CHAPTER V

DISCUSSION OF RESULTS

The annual peak discharge of ten gaging stations in the Mae Klong basin are subjected to a frequency analysis (by Gumbel's theory of extreme value statistics). The annual floods for various return periods at each gaging station are derived by the analysis. These annual floods are then related to the basin characteristics obtained from the topographic map of the Mae Klong basin. By the use of a multiple regression method and a computer programming, the relationship is found. The results are shown in Tables 4.1 - 4.3 and 4.4.1 - 4.4.9 on pages 37, 40, 42 and 43 - 51 respectively, with the following discussions.

5.1 Flood at any Return Period

According to the results of the calculation of an annual flood for various return periods shown in Table 3, it is evident that :

5.1.1 The average annual flood ($Q_{2.33}$) varies from 24 cu.m./sec. at station K 12 (2340 sq.km. basin area) to 901 cu.m./sec. at station K 19 (11,071 sq.km. basin area) in the Khwai Yai, and varies from 149 cu.m./sec. at station K 22A (327 sq.km. basin area) to 1,897 cu.m./sec. at station K 10 (7.004 sq.km. basin area) in the

Khwai Noi river. Table 4.2 also shows that the average annual flood can be estimated from the following equation

$$Q_{2.33} = 0.86954\ A^{0.771}$$

It can be seen that the average annual flood increases with the increase in size of the basin. The annual flood at other return periods (2, 5, 10, 20, 50, 100, 500, and 1,000 years) also increases with the increase in size of the basin; see Table 4.3 and Tables 4.4.1-4.4.9

5.1.2 The annual flood at any return period in the Khwai Noi river (at stations K 13, K 9, K 10) is usually larger than the annual flood in the Khwai Yai river (at stations N 1, K 19 K 6, K 20) for the same return period, although the basin area of the Khwai Yai river is larger and has a steeper slope than the Khwai Noi river. This may be due to the fact that the Khwai Noi basin rises in the southwest of the Khwai Yai basin, that is in the windward side of the southwest monsoon. When the southwest monsoon brings some heavy rainfall to Thailand, it first passes through the mountainous area of the Khwai Noi basin, and because of the orographic effect, it therefore gives more rain to this basin than the Khwai Yai basin.

5.1.3 The specific flood yield in the Khwai Noi river at station K 13 is larger than the specific flood yield of the same return period at station K 10 which is located downstream of station K 13 and has a larger basin area; see Table 5.1 below.

Table 5.1 Specific flood yield at various return period

Return period (years)	Specific flood yield (cu.m./sec./sq.km.)			
	For Article 5.1.3		For Article 5.1.4	
	sta. K 10	sta. K 13	sta. K 12	sta. K 22A
2	0.256	0.449	0.009	0.434
2.33	0.271	0.478	0.010	0.456
5	0.336	0.603	0.014	0.550
10	0.389	0.704	0.017	0.627
20	0.441	0.802	0.020	0.703
50	0.506	0.928	0.024	0.798
100	0.556	1.022	0.026	0.872
500	0.671	1.241	0.032	1.037
1000	0.720	1.335	0.035	1.110

This may be due to the reason that the upper part of the Khwai Noi basin lies in the west hence the windward side, therefore it recieves more rain from the southwest monsoon than the lower part which results in a higher specific flood yield.

5.1.4 The specific flood yield in the Lam Taphoen river (in the Khwai Yai basin) at station K 12 (2340 basin area) is smaller than the specific flood yield of the same return period in the Huai Mae Num Noi (in the Khwai Noi basin) at station K 22A (327 sq.km. basin area); see Table 5.1 on page 62, although the Lam Taphoen river has a larger basin area than that of the Huai Mae Num Noi. This may be due to the orographic effect. Considering the direction of the southwest monsoon, the Lam Taphoen basin is in the windward side. Therefore the Lam Taphoen basin recieves lighter rain from the southwest monsoon than that of Mae Num Noi, hence a small specific flood yield.

5.2 Physical Characteristics of Subbasins

Table 4.2 shows the studied physical characteristics of the subbasin for each gaging station and their evaluated values are discussed here.

5.2.1 Basin area

It varies from 5,800 sq.km. at station N 1 to 11,253 sq.km. at station K 20 in the Khwai Yai river, and varies from 327 sq.km. at station K 22A to 7,004 sq.km. at station K 10 in the Khwai Noi river.

5.2.2 Shape number

It varies from 0.08355 at station K 20 to 0.12658 at station K 19 in the Khwai Yai river, and varies from

0.07697 at station K 10 to 0.18537 at station K 22A in the Khwai Noi river. Its variation in the Khwai Noi is wider than that in the Khwai Yai river.

5.2.3 Drainage density

It varies from 0.27776 km./sq.km. at station N 1 to 0.30383 km./sq.km. at station K 20 in the Khwai Yai river, and varies from 0.32691 km./sq.km. at station K 13 to 0.33945 km./sq.km. at station K 22A in the Khwai Noi river. This shows that the Khwai Noi basin has more stream length per unit area than the Khwai Yai basin. However the drainage density of the whole basin is nearly constant.

