TR 137

REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF WATER AFFAIRS

REGIONAL MAXIMUM FLOOD PEAKS IN SOUTHERN AFRICA

Z Kovaćs

DEPARTMENT OF WATER AFFAIRS

Directorate of Hydrology

Technical Report TR 137

REGIONAL MAXIMUM FLOOD PEAKS IN SOUTHERN AFRICA

By

Z. KOVACS

December 1988

Private Bag X313
Pretoria
SOUTH AFRICA
0001

ISBN

ABSTRACT

The regional maximum flood (RMF) is an empirically established upper limit of flood peaks that can be reasonably expected at a given site. The proposed method for the estimation of RMF is a revised and updated version of Departmental technical report TR 105 published in 1980[1] The method is based on maximum flood peaks recorded since 1856 at more than 500 sites in Southern Africa. The relative flood peak magnitude is expressed by the Francou-Rodier regional coëfficient K. Eight maximum flood peak regions were delimited by a joint consideration of K, maximum observed 3 day rainfall and catchment characteristics. The respective K envelope lines (K_e) were established by taking onto account the number and quality of data. The RMF can be instantly calculated if the geographic position of the site and its effective catchment area are known. Owing to its consistency the RMF compares favourably with results obtained by other methods. It is also shown that flood peaks in the 50 to 200 year recurrence interval can be estimated from RMF.

ACKNOWLEDGEMENTS

Thanks are due to the following persons and organisations who contributed to the maximum flood peak catalogue: South African Transport Services through Mr J Szombati; Transvaal Roads Department through Mr G Orczy; South West African Department of Water Affairs through Mr G van Langenhove; Division of Water Resources and Development, Harare, through Mr WG Wannel; Direccao Nacional de Aguas, Maputo, through Dr A Lopes Pereira; Botswana Department of Water Affairs through Mr S Child; Water Apportionment of Swaziland.

The author is particularly indebted to the following persons for their interest in this study: Professor WJR Alexander of the University of Pretoria who, through his lectures and courses, had been the principal propagator of the original report(1); Professor em DC Midgley of the University of Witwatersrand, particularly for his comments on effective catchment areas; Mr E Beesley of Umkomaas, for the valuable information and comments on extreme floods in Southern Natal and Mrs JE Perry of the National Research Institute for Oceanology, Stellenbosch, for drawing my attention to historical floods in the Mkomazi and Mzumbe Rivers.

Last but not least I wish to thank the staff of the Subdirectorate: Flood Studies who have surveyed and calculated the lion's share of extreme flood peaks occurred in South Africa since 1975. They were efficiently supported by the subdirectorates of Hydrometry and Network Services. The maps were compiled by Mrs V Petras. The figures were drawn by Miss T de Klerk and Miss G Mashile.

CONTENTS

1. INTRODUCTION

A realistic estimate of the maximum flood peak, understood in this report as an approximate upper limit of flood peaks at a given site, is imperative if the related inundation could result in deaths or great economic damage. Even if the potential for a flood catastrophe did not exist, the estimation of the maximum flood peak is often recommendable because it can provide an impression on the maximum flood level and its consequences.

There are three basic methods for the estimation of the maximum flood peak: empirical, probabilistic and deterministic.

<u>Empirical methods</u> (employed since the 19th century)

In this approach maximum flood peaks observed in a hydrologically homogeneous region are plotted against catchment area and an envelope curve is drawn for the points which is then considered as the upper limit of expected flood peaks, Q_{max}. The general algebraic expression of envelope curves is

$$Q_{max} = cA^{x}$$

where A is the catchment area and

c, x are regional constants

Before the popularisation of the probabilistic and deterministic methods during the period 1930-1960, the design flood was usually determined on empirical basis. A great number of empirical equations were established in various parts of the world, first of all in Europe and the United States (obviously, the use of the highest observed flood at a specific site as maximum flood is also an empirical method).

The merit of the regional empirical approach is that it represents a vast amount of experience and, if the observations cover relatively large areas and periods, there is a fair chance for the inclusion of a few really extraordinary events in the data-basis.

The common shortcomings of the empirical approach are:

- Uncertainty regarding the boundaries of homogeneous regions. This is a common drawback of all regional approaches in hydrology.
- Very large and very small catchments often cannot be accounted for by the regional approach because of unusual hydrological features.

- There is no objective criterion for the location of envelope curves.

The empirical equations of maximum flood peak envelope curves dating from the period before 1960 lacked physical meaning. Consequently, their justified application was restricted to well defined areas.

Once civil engineers and hydrologists became familiarised with the more sophisticated and universal probabilistic and deterministic methods, the empirical approach has become considered outdated and unscientific to such an extent that in many hydrological textbooks published after 1950 it was not even mentioned.

Probabilistic methods (employed since ± 1930)

Here the maximum flood peak is associated with a very low probability, most often p = 0,0001 i.e., a return period (= recurrence interval) of 10 000 year. This estimate is obtained from the extrapolation of a theoretical probability distribution fitted to annual maximum flood peak records. The extrapolated period is usually 100 to 500 times longer than the period of record.

Some of the fundamental shortcomings of this approach are the following:

- The theoretical distributions most often employed were constructed for different purposes and with different aims[2] and, therefore, have no causal relationship with the physical factors that govern the genesis and propagation of floods.

- The return period of 10 000 year is entirely arbitrary.

- The representativeness of a relatively short-period sample (generally shorter than 50 years) is unknown[3]. Therefore, the extrapolation of probability distributions for periods longer than two to three times the record length cannot be justified without supporting evidence by paleoflood data. The latter were not yet investigated in South Africa and only in very few cases elsewhere.

- The preference for one particular method cannot be established.

Notwithstanding the above, the use of the probabilistic approach may give realistic results in large catchments where the increase of flood peaks is limited by natural storage over extensive flood plains. In this case a long record (> 50 years) should be required.

Deterministic methods (since ± 1950)

Here the maximum flood peak is identified with the "probable maximum flood" (PMF). It is calculated by unitgraph principles on the presumption that the "probable maximum precipitation" (PMP) is falling on a saturated catchment.

The merit of the deterministic approach is that it is based on a rational analysis of physical factors which play an important role in the flood process.

The most serious drawback of this method is that in lack of adequate data it has to resort to not yet verified or unverifiable hypotheses and average regional coëfficients. Examples:

- storm rainfall areal reduction factor
- transposition of storms
- storm loss
- validity of unitgraph principles in case of extreme flood conditions

The consequence is that the cumulative error may reach the magnitude of PMF itself.

In the last decade it has become evident, during maximum flood peak calculations carried out by the Department of Water Affairs at more than one hundred dam sites, that both the probabilistic and deterministic methods frequently result in grossly unrealistic and inconsistent figures. It thus became obvious that there is an urgent need in South Africa to revive the neglected empirical approach in the hope to arrive at more realistic and consistent maximum flood peaks.

2. THE FRANCOU-RODIER METHOD OF FLOOD PEAK CLASSIFICATION

In 1967, after a long oblivion, the empirical approach was revived by Francou and Rodier[4] who compiled a catalogue of about 1 200 maximum recorded flood peaks representing most regions of the world. When the peaks were plotted against corresponding catchment areas, they found that in hydrologically homogeneous regions and catchments larger than about 100 km^2 the regional envelope curves were straight and apparently converged towards a single point representing the approximate total drained land surface and mean annual discharge of the earth.

The Francou-Rodier diagram of flood peak classification is shown in Figure 1. Francou's comments made in 1968[5] were the following:

(i) The diagram consists of three zones: the flood zone, the storm zone and the transition zone.

(ii) In the flood zone ($A > 100\ km^2$) the flood peak depends both upon storm rainfall (intensity, area and duration) and catchment characteristics. This is the zone of converging envelope lines which are described by the Francou-Rodier equation:

$$Q = 10^6 (A/10^8)^{1-0,1K}$$

where Q = flood peak (m^3/s)
10^6 = mean annual discharge from all drained land on earth (m^3/s)
A = drainage area (km^2)
10^8 = total drained land surface on earth (km^2)
K = regional coëfficient expressing relative flood peak magnitude = $10\ (1 - \tan\alpha)$ where α is the slope of the envelope line. It varies between 0 and 6,5 but negative values do occur in very flat, permeable, dry or swampy large catchments. In Table 1 the influence of K on Q is shown for different catchment areas

(iii) In the storm zone ($A < 1\ km^2$) the peak discharge depends only on rainfall intensity. For $A = 1\ km^2$ the discharge is $Q = 0{,}278\ i$, where i is the maximum 15 minute rainfall intensity in mm/h (15 min. is the approximate time of concentration in a catchment of 1 km^2). In this zone the Q vs A lines represent constant storm intensities and will plot as 45° lines (strictly speaking, the lines should become slightly steeper in catchment areas smaller than 1 km^2). The lower limit of the envelope lines indicate a rainfall intensity which is just capable of generating a flood. The upper limit corresponds to world record rainfall intensities for 15 minute storm duration (± 800 mm/h).

(iv) Between the storm zone and flood zone there lies a transition zone ($1\ km^2 < A < 100$ to $500\ km^2$) where the envelope lines are supposed to provide a smooth transition between the regional 15 minute point rainfall discharge and the regional K envelope curve in the flood zone.

TABLE 1: CHANGE OF Q (m^3/s) WITH AREA AND THE FRANCOU-RODIER K

Francou-Rodier K	Area (km^2)			
	100	1 000	10 000	100 000
0	1	10	100	1 000
0,5	2	17,8	158	1 410
1	3,98	31,6	251	2 000
1,5	7,94	56,2	398	2 820
2	15,9	100	631	3 980
2,5	31,6	178	1 000	5 620
3	63,1	316	1 580	7 940
3,5	126	562	2 510	11 200
4	251	1 000	3 980	15 800
4,5	501	1 780	6 310	23 400
5	1 000	3 160	10 000	31 600
5,5	2 000	5 620	15 800	44 700
6	3 980	10 000	25 100	63 100
6,5	7 940	17 800	39 800	89 100

In Figure 2 world record flood peaks[6][7] (as in 1960 and 1984) and South African record flood peaks (as in 1960 and 1988) are plotted against catchment area in log-log scale. The world record peaks seem to have stabilised between K = 6 to 6,5 which is an indication that the sample is fairly complete. The envelope of South African flood peaks has moved upwards during the last 28 years from about K = 5,2 to K = 5,6, not the least because the sample size was much larger in 1988.

The trends of both sets of data are strikingly similar: in the flood zone the points are well aligned with the direction of the corresponding K lines and the change from the transition zone to the flood zone is clearly visible between A = 100 to 200 km^2.

To sum up: the Francou-Rodier method, by virtue of the incorporated physical boundary conditions and according to the testimony of Figure 2, is eminently suited for the definition of regional maximum flood peak envelope curves.

In Table 2 typical maximum K values are listed for different parts of the world.

TABLE 2: TYPICAL MAXIMUM FRANCOU-RODIER K VALUES IN THE WORLD

Region		K_{max}
Tropical Africa		2 - 3
Central Europe, UK, USSR, Canada		3 - 4
Argentina, Uruguay, most parts of USA		4 - 5
Mediterranean Europe		5 - 5,5
Madagascar, New Zealand, India		5,5 - 6
Far East, Central America, Texas		6 - 6,5
Southern Africa:	Kalahari	< 3
	Highvelds	4 ,5 - 5
	South Eastern coastal belt	5 - 5,5

In South Africa the Francou-Rodier method had been used for the first time in 1980 when five maximum flood peak regions were delimited by a joint consideration of K values at 355 sites, 100 year, 1 day storm rainfall depth and general topography. The flood peak associated with the K_e envelope values was later termed as the "regional maximum flood" (RMF).

3. CATALOGUE OF MAXIMUM RECORDED FLOOD PEAKS

In the eight years elapsed since the publication of the first study (report TR105) South Africa has experienced not less than five extraordinary, large area storms which at many places resulted in the highest recorded or remembered flood peaks. The regional envelope curves established in 1980 were exceeded at 18 sites. The excess was in most cases less than $\Delta K = 0,2$, but during the January 1984 floods caused by tropical cyclone Domoina a maximum excess of $\Delta K = 0,31$ occurred in Northern Natal (in terms of discharge $\Delta K = 0,2$ is equivalent to 15% to 30% change depending on catchment size, see Table 1).

It became evident, especially after the Domoina floods, that in many regions the 1980 data base was lacking in extreme peaks and that the regional boundaries also required adjustments. The need for revision was underlined also by the uncertainty of K_e values along international borders due to absence of data from neighbouring countries. This meant that the revised and updated catalogue ought to cover the whole subcontinent.

The gathering of a new data base commenced in 1985 and has been completed after the February - March 1988 Orange-Vaal region floods. Its main sources were the following:

(1) Flood peaks retained from the 1980 catalogue.

(2) Flood peaks gauged since 1980 at Departmental stations.

(3) Flood peaks surveyed since 1980 by the Department in slope-area reaches, at bridges, culverts and weirs.

(4) Flood peaks calculated to flood levels recorded by the South African Transport Services at some of their oldest bridges. The earliest of these records dates from 1874.

(5) Flood peaks obtained from Lesotho, Swaziland, South-West Africa, Botswana, Zimbabwe[8] and Mozambique.

In drawing up the catalogue the principle had been that (i) at any one site only the largest peak should be selected and (ii) peaks observed at any site should be included only if judged to be sufficiently large in comparison to other maxima in the neighbourhood. In addition to flood peaks originated by rainfall, a few known large peaks caused by dambreak were also included.

The new catalogue, presented in Appendices 1 - 5, contains 519 peaks of which 354 correspond to South Africa and 165 were recorded in the other countries. The flood peak sites are shown in Figure 3.

The columns of the catalogue require the following notes:

Column 1: Drainage region or station number. Whenever an observation was made in reasonably close proximity to a Departmental gauge in South Africa, then the station number was used as opposed to the region number only. Sites included in the frequency analysis (Chapter 8) are denoted by symbol°.

Column 2: Geographic position. This was rounded-off to the nearest minute.

Column 4: Gross catchment area, A. At gauges it was taken from the latest available Departmental station lists. Elsewhere it was determined by planimetry. In a few cases (Appendix 2) it was guessed.

Column 5: Effective catchment area, A_e. It is the gross catchment area less ineffective areas from which the runoff cannot reach the catchment outlet (such as pans, marshes). Information on A_e was available only in South Africa[9][10]. It is believed that in the neighbouring countries only a few of the listed catchments comprise non-negligible ineffective areas.

Column 6: Flood peak, Q. It was rounded-off to three significant digits. Flood peaks caused by dambreak are shown between brackets.

Column 7: Francou-Rodier regional coëfficient K. This was calculated from A_e and Q by the Francou-Rodier equation, also in the transition zone (Chapter 2, Figure 1).

Column 9: Representative period, N. This is not the return period, except by chance. At gauges it represents the length of record. At other sites or in the case of historic floods N represents the number of years that have elapsed between the event and 1988. In cases when (i) the year of occurrence was unknown, (ii) an obviously extreme peak occurred fairly recently or, (iii) a relatively moderate historic flood occurred a long time ago, then N was estimated as described in Chapter 8. The estimated values are shown between brackets. The upper limit of N was set at 200 years.

Column 10: Method of measurement. Meaning of symbols:

G: gauged at calibrated stations
SA: slope-area survey
B: bridge contraction survey
C: culvert contraction survey
DI: inflow to dam
DΘ: outflow from dam
W: uncalibrated weir or embankment
FA: float velocity area
VA: velocity area
u: unknown

Column 11: Accuracy rating. Meaning of symbols

1: error is less than ± 10%
2: error is less than ± 30%
u: unknown error

The accuracy rating was decided upon in each case after consideration of available information on the measurement. For a large number of historic peaks, or those estimated after a substantial extrapolation of the calibration curve, it was not possible to estimate accuracy. Yet it is believed that, in general, peaks rated 'u' are of acceptable accuracy, not in the least because of the technical quality of the personnel who carried out the survey.

Column 12: RMF region number, K_e. It is the Francou-Rodier K value of the regional envelope curve in the flood zone. The asterisk indicates that the particular K envelope value at the site (K_e') is different from K_e. This can be the case along larger rivers or in catchments including extensive dolomitic areas or forest plantations. Coëfficient K_e' is shown in Column 13.

For the sake of interest the following statistics have been abstracted from the catalogue:

TABLE 3(a): DATE OF EVENTS AND MEAN REPRESENTATIVE PERIOD <N>

Country	Number of peaks	Date of peak				<N> (year)
		before 1900	1900 - 1929	1930 - 1959	1960 - 1988	
South Africa) Lesotho) Swaziland)	374	6	50	85	232	62
SWA	64	-	-	17	47	43
Botswana	14	-	-	-	14	14
Zimbabwe	54	-	8	17	29	48
Mozambique	13	-	-	2	11	59
Total	519	6	58	121	333	

In South Africa, Lesotho and Swaziland the <N> values in five large geographical regions are the following:

Northern Transvaal, Eastern Transvaal Lowveld	49 years
Vaal-Orange, West Coast	69 years
South Western Cape	47 years
Karoo, Southern and Eastern Cape	66 years
Transkei, Natal, Swaziland	65 years

Considering both the number of peaks and N, the best documented drainage regions in South Africa, Lesotho and Swaziland are C, J, M, U and W and those with the least representative coverage are B, F, N and P (Figure 4).

TABLE 3(b): METHOD OF MEASUREMENT AND ACCURACY

Method	Number of peaks	Probable error		
		< 10%	< 30%	Unknown
Gauge	209	44	63	102
Slope area	151	11	100	40
Bridge	27	4	20	3
Dam	54	24	26	4
Other	13	2	10	1
Unknown	65	-	-	65
Total	519	85	219	215
% of total	100	17	42	41

The most important conclusion from Table 3(b) is that the reliability of the two indirect methods i.e., the slope area and bridge contraction, compare well with that of gauging weirs for they yield proportionally much fever peaks of unknown accuracy. This is the more significant because by far the greatest number of extreme peaks were obtained by the indirect methods. The implication is obvious: the indirect methods are indispensable in the estimation of exceptionally large peaks.

