IDENTIFICATION OF DATA REQUIREMENTS AND USES IN THE PACFICIC AND YUKON REGION

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Identification of data requirements and uses in the Pacific and Yukon Region.

IDENTIFICATION OF DATA REQUIREMENTS AND USES IN THE PACIFIC AND YUKON REGION

by W.L. Kreuder

1. Why stations are being operated:

The review of 1984 of hydrometric stations in British Columbia identified the requirements of the stations in operation in categories suggested by the new responsibility classification guidelines. It was decided to rank the requirements of the stations according to the following priorities:

A. Federal programs:
1) International commitments
2) Interprovincial commitments
3) Other statutory obligations

B. Federal Provincial
4) Formal agreements
5) Regional water quantity network

C. Other programs (equal priorities)

Federal:
- Navigation
- Fisheries requirements
- Water quality studies
- Research
- National inventory

Provincial:
- Basin studies
- Forecasting
- Fish and wildlife needs
- Water licensing and irrigation
- Power production and reservoir operation

Examples of networks in British Columbia where specific uses of data can be identified are given below for the current operating year 1986-1987.

International Commitments: There are 19 International Gauging Stations along the B.C.-U.S.A. boundary with fourteen stations operated by the USGS. International Boards of Control include 11 stations for the Columbia River Treaty Permanent Engineering Board, 5 for the Kootenay Lake Board, 6 for the Osoyoos Lake Board and 2 stations for the Skagit River Board.

Interprovincial Commitments: Only 7 stations along the boundary with the Yukon Territory are considered.

Federal Provincial Agreements: Most of the 31 stations in this category are required for the Okanagan River Basin implementation plan.

Federal Provincial Regional Network: About 140 stations have been selected to provide an assessment of water quantity in distinct hydrologic zones throughout the Province.

Flood Warning Network: Required by the Province during spring freshet; data are supplied on a daily basis usually beginning in the middle of April. The stations are located as follows:

Fraser River basin	-	11 stations
Thompson River basin	-	8 stations
Columbia River basin	-	6 stations
Okanagan River Basin	-	6 stations
Other basins	-	4 stations

Reservoir Operation: The B.C. Hydro and Power Authority has the responsiblity for regulating Williston Lake Reservoir which has a usable storage of 39,000,000 dam^3. A network of about a dozen stations on the major tributaries helps B.C. Hydro forecast runoff from 70% of the contributing drainage area of $72,000^2$ km .

Other Current Use Networks: Provincial irrigation licensing requirements account for 60-75 stations per year operated on a seasonal basis from April 1 to September 30; other provincial requirements are responsible for the operation of 40 stations plus 90 stations shared jointly to meet specific federal monitoring needs. Current use data are employed in studies of municipal water supply and small hydro power projects, in bridge and culvert design by the Provincial Highways Department, in impact studies on fisheries habitat and in pollution control evaluations. Federal current use data are collected from 71 stations for the Fisheries Department Salmonid Enhancement program (S.E.P.) for estuary studies directed by DOE, or the Department of Public Works channel improvement projects, and for our own sediment discharge inventory.

National Inventory: In order to provide information for a national inventory of surface water such as included in the Hydrologic Atlas of Canada and to measure significant discharge to the Pacific Ocean a network of 60 stations is being operated in British Columbia.

2. Which stations are no longer needed?

The network in British Columbia is constantly changing, perhaps more so than in the other provinces. During the past five years 134 stations have been discontinued while 73 stations have been added, which does not include the many changes to the irrigation station network operated on a seasonal basis.

A station may be considered for discontinuation for two reasons:

a) the cooperator--federal, provincial or private--no longer wants to pay or share in the cost of operating the station,

b) the station needs repairs or upgrading with costs involved that approach the cost of a new station

Before the station can be discontinued it is placed on a list with other stations to be circulated to the cooperators in the Pacific and Yukon Region with a request to review the need for the continued operation of each station. One of the cooperators is the Planning and Studies Section of WRB in Vancouver who will advise if the station is required in the Regional Network. Before a formal investigation is undertaken, a set of minimum requirements should be met. These are:

- station is recording natural flow
- contributing drainage area size is between 200 and 3,000 km^2; if greater than 3,000 km^2 the station may be included in major or national stream inventory network
- history of few operational problems and little missing record
- stable section and reliable stage-discharge relation.

If these requirements are met, a formal investigation is undertaken; depending on how much time is available the formal investigation may be short such as an "Evaluation of Hydrometric Station 08LE086 Ratchford Creek at 600 m Contour" by R.M. Leith, in which simple correlation and regression models are considered (see Attachment 1).

When time permits an extensive review of the station can be made which examines the quality of record before evaluating the station within the Regional Network. An example is the 114 page report on the Tulameen River at Princeton by A.G. Smith and G. Vallières; Attachment 2 shows the Table of Contents of the report.

In the final analysis of a station's value within the Regional Network it has been found that a station which is located in the sparsely gauged region of British Columbia north of latitude 54° (Prince George) and meets the basic requirements stated above will automatically be continued. The question of which stations are no longer needed can in most cases apply only to the densely gauged areas of the Lower Mainland, the Okanagan and the Kootenay-Columbia River basins in southern British Columbia.

3. What information on water quantity is needed in the Pacific and Yukon Region?

"Data" reports such as the annual surface water data publications and the triennial historical streamflow summaries are well known and distributed to cooperators, consultants and technical libraries. But in order to increase the usefulness of our data we also provide noninterpretive statistics and graphical plots of information such as shown in Attachment 3 and listed below:

- statistical summary of monthly and annual discharges (1)
- flood frequency plots and tables (2)
- 7-day low flow frequency plots and tables (3)
- flow duration curves (4)
- area-elevation curves (5)
- streamflow hydrographs (6)
- discharge measurement summaries (7)
- water temperature plots and tables (8)
- drainage basin characteristics (9)

In addition, we have provided interpretive information to meet specific client needs. Examples are also shown in Attachment 3 and listed below:

-flood frequency estimates (10)
-7-day low flow frequency estimates (11)
-regression equations (12)
-envelope curves of extreme floods (13)
-annual runoff maps (14)
-n-day lowest average flow summaries (15)
-n-day highest average flow summaries (16)

Finally, in order to meet future requirements for water quantity information we have developed a summary of the available information which might tentatively be called a station profile and is stored conveniently in a computer file. Attachment 4 lists the station profile for station 08NL024 Tulameen River at Princeton. Future considerations also include receiving data on daily flows from some 30 stations in British Columbia and the Yukon Territory which have data collection platforms, with the data automatically recorded and providing month-end summaries for use in evaluating runoff conditions in the Region.

W.L. Kreuder
September 1986

Attachment 1

Evaluation of Station 08LE086

Ratchford Creek at 600 m Contour

Evaluation of Hydrometric Station 08LE086 Ratchford Creek at 600 m Contour

With the object of providing input to the question of whether or not to re-establish the station 08LE086, simple correlation and regression exercises have been conducted on selected hydrologic quantities from nearby stations.

Results are based on records from 1973 to 1983 inclusive.

Notes: 1. The following results are for calibration only over a relatively short period. The correlation-regression relations may not be well defined. Errors of validation are generally greater than those of calibration.

2. Ratchford Creek is tributary to the Seymour River.

1. For annual maximum daily flows:

	Linear Correlation Coefficient	Occurrence of Relative Errors in Percent			
		0-10	10-20	20-30	30+
08LE086 Ratchford versus:					
08ND019 Kirbyville	0.73	4	5	1	1
08ND012 Goldstream	0.86	5	5	0	1
08LE027 Seymour	0.94	7	3	1	0

The relative error is the difference between maximum daily flow observed and maximum daily flow estimated by simple linear regression divided by the maximum daily flow observed and multiplied by 100. For example, for Ratchford Creek and Seymour River the regression equation is:

Ratchford Maximum Daily = 0.38 * Seymour Maximum Daily - 11.4

From this equation, if the maximum daily for Seymour River is 206 m^3/sec. (1973) then the estimated maximum daily for Ratchford Creek is 66.9 m^3/sec. The observed value of maximum daily flow in 1973 for Ratchford Creek is 60.6 m^3/sec., so the relative error is (60.6 - 66.9)/60.6 or -10%. The relative errors in the tables are quoted without regard to over or under-estimate.

The indication from the preceding Table is that for the eleven years 1973 to 1983, the maximum daily flows for the Ratchford could be estimated from those of the Seymour with no errors greater than 30%.

2. For one day low flows:
(lowest daily flow of the year at each station, not necessarily occurring on coincident dates)

		Linear Correlation Coefficient	Occurrence of Relative Errors in Percent			
			0-10	10-20	20-30	30+
08LE086 Ratchford versus:						
08ND019	Kirbyville	0.67	5	0	3	3
08ND012	Goldstream	0.68	4	4	1	3
08LE027	Seymour	0.65	5	1	1	3

Regression Equation

Ratchford Low Flow = 0.086 * Seymour Low Flow + 0.40

3. For one day low flows:
Take low flow for predictor station versus the flow at Ratchford Creek on the corresponding day, i.e. this is what would be estimated if flow were missing at Ratchford Creek.

		Linear Correlation Coefficient	Occurrence of Relative Errors in Percent			
			0-10	10-20	20-30	30+
08LE086 Ratchford versus:						
08ND019	Kirbyville	0.43	2	3	1	5
08ND012	Goldstream	0.59	5	2	0	3
08LE027	Seymour	0.47	6	3	1	1

Regression Equation

Ratchford Low Flow = 0.044 * Seymour Low Flow + 0.80

Tables from Sections 2 and 3 indicate that low flows do not occur on the same day for these streams and that prediction of low flows for Ratchford Creek from observations on any of the three neighbouring streams will be biased toward high estimates.

