condition Factor The coefficient of condition describes the condition or plumpness of a fish; the most widely used definition is:

$$K = \frac{W \times 10^5}{L^3}$$ (Ricker 1958)

where: K = coefficient of condition

W = weight (g)

L = length (mm)

The higher the value of K, the greater the weight per unit length. The condition and general well being of the fish in our collections give an indication as to the suitability of the habitat. The coefficient of condition (K), using both total length (TL) and fork length (FL), were calculated for each grayling in the collection (See Table3-18). The average K based on fork length, K (FL), for the grayling from the South Macmillan River is 0.98, and the average K based on total length, K(TL) is 0.74.

Maturity All Arctic grayling from the South Macmillan River were immature at the time of capture and, except for a few specimens, sex could not be determined (Table 3-18). Northern populations of grayling usually mature at a later age than those at more southerly latitudes. In the Yukon and Northwest Territories, grayling have been reported to mature at age four and younger (Carlander 1969, Tripp and McCart 1974); however, other studies suggest that at northern latitudes, the greatest percentage of grayling mature at age five or six (Craig and Poulin 1974, Saskmont Engineering Company Limited 1980, Bishop 1967, Falk and Gillam 1974, de Bruyn and McCart 1974). The age of maturity is similar for both sexes and once mature, females appear to spawn every year (Falk and Gillam 1974, Tripp and McCart 1974).

Food Habits Arctic grayling are opportunistic in their feeding habits and will consume an array of food items if available. Dietary components can include bottom fauna, drift, terrestrial insects, fish, fish eggs, small mammals, plant material and items of no nutritional value such as sand, gravel and animal hair.

A total of 25 grayling stomachs from South Macmillan River fish was sampled. A summary of food preferences is presented in Table 3-24.

The stomach contents of the fish collected in the South Macmillan River demonstrate that the food base of this population was invertebrates. Of the 25 fish collected, 20 had between 80 and 100 percent of the stomach contents as insects, with the most prominent being immature chironomids (Chironomidae). Ten fish were also found to have the remains of fish in their stomachs with two having this component making up greater than 50 percent of the volume. One fish had the remains of 17 pelecypods or clams in its stomach. A high percentage of fish (78%) had eaten vegetation. Terrestrial insects, mainly Hymenoptera, were also consumed as food.

The presence of unidentified fish in grayling as small as those captured in the South Macmillan River was unexpected. The low productivity observed in fluvial habitats in the area may partially explain the necessity for predation on smaller fish. The relevance of finding fish remains in the grayling stomachs is further discussed below.

Reproduction No mature grayling or evidence of spawning was collected during this study. However, the capture of year old grayling and the sighting of a fry-sized fish of unknown species in Reach R21 suggests that reproduction could be occurring in the area. Fish remains in the stomachs of grayling are also evidence that some type of smaller fish which was not captured during sampling is present in the area. These

TABLE 3-24

Stomach Contents of Arctic Grayling from South Macmillan River, Jason Property, August 18, 1981

Stomach Contents		Size Class - Fork Length					
		0 - 150 mm		150 - 200 mm		200 mm	
		N	% occurrence	N	% occurrence	N	% occurrence
Plecoptera	nymphs	3	21.4	3	33.3		
Ephemeroptera	nymphs	2	14.3	1	11.1		
	adults			1	11.1		
Coleoptera	larvae	1	7.1	1	11.1		
	adults	5	35.7	4	44.4		
Chironomidae	larvae pupae adults	14	100.0	7	77.8	2	100.0
Other Diptera	larvae	3	21.4	2	22.2		
	pupae	7	50.0	3	33.3		
	adults	13	92.9	8	88.9	2	100.0
Neuroptera	adults	4	28.6				
Araneae		3	21.4	2	22.2		
Tricoptera	larvae	3	21.4	2	22.2		
	adults	2	14.3				
Hymenoptera	adults	8		7	77.8	1	50.0
Pelecypoda		1	7.1				
Amphipoda		1	7.1				
Nematoda		1	7.1				
Hemiptera	nymphs			3	33.3	1	50.0
	adults			5	55.6		
Lepidoptera	larvae			2	22.2		
Oligochaeta		3	21.4	6	66.7		
Collembola				1	11.1		
Psocoptera	adults			3	33.3	1	50.0
Cladocera				1	11.1		
Hydracarina				2	22.2		
Unidentifiable invertebrates (most Insecta)		12	85.7	8	88.9	2	100.0
Unidentifiable Fish		4	28.6	6	66.7		
Vegetation		13	92.9	6	66.7	2	100.0
Total No. of Stomachs Sampled		14		9		2	
Total No. with Food Items		14		9		2	

smaller fish could be grayling fry preyed upon by larger grayling or could represent another species, not yet identified as being present section of the river. Grayling typically spawn from March to June over their geographical range, but usually from mid-May to mid-June (Carlander 1969, McPhail and Lindsey 1970, and de Bruyn and McCart 1974) at more northerly latitudes. Coarse sand, gravel and rock bottoms have all been listed as preferred grayling spawning substrates (Nelson 1954, Shallock 1965, McPhail and Lindsey 1970, Scott and Crossman 1973). Suitable sized spawning substrate exists in the South Macmillan River in reaches R21 and R22.

As the initial field trip to the study area was undertaken in mid-June, mature Arctic grayling should have been present if they use the area. River discharge conditions (high water levels and velocity) in June restricted access all suitable habitat that could have supported fish, and was further complicated by turbid conditions that reduced visibility in the water. Thus, the likelihood of missing adult grayling, if they were present in small numbers, was high. The possibility of grayling spawning on the Jason property cannot yet be ruled out and would require further investigation to verify it.

Tissue Analysis

Fish tissue analysis was performed on a single grayling specimen collected in October 1981. These analytical results are presented in Table 3-25. This data is presented for information only, since it is insufficient to provide a basis for comparison with other studies.

In the context of this study, the use of grayling as an indicator of heavy metal contamination in the aquatic environment is questionable due to lack of information available about the extent of their movements and residence time in different reaches of the South Macmillan River. Attempting to define relationships between grayling tissue

TABLE 3-25

Fish Tissue Analysis

Element	Concentration (μg/g wet weight)
Ag	0.3 ± 0.1
As	0.15 ± 0.03
Ba	5.0 ± 2.0
Cd	0.81 ± 0.01
Co	0.3 ± 0.15
Cu	1.87 ± 0.02
Fe	1.88 ± 9
Hg	0.0006 ± 0.0004
Mn	1.60 ± 0.02
Pb	2.3 ± 0.1
Sb	10.0 ± 1.0
Se	0.85 ± 0.08
Sr	8.8 ± 0.2
V	1.51
Zn	37.0 ± 1.0

concentrations and heavy metal contamination resulting from exploratory and mining development in the area, would be tenuous at best. Further, Wiener and Giesy (1979) report that certain elements such as Cu, Mn, and Zn are homeostatically regulated in fish, negating their bio-monitoring usefulness for these parameters. It is suggested that Arctic grayling not be considered for use as a biomonitor of heavy metal accumulation in the aquatic environment unless extensive additional information is acquired regarding their movements and residence in reaches of the river affected by the project.

.3 Comparison with Other Data

The number and diversity of fish collected on the South Macmillan River is typical of what would be expected of the area. Other studies in the Yukon have had similar results although the wider variety of downstream habitats sampled in those studies generally produced either more fish or a more diverse community than the collection from the South Macmillan River. Three immature Dolly Varden (*Salvelinus malma*) were collected in a small tributary of the Hess River northeast of the project site (Sergy *et al*. 1976). The same study yielded eight slimy sculpins (*Cottus cognatus*) and one Arctic grayling in an adjacent river (the Tsichu River) in the Northwest Territories. Farther west, a baseline study of the small creeks draining into the Stewart River produced five species of fish: Arctic grayling, longnose sucker (*Catostomus catostomus*), Arctic lamprey (*Lampetra japonica*), humpback whitefish (*Coregonus clupeaformis*), and northern pike (*Esox lucius*) (Environmental Protection Service 1978).

South of the present study area, an environmental baseline study on the small creeks draining into the Pelly River at Faro, Yukon Territory (Montreal Engineering Company, Limited 1978) produced only three slimy sculpins, and four Arctic grayling. Upstream from the confluence of the Pelly with the Yukon River, a biological assessment of four creeks draining directly into the Yukon River (Kelso et al. 1977) produced 41 slimy sculpins, 15 Arctic grayling, two longnose suckers, and five chinook salmon. In another study in the same general area, the Environmental Protection Service (1979) captured 59 grayling and six sculpins. Arctic grayling were present in the Howard's Pass area (Archibald and Burns 1981); however, sampling consisted of only angling, with emphasis on collecting fish tissue for metals analysis rather than assessing the abundance and diversity of fish.

Recent fisheries investigations (Davies and Shepard 1981, Davies pers. comm.) support the patterns of fish distributions of past studies and also include the presence of northern pike and burbot (Lota lota) in tributaries (Hess Creek and Jeff Creek) of the South Macmillan River, a short distance downstream of Bridge #2. The bridge is located approximately six kilometers south of the Cordilleran Engineering base camp.

Compared to the grayling collected in Collins Creek in northern Saskatchewan (Saskmont Engineering Company Limited, 1980) which had an average K(FL) of 1.29, the South Macmillan River grayling were less plump with a K(FL) of 0.98. The average K(TL) for the grayling of the South Macmillan River is 0.74 which was below the value of 0.82 reported for 100 grayling from Tolovana River (Yukon Drainage), Alaska (Reed and McCann 1971). The Tolovana River population existed under conditions of rapid runoff in the spring and fall, poor aquatic insect production, and fluctuating water temperatures. The South Macmillan population may exist under similar conditions and this may restrict further upstream movement of the population.

.4 Relation to Other Parameters

The chemical composition of the water can be an important factor governing fish distribution. High levels of dissolved metals can be directly toxic to fish or can have sublethal affects which reduce population fitness. The possible relation between the low fish numbers present in the South Macmillan River and the observed metal concentrations in the water therefore requires discussion.

One important aspect of aqueous metal concentrations is the difference between dissolved and total metals. Total metals include all fractions adsorbed or attached to particulate material plus the fraction which is truly dissolved. The metals in the particulate fraction are generally not available to aquatic organisms unless ingested. By contrast, the dissolved fraction is usually considered to be biologically available due to its ionized form and ability to penetrate membrane surfaces. It must also be realized that some dissolved metals are adsorbed to or chelated with large dissolved organic molecules, making them much less available to biological systems.

In view of this, the reported concentrations of total iron and other metals can be viewed as a "worst case" situation (i.e., 100% of the concentrations reported are biologically available) even though it is realized that this is very conservative. If the distinction is to be made between dissolved and total metals, two samples must be taken, and one must be filtered on site before both are acidified to a pH of less than two. Without acidification, the precipitation, chelation, and adsorption reactions occurring in the sample container could yield results which are not representative of the system from which they were collected.

With the exception of iron and zinc, the other metals analyzed were below levels in the water at which they would be detrimental to fish. The South Macmillan River is naturally high in iron, and while this metal is one of the least toxic to aquatic organisms in its dissolved state, the flocs and precipitates formed by iron may be harmful to membrane surfaces used for respiration. Total iron concentrations of Station M8, where grayling were captured, approached or were within 1000-3000 ppb/L, which is the range where interactions between floc size and fish toxicity are reported to occur (American Fisheries Society, 1979).

The recommended criterion for zinc for the protection of freshwater life (at a water hardness of 0-150 ppm) is 0.05 mg/l or 50 ppb. At those stations sampled in the South Macmillan River, zinc ranged from 100 to 1200 ppb. If these concentrations were representative of what was biologically available, they they would certainly seem detrimental to the fish. However, the work of Holcombe *et al*. (1979) showed that the exposure of three generations of brook trout (*Salvelinus fontinalis*) to zinc concentrations ranging from 2.6 to 534 ppb produced no significant harmful effects. The range of zinc concentrations measured in the South Macmillan River during this study were within the range of concentrations used by Holcombe *et al*. (1979). Water hardness, which generally modifies (reduces) the effects of toxic metals as it increases, was 45.4 ppm in the aforementioned test while the average value for the South Macmillan River during this study was 71.9 ppm. Holcombe *et al*. also reported the apparent acclimation of their test fish to the zinc concentrations and referred to other reports concerning zinc acclimation in rainbow trout (*Salmo gairdneri*) and flagfish (*Jordanella floridae*). Thus, given the hardness of the water and the likely potential of Arctic grayling to acclimate to the zinc levels, their existence at station M8 would not seem unusual.

