CANADA

FLOOD FREQUENCIES

OF

NOVA SCOTIA STREAMS

TECHNICAL BULLETIN No. 4

A. COULSON

WATER RESOURCES BRANCH

DEPARTMENT OF ENERGY, MINES AND RESOURCES

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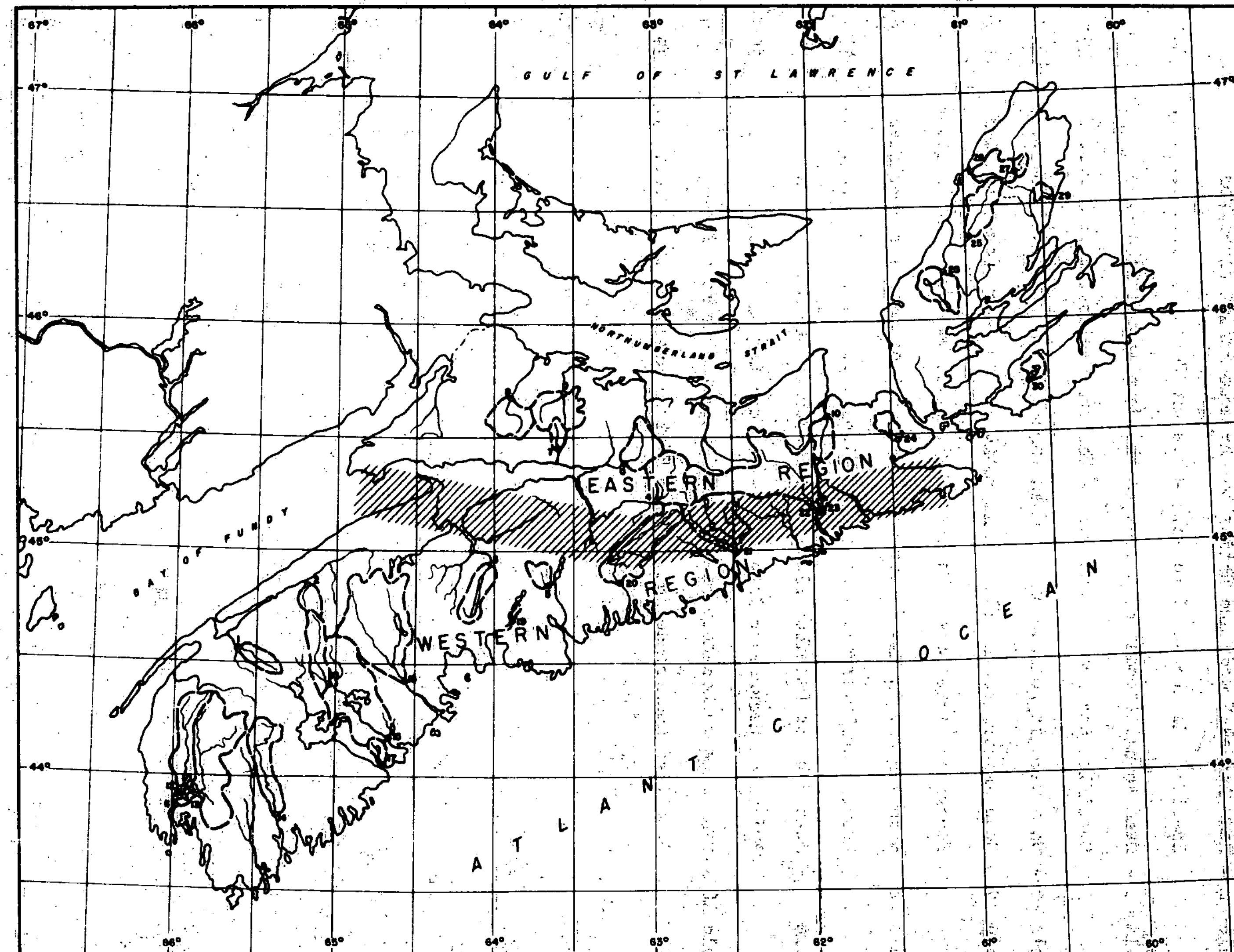

Figure 1 Gauging Stations and Flood Frequency Regions

KEY NO.	INDEX NO.	GAUGING STATION	DRAIN. AREA (SQ. MI.)
1	1DB-2	BEAR RIVER (EAST BRANCH) AT BEAR RIVER	74·7
2	1DC-3	PARADISE BROOK NEAR PARADISE	36·5
3	1DE-1	ST. CROIX RIVER AT HARTVILLE	88·2
4	1DG-1	STEWIAKE RIVER AT UPPER STEWIAKE	155
5	1DG-3	RAWDON RIVER AT KINSAC	37·4
6	1DH-1	SALMON RIVER AT VALLEY	122
7	1DJ-1	GREAT VILLAGE RIVER NEAR GREAT VILLAGE	37·3
8	1DN-2	PHILIP RIVER NEAR PHILIP RIVER P.O.	88
9	1DN-3	WALLACE RIVER AT HOWARDS MILL	152
10	1DR-1	SOUTH RIVER AT ST. ANDREWS	68·5
11	1EA-1	TUSKET RIVER AT TUSKET FALLS	561
12	1EA-2	TUSKET RIVER AT REYNARDS BRIDGE	130
13	1EA-3	TUSKET RIVER AT WILSON'S BRIDGE	413
14	1EC-1	ROSEWAY RIVER AT LOWER OHIO	191
15	1EE-1	MEDWAY RIVER AT CHARLESTON	535
16	1EE-2	MEDWAY RIVER AT HARMONY MILLS	132
17	1EE-3	HERRING COVE BROOK NEAR BROOKLYN	23·0
18	1EF-1	LAHAVE RIVER AT WEST NORTHFIELD	484
19	1EH-3	EAST RIVER AT ST. MARGARETS BAY	10·4
20	1EK-1	MUSQUODOBOIT RIVER AT CRAWFORD'S FALLS	251
21	1EM-1	EAST RIVER NEAR SHEET HARBOUR	203
22	1EO-1	ST. MARY'S RIVER AT STILLWATER	523
23	1EO-2	ARCHIBALD BROOK AT STILLWATER	19·0
24	1ER-1	CLAM HARBOUR RIVER NEAR BIRCHTOWN	17·4
25	1FB-1	NORTHEAST MARGAREE RIVER AT FRIZZLETON	142
26	1FB-3	SOUTHWEST MARGAREE R. NEAR UPPER MARGAREE	138
27	1FC-1	CHETICAMP RIVER NEAR CHETICAMP LAKE	19·0
28	1FC-2	CHETICAMP RIVER ABOVE ROBERT BROOK	92
29	1FD-1	WRECK COVE BROOK NEAR WRECK COVE	10·7
30	1FH-1	GRAND RIVER AT LOCH LOMOND	46·4

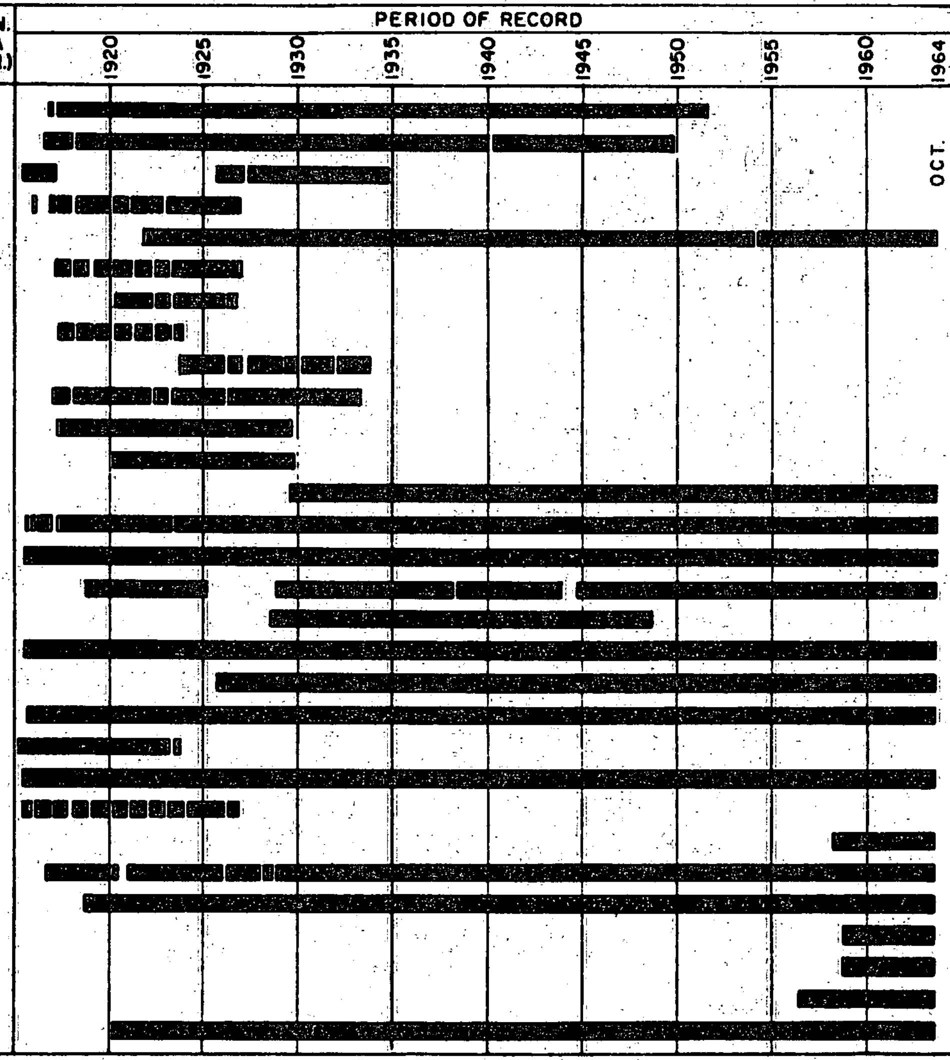

Table 1 – Inventory of data used to define Regional Flood Frequency relations

FLOOD FREQUENCIES

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NOVA SCOTIA STREAMS

Introduction

Flood flows can be both damaging and beneficial. A flood flow which reaches a stage high enough for water to cover lands outside the normal channel boundaries can cause extensive property damage and loss of both animal and human life. On the other hand, if the flood water can be controlled and the water stored in a reservoir, it may be released after the flood period to augment low flows for beneficial purposes.

Reduction in flood damage by prevention of flooding is the principal justification for a flood control project. A statistical analysis of the frequency of floods is required in order to estimate flood control benefits and it is therefore an important part of a comprehensive study of flood flows.

A statistical analysis of floods also yields useful information for the design of permanent or temporary control works, both large and small. The final design will often be dictated by how much expenditure can be justified to achieve the desired purpose. The decision as to how much may be spent should always be tempered by a knowledge of the odds against the success of the project. For instance, the height of a cofferdam which will be in existance for only a short time will be decided after consideration of the construction costs for various heights, the chances of each height being overtopped, and the damage which will be caused should the cofferdam fail. The design of a bridge will depend on an analysis of the construction costs of various types of bridges, the probability of their being washed-out, and the resulting replacement cost. The probability of a spillway being able to pass the flood flows expected during the life of a dam should be known before the spillway design is accepted. If the dam is to be of such a size and in such a location that the consequences of its failure would be catostrophic, then the spillway should be designed to pass safely the largest flood expected on the stream. Thus an analysis of floods which yields recurrence intervals of "design" floods, maximum possible floods or floods of any other magnitude is useful in the justification and design of many types of projects of many degrees of importance.

The destructive power of floods can be controlled and the flows harnessed for beneficial purposes if the topography lends itself to reservoir development. If the flood wave can be trapped and stored in a reservoir, not only will downstream flood damage be prevented but, also, the water can be released after the flood period for the generation of power, or for irrigation purposes, pollution control and so on. A knowledge of the volume of flood water and the shape of the flood hydrograph is thus desirable, in addition to a knowledge of the magnitude of the flood peak.