These opinions are based on the larger correlation coefficients and regression slope coefficient in Section 2, as compared with those in Section 3.

4. For seven day low flows:

	Linear Correlation Coefficient	Occurrence of Relative Errors in Percent			
		0-10	10-20	20-30	30+
08LE086 Ratchford versus:					
08ND019 Kirbyville	0.42	2	3	1	5
08ND012 Goldstream	0.66	6	2	0	3
08LE027 Seymour	0.79	6	3	1	1

Regression Equation

Ratchford Seven Day Low Flow = 0.28 * Seymour Seven Day Low Flow - 0.23

Seven day low flows for Ratchford Creek are better estimated from Seymour River than are shorter term low flows, but in general low flows are not well correlated and large errors can be expected. In general, larger relative errors are prevalent with low flow estimation than with high flow estimation.

5. Deseasonalized monthly flows from Ratchford Creek were correlated with deseasonalized monthly flows from Seymour River. Deseasonalization was achieved by subtraction of appropriate monthly means. Monthly flows for Ratchford Creek can be estimated from the Seymour River monthly flows with relative errors less than 25% in 80% of the months from 1973 to 1983. Relative errors greater than 50% occur 6% of the time. Large relative errors are restricted to low flow months. The residuals from the correlation of deseasonalized months show a significant lag one autocorrelation, so significant serial effects may remain. The effects of the serial correlation on magnitude of relative errors should not be large.

Monthly flows for Ratchford Creek between January 1973 and December 1977 were estimated from a lumped parametric model using inputs of precipitation and temperature from Revelstoke Airport and snow course data from nearby snow courses. Relative errors less than 25% occurred in 36% of the months and relative errors greater than 50% occurred in 35% of the months. Apparently estimation of monthly flows from nearby streams provide better estimates than the use of meteorological data.

6. To put the results into context with the other stations, a matrix of correlation coefficients for the seven day lows and maxmimum daily flows are included. Apparently the Ratchford correlates about as well with any other station as any other pair of stations, i.e. the correlations with other basins are not outstandingly low, except for 08ND018 Stitt Creek at the Mouth.

Correlation Coefficients

1) Seven Day Low Flow

	Goldstream	Kirbyville	Ratchford	Seymour	Stitt
Goldstream	X	0.85	0.66	0.51	0.58
Kirbyville	0.85	X	0.42	0.79	0.71
Ratchford	0.66	0.42	X	0.79	0.30
Seymour	0.51	0.79	0.79	X	0.54
Stitt	0.58	0.71	0.30	0.54	X

2) Annual Maximum Daily

	Goldstream	Kirbyville	Ratchford	Seymour	Stitt
Goldstream	X	0.68	0.86	0.86	0.50
Kirbyville	0.68	X	0.73	0.90	0.50
Ratchford	0.86	0.73	X	0.94	0.17
Seymour	0.86	0.90	0.94	X	0.32
Stitt	0.50	0.50	0.17	0.32	X

Hypsometric curves indicate that Ratchford Creek has a generally different distribution of elevations and has greater elevations than Kirbyville Creek.

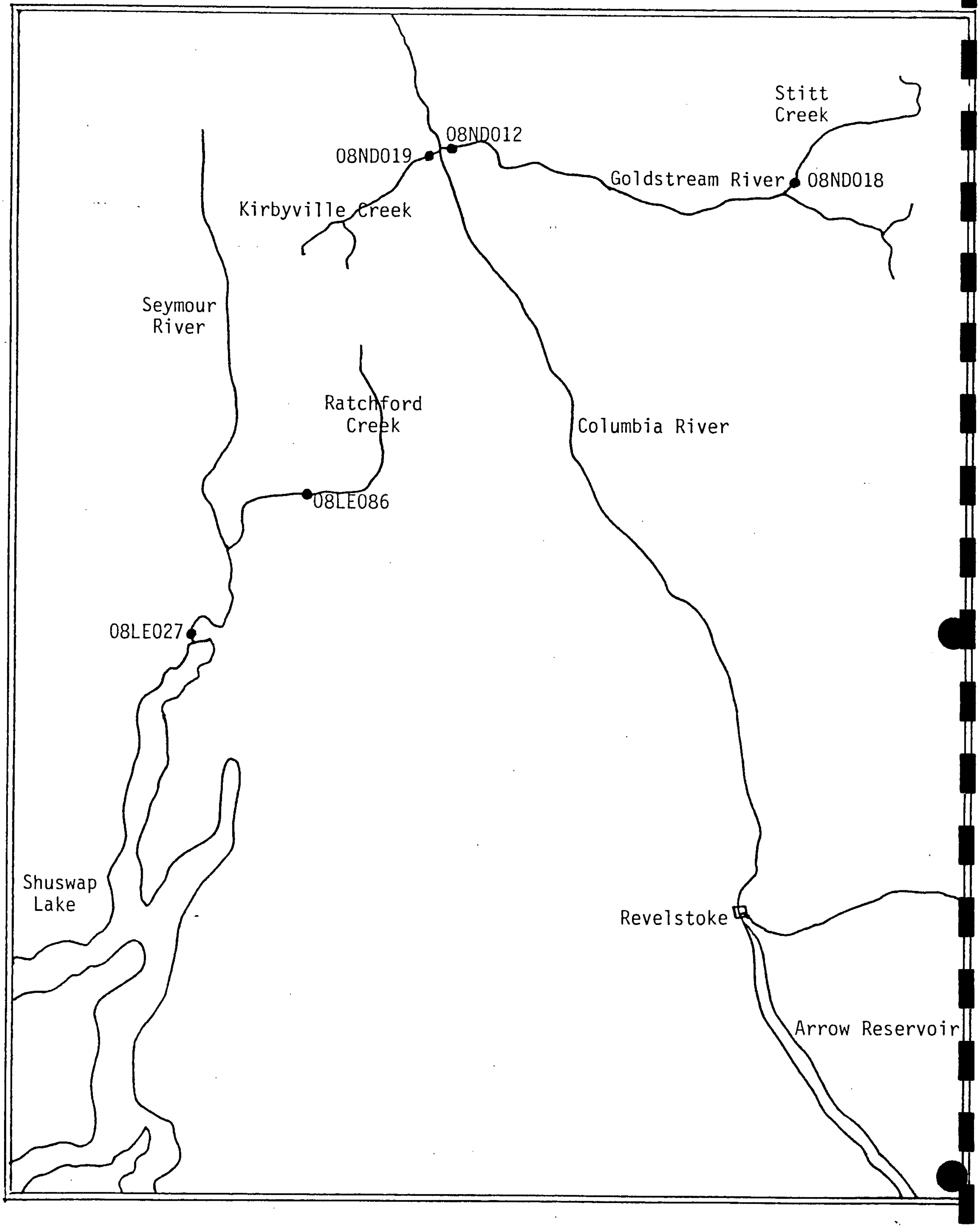
Ratchford Creek has a smaller percentage for any given elevation and has a smaller range than the Seymour River, although the upper ranges of the basins are similar, i.e. Ratchford Creek represents the major upper elevation portion of the Seymour River.

7. Recommendations:

1. Given the pair-wise correlations, there appears to be no compelling reason to re-establish station 08LE086 Ratchford Creek at 600 m Contour.

2. The stage-discharge relation for this basin should be examined. If this station had a very good section then the first recommendation should be re-assessed with regard to operating costs of station 08LE086 relative to nearby stations.

R.M. Leith
Water Resources Branch
Vancouver, B.C.
March 1986



Stations Used in the Evaluation of Station 08LE086 Ratchford Creek at 600 m Contour

