Canada – Newfoundland
Flood Damage Reduction
Program

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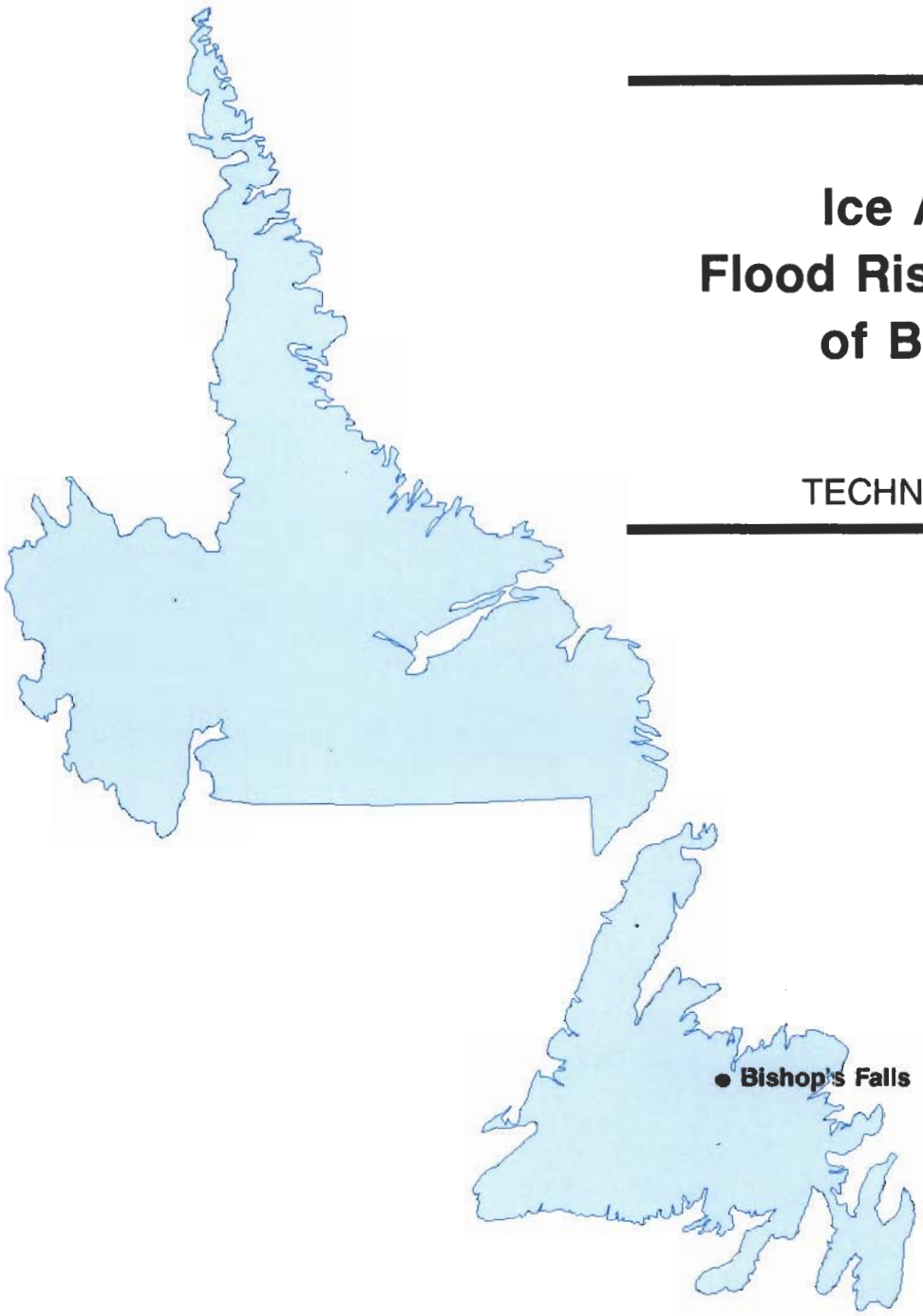
(Hydrologic Modelling Section)



Ice Analysis and Flood Risk Mapping Study of Bishop's Falls

TECHNICAL APPENDICES

FENCO NEWFOUNDLAND LIMITED

Department of Environment and Lands

Environment Canada

Fenco Newfoundland

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52556-C1-380000

November 26, 1990

Canada-Newfoundland Flood Damage Reduction Program
Government of Newfoundland and Labrador
c/o Department of Environment and Lands
Confederation Complex
4th Floor West Block
P.O. Box 8700
St. John's, Newfoundland
AIB 4J6

Attention: Dr. W. Ullah, Ph.D., P.Eng.
Director, Water Resources Management

Re: <u>Bishop's Falls - Ice Analysis and Flood Risk Mapping Study</u>

Dear Dr. Ullah:

We take pleasure in submitting the enclosed Report and Technical Appendix on the above-titled study. The most up-to-date procedures were employed in determining the hydrologic and hydraulic regime of the Bishop's Falls area, and we anticipate that the enclosed will serve the Program well in the coming years.

The main report initially provides details about 1983 flood and the hydrologic modelling of the 20 and 100 year return period flood flows. These flows are then evaluated through hydraulic analysis to determine flood levels and the effect of ice accumulations. The last section of the report describes the flood-prone areas and flood damage reduction alternatives. A Technical Appendix (under separate cover) provides additional particulars about the study for use by your technical specialists.

It has been a distinct pleasure working on this project with members of the Flood Damage Reduction Program team. We particularly wish to thank you, Mr. Picco and Ms. Langley for the considerable assistance and constructive comments provided throughout the course of this study.

Yours very truly,

FENCO NEWFOUNDLAND LTD.

Clarence Hewitt, P.Eng.
Project Director

Douglas B. Hodgins, P.Eng.
Project Manager

Lavalin

Ice Analysis and Flood Risk Mapping Study of Bishop's Falls

TECHNICAL APPENDICES

FENCO NEWFOUNDLAND LIMITED

TECHNICAL APPENDIX TA-1

(a) Mann-Whitney Homogeneity Testing - Bishop's Falls Data (1933-68 Period vs 1969-83)

(b) Mann-Whitney Homogeneity Testing - Bishop's Falls Data Adjustment Based on Diverted Drainage Area

5022

BISHOP FALLS

ANNUAL MAXIMUM FLOW SERIES 1933 TO 1983 DRAINAGE AREA= 999.0000

SPLIT BY TIME SPAN, SUBSAMPLE 1 SAMPLE SIZE = 15 1969- 1983
SUBSAMPLE 2 SAMPLE SIZE = 36 1933- 1968

(NOTE: Z IS THE STANDARD NORMAL VARIATE.)
FOR THIS TEST, Z = -0.041
CRITICAL Z VALUE AT 5% SIGNIFICANT LEVEL = -1.645 NOT SIGNIFICANT
- - - - 1% - - = -2.326 NOT SIGNIFICANT

INTERPRETATION: THE NULL HYPOTHESIS IS THAT THERE IS NO LOCATION DIFFERENCE BETWEEN THE TWO SAMPLES.

AT THE 5% LEVEL OF SIGNIFICANCE, THERE IS NO SIGNIFICANT LOCATION DIFFERENCE BETWEEN THE TWO SAMPLES. THAT IS, THEY APPEAR TO BE FROM THE SAME POPULATION.

SC STATION NO.=5022
.. STATION NAME=BISHOP FALLS

SEQ.NO.	YEAR	MON	FLOW
1	1933	11	46385.000
2	1934	4	68759.000
3	1935	5	42593.000
4	1936	3	61978.000
5	1937	12	30220.000
6	1938	5	27249.000
7	1939	5	47017.000
8	1940	5	59519.000
9	1941	5	55125.000
10	1942	5	56638.000
11	1943	11	34545.000
12	1944	11	51671.000
13	1945	5	50536.000
14	1946	4	55219.000
15	1947	5	60052.000
16	1948	5	67212.000
17	1949	3	27433.000
18	1950	5	55726.000
19	1951	4	58102.000
20	1952	5	60000.000
21	1953	4	42856.000
22	1954	12	77130.000
23	1955	1	25084.000
24	1956	5	43153.000
25	1957	5	19450.000
26	1958	9	17842.000
27	1959	12	23966.000
28	1960	5	19940.000
29	1961	5	27715.000
30	1962	4	40253.000
31	1963	5	29007.000
32	1964	5	29430.000
33	1965	6	56084.000
34	1966	5	23043.000
35	1967	5	43628.000
36	1968	5	46684.000
37	1969	12	54300.000
38	1970	5	48419.000
39	1971	4	57815.000
40	1972	6	28430.000
41	1973	5	33182.000
42	1974	4	28177.000
43	1975	4	40903.000
44	1976	5	33700.000
45	1977	12	55884.000
46	1978	1	31654.000
47	1979	3	46335.000
48	1980	7	38178.000
49	1981	5	48270.000
50	1982	5	42153.000
51	1983	1	115000.000

Appendix 1(a)

Data & Mann-Whitney Statistics for Bishop's Falls

1933-68 vs
1969-83

6023 BISHOP FALLS
ANNUAL MAXIMUM FLOW SERIES 1933 TO 1983 DRAINAGE AREA= 999.0000

SPLIT BY TIME SPAN, SUBSAMPLE 1 SAMPLE SIZE = 15
SUBSAMPLE 2 SAMPLE SIZE = 36

(NOTE: Z IS THE STANDARD NORMAL VARIATE.)
FOR THIS TEST, Z = -0.889
CRITICAL Z VALUE AT 5% SIGNIFICANT LEVEL = -1.645 NOT SIGNIFICANT
- - - - 1% - - = -2.326 NOT SIGNIFICANT

INTERPRETATION: THE NULL HYPOTHESIS IS THAT THERE IS NO LOCATION DIFFERENCE BETWEEN THE TWO SAMPLES.

AT THE 5% LEVEL OF SIGNIFICANCE, THERE IS NO SIGNIFICANT LOCATION DIFFERENCE BETWEEN THE TWO SAMPLES. THAT IS, THEY APPEAR TO BE FROM THE SAME POPULATION.

WSC STATION NAME=BISHOP FALLS

SEQ.NO.	YEAR	MON	FLOW
1	1933	11	42004.000
2	1934	4	62264.000
3	1935	5	38570.000
4	1936	3	56124.000
5	1937	12	27366.000
6	1938	5	24675.000
7	1939	5	42576.000
8	1940	5	53897.000
9	1941	5	49918.000
10	1942	5	51289.000
11	1943	11	31282.000
12	1944	11	46791.000
13	1945	5	45763.000
14	1946	4	50004.000
15	1947	5	54380.000
16	1948	5	60864.000
17	1949	3	24842.000
18	1950	5	50463.000
19	1951	1	52614.000
20	1952	5	54333.000
21	1953	4	38808.000
22	1954	12	69845.000
23	1955	1	22715.000
24	1956	5	39077.000
25	1957	5	17613.000
26	1958	9	16157.000
27	1959	12	21702.000
28	1960	5	18057.000
29	1961	5	25097.000
30	1962	4	36451.000
31	1963	5	26267.000
32	1964	5	26650.000
33	1965	6	50787.000
34	1966	5	20867.000
35	1967	5	39507.000
36	1968	5	42275.000
37	1969	12	54300.000
38	1970	5	48419.000
39	1971	4	57815.000
40	1972	6	28430.000
41	1973	5	33182.000
42	1974	4	28177.000
43	1975	4	40903.000
44	1976	5	33700.000
45	1977	12	55884.000
46	1978	1	31654.000
47	1979	3	46335.000
48	1980	7	38178.000
49	1981	5	48270.000
50	1982	5	42153.000
51	1983	1	115000.000

Appendix 1(b)

Data and Mann-Whitney Statistics

1933-68 Flow Adjustment

$\left(\frac{DA'}{DA} = 0.90555 \right)$

vs 1969-83

TECHNICAL APPENDIX TA-2

2. Flood Flow Frequency Analysis

Bishop's Falls

(a) FDRPFFA Program

(b) CFA-88 Program

(c) Analysis with Drainage Area Adjustment

(d) Flood Flow Frequency Analysis - Intervening Area Between Grand Falls and Bishop's Falls (1933-83)

Appendix 2(i)

(a)Flood Flow Frequency Analysis - Bishop's Falls (FDRPFFA)

bishop falls 1933-1983 obs. data from run 5022 M

(m³/s)

YEAR	DATA	ORDERED	RANK	PROB.	RET. PERIOD
33	1313.5	3256.4	1	.019	52.000
34	1947.0	2184.0	2	.038	26.000
35	1206.1	1947.0	3	.058	17.333
36	1755.0	1903.0	4	.077	13.000
37	855.7	1755.0	5	.096	10.400
38	771.6	1700.5	6	.115	8.667
39	1331.4	1699.0	7	.135	7.429
40	1685.4	1685.4	8	.154	6.500
41	1561.0	1645.3	9	.173	5.778
42	1603.8	1637.1	10	.192	5.200
43	978.2	1603.8	11	.212	4.727
44	1463.2	1588.1	12	.231	4.333
45	1431.0	1582.5	13	.250	4.000
46	1563.6	1577.9	14	.269	3.714
47	1700.5	1563.6	15	.288	3.467
48	1903.0	1561.0	16	.308	3.250
49	776.8	1537.6	17	.327	3.059
50	1577.9	1463.2	18	.346	2.889
51	1645.3	1431.0	19	.365	2.737
52	1699.0	1371.1	20	.385	2.600
53	1213.5	1366.9	21	.404	2.476
54	2184.0	1331.4	22	.423	2.364
55	710.3	1321.9	23	.442	2.261
56	1221.9	1313.5	24	.462	2.167
57	550.8	1312.1	25	.481	2.080
58	505.2	1235.4	26	.500	2.000
59	678.6	1221.9	27	.519	1.926
60	564.6	1213.5	28	.538	1.857
61	784.8	1206.1	29	.558	1.793
62	1139.8	1193.6	30	.577	1.733
63	821.4	1158.2	31	.596	1.677
64	833.4	1139.8	32	.615	1.625
65	1588.1	1081.1	33	.635	1.576
66	652.5	978.2	34	.654	1.529
67	1235.4	954.3	35	.673	1.486
68	1321.9	939.6	36	.692	1.444
69	1537.6	896.3	37	.712	1.405
70	1371.1	855.7	38	.731	1.368
71	1637.1	833.4	39	.750	1.333
72	805.0	821.4	40	.769	1.300
73	939.6	805.0	41	.788	1.268
74	797.9	797.9	42	.808	1.238
75	1158.2	784.8	43	.827	1.209
76	954.3	776.8	44	.846	1.182
77	1582.5	771.6	45	.865	1.156
78	896.3	710.3	46	.885	1.130
79	1312.1	678.6	47	.904	1.106
80	1081.1	652.5	48	.923	1.083
81	1366.9	564.6	49	.942	1.061
82	1193.6	550.8	50	.962	1.040
83	3256.4	505.2	51	.981	1.020

bishop falls 1933-1983 obs. data from run 5022

```
0          SAMPLE STATISTICS
0      MEAN =     1268.          S.D. =     496.4          C.S. =    1.2162          C.K. =    6.9072
0          SAMPLE STATISTICS (LOGS)
0      MEAN =    7.0725          S.D. =     .3892          C.S. =    -.1631          C.K. =    3.0444
0      SAMPLE MIN =    505.     SAMPLE MAX =   3256.     N =  51
0      PARAMETERS FOR GUMBEL I      A =  .002554     U =     1045.
0      PARAMETERS FOR LOGNORMAL     M =  7.0725     S =  .3892
0      PARAMETERS FOR THREE PARAMETER LOGNORMAL     A =    -168.     M =  7.2139     S =  .3374
0          STATISTICS OF LOG(X-A)
0      MEAN =    7.2139          S.D. =     .3374          C.S. =    -.0362          C.K. =    3.1211
0      PARAMETERS FOR LOG PEARSON III BY MOMENTS     A = -.0317     B = .1504E+03   LOG(M) =11.8451     M =    .1394E+06
0      PARAMETERS FOR LOG PEARSON III BY MAXIMUM LIKELIHOOD    A = -.0329    B = .1376E+03   LOG(M) =11.5924    M =  .1083E+06
0      DISTRIBUTION STATISTICS     MEAN =  7.0725     S.D. =  .3853     C.S. = -.1705
```

	GUMBEL I		LOGNORMAL		THREE PARAMETER LOGNORMAL		LOG PEARSON III MAX. LIKELIHOOD		LOG PEARSON III MOMENTS	
RETURN PERIOD	FLOOD ESTIMATE	ST. ERROR PERCENT	FLOOD ESTIMATE	ST.ERROR PERCENT	FLOOD ESTIMATE	ST. ERROR PERCENT	FLOOD ESTIMATE	ST. ERROR PERCENT	FLOOD ESTIMATE	ST. ERROR PERCENT
1.005	391.0		433.0		402.0		411.0		408.0	
1.050	609.0		622.0		612.0		614.0		611.0	
1.250	858.0		850.0		854.0		856.0		853.0	
2.000	1190.0		1180.0		1190.0		1190.0		1190.0	
5.000	1630.0	6.05	1640.0	6.34	1640.0	6.06	1640.0	6.04	1640.0	6.10
10.000	1930.0	6.58	1940.0	7.36	1930.0	7.12	1920.0	6.86	1930.0	6.95
20.000	2210.0	7.02	2240.0	8.36	2200.0 ←	8.53	2180.0	8.22	2200.0	8.38
50.000	2570.0	7.50	2620.0	9.61	2550.0	10.60	2510.0	10.60	2530.0	10.90
100.0	2850.0	7.79	2920.0	10.50	2810.0 ←	12.20	2750.0	12.60	2780.0	13.00
200.0	3120.0	8.04	3210.0	11.30	3070.0	13.90	2990.0	14.80	3030.0	15.30
500.0	3480.0	8.31	3620.0	12.40	3420.0	16.00	3300.0	17.80	3350.0	18.50

Appendix 2(b)

Flood Flow Frequency Analysis - Bishop's Falls (CFA88)

WSC STATION NO=5022
WSC STATION NAME=BISHOP FALLS

MONTH (1)	YEAR (2)	DATA (3) (CMS)	ORDERED (4) (CMS)	RANK (5)	PROB. (6) (%)	RET. PERIOD (7) (YEARS)
11	1933	46385.000	115000.000	1	1.17	85.333
4	1934	68759.000	77130.000	2	3.12	32.000
5	1935	42593.000	68759.000	3	5.08	19.692
3	1936	61978.000	67212.000	4	7.03	14.222
12	1937	30220.000	61978.000	5	8.98	11.130
5	1938	27249.000	60052.000	6	10.94	9.143
5	1939	47017.000	60000.000	7	12.89	7.758
5	1940	59519.000	59519.000	8	14.84	6.737
5	1941	55125.000	58102.000	9	16.80	5.953
5	1942	56638.000	57815.000	10	18.75	5.333
11	1943	34545.000	56638.000	11	20.70	4.830
11	1944	51671.000	56084.000	12	22.66	4.414
5	1945	50536.000	55884.000	13	24.61	4.063
4	1946	55219.000	55726.000	14	26.56	3.765
5	1947	60052.000	55219.000	15	28.52	3.507
5	1948	67212.000	55125.000	16	30.47	3.282
3	1949	27433.000	54300.000	17	32.42	3.084
5	1950	55726.000	51671.000	18	34.37	2.909
4	1951	58102.000	50536.000	19	36.33	2.753
5	1952	60000.000	48419.000	20	38.28	2.612
4	1953	42856.000	48270.000	21	40.23	2.485
12	1954	77130.000	47017.000	22	42.19	2.370
1	1955	25084.000	46684.000	23	44.14	2.265
5	1956	43153.000	46385.000	24	46.09	2.169
5	1957	19450.000	46335.000	25	48.05	2.081
9	1958	17842.000	43628.000	26	50.00	2.000
12	1959	23966.000	43153.000	27	51.95	1.925
5	1960	19940.000	42856.000	28	53.91	1.855
5	1961	27715.000	42593.000	29	55.86	1.790
4	1962	40253.000	42153.000	30	57.81	1.730
5	1963	29007.000	40903.000	31	59.77	1.673
5	1964	29430.000	40253.000	32	61.72	1.620
6	1965	56084.000	38178.000	33	63.67	1.571
5	1966	23043.000	34545.000	34	65.62	1.524
5	1967	43628.000	33700.000	35	67.58	1.480
5	1968	46684.000	33182.000	36	69.53	1.438
12	1969	54300.000	31654.000	37	71.48	1.399
5	1970	48419.000	30220.000	38	73.44	1.362
4	1971	57815.000	29430.000	39	75.39	1.326
6	1972	28430.000	29007.000	40	77.34	1.293
5	1973	33182.000	28430.000	41	79.30	1.261
4	1974	28177.000	28177.000	42	81.25	1.231
4	1975	40903.000	27715.000	43	83.20	1.202
5	1976	33700.000	27433.000	44	85.16	1.174
12	1977	55884.000	27249.000	45	87.11	1.148
1	1978	31654.000	25084.000	46	89.06	1.123
3	1979	46335.000	23966.000	47	91.02	1.099
7	1980	38178.000	23043.000	48	92.97	1.076
5	1981	48270.000	19940.000	49	94.92	1.053
5	1982	42153.000	19450.000	50	96.87	1.032
1	1983	115000.000	17842.000	51	98.83	1.012

SAMPLE STATISTICS

	MEAN	S.D.	C.V.	C.S.	C.K.
X SERIES	44777.332	17531.812	0.392	1.216	6.907
LN X SERIES	10.637	0.389	0.037	-0.163	3.044
LN(X-A) SERIES	10.778	0.337	0.031	-0.036	3.121

X(MIN)= 17842.000
X(MAX)= 115000.000
LOWER OUTLIER LIMIT OF X=14142.208

TOTAL SAMPLE SIZE= 51
NO. OF LOW OUTLIERS= 0
NO. OF ZERO FLOWS= 0

SOLUTION OBTAINED VIA MAXIMUM LIKELIHOOD

3LN PARAMETERS: A= -5924.011 M=10.778 S= 0.337

FLOOD FREQUENCY REGIME

RETURN PERIOD	EXCEEDANCE PROBABILITY	FLOOD (cfs)
1.003	0.997	13000.00
1.050	0.952	21400.00
1.250	0.800	30200.00
2.000	0.500	42000.00
5.000	0.200	57800.00
10.000	0.100	68000.00
20.000	0.050	77600.00
50.000	0.020	90000.00
100.000	0.010	99200.00
200.000	0.005	108000.00
500.000	0.002	121000.00

