

094003

**CARMACKS COPPER REPORT OF REPRESENTATION OF WORK
BOOKS 1, 2 & 3**

BOOK #1

1. Claim Grouping and Representation Work Report
- 1.1. Claim Grouping and Representation Work Letter
2. Run-of-Mine Bulk Sample Collection-
Report by Kilborn Engineering Pacific Ltd.
3. Draft Design Memorandum CCL-CC2 - Site Hydrology Revisions-
Report by Clearwater Consultants Ltd.
4. Design Memorandum CCL-CC4 - Heap Leach Facility Water Balance-
Report by Clearwater Consultants Ltd.
- 21
5. Summary of Geotechnical Site Investigations, Heap Leach Pad
Report by Access Consulting Group
6. Tespit & Laborotary Test Results - Heap Leach Pad Area-
Report by EBA Engineering Consultants Ltd..

BOOK #2

Western Copper Holdings Limited - Baseline Data Compilation-
Report by Access Consulting Group

BOOK #3

Western Copper Holdings Limited - Design Criteria & Parameters
Report by Sitka Corporation

This report refers to the following claims located in the Whitehorse mining district in the vicinity of Merrice Lake, claim sheet number 115 I/7, latitude 62 d 24', longitude 136 d 49' and owned by Western Copper Holdings Ltd.:

<u>Claim Name and Number</u>	<u>Grant No.</u>
WC 1- 4	YB36689- YB36692
WC19- 22	YB 36707- YB36710
WC 37-39	YB36725- YB36727
WC 55- 56	YB36743- YB36744
WC 73-74	YB36761- YB36762

This report has been examined by
the Geological Evaluation Unit
under Section 53 (4) Yukon Quartz
Mining Act and is allowed as
representation work in the amount
of \$ 13 500.00.

M. Bunker
for Regional Manager, Exploration and
Geological Services for Commissioner
of Yukon Territory.



Claim Status Report

21 September 1999

Claim Name and Nbr.	Grant No.	Expiry Date	Registered Owner	% Owned	NTS #'s
~~WC 99~~	~~YB36648~~	~~1999/03/09~~	~~Western Copper Holdings Limited~~	~~100.00~~	~~115-I-07~~
WC 1 - 4	YB36689 - YB36692	1999/03/09	Western Copper Holdings Limited	100.00	115-I-07
WC 19 - 22	YB36707 - YB36710	1999/03/09	Western Copper Holdings Limited	100.00	115-I-07
WC 37 - 39	YB36725 - YB36727	1999/03/09	Western Copper Holdings Limited	100.00	115-I-07
WC 55 - 56	YB36743 - YB36744	1999/03/09	Western Copper Holdings Limited	100.00	115-I-07
WC 73 - 74	YB36761 - YB36762	1999/03/09	Western Copper Holdings Limited	100.00	115-I-07
~~WC 1 - 2~~	~~YB36896 - YB36897~~	~~1999/03/09~~	~~Western Copper Holdings Limited~~	~~100.00~~	~~115-I-07~~

Criteria(s) used for search:

CLAIM STATUS: ALL, EXPIRED & LAPSED OWNER RPN: 2505111 REGULATION TYPE: QUARTZ

Left column indicator legend:

- R - Indicates the claim is on one or more pending renewal(s).
- P - Indicates the claim is pending.

Total claims selected : 18

R-9A
C/LB

HOCH E KOO

STU

STU

STU

WC

WC

Quad Sheet
115 I/7

Merrice Lake

WARI

WC

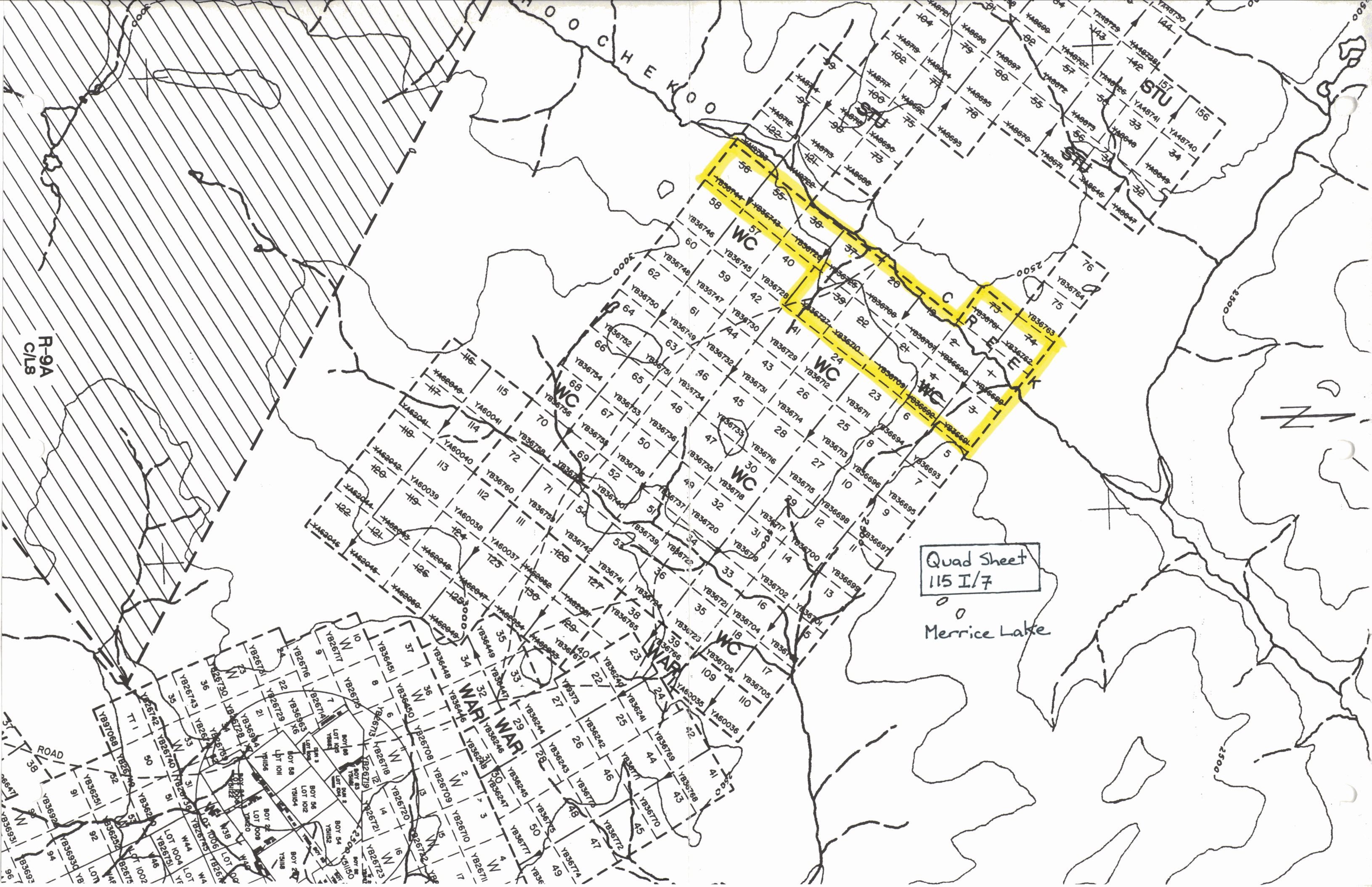
WC

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**LAMERTON & ASSOCIATES
PROFESSIONAL SURVEYORS LTD.**

Suite 204, Phelps Building
107 Main Street
Whitehorse, Yukon, Y1A 2A7

Phone: (867) 667-6664
Fax: (867) 668-7236
E-Mail: lamerton@yknet.yk.ca

September 30, 1999
File: 96022

Mike Burke, P. Geol.
Whitehorse Mining Recorders Office
300 Main St.
Whitehorse YT
Y1A 2B5

Dear Mr. Burke:

I, Glen Lamerton, have been a Canada Lands Surveyor for 14 years and am acting as agent on behalf of Western Copper Holdings Ltd. for the purposes of this representation of work report.

Sincerely,

Glen W. Lamerton



**LAMERTON & ASSOCIATES
PROFESSIONAL SURVEYORS LTD.**

Suite 204, Phelps Building
107 Main Street
Whitehorse, Yukon, Y1A 2A7

Phone: (867) 667-6664
Fax: (867) 668-7236
E-Mail: lamerton@yknet.yk.ca

September 30, 1999

**STATEMENT OF EXPENSES FOR
REPRESENTATION OF WORK FOR WESTERN COPPER HOLDINGS LTD. :**

Preparation of report- " Carmacks Copper Project- Design Criteria and Parameters" by Sitka Corporation	79 695.64
Preparation of report, "Carmacks Copper Project - Heap Leach Facility Water Balance" by Clearwater Consultants Ltd.	32 750.04
Environmental studies- Access Mining Consultants Ltd.	3976.56
Geotechnical work- Access Mining Consultants Ltd.	8104.42
Total expenses 1998, including GST	\$124 526.66

1998 Environmental Work Costs and Claim Locations - Carmacks Copper Project
All Work Conducted in Support of the Environmental Assessment for the Project

Date	Purpose	Claim*	Professional Fees (including GST)	Disbursements (including GST)	Comments
Jul-27-98	Environmental Studies: Collect surface and groundwater water quality samples, measure well depths and read thermistor strings	W11, 12, 14, W16, 21, 29, 31, W39, BOY 22, BOY 24, BOY 52, BOY 55, BOY 56, BOY 58, DUN3.	\$1,679.90	\$2,296.66	Claims W16, 21, 29 and 31 represent approximately 80% of the disbursements and 20% of the professional fees. Water quality samples were collected on these claims.
Aug-21-98	Collect bulk ore samples for geochemical evaluation	BOY 56, BOY 58, BOY 85, DUN3	\$5,131.99	\$1,917.41	
Sep-28-98	Geological and geochemical site evaluation	W11, 12, 14, W16, 21, 29, 31, W39, BOY 22, BOY 24, BOY 52, BOY 55, BOY 56, BOY 58, DUN2, DUN3.	\$770.40	\$284.62	
Oct-9-98	Preparation of the "Carmacks Copper Project - Design Criteria and Parameters" report by Sitka Corp.	All Claims	\$55,293 (approximate)		Contact Roy Mayfield - Sitka Corp at (425) 820-7791 for a more accurate cost estimate
Dec-4-98	Preparation of the "Carmacks Copper Project - Heap Leach Facility Water Balance" report by Clearwater Consultants Ltd.	All Claims	\$29,336 (approximate)		Contact Peter McCreath - Clearwater Consultants Ltd. at (604) 525-4331 for a more accurate cost estimate

* Indicates that mineral claims located using Claim Map Sheet 115-I-7 and denoted on "Borehole and Test Pit Location Plan" Drawing No. 100-13-35 dated January/96

these values are ~~low~~ low
Sept. 1999

Sitka Corp.

Invoice

Our File No. W37.1
Invoice Number: W37.1.98.1

May 4, 1998

Western Copper Holdings Ltd.
1650-1185 West Georgia Street
Vancouver, B. C.
Canada, V6E 4E6
Att: F. Dale Corman, P. Eng.

Details

Description: Carmacks Copper Project, April 1998	Charges
Review of design documents for pad and waste dump. Charges per Sitka letter to Access Mining Consultants dated March 12, 1998:	
Time charges, \$4,000.00	\$4,000.00
Expenses, \$400.00	\$400.00
Provide advice to Access Mining Consultants and attend meeting in Kilborn office. April 30:	
Time Charges:	
E. Harper, 13.5 hours @ \$105	1,417.50
Reimbursable Office Expenses @ 10% of time charges:	\$141.75
Field Expenses:	
290 miles to Vancouver @ \$0.32	\$92.80
parking, \$1.40	\$1.40
10% markup on field expenses:	\$9.42
Total	\$6,062.87US

Payment is due upon receipt. Interest will be charged at 7 percent on the balance unpaid after 30 days from the date of this invoice.

Thank you for doing business with Sitka Corp!

SITKA CORP

Our File No: W37.1
Invoice Number: W37.1.98.2

June 4, 1998

Mr. F. Dale Corman, P. Eng.
Western Copper Holdings, Ltd.
1650-1185 West Georgia Street
Vancouver, BC, Canada
V6E 4E6

<i>Carmacks Copper Project, May 1998</i>	<i>Charges</i>
<i>Review letters and provide advice to Access Mining Consultants, attend meeting in Knight Piésold office, May 20 and 21, 1998, and prepare a summary of our work on the Design Criteria report</i>	
Time charges:	
Tom Harper 6.5 hours @ \$105	\$682.50
Roy Mayfield 39.0 hours @ \$95	\$3,705.00
Office expenses: 10% of time charges	\$438.75
Field expenses:	
290 miles to Vancouver @ \$0.32/mile	\$92.80
Hotel, meals, parking (\$183.36 Canadian)	\$127.90
10% markup on field expenses	\$22.07
Total	\$5,069.02 US

Payment is due upon receipt. Interest will be charged at 7 percent APR on the balance unpaid after 30 days from the date of this invoice.

Thank you for doing business with Sitka Corp!

SITKA CORP

Our File No: W37.1
Invoice Number: W37.1.98.3

July 1, 1998

Mr. F. Dale Corman, P. Eng.
Western Copper Holdings, Ltd.
1650-1185 West Georgia Street
Vancouver, BC, Canada
V6E 4E6

<i>Carmacks Copper Project, June 1998</i>	<i>Charges</i>
<i>Review and provide comments on Knight Piésold's first draft of the Design Criteria Report, review and provide comments on the ore permeability testing, discuss ore permeability with Paul Chamberlin, and participate in conference call about ore permeability.</i>	
Time charges:	
Tom Harper 7.0 hours @ \$105	\$735.00
Roy Mayfield 27.0 hours @ \$95	\$2,565.00
Office expenses: 10% of time charges	\$330.00
Total	\$3,630.00 US

Payment is due upon receipt. Interest will be charged at 7 percent APR on the balance unpaid after 30 days from the date of this invoice.

Thank you for doing business with Sitka Corp!

SITKA CORP

Our File No: W37.1
Invoice Number: W37.1.98.4

August 12, 1998

Mr. F. Dale Corman, P. Eng.
Western Copper Holdings, Ltd.
1650-1185 West Georgia Street
Vancouver, BC, Canada
V6E 4E6

<i>Carmacks Copper Project, July 1998</i>	<i>Charges</i>
<i>Set up laboratory test program to measure permeability of 2-inch crush ore and begin review of Design Criteria report.</i>	
Time charges:	
Tom Harper 4.0 hours @ \$105	\$420.00
Roy Mayfield 24.0 hours @ \$95	\$2,280.00
Office expenses: 10% of time charges	\$270.00
Total	\$2,970.00 US

Payment is due upon receipt. Interest will be charged at 7 percent APR on the balance unpaid after 30 days from the date of this invoice.

Thank you for doing business with Sitka Corp!

SITKA CORP

Our File No: W37.1
Invoice Number: W37.1.98.5

September 4, 1998

Mr. F. Dale Corman, P. Eng.
Western Copper Holdings, Ltd.
1650-1185 West Georgia Street
Vancouver, BC, Canada
V6E 4E6

<i>Carmacks Copper Project, August 1998</i>	<i>Charges</i>
<i>Complete setting up laboratory test program to measure permeability of 2-inch crush ore and continue review of Design Criteria report.</i>	
Time charges: Roy Mayfield 47.5 hours @ \$95	\$4,512.50
Office expenses: 10% of time charges	\$451.25
Total	\$4,963.75 US

Payment is due upon receipt. Interest will be charged at 7 percent APR on the balance unpaid after 30 days from the date of this invoice.

Thank you for doing business with Sitka Corp!

SITKA CORP

Our File No W37.1
Invoice No. W37.1.98.6

October 8, 1998

Mr. F. Dale Corman, P. Eng.
Western Copper Holdings, Ltd.
1650 - 1185 West Georgia Street
Vancouver, BC, Canada
V6E 4E6

Carmacks Copper Project
Invoice for the period ending September 30, 1998

<i>Description</i>	<i>Charges</i>
Final draft of the design criteria report, site visit, meeting with DIAND in Whitehorse, summary of geotechnical conditions of heap and waste rock storage sites.	\$16,183.56
<i>Invoice total (US currency)</i>	<i>\$16,183.56</i>

The following pages contain a breakdown of these charges. Payment is due upon receipt. Interest will be charged at 7 percent APR on the balance unpaid after 30 days from the date of this invoice.

Thank you for doing business with Sitka Corp!

SITKA CORP

Our File No W37.1
Invoice No. W37.1.98.7

November 6, 1998

Mr. F. Dale Corman, P. Eng.
Western Copper Holdings Ltd.
1650 - 1185 West Georgia Street
Vancouver, BC, Canada
V6E 4E6

Carmacks Copper Project
Invoice for period ending October 31, 1998

<i>Description</i>	<i>Charges</i>
Developed Sitka work plan for Addendum 4 to address issues raised by RERC, developed list of drawings for Addendum 4, reviewed the proposed Addendum 4 table of contents, developed a list of future drilling requirements, tracked down the KP AutoCAD files and started work on them.	\$10,978.00
<i>Invoice total (US currency)</i>	<i>\$10,978.00</i>

The following pages contain a breakdown of these charges. Payment is due upon receipt. Interest will be charged at 7 percent APR on the balance unpaid after 30 days from the date of this invoice.

Thank you for doing business with Sitka Corp!

SITKA CORP

Our File No W37.1
Invoice No. W37.1.98.8

December 9, 1998

Mr. Bob Gayton
Western Copper Holdings Ltd.
1650 - 1185 West Georgia Street
Vancouver, BC, Canada
V6E 4E6

Carmacks Copper Project
Invoice for period ending November 30, 1998

Description	Charges
Work on Addendum 4 per November 9, 1998 fax to Access Mining Consultants. Descriptions of individual tasks are on the following pages.	
Task 1 Project management, meetings, etc.	\$2,158.75
Task 2 Heap design modifications	\$1,795.75
Task 3 Pond design modifications	\$891.00
Task 4 Waste rock pile design modifications	\$3,470.50
Invoice total (US currency)	\$8,316.00

The following pages contain a breakdown of these charges. Payment is due upon receipt. Interest will be charged at 7 percent APR on the balance unpaid after 30 days from the date of this invoice.

Thank you for doing business with Sitka Corp!

CLEARWATER CONSULTANTS LTD.
RECORD OF INVOICES - Western Copper Holdings Ltd.

Inv. No.	Job #	TO	Period Covered	Total Amount	CCL Fees	Disb'ts S'Charge	3rd Party Disb'ts	Subcons. Fees	GST Amount	Invoice Date	Date Sent	Payment Received	Payment Period
9811	044.01	Western Copper (Carmacks)	Dec 27/87 - Jan 30/88	\$ 2,789.89	\$ 2,475.00	\$ 122.75	\$ -	\$ -	\$ 181.81	31-Jan-88	31-Jan-88	08-Apr-88	08
9814	044.01	Western Copper (Carmacks)	Jan 31 - Feb 27, 1988	\$ 3,338.80	\$ 2,970.00	\$ 148.50	\$ -	\$ -	\$ 218.30	28-Feb-88	28-Feb-88	08-Apr-88	37
9818	044.02	Western Copper (Carmacks)	Feb 28 - March 27, 1988	\$ 8,454.25	\$ 8,415.00	\$ 420.75	\$ -	\$ -	\$ 618.60	28-Mar-88	28-Mar-88	11-May-88	44
9824	044.02	Western Copper (Carmacks)	March 28 - April 24, 1988	\$ 3,787.56	\$ 3,300.00	\$ 185.00	\$ -	\$ -	\$ 242.55	25-Apr-88	25-Apr-88	21-May-88	25
9828	044.02	Western Copper (Carmacks)	April 25 - May 29, 1988	\$ 5,932.08	\$ 5,288.00	\$ 204.00	\$ -	\$ -	\$ 388.08	30-May-88	30-May-88	30-Jun-88	31
9841	044.02	Western Copper (Carmacks)	May 30 - June 28, 1988	\$ 803.30	\$ 715.00	\$ 38.75	\$ -	\$ -	\$ 52.55	27-Jun-88	27-Jun-88	10-Jul-88	13
9851	044.02	Western Copper (Carmacks)	August 1 - 28, 1988	\$ 123.59	\$ 110.00	\$ 5.50	\$ -	\$ -	\$ 8.09	29-Aug-88	29-Aug-88	21-Oct-88	53
9853	044.02	Western Copper (Carmacks)	Sept 29 - Oct 31, 1988	\$ 4,387.27	\$ 3,905.00	\$ 195.25	\$ -	\$ -	\$ 287.02	31-Oct-88	31-Oct-88		
9882	044.02	Western Copper (Carmacks)	Nov. 1 - 27, 1988	\$ 988.68	\$ 880.00	\$ 44.00	\$ -	\$ -	\$ 64.68	29-Nov-88	30-Nov-88		
9887	044.02	Western Copper (Carmacks)	Nov 28 - Dec 25, 1988	\$ 1,235.85	\$ 1,100.00	\$ 55.00	\$ -	\$ -	\$ 80.85	28-Dec-88	28-Dec-88		
		TOTALS											
10		Western Copper (Carmacks)	Dec 27/87 to Dec 25/88	\$ 32,750.03	\$ 29,150.00	\$ 1,457.50	\$ -	\$ -	\$ 2,142.53				

**ACCESS MINING CONSULTANTS LTD.**

204 D Strickland Street, Whitehorse, Yukon Y1A 2J8
Phone (403) 668-6463

INVOICE
GST # 89899 7689

To: Western Copper Holdings Ltd.
Suite 1650
1185 West Georgia Street
Vancouver, BC V6E 4E6
Attn: Mr. Dale Corman

Invoice #	WCOPP0798
Date	31-Jul-98
Period ending	31-Jul-98

Re: Carmack's Copper Project - Consultant's Contract

CONSULTING AND PROFESSIONAL SERVICES (Costs are inclusive of GST)				
HOURS	PERSON	RATE/HOUR	AMOUNT	GST
62.00	D. Cornett, Project Management	\$90	\$5,580.00	\$390.60
16.00	G.A. Jilson, Project Strategy, Geochemistry and Project Coordination	\$120	\$1,920.00	\$134.40
37.00	R. Snider, Compilation for Addendum #4 & Field Work	\$60	\$2,220.00	\$155.40
2.75	K. Borden, Secretarial	\$45	\$123.75	\$8.66
6.25	C. MacMillan, Secretarial	\$45	\$281.25	\$19.69
Sub-total			\$10,125.00	\$708.75

DISBURSEMENTS (Costs plus 10%)			
DATE	DESCRIPTION	AMOUNT	GST
9-Jul-98	Canadian Airlines Int'l, Invoice S50783208, return cooler & sample bottles to Whitehorse	\$94.20	\$6.59
27-Jul-98	Vehicle kilometers for site visit, Whitehorse to Carmacks return, 500 km @ \$0.56/km	\$280.00	\$19.60
27-Jul-98	Lab supplies, 32mm filters and dissolved metals syringes (amount includes shipping)	\$34.40	\$2.41
29-Jul-98	J. Gibson & Associates, Invoice #98-30, rental of thermistor and piezometer m scope equipment	\$50.00	\$3.50
30-Jul-98	Superstore, Receipt #1529, purchase blank video cassettes	\$8.94	\$0.63
31-Jul-98	D. Cornett, Expense Report #EXDC98-07-02, Re Carmacks Site Tour & Field work	\$10.47	\$0.73
31-Jul-98	R. Snider, Expense Report #RCS-EX-0798-A re Carmacks Site Tour & Field work	\$29.93	\$2.10
31-Jul-98	Long distance telephone and fax for June/July	\$1,075.05	\$75.25
31-Jul-98	Fax and laser page charges, 118 pages @ \$0.25/page	\$29.50	\$2.07
31-Jul-98	Photocopy page charges, 388 pages @ \$0.15/page	\$58.20	\$4.07
31-Jul-98	Flow meter rental, 1 day @ \$50/day	\$50.00	\$3.50
31-Jul-98	In situ pH/conductivity meters and thermometer, 1 day @ \$25/day	\$25.00	\$1.75
	10% Disbursement handling charge	\$174.57	\$12.22
Sub-total		\$1,920.26	\$134.42

Thank you
[Signature]

	AMOUNT	GST
Totals	\$12,045.26	\$843.17
Grand total	\$12,888.43	Incl. GST

Please make cheque payable to Access Mining Consultants Ltd at the above address. Thank You
Terms. Payable 30 days from date of invoice. 1.5% interest per month charged on overdue accounts

paid
Sept 8/98
1031



ACCESS MINING CONSULTANTS LTD.

204 D Strickland Street, Whitehorse, Yukon Y1A 2J8
Phone (403) 668-6463

INVOICE
G.S.T # 89899 7689

To: Western Copper Holdings Ltd.
Suite 1650
1185 West Georgia Street
Vancouver, BC V6E 4E6
Attn: Mr. Dale Corman

Invoice #:	WCOP0898
Date:	08-Sep-98
Period ending:	31-Aug-98

Re: Carmack's Copper Project - Consultant's Contract

CONSULTING AND PROFESSIONAL SERVICES (see attached breakdown)				
HOURS	PERSON	RATE/HOUR	AMOUNT	G.S.T.
53.00	D. Cornett, Project Management	\$90	\$4,770.00	\$333.90
2.50	G.A. Jilson, Project Strategy, Geochemistry and Project Coordination	\$120	\$300.00	\$21.00
29.00	R. McIntyre, Rock Sampling Field Trip and Sampling Report	\$90	\$2,610.00	\$182.70
20.25	R. Snider, Compilation for Addendum #4 & Field Work	\$60	\$1,215.00	\$85.05
3.50	C. MacMillan, Secretarial	\$45	\$157.50	\$11.03
Sub-total			\$9,052.50	\$633.68

DISBURSEMENTS (cost plus 10%)			
DATE	DESCRIPTION	AMOUNT	GST
4-Aug-98	Main St. Postal Outlet, TR#230303, postage	\$9.85	\$0.69
6-Aug-98	Superstore, #1722, photo developing	\$2.91	\$0.20
29-Jul-98	Superstore, #1529, purchase video cassettes	\$8.94	\$0.63
6-Aug-98	Canadian Airlines Int'l, Invoice S58303754, courier charges	\$114.40	\$8.01
7-Aug-98	Integratics, Invoice 45511, copying charges	\$59.72	\$4.18
20-Aug-98	ASL Laboratories, Invoice 72226, Water Analysis	\$1,849.50	\$129.47
22-Aug-98	National Tilden, Invoice 11447, vehicle rental for Bulk Sample field trip	\$396.80	\$27.78
20-Aug-98	Horwood's Office Supply, Invoice 4299, Re: office supplies for Bulk Sample field trip	\$32.69	\$2.29
25-Aug-98	Rob McIntyre, Expense Report #EXRM98-10, expenses for Bulk Sample field trip	\$365.81	\$25.61
24-Aug-98	Integratics, Invoice 45686, copying charges	\$14.04	\$0.98
25-Aug-98	Superstore, #1529 3595, photo developing	\$10.58	\$0.74
26-Aug-98	Main St. Postal Outlet, TR#196864, postage	\$5.85	\$0.41
28-Aug-98	Dan Cornett, Expense Report #EXDC98-08-02, expenses for Bulk Sample field trip	\$123.58	\$8.65
31-Aug-98	Long distance telephone and fax charges for July/August	\$573.87	\$40.17
31-Aug-98	Fax and laser page charges, 249 pages @ \$0.25/page	\$62.25	\$4.36
31-Aug-98	Photocopy page charges, 154 pages @ 0.15/page	\$23.10	\$1.62
10% Disbursement handling charge		\$365.39	\$25.58
Sub-total		\$4,019.28	\$281.35

Thank you
[Signature]

	AMOUNT	G.S.T.
Totals	\$13,071.78	\$915.02
Grand Total	\$13,986.80	incl. GST

Please make cheque payable to Access Mining Consultants Ltd. at the above address, Thank You
Terms: Payable 30 days from date of invoice, 1.5% interest per month charged on overdue accounts

paid \$5,000.00 Nov. 2/98
Bal 8,986.80
105

PAID

Dec 2/98
\$8,986.80
1114



ACCESS MINING CONSULTANTS LTD.

204 D Strickland Street, Whitehorse, Yukon Y1A 2J8
Phone (403) 668-6463

847

INVOICE
G.S.T # 89899 7689

To: Western Copper Holdings Ltd.
Suite 1650
1185 West Georgia Street
Vancouver, BC V6E 4E6

Attn: Mr. Dale Corman

Re: Carmack's Copper Project - Consultant's Contract

Invoice #	WCOP0998
Date	02-Oct-98
Period ending	30-Sep-98

CONSULTING AND PROFESSIONAL SERVICES (100% INCL. GST)			
HOURS	PERSON	RATE/HOUR	AMOUNT
23.00	D. Cornett, Project Management	\$90	\$2,070.00
39.75	G.A. Jilson, Project Strategy, Geochemistry and Project Coordination	\$120	\$4,770.00
6.25	R. Snider, Compilation for Addendum #4 & Upkeep of Field Supplies	\$60	\$375.00
8.50	C. MacMillan, Secretarial	\$45	\$382.50
Sub-total			\$7,597.50
			\$531.83

DISBURSEMENTS (100% INCL. GST)		
DATE	DESCRIPTION	AMOUNT
30-Sep-98	Communications expenses for Watermark Consulting Inc.	\$82.65
1-Sep-98	EBA Engineering Consultants Ltd., August Sieve analysis, Invoice #W-1361	\$316.00
30-Sep-98	Long distance telephone and fax charges for August/September	\$414.57
30-Sep-98	Fax and laser and page totals for September, 169 pages @ \$0.25/page	\$42.25
30-Sep-98	Photocopy page totals for September, 310 pages @ \$0.15/page	\$46.50
	10% Disbursement handling charge	\$90.20
Sub-total		\$992.17
		\$69.45

AMOUNT	GST
\$8,589.67	\$601.28

\$9,190.94	Incl. GST

Please make cheque payable to Access Mining Consultants Ltd. at the above address, Thank You
Terms: Payable 30 days from date of invoice, 1.5% interest per month charged on overdue accounts

PAID

Rec 16/98

#1123



ACCESS MINING CONSULTANTS LTD.

204 D Strickland Street, Whitehorse, Yukon Y1A 2J8
Phone (867) 668-6463

INVOICE
G.S.T # 89899 7689

To: Western Copper Holdings Ltd.
Suite 1650
1185 West Georgia Street
Vancouver, BC V6E 4E6

Invoice #	WCOPP1098
Date	04-Nov-98
Period ending	31-Oct-98

Attn: Mr. Dale Corman

Re: Carmack's Copper Project - Consultant's Contract

CONSULTING AND PROFESSIONAL SERVICES (C. MacMillan)				
TOURS	PERSON	RATE/HOUR	AMOUNT	G.S.T.
3.00	D. Cornett, Project Management	\$90	\$270.00	\$18.90
30.00	G.A. Jilson, Project Strategy, Geochemistry and Project Coordination	\$120	\$3,600.00	\$252.00
5.00	L.M. Broughton, P.Eng., Geochemistry	\$110	\$550.00	\$38.50
5.00	R. Snider, Compilation for Addendum #4 & Upkeep of Field Supplies	\$60	\$300.00	\$21.00
8.50	C. MacMillan, Secretarial	\$45	\$382.50	\$26.78
Sub-total			\$5,102.50	\$357.18

DISBURSEMENTS (C. MacMillan)			
DATE	DESCRIPTION	AMOUNT	G.S.T.
1-Oct-98	Communications expenses for Watermark Consulting Inc.	\$106.88	\$7.48
16-Oct-98	Mac's Fireweed Books, Inv. 289322, topographical maps	\$26.75	\$1.87
31-Oct-98	Yukon Office Supplies, Invoice #95370, office supplies	\$6.03	\$0.42
31-Oct-98	Long distance telephone and fax charges for September/October	\$473.66	\$33.16
31-Oct-98	Gregg Jilson Expense Report #EXGJ9810, telecommunications expenses	\$116.18	\$8.13
31-Oct-98	G.A. Jilson & Associates Inc., Expense Report #98-10, vehicle rental	\$266.00	\$18.62
31-Oct-98	Fax and laser and page totals for October, 79 pages @ \$0.25/page	\$19.75	\$1.38
31-Oct-98	Photocopy page totals for October, 332 pages @ \$0.15/page	\$49.80	\$3.49
	10% Disbursement handling charge	\$106.51	\$7.46
Sub-total		\$1,171.56	\$82.01

Thank you
[Signature]

AMOUNT	G.S.T.
\$6,274.06	\$439.18

\$6,713.24	incl. GST

Please make cheque payable to Access Mining Consultants Ltd. at the above address, Thank You
Terms: Payable 30 days from date of invoice, 1.5% interest per month charged on overdue accounts

PAID

1174
Feb 4/99

C. MacMillan

review design criteria report and discuss issues with

8.50



ACCESS MINING CONSULTANTS LTD.

204 D Strickland Street, Whitehorse, Yukon Y1A 2J8
Phone (867) 668-6463

INVOICE
G.S.T # 89899 7689

To: Western Copper Holdings Ltd.
Suite 1650
1185 West Georgia Street
Vancouver, BC V6E 4E6

Invoice #	WCOPP1198
Date	03-Dec-98
Period ending	30-Nov-98

Attn: Mr. Dale Corman

Re: Carmack's Copper Project - Consultant's Contract

CONSULTING AND PROFESSIONAL SERVICES FOR 100% DEVELOPMENT				
HOURS	PERSON	RATE/HOUR	AMOUNT	GST
27.00	D. Cornett, Project Management	\$90	\$2,430.00	\$170.10
22.50	G.A. Jilson, Project Strategy, Geochemistry and Project Coordination	\$120	\$2,700.00	\$189.00
16.00	R. Snider, Compilation for Addendum #4	\$60	\$960.00	\$67.20
7.75	C. MacMillan, Secretarial	\$45	\$348.75	\$24.41
Sub-total			\$6,438.75	\$450.71

DISBURSEMENTS (60% (0%))			
DATE	DESCRIPTION	AMOUNT	GST
30-Oct-98	Arctic Star Printing Inc., Invoice No. 16546, copying charges	\$12.50	\$0.88
6-Nov-98	Loomis Courier, Invoice HA5883 331, courier charges, package to Vancouver	\$43.47	\$3.04
9-Nov-98	R. Snider Expense Report #EX-RS-10/98G, Manufacture & transportation of 45 gal Drums	\$579.20	\$40.54
30-Nov-98	Fax and laser pages for November, 112 pages @ \$0.25/page	\$28.00	\$1.96
30-Nov-98	Photocopy pages for November, 109 pages @ \$0.15/page	\$16.35	\$1.14
30-Nov-98	Long distance telephone and fax charges for Oct/Nov	\$153.99	\$10.78
	10% Disbursement handling charge	\$83.35	\$5.83
Sub-total		\$916.86	\$64.18

Thank you
D. Cornett

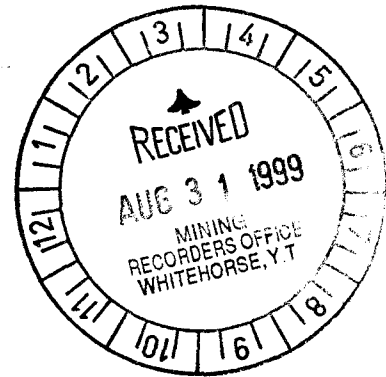
	AMOUNT	GST
Total	\$7,355.61	\$514.89

Grand Total	\$7,870.50	incl. GST

Please make cheque payable to Access Mining Consultants Ltd. at the above address, Thank You
Terms: Payable 30 days from date of invoice, 1.5% interest per month charged on overdue accounts

#1 CLAIM GROUPING & REPRESENTATION WORK REPORT

**LAMERTON & ASSOCIATES
PROFESSIONAL SURVEYORS LTD.**
204 - 107 Main Street
Whitehorse, Yukon Y1A 2A7
867-667-6664
867-668-7236 FAX



August 30, 1999

File: 96022

Mike Burke, P. Geol.
DIAND
300 Main Street
Whitehorse, Yukon
Y1A 2B5

Re: Carmacks Copper Project, Claim Grouping and Representation Work, Yukon

REPORT

Further to our report of March 1999 we enclose on behalf of our client Western Copper Holdings Ltd. of Vancouver, British Columbia various reports referred to.

As related to you at that time these reports are all available in the DIAND library in Whitehorse and we make copies available to you here enclosed.

The reports included are listed below:

- 1) Environmental Studies: collecting surface water, quality samples, measure well depths and read thermistor strings.
- 2) Bulk Sample collection of ore samples for geotechnical evaluation
- 3) Geological and geotechnical site evaluation

4) Preparation of the Carmacks Copper Project -Design Criteria and Parameters

5) Preparation of the Carmacks Copper Project - Heap Leach Facility Water Balance

Please do not hesitate to phone the writer at the above number if any area of this report needs clarification.

Yours Truly,

A handwritten signature in black ink, appearing to read 'G. W. Lamerton', with a large, stylized flourish at the end.

Glen W. Lamerton, CLS

#1.1 CLAIM GROUPING & REPRESENTATION WORK LETTER

**LAMERTON & ASSOCIATES
PROFESSIONAL SURVEYORS LTD.**

**204 - 107 Main Street
Whitehorse, Yukon Y1A 2A7
867-667-6664
867-668-7236 FAX**



August 30, 1999

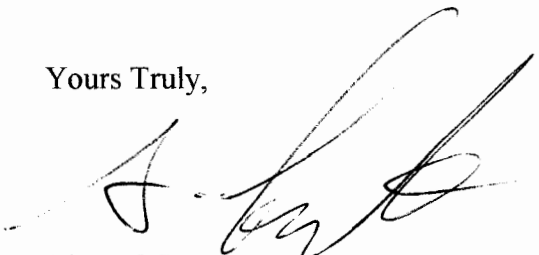
File: 96022

Rona Clark
Mining Recorder
Whitehorse Mining District
Yukon
DIAND
300 Main Street
Whitehorse, Yukon
Y1A 2B5

Re: Carmacks Copper Project, Claim Grouping and Representation Work, Yukon

Please find enclosed a copy of the cover letter sent to Mike ~~Burke~~ regarding the above mentioned file.

Yours Truly,


Glen W. Lamerton, CLS

**LAMERTON & ASSOCIATES
PROFESSIONAL SURVEYORS LTD.
204 - 107 Main Street
Whitehorse, Yukon Y1A 2A7
867-667-6664
867-668-7236 FAX**

August 30, 1999

File: 96022

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300 Main Street
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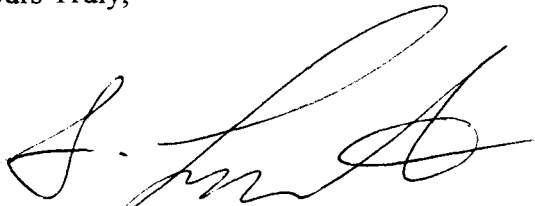
- 1) Environmental Studies: collecting surface water, quality samples, measure well depths and read thermistor strings.
- 2) Bulk Sample collection of ore samples for geotechnical evaluation
- 3) Geological and geotechnical site evaluation

4) Preparation of the Carmacks Copper Project -Design Criteria and Parameters

5) Preparation of the Carmacks Copper Project - Heap Leach Facility Water Balance

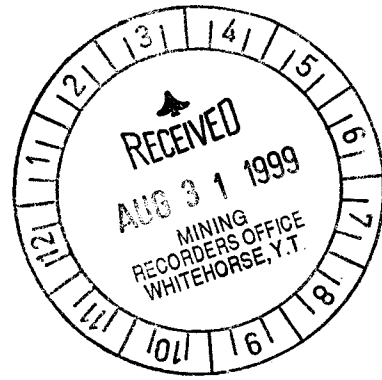
Please do not hesitate to phone the writer at the above number if any area of this report needs clarification.

Yours Truly,

A handwritten signature in black ink, appearing to read 'G. W. Lamerton', with a stylized, flowing script.

Glen W. Lamerton, CLS

#2. RUN- OF -MINE BULK SAMPLE COLLECTION



WESTERN COPPER HOLDINGS LIMITED

CARMACKS, YUKON TERRITORY

CARMACKS COPPER PROJECT

Project No. 8555-25

RUN-OF-MINE BULK SAMPLE COLLECTION

**KILBORN ENGINEERING PACIFIC LTD.
400 - 1380 Burrard Street
Vancouver, B.C.
V6Z 2B7**

JANUARY 1998

1.0 INTRODUCTION

1.0 INTRODUCTION

1.1 SCOPE OF WORK

Western Copper (Western) requested Kilborn to obtain a bulk composite sample from the Carmacks Copper Project located at Williams Creek near Carmacks, Yukon (Kilborn letter March 10, 1997). The 18,000 kg bulk sample is to be used for copper heap leach metallurgical testing for run-of-mine ore.

The bulk sample was to be taken from four trenches and blended at the proportions as listed in Table 1.1-1. The material taken from the each trench was designed to obtain a representative sample from the near surface mineralization at the Carmacks Copper Mine Zone 1 deposit. Kilborn has relied on Max Holtby's detailed knowledge of the deposit to select the trenches to be sampled and determined the proportion of sample to be taken from each trench. Trench locations are shown on Drawing No. 1.1-1.

**Table 1.1-1
Trench Sample Proportions**

Trench	Proportion
T91-22	30
T91-20	30
T92-68	20
T91-18	20

1.2 GEOLOGY

The Carmacks Copper deposit occurs as a gneissic roof pendant within the Upper Triassic Granite Mountain Batholith. This Batholith is principally of granodioritic composition including rocks of diorite, tonalite and quartz monzonite composition. The mineralized roof pendant consist of a feldspathic-biotite-hornblende-quartz gniesses. The gniesses are generally quartz deficient. Gneiss compositions vary from basaltic to

granodiorite. The gneisses are well foliated with coarse to fine grained textures. Aplite and pegmatite dykes intrude both the batholithic rocks and the gneisses. Rocks of this deposited are oxidized to a depth of 260 m (Holtby and McNoughton, 1993).

Copper and gold mineralization occurs in the Carmacks Copper deposit. Holtby and McNoughton (1993) indicate that 86% of the deposit consists of secondary copper minerals mainly malachite, cuprite, azurite and tenorite. Unoxidized mineralization consist of bornite and chalcopyrite. Gold mineralization is commonly associated with limonite but is also associated with malachite, plagioclase, chlorite and quartz. Gold occurs as native grains rarely greater than 5 μm in size.

The geological resources for Zone 1 of the deposit has been estimated at 20.7 mt at a grade of 0.98% copper, using a cut off grade of 0.20% copper (Kilborn, 1994).

1.3 DISCLAIMER

Kilborn has followed standard professional procedures in preparing the contents of this report, but it is based in part on details, information and assumptions provided by others. Kilborn, therefore cannot guarantee the correctness of all the information, but to the extent of its investigation and within the scope of the work delegated to it, Kilborn believes that the report is substantially correct.

2.0 PROCEDURES

2.0 PROCEDURES

2.1 IDENTIFICATION OF TRENCHES AND MINERALIZED ZONES

Trenches 91-18, 92-68, 91-20 and 91-22 were previously marked by Lamerton & Associates. Kilborn confirmed trench locations by locating nearby drill holes and other marked trenches.

Discussions with Silver Standard (Holtby, per. com) indicated that the footwall contact in each trench could be readily located. It was suggested that the hanging wall contact could be located approximately by measuring from the foot wall. The distance to be measured could be obtained from trench plans or sections.

Kilborn was readily able to identify footwall contacts in each of the trenches. Hangingwall contacts were determined by measuring distances from trench footwall contact and by identifying the geological contact based on examination of other trenches where hangingwall contacts were marked with pickets. A comparison of mineralized trench intersections from Holtby and McNaughton (1993) sections and Kilborn's determinations is shown in Table 2.1-1. The distance between footwall and hangingwall determined by Kilborn was from 0.3 to 9.1 m shorter than distances determined from sections. These differences are believed to be within the accuracy of the 1" to 100' map scale of the sections used to determine the distances.

Table 2.1-1
Comparison of Trench Mineralization Distances

	Length of Mineralized Intersection		
Trench	Sections*	Sampled	Difference
91-18	39.6	39.3	0.3
92-68	73.1	66.1	7
91-20	36.6	33.9	2.7
91-22	33	23.9	9.1

* Mineralization distances from cross-sections in appendix 1 of the Holtby and McNaughton (1993) report.

2.2 EQUIPMENT

The following equipment was used:

- 1 Cat 225LC excavator;
- 1 Cat D7G bulldozer;
- 2 Dump trucks, tandem axle, 29 t gvwt;
- 1 Air track percussion drill;
- 1 450 compressor for drill; and
- 1 Flat deck truck with Hiab crane.

As a contractor based in Carmacks was not available, a contractor from Whitehorse was chosen. The contractor chosen to supply the equipment and personnel was H. Coyne & Sons Ltd. The contractor set up a camp for equipment operators beside the Freegold Road on the access road to Williams Creek. The camp was established to reduce travel time for equipment operators to and from the site.

The excavator and bulldozer were used to deepen and widen trenches. Dump trucks were necessary to move excavated ground from trench 91-20 as the trench was too deep to pile ground on trench sides. Ground removed from trench 91-20 was stock piled in a nearby pit. Care was taken to pile waste (footwall and hangingwall rock) material separately. The dump trucks were also used to move the bulk sample out of trenches to mixing sites.

Additionally a Hiab-crane truck was used for weighing bulk sample bags, loading bulk sample bags and loading equipment.

2.3 TRENCH DEVELOPMENT

Trenches selected by Western were widened to approximately 6 m to allow rotation of the excavator for loading of bulk sample on to dump trucks. Initially existing trenches were about 2 to 4 m deep. Generally these trenches were deepened an additional 2 to 3 m to ensure that the ground was below previous blast fragmentation (Figures 2.3-1, 2.3-2, 2.3-3). Trench 91-20 was deepened from the original 3-4 m from surface to 9 to 11 m from the surface (Figure 2.3-4). This trench was deepened to confirm an unexpected footwall contact that paralleled the trench direction for 15 to 20 m. This contact was excavated to ensure that sampling began at the proper contact. The trench was deepened to a depth where rocks were more competent and therefore more representative of run-of-mine material.

The side walls of trenches, in particular trench 91-20, were benched to prevent rock falls into the trench and to allow clearance for the excavator bucket. Ground removed from trench 91-20 was stockpiled in a nearby pit. Care was taken to pile waste (hangingwall and footwall rock) material separately.



Figure 2.3-1 Trench 91-18 after excavation,
before blasting.



Figure 2.3-2 Trench 92-68 after bulk sampling.



Figure 2.3-3 Trench 91-22. After bulk sampling.

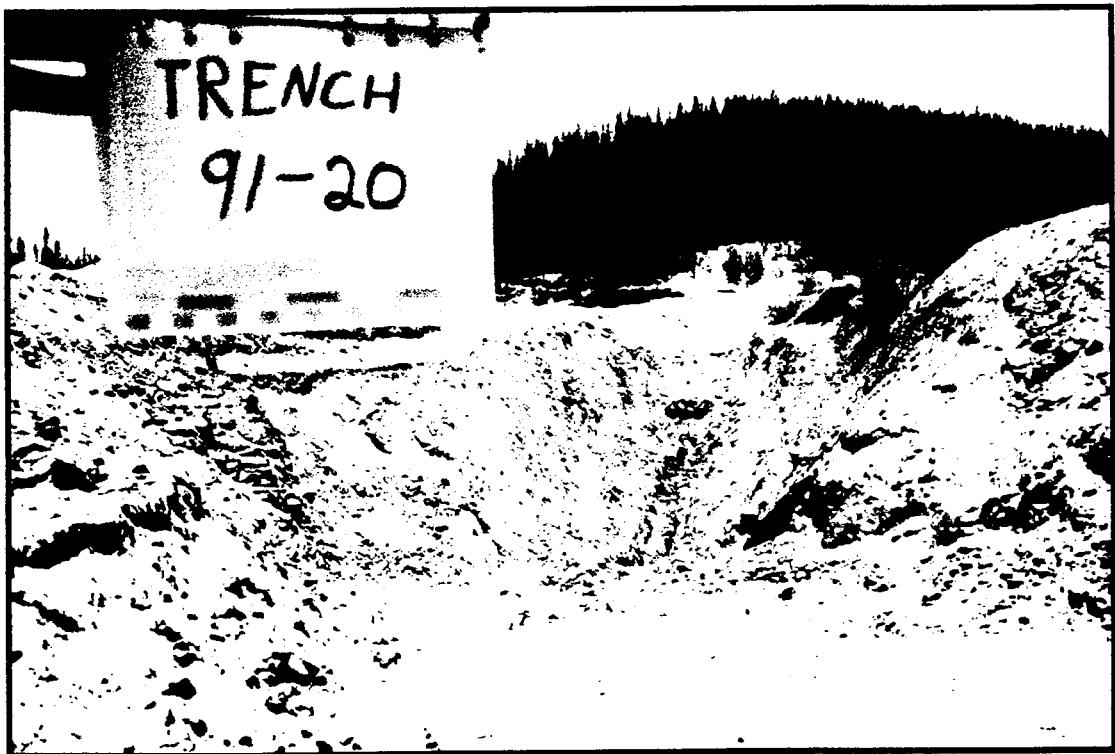


Figure 2.3-4 Trench 92-20. After bulk sampling.

2.4 BLASTING

The bulk sample was obtained by drop cut blasting of the trench floor. The blast was designed to ensure that blasted material was slightly wider than the excavator bucket (.95 m wide, 1.2 m deep). Blast holes were initially drilled by a Mini Air Track drill which was replaced by an Air Track drill because of break downs. Blast holes were drilled vertically at a depth of 1.5 m and a diameter of 0.05 m. A three blast hole pattern was drilled centered across the width of the trench at a hole spacing of 0.75 m. This three hole pattern was spaced along the length of the trench at 1.5 m.

Inclined blasted hole fans were drilled over the eastern end of trench 91-18 over a hill of competent rock.

In areas where the rock was highly friable no blast holes were drilled. In trench ⁹²⁻⁶⁸91-68 an intervening 4.5 m section of granodiorite waste rock was not blasted.

Blast holes were charged with a half stick of Unimax Yellow TS (32 mm x 40 mm) powder and loaded 0.6 m from the collar with anfo. Holes were then stemmed to the collar with drill cuttings and fine grained ground. Non-electric detonators with 25 ms delays were used. The blasting pattern schematic is shown in Figure 2.4-1.

2.5 BULK SAMPLING

2.5.1 Sampling

Each trench was sampled using the excavator. A continuous sample about 1.0 m wide and 1.0 m deep was taken from each trench. The sample was taken from the footwall contact to the hangingwall contact and in the case of trench 91-68 the intervening granodiorite was excluded. Each bucket near these contacts was inspected to ensure that no waste rock was included.

The following steps were taken to ensure that contamination from trench side walls was excluded from the bulk sample:

- The top 0.15 m to 0.2 m from blasted material was scraped off before sampling to ensure that no debris from the trench walls was included;
- Material that fell into the trench from sidewalls was moved aside before the next bucket of sample was taken. This ensured no contamination from sidewall material. Unblasted very friable sections of the trenches were sampled in the same manner.

Each excavator bucket of sample was loaded directly into a dump truck. The bulk sample was then transported to and dumped at a mixing site nearby each trench.

* In addition to the bulk sample weathered previously leached ore from trench 91-20 was collected. Approximately 800 lbs of this material was placed separately in a bulk sample bag.

2.5.2 Mixing and Blending

The bulk sample from each trench was rolled, moved and repiled for one-half hour. A new pile was made from this material by moving the material bucket load by bucket load on to a new pile. Care was taken to keep the new pile in a regularly shaped cone, this process is called coning. A skin of 3 to 5 cm of bulk sample was left on the mixing pad surface to reduce dilution from introduction of ground material.

The mass of the bulk sample was estimated from the volume of sample moved out of the trench multiplied by a density of 2.68 (ore density (Holtby and McNaughton, 1993)). The masses of bulk samples from each trench were reduced to masses which when combined would maintain the mixing ratio suggested by Western/Silver Standard:

<u>Trench</u>	<u>Ratio</u>
91-18	20%
92-68	20%
91-20	30%
91-22	30%

The estimated masses were obtained by physically splitting the pile in quarters or multiples of quarters. Each successive split was re-coned for further splitting. The final mass from each trench was loaded into one dump truck and dumped on to a new mixing pad. This sample containing a proportion from other trenches was then mixed by rolling, moving and repiling for about half an hour. The bulk sample was then coned twice to ensure good mixing. This bulk sample was then loaded into bulk sample bags with two 3 mil thick polyethylene liners. The plastic liners ensure that fines were not lost during transport and to ensure that the sample did not get wet during transport. Each bag was then weighed to ensure that approximately one tonne of material was loaded in each bag.

Despite a calculated bulk sample excess of 5 tonnes a shortfall of three tonnes of bulk sample was discovered upon weighing bulk sample material. This shortfall was made up by blending and mixing excess sample material from each trench. The same relative proportions from each trench was maintained.

Bulk sample bags were sealed, loaded onto the dump trucks and transported to Whitehorse. The bulk samples were then trans-shipped to Vancouver by truck.

2.6 CHANNEL-CHIP SAMPLES

Two meter channel-chip samples were taken along each trench. A channel-chip sample is a continuous sample of rock similar to a channel sample. The channel-chip sample is different from a channel sample because the width and depth of the channel-chip sample is roughly the same. In a channel sample the width and depth of the sample is exactly uniform as equipment such as a diamond saw would be used to cut the sample from rock. Kilborn channel-chip sampled the side walls of the trenches. All samples consisted in-situ blasted rock and in place unblasted rock. Only the portions of the trench used in the bulk sample were channel-chip sampled. Geological notes on the channel-chip samples are attached.

TRENCH 91-18 CHANNEL-CHIP SAMPLING

Samples taken from footwall contact to hangingwall.

Sample start marked with picket.

SAMPLE NUMBER	FROM [m]	TO [m]	DESCRIPTION
588801	0.0	2.0	Biotite+feldspar gneiss, fine grained, rusty brown, mod. weathered, foliated at 128o 84oNE, tr-1% malachite, 2-5% ?tenorite+lim.
588802	2.0	4.0	Bt+fspar gneiss, f. gr. rusty brown, mod. weathered, 2-5% ?tenorite+lim., minor granodiorite dykes
588803	4.0	6.0	Bt+fspar gneiss, f.gr., rusty brown-yellow, mod. to intense clay weathering, 2-5% ?tenorite+lim.
588804	6.0	8.0	Bt+fspar gneiss, f.gr., rusty brown, very friable, tr-1% malachite(locally 2-3%), 5% ?tenorite+lim.
588805	8.0	10.0	Bt+fspar gneiss,m-f gr., rusty brown, mod-very friable, 1-2% malachite, 5% ?tenorite+lim., minor pegmatite veins
588806	10.0	12.0	Bt+fspar gneiss,m gr., rusty brown, mod. friable, tr-1% malachite, 2-3% ?tenorite+lim., biotite bands
588807	12.0	14.0	Bt+fspar gneiss,m gr., rusty brown-yellow, friable, highly fractured, tr-1% malachite, 2-3% ?tenorite+lim., biotite 20-30%
588808	14.0	16.0	Bt+fspar gneiss, m gr., intense to mod. weathering, rusty brown-yellow, v. friable, clayey to bt sand texture, 5-10% ?tenorite+lim., tr-1% malachite,
588809	16.0	18.0	Bt+fspar gneiss, f-m gr., mod. weathering, rusty brown-yellow, v. friable, clayey to bt sand texture, 2-5% ?tenorite+lim., 1-2% malachite
588810	18.0	20.0	Bt+fspar gneiss, f-m gr., mod. weathering, rusty brown-yellow, v. friable, clayey to bt sand texture, 2-5% ?tenorite+lim., 1-2% malachite
588811	20.0	22.0	Bt+fspar gneiss, f-m gr., mod. weathering, rusty brown-yellow, v. friable, clayey to bt sand texture, 2-5% ?tenorite+lim., 1-2% malachite
588812	22.0	24.0	Bt+fspar gneiss, f-m gr., mod. weathering, rusty brown, mod competant and v. friable sections, 2-5% ?tenorite+lim., 2-3% malachite, minor pegmatite (?qtz veins) dykes
588813	24.0	26.0	Bt+fspar gneiss, c-f gr., mod. weathering, rusty brown, mod foliated, mod fractured, 5% ?tenorite+lim., 2-4% malachite
588814	26.0	28.0	Bt+fspar gneiss, f gr., mod. weathering, rusty brown, mod foliated, mod competant fractured, 5% ?tenorite+lim., 2-3% malachite(locally 4%)
588815	28.0	30.0	Bt+fspar gneiss, f gr., mod. weathering, grey- brown, mod foliated, mod competant, fractured, 2% ?tenorite+lim., 3-4% malachite, minor pegmatite
588816	30.0	32.0	Bt+fspar gneiss, c gr., wk weathered, grey-black, mod foliated, competant, mod. fractured, 3-4% malachite, forms resistant outcrop, mineralization occurs along fracture planes, weakly foliated
588817	32.0	34.0	Bt+fspar gneiss, c gr., wk weathered, grey-black, mod foliated, competant, mod. fractured, 3-5% malachite, resistant, wk foliated
588818	34.0	36.0	Bt+fspar gneiss, c gr., wk weathered, grey-black, mod foliated, competant, mod. fractured, 3-5% malachite, resistant, wk. foliated
588819	36.0	39.3	Bt+fspar gneiss, c gr., wk weathered, grey-black, mod foliated, competant, mod. fractured, 2-3% malachite, resistant, wk. foliated
			End of Sampling

TRENCH 91-20 CHANNEL-CHIP SAMPLING

Samples taken from footwall contact to hangingwall.

Sample start marked with picket.

SAMPLE NUMBER	FROM [m]	TO [m]	DESCRIPTION
586251	0.0	2.0	Biotite+feldspar gneiss, fine grained, rusty brown-yellow, v. oxidized, very friable, 2-5% ?tenorite+lim, well foliated
586252	2.0	4.0	Bt+fspar gneiss, fine grained, rusty brown-yellow, v. oxidized, very friable, 2-5% ?tenorite+lim, locally 2-3%chalcocite
582563	4.0	6.0	Bt+fspar gneiss, fine grained, rusty brown-yellow, v. oxidized, mod. friable, 2-5% ?tenorite+lim, tr-2%malachite
582654	6.0	8.0	Bt+fspar gneiss, fine grained, rusty brown-yellow, v. oxidized, weakly friableto blocky, 2-53% ?tenorite+lim, tr-2%malachite
586255	8.0	10.0	Bt+fspar gneiss, fine grained, rusty brown-yellow, v. oxidized, blocky, mod fractured, 10-13% ?tenorite+lim, 1-3%malachite,
586256	10.0	12.0	Bt+fspar gneiss, fine grained, rusty brown-yellow, v. oxidized, blocky, mod fractured, 3-5% ?tenorite+lim, 3-54%malachite, minor granodiorite dykes
586257	12.0	14.0	Bt+fspar gneiss, fine grained, rusty brown-yellow, v. oxidized, blocky, mod fractured, 3-5% ?tenorite+lim, 2-4%malachite, pegmatite dykes 20cm wide
586258	14.0	16.0	Bt+fspar gneiss, f-c. grained, rusty brown-yellow, v. oxidized, mod-v. friable, 2-4%malachite, 3-5 ?tenorite+lim,
586259	16.0	18.0	Bt+fspar gneiss, f. grained, rusty brown-yellow, v. oxidized, mod-v. friable, 1-3%malachite, 1-3 ?tenorite+lim,
586260	18.0	20.0	Bt+fspar gneiss, f. grained, rusty brown-yellow, v. oxidized, mod-v. friable, 1-3%malachite, 1-3 ?tenorite+lim,
586261	20.0	22.0	Bt+fspar gneiss, f-c. grained, rusty brown-yellow, v. oxidized, v. friable, 1-3%malachite, 1-3 ?tenorite+lim,
586262	22.0	24.0	Bt+fspar gneiss, f-c. grained, rusty brown-yellow, v. oxidized, mod-v. friable, clayey texture, 2-4%malachite, 6-7% ?tenorite+lim,
586263	24.0	26.0	Bt+fspar gneiss, f. grained, rusty brown-yellow, v. oxidized, v. friable, clayey texture, 1-3%malachite, 3-5% ?tenorite+lim
586264	26.0	28.0	Bt+fspar gneiss, f. grained, rusty brown-yellow, v. oxidized, v. friable, clayey texture, 1-3%malachite, 3-5% ?tenorite+lim
586265	28.0	30.0	Bt+fspar gneiss, f-c. grained, rusty brown-yellow, v. oxidized, v. friable, clayey texture, 2-3%malachite, 3-5% ?tenorite+lim
586266	30.0	32.0	Bt+fspar gneiss, c. grained, rusty brown-yellow, v. oxidized, mod. friable, 2-3%malachite, 3-5% ?tenorite+lim
586267	32.0	33.9	Bt+fspar gneiss, c. grained, rusty brown-yellow, v. oxidized, mod. friable, 3-4%malachite, 2-3% ?tenorite+lim, contact with granodiorite hanging wall
			End of Sampling

TRENCH 91-22 CHANNEL-CHIP SAMPLING

Samples taken from footwall contact to hangingwall.

Sample start marked with picket.

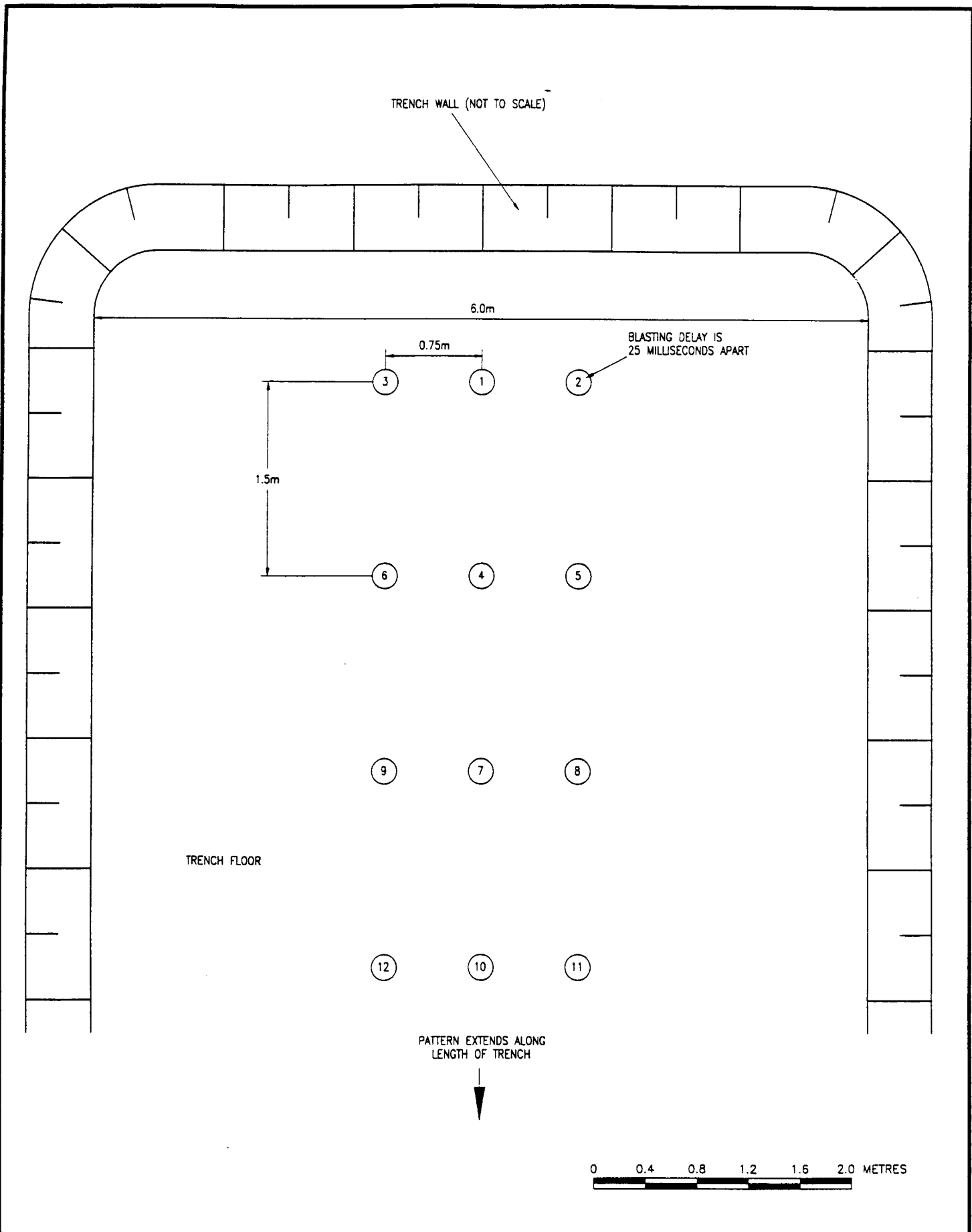
SAMPLE NUMBER	FROM [m]	TO [m]	DESCRIPTION
586568	0.0	2.0	Biotite+feldspar gneiss, fine to medium grained, rusty brown-yellow, v. oxidized, mod. friable, 2-3% ?tenorite+lim, 3-4% malachite 1-2% azurite,
586269	2.0	4.0	Bt+fspar gneiss, f-c. grained, rusty brown-yellow, v. oxidized, blocky, 3-6% malachite, 2-3 ?tenorite+lim,
586270	4.0	6.0	Bt+fspar gneiss, f-c. grained, rusty brown-yellow, v. oxidized, blocky, 2-3% malachite, 2-3 ?tenorite+lim, minor pegmatite dyke
586271	6.0	8.0	Bt+fspar gneiss, m-c. grained, rusty brown-yellow, v. oxidized, blocky, 3-4% malachite, 2-3 ?tenorite+lim, 2-3% azurite
586272	8.0	10.0	Bt+fspar gneiss, m-c. grained, rusty brown-yellow, v. oxidized, mod. friable, 2-3% malachite, 2-4% ?tenorite+lim, tr-13% azurite
586273	10.0	12.0	Bt+fspar gneiss, m-c. grained, rusty brown, v. oxidized, v. friable, 2-3% malachite, 2-4% ?tenorite+lim, tr-13% azurite, clayey-texture, intense hematite staining
586274	12.0	14.0	Bt+fspar gneiss, m-c. grained, rusty brown, v. oxidized, v. friable, 2-3% malachite, 2-4% ?tenorite+lim, tr-13% azurite, clayey-texture, intense hematite staining
586275	14.0	16.0	Bt+fspar gneiss, m-c. grained, rusty brown, v. oxidized, v. friable, 2-3% malachite, 4-6% ?tenorite+lim, tr % azurite, mod. hematite staining
586276	16.0	18.0	Bt+fspar gneiss, m-c. grained, rusty brown, v. oxidized, v. friable, 2-3% malachite, 4-6% ?tenorite+lim, tr % azurite, mod. hematite staining
586277	18.0	20.0	Bt+fspar gneiss, m-c. grained, rusty brown, v. oxidized, v. friable, 2-3% malachite, 3-5% ?tenorite+lim, 1-2% azurite, mod. hematite staining
586278	20.0	22.0	Bt+fspar gneiss, f-c. grained, rusty brown, v. oxidized, blocky wk. friable, 1-3% malachite, 2-3% ?tenorite+lim, 1% azurite
586279	22.0	23.5	Bt+fspar gneiss, f-c. grained, rusty brown, v. oxidized, blocky mod. friable, mod. hematization, increasing abundance of grnodiorite dykes, hanging wall contact.
			End of Sampling

TRENCH 92-68 CHANNEL-CHIP SAMPLING

Samples taken from footwall contact to hangingwall.

Sample start marked with picket.

SAMPLE NUMBER	FROM [m]	TO [m]	DESCRIPTION
588820	0.0	2.0	Biotite+felspar gneiss, fine to medium grained, rusty brown, mod. weathered, mod foliated, tr-0.5% malachite, 2-5% ?tenorite+lim., minor granodiorite dyke
588821	2.0	4.0	Bt+fspar gneiss, f-m. gr. rusty brown, mod. weathered, 5% ?tenorite+lim., 1-2% malachite, minor pegmatite dykes
588822	4.0	6.0	Bt+fspar gneiss, f-m. gr. rusty brown, mod. weathered, 5% ?tenorite+lim., 1-2% malachite, minor pegmatite dykes
588823	6.0	8.0	Bt+fspar gneiss, f-m. gr. rusty brown, mod. weathered, 5% ?tenorite+lim., 1-2% malachite, minor pegmatite dykes
588824	8.0	10.0	Bt+fspar gneiss, f-m. gr. rusty brown, mod. weathered, 5% ?tenorite+lim., 1-3% malachite, some pegmatite dykes
588825	10.0	12.0	Bt+fspar gneiss, m-c. gr. rusty brown, mod. weathered, very friable, 3-6% ?tenorite+lim., 1-2% malachite, tr. azurite
588826	12.0	14.0	Bt+fspar gneiss, f-c. gr. rusty brown, mod. weathered, very friable, 3-6% ?tenorite+lim., 1-2% malachite, tr. azurite
588827	14.0	16.0	Bt+fspar gneiss, f-c. gr. rusty brown, mod. weathered, very friable, 3-6% ?tenorite+lim., 1-2% malachite, tr. azurite
588828	16.0	18.0	Bt+fspar gneiss, f-c. gr. rusty brown, mod. weathered, friable, 3-6% ?tenorite+lim., 1-3% malachite, mod. competent
588829	18.0	20.0	Bt+fspar gneiss, f-m. gr. rusty brown-yellow, mod. weathered, friable, 3-6% ?tenorite+lim., 1-2% malachite, mod. competent
588830	20.0	22.0	Bt+fspar gneiss, f-m. gr. rusty brown-yellow, mod. weathered, friable, 3-6% ?tenorite+lim., 1-2% malachite, mod. competent
588831	22.0	24.0	Bt+fspar gneiss, f-m. gr. rusty brown, mod. weathered, friable, 3-6% ?tenorite+lim., 2-3% malachite, mod. competent
588832	24.0	26.9	Bt+fspar gneiss, f-m. gr. rusty brown, mod-v. weathered, mod-very friable, 3-6% ?tenorite+lim., 2-3% malachite, minor granodiorite dykes, contact with granodiorite unit
588833	31.4	34.0	Bt+fspar gneiss, f-m. gr. rusty brown-yellow, mod-v. weathered, mod-very friable, 5% ?tenorite+lim., 1-2% malachite, contact with granodiorite unit
588834	34.0	36.0	Bt+fspar gneiss, f-m. gr. rusty brown-yellow, mod-v. weathered, mod-very friable, 5% ?tenorite+lim., 2-3% malachite, contact with granodiorite unit
588835	36.0	38.0	Bt+fspar gneiss, f-m. gr. rusty brown-yellow, mod-v. weathered, mod-very friable, 2-5% ?tenorite+lim., 2-4% malachite
588836	38.0	40.0	Bt+fspar gneiss, f-m. gr. rusty brown-yellow, mod-v. weathered, mod-very friable, 2-5% ?tenorite+lim., 2-3% malachite
588837	40.0	42.0	Bt+fspar gneiss, m-c. gr. rusty brown, mod-v. weathered, mod friable to mod competent, 5% ?tenorite+lim., 1-2% malachite
588838	42.0	44.0	Bt+fspar gneiss, m-c. gr. rusty brown, mod. weathered, mod competent, 5% ?tenorite+lim., 1-2% malachite
588839	44.0	46.0	Bt+fspar gneiss, f-c. gr. rusty brown-yellow, mod. weathered, 7% ?tenorite+lim., 2-3% malachite
588840	46.0	48.0	Bt+fspar gneiss, f-c. gr. rusty brown-yellow, mod. weathered, 4-50% ?tenorite+lim., 2-3% malachite
588841	48.0	50.0	Bt+fspar gneiss, f-c. gr. rusty brown-yellow, mod. weathered, 3-7% ?tenorite+lim., 2-3% malachite
588842	50.0	52.0	Bt+fspar gneiss, f-c. gr. rusty brown-yellow, mod-v. weathered, 3-7% ?tenorite+lim., 2-3% malachite
588843	52.0	54.0	Bt+fspar gneiss, c. gr. rusty brown-yellow, v. weathered, mod-v. friable, 5-6% ?tenorite+lim., 3-4% malachite
588844	54.0	56.0	Bt+fspar gneiss, c. gr. rusty brown-yellow, v. weathered, mod-v. friable, 5-6% ?tenorite+lim., 3-4% malachite
588845	56.0	58.0	Bt+fspar gneiss, c. gr. rusty brown-yellow, v. weathered, mod-v. friable, 5-6% ?tenorite+lim., 3-4% malachite
588846	58.0	60.0	Bt+fspar gneiss, c. gr. rusty brown-yellow, v. weathered, mod-v. friable, 4-6% ?tenorite+lim., 2-3% malachite, 1-2% azurite
588847	60.0	62.0	Bt+fspar gneiss, c. gr. rusty brown-yellow, v. weathered, mod-v. friable, 4-6% ?tenorite+lim., 2-4% malachite, 2-3% azurite, transitional change from gneissic to massive igneous texture
588848	62.0	64.0	Bt+fspar gneiss, c. gr. rusty brown-yellow, v. weathered, mod-v. friable, 4-6% ?tenorite+lim., 2-4% malachite, 2-3% azurite, transitional change from gneissic to massive igneous texture
			End of Sampling



3K11 DWG P.A.H. 30AUG93

SECTION: MINING	CLIENT: WESTERN COPPER HOLDINGS LTD.
SCALE: AS SHOWN	DATE: 23OCT97
DESIGNED: D.K.	23OCT97
DRAWN: T.M.	23OCT97
CHECKED: D.K.	23OCT97
APPROVED: D.K.	23OCT97
LOCATION: CARMAKS, YUKON TERRITORY	
THE ENGINEERING DATA ON THIS DRAWING IS SOLELY FOR THE PURPOSE AND PROJECT FOR WHICH THIS DRAWING IS ISSUED	
A ISSUED FOR APPROVAL	23OCT97 T.M.
DATE: 23OCT97	DATE: 23OCT97

**KILBORN
SNC-LAVALIN**

CARMAKS COPPER PROJECT

FIG 2.4-1
TRENCH BLASTING SCHEMATIC

FIG 2.4-1.DWG	
EQUIP/UNIT/LOOP No.	
PROJECT No.	DIVISION No.
8555	25
DRAWING NUMBER	REV
FIG 2.4-1	A

7/10/23 11 10

3.0 PROGRAM SCHEDULE

3.0 PROGRAM SCHEDULE

Removal of the bulk sample commenced on September 23, 1997 and was completed October 9, 1997. The sample was received at Process Research's Vancouver Laboratory on October 27, 1997. Activities during collection of samples are outlined in Table 3.0-1.

Table 3.0-1
Activity Schedule for Bulk Sampling Program

DATE	EVENT
September 22	Mobilization to Carmacks.
September 23	Equipment and operators on site. Start excavation of trench 91-18.
September 25	Excavation of trench 91-18 complete. Start excavation of trench 92-68.
September 28	Excavation of trench 92-68 complete.
September 29	Final work on trench 91-22 completed by excavator. Start excavation of trench 91-20. Dump trucks and Mini-Air Trac drill arrive on site.
September 30	Blast hole drilling started on trench 91-18.
October 02	Blast hole drilling on trench 91-18 complete. Trench 91-18 loaded and blasted.
October 04	Blast hole drilling for trench 92-68 started. Drill break down. Channel-chip sampling completed for trench 91-18.
October 06	Blast hole drilling for trench 92-68 completed. Blast hole drilling for trench 91-20 completed. Blast hole drilling for trench 91-22 completed. Trenches 92-68, 91-20, and 91-22 loaded and blasted.
October 07	Bulk sample taken from trenches 92-68, 91-20 and 91-22. Bulk sample from trench 92-68 mixed.
October 08	Bulk sample from trenches 91-20 and 91-22 mixed. Composite bulk sample blended and mixed. Composite bulk sample loaded into ore bags. Channel-chip sampling of trench 92-68 complete.
October 09	Additional composite bulk sample blended and mixed. Additional composite bulk loaded into ore bags.
October 10	Channel-chip sampling of trenches 91-20 and 91-22. Demobilization from Carmacks to Whitehorse.
October 11	Demobilization from Whitehorse.

4.0 COMMENTS

4.0 COMMENTS

Mineralization

Kilborn observed that malachite azurite and chalcocite mineralization occurred principally along rock fractures and as small aggregates in fine grained highly friable zones. Some malachite mineralization was observed along mineral grains in coarse grained gneisses that were moderately to weakly friable. In resistant competent coarse grained gneisses malachite appeared to occur only along fracture planes.

Run-of-Mine Simulation

Fine grained material from coarse sand size to fine silt size and smaller particles appeared to dominate the bulk sample material. The main source of this fine material is probably in-situ. This is evidenced by some sections in trenches 91-18 and 91-20 which were not blasted because the material was fine grained and could be excavated without blasting. It was also observed that much of the trench material was moderately to very friable and broke into small particles with a minimum of force. This fine grained material was observed to a depth of 11 m in trench 91-20. It was not possible for Kilborn to determine to what depths this fine grained friable rock extends.

Trench blasting compared to production blasting can generate finer material. Blasting in a trench confines the blast and typically results in finer fragmentation. A production blast that is less confined typically results in coarser fragmentation. Since all material for the bulk sample was necessarily extracted from trenches, the size of blast fragments may be expected to be finer than from a production blast.

The bulk sample extracted from trenches may be biased towards finer grained material. Blast fragmentation from trenches and possibly finer and more friable ore material in the upper portion of the deposit may contribute to higher amounts of fine materials than would be expected from a run-of-mill production blast.

5.0 REFERENCES

5.0 REFERENCES

1. Holtby, M. and K. McNaughton. Williams Creek Project; Yukon Territory, Silver Standard Resources Inc. February 1993.
2. Kilborn Engineering Pacific Ltd. Wester Copper Holdings Limited, Carmacks Copper Project; Feasibility Study. October 1994.
3. Holtby, M. Personal Communication. September 9, 1997.

APPENDIX A

FIELD REPORTS

From: David Keller
To: WACHT
Date: 10/2/97 6:01pm
Subject: Carmacks Bulk Sampling

Tony,

Just a short note. Production today on trench 20 is stalled because of excavator break down. However trench 18 was loaded and blasted this morning.

Due to this delay I expect that work will be finished around the middle of next week.

Dave

From: David Keller
To: WACHT
Date: 9/30/97 8:02pm
Subject: Carmacks Bulk Sampling -Reply -Reply

Tony,

I have talked to Jim Coyne about leaving the Cat (D7) at site for the next program. Jim is quite happy to leave the Cat until the next program starts up.

Trenches 19, 68 and 22 are ready for blasting and removing the sample. Work on trench 20 is progressing. Trench 20 needs to be cleaned out and widened for equipment. As this was a previous bulk sample trench the trench has to be deepened. Rock can be only removed using dump trucks. Benching of trench sides is necessary to reduce slumping of trench sides. I expect this trench to be completed in about two days.

Two dump trucks arrived at site yesterday afternoon with the air-track drill and compressor for drill. Blasting\Drilling was delayed today for about 8 hours today because the drill was broken. Late in the afternoon the drill was fixed and drilling on trench 19 started.

I expect bulk sampling to be completed early next week.

Jim Coyne has organized a camp for his men just off of the main road. He will give the cost per man shortly.

Last weekend Access Mining Consultants from Whitehorse did piezometer testing. The brushing crew started about Wednesday last week.

The 500kg sample of the previous bulk sample needs some clarification. The only material in one of the trenches appears to be leached ore. Ken and one or two other people have indicated that the material is from the leach pad set up in Carmacks. I concur with this as plastic sheets and plastic pipes are buried with this material. It was my understanding that the material wanted was weathered crushed ore not weathered crushed and leached material. There does not appear to be any crushed unleached ore available. Please confirm if a sample of this material should be sampled.

I seem to have misplaced the address for Process Research Associates (PRA). Could you please send me their address and phone number.

Jim Coyne has made preliminary inquiries concerning shipping about 20 tonnes to Vancouver. The cost will be around \$1000.00.

Are the trench channel samples to be sent to PRA also or to another lab such as Chemex?

Regards,

Dave

From: David Keller
To: WACHT
Date: 9/27/97 10:11am
Subject: Carmacks Bulk Sampling

Carmacks Bulk Sampling

Tony,

Trench 18 is completed ready for blasting and sampling. A good portion of the trench won't need blasting as the rock is very friable.

Work on trench 68 is still in progress. A large amount of ground has to be moved to get access for excavator and mini-air track. At the moment this is holding up progress. This trench should be completed by tomorrow.

Trench 22 has been enlarged by the bulldozer and will need only minor work before blasting/sampling.

Trench 20 will need dump trucks to clean out trench. The trench (including muck piles beside trench) is 5-6m deep.

Bulk sample bags were in Whitehorse the same day I arrived.

Contractor recommends some minor road work so that dump trucks can access site and take out bulk samples. I will try to minimize road work as much as possible.

Please find attached a summary of men and equipment hours up to the 24. Further update Sunday evening.

Dave

From: David Keller
To: WACHT
Date: 9/24/97 6:20pm
Subject: Hi Tony,

Hi Tony,

The trenching is progressing. The first trench number 18 will probably be complete tonight. Initial work on trench 68 has started today. Ken Roberts equipment is was working on another site so he arranged for another contractor to do the work. The contractor is Jim Coyne, he is based out of Whitehorse. Jim's equipment is essentially the same as Ken's, possibly newer. The blaster was at site and advised of what was needed. I will get him to start blasting when at least three trenches have been cleaned out.

Trenches may need more work than I expected because equipment about six feet wide and trench sides are piled high from previous work. So far progress is good. Operators were at site yesterday afternoon.

Otherwise things are okay. The equipment operators seem to be quite competent.

Dave

APPENDIX B

SAMPLE DESCRIPTION MEMO



**KILBORN
SNC-LAVALIN**

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Vancouver, B.C.
Canada V6Z 2B7

Telephone: (604) 669-8811

**FAX
(604) 669-0847**

TO: Morris Beattie
COMPANY: Beattie Consulting Ltd.
FAX NO.: (604) 263-0895
COPY TO:
COPY TO:

FROM: Dave Keller

DATE: October 19, 1997

SUBJECT: Carmacks Samples

PROJECT #: 8555-25

NUMBER OF PAGES SENT: 3 (INCLUDING TRANSMITTAL PAGE)

MESSAGE:

Morris Beattie:

Samples from the Carmacks bulk sampling program should arrive in Vancouver this week.

There are 18 bulk sample bags numbered 1-18 containing a blended ore from four trenches. Each bag weighs about 1 tonne. Also there is 1 bulk sample bag containing the previously leached ore which was left to weather in one of the trenches. This bag is marked as L1 and weighs approximately 800lbs.

Additionally each trench was sampled by channel-chip sampling along each trench wall. Nineteen samples are in one bulk sample bag, sample numbers 588801 to 588819. Additionally 109 samples are in another bulk sample bag, sample numbers 588820 to 588850 and 586251 to 586279.

I have attached a list of channel-chip samples indicating trench number and distance from the footwall contact.

G. David Keller

CARMACKS CHANNEL-CHIP SAMPLES

SAMPLE NO.	F/W CONTACT DISTANCE		TRENCH
	FROM	TO	
588801	0.0	2.0	91-18
588802	2.0	4.0	91-18
588803	4.0	6.0	91-18
588804	6.0	8.0	91-18
588805	8.0	10.0	91-18
588806	10.0	12.0	91-18
588807	12.0	14.0	91-18
588808	14.0	16.0	91-18
588809	16.0	18.0	91-18
588810	18.0	20.0	91-18
588811	20.0	22.0	91-18
588812	22.0	24.0	91-18
588813	24.0	26.0	91-18
588814	26.0	28.0	91-18
588815	28.0	30.0	91-18
588816	30.0	32.0	91-18
588817	32.0	34.0	91-18
588818	34.0	36.0	91-18
588819	36.0	39.3	91-18
588820	0.0	2.0	92-68
588821	2.0	4.0	92-68
588822	4.0	6.0	92-68
588823	6.0	8.0	92-68
588824	8.0	10.0	92-68
588825	10.0	12.0	92-68
588826	12.0	14.0	92-68
588827	14.0	16.0	92-68
588828	16.0	18.0	92-68
588829	18.0	20.0	92-68
588830	20.0	22.0	92-68
588831	22.0	24.0	92-68
588832	24.0	26.9	92-68
588833	26.9	31.4	92-68
588834	31.4	34.0	92-68
588835	34.0	36.0	92-68
588836	36.0	38.0	92-68
588837	38.0	40.0	92-68
588838	40.0	42.0	92-68
588839	42.0	44.0	92-68
588840	44.0	46.0	92-68
588841	46.0	48.0	92-68
588842	48.0	50.0	92-68

588843	50.0	52.0	92-68
588844	52.0	54.0	92-68
588845	54.0	56.0	92-68
588846	56.0	58.0	92-68
588847	58.0	60.0	92-68
588848	60.0	62.0	92-68
588849	62.0	64.0	92-68
588850	64.0	66.1	92-68
586251	0.0	2.0	91-20
586252	2.0	4.0	91-20
586253	4.0	6.0	91-20
586254	6.0	8.0	91-20
586255	8.0	10.0	91-20
586256	10.0	12.0	91-20
586257	12.0	14.0	91-20
586258	14.0	16.0	91-20
586259	16.0	18.0	91-20
586260	18.0	20.0	91-20
586261	20.0	22.0	91-20
586262	22.0	24.0	91-20
586263	24.0	26.0	91-20
586264	26.0	28.0	91-20
586265	28.0	30.0	91-20
586266	30.0	32.0	91-20
586267	32.0	33.9	91-20
586268	0.0	2.0	91-22
586269	2.0	4.0	91-22
586270	4.0	6.0	91-22
586271	6.0	8.0	91-22
586272	8.0	10.0	91-22
586273	10.0	12.0	91-22
586274	12.0	14.0	91-22
586275	14.0	16.0	91-22
586276	16.0	18.0	91-22
586277	18.0	20.0	91-22
586278	20.0	22.0	91-22
586279	22.0	23.9	91-22

APPENDIX C

DRAWINGS

**#3. DRAFT DESIGN MEMORANDUM CCL-CC2
SITE HYDROLOGY REVISIONS**

Date: March 9, 1998

To: Western Copper Holdings Limited - Dale Corman

cc: Access Mining Consultants Ltd. - Dan Cornett
Kilborn Engineering Pacific Ltd. - Tony Wachmann

From: Clearwater Consultants Ltd. - Peter S. McCreath

Subject: Carmacks Copper Project - Site Hydrology Revisions
Draft Design Memorandum CCL-CC2

Our File: 044.02



This memorandum presents the results of Clearwater Consultants Ltd.'s review of and revisions to the site hydrological characterization for the proposed Carmacks Copper heap leaching project located near Carmacks, Yukon. The work has been carried out in accordance with Design Memorandum CCL-CC1 dated February 10, 1998 and the Consultant Contract between Western Copper Holdings Limited and Clearwater Consultants Ltd. dated January 29, 1998. This memorandum CCL-CC2 summarizes the site hydrology analyses carried out by Clearwater Consultants Ltd. to address the hydrological issues and areas of concern identified by the RERC. The draft memorandum will be finalized after review by the project team and the RERC.

1. Outstanding Issues

Outstanding issues related to hydrology were discussed in Memorandum CCL-CC1 and are summarized briefly below. Resolution of the basic hydrological issues is a crucial first step that must be carried out prior to any revisions to the water balance analysis.

- Is the precipitation analysis carried out for the Williams Creek site "conservative" and how does measured site precipitation compare to precipitation measured at the regional stations at Carmacks and at Pelly Ranch? The RERC reviewers have stated that they want to see more justification for the estimated site precipitation based on regional data.
- A concern remains related to the derivation and application of the "critical wet period occurring at the most critical point in time". This concern is directly connected to the item above and impacts directly on the design solution storage volume for the heap.
- The RERC reviewers have expressed a concern related to the assumed distribution of the annual snowmelt runoff in the April and May period.
- Estimated annual evaporation and evapotranspiration losses have been questioned. The relative impact on the water balance of the annual estimated evaporation depth is minor.

This Memorandum addresses the above issues.

2. Available Data

Sources of hydrology data used in this study are summarized in Table 1. The data include summer rainfall data collected at the Williams Creek site and long-term precipitation (rainfall and snowfall) data reported by the Atmospheric Environment Service (AES) of Environment Canada for nearby regional stations at Carmacks and at Pelly River Ranch (previously referred to as Fort Selkirk). Regional snow survey data reported by the Water Resources Division of DIAND are available for several long-term stations in the area as shown on Table 1. Snow surveys were carried out at the Williams Creek site in 1992 and from 1995 to 1997. The Water Resources Division of DIAND have been responsible for the operation of the Williams Creek meteorological station and collection of snow survey data at the site since 1995.

Table 1 - Hydrology Data Sources

Data Type	Station Name	Station Number	Elevation (m)	Distance from Site	Years of Record
Precipitation	Williams Creek	(Note)	850	-	1994-97
	Carmacks	2100300	525	35 km SE	1964-97
	Pelly River Ranch	2100880	454	70 km NNW	1951-97
Lake Evaporation	Pelly River Ranch	2100880	454	70 km NNW	1964-90
	Whitehorse A.	2101300	703	190 km SSE	1974-90
Snow Surveys	Williams Creek	#1	739	-	1992
	Williams Creek	#2	755	-	1992
	Williams Creek	#3	876	-	1992
	Williams Creek	09AH-SC04	914	-	1995-97
	Pelly Farm	09CD-SC03	472	70 km NNW	1986-97
	Mt. Nansen	09CA-SC01	1021	50 km SW	1976-97
	Mt. Berdoe	09AH-SC01	1035	50 km SE	1975-97
	MacIntosh	09AC-SC02	1160	80 km SW	1976-97
	Satasha Lake	09AH-SC03	1106	90 km S	1987-97
	Casino Creek	09CD-SC01	1065	120 km WNW	1977-97

NOTE : Williams Creek station reports only summer rainfall. Regional stations report rainfall, snowfall, and total precipitation.

3. Precipitation

3.1. General

Annual total precipitation in Yukon typically increases with elevation as described in the AES report "Climate of Yukon" (AES Climatological Studies Number 40). Previous studies for the Williams Creek site area reported in the IEE and subsequent Addenda used an "orographic factor" of about 1.29 based on an assumed 8% increase in annual precipitation per 100 m increase in elevation to estimate Williams Creek precipitation at elevation 850 m from the average of regional data collected at lower elevations (Carmacks and Pelly River Ranch stations). The magnitude of the orographic factor has been questioned by RERC reviewers. Since the earlier studies, additional concurrent site and regional rainfall and snow survey data have been collected in 1995 through 1997.

The general approach used for the present study was to first compare all common periods of record for Williams Creek and the regional data to estimate orographic factors and then, using frequency analyses of the long-term regional data, estimate conditions applicable to the Williams Creek site.

Total precipitation, rainfall and snowfall data reported by AES for Carmacks and Pelly River Ranch are shown in Tables I.1 to I.6 in Appendix I. All the available climatic data recorded since 1994 at the Williams Creek station are shown on Table I.7. Concurrent Williams Creek and regional rainfall data are shown on Table I.8. Regional and site snow survey data are presented in Table I.9.

Although Carmacks is slightly closer to the Williams Creek site, Pelly River has the longest and most complete regional database, including concurrent data for precipitation, rainfall, snowfall (Pelly River Ranch) and snow surveys (Pelly Farm). The Pelly stations were, therefore, adopted as the "base" stations for estimating conditions at the Williams Creek site. Carmacks data are presented in this report for completeness.

3.2. Average Annual Rainfall, Snowfall and Total Precipitation

Table 2 summarizes long-term average precipitation, rainfall and snowfall for Carmacks and for Pelly River Ranch.

Table 2 - Regional Average Precipitation

Item	Carmacks	Pelly River Ranch
Elevation (m)	525	454
Years of Data	1964 - 1997	1951 - 1997
Average Annual Precipitation (mm)	282	300
Average Annual Rainfall (mm)	180	185
Rainfall % of Total Precipitation	64%	62%
Average Annual Snowfall (mm)	101	115
Snowfall % of Total Precipitation	36%	38%

(Precipitation = Rainfall plus Snowfall, all as mm water)

Rainfall at Pelly River Ranch usually occurs from May through September with minor amounts occasionally recorded in April, October and November. Snowfall typically occurs in October through March with minor amounts recorded in September and April.

For both Carmacks and Pelly River Ranch, snowfall water equivalent in millimetres has been calculated based on the measured depth of snowfall in centimetres and an assumed constant snowfall density of 10%. Table I.10 compares concurrent snow survey and snowfall data for Pelly River. The data indicate that, on average over the 1986 to 1997 period for the maximum measured snowpack, either snowfall density has averaged about 8% with no sublimation losses or, with a 10% density, an average of about 20 mm of snowfall may have been lost to sublimation during the winter months.

Table 2 indicates that, for these two stations, annual precipitation may in fact decrease slightly with increasing elevation in this area, an observation at odds with the general behaviour typically expected in Yukon. Table I.8, however, indicates that for the 12 months of concurrent rainfall data at Williams Creek and at Pelly River Ranch, total recorded rainfall increased at about 1.3% per 100 m increase in elevation. The orographic factor for rainfall (OF_R) was calculated as follows:

$$\text{Rainfall Orographic Factor } OF_R = 1 + [(\text{Elev}_{WC} - \text{Elev}_{PR})/100] \times 0.013 = 1.0515$$

where Elev = elevation in metres, and subscripts WC and PR refer to Williams Creek (elevation 850 m) and Pelly River Ranch (elevation 454 m), respectively.

Orographic Factor OF_R was adopted to estimate an annual average rainfall at Williams Creek of 195 mm based on long-term average annual rainfall of 185 mm at Pelly River Ranch.

In order to estimate annual average snowfall at Williams Creek elevation 850 m, comparisons were made between the concurrent snow survey data at Williams Creek (elevation 914 m, Table I.9) and at Pelly Farm (elevation 472 m, Table I.9) for 1995 to 1997, the long-term Pelly Farm snow survey data (1986 to 1997) and the long-term cumulative winter snowfall data at Pelly River Ranch (1955 to 1997 at elevation 454 m, Table I.6) as shown in Table 3.

Table 3 - Estimation of Average Annual Total Snowfall at Williams Creek

Item	Williams Creek		Pelly Farm/Pelly River		
	1995-97	Long Term	1995-97	1986-97	Long Term
Average Maximum Snowpack	86.3	108.5 (B)	67.3	84.8	84.6 (A)
Total Snowfall	n/a	147.5 (C)	93.8	115.3	115.0

(Note - average maximum snowpack in mm water equivalent, total snowfall from the previous Fall through April period, maximum snowpacks measured on April 1 each year)

The calculation methodology for items A, B, and C is described following:

- Pelly Farm 1986-97 average maximum snowpack represents 126% of the 1995-97 average (= 84.8 / 67.3);
- Pelly River long term (1955 to 1997) average snowfall at elevation 454 m represents 99.7% of the 1986 to 1997 average snowfall (= 115.0 / 115.3);

- Pelly Farm 1986-97 average maximum snowpack represents 73.5% of the average total snowfall ($= 84.8 / 115.3$); therefore,
- Item A (estimated long term average Pelly Farm maximum snowpack) equals $(67.3 \times 1.26 \times 0.997) = 84.6$ mm;
- Item B (estimated long term Williams Creek average maximum snowpack) equals $(86.3 \times 1.26 \times 0.997) = 108.5$ mm;
- Item C (estimated long term average Williams Creek total snowfall at elevation 914 m) equals $(108.5 / 0.735) = 147.5$ mm

From the above, annual total snowfall appears to increase at a rate of about 6.1% per 100 m rise in elevation (115 mm at elevation 454 m to 147.5 mm at elevation 914 m). The orographic factor for snowfall (OF_S) was calculated as follows:

$$\text{Snowfall Orographic Factor } OF_S = 1 + [(\text{Elev}_{WC} - \text{Elev}_{PR})/100] \times 0.061 = 1.2416$$

where Elev = elevation in metres, and subscripts WC and PR refer to Williams Creek (850 m) and Pelly River (454 m), respectively.

Orographic Factor OF_S was adopted to estimate an annual average snowfall at Williams Creek of 143 mm based on long-term average annual snowfall of 115 mm at Pelly River Ranch.

The estimated annual average total precipitation at the Williams Creek site is thus 338 mm comprised of 195 mm rainfall (58%) and 143 mm snowfall (42%). Overall based on the above analysis, average annual total precipitation appears to increase at a rate of about 3.2% per 100 m between Pelly River Ranch (300 mm at elevation 454 m) and Williams Creek (338 mm at elevation 850 m). The orographic factor for annual total precipitation (OF_P) was calculated as follows:

$$\text{Total Precipitation Orographic Factor } OF_P = 1 + [(\text{Elev}_{WC} - \text{Elev}_{PR})/100] \times 0.032 = 1.1267$$

The above analysis indicates that the assumed 8% increase in annual total precipitation per 100 m increase in elevation (equivalent orographic factor $OF_P = 1.3168$) used in the previous studies was perhaps overly conservative. The orographic factors and average Williams Creek rainfall, snowfall and total precipitation derived herein were based on assessment of all available concurrent and long-term site and regional precipitation data.

3.3. Wet and Dry Year Precipitation

Precipitation data for Pelly River Ranch were selected as the primary database. Values for Williams Creek were estimated using the factors developed in Section 3.2. Frequency analyses of the Pelly River Ranch data were carried out using the Consolidated Frequency Analysis (CFA) computer program Version 3.1 developed by the Surveys and Information Systems Branch of Environment Canada. Analyses were carried out using various frequency distributions including the generalized extreme value (GEV), three parameter log-normal, log-Pearson Type III, and non-parametric distribution. Results did not differ significantly (about 2% variation at the 100 year return period level) among the various frequency distributions and the GEV distribution was selected as an appropriate frequency distribution.

Table I.11 presents the results of the frequency analysis of annual total precipitation for Pelly River Ranch for annual events ranging from a 20 year return period dry year to a 500 year return period wet

year. Also shown on the Table are the corresponding values of estimated annual total precipitation, annual rainfall and annual snowfall for the Williams Creek site at an elevation of 850 m.

3.4. Wet Periods

3.4.1. One to Three Month Rainfall

Analyses were carried out of the maximum one month and consecutive two and three month duration periods of rainfall that could occur during the May to September period. The analyses were based on the common data in 1996 and 1997 for Williams Creek and Pelly River Ranch shown on Table I.8 and the long term data for Pelly River Ranch shown on Table I.13. The data indicate that orographic factors may be higher for one and two month duration rainfall than for annual total rainfall as shown in Table I.14. Based on the number of occurrences of maximum events (Table I.13) and the concurrent data, the following conclusions were drawn:

- the maximum individual rainfall month is most likely to be July although annual maxima have occurred in each of the five months;
- maximum two month and three month duration wet periods are most likely to start in either June or July but could start in any of the five months;
- maximum one, two and three month duration rainfall recorded during the summer of 1996 and 1997 were above average at Pelly River Ranch with the 1997 three month rainfall (May, June and July) of 223.2 mm having an estimated return period in the order of fifty years. Data recorded at Williams Creek for these years displayed similar behaviour.

Frequency analysis of the Pelly River Ranch multi-month rainfall data were carried out and the orographic factors (Table I.14) applied to estimate the corresponding rainfall depths for the Williams Creek site. The results are presented in Table I.15.

3.4.2. Winter Snow Accumulation

Frequency analyses were carried out of total cumulative precipitation at Pelly River Ranch over six month (October through March) and seven month (October through April) periods. The results were projected to Williams Creek using the estimated orographic factor for annual average snowfall (Section 3.2). This analysis, therefore, conservatively assumes that all precipitation falling in the six or seven month periods was snowfall. The results for Pelly River Ranch and for Williams Creek are presented in Table I.15.

3.5. Monthly Precipitation Distribution

Average monthly precipitation (rainfall, snowfall and total precipitation) conditions were estimated for Williams Creek based on conditions at Pelly River Ranch modified in accordance with the estimated annual Williams Creek rainfall and snowfall values derived previously. The results are shown on Table I.16. Total rainfall is expected to be zero from November through March with zero snowfall in the May through September period. The spring and fall transition months of April and October may experience a mixture of rainfall and snowfall.

4. Maximum Annual Snowpack and Snowmelt Runoff

4.1. Timing of Snowmelt

For all the data for snow survey stations within 100 km of the site (Table I.9), annual maximum snowpacks have been reported on April 1 more than 80% of the time. Maximums on May 1 have occurred less than 5% of the time. Based on the regional and site snow survey data, the annual maximum snowpack for the Williams Creek site is, therefore, most likely to occur on or about April 1 each year. The data also show that, based on the rate of depletion of the snowpacks, on average about 70% of the snowmelt has occurred during April with the remainder in May. However, about one-third of the time 100% of the snowmelt has occurred during April. The Williams Creek data for 1995 to 1997 averaged about 60% melt during April and 40% melt in May with maximum snowpack on April 1 for each year. For design purposes it is recommended that the following timing of the snowmelt be assumed:

- for the design of the heap leach pad maximum solution storage volumes, 100% of the annual snowmelt will occur during April. Based on the magnitude of the snowpacks and typical maximum daily rates of snowmelt, the entire snowpack could melt and runoff could occur over a period of about two weeks under extreme design conditions;
- for average conditions in the heap leach pad water balance the snowmelt will be distributed 70%/30% between April and May;
- for conditions in receiving waters downstream of the leach pad, 70% of the area snowmelt will occur during April with the remaining 30% during May.

4.2. Annual Maximum Snowpack

As presented in Table 3, the estimated average annual maximum snowpack at Williams Creek is 108.5 mm of water equivalent occurring on April 1. This depth is essentially equivalent to the cumulative average six month (October to March) snowfall depth of 114 mm for Pelly River Ranch. Thus, one method of estimating the maximum April 1 snowpack for extreme years would be to assume that the Williams Creek maximum snowpack is equal to the six month October to March cumulative precipitation at Pelly River Ranch as shown in Table I.15A.

Another method would be to estimate Williams Creek maximum snowpack as equal to the six month October to March cumulative precipitation at Williams Creek as shown in Table I.15B minus an allowance for winter sublimation losses from the snowpack. Table I.10 indicates that an average of about 20 mm of snowpack water equivalent may be lost during the winter due to sublimation, although the actual loss may vary from zero to about 60 mm. Assuming a nominal average sublimation loss of 20 mm, this method yields a higher, more conservative estimate of the annual maximum snowpack water equivalent for Williams Creek for extreme years than the method discussed in the previous paragraph. Therefore, it is recommended that the maximum April 1 snowpack water equivalent for extreme years at Williams Creek be estimated as follows:

- Maximum Snowpack = Total October to March precipitation *minus* 20 mm sublimation loss
(total October to March six month precipitation for extreme years shown in Table I.15B)

4.3. Snowmelt Runoff Volume

The total runoff volume each spring will consist of the runoff depth from the melting snowpack plus runoff from concurrent precipitation occurring during the snowmelt period, both applied to the catchment area of interest. For design solution storage conditions it is appropriate to assume that no losses will occur during the April snowmelt runoff period. Thus, the total runoff during April will be equal to 100% of the maximum snowpack plus 100% runoff of the concurrent April total precipitation.

5. Evaporation

Previous reviews of reports by the RERC and their consultants have questioned the magnitude of annual evaporation and evapotranspiration applied to the Williams Creek area and, in particular, whether the estimates are conservative. Table I.16 summarizes the monthly and annual lake evaporation reported for Pelly Ranch and Whitehorse as well as estimates of lake evaporation and evapotranspiration prepared by the Water Resources Division of DIAND. Also shown in the Table are estimated values for Williams Creek based on the 10% decrease per 350 m elevation increase factor reported in the Manual of Operational Hydrology in BC.

The use of a "conservative" evaporation rate will be a function of the application. The following are recommended based on the information contained in Table I.16:

- for the determination of maximum design solution storage volumes, a conservative evaporation rate would correspond to a low estimate, for which a value of 402 mm per year is appropriate. This is the same value used in the previous water balance studies;
- for the determination of maximum likely make-up water requirements, a conservative evaporation rate would correspond to a high estimate, for which a value of 521 mm/year is appropriate;
- for average conditions a value of 460 mm/year is suggested, the average of the above two values. This value also corresponds essentially to the average Pelly Ranch lake evaporation without allowing for any adjustment due to elevation difference.

Monthly rates of evaporation should be determined using the above annual values distributed between May and September based proportionally on the Pelly Ranch monthly evaporation rates.

APPENDIX I

HYDROLOGY DATA

APPENDIX I - Hydrology Data

<u>Table Number</u>	<u>Table Title</u>
I.1	Carmacks Total Precipitation (mm)
I.2	Carmacks Total Rainfall (mm)
I.3	Carmacks Total Snowfall (cm)
I.4	Pelly River Ranch Total Precipitation (mm)
I.5	Pelly River Ranch Total Rainfall (mm)
I.6	Pelly River Ranch Total Snowfall (cm)
I.7	Average Monthly Values - Williams Creek Climate Station
I.8	Williams Creek & Concurrent Regional Rainfall Data
I.9	Regional and Site Snow Survey Data (4 pages)
I.10	Pelly Farm Snow Survey & Concurrent Snowfall Data
I.11	Wet and Dry Year Precipitation, Rainfall, Snowfall - Williams Creek Site
I.12	Carmacks Wet Period Precipitation
I.13	Pelly River Ranch Wet Period Precipitation
I.14	One, Two and Three Month Duration Wet Period Rainfall - Common Data
I.15	Wet Period Precipitation - One to Seven Month Duration
I.15A	Pelly River Ranch
I.15B	Williams Creek Site
I.16	Average Monthly Precipitation Conditions - Williams Creek Site
I.17	Lake Evaporation Data and Estimates

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TABLE I.1 - CARMACKS Total Precipitation (mm)

													Station 2100300		Lat 62° 6' N	
													Elevation 525 m		Long 136° 18' W	
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual			
1963									40.4	17.5	12.2	10.4				
1964	14.2	13.5	6.1	0.5	29.7	56.1	39.6	41.4	14.2	12.2	6.1	4.3	237.9			
1965	18.5	5.6	5.3	1.8	16.8	23.6	32.8	15.0	23.4	23.9	6.6	13.5	186.8			
1966	3.3	10.2	3.6	8.6	11.4	35.1	42.4	43.7	18.3	22.6	51.6	6.6	257.4			
1967	42.7	23.4	23.4	7.6	42.4	45.0	54.1	25.4	12.2	20.1	14.5	7.6	318.4			
1968	42.7	11.2	4.8	16.0	21.8	20.1	59.2	33.8	50.0	10.9	24.1	6.6	301.2			
1969	13.0	2.8	4.1	4.3	11.7	5.8	55.4	32.0	27.9	6.4	16.3	9.4	189.1			
1970	11.9	16.8	7.9	11.4	29.0	11.2	25.1	18.5	51.6	44.5	24.9	22.1	274.9			
1971	5.8	4.3	3.3	1.5	0.1	9.4	37.1	39.6	23.1	22.6	13.5	21.6	181.9			
1972	24.1	8.4	0.1	14.5	15.5	65.3	34.0	25.9	43.2	23.4	16.3	18.5	289.2			
1973	13.2	2.5	3.8	7.4	5.8	35.3	28.7	63.5	9.1	19.8	41.7	17.3	248.1			
1974	7.6	33.8	15.0	2.0	6.4	36.3	52.6	68.6	19.6	14.5	10.7	34.3	301.4			
1975	23.9	5.6	9.7	18.0	5.6	13.2	60.2	57.4	38.4	23.4	15.2	19.6	290.2			
1976	33.5	4.3	8.4	2.3		30.5		6.6	0.3	4.8	8.1	12.7				
1977	14.4	9.7	14.1	8.1	24.7	49.5	57.1	52.5	63.7		10.2	5.6				
1978	0.5	3.0	1.0	7.6	15.0	46.6	56.8	39.6	13.8	9.0	14.6					
1979	5.0				23.2	47.6	104.4	23.6	23.4	3.6	9.6	28.4				
1980	28.0	17.2	13.2	5.6	20.6	24.8	72.8	53.6	55.2	24.8	37.6	6.4	359.8			
1981	7.2	13.8	3.0	7.8	8.8	27.1	105.2	27.8	37.3	22.0	16.2	4.2	280.4			
1982	19.8	14.6	13.4	2.0	33.0	11.4	66.9	46.1	26.7	48.6	14.2	11.8	328.5			
1983	17.6	5.0	5.0	5.8	35.5	53.0	71.6	69.2	37.6	17.0	2.2	9.4	328.9			
1984	23.6	17.5	3.2	2.0	27.8	37.8	42.8	32.4	12.3	17.0	17.5	23.6	257.5			
1985	31.4	21.0	0.5	5.0	4.6	30.1	79.0	48.6	24.6	27.4	22.0	12.5	306.7			
1986	30.0	2.5	22.0	16.4	24.4	27.9	47.4	31.3	37.0	11.0	18.5	11.5	279.9			
1987	2.0	34.5	1.5	0.8	40.0	30.8	26.0	36.0	34.2	13.6	18.5	19.0	256.9			
1988	10.2	10.5	22.5	2.0	27.0	37.4	88.8	33.6	17.8	18.7	24.0	8.5	301.0			
1989	18.0	2.0		0.1	32.7	41.9	31.6	17.6	19.9	23.1	30.5	26.0				
1990	22.0	23.5	1.0	6.0	37.2	78.6	40.2	50.1	61.2	26.3	13.0	35.7	394.8			
1991	17.4	20.4	8.5	2.0	11.7	53.2	62.7	37.2	44.0	31.9	35.5	45.0	369.5			
1992	22.5	8.4	0.5	20.0	36.3	18.0	68.7	27.9	48.5	17.5	19.0	21.9	309.2			
1993	17.0	10.5	10.5	0.0	52.0	29.4	35.0	56.3	38.8	34.3	35.5	15.5	334.8			
1994	25.0	8.0	20.0	3.0	16.3	27.4	25.4	21.9	27.6	29.0	20.9	4.0	228.5			
1995	5.5	12.8	8.5	4.5	11.2	6.6	60.2	56.9	26.4	12.1	26.0	16.6	247.3			
1996	9.2	8.0	13.0	4.0	11.4	10.2	87.3	55.7	14.1	41.0	5.7	17.0	276.6			
1997	9.9	13.0	11.5	11.8	32.2	39.2	45.0	17.0	15.6	25.2	19.5	18.0	257.9			
# years	34	33	32	33	33	34	33	34	35	34	35	34	29			
Mean	17.4	12.1	8.4	6.4	21.9	32.8	55.0	38.4	30.0	21.2	19.2	16.0				
Max.	42.7	34.5	23.4	20.0	52.0	78.6	105.2	69.2	63.7	48.6	51.6	45.0	394.8			
Min.	0.5	2.0	0.1	0.0	0.1	5.8	25.1	6.6	0.3	3.6	2.2	4.0	181.9			
Std. Dev	10.81	8.40	6.81	5.53	12.77	17.39	22.42	16.19	15.69	10.51	10.97	9.73	52.98			
													Sum of Average Months =		278.8	
													Average of Complete Years =		282.6	

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TABLE 1.2 - CARMACKS Total Rainfall (mm)

Station 2100300 Elevation 525 m													Lat 62° 6' N Long 136° 18' W
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1963									40.4	10.7	0.0	0.0	
1964	0.0	0.0	0.0	0.0		56.1	39.6	41.4	14.2	3.3	0.0	0.0	
1965	0.0	0.0	0.0	0.0	0.1	23.6	32.8	15.0	23.4	2.0	0.0	0.0	96.9
1966	0.0	0.0	0.0	1.5	11.4	35.1	42.4	43.7	18.3	7.9	0.0	0.0	160.3
1967	0.0	0.0	0.0	0.1	39.9	45.0	54.1	25.4	12.2	4.6	8.6	0.0	189.9
1968	0.0	0.0	0.1	1.0	21.8	20.1	59.2	33.8	43.7	0.0	0.0	0.0	179.7
1969	0.0	0.0	0.0	4.1	11.7	5.8	55.4	32.0	27.9	5.8	2.5	0.0	145.2
1970	0.0	0.0	5.1	0.1	29.0	11.2	25.1	18.5	47.5	0.0	0.0	0.0	136.5
1971	0.0	0.0	0.0	0.0	0.1	9.4	37.1	39.6	23.1	5.8	0.0	0.0	115.1
1972	0.0	0.0	0.0	0.0	13.7	65.3	34.0	25.9	43.2	8.6	0.0	0.0	190.7
1973	0.0	0.0	0.0	0.0	5.8	35.3	28.7	63.5	9.1	1.0	0.0	0.0	143.4
1974	0.0	0.0	0.0	1.3	2.8	36.3	52.6	68.6	18.0	8.4	0.0	0.0	188.0
1975	0.0	0.0	0.0	0.0	5.1	13.2	60.2	57.4	38.4	9.1	0.0	0.0	183.4
1976	0.0	0.0	0.0	0.0		30.5		6.6	0.3	2.5	0.1	0.0	
1977	0.0	0.0	0.0	0.1	24.7	49.5	57.1	52.5	59.7		0.0	0.0	
1978	0.0	0.0	0.0	0.0	15.0	46.6	56.8	39.6	13.8	9.0	0.0	0.1	180.9
1979	0.0				23.2	47.6	104.4	23.6	23.4	2.2	0.0	0.0	
1980	0.0	0.0	0.0	5.6	20.6	24.8	72.8	53.6	51.6	14.8	0.0	0.0	243.8
1981	0.0	0.0	0.1		8.8	27.1	105.2	27.8	33.3	14.4	0.0	0.0	
1982	0.0	0.0		0.0	30.0	11.4	86.9	46.1	26.7	3.4	0.0	0.0	
1983	0.0	0.0	0.0	5.8	35.5	53.0	71.6	69.2	37.6	3.4	0.0	0.0	276.1
1984	0.0	0.0	0.0	1.0	27.8	37.8	42.8	31.4	12.3	2.0	0.0	0.0	155.1
1985	0.0	0.0	0.0	0.0	4.6	30.1	79.0	48.6	24.6	2.2	0.0	0.0	189.1
1986	0.0	0.0	0.0	0.1	24.4	27.9	47.4	31.3	32.0	11.0	0.0	0.0	174.1
1987	0.0	0.0	0.0	0.1	40.0	30.8	26.0	36.0	34.2	6.6	0.0	0.0	173.7
1988	0.0	0.0	0.0	0.0	27.0	37.4	88.8	33.6	17.8	0.2	0.0	0.0	204.8
1989	0.0	0.0	0.0	0.1	32.7	41.9	31.6	17.6	19.9	11.1	0.0	0.1	155.0
1990	0.0	0.0	0.0	6.0	37.2	78.8	40.2	50.1	61.2	2.3	0.0	0.0	275.6
1991	0.0	0.0	0.0	0.1	11.7	53.2	62.7	37.2	44.0	19.9	0.0	0.0	228.8
1992	0.0	0.0	0.1	0.1	34.3	18.0	68.7	27.9	37.0	5.0	0.1	0.0	191.2
1993	0.0	0.0	0.0	0.0	52.0	29.4	35.0	56.3	37.8	1.2	0.0	0.0	211.7
1994	0.0	0.0	1.0	0.1	16.3	27.4	25.4	21.9	27.6	21.1	0.0	0.0	140.8
1995	0.0	0.0	0.0	4.5	11.2	6.6	60.2	56.9	26.4	10.6	0.0	0.0	176.4
1996	0.0	0.0	0.0	4.0	11.4	10.2	87.3	55.7	14.1	0.0	0.0	0.0	182.7
1997	0.0	0.0	0.0	6.0	32.2	39.2	45.0	17.0	15.6	0.2	0.0	0.0	155.2
# years	34	33	32	32	32	34	33	34	35	34	35	35	28
Mean	0.0	0.0	0.2	1.3	20.7	32.8	55.0	38.4	28.9	6.2	0.3	0.0	
Max.	0.0	0.0	6.1	6.0	52.0	78.6	105.2	69.2	61.2	21.1	8.6	0.1	276.1
Min.	0.0	0.0	0.0	0.0	0.1	5.8	25.1	6.6	0.3	0.0	0.0	0.0	96.9
Std. Dev	0.00	0.00	0.91	2.14	13.34	17.39	22.42	16.20	14.52	5.59	1.50	0.02	45.10
Sum of Average Months =													183.8
Average of Complete Years =													180.1

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09/03/98

TABLE 1.3 - CARMACKS Total Snowfall (cm) Station 2100300 Lat 62° 6' N
Elevation 525 m Long 136° 18' W

(Note - Calculation of Total Precipitation (Table 1.1) assumes constant 10% density for snowfall)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1963								0.0	0.0	6.9	12.2	10.4	
1964	14.2	13.5	6.1	0.5		0.0	0.0	0.0	0.0	8.9	6.1	4.3	
1965	18.5	5.6	5.3	1.8	16.8	0.0	0.0	0.0	0.1	21.8	6.6	13.5	90.0
1966	3.3	10.2	3.6	7.1	0.1	0.0	0.0	0.0	0.0	14.7	51.6	6.6	97.2
1967	42.7	23.4	23.4	7.6	2.5	0.0	0.0	0.0	0.0	15.5	5.8	7.6	128.5
1968	42.7	11.2	4.8	15.0	0.0	0.0	0.0	0.0	6.4	10.9	24.1	6.6	121.7
1969	13.0	2.8	4.1	0.3	0.0	0.0	0.0	0.0	0.0	0.5	13.7	9.4	43.8
1970	11.9	16.8	2.8	11.4	0.0	0.0	0.0	0.0	4.1	44.5	24.9	22.1	138.5
1971	5.8	4.3	3.3	1.5	0.0	0.0	0.0	0.0	0.1	16.8	13.5	21.6	66.9
1972	24.1	8.4	0.1	14.5	1.8	0.0	0.0	0.0	0.1	14.7	16.3	18.5	98.5
1973	13.2	2.5	3.8	7.4	0.0	0.0	0.0	0.0	0.0	18.8	41.7	17.3	104.7
1974	7.6	33.8	15.0	0.8	3.6	0.0	0.0	0.1	1.5	6.1	10.7	34.3	113.5
1975	23.9	5.6	9.7	12.4	0.5	0.0	0.0	0.0	0.0	14.2	15.2	19.6	101.1
1976	33.5	4.3	8.4	2.3	0.1	0.0		0.0	0.0	2.3	8.1	12.7	
1977	14.4	9.7	14.1	8.1	0.0	0.0	0.0	0.0	4.0		10.2	5.6	
1978	0.5	3.0	1.0	7.6	0.0	0.0	0.0	0.0	0.1	0.1	14.6		
1979	5.0				0.0	0.0	0.0	0.0	0.0	1.4	9.6	28.4	
1980	28.0	17.2	13.2	0.1	0.0	0.0	0.0	0.0	3.6	10.0	37.6	6.4	116.1
1981	7.2	13.8	3.0		0.0	0.0	0.0	0.0	4.0	7.6	16.2	4.2	
1982	19.8	14.6		2.0	3.0	0.0	0.0	0.0	0.0	45.2	14.2	11.8	
1983	17.6	5.0	5.0	0.0	0.1	0.0	0.0	0.0	0.1	13.6	2.2	9.4	53.0
1984	23.6	17.5	3.2	1.0	0.0	0.0	0.0	1.0	0.0	15.0	17.5	23.6	102.4
1985	31.4	21.0	0.5	5.0	0.0	0.0	0.0	0.0	0.0	25.2	22.0	12.5	117.6
1986	30.0	2.5	22.0	16.4	0.0	0.0	0.0	0.0	5.0	0.1	18.5	11.5	106.0
1987	2.0	34.5	1.5	0.8	0.0	0.0	0.0	0.0	0.0	7.0	18.5	19.0	83.3
1988	10.2	10.5	22.5	2.0	0.0	0.0	0.0	0.0	0.0	18.5	24.0	8.5	96.2
1989	18.0	2.0		0.1	0.0	0.0	0.0	0.0	0.0	12.0	30.5	26.0	
1990	22.0	23.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0	24.0	13.0	35.7	119.2
1991	17.4	20.4	8.5	2.0	0.0	0.0	0.0	0.0	0.0	12.0	35.5	45.0	140.8
1992	22.5	8.4	0.5	20.0	2.0	0.0	0.0	0.0	11.5	12.5	19.0	21.9	118.3
1993	17.0	10.5	10.5	0.0	0.1	0.0	0.0	0.0	1.0	33.1	35.5	15.5	123.2
1994	25.0	8.0	19.0	3.0	0.1	0.0	0.0	0.0	0.0	7.9	20.9	4.0	87.9
1995	5.5	12.8	8.5	0.0	0.0	0.0	0.0	0.0	0.0	1.5	26.0	16.6	70.9
1996	9.2	8.0	13.0	0.1	0.0	0.0	0.0	0.0	0.0	41.0	5.7	17.0	94.0
1997	9.9	13.0	11.5	5.8	0.0	0.0	0.0	0.0	0.0	25.0	19.5	18.0	102.7
# years	34	33	31	32	33	34	33	35	35	34	35	34	26
Mean	17.4	12.1	8.0	4.9	0.9	0.0	0.0	0.0	1.2	15.0	18.9	16.0	
Max.	42.7	34.5	23.4	20.0	16.8	0.0	0.0	1.0	11.5	45.2	51.6	45.0	138.5
Min.	0.5	2.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	2.2	4.0	43.8
Std. Dev	10.81	8.40	6.88	5.68	3.01	0.00	0.00	0.17	2.51	12.00	11.21	9.73	24.51
Sum of Average Months =													94.4
Average of Complete Years =													101.4

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09/03/98

TABLE 1.4 - PELLY RIVER RANCH Total Precipitation (mm)

Year	Station 2100880 Elevation 454 m												Annual
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1951													48.3
1952	48.3	5.1	6.4	2.5	6.6								
1954						6.1	40.6	17.8	23.4	2.5	18.8	32.8	
1955	22.4	5.3	8.1	0.1	7.1	43.2	14.0	86.1	10.7	4.8	26.4	23.6	251.8
1956	12.7	11.7		6.9	40.1	45.0	48.3	40.9	2.8	37.1	33.0	18.0	
1957	14.7	23.9	13.7	7.9	15.2	12.7	34.8	19.6	19.8	2.3	33.3	20.8	218.7
1958	20.8	16.3	1.3	3.0	14.2	33.5	62.0	67.1	17.0	45.2	35.1	12.4	327.9
1959	10.2	21.1	24.4	10.7	19.3	46.7	29.0	37.6	25.1	6.4	20.1	14.5	265.1
1960	11.2	15.2	12.7	5.1	18.5	26.4	117.9	36.6	28.4	8.4	24.1	17.8	322.3
1961	13.5	10.9	11.2	6.6	23.4	45.0	44.5	25.9	18.3	41.9	24.4	29.2	294.8
1962	25.4	17.3	4.1	24.9	16.3	55.9	35.6	39.4	13.0	6.4	15.0	37.8	291.1
1963	47.8	7.4	10.7	10.9		47.5	58.7	18.5	35.1	27.2	14.7	47.5	
1964	24.1	19.1	16.5	16.0	26.2	53.6	88.1	30.7	21.1	19.8	19.1	20.1	354.4
1965	12.2	9.9	5.1	3.6	14.0	30.0	41.9	17.5	40.4	42.4	17.8	24.9	259.7
1966	7.6	26.2	6.6	10.2	5.8	28.2	7.1	20.3	16.0	35.3	61.0	10.4	234.7
1967	37.6	26.7	31.2	14.2	16.5	46.2	65.0	56.4	28.4	13.0	16.3	18.5	370.0
1968	30.7	12.2	19.8	15.7	25.1	21.3	29.7	25.7	59.7	14.2	27.4	10.7	292.2
1969	11.7	3.6	14.5	11.9	30.5	3.3	81.5	12.2	22.9	7.9	25.7	14.5	240.2
1970	8.4	16.0	2.0	7.6	48.8	24.4	5.3	42.7	50.3	35.3	25.7	35.3	301.8
1971	4.6	6.6	7.9	4.8	7.4	11.7	24.1	45.0	22.1	28.4	28.4	40.4	231.4
1972	23.1	13.7	7.9	12.7	14.7	70.9	47.2	23.1	23.4	54.1	20.1	12.2	323.1
1973	25.1	12.4	17.8	30.5	5.1	50.8	47.5	54.1	8.6	17.3	22.6	34.3	326.1
1974	4.6	37.3	9.7	19.1	7.4	14.7	65.8	31.8	8.6	27.9	14.0	30.5	271.4
1975	20.3	4.6	0.3	18.3	13.7	16.5	71.6	29.0	32.3	20.8	15.7	12.2	255.3
1976	30.5	14.0	26.9	10.7	42.9	37.3	46.7	19.3	14.5	15.2	24.1	13.7	295.8
1977	31.1	4.1	16.8	25.0	24.2	44.8	30.3	18.3	14.9	18.1	21.7	11.7	261.0
1978	10.8	3.3	3.4	12.9	17.8	33.4	100.0	46.7	23.8	24.7	23.7	26.9	327.4
1979	23.8	19.5	20.9	4.6	29.5	47.7	54.1	10.2	33.5	4.0	18.9	17.6	284.3
1980	24.3	11.5	2.8	3.2	9.2	24.8	44.4	33.0	53.4	17.6	21.5	1.8	247.5
1981	5.4	27.0	4.3	11.0	13.2	33.3	87.9	43.6	52.9	43.0	41.5	6.0	369.1
1982	11.3	13.1	6.4	13.9	33.7	13.3	62.7	22.4	31.7	25.4	22.0	13.2	269.1
1983	30.1	27.2	3.3	5.8	29.0	50.3	53.8	82.2	26.0	20.6	6.6	11.3	346.2
1984	24.1	23.6	8.2	8.5	33.5	27.0	44.6	48.7	25.0	14.4	14.7	28.9	301.2
1985	27.6	17.0	5.6	8.9	20.5	69.8	88.4	48.8	28.5	23.1	17.2	10.9	366.3
1986	27.7	4.7	16.9	5.8	30.0	47.4	73.0	44.5	8.0	9.0	20.9	14.5	302.4
1987	11.7	25.7	8.3	9.2	22.3	26.6	53.4	34.6	43.1	42.9	32.4	25.2	335.4
1988	12.4	14.8	13.9	4.1	23.8	26.2	68.8	28.6	9.8	26.6	22.0	21.3	272.3
1989	14.0	6.0	5.6	0.2	32.6	49.1	13.1	20.4	23.8	18.6	35.9	12.0	231.3
1990	11.6	21.9	6.8	1.6	48.4	57.0	13.0	41.0	45.0	34.0	23.2	40.0	343.5
1991	16.6	23.8	9.9	4.0	25.1	30.0	47.8	34.7	43.0	23.4	40.1	30.0	328.4
1992	32.0	11.2	16.0	46.6	28.2	32.2	44.3	47.4	56.4	39.2	31.0	19.4	403.9
1993	24.9	6.8	34.4	8.8	18.4	16.8	61.9	40.0	20.8	28.1	34.8	7.0	302.7
1994	24.6	4.8	15.9	7.7	37.8	53.6	36.2	8.6	21.6	27.4	27.4	3.6	269.2
1995	5.8	12.4	4.6	0.2	16.8	31.8	84.4	78.2	10.6	22.9	15.8	22.4	305.9
1996	12.8	16.6	9.9	16.6	3.4	27.9	67.2	58.2	33.6	32.8	6.2	24.4	309.6
1997	7.6	17.0	18.4	12.6	86.0	56.8	80.6	36.0	29.4	24.0	24.7	18.2	411.1
# years	44	44	43	44	43	44	44	44	44	44	44	45	41
Mean	19.5	14.7	11.4	10.6	23.3	35.7	52.7	36.9	26.7	23.5	24.2	21.0	
Max.	48.3	37.3	34.4	46.6	86.0	70.9	117.9	86.1	59.7	54.1	61.0	48.3	411.1
Min.	4.6	3.3	0.3	0.1	3.4	3.3	5.3	8.6	2.8	2.3	6.2	1.8	218.7
Std. Dev	10.76	8.09	7.96	8.76	15.13	16.45	25.37	18.38	14.12	13.00	9.70	11.25	47.14
Sum of Average Months =													300.2
Average of Complete Years =													300.4

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09/03/98

TABLE 1.5 - PELLY RIVER RANCH Total Rainfall (mm)

	Station 2100880 Elevation 454 m										Lat 62° 49' N Long 137° 22' W		
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1951													0.0
1952	0.0	0.0	0.0	0.0	6.6								
1954						6.1	40.6	17.8	19.3	2.5	0.0	5.1	
1955	0.0	0.0	0.0	0.0	7.1	43.2	14.0	86.1	10.4	1.5	0.0	0.0	162.3
1956	0.0	0.0		0.0	40.1	45.0	48.3	40.9	2.5	16.0	0.0	0.0	
1957	0.0	0.0	0.0	7.6	15.2	12.7	34.8	19.6	13.5	0.1	2.5	0.0	106.0
1958	0.0	0.0	0.0	0.0	14.2	33.5	62.0	67.1	12.7	4.6	0.0	0.0	194.1
1959	0.0	0.0	0.0	0.1	18.8	46.7	29.0	37.6	25.1	0.0	0.0	0.0	157.3
1960	0.0	0.0	0.0	2.3	18.5	26.4	117.9	36.6	28.4	7.4	0.3	0.0	237.8
1961	0.0	0.0	0.0	0.0	23.4	45.0	44.5	25.9	18.3	12.4	0.0	0.0	169.5
1962	0.0	0.0	0.0	20.8	16.3	55.9	35.6	39.4	13.0	5.1	0.0	0.0	186.1
1963	0.0	0.0	0.0	5.1		47.5	58.7	18.5	35.1	14.5	0.0	0.0	
1964	0.0	0.0	0.0	0.0	19.8	53.6	88.1	30.7	21.1	4.6	0.0	0.0	217.9
1965	0.0	0.0	0.0	0.3		30.0	41.9	17.5	40.4	10.4	0.0	0.0	
1966	0.0	0.0	0.0		5.8	28.2	7.1	20.3	16.0	8.6	0.0	0.0	
1967	0.0	0.0	0.0	1.3	16.5	46.2	65.0	56.4	28.4	8.6	1.3	0.0	223.7
1968	0.0	0.0	2.5	5.1	26.1	21.3	29.7	25.7	50.8	0.0	0.0	0.0	160.2
1969	0.0	0.0	0.0	0.8	30.5	3.3	81.5	12.2	22.9	1.5	0.0	0.0	152.7
1970	0.0	0.0	0.0	1.0	47.5	24.4	5.3	42.7	41.7	11.9	2.5	0.0	177.0
1971	0.0	0.0	0.0	1.0	7.4	11.7	24.1	45.0	22.1	4.1	0.0	0.0	115.4
1972	0.0	0.0	0.0	0.0	13.0	70.9	47.2	23.1	17.3	2.8	0.0	0.0	174.3
1973	0.0	0.0	0.0	22.4	5.1	50.8	47.5	54.1	8.6	1.5	0.0	0.0	190.0
1974	0.0	0.0	0.0	0.8	6.4	14.7	65.8	31.8	8.6	12.7	0.1	0.0	140.9
1975	0.0	0.0	0.0	7.4	13.7	16.5	71.6	29.0	32.3	3.3	0.0	0.1	173.9
1976	0.0	0.0	0.0	0.1	42.9	37.3	46.7	19.3	14.5	2.3	2.0	0.0	165.1
1977	0.0	0.3	0.0	1.8	24.2	44.8	30.3	18.3	14.9	16.8	0.0	0.0	151.4
1978	0.0	0.0	0.0	4.0	17.8	33.4	100.0	46.7	23.8	0.5	0.0	0.0	226.2
1979	0.0	0.0	2.5	0.0	29.5	47.7	54.1	10.2	33.5	2.2	10.0	0.0	189.7
1980	0.0	0.0	0.0	3.2	9.2	24.8	44.4	33.0	49.9	11.2	0.0	0.0	175.7
1981	0.0	0.0	0.8	7.6	13.2	33.3	87.9	43.6	50.9	31.4	0.0	0.0	268.7
1982	0.0	0.1	0.0	0.0	33.7	13.3	62.7	22.4	31.7	2.3	0.0	0.0	166.2
1983	0.0	0.0	0.0	4.8	29.0	50.3	53.8	82.2	23.7	9.8	0.0	0.0	253.6
1984	0.0	0.0	0.0	3.4	33.5	27.0	44.6	47.7	25.0	8.7	0.0	0.0	189.9
1985	0.0	0.0	0.0	0.0	20.5	69.8	88.4	48.8	28.5	2.4	0.0	0.1	258.5
1986	0.0	0.0	0.0	0.1	30.0	47.4	73.0	44.5	8.0	9.0	0.0	0.1	212.1
1987	0.0	0.0	2.0	2.0	17.9	26.6	53.4	34.6	43.1	33.4	0.0	0.0	213.0
1988	0.0	0.0	0.0	2.9	23.8	26.2	68.8	28.6	9.6	0.0	0.0	0.0	159.9
1989	0.0	0.0	0.0	0.2	32.6	49.1	13.1	20.4	21.0	2.8	0.0	0.0	139.2
1990	0.0	0.0	0.1	0.6	48.4	57.0	13.0	41.0	45.0	12.4	0.0	0.0	217.5
1991	0.0	0.0	0.0	0.0	25.1	30.0	47.8	34.7	43.0	14.6	0.0	0.0	195.2
1992	0.0	0.0	0.8	18.0	24.4	32.2	44.3	47.4	34.2	2.6	0.0	0.0	203.9
1993	0.0	0.0	0.0	7.8	18.4	16.8	61.9	40.0	18.8	14.2	0.0	0.0	177.9
1994	0.0	0.0	0.1	1.4	37.8	53.6	36.2	8.6	21.6	7.4	0.1	0.0	166.8
1995	0.0	0.0	0.4	0.2	16.8	31.8	84.4	78.2	10.6	14.6	0.0	0.0	237.0
1996	0.0	0.0	0.0	7.6	3.4	27.9	67.2	58.2	33.6	0.0	0.0	0.0	197.9
1997	0.0	0.0	0.0	5.8	86.0	56.6	80.6	36.0	29.4	0.0	0.0	0.0	294.4
# years	44	44	43	43	42	44	44	44	44	44	44	45	39
Mean	0.0	0.0	0.2	3.4	23.1	35.7	52.7	36.9	25.1	7.6	0.4	0.1	
Max.	0.0	0.3	2.5	22.4	86.0	70.9	117.9	86.1	50.9	33.4	10.0	5.1	294.4
Min.	0.0	0.0	0.0	0.0	3.4	3.3	5.3	8.6	2.5	0.0	0.0	0.0	106.0
Std. Dev	0.00	0.05	0.62	5.38	15.26	16.45	25.37	18.37	12.72	7.58	1.60	0.76	40.69
Sum of Average Months =													185.1
Average of Complete Years =													189.7

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TABLE 1.6 - PELLY RIVER RANCH Total Snowfall (mm)

Station 2100880

62° 49' N

Elevation 454 m

137° 22' W

(Note - Calculation of Total Precipitation (Table 1.4) assumes constant 10% density for snowfall)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1951												48.3	
1952	48.3	5.1	6.4	2.5	0.0								
1954						0.0	0.0	0.0	4.1	0.0	18.8	27.7	
1955	22.4	5.3	8.1	0.1	0.1	0.0	0.0	0.0	0.3	3.3	26.4	23.6	89.6
1956	12.7	11.7		8.9	0.1	0.0	0.0	0.0	0.3	21.8	33.0	18.0	
1957	14.7	23.9	13.7	0.3	0.1	0.0	0.0	0.0	6.4	2.3	30.7	20.8	112.9
1958	20.8	16.3	1.3	3.0	0.0	0.0	0.0	0.0	4.3	40.6	35.1	12.4	133.8
1959	10.2	21.1	24.4	10.7	0.5	0.0	0.0	0.0	0.0	6.4	20.1	14.5	107.9
1960	11.2	15.2	12.7	2.8	0.0	0.0	0.0	0.0	0.0	1.0	23.9	17.8	84.6
1961	13.5	10.9	11.2	6.6	0.1	0.0	0.0	0.0	0.0	29.5	24.4	29.2	125.4
1962	25.4	17.3	4.1	4.1	0.0	0.0	0.0	0.0	0.0	1.3	15.0	37.8	105.0
1963	47.8	7.4	10.7	5.8		0.0	0.0	0.0	0.0	12.7	14.7	47.5	
1964	24.1	19.1	16.5	16.0	6.4	0.0	0.0	0.0	0.0	15.2	19.1	20.1	136.5
1965	12.2	9.9	5.1	3.3		0.0	0.0	0.0	0.1	32.0	17.8	24.9	
1966	7.6	26.2	6.6		0.0	0.0	0.0	0.0	0.0	26.7	61.0	10.4	
1967	37.6	26.7	31.2	13.0	0.1	0.0	0.0	0.0	0.0	4.3	15.0	18.5	146.4
1968	30.7	12.2	17.3	10.7	0.0	0.0	0.0	0.0	8.9	14.2	27.4	10.7	132.1
1969	11.7	3.6	14.5	11.2	0.0	0.0	0.0	0.0	0.0	6.4	25.7	14.5	87.6
1970	8.4	16.0	2.0	6.6	1.3	0.0	0.0	0.0	8.6	23.4	23.1	35.3	124.7
1971	4.6	6.6	7.9	3.8	0.1	0.0	0.0	0.0	0.1	24.4	28.4	40.4	116.3
1972	23.1	13.7	7.9	12.7	1.8	0.0	0.0	0.0	6.1	51.3	20.1	12.2	148.9
1973	25.1	12.4	17.8	8.1	0.0	0.0	0.0	0.0	0.0	15.7	22.6	34.3	136.0
1974	4.6	37.3	9.7	18.3	1.0	0.0	0.0	0.0	0.0	15.2	14.0	30.5	130.6
1975	20.3	4.6	0.3	10.9	0.0	0.0	0.0	0.0	0.0	17.5	15.7	12.2	81.5
1976	30.5	14.0	28.9	10.7	0.1	0.0	0.0	0.0	0.0	13.0	22.1	13.7	131.0
1977	31.1	3.8	16.8	23.2	0.0	0.0	0.0	0.0	0.0	1.3	21.7	11.7	109.6
1978	10.8	3.3	3.4	8.9	0.0	0.0	0.0	0.0	0.0	24.2	23.7	26.9	101.2
1979	23.8	19.5	18.4	4.6	0.0	0.0	0.0	0.0	0.0	1.8	8.9	17.6	94.6
1980	24.3	11.5	2.8	0.0	0.0	0.0	0.0	0.0	3.5	6.4	21.5	1.8	71.8
1981	5.4	27.0	3.5	3.4	0.1	0.0	0.0	0.0	2.0	11.6	41.5	6.0	100.5
1982	11.3	13.1	6.4	13.9	0.1	0.0	0.0	0.0	0.0	23.1	22.0	13.2	103.1
1983	30.1	27.2	3.3	1.0	0.0	0.0	0.0	0.0	2.3	10.8	6.6	11.3	92.6
1984	24.1	23.6	8.2	5.1	0.0	0.0	0.0	1.0	0.0	5.7	14.7	28.9	111.3
1985	27.6	17.0	5.6	8.9	0.0	0.0	0.0	0.0	0.0	20.7	17.2	10.9	107.9
1986	27.7	4.7	16.9	5.8	0.0	0.0	0.0	0.0	0.1	0.1	20.9	14.5	90.7
1987	11.7	25.7	6.3	7.2	4.4	0.0	0.0	0.0	0.0	9.5	32.4	25.2	122.4
1988	12.4	14.8	13.9	1.2	0.0	0.0	0.0	0.0	0.2	26.6	22.0	21.3	112.4
1989	14.0	6.0	5.6	0.1	0.0	0.0	0.0	0.0	2.8	15.8	35.9	12.0	92.2
1990	11.6	21.9	6.8	1.0	0.0	0.0	0.0	0.0	0.0	21.6	23.2	40.0	126.1
1991	16.6	23.8	9.9	4.0	0.0	0.0	0.0	0.0	0.0	8.8	40.1	30.0	133.2
1992	32.0	11.2	15.2	28.6	3.8	0.0	0.0	0.0	22.2	36.6	31.0	19.4	200.0
1993	24.9	6.8	34.4	1.0	0.0	0.0	0.0	0.0	2.0	13.9	34.8	7.0	124.8
1994	24.6	4.8	15.9	6.3	0.0	0.0	0.0	0.0	0.0	20.0	27.4	3.6	102.6
1995	5.8	12.4	4.2	0.0	0.0	0.0	0.0	0.0	0.0	8.3	15.8	22.4	68.9
1996	12.8	16.6	9.9	9.0	0.0	0.0	0.0	0.0	TR	32.8	6.2	24.4	111.7
1997	7.6	17.0	18.4	6.8	0.0	0.0	0.0	0.0	0.0	24.0	24.7	18.2	116.7
# years	44	44	43	43	42	44	44	44	43	44	44	45	39
Mean	19.5	14.7	11.2	7.2	0.5	0.0	0.0	0.0	1.7	16.0	23.8	20.9	
Max.	48.3	37.3	34.4	28.6	6.4	0.0	0.0	1.0	22.2	51.3	61.0	48.3	200.0
Min.	4.6	3.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2	1.8	68.9
Std. Dev	10.76	8.10	7.88	6.25	1.32	0.00	0.00	0.15	3.98	11.91	9.92	11.15	24.36

Sum of Average Months = 115.5

Average of Complete Years = 113.5

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TABLE 1.7 - Average Monthly Values - Williams Creek Climate Station (1994-1998)

Date	Net Radiation	Licor Shortwave Incoming	Licor Shortwave Outgoing	REBS Soil Heat Flux	Soil Temp 6cm Depth	HM35CF Upper Temp	HM35C Upper RH	Lower Wind Speed	Upper Wind Speed	Precip. Tip Bucket Totalized
	W/m ²	W/m ²	W/m ²	W/m ²	°C	°C	%	m/s	m/s	mm
1994										
*Sep-94	-6998	89.03	8.82	0.47	3.11	5.47	82.73	19.43	-7.42	22.2
**Oct-94	8.48	42.59	6.09	-1.64	-0.17	-0.71	76.82	2.98	-0.63	5.10
Nov-94	-10.98	5.05	0.97	-6.10	-7.53	-16.42	76.38	0.83	0.39	0.00
Dec-94	-3.08	13.79	2.57	-7.13	-4.62	-15.92	75.85	0.82	-0.02	0.00
* Average of records from September 13 to September 30, 1997; Average excludes Sept-13 Upper Temperature record										
** Average does not include October 1 to October 4 Net Radiation record										
1995										
Jan-95	-1.17	7.48	2.12	-4.96	-8.46	-15.32	80.22	0.93	0.71	0.00
Feb-95	6.70	38.10	6.13	-3.36	-6.79	-11.93	71.99	0.87	0.32	0.00
Mar-95	53.30	96.72	12.83	-2.81	-7.09	-10.50	58.51	1.03	2.64	3.30
Apr-95	148.41	193.65	21.84	1.33	-0.26	4.09	46.55	1.03	2.21	19.50
May-95	185.37	221.94	22.31	6.89	3.69	10.82	43.71	1.05	2.32	772.3 ^s
Jun-95	210.51	245.25	25.31	6.60	7.62	14.60	43.53	1.08	2.57	546.9 ^s
Jul-95	160.87	175.79	16.81	6.72	10.71	15.07	60.98	0.84	1.90	118.9 ^s
Aug-95	138.42	155.49	14.21	4.81	8.51	11.67	64.36	0.89	2.09	661.4 ^s
Sep-95	79.92	110.45	10.14	2.56	6.34	10.85	58.48	1.08	2.23	25.00
Oct-95	20.85	39.05	4.17	-2.07	0.71	-0.68	84.10	0.80	1.45	8.50
*Nov-95	7.47	13.87	2.74	-9.16	-2.61	-12.35	82.66	0.72	1.35	0.30
* Average of records from November 1 to November 25, 1995										
1996										
*Mar-96	130.92	169.73	20.13	-1.73	-5.71	-8.20	36.99	0.93	2.89	0.00
Apr-96	153.07	184.37	20.38	0.38	-2.52	1.10	44.29	0.99	2.26	5.90
May-96	194.10	219.95	20.73	3.76	1.65	6.90	41.47	0.89	2.44	16.00
Jun-96	222.97	248.81	23.48	7.78	4.45	12.71	40.08	0.99	2.50	12.00
Jul-96	179.32	208.10	19.13	9.46	7.84	14.83	57.95	0.85	2.10	91.00
Aug-96	133.40	155.58	13.96	5.36	7.27	10.54	68.66	0.86	2.16	79.90
Sep-96	73.25	109.36	9.87	0.39	3.21	5.19	63.12	1.03	2.47	10.30
Oct-96	17.96	28.06	7.44	-3.68	-0.72	-7.68	83.91	0.74	1.53	19.10
Nov-96	5.66	10.69	2.68	-13.69	-2.65	-15.25	82.05	0.70	1.04	0.00
Dec-96	-0.26	1.42	1.35	-11.41	-5.49	-17.80	80.64	0.68	1.28	0.00
* Average of records from March 28 to March 31, 1996										
1997										
Jan-97	-0.37	4.00	2.60	-11.93	-9.57	-21.60	76.16	0.69	1.11	0.00
Feb-97	2.68	24.91	5.67	-3.02	-5.99	-7.54	82.42	0.83	1.60	19.00
Mar-97	66.02	100.87	13.28	-4.81	-8.37	-11.48	62.68	0.80	1.96	1.90
Apr-97	139.50	182.76	22.36	3.47	-1.73	1.99	47.84	0.91	2.16	7.30
May-97	190.43	218.61	19.85	2.97	1.69	7.64	51.69	0.97	2.39	57.70
Jun-97	204.59	229.80	21.28	8.83	5.42	13.13	54.68	0.96	2.41	48.50
Jul-97	181.13	201.43	19.02	8.25	9.48	15.51	63.51	0.90	2.09	102.40
Aug-97	145.75	169.56	15.92	4.90	9.32	13.67	62.72	0.90	2.18	14.60
*Sep-97	101.51	122.49	11.33	3.14	7.75	11.70	71.85	0.88	1.80	2.70
**Nov-97	2.83	5.40	1.89	-5.55	-2.53	-9.87	89.05	0.75	1.35	0.00
Dec-97	-11.56	3.55	0.83	-4.58	-3.27	-9.19	82.82	0.91	1.73	8.20
* Average of records from September 1 to September 5, 1997										
** Average of records from November 20 to Nov 30, 1997										
1998										
*Jan-98	0.22	2.33	1.90	-6.76	-9.61	-27.12	73.72	0.68	0.88	0.00
* Average of records from January 1 to January 21, 1998										
Note: Erroneous precipitation values caused by electrical short in wire to tipping gauge. Wire replaced on Aug-30-95.										
Reported 1995 rainfall data not used in this study.										
Precipitation values represent the total sum of values recorded within a given month rather than an average										

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TABLE 1.8 - Williams Creek and Concurrent Regional Rainfall Data

Month & Year	Rainfall (mm)				Total Precipitation (mm)		
	Williams Creek	Carmacks	Pelly River Ranch	Average Carmacks & Pelly)	Carmacks	Pelly River Ranch	Average Carmacks & Pelly)
Sep 13-30, 94 *	22.2	20.3	14.5	17.4	20.3	14.5	17.4
Sept 1 - 30, 94		27.6	21.6	24.6	27.6	21.6	24.6
**Oct-94	5.1	21.1	7.4	14.3	29.0	27.4	28.2
Mar-95	3.3	0	0.4	0.2	8.5	4.6	6.6
Apr-95 *	19.5	4.5	0.2	2.4	4.5	0.2	2.4
Sep-95 *	25.0	26.4	10.6	18.5	26.4	10.6	18.5
Oct-95	8.5	10.6	14.6	12.6	12.1	22.9	17.5
Apr-96	5.9	4.0	7.6	5.8	4.0	16.6	10.3
May-96 *	16.0	11.4	3.4	7.4	11.4	3.4	7.4
Jun-96 *	12.0	10.2	27.9	19.1	10.2	27.9	19.1
Jul-96 *	91.0	87.3	67.2	77.3	87.3	67.2	77.3
Aug-96 *	79.9	55.7	58.2	57.0	55.7	58.2	57.0
Sep-96 *	10.3	14.1	33.6	23.9	14.1	33.6	23.9
Oct-96	19.1	0	0	0.0	41.0	32.8	36.9
Feb-97	19.0	0	0	0.0	13.0	17.0	15.0
Mar-97	1.9	0	0	0.0	11.5	18.4	15.0
Apr-97	7.3	6.0	5.8	5.9	11.8	12.6	12.2
May-97 *	57.7	32.2	86.0	59.1	32.2	86.0	59.1
Jun-97 *	48.5	39.2	56.6	47.9	39.2	56.6	47.9
Jul-97 *	102.4	45.0	80.6	62.8	45.0	80.6	62.8
Aug-97 *	14.6	17.0	36.0	26.5	17.0	36.0	26.5
Total Rainfall							
All Common Data	569.2	405	510.6	457.8	494.2	627.1	560.7
Number	21	21	21	21	21	21	21
Total Rainfall (Note)							
Rainfall Months Only *	499.1	363.3	474.8	419.1	363.3	474.8	419.1
Number	12	12	12	12	12	12	12
Total Rainfall							
1994 (1 mo.)	22.2	20.3	14.5	17.4	20.3	14.5	17.4
1995 (2 mo.)	44.5	30.9	10.8	20.9	30.9	10.8	20.9
1996 (5 mo.)	209.2	178.7	190.3	184.5	178.7	190.3	184.5
1997 (4 mo.)	223.2	133.4	259.2	196.3	133.4	259.2	196.3
Station Elevation (m)	850	525	454	489.5	525	454	489.5

NOTES

- 1) Concurrent rainfall data for Carmacks and Pelly River Ranch indicate a decrease in rainfall with increasing elevation.
- 2) Total concurrent rainfall data for 12 months between Williams Creek and Pelly River Ranch indicates an orographic factor for rainfall of 1.3% increase per 100 m increase in elevation.