Attachment 2

Table of Contents of a Report on

Station Tulameen River at Princeton

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Attachment 3

Examples of Water Quantity Information

Provided by Water Resources Branch

Pacific and Yukon Region

Attachment 3
Item 1

Monthly Averages: 08NP003 Howell Creek

Statistical Summaries of Streamflow Record

Monthly and Annual Mean Discharges

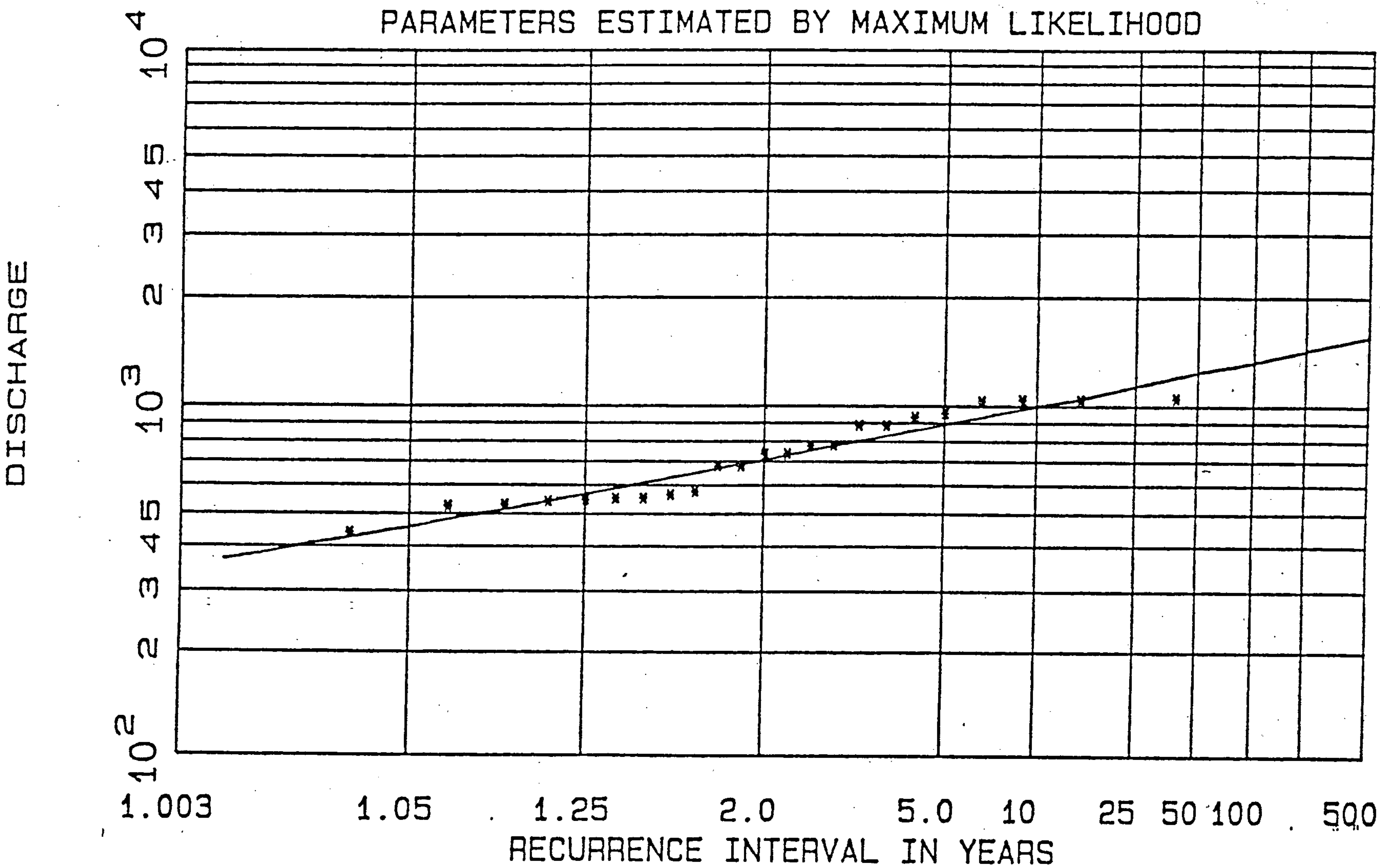
Month	Maximum m^3/sec	Minimum m^3/sec	Mean m^3/sec	Standard deviation m^3/sec	Coefficient of variation in percent	Percent of annual runoff
October	1.23	0.615	0.874	0.201	22.9	2.6
November	1.49	0.469	0.853	0.373	43.6	2.6
December	1.74	0.409	0.703	0.433	61.7	2.1
January	1.65	0.352	0.715	0.474	66.2	2.2
February	0.907	0.417	0.591	0.195	33.0	1.8
March	1.00	0.392	0.596	0.201	33.8	1.8
April	4.34	0.851	2.48	1.15	46.3	7.5
May	12.5	6.26	9.90	1.92	19.4	30.0
June	12.6	5.33	8.98	2.30	25.5	27.2
July	5.60	2.35	4.15	1.28	30.9	12.6
August	2.59	1.39	1.94	0.463	23.9	5.9
September	1.66	0.901	1.27	0.261	20.5	3.7
Annual	3.20	2.26	2.77	0.375	13.5	100

Attachment 3
Item 2

10BC001 COAL RIVER AT THE MOUTH

FLOOD FREQUENCY - LOG PEARSON TYPE III DISTRIBUTION

PARAMETERS ESTIMATED BY MAXIMUM LIKELIHOOD



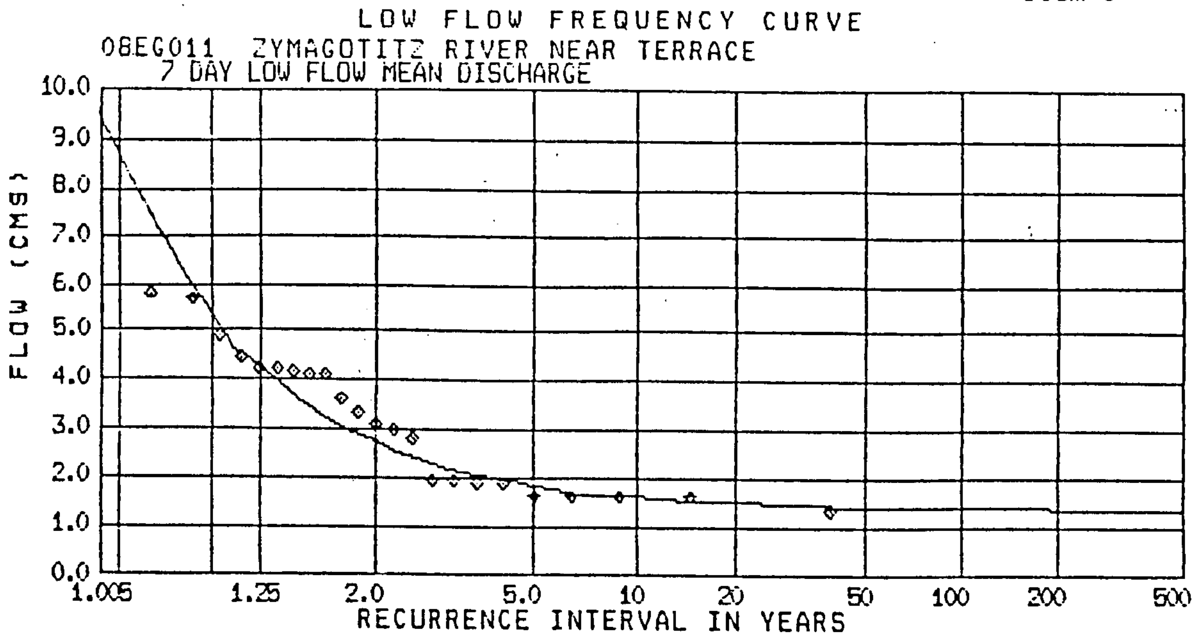
WSC STATION NO=10BC001
WSC STATION NAME=COAL RIVER AT THE MOUTH

MONTH (1)	YEAR (2)	DATA (3) (CMS)	ORDERED (4) (CMS)	RANK (5)	PROB. (6) (%)	RET. PERIOD (7) (YEARS)
6	1962	677.000	1040.000	1	2.59	38.667
6	1963	770.000	1030.000	2	6.90	14.500
6	1964	1030.000	1030.000	3	11.21	8.923
5	1965	564.000	1020.000	4	15.52	6.444
5	1966	552.000	951.000	5	19.83	5.043
5	1967	677.000	925.000	6	24.14	4.143
7	1968	1020.000	875.000	7	28.45	3.515
5	1969	518.000	875.000	8	32.76	3.053
6	1970	552.000	770.000	9	37.07	2.698
6	1971	1030.000	767.000	10	41.38	2.417
5	1972	1040.000	733.000	11	45.69	2.189
6	1973	767.000	730.000	12	50.00	2.000
6	1974	875.000	677.000	13	54.31	1.841
6	1975	875.000	677.000	14	58.62	1.706
6	1976	951.000	575.000	15	62.93	1.589
5	1977	733.000	564.000	16	67.24	1.487
7	1978	527.000	552.000	17	71.55	1.398
5	1979	730.000	552.000	18	75.86	1.318
6	1980	435.000	545.000	19	80.17	1.247
5	1981	540.000	540.000	20	84.48	1.184
5	1982	575.000	527.000	21	88.79	1.126
6	1983	545.000	518.000	22	93.10	1.074
6	1984	925.000	435.000	23	97.41	1.027

Drainage Area: 9190 Sq. Km.

Mean Annual Flood: 735 CMS

Standard Deviation: 197 CMS



PARAMETERS BY MAXIMUM LIKELIHOOD

A= 1.13420 E= 1.3353 U= 3.25369

RETURN PERIOD (YRS)	DROUGHT ESTIMATE (CMS)
1.005	9.687
1.010	8.723
1.110	5.351
1.250	4.254
2.000	2.724
5.000	1.847
10.000	1.599
20.000	1.475
50.000	1.397
100.000	1.369
200.000	1.353
500.000	1.343