Appendix 2(c)

Frequency Analysis - Adjusted Data at Bishop's Falls (FDRPFFA)

Data from Appendix 1(b) (1933-68 Adjusted by Drainage Area Loss to Victoria Diversion)

```
bishop f 1933-1968 obs. data * .90555 (run 5023)

0          SAMPLE STATISTICS
0     MEAN =    41849.          S.D. =    16847.9          C.S. =    1.5175          C.K. =    8.9396
0          SAMPLE STATISTICS (LOGS)
0     MEAN =    10.5668         S.D. =      .3955          C.S. =    -.1906          C.K. =    3.3387
0     SAMPLE MIN =  16157.     SAMPLE MAX = 115000.     N =  51
0     PARAMETERS FOR GUMBEL 1      A =  .000076     U =    34405.
0     PARAMETERS FOR LOGNORMAL     M = 10.5668     S =  .3955
0     NO MAXIMUM LIKELIHOOD SOLUTION FOR THREE PARAMETER LOGNORMAL
0     PARAMETERS FOR THREE PARAMETER LOG NORMAL BY MOMENTS     A =    .6078E+04     M = 10.3847     S =  .4476
0          STATISTICS OF LOG(X-A)
0     MEAN =    10.3774         S.D. =      .4830          C.S. =    -.4169          C.K. =    3.3284
0     PARAMETERS FOR LOG PEARSON III BY MOMENTS     A = -.0377     B = .1101E+03   LOG(M) =14.7175     M =    .2465E+07
0     PARAMETERS FOR LOG PEARSON III BY MAXIMUM LIKELIHOOD     A = -.0311     B = .1579E+03   LOG(M) =15.4855     M =  .5312E+07
0     DISTRIBUTION STATISTICS     MEAN = 10.5668     S.D. =  .3914     C.S. = -.1592
```

RETURN PERIOD	GUMBEL 1 FLOOD ESTIMATE	GUMBEL 1 ST. ERROR PERCENT	LOGNORMAL FLOOD ESTIMATE	LOGNORMAL ST.ERROR PERCENT	THREE PARAMETER LOGNORMAL FLOOD ESTIMATE (cfs)	THREE PARAMETER LOGNORMAL ST. ERROR PERCENT	LOG PEARSON III MAX. LIKELIHOOD FLOOD ESTIMATE	LOG PEARSON III MAX. LIKELIHOOD ST. ERROR PERCENT	LOG PEARSON III MOMENTS FLOOD ESTIMATE	LOG PEARSON III MOMENTS ST. ERROR PERCENT
1.005	12500.0		14000.0		16300.0		13400.0		13100.0	
1.050	19800.0		20300.0		21600.0		20000.0		19800.0	
1.250	28200.0		27800.0		28300.0		28000.0		27900.0	
2.000	39200.0		38800.0		38400.0		39200.0		39300.0	
5.000	54100.0	6.12	54200.0	6.45	53300.0	7.48	54100.0	6.12	54300.0	6.15
10.000	63900.0	6.64	64500.0	7.48	63500.0	7.96	63700.0	6.98	63900.0	6.97
20.000	73400.0	7.08	74400.0	8.50	73700.0 20687	10.40	72600.0	8.40	72800.0	8.39
50.000	85600.0	7.55	87500.0	9.77	87200.0	15.50	83900.0	10.80	84000.0	10.90
100.0	94800.0	7.84	97400.0	10.70	97700.0 27467	19.80	92200.0	12.90	92200.0	13.00
200.0	104000.0	8.08	108000.0	11.50	109000.0	24.30	100000.0	15.20	100000.0	15.40
500.0	116000.0	8.35	121000.0	12.60	124000.0	30.40	111000.0	18.30	111000.0	18.60

Appendix 2(d)

Flood Flow Frequency Analysis - Intervening Area Between Grand Falls and Bishop's Falls

WSC STATION NO=5031
WSC STATION NAME=INTERVENING DRAIN 1933-1983

MONTH	YEAR	DATA	ORDERED	RANK	PROB.	RET. PERIOD
(1)	(2)	(3) (CMS)	(4) (CMS)	(5)	(6) (%)	(7) (YEARS)
11	1933	24594.000	50000.000	1	1.17	85.333
4	1934	19853.000	32960.000	2	3.12	32.000
12	1935	12095.000	29690.000	3	5.08	19.692
3	1936	29357.000	29357.000	4	7.03	14.222
11	1937	15960.000	26070.000	5	8.98	11.130
5	1938	8514.000	25981.000	6	10.94	9.143
5	1939	15324.000	24594.000	7	12.89	7.758
5	1940	29690.000	24536.000	8	14.84	6.737
5	1941	17564.000	24305.000	9	16.80	5.953
5	1942	16155.000	22377.000	10	18.75	5.333
11	1943	11252.000	21359.000	11	20.70	4.830
11	1944	20328.000	20498.000	12	22.66	4.414
5	1945	10300.000	20328.000	13	24.61	4.063
4	1946	13688.000	20005.000	14	26.56	3.765
5	1947	18792.000	19853.000	15	28.52	3.507
5	1948	18023.000	19029.000	16	30.47	3.282
3	1949	15436.000	18857.000	17	32.42	3.084
5	1950	18231.000	18792.000	18	34.37	2.909
4	1951	16495.000	18231.000	19	36.33	2.753
5	1952	20498.000	18023.000	20	38.28	2.612
4	1953	12752.000	17564.000	21	40.23	2.485
12	1954	24305.000	17360.000	22	42.19	2.370
1	1955	6957.000	16495.000	23	44.14	2.265
5	1956	19029.000	16155.000	24	46.09	2.169
5	1957	4934.000	15960.000	25	48.05	2.081
12	1958	6354.000	15436.000	26	50.00	2.000
12	1959	6615.000	15399.000	27	51.95	1.925
5	1960	5382.000	15324.000	28	53.91	1.855
5	1961	7763.000	13688.000	29	55.86	1.790
4	1962	15399.000	13607.000	30	57.81	1.730
5	1963	7966.000	13014.000	31	59.77	1.673
5	1964	13607.000	12752.000	32	61.72	1.620
6	1965	17360.000	12369.000	33	63.67	1.571
5	1966	6332.000	12095.000	34	65.62	1.524
5	1967	13014.000	12073.000	35	67.58	1.480
5	1968	21359.000	11952.000	36	69.53	1.438
12	1969	20005.000	11252.000	37	71.48	1.399
5	1970	24536.000	10300.000	38	73.44	1.362
4	1971	32960.000	10091.000	39	75.39	1.326
6	1972	9590.000	10076.000	40	77.34	1.293
5	1973	12073.000	9590.000	41	79.30	1.261
4	1974	18857.000	8514.000	42	81.25	1.231
4	1975	22377.000	7966.000	43	83.20	1.202
5	1976	10091.000	7763.000	44	85.16	1.174
12	1977	25981.000	6957.000	45	87.11	1.148
1	1978	11952.000	6615.000	46	89.06	1.123
3	1979	26070.000	6354.000	47	91.02	1.099
7	1980	12369.000	6332.000	48	92.97	1.076
5	1981	6084.000	6084.000	49	94.92	1.053
5	1982	10076.000	5382.000	50	96.87	1.032
1	1983	50000.000	4934.000	51	98.83	1.012

FREQUENCY ANALYSIS - THREE-PARAMETER LOGNORMAL DISTRIBUTION
5031 INTERVENING DRAIN 1933-1983

SAMPLE STATISTICS

	MEAN	S.D.	C.V.	C.S.	C.K.
X SERIES	16358.784	8407.138	0.514	1.411	7.011
LN X SERIES	9.578	0.513	0.054	-0.188	2.871
LN(X-A) SERIES	9.677	0.464	0.048	-0.082	2.894

X(MIN)= 4934.000 TOTAL SAMPLE SIZE= 51
X(MAX)= 50000.000 NO. OF LOW OUTLIERS= 0
LOWER OUTLIER LIMIT OF X= 3479.016 NO. OF ZERO FLOWS= 0

SOLUTION OBTAINED VIA MAXIMUM LIKELIHOOD

3LN PARAMETERS: A= -1339.891 M= 9.677 S= 0.464

FLOOD FREQUENCY REGIME

RETURN PERIOD	EXCEEDANCE PROBABILITY	FLOOD (cfs)	(cms)
1.003	0.997	3110.00	
1.050	0.952	6010.00	
1.250	0.800	9460.00	
2.000	0.500	14600.00	
5.000	0.200	22200.00	
10.000	0.100	27600.00	
20.000 -	0.050	32900.00	932 m³/s
50.000	0.020	40000.00	
100.000 -	0.010	45600.00	1291 m³/s
200.000	0.005	51400.00	
500.000	0.002	59300.00	

TECHNICAL APPENDIX TA-3

(a) Detailed Hydrograph Analysis

(b) Regression Analysis - Pre and Post Diversion Inflows to Red Indian Lake

(c) Flood Flow Frequency Analysis - Red Indian Lake Inflows (1948-87)

    (a) Spring Inflow Peaks
    (b) Summer Inflow Peaks

(d) Flood Flow Frequency Analysis - Stony Brook WSC Station (1969-86)

TABLES*

4-2 Spring Inflow Peaks - Red Indian Lake

4-3 Summer Inflow Peaks - Red Indian lake

4-4 Inflow Frequency Analysis - Red Indian Lake

4-5 Dimensionless Inflow Hydrograph - Exploits Dam

4-6 Exploits Dam Operations Options

4-7 Return Period Discharge - Exploits Dam

4-8 Local Inflow - Exploits Dam to Grand Falls and Grand Falls to Bishop's Falls

4-9 Grand Falls Peak Daily inflows

FIGURE*

4-2 Frequency Analysis - Red Indian Lake

* Table, Figure and Section numbering in this Appendix correspond to sections in Chapter 4 of the main report to facilitate cross-referencing

4.3.2 Hydrograph Analysis - Bishop's Falls

As noted in Chapter 4 of the main report, it is also possible to develop and route natural hydrographs through the Exploits River system to determine how they combine with tributary flows and add to give flood flows at Bishop's Falls. There are more uncertainties with this approach (than with the single station frequency analysis completed in Section 4.3.1.2 (main report)) because it requires some data which must be estimated, and it is somewhat more theoretical. Hence, this second approach is completed herein to provide a set of flood flow estimates to confirm the single station frequency analysis.

The analysis of flood events in this approach began at Exploits Dam and carried downstream to completion at Bishop's Falls Dam.

4.3.2.1 Exploits Dam / Millertown

The analysis of natural streamflow data was initiated at Red Indian Lake where water levels, gate settings and rating curves are available from previous studies and records of daily monitoring (Abitibi-Price, Grand Falls). The historical lake level data were initially screened to identify periods of rapid infilling, and gate settings were reviewed for periods of significant outflow. The two were then combined to determine major inflow periods (in each of the spring, summer, fall and winter periods) for each year since 1948 (40 year record period).

The diversion of streamflow through the Victoria Diversion (since August 1968) was then factored into the analysis. Recorded inflows to the diversion (Newfoundland and Labrador Hydro) show that the inflow peaks typically occur on the same day as peak inflows to Red Indian Lake. Hence, a regression between pre- and post-Diversion inflows at Red Indian Lake was possible, and was undertaken to extend the historical inflow record at Exploits Dam (to reflect a longer period of post-Diversion conditions).

This regression demonstrated that post-Diversion inflow peaks (Q_{post}) are approximately 84

percent of pre-Diversion inflows (Q_{pre}). This is about the same as the ratio of pre- and post-Diversion drainage areas (82%), considered in earlier studies (Fenco Newfoundland, 1985) based on about 20% less data.

The form of the regression equation for inflow (m^3/s) is:

$$Qpost = 0.8474(Qpre) - 37.97 \ m^3/s$$

The regression data from above was then employed to complete a 40 year period of peak daily inflows to Red Indian Lake (1948 - 1987). The majority of these events occurred in the spring, but about one quarter of the peak annual flows were late fall or early winter events. One summer flood flow was marginally higher than its spring counterpart.

The spring, late fall and early winter floods were grouped into one category (termed "Spring") because most are indeed spring runoff events, they have similar durations, they usually involve snowmelt with rainfall, and they correspond to peak flow periods at Bishop's Falls. The remaining category of events ("Summer") are typically smaller than the spring peaks, of shorter duration, are localized to one portion of the 4754 km^2 watershed, and consequently do not effect downstream flooding.

The peak annual inflows for each series are given in Table 4-2 and Table 4-3. Table 4-2 summarizes the spring inflow series and Table 4-3 gives the summer peaks. The tabled values are natural, unregulated inflows to Red Indian Lake (4754 m^2).

It should be noted that these flow data are reliably accurate and the best available estimates of the instantaneous maxima for this drainage area. All flow calculations employed hourly (to half hourly) reports on gate settings contained in the Abitibi-Price Inc. records and daily water level observations, are based on rating curves which have been checked for accuracy, and are calculated by water level observations (to a hundredth of a foot) and gate settings (to one half of a foot) having a narrow measurement range. In all, the monitored peak flow estimates are within 2-3% of actual values during high flow periods.

TABLE 4-2

SUMMARY OF SPRING INFLOW PEAKS TO RED INDIAN LAKE - EXPLOITS/MILLERTOWN DAM

YEAR	MONTH	FLOW (m^3/s)*	YEAR	MONTH	FLOW (m^3/s)**
1948	May	1509	1968	Nov.	1233
1949	Nov.	1212	1969	Feb.	1239
1950	May	901	1970	May	1193
1951	May	1105	1971	Apr.	1362
1952	May	976	1972	May	1229
1953	Apr.	1207	1973	May	791
1954	Dec.	1134	1974	May	750
1955	Sep.	489	1975	May	1045
1956	May	734	1976	Apr.	1345
1957	Dec.	1062	1977	Dec.	1769
1958	Nov.	761	1978	May	891
1959	Dec.	624	1979	Mar.	1076
1960	May	721	1980	Apr.	1178
1961	May	1024	1981	May	905
1962	Apr.	669	1982	Feb.	724
1963	May	831	1983	Jan.	2686
1964	Apr.	765	1984	May	935
1965	Nov.	1257	1985	May	1325
1966	May	505	1986	Apr.	1564
1967	May	842	1987	Apr.	1027

* adjusted by regression to reflect post-Victoria Diversion

** post-Diversion conditions or monitored flow at Diversion site

TABLE 4-3

SUMMARY OF SUMMER INFLOW PEAKS TO RED INDIAN LAKE - EXPLOITS/MILLERTOWN DAM

YEAR	MONTH	FLOW (m^3/s)*	YEAR	MONTH	FLOW (m^3/s)**
1948	Sep.	713	1968	Aug.	599
1949	Sep.	162	1969	Sep.	311
1950	June	150	1970	June	574
1951	Aug.	376	1971	Aug.	353
1952	June	154	1972	June	581
1953	June	259	1973	June	487
1954	Aug.	306	1974	June	708
1955	Sep.	488	1975	June	182
1956	June	357	1976	June	265
1957	Sep.	493	1977	July	376
1958	June	365	1978	June	369
1959	Aug.	264	1979	Sep.	256
1960	June	103	1980	July	703
1961	May	590	1981	Aug.	973
1962	June	327	1982	June	239
1963	June	642	1983	Aug.	1379
1964	June	526	1984	June	620
1965	June	642	1985	June	1325
1966	Aug.	505	1986	June	361
1967	June	469	1987	May	331

* adjusted to reflect post-Victoria Diversion

** post-Diversion conditions or monitored at Diversion site

Inflow Frequency Analysis

The inflow floods listed in Table 4-2 and Table 4-3 were subject to frequency analyses to estimate 1:20 year and 1:100 year return period inflows. The three parameter lognormal distribution was selected to give the return period flood inflows which are provided in Table 4-4. As the spring flows are higher than summer flows for the same return periods, the spring flows alone were retained for subsequent analysis.

Inflow Hydrograph, Starting Levels and Operations

The inflow hydrographs for high spring occasions were assembled and reviewed to determine the typical duration and distribution of flood flows. Spring events typically rise from near base flow conditions to reach a peak over a period of four to six days before gradually declining. The five largest spring events were selected as representative of extreme inflow events and were made dimensionless. The co-ordinates of the resulting flood hydrograph are given in Table 4-5.

Twenty years of water level data before and during flood inflows were then reviewed to identify water levels most likely to be present before the initiation of flood inflows. Spring flood flows invariably arrive when water levels are below 502 ft, and recently (since the Victoria Diversion) in the range from the low 480's to mid 490's (feet). The mean lake level (20 year record) prior to peak spring inflows are also given in Table 4-5.

It is appropriate to note that the column titled, "Day" in this Table is retained in subsequent tables (e.g. Table 4-9) to give a constant time base for comparing inflow hydrographs in the basin. In all cases, Day 5 is the same day as peak inflows into Red Indian Lake.

Effect of Gate Settings

Last, the gate settings during historical floods were reviewed to select a gate operation which represented pre-flood conditions. In the spring, watershed surveys of the snowpack are made

Figure 4-2

Frequency Analysis - Red Indian Lake
Spring/Annual Flood Instant Flow Series

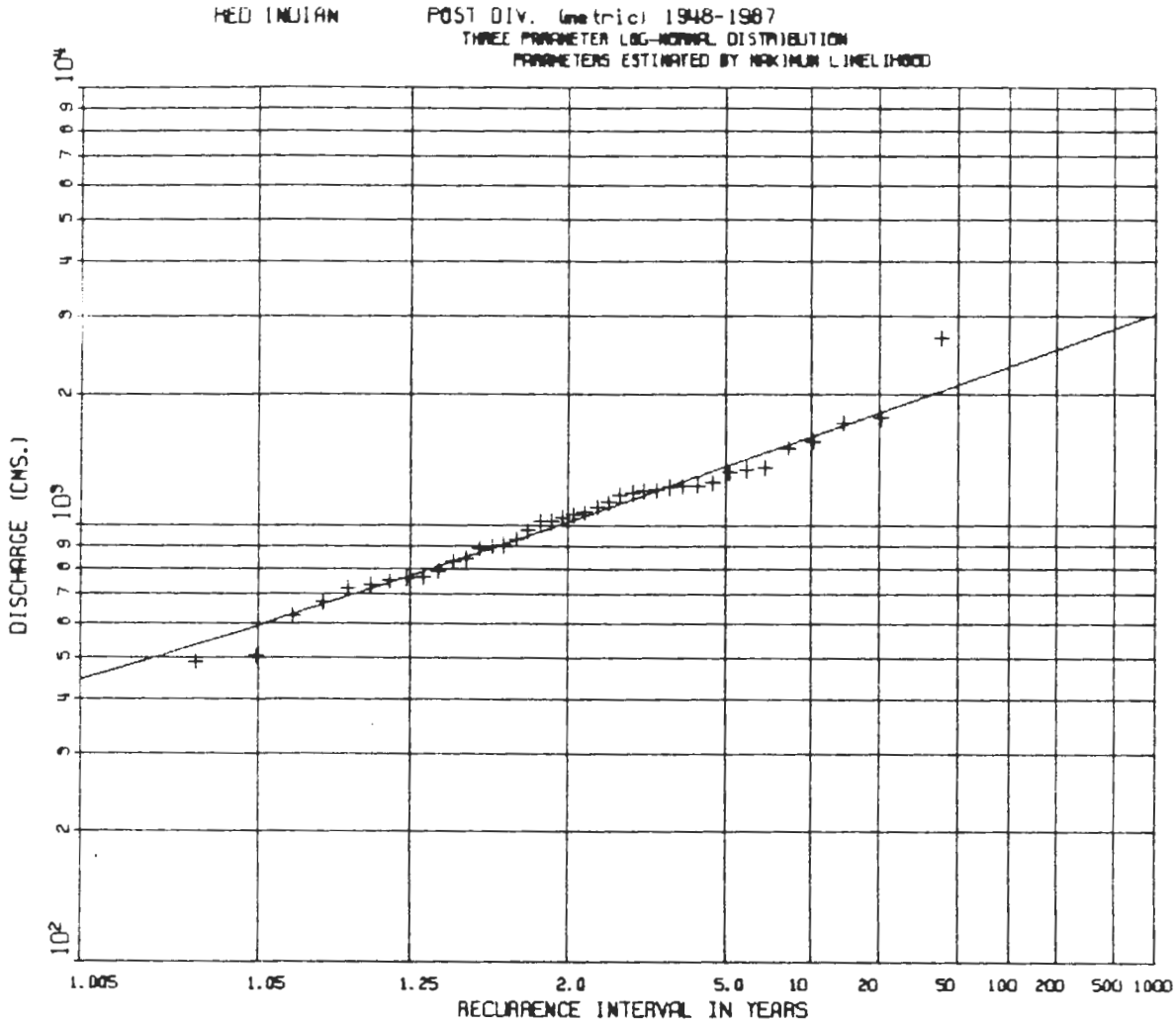


TABLE 4-4

FREQUENCY ANALYSIS OF INFLOWS
RED INDIAN LAKE AT EXPLOITS DAM[1]

SPRING INFLOWS			SUMMER INFLOWS		
RETURN PERIOD	FLOW	FLOW	RETURN PERIOD	FLOW	FLOW
(years)	(cfs)	(m^2/s)	(years)	(cfs)	(m^3/s)
1:100	81,577	2,310	1:100	51,560	1,460
1:20	63,920	1,810	1:20	35,668	1,010

[1] by three parameter lognormal distribution

TABLE 4-5

DIMENSIONLESS INFLOW HYDROGRAPH
EXPLOITS DAM - MILLERTOWN

SPRING INFLOWS		
DAY	RELATIVE INFLOW	NORMAL LEVEL (ft)**
1	0.10	490.00
2	0.24	490.56
3	0.47	491.10
4	0.67	492.29
5*	1.00	493.39
6	0.68	-
7	0.55	-
8	0.37	-
9	0.35	-
10	0.32	-

* day of peak flow relative to inflow hydrograph
** levels at 8 a.m. of indicated day
\- normal levels not assessed

by Abitibi-Price and Newfoundland and Labrador Hydro and combined with meteorological forecasts to give Abitibi personnel a basis on which to estimate inflows for managing Red Indian Lake. Outflow is generally kept to the minimum required to meet downstream power needs, while storage is maximized through gate operations ranging from all gates closed to typical use of a combination of the A, B and C flood gates. Other gates (log sluice and submerged gates) are opened if needed when anticipated inflow volumes may exceed the maximum level for storage in Red Indian Lake (about 504 feet).