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TABLE I.9 - Regional & Site Snow Survey Data**Regional Snow Survey Stations**

Number	Name	Elevation (m)	Location	Years
No. 1	Williams Creek	739	at site	1992
No. 3	Williams Creek	755	at site	1992
No. 2	Williams Creek	876	at site	1992
09AH-SC04	Williams Creek	914	at site	1995 - 1997
09CD-SC03	Pelly Farm	472	70 km NNW	1986 - 1997
09CA-SC01	Mt. Nansen	1021	50 km SW	1976 - 1997
09AH-SC01	Mt. Berdoe	1035	50 km SE	1975 - 1997
09CA-SC02	MacIntosh	1160	80 km SW	1976 - 1997
09AH-SC03	Satasha Lake	1106	90 km S	1987 - 1997
09CD-SC01	Casino Creek	1065	120 km WNW	1977 - 1997

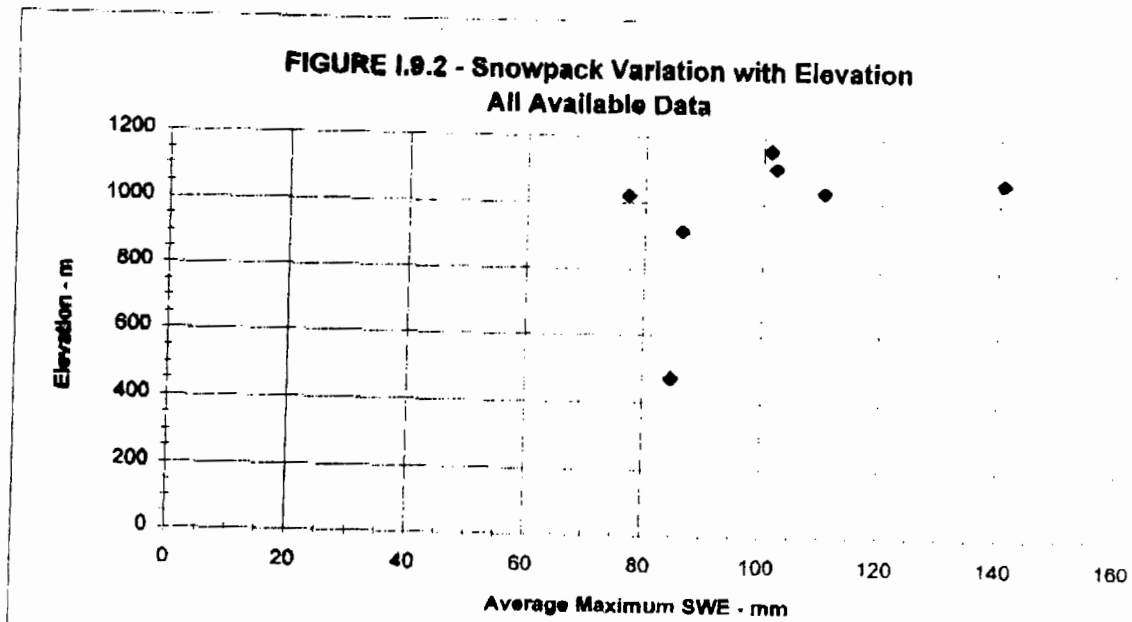
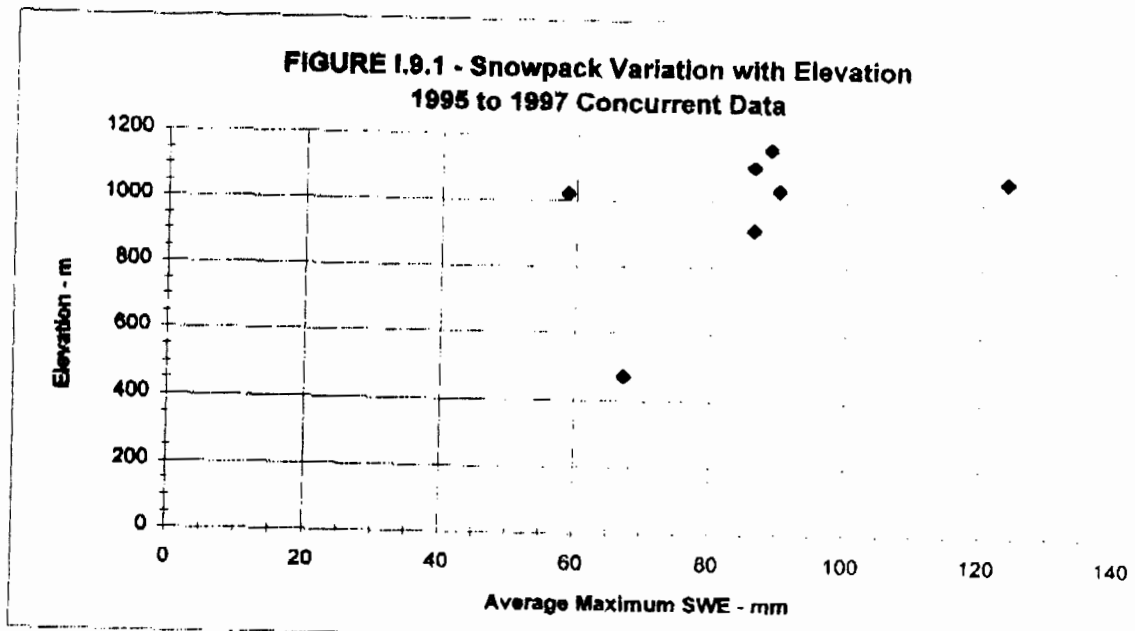
Average Maximum Annual Snowpack SWE (mm water)

Period	Station	Avg. Max. SWE	Elevation (m)	Max. Max.	Min. Max.
1992 only	Pelly Farm	97	472		
	Williams Creek	141	790		
	Mt. Nansen	102	1021		
	Mt. Berdoe	170	1035		
	MacIntosh	140	1160		
	Satasha Lake	167	1106		
	Casino Creek	207	1065		
1995 - 1997	Pelly Farm	67.3	472	77	52
	Williams Creek	86.3	914	93	78
	Mt. Nansen	59	1021	64	50
	Mt. Berdoe	90	1035	106	74
	MacIntosh	89	1160	103	78
	Satasha Lake	86	1106	106	67
	Casino Creek	124	1065	149	104
1986 - 1997	Pelly Farm	84.8	472	116	52
	Mt. Nansen	81	1021	106	50
	Mt. Berdoe	123	1035	175	74
	MacIntosh	109	1160	162	59
	Satasha Lake	102	1106	167	50
	Casino Creek	147	1065	225	99
1977 - 1997	Mt. Nansen	79	1021	106	50
	Mt. Berdoe	111	1035	175	74
	MacIntosh	102	1160	162	45
	Casino Creek	141	1065	225	88
All Data	Pelly Farm	85	472	116	52
	Williams Creek	86	914	93	78
	Mt. Nansen	77	1021	106	50
	Mt. Berdoe	110	1035	175	74
	MacIntosh	101	1160	162	45
	Satasha Lake	102	1106	167	50
	Casino Creek	141	1065	225	88

(SWE = snow water equivalent in mm water)

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TABLE I.9 - Regional & Site Snow Survey Data (continued)

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TABLE 1.2 (continued) - Snowpack SWE (Snow Water Equivalents) as mm water**PELLEY FARM (09CD-9C03)**

Year	Feb-01	Mar-01	Apr-01	May-01	May-15
1986		74	84	70	0
1987		73	56	0	0
1988		88	89	0	0
1989		76	77	0	0
1990		105	89	0	0
1991		113	116	0	0
1992		95	97	31	0
1993		95	113	15	0
1994		62	60	0	0
1995		52	52	0	0
1996		50	73	0	0
1997			77	9	
Avg.		80.3	81.9	10.4	0.0
Max.		113	116	70	0
Min.		50	52	0	0
No. of Maximums		3	9	0	0
Average of all Maximums			84.8		

MT. NANSEN (09CA-SC01)

Year	Feb-01	Mar-01	Apr-01	May-01	May-15
1976	48	66	66	20	0
1977	44	48	63	0	0
1978	53	64	51	0	0
1979	38	56	87		0
1980	45	76	60	0	0
1981	44	52	56	0	0
1982	60	69	65	0	0
1983	69	70	80	0	0
1984	49	65	60	0	0
1985	74	95	104	101	0
1986		59	82	78	0
1987		28	51	0	0
1988		77	92	0	0
1989		79	99	0	0
1990		63	92	0	0
1991		102	106	0	0
1992		92	102	68	0
1993		67	96	0	0
1994		73	73	0	0
1995		50	49	0	0
1996		50	62	0	0
1997		64	63	0	
Avg.	52.2	66.6	75.4	12.7	0.0
Max.	74	102	106	101	0
Min.	38	28	49	0	0
No. of Maximums		6	16		
Average of all Maximums			77.2		

MT. BERDOE (09AH-SC01)

Year	Feb-01	Mar-01	Apr-01	May-01	May-15
1975		91	109		
1976		104	107	89	0
1977	51	60	79	0	0
1978	59	72	75	41	0
1979	44	63	79	12	0
1980	60	80	92	32	0
1981	61	71	75	34	0
1982	61	81	94	89	0
1983	91	95	100	43	0
1984	56	82	94	62	0
1985	94	111	156	160	118
1986		117	167	169	102
1987		89	72	40	0
1988		81	82	31	0
1989		110	130	23	18
1990		91	133	0	0
1991		155	175	107	0
1992		165	170	126	115
1993		134	147	35	0
1994		97	110	51	0
1995		54	74	18	
1996		81	90	15	
1997		106	106	49	
Avg.	64.1	95.2	109.4	55.7	18.6
Max.	94	165	175	169	118
Min.	44	54	72	0	0
No. of Maximums		1	20	2	
Average of all Maximums			110.4		

SATASHA LAKE (09AH-SC03)

Year	Feb-01	Mar-01	Apr-01	May-01	May-15
1987		31	50	0	0
1988		87	86	25	0
1989		80	107	12	25
1990		91	96	0	0
1991		130	139	55	0
1992		162	167	108	39
1993		109	118	24	0
1994		78	101	25	0
1995		51	67	0	
1996		78	86	14	
1997		74	106	17	
Avg.		88.3	102.1	25.5	8.0
Max.		162	167	108	39
Min.		31	50	0	0
No. of Maximums		1	10		
Average of all Maximums			102.182		

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TABLE 1.9 (continued) - Snowpack SWE (Snow Water Equivalents) as mm water**MACINTOSH (09CA-SC02)**

Year	Feb-01	Mar-01	Apr-01	May-01	May-15
1976	48	76	90	61	0
1977	34	42	59	0	0
1978	60	68	88	70	0
1979	50	65	94	0	0
1980	53	70	119	92	0
1981	35	45	55	34	0
1982	92	114	140	160	0
1983	72	78	87	0	0
1984	38	45	35	0	0
1985	95	115	122	130	105
1986		99	134	126	69
1987		41	69	0	0
1988		91	116	51	0
1989		68	101	65	25
1990		127	120	0	0
1991		120	162	104	0
1992		138	140	121	92
1993		87	110	0	0
1994		87	88	23	0
1995		56	78	13	
1996		69	85	0	
1997		70	103		
Avg.	57.7	80.5	99.3	50.0	15.3
Max.	95	138	162	160	105
Min.	34	41	35	0	0
No. of Maximums		2	18	2	
Average of all Maximums			101.3		

CASINO CREEK (09CD-SC01)

Year	Feb-01	Mar-01	Apr-01	May-01	May-15
1977	53	68	80	125	
1978	80	90	98	86	
1979	97	113	170	145	
1980	40	68	81	95	0
1981	45	70	78	88	0
1982	94	110	118	165	173
1983	43	118	120	80	0
1984	86	105	110	139	72
1985	116	130	143	180	166
1986		108	127	168	150
1987		63	92	101	117
1988		98	99	54	
1989			136	80	0
1990		119	144	100	0
1991		179	225	167	79
1992		124	135	207	207
1993		148	184	190	0
1994		83	110	56	0
1995		75		104	
1996		89	118	110	
1997		110	149	94	
Avg.	72.7	103.4	125.9	120.7	68.9
Max.	116	179	225	207	207
Min.	40	63	78	54	0
No. of Maximums			10	9	2
Average of all Maximums			140.7		

WILLIAMS CREEK

Year	Feb-01	Mar-01	Apr-01	May-01	May-15
1992 only					
No. 1	128	104	120	84	0 Elev. 739 m
No. 2	164	110	130	129	38 Elev. 876 m
No. 3	130	150	132	103	36 Elev. 755 m
Averages at approx. Elev. 790 m					
	140.7	121.3	127.3	105.3	24.7

WILLIAMS CREEK #09AH-SC04

Year	Feb-01	Mar-01	Apr-01	May-01	May-15
1995		55	78	20	
1996		79	88	17	
1997		84	93	59	
Avg.		72.7	86.3	32.0	
Max.		84	93	59	
Min.		55	78	17	
No. of Maximums			3		
Average of all Maximums			86.3		

TABLE I.10 - Pelly Farm Snow Survey & Concurrent Snowfall Data - 1986-1997

Pelly Farm Snow Survey Station # 09CD-SC03 at Elevation 472 m

Pelly River Ranch Precipitation Station # 2100880 at Elevation 454 m

Year	March 1 SWE	Oct - Feb Total Snowfall	Apparent Sublimation Losses	OR, Apparent Snowfall Density	April 1 SWE	Oct - Mar Total Snowfall	Apparent Sublimation Losses	OR, Apparent Snowfall Density	May 1 SWE	Oct - Apr Total Snowfall	Apparent Sublimation Losses	OR, Apparent Snowfall Density
1986	74	81.2	7.2	9.1%	84	98.1	14.1	8.6%	70	103.9	33.9	6.7%
1987	73	72.9	-0.1	10.0%	56	79.2	23.2	7.1%	0	86.4	86.4	0.0%
1988	88	94.3	6.3	9.3%	89	108.2	19.2	8.2%	0	109.4	109.4	0.0%
1989	76	89.9	13.9	8.5%	77	95.5	18.5	8.1%	0	95.6	95.6	0.0%
1990	105	100.0	-5.0	10.5%	89	106.8	17.8	8.3%	0	107.8	107.8	0.0%
1991	113	125.2	12.2	9.0%	116	136.1	19.1	8.6%	0	139.1	139.1	0.0%
1992	95	122.1	27.1	7.8%	97	137.3	40.3	7.1%	31	165.9	134.9	1.9%
1993	95	140.9	45.9	6.7%	113	175.3	62.3	6.4%	15	176.3	161.3	0.9%
1994	62	85.1	23.1	7.3%	60	101.0	41.0	5.9%	0	107.3	107.3	0.0%
1995	52	69.2	17.2	7.5%	52	73.4	21.4	7.1%	0	73.4	73.4	0.0%
1996	50	75.9	25.9	6.6%	73	85.8	12.8	8.5%	0	94.8	94.8	0.0%
1997	M				77	106.4	29.4	7.2%	9	113.2		
Averages	80.3	96.1	15.8	8.4%	81.9	108.5	26.6	7.6%	10.5	114.5	104.0	0.9%
Maximum	113.0	140.9	45.9	10.5%	116.0	175.3	62.3	8.6%	70.0	176.3	161.3	6.7%
Minimum	50.0	69.2	-5.0	6.6%	52.0	73.4	12.8	5.9%	0.0	73.4	33.9	0.0%

Maximum Reported Snowpack each year

Average Maximum Snowpack SWE	84.8	mm water (9 of 12 maximums occurred on April 1)
Average Total Snowfall to time of Maximum Snowpack	106.1	mm water
Average Apparent Sublimation Loss	21.3	mm water
OR, Average Apparent Snowfall Density	8.1%	(assuming zero sublimation)

NOTES

- 1) "SWE" = Snow Water Equivalent of the snowpack in millimetres
- 2) Total Snowfall = Cumulative recorded snowfall from October of previous year up to start of indicated month
All reported snowfall (as mm precipitation) for Pelly assumes a constant 10% density for new snowfall measured in centimetres depth.
(NOTE - September 1989 & 1992 snowfall depths included in 1990 & 1993 (respectively) total snowfalls above)
- 3) September 1992 Total Precipitation was the second highest on record since 1954
- 4) "Apparent Sublimation Losses" = (Reported Total Snowfall mm) minus (Snow Water Equivalent mm) for indicated date.
- 5) "Apparent Snowfall Density" = Snowfall Density required such that the total snowfall (as mm water) would equal the SWE (as mm water) assuming zero sublimation losses over the indicated period.

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TABLE I.11 - Wet & Dry Year Precipitation, Rainfall and Snowfall - Williams Creek Site

Return Period (years)	Annual Percent Probability	Pelly Ranch Total Precipitation (Elev. 454 m)	Williams Creek Total Precipitation (Elev. 850 m)	Williams Creek Rainfall	Williams Creek Snowfall
		Note 1	Note 2	Note 3	Note 3
20 (Dry)	95.0%	224	252	146	106
5 (Dry)	80.0%	257	290	168	122
2 (Average)	50.0%	300	338	195	143
5 (Wet)	20.0%	342	385	223	162
10 (Wet)	10.0%	369	416	241	175
20 (Wet)	5.0%	392	442	256	185
50 (Wet)	2.0%	418	471	273	198
100 (Wet)	1.0%	436	491	285	206
200 (Wet)	0.5%	452	509	295	214
500 (Wet)	0.2%	471	531	308	223

NOTES

- 1) Frequency analysis results from GEV distribution for Pelly Ranch 1955 to 1997 Total Precipitation data.
Mean Annual Total Precipitation = 300 mm (62% Rainfall, 38% Snowfall)
Standard Deviation = 47.14 mm
Coefficient of Variation = 0.157
- 2) Williams Creek total precipitation estimated assuming 3.2% increase per 100 m elevation difference between Pelly River Ranch and Williams Creek, equal to a factor of 1.1267 times the precipitation at Pelly River Ranch.
- 3) Rainfall and Snowfall for extreme years above estimated assuming Rainfall = 58% of Total Precipitation and Snowfall = 42% of Annual Total Precipitation.

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TABLE I.12 - CARMACKS Wet Period Precipitation

(May through September = Rainfall, Winter October through April = Snowfall)

Year	Maximum One Month						Maximum Two Month Periods					Maximum Three Months				Winter Precip.	
	May	June	July	Aug	Sept	MAX	M/J	J/J	J/A	A/S	MAX	M/J/J	J/J/A	J/A/S	MAX	6-mo. O - M	7-mo O - A
1963					40.4	40.4											
1964	29.7	56.1	39.6	41.4	14.2	56.1	85.8	95.7	81.0	55.6	95.7	125.4	137.1	95.2	137.1	73.9	74.4
1965	16.8	23.6	32.8	15.0	23.4	32.8	40.4	56.4	47.8	38.4	56.4	73.2	71.4	71.2	73.2	52.0	53.8
1966	11.4	35.1	42.4	43.7	18.3	43.7	48.5	77.5	86.1	62.0	86.1	88.9	121.2	104.4	121.2	61.1	69.7
1967	42.4	45.0	54.1	25.4	12.2	54.1	87.4	99.1	79.5	37.6	99.1	141.5	124.5	91.7	141.5	170.3	177.9
1968	21.8	20.1	59.2	33.8	50.0	59.2	41.9	79.3	93.0	83.8	93.0	101.1	113.1	143.0	143.0	100.9	116.9
1969	11.7	5.8	55.4	32.0	27.9	55.4	17.5	61.2	87.4	59.9	87.4	72.9	93.2	115.3	115.3	61.5	65.8
1970	29.0	11.2	25.1	18.5	51.6	51.6	40.2	36.3	43.6	70.1	70.1	65.3	54.8	95.2	95.2	68.7	80.1
1971	0.1	9.4	37.1	39.6	23.1	39.6	9.5	46.5	76.7	62.7	76.7	46.6	86.1	99.8	99.8	104.9	106.4
1972	15.6	65.3	34.0	25.9	43.2	65.3	80.8	99.3	59.9	69.1	99.3	114.8	125.2	103.1	125.2	90.3	104.8
1973	5.8	35.3	28.7	63.5	9.1	63.5	41.1	64.0	92.2	72.6	92.2	69.8	127.5	101.3	127.5	77.7	85.1
1974	8.4	36.3	52.6	68.8	19.6	68.8	42.7	88.9	121.2	88.2	121.2	95.3	157.5	140.8	157.5	135.2	137.2
1975	5.6	13.2	60.2	57.4	38.4	60.2	18.8	73.4	117.6	95.8	117.6	79.0	130.8	156.0	156.0	98.7	116.7
1976		30.5		6.6	0.3	30.5				6.9						104.4	106.7
1977	24.7	49.5	57.1	52.5	63.7	63.7	74.2	106.6	109.6	116.2	116.2	131.3	159.1	173.3	173.3	63.8	71.9
1978	15.0	46.6	56.8	39.6	13.8	56.8	61.6	103.4	96.4	53.4	103.4	118.4	143.0	110.2	143.0		
1979	23.2	47.6	104.4	23.6	23.4	104.4	70.8	152.0	128.0	47.0	152.0	175.2	175.6	151.4	175.6		
1980	20.6	24.8	72.8	53.6	55.2	72.8	45.4	97.6	126.4	108.8	126.4	118.2	151.2	181.6	181.6	100.0	105.6
1981	8.8	27.1	105.2	27.8	37.3	105.2	35.9	132.3	133.0	65.1	133.0	141.1	160.1	170.3	170.3	92.8	100.6
1982	33.0	11.4	86.9	46.1	26.7	86.9	44.4	98.3	133.0	72.8	133.0	131.3	144.4	159.7	159.7	90.2	92.2
1983	35.5	53.0	71.6	69.2	37.6	71.6	88.5	124.6	140.8	106.8	140.8	160.1	193.8	178.4	193.8	102.2	108.0
1984	27.8	37.8	42.8	32.4	12.3	42.8	65.6	80.6	75.2	44.7	80.6	108.4	113.0	87.5	113.0	72.9	74.9
1985	4.8	30.1	79.0	48.6	24.8	79.0	34.7	109.1	127.6	73.2	127.6	113.7	157.7	152.2	157.7	111.0	116.0
1986	24.4	27.9	47.4	31.3	37.0	47.4	52.3	75.3	78.7	68.3	78.7	99.7	106.6	115.7	115.7	116.4	132.8
1987	40.0	30.8	26.0	36.0	34.2	40.0	70.8	56.8	62.0	70.2	70.8	96.8	92.8	96.2	96.8	79.0	79.8
1988	27.0	37.4	88.8	33.6	17.8	88.8	64.4	126.2	122.4	51.4	126.2	153.2	159.8	140.2	159.8	94.3	96.3
1989	32.7	41.9	31.6	17.6	19.9	41.9	74.6	73.5	49.2	37.5	74.6	106.2	91.1	69.1	106.2		
1990	37.2	78.6	40.2	50.1	61.2	78.6	115.8	118.8	90.3	111.3	118.8	156.0	168.9	151.5	168.9	126.1	132.1
1991	11.7	53.2	62.7	37.2	44.0	62.7	64.9	115.9	99.9	81.2	115.9	127.6	153.1	143.9	153.1	121.3	123.3
1992	36.3	18.0	68.7	27.9	48.5	68.7	54.3	86.7	96.6	76.4	96.6	123.0	114.6	145.1	145.1	143.8	163.8
1993	52.0	29.4	35.0	56.3	38.8	56.3	81.4	64.4	91.3	95.1	95.1	116.4	120.7	130.1	130.1	96.4	96.4
1994	16.3	27.4	25.4	21.9	27.6	27.6	43.7	52.8	47.3	49.5	52.8	69.1	74.7	74.9	74.9	138.3	141.3
1995	11.2	6.6	60.2	56.9	26.4	60.2	17.8	66.8	117.1	83.3	117.1	78.0	123.7	143.5	143.5	80.7	85.2
1996	11.4	10.2	87.3	55.7	14.1	87.3	21.6	97.5	143.0	69.8	143.0	108.9	153.2	157.1	157.1	84.9	88.9
1997	32.2	39.2	45.0	17.0	15.6	45.0	71.4	84.2	62.0	32.6	84.2	116.4	101.2	77.6	116.4	98.1	109.9
# years	33	34	33	34	35	35	33	33	33	34	33	33	33	33	33	31	31
Average	21.9	32.8	55.0	38.4	30.0	60.2	54.7	87.9	94.4	68.2	102.5	109.8	127.3	125.0	137.2	97.2	103.7
Max.	52.0	78.6	105.2	69.2	63.7	105.2	115.8	152.0	143.0	116.2	152.0	175.2	193.8	181.6	193.8	170.3	177.9
Min.	0.1	5.8	25.1	6.6	0.3	27.6	9.5	36.3	43.6	6.9	52.8	46.6	54.8	69.1	73.2	52.0	53.8
Std. Dev	12.77	17.39	22.42	16.19	15.69	19.42	24.66	26.79	29.24	24.57	25.58	30.44	34.18	34.17	31.08	26.83	27.96
# Max.	1	5	20	5	4	35	2	12	16	3	33	5	13	15	33		

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TABLE I.13 - PELLY RIVER RANCH Wet Period Precipitation

(May through September = Rainfall, Winter October through April = Snowfall)

Year	Maximum One Months						Maximum Two Month Periods					Maximum Three Months				Winter Precip	
	May	June	July	Aug	Sept	MAX	M/J	J/J	J/A	A/S	MAX	M/J/J	J/J/A	J/A/S	MAX	6-mo O - M	7-mo O - A
1951																	
1952	6.6																
1954		6.1	40.6	17.8	23.4	40.6		46.7	58.4	41.2	58.4		64.5	81.8	81.8		
1955	7.1	43.2	14.0	86.1	10.7	86.1	50.3	57.2	100.1	96.8	100.1	64.3	143.3	110.8	143.3	89.9	90.0
1956	40.1	45.0	48.3	40.9	2.8	48.3	85.1	93.3	89.2	43.7	93.3	133.4	134.2	92.0	134.2		
1957	16.2	12.7	34.8	19.6	19.8	34.8	27.9	47.5	54.4	39.4	54.4	62.7	67.1	74.2	74.2	140.4	148.3
1958	14.2	33.5	62.0	67.1	17.0	67.1	47.7	95.5	129.1	84.1	129.1	109.7	162.6	146.1	162.6	94.8	97.8
1959	19.3	46.7	29.0	37.6	25.1	46.7	66.0	75.7	66.6	62.7	75.7	95.0	113.3	91.7	113.3	148.4	159.1
1960	18.5	26.4	117.9	36.6	28.4	117.9	44.9	144.3	154.5	65.0	154.5	162.8	180.9	182.9	182.9	80.1	85.2
1961	23.4	45.0	44.5	25.9	18.3	45.0	68.4	89.5	70.4	44.2	89.5	112.9	115.4	88.7	115.4	85.9	92.5
1962	16.3	55.9	35.6	39.4	13.0	55.9	72.2	91.5	75.0	52.4	91.5	107.8	130.9	88.0	130.9	142.3	167.2
1963		47.5	58.7	18.5	35.1	58.7		106.2	77.2	53.6	106.2		124.7	112.3	124.7	125.1	136.0
1964	26.2	53.6	88.1	30.7	21.1	88.1	79.8	141.7	118.8	51.8	141.7	167.9	172.4	139.9	172.4	149.1	165.1
1965	14.0	30.0	41.9	17.5	40.4	41.9	44.0	71.9	59.4	57.9	71.9	85.9	89.4	99.8	99.8	86.2	89.8
1966	5.8	28.2	7.1	20.3	16.0	28.2	34.0	35.3	27.4	36.3	36.3	41.1	55.6	43.4	55.6	125.5	135.7
1967	16.5	48.2	65.0	56.4	28.4	65.0	62.7	111.2	121.4	84.8	121.4	127.7	167.6	149.8	167.6	202.2	216.4
1968	25.1	21.3	29.7	25.7	59.7	59.7	46.4	51.0	55.4	85.4	85.4	76.1	76.7	115.1	115.1	110.5	126.2
1969	30.5	3.3	81.5	12.2	22.9	81.5	33.8	84.8	93.7	35.1	93.7	115.3	97.0	116.6	116.6	82.1	94.0
1970	48.8	24.4	5.3	42.7	50.3	50.3	73.2	29.7	48.0	93.0	93.0	78.5	72.4	98.3	98.3	74.5	82.1
1971	7.4	11.7	24.1	45.0	22.1	45.0	19.1	35.8	69.1	67.1	69.1	43.2	80.8	91.2	91.2	115.4	120.2
1972	14.7	70.9	47.2	23.1	23.4	70.9	85.6	118.1	70.3	46.5	118.1	132.8	141.2	93.7	141.2	141.9	154.6
1973	5.1	50.8	47.5	54.1	8.6	54.1	55.9	98.3	101.6	62.7	101.6	103.4	152.4	110.2	152.4	141.7	172.2
1974	7.4	14.7	65.8	31.8	8.6	65.8	22.1	80.5	97.6	40.4	97.6	87.9	112.3	106.2	112.3	125.8	144.9
1975	13.7	16.5	71.6	29.0	32.3	71.6	30.2	88.1	100.6	61.3	100.6	101.8	117.1	132.9	132.9	97.6	115.9
1976	42.9	37.3	46.7	19.3	14.5	46.7	80.2	84.0	66.0	33.8	84.0	126.9	103.3	80.5	126.9	120.1	130.8
1977	24.2	44.8	30.3	18.3	14.9	44.8	69.0	75.1	48.6	33.2	75.1	99.3	93.4	63.5	99.3	105.0	130.0
1978	17.8	33.4	100.0	46.7	23.8	100.0	51.2	133.4	146.7	70.5	146.7	151.2	180.1	170.5	180.1	69.0	81.9
1979	29.5	47.7	54.1	10.2	33.5	54.1	77.2	101.8	64.3	43.7	101.8	131.3	112.0	97.8	131.3	139.5	144.1
1980	9.2	24.8	44.4	33.0	53.4	53.4	34.0	69.2	77.4	86.4	86.4	78.4	102.2	130.8	130.8	79.1	82.3
1981	13.2	33.3	87.9	43.6	52.9	87.9	46.5	121.2	131.5	96.5	131.5	134.4	164.8	184.4	184.4	77.6	88.6
1982	33.7	13.3	62.7	22.4	31.7	62.7	47.0	76.0	85.1	54.1	85.1	109.7	98.4	116.8	116.8	121.3	135.2
1983	29.0	50.3	53.8	82.2	26.0	82.2	79.3	104.1	136.0	108.2	136.0	133.1	186.3	162.0	186.3	121.2	127.0
1984	33.5	27.0	44.6	48.7	25.0	48.7	60.5	71.6	93.3	73.7	93.3	105.1	120.3	118.3	120.3	94.4	102.9
1985	20.5	69.8	88.4	48.8	28.5	88.4	90.3	158.2	137.2	77.3	158.2	178.7	207.0	165.7	207.0	108.2	117.1
1986	30.0	47.4	73.0	44.5	8.0	73.0	77.4	120.4	117.5	52.5	120.4	150.4	164.9	125.5	164.9	100.5	106.3
1987	22.3	26.6	53.4	34.6	43.1	53.4	48.9	80.0	88.0	77.7	88.0	102.3	114.6	131.1	131.1	90.1	99.3
1988	23.8	26.2	68.8	28.6	9.8	68.8	50.0	95.0	97.4	38.4	97.4	118.8	123.6	107.2	123.6	141.6	145.7
1989	32.6	49.1	13.1	20.4	23.8	49.1	81.7	62.2	33.5	44.2	81.7	94.8	82.6	57.3	94.8	95.5	95.7
1990	48.4	57.0	13.0	41.0	45.0	57.0	105.4	70.0	54.0	66.0	105.4	118.4	111.0	99.0	118.4	106.8	108.4
1991	25.1	30.0	47.6	34.7	43.0	47.8	55.1	77.8	82.5	77.7	82.5	102.9	112.5	125.5	125.5	147.5	151.5
1992	28.2	32.2	44.3	47.4	56.4	56.4	60.4	76.5	91.7	103.8	103.8	104.7	123.9	148.1	148.1	152.7	199.3
1993	18.4	16.8	61.9	40.0	20.8	61.9	35.2	78.7	101.9	60.8	101.9	97.1	118.7	122.7	122.7	155.7	164.5
1994	37.8	53.6	36.2	8.6	21.6	53.6	91.4	89.8	44.8	30.2	91.4	127.6	98.4	66.4	127.6	115.2	122.9
1995	16.8	31.8	84.4	78.2	10.6	84.4	48.6	116.2	162.6	88.8	162.6	133.0	194.4	173.2	194.4	81.2	81.4
1996	3.4	27.9	67.2	58.2	33.6	67.2	31.3	95.1	125.4	91.8	125.4	98.5	153.3	159.0	159.0	100.4	117.0
1997	86.0	56.6	80.6	36.0	29.4	86.0	142.6	137.2	116.6	65.4	142.6	223.2	173.2	146.0	223.2	106.4	119.0
# years	43	44	44	44	44	44	42	44	44	44	44	42	44	44	44	42	42
Average	23.3	35.7	52.7	36.9	26.7	62.5	59.8	88.3	89.6	63.6	101.9	112.6	125.2	116.3	134.9	114.0	124.9
Max.	86.0	70.9	117.9	86.1	59.7	117.9	142.6	158.2	162.6	108.2	162.6	223.2	207.0	184.4	223.2	202.2	216.4
Min.	3.4	3.3	5.3	8.6	2.8	28.2	19.1	29.7	27.4	30.2	36.3	41.1	55.6	43.4	55.6	69.0	81.4
Std. Dev	15.13	16.45	25.37	18.38	14.12	18.60	24.73	29.65	33.18	21.79	28.06	34.88	37.97	34.34	35.76	28.63	32.90
# Max.	1	9	24	6	4	44	4	13	22	5	44	7	20	17	44		

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09/03/98

TABLE I.14 - One, Two and Three Month Duration Wet Period Rainfall - Common Data

	One Month Duration		Two Month Duration		Three Month Duration	
	Pelly	Williams	Pelly	Williams	Pelly	Williams
Maximum Recorded Rainfall Amounts (mm)						
1996	87.2	91.0	125.4	170.9	159.0	182.9
1997	86.0	102.4	142.6	150.9	223.2	208.6
Average	76.6	96.7	134.0	160.9	191.1	195.8
Ratio (Williams / Pelly) for 1996/97 Averages % per 100 m	1.262 6.6%		1.201 5.1%		1.024 0.6%	
Long Term Pelly Average (mm, 1955 - 1997)	62.5		101.9		134.9	
Ratio Pelly (Long Term / 1996/97 Average)	0.816		0.760		0.706	
Estimated Williams Creek Average (mm)		78.9		122.4		138.2

	1-Month	2-Month	3-Month
Orographic Factors	1.262	1.201	1.024

NOTE

Historic data for Pelly River Ranch shown on Table I.13

CCL File 044.02

09/03/98

TABLE I.15 - Wet Period Precipitation - One to Seven Month Duration**Table I.15A - Pelly River Ranch**

Return Period (years)	Annual Percent Probability	1 -Month Rainfall	2 -Month Rainfall	3 -Month Rainfall	6 -Month Precipitation	7 -Month Precipitation
20 (Dry)	95.0%	36.7	64.3	85.8	70.9	76.8
5 (Dry)	80.0%	46.5	79.2	105	88.6	95.8
2 (Average)	50.0%	62.5	101.9	135	114	125
5 (Wet)	20.0%	76.6	124	163	138	151
10 (Wet)	10.0%	88.0	140	183	154	171
20 (Wet)	5.0%	98.9	155	203	169	189
50 (Wet)	2.0%	113	174	226	186	212
100 (Wet)	1.0%	123	188	244	198	228
200 (Wet)	0.5%	134	202	260	210	244
500 (Wet)	0.2%	148	219	281	224	264

NOTE - Six and seven month precipitation assumed to be all snowfall accumulating from October to March (6 months) and October to April (7 months) respectively.

Table I.15B - Williams Creek Site

Return Period (years)	Annual Percent Probability	1 -Month Rainfall	2 -Month Rainfall	3 -Month Rainfall	6 -Month Precipitation	7 -Month Precipitation
Factor (times Pelly)		1.282	1.201	1.024	1.242	1.242
20 (Dry)	95.0%	46.3	77.2	87.9	88.1	95.4
5 (Dry)	80.0%	58.7	95.1	108	110	119
2 (Average)	50.0%	78.9	122	138	142	155
5 (Wet)	20.0%	96.7	149	167	171	188
10 (Wet)	10.0%	111	168	187	191	212
20 (Wet)	5.0%	125	186	208	210	235
50 (Wet)	2.0%	143	209	231	231	263
100 (Wet)	1.0%	155	226	250	246	283
200 (Wet)	0.5%	169	243	266	261	303
500 (Wet)	0.2%	187	263	288	278	328

NOTES

- 1) Orographic Factors for One-, Two-, and Three-Month Rainfall from Table I.14
- 2) Orographic Factors for Six- and Seven-Month precipitation based on the factor for annual total snowfall as described in Section 3.2 of this report.
- 3) For extreme winter snowfall years, the total snowfall will represent a greater proportion of the annual total precipitation than the 42% estimated for average conditions.
- 4) The Seven Month cumulative precipitation includes April precipitation, all assumed conservatively to be snowfall.

TABLE I.16 - Average Monthly Precipitation Conditions - Williams Creek Site

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Pelly River Ranch at Elevation 454 m													
Average Conditions - Monthly Depths - mm													
Average Rainfall	0.0	0.0	0.2	3.4	23.1	35.7	52.7	36.9	25.1	7.6	0.3	0.0	185.0
Average Snowfall	19.5	14.7	11.2	7.2	0.0	0.0	0.0	0.0	1.7	16.0	23.8	20.9	115.0
Average Precipitation	19.5	14.7	11.4	10.6	23.1	35.7	52.7	36.9	26.8	23.6	24.1	20.9	300.0
Percent per month of Total Annual Precipitation													
Rainfall	0.0%	0.0%	0.1%	1.1%	7.7%	11.9%	17.6%	12.3%	8.4%	2.5%	0.1%	0.0%	61.7%
Snowfall	6.5%	4.9%	3.7%	2.4%	0.0%	0.0%	0.0%	0.0%	0.6%	5.3%	7.9%	7.0%	38.3%
Total Precipitation	6.5%	4.9%	3.8%	3.5%	7.7%	11.9%	17.6%	12.3%	8.9%	7.9%	8.0%	7.0%	100.0%
Williams Creek Site at Elevation 850 m													
Percent per month of Total Annual Precipitation													
Rainfall	0.0%	0.0%	0.0%	1.2%	7.2%	11.1%	16.5%	11.6%	8.0%	2.4%	0.0%	0.0%	58.0%
Snowfall	7.2%	5.4%	4.1%	2.3%	0.0%	0.0%	0.0%	0.0%	0.0%	6.5%	8.7%	7.7%	42.0%
Total Precipitation	7.2%	5.4%	4.1%	3.5%	7.2%	11.1%	16.5%	11.6%	8.0%	9.0%	8.7%	7.7%	100.0%
Average Conditions - Monthly Depths - mm													
Rainfall	0.0	0.0	0.0	4.1	24.3	37.6	55.4	38.6	26.9	8.2	0.0	0.0	195.0
Snowfall	24.3	18.7	13.8	7.8	0.0	0.0	0.0	0.0	0.0	22.0	29.8	26.2	143.0
Total Precipitation	24.1	18.7	13.7	12.7	24.5	37.8	55.4	38.6	26.7	30.1	29.8	25.9	338.0

NOTES

- 1) Williams Creek % per month for rainfall, snowfall and total precipitation calculated assuming annual rainfall = 58% and annual snowfall = 42% of total annual precipitation.

CCL File 044.02

09/03/98

TABLE I.17 - Lake Evaporation Data and Estimates

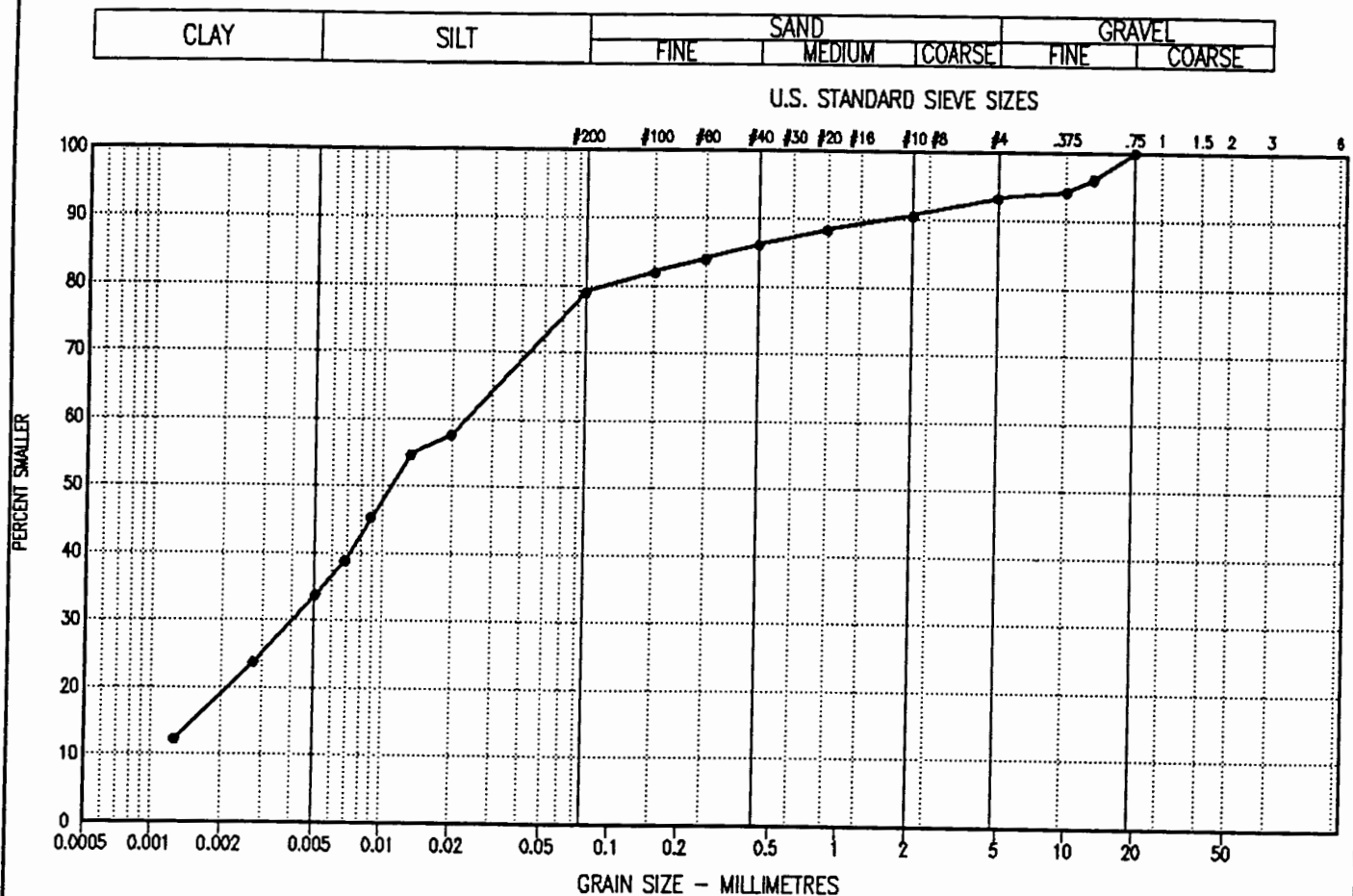
Station or Method	Elevation	March	April	May	June	July	Aug	Sept	Total	
Pelly Ranch	454			104.7	121.2	111.2	80.2	36.4	453.7	Note 1
Whitehorse	703			106.4	126.3	113.2	95.7	50.9	492.5	Note 2
Average	579			105.6	123.8	112.2	88.0	43.7	473.1	
Williams Ck (estimated)	850			97.4	114.2	103.5	81.1	40.3	436.4	Note 3
Williams Ck (estimated)	850			92.9	107.5	98.6	71.1	32.3	402.4	Note 4
Williams Ck (estimated)	850			101.9	121.0	108.4	91.7	48.8	471.8	Note 5
Calculation for Carmacks/Pelly Ranch region										Note 6
Lake Evaporation	850	4.2	42.9	98.3	129.4	131.1	89.1	25.9	520.9	Note 7
Evapotranspiration	850		27.0	70.4	95.1	96.3	62.5	14.0	365.3	

NOTES

- 1) Reported by AES, 1974 to 1990 period
- 2) Reported by AES, 1964 to 1990 period
- 3) Estimated using 10% decrease per 350 m increase in elevation above elevation 579 m
- 4) Estimated using 10% decrease per 350 m increase in elevation above elevation 454 m (Pelly)
- 5) Estimated using 10% decrease per 350 m increase in elevation above elevation 703 m (Whitehorse) (as recommended in manual of Operational Hydrology in BC)
- 6) Calculated by DIAND Water Resources using Morton's Method & shown in Appendix V of Baseline Data Compilation Report compiled by Access Mining Consultants
- 7) Total lake evaporation calculated by Morton but excluding March & April = 473.8 mm which is the same as the average of the historical data reported for Pelly Ranch and for Whitehorse for the May through September period.
- 8) For application purposes a "conservative" lake evaporation should be used depending on the application:
 - for solution storage determination, use minimum lake evaporation = 402.4 mm per year.
 - for make-up water demand, use maximum lake evaporation = 520.9 mm per year.
 - for average conditions, use average value of 460 mm/year based on average of AES data

**#4. DESIGN MEMORANDUM CCL-CC4
HEAP LEACH FACILITY WATER BALANCE**

PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION				Cu	Cc	U.S.C
			CLAY %	SILT %	SAND %	GRAVEL %			
—●—	TP04	2.60 - 2.80	33.7	45.2	14.3	6.8	—	—	

Project: 0201-97-13103

Date Tested: 97/11/03

BY: JSB

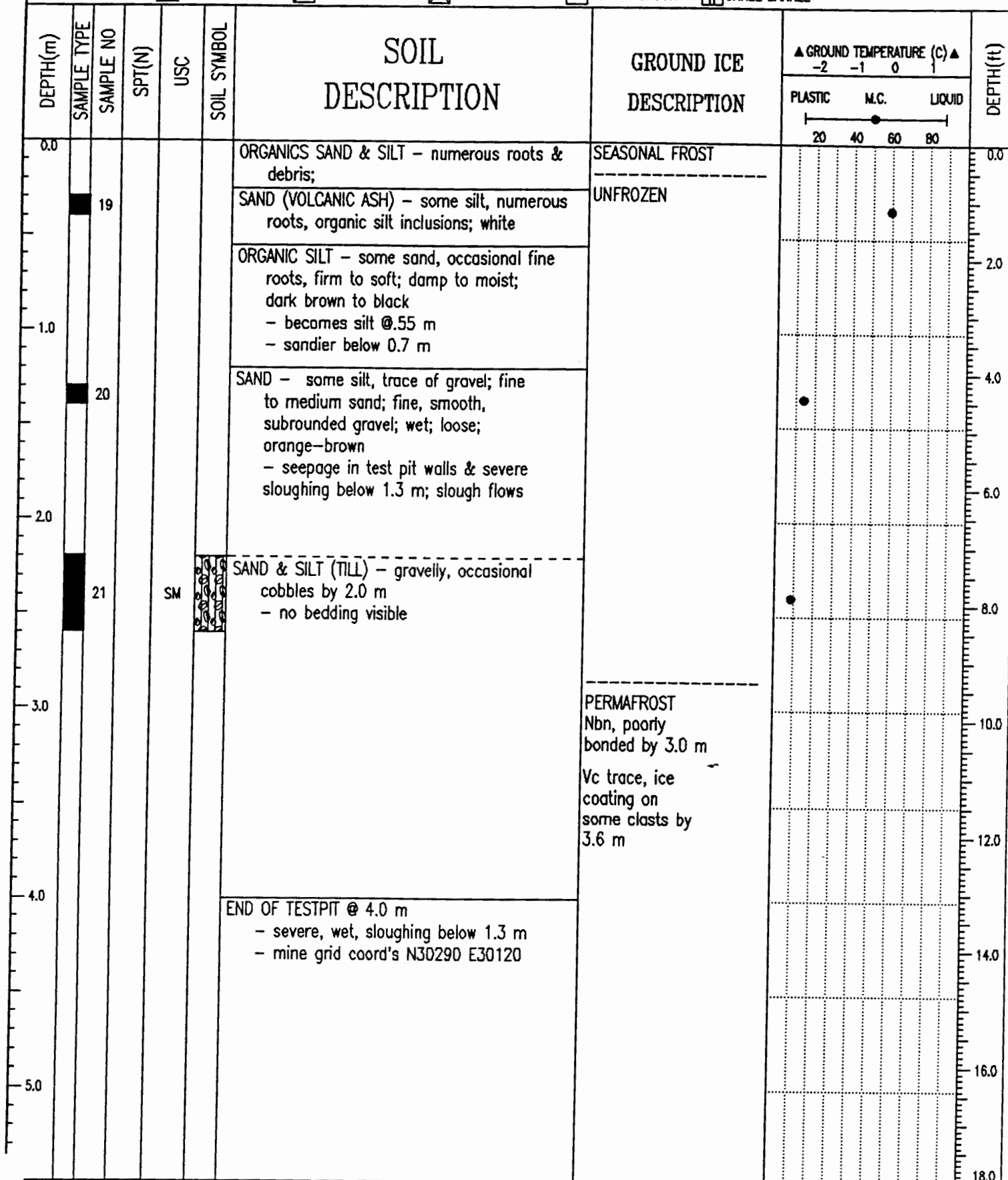
Tested in accordance with ASTM D422 unless otherwise noted.

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SAMPLE TYPE GRAB SAMPLE ☒ NO RECOVERY ☒ STANDARD PEN. ☒ 75 mm SPOON ☐ CRREL BARREL



EBA Engineering Consultants Ltd.
 Whitehorse, Yukon

LOGGED BY: CRH

REVIEWED BY: JRT

Fig. No:

COMPLETION DEPTH: 4 m

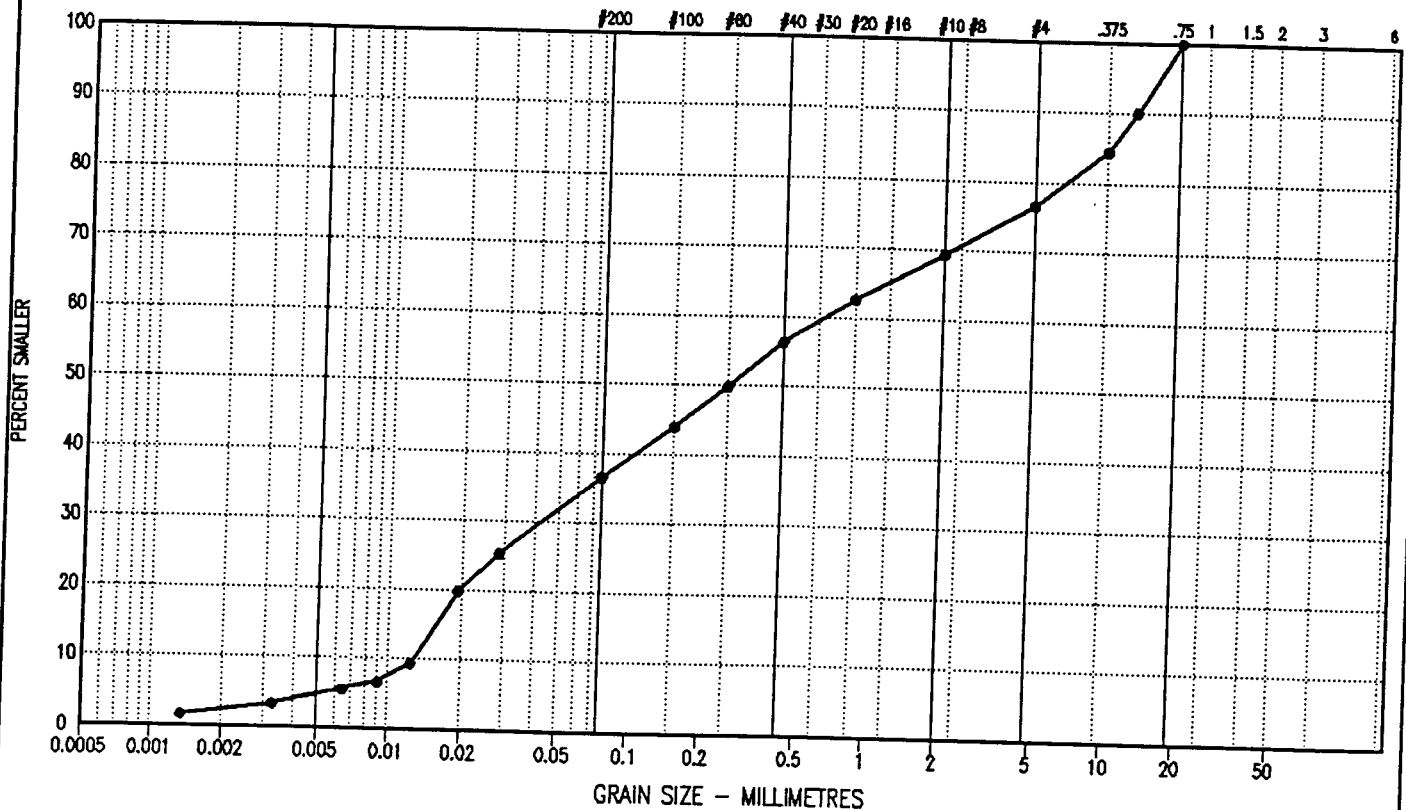
COMPLETE: 97/10/29

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PARTICLE SIZE - ANALYSIS OF SOILS

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE

U.S. STANDARD SIEVE SIZES



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION				Cu	Cc	U.S.C
			CLAY %	SILT %	SAND %	GRAVEL %			
—●—	TP05	2.20 - 2.60	4.5	32.0	40.0	23.5	52.9	0.3	SM

Project: 0201-97-13103

Date Tested: 97/11/03

BY: JSB

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GEOTECHNICAL EXPLORATION-HEAP LEACH PAD EXCAVATOR: CAT 225 TEST PIT NO: 13103-TP06
 WILLIAMS CREEK, YUKON UTM ZONE: 8 N - E - PROJECT NO: 0201-97-13103
 ELEVATION: 1598 m

SAMPLE TYPE GRAB SAMPLE ☒ NO RECOVERY ☒ STANDARD PEN. 75 mm SPOON ☐ CORREL BARREL

SOIL DESCRIPTION

STANDARD PENETRATION
 10 20 30 40
 PLASTIC M.C. LIQUID
 10 20 30 40

PERCENT GRAVEL
 20 40 60 80
 PERCENT SAND
 20 40 60 80
 PERCENT SILT OR FINES
 20 40 60 80
 PERCENT CLAY
 20 40 60 80

VOLCANIC ASH - sandy; frozen; white

SAND & SILT - trace of subangular gravel, occasional roots; medium brown

SAND (FLUVIAL) - trace of gravel, trace of silt; fine to medium grained sand; smooth, subrounded fine gravel; compact; damp; orange brown

SAND (RESIDUUM) - trace of gravel and cobbles; well graded, angular, friable sand; friable, angular gravel & cobble clasts; dense; damp; mottled brown

- becomes more competent with depth; difficult excavation below 2.0 m

END OF TESTPIT @ 2.9 m

- no sloughing or seepage observed
- sand layers overlying the residual sand increase in thickness towards the valley centre
- mine grid coord's N30340 E30150

EBA Engineering Consultants Ltd.
 Whitehorse, Yukon

LOGGED BY: CRH
 REVIEWED BY: JRT
 Fig. No:

COMPLETION DEPTH: 2.9 m
 COMPLETE: 97/10/29

Page 1 of 1

SAMPLE TYPE ☒ GRAB SAMPLE ☒ NO RECOVERY ☒ STANDARD PEN. ☒ 75 mm SPOON ☐ CORREL BARREL

DEPTH(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	USC	SOIL SYMBOL	SOIL DESCRIPTION	GROUND ICE DESCRIPTION	▲ GROUND TEMPERATURE (C) ▲ -2 -1 0 1 PLASTIC M.C. LIQUID 20 40 60 80	DEPTH(ft)
0.0						ORGANIC SILT (TOP SOIL) - numerous roots;	SEASONAL FROST		0.0
		25				SAND & SILT - frequent ash inclusions, occasional fine roots; fine to medium sand, nonplastic; firm, damp, brown	UNFROZEN		2.0
1.0		26		SP-SM		SAND & GRAVEL (FLUVIAL) - trace of silt; fine to medium sand; fine to coarse; smooth, rounded gravel; compact; moist; orange-brown			4.0
		27				SILT (TILL) - some sand, trace of clay, trace of gravel; fine to medium sand; subangular to rounded gravel; low plastic; moist to wet; firm; medium brown - cobbles disseminated throughout; occasional degraded granodiorite clasts			6.0
2.0									8.0
3.0		28							10.0
		29		SM		- bulk frozen density = 2.2 Mg/m ³ - slow difficult excavation below 3.6 m - bulk frozen density = 2.1 Mg/m ³	PERMAFROST Vs, trace, ice in irregular stratified layers <2 mm thick		12.0
4.0		30				SILT & CLAY - sandy, trace of gravel			14.0
						END OF TESTPIT @ 4.2 m - no seepage observed - mine grid coord's N30180 E30280			16.0
5.0									18.0

EBA Engineering Consultants Ltd.
Whitehorse, Yukon

LOGGED BY: CRH

REVIEWED BY: JRT

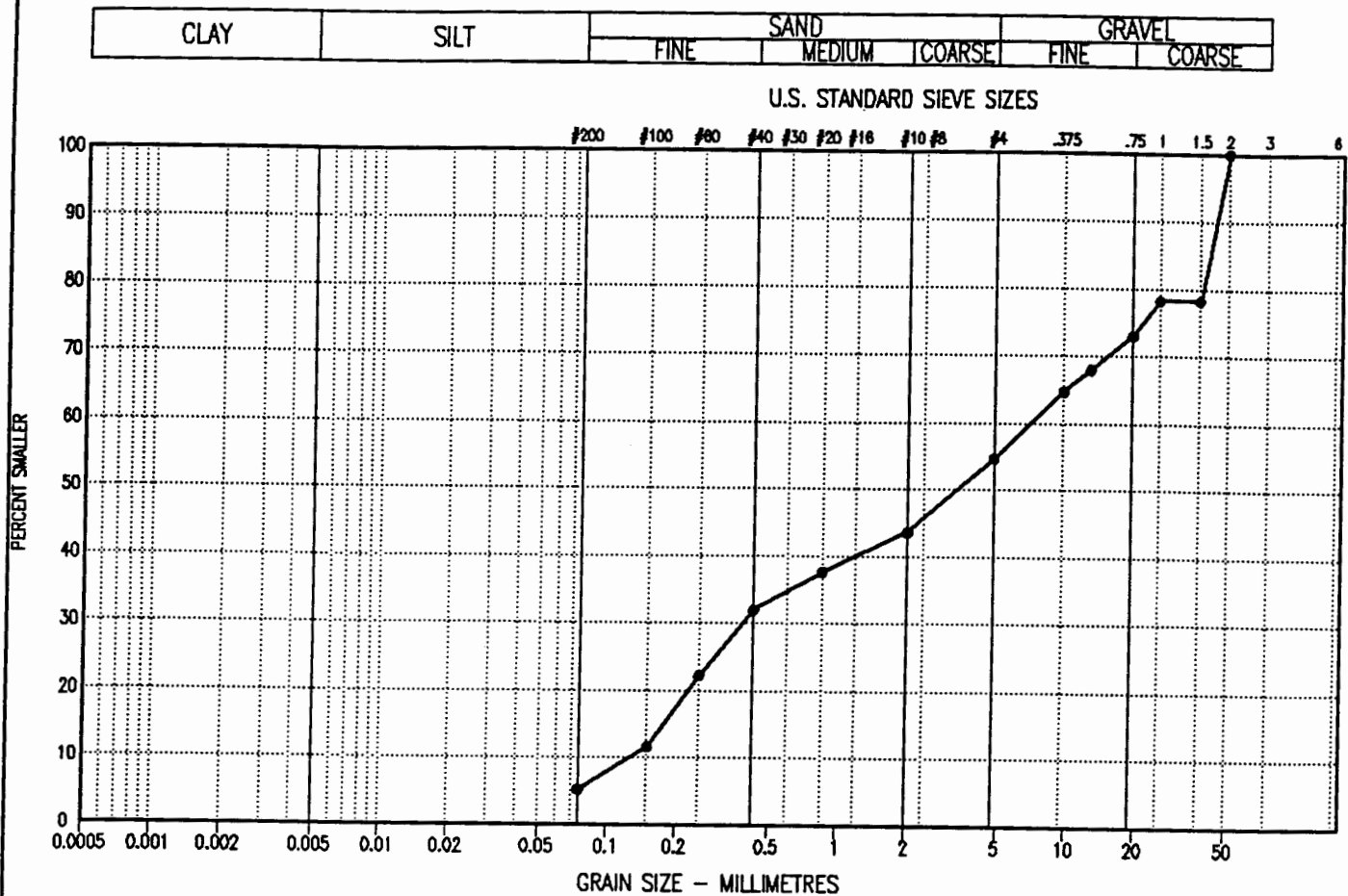
Fig. No:

COMPLETION DEPTH: 4.2 m

COMPLETE: 97/10/29

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PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
—●—	TP07	0.80 - 0.90	5.2	49.5	45.3	55.4	0.2	SP-SM

Project: 0201-97-13103

Date Tested: 97/11/03

BY: JSB

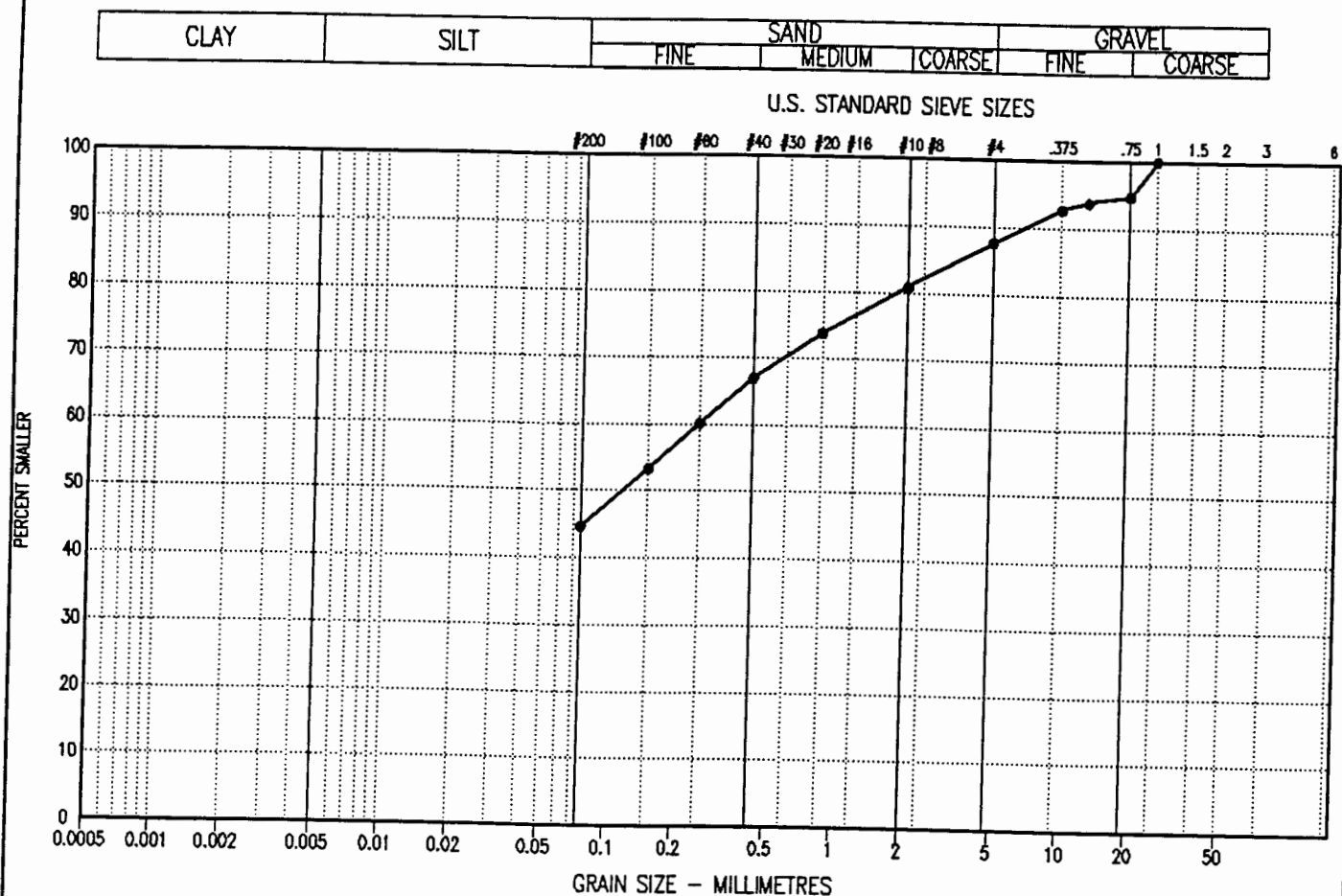
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PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
●—●	13103-TP07	3.50 - 3.60	44.5	43.1	12.4	14.7	0.6	SM

Project: 0201-97-13103

Date Tested: 97/11/10

BY: JSB

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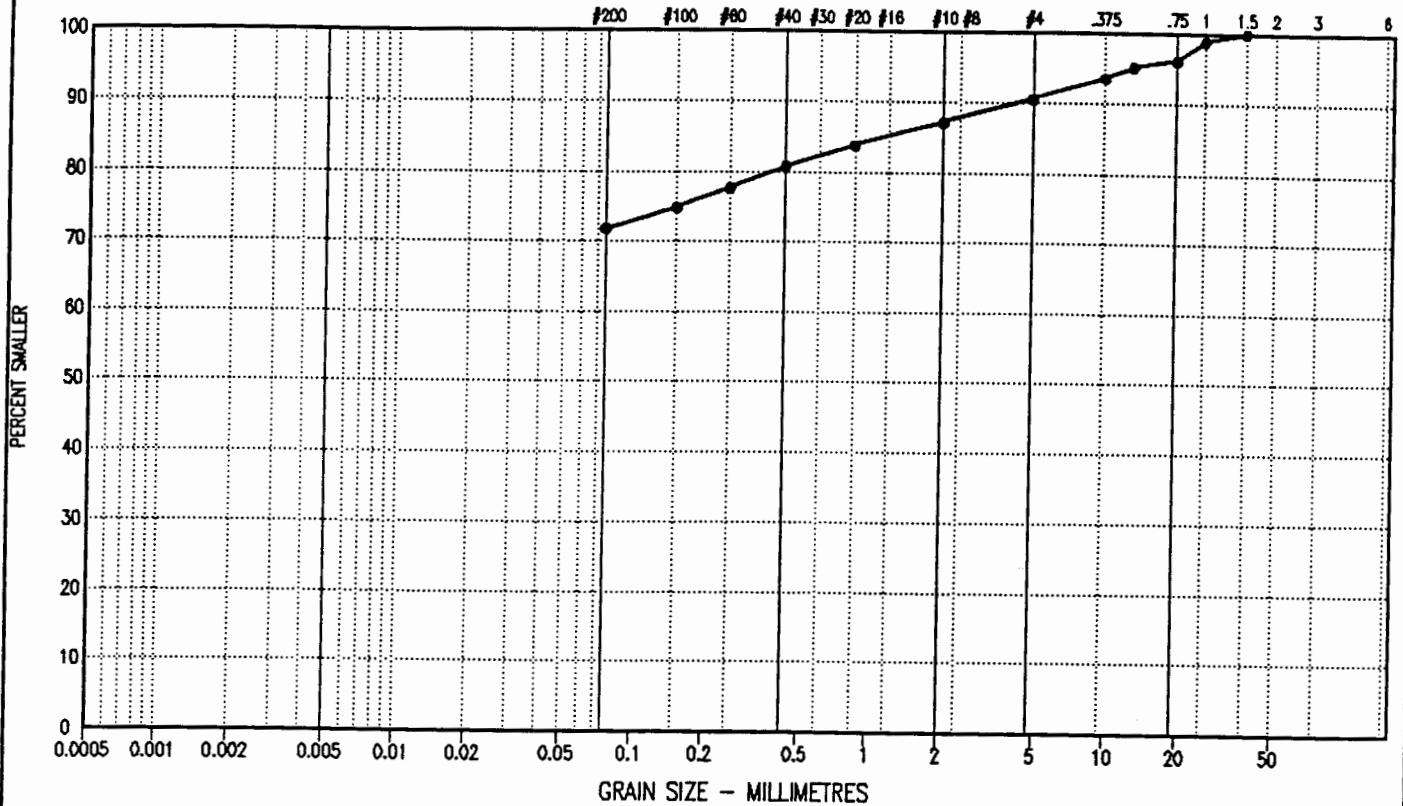
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PARTICLE SIZE - ANALYSIS OF SOILS

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE

U.S. STANDARD SIEVE SIZES



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
—●—	13103-TP07	4.00 - 4.20	71.7	18.8	9.5	6.0	1.5	

Project: 0201-97-13103

Date Tested: 97/11/10

BY: JSB

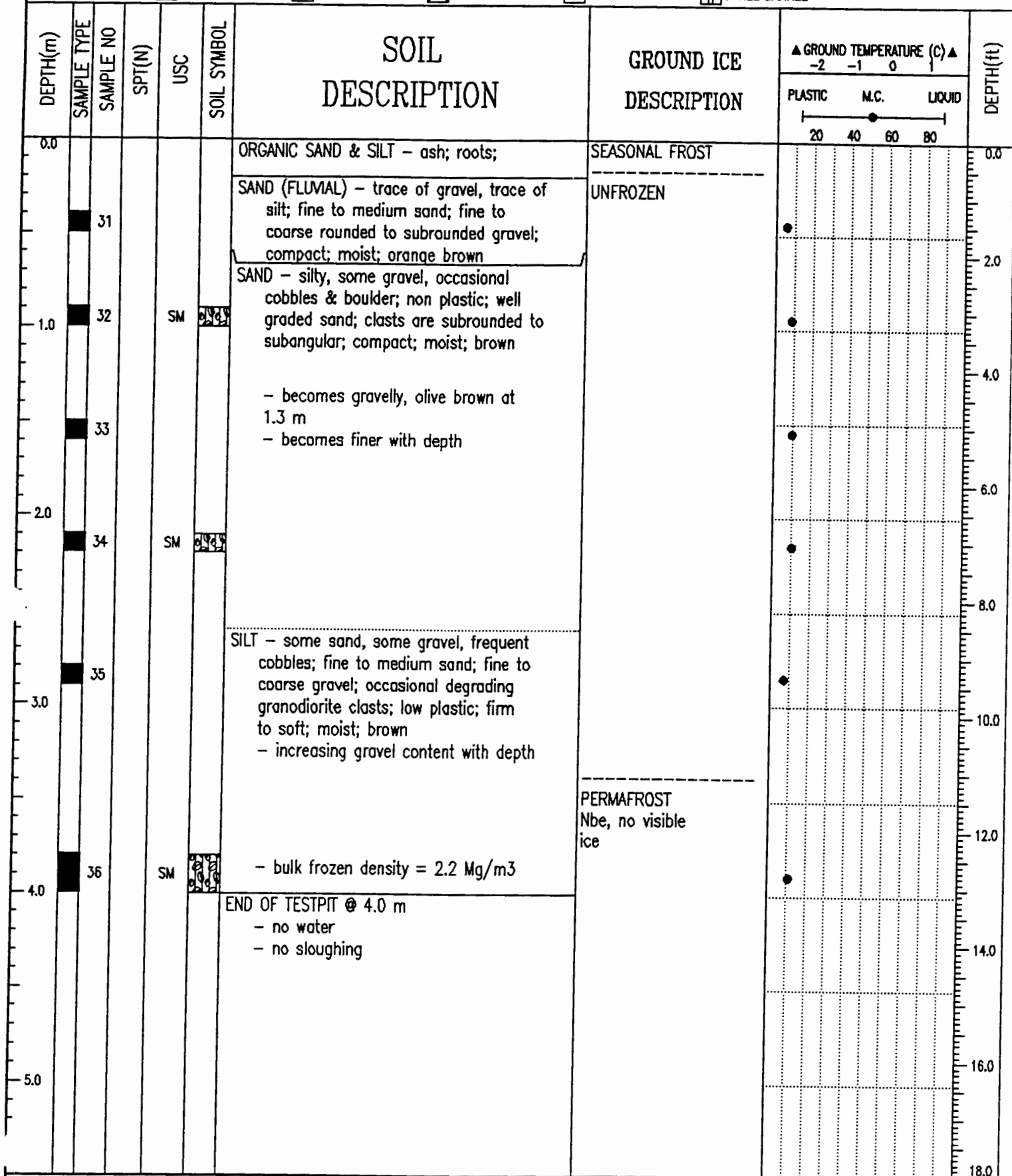
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GEOTECHNICAL EXPLORATION-HEAP 1 4 PAD		EXCAVATOR: CAT 225	BOREHOLE NO: 13105-1P08
WILLIAMS CREEK, YUKON		UTM ZONE: 8 N - E -	PROJECT NO: 0201-97-13103
SAMPLE TYPE		☒ GRAB SAMPLE ☐ NO RECOVERY ☒ STANDARD PEN. ☐ 75 mm SPOON ☐ CRREL BARREL	ELEVATION: 1500 m



EBA Engineering Consultants Ltd.
Whitehorse, Yukon

LOGGED BY: CRH

REVIEWED BY: JRT

Fig. No:

COMPLETION DEPTH: 4 m

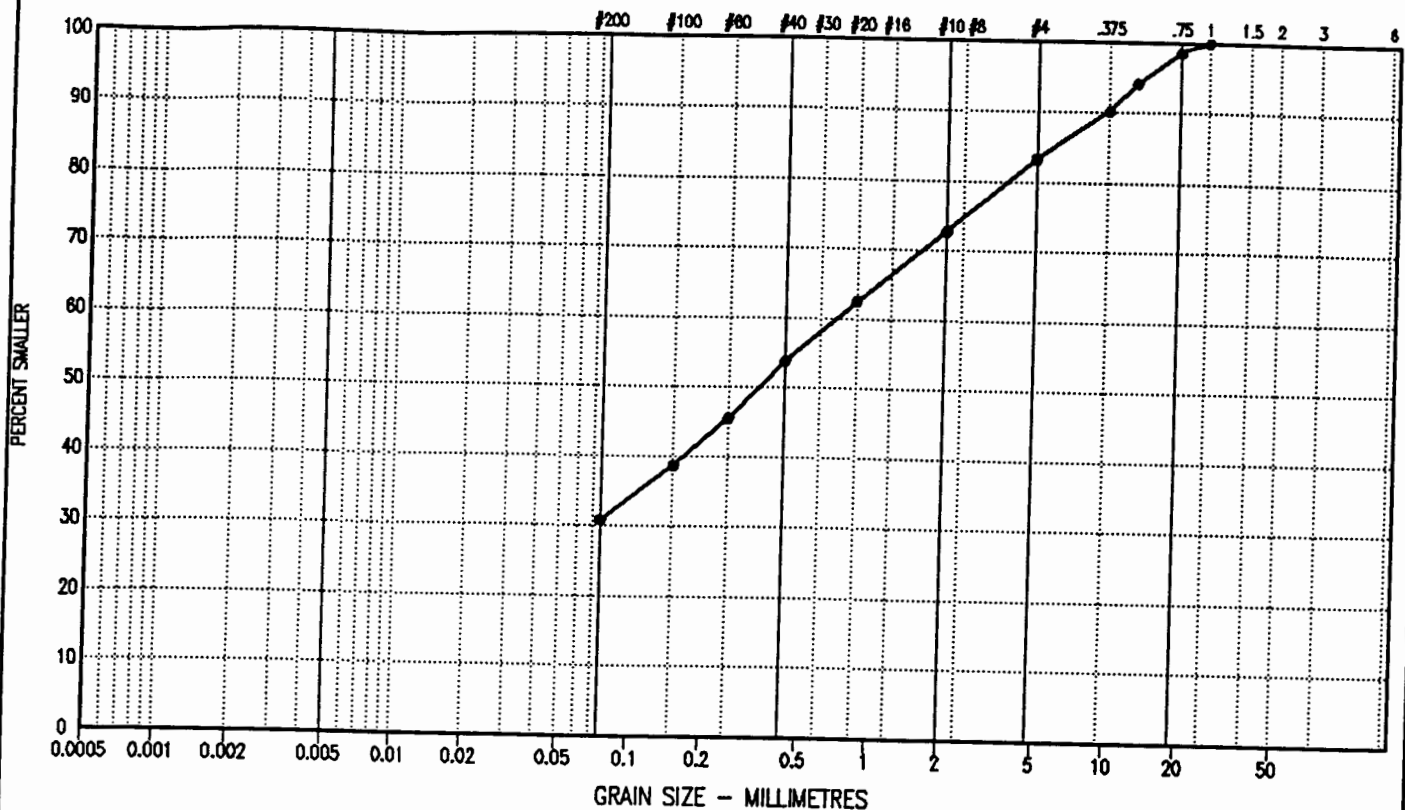
COMPLETE: 97/10/29

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PARTICLE SIZE - ANALYSIS OF SOILS

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE

U.S. STANDARD SIEVE SIZES



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
—●—	TP08	0.90 - 1.00	30.7	52.5	16.8	30.0	0.3	SM

Project: 0201-97-13103

Date Tested: 97/11/04

BY: JSB

Tested in accordance with ASTM D422 unless otherwise noted.

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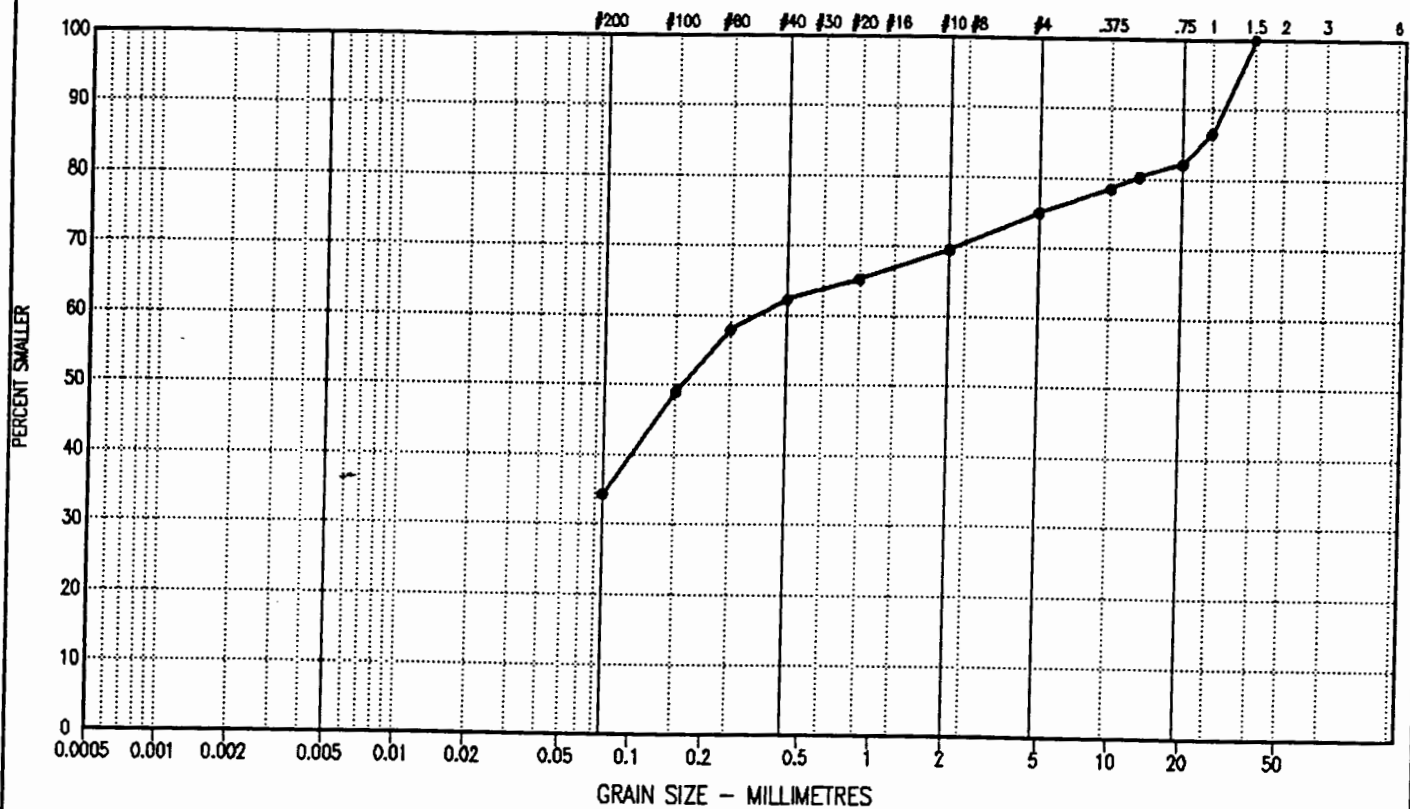
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PARTICLE SIZE - ANALYSIS OF SOILS

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE

U.S. STANDARD SIEVE SIZES



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
●—●	TP08	2.10 - 2.20	34.2	40.7	25.1	15.3	0.6	SM

Project: 0201-97-13103

Date Tested: 97/11/05

BY: JSB

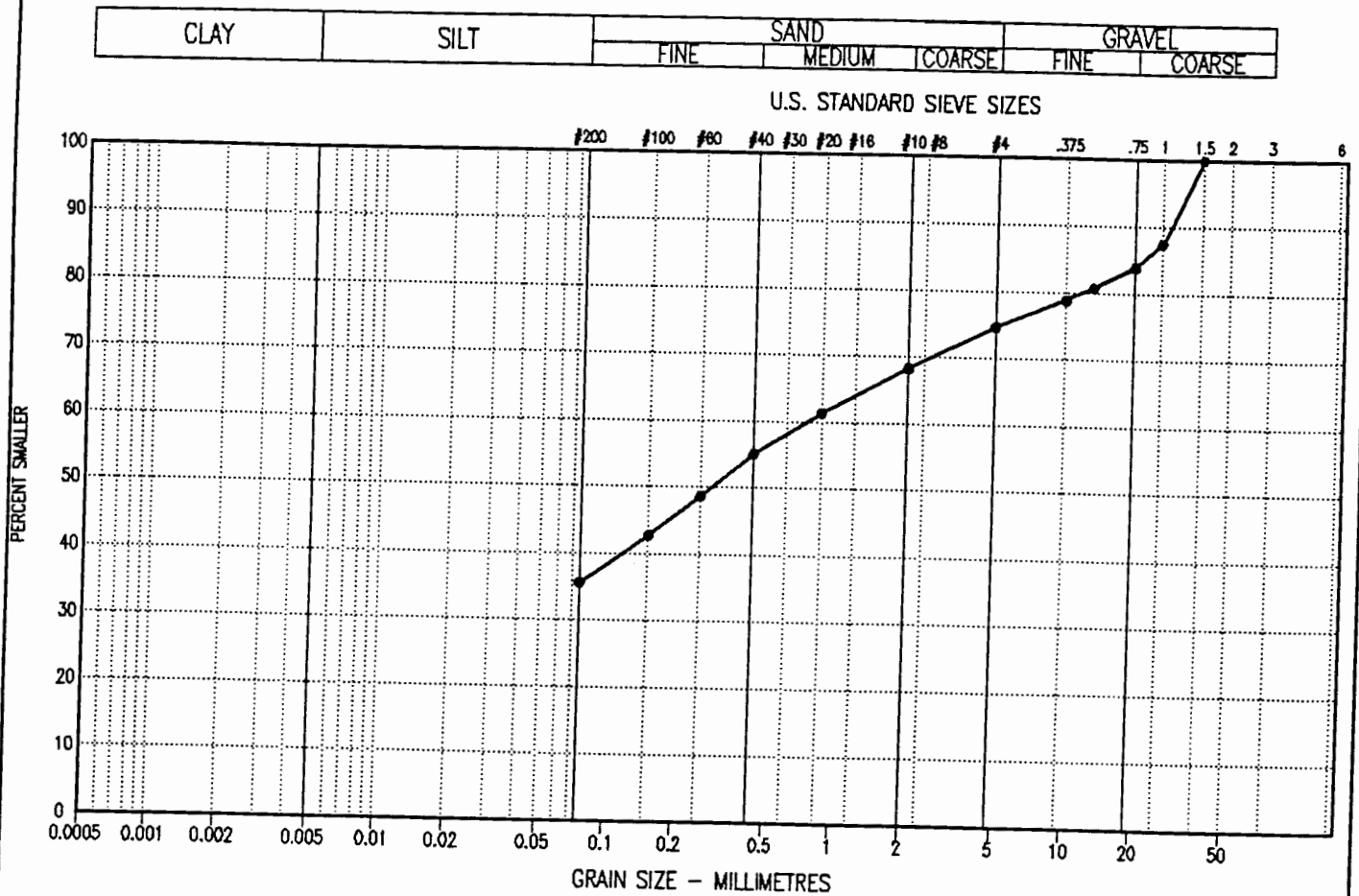
Tested in accordance with ASTM D422 unless otherwise noted.

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PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
●—	13103-TP08	3.80 - 4.00	35.5	39.0	25.5	36.1	0.2	SM

Project: 0201-97-13103

Date Tested: 97/11/10

BY: JSB

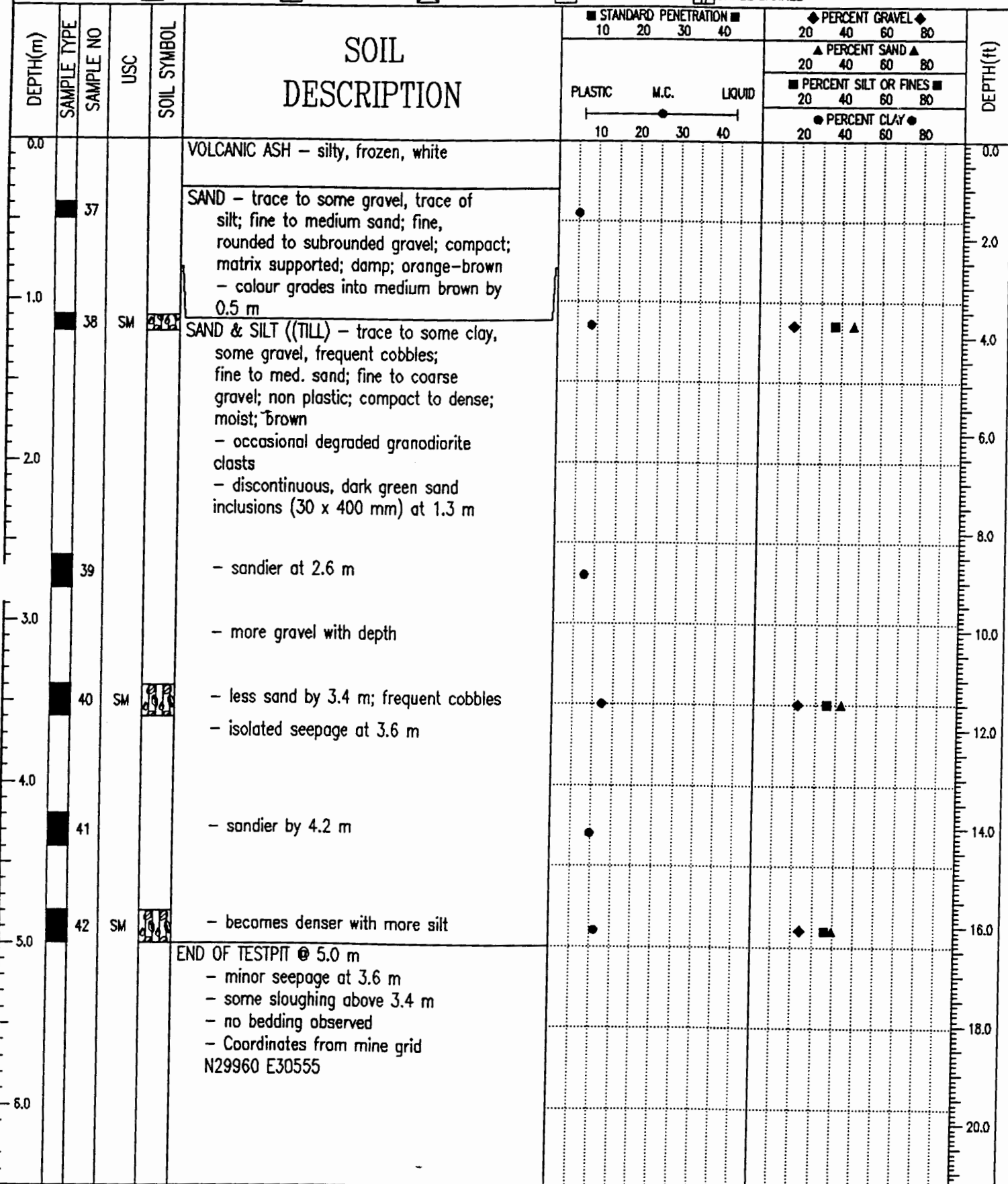
Tested in accordance with ASTM D422 unless otherwise noted.

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CARMACKS COPPER PROJECT	CLIENT: WESTERN COPPER HOLDIN .TD.	TEST PIT NO: 13103-TP09
GEOTECHNICAL EXPLORATION-HEAP LEACH PAD	EXCAVATOR: CAT 225	PROJECT NO: 0201-97-13103
WILLIAMS CREEK, YUKON	UTM ZONE: 8 N - E -	ELEVATION: 1472 m
SAMPLE TYPE	☒ GRAB SAMPLE ☒ NO RECOVERY ☒ STANDARD PEN. ☒ 75 mm SPOON ☐ CRREL BARREL	



EBA Engineering Consultants Ltd.
Whitehorse, Yukon

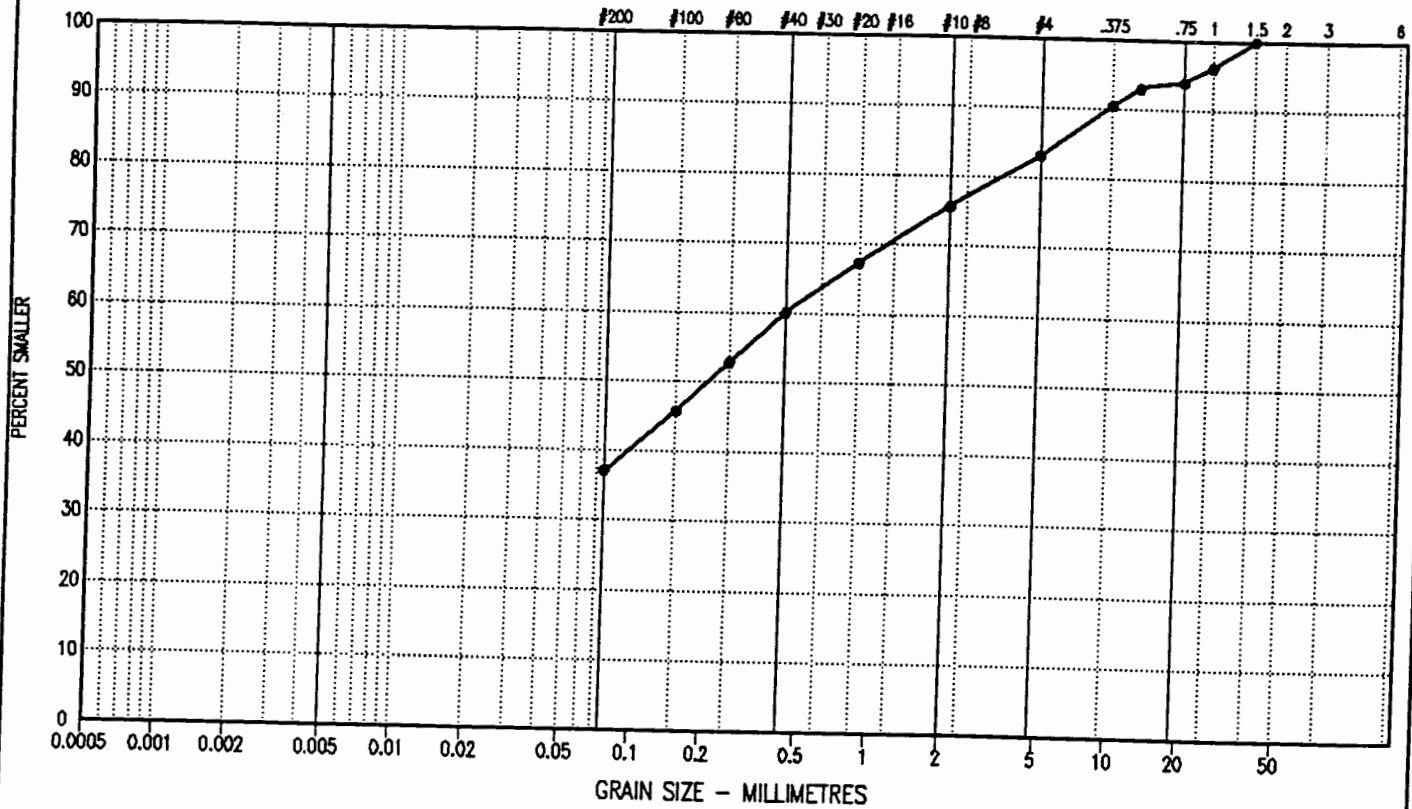
LOGGED BY: CRH
REVIEWED BY: JRT
Fig. No:

COMPLETION DEPTH: 5 m
COMPLETE: 97/10/29

PARTICLE SIZE - ANALYSIS OF SOILS

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE

U.S. STANDARD SIEVE SIZES



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
—	TP09	1.10 - 1.20	37.0	46.1	16.9	20.9	0.4	SM

Project: 0201-97-13103

Date Tested: 97/11/05

BY: JSB

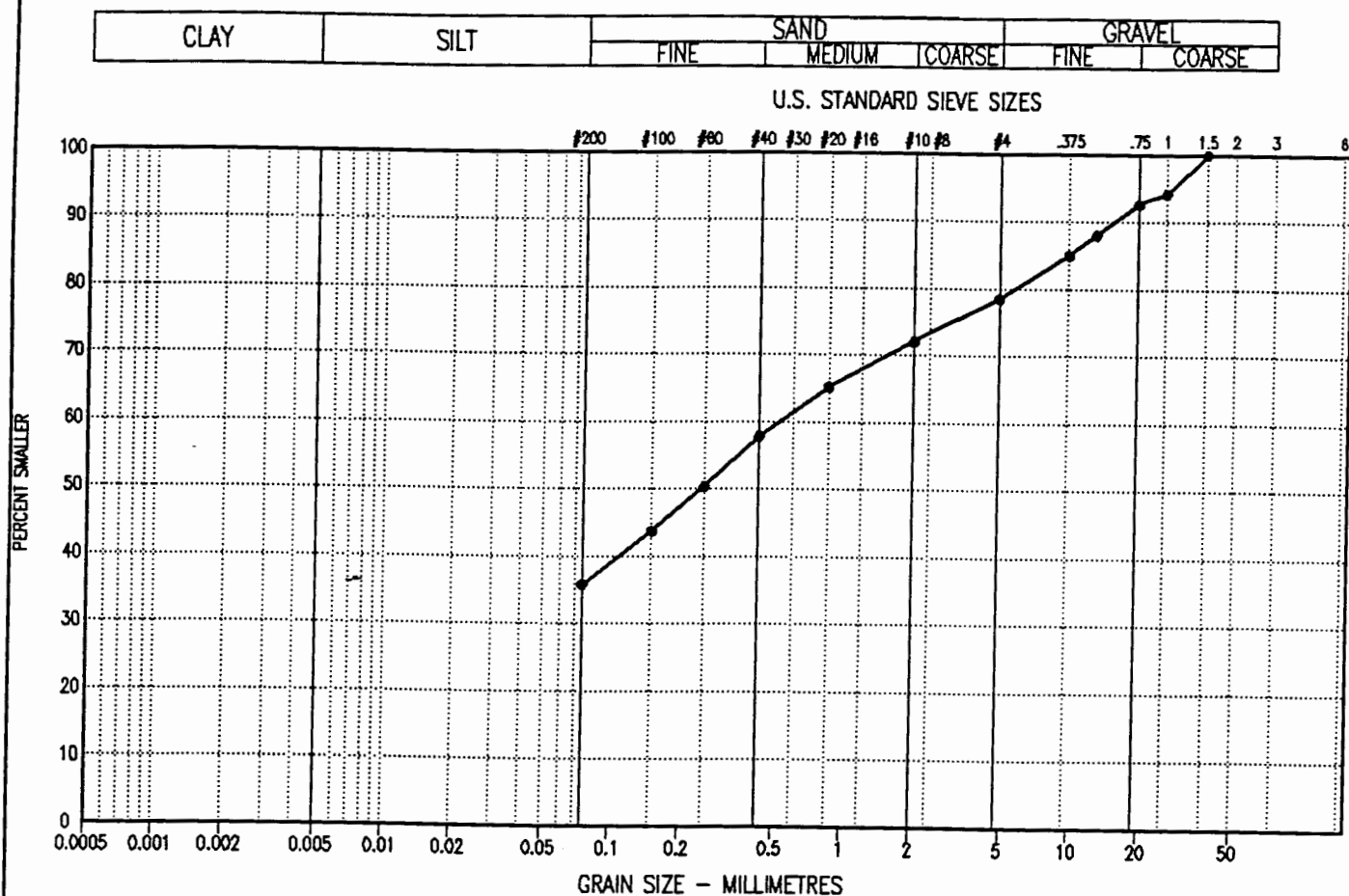
Tested in accordance with ASTM D422 unless otherwise noted.

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PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
●—●	TP09	3.40 - 3.60	35.7	42.7	21.6	26.5	0.3	SM

Project: 0201-97-13103

Date Tested: 97/11/05

BY: JSB

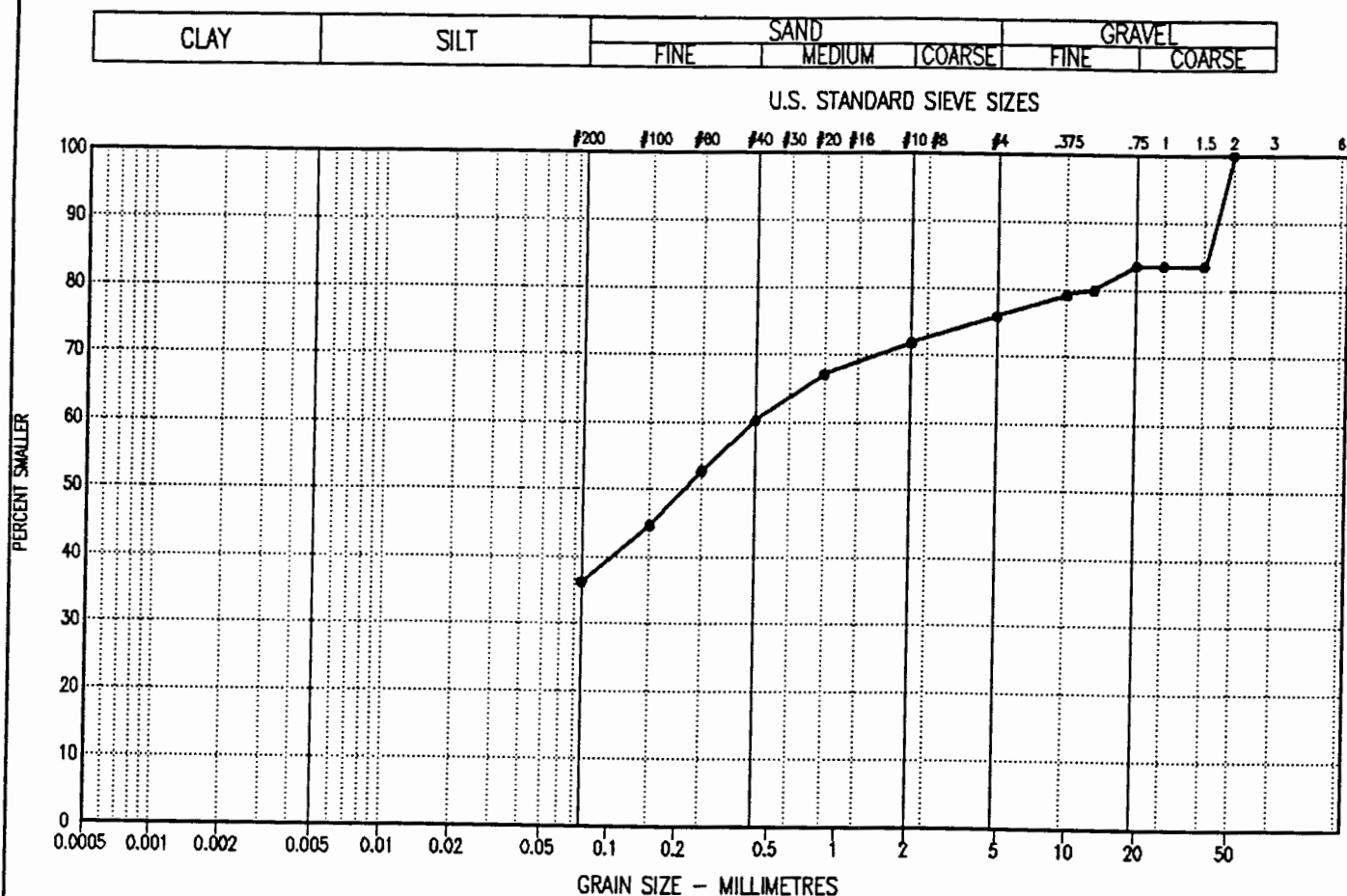
Tested in accordance with ASTM D422 unless otherwise noted.

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PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
—●—	TP09	4.80 - 5.00	36.1	39.6	24.3	20.2	0.4	SM

Project: 0201-97-13103

Date Tested: 97/11/05

BY: JSB

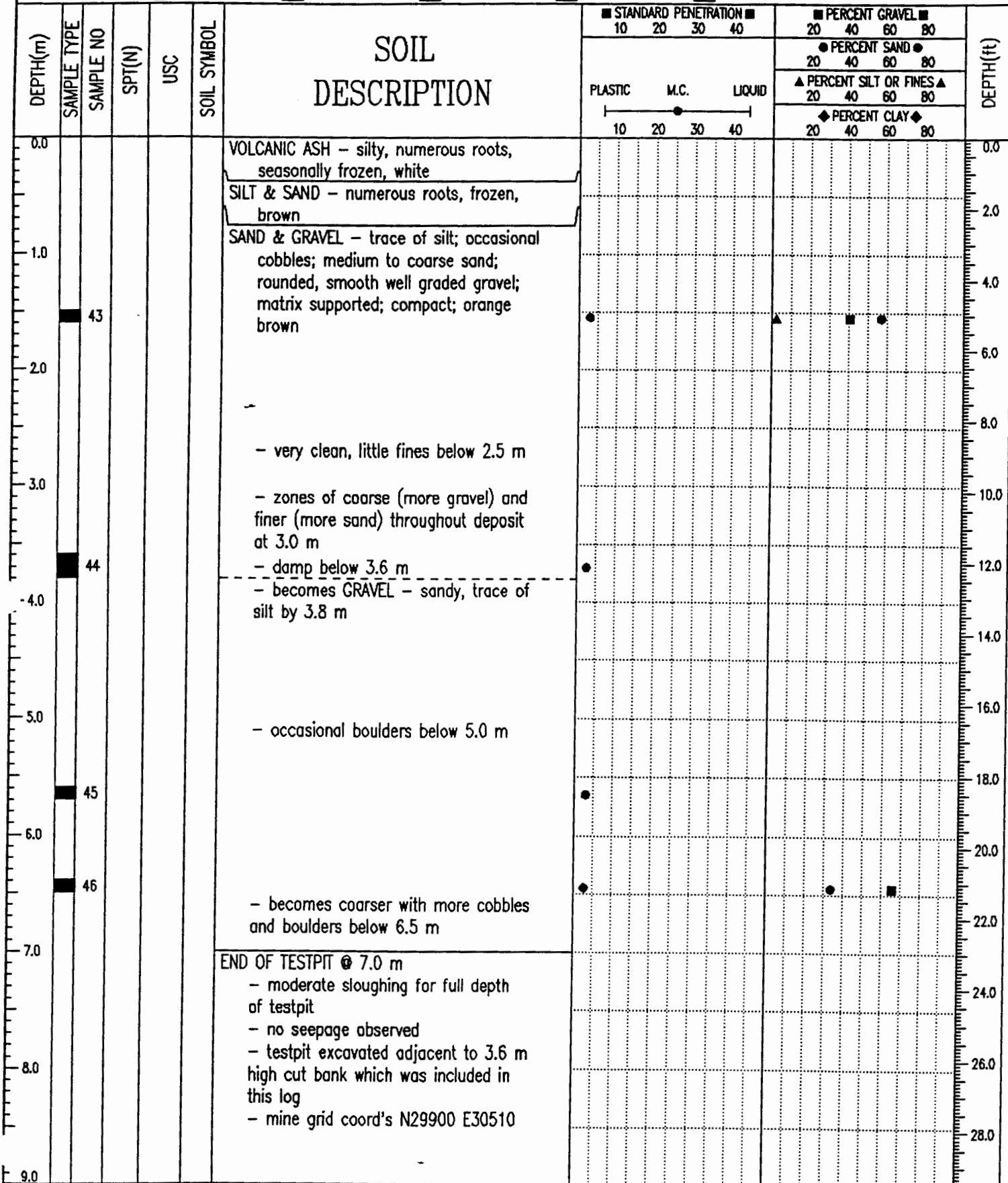
Tested in accordance with ASTM D422 unless otherwise noted.