5.2.4 Slope of the main stream

It varies from 0.140% at station K 20 to 0.226% at station N 1 in the Khwai Yai river, and varies from 0.058% at station K 10 to 0.642% at station K 22A in the Khwai Noi river. It shows that generally the Khwai Yai river has a steeper slope than that of the Khwai Noi river.

5.3 Relationship between Flood Flow and Basin Characteristics

It can be seen from Table 4.4.1-4.4.9 that the annual flood at any return period is the exponential function of the basin characteristics and can be written in the form of eq. (14) to (21). The results can be discussed as follow :

5.3.1 The coefficient of multiple correlation (R_1) between the annual flood at any return period and the studied basin characteristics, which indicates the combined influence of all basin characteristics to the annual flood increases with the numbers of the included basin characteristics. This shows that each basin characteristic (basin area, shape number, drainage density and the slope of the main stream) affects the magnitude of the annual flood. The correlation coefficient R_1 for the studied return periods are shown in Table 5.2 below.

Table 5.2 Variation of the coefficient of multiple correlation

Return period (years)	Multiple correlation coefficient (R_1)
2	0.608 to 0.773
2.33	0.613 to 0.775
5	0.631 to 0.782
10	0.639 to 0.785
20	0.643 to 0.786
50	0.648 to 0.790
100	0.652 to 0.792
500	0.656 to 0.794
1000	0.657 to 0.795

These values of the correlation coefficient R_1 are in the range $0.6 < R_1 < 1.0$, which show a good direct correlation between the annual flood and the studied basin characteristics.

5.3.2 The basin area and the shape number give positive exponents of the exponential function which show that the magnitude of the annual flood at any return period increases with the higher value of the basin area and the shape number

5.3.3 The slope of the main stream gives a negative exponent of the exponential function which shows that the magnitude of the annual flood at any return period decreases with the higher value of the slope of the main stream.

5.3.4 The drainage density sometime gives a positive exponent of the exponential function but othertime gives a negative exponent, see example below.

Return period (years)	Exponent of the factor D		
	$Q=KA^{n_1} S_n^{n_2} D^{n_3}$	$Q=KA^{m_1} D^{n_2} S^{n_3}$	$Q=KA^{n_1} S^{n_2} D^{n_3} S^{n_4}$
2	-0.260	-1.296	-4.905
2.33	-0.115	-1.082	-4.676
5	0.315	-0.451	-3.998
10	0.555	0.107	-3.633
20	0.712	0.130	-3.394
50	0.884	0.370	-3.140
100	0.980	0.501	-2.996
500	1.151	0.740	-2.748
1000	1.201	0.815	-2.675

This shows that the effect of drainage density on the annual flood are interrelated with the effects of other basin characteristics.

For some considerations about the effect of the studied basin characteristics on the annual flood at any return period, the equations of the regression line for a 2-yr. return period are submitted here as example.

Equation of regression line	R_1
$Q_2=0.93077\ A^{0.978}\ S_n^{0.855}$	0.623
$Q_2=1.09663\ A^{0.778}\ D^{0.394}$	0.608
$Q_2=0.15694\ A^{0.374}\ S^{-0.775}$	0.675
$Q_2=0.77831\ A^{0.970}\ S_n^{0.876}\ D^{-0.260}$	0.624
$Q_2=0.05650\ A^{0.280}\ D^{-1.296}\ S^{-0.827}$	0.678
$Q_2=0.08556\ A^{0.689}\ D^{-1.185}\ S_n^{2.123}$	0.740
$Q_2=0.00144\ A^{0.448}\ S_n^{2.899}\ D^{-4.905}\ S^{-1.535}$	0.773

The exponents of each factor in the basin characteristic function, the coefficient of multiple correlation and the magnitude of each basin characteristic (see Table 4.2) are considered together and the following statements are found.

a.) The drainage density is the factor least affecting the annual flood than other basin characteristics used in this analysis. This may be due to the fact that the magnitudes of the drainage density obtained from the topographic map for various gaging stations are nearly equal (0.27776 to 0.39616), therefore it does not show a strong effect on the annual flood.

b.) The basin area shows the stronger effect on the annual flood than the shape number and the drainage density but shows a lesser effect on the annual flood than the slope of the main stream. It can be considered as one of the second most important factor in the prediction of the magnitude of the annual flood.

c.) The exponent of each factor in the basin characteristic function changes with the change in another factors and the number of the included factors. This shows that the effect of each factor is interrelated with that of other factors.