4. DELIMITATION OF MAXIMUM FLOOD PEAK REGIONS

The K values of 512 flood peaks were plotted in 1:1 000 000 and 1:2 500 000 scale contour maps (seven peaks judged to be unrepresentative, mainly because of dambreaks, were omitted). In delimiting the regional boundaries consideration was given to individual K values, the number and accuracy of data in a particular area, existing boundaries, maximum recorded 3 day storm rainfall depths in South Africa, Lesotho, Swaziland and SWA(11)(12)(13) (Figure 5), topography, catchment orientation with respect of dominant storm generating weather systems, general soil permeability(14)(15)(16)(17)(18) (Figure 6), main drainage network and very large dams situated upstreams.

Of these factors K was evidently the most important. Therefore, in tracing the boundaries care was taken to allow for sufficient difference between the highest K values in the respective regions. From a practical viewpoint a minimum difference of $\Delta K = 0,2$ between regions with $K_{max} > 5$ was regarded as suitable (in terms of discharge this difference is equivalent to 15% to 30%). Between regions of low flood peak potential, where the data basis was much smaller, ΔK was increased to 0,6.

The result of the deliberations is Figure 7 where nine RMF regions are delimited. In areas with sparse or lacking information the boundaries are shown in dashed lines. The RMF regions are characterised by the corresponding Francou-Rodier 'flood zone' K_e envelope values (Chapter 5).

Some of the principal hydrological characteristics of the RMF regions in South Africa, Lesotho and Swaziland are listed in Table 4.

TABLE 4: HYDROLOGICAL CHARACTERISTICS OF EIGHT RMF REGIONS IN SOUTH AFRICA, LESOTHO AND SWAZILAND

Region	3 day max. observed rainfall (mm)	Mean annual rainfall (mm)	Dominant relief	Soil permeability
5,6	400 - 900 Tropical cyclones	600 - 1 000	Hilly to mountainous	Variable
5,4	400 - 900	Generally > 1 000	Hilly	Semi-permeable
5,2	South coast: 300 - 500 Far north: 400 - 700 Other: 200 - 400	Generally > 900	Mountainous	Except in the south, more permeable than 5,4 & 5,6
5	Western Cape: 200 - 500 Karoo: 150 - 300 Other: 200 - 300	200 - 1 500	Mountainous to hilly	S&W: semi-permeable to imperm N&E: perm to semi-permeable
4,6	SW: 100 - 200 NE: 150 - 250	SW: 200-500 NE: 500-800	Undulating to flat with mountainous patches	SW: semi-permeable NE: variable
4	W of 24°E: 100 - 200 E of 24°E: 150 - 250	100 - 500	Flat to undulating with pans	NE & Western Cape coast: permeable; elsewhere: semi-perm.
3,4	S & W: ≤ 150 N: 150 - 250	S & W: <200 N: 150-500	S&W: flat N: flat to undulating	S: semi-perm to imperm N: semi-perm to permeable; dolomitic
≤2,8	100 - 200	150 - 400	Flat to undulating	Kalahari sand: very permeable

Note: N = north S = south E = east W = west

In SWA, Botswana, Zimbabwe and Mozambique, due to the relatively smaller data base, shorter representative periods and less accessible hydrological parameters (i.e., 3 day maximum storm rainfall etc.) most of the boundaries are tentative. In establishing the regions it has been an important regard to apply the same K_e values as in South Africa, Lesotho and Swaziland. Some of the main features of these regions are as follows:

South-West Africa

Region 5: The surroundings of Windhoek. The 3 day maximum recorded rainfall is 200 to 300 mm; the mean annual rainfall is 300 to 400 mm; mountainous, impermeable highland above 1 500 m.

Region 4,6: Similar to region 5 but the 3 day maximum rainfall is generally lower, the mean annual rainfall varies between wider limits and the altitude is lower. In future this region might be extended further south-eastwards and parts of it might become region 5 if justified by observed peaks.

Region 4: This is a transition zone to regions of markedly lower extreme flood peak potential. It includes dolomitic zones in the north which should be associated with lower K_e.

Region 3,4: It includes the coastal strip north of Swakopmund where the upper catchments of rivers experience higher rainfalls than in the southern coastal zone. The rest of this region is transition to the very permeable areas of the Namib and the Kalahari.

Botswana

Region 5: A small area adjoining region 5 in Zimbabwe, including the Shashe River. The 3 day maximum rainfall could be ± 300 mm, the mean annual rainfall is 450 to 650 mm, the relief is hilly and the soil is impermeable (granite sandveld).

Region 4,6: Similar to region 5 but drier, hilly to flat and lower lying.

Region 4: It comprises mainly the left-bank catchment of the Limpopo River. The 3 day maximum rainfall should be similar to that of the right bank catchments i.e., 200 to 300 mm (Figure 5). The mean annual rainfall is ± 500 mm. In the central parts relief is more hilly than in region 4,6. The soils are impermeable in the north, mixed in the central zone and generally permeable south of the Tropic of Capricorn. In future parts of the impermeable area i.e., those lying between latitude 22° and the Tropic of Capricorn might be added to region 4,6 if justified by observed peaks.

Region 3,4: A narrow and undefiniable belt of transition to the Kalahari.

Zimbabwe

Region 5,6: It includes the eastern slopes of the Chimanimani mountains from which the rivers flow directly to Mozambique. The 3 day maximum rainfall could be higher than 1 000 mm because of tropical cyclones(19), the mean annual rainfall is more than 1 500 mm, the dominant soils are semi-permeable to impermeable. This narrow region forms the western part of the larger region 5,6 in Mozambique. Its northern limit should not stretch beyond the Inyanga mountains (latitude ± 18°).

Region 5,2: The 3 day maximum rainfall should be high (say, 500 to 700 mm) because the area is still influenced by tropical cyclones. The mean annual rainfall is 500 to 1 000 mm, the relief is hilly to mountainous, the soils are impermeable. Most probably parts of the north-eastern escarpment (e.g. Mudzi and Ruenga catchments) belong also to this region.

Region 5: This large region covers most of the south-eastern half of Zimbabwe. The 3 day maximum storm rainfall is moderate to high. The mean annual rainfall increases from 350 mm in the Limpopo valley to about 1 200 mm in the north-eastern areas. The relief is variable with extensive areas of relatively flat land. The soils are predominantly impermeable.

Region 4,6: This is a narrow transition belt between regions 5 and 4. It also includes a few predominantly impermeable catchments along the southern bank of the Zambezi River in the north-western corner of the country.

Region 4: This covers most of the north-western part of the country. The 3 day maximum rainfall should be similar to or somewhat less than in region 5. The mean annual rainfall is 600 to 750 mm. The relief is hilly to flat and the soils are mainly permeable.

Region 3,4: It includes most of the Hwange National Park (formerly Wankie) and adjoining areas which are very flat and permeable (Kalahari Sandveld).

Mozambique

Region 5,6: For the northern region consult its Zimbabwean part. The southern region is an extension of region 5,6 in South Africa and Swaziland (Table 4) but the relief is hilly to flat.

Region 5,2: This small area is the easternmost corner of region 5,2 in South Africa.

Region 5: Its northern part is an undefined transition between region 5,6 in the west and the very flat, swampy coastal belt where, in spite of very high storm rainfall (tropical cyclones) and high mean annual rainfall (1 000 to 1 500 mm) extreme flood peaks are limited by natural storage over the flood plains. The southern part is the eastward extension of the same region in South Africa.

5. REGIONAL MAXIMUM FLOOD PEAK ENVELOPE CURVES (K_e) AND THEIR EQUATIONS

The envelope curves were established by (i) considering the regional boundaries, (ii) plotting peaks against respective effective catchment areas, (iii) defining the separation between flood zone and transition zone and, (iv) determining the discharge associated to the 15 minute duration storm rainfall over 1 km^2.

Figure 8 is an overview of eight regional curves. Curves 3,4 to 5,6 were established on the basis of plotted data (Figures 9 to 11) and curve 2,8 is a guessed addition.

The Francou-Rodier equation is valid only in the flood zone where the envelope lines corresponds to K_e = constant numbers. The catchment areas separating the flood zones and transition zones were chosen by heeding to the author's comments(5),(6) and consulting Figures 2, 9, 10 and 11. The envelope curves in the transition zone (dashed lines) should be viewed as tentative because of sparse data, especially in catchments smaller than 10 km^2. The discharges corresponding to the lower limit of the transition zone (A_e = 1 km^2) were estimated from maximum recorded short duration rainfall in South Africa(20(21) and SWA(20) by assuming no storm loss. These discharges were supposed to be valid also for the other countries.

In Figures 9(a) - (h), 10(a) - (d) and 11(a) - (b) the peaks of the catalogue were plotted against A_e in each region where the data base was regarded adequate. Plots in the same RMF region were presented separately for South Africa-Lesotho-Swaziland, SWA and Zimbabwe on purpose to encourage the gathering of extreme flood peaks in the two latter countries. In Botswana and Mozambique more complete data bases are needed for a meaningful graphical presentation.

In the flood zones the K_e = constant envelope lines were traced close to the highest observed K and not higher than by ΔK = 0,1 to 0,3. To shift the lines, namely, too far above observed maxima would be tantamount to the abandonment of the essence of the empirical approach. The separation between the flood zone and transition zone in regions 4,6 to 5,6 was fixed at A_e = 100 km^2. In the very flat and dry regions the separation had to be shifted toward larger A_e. The reason is that even here comparatively high flood peaks can be caused by short duration local storms.

An examination of Figures 9 - 11 reveals that

- in the flood zone the cloud of points, especially their upper bounds, tend to follow the direction of the K_e = constant lines fairly well, thereby giving substantial credence to the Francou-Rodier approach of maximum flood peak appraisal in Southern Africa;

- there are relatively few data in catchments smaller than 100 km^2 and less than a dozen in catchments smaller than 10 km^2;

- in South Africa distinction was made between region 5 and 5_{GH}. The latter comprises winter rainfall drainage regions 'G' and 'H' in the South Western Cape (Figures 9(d) - (e)). The distinction became necessary in view of the estimation of 50 year to 200 year flood peaks from RMF (Chapter 8);

- simultaneous reference to Figures 9 - 11 and column 11 of the Appendices discloses that most peaks of unknown accuracy ('u'), particularly those near to the regional upper bound, associate very well with the peaks of defined accuracy. This is an indication that, on the whole, the 'u' peaks lie within a realistic range;

- in a few cases the observed K values were marginally higher than K_e, see Figures 9(d) - (f). However, this is not disturbing since the excess discharge is very small in comparison to RMF.

Certain reaches of larger rivers that flow across several regional boundaries required particular K_e values (K_e') which differ from that of the region, see Table 5 and Figure 7.

TABLE 5: K ENVELOPE VALUES IN PARTICULAR REACHES OF LARGER RIVERS IN SOUTH AFRICA, LESOTHO AND SWAZILAND

River	Drainage region	Reach		K_e'
		From	To	
Limpopo	A	in regions 4,6; 5 & 5,2		4
Krokodil	A	Pienaars River	Limpopo River	4
Mogalakwena	A	Glen Alpine Dam	Limpopo River	4
Olifants	B	Elands River	31°00 East	4
Olifants	B	31°00 East	Mozambique border	4,6
Vaal	C	Bloemhof Dam	Orange River	3,4
Riet	C	Kalkfontein Dam	Koffiefontein	5
Riet	C	Koffiefontein	Modder River	4,6
Riet	C	Modder River	Vaal River	4,3
Orange	D	P.K. le Roux Dam	Vaal River	4,3
Orange	D	Brak River	Upington (d/s)	3,7
Orange	D	Upington (d/s)	Hartbees River	3,4
Orange	D	Hartbees River	Augrabies Falls (d/s)	3,1
Orange	D	Augrabies Fall (d/s)	Atlantic Ocean	2,8
Caledon	D	Leeu River	Orange River	4,6
Sak-Hartbees	D	Brandvlei	Orange River	2,8
Berg	G	in region 4		4,6
Groot	L	Beervlei Dam	Gamtoos River	4,6
Gamtoos	L	Groot River	Indian Ocean	5
Sundays	N	Mentz Dam	Indian Ocean	5
Great Kei	S	in region 5,4		5,2
Mzimvubu	T	in region 5,4		5,2
Tugela	V	in region 5,4		5,2
Great Usutu	W	Western limit of reg. 5,6	Phongolo River	5,2
Komati	X	in region 5,6		5,2

Along the Limpopo and Elefantes Rivers in Mozambique the following K_e' values are suggested:

Limpopo:	South African border - Mwenezi River	4
	Mwenezi River - Elefantes River	3,4
	d/s of Elefantes River	$\leq$ 2,8
Elefantes:	South African border - Massingir Dam	4,6
	Massingir Dam - Limpopo River	4

Elsewhere in Mozambique, SWA, Botswana and Zimbabwe K_e' values for particular reaches of large rivers should be established by professionals having a thorough knowledge of the hydrological regimes in question.

The regional RMF equations and their areal range of application are listed in Table 6.

TABLE 6: RMF EQUATIONS IN SOUTHERN AFRICA

Region	Transition zone		Flood zone	
	RMF (m^3/s)	Areal range (km^2)	RMF (m^3/s)	Areal range* (km^2)
2,8	$30A_e^{0,262}$	1 - 500	$1,74A_e^{0,72}$	500 - 500 000
3,4	$50A_e^{0,265}$	1 - 300	$5,25A_e^{0,66}$	300 - 500 000
4	$70A_e^{0,34}$	1 - 300	$15,9A_e^{0,60}$	300 - 300 000
4,6	$100A_e^{0,38}$	1 - 100	$47,9A_e^{0,54}$	100 - 100 000
5	$100A_e^{0,50}$	1 - 100	$100A_e^{0,50}$	100 - 100 000
5,2	$100A_e^{0,56}$	1 - 100	$145A_e^{0,48}$	100 - 30 000
5,4	$100A_e^{0,62}$	1 - 100	$209A_e^{0,46}$	100 - 20 000
5,6	$100A_e^{0,68}$	1 - 100	$302A_e^{0,44}$	100 - 10 000

* the upper limit refers only to South Africa

6. NOTES FOR THE CALCULATION OF RMF

The equations listed in Table 6 enable the instant determination of RMF if the geographic position of the site and its effective catchment area are known. The method is expected to render the best results for catchment sizes approximately between 300 km^2 and 20 000 km^2. In both the small and large catchments one is confronted with the inherent weakness of all regionally based methods, namely that the particular characteristics of these catchments cannot be easily expressed by one common regional factor, in this case K_e.

The following recommendations may help to tackle various problems in the application of the method.

(1) As a general rule, a site located in a given region is characterised by the K_e line of that region even if parts of the catchment extend into other regions. At sites located on or about regional boundaries the average K_e value or, where particularly justified, the higher of the two values may be adopted.

(2) Small to medium catchments ($A_e < \pm$ 5 000 km^2)

The smaller the catchment, the greater the chance that its features could considerably differ from the typical regional values listed in Table 4.

Excepting regions 2,8 and 3,4, K_e may be reduced if (i) more than the half of the area is very permeable, dolomitic or covered by plantations (forest, orchards, etc.), (ii) the 1 day maximum rainfall obtained from a record of at least 50 years is markedly lower than in adjoining areas and (iii) the catchment is unusually flat. The reduced K_e' may not be lower, however, than the K_e of the next lower number region (for instance, in region 5 the maximum permissible reduction is $\Delta K = 0,4$).

Excepting regions 5,4 and 5,6, K_e may be increased if (i) the catchment is very steep (mainly in regions 4 to 5,2) or impermeable (mainly in regions 2,8 and 3,4) and (ii) the 1 day maximum rainfall is substantially higher than in the surroundings. The increased K_e' may not exceed the K_e of the next higher number region.

Important: In catchments larger than about 5 000 km^2 the above-mentioned changes are not justified in South Africa, Lesotho and Swaziland.

In very small catchments, say $A_e <$ 10 km^2, the maximum flood peak should preferably be calculated by other methods in which the particular local conditions can be incorporated.

(3) Large rivers

As already noted in the previous chapter, rivers which flow across several RMF regions have distinct flood characteristics which may differ substantially from those of the region (Table 5). In the lower reaches of such rivers the flood peak reduction is often very important because of storage in the wide flood plains. Here the prominent feature of extreme floods are rather the flood volume and duration than flood peak which is limited by the inundations. In Figure 12 the change in maximum recorded K is shown along the Orange River. In Lesotho, where the catchment is wet and steep, K is fairly constant. In South Africa it is gradually reduced as the effects of decreasing mean annual rainfall and flatter catchment become apparent.

(4) The influence of a few relatively very large dams on RMF has been considered in the delimitation of regional boundaries (Figure 7). As a rule of thumb, RMF should not be reduced

because of upstream dams except in rare occasions when the dam capacity (at full supply level) is larger than the RMF volume associated with long duration (3 day and longer) storm rainfall.

7. COMPARISON OF RMF AND THE PROBABLE MAXIMUM FLOOD (PMF) IN SOUTH AFRICA

In a study made in 1983[22] the relative reliability of the 10 000 year peak, PMF and the originally recommended RMF was tested in 120 catchments where the flow record was 20 years or longer. It was found that the consistency of RMF, in terms of the mean annual and 10 year flood peaks, was clearly the best. It was also concluded that the 10 000 year peak should not be used at all for the estimation of maximum flood peaks because of its highly erratic character.

In this study revised RMF values were compared with PMF at 75 Departmental dams where PMF peaks calculated by the most widely employed method in South Africa, the synthetic unitgraph method, were available[23]. The mean ratio PMF/RMF was 1,82, with a minimum of 0,54 (Paul Sauer Dam on the Cougha River, Southern Cape A_e = 3 887 km^2) and a maximum of 4,49 (Spioenkop Dam in the Tugela River, Natal, A_e = 2 452 km^2).