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CARMACKS COPPER PROJECT		CLIENT: WESTERN COPPER HOLDIN LTD.	BOREHOLE NO: 13103-TP10
GEOTECHNICAL EXPLORATION-HEAP LEACH PAD		EXCAVATOR: CAT 225	PROJECT NO: 0201-97-13103
WILLIAMS CREEK, YUKON		UTM ZONE: 8 N - E -	ELEVATION: 1459 m
SAMPLE TYPE	☒ GRAB SAMPLE	☒ NO RECOVERY	☒ STANDARD PEN.
		☐ 75 mm SPOON	☐ CRREL BARREL



EBA Engineering Consultants Ltd.
Whitehorse, Yukon

LOGGED BY: CRH
REVIEWED BY: JRT
Fig. No:

COMPLETION DEPTH: 7 m
COMPLETE: 97/10/30

AGGREGATE ANALYSIS REPORT (CONCRETE AGGREGATE)

Project: CARMACKS COPPER PROJECT

Address: WILLIAMS CREEK, YT

Project Number: 0201-97-13103

Date Tested: 97/11/05 By: JSB

Client: WESTERN COPPER HOLDINGS

Attention: _____

Sample Number: TP10-SA1

Sample Description: SAND & GRAVEL - trace of silt

Natural Moisture Content: 2.9 %

Organic Content: _____

State of Alaska Method _____

Plate Number: _____

Organic Impurities in Sands for Concrete _____

Bulk Relative Density: _____

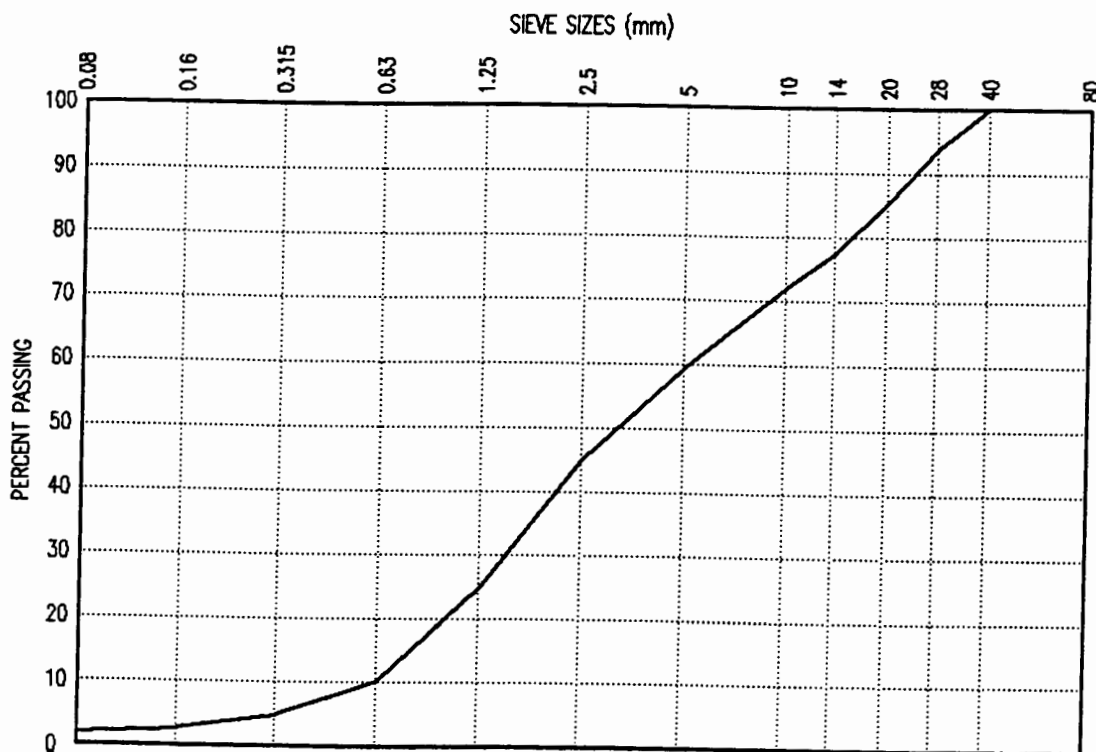
Bulk Relative Density (SSD): _____

Apparent Relative Density: _____

Absorption: _____

Remarks: Depth 1.5 - 1.6 m

Sieve	% Passing
40	100.0
28	93.6
20	85.2
14	77.2
10	71.9
5	59.1
2.5	44.7
1.25	24.6
0.63	10.0
0.315	4.8
0.16	2.6
0.08	1.9
F.M.	5.26



Reviewed By: _____

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AGGREGATE ANALYSIS REPORT (CONCRETE AGGREGATE)

Project: CARMACKS COPPER PROJECT

Address: WILLIAMS CREEK, YT

Project Number: 0201-97-13103

Date Tested: 97/11/05 By: MCP

Client: WESTERN COPPER HOLDINGS

Attention: _____

Sample Number: TP10-SA1

Sample Description: COARSE AGGREGATE

Theoretical Spirt

Natural Moisture Content: _____

Organic Content: _____

State of Alaska Method _____

Plate Number: _____

Organic Impurities in Sands for Concrete _____

Bulk Relative Density: _____

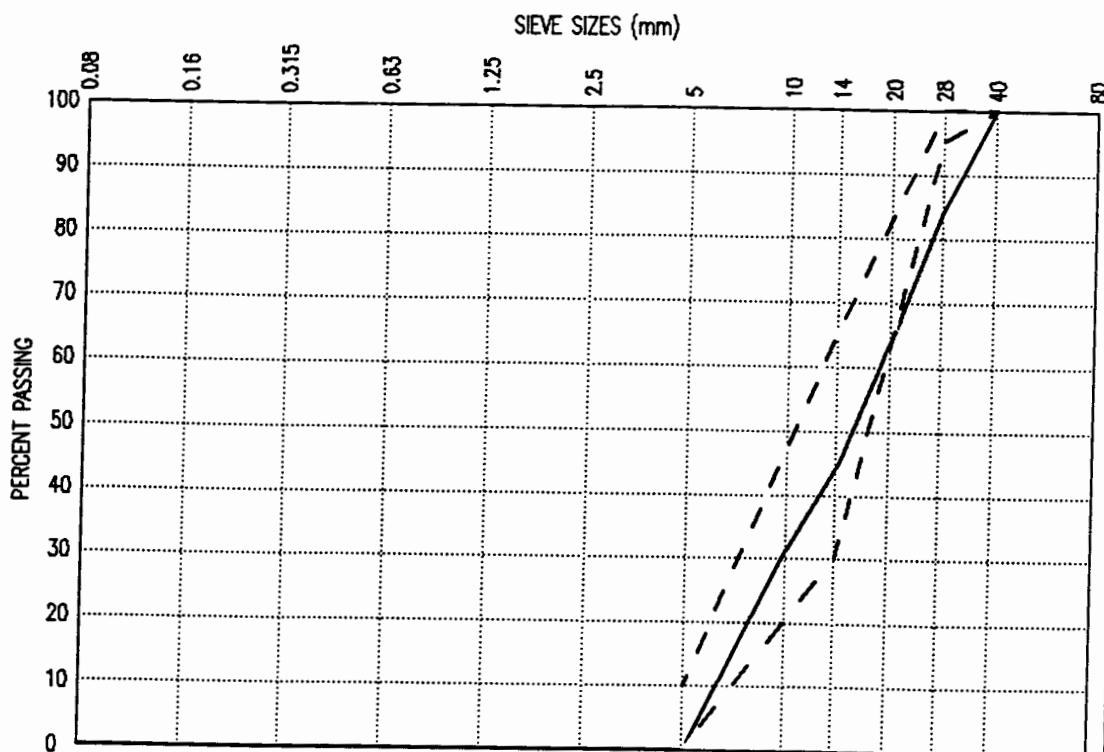
Bulk Relative Density (SSD): _____

Apparent Relative Density: _____

Absorption: _____

Remarks: Depth 1.5 - 1.6 m

Sieve	% Passing
40	100.0
28	84.4
20	63.7
14	44.3
10	31.2
5	
2.5	
1.25	
0.63	
0.315	
0.16	
0.08	
F.M.	1.76



Reviewed By: Miles Zimbe

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AGGREGATE ANALYSIS REPORT (CONCRETE AGGREGATE)

Project: CARMACKS COPPER PROJECT

Address: WILLIAMS CREEK, YT

Project Number: 0201-97-13103

Date Tested: 97/11/05 By: MCP

Client: WESTERN COPPER HOLDINGS

Attention: _____

Sample Number: TP10-SA1A

Sample Description: SAND

Theoretical Split

Natural Moisture Content: _____

Organic Content: _____

State of Alaska Method

Plate Number: _____

Organic Impurities in Sands for Concrete

Bulk Relative Density: _____

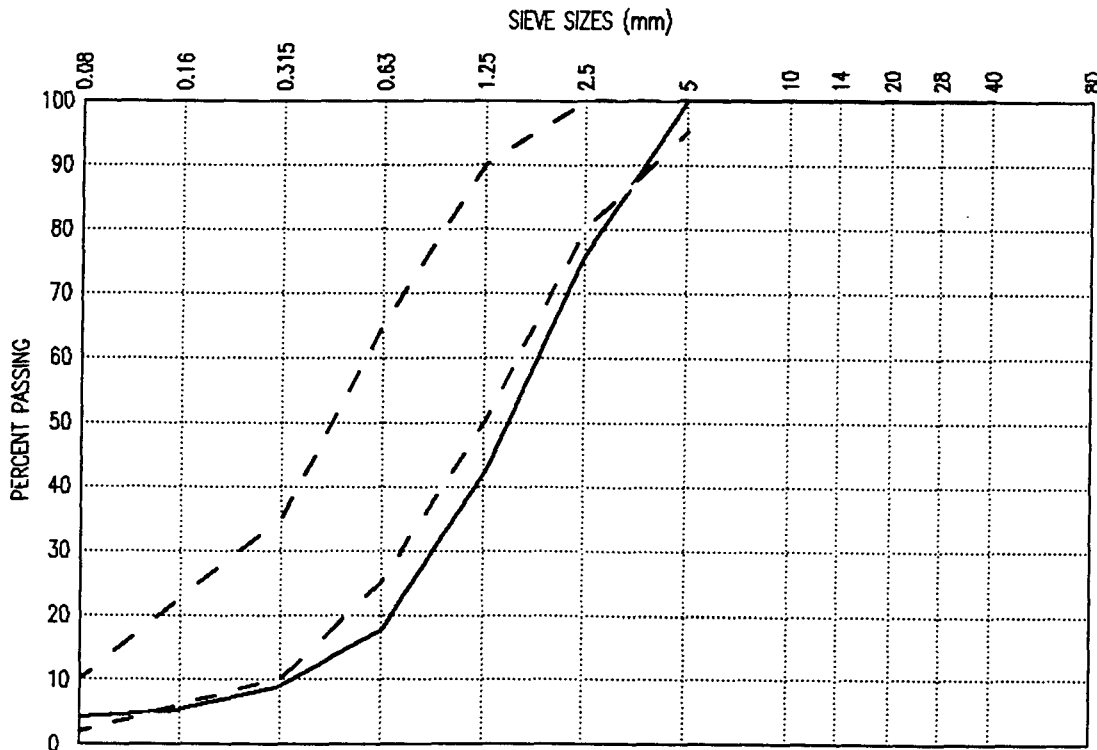
Bulk Relative Density (SSD): _____

Apparent Relative Density: _____

Absorption: _____

Remarks: Depth 1.5 - 1.6

Sieve	% Passing
40	100.0
28	100.0
20	100.0
14	100.0
10	100.0
5	100.0
2.5	75.9
1.25	42.0
0.63	17.6
0.315	8.8
0.16	5.3
0.08	4.1
F.M.	3.50



Reviewed By: Michael J. Smith

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AGGREGATE ANALYSIS REPORT (CONCRETE AGGREGATE)

Project: CARMACKS COPPER PROJECT

Sample Number: TP10-SA2

Address: WILLIAMS CREEK, YT

Sample Description: GRAVEL - sandy, trace of silt

Project Number: 0201-97-13103

Natural Moisture Content: 2.7 %

Date Tested: 97/11/05 By: JSB

Organic Content: _____

State of Alaska Method

Client: WESTERN COPPER HOLDINGS

Plate Number: _____

Organic Impurities in Sands for Concrete

Bulk Relative Density: _____

Bulk Relative Density (SSD): _____

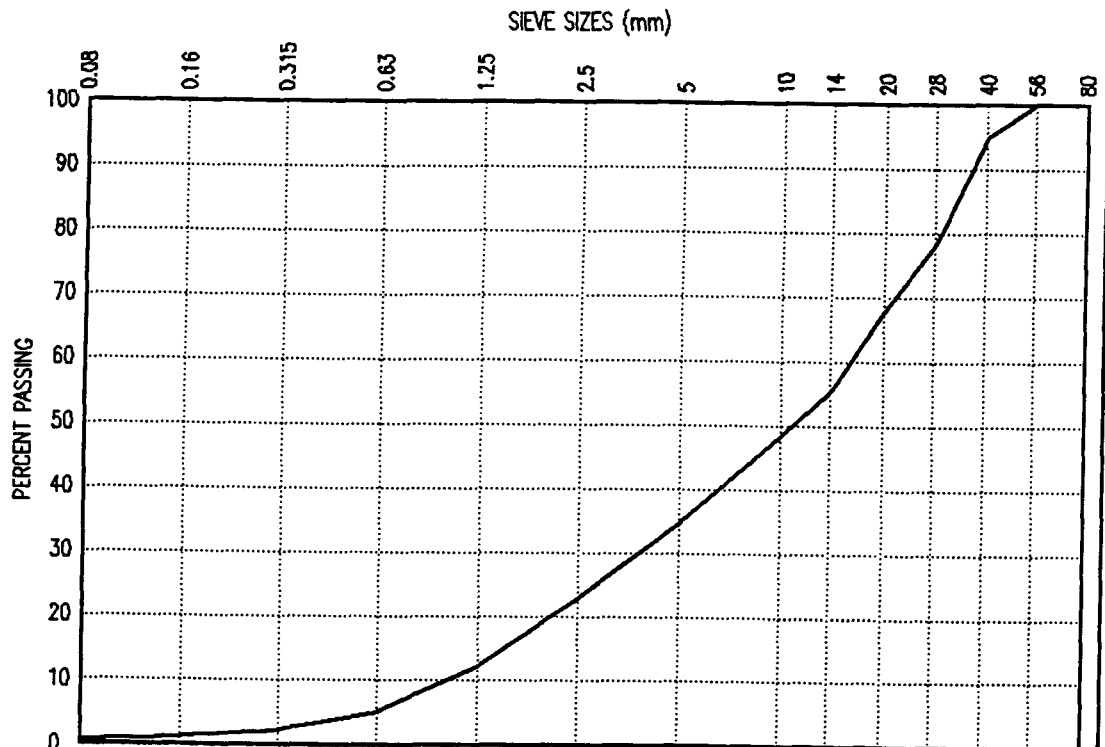
Apparent Relative Density: _____

Attention: _____

Absorption: _____

Remarks: Depth 6.4 - 6.5 m

Sieve	% Passing
56	100.0
40	94.7
28	78.1
20	67.7
14	55.2
10	48.2
5	34.5
2.5	22.7
1.25	12.2
0.63	4.9
0.315	2.2
0.16	1.2
0.08	0.8
F.M.	6.78



Reviewed By: M. J. Limble

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AGGREGATE ANALYSIS REPORT (CONCRETE AGGREGATE)

Project: CARMACKS COPPER PROJECT

Address: WILLIAMS CREEK, YT

Project Number: 0201-97-13103

Date Tested: 97/11/05 By: MCP

Client: WESTERN COPPER HOLDINGS

Attention: _____

Sample Number: TP10-SA2

Sample Description: COARSE AGGREGATE

Theoretical Split

Natural Moisture Content: _____

Organic Content: _____

State of Alaska Method

Plate Number: _____

Organic Impurities in Sands for Concrete

Bulk Relative Density: _____

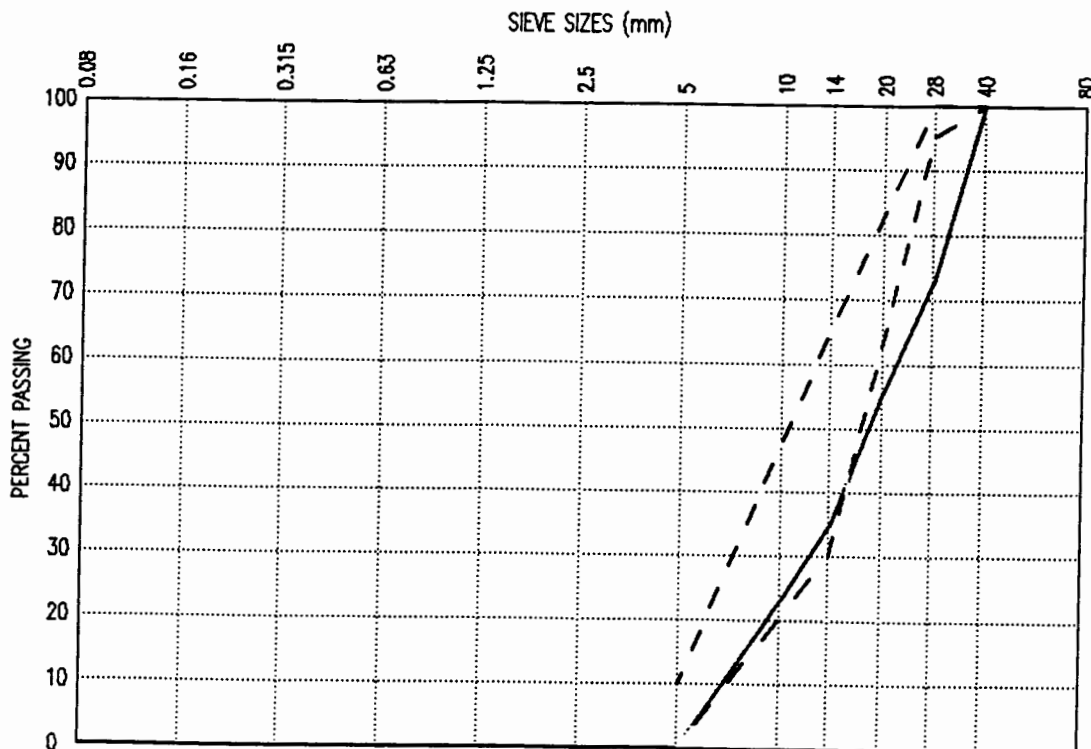
Bulk Relative Density (SSD): _____

Apparent Relative Density: _____

Absorption: _____

Remarks: Depth 6.4 - 6.5 m

Sieve	% Passing
40	100.0
28	72.3
20	55.2
14	34.3
10	22.7
5	
2.5	
1.25	
0.63	
0.315	
0.16	
0.08	
F.M.	2.15



Reviewed By: Michael Spindle

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AGGREGATE ANALYSIS REPORT (CONCRETE AGGREGATE)

Project: CARMACKS COPPER PROJECT

Address: WILLIAMS CREEK, YT

Project Number: 0201-97-13103

Date Tested: 97/11/05 By: MCP

Client: WESTERN COPPER HOLDINGS

Attention: -

Sample Number: TP10-SA2A

Sample Description: SAND

Theoretical Split

Natural Moisture Content: _____

Organic Content: _____

State of Alaska Method

Plate Number: _____

Organic Impurities in Sands for Concrete

Bulk Relative Density: _____

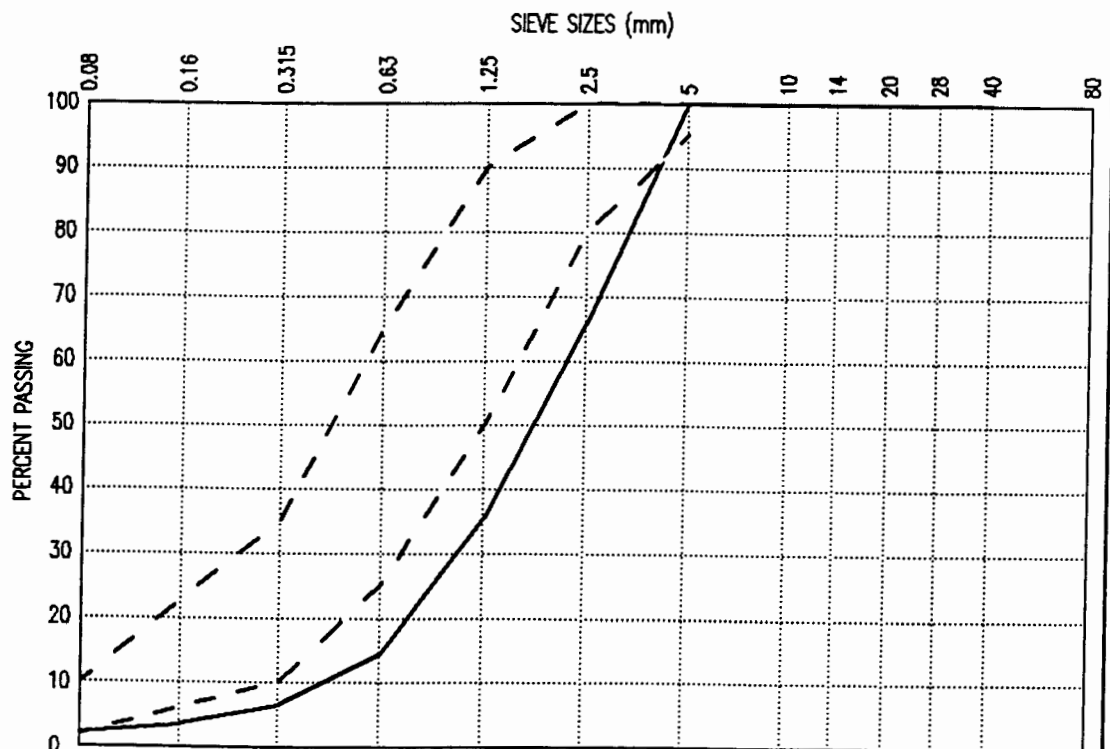
Bulk Relative Density (SSD): _____

Apparent Relative Density: _____

Absorption: _____

Remarks: Depth 6.4 - 6.5

Sieve	% Passing
40	100.0
28	100.0
20	100.0
14	100.0
10	100.0
5	100.0
2.5	65.8
1.25	35.3
0.63	14.3
0.315	6.4
0.16	3.3
0.08	2.2
F.M.	3.75



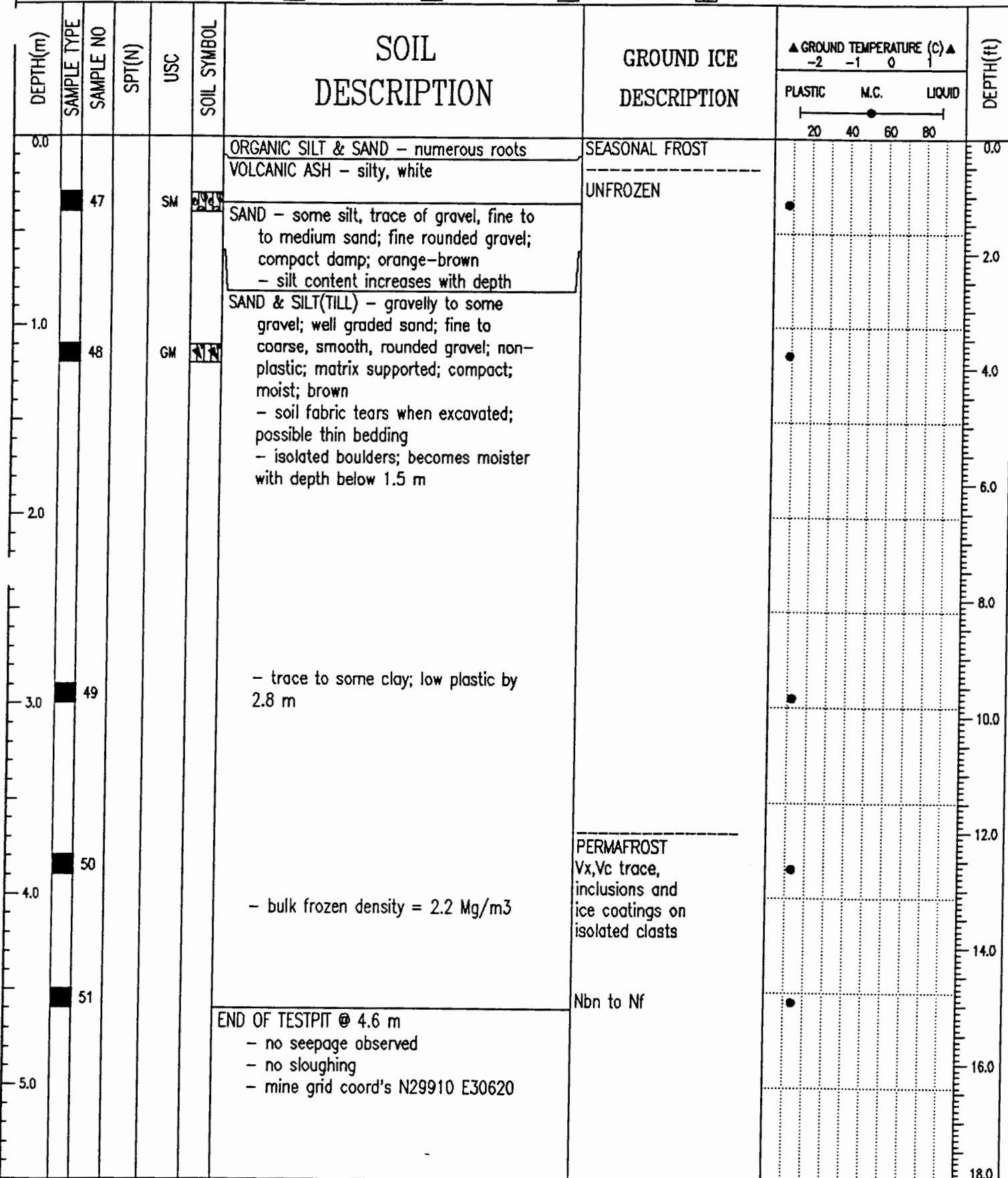
Reviewed By: M. J. J. J.

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CARMACKS COPPER PROJECT		CLIENT: WESTERN COPPER HOLDINGS LTD.	BOREHOLE NO: 13103-TP11
GEOTECHNICAL EXPLORATION-HEAP LEACH PAD		EXCAVATOR: CAT 225	PROJECT NO: 0201-97-13103
WILLIAMS CREEK, YUKON		UTM ZONE: 8 N - E -	ELEVATION: 1450 m
SAMPLE TYPE	☒ GRAB SAMPLE	☒ NO RECOVERY	☒ STANDARD PEN.
		☒ 75 mm SPOON	☐ CRREL BARREL



EBA Engineering Consultants Ltd.
Whitehorse, Yukon

LOGGED BY: CRH

REVIEWED BY: JRT

Fig. No:

COMPLETION DEPTH: 4.6 m

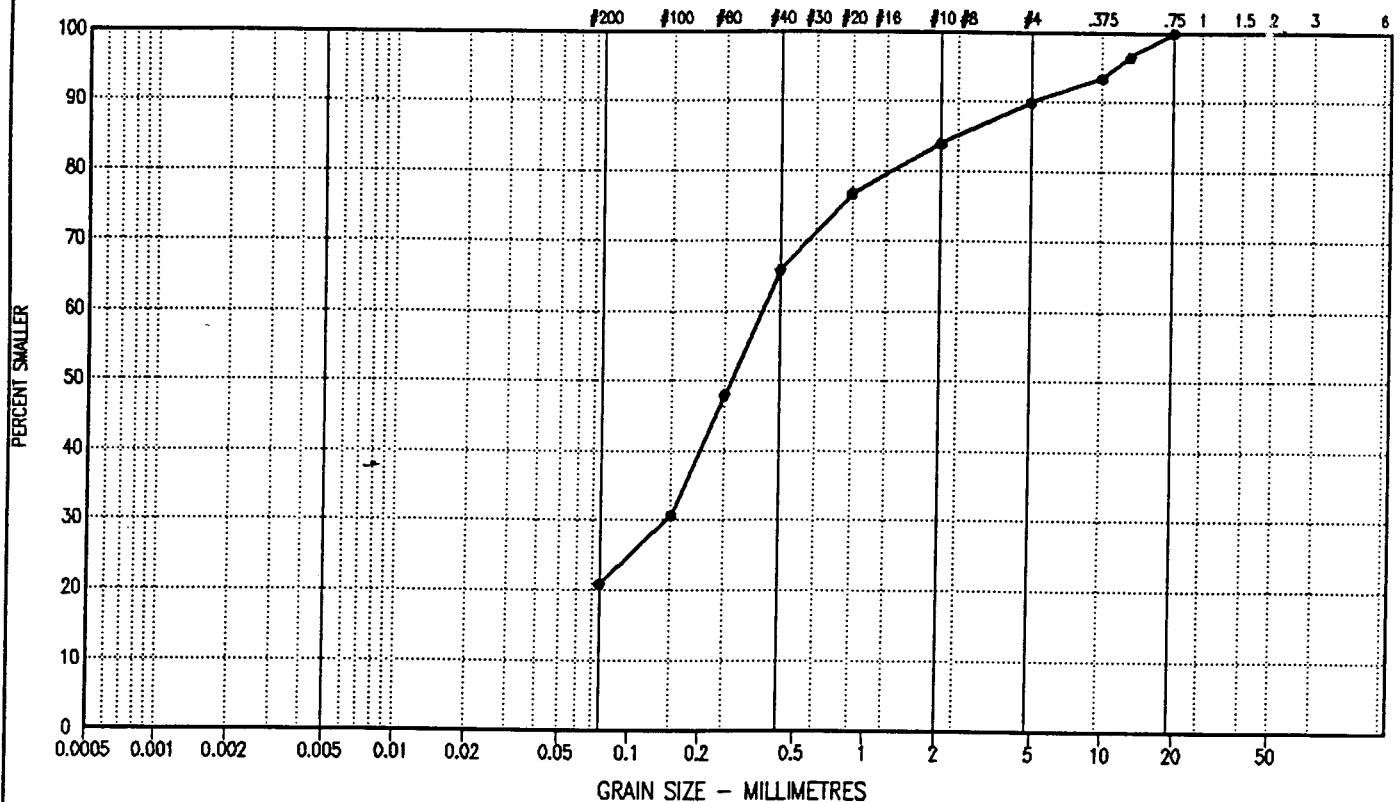
COMPLETE: 97/10/30

Page 1 of 1

PARTICLE SIZE - ANALYSIS OF SOILS

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE

U.S. STANDARD SIEVE SIZES



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
—●—	TP11	0.30 - 0.40	20.8	69.0	10.2	10.2	1.6	SM

Project: 0201-97-13103

Date Tested: 97/11/05

BY: JSB

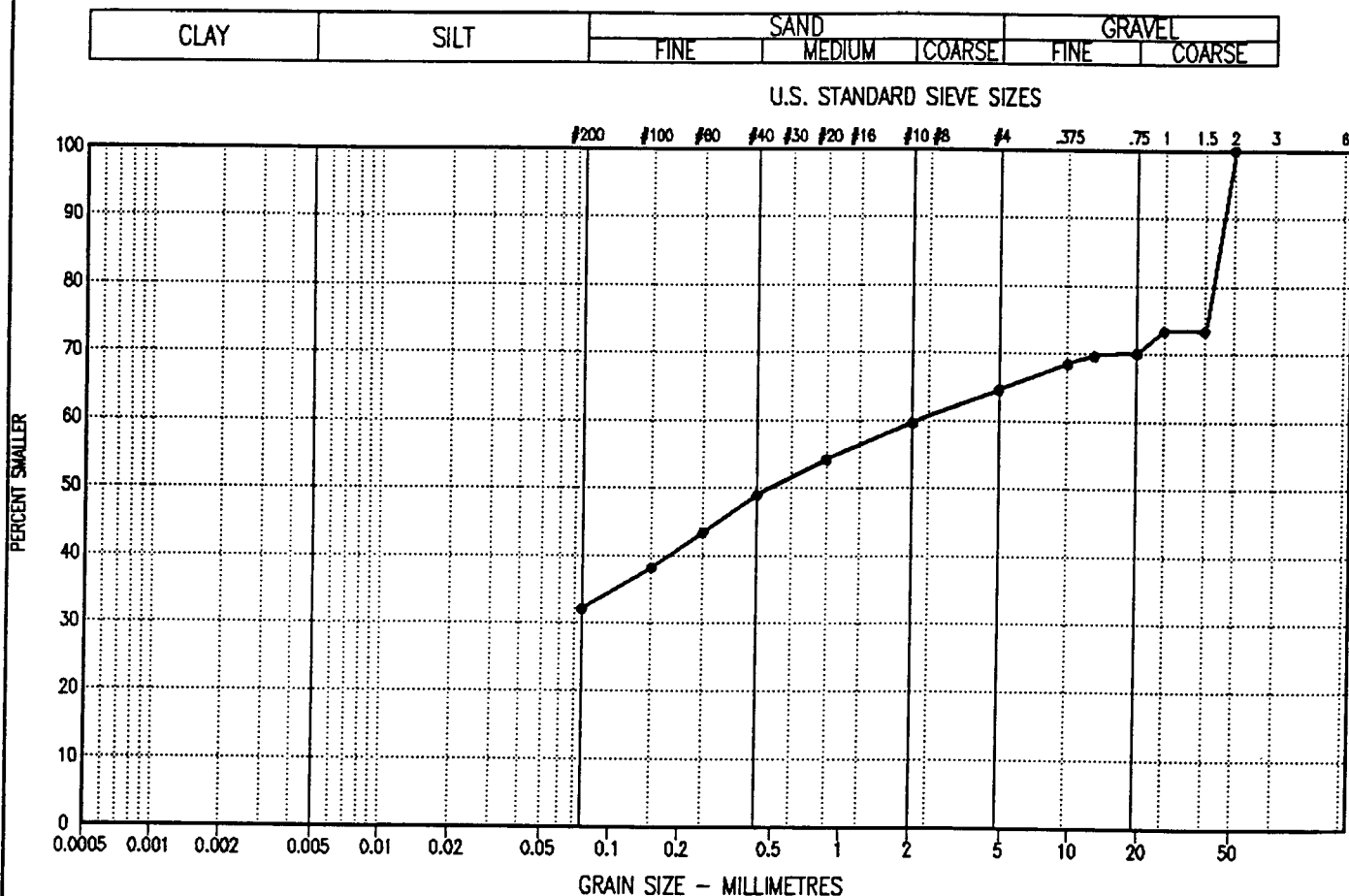
Tested in accordance with ASTM D422 unless otherwise noted.

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PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
●—●	TP11	1.10 - 1.20	32.0	32.5	35.5	95.4	0.1	GM

Project: 0201-97-13103

Date Tested: 97/11/06

BY: JSB

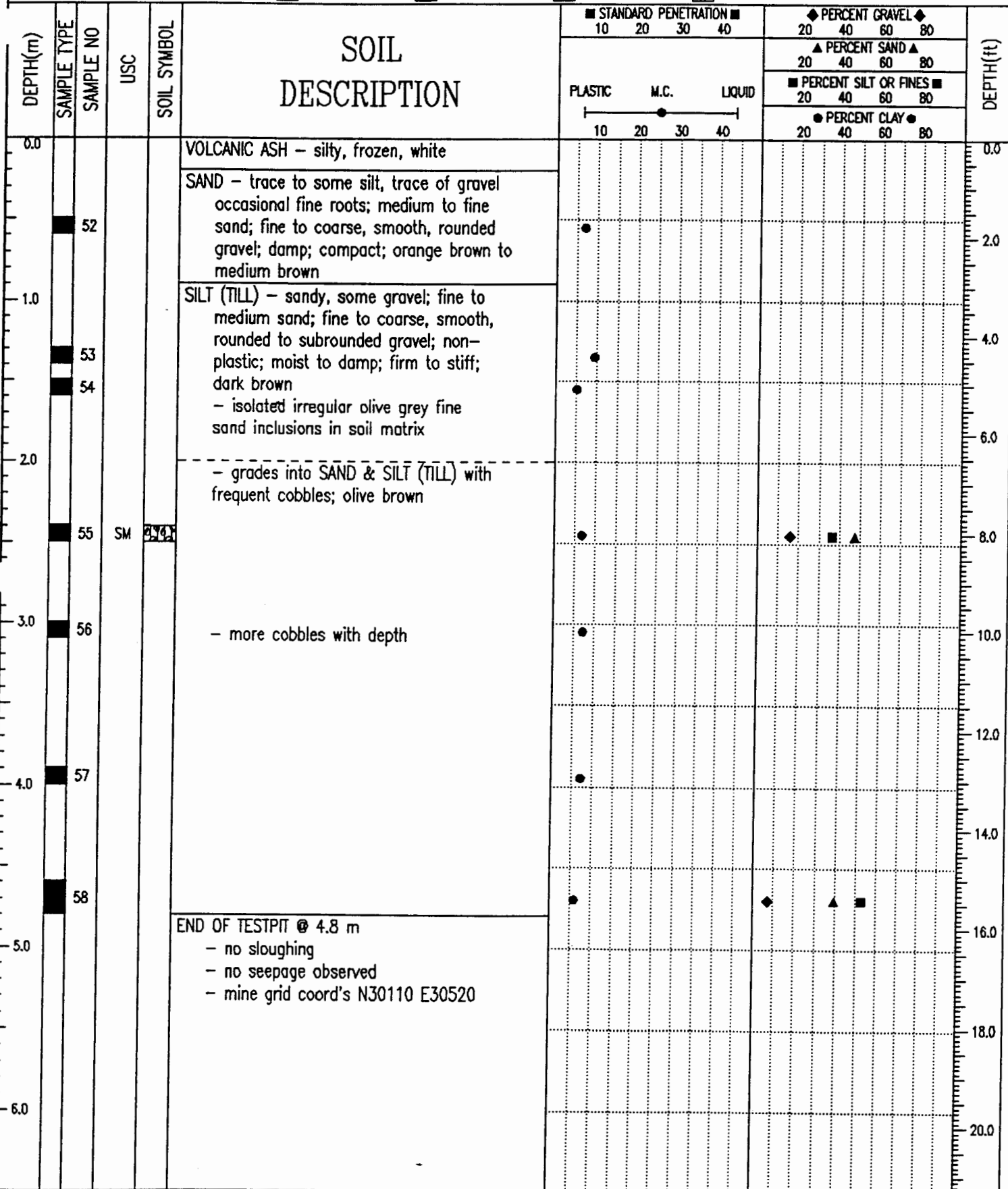
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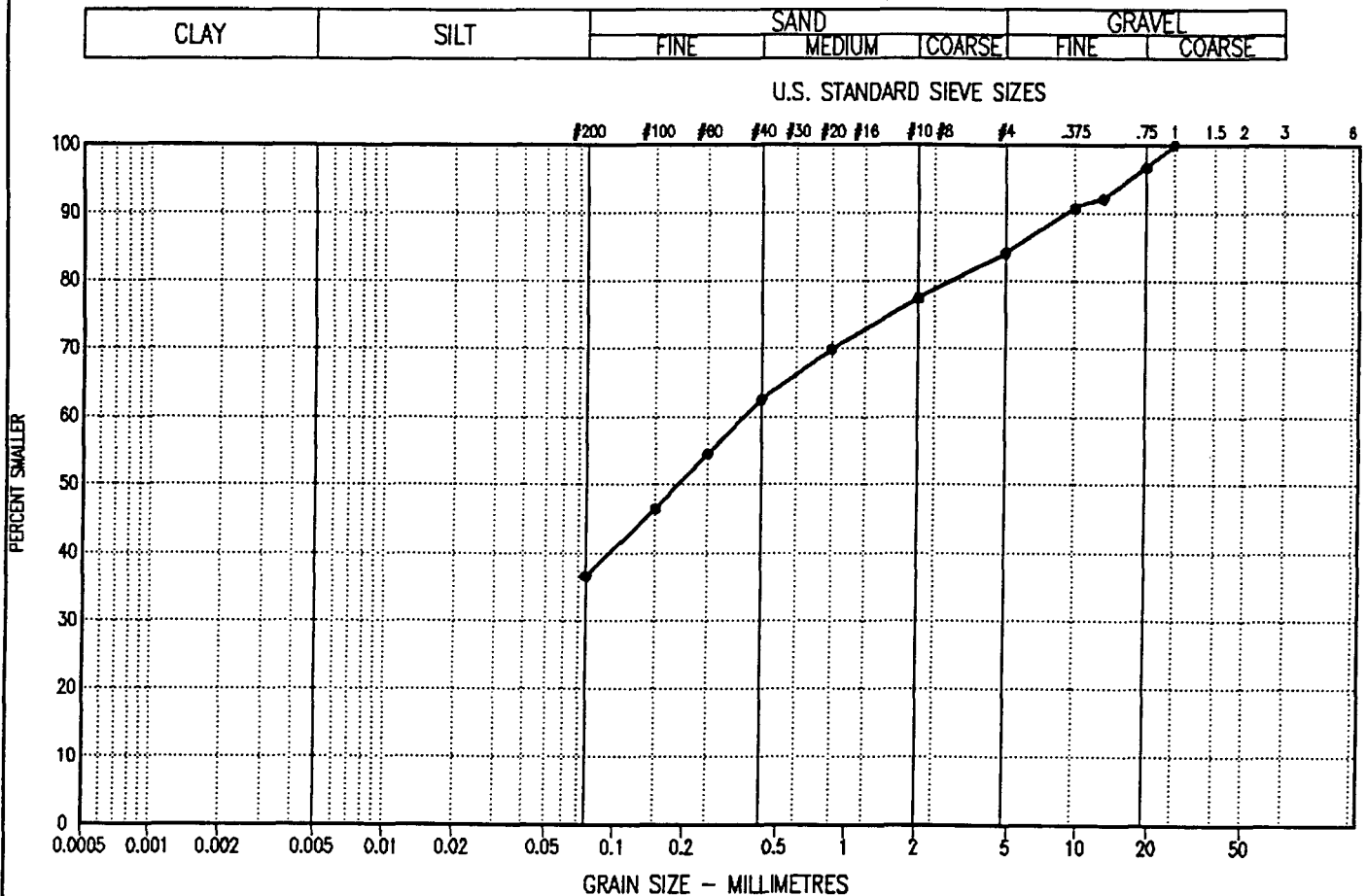
CARMACKS COPPER PROJECT		CLIENT: WESTERN COPPER HOLDINGS Ltd.	TEST PIT NO: 13103-TP12
GEOTECHNICAL EXPLORATION-HEAP LEACH PAD		EXCAVATOR: CAT 225	PROJECT NO: 0201-97-13103
WILLIAMS CREEK, YUKON		UTM ZONE: 8 N - E -	ELEVATION: 1511 m
SAMPLE TYPE	☒ GRAB SAMPLE	☐ NO RECOVERY	☒ STANDARD PEN.
		☐ 75 mm SPOON	☐ CRREL BARREL



EBA Engineering Consultants Ltd.
Whitehorse, Yukon

LOGGED BY: CRH	COMPLETION DEPTH: 4.8 m
REVIEWED BY: JRT	COMPLETE: 97/10/30
Fig. No:	Page 1 of 1

PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
●—●	TP12	2.40 - 2.50	36.6	47.4	16.0	18.0	0.5	SM

Project: 0201-97-13103

Date Tested: 97/11/06

BY: JSB

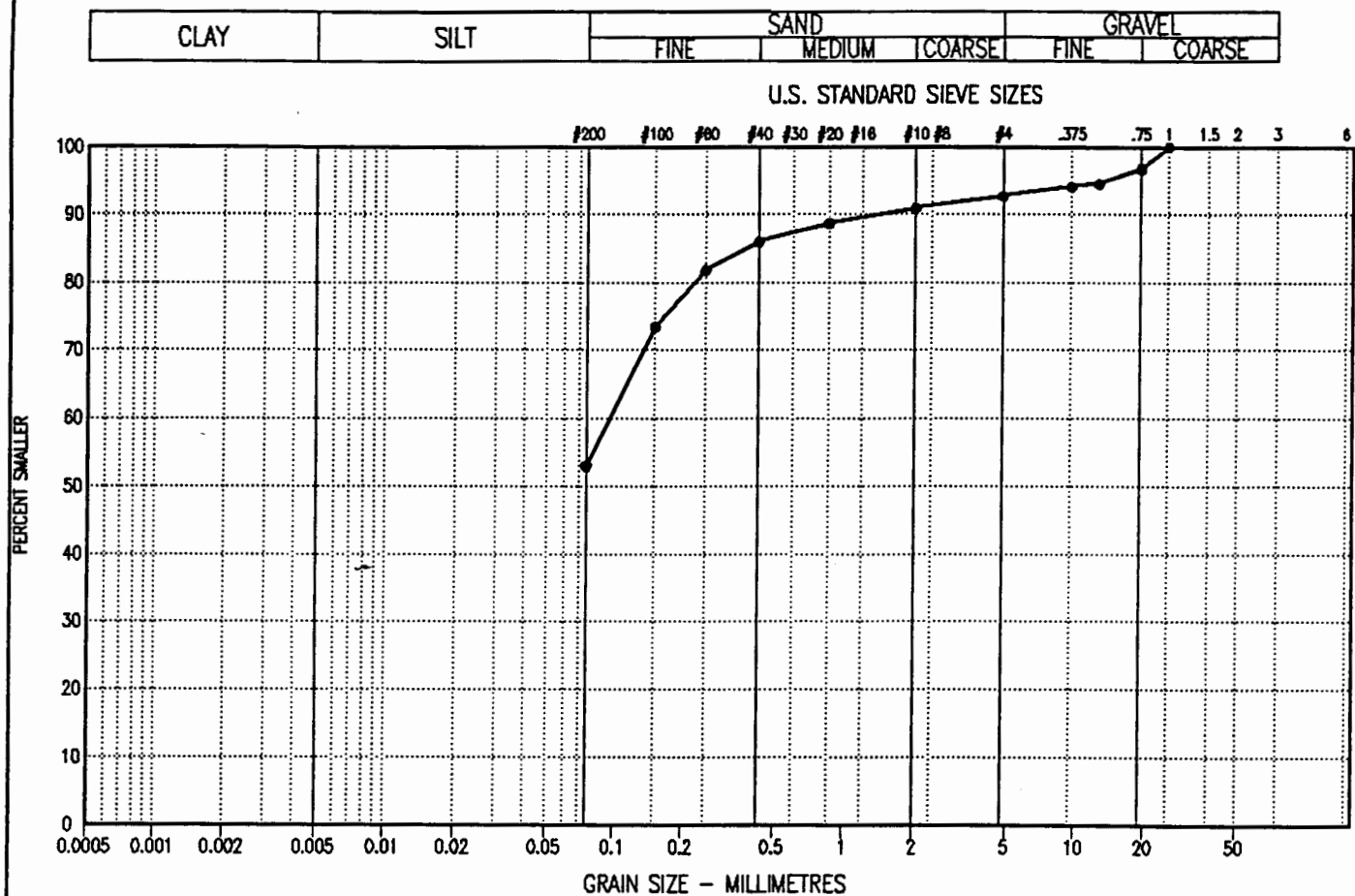
Tested in accordance with ASTM D422 unless otherwise noted.

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PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
—●—	TP12	4.60 - 4.80	52.9	39.7	7.4	7.1	1.3	

Project: 0201-97-13103

Date Tested: 97/11/06

BY: JSB

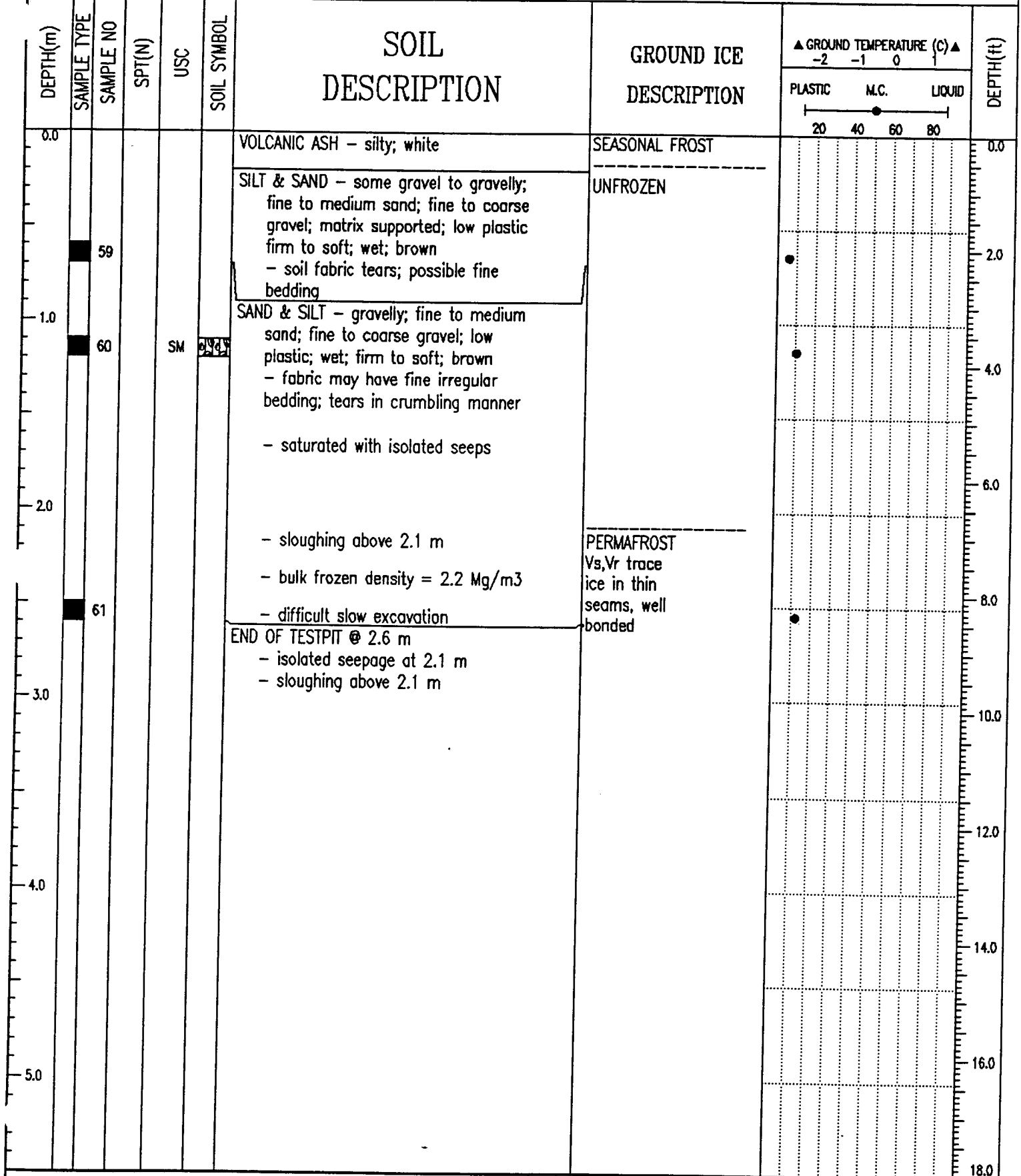
Tested in accordance with ASTM D422 unless otherwise noted.

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CARMACKS COPPER PROJECT		CLIENT: WESTERN COPPER HOLDINGS L.D.	BOREHOLE NO: 13103-TP13
GEOTECHNICAL EXPLORATION-HEAP LEACH PAD		EXCAVATOR: CAT 225	PROJECT NO: 0201-97-13103
WILLIAMS CREEK, YUKON		UTM ZONE: 8 N - E -	ELEVATION: 1519 m
SAMPLE TYPE	☒ GRAB SAMPLE	☒ NO RECOVERY	☒ STANDARD PEN.
		☐ 75 mm SPOON	☐ CRREL BARREL

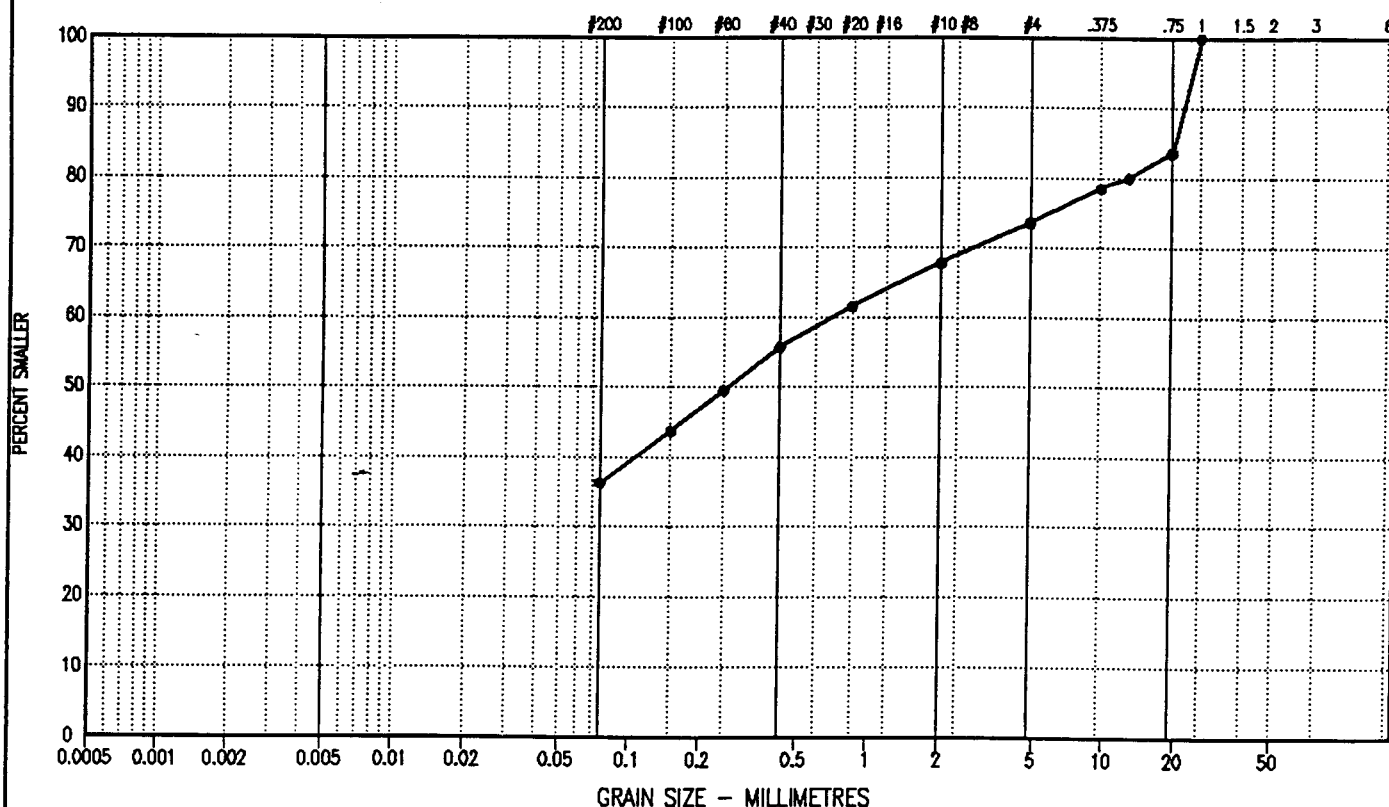


EBA Engineering Consultants Ltd.		LOGGED BY: CRH	COMPLETION DEPTH: 2.6 m
Whitehorse, Yukon		REVIEWED BY: JRT	COMPLETE: 97/10/30
		Fig. No:	Page 1 of 1

PARTICLE SIZE - ANALYSIS OF SOILS

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE

U.S. STANDARD SIEVE SIZES



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
—●—	TP13	1.10 - 1.30	36.2	37.3	26.5	35.7	0.3	SM

Project: 0201-97-13103

Date Tested: 97/11/06

BY: JSB

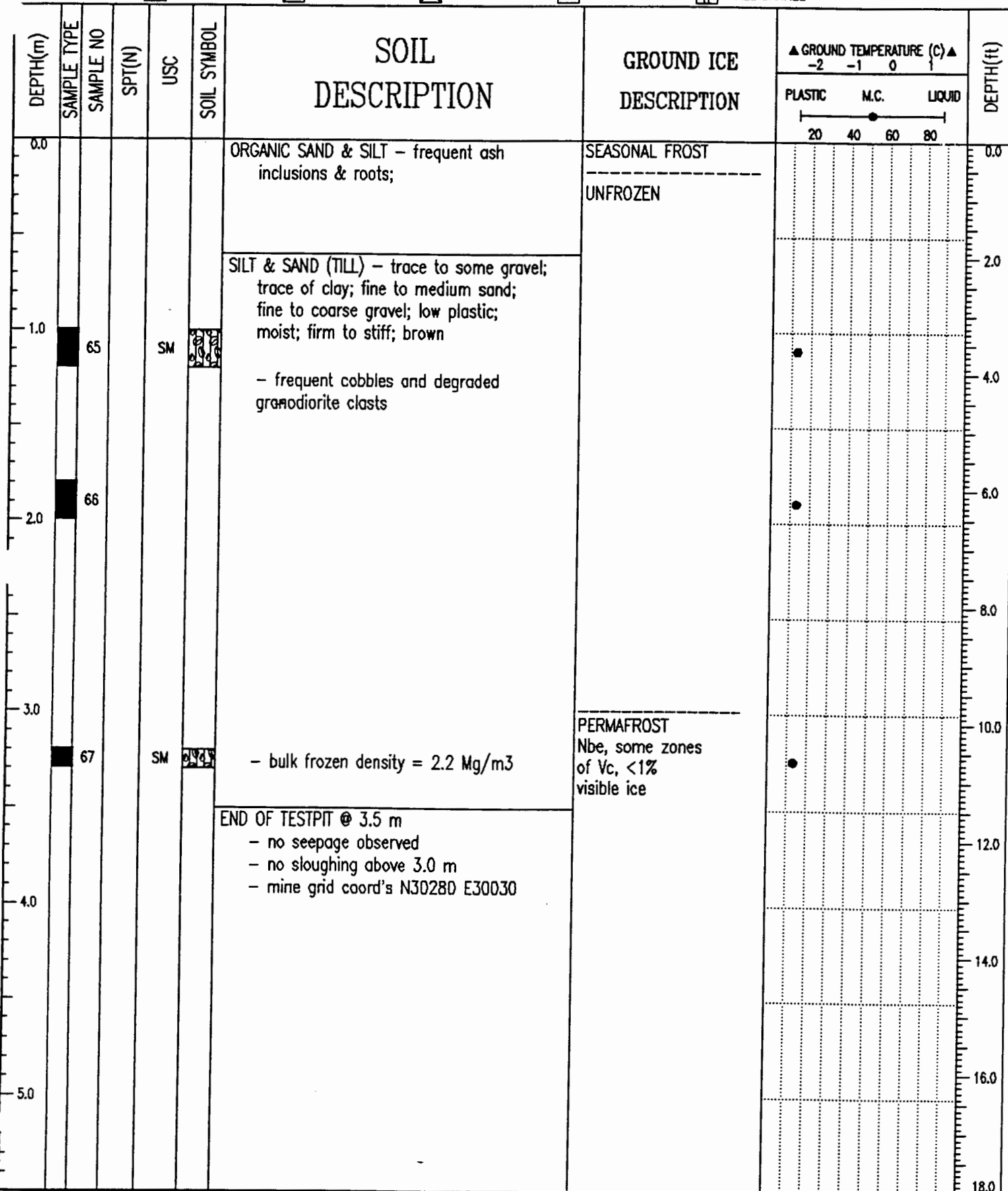
Tested in accordance with ASTM D422 unless otherwise noted.

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The testing services reported herein have been performed by an EBA technician to recognized industry standards, unless otherwise noted. No other warranty is made. These data do not include or represent any interpretation or opinion of specification compliance or material suitability. Should engineering interpretation be required, EBA will provide it upon written request.



CARMACKS COPPER PROJECT		CLIENT: WESTERN COPPER HOLDINGS LTD.	BOREHOLE NO: 13103-TP15
GEOTECHNICAL EXPLORATION-HEAP LEACH PAD		EXCAVATOR: CAT 225	PROJECT NO: 0201-97-13103
WILLIAMS CREEK, YUKON		UTM ZONE: 8 N - E -	ELEVATION: 1610 m
SAMPLE TYPE	☒ GRAB SAMPLE ☐ NO RECOVERY ☒ STANDARD PEN. ☐ 75 mm SPOON ☐ CRREL BARREL		



EBA Engineering Consultants Ltd.
Whitehorse, Yukon

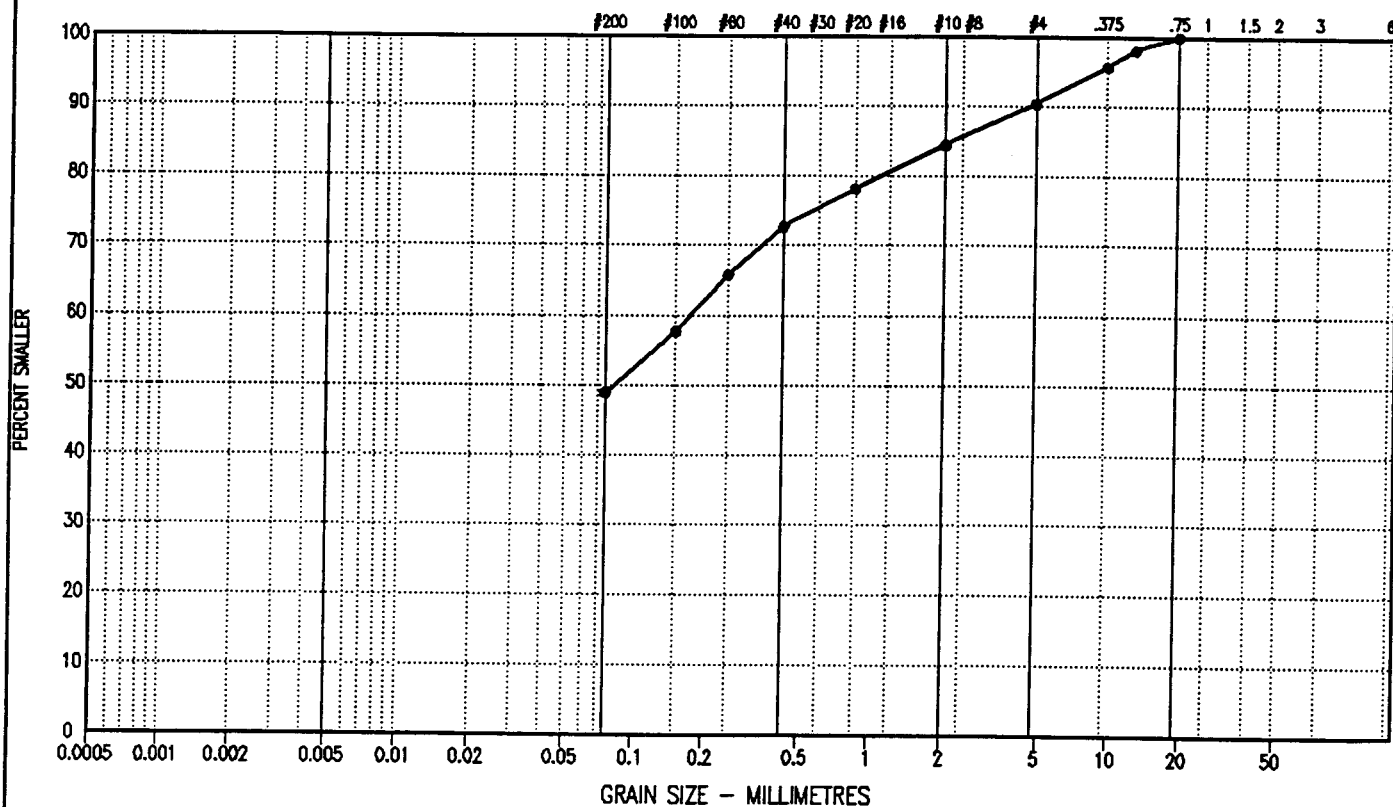
LOGGED BY: CRH
REVIEWED BY: JRT
Fig. No:

COMPLETION DEPTH: 3.5 m
COMPLETE: 97/10/30

PARTICLE SIZE - ANALYSIS OF SOILS

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE

U.S. STANDARD SIEVE SIZES



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
●—●	TP15	1.00 - 1.10	48.9	41.4	9.7	11.6	0.8	SM

Project: 0201-97-13103

Date Tested: 97/11/06

BY: JSB

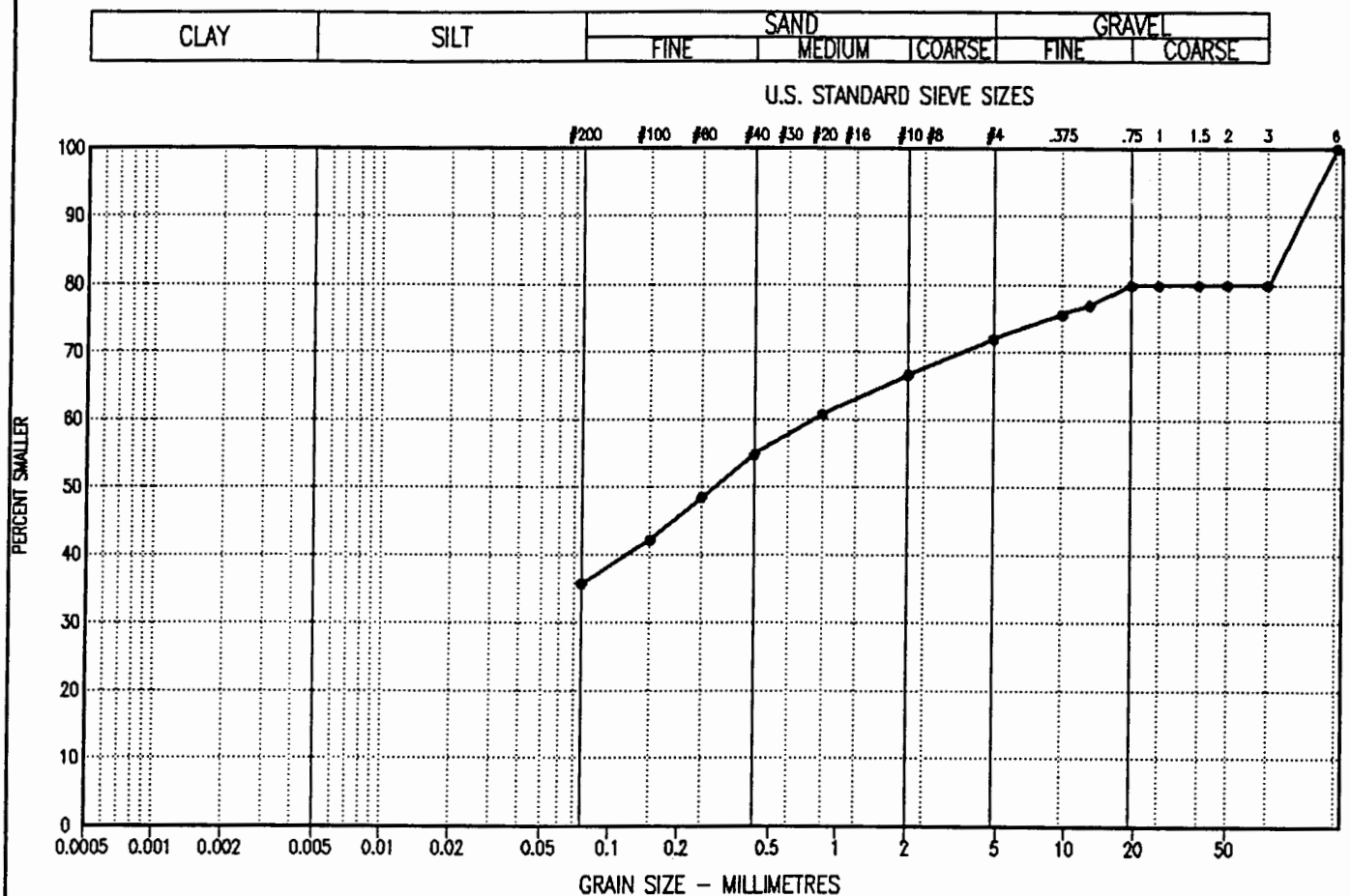
Tested in accordance with ASTM D422 unless otherwise noted.

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PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
—	13103-TP15	3.20 - 3.30	35.7	36.2	28.1	38.1	0.2	SM

Project: 0201-97-13103

Date Tested: 97/11/10

BY: JSB

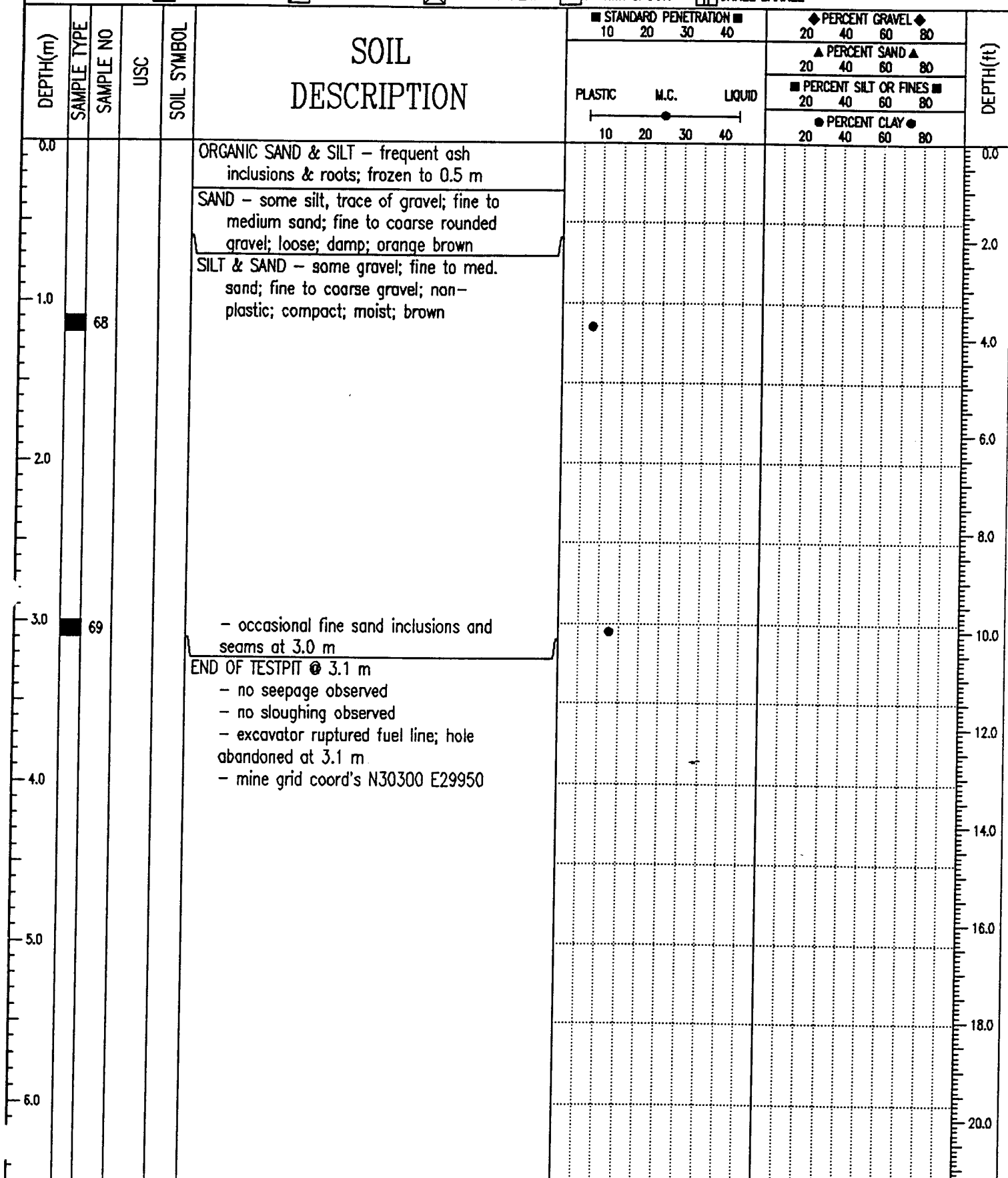
Tested in accordance with ASTM D422 unless otherwise noted.

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SAMPLE TYPE	☒ GRAB SAMPLE	☐ NO RECOVERY	☒ STANDARD PEN.	☐ 75 mm SPOON	☐ CORREL BARREL



EBA Engineering Consultants Ltd.
Whitehorse, Yukon

LOGGED BY: CRH	COMPLETION DEPTH: 3.1 m
REVIEWED BY: JRT	COMPLETE: 97/10/30
Fig. No:	Page 1 of 1



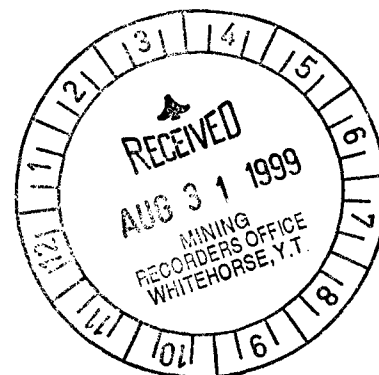
**WESTERN COPPER
HOLDINGS LIMITED**

1650 - 1185 West Georgia St.
Vancouver, B.C.
Canada V6E 4E6

Telephone: (604) 684-9497
Facsimile: (604) 688-4670

December 4, 1998

Department of Indian Affairs and Northern Development
Environment Directorate
Room 345 - 300 Main Street
Whitehorse, YT
Y1A 2B5



Attention: Kevin McDonnell, Project Manager

Dear Mr. McDonnell:

**Re: Western Copper Holdings Limited - Carmacks Copper Project – Heap Leach
Facility Water Balance – Design Memorandum CCL-CC4**

Please find attached, Western Copper Holdings Limited draft Design Memorandum CCL-CC4 on the Heap Leach Facility Water Balance, dated December 4, 1998. This report was prepared by Clearwater Consultants Ltd. and is intended for review by the RERC Technical Sub Group Committee.

This is a new water balance for the project based on a run-of-mine (ROM) ore. The project design is consistent with the Design Criteria and Parameters Report recently submitted to DIAND. The report presents our proposed design criteria for solution storage as well as detailed modelling and calculations to support the water balance. Hydrological input parameters used in the report are based on previous submissions prepared by Clearwater Consultants Ltd. (Design Memorandum CCL-CC2 and CCL-CC2A). We have discussed these submissions with the RERC Technical Sub Group and have assumed that the hydrological input parameters were agreed upon.

This document should be reviewed by DIAND and the RERC Technical Sub Group to ensure concurrence on our approach and design criteria prior to final submission in the IEE Addendum #4 report. We understand that there may be some initial concern by DIAND with our stated design criteria for solution storage for the heap leach facility and we are prepared to discuss this with RERC.

Once the RERC Technical Sub Group Committee has reviewed the report, we are prepared to meet with the committee to discuss the water balance and solution storage design criteria and address specific questions. Should you have any questions, please call me at (604) 684-9497 or Dan Cornett at (867) 668-6463 to arrange a suitable meeting schedule for the Technical Sub Group committee.

Sincerely,

WESTERN COPPER HOLDINGS LIMITED



F. Dale Corman, P. Eng.

Chairman & Chief Executive Officer

Cc Lee Bilheimer, Western Copper

Tony Wachmann, Kilborn

Peter McCreath, Clearwater

Dan Cornett, Access Mining Consultants Ltd

Committee Members:

Hugh Copland, DIAND

Bill Slater, DIAND

Benoit Godin, Environment Canada

Fritz Mueller, DIAND

Kevin McDonnell, DIAND

Attachment (1)

Design Memorandum CCL-CC4

Date: December 4, 1998 **Our File:** 044.02
To: Western Copper Holdings Limited - Dale Corman
c/c: Lee Bilheimer
Access Mining Consultants Ltd. – Dan Cornett
From: Clearwater Consultants Ltd. - Peter S. McCreath
Subject: Carmacks Copper Project - Heap Leach Facility Water Balance

Design Memorandum CCL-CC4

1. Introduction

The report "Updated Detailed Design of the Heap Leach Pad and Events Pond" (prepared for Western Copper Holdings Ltd. by Knight Piesold Ltd., reference 1785/1, April 23, 1997) presented an evaluation of the Carmacks Copper Project heap leach facility water balance. The report included a description of the water balance model used and the results of the model in terms of the requirements for solution storage and make-up water demands. The report recommended a total Events Pond storage volume of 160,000 m³ to meet the solution storage design criteria. Reviews of the report carried out by the RERC and their consultants identified concerns with regard to the water balance modeling methodology and the derivation of the total design solution storage volume.

This Design Memorandum CCL-CC4 prepared by Clearwater Consultants Ltd. describes a new water balance model and summarizes the most recent water balance analyses carried out for the Carmacks Copper Project. The study has been carried out in accordance with the Consultant Contract between Western Copper Holdings Ltd. and Clearwater Consultants Ltd. dated January 29, 1998.

The basis for this report is Design Memorandum CCL-CC2, "Site Hydrology Revisions" dated March 12, 1998 and Design Memorandum CCL-CC2A "Revisions to Site Hydrology, Response to RERC" dated April 23, 1998. It is understood that the RERC concurs with the design hydrological parameters presented therein. The analyses and results presented herein have focused on the primary areas of concern identified during the RERC review process: the water balance modeling methodology, input parameters, calculation of drawdown volumes, and, total design solution storage volume. As discussed in the Sitka Corp. report "Design Criteria and Parameters Report", Western Copper plan to use run-of-mine ore (ROM ore) for the heap and all water balance results presented herein are for ROM ore.

2. Leach Pad Water Balance Model

2.1. General Description

The water balance for the heap leach facility at the Carmacks Copper project Williams Creek site was modeled using a spreadsheet analysis developed in Microsoft Excel. The analysis used monthly time steps to allow a continuous simulation of the water balance over the eight year

mine operating life plus a period of five years (two years residual leaching plus three years heap rinsing) after the completion of ore placement. The model includes user-defined water inputs for the leaching process and for the site hydrology (precipitation, rainfall, snowfall and evaporation). The spreadsheet workbook file CC_WB10.XLS is made up of linked worksheets entitled "Input&Output", "Summary", "Graphs", "Annual", and "Storage", respectively. Copies of the worksheets are contained in the Appendices. Descriptions of the input data and assumptions and the modeling methodology are presented following.

The hydrology of the leach pad area at an assumed nominal elevation of 850 m was presented in the Clearwater Consultants Ltd. design memoranda CCL-CC2 (March 12, 1998) and CCL-CC2A (April 23, 1998).

2.2. Input Data and Assumptions

Process-related input data for the water balance analysis have been based on data provided by Kilborn Engineering Pacific Ltd. All input data are presented on page 1 of worksheet "Input&Output" (Table I.2 in Appendix I). The key process-related input data and assumptions are summarized following:

- ore will be placed for leaching at a maximum rate of 9 872 tonnes per day (tpd) over an eight year period. A total of 13.3 million tonnes of ore will be placed in the heap;
- ore placement will commence in May of Year 1 and will be completed by June of Year 8;
- ore will be placed from mid-May to the end of November each year. The model assumes a maximum of 200 days per year of ore placement;
- ore will be placed in nominal 8 m lifts and will have a dry density of 1.6 t/m³;
- based on heap layouts prepared by Kilborn, the number of complete lifts of ore under leach was estimated to increase from about three during the first year to eight in Year 8;
- the maximum total area under leach at any time will be 47,400 m²;
- barren leaching solution will be applied to the heap using drip emitters at a total flow rate of 540 m³/hour. Pregnant leach solution (PLS) will flow by gravity from the heap to the plant. The maximum total solution flow from the heap to the plant will be equal to the maximum flow of barren solution;
- excess solution and runoff water will be stored as required in the Events Pond only. No active solution storage will be available in the in-heap area;
- the area of the leach pad will increase in stages over the eight years of ore placement as shown on Table 1. Subsequent stages of activity are also shown on the table. Assumptions shown below related to the timing and duration of operational stages after the completion of ore placement have been made herein for the purposes of this water balance evaluation. These stages will be subject to change as the closure plan is developed and, at this time, should not be construed as formal commitments by WCHL;

Table 1 - Stages of Development

Stage	Years	Tonnes Placed	Leach Pad Area (m ²)
I	1	1 963 500	142 000
II	2 and 3	3 947 625	219 000
III	4 to 8	7 366 744	315 000
IV	8 and 9	0	315 000
V	10, 11, 12	0	315 000
VI	13 onwards	0	315 000

- leach solution application and copper recovery will continue for two years after all ore has been placed. Stage IV thus corresponds to the most of Year 8 and all of Year 9;
- heap rinsing (Stage V) will be carried out after all leaching and copper recovery has been completed. The model assumes that this stage will be completed over a three year period, Years 10 to 12. During this stage the heap draindown inventory would be progressively released from the system. A soil cover will be placed on the heap to reduce infiltration. Specific requirements for the soil cover will be developed and reviewed as part of the closure plan development. At this time the water balance model does not include installation of a soil cover after completion of ore placement;
- Stage VI applies to Year 13 onwards and corresponds to the decommissioned condition. A water treatment plant and measures to collect and treat runoff and seepage will remain in place if required after decommissioning;
- each "year" in the model is from April 1 to March 31;
- ROM ore moisture contents were estimated by Beattie Consulting Ltd. based on large diameter column leach tests. All moisture contents shown in Table 2 are expressed as a percent by weight of the weight of ore.

Table 2 – ROM Ore Moisture Contents

Condition	Moisture Content
Initial Moisture Content (assumed)	3.0 %
Leaching Moisture Content	12.0 %
Residual Moisture Content	10.0 %
Potential Draindown (Leaching <i>minus</i> Residual)	2.0 %

Hydrological data and assumptions used in the model include the following:

- monthly depths of average site rainfall, snowfall, snowmelt and evaporation were presented in the Clearwater Consultants Ltd. Design Memoranda CCL-CC2 and CCL-CC2A and are shown on Table I.2 in Appendix I;
- different return periods for annual precipitation may be specified in the model for each individual year of operation. Annual precipitation may range from a 20 year return period dry year up to a 100 year return period wet year. The base case for the water

balance assumes average conditions (assumed equivalent to a two year return period) of monthly precipitation for every year of operation;

- snowmelt is conservatively assumed to occur in a one month period during either April or May each year. There is no provision in the present water balance model for the potential removal of snow from the heap prior to snowmelt;
- evaporation coefficients may be specified for the area under active leaching, for the heap and overliner area, and for other areas draining to the Events Pond. The coefficients are applied to the average monthly lake evaporation to estimate monthly evaporative losses from areas not covered with ponded water;
- allowable maximum, minimum and initial (Year 1) solution storage volumes must be specified in the model input for the in-heap area and for the Events Pond. These volume limitations apply over the complete simulation period. The base case model assumes no active storage of solution within the in-heap area and a maximum and minimum nominal in-heap storage volume of 500 m³. The Events Pond was also assumed to have a nominal minimum operating volume of 500 m³. Recommended maximum Events Pond storage capacities are presented in Section 4.4.

The results of the water balance analyses are discussed in Sections 3 and 4 and complete output from the model is presented in Appendices I, II and III.

2.3. Modeling Methodology and Base Case Settings

Appendix I contains output from the "Input&Output" worksheet as Tables I.2 to I.4. Table I.2 summarizes the process and hydrological input data and assumptions as discussed above. Table I.3 (pages 2 to 5) includes a summary of the basic input data and a series of columns labeled "A" to "X" for the heap leach pad monthly water balance. The calculation methodology for each column is described following:

Columns A to H present input process and hydrological parameters for each month as follows:

- Column A "Stacked Leach Ore, Stacked tonnes" - calculated for each month based on the annual tonnage of placed ore and the number of operating days for that month;
- Column B "Stacked Leach Ore, Stacked Volume" - stacked tonnes converted to cubic metres in place with an assumed dry density of 1.6 t/m³;
- Column C "Areas, Under Leach" - maximum area up to 47 400 m²;
- Column D "Areas, Total Heap and Overliner" = total heap area for that year;
- Column E "Areas, Uncovered Heap", equal to the total heap area. This column is included to allow for the possible installation of a cover over part or all of the heap at some time if needed to minimize infiltration. A soil cover will be placed on the heap during decommissioning, however, the base case setting conservatively assumes that no cover will be placed on the heap;
- Column F "Runoff Return Period" - defined in the input section for each year, may range from 20 year return period dry year up to 100 year return period wet year. The base case setting is a return period of 2 years representing average conditions;

- Column G "Runoff Depth" - calculated for each month based on prorating the monthly average runoff depth (defined in the input section as equal to rainfall plus snowmelt for each month) by the ratio of the actual annual total precipitation (for the defined return period for that year) divided by the estimated long-term average annual total precipitation;
- Column H "Evaporation Depth" - average monthly freewater evaporation depth defined in the input section.

Columns I to K calculate water inflows to the heap as follows:

- Column I "Water Inflows, Leach Pad Runoff" = monthly runoff depth *times* total leach pad area, Column G *times* Column D;
- Column J "Water Inflows, Other Inflows" = monthly volume for other possible inflows to the leach pad defined in the input. The base case setting is zero for other inflows;
- Column K "Water Inflows, Total In" = Column I *plus* Column J.

Columns L to P calculate water outflows and losses from the heap as follows:

- Column L "Evaporation Losses, Leach Area" = monthly evaporation depth *times* coefficient for area under leach irrigation *times* the area under leach, Column H *times* coefficient *times* Column C. The base case evaporation coefficient for the area under leach irrigation is 0.10 (10% of lake evaporation);
- Column M "Evaporation Losses, Heap & Overliner" = monthly evaporation depth *times* coefficient for heap and overliner area *times* (the heap and overliner area minus the area under leach), Column H *times* coefficient *times* (Column D *minus* Column C). The base case evaporation coefficient for the heap and overliner area is 0.05 (5% of lake evaporation);
- Column N "Permanent Loss to Ore Moisture" = water permanently lost in raising the moisture content of the ore from the initial run-of-pit moisture content to the residual moisture content, equal to the stacked ore tonnes in Column A *times* the moisture change (residual *minus* initial). This water loss occurs only when leaching solution is applied to newly-placed ore on the heap. The model assumes that leaching of newly-placed ore will not start each year until June 1, therefore, during May this loss is conservatively set equal to zero;
- Column O "Initial Loss to Leaching Ore" = water temporarily tied up in raising the moisture content of a new lift of ore from the residual moisture content to the leaching moisture content. Column O is equal to the tonnage of ore in one lift (leaching area of 47 400 m² *times* the lift depth of 8 m *times* the ore dry density of 1.6 t/m³) *times* the moisture change (leaching *minus* residual) *times* the number of new lifts of ore in the year (generally equal to one). This loss is also conservatively set equal to zero for May. At any time in the heap operating life, the total of all the initial losses to leaching ore up to that time represents the potential total draindown volume from the heap;
- Column P "Total Out" = sum of Columns L, M, N and O.

Columns Q to U calculate process make-up water requirements for the operation as follows:

- Column Q "Total Required" - equal to zero if the total monthly inflow (Column K) is greater than the total monthly outflow (Column P), otherwise equals Column P *minus* Column K;
- Column R "From Heap Storage" - since no active storage of solution is allowed within the in-heap area, this column is always equal to zero;
- Column S "Total Other" = Column Q *minus* Column R;
- Column T "From Events Pond" - excess runoff to and stored in the Events Pond for that month is used for make-up water if required. This column is linked to the Events Pond water balance portion of the spreadsheet (see Column AD below);
- Column U "From Fresh" = Column Q *minus* Column R *minus* Column T. This is the quantity of additional water that must be provided from an outside source of freshwater to satisfy the total make-up water requirement for that month.

Columns V to X calculate the net monthly inflow of water to the heap and the required release to the Events Pond as follows:

- Column V "Net Inflow to Heap" = total inflow *minus* total outflow *plus* make-up water from Events Pond *plus* make-up water from freshwater source, Column K *minus* Column P *plus* Column T *plus* Column U;
- Column W "Release to Events Pond" - since no active storage is allowed within the in-heap area, this column is always equal to Column V, the net inflow to the heap;
- Column X "Total In-Heap Storage" = previous month-end storage volume *plus* net inflow for the current month *minus* water released to the Events Pond in the current month, equal to previous month Column X *plus* current month (Column V *minus* Column W). This column is always equal to 500 m³ since no active storage of solution is allowed within the heap.

Table I.4 (pages 6 to 9 from worksheet "Input&Output") in Appendix I presents the monthly water balance for the Events Pond. Columns "AA" to "AL" are described following:

- Column AA "Water Inflows, from Precipitation Runoff" = monthly runoff depth (Column G) *times* Events Pond catchment area;
- Column AB "Water Inflows, from Heap Storage" - water released to the Events Pond from the in-heap storage pond, equal to Column W;
- Column AC "Water Losses to, Evaporation" - monthly lake evaporation depth (Column H) *times* pond area of the Events Pond;
- Column AD "Water Losses to, Make-up to Heap" - water stored in the Events Pond used to partially or to fully meet the total make-up water demand. This column is zero unless the monthly runoff inflow (AA) *plus* water in storage at the end of the previous month (AI) exceeds the monthly evaporation loss (AC) and additional make-up water is required (Column Q). This value is used in Column T;
- Column AE "Net Inflow" = total inflow *minus* total outflow = Column AA *plus* Column AB *minus* Column AC *minus* Column AD;

- Column AF "Potential Volume in Storage" = previous month-end volume in storage plus net inflow for the current month before any allowance for treatment or release from the Events Pond;
- Column AG "Treated Volume Released" - treatment and release of excess solution, if required, is allowed in the model anytime between May and October. Generally, water is not released from the system during the first eight years until October of each year so that maximum use may be made of water stored in the Events Pond to meet make-up water requirements during the summer months. By the end of October each year, the Events Pond volume is assumed to be drawn down to the minimum allowable operating volume to ensure maximum storage availability during the winter and prior to the following year's snowmelt;
- Column AH "Untreated Volume" - This column is equal to zero unless the previous month-end storage volume (Column AI) *plus* the current month net inflow (Column AE) *minus* the current month treat and release volume (Column AG) is greater than the maximum allowable Events Pond storage volume, in which case the surplus volume would be spilled during that month. Spillage would take place from a lined open channel spillway at the Events Pond dam and would only occur for extreme inflow events more severe than the design events (Section 4.). For all cases modeled in this study this column was always equal to zero, that is, no untreated solution was ever spilled from the Events Pond;
- Column AI "Remaining Volume in Storage" = previous month-end storage volume *plus* net inflow (AE) *minus* treated volume (AG) *minus* spilled volume (AH);
- Column AJ "Cumulative Volumes, Treated & Released" - total volume treated and released since the start of operations;
- Column AK "Cumulative Volumes, Untreated" - total untreated volume that may have been spilled since the start of operations. For the parameters used in this study adequate storage has been provided such that this column is always equal to zero;
- Column AL "Total Solution Storage" - total volume of solution in storage at the end of the present month, equal to total in-heap storage (Column X) *plus* total Events Pond storage (Column AI).

3. Water Balance Results

3.1. General

The water balance results discussed following refer to ROM ore and are presented as a series of tables and figures in Appendices I, II and III. Appendix I contains the results of the base case average precipitation conditions water balance model:

- worksheet "Summary" (Table I.1, one page);
- worksheet "Input&Output" (nine pages) with the input data and assumptions (Table I.2, page 1), the leach pad monthly water balance (Table I.3, pages 2 to 5), and the Events Pond monthly water balance (Table I.4, pages 6 to 9);

- worksheet "Graphs" (one page) with Figure I.1 (Events Pond Water Storage Variation) and Figure I.2 (Variation in Monthly Treat and Release Volumes).

Appendix II contains copies of the worksheet "Summary" for dry years (Table II.1, 20 year return period) and for wet years (Table II.2, 100 year return period). Table II.3 presents worksheet "Annual", a comparison of the three hydrologic conditions on an annual basis.

Tables 3 and 4 summarize and compare annual make-up water volumes and treat and release volumes, respectively, for each stage of heap development.

3.2. Make-Up Water Requirements

The results on Table 3 and in Appendix I show that, for average and 20 year return period dry year conditions of annual precipitation, the heap will be in a water deficit position until the end of Year 7. For 100 year return period wet years the heap will be in a water deficit position until the end of Year 3. No make-up water will be required after Year 8.

Table 3 - Annual Make-Up Water Requirements (m³ per year)

Condition	Stage I	Stage II	Stage III (Years 4 to 7)	Stages IV to VI
Average	123 000	69 000	9 000 to 29 000 (2)	0
Dry Years	139 000	93 000	42 000 to 61 000	0
Wet Years	94 000	27 000	0	0

Notes for Table 3

- 1) Volumes shown represent average values for the indicated stage of operations rounded up to the nearest 1000 m³. Year-to-year values will vary as shown in the Appendices.
- 2) Stage III make-up water demands will depend on the number of lifts of ore under leach. Table shows the estimated ranges for Years 4 to 7.

3.3. Treat and Release Requirements

As shown on Table 4 for all precipitation conditions, the system will not require the treatment and release of any excess water during the first three years of ore placement. Average and drier conditions will not require any releases until after Year 7. Some excess water may require treatment and release during Years 4 to 7 as a result of 100 year wet years.

Table 4 - Annual Treat and Release Volumes (m³ per year)

Condition	Stages I & II (Years 1 to 3)	Stage III (Years 4 to 7)	Stage IV (Years 8 & 9)	Stage V (Note 2)	Stage VI
Average	0	0	91 000 to 112 000	145 000	113 000
Dry Years	0	0	58 000 to 79 000	113 000	80 000
Wet Years	0	29 000 to 49 000	149 000 to 170 000	203 000	171 000

Notes for Table 4

- 1) Volumes shown represent average values for the indicated stage of operations rounded up to the nearest 1000 m³. Year-to-year values will vary as shown in the Appendices.
- 2) Stage V includes the controlled treatment and release of the draindown inventory.

After all ore has been placed but while leaching is still on-going in Stage IV, 91 000 to 112 000 m³ per year of excess water may have to be treated and released during average conditions since moisture will no longer be lost to wetting of new ore. During the heap rinsing phase (Stage V, Years 10 to 12), it has been assumed that pumping and recirculation rates will be progressively decreased such that drawdown of the heap would be accomplished in a controlled manner over a three year period. About 145 000 m³ per year will require treatment during this stage for average conditions. This volume would decrease significantly after placement of a soil cover on the heap. Volumes for Stage VI are shown in the table to provide an indication of the annual volumes of water expected to report to Williams Creek after heap rinsing has been completed.

Actual monthly treatment and release volumes will be optimized during operations so as to satisfy water quality criteria in the downstream receiving environment. Actual year-to-year treatment volumes will vary depending on the number of lifts of ore under leach, actual ore moisture conditions, and the actual magnitude of monthly and annual precipitation.

3.4. Normal Maximum Solution Storage Volumes

Table 5 summarizes normal maximum solution storage volumes, which would occur each year for average, 20 year dry year and 100 year wet year precipitation conditions. The volumes result from hydrological inflows only with no allowance for any additional process-related inflows.

Table 5 - Normal Maximum Solution Storage Volumes (m³)

	Stage I	Stage II	Stage III	Stage IV	Stage V
Average Precipitation					
In-Heap	500	500	500	500	500
Events Pond	28 000	42 000	58 500	58 500	500
Total Storage (Note 1)	28 500	42 500	59 000	59 000	1 000
Dry Years (20-year)					
In-Heap	500	500	500	500	500
Events Pond	20 000	30 000	41 500	41 500	500
Total Storage	20 500	30 500	42 000	42 000	1 000
Wet Years (100-year)					
In-Heap	500	500	500	500	500
Events Pond	43 000	64 000	88 500	88 500	500
Total Storage	43 500	64 500	89 000	89 000	1 000

Notes for Table 5

- 1) "Total Storage" corresponds to the maximum concurrent total of In-Heap (nominal 500 m³) plus Events Pond storage for each stage. The Events Pond capacity will be 160 000 m³ (see Section 4.4).
- 2) Volumes are averaged over the respective periods and rounded to the nearest 500 m³. Volumes for individual years in each stage are shown in Tables I.1, II.1 and II.2.
- 3) Stage V volumes correspond to nominal minimum pond volumes. The treatment plant capacity during this stage will be sufficient to treat and release water as fast as it reports to the Events Pond. Temporary storage of water, therefore, will not be required for normal operations during Stage V although the Events Pond facility will remain operational if needed during this stage.

Annual maximum volumes generally occur at the end of the snowmelt period and subsequently decrease during the summer and fall. Minimum volumes are attained by the end of October and maintained throughout the winter period.

The volumes in Table 5 represent averages for each stage of operations. The maximum solution storage volume experienced in a year will depend in part on the actual magnitude of the precipitation each month and year. Extreme hydrological events used for design and recommended total design solution storage volumes are presented in Section 4 following.

4. Total Solution Storage Requirements

4.1. Hydrological Events

Total solution storage requirements will depend in part on the duration and return period of the critical hydrological event adopted for design. The recommended hydrological return period for design of the solution storage is 100 years based on discussions held with the RERC. A number of combinations of hydrological events were evaluated to determine the critical duration and combinations of events for design of the total solution storage volume. The magnitudes (depth of rainfall or runoff) of the various events were presented in the Clearwater Consultants Ltd. Design Memoranda CCL-CC2 and CCL-CC2A.

The hydrological inflow cases evaluated during this study are described following:

Case A - average conditions of rainfall and snowfall throughout the year. This is the "Base Case" and involves annual total precipitation of 372 mm with the snowmelt occurring during April each year. The total runoff depth during the snowmelt period is 161 mm based on a seven month period from October through the end of April. This April runoff depth, therefore, includes snowmelt plus concurrent rainfall during the snowmelt period.

Three cases were considered which involved extreme rainfall wet periods of various duration following immediately after the average April snowmelt as follows:

Case Ai - Case A above with a 100 year return period one month duration wet period in May and average precipitation conditions thereafter. The 100 year one month wet month has an estimated precipitation of 155 mm assumed to be rainfall. The total annual precipitation for this case is 514 mm.

Case Aii - Case A above with a 100 year return period two month duration wet period in May and June and average precipitation conditions thereafter. The 100 year two month wet period has an estimated total precipitation of 229 mm assumed to be rainfall equally distributed in each of May and June. The total annual precipitation for this case is 546 mm, equivalent to a 100 year wet year.

Case Aiii - Case A above with a 100 year return period three month duration wet period in May, June and July and average precipitation conditions thereafter. The 100 year three month wet period has an estimated total precipitation of 288 mm assumed to be rainfall equally distributed in each of May, June and July. The total annual precipitation for this case is 544 mm, equivalent to a 100 year wet year.

Three other cases were considered which involved a 100 year return period wet year as follows:

Case B - a 100 year return period wet year with a total annual precipitation of 541 mm and snowmelt occurring during April. This case represents an incremental annual depth of precipitation of 169 mm over and above average conditions. The additional precipitation was distributed over the May to September period as rainfall in proportion to average monthly rainfall depths. The total April runoff depth for this case was 244 mm;

Case B1 - a 100 year return period wet year including a 100 year return period snowmelt occurring during April. The total April runoff depth for this case was 311 mm based on a seven months duration wet period from the previous October through and including April. Monthly rainfall from May to September was prorated so that the total annual precipitation was equal to 541 mm; and,

Case B2 - a 100 year return period wet year including a 100 year return period snowmelt occurring during May. For this case April runoff was assumed to be zero and total May runoff was 325 mm based on an eight months duration wet period from the previous October through and including May. Monthly rainfall from June to September was prorated so that the total annual precipitation was equal to 541 mm. For this case, evaporation losses during the May snowmelt period were conservatively assumed equal to zero.

The cases above include a range of wet period durations for the calculation of 100 year return period total precipitation, snowfall, snowmelt and runoff as follows:

- one, two and three months duration for rainfall occurring in the summer period after snowmelt (Cases Ai, Aii and Aiii);
- seven months duration (October through April) for snowfall plus rainfall to calculate total runoff in April (Case B1);
- eight months duration (October through May) for snowfall plus rainfall to calculate total runoff in May (Case B2); and,
- twelve months duration to calculate monthly snowfall and rainfall for the 100 year wet year (Case B).

4.2. Process Interruptions

Process interruptions due to power failures, pump breakdown or other operational disruptions may impact directly on the total solution storage requirements. The process interruptions considered during the study included the following:

- if the snowmelt is late and occurs during May, no new ore will be placed or leached during May and, therefore, no water will be consumed due to saturating newly placed ore. In addition, there would be no evaporation losses during a May snowmelt. These conditions would apply only to Case B2 above;
- a loss of solution pumping capacity such that a portion of the total potential draindown volume from the heap must be contained in storage.

Partial heap draindown could result from a power failure causing all solution pumping to cease so that no solution is either applied to the top of the heap or is recycled from the Events Pond to the top of the heap for some period of time until power and pumping capacity is restored. The potential total draindown volume is related to the change in moisture content of the ore from the leaching moisture content to the residual moisture content and to the total tonnes of ore under leach at any time.

The total potential draindown volume at any time is equal to: the area of leach solution application ($47\,400\text{ m}^2$) *times* the ore density (1.6 t/m^3) *times* the individual lift height (8 m) *times* the number of lifts under leach (varies over the mine life) *times* the moisture change (2.0%). Based on the process data described in Section 2.2, the total potential draindown volume may range from $39\,000\text{ m}^3$ (3 lifts of ore) at the end of Year 1 to $97\,000\text{ m}^3$ in the last year of operation when about eight lifts of ore may be under leach.

The proportion of the total potential draindown volume reaching the Events Pond storage will depend on the length of time that all solution pumping capacity is lost. The rate of flow of draindown solution from the heap may initially remain constant for a few days and equal to the previous rate of solution application. The total time that the flow will remain constant will depend on the depth of ore under leach. The flow rate, however, will decrease with time in an exponential manner: in theory, an infinite time would be required to completely drain down the heap. The time necessary for 90% to 100% of the total potential draindown volume to flow into the Events Pond will be a function of the depth of ore under leach and the particle size, and hence permeability, of the ore. Solution will be applied to the heap at a total rate of $540\text{ m}^3/\text{hour}$.

Mine operators agree that emergency dedicated stand-alone power generation is critical to ensure continued heap operation:

- to ensure continued normal operation of the recovery plant;
- to prevent the freezing of solution application pipelines as a result of temporary shutdowns during winter operations; and,
- to minimize the potential volume of draindown solution that may report to the solution storage facilities.

Existing heap leach operations typically have either dedicated emergency generation capability on-site or access to emergency generators and pumps that could be delivered from off-site and made operational within a 12 hour to 48 hour time frame.

Western Copper Holdings Ltd. will undertake to have dedicated, stand-alone power generation capability on site sufficient to run all solution pumps. A two day period will allow a reasonable length of time to ensure pumping capacity is restored using the emergency power generator. In addition, various other operational measures and actions will be studied by Western Copper Holdings Ltd. to ensure that design total storage capacities will not be exceeded. These measures may include the provision of duplicate redundant solution pumps and the availability of spare parts on-site for prompt repair in case of pump failure.

The design draindown criterion used in this study was: in conjunction with extreme hydrologic events as described in Section 4.3, the minimum draindown storage capacity will be a volume of about $26\,000\text{ m}^3$ equivalent to two days (48 hours) application of leaching solution.

4.3. Combinations of Events

The critical case for the design of total solution storage volumes was determined by running the water balance model for each of the hydrological inflow cases described in Section 4.1 to calculate total volumes of solution in storage for each month of the entire simulation period. Additional volumes due to process interruptions (Section 4.2) were then added to determine total solution storage requirements. Table III.1 in Appendix III presents the resulting storage volumes for all the above cases. The design total storage volume requirements for each month and each year were taken as the maximum volumes calculated from the various storage cases described above. The results are shown on page 4 of Table III.1 and are discussed following.

4.4. Design Storage Volumes

Table 6 summarizes the maximum total solution storage requirements for each year of operation necessary to prevent an uncontrolled release of solution from the Events Pond for the combinations of hydrologic and process events described previously. The table also shows the month in which the maximum occurs each year and the combination of events case leading to the maximum.

Table 6 - Summary of Solution Storage Requirements

Year	Maximum Total Solution Storage (m ³)	Month of Occurrence	Case
1	55 000	May	B2
2	107 000	May	B2
3	107 000	May	B2
4	138 000	May	B2
5	138 000	May	B2
6	138 000	May	B2
7	138 000	May	B2
8	138 000	May	B2
9	133 000	April	B1

Note for Table 6 Maximum total solution storage volumes are rounded up to the nearest 1 000 m³ (see Appendix III).

Previous site assessments, geotechnical investigations and engineering design work have indicated that an Events Pond with a storage capacity of 160,000 m³ can be accommodated. Western Copper Holdings Ltd. intends to construct the Events Pond based on this volume. As shown in Table 6, this capacity comfortably exceeds the maximum required total solution storage volume conservatively estimated in the present water balance study by 22,000 m³.

Storage capacity for the Events Pond may be increased in stages over the operating period allowing deferment of capital expenditures and flexibility in the provision of total solution storage capability. Routine monitoring of site precipitation, snowpack and all water balance flows during operations must be carried out.

4.5. Capacity for Draindown Storage

During the winter months the Events Pond will contain only minimum volumes of solution in storage. The total available solution storage volume of 160 000 m³ will provide storage for 100% of the total potential draindown volumes in the winter months. If any draindown from the heap were to occur at any time during the winter, full normal operations and design storage volumes must be re-established prior to the start of the spring snowmelt.

Based on the monthly Events Pond storage volumes calculated from the water balance model (Appendix I, pages 7 to 9, Column AI), 100% of the total potential draindown volume may be stored at all times throughout the mine life for average precipitation conditions.

4.6. Available Solution Storage and System Performance

The following is a summary of the conservative design criteria, operating concepts and design contingencies proposed by Western Copper Holdings Ltd. (WCHL) for the Carmacks Copper Project to ensure that there is adequate solution storage capacity within the system. The expected performance of the heap leach facility as a result of the design criteria and operating concepts is also presented:

Design Criteria

Water balance design criteria are conservative and are based on a combination of several extreme events occurring at the same time during the maximum storage month. The design criteria for solution storage during the maximum storage month are:

- ⇒ Average precipitation and runoff conditions, *plus*
- ⇒ Runoff from the 100 year return period snowmelt assumed to occur in the last two weeks of May, *plus*
- ⇒ No placement of ore and no loss of water to wetting new ore during May, *plus*
- ⇒ No evaporation losses from the heap or Events Pond during May, *plus*
- ⇒ 48 hours of heap drain down at a constant rate of 540 m³/hour assumed to occur during or at the end of the snowmelt.

It is emphasized that the 48 hour draindown criterion applies only in conjunction with all the other inflow events listed above.

Operating Concepts

The heap leach storage facility will be operated to ensure adequate solution storage capacity as follows:

- A storage volume of 160,000 m³ will be provided in the Events Pond. This volume is 22,000 m³ more than the maximum required solution storage volume calculated using the above criteria and the present water balance model;
- At the start of the winter season and until the start of the snowmelt every year, the Events Pond will be empty thereby ensuring that the full solution storage capacity of the system is available during the winter and in advance of the annual snowmelt.

Therefore, 100% of the total potential draindown volume may be stored in the winter at all times throughout the mine life for all precipitation conditions;

- Emergency systems for power generation are available year round;
- Provision for a water treatment plant by year 3 so that excess solutions are released in a controlled manner to ensure maximum storage capacities are maintained.

Design Contingencies

As part of the water balance modeling study, design contingencies were considered and used conservatively in the development of the water balance model. The water balance does not rely on implementation of these contingencies but they are available to the operator as necessary:

- No snow removal is required to maintain the water balance and satisfy the design solution storage criteria;
- No active evaporation of solutions is required during the summer to reduce solution inventories. Sprinklers or temporary pad covers could be used during summer months to reduce solution inventories if necessary.

System Performance

Based on the water balance study and with implementation of the above noted design criteria, operating concepts and other system contingencies, the heap leach solution storage system is expected to perform as follows:

- There will be storage for 100% of the total potential draindown volume available at all times throughout the mine life for average precipitation conditions;
- There will be 100% draindown storage available in the winter for all conditions as discussed in Section 4.5;
- There will be 3.7 days of draindown solution storage available in combination with the design extreme spring events at a heap draindown rate of 540 m³/hr.

To ensure that the heap leach facility meets the intended design performance, Western Copper Holdings Limited proposes the following:

- ⇒ Provision of stand-alone emergency power generation capability at all times.
- ⇒ Provision of critical spare parts on-site at all times.
- ⇒ Studies by Year 3 of the need for complete redundant systems, including solution pumping and distribution systems.
- ⇒ Construction by Year 3 of operations of a water treatment plant with a capacity to release excess solutions in a controlled manner and to ensure maximum storage capacities are maintained.
- ⇒ Use of on-line instrumentation and meteorological monitoring to provide input to and monitoring of a dynamic water balance model.

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- ⇒ Use of the on-going monitoring and modeling information to review pond capacities and provide information for regulatory review prior to any additional pond construction.
- ⇒ Review of the water balance model and input parameters after three years of operations and available for regulatory review for year 4 operations.

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APPENDIX I

Carmacks Copper Project Heap Leach Facility Water Balance Base Case Average Conditions

Run-of-Mine (ROM) Ore

Table I.1 - Summary of Monthly Water Balance - Average Conditions

Table I.2 - Input Data

Table I.3 - Heap Leach Pad Monthly Water Balance

Table I.4 - Events Pond Monthly Water Balance

Figure I.1 - Events Pond Storage Variation

Figure I.2 - Variation in Monthly Treat and Release Volumes

Table I.1 - Summary of Monthly Water Balance**Average Conditions****VERSION 1.2**

	<u>Maximum</u>	<u>Minimum</u>	<u>Initial</u>		<u>Ore Moistures</u>	
Nominal In-Heap Storage	500	500	500	m3	Initial	3.0%
Events Pond Storage	160,000	500	0	m3	Leaching	12.0%
Total Solution Storage	160,500	1,000	500	m3	Residual	10.0%
Treatment Capacity =	270	m3/hour	270			
Maximum Daily Ore Production	9,872	tpd	9872			

Run-of-Mine (ROM) Ore

Year	Stage	Precipitation Return Period	In-Heap Storage		Events Pond Storage		Maximum Total Storage	Total Treated	Total Spilled	Make-Up Water (Fresh)
			Minimum Volume	Maximum Volume	Minimum Volume	Maximum Volume				
1	I	2	500	500	500	28,119	28,619	-	-	122,732
2	II	2	500	500	500	42,023	42,523	-	-	69,168
3	II	2	500	500	500	42,023	42,523	-	-	69,250
4	III	2	500	500	500	58,310	58,810	-	-	29,011
5	III	2	500	500	500	58,310	58,810	-	-	25,835
6	III	2	500	500	500	58,310	58,810	-	-	19,803
7	III	2	500	500	500	58,310	58,810	-	-	9,296
8	III / IV	2	500	500	500	58,310	58,810	90,566	-	-
9	IV	2	500	500	500	55,900	56,400	111,739	-	-
10	V	2	500	500	500	500	1,000	145,051	-	-
11	V	2	500	500	500	500	1,000	145,051	-	-
12	V	2	500	500	500	500	1,000	145,051	-	-
13	VI	2	500	500	500	500	1,000	112,693	-	-
14	VI	2	500	500	500	500	1,000	112,693	-	-
15	VI	2	500	500	-	-	500	113,193	-	-

NOTES 1) All volumes in cubic metres.

2) "Maximum Total Water Storage" corresponds to the maximum concurrent total of In-Heap plus Events Pond storage.

3) Return Period is for Annual Precipitation, Rainfall and Snowfall.

Table I.2 - Carmacks Copper Project - Heap Leach Pad Water Balance - Input Data**Process Input Data**

Stage	Year	Stacked Ore Tonnes	Leach Pad Area m2	Precipitation Return Period	No. of Leaching Lifts	Top of Heap Area m2	% of Heap Covered
I	1	1,963,500	142,000	2	3.2	50,000	0%
II	2	1,973,229	219,000	2	4.1	70,000	0%
II	3	1,974,398	219,000	2	5	90,000	0%
III	4	1,837,363	315,000	2	6	110,000	0%
III	5	1,792,000	315,000	2	7	120,000	0%
III	6	1,792,500	315,000	2	7.5	130,000	0%
III	7	1,642,400	315,000	2	8	120,000	0%
III / IV	8	302,481	315,000	2	8	110,000	0%
IV	9	0	315,000	2	8	100,000	0%
V	10	0	315,000	2	0	100,000	0%
V	11	0	315,000	2	0	100,000	0%
V	12	0	315,000	2	0	100,000	0%
VI	13	0	315,000	2	0	100,000	0%
VI	14	0	315,000	2	0	100,000	0%
VI	15	0	315,000	2	0	100,000	0%
TOTAL		13,277,869					

Notes

- 1) Top of heap area is at the start of the indicated year.
- 2) No. of Leaching Lifts is at the end of the indicated year.
- 3) 100% soil cover may be placed on heap after Year 12.

Hydrological Input Data - Williams Creek Area

Average Monthly Conditions						
Month	Rainfall mm	Snowfall mm	Snowmelt mm	Evaporation mm	Number of Days/Month	
					Total	Operating
March	0	15.5	0	0	31	0
April	14.0	14.5	147.0	0	30	0
May	13.3	0	0.0	92.9	31	17
June	41.7	0	0	107.5	30	30
July	61.0	0	0	98.6	31	31
Aug	43.6	0	0	71.1	31	31
Sept	31.4	0	0	32.3	30	30
Oct	0	33.1	0	0	31	31
Nov	0	31.2	0	0	30	30
Dec	0	27.4	0	0	31	0
Jan	0	25.6	0	0	31	0
Feb	0	19.7	0	0	28	0
TOTAL	205.0	167.0	147.0	402.4	365	200

% of Annual Snowmelt in	
April	100%
May	0%

Winter Sublimation Losses 20 mm

Average Conditions

ROM Ore	
VERSION	1.2

Ore Production Parameters

Maximum Daily Ore Production	9,872	tpd
Leaching Lift Height	8	m
Dry Density of Heap Ore	1.6	t/m3

ROM Ore**Ore Moisture Contents**

Initial	3.0%	by weight
Leaching	12.0%	by weight
Residual	10.0%	by weight

Leach Cycle Time 120 days

Flow Rates

Max. Solution Flow On Pad	540	m3/hr
Maximum Treatment Rate	270	m3/hr
Maximum Area under Leach	47,400	m2
Other Inflows to Heap Leach	0	m3/hr

Events Pond Areas

Total Catchment	29,100	m2
Pond Area	5,200	m2

Water Storage Volumes (m3)

	Maximum	Minimum	Initial
Nominal In-Heap Storage	500	500	500
Events Pond Storage	160,000	500	0
Total Solution Storage	160,500	1,000	500

Annual Total Precipitation

Return Period (years)	Precipitation	Rainfall
1	Dry	278
2	Average	372
10	Wet	458
20	Wet	487
100	Wet	541
200	Wet	561
500	Wet	585

(Note - Dry Year equal to 20 year return period)

Annual Percent Rainfall 55%

Evaporation Coefficients

For Area under Leach Irrigation	10%
For Heap & Overliner	5%
For Events Pond Catchment	100%

Table I.3 - Carmacks Copper Project - Heap Leach Pad Monthly Water Balance

Average Conditions

ROM Ore

Version 1.2

Daily Ore Production 9,872 tpd
 Initial Ore Moisture 3.0% by weight
 Leaching Ore Moisture 12.0%
 Residual ore Moisture 10.0%
 Maximum Area under Leach 47,400 m2
 Leaching Lift Height 8 m
 Dry Density of Heap Ore 1.6 t/m3

Leach Cycle Time 120 days
 Max. Solution Flow On Pad 540 m3/hr
 Other Inflows to Heap 0 m3/hr

Events Pond Areas (m2)
 Total Catchment 29,100
 Pond Area 5,200

Maximum Allowable Storage
 In-Heap 500 m3 (nominal)
 Events Pond 160,000 m3
 Total Solution Storage 160,500 m3

Evaporation Coefficients
 For Area under Leach 10%
 For Heap & Overliner 5%
 For Events Pond Catchment 100%

No. of Days	YEAR	Month	Stacked Leach Ore		AREAS - m2			Runoff		Evap'n Depth mm	WATER INFLOWS - m3			WATER OUTFLOWS and LOSSES - m3					MAKE-UP WATER REQUIREMENTS					NET INFLOW TO HEAP	Release to Events Pond	TOTAL IN-HEAP STORAGE
			tonnes	Volume m3	Under Leach	Total Heap & Overliner	Uncovered Heap	Return Period	Depth mm		Leach Pad Runoff	Other Inflows	TOTAL IN	Evaporation Losses		Permanent Loss to Ore Moisture	Initial Loss to Leaching Ore	TOTAL OUT	Total Required	From Heap Storage	Total Other	From Events Pond	From Fresh			
			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
31	0	1	-1-March	0	0	0	142,000	142,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	1	1-April	0	0	0	142,000	142,000	2	161.0	0	0	22,862	0	0	0	0	0	0	0	0	0	0	22,862	22,362	500
31	17	1	1-May	167,824	104,890	13,111	142,000	142,000	2	13.3	92.9	1,889	0	1,889	122	599	0	720	0	0	0	0	0	1,168	1,168	500
30	30	1	1-June	296,160	185,100	36,249	142,000	142,000	2	41.7	107.5	5,921	0	5,921	390	568	32,479	9,280	42,717	36,795	0	36,795	28,274	8,522	0	500
31	31	1	July	306,032	191,270	47,400	142,000	142,000	2	61.0	98.6	8,662	0	8,662	467	466	21,422	6,121	28,477	19,815	0	19,815	1,262	18,552	0	500
31	31	1	Aug	306,032	191,270	47,400	142,000	142,000	2	43.6	71.1	6,191	0	6,191	337	336	21,422	6,121	28,216	22,025	0	22,025	899	21,126	0	500
30	30	1	Sept	296,160	185,100	47,400	142,000	142,000	2	31.4	32.3	4,459	0	4,459	153	153	20,731	5,923	26,960	22,501	0	22,501	746	21,756	0	500
31	31	1	Oct	306,032	191,270	47,400	142,000	142,000	2	0.0	0	0	0	0	0	0	21,422	6,121	27,543	27,543	0	27,543	0	27,543	0	500
30	30	1	Nov	285,260	178,288	47,400	142,000	142,000	2	0	0	0	0	0	0	0	19,968	5,265	25,233	25,233	0	25,233	0	25,233	0	500
31	0	1	Dec	0	0	47,400	142,000	142,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	1	Jan	0	0	47,400	142,000	142,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
28	0	1	Feb	0	0	47,400	142,000	142,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	1	March	0	0	47,400	142,000	142,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
30	0	2	2-April	0	0	47,400	219,000	219,000	2	161.0	0	0	35,259	0	0	0	0	0	0	0	0	0	0	35,259	35,259	500
31	17	2	2-May	167,824	104,890	47,400	219,000	219,000	2	13.3	92.9	2,913	0	2,913	440	797	0	1,237	0	0	0	0	0	1,675	1,675	500
30	30	2	2-June	296,160	185,100	47,400	219,000	219,000	2	41.7	107.5	9,132	0	9,132	510	922	32,479	4,368	38,279	29,147	0	29,147	29,147	0	0	500
31	31	2	July	306,032	191,270	47,400	219,000	219,000	2	61.0	98.6	13,359	0	13,359	467	846	21,422	4,368	27,104	13,745	0	13,745	13,745	0	0	500
31	31	2	Aug	306,032	191,270	47,400	219,000	219,000	2	43.6	71.1	9,548	0	9,548	337	610	21,422	2,184	24,553	15,005	0	15,005	1,447	13,558	0	500
30	30	2	Sept	296,160	185,100	47,400	219,000	219,000	2	31.4	32.3	6,877	0	6,877	153	277	20,731	0	21,161	14,285	0	14,285	746	13,539	0	500
31	31	2	Oct	306,032	191,270	47,400	219,000	219,000	2	0.0	0	0	0	0	0	0	21,422	0	21,422	21,422	0	21,422	0	21,422	0	500
30	30	2	Nov	294,989	184,368	47,400	219,000	219,000	2	0	0	0	0	0	0	0	20,649	0	20,649	20,649	0	20,649	0	20,649	0	500
31	0	2	Dec	0	0	47,400	219,000	219,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	2	Jan	0	0	47,400	219,000	219,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
28	0	2	Feb	0	0	47,400	219,000	219,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	2	March	0	0	47,400	219,000	219,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
30	0	3	3-April	0	0	47,400	219,000	219,000	2	161.0	0	0	35,259	0	0	0	0	0	0	0	0	0	0	35,259	35,259	500
31	17	3	3-May	167,824	104,890	47,400	219,000	219,000	2	13.3	92.9	2,913	0	2,913	440	797	0	1,237	0	0	0	0	0	1,675	1,675	500
30	30	3	3-June	296,160	185,100	47,400	219,000	219,000	2	41.7	107.5	9,132	0	9,132	510	922	32,479	4,368	38,279	29,147	0	29,147	29,147	0	0	500
31	31	3	July	306,032	191,270	47,400	219,000	219,000	2	61.0	98.6	13,359	0	13,359	467	846	21,422	4,368	27,104	13,745	0	13,745	13,745	0	0	500
31	31	3	Aug	306,032	191,270	47,400	219,000	219,000	2	43.6	71.1	9,548	0	9,548	337	610	21,422	2,184	24,553	15,005	0	15,005	1,447	13,558	0	500
30	30	3	Sept	296,160	185,100	47,400	219,000	219,000	2	31.4	32.3	6,877	0	6,877	153	277	20,731	0	21,161	14,285	0	14,285	746	13,539	0	500
31	31	3	Oct	306,032	191,270	47,400	219,000	219,000	2	0.0	0	0	0	0	0	0	21,422	0	21,422	21,422	0	21,422	0	21,422	0	500
30	30	3	Nov	296,156	185,098	47,400	219,000	219,000	2	0	0	0	0	0	0	0	20,731	0	20,731	20,731	0	20,731	0	20,731	0	500
31	0	3	Dec	0	0	47,400	219,000	219,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	3	Jan	0	0	47,400	219,000	219,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
28	0	3	Feb	0	0	47,400	219,000	219,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	3	March	0	0	47,400	219,000	219,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
30	0	4	4-April	0	0	47,400	315,000	315,000	2	161.0	0	0	50,715	0	0	0	0	0	0	0	0	0	0	50,715	50,715	500
31	17	4	4-May	167,824	104,890	47,400	315,000	315,000	2	13.3	92.9	4,190	0	4,190	440	1,243	0	1,683	0	0	0	0	0	2,506	2,506	500
30	30	4	4-June	296,160	185,100	47,400	315,000	315,000	2	41.7	107.5	13,136	0	13,136	510	1,438	32,479	4,854	39,281	26,145	0	26,145	26,145	0	0	500
31	31	4	July	306,032	191,270	47,400	315,000	315,000	2	61.0	98.6	19,215	0	19,215	467	1,319	21,422	4,854	28,063	8,848	0	8,848	8,848	0	0	500
31	31	4	Aug	306,032	191,270	47,400	315,000	315,000	2	43.6	71.1	13,734	0	13,734	337	951	21,422	2,427	25,137	11,403	0	11,403	11,403	0	0	500
30	30	4	Sept	296,160	185,100	47,400	315,000	315,000	2	31.4	32.3	9,891	0	9,891	153	432	20,731	0	21,316	11,425	0	11,425	11,425	0	0	500
31	31	4	Oct	306,032	191,270	47,400	315,000	315,000	2	0.0	0	0	0	0	0	0	21,422	0	21,422	21,422	0	21,422	3,550	17,872	0	500
30	30	4	Nov	159,123	99,452	47,400	315,000	315,000	2	0	0	0	0	0	0	0	11,139	0	11,139	11,139	0	11,139	0	11,139	0	500
31	0	4	Dec	0	0	47,400	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	4	Jan	0	0	47,400	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
28	0	4	Feb	0	0	47,400	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	4	March	0	0	47,400	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500

Table I.3 - Carmacks Copper Project - Heap Leach Pad Monthly Water Balance

Average Conditions

ROM Ore

Version 1.2

Daily Ore Production 9,872 lpd
Initial Ore Moisture 3.0% by weight
Leaching Ore Moisture 12.0%
Residual ore Moisture 10.0%
Maximum Area under Leach 47,400 m2
Leaching Lift Height 8 m
Dry Density of Heap Ore 1.6 t/m3

Leach Cycle Time 120 days
Max. Solution Flow On Pad 540 m3/hr
Other Inflows to Heap 0 m3/hr

Events Pond Areas (m2)
Total Catchment 29,100
Pond Area 5,200

Maximum Allowable Storage
In-Heap 500 m3 (nominal)
Events Pond 160,000 m3
Total Solution Storage 160,500 m3

Evaporation Coefficients
For Area under Leach 10%
For Heap & Overliner 5%
For Events Pond Catchment 100%

No. of Days		YEAR	Month	Stacked Leach Ore		AREAS - m2			Runoff		Evap'n Depth mm	WATER INFLOWS - m3			WATER OUTFLOWS and LOSSES - m3					MAKE-UP WATER REQUIREMENTS					NET INFLOW TO HEAP	Release to Events Pond	TOTAL IN-HEAP STORAGE
				Stacked tonnes	Volume m3	Under Leach	Total Heap & Overliner	Uncovered Heap	Return Period	Depth mm		Leach Pad Runoff	Other Inflows	TOTAL IN	Evaporation Losses Leach Area Heap&O'liner	Permanent Loss to Ore Moisture	Initial Loss to Leaching Ore	TOTAL OUT	Total Required	From Heap Storage	Total Other	From Events Pond	From Fresh				
Total	Operating			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
30	0	5	5-April	0	0	47,400	315,000	315,000	2	161.0	0	50,715	0	50,715	0	0	0	0	0	0	0	0	0	0	50,715	50,715	500
31	17	5	5-May	167,824	104,890	47,400	315,000	315,000	2	13.3	92.9	4,190	0	4,190	440	1,243	0	0	1,683	0	0	0	0	0	2,506	2,506	500
30	30	5	5-June	296,160	185,100	47,400	315,000	315,000	2	41.7	107.5	13,136	0	13,136	510	1,438	32,479	4,854	39,281	26,145	0	26,145	26,145	0	0	500	
31	31	5	July	306,032	191,270	47,400	315,000	315,000	2	61.0	98.6	19,215	0	19,215	467	1,319	21,422	4,854	28,063	8,848	0	8,848	8,848	0	0	500	
31	31	5	Aug	306,032	191,270	47,400	315,000	315,000	2	43.6	71.1	13,734	0	13,734	337	951	21,422	2,427	25,137	11,403	0	11,403	11,403	0	0	500	
30	30	5	Sept	296,160	185,100	47,400	315,000	315,000	2	31.4	32.3	9,891	0	9,891	153	432	20,731	0	21,316	11,425	0	11,425	11,425	0	0	500	
31	31	5	Oct	306,032	191,270	47,400	315,000	315,000	2	0.0	0	0	0	0	0	0	21,422	0	21,422	21,422	0	3,550	17,872	0	0	500	
30	30	5	Nov	113,760	71,100	47,400	315,000	315,000	2	0	0	0	0	0	0	0	7,963	0	7,963	7,963	0	7,963	0	7,963	0	500	
31	0	5	Dec	0	0	47,400	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	
31	0	5	Jan	0	0	47,400	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	
28	0	5	Feb	0	0	47,400	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	
31	0	5	March	0	0	47,400	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	
30	0	6	6-April	0	0	47,400	315,000	315,000	2	161.0	0	50,715	0	50,715	0	0	0	0	0	0	0	0	0	0	50,715	50,715	500
31	17	6	6-May	167,824	104,890	47,400	315,000	315,000	2	13.3	92.9	4,190	0	4,190	440	1,243	0	0	1,683	0	0	0	0	0	2,506	2,506	500
30	30	6	6-June	296,160	185,100	47,400	315,000	315,000	2	41.7	107.5	13,136	0	13,136	510	1,438	32,479	2,427	36,854	23,718	0	23,718	23,718	0	0	500	
31	31	6	July	306,032	191,270	47,400	315,000	315,000	2	61.0	98.6	19,215	0	19,215	467	1,319	21,422	2,427	25,636	6,421	0	6,421	6,421	0	0	500	
31	31	6	Aug	306,032	191,270	47,400	315,000	315,000	2	43.6	71.1	13,734	0	13,734	337	951	21,422	1,213	23,924	10,190	0	10,190	10,190	0	0	500	
30	30	6	Sept	296,160	185,100	47,400	315,000	315,000	2	31.4	32.3	9,891	0	9,891	153	432	20,731	0	21,316	11,425	0	11,425	11,425	0	0	500	
31	31	6	Oct	306,032	191,270	47,400	315,000	315,000	2	0.0	0	0	0	0	0	0	21,422	0	21,422	21,422	0	9,617	11,805	0	0	500	
30	30	6	Nov	114,260	71,413	47,400	315,000	315,000	2	0	0	0	0	0	0	0	7,998	0	7,998	7,998	0	7,998	0	7,998	0	500	
31	0	6	Dec	0	0	47,400	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	
31	0	6	Jan	0	0	47,400	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	
28	0	6	Feb	0	0	47,400	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	
31	0	6	March	0	0	47,400	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	
30	0	7	7-April	0	0	47,400	315,000	315,000	2	161.0	0	50,715	0	50,715	0	0	0	0	0	0	0	0	0	0	50,715	50,715	500
31	17	7	7-May	167,824	104,890	47,400	315,000	315,000	2	13.3	92.9	4,190	0	4,190	440	1,243	0	0	1,683	0	0	0	0	0	2,506	2,506	500
30	30	7	7-June	296,160	185,100	47,400	315,000	315,000	2	41.7	107.5	13,136	0	13,136	510	1,438	32,479	2,427	36,854	23,718	0	23,718	23,718	0	0	500	
31	31	7	July	306,032	191,270	47,400	315,000	315,000	2	61.0	98.6	19,215	0	19,215	467	1,319	21,422	2,427	25,636	6,421	0	6,421	6,421	0	0	500	
31	31	7	Aug	306,032	191,270	47,400	315,000	315,000	2	43.6	71.1	13,734	0	13,734	337	951	21,422	1,213	23,924	10,190	0	10,190	10,190	0	0	500	
30	30	7	Sept	296,160	185,100	47,400	315,000	315,000	2	31.4	32.3	9,891	0	9,891	153	432	20,731	0	21,316	11,425	0	11,425	11,425	0	0	500	
31	31	7	Oct	270,192	168,870	47,400	315,000	315,000	2	0.0	0	0	0	0	0	0	18,913	0	18,913	18,913	0	18,913	9,617	9,296	0	500	
30	0	7	Nov	0	0	47,400	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	
31	0	7	Dec	0	0	47,400	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	
31	0	7	Jan	0	0	47,400	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	
28	0	7	Feb	0	0	47,400	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	
31	0	7	March	0	0	47,400	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	
30	0	8	8-April	0	0	47,400	315,000	315,000	2	161.0	0	50,715	0	50,715	0	0	0	0	0	0	0	0	0	0	50,715	50,715	500
31	17	8	8-May	167,824	104,890	47,400	315,000	315,000	2	13.3	92.9	4,190	0	4,190	440	1,243	0	0	1,683	0	0	0	0	0	2,506	2,506	500
30	13.6	8	8-June	134,657	84,161	47,400	315,000	315,000	2	41.7	107.5	13,136	0	13,136	510	1,438	21,174	0	23,122	9,986	0	9,986	9,986	0	0	500	
31	0	8	July	0	0	47,400	315,000	315,000	2	61.0	98.6	19,215	0	19,215	467	1,319	0	0	1,787	0	0	0	0	0	17,428	17,428	500
31	0	8	Aug	0	0	47,400	315,000	315,000	2	43.6	71.1	13,734	0	13,734	337	951	0	0	1,288	0	0	0	0	0	12,446	12,446	500
30	0	8	Sept	0	0	47,400	315,000	315,000	2	31.4	32.3	9,891	0	9,891	153	432	0	0	585	0	0	0	0	0	9,306	9,306	500
31	0	8	Oct	0	0	47,400	315,000	315,000	2	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	
30	0	8	Nov	0	0	47,400	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	
31	0	8	Dec	0	0	47,400	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	
31	0	8	Jan	0	0	47,400	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	
28	0	8	Feb	0	0	47,400	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	
31	0	8	March	0	0	47,400	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	

Table I.3 - Carmacks Copper Project - Heap Leach Pad Monthly Water Balance

Average Conditions

ROM Ore

Version 1.2

Daily Ore Production 9,872 tpd
 Initial Ore Moisture 3.0% by weight
 Leaching Ore Moisture 12.0%
 Residual ore Moisture 10.0%
 Maximum Area under Leach 47,400 m²
 Leaching Lift Height 8 m
 Dry Density of Heap Ore 1.6 t/m³

Leach Cycle Time 120 days
 Max. Solution Flow On Pad 540 m³/hr
 Other Inflows to Heap 0 m³/hr

Events Pond Areas (m²)
 Total Catchment 29,100
 Pond Area 5,200

Maximum Allowable Storage
 In-Heap 500 m³ (nominal)
 Events Pond 160,000 m³
 Total Solution Storage 160,500 m³

Evaporation Coefficients
 For Area under Leach 10%
 For Heap & Overliner 5%
 For Events Pond Catchment 100%

No. of Days		YEAR	Month	Stacked Leach Ore		AREAS - m2			Runoff		Evap'n Depth mm	WATER INFLOWS - m3			WATER OUTFLOWS and LOSSES - m3					MAKE-UP WATER REQUIREMENTS					NET INFLOW TO HEAP	Release to Events Pond	TOTAL IN-HEAP STORAGE
				Stacked tonnes	Volume m3	Under Leach	Total Heap & Overliner	Uncovered Heap	Return Period	Depth mm		Leach Pad Runoff	Other Inflows	TOTAL IN	Evaporation Losses		Permanent Loss to Ore Moisture	Initial Loss to Leaching Ore	TOTAL OUT	Total Required	From Heap Storage	Total Other	From Events Pond	From Fresh			
															Leach Area	Heap&O'Liner											
Total	Operating			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
30	0	9	9-April	0	0	47,400	315,000	315,000	2	161.0	0	50,715	0	50,715	0	0	0	0	0	0	0	0	0	0	50,715	50,715	500
31	0	9	9-May	0	0	47,400	315,000	315,000	2	13.3	92.9	4,190	0	4,190	440	1,243	0	0	1,683	0	0	0	0	0	2,506	2,506	500
30	0	9	9-June	0	0	47,400	315,000	315,000	2	41.7	107.5	13,136	0	13,136	510	1,438	0	0	1,948	0	0	0	0	0	11,188	11,188	500
31	0	9	9-July	0	0	47,400	315,000	315,000	2	61.0	98.6	19,215	0	19,215	467	1,319	0	0	1,787	0	0	0	0	0	17,428	17,428	500
31	0	9	9-Aug	0	0	47,400	315,000	315,000	2	43.6	71.1	13,734	0	13,734	337	951	0	0	1,288	0	0	0	0	0	12,446	12,446	500
30	0	9	9-Sept	0	0	47,400	315,000	315,000	2	31.4	32.3	9,891	0	9,891	153	432	0	0	585	0	0	0	0	0	9,306	9,306	500
31	0	9	9-Oct	0	0	47,400	315,000	315,000	2	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
30	0	9	9-Nov	0	0	47,400	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	9	9-Dec	0	0	47,400	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	9	9-Jan	0	0	47,400	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
28	0	9	9-Feb	0	0	47,400	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	9	9-March	0	0	47,400	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
30	0	10	10-April	0	0	0	315,000	315,000	2	161.0	0	50,715	0	50,715	0	0	0	0	0	0	0	0	0	0	50,715	50,715	500
31	0	10	10-May	0	0	0	315,000	315,000	2	13.3	92.9	4,190	0	4,190	0	1,463	0	-5,393	-3,930	0	0	0	0	0	8,119	8,119	500
30	0	10	10-June	0	0	0	315,000	315,000	2	41.7	107.5	13,136	0	13,136	0	1,693	0	-5,393	-3,700	0	0	0	0	0	16,835	16,835	500
31	0	10	10-July	0	0	0	315,000	315,000	2	61.0	98.6	19,215	0	19,215	0	1,553	0	-5,393	-3,840	0	0	0	0	0	23,055	23,055	500
31	0	10	10-Aug	0	0	0	315,000	315,000	2	43.6	71.1	13,734	0	13,734	0	1,120	0	-5,393	-4,273	0	0	0	0	0	18,007	18,007	500
30	0	10	10-Sept	0	0	0	315,000	315,000	2	31.4	32.3	9,891	0	9,891	0	509	0	-5,393	-4,884	0	0	0	0	0	14,775	14,775	500
31	0	10	10-Oct	0	0	0	315,000	315,000	2	0.0	0	0	0	0	0	0	0	-5,393	-5,393	0	0	0	0	0	5,393	5,393	500
30	0	10	10-Nov	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	10	10-Dec	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	10	10-Jan	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
28	0	10	10-Feb	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	10	10-March	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
30	0	11	11-April	0	0	0	315,000	315,000	2	161.0	0	50,715	0	50,715	0	0	0	0	0	0	0	0	0	0	50,715	50,715	500
31	0	11	11-May	0	0	0	315,000	315,000	2	13.3	92.9	4,190	0	4,190	0	1,463	0	-5,393	-3,930	0	0	0	0	0	8,119	8,119	500
30	0	11	11-June	0	0	0	315,000	315,000	2	41.7	107.5	13,136	0	13,136	0	1,693	0	-5,393	-3,700	0	0	0	0	0	16,835	16,835	500
31	0	11	11-July	0	0	0	315,000	315,000	2	61.0	98.6	19,215	0	19,215	0	1,553	0	-5,393	-3,840	0	0	0	0	0	23,055	23,055	500
31	0	11	11-Aug	0	0	0	315,000	315,000	2	43.6	71.1	13,734	0	13,734	0	1,120	0	-5,393	-4,273	0	0	0	0	0	18,007	18,007	500
30	0	11	11-Sept	0	0	0	315,000	315,000	2	31.4	32.3	9,891	0	9,891	0	509	0	-5,393	-4,884	0	0	0	0	0	14,775	14,775	500
31	0	11	11-Oct	0	0	0	315,000	315,000	2	0.0	0	0	0	0	0	0	0	-5,393	-5,393	0	0	0	0	0	5,393	5,393	500
30	0	11	11-Nov	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	11	11-Dec	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	11	11-Jan	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
28	0	11	11-Feb	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	11	11-March	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
30	0	12	12-April	0	0	0	315,000	315,000	2	161.0	0	50,715	0	50,715	0	0	0	0	0	0	0	0	0	0	50,715	50,715	500
31	0	12	12-May	0	0	0	315,000	315,000	2	13.3	92.9	4,190	0	4,190	0	1,463	0	-5,393	-3,930	0	0	0	0	0	8,119	8,119	500
30	0	12	12-June	0	0	0	315,000	315,000	2	41.7	107.5	13,136	0	13,136	0	1,693	0	-5,393	-3,700	0	0	0	0	0	16,835	16,835	500
31	0	12	12-July	0	0	0	315,000	315,000	2	61.0	98.6	19,215	0	19,215	0	1,553	0	-5,393	-3,840	0	0	0	0	0	23,055	23,055	500
31	0	12	12-Aug	0	0	0	315,000	315,000	2	43.6	71.1	13,734	0	13,734	0	1,120	0	-5,393	-4,273	0	0	0	0	0	18,007	18,007	500
30	0	12	12-Sept	0	0	0	315,000	315,000	2	31.4	32.3	9,891	0	9,891	0	509	0	-5,393	-4,884	0	0	0	0	0	14,775	14,775	500
31	0	12	12-Oct	0	0	0	315,000	315,000	2	0.0	0	0	0	0	0	0	0	-5,393	-5,393	0	0	0	0	0	5,393	5,393	500
30	0	12	12-Nov	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	12	12-Dec	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	12	12-Jan	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
28	0	12	12-Feb	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	12	12-March	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500

Table 1.3 - Carmacks Copper Project - Heap Leach Pad Monthly Water Balance

Average Conditions
ROM Ore

Version 1.2

Daily Ore Production 9,872 tpd
Initial Ore Moisture 3.0% by weight
Leaching Ore Moisture 12.0%
Residual ore Moisture 10.0%
Maximum Area under Leach 47,400 m²
Leaching Lift Height 8 m
Dry Density of Heap Ore 1.6 t/m³

Leach Cycle Time 120 days
Max. Solution Flow On Pad 540 m³/hr
Other Inflows to Heap 0 m³/hr

Events Pond Areas (m²)
Total Catchment 29,100
Pond Area 5,200

Maximum Allowable Storage
In-Heap 500 m³ (nominal)
Events Pond 160,000 m³
Total Solution Storage 160,500 m³

Evaporation Coefficients
For Area under Leach 10%
For Heap & Overliner 5%
For Events Pond Catchment 100%

No. of Days	YEAR	Month	Stacked Leach Ore		AREAS - m2			Runoff		Evap'n Depth mm	WATER INFLOWS - m3			WATER OUTFLOWS and LOSSES - m3					MAKE-UP WATER REQUIREMENTS					NET INFLOW TO HEAP	Release to Events Pond	TOTAL IN-HEAP STORAGE	
			Stacked tonnes	Volume m3	Under Leach	Total Heap & Overliner	Uncovered Heap	Return Period	Depth mm		Leach Pad Runoff	Other Inflows	TOTAL IN	Evaporation Losses		Permanent Loss to Ore Moisture	Initial Loss to Leaching Ore	TOTAL OUT	Total Required	From Heap Storage	Total Other	From Events Pond	From Fresh				
														Leach Area	Heap&O'Liner									N	O	P	Q
Total	Operating		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	
30	0	13	13-April	0	0	0	315,000	315,000	2	161.0	0	50,715	0	50,715	0	0	0	0	0	0	0	0	0	0	50,715	50,715	500
31	0	13	13-May	0	0	0	315,000	315,000	2	13.3	92.9	4,190	0	4,190	0	1,463	0	1,463	0	0	0	0	0	0	2,726	2,726	500
30	0	13	13-June	0	0	0	315,000	315,000	2	41.7	107.5	13,136	0	13,136	0	1,693	0	1,693	0	0	0	0	0	0	11,442	11,442	500
31	0	13	July	0	0	0	315,000	315,000	2	61.0	98.6	19,215	0	19,215	0	1,553	0	1,553	0	0	0	0	0	0	17,662	17,662	500
31	0	13	Aug	0	0	0	315,000	315,000	2	43.6	71.1	13,734	0	13,734	0	1,120	0	1,120	0	0	0	0	0	0	12,614	12,614	500
30	0	13	Sept	0	0	0	315,000	315,000	2	31.4	32.3	9,891	0	9,891	0	509	0	509	0	0	0	0	0	0	9,382	9,382	500
31	0	13	Oct	0	0	0	315,000	315,000	2	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
30	0	13	Nov	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	13	Dec	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	13	Jan	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
28	0	13	Feb	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	13	March	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
30	0	14	14-April	0	0	0	315,000	315,000	2	161.0	0	50,715	0	50,715	0	0	0	0	0	0	0	0	0	0	50,715	50,715	500
31	0	14	14-May	0	0	0	315,000	315,000	2	13.3	92.9	4,190	0	4,190	0	1,463	0	1,463	0	0	0	0	0	0	2,726	2,726	500
30	0	14	14-June	0	0	0	315,000	315,000	2	41.7	107.5	13,136	0	13,136	0	1,693	0	1,693	0	0	0	0	0	0	11,442	11,442	500
31	0	14	July	0	0	0	315,000	315,000	2	61.0	98.6	19,215	0	19,215	0	1,553	0	1,553	0	0	0	0	0	0	17,662	17,662	500
31	0	14	Aug	0	0	0	315,000	315,000	2	43.6	71.1	13,734	0	13,734	0	1,120	0	1,120	0	0	0	0	0	0	12,614	12,614	500
30	0	14	Sept	0	0	0	315,000	315,000	2	31.4	32.3	9,891	0	9,891	0	509	0	509	0	0	0	0	0	0	9,382	9,382	500
31	0	14	Oct	0	0	0	315,000	315,000	2	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
30	0	14	Nov	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	14	Dec	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	14	Jan	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
28	0	14	Feb	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	14	March	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
30	0	15	15-April	0	0	0	315,000	315,000	2	161.0	0	50,715	0	50,715	0	0	0	0	0	0	0	0	0	0	50,715	50,715	500
31	0	15	15-May	0	0	0	315,000	315,000	2	13.3	92.9	4,190	0	4,190	0	1,463	0	1,463	0	0	0	0	0	0	2,726	2,726	500
30	0	15	15-June	0	0	0	315,000	315,000	2	41.7	107.5	13,136	0	13,136	0	1,693	0	1,693	0	0	0	0	0	0	11,442	11,442	500
31	0	15	July	0	0	0	315,000	315,000	2	61.0	98.6	19,215	0	19,215	0	1,553	0	1,553	0	0	0	0	0	0	17,662	17,662	500
31	0	15	Aug	0	0	0	315,000	315,000	2	43.6	71.1	13,734	0	13,734	0	1,120	0	1,120	0	0	0	0	0	0	12,614	12,614	500
30	0	15	Sept	0	0	0	315,000	315,000	2	31.4	32.3	9,891	0	9,891	0	509	0	509	0	0	0	0	0	0	9,382	9,382	500
31	0	15	Oct	0	0	0	315,000	315,000	2	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
30	0	15	Nov	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	15	Dec	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	15	Jan	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
28	0	15	Feb	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500
31	0	15	March	0	0	0	315,000	315,000	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500