Comparisons of the grayling stomach contents with the results of Surber and artificial substrate samples showed little if any relationship. One similarity was the presence of stoneflies (Plecoptera) in a few stomachs (6 of 25) and in the Surber samples. The stomach contents indicated the existence of a more diverse benthic fauna in this section of the river than was observed by standard benthos sampling techniques. For example, the stomach contents revealed the existence of mayflies (Ephemeroptera) amphipods (Amphipoda), and aquatic beetles (Coleoptera) which would have been expected in the stream, but were not recorded in the benthic samples. These may have been consumed off the Jason property, or they may be components of the drift from upstream reaches. Stream invertebrate drift is known to be an important food source for fish.

.5 Summary

Arctic grayling were captured in the South Macmillan River in June, August and October, 1981. The population was composed of fish mostly less than 200 mm in length and from one to three years old. The growth rate of the population is low, but within the range of growth observed for the species. Population parameters suggest South Macmillan River grayling are much like other northern grayling populations. Food habits of these fish support the opportunistic feeding tendencies notable in grayling and the presence of fish remains in grayling stomachs may be indicative of limited food sources and cannibalism.

PART FOUR

DISCUSSION

PART FOUR - DISCUSSION

CONTENTS

PHOTOGRAPHS

4.1 ECOSYSTEM PRODUCTIVITY

The results presented in Part 3 provide strong indications that production in all three of the taxonomic groupings examined (periphyton, benthos and fish) is low. Periphyton were not especially abundant, and thus would not represent a large food source for benthic invertebrates. The benthos were also present in low numbers, and fish were only collected after extensive searches throughout the river. There may be a number of possible reasons for the low numbers and biomass of aquatic organisms observed in this area, including:

- low water temperatures and short growing season which limit metabolic activity;
- low nutrient levels which limit algal growth rates, and hence the growth of herbivorous benthos;
- lack of suitable habitat; and
- presence of toxins or other metabolic inhibitors.

Low temperatures and short growing season are likely to be a factor in the Yukon, although results of limnological studies in the Arctic have shown that aquatic production can be relatively high in spite of these factors. Low nutrient availability for primary production is more likely to be the major impediment to greater production at all trophic levels on the Jason property.

Habitat availability is an additional constraining feature for fish populations. As shown by the assessment of stream habitat on the Jason property, suitable pool habitat is limited, and when combined with the low food supply may explain to a large degree the low numbers of fish present.

The presence of any of a range of substances inimical to biological metabolism, whether present as a natural occurrence or as a result of man's activity, could result in limitation of biological production in spite of otherwise suitable habitat conditions. Our review of the available water chemistry data indicates that it is unlikely that any of the trace metals examined are present at levels which would be immediately toxic to the populations present. Similar conclusions were made by Beak Consultants Ltd. (1980). However, it is possible that short-term inputs of contaminants to the river could be responsible for the lack of fish and invertebrates found in 1981. Release of materials from upstream mining activities by another company active in this area has been reported to have occurred recently. Visible evidence of such releases was present along the margins of the South Macmillan River in the form of heavily pigmented detrital accummulations, presumably due to high concentrations of iron compounds (Photograph 4-1). Short-term releases of contaminants are known to result in both increased downstream drift of invertebrates, thus depleting benthos populations, and in downstream movements of fish as behavioural responses to unfavourable conditions. Although the most recent occurrence of this phenomenon is likely due to man's activities, there is evidence that pulse inputs of contaminants may occasionally result from natural processes. Stream meander movements can result in encroachment on bog areas having high accumulations of iron-rich compounds, or other trace elements (Photograph 4-2), resulting in instances of sudden high loading to the river. Examination of undercut banks along the river (Photograph 4-3) adjacent to the airport indicated that certain strata in the floodplain deposits were high in similarly pigmented material, probably indicating the occurrence of such events at intervals in the past. Natural processes of this type could thus account for apparent variations in numbers and biomass of organisms present in the aquatic environment.

Photograph 4-1

Detrital Accumulation at Margin
of South Macmillan River

Photograph 4-2

Active Erosion Through Iron-Rich Bank Material, South Macmillan River, Downstream of Airstrip

Photograph 4-3

Streambank Erosion Due to Undercutting, South Macmillan River, Upstream of Airstrip

In summary, aquatic production is low in streams in the Jason area, most likely due primarily to low nutrient levels and unsuitable habitat conditions for aquatic fauna. However, sporadic man-made and natural releases of contaminants may also have detrimental impacts upon the populations present, and the low numbers and biomass seen in 1981 may be a result of such processes.

4.2 POTENTIAL IMPACTS ON AQUATIC COMMUNITIES OF MINE AND MILL DEVELOPMENT

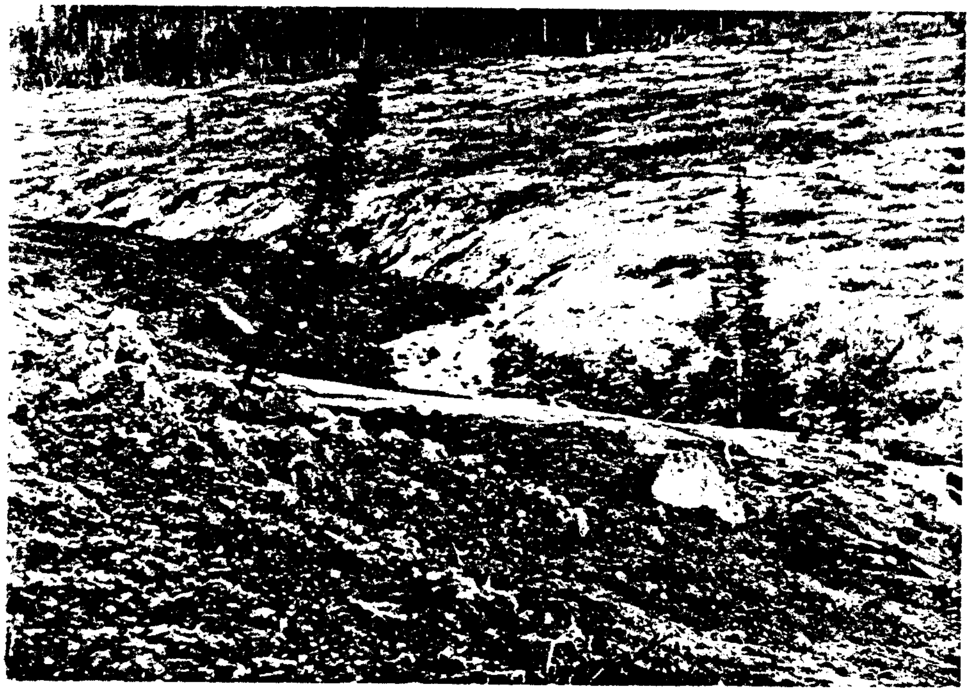
421 INTRODUCTION

Project details regarding possible mine and mill development on the Jason property have yet to be defined. In the absence of a specific project description, the following discussion addresses only the general types of impacts on the aquatic environment which are likely to be important. Specific impacts and appropriate mitigative measures will need to be defined once the project details are available.

422 EXPLORATION AND CONSTRUCTION PHASE

The impacts of mining developments on the aquatic environment during the exploration phase are largely the result of drilling, road building, and associated surface disturbances. These activities generally permit the introduction of suspended and dissolved solids loads to lakes or streams. Some release of minerals can also be expected, but, at this point in mine development, it is usually of minor concern. Some examples of such affects upon streams in the Jason area are given in Photographs 4-4 to 4-7.

Impacts associated with the construction phase of a mining operation also involve the disturbance of riparian areas along the streams, as in the case of road building (Photograph 4-8). High water velocities from the placement of culverts at stream crossings may also prevent fish movement upstream. Large amounts of suspended solids and debris can be introduced into streams during the course of these activities. Suspended solids can kill fish directly, reduce their growth rate and disease resistance, prevent development of eggs and fry, affect natural movements, and reduce the abundance of food. Scouring of the



Photograph 4-4

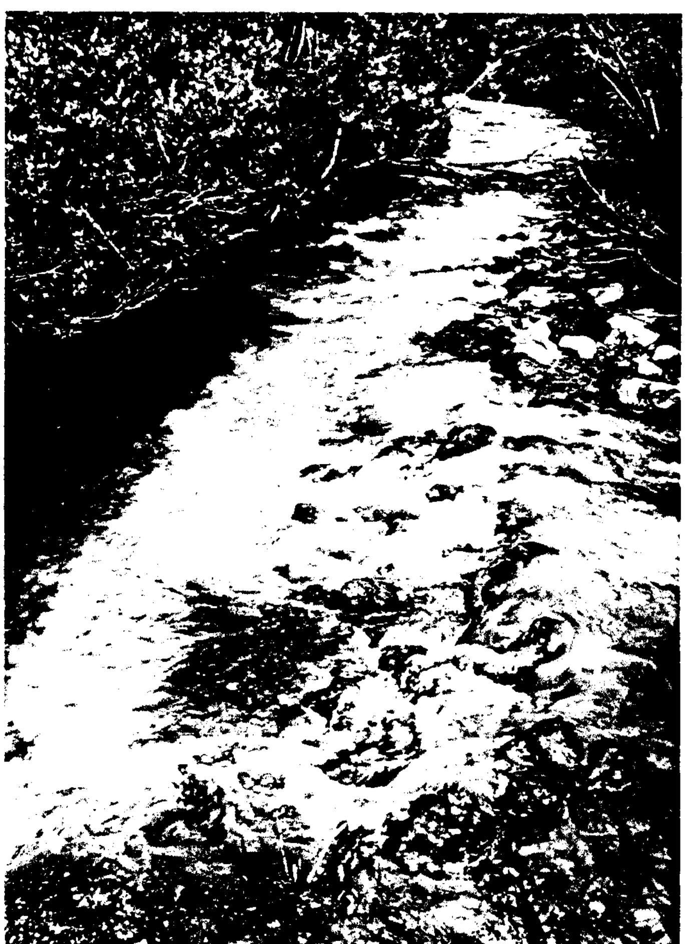
Active Erosion and Sedimentation of Rust Creek
Due to Road Construction bv Hudson's
Bay Mining and Smelting Co.

Photograph 4-5

Increased Turbidity and Silt
Deposition in Rust Creek
Due to Upstream Road
Construction

Photograph 4-6

Siltation of Nidd Creek Due to Upstream Exploration Activity by Cominco Ltd.



Photograph 4-7

Silt Plume Observed in Hess River Tributary at the Confluence of Nidd Creek Downstream of Cominco's Activities

Photograph 4-8

Surface Disturbance Along Small Stream Draining
From Jason Ridge

natural stream substrate also eliminates or reduces the attached algal growth which is essential as a food base for benthic invertebrates. On settling, suspended sediments can ruin invertebrate habitats and reduce or eliminate the food base of the fish population (Clark 1974). Methods for minimizing the impact of road construction and stream crossings are contained in several publications (Whitehead 1978, Dryden and Stein 1975, Rowe 1974, Curran and Etter 1976).

423 MINING PHASE

Impacts on the aquatic environment during the mining phase are primarily the result of the release of mine water. There are four main sources of mine water (Montreal Engineering Company, Limited 1972):

1) groundwater seepage (subsurface flow of tailings pond or other impounded water in mine);
2) surface drainage (precipitation and runoff in the mine area);
3) waste water from mine operations (termed process water); and
4) water from hydraulic backfilling methods.

The quantity and chemical composition of mine water are dependent on the characteristics of the ore body, the mining methods used, and the hydrogeology.

The major potential problems characteristic of mine water are acidity and high metal concentrations. In addition, mine water may contain ammonia in concentrations from 0.2 to 100 ppm. The source of the ammonia is ammonium nitrate used as an explosive in some mining operations (Clarke 1974). Mine water may also contain small quantities of hydrocarbon pollutants from vehicle and machinery maintenance areas, fuel storage areas, and runoff from heavily trafficked areas.

Potential sources of contaminated water are:

1) areas around ore handling facilities;
2) mill and concentrator areas;
3) haul roads;
4) waste rock piles and tailings; and
5) any area where rock surface is exposed, including the mine itself.

The acidity of surface and mine water can be caused by the oxidation of iron sulphide minerals, such as pyrite (FeS_2), marcasite (Fe_2S_3), and other sulphide minerals, if present. The oxidation reactions, which are sometimes augmented by bacteria, result in the formation of acid which further dissolves quantities of other metals producing possibly high concentrations of these in acid mine water drainage. Sulphides of Cu, Cr, Mn, Ni, V, and Zn dissolve under these acid conditions, but PbS does not (Hawley 1972).