In order to provide data useful as a starting point in specific studies of problems of the type discussed above, a comprehensive study of streamflow and hydrometeorological data associated with the magnitude and frequency of flood flows in the streams of Nova Scotia has been undertaken on a cooperative basis by the Nova Scotia Power Commission, the Meteorological Service of Canada and the Water Resources Branch. This report presents the results of one section of the comprehensive study - the section on flood frequency. Recorded flood flows have been analysed on a regional basis and a method for estimating the flood frequency curve for any stream in the Province is outlined.

Various procedures have been used from time to time in the analysis of streamflow records to determine the probable frequency or recurrence interval of floods of a given magnitude. However, regardless of which procedure may be adopted, it does not alter the fact that the hydrometric record for a single gauging station is only a sample of the long-term runoff conditions at the site. Any of the various methods of flood frequency analysis of such a record, regardless of its relative merit, is subject to the same sampling error. Although the sampling error decreases with the length of the record, it has been demonstrated (Benson 1952) that periods of record up to 25 years cannot define satisfactorily even short-term floods.

The hydrologist is seldom fortunate enough to have long-term records available to him for study at his point of interest on a stream. However, estimates of flood frequency may often be obtained by a regional flood frequency analysis when long-term records are lacking. Furthermore, Dalrymple (1960) has demonstrated that a frequency curve derived by the combination of short-term records from a number of gauging stations in a homogeneous region tends to be more reliable than one based on a record of 25 years or less from a single station.

The prerequisite for the regional approach is the existence of streamflow records at current or discontinued gauging stations in the basin, or in adjacent basins with similar precipitation and runoff characteristics. In Nova Scotia, streamflow records are available from 51 gauging stations distributed throughout the Province; the periods of record vary from a few months to 48 years (up to 1963). Twenty-one streams with excessive artificial regulation or with periods of record of less than five years were not considered useful for flood frequency analysis and were discarded. The remaining thirty stations are shown on the bar graph in Table 1 and their locations indicated on Figure 1.

Regional flood frequency curves have been developed for two regions within the

Provinces. They are presented in this report together with some of the data upon which the analyses were based. The derivation of the regional curves is described and the reliability of the results discussed.

Single-station Analyses of Annual Floods

The first step in a regional flood frequency analysis is the construction of an individual frequency curve for each of the stations in the region. In this study it was decided to derive confidence limits for the regional curve and, therefore, some mathematical distribution had to be assumed for the frequency curves. The work of E. J. Gumbel, as described by Kendall (1959), has been followed and the annual floods have been assumed to fit the first asymptotic distribution of extreme values.

A typical single-station frequency curve with its 95 per cent confidence limits is shown in Figure 2. This curve is for the 48 years of record, from 1916 to 1963, on the St. Mary's River at Stillwater. Similar frequency curves with their corresponding confidence limits were computed for each of the 18 stations in Nova Scotia having periods of record of 10 years or more.

The annual flood was defined for the purpose of this study as the maximum mean daily flow occurring in the 12-month period June 1 to May 31. The maximum mean daily flow was chosen, rather than the instantaneous maximum, because the instantaneous peak is not available for the whole period of record at most of the stations. The period June 1 to May 31 was selected to minimise the possibility that a single flood would overlap the end of one period and the beginning of the next.

Although it was considered impractical to derive frequency curves by the Gumbel

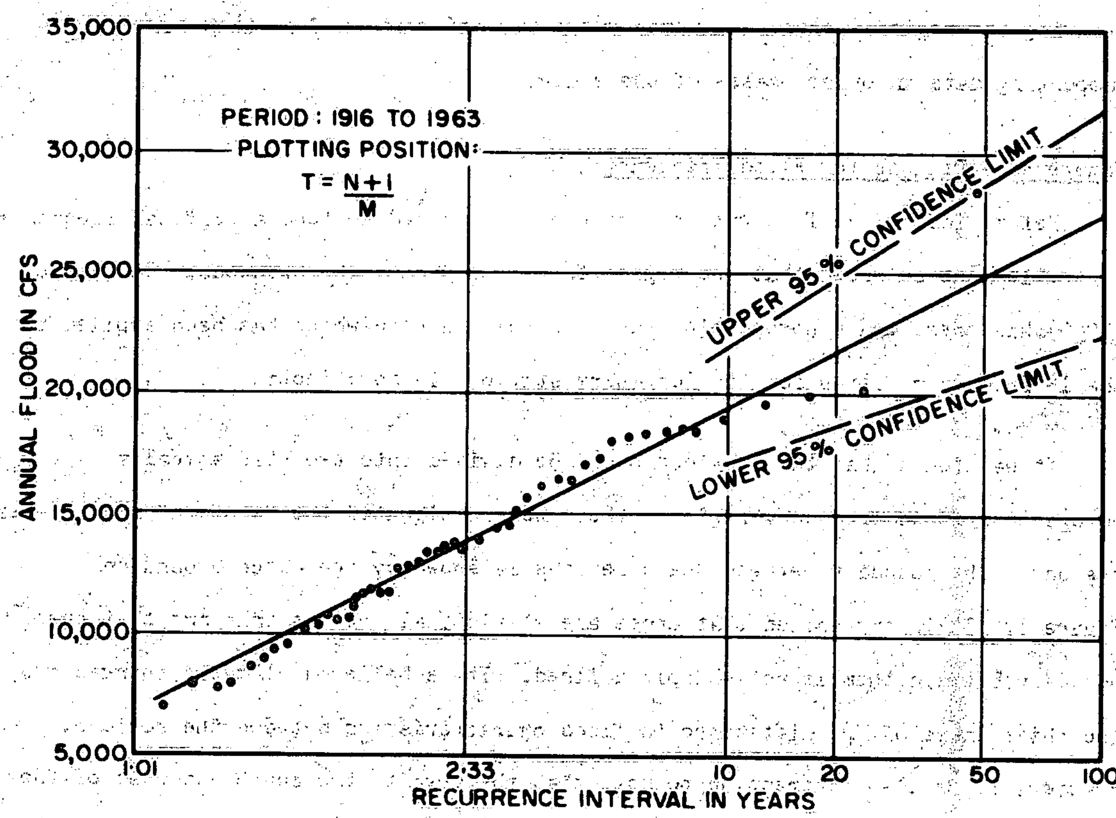

Figure 2 - Frequency Curve of Annual Floods for St. Mary's River at Stillwater

method for the 12 stations with less than 10 years of record, it was recognized that these records contributed additional useful information. Therefore, the records were extended to a common base period, by correlation with longer records from neighbouring stations. Frequency curves were drawn from the extended records by the methods described by Dalrymple (1960). These curves were not used in deriving the regional flood frequency curve but information from them was used as supporting data in other phases of the study.

Homogeneous Regions for Flood Frequency

Before individual frequency curves can be combined to form a regional frequency curve, it must be shown that the region they represent is homogeneous. Dalrymple (1960) has presented a homogeneity test for this purpose which has been applied to the 18 frequency curves for the long-term stations in Nova Scotia.

It was found that the Province could be divided into two statistically homogeneous flood frequency regions; these were designated the "western" and "eastern" regions. The boundary between these regions is shown by the hatched band on Figure 1. It is emphasized that these are statistical regions only and that the boundary between them is not sharply defined. It is believed climatic changes are the chief cause of the difference in flood characteristics between the regions. However, it is also interesting to note that the area to the south and west of the boundary is composed almost entirely of hard rocks (granite, slate and quartzite) while the area to the north and east is composed of soft rocks (sandstone, limestone, conglomerate and shale) with some outcroppings of granite.

The homogeneity tests for the two regions are shown in Figures 3 and 4. The data for the graphs are tabulated in Tables 2 and 3. Although the twelve short-term records were not used in the delineation of the two homogeneous regions, further verification of homogeneity within each region was obtained by incorporating the data from the short-term stations in subsequent tests. The thirty long- and short-term stations were divided into two groups, each group containing all the stations in one or other of the two selected regions. Homogeneity tests on each of the two groups were successful.

Regional Flood Frequency Curves

The regional flood frequency curve for a homogeneous region is assumed to be the mean of the frequency curves for the individual stations in the region. The effect of the varying size of the catchment area must be removed and the individual curves reduced to dimensionless form before they are combined. This is achieved by expressing the floods for given recurrence intervals in terms of ratios to the mean annual flood at the site. The mean of these ratios from each of the sites for any given recurrence interval is taken as the ratio for that recurrence interval for the regional curve. The concept is based on the assumption that the slope of the flood frequency curve is uniform throughout the region and that the variations in the slopes of the individual curves, which are derived from limited periods of record, are due to sampling errors only.

Regional curves for the two selected homogenous regions in Nova Scotia were derived in the manner described above. The data are listed in Tables 4 and 5 and the curves are shown in Figures 5 and 6.

Confidence Limits for the Regional Curves

The confidence limits for each regional curve were computed by combining the confidence limits for the individual frequency curves in the region. Figure 7 illustrates the frequency curve for the St. Mary's River at Stillwater. At a recurrence interval of 10 years the flood and the confidence limits are:

$$Q_{10} = 19{,}580 \text{ cfs} = 1.405\, Q_{2.33}$$

$$\text{Upper confidence limit} = 22{,}040 \text{ cfs} = 1.58\, Q_{2.33}$$

$$\text{Lower confidence limit} = 17{,}120 \text{ cfs} = 1.23\, Q_{2.33}$$

If E_1 is defined as the error in Q_{10} for the St. Mary's River station which will not be exceeded at 95 per cent confidence, the value of E_1 expressed as a ratio to the mean annual flood is given by:

$$E_1 = 1.58 - 1.405 = 1.405 - 1.23 = 0.175$$

Similarly, values of E_2, E_3 ... E_N, the errors in Q_{10} for the remainder of N individual frequency curves may be computed. The mean of the values of Q_{10} expressed as ratios to $Q_{2.33}$, gives the required value of Q_{10} for the regional curve. The value of E_R, the error in Q_{10} for the regional curve at 95 per cent confidence, may be computed from the central limits theorem as:

$$E_R = \sqrt{\frac{E_1^2 + E_2^2 + \ldots + E_N^2}{N}} \qquad (1)$$

The 95 per cent confidence limits for the regional curves were derived in this way for a recurrence interval of 10 years. The 95 per cent confidence bands shown in Figures 5 and 6 were produced by repeating the computations for several other recurrence intervals.

Figures 8 and 9 again show the regional curves with their confidence limits superimposed on the individual frequency curves for the respective regions.

An interesting illustration of the reliability of the regional curve is shown in Figure 10. The curve for station 19 is compared with the regional curve for the western region. The regional curve falls well within the confidence limits for the curve of station 19 and thus there is no reason to reject the hypothesis at the five per cent level that the regional curve is the true curve for station 19 and that the difference between the two is due to sampling error only. Station 19 was chosen for this illustration because it lies farthest from the regional curve. The same argument could be developed for any of the other stations in either region.

Mean Annual Flood

The magnitude of a flood of a given recurrence interval in a particular basin cannot be read directly from the regional curves given in Tables 4 and 5. The ratio of the magnitude of the required flood to the mean annual flood is determined from the appropriate regional curve. It is then necessary to determine the mean annual flood at the point of interest before the magnitude of the required flood can be computed.

The mean annual flood is dependent on many factors, including drainage area, precipitation, land and stream slopes, land use, geology, natural storage in river channels, lakes and swamps, the shape of the basin and its position relative to the direction of storm travel. It is virtually impossible to assess the affect of all these factors when estimating the mean annual flood. However, numerical values may be assigned to some of them and multiple correlations may be carried out to determine their significance and to relate the mean annual flood to those that are particularly significant.