Table I.4 - Carmacks Copper Project - Events Pond Monthly Water Balance

Average Conditions

ROM Ore

Version 1.2

Events Pond Areas			Events Pond Water Storage Limits		
Total Catchment	29,100	m2	Maximum	160,000	m3
Pond Area	5,200	m2	Minimum	500	m3
			Initial	0	m3

In-Heap plus Events Pond																	
YEAR	Month	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL				
		Water Inflows from		Water Losses to		NET INFLOW	Potential Volume in Storage	Treated Volume Released	Untreated Volume	Remaining Volume in Storage	Cumulative Volumes Treated & Released		Total Solution Storage				
		Precipitation	Heap Runoff	Evaporation	Make-up to Heap						Treated	Untreated					
1	-1-March	0	0	0	0	0	0	0	0	0	0	0	0				
1	1-April	4,685	22,362	0	0	27,047	27,047	0	0	27,047	0	0	27,547				
1	1-May	387	1,168	483	0	1,072	28,119	0	0	28,119	0	0	28,619				
1	1-June	1,213	0	559	28,274	-27,619	500	0	0	500	0	0	1,000				
1	July	1,775	0	513	1,282	0	500	0	0	500	0	0	1,000				
1	Aug	1,269	0	370	899	0	500	0	0	500	0	0	1,000				
1	Sept	914	0	168	746	0	500	0	0	500	0	0	1,000				
1	Oct	0	0	0	0	0	500	0	0	500	0	0	1,000				
1	Nov	0	0	0	0	0	500	0	0	500	0	0	1,000				
1	Dec	0	0	0	0	0	500	0	0	500	0	0	1,000				
1	Jan	0	0	0	0	0	500	0	0	500	0	0	1,000				
1	Feb	0	0	0	0	0	500	0	0	500	0	0	1,000				
1	March	0	0	0	0	0	500	0	0	500	0	0	1,000				
2	2-April	4,685	35,259	0	0	39,944	40,444	0	0	40,444	0	0	40,944				
2	2-May	387	1,675	483	0	1,579	42,023	0	0	42,023	0	0	42,523				
2	2-June	1,213	0	559	29,147	-28,492	13,531	0	0	13,531	0	0	14,031				
2	July	1,775	0	513	13,745	-12,483	1,048	0	0	1,048	0	0	1,548				
2	Aug	1,269	0	370	1,447	-548	500	0	0	500	0	0	1,000				
2	Sept	914	0	168	746	0	500	0	0	500	0	0	1,000				
2	Oct	0	0	0	0	0	500	0	0	500	0	0	1,000				
2	Nov	0	0	0	0	0	500	0	0	500	0	0	1,000				
2	Dec	0	0	0	0	0	500	0	0	500	0	0	1,000				
2	Jan	0	0	0	0	0	500	0	0	500	0	0	1,000				
2	Feb	0	0	0	0	0	500	0	0	500	0	0	1,000				
2	March	0	0	0	0	0	500	0	0	500	0	0	1,000				
3	3-April	4,685	35,259	0	0	39,944	40,444	0	0	40,444	0	0	40,944				
3	3-May	387	1,675	483	0	1,579	42,023	0	0	42,023	0	0	42,523				
3	3-June	1,213	0	559	29,147	-28,492	13,531	0	0	13,531	0	0	14,031				
3	July	1,775	0	513	13,745	-12,483	1,048	0	0	1,048	0	0	1,548				
3	Aug	1,269	0	370	1,447	-548	500	0	0	500	0	0	1,000				
3	Sept	914	0	168	746	0	500	0	0	500	0	0	1,000				
3	Oct	0	0	0	0	0	500	0	0	500	0	0	1,000				
3	Nov	0	0	0	0	0	500	0	0	500	0	0	1,000				
3	Dec	0	0	0	0	0	500	0	0	500	0	0	1,000				
3	Jan	0	0	0	0	0	500	0	0	500	0	0	1,000				
3	Feb	0	0	0	0	0	500	0	0	500	0	0	1,000				
3	March	0	0	0	0	0	500	0	0	500	0	0	1,000				
4	4-April	4,685	50,715	0	0	55,400	55,900	0	0	55,900	0	0	56,400				
4	4-May	387	2,506	483	0	2,410	58,310	0	0	58,310	0	0	58,810				
4	4-June	1,213	0	559	26,145	-25,491	32,820	0	0	32,820	0	0	33,320				
4	July	1,775	0	513	8,848	-7,585	25,234	0	0	25,234	0	0	25,734				
4	Aug	1,269	0	370	11,403	-10,504	14,730	0	0	14,730	0	0	15,230				
4	Sept	914	0	168	11,425	-10,680	4,050	0	0	4,050	0	0	4,550				
4	Oct	0	0	0	3,550	-3,550	500	0	0	500	0	0	1,000				
4	Nov	0	0	0	0	0	500	0	0	500	0	0	1,000				
4	Dec	0	0	0	0	0	500	0	0	500	0	0	1,000				
4	Jan	0	0	0	0	0	500	0	0	500	0	0	1,000				
4	Feb	0	0	0	0	0	500	0	0	500	0	0	1,000				
4	March	0	0	0	0	0	500	0	0	500	0	0	1,000				

Table I.4 - Carmacks Copper Project - Events Pond Monthly Water Balance

Average Conditions
ROM Ore

Version 1.2

Events Pond Areas
Total Catchment 29,100 m2
Pond Area 5,200 m2

Events Pond Water Storage Limits
Maximum 160,000 m3
Minimum 500 m3
Initial 0 m3

													In-Heap plus Events Pond
YEAR	Month	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
		Water Inflows from		Water Losses to		NET INFLOW	Potential Volume in Storage	Treated Volume Released	Untreated Volume	Remaining Volume in Storage	Cumulative Volumes Treated & Untreated		Total Solution Storage
		Precipitation Runoff	Heap Storage	Evaporation	Make-up to Heap								
5	5-April	4,685	50,715	0	0	55,400	55,900	0	0	55,900	0	0	56,400
5	5-May	387	2,506	483	0	2,410	58,310	0	0	58,310	0	0	58,810
5	5-June	1,213	0	559	26,145	-25,491	32,820	0	0	32,820	0	0	33,320
5	July	1,775	0	513	8,848	-7,585	25,234	0	0	25,234	0	0	25,734
5	Aug	1,269	0	370	11,403	-10,504	14,730	0	0	14,730	0	0	15,230
5	Sept	914	0	168	11,425	-10,680	4,050	0	0	4,050	0	0	4,550
5	Oct	0	0	0	3,550	-3,550	500	0	0	500	0	0	1,000
5	Nov	0	0	0	0	0	500	0	0	500	0	0	1,000
5	Dec	0	0	0	0	0	500	0	0	500	0	0	1,000
5	Jan	0	0	0	0	0	500	0	0	500	0	0	1,000
5	Feb	0	0	0	0	0	500	0	0	500	0	0	1,000
5	March	0	0	0	0	0	500	0	0	500	0	0	1,000
6	6-April	4,685	50,715	0	0	55,400	55,900	0	0	55,900	0	0	56,400
6	6-May	387	2,506	483	0	2,410	58,310	0	0	58,310	0	0	58,810
6	6-June	1,213	0	559	23,718	-23,064	35,247	0	0	35,247	0	0	35,747
6	July	1,775	0	513	6,421	-5,158	30,088	0	0	30,088	0	0	30,588
6	Aug	1,269	0	370	10,190	-9,291	20,797	0	0	20,797	0	0	21,297
6	Sept	914	0	168	11,425	-10,680	10,117	0	0	10,117	0	0	10,617
6	Oct	0	0	0	9,617	-9,617	500	0	0	500	0	0	1,000
6	Nov	0	0	0	0	0	500	0	0	500	0	0	1,000
6	Dec	0	0	0	0	0	500	0	0	500	0	0	1,000
6	Jan	0	0	0	0	0	500	0	0	500	0	0	1,000
6	Feb	0	0	0	0	0	500	0	0	500	0	0	1,000
6	March	0	0	0	0	0	500	0	0	500	0	0	1,000
7	7-April	4,685	50,715	0	0	55,400	55,900	0	0	55,900	0	0	56,400
7	7-May	387	2,506	483	0	2,410	58,310	0	0	58,310	0	0	58,810
7	7-June	1,213	0	559	23,718	-23,064	35,247	0	0	35,247	0	0	35,747
7	July	1,775	0	513	6,421	-5,158	30,088	0	0	30,088	0	0	30,588
7	Aug	1,269	0	370	10,190	-9,291	20,797	0	0	20,797	0	0	21,297
7	Sept	914	0	168	11,425	-10,680	10,117	0	0	10,117	0	0	10,617
7	Oct	0	0	0	9,617	-9,617	500	0	0	500	0	0	1,000
7	Nov	0	0	0	0	0	500	0	0	500	0	0	1,000
7	Dec	0	0	0	0	0	500	0	0	500	0	0	1,000
7	Jan	0	0	0	0	0	500	0	0	500	0	0	1,000
7	Feb	0	0	0	0	0	500	0	0	500	0	0	1,000
7	March	0	0	0	0	0	500	0	0	500	0	0	1,000
8	8-April	4,685	50,715	0	0	55,400	55,900	0	0	55,900	0	0	56,400
8	8-May	387	2,506	483	0	2,410	58,310	0	0	58,310	0	0	58,810
8	8-June	1,213	0	559	9,986	-9,332	48,979	48,479	0	500	48,479	0	1,000
8	July	1,775	17,428	513	0	18,691	19,191	18,691	0	500	67,169	0	1,000
8	Aug	1,269	12,446	370	0	13,345	13,845	13,345	0	500	80,514	0	1,000
8	Sept	914	9,306	168	0	10,052	10,552	10,052	0	500	90,566	0	1,000
8	Oct	0	0	0	0	0	500	0	0	500	90,566	0	1,000
8	Nov	0	0	0	0	0	500	0	0	500	90,566	0	1,000
8	Dec	0	0	0	0	0	500	0	0	500	90,566	0	1,000
8	Jan	0	0	0	0	0	500	0	0	500	90,566	0	1,000
8	Feb	0	0	0	0	0	500	0	0	500	90,566	0	1,000
8	March	0	0	0	0	0	500	0	0	500	90,566	0	1,000

Table I.4 - Carmacks Copper Project - Events Pond Monthly Water Balance

Average Conditions

ROM Ore

Version 1.2

Events Pond Areas
 Total Catchment 29,100 m2
 Pond Area 5,200 m2

Events Pond Water Storage Limits
 Maximum 160,000 m3
 Minimum 500 m3
 Initial 0 m3

YEAR	Month	Water Inflows from		Water Losses to		NET INFLOW	Potential Volume in Storage	Treated Volume Released	Untreated Volume	Remaining Volume in Storage	Cumulative Volumes		Total Solution Storage
		Precipitation Runoff	Heap Storage	Evaporation	Make-up to Heap						Treated & Released	Untreated	
		AA	AB	AC	AD						AJ	AK	
9	9-April	4,685	50,715	0	0	55,400	55,900	0	0	55,900	90,566	0	56,400
9	9-May	387	2,506	483	0	2,410	58,310	57,810	0	500	148,376	0	1,000
9	9-June	1,213	11,188	559	0	11,842	12,342	11,842	0	500	160,218	0	1,000
9	9-July	1,775	17,428	513	0	18,691	19,191	18,691	0	500	178,909	0	1,000
9	9-Aug	1,269	12,446	370	0	13,345	13,845	13,345	0	500	192,253	0	1,000
9	9-Sept	914	9,306	168	0	10,052	10,552	10,052	0	500	202,305	0	1,000
9	9-Oct	0	0	0	0	0	500	0	0	500	202,305	0	1,000
9	9-Nov	0	0	0	0	0	500	0	0	500	202,305	0	1,000
9	9-Dec	0	0	0	0	0	500	0	0	500	202,305	0	1,000
9	9-Jan	0	0	0	0	0	500	0	0	500	202,305	0	1,000
9	9-Feb	0	0	0	0	0	500	0	0	500	202,305	0	1,000
9	9-March	0	0	0	0	0	500	0	0	500	202,305	0	1,000
10	10-April	4,685	50,715	0	0	55,400	55,900	55,400	0	500	257,705	0	1,000
10	10-May	387	8,119	483	0	8,023	8,523	8,023	0	500	265,728	0	1,000
10	10-June	1,213	16,835	559	0	17,490	17,990	17,490	0	500	283,218	0	1,000
10	10-July	1,775	23,055	513	0	24,317	24,817	24,317	0	500	307,536	0	1,000
10	10-Aug	1,269	18,007	370	0	18,906	19,406	18,906	0	500	326,442	0	1,000
10	10-Sept	914	14,775	168	0	15,521	16,021	15,521	0	500	341,963	0	1,000
10	10-Oct	0	5,393	0	0	5,393	5,893	5,393	0	500	347,356	0	1,000
10	10-Nov	0	0	0	0	0	500	0	0	500	347,356	0	1,000
10	10-Dec	0	0	0	0	0	500	0	0	500	347,356	0	1,000
10	10-Jan	0	0	0	0	0	500	0	0	500	347,356	0	1,000
10	10-Feb	0	0	0	0	0	500	0	0	500	347,356	0	1,000
10	10-March	0	0	0	0	0	500	0	0	500	347,356	0	1,000
11	11-April	4,685	50,715	0	0	55,400	55,900	55,400	0	500	402,756	0	1,000
11	11-May	387	8,119	483	0	8,023	8,523	8,023	0	500	410,780	0	1,000
11	11-June	1,213	16,835	559	0	17,490	17,990	17,490	0	500	428,269	0	1,000
11	11-July	1,775	23,055	513	0	24,317	24,817	24,317	0	500	452,587	0	1,000
11	11-Aug	1,269	18,007	370	0	18,906	19,406	18,906	0	500	471,493	0	1,000
11	11-Sept	914	14,775	168	0	15,521	16,021	15,521	0	500	487,014	0	1,000
11	11-Oct	0	5,393	0	0	5,393	5,893	5,393	0	500	492,407	0	1,000
11	11-Nov	0	0	0	0	0	500	0	0	500	492,407	0	1,000
11	11-Dec	0	0	0	0	0	500	0	0	500	492,407	0	1,000
11	11-Jan	0	0	0	0	0	500	0	0	500	492,407	0	1,000
11	11-Feb	0	0	0	0	0	500	0	0	500	492,407	0	1,000
11	11-March	0	0	0	0	0	500	0	0	500	492,407	0	1,000
12	12-April	4,685	50,715	0	0	55,400	55,900	55,400	0	500	547,808	0	1,000
12	12-May	387	8,119	483	0	8,023	8,523	8,023	0	500	555,831	0	1,000
12	12-June	1,213	16,835	559	0	17,490	17,990	17,490	0	500	573,321	0	1,000
12	12-July	1,775	23,055	513	0	24,317	24,817	24,317	0	500	597,638	0	1,000
12	12-Aug	1,269	18,007	370	0	18,906	19,406	18,906	0	500	616,545	0	1,000
12	12-Sept	914	14,775	168	0	15,521	16,021	15,521	0	500	632,066	0	1,000
12	12-Oct	0	5,393	0	0	5,393	5,893	5,393	0	500	637,459	0	1,000
12	12-Nov	0	0	0	0	0	500	0	0	500	637,459	0	1,000
12	12-Dec	0	0	0	0	0	500	0	0	500	637,459	0	1,000
12	12-Jan	0	0	0	0	0	500	0	0	500	637,459	0	1,000
12	12-Feb	0	0	0	0	0	500	0	0	500	637,459	0	1,000
12	12-March	0	0	0	0	0	500	0	0	500	637,459	0	1,000

Table I.4 - Carmacks Copper Project - Events Pond Monthly Water Balance

Average Conditions
ROM Ore

Version 1.2

Events Pond Areas
Total Catchment 29,100 m²
Pond Area 5,200 m²

Events Pond Water Storage Limits

Maximum 160,000 m³
Minimum 500 m³
Initial 0 m³

		In-Heap plus Events Pond											
		AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
YEAR	Month	Water Inflows from		Water Losses to		NET INFLOW	Potential Volume in Storage	Treated Volume Released	Untreated Volume	Remaining Volume in Storage	Cumulative Volumes		Total Solution Storage
		Precipitation	Heap	Evaporation	Make-up						Treated &	Untreated	
		Runoff	Storage		to Heap						Released	Released	
13	13-April	4,685	50,715	0	0	55,400	55,900	55,400	0	500	692,859	0	1,000
13	13-May	387	2,726	483	0	2,630	3,130	2,630	0	500	695,489	0	1,000
13	13-June	1,213	11,442	559	0	12,097	12,597	12,097	0	500	707,586	0	1,000
13	July	1,775	17,662	513	0	18,924	19,424	18,924	0	500	726,510	0	1,000
13	Aug	1,269	12,614	370	0	13,513	14,013	13,513	0	500	740,024	0	1,000
13	Sept	914	9,382	168	0	10,128	10,628	10,128	0	500	750,152	0	1,000
13	Oct	0	0	0	0	0	500	0	0	500	750,152	0	1,000
13	Nov	0	0	0	0	0	500	0	0	500	750,152	0	1,000
13	Dec	0	0	0	0	0	500	0	0	500	750,152	0	1,000
13	Jan	0	0	0	0	0	500	0	0	500	750,152	0	1,000
13	Feb	0	0	0	0	0	500	0	0	500	750,152	0	1,000
13	March	0	0	0	0	0	500	0	0	500	750,152	0	1,000
14	14-April	4,685	50,715	0	0	55,400	55,900	55,400	0	500	805,552	0	1,000
14	14-May	387	2,726	483	0	2,630	3,130	2,630	0	500	808,182	0	1,000
14	14-June	1,213	11,442	559	0	12,097	12,597	12,097	0	500	820,279	0	1,000
14	July	1,775	17,662	513	0	18,924	19,424	18,924	0	500	839,203	0	1,000
14	Aug	1,269	12,614	370	0	13,513	14,013	13,513	0	500	852,717	0	1,000
14	Sept	914	9,382	168	0	10,128	10,628	10,128	0	500	862,845	0	1,000
14	Oct	0	0	0	0	0	500	0	0	500	862,845	0	1,000
14	Nov	0	0	0	0	0	500	0	0	500	862,845	0	1,000
14	Dec	0	0	0	0	0	500	0	0	500	862,845	0	1,000
14	Jan	0	0	0	0	0	500	0	0	500	862,845	0	1,000
14	Feb	0	0	0	0	0	500	0	0	500	862,845	0	1,000
14	March	0	0	0	0	0	500	0	0	500	862,845	0	1,000
15	15-April	4,685	50,715	0	0	55,400	55,900	55,900	0	0	918,745	0	500
15	15-May	387	2,726	483	0	2,630	2,630	2,630	0	0	921,375	0	500
15	15-June	1,213	11,442	559	0	12,097	12,097	12,097	0	0	933,472	0	500
15	July	1,775	17,662	513	0	18,924	18,924	18,924	0	0	952,396	0	500
15	Aug	1,269	12,614	370	0	13,513	13,513	13,513	0	0	965,909	0	500
15	Sept	914	9,382	168	0	10,128	10,128	10,128	0	0	976,038	0	500
15	Oct	0	0	0	0	0	0	0	0	0	976,038	0	500
15	Nov	0	0	0	0	0	0	0	0	0	976,038	0	500
15	Dec	0	0	0	0	0	0	0	0	0	976,038	0	500
15	Jan	0	0	0	0	0	0	0	0	0	976,038	0	500
15	Feb	0	0	0	0	0	0	0	0	0	976,038	0	500
15	March	0	0	0	0	0	0	0	0	0	976,038	0	500

FIGURE I.1 - Events Pond Water Storage Variation
Average Conditions

VERSION 1.2
Run-of-Mine (ROM) Ore

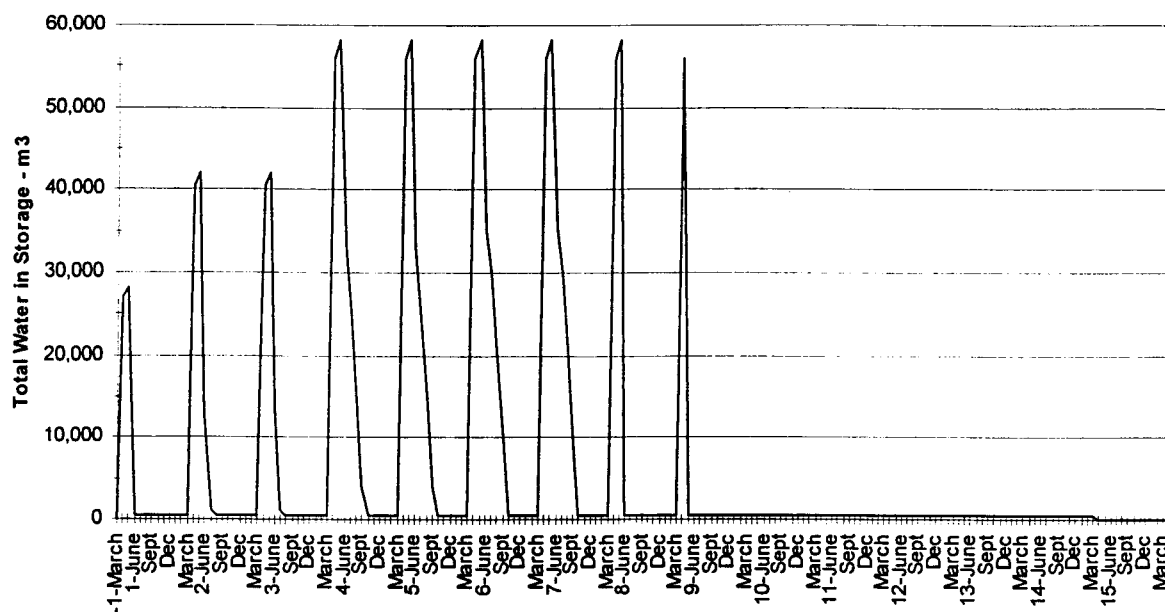
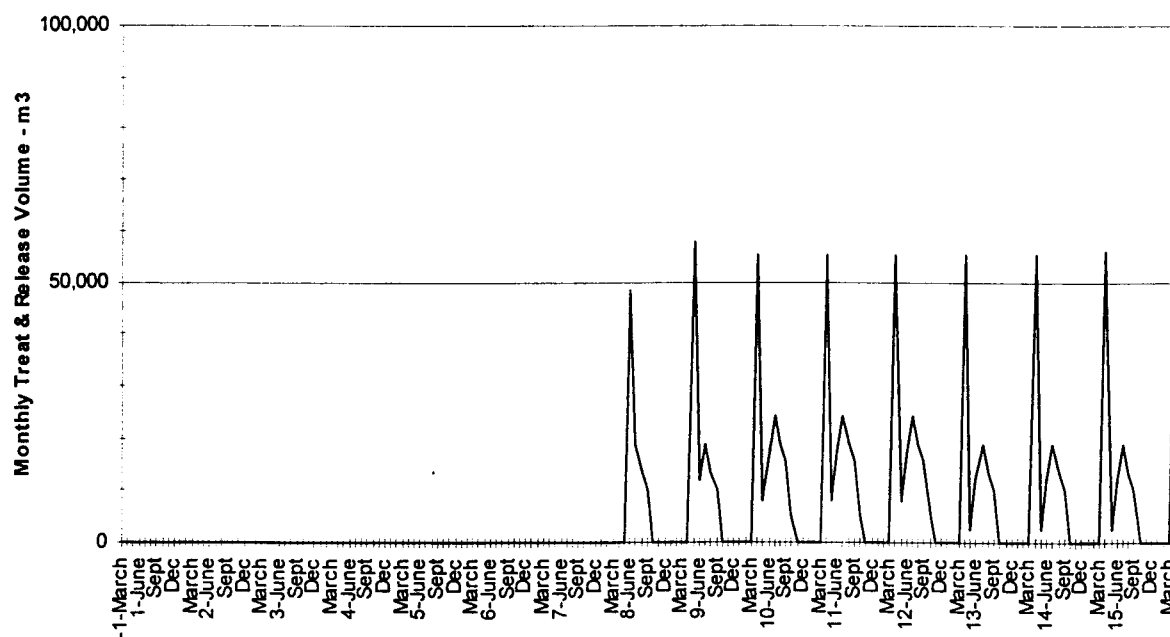


FIGURE I.2 - Variation in Monthly Treat and Release Volumes
Average Conditions



APPENDIX II

Carmacks Copper Project Heap Leach Facility Water Balance Dry and Wet Years

Run-of-Mine (ROM) Ore

Table II.1 - Summary of Monthly Water Balance - Dry Years

Table II.2 - Summary of Monthly Water Balance - Wet Years

Table II.3 - Summary of Annual Water Balances - Average, Dry & Wet Years

Table II.1 - Summary of Monthly Water Balance**Dry Years****VERSION 1.2**

	<u>Maximum</u>	<u>Minimum</u>	<u>Initial</u>	
Nominal In-Heap Storage	500	500	500	m3
Events Pond Storage	160,000	500	0	m3
Total Solution Storage	160,500	1,000	500	m3

<u>Ore Moistures</u>	
Initial	3.0%
Leaching	12.0%
Residual	10.0%

Treatment Capacity = 270 m3/hour
Maximum Daily Ore Production 9,872 tpd

Run-of-Mine (ROM) Ore

Year	Stage	Precipitation Return Period	In-Heap Storage		Events Pond Storage		Maximum Total Storage	Total Treated	Total Spilled	Make-Up Water (Fresh)
			Minimum Volume	Maximum Volume	Minimum Volume	Maximum Volume				
1	I	20 yr Dry	500	500	500	19,719	20,219	-	-	138,815
2	II	20 yr Dry	500	500	500	29,842	30,342	-	-	92,490
3	II	20 yr Dry	500	500	500	29,842	30,342	-	-	92,571
4	III	20 yr Dry	500	500	500	41,416	41,916	-	-	61,356
5	III	20 yr Dry	500	500	500	41,416	41,916	-	-	58,181
6	III	20 yr Dry	500	500	500	41,416	41,916	-	-	52,148
7	III	20 yr Dry	500	500	500	41,416	41,916	-	-	41,641
8	III / IV	20 yr Dry	500	500	500	41,416	41,916	58,220	-	-
9	IV	20 yr Dry	500	500	500	40,162	40,662	79,394	-	-
10	V	20 yr Dry	500	500	500	500	1,000	112,706	-	-
11	V	20 yr Dry	500	500	500	500	1,000	112,706	-	-
12	V	20 yr Dry	500	500	500	500	1,000	112,706	-	-
13	VI	20 yr Dry	500	500	500	500	1,000	80,348	-	-
14	VI	20 yr Dry	500	500	500	500	1,000	80,348	-	-
15	VI	20 yr Dry	500	500	-	-	500	80,848	-	-

NOTES 1) All volumes in cubic metres.

2) "Maximum Total Water Storage" corresponds to the maximum concurrent total of In-Heap plus Events Pond storage.

3) Return Period is for Annual Precipitation, Rainfall and Snowfall.

Table II.2 - Summary of Monthly Water Balance**Wet Years****VERSION 1.2**

	<u>Maximum</u>	<u>Minimum</u>	<u>Initial</u>		<u>Ore Moistures</u>	
Nominal In-Heap Storage	500	500	500	m3	Initial	3.0%
Events Pond Storage	160,000	500	0	m3	Leaching	12.0%
Total Solution Storage	160,500	1,000	500	m3	Residual	10.0%

Treatment Capacity = 270 m3/hour
Maximum Daily Ore Production 9,872 tpd

Run-of-Mine (ROM) Ore

Year	Stage	Precipitation Return Period	In-Heap Storage		Events Pond Storage		Maximum Total Storage	Total Treated	Total Spilled	Make-Up Water (Fresh)
			Minimum Volume	Maximum Volume	Minimum Volume	Maximum Volume				
1	I	100	500	500	500	43,222	43,722	-	-	93,816
2	II	100	500	500	500	63,923	64,423	-	-	27,239
3	II	100	500	500	500	63,923	64,423	-	-	27,321
4	III	100	500	500	500	88,684	89,184	29,142	-	-
5	III	100	500	500	500	88,684	89,184	32,318	-	-
6	III	100	500	500	500	88,684	89,184	38,350	-	-
7	III	100	500	500	500	88,684	89,184	48,857	-	-
8	III / IV	100	500	500	500	88,684	89,184	148,718	-	-
9	IV	100	500	500	500	84,195	84,695	169,892	-	-
10	V	100	500	500	500	500	1,000	203,204	-	-
11	V	100	500	500	500	500	1,000	203,204	-	-
12	V	100	500	500	500	500	1,000	203,204	-	-
13	VI	100	500	500	500	500	1,000	170,846	-	-
14	VI	100	500	500	500	500	1,000	170,846	-	-
15	VI	100	500	500	-	-	500	171,346	-	-

- NOTES**
- 1) All volumes in cubic metres.
 - 2) "Maximum Total Water Storage" corresponds to the maximum concurrent total of In-Heap plus Events Pond storage.
 - 3) Return Period is for Annual Precipitation, Rainfall and Snowfall. Results are for individual years with 100 year return periods with average conditions assumed for all preceeding and following years..

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[illegible]

(all volumes in cubic metres per year)

YEAR	Stacked Ore tonnes	Runoff Depth mm	Evap. Depth mm	Runoff Inflows		TOTAL RUNOFF IN	Evaporation & Ore Moisture Losses					TOTAL LOSSES OUT	Make-Up Water			NET TOTAL INFLOW	Release to Events Pond	Treat and Release AG	Remaining Solution in Storage at Year-End
				Leach Pad	Events Pond		Leach Area	Heap & O'Liner	Events Pond	Ore Moisture to			From Heap	From E. Pond	From Fresh U				
										Permanent	Leaching								
Average Conditions							L	M	AC	N	M		R	T	U		W		
1	1,963,500	352	402	49,984	10,243	60,227	1,469	2,123	2,092	137,445	38,830	181,959	-	31,181	122,732	1,000	23,530	-	1,000
2	1,973,229	352	402	77,088	10,243	87,331	1,907	3,453	2,092	138,126	10,921	156,499	-	45,085	69,168	0	36,934	-	1,000
3	1,974,396	352	402	77,088	10,243	87,331	1,907	3,453	2,092	138,208	10,921	156,581	-	45,085	69,250	0	36,934	-	1,000
4	1,837,363	352	402	110,880	10,243	121,123	1,907	5,384	2,092	128,615	12,134	150,134	-	61,372	29,011	0	53,221	-	1,000
5	1,792,000	352	402	110,880	10,243	121,123	1,907	5,384	2,092	125,440	12,134	146,958	-	61,372	25,835	0	53,221	-	1,000
6	1,792,500	352	402	110,880	10,243	121,123	1,907	5,384	2,092	125,475	6,067	140,926	-	61,372	19,803	-	53,221	-	1,000
7	1,642,400	352	402	110,880	10,243	121,123	1,907	5,384	2,092	114,968	6,067	130,419	-	61,372	9,296	0	53,221	-	1,000
8	302,481	352	402	110,880	10,243	121,123	1,907	5,384	2,092	21,174	-	30,558	-	9,986	-	90,566	92,401	90,566	1,000
9	-	352	402	110,880	10,243	121,123	1,907	5,384	2,092	-	-	9,384	-	-	-	111,739	103,589	111,739	1,000
10	-	352	402	110,880	10,243	121,123	-	6,338	2,092	-	-	32,358	-	-	-	145,051	136,901	145,051	1,000
11	-	352	402	110,880	10,243	121,123	-	6,338	2,092	-	-	32,358	-	-	-	145,051	136,901	145,051	1,000
12	-	352	402	110,880	10,243	121,123	-	6,338	2,092	-	-	32,358	-	-	-	145,051	136,901	145,051	1,000
13	-	352	402	110,880	10,243	121,123	-	6,338	2,092	-	-	-	-	-	-	112,693	104,542	112,693	1,000
14	-	352	402	110,880	10,243	121,123	-	6,338	2,092	-	-	-	-	-	-	112,693	104,542	112,693	1,000
15	-	352	402	110,880	10,243	121,123	-	6,338	2,092	-	-	-	-	-	-	112,693	104,542	113,193	500
Dry Years (20-year Return Period)																			
1	1,963,500	258	402	36,636	7,508	44,144	1,469	2,123	2,092	137,445	38,830	181,959	-	21,474	138,815	1,000	16,558	-	1,000
2	1,973,229	258	402	56,502	7,508	64,010	1,907	3,453	2,092	138,126	10,921	156,499	-	31,597	92,490	-	26,182	-	1,000
3	1,974,396	258	402	56,502	7,508	64,010	1,907	3,453	2,092	138,208	10,921	156,581	-	31,597	92,571	-	26,182	-	1,000
4	1,837,363	258	402	81,270	7,508	88,778	1,907	5,384	2,092	128,615	12,134	150,134	-	43,171	61,356	-	37,755	-	1,000
5	1,792,000	258	402	81,270	7,508	88,778	1,907	5,384	2,092	125,440	12,134	146,958	-	43,171	58,181	-	37,755	-	1,000
6	1,792,500	258	402	81,270	7,508	88,778	1,907	5,384	2,092	125,475	6,067	140,926	-	43,171	52,148	-	37,755	-	1,000
7	1,642,400	258	402	81,270	7,508	88,778	1,907	5,384	2,092	114,968	6,067	130,419	-	43,171	41,641	-	37,755	-	1,000
8	302,481	258	402	81,270	7,508	88,778	1,907	5,384	2,092	21,174	-	30,558	-	13,305	-	58,220	66,110	58,220	1,000
9	-	258	402	81,270	7,508	88,778	1,907	5,384	2,092	-	-	9,384	-	-	-	79,394	73,979	79,394	1,000
10	-	258	402	81,270	7,508	88,778	-	6,338	2,092	-	-	32,358	-	-	-	112,706	107,291	112,706	1,000
11	-	258	402	81,270	7,508	88,778	-	6,338	2,092	-	-	32,358	-	-	-	112,706	107,291	112,706	1,000
12	-	258	402	81,270	7,508	88,778	-	6,338	2,092	-	-	32,358	-	-	-	112,706	107,291	112,706	1,000
13	-	258	402	81,270	7,508	88,778	-	6,338	2,092	-	-	-	-	-	-	80,348	74,932	80,348	1,000
14	-	258	402	81,270	7,508	88,778	-	6,338	2,092	-	-	-	-	-	-	80,348	74,932	80,348	1,000
15	-	258	402	81,270	7,508	88,778	-	6,338	2,092	-	-	-	-	-	-	80,348	74,932	80,848	500
Wet Years (100-year Return Period)																			
1	1,963,500	521	402	73,982	15,161	89,143	1,469	2,123	2,092	137,445	38,830	181,959	-	48,633	93,816	1,000	36,065	-	1,000
2	1,973,229	521	402	114,099	15,161	129,260	1,907	3,453	2,092	138,126	10,921	156,499	-	69,334	27,239	-	56,266	-	1,000
3	1,974,396	521	402	114,099	15,161	129,260	1,907	3,453	2,092	138,208	10,921	156,581	-	69,334	27,321	-	56,266	-	1,000
4	1,837,363	521	402	164,115	15,161	179,276	1,907	5,384	2,092	128,615	12,134	150,134	-	64,953	-	29,142	81,026	29,142	1,000
5	1,792,000	521	402	164,115	15,161	179,276	1,907	5,384	2,092	125,440	12,134	146,958	-	61,777	-	32,318	81,026	32,318	1,000
6	1,792,500	521	402	164,115	15,161	179,276	1,907	5,384	2,092	125,475	6,067	140,926	-	58,054	-	38,350	83,335	38,350	1,000
7	1,642,400	521	402	164,115	15,161	179,276	1,907	5,384	2,092	114,968	6,067	130,419	-	47,547	-	48,857	83,335	48,857	1,000
8	302,481	521	402	164,115	15,161	179,276	1,907	5,384	2,092	21,174	-	30,558	-	4,019	-	148,718	129,668	148,718	1,000
9	-	521	402	164,115	15,161	179,276	1,907	5,384	2,092	-	-	9,384	-	-	-	169,892	156,824	169,892	1,000
10	-	521	402	164,115	15,161	179,276	-	6,338	2,092	-	-	32,358	-	-	-	203,204	190,136	203,204	1,000
11	-	521	402	164,115	15,161	179,276	-	6,338	2,092	-	-	32,358	-	-	-	203,204	190,136	203,204	1,000
12	-	521	402	164,115	15,161	179,276	-	6,338	2,092	-	-	32,358	-	-	-	203,204	190,136	203,204	1,000
13	-	521	402	164,115	15,161	179,276	-	6,338	2,092	-	-	-	-	-	-	170,846	157,777	170,846	1,000
14	-	521	402	164,115	15,161	179,276	-	6,338	2,092	-	-	-	-	-	-	170,846	157,777	170,846	1,000
15	-	521	402	164,115	15,161	179,276	-	6,338	2,092	-	-	-	-	-	-	170,846	157,777	171,346	500

APPENDIX III

Carmacks Copper Project
Heap Leach Facility Water Balance
Design Inflow Events and Storage Volumes

Run-of-Mine (ROM) Ore

Table III.1 - Carmacks Copper Project - Design Inflow Events and Storage Volumes

Run-of-Mine (ROM) Ore

In-Heap Storage Volumes **Maximum** **Minimum**
 500 500 m3

VERSION	1.2

Events Pond Storage

CASE	HYDROLOGIC EVENT	Month	Month-End Volumes (m3) in Events Pond Storage														
			Year 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	Base Case Average Conditions	372 mm/year	April	27,047	40,444	40,444	55,900	55,900	55,900	55,900	55,900	500	500	500	500	500	0
	- Average Snowmelt in April		May	28,119	42,023	42,023	58,310	58,310	58,310	58,310	58,310	500	500	500	500	500	0
	Total April Runoff =	161 mm	June	500	13,531	13,531	32,820	32,820	35,247	35,247	500	500	500	500	500	500	0
	May Runoff =	13.3 mm	July	500	1,048	1,048	25,234	25,234	30,088	30,088	500	500	500	500	500	500	0
	(average runoff thereafter)		August	500	500	500	14,730	14,730	20,797	20,797	500	500	500	500	500	500	0
			Sept	500	500	500	4,050	4,050	10,117	10,117	500	500	500	500	500	500	0
			Oct	500	500	500	500	500	500	500	500	500	500	500	500	500	0
AI	Base Case Average Conditions		April	27,047	40,444	40,444	55,900	55,900	55,900	55,900	55,900	500	500	500	500	500	0
	Snowmelt in April...Total April Runoff =	161 mm	May	52,364	77,179	77,179	107,069	107,069	107,069	107,069	107,069	500	500	500	500	500	0
	PLUS 100 year One Month Wet Period		June	16,223	48,687	48,687	81,579	81,579	84,005	84,005	500	500	500	500	500	500	0
	May Runoff =	155 mm	July	500	36,204	36,204	73,993	73,993	78,847	78,847	500	500	500	500	500	500	0
	(average runoff thereafter)		August	500	22,098	22,098	63,489	63,489	69,556	69,556	500	500	500	500	500	500	0
			Sept	500	8,559	8,559	52,809	52,809	58,876	58,876	500	500	500	500	500	500	0
			Oct	500	500	500	11,639	8,463	8,498	500	500	500	500	500	500	500	0
All	Base Case Average Conditions		April	27,047	40,444	40,444	55,900	55,900	55,900	55,900	55,900	500	500	500	500	500	0
	Snowmelt in April...Total April Runoff =	161 mm	May	45,434	67,131	67,131	93,133	93,133	93,133	93,133	93,133	500	500	500	500	500	0
	PLUS 100 year Two Month Wet Period		June	21,750	56,700	56,700	92,693	92,693	95,120	95,120	500	500	500	500	500	500	0
	May Runoff =	114.5 mm	July	3,198	44,218	44,218	85,108	85,108	89,962	89,962	500	500	500	500	500	500	0
	June Runoff =	114.5 mm	August	500	30,112	30,112	74,603	74,603	80,671	80,671	500	500	500	500	500	500	0
	(average runoff thereafter)		Sept	500	16,573	16,573	63,924	63,924	69,991	69,991	500	500	500	500	500	500	0
			Oct	500	500	500	11,639	8,463	8,498	500	500	500	500	500	500	500	0
AllI	Base Case Average Conditions		April	27,047	40,444	40,444	55,900	55,900	55,900	55,900	55,900	500	500	500	500	500	0
	Snowmelt in April...Total April Runoff =	161 mm	May	42,269	62,541	62,541	86,767	86,767	86,767	86,767	86,767	500	500	500	500	500	0
	PLUS 100 year Three Month Wet Period		June	15,419	47,521	47,521	79,961	79,961	82,388	82,388	500	500	500	500	500	500	0
	May Runoff =	96 mm	July	2,855	43,722	43,722	84,420	84,420	89,273	89,273	500	500	500	500	500	500	0
	June Runoff =	96 mm	August	500	29,615	29,615	73,915	73,915	79,982	79,982	500	500	500	500	500	500	0
	July Runoff =	96 mm	Sept	500	16,076	16,076	63,235	63,235	69,303	69,303	500	500	500	500	500	500	0
	(average runoff thereafter)		Oct	500	500	500	11,639	8,463	8,498	500	500	500	500	500	500	500	0
B	100 year Wet Year	541 mm/year	April	41,308	61,124	61,124	84,581	84,581	84,581	84,581	84,581	500	500	500	500	500	0
	with Snowmelt in April		May	43,413	64,200	64,200	89,068	89,068	89,068	89,068	89,068	500	500	500	500	500	0
	Total April Runoff =	244 mm	June	10,509	40,401	40,401	70,087	70,087	72,513	72,513	500	500	500	500	500	500	0
	Total May Runoff =	19.3 mm	July	500	34,784	34,784	72,024	72,024	76,877	76,877	500	500	500	500	500	500	0
	(monthly precipitation prorated each month)		August	500	25,585	25,585	68,325	68,325	74,393	74,393	500	500	500	500	500	500	0
			Sept	500	15,580	15,580	62,547	62,547	68,614	68,614	500	500	500	500	500	500	0
			Oct	500	500	500	11,639	8,463	8,498	500	500	500	500	500	500	500	0
B1	100 year Wet Year		April	52,712	77,659	77,659	107,515	107,515	107,515	107,515	107,515	500	500	500	500	500	0
	with 100 Year Snowmelt in APRIL		May	54,022	79,584	79,584	110,404	110,404	110,404	110,404	110,404	500	500	500	500	500	0
	Total April Runoff =	311 mm	June	18,629	52,175	52,175	86,416	86,416	88,843	88,843	500	500	500	500	500	500	0
	Total May Runoff =	14.7 mm	July	1,169	41,277	41,277	81,029	81,029	85,883	85,883	500	500	500	500	500	500	0
	(April runoff from 7 Month Wet Period)		August	500	28,304	28,304	72,096	72,096	78,163	78,163	500	500	500	500	500	500	0
			Sept	500	15,580	15,580	62,547	62,547	68,614	68,614	500	500	500	500	500	500	0
			Oct	500	500	500	11,639	8,463	8,498	500	500	500	500	500	500	500	0
B2	100 year Wet Year		April	0	500	500	500	500	500	500	500	500	500	500	500	500	0
	with 100 Year Snowmelt in MAY		May	53,904	79,412	79,412	110,166	110,166	110,166	110,166	110,166	500	500	500	500	500	0
	Total April Runoff =	0 mm	June	18,538	52,043	52,043	86,234	86,234	88,661	88,661	500	500	500	500	500	500	0
	Total May Runoff =	325 mm	July	1,119	41,204	41,204	80,928	80,928	85,782	85,782	500	500	500	500	500	500	0
	(May runoff from 8 Month Wet Period)		August	500	28,273	28,273	72,053	72,053	78,121	78,121	500	500	500	500	500	500	0
			Sept	500	15,580	15,580	62,547	62,547	68,614	68,614	500	500	500	500	500	500	0
			Oct	500	500	500	11,639	8,463	8,498	500	500	500	500	500	500	500	0

Table III.1 (continued)

Run-of-Mine (ROM) Ore

Inflow Volumes from Process-Related Events

VERSION 1.2

Heap Draindown Volumes

Maximum Area under Leach 47,400 m2
 Leaching Lift Height 8 m
 Dry Density of Heap Ore 1.6 t/m3
 Leaching Ore Moisture Content 12.0% by weight
 Residual Ore Moisture Content 10.0% by weight

Max. Solution Flow On Pad 540 m3/hr
 Use 100% of Full Draindown Volume in Year 1
 Maximum of 25,920 m3 thereafter
 (Equal to 2.0 days at maximum solution flow)

Period	100% Draindown	# Lifts	Year 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Stage I - end of Year 1	38,830 m3	3.2	38,830														
end of Year 2	49,751 m3	4.1		25,920													
Stage II - end of Year 3	60,672 m3	5			25,920												
end of Year 4	72,806 m3	6				25,920											
end of Year 5	84,941 m3	7					25,920										
Stage III - end of Year 6	91,008 m3	7.5						25,920									
end of Year 7	97,075 m3	8							25,920								
Stage IV - end of Year 8	97,075 m3	8								25,920							
end of Year 9	97,075 m3	8									25,920						
Stage V - start of Year 10	97,075 m3	0										25,920					
start of year 11	64,717 m3	0											25,920				
start of Year 12	32,358 m3	0												25,920			
Stage VI - Years 13 to ...	- m3	0													0	0	0

NOTES

1) During the first year, potential draindown volumes increase from zero at the end of May to the maximum indicated above by the end of November
 100% draindown volumes at the end of each month during Year 1 are:

April 0 m3
 May 0 m3
 June 9,280 m3
 July 15,401 m3
 August 21,522 m3
 September 27,445 m3
 October 33,566 m3
 November 38,831 m3

These draindown volumes are added for the respective months for Year 1 ONLY.

2) The total draindown "inventory" is assumed to be progressively treated and released during Years 10, 11 and 12.

Evaporation Losses from Ore Sprinkling during May

No ore will be placed or sprinkled during May if Snowmelt occurs during May.
 i.e. these evaporation losses are added for Case B2 ONLY

Case	100% Snowmelt in	Year 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A - Base Case Average Conditions	April															
Al - Base Case + 100 year One Month	April															
Aii - Base Case + 100 year Two Month	April															
Aiii - Base Case + 100 year Three Month	April															
B - 100 year Wet Year	April															
B1 - 100 yr. Wet Yr with 100 yr. APRIL Snowmelt	April															
B2 - 100 yr. Wet Yr with 100 yr. MAY Snowmelt	May	720	1,237	1,237	1,683	1,683	1,683	1,683	1,683	1,683						

Table III.1 (continued)

Combinations of Events - Total Solution Storage Requirements - Events Pond

Event Combinations are: Hydrologic Cases plus Process-Related Events

(Note - Hydrologic cases determined from water balance model runs and include minimum pond operating volume at all times)

Run-of-Mine (ROM) Ore

VERSION 1.2

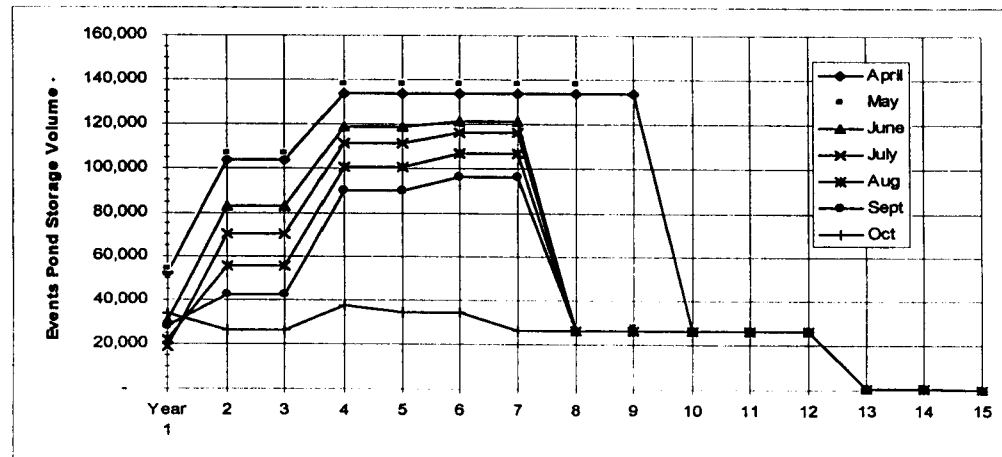
			Total Events Pond Solution Storage (m3) at end of indicated month and Year														
CASE	DESCRIPTION	Month	Year 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	Base Case Average Conditions plus Draindown allowance	April	27,047	66,364	66,364	81,820	81,820	81,820	81,820	81,820	81,820	26,420	26,420	26,420	500	500	-
		May	28,119	67,943	67,943	84,230	84,230	84,230	84,230	84,230	26,420	26,420	26,420	26,420	500	500	-
		June	9,780	39,451	39,451	58,740	58,740	61,167	61,167	26,420	26,420	26,420	26,420	26,420	500	500	-
		July	15,901	26,968	26,968	51,154	51,154	56,008	56,008	26,420	26,420	26,420	26,420	26,420	500	500	-
		August	22,022	26,420	26,420	40,650	40,650	46,717	46,717	26,420	26,420	26,420	26,420	26,420	500	500	-
		Sept	27,945	26,420	26,420	29,970	29,970	36,037	36,037	26,420	26,420	26,420	26,420	26,420	500	500	-
		Oct	34,066	26,420	26,420	26,420	26,420	26,420	26,420	26,420	26,420	26,420	26,420	26,420	500	500	-
AI	Base Case Average Conditions plus 100 year One Month Wet Period plus Draindown allowance	April	27,047	66,364	66,364	81,820	81,820	81,820	81,820	81,820	81,820	26,420	26,420	26,420	500	500	-
		May	52,364	103,099	103,099	132,989	132,989	132,989	132,989	132,989	26,420	26,420	26,420	26,420	500	500	-
		June	25,503	74,607	74,607	107,499	107,499	109,925	109,925	26,420	26,420	26,420	26,420	26,420	500	500	-
		July	15,901	62,124	62,124	99,913	99,913	104,767	104,767	26,420	26,420	26,420	26,420	26,420	500	500	-
		August	22,022	48,018	48,018	89,409	89,409	95,476	95,476	26,420	26,420	26,420	26,420	26,420	500	500	-
		Sept	27,945	34,479	34,479	78,729	78,729	84,796	84,796	26,420	26,420	26,420	26,420	26,420	500	500	-
		Oct	34,066	26,420	26,420	37,559	34,383	34,418	26,420	26,420	26,420	26,420	26,420	26,420	500	500	-
AII	Base Case Average Conditions plus 100 year Two Month Wet Period plus Draindown allowance	April	27,047	66,364	66,364	81,820	81,820	81,820	81,820	81,820	81,820	26,420	26,420	26,420	500	500	-
		May	45,434	93,051	93,051	119,053	119,053	119,053	119,053	119,053	26,420	26,420	26,420	26,420	500	500	-
		June	31,030	82,620	82,620	118,613	118,613	121,040	121,040	26,420	26,420	26,420	26,420	26,420	500	500	-
		July	18,599	70,138	70,138	111,028	111,028	115,882	115,882	26,420	26,420	26,420	26,420	26,420	500	500	-
		August	22,022	56,032	56,032	100,523	100,523	106,591	106,591	26,420	26,420	26,420	26,420	26,420	500	500	-
		Sept	27,945	42,493	42,493	89,844	89,844	95,911	95,911	26,420	26,420	26,420	26,420	26,420	500	500	-
		Oct	34,066	26,420	26,420	37,559	34,383	34,418	26,420	26,420	26,420	26,420	26,420	26,420	500	500	-
AIII	Base Case Average Conditions plus 100 year Three Month Wet Period plus Draindown allowance	April	27,047	66,364	66,364	81,820	81,820	81,820	81,820	81,820	81,820	26,420	26,420	26,420	500	500	-
		May	42,269	88,461	88,461	112,687	112,687	112,687	112,687	112,687	26,420	26,420	26,420	26,420	500	500	-
		June	24,699	73,441	73,441	105,881	105,881	108,308	108,308	26,420	26,420	26,420	26,420	26,420	500	500	-
		July	18,256	69,642	69,642	110,340	110,340	115,193	115,193	26,420	26,420	26,420	26,420	26,420	500	500	-
		August	22,022	55,535	55,535	99,835	99,835	105,902	105,902	26,420	26,420	26,420	26,420	26,420	500	500	-
		Sept	27,945	41,996	41,996	89,155	89,155	95,223	95,223	26,420	26,420	26,420	26,420	26,420	500	500	-
		Oct	34,066	26,420	26,420	37,559	34,383	34,418	26,420	26,420	26,420	26,420	26,420	26,420	500	500	-
B	100 year Wet Year with Snowmelt in April plus Draindown allowance	April	41,308	87,044	87,044	110,501	110,501	110,501	110,501	110,501	110,501	26,420	26,420	26,420	500	500	-
		May	43,413	90,120	90,120	114,988	114,988	114,988	114,988	114,988	26,420	26,420	26,420	26,420	500	500	-
		June	19,789	66,321	66,321	96,007	96,007	98,433	98,433	26,420	26,420	26,420	26,420	26,420	500	500	-
		July	15,901	60,704	60,704	97,944	97,944	102,797	102,797	26,420	26,420	26,420	26,420	26,420	500	500	-
		August	22,022	51,505	51,505	94,245	94,245	100,313	100,313	26,420	26,420	26,420	26,420	26,420	500	500	-
		Sept	27,945	41,500	41,500	88,467	88,467	94,534	94,534	26,420	26,420	26,420	26,420	26,420	500	500	-
		Oct	34,066	26,420	26,420	37,559	34,383	34,418	26,420	26,420	26,420	26,420	26,420	26,420	500	500	-
B1	100 year Wet Year with 100 Year Snowmelt in APRIL plus Draindown allowance	April	52,712	103,579	103,579	133,435	133,435	133,435	133,435	133,435	133,435	26,420	26,420	26,420	500	500	-
		May	54,022	105,504	105,504	136,324	136,324	136,324	136,324	136,324	26,420	26,420	26,420	26,420	500	500	-
		June	27,909	78,095	78,095	112,336	112,336	114,763	114,763	26,420	26,420	26,420	26,420	26,420	500	500	-
		July	16,570	67,197	67,197	106,949	106,949	111,803	111,803	26,420	26,420	26,420	26,420	26,420	500	500	-
		August	22,022	54,224	54,224	98,016	98,016	104,083	104,083	26,420	26,420	26,420	26,420	26,420	500	500	-
		Sept	27,945	41,500	41,500	88,467	88,467	94,534	94,534	26,420	26,420	26,420	26,420	26,420	500	500	-
		Oct	34,066	26,420	26,420	37,559	34,383	34,418	26,420	26,420	26,420	26,420	26,420	26,420	500	500	-
B2	100 year Wet Year with 100 Year Snowmelt in MAY plus Draindown allowance plus no ore sprinkling in May	April	-	26,420	26,420	26,420	26,420	26,420	26,420	26,420	26,420	26,420	26,420	26,420	500	500	-
		May	54,624	106,569	106,569	137,769	137,769	137,769	137,769	137,769	28,103	26,420	26,420	26,420	500	500	-
		June	27,818	77,963	77,963	112,154	112,154	114,581	114,581	26,420	26,420	26,420	26,420	26,420	500	500	-
		July	16,520	67,124	67,124	106,848	106,848	111,702	111,702	26,420	26,420	26,420	26,420	26,420	500	500	-
		August	22,022	54,193	54,193	97,973	97,973	104,041	104,041	26,420	26,420	26,420	26,420	26,420	500	500	-
		Sept	27,945	41,500	41,500	88,467	88,467	94,534	94,534	26,420	26,420	26,420	26,420	26,420	500	500	-
		Oct	34,066	26,420	26,420	37,559	34,383	34,418	26,420	26,420	26,420	26,420	26,420	26,420	500	500	-

Table III.1 (continued)**VERSION 1.2****Run-of-Mine (ROM) Ore****Total Events Pond Solution Storage - Maximum Volumes each Month**

Month	Year 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
April	52,712	103,579	103,579	133,435	133,435	133,435	133,435	133,435	133,435	26,420	26,420	26,420	500	500	-
May	54,624	106,569	106,569	137,769	137,769	137,769	137,769	137,769	28,103	26,420	26,420	26,420	500	500	-
June	31,030	82,620	82,620	118,613	118,613	121,040	121,040	26,420	26,420	26,420	26,420	26,420	500	500	-
July	18,599	70,138	70,138	111,028	111,028	115,882	115,882	26,420	26,420	26,420	26,420	26,420	500	500	-
Aug	22,022	56,032	56,032	100,523	100,523	106,591	106,591	26,420	26,420	26,420	26,420	26,420	500	500	-
Sept	27,945	42,493	42,493	89,844	89,844	95,911	95,911	26,420	26,420	26,420	26,420	26,420	500	500	-
Oct	34,066	26,420	26,420	37,559	34,383	34,418	26,420	26,420	26,420	26,420	26,420	26,420	500	500	-

Events Pond Storage Capacity

	Year 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Minimum Required Volume	54,624	106,569	106,569	137,769	137,769	137,769	137,769	137,769	133,435	26,420	26,420	26,420	500	500	0

FIGURE III.1 - Maximum Events Pond Storage each Month

**#5. SUMMARY OF GEOTECHNICAL SITE INVESTIGATIONS,
HEAP LEACH PAD**

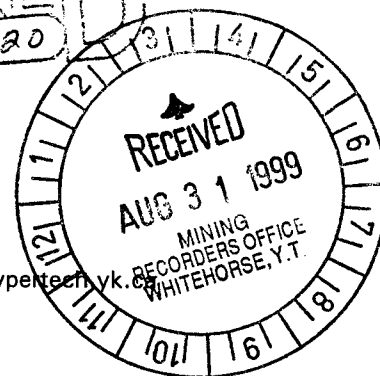


■ Access Mining Consultants Ltd.

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FAXED
May 20



Date: May 20, 1998

Number of pages including cover sheet 17

Original to be mailed: Yes No

FAX

To:	<u>Sitka Corp</u>	From:	<u>Kim Borden</u>
Attn:	<u>Tom Harper</u>		<u>Office Assistant</u>
Ph#:	<u> </u>	Phone	<u>(867) 668 - 6463</u>
Fax #:	<u>(425) 788-8068</u>	Fax	<u>(867) 667 - 6680</u>
Cc:	<u> </u>	E-Mail	<u>Access@hypertech.yk.ca</u>

Re: Western Copper Holdings Limited, Carmacks Copper Project - Geotechnical

Mr. Harper,

Please see attached.

Thank you,

ACCESS MINING CONSULTANTS LTD.

Kim Borden

If you or other RERC members have any questions with either report, give me a call at 668-6463.

Yours truly,

ACCESS CONSULTING GROUP



Dan Cornett, B. Sc., P.Biol.
Vice President

Attachment (2)

cc Dale Corman, Western Copper Holdings Limited (w/o EBA Report)
Lee Bilheimer, Western Copper Holdings Limited (w/o EBA Report)
John Wilkinson, Knight Piesold (w/o EBA Report)

RERC Technical Sub Group Members

Hugh Copland, DIAND
Bill Slater, DIAND
Benoit Godin, Environment Canada
Kevin McDonnell, DIAND
Fritz Mueller, DIAND
Naresh Prasad, YTG

WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
SUMMARY OF GEOTECHNICAL SITE INVESTIGATIONS –
HEAP LEACH PAD

BACKGROUND

Knight Piésold has conducted site investigations at the Carmacks Copper Project site on three separate occasions.

The first program was a preliminary surficial geotechnical investigation completed between mid-August and mid-September, 1992. This program examined the geotechnical and hydrogeological conditions for the open pit, four potential heap leach pad sites, process plant site, waste rock storage area, and a water storage dam site.

The second geotechnical site investigation program was carried out by Knight Piésold between February 21 and March 10, 1995. This program examined the geotechnical and hydrogeological conditions at the present heap leach pad site, the water storage dam site, and identified potential surficial material for earthworks construction.

The third geotechnical and hydrogeological site investigation program was carried out by Knight Piésold between February 9 and March 4, 1996. This program examined the geotechnical and hydrogeological conditions for the process plant site, the camp location, the crusher site, the present heap leach pad site, the waste rock storage site, and the open pit.

The results of the three site investigations were presented and discussed in the following reports:

"Report on 1992 Surficial Geotechnical Investigations", Knight Piésold Ltd., May 1993, Ref. No. 1782/2.

"Report on Preliminary Design", Knight Piésold Ltd., May 1, 1995, Ref. No. 1783/1.

"Report on 1996 Geotechnical and Hydrogeological Site Investigations", June 7, 1996, Ref. No. 1784/1.

EBA Engineering Consultants undertook an additional site investigation in October 1997. The purpose of this investigation was to confirm geotechnical conditions, specifically within the heap leach pad area, events pond, sediment control pond, and a proposed granular borrow area.

The results of the EBA site investigation, including test pit logs and laboratory test work, is presented in the following letter report:

"Submission of Testpit & Laboratory Test Results – Heap Leach Pad Area Carmacks Copper Project", EBA Engineering Consultants Ltd., December 5, 1997, File Reference 0201-97-13103.

Both Knight Piésold and EBA Engineering Consultants encountered a discontinuous loose to compact sand and gravel layer near the ground surface (see Knight Piésold TR95-4A-1, 1 m; TR95-4A-2, 0.5 m; TR96-5-1, 0.5 m; TR96-6-1, 0.5 m, and EBA Engineering Consultants TP04, 0.8-1.0 m; TP07, 0.8-0.9 m; TP11, 0.3-0.4 m). However, it was not possible to determine with any certainty which areas of the leach pad site contain this sand and gravel layer and which areas do not. For the analyses and designs, this layer was conservatively assumed to be present across the entire leach pad site.

DESIGN AND ANALYSIS

A hydrogeological model of the heap leach pad area has been developed based on the results of the site investigation programs, measured depths to groundwater, and measured and interpreted permeabilities for the various geological units.

The hydrogeological model of the heap leach pad area uses the two-dimensional program SEEP/W, which is a finite element seepage analysis program widely used in the industry. Seepage of leachate from the leach pad will consider two cases, each documented in the updated addendum text, tables and figures: a) seepage from a breach in the liner system into a near-surface, highly permeable drainage system, confined by relatively shallow and impermeable frozen soils, and b) seepage from a breach in the liner system into thawed, unconfined, deeper, and moderately permeable foundation layers beneath the leach pad. Both analyses will be presented and discussed, with the worst case selected for impact assessment.

The hydrogeological impact of leakage from the leach pad will, again, be modelled using SEEP/W, using the 3.1 mm² hole size recommended by Giroud & Bonaparte (1989) for impact / performance calculations and specified hydraulic head and liner permeabilities.

For modelling purposes, the sand and gravel geologic unit identified by Knight Piésold and EBA Engineering Consultants was assumed to be directly beneath the leach pad and events pond soil liner and was conservatively modelled to be continuous over the entire leach pad area with thicknesses varying between 1 and 2 m. The sand and gravel unit was classified as SM-SW and has a typical range of permeabilities of 10^{-5} to 10^{-7} m/s, (10^{-3} to 10^{-5} cm/s). As the main concern is that this layer may act as a conduit for seepage of leaks from beneath the leach pad, the higher end of the range of permeabilities was selected in the model. The seepage analysis will be re-analyzed for a variety of cases and presented in the Addendum report.

All stability analyses will be reviewed and updated using new/updated estimates of thaw-induced pore pressures, material strengths and operating conditions. Stability analyses were carried out for the heap leach pad using limit equilibrium methods and the computer program SLOPE/W. The stability assessment concentrated on the smooth HDPE geomembrane - soil liner and the smooth HDPE geomembrane - geonet interfaces since these represent the corresponding weak layers in the model. The shear strength of the heap leach pad foundation was not considered by Knight Piésold to be the critical factor in the stability analyses, thus the sand and/or gravel unit was disregarded and the foundation was modelled as homogeneous. In terms of geotechnical stability, the presence of a sand and/or gravel unit beneath these interlayered geotextiles is inconsequential.

SUMMARY

The geotechnical investigations undertaken on the site have confirmed the presence of a discontinuous sand and gravel unit near the surface. Both the hydrogeological impact assessment and geotechnical design of the heap leach pad will account for this geologic unit. A complete discussion of the results of the investigations, rationale for material properties selection, analyses and use in the geotechnical aspects in the project design will be presented

in Addendum #4. The QA/QC Program and Technical Specifications will be updated and will address materials handling and testing of various geologic units. Materials considered unsuitable within the limits of an excavation shall be removed and wasted as directed by the Engineer. The QA/QC Program will specifically consider materials' handling of the discontinuous sand and/or gravel unit.



ACCESS
CONSULTING
GROUP

■ Access Mining Consultants Ltd.

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COPY

FAXED
May 12/98

BY FACSIMILE

May 11, 1998

Department of Indian Affairs & Northern Development
Environment
Room 330 – 300 Main Street
Whitehorse, Yukon
Y1A 2B5

Attention: Kevin McDonnell, Project Manager

Dear Kevin:

**Re: Western Copper Holdings Limited - Carmacks Copper Project -
Geotechnical Review of Updated Design and Response Strategy For
Addendum #4**

Accompanying this letter, please find attached a response strategy to address various geotechnical issues associated with the project. Knight Piesold prepared the strategy with input from Access Mining Consultants Ltd. and Western Copper Holdings Ltd.'s independent geotechnical reviewer. This strategy is provided to RERC for their information and is intended to keep the RERC Technical Sub group apprised of the company's ongoing efforts to optimize the project design and address RERC members' concerns.

As noted in the response strategy, the approach is to present the complete analysis and data from the geotechnical review in the Addendum #4 report in support of the environmental screening. An interim product that we intend to present to the RERC Technical Sub Group for discussion is a draft 'Report on Detailed Design Criteria and Parameters'. This report will provide the basis for the project's design criteria and will be expanded to include a summary of the design parameters used and the rationale for their selection. We would see this report forming the basis for a RERC Technical Sub group meeting. Our schedule is to complete the report for project team review and present the report to RERC by May 30, 1998. A meeting with the Technical Sub group could be convened after members have reviewed the document.

Should you have any questions with the response strategy or the strategy output, please call me at my office.

Yours truly,
ACCESS MINING CONSULTANTS LTD.

A handwritten signature in black ink, appearing to read 'D. Cornett', with a stylized flourish at the end.

Dan Cornett, B.Sc., P.Biol.
Vice President

Attachment

cc Dale Corman, Western Copper
Lee Bilheimer, Western Copper
John Wilkinson, Knight Piesold

RERC Technical Sub group Members
Hugh Copland, DIAND
Bill Slater, DIAND
Benoit Godin, Environment Canada
Kevin McDonnell, DIAND
Fritz Mueller, DIAND
Naresh Prasad, YTG

10178/6.01
May 4, 1998

CARMACKS COPPER PROJECT
GEOTECHNICAL REVIEW OF UPDATED DESIGN
AND RESPONSE STRATEGY FOR ADDENDUM #4

The proposed Carmacks Copper Project, owned and under development by Western Copper Holdings Limited (WCHL), has been the subject of several recent technical reports and reviews prepared by WCHL, Access Mining Consultants Limited (AMCL), Kilborn Engineering Pacific Ltd. (KEPL), and Knight Piésold Ltd., amongst others. These reports have been in support of an Environmental Assessment Review Process Guidelines Order (EARP) Screening and Water License Application or in response to concerns raised by the various regulatory and review committees, their independent consultants, and other stakeholders. Additionally, review documents have been prepared by several independent groups on behalf of the review committee, and further, by several independent reviewers on behalf of WCHL.

In particular, three (3) addenda to an Initial Environmental Evaluation (IEE) have been prepared and submitted to these review groups; each responding to specific and general technical issues related to the various stages of mine development planning and design. Detailed design of the various project components (open pit, crushing plant, acid heap leach and copper extraction facility, associated waste dumps, soil stockpiles, process water ponds, drainage ditches, sediment control ponds and other miscellaneous structures) has evolved through this reporting and review process. In particular, revisions to the designs and methods of analysis include, but are not limited to, consideration of stability, settlement, frost protection, hydrogeology, instrumentation, solution management, borrow material properties, availability and suitability, and mine closure.

Many issues raised during the previous reviews have been a simple matter of clarity, addressed appropriately through further compilation and presentation of data, analyses, and design details and a clear, explicit description of these details. Other issues, or comments, have aptly demonstrated areas of potential improvement

and protection. These comments have previously been addressed through further analysis and/or design alterations where required.

A 'Response Strategy Table - Based on RERC Summary of Issues', 'Summary List of Commitments', and 'Proposed Table of Contents - Addendum #4' have been prepared by AMCL. The Response Strategy Table included individual RERC member's comments based on the most recent submissions by WCHL. Following a review of these summary tables, discussion with Mr. Milos Stepanek, of Geo-Engineering Ltd., and meetings and subsequent communication with WCHL's independent geotechnical advisor, Knight Piésold proposes the following strategy and prioritization for our contributions to the Addendum #4 document.

The majority of comments provided by the above-mentioned parties may be categorized according to the project component being considered, and the type of comment:

- A. Request for clarity, further information or compilation, and complete description in Addendum #4 text (including issues related to geological origin or terminology, and materials classification).
- B. Request for the provision of further data supporting a stated design / construction parameter (e.g. borrow material availability, thermistor or piezometer data).
- C. Detailed technical comment related to a design feature or results of an analysis or calculation, requiring confirmation or adjustment of design.

The following sections (listed in order of priority) list the various project components to be reviewed, and summarize the proposed approach for responding to all outstanding comments. The anticipated response to these outstanding comments will involve one or more of the following tasks:

- A. Review and update proposed design, with supporting text and rationale for design concept.
- B. Review and confirm supporting analyses, with supporting text and implications of analysis results.

- C. Provide further explanation of existing design rationale in supporting text and drawings, leaving the design unchanged.

All other comments related to the operation and maintenance of the facility, and design adjustments such as frost protection, liner protection, pipe sizing and bedding will be considered and addressed in the updated text and drawings. It is intended that the Addendum #4 response and updated design be treated as a 'Preliminary Design', and reviewed at a level of detail appropriate for this stage. It is not intended to provide full connection details for all design components until a later stage (i.e. for Final Design and Construction).

Borrow Material Suitability and Availability

Proposed particle size gradations for the soil liner, filter and drainage, and structural random fill materials have been presented. Concerns regarding these materials include:

- availability of each material from proposed borrow areas (including borrow locations and calculated volumes)
- in-situ, natural moisture contents
- ability to achieve specified densities and permeabilities
- geotechnical properties (e.g. strength, frost susceptibility, pore pressure development and dissipation) of proposed materials

These concerns will be addressed through the compilation and presentation of all borehole and test pit logs and all laboratory data, including strength, proctor density and permeability measurements. An emphasis will be placed on the relevant in-situ and achievable geotechnical properties of the borrow materials rather than their geological origin and nomenclature. A description of the field and laboratory tests to be performed during fill placement and construction to ensure the achievement of all relevant geotechnical properties will be provided in the addendum text, including the use and frequency of the following tests:

- in-situ air entry permeameter

- laboratory permeability
- nuclear density and moisture content
- test pad density and proctor determinations

The conservative assumptions and calculations used to estimate volumes of available borrow materials will be described and presented. Sources for additional borrow, if required, will be identified.

Waste Rock Storage Area and Leach Pad Foundation Preparation

The estimated lateral extent and depth of 'thaw unstable' and permafrost materials in the waste rock storage area and leach pad foundations will be mapped, together with a detailed description of the drilling program to further delineate these areas. The treatment (removal, replacement, or design contingency) of permafrost and thaw unstable soils will be described, as will a detailed and more rigorous study of thaw-induced pore pressure generation and consolidation in the waste rock storage area. In particular, the potential effect of excess pore pressures on slope stability and strains within the liner system due to differential settlement will be reviewed, updated and explained.

A detailed description of the re-contouring, foundation preparation, and foundation drain installation beneath the leach pad will be provided. Design of the leach pad foundation drains will consider the observed locations of natural seeps and swales, differential settlements, overburden pressure, frost protection, flow and quality monitoring, and redundancy.

In particular, a detailed description of the observational approach, including monitoring, 'trigger levels', and action plans or alternatives will be provided. Also, a detailed description of the observational approach and treatment of the buffer zone, located at the toe of the waste rock storage area, will be provided in the addendum.

Leach Pad and Events Pond Liner Designs

All estimated, measured and anticipated geotechnical properties of the liner system will be reviewed and confirmed or adjusted. The QA/QC and field testing program to ensure the achievement of these properties will be described, along with the steps that will be taken in the case of non-compliance. Consideration will be given to the following items:

- selection of a liner system for the leach pad, upstream face of the confining embankment, and events pond with acceptable predicted leakage rates
- determination of appropriate permeabilities and expected durability of the overliner material
- transmissivity of the overliner material and the potential for use of a perforated pipe and header pregnant solution collection system, constructed in separate, and independently operated cells
- determination of LDRS cell sizes, pipe collection systems, and required permeabilities to obtain estimated leakage rates well below (approximately one order of magnitude below) stated allowable leakage rates
- leachate collection system redundancies and boot sealing or strapping of collection sumps to HDPE liners
- provision of a long-term and redundant french drain system for drainage from behind the confining embankment following detoxification and closure of the leach pad

Leach Pad and Waste Rock Storage Area Stability and Seepage Analyses

Seepage from the waste rock storage area will be considered from the point of view of pore pressure development and dissipation, and its impact on the stability of the waste rock and foundations. Seepage of leachate from the leach pad will consider two cases, each documented in the updated addendum text, tables and figures: a) seepage from a breach in the liner system into a near-surface, highly permeable drainage system, confined by relatively shallow and impermeable frozen soils, and b) seepage from a breach in the liner system into thawed, unconfined, deeper, and

moderately permeable foundation layers beneath the leach pad. Both analyses will be presented and discussed, with the worst case selected for impact assessment.

The hydrogeological impact of leakage from the leach pad will, again, be modelled using the two-dimensional finite element program, SEEP/W, using the 3.1 mm² hole size recommended by Giroud & Bonaparte (1989) for impact / performance calculations and specified hydraulic head and liner permeabilities. Given the recommended frequency of modelled defects and the plan area of the leach pad, approximately 83 holes in each of the geomembrane layers will be simulated in the SEEP/W model.

Liner leakage estimates will be revisited based on the updated liner design, estimated hydraulic heads (accounting for perforated solution collection and leak collection pipes), and the appropriate size and spacing of apertures.

All stability analyses will be reviewed and updated using new/updated estimates of thaw-induced pore pressures, material strengths and operating conditions. Consideration will be given to the analysis of the leach pad and confining embankment as a water retaining structure with the associated higher factors of safety. Seismic (pseudo-static) stability of both structures (combined leach pad and confining embankment and waste rock storage areas) will be considered in terms of allowable displacements rather than initial yielding, resulting in slightly higher seismic factors of safety. All failure mechanisms and results will be presented and discussed. The geotechnical stability of the events and sediment control ponds will also be confirmed and presented.

'Integration' Issues

The following project components, amongst others, are currently under review by other members of the project team (AMCL, KEPL, Clearwater Consultants Ltd.), and will impact the final sizing, operation, analyses and drawings of various other project components:

- solution management
- pond sizing, numbers, order, normal operating volumes and storm design

- overliner material specifications (crushed ore, durable rock, etc.)
- solution application rates and saturation of leach ore

Summary

For all designs, selection of various design criteria, and the process of elimination of various design concepts or alternatives will be described. The rationale for selection of material properties and assumptions, and the design / analysis methods and results will be provided. Additionally, where an opportunity or potential for failure of a component is present, mitigative measures and alternatives will be discussed. Also, monitoring and contingency plans and operating procedures will be described where possible.

Other comments not mentioned above, such as freeboard requirements, pipe capacities, frost protection, spillway design, and other miscellaneous items will receive proper attention and presentation in the addendum text and/or drawings.

Output:

A short-term product of this response strategy will be the production of a 'Report on Detailed Design Criteria and Parameters', for submission to the RERC by the end of May, 1998. The contents of this report will be organized by Knight Piésold, for review and input by AMCL, Clearwater Consultants Ltd., Morris Beattie, KEPL and WCHL.



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May 12/98

10 Pages

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TO: Dale Corman, Western Copper, Fax: (604) 688-4670
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Fritz Mueller, DIAND, Fax (867) 667-3216
Naresh Prasad, YTG WCHSB, Fax (867) 393-6279

FROM: Dan Cornett, B.Sc., P.Biol., Vice President

DATE: May 11, 1998

Please see the attached correspondence.

Thank you.

#6. TESPIT & LABORATORY TEST RESULTS - HEAP LEACH PAD AREA.

EBA Engineering Consultants Ltd.

December 5, 1997

Western Copper Holdings Ltd.
Suite 1700 - 1185 West Georgia Street
Vancouver, British Columbia
V6E 4E6

Attention: Mr. Dale Corman, P.Eng.
President

Dear Sir:

Subject: Submission of Testpit & Laboratory Test Results—Heap Leach Pad Area
Carmacks Copper Project - NW of Carmacks, Yukon



Attached to this cover letter are the testpit logs and laboratory test results from the recent geotechnical program completed to confirm soil and geotechnical conditions at the above captioned site.

1.0 FIELD PROGRAM

As noted on the attached Site Plan, sixteen testpits were excavated within the heap leach pad area, events pond and sediment control pond plus one testpit excavated within the proposed granular borrow area. The testpitting program commenced on October 28, 1997 and was finished on October 30, 1997. Testpits were excavated with a CAT 225 tracked excavator contracted from Coyne & Sons of Whitehorse, Yukon. Excavation depths varied from 2.0 m to 7.0 m (including pit exposure). Representative soil samples were collected at regular intervals and returned to EBA's Whitehorse laboratory for natural moisture content determination and basic classification testing. EBA's field representative was Mr. Cord Hamilton, P. Eng.

2.0 LABORATORY TESTING PROGRAM

A total of 71 natural moisture content tests, 29 grain size analysis tests and 7 bulk frozen density determinations were completed in EBA's Whitehorse laboratory. The test results are presented on the applicable testpit logs attached to this letter and on the test result forms following the corresponding log.

3.0 GEOMORPHOLOGY OF THE HEAP LEACH PAD SITE

The testpit data confirms the presence of a discontinuous near-surface layer of alluvial sand and/or gravel. As this material is more pervious than the underlying till or residuum, it will need to be stripped and/or replaced as necessary during the heap leach pad base construction. Several areas of ice-poor permafrost (bulk densities ranging from 2.1 Mg/m³ to 2.2 Mg/m³) were also detected. This permafrost is not considered to be susceptible to significant settlements when thawed.

Based on the limited data obtained, no attempt has been made to clearly define areas of alluvial cover or permafrost within the heap leach pad site, therefore, site inspection during construction will be necessary to delineate these areas, and deal with them appropriately at that time.

4.0 USE OF GRANULAR BORROW AREA FOR CONCRETE PRODUCTION

Testpit 13103-TP10 was excavated within the proposed granular borrow area #2 located along the south edge of the Events Pond. Two samples were tested to establish the grain size characteristics throughout the depth of the granular borrow source. The conditions noted were documented as Sand & Gravel over coarse sandy Gravel on the testpit log. Further analysis of the aggregate for use in normal concrete production included the theoretical splitting of the natural deposit into coarse and fine fractions for each of the two samples tested. The theoretical gradations were then plotted against CSA specifications for coarse concrete aggregate (5 mm to 28 mm) and fine concrete aggregate (80 µm to 5 mm) production. Analysis of the test results indicates that the sand portion of the natural deposit is much coarser than specified, as is the top end of the coarse fraction. Thus, the natural gradation dictates the splitting of the pit run material into two piles and then recombining them during concrete production. It is important to note that although the material does not conform to CSA specifications, it is clean enough to produce bulk concrete. The placeability, workability and finish would be in question and trial batches would be required to accurately determine the proper cement dosage to meet project specifications. Additional testing of the actual aggregates processed (specific gravity, absorption and dry rodded bulk unit weight testing) would also be necessary to determine the batch weights.

It is hoped that this brief report satisfies your requirements at the present time. If you require additional information, please contact the undersigned.

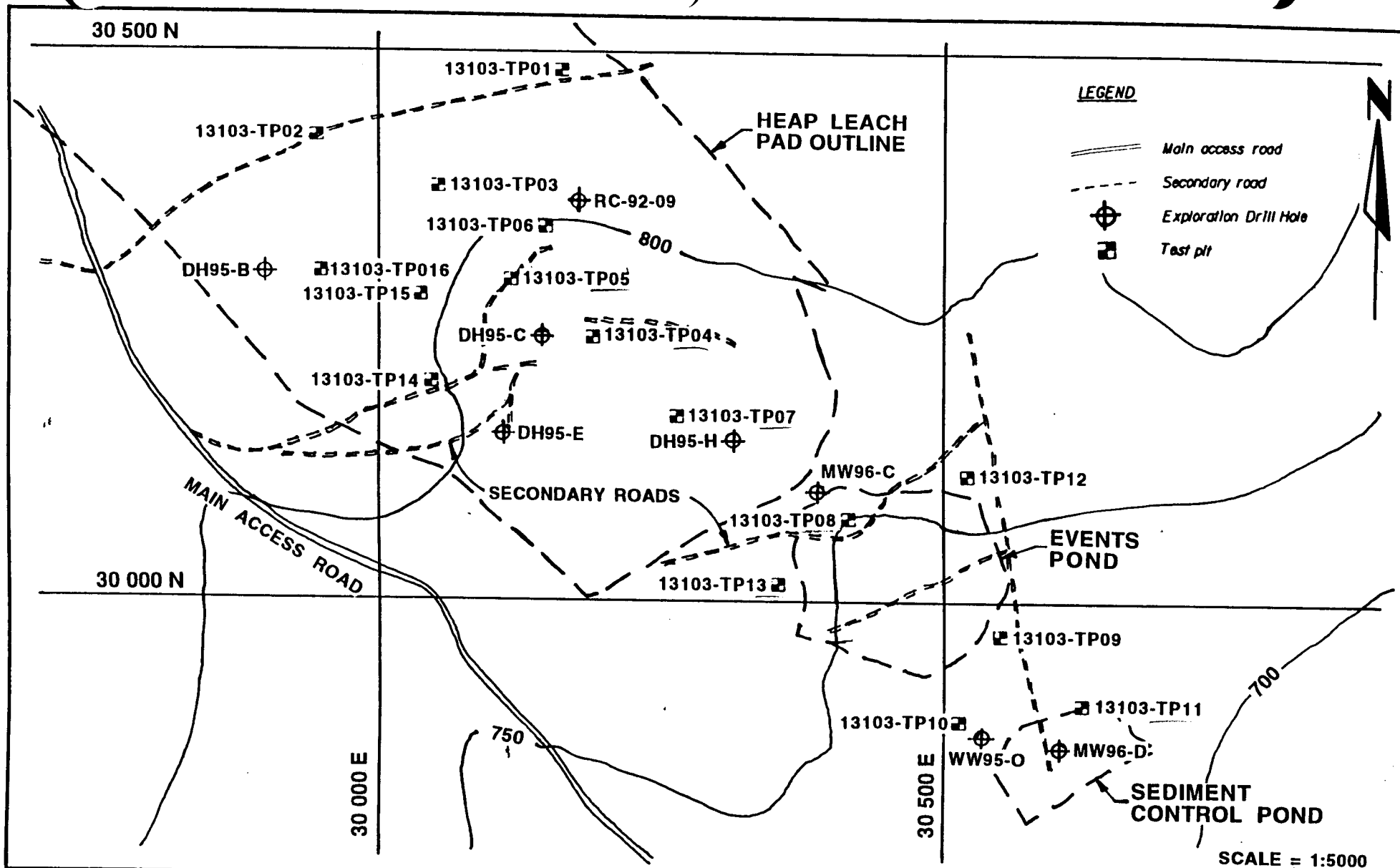
Yours truly,
EBA Engineering Consultants Ltd.



J. R. Trimble, P.Eng.
Program Director, Yukon Region

Enclosures: Site Plan showing TP locations, TP logs, laboratory test results.

cc. Mr. Tony Wachmann, P.Eng., Kilborn Engineering, Vancouver, BC



EBA Engineering Consultants Ltd.				PROJECT CARMACKS COPPER PROJECT	
CLIENT WESTERN COPPER HOLDINGS LTD				TITLE SITE PLAN SHOWING TESTPITS IN HEAP LEACH PAD AREA	
DATE 97/11-27	DWN JSB	CHKD JRT	DWG NO. 13103-1	0201-97-13103	

GEOTECHNICAL EXPLORATION-HEAP

CH PAD

EXCAVATOR: CAT 225

TEST PIT NO: 13103-TP01

WILLIAMS CREEK, YUKON

UTM ZONE: 8 N - E -

PROJECT NO: 0201-97-13103

ELEVATION: 1680 m

SAMPLE TYPE

GRAB SAMPLE

☒ NO RECOVERY☒ STANDARD PEN.☐ 75 mm SPOON☐ CRREL BARRELSOIL
DESCRIPTION

STANDARD PENETRATION

10 20 30 40

PERCENT GRAVEL

20 40 60 80

PERCENT SAND

20 40 60 80

PERCENT SILT OR FINES

20 40 60 80

PERCENT CLAY

20 40 60 80

PLASTIC

M.C.

LIQUID

10 20 30 40

VOLCANIC ASH-silty, numerous roots, white

SAND(RESIDUUM) - some silt, numerous fine roots; well graded, angular, friable sand; compact; damp; medium brown

GRANDIORITE(BEDROCK) - highly weathered grandiorite with sand lenses & seams; clasts are highly weathered angular cobbles, boulders and gravel; matrix is residual

- becomes less weathered with depth

END OF TESTPIT (REFUSAL) @ 2.0 m

- mine grid coord's N30480 E30160

EBA Engineering Consultants Ltd.
Whitehorse, Yukon

LOGGED BY: CRH

REVIEWED BY: JRT

Fig. No:

COMPLETION DEPTH: 2 m

COMPLETE: 97/10/28

Page 1 of 1

GEOTECHNICAL EXPLORATION-HEAP

CH PAD

EXCAVATOR: CAT 225

TEST PIT NO: 13103-TP02

WILLIAMS CREEK, YUKON

UTM ZONE: 8 N - E -

PROJECT NO: 0201-97-13103

ELEVATION: 1660 m

SAMPLE TYPE

GRAB SAMPLE

☐ NO RECOVERY☒ STANDARD PEN.☐ 75 mm SPOON☐ CRREL BARREL

SOIL DESCRIPTION

STANDARD PENETRATION

10 20 30 40

PERCENT GRAVEL

20 40 60 80

PERCENT SAND

20 40 60 80

PERCENT SILT OR FINES

20 40 60 80

PERCENT CLAY

20 40 60 80

 PLASTIC M.C. LIQUID
 10 20 30 40

 ORGANIC SAND & SILT - numerous roots;
 seasonally frozen

 VOLCANIC ASH - silty, frequent fine roots
 seasonally frozen; white

 SAND - silty, trace of clay; trace of
 gravel; fine to medium grained sand;
 fine to coarse, round to subrounded,
 smooth gravel; matrix supported; non-
 plastic; compact; damp; medium brown
 - frequent small lenses of SAND -
 trace of silt throughout
 - occasional rounded, smooth cobbles
 - becomes SAND - silty, some gravel,
 trace to some clay

 - no bedding visible in deposit;
 occasional to frequent discontinuous
 lens of SAND - trace of silt and
 SILT - trace of sand disseminated
 throughout

 - sample at 4.2 m contains clean well
 graded sand with fine grained, rounded
 to subrounded gravel; no visible
 evidence of a continuous layer
 - decomposed granodiorite clasts are
 present in soil matrix; excavation
 becomes difficult
 - excavation refusal at 5.0 m;
 possible highly weathered bedrock

END OF TESTPIT (REFUSAL) 5.0 m

 - no permafrost or groundwater
 observed

- mine grid coord's N30420 E29940

 EBA Engineering Consultants Ltd.
 Whitehorse, Yukon

LOGGED BY: CRH

REVIEWED BY: JRT

Fig. No:

COMPLETION DEPTH: 5 m

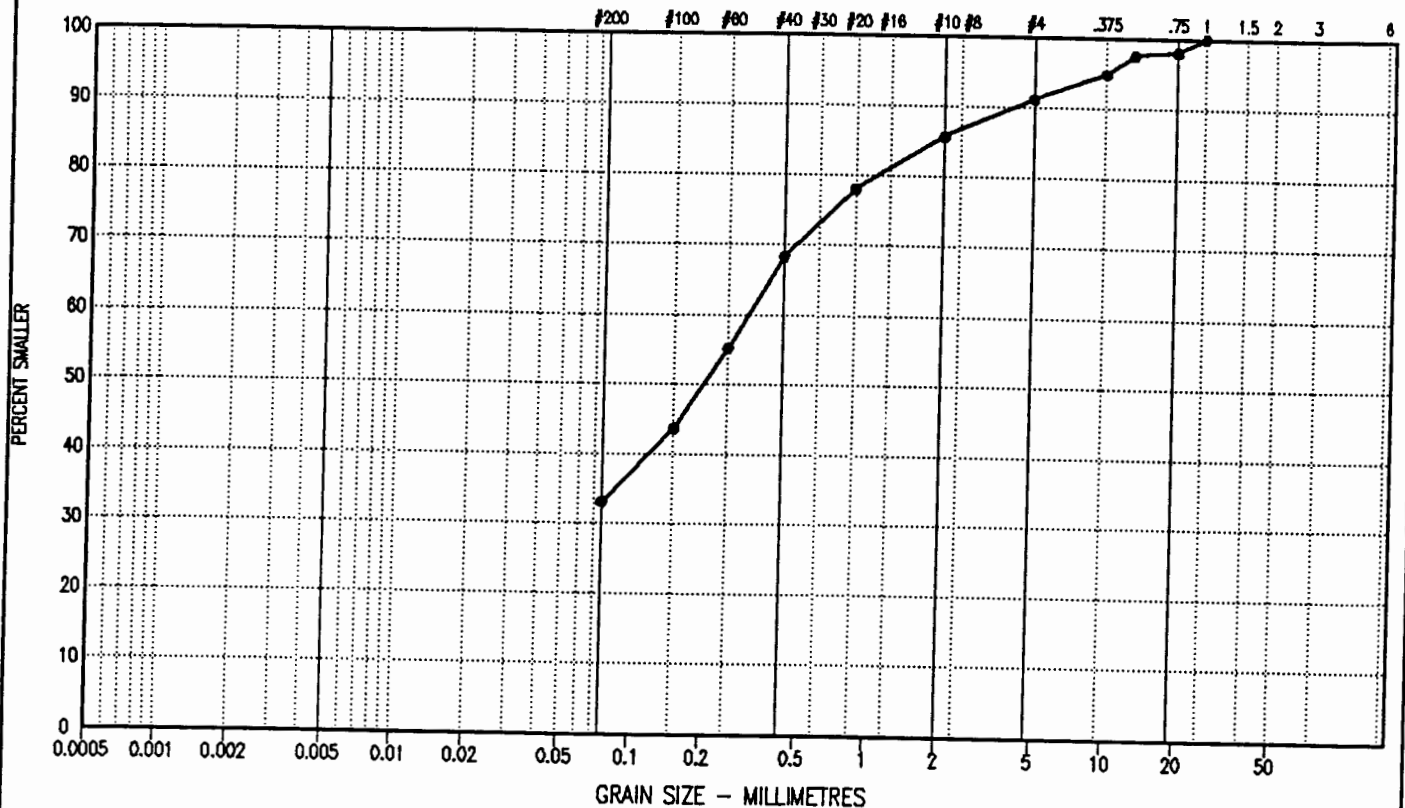
COMPLETE: 97/10/28

Page 1 of 1

PARTICLE SIZE - ANALYSIS OF SOILS

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE

U.S. STANDARD SIEVE SIZES



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
—●—	TP02	0.60 - 0.80	33.0	58.1	8.9	13.9	0.6	SM

Project: 0201-97-13103

Date Tested: 97/11/03

BY: JSB

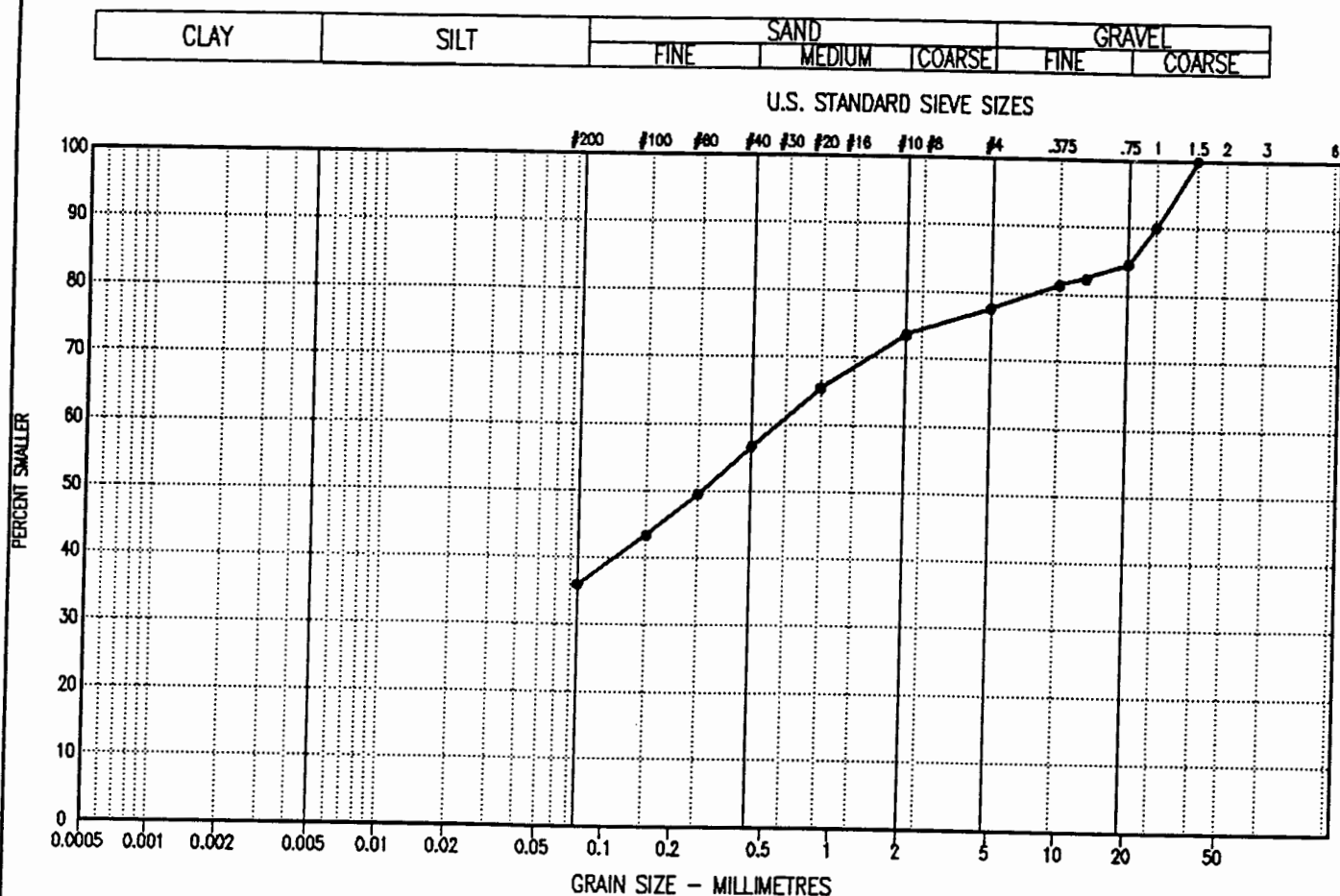
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PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
—●—	TP02	2.60 - 2.80	35.8	41.7	22.5	28.1	0.3	SM

Project: 0201-97-13103

Date Tested: 97/11/03

BY: JSB

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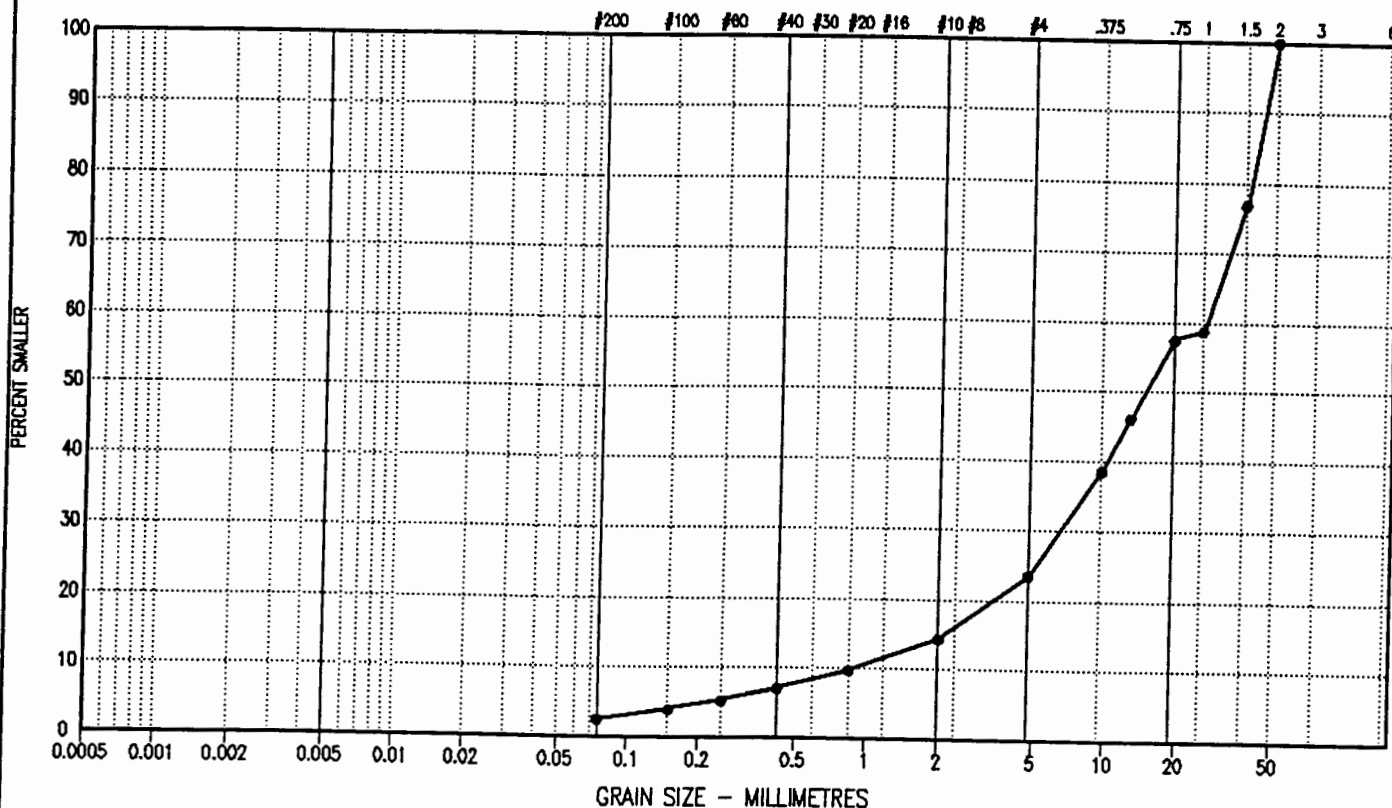
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PARTICLE SIZE - ANALYSIS OF SOILS

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE

U.S. STANDARD SIEVE SIZES



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
●—●	TP02	4.90 - 5.00	2.5	21.0	76.5	27.9	1.9	GW

Project: 0201-97-13103

Date Tested: 97/11/03

BY: JSB

Tested in accordance with ASTM D422 unless otherwise noted.

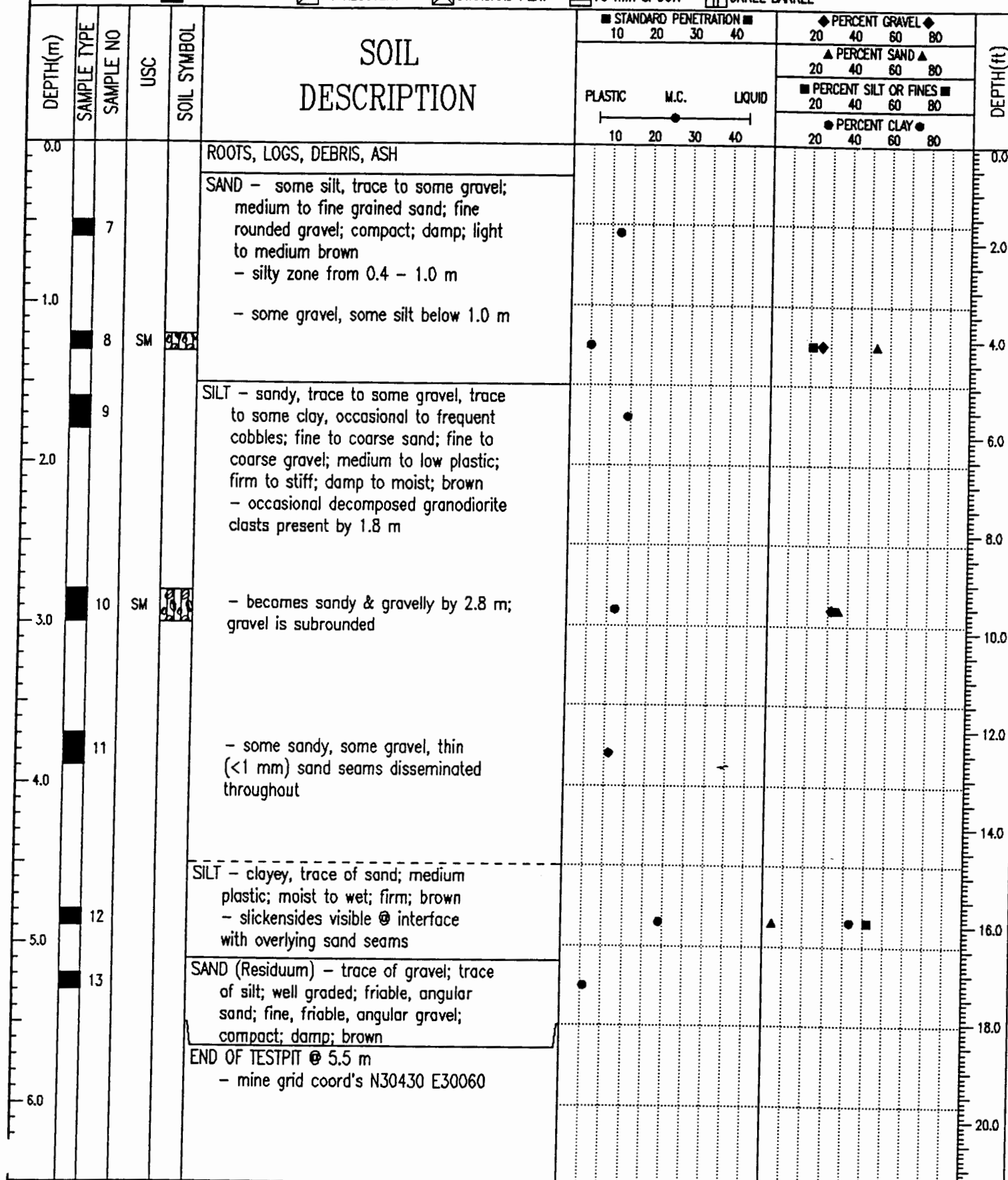
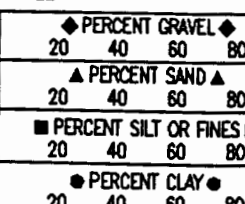
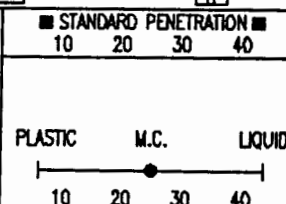
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SAMPLE TYPE GRAB SAMPLE ☒ NO RECOVERY ☒ STANDARD PEN. 75 mm SPOON CRREL BARREL

SOIL DESCRIPTION

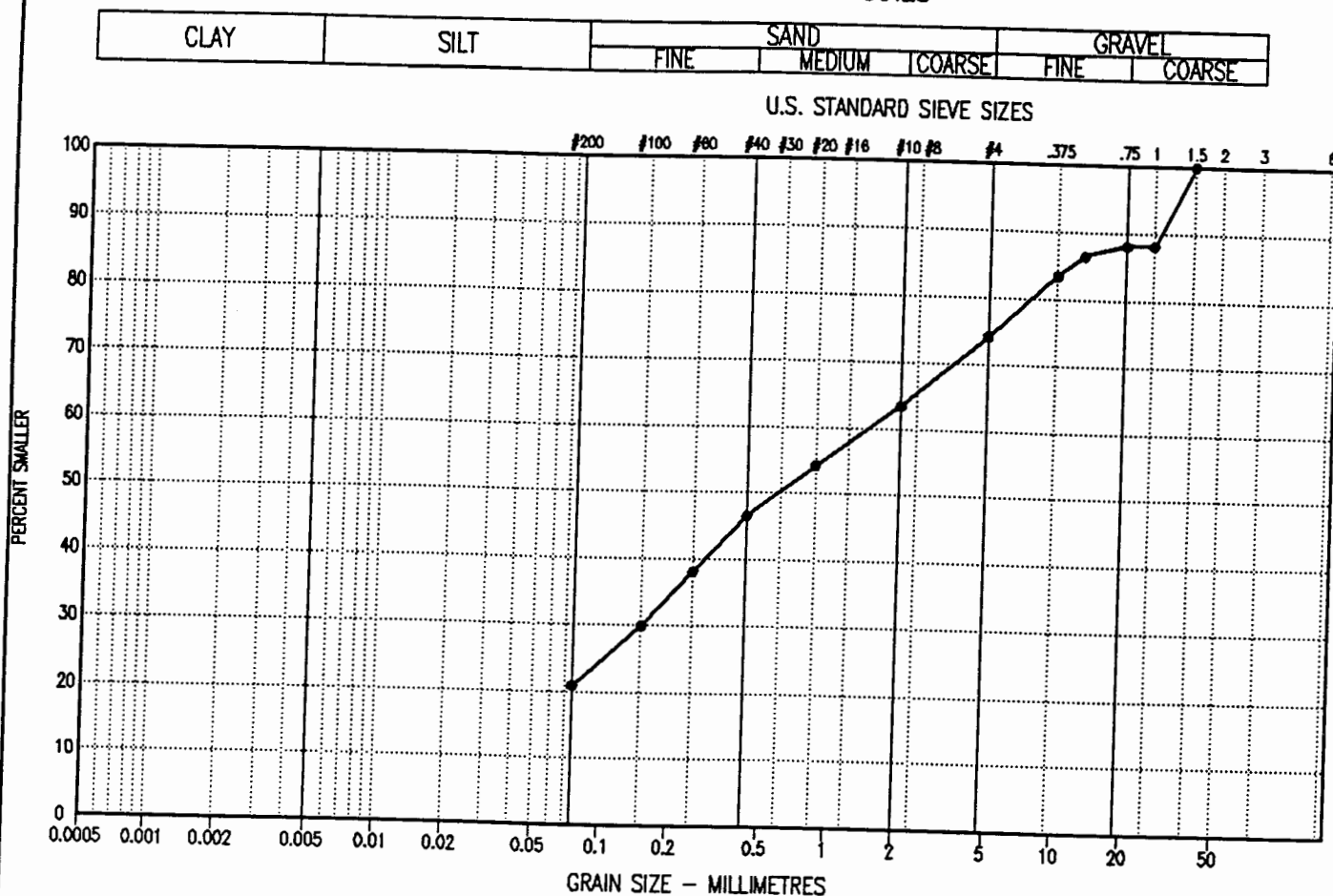


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 Whitehorse, Yukon

LOGGED BY: CRH
 REVIEWED BY: JRT
 Fig. No:

COMPLETION DEPTH: 5.5 m
 COMPLETE: 97/10/28

PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
●—●	TP03	1.20 - 1.30	20.8	53.3	25.9	43.6	0.4	SM

Project: 0201-97-13103

Date Tested: 97/11/03

BY: JSB

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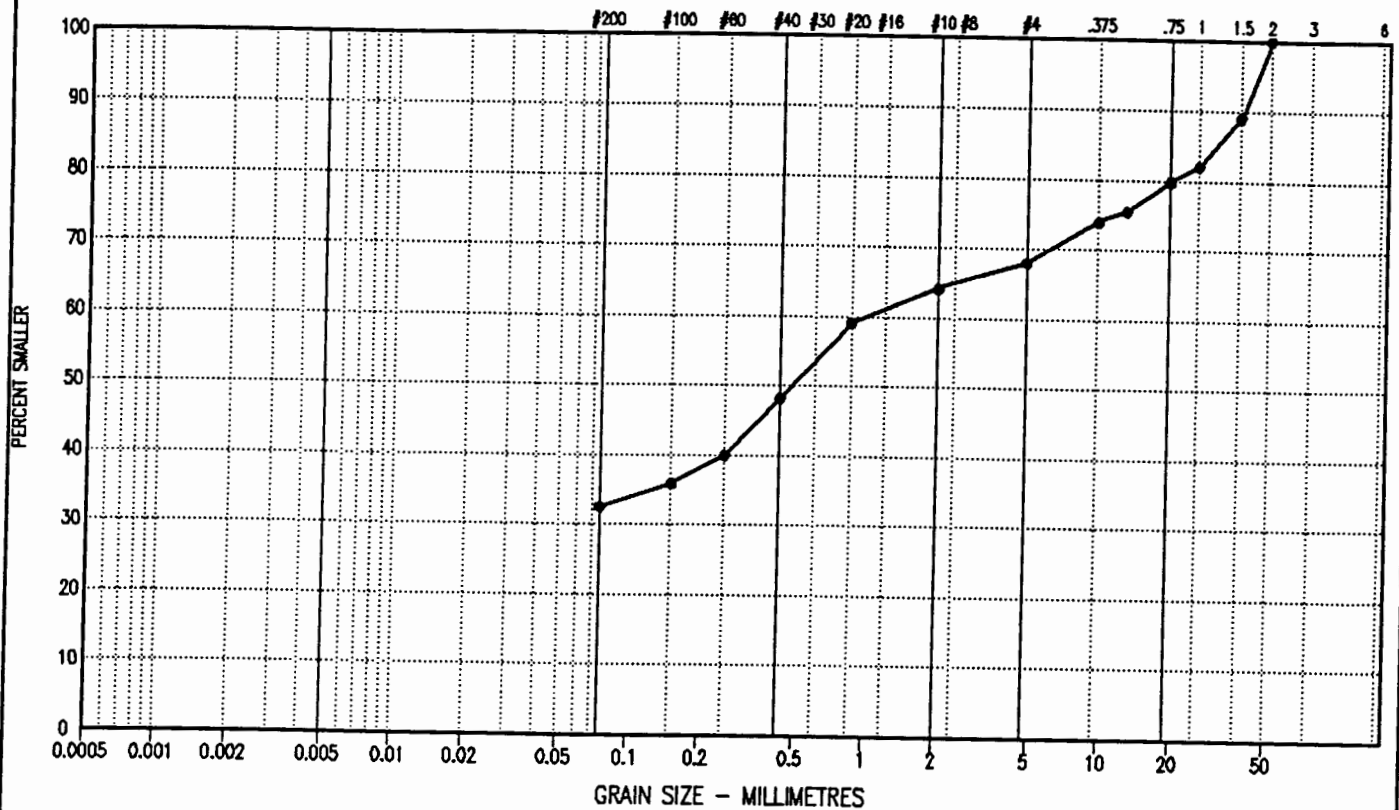
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PARTICLE SIZE - ANALYSIS OF SOILS

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE

U.S. STANDARD SIEVE SIZES



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
—●—	TP03	2.80 - 3.00	32.4	35.6	32.0	45.6	0.2	SM

Project: 0201-97-13103

Date Tested: 97/11/03

BY: JSB

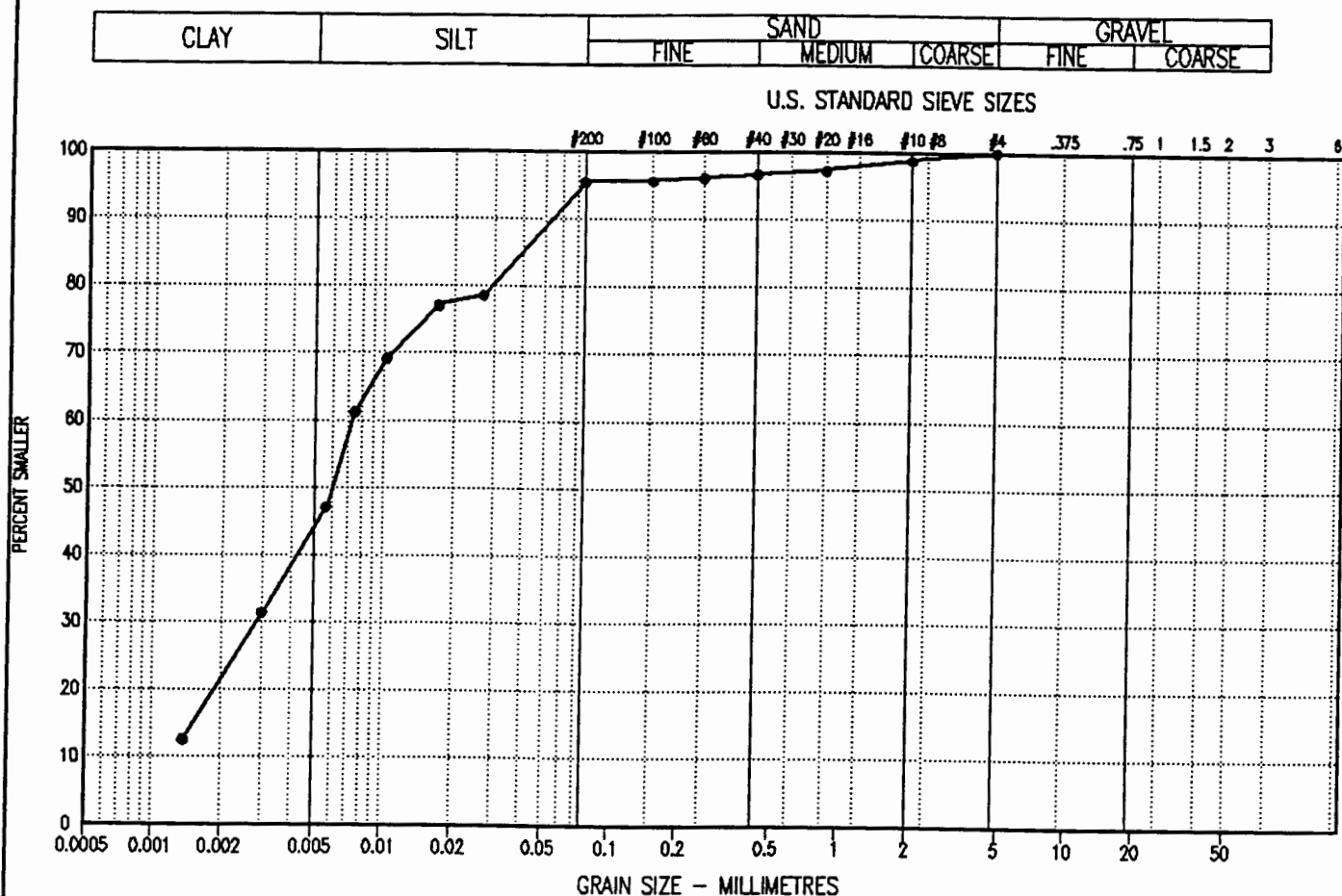
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PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION				Cu	Cc	U.S.C
			CLAY %	SILT %	SAND %	GRAVEL %			
—●—	TP03	4.80 - 4.90	43.3	52.1	4.6	0.0	—	—	

Project: 0201-97-13103

Date Tested: 97/11/03

BY: JSB

Tested in accordance with ASTM D422 unless otherwise noted.

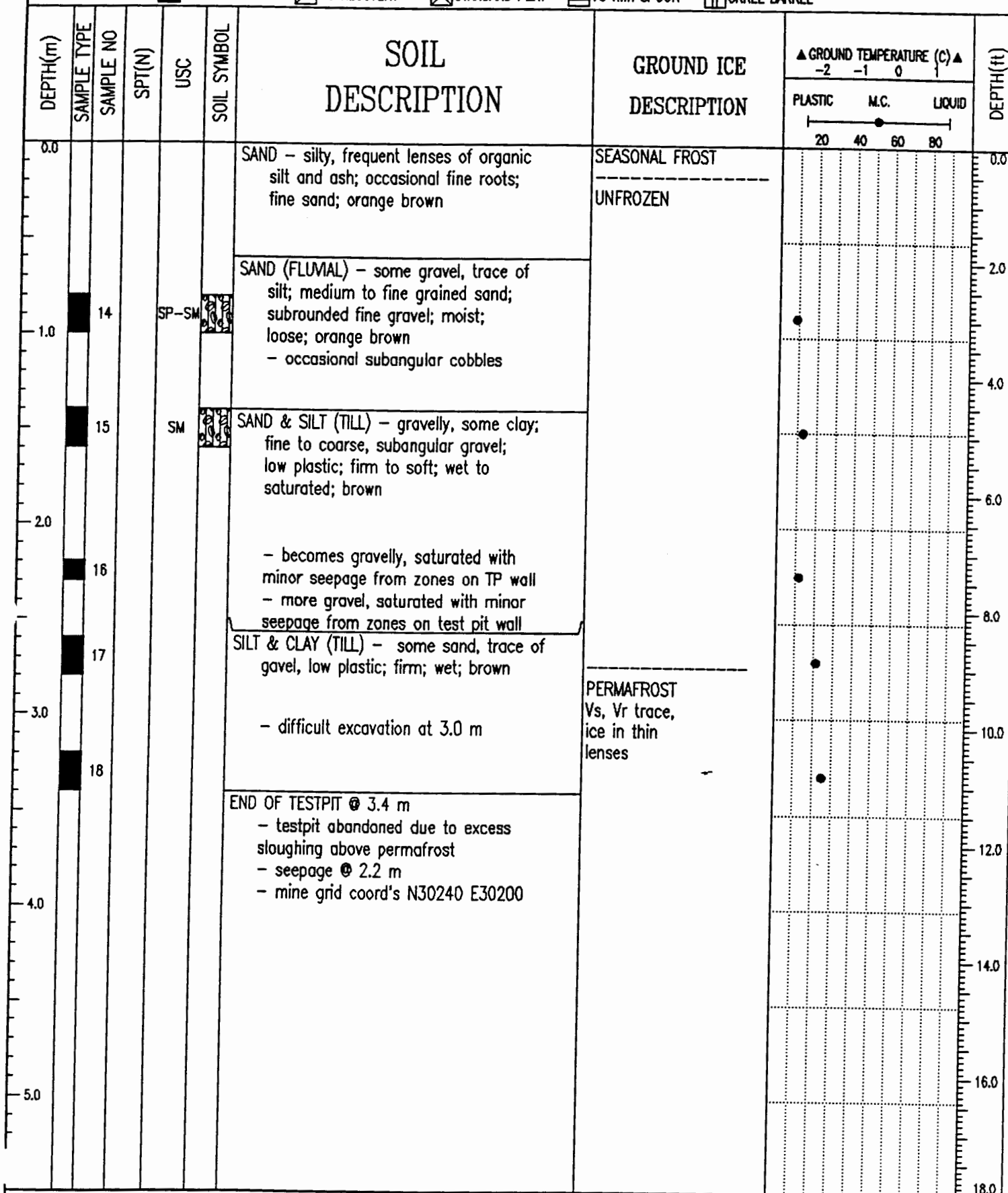
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GEOTECHNICAL EXPLORATION-HEAP 1 4 PAD EXCAVATOR: CAT 225 PROJECT NO: 0201-97-13103
 WILLIAMS CREEK, YUKON UTM ZONE: 8 N - E - ELEVATION: 1573 m

SAMPLE TYPE GRAB SAMPLE ☒ NO RECOVERY ☒ STANDARD PEN. ☒ 75 mm SPOON ☒ CRREL BARREL

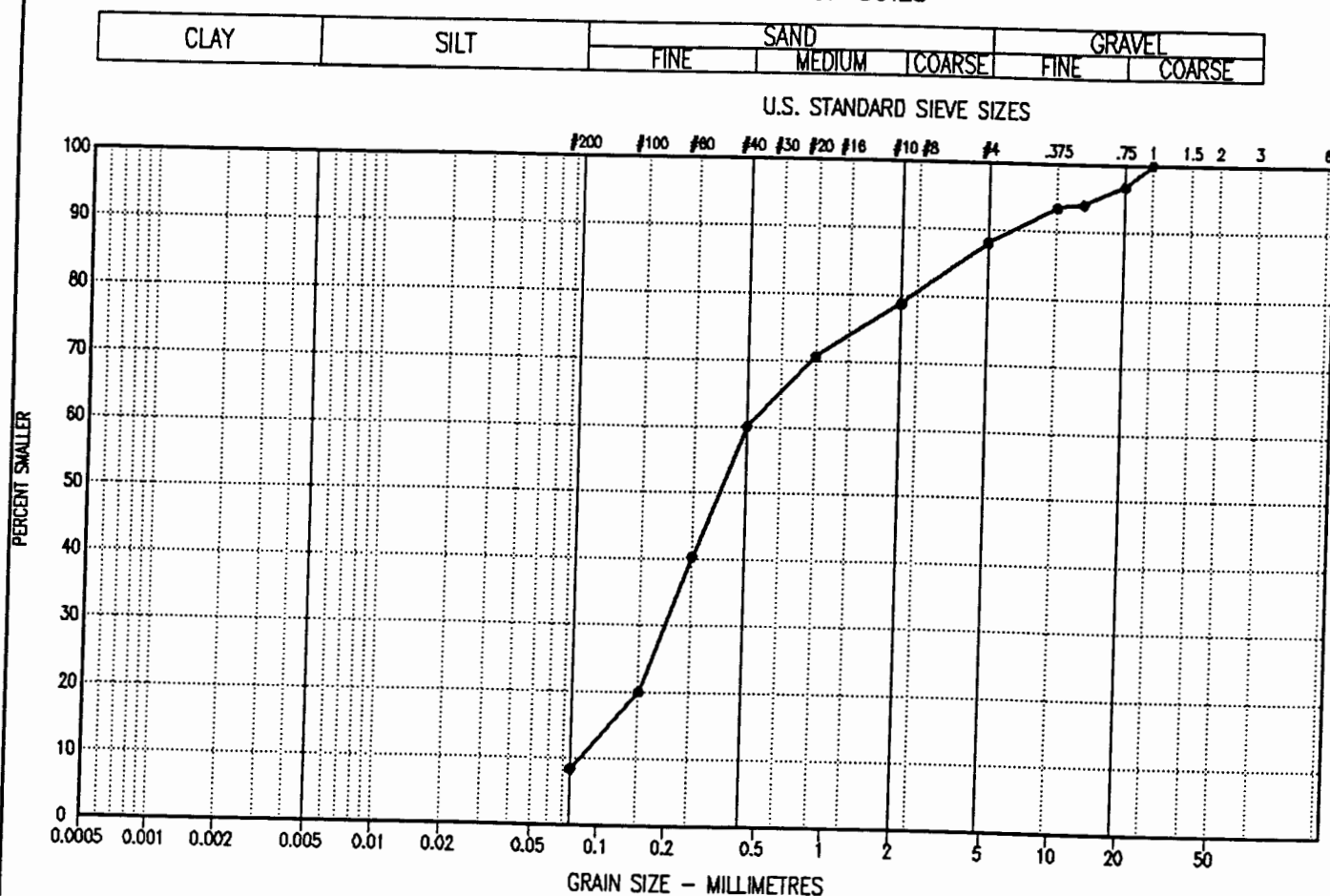


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 Whitehorse, Yukon

LOGGED BY: CRH
 REVIEWED BY: JRT
 Fig. No:

COMPLETION DEPTH: 3.4 m
 COMPLETE: 97/10/29

PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
—	TP04	0.80 - 1.00	8.4	79.6	12.0	5.0	1.1	SP-SM

Project: 0201-97-13103

Date Tested: 97/11/03

BY: JSB

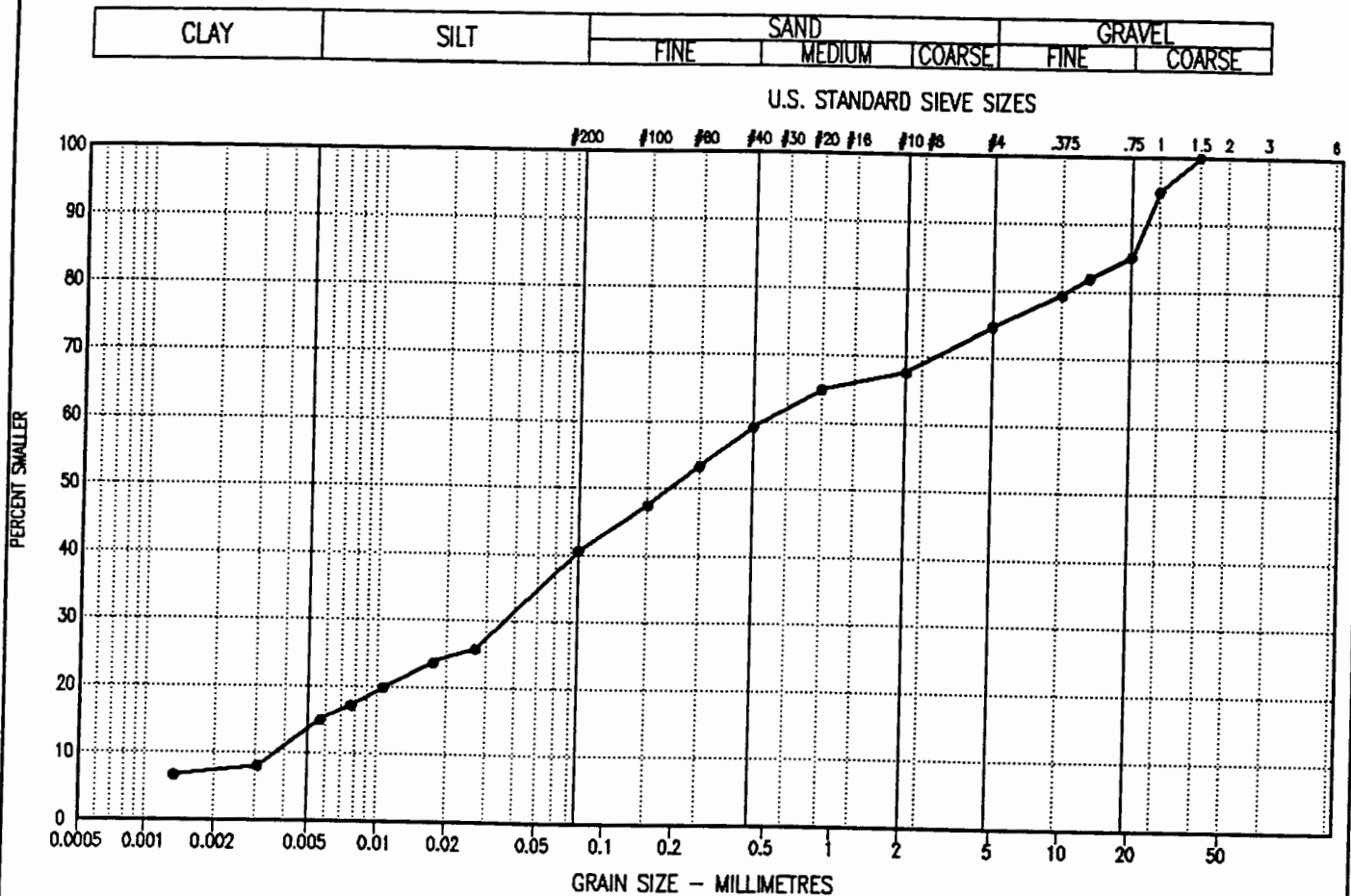
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PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION				Cu	Cc	U.S.C
			CLAY %	SILT %	SAND %	GRAVEL %			
—●—	TP04	1.40 - 1.60	13.1	27.5	33.9	25.5	128.1	0.9	SM

Project: 0201-97-13103

Date Tested: 97/11/03

BY: JSB

Tested in accordance with ASTM D422 unless otherwise noted.

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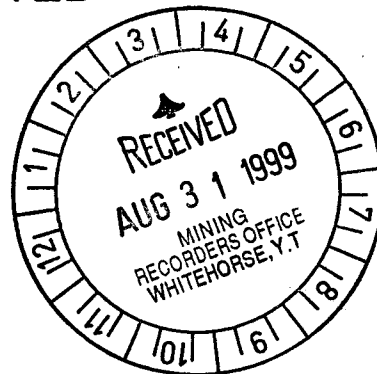
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**WESTERN COPPER
HOLDINGS LIMITED**

094003



Baseline Data Compilation Report

January 14, 1998



**ACCESS
CONSULTING
GROUP**

Access Mining Consultants Ltd.

**Western Copper Holdings Ltd. Carmacks Copper Project
Baseline Data Compilation Report**

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Appendix

- I** **Piezometer Record Sheets (Data From 1993 to September, 1997)**
- II** **Thermistor Record Sheets (Th-1 to Th-5) and Ground Temperature Envelopes (Th-1 to Th-3) (Data From 1993 to September, 1997)**
- III** **Water Quality Data**
- III.A Surface Water Quality Data for Stations W-1 W-2, W-3, W-4, W-5, W-6, W-7, W-9, W-10 and W-11 for the Period from October, 1989 to October, 1992 and a Data Summary
- III.B Surface Water Quality from Stations W-3, W-4, W-5, W-7 and W-9 for May, 1994
- III.C 1995 Groundwater Quality for Well RC-92-01 and WW95-01
- III.D Water Quality Data (Surface and Groundwater) from September, 1997 Field Trip
- IV** **Hydrological Data**
- IV.A Upper Williams Creek Stream Flow Data for the Period from June 10 to August 31, 1992 at Site W-9
- IV.B 1993 and 1994 Hydrological Data.
- IV.C Hydrological Data and Analysis Displayed in Tables and Figures
- IV.D Runoff Coefficients for Big Creek.
- V** **Climate Data**
- V.A Precipitation, Temperature and Snow Pack Data from Williams Creek and Surrounding Area, Including Historic and 1992 Climate Data.
- V.B 1992 and 1994 Temperature, Precipitation and Snow Pack Data
- V.C Graphical Representations of Precipitation Rate for Actual, Estimated and Long term for July to September, 1996
- V.D Daily and Monthly Averages of Meteorological Parameters Measured at the Williams Creek Climate Station (1994 to 1997)

1.0 Introduction

A field reconnaissance was undertaken on September 27th and 28th, 1997 to conduct piezometric and thermistor measurements at existing monitoring stations and collect surface / groundwater quality samples at Western Copper's Carmacks Copper Project property. This report summarizes the data collected during the September field trip to Western Copper's Carmacks Copper Project.