Gate settings for the last 20 years (since the Victoria Diversion) were reviewed to project the effect of gate settings on discharge and lake levels. Two scenarios were selected:

- the first considers complete inflow storage (closed gates) prior to the days just before the peak inflow

- the second, like the first, assumes early storage, but more rapid release of water from the dam above elevation 502 feet

Both options are realistic and appropriate to establish upper limits on lake elevations at Exploits Dam, and to give an indication of the sensitivity of discharge to operation variations. Table 4-6 summarizes these gate operation scenarios in terms of lake level and discharge.

Reservoir Routing and Design Water Levels - Red Indian Lake

Inflow floods listed in Table 4-4 were combined with the dimensionless hydrographs of Table 4-5 to develop inflow hydrographs for each return period. These were input to the reservoir at starting levels given in Table 4-5 and were routed through the dam with operations outlined in Table 4-6 and by use of stage-storage discharge information available provided by Abitibi-Price. The resulting levels and discharges are given in Table 4-7. The value of this table is that it provides a realistic estimate of regulated flood flows moving downstream from Exploits Dam.

TABLE 4-6

EXPLOITS DAM OPERATIONS

SPRING CASE: LAKE LEVEL (feet)	OPTION 1* DISCHARGE (cfs)	OPTION 2** DISCHARGE (cfs)	COMMENTS ON GATE SETTINGS
490	0	0	- gates closed during infilling
492	0	0	
494	0	0	
496	2,900	2,900	- A or C gate
498	5,700	5,700	- A or C gate
500	7,900	7,900	- A or C gate + log sluice
502	9,200	37,400	- A or C gate _ log sluice [4]/
503	18,300	39,900	- A + C + log + spillway [4]/
504	43,000	43,000	- above + 5 sub gates [4]/
505	46,500	46,500	- all gates open
506	50,140	50,140	- all gates open
507	54,200	54,200	- all gates open
508	58,290	58,290	- all gates open

* conservative operation assuming local inflow between Red Indian Lake and Grand Falls is sufficient to meet Grand Falls power needs

** option with initial storage coupled with early, high flow releases

[4]/ all gates open at this level with Option 2

TABLE 4-7

DESIGN WATER LEVELS AND DISCHARGES

RED INDIAN LAKE AT EXPLOITS DAM

SPRING FLOOD	RETURN PERIOD, LAKE LEVEL AND DISCHARGE	
OPTION 1	1:100 YEAR	1:20 YEAR
Inflow (cfs)	81,577	63,920
Inflow (m^3/s)	2,310	1,810
Discharge (cfs)	20,026	9,042
Discharge (m^3/s)	567	256
Level (feet)	502-503	502-503
OPTION 2		
Inflow (cfs)	81,577	63,920
Inflow (m^3/s)	2,310	1,810
Discharge (cfs)	31,685	19,348
Discharge (m^3/s)	897	548
Level (feet)	502.30	502-503

4.3.2.2 Grand Falls Dam

Flood Routing - Exploits Dam to Grand Falls

Recession limbs of hydrographs at Grand Falls were examined during periods when operations at Exploits Dam changed from complete gate closure to resumption of releases (e.g. April 1976). The object of this analysis was to determine the lag time for hydrologic routing of peak flows from Exploits Dam to Grand Falls, and our review suggests a range from 24 hours to about 30 hours.

Notes on the same topic from Abitibi-Price records (1954 and Cater, p.c) suggest 18 to 24 hours. As the overall range (18 - 30 hours) cannot be precisely defined from the available field data, 24 hours was taken as representative of the lag time.

Peak discharges from Exploits Dam are also attenuated in transit from Red Indian Lake to Grand Falls. However, observed data (augmented by hydrograph routing, using the HYMO model VSC routing procedure) show the attenuation is not large, and only in the range of 8 percent for typical high flows - and less for significant flood peaks. This attenuation is practically the same as the increase from peak daily flows to peak instantaneous values.

Natural Flows - Grand Falls

Historical discharges from Red Indian Lake were routed to Grand Falls and subtracted from Grand Falls discharges to compute an estimate of natural inflow hydrographs and a record of peak flows for the large unregulated area between Exploits and Grand Falls Dams (3636 km^2). The configuration of the dimensionless hydrograph for the intervening/local area is given on the left side of Table 4-8.

Last, the record of computed peak flows from the intervening area (3636 km^2) were then evaluated to determine the local 1:20 year and 1:100 year flood flow to allow us to transform the dimensionless hydrograph into flood flow hydrographs.

TABLE 4-8

ABITIBI DAMS - NEWFOUNDLAND

LOCAL DIMENSIONLESS SPRING INFLOW HYDROGRAPHS

FOR AREAS BETWEEN EXPLOITS DAM AND GRAND FALLS TO BISHOP'S FALLS

EXPLOITS DAM TO GRAND FALLS (3636 km²)		GRAND FALLS TO BISHOP'S FALLS (1746 km²)	
DAY	RELATIVE INFLOW**	DAY	RELATIVE INFLOW**
1	0.02	1	0.10
2	0.02	2	0.11
3	0.03	3	0.12
4	0.07	4	0.13
5	0.60	5	0.30
6	1.00	6	1.00
7	0.57	7	0.60
8	0.36	8	0.32
9	0.27	9	0.30
10	0.21	10	0.20

** date and relative inflow co-ordinate established in relation to peak inflow in the upper watershed at Red Indian Lake/Exploits Dam

Noteworthy in this analysis is that:

- flood flow discharges at Grand Falls were taken to be those recorded by Abitibi personnel. Previous studies (e.g. ShawMont, 1980) suggest that average or low flows may be under-estimated, but that flood flow estimates are reliable (Fenco Newfoundland, 1985). In all, any small under-estimation of flow would only affect a modification in the natural flood estimate by about 1%.

- the majority of peak local inflows at Grand Falls occur on the day following peak inflows into Red Indian Lake. However, with regulation and storage at Exploits Dam and downstream routing delays, spring flood peaks from Exploits Dam arrive at Grand Falls well after the peak of local inflows. Evidence of this is shown, for example, in 1977. Inflow to Red Indian Lake peaked at about 62,500 cfs on Dec. 27 and outflow was stored and regulated to result in nearly zero outflow. Grand Falls flows - almost all local - peaked at about 30,000 the following day. The peak discharge from Exploits Dam occurred several days later after storage needs in Red Indian Lake were satisfied.

Discharge for each of the 1:20 year and 1:100 year spring floods from Exploits Dam were routed downstream and summed with corresponding local drainage hydrographs to give total inflow floods at Grand Falls. As noted earlier, the peak flows from the local drainages occur after the peak inflow at Red Indian Lake, but do not combine with peak discharges from Exploits Dam because of routing effects within Red Indian Lake and then between the lake and Grand Falls. This is shown in Table 4-9.

Table 4-9 gives the design inflows considering discharge Option 1 (Table 4-7) from Exploits Dam. Table 4-10 gives the same results, but for a different operation at Exploits Dam (Option 2 - Table 4-7).

The left column in Table 4-9 gives the day and chronology of spring events in the Exploits Basin. The second column gives the peak daily inflows in the local area between the Exploits

TABLE 4-9

GRAND FALLS PEAK DAILY INFLOWS

	INFLOW FOR VARIOUS RETURN PERIODS**					
	1:100 YEAR			1:20 YEAR		
DAY	LOCAL INFLOW (m^3/s)	INFLOW FROM EXPLOITS (m^3/s)	TOTAL INFLOW ($m^3/2$)	LOCAL INFLOW (m^3/s)	INFLOW FROM EXPLOITS (m^3/s)	TOTAL INFLOW (m^3/s)
1	34	0	34	26	0	26
2	34	0	34	26	0	26
3	51	0	51	39	0	39
4	119	0	119	90	0	90
5[1]	1016	2	1018	773	0	773
6[2]	1693	104	1797	1289	24	1313
7	965	224	1189	734	143	877
8	609	307	916	464	203	667
9[3]	457	453	910	348	228	576
10	356	-	-	271	241	512
Max. Water Levels: (Abitibi Datum)			293.6 ft			292.2 ft

1/ day of peak inflow to Red Indian Lake

2/ day of peak local inflow to Grand Falls, and overall peak inflow

3/ day of peak outflow from Exploits Dam reaching Grand Falls

\- not computed

** resulting from Exploits Dam operation Option 1 (Table 4-6)

TABLE 4-10

GRAND FALLS PEAK DAILY INFLOWS

	INFLOW FOR VARIOUS RETURN PERIODS**					
	1:100 YEAR			1:20 YEAR		
DAY	LOCAL INFLOW (m^3/s)	INFLOW FROM EXPLOITS (m^3/s)	TOTAL INFLOW ($m^3/2$)	LOCAL INFLOW (m^3/s)	INFLOW FROM EXPLOITS (m^3/s)	TOTAL INFLOW (m^3/s)
1	34	0	34	26	0	26
2	34	0	34	26	0	26
3	51	0	51	39	0	39
4	119	0	119	90	0	90
5[1]	1016	5	1021	773	0	773
6[2]	1693	119	1812	1289	49	1339
7	965	309	1274	734	153	887
8	609	-	-	464	203	667
9[3]	457	-	-	348	322	670
10	356	-	-	271	456	727
Max. Water Levels (Abitibi Datum)			293.7 ft			292.3 ft

1/ day of peak inflow to Red Indian Lake

2/ day of peak local inflow to Grand Falls, and overall peak inflow

3/ day of peak outflow from Exploits Dam reaching Grand Falls

\- not computed

** resulting from Exploits Dam operation Option 2 (Table 4-6)

and Grand Falls Dams. The third column is the routed inflow to Grand Falls from Exploits Dam and the fourth is the total inflow for the 1:100 year flood. The remaining columns give the same information for the 1:20 year event.

Last, the line above the footnotes in Table 4-9 gives the water elevation associated with each flood flow. To give an historical perspective, the flood of January 1983 resulted in a water level of about 294 feet, in the 1:200 to 1:500 year flood level range.

Before continuing this theoretical hydrograph analysis to Bishop's Falls, it is appropriate to note that the peak daily flows with Option 2 are similar to those determined for Grand Falls in previous studies for Badger and Rushy Pond (Fenco Newfoundland, 1985). Therein, the 1:20 and 1:100 year peak daily flows at Grand Falls were determined to be 1390 m^3/s and 1870 m^3/s, respectively (1446 m^3/s and 1945 m^3/s instantaneous peaks) as compared to peak daily flows of 1,339 and 1,812 m^3/s computed herein (Table 4-10) in this confirmatory approach.

4.3.2.3 Bishop's Falls

Flood Routing - Grand Falls to Bishop's Falls

Routing effects through Grand Falls dam are negligible because there is little storage in the head pond. Thus the peak inflows provided in Table 4-9 and Table 4-10 translate directly to peak daily outflows at Grand Falls. Local drainage inflows between Grand Falls and Bishop's Falls must be added to these river flows to give the total inflow to Bishop's Falls.

Table 4-12 summarizes inflow and water level data at Bishop's Falls in the same format as Table 4-9 and considers a 3-hour lag (shown in streamflow records) in the hydrologic routing between Grand Falls and Bishop's Falls. As at Grand Falls, this value was established by review of hydrographs monitored at Stony Brook (hourly data) and hourly data of reservoir levels at Bishop's Falls. (Abitibi-Price Inc.)

Unfortunately, there is insufficient information to attenuate peak flows in transit from Grand Falls

TABLE 4-11

BISHOP'S FALLS
PEAK FLOOD FLOWS FOR INTERVENING DRAINAGE AREA
GRAND FALLS TO BISHOP'S FALLS

YEAR	FLOW ESTIMATE (m^3/s)	YEAR	FLOW ESTIMATE (m^3/s)
1933	696.4	1958	179.9
1934	562.2	1959	187.3
1935	342.5	1960	152.4
1936	931.3	1961	219.8
1937	451.9	1962	436.1
1938	241.1	1963	225.6
1939	433.9	1964	385.3
1940	840.7	1965	491.6
1941	497.4	1966	179.3
1942	457.5	1967	368.5
1943	318.6	1968	604.5
1944	575.6	1969	566.5
1945	291.7	1970	694.8
1946	387.6	1971	933.3
1947	532.1	1972	271.6
1948	510.4	1973	341.9
1949	437.1	1974	534.0
1950	516.2	1975	633.7
1951	467.1	1976	285.7
1952	580.4	1977	735.8
1953	361.1	1978	338.4
1954	688.2	1979	738.2
1955	197.0	1980	350.3
1956	538.8	1981	172.3
1957	139.7	1982	285.3
		1983	1415.8

TABLE 4-12

BISHOP'S FALLS DESIGN INFLOWS*

	INFLOW FOR VARIOUS RETURN PERIODS**					
	1:100 Year			1:20 Year		
Day	Local Inflow (m^3/s)	Inflow From Grand Falls* (m^3/s)	Total Inflow (m^3/s)	Local Inflow (m^3/s)	Inflow From Grand Falls* (m^3/s)	Total Inflow (m^3/s)
1	129	34	163	93	26	119
1	142	34	176	103	26	129
3	155	51	206	112	39	151
4	168	119	287	121	89	210
5[1]	387	1018	1405	280	688	968
6[2]	1291	1689	2980	932	1239	2171
7	775	1189	1964	559	933	1492
8	413	916	1329	298	696	994
9	387	900	1287	280	589	869
10	258	-	-	186	-	-

* considering a 3-hour lag in hydrologic routing from Grand to Bishop's Falls

1/ day of peak inflow into Red Indian Lake

2/ day of peak local inflow to Bishop's Falls, and overall peak inflow to Bishop's Falls

\- not computed in detail as less than Total Inflow

** resulting from Exploits Dam operation Option 1 (Table 4-6)

to Bishop's Falls. Some attenuation is likely, and hence our estimates of routed daily peaks will be conservatively high, but closely representative of instantaneous peaks.

Natural Inflows - Bishop's Falls

Historical discharges from Grand Falls were transposed to Bishop's Falls and subtracted from Bishop's Falls discharges to give a series of natural inflow hydrographs for the unregulated area between the two dams (1746 km^2). These local inflow hydrographs were then made dimensionless (see previous Table 4-8).

The peak flows from this intervening drainage area are summarized in Table 4-11 and were analyzed to determine flood flow frequency. The results are provided in Appendix TA-2(d) and summarized for the 1:100 year and 1:20 year cases in Table 4-12 and Table 4-13.

It is again noteworthy that the majority of peak local inflows and Bishop's Falls occur on the day following peak inflows into Red Indian Lake. Hence, with regulation at Exploits Dam and downstream routing, the spring flood peaks from upstream arrive at Bishop's Falls well after the peak of local inflows.

All of the flood flow estimates in Table 4-12 are for "spring" flood flow cases which yield the largest inflows to Bishop's Falls. More specifically, they result from inflows which would result from discharge from Red Indian Lake/Exploits Dam through operations Option 1 (Table 4-6).

Table 4-13 gives similar results, but is based on a different operation at Exploits Dam (Option 2 - Table 4-6). That option allows for slightly greater releases during flood inflows. A comparison between Tables 4-12 and 4-13 is given in Table 4-14 which shows that flows at Bishop's Falls are relatively insensitive to typical changes in the typical operation of Exploits Dam.

The tabulated results in Table 4-14 are all based on maximum daily flows which can be calculated with confidence from the daily records, and hourly routing of these flows. Hence,

TABLE 4-13

BISHOP'S FALLS DESIGN INFLOWS*

	INFLOW FOR VARIOUS RETURN PERIODS**					
	1:100 Year			1:20 Year		
Day	Local Inflow (m^3/s)	Inflow From Grand Falls* (m^3/s)	Total Inflow (m^3/s)	Local Inflow (m^3/s)	Inflow From Grand Falls* (m^3/s)	Total Inflow (m^3/s)
1	129	34	163	93	26	119
2	142	34	176	103	26	129
3	155	51	206	112	39	151
4	168	111	279	121	89	210
5[1]	387	906	1293	280	665	945
6[2]	1291	1709	3000	932	1260	2192
7	775	1324	2099	559	948	1507
8	413	1300	1713	298	695	993
9	387	-	-	280	662	942
10	258	-	-	86	-	-

* considering a 3-hour lag in hydrologic routing from Grand to Bishop's Falls

1/ day of peak inflow into Red Indian Lake

2/ day of peak local inflow to Bishop's Falls, and overall peak inflow to Bishop's Falls

\- not computed in detail as less than Total Inflow

** resulting from Exploits Dam operation Option 2 (Table 4-6)

TABLE 4-14

ABITIBI DAMS - NEWFOUNDLAND
BISHOP'S FALLS SUMMARY

OPTION	SUMMARY FOR VARIOUS RETURN PERIODS 1:100 YEAR MAX. INST. (m^3/s)	1:20 YEAR MAX. INST. (m^3/s)
1 (Table 4-12)	2980	2171
3 (Table 4-13)	3000	2192

these hourly values are essentially equivalent to instantaneous peak flows. Of immediate interest is the similarity between these values and those derived previously from the single station frequency analysis (Section 4.3.1.2).

FREQUENCY ANALYSIS		HYDROGRAPH ANALYSIS	
1:20 year	2257 m^3/s	1:20 year	2171-2192 m^3/s
1:100 year	2883 m^3/s	1:100 year	2980-3000 m^3/s

The hydrograph approach, although somewhat more theoretical, gives much the same results as the single station frequency analysis, and confirms that the frequency analysis results are reasonable.

Appendix TA-3(b)

Regression Analysis Pre- and Post-Diversion Inflows to Red Indian Lake

Post (depend)	Pre (indepen)	reg dep
	0	-1340.76
27917	32917	26552.92
29719	33819	27317.27
26480	36071	29225.60
31468	38412	31209.35
33036	40422	32912.62
36887	42201	34420.13
31970	42400	34588.76
36254	44057	35992.90
41610	46131	37750.39
43388	50119	41129.80
37989	53583	44065.18
46780	55739	45892.16
55222	61942	51148.55
47504	63650	52595.90
60893	73212	60698.68
62455	84099	69924.27
94861	106620	89008.44

Y = (x) m + b

26552.92 = 32917 x .847394 - 1340.76

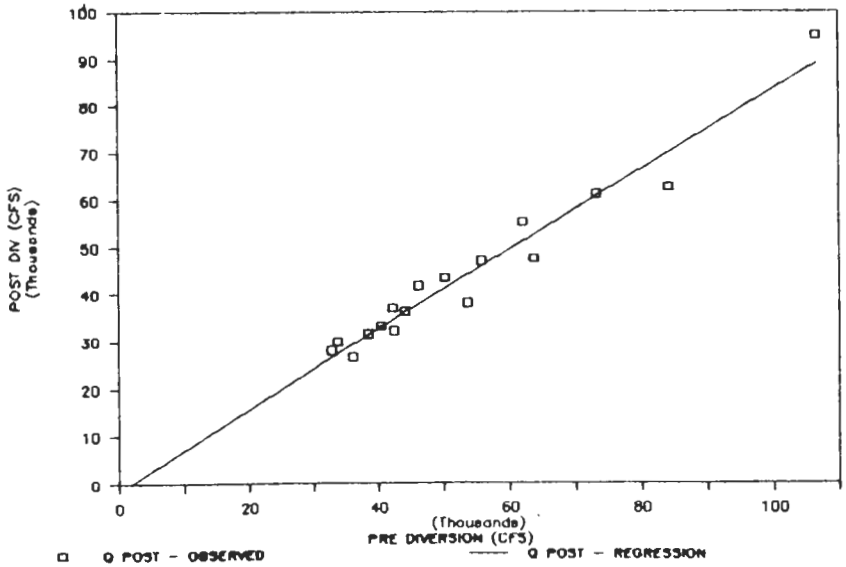
Regression Output:

Constant	-1340.76
Std Err of Y Est	3817.205
R Squared	0.953519
No. of Observations	17
Degrees of Freedom	15
X Coefficient(s)	0.847394
Std Err of Coef.	0.048306

Regression Output:

Constant	0
Std Err of Y Est	3725.498
R Squared	0.952774
No. of Observations	17
Degrees of Freedom	16
X Coefficient(s)	0.825106
Std Err of Coef.	0.015963

DIVERSION - REGRESSION RESULTS



Post = Pre x .847394 - 1340.76 cfs

Appendix TA-3(c)

Frequency Analysis - Red Indian Lake (1948-87)
Spring Inflows

RED INDIAN POST DIV. (metric) 1948-1987

YEAR	DATA	ORDERED	RANK	PROB.	RET. PERIOD
48	1509.0	2686.0	1	.024	41.000
49	1212.0	1769.0	2	.049	20.500
50	901.0	1724.0	3	.073	13.667
51	1105.0	1564.0	4	.098	10.250
52	976.0	1509.0	5	.122	8.200
53	1207.0	1362.0	6	.146	6.833
54	1134.0	1345.0	7	.171	5.857
55	489.0	1325.0	8	.195	5.125
56	734.0	1257.0	9	.220	4.556
57	1062.0	1239.0	10	.244	4.100
58	761.0	1233.0	11	.268	3.727
59	624.0	1229.0	12	.293	3.417
60	721.0	1212.0	13	.317	3.154
61	1024.0	1207.0	14	.341	2.929
62	669.0	1193.0	15	.366	2.733
63	831.0	1178.0	16	.390	2.563
64	765.0	1134.0	17	.415	2.412
65	1257.0	1105.0	18	.439	2.278
66	505.0	1076.0	19	.463	2.158
67	842.0	1062.0	20	.488	2.050
68	1233.0	1045.0	21	.512	1.952
69	1239.0	1027.0	22	.537	1.864
70	1193.0	1024.0	23	.561	1.783
71	1362.0	976.0	24	.585	1.708
72	1229.0	935.0	25	.610	1.640
73	791.0	905.0	26	.634	1.577
74	750.0	901.0	27	.659	1.519
75	1045.0	891.0	28	.683	1.464
76	1345.0	842.0	29	.707	1.414
77	1769.0	831.0	30	.732	1.367
78	891.0	791.0	31	.756	1.323
79	1076.0	765.0	32	.780	1.281
80	1178.0	761.0	33	.805	1.242
81	905.0	750.0	34	.829	1.206
82	1724.0	734.0	35	.854	1.171
83	2686.0	721.0	36	.878	1.139
84	935.0	669.0	37	.902	1.108
85	1325.0	624.0	38	.927	1.079
86	1564.0	505.0	39	.951	1.051
87	1027.0	489.0	40	.976	1.025

RED INDIAN POST DIV. (metric) 1948-1987

SAMPLE STATISTICS

MEAN = 1090. S.D. = 399.0 C.S. = 1.6994 C.K. = 8.7055

SAMPLE STATISTICS (LOGS)

MEAN = 6.9363 S.D. = .3398 C.S. = .1501 C.K. = 4.0476

SAMPLE MIN = 489. SAMPLE MAX = 2686. N = 40

PARAMETERS FOR GUMBEL I A = .003405 U = 920.