For this study, stepwise linear multiple regressions were run on a computer using, as independent variables, values corresponding to the following factors:

(a) drainage area,

(b) size and location of lakes relative to drainage area,

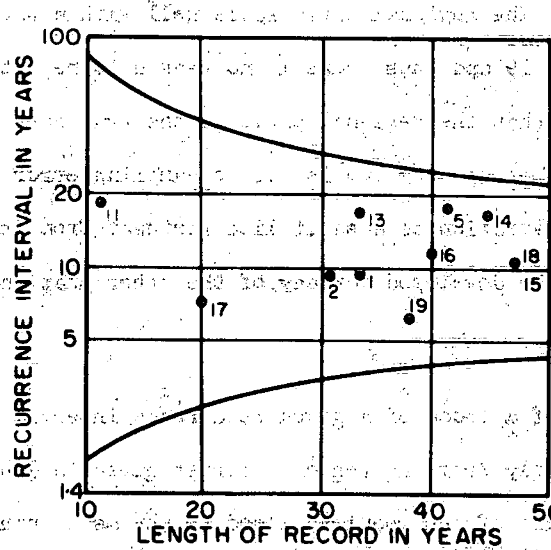

Figure 3 - Homogeneity Test Chart
for Western Region

NO.	Stream	Mean Annual flood $Q_{2.33}$ (cfs)	10-Year flood Q_{10} (cfs)	Ratio $\frac{Q_{10}}{Q_{2.33}}$	$Q_{2.33}$ x 1.80 (cfs)	T for Q of Column 6 (years)	Period of Record (years)
1	2	3	4	5	6	7	8
1	Bear River	1,420	2,600	1.83	2,560	10	34
2	Paradise Brook	843	1,640	1.95	1,520	9	31
5	Rawdon River	1,070	1,700	1.59	1.920	18	42
11	Tusket River	6,622	10,530	1.59	11,900	18	12
13	Tusket River	7,082	11,340	1.60	12,700	17	34
14	Roseway River	2,474	3,980	1.61	4,450	17	45
15	Medway River	6,047	10,800	1.79	10,900	10	47
16	Medway River	2,225	3,910	1.75	4,050	11	40
17	Herring Cove Brook	330	663	2.00	594	7	20
18	Lahave River	8,390	16,140	1.93	15,100	10	47
19	East River	307	675	2.20	552	6	38
	Average Ratio 1.80						

Table 2 - Data for Homogeneity Test - Western Region

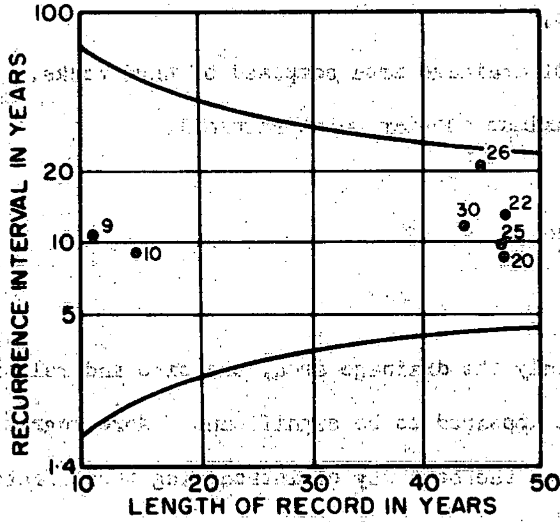

Figure 4 - Homogeneity Test Chart for Eastern Region

NO.	Stream	Mean Annual flood $Q_{2.33}$ (cfs)	10-Year flood Q_{10} (cfs)	Ratio $\frac{Q_{10}}{Q_{2.33}}$	$Q_{2.33}$ x 1.80 (cfs)	T for Q of Column 6 (years)	Period of Record (years)
1	2	3	4	5	6	7	8
9	Wallace River	5,173	7,470	1.44	7,450	10	11
10	South River	2,404	3,650	1.52	3,460	8	14
20	Musquodoboit River	4,768	7,190	1.51	6,870	8	47
22	St. Mary's River	13,946	19,580	1.40	20,100	12	47
25	Northeast Margaree River	5,841	8,650	1.48	8,400	8	47
26	Southwest Margaree River	1,346	1,760	1.31	1,940	20	45
30	Grand River	685	980	1.43	1,000	11	43
	Average Ratio 1.44						

Table 3 - Data for Homogeneity Test - Eastern Region

(c) position of lakes in the basin,

(d) stream slope,

(e) proportion of drainage area composed of hard rocks,

(f) 2.33-year maximum one-day point rainfall,

(g) elevation,

(h) latitude, and

(i) longitude

Of these factors, only the drainage area, the size and relative position of lakes, and the longitude appeared to be significant. More regressions were therefore run to determine the best way of introducing these factors into an estimating equation for the mean annual flood.

The equation which emerged from these investigations was of the form:

$$Q = \text{function} \left[(A_u + \lambda^K A_c),\ L \right] \qquad (2)$$

where

Q = mean annual flood, in cfs

A_u = drainage area uncontrolled by major lakes, in square miles

A_c = drainage area controlled by a major lake, in square miles

K = a constant

L = longitude

$\lambda = \frac{A_c - A_l}{A_c}$, where A_l = surface area of major lakes, in square miles

The value of the constant K was determined by assuming different values for it in successive regression analyses and selecting the value which gave the minimum standard error of estimate. The results of these trials are shown in the graph of

Se^2 against K in Figure 11. The value of K = 7 was selected.

The following regression equation using K = 7 arose out of the same series of trials:

$$\log Q = 0.8487 \log (A_u + \lambda^7 A_c) - 0.04711 L + 4.811 \quad (3)$$

This regression equation may be used to estimate mean annual flood within a standard error of estimate of 0.0684 log units or +17 and -15 per cent. The data used in the regression analysis are listed in Table 6, together with the deviations of the estimates from the recorded values of Q. It will be noted that the data from the thirty stations were used in developing the equation.

Application of the Regression Equation for Mean Annual Flood

The mean annual flood at the point of interest may be computed directly from equation (3) or by use of the curves in Figure 12. In any case, it is necessary to compute the value of $(A_u + \lambda^7 A_c)$. The total drainage area of the basin is determined and also the total area of the major lakes in the basin. The next step is to estimate the portion of the basin that is controlled by major lakes. This can be determined by delineating the watershed upstream from the outlets of the lakes on topographic maps, Scale 1:50,000. Where a chain of two or more lakes are involved, the area above the outlet of the lowest is used. Judgement is required in deciding what constitutes a major lake. It is suggested that any lake with a surface area of more than one per cent of its watershed area should be considered.

From the values of A, the total drainage area, and A_c and A_1, the values of A_u and λ are easily computed by equations (4) and (5):

$$A_u = A - A_c \quad (4)$$

$$\lambda^7 = \frac{A_c - A_1}{A_c} \qquad (5)$$

Figure 13 gives a convenient graphical method for solving equation (5) to obtain a value for λ^7. A value for $(A_u + \lambda^7 A_c)$ having been computed, the curves in Figure 12 may be entered and a value for Q read off by interpolating between curves for the appropriate longitude.

Thus, given only a topographic map from which drainage areas, lake areas and longitude may be determined, the mean annual flood at the point of interest on any stream in Nova Scotia may be estimated with a standard error of about 16 per cent.

Using the estimated mean annual flood and the appropriate regional frequency curve, a frequency curve of annual floods may be derived for the site. This estimated frequency curve has two sources of error - the error in the regional frequency curve and the error in the mean annual flood. When the mean annual flood is estimated for an ungauged stream, the error in this estimate far outweighs the error in the regional frequency curve. It is always preferable, therefore, to estimate the mean annual flood from actual streamflow records, where possible, rather than from the regression equation.

Regional curves for part-year flood series

Regional flood frequency curves have also been prepared for the seasons of January to May and June to December. These two seasons were selected because the January to May floods usually have a contribution from snowmelt while those occurring in the June to December season are usually caused by rain only.

The data for the regional curves and the individual curves on which they are based are given in Tables 7 to 10. The regional curves and their 95 per cent confidence limits are shown on Figures 14 to 17. Just as in the case of annual flood studies an estimate of the mean seasonal flood at the point of interest is required before these regional curves can be applied.

Figure 18 shows the correlation of the mean January to May flood with the mean annual flood. The mean January to May flood may be estimated with a standard error of estimate of about five per cent by multiplying the mean annual flood by 0.9.

Figure 19 shows the correlation of the mean June to December flood with the mean annual flood. The mean June to December flood may be estimated with a standard error of estimate of about 12 per cent by multiplying the mean annual flood by 0.66.

When there are no records at the point of interest, the mean annual flood may be estimated from regression equation (3) and the mean seasonal flood then estimated from one of the correlations shown in Figures 18 and 19. Where records are available, however, it will usually be advisable to estimate the mean seasonal flood from the actual records.

Comprehensive Flood Flow Study

This report is not presented as a comprehensive analysis of flood flows in Nova Scotia streams, as it is concerned only with the frequency of annual and seasonal floods. A comprehensive flood study would involve consideration of such other aspects as the ratio between maximum instantaneous and maximum daily flows, storm characteristics, snow accumulation and melt, precipitation - runoff relations and hydrograph analysis. These aspects will be dealt with in a comprehensive study which is now being made of Nova Scotia stream floods. The present report will appear as one chapter in the final report on that more general study.

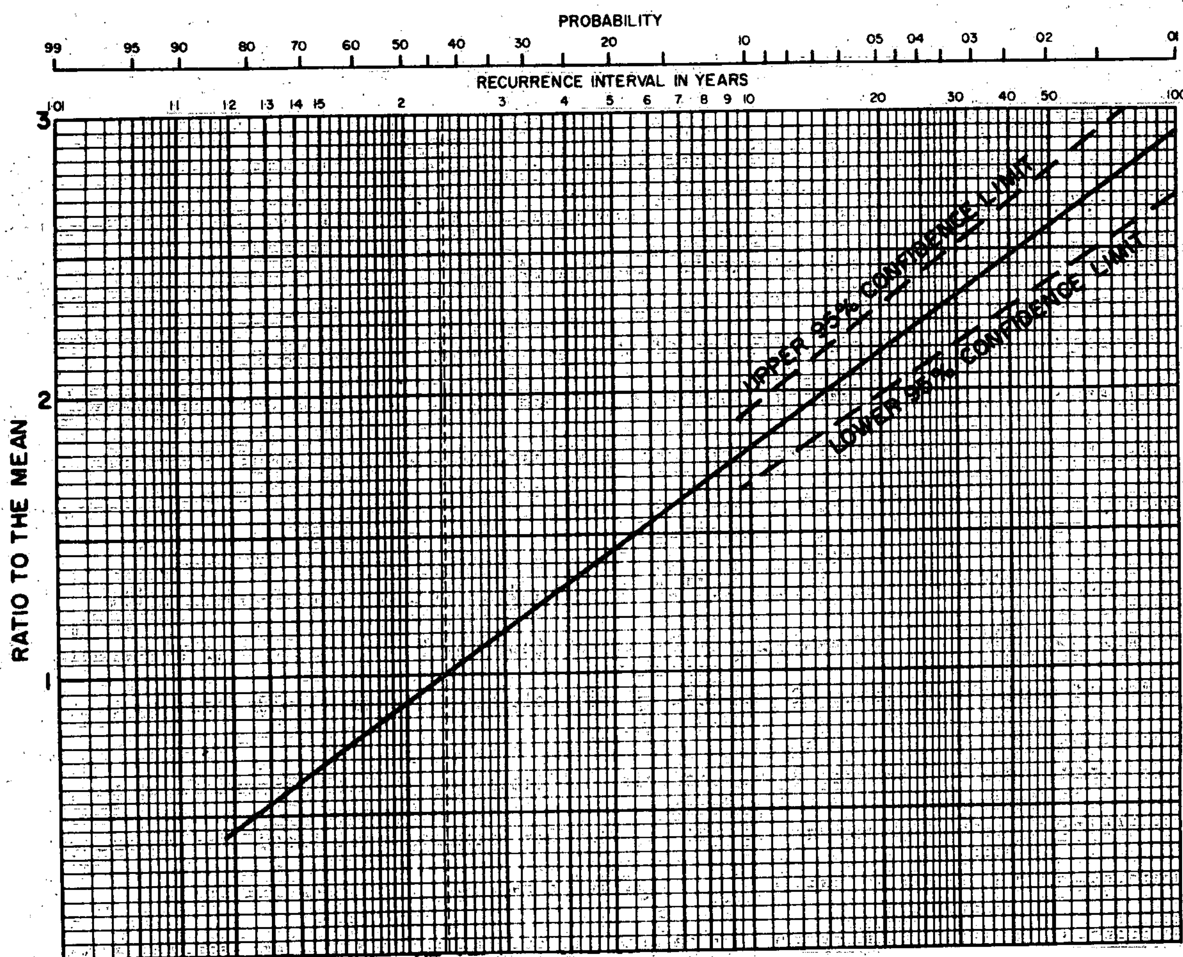

Figure 5 - Regional Frequency Curve of Annual Floods for Western Region.