08EG011 ZYMAGOTITZ RIVER NEAR TERRACE

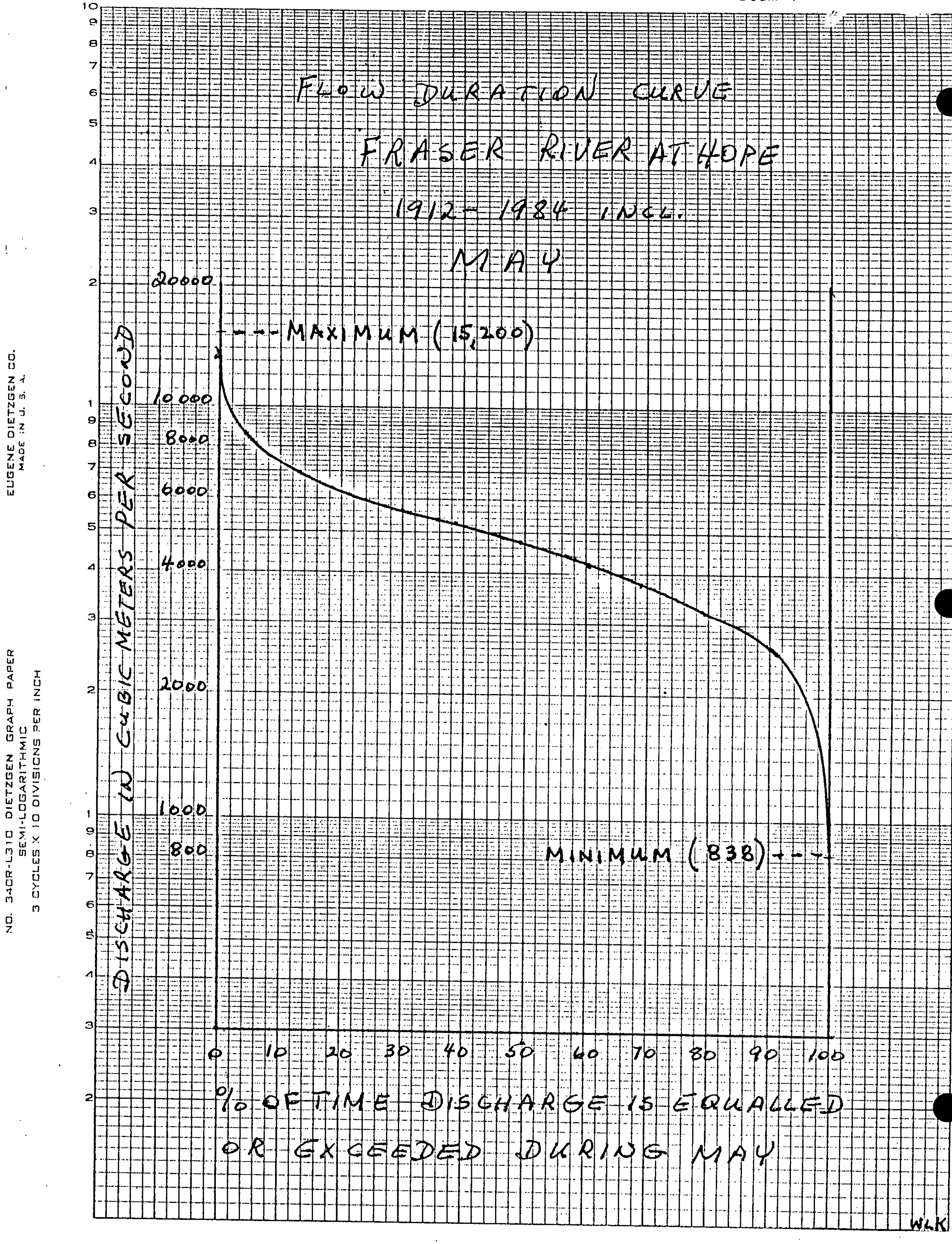
Attachment 3
Item 3

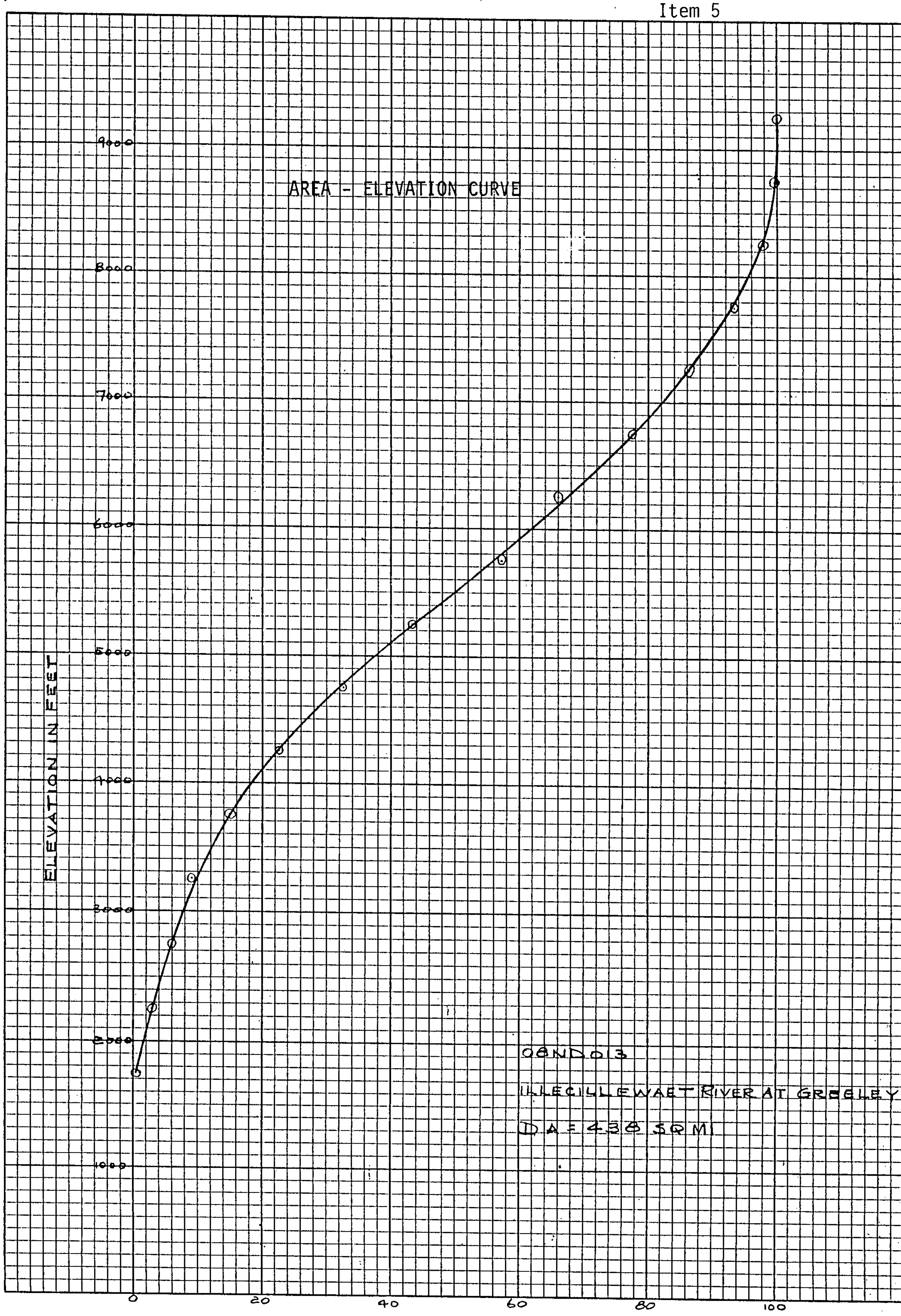
7 DAY LOW FLOW MEAN DISCH. IN PERIOD 1961-1984

STARTING MONTH	YEAR	7 DAY MEAN FLOW (CMS)	ASCENDING ORDER (CMS)	RANK	CUMULAT. PROBABIL. (%)	RETURN PERIOD (YEARS)
3	1961	4.1900	1.3500	1	2.59	38.67
3	1962	4.9300	1.5900	2	6.90	14.50
1	1963	5.7200	1.5900	3	11.21	8.92
4	1965	4.4700	1.6000	4	15.52	6.44
2	1966	1.6400	1.6400	5	19.83	5.04
3	1967	3.0900	1.8900	6	24.14	4.14
1	1968	4.2500	1.8900	7	28.45	3.52
3	1969	1.5900	1.9400	8	32.76	3.05
1	1970	2.9700	1.9900	9	37.07	2.70
2	1971	1.8900	2.8100	10	41.38	2.42
3	1972	1.8900	2.9700	11	45.69	2.19
1	1973	1.5900	3.0900	12	50.00	2.00
3	1974	1.6000	3.2900	13	54.31	1.84
3	1975	1.9900	3.6200	14	58.62	1.71
3	1976	4.0900	4.0900	15	62.93	1.59
1	1977	4.1100	4.1100	16	67.24	1.49
2	1978	1.9400	4.1900	17	71.55	1.40
1	1979	2.8100	4.2500	18	75.86	1.32
2	1980	4.2600	4.2600	19	80.17	1.25
3	1981	5.8400	4.4700	20	84.48	1.18
3	1982	1.3500	4.9300	21	88.79	1.13
1	1983	3.6200	5.7200	22	93.10	1.07
12	1984	3.2900	5.8400	23	97.41	1.03