Process water (water used in the extraction of the mineral from the ore) also must be disposed of and may impact the receiving water depending on the extent of treatment it receives prior to release. Process water will result from either of two basic methods of concentrating the mineral: differential flotation or leaching.

The chemical characteristics of the process water vary with the ore preparation (separation of valueless minerals associated with the element being mined), the ore characteristics and the quality of the raw water. The pH of the process water is rarely neutral, since flotation usually occurs under alkaline conditions and leaching may utilize acid or basic reagents. In addition to pH alteration, process water usually contains high concentrations of metals and suspended solids and residual amounts of the chemicals used in ore processing (Clarke 1974).

The tailings pond is the major method of treating process water. Lime is often added to the discharge of mine water and/or to the discharge of process water to the tailings pond for neutralization of the acidity. Tailings ponds perform the following functions (Montreal Engineering Company, Limited 1972):

1) final retention of solid wastes;
2) heavy metal precipitate formation if proper coagulant is added;
3) sedimentation of precipitates;
4) sedimentation of other suspended solids;
5) pH control if a neutralizing agent is added;
6) stabilization of oxidizable constituents in the wastes;
7) balancing volume for influent quality and quantity fluctuations; and
8) storm water storage and balancing.

Depending on the type and extent of treatment given the process water in the tailings ponds, the aquatic environment receiving the tailings pond discharge may sustain consequences ranging from insignificant changes in density and diversity to the complete eradication of fauna and flora. Stimulation and increased density of floral or faunal components may result at some locations.

Of 22 Canadian localities receiving effluents from metal mines (Clarke 1974), no obvious effects on the aquatic community were reported at three sites. Reduced diversity and/or altered composition of the benthic fauna occurred at 16 sites. Fish populations were affected at eight sites and the phytoplankton-zooplankton communities were affected at one site. Of the eight sites where fish were affected, two sites were devoid of fish. Toxic concentrations of arsenic and metals were believed to be the cause of their absence at one location while heavy siltation was considered responsible for the other. Mine effluents have been held responsible (in part) for the reduction of fish in the Tomogonops and Nepisiquit Rivers in New Brunswick (Clarke 1974). Letterman and Mitsch (1978) found that the major factor affecting the benthic and fish communities downstream from an alkaline coal mine drainage discharge was the deposition of ferric hydroxide. In areas receiving acid discharges, the production of acidaemia in fish, following the destruction of the carbonate-bicarbonate buffer system, is one of the obvious effects of this type of pollution (Parsons 1977).

The most commonly studied effect of mine effluents is their effect on benthos. In many instances, areas below mine effluent discharges are devoid of benthos. When present, benthic populations in such locations are generally low in both diversity and abundance although some sites are known where high densities of organisms have been produced by the mine effluents. This latter situation could result from the elimination of a more sensitive predator allowing the enhanced growth of a less sensitive prey. Relative sensitivity varies widely among the many types of benthos, but generally mayflies (Ephemeroptera) appear to be one of the more sensitive groups (Warnick and Bell 1969, Roback 1974). Aquatic hemiptera, arachnida, and leptocerid caddisfly larvae (Trichoptera) have been found to be very tolerant of the high metal concentrations. Roback and Richardson (1969) found that dragonflies (Odonata), mayflies and stoneflies (Plecoptera) were completely eliminated by acid mine drainage. However, _Ptilostomis_ (Trichoptera), _Sialis_ (Megaloptera), and _Chironomus attenuatus_ survived the acid mine conditions. The work of Tomkiewicz and Dunson (1977) supports that of Roback and Richardson (1969) and in addition shows that stonefly larvae tend to recover faster than either mayflies or caddisflies as the impact lessens with distance from the mine effluent.

Aquatic organisms may be affected by a toxic effluent in several ways. A single toxic element may have a direct lethal effect or it may act in concert with other elements (synergism) to produce the acute lethal effect. Sublethal effects may result in decreased reproductive success or decreased resistance to disease or other environmental stresses. Other indirect effects would include bioaccumulation of the potentially toxic element through the food chain to produce the aforementioned sublethal effects. Accumulation of toxic substances in the sediment could, over a period of time, reach toxic levels for organisms living at the sediment-water interface. Changes in the oxidation-reduction potential of the sediment could conceivably release large amounts of toxic metals which had accumulated in the sediment over a long period of time.

Just as there are many ways in which the toxic action of the elements in mine effluents may be expressed, there are also many ways in which the toxicity may be attenuated by the aquatic environment. Some large naturally occurring organic molecules have the ability to bind or chelate toxic metals making them less available to living organisms. The adsorption and coagulation of toxic metals onto organic or inorganic materials removes the toxic metal from the water. The presence of less toxic anions or cations in the receiving water may also reduce the toxicity of specific metals in solution. The toxic effects of certain metals are reduced in hard water (water with large concentrations of calcium and magnesium ions) when compared to soft water.

The impact of mine effluents upon the aquatic environment is ultimately determined by the nature of the effluent, the treatment it receives, the nature of the receiving water and the sum total of all physical and chemical interactions between the effluent and receiving water (i.e., adsorption, desorption, chelation, floculation, sedimentation, antagonism, synergism, dilution, buffering capacity, and bioaccumulation).

424 ABANDONMENT PHASE

Abandoned mines generally continue to produce wastes since acid mine water is often formed in the drainage of the mine and tailings. Thus, there may be a continued long-term impact to the aquatic environment. This impact may be mitigated by terrestrial reclamation of the mine site and sealing of the tailings pond during its construction. Reclamation methods should attempt to decrease the exposure of both ore in the abandoned mine and tailings to surface water. Reduction in the quantity of water leaving the mine area could allow dilution and neutralization by the natural aquatic environment to the point where impacts from the abandoned mine would be insignificant.

PART FIVE

CONCLUSIONS AND RECOMMENDATIONS

PART FIVE - CONCLUSIONS AND RECOMMENDATIONS

CONTENTS

5.1 CONCLUSIONS

This study of fluvial aquatic habitat on the Jason property was designed to produce baseline aquatic information for use in future environmental assessment documents. The study has emphasized physical habitat descriptions and investigation of fish populations and fish habitat. Data on periphyton, benthic invertebrates and sediment chemistry were also collected, in order to present a comprehensive overview of fluvial aquatic systems in this area.

The 1981 studies discussed in this report are adequate to provide an overall description of the aquatic habitat in streams on the Jason property. They illustrate a consistent pattern of low numbers of organisms in the three communities (periphyton, benthos and fish) examined. Low biological production could be due to several different factors, with low nutrient availability likely being of primary importance in these cold, headwater streams. Levels of trace metals in the water were not high enough to limit biological populations, although upstream releases of iron-rich contaminants may have reduced the populations that otherwise would be present. Few fish were found in the South Macmillan River, probably due to a paucity of fish food organisms. Population characteristics of the Arctic grayling collected were similar to other northern populations.

The data presented here cover only part of one year, and so do not adequately address the questions of seasonal or annual variability. Further intensive sampling would be needed to better define the biological populations present, but it is unlikely that the overall finding of low biological activity would be changed through such additional work. The results presented here suggest a number of additional areas which could be pursued in the future and these are outlined in the recommendations below.

5.2 RECOMMENDATIONS

The aquatic studies to date have provided an overview of the chemical and biological characteristics of streams in the study area. Based on these results, there are a number of topics that should be addressed, if additional work is done in the area.

The major necessity in future aquatic studies, from both project management and scientific view points, should be improvements in the water chemistry sampling program. The chemical composition of surface waters is a major determinant of the biological populations present, and accurate, detailed knowledge of chemical parameters is a necessity for any valid interpretation of biological data. Changes and additions could be made in the following aspects:

- changes in frequency of sample collection. Samples from tributary streams draining undisturbed watersheds have been sufficiently characterized that only seasonal sampling is necessary. More intensive weekly sampling is recommended for one station on the South Macmillan River and one on the Hess tributary, in order to obtain data on which to assess temporal variability at that time scale.
- improvements in sample collection and treatment, including greater care in collection of the water from the stream in order to avoid sampling resuspended sediment, immediate sample filtration to avoid changes in dissolved and particulate fractions, and field determinations of certain parameters including pH, alkalinity, temperature, conductivity and dissolved oxygen;
- changes in parameters examined. Data on nutrient concentrations would be useful in assessing whether nutrients are limiting biological production, as we have suggested. We recommend that determinations of soluble reactive phosphate, soluble

organic phosphorus, nitrate, ammonia and soluble organic carbon be included. Those parameters which are consistently below detection or unchanging, such as As, Mo, Cl and Hg, should be sampled only on a seasonal basis and determination of total and ionic fractions of metals such as Cu, Pb, Zn and Cd should be added;

- direct toxicity tests of water samples should be carried out to confirm that the present chemical composition is not toxic to fish.

Since benthos are widely used for biomonitoring purposes, and their responses to contaminants are well known, they are therefore recommended as the basis of any long-term studies. Additional effort should be expended in obtaining further information on benthic invertebrate populations in the South Macmillan River. Two stations, at the upstream and downstream boundaries of the property, should be established for further detailed studies of seasonal and yearly variation. Surber samplers should be the method of choice for sample collection, since problems were encountered with the artificial substrate samplers in relation to fluctuating water levels. Downstream movement (or drift) of benthic invertebrates is an additional process which could be monitored. The composition of the drift samples may be useful in explaining differences between benthos samples and fish stomach contents.

Wetlands are widely recognized as accumulators of nutrients and potential contaminants such as metals, and have been used as natural waste treatment sites in certain instances. It is possible that mine-mill wastes from future operations at this site could receive final treatment or polishing by passing them through wetland areas in the South Macmillan River floodplain. The area adjacent to the mouth of Jason Creek may be one suitable area. If not overloaded, such areas could perform a useful service in removing both turbidity and residual metals from the mine-mill wastes after more conventional treatment processes have been applied. A study of the assimilative capacity of wetlands would be of great potential use in future waste management planning. In addition, the general biological and chemical characteristics of these wetlands could also be evaluated.

Additional analyses of metal levels in Arctic grayling tissues are not recommended, since the fish are mobile and the tissue accumulations cannot be related to the location where the fish are captured. Analyses of benthic invertebrate tissues may be more suitable for this purpose, but it is expected that the low numbers of organisms present would make it difficult to obtain enough biomass.

Further information on fish populations would be useful in assessing mining impacts. Further confirmation of fish presence or absence, especially on the Hess tributary, should be carried out, as well as fry trap sampling for young fish. The presence of fish in the floodplain ponds should also be investigated.

Other studies which would provide additional aquatic data could include:

- physical, chemical and biological characterization of headwater ponds on the divide between the South Macmillan and Hess drainages. If tailings ponds are constructed in this area, it may be useful to be able to quantitatively describe the aquatic habitat being lost;
- the chemistry and biology of acid streams such as Tom Creek;
- hydrometric studies on the Hess tributary;
- descriptions of other taxonomic groups such as protozoans or zooplankton, or processes such as microbial metabolism.

The studies suggested above can be ranked according to their usefulness from both managerial and scientific viewpoints. Certain studies would rank high on both aspects and are highly recommended for inclusion in Pan Ocean's future activities. These studies would include, in order of importance:

1. Alterations to the water chemistry sampling program as outlined previously.
2. Further benthos studies, including drift.
3. A study of wetland assimilative capacity.

In addition, there may be management requirements for further fish population characterization, and characterization of headwater ponds. These studies would be of less scientific value but may be useful in assessment of mine impacts.

The remaining studies mentioned would contribute to further defining aquatic habitat and ecosystem processes in the area, but would be of lesser value in terms of impact assessment and are therefore not recommended at this time.