5.3.5 For the range of the return period used in this study (2-yr. to 1000-yr.), the exponents and constants of the equation showing the relationship between the annual flood and basin characteristics are summarizod here as :

a.) when A is used only, the equation showing the relationship is

$$Q_T = K\,A^{n_1}$$

n_1	varies from	0.767	to	0.805
K	varies from	0.83217	to	1.97514
R_1	varies from	0.608	to	0.657

b.) when A and S_n are used, the equation showing the relationship is

$$Q_T = KA^{n_1}\,S_n^{n_2}$$

n_1	varies from	0.978	to	1.104
n_2	varies from	0.855	to	1.214
K	varies from	0.93077	to	2.31570
R_1	varies from	0.623	to	0.687

c.) when A snd D are used, the equation showing the relationship is

$$Q_T = K\,A^{n_1}\,D^{n_2}$$

n_1	varies from	0.788	to	0.911
n_2	varies from	0.394	to	2.033
K	varies from	1.09663	to	8.19724
R_1	varies from	0.608	to	0.667

d.) when A and S are used, the equation showing the relationship is

$$Q_T = K\, A^{n_1}\, S^{n_2}$$

n_1	varies from	0.374	to	0.486
n_2	varies from	-0.775	to	-0.630
K	varies from	0.15694	to	0.50917
R_1	varies from	0.675	to	0.702

e.) when A, S_n and D are used, the equation showing the relationship is

$$Q_T = K\, A^{n_1}\, S_n^{n_2}\, D^{n_3}$$

n_1	varies from	0.970	to	1.142
n_2	varies from	0.876	to	1.116
n_3	varies from	-0.260	to	1.201
K	varies from	0.77831	to	5.29755
R_1	varies from	0.624	to	0.690

f.) when A, D and S are used, the equation showing the the relationship is

$$Q_T = K\, A^{n_1}\, D^{n_2}\, S^{n_3}$$

n_1	varies from	0.280	to	0.545
n_2	varies from	-1.296	to	0.815
n_3	varies from	-0.827	to	-0.596
K	varies from	0.05656	to	0.96748
R_1	varies from	0.678	to	0.703

g.) when A, S and S_n are used, the equation showing the relationship is

$$Q_T = K A^{n_1} S^{n_2} S_n^{n_3}$$

n_1	varies from	0.689	to	0.839
n_2	varies from	-1.185	to	-1.090
n_3	varies from	2.123	to	2.380
K	varies from	0.08556	to	0.25786
R_1	varies from	0.746	to	0.785

h.) when A , S_n, D and S are used, the equation showing the relationship is

$$Q_T = K A^{n_1} S_n^{n_2} D^{n_3} S^{n_4}$$

n_1	varies from	0.448	to	0.707
n_2	varies from	2.899	to	2.804
n_3	varies from	-4.905	to	-2.675
n_4	varies from	-1.535	to	-1.281
K	varies from	0.00144	to	0.02778
R_1	varies from	0.773	to	0.795

From the above summary, it can easily be seen that the values of the exponents (n_1, n_2, n_3 and n_4) usually in increase with the magnitude of flood. This supports the hypothesis that the relationship of the flood flow and basin characteristics as shown by the eq. (14) to (21) is correct.

5.3.6 There is a scatter of points about the regression line and occasionally a wild point occurs (see graphs showing relation between the annual flood and the basin area in Appendix II pages 92 - 100). Such wild points are called outliers in statistics. It seems questionable whether outliers in hydrologic analysis such as this should be reject or not. Acton (1956) concluded that the physical scientists and engineers need not be encouraged to ignore obstinate outlying data, rather they need to be held in check. Therefore the outlying data are included in this analysis.

5.4 Other Possible Variables

5.4.1 The altitude of gaging station above the M.S.L. is not considered as one of the factors affecting the flood flow in the Mae Klong basin, because the altitude of the gaging stations used in this study varies in a very close range (from approx. 32 m. above M.S.L. at station K12 to approx. 138 m. above M.S.L. at station N 1 in the distance of about 180 km. along the stream).

5.4.2 The lengths, L and L_c are not included in the function of basin characteristics, because of the limitation of the use of the subcribed variable in the computer at the Computing Center of the Chulalongkorn University. It will take more computing time and will be more expensive if they are included in the function. However they are also studied separately, and are found that they relate with the basin area and the slope of the main stream in the form of eq. (30). The graph showing the relation between A, L, L_c and S is shown on page 54.

5.4.3 The annual rainfall is not included as a factor affecting the flood flow in the Mae Klong river, because the rainfall records are not available for every studied subbasin . Of the available records, some are missing, see Table on page 117.

5.5 Length of the Recorded Data

The length of the recorded data of the annual peak discharges used in this analysis are shown below :

Gaging Station	Length of Record (years)	Water Year
K 6	8	1965 - 72
K 9	8	1965 - 72
K 10	8	1965 - 72
K 12	8	1966 - 73
K 13	8	1966 - 73
K 17	8	1966 - 73
K 19	7	1966 - 72
K 20	8	1966 - 73
K 22A	5	1969 - 73
N 1	7	1965 - 71

It is seen that the length of the recorded data are a little too short. Theoretically more desirable results will be obtained if the length of record of the annual peak discharges are longer, and the distributions of the values of the basin characteristics (see article 5.2) are wider then evaluated values.