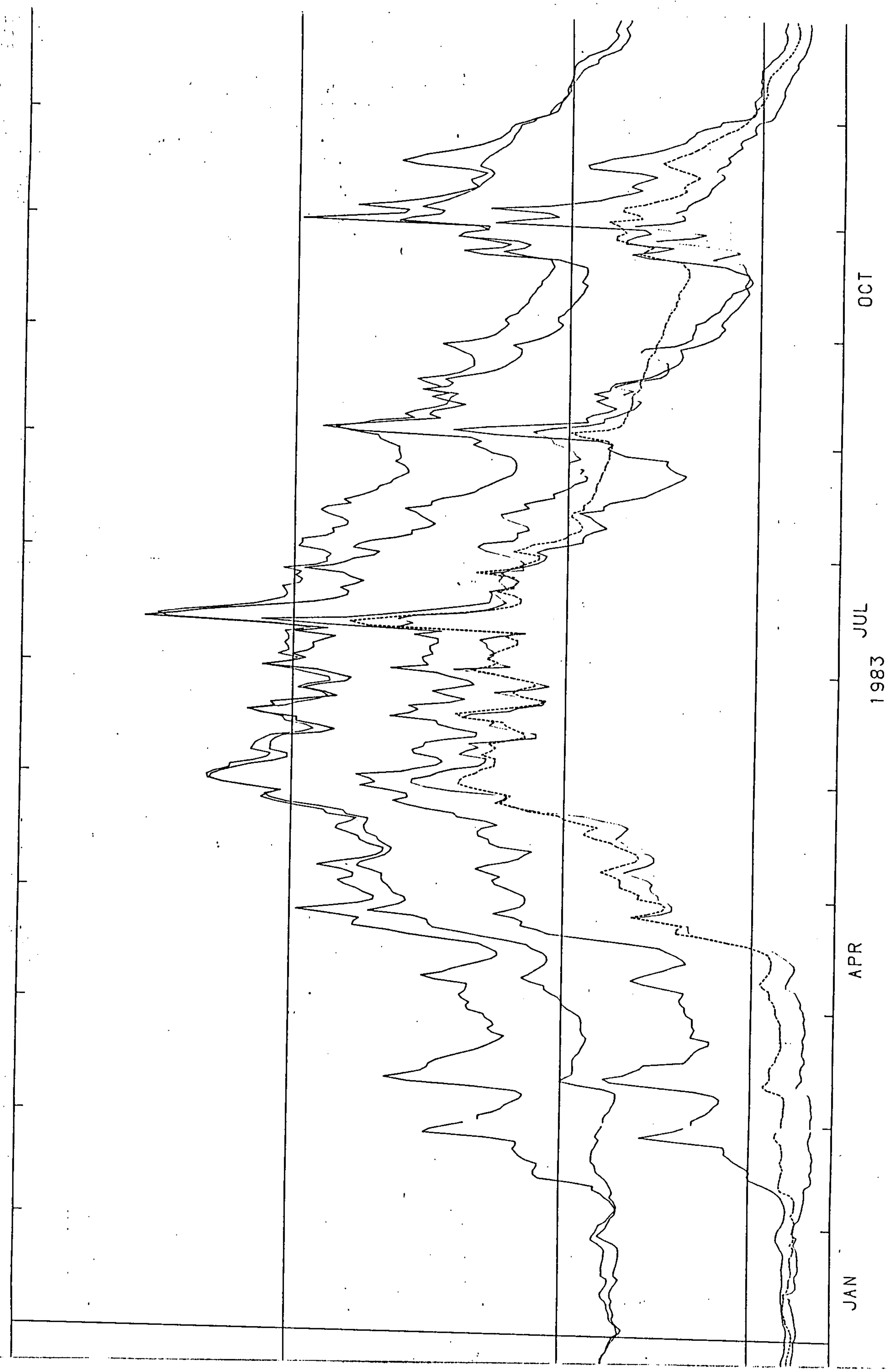
MEAN= 3.18 S.D.= 1.4018 SKEW= 0.3303 C.V.= 0.4409

Drainage Area: 376 Sq. Km.


FLOW DURATION CURVE
FRASER RIVER AT HOPE
1912 - 1984 INCL.
MAY
DISCHARGE IN CUBIC METERS PER SECOND
20000
10000
8000
6000
4000
2000
1000
800
MAXIMUM (15,200)
MINIMUM (838)
0
10
20
30
40
50
60
70
80
90
100
% OF TIME DISCHARGE IS EQUALLED OR EXCEEDED DURING MAY
WLK
NO. 340R-L310 DIETZGEN GRAPH PAPER
SEMI-LOGARITHMIC
3 CYCLES X 10 DIVISIONS PER INCH
EUGENE DIETZGEN CO.
MADE IN U. S. A.


AREA - ELEVATION CURVE
ELEVATION IN FEET
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
20
40
60
80
100
08ND013
ILLECILLEWAET RIVER AT GREELEY
DA = 438 SQ MI

Attachment 3
Item 6



Attachment 3
Item 7

08NL004 - ASHNOLA RIVER NEAR KEREMEOS

SUMMARY OF DISCHARGE MEASUREMENT NOTES

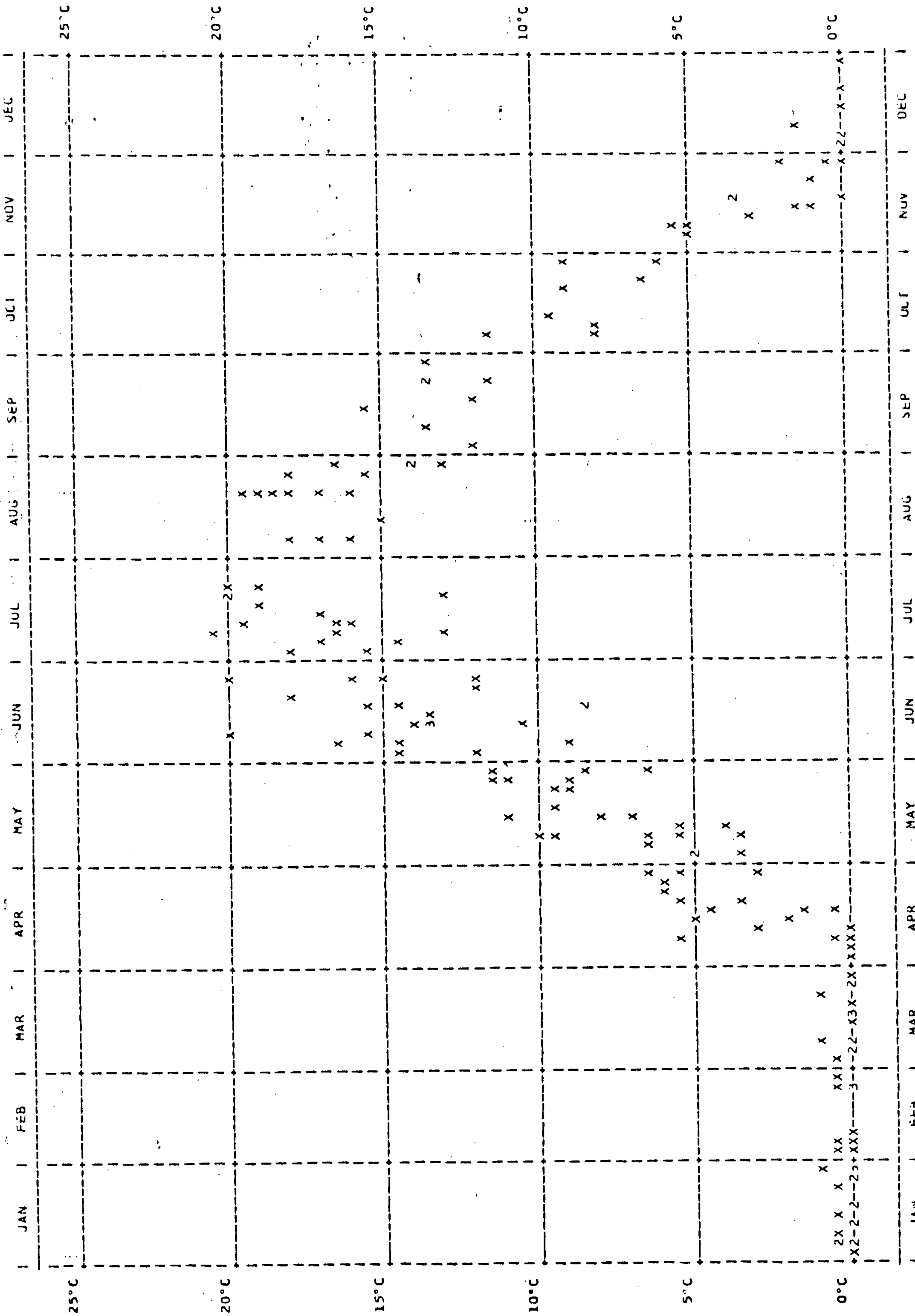
DATE	TIME START	TIME END	WIDTH	AREA	MEAN VELOCITY	MEAN G.H.	FLOW	PTS.	TEMPERATURE AIR	TEMPERATURE WATER	METHOD	DISTANCE A/B GAUGE	REMARKS
3 MAY 1957	09:20	10:20	63.0	176	5.0	5.40	878	20			CABLE	40 FT	
27 JUN 1957	10:35	11:30	38.0	112	3.2	4.35	356	20			CABLE	-40 FT	
7 NOV 1957	15:20	16:20	53.0	70.0	1.1	2.81	74.0	20			WADING	-350 FT	
30 JAN 1958	15:00	16:00	55.0	80.0	0.56	2.61	44.3	20	38 F		WADING	-300 FT	IS
6 MAR 1958	15:10	16:00	55.0	76.0	0.58	2.57	43.9	20			WADING	-600 FT	
28 APR 1958	10:35	11:40	54.0	84.0	0.68	2.71	57.0	20			WADING	-1500 FT	
28 MAY 1958	14:10	15:25	75.0	265	7.8	6.75	2070	20			CABLE	50 FT	
3 JUN 1958	13:30	14:30	64.0	186	5.5	5.60	1030	20	80 F	51 F	CABLE	40 FT	
11 JUL 1958	10:10	11:10	50.0	89.0	2.9	3.97	256	24			CABLE	15 FT	
23 SEP 1958	13:30	15:00	54.0	63.0	0.89	2.70	56.0	24	55 F	47 F		-200 YD	
1 OCT 1958													LEVELS
10 DEC 1958	15:15	16:45	42.0	89.0	0.55	4.19	49.1	20	30 F	32 F	WADING	-1.5 MI	
5 MAR 1959	11:05	11:50	41.0	33.6	1.0	2.70	33.9	20	44 F	34 F	WADING	-1.5 MI	IS
5 JUN 1959	12:30	13:25	78.0	286	8.9	7.10	2540	20	66 F	44 F	CABLE	-40 FT	
9 JUL 1959	10:15	11:34	65.0	171	4.7	5.25	808	20			CABLE		
19 AUG 1959	09:13	10:08	66.0	95.7	1.6	3.32	157	20	65 F	51 F	WADING	500 FT	
16 DEC 1959	13:25	14:25	69.0	98.0	1.6	3.36	160	20	38 F	34 F	WADING	-200 FT	
2 FEB 1960	14:00	14:45	56.0	37.8	1.6	2.85	60.0	20	38 F	32 F	WADING	-1.0 MI	ICE
28 APR 1960			51.0	67.0	2.7	3.42	184	20	48 F	42 F	CABLE		
15 JUN 1960	10:30	11:42	69.0	224	6.2	6.08	1390	20	60 F	46 F	CABLE		
12 AUG 1960	09:18	10:13	55.0	58.0	1.5	2.97	88.0	20	65 F	58 F	WADING	-0.75 MI	
5 OCT 1960	14:30	15:20	46.0	416	0.11	2.66	47.0	20	78 F	50 F	WADING	-0.50 MI	
15 FEB 1961	09:45	10:55	52.0	67.6	0.61	2.54	41.4	23	38 F	36 F		-125 FT	
21 MAR 1961	10:50	22:40	35.0	326	0.14	2.64	46.7	20	43 F	36 F	WADING		
13 APR 1961	10:10	11:03	37.0	36.3	1.5	2.62	56.0	20	58 F	42 F	WADING	-0.50 MI	
16 MAY 1961	15:45	16:35	55.0	97.0	3.6	4.05	345	20			CABLE		
1 JUN 1961	16:15	17:20	78.0	312	9.4	7.40	2920	20	83 F	48 F	CABLE		
27 JUN 1961	13:15	14:10	59.0	129	3.9	4.55	498	20	80 F	52 F	CABLE	50 FT	
9 AUG 1961			4.5	44.5	1.6	2.90	73.0	23	82 F	65 F	WADING	-0.50 MI	
14 SEP 1961	14:45	15:30	44.0	37.4	1.2	2.66	46.0	20	61 F	45 F	WADING	-1.0 MI	
14 DEC 1961	15:30	16:20	21.0	28.4	1.2	3.63	32.8	20	25 F	32 F		-1.0 MI	
16 FEB 1962	11:30	12:15	44.0	41.6	11.8	2.68	489	30	36 F	36 F	WADING	-0.50 MI	
5 APR 1962	09:55	10:45	45.0	53.0	1.3	2.93	67.5	20	58 F	40 F	WADING	-1.0 MI	
9 MAY 1962	15:30	16:25	51.0	71.2	2.7		193	17			CABLE	8 FT	
15 JUN 1962	07:45	08:57	69.0	232	6.5	6.00	1500	20	58 F	46 F	CABLE		
13 AUG 1962	08:45	09:35	49.0	55.0	2.3	3.24	124	20	55 F	47 F	WADING	-1.0 MI	
12 SEP 1962													LEVELS
14 SEP 1962	09:30	10:25	46.0	53.0	1.3	2.72	68.0	20	48 F	48 F	WADING	-1.0 MI	
11 DEC 1962	10:20	11:10	47.0	56.0	1.3	2.76	73.0	20	40 F	34 F	WADING	-0.50 MI	
30 JAN 1963	12:00	12:50	30.0	43.8	0.39	6.10	17.2	20	12 F	32 F	WADING		
11 MAY 1963	12:00	13:00	36.0	47.6	2.6	3.14	124	23	61 F	46 F	WADING	-1.0 MI	
11 JUL 1963	12:10	13:25	65.0	189	5.9	5.62	1120	25	60 F	50 F	CABLE	10 FT	
19 SEP 1963	08:50	10:00	35.0	58.0	2.7	3.36	154	25	54 F	48 F	WADING	-3500 FT	
6 DEC 1963	14:00	15:15	31.0	63.1	1.4	3.55	85.7	22	26 F	33 F	WADING		IS
20 JAN 1964	10:00	11:00	42.0	60.8	1.0	3.21	63.6	21	24 F	33 F	WADING	1.0 MI	ICE
20 APR 1964	11:53	12:35	48.0	67.1	1.5	2.98	102	25	47 F	45 F	WADING	1.0 MI	
6 MAY 1964	11:15	12:25	535	8210	7.3	11.50	60100	20			CABLE	-500 FT	
13 JUN 1964	15:10	16:25	67.0	254	9.7	6.60	2460	20	72 F	49 F	CABLE	30 FT	