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APPENDIX A

SELECTED AQUATIC HABITAT ASSESSMENT INFORMATION

APPENDIX A - SELECTED AQUATIC HABITAT ASSESSMENT INFORMATION

CONTENTS

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TABLES

Table

TABLE A-1

Reach Card Sample

Reach No. ____

C	ACTIVE VALLEY WALL PROC.	Loc	
	Avalanche		Nil L M H
	Debris flow/torrent		Nil L M H
	Slump		Nil L M H
	Slide		Nil L M H
	Gully		Nil L M H
	Periglacial		Nil L M H

	BAR PRESENCE	
	Side / Point	Nil L M H
	Mid Channel	Nil L M H
	Transverse	Nil L M H
	Junction	Nil L M H
	Diamond / Braiding	Nil L M H
	Lee	Nil L M H
	Dunes	Nil L M H
	Islands	Nil L M H

	LATERAL CHANNEL MOVEMENT		
	Apparently Stable	Yes No	
	Bar Veg. Progressions	Nil L M H	
	Cut-Offs / Ox Bows	Nil L M H	
	Meander Scars	Nil L M H	
	Avulsions	Yes No	#
	Terraces	Yes No	#
	Constrictions	Yes No	#
	Unstable Banks (%)		

	TOTAL POOLS (%)	
	Bedrock control (%)	

	BED MATERIAL (%)	
	Fines — clay silt sand	
	Gravel (2-64 mm)	
	Large (64 mm+)	
	Bedrock	

	CHANNEL COVER		
	Level	% Area	Distr.
	Crown		
	Overhang		

	RIPARIAN VEG.		
	Storey	Sp	Distr.
	Coniferous		
	Deciduous		
	Understorey		
	Ground		

	CHAN. WIDTH (m)	
	Stage	Dry L M H Fld
	Flow Char.	P S R B T
	Valley: Chan	0-2 2-5 5-10 10+ N/A
	Confinement	Ent Conf Fr Oc Un N/A
	Pattern	St Sin Ir Im Rm Tm
	Vert. Stab.	Deg ? Agr N/A
	Side Chan	Nil L M H

System Name ____
No. ____
Survey Date ____ (yr mo day) Compiling Agency ____ Field Obs. ____
Access ____ Weather ____
Field Photo Init. ____ Photo Nos. ____
Photo Interp. Init. ____ NTS Sheets ____ , ____ , ____
Air Photo. ____ : ____ Yr. ____ Scale 1: ____

FISH SUMMARY

C	Species	Use	Ref	Map

STREAM FEATURE

F	Type Code	Ht (m)	Length (m)

	Channel Debris	Nil L M H		Stable Debris (%)
	Floodplain Debris	Nil L M H		Turbidity Nil L M H

(Fish)

(Width) (Vall:Chan) (Slope) (Bed Material)

R 5 80

SOURCE: Belford and Chamberlin 1980.

TABLE A-2

Hierarchical Codes for Fluvial Systems
in the Jason Property Area, Macmillan Pass, Yukon

64 Pelly River Tributaries		62 Stewart River Tributaries	
		62	Stewart River
64	Pelly River	6030	Hess River
1600	Macmillan River	405	Unnamed Creek (L. Bank)
700	North Macmillan River	100	Unnamed Creek (R. Bank)
710	South Macmillan River	160	Unnamed Creek (Nidd Creek)
900	Unnamed Creek (R. Bank)	180	Unnamed Creek (R. Bank)
910	Unnamed Creek (Sekie Creek #1)	010	Unnamed Creek (L. Bank)
930	Unnamed Creek (Tom Creek)	010	Unnamed Creek (R. Bank)
940	Unnamed Creek (Sekie Creek #2)	190	Unnamed Creek (L. Bank)
		200	Unnamed Creek (L. Bank)
		210	Unnamed Creek (R. Bank)

SOURCE: D. Davies, Government of Yukon, Department of Renewable Resources.

The following material

is taken from

Chamberlin 1980a, b

and is presented here for

assistance in the interpretation

of the aquatic assessment

portion of this report

REACH DATA CARDS

Card Ref. No.	Field Name	Field Limits	Field Width	Field Type	Field and Data Entry Instructions
1	Reach No.	Z999.99Z	7	A/N	Mandatory. Reach numbers are assigned in upstream integer sequence with the number placed to the left of the implied decimal point. Reach numbers are a 7 character code of the following form: 1 character DISTRIBUTARY code, if applicable. 3 digit max., integer reach number. 2 digit max., "complex" number to the right of implied decimal point. 1 character ARCHIVE code, if applicable. Assignment of distributary codes, complex reach numbers and archive codes (see "Aquatic Survey Terminology") requires special instructions.
2	System Name		20	A	Mandatory. Either UNNAMED or the exact name listed in the watershed code dictionary, with particular attention to spelling and punctuation. Separate compound names with a slash. Abbreviate River as R, Lake as L and Creek as C. An alias may be written to the right of the name if in brackets or quotes. Note: all watershed names in the dictionary should be gazetted. Any errors or discrepancies must be reported to the Aquatics Studies Branch.
3	System No.		21	N	Mandatory. As given in dictionary. All significant digits should be recorded plus one extra zero. (e.g. 92 0341 0)
4	Survey Date		6	N	Mandatory. Two digits for each of year, month, and day. $ permitted only for month and day (e.g. 77-$-$). If month or day is not known record as zeroes (e.g. 770000). Year is mandatory. Month and day must not be blank.
5	Compiling Agency		3	A/N	Use "Agency/Reference" code. $ okay.
6	Field Obs.	ZZZ/ZZZ	7	A	Two observers maximum. Use initials as code with three letters maximum for each observer, separated by a slash. Do not put periods after each initial. $ okay. If air photo interpretation only, leave blank.
7	Access		2	A/N	Use "Access" code. Record major form of access only.
8	Weather		30	A/N	If possible, limit to 8 characters.
9	Field Photo Init. & Photos Nos.				Any convention useful for the survey may be used. Only Yes or No is stored in data base. $ stored as yes.
10	Photo Interp. Init.	ZZZ	3	A/N	$ okay.
11	NTS Sheets		23	A/N	MAXIMUM of 3 sheet numbers, separated by commas (e.g. 92F8, 92F9, 92F10). $ okay.
12	Air Photo	1 photo #	12	A/N	Only record one photo no. in this area; maximum 12 characters. Record additional numbers on card as a "CX" comment. Colon (:) between flight line and photo number. Preface flight line with appropriate provincial or federal code (BC or A, resp.). e.g. provincial BC#####:### federal A#####:### $ okay.
	Year		2	N	Last 2 digits only. $ okay.

REACH DATA CARDS

Card Ref. No.	Field Name	Field Limits	Field Width	Field Type	Field and Data Entry Instructions
	Scale		7	N	Natural scale (e.g. 1:15 284); NOT chains or feet to the inch. Maximum 7 digits, not including the "1:".
13	Active Valley Proc. (all categories)				Use "Valley Wall Process Location" code (M, F or B) and circle one of Nil, L, M or H. Nil: Nowhere present L: Less than 5 % of valley walls M: 5-25% of valley wall H: Greater than 25% of valley walls
14	Bar Presence (all categories)				Circle one of Nil, L, M or H: Nil: Not present in reach L: One or two isolated examples. Less than 10% of channel area M: 10-50% of channel area at low flow H: Greater than 50% of channel area at low flow
15	Lateral Channel Movement Apparently Stable Bar Veg. Progressions Cut Offs/Ox Bows Meander Scars				For Apparently Stable circle Yes or No. For Bar Veg. Progressions, Cut Offs/Ox Bows and Meander Scars circle one or Nil, L, M or H. Nil: No indicators exist in valley flat L: A single indication exists M: Indicators present in small groups H: Indicators repeat continuously through reach
16	Avulsions	0 - 9	1	N	Circle Yes or No and how many to a maximum of 9.
17	Terraces, Constrictions	0 - 9	1	N	Circle Yes or No and how many terrace levels, to a maximum of 9. The same terrace level on both sides of a river is 1 terrace. Likewise constriction locations.
18	Unstable banks (%)	0 - 99	2	N	If value is 100%, enter 99.
19	Total pools (%), Bedrock Control (%)	0 - 99	2	N	If value is 100%, enter 99.
20	Bed Material	0 - 90 T F,G,L or R	2 1	N or A	Enter percentage, rounded to nearest 10%, or T (trace) if <5%, or 0, as appropriate, for each category. If one category value is equal to 100%, enter F (fines), G (gravels), L (larges) or R (bedrock) in the appropriate place. Comment and circle dominant material in fines category if known. Bed material total must sum to 100%. Note: Code for 100% Bedrock is R and should not be confused with the map symbol use of the same code to indicate a trace of bedrock.
21	Channel Cover Crown Overhang % Area Distr.	 0 - 100 0 - 9	 3 1	 N N	Enter 0 - 100 for % Area and 0 - 9 from "Vegetation Distribution" code for Distr. Trace is NOT allowed.
22	Riparian Veg. Coniferous Deciduous Understorey Ground Sp. Distr.	 0 - 9 0 - 9	 1 1	 N N	For each vegetation category: enter number (1-9) of appropriate species list (labelled S# on card back) in Sp column; enter 0 - 9 from "Vegetation Distribution" code in Distr. column.
23	Channel Width	0 - 9999 0 - 99.9	4	N	Decimal allowed as indicated. Do not enter units.

REACH DATA CARDS

Card Ref. No.	Field Name	Field Limits	Field Width	Field Type	Field and Data Entry Instructions
24	Stage Flow Char. Valley:chan Confinement Pattern Vert. Stab. Side Chan				Circle appropriate category. For flow character: 2 categories okay; comment dominant character. For vertical stability: use ? when channel does not show clear signs of either degrading or aggrading (i.e., it is probably in equilibrium) For relative side channel abundance: Nil: No side channels in reach L: One or two side channels M: Side channels up to 25% of reach H: Zones of side channels over 25% of reach
25	Channel Debris, Floodplain Debris				Circle appropriate category. Nil: No debris L: Isolated bits; 1 or 2 clumps M: Few clumps; scattered pieces throughout reach H: Debris on most bars; large jams; greater than 25% of channel area covered.
26	Stable Debris (%)	0 - 99	2	N	If value is 100%, enter 99.
27	Turbidity				Circle appropriate category. Nil: Crystal clear; gin clear L: Slight turbidity but bottom can usually be seen in rivers less than 2 m deep M: Bottom usually not visible (i.e., visibility 0.1-2 m) H: Less than 0.1 m of visibility
28	Fish Summary Species Map Ref.		 4 1 3	 A A A/N	Use "Fish Species - Mapped and Non-mapped" code for all fish sampled, known or inferred to be in reach. 0 is a valid species (i.e., it tells the
	Use	max. of 3 uses	6	A	user that sampling occurred but no fish were caught). OS should not be used unless data are old (prior to 1980) and the actual fish species are unknown. Use brackets ( ) to infer species or use. Use "Fish Use" code and "Agency/Reference" code to record Use and Ref. Code reference even if obvious (e.g. code RAB or ASB, etc. as appropriate). Indicate with a check mark ( ) or Y (yes) if map has zonal (spawning, rearing) information. All species on fish or point cards must appear in the reach fish summary. If more than 8 fish species, continue list on another card. Indicate "continued" on the first card, re-enter mandatory data on the second card (items 1 to 4), and staple cards together. Use capital letters to code data elements (e.g. CT, IN).
29	Stream Feature Type HT (m) Length (m)	 ZZ99	 4	 A/N	Use "Stream Features" codes to record stream feature type. Point, lake, water quality and water quantity alphabetic codes are followed by a number (2 digits maximum). Only the feature comment number and the feature type are actually keypunched from this data source. Since there may be more than one feature of a particular type in a reach (e.g. 2 CS's), try to make feature comments explicit.
30	Reach Symbol				Must be identical to symbol on map. Slopes are recorded to nearest 0.1% if less than 3% and to nearest whole % if equal to or greater than 3%. Bed material format follows map legend (see Reach Map Symbol, Table 1), not that of card ref. 20.

REACH DATA CARDS

Card Ref. No.	Field Name	Field Limits	Field Width	Field Type	Field and Data Entry Instructions
31	Comments	CX C99 S99 F99	999 500 500 300	A/N A/N A/N A/N	Numbered comments (associated with parameters) must be preceded by C, S or F. General comments (CX), as well as like numbered attribute comments, are run together (concatenated) in output so be clear, concise and use punctuation (e.g. Comments written in tabular format on the card will not appear tabular on output). Strive for brevity since the record length is limited.

REACH MAP SYMBOL

2. Example (Reach Symbol)

Applied to stream reaches with full biophysical data available in RAB Aquatic Data Base.

Example:

Rb Ch↑ (Co) — Fish Species (see Box 3): Rainbow trout (present), Chinook (migration), Coho (probable)

9 B 1.5 | 2 3 4 1

Channel Components (see Box 4): Width = 9 metres; Valley flat to channel ration is between 2 and 5; Average reach slope = 1.5%

Bed (Substrate) Materials (see Box 5): Fines = 20%; Gravels = 30%; Larges = 40%; Bedrock = 10%

Note: 1) where the channel or substrate component is man-made, the symbol is underlined.
2) where channel or substrate data has not been verified the symbol is placed in parenthesis.