A convincing proof for the inconsistency of PMF is given in Table 7 where the K_o values are compared with the means of the K equivalents of PMF ($\langle K \rangle_{PMF}$) in six PMF regions.

TABLE 7: COMPARISON OF K_e AND $\langle K \rangle_{PMF}$

RMF	Number of dams	$\langle K \rangle_{PMF}$
4	1	5,34
4,6	17	5,51
5	41	5,47
5,2	8	5,60
5,4	6	5,39
5,6	2	5,90

Disregarding regions 4 and 5,6 because of the small number of dams, $\langle K \rangle_{PMF}$ does not seem to increase between region 4,6 (in this case mainly the Northern Orange Free State and the Transvaal Highveld) where the extreme flood peak potential is moderate, and region 5,4 (in this case the Eastern Cape coastal belt) where extremely high peaks are fairly frequent.

The conclusion is, thus, that RMF is a more consistent basis for the maximum design peak.

8. ESTIMATION OF 50 YEAR TO 200 YEAR FLOOD PEAKS FROM RMF

Knowledge of 50 year to 200 year peak discharges is required in practice for the design of bridges, dams and also in various flood defence problems.

A simple, unorthodox analysis of the K value and the representative period (N) of entirely independent flood peaks has provided coëfficients which represent the 50 year to 200 year peaks as fractions of RMF. The analysis was carried out in South Africa, Lesotho and Swaziland for regions 3,4 to 5,6, in SWA for regions 3,4 to 5 and in Zimbabwe for regions 5 and 5,2. In the remaining regions of these countries, Botswana and Mozambique the data basis of entirely independent flood peaks was insufficient for an analysis.

The analysis comprised the following steps and considerations (carried out for each region in question):

(1) The catalogue was screened and only the entirely independent peaks were selected for the study. This meant that for a given flood event in a region only the flood peak associated with the highest K was considered. For instance, from the 15 peaks listed in Appendix 1 for the Domoina flood (1984) in region 5,6 only the one that occurred in the Black Mfolozi River (K = 5,56) was chosen. As a result of this strict criterion the 519 peaks listed in the catalogue were reduced to 262.

(2) Each flood peak was associated with an N. If this could not be directly done (see Chapter 3, comments on column 9 of the catalogue) then a provisional N was estimated on the assumption that the ratio of the 200 year peak to RMF, Q200/RMF is 0,65, Q100/RMF is 0,575, Q50/RMF is 0,50 and Q20/RMF is 0,2. The first of these values was derived already in Chapter 5 of the original study[1], the rest were provisional approximations based on the first value and experience. These four ratios were supposed to be valid in all regions. Thus, in a particular case first the ratio of the observed peak to RMF (= Q/RMF) was calculated and then interpolated between the four selected frequences. The upper limit of N was set at 200 year (in other words, all Q/RMF $\geq$ 0,65 values were associated with N = 200 year). Undoubtedly, several of the observed extreme peaks could have been associated with longer representative periods than 200 year. On the other hand, the peaks of the screened catalogue are but an incomplete sample, for many of the extreme flood events occurred since 1856 are not represented (mainly those in smaller catchments). This implies that many of the flood peaks in the sample are associated with longer N than should be. The above-mentioned two considerations should have the opposite influence on $\sum N$ which is the sum of the individual N in the region, also known as 'station years'.

(3) As already noted in Chapter 3 (comments on column 9 of the catalogue) in the case of individual peaks N is not the return period (T), except by chance. However, its mean value in the region, $\langle N\rangle = \sum N/M$ where M is the number of peaks, could be reasonably assumed to be equal with the mean return period of peaks, $\langle T\rangle$. This assumption becomes more realistic if M is large. Consequently, the mean value of K, $\langle K\rangle = \sum K/M$ could be associated with $\langle N\rangle$.

(4) Following the proven assumption made in the British Flood Studies report[24], the return period of the peak with the highest K was taken as $T = \sum N$. Likewise, the return period of the few next highest ranking K events were taken as $\sum N/2$, $\sum N/3$, etc. The corresponding K,T values and also $\langle K\rangle$, $\langle T\rangle$ were plotted in a linear-logarithmic scale. Folllowing the British report, it is important to note that only the few highest K,T and $\langle K\rangle$, $\langle T\rangle$ are the representative points. Thereafter a frequency distribution curve was fitted to the representative points by eye, allowing the determination of K_T values in the range of 50 year $< T <$ 200 year.

In Figure 13 the above process is illustrated for region 4,6 in South Africa. The curve was drawn slightly above the most important $\langle K\rangle$, $\langle T\rangle$ point (owing to its stability) in order to remain on the conservative side. Observe that downward from the 4th highest K the points are gradually deviating from the experimental frequency curve which is an indication that their return periods (calculated as $T = \sum N/m$, where m is the ranking order) are not representative.

The recommended upper limit for the application of the frequency curve is 200 years. The reason is that the upper tail of the curve is very sensitive for the position of the highest K values. As to the lower limit, flood peaks associated with $T <$ 50 year cannot be considered extreme and should be estimated by conventional methods. Suffice is to say that in the 20 year $< T <$ 50 year range the frequency curve is, on the whole, expected to be steeper than beyond 50 year (see Figure 8 in reference[1]).

Once steps 2 - 4 were performed, the provisional N (see step 2) was corrected by using the revised Q_T/RMF ratios which vary from region to region. The process was repeated until the N estimates became stable. In column 9 of the catalogue the final N are shown between brackets.

The practical outcome of the frequency analysis is summarised in Figures 14(a) - (c) and Appendices 6 and 7 where the Q_T/RMF ratios are shown in the 50 year $< T <$ 200 year range for the different regions. Note that the accuracy of the ratios is only two-decimal and the three decimals displayed in the Appendices are merely intended to enable more correct plotting.

In region 5 of Zimbabwe the same Q_T/RMF may be used as in region 5 of South Africa.

Appendix 8 provides a summary of pertinent statistics of the independent events selected for the analysis.

Some of the conclusions from Figures 14 and Appendices 6 - 8 are the following:

(i) In the flood zone and for T = constant, ratio Q_T/RMF increases with the catchment area. This is the consequence of the convergence of the K = constant lines in the Francou-Rodier diagram (Figure 1). For the same reason, Q_T/RMF should have its minimum value at the catchment area which separates the flood zone and the transition zone.

(ii) There are considerable regional differences in Q_T/RMF (for constant T and A_e) owing to storm rainfall pattern, mean regional catchment size and the relative conservatism of RMF. Ratio Q_T/RMF tends to increase if high rainfall depths occur more frequently, the mean regional catchment size is very large or very small and $\sum N$ is small.

(iii) As expected, the "steepness" of the flood peak frequency curve, expressed by Q200/Q50, is higher in drier regions where the flood regime is more extreme.

In Table 8 the 100 year flood peak estimates obtained from RMF and the above described analysis (Q100) and as the mean value from three to four other methods (<Q100>) are compared in eight RMF regions and five geographic zones of South Africa. The information refers to 36 Departmental dam sites where flood frequency calculations have been carried out during the last years. The "other" methods, well known and widely employed in South Africa, were the log-Normal or log-Pearson 3 distributions of annual maximum flood peak records (probabilistic), the rational and unitgraph methods (semi-deterministic) and the regional empirical/probabilistic method developed by Pitman and Midgley in 1967[25]. In a broader sense all of the "other" methods rely on long established theoretical frequency distributions of storm rainfall or flood peak maxima.

Table 8(a) reveals that ratio Q100/<Q100> is gradually increasing from region 3,4 to region 5,6, in spite of the very uneven distribution of sites. Whereas in the drier and comparatively flat regions 3,4 and 4 peaks Q100 and <Q100> are practically the same, in regions 5,2 to 5,6 (Figure 7) where the highest K are recorded, the RMF based Q100 peak is significantly greater than <Q100>.

In Table 8(b) the information is grouped according to five large hydrogeographic areas. The distribution of sites is much more even than in Table 8(a) but the general scene is the same: there is a consistent increase in ratio Q100/<Q100> as one moves from areas of low flood peak potential to those of very high peaks.

TABLE 8: COMPARISON OF 100 YEAR FLOOD PEAK ESTIMATES

(a) According to RMF regions (b) According to hydrogeographic regions

RMF region K_e	Number of sites	Q100/<Q100>	Hydrogeo-graphic region	Number of sites	Q100/<Q100>
3,4 & 4	2	0,98	Limpopo	9	1,15
4,6	10	1,13	Vaal/Orange	9	1,08
5	18	1,32	SW Cape	3	1,29
5,2	2	1,80	Karoo	7	1,54
5,4	3	2,29	SE & E		
5,6	1	2,68	Coastal belt	8	1,93

The inference from Table 8 is clear: the currently employed theoretical distributions, which serve as basis for the "other" methods, may result in seriously underestimated Q50 to Q200 peaks in regions of high extreme peaks. This is a confirmation and generalisation of the evidence found after the September 1987 Natal floods[26][27].

The RMF derivates, on the other hand, are able to provide more consistent and generally more realistic answers.

9. RESUMé OF APPLICATION

The principal steps of the herein presented empirical method are as follows:

(1) Determine geographical position and effective catchment area.

(2) Determine the Francou-Rodier K_e value from Figure 7.

(3) Calculate RMF from Figures 9 - 11 or Table 6.

(4) Estimate Q50 to Q200 peaks from RMF by using Figures 14(a) - (c) or Appendices 6 - 7.

10. EPILOGUE

In a general sense all scientific methods that are able to say something about nature are empirical i.e., they are contingent and revisable. The need for revision arises if the calculation results are consistently confuted by observations.

The empirical methods in the proper sense of the word, such as the one presented in this report, rely on in situ observations to a higher degree than do other methods. The frequency of their revision will depend first of all on the representativeness of the data base.

The herein included data base of maximum flood peaks observed in South Africa is a great improvement in comparison to the catalogue of the original 1980 report. The regional boundaries, shown in Figure 7, should require adjustments only if the respective K_e were consistently exceeded by more than $\Delta K = 0,1$.

By considering the maximum attained K values in Madagascar[6] (5,78), where the extreme floods are caused by fairly frequent tropical cyclones, the size of the data-base and presuming no changes in the climate, it is believed that regions 5 to 5,6 might require but modest adjustments in the future whereby the increase in K_e will be limited to $\Delta K = 0,2$. The most likely areas for this to happen are the South Western Cape and adjacent Karoo where $K_e = 5,2$ is possible and the Transvaal Lowveld where the data-base is small and which could be affected by tropical cyclones.

In the dryer western and northwestern areas of South Africa the data base is sparse, thus there is a greater chance for future modifications, particularly in Namaqualand where no data are available yet and in North Western Transvaal. However, it is not likely that the K_e' values recommended for certain reaches of large rivers, such as the Lower Orange, Vaal, Hartbees, Harts and Limpopo, should soon be changed.

As to the neighbouring countries, this catalogue is a first attempt for a combined gathering of maximum flood peaks in the subcontinent. Consequently, the results are tentative and might require considerable modifications on the basis of more representative data. This is especially true for Botswana where the mean representative period of the catalogue is far too short. On the other hand, in Lesotho and Swaziland future adjustments are expected to be minimal.

REFERENCES

1. **KOVACS, Z.P.:** Maximum flood peak discharges in South Africa: An empirical approach. Technical Report TR105, Department of Water Affairs, Forestry and Environmental Conservation, Division of Hydrology, 1980.

2. **KLEMES, V.:** A hydrological perspective. Journal of Hydrology, Vol. 100, pp 3 - 28, 1988.

3. **ADAMSON, P.T.:** The statistics of extreme values and the analyses of floods in South Africa. Technical Report TR86, Department of Water Affairs, Division of Hydrology, 1978.

4. **FRANCOU, J. and RODIER, J.A.:** Essai de classification des crues maximales. Proceedings of the Leningrad Symposium on Floods and their computation, UNESCO, 1967.

5. **SOCIéTé HYDROTECHNIQUE DE FRANCE:** La prévision des crues. X^{e} Journées de l' Hydraulique, Tome I: Discussion de la Question I, Paris, 1968.

6. **RODIER, J.A. and ROCHE, M.:** World catalogue of maximum observed floods. IAHS Publication No. 143, Wallingford, 1984.

7. **LUO CHENG-ZHENG:** Investigation and regionalisation of historical floods in China. Journal of Hydrology, Vol. 96, pp 41-51, 1987.

8. **MITCHELL, T.B.:** A study of Rhodesian floods and proposed flood formulae. The Rhodesian Engineer, November, 1974.

9. **HYDROLOGICAL RESEARCH UNIT:** Surface water resources of South Africa. Reports No. 8/81 - 13/81, Part 2, Appendix E. University of the Witwatersrand, Department of Civil Engineering, 1981.

10. **Prof em D.C. MIDGLEY:** Personal communication.

11. **ADAMSON, P.T.:** Southern African storm rainfall. Technical Report TR102, Department of Environment Affairs, Division of Hydrology, 1983.

12. **SUBDIRECTORATE FLOOD STUDIES:** 3 day storm rainfall depths compiled for the documentation of the following floods: South Western Cape, 1981, South Eastern Cape, 1981, Domoina, 1984, Natal, 1987 and Vaal-Orange, 1988. Department of Water Affairs, Directorate of Hydrology.

13. **WEATHER BUREAU:** 3 day storm rainfall data for various events between 1984-1988 (personal communication).

14. **BRINK, A.B.A.:** Engineering geology of Southern Africa. Vol. 4, Building Publications, Pretoria, 1985.

15. **SCHULZE, R.E.:** Hydrological characteristics and properties of soils in Southern Africa. Water SA, Vol. 11 No. 3, July 1985.

16. **MACVICAR, C.N.:** (Department of Agriculture, Pretoria): Personal communication.

17. **VAN LANGENHOVE, G.:** (Department of Water Affairs, South-West Africa, Windhoek): Personal communication.

18. **PITMAN, W.V. and Stern, J.A.:** Design flood determination in SWA-Namibia. Report No. 14/81, Hydrological Research Unit, University of the Witwatersrand, Department of Civil Engineering, 1981.

19. **DUNN, P.:** An investigation into tropical cyclones in the South West Indian Ocean. Flood Studies Technical Note 1, Department of Water Affairs, Directorate of Hydrology, 1984.

20. **MIDGLEY, D.C. and PITMAN, W.V.:** A depth-duration-frequency diagram for point rainfall in Southern Africa. Report No. 2/78, Hydrological Research Unit, University of the Witwatersrand, Department of Civil Engineering, 1978.

21. **VILJOEN, F.:** Weergeskiedenis van Suid-Afrika. Department of Environment Affairs, Monthly issues of 'Newsletter' between May 1987 - April 1988.

22. **KOVACS, Z.P.:** Problems in the estimation of maximum flood peaks. Proceedings, South African National Hydrological Symposium, Pretoria, 1983.

23. **PITMAN, W.V. and MIDGLEY, D.C.:** Amendments to design flood manual HRU 1/69. Report No. 1/71, Hydrological Research Unit, University of Witwatersrand, Department of Civil Engineering, 1971.

24. **NATURAL ENVIRONMENT RESEARCH COUNCIL:** Flood Studies Report, Vol. I, Institute of Hydrology, Wallingford, UK, 1975.

25. **PITMAN, W.V. and MIDGLEY, D.C.:** Flood studies in South Africa: Frequency analysis of peak discharges. The Civil Engineer in South Africa, August 1967.

26. **KOVACS, Z.P.:** Preliminary hydrological assessment of the Natal Flood. The Civil Engineer in South Africa, January 1988.

27. **PEGRAM, G. and ADAMSON, P.T.:** Revised risk analysis for extreme storms and floods in Natal/KwaZulu. The Civil Engineer in South Africa, January 1988.