PARAMETERS FOR LOGNORMAL M = 6.9363 S = .3398

PARAMETERS FOR THREE PARAMETER LOGNORMAL A = 74. M = 6.8563 S = .3679

STATISTICS OF LOG(X-A)

MEAN = 6.8563 S.D. = .3679 C.S. = .0485 C.K. = 3.9902

PARAMETERS FOR LOG PEARSON III BY MOMENTS A = .0255 B = .1775E+03 LOG(M) = 2.4098 M = .1113E+02

PARAMETERS FOR LOG PEARSON III BY MAXIMUM LIKELIHOOD A = .0180 B = .3470E+03 LOG(M) = .6882 M = .1990E+01

DISTRIBUTION STATISTICS MEAN = 6.9363 S.D. = .3354 C.S. = .1074

	GUMBEL I		LOGNORMAL		THREE PARAMETER LOGNORMAL		LOG PEARSON III MAX. LIKELIHOOD		LOG PEARSON III MOMENTS	
RETURN PERIOD	FLOOD ESTIMATE	ST. ERROR PERCENT	FLOOD ESTIMATE	ST.ERROR PERCENT	FLOOD ESTIMATE (m^3/s)	ST. ERROR PERCENT	FLOOD ESTIMATE	ST. ERROR PERCENT	FLOOD ESTIMATE	ST. ERROR PERCENT
1.005	430.0		429.0		443.0		449.0		450.0	
1.050	593.0		588.0		593.0		599.0		597.0	
1.250	780.0		773.0		771.0		775.0		771.0	
2.000	1030.0		1030.0		1020.0		1020.0		1020.0	
5.000	1360.0	6.15	1370.0	6.25	1370.0	6.40	1360.0	6.34	1370.0	6.53
10.000	1580.0	6.79	1590.0	7.25	1600.0	7.69	1590.0	7.57	1600.0	7.89
20.000	1790.0	7.33	1800.0	8.24	1810.0	9.35	1800.0	9.47	1830.0	9.84
50.000	2070.0	7.91	2070.0	9.47	2100.0	11.80	2090.0	12.50	2120.0	13.00
100.0	2270.0	8.27	2270.0	10.30	2310.0	13.70	2310.0	14.90	2350.0	15.70
200.0	2480.0	8.57	2470.0	11.20	2520.0	15.60	2530.0	17.70	2590.0	18.50
500.0	2740.0	8.92	2740.0	12.20	2810.0	18.10	2830.0	21.40	2910.0	22.40
1000.0	2950.0	9.14	2950.0	12.90	3040.0	20.00	3060.0	24.30	3170.0	25.50
2000.0	3150.0	9.33	3160.0	13.60	3270.0	21.80	3300.0	27.20	3440.0	28.60
5000.0	3420.0	9.56	3430.0	14.50	3570.0	24.10	3620.0	31.00	3780.0	32.60
10000.0	3620.0	9.71	3640.0	15.10	3810.0	25.80	3870.0	34.00	4070.0	35.80

RED INDIAN SUMMER INFLOWS (CMS) 1948-1987

YEAR	DATA	ORDERED	RANK	PROB.	RET. PERIOD
48	713.0	1379.0	1	.024	41.000
49	162.0	1325.0	2	.049	20.500
50	150.0	973.0	3	.073	13.667
51	376.0	713.0	4	.098	10.250
52	154.0	708.0	5	.122	8.200
53	259.0	703.0	6	.146	6.833
54	306.0	642.0	7	.171	5.857
55	488.0	642.0	8	.195	5.125
56	357.0	620.0	9	.220	4.556
57	493.0	599.0	10	.244	4.100
58	365.0	590.0	11	.269	3.727
59	264.0	581.0	12	.293	3.417
60	103.0	574.0	13	.317	3.154
61	590.0	526.0	14	.341	2.929
62	327.0	505.0	15	.366	2.733
63	642.0	493.0	16	.390	2.563
64	526.0	488.0	17	.415	2.412
65	642.0	487.0	18	.439	2.278
66	505.0	469.0	19	.463	2.158
67	469.0	376.0	20	.488	2.050
68	599.0	375.0	21	.512	1.952
69	311.0	369.0	22	.537	1.864
70	574.0	365.0	23	.561	1.783
71	353.0	361.0	24	.585	1.708
72	581.0	357.0	25	.610	1.640
73	487.0	353.0	26	.634	1.577
74	708.0	331.0	27	.659	1.519
75	182.0	327.0	28	.683	1.464
76	265.0	311.0	29	.707	1.414
77	376.0	306.0	30	.732	1.367
78	369.0	265.0	31	.756	1.323
79	256.0	264.0	32	.780	1.281
80	703.0	259.0	33	.805	1.242
81	973.0	256.0	34	.829	1.206
82	239.0	239.0	35	.854	1.171
83	1379.0	182.0	36	.878	1.139
84	620.0	162.0	37	.902	1.108
85	1325.0	154.0	38	.927	1.079
86	361.0	150.0	39	.951	1.051
87	331.0	103.0	40	.976	1.025

RED INDIAN SUMMER INFLOWS (CMS) 1948-1987

SAMPLE STATISTICS

MEAN = 472. S.D. = 278.9 C.S. = 1.6263 C.K. = 6.6779

SAMPLE STATISTICS (LOGS)

MEAN = 6.0031 S.D. = .5695 C.S. = -.1502 C.K. = 3.4218

SAMPLE MIN = 103. SAMPLE MAX = 1379. N = 40

PARAMETERS FOR GUMBEL I A = .005238 U = 355.

PARAMETERS FOR LOGNORMAL M = 6.0031 S = .5695

PARAMETERS FOR THREE PARAMETER LOGNORMAL A = -29. M = 6.0839 S = .5246

STATISTICS OF LOG(X-A)

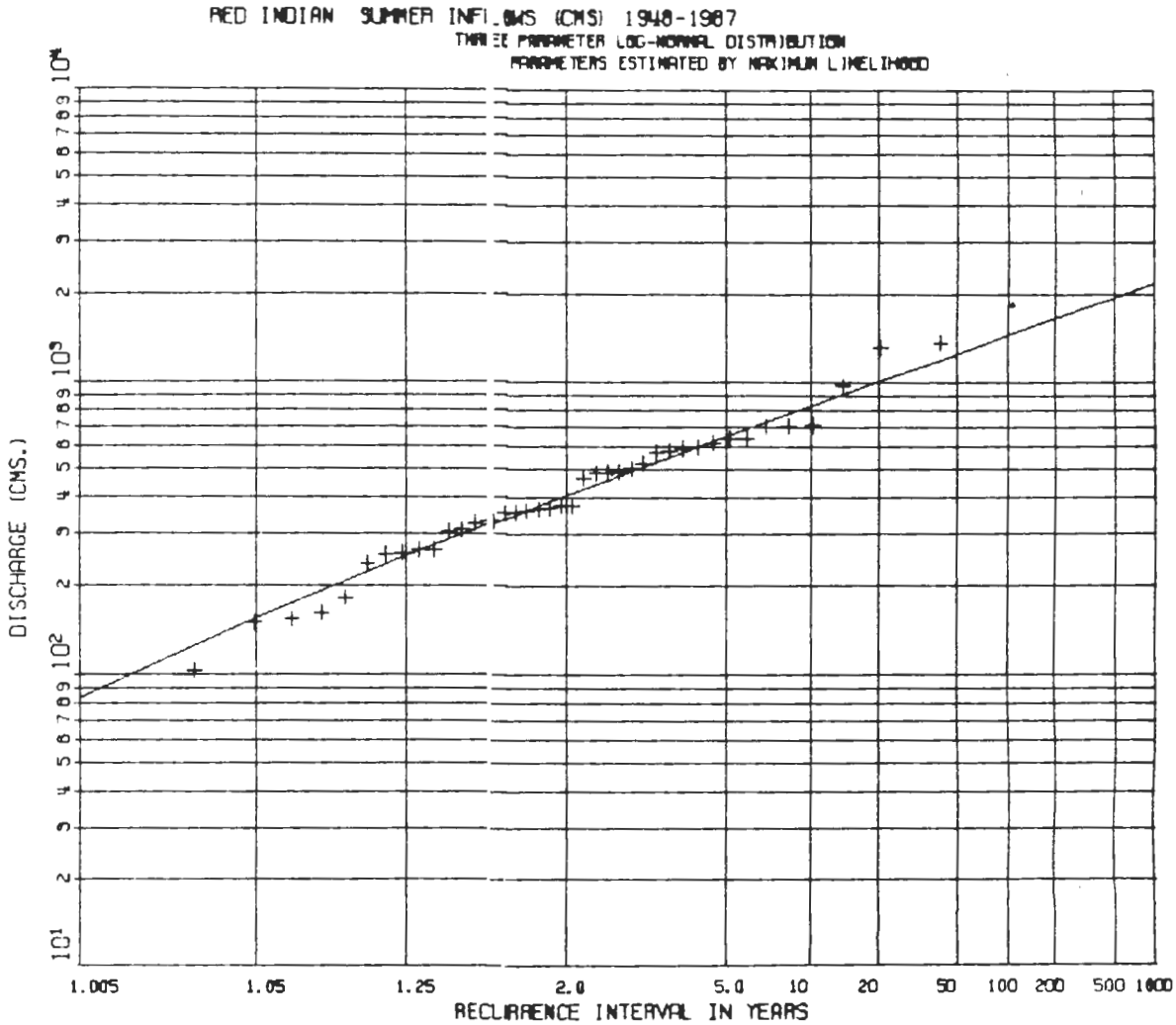
MEAN = 6.0839 S.D. = .5246 C.S. = -.0208 C.K. = 3.3662

PARAMETERS FOR LOG PEARSON III BY MOMENTS A = -.0428 B = .1774E+03 LOG(M) =13.5874 M = .7960E+06

PARAMETERS FOR LOG PEARSON III BY MAXIMUM LIKELIHOOD A = -.0401 B = .1963E+03 LOG(M) =13.8813 M = .1068E+07

DISTRIBUTION STATISTICS MEAN = 6.0031 S.D. = .5623 C.S. = -.1428

	GUMBEL I		LOGNORMAL		THREE PARAMETER LOGNORMAL		LOG PEARSON III MAX. LIKELIHOOD		LOG PEARSON III MOMENTS	
RETURN PERIOD	FLOOD ESTIMATE	ST. ERROR PERCENT	FLOOD ESTIMATE	ST.ERROR PERCENT	FLOOD ESTIMATE (m³/s)	ST. ERROR PERCENT	FLOOD ESTIMATE	ST. ERROR PERCENT	FLOOD ESTIMATE	ST. ERROR PERCENT
1.005	36.8		93.3		84.2		88.1		86.1	
1.050	143.0		159.0		156.0		157.0		155.0	
1.250	264.0		251.0		253.0		253.0		252.0	
2.000	425.0		405.0		409.0		410.0		410.0	
5.000	642.0	8.48	654.0	10.50	653.0	10.10	652.0	10.00	656.0	10.10
10.000	785.0	8.89	840.0	12.20	830.0	11.90	825.0	11.50	832.0	11.60
20.000	922.0	9.26	1030.0	13.80	1010.0	14.20	997.0	13.80	1010.0	14.00
50.000	1100.0	9.65	1300.0	15.90	1260.0	17.40	1230.0	17.80	1240.0	18.10
100.0	1230.0	9.89	1520.0	17.30	1460.0	19.80	1410.0	21.30	1430.0	21.70
200.0	1370.0	10.10	1750.0	18.70	1670.0	22.20	1600.0	25.10	1620.0	25.50
500.0	1540.0	10.30	2090.0	20.40	1960.0	25.20	1860.0	30.20	1880.0	30.80
1000.0	1670.0	10.50	2360.0	21.70	2200.0	27.50	2060.0	34.30	2090.0	35.00
2000.0	1810.0	10.60	2650.0	22.80	2450.0	29.70	2270.0	38.40	2300.0	39.20
5000.0	1980.0	10.70	3040.0	24.30	2780.0	32.40	2550.0	43.70	2590.0	44.60
10000.0	2110.0	10.80	3360.0	25.30	3060.0	34.40	2770.0	47.80	2810.0	48.80


RED INDIAN SUMMER INFLOWS (CMS) 1948-1987
THREE PARAMETER LOG-NORMAL DISTRIBUTION
PARAMETERS ESTIMATED BY MAXIMUM LIKELIHOOD
DISCHARGE (CMS.)
RECURRENCE INTERVAL IN YEARS
1.005
1.05
1.25
2.0
5.0
10
20
50
100
200
500
1000

Appendix TA-3(d)

Flood Flow Frequency Analysis - Stony Brook

WSC STATION NO=510
WSC STATION NAME=STONY BROOK 1969-1986

MONTH	YEAR	DATA	ORDERED	RANK	PROB.	RET. PERIOD
(1)	(2)	(3) (CMS)	(4) (CMS)	(5)	(6) (%)	(7) (YEARS)
12	1969	48500.000	80000.000*	1	4.23	23.667
5	1970	32701.000	53325.000	2	11.27	8.875
4	1971	41318.000	48500.000	3	18.31	5.462
6	1972	25709.000	44143.000	4	25.35	3.944
5	1973	27700.000	41318.000	5	32.39	3.087
5	1974	21400.000	39199.000	6	39.44	2.536
5	1975	27298.000	38846.000	7	46.48	2.152
5	1976	33090.000	38140.000	8	53.52	1.868
5	1981	44143.000	33090.000	9	60.56	1.651
5	1982	39199.000	32701.000	10	67.61	1.479
1	1983	80000.000	27700.000	11	74.65	1.340
5	1984	38140.000	27298.000	12	81.69	1.224
6	1985	53325.000	25709.000	13	88.73	1.127
4	1986	38846.000	21400.000	14	95.77	1.044

FREQUENCY ANALYSIS - THREE-PARAMETER LOGNORMAL DISTRIBUTION
510 STONY BROOK 1969-1986

SAMPLE STATISTICS

	MEAN	S.D.	C.V.	C.S.	C.K.
X SERIES	39383.500	14761.348	0.375	1.627	7.603
LN X SERIES	10.525	0.338	0.032	0.551	4.627
LN(X-A) SERIES	10.011	0.551	0.055	-0.052	4.180

X(MIN)= 21400.000 TOTAL SAMPLE SIZE= 14
X(MAX)= 80000.000 NO. OF LOW OUTLIERS= 0
LOWER OUTLIER LIMIT OF X=17623.340 NO. OF ZERO FLOWS= 0

SOLUTION OBTAINED VIA MAXIMUM LIKELIHOOD

3LN PARAMETERS: A= 13784.457 M=10.011 S= 0.551

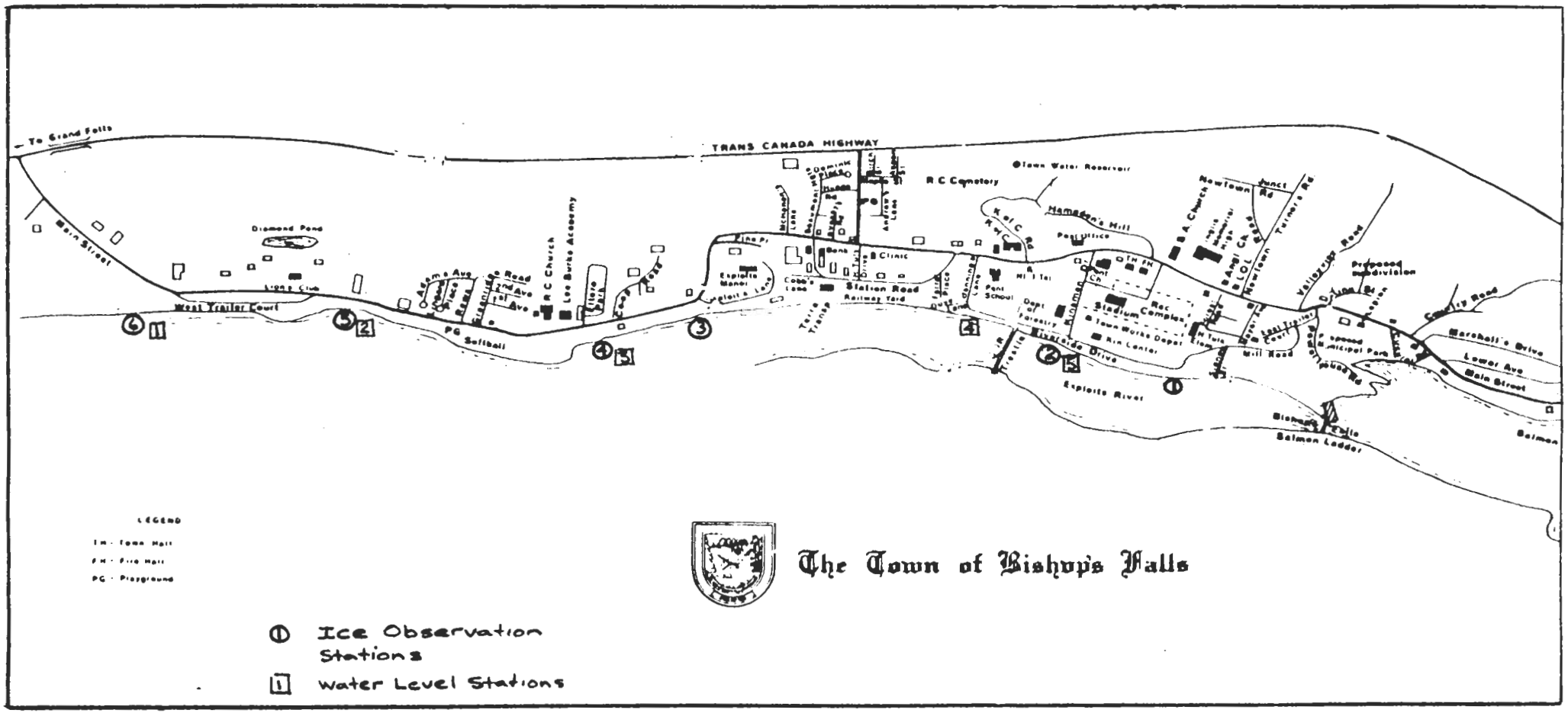
FLOOD FREQUENCY REGIME

RETURN PERIOD	EXCEEDANCE PROBABILITY	FLOOD (cfs)	(cms)
1.003	0.997	18700.00	
1.050	0.952	22700.00	
1.250	0.800	27800.00	
2.000	0.500	36000.00	
5.000	0.200	49200.00	
10.000	0.100	58900.00	
20.000	0.050	68900.00	1951 m³/s
50.000	0.020	82900.00	
100.000	0.010	94100.00	2665 m³/s
200.000	0.005	106000.00	
500.000	0.002	123000.00	

TECHNICAL APPENDIX TA-4

Break Up Ice Observations at Bishop's Falls

- March 29, 1988
- Spring 1988



The Town of Bishop's Falls

① Ice Observation Stations

[1] Water Level Stations

TABLE A-1

BISHOP'S FALLS

SUMMARY OF ICE OBSERVATIONS

March 29, 1988

Station Number	Ice Elevation	Ice Thickness and Comments
1	0.561 m below TBM 3 at 2 m from shore (beyond the second shore-parallel crack)	55 cm thick (21.7 inches) with the top 30 cm (12 inches) being very soft. Open water about 100-200 m downstream and central ponding on Mill Pond surface. About four lines of shore parallel cracks and a transverse crack in evidence
2	1.562 m below TBM 4	unsafe ice - no measurement. Open water at shore and RR piers with extensive surface water across the ice on the Mill Pond. About four shore-parallel cracks, with transverse cracks every 100 m
3	2.393 m below TBM 5 at 3 m from shore	73 cm thick (28.7 inches) in inlet with top 30 cm (12 inches) being very soft. No snow cover and shore parallel cracking interspersed with longitudinal cracks
4	0.896 below TBM 6	unsafe ice - no measurement. Three shore parallel shear cracks and transverse cracks each 30 m. Ice soft and surface water pools randomly distributed across the reservoir
5	2.627 m below TBM 2 near the shore	unsafe ice - no measurement. Surface uniform and soft with extensive water ponding on ice in centre of Mill Pond. three or four lines of shore parallel shear cracks (two major cracks)
6	0.843 below TBM at 1 m from shore	13-20 cm (5-8 inches). Surface fairly level, no snow cover, some puddles and nearshore holes. Considerable surface water on ice to 100 m from both banks. Shore parallel cracking in three lines