3. Fish Species

1. Sport and Commercial Species Abbreviations

Symbol	Species	Symbol	Species
Ch	Chinook salmon	DV	Dolly Varden Char
Co	Coho salmon	WF	Whitefish (unspecified)
Cm	Chum salmon	MW	Mountain Whitefish
Pk	Pink salmon	LW	Lake Whitefish
Sk	Sockeye salmon	Gr	Grayling
Ko	Kokanee salmon	LMB	Largemouth bass
Rb	Rainbow trout	SMB	Smallmouth bass
St	Steelhead trout	NP	Northern pike
Ct	Cutthroat trout (Coastal)	WP	Walleye pike (Pickerel)
YCt	Yellowstone Cutthroat trout	YP	Yellow perch
EB	Eastern Brook trout	Sg	Sturgeon
LT	Lake trout	Bb	Ling (Burbot)
GB	German Brown trout	Cp	Carp
BCB	Black crappie		

2. OS - indicates known but non-sport or non-commercial species, data bank must be consulted for complete species list.

3. Sp - indicates fish observed but not identified.

4. Ø - indicates fish not detected at time and place of sampling.

5. Absence of any fish species symbol indicates that no sampling information was available.

6. (Co) - indicates probable but unconfirmed presence.

7. Sk↑- indicates reach used by species for migration only, no resident population.

8. Note: no specific symbol exists for a barren stream. When such a condition is suspected, it may be indicated by (Ø) which is an inference that if sampling took place, fish would not be detected.

4. Channel Components

1. Channel width in metres. Equal to distance between rooted vegetation, including islands.

2. Valley flat to channel ratio. The ratio between width of valley flat and width of channel.

Map Designation	Ratio
A	0- 2
B	2- 5
C	5-10
D	10+
E	N/A (eg. Fan or delta)

3. Slope (elevation gain/reach length) calculated as an average for the reach, expressed as a percentage; measured from topographic base map.
   - >3% rounded off to the nearest percent.
   - <3% rounded off to 1 decimal place.

5. Bed (Substrate) Materials

Fines, gravels, larges and bedrock are listed in sequence to nearest 10%, expressed as an integer.

1. Fines 'F'; materials in the 0-2 mm size class
   Gravels 'G'; materials in the 2-64 mm size class
   Larges 'L'; materials greater than 64 mm
   Bedrock 'R'; consolidated materials

2. F, G, L or R used alone indicates 90-100% reach is in that size class.

3. A trace of bedrock (0-5%) may be indicated by R following the 3 material components (eg. 253R). Traces (0-5%) of fine, gravel, or large material are indicated by a 0 (eg. 0073).

STREAM FEATURES

ALLUVIAL SINK	AS	POINT SAMPLE	P
BLOCKS	BL	POND	PD
BRIDGE	BR	WATER QUANTITY SITE	QN
BEAVER DAM	BV	WATER QUALITY SITE	QU
CANYON	CN	REACH - DETAILED	R
CASCADE/CHUTE	CS	REACH - NON-DETAILED	H
CULVERT	CV	ROCK	RK
CHANNELIZATION	CZ	RAILWAY CROSSING	RR
DISTRIBUTARY INFORMATION	D	ROAD CROSSING	RX
DYKE	DK	SPRING	SP
MAN MADE DAM	DM	START OF THE SURVEY	SS
EXTENT STREAM SURVEYED	ES	TRIBUTARY WITH INFO	T
FORD	FD	SURVEY TERMINATION	TS
UNKNOWN FALL TYPE	FL	SUBSURFACE FLOW	UG
HABITAT IMPROVEMENT	HI	UPPER ZONAL BOUNDARY	UP
HEAD WATERS	HW	VELOCITY	VL
LAKE	L	WETLAND	WL
LOG	LG	SLUMP	WW
SPAWNING ZONE	OO	DEBRIS ACCUMULATION	XX
		FLOOD/SIDE CHANNEL ZONE	ZQ

VEGETATION DISTRIBUTION

NO PLANTS OBSERVED	0
RARE INDIVIDUAL PLANT	1
A FEW SCATTERED INDIVIDUALS	2
SINGLE PATCH OF SPECIES	3
SEVERAL SCATTERED INDIVIDUALS	4
FEW (SMALL) PATCHES	5
SEVERAL WELL SPACED PATCHES	6
CONTINUOUS COVER OF WELL SPACED INDIVIDUALS	7
CONTINUOUS DENSE COVER WITH A FEW SMALL OPENINGS	8
CONTINUOUS DENSE COVER UNINTERRUPTED	9

FLOW CHARACTER

BROKEN	B
PLACID	P
ROLLING	R
SWIRLING	S
TUMBLING	T

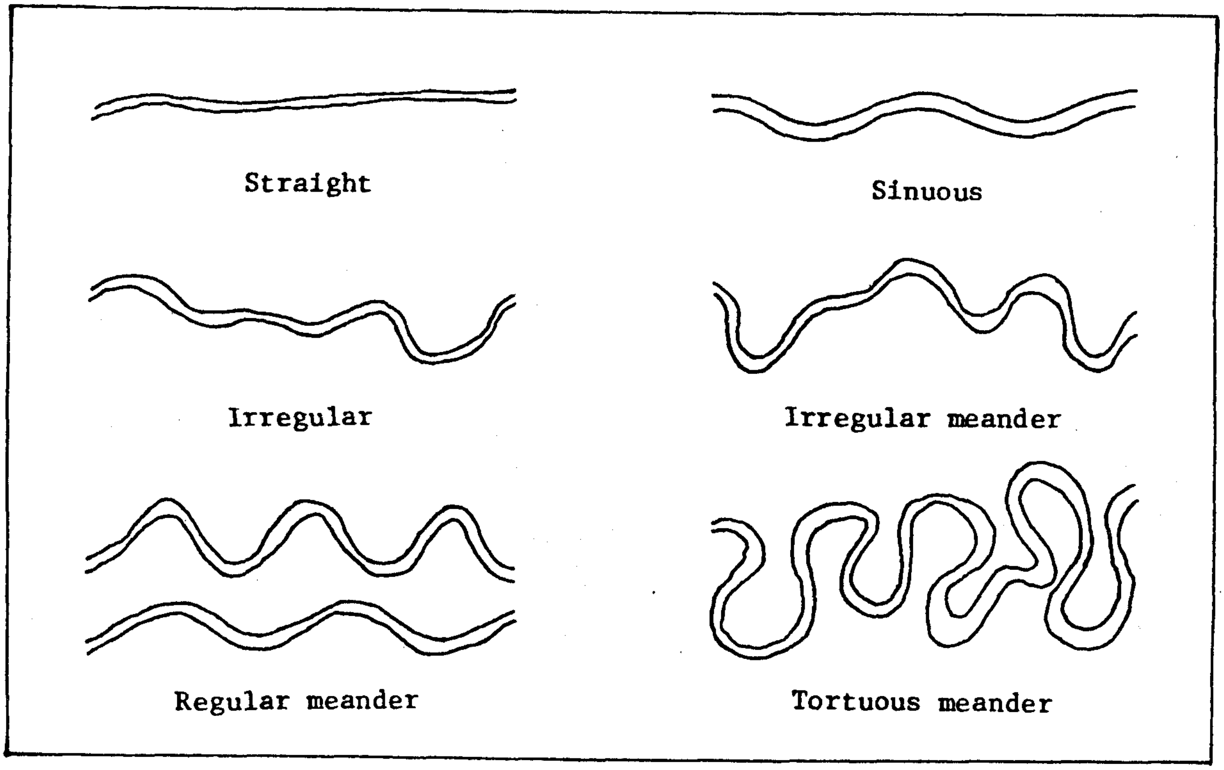
Selected Parameter

Definitions Used

On Reach Data Cards

pattern (R24) - The channel pattern of a reach described in terms of its relative meander curvature as follows:

St - straight - very little curvature within the reach.
Sin - sinuous - slight curvature within a belt of less than approximately two channel widths.
Ir - irregular - no repeatable pattern.
Im - irregular meander - a repeated pattern is vaguely present in the channel plan. The angle between the channel and the general valley trend is less than 90°.
Rm - regular meanders - characterized by a clearly repeated pattern.
Tm - tortuous meanders - a more or less repeated pattern characterized by angles greater than 90°.



valley:chan (P31,R24) - The ratio of the width of the valley flat (e.g. 80 m) to the width of the channel (e.g. 20 m) is calculated (e.g. 80/20 = 4/1). The numerator of the reduced ratio (4) is grouped into one of the following classes: 0-2, 2-5, 5-10, 10+ or not applicable (e.g. a delta). In a reach map symbol these are characterized by A,B,C,D,E respectively.

vertical stability (R24) - An indication of the net effect over a long time period of processes of deposition or scour of the stream bed in a reach. Described either as degrading (Deg), aggrading (Agr), not obviously aggrading or degrading (?) and not applicable.

confinement (R24) - The degree to which the river channel is limited in its lateral movement by relic terraces or valley walls. The channel is either:

entrenched - The stream bank is in continuous contact (coincident) with valley walls or terraces (see entrenchment).

confined - In continuous or repeated contact at the outside of major meander bends.

frequently confined - Frequently confined by the valley wall or terraces.

occasionally confined - Occasionally confined by the valley wall or terraces.

unconfined - Not touching the valley wall or terraces.

not applicable - No valley wall exists.

APPENDIX B

AQUATIC HABITAT ASSESSMENT

DETAILED REACH DESCRIPTIONS

AQUATIC HABITAT ASSESSMENT

APPENDIX B - DETAILED REACH DESCRIPTIONS

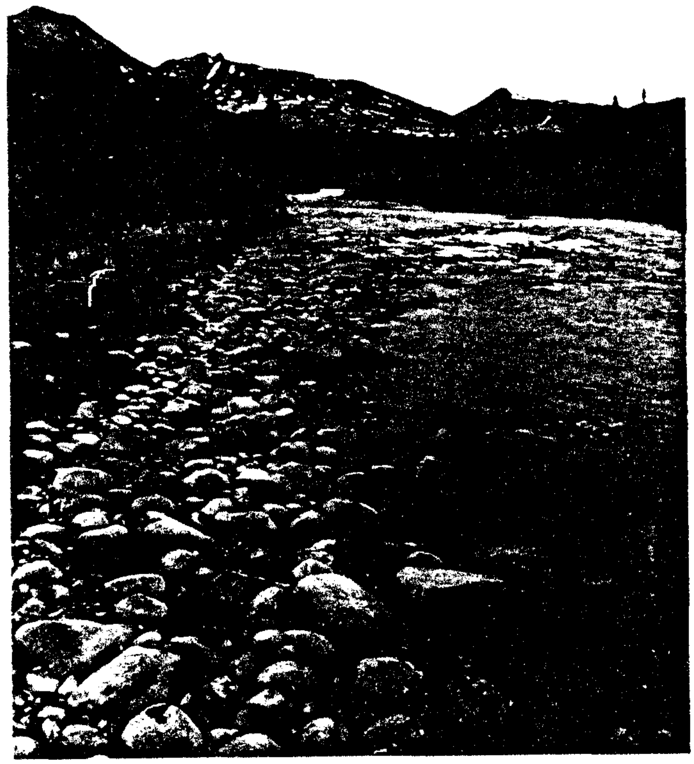
CONTENTS

PAGE

FIGURES

Stream Description: South Macmillan River
Watershed Code Number: 64-1600-710

Reach Number: R21
Reach Symbol: Gr / 12D 0.6 | 1180



Reach Card Data:

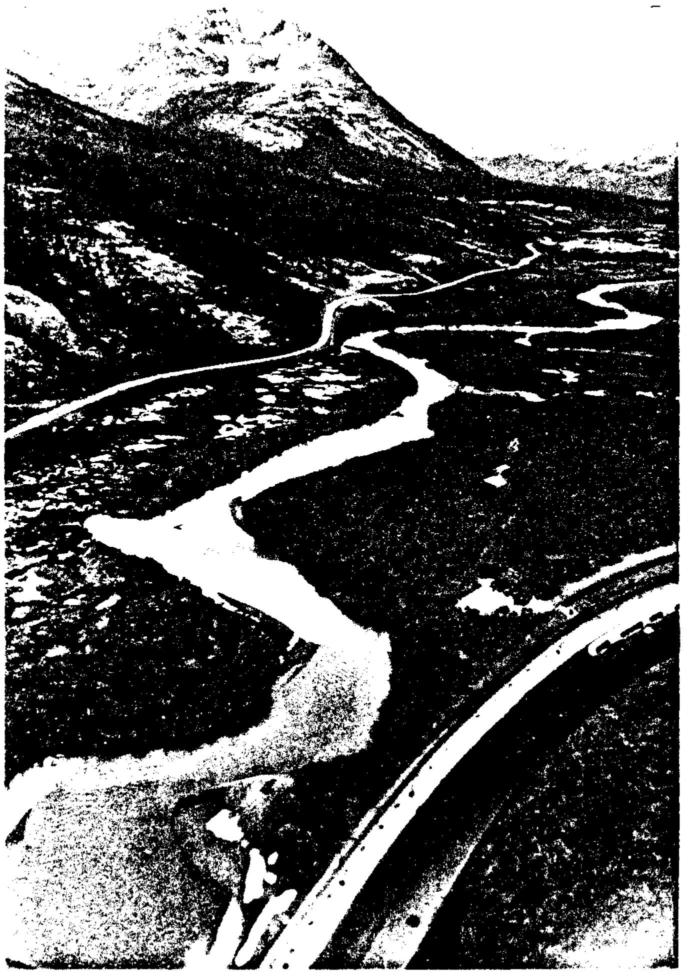
Date: 1981-08-19

(a) Active Valley Wall Process: Debris Flow (L)
(b) Bar Presence: Side/Point (L); Lee (L)
(c) Lateral Channel Movement: Apparently Stable
(d) Total Pools (%): 10%
(e) Channel Cover: Crown (% Area): 0
Overhang (% Area): Trace
(f) Riparian Vegetation (Dist): Coniferous (2); Decid. (2); Understory (8); Ground (8)
(g) Stage: L
(h) Flow Characteristics: B
(i) Confinement: Oc
(j) Pattern: Im
(k) Vertical Stability: ?
(l) Side channels: L
(m) Channel Debris: L ; Floodplain Debris: L ; Stable Debris: 50
(n) Turbidity: M
(o) Observations and comments:
- Arctic grayling captured in reach.
- one fry-size fish observed in side channel in reach.
- moderate quality fish habitat and overwintering potential.