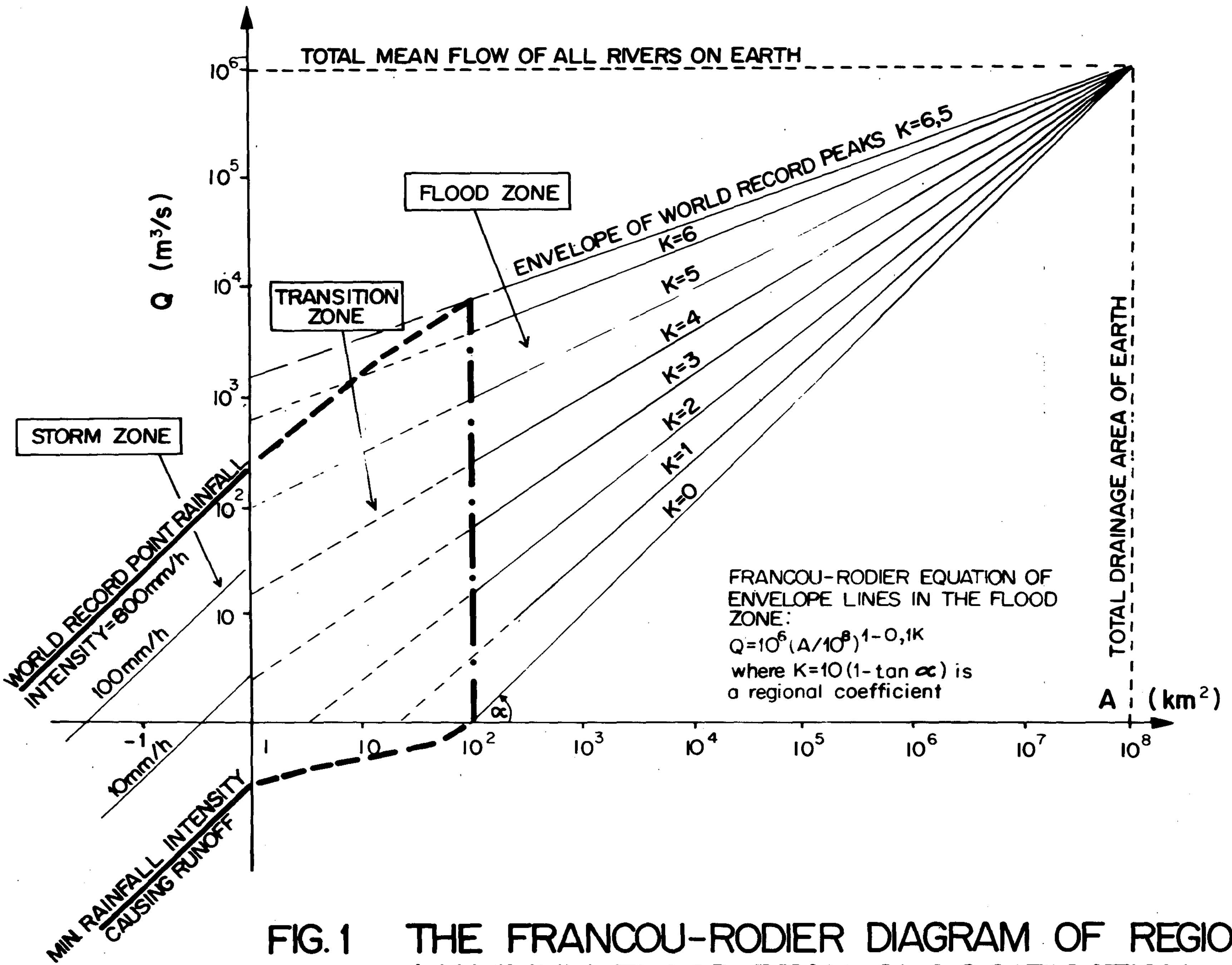

FIG. 1 THE FRANCOU-RODIER DIAGRAM OF REGIONAL MAXIMUM FLOOD PEAK CLASSIFICATION

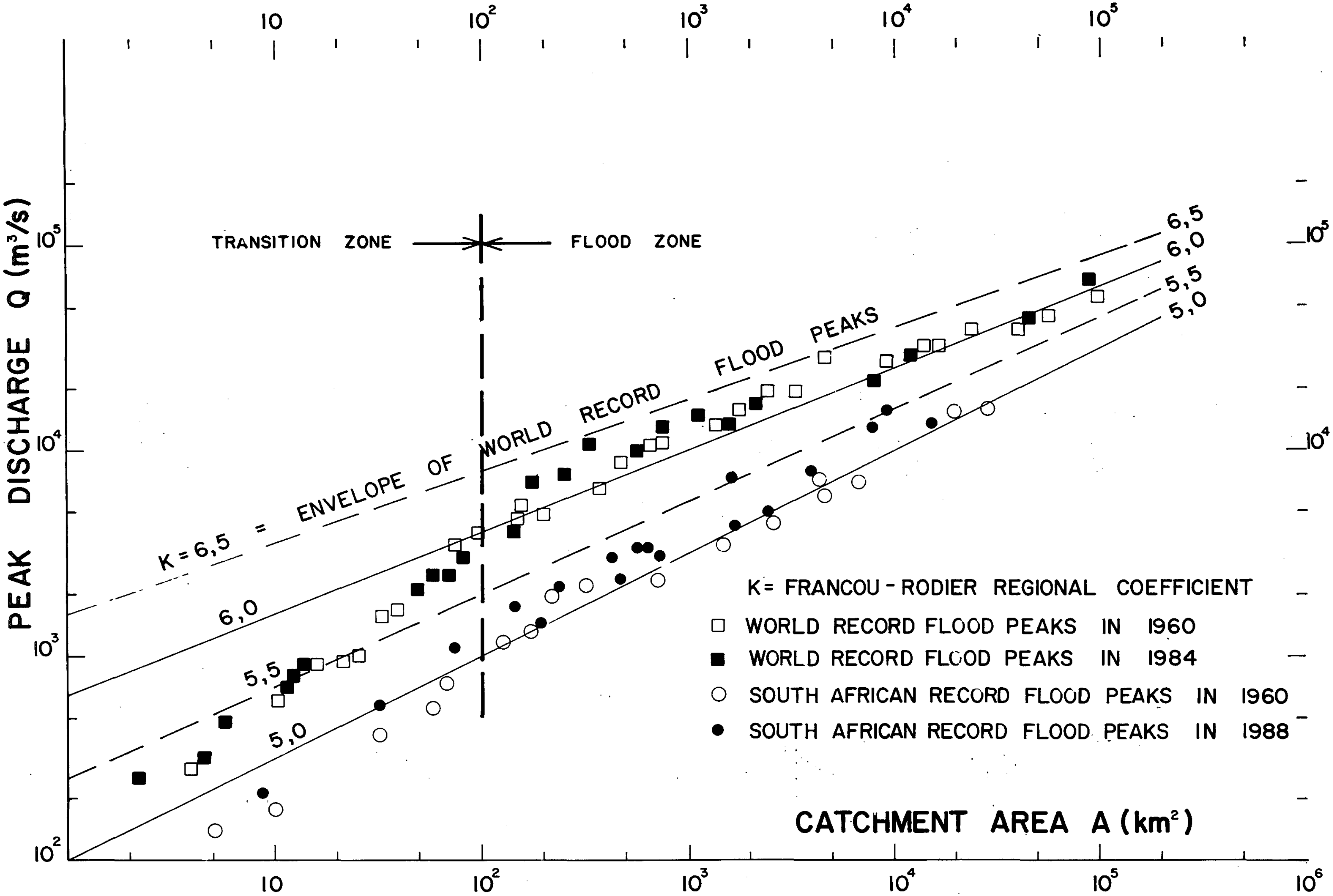

FIG. 2 WORLD- AND SOUTH AFRICAN RECORD FLOOD PEAKS

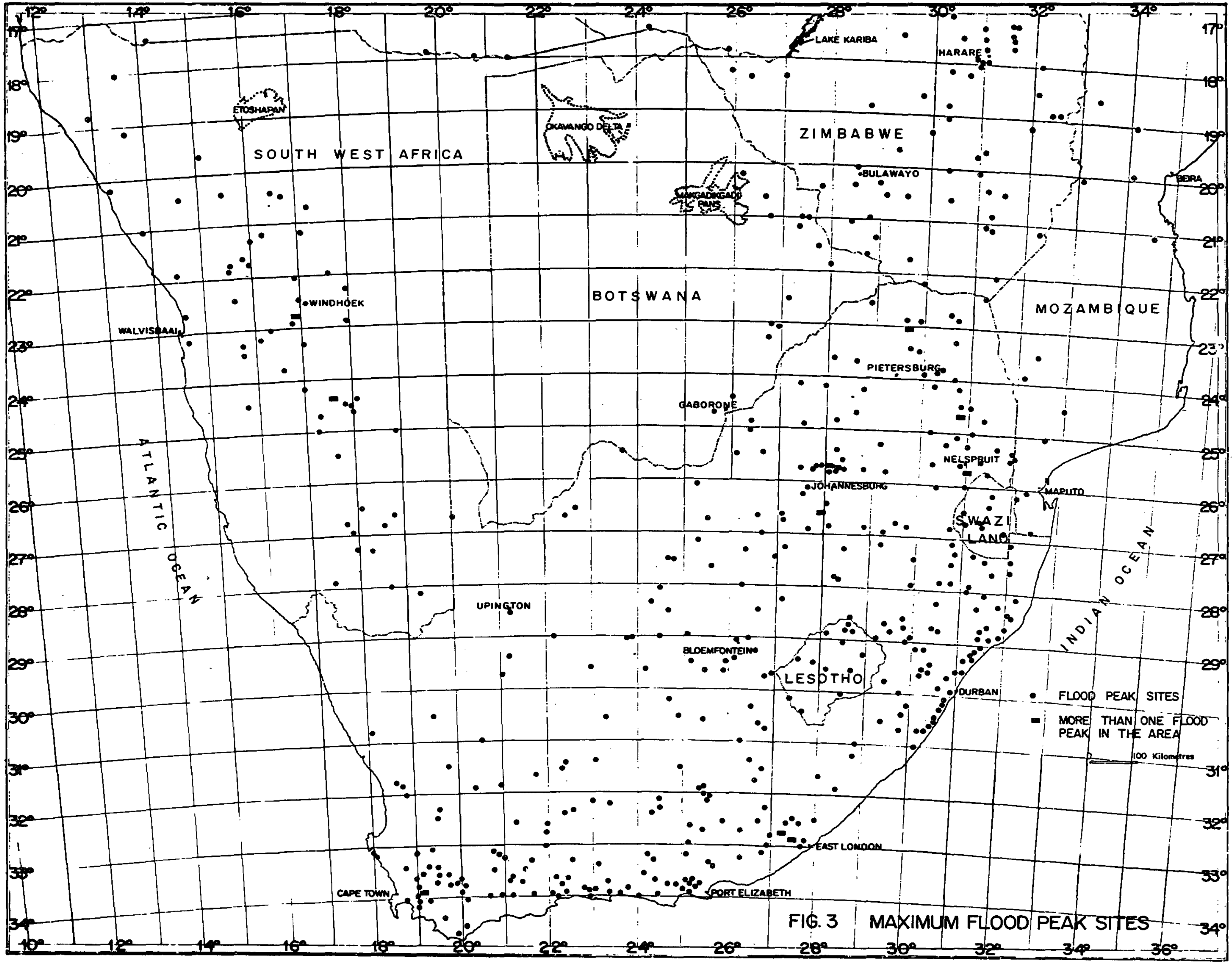

FIG. 3 MAXIMUM FLOOD PEAK SITES

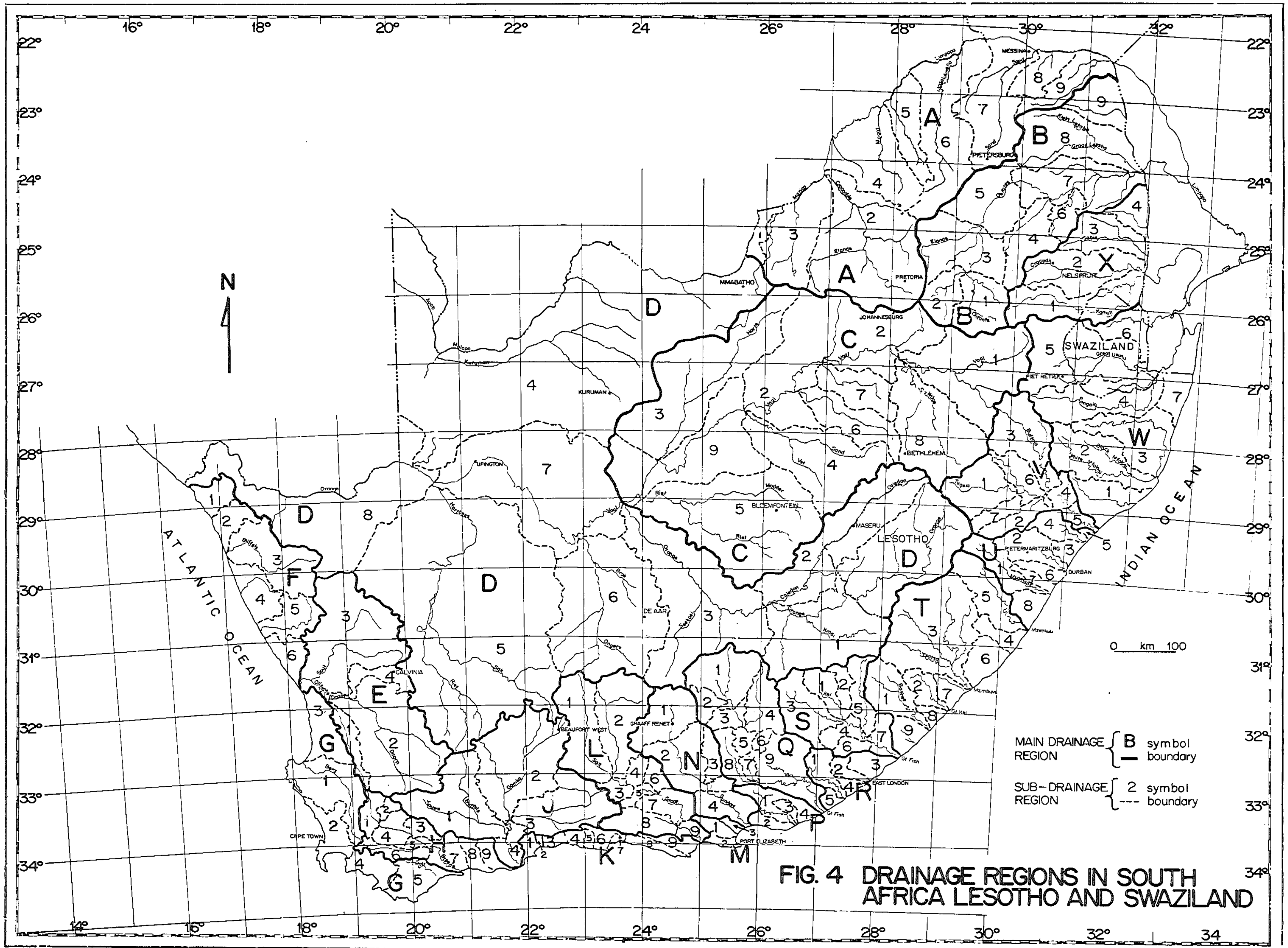

FIG. 4 DRAINAGE REGIONS IN SOUTH AFRICA LESOTHO AND SWAZILAND

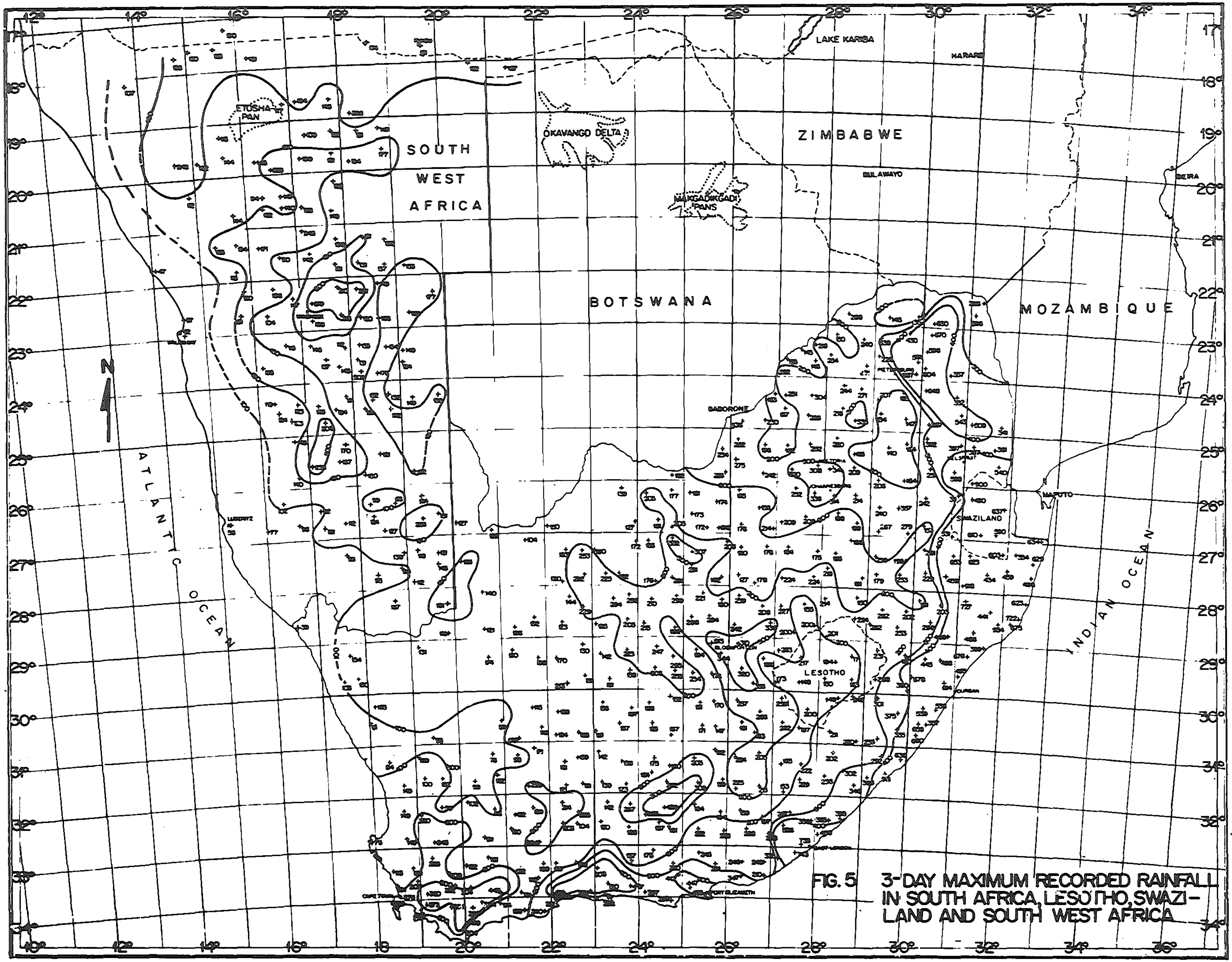

FIG. 5 3-DAY MAXIMUM RECORDED RAINFALL IN SOUTH AFRICA, LESOTHO, SWAZILAND AND SOUTH WEST AFRICA

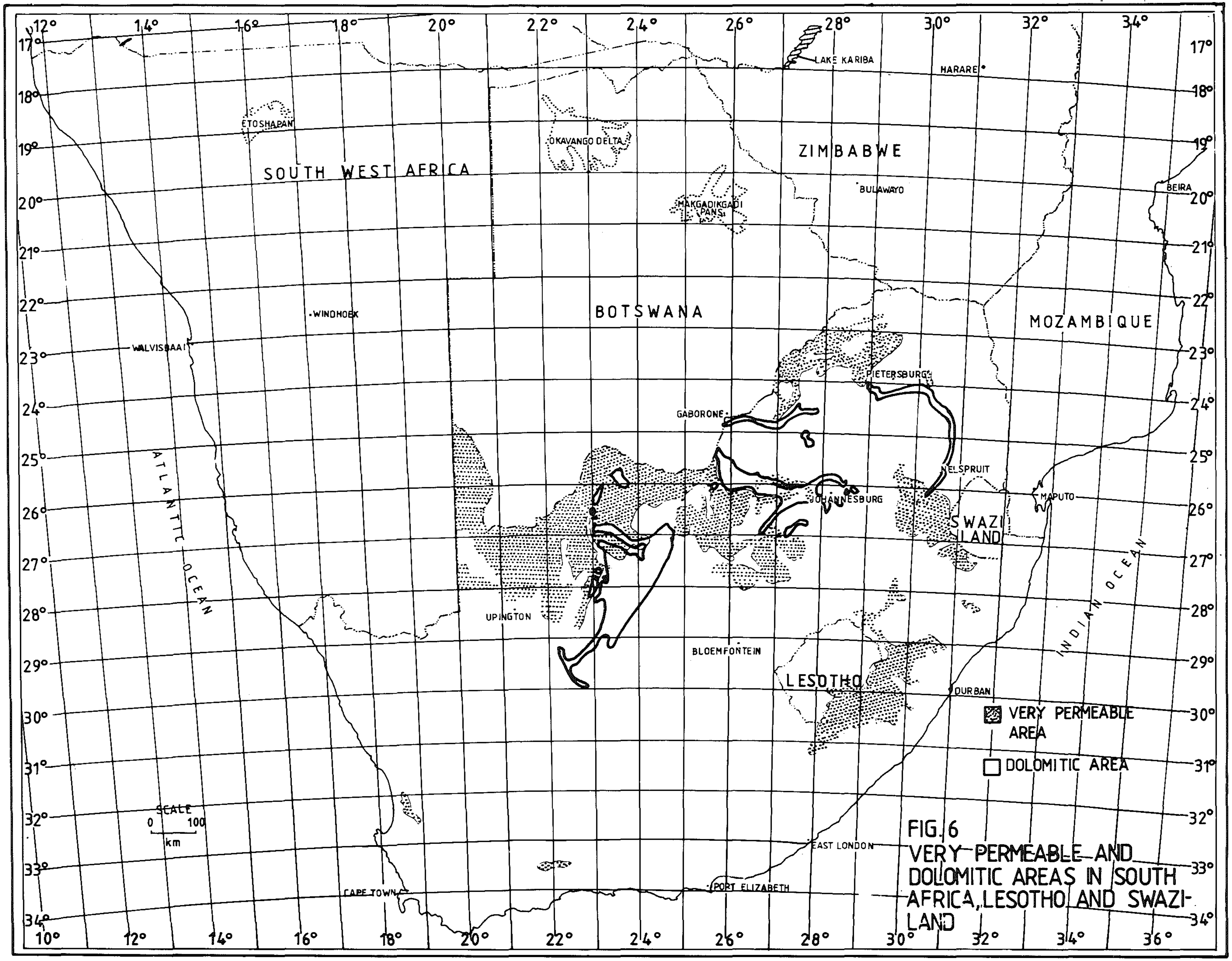

FIG. 6
VERY PERMEABLE AND DOLOMITIC AREAS IN SOUTH AFRICA, LESOTHO AND SWAZILAND

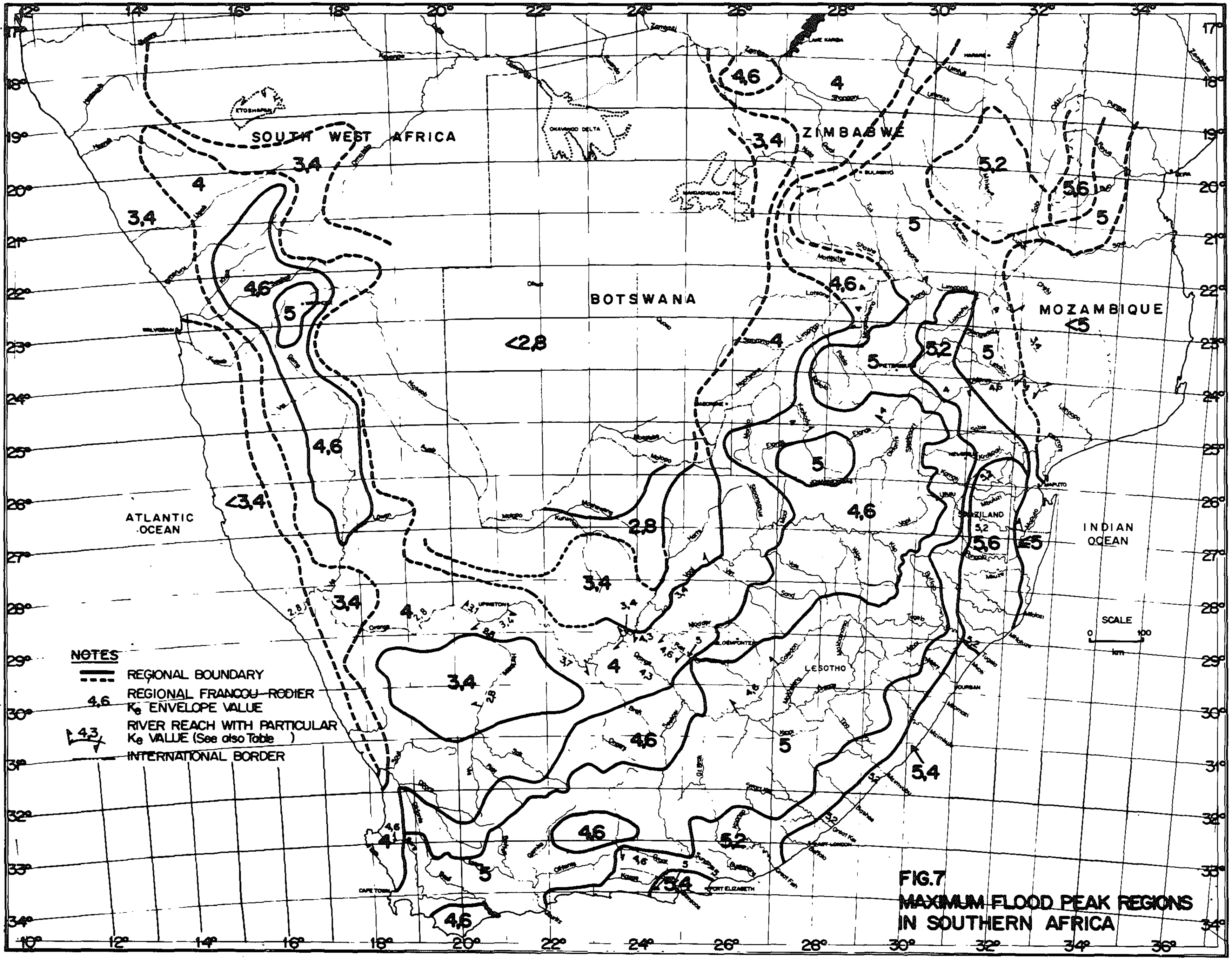

FIG.7
MAXIMUM FLOOD PEAK REGIONS
IN SOUTHERN AFRICA

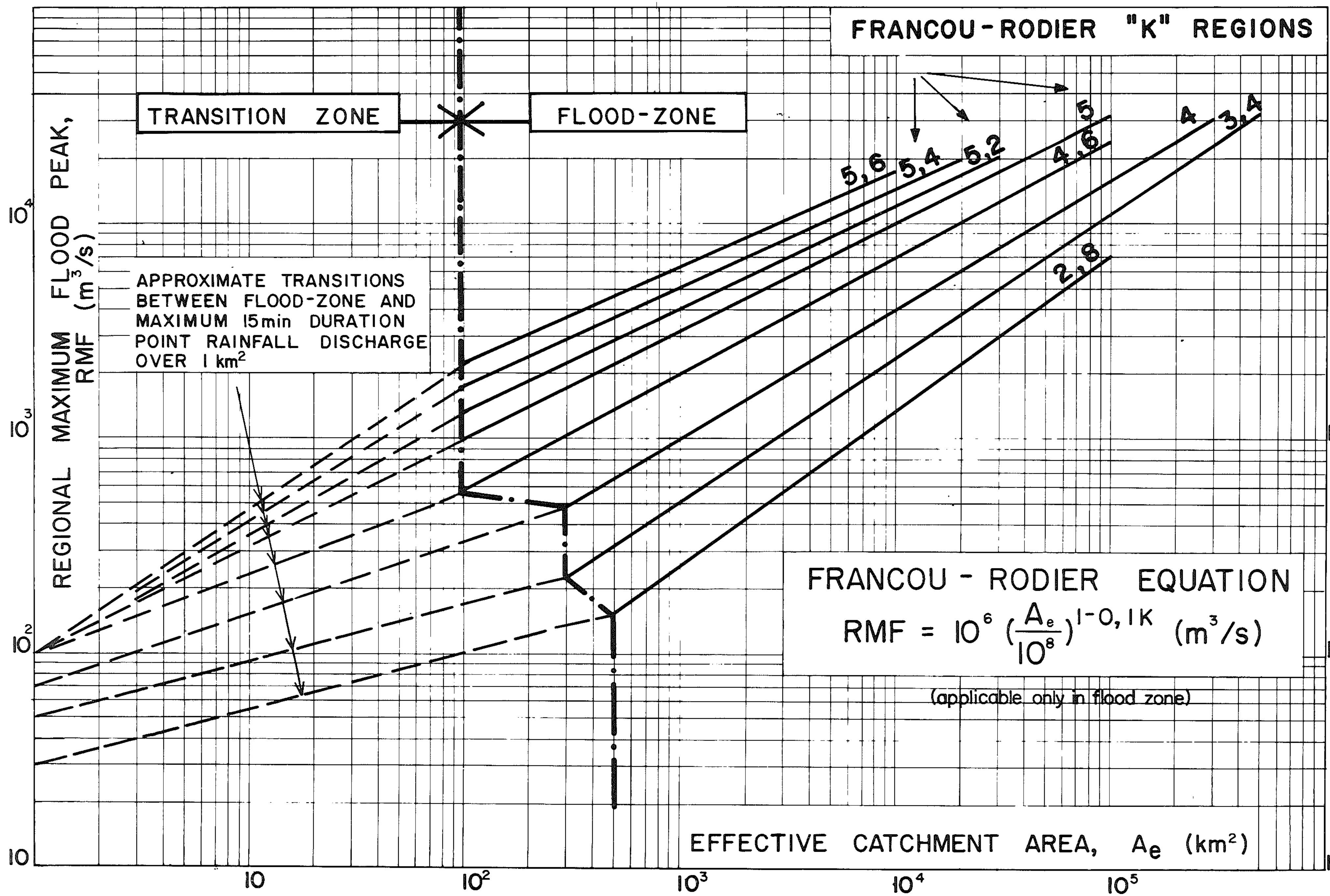

FIG. 8 REGIONAL MAXIMUM FLOOD PEAK CURVES FOR SOUTHERN AFRICA