TABLE A-2

BISHOP'S FALLS
SUMMARY OF BREAK-UP OBSERVATIONS

SPRING 1988

Date	General Observations* and Comments
March 28	. Fenco ice survey. No ice in tail race. Continuous cover from about 100 m upstream of dam. No snow cover and puddles of melt water over entire cover
March 31	. little change in ice conditions
April 1	. puddling on surface more pronounced
April 2	. ice front still 100 m above dam, but deteriorating. Considerable deterioration along south bank at rail bridge
April 3	. ice front significantly deteriorated, with only patches present in pond upstream to log boom. Open lead along south shore upstream of rail bridge extending beyond ARMCO Road
	. ice shifting above rail bridge late in day, but still continuous cover upstream of town
April 4	. considerable decay. Almost complete clearing up to log boom above dam and ice free across fall river of ARMCO Rd. Continuous cover upstream to beyond study limit/community boundary
April 5	. rapid in-situ melt continues. Open water up from dam almost to rail bridge. Rapidly deteriorating cover upstream of rail/bridge to Canning Rd., then open water up to ARMCO. Complete cover, except for lead along south bank, above and below West End Trailor Park
April 6	. much the same as April 5, with weakening upstream cover still in place between piers of rail bridge. Open water upstream of town and rapidly deteriorating ice near West End Trailor Park (WETP)
April 7	. ice clear throughout study reach, except at southern pier of rail bridge and on north bank near West End Trailor Park
April 8	. entire study area free of ice

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* photographs and notes about break-up progression along the river at Bishop's Falls are contained in a separate album, available for viewing at Newfoundland Department of Environment and Lands, St. John's

TECHNICAL APPENDIX TA-5

Bishop's Falls Characteristics of the Spilling Structures

- Table of Values
- Spillway Rating Curve
  - pre 1983
  - post 1983

TABLE 9.4

BISHOP'S FALLS

CHARACTERISTICS OF THE SPILLING STRUCTURES

FSL: 13.04 m (131.5')

TWL: Normal : 1.4 m (93.5')

Max. observed: 9.5 m (120')

DECK ELEVATION: 15.29 m (139.16')

CLOSURE EMBANKMENT: El. 16.5 m

TYPE	No. of Openings	CREST		INVERT EL.	SIZE		NOTES
		Shape	El. m (ft)	m (ft)	Width m (ft)	Height m (ft)	
Free overflow spillway	-	Ogee	12.04 (128.5)	-	243.8 (800)	-	Before 1983 failure
			12.12 (128.8)		175.9 (577)		After rebuilt
Top of Flashboards	-		13.04 (131.8)	-			
Sluices gate openings	10	-	-	32.0 (105)	5.5 (18.0)		After rebuilt
Old Earth Dam			15.184				old dam
New earth dam			16.50				after rebuilt
Forebay Deck			15.093				old dam
			15.29				after rebuilt

Correction El. (m) = (El. ft/3.281) - 27.12

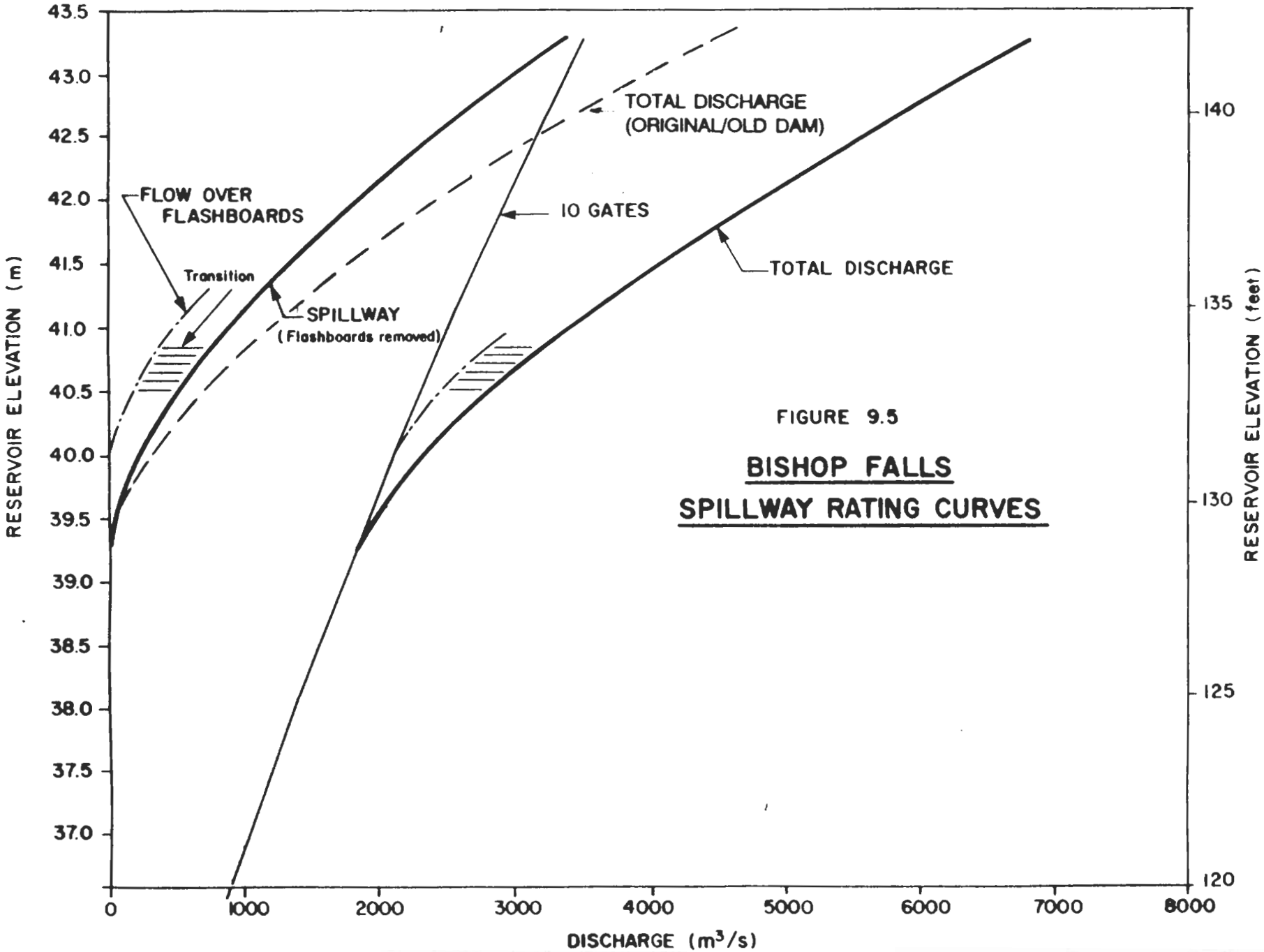


FIGURE 9.5

BISHOP FALLS

SPILLWAY RATING CURVES

TECHNICAL APPENDIX TA-6

(a) Physical Survey - Cross Sections

- Survey Description
- Roughness Values
- HEC-2 Section Plots

(b) RAND Hydrodynamic Model

- input data
- output velocity components

APPENDIX

PHYSICAL SURVEY - CROSS SECTIONS (1988)

The cross-section surveys were conducted in four stages:

1) River and overbank physical surveys

2) Water level surveys (May, July 1988)

3) Surveys to obtain estimates of 1983 flood levels along the channel (based on 1983 photographs and resident interviews)

4) Upstream channel survey (southwest of Bishop's Falls)

DATE	PROGRAM
July 11	- Locate bench marks - Take 1983 flood levels and cross section of Dam 1
July 12	- Continue bench mark tie-in - Take 1983 flood levels at R.R. bridge, Site D - Take 1988 ice levels, water levels
July 13	- Re-check bench mark datum (re-survey) - Measure sections 9, 8, 7
July 14	- Measure sections 4, 5, 2 - Continue 1988 ice level collection - Continue 1983 water level survey
July 15	- Cross sections 6, 3, 10 - Final 1983, 1988 levels
July 16	- Attempt to obtain section upstream of 10 (rapids prevent this)

Appendix TA-6

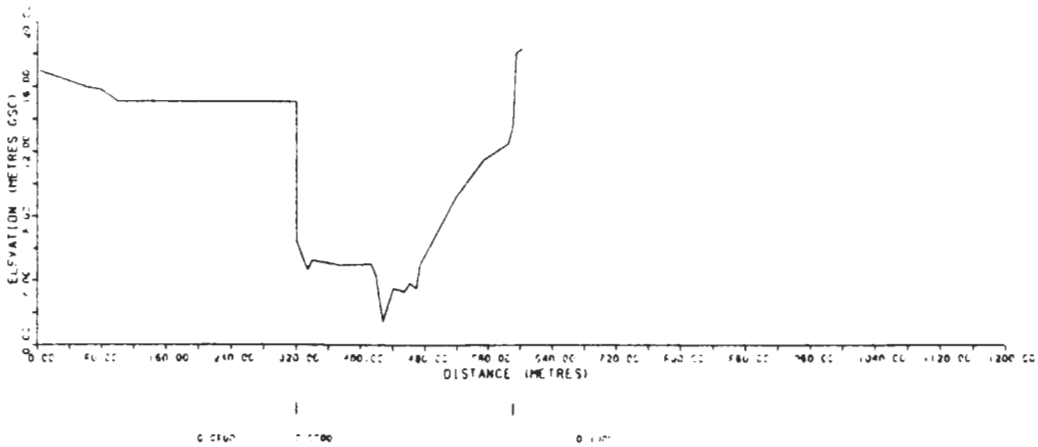
Roughess Values and Description

The following plots of the cross-section data show each section from an upstream position, looking downstream at the section. The left section of each plot is the northwest bank, the right section is the southeast bank.

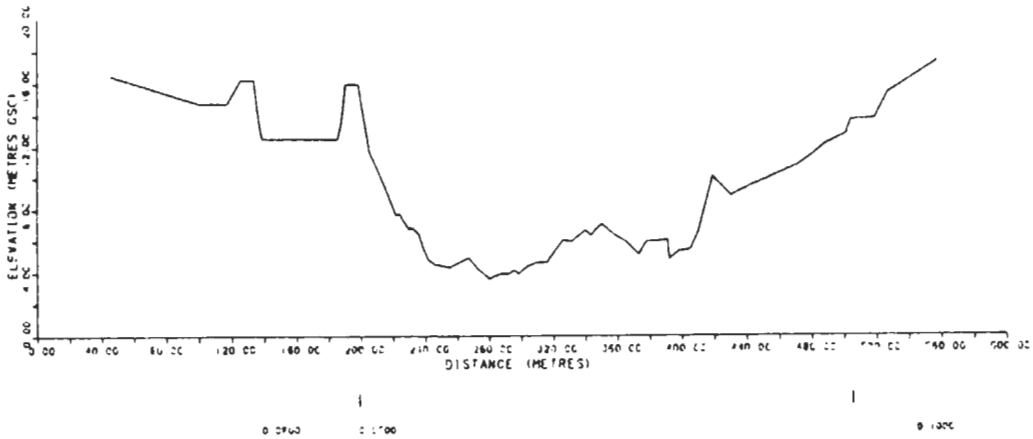
The following Manning's roughess values were employed:

Section	"n" left bank	"n" channel	"n" right bank
1.1	0.08	0.05	0.10
2.0	0.08	0.05	0.10
3.0	0.08	0.05	0.10
3.1	0.08	0.05	0.08
4.0	0.08	0.05	0.08
4.1	0.08	0.05	0.08
5.0	0.08	0.05	0.08
6.0	0.08	0.05	0.08
7.0	0.08	0.05	0.08
8.0	0.08	0.05	0.08
9.0	0.10	0.07	0.10
9.1	0.10	0.07	0.10
10.0	0.10	0.07	0.10
10.1	0.10	0.08	0.10

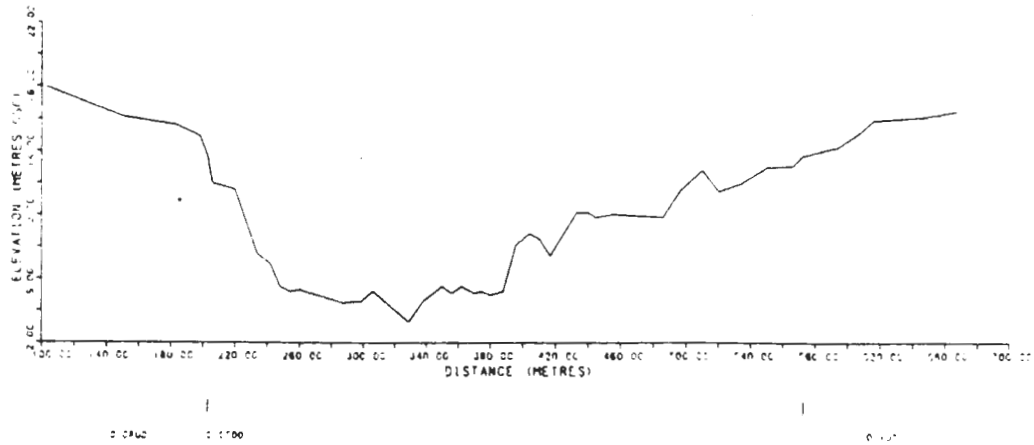
EXPLOITS RIVER HEC-2 MODEL
CROSS SECTION NUMBER 1.1



EXPLOITS RIVER HEC-2 MODEL
CROSS SECTION NUMBER 2.0



EXPLOITS RIVER HEC-2 MODEL
CROSS SECTION NUMBER 3.



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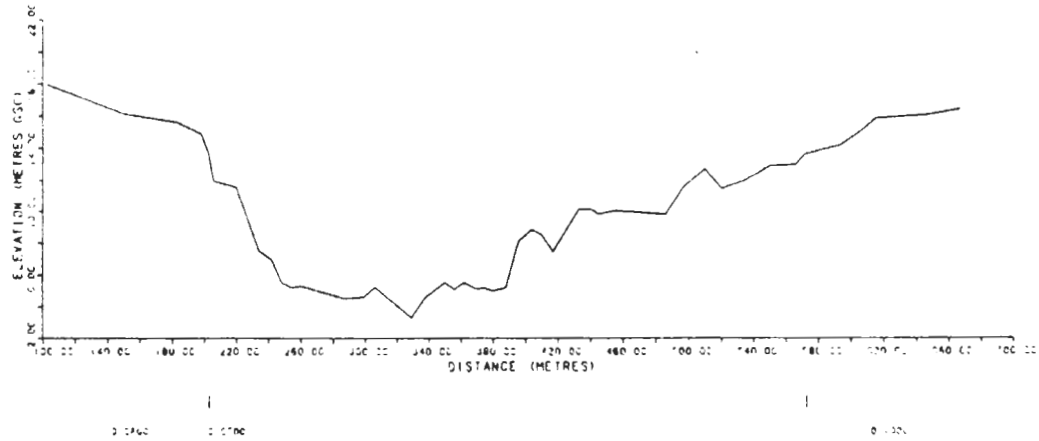
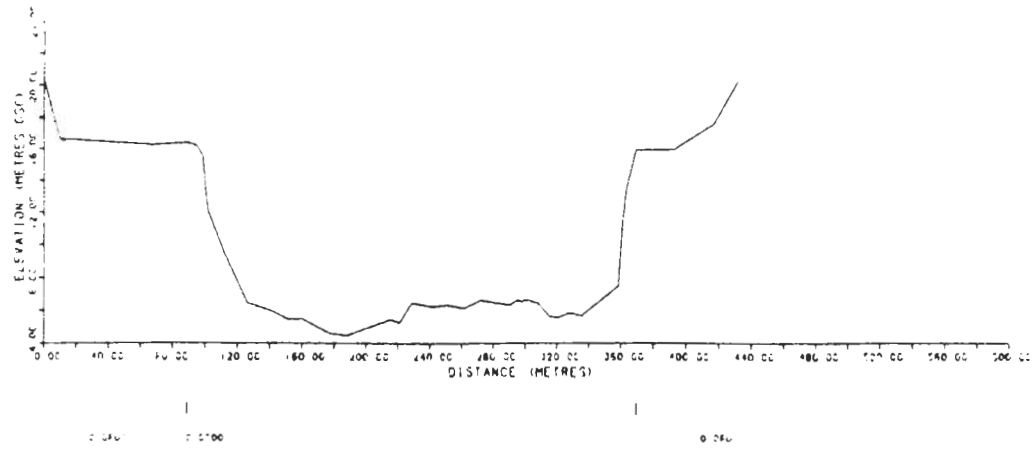
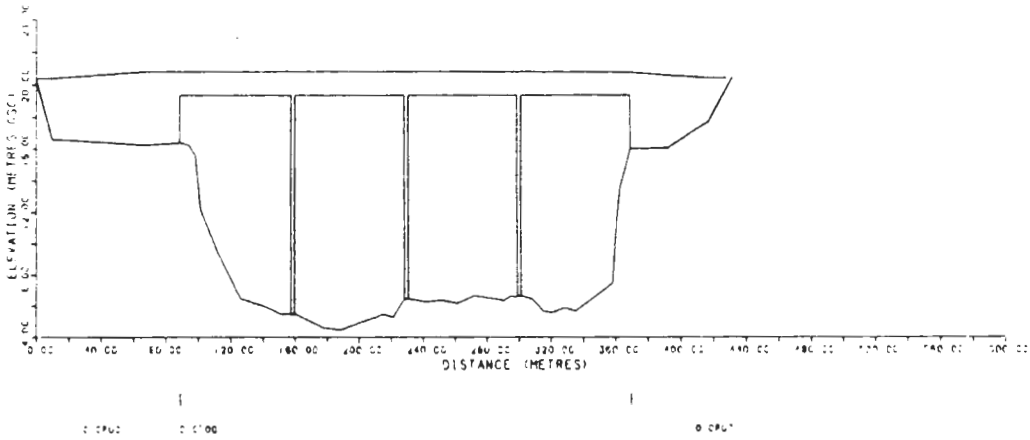


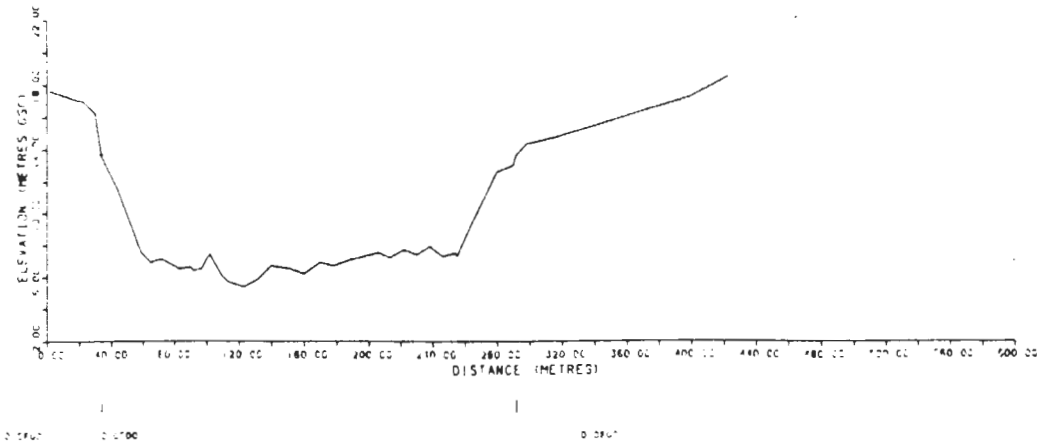
EXPLOITS RIVER HEC-2 MODEL
CROSS SECTION NUMBER 4.



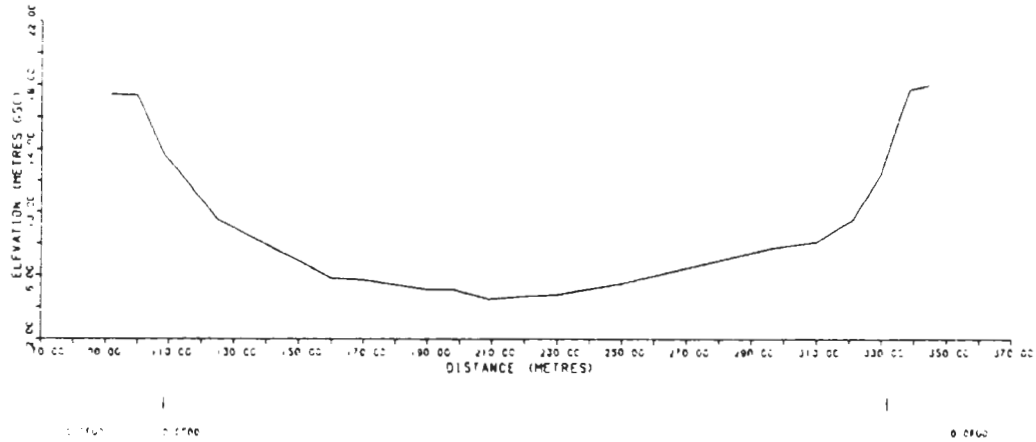
EXPLOITS RIVER HEC-2 MODEL
CROSS SECTION NUMBER 4.1



EXPLOITS RIVER HEC-2 MODEL
CROSS SECTION NUMBER 5.



EXPLOITS RIVER HEC-2 MODEL
CROSS SECTION NUMBER 6.