NO.	Stream	Mean Annual Flood (cfs)	Recurrence Interval (years)				
			5	10	20	50	100
1	Bear River	1,420	1.46	1.83	2.18	2.64	2.98
2	Paradise Brook	843	1.53	1.95	2.59	2.85	3.26
5	Rawdon River	1,070	1.33	1.59	1.84	2.15	2.40
11	Tusket River	6,622	1.33	1.59	1.83	2.15	2.38
13	Tusket River	7,082	1.34	1.60	1.86	2.18	2.43
14	Roseway River	2,474	1.34	1.61	1.87	2.21	2.45
15	Medway River	6,047	1.44	1.78	2.11	2.54	2.88
16	Medway River	2,225	1.42	1.76	2.08	2.48	2.80
17	Herring Cove Brook	330	1.57	2.01	2.42	2.97	3.38
18	Lahave River	8,390	1.51	1.92	2.26	2.82	3.21
19	East River	307	1.67	2.20	2.70	3.38	3.84
	Regional Curve		1.45	1.80	2.16	2.58	2.91

Table 4 - Mean Annual Floods and Ratios to the Mean Annual Flood for Specified Recurrence Intervals - Western Region.

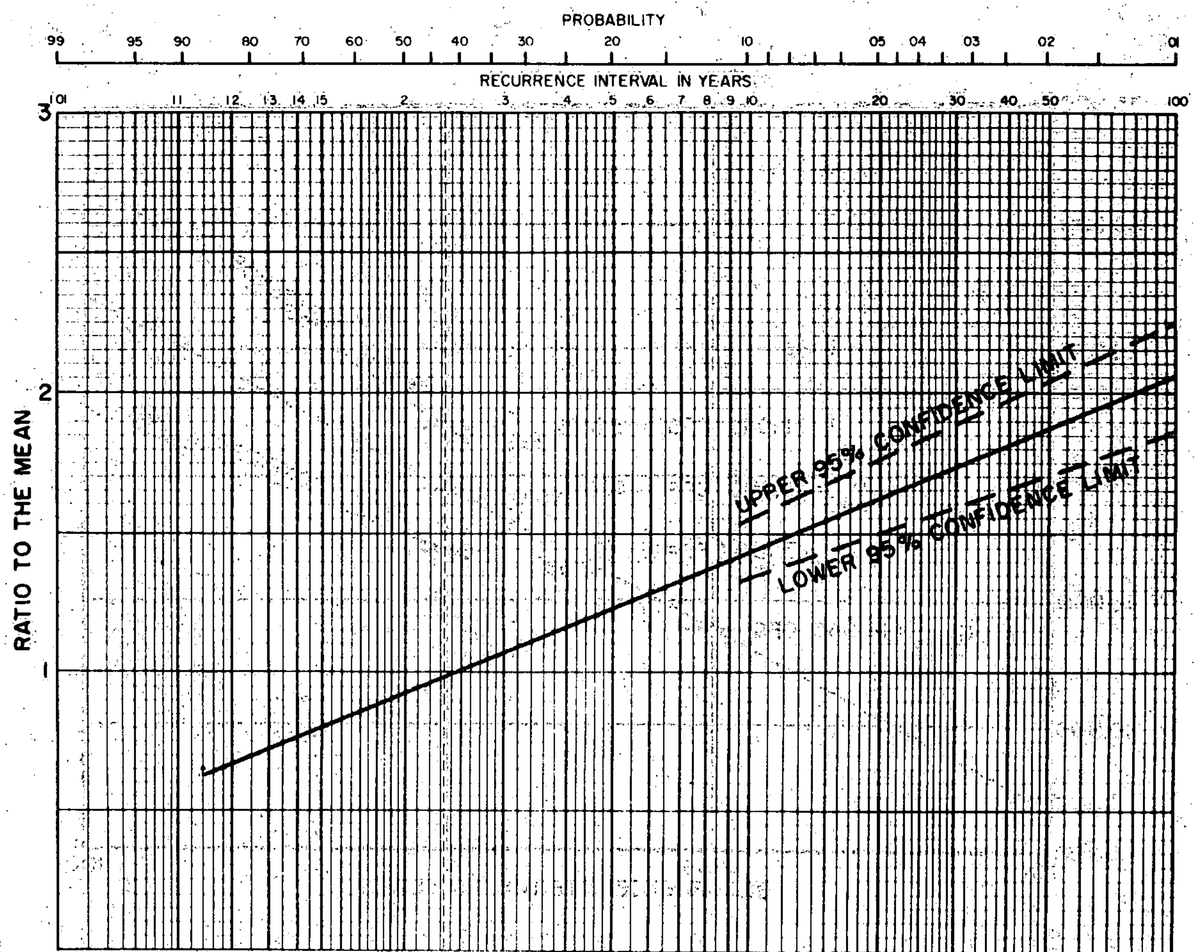

Figure 6 - Regional Frequency Curve of Annual Floods for Eastern Region.

NO.	Stream	Mean Annual Flood (cfs)	Recurrence Interval (years)				
			5	10	20	50	100
9	Wallace River	5,173	1.25	1.44	1.63	1.86	2.04
10	South River	2,404	1.30	1.52	1.73	2.01	2.22
20	Musquodoboit River	4,768	1.31	1.54	1.76	2.02	2.26
22	St. Mary's River	13,946	1.22	1.40	1.57	1.79	1.96
25	Northeast Margaree River	5,841	1.27	1.48	1.68	1.94	2.14
26	Southwest Margaree River	1,346	1.17	1.31	1.43	1.60	1.74
30	Grand River	685	1.24	1.43	1.61	1.84	2.02
	Regional Curve		1.25	1.44	1.63	1.87	2.05

Table 5 - Mean Annual Floods and Ratios to the Mean Annual Flood for Specified Recurrence Intervals - Eastern Region.

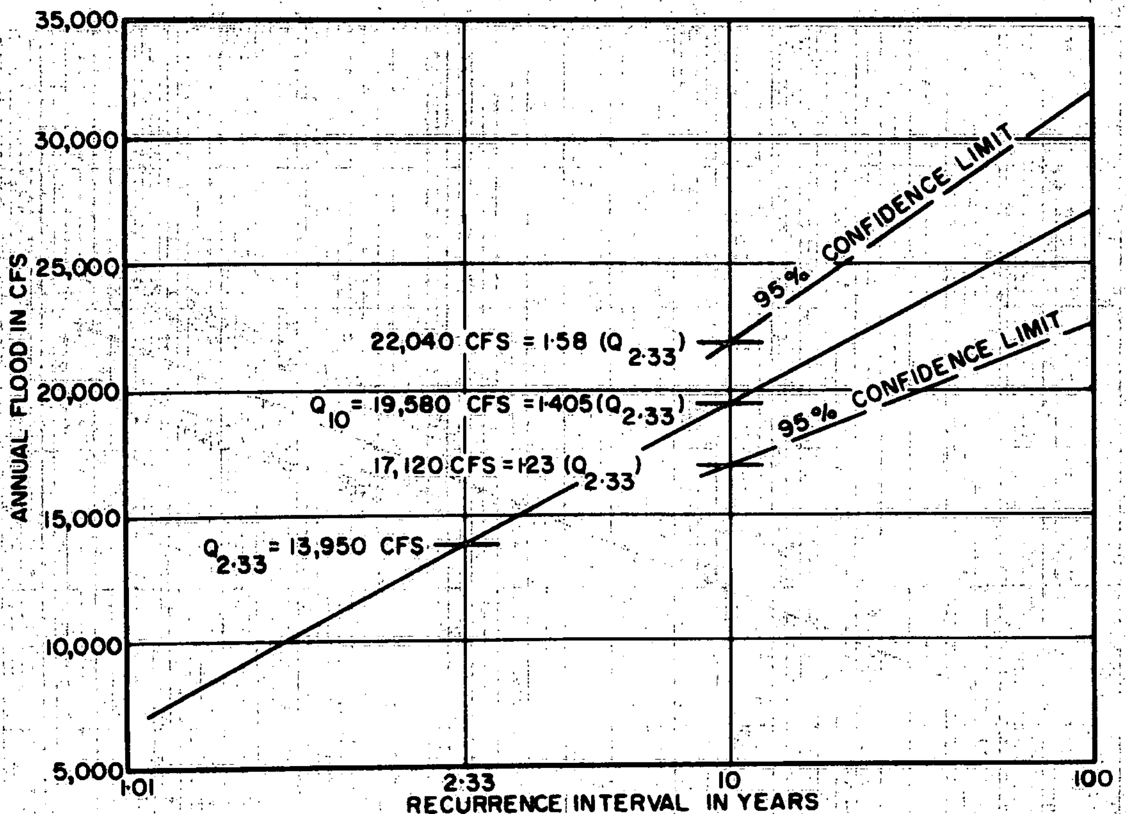

Figure 7 - Frequency Curve for St. Mary's River at Stillwater showing development of ratios to Mean Annual Flood

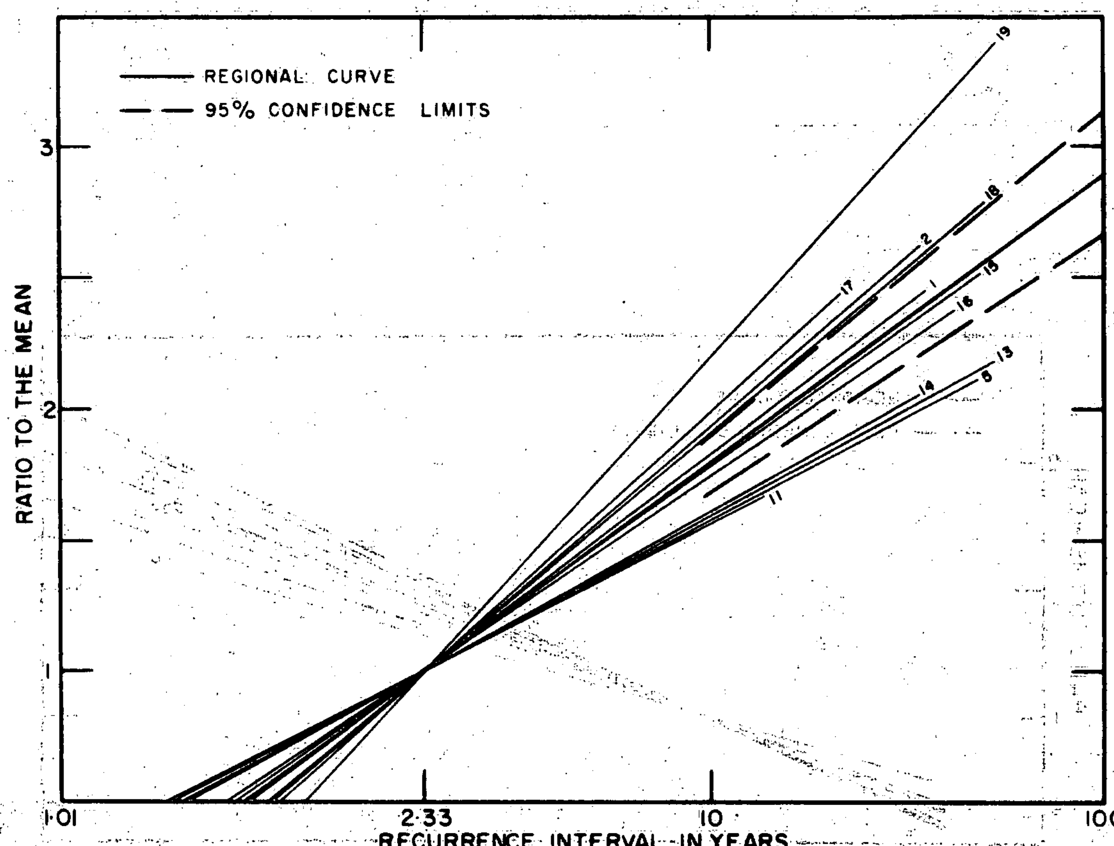

Figure 8 - Single-station Flood Frequency Curves and Regional Curve with 95 per cent confidence limits for Western Region