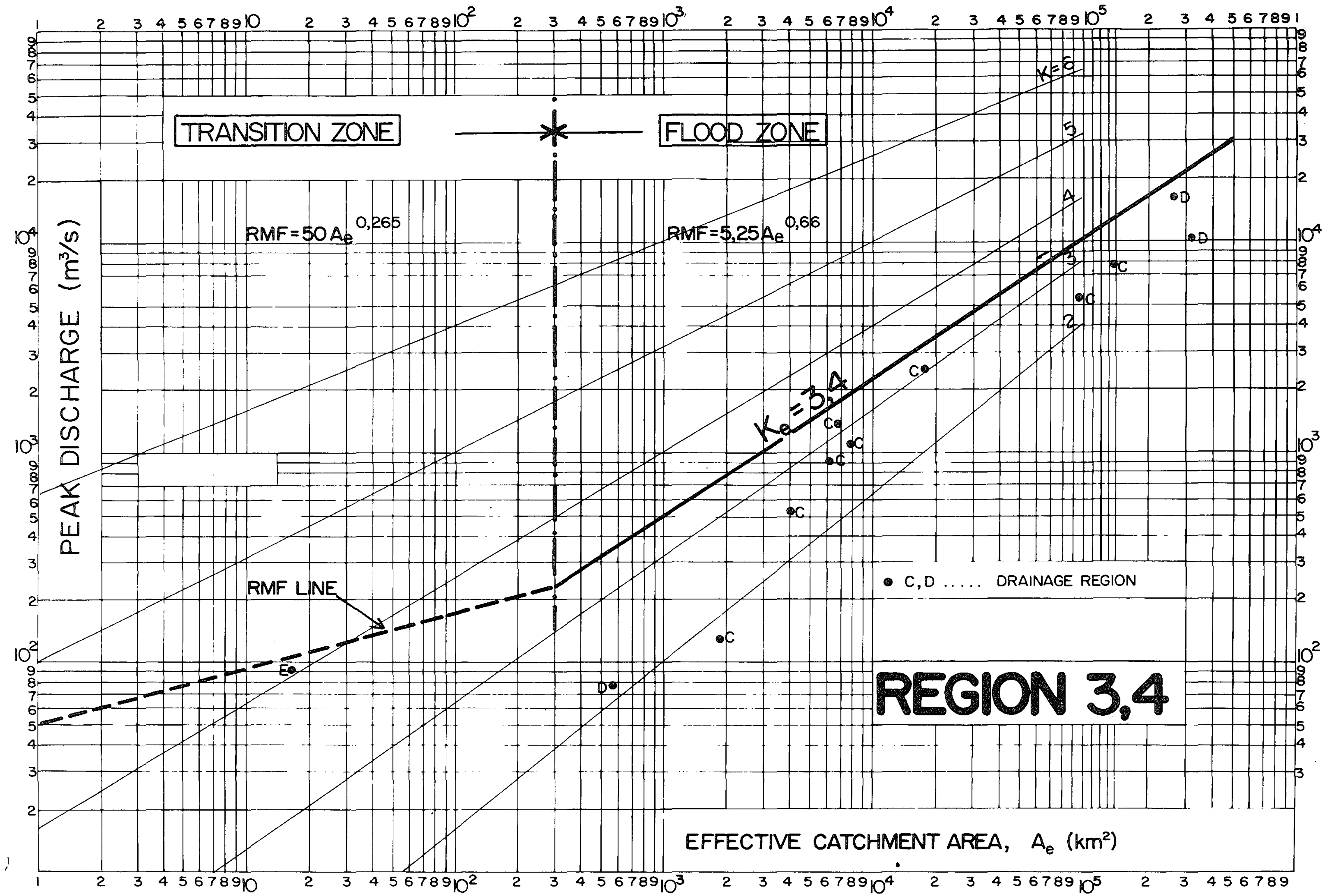

FIG. 9a HIGHEST RECORDED FLOOD PEAKS AND RMF IN REGION 3,4

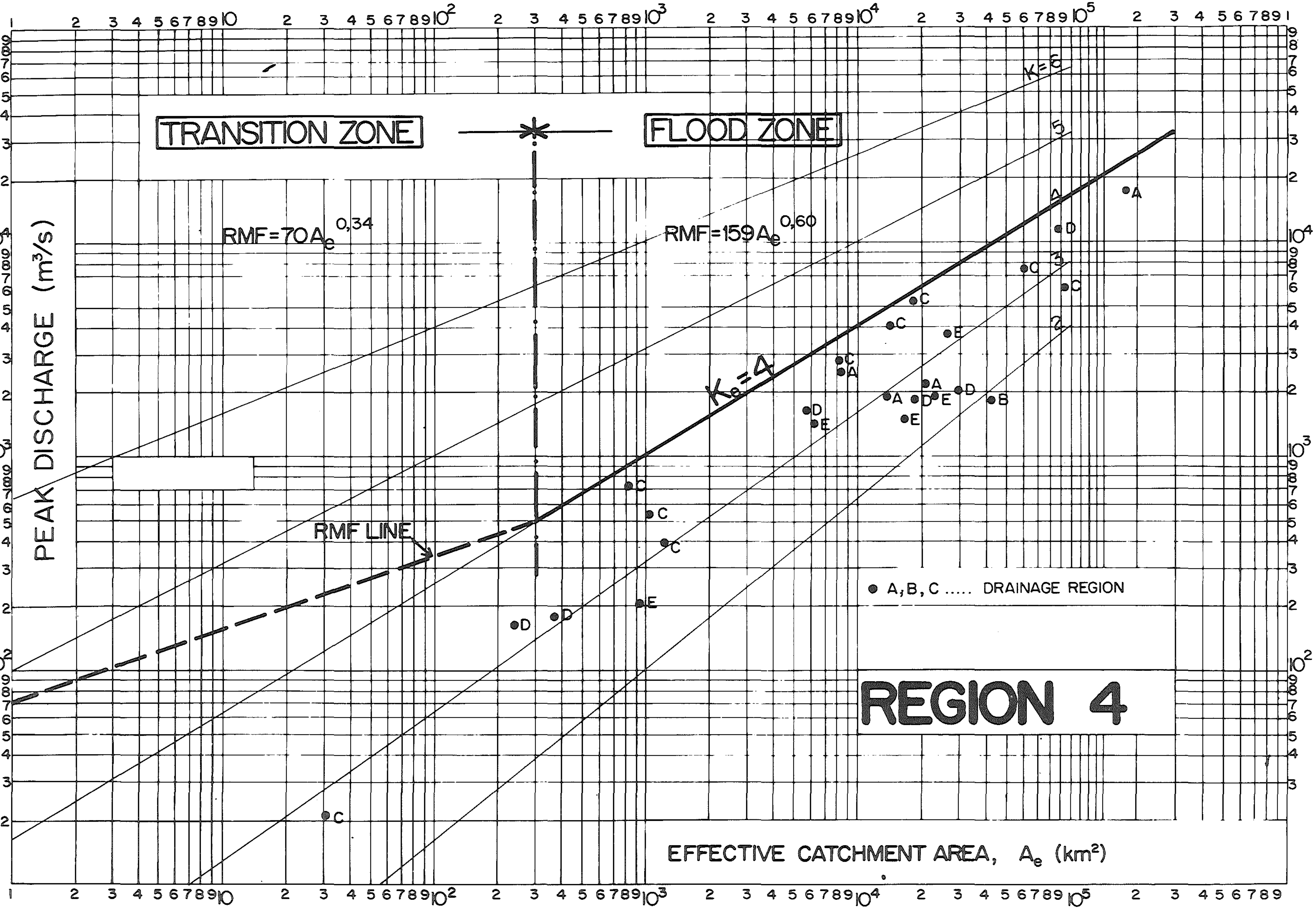

FIG. 9b HIGHEST RECORDED FLOOD PEAKS AND RMF IN REGION 4

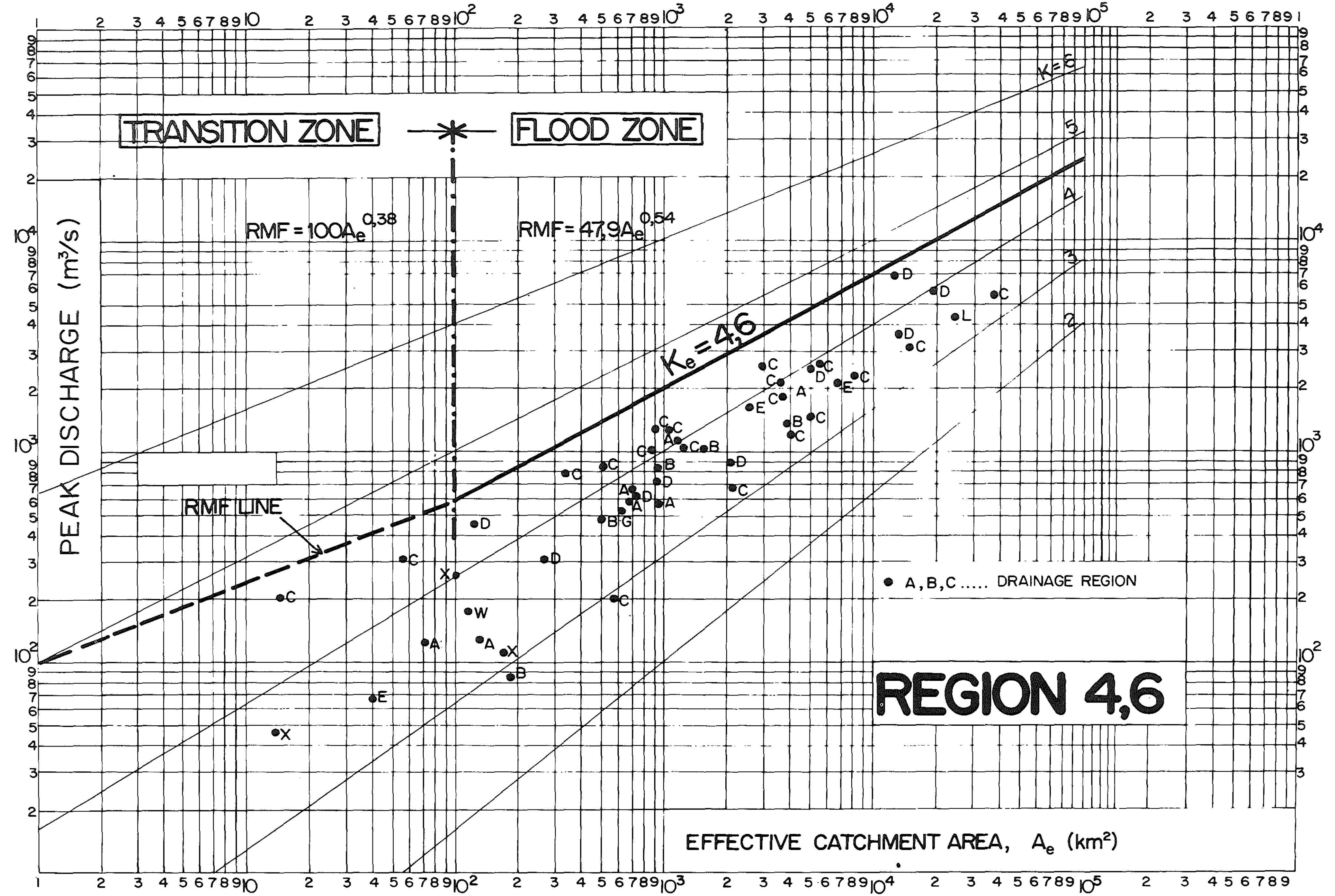

FIG. 9c HIGHEST RECORDED FLOOD PEAKS AND RMF IN REGION 4,6

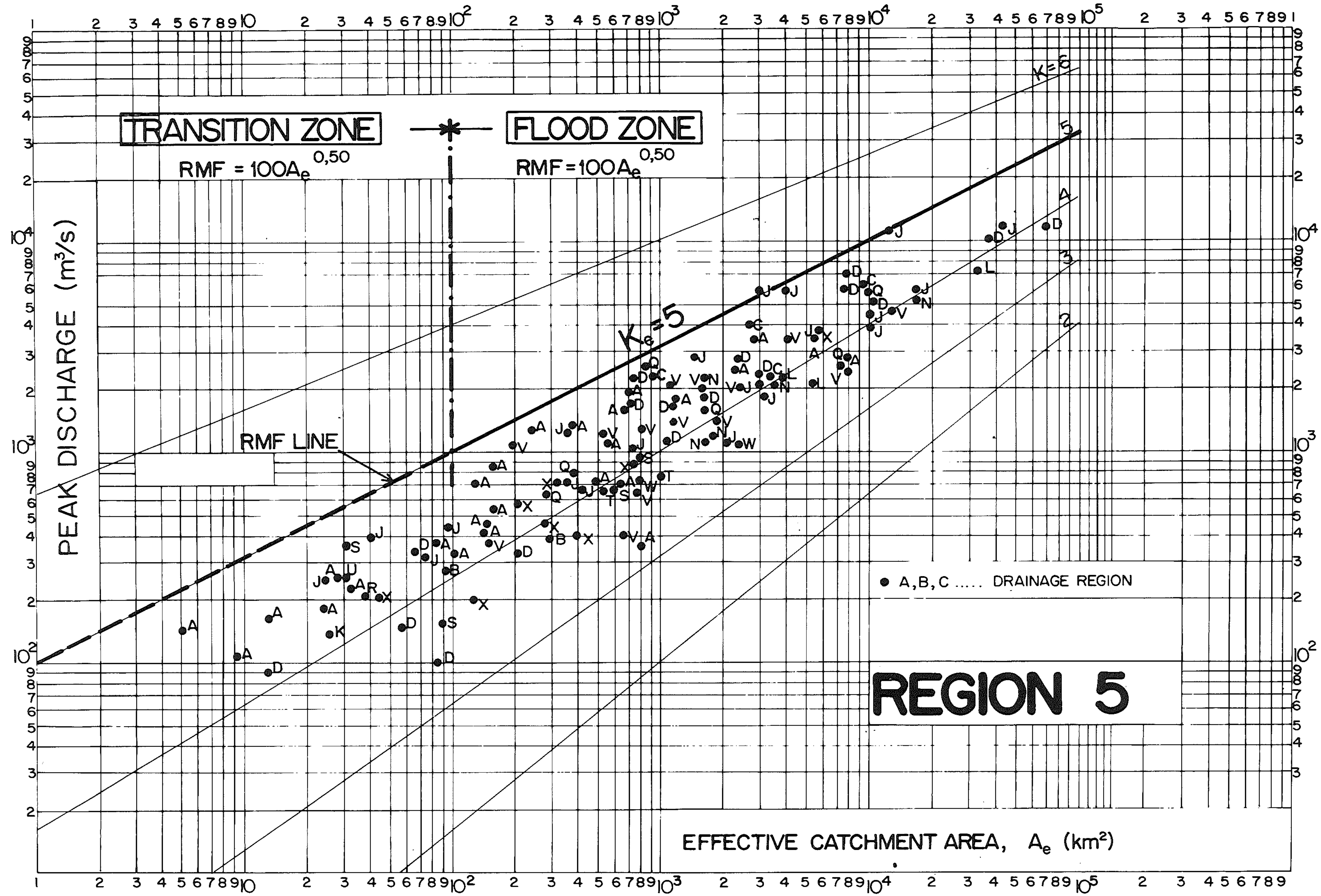

FIG. 9d HIGHEST RECORDED FLOOD PEAKS AND RMF IN REGION 5

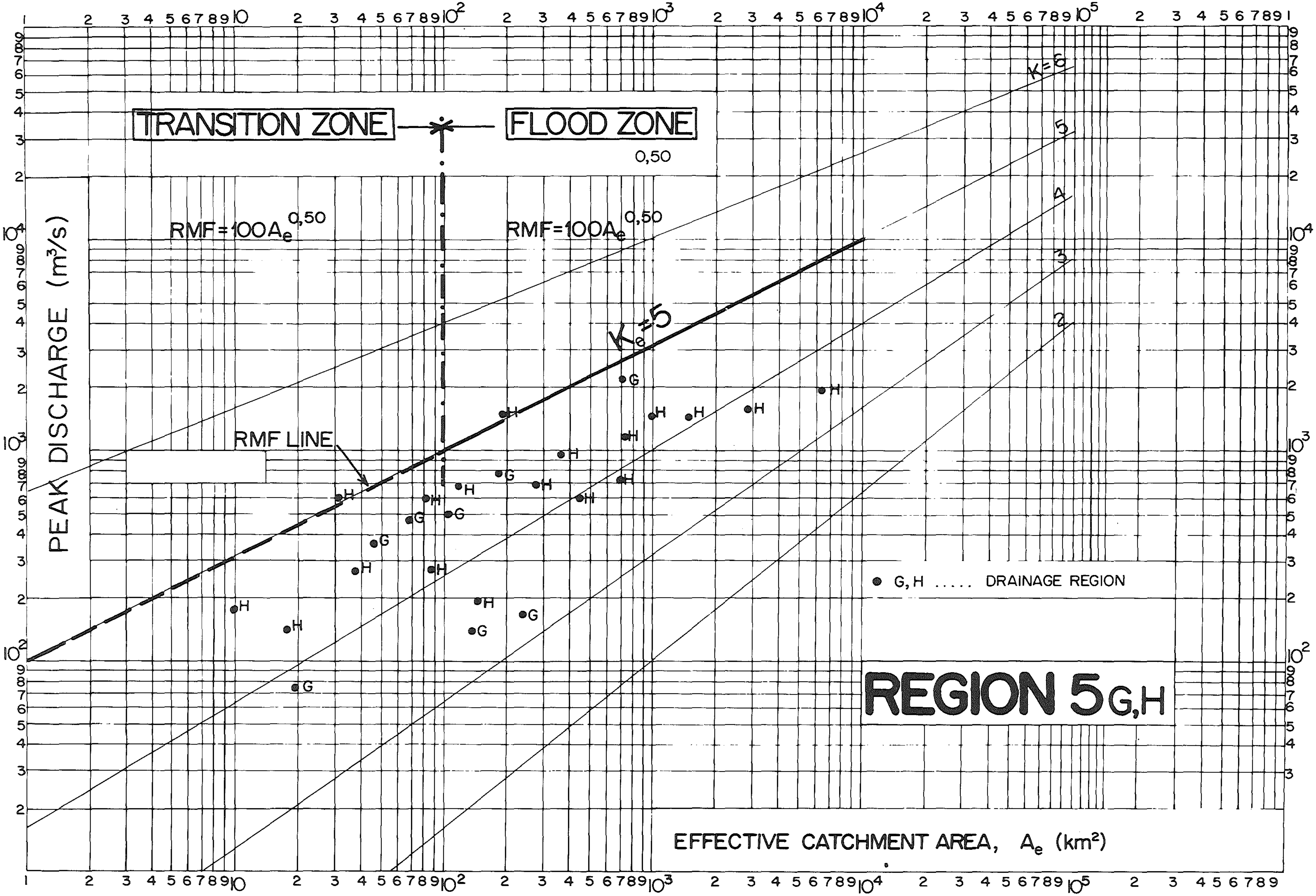

FIG. 9e HIGHEST RECORDED FLOOD PEAKS AND RMF IN REGION 5 G,H

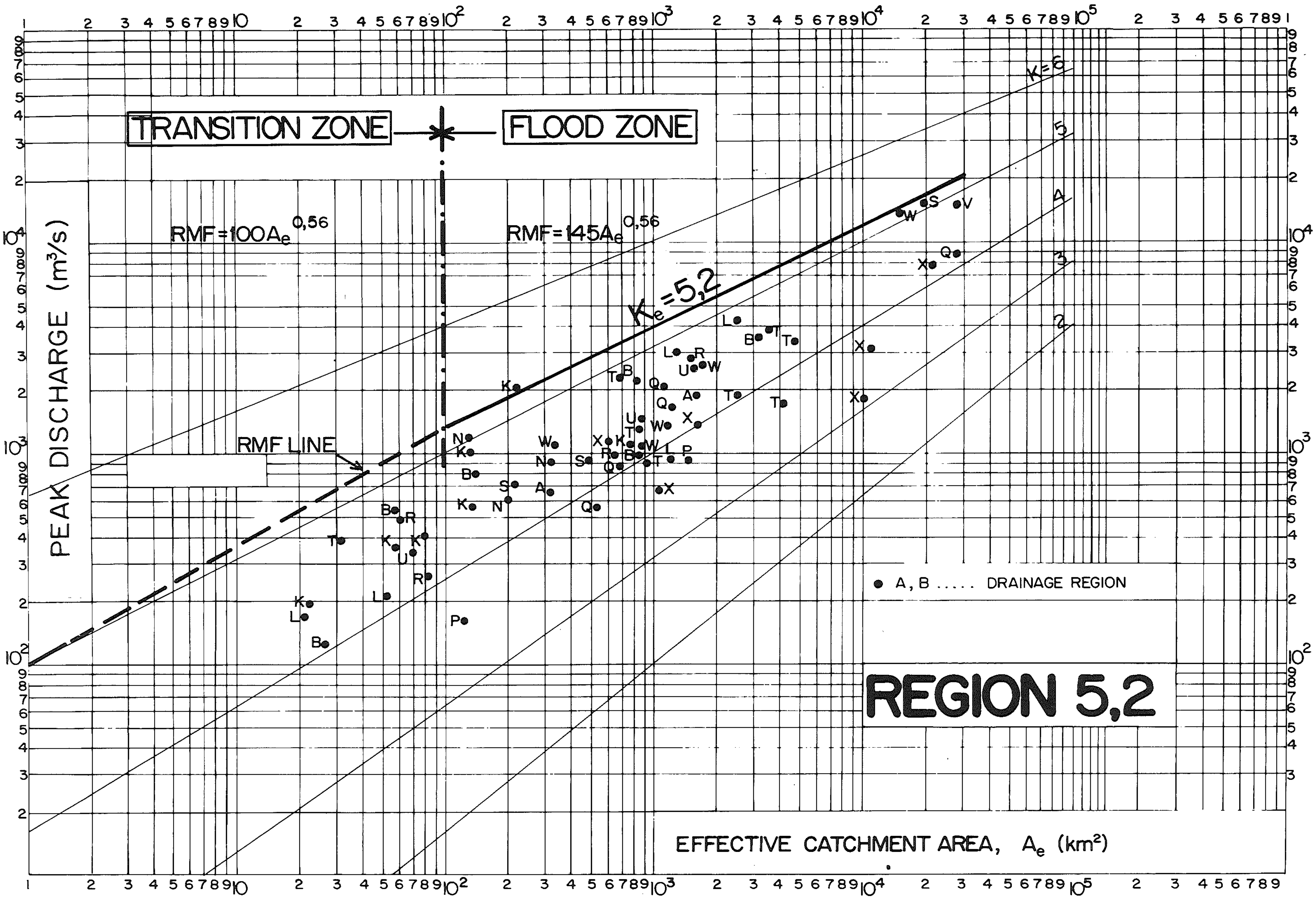

FIG. 9f HIGHEST RECORDED FLOOD PEAKS AND RMF IN REGION 5,2

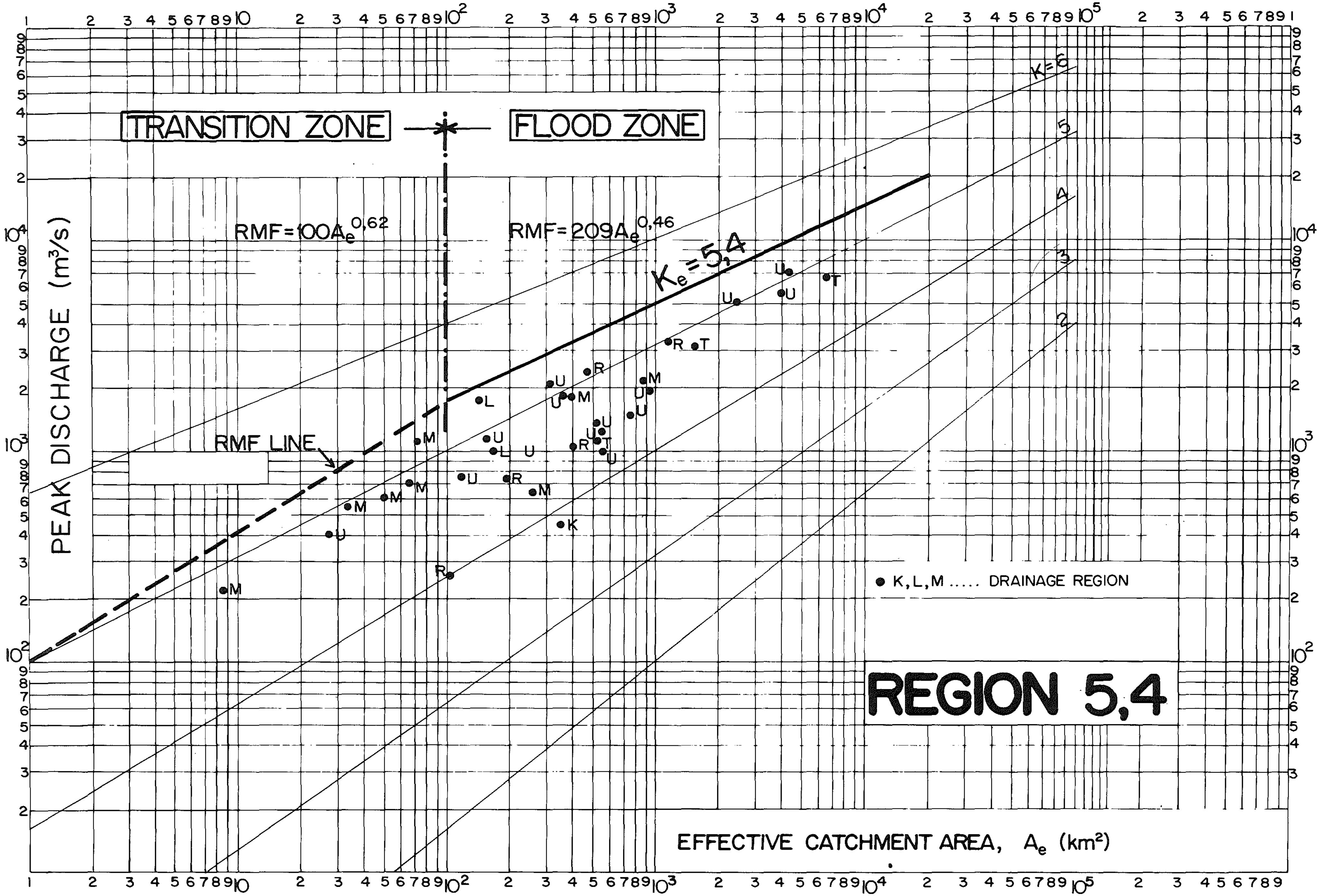

FIG. 9g HIGHEST RECORDED FLOOD PEAKS AND RMF IN REGION 5,4

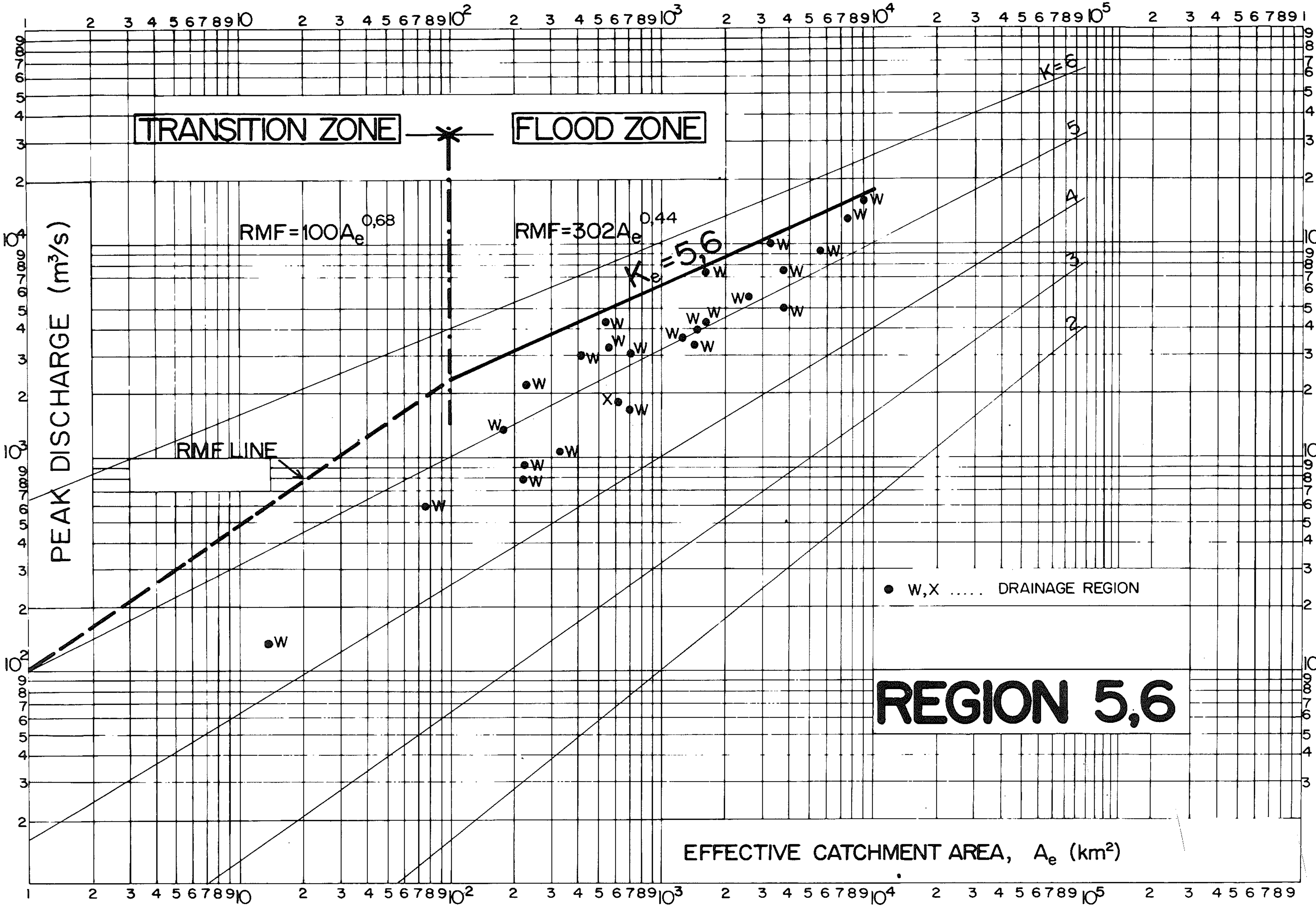

FIG. 9h HIGHEST RECORDED FLOOD PEAKS AND RMF IN REGION 5,6