(p) Unstable Banks (%): 10-20
(q) Bedrock control (%): 0
Distribution: -
Distribution: 2

Stream Description: South Macmillan River
Watershed Code Number: 64-1600-710

Reach Number: R22
Reach Symbol: Ø / 11D 0.6 | 2440



Reach Card Data:

Date: 1981-08-20

(a) Active Valley Wall Process: Slide (L)
(b) Bar Presence: Side/Point (M);Mid-Channel (L);Transverse (L);Junction (L); Islands (L)
Bar Veg. Progressions - (L);Cutoffs/Ox Bows-(L);Meander Scars (L);Avulsions-Yes
(c) Lateral Channel Movement: Apparently Stable
(d) Total Pools (%): 25%
(e) Channel Cover: Crown (% Area): 0
Overhang (% Area): 2
(f) Riparian Vegetation (Dist): Coniferous (4);Decid. (4);Understory (8);Ground (8)
(g) Stage: L
(h) Flow Characteristics: R
(i) Confinement: Oc
(j) Pattern: Im
(k) Vertical Stability: ?
(l) Side channels: L
(m) Channel Debris: L ; Floodplain Debris: L ; Stable Debris: 80%
(n) Turbidity: M
(o) Observations and comments:
- reach appears to have suitable fish habitat for spawning, feeding and overwintering.
- electroshocking produced no fish during sampling program.

(p) Unstable Banks (%): 5
(q) Bedrock control (%): 0
Distribution: -
Distribution: 6

Stream Description: Unnamed Trib - South Macmillan R.
Watershed Code Number: 64-1600-710-900

Reach Number: R2
Reach Symbol: Ø / .5D 11| 3610

Reach Card Data:

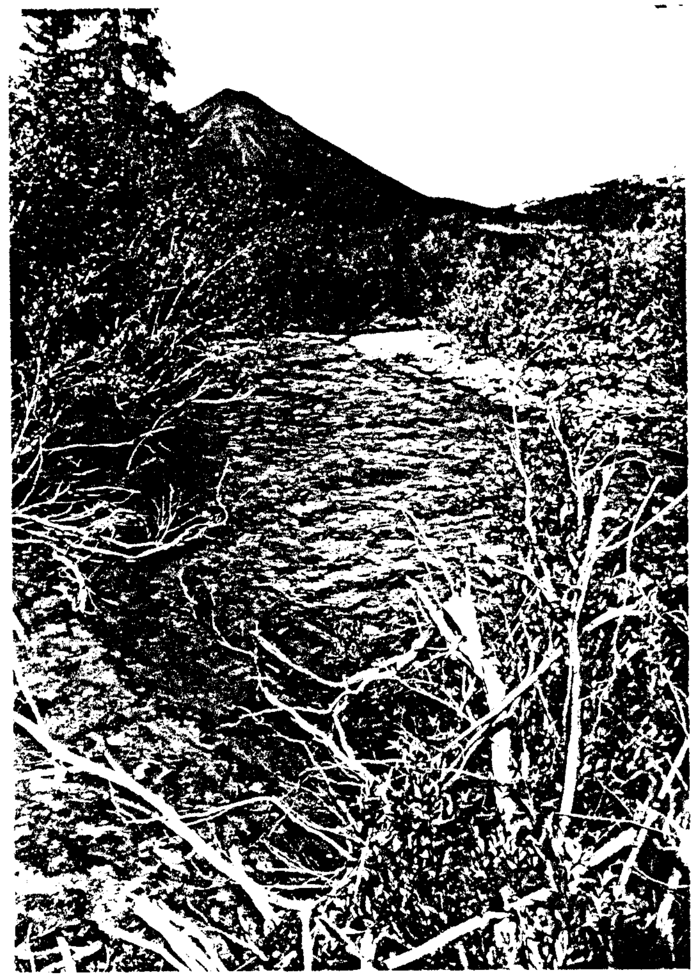
Date: 1981-08-19

(a) Active Valley Wall Process: Nil
(b) Bar Presence: Nil
(c) Lateral Channel Movement: Apparently Stable
(d) Total Pools (%): ?
(e) Channel Cover: Crown (% Area): 0
Overhang (% Area): 100
(f) Riparian Vegetation (Dist): Coniferous (2);Decid. (0);Understory (9);Ground (9)
(g) Stage: L
(h) Flow Characteristics: T
(i) Confinement: Un
(j) Pattern: Ir
(k) Vertical Stability: ?
(l) Side channels: Nil
(m) Channel Debris: L ; Floodplain Debris: L ; Stable Debris: (%)-50
(n) Turbidity: L
(o) Observations and comments:
- stream heavily undercuts and is overgrown by understory and ground vegetation.
- values for some stream parameters questionable due to extensive and heavy vegetative overgrowth.
- some erosion and stream sedimentation evident due to drilling activity on Jason Ridge.
- poor quality fish habitat; no overwintering potential.

(p) Unstable Banks (%): 0
(q) Bedrock control (%): 0
Distribution: 0
Distribution: 9

Stream Description: Sekie Creek #1
Watershed Code Number: 64-1600-710-910

Reach Number: R1
Reach Symbol: Ø / 4D 6|0280



Reach Card Data:

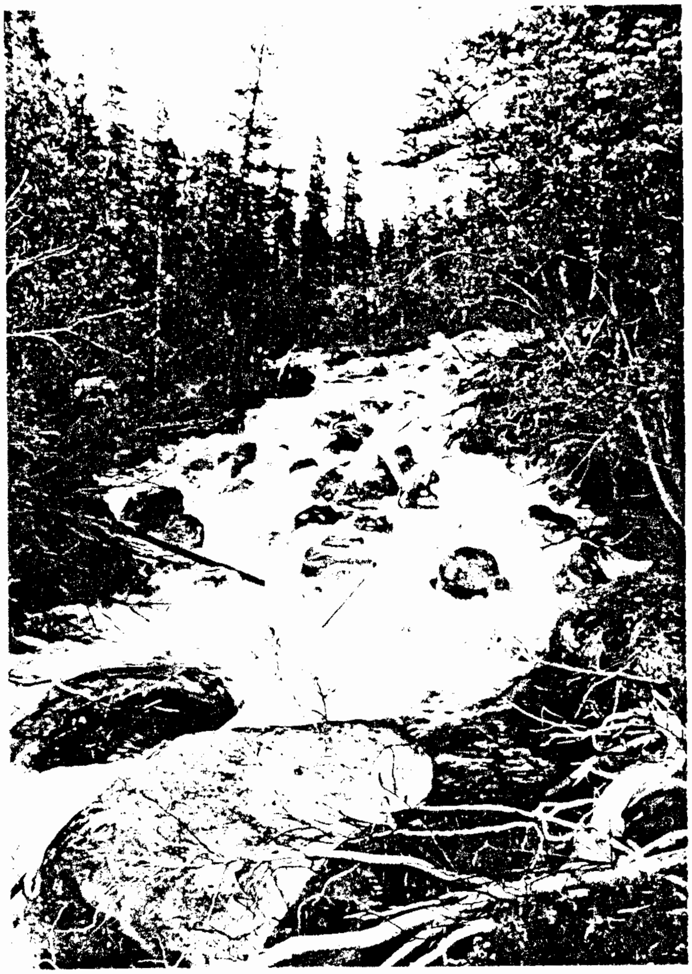
Date: 1981-08-19

(a) Active Valley Wall Process: Nil
(b) Bar Presence: Side/Point (L); Mid Channel (L); Transverse (L)
(c) Lateral Channel Movement: Apparently Stable
(d) Total Pools (%): 20%
(e) Channel Cover: Crown (% Area): -
Overhang (% Area): 20
(f) Riparian Vegetation (Dist): Understory (8); Ground (9)
(g) Stage: L
(h) Flow Characteristics: B
(i) Confinement: Un
(j) Pattern: Im
(k) Vertical Stability: ?
(l) Side channels: L
(m) Channel Debris: L ; Floodplain Debris: Nil ; Stable Debris: 80%
(n) Turbidity: Nil
(o) Observations and comments:
- stream used as water supply for Cordilleran Engineering base camp.
- electroshocking produced no fish.

(p) Unstable Banks (%): 10
(q) Bedrock control (%): 0
Distribution: -
Distribution: 8

Stream Description: Sekie Creek #1
Watershed Code Number: 64-1600-710-910

Reach Number: R2
Reach Symbol: 8 / 3D 22| 0280



Reach Card Data:

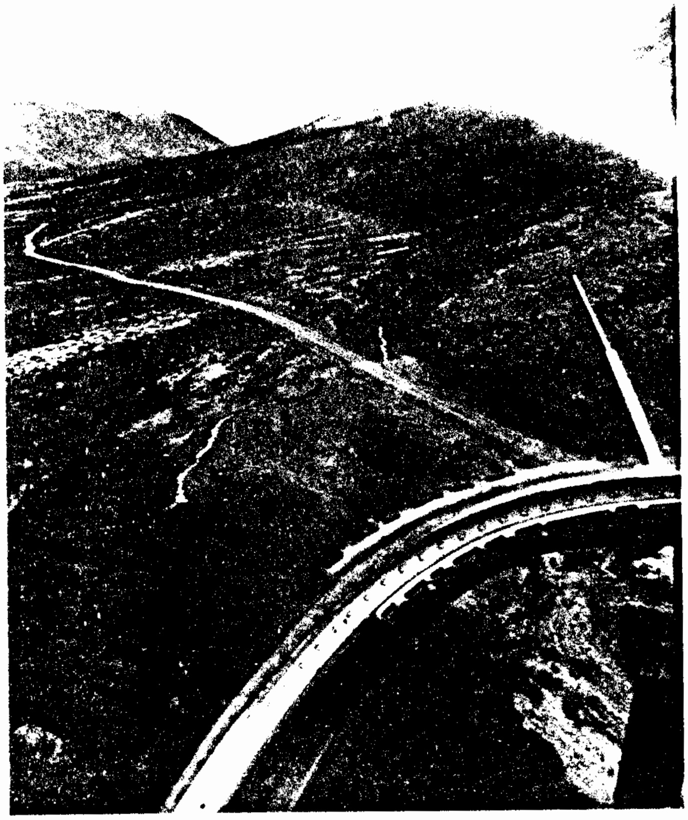
Date: 1981-08-19

(a) Active Valley Wall Process: Debris Flow (L)
(b) Bar Presence: Nil
(c) Lateral Channel Movement: Apparently Stable
(d) Total Pools (%): 0
(e) Channel Cover: Crown (% Area): 5
Overhang (% Area): 10
(f) Riparian Vegetation (Dist): Coniferous (5);Decid. (4);Understory (7);Ground (8)
(g) Stage: L
(h) Flow Characteristics: T
(i) Confinement: Un
(j) Pattern: Ir
(k) Vertical Stability: ?
(l) Side channels: L
(m) Channel Debris: M ; Floodplain Debris: L ; Stable Debris: 50%
(n) Turbidity: Nil
(o) Observations and comments:
- stream used as water supply for Cordilleran Engineering base camp.
- stream not suitable fish habitat due to steep gradient and no pools.