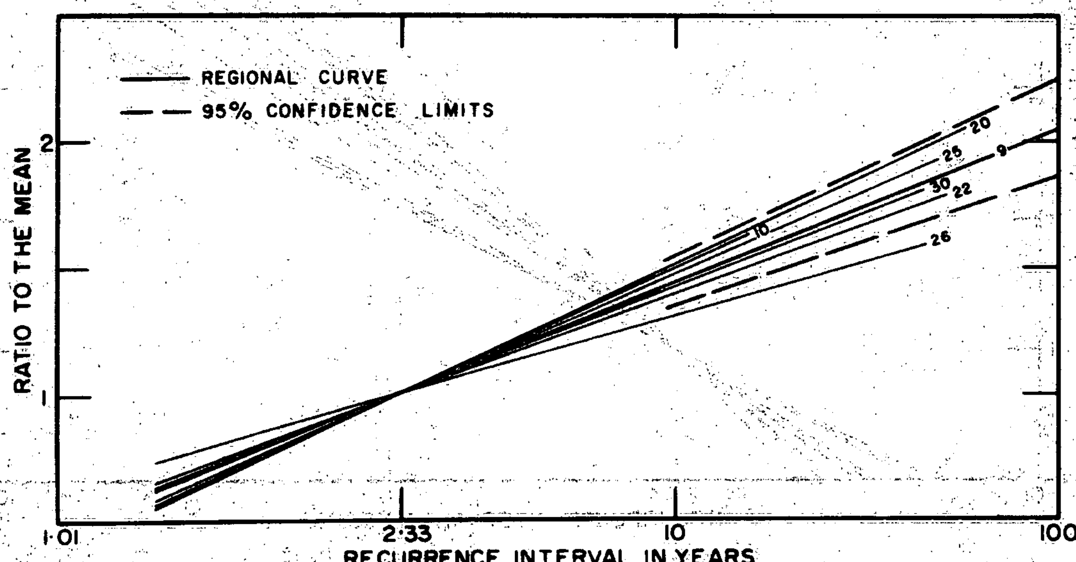

Figure 9 - Single-station Flood Frequency Curves and Regional Curve with 95 per cent confidence limits for Eastern Region

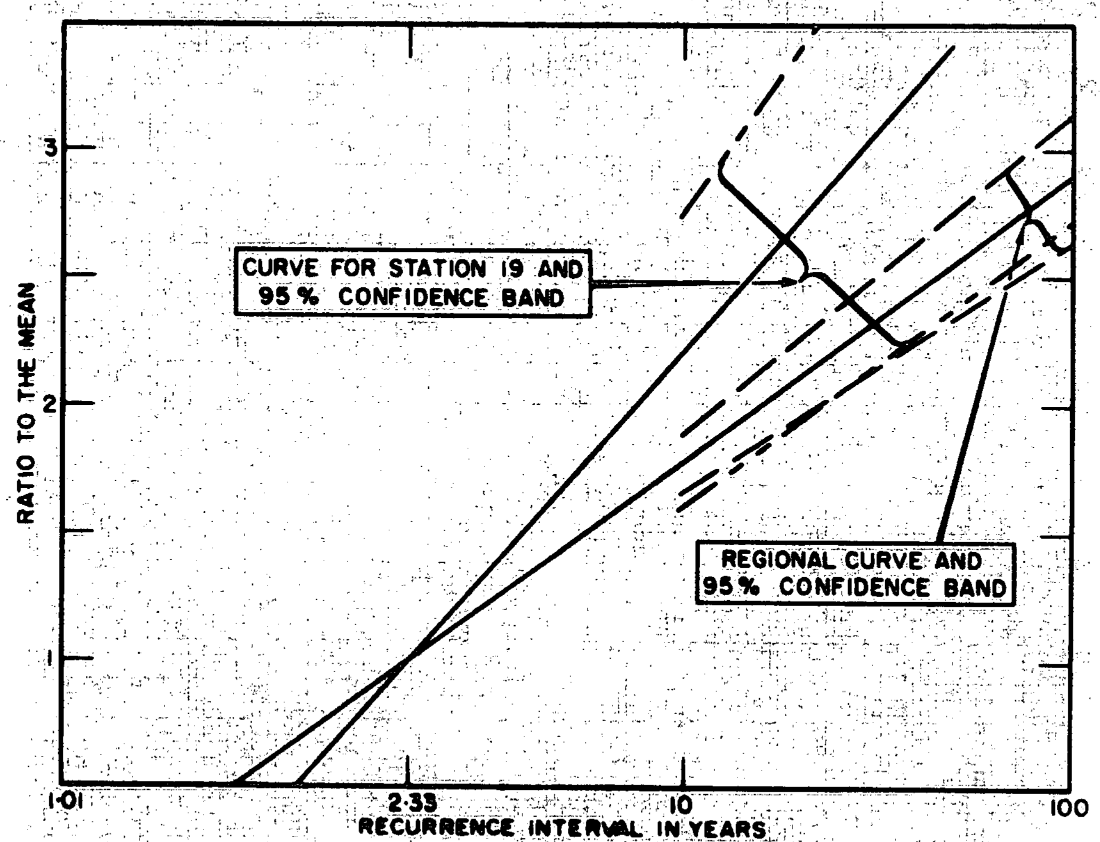

Figure 10 - Comparison of Flood Frequency Curve for Station 19 with Regional Curve