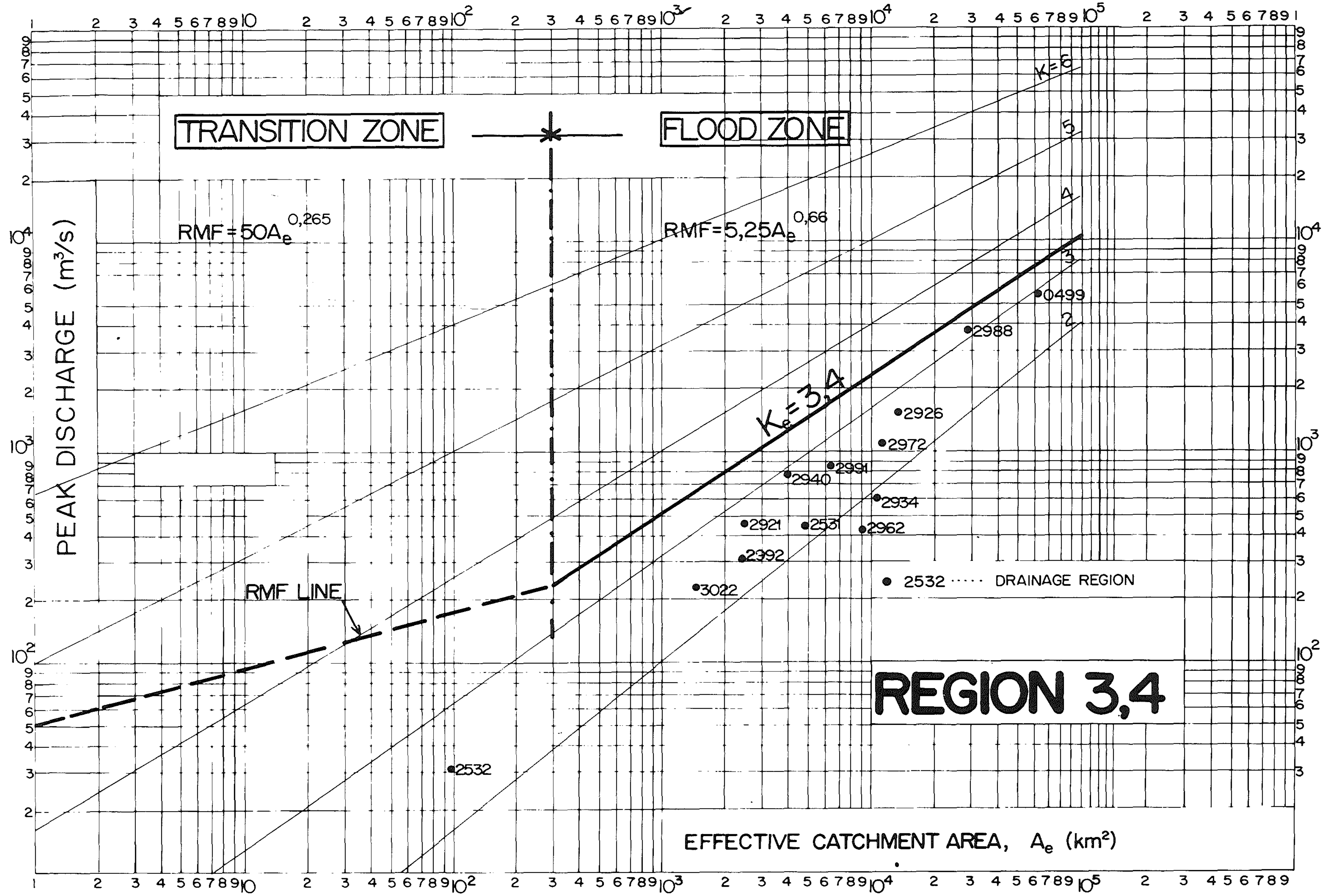

FIG. 10a HIGHEST RECORDED FLOOD PEAKS AND RMF IN SOUTH WEST AFRICA

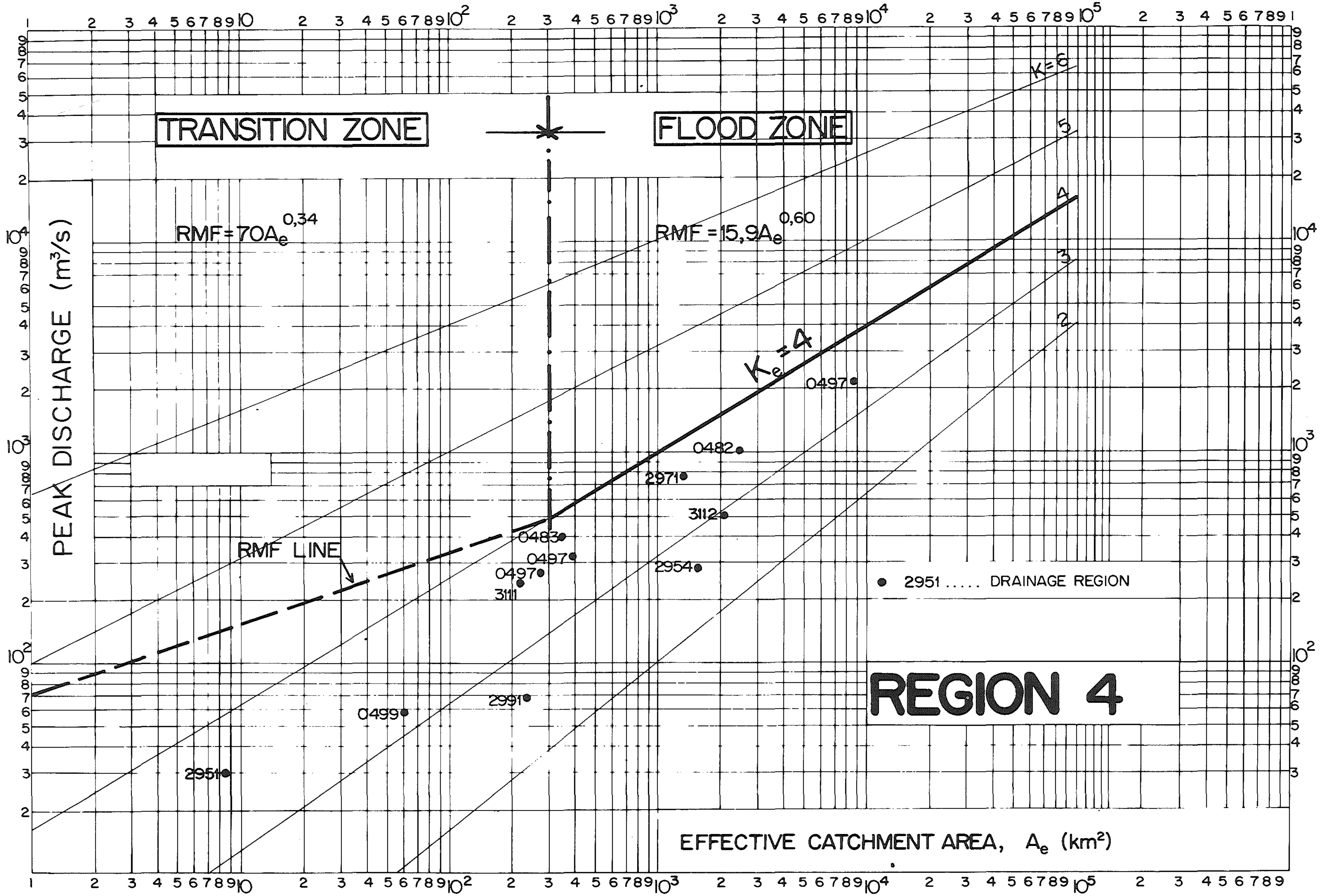

FIG. 10b HIGHEST RECORDED FLOOD PEAKS AND RMF IN SOUTH WEST AFRICA

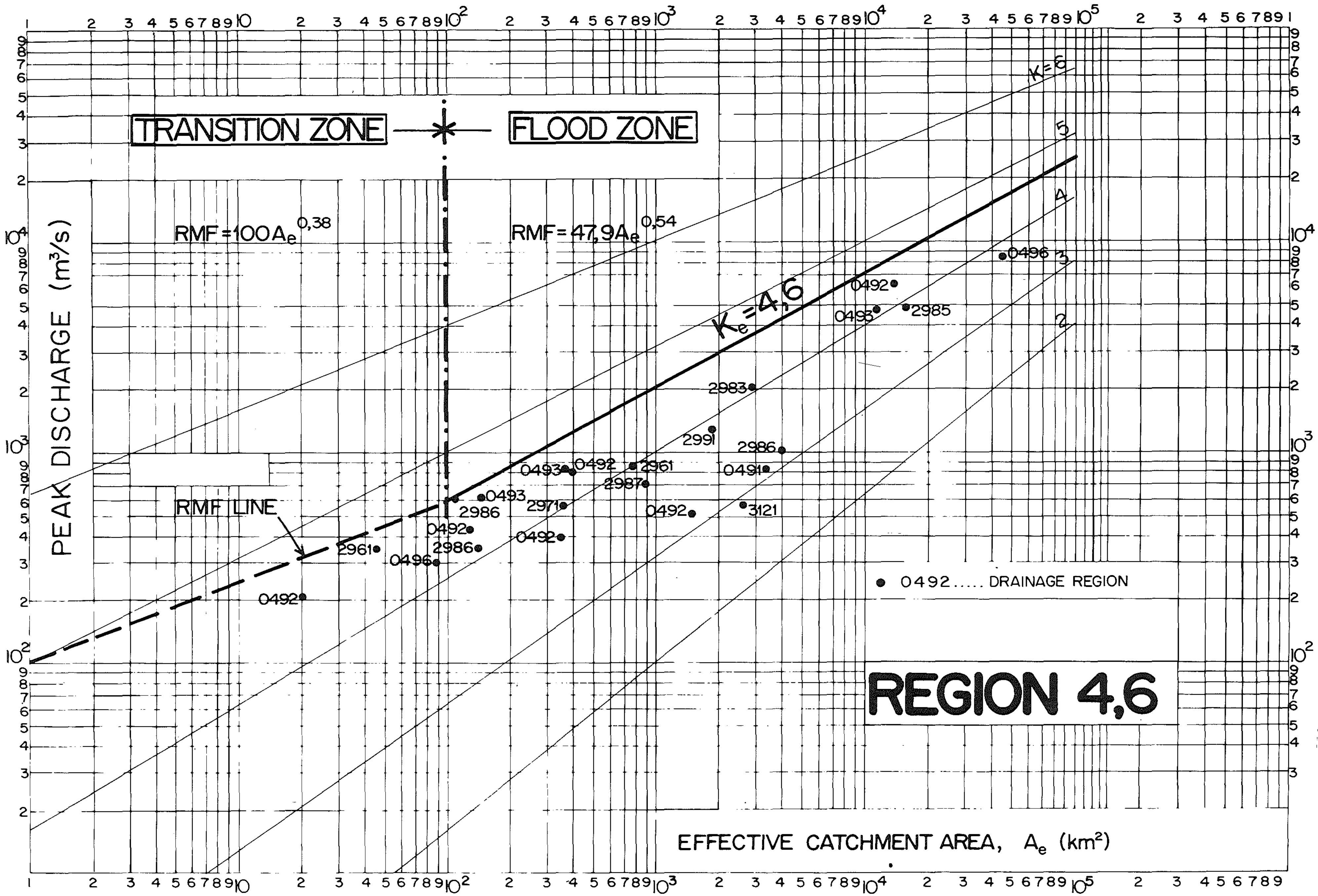

FIG. 10c HIGHEST RECORDED FLOOD PEAKS AND RMF IN SOUTH WEST AFRICA

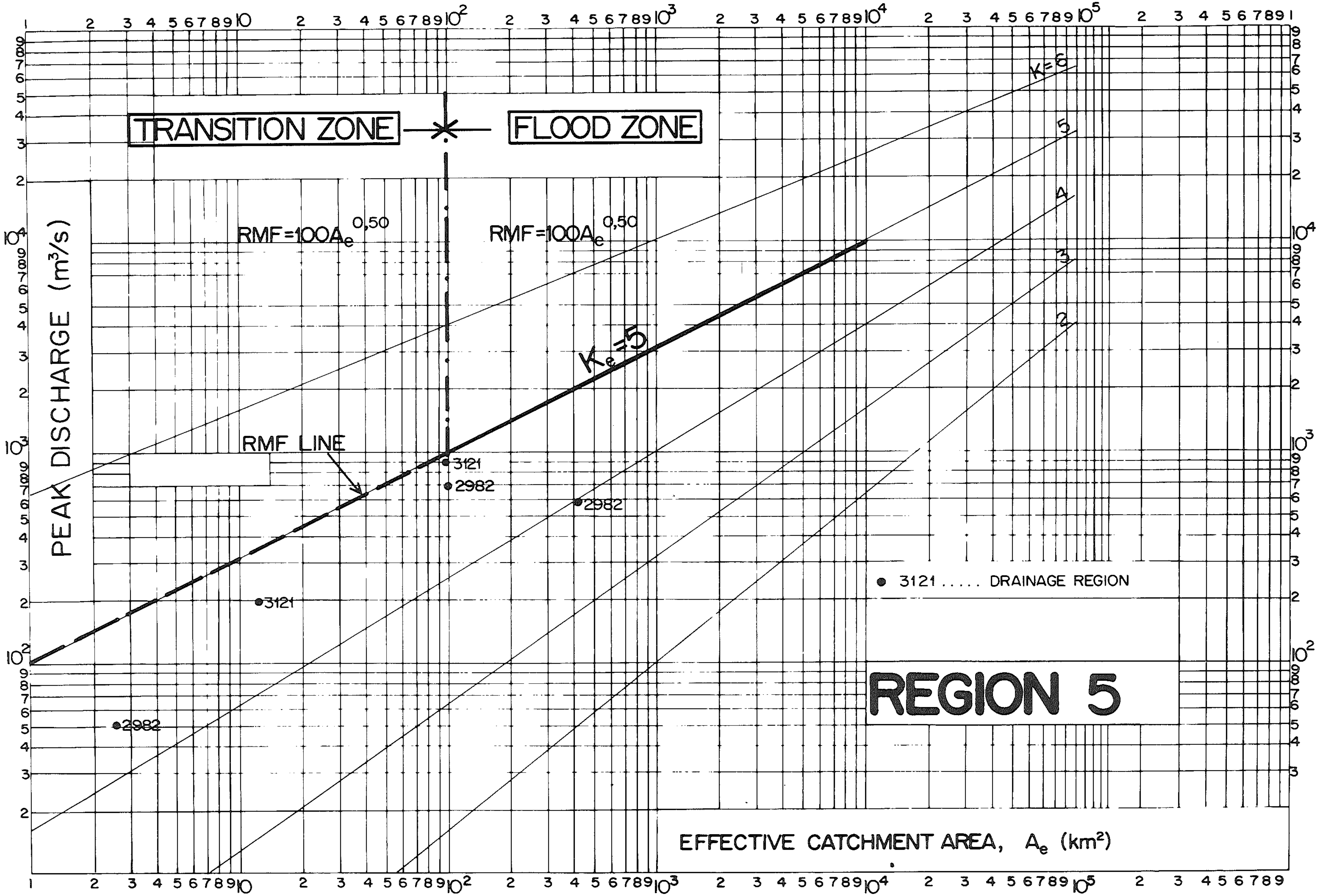

FIG. 10d HIGHEST RECORDED FLOOD PEAKS AND RMF IN SOUTH WEST AFRICA

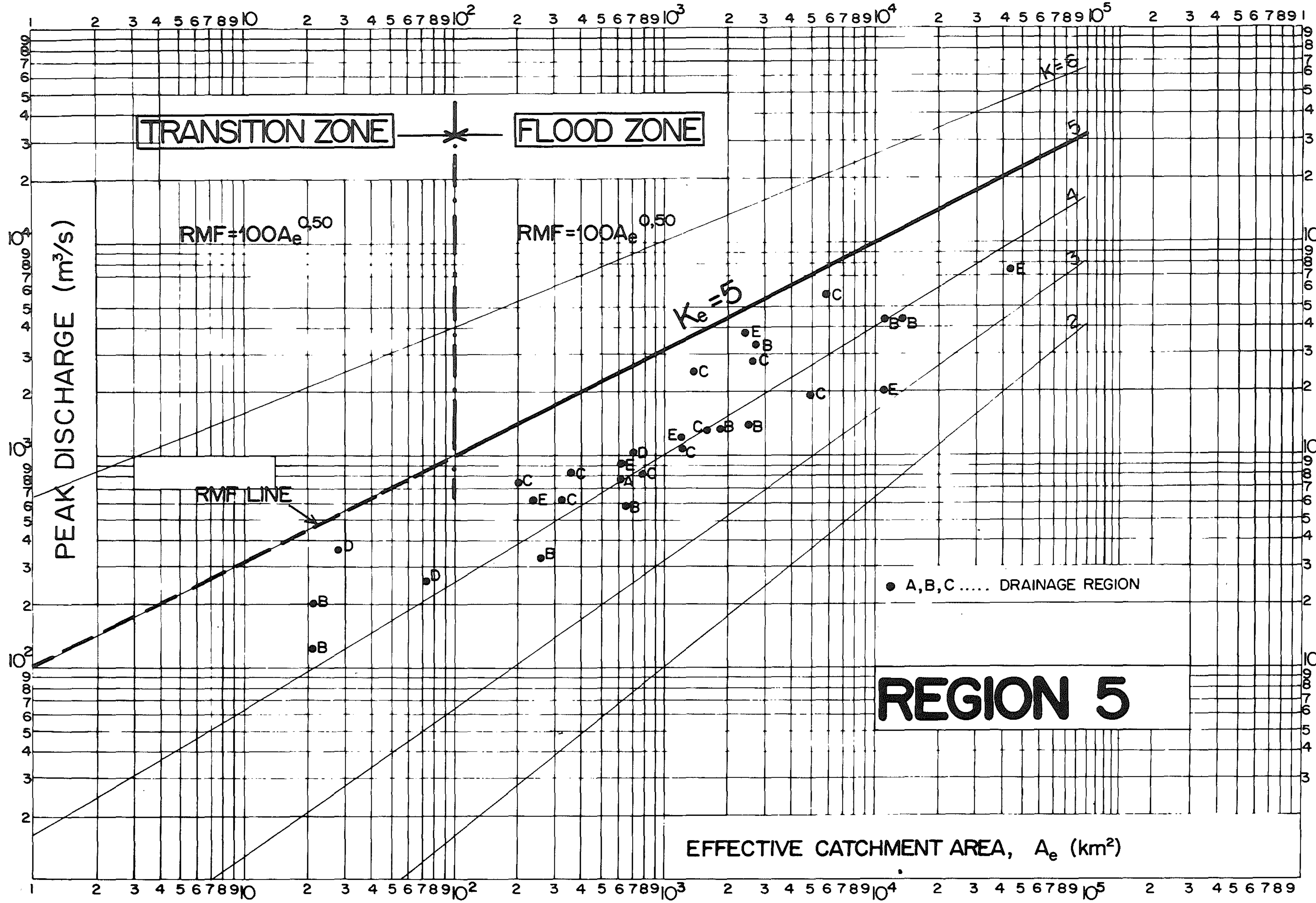

FIG. 11a HIGHEST RECORDED FLOOD PEAKS AND RMF IN ZIMBABWE

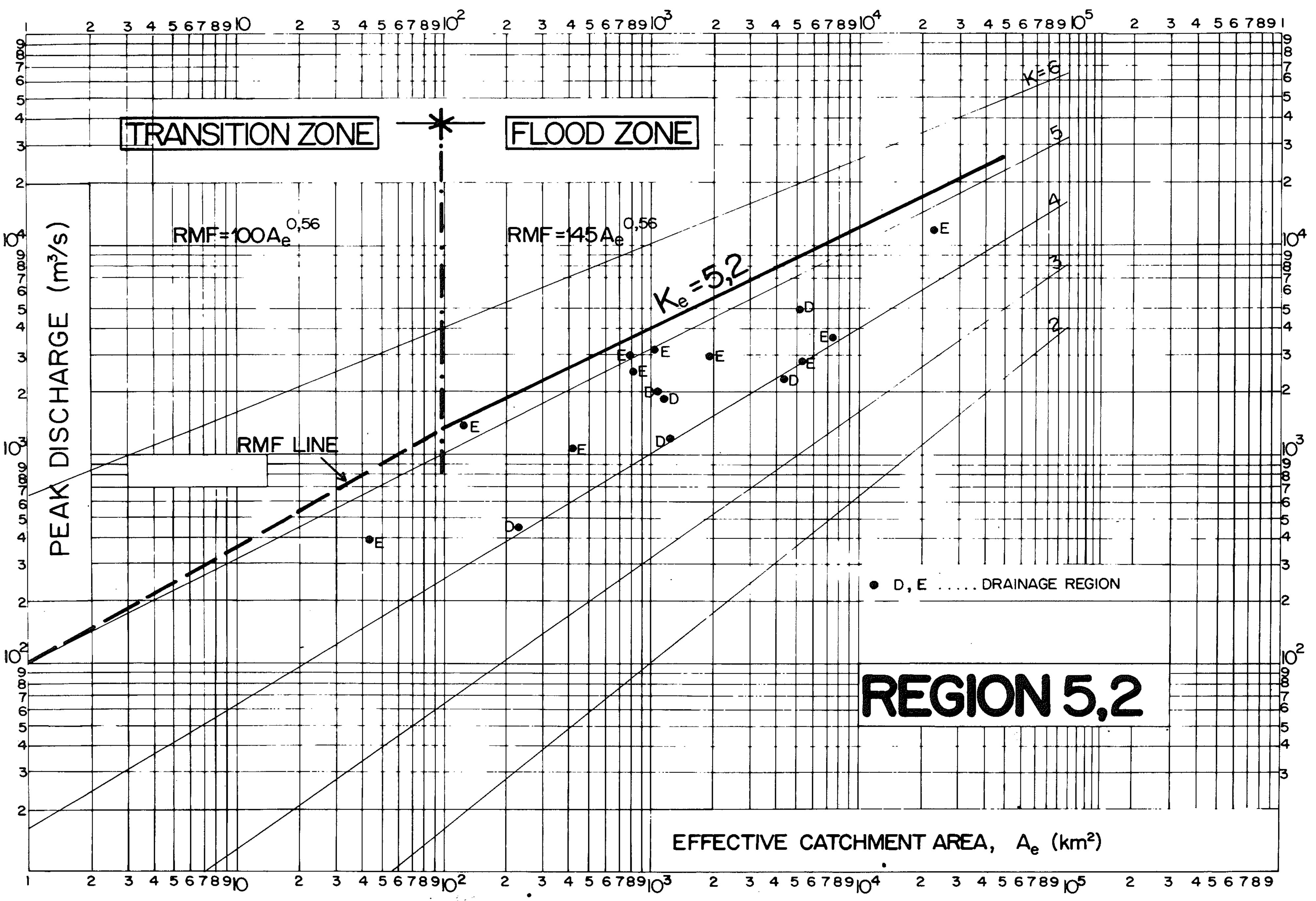

FIG. 11b HIGHEST RECORDED FLOOD PEAKS AND RMF IN ZIMBABWE

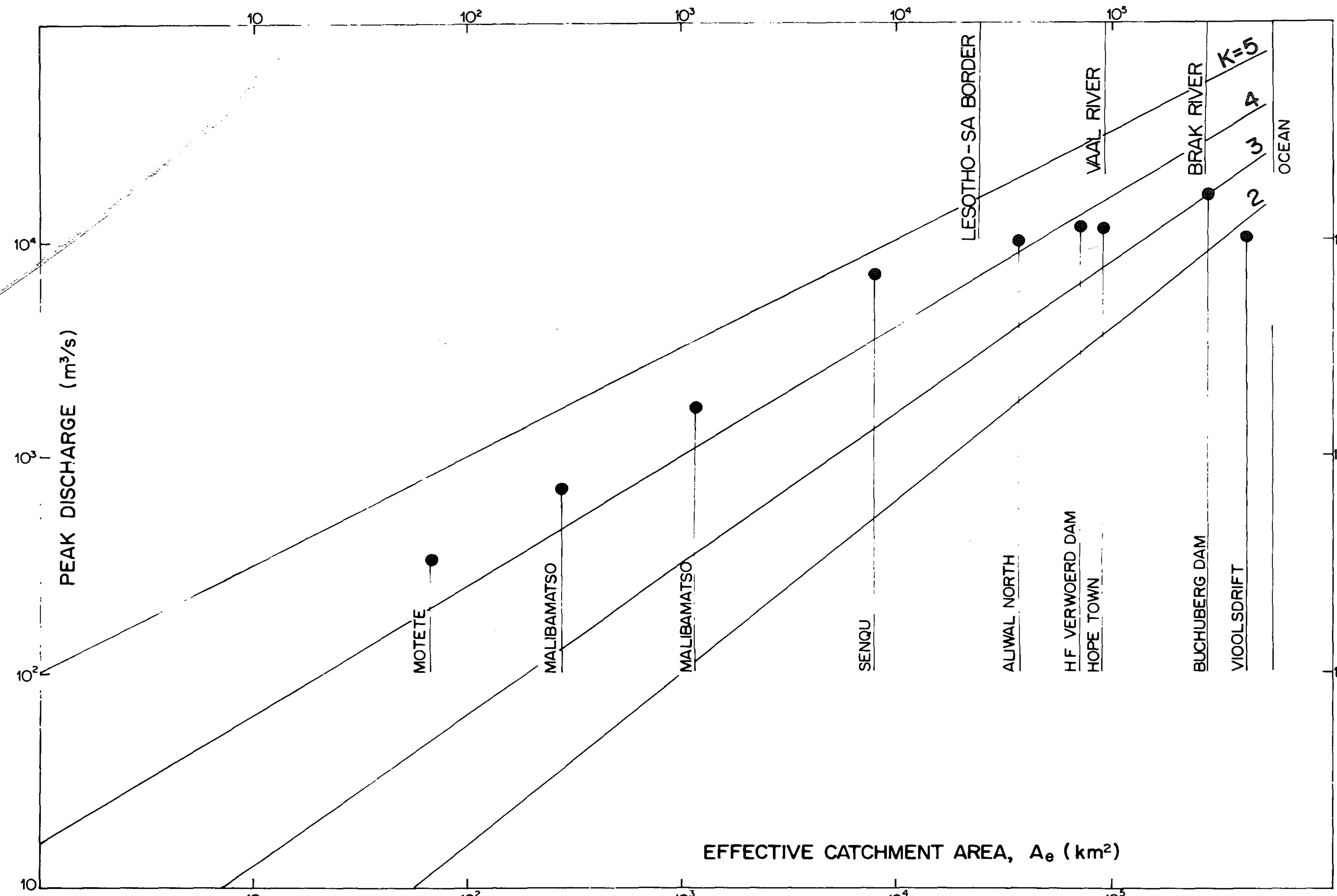

FIG. 12 HIGHEST RECORDED FLOOD PEAKS ALONG THE ORANGE RIVER