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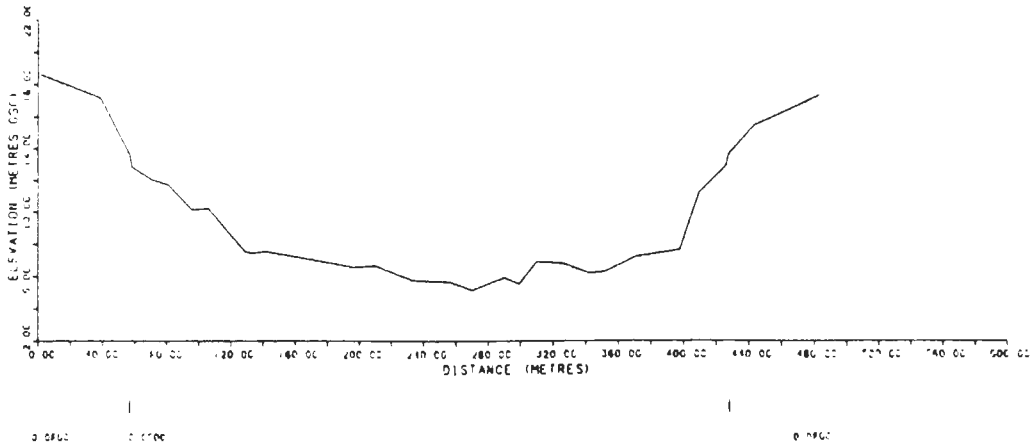

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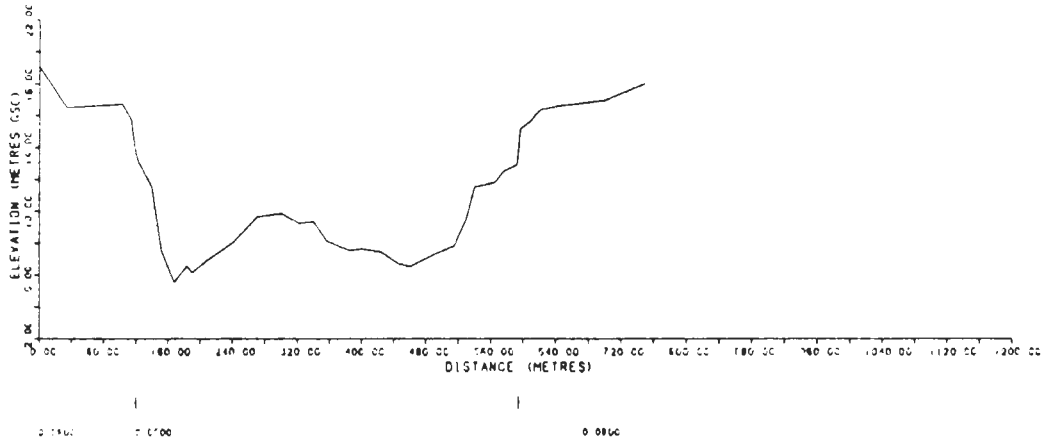

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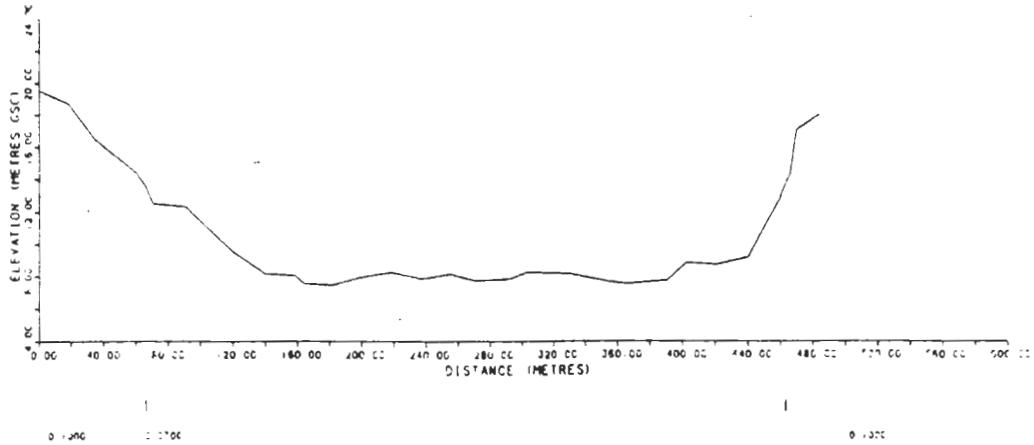
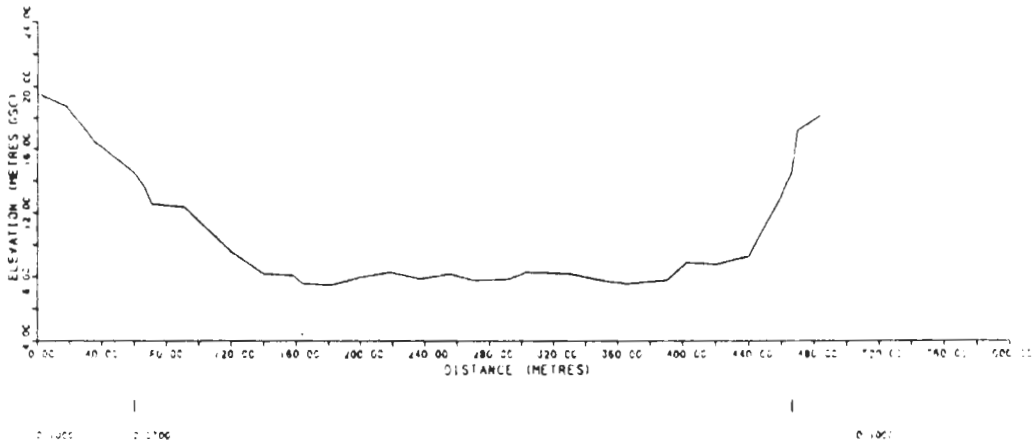
CROSS SECTION NUMBER 9.

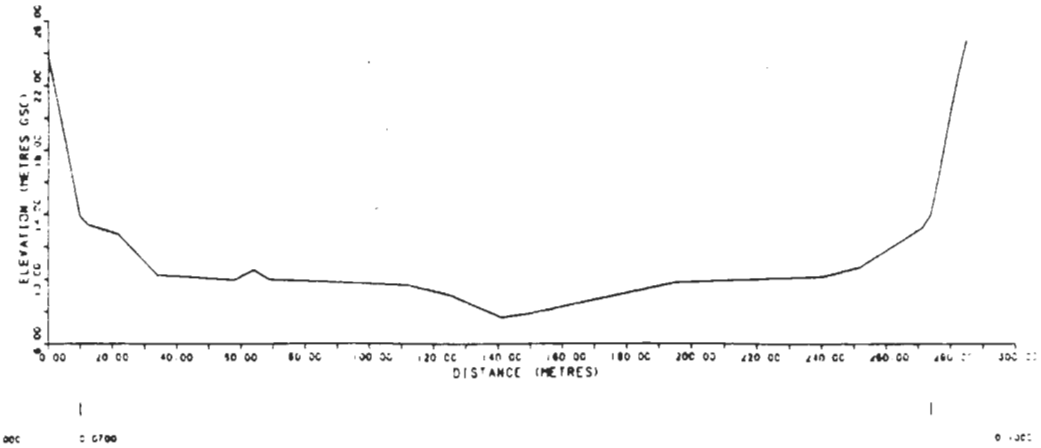


EXPLOITS RIVER HEC-2 MODEL

CROSS SECTION NUMBER 9.1



EXPLOITS RIVER HEC-2 MODEL
CROSS SECTION NUMBER 10.0



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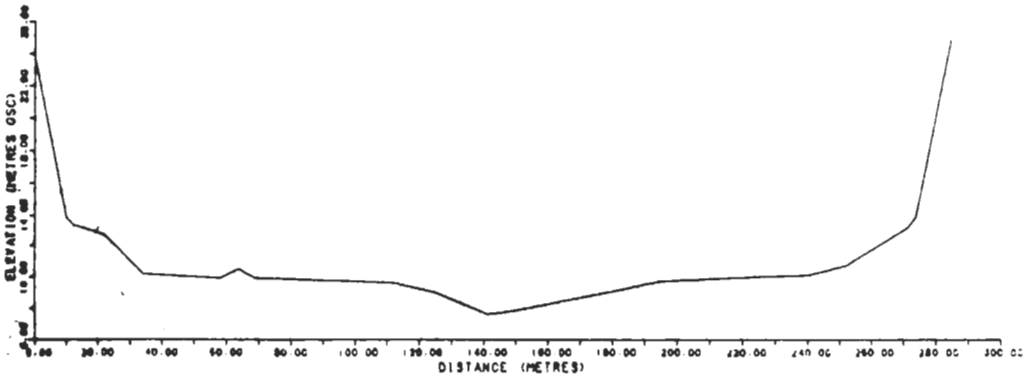

* Note:

- All elevations are referenced to Benchmark #76G2198 located at the Post Office on Main Street (elevation = 12.192 m) where a correction to Geodetic datum was subsequently applied (i.e. Geodetic elevation (m) = Post Office datum + 8.88 m).

- For conversion to the Abitibi datum (ft) from Geodetic (m)
(i.e. Geodetic elevation (m) = Abitibi (ft) / 3.281 - 27.413 m)

THIS RUN EXECUTED 6-MAR-89 14:06:26

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**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
  ERROR CORR -  01,02,03,04,05,06
  MODIFICATION -  50,51,52,53,54,55,56
**************************************************
```

T1 BISHOP FALLS GENERATING STATION HEC-2 MODEL
T2 MACLAREN PLANSEARCH MODEL 1983 FLOOD EVENT (115,000 CFS)
T3 BISHOP FALLS HEC-2 BACKWATER MODEL (POST OFFICE DATUM + 9.1)

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0.	0.	0.	0.	0.000000	1.00	0.0	3256.	16.100	0.000

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	1.000	0.000	-1.000	0.000	0.000	0.000	0.000	8.000	0.000	0.000

J3 VARIABLE CODES FOR SUMMARY PRINTOUT

38.000	1.000	43.000	25.000	42.000	41.000	40.000	26.000	8.000	10.000
5.000	4.000	3.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

NC	0.080	0.100	0.050	0.300	0.500	0.000	0.000	0.000	0.000	0.000
X1	1.100	24.000	320.000	591.000	0.000	0.000	0.000	0.000	0.000	0.000
GR	17.000	0.000	16.000	60.000	15.800	80.000	15.093	100.000	15.093	280.000
GR	15.093	320.000	6.450	320.100	4.650	334.000	5.250	340.000	4.950	373.000
GR	5.050	413.000	4.350	419.000	1.450	428.000	3.550	441.000	3.350	454.000
GR	3.850	461.000	3.550	469.000	5.050	474.000	9.250	519.000	11.550	554.000
GR	12.550	585.000	13.600	591.000	18.170	595.000	18.387	602.000	0.000	0.000
X1	2.000	54.000	109.000	504.400	180.000	210.000	245.000	0.000	0.000	0.000
GR	16.550	43.520	14.750	100.600	13.650	109.000	12.500	133.000	13.650	158.500
GR	14.100	188.500	13.650	199.000	11.750	202.600	11.750	205.700	9.250	216.000
GR	7.650	222.000	7.750	224.000	6.750	230.000	6.850	232.000	6.450	236.000
GR	5.550	239.000	4.850	242.000	4.550	246.000	4.350	255.000	4.950	267.000
GR	4.250	273.000	3.650	280.000	3.950	288.000	3.950	292.000	4.150	296.000
GR	3.950	298.000	4.450	305.000	4.650	310.000	4.650	316.000	6.050	326.000
GR	5.950	331.000	6.650	340.000	6.350	343.000	7.050	350.000	6.350	358.000
GR	6.250	360.000	5.950	365.000	5.150	373.000	5.950	378.000	6.050	391.000
GR	4.850	392.000	5.350	398.000	5.450	405.000	6.550	410.000	10.050	419.000
GR	8.850	430.000	9.550	444.000	10.750	471.000	12.150	489.000	12.750	501.310
GR	13.650	504.400	13.760	519.300	15.330	527.200	17.320	558.000	0.000	0.000

NC	0.080	0.100	0.050	0.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	3.000	46.000	203.000	572.100	395.000	440.000	380.000	0.000	0.000	0.000
GR	18.065	100.000	16.116	150.600	15.602	183.300	14.876	198.400	13.620	203.000
GR	11.920	206.000	11.520	220.000	7.520	234.000	6.920	242.000	5.520	248.000
GR	5.220	254.000	5.320	260.000	4.520	287.000	4.620	299.000	5.220	306.000
GR	3.320	329.000	4.620	338.000	5.520	350.000	5.120	356.000	5.520	362.000
GR	5.120	370.000	5.220	374.000	5.020	380.000	5.220	388.000	8.120	396.000
GR	8.820	404.000	8.520	410.000	7.420	417.000	10.120	433.000	10.120	440.000
GR	9.820	445.000	10.020	455.000	9.820	486.000	11.520	497.000	12.720	510.000
GR	11.420	520.000	11.920	534.000	12.920	550.000	13.020	566.000	13.620	572.100
GR	13.960	584.000	14.190	594.000	15.020	606.000	15.886	616.000	16.102	648.000
GR	16.450	668.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	3.100	0.000	0.000	0.000	360.000	515.000	430.000	0.000	0.000	0.000
NC	0.080	0.080	0.050	0.300	0.500	0.000	0.000	0.000	0.000	0.000
X1	4.000	49.000	89.000	369.300	400.000	400.000	400.000	0.000	0.000	0.000
X3	10.000	0.000	0.000	0.000	0.000	0.000	0.000	19.400	19.400	0.000
GR	20.400	0.000	16.600	10.000	16.250	67.000	16.400	89.000	16.400	89.100
GR	16.222	94.400	15.590	98.400	12.190	101.450	9.490	112.000	6.490	126.000
GR	5.990	141.000	5.490	151.000	5.490	157.400	5.490	157.500	5.490	159.900
GR	5.490	160.000	4.590	178.000	4.490	188.000	5.290	210.000	5.490	215.000
GR	5.290	221.000	6.490	228.200	6.490	228.300	6.490	230.700	6.490	230.800
GR	6.290	241.000	6.390	251.000	6.190	261.000	6.690	272.000	6.390	290.000
GR	6.690	295.000	6.590	298.000	6.690	298.800	6.690	298.900	6.690	301.300
GR	6.690	301.400	6.490	308.000	5.686	315.000	5.590	320.000	5.890	328.000
GR	5.690	335.000	7.490	358.000	11.390	360.800	13.590	363.200	16.000	369.300
GR	16.000	369.400	16.050	392.570	17.650	417.000	20.400	432.000	0.000	0.000
SB	1.050	1.560	1.600	0.000	265.000	8.000	4250.000	2.000	0.000	0.000
X1	4.100	0.000	0.000	0.000	6.000	6.000	6.000	0.000	0.000	0.000
X2	0.000	0.000	1.000	19.350	20.400	0.000	0.000	0.000	0.000	0.000
X3	10.000	0.000	0.000	0.000	0.000	0.000	0.000	20.400	20.400	0.000
BT	22.000	0.000	20.400	20.400	10.000	20.400	16.600	67.000	20.800	16.250
BT	89.000	20.800	16.400	89.100	20.800	19.350	157.400	20.800	19.350	157.500
BT	20.800	5.490	159.900	20.800	5.490	160.000	20.800	19.350	228.200	20.800
BT	19.350	228.300	20.800	6.490	230.700	20.800	6.490	230.800	20.800	19.350
BT	298.800	20.800	19.350	298.900	20.800	6.690	301.300	20.800	6.690	301.400
BT	20.800	19.350	369.300	20.740	19.350	369.400	20.740	16.000	392.570	20.550
BT	16.050	417.000	20.400	17.650	432.000	20.400	20.400	0.000	0.000	0.000
X1	5.000	41.000	34.000	291.500	355.000	355.000	355.000	0.000	0.000	0.000
GR	17.690	0.000	17.010	20.080	16.960	22.580	16.280	29.900	13.600	34.000
GR	13.000	36.440	11.500	44.000	7.500	59.000	6.900	65.000	7.100	72.000
GR	6.500	83.000	6.600	90.000	6.400	92.000	6.500	97.000	7.400	102.000
GR	6.000	110.000	5.700	114.000	5.400	123.000	5.900	132.000	6.700	140.000
GR	6.500	152.000	6.200	160.000	6.900	170.000	6.700	178.000	7.100	190.000
GR	7.500	206.000	7.200	213.000	7.700	222.000	7.400	230.000	7.900	238.000
GR	7.300	246.000	7.500	254.000	7.300	255.000	9.500	265.000	12.600	280.000
GR	13.000	290.000	13.600	291.500	14.330	298.000	14.720	315.000	17.220	399.000
GR	18.530	423.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

NC	0.080	0.080	0.050	0.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	6.000	22.000	108.540	331.900	1010.000	780.000	895.000	0.000	0.000	0.000
GR	17.400	90.000	17.320	100.000	13.600	108.540	12.800	112.200	9.500	125.000
GR	7.500	144.000	6.800	151.000	5.800	160.000	5.700	170.000	5.100	190.000
GR	5.100	198.000	4.500	209.000	4.700	220.000	4.800	230.000	5.500	250.000
GR	7.700	296.000	8.100	310.000	9.500	321.000	12.400	329.800	13.600	331.900
GR	17.720	339.200	18.000	345.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	7.000	29.000	57.000	428.000	520.000	450.000	480.000	0.000	0.000	0.000
GR	18.680	0.000	17.150	39.000	13.660	57.000	12.860	58.500	12.060	71.000
GR	11.760	81.000	10.160	96.000	10.260	106.000	7.560	129.000	7.460	134.000
GR	7.560	141.000	6.560	196.000	6.660	210.000	5.760	234.000	5.660	256.000
GR	5.160	270.000	5.960	290.000	5.560	299.000	6.960	310.000	6.860	326.000
GR	6.260	342.000	6.360	352.000	7.260	371.000	7.660	398.000	11.260	410.000
GR	12.960	426.400	13.660	428.000	15.480	443.900	17.350	484.000	0.000	0.000
X1	8.000	38.000	120.000	594.000	600.000	870.000	720.000	0.000	0.000	0.000
GR	19.080	0.000	16.540	34.000	16.740	103.000	15.750	114.000	13.650	120.000
GR	13.150	123.000	11.550	140.000	7.550	152.000	5.550	168.000	6.550	184.000
GR	6.150	190.000	6.950	210.000	8.050	241.000	9.650	271.000	9.850	300.000
GR	9.250	322.000	9.350	340.000	8.150	356.000	7.850	370.000	7.550	385.000
GR	7.650	400.000	7.450	424.000	6.750	445.000	6.550	460.000	7.350	492.000
GR	7.850	515.000	9.550	530.000	11.550	540.000	11.850	565.000	12.550	576.000
GR	12.950	592.300	13.650	594.000	15.158	596.000	15.616	608.500	16.379	621.100
GR	16.640	643.000	17.000	700.000	18.000	750.000	0.000	0.000	0.000	0.000
NC	0.100	0.100	0.070	0.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	9.000	32.000	66.100	462.450	1950.000	2100.000	1910.000	0.000	0.000	0.000
GR	19.524	0.000	18.723	18.000	16.478	35.000	14.483	60.000	13.650	66.100
GR	12.550	70.700	12.350	91.000	9.550	120.000	8.150	140.000	8.050	158.000
GR	7.550	164.000	7.450	181.000	7.950	200.000	8.250	218.000	7.850	237.000
GR	8.150	255.000	7.750	270.000	7.850	292.000	8.250	303.000	8.150	330.000
GR	7.650	355.000	7.550	365.000	7.750	390.000	8.850	402.000	8.750	420.000
GR	9.250	440.000	11.550	452.000	12.850	459.400	13.650	462.450	14.402	466.100
GR	17.150	470.000	18.070	484.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	9.100	32.000	60.000	466.100	1400.000	1400.000	1400.000	0.000	0.100	0.000
GR	19.524	0.000	18.723	18.000	16.478	35.000	14.483	60.000	13.650	66.100
GR	12.550	70.700	12.350	91.000	9.550	120.000	8.150	140.000	8.050	158.000
GR	7.550	164.000	7.450	181.000	7.950	200.000	8.250	218.000	7.850	237.000
GR	8.150	255.000	7.750	270.000	7.850	292.000	8.250	303.000	8.150	330.000
GR	7.650	355.000	7.550	365.000	7.750	390.000	8.850	402.000	8.750	420.000
GR	9.250	440.000	11.550	452.000	12.850	459.400	13.650	462.450	14.402	466.100
GR	17.150	470.000	18.070	484.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	10.000	22.000	10.000	273.800	750.000	750.000	750.000	0.000	-0.200	0.000
GR	23.850	0.000	13.850	10.000	13.350	12.400	12.750	22.000	10.250	34.000
GR	9.950	58.000	10.550	64.000	9.950	69.000	9.850	84.000	9.650	112.000
GR	9.050	125.000	7.650	141.000	7.850	149.000	8.750	171.000	9.750	195.000
GR	10.050	224.000	10.150	240.000	10.750	252.000	13.150	271.400	13.850	273.800
GR	14.850	275.000	24.850	285.000	0.000	0.000	0.000	0.000	0.000	0.000

NC	0.100	0.100	0.080	0.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	10.100	22.000	10.000	273.800	650.000	650.000	650.000	0.000	0.200	0.000
GR	23.850	0.000	13.850	10.000	13.350	12.400	12.750	22.000	10.250	34.000
GR	9.950	58.000	10.550	64.000	9.950	69.000	9.850	84.000	9.650	112.000
GR	9.050	125.000	7.650	141.000	7.850	149.000	8.750	171.000	9.750	195.000
GR	10.050	224.000	10.150	240.000	10.750	252.000	13.150	271.400	13.850	273.800
GR	14.850	275.000	24.850	285.000	0.000	0.000	0.000	0.000	0.000	0.000
EJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

```
   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST

*PROF 1

CCHV=   0.300 CEHV=   0.500
*SECNO 1.100
     1.10     14.65     16.10      0.00     16.10     16.18      0.08      0.00      0.00     15.09
    3256.       43.     3213.        0.       239.     2541.        3.        0.        0.     13.60
     0.00      0.18      1.26      0.13     0.080     0.050     0.100     0.000      1.45     54.00
 0.000212        0.        0.        0.         0         0         0      0.00    539.19    593.19

*SECNO 2.000
     2.00     12.53     16.18      0.00      0.00     16.24      0.06      0.05      0.01     13.65
    3256.        9.     3234.       13.       49.     2954.       55.       705.      114.     13.65
     0.06      0.19      1.09      0.23     0.080     0.050     0.100     0.000      3.65     55.35
 0.000208      180.      245.      210.         2         0         0      0.00    484.96    540.31