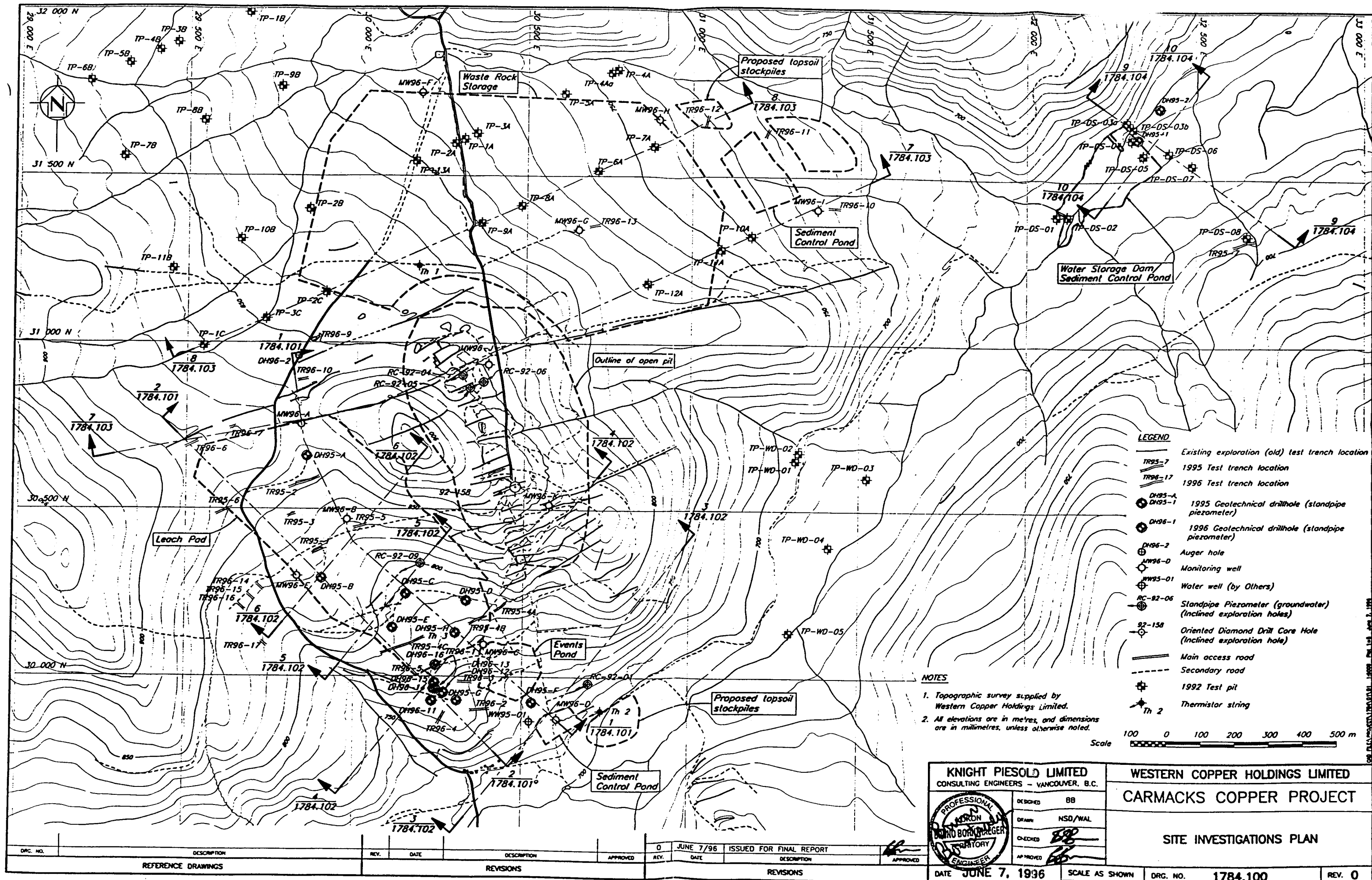
The September field trip comprised the following:

- Measuring water levels at all piezometer stations;
- Recording thermistor readings on both the 27th and 28th;
- Collecting groundwater quality samples for total metals, dissolved metals, nutrient and physical parameter samples from wells RC-92-01, DH95-B, MW96-B and MW96-F; and
- Collecting surface water quality samples for total metals, dissolved metals, nutrient and physical parameter samples and conducting flow measurements at surface water stations W-3 (unnamed tributary to Williams Creek, upstream of station W-4), W-4 (Williams Creek, downstream of station W-3) and W-9 (Williams Creek, at existing site access road).

This report also contains updates and presents a compilation of existing information for piezometer, thermistor, water quality, hydrology and climate data from reports submitted as part of the environmental review. Additional data was also obtained from J. Gibson and Associates Ltd. and DIAND Water Resources in the form of piezometer and thermistor data and data logger files from the Williams Creek automated climate station, respectively.

2.0 Piezometers

Standpipe piezometer wells were installed at the Carmacks Copper site in 1992, 1995 and 1996 to measure groundwater levels and allow for the collection of water quality samples. In total, 36 piezometers were installed at the site from 1992 to 1996. Piezometer records from 1992 to 1996 and the 1997 field trip are contained in Appendix I. The results from the 1997 survey are summarized in the following sections. The locations of the piezometers are shown on the Site Investigations Plan, Drawing 1784.100.



KNIGHT PIESOLD LIMITED CONSULTING ENGINEERS - VANCOUVER, B.C.		WESTERN COPPER HOLDINGS LIMITED	
		CARMACKS COPPER PROJECT	
DESIGNED BB DRAWN NSD/WAL CHECKED BB APPROVED BB		SITE INVESTIGATIONS PLAN	
DATE JUNE 7, 1936	SCALE AS SHOWN	DRG. NO. 1784-100	REV. 0

2.1 Waste Rock Storage Area

As can be observed from the piezometer logs, the water within the wells in the Waste Rock Storage Area (WRSA) site, and the well near the WRSA sediment control pond, appeared to be frozen near the surface during the 1997 survey. Barriers were encountered much closer to the surface than the recorded end of hole depths, or water levels reported during installation of the wells in 1996. It appears that the water levels rose within the piezometers under pressure and then froze. The thermistor data from Th-1, within the WRSA, indicate that ground temperatures within the area are consistently at or below freezing at a depth of 5.2 m.

Monitoring well MW96-F was the only piezometer within the WRSA in which water was observed. Mud and ice were also observed on the probe after it hit a barrier at 3.85 m. This well was partially purged on September 27 and observed again the next day. There was very little change in water level after the initial purge and the well did not recharge overnight indicating that the water within the well was probably surface water that had collected on a layer of ice.

A water quality sample was collected from the water purged the previous day.

2.2 Open Pit

Water was not encountered in any of the piezometers measured within the Open Pit. However, well MW96-K could not be located and friction along the walls of the 1992 inclined piezometers prevented the M-Scope from reaching the bottom of the hole.

2.3 Heap Leach Pad

There are several piezometers located within, and immediately downslope of, the heap leach pad and events pond (Drawing 1784.100). The depth to water was recorded in all of the wells and water quality samples were collected from two wells, MW96-B and DH95-B, within the proposed pad area.

Field personnel attempted to record the piezometer water level and collect ground water quality samples from water well WW95-01; however it was not possible due to the well casing installation. Camp personnel indicated that they were not successful in getting the electric pump within the well operational.

3.0 Thermistors

Thermistor data from monitoring stations Th-1 to Th-5, including ground temperature envelopes for Th-1 to Th-3, are contained in Appendix II. The locations of the thermistors are shown on Drawing 1784.100. The records contained in Appendix II include additional thermistor data from 1994 and 1995 and the 1997 field trip.

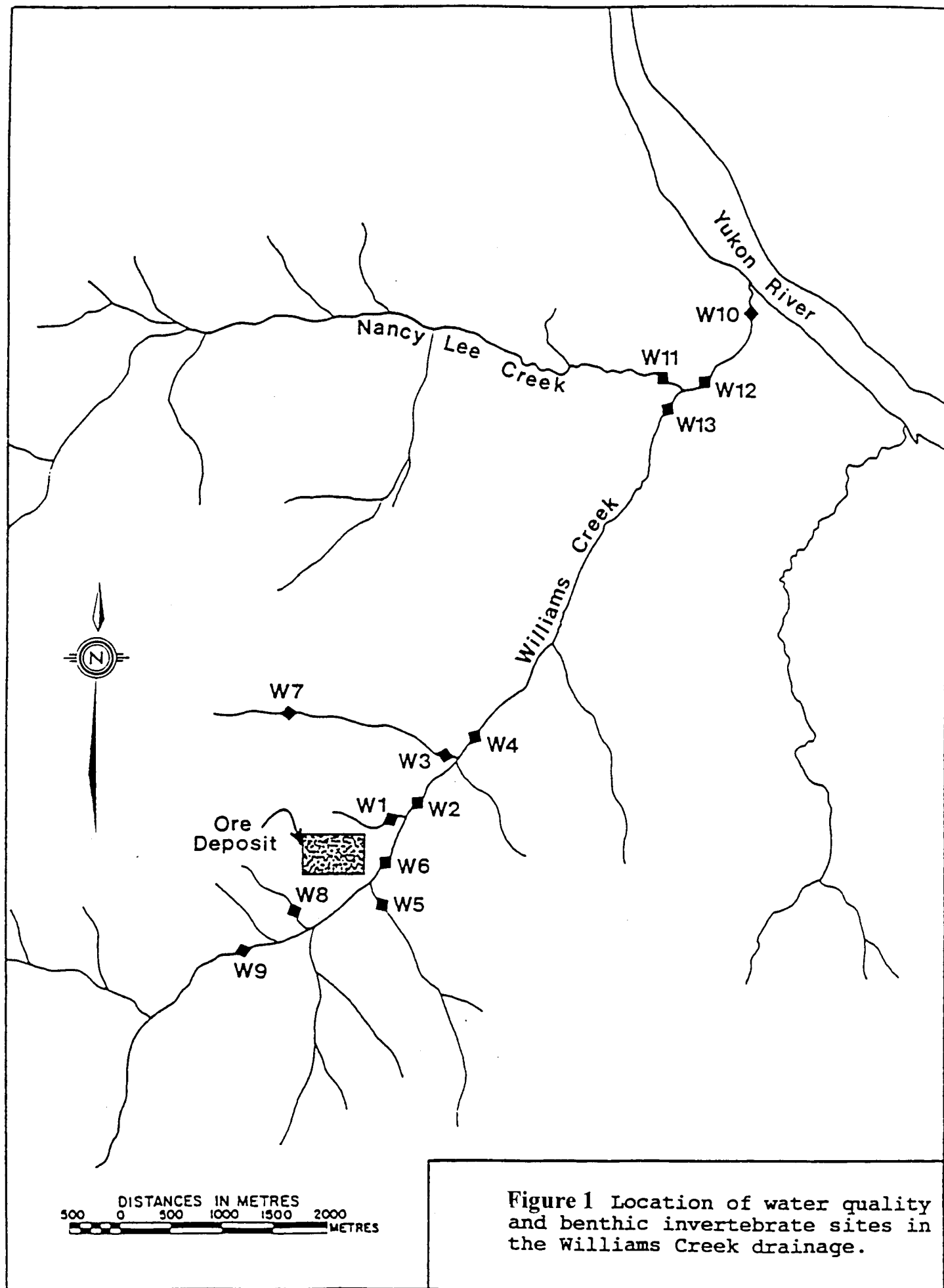
4.0 Water Quality

Both ground and surface water quality samples were collected at the project site during 1997.

4.1 Surface Water

Surface water quality samples were collected from stations W-3 (Tributary to Williams Creek), W-4 (Williams Creek downstream of confluence with W-3 station) and W-9 (Williams Creek upstream of access road). Figure 1 details the locations of the water quality stations. The titles and locations of the water quality monitoring stations are also provided in Table 1.

In Situ and laboratory water quality data for surface stations are contained within Table 1 of Appendix III.D. Selected parameters, and the applicable guidelines for the protection of freshwater aquatic life (CCREM, 1997) are contained on Table 2.



**Western Copper Holdings Ltd. Carmacks Copper Project
Baseline Data Compilation Report**

Table 1	
Water Quality and Hydrology Monitoring Stations	
Station	Description / Location
Water Quality	
W-1	Tributary to Williams Creek
W-2	Williams Creek Downstream of W-1 Tributary
W-3	Tributary to Williams Creek (from Waste Rock Storage Area)
W-4	Williams Creek downstream of Confluence with W-3 Tributary
W-5	South East Tributary to Williams Creek
W-6	Williams Creek downstream of South East Tributary
W-7	Waste Rock Storage Area Tributary Near Road (Upstream of W-3)
W-8	Tributary to Williams Creek Near Access Road
W-9	Williams Creek Upstream of Access Road
W-10	Williams Creek Upstream of Yukon River
W-11	Nancy Lee Creek (Tributary of Williams Creek)
W-12	Williams Creek Downstream of Confluence with Nancy Lee Creek
W-13	Williams Creek Upstream of Confluence with Nancy Lee Creek
Hydrology Stations	
W-9 (Staff Gauge)	Staff Gauge Site (1991) on Williams Creek Immediately Downstream of Access Road (Immediately Downstream of Water Quality Site W-9)
W-2 (Recorder No. 2)	Data Logger Site No. 2 on Williams Creek Upstream of Waste Rock Tributary
W-4 (Recorder No. 3)	Data Logger Site No. 3 on Williams Creek Downstream of Waste Rock Tributary
W-10 (Recorder No. 1)	Data Logger Site No. 1 on Williams Creek Upstream of Yukon River

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Baseline Data Compilation Report

Table 2				
Surface Water Quality for Selected Parameters				
Station	W-3	W-4	W-9	CCREM Guideline
Sample Date	28-Sep-97	28-Sep-97	28-Sep-97	
Hardness (CaCO ₃), mg/L	158	129	135	
Aluminum (total), mg/L	0.197	0.033	0.569	0.1 for pH > 6.5
Arsenic (total), mg/L	0.0007	0.0006	0.0011	0.05
Cadmium (total), mg/L	<0.00005	<0.00005	<0.00005	0.0002-0.0018 ^H
Chromium (total), mg/L	<0.0005	<0.0005	0.0009	0.002*
Copper (total), mg/L	0.0017	0.0011	0.0025	0.002-0.004 ^H
Iron (total), mg/L	0.6	0.48	0.91	0.3
Lead (total), mg/L	0.00015	<0.00005	0.00049	0.001-0.007 ^H
Mercury (total), mg/L	<0.00005	<0.00005	<0.00005	0.0001
Nickel (total), mg/L	0.0014	0.001	0.0018	0.025-0.150 ^H
Selenium (total), mg/L	<0.001	<0.001	<0.001	0.001
Silver (total), mg/L	<0.00001	<0.00001	0.00001	0.0001
Zinc (total), mg/L	0.002	0.003	0.005	0.03

Note: * Indicates guideline to protect aquatic life including zooplankton and phytoplankton, ^H denotes that guideline depends on Hardness, **bold** denotes that CCREM guideline exceeded

Most surface water quality parameters were below CCREM freshwater aquatic guidelines. The only two parameters exceeding the guideline were aluminum and iron. Stations W-3 (tributary to Williams Creek) and W-9 (Williams Creek) both reported aluminum concentrations above the guideline. Iron exceeded the guideline at all three stations.

4.2 Groundwater

The *in situ* and laboratory water quality data from the 1997 field trip for piezometers RC-92-01, DH95-B, MW96-B and MW96-F are contained within Table 2 of Appendix III.D. Selected parameters, and the applicable guidelines for the protection of freshwater aquatic life (CCREM, 1997) where applicable, are presented in Table 3. The locations of the groundwater wells are shown on Drawing 1784.100.

**Western Copper Holdings Ltd. Carmacks Copper Project
Baseline Data Compilation Report**

As can be observed from Table 3, the groundwater quality parameters were generally below CCREM guidelines for freshwater aquatic life. Total selenium concentrations were below the CCREM guideline, or below the detection limit of 0.01 mg/L at piezometer DH95-B, at all sites except for piezometer RC-92-01. Total aluminum and iron concentrations were above the guideline at wells MW96-B, MW96-F and DH95-B. Piezometers DH95-B and MW96-F reported total copper levels above the guideline. Piezometer DH95-B had total lead levels above the guideline. Total zinc concentrations were above the guideline at MW96-F and DH95-B.

Table 3					
Groundwater Quality for Selected Parameters					
Well	RC92-01	MW96-B	MW96-F	DH95-B	CCREM Guideline
Sample Date	27-Sep-97	28-Sep-97	28-Sep-97	28-Sep-97	
Hardness (CaCO ₃), mg/L	273	131	189	140	
Aluminum (total), mg/L	0.068	1.35	0.231	26.1	0.1 for pH > 6.5
Arsenic (total), mg/L	0.0003	0.0005	0.0011	0.002	0.05
Cadmium (total), mg/L	<0.00005	0.00006	0.00025	<0.0005	0.0002-0.0018 ^H
Chromium (total), mg/L	<0.0005	0.001	0.001	0.011	0.002*
Copper (total), mg/L	0.001	0.0018	0.0147	0.009	0.002-0.004 ^H
Iron (total), mg/L	0.06	1.14	0.4	3.52	0.3
Lead (total), mg/L	0.00024	0.00173	0.0036	0.0121	0.001-0.007 ^H
Mercury (total), mg/L	<0.00005	<0.00005	<0.00005	<0.00005	0.0001
Nickel (total), mg/L	0.0014	0.0011	0.0094	0.005	0.025-0.150 ^H
Selenium (total), mg/L	0.002	<0.001	<0.001	<0.01	0.001
Silver (total), mg/L	<0.00001	<0.00001	0.00002	<0.00001	0.0001
Zinc (total), mg/L	0.004	0.007	0.047	0.09	0.03

Note: * Indicates guideline to protect aquatic life including zooplankton and phytoplankton, ^H denotes that guideline depends on Hardness, **bold** denotes that CCREM guideline exceeded

4.3 Quality Assurance / Quality Control (QA/QA)

A strict QA/QC program for the collection, preservation and shipping of water quality samples was followed during the surface and ground water investigations. As part of the QA/QC wells were purged three times before samples were collected with the following exceptions:

- Well MW96-F was partially purged once. As previously noted, the well had frozen near the surface and only water which had ponded above the ice could be sampled. This sample was not intended to be an accurate representation of the groundwater chemistry for the area; and
- Just over two purges of well MW96-B was completed. Slow well recharge after the second purge inhibited further purging.

In addition, it is important to note that the water depth within the inclined well RC-92-01, could not be recorded by the M-Scope due to excessive friction along the walls. Thus purge volumes for this well were determined using one of the deepest water level depths previously recorded. In order to account for this, over three purge volumes were removed from the well prior to sampling.

4.4 Data Summary

Surface and ground water quality data previously submitted as part of the environmental review process are included with the Appendices of this report. Appendix III.B and III.C provide surface water quality data from October (1989) to October (1992) and May (1994), respectively. Water quality data from wells RC-92-01 and WW95-01 are provided in Appendix III.C.

5.0 Hydrology

5.1 Field Trip

Flows were recorded at stations W-4 (Recorder No. 3), Williams Creek downstream of the waste rock storage area tributary, and immediately downstream of the present site access road at station W-9 (Staff Gauge, 1991). The approximate locations of the hydrology stations within

the Williams Creek drainage are shown on Figure 2. Table 2 provides the titles and locations of the sites.

The flows for W-4 and W-9 were 0.038 m³/s and 0.015 m³/s, respectively. The flows at these stations were determined using a price type AA current meter and the six tenths of depth, velocity/area method. The current meter could not be used at Station W-3 (waste rock storage area tributary to Williams Creek) due to braiding of the stream, subsurface flow and excessive algae growth so the flow was visually estimated to be 2 L/s (0.002 m³/s).

5.2 Hydrological Data Summary

Hydrological data, previously submitted as part of the environmental review process, is contained within the following appendices:

Appendix IV.A	Upper Williams Creek Stream Flow Data for the Period from June 10 to August 31, 1992 at Site W-9.
Appendix IV.B	1993 and 1994 Hydrological Data.
Appendix IV.C	Hydrological Data and Analysis Displayed in Tables and Figures
Appendix IV.D	Runoff Coefficients for Big Creek.

In addition to the data contained within the appendices, Table 4 has been prepared which summarizes the sport flow measurement data reported in the IEE and the data from the 1997 field trip.

6.0 Climate Data

Climate data from the IEE and Addendums are provided in the following appendices:

Appendix V.A	Precipitation, Temperature and Snow Pack Data from Williams Creek and Surrounding Area, Including Historic and 1992 Climate Data
Appendix V.B	1992 and 1994 Temperature, Precipitation and Snow Pack Data
Appendix V.C	Graphical Representations of Precipitation Rate for Actual, Estimated and Long Term for July to September, 1996
Appendix V.D	Daily and Monthly Averages of Meteorological Parameters Measured at the Williams Creek Climate Station (1994 to 1997)

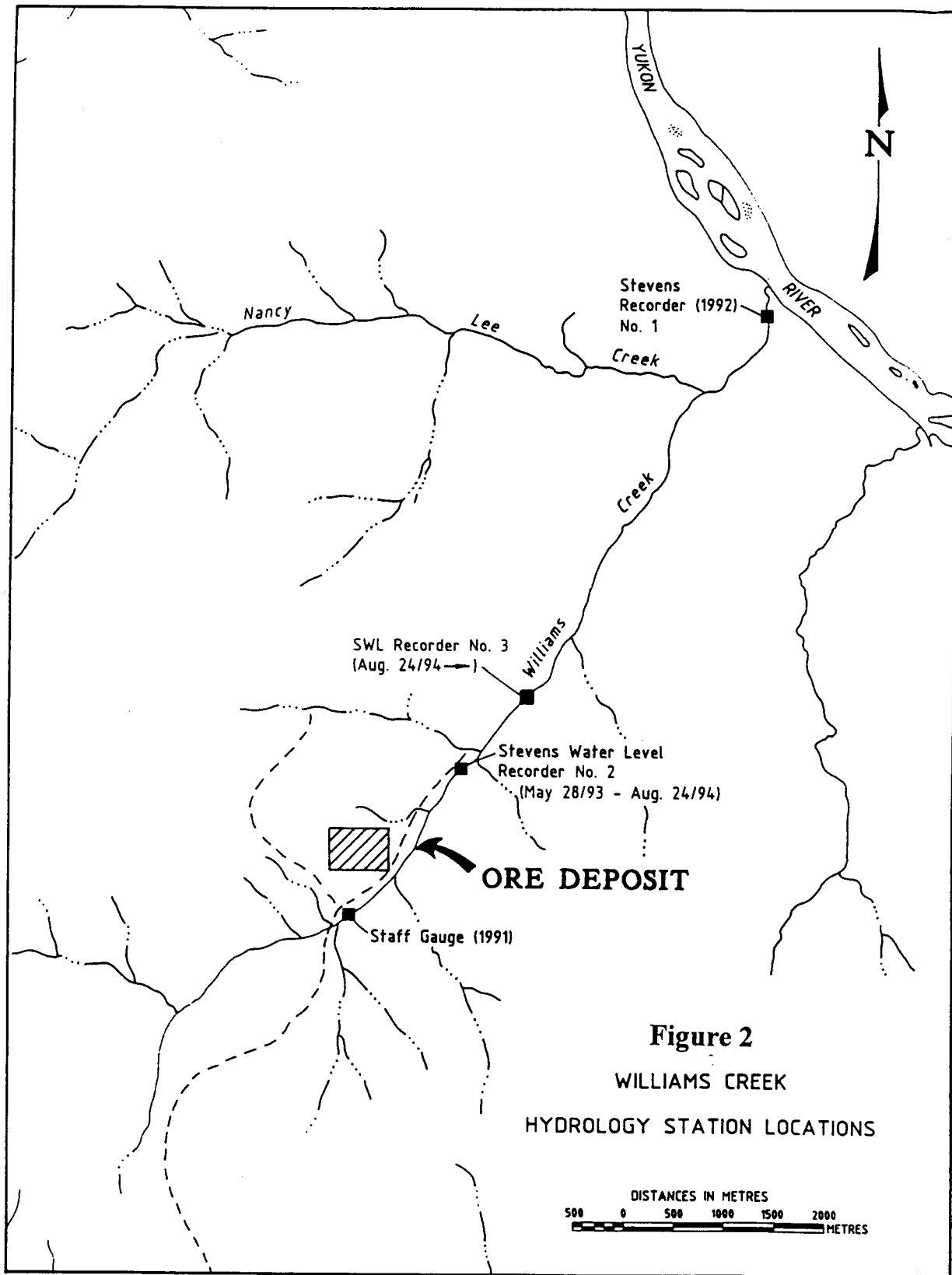


TABLE 4 SUMMARY OF STREAMFLOW MEASUREMENTS

Station	Description	Date	Time	Water Level (m)		Discharge (m ³ /s)
				Staff Gauge	Water Level Recorder	
W-2	Williams Creek - Recorder No. 2	07-Aug-91	16:50			0.044
		17-May-92	11:35			0.403
		05-Jul-92				0.08
		28-May-93		0.533	97.923 ^E	0.144
		28-May-93		0.539	97.93 ^E	0.145
		02-Jul-93		0.37	97.761 ^E (0.368)	0.036
		02-Jul-93		0.368	97.759 ^E	0.035
		02-Aug-93		0.22	97.611 ^E (0.221)	0.009
		02-Sep-93		0.4	97.791 ^E (0.4)	0.035
		02-Sep-93		0.401	97.792 ^E	0.036
		29-Oct-93		0.398	97.789 ^E	0.029 ^I
		02-May-94				0.247 ^I
		13-May-94				0.046 ^I
		30-May-94		0.399		0.043
		30-May-94		0.409		0.043
		09-Jul-94		0.423	0.481	0.046
		10-Jul-94		0.41		0.403
W-3	Unnamed tributary to Williams Creek					
W-4	Williams Creek downstream of Waste Rock Storage Area Tributary - Recorder No. 3	28-Sep-97	16:00	0.468		0.038
W-5	Southeast tributary to Williams Creek	07-Aug-91				0.023
Mainstem	Upstream of W-5	07-Aug-92				0.023
W-9	Williams Creek immediately downstream of Access Road (downstream of W-9)	06-Jul-91	9:25	0.117 ***		0.014
		06-Jul-91		0.117		0.011
		06-Jul-91	20:00	0.119		0.014
		06-Jul-91		0.119		0.012
		07-Aug-91	8:00	0.129		0.013
		07-Aug-91		0.129		0.015
		07-Aug-91		0.129		0.012
		17-Sep-91	13:00	0.25		0.029
		17-Sep-91		0.25		0.027
		16-May-92	20:00	0.585		0.291
		17-May-92	13:05	0.544		0.234
		08-Jul-92		0.381		0.069
		29-May-93		under complete ice cover/glaciated		
		02-Jul-93		0.223		0.25
		02-Aug-93		0.096		0.01
		02-Sep-93		0.198		0.026
		29-Oct-93		under complete ice cover/glaciated		
		30-May-94		0.238		0.026
		10-Jul-94		0.195		0.031
		28-Sep-97	17:30			0.015
W-10	Williams Creek Upstream of Yukon River - Recorder No. 1	07-Aug-91				0.202
		17-Sep-91				0.19
		31-Mar-92				0.005
		18-May-92*	14:10	0.391	0.391	0.894
		07-Jul-92				0.271
		10-Jul-92**	14:20	0.434	0.455	0.376
		23-Jul-92	11:45	0.215	0.225	0.235
			12:15	0.215	0.225	0.211
		19-Oct-92		under complete ice cover/float frozen		0.034
		02-May-94		under complete ice cover/float frozen		0.247
		13-May-94				0.046 ^I
		30-May-94		0.458	0.46	0.043
		30-May-94		0.465	0.466	0.043
Nancy Lee	Mainstem - upstream of W-11	07-Jul-92				0.077
		18-May-92	15:07			0.61
W-11	Nancy Lee Creek Upstream of Williams Creek	07-Jul-92				0.141
		19-Oct-92	12:20			0.105 ^I

Notes:

* Data logger installed on May 18, 1992

** Measurement under backwater effect from Yukon River

*** At lower gauge (W-9) heights, two or more flows were taken for better definition of lower end of rating curve

I Ice on channel bottom

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Electronic copies of the 1994 to 1997 data logger files for the Williams Creek Climate Station were obtained from DIAND Water Resources. Daily and monthly averages for the data were determined and are contained within Appendix V.D. The dates of climate data records are summarized below:

	From	To
Year	Day	Day
1994	September 13	December 31
1995	January 1	November 25
1996	March 28	December 31
1997	January 1	September 5

There are no data records from November 26, 1995 to March 27, 1996.

7.0 Conclusions

The data contained within this report is meant to assist Western Copper and its consultants to address issues raised by the RERC as part of the project's environmental review.

Appendix I

Piezometer Record Sheets

Data From 1993 to September, 1997

PIEZOMETER RECORD SHEET

WESTERN COPPER HOLDINGS LIMITED CARMACKS COPPER PROJECT

PIEZOMETER NUMBER	RC-92-01
PIEZOMETER LOCATION	DOWNSLOPE OF EVENTS POND
SURVEY LOCATION (m)	
GROUND ELEVATION (m)	
DATE OF INSTALLATION	August/September, 1992
TOP OF WELL COMPLETION INTERVAL (m)	
BOTTOM OF WELL COMPLETION INTERVAL (m)	64.8 (angled hole)
WELL COMPLETION INTERVAL (m)	
PIEZOMETER STICKUP ABOVE GROUND (m)	
SIZE OF PIEZOMETER	2 inch (5.08 cm) diameter

PIEZOMETER READINGS AND STATUS

DATE	TIME	DEPTH TO WATER FROM TOP OF PVC		WATER ELEVATION (meters)	COMMENTS
		(feet)	(meters)		
29-Apr-93		65.9	20.1		
2-Aug-93		66.3	20.2		
2-Sep-93		66.5	20.3		
29-Oct-93		>66.0	>20.1		No water encountered
15-Apr-94		66.3	20.2		
13-May-94		67.0	20.4		
26-Oct-94		67.5	20.6		
15-Aug-95		>68.9	>21		Water quality samples taken
27-Sep-97		>32.8	>10		Water quality samples taken

Note: > Indicates that the maximum depth achieved by M-Scope after 3 attempts

PIEZOMETER RECORD SHEET

WESTERN COPPER HOLDINGS LIMITED CARMACKS COPPER PROJECT

PIEZOMETER NUMBER	RC-92-04
PIEZOMETER LOCATION	OPEN PIT
SURVEY LOCATION (m)	
GROUND ELEVATION (m)	
DATE OF INSTALLATION	August/September, 1992
TOP OF WELL COMPLETION INTERVAL (m)	
BOTTOM OF WELL COMPLETION INTERVAL (m)	63.8 (angled hole)
WELL COMPLETION INTERVAL (m)	
PIEZOMETER STICKUP ABOVE GROUND (m)	
SIZE OF PIEZOMETER	2 inch (5.08 cm) diameter

PIEZOMETER READINGS AND STATUS

DATE	TIME	DEPTH TO WATER FROM TOP OF PVC		WATER ELEVATION (meters)	COMMENTS
		(feet)	(meters)		
29-Apr-93		>132	>40.2		No water encountered
28-May-93		>140.2**	>42.7		No water encountered
2-Aug-93		>56.5	>17.2		No water encountered
2-Sep-93		>79.5	>24.2		No water encountered
29-Oct-93		>65.0	>19.8		No water encountered
15-Apr-94		DW			DW-Dry Well; probe hit bottom at 66.1 m
13-May-94		>148	>45.1		No water encountered
26-Oct-94		>186	>56.7		No water encountered
19-May-95		>105	>32		No water encountered
22-Jul-95		>98.4	>30		No water encountered
27-Sep-97		>134.5	>41		No water encountered

Note: > Indicates that the maximum depth achieved by M-Scope after 3 attempts

• Three gallons of de-ionized water was poured down the well to wash out piezometer and allow the M-Scope to slide further down the well. Still could not get M-Scope to bottom of well.

PIEZOMETER RECORD SHEET

WESTERN COPPER HOLDINGS LIMITED CARMACKS COPPER PROJECT

PIEZOMETER NUMBER	RC-92-05
PIEZOMETER LOCATION	OPEN PIT
SURVEY LOCATION (m)	
GROUND ELEVATION (m)	
DATE OF INSTALLATION	August/September, 1992
TOP OF WELL COMPLETION INTERVAL (m)	
BOTTOM OF WELL COMPLETION INTERVAL (m)	61.9 (angled hole)
WELL COMPLETION INTERVAL (m)	
PIEZOMETER STICKUP ABOVE GROUND (m)	
SIZE OF PIEZOMETER	2 inch (5.08 cm) diameter

PIEZOMETER READINGS AND STATUS

DATE	TIME	DEPTH TO WATER FROM TOP OF PVC		WATER ELEVATION (meters)	COMMENTS
		(feet)	(meters)		
29-Apr-93		>160	>48.8		No water encountered
28-May-93		>105*	>32		No water encountered
2-Aug-93		>83	>25.3		No water encountered
2-Sep-93		>87	>26.5		No water encountered
29-Oct-93		>54	>16.4		No water encountered
15-Apr-94		>147	>44.8		No water encountered
13-May-94		DW			DW-Dry Well; Probe hit
26-Oct-94		DW			bottom at 61.9 m
19-May-95		>44.3	>13.5		No water encountered
22-Jul-95		>23.0	>7		No water encountered
27-Sep-97		>190.3	>58		No water encountered

Note: > Indicates that the maximum depth achieved by M-Scope after 3 attempts

* Three gallons of de-ionized water was poured down the well to wash out piezometer and allow the M-Scope to slide further down the well. Still could not get M-Scope to bottom of well.

PIEZOMETER RECORD SHEET

WESTERN COPPER HOLDINGS LIMITED CARMACKS COPPER PROJECT

PIEZOMETER NUMBER	RC-92-06
PIEZOMETER LOCATION	OPEN PIT
SURVEY LOCATION (m)	
GROUND ELEVATION (m)	
DATE OF INSTALLATION	August/September, 1992
TOP OF WELL COMPLETION INTERVAL (m)	
BOTTOM OF WELL COMPLETION INTERVAL (m)	121.9 (angled hole)
WELL COMPLETION INTERVAL (m)	
PIEZOMETER STICKUP ABOVE GROUND (m)	
SIZE OF PIEZOMETER	2 inch (5.08 cm)

PIEZOMETER READINGS AND STATUS

DATE	TIME	DEPTH TO WATER FROM TOP OF PVC		WATER ELEVATION (meters)	COMMENTS
		(feet)	(meters)		
29-Apr-93		>303	>92.4		No water encountered
28-May-93		>280	>85.3		No water encountered
2-Aug-93		>48	>14.6		No water encountered
2-Sep-93		>62	>18.9		No water encountered
29-Oct-93		>67	>20.4		No water encountered
15-Apr-94		>210	>64.0		No water encountered
13-May-94		>343	>104.5		No water encountered
26-Oct-94		>382	>116.4		No water encountered
19-May-95		>328.1	>100		No water encountered
22-Jul-95		>328.1	>100		No water encountered
27-Sep-97		>42.6	>13		No water encountered
					Probe hit obstacle at 13m

Note: > Indicates that the maximum depth achieved by M-Scope after 3 attempts

- Three gallons of de-ionized water was poured down the well to wash out piezometer and allow the M-Scope to slide further down the well. Still could not get M-Scope to bottom of well.

PIEZOMETER RECORD SHEET

WESTERN COPPER HOLDINGS LIMITED CARMACKS COPPER PROJECT

PIEZOMETER NUMBER	RC-92-09
PIEZOMETER LOCATION	HEAP LEACH PAD SITE
SURVEY LOCATION (m)	
GROUND ELEVATION (m)	
DATE OF INSTALLATION	August/September, 1992
TOP OF WELL COMPLETION INTERVAL (m)	
BOTTOM OF WELL COMPLETION INTERVAL (m)	92.2 (angled hole)
WELL COMPLETION INTERVAL (m)	
PIEZOMETER STICKUP ABOVE GROUND (m)	
SIZE OF PIEZOMETER	2 inch (5.08 cm) diameter

PIEZOMETER READINGS AND STATUS

DATE	TIME	DEPTH TO WATER FROM TOP OF PVC		WATER ELEVATION (meters)	COMMENTS
		(feet)	(meters)		
29-Apr-93		191.80	58.5		
2-Aug-93		190.50	58.1		
2-Sep-93		189.80	57.9		
29-Oct-93		>70	>21.3		No water encountered
15-Apr-94		>221	>67.4		No water encountered
13-May-94		190.0	57.9		
26-Oct-94		189.9	57.9		
28-Sep-97		>39.4	>12		No water encountered

Note: > Indicates that the maximum depth achieved by M-Scope after 3 attempts

	PIEZOMETER RECORD SHEET

WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT

DH95-G(1)

PROCESS PLANT SITE

765

27-Feb-95

9.14 (10.7 EOH)

0.6

1 inch (2.54 cm) diameter

PIEZOMETER READINGS AND STATUS

[illegible]

	PIEZOMETER RECORD SHEET

WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT

MW96-A1

HEAP LEACH PAD SITE

30755 N 29835 E

861

17-Feb-96

34.4

45.7

11.3

0.6

2 inch (5.08 cm) diameter SCH 40 PVC

PIEZOMETER READINGS AND STATUS

[illegible]

	PIEZOMETER RECORD SHEET

WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT

MW96-A2

HEAP LEACH PAD SITE

30755 N 29835 E

861

17-Feb-96

81.7

91.4

9.7

0.6

2 inch (5.08cm) diameter SCH 40 PVC

PIEZOMETER READINGS AND STATUS

[illegible]

	PIEZOMETER RECORD SHEET

WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT

MW96-B

HEAP LEACH PAD SITE

30470 N 29974 E

833

18-Feb-96

73.4

91.4

18.0

0.3

2 inch (5.08cm) diameter SCH 40 PVC

PIEZOMETER READINGS AND STATUS

[illegible]

	PIEZOMETER RECORD SHEET

WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT

PIEZOMETER NUMBER
PIEZOMETER LOCATION
SURVEY LOCATION (m)
GROUND ELEVATION (m)
DATE OF INSTALLATION
WELL COMPLETION INTERVAL (m)
WELL COMPLETION INTERVAL (m)
WELL COMPLETION INTERVAL (m)
PIEZOMETER STICKUP ABOVE GROUND (m)
SIZE OF PIEZOMETER

MW96-D
HEAP LEACH PAD SITE
29875 N 30605 E
717
27-Feb-96
31.7
41.2
9.5
0.3
2 inch (5.08 cm) diameter SCH 40 PVC

PIEZOMETER READINGS AND STATUS

[illegible]

	PIEZOMETER RECORD SHEET

PIEZOMETER NUMBER
PIEZOMETER LOCATION
SURVEY LOCATION (m)
GROUND ELEVATION (m)
DATE OF INSTALLATION
TOP OF WELL COMPLETION INTERVAL (m)
BOTTOM OF WELL COMPLETION INTERVAL (m)
WELL COMPLETION INTERVAL (m)
PIEZOMETER STICKUP ABOVE GROUND (m)
SIZE OF PIEZOMETER

HEAP LEACH PAD SITE
30095 N 30385 E
755
26-Feb-96
43.3
50.0
6.7
0.4
2 inch (5.08cm) diameter SCH 40 PVC

[illegible]

	PIEZOMETER RECORD SHEET

WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT

MW96-F

WASTE ROCK STORAGE AREA

31745 N 30185 E

785

20-Feb-96

57.9

62.5

4.6

0.3

2 inch (5.08 cm) diameter SCH 40 PVC

PIEZOMETER READINGS AND STATUS

[illegible]

	PIEZOMETER RECORD SHEET

WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT

MW96-G

WASTE ROCK STORAGE AREA

31341 N 30655 E

777

25-Feb-96

60.7

74.7

14.0

0.3

2 inch (5.08 cm) diameter SCH 40 PVC

PIEZOMETER READINGS AND STATUS

[illegible]

	PIEZOMETER RECORD SHEET

WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT

2 inch (5.08 cm) diameter SCH 40 PVC

PIEZOMETER READINGS AND STATUS

[illegible]

	PIEZOMETER RECORD SHEET

WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT

MW96-I

WASTE ROCK STORAGE AREA

31404 N 31371 E

715

22-Feb-96

49.7

54.9

5.2

0.3

2 inch (5.08 cm) diameter SCH 40 PVC

PIEZOMETER READINGS AND STATUS

[illegible]

	PIEZOMETER RECORD SHEET

WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT

MW96-J

OPEN PIT

30935 N 30390 E

846

26-Feb-96

78.6

90.5

11.9

0.55

2 inch (5.08 cm) diameter SCH 40 PVC

PIEZOMETER READINGS AND STATUS

[illegible]

	PIEZOMETER RECORD SHEET

WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT

MW96-K

OPEN PIT

30515 N 30545 E

849

29-Feb-96

76.9

93.0

16.1

0.3

2 inch (5.08 cm) diameter SCH 40 PVC

PIEZOMETER READINGS AND STATUS

[illegible]

	PIEZOMETER RECORD SHEET

WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT

BRISBANE

PROCESS LEAD TIME

3.2

PIEZOMETER READINGS AND STATUS

[illegible]

	PIEZOMETER RECORD SHEET

WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT

DH96-12

PROCESS PLANT SITE

29953 N 30267 E

769

13-Feb-96

14.3

18.4

4.1

0.3

1 inch (2.54 cm) diameter SCH 40 PVC

PIEZOMETER READINGS AND STATUS

[illegible]

	PIEZOMETER RECORD SHEET

WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT

DH96-14

PROCESS PLANT SITE

29964 N 30239 E

768

10-Feb-96

9.5

14.3

4.9

0.3

1 inch (2.54 cm) diameter SCH 40 PVC

PIEZOMETER READINGS AND STATUS

[illegible]

	PIEZOMETER RECORD SHEET

WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT

DH96-15

PROCESS PLANT SITE

29982 N 30241 E

769

12-Feb-96

12.5

16.8

4.3

0.3

1 inch (2.54 cm) diameter SCH 40 PVC

PIEZOMETER READINGS AND STATUS

[illegible]

Appendix II

Thermistor Record Sheets (Th-1 to Th-5)

and

Ground Temperature Envelopes (Th-1 to Th-3)

Data From 1993 to September, 1997

THERMISTOR RECORD SHEET

WESTERN COPPER HOLDINGS LIMITED CARMACKS COPPER PROJECT

SUMMARY OF TEMPERATURE MEASUREMENTS

THERMISTOR NUMBER Th-1
LOCATION Drill Hole RC92-7
 31230 N 30180 E (scaled)
 vertical hole
INSTALLATION DATE Sept. 07, 1992

CHANNEL #	1	2	3	4	5	6	7	8	9	10
DEPTH (ft)	0	7	9	11	13	17	20	25	45	65
DEPTH (m)	0.00	2.13	2.74	3.35	3.96	5.18	6.10	7.62	13.72	19.81

DATE	TEMPERATURE READING (degrees C)									
	CHANNEL NUMBER									
	1	2	3	4	5	6	7	8	9	10
29-Apr-93	0.0	0.0	0.0	0.1	0.0	0.0	0.0	-0.2	-0.3	-0.3
2-Aug-93	4.7	3.1	2.0	1.3	0.3	0.0	0.0	-0.2	-0.3	-0.3
2-Sep-93	5.0	3.8	2.9	2.1	0.7	0.0	0.0	-0.2	-0.3	-0.3
29-Oct-93	2.0	2.0	1.9	1.7	0.7	0.1	0.0	-0.2	-0.3	-0.3
15-Apr-94	0.0	0.0	0.0	0.1	0.0	0.0	0.0	-0.2	-0.3	-0.3
** 9-Jul-94	4.0	2.8	2.1	1.8	1.5	1.5	1.4	1.2	1.1	1.1
28-Mar-95	-0.1	-0.1	0.0	0.1	0.0	-0.1	0.0	-0.2	-0.3	-0.3
21-Apr-95	-0.2	0.0	0.0	0.1	0.0	0.0	0.0	-0.2	-0.3	-0.3
19-May-95	-0.1	-0.1	0.0	0.1	0.0	0.0	-0.1	-0.2	-0.3	-0.3
22-Jul-95	0.9	0.0	0.0	0.0	0.0	0.0	-0.1	-0.2	-0.3	-0.3
15-Aug-95	0.9	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.2	-0.3	-0.3
5-Oct-95	3.4	2.7	2.1	1.7	0.6	0.1	-0.1	-0.2	-0.3	-0.3
26-Oct-95	2.4	2.2	1.9	1.6	0.7	0.1	-0.1	-0.2	-0.3	-0.3
29-Feb-96	-0.5	0.0	0.1	0.2	0.1	0.0	-0.1	-0.1	0.1	-0.2
27-Sep-97	3.0	2.3	1.7	1.2	0.4	0.0	-0.1	-0.2	-0.3	-0.3
28-Sep-97	3.0	2.3	1.7	1.2	0.3	0.0	-0.1	-0.2	-0.3	-0.3

** As readings were significantly different from past records, instrument battery was changed. Readings remained the same after battery replacement.

THERMISTOR RECORD SHEET

WESTERN COPPER HOLDINGS LIMITED CARMACKS COPPER PROJECT

SUMMARY OF TEMPERATURE MEASUREMENTS

THERMISTOR NUMBER TH-2
LOCATION Drill Hole RC92-10
 29990 N 30740 E (scaled)
 inclined at 247°, -50°
INSTALLATION DATE Sept. 11, 1992

CHANNEL #	1	2	3	4	5	6	7	8	9	10
DEPTH (ft)	0	5.3	6.9	8.4	10	13	15.3	19.2	34.4	49.9
DEPTH (m)	0.00	1.62	2.10	2.56	3.05	3.96	4.66	5.85	10.49	15.21

DATE	TEMPERATURE READING (degrees C)									
	CHANNEL NUMBER									
	1	2	3	4	5	6	7	8	9	10
29-Apr-93	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2
2-Aug-93	6.3	2.9	0.0	-0.2	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2
2-Sep-93	5.8	3.7	1.7	-0.1	-0.3	-0.3	-0.3	-0.3	-0.2	-0.3
29-Oct-93	1.2	1.0	0.6	0.3	-0.2	-0.3	-0.3	-0.3	-0.2	-0.3
15-Apr-94	0.0	0.0	-0.1	0.0	-0.1	-0.2	-0.2	-0.3	-0.2	-0.3
13-May-94	0.1	0.0	-0.1	0.0	-0.1	-0.2	-0.2	-0.3	-0.2	-0.3
** 9-Jul-94	9.0	6.7	4.9	3.5	2.4	2.2	2.2	2.0	2.0	1.8
10-Jul-94	9.0	6.7	4.9	3.5	2.4	2.2	2.2	2.0	2.0	1.8
26-Oct-94	2.6	2.6	2.3	1.9	0.4	-0.1	-0.2	-0.3	-0.2	-0.3
28-Mar-95	-0.1	-0.1	-0.1	-0.1	0.0	-0.1	-0.2	-0.3	-0.2	-0.4
21-Apr-95	-0.4	-0.1	-0.1	-0.1	0.0	-0.1	-0.2	-0.3	-0.2	-0.4
19-May-95	-0.1	-0.1	-0.1	-0.1	0.0	-0.1	-0.2	-0.3	-0.2	-0.4
22-Jul-95	8.4	5.7	3.7	2.3	0.3	-0.1	-0.2	-0.3	-0.4	
15-Aug-95	9.0	6.9	5.1	3.8	0.9	-0.1	-0.1	-0.3	-0.2	-0.4
5-Oct-95	6.6	5.8	4.8	3.8	1.5	0.0	-0.1	-0.3	-0.2	-0.4
26-Oct-95	3.4	3.7	3.4	3.0	1.3	0.2	-0.1	-0.3	-0.2	-0.4
29-Feb-96	-1.4	-0.2	-0.1	0.0	0.0	0.0	0.0	-0.3	-0.1	-0.3
27-Sep-97	7.3	6.6	5.7	4.8	2.5	1.1	0.0	-0.3	-0.2	-0.3
28-Sep-97	7.3	6.6	5.6	4.7	2.5	1.1	-0.1	-0.3	-0.2	-0.3

** As readings were significantly different from past records, instrument battery was changed. Readings remained the same after battery replacement.

	THERMISTOR RECORD SHEET

CARMACKS COPPER PROJECT

THERMISTOR NUMBER	Th-3
LOCATION	Drill Hole DH95-H 30130 N 30300 E (scaled) vertical hole
INSTALLATION DATE	March 09, 1995

-5 -4 -3 -2 -1 0 1 2 3 4 5

[illegible]

	THERMISTOR RECORD SHEET

WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT

SUMMARY OF TEMPERATURE MEASUREMENTS

Feb. 14, 1996

CHANNEL #	1	2	3	4	5	6	7	8	9	10
DEPTH (ft)	0	3	6	9	12	16	20	25	40	60
DEPTH (m)	0.00	0.91	1.83	2.74	3.66	4.88	6.10	7.62	12.19	18.29

[illegible]

FIGURE 1
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
GROUND TEMPERATURE ENVELOPE - THERMISTOR Th-1

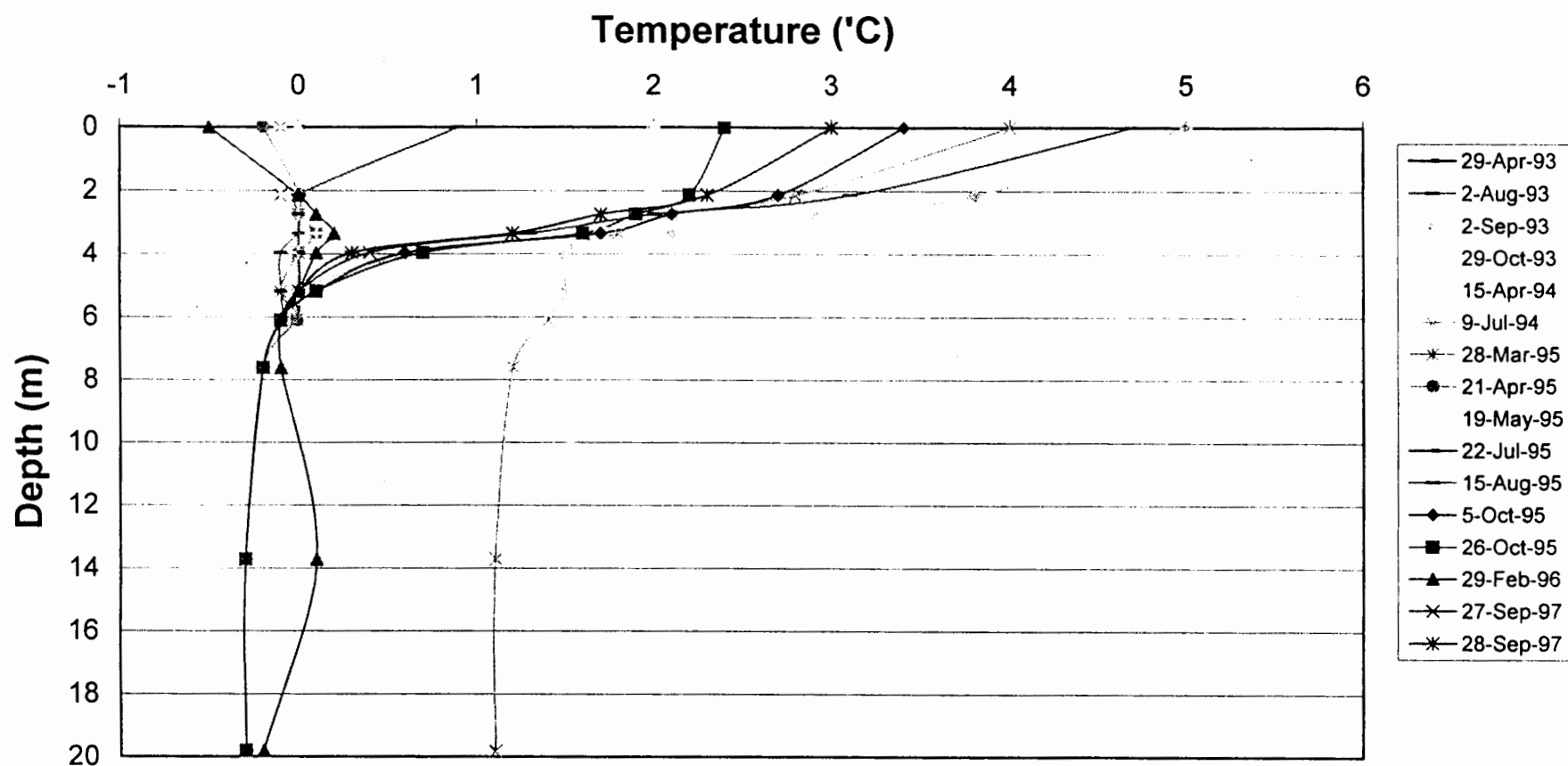


FIGURE 2
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
GROUND TEMPERATURE ENVELOPE - THERMISTOR Th-2

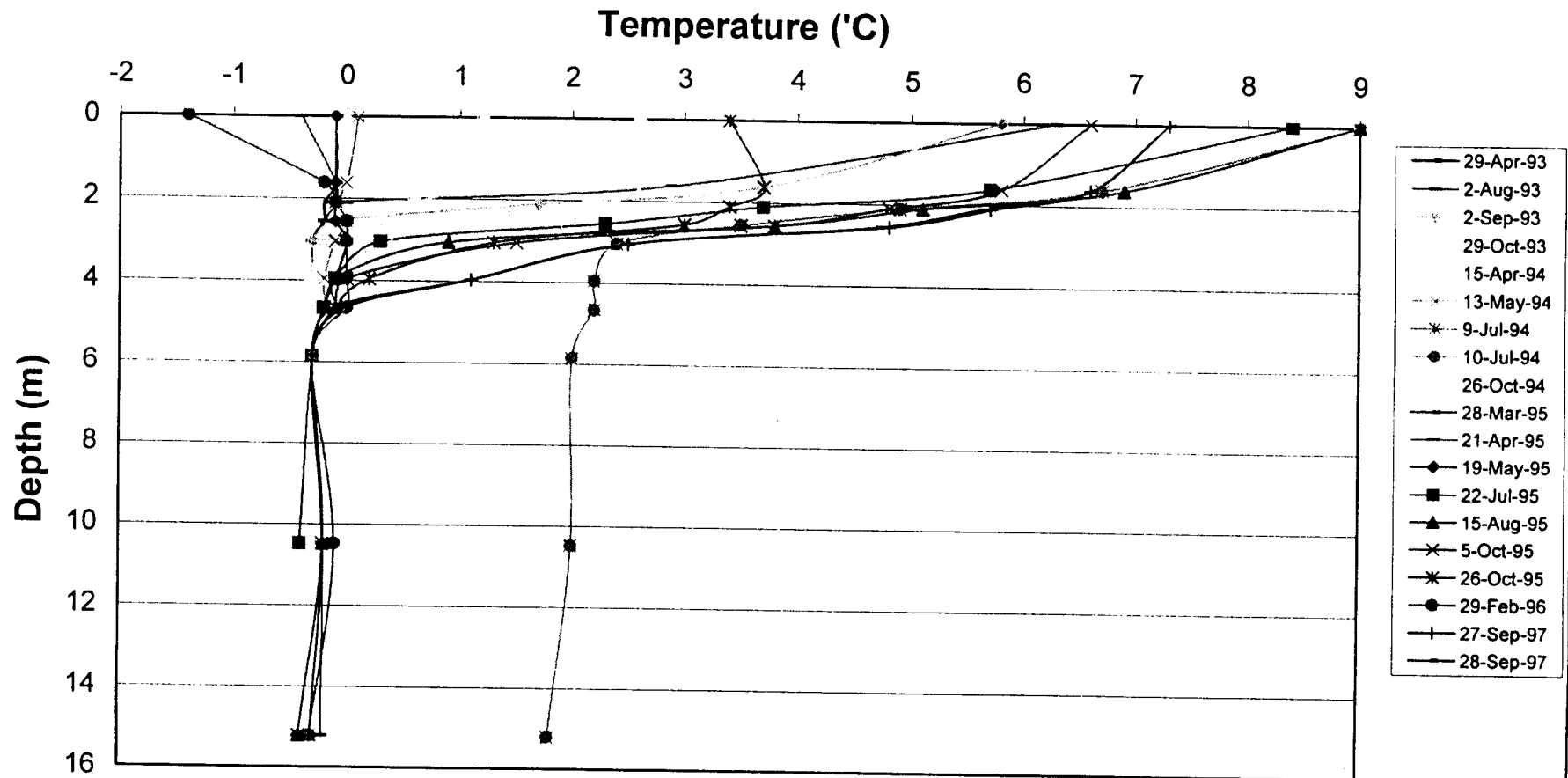
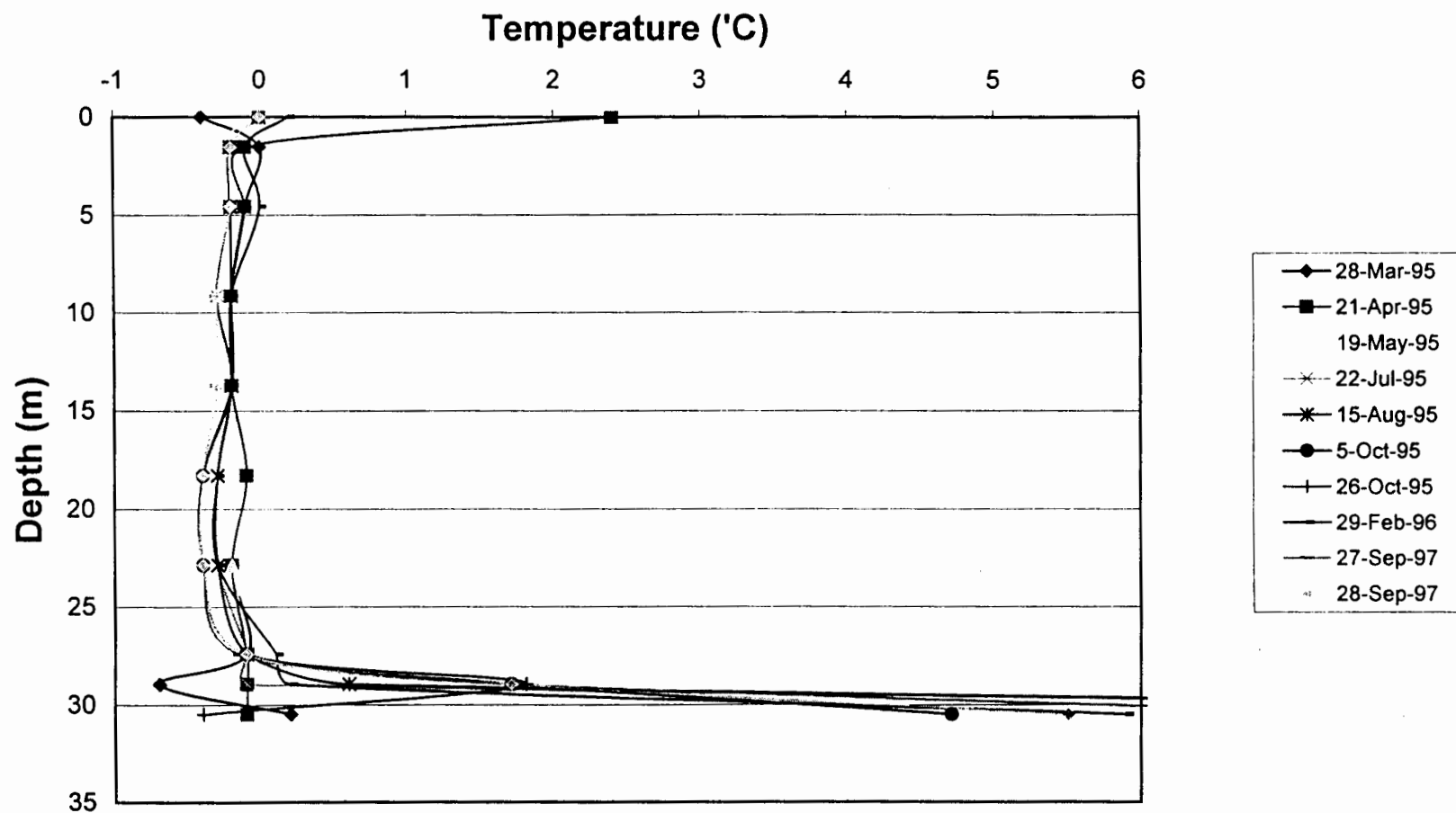


FIGURE 3
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
GROUND TEMPERATURE ENVELOPE - THERMISTOR Th-3



Appendix III

Water Quality Data

Appendix III.A

Surface Water Quality Data for Stations W-1 W-2. W-3, W-4, W-5, W-6, W-7, W-9, W-10 and W-11 for the Period from October, 1989 to October, 1992 and a Data Summary

Obtained from the IEE "Volume 1 Biophysical Assessment of the Williams Creek Mine Site" (January, 1994)

APPENDIX 3. Table 3.1. Analyses of total metals for Station W1 on an unnamed east flowing tributary of Williams Creek for the period October 1989 to October 1992.

PARAMETER	CONCENTRATION (mg/L) BY SAMPLE PERIOD						AVERAGE
	OCT 89	AUG 91	DEC 91	MAY 92	JUL 92	OCT 92	
pH	7.7	7.9	8.1	7.9	7.9	7.5	7.833
Conductivity	462	410	450	389	350	475	422.667
Suspended Solids	20	17	100	<5	12	33	31.167
Turbidity	----	3	12	2	1	3	4.200
Aluminum	0.03	<0.005	<0.005	<0.005	<0.005	0.091	0.024
Antimony	<0.005	<0.05	<0.05	<0.02	<0.02	<0.02	<0.05
Arsenic	<0.02	<0.05	0.16	<0.04	<0.04	<0.05	0.060
Barium	0.146	0.087	0.186	0.054	0.068	0.385	0.154
Beryllium	<0.0001	<0.0005	<0.0005	<0.0002	<0.0002	<0.0002	<0.0005
Bismuth	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02
Boron	0.004	----	----	----	----	----	0.004
Cadmium	<0.0002	<0.0003	<0.0003	<0.0003	<0.0003	0.0004	0.0003
Calcium	55.3	64.4	63.9	59	59	62	60.600
Chromium	0.0066	0.002	0.009	<0.001	<0.001	0.002	0.004
Cobalt	<0.0005	<0.001	0.002	<0.001	<0.001	0.003	0.001
Copper	<0.0005	<0.001	<0.001	<0.001	<0.001	0.008	0.002
Iron	0.181	0.038	0.244	0.1	0.099	0.152	0.136
Lead	<0.002	<0.004	<0.004	<0.004	<0.004	<0.005	<0.005
Lithium	0.26	<0.05	<0.05	<0.05	<0.05	<0.05	0.085
Magnesium	11.2	13.7	13.2	14	13.4	14.2	13.283
Manganese	<0.001	0.003	0.01	<0.001	<0.001	0.005	0.004
Mercury	<0.005	----	----	----	----	----	<0.005
Molybdenum	0.015	0.021	0.025	0.022	0.015	0.023	0.020
Nickel	0.0009	<0.001	0.005	<0.001	0.003	0.002	0.002
Phosphorous	<0.05	0.02	0.06	0.03	<0.02	0.08	0.043
Potassium	1.1	1.27	1.18	1.22	1.1	1.51	1.230
Selenium	<0.005	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02
Silicon	4.42	7.5	2.7	8.72	6.548	----	----
Silver	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002
Sodium	4.42	10.9	8.8	9.34	8.91	11.4	8.962
Strontium	0.644	0.74	0.62	0.82	0.75	0.75	0.721
Thorium	<0.01	<0.02	<0.02	<0.005	<0.005	<0.01	<0.02
Titanium	<0.001	<0.001	0.01	0.001	<0.001	<0.001	0.002
Uranium	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Vanadium	<0.0002	0.0059	<0.0005	<0.001	<0.001	0.015	0.004
Zinc	0.0476	0.008	<0.001	0.005	0.002	0.01	0.012
Zirconium	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chloride	4.7	----	----	----	----	----	4.700
Fluoride	3.3	----	----	----	----	----	3.300
Nitrate	<0.1	<0.5	0.6	1.1	<0.2	0.6	0.517
Sulphate	129	112	102	95	93.9	83.9	102.633
Nitrite	<0.003	<0.003	<5.0	<0.03	<2.0	<2.0	<5.0
T. Phosphorous	----	----	0.05	0.005	0.011	0.049	0.029
Ammonia	0.1	<0.05	<0.05	<0.05	<0.05	<0.05	0.058
Alkalinity as CaCO ₃	53	119	125	115	142	140	115.667
Hardness as CaCO ₃	184.2	217	213.9	206	202	214	206.183

APPENDIX 3. Table 3.2. Analyses of dissolved metals for Station W1 on an unnamed east flowing tributary of Williams Creek for the period October 1989 to October 1992.

PARAMETER	CONCENTRATION (mg/L) BY SAMPLE PERIOD						AVERAGE
	OCT 89	AUG 91	DEC 91	MAY 92	JUL 92	OCT 92	
Aluminum	----	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Antimony	----	<0.05	<0.05	<0.02	<0.02	<0.02	<0.05
Arsenic	----	<0.05	0.12	<0.04	<0.04	<0.05	0.060
Barium	----	0.057	0.065	0.041	0.066	0.067	0.059
Beryllium	----	<0.0005	<0.0005	<0.0002	<0.0002	<0.0002	<0.0005
Bismuth	----	<0.01	<0.01	<0.02	<0.02	<0.02	0.000
Boron	----	----	----	----	----	----	----
Cadmium	----	<0.0003	<0.0003	<0.0003	<0.0003	<0.0004	<0.0004
Calcium	----	61.8	64.7	57.9	52.8	59.9	59.420
Chromium	----	<0.001	0.001	<0.001	<0.001	<0.001	0.001
Cobalt	----	<0.001	0.001	<0.001	<0.001	0.002	0.001
Copper	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron	----	<0.005	0.08	0.08	0.09	<0.004	0.052
Lead	----	<0.004	<0.004	<0.004	<0.004	<0.005	<0.005
Lithium	----	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Magnesium	----	13.1	13	12.4	11.6	13.9	12.800
Manganese	----	0.003	0.003	<0.001	<0.001	0.002	0.002
Mercury	----	----	----	----	----	----	----
Molybdenum	----	0.024	0.023	0.019	0.014	0.021	0.020
Nickel	----	<0.001	0.002	<0.001	<0.001	<0.001	0.001
Phosphorous	----	<0.02	0.03	0.02	0.02	0.05	0.028
Potassium	----	1.19	1.04	0.99	1.1	1.45	1.154
Selenium	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02
Silicon	----	6.8	2.6	6.36	8.64	9.47	6.774
Silver	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sodium	----	10	9.64	8.26	8.6	10.9	9.480
Strontium	----	0.69	0.61	0.73	0.68	0.7	0.682
Thorium	----	<0.02	<0.02	<0.005	<0.005	<0.01	<0.02
Titanium	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	----	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Vanadium	----	0.0044	<0.0005	<0.001	<0.001	0.015	0.021
Zinc	----	0.006	<0.001	0.002	0.002	0.01	0.004
Zirconium	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Hardness as CaCO ₃	----	208	215.1	196	180	207	201.220

APPENDIX 3. Table 3.3. Analyses of total metals for Station W2 on Williams Creek 20 m downstream of the confluence with W1 for the period October 1989 to October 1992.

PARAMETER	CONCENTRATION (mg/L) BY SAMPLE PERIOD						AVERAGE
	OCT 89	AUG 91	DEC 91	MAY 92	JUL 92	OCT 92	
pH	7.7	----	----	----	----	----	7.700
Conductivity	431	----	----	----	----	----	431.000
Suspended Solids	8	----	----	----	----	----	8.000
Turbidity	----	----	----	----	----	----	----
Aluminum	<0.02	----	----	----	----	----	<0.02
Antimony	<0.005	----	----	----	----	----	<0.005
Arsenic	<0.02	----	----	----	----	----	<0.02
Barium	0.035	----	----	----	----	----	0.035
Beryllium	<0.0001	----	----	----	----	----	<0.0001
Bismuth	----	----	----	----	----	----	----
Boron	<0.001	----	----	----	----	----	<0.001
Cadmium	<0.0002	----	----	----	----	----	<0.0002
Calcium	44.2	----	----	----	----	----	44.200
Chromium	<0.0002	----	----	----	----	----	<0.0002
Cobalt	<0.0005	----	----	----	----	----	<0.0005
Copper	<0.0005	----	----	----	----	----	<0.0005
Iron	0.371	----	----	----	----	----	0.371
Lead	<0.002	----	----	----	----	----	<0.002
Lithium	0.3	----	----	----	----	----	0.300
Magnesium	12.8	----	----	----	----	----	12.800
Manganese	0.068	----	----	----	----	----	0.068
Mercury	<0.005	----	----	----	----	----	<0.005
Molybdenum	0.003	----	----	----	----	----	0.003
Nickel	0.0015	----	----	----	----	----	0.002
Phosphorous	<0.05	----	----	----	----	----	<0.05
Potassium	0.9	----	----	----	----	----	0.900
Selenium	<0.005	----	----	----	----	----	<0.005
Silicon	3.99	----	----	----	----	----	3.990
Silver	<0.002	----	----	----	----	----	<0.002
Sodium	12.8	----	----	----	----	----	12.800
Strontium	0.444	----	----	----	----	----	0.444
Thorium	<0.01	----	----	----	----	----	<0.01
Titanium	<0.001	----	----	----	----	----	<0.001
Uranium	<0.02	----	----	----	----	----	<0.02
Vanadium	<0.0002	----	----	----	----	----	<0.0002
Zinc	0.033	----	----	----	----	----	0.033
Zirconium	----	----	----	----	----	----	----
Chloride	3.6	----	----	----	----	----	3.600
Fluoride	1.1	----	----	----	----	----	1.100
Nitrate	<0.1	----	----	----	----	----	<0.1
Sulphate	76	----	----	----	----	----	76.000
Nitrite	<0.003	----	----	----	----	----	<0.003
T. Phosphorous	----	----	----	----	----	----	----
Ammonia	0.06	----	----	----	----	----	0.060
Alkalinity as CaCO ₃	100	----	----	----	----	----	100.000
Hardness as CaCO ₃	133.1	----	----	----	----	----	133.100

APPENDIX 3. Table 3.4. Analyses of total metals for Station W3 on an unnamed east flowing tributary of Williams Creek for the period October 1989 to October 1992.

PARAMETER	CONCENTRATION (mg/L) BY SAMPLE PERIOD						AVERAGE
	OCT 89	AUG 91	DEC 91	MAY 92	JUL 92	OCT 92	
pH	7.5	8.2	NO FLOW	7.9	7.5	7.4	7.700
Conductivity	380	263	----	114	210	340	261.400
Suspended Solids	<5	<5	----	<5	<5	<5	<5
Turbidity	----	<1	----	1	1	<1	1.000
Aluminum	<0.02	<0.005	----	0.091	0.067	0.03	0.036
Antimony	<0.005	<0.05	----	<0.02	<0.02	<0.02	<0.05
Arsenic	<0.02	<0.05	----	<0.04	<0.04	<0.05	<0.05
Barium	0.037	0.051	----	0.019	0.038	0.092	0.047
Beryllium	<0.0001	<0.0005	----	<0.0002	<0.0002	<0.0002	<0.0005
Bismuth	----	<0.01	----	<0.02	<0.02	<0.02	<0.02
Boron	<0.001	----	----	----	----	----	<0.001
Cadmium	<0.0002	<0.0003	----	<0.0003	<0.0003	<0.0004	<0.0004
Calcium	52.4	48.3	----	15	39.8	53.3	41.760
Chromium	0.0024	0.009	----	<0.001	<0.001	<0.001	0.003
Cobalt	<0.0005	<0.001	----	<0.001	<0.001	0.002	0.001
Copper	<0.0005	<0.001	----	<0.001	0.009	0.013	0.005
Iron	0.084	0.088	----	0.171	0.172	0.261	0.155
Lead	<0.002	<0.004	----	<0.004	<0.004	<0.005	<0.005
Lithium	0.34	<0.05	----	<0.05	<0.05	<0.05	0.108
Magnesium	8.89	8.74	----	3.56	7.3	11.1	7.918
Manganese	0.57	0.004	----	0.004	0.159	0.361	0.220
Mercury	<0.005	----	----	----	----	----	<0.005
Molybdenum	<0.001	<0.005	----	<0.003	<0.003	<0.004	<0.005
Nickel	0.0009	<0.001	----	<0.001	0.005	0.006	0.003
Phosphorous	<0.05	<0.02	----	0.03	0.03	0.03	0.032
Potassium	0.8	0.38	----	1.26	0.69	0.96	0.818
Selenium	<0.005	<0.01	----	<0.02	<0.02	<0.02	<0.02
Silicon	4.33	13	----	5.19	10.2	12.6	9.064
Silver	<0.002	<0.001	----	<0.001	<0.001	<0.001	<0.002
Sodium	7.32	8.06	----	2.36	6.44	8.51	6.538
Strontium	0.481	0.27	----	0.11	0.36	0.46	0.336
Thorium	<0.01	<0.02	----	<0.005	<0.005	<0.01	<0.02
Titanium	<0.001	<0.001	----	0.002	<0.001	<0.001	0.001
Uranium	<0.02	<0.02	----	<0.02	<0.02	<0.02	<0.02
Vanadium	<0.0002	0.0032	----	<0.001	<0.001	0.006	0.002
Zinc	0.0523	0.002	----	0.005	0.004	0.009	0.014
Zirconium	----	<0.001	----	<0.001	<0.001	<0.001	<0.001
Chloride	2.8	----	----	----	----	----	2.800
Fluoride	<1	----	----	----	----	----	<1
Nitrate	<0.1	<0.1	----	<0.05	<0.2	<0.2	<0.2
Sulphate	21	8.1	----	3.6	9.5	16.8	11.800
Nitrite	<0.003	<0.003	----	<0.03	<2.0	<2	<2
T. Phosphorous	----	----	----	0.02	0.013	0.01	0.014
Ammonia	0.08	<0.05	----	<0.05	<0.05	0.07	0.060
Alkalinity as CaCO ₃	130	153	----	57	152	160	130.400
Hardness as CaCO ₃	167.4	157	----	52.9	131	180	137.660

APPENDIX 3. Table 3.5. Analyses of dissolved metals for Station W3 on an unnamed east flowing tributary of Williams Creek for the period October 1989 to October 1992.

PARAMETER	CONCENTRATION (mg/L) BY SAMPLE PERIOD						AVERAGE
	OCT 89	AUG 91	DEC 91	MAY 92	JUL 92	OCT 92	
Aluminum	----	<0.005	NO FLOW	0.046	0.066	<0.005	0.030
Antimony	----	<0.05	----	<0.02	<0.02	<0.02	<0.05
Arsenic	----	<0.05	----	<0.04	<0.04	<0.05	<0.05
Barium	----	0.05	----	0.017	0.036	0.046	0.037
Beryllium	----	<0.0005	----	<0.0002	<0.0002	<0.0002	<0.0005
Bismuth	----	<0.01	----	<0.02	<0.02	<0.02	<0.02
Boron	----	----	----	----	----	----	----
Cadmium	----	<0.0003	----	<0.0003	<0.0003	<0.0004	<0.0004
Calcium	----	45.8	----	14.4	33.6	46	34.950
Chromium	----	<0.001	----	<0.001	<0.001	<0.001	<0.001
Cobalt	----	<0.001	----	<0.001	<0.001	0.002	0.001
Copper	----	<0.001	----	<0.001	<0.001	0.002	0.001
Iron	----	0.064	----	0.11	0.11	0.26	0.136
Lead	----	<0.004	----	<0.004	<0.004	<0.005	<0.005
Lithium	----	<0.05	----	<0.05	<0.05	<0.05	<0.05
Magnesium	----	8.6	----	3.4	5.9	11.2	7.275
Manganese	----	0.004	----	0.002	0.154	0.36	0.130
Mercury	----	----	----	----	----	----	----
Molybdenum	----	<0.005	----	<0.003	<0.003	<0.004	<0.005
Nickel	----	<0.001	----	<0.001	0.003	0.003	0.002
Phosphorous	----	<0.02	----	0.02	<0.02	0.02	0.020
Potassium	----	0.34	----	1.1	0.7	0.91	0.763
Selenium	----	<0.01	----	<0.02	<0.02	<0.02	<0.02
Silicon	----	9	----	5.08	7.9	9	7.745
Silver	----	<0.001	----	<0.001	<0.001	<0.001	<0.001
Sodium	----	7.42	----	2.33	6.16	8.01	5.980
Strontium	----	0.26	----	0.1	0.31	0.4	0.268
Thorium	----	<0.02	----	<0.005	<0.005	<0.01	<0.02
Titanium	----	<0.001	----	<0.001	<0.001	<0.001	<0.001
Uranium	----	<0.02	----	<0.02	<0.02	<0.02	<0.02
Vanadium	----	0.0016	----	<0.001	<0.001	0.006	0.002
Zinc	----	0.002	----	0.003	0.002	0.008	0.004
Zirconium	----	<0.001	----	<0.001	<0.001	<0.001	<0.001
Hardness as CaCO ₃	----	150	----	50.3	109	162	117.825

APPENDIX 3. Table 3.6. Analyses of total metals for Station W4 on Williams Creek 100m downstream of the confluence with W3 for the period October 1989 to October 1992.

PARAMETER	CONCENTRATION (mg/L) BY SAMPLE PERIOD						AVERAGE
	OCT 89	AUG 91	DEC 91	MAY 92	JUL 92	OCT 92	
pH	7.7	8	8.1	7.4	7.8	7.5	7.750
Conductivity	395	210	465	98	210	370	291.333
Suspended Solids	<5	37	<5	253	258	<5	93.800
Turbidity	----	4	1	14	25	1	9.000
Aluminum	<0.02	0.154	<0.005	2.75	3.89	0.036	1.142
Antimony	<0.005	<0.05	<0.05	<0.02	<0.02	<0.02	<0.05
Arsenic	<0.02	<0.05	0.12	<0.04	<0.04	<0.05	0.053
Barium	0.031	0.049	0.057	0.078	0.11	0.175	0.083
Beryllium	<0.0001	<0.0005	<0.0005	<0.0002	<0.0002	<0.0002	<0.0005
Bismuth	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02
Boron	<0.001	----	----	----	----	----	<0.001
Cadmium	<0.0002	<0.0003	<0.0003	<0.0003	<0.0003	<0.0004	<0.004
Calcium	40.5	32.7	63.4	15.6	27.7	46.4	37.717
Chromium	<0.0002	0.012	0.006	0.002	0.006	0.002	0.005
Cobalt	<0.0005	<0.001	0.002	0.003	0.002	0.003	0.002
Copper	<0.0005	<0.001	<0.001	0.01	0.014	0.008	0.006
Iron	0.519	1.11	0.349	3.68	6.6	0.709	2.161
Lead	<0.002	<0.004	<0.004	<0.004	0.005	<0.005	0.004
Lithium	0.35	<0.05	<0.05	<0.05	<0.05	<0.05	0.100
Magnesium	10.7	8.47	16.1	5.2	7.7	13	10.195
Manganese	0.077	0.058	0.1	0.136	0.191	0.166	0.121
Mercury	<0.005	----	----	----	----	----	<0.005
Molybdenum	<0.001	<0.005	0.01	<0.003	<0.003	<0.004	0.004
Nickel	0.0014	0.002	0.005	<0.001	0.014	0.005	0.005
Phosphorous	<0.05	0.05	0.04	0.03	0.2	0.03	0.067
Potassium	0.8	0.48	1.14	1.41	1	0.95	0.963
Selenium	<0.005	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02
Silicon	4.86	13.4	5.5	9.71	16.3	11	10.128
Silver	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002
Sodium	11.2	9.93	14.9	2.77	6.58	12.6	9.663
Strontium	0.372	0.26	0.42	0.142	0.24	0.4	0.306
Thorium	<0.01	<0.02	<0.02	<0.005	<0.005	<0.01	<0.02
Titanium	<0.001	0.016	0.002	0.146	0.192	<0.001	0.060
Uranium	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Vanadium	<0.0002	0.0049	<0.0005	<0.001	0.016	0.01	0.005
Zinc	0.0578	0.004	<0.001	0.019	0.018	0.008	0.018
Zirconium	----	<0.001	<0.001	<0.001	0.002	<0.001	0.001
Chloride	3.6	----	----	----	----	----	3.600
Fluoride	<1	----	----	----	----	----	<1
Nitrate	<0.1	<0.1	<0.5	0.05	<0.1	<0.02	0.022
Sulphate	47	20.7	80.6	3.5	8.9	59.8	36.750
Nitrite	<0.0003	<0.003	<5	<0.03	<1	<2.0	<5
T. Phosphorous	----	----	0.032	0.018	0.173	0.017	0.060
Ammonia	<0.05	<0.05	<0.05	<0.05	<0.05	0.06	0.052
Alkalinity as CaCO ₃	120	103	169	28	94	125	106.500
Hardness as CaCO ₃	145.1	119	224	82.5	135	170	145.933

APPENDIX 3. Table 3.7. Analyses of dissolved metals for Station W4 on Williams Creek 100 m downstream of the confluence with W3 for the period October 1989 to October 1992.

PARAMETER	OCT 89	CONCENTRATION (mg/L) BY SAMPLE PERIOD					AVERAGE
		AUG 91	DEC 91	MAY 92	JUL 92	OCT 92	
Aluminum	----	0.007	<0.005	0.03	0.043	0.018	0.020
Antimony	----	<0.05	<0.05	<0.02	<0.02	<0.02	<0.05
Arsenic	----	<0.05	0.11	<0.04	<0.04	<0.05	0.058
Barium	----	0.04	0.053	0.01	0.041	0.054	0.040
Beryllium	----	<0.0005	<0.0005	<0.0002	<0.0002	<0.0002	<0.0005
Bismuth	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02
Boron	----	----	----	----	----	----	----
Cadmium	----	<0.0003	<0.0003	<0.0003	<0.0003	<0.0004	<0.0004
Calcium	----	30.7	61.3	7.49	27.3	43.4	34.038
Chromium	----	0.002	0.004	<0.001	<0.001	<0.001	0.002
Cobalt	----	<0.001	0.002	<0.001	<0.001	0.003	0.002
Copper	----	<0.001	<0.001	<0.001	<0.001	0.002	0.001
Iron	----	0.472	0.252	0.12	0.396	0.628	0.374
Lead	----	<0.004	<0.004	<0.004	<0.004	<0.005	<0.005
Lithium	----	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Magnesium	----	8.11	15.3	2.24	7.66	12	9.062
Manganese	----	0.037	0.098	0.014	0.033	0.165	0.069
Mercury	----	----	----	----	----	----	----
Molybdenum	----	<0.005	0.009	<0.003	<0.003	<0.004	0.005
Nickel	----	<0.001	0.004	<0.001	0.002	0.004	0.002
Phosphorous	----	0.03	0.02	0.02	0.03	0.02	0.024
Potassium	----	0.48	0.97	0.61	0.54	0.99	0.718
Selenium	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02
Silicon	----	10.5	4.8	2.73	14	10	8.406
Silver	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sodium	----	9.2	13.8	1.74	6.37	12.5	8.722
Strontium	----	0.26	0.41	0.063	0.24	0.36	0.267
Thorium	----	<0.02	<0.02	<0.005	<0.005	<0.01	<0.02
Titanium	----	0.002	<0.001	<0.001	0.002	<0.001	0.001
Uranium	----	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Vanadium	----	0.003	<0.0005	<0.001	<0.001	0.014	0.004
Zinc	----	0.003	<0.001	0.004	0.007	0.008	0.004
Zirconium	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Hardness as CaCO ₃	----	111	216	28.3	103	159	123.460

APPENDIX 3. Table 3.8. Analyses of total metals for Station W5 on an unnamed northwest flowing tributary of Williams Creek for the period October 1989 to October 1992.

PARAMETER	CONCENTRATION (mg/L) BY SAMPLE PERIOD						AVERAGE
	OCT 89	AUG 91	DEC 91	MAY 92	JUL 92	OCT 92	
pH	7.5	*dupl. 7.2	8.1	7.2	7.2	7.5	7.450
Conductivity	157	91	280	91	89	228	156.000
Suspended Solids	<5	1825	34	103	800	<5	462.000
Turbidity	----	120	17	11	27	3	35.600
Aluminum	<0.02	9.58	<0.005	1.71	8.02	0.037	3.229
Antimony	<0.005	<0.05	<0.05	<0.02	<0.02	<0.02	<0.05
Arsenic	<0.02	0.11	0.11	0.04	<0.04	<0.05	0.062
Barium	0.013	0.455	0.035	0.051	0.239	0.037	0.138
Beryllium	<0.0001	0.00065	<0.0005	<0.0002	<0.0002	<0.0002	0.0003
Bismuth	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02
Boron	<0.001	----	----	----	----	----	<0.001
Cadmium	<0.0002	0.0006	<0.0003	<0.0003	<0.0003	0.0004	0.0004
Calcium	18.8	29.5	39.6	13.1	25.3	30.3	26.100
Chromium	0.0016	0.05	0.007	<0.001	0.014	0.002	0.013
Cobalt	<0.0005	0.016	0.001	<0.001	0.007	0.003	0.005
Copper	<0.0005	0.059	<0.001	0.007	0.034	0.004	0.018
Iron	0.458	31.4	1.48	2.2	14.4	0.664	8.434
Lead	<0.002	0.015	<0.004	<0.004	0.009	<0.005	0.007
Lithium	0.36	<0.05	<0.05	<0.05	<0.05	<0.05	0.102
Magnesium	4.16	8.95	10.1	4.09	6.9	7.62	6.970
Manganese	0.046	0.62	0.191	0.098	0.419	0.304	0.280
Mercury	<0.005	----	----	----	----	----	<0.005
Molybdenum	<0.001	<0.005	<0.005	<0.003	<0.003	<0.004	<0.005
Nickel	0.0029	0.04	0.007	<0.001	0.025	0.004	0.013
Phosphorous	<0.05	1.64	0.16	0.08	0.82	0.03	0.463
Potassium	<0.2	3.28	1.65	1.61	1.21	0.52	1.410
Selenium	<0.005	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02
Silicon	5.53	19.8	5.9	7.84	22.2	13	12.378
Silver	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002
Sodium	5.57	6.56	9.7	2.85	6.28	8.65	6.602
Strontium	0.089	0.22	0.159	0.083	0.15	0.157	0.143
Thorium	<0.01	<0.02	<0.02	<0.005	<0.005	<0.01	<0.02
Titanium	<0.001	1.07	0.005	0.084	0.364	<0.001	0.262
Uranium	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Vanadium	<0.0002	0.126	<0.0005	0.008	0.043	0.007	0.031
Zinc	0.0661	0.072	0.004	0.015	0.043	0.01	0.035
Zirconium	----	0.005	<0.001	<0.001	0.003	<0.001	0.002
Chloride	1.01	----	----	----	----	----	1.010
Fluoride	<1	----	----	----	----	----	<1
Nitrate	<0.1	<0.05	<0.2	<0.05	<0.03	<0.2	<0.2
Sulphate	3.29	3.2	3.8	2	2.7	9.4	4.065
Nitrite	<0.003	0.003	<2.0	<0.03	<0.05	<2.0	0.001
T. Phosphorous	----	----	0.132	0.022	0.24	0.027	0.070
Ammonia	<0.05	0.08	<0.05	<0.05	0.11	0.2	0.065
Alkalinity as CaCO ₃	88	58	145	44	66	100	83.500
Hardness as CaCO ₃	84	51.8	140	63.3	163	109	101.850

APPENDIX 3. Table 3.9. Analyses of dissolved metals for Station W5 on an unnamed northwest flowing tributary of Williams Creek for the period October 1989 to October 1992.

PARAMETER	CONCENTRATION (mg/L) BY SAMPLE PERIOD						AVERAGE
	OCT 89	AUG 91	DEC 91	MAY 92	JUL 92	OCT 92	
		*dupl.					
Aluminum	----	0.037	<0.005	0.058	0.06	0.034	0.039
Antimony	----	<0.05	<0.05	<0.02	<0.02	<0.02	<0.05
Arsenic	----	<0.05	0.09	<0.04	<0.04	<0.05	0.005
Barium	----	0.037	0.032	0.017	0.041	0.031	0.032
Beryllium	----	<0.0005	<0.0005	<0.0002	<0.0002	<0.0002	<0.0005
Bismuth	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02
Boron	----	----	----	----	----	----	----
Cadmium	----	<0.0003	<0.0003	<0.0003	<0.0003	<0.0004	<0.0004
Calcium	----	23.7	39.4	10	19	26.1	23.640
Chromium	----	0.007	0.006	<0.001	<0.001	<0.001	0.003
Cobalt	----	0.001	0.001	<0.001	<0.001	0.003	0.001
Copper	----	0.001	<0.001	0.006	<0.001	0.001	0.002
Iron	----	0.987	0.748	0.392	0.63	0.322	0.616
Lead	----	<0.004	<0.004	<0.004	<0.004	<0.005	<0.005
Lithium	----	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Magnesium	----	5.82	9.83	2.88	4.37	6.6	5.900
Manganese	----	0.142	0.224	0.053	0.194	0.271	0.177
Mercury	----	----	----	----	----	----	----
Molybdenum	----	<0.005	<0.005	<0.003	<0.003	<0.004	<0.005
Nickel	----	0.0045	0.005	<0.001	0.002	0.003	0.003
Phosphorous	----	<0.02	0.11	0.03	0.03	0.03	0.044
Potassium	----	0.23	1.25	1.12	0.28	0.5	0.676
Selenium	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02
Silicon	----	10.6	5.5	4.3	14.3	11.4	9.220
Silver	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sodium	----	5.38	7.95	2.47	5.44	6.96	5.640
Strontium	----	0.074	0.156	0.06	0.11	0.136	0.107
Thorium	----	<0.02	<0.02	<0.005	<0.005	<0.01	<0.01
Titanium	----	0.003	0.003	<0.001	0.002	<0.001	0.002
Uranium	----	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Vanadium	----	0.004	<0.0005	0.001	<0.001	0.006	0.003
Zinc	----	0.004	<0.001	0.008	0.005	0.008	0.005
Zirconium	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Hardness as CaCO ₃	----	51.8	139	38	135	93.7	91.500

APPENDIX 3. Table 3.10. Analyses of total metals for Station W6 on Williams Creek 50 m downstream of the confluence with W5 for the period October 1989 to October 1992.

PARAMETER	CONCENTRATION (mg/L) BY SAMPLE PERIOD						AVERAGE
	OCT 89	AUG 91	DEC 91	MAY 92	JUL 92	OCT 92	
pH	7.9	----	----	----	----	----	7.900
Conductivity	415	----	----	----	----	----	415.000
Suspended Solids	<5	----	----	----	----	----	<5
Turbidity	----	----	----	----	----	----	----
Aluminum	<0.02	----	----	----	----	----	<0.02
Antimony	<0.005	----	----	----	----	----	<0.005
Arsenic	<0.02	----	----	----	----	----	<0.02
Barium	0.034	----	----	----	----	----	0.034
Beryllium	<0.0001	----	----	----	----	----	<0.0001
Bismuth	----	----	----	----	----	----	----
Boron	0.002	----	----	----	----	----	0.002
Cadmium	<0.0002	----	----	----	----	----	<0.0002
Calcium	43.8	----	----	----	----	----	43.800
Chromium	0.0012	----	----	----	----	----	0.001
Cobalt	<0.0005	----	----	----	----	----	<0.0005
Copper	0.001	----	----	----	----	----	0.001
Iron	0.637	----	----	----	----	----	0.637
Lead	<0.002	----	----	----	----	----	<0.002
Lithium	0.3	----	----	----	----	----	0.300
Magnesium	13.9	----	----	----	----	----	13.900
Manganese	0.101	----	----	----	----	----	0.101
Mercury	<0.005	----	----	----	----	----	<0.005
Molybdenum	<0.001	----	----	----	----	----	<0.001
Nickel	0.0018	----	----	----	----	----	0.002
Phosphorous	<0.05	----	----	----	----	----	<0.05
Potassium	0.9	----	----	----	----	----	0.900
Selenium	<0.005	----	----	----	----	----	<0.005
Silicon	5.08	----	----	----	----	----	5.080
Silver	<0.002	----	----	----	----	----	<0.002
Sodium	14.3	----	----	----	----	----	14.300
Strontium	0.426	----	----	----	----	----	0.426
Thorium	<0.01	----	----	----	----	----	<0.01
Titanium	<0.001	----	----	----	----	----	<0.001
Uranium	<0.02	----	----	----	----	----	<0.02
Vanadium	<0.0002	----	----	----	----	----	<0.0002
Zinc	0.108	----	----	----	----	----	0.108
Zirconium	----	----	----	----	----	----	----
Chloride	1.3	----	----	----	----	----	1.300
Fluoride	<1	----	----	----	----	----	<1
Nitrate	<0.1	----	----	----	----	----	<0.1
Sulphate	51	----	----	----	----	----	51.000
Nitrite	0.003	----	----	----	----	----	0.003
T. Phosphorous	----	----	----	----	----	----	----
Ammonia	0.05	----	----	----	----	----	0.050
Alkalinity as CaCO ₃	140	----	----	----	----	----	140.000
Hardness as CaCO ₃	168.6	----	----	----	----	----	168.600

APPENDIX 3. Table 3.11. Analyses of total metals for Station W7 on an unnamed east flowing tributary of Williams Creek for the period October 1989 to October 1992.

PARAMETER	CONCENTRATION (mg/L) BY SAMPLE PERIOD						AVERAGE
	OCT 89	AUG 91	DEC 91	MAY 92	JUL 92	OCT 92	
pH	7.7	7.6	7.3	7.4	7.6	7.5	7.517
Conductivity	325	192	435	81	166	345	257.333
Suspended Solids	<5	<5	23	<5	<5	<5	8.000
Turbidity	----	1	6	2	4	<1	2.800
Aluminum	<0.02	<0.005	<0.005	0.084	0.192	0.035	0.057
Antimony	<0.005	<0.05	<0.05	<0.02	<0.02	<0.02	<0.05
Arsenic	<0.02	<0.05	0.16	<0.04	<0.04	<0.05	0.060
Barium	0.037	0.036	0.091	0.012	0.039	0.062	0.046
Beryllium	<0.0001	<0.0005	<0.0005	<0.0002	<0.0002	<0.0002	<0.0005
Bismuth	----	<0.01	<0.01	<0.02	<0.02	<0.02	0.016
Boron	0.007	----	----	----	----	----	0.007
Cadmium	<0.0002	<0.0003	<0.0003	<0.0003	<0.0003	<0.0004	0.0003
Calcium	38.2	36.2	68.3	11.5	37	54.4	40.933
Chromium	0.0081	0.007	0.007	<0.001	<0.001	<0.001	0.004
Cobalt	<0.0005	<0.001	0.007	<0.001	<0.001	0.002	0.002
Copper	0.009	<0.001	<0.001	0.01	0.004	0.005	0.005
Iron	0.195	0.267	11.6	0.072	0.266	0.219	2.103
Lead	0.003	<0.004	<0.004	<0.004	<0.004	<0.005	0.004
Lithium	0.36	<0.06	<0.05	<0.05	<0.05	<0.05	0.103
Magnesium	8.84	6.83	12.6	2.83	7.2	11.3	8.267
Manganese	0.026	0.03	3.62	0.004	0.007	0.073	0.627
Mercury	<0.005	----	----	----	----	----	<0.005
Molybdenum	<0.001	<0.005	0.008	<0.003	<0.003	<0.004	0.004
Nickel	0.002	0.002	0.009	<0.001	0.007	0.002	0.004
Phosphorous	<0.05	<0.02	0.34	0.03	0.03	0.03	0.083
Potassium	0.3	0.25	0.5	1.54	0.35	0.44	0.563
Selenium	<0.005	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02
Silicon	4.69	13.9	5.8	4.14	13.9	14.8	9.538
Silver	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002
Sodium	7.21	5.56	6.45	1.74	6.09	9.93	6.163
Strontium	0.161	0.14	0.23	0.053	0.18	0.26	0.171
Thorium	<0.01	<0.02	<0.02	<0.005	<0.005	<0.01	<0.01
Titanium	<0.001	<0.001	0.005	0.002	0.008	<0.001	0.003
Uranium	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Vanadium	<0.0002	0.0008	<0.0005	<0.001	<0.001	0.006	0.007
Zinc	0.0185	0.01	0.003	0.005	0.007	0.014	0.010
Zirconium	----	0.001	<0.001	<0.001	0.002	<0.001	0.001
Chloride	2.6	----	----	----	----	----	0.433
Fluoride	<1	----	----	----	----	----	<1
Nitrate	<0.1	<0.1	<0.05	<0.05	<0.1	<0.2	<0.2
Sulphate	15.1	10.9	0.83	1.1	11	29.6	11.422
Nitrite	<0.003	<0.003	<0.5	<0.03	<1	<2.0	<2.0
T. Phosphorous	----	----	0.3	0.016	0.015	<0.005	0.084
Ammonia	0.05	<0.05	0.05	<0.05	<0.05	0.06	0.052
Alkalinity as CaCO ₃	120	111	230	41	110	141	125.500
Hardness as CaCO ₃	123.6	119	222	41	124	183	135.433

APPENDIX 3. Table 3.12. Analyses of dissolved metals for Station W7 on an unnamed east flowing tributary of Williams Creek for the period October 1989 to October 1992.

PARAMETER	CONCENTRATION (mg/L) BY SAMPLE PERIOD						AVERAGE
	OCT 89	AUG 91	DEC 91	MAY 92	JUL 92	OCT 92	
Aluminum	----	<0.005	<0.005	0.059	0.017	0.035	0.024
Antimony	----	<0.05	<0.05	<0.02	<0.02	<0.02	<0.05
Arsenic	----	<0.05	0.12	<0.04	<0.04	<0.05	0.060
Barium	----	0.036	0.09	0.01	0.039	0.061	0.047
Beryllium	----	<0.0005	0.003	<0.0002	<0.0002	<0.0002	0.0008
Bismuth	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02
Boron	----	----	----	----	----	----	----
Cadmium	----	<0.0003	<0.0003	<0.0003	<0.0003	<0.0004	<0.0004
Calcium	----	34.5	60.3	11.1	37	44.6	37.500
Chromium	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	----	<0.001	0.007	<0.001	<0.001	<0.001	0.002
Copper	----	<0.001	<0.001	0.009	<0.001	0.002	0.002
Iron	----	0.199	9.4	0.07	0.054	0.161	1.977
Lead	----	<0.004	<0.004	<0.004	<0.004	<0.005	<0.005
Lithium	----	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Magnesium	----	6.63	9	2.73	7.24	11.1	7.340
Manganese	----	0.024	2.59	0.002	0.004	0.066	0.537
Mercury	----	----	----	----	----	----	----
Molybdenum	----	<0.005	<0.005	<0.003	<0.003	<0.004	<0.005
Nickel	----	0.004	0.005	<0.001	0.002	0.001	0.003
Phosphorous	----	<0.02	0.2	0.02	<0.02	<0.02	0.056
Potassium	----	0.19	0.45	1.46	0.23	0.4	0.546
Selenium	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.001
Silicon	----	11	5.3	3.9	13.5	9.9	8.720
Silver	----	<0.001	<0.001	<0.001	<0.001	<0.001	0.000
Sodium	----	6.86	6.35	1.69	6.06	9.92	6.176
Strontium	----	0.138	0.16	0.051	0.176	0.2	0.145
Thorium	----	<0.02	<0.02	<0.005	<0.005	<0.01	<0.02
Titanium	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	----	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Vanadium	----	0.0007	<0.0005	<0.001	<0.001	0.003	0.001
Zinc	----	0.003	0.002	0.004	0.006	0.009	0.005
Zirconium	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Hardness as CaCO ₃	----	114	188	39.4	122	158	124.280

APPENDIX 3. Table 3.13. Analyses of total metals for Station W9 on Williams Creek for the period October 1989 to October 1992.

PARAMETER	CONCENTRATION (mg/L) BY SAMPLE PERIOD						AVERAGE
	OCT 89	AUG 91	DEC 91	MAY 92	JUL 92	OCT 92	
pH	7.8	8.2	7.9	7.5	7.9	7.6	7.815
Conductivity	505	275	635	85	130	475	350.833
Suspended Solids	<5	<5	15	<5	<5	<5	6.667
Turbidity	----	<1	7	2	<1	<1	2.400
Aluminum	<0.02	<0.005	<0.005	0.088	0.057	0.026	0.034
Antimony	<0.005	<0.05	<0.05	<0.02	<0.02	<0.02	<0.05
Arsenic	<0.02	<0.05	0.16	<0.04	<0.04	<0.05	0.060
Barium	0.043	0.049	0.082	0.013	0.034	0.067	0.288
Beryllium	<0.0001	<0.0005	<0.0005	<0.0002	<0.0002	<0.0002	<0.0005
Bismuth	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02
Boron	0.004	----	----	----	----	----	0.004
Cadmium	<0.0002	<0.0003	<0.0003	0.0004	<0.0003	<0.0004	0.0003
Calcium	44.2	35.6	83	9.8	25.7	48.5	41.133
Chromium	0.0005	0.008	0.007	<0.001	<0.001	<0.001	0.003
Cobalt	<0.0005	<0.001	0.004	<0.001	0.001	0.003	0.002
Copper	<0.0005	<0.001	<0.001	0.002	0.004	0.003	0.002
Iron	0.199	0.138	3.17	0.117	0.137	0.197	0.660
Lead	<0.002	<0.004	<0.004	<0.004	<0.004	<0.005	<0.005
Lithium	0.29	<0.06	<0.05	<0.05	<0.05	<0.05	<0.06
Magnesium	18.2	13.8	22.7	3.1	7.5	19.2	14.083
Manganese	0.015	0.016	1.3	0.003	<0.001	0.044	1.379
Mercury	<0.005	----	----	----	----	----	<0.005
Molybdenum	<0.001	<0.005	0.007	<0.003	<0.003	<0.004	0.004
Nickel	0.0012	0.005	0.007	<0.001	0.006	0.003	0.004
Phosphorous	<0.05	<0.02	0.37	0.03	<0.02	0.02	0.085
Potassium	1.3	0.82	1.91	0.85	0.45	1.64	1.162
Selenium	<0.005	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02
Silicon	4.92	9.9	4.3	3.66	13	12	7.963
Silver	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002
Sodium	19.1	14.2	7	2.13	5.98	22.9	11.885
Strontium	0.583	0.4	0.56	0.078	0.28	0.54	0.407
Thorium	<0.01	<0.02	<0.02	<0.005	0.01	<0.01	0.013
Titanium	<0.001	<0.001	0.007	0.004	0.002	<0.001	0.003
Uranium	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Vanadium	<0.0002	0.0038	<0.0005	0.001	<0.001	0.016	0.004
Zinc	0.0064	0.008	<0.001	0.007	0.003	0.017	0.006
Zirconium	----	<0.001	<0.001	<0.001	0.002	<0.001	0.001
Chloride	2	----	----	----	----	----	2.000
Fluoride	<1	----	----	----	----	----	<1
Nitrate	<0.1	<0.1	<0.05	<0.05	<0.1	<0.2	<0.2
Sulphate	54	17	50.8	1.8	6.2	47.8	29.600
Nitrite	<0.003	<0.003	<5.0	<0.03	<1	<2.0	<5
T. Phosphorous	----	----	0.29	0.012	0.009	0.009	0.080
Ammonia	0.08	<0.05	0.44	<0.05	<0.05	0.06	0.122
Alkalinity as CaCO ₃	170	157	255	38	84	188	148.667
Hardness as CaCO ₃	185.3	145	301	38	96.4	200	160.950

APPENDIX 3. Table 3.14. Analyses of dissolved metals for Station W9 on Williams Creek for the period October 1989 to October 1992.

PARAMETER	CONCENTRATION (mg/L) BY SAMPLE PERIOD						AVERAGE
	OCT 89	AUG 91	DEC 91	MAY 92	JUL 92	OCT 92	
Aluminum	----	<0.005	<0.005	0.035	0.022	0.022	0.178
Antimony	----	<0.05	<0.05	<0.02	<0.02	<0.02	<0.05
Arsenic	----	<0.05	0.16	<0.04	<0.04	<0.05	0.050
Barium	----	0.049	0.066	0.009	0.029	0.064	0.043
Beryllium	----	<0.0005	<0.0005	<0.0002	<0.0002	<0.0002	<0.0005
Bismuth	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02
Boron	----	----	----	----	----	----	----
Cadmium	----	<0.0003	<0.0003	<0.0003	<0.0003	<0.0004	<0.0004
Calcium	----	35.5	81.9	8.15	25.5	46.3	39.470
Chromium	----	<0.001	0.005	<0.001	<0.001	<0.001	0.002
Cobalt	----	<0.001	0.004	<0.001	<0.001	0.003	0.002
Copper	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron	----	0.094	1.24	0.043	0.379	0.161	0.383
Lead	----	<0.004	<0.004	<0.004	<0.004	<0.005	<0.005
Lithium	----	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Magnesium	----	13	22.5	2.58	7.54	18.9	12.904
Manganese	----	0.016	1.26	0.001	<0.001	0.042	0.264
Mercury	----	----	----	----	----	----	----
Molybdenum	----	<0.005	0.006	<0.003	<0.003	<0.004	0.004
Nickel	----	0.005	0.004	<0.001	0.004	0.003	0.003
Phosphorous	----	<0.02	0.23	0.02	<0.02	<0.02	0.062
Potassium	----	0.81	1.83	0.62	0.38	1.41	1.010
Selenium	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02
Silicon	----	9.9	4	2.95	12.6	11.6	8.210
Silver	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sodium	----	13.9	6.7	1.84	5.91	22.7	10.210
Strontium	----	0.4	0.55	0.065	0.232	0.53	0.355
Thorium	----	<0.02	<0.02	<0.005	<0.005	<0.01	<0.02
Titanium	----	<0.001	0.002	<0.001	<0.001	<0.001	0.001
Uranium	----	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Vanadium	----	0.0037	<0.0005	<0.001	<0.001	0.011	0.003
Zinc	----	0.004	<0.001	0.003	0.002	0.008	0.004
Zirconium	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Hardness as CaCO ₃	----	142	297	31.2	95.6	194	151.960

APPENDIX 3. Table 3.15. Analyses of total metals for Station W10 on Williams Creek upstream of the Yukon River confluence for the period October 1989 to October 1992.

PARAMETER	CONCENTRATION (mg/L) BY SAMPLE PERIOD						AVERAGE
	OCT 89	AUG 91	DEC 91	MAY 92	JUL 92	OCT 92	
pH	----	8.1	8.1	7.6	8	7.7	7.900
Conductivity	----	188	204	97	140	355	196.800
Suspended Solids	----	<5	<5	25	20	<5	13.000
Turbidity	----	2	1	7	6	<1	3.400
Aluminum	----	<0.005	<0.005	0.389	0.463	0.043	0.181
Antimony	----	<0.05	<0.05	<0.02	<0.02	<0.02	<0.05
Arsenic	----	<0.05	0.08	<0.04	<0.04	<0.05	0.052
Barium	----	0.026	0.146	0.026	0.034	0.055	0.057
Beryllium	----	<0.0005	<0.0005	<0.0002	<0.0002	<0.0002	<0.0005
Bismuth	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02
Boron	----	----	----	----	----	----	----
Cadmium	----	<0.0003	<0.0003	<0.0003	<0.0003	<0.0004	<0.0004
Calcium	----	32.1	59	16.3	29.9	47.9	37.040
Chromium	----	0.009	0.004	<0.001	<0.001	<0.001	0.003
Cobalt	----	<0.001	0.002	<0.001	<0.001	0.002	0.001
Copper	----	<0.001	<0.001	0.001	0.005	0.005	0.003
Iron	----	0.163	0.07	0.454	0.824	0.257	0.354
Lead	----	<0.004	<0.004	<0.004	<0.004	<0.005	<0.005
Lithium	----	<0.06	<0.05	<0.05	<0.05	<0.05	<0.06
Magnesium	----	6.79	8.61	4.53	6.71	12	7.728
Manganese	----	0.004	0.034	0.024	0.027	0.018	0.021
Mercury	----	----	----	----	----	----	----
Molybdenum	----	<0.005	<0.003	<0.003	<0.003	<0.004	<0.005
Nickel	----	0.006	0.004	<0.001	0.006	0.003	0.004
Phosphorous	----	<0.02	<0.02	0.02	0.04	0.03	0.026
Potassium	----	0.41	1.24	1.4	0.62	1.3	0.994
Selenium	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02
Silicon	----	13.2	1.4	6.18	12.2	10	8.596
Silver	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sodium	----	7.77	2.57	3.49	6.02	11.1	6.190
Strontium	----	0.24	0.166	0.132	0.29	0.47	0.260
Thorium	----	<0.02	<0.02	<0.005	<0.005	<0.01	<0.02
Titanium	----	0.002	0.001	0.017	0.02	<0.001	0.008
Uranium	----	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Vanadium	----	0.0021	<0.0005	<0.001	<0.001	0.01	0.003
Zinc	----	0.003	0.195	0.007	0.01	0.008	0.045
Zirconium	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chloride	----	----	----	----	----	----	----
Fluoride	----	----	----	----	----	----	----
Nitrate	----	<0.1	0.08	<0.05	<0.1	<0.20	0.106
Sulphate	----	15.5	12.2	4.9	9.5	34.8	15.380
Nitrite	----	<0.003	<0.5	<0.03	<1	<2.0	<2.0
T. Phosphorous	----	----	0.015	0.014	0.04	0.025	0.019
Ammonia	----	<0.05	0.05	<0.05	<0.05	<0.05	0.050
Alkalinity as CaCO ₃	----	103	166	59	94	144	113.200
Hardness as CaCO ₃	----	108	183	62.5	102.2	170	125.140

APPENDIX 3. Table 3.16. Analyses of dissolved metals for Station W10 on Williams Creek upstream of the Yukon River confluence for the period October 1989 to October 1992.

PARAMETER	CONCENTRATION (mg/L) BY SAMPLE PERIOD						AVERAGE
	OCT 89	AUG 91	DEC 91	MAY 92	JUL 92	OCT 92	
Aluminum	----	<0.005	<0.005	0.08	0.042	0.043	0.035
Antimony	----	<0.05	<0.05	<0.02	<0.02	<0.02	<0.05
Arsenic	----	<0.05	0.06	<0.04	<0.04	<0.05	0.048
Barium	----	0.026	0.038	0.017	0.03	0.054	0.033
Beryllium	----	<0.0005	<0.0005	<0.0002	<0.0002	<0.0002	<0.0005
Bismuth	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02
Boron	----	----	----	----	----	----	----
Cadmium	----	<0.0003	<0.0003	<0.0003	<0.0003	<0.0004	<0.0004
Calcium	----	31	57.1	15.8	29.5	43.5	35.380
Chromium	----	<0.001	0.004	<0.001	<0.001	<0.001	0.002
Cobalt	----	<0.001	<0.001	<0.001	<0.001	0.001	0.001
Copper	----	<0.001	<0.001	<0.001	<0.001	0.005	0.002
Iron	----	0.08	0.022	0.171	0.164	0.129	0.113
Lead	----	<0.004	<0.004	<0.004	<0.004	<0.005	<0.005
Lithium	----	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Magnesium	----	6.63	6.92	4.38	6.65	11	7.116
Manganese	----	0.001	0.002	<0.001	<0.001	0.016	0.004
Mercury	----	----	----	----	----	----	----
Molybdenum	----	<0.005	<0.005	<0.003	<0.003	<0.004	<0.005
Nickel	----	0.004	<0.001	<0.001	0.004	0.003	0.003
Phosphorous	----	<0.02	<0.02	0.02	0.04	0.02	0.016
Potassium	----	0.59	0.64	1.25	0.5	1.32	0.860
Selenium	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02
Silicon	----	10.4	1.2	5.21	11.5	8.9	7.442
Silver	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sodium	----	7.35	0.89	3.48	5.92	11.1	5.748
Strontium	----	0.24	0.11	0.131	0.234	0.43	0.229
Thorium	----	<0.02	<0.02	<0.005	<0.005	<0.01	<0.02
Titanium	----	0.001	0.001	0.001	<0.001	<0.001	0.005
Uranium	----	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Vanadium	----	0.0011	<0.0005	<0.001	<0.001	0.004	0.004
Zinc	----	0.002	<0.001	0.005	0.01	0.008	0.005
Zirconium	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Hardness as CaCO ₃	----	105	171	58.1	102	156	118.420

APPENDIX 3. Table 3.17. Analyses of total metals for Station W11 on Nancy Lee Creek upstream of the Williams Creek confluence for the period October 1989 to October 1992.

PARAMETER	CONCENTRATION (mg/L) BY SAMPLE PERIOD						AVERAGE
	OCT 89	AUG 91	DEC 91	MAY 92	JUL 92	OCT 92	
pH	----	----	8.1	7.4	----	7.8	7.767
Conductivity	----	----	350	84	----	320	251.333
Suspended Solids	----	----	<5	8	----	<5	6.000
Turbidity	----	----	1	5	----	<1	2.333
Aluminum	----	----	<0.005	0.13	----	0.055	0.063
Antimony	----	----	<0.05	<0.02	----	<0.02	<0.05
Arsenic	----	----	0.12	<0.04	----	<0.05	0.070
Barium	----	----	0.04	0.016	----	0.046	0.034
Beryllium	----	----	<0.0005	<0.0002	----	<0.0002	<0.0005
Bismuth	----	----	<0.01	<0.02	----	<0.02	<0.02
Boron	----	----	----	----	----	----	----
Cadmium	----	----	<0.0003	<0.0003	----	<0.0004	<0.0004
Calcium	----	----	53.9	13.8	----	42.6	36.767
Chromium	----	----	0.004	<0.001	----	<0.001	0.002
Cobalt	----	----	<0.001	<0.001	----	0.002	0.001
Copper	----	----	<0.001	0.003	----	0.005	0.003
Iron	----	----	<0.005	0.161	----	0.268	0.143
Lead	----	----	<0.004	<0.004	----	<0.005	<0.005
Lithium	----	----	<0.05	<0.05	----	<0.05	<0.05
Magnesium	----	----	11.3	3.4	----	11.5	8.733
Manganese	----	----	0.003	0.007	----	0.083	0.031
Mercury	----	----	----	----	----	----	----
Molybdenum	----	----	<0.05	<0.003	----	<0.004	<0.05
Nickel	----	----	0.002	<0.001	----	<0.02	0.007
Phosphorous	----	----	<0.02	<0.02	----	<0.02	<0.02
Potassium	----	----	1.13	1.3	----	1	1.143
Selenium	----	----	<0.01	<0.02	----	<0.02	<0.02
Silicon	----	----	3.6	4.92	----	10	6.173
Silver	----	----	<0.001	<0.001	----	<0.001	<0.001
Sodium	----	----	9.29	2.78	----	9.69	7.253
Strontium	----	----	0.39	0.088	----	0.33	0.269
Thorium	----	----	<0.02	<0.005	----	<0.01	<0.02
Titanium	----	----	0.002	0.003	----	<0.001	0.002
Uranium	----	----	<0.02	<0.02	----	<0.02	<0.02
Vanadium	----	----	<0.0005	<0.001	----	0.008	0.003
Zinc	----	----	0.004	0.007	----	0.007	0.006
Zirconium	----	----	<0.001	<0.001	----	<0.001	<0.001
Chloride	----	----	----	----	----	----	----
Fluoride	----	----	----	----	----	----	----
Nitrate	----	----	<0.2	<0.05	----	<0.2	<0.2
Sulphate	----	----	49.2	2.6	----	29.2	27.000
Nitrite	----	----	<2	<0.03	----	<2.0	<2.0
T. Phosphorous	----	----	0.01	0.012	----	0.006	0.009
Ammonia	----	----	<0.05	<0.05	----	<0.05	<0.05
Alkalinity as CaCO ₃	----	----	135	50	----	143	109.333
Hardness as CaCO ₃	----	----	181	49.5	----	155	128.500

APPENDIX 3. Table 3.18. Analyses of dissolved metals for Station W11 on Nancy Lee Creek upstream of the Williams Creek confluence for the period October 1989 to October 1992.

PARAMETER	CONCENTRATION (mg/L) BY SAMPLE PERIOD						AVERAGE
	OCT 89	AUG 91	DEC 91	MAY 92	JUL 92	OCT 92	
Aluminum	----	----	<0.005	0.084	----	0.05	0.046
Antimony	----	----	<0.05	<0.02	----	<0.02	<0.05
Arsenic	----	----	0.1	<0.04	----	<0.05	0.063
Barium	----	----	0.035	0.014	----	0.045	0.031
Beryllium	----	----	<0.0005	<0.0002	----	<0.0002	<0.0005
Bismuth	----	----	<0.01	<0.02	----	<0.02	<0.02
Boron	----	----	----	----	----	----	----
Cadmium	----	----	<0.0003	<0.0003	----	<0.0004	<0.0004
Calcium	----	----	50.1	13.2	----	41.4	34.900
Chromium	----	----	0.003	<0.001	----	<0.001	0.002
Cobalt	----	----	<0.001	<0.001	----	0.001	0.001
Copper	----	----	<0.001	<0.001	----	0.004	0.002
Iron	----	----	----	0.115	----	0.2	0.105
Lead	----	----	<0.004	<0.004	----	<0.005	<0.005
Lithium	----	----	<0.05	<0.05	----	<0.05	<0.05
Magnesium	----	----	10.7	3.24	----	11.4	8.447
Manganese	----	----	<0.001	<0.001	----	0.08	0.027
Mercury	----	----	----	----	----	----	----
Molybdenum	----	----	<0.005	<0.003	----	<0.004	<0.005
Nickel	----	----	0.002	<0.001	----	0.003	0.002
Phosphorous	----	----	<0.02	<0.02	----	<0.02	<0.02
Potassium	----	----	0.92	1.19	----	0.99	1.033
Selenium	----	----	<0.01	<0.02	----	<0.02	<0.02
Silicon	----	----	3.3	4.47	----	9.6	5.790
Silver	----	----	<0.001	<0.001	----	<0.001	<0.001
Sodium	----	----	8.24	2.74	----	9.6	6.860
Strontium	----	----	0.37	0.084	----	0.33	0.261
Thorium	----	----	<0.02	<0.005	----	<0.01	<0.02
Titanium	----	----	<0.001	0.001	----	<0.001	0.001
Uranium	----	----	<0.02	<0.02	----	<0.02	<0.02
Vanadium	----	----	<0.0005	<0.001	----	0.006	0.003
Zinc	----	----	<0.001	0.003	----	0.006	0.003
Zirconium	----	----	<0.001	<0.001	----	<0.001	<0.001
Hardness as CaCO ₃	----	----	169	47	----	151	122.333

TABLE 3.5.1
Summary of Physical Water Quality Parameters
for Sampling Stations in the
Williams Creek Drainage based on
Average Values Calculated for the October 1989 to October 1992 period.

SAMPLE SITE	# OF SAMPLES	pH	ALKTY (mg/L CaCO3)	H ₂ O hardness (mg/L CaCO3)	AVERAGE VALUES				
					SO ₄ (mg/L)	SUSP. SOLIDS (mg/L)	NO ₄ (mg/L)	NO ₃ (mg/L)	NH ₄ (mg/L)
MAINSTEM									
W10	5	7.9	113	125	15	13	0.01	BD	0.25
W4	6	7.8	107	146	37	94	0.02	BD	0.05
W9	6	7.8	149	161	30	7	BD	BD	0.12
TRIBUTARY									
W11	3	7.8	109	128	27	6	BD	BD	BD
W1	6	7.8	116	206	103	31	0.5	BD	0.06
W3	5	7.7	130	138	12	BD	BD	BD	0.06
W5	6	7.5	84	102	4	462	BD	BD	0.07
W7	6	7.5	126	135	11	8	BD	BD	0.05
W2	1	7.7	100	133	76	8	BD	BD	0.06
W6	1	7.9	140	169	51	BD	BD	0.003	0.05

*No data for W8.

TABLE 3.5.2
Summary of Total Metal Concentrations
for sampling stations in the
Williams Creek drainage
based on average values calculated for the October 1989 to October 1992 period.

SAMPLE SITE	# OF SAMPLES	AVERAGE VALUES (mg/L)									
		Al	As	Cd	Ca	Cu	Fe	Pb	Mg	Na	Zn
MAINSTEM											
W10	5	0.18	0.05	BD	37.0	0.003	0.35	BD	7.7	6.19	0.045
W4	6	1.14	0.05	BD	37.7	0.006	2.16	0.004	10.2	9.66	0.018
W9	6	0.03	0.06	0.0003	41.1	0.002	0.66	BD	14.1	11.9	0.006
TRIBUTARY											
W11	3	0.06	0.07	BD	36.8	0.003	0.14	BD	8.7	8.7	0.006
W1	6	0.02	0.06	0.0003	60.6	0.002	0.14	BD	13.3	9.0	0.012
W3	5	0.04	BD	BD	41.2	0.005	0.15	BD	7.9	6.5	0.014
W5	6	3.23	0.06	0.0004	26.1	0.018	8.43	0.007	7.0	6.6	0.035
W7	6	0.06	0.06	0.0003	40.9	0.005	2.10	0.004	8.3	6.2	0.010
W2	1	BD	BD	BD	44.2	BD	0.37	BD	12.8	12.8	0.033
W6	1	BD	BD	BD	43.8	0.001	0.64	BD	13.9	14.3	0.108

*No data for W8

TABLE 3.5.3
Summary of Dissolved Metal Concentrations
for Sampling Stations in the Williams Creek Drainage
based on average values calculated for the October 1989 to October 1992 period.

SAMPLE SITE	# OF SAMPLES	AVERAGE VALUES (mg/L)									
		Al	As	Cd	Ca	Cu	Fe	Pb	Mg	Na	Zn
MAINSTEM											
W10	5	0.04	0.05	BD	35.4	0.002	0.11	BD	7.1	5.7	0.005
W4	5	0.02	0.06	BD	34.0	0.001	0.37	BD	9.1	8.7	0.004
W9	5	0.18	0.05	BD	39.5	BD	0.38	BD	12.9	10.2	0.004
TRIBUTARY*											
W11	3	0.05	0.06	BD	34.9	0.002	0.10	BD	8.4	6.9	0.003
W1	5	BD	0.06	BD	59.4	BD	0.05	BD	12.8	9.5	0.004
W3	4	0.03	BD	BD	35.0	0.001	0.14	BD	7.3	6.0	0.004
W5	5	0.04	0.005	BD	23.6	0.002	0.62	BD	5.9	5.6	0.005
W7	5	0.02	0.06	BD	37.5	0.002	1.98	BD	7.3	6.2	0.005

* no data for site W2, W6 or W8

WILLIAMS CREEK COPPER OXIDE PROJECT

TABLE 3.5.4
Average Concentrations of Selected Parameters
for Site W-10 in Lower Williams Creek and Site W-4 in the Upper Watershed
compared to CCREM Guideline Values for Waters of Similar pH and hardness.
(Metal Values reported are totals in mg/L).

PARAMETER	WILLIAMS W-10	WILLIAMS W-4	CCREM GUIDELINE FOR AQUATIC LIFE
Hardness	75 to 225 mg/L CaCO ₃	146 mg/L CaCO ₃	none
pH	7.9	7.8*	6.5 to 9.0
Aluminum	0.181	1.142	0.1
Arsenic	0.052	0.053	0.05
Cadmium	<0.0004	<0.0004	0.0008 (hardness > 60 mg/L CaCO ₃)
Chromium	0.003	0.005	0.002 mg/L (0.02 mg/L for fish)
Copper	0.003	0.006	0.002 (hardness < 120 mg/L CaCO ₃) 0.003 (hardness 120-180 mg/L CaCO ₃) 0.004 (hardness > 180 mg/L CaCO ₃)
Iron	0.354	2.161	0.3
Lead	<0.005	0.004	0.002 to 0.004 mg/L*
Nickel	0.004	0.005	0.065 to 0.110 mg/L*
Silver	<0.001	<0.002	0.0001 mg/L
Zinc	0.045	0.018	0.03 mg/L

*75 to 225 mg/L CaCO₃

WILLIAMS CREEK COPPER OXIDE PROJECT

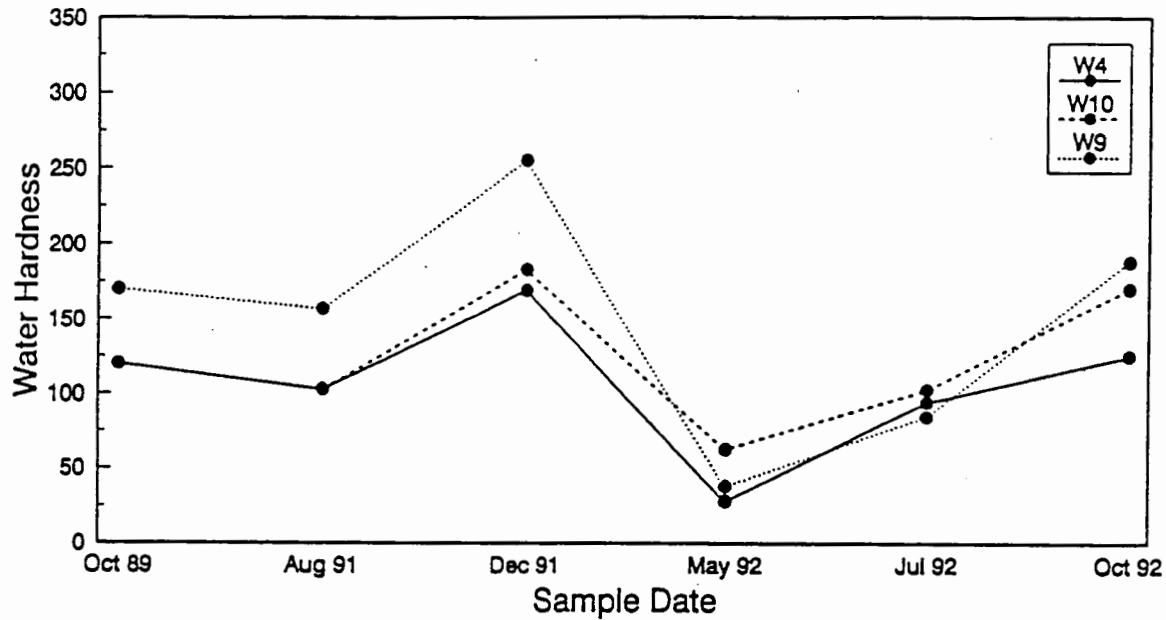
TABLE 3.5.5
Comparison of average total and dissolved metal
concentrations for Site W-10 in lower Williams Creek
based on data collected between October 1989 and October 1992.

ELEMENT	TOTAL CONCENTRATION (mg/L)	DISSOLVED CONCENTRATION (mg/L)	PERCENT DISSOLVED
Al	0.180	0.035	20%
As	0.052	0.048	95%
Cd	<0.0004	<0.0004	-
Cr	0.003	0.002	66%
Cu	0.003	0.002	66%
Fe	0.0354	0.113	32%
Ni	0.004	0.003	75%
Zn	0.045	0.005	11%

BD= Below detection limits

ALKALINITY: WILLIAMS CREEK

Oct. 1989 - Oct. 1992



ALKALINITY: TRIBUTARY SITES

Oct. 1989 - Oct. 1992

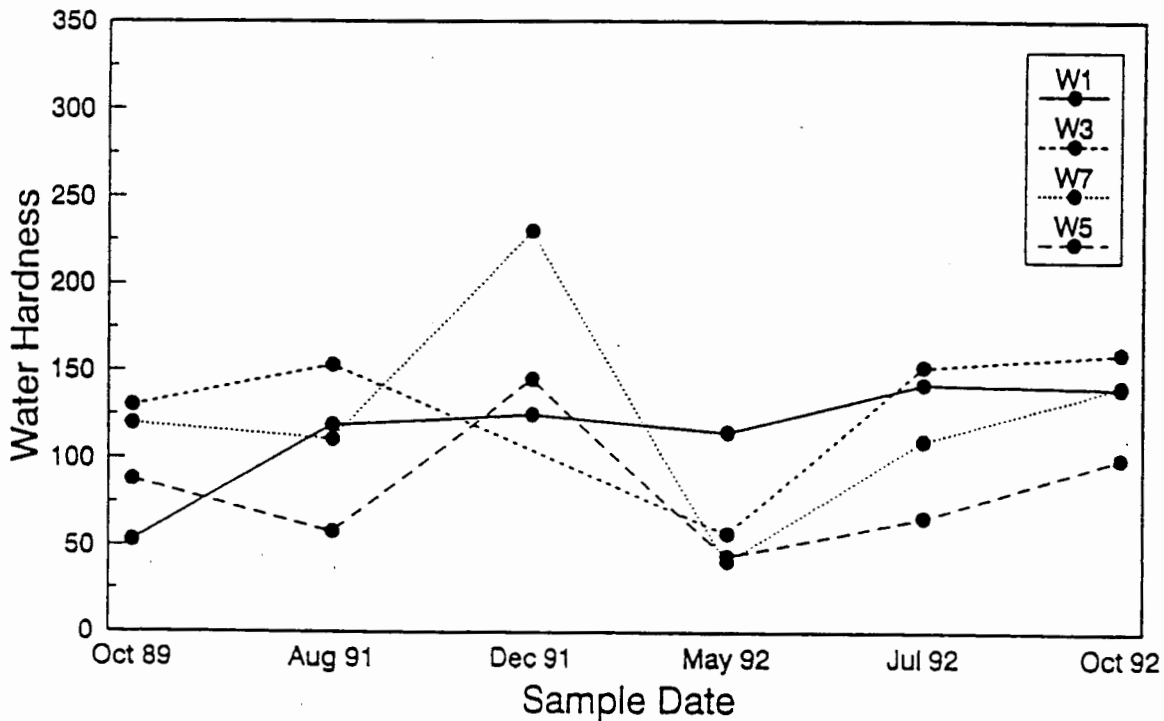
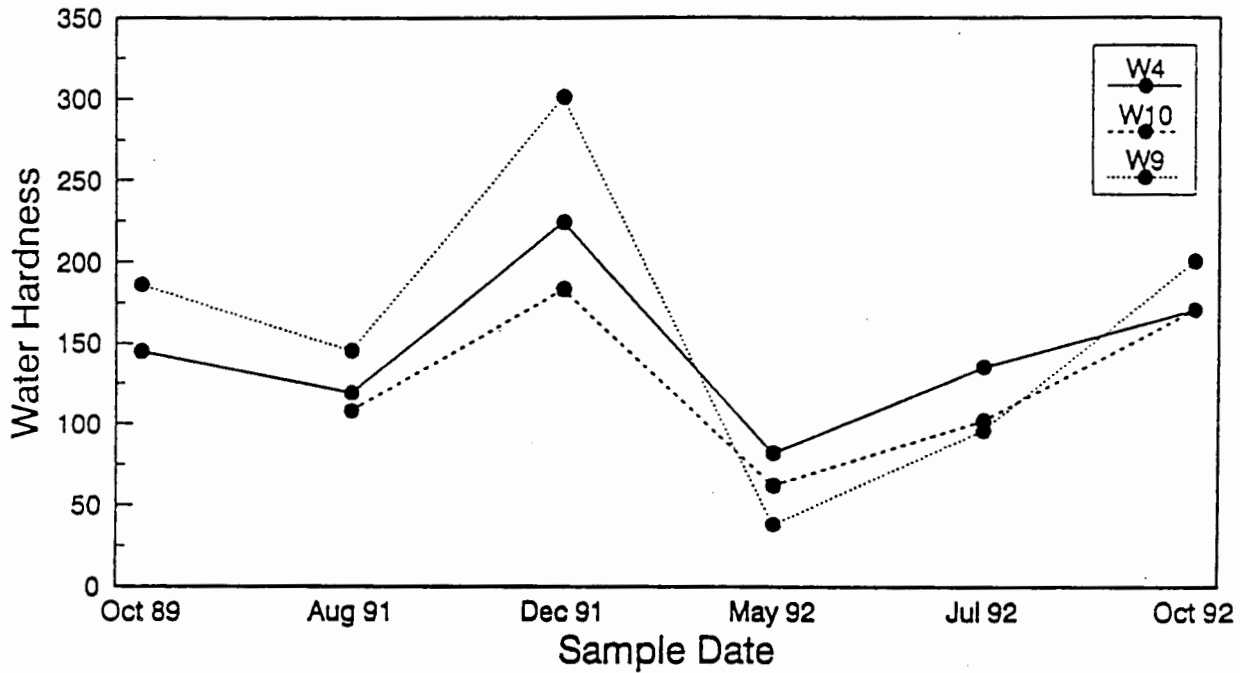


FIGURE 3.5.1 Alkalinity values for mainstem Williams Creek (Top) and tributary sites (Bottom) between October 1989 and October 1992.

WATER HARDNESS: WILLIAMS CREEK

Oct. 1989 - Oct. 1992



WATER HARDNESS: TRIBUTARY SITES

Oct. 1989 - Oct. 1992

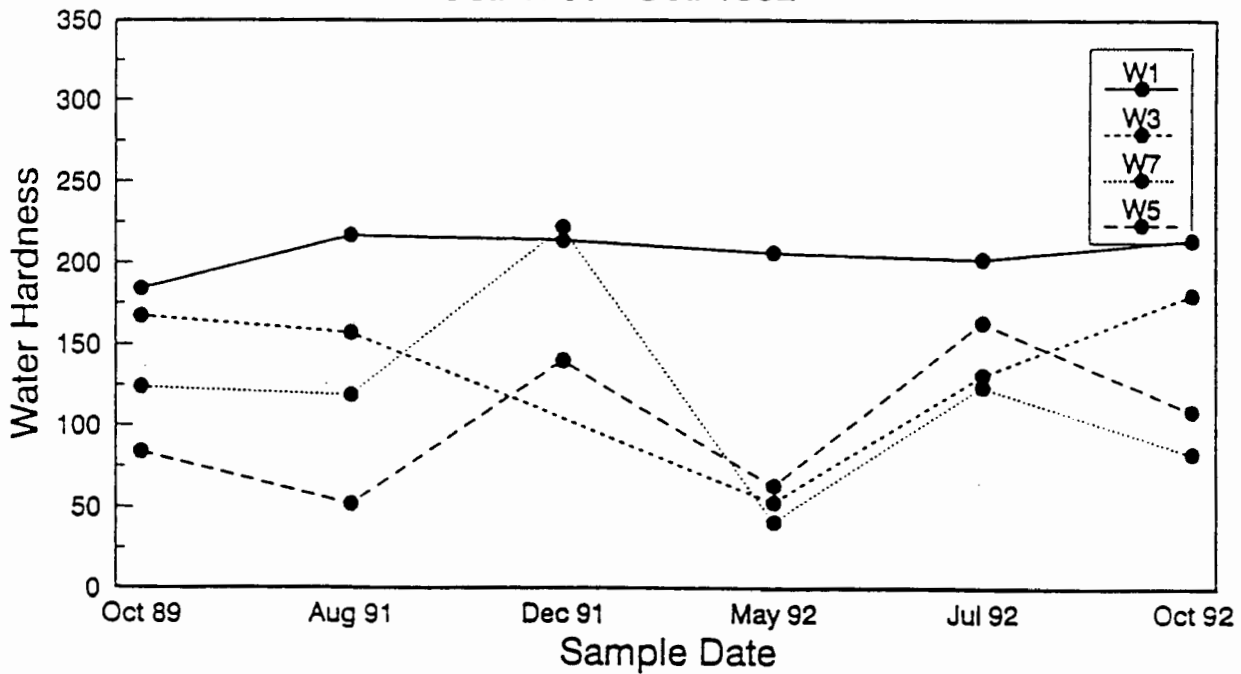


FIGURE 3.5.2 Water Hardness values for mainstem Williams Creek (Top) and tributary sites (Bottom) between October 1989 and October 1992.