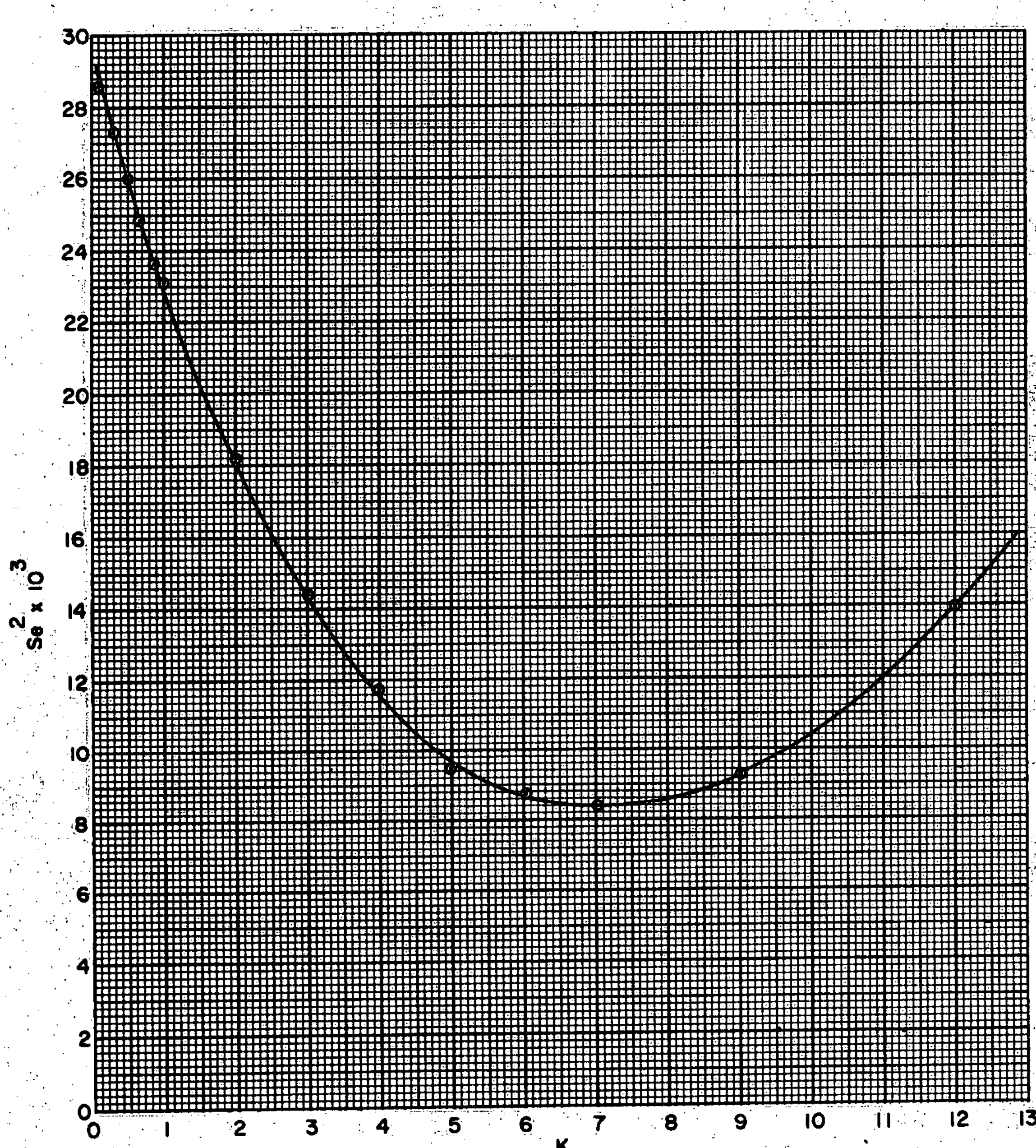

Figure 11 -Graph for determination of best value of K

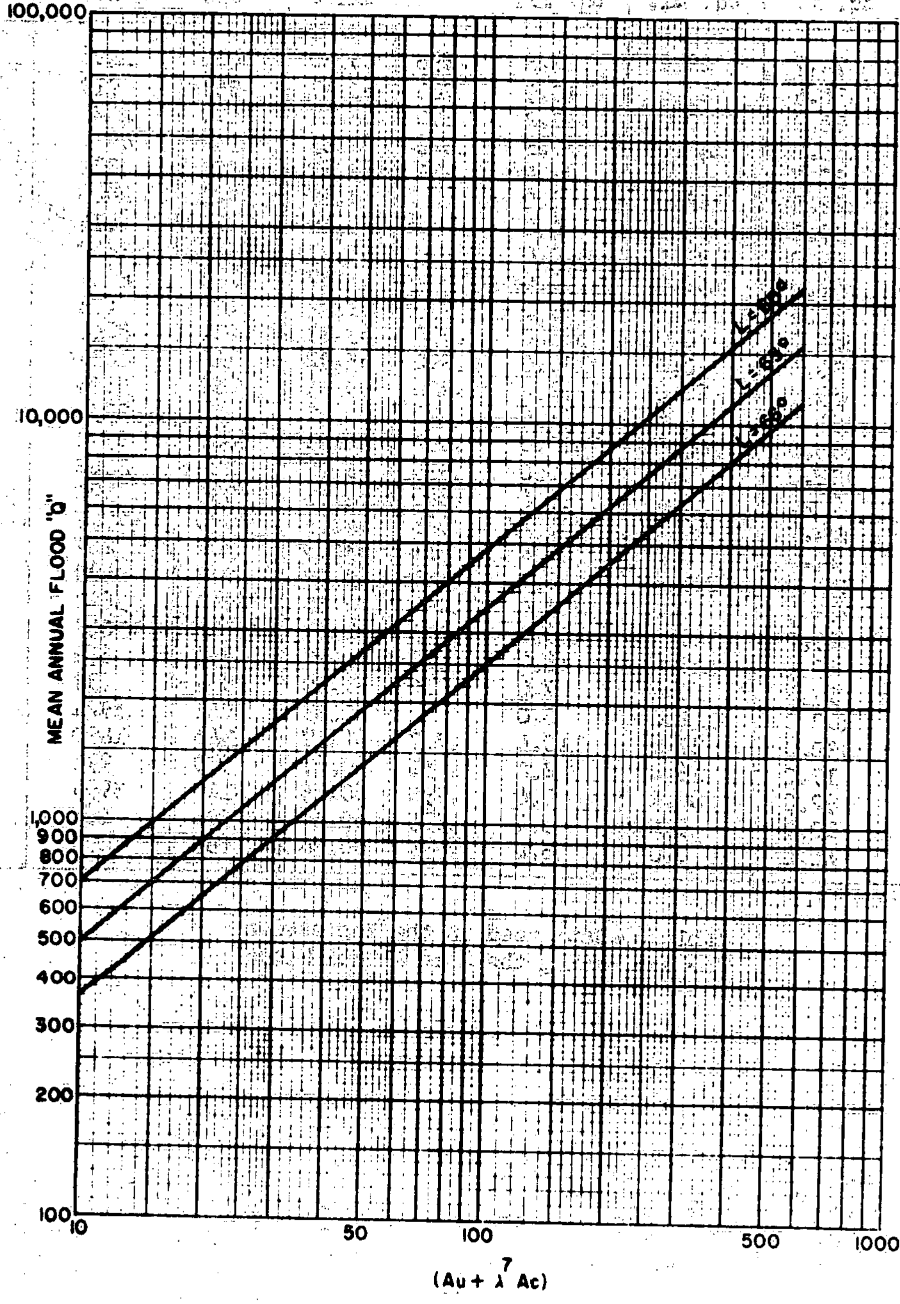

Figure 12 - Curves for determination of Mean Annual Flood

Station	DA sq. mi.	A_u sq. mi.	A_c sq. mi.	λ	L miles	Q cfs	Estimated Q cfs	Error (%)
1	74.7	29.9	44.8	.896	65.50	1420	1496	+ 5.4
2	36.5	25.6	10.9	.786	65.17	843	919	+ 9.0
3	88.2	0.0	88.2	.892	64.17	1490	1424	- 4.4
4	155.0	147.0	7.8	.626	62.83	4150	4924	+ 18.6
5	37.4	0.0	37.4	.934	63.67	1070	922	- 13.8
6	122.0	122.0	0.0		63.17	3920	4040	+ 3.1
7	37.3	37.3	0.0		63.58	1510	1414	- 6.4
8	88.0	88.0	0.0		63.83	2560	2850	+ 11.3
9	152.0	152.0	0.0		63.67	5173	4613	- 10.8
10	68.5	10.3	58.2	.975	61.92	2404	2475	+ 3.0
11	561.0	0.0	561.0	.910	65.83	6622	6241	- 5.8
12	130.0	0.0	130.0	.890	65.92	1140	1637	+ 43.6
13	413.0	20.6	392.4	.920	65.95	7082	5386	- 23.9
14	191.0	4.6	181.4	.924	65.42	2474	2934	+ 18.6
15	535.0	107.0	428.0	.882	64.83	6047	6970	+ 15.3
16	132.0	0.0	132.0	.916	65.17	2225	2062	- 7.3
17	23.0	3.4	19.6	.840	64.58	330	390	+ 18.2
18	484.0	96.8	387.2	.923	64.75	8390	7745	- 7.7
19	10.4	0.0	10.4	.911	63.83	307	267	- 13.0
20	251.0	200.8	50.2	.814	63.08	4768	6528	+ 36.9
21	203.0	0.0	203.0	.904	62.58	6840	3622	- 47.0
22	523.0	366.1	156.9	.873	62.17	13946	13043	- 6.5
23	19.0	2.8	16.2	.912	61.92	750	619	- 17.5
24	17.4	10.4	7.0	.880	61.50	934	738	- 21.0
25	142.0	142.0	0.0		60.83	5841	5924	+ 1.4
26	138.0	27.6	110.4	.717	61.17	1346	1890	+ 40.4
27	19.0	16.2	2.8	.851	60.67	900	998	+ 10.9
28	92.0	87.4	4.6	.798	60.75	4120	3993	- 3.1
29	10.7	5.4	5.4	.835	60.50	506	465	- 8.0
30	46.4	0.0	46.4	.834	60.58	685	893	+ 30.4

Table 6 - Data used in the regression for estimating the Mean Annual Flood

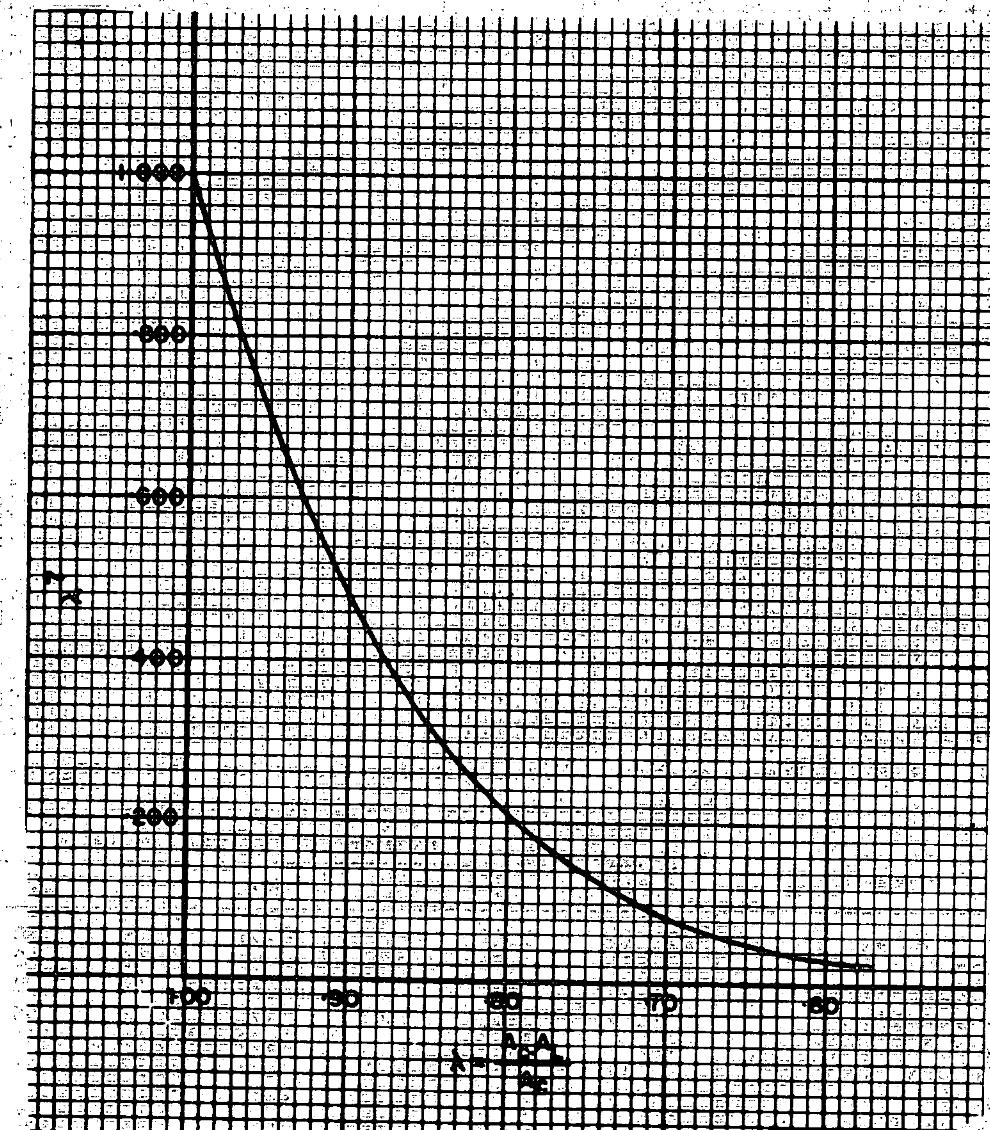

Figure 13 - Curve for the determination of λ^7

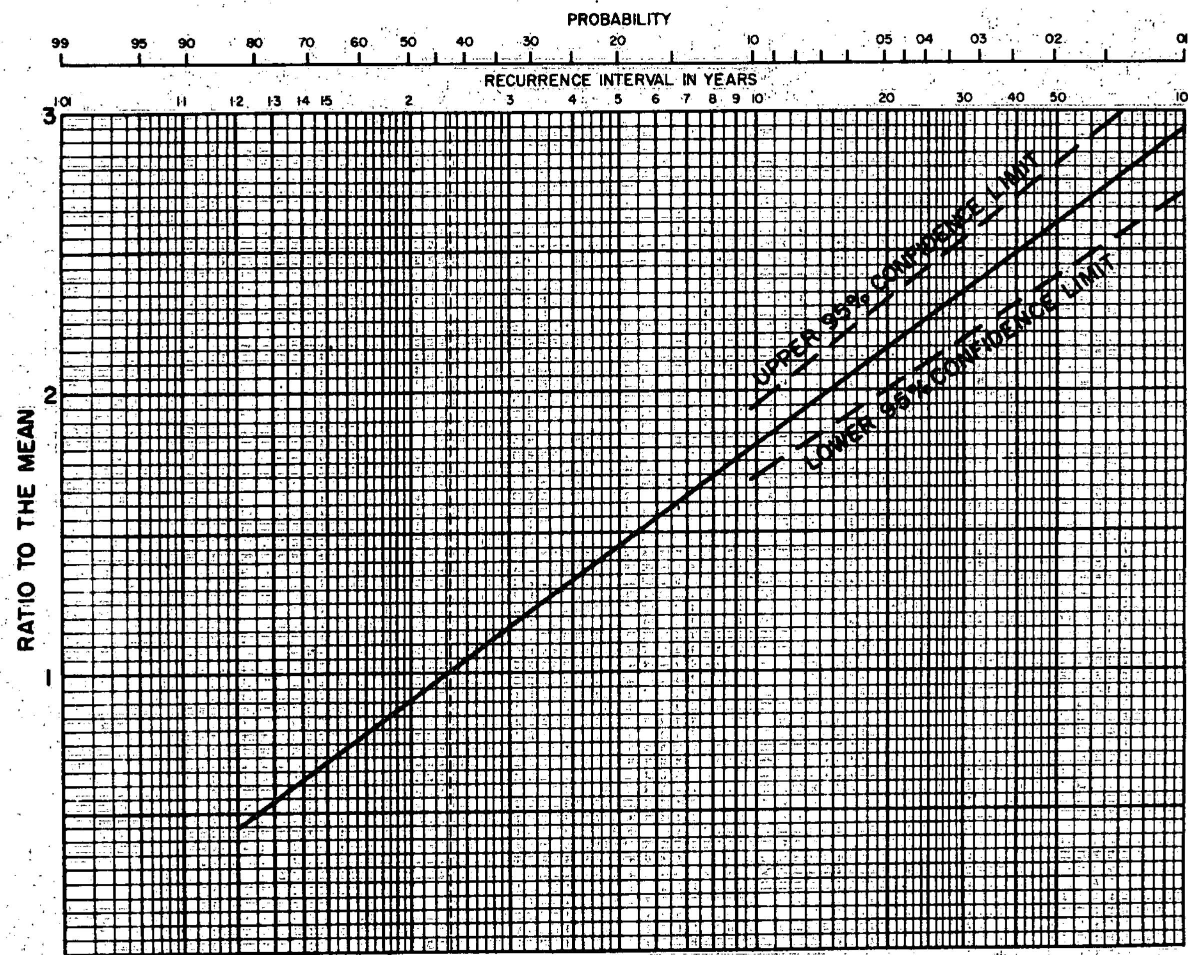

Figure 14 - Regional Frequency Curve of January to May Floods for Western Region.