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km²) gross A	effective Ae	FLOOD PEAK Q (m³/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRE-SENTATIVE PERIOD N(yr)	METHOD OF MEASURE-MENT	ACCU-RACY	RMF REGION Ke	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
D4M02°	26 06	25 17	Mareetsane	566	566	75	2,13	28 01 13	37	G	2	3,4	
D2M10*°	28 55	28 06	Hlotse	728	728	1650	4,58	78 12 10	(150)	G	u	5	*Lesotho, G25
D2°	29 45	26 51	Rietspruit	752	752	2190	4,81	88 02 22	(200)	SA	2	5	Novo
D5M09°	31 31	22 19	Brak	766	766	611	3,72	41 02 04	25	G	u	4,6	
D2M09*	29 24	27 34	South Phuthiatsana	945	945	1140	4,14	66 01 21	23	G	2	5	*Lesotho, G24
D1*°	29 34	28 09	Senqunyane	1087	1087	1100	4,04	77 03 05	24	G	u	5	*Lesotho, G17
D5°	31 55	20 24	Vis	1153	1153	411	3,14	57 07	(20)	u	u	4	"Leeukloof"
D1*°	29 04	28 30	Malibamatso	1157	1157	1690	4,39	82 04 10	16	G	u	5	*Lesotho, G45
D3	30 12	24 43	Hondeblaf	1365	965	738	3,76	74 03 03	(35)	SA	2	4,6	"Carbonaatjies Kraal"