(p) Unstable Banks (%): 0
(q) Bedrock control (%): 0
Distribution: 6
Distribution: 7

Stream Description: Tom Creek
Watershed Code Number: 64-1600-710-930

Reach Number: R2
Reach Symbol: $\frac{8}{.3D \quad 25 | R*}$



Reach Card Data:

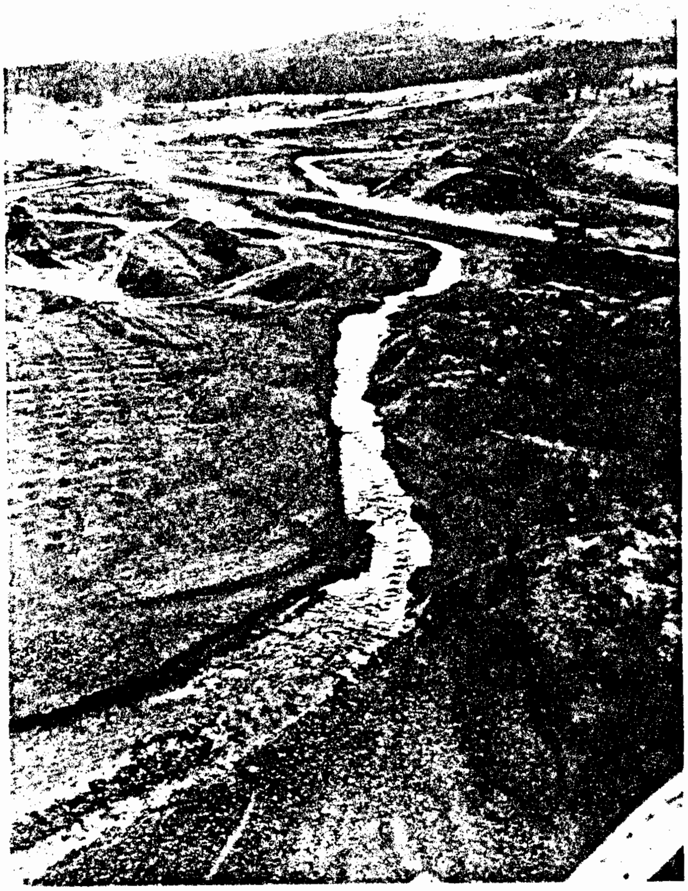
Date: 1981-08-19

(a) Active Valley Wall Process: Slide (L)
(b) Bar Presence: Nil
(c) Lateral Channel Movement: Apparently Stable
(d) Total Pools (%): 10
(e) Channel Cover: Crown (% Area): -
Overhang (% Area): 10
(f) Riparian Vegetation (Dist): Understory (7); Ground (9)
(g) Stage: Low
(h) Flow Characteristics: B
(i) Confinement: Ent
(j) Pattern: Ir
(k) Vertical Stability: Agr
(l) Side channels: L
(m) Channel Debris: L ; Floodplain Debris: M ; Stable Debris: 30%
(n) Turbidity: Nil
(o) Observations and comments:
- R* - boulder and gravel substrate cemented together with iron rich precipitate to form bedrock - like stubstrate.
Interstices absent between rocks.

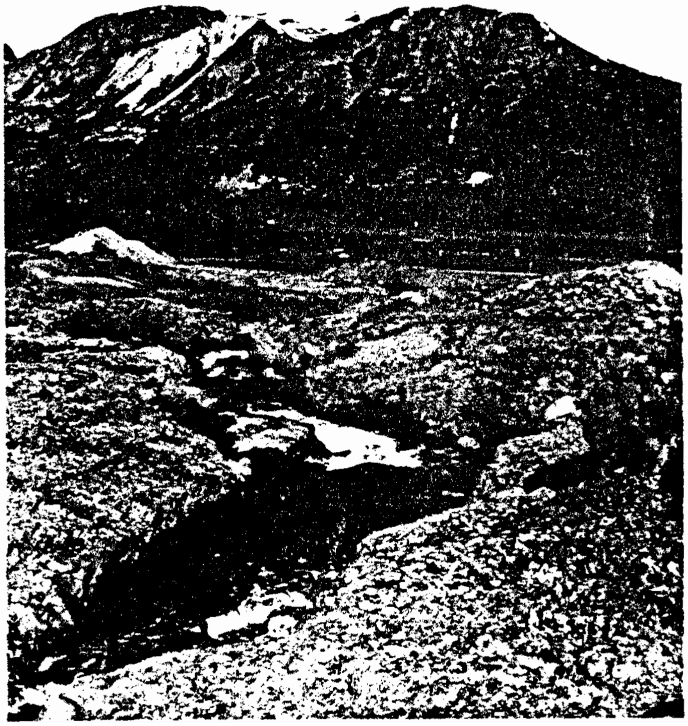
(p) Unstable Banks (%): 0
(q) Bedrock control (%): 0
Distribution: -
Distribution: 6

Stream Description: Sekie Creek #2
Watershed Code Number: 64-1600-710-940

Reach Number: R2
Reach Symbol: 8 / 3D 20 | 0280



R1



R2

Reach Card Data.

Date: 1981-08-20

(a) Active Valley Wall Process: Slide (L); Gully (L)
(b) Bar Presence: Nil
(c) Lateral Channel Movement: Apparently Stable
(d) Total Pools (%): 10
(e) Channel Cover: Crown (% Area): 0
Overhang (% Area): 0
(f) Riparian Vegetation (Dist): Conif (4);Decid. (0);Understory (6);Ground (6)
(g) Stage: L
(h) Flow Characteristics: B
(i) Confinement: Oc
(j) Pattern: Ir
(k) Vertical Stability: Degrading
(l) Side channels: Nil
(m) Channel Debris: L ; Floodplain Debris: L ; Stable Debris: (%) - 100
(n) Turbidity: M
(o) Observations and comments:
- no reach data collected for R1 due to extensive alternations to stream channel caused by nearby gravel crushing operation & airstrip extension.
- new road construction has occurred along R2 causing increasing turbidity.
- turbidity evident during rains.
- stream has been extensively impacted by road and airstrip construction and upsteam exploration activity.

(p) Unstable Banks (%): 0
(q) Bedrock control (%): 0
Distribution: -
Distribution: -

Stream Description: Hess River Tributary
Watershed Code Number: 62-6030-405-100

Reach Number: R3
Reach Symbol: -θ- / 3D 1.3| 0190

Reach Card Data:

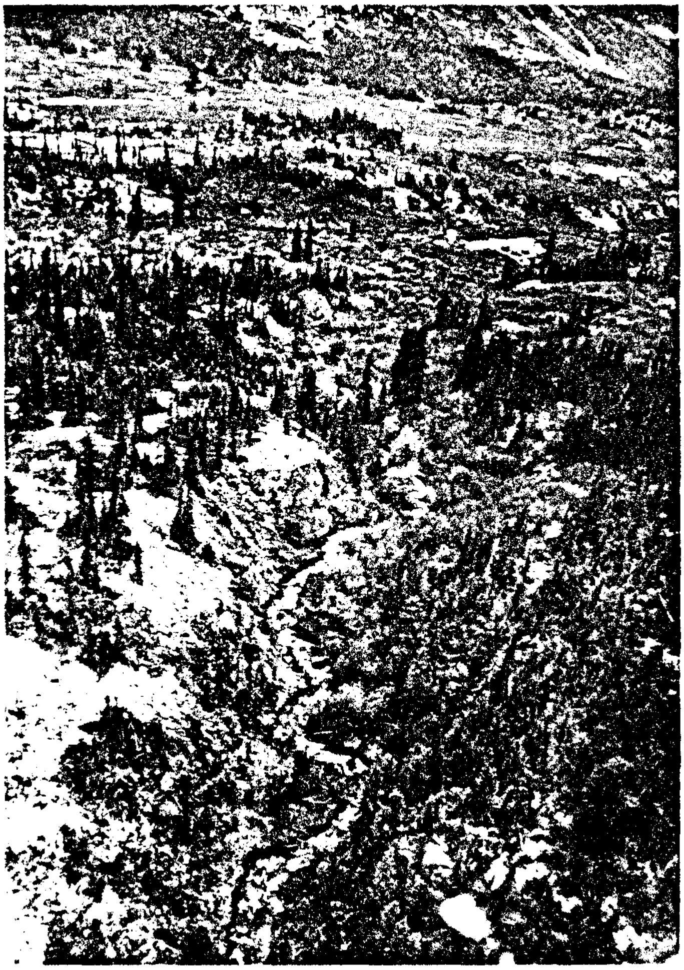
Date: 1981-08-19

(a) Active Valley Wall Process: Debris flow (L)
(b) Bar Presence: Nil
(c) Lateral Channel Movement: Apparently Stable
(d) Total Pools (%): 10
(e) Channel Cover: Crown (% Area): 0
Overhang (% Area): 20
(f) Riparian Vegetation (Dist): Coniferous (2);Decid. (0);Understory (8);Ground (8)
(g) Stage: L
(h) Flow Characteristics: T
(i) Confinement: Oc
(j) Pattern: Ir
(k) Vertical Stability: ?
(l) Side channels: Nil
(m) Channel Debris: L ; Floodplain Debris: L ; Stable Debris: (%) 80
(n) Turbidity: Nil
(o) Observations and comments:
- stream has high gradient in this reach and has negligible holding water for fish.
- a single terrace is located in valley.
- poor fish habitat and overwintering potential.

(p) Unstable Banks (%): 10
(q) Bedrock control (%): 0
Distribution: 0
Distribution: 6

Stream Description: Nidd Creek
Watershed Code Number: 62-6030-405-100-160

Reach Number: R1
Reach Symbol: 0 / 2D 12| 0280



Reach Card Data:

Date: 1981-08-19

(a) Active Valley Wall Process: Debris Flow (L)
(b) Bar Presence: Nil
(c) Lateral Channel Movement: Apparently Stable
(d) Total Pools (%): 10
(e) Channel Cover: Crown (% Area): 20
Overhang (% Area): 40
(f) Riparian Vegetation (Dist): Coniferous (6);Decid. (7);Understory (8);Ground (8)
(g) Stage: L
(h) Flow Characteristics: T
(i) Confinement: Oc
(j) Pattern: Ir
(k) Vertical Stability: ?
(l) Side channels: Nil
(m) Channel Debris: L ; Floodplain Debris: L ; Stable Debris: (%)-50
(n) Turbidity: M
(o) Observations and comments:
- Cominco camp and drilling sites near Nidd Creek occasionally contribute to increased turbidity in stream. (See Photographs 4-6, 4-7.)
- negligible fish holding water and overwintering potential.