NO.	Stream	Mean Flood (cfs)	Recurrence Interval (years)				
			5	10	20	50	100
1	Bear River	1,216	1.42	1.75	2.05	2.49	2.80
2	Paradise Brook	752	1.56	2.02	2.45	3.00	3.42
5	Rawdon River	950	1.31	1.56	1.79	2.09	2.32
11	Tusket River	6,125	1.39	1.67	1.96	2.32	2.58
13	Tusket River	6,310	1.40	1.71	2.00	2.40	2.68
14	Roseway River	2,300	1.37	1.67	1.95	2.32	2.58
15	Medway River	5,750	1.47	1.85	2.20	2.68	3.02
16	Medway River	2,030	1.50	1.89	2.26	2.74	3.11
17	Herring Cove Brook	295	1.25	1.44	1.64	1.88	2.06
18	Lahave River	7,960	1.55	1.99	2.42	2.95	3.35
19	East River	252	1.81	2.44	3.04	3.84	4.42
	Regional Curve		1.46	1.82	2.16	2.61	2.94

Table 7 - Mean January to May Floods and Ratios to the Mean for Specified Recurrence Intervals - Western Region.

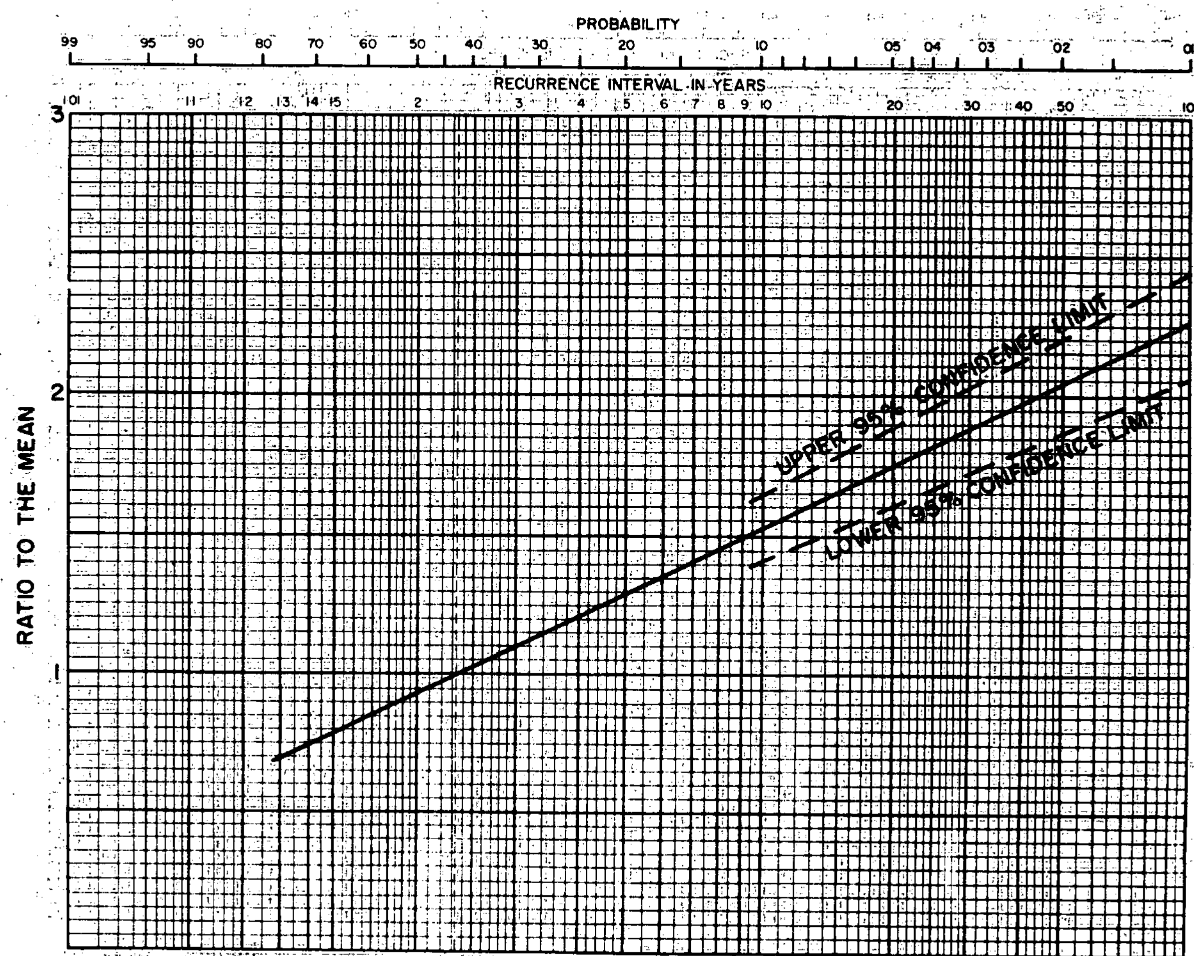

Figure 15 - Regional Frequency Curve of January to May Floods for Eastern Region.

NO.	Stream	Mean Flood (cfs)	Recurrence Interval (years)				
			5	10	20	50	100
10	South River	1,980	1.26	1.46	1.64	1.89	2.08
20	Musquodoboit River	4,360	1.34	1.60	1.85	2.18	2.43
22	St. Mary's River	12,610	1.30	1.54	1.78	2.07	2.30
25	Northeast Margaree River	5,000	1.37	1.67	1.95	2.32	2.60
26	Southwest Margaree River	1,240	1.22	1.40	1.56	1.78	1.95
30	Grand River	625	1.28	1.49	1.70	1.97	2.16
	Regional Curve		1.30	1.53	1.75	2.04	2.25

Table 8 - Mean January to May Floods and Ratios to the Mean for Specified Recurrence Intervals - Eastern Region.

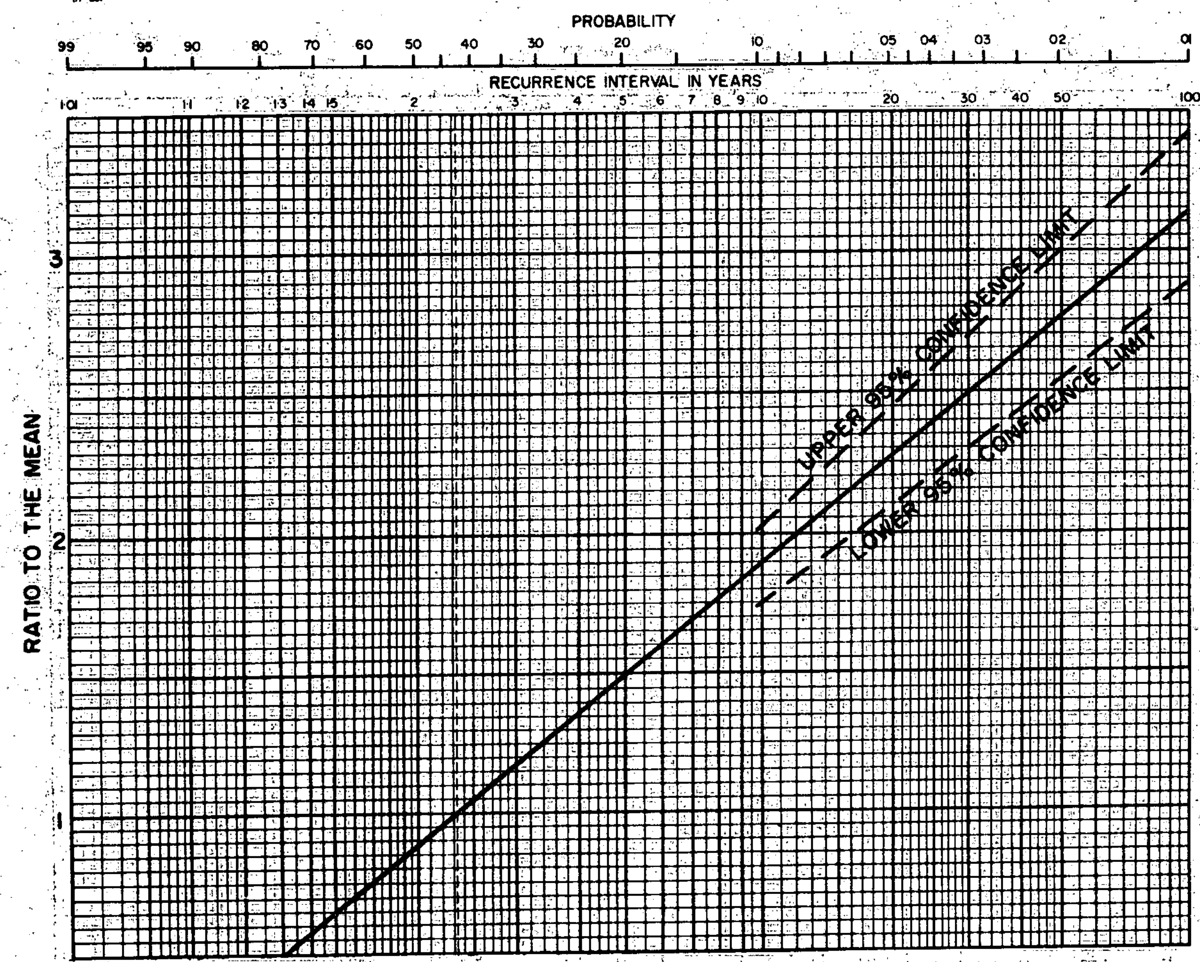

Figure 16 - Regional Frequency Curve of June to December Floods for Western Region.

NO.	Stream	Mean Flood (cfs)	Recurrence Interval (years)				
			5	10	20	50	100
1	Bear River	890	1.75	2.32	2.86	3.58	4.13
2	Paradise Brook	514	1.57	2.01	2.44	2.98	3.39
5	Rawdon River	720	1.43	1.77	2.08	2.50	2.80
11	Tusket River	4,900	1.34	1.60	1.86	2.18	2.42
13	Tusket River	4,260	1.47	1.84	2.19	2.66	2.99
14	Roseway River	1,700	1.38	1.68	1.97	2.35	2.63
15	Medway River	3,500	1.37	1.67	1.95	2.31	2.58
16	Medway River	1,125	1.45	1.81	2.16	2.59	2.94
17	Herring Cove Brook	230	1.70	2.22	2.74	3.40	3.87
18	Lahave River	4,740	1.46	1.61	2.16	2.60	2.94
19	East River	173	1.69	2.22	2.74	3.40	3.90
	Regional Curve		1.51	1.89	2.29	2.78	3.14

Table 9 - Mean June to December Floods and Ratios to the Mean for Specified Recurrence Intervals - Western Region.