*SECNO 3.000
     3.00     12.93     16.25      0.00      0.00     16.31      0.06      0.08      0.00     13.62
    3256.        6.     3232.       18.       38.     2949.       89.      1876.      308.     13.62
     0.16      0.17      1.10      0.20     0.080     0.050     0.100     0.000      3.32    146.81
 0.000190      395.      380.      440.         0         0         0      0.00    510.38    657.19

*SECNO 3.100
     3.10     13.01     16.33      0.00      0.00     16.39      0.06      0.08      0.00     13.62
    3256.        7.     3230.       19.       43.     2977.       95.      3212.      532.     13.62
     0.27      0.17      1.08      0.20     0.080     0.050     0.100     0.000      3.32    144.82
 0.000184      360.      430.      515.         0         0         0      0.00    516.79    661.61

CCHV=   0.300 CEHV=   0.500
*SECNO 4.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=       19.40 ELREA=       19.40

     4.00     11.91     16.40      0.00      0.00     16.48      0.08      0.07      0.01     16.40
    3256.        0.     3256.        0.         0.     2662.        0.      4367.      692.     16.00
     0.36      0.00      1.22      0.00     0.000     0.050     0.000     0.000      4.49     89.00
 0.000191      400.      400.      400.         0         0         0      0.00    280.30    369.30
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   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SGTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST


SPECIAL BRIDGE

5070.VARIABLE ELCHU OR ELCHD ON CARD SB NOT SPECIFIED
SB  XK        XKOR      COFQ      RDLEN     BWC       BWP       BAREA     SS        ELCHU     ELCHD
     1.05      1.56      1.60      0.00    265.00      8.00   4250.00      2.00      4.49      4.49

*SECNO 4.100
CLASS A LOW FLOW

3420 BRIDGE W.S.=      16.40 BRIDGE VELOCITY=,      0.97      CALCULATED CHANNEL AREA=,      3344.

 EGPRS     EGLWC     H3        QWEIR     QLOW      BAREA     TRAPEZOID     ELLC      ELTRD
                                                             AREA
     0.00     16.48      0.00        0.      3256.     4250.     4261.     19.35     20.40


3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=       20.40 ELREA=       20.40

     4.10     11.91     16.40      0.00      0.00     16.48      0.08      0.00      0.00     16.40
    3256.        0.     3256.        0.        0.     2660.        0.     4383.      693.     16.00
     0.36      0.00      1.22      0.00     0.000     0.050     0.000     0.000      4.49     89.00
 0.000192        6.        6.        6.         0         0         0      0.00    280.30    369.30

*SECNO 5.000
     5.00     11.07     16.47      0.00      0.00     16.58      0.10      0.08      0.01     13.60
    3256.        2.     3227.       28.        6.     2238.      101.     5271.      804.     13.60
     0.43      0.25      1.44      0.27     0.080     0.050     0.080     0.000      5.40     27.84
 0.000294      355.      355.      355.         0         0         0      0.00    345.99    373.84

*SECNO 6.000
     6.00     12.22     16.72      0.00      0.00     16.83      0.11      0.25      0.00     13.60
    3256.        3.     3251.        2.       11.     2180.        9.     7300.     1061.     13.60
     0.60      0.26      1.49      0.25     0.080     0.050     0.080     0.000      4.50    101.38
 0.000269     1010.      895.      780.         2         0         0      0.00    236.05    337.43

*SECNO 7.000
     7.00     11.73     16.89      0.00      0.00     16.93      0.05      0.08      0.02     13.66
    3256.        5.     3240.       11.       27.     3403.       58.     8665.     1221.     13.66
     0.74      0.19      0.95      0.19     0.080     0.050     0.080     0.000      5.16     40.35
 0.000119      520.      480.      450.         2         0         0      0.00    433.76    474.11
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SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	LEFT/RIGHT
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST
•SECNO 8.000									
8.00	11.43	16.98	0.00	0.00	17.02	0.03	0.08	0.00	13.65
3256.	5.	3244.	7.	47.	3954.	57.	11386.	1623.	13.65
0.98	0.11	0.82	0.12	0.080	0.050	0.080	0.000	5.55	28.08
0.000100	600.	720.	870.	2	0	0	0.00	669.12	697.20
•SECNO 9.000									
9.00	9.82	17.27	0.00	0.00	17.31	0.05	0.29	0.01	13.65
3256.	18.	3233.	5.	67.	3368.	18.	18568.	2698.	13.65
1.54	0.26	0.96	0.29	0.100	0.070	0.100	0.000	7.45	29.02
0.000261	1950.	1910.	2100.	2	0	0	0.00	442.77	471.79
•SECNO 9.100									
9.10	10.07	17.62	0.00	0.00	17.66	0.04	0.35	0.00	14.58
3256.	13.	3242.	1.	55.	3502.	8.	23481.	3322.	14.50
1.96	0.24	0.93	0.18	0.100	0.070	0.100	0.000	7.55	27.11
0.000238	1400.	1400.	1400.	2	0	0	0.00	448.53	475.64
•SECNO 10.000									
10.00	10.42	17.87	0.00	0.00	17.99	0.12	0.29	0.04	13.65
3256.	3.	3249.	4.	9.	2134.	10.	25625.	3592.	13.65
2.10	0.35	1.52	0.40	0.100	0.070	0.100	0.000	7.45	5.78
0.000702	750.	750.	750.	2	0	0	0.00	272.44	278.22
•SECNO 10.100									
10.10	10.53	18.38	0.00	0.00	18.50	0.11	0.51	0.00	14.05
3256.	4.	3248.	5.	9.	2163.	10.	27033.	3769.	14.05
2.22	0.39	1.50	0.46	0.100	0.080	0.100	0.000	7.85	5.67
0.000876	650.	650.	650.	2	0	0	0.00	272.66	278.33

Appendix TA-6(b)

RAND (Leendertse, 1970) Model

- input data set
- output velocity components

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BISHOPS FALLS NEW DAM 2D-HYDRODYNAMIC MODEL FOR ICE  34.6M,GRID 10SEC T

  N    M  NBW1  NBW2  ANGLAT      AL       AG       AT     CSET      VAR    SEINV     GAMM     DCO      DML   DEPDEF
 26   55    1    25   48.900   34.600    9.810    5.000   30.000    0.100    0.600    0.500    4.000    1.000    1.000

NST NTAP MAXT NTFR NWLC NSMO NCVL NREQ  NFL,     NSRC KPOL NOWL NOCR NFLD NTRA LMAX NWLT
  0    0   36  450    6   30   10    6   18    1    1    3    1  555    3    2    6

  COEF          WSTR          DAIR          DWAT          WCONV         CDCON
-0.719193E-06  0.230000E-02  0.120100E+01  0.999000E+03 /0.510000E+00  0.300000E+02

 LOX       SOX          AKTP  LRMX
   0  0.720000E+01  0.300000E-04     1
 30  288  294  300  432 1440 2000    0    0    0    0    0    0    0    0    0 8000    0    0    0
  0    0    0    0    0    0    0    0    0    0    0    0 9000    0    0    0    0    0    0    0
  0    0    0    0    0    0    0    0
  1    4   15
  2   50   15
  3   53   15
  1   50   15
  1    6    7
  1    2   14
  1    8    8   21
  2   49   21   25
  3   50    9   21