Attachment 3
Item 8

1215

NECHAKO RIVER AT VANDERHOOF - STATION NO. 08JC001

SPOT OBSERVATIONS OF WATER TEMPERATURES IN DEGREES CELSIUS



Attachment 3
Item 8

NECHAKO RIVER AT VANDERHOOF - STATION NO. 08JC001

SPOT OBSERVATIONS OF WATER TEMPERATURES IN DEGREES CELSIUS

13 JAN 1956	0	15 MAR 1956	0	26 MAY 1952	11.5	2 JUL 1953	18	24 SEP 1949	13.5	23 NOV 1953	1
28 JAN 1958	1	20 MAR 1957	0	8 MAY 1953	5.5	15 JUL 1953	17	2 SEP 1958	12	16 NOV 1955	0
16 JAN 1959	0	24 MAR 1958	1	24 MAY 1953	9	4 JUL 1956	17	22 SEP 1961	11.5	28 NOV 1956	0
6 JAN 1960	0.5	9 MAR 1961	1	15 MAY 1956	11	24 JUL 1957	19	24 SEP 1962	13.5	12 NOV 1957	3
4 JAN 1961	0.5	27 MAR 1962	0	7 MAY 1957	3.5	10 JUL 1958	19.5	30 SEP 1963	13.5	18 NOV 1957	3.5
23 JAN 1962	0.5	25 MAR 1964	0	10 MAY 1958	4	21 JUL 1958	20	13 SEP 1972	15.5	7 NOV 1958	5
28 JAN 1963	0	5 MAR 1965	0	13 MAY 1960	8	6 JUL 1959	14.5	18 SEP 1973	12	6 NOV 1959	5
31 JAN 1964	0	1 MAR 1966	0.5	26 MAY 1961	11	22 JUL 1959	20	9 SEP 1974	13.5	29 NOV 1962	2
27 JAN 1965	0	31 MAR 1967	0	30 MAY 1962	5.5	21 JUL 1960	20			7 NOV 1963	5.5
14 JAN 1965	0.5	17 MAR 1969	0	29 MAY 1964	8.5	10 JUL 1961	16			28 NOV 1963	0.5
4 JAN 1967	0	16 MAR 1971	0	7 MAY 1965	9.5	9 JUL 1973	16.5			13 NOV 1964	1
31 JAN 1967	0	8 MAR 1972	0	27 MAY 1971	9	10 JUL 1973	16.5			15 NOV 1971	1.5
29 JAN 1969	0	6 MAR 1973	0	2 MAY 1972	3.5	18 JUL 1973	19			17 NOV 1975	3.5
6 JAN 1971	0	13 MAR 1974	0	9 MAY 1973	6.5	3 JUL 1974	15.5				
12 JAN 1972	0	7 MAR 1975	0	2 MAY 1974	5	8 JUL 1975	20.5				
8 JAN 1973	0.5			3 MAY 1974	5	9 JUL 1976	13				
25 JAN 1973	0			13 MAY 1974	7	21 JUL 1976	13				
31 JAN 1974	0			28 MAY 1974	11.5						
10 JAN 1975	0			16 MAY 1975	9.5						
2 JAN 1976	0			22 MAY 1975	9.5						
				4 MAY 1976	6.5						
				7 MAY 1976	10						
				12 MAY 1976	5.5						

24 FEB 1956	0	18 APR 1956	0.5	1 JUN 1953	12	4 AUG 1952	18	23 OCT 1958	6.5	15 DEC 1955	0
24 FEB 1959	0	11 APR 1958	3	6 JUN 1953	16.5	5 AUG 1953	16	6 OCT 1960	11.5	9 DEC 1957	1.5
4 FEB 1960	0.5	7 APR 1960	5.5	16 JUN 1953	15.5	21 AUG 1956	19.5	29 OCT 1962	9	4 DEC 1958	0
24 FEB 1960	0.5	13 APR 1961	5	26 JUN 1953	16	29 AUG 1957	13	4 OCT 1972	8	29 DEC 1958	0
2 FEB 1961	0.5	30 APR 1962	5.5	9 JUN 1958	20	4 AUG 1958	17	9 OCT 1973	8	21 DEC 1961	0
27 FEB 1962	0.5	26 APR 1963	6	26 JUN 1958	20	26 AUG 1958	18	21 OCT 1974	9	3 DEC 1970	0
9 FEB 1971	0	20 APR 1966	5.5	3 JUN 1959	14.5	19 AUG 1960	16	10 OCT 1975	9.5	4 DEC 1973	0
1 FEB 1972	0	7 APR 1972	0.5	12 JUN 1959	14	28 AUG 1962	14	28 OCT 1975	6	1 DEC 1975	0
5 FEB 1975	0	20 APR 1972	3.5	6 JUN 1960	9	29 AUG 1965	16.5				
24 FEB 1976	0	1 APR 1974	0	27 JUN 1963	12	10 AUG 1972	15				
		4 APR 1974	0	13 JUN 1964	13.5	28 AUG 1973	14				
		9 APR 1974	0	9 JUN 1965	15.5	20 AUG 1974	18				
		10 APR 1974	0	17 JUN 1965	14.5	19 AUG 1975	19				
		17 APR 1974	4.5	17 JUN 1966	8.5	20 AUG 1975	18.5				
		24 APR 1974	6	21 JUN 1967	18	21 AUG 1975	17				
		17 APR 1975	1.5	17 JUN 1968	8.5	25 AUG 1975	15.5				
		13 APR 1976	2	5 JUN 1973	14.5						
		28 APR 1976	6.5	10 JUN 1974	13.5						
		29 APR 1976	3	11 JUN 1974	13.5						
				11 JUN 1975	13.5						
				27 JUN 1975	15						
				11 JUN 1976	10.5						
				23 JUN 1976	12						