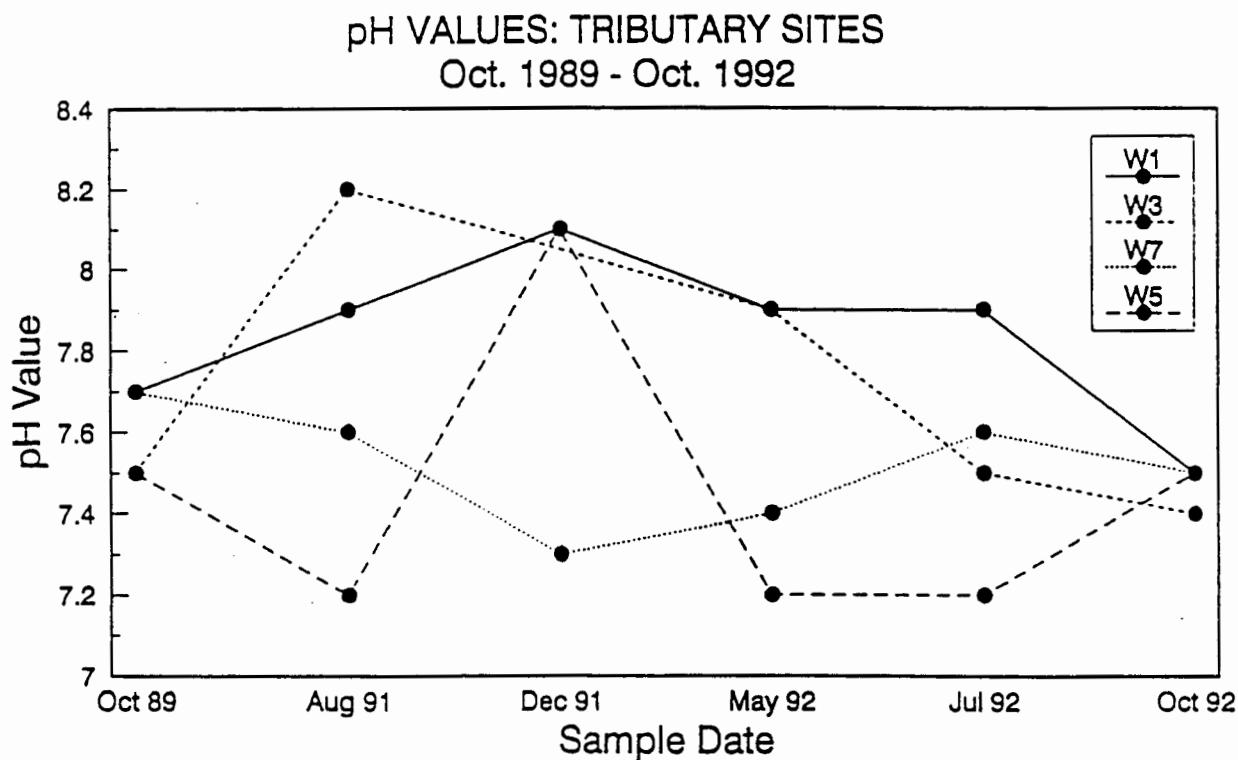
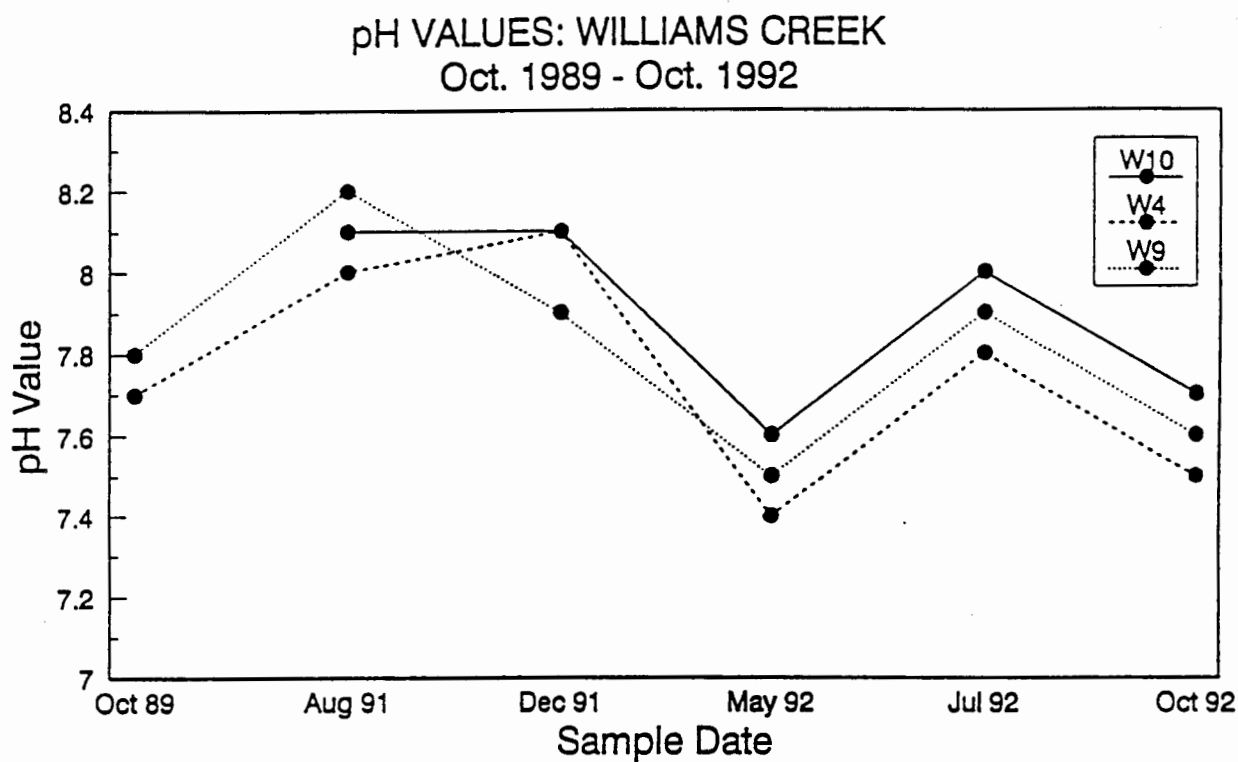
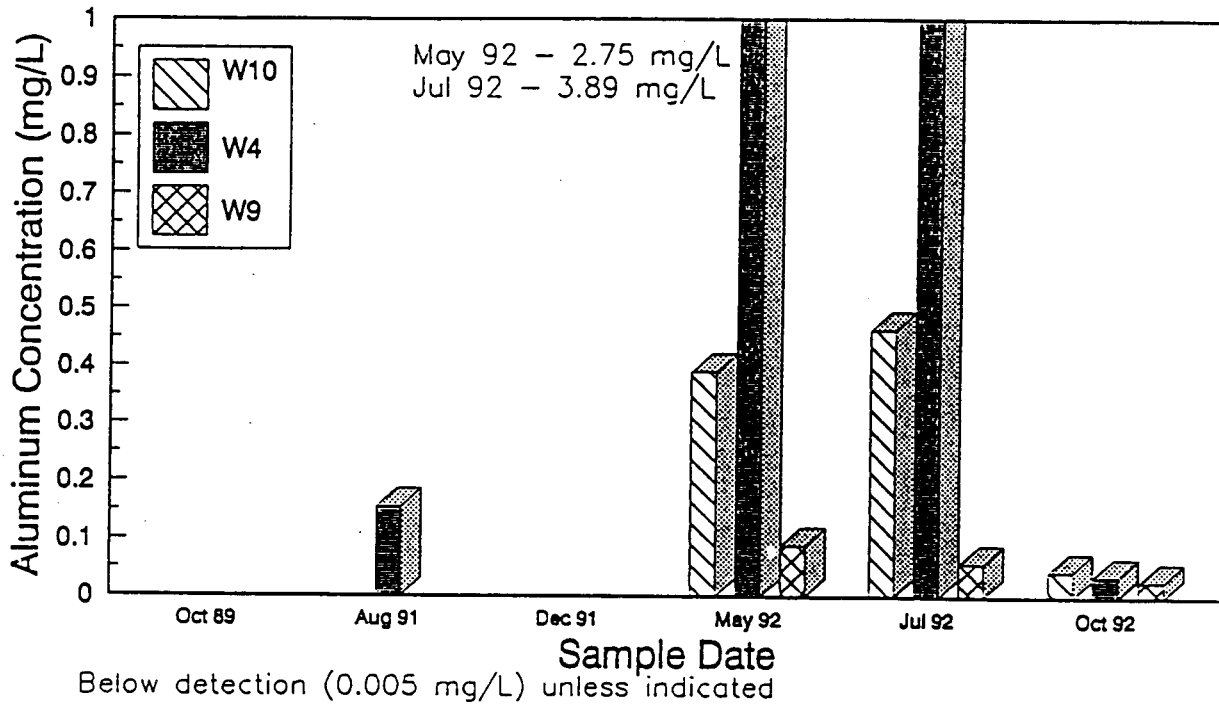


FIGURE 3.5.3 pH values for mainstem Williams Creek (Top) and tributary sites (Bottom) between October 1989 and October 1992.

TOTAL ALUMINUM: WILLIAMS CREEK
Oct. 1989 - Oct. 1992



TOTAL ALUMINUM: TRIBUTARY SITES
Oct. 1989 - Oct. 1992

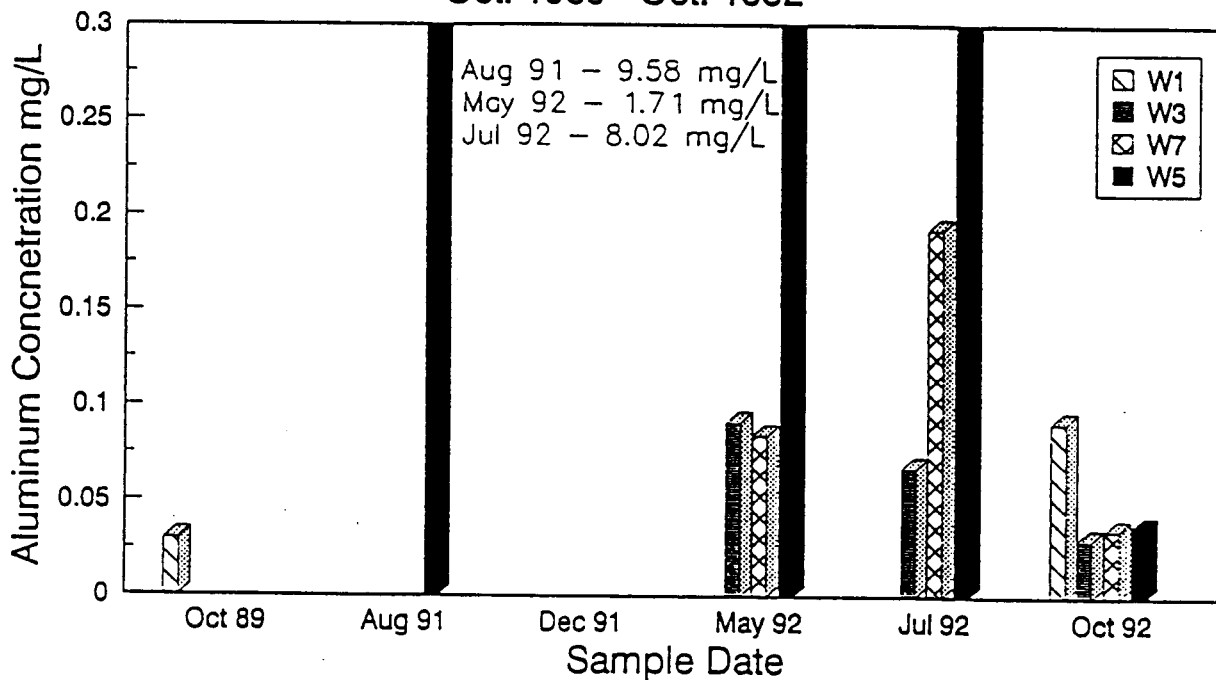
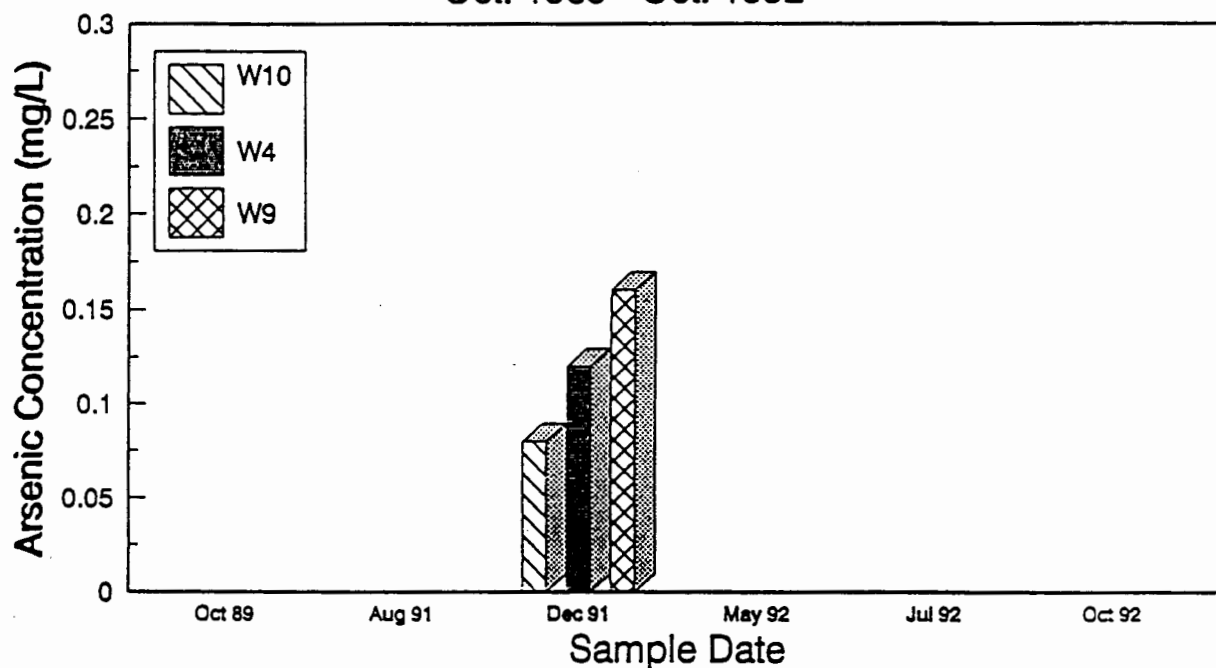


FIGURE 3.5.4 Concentration of total aluminum for Williams Creek mainstem and selected tributary sites between October 1989 and October 1992.

TOTAL ARSENIC: WILLIAMS CREEK Oct. 1989 - Oct. 1992



TOTAL ARSENIC: TRIBUTARY SITES Oct. 1989 - Oct. 1992

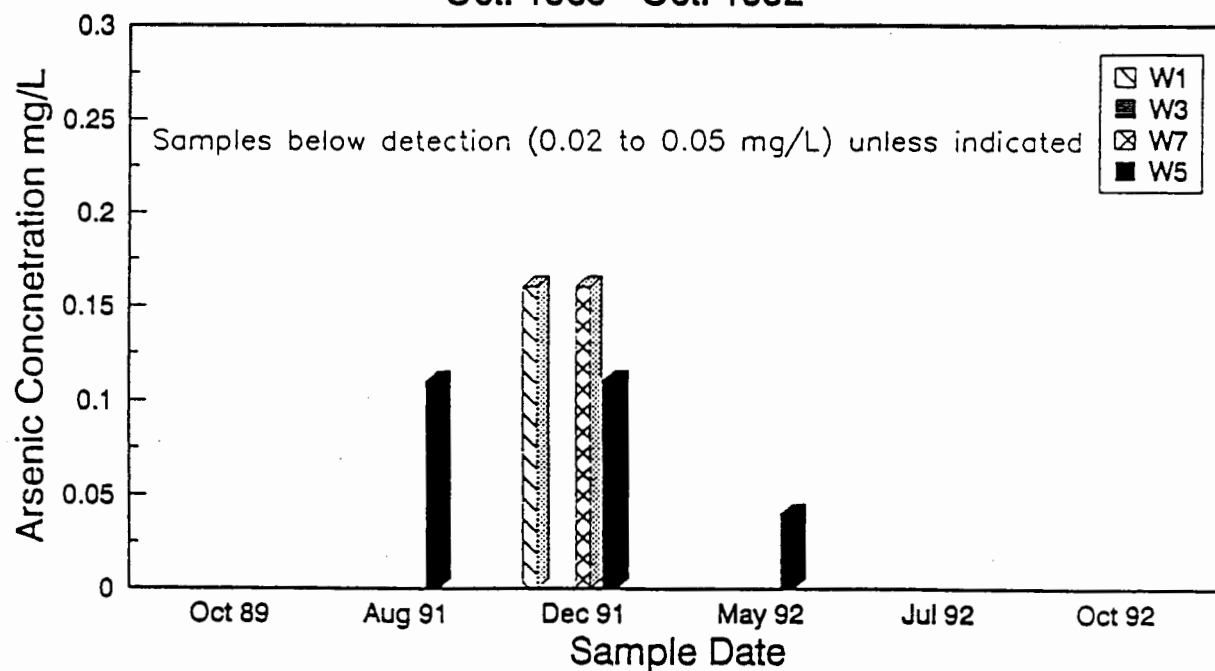
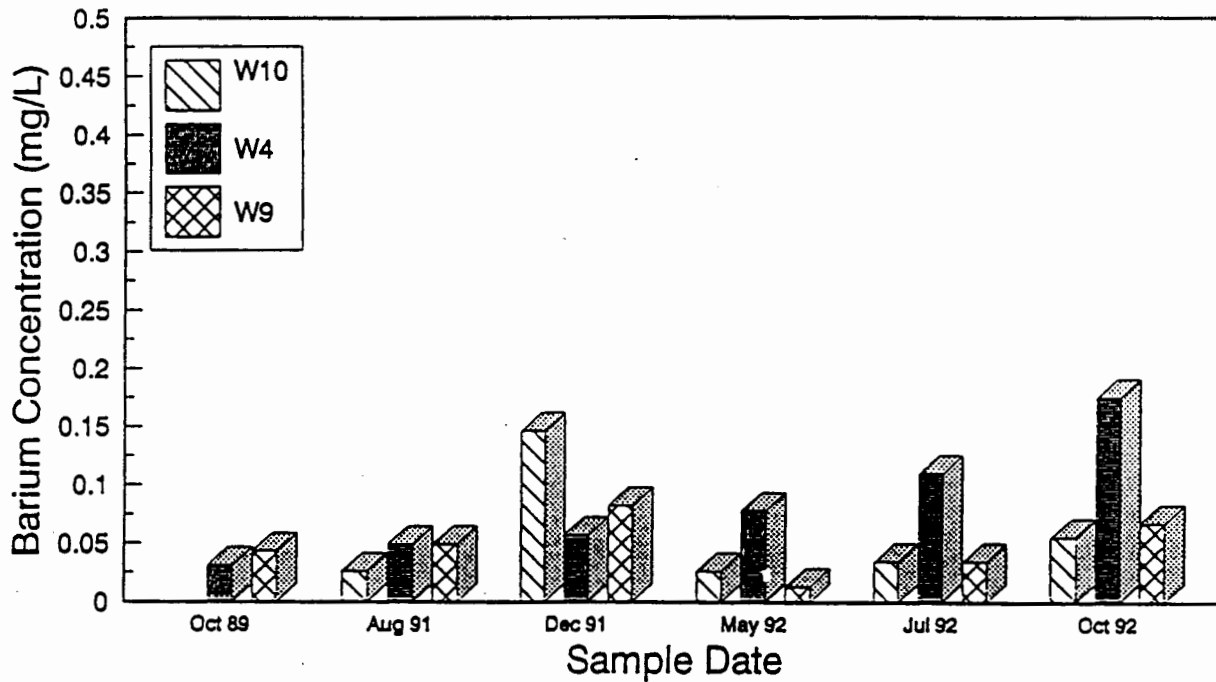


FIGURE 3.5.5 Concentration of total arsenic for Williams Creek mainstem and selected tributary sites between October 1989 and October 1992.

TOTAL BARIUM: WILLIAMS CREEK
Oct. 1989 - Oct. 1992



TOTAL BARIUM: TRIBUTARY SITES
Oct. 1989 - Oct. 1992

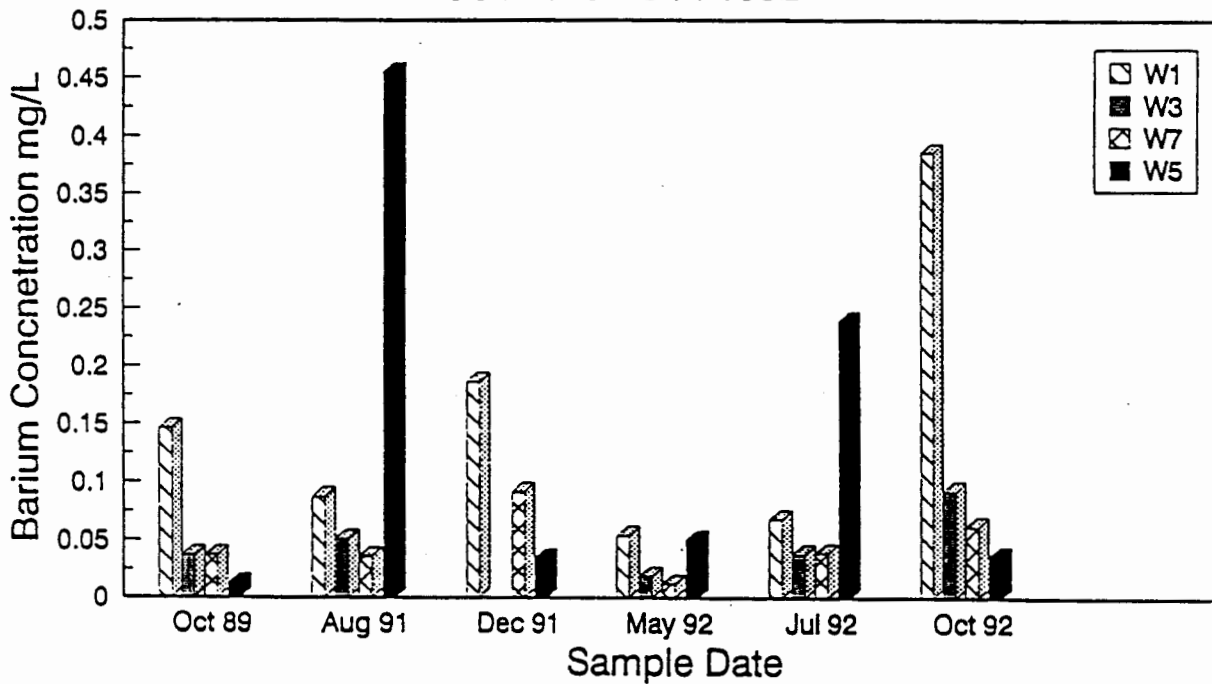
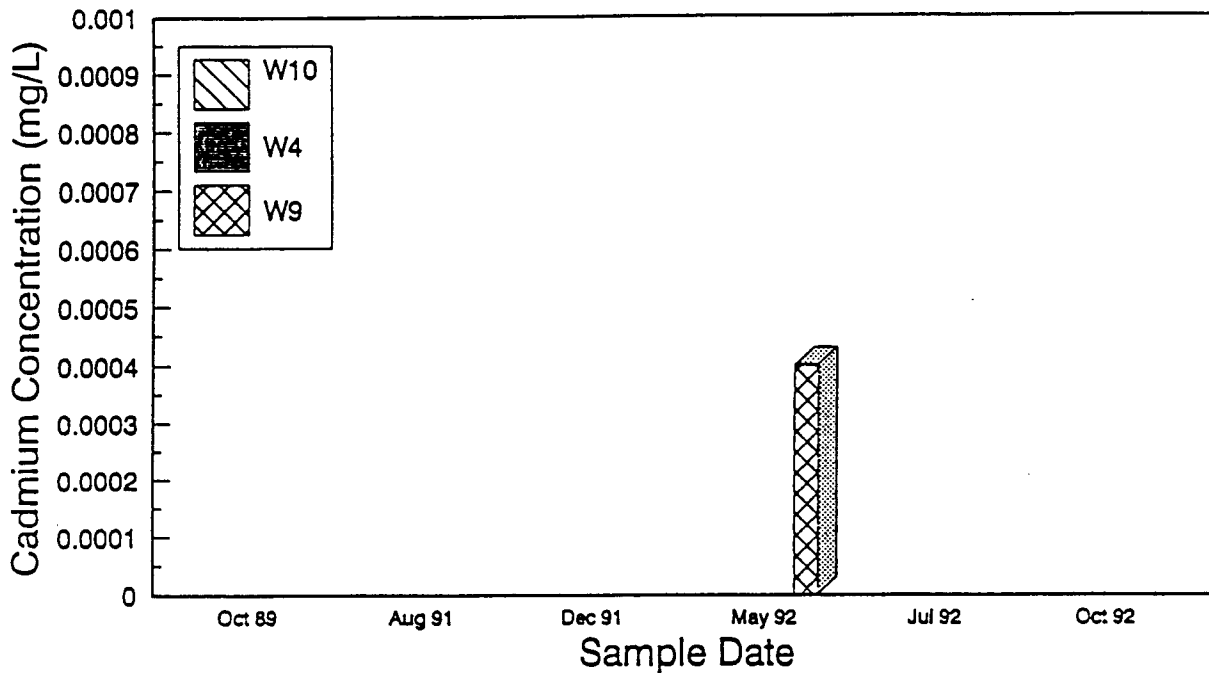


FIGURE 3.5.6 Concentration of total barium for Williams Creek mainstem and selected tributary sites between October 1989 and October 1992.

TOTAL CADMIUM: WILLIAMS CREEK
Oct. 1989 - Oct. 1992



Samples below detection (0.00002 to 0.00003 mg/L) unless indicated

TOTAL CADMIUM: TRIBUTARY SITES
Oct. 1989 - Oct. 1992

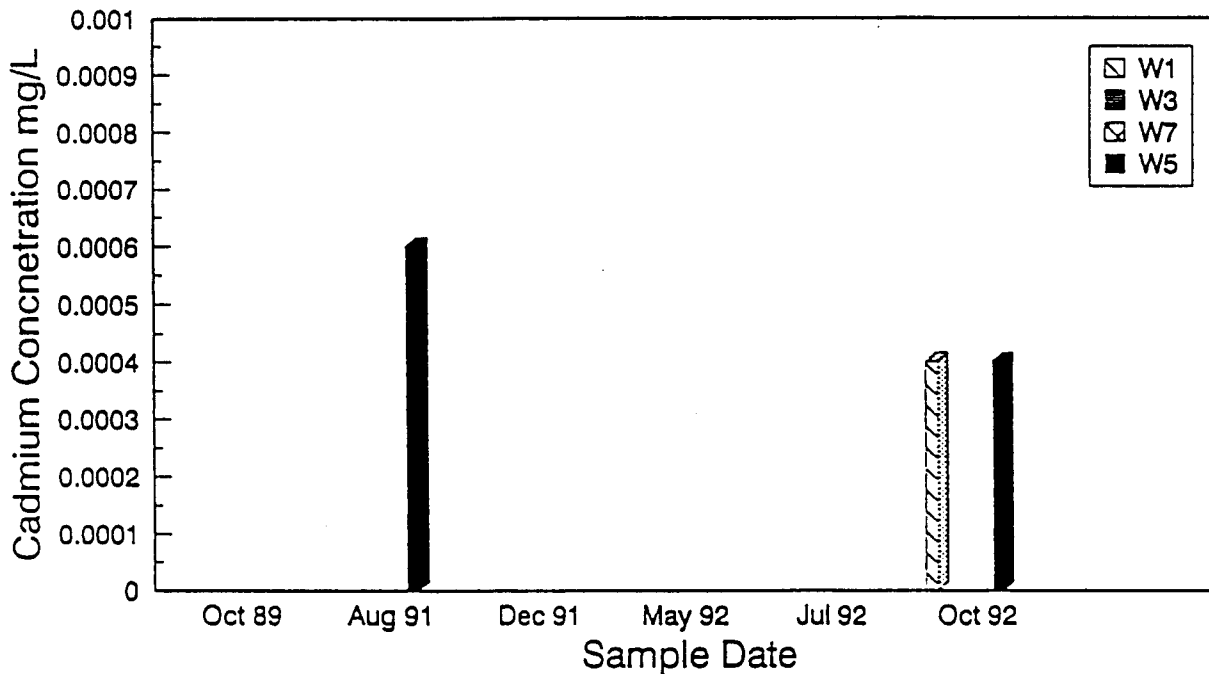
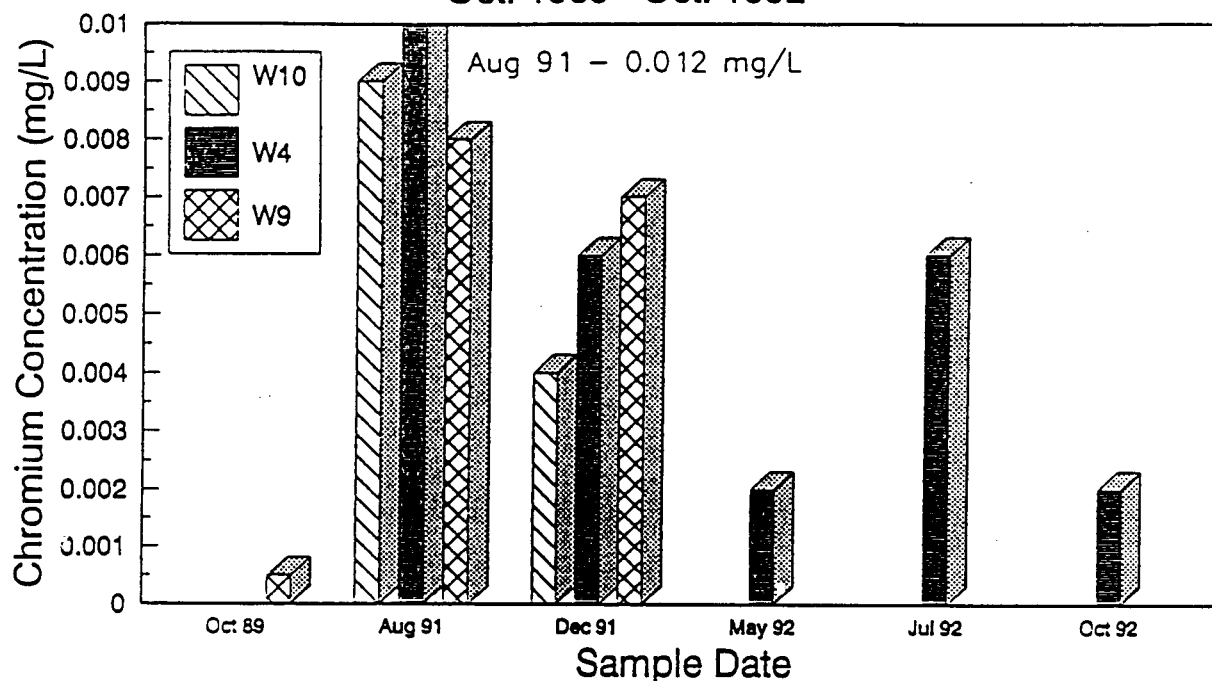


FIGURE 3.5.7 Concentration of total cadmium for Williams Creek mainstem and selected tributary sites between October 1989 and October 1992.

TOTAL CHROMIUM: WILLIAMS CREEK

Oct. 1989 - Oct. 1992



Samples below detection (0.0002 mg/L) unless indicated

TOTAL CHROMIUM: TRIBUTARY SITES

Oct. 1989 - Oct. 1992

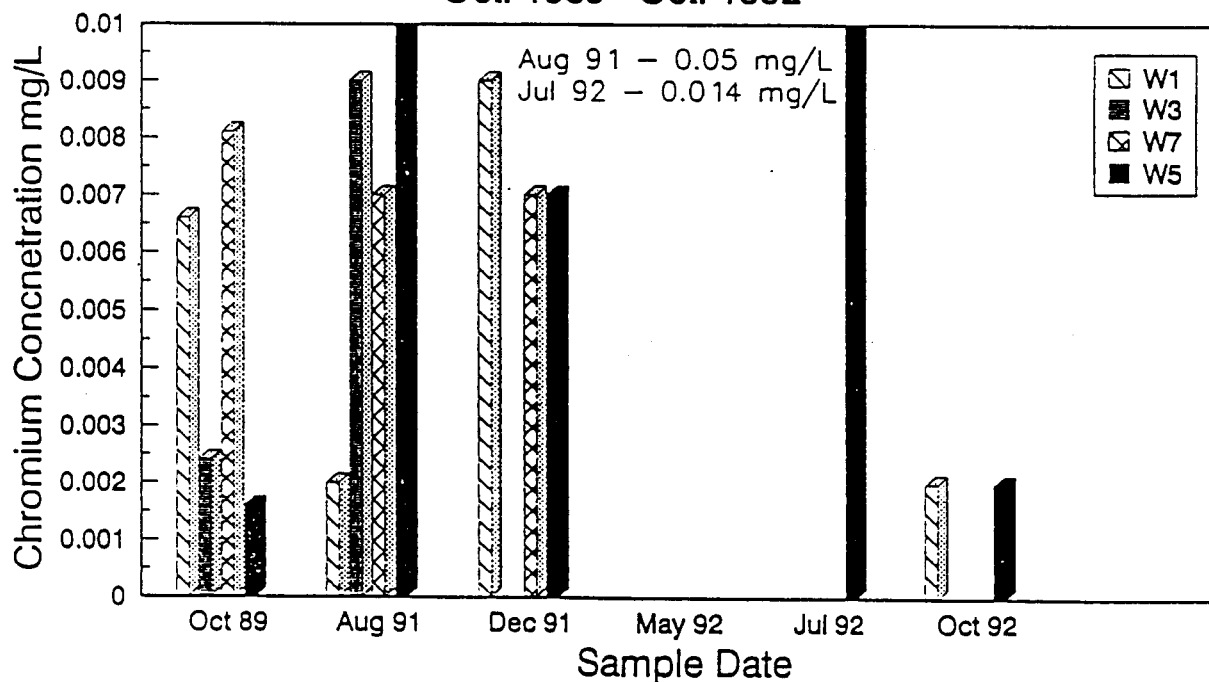
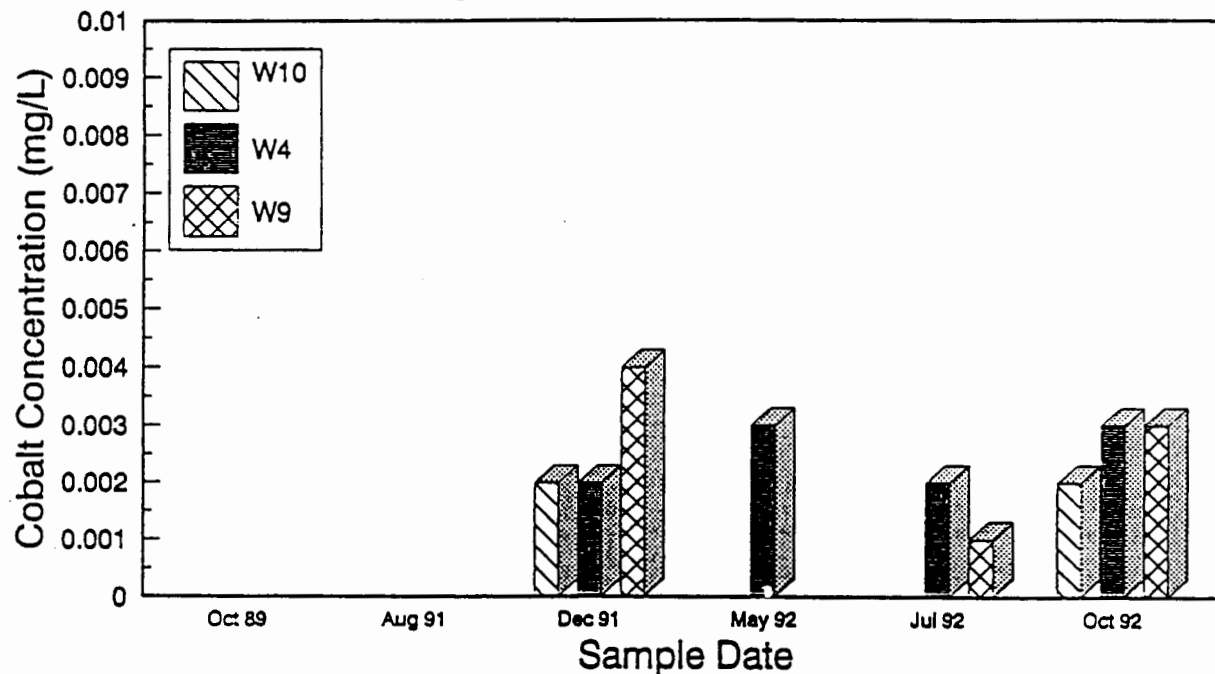


FIGURE 3.5.8 Concentration of total chromium for Williams Creek mainstem and selected tributary sites between October 1989 and October 1992.

TOTAL COBALT: WILLIAMS CREEK Oct. 1989 - Oct. 1992



Samples below detection (0.0005 mg/L) unless indicated

TOTAL COBALT: TRIBUTARY SITES Oct. 1989 - Oct. 1992

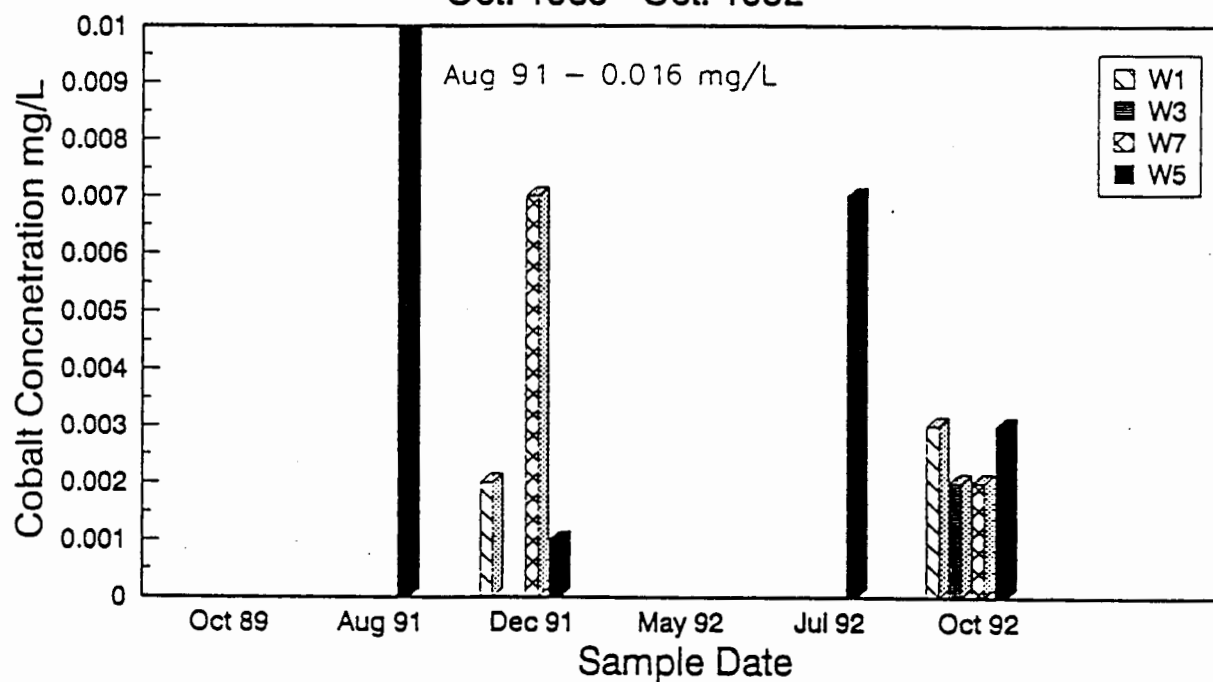
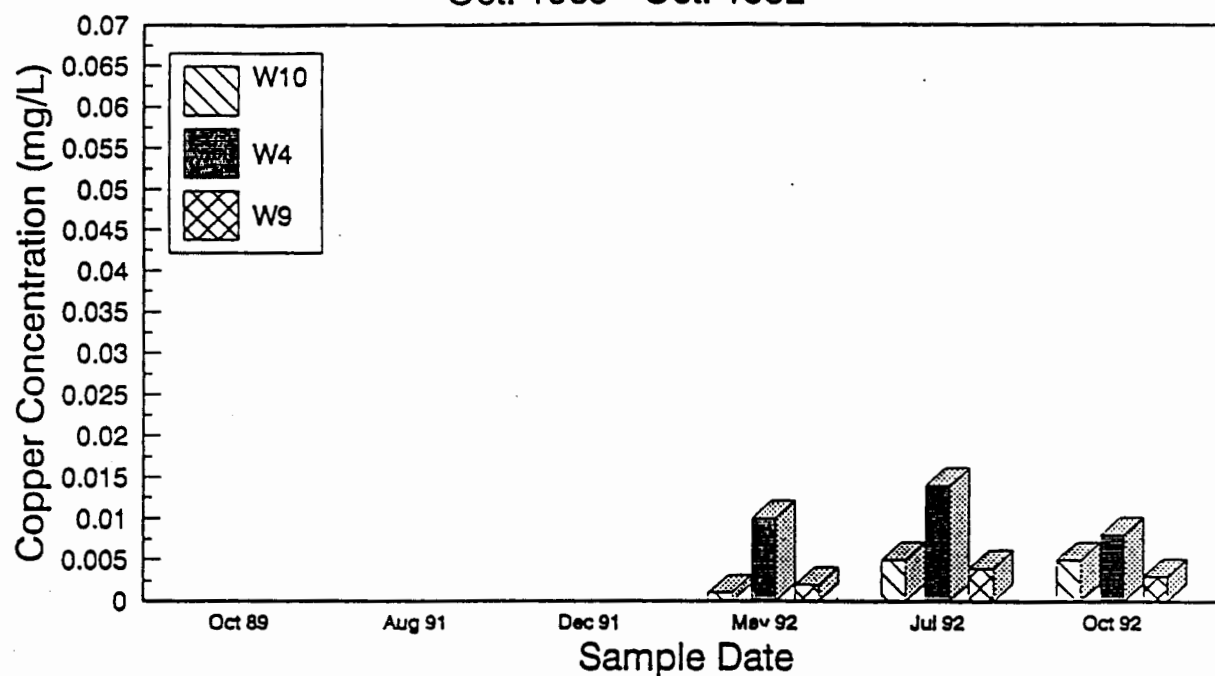


FIGURE 3.5.9 Concentration of total cobalt for Williams Creek mainstem and selected tributary sites between October 1989 and October 1992.

TOTAL COPPER: WILLIAMS CREEK
Oct. 1989 - Oct. 1992



Samples below detection (0.0005 mg/L) unless indicated

TOTAL COPPER: TRIBUTARY SITES
Oct. 1989 - Oct. 1992

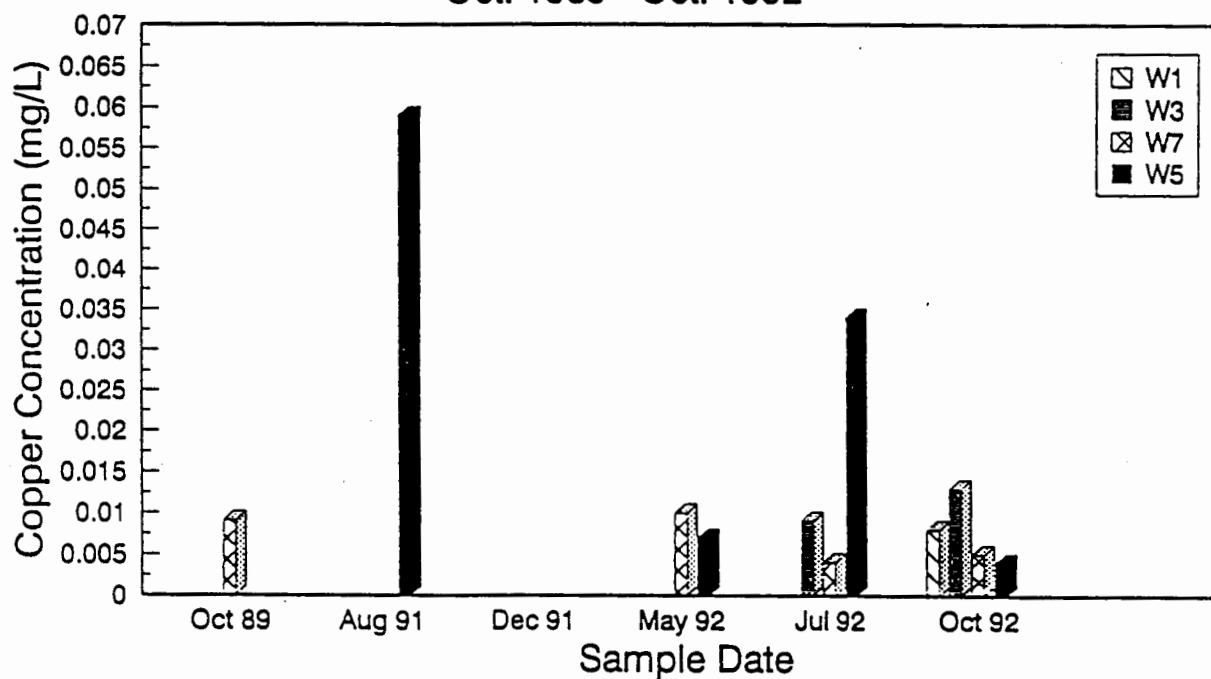
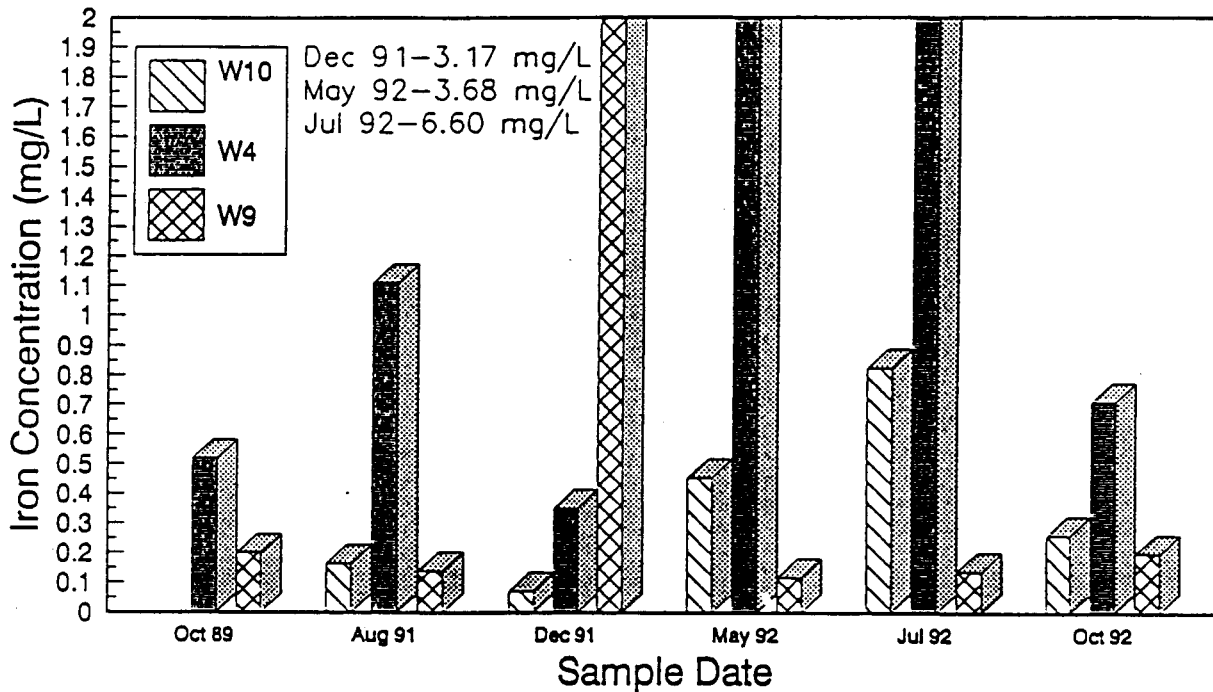


FIGURE 3.5.10 Concentration of total copper for Williams Creek mainstem and selected tributary sites between October 1989 and October 1992.

TOTAL IRON: WILLIAMS CREEK Oct. 1989 - Oct. 1992



TOTAL IRON: TRIBUTARY SITES Oct. 1989 - Oct. 1992

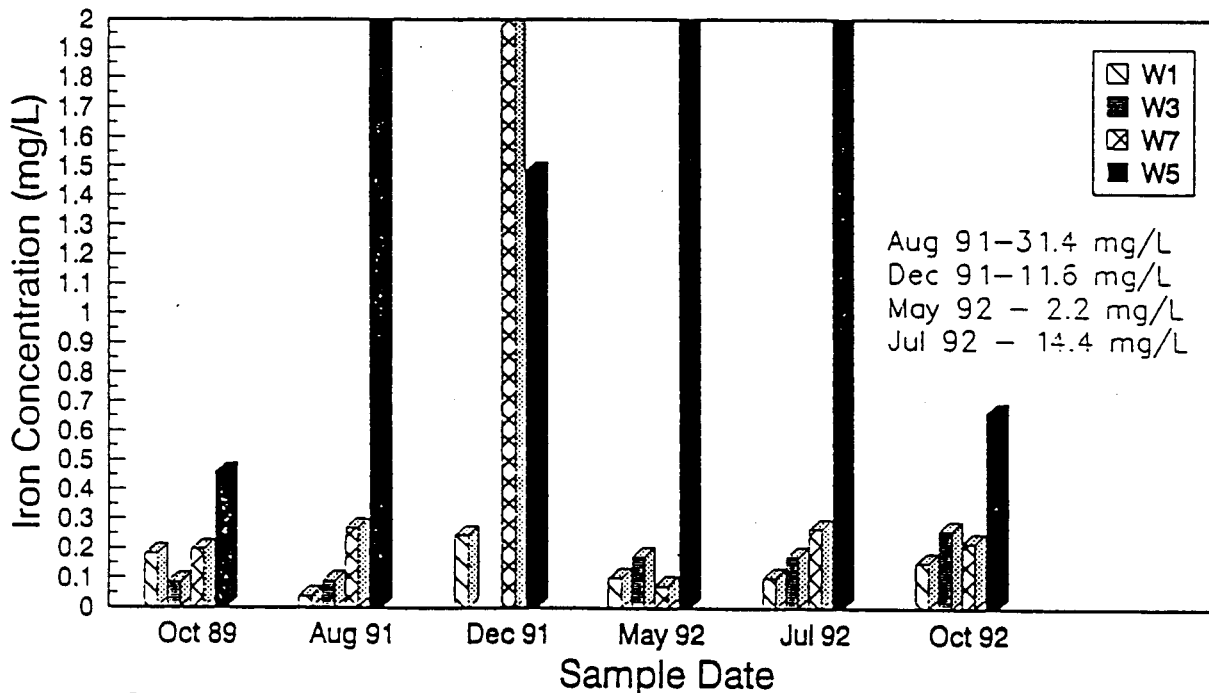
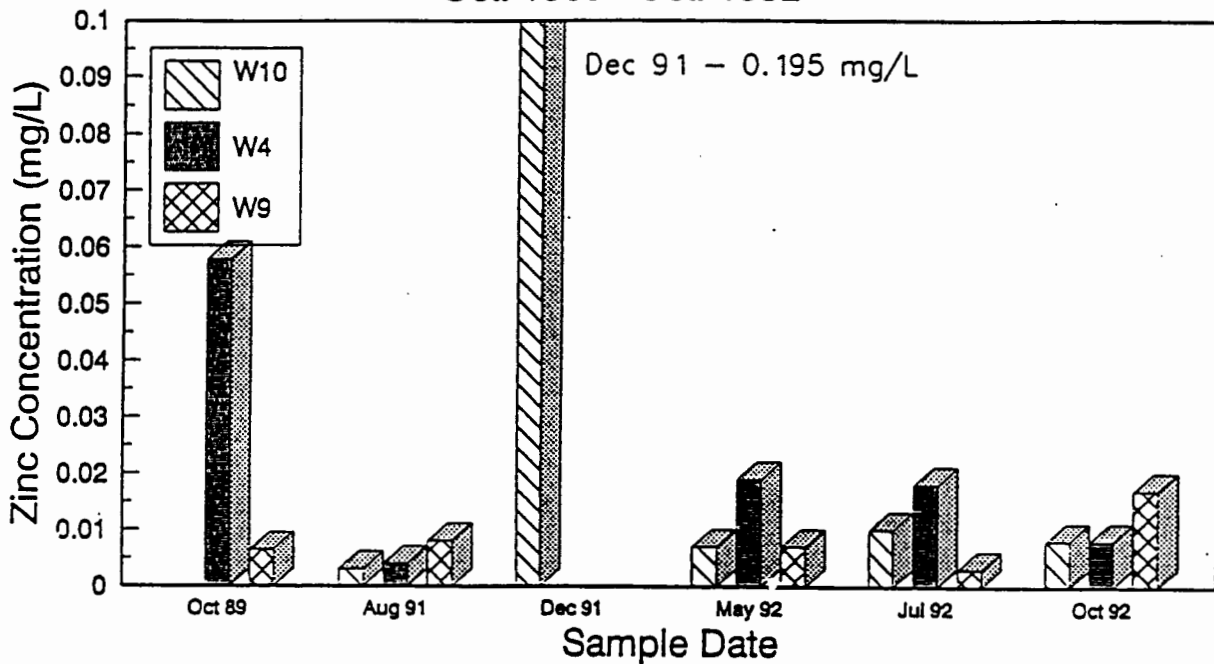


FIGURE 3.5.11 Concentration of total iron for Williams Creek mainstem and selected tributary sites between October 1989 and October 1992.

TOTAL ZINC: WILLIAMS CREEK
Oct. 1989 - Oct. 1992



TOTAL ZINC: TRIBUTARY SITES
Oct. 1989 - Oct. 1992

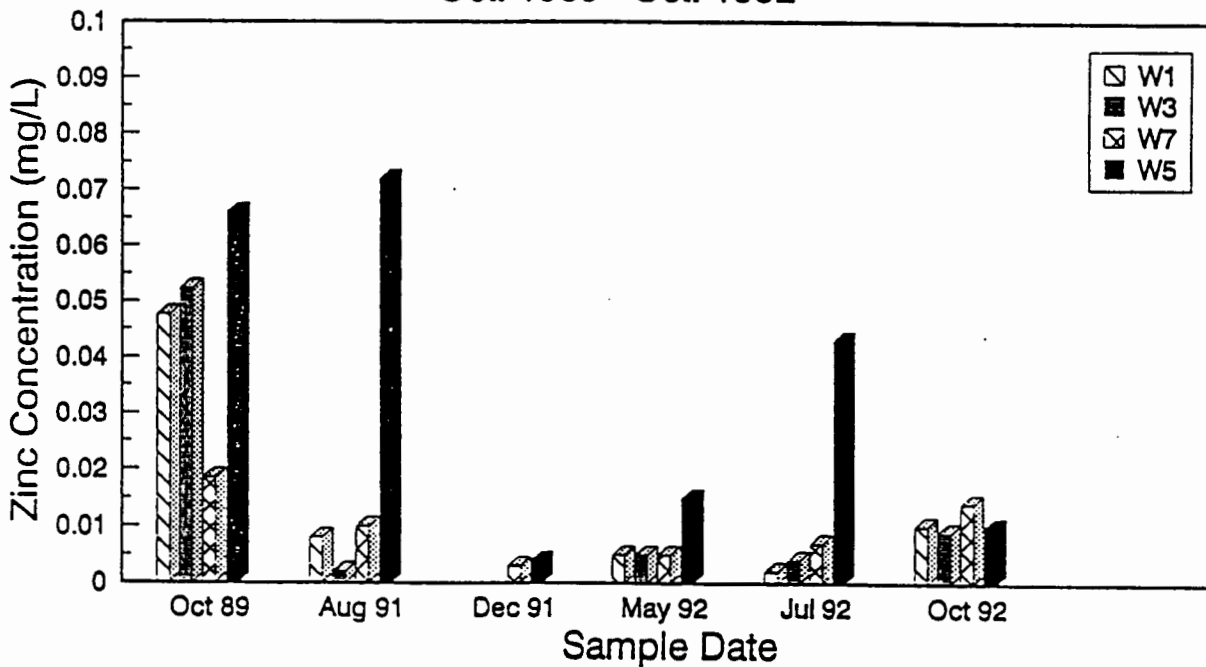


FIGURE 3.5.12 Concentration of total zinc for Williams Creek mainstem and selected tributary sites between October 1989 and October 1992.

Appendix III.B

Surface Water Quality from Stations W-3, W-4, W-5, W-7 and W-9 for
May, 1994

Obtained from the IEE "Addendum to Volume I Biophysical Assessment of
the Carmacks Copper Mine Site" (November, 1994)

Tel: (604) 438-5211
Fax: (604) 436-0561



Quanta Trace Laboratories Inc.

#401-3700 Gilmore Way
Burnaby, B.C. V5G 4M1

Tel: (604) 438-522

Fax: (604) 436-056

To: NORTHERN AFFAIRS PROGRAM

W/O: 23281 Page

Sample type	fresh	fresh	fresh	fresh	fresh
Identification	4069 W3	4069 W3	4070, W4	4070, W4	4071, W5
	13-May-94	13-May-94	13-May-94	13-May-94	13-May-94
Lab Reference #	23281-001	23281-001	23281-002	23281-002	23281-003
PHYSICAL TESTS - ALKALINITY					
Hydroxide CaCO3	< 5.	-	< 5.	-	< 5.
Carbonate CaCO3	< 5.	-	< 5.	-	< 5.
Bicarb. CaCO3	112.	-	79.	-	50.
Total Alk. CaCO3	112.	-	79.	-	50.
Results in	mg/L		mg/L		mg/L
PHYSICAL TESTS					
Conduct. uS/cm	240.	-	207.	-	135.
pH	7.7	-	7.8	-	7.8
Turbidity FTU	1.	-	2.	-	2.
SOLIDS					
Suspended 105C	< 5.	-	< 5.	-	6.
Dissolved 105C	188.	-	179.	-	129.
Results in	mg/L		mg/L		mg/L
ANIONS BY IEC					
Chloride Cl	0.83	-	0.78	-	0.59
Fluoride F	< 1.	-	< 1.	-	< 1.
Nitrate NO3-N	< 0.05	-	< 0.05	-	< 0.05
Nitrite NO2-N	< 0.5	-	< 0.5	-	< 0.5
Sulfate SO4	14	-	18.6	-	11.6
Results in	mg/L		mg/L		mg/L
NITROGEN					
Ammonia NH3-N	< 0.05	-	0.07	-	< 0.05
Results in	mg/L		mg/L		mg/L
PHOSPHOROUS					
Total PO4-P	0.008	-	0.040	-	0.009
Results in	mg/L		mg/L		mg/L
TOTAL HARDNESS					
T Hardness CaCO3	110.	105.	88.2	83.1	52.4

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To: NORTHERN AFFAIRS PROGRAM

W/O: 23281 Page 1

Sample type		fresh		fresh		fresh		fresh		fresh
Identification		4069 W3		4069 W3		4070, W4		4070, W4		4071, W5
		13-May-94		13-May-94		13-May-94		13-May-94		13-May-94
Lab Reference #		23281-001		23281-001		23281-002		23281-002		23281-003
ICP - ULTRASONIC NEBULIZATION										
Method used		filt. 0.45µ wave HNO3			filt. 0.45µ wave HNO3			filt. 0.45µ		
		DISSOLVED		TOTAL		DISSOLVED		TOTAL		DISSOLVED
Aluminum	Al	< 0.01		0.04		< 0.01		0.03		0.01
Antimony	Sb	< 0.02		0.02		< 0.02		0.02		0.02
Arsenic	As	< 0.02		0.02		< 0.02		0.02		0.02
Barium	Ba	0.039		0.040		0.030		0.030		0.023
Beryllium	Be	< 0.0002		0.0002		< 0.0002		0.0002		0.0002
Bismuth	Bi	< 0.02		0.02		< 0.02		0.02		0.02
Cadmium	Cd	< 0.0005		0.0005		< 0.0005		0.0005		0.0005
Calcium	Ca	33.9		33.9		24.5		25.0		15.1
Chromium	Cr	< 0.001		0.001		< 0.001		0.001		0.001
Cobalt	Co	< 0.001		0.001		< 0.001		0.001		0.001
Copper	Cu	0.023		0.028		0.021		0.016		0.009
Iron	Fe	0.160		0.380		0.245		0.390		0.076
Lead	Pb	< 0.01		0.01		< 0.01		0.01		0.01
Lithium	Li	< 0.002		0.002		< 0.002		0.002		0.002
Magnesium	Mg	5.96		6.00		6.43		6.50		3.51
Manganese	Mn	0.097		0.124		0.068		0.069		0.007
Molybdenum	Mo	< 0.005		0.005		< 0.005		0.005		0.005
Nickel	Ni	0.005		0.005		0.004		0.003		0.004
Phosphorus	P	< 0.05		0.05		< 0.05		0.05		0.05
Potassium	K	1.4		1.4		1.2		1.		1.1
Selenium	Se	< 0.02		0.02		< 0.02		0.02		0.02
Silicon	Si	6.17		6.23		5.09		5.10		4.97
Silver	Ag	< 0.001		0.001		< 0.001		0.001		0.001
Sodium	Na	5.37		5.41		6.55		6.58		5.22
Strontium	Sr	0.248		0.235		0.229		0.218		0.085
Sulfur	S	3.93		3.92		5.39		5.40		3.08
Tin	Sn	< 0.01		0.01		< 0.01		0.01		0.01
Titanium	Ti	0.002		0.005		0.002		0.004		0.002
Thorium	Th	< 0.01		0.01		< 0.01		0.01		0.01
Uranium	U	< 0.06		0.06		< 0.06		0.06		0.06
Vanadium	V	< 0.002		0.002		< 0.002		0.002		0.002
Zinc	Zn	< 0.005		0.005		< 0.005		0.005		0.008
Zirconium	Zr	< 0.001		0.001		< 0.001		0.001		0.001
Results in		mg/L		mg/L		mg/L		mg/L		mg/L

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To: NORTHERN AFFAIRS PROGRAM

W/O: 23281 Page 1

Sample type	fresh	fresh	fresh	fresh	fresh
Identification	4071, W3	4072, W7	4072, W7	4072, W7	4072, W7
	13-May-94	13-May-94	13-May-94	13-May-94	13-May-94
Lab Reference #	23281-003	23281-004A	23281-004A	23281-004B	23281-004B

PHYSICAL TESTS - ALKALINITY

Hydroxide CaCO3	-	< 5.	-	< 5.	-
Carbonate CaCO3	-	< 5.	-	< 5.	-
Bicarb. CaCO3	-	73.	-	74.	-
Total Alk. CaCO3	-	73.	-	74.	-
Results in		mg/L		mg/L	

PHYSICAL TESTS

Conduct. uS/cm	-	145.	-	143.	-
pH	-	7.7	-	7.7	-
Turbidity FTU	-	1.	-	1.	-

SOLIDS

Suspended 105C	-	< 5.	-	< 5.	-
Dissolved 105C	-	145.	-	147.	-
Results in		mg/L		mg/L	

ANIONS BY IEC

Chloride Cl	-	< 0.3	-	< 0.3	-
Fluoride F	-	< 1.	-	< 1.	-
Nitrate NO3-N	-	< 0.05	-	< 0.05	-
Nitrite NO2-N	-	< 0.5	-	< 0.5	-
Sulfate SO4	-	4.6	-	4.6	-
Results in		mg/L		mg/L	

NITROGEN

Ammonia NH3-N	-	< 0.05	-	< 0.05	-
Results in		mg/L		mg/L	

PHOSPHOROUS

Total PO4-P	-	< 0.005	-	< 0.005	-
Results in		mg/L		mg/L	

TOTAL HARDNESS

T Hardness CaCO3	53.3	61.5	62.9	61.7	63.5

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W/O: 23281 Page 1

Sample type		fresh		fresh		fresh		liquid		liquid
Identification		4071, W5		4072, W7		4072, W7		4072, W7		4072, W7
		13-May-94		13-May-94		13-May-94		13-May-94		13-May-94
Lab Reference #		23281-003		23281-004A		23281-004A		23281-004B		23281-004B
CF - ULTRASONIC NEBULIZATION										
Method used		lowwave HNO3		filt. 0.45u		lowwave HNO3		filt. 0.45u		lowwave HNO3
		TOTAL		DISSOLVED		TOTAL		DISSOLVED		TOTAL
Aluminum	Al	0.25	<	0.01	<	0.01	<	0.01	<	0.01
Antimony	Sb	0.02	<	0.02	<	0.02	<	0.02	<	0.02
Arsenic	As	0.02	<	0.02	<	0.02	<	0.02	<	0.02
Barium	Ba	0.024		0.027		0.024		0.025		0.024
Beryllium	Be	0.0002	<	0.0002	<	0.0002	<	0.0002	<	0.0002
Bismuth	Bi	0.02	<	0.02	<	0.02	<	0.02	<	0.02
Cadmium	Cd	0.0005	<	0.0005	<	0.0005	<	0.0005	<	0.0005
Calcium	Ca	15.2		18.8		19.2		18.9		19.4
Chromium	Cr	0.001	<	0.001	<	0.001	<	0.001	<	0.001
Cobalt	Co	0.001	<	0.001	<	0.001	<	0.001	<	0.001
Copper	Cu	0.023		0.01		0.014		0.021		0.014
Iron	Fe	0.447		0.166		0.172		0.175		0.175
Lead	Pb	0.01	<	0.01	<	0.01	<	0.01	<	0.01
Lithium	Li	0.002	<	0.002	<	0.002	<	0.002	<	0.002
Magnesium	Mg	3.55		3.41		3.54		3.44		3.57
Manganese	Mn	0.014		0.012		0.013		0.011		0.013
Molybdenum	Mo	0.005	<	0.005	<	0.005	<	0.005	<	0.005
Nickel	Ni	0.002		0.004		0.003		0.005		0.001
Phosphorus	P	0.05	<	0.05	<	0.05	<	0.03	<	0.03
Potassium	K	1.2		1.		1.0		1.		1.2
Selenium	Se	0.02	<	0.02	<	0.02	<	0.02	<	0.02
Silicon	Si	5.26		5.25		5.42		5.27		5.46
Silver	Ag	0.001	<	0.001	<	0.001	<	0.001	<	0.001
Sodium	Na	5.25		3.48		3.48		3.54		3.60
Strontium	Sr	0.086		0.082		0.086		0.084		0.088
Sulfur	S	2.99		1.32		1.31		1.35		1.38
Tin	Sn	0.01	<	0.01	<	0.01	<	0.01	<	0.01
Titanium	Ti	0.016		0.002		0.002		0.002		0.002
Thorium	Th	0.01	<	0.01	<	0.01	<	0.01	<	0.01
Uranium	U	0.06	<	0.06	<	0.06	<	0.06	<	0.06
Vanadium	V	0.002	<	0.002	<	0.002	<	0.002		0.002
Zinc	Zn	0.005	<	0.005	<	0.005	<	0.005	<	0.005
Zirconium	Zr	0.001	<	0.001	<	0.001	<	0.001	<	0.001
Results in		mg/L		mg/L		mg/L		mg/L		mg/L

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To: NORTHERN AFFAIRS PROGRAM

W/O: 23281 Page

Sample type		fresh		fresh	
Identification		4073, W9		4073, W9	
		13-May-94		13-May-94	
Lab Reference #		23281-005		23281-005	
ICP - ULTRASONIC NEBULIZATION					
Method used		filt. 0.45µm wave HNO3			
		DISSOLVED		TOTAL	
Aluminum	Al	<	0.01	<	0.01
Antimony	Sb	<	0.02	<	0.02
Arsenic	As	<	0.02	<	0.02
Barium	Ba		0.027		0.028
Beryllium	Be	<	0.0002	<	0.0002
Bismuth	Bi	<	0.02	<	0.02
Cadmium	Cd	<	0.0005	<	0.0005
Calcium	Ca		20.1		20.9
Chromium	Cr	<	0.001	<	0.001
Cobalt	Co	<	0.001	<	0.001
Copper	Cu		0.022		0.027
Iron	Fe		0.098		0.137
Lead	Pb	<	0.01	<	0.01
Lithium	Li	<	0.002	<	0.002
Magnesium	Mg		6.30		6.60
Manganese	Mn		0.021		0.023
Molybdenum	Mo	<	0.005	<	0.005
Nickel	Ni		0.002		0.002
Phosphorus	P	<	0.05	<	0.05
Potassium	K		1.1		1.1
Selenium	Se	<	0.02	<	0.02
Silicon	Si		4.60		4.80
Silver	Ag	<	0.001	<	0.001
Sodium	Na		6.72		6.72
Strontium	Sr		0.222		0.238
Sulfur	S		3.60		3.71
Tin	Sn	<	0.01	<	0.01
Titanium	Ti		0.002		0.003
Thorium	Th	<	0.01	<	0.01
Uranium	U	<	0.06	<	0.06
Vanadium	V	<	0.002		0.002
Zinc	Zn	<	0.005	<	0.005
Zirconium	Zr	<	0.001	<	0.001
Results in		mg/L		mg/L	

est results are for internal use only. Quanta Trace liability is limited to the testing fee paid.

Analyst



Quanta Trace Laboratories Inc.
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To: NORTHERN AFFAIRS PROGRAM

W/O: 23281 Page

Sample type	fresh	fresh
Identification	4073, W9	4073, W9
	13-May-94	13-May-94
Lab Reference #	23281-005	23281-005

PHYSICAL TESTS - ALKALINITY

Hydroxide	CaCO3	< 5.	-
Carbonate	CaCO3	< 5.	-
Bicarb.	CaCO3	102.	-
Total Alk.	CaCO3	102.	-
Results in		mg/L	

PHYSICAL TESTS

Conduct.	uS/cm	200.	-
pH		7.8	-
Turbidity	FTU	1.	-

SOLIDS

Suspended	105C	< 5.	-
Dissolved	105C	160.	-
Results in		mg/L	

ANIONS BY IEC

Chloride	Cl	0.5	-
Fluoride	F	< 1.	-
Nitrate	NO3-N	< 0.05	-
Nitrite	NO2-N	< 0.5	-
Sulfate	SO4	14.4	-
Results in		mg/L	

NITROGEN

Ammonia	NH3-N	< 0.05	-
Results in		mg/L	

PHOSPHOROUS

Total	PO4-P	< 0.005	-
Results in		mg/L	

TOTAL HARDNESS

T Hardness	CaCO3	76.5	79.8

Appendix III.C

1995 Groundwater Quality for Well RC-92-01 and WW95-01

Obtained from the "Technical Issues Response Document" (June, 1997)

Western Copper Holdings Ltd.
Carmacks Copper Project

Groundwater Quality (RC-92-01) - Preliminary Data

Parameter		March 1995 RC-92-01		April 1995 RC-92-01		August 1995 RC-92-01	
Physical tests							
Hydroxide	CaCO ₃	<5.		<5.		<5	
Carbonate	CaCO ₃	<5.		<5.		<5	
Bicarbonate	CaCO ₃	113		114		98	
Total Alk.	CaCO ₃	113		114		98	
pH		7.8		7.8		7.7	
Solids							
Suspended	105C	80		47		287	
Dissolved	105C	384		403		398	
ANIONS BY IEC							
Chloride	Cl	2.4		2.5		2.4	
Fluoride	F	<2.		<3.		<2	
Nitrate	NO ₃ -N	0.6		0.7		0.6	
Nitrite	NO ₂ -N	<2.		<1.		<2	
Sulfate	SO ₄	168		187		162	
Total Cyanide	CN _{TOT}	<0.005		<0.005		<0.005	
Metals		Dissolved	Total	Dissolved	Total	Dissolved	Total
Aluminium	Al	0.04	3.4	<0.01	1.44	0.03	6.4
Antimony	Sb	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Arsenic	As	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Barium	Ba	0.190	0.240	0.169	0.194	0.162	0.230
Beryllium	Be	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Bismuth	Bi	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cadmium	Cd	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Calcium	Ca	74.6	76.2	71.0	72.4	76.4	78.4
Chromium	Cr	0.002	0.005	<0.001	0.003	<0.001	0.008
Cobalt	Co	<0.001	0.002	<0.001	<0.001	<0.001	0.002
Copper	Cu	0.031	0.157	0.007	0.038	0.013	0.079
Iron	Fe	1.07	4.09	0.009	1.71	0.006	6.82
Lead	Pb	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lithium	Li	<0.002	<0.002	<0.002	<0.002	0.003	0.003
Magnesium	Mg	19.0	19.4	17.0	17.6	16.7	18.2
Manganese	Mn	0.037	0.215	0.082	0.146	0.059	0.242
Mercury CVUV	Hg	-	<0.001	-	<0.001	-	<0.0002
Molybdenum	Mo	0.053	0.059	0.060	0.061	0.064	0.061
Nickel	Ni	0.003	0.004	<0.001	<0.001	0.002	0.007
Phosphorus	P	<0.06	0.13	<0.06	<0.06	<0.06	0.27
Potassium	K	2.4	2.2	1.7	1.8	2.1	2.5
Selenium	Se	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Silicon	Si	6.83	14.0	6.18	9.27	6.16	18.2
Silver	Ag	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sodium	Na	10.4	10.5	12.7	13.3	10.0	9.97
Strontium	Sr	0.79	0.79	0.74	0.75	0.75	0.75
Sulfur	S	51.0	54.2	51.1	51.6	49.8	50.6
Thorium	Th	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Tin	Sn	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Titanium	Ti	0.003	0.128	<0.001	0.044	<0.001	0.312
Uranium	U	<0.07	<0.07	<0.07	0.07	<0.07	<0.07
Vanadium	V	0.004	0.011	0.003	0.007	0.003	0.016
Zinc	Zn	0.010	0.016	0.006	0.009	0.010	0.034
Zirconium	Zr	<0.001	0.002	<0.001	0.003	<0.001	<0.001

Western Copper Holdings Ltd.
Carmacks Copper Project

Groundwater Quality (WW95-01) - Preliminary Data

Parameter		September 1995			
		WW95-01		WW95-01	
		#1		#2	
Physical Tests					
Hydroxide	CaCO ₃	<5		<5	
Carbonate	CaCO ₃	<5		<5	
Bicarbonate	CaCO ₃	114		117	
Total Alk.	CaCO ₃	114		117	
pH		7.8		7.8	
Solids					
Suspended	105C	<5		<5	
Dissolved	105C	433		402	
Anions IEC					
Chloride	Cl	6		2.9	
Fluoride	F	<2		<2	
Nitrate	NO ₃ -N	0.9		0.6	
Nitrite	NO ₂ -N	2		2	
Sulfate	SO ₄	183		189	
Total Cyanide	CN _{TOT}	<0.005		<0.005	
Metals		Dissolved		Dissolved	
		Total		Total	
Aluminium	Al	0.02	0.03	0.03	0.03
Antimony	Sb	<0.02	<0.02	<0.02	<0.02
Arsenic	As	<0.02	<0.02	<0.02	<0.02
Barium	Ba	0.0330	0.0337	0.0322	0.0325
Beryllium	Be	<0.0002	<0.0002	<0.0002	<0.0002
Bismuth	Bi	<0.02	<0.02	<0.02	<0.02
Cadmium	Cd	<0.0005	<0.0005	<0.0005	<0.0005
Calcium	Ca	84.5	84.8	84.2	84.4
Chromium	Cr	<0.001	<0.001	<0.001	<0.001
Cobalt	Co	<0.001	<0.001	<0.001	<0.001
Copper	Cu	<0.002	<0.002	0.012	<0.002
Iron	Fe	0.089	0.245	0.135	0.136
Lead	Pb	<0.005	<0.005	<0.005	<0.005
Lithium	Li	<0.002	<0.002	<0.002	<0.002
Magnesium	Mg	18.5	17.7	18.8	17.2
Manganese	Mn	0.0015	0.0030	0.0017	0.0019
Mercury CVUV	Hg	-	<0.001	-	<0.001
Molybdenum	Mo	0.048	0.046	0.055	0.059
Nickel	Ni	<0.002	<0.002	<0.002	<0.002
Phosphorus	P	0.29	0.27	0.28	0.28
Potassium	K	1.1	1.2	1.3	1.2
Selenium	Se	<0.02	<0.02	<0.02	<0.02
Silicon	Si	6.57	6.83	6.74	6.76
Silver	Ag	<0.001	<0.001	<0.001	<0.001
Sodium	Na	13.2	13.8	11.2	11.4
Strontium	Sr	1.46	1.47	1.44	1.44
Sulfur	S	80.7	81.3	59.2	60.4
Thorium	Th	<0.005	<0.005	<0.005	<0.005
Tin	Sn	<0.005	<0.005	<0.005	<0.005
Titanium	Ti	<0.001	<0.001	<0.001	<0.001
Uranium	U	<0.06	<0.06	<0.06	<0.06
Vanadium	V	0.005	0.005	0.005	0.005
Zinc	Zn	0.009	0.011	0.008	0.008
Zirconium	Zr	<0.001	<0.001	<0.001	<0.001

Appendix III.D

Water Quality Data (Surface and Groundwater) from September, 1997
Field Trip

Western Copper Holdings Limited
Carmacks Copper Project

Table 1 1997 Surface Water Quality Data

Parameter	Station / Sample Date		
	VW3	VW4	VW9
	28-Sep-97	28-Sep-97	28-Sep-97
In-Situ Parameters			
pH	7.4	7.8	7.6
Conductivity, umho/cm	200	160	160
Physical Tests			
pH	7.35	7.71	7.63
Total Dissolved Solids, mg/L	216	178	195
Total Suspended Solids, mg/L	2	3	72
Anions			
Alkalinity-Total (CaCO ₃), mg/L	156	111	127
Alkalinity-Bicarbonate (CaCO ₃), mg/L	156	111	127
Alkalinity-Carbonate (CaCO ₃), mg/L	<1	<1	<1
Alkalinity-Hydroxide (CaCO ₃), mg/L	<1	<1	<1
Chloride, mg/L	1.4	1.3	1.4
Fluoride, mg/L	0.18	0.2	0.23
Sulphate, mg/L	20	24	21
Total Hardness (CaCO ₃), mg/L	156	129	135
Nutrients			
Nitrate Nitrogen, mg/L	0.017	<0.005	0.007
Nitrite Nitrogen, mg/L	0.001	0.001	0.002
Total Metals			
Aluminum (total), mg/L	0.197	0.033	0.569
Antimony (total), mg/L	0.00006	0.00006	0.00007
Arsenic (total), mg/L	0.0007	0.0006	0.0011
Barium (total), mg/L	0.0429	0.0354	0.0556
Beryllium (total), mg/L	<0.0005	<0.0005	<0.0005
Bismuth (total), mg/L	<0.0005	<0.0005	<0.0005
Boron (total), mg/L	0.003	0.004	0.006
Cadmium (total), mg/L	<0.00005	<0.00005	<0.00005
Calcium (total), mg/L	51.6	35.9	34.3
Chromium (total), mg/L	<0.0005	<0.0005	0.0009
Cobalt (total), mg/L	0.0002	0.0002	0.0005
Copper (total), mg/L	0.0017	0.0011	0.0025
Iron (total), mg/L	0.6	0.48	0.91
Lead (total), mg/L	0.00015	<0.00005	0.00049
Lithium (total), mg/L	<0.001	<0.001	0.001
Magnesium (total), mg/L	9.27	9.5	11.1
Manganese (total), mg/L	0.293	0.0477	0.0713
Mercury (total), mg/L	<0.00005	<0.00005	<0.00005
Molybdenum (total), mg/L	0.00087	0.00242	0.00049
Nickel (total), mg/L	0.0014	0.001	0.0018
Phosphorus (total), mg/L	<0.3	<0.3	<0.3
Potassium (total), mg/L	<2	<2	<2
Selenium (total), mg/L	<0.001	<0.001	<0.001
Silicon (total), mg/L	8.16	8.54	8.94
Silver (total), mg/L	<0.00001	<0.00001	0.00001
Sodium (total), mg/L	8	9	11
Strontium (total), mg/L	0.383	0.273	0.294
Thallium (total), mg/L	<0.00005	<0.00005	<0.00005
Tin (total), mg/L	<0.0001	<0.0001	<0.0001
Titanium (total), mg/L	<0.01	<0.01	<0.01
Uranium (total), mg/L	0.00028	0.00031	0.00061
Vanadium (total), mg/L	0.001	<0.001	0.003
Zinc (total), mg/L	0.002	0.003	0.005
Dissolved Metals			
Aluminum (dissolved), mg/L	0.011	0.021	0.018
Antimony (dissolved), mg/L	0.0001	0.00008	0.00008
Arsenic (dissolved), mg/L	0.0005	0.0006	0.0006
Barium (dissolved), mg/L	0.0377	0.0343	0.0406
Beryllium (dissolved), mg/L	<0.0005	<0.0005	<0.0005
Bismuth (dissolved), mg/L	<0.0005	<0.0005	<0.0005
Boron (dissolved), mg/L	0.002	0.004	0.006
Cadmium (dissolved), mg/L	<0.00005	<0.00005	<0.00005
Calcium (dissolved), mg/L	49.2	35.9	35.1
Chromium (dissolved), mg/L	<0.0005	<0.0005	<0.0005
Cobalt (dissolved), mg/L	0.0001	0.0003	0.0001
Copper (dissolved), mg/L	0.0015	0.0011	0.0009
Iron (dissolved), mg/L	0.07	0.34	0.23
Lead (dissolved), mg/L	<0.00005	<0.00005	<0.00005
Lithium (dissolved), mg/L	<0.001	<0.001	<0.001
Magnesium (dissolved), mg/L	8.67	9.63	11.5
Manganese (dissolved), mg/L	0.305	0.0351	0.058
Molybdenum (dissolved), mg/L	0.00107	0.00239	0.0005
Nickel (dissolved), mg/L	0.0012	0.0011	0.0009
Phosphorus (dissolved), mg/L	<0.3	<0.3	<0.3
Potassium (dissolved), mg/L	<2	<2	<2
Selenium (dissolved), mg/L	<0.001	<0.001	<0.001
Silicon (dissolved), mg/L	8.12	8.64	8.6
Silver (dissolved), mg/L	<0.00001	<0.00001	<0.00001
Sodium (dissolved), mg/L	7	9	12
Strontium (dissolved), mg/L	0.322	0.279	0.304
Thallium (dissolved), mg/L	<0.00005	<0.00005	<0.00005
Tin (dissolved), mg/L	<0.0001	<0.0001	<0.0001
Titanium (dissolved), mg/L	<0.01	<0.01	<0.01
Uranium (dissolved), mg/L	0.00031	0.00031	0.00054
Vanadium (dissolved), mg/L	<0.001	<0.001	<0.001
Zinc (dissolved), mg/L	0.001	0.002	0.001

Note: < indicates below laboratory detection limit

Western Copper Holdings Limited
Carmacks Copper Project

Table 2 1997 Groundwater Quality Data

Parameter	Groundwater Well / Sample Date			
	RC92-01 27-Sep-97	MW96-B 26-Sep-97	MW96-F 26-Sep-97	DH95-B 26-Sep-97
In-Situ Parameters				
pH		7.9	7.9	7.8
Conductivity, umho/cm		160	260	360
Physical Tests				
pH	7.89	7.82	7.48	7.81
Total Dissolved Solids, mg/L	355	200	275	396
Total Suspended Solids, mg/L	3	444	63	622
Anions				
Alkalinity-Total (CaCO ₃), mg/L	112	122	140	180
Alkalinity-Bicarbonate (CaCO ₃), mg/L	112	122	140	29
Alkalinity-Carbonate (CaCO ₃), mg/L	<1	<1	<1	<1
Alkalinity-Hydroxide (CaCO ₃), mg/L	<1	<1	<1	<1
Chloride, mg/L	2.4	1.2	4.5	2.4
Fluoride, mg/L	1.02	0.23	0.22	0.29
Sulphate, mg/L	147	8	54	105
Total Hardness (CaCO ₃), mg/L	273	131	189	140
Nutrients				
Nitrate Nitrogen, mg/L	0.561	0.879	0.005	2.27
Nitrite Nitrogen, mg/L	0.001	0.002	0.001	0.011
Total Metals				
Aluminum (total), mg/L	0.068	1.35	0.231	26.1
Antimony (total), mg/L	0.00006	0.0001	0.00076	<0.0005
Arsenic (total), mg/L	0.0003	0.0005	0.0011	0.002
Barium (total), mg/L	0.115	0.274	0.0752	0.612
Beryllium (total), mg/L	<0.0005	<0.0005	<0.0005	<0.005
Bismuth (total), mg/L	<0.0005	<0.0005	<0.0005	<0.005
Boron (total), mg/L	0.009	0.002	0.002	0.01
Cadmium (total), mg/L	<0.00005	0.00006	0.00025	<0.0005
Calcium (total), mg/L	77.2	42.7	65.5	65.7
Chromium (total), mg/L	<0.0005	0.001	0.001	0.011
Cobalt (total), mg/L	<0.0001	0.0004	0.0004	0.006
Copper (total), mg/L	0.001	0.0018	0.0147	0.009
Iron (total), mg/L	0.06	1.14	0.4	3.52
Lead (total), mg/L	0.00024	0.00173	0.00336	0.0121
Lithium (total), mg/L	<0.001	0.001	0.002	0.01
Magnesium (total), mg/L	18.2	7.16	7.39	8.17
Manganese (total), mg/L	0.0245	0.0487	0.0362	0.764
Mercury (total), mg/L	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum (total), mg/L	0.0636	0.00212	0.00191	0.0056
Nickel (total), mg/L	0.0014	0.0011	0.0094	0.005
Phosphorus (total), mg/L	<0.3	<0.3	<0.3	0.4
Potassium (total), mg/L	<2	<2	<2	2
Selenium (total), mg/L	0.002	<0.001	<0.001	<0.01
Silicon (total), mg/L	5.83	8.83	8.7	8.71
Silver (total), mg/L	<0.00001	<0.00001	0.00002	<0.0001
Sodium (total), mg/L	10	7	11	55
Strontium (total), mg/L	0.687	0.147	0.281	0.217
Thallium (total), mg/L	<0.00005	<0.00005	<0.00005	<0.0005
Tin (total), mg/L	0.0001	0.0008	0.0079	0.003
Titanium (total), mg/L	<0.01	0.04	0.01	<0.01
Uranium (total), mg/L	0.00154	0.00056	0.00056	0.0028
Vanadium (total), mg/L	<0.001	0.002	<0.001	0.04
Zinc (total), mg/L	0.004	0.007	0.047	0.09
Dissolved Metals				
Aluminum (dissolved), mg/L	0.002	0.009	0.033	0.016
Antimony (dissolved), mg/L	<0.00005	0.00006	0.00041	0.00007
Arsenic (dissolved), mg/L	0.0003	0.0002	0.0007	0.0002
Barium (dissolved), mg/L	0.107	0.227	0.0656	0.0634
Beryllium (dissolved), mg/L	<0.0005	<0.0005	<0.0005	<0.0005
Bismuth (dissolved), mg/L	<0.0005	<0.0005	<0.0005	<0.0005
Boron (dissolved), mg/L	0.01	0.002	0.002	0.003
Cadmium (dissolved), mg/L	<0.00005	<0.00005	0.00016	<0.00005
Calcium (dissolved), mg/L	78.2	41.2	63.9	45.4
Chromium (dissolved), mg/L	<0.0005	<0.0005	<0.0005	<0.0005
Cobalt (dissolved), mg/L	<0.0001	<0.0001	0.0002	<0.0001
Copper (dissolved), mg/L	0.0003	0.0003	0.0099	0.0008
Iron (dissolved), mg/L	<0.03	<0.03	0.06	<0.03
Lead (dissolved), mg/L	<0.00005	<0.00005	0.00028	<0.00005
Lithium (dissolved), mg/L	<0.001	0.001	0.002	0.002
Magnesium (dissolved), mg/L	18.8	6.76	7.25	6.49
Manganese (dissolved), mg/L	0.0206	0.00913	0.0301	0.032
Molybdenum (dissolved), mg/L	0.0622	0.00183	0.00195	0.00477
Nickel (dissolved), mg/L	0.0006	0.0005	0.0056	0.0006
Phosphorus (dissolved), mg/L	<0.3	<0.3	<0.3	<0.3
Potassium (dissolved), mg/L	<2	<2	<2	<2
Selenium (dissolved), mg/L	0.002	<0.001	<0.001	0.004
Silicon (dissolved), mg/L	5.93	5.14	8.23	5.67
Silver (dissolved), mg/L	<0.00001	<0.00001	<0.00001	<0.00001
Sodium (dissolved), mg/L	10	6	11	52
Strontium (dissolved), mg/L	0.702	0.147	0.284	0.118
Thallium (dissolved), mg/L	<0.00005	<0.00005	<0.00005	<0.00005
Tin (dissolved), mg/L	<0.0001	0.0001	0.0061	0.0005
Titanium (dissolved), mg/L	<0.01	<0.01	<0.01	<0.01
Uranium (dissolved), mg/L	0.00153	0.00041	0.00053	0.0014
Vanadium (dissolved), mg/L	<0.001	<0.001	<0.001	<0.001
Zinc (dissolved), mg/L	0.005	0.003	0.031	0.001

Note: < indicates below laboratory detection limit indicates above CCREM guideline for freshwater aquatic life

Appendix IV

Hydrological Data

Appendix IV.A

Upper Williams Creek Stream Flow Data for the Period from June 10 to
August 31, 1992 at Site W-9

Obtained from the IEE " Volume I Biophysical Assessment of the Williams
Creek Mine Site" (January, 1994)

DATE	MONTH					
	JUNE		JULY		AUGUST	
	GAUGE HEIGHT (m)	DISCHARGE (m3/s)	GAUGE HEIGHT (m)	DISCHARGE (m3/s)	GAUGE HEIGHT (m)	DISCHARGE (m3/s)
1			0.17	0.016	0.29	0.035
2			0.16	0.015	0.30	0.032
3			0.16	0.015	0.32	0.045
4			0.16	0.015	0.29	0.035
5			0.16	0.015	0.26	0.022
6			0.24	0.024	0.25	0.026
7			0.30	0.038	NA	NA
8			0.43	0.106	0.29	0.035
9			0.40	0.085	0.30	0.032
10	0.28	0.033	0.41	0.092	0.28	0.033
11	0.27	0.030	0.46	0.132	0.27	0.030
12	0.26	0.028	0.55	0.238	0.26	0.022
13	0.25	0.026	0.58	0.285	0.25	0.026
14	0.27	0.030	0.60	0.320	0.24	0.024
15	0.26	0.028	0.53	0.210	0.23	0.022
16	0.26	0.028	0.47	0.141	0.22	0.021
17	0.27	0.030	0.44	0.114	0.22	0.021
18	0.26	0.028	0.43	0.106	0.21	0.019
19	0.25	0.026	0.41	0.092	0.20	0.012
20	0.25	0.026	0.41	0.092	0.20	0.012
21	0.24	0.024	0.39	0.079	0.00	0.012
22	0.23	0.022	0.35	0.057	NA	NA
23	0.21	0.019	0.31	0.042	NA	NA
24	0.20	0.018	NA	NA	NA	NA
25	0.19	0.017	NA	NA	0.20	0.012
26	0.18	0.016	NA	NA	0.20	0.012
27	0.18	0.016	0.30	0.038	0.21	0.012
28	0.18	0.016	0.28	0.033	0.22	0.021
29	0.17	0.016	0.25	0.026	0.23	0.022
30	0.17	0.016	0.26	0.028	0.24	0.024
31			0.27	0.030	0.25	0.026

Upper Williams Creek Streamflow data for the period
June 10 - August 31, 1992 at Site W-9.

Appendix IV.B

1993 and 1994 Hydrological Data.

From the IEE "Addendum to Volume I – Biophysical Assessment of the
Carmacks Copper Mine Site" (November, 1994)

Stage Discharge Relationship for
Williams Creek at Data Logger Station #2
May 1993 - August 1994.

Gauge Height (m)	Flow Volume (cms)	Gauge Height (m)	Flow Volume (cms)
0.2	0.01	0.48	0.0966
0.21	0.0104	0.49	0.1038
0.22	0.0108	0.5	0.111
0.23	0.0112	0.51	0.1198
0.24	0.0116	0.52	0.1286
0.25	0.012	0.53	0.1374
0.26	0.0128	0.54	0.1462
0.27	0.0136	0.55	0.155
0.28	0.0144	0.56	0.1644
0.29	0.0152	0.57	0.1738
0.3	0.016	0.58	0.1832
0.31	0.0174	0.59	0.1926
0.32	0.0188	0.6	0.202
0.33	0.0202	0.61	0.213
0.34	0.0216	0.62	0.224
0.35	0.023	0.63	0.235
0.36	0.027	0.64	0.246
0.37	0.031	0.65	0.257
0.38	0.035	0.66	0.27
0.39	0.039	0.67	0.283
0.4	0.043	0.68	0.296
0.41	0.0494	0.69	0.309
0.42	0.0558	0.7	0.322
0.43	0.0622	0.71	0.3364
0.44	0.0686	0.72	0.3508
0.45	0.075	0.73	0.3652
0.46	0.0822	0.74	0.3796
0.47	0.0894	0.75	0.394

Williams Creek Hydrology Data 1994
Data Logger Station # 2
Period May 2 to July 24, 1994.

Date	Av.GH(m)	Q (cms)	MaxGH(m)	Q (cms)	MinGH(m)	Q (cms)
May 2/94	1.183	Ice	1.183	Ice	1.183	Ice
3	1.183	Ice	1.183	Ice	1.183	Ice
4	1.183	Ice	1.183	Ice	1.183	Ice
5	1.183	Ice	1.183	Ice	1.179	Ice
6	1.175	Ice	1.177	Ice	1.173	Ice
7	1.173	Ice	1.174	Ice	1.173	Ice
8	1.172	Ice	1.173	Ice	1.172	Ice
9	1.172	Ice	1.172	Ice	1.172	Ice
10	1.172	Ice	1.172	Ice	1.172	Ice
11	1.172	Ice	1.172	Ice	1.172	Ice
12	1.172	Ice	1.172	Ice	1.172	Ice
13	0.840	Ice	0.904	Ice	0.013	Ice
14	0.901	Ice	0.906	Ice	0.900	Ice
15	0.896	Ice	0.902	Ice	0.894	Ice
16	0.897	Ice	0.900	Ice	0.895	Ice
17	0.891	Ice	0.894	Ice	0.888	Ice
18	0.881	Ice	0.887	Ice	0.876	Ice
19*	0.652	0.257	0.672	0.283	0.632	0.237
20*	0.624	0.224	0.629	0.235	0.623	0.227
21*	0.553	0.155	0.620	0.224	0.446	0.070
22	0.354	0.021	0.361	0.027	0.340	0.022
23	0.309	0.017	0.329	0.021	0.284	0.014
24	0.288	0.015	0.302	0.016	0.273	0.014
25	0.277	0.014	0.287	0.014	0.264	0.013
26	0.275	0.014	0.285	0.014	0.264	0.013
27	0.334	0.020	0.383	0.036	0.275	0.014
28	0.393	0.039	0.398	0.042	0.385	0.037
29	0.402	0.043	0.407	0.046	0.396	0.041
30	0.411	0.049	0.418	0.052	0.398	0.042
May 31	0.415	0.053	0.419	0.052	0.412	0.050
June 1	0.406	0.049	0.409	0.047	0.402	0.044
2	0.397	0.043	0.405	0.046	0.392	0.040
3	0.379	0.035	0.390	0.039	0.372	0.032
4	0.360	0.027	0.369	0.030	0.356	0.025
5	0.354	0.023	0.360	0.027	0.351	0.023
6	0.335	0.020	0.348	0.022	0.328	0.019
7	0.310	0.017	0.325	0.019	0.305	0.016
8	0.292	0.015	0.302	0.016	0.287	0.015
9	0.280	0.014	0.288	0.015	0.275	0.014
10	0.272	0.014	0.275	0.014	0.268	0.013
11	0.263	0.013	0.268	0.013	0.260	0.013
12	0.258	0.013	0.260	0.013	0.255	0.012
13	0.251	0.012	0.255	0.012	0.246	0.012
14	0.241	0.012	0.245	0.011	0.236	0.011
15	0.235	0.011	0.236	0.011	0.232	0.011
16	0.232	0.011	0.233	0.011	0.230	0.011
17	0.240	0.012	0.241	0.012	0.238	0.012

Date	Av.GH(m)	Q (cms)	MaxGH(m)	Q (cms)	MinGH(m)	Q (cms)
June 18	0.237	0.011	0.238	0.011	0.234	0.011
19	0.249	0.012	0.255	0.013	0.238	0.012
20	0.252	0.012	0.259	0.013	0.251	0.012
21	0.272	0.014	0.281	0.014	0.259	0.013
22	0.295	0.015	0.299	0.016	0.283	0.014
23	0.292	0.015	0.298	0.016	0.284	0.014
24	0.279	0.014	0.284	0.015	0.272	0.013
25	0.278	0.014	0.303	0.016	0.269	0.013
26	0.407	0.049	0.466	0.086	0.323	0.018
27	0.501	0.111	0.557	0.160	0.469	0.090
28	0.560	0.164	0.567	0.169	0.550	0.155
29	0.533	0.137	0.548	0.152	0.519	0.128
June 30	0.511	0.120	0.522	0.131	0.496	0.107
July 1	0.480	0.097	0.492	0.104	0.468	0.086
2	0.490	0.104	0.497	0.109	0.480	0.097
3	0.499	0.110	0.501	0.111	0.495	0.108
4	0.486	0.097	0.495	0.109	0.471	0.089
5	0.464	0.085	0.470	0.089	0.460	0.082
6	0.456	0.079	0.461	0.083	0.449	0.075
7	0.447	0.071	0.451	0.075	0.443	0.070
8	0.447	0.071	0.452	0.076	0.436	0.066
9	0.428	0.062	0.436	0.066	0.419	0.054
10	0.409	0.049	0.417	0.053	0.399	0.042
11	0.388	0.039	0.397	0.042	0.378	0.034
12	0.366	0.031	0.376	0.033	0.354	0.024
13	0.337	0.022	0.353	0.025	0.317	0.018
14	0.306	0.016	0.316	0.018	0.294	0.015
15	0.293	0.015	0.294	0.015	0.291	0.015
16	0.288	0.015	0.291	0.015	0.283	0.014
17	0.280	0.014	0.282	0.014	0.275	0.014
18	0.273	0.013	0.274	0.014	0.270	0.013
19	0.267	0.013	0.269	0.014	0.262	0.012
20	0.268	0.013	0.277	0.014	0.262	0.012
21	0.275	0.014	0.277	0.014	0.267	0.013
22	0.264	0.013	0.267	0.014	0.258	0.012
23	0.250	0.012	0.254	0.012	0.238	0.011
July 24	0.240	0.012	0.242	0.012	0.238	0.011

All gauge heights are corrected for gauge shifts

May 19,20,21* - Final transition from ice effect
to open water channel

Williams Creek, Yukon. Comparison of Average
Daily Flow Volumes between 1993 and 1994.
Data Logger Station #2.

Date	1993	1994
-----	-----	-----
May 28	0.164	0.039
29	0.336	0.043
30	0.322	0.049
31	0.235	0.053
June 1	0.183	0.049
2	0.155	0.043
3	0.129	0.035
4	0.104	0.027
5	0.089	0.023
6	0.082	0.02
7	0.069	0.017
8	0.056	0.015
9	0.049	0.014
10	0.039	0.014
11	0.035	0.013
12	0.031	0.013
13	0.023	0.012
14	0.017	0.012
15	0.015	0.011
16	0.014	0.011
17	0.014	0.012
18	0.014	0.011
19	0.017	0.012
20	0.02	0.012
21	0.017	0.014
22	0.015	0.015
23	0.016	0.015
24	0.016	0.014
25	0.014	0.014
26	0.014	0.049
27	0.013	0.111
28	0.012	0.164
29	0.012	0.137
30	0.011	0.12
July 1	0.012	0.097
2	0.023	0.104
3	0.043	0.11
4	0.035	0.097
5	0.023	0.085
6	0.023	0.079
7	0.023	0.071
8	0.039	0.071
9	0.049	0.062
10	0.049	0.049

Date	1993	1994
11	0.043	0.039
12	0.035	0.031
13	0.023	0.022
14	0.02	0.016
15	0.017	0.015
16	0.014	0.015
17	0.014	0.014
18	0.012	0.013
19	0.012	0.013
20	0.012	0.013
21	0.012	0.014
22	0.013	0.013
23	0.012	0.012
24	0.012	0.012
	cms	cms

1993 period of record - May 28 to Oct 29

1994 period of record - May 2 to July 24

Appendix IV.C

Hydrological Data and Analysis Displayed in Tables and Figures

Obtained from the IEE Addendum #2 "Report of Preliminary Design" (May,
1995)

TABLE 2.12
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
REGIONAL STREAMFLOW RECORDS

Description	Station No.	Years of Record	Measurement Period	Control	Distance Between Sites (km)	Basin Area (km ²)	Approx. Mean Basin Elev. (m)	Mean Annual Runoff	
								(m ³ /s)	(mm)
Big Salmon River	09AG001	30	year round	unregulated	140 SE	6760	1300	68.8	321
South Big Salmon River	09AG003	11	year round	unregulated	140 SE	515	2000	4.2	258
Big Creek Near the Mouth	09AH003	17	year round	unregulated	25 NW	1750	1150	8.0	143
Nordenskiöld River	09AH004	10	year round	unregulated	50 SE	6370	1000	16.3	80
Thistle Creek	29CD001	8	thaw	partially regulated	190 NW	210	750	0.6	88
Scroggie Creek	29DD003	9	thaw	partially regulated	150 NW	730	750	1.6	68
Williams Creek	n/a	n/a	n/a	unregulated	n/a	31	830	n/a	n/a

Notes:

- 1) Data for stations 09AG001 to 09AH004 supplied by Water Survey of Canada (WSC). Gauges operated year round.
- 2) Data for stations 29CD001 and 29DD003 supplied by Dept. of Indian and Northern Affairs Canada (INAC). Gauges not operated during freeze period.
- 3) Distance between sites refers to distances between centers of basin areas.
- 4) Williams Creek area is not the entire basin but just the area that upstream of the location of the proposed water storage pond.

TABLE 2.13
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
SITE STREAMFLOW VALUES

Years of Record	Streamflow Station	Area (km ²)	unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1992	Williams Creek (staff gauge)	12.8	m ³ /s mm						0.02 4.7	0.09 18.6	0.03 5.4					
	Big Creek (09AH003)	1750	m ³ /s mm	1.10 1.7	0.45 0.6	0.49 0.7	1.37 2.0	52.20 79.9	33.70 49.9	36.20 55.4	12.40 19.0	16.50 24.4	4.92 7.5	2.02 3.0	1.10 1.7	13.54 243.9
	ratio Williams/Big		%						9%	34%	29%					
1993	Williams Creek (data logger No. 2)	23.9	m ³ /s mm						0.04 4.7	0.03 3.5	0.04 3.3	0.07 7.1	0.09 10.0			28
	Big Creek (09AH003)	1750	m ³ /s mm	0.48 0.7	0.24 0.3	0.19 0.3	5.33 7.9	36.00 55.1	10.00 14.8	12.60 19.3	13.50 20.7	7.22 10.7	2.07 2.9	1.89 2.8	1.33 2.0	7.64 137.7
	ratio Williams/Big		%						31%	18%	16%	67%	348%			
1994	Williams Creek (data logger No. 2)	23.9	m ³ /s mm					0.07 3.07	0.03 3.69	0.04 3.82						
	Big Creek (09AH003)	1750	m ³ /s mm						8.59 12.7							
	ratio Williams/Big		%						29%							

Notes:

- 1) Big Creek data from Water Survey of Canada (WSC).
- 2) Bold values are for period of record only, not entire month. October '93 is for 1-28, May '94 is for 19-31 and July '94 is for 1-24.
Comparative Big Creek values are for comparative periods of record.

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TABLE 2.14
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
ESTIMATED RUNOFF COEFFICIENT

Creek	Mean Basin Elevation	Basin Area	Time Period	Total Flow (mm)	Estimated Precipitation (mm)	Runoff Coeff.
Williams 1992	830	12.84	June 10 to August 31	26.73	295 (1) 129	9.1% 20.7%
Williams 1993	830	23.92	June 17 to October 28	23.41	not available	n/a
Williams 1994	830	23.92	May 22 to July 24	8.44	106	8.0%
Big Creek	1150	1750	1975-93	143.0	491	29.1%
Big Creek	1150	1750	June 1975-93	26.0	60	43.3%
Big Creek	1150	1750	Jul. Aug. Sep 1975-93	64	214 (2)	29.9%
Big Creek	1150	1750	Apr. May. Jun 1975-93	69.4	118	58.8%

Notes:

1) Actual measured site precipitation. There is some doubt as to the validity of this value as it is so large.

This is the only precipitation value in the table which is not estimated.

2) Jul. Aug. Sep 1975-93 runoff likely contains very little snowmelt.

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TABLE 2.15
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
ESTIMATED RAINFALL AND SNOWMELT DISTRIBUTIONS

Total Annual Runoff at the Water Storage Pond = 56 mm

Location	Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Williams Creek Site (water storage pond)	Rainfall	0	0	0	0	3	7	11	8	5	1	0	0	35
	% rainfall	0.0%	0.0%	0.0%	0.0%	7.9%	20.2%	32.1%	22.9%	15.3%	1.6%	0.0%	0.0%	100.0%
	% runoff	0.0%	0.0%	0.0%	0.0%	4.9%	12.5%	19.9%	14.2%	9.5%	1.0%	0.0%	0.0%	62.0%
	Snowmelt	0	0	0	15	6	0	0	0	0	0	0	0	21
	% snowmelt	0.0%	0.0%	0.0%	70.0%	30.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
	% runoff	0.0%	0.0%	0.0%	26.6%	11.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	38.0%
	Total Runoff (mm)	0	0	0	15	9	7	11	8	5	1	0	0	56
	Total Runoff (m ³ /s)	0.00	0.00	0.00	0.18	0.11	0.08	0.13	0.09	0.06	0.01	0.00	0.00	0.06
	% runoff	0.0%	0.0%	0.0%	26.6%	16.3%	12.5%	19.9%	14.2%	9.5%	1.0%	0.0%	0.0%	100.0%

Notes:

1) For water balance modeling, the total runoff values should be used to represent water inflow due to precipitation on the basin draining into the water storage pond.

TABLE 2.16
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
WET AND DRY YEAR RUNOFF

1) At Water Storage Pond

Annual Runoff mean = 56 mm
 standard deviation = 19 mm

Return Period	Runoff (mm)
1:10 year dry (mean - 1.282 s.d.)	32
1:20 year dry (mean - 1.645 s.d.)	25
1:10 year wet (mean + 1.282 s.d.)	80
1:20 year wet (mean + 1.645 s.d.)	87
1:50 year wet (mean + 2.054 s.d.)	95
1:100 year wet (mean + 2.326 s.d.)	100
1:200 year wet (mean + 2.575 s.d.)	105

Notes:

- 1) Estimates assume a normal distribution of annual runoff.
- 2) Standard deviation estimated from a C.V. value of 0.34, calculated with 18 years of WSC Big Creek flow data (1975 - 1993).

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TABLE 2.17
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
WET AND DRY YEAR RUNOFF COEFFICIENTS

Return Period	Runoff (mm)	Precipitation (mm)	Runoff Coefficient
average year	56	370	0.15
1:10 year dry	32	275	0.11
1:20 year dry	25	248	0.10
1:10 year wet	80	465	0.17
1:20 year wet	87	492	0.18
1:50 year wet	95	522	0.18
1:100 year wet	100	542	0.18
1:200 year wet	105	561	0.19

Notes:

- 1) Runoff and precipitation estimates are for the basin draining into the water storage pond.
Average elevation of the basin is 830 m.

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TABLE 2.18
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
DRY, WET AND AVERAGE YEAR STREAMFLOW DISTRIBUTIONS

Streamflow Station	Years of Record	unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Big Creek (DRY)	1989	m3/s	0.40	0.18	0.08	0.18	10.60	7.88	6.13	4.74	3.96	2.47	1.13	0.52	3.19
		%	1.1%	0.5%	0.2%	0.5%	27.7%	20.6%	16.0%	12.4%	10.3%	6.5%	3.0%	1.3%	100.0%
	1981	m3/s	0.18	0.17	0.17	0.23	12.80	4.72	18.40	14.00	5.89	4.80	1.61	0.43	5.28
		%	0.3%	0.3%	0.3%	0.4%	20.2%	7.4%	29.0%	22.1%	9.3%	7.6%	2.5%	0.7%	100.0%
	1977	m3/s	0.22	0.20	0.15	0.51	17.60	17.90	15.80	3.92	4.28	2.79	0.70	0.09	5.35
		%	0.3%	0.3%	0.2%	0.8%	27.4%	27.9%	24.6%	6.1%	6.7%	4.3%	1.1%	0.1%	100.0%
	average	%	0.6%	0.4%	0.2%	0.5%	25.1%	18.6%	23.2%	13.5%	8.8%	6.1%	2.2%	0.7%	100.0%
	st. dev.		0.4%	0.1%	0.0%	0.2%	4.3%	10.4%	6.6%	8.0%	1.9%	1.6%	1.0%	0.6%	
Big Creek (WET)	1992	m3/s	1.10	0.45	0.49	1.37	52.20	33.70	36.20	12.40	16.50	4.92	2.02	1.10	13.54
		%	0.7%	0.3%	0.3%	0.8%	32.1%	20.7%	22.3%	7.6%	10.2%	3.0%	1.2%	0.7%	100.0%
	1990	m3/s	0.26	0.11	0.07	21.80	76.80	17.00	8.48	3.65	19.00	5.88	0.96	0.32	12.90
		%	0.2%	0.1%	0.0%	14.1%	49.8%	11.0%	5.5%	2.4%	12.3%	3.8%	0.6%	0.2%	100.0%
	1991	m3/s	0.21	0.26	0.37	2.77	49.60	23.10	18.10	18.00	20.50	5.75	3.59	2.15	12.03
		%	0.1%	0.2%	0.3%	1.9%	34.4%	16.0%	12.5%	12.5%	14.2%	4.0%	2.5%	1.5%	100.0%
	average	%	0.3%	0.2%	0.2%	5.6%	38.7%	15.9%	13.4%	7.5%	12.2%	3.6%	1.5%	0.8%	100.0%
	st. dev.		0.3%	0.1%	0.1%	7.4%	9.6%	4.9%	8.4%	5.1%	2.0%	0.5%	0.9%	0.6%	
Big Creek (AVERAGE)	average	%	0.3%	0.2%	0.2%	2.1%	28.2%	18.2%	20.4%	14.0%	10.5%	4.0%	1.3%	0.6%	100.0%

Notes:

- 1) Big Creek data from Water Survey of Canada (WSC).
- 2) Given the large standard deviation values, wet and dry distributions are not significantly different than the average distribution.

TABLE 2.19
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
PEAK INSTANTANEOUS FLOWS

Summary of Return Period Peak Flow Estimates (m³/s)

Basin	Area (km ²)	Technique	Return Period (years)					
			2	10	25	50	100	200
Water Storage Pond	31	Janowicz - Mountain	2.7	6.1		10	11.9	
		Janowicz - Interior	2.2	4.1		6	6.9	
		Regional - Big Creek	4.6	7.7	8.9	9.7	10.4	11
		Regional - Thistle Creek	3.8	6.4	7.7	8.8	9.8	10.9
		HEC-1	1.7	5	7.7	9.8	11.7	14.3
		Best Estimate	5.1	8.5	9.8	10.7	11.4	12.1

Notes:

1) "Best Estimates" were generated by increasing regional-Big Creek values by 10%.

TABLE 2.20
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
JANOWICZ ESTIMATES OF PEAK INSTANTANEOUS FLOWS

Janowicz Technique

Basin	Area (km ²)	Region	Return Period (years)	Regression Constant "a"	Regression Constant "b"	Peak Discharge (m ³ /s)
Williams Creek (water storage pond)	31	Mountain	2	0.085	1.007	2.7
			10	0.257	0.923	6.1
			25			
			50	0.5	0.873	10.0
			100	0.631	0.855	11.9
			200			
Williams Creek (water storage pond)	31	Interior	2	0.083	0.951	2.2
			10	0.176	0.917	4.1
			25			
			50	0.277	0.897	6.0
			100	0.324	0.89	6.9
			200			

Notes:

Estimating technique developed by Rick Janowicz, Senior Hydrologist with the Department of Indian and Northern Affairs Canada (INAC).

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TABLE 2.21
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
REGIONAL FREQUENCY ESTIMATES OF PEAK INSTANTANEOUS FLOWS

Regional Analysis - Big Creek

Basin	Area (km ²)	Return Period (years)	Peak Flows (based on various distributions)				
			Extreme Value	3-P Lognormal	Log Pearson III	Wakeby	Best Guess
Big Creek	1750	2	116	115	114	115	115
		10	195	201	207	203	204
		25	223	236	240	243	238
		50	245	265	265	277	265
		100	262	290	284	305	287
		200	277	315	300	332	308
Williams Creek (water storage pond)	31	2	4.6	4.6	4.5	4.6	4.6
		10	7.7	8.0	8.2	7.7	7.7
		25	8.9	9.4	9.5	8.9	8.9
		50	9.7	10.5	10.5	9.7	9.7
		100	10.4	11.5	11.3	10.4	10.4
		200	11.0	12.5	11.9	11.0	11.0

Regional Analysis - Thistle Creek

Basin	Area (km ²)	Return Period (years)	Peak Flows (based on various distributions)				
			Extreme Value	3-P Lognormal	Log Pearson III	Wakeby	Best Guess
Thistle Creek	210	2	17.5	17.4	17.5	17.4	17.5
		10	29	29.9	29.1	29.8	29.5
		25	34.6	36.1	34.6	36.7	35.4
		50	39.7	41.8	39.4	42.9	40.6
		100	44.4	47.1	43.8	48.7	45.5
		200	49.2	52.5	48.3	54.7	50.4
Williams Creek (water storage pond)	31	2	3.8	3.8	3.8	3.8	3.8
		10	6.3	6.5	6.3	6.4	6.4
		25	7.5	7.8	7.5	7.9	7.7
		50	8.6	9.0	8.5	9.3	8.8
		100	9.6	10.2	9.5	10.5	9.8
		200	10.6	11.4	10.5	11.8	10.9

Notes

- 1) All peak flow values generated with WSC's flood frequency software CFA88.
- 2) Values based on 15 years of Big Creek data and 14 years of Thistle Creek data.

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TABLE 2.22
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
HEC-1 INPUT PARAMETERS

Input Parameter	Estimated Value
Time of Concentration (Tc)	4 hrs
Basin Area	31.0 sq. km
Storage Coefficient	4 hrs
Curve Number (CN)	83
Initial Abstraction (Ia)	10.4 mm
Starting Flow	0.11 m ³ /s
End Flow	0.11 m ³ /s
24 hr - 1 in 2 Year Precipitation	24 mm
24 hr - 1 in 10 Year Precipitation	36 mm
24 hr - 1 in 25 Year Precipitation	43 mm
24 hr - 1 in 50 Year Precipitation	48 mm
24 hr - 1 in 100 Year Precipitation	52 mm
24 hr - 1 in 200 Year Precipitation	57 mm
Precipitation Distribution	SCS Type 1
Unit Hydrograph Type	Clark
Rate of Decay	1.001 (0.1% per hour)

Notes:

- 1) Assume antecedent moisture condition (AMC) III for all return periods.
This assumes that peak storms occur during the freshet when the ground is saturated and/or partially frozen.
- 2) Initial abstraction = 0.2S.

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TABLE 2.23
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
HEC-1 PEAK INSTANTANEOUS FLOW ESTIMATES

HEC-1 Analysis

Basin	Area (km ²)	Return Period (years)	24 hr Rainfall (mm)	Peak Discharge (m ³ /s)
Water Storage Pond	31	2	24	1.7
		10	36	5.0
		25	43	7.7
		50	48	9.8
		100	52	11.7
		200	57	14.3

Notes: All flow estimates assume the ground is either saturated and/or partially frozen.

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FIGURE 2.4
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT - WILLIAMS CREEK

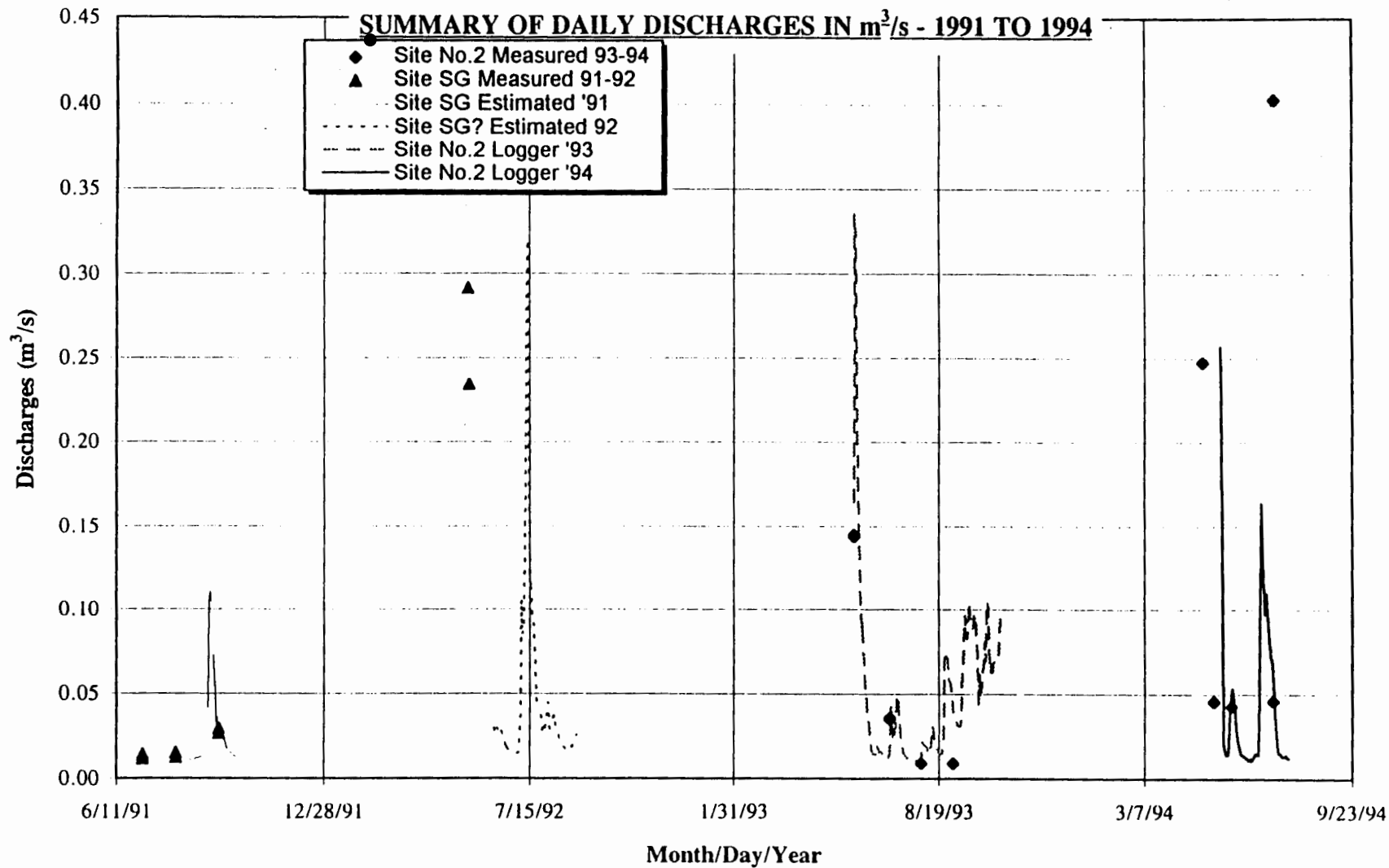


FIGURE 2.5
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT - WILLIAMS CREEK

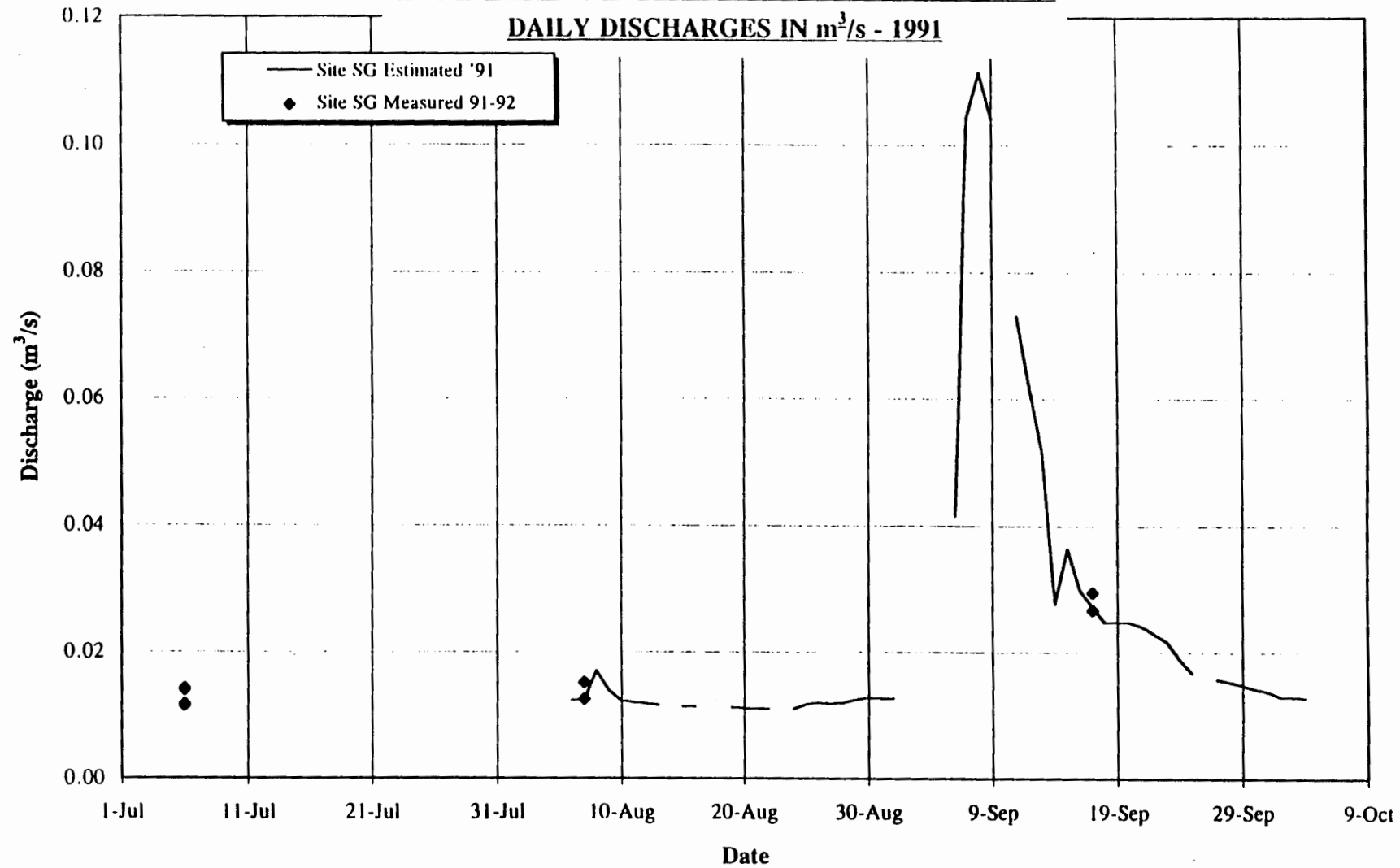


FIGURE 2.6
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT - WILLIAMS CREEK

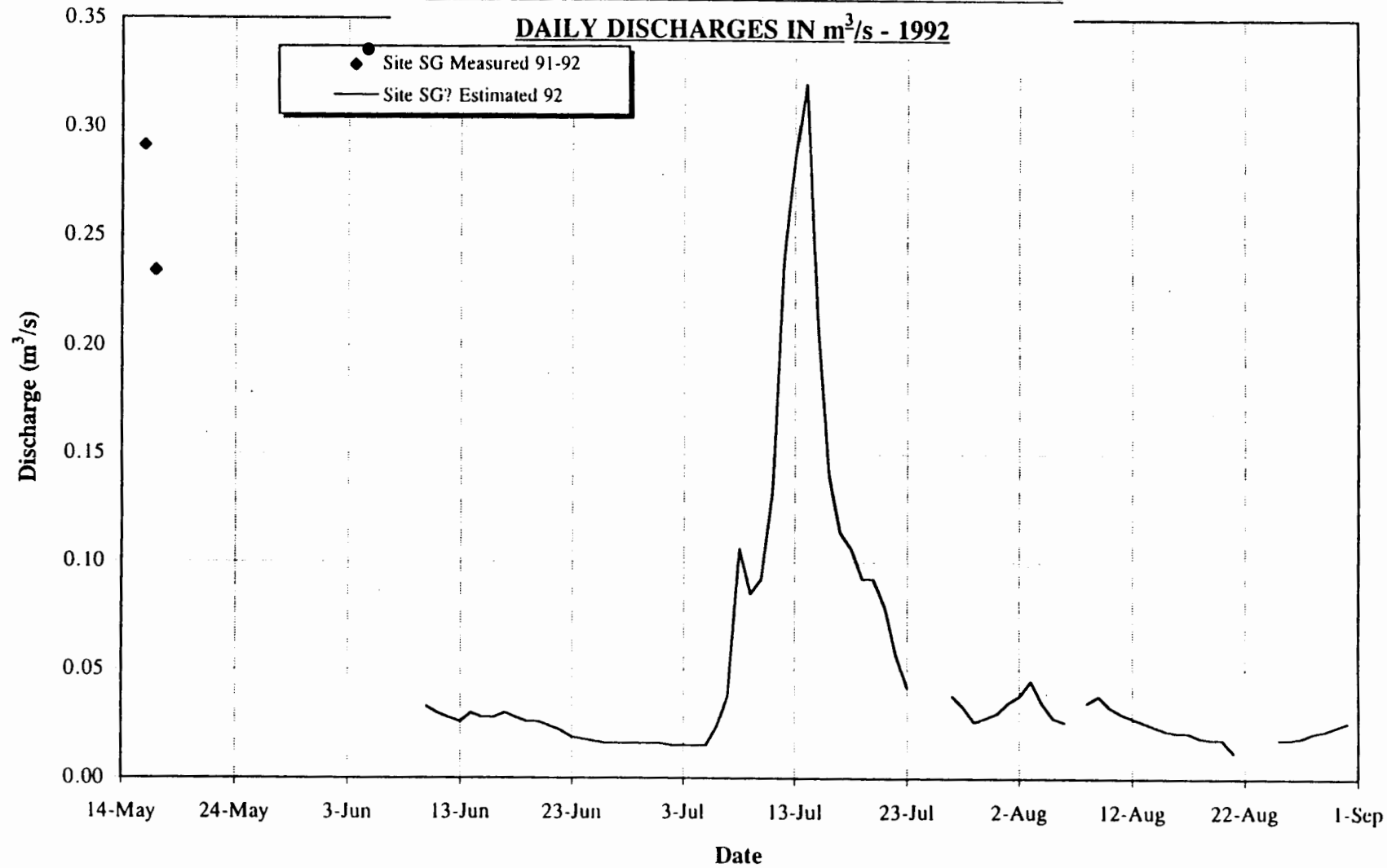


FIGURE 2.7
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT - WILLIAMS CREEK
DAILY DISCHARGES IN m^3/s - 1993

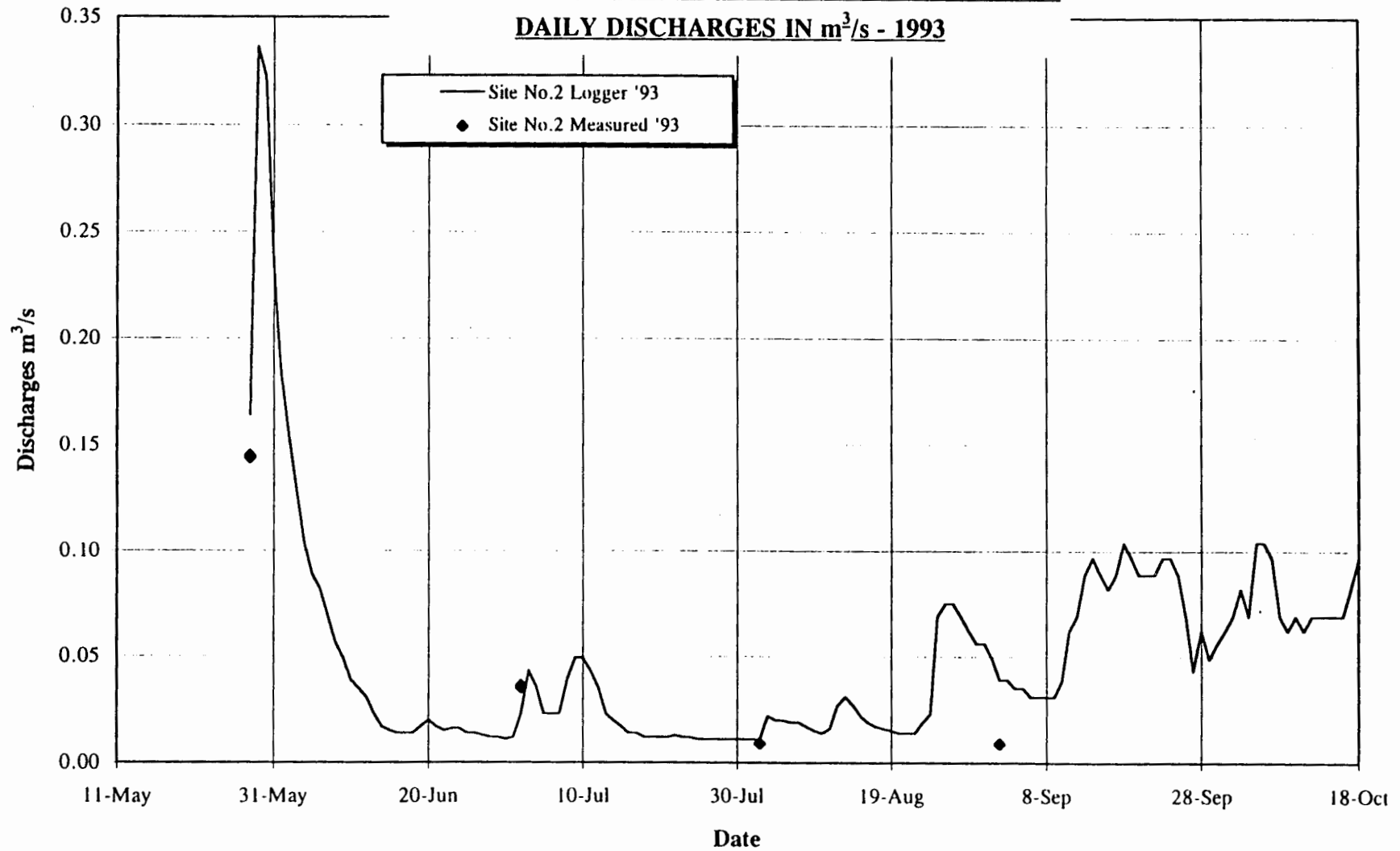
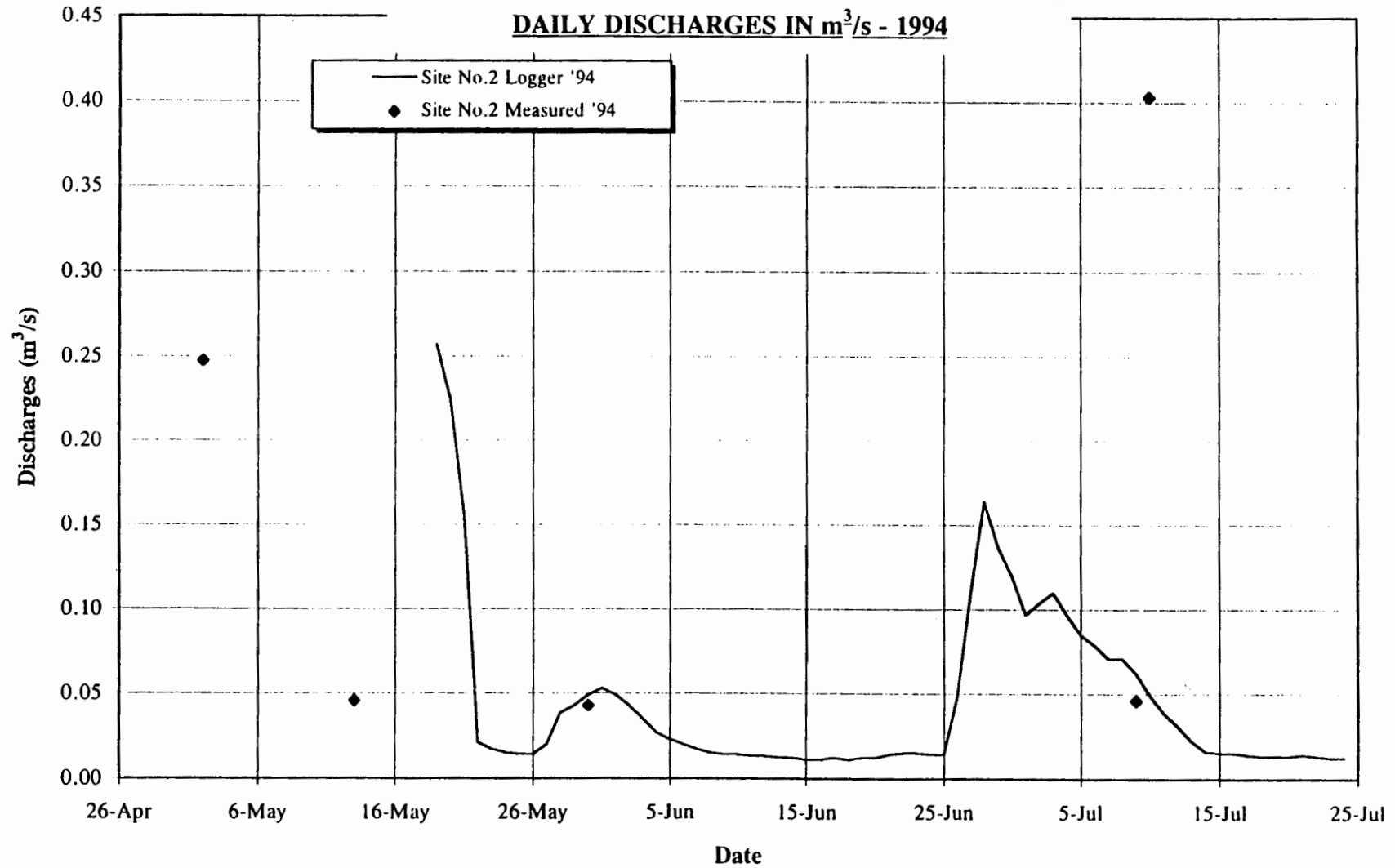


FIGURE 2.8
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT - WILLIAMS CREEK



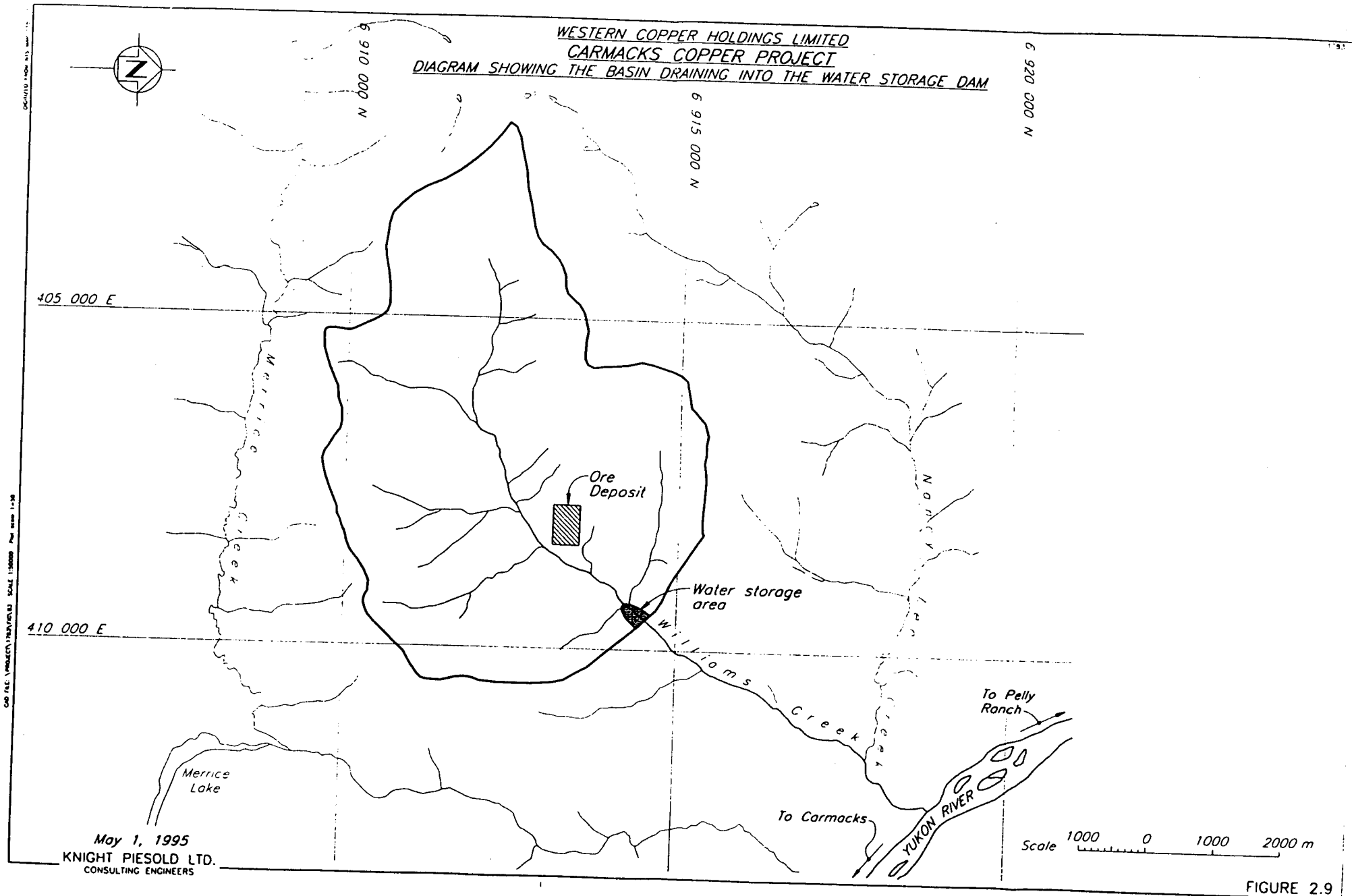


FIGURE 2.9

Appendix IV.D

Runoff Coefficients for Big Creek.