0.00000E+00    E.COLI SIST

0.00000E+00    E.COLI SIST


0.160000E-04  0.000000E+00
0.000000E+00  0.160000E-04
```

BISHOPS FALLS NEW DAM 2D-HYDRODYNAMIC MODEL FOR ICE 34.6M,GRID 10SEC T

C VALUES UNTIL NEXT PRINTOUT N= 1 , 26

1	75.	75.	75.	75.	75.	75.	75.	75.	75.	75.	75.	75.	75.	75.	75.	75.	75.	75.	75.	75.	75.	75.	75.	75.	75.	0.
2	75.	59.	59.	59.	59.	59.	59.	59.	59.	59.	59.	59.	59.	59.	59.	59.	59.	59.	59.	59.	56.	0.	0.	0.	0.	0.
3	75.	60.	57.	0.	0.	0.	0.	0.	0.	0.	56.	59.	59.	59.	59.	59.	59.	59.	59.	59.	0.	0.	0.	0.	0.	0.
4	75.	60.	0.	0.	0.	0.	0.	0.	0.	0.	0.	59.	59.	59.	59.	59.	59.	59.	59.	59.	0.	0.	0.	0.	0.	0.
5	75.	60.	0.	0.	0.	0.	0.	0.	0.	0.	0.	59.	59.	59.	59.	59.	59.	59.	59.	59.	0.	0.	0.	0.	0.	0.
6	75.	60.	0.	0.	0.	0.	0.	0.	0.	0.	0.	59.	59.	59.	59.	59.	59.	59.	58.	55.	0.	0.	0.	0.	0.	0.
7	75.	60.	0.	0.	0.	0.	0.	0.	0.	0.	0.	59.	59.	59.	60.	61.	60.	60.	56.	0.	0.	0.	0.	0.	0.	0.
8	75.	60.	0.	0.	0.	0.	0.	0.	0.	0.	54.	59.	59.	59.	61.	62.	61.	58.	51.	0.	0.	0.	0.	0.	0.	0.
9	75.	60.	0.	0.	0.	0.	0.	0.	0.	0.	56.	60.	60.	60.	61.	62.	61.	57.	0.	0.	0.	0.	0.	0.	0.	0.
10	75.	60.	0.	0.	0.	0.	0.	0.	0.	0.	56.	60.	61.	61.	61.	61.	61.	57.	0.	0.	0.	0.	0.	0.	0.	0.
11	75.	60.	0.	0.	0.	0.	0.	0.	0.	0.	56.	60.	61.	61.	61.	61.	61.	55.	0.	0.	0.	0.	0.	0.	0.	0.
12	75.	60.	0.	0.	0.	0.	0.	0.	0.	0.	56.	60.	61.	61.	61.	61.	60.	55.	0.	0.	0.	0.	0.	0.	0.	0.
13	75.	60.	0.	0.	0.	0.	0.	0.	0.	0.	56.	60.	61.	61.	61.	61.	59.	54.	0.	0.	0.	0.	0.	0.	0.	0.
14	75.	60.	0.	0.	0.	0.	0.	0.	0.	0.	56.	60.	61.	61.	61.	60.	58.	52.	0.	0.	0.	0.	0.	0.	0.	0.
15	75.	60.	0.	0.	0.	0.	0.	0.	0.	0.	56.	60.	61.	61.	61.	60.	58.	52.	0.	0.	0.	0.	0.	0.	0.	0.
16	75.	60.	0.	0.	0.	0.	0.	0.	0.	48.	56.	60.	61.	61.	61.	60.	58.	52.	0.	0.	0.	0.	0.	0.	0.	0.
17	75.	60.	0.	0.	0.	0.	0.	0.	0.	51.	57.	60.	61.	61.	61.	60.	58.	52.	0.	0.	0.	0.	0.	0.	0.	0.
18	75.	60.	0.	0.	0.	0.	0.	0.	0.	52.	57.	60.	61.	61.	61.	60.	58.	52.	0.	0.	0.	0.	0.	0.	0.	0.
19	75.	61.	0.	0.	0.	0.	0.	0.	0.	52.	57.	60.	61.	61.	61.	60.	58.	52.	0.	0.	0.	0.	0.	0.	0.	0.
20	75.	61.	0.	0.	0.	0.	0.	0.	0.	52.	57.	60.	61.	61.	61.	60.	57.	51.	0.	0.	0.	0.	0.	0.	0.	0.
21	75.	60.	0.	0.	0.	0.	0.	0.	48.	52.	57.	60.	61.	60.	61.	60.	56.	50.	0.	0.	0.	0.	0.	0.	0.	0.
22	75.	60.	0.	0.	0.	0.	0.	0.	52.	53.	57.	60.	60.	59.	60.	60.	55.	49.	0.	0.	0.	0.	0.	0.	0.	0.
23	75.	60.	0.	0.	0.	0.	0.	48.	53.	54.	57.	60.	60.	59.	60.	59.	54.	48.	0.	0.	0.	0.	0.	0.	0.	0.
24	75.	60.	0.	0.	0.	0.	0.	50.	55.	57.	58.	60.	60.	59.	60.	59.	54.	44.	0.	0.	0.	0.	0.	0.	0.	0.
25	75.	60.	0.	0.	0.	0.	0.	51.	55.	58.	59.	60.	61.	60.	60.	59.	54.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	75.	60.	0.	0.	0.	0.	0.	51.	55.	56.	58.	60.	61.	61.	61.	59.	54.	0.	0.	0.	0.	0.	0.	0.	0.	0.
27	75.	60.	0.	0.	0.	0.	44.	51.	55.	56.	58.	60.	61.	61.	61.	59.	54.	43.	0.	0.	0.	0.	0.	0.	0.	0.
28	75.	60.	0.	0.	0.	0.	47.	50.	55.	57.	59.	60.	61.	61.	61.	59.	54.	45.	0.	0.	0.	0.	0.	0.	0.	0.
29	75.	61.	0.	0.	0.	0.	47.	50.	54.	56.	57.	59.	61.	61.	60.	58.	52.	44.	0.	0.	0.	0.	0.	0.	0.	0.
30	75.	61.	0.	0.	0.	0.	47.	50.	53.	56.	57.	59.	61.	61.	60.	58.	51.	43.	39.	0.	0.	0.	0.	0.	0.	0.
31	75.	60.	0.	0.	0.	0.	47.	50.	53.	55.	58.	58.	59.	61.	60.	58.	53.	48.	44.	0.	0.	0.	0.	0.	0.	0.
32	75.	60.	0.	0.	0.	0.	48.	50.	52.	54.	57.	57.	59.	61.	60.	59.	56.	52.	45.	0.	0.	0.	0.	0.	0.	0.
33	75.	60.	0.	0.	0.	0.	47.	49.	51.	53.	57.	59.	60.	61.	61.	60.	57.	52.	45.	0.	0.	0.	0.	0.	0.	0.
34	75.	60.	0.	0.	0.	0.	42.	48.	50.	53.	57.	59.	58.	59.	61.	60.	58.	52.	46.	0.	0.	0.	0.	0.	0.	0.
35	75.	60.	0.	0.	0.	0.	0.	46.	48.	52.	56.	59.	59.	59.	61.	60.	58.	53.	46.	0.	0.	0.	0.	0.	0.	0.
36	75.	60.	0.	0.	0.	0.	0.	42.	47.	50.	56.	59.	60.	59.	59.	60.	58.	53.	46.	42.	0.	0.	0.	0.	0.	0.
37	75.	60.	0.	0.	0.	0.	0.	0.	45.	50.	54.	58.	60.	59.	59.	60.	59.	54.	46.	45.	0.	0.	0.	0.	0.	0.
38	75.	60.	0.	0.	0.	0.	0.	0.	43.	50.	53.	57.	60.	59.	59.	60.	59.	55.	47.	46.	0.	0.	0.	0.	0.	0.
39	75.	60.	0.	0.	0.	0.	0.	0.	0.	50.	53.	57.	60.	59.	59.	60.	59.	55.	48.	47.	0.	0.	0.	0.	0.	0.
40	75.	60.	0.	0.	0.	0.	0.	0.	0.	49.	53.	57.	60.	61.	59.	58.	59.	55.	45.	0.	0.	0.	0.	0.	0.	0.
41	75.	60.	0.	0.	0.	0.	0.	0.	0.	48.	53.	57.	60.	61.	59.	58.	59.	54.	0.	0.	0.	0.	0.	0.	0.	0.
42	75.	60.	0.	0.	0.	0.	0.	0.	0.	47.	53.	57.	60.	61.	61.	60.	59.	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	75.	60.	0.	0.	0.	0.	0.	0.	0.	0.	53.	57.	60.	60.	61.	61.	60.	54.	43.	45.	47.	47.	0.	0.	0.	0.
44	75.	60.	0.	0.	0.	0.	0.	0.	0.	49.	53.	57.	59.	59.	60.	61.	60.	57.	0.	0.	47.	47.	0.	0.	0.	0.
45	75.	60.	0.	0.	0.	0.	0.	0.	0.	50.	52.	56.	58.	59.	60.	61.	61.	57.	50.	45.	47.	44.	0.	0.	0.	0.
46	75.	60.	0.	0.	0.	0.	0.	0.	0.	45.	50.	54.	58.	59.	60.	61.	61.	58.	53.	49.	44.	0.	0.	0.	0.	0.
47	75.	60.	0.	0.	0.	0.	0.	0.	0.	0.	48.	53.	56.	58.	60.	61.	61.	59.	56.	50.	0.	0.	0.	0.	0.	0.
48	75.	60.	0.	0.	0.	0.	0.	0.	0.	0.	48.	52.	55.	58.	60.	61.	61.	60.	58.	0.	0.	0.	0.	0.	0.	0.
49	75.	60.	0.	0.	0.	0.	0.	0.	0.	0.	48.	52.	54.	58.	60.	61.	61.	60.	58.	0.	0.	0.	0.	0.	0.	0.
50	75.	60.	0.	0.	0.	0.	0.	0.	0.	0.	47.	49.	51.	53.	56.	57.	58.	60.	57.	0.	0.	0.	0.	0.	0.	0.
51	75.	60.	0.	0.	0.	0.	0.	0.	0.	0.	53.	55.	55.	55.	55.	55.	57.	59.	57.	53.	0.	56.	58.	53.	0.	0.
52	75.	60.	0.	0.	0.	0.	0.	0.	0.	0.	55.	59.	59.	59.	59.	59.	59.	59.	59.	59.	59.	57.	52.	0.	0.	0.
53	75.	60.	0.	0.	0.	0.	0.	0.	0.	0.	0.	59.	59.	59.	59.	59.	59.	59.	59.	59.	59.	54.	0.	0.	0.	0.
54	75.	60.	57.	0.	0.	0.	0.	0.	0.	0.	56.	59.	59.	59.	59.	59.	59.	59.	59.	59.	56.	0.	0.	0.	0.	0.
55	75.	59.	59.	59.	59.	59.	59.	59.	59.	59.	59.	59.	59.	59.	59.	59.	59.	59.	59.	59.	56.	0.	0.	0.	0.	0.

DIFFUSION COEFFICIENTS N= 1 , 16

BISHOPS FALLS NEW DAM 2D-HYDRODYNAMIC MODEL FOR ICE 34.6M,GRID 10SEC T

INITIAL DEPTHS IN .1 N= 1 , 26

1	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	-9	-9	-9	-9	-9
2	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	-9	-9	-9	-9	-9
3	100	120	-9	-9	-9	-9	-9	-9	-9	-9	100	100	100	100	100	100	100	100	100	-9	-9	-9	-9	-9
4	100	120	-9	-9	-9	-9	-9	-9	-9	-9	100	100	100	100	100	100	100	100	100	-9	-9	-9	-9	-9
5	100	120	-9	-9	-9	-9	-9	-9	-9	-9	100	100	100	100	100	100	100	100	100	-9	-9	-9	-9	-9
6	100	120	-9	-9	-9	-9	-9	-9	-9	-9	100	100	100	100	100	100	100	100	50	-9	-9	-9	-9	-9
7	100	120	-9	-9	-9	-9	-9	-9	-9	-9	100	100	100	100	130	130	120	100	20	-9	-9	-9	-9	-9
8	100	120	-9	-9	-9	-9	-9	-9	-9	40	100	100	100	100	130	130	100	40	-9	-9	-9	-9	-9	-9
9	109	120	-9	-9	-9	-9	-9	-9	-9	40	100	120	109	120	130	130	120	40	-9	-9	-9	-9	-9	-9
10	100	120	-9	-9	-9	-9	-9	-9	-9	40	100	120	120	120	120	120	120	20	-9	-9	-9	-9	-9	-9
11	100	120	-9	-9	-9	-9	-9	-9	-9	40	100	120	120	120	120	120	100	20	-9	-9	-9	-9	-9	-9
12	100	120	-9	-9	-9	-9	-9	-9	-9	40	100	120	120	120	120	120	100	20	-9	-9	-9	-9	-9	-9
13	100	120	-9	-9	-9	-9	-9	-9	-9	40	100	120	120	120	120	160	70	20	-9	-9	-9	-9	-9	-9
14	100	120	-9	-9	-9	-9	-9	-9	-9	40	100	120	120	120	120	100	70	20	-9	-9	-9	-9	-9	-9
15	100	120	-9	-9	-9	-9	-9	-9	-9	40	100	120	120	120	120	100	70	20	-9	-9	-9	-9	-9	-9
16	100	120	-9	-9	-9	-9	-9	-9	20	40	100	120	120	120	120	100	70	20	-9	-9	-9	-9	-9	-9
17	100	120	-9	-9	-9	-9	-9	-9	20	60	100	120	120	120	120	100	70	20	-9	-9	-9	-9	-9	-9
18	100	120	-9	-9	-9	-9	-9	-9	20	60	100	120	120	120	120	100	70	20	-9	-9	-9	-9	-9	-9
19	119	120	-9	-9	-9	-9	-9	-9	20	60	100	120	119	120	120	100	60	20	-9	-9	-9	-9	-9	-9
20	100	120	-9	-9	-9	-9	-9	-9	20	60	100	120	120	120	120	100	50	20	-9	-9	-9	-9	-9	-9
21	100	120	-9	-9	-9	-9	-9	40	40	60	100	120	95	95	120	100	40	20	-9	-9	-9	-9	-9	-9
22	100	120	-9	-9	-9	-9	-9	40	40	60	100	120	95	95	110	90	30	20	-9	-9	-9	-9	-9	-9
23	100	120	-9	-9	-9	-9	20	40	70	60	100	120	95	95	110	90	20	20	-9	-9	-9	-9	-9	-9
24	100	120	-9	-9	-9	-9	20	55	70	100	100	120	95	95	110	90	20	-9	-9	-9	-9	-9	-9	-9
25	100	120	-9	-9	-9	-9	20	55	70	100	100	120	120	120	110	90	20	-9	-9	-9	-9	-9	-9	-9
26	100	120	-9	-9	-9	-9	20	55	70	45	100	120	120	120	110	90	20	-9	-9	-9	-9	-9	-9	-9
27	100	120	-9	-9	-9	20	20	55	70	100	100	120	120	120	110	90	20	10	-9	-9	-9	-9	-9	-9
28	100	120	-9	-9	-9	20	20	40	70	80	100	120	120	120	110	80	20	10	-9	-9	-9	-9	-9	-9
29	129	120	-9	-9	-9	20	20	40	60	80	45	120	129	120	100	70	10	5	-9	-9	-9	-9	-9	-9
30	100	120	-9	-9	-9	20	20	40	60	80	100	120	120	110	100	60	10	10	5	-9	-9	-9	-9	-9
31	100	120	-9	-9	-9	20	20	40	60	60	90	45	120	110	105	70	60	20	10	-9	-9	-9	-9	-9
32	100	120	-9	-9	-9	20	30	34	40	60	90	100	120	120	110	90	60	20	10	-9	-9	-9	-9	-9
33	103	120	-9	-9	-9	5	20	30	35	60	90	100	120	120	120	100	70	20	10	-9	-9	-9	-9	-9
34	100	120	-9	-9	-9	-9	15	25	30	60	90	100	45	120	120	100	70	20	15	-9	-9	-9	-9	-9
35	100	120	-9	-9	-9	-9	5	20	25	50	90	100	123	120	120	100	80	20	10	-9	-9	-9	-9	-9
36	100	120	-9	-9	-9	-9	-9	15	20	40	90	100	120	45	120	100	80	20	15	14	-9	-9	-9	-9
37	100	120	-9	-9	-9	-9	-9	5	20	40	60	100	120	120	120	100	90	20	15	14	-9	-9	-9	-9
38	100	120	-9	-9	-9	-9	-9	-9	20	40	60	100	120	45	120	100	100	25	20	20	-9	-9	-9	-9
39	100	120	-9	-9	-9	-9	-9	-9	20	40	60	100	120	120	120	100	100	25	20	20	-9	-9	-9	-9
40	100	120	-9	-9	-9	-9	-9	-9	15	40	60	100	122	120	45	100	100	25	-9	-9	-9	-9	-9	-9
41	100	120	-9	-9	-9	-9	-9	-9	5	40	60	100	120	120	120	100	95	-9	-9	-9	-9	-9	-9	-9
42	100	120	-9	-9	-9	-9	-9	-9	-9	40	60	100	120	120	120	110	90	-9	20	25	20	20	-9	-9
43	100	120	-9	-9	-9	-9	-9	-9	-9	40	60	100	101	100	120	120	100	40	-9	20	20	18	-9	-9
44	100	120	-9	-9	-9	-9	-9	-9	35	40	55	90	100	100	120	120	105	50	-9	20	20	20	-9	-9
45	100	120	-9	-9	-9	-9	-9	-9	20	30	40	80	90	100	120	120	110	60	30	20	20	-9	-9	-9
46	100	120	-9	-9	-9	-9	-9	-9	-9	20	35	70	90	100	120	120	110	70	40	20	-9	-9	-9	-9
47	100	120	-9	-9	-9	-9	-9	-9	-9	10	35	60	70	100	120	120	110	90	70	-9	-9	-9	-9	-9
48	100	120	-9	-9	-9	-9	-9	-9	-9	10	35	50	70	100	120	120	110	100	70	-9	-9	-9	-9	-9
49	100	120	-9	-9	-9	-9	-9	-9	-9	10	35	43	65	95	131	131	110	110	80	-9	-9	-9	-9	-9
50	100	120	-9	-9	-9	-9	-9	-9	-9	10	20	20	20	20	20	20	100	100	10	-9	-9	100	80	40
51	100	120	-9	-9	-9	-9	-9	-9	-9	60	100	100	100	100	100	100	100	100	100	100	100	100	60	15
52	100	120	-9	-9	-9	-9	-9	-9	-9	-9	100	100	100	100	100	100	100	100	100	100	100	20	-9	-9
53	100	120	-9	-9	-9	-9	-9	-9	-9	-9	100	100	100	100	100	100	100	100	100	100	100	-9	-9	-9
54	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	-9	-9	-9	-9
55	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	-9	-9	-9

SE FOR SECOND HALF OF STEP 30

N= 1 , 26

1	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	60	62	40	26	20	12	4	-2	-5	-8	-4	-6	-7	-8	-7	-5	-7	-9	-12	-12	-11	0	0	0	0
3	60	47	37	0	0	0	0	0	0	0	8	-3	-7	-9	-7	-5	-6	-9	-11	-11	0	0	0	0	0
4	60	49	0	0	0	0	0	0	0	0	0	-2	-6	-7	-6	-5	-6	-9	-10	-9	0	0	0	0	0
5	60	54	0	0	0	0	0	0	0	0	0	-6	-7	-7	-6	-6	-8	-10	-11	-8	0	0	0	0	0
6	60	57	0	0	0	0	0	0	0	0	0	-5	-6	-7	-7	-7	-9	-11	-12	-5	0	0	0	0	0
7	60	58	0	0	0	0	0	0	0	0	0	-6	-7	-8	-8	-10	-11	-13	-14	0	0	0	0	0	0
8	60	59	0	0	0	0	0	0	0	0	-4	-7	-8	-8	-8	-10	-11	-13	-12	0	0	0	0	0	0
9	60	59	0	0	0	0	0	0	0	0	0	-5	-7	-7	-7	-9	-10	-13	0	0	0	0	0	0	0
10	60	59	0	0	0	0	0	0	0	0	0	-4	-5	-4	-5	-7	-8	-7	0	0	0	0	0	0	0
11	60	59	0	0	0	0	0	0	0	0	-1	-3	-4	-4	-5	-6	-6	-5	0	0	0	0	0	0	0
12	60	59	0	0	0	0	0	0	0	0	0	-2	-2	-3	-4	-6	-5	-3	0	0	0	0	0	0	0
13	60	59	0	0	0	0	0	0	0	0	2	1	0	-2	-4	-5	-4	-2	0	0	0	0	0	0	0
14	60	59	0	0	0	0	0	0	0	0	3	2	1	-1	-3	-5	-5	-3	0	0	0	0	0	0	0
15	60	59	0	0	0	0	0	0	0	0	1	1	0	-1	-3	-4	-4	-2	0	0	0	0	0	0	0
16	60	59	0	0	0	0	0	0	0	1	0	0	0	-2	-2	-2	-1	-1	0	0	0	0	0	0	0
17	60	59	0	0	0	0	0	0	0	6	0	0	0	-1	0	0	1	0	0	0	0	0	0	0	0
18	60	59	0	0	0	0	0	0	0	10	4	2	1	1	2	3	3	0	0	0	0	0	0	0	0
19	60	60	0	0	0	0	0	0	0	8	5	4	3	4	5	5	4	-1	0	0	0	0	0	0	0
20	60	60	0	0	0	0	0	0	0	3	5	5	5	6	7	6	3	-3	0	0	0	0	0	0	0
21	60	60	0	0	0	0	0	0	13	2	5	6	6	7	7	7	5	1	0	0	0	0	0	0	0
22	60	60	0	0	0	0	0	0	19	8	7	7	6	5	7	7	7	12	0	0	0	0	0	0	0
23	60	60	0	0	0	0	0	21	22	12	10	9	8	6	6	6	5	15	0	0	0	0	0	0	0
24	60	60	0	0	0	0	0	24	25	19	14	12	9	7	6	5	0	3	0	0	0	0	0	0	0
25	60	60	0	0	0	0	0	27	28	24	20	16	13	10	8	7	3	0	0	0	0	0	0	0	0
26	60	60	0	0	0	0	0	31	29	25	21	18	17	15	13	11	10	0	0	0	0	0	0	0	0
27	60	60	0	0	0	0	48	35	31	25	21	20	19	17	16	15	15	17	0	0	0	0	0	0	0
28	60	60	0	0	0	0	51	38	33	29	26	22	20	19	18	18	18	17	0	0	0	0	0	0	0
29	60	60	0	0	0	0	51	39	32	27	24	22	21	21	20	19	17	12	0	0	0	0	0	0	0
30	60	60	0	0	0	0	51	40	32	27	22	22	23	22	20	17	12	-10	0	0	0	0	0	0	0
31	60	60	0	0	0	0	50	40	33	28	25	25	22	21	20	18	13	2	0	0	0	0	0	0	0
32	60	59	0	0	0	0	49	40	33	26	22	20	21	24	24	23	24	19	17	0	0	0	0	0	0
33	60	59	0	0	0	0	47	36	29	23	22	24	27	27	26	27	27	27	33	0	0	0	0	0	0
34	60	59	0	0	0	0	40	27	23	20	22	23	26	26	27	29	31	33	43	0	0	0	0	0	0
35	60	59	0	0	0	0	0	25	17	19	22	23	23	27	30	31	32	37	50	0	0	0	0	0	0
36	60	59	0	0	0	0	0	0	16	18	23	26	31	33	31	32	35	38	49	0	0	0	0	0	0
37	60	59	0	0	0	0	0	0	24	16	23	27	32	33	33	36	37	40	48	64	0	0	0	0	0
38	60	59	0	0	0	0	0	0	0	22	25	30	36	40	41	41	43	45	53	70	0	0	0	0	0
39	60	60	0	0	0	0	0	0	0	25	30	35	41	43	45	47	50	50	58	75	0	0	0	0	0
40	60	60	0	0	0	0	0	0	0	29	37	43	49	53	55	55	58	53	60	0	0	0	0	0	0
41	60	59	0	0	0	0	0	0	0	32	45	53	58	61	64	66	66	61	0	0	0	0	0	0	0
42	60	59	0	0	0	0	0	0	0	0	61	66	70	74	79	82	78	0	0	0	0	0	0	0	0
43	60	59	0	0	0	0	0	0	0	0	80	81	83	86	91	93	94	105	0	0	-51	-49	0	0	0
44	60	59	0	0	0	0	0	0	0	99	96	96	96	98	101	103	104	113	0	0	-52	-48	0	0	0
45	60	59	0	0	0	0	0	0	0	106	106	107	107	109	112	113	112	119	127	0	-46	0	0	0	0
46	60	59	0	0	0	0	0	0	0	122	116	116	115	117	119	119	117	121	129	147	0	0	0	0	0
47	60	59	0	0	0	0	0	0	0	0	121	121	120	123	125	125	122	124	132	0	0	0	0	0	0
48	60	59	0	0	0	0	0	0	0	0	121	123	124	128	130	131	127	126	130	0	0	0	0	0	0
49	60	59	0	0	0	0	0	0	0	0	115	118	125	134	135	136	129	127	129	0	0	0	0	0	0
50	60	59	0	0	0	0	0	0	0	0	116	114	120	129	132	134	126	127	129	0	0	0	0	0	0
51	60	59	0	0	0	0	0	0	0	0	107	115	110	106	106	111	119	123	125	0	0	209	256	270	0
52	60	59	0	0	0	0	0	0	0	0	101	119	123	122	124	127	126	127	127	131	136	192	0	0	0
53	60	59	0	0	0	0	0	0	0	0	0	121	123	123	126	124	121	127	124	123	127	0	0	0	0
54	60	59	59	0	0	0	0	0	0	0	105	119	120	122	128	126	123	131	125	122	123	0	0	0	0
55	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	0	0	0	0

AVERAGED U AND UP FOR SECOND HALF OF STEP 30

N= 1 , 26

1	0	1	1	1	1	2	2	2	2	2	2	101	101	101	101	101	101	101	101	101	0	0	0	0	0	0
2	0	142	57	0	0	0	0	0	0	0	-72	68	88	98	101	102	101	100	99	98	0	0	0	0	0	0
3	0	166	0	0	0	0	0	0	0	0	0	59	80	95	101	103	101	98	93	88	0	0	0	0	0	0
4	0	143	0	0	0	0	0	0	0	0	0	89	91	97	102	104	102	96	86	73	0	0	0	0	0	0
5	0	113	0	0	0	0	0	0	0	0	0	106	103	104	107	109	107	100	82	45	0	0	0	0	0	0
6	0	82	0	0	0	0	0	0	0	0	0	121	116	114	117	122	119	111	104	0	0	0	0	0	0	0
7	0	56	0	0	0	0	0	0	0	0	0	129	123	118	111	107	103	92	66	0	0	0	0	0	0	0
8	0	37	0	0	0	0	0	0	0	0	39	117	128	127	124	120	124	133	0	0	0	0	0	0	0	0
9	0	23	0	0	0	0	0	0	0	0	64	105	119	122	121	118	112	99	0	0	0	0	0	0	0	0
10	0	15	0	0	0	0	0	0	0	0	81	107	119	124	127	124	114	103	0	0	0	0	0	0	0	0
11	0	10	0	0	0	0	0	0	0	0	94	112	123	127	128	125	119	112	0	0	0	0	0	0	0	0
12	0	6	0	0	0	0	0	0	0	0	107	119	128	131	130	124	114	108	0	0	0	0	0	0	0	0
13	0	4	0	0	0	0	0	0	0	0	118	127	133	135	135	136	137	135	0	0	0	0	0	0	0	0
14	0	3	0	0	0	0	0	0	0	0	126	132	136	137	137	135	132	128	0	0	0	0	0	0	0	0
15	0	2	0	0	0	0	0	0	0	0	131	136	138	138	137	135	131	124	0	0	0	0	0	0	0	0
16	0	1	0	0	0	0	0	0	0	47	129	139	141	141	139	137	132	124	0	0	0	0	0	0	0	0
17	0	1	0	0	0	0	0	0	0	71	122	140	144	145	143	140	135	127	0	0	0	0	0	0	0	0
18	0	1	0	0	0	0	0	0	0	100	131	145	148	148	146	143	136	125	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	124	141	150	152	150	148	146	141	131	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	153	153	157	153	147	148	149	144	132	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	36	137	157	165	170	171	163	154	146	132	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	76	149	161	167	169	170	171	167	156	126	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	15	71	131	163	165	168	170	170	167	162	120	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	33	73	111	136	155	167	176	176	172	156	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	59	87	113	130	150	153	155	161	161	140	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	79	106	148	165	156	159	162	163	157	138	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	22	75	98	110	127	149	159	165	165	155	130	44	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	43	86	109	126	134	146	163	169	168	160	138	76	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	57	88	117	140	170	177	166	169	178	180	173	162	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	64	87	109	124	130	135	159	181	191	197	204	176	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	65	82	102	133	164	194	203	189	187	180	136	50	-38	0	0	0	0	0	0	0
32	0	0	0	0	0	0	50	75	111	143	153	150	154	168	169	162	129	60	-17	0	0	0	0	0	0	0
33	0	0	0	0	0	0	56	86	113	139	151	156	149	156	162	152	125	71	12	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	89	124	142	157	173	198	195	171	156	136	93	43	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	147	152	163	165	152	140	153	157	140	109	81	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	128	159	159	167	173	192	193	168	150	126	110	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	165	178	181	171	147	142	155	144	121	86	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	134	159	172	182	192	184	161	137	111	51	-2	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	109	138	158	165	154	140	140	129	103	29	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	97	118	143	158	168	179	164	138	127	0	0	0	0	0	0	0	0
41	0	0	0	0	0	0	0	0	0	0	126	137	147	150	139	143	169	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0	101	121	132	135	139	147	142	0	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0	0	0	87	109	128	139	144	144	116	0	0	0	-32	-19	0	0	0	0
44	0	0	0	0	0	0	0	0	0	1	65	99	119	128	134	135	107	15	0	0	-31	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	8	53	91	113	123	128	127	104	31	-12	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0	0	0	53	82	103	115	122	122	103	48	-1	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0	0	0	0	64	87	106	115	121	120	102	59	20	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0	0	69	93	106	111	115	113	102	69	40	0	0	0	0	0	0	0
49	0	0	0	0	0	0	0	0	0	0	82	108	109	101	92	95	102	79	59	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	132	179	248	294	316	285	179	136	106	0	0	0	0	0	0	0
51	0	0	0	0	0	0	0	0	0	0	10	62	79	83	78	87	121	121	99	0	0	68	0	0	0	0
52	0	0	0	0	0	0	0	0	0	0	0	80	79	69	68	99	147	140	120	40	6	0	0	0	0	0
53	0	1	0	0	0	0	0	0	0	0	0	81	75	67	74	107	146	134	115	56	0	0	0	0	0	0
54	0	1	1	1	1	2	2	2	2	2	2	101	101	101	101	101	101	101	101	101	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

M N SE SEN SEP U V R1 2

AVERAGED V AND VP FOR SECOND HALF OF STEP 30

N= 1 , 26

1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	-134	-189	-189	-188	187	-185	-182	-179	-173	-93	-57	-40	-34	-30	-26	-23	-18	-12	-4	0	0	0	0	0	0
3	-7	-47	0	0	0	0	0	0	0	0	-62	-49	-39	-34	-31	-28	-24	-19	-11	0	0	0	0	0	0	0
4	-19	0	0	0	0	0	0	0	0	0	0	-25	-32	-34	-33	-31	-29	-24	-16	0	0	0	0	0	0	0
5	-29	0	0	0	0	0	0	0	0	0	0	-13	-23	-29	-32	-33	-35	-35	-29	0	0	0	0	0	0	0
6	-32	0	0	0	0	0	0	0	0	0	0	-8	-15	-22	-29	-37	-46	-54	-64	0	0	0	0	0	0	0
7	-27	0	0	0	0	0	0	0	0	0	0	-5	-11	-14	-21	-35	-45	-38	0	0	0	0	0	0	0	0
8	-20	0	0	0	0	0	0	0	0	0	-22	-8	-11	-18	-22	-33	-49	-60	0	0	0	0	0	0	0	0
9	-13	0	0	0	0	0	0	0	0	0	-11	-7	-12	-20	-21	-17	-15	0	0	0	0	0	0	0	0	0
10	-9	0	0	0	0	0	0	0	0	0	-8	-7	-12	-18	-16	-11	-7	0	0	0	0	0	0	0	0	0
11	-5	0	0	0	0	0	0	0	0	0	-6	-8	-10	-12	-12	-11	-6	0	0	0	0	0	0	0	0	0
12	-3	0	0	0	0	0	0	0	0	0	-4	-6	-8	-9	-10	-9	-4	0	0	0	0	0	0	0	0	0
13	-2	0	0	0	0	0	0	0	0	0	-2	-4	-6	-8	-12	-13	-6	0	0	0	0	0	0	0	0	0
14	-1	0	0	0	0	0	0	0	0	0	-2	-4	-5	-6	-7	-7	-4	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	-2	-5	-5	-6	-5	-5	-3	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	-20	-4	-4	-6	-6	-6	-5	-2	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	-14	-10	-7	-7	-7	-7	-5	-3	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	-10	-8	-8	-9	-9	-8	-7	-3	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	-10	-10	-11	-11	-10	-9	-10	-6	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	-15	-15	-16	-16	-12	-9	-12	-10	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	-41	-34	-21	-23	-24	-11	-7	-13	-16	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	-33	-33	-22	-19	-23	-22	-19	-21	-32	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	-14	-22	-39	-24	-17	-20	-20	-17	-20	-46	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	-18	-19	-27	-26	-12	-14	-19	-21	-29	-111	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	-17	-24	-18	-11	-3	-6	-21	-22	-12	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	-13	-25	-10	3	-2	-6	-11	-12	-6	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	-13	-4	3	-6	-11	-3	-3	-5	-6	-2	23	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	-10	-1	0	-2	3	5	1	-1	-3	1	22	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	3	2	3	-3	13	19	9	3	1	1	5	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	13	13	15	24	11	3	15	17	14	14	54	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	20	19	19	23	9	29	38	32	34	52	46	38	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	23	25	40	46	39	33	18	32	39	44	40	58	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	40	52	65	53	38	28	27	38	39	39	38	47	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	71	72	79	51	30	12	36	45	35	35	32	39	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	99	99	65	44	47	27	12	28	31	25	22	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	56	53	38	32	9	24	34	27	20	25	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	101	43	38	38	32	24	6	18	16	31	37	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	16	22	17	3	20	24	18	14	27	25	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	8	15	16	25	3	-12	1	3	12	18	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	-4	1	6	6	-12	-3	23	12	-25	0	0	0	0	0	0	0	0
41	0	0	0	0	0	0	0	0	0	37	4	0	5	18	0	-39	-72	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0	-1	0	4	10	3	-13	0	0	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0	0	0	-7	-7	-2	6	5	-4	1	0	0	0	1	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0	-17	-8	0	4	6	7	10	13	0	0	0	6	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	-22	-10	2	9	11	10	13	9	-12	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0	0	6	-1	5	11	13	13	15	14	-3	-14	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0	0	0	0	2	4	16	21	19	21	24	14	0	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0	0	-4	4	13	15	18	26	28	18	0	0	0	0	0	0	0	0
49	0	0	0	0	0	0	0	0	0	0	-10	-14	-7	8	26	37	35	22	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	-19	-20	-18	-5	14	67	56	8	0	0	0	0	0	0	0	0
51	0	0	0	0	0	0	0	0	0	0	30	11	-6	-7	14	14	9	29	0	0	0	-61	-42	0	0	0
52	0	0	0	0	0	0	0	0	0	0	8	-8	-10	1	13	5	-17	-34	-56	-97	-100	0	0	0	0	0
53	0	0	0	0	0	0	0	0	0	0	0	-2	0	4	2	-3	-6	-2	1	-12	0	0	0	0	0	0
54	0	0	0	0	0	0	0	0	0	0	-7	-19	-37	-61	-78	-64	-19	17	34	-6	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

AVERAGED U AND UP FOR SECOND HALF OF STEP 30

N= 1 , 26

TECHNICAL APPENDIX TA-7

- Historical (1983) Flood Levels

TABLE T2-A
BISHOP'S FALLS
HISTORICAL FLOOD LEVELS (1983)

FLOOD LEVEL (M) *	SITE CODE AND LOCATION DESCRIPTION
16.17	H - Mill Road at first house upstream of dam
16.14	E - Sydney Street at second house from Mill Road
16.33	F - homes at Riverside Drive and Kinsmens Drive
16.27	C - road at Riverside Drive and Kinsmens Drive
16.16	D - metal boiler at ARMCO Cove (perhaps moved)
17.06	G - Mr. Gill's trailer at west end Trailer Court (includes other level data)

* Datum currently related to available mapping.