PHYSIOGRAPHIC PARAMETERS

STATION	BASIN AREA (km^2)	AVE. ELEV. (m)	% OF LAKES (%)	STREAM DENS. (km/km^2)	AVE. SLOPE (m/km)
08NL004	1072	1834	0.4625	1.0535	349.6
08NL007	1850	1557	0.2215	1.0647	321.4
08NL012	593.0	1237	1.386	0.5141	207.1
08NL023	673.0	1205	1.592	0.5717	200.2
08NL024	1760	1342	0.7182	0.5459	250.1
08NL034	127.0	1504	0.1260	0.5393	203.9
08NL036	185.0	1445	0.1512	0.6092	248.9
08NL038	5590	1407	0.6573	0.7102	259.5
08NL050	389.0	1661	0.5906	0.3243	212.3
08NL069	562.0	1718	0.1916	1.0719	373.3
08NL070	407.0	1639	0.2361	1.4293	356.4
08NL071	256.0	1545	0.4839	0.5223	304.5

STATION	MAIN CHANNEL LENGTH (KM)	MAIN CHANNEL SLOPE (M/K)
08NL024	71.5	12.7
08NL023	52.5	6.17

FLOOD ESTIMATES FROM PROBABILITY DISTRIBUTIONS

Station Number	River or Creek	Return Period in Years	Generalized Extreme Value	Three Parameter Lognormal	Log Pearson III	Wakeby	Weibull
09AA011	Tagish	50	4.2	4.2	4.6	4.8	
		100	4.8	4.8	5.5	5.9	
		200	5.4	5.4	6.6	7.1	
09AC004	Takhini	50	286	303	291	300	
		100	298	321	305	309	
		200	307	339	318	315	
09AC001	Takhini	50	398	398	395	408	
		100	440	436	435	479	
		200	484	476	477	568	
09AE001	Teslin	50	1830	1870	1860	1910	
		100	1990	2040	2030	2100	
		200	2150	2220	2210	2280	
09AF001	Teslin	50	2020	2120	2070	2120	
		100	2180	2320	2260	2260	
		200	2340	2510	2460	2390	
10AA002	Tom	50	31	33	38	33	34
		100	32	34	40	38	35
		200	33	35	42	46	37
09AA009	Watson	50	48	52	53	54	
		100	51	57	58	60	
		200	54	62	62	66	
09AA012	Wheaton	50	83	83	83	90	
		100	89	89	88	102	
		200	94	95	94	115	

Station Number	River or Creek	Return Period in Years	Gumbel III
08KH001	Quesnel	2	28.06
		5	20.20
		10	17.01
		20	14.92
		50	13.14
		100	12.26
08KH006	Quesnel	2	50.37
		5	38.80
		10	34.52
		20	31.90
		50	29.84
		100	28.90
08HD005	Quinsam	2	1.730
		5	1.460
		10	1.320
		20	1.209
		50	1.091
		100	1.020
08GA020	Rainy	2	.3646
		5	.1396
		10	.0681
		20	.0289
		50	.0017
08LE086	Ratchford	2	.8231
		5	.5800
		10	.5269
		20	.5049
		50	.4935
		100	.4902
08NJ061	Redfish	2	.1062
		5	.0889
		10	.0828
		20	.0792
		50	.0765
		100	.0754

Station Number	River or Creek	Return Period in Years	Gumbel III
08EE009	Richfield	2	.0424
		5	.0213
		10	.0138
		20	.0094
		50	.0059
		100	.0044
08GA047	Roberts	2	.0729
		5	.0563
		10	.0475
		20	.0402
		50	.0325
		100	.0276
09AB001	Ross	2	5.623
		5	4.500
		10	3.959
		20	3.554
		50	3.155
		100	2.927
08GA023	Rubble	2	3.031
		5	2.623
		10	2.495
		20	2.415
		50	2.356
		100	2.330
08MG006	Rutherford	2	1.724
		5	1.034
		10	0.7622
		20	0.5865
		50	0.4401
		100	0.3698
08FB004	Salloomt	2	2.129
		5	1.447
		10	1.225
		20	1.100
		50	1.012
		100	0.9762

*Flow affected by regulation or diversion
**Distribution will not fit data

ABSTRACT

The mean annual flood has been regressed on certain physiographic parameters and climatological variables for 144 stations in seven regions of British Columbia. The prime objective of this study was to examine regression as a tool for regionalization. If distinct regression equations could be produced for each region then regionalization would be considered effective and three results could be achieved:

1. a means of evaluating the present network,
2. identification of important physiographic parameters,
3. a means of estimating mean annual flood for ungauged basins.

Distinct equations were developed. The best equations for Mean Annual Flood, M.A.F., for each region are listed below. In this context, best equation means the last equation produced by backward elimination of variables. The units of Mean Annual Flood are cubic feet per second, cfs.

Cranbrook Region
M.A.F. = 0.1448×10^5 - 144.0 x RA FOR + 0.2131 x TB PRE

Kamloops-Merritt Region
M.A.F. = 2890. - 1.425 x AREA - 0.1434 x ELEV - 1.601 x DS W - 13.19 x RA FOR + 0.1313 x TB PRE

Prince George Region
M.A.F. = 584.2 + 166.4 x RA GLC + 0.2047 x TB PRE

Princeton-Penticton Region
M.A.F. = 5983. - 6.090 x DS N + 0.1606 x SE N - 33.48 x MA PRE + 0.1697 x TB PRE

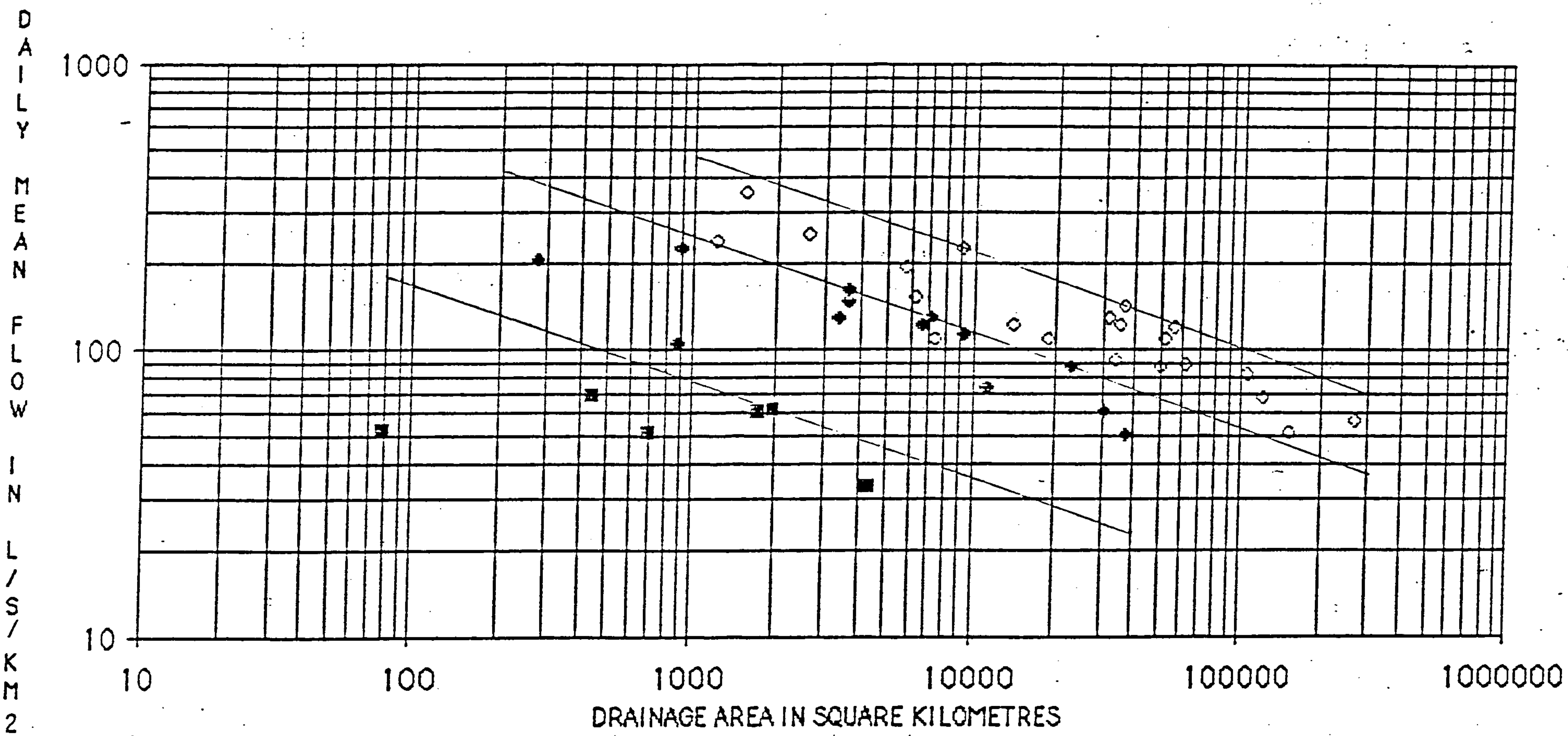
Revelstoke Region
M.A.F. = 4516. + 16.94 x AREA + 139.4 x RA FOR - 0.5191 x 10^5 x RA SWP - 0.3522 x SE N

Vancouver Region
M.A.F. = 572.3 + 13.67 x AREA + 36.19 x SLP %

Windermere Region
LOG (M.A.F.) = 9.490 + 1.019 x LAREA - 1.086 x LELEV - 1.544 x LBH W + 0.4822 x LSS NE - 0.4342 x LSS E + 0.4750 x LMA PRE

The equations were developed by backward elimination of variables and were tested by plotting residuals and with split samples.