From the "Technical Issues Response Document" (June, 1997)

TABLE 3.7
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
RUNOFF COEFFICIENTS FOR BIG CREEK

1) Precipitation estimate based on Carmacks and Pelly Ranch values.

Year	Estimated Big Creek Basin Precipitation (mm)	Annual Big Creek Runoff (mm)	Runoff Coefficient	Coefficient Relative to Average	Carmacks Precipitation (mm)	Pelly Ranch Precipitation (mm)	Big Creek Runoff (m ³ /s)
1975	448	179.5	0.40	38%	290.9	256.1	9.96
1980	473	107.9	0.23	-21%	359.8	247.5	5.99
1981 ⁽²⁾	576	96.4	0.17	-42%	280.1	369.1	5.35
1983	573	133.0	0.23	-20%	328.9	346.2	7.38
1985 ⁽²⁾	583	147.9	0.25	-13%	302.1	366.3	8.21
1990 ⁽²⁾	607	232.5	0.38	32%	401.5	343.5	12.90

2) Precipitation estimate based on Carmacks values.

Year	Estimated Big Creek Basin Precipitation (mm)	Annual runoff (mm)	Runoff Coefficient	Coefficient Relative to Average	Carmacks Precipitation (mm)	Big Creek Runoff (m ³ /s)
1975	471	179.5	0.38	20%	290.9	9.96
1980	582	107.9	0.19	-42%	359.8	5.99
1981 ⁽²⁾	453	96.4	0.21	-33%	280.1	5.35
1983	532	133.0	0.25	-22%	328.9	7.38
1985 ⁽²⁾	489	147.9	0.30	-5%	302.1	8.21
1990 ⁽²⁾	650	232.5	0.36	12%	401.5	12.90

3) Precipitation estimate based on Pelly Ranch values.

Year	Estimated Big Creek Basin Precipitation (mm)	Annual runoff (mm)	Runoff Coefficient	Coefficient Relative to Average	Pelly Ranch Precipitation (mm)	Big Creek Runoff (m ³ /s)
1975	438	179.5	0.41	47%	256.1	9.96
1976	507	157.1	0.31	11%	296.9	8.72
1977	446	97.1	0.22	-22%	261.0	5.39
1978	559	161.3	0.29	3%	327.4	8.95
1979	486	127.0	0.26	-6%	284.3	7.05
1980	423	107.9	0.26	-9%	247.5	5.99
1981	631	96.4	0.15	-45%	369.1	5.35
1982	460	108.1	0.24	-16%	269.1	6.00
1983	592	133.0	0.22	-19%	346.2	7.38
1985	626	147.9	0.24	-15%	366.3	8.21
1986	517	125.8	0.24	-13%	302.4	6.98
1987	573	118.6	0.21	-26%	335.4	6.58
1988	465	135.2	0.29	4%	272.3	7.50
1989	395	58.0	0.15	-47%	231.3	3.22
1990	587	232.5	0.40	42%	343.5	12.90

Notes: (1) Average year refers to the average of the full periods of records for Carmacks, Pelly Ranch and E
(2) The Carmacks annual precipitation values were estimated as there were some months with missing

Appendix V

Climate Data

Appendix V.A

Precipitation, Temperature and Snow Pack Data from Williams Creek and
Surrounding Area, Including Historic and 1992 Climate Data

Obtained from the IEE "Volume I Biophysical Assessment of the Williams
Creek Mine Site" (January, 1994)

Table 3.2.2

Comparison of Meteorology between Williams Creek and Carmacks

Month	Precipitation		Temperature					
	Williams Creek	Carmacks	Williams Creek			Carmacks		
	(mm)	(mm)	Maximum (°C)	Minimum (°C)	Mean (°C)	Maximum (°C)	Minimum (°C)	Mean (°C)
June	48.8	18	22.9	1.9	12.4	20.6	5.1	12.9
July	103.5	68.7	21.7	5.2	13.4	21.2	9.3	15.4
August	143	27.9	17.5	4.7	11.1	20.3	5.9	13.7

Table 3.2.4

DATE	SNOW COURSE	SNOW DEPTH (cm)	WATER EQUIV. (mm)	HISTORICAL AVERAGE WATER EQUIV. (mm)	YEARS OF RECORD
92-01-31	Williams #1	69.8	128	-	-
	Williams #2	73.6	164	-	-
	Williams #3	72.0	130	-	-
92-03-02	Mt. Nansen	54	92 E	68	16
	Mt. Berdoe	76	165	91	17
	Casino Cr.	67	124	98	17
	MacIntosh	69	138	79	16
	Williams #1	60	104	-	-
	Williams #2	69	110	-	-
	Williams #3	70	150	-	-
92-03-30	Mt. Nansen	60	102	74	16
	Mt. Berdoe	72	132	106	16
	Casino Cr.	70	135	121	15
	MacIntosh	73	111	97	16
	Williams #1	70	120	-	-
	Williams #2	73	130	-	-
	Williams #3	74	132	-	-
92-04-30	Mt. Nansen	25	68 E	13	15
	Mt. Berdoe	50	126	58	16
	Casino Cr.	83	207	118	15
	MacIntosh	53	121	56	16
	Williams #1	22	84	-	-
	Williams #2	36	129	-	-
	Williams #3	36	103	-	-
92-05-14	Mt. Nansen	0	68	0	16
	Mt. Berdoe	38	126	15	16
	Casino Cr.	83	207	69	11
	MacIntosh	39	121	12	16
	Williams #1	0	84	-	-
	Williams #2	11	129	-	-
	Williams #3	9	103	-	-

E = Estimated

Snow survey data for Williams Creek and Carmacks
Regional Snow Courses. Period March 1 to May 16, 1992
(after Gibson, 1992).

Table 3.2.5

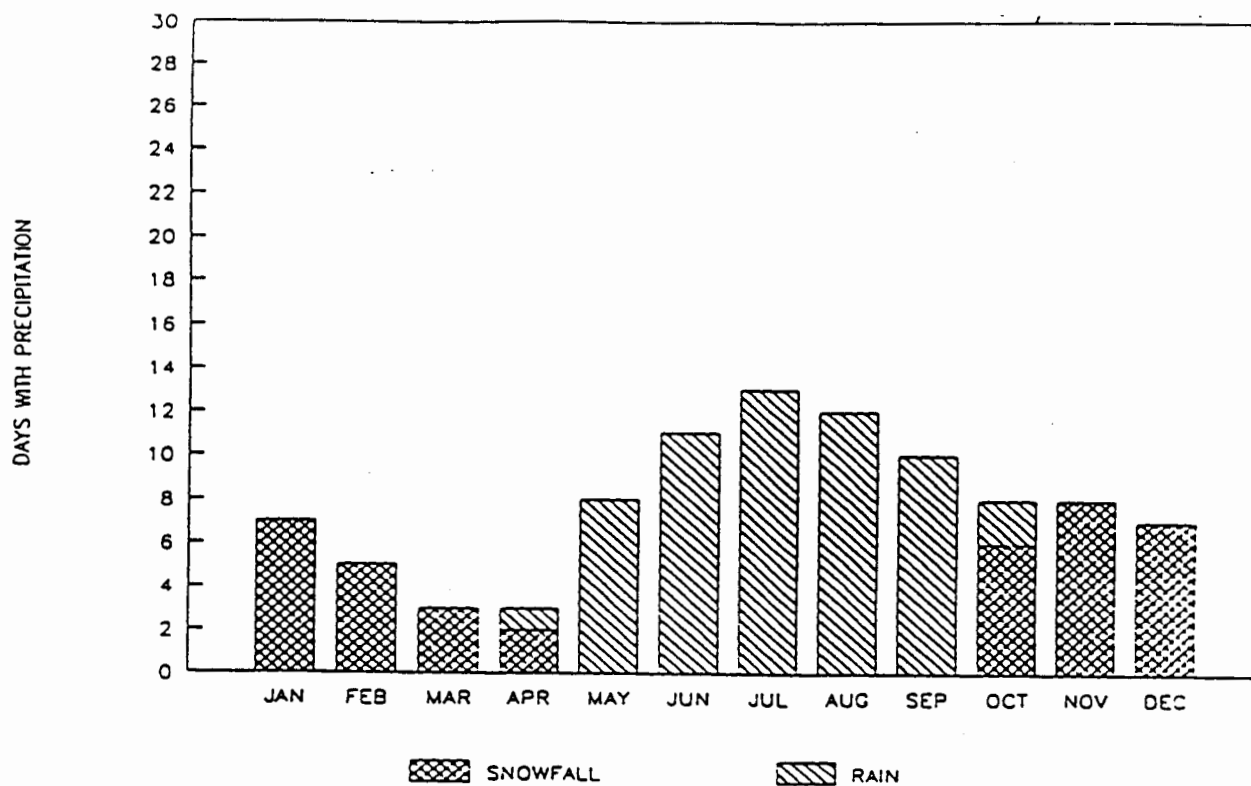
DATE	YEARS OF RECORD	SNOW WATER EQUIVALENT (mm)											
		MT. NANSEN			WILLIAMS CREEK								
					SITE 1			SITE 2			SITE 3		
		MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN
Feb 01	10	74	52	36	87	61	43	109	90	76	114	91	74
Mar 01	16	126	68	28	147	80	33	154	104	69	169	108	66
Apr 01	15	104	72	51	122	85	60	135	107	89	146	112	90
May 01	14	102	14	0	119	17	1	133	57	45	144	51	36
May 15	15	0	0	0	1	1	1	45	45	45	36	36	36

Preliminary estimates of the seasonal variation in snow cover at the Williams Creek snow survey sites, predicted on the basis of data from Mt. Nansen.

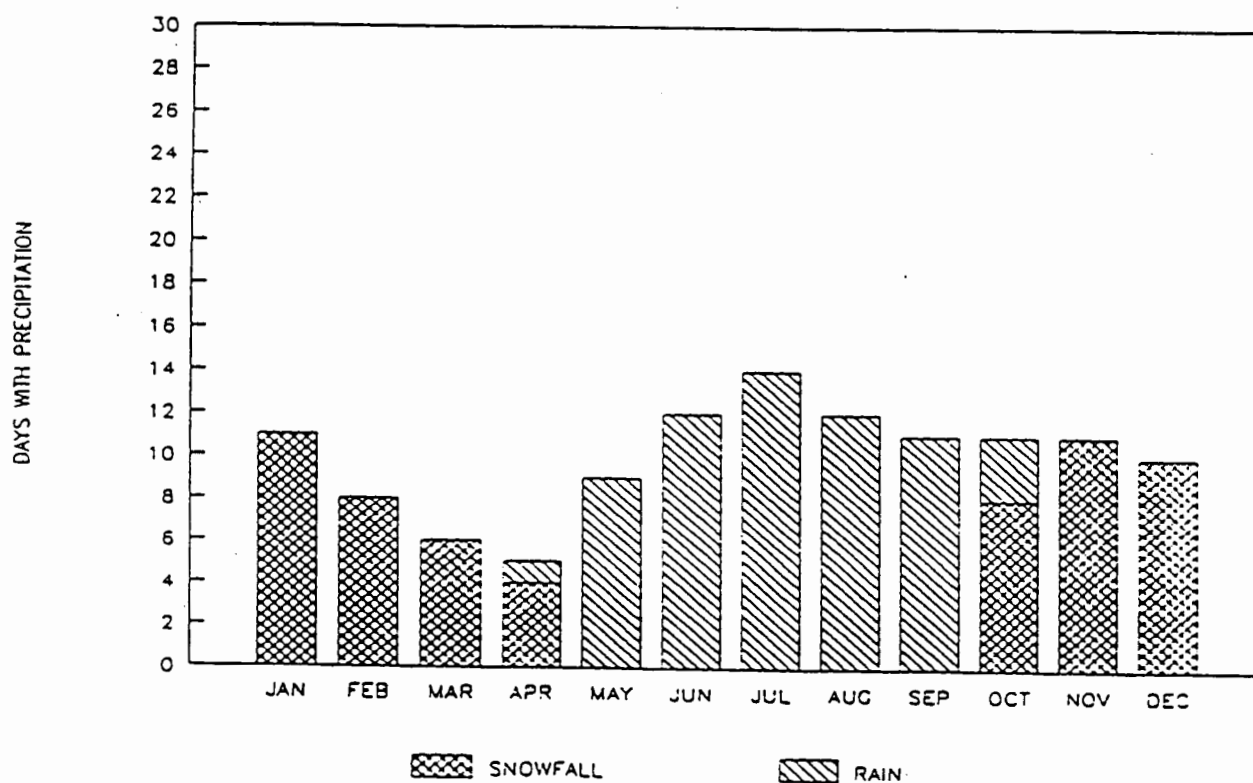
PARAMETER	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	DATA SOURCE
OBSERVED SUNSHINE (hrs)	7.0	90.0	171.7	230.4	270.4	278.2	270.2	239.4	142.4	77.8	15.9	7.7	1,801	AES 1982C. Normals for Pelly Ranch
DAYLIGHT HOURS	193.0	246.5	362.7	442.5	547.3	586.1	579.4	495.6	391.3	311.3	215.2	166.1	4,537	Russelo, Edey and Godfrey, 1974. Latitude 62°N
SOLAR RADIATION MJ/m ² /month	78.5	209.4	506.2	819.5	1,144.2	1,252.9	1,224.7	972.0	622.3	337.2	119.7	44.9	7,332	Russelo, Edey and Godfrey, 1974. Latitude 62°N
MEAN AIR TEMPERATURE (°C)	-28.0	-20.0	-11.0	0.0	7.5	13.0	15.0	12.5	5.0	-2.0	-15.5	-25.0	-49	Average Carmacks and Fort Selkirk. Table 2.3.2 this report
GROUND HEAT FLUX MJ/m ² /month	0	0	0	0	0	0	0	0	0	0	0	0	0	Assumed
ET mm/month	0	0	0	27.0	70.4	95.1	96.3	62.5	14.0	0	0	0	365	Calculated
LAKE EVAPORATION (mm/month)	0	0	4.2	42.9	98.3	129.4	131.1	89.1	25.9	0	0	0	521	Calculated
AVERAGE PRECIPITATION (mm/month)	18.9	13.6	8.8	8.3	21.5	35.1	53.2	37.0	28.0	21.1	21.1	18.4	285	Average Carmacks and Fort Selkirk. Table 2.3.3 this report
WATER BALANCE • ET (mm)	18.9	13.6	8.8	-18.8	-48.9	-60.0	-43.2	-25.5	14	21.1	21.1	18.4	-81	Calculated
• Lake (mm)	18.9	13.6	4.6	-34.6	-76.8	-94.3	-78.0	-52.1	2.1	21.1	21.1	18.4	-236	Calculated

Preliminary estimates of potential lake evaporation, evapotranspiration and water balance.

Figure 3.2.5



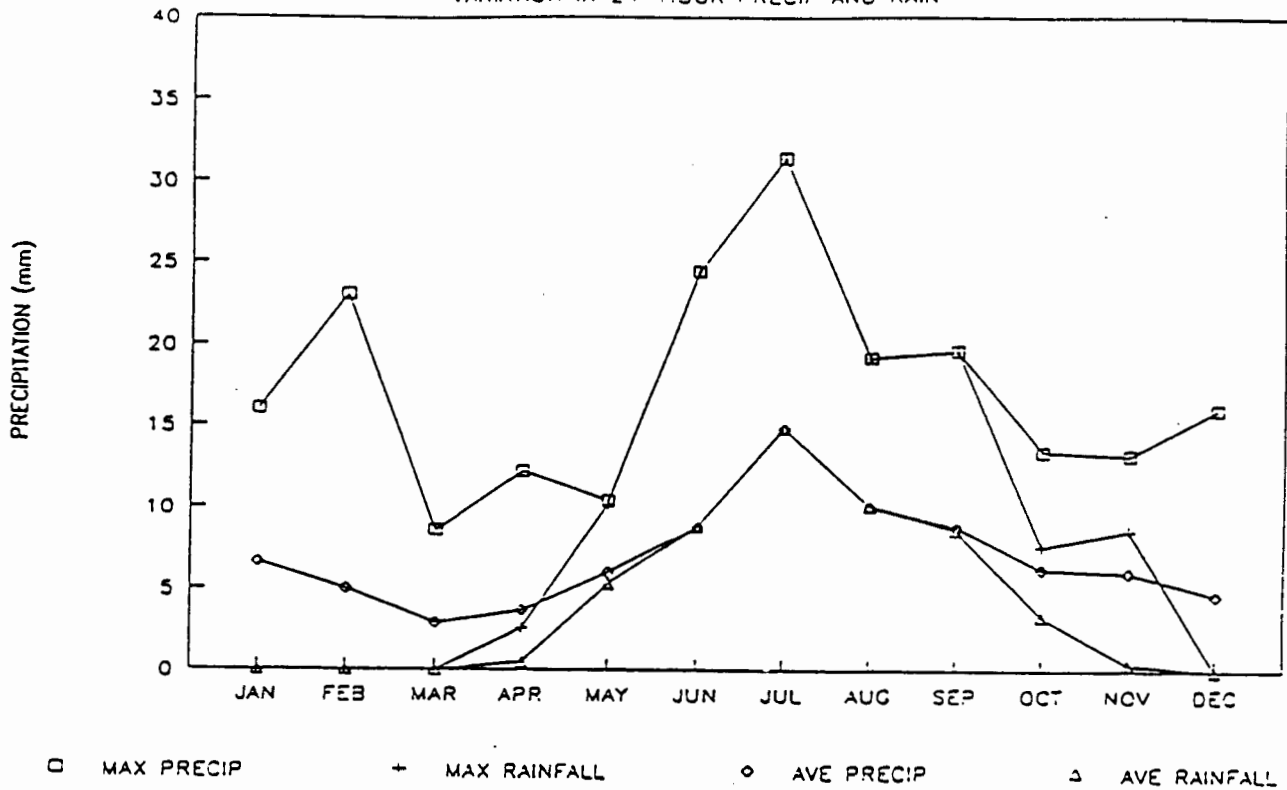
FORT SELKIRK, 1898-1990



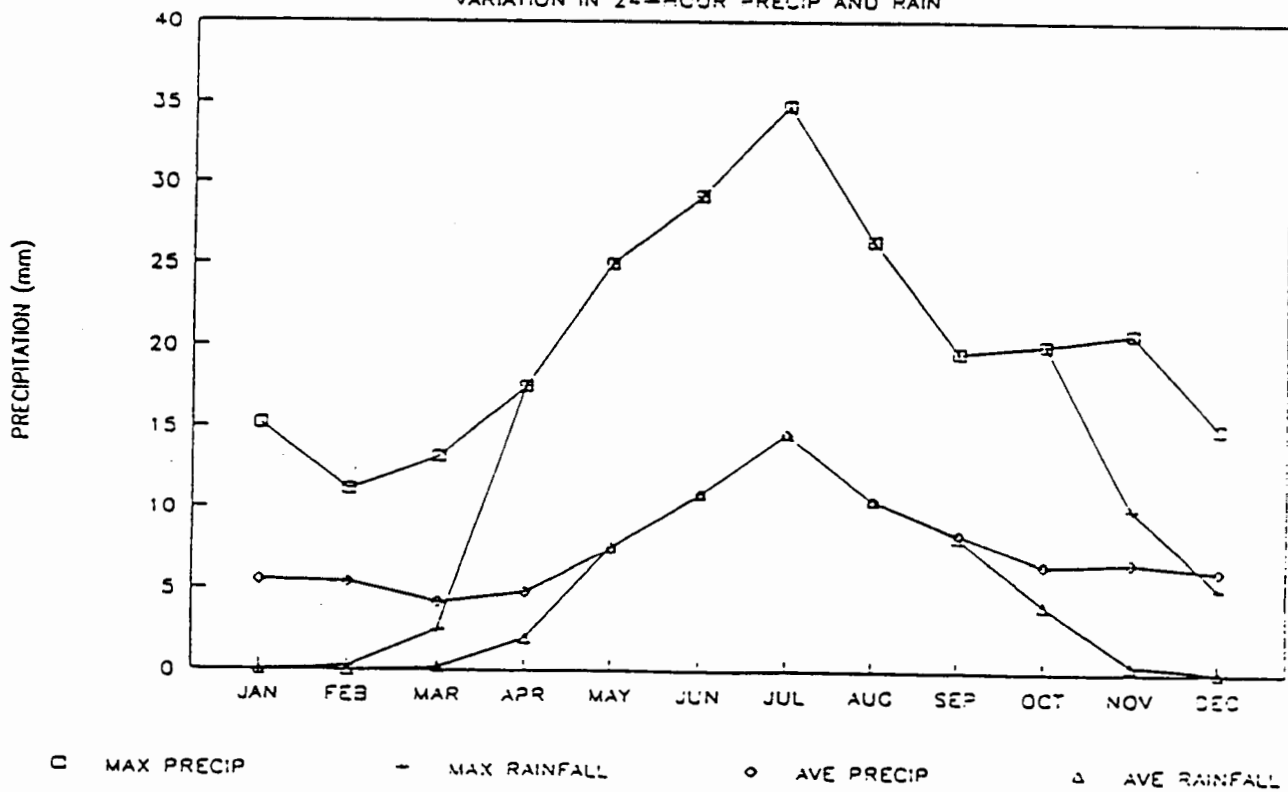
Seasonal variation in number of days with rainfall or snowfall at Carmacks and Fort Selkirk.

Figure 3.2.6

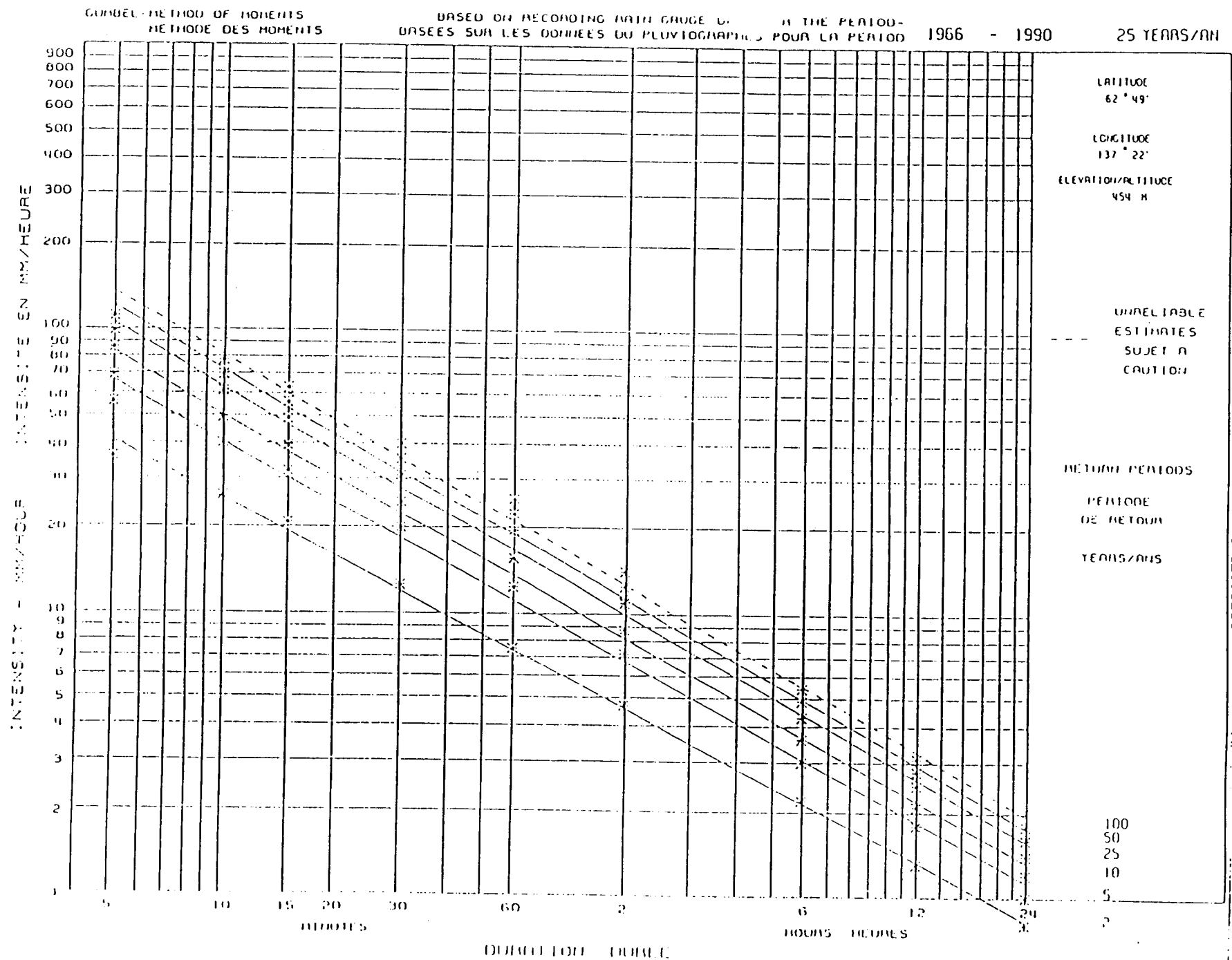
CARMACKS, 1963-1990
VARIATION IN 24-HOUR PRECIP AND RAIN



FORT SELKIRK, 1951-1990
VARIATION IN 24-HOUR PRECIP AND RAIN

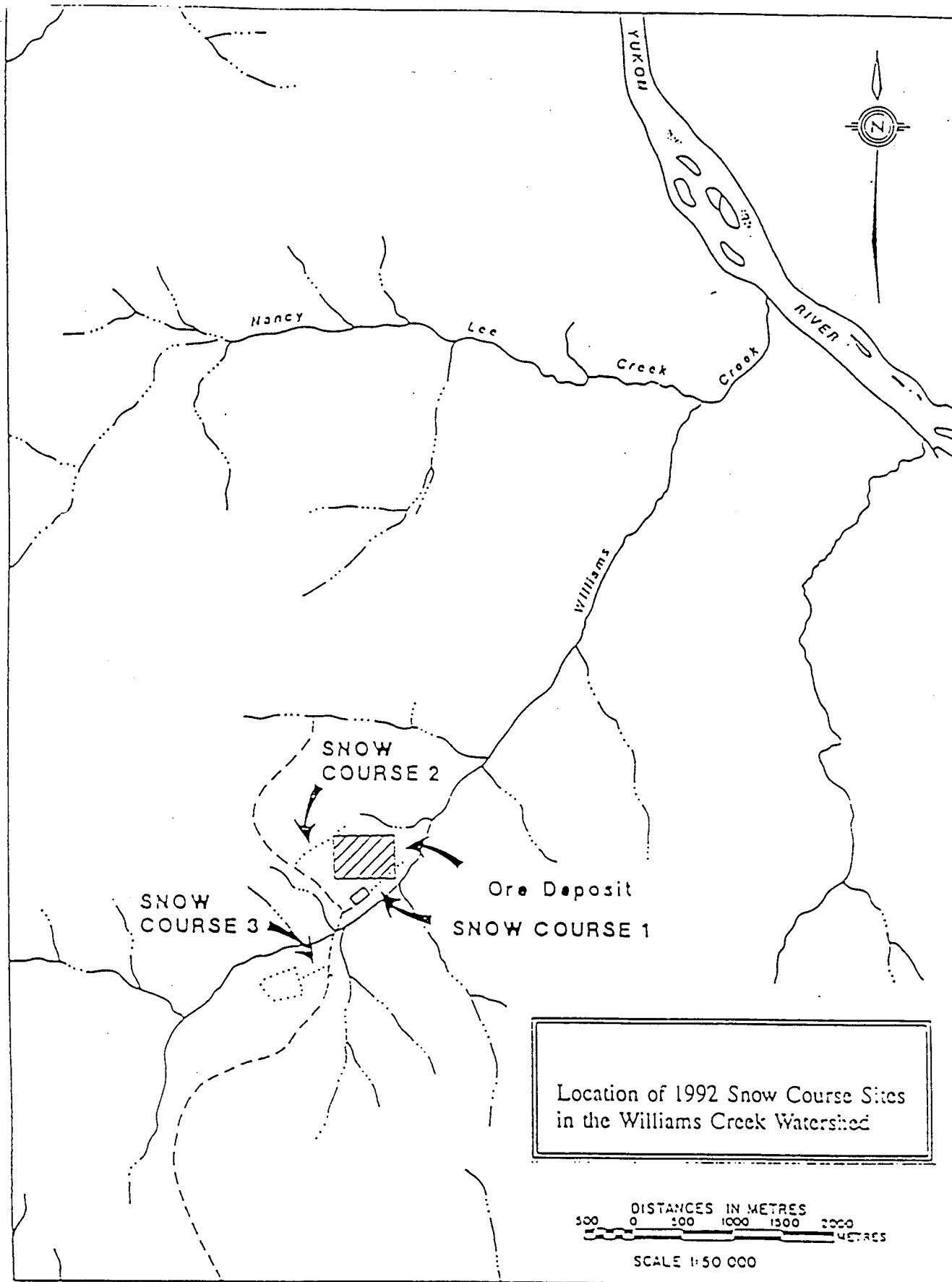


Seasonal variation in 24-hour rainfall and precipitation at Carmacks and Fort Selkirk.



Short-duration rainfall-intensity-duration frequency analysis for Pelly Ranch (Fort Selkirk).

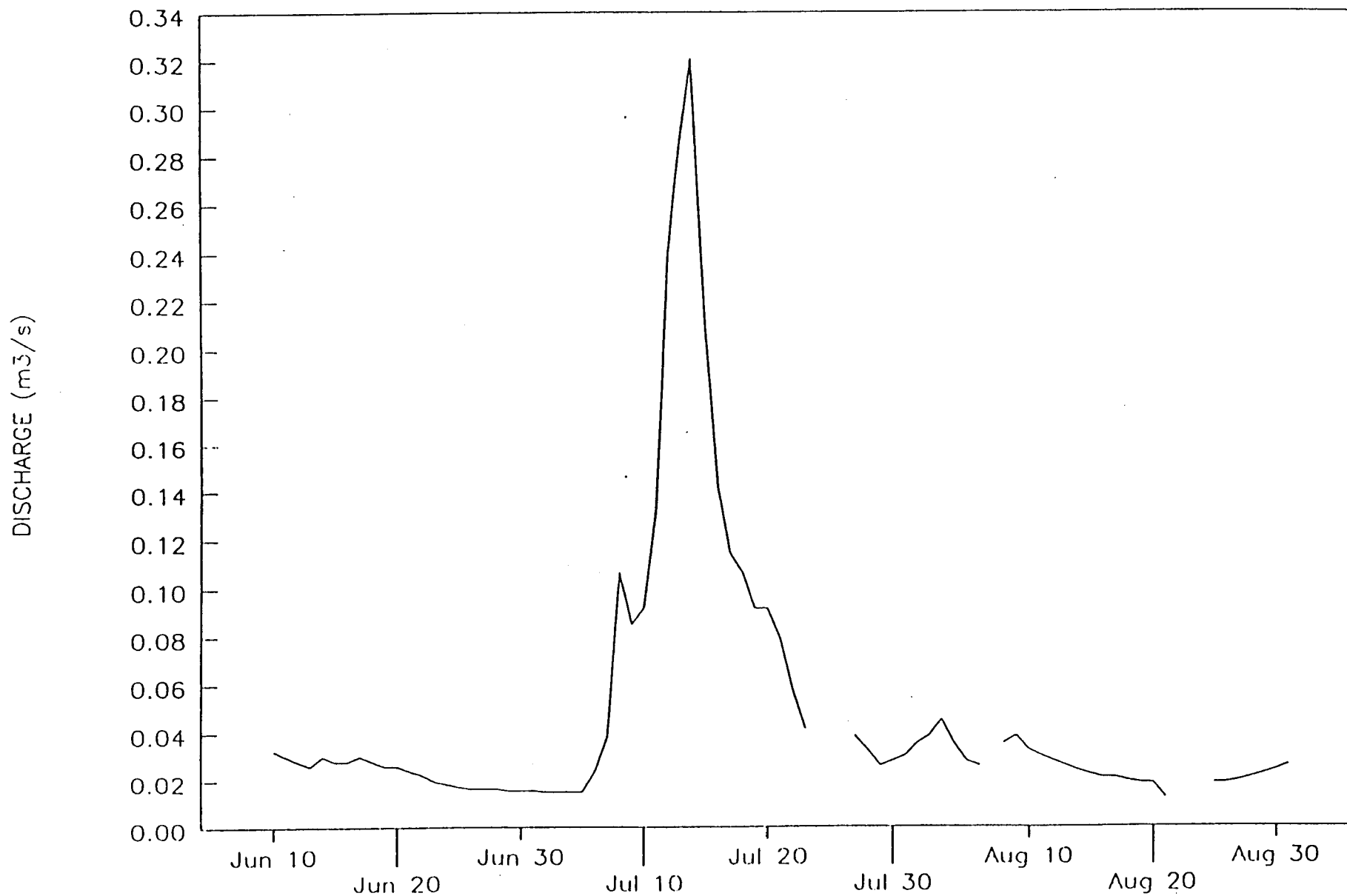
Figure 3.2.8



Location of 1992 snow course sites in the Williams Creek watershed.

WILLIAMS CREEK, 1992

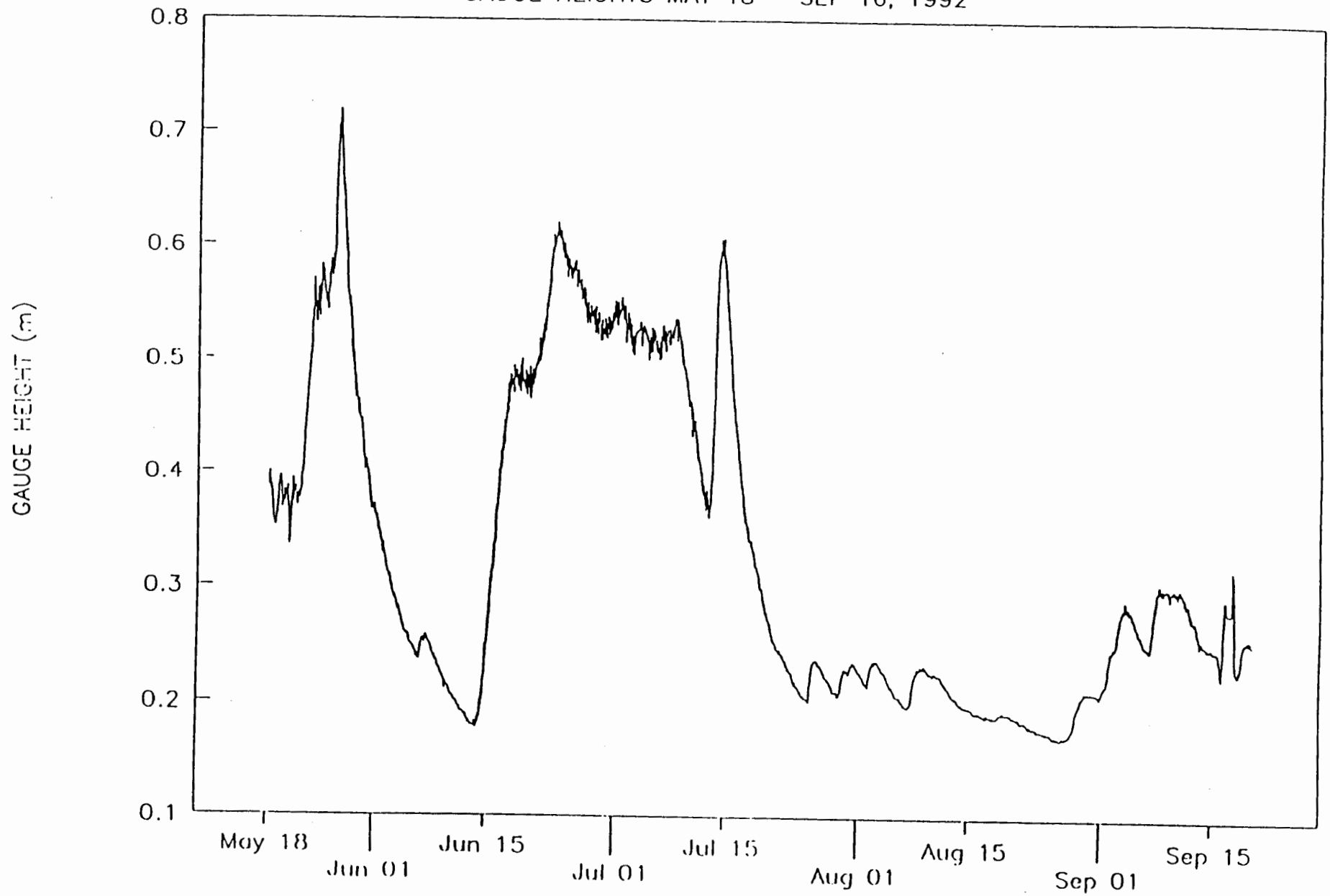
DISCHARGE UPSTREAM OF THE ORE BODY



1992 discharge, Williams Creek above the Ore Body (Site W-9)

WILLIAMS CREEK

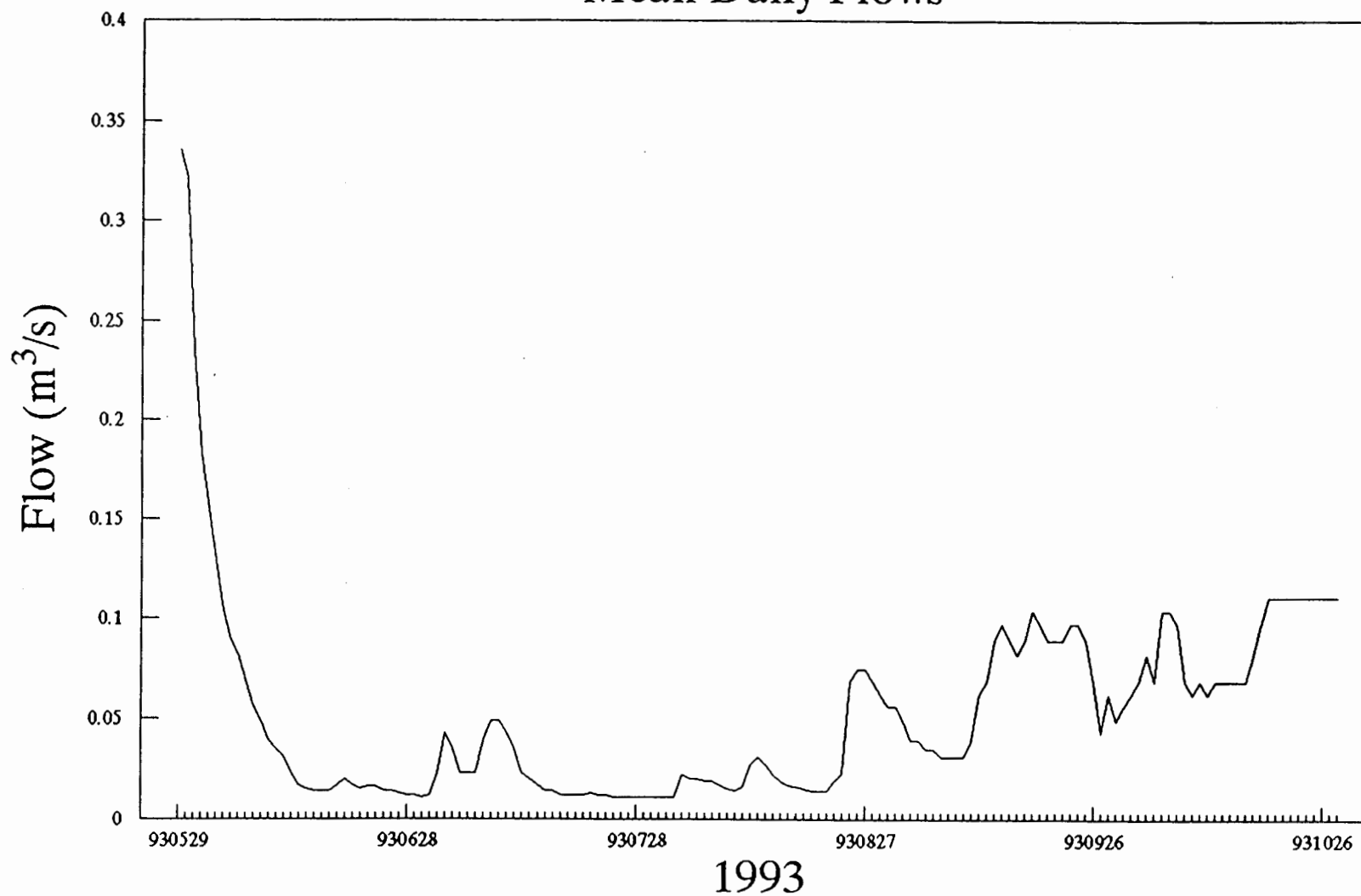
GAUGE HEIGHTS MAY 18 - SEP 16, 1992



1992 water level measurements on Williams Creek above Yukon River (Site W-10)

Williams Creek near Station W-4

Mean Daily Flows

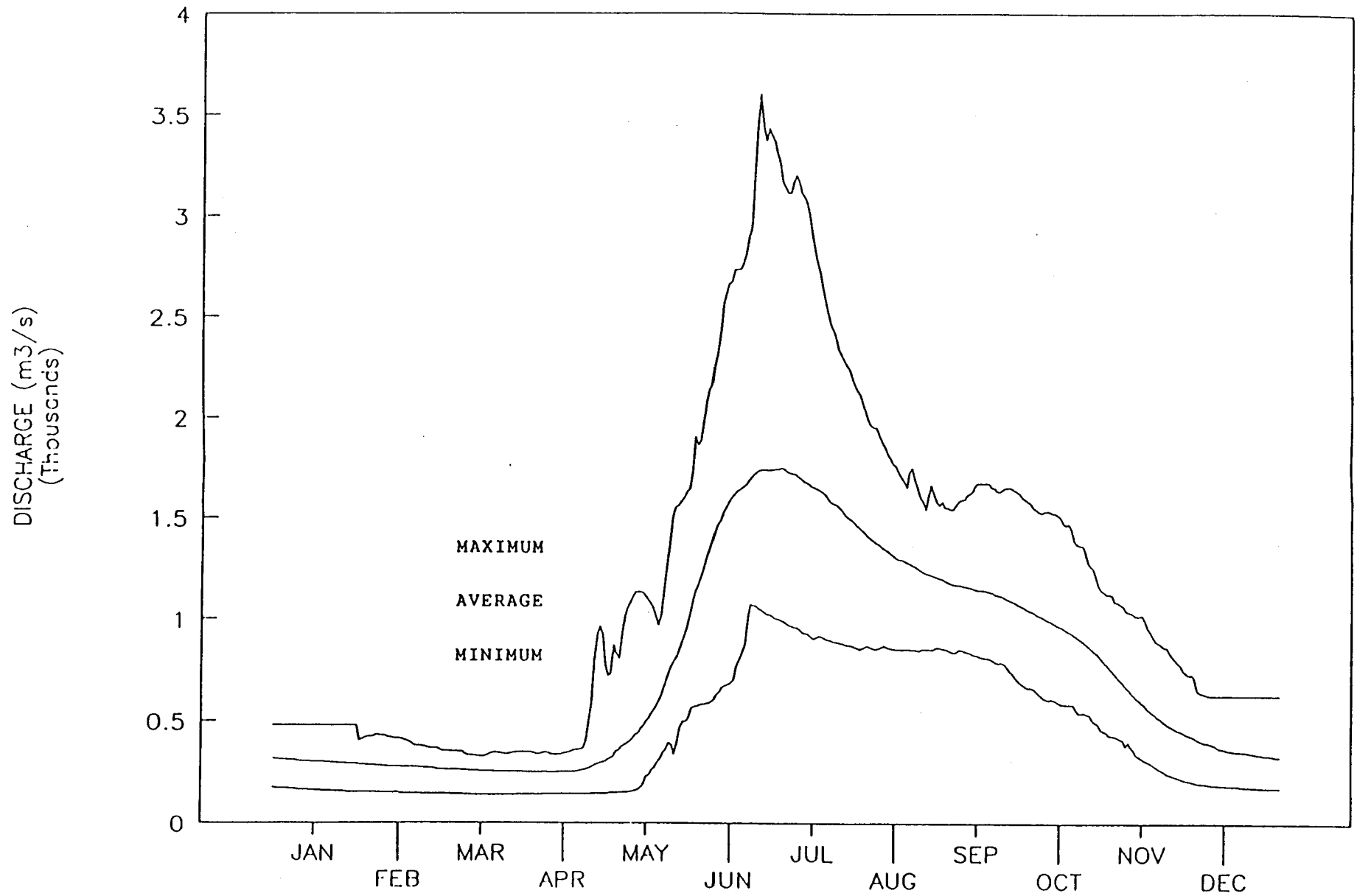


L:\HALLAMH1811\W4FLOW.WK3

Figure 3.4.4

YUKON RIVER AT CARMACKS

SEASONAL VARIATION IN FLOW, 1951-1991

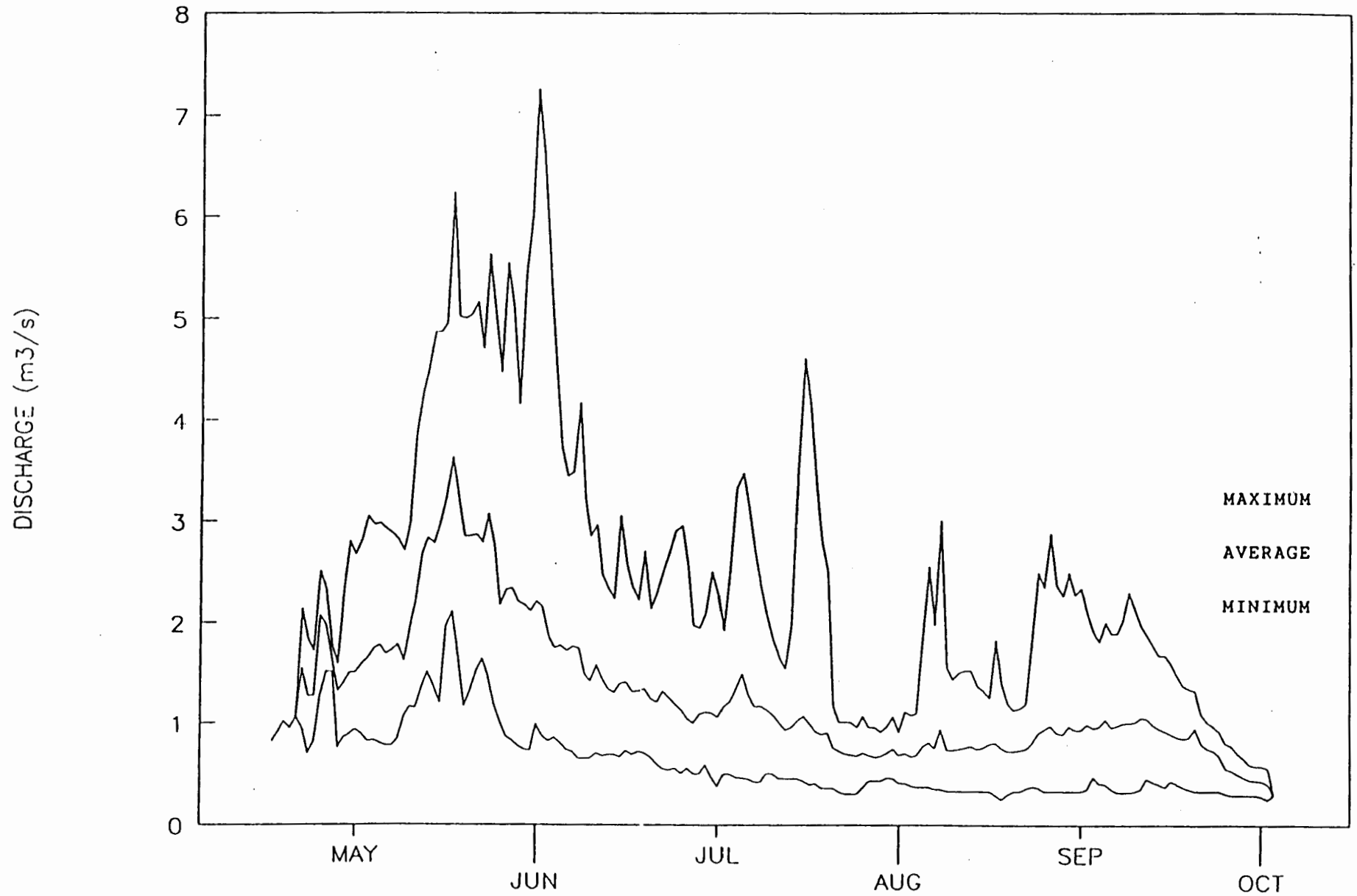


Seasonal variation in discharge, Yukon River at Carmacks.

Figure 3.4.6

VANGORDA CREEK AT FARO TOWNSITE ROAD

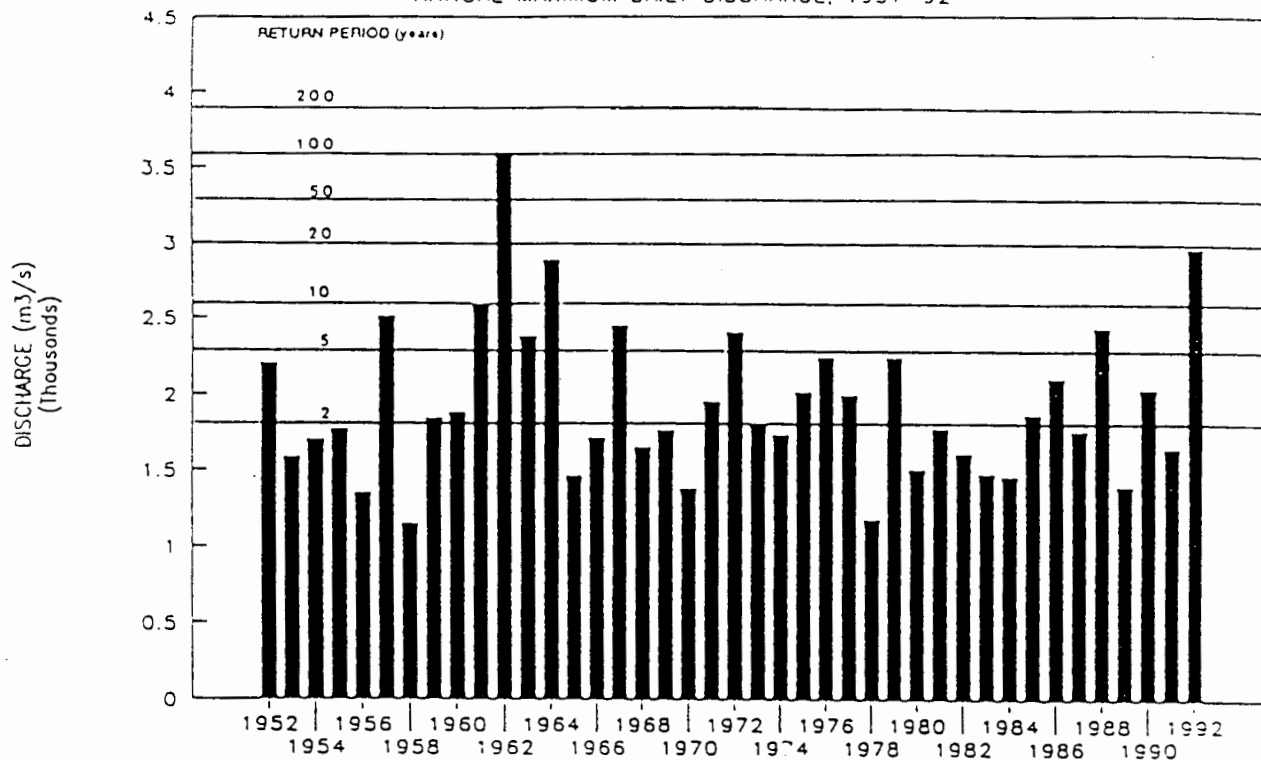
SEASONAL VARIATION IN FLOW, 1977 - 1992



Seasonal variation in discharge, Vangorda Creek near Faro Townsite Road.

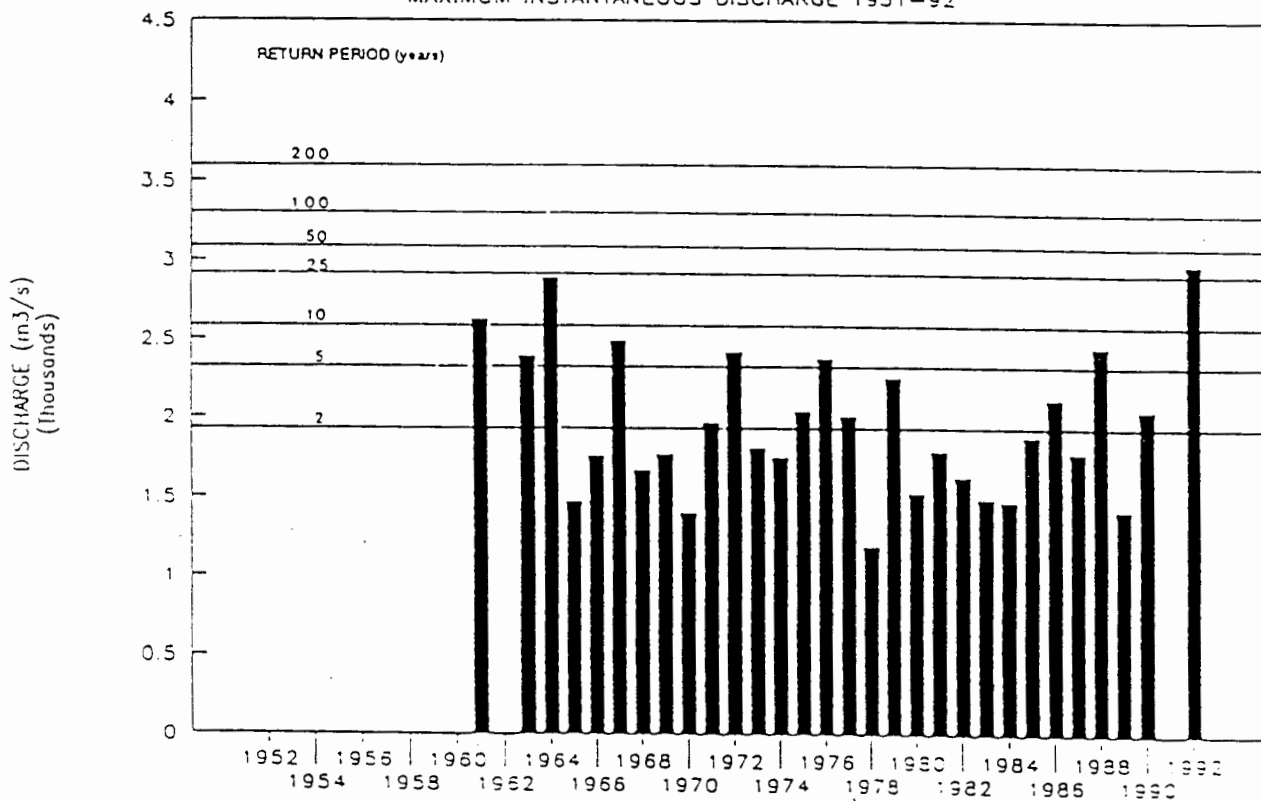
Figure 3.4.7 YUKON RIVER AT CARMACKS

ANNUAL MAXIMUM DAILY DISCHARGE, 1951-92



YUKON RIVER AT CARMACKS

MAXIMUM INSTANTANEOUS DISCHARGE 1951-92



Historical variation in annual maximum daily and instantaneous discharges, Yukon River at Carmacks.

DATE JUNE	PRECIPITATION		TEMPERATURE					
	WILLIAMS CREEK (mm)	CARMACKS (mm)	WILLIAMS CREEK			CARMACKS		
			MAXIMUM (oC)	MINIMUM (oC)	AVERAGE (oC)	MAXIMUM (oC)	MINIMUM (oC)	AVERAGE (oC)
1		4.8				17.5	3.0	10.3
2						19.0	2.0	10.5
3						19.5	5.0	12.3
4						17.0	5.0	11.0
5							7.0	7.0
6								
7						17.0		17.0
8						17.0	0.0	8.5
9			25.0	-2.0	12.0	21.0	1.0	11.0
10			25.0	-1.0	12.5	21.5	3.0	12.3
11			27.0	6.0	16.5	26.0	5.0	15.5
12	1.0		28.0	4.0	16.0		6.0	6.0
13	9.8		21.0	5.0	13.0			
14	1.0	6.2	23.0	5.0	14.0	28.0		29.0
15	2.0	trace	23.0	7.0	15.0	21.0	7.0	14.0
16		0.6	22.0	3.0	12.5	19.5	8.0	13.8
17	2.0		21.0	1.0	11.0	19.0	7.0	13.0
18			24.0	2.0	13.0	22.0	4.0	13.0
19			18.0	2.0	10.0		6.0	6.0
20	10.0		17.0	3.0	10.0			
21	18.0	2.4	15.0	2.0	8.5	20.5		20.5
22	2.0	1.2	20.0	-1.0	9.5	16.0	7.0	11.5
23	1.0	trace	14.0	0.0	7.0	18.5	8.0	13.3
24		1.4	21.0	-2.0	9.5	13.5	4.0	8.8
25	2.0	1.4	20.0	-2.0	9.0	17.0	3.0	10.0
26			22.0	-1.0	10.5		4.0	4.0
27			27.0	-1.0	13.0			
28			30.0	2.0	16.0	30.5		30.5
29			31.0	4.0	17.5	31.0	7.0	19.0
30			29.0	5.0	16.5		10.0	10.0
TOTAL	48.8	18.0						
MEAN			22.9	1.9	12.4	20.6	5.1	12.9

Preliminary Temperature and Precipitation Data-June, 1992

DATE JULY	PRECIPITATION		TEMPERATURE					
	WILLIAMS CREEK (mm)	CARMACKS (mm)	WILLIAMS CREEK			CARMACKS		
			MAXIMUM (oC)	MINIMUM (oC)	AVERAGE (oC)	MAXIMUM (oC)	MINIMUM (oC)	AVERAGE (oC)
1			29.0	8.0	18.5	29.0	13.0	21.0
2			28.0	9.0	18.5	29.0	14.0	21.5
3	6.0	2.0	21.0	8.0	14.5	29.0	13.0	21.0
4	1.0		22.0	8.0	15.0		13.0	13.0
5	10.0	7.0	21.0	7.0	14.0	21.0		21.0
6	14.0	17.4	22.0	6.0	14.0	16.5	12.0	14.3
7	2.0	5.2	21.0	7.0	14.0	17.0	12.0	14.5
8		trace	24.0	8.0	16.0	22.0	11.0	16.5
9	3.0		21.0	8.0	14.5	22.0	8.0	15.0
10	16.0		20.0	4.0	12.0		8.0	8.0
11	11.0		21.0	4.0	12.5			
12	4.0	8.2	20.0	6.0	13.0	25.0		25.0
13		14.0	18.0	8.0	13.0	13.0	10.0	11.5
14		0.5	18.0	8.0	13.0	18.0	10.0	14.0
15	2.0		22.0	4.0	13.0	19.0	9.0	13.5
16	3.0		23.0	3.0	13.0	19.5	6.0	12.8
17		trace	24.0	4.0	14.0	21.5	6.0	13.8
18			20.0	4.0	12.0	24.0	10.0	17.0
19		trace	21.0	5.0	13.0	21.0	10.0	15.5
20	3.0	1.4	20.0	2.0	11.0	20.0	8.0	14.0
21		3.0	22.0	3.0	12.5	19.5	9.0	14.3
22			21.0	2.0	11.5	21.0	8.0	14.5
23	4.0		20.0	4.0	12.0	23.0	8.0	15.5
24	6.0		21.0	4.0	12.5		9.0	9.0
25			23.0	5.0	14.0			
26		4.0	19.0	5.0	12.0	23.5		23.5
27	2.5	trace	20.0	1.0	10.5	18.5	6.0	12.3
28			22.0	3.0	12.5	21.0	6.0	13.5
29	2.0	2.8	23.0	4.0	13.5	18.0	6.0	12.0
30	4.0	2.8	22.0	3.0	12.5	16.5	7.0	11.8
31	10.0	0.4	23.0	5.0	14.0	23.5	9.0	16.3
TOTAL	103.5	68.7						
MEAN			21.7	5.2	13.4	21.2	9.3	15.4

Preliminary Temperature and Precipitation Data-July, 1992

DATE AUGUST	PRECIPITATION		TEMPERATURE					
	WILLIAMS CREEK (mm)	CARMACKS (mm)	WILLIAMS CREEK			CARMACKS		
			MAXIMUM (oC)	MINIMUM (oC)	AVERAGE (oC)	MAXIMUM (oC)	MINIMUM (oC)	AVERAGE (oC)
1	5.0		24.0	4.0	14.0	23.5		23.5
2		0.4	21.0	2.0	11.5	23.5		23.5
3			23.0	6.0	14.5	22.0	5.0	13.5
4			23.0	14.0	18.5	24.5	5.0	14.8
5	6.0		21.0	9.0	15.0	23.0	11.0	17.0
6		3.5		10.0	10.0	22.0	10.0	16.0
7	8.0		22.0		22.0		11.0	11.0
8	1.0		21.0	9.0	15.0			
9		9.0	20.0	8.0	14.0	22.0		22.0
10			22.0	6.0	14.0	23.0	12.0	17.5
11			20.6	6.0	13.3	22.0	8.0	15.0
12			18.0	5.0	11.5	21.0	8.0	14.5
13			11.0	6.0	8.5	20.0	6.0	13.0
14			11.0	0.0	5.5		6.0	6.0
15			12.0	0.0	6.0			
16			10.0	0.0	5.0			
17	30.0	3.0	14.0	0.0	7.0	19.5		19.5
18	2.0	1.2	14.0	2.0	8.0	14.0	3.0	8.5
19			19.0	2.0	10.5	17.0	5.0	11.0
20			18.0	-1.0	8.5	19.5	5.0	12.3
21			20.0	1.0	10.5		0.0	0.0
22			21.0	1.0	11.0			
23			19.0	7.0	13.0	23.0		23.0
24			18.0	11.5	14.8	20.0	0.0	10.0
25	4.0		17.0	13.0	15.0	18.0	10.0	14.0
26	14.0	trace	14.0	3.0	8.5	18.0	6.0	12.0
27	46.0	2.8	12.0	5.0	8.5	18.0	3.0	10.5
28	3.0		13.0	7.0	10.0		3.0	3.0
29			16.0	-2.0	7.0			
30	24.0		12.0	3.0	7.5	16.0		16.0
31		8.0		5.0	5.0	17.0	0.0	8.5
TOTAL	143.0	27.9						
MEAN			17.5	4.7	11.1	20.3	5.9	13.7

Preliminary Temperature and Precipitation Data-August, 1992

A: CARMACKS

MONTH	EXTREME MINIMUM TEMP (oC)	MEAN MONTHLY MINIMUM (oC)	MEAN MONTHLY TEMP (oC)	MEAN MONTHLY MAXIMUM (oC)	EXTREME MAXIMUM TEMP (oC)
JAN	-58.9	-33.9	-28.5	-23.1	10.0
FEB	-60.0	-29.3	-21.9	-14.5	12.2
MAR	-50.0	-21.7	-12.4	-3.1	12.8
APR	-38.3	-7.7	-0.3	7	23.3
MAY	-12.2	0.2	7.5	14.7	32.5
JUN	-3.5	5.3	12.9	20.5	35.0
JUL	-2.8	7.7	15.0	22.3	32.5
AUG	-7.0	5.0	12.4	19.8	33.0
SEP	-20.0	-0.3	6.4	13.1	25.6
OCT	-37.0	-7.7	-2.8	2.1	20.0
NOV	-51.0	-21.1	-16.2	-11.5	14.0
DEC	-56.7	-30.8	-25.7	-20.5	12.8

B: PELLY RANCH/FORT SELKIRK

MONTH	EXTREME MINIMUM TEMP (oC)	MEAN MONTHLY MINIMUM (oC)	MEAN MONTHLY TEMP (oC)	MEAN MONTHLY MAXIMUM (oC)	EXTREME MAXIMUM TEMP (oC)
JAN	-57.8	-31.2	-27.3	-21.3	6.0
FEB	-57.2	-25	-19.1	-12.2	12.8
MAR	-50	-17.9	-10.1	-1.5	14.4
APR	-32	-6.6	0.3	7.4	23.3
MAY	-12.2	-0.1	7.3	14.7	35.0
JUN	-3.9	5.3	13.0	20.3	35.0
JUL	-1.1	7.7	15.1	22.2	31.7
AUG	-5	5.2	12.6	19.8	31.1
SEP	-16.5	0.3	3.9	13.4	26.7
OCT	-32.5	-6.1	-1.9	2.9	19.3
NOV	-46.7	-18.2	-14.7	-10.4	12.8
DEC	-54.4	-27.9	-24.4	-19.5	5.6

NOTE: Data from AES computer files for the period up to 1990

Seasonal variation in temperature at Carmacks and Fort Selkirk.

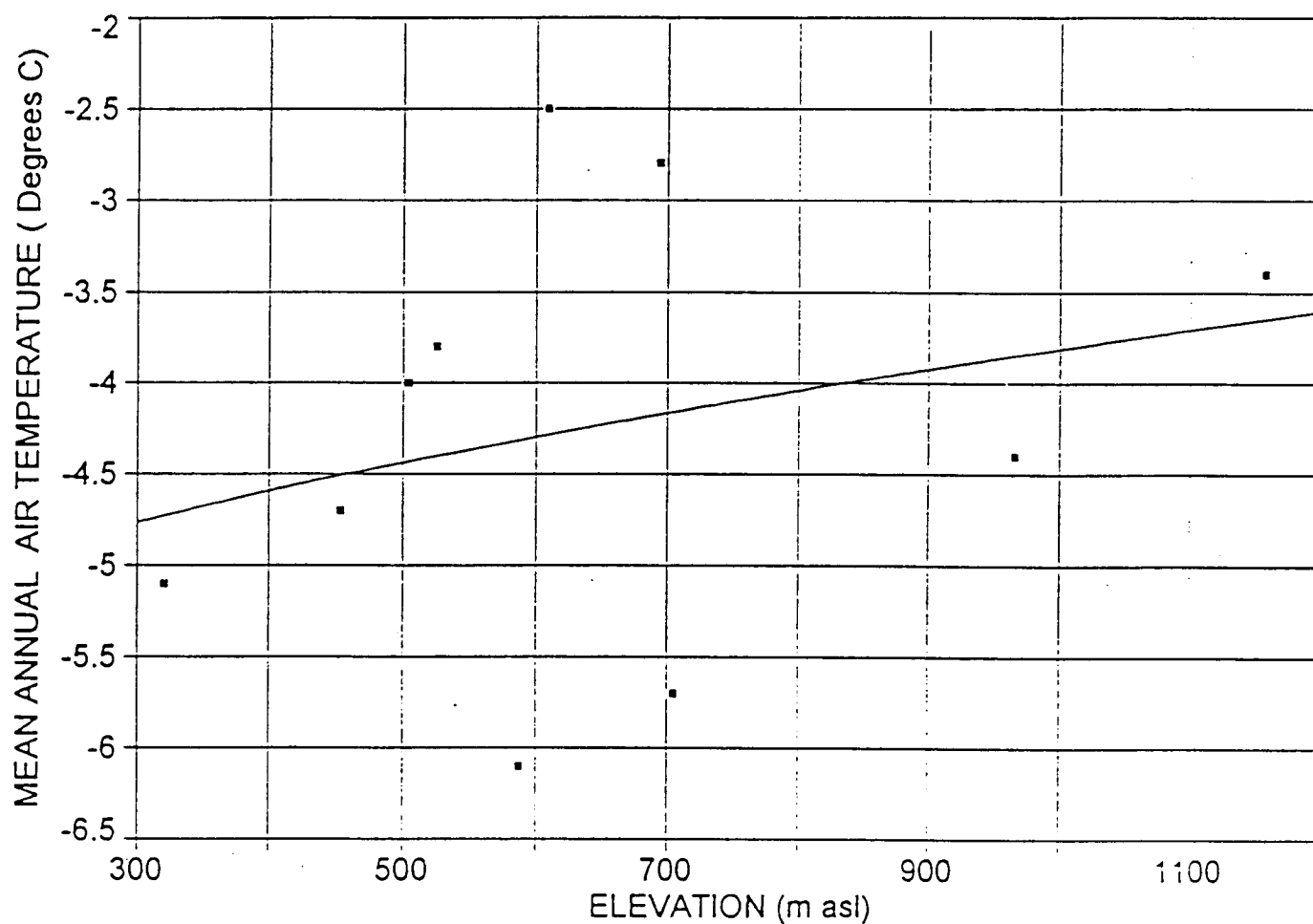
MEAN ANNUAL AIR TEMPERATURE AS FUNCTION OF ELEVATION

Rank 12 Eqn 8010 $y=a+bx^c$ [Power]

$r^2=0.0718204499$ DF Adj $r^2=0$ FitStdErr=1.29384625 Fstat=0.270822143

$a=-5.761413$ $b=0.041136844$

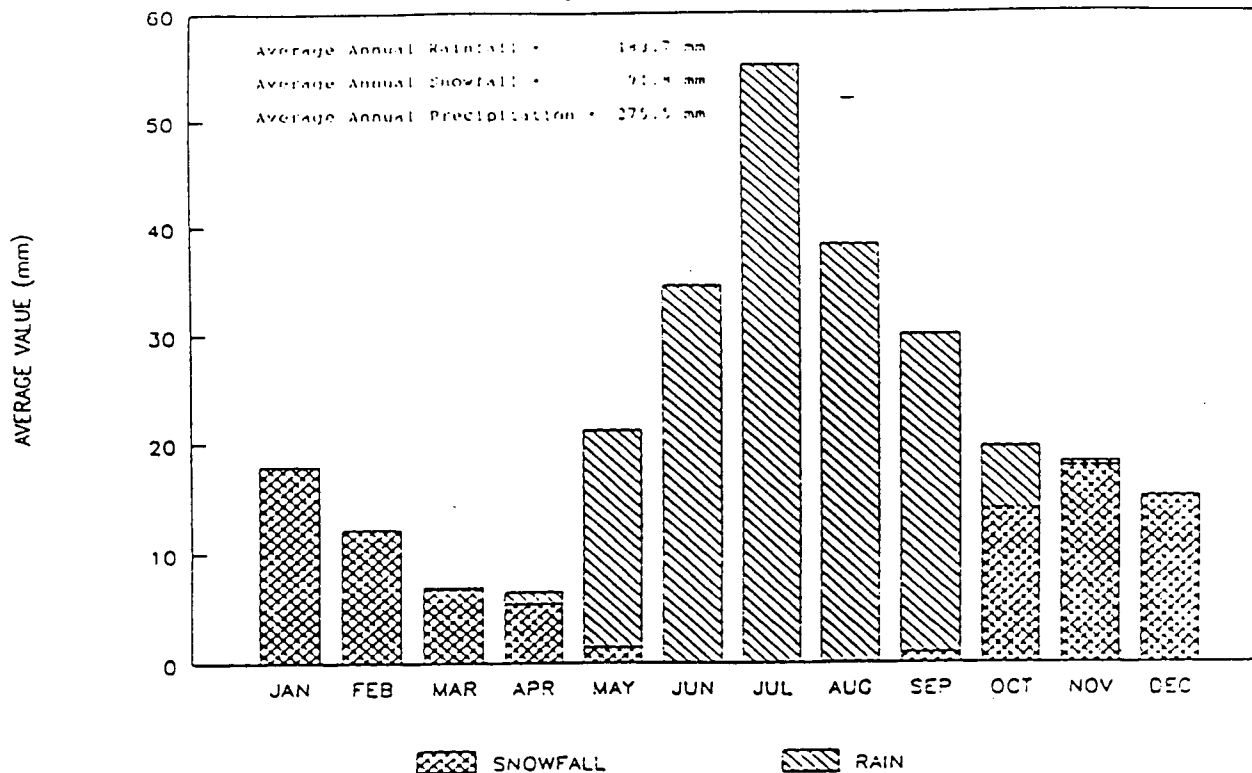
$c=0.55846191$



Mean annual air temperature as a function of elevation.

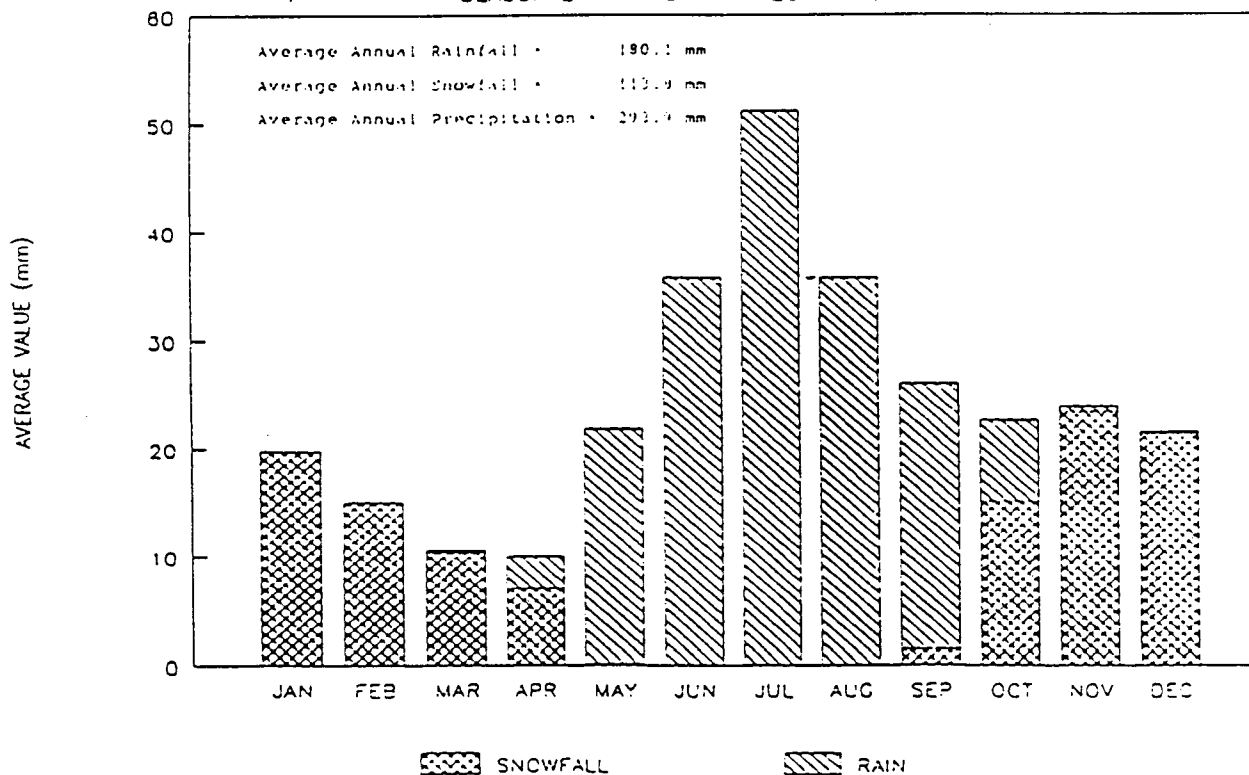
CARMACKS, 1903-1990

SEASONAL VARIATION IN PRECIPITATION



FORT SELKIRK, 1951-1990

SEASONAL VARIATION IN PRECIPITATION



Seasonal variation in precipitation at Carmacks and Fort Selkirk air temperature as a function of elevation.

A: CARMACKS

MONTH	TOTAL RAINFALL (mm)	TOTAL SNOWFALL (mm)	TOTAL PRECIPITATION (mm)
JAN	0.0	17.9	17.9
FEB	0.0	12.2	12.2
MAR	0.2	6.8	7.0
APR	1.1	5.4	6.5
MAY	19.7	1.5	21.2
JUN	34.5	0.0	34.5
JUL	55.1	0.0	55.1
AUG	38.2	0.1	38.3
SEP	28.9	1.0	29.9
OCT	5.6	14.0	19.6
NOV	0.4	17.8	18.2
DEC	0.0	15.1	15.1
TOTAL	183.7	91.8	275.5

B: FORT SELKIRK

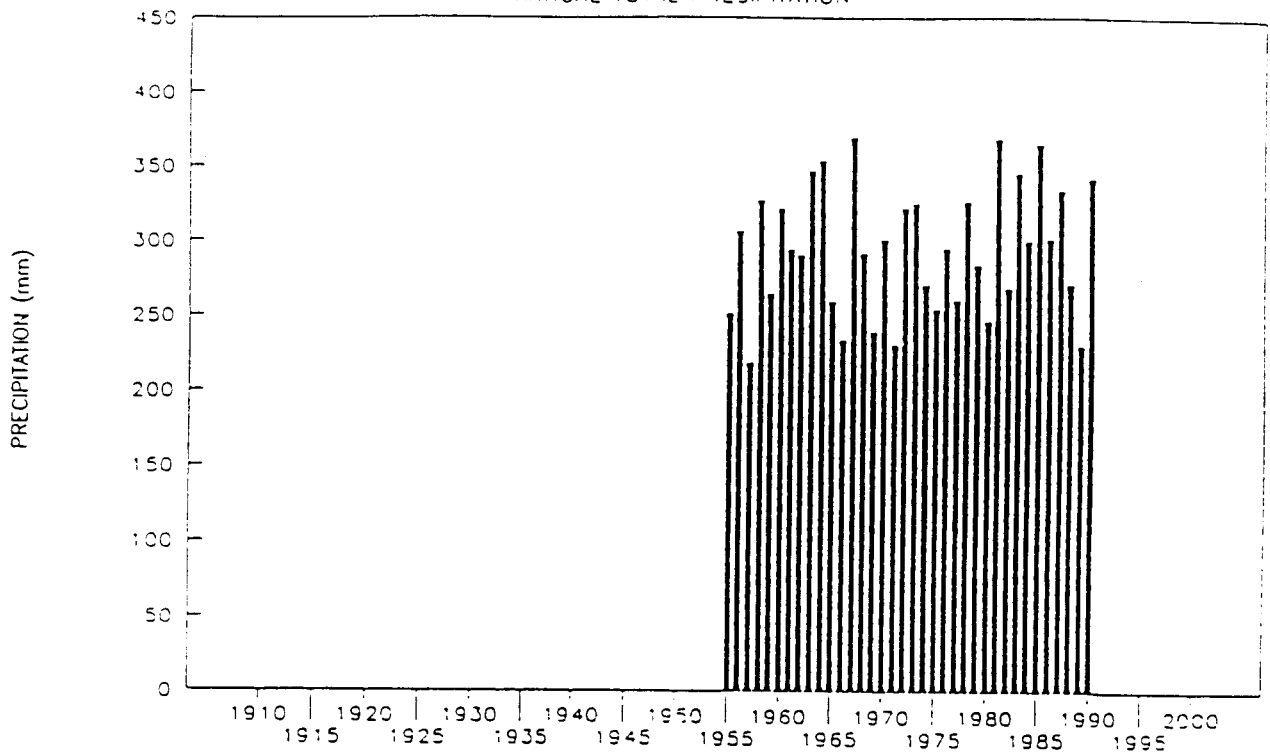
MONTH	TOTAL RAINFALL (mm)	TOTAL SNOWFALL (mm)	TOTAL PRECIPITATION (mm)
JAN	0.0	19.8	19.8
FEB	0.0	15.0	15.0
MAR	0.2	10.4	10.6
APR	3.0	7.0	10.0
MAY	21.6	0.2	21.8
JUN	35.7	0.0	35.7
JUL	51.2	0.0	51.2
AUG	35.7	0.0	35.7
SEP	24.6	1.4	26.0
OCT	7.5	15.1	22.6
NOV	0.5	23.4	23.9
DEC	0.1	21.5	21.6
TOTAL	180.1	113.8	293.9

Data from AES computer listing for period of record up to 1990

Seasonal variation in precipitation at Carmacks and Fort Selkirk

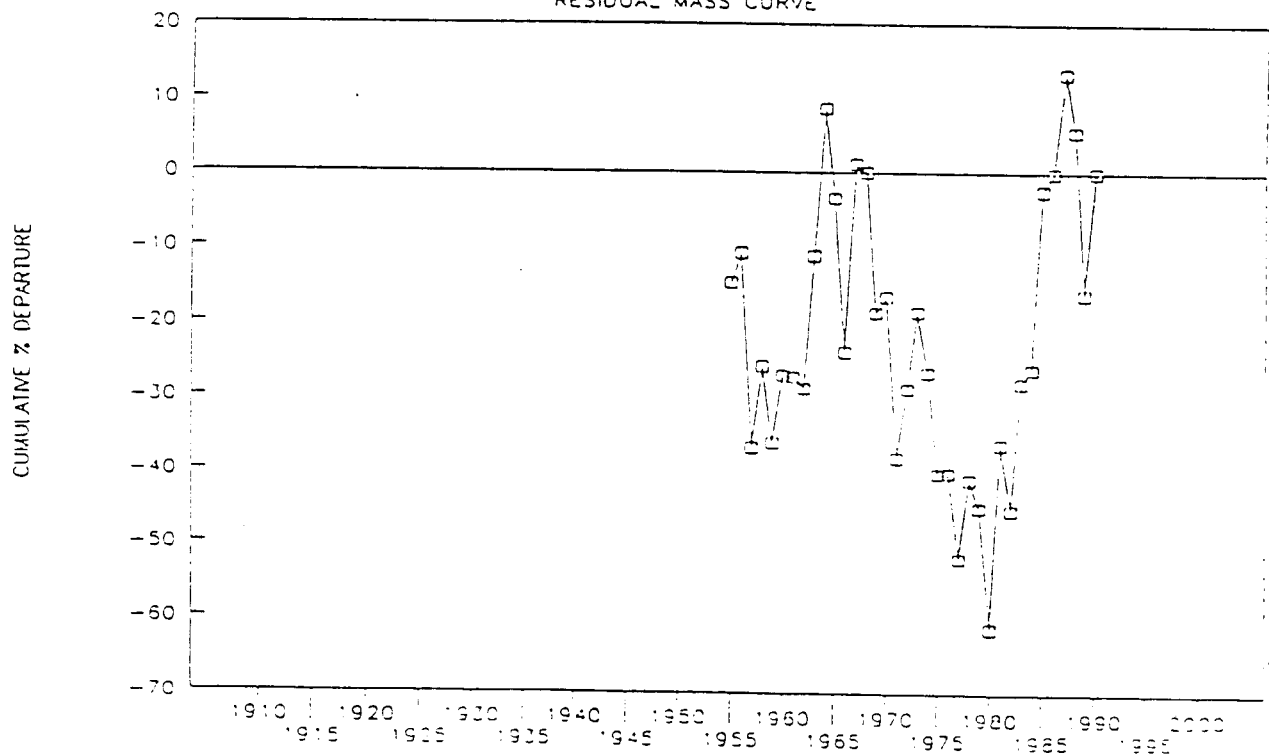
FORT SELKIRK, 1951-1990

ANNUAL TOTAL PRECIPITATION



FORT SELKIRK, 1951-1990

RESIDUAL MASS CURVE



Historical variation in annual total precipitation at Carmacks and Fort Selkirk.

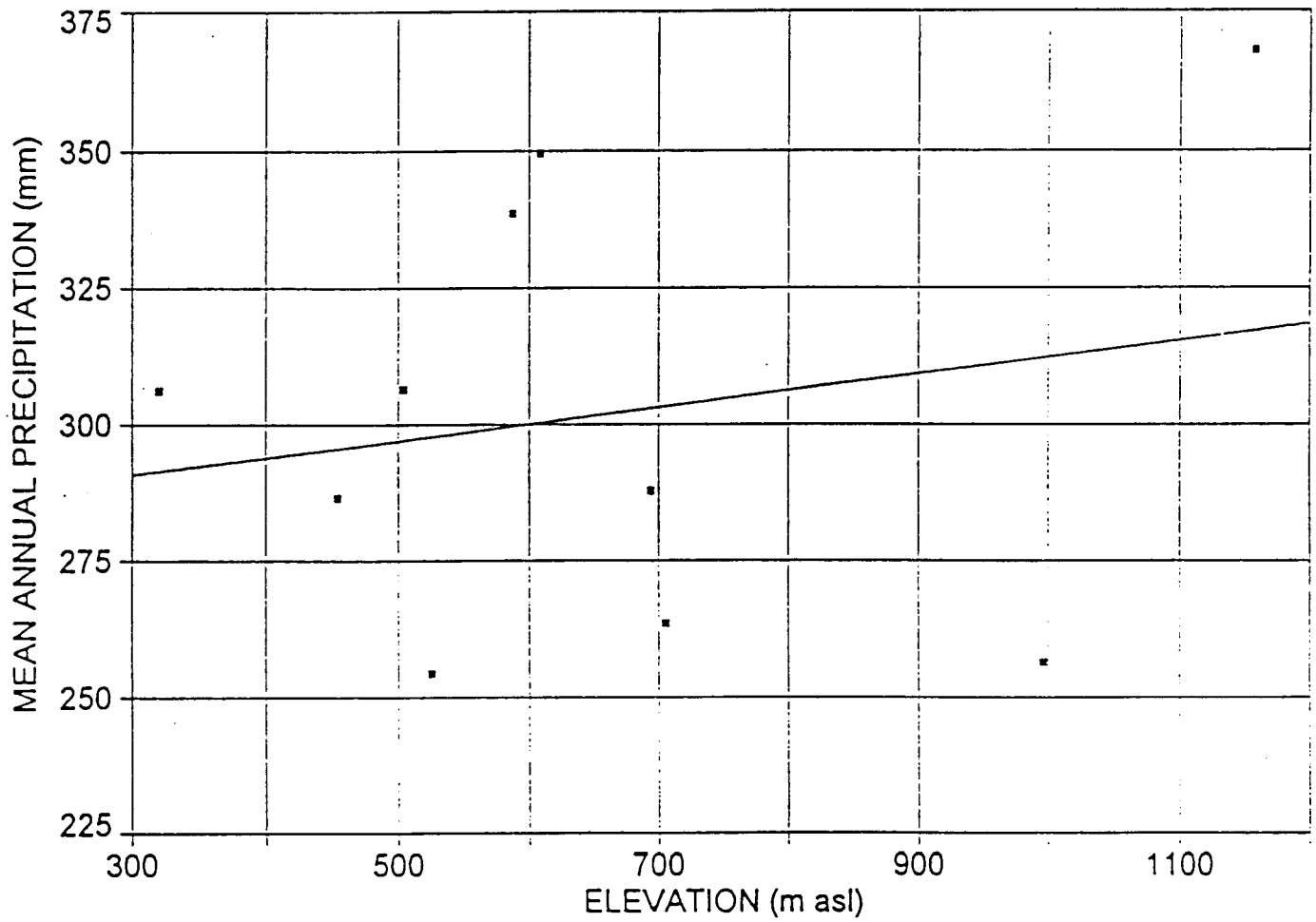
MEAN ANNUAL PRECIPITATION AS FUNCTION OF ELEVATION

Rank 17 Eqn 1 $y=a+bx$

$r^2=0.0381913028$ DF Adj $r^2=0$ FitStdErr=41.3521948 Fstat=0.317662362

$a=281.43568$

$b=0.030806342$



Mean annual precipitation as a function of elevation.

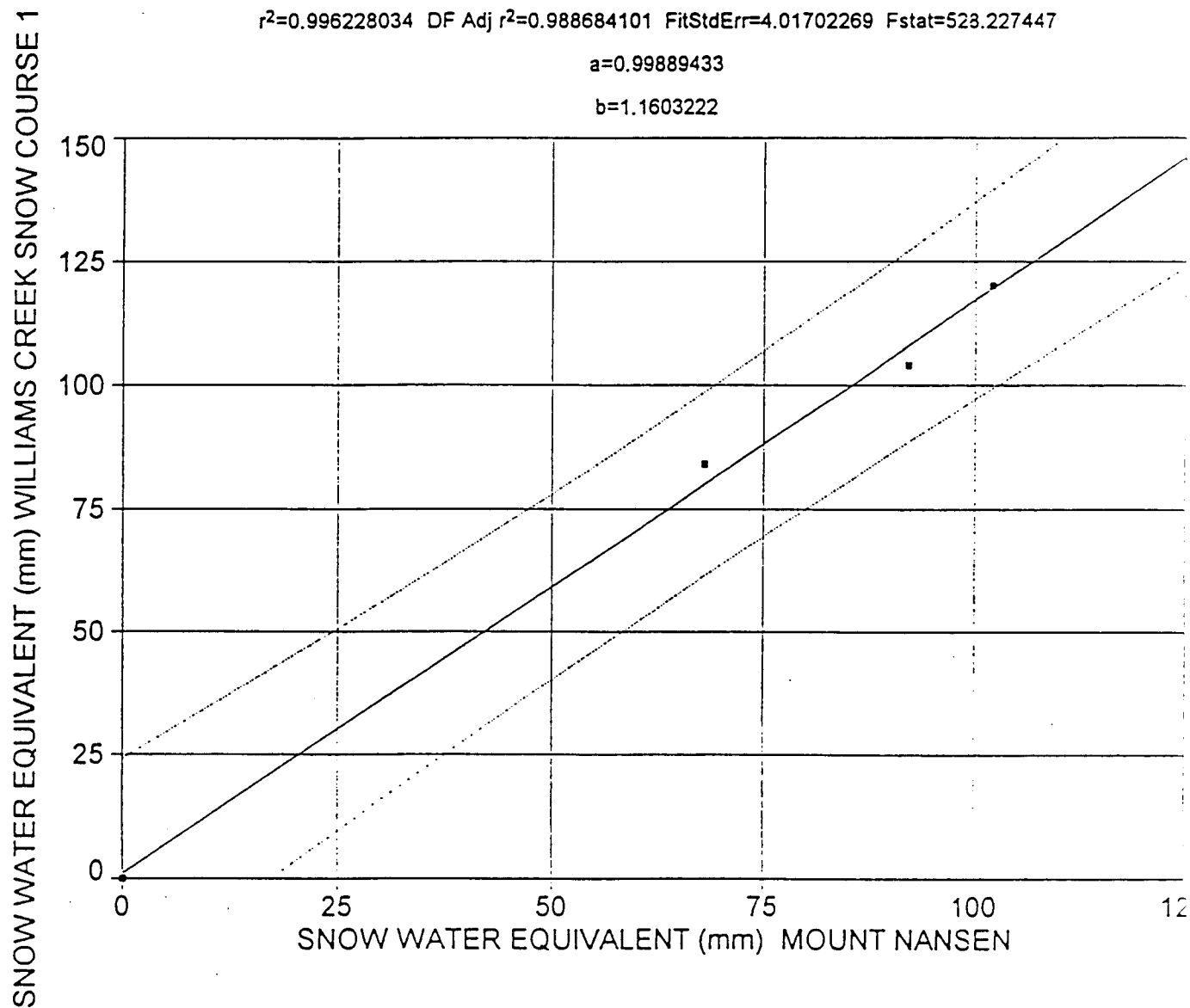
MOUNT NANSEN VERSUS WILLIAMS CREEK SNOW COURSE 1

Rank 4 Eqn 1 $y=a+bx$

$r^2=0.996228034$ DF Adj $r^2=0.988684101$ FitStdErr=4.01702269 Fstat=528.227447

$a=0.99889433$

$b=1.1603222$



Relationship between snow cover at Williams Creek
Snow Course 1 and Mount Nansen.

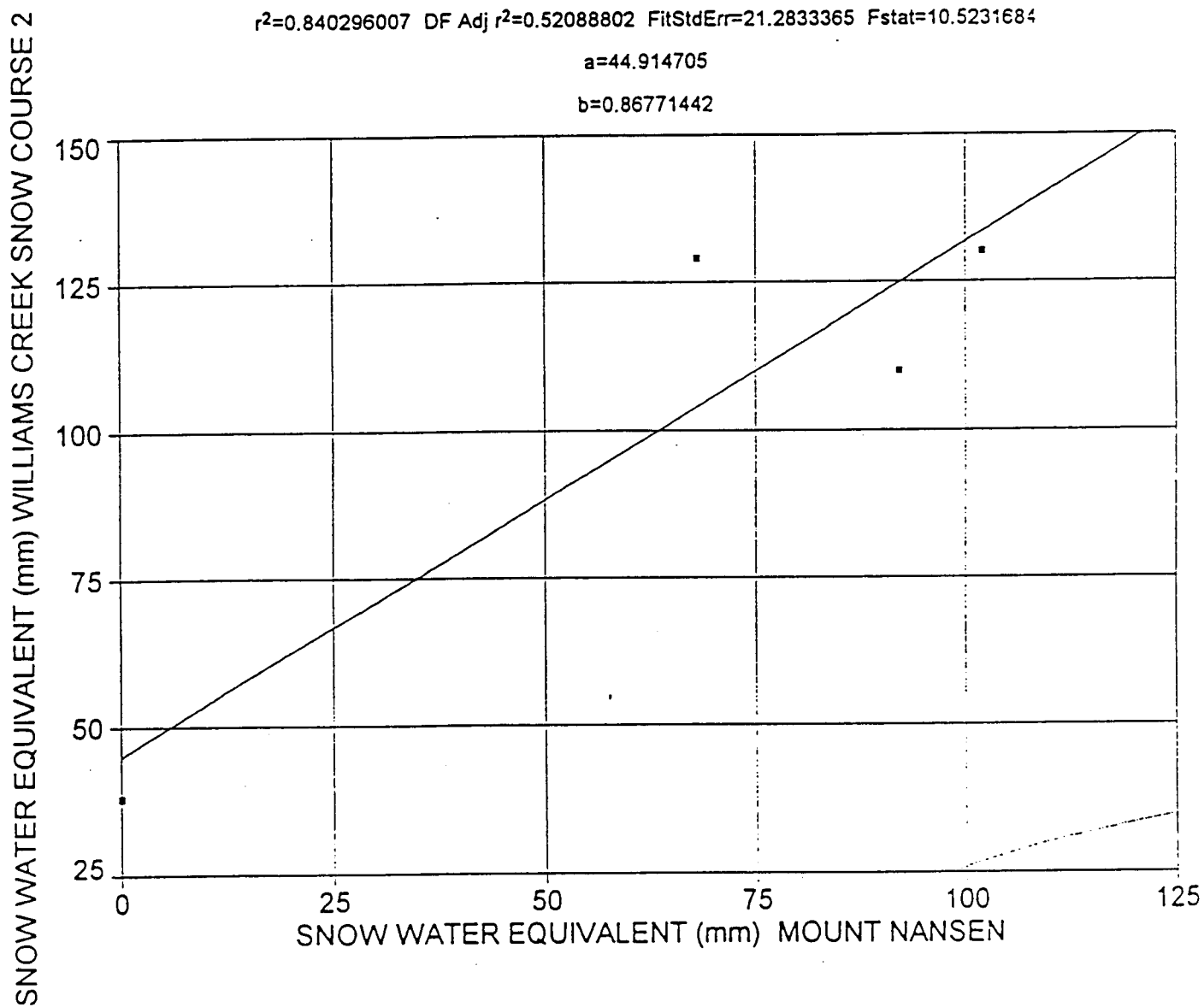
MOUNT NANSEN VERSUS WILLIAMS CREEK SNOW COURSE 2

Rank 23 Eqn 1 $y=a+bx$

$r^2=0.840296007$ DF Adj $r^2=0.52088802$ FitStdErr=21.2833365 Fstat=10.5231684

$a=44.914705$

$b=0.86771442$



Relationship between snow cover at Williams Creek
Snow Course 2 and Mount Nansen.

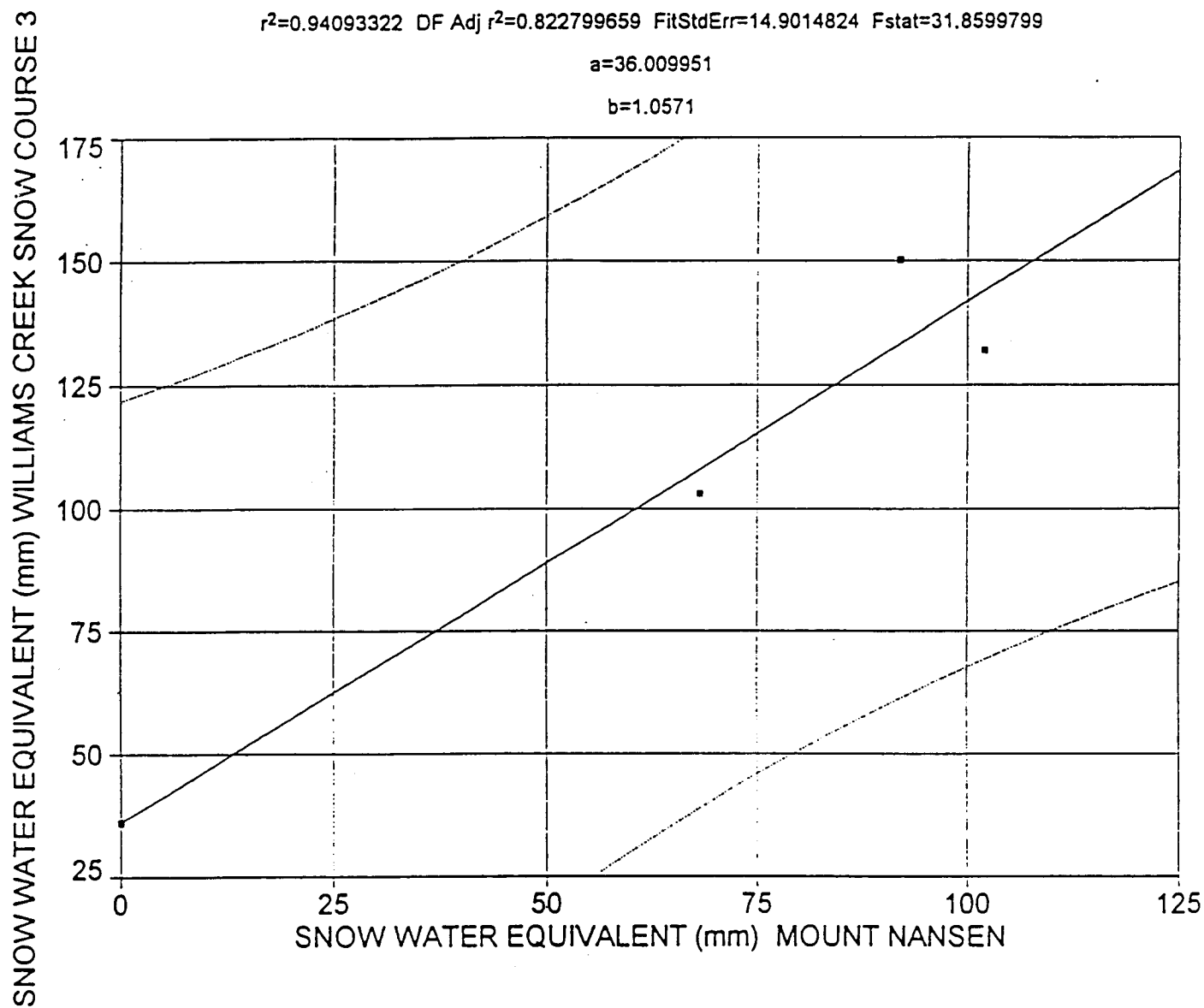
MOUNT NANSEN VERSUS WILLIAMS CREEK SNOW COURSE 3

Rank 3 Eqn 1 $y=a+bx$

$r^2=0.94093322$ DF Adj $r^2=0.822799659$ FitStdErr=14.9014824 Fstat=31.8599799

$a=36.009951$

$b=1.0571$



Relationship between snow cover at Williams Creek Snow Course 3 and Mount Nansen.

Appendix V.B

1992 and 1994 Temperature, Precipitation and Snow Pack Data

Obtained from the IEE Addendum #2 "Report on Preliminary Design" (May,
1995)

TABLE 2.1
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
1992 JUNE TEMPERATURE (°C)

June	Pelly Ranch	Carmacks	Site
1	11.8	10.3	
2	12.0	10.5	
3	13.3	12.3	
4	10.8	11.0	
5	10.0	7.0	
6	9.3	M	
7	8.5	17.0	
8	7.3	8.5	
9	9.8	11.0	12.0
10	13.3	12.3	12.5
11	14.0	15.5	16.5
12	15.8	6.0	16.0
13	17.8	M	13.0
14	14.8	28.0	14.0
15	15.0	14.0	15.0
16	14.8	13.8	12.5
17	10.5	13.0	11.0
18	13.8	13.0	13.0
19	14.5	6.0	10.0
20	14.5	M	10.0
21	14.3	20.5	8.5
22	13.5	11.5	9.5
23	12.5	13.3	7.0
24	8.5	8.8	9.5
25	10.5	10.0	9.0
26	14.3	4.0	10.5
27	17.0	M	13.0
28	18.0	30.5	16.0
29	19.3	19.0	17.5
30	20.5	10.0	16.5
Average	14.1	13.7	12.4

Notes:

- 1) Averages are for concurrent days of data only.
- 2) M = missing data.

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TABLE 2.1 (CONTINUED)
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
1992 JULY & AUGUST TEMPERATURE (°C)

Jul	Pelly Ranch	Carmacks	Site
1	20.8	21.0	18.5
2	22.8	21.5	18.5
3	19.5	21.0	14.5
4	17.5	13.0	15.0
5	15.3	21.0	14.0
6	16.0	14.3	14.0
7	14.5	14.5	14.0
8	15.8	16.5	16.0
9	14.0	15.0	14.5
10	15.3	8.0	12.0
11	16.0	M	12.5
12	16.0	25.0	13.0
13	15.5	11.5	13.0
14	15.8	14.0	13.0
15	16.0	13.5	13.0
16	12.3	12.8	13.0
17	16.3	13.8	14.0
18	14.8	17.0	12.0
19	15.8	15.5	13.0
20	14.5	14.0	11.0
21	12.5	14.3	12.5
22	13.8	14.5	11.5
23	15.0	15.5	12.0
24	15.8	9.0	12.5
25	16.0	M	14.0
26	16.3	23.5	12.0
27	11.8	12.3	10.5
28	15.0	13.5	12.5
29	13.5	12.0	13.5
30	13.8	11.8	12.5
31	12.5	16.3	14.0
Average	15.5	15.4	13.4

Aug	Pelly Ranch	Carmacks	Site
1	13.3	23.5	14.0
2	12.0	23.5	11.5
3	12.8	13.5	14.5
4	16.8	14.8	18.5
5	18.5	17.0	15.0
6	18.3	16.0	10.0
7	15.5	11.0	22.0
8	17.8	M	15.0
9	17.0	22.0	14.0
10	16.8	17.5	14.0
11	13.8	15.0	13.3
12	14.8	14.5	11.5
13	14.3	13.0	8.5
14	8.0	6.0	5.5
15	9.5	M	6.0
16	10.5	M	5.0
17	9.0	19.5	7.0
18	5.8	8.5	8.0
19	8.8	11.0	10.5
20	10.8	12.3	8.5
21	10.5	0.0	10.5
22	11.8	M	11.0
23	12.3	23.0	13.0
24	15.0	10.0	14.8
25	13.5	14.0	15.0
26	9.5	12.0	8.5
27	8.0	10.5	8.5
28	10.3	3.0	10.0
29	9.5	M	7.0
30	7.5	16.0	7.5
31	12.8	8.5	5.0
Average	12.5	13.7	11.5

Notes:

- 1) Averages are for concurrent days of data only.
- 2) M = missing data.

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TABLE 2.1 (CONTINUED)
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
1994 SEPTEMBER & OCTOBER TEMPERATURE (°C)

Sept	Pelly Ranch	Carmacks	Site
1	7.8	8.3	
2	7.8	M	
3	6.5	M	
4	7.5	9.0	
5	6.3	M	
6	9.3	9.0	
7	7.0	9.0	
8	4.5	8.0	
9	7.5	4.5	
10	1.5	M	
11	2.5	3.0	
12	3.3	M	
13	6.3	6.0	
14	9.0	7.5	7.6
15	14.5	11.5	9.3
16	12.0	11.0	9.4
17	7.0	M	7.8
18	7.3	M	6.3
19	6.3	8.0	7.8
20	3.5	4.8	4.6
21	4.8	4.3	6.3
22	6.8	6.8	5.4
23	6.0	M	5.5
24	6.8	M	4.4
25	4.8	9.3	7.6
26	4.0	4.5	3.8
27	2.8	4.8	1.6
28	2.8	3.0	1.5
29	3.3	4.0	2.3
30	2.8	2.3	2.0
Average	5.6	5.4	5.3

Oct	Pelly Ranch	Carmacks	Site
1	-1.5	M	0.8
2	3.3	M	3.8
3	4.8	M	4.6
4	7.0	6.3	5.5
5	4.0	6.0	4.9
6	5.8	5.3	4.9
7	2.5	5.8	4.4
8	4.8	M	2.4
9	1.8	M	2.2
10	0.3	M	-0.5
11	-3.0	-2.0	-1.7
12	1.5	2.5	2.1
13	-1.8	-3.0	0.9
14	-1.0	M	-0.3
15	0.0	M	0.6
16	5.0	M	2.9
17	1.5	M	0.9
18	-3.0	-1.0	-4.7
19	-4.8	-1.3	-1.8
20	-2.0	-1.3	-2.1
21	-3.0	-0.5	-3.1
22	-6.0	M	-6.6
23	-10.5	M	-7.5
24	-3.0	M	-2.4
25	-1.8	-0.3	-0.6
26	-8.0	-3.8	-3.6
27	-8.0	-8.0	-3.0
28	-7.0	-3.8	-3.0
29	-6.8	M	-5.4
30	-4.5	M	-6.6
31	-8.8	-9.8	-10.2
Average	-1.9	-0.6	-0.7

Notes:

- 1) Averages are for concurrent days of data only.
- 2) M = missing data.

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TABLE 2.1 (CONTINUED)
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
1994 NOVEMBER & DECEMBER TEMPERATURE (°C)

Nov	Pelly Ranch	Carmacks	Site
1	-14.3	-11.5	-12.0
2	-8.0	-7.5	-11.1
3	-1.5	-0.8	-1.6
4	-8.3	-6.0	-5.8
5	-12.5	M	-9.7
6	-11.5	-12.0	-12.6
7	-12.5	-11.8	-10.8
8	-10.8	-10.5	-12.0
9	-14.8	-14.3	-15.7
10	-9.8	-13.3	-6.0
11	-6.5	-10.0	-7.0
12	-21.5	-20.5	-13.6
13	-18.8	M	-15.6
14	-19.3	M	-17.0
15	-18.8	-18.5	-18.5
16	-25.0	-21.5	-18.3
17	-19.5	-14.0	-14.5
18	-13.3	-12.5	-10.3
19	-29.0	-22.5	-17.1
20	-23.3	M	-18.4
21	-15.5	M	-14.8
22	-20.0	-15.0	-19.9
23	-27.5	-25.8	-27.4
24	-28.0	-26.5	-28.8
25	-34.3	-25.8	-28.6
26	-32.3	M	-23.2
27	-28.0	-23.8	-20.9
28	-28.3	M	-19.7
29	-27.8	-24.5	-20.7
30	-26.8	-24.0	-26.0
Average	-18.2	-16.2	-15.6

Dec	Pelly Ranch	Carmacks	Site
1	-35.0	-28.8	-27.0
2	-34.0	M	-29.4
3	-20.5	M	-22.4
4	-11.8	M	-5.5
5	-14.5	M	-9.5
6	-32.0	-19.3	-24.3
7	-31.5	-26.0	-27.5
8	-43.0	-37.5	-30.2
9	-40.3	M	-32.3
10	-35.3	M	-29.6
11	-30.8	M	-27.4
12	-21.8	M	-11.6
13	-11.0	-11.0	-2.1
14	-18.0	-9.5	-3.5
15	-27.3	-23.0	-13.5
16	-27.3	M	-16.8
17	-29.5	M	-16.3
18	-25.0	M	-12.9
19	-22.8	M	-7.7
20	-21.5	-12.8	-4.9
21	-15.5	-10.5	-4.9
22	-16.5	-12.3	-5.3
23	-22.0	-16.3	-9.3
24	-32.0	M	-15.1
25	-29.3	M	-23.1
26	-26.8	M	-24.4
27	-39.5	M	-23.5
28	-36.8	-33.3	-20.1
29	-22.0	-20.5	-13.9
30	-21.5	M	-5.3
31	-30.0	M	-10.0
Average	-25.5	-20.1	-14.3

Notes:

- 1) Averages are for concurrent days of data only.
- 2) M = missing data.

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TABLE 2.1 (CONTINUED)
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
1995 JANUARY TEMPERATURE (°C)

Jan	Pelly Ranch	Carmacks	Site
1			-15.0
2			-15.8
3			-17.0
4			-20.9
5			-23.3
6			-24.2
7			-24.8
8			-27.8
9			-28.1
10			-24.9
11			-23.0
12			-22.0
13			-18.9
14			-10.3
15			-13.1
16			-15.6
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			
Average			

Notes:

- 1) Averages are for concurrent days of data only.
- 2) M = missing data.

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TABLE 2.2
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
MEAN MONTHLY TEMPERATURE DATA (°C)

Long-term regional values

Station	Years of Record	Elev. (m)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Pelly Ranch	1961 - 1990	454	-27.9	-21.7	-11.9	-0.2	7.5	13	15.1	12.5	6.5	-2.3	-16.7	-25.5	-4.3
Carmacks	1963 - 1990	525	-28.6	-18.2	-11.6	-0.1	7.2	12.9	14.8	12.5	6.9	-1.6	-14.7	-24.7	-3.8
Williams Creek (est.)	N/A	850	-30.6	-20.2	-13.6	-2.1	5.2	10.9	12.8	10.5	4.9	-3.6	-16.7	-26.7	-5.8

Notes:

- 1) Pelly Ranch and Carmacks values from AES climate normals for 1961-1990.
- 2) Carmacks March and April values from AES climate normals for 1951 to 1980.
- 2) Williams Creek site values estimated by adjusting Carmacks data by a lapse rate of approximately 6 °C/1000 m (ie. 2°C for 325m).

TABLE 2.3
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
FREEZE - THAW INDEXES (DEGREE-DAYS)

Long-term regional values

Parameter	Station	Years of Record	Elev. (m)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Air Freezing Index (below 0°C)	Pelly Ranch	1951 - 1980	454	919.6	618.5	400.9	62.6	1.7	0.0	0.0	0.0	3.6	121.6	466.7	821.5	3416.7
	Carmacks	1951 - 1980	525	876.6	549.6	355.8	51.7	1.7	0.0	0.0	0.0	2.5	106.6	424.6	750.6	3119.7
	Williams Creek (est.)	N/A	850	932	627	418	100	1.7	0	0	0	10	130	487	844	3550
Air Thawing Index (above 0°C)	Pelly Ranch	1951 - 1980	454	0.1	0.9	3.0	49.7	225.8	386.3	460.4	384.3	198.6	35.7	3.2	0.1	1748.1
	Carmacks	1951 - 1980	525	0.1	1.3	3.5	51.9	220.3	376.1	449.5	382.9	198.8	42.1	3.2	0.0	1729.7
	Williams Creek (est.)	N/A	850	0	0	0	35	219	377	450	380	195	20	0	0	1676
Air Heating Index (below 18°C)	Pelly Ranch	1951 - 1980	454	1477.5	1126.4	955.9	553.0	333.9	155.7	102.0	175.0	345.0	643.9	1003.6	1379.4	8251.3
	Carmacks	1951 - 1980	525	1434.0	1057.5	910.8	540.2	338.5	165.2	113.1	176.7	343.4	622.6	959.7	1308.6	7970.3
	Williams Creek (est.)	N/A	850	1490	1135	973	600	340	164	113	170	360	655	1025	1402	8427

Notes:

- 1) Pelly Ranch and Carmacks values from AES climate normals for 1951-1980.
- 2) Carmacks March and April values from AES climate normals for 1951 to 1980.
- 3) Williams Creek site values estimated by adjusting Carmacks and Pelly Ranch data on the basis of monthly temperature records and estimates.

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TABLE 2.4
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
1992 JUNE PRECIPITATION (mm)

Jun	Pelly Ranch	Carmacks	Site
1	0.0	4.8	0.0
2	0.0	0.0	0.0
3	0.0	0.0	0.0
4	0.4	0.0	0.0
5	0.4	0.0	0.0
6	2.4	0.0	0.0
7	0.0	0.0	0.0
8	0.0	0.0	0.0
9	0.0	0.0	0.0
10	0.0	0.0	0.0
11	0.0	0.0	0.0
12	0.0	0.0	1.0
13	T	0.0	9.8
14	12.2	6.2	1.0
15	0.2	T	2.0
16	0.6	0.6	0.0
17	0.8	0.0	2.0
18	0.0	0.0	0.0
19	0.0	0.0	0.0
20	4.8	0.0	10.0
21	0.6	2.4	18.0
22	2.2	1.2	2.0
23	0.8	T	1.0
24	2.6	1.4	0.0
25	4.2	1.4	2.0
26	0.0	0.0	0.0
27	0.0	0.0	0.0
28	0.0	0.0	0.0
29	0.0	0.0	0.0
30	0.0	0.0	0.0
Total	32.0	18.0	48.8

Notes:

- 1) Totals are for concurrent days of data only.
- 2) C = precipitation occurred, amount unknown, value accumulated in next days value.
- 3) T = Trace of precipitation.

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TABLE 2.4 (CONTINUED)
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
1992 JULY & AUGUST PRECIPITATION (mm)

Jul	Pelly Ranch	Carmacks	Site
1	0.0	0.0	0.0
2	2.6	0.0	0.0
3	T	2.0	6.0
4	1.2	0.0	1.0
5	7.8	7.0	10.0
6	2.6	17.4	14.0
7	0.6	5.2	2.0
8	0.0	T	0.0
9	0.0	0.0	3.0
10	0.0	0.0	16.0
11	0.8	0.0	11.0
12	6.0	8.2	4.0
13	3.0	14.0	0.0
14	0.0	0.5	0.0
15	0.0	0.0	2.0
16	3.0	0.0	3.0
17	0.8	T	0.0
18	0.0	0.0	0.0
19	1.0	T	0.0
20	0.2	1.4	3.0
21	9.2	3.0	0.0
22	0.4	0.0	0.0
23	0.0	0.0	4.0
24	T	0.0	6.0
25	1.1	0.0	0.0
26	0.0	4.0	0.0
27	0.0	T	2.5
28	1.8	0.0	0.0
29	2.2	2.8	2.0
30	0.0	2.8	4.0
31	0.0	0.4	10.0
Total	19.7	68.7	103.5

Aug	Pelly Ranch	Carmacks	Site
1	0.2	0.0	5.0
2	5.4	0.4	0.0
3	0.0	0.0	0.0
4	0.0	0.0	0.0
5	0.0	0.0	6.0
6	0.0	3.5	0.0
7	3.2	0.0	8.0
8	0.0	0.0	1.0
9	0.0	9.0	0.0
10	0.0	0.0	0.0
11	0.0	0.0	0.0
12	0.0	0.0	0.0
13	0.4	0.0	0.0
14	9.6	0.0	0.0
15	T	0.0	0.0
16	0.0	0.0	0.0
17	7.2	3.0	30.0
18	1.8	1.2	2.0
19	0.0	0.0	0.0
20	0.0	0.0	0.0
21	0.0	0.0	0.0
22	0.2	0.0	0.0
23	0.0	0.0	0.0
24	0.0	0.0	0.0
25	1.0	0.0	4.0
26	0.2	T	14.0
27	5.4	2.8	46.0
28	5.2	0.0	3.0
29	6.8	0.0	0.0
30	0.0	0.0	24.0
31	0.8	8.0	0.0
Total	26.0	27.9	143.0

Notes:

- 1) Totals are for concurrent days of data only.
- 2) C = precipitation occurred, amount unknown, value accumulated in next days value.
- 3) T = Trace of precipitation.

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TABLE 2.4 (CONTINUED)
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
1994 SEPTEMBER & OCTOBER PRECIPITATION (mm)

Sept	Pelly Ranch	Carmacks	Site
1	0.8	0.0	
2	0.0	T	
3	0.4	C	
4	0.0	C	
5	0.0	2.4	
6	0.0	0.3	
7	0.0	0.0	
8	0.4	0.0	
9	0.2	1.0	
10	0.0	0.0	
11	5.6	3.2	
12	0.0	0.4	
13	T	0.0	
14	0.0	0.0	0.0
15	0.0	0.0	0.0
16	0.0	0.0	0.0
17	0.0	0.0	0.0
18	1.2	1.0	0.6
19	0.0	0.0	0.0
20	0.0	0.0	0.2
21	8.8	3.6	6.8
22	0.0	2.4	0.5
23	T	C	0.0
24	4.0	C	1.8
25	T	6.5	1.4
26	0.2	5.0	0.0
27	0.0	1.8	0.0
28	0.0	0.0	0.0
29	0.0	0.0	0.0
30	0.0	0.0	0.0
Total	14.2	20.3	11.3

Oct	Pelly Ranch	Carmacks	Site
1	0.0	0.0	0.0
2	T	5.0	0.0
3	0.0	2.5	0.2
4	0.8	7.0	4.9
5	0.2	0.4	0.0
6	0.0	0.0	0.0
7	2.2	C	0.0
8	T	3.0	0.0
9	2.6	0.0	0.0
10	0.0	0.0	0.0
11	0.0	0.0	0.0
12	0.0	0.0	0.0
13	0.0	0.0	0.0
14	0.0	0.0	0.0
15	2.0	C	0.0
16	0.2	2.8	0.0
17	1.0	0.4	0.0
18	1.0	0.0	0.0
19	7.0	0.5	0.0
20	3.8	1.0	0.0
21	1.8	0.2	0.0
22	0.0	0.0	0.0
23	0.0	0.0	0.0
24	0.0	0.0	0.0
25	0.0	0.2	0.0
26	0.4	1.0	0.0
27	0.0	0.0	0.0
28	1.0	C	0.0
29	3.0	C	0.0
30	0.4	5.0	0.0
31	T	0.0	0.0
Total	27.4	29.0	5.1

Notes:

- 1) Totals are for concurrent days of data only.
- 2) C = precipitation occurred, amount unknown, value accumulated in next days value.
- 3) T = Trace of precipitation.

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TABLE 2.4 (CONTINUED)
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
1994 NOVEMBER & DECEMBER PRECIPITATION (mm)

Nov	Pelly Ranch	Carmacks	Site
1	T	0.0	0.0
2	0.0	0.0	0.0
3	T	0.0	0.0
4	1.0	T	0.0
5	1.2	0.0	0.0
6	0.0	0.0	0.0
7	4.6	0.8	0.0
8	0.0	0.5	0.0
9	1.2	T	0.0
10	1.0	3.0	0.0
11	0.0	0.0	0.0
12	0.8	0.0	0.0
13	0.0	0.0	0.0
14	1.6	0.2	0.0
15	0.0	0.7	0.0
16	0.0	T	0.0
17	0.0	4.0	0.0
18	0.0	0.0	0.0
19	0.0	0.0	0.0
20	2.4	0.5	0.0
21	8.8	6.0	0.0
22	0.0	0.2	0.0
23	0.6	1.0	0.0
24	0.0	0.0	0.0
25	0.0	0.0	0.0
26	0.6	0.0	0.0
27	1.2	1.5	0.0
28	1.4	0.5	0.0
29	1.0	1.5	0.0
30	T	0.5	0.0
Total	27.4	20.9	0.0

Dec	Pelly Ranch	Carmacks	Site
1	0.0	0.0	0.0
2	0.0	0.0	0.0
3	0.0	0.0	0.0
4	0.0	0.0	0.0
5	2.0	1.8	0.0
6	0.0	0.0	0.0
7	0.0	0.0	0.0
8	0.0	0.0	0.0
9	0.0	0.0	0.0
10	0.0	0.2	0.0
11	0.0	0.0	0.0
12	0.6	0.0	0.0
13	0.0	0.0	0.0
14	0.0	0.0	0.0
15	0.0	0.0	0.0
16	0.0	0.0	0.0
17	0.0	0.0	0.0
18	1.0	1.2	0.0
19	0.0	T	0.0
20	0.0	0.0	0.0
21	0.0	0.0	0.0
22	0.0	0.2	0.0
23	0.0	0.0	0.0
24	0.0	0.0	0.0
25	0.0	0.0	0.0
26	0.0	0.6	0.0
27	0.0	0.0	0.0
28	0.0	0.0	0.0
29	0.0	0.0	0.0
30	0.0	0.0	0.0
31	0.0	0.0	0.0
Total	3.6	4.0	0.0

Notes:

- 1) Totals are for concurrent days of data only.
- 2) C = precipitation occurred, amount unknown, value accumulated in next days value.
- 3) T = Trace of precipitation.

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TABLE 2.4 (CONTINUED)
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
1995 JANUARY PRECIPITATION (mm)

Jan	Pelly Ranch	Carmacks	Site
1			0.0
2			0.0
3			0.0
4			0.0
5			0.0
6			0.0
7			0.0
8			0.0
9			0.0
10			0.0
11			0.0
12			0.0
13			0.0
14			0.0
15			0.0
16			0.0
17			0.0
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			
Total	0.0	0.0	0.0

Notes:

- 1) Totals are for concurrent days of data only.
- 2) C = precipitation occurred, amount unknown, value accumulated in next days value.
- 3) T = Trace of precipitation.

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TABLE 2.5
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
PRECIPITATION DATA

Regional Values

Precipitation Station	Years of Record	Elevation	Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Pelly Ranch	1961 - 1990	454 m	rain (mm)	0	0	0.3	3.3	22.8	37	51.7	33.8	26.7	8.3	0.5	0	184.4
			% precip.	0.0%	0.0%	0.1%	1.1%	7.6%	12.4%	17.3%	11.3%	8.9%	2.8%	0.2%	0.0%	61.7%
			snow (mm)	19.8	15.3	10.2	7.8	0.2	0	0	0.1	1.1	16.1	22.7	21.2	114.5
			% precip.	6.6%	5.1%	3.4%	2.6%	0.1%	0.0%	0.0%	0.4%	5.4%	7.6%	7.1%	7.1%	38.3%
			precip.(mm)	19.8	15.3	10.5	11.1	23	37	51.7	33.9	27.8	24.4	23.2	21.2	298.9
			% precip.	6.6%	5.1%	3.5%	3.7%	7.7%	12.4%	17.3%	11.3%	9.3%	8.2%	7.8%	7.1%	100.0%
Carmacks	1963 - 1990	525m	rain	0	0	0.2	1.1	18.3	34.5	55.1	39.3	29.5	5.2	0.4	0	183.6
			% precip.	0.0%	0.0%	0.1%	0.4%	6.6%	12.5%	19.9%	14.2%	10.7%	1.9%	0.1%	0.0%	66.4%
			snow	17.9	12.3	6.8	5.7	1.8	0	0	0.1	1.1	14	17.9	15.3	92.9
			% precip.	6.5%	4.4%	2.5%	2.1%	0.7%	0.0%	0.0%	0.0%	0.4%	5.1%	6.5%	5.5%	33.6%
			precip.(mm)	17.9	12.3	7	6.8	20.1	34.5	55.1	39.4	30.6	19.2	18.3	15.3	276.5
			% precip.	6.5%	4.4%	2.5%	2.5%	7.3%	12.5%	19.9%	14.2%	11.1%	6.9%	6.6%	5.5%	100.0%

Estimated Site Values

Precipitation Station	Years of Record		Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Williams Creek	long - term	850 m	rain (mm)	0	0	0	0	18	47	75	53	36	4	0	0	233
			% precip.	0.0%	0.0%	0.0%	0.0%	4.9%	12.5%	19.9%	14.2%	9.5%	1.0%	0.0%	0.0%	62.0%
			snow (mm)	24	17	9	9	9	0	0	0	6	22	25	21	143
			% precip.	6.5%	4.4%	2.5%	2.5%	2.4%	0.0%	0.0%	0.0%	1.6%	5.9%	6.6%	5.5%	38.0%
			precip.(mm)	24	17	9	9	27	47	75	53	42	26	25	21	375
			% precip.	6.5%	4.4%	2.5%	2.5%	7.3%	12.5%	19.9%	14.2%	11.1%	6.9%	6.6%	5.5%	100.0%

Notes:

1) Precipitation estimate for elevation 850 m.

2) Estimate made by modifying Carmacks Data:

Data from Canadian Climate Normals: 1961 - 1990

Annual Precipitation : Mean annual value for Williams Creek at its mouth plus orographic allowance (8% per 100m) ie. $286 \text{ mm} \times 1.08^{((850-497)/100)} = 375 \text{ mm}$.

Precipitation for Williams Creek at its mouth estimated from AES Carmacks and Pelly Ranch data. Orographic allowance from text "Climate of Yukon".

Precipitation Distribution : Precipitation distribution same as Carmacks, however proportion falling as rain and snow has been altered slightly. Williams Creek site is approximately 2 °C colder than Carmacks.

Assume no rain in March, April and November, and less rain in May and October.

WET AND DRY YEAR PRECIPITATION

75 mm

Return Period	Precipitation (mm)
1:10 year dry (mean - 1.282 s.d.)	279
1:20 year dry (mean - 1.645 s.d.)	252
1:10 year wet (mean + 1.282 s.d.)	471
1:20 year wet (mean + 1.645 s.d.)	498
1:50 year wet (mean + 2.054 s.d.)	529
1:100 year wet (mean + 2.326 s.d.)	549
1:200 year wet (mean + 2.575 s.d.)	568

Notes:

- 1) Precipitation estimates for elevation 850 m. Estimates for other elevations can be made by increasing values 8% per 100 m increase in elevation..
- 2) Mean value estimated from Pelly Ranch and Carmacks data (AES Climate Normals 1961 - 1990) plus an orographic allowance.
- 3) Standard deviation estimated from a C.V. value of 0.20, calculated with 14 years of Carmacks data (1964 - 1975, 80, 83).

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TABLE 2.7
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
SITE IDF CURVES

Developed from the "Rainfall Frequency Atlas of Canada".

Duration	Mean	St. Dv.	Factor	Year
5 min	3	2	-0.164	2
10 min	4.1	2.2	0.719	5
15 min	4.2	3	1.305	10
30 min	6.1	2.5	1.635	15
1 hr	8.1	4	1.866	20
2 hr	10	4	2.044	25
6 hr	15	6	2.592	50
12 hr	19	6.1	3.137	100
24 hr	20	7	3.679	200
			18.1741	PMP

Return Period Rainfall Amounts (mm)

Duration	2 yrs	5 yrs	10 yrs	15 yrs	20 yrs	25 yrs	50 yrs	100 yrs	200 yrs	PMP
5 min	2.7	4.4	5.6	6.3	6.7	7.1	8.2	9.3	10.4	39.0
10 min	3.7	5.7	7.0	7.7	8.2	8.6	9.8	11.0	12.2	43.7
15 min	3.7	6.4	8.1	9.1	9.8	10.3	12.0	13.6	15.2	58.2
30 min	5.7	7.9	9.4	10.2	10.8	11.2	12.6	13.9	15.3	51.1
1 hr	7.4	11.0	13.3	14.6	15.6	16.3	18.5	20.6	22.8	80.2
2 hr	9.3	12.9	15.2	16.5	17.5	18.2	20.4	22.5	24.7	82.1
6 hr	14.0	19.3	22.8	24.8	26.2	27.3	30.6	33.8	37.1	123.1
12 hr	22.5	29.2	33.7	36.2	38.0	39.3	43.5	47.7	51.8	161.1
24 hr	23.6	31.3	36.4	39.3	41.3	42.9	47.7	52.4	57.2	182.6

* Calculations include an orographic factor = 1.25 for durations of 12 hours and more.