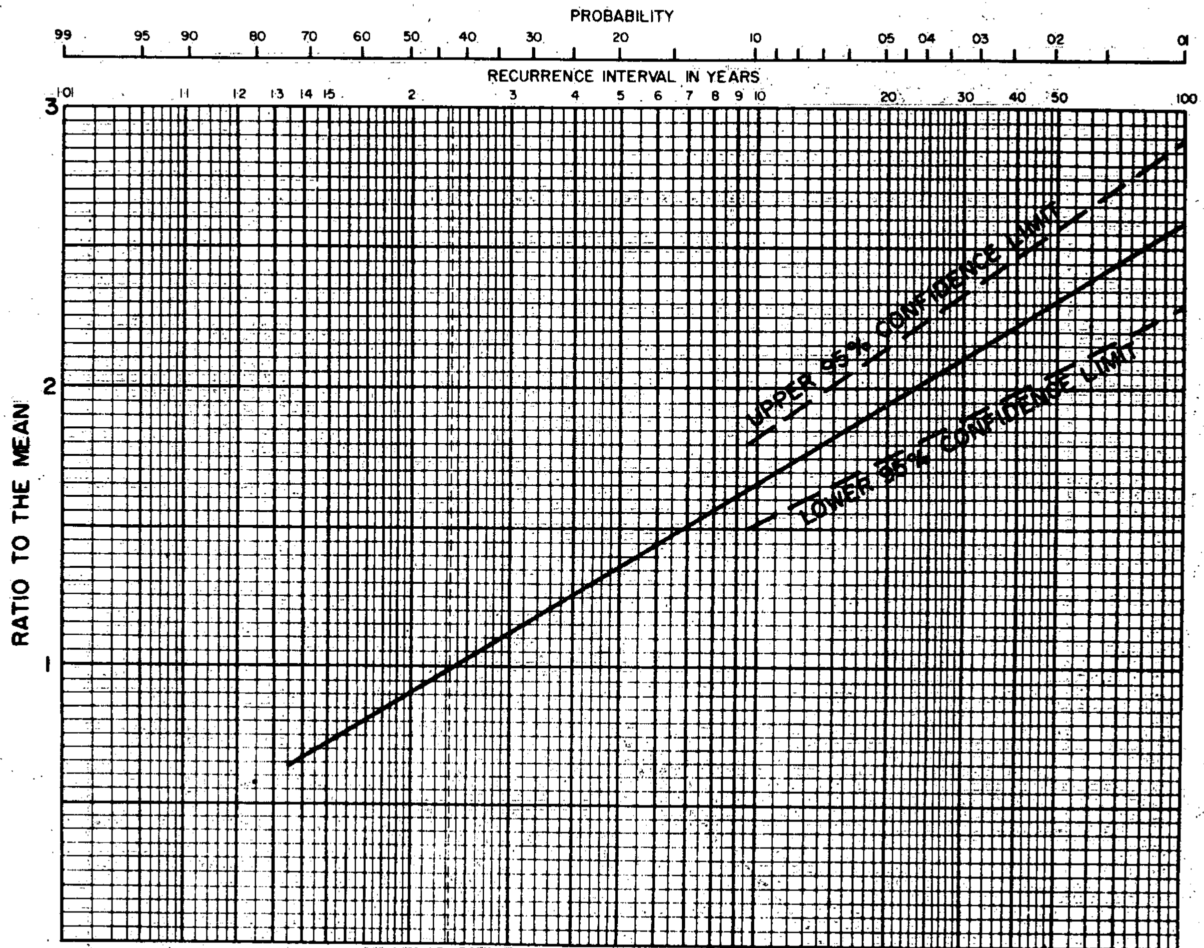

Figure 17 - Regional Frequency Curve of June to December Floods for Eastern Region.

NO.	Stream	Mean Flood (cfs)	Recurrence Interval (years)				
			5	10	20	50	100
9	Wallace River	3,760	1.58	2.00	2.42	2.96	3.36
10	South River	1,950	1.48	1.84	2.18	2.64	2.97
20	Musquodoboit River	3,500	1.27	1.48	1.69	1.95	2.15
22	St. Mary's River	9,900	1.30	1.53	1.75	2.14	2.25
25	Northeast Margaree River	3,970	1.36	1.64	1.92	2.27	2.54
26	Southwest Margaree River	890	1.31	1.56	1.80	2.10	2.34
30	Grand River	480	1.35	1.62	1.90	2.25	2.50
	Regional Curve		1.38	1.67	1.95	2.33	2.59

Table 10 - Mean June to December Floods and Ratios to the Mean for Specified Recurrence Intervals - Eastern Region.

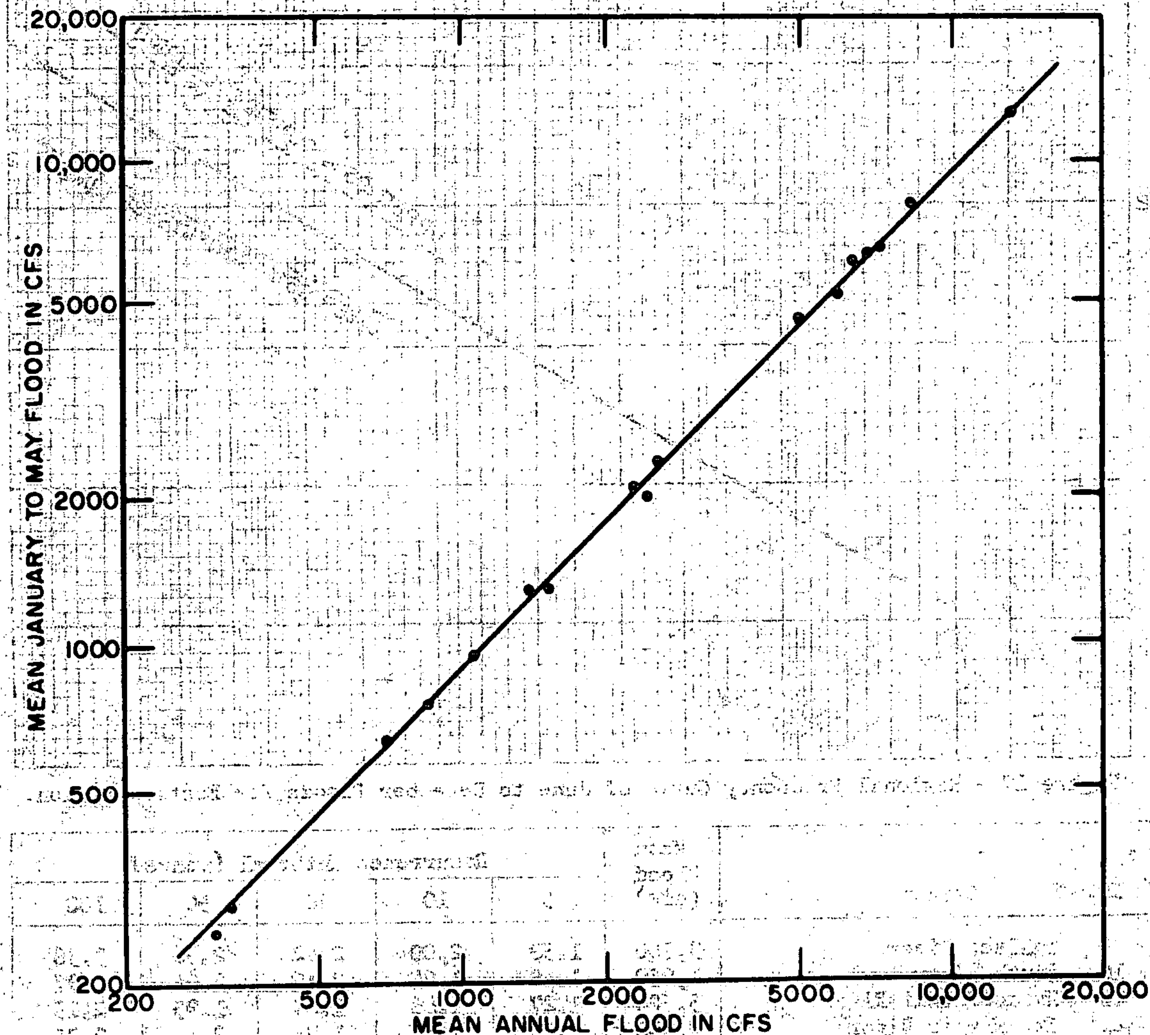

Figure 18 - Correlation of Mean January to May Flood with Mean Annual Flood

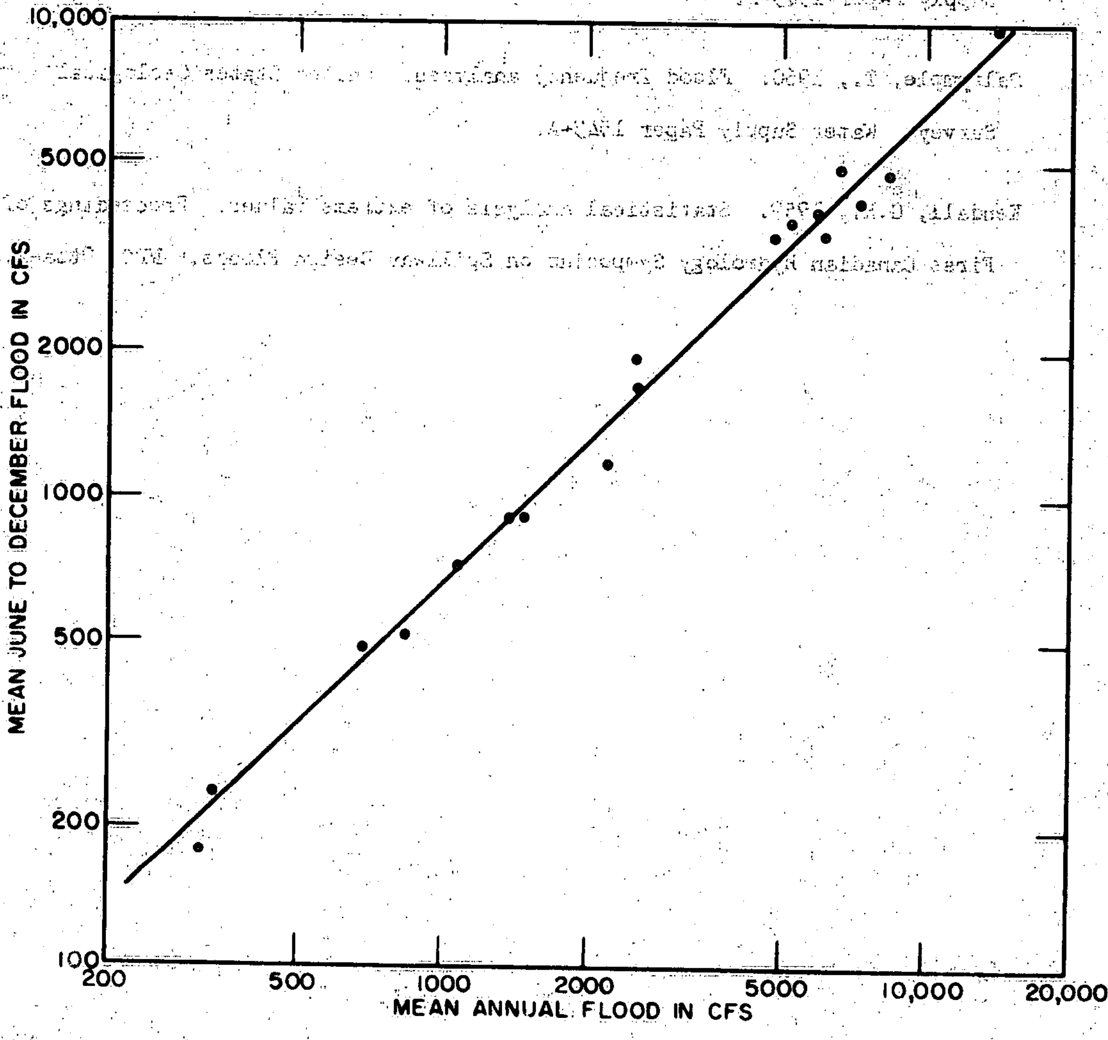

Figure 19 - Correlation of Mean June to December Flood with Mean Annual Flood

References

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Other TECHNICAL BULLETINS issued:

Technical Bulletin No. 1

E. P. Collier and A. Coulson, October 1965. Natural flow of North Saskatchewan River at Alberta - Saskatchewan boundary by the rim station method.

Discusses methods of estimating the natural flow of the North Saskatchewan River at the provincial boundary by simple regression with the flow at Rocky Mountain House and also by multiple regression techniques involving precipitation.

Technical Bulletin No. 2

R. O'N. Lyons, November 1965. LACOR - Program for streamflow correlation.

A program for the IBM 1620 computer to correlate streamflow records in terms of deviations in log units from the geometric mean of each calendar month's discharges.

Technical Bulletin No. 3

A. Coulson, 1966. Tables for computing and plotting flood frequency curves.

A compilation of tables for the computation and plotting of flood frequency curves according to the first asymptotic distribution of extreme values (the Gumbel method). A worked example of the use of the tables is included.

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