ENVELOPE CURVE OF EXTREME FLOODS IN YUKON TERRITORY AND NORTHERN BRITISH COLUMBIA

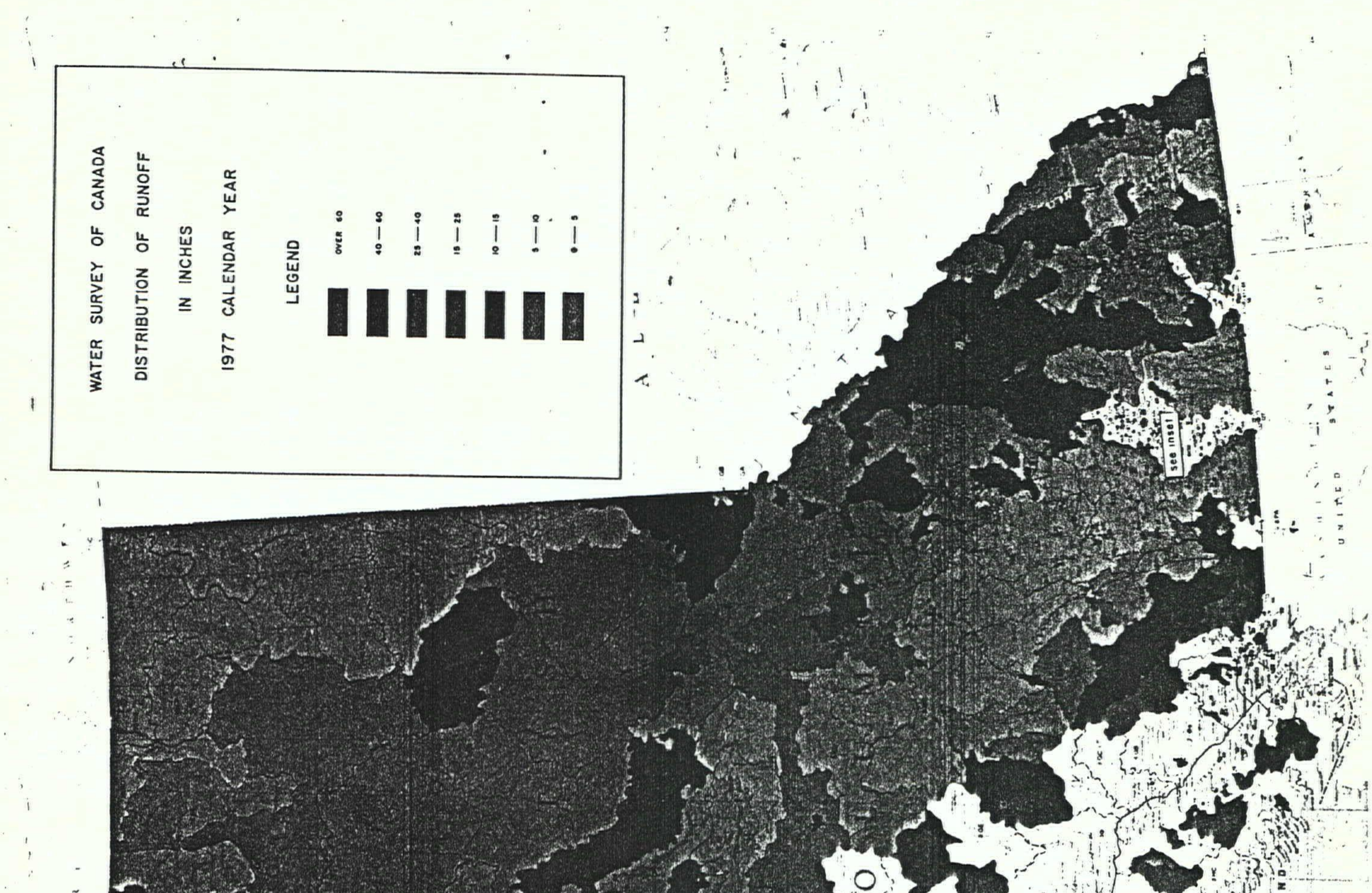


LEGEND

◇ Northern Yukon & Selwyn Mountains $q = 7950A^{-0.35}$

◆ Plateau Mountains $q = 2560A^{-0.35}$

■ Plateau $q = 890A^{-0.35}$


WATER SURVEY OF CANADA
DISTRIBUTION OF RUNOFF
IN INCHES
1977 CALENDAR YEAR
LEGEND
OVER 60
40 — 60
25 — 40
15 — 25
10 — 15
5 — 10
0 — 5
see inset
QUEEN CHARLOTTE SOUND
VANCOUVER ISLAND
QUEEN CHARLOTTE ISLANDS
UNITED STATES
PACIFIC
SIMILKAMEEN

08NP004 Cabin Creek

Probability of Annual Low Flows

Non exceedance probability in percent	Lowest Average Flow in Cubic Metres per Second						
	Consecutive Days						
	1 day	3	7	14	30	60	90
	CALENDAR YEAR JAN 1 - DEC 31						
1	0.115	0.125	0.130	0.160	0.160	0.180	0.188
2	0.132	0.140	0.148	0.180	0.180	0.200	0.210
5	0.155	0.160	0.172	0.205	0.210	0.235	0.250
10	0.175	0.180	0.195	0.230	0.235	0.265	0.285
20	0.195	0.200	0.225	0.260	0.265	0.300	0.330
50	0.235	0.235	0.275	0.310	0.310	0.365	0.400
	WATER YEAR OCT 1 - SEPT 30						
1	0.115	0.120	0.125	0.130	0.130	0.150	0.165
2	0.130	0.138	0.140	0.150	0.150	0.170	0.185
5	0.156	0.162	0.170	0.180	0.180	0.200	0.225
10	0.180	0.185	0.192	0.202	0.210	0.230	0.255
20	0.205	0.212	0.225	0.230	0.245	0.270	0.295
50	0.255	0.262	0.280	0.290	0.305	0.330	0.370

08NP004 Cabin Creek

Probability of Annual High Flows

Exceedance probability in percent	Highest Average Flow in Cubic Metres per Second Consecutive Days						
	1 day	3	7	15	30	60	90
	CALENDAR YEAR JAN 1 - DEC 31 or WATER YEAR OCT 1 - SEPT 30						
50	16.0	15.5	14.0	11.5	9.4	7.2	5.6
20	18.8	18.0	16.8	13.8	10.8	8.6	6.6
10	20.5	20.0	18.5	15.2	12.0	9.5	7.2
4	23.5	22.5	21.5	18.0	13.2	11.0	8.3
2	26.0	25.0	24.0	20.0	14.5	12.0	9.0
1	28.0	27.5	26.5	22.0	16.0	13.4	10.0

Magnitude and Probability of Instantaneous Peak Flow
Based on Period of Records
Discharge in m^3/sec for Indicated Recurrence Interval, in Years
and Annual Exceedance Probability, in Percent

1.25 80%	2 50%	5 20%	10 10%	25 4%	50 2%	100 1%
19	21	24	26.5	30	33	36

Attachment 4

Station Profile

Station Information compiled by: W.L. Kreuder

Date: August 18, 1986

A. STATION IDENTIFICATION

1. Station Number and Name
   08NL024 Tulameen River at Princeton
2. Hydrologic Region
   08NL Similkameen River
3. Tributary to
   Similkameen River
4. Latitude
   49°27'27"
   Longitude
   120°31'05"
5. National Topographic Map
   92H/7 East
6. Elevation of Station
   2200 feet, 671 metres

B. BASIN DESCRIPTION

11. Channel Length (Station to Divide)
    72 km
12. Channel Slope
    12.7 metres per kilometre
13. Drainage Area
    1760 km^2
14. Storage (Area of Lakes and Swamps) as Percentage of Drainage Area
    0.72%
15. Mean Basin Elevation (2 km X 2 km)
    1342 metres
16. Basin Steepness (2 km X 2 km)
    250 m/km (Horton)
17. Average Basin Slope (2 km X 2 km)
    131 m/km (Solomon)
18. Basin Shape (D.A. divided by Channel Length)
    24 km^2/km
19. Stream Density
    0.5 km/km^2

C. DISCHARGE RECORDS

21. Period of Record
1950-1973 (manual gauge) 1974-Present (recorder)

22. Maximum Instantaneous Discharge and Date
343 m^3/sec December 24, 1980

23. Maximum Mean Daily and Date
374 m^3/sec May 30, 1972

24. Minimum Mean Daily and Date
0.991 m^3/sec December 17, 1964

25. Annual Mean Discharge (Period of Record)
22.9 m^3/sec (1952-1984)

26. Monthly Mean Discharge and % of Annual Flow

January	7.65 m^3/sec	2.7%
February	6.30	2.3
March	7.53	2.7
April	22.6	8.1
May	93.9	33.5
June	85.7	30.6
July	22.0	7.9
August	5.3	1.9
September	4.37	1.6
October	6.73	2.4
November	9.09	3.2
December	8.33	3.0

27. Natural or Regulated Flow
Small amount of irrigation diversion; regulation on Otter Lake not significant.

D. STREAMFLOW CHARACTERISTICS

31. Annual Mean Daily Peak Flows in m^3/sec

Period of Record (1951 - 1984)

Mean 200

Maximum 374

Minimum 92

Standard Deviation 60.5

50 Year Flood (Log Pearson III) 348

100 Year Flood 376

200 Year Flood 404

32. Annual 7-day Mean Daily Low Flows in m /sec

Period of Record (1952-1983)

Mean 2.31

Minimum 1.13

Maximum 5.97

Standard Deviation 1.01

50 year Drought (Gumbel III) 1.17

100 Year Drought 1.15

200 Year Drought 1.10

E. ADDITIONAL INFORMATION

Flow duration data, station evaluation report, flood frequency curve, 7-day low flow frequency curve, area-elevation curve.