Rainfall Intensity (mm/hr)

Duration	2 yrs	5 yrs	10 yrs	15 yrs	20 yrs	25 yrs	50 yrs	100 yrs	200 yrs	PMP
5 min	32.1	53.3	67.3	75.2	80.8	85.1	98.2	111.3	124.3	468.3
10 min	22.4	34.1	41.8	46.2	49.2	51.6	58.8	66.0	73.2	262.4
15 min	14.8	25.4	32.5	36.4	39.2	41.3	47.9	54.4	60.9	233.0
30 min	11.4	15.8	18.7	20.4	21.5	22.4	25.2	27.9	30.6	102.3
1 hr	7.4	11.0	13.3	14.6	15.6	16.3	18.5	20.6	22.8	80.2
2 hr	4.7	6.4	7.6	8.3	8.7	9.1	10.2	11.3	12.4	41.0
6 hr	2.3	3.2	3.8	4.1	4.4	4.5	5.1	5.6	6.2	20.5
12 hr	1.9	2.4	2.8	3.0	3.2	3.3	3.6	4.0	4.3	13.4
24 hr	1.0	1.3	1.5	1.6	1.7	1.8	2.0	2.2	2.4	7.6

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TABLE 2.8
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
WILLIAMS CREEK SNOWMELT DATA

1992 Snow Survey Summary

Station Name	Elevation (m)	Approx. Dist. from Site (km)	1992 Snowpack Data (mm)								% Snow Melt			
			March 1		April 1		May 1		May 15		March	April	15-May	> May 15
			snow	water eq.	snow	water eq.	snow	water eq.	snow	water eq.				
Williams #1	739	n/a	60.0	104.0	70.0	120.0	22.0	84.0	0.0	0.0	0%	30%	70%	0%
Williams #2	876	n/a	69.0	110.0	73.0	130.0	36.0	129.0	11.0	38.0	0%	1%	70%	29%
Williams #3	755	n/a	70.0	150.0	74.0	132.0	36.0	103.0	9.0	36.0	12%	19%	45%	24%
Mt. Nansen	1021	50 SW	54.0	92.0	60.0	102.0	25.0	68.0	0.0	0.0	0%	33%	67%	0%
Casino Creek	1065	50 SE	67.0	124.0	70.0	135.0	83.0	207.0	83.0	207.0	0%	0%	0%	100%
Mt. Berdoe	1035	90 NW	76.0	165.0	72.0	170.0	50.0	126.0	38.0	115.0	0%	26%	6%	68%

Long-term Snow Survey Summary

Station Name	Elevation (m)	Years of Record	Water Equivalent (mm)				% Snow Melt			
			March 1	April 1	May 1	May 15	March	April	15-May	> May 15
Mt. Nansen	1021	20	69.0	75.0	15.0	0.0	0%	80%	20%	0%
Casino Creek	1065	16	104.0	124.0	124.0	69.0	0%	0%	44%	56%
Mt. Berdoe	1035	19	95.0	108.0	60.0	19.0	0%	44%	38%	18%

Estimated Long-term Williams Creek Site Snow Melt Distribution

Station Name	% Snow Melt		
	March	April	May
Williams Creek	0%	70%	30%

Notes:

- 1) Mt. Nansen, Casino Creek and Mt. Berdoe data from Yukon Territory Snow Survey Bulletin.
- 2) Estimates of long-term Williams Creek values are based on long-term Mt. Nansen records.

TABLE 2.9
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
MINTO CREEK SNOWMELT DATA

1994 Snow Survey Summary

Station Name	Elevation (m)	Approx. Dist. from Site (km)	1994 Snowpack Data (mm)								% Snow Melt		
			March 1		April 1		May 1		May 15		March	April	May
			snow	water eq.	snow	water eq.	snow	water eq.	snow	water eq.			
Minto #1	914	n/a	53.4	98.0	55.9	112.0	0.0	0.0	0.0	0.0	0%	100%	0%
Minto #2	823	n/a	52.1	86.5	51.7	93.0	0.0	0.0	0.0	0.0	0%	100%	0%
Minto #3	823	n/a	51.0	84.0	43.0	78.0	0.0	0.0	0.0	0.0	7%	93%	0%
Mt. Nansen	1021	50 SW	48.0	73.0	52.0	73.0	0.0	0.0	0.0	0.0	0%	100%	0%
Casino Creek	1065	50 SE	51.0	83.0	61.0	83.0	22.0	56.0	0.0	0.0	0%	33%	67%
Mt. Berdoe	1035	90 NW	56.0	97.0	60.0	110.0	9.0	51.0	0.0	0.0	0%	54%	46%

Long-term Snow Survey Summary

Station Name	Elevation (m)	Years of Record	Water Equivalent (mm)				% Snow Melt		
			March 1	April 1	May 1	May 15	March	April	May
Mt. Nansen	1021	18	70.0	77.0	16.0	0.0	0%	79%	21%
Casino Creek	1065	16	107.0	126.0	128.0	74.0	0%	0%	100%
Mt. Berdoe	1035	19	97.0	110.0	61.0	20.0	0%	45%	55%

Estimated Long-term Minto Site Snow Melt Distribution

Station Name	% Snow Melt		
	March	April	May
Minto	0%	80%	20%

Notes:

- 1) Mt. Nansen, Casino Creek and Mt. Berdoe data from Yukon Territory Snow Survey Bulletin.
- 2) All May 15th snow pack is assumed to melt by the end of May.
- 3) Estimates of long-term Minto Creek values are based on long-term Mt. Nansen records.

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TABLE 2.10
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
ESTIMATED RAINFALL AND SNOWMELT DISTRIBUTIONS

Total Annual Precipitation at elevation 850 m = 375 mm

Location	Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Williams Creek Site	Rainfall	0	0	0	0	18	47	75	53	36	4	0	0	233
	% rainfall	0.0%	0.0%	0.0%	0.0%	7.9%	20.2%	32.1%	22.9%	15.3%	1.6%	0.0%	0.0%	100.0%
	% precip.	0.0%	0.0%	0.0%	0.0%	4.9%	12.5%	19.9%	14.2%	9.5%	1.0%	0.0%	0.0%	62.0%
	Snowmelt	0	0	0	100	43	0	0	0	0	0	0	0	143
	% snowmelt	0.0%	0.0%	0.0%	70.0%	30.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
	% precipitation	0.0%	0.0%	0.0%	26.6%	11.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	38.0%
	Total Precipitation	0	0	0	100	61	47	75	53	36	4	0	0	375
	% precipitation	0.0%	0.0%	0.0%	26.6%	16.3%	12.5%	19.9%	14.2%	9.5%	1.0%	0.0%	0.0%	100.0%

Notes:

1) For water balance modeling, the total precipitation values should be used to represent water inflow due to direct precipitation.

TABLE 2.11
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
MEAN MONTHLY POND EVAPORATION (mm)

Station	Elevation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Pelly Ranch	454 m	0	0	0	0	105	121.3	111.2	80	36.6	0	0	0	454.1
Williams Creek Site	675 m	0	0	0	0	99	114	105	75	34	0	0	0	427
Williams Creek Site	850 m	0	0	0	0	93	108	99	71	33	0	0	0	404

Notes:

- 1) Pelly Ranch values from 28 years of data collected from AES station 2100880, at elevation 454 m.
- 2) Williams Creek site data generated by reducing Pelly Ranch values by 10% per 350m rise in elevation, as suggested by the MOE Manual of Operational Hydrology in B.C.
ie. $675 - 454 = 221$ and $221/350 \times 10\% = 6\%$.

28-Apr-95 15:21

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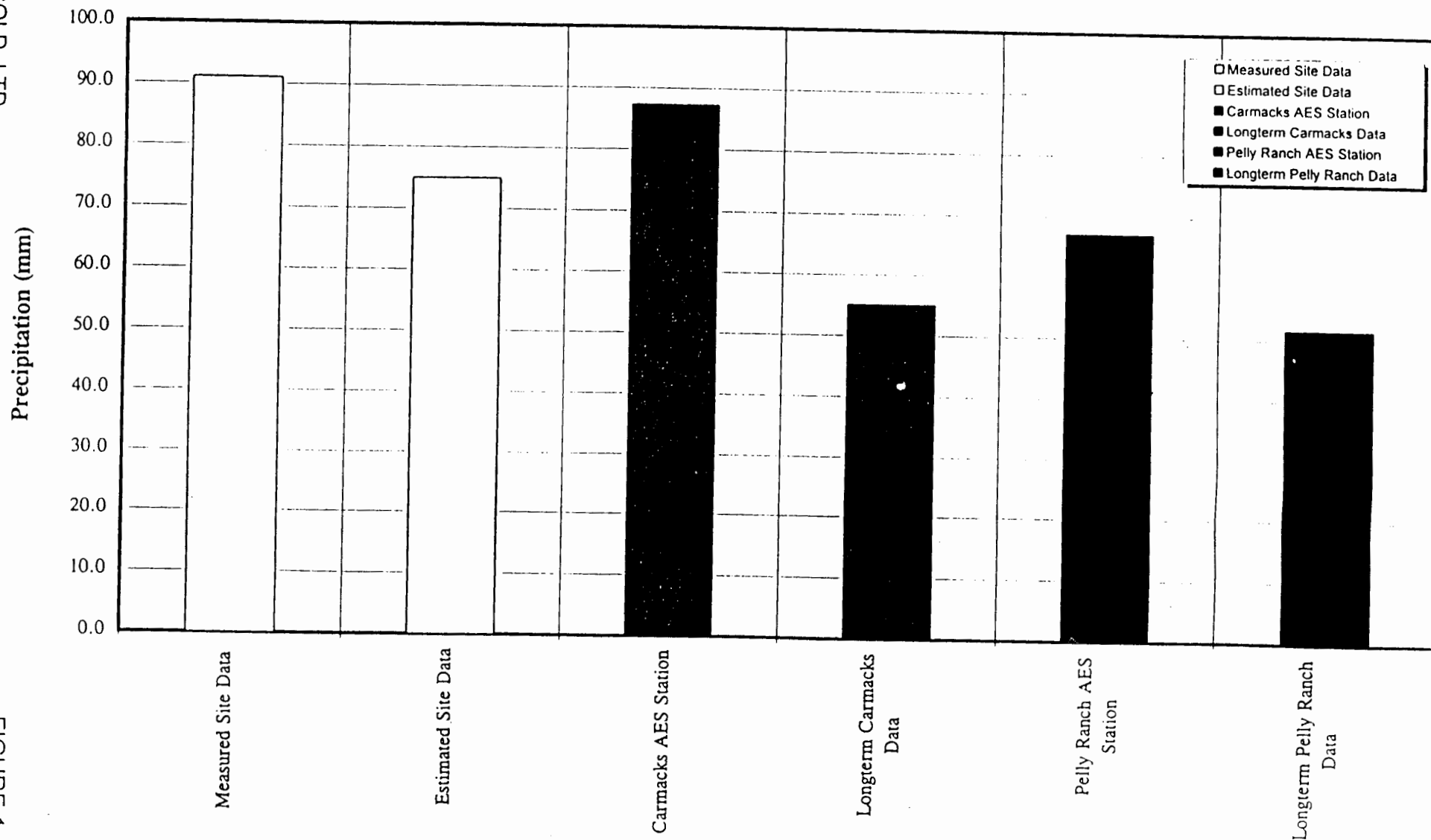
Appendix V.C

Graphical Representations of Precipitation Rate for Actual, Estimated and
Long term for July to September, 1996

Obtained from the "Technical Issues Response Document" (June, 1997)

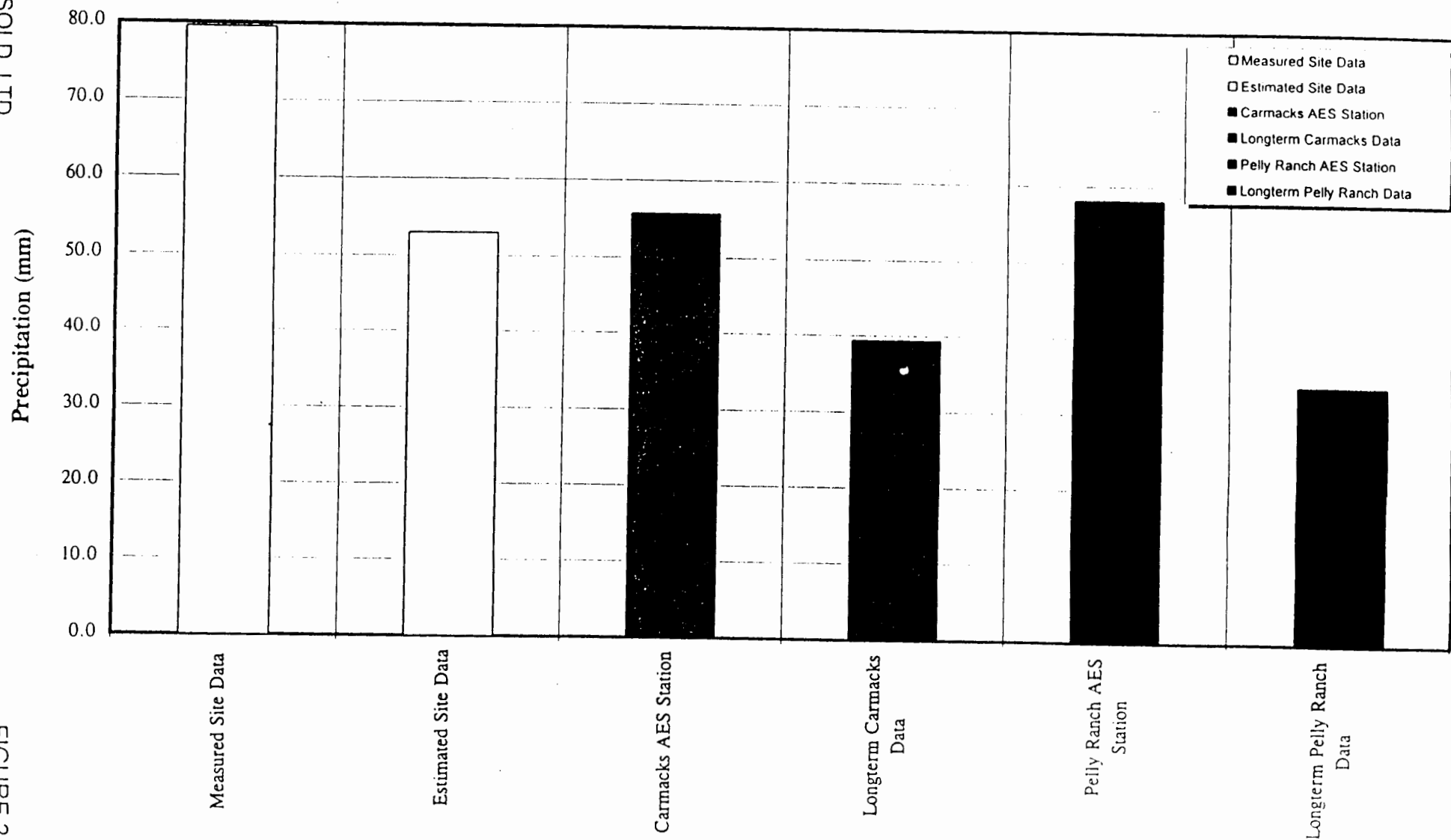
WESTERN COPPER HOLDINGS LIMITED
CARMACHS COPPER PROJECT
PRECIPITATION RATES: ACTUAL, ESTIMATED AND LONGTERM

JULY 1996



WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
PRECIPITATION RATES: ACTUAL, ESTIMATED AND LONGTERM

AUGUST 1996



KNIGHT PIESOLD LTD.

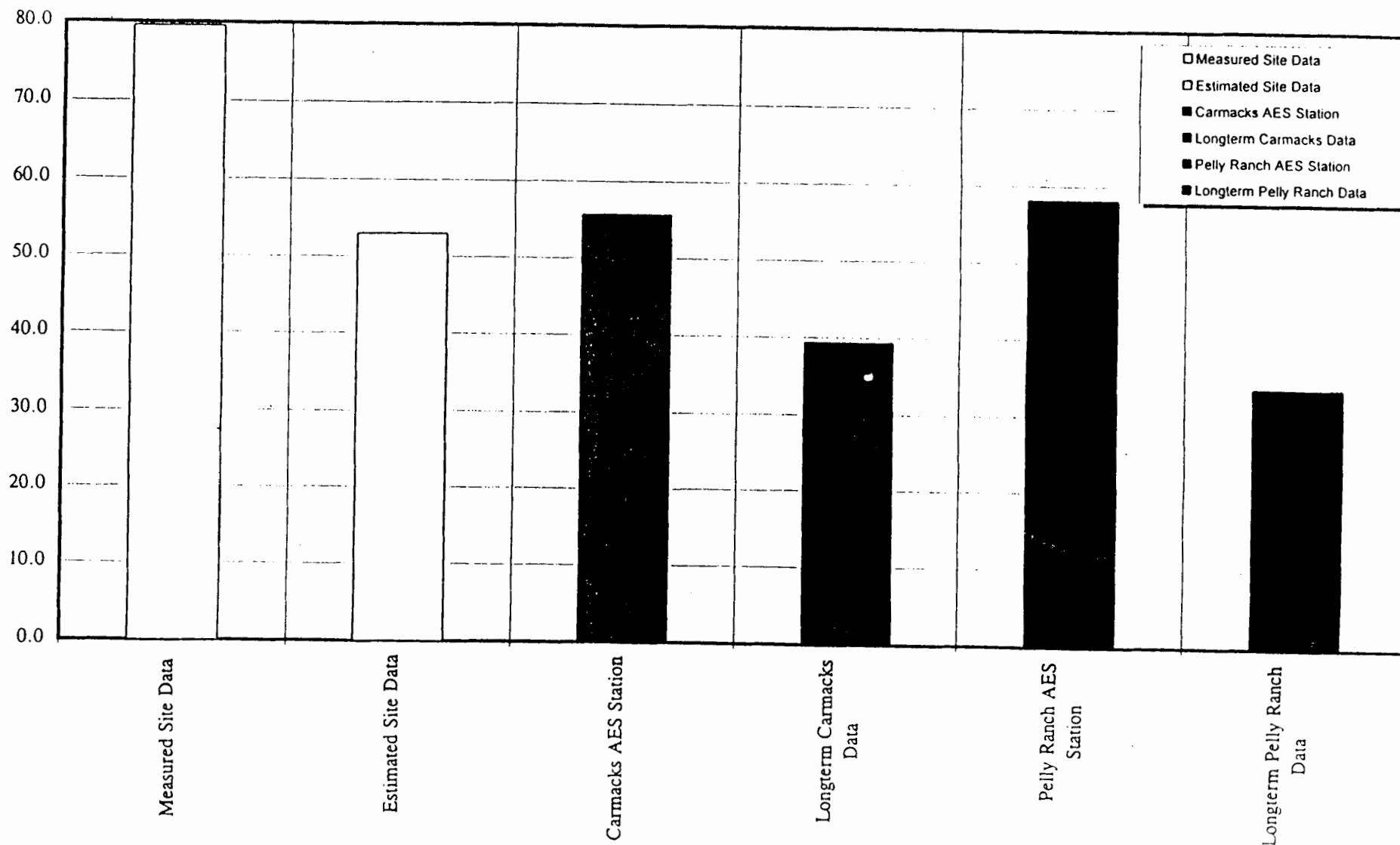
FIGURE 2

WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
PRECIPITATION RATES: ACTUAL, ESTIMATED AND LONGTERM

AUGUST 1996

KNIGHT PLESOLD LTD.

Precipitation (mm)



ENCLOSURE

WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
PRECIPITATION RATES: MEASURED, ESTIMATED AND LONGTERM

1 - 25 SEPTEMBER 1996

KNIGHT PIESOLD LTD.

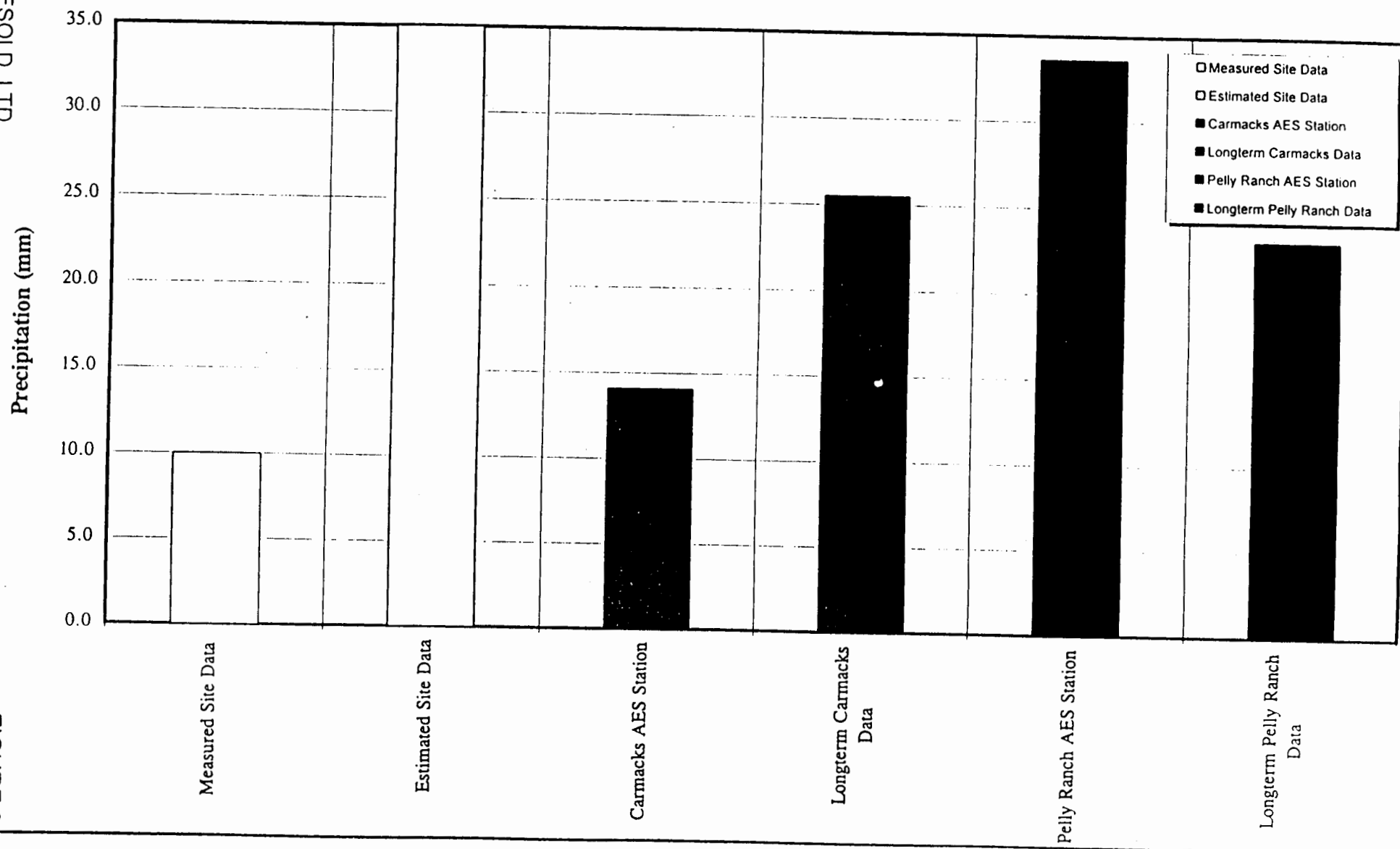


FIGURE 2

Appendix V.D

Daily and Monthly Averages of Meteorological Parameters Measured at the
Williams Creek Climate Station
(1994 to 1997)

Raw Data Obtained from DIAND Water Resources (December, 1997)

Daily Averages of Meteorological Parameters Measured at the Williams Creek Climate Station - 1994
(September 13 to December 31)

Date	Net Radiation W/m ²	Licor Shortwave Incoming W/m ²	Licor Shortwave Outgoing W/m ²	REBS Soil Heat Flux W/m ²	Soil Temp 6cm Depth °C	HM35CF Upper Temp °C	HM35C Upper RH %	Lower Wind Speed m/s	Upper Wind Speed m/s	Precip Tip Bucket Totalized mm
13-Sep-94	-6999	47.69	5.02	1.99	4.96	-773.66	64.07	17.04	-7.11	10.9
14-Sep-94	-6999	81.14	8.00	1.66	4.56	7.56	78.02	19.44	-7.41	0
15-Sep-94	-6999	111.55	10.79	1.96	5.15	9.33	59.83	19.48	-7.34	0
16-Sep-94	-6999	152.64	14.95	1.12	4.48	9.43	47.42	19.53	-7.33	0
17-Sep-94	-6999	156.90	15.66	0.31	3.54	7.81	52.81	19.55	-7.38	0
18-Sep-94	-6999	58.97	5.67	0.25	3.23	6.26	62.83	19.57	-7.42	0.6
19-Sep-94	-6999	117.39	11.81	0.38	3.28	7.79	39.58	19.59	-7.41	0
20-Sep-94	-6999	53.81	5.15	-0.36	2.36	4.61	60.64	19.58	-7.46	0.2
21-Sep-94	-6999	91.49	10.12	0.12	2.60	6.28	61.00	19.60	-7.43	6.8
22-Sep-94	-6999	89.58	9.23	1.11	3.34	5.37	72.25	19.59	-7.45	0.5
23-Sep-94	-6999	121.41	12.02	-0.49	2.36	5.52	51.53	19.59	-7.47	0
24-Sep-94	-6999	59.07	5.16	-0.56	2.02	4.39	72.21	19.60	-7.47	1.8
25-Sep-94	-6999	77.75	7.94	1.67	3.23	7.55	59.71	19.63	-7.38	1.4
26-Sep-94	-6999	76.44	7.18	1.26	3.28	3.76	87.79	19.60	-7.47	0
27-Sep-94	-6999	76.14	6.79	0.04	2.51	1.62	81.54	19.58	-7.50	0
28-Sep-94	-6999	52.79	5.04	-0.61	1.92	1.46	70.83	19.58	-7.51	0
29-Sep-94	-6999	57.40	5.53	-0.26	1.89	2.31	58.45	19.59	-7.50	0
30-Sep-94	-6999	120.37	12.62	-1.10	1.27	1.95	48.65	19.57	-7.53	0
1-Oct-94	-6999	121.26	12.71	-1.80	0.50	0.82	46.47	19.56	-7.54	0
2-Oct-94	-6999	40.59	3.99	-1.74	0.19	3.76	55.07	19.61	-7.48	0
3-Oct-94	-6999	20.05	1.95	-1.00	0.59	4.63	87.11	19.62	-7.45	0.2
4-Oct-94	-4232	16.08	1.51	1.47	2.20	5.53	88.32	12.17	-4.28	4.9
5-Oct-94	21.17	92.75	9.92	-0.16	1.59	4.86	66.28	0.58	-0.27	0
6-Oct-94	0.56	54.72	5.52	-0.21	1.41	4.86	57.30	0.61	-0.08	0
7-Oct-94	23.81	85.34	8.87	-0.10	1.44	4.37	45.62	0.68	-0.14	0
8-Oct-94	16.47	65.62	8.79	-0.56	1.15	2.44	67.81	0.11	-1.37	0
9-Oct-94	17.89	70.86	8.36	-0.76	0.86	2.24	59.85	0.74	0.03	0
10-Oct-94	26.15	83.45	8.28	-0.75	0.74	-0.45	70.16	0.90	0.57	0
11-Oct-94	10.62	71.78	7.95	-1.34	0.18	-1.72	64.82	0.64	-0.19	0
12-Oct-94	-4.31	49.31	5.21	-1.37	-0.07	2.11	67.02	0.68	0.04	0
13-Oct-94	7.30	82.68	8.61	-1.48	-0.38	0.85	71.38	0.97	0.50	0
14-Oct-94	11.20	41.03	4.06	-1.30	-0.46	-0.31	82.11	0.99	0.91	0
15-Oct-94	-1.39	31.25	3.18	-1.14	-0.36	0.64	77.91	0.49	-0.43	0
16-Oct-94	6.86	24.50	2.34	-0.92	-0.05	2.85	91.74	0.38	-0.83	0
17-Oct-94	15.11	36.11	3.40	-0.77	0.10	0.94	79.87	0.92	0.30	0
18-Oct-94	11.56	33.03	3.25	-0.68	0.15	-4.71	87.75	0.95	0.72	0
19-Oct-94	19.95	61.04	6.39	-1.11	-0.53	-1.77	84.66	0.85	0.54	0
20-Oct-94	5.45	9.54	4.74	-0.93	-0.58	-2.06	96.19	1.00	0.97	0
21-Oct-94	1.28	6.44	6.19	-0.77	-0.45	-3.08	94.97	1.00	0.99	0
22-Oct-94	-0.52	4.77	8.39	-0.73	-0.80	-6.59	89.13	1.00	1.00	0
23-Oct-94	15.78	10.48	12.50	-0.45	-1.54	-7.49	86.50	1.00	1.00	0
24-Oct-94	11.14	12.59	9.21	-1.87	-1.33	-2.41	81.33	0.23	-1.14	0
25-Oct-94	-12.78	69.38	6.48	-3.07	-1.12	-0.57	66.25	0.89	0.50	0
26-Oct-94	-3.02	19.96	3.94	-4.37	-1.28	-3.60	87.42	0.95	0.29	0
27-Oct-94	19.83	30.09	6.41	-4.55	-1.32	-2.96	88.60	0.97	0.73	0
28-Oct-94	5.75	26.04	4.86	-4.77	-1.40	-2.96	83.74	0.96	0.80	0
29-Oct-94	-2.96	10.13	3.71	-4.91	-1.57	-5.41	87.71	0.97	0.53	0
30-Oct-94	3.49	16.76	3.49	-4.28	-1.45	-6.64	85.91	0.98	0.50	0
31-Oct-94	2.66	22.59	4.56	-4.33	-1.67	-10.24	82.48	0.99	0.60	0
1-Nov-94	4.79	43.66	6.21	-5.40	-2.19	-12.00	82.28	0.82	0.26	0
2-Nov-94	1.58	13.20	2.84	-6.62	-2.73	-11.11	87.00	0.63	-0.41	0
3-Nov-94	-3.43	38.26	4.57	-4.85	-2.15	-1.59	69.24	-0.07	-1.76	0
4-Nov-94	-14.70	30.57	3.82	-3.97	-1.95	-5.76	65.11	0.81	-0.37	0
5-Nov-94	-1.83	18.37	2.60	-4.85	-2.39	-9.71	82.05	0.86	-0.17	0
6-Nov-94	2.67	21.98	4.06	-5.78	-2.86	-12.55	86.69	0.96	0.78	0
7-Nov-94	3.87	15.49	3.06	-6.42	-3.23	-10.78	88.60	1.00	0.98	0
8-Nov-94	4.14	16.14	3.80	-5.75	-3.07	-12.03	74.47	0.95	0.37	0

Note: Precipitation values represent the sum of total precipitation during the day rather than an average value

Daily Averages of Meteorological Parameters Measured at the Williams Creek Climate Station - 1994
(September 13 to December 31)

Date	Net Radiation W/m ²	Licor Shortwave Incoming W/m ²	Licor Shortwave Outgoing W/m ²	REBS Soil Heat Flux W/m ²	Soil Temp 6cm Depth °C	HM35CF Upper Temp °C	HM35C Upper RH %	Lower Wind Speed m/s	Upper Wind Speed m/s	Precip Tip Bucket Totalized mm
9-Nov-94	1.68	15.53	2.72	-7.31	-3.84	-15.68	80.38	0.78	0.11	0
10-Nov-94	0.65	20.18	2.70	-6.70	-3.65	-6.04	76.29	-0.14	-1.81	0
11-Nov-94	-14.11	20.44	3.13	-4.00	-2.50	-7.01	65.58	0.83	-0.16	0
12-Nov-94	-15.75	20.32	2.72	-5.41	-3.18	-13.58	78.82	1.00	0.98	0
13-Nov-94	2.43	10.24	2.88	-7.14	-4.10	-15.56	77.84	1.00	0.72	0
14-Nov-94	1.08	10.82	2.44	-7.66	-4.51	-17.00	79.25	0.98	0.81	0
15-Nov-94	1.58	7.28	2.56	-8.42	-5.01	-18.45	81.04	0.94	0.36	0
16-Nov-94	4.77	9.93	2.83	-8.58	-5.29	-18.33	80.09	1.00	0.92	0
17-Nov-94	0.10	3.00	1.23	-8.80	-5.53	-14.54	84.78	0.52	-1.02	0
18-Nov-94	-3.85	10.46	2.21	-6.12	-4.32	-10.32	70.46	0.77	-0.66	0
19-Nov-94	-16.99	17.21	2.24	-6.96	-4.68	-17.10	56.44	0.98	0.65	0
20-Nov-94	-6.14	8.90	1.56	-8.50	-5.61	-18.37	72.69	0.76	0.10	0
21-Nov-94	-5.45	2.11	1.08	-7.45	-5.31	-14.81	83.50	0.97	0.85	0
22-Nov-94	0.79	5.38	1.95	-6.37	-4.82	-19.93	73.30	0.81	-1.43	0
23-Nov-94	-11.55	9.77	2.01	-8.24	-5.89	-27.43	65.07	0.88	-0.92	0
24-Nov-94	-6.23	6.39	1.34	-9.83	-7.04	-28.81	64.67	0.89	-0.65	0
25-Nov-94	-7.40	12.63	2.22	-9.93	-7.45	-28.63	69.08	0.97	0.67	0
26-Nov-94	-3.38	7.58	1.69	-9.79	-7.62	-23.21	76.19	0.97	0.77	0
27-Nov-94	-2.68	6.16	1.66	-8.55	-7.09	-20.90	78.61	1.00	1.00	0
28-Nov-94	-3.59	3.78	2.13	-7.93	-6.74	-19.73	79.81	1.00	1.00	0
29-Nov-94	-1.17	1.70	1.26	-7.66	-6.61	-20.74	78.32	0.98	0.60	0
30-Nov-94	-4.54	6.12	1.44	-8.83	-7.41	-26.02	67.87	0.60	-3.03	0
1-Dec-94	-28.68	9.20	1.44	-10.18	-8.47	-26.95	62.05	0.95	0.20	0
2-Dec-94	-7.28	8.67	1.79	-10.33	-8.90	-29.37	69.41	0.89	0.07	0
3-Dec-94	-1.40	3.99	0.93	-9.39	-8.73	-22.36	76.10	0.62	-0.63	0
4-Dec-94	-24.24	3.84	0.67	-6.42	-7.21	-5.52	76.99	-0.50	-2.42	0
5-Dec-94	-19.08	3.15	0.54	-3.47	-5.18	-9.49	77.30	0.43	-1.09	0
6-Dec-94	-11.55	8.71	0.98	-4.96	-5.68	-24.31	72.14	0.95	0.47	0
7-Dec-94	-16.23	6.47	0.80	-7.66	-7.44	-27.46	67.64	1.00	0.93	0
8-Dec-94	-10.53	7.86	0.90	-9.28	-8.96	-30.19	68.52	0.98	0.82	0
9-Dec-94	0.95	3.81	0.82	-10.17	-10.11	-32.28	66.78	1.00	1.00	0
10-Dec-94	-2.19	6.76	1.06	-9.83	-10.43	-29.56	68.83	1.00	1.00	0
11-Dec-94	1.43	5.62	0.97	-9.54	-10.59	-27.42	71.37	1.00	0.99	0
12-Dec-94	-4.56	3.69	0.70	-7.81	-9.81	-11.61	82.11	0.84	0.51	0
13-Dec-94	-19.14	4.68	0.79	-3.65	-7.11	-2.06	82.95	0.18	-0.96	0
14-Dec-94	-40.78	4.51	0.61	-1.99	-5.36	-3.49	58.13	0.76	0.38	0
15-Dec-94	-21.75	5.16	0.82	-3.40	-5.67	-13.49	83.02	1.00	0.97	0
16-Dec-94	-1.80	6.43	1.05	-4.98	-6.61	-16.82	82.64	1.00	1.00	0
17-Dec-94	-1.67	2.95	0.66	-5.91	-7.38	-16.35	83.15	1.00	1.00	0
18-Dec-94	1.00	6.77	1.56	-5.54	-7.38	-12.94	85.73	1.00	0.98	0
19-Dec-94	0.17	1.30	0.99	-4.33	-6.73	-7.72	91.05	1.00	0.97	0
20-Dec-94	2.42	3.28	0.95	-3.07	-5.75	-4.91	81.37	0.97	0.47	0
21-Dec-94	-19.95	5.45	0.77	-2.71	-5.27	-4.91	79.80	0.60	-0.91	0
22-Dec-94	-30.11	3.24	0.50	-2.50	-4.90	-5.30	69.58	0.86	0.47	0
23-Dec-94	-35.01	5.07	0.73	-3.05	-5.11	-9.26	70.45	0.70	0.07	0
24-Dec-94	-24.70	6.21	0.59	-4.21	-5.81	-15.13	81.37	0.96	0.87	0
25-Dec-94	-5.98	3.92	0.85	-6.27	-7.26	-23.08	76.84	1.00	1.00	0
26-Dec-94	-2.27	3.35	1.41	-7.60	-8.59	-24.39	74.83	1.00	1.00	0
27-Dec-94	-4.81	3.45	2.56	-8.13	-9.45	-23.54	75.67	1.00	1.00	0
28-Dec-94	-2.14	2.34	0.89	-8.24	-9.98	-20.11	79.33	0.95	0.84	0
29-Dec-94	-1.18	2.30	0.84	-6.76	-9.32	-13.94	84.05	0.88	0.56	0
30-Dec-94	-4.82	8.70	0.95	-4.24	-7.65	-5.26	80.60	0.81	0.02	0
31-Dec-94	-4.52	5.62	0.88	-3.38	-6.67	-9.97	87.85	0.91	0.38	0

Note: Precipitation values represent the sum of total precipitation during the day rather than an average value

Daily Averages of Meteorological Parameters Measured at the Williams Creek Climate Station - 1995
(January 1 to November 25)

Date	Net Radiation	Licor Shortwave Incoming	Licor Shortwave Outgoing	REBS Soil Heat Flux	Soil Temp 6cm Depth	HM35CF Upper Temp	HM35C Upper RH	Lower Wind Speed	Upper Wind Speed	Precip. Tip Bucket Totalized
	W/m ²	W/m ²	W/m ²	W/m ²	°C	°C	%	m/s	m/s	mm
1-Jan-95	2.22	4.53	0.94	-4.50	-7.14	-15.04	84.83	1.00	1.00	0
2-Jan-95	5.41	6.29	1.61	-5.47	-7.84	-15.79	83.65	1.00	1.00	0
3-Jan-95	8.40	9.87	1.86	-5.60	-8.12	-17.00	81.69	1.00	1.00	0
4-Jan-95	5.88	8.84	1.68	-6.50	-8.82	-20.89	79.01	1.00	1.00	0
5-Jan-95	6.67	9.18	1.94	-7.44	-9.73	-23.26	75.75	1.00	1.00	0
6-Jan-95	7.13	9.32	2.07	-8.02	-10.47	-24.24	75.25	1.00	1.00	0
7-Jan-95	5.51	8.40	2.08	-8.41	-11.06	-24.80	74.12	1.00	1.00	0
8-Jan-95	0.26	4.84	1.34	-8.62	-11.50	-27.76	71.83	1.01	1.00	0
9-Jan-95	0.69	1.91	1.00	-8.86	-11.95	-28.12	71.00	1.01	1.00	0
10-Jan-95	0.97	2.60	1.43	-8.05	-11.69	-24.86	74.27	1.00	1.00	0
11-Jan-95	3.45	7.12	3.75	-7.42	-11.32	-22.96	75.96	1.00	1.00	0
12-Jan-95	0.11	1.34	1.04	-6.80	-10.93	-21.95	77.45	1.00	1.00	0
13-Jan-95	0.60	1.95	1.48	-6.14	-10.42	-18.90	80.54	1.00	1.00	0
14-Jan-95	0.94	4.30	3.46	-4.64	-9.33	-10.34	88.32	1.00	1.00	0
15-Jan-95	0.29	1.51	1.23	-3.56	-8.22	-13.08	86.29	1.00	1.00	0
16-Jan-95	0.74	4.95	3.80	-4.03	-8.17	-15.59	83.30	1.00	1.00	0
17-Jan-95	-4.56	5.64	4.01	-4.59	-8.49	-12.72	85.56	1.00	0.96	0
18-Jan-95	0.91	6.55	1.84	-4.59	-8.46	-15.80	84.22	1.00	0.89	0
19-Jan-95	0.40	11.33	2.93	-4.14	-8.21	-7.99	86.62	0.93	-0.02	0
20-Jan-95	-3.68	9.08	2.56	-2.63	-7.05	-4.16	86.95	0.89	-0.23	0
21-Jan-95	-25.63	10.79	1.80	-1.19	-5.74	-0.82	78.14	0.18	-1.43	0
22-Jan-95	-27.52	14.19	1.48	-0.33	-4.69	0.22	68.30	0.02	-1.87	0
23-Jan-95	-28.37	13.69	1.94	-0.92	-4.59	-8.06	68.17	0.96	0.75	0
24-Jan-95	-9.17	9.26	2.15	-3.70	-6.28	-17.65	82.02	1.00	1.00	0
25-Jan-95	2.07	6.49	1.90	-5.17	-7.72	-18.12	81.47	1.00	1.00	0
26-Jan-95	0.81	4.78	2.06	-5.40	-8.29	-20.30	79.20	1.00	1.00	0
27-Jan-95	1.94	3.79	1.79	-6.01	-8.98	-20.79	78.72	1.00	1.00	0
28-Jan-95	2.41	4.64	2.17	-5.26	-8.85	-9.15	90.12	0.99	0.97	0
29-Jan-95	1.21	7.41	2.41	-2.21	-6.77	-2.33	85.99	0.91	0.43	0
30-Jan-95	3.83	20.58	2.91	-1.50	-5.75	-3.57	78.29	0.85	0.49	0
31-Jan-95	-0.21	16.77	3.09	-2.09	-5.77	-8.98	89.81	0.99	0.98	0
1-Feb-95	7.38	15.79	3.64	-2.57	-5.99	-10.03	89.69	0.96	0.89	0
2-Feb-95	24.14	37.51	5.06	-2.56	-5.99	-10.11	87.09	0.70	-0.07	0
3-Feb-95	1.62	8.73	2.73	-2.67	-6.07	-6.96	90.16	0.98	0.90	0
4-Feb-95	14.97	35.52	4.29	-2.37	-5.82	-4.93	83.03	0.90	0.50	0
5-Feb-95	-0.41	40.72	3.93	-2.28	-5.68	-3.01	80.37	0.51	-0.32	0
6-Feb-95	-21.41	26.93	3.57	-1.24	-4.94	0.71	69.72	0.45	-0.48	0
7-Feb-95	-15.57	17.41	2.55	-0.53	-4.21	0.82	66.90	0.76	0.26	0
8-Feb-95	-16.86	23.62	2.82	-0.12	-3.67	0.87	62.35	0.58	-0.19	0
9-Feb-95	3.20	13.71	2.11	-0.17	-3.43	-2.71	82.79	0.95	0.72	0
10-Feb-95	4.42	13.81	3.41	-0.53	-3.48	-7.22	87.27	0.98	0.76	0
11-Feb-95	14.69	35.46	5.92	-1.33	-3.93	-10.25	84.10	0.98	0.07	0
12-Feb-95	9.74	31.11	6.54	-2.43	-4.72	-16.41	81.77	0.88	0.43	0
13-Feb-95	-6.05	31.25	6.39	-3.34	-5.61	-16.84	75.12	0.97	0.19	0
14-Feb-95	-17.35	26.62	5.40	-4.32	-6.54	-17.44	70.81	0.77	-1.69	0
15-Feb-95	-12.69	52.99	6.37	-5.45	-7.57	-19.61	55.76	0.70	-2.48	0
16-Feb-95	-4.59	28.52	4.37	-6.20	-8.67	-23.56	65.62	0.98	0.74	0
17-Feb-95	6.33	22.73	6.98	-6.18	-9.14	-23.22	74.34	0.99	0.75	0
18-Feb-95	8.65	25.40	7.10	-6.30	-9.55	-24.83	68.95	0.99	0.25	0
19-Feb-95	15.87	26.71	6.71	-6.48	-9.99	-23.09	68.98	0.97	0.72	0
20-Feb-95	13.19	10.57	7.29	-5.80	-9.79	-15.28	76.37	0.84	0.47	0
21-Feb-95	17.57	30.42	10.27	-4.21	-8.76	-5.55	56.33	0.87	0.53	0
22-Feb-95	7.24	50.37	8.20	-3.19	-7.78	-9.14	57.12	0.99	0.97	0
23-Feb-95	19.88	104.33	9.14	-3.32	-7.62	-14.79	78.71	1.00	1.00	0
24-Feb-95	12.07	34.04	8.20	-3.95	-8.00	-14.97	77.61	0.98	0.27	0
25-Feb-95	11.19	86.25	10.13	-3.94	-8.07	-17.05	61.59	0.98	0.93	0
26-Feb-95	27.10	74.20	9.65	-4.45	-8.49	-16.56	58.49	1.17	0.38	0
27-Feb-95	34.84	80.71	9.40	-4.21	-8.47	-12.38	50.31	0.71	1.13	0
28-Feb-95	28.42	81.36	9.53	-3.86	-8.24	-10.42	54.46	0.75	1.38	0
1-Mar-95	22.32	63.94	8.89	-3.47	-7.93	-9.08	56.22	0.72	1.27	0
2-Mar-95	30.75	57.47	8.20	-2.64	-7.25	-5.16	74.89	0.78	2.59	0
3-Mar-95	15.33	63.87	8.09	-1.75	-6.36	-6.15	72.18	0.73	2.47	0
4-Mar-95	20.36	46.77	7.45	-1.73	-6.05	-7.99	71.77	0.72	1.55	0.5
5-Mar-95	18.98	55.18	7.87	-1.66	-5.84	-7.36	67.46	0.78	3.00	0.4
6-Mar-95	33.91	87.53	12.10	-1.88	-5.84	-9.98	59.17	0.71	1.79	0.3
7-Mar-95	55.42	83.70	12.91	-2.33	-6.12	-11.31	73.23	0.73	1.98	0.6
8-Mar-95	56.76	97.68	11.84	-2.79	-6.50	-11.70	61.96	0.71	1.42	1.2
9-Mar-95	27.30	89.93	14.36	-2.85	-6.67	-12.38	74.88	0.84	3.70	0

*Note: Precipitation values represent the sum of total precipitation during the day rather than an average value

Daily Averages of Meteorological Parameters Measured at the Williams Creek Climate Station - 1995
(January 1 to November 25)

Date	Net Radiation W/m ²	Licor Shortwave Incoming W/m ²	Licor Shortwave Outgoing W/m ²	REBS Soil Heat Flux W/m ²	Soil Temp 6cm Depth °C	HM35CF Upper Temp °C	HM35C Upper RH %	Lower Wind Speed m/s	Upper Wind Speed m/s	Precip Tip Bucket Totalized mm
10-Mar-95	40.68	89.97	12.41	-3.00	-6.81	-16.70	62.93	0.72	2.04	0.3
11-Mar-95	18.05	62.53	9.78	-3.56	-7.30	-20.73	67.82	0.86	3.80	0
12-Mar-95	72.94	115.51	15.02	-4.37	-8.05	-25.24	58.45	0.71	1.54	0
13-Mar-95	64.90	89.76	11.98	-5.07	-8.87	-23.68	59.60	0.72	2.11	0
14-Mar-95	52.21	70.30	10.48	-5.09	-9.21	-23.80	62.26	0.75	2.43	0
15-Mar-95	78.94	126.54	15.78	-5.12	-9.43	-19.12	60.53	0.96	2.10	0
16-Mar-95	2.33	55.79	8.40	-4.37	-9.09	-3.35	51.26	2.29	5.08	0
18-Mar-95	66.82	125.82	15.40	-1.97	-7.28	2.86	52.68	2.45	5.22	0
19-Mar-95	80.82	134.08	15.61	-0.24	-5.51	3.44	55.87	1.24	2.92	0
20-Mar-95	37.53	84.37	11.87	0.34	-4.53	-2.08	45.10	0.77	1.79	0
21-Mar-95	74.72	147.40	16.91	-0.43	-4.61	-5.72	34.20	0.72	1.35	0
22-Mar-95	37.98	76.67	11.29	-1.75	-5.41	-11.27	63.69	1.49	5.18	0
23-Mar-95	72.28	92.92	14.01	-2.64	-6.19	-18.41	63.46	1.56	5.34	0
24-Mar-95	80.78	112.55	16.52	-3.88	-7.33	-23.31	57.72	0.93	3.28	0
25-Mar-95	105.10	160.07	19.03	-4.94	-8.46	-22.47	45.25	0.77	1.79	0
26-Mar-95	108.32	158.05	19.24	-5.58	-9.36	-20.06	41.71	0.76	1.60	0
27-Mar-95	74.22	103.27	14.32	-5.22	-9.52	-15.04	42.91	0.72	1.34	0
28-Mar-95	110.95	143.47	17.11	-4.00	-8.80	-7.89	52.63	0.72	1.09	0
29-Mar-95	71.88	106.47	15.45	-2.49	-7.60	0.51	60.71	1.42	2.99	0
30-Mar-95	82.46	126.39	15.44	-0.31	-5.57	3.47	53.72	0.75	1.36	0
31-Mar-95	115.95	170.48	19.95	0.87	-4.09	3.40	53.23	0.83	1.53	0
1-Apr-95	43.76	74.14	10.51	1.39	-3.17	3.36	67.13	0.83	1.64	0
2-Apr-95	143.41	172.94	20.48	2.33	-2.09	2.50	63.72	0.87	1.69	0
3-Apr-95	129.30	185.16	22.13	2.07	-1.80	2.25	52.47	1.00	2.21	0
4-Apr-95	76.28	99.67	13.51	1.92	-1.61	1.29	82.71	1.24	2.70	0
5-Apr-95	140.75	182.97	20.55	2.22	-1.20	2.01	63.20	1.20	2.60	0
6-Apr-95	102.74	165.57	20.33	2.06	-1.05	1.35	42.26	0.77	1.42	0
7-Apr-95	158.79	212.04	25.27	1.83	-1.02	1.98	34.48	0.87	1.61	0
8-Apr-95	141.96	201.53	23.84	1.53	-1.05	2.75	35.59	0.91	1.84	0
9-Apr-95	149.44	205.45	24.10	1.60	-0.94	4.32	42.30	0.94	1.88	0
10-Apr-95	153.68	198.46	22.81	2.10	-0.67	3.81	49.10	1.01	2.15	0
11-Apr-95	152.53	208.30	24.46	2.22	-0.39	1.98	41.52	1.03	2.30	0
12-Apr-95	155.63	203.65	23.59	2.39	-0.32	3.32	45.34	1.13	2.32	0
13-Apr-95	157.16	220.53	25.19	3.26	-0.24	1.88	41.71	1.01	2.11	0
14-Apr-95	142.23	200.99	23.68	0.05	-0.19	2.44	35.83	0.80	1.39	0.1
15-Apr-95	141.68	204.87	24.24	0.21	-0.14	3.38	35.30	0.92	1.92	0
16-Apr-95	167.22	220.78	25.40	0.21	-0.11	1.96	35.38	1.33	2.85	0.1
17-Apr-95	129.87	163.22	19.49	0.22	-0.08	2.34	43.35	1.54	3.52	0
18-Apr-95	181.54	216.58	24.99	0.24	-0.07	3.00	49.38	0.95	2.04	0.5
19-Apr-95	188.36	237.24	26.58	0.24	-0.07	2.75	44.73	1.17	2.48	0.3
20-Apr-95	159.53	200.28	23.26	0.21	-0.06	1.22	44.93	1.03	2.29	1.4
21-Apr-95	125.53	168.92	19.63	0.19	-0.06	4.12	37.34	0.81	1.52	3.4
22-Apr-95	188.99	242.06	26.53	0.17	-0.06	4.35	40.29	0.99	2.14	2.4
23-Apr-95	112.87	150.24	16.77	0.18	-0.06	5.32	49.70	2.04	4.48	0.3
24-Apr-95	72.90	118.64	12.79	0.19	-0.04	4.37	60.54	0.79	1.51	0.1
25-Apr-95	138.08	190.20	20.09	0.19	0.15	6.46	46.61	0.98	1.98	0.3
26-Apr-95	191.66	235.06	24.27	0.19	0.68	8.76	34.85	0.91	1.83	0.1
27-Apr-95	215.87	238.16	23.25	0.23	1.76	11.34	41.12	0.84	1.80	0
28-Apr-95	212.83	257.53	25.47	0.64	2.63	14.31	33.92	1.29	2.94	4.8
29-Apr-95	132.34	162.82	16.15	4.18	1.84	7.03	47.79	1.06	3.36	1.9
30-Apr-95	245.40	268.57	25.91	5.42	1.65	6.69	53.81	0.78	1.87	3.8
1-May-95	208.68	254.19	25.58	8.68	2.59	11.70	38.78	0.78	1.52	10
2-May-95	220.92	271.17	27.07	8.48	2.54	11.12	31.23	0.89	1.75	13.1
3-May-95	161.53	210.27	20.96	7.42	2.29	8.64	37.50	1.14	2.43	13.7
4-May-95	207.62	256.06	26.02	5.43	1.93	8.02	41.12	1.05	2.28	8.2
5-May-95	140.50	189.14	19.72	6.20	2.32	10.15	33.17	0.78	1.50	2.7
6-May-95	141.94	195.43	20.72	6.04	2.31	9.13	43.59	0.79	2.00	4.5
7-May-95	164.59	205.99	20.90	5.01	2.08	8.25	42.35	1.57	3.33	12.9
8-May-95	172.65	219.61	21.95	6.03	2.66	9.77	39.49	1.53	3.51	16.8
9-May-95	232.45	278.20	27.22	7.24	3.43	12.54	32.93	1.29	2.99	26
10-May-95	192.56	256.14	26.49	8.22	4.08	16.60	19.67	0.97	2.14	4
11-May-95	211.80	261.31	25.83	11.01	5.62	19.80	19.17	0.80	1.43	1.4
12-May-95	240.25	290.83	28.59	11.12	5.86	20.11	20.62	0.87	1.68	7.6
13-May-95	165.72	209.44	20.52	11.06	6.05	19.96	25.54	0.71	1.46	5
14-May-95	162.67	200.79	20.09	10.83	6.05	16.81	39.55	0.89	2.52	11.5
15-May-95	61.59	64.36	7.64	5.91	3.39	6.14	76.41	0.72	1.44	1.3
16-May-95	204.60	234.46	23.60	5.31	3.14	8.93	48.99	0.93	2.21	5.2
17-May-95	121.50	153.45	15.30	4.94	2.88	6.48	60.01	0.77	1.61	1.8
18-May-95	197.75	209.92	20.32	4.03	2.51	5.35	69.82	0.73	1.43	1.3

*Note: Precipitation values represent the sum of total precipitation during the day rather than an average value

Daily Averages of Meteorological Parameters Measured at the Williams Creek Climate Station - 1995
(January 1 to November 25)

Date	Net Radiation	Licor Shortwave Incoming	Licor Shortwave Outgoing	REBS Soil Heat Flux	Soil Temp 6cm Depth	HM35CF Upper Temp	HM35C Upper RH	Lower Wind Speed	Upper Wind Speed	Precip Tip Bucket Totalized
	W/m ²	W/m ²	W/m ²	W/m ²	°C	°C	%	m/s	m/s	mm
19-May-95	123.81	137.51	13.29	4.76	2.85	5.31	70.60	0.73	1.71	1.1
20-May-95	219.09	243.11	23.48	5.83	3.28	7.92	57.15	0.77	1.82	2.6
21-May-95	250.78	290.23	29.03	6.72	3.90	12.08	26.86	0.83	1.99	3.9
22-May-95	112.54	127.02	12.33	6.03	3.54	5.34	68.35	0.87	3.06	1.6
23-May-95	167.90	171.08	17.84	3.90	2.43	3.76	75.70	0.74	1.28	0
24-May-95	227.75	263.57	27.08	6.36	3.90	10.97	49.89	0.89	1.88	7.8
25-May-95	183.73	225.69	22.79	7.91	4.97	13.56	37.82	1.20	2.69	8.1
26-May-95	203.83	233.05	23.17	9.68	6.13	15.85	41.17	1.54	3.24	47.7
27-May-95	157.06	183.73	18.37	8.51	5.79	13.20	44.23	1.62	3.61	72.6
28-May-95	238.39	264.96	25.81	7.86	5.54	13.27	42.64	2.03	4.37	123.1
29-May-95	237.00	278.93	28.66	5.47	4.17	9.55	34.08	1.90	4.15	253
30-May-95	245.35	292.58	30.00	4.34	3.41	8.59	36.02	1.36	3.01	63.8
31-May-95	170.07	208.06	21.20	3.41	2.75	6.53	50.44	0.84	1.99	40
1-Jun-95	211.82	256.23	26.06	4.56	3.49	8.64	44.76	1.19	2.60	62.3
2-Jun-95	251.91	296.65	30.31	3.99	3.25	8.77	36.80	1.18	2.66	2.8
3-Jun-95	155.63	209.57	22.73	3.62	3.05	7.59	45.09	1.10	2.41	66.2
4-Jun-95	239.40	273.28	28.28	3.41	2.92	6.92	38.04	1.22	2.83	7.1
5-Jun-95	132.92	169.61	17.73	5.29	4.28	9.30	68.36	1.10	2.49	18.9
6-Jun-95	182.80	218.33	22.66	5.88	4.94	11.13	46.95	0.80	1.51	13.4
7-Jun-95	294.18	316.26	30.99	5.88	5.26	11.05	41.31	1.66	3.43	112.9
8-Jun-95	186.21	215.23	21.35	5.91	5.31	11.86	44.90	1.91	4.30	25.2
9-Jun-95	174.80	201.33	19.94	7.48	6.62	14.81	40.67	1.70	3.78	1.2
10-Jun-95	229.24	265.15	27.03	9.06	8.02	18.93	35.65	0.89	1.95	1.2
11-Jun-95	312.84	352.74	35.63	10.39	9.58	22.42	31.63	0.84	1.95	2
12-Jun-95	165.58	200.63	20.04	10.16	10.06	20.83	40.46	0.98	3.11	24.6
13-Jun-95	277.10	309.46	31.23	9.05	9.73	19.06	46.62	0.94	3.03	36.3
14-Jun-95	304.73	348.02	35.53	8.79	9.84	19.67	38.46	1.05	3.65	5.3
15-Jun-95	293.03	327.52	33.22	8.22	9.60	17.71	52.14	1.10	2.50	6.8
16-Jun-95	258.67	293.03	30.10	6.74	8.81	13.76	57.34	1.37	3.20	9.1
17-Jun-95	166.99	193.91	20.25	4.82	7.35	11.84	54.19	0.95	2.24	4.5
18-Jun-95	112.54	131.14	13.61	5.76	7.88	12.33	66.24	0.78	2.33	1.8
19-Jun-95	214.46	247.91	25.80	6.83	8.66	15.33	53.22	0.80	1.73	5.7
20-Jun-95	235.50	269.05	28.16	9.28	10.41	19.62	33.30	0.84	1.64	4.9
21-Jun-95	256.49	299.95	30.99	9.60	11.06	20.46	29.19	1.01	2.14	10.3
22-Jun-95	253.56	307.54	32.92	7.47	10.01	18.97	27.13	1.26	2.78	8.3
23-Jun-95	273.08	297.60	30.39	8.49	10.66	18.37	38.46	1.43	3.19	12.4
24-Jun-95	241.35	270.17	28.02	4.36	8.20	10.98	41.91	1.51	3.52	47.5
25-Jun-95	140.17	172.23	18.26	2.57	6.29	8.23	53.79	0.94	2.35	14.5
26-Jun-95	185.21	201.99	20.45	5.17	7.64	12.53	43.98	0.76	2.08	3.3
27-Jun-95	125.05	151.35	16.21	5.61	8.23	14.37	42.71	0.81	2.62	4.9
28-Jun-95	172.59	219.78	24.36	5.63	8.33	15.30	42.14	0.78	1.77	0.5
29-Jun-95	107.61	152.33	16.65	6.07	8.78	17.60	33.71	0.75	1.49	1.2
30-Jun-95	159.73	189.47	20.32	8.00	10.39	19.52	36.86	0.76	1.72	31.8
1-Jul-95	159.32	188.32	20.20	8.36	11.12	18.56	48.09	0.81	2.27	0.3
2-Jul-95	189.34	212.31	22.34	8.24	11.36	17.79	51.82	1.00	1.97	3.1
3-Jul-95	81.71	79.70	7.72	6.48	10.36	12.23	96.64	0.68	0.96	0
4-Jul-95	132.64	136.30	13.72	6.79	10.45	12.36	85.58	0.72	1.15	1.1
5-Jul-95	225.18	234.41	22.65	7.61	11.09	16.14	69.42	0.79	1.92	4.7
6-Jul-95	205.23	233.63	23.87	8.17	11.85	18.63	48.57	0.87	2.30	7
7-Jul-95	168.74	210.76	22.35	6.93	11.17	17.67	51.67	0.77	1.63	2.9
8-Jul-95	201.01	220.46	21.15	6.48	11.49	18.66	49.64	0.87	1.94	8.5
9-Jul-95	153.27	169.21	15.85	9.12	12.01	17.06	51.55	0.84	2.16	3.6
10-Jul-95	201.28	207.53	19.68	8.84	11.82	16.74	61.64	0.86	2.80	1.7
11-Jul-95	206.76	216.25	20.00	9.06	12.10	17.94	55.67	0.89	1.64	3.6
12-Jul-95	208.17	224.98	21.27	8.42	11.97	18.34	42.84	1.10	2.22	5.9
13-Jul-95	174.43	181.41	16.79	7.48	11.59	15.56	58.11	0.98	2.20	7.7
14-Jul-95	175.80	197.86	18.73	6.63	11.00	16.04	53.61	0.81	1.74	3
15-Jul-95	221.47	233.76	22.48	7.33	11.26	16.36	49.18	0.97	2.34	3.9
16-Jul-95	190.98	194.97	17.83	6.11	10.60	13.78	51.34	0.76	1.52	1.1
17-Jul-95	230.06	249.08	23.65	6.74	10.93	16.55	42.76	0.95	2.24	4.8
18-Jul-95	204.11	230.45	22.27	7.06	11.21	18.55	41.67	0.80	1.81	15.8
19-Jul-95	146.80	169.18	16.19	6.50	11.00	16.40	50.88	0.72	1.70	3.6
20-Jul-95	159.32	181.96	17.38	6.00	10.70	16.19	53.44	0.79	2.18	8.6
21-Jul-95	156.77	177.89	16.88	6.64	11.01	17.46	45.74	0.78	2.57	9.9
22-Jul-95	106.54	131.53	12.67	6.32	10.99	17.43	48.28	0.84	2.61	5.9
23-Jul-95	73.82	80.89	7.30	5.58	10.52	12.64	82.25	0.69	1.29	0.7
24-Jul-95	109.25	114.00	10.12	5.64	10.37	11.53	89.29	0.70	1.27	0.3
25-Jul-95	111.17	111.34	9.89	5.43	9.89	10.19	78.40	0.95	2.05	0
26-Jul-95	177.80	179.34	16.37	6.09	9.80	12.01	73.13	0.95	2.42	0

*Note: Precipitation values represent the sum of total precipitation during the day rather than an average value

Daily Averages of Meteorological Parameters Measured at the Williams Creek Climate Station - 1995
(January 1 to November 25)

Date	Net Radiation	Licor Shortwave Incoming	Licor Shortwave Outgoing	REBS Soil Heat Flux	Soil Temp 6cm Depth	HM35CF Upper Temp	HM35C Upper RH	Lower Wind Speed	Upper Wind Speed	Precip Tip Bucket Totalized
	W/m ²	W/m ²	W/m ²	W/m ²	°C	°C	%	m/s	m/s	mm
27-Jul-95	29.24	40.14	3.37	4.08	8.75	9.11	88.95	0.69	1.12	0
28-Jul-95	151.10	150.72	13.36	4.94	8.84	9.49	84.49	0.73	1.38	2.3
29-Jul-95	169.17	178.77	15.70	5.09	8.86	11.69	61.34	0.75	1.71	5.5
30-Jul-95	175.20	210.21	20.07	5.97	9.34	14.31	44.61	0.95	1.91	0.1
31-Jul-95	84.94	102.09	9.17	4.26	8.56	9.69	79.90	0.91	1.76	3.3
1-Aug-95	127.05	128.58	11.17	6.21	9.30	11.16	75.19	0.73	1.57	12.5
2-Aug-95	187.40	194.36	17.16	6.48	9.63	13.11	64.21	0.79	1.66	14.7
3-Aug-95	223.25	249.11	23.35	4.93	9.00	12.72	47.76	1.31	2.90	7.8
4-Aug-95	120.72	132.15	11.72	4.75	8.78	11.95	64.60	1.11	2.42	6.5
5-Aug-95	133.04	133.25	11.57	4.68	8.52	9.50	83.03	0.83	1.75	7.2
6-Aug-95	143.04	149.84	13.20	5.19	8.66	9.83	81.17	0.73	1.30	3
7-Aug-95	183.02	204.99	19.08	4.86	8.50	12.39	58.93	0.74	1.89	4.2
8-Aug-95	216.08	243.03	22.87	6.01	9.14	14.63	47.80	0.94	1.75	13.6
9-Aug-95	213.23	235.85	22.20	7.06	9.93	15.57	47.85	0.82	1.49	8.1
10-Aug-95	211.22	237.95	22.28	6.28	9.73	15.26	47.42	1.20	2.49	1.2
11-Aug-95	189.23	209.34	19.52	6.03	9.65	14.26	52.69	1.11	2.22	16.7
12-Aug-95	210.57	234.77	22.13	6.67	10.07	15.63	54.95	0.85	1.65	24
13-Aug-95	209.33	229.30	21.68	5.31	9.57	14.54	47.51	1.66	3.37	106.7
14-Aug-95	114.11	132.74	12.10	3.97	8.76	12.23	56.21	1.67	3.69	15.1
15-Aug-95	178.66	200.64	18.21	3.64	8.34	11.89	60.91	0.76	1.82	51.1
16-Aug-95	55.32	78.54	7.51	3.52	8.14	11.76	67.37	0.83	3.52	8.7
17-Aug-95	47.40	62.88	6.03	4.65	8.68	11.79	78.60	0.75	2.59	0
18-Aug-95	54.89	56.24	4.82	4.83	8.94	9.91	95.75	0.69	1.32	0
19-Aug-95	124.78	122.26	10.67	5.99	9.20	10.95	85.57	0.70	1.35	5.6
20-Aug-95	156.58	167.49	14.91	5.32	9.00	11.68	71.03	0.77	1.75	46.3
21-Aug-95	119.75	137.37	12.52	4.31	8.45	10.63	72.75	0.81	2.27	8
22-Aug-95	118.95	131.01	11.46	4.03	8.16	10.17	74.59	0.88	3.25	1.7
23-Aug-95	136.54	154.73	13.71	3.79	7.92	10.91	62.02	0.74	1.52	20.5
24-Aug-95	129.26	151.80	13.93	3.75	7.86	10.64	63.04	0.75	1.54	75.3
25-Aug-95	119.03	136.91	12.24	3.95	7.89	11.74	51.13	0.77	1.64	27.1
26-Aug-95	98.89	116.77	10.15	3.35	7.57	9.85	69.54	0.78	2.10	22.2
27-Aug-95	71.93	92.41	8.58	2.61	7.09	7.80	75.30	0.74	2.14	33.4
28-Aug-95	110.79	134.56	12.56	1.63	6.42	8.85	64.45	0.77	1.93	58.4
29-Aug-95	140.24	152.88	13.35	2.90	6.93	8.21	68.70	0.83	2.37	22.4
30-Aug-95	106.86	143.94	14.02	2.65	6.69	11.40	47.15	0.79	1.85	14.5
31-Aug-95	39.87	64.49	5.88	3.59	7.16	10.92	57.83	0.77	1.53	24.9
1-Sep-95	112.87	121.07	10.27	3.87	7.36	8.99	83.37	0.73	1.35	10.2
2-Sep-95	80.16	96.16	8.46	3.82	7.30	10.09	77.86	0.81	1.71	5.7
3-Sep-95	81.22	95.99	8.30	3.82	7.36	9.05	77.87	0.72	1.63	3.9
4-Sep-95	145.07	171.07	16.09	2.59	6.80	10.50	58.84	0.95	1.98	0
5-Sep-95	91.70	126.81	11.07	1.25	6.04	6.74	64.50	0.89	2.68	0
6-Sep-95	115.24	138.97	12.93	-0.04	5.14	8.12	54.42	0.91	1.54	0
7-Sep-95	85.04	105.97	9.56	4.42	7.01	11.84	58.54	0.75	1.16	0
8-Sep-95	12.87	37.36	3.42	4.94	7.53	12.68	65.97	1.28	2.57	0
9-Sep-95	54.52	84.83	7.93	6.11	8.23	14.41	57.97	1.40	3.03	0.4
10-Sep-95	114.62	135.82	12.25	4.43	7.74	12.24	59.33	0.91	1.77	0
11-Sep-95	53.94	76.82	7.15	3.61	7.29	10.80	77.32	1.27	2.45	0
12-Sep-95	137.21	161.92	14.96	3.14	7.03	11.65	52.41	1.27	2.65	0
13-Sep-95	97.02	134.89	12.37	1.83	6.32	11.28	48.10	1.16	2.31	0
14-Sep-95	77.83	98.25	9.15	2.14	6.29	8.64	62.42	1.09	2.20	1.1
15-Sep-95	108.45	118.18	10.70	2.51	6.39	8.60	76.12	0.71	1.23	3.5
16-Sep-95	104.56	124.66	11.60	1.57	5.91	8.62	73.73	0.72	1.13	0
17-Sep-95	32.41	64.18	5.46	2.60	6.25	9.33	66.60	0.68	1.07	0
18-Sep-95	103.19	153.29	14.12	-0.89	4.53	8.15	47.90	0.89	1.73	0
19-Sep-95	95.95	143.01	13.30	-1.35	3.87	8.45	42.81	1.41	2.98	0
20-Sep-95	85.77	128.09	11.96	1.39	4.96	11.56	44.30	1.32	2.88	0
21-Sep-95	94.83	130.61	12.08	3.63	6.16	14.18	50.72	2.18	4.64	0
22-Sep-95	28.64	63.17	5.91	6.72	7.97	16.57	50.92	2.22	4.82	0
23-Sep-95	32.05	67.81	6.55	6.78	8.50	16.38	56.30	1.84	4.05	0
24-Sep-95	65.42	116.65	11.16	3.92	7.39	15.40	28.11	0.97	2.10	0
25-Sep-95	80.50	128.90	11.87	2.11	6.38	15.39	28.90	1.06	2.20	0
26-Sep-95	66.47	113.01	10.63	1.84	6.06	14.00	36.82	1.16	2.63	0
27-Sep-95	60.75	99.22	9.75	0.77	5.35	9.64	58.07	0.76	1.44	0
28-Sep-95	68.86	108.90	9.60	0.05	4.74	8.81	58.85	0.80	2.58	0
29-Sep-95	38.23	78.17	7.07	-0.66	4.10	6.76	67.15	0.73	1.18	0
30-Sep-95	72.12	89.73	8.65	-0.01	4.21	6.78	68.22	0.77	1.33	0.2
1-Oct-95	8.08	39.76	3.69	0.37	4.24	5.57	73.73	0.74	1.36	2.2
2-Oct-95	23.16	50.90	4.59	-2.10	2.85	2.66	77.44	1.41	2.96	0
3-Oct-95	61.82	83.23	8.04	-0.55	3.27	4.84	64.81	0.83	1.59	0

*Note: Precipitation values represent the sum of total precipitation during the day rather than an average value

Daily Averages of Meteorological Parameters Measured at the Williams Creek Climate Station - 1995
(January 1 to November 25)

Date	Net Radiation	Licor Shortwave Incoming	Licor Shortwave Outgoing	REBS Soil Heat Flux	Soil Temp 6cm Depth	HM35CF Upper Temp	HM35C Upper RH	Lower Wind Speed	Upper Wind Speed	Precip. Tip Bucket Totalized
	W/m ²	W/m ²	W/m ²	W/m ²	°C	°C	%	m/s	m/s	mm
4-Oct-95	26.90	44.03	3.89	-0.46	3.25	3.45	81.04	0.69	0.88	0.6
5-Oct-95	22.18	30.28	2.79	-0.49	3.13	2.33	91.06	0.70	0.94	0
6-Oct-95	37.38	40.47	3.61	-0.60	2.96	1.52	95.33	0.69	1.45	2
7-Oct-95	48.50	47.76	5.96	-1.35	2.44	1.30	90.29	0.71	0.95	0.9
8-Oct-95	16.94	17.01	2.13	-1.47	2.16	1.62	97.89	0.80	1.47	0.8
9-Oct-95	16.58	31.03	3.26	-0.65	2.43	3.00	87.84	0.95	1.90	0
10-Oct-95	44.62	74.26	7.43	-1.97	1.69	2.25	79.55	0.71	1.09	0
11-Oct-95	18.44	28.11	2.46	-1.05	1.91	1.85	88.41	0.68	0.89	0
12-Oct-95	28.44	37.33	3.35	-0.59	2.12	1.99	89.06	0.84	1.58	0
13-Oct-95	30.37	77.16	7.50	-1.60	1.56	1.76	56.07	0.92	1.88	0
14-Oct-95	4.14	22.95	3.19	-2.32	0.97	-1.48	74.03	0.68	1.10	0
15-Oct-95	-7.86	41.21	4.18	-2.80	0.27	-2.49	69.16	0.69	1.13	0
16-Oct-95	13.88	45.11	4.32	-3.65	-0.76	-6.02	89.15	0.69	0.98	0
17-Oct-95	39.04	66.42	6.44	-3.48	-1.38	-6.62	87.37	0.72	1.03	0
18-Oct-95	20.43	40.37	4.16	-2.79	-1.63	-6.92	77.12	0.68	0.84	0
19-Oct-95	36.48	61.36	5.72	-2.40	-1.33	-3.65	79.96	0.70	1.05	0
20-Oct-95	-10.26	12.28	1.45	-2.36	-0.67	0.27	87.09	1.18	2.59	0.9
21-Oct-95	9.68	15.63	2.90	-2.21	-0.36	-0.31	89.03	0.68	0.90	0.5
22-Oct-95	40.28	52.17	6.15	-2.02	-0.69	-1.62	83.43	0.73	1.23	0.1
23-Oct-95	3.84	12.57	1.73	-1.92	-0.61	-1.19	90.50	0.72	1.14	0
24-Oct-95	27.63	57.52	5.75	-1.83	-0.36	-0.29	86.40	0.88	1.79	0.1
25-Oct-95	-8.83	28.47	3.40	-1.78	-0.71	-1.17	80.08	1.25	2.80	0
26-Oct-95	6.35	26.71	3.03	-1.73	-0.32	1.35	82.72	1.15	2.45	0.1
27-Oct-95	6.78	20.16	2.82	-1.58	-0.13	-0.52	92.69	0.69	1.02	0.3
28-Oct-95	5.16	16.10	2.58	-1.45	-0.56	-5.59	89.58	0.68	1.70	0
29-Oct-95	24.00	30.66	4.09	-2.99	-1.08	-6.61	91.86	0.68	1.34	0
30-Oct-95	37.60	36.21	4.93	-5.94	-1.28	-6.11	91.16	0.68	1.10	0
31-Oct-95	14.55	23.36	3.71	-8.26	-1.48	-6.28	93.12	0.68	1.69	0
1-Nov-95	45.72	26.64	4.64	-9.06	-1.64	-5.95	86.57	0.68	1.72	0
2-Nov-95	-12.34	24.24	2.79	-6.79	-1.19	-1.23	60.35	1.01	2.76	0
3-Nov-95	-6.77	19.78	2.76	-3.52	-0.64	-0.31	76.00	0.75	1.53	0.3
4-Nov-95	-4.31	23.87	3.06	-4.78	-1.08	-6.07	84.86	0.68	0.98	0
5-Nov-95	1.35	22.04	2.45	-9.06	-1.80	-10.20	82.91	1.03	4.25	0
6-Nov-95	-0.60	16.95	2.34	-11.50	-2.29	-12.52	76.21	0.91	3.49	0
7-Nov-95	7.78	14.21	3.39	-9.55	-2.13	-14.40	84.11	0.68	1.08	0
8-Nov-95	9.62	19.32	2.96	-10.00	-2.35	-15.28	79.41	0.71	1.55	0
9-Nov-95	23.94	29.67	3.60	-11.78	-2.90	-18.27	78.25	0.69	1.35	0
10-Nov-95	12.91	22.30	2.77	-14.14	-3.67	-21.66	78.74	0.68	0.78	0
11-Nov-95	28.14	24.27	3.60	-16.11	-4.35	-24.17	76.34	0.68	0.83	0
12-Nov-95	26.60	26.81	3.79	-14.73	-4.17	-21.03	77.21	0.68	0.83	0
13-Nov-95	10.55	9.59	3.33	-13.72	-4.06	-20.19	79.26	0.68	0.78	0
14-Nov-95	-1.38	5.37	3.04	-11.31	-3.52	-16.51	83.56	0.68	0.77	0
15-Nov-95	11.04	18.38	3.75	-11.60	-3.68	-16.19	82.52	0.68	0.79	0
16-Nov-95	0.06	11.22	3.92	-13.28	-4.29	-20.04	80.42	0.68	0.77	0
17-Nov-95	-0.22	5.59	2.49	-10.96	-3.71	-12.94	87.28	0.71	1.24	0
18-Nov-95	3.36	10.54	2.43	-5.94	-2.18	-3.14	93.11	0.71	1.26	0
19-Nov-95	0.97	6.13	1.62	-4.77	-1.79	-4.99	87.82	0.68	0.91	0
20-Nov-95	30.13	4.98	2.32	-7.07	-2.50	-9.04	84.66	0.69	1.37	0
21-Nov-95	0.65	1.07	1.38	-6.73	-2.49	-9.02	91.08	0.68	0.82	0
22-Nov-95	0.43	1.45	1.77	-4.94	-1.94	-7.92	93.10	0.68	0.79	0
23-Nov-95	-0.10	1.13	2.01	-5.55	-2.13	-11.06	89.54	0.68	0.77	0
24-Nov-95	-0.26	0.70	1.28	-6.22	-2.38	-12.24	87.78	0.68	1.14	0
25-Nov-95	-0.47	0.47	1.07	-6.30	-2.46	-14.42	85.82	0.68	1.13	0

*Note: Precipitation values represent the sum of total precipitation during the day rather than an average value

Daily Averages of Meteorological Parameters Measured at the Williams Creek Climate Station - 1996
(March 28 to December 31)

Date	Radiation Net	Incoming Shortwave Licor	Outgoing Shortwave Licor	Flux Soil Heat REBS	6cm Depth Temp Soil	Temp Upper HM35CF	RH Upper HM35C	Speed Wind Lower	Speed Wind Upper	Precip. Tip Bucket Totalized
	W/m ²	W/m ²	W/m ²	W/m ²	°C	°C	%	m/s	m/s	mm
28-Mar-96	165.66	194.96	23.66	-0.71	-5.23	-4.83	42.35	0.89	3.20	0
29-Mar-96	106.90	144.78	18.02	-1.27	-5.44	-6.57	43.72	1.08	3.92	0
30-Mar-96	131.73	177.18	20.02	-2.01	-5.80	-10.38	30.12	0.87	2.19	0
31-Mar-96	119.41	162.01	18.82	-2.92	-6.36	-11.00	31.76	0.89	2.26	0
1-Apr-96	124.96	164.31	19.93	-3.54	-6.82	-15.16	37.36	0.99	2.59	0
2-Apr-96	147.45	180.64	21.47	-4.30	-7.39	-15.73	38.56	0.74	1.29	0
3-Apr-96	147.73	175.77	20.37	-4.35	-7.71	-10.26	40.89	0.94	2.04	0
4-Apr-96	121.42	143.22	18.16	-2.31	-6.94	0.06	53.33	1.99	4.64	0
5-Apr-96	75.57	118.70	15.90	0.66	-5.34	3.03	52.54	1.94	4.45	0
6-Apr-96	143.67	177.25	20.34	1.55	-4.44	1.39	43.99	1.75	3.65	0
7-Apr-96	130.28	157.66	19.15	0.76	-4.39	-2.89	51.38	1.02	2.71	0
8-Apr-96	163.29	204.39	23.48	-0.01	-4.54	-2.27	30.94	0.74	2.59	0
9-Apr-96	166.55	208.50	24.11	-0.67	-4.75	-2.34	31.11	0.76	1.82	0
10-Apr-96	170.55	213.96	24.72	-0.85	-4.83	-2.36	30.87	0.76	1.53	0
11-Apr-96	174.22	218.39	25.33	-0.97	-4.87	-1.89	30.52	0.74	1.51	0
12-Apr-96	176.90	221.31	25.61	-0.74	-4.75	-0.98	28.43	0.84	1.86	0
13-Apr-96	181.35	222.91	25.84	-0.48	-4.56	0.36	29.15	0.76	1.68	0
14-Apr-96	185.63	226.47	26.14	0.23	-4.14	1.92	34.70	1.02	2.57	0
15-Apr-96	140.74	155.83	18.73	6.94	-3.00	5.06	49.71	1.05	2.58	0
16-Apr-96	146.34	175.42	20.51	8.41	-1.03	4.60	56.77	0.98	2.26	0
17-Apr-96	172.87	190.42	22.16	4.09	-0.17	6.83	47.66	0.86	1.88	0
18-Apr-96	140.68	158.04	17.71	1.57	0.00	5.58	64.91	0.76	1.64	0.3
19-Apr-96	113.04	149.50	16.43	0.65	0.01	5.70	65.08	0.76	1.61	0.7
20-Apr-96	128.37	151.90	15.91	0.49	0.01	5.33	51.23	0.84	2.13	0
21-Apr-96	214.47	247.01	25.62	0.43	0.01	4.40	43.94	1.00	2.23	0
22-Apr-96	177.65	214.62	22.34	0.41	0.02	6.17	35.11	0.98	2.32	0
23-Apr-96	142.26	170.88	17.96	0.39	0.07	6.22	40.64	1.01	2.28	0
24-Apr-96	195.59	230.25	22.77	0.42	0.20	5.30	36.86	1.22	2.76	0
25-Apr-96	190.32	219.43	21.15	0.41	0.50	5.37	42.14	1.16	2.91	0
26-Apr-96	133.88	161.51	15.44	0.41	0.67	5.09	48.60	0.77	1.59	0.9
27-Apr-96	121.05	144.47	13.27	0.42	0.70	3.52	67.24	0.91	2.37	1
28-Apr-96	183.54	211.92	20.34	0.42	0.41	2.34	42.52	0.88	1.99	0
29-Apr-96	160.58	183.75	17.66	0.41	0.65	4.46	37.09	0.74	1.44	0
30-Apr-96	121.04	132.82	12.95	0.40	0.68	4.08	65.38	0.71	1.39	3
1-May-96	87.29	87.17	13.95	0.48	0.38	2.04	90.81	0.72	1.21	11
2-May-96	153.73	163.77	16.19	0.49	0.71	3.04	65.65	0.79	2.94	0.7
3-May-96	152.93	175.17	15.91	0.49	0.36	2.21	38.68	0.86	3.09	0
4-May-96	172.08	194.29	17.57	0.49	0.31	2.20	45.24	1.12	4.33	0
5-May-96	241.66	282.92	26.45	0.48	0.03	0.38	22.82	0.90	3.11	0
6-May-96	247.95	287.31	26.78	0.43	0.02	2.70	18.53	0.86	2.03	0
7-May-96	244.48	288.39	26.81	0.38	0.04	2.04	18.99	0.92	2.29	0
8-May-96	221.85	264.74	25.00	0.33	-0.01	0.90	23.94	0.86	2.06	0
9-May-96	252.22	289.08	26.89	0.31	0.22	4.34	26.46	0.75	1.46	0
10-May-96	176.19	207.38	19.69	0.35	1.08	7.93	24.04	0.91	2.60	0
11-May-96	150.90	161.55	14.72	0.56	1.93	9.10	41.69	0.89	3.07	0
12-May-96	164.23	187.67	17.28	0.66	2.02	8.62	41.51	0.90	2.92	0
13-May-96	250.90	274.40	25.42	0.53	1.59	7.51	32.43	0.83	2.39	0
14-May-96	62.96	107.49	10.04	0.45	0.75	4.74	44.50	0.80	2.43	0.1
15-May-96	139.53	154.84	14.23	0.38	0.26	0.46	47.82	0.73	2.03	0
16-May-96	222.23	243.47	23.24	0.68	1.03	4.40	40.76	0.83	1.65	0
17-May-96	204.72	227.52	21.14	3.26	1.43	5.87	56.80	0.79	1.64	1.6
18-May-96	238.18	261.02	24.03	6.28	2.01	9.03	42.79	0.83	1.62	0
19-May-96	163.91	194.91	18.37	7.49	2.22	10.15	33.40	0.80	2.37	0
20-May-96	225.05	255.39	24.12	7.68	2.36	9.84	39.32	1.01	2.39	0
21-May-96	249.75	287.20	27.04	6.96	2.24	10.49	33.37	0.93	2.22	0
22-May-96	211.30	237.74	22.53	8.66	2.99	11.79	37.67	0.84	2.01	0
23-May-96	273.03	296.08	27.42	9.17	3.23	11.76	46.30	1.45	3.27	0
24-May-96	183.44	206.14	19.44	7.66	2.77	9.91	39.16	1.37	3.42	0
25-May-96	137.85	149.78	13.80	7.12	2.66	6.97	68.94	0.99	2.51	1.6

*Note: Precipitation values represent the sum of total precipitation during the day rather than an average value

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Western Copper Holdings Ltd.

Carmacks Copper Project Design Criteria and Parameters

October 9, 1998

W37.1

SITKA CORP.

SITKA CORP

October 9, 1998

Our File: W37.1

Mr. Dale Corman
Western Copper Holdings Ltd.
1650-1185 West Georgia Street
Vancouver, BC, Canada
V6E 4E6

Re: *Carmacks Copper Project Design Criteria and Parameters*

Dear Dale:

We are pleased to submit our report on the design criteria and engineering parameters for the Carmacks Copper Project. If we can serve you further, please call.

Sincerely,
SITKA CORP



Roy T. Mayfield, P. Eng.
Principal

Cc: Kevin McDonnell, DIAND (10 copies)
Lee Bilheimer, Project Management Consulting
Gregg Jilson, Access Mining Consultants Ltd
Morris Beattie, Beattie Consulting Ltd
Peter McCreath, Clearwater Consultants Ltd
Tony Wachman, Kilborn Engineering Pacific Ltd

Enclosure: Carmacks Copper Project Design Criteria and Parameters dated
October 9, 1998.

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TABLES

1. INTRODUCTION

1.1 General

The Carmacks Copper Project is an open pit copper mine and processing facility being developed by Western Copper Holdings Limited. It is located in Yukon, approximately 38 km northwest of the town of Carmacks. The project will include an open pit, acid heap leach and copper extraction facility, waste rock storage area, soil stockpiles, events pond, drainage ditches, sediment control ponds, roads, and miscellaneous structures to support mining operations.

This report is in support of an Environmental Assessment Review Process Guidelines Order (EARP) Screening and Water License Application. It presents the design criteria and parameters that will be used to update the analysis and design of the mine facilities for presentation to the review and regulatory committees. These criteria and parameters consider primarily the geotechnical and operational aspects of the design of the mine facilities, and do not address the SX/EW processing plant or its associated infrastructure. More detailed information will be presented in the design report, construction quality assurance plan, technical specifications, and the closure and reclamation plan.

For the purposes of this report, the distinction between a design criterion and a design parameter is the difference between the intended output and input. For example, the design criterion for stability of an embankment may be a static factor of safety of greater than 1.3 (output). A related design parameter could be the frictional strength of the embankment or foundation materials (e.g. 36 degrees), used as input to a stability analysis to demonstrate the required factor of safety.

1.2 Project Description

Active mining at the Carmacks Copper project will be for eight years, moving about 60 million tonnes of waste rock and 13.3 million tonnes of copper ore. Using shovels and trucks, the mine will remove an overall average of about 20 500 tonnes per day of waste rock and overburden year round from the open pit to the appropriate stockpiles. For about 200 days each year, the mine will use the same equipment to place up to 9872 tonnes per day of ore on a 31.5 ha double-lined heap leach pad in 8-m lifts. Studies are underway to consider the possibility of crushing the ore and conveying it to the leach pad.

Once on the heap, about 540 m³/hr of raffinate—a barren acid solution—from the process plant will be applied to approximately 47 400 m² of the surface of the ^{heap} by a system of buried drip emitters. After leaching through the ore, the pregnant leachate solution (PLS) will be collected in a network of pipes on top of the leach pad liner and flow either directly to the process plant or to the events pond below the heap.

After mining ceases, the heap will be leached for about two more years. When the leaching is no longer economical, the heap will be rinsed for about three years, then decommissioned.

1.3 Design Objectives

The principal environmental objectives of the design for the various mine facilities are to:

- Ensure protection of the regional groundwater and surface water quality and flows both during operations and in the long-term.

- Stage the development to minimize the environmental disturbance at any one time during operations and to distribute capital expenditures over the life of the facility.
- Monitor the operation to check that the design objectives are met and that environmental impacts are predictable and acceptable.
- Reclaim the facilities to a condition compatible with the original land use, ensuring long-term stability under extreme precipitation and design seismic events.

2. GENERAL DESIGN CRITERIA AND PARAMETERS

2.1 Design Life and Consequence Categories

The design life of the mine facilities is approximately 12 years, with long-term decommissioning, reclamation, and monitoring following.

The embankments at the Carmacks Copper site will not impound large fluid volumes for long periods during operations. The following measures will achieve this:

- low-level outlets within the heap confining embankment will prevent fluid impoundment during normal operations;
- solution in the events pond will be used as makeup water in the heap; and,
- water in the sediment ponds will drain through decant structures in the abutments.

Despite the lack of long-term impoundment behind the heap confining embankment and the events pond embankment, there would be potential for loss of life and substantial downstream environmental impacts if these structures failed or breached. Thus, according to the classification method proposed by the Canadian Dam Safety Association (CDSA, 1995), the

consequence category for the heap leach and events pond embankments is "high". The appropriate consequence category for the sediment pond confining embankments and the waste rock pile is "very low" to "low".

2.2 Site Hydrology

Details of the site hydrology are presented in the Clearwater Consultants Ltd. Design Memoranda CCL-CC2 (March 13, 1998) and CCL-CC2A (April 28, 1998). Average values for key hydrologic parameters are summarized in the table below for a typical elevation of 850 m at the Williams Creek site. Values for extreme wet and dry conditions are presented in the source documents.

Parameter	Average Value, mm
Total Annual Precipitation	372
Annual Rainfall	205
Annual Snowfall	168
Wet Period Precipitation	
One-Month Rainfall	78.8
Two Month Rainfall	124
Three Month Rainfall	159
Four Month Rainfall	183
Five Month Rainfall	196
Six Month Snowfall	165
Seven Month Precipitation	181
Eight Month Precipitation	209
Maximum Snowpack, mm water	145
Annual Lake Evaporation	
Low	400
Average	460
High	520

2.3 Spillways

Emergency overflow spillways will be provided for all water and solution storage reservoirs to prevent uncontrolled overtopping of embankments. The spillways will be sized to pass the peak flow from a 100-yr return

period storm with a duration consistent with the local characteristics of the catchment area. Embankment crest elevations will be determined by adding 500 mm of freeboard to the maximum routed water elevation.

2.4 Diversion Channels

Surface water diversion channels will be provided around key project facilities to divert natural runoff water away from the structures. The channels will be designed with 250 mm freeboard above the peak flows from a 100-yr return period storm event with a storm duration consistent with the time of concentration of the local catchment area draining to the diversion channel. Erosion protection measures for diversion channels will be consistent with the design hydraulic capacity of the structure and will be based on the maximum flow velocities expected in the local channel.

2.5 Sediment Control

Sedimentation below the leach pad and events pond areas, waste dumps, and plant site will be controlled with conventional settling ponds. The settling ponds will be sized to remove inflowing suspended sediments down to fine silt sizes for events up to a 10-yr return period 24-hr duration storm. Emergency spillways will be provided for each pond as described in Section 2.3.

2.6 Seismic Criteria

2.6.1 Maximum Credible and Design Basis Earthquakes

The heap confining embankment and the events pond dam have a "high" consequence category as described by CDSA. Accordingly, these two embankments will be designed to withstand the greater of the following two cases:

- 50 percent of the acceleration from the Maximum Credible Earthquake (MCE) from a deterministic analysis;
- the acceleration from an earthquake with a 1000-yr return period from a probabilistic analysis.

The lower end of the range of design criteria suggested by CDSA has been selected due to the relatively short design life of these two embankments and the resulting reduced risk exposure. The sediment control pond dams and the waste rock storage area have "very low" to "low" consequence categories, thus will be designed to withstand earthquake accelerations with a 475-yr return period.

From probabilistic analyses conducted by the Pacific Geoscience Centre the maximum ground accelerations associated with the 475- and 1000-yr return period earthquakes are estimated to be 8.5 percent and 10.3 percent of gravity, respectively.

Using deterministic methods, the MCE is associated with the Fairweather-Yakutat source zone, with a maximum magnitude of 8.5. At an epicentral distance of 250 km, it is estimated to generate a maximum ground acceleration of 13.2 percent of gravity. Despite their shorter epicentral distances, three other potential source zones (Northern B.C., Denali-Shakwak, and Mackenzie) all generate lower maximum accelerations of 8.8 percent, 3.9 percent, and 2.1 percent of gravity, respectively. Thus, the design acceleration from the deterministic analysis is 50 percent of 13.2 percent of gravity, or 6.6 percent of gravity. Since the acceleration from the probabilistic analysis is greater, it will be used rather than the acceleration from the deterministic analysis.

To summarize, the heap confining embankment and events pond dam will be designed to withstand horizontal accelerations of 10.3 percent of

gravity. The other embankments and waste rock storage area will be designed for 8.5 percent of gravity.

2.6.2 Allowable Deformations and Seismic Coefficients

To analyze the stability of an embankment under seismic load, Seed (1979) states that a pseudostatic analysis is appropriate provided that materials subject to liquefaction do not make up a significant portion of the structure or foundation. From the site investigations to date, there are few materials on site that are subject to liquefaction during an earthquake, making pseudostatic analysis appropriate.

For the pseudostatic analysis, Hynes-Griffin and Franklin (1984) describe a method for determining the appropriate seismic coefficient from the maximum ground acceleration and the allowable displacement from seismic activity. This allowable displacement varies with the type of embankment or structure.

For a conventional dam, Seed (1979) suggests that about 1 m of crest displacement is usually acceptable. At Carmacks Copper, this displacement is appropriate for sediment pond dams. For the waste rock pile, displacements of up to 3 m will be acceptable.

Where geomembrane liners form a component of an embankment, such as in the heap confining embankment and events pond dam, a smaller crest displacement is allowed to ensure the integrity of the liner system during the design seismic event. For lined waste impoundments in the U.S., Seed and Bonaparte (1992) describe the current practice as using an allowable seismic displacement of 150 to 300 mm. A displacement of 150 mm will be allowed at the crest of the heap confining embankment and the events pond dam.

The following table summarizes the seismic coefficients from Hynes-Griffin and Franklin (1984) using the allowable crest displacements described above.

Table 2.1, Seismic coefficients

Embankment	Consequence category	Max ground accel, %g	Allowable disp, m	Seismic coef, %g
Heap confining embankment	High	10.3	0.15	6.7
Events pond dam	High	10.3	0.15	6.7
Sediment pond dam	V. low-low	8.5	1.0	1.5
Waste rock pile	V. low-low	8.5	3.0	< 1

2.7 Geotechnical Stability

The targeted minimum factor of safety of embankments depends on loading condition and the assigned consequence category of the embankment. The three primary loading conditions are steady-state static, seismic, and end of construction.

For the steady-state static loading condition at the "high" consequence structures—the heap confining embankment and events pond dam—the factor of safety will be at least 1.5 for all failure mechanisms. For all "very low" to "low" consequence structures, the factor of safety will be at least 1.3 under the same conditions.

For the seismic loading condition, the factor of safety for the heap confining embankment and the events pond dam will be at least 1.15 using the seismic coefficients provided in Section 2.6.2. No seismic analyses will be performed for the "very low" to "low" consequence structures because the seismic coefficients are so low.

For the end of construction static loading condition, all structures will have a factor of safety of at least 1.3, regardless of consequence category.

2.8 Permafrost

The project site is in the southern fringe of the permafrost region as defined by Brown (1970). In this region, the permafrost is discontinuous and its character is widely variable. Test holes across the site confirm this, with slightly more than half the holes encountering permafrost. The upper and lower limits of the permafrost vary significantly, but the deepest thermistors on site suggest that the permafrost does not extend more than about 25 m below ground surface and that its temperature is only a few tenths of a degree below freezing. Brown (1970) indicates the active zone—the zone subject to annual freeze-thaw cycles—usually ranges from about 1.5 m to 4 m depending on the thickness and character of the organic ground cover.

Thaw-unstable soils within the permafrost will be addressed. These soils contain sufficient ice to possibly cause unacceptable settlement or loss of shear strength as they melt. Without specific tests on individual soils to determine their thaw-instability, moisture content greater than 17 percent of the dry soil weight has been accepted for other Yukon projects as an indication that the soils may be thaw-unstable.

It is important to distinguish deep samples that are potentially thaw-unstable from the ones within the active zone because the shallower samples should melt in a single construction season after the ground surface is stripped of its organic cover layer. Soils below the active zone that are thaw-unstable could take several years to thaw, thus delaying their potentially adverse effects until after construction. Also, potentially

thaw-unstable soils within about 5 m of the ground surface can be readily excavated and replaced using conventional construction equipment.

Of the 191 samples collected on site and tested, only 15 that were frozen had moisture contents greater than 17 percent. Of these, only 5 were deeper than 5 m: 2 were from a single test hole in the proposed heap area (DH95-C), 2 were from test holes on the north side of the proposed waste rock storage area (MW96-F and H), and 1 was east of the proposed development area (DH95-2).

Prior to construction of the plant facilities, leach pad and confining dike, events pond, and waste rock storage area, test holes will be drilled in an approximate 50-m grid pattern to bedrock or a maximum depth of 25 m, whichever is shallower. As mentioned previously, thermistor readings at the site suggest 25 m is the limit of permafrost. In the test holes, the upper 1.5 m will be sampled continuously to check for moisture content and suitable soil liner material. Below 1.5 m, samples will be collected approximately every 1.5 m or as required by material changes, and tested for moisture content. Where the soils are unfrozen, or frozen but with a moisture content not greater than 17 percent, construction can proceed without any special foundation treatment. Where there are frozen soils with a moisture content greater than 17 percent within 5 m of the ground surface, the potentially thaw-unstable soils will be excavated and the excavation backfilled with durable rock. This program and procedures will be described in more detail in the construction quality assurance plan.

As noted above, less than 10 percent of the samples tested to date have been frozen with moisture contents greater than 17 percent. Because of the advanced stripping and thawing, this proportion should decrease significantly and the amount of excavation should be minimal.

Also as noted above, there have been only 3 locations in the areas currently proposed for development where there have been frozen soils deeper than 5 m with water contents greater than 17 percent. Because these are below the active zone, the advanced stripping likely will not cause thawing in a single year at these depths. Also, because of their depth, they can not simply be excavated.

Each area where there are deep soils that are potentially thaw-unstable will require further engineering analysis and/or testing to determine the proper treatment. For example, drill hole DH95-C in the proposed leach pad area encountered deep potentially thaw-unstable soil at depths of 6.1 m and 12.2 m. Surrounding drill holes did not encounter these soils, so for this example, the problem area could be considered to be local. In this case, a potential reduction in soil shear strength would not be critical to successful performance because the surrounding soils are stable and because the ore will be loaded in an uphill direction. However, without special treatment, local differential settlement could be enough to unacceptably strain the liner system. By subexcavating the subgrade several metres in this area and constructing a raft of heavily compacted durable rock fill, these potential differential settlements can be spread over a wider area to reduce the liner strains to an acceptable amount. For higher ice contents, the raft could be made more rigid to better spread the settlement by reinforcing it with geogrid or high-strength geotextile.

As another example, two drill holes in the proposed waste rock storage area, MW96-F and H, encountered deep potentially thaw-unstable soils. These drill holes are along the edge of the proposed waste rock storage area bordering North Williams Creek. While settlement is not a concern for the waste rock pile, a reduction in shear strength at the edge of the pile—particularly bordering the creek—needs to be dealt with to ensure

long-term stability. Because the area of concern is at the edge of the pile, it will not be built for several years; thus, there will be ample time to investigate and monitor the thawing and pore pressure generation. If the potentially thaw-unstable zones have not melted and the resulting pore pressures dissipated before the area is to be covered, it will be necessary to reassess the stability of the waste rock pile in that area. This likely would result in a toe buttress of limited height that would be stable with a pore pressure ratio, r_u , of 1.0 in the potentially thaw-unstable zones.

These examples are not prescriptive methods to be employed on site, but are only illustrative of the types of engineering rationale and analyses that may be required to deal with the conditions encountered in the pre-construction drilling program and before the start of construction. Further details will be in the Construction Quality Assurance document.

3. HEAP LEACH FACILITY

3.1 Design Basis

The heap will be designed to store approximately 13.3 million tonnes of ore at a dry density of 1.6 tonnes/m³. The ore density may be higher in the later years of operation due to consolidation under load, possibly reducing the size of the final pad expansion. The leach pad could be expanded beyond this capacity to the west or the height could be increased. Ore will be placed for eight years at a maximum rate of 9872 tonnes per day for up to 200 days per year. The 31.5 ha leach pad will be constructed in three stages ahead of ore placement. Ore will be placed in 8-m lifts at an overall slope of 2½h:1v using haul trucks. It is anticipated that two years of residual leaching, three years of heap rinsing and eventual decommissioning will follow the eight years of ore placement.

The raffinate will be applied to about 47 400 m² of the ore surface through a system of drip emitters. The total raffinate flow to the heap will be 540 m³/hr for a design leaching cycle of 120 days. Solution will not be stored within the heap but will drain through perimeter piping and a low-level outlet to the process plant or the events pond.

3.2 General Description

The ore will be placed on the valley-fill heap in 8-m lifts by haul trucks and leached in subsequent lifts, progressing up slope and atop previously leached lifts. Storage for excess solution and extreme precipitation events will be provided in an events pond located down gradient from the heap.

The proposed leach pad will be lined with a double composite liner system with a leak detection and recovery system (LDRS). The pad will be surrounded by a 2-m high perimeter berm on the north and west sides and a perimeter bench on the east side. A confining embankment will form the lower limit of the leach pad to support the heap. With a crest elevation of about 780 m, it will be about 22 m high and 350 m long.

There will be no in-heap solution storage behind this confining embankment. Solution from the heap will be collected by a network of corrugated polyethylene tubing (CPT) above the leach pad liner and conveyed by gravity flow to the process plant. There will be the option of diverting flows to the events pond. There will be a double-lined spillway over the heap confining embankment to the events pond to convey solution during extreme precipitation events. Diversion ditches will collect and convey runoff from upslope of the heap leach facility to a sediment control pond, thereby reducing the quantity of water reporting to the heap and minimizing PLS dilution.

3.3 Staged Development

The proposed heap will be developed in stages to defer capital costs, minimize the extent of disturbed areas during the mine life, and minimize the undiverted catchment area within the active heap leaching facility. Six stages of construction are planned:

- Stage I Pre-production and Year 1;
- Stage II Production - Years 2 and 3;
- Stage III Production - Years 4 to 8;
- Stage IV Residual Leaching - Years 8 and 9;
- Stage V Heap Rinsing - Years 10 to 12;
- Stage VI Decommissioning and Closure - after Year 12.

The durations of the individual stages, particularly Stages IV, V, and VI, are tentative and under study. The durations listed above have been assumed for the current analyses.

In conjunction with development of the open pit and waste rock storage areas, the pad will undergo two upslope expansions; the first between Stages I and II and the second between Stages II and III. The capacity of the events pond will be reviewed prior to the Stage III construction to ensure there is adequate temporary storage for extreme runoff events.

3.4 Geotechnical and Hydrogeological Properties

The geotechnical and hydrogeological properties of the foundation, zoned earthfill, liner, waste rock, ore, drainage layer, and overliner materials have been estimated from drilling and test pitting, site-specific laboratory results, published literature, and professional experience. The following documents form the basis for selecting the principal geotechnical and hydrogeological properties for final design of the leach pad, heap

confining embankment, waste rock storage area, events pond dam, and other foundation structures:

- Knight Piésold, Ref. No. 1783/1, May 1995, *Report on Preliminary Design* - Laboratory test work and index test results, including foundation materials, pre- and post-leach ore, geosynthetic/soil interfaces, and geosynthetic/geosynthetic interfaces.
- Knight Piésold, Ref. No. 1784/1, June 1996, *Report on 1996 Geotechnical and Hydrogeological Site Investigations* - Laboratory test work and index test results, including permeability, coefficient of consolidation, coefficient of volume compressibility, and uniaxial compressive strength of bedrock.

The complete site-specific test results are not repeated in this report. Table 3.1 at the end of this report provides a list of all materials and interfaces to be considered during design and the principal geotechnical and hydrogeological parameters adopted for each. Where available, the range of test results is provided in parentheses. In general where test data are available, the selected parameters are at or near the lower bound of the test data. In the few exceptions to this, the parameters were selected after considering the variability of the data and experience in similar circumstances.

3.5 Foundation Preparation

3.5.1 Pad Grading

Most of the organics and topsoil were stripped from the foundation area in 1996. At the start of construction, any remaining windrows or piles will be removed and the area will be rough graded.

As described in Section 2.8, all potentially thaw-unstable materials within 5 m of the ground surface that are identified during the delineation program will be excavated. Excavations deeper than 1 m below final subgrade will be filled to 1 m below final subgrade with acceptable rock

fill, then filled with soil liner material to final subgrade. Excavations less than 1 m below final subgrade will be filled entirely with soil liner material. These materials will be placed and compacted as subgrade as described in Section 3.7.2. Further details will be provided in CQA Manual.

Areas where potentially thaw-unstable materials are deeper than 5 m will be assessed individually and specific treatments developed.

In unexcavated areas, surficial samples from the pre-construction investigation will be tested for particle size, plasticity indices, and natural moisture content. There will also be enough control tests to relate the index properties and visual characteristics of the surficial soils to the expected permeabilities. From the test results, the soils to be classified as follows:

- Soil liner material will have a permeability not greater than 10^{-8} m/s, will satisfy the grading requirements for soil liner material, and will be suitable for compaction.
- Random fill will have a permeability greater than 10^{-8} m/s, thus will be unsuitable for soil liner but suitable for compaction as subgrade or use in zoned earthfills based on grading requirements.
- Material that is unacceptable for fill due to permafrost, thaw-instability or the presence of organics will be excavated and hauled to a designated waste stockpile.

Where there is more than 300 mm of suitable soil liner material at the surface, the excess may be removed and stockpiled. Where there is less than 300 mm of suitable soil liner, additional will be hauled in. The surface will be ripped and disked to a depth of at least 300 mm, moisture conditioned, then recompacted to form the lower soil liner.

In all areas where there is no suitable soil liner material at the surface, unacceptable materials will be removed and the surface compacted and proof-rolled.

3.5.2 Foundation Drainage

A foundation drainage system will be installed beneath the leach pad to intercept and remove near-surface and seasonal groundwater flows and to minimize uplift pressures beneath the liner. The foundation drains will be installed at least 1.5 m below the prepared subgrade surface and will comprise perforated CPT surrounded by select drain gravel and wrapped in geotextile. The select drain gravel will provide continued foundation drainage in the event of blockage or collapse of the CPT. The drains will be located in the natural drainage swales and extended to intercept any springs, seeps, or damp spots identified during pad grading and mapping. These drains will convey any intercepted groundwater seepage under the embankment to a foundation drainage collection sump located at the toe of the confining embankment. Flow into the sump will be tested periodically. If its quality is acceptable, it will be discharged below the events ponds; otherwise, it will be discharged into the events pond.

Once the foundation drains are installed, they will be covered by compacted soil liner material and the double composite liner system. The upslope ends of the main collection pipes will extend beyond the limits of the pad area through solid CPT pipe so they can be periodically flushed with dye-traced water to verify operation of the drain. The ends of the pipes will be capped to prevent animals from entering the pipe and to prevent icing. If blockage of the CPT is suspected an attempt will be made to pressure clean with water or mechanically clean the tubing. Given the redundant drainage provided by the surrounding drain gravel, no further

attempt to recover the CPT installation will be made if cleaning is unsuccessful.

3.6 Perimeter Berm and Bench

The perimeter bench on the east side of the leach pad will be wide enough for the access road, perimeter diversion ditch, perimeter piping and sumps, and the liner anchor trench. The perimeter berm on the north and west sides of the pad will incorporate the liner anchor trench and perimeter piping and sumps. The perimeter road and diversion ditch will be outside of this berm. The berm and bench will separate the surrounding diverted areas and the heaped ore. A channel, formed by the depression between the perimeter berm or bench and the sloping ore, will convey surface runoff from the heaped ore to the perimeter sumps. From there, it will be piped to the plant or events pond.

3.7 Liner System

3.7.1 General

The entire leach pad and the uphill face of the confining embankment will be lined with a double composite liner with an integral LDRS. From the bottom up, the liner system will be comprised of the following components:

- Subgrade;
- Compacted lower soil liner with a permeability not greater than 10^{-8} m/s;
- 1.5 mm HDPE lower liner;
- Leak detection and recovery system (LDRS) made with drain gravel, a pipe network, and cell divisions;
- Non-woven geotextile for separation and filtration;
- Compacted upper soil liner with a permeability not greater than 10^{-8} m/s;

- 1.5 mm HDPE upper liner;
- High-permeability, durable overliner cushion layer with solution collection piping and cell divisions.

3.7.2 Subgrade

The subgrade will be suitable in-situ material that has been disked and recompactd or borrow material imported to backfill excavations of unsuitable material as described above in Section 3.5.1. The design criteria for subgrade are:

- Random fill as defined in the technical specifications;
- Maximum particle size of three-quarters of the approved layer thickness.

3.7.3 Soil Liner

The upper and lower soil liners will have the same specifications. Laboratory tests and correlations with index properties will confirm that the liner material meets the required permeability criterion of 10^{-8} m/s. These will be described in the CQA manual.

The soil liners will be compacted with a smooth drum vibratory roller, with careful inspection of the soil surface to ensure the removal of any stones larger than 10 mm. The liner installer will certify acceptance of the final surface as part of the QC and warranty process.

3.7.4 HDPE Liner

Both geomembrane liners will be 1.5 mm smooth HDPE. Careful manufacturing quality control and construction quality assurance will confirm the specifications are achieved.

3.7.5 Geotextile

A heavy, non-woven, needle punched geotextile will be used as a separation and filtration layer between the upper soil liner and the LDRS drainage layer. Final selection of this geotextile will be based primarily on the requirement for durability during construction.

3.7.6 Leak Detection and Recovery System

An LDRS will be constructed using clean sand and gravel with a minimum permeability of 10^{-4} m/s and a regularly spaced arrangement of CPT collection pipes. The anticipated LDRS layer thickness is 500 mm placed in a single lift. The LDRS will be subdivided into cells of approximately 1 ha to allow for solution management in each pad area.

3.7.7 Overliner

A 1-m layer of processed, durable crushed ore or sand and gravel will cover the upper HDPE liner to protect it from puncture under ore loading and to promote the effective under-drainage and collection of pregnant leachate solution (PLS) from the ore. The design criteria for the overliner are as follows:

- Maximum particle size of 19 mm to prevent liner puncture, unless specific testing shows a larger size is acceptable.
- Durable, hard rock resistant to acid degradation.
- Permeability of at least 5×10^{-4} m/s to enhance PLS recovery and to minimize hydraulic head on the upper liner.

Within the overliner, there will be a network of CPT to collect the solution within the overliner and transfer it to either the process plant or the events pond. This system of solution recovery piping also will reduce the hydraulic head on the upper liner. As within the LDRS, the overliner will

be subdivided into cells of approximately 1 ha to allow solution management above the liner.

3.8 Leakage Criteria

Leakage through the upper composite liner system, which will be collected and monitored through the LDRS, will be estimated. The design parameters for the leakage calculations are:

- Overliner hydraulic conductivity, $k \geq 5 \times 10^{-4}$ m/s;
- Soil liner hydraulic conductivity, $k \leq 10^{-8}$ m/s;
- LDRS hydraulic conductivity, $k \geq 10^{-4}$ m/s.

Using the methods described by Giroud and Bonaparte (1989b), the allowable leakage rate into each cell of the LDRS is 100 L/day averaged over a 12-month period, and 300 L/day averaged over a 3-month period. The estimated leakage rates will be achieved by placing solution recovery pipes in the overliner and LDRS layers to reduce the hydraulic heads on, and thus the flow through, the underlying liners. The collection pipe systems within the overliner and LDRS layers will flow by gravity to the perimeter of the pad and then to the plant. Flow rates from individual cells of the LDRS will be monitored daily.

3.9 Liner Terminations

All HDPE liners will be terminated in anchor trenches. These trenches will be either permanent trenches along the perimeter berm, bench and embankment, or temporary trenches on the edges of pad extensions. The design criteria for the trenches are:

- To ensure water cannot enter drainage systems by seeping through the trench backfill;

- To provide adequate anchoring resistance to withstand the pullout forces generally generated by gravity and thermal expansion and contraction of the HDPE geomembranes.

3.10 Frost Protection

To protect the soil portion of the leach pad liner from frost damage, the liner will be covered with at least 4.5 m of ore and overliner prior to winter. At least 1.5 m of ore will provide frost protection of the active drip emitter pipes, with exothermally generated heat from the leaching process, solution heating, and snow insulation providing the remaining protection.

3.11 Leach Pad Settlement

Some liner settlement will occur due to vertical loads imposed by the heap. The design criteria for the leach pad settlement are as follows:

- Differential settlements will not compromise the integrity of the liner system. Tensile strains of less than 5 percent in the synthetic and soil liner systems will be maintained.
- Positive drainage of foundation drains and LDRS and PLS collection pipes will be maintained. All drainage grades and locations will be determined with an allowance for settlements of the foundations.
- Pipe joints will be capable of sustaining settlement-induced tensions without separation.

4. EVENTS POND

4.1 Design Basis

Active solution storage will not be within the heap, but in the events pond below the heap confining embankment. The events pond will have the capacity to store the following combinations of events:

- The operating solution volume, plus

- Excess runoff inflows from the critical duration 100-yr return period event occurring at the most critical point in time, plus
- An allowance for heap draindown as follows:
 - During the first year of operation, 100% of the total potential heap draindown volume, or
 - During subsequent years of operation, 48 hours of draindown at the full rate of solution application. For a solution application rate of 540 m³/hr this volume is 26 000 m³.

This capacity will be available each year at the start of the winter season.

Details of the leach pad water balance and the determination of design solution storage volumes will be presented in the Clearwater Consultants Ltd. Design Memorandum CCL-CC4.

4.2 General Description

Normally, solution will flow directly from the heap to the plant. When there is a high-rainfall or high-precipitation event, or when the plant cannot accept solution, the flow can be directed from the heap to the events pond.

Immediately below the heap confining embankment toe, the events pond will have a lined area of about 6 200 m² and a storage capacity of about 160 000 m³. This storage will be created by a dam across the valley at the lower end of the pond about 30 m high, 380 m long with a crest elevation of about 754 m.

The events pond will incorporate two HDPE geomembrane liners with a high-transmissivity geonet drainage layer placed in between. There will be an emergency spillway in the dam crest as described in Section 2.3

4.3 Geotechnical and Hydrogeological Properties

Refer to the parameters described in Section 3.4 and Table 3.1.

4.4 Foundation Preparation

Pad grading and foundation drainage will be completed in the events pond area in a similar manner to the leach pad, as described in Section 3.5.

4.5 Liner System

4.5.1 General

The entire events pond will have a double liner with an integral LDRS. From the bottom up, the liner system will be comprised of the following components:

- Prepared subgrade;
- 1.5 mm HDPE lower liner;
- Geonet drainage layer;
- 1.5 mm HDPE upper liner.

4.5.2 Subgrade

The subgrade will comprise areas of suitable in-situ material and areas that will be covered by borrow material backfilling excavations of unsuitable material as described above in Section 3.5.1. The design criteria for subgrade are:

- Random fill as defined in the technical specifications;
- Maximum particle size of three-quarters of the approved layer thickness.

4.5.3 HDPE Liner

Both geomembrane liners will be 1.5 mm smooth HDPE. Careful manufacturing quality control and construction quality assurance will confirm the specifications are achieved.

4.5.4 Leak Detection and Recovery System

An LDRS will be provided by a high transmissivity polyethylene geonet placed between the two geomembranes. This geonet will prevent the build up of hydraulic head caused by any leaks within the upper HDPE liner. Specifically, the transmissivity of the geonet will be sufficient to pass flows predicted using the method proposed by Giroud and Bonaparte (1989a). Leakage into the LDRS layer will be conveyed to the plant site via a sump at the low point of the events pond accessed by an inclined riser and submersible pump. Flow rates from the LDRS will be monitored daily when there is solution in the pond.

4.6 Leakage Criteria

As part of the CQA program, a hydrostatic test will be performed on the events pond liner prior to acceptance of the complete liner system. This hydrostatic test will be conducted by monitoring the LDRS while filling the pond with water. If leakage is recorded in the LDRS during the hydrostatic test, the pond level will be lowered and the hole located and repaired.

Using the methods described by Giroud and Bonaparte (1989b), the allowable leakage rate into the events pond LDRS will be 200 L/day averaged over a 12-month period, and 600 L/day averaged over a 3-month period.

4.7 Bird Netting

Netting will be strung over the events pond to keep birds from accessing the solution. The netting will be polypropylene, supported on steel cables with anchors around the perimeter. Sag in the netting across the ponds will be considerable, and elevated supports around the pond perimeter

will be needed. The netting will be designed so it can be retracted during the winter so it will not have to carry snow loads.

5. MAKEUP WATER, TREATMENT AND RELEASE

Sufficient makeup water will be provided to accommodate leaching while ore is being placed on the pad through a 20-year dry year. It will be obtained by pumping from one or more of the following sources: water temporarily stored in the events pond during the summer and fall seasons; water temporarily stored in the leach pad sediment control pond; water from the pit; and a series of wells located down gradient of the leach pad.

During operations, there will be provisions to accommodate the excess solution from a 100-year wet year. The volumes and measures required to handle them are currently being studied and will be presented in the Clearwater Consultants Ltd. Design Memorandum CCL-CC4.

6. WASTE ROCK STORAGE

6.1 Design Basis

The waste rock storage area will cover an area of 70 ha and have a storage capacity of about 60 million tonnes. Waste rock will be placed year round at an annual rate of approximately 7.5 million tonnes.

Designs for the waste rock storage area will conform to the British Columbia Mine Waste Rock Pile Research Committee Investigation and Design Manual Interim Guidelines, May 1991.

6.2 General Description

The waste rock storage area will be developed in horizontal lifts by trucks and bulldozers. The waste rock will be dumped in 25-m high lifts with

intermediate benches wide enough to maintain an overall slope of 2¼h:1v. A 100-m wide stripped buffer will be maintained below the toe of the waste rock pile until the final configuration is achieved.

Most of the upper limit of the waste rock storage area is either immediately below the open pit or on a local drainage divide, so there is no need to divert upslope runoff. Ditches around the lower perimeter will collect surface runoff and seepage from the waste rock pile and drain to a sediment control pond.

6.3 Geotechnical and Hydrogeological Properties

The geotechnical and hydrogeological properties of the foundation materials and waste rock are presented in Section 3.4 and Table 3.1. The foundation materials in the waste rock storage area are primarily weathered granodiorite sands overlain with various colluvial and glaciofluvial materials. A complete interpreted section of the foundation materials, showing the depth to competent bedrock and areas of known permafrost will be presented as part of the design report.

6.4 Geotechnical Instrumentation

The waste rock storage area will be monitored during operations and decommissioning of the facility with surface movement monuments established on final lifts. Observed movements will be compared to expected deformations on a weekly basis during thawing months to confirm adequate performance. Visual observations and monitoring for tension cracking and slumping of the crest and toe areas will also be conducted on a regular basis. Also, thermistors and piezometers will be installed along the toe of the waste rock pile if deep, thaw-unstable soils are encountered during the pre-construction investigation.

7. OPEN PIT

The proposed open pit is approximately 800 by 400 m at the existing ground surface and will be approximately 275 m deep at its deepest point. Based on preliminary estimates, the layout of the pit calls for ultimate inter-ramp angles of 55 degrees with overall angles of 41 degrees in the northwest and southeast sectors and 45 degrees and 55 degrees in the northeast and southwest sectors respectively. Double benching will be used, with the bench height and catchment berm width being 12 m and 8 m respectively. Bench face angles will be blasted to 70 degrees.

In developing these slope angles, various failure mechanisms, including failure along local structural discontinuities and deep-seated failures through the surrounding rock mass have been considered. Further open pit details are provided in *Report on Pit Slope Stability* (Knight Piésold Ref. No. 1782/3, January, 1993).

Water from the open pit will be used for process makeup water to the fullest possible extent. Excess pit water will be discharged to the environment in full compliance with the discharge criteria to be specified in the water license.

8. PLANT SITE

8.1 Foundations

Frost susceptible and thaw-unstable materials within the plant site foundations will be identified during the pre-construction investigation program and will be excavated and replaced. Surficial mapping of the materials in the foundation area and geotechnical boreholes will be completed to determine allowable bearing pressures.

Once foundation excavations have been completed, they will be protected from deterioration by 50 mm of slush concrete. A combination of foundation insulation and depth to foundation footings will be used to protect against differential heaving or settlement due to frost action.

8.2 Drainage

Foundation drains, surface diversions, and collection ditches will be installed to convey intercepted precipitation, melt water and groundwater to a sediment pond located downstream of the events pond. Flow rates and water quality from this sediment pond will be monitored on a regular basis.

9. HAUL AND ACCESS ROADS

9.1 Haul Roads

Haul roads within and around the open pit, waste rock storage area and heap leach facility will have an overall width of 26 m, including an allowance for ditches and safety berms. The maximum grade will be 10 percent on all main roads and 12 percent on bench access roads.

All haul roads will be protected from flooding or washout at stream crossings. In general, culverts will be sized to convey peak flows from a 25-yr return period event without water surcharge above the culvert crown. Extreme peak flows with return periods of up to 200 years may be considered for critical road sections. Small stilling basins will be excavated at the intake of all culverts to prevent sedimentation and blocking within the culverts and to improve water quality.

Bridges will be sized to convey peak flows from a 100-yr return period event. Riprap and other erosion protection measures for culverts and bridges will be designed for the same event as the culvert or bridge.

9.2 Access Road

From Carmacks, the project site is accessed by 33 km on the gravel, all-weather, government-maintained Freegold Road; and 13 km on a seasonal exploration tote road. The Freegold Road will require upgrading to 80 km/hr secondary road standards. The bridge over the Nordenskiöld River, 1.5 km from Carmacks, and a second bridge 25.5 km from Carmacks will be replaced to accommodate highway truck loading. It is understood that the Yukon government will replace the bridges and upgrade the road upon Western Copper's production decision.

The tote road between the Freegold Road and the project site will be replaced by a new 13.3 km access road just east of the tote road. It will be constructed to resource road standards with a 5 m wide, all-weather gravel surface, widened to 8 m at sharp corners and at turnouts approximately every 250 m. The maximum grade will be 8 percent and the design speed 60 km/hr. The selected route follows the alignment of the proposed Yukon Electric powerline right-of-way from Carmacks, except as necessary to comply with grade or road curvature requirements. The new road will be operated as a private controlled access and will be maintained by mine equipment.

10. CLOSURE REQUIREMENTS AND RECLAMATION

10.1 Heap Leach Facility

Closure requirements for all facilities will be planned to satisfy the requirements of the Yukon Waters Act and Regulations and the water license; they will be fully described in the Closure and Reclamation Plan.

Neutralization of the spent ore pile may not be feasible. Once the last ore is loaded and the full leach cycle is complete there will be a period when

acid is no longer applied but copper recovery continues (Stage IV, Years 8 and 9). This stage will end when copper recovery is no longer economical.

At that time, the heap will be rinsed with water for a period yet to be determined but for the current analysis is assumed to be 3 years (Stage V). Reagents such as soda ash may be added to the rinse water depending on results of tests currently underway. Stage V may be significantly shortened if the tests indicate there is little benefit from prolonged rinsing. The length of the rinsing period will depend on economic and chemical criteria, focussing on the cost to achieve effluent that can be directly discharged versus the cost to ensure the effluent meets discharge criteria by other means.

Following Stage V, the heap will be fully drained down, excess solutions will be treated and released, and a low permeability cap will be placed. At closure, the heap will be a stable rock pile that will not impound water except temporarily during high-precipitation or high-runoff events.

The low-permeability soil cap will cover the ore to reduce the volume of precipitation entering the heap. The permeability of the cap will be finalized after further testing and analysis of the results. To allow placement of the cap, the heap slopes will be re-contoured to a continuous 2½h:1v slope by regrading the intermediate benches and angle of repose slopes. Runoff interception ditches will cross the final surface of the cap to prevent surface erosion. These ditches will be designed to convey peak flows from a 100-yr return period storm event of critical duration, and will be armored to prevent erosion.

Diversion channels surrounding the heap will be left intact and stabilized for closure to reduce the volume of upslope runoff entering the heap.

Diversion channels will be designed to convey peak flows from a 100-yr return period storm event of critical duration.

Water entering the heap will be drained to the events pond. After the heap has been rinsed, a series of large-diameter holes will be drilled through the base of the liner at the upstream toe of the heap containment embankment into the underlying high capacity french drain. These holes will be backfilled with coarse, durable drain rock to form a continuous drain from the heap to the events pond and prevent long term impoundment.

Spillways will be sized to accommodate a peak flow consistent with a CDSA 'high' consequence category structure (between 1000-yr return period and Probable Maximum Flood for the project site) with allowances for freeboard.

If attempts to rinse and neutralize the spent ore pile are not successful or practical, then a water treatment plant will be required at closure to treat and release seepage from the spent ore pile. The plant discharge rate will be sufficient to reduce storage inventory in the events pond to minimal operating levels by the end of October each year to accommodate spring runoff. Discharge water quality will be consistent with other discharge standards set by the Yukon Territory Water Board per the Yukon Waters Act, but as a minimum will meet the Metal Mining Liquid Effluent Regulations. The plant will be designed to allow removal of treatment sludge for disposal consistent with regulatory requirements. The criteria to judge the requirement for a treatment plant will be the same discharge criteria applied to direct effluent from the heap. The treatment plant components will not be finalized until the nature of the solutions it must

treat will be known but it appears that a polishing pond could be required.

10.2 Events Pond

The events pond will be retained and used for storing spent ore seepage at closure. Spent ore seepage will be treated in the water treatment plant and released to the sediment pond or allowed to evaporate seasonally in the events pond. The events pond design criteria for solution storage will remain the same as the operational design criteria. These design criteria also consider the criteria for sizing the water treatment plant. Physical stability criteria will be as those for operations. The pond spillway will be sized to pass the peak flow from a critical duration event of between 1000-yr return period and Probable Maximum Flood for the project site. Since the solution volume will be less than during operations and the solution will be diluted, there will be no leakage criteria specified after closure.

When the spent ore seepage meets effluent discharge criteria and is suitable for direct release to the environment, the events ponds will be decommissioned by draining all fluids, sampling and testing any sediment, and disposing the sediment in a manner consistent with the regulations then in effect. Liners will be folded over, the ponds filled and the dikes breached to prevent water accumulation.

10.3 Waste Rock Storage Area

The overall dump geometry will not be modified at closure. Surface water ditches and the sediment pond will remain until water quality, as a minimum, meets the Metal Mining Liquid Effluent Regulations effluent discharge criteria and is suitable for direct release. Diversions and the

sediment pond will be stabilized with the closure design criteria remaining the same as during operations.

10.4 Open Pit

Preliminary calculations estimate that it will take over 300 years to flood the open pit from direct precipitation alone, assuming no exfiltration to ground water. Based on the current understanding of the ground water regime, ground water contributions to mine water are expected to be negligible. Consequently it is unlikely that the open pit can be flooded.

Criteria for measures to close the pit will include the public safety. Steep slopes will be blocked with fences or large rocks to prevent inadvertent access.

10.5 Plant Site

Criteria for closure include a chemically and physically stable land surface, land use capability consistent with the surrounding area, public health and safety, minimal hazards to wildlife and self-sustaining vegetation.

It will be important to maintain access as required by the closure plan. Once safety issues have been dealt with, a significant criterion for road closure will be the desires of the Little Salmon/Carmacks First Nation and the local community. Where necessary, mine haul roads will be stabilized, scarified to minimize future erosion, and revegetated.

REFERENCES

- Brown, Roger J. E., (1970). *Permafrost in Canada*, University of Toronto Press, Toronto, Ontario.
- Canadian Dam Safety Association, (1995). *Dam Safety Guidelines*, Canadian Dam Safety Association, Edmonton, Alberta.
- Clearwater Consultants Ltd., (1998). *Design Memoranda CCL-CC2*, March 13, 1998.
- Clearwater Consultants Ltd., (1998). *Design Memoranda CCL-CC2A*, April 28, 1998.
- Giroud, J.P. and Bonaparte, R., (1989a). "Leakage Through Liners Constructed with Geomembranes - Part I, Geomembrane Liners," *Geotextiles and Geomembranes*, Vol. 8(1), pp. 27-67.
- Giroud, J.P. and Bonaparte, R., (1989b). "Leakage Through Liners Constructed with Geomembranes - Part II, Composite Liners," *Geotextiles and Geomembranes*, Vol. 8(2), pp. 71-111.
- Harper, T.G., Leach, J.A., Tape, R.T. (1987). "Slope Stability in Heap Leach Design," in *Geotechnical Aspects of Heap Leach Design*, Ed. Dirk VanZyl, Society Of Mining Engineers.
- Hynes-Griffin, Mary E., and Franklin, Arley G., (1984). *Rationalizing the Seismic Coefficient Method*, US Army Corps of Engineers, WES, misc. paper GL-84-13.
- Knight Piésold Ltd., (1993). *Report on 1992 Surficial Geotechnical Investigations*, Ref. No. 1782/2.
- Knight Piésold Ltd., (1993). *Report on Pit Slope Stability*, Ref. No. 1782/3.
- Knight Piésold Ltd., (1995). *Report on Preliminary Design*, Ref. No. 1783/1.
- Knight Piésold Ltd., (1996). *Report on 1996 Geotechnical and Hydrogeological Site Investigations*, Ref. No. 1784/1.
- Leps, T.M., (1970). "Review of Shearing Strength of Rockfill," *ASCE Journal of Geotechnical Engineering*, Vol. 96.
- Newmark, N.M. (1965). "Effects of Earthquakes on Dams and Embankments," *Geotechnique*, London, U.K., 15(2).
- Seed, H.B., (1979). "Considerations in the earthquake-resistant design of earth and rockfill dams," *Geotechnique*, London, U.K., 29(3), pp. 215-263.
- Seed, R.B., and Bonaparte, R., (1992). "Seismic analysis of lined waste fills: current practice," *Proc. ASCE Speciality Conference on Stability and Performance of Slopes and Embankments - II*, ASCE, New York, NY, pp. 1152-1187.

**WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT**

Table 3.1, Summary of Geotechnical and Hydrogeological Properties of Ore, Foundation and Construction Materials

Material	Bulk Unit Weight, γ_{bulk} (kN/m ³)	Friction Angle, ϕ' (degrees)	Cohesion, c (kPa)	Permeability, k (m/s)	Coefficient of Consolidation, C_v (m ² /year)	Uniaxial Compressive Strength, UCS (MPa)
Ore Materials						
Crushed Ore (saturated)	19.5	37	0	-	-	-
Crushed Ore (unsaturated)	17	37	0	-	-	-
Foundation Materials						
Sands and gravels	21 (20.9 to 21.8)	36 (35 to 44)	0 (0)	1×10^{-5}	150	-
Finer grained sand, silt and clay mixtures	21 (17.5 to 23.2)	33 (33 to 42)	0 (0)	1×10^{-7} (1×10^{-7} to 6×10^{-11})	15 (6 to 35)	-
Plastic clays	14 (14)	10 (10)	61 (61)	1×10^{-9} (6×10^{-10})	3 (3 to 13)	-
Frozen soils	21.7 (20.4 to 23.0)	-	0	1×10^{-15}	-	-
Weathered granodiorite	21 (21)	35 (35 to 36)	0	1×10^{-6}	-	5
Fresh granodiorite	25	45	15,000	2×10^{-7}	-	40 (35 to 75)
Fresh to weathered biotite gneiss	25	37 to 40	0	1×10^{-6} to 2×10^{-7}	-	56 (35 to 92)
Construction Materials						
Rockfill	22.5	40	0	-	-	-
Zoned earthfill	22.5	35	0	-	-	-
Waste rock	19.5	37	0	-	-	-
Overliner	19.5	37	0	5×10^{-4}	-	-
Soil liner	21	33	0	1×10^{-8} (1×10^{-9} to 6×10^{-11})	-	-
LDRS drain rock	19.5	37	0	1×10^{-4}	-	-
Geomembrane / Soil liner interface	-	20 (16 to 27)	0	-	-	-
Geomembrane / Ore or overliner interface	-	25	0	-	-	-
Geomembrane / Geonet interface	-	13 (13)	0	-	-	-

Notes:

1. Sources: Site-specific laboratory testwork, references provided in Section 3.1 Design Criteria Report, and professional experience.
2. Range of site-specific laboratory results presented in parentheses.
3. Ore and overliner permeabilities to be confirmed, including stress dependency and degradation during leaching.
4. Plastic clays not considered in hydrogeological modelling.
5. The range of measured permeabilities for all fresh bedrock is 2×10^{-6} to 4×10^{-10} m/s.