(p) Unstable Banks (%): 10
(q) Bedrock control (%): 0
Distribution: 6
Distribution: 8

Stream Description: Hess River Tributary
Watershed Code Number: 62-6030-405-100

Reach Number: R4
Reach Symbol: 8 / 3D 1.3 | 0280

Reach Card Data:

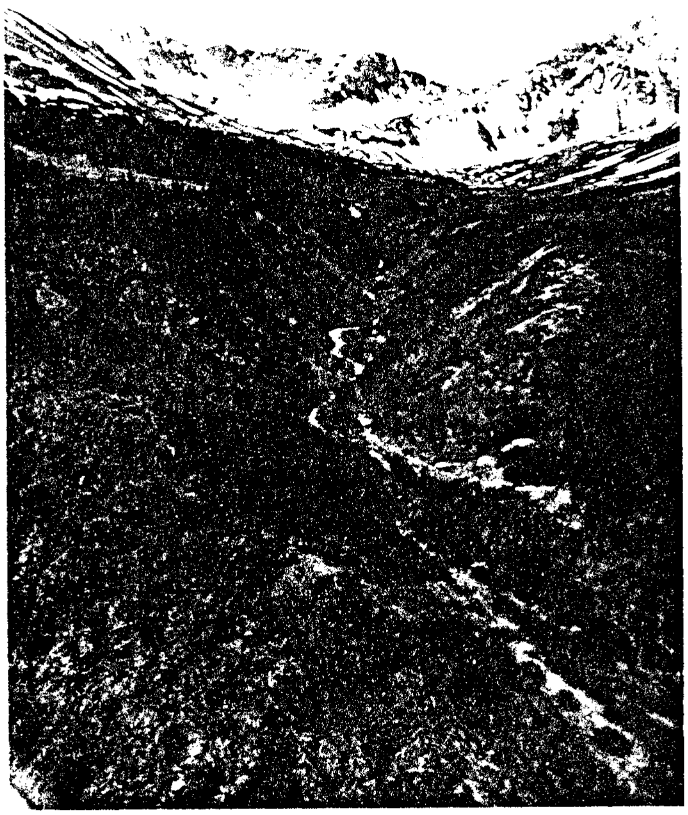
Date: 1981-08-19

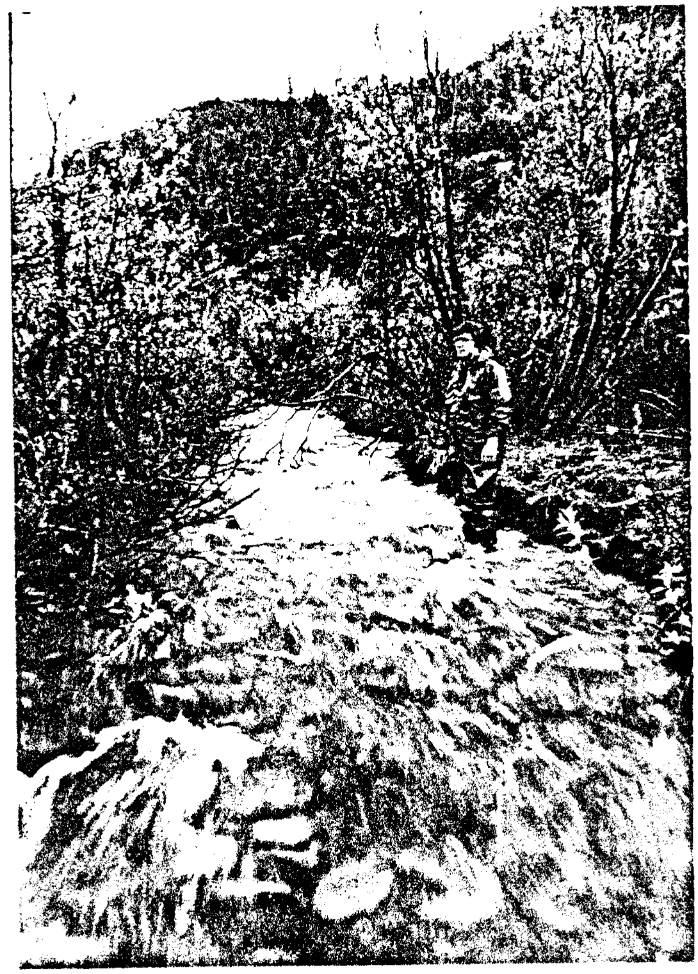
(a) Active Valley Wall Process: Debris Flow (L)
(b) Bar Presence: Side/Point (L)
(c) Lateral Channel Movement: Apparently Stable
(d) Total Pools (%): 10
(e) Channel Cover: Crown (% Area): 0
Overhang (% Area): 30
(f) Riparian Vegetation (Dist): Coniferous (1); Decid (2); Understory (7); Ground (8)
(g) Stage: L
(h) Flow Characteristics: B
(i) Confinement: Un
(j) Pattern: Ir
(k) Vertical Stability: ?
(l) Side channels: Nil
(m) Channel Debris: L ; Floodplain Debris: L ; Stable Debris: (%) 90
(n) Turbidity: L
(o) Observations and comments:
- active beaver dam construction occurring in this reach.
- low quality fish habitat and low overwintering potential due to lack of pools and shallow water.

(p) Unstable Banks (%): 5
(q) Bedrock control (%):0
Distribution: 0
Distribution: 6

Stream Description: Hess River Tributary
Watershed Code Number: 62-6030-405-100-190

Reach Number: R5
Reach Symbol: 8 / 4C 1.3| 0190





Reach Card Data:

Date: 1981-08-19

(a) Active Valley Wall Process: Nil
(b) Bar Presence: Nil
(c) Lateral Channel Movement: Apparently Stable
(d) Total Pools (%): 10
(e) Channel Cover: Crown (% Area): 0
Overhang (% Area): 30
(f) Riparian Vegetation (Dist): Coniferous (2);Decid. (5);Understory (6);Ground (8)
(g) Stage: L
(h) Flow Characteristics: T
(i) Confinement: Conf
(j) Pattern: Ir
(k) Vertical Stability: Deg.
(l) Side channels: Nil
(m) Channel Debris: L ; Floodplain Debris: Nil ; Stable Debris: (%) -
(n) Turbidity: Nil
(o) Observations and comments:
- meltwater stream with high gradient.
- no fish holding water.
- very cold and unproductive.

(p) Unstable Banks (%): 10
(q) Bedrock control (%): 0
Distribution: 0
Distribution: 6

Stream Description: Hess River Tributary
Watershed Code Number: 62-6030-405-100-190

Reach Number: R6
Reach Symbol: 8 / 4A 1.6| 0190

Reach Card Data:

Date: 1981-08-09

(a) Active Valley Wall Process: Debris Flow (M)
(b) Bar Presence: Nil
(c) Lateral Channel Movement: Apparently Stable
(d) Total Pools (%): 20
(e) Channel Cover: Crown (% Area): 0
Overhang (% Area): 0
(f) Riparian Vegetation (Dist): None
(g) Stage: L
(h) Flow Characteristics: T
(i) Confinement: Conf
(j) Pattern: Ir
(k) Vertical Stability: Deg.
(l) Side channels: Nil
(m) Channel Debris: Nil ; Floodplain Debris: Nil ; Stable Debris: (%) -
(n) Turbidity: Nil
(o) Observations and comments:
- numerous cascades and small waterfalls in reach that could be potential fish migration barriers.
- negligible fish holding water or overwintering potential.

(p) Unstable Banks (%): 30
(q) Bedrock control (%): 0
Distribution: -
Distribution: 0

Stream Description: Hess River Tributary
Watershed Code Number: 62-6030-405-100-190

Reach Number: R7
Reach Symbol: 8 / 4D 8 | 0190

Reach Card Data:

Date: 1981-08-19

(a) Active Valley Wall Process: Debris Flow (L)
(b) Bar Presence: Nil
(c) Lateral Channel Movement: Apparently Stable
(d) Total Pools (%): 10
(e) Channel Cover: Crown (% Area): 0
Overhang (% Area): 10
(f) Riparian Vegetation (Dist): Coniferous (5);Decid. (2);Understory (5);Ground (6)
(g) Stage: L
(h) Flow Characteristics: T
(i) Confinement: Un
(j) Pattern: Ir
(k) Vertical Stability: Deg.
(l) Side channels: Nil
(m) Channel Debris: Nil ; Floodplain Debris: Nil ; Stable Debris: (%) -
(n) Turbidity: Nil
(o) Observations and comments:
- negligible fish holding water or overwintering potential.

(p) Unstable Banks (%): 10
(q) Bedrock control (%): 0
Distribution: 0
Distribution: 5

Stream Description: Unnamed Tributary to Hess R. Trib.
Watershed Code Number: 62-6030-405-180-010

Reach Number: R2
Reach Symbol: θ / .5D 10| 1810

Reach Card Data:

Date: 1981-08-19

(a) Active Valley Wall Process: Slide (L)
(b) Bar Presence: Side/Point (L)
(c) Lateral Channel Movement: Apparently Stable
(d) Total Pools (%): 20
(e) Channel Cover: Crown (% Area): 0
Overhang (% Area): 20
(f) Riparian Vegetation (Dist): Coniferous (2);Decid. (2);Understory (6);Ground (9)
(g) Stage: L
(h) Flow Characteristics: B
(i) Confinement: Oc
(j) Pattern: Ir
(k) Vertical Stability: ?
(l) Side channels: Nil
(m) Channel Debris: Nil ; Floodplain Debris: Nil ; Stable Debris: (%)-
(n) Turbidity: Nil
(o) Observations and comments:
- reach located above waterfall.
- no potential as fish habitat.

(p) Unstable Banks (%): 0
(q) Bedrock control (%): 0
Distribution: 0
Distribution: 6

APPENDIX C

MACROBENTHOS

DATA

TABLE C-1

Organisms Collected in Surber Samples

	SM1	SM2	SM3	SM4	HR1
Annelida					
Oligochaeta	0,0,1				1,0,0
Arthropoda					
Insecta					
Plecoptera	5,3,4	2,0,0			3,3,4
Perlodidae	3,0,0				2,2,1
Megarcys	0,0,1				0,0,3
Chloroperlidae	9,1,3		3,0,0		3,7,3
Nemouridae			1,0,0		3,1,2
Zapada	6,1,3	1,0,0			4,2,4
Taeniopterigidae	0,3,1				
Doddsia		0,0,1			
Trichoptera					
Rhyacophilidae					
Rhyacophila	0,0,1				0,0,1
Limnephilidae					
Ecclisomyia				0,0,1	0,0,1
Diptera					
Chironomidae	5,15,7	0,1,1		0,0,1	14,8,17
Tipulidae	2,0,2				0,1,0
Empididae					2,1,0

NOTE: Numbers separated by commas represent replicates.

TABLE C-2

Organisms Collected in Pot Samplers

	SM1	SM2	SM3	SM4	HR1
Annelida					
Oligochaeta		2,0			0,0,2
Arthropoda					
Insecta					
Plecoptera					0,1,0
Perlodidae					0,0,3
Chloroperlidae	0,1				0,0,1
Nemouridae					
Zapada	0,1				
Trichoptera					
Limnephilidae					
Ecclisomyia					0,0,1
Diptera	1,2	1,0		0,1,0	
Chironomidae	2,4	3,0		0,1,1	1,1,27
Tipulidae	1,0	1,0			0,0,3
Empididae					0,1,0
Lepidoptera		1,0			
Collembola					
Isotomidae		2,0			

Note: Numbers separated by commas represent replicates.

SM1, SM2 & SM3 - Results of 2 samplers
SM4 & HR1 - Results of 3 pot samplers

ADDENDA

Page

3.21 .3 should be .22

3.25 321 Water Chemistry

.3 Comparison to Other Data (add between 2nd and 3rd paragraphs).

In a study on the continental divide about 5 miles North of Macmillan Pass, Sergy et al (1976) showed that Cirque Lake and nearby mountain streams had more neutral waters with lower metals contents. Data from Howard's Pass (Archibald and Burns 1981) in a headwaters region 30 miles to the southeast of Jason, showed samples from 7 sites as being very similar to the alkaline streams of the Jason area. They had similar low levels of metals and also had the low levels of nitrogenous nutrients expected at Jason but not yet analysed for. No acid streams were noted in that area. The Environmental Protection Service (1978) showed similar low levels of metals in the vicinity of United Keno Hill Mines at Elsa. Baker (1979) and Bethell and Davidge (1981) provide several years of water chemistry data from streams in the region of the Cyprus Anvil mine near Faro. While the emphasis was upon impacts of the mine upon creek waters, measurements from unaffected areas were similar to those from Jason. The other sites in Table 3-8 are farther away than these four, and are not in the Selwyn Mountains.

3.31 322 Sediment Chemistry

.3 Comparison with Other Data (replace existing paragraph).

Sediment from the Howard's Pass area (Archibald and Burns 1981), analysed for eight elements, showed generally similar levels of metals except for Vanadium and zinc. For both of these the levels at Howard's Pass were over twice those at Jason, although amounts were still quite low. Sediments from Tagish Lake (Robson and Weagle 1978) which received effluent from the now abandoned Venus mine, show similar levels of zinc as these samples but somewhat higher levels of lead and mercury. Jack (1981) analysed samples in the same region and found elevated levels of cadmium, lead and zinc in the areas near the former tailings pond.

332 Benthic Invertebrates

3-42 .3 Comparison with Other Data (add at end)

Other studies of benthic invertebrates in streams of nearby areas (Archibald and Burns 1981, Baker 1979, EPS 1978, Sergy et al 1976) showed greater taxonomic diversity than did this investigation. The density of individuals was not recorded in those reports and therefore cannot be compared. Robson and Weagle (1977), also showed greater numbers of species but the sites were less similar to Jason.

3-45 .4 Relation to other Parameters (add at end).

The introduction of dissolved metals from Rust Creek, in either chronic or occasionally acute dosages, may also have affected both the periphyton and the invertebrates.

3-61 Tissue analysis (add at end of first paragraph).

Fish tissue analysis has been performed by others in Yukon (Baker 1979, EPS 1979, Archibald and Burns 1981) none of whom found levels to be abnormally high, or much different from those at Jason.

3-65 2nd line "population fitness" should be "the fitness of the individuals present".

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