D1*°	29 17	28 59	Senqu	1660	1660	1850	4,28	67 02 01	20	G	2	5	*Lesotho, G6
D5	31 52	20 59	Klein Riet	2129	2129	889	3,47	61 03 26	27	u	u	4,6	"Plattekraal"
D1M01	31 00	26 20	Stormbergspruit	2397	2397	2690	4,44	25 03 22	76	G	u	5	
D1M06°	30 10	27 24	Kornetspruit	3014	3014	2270	4,15	66 01 22	29	G	u	5	
D3°	30 31	24 58	Seekoei	5430	5170	2440	3,90	74 03 01	(55)	SA	2	4,6	near to the Colesberg- Petrusville road
D5M04°	31 39	21 46	Sak	5839	5839	1600	3,40	61 03 27	59	G	2	4	
D1°	30 47	26 51	Kraai	7805	7805	5850	4,56	25 03 23	63	B	2	5	at railway bridge
D1*°	29 35	28 43	Senqu	7950	7950	6820	4,72	76 03 21	(200)	G	2	5	*Lesotho, G5
D4	26 35	22 40	Moshaweng	9860	9075	63	–0,39	88 03 05	(10)	SA	2	<2,8	"Concordia"
D1M05*	30 03	28 31	Orange	10758	10758	5000	4,19	67 02 01	42	G	2	5	*Lesotho, G4
D6R02°	30 37	23 18	Ongers	13394	13224	6940	4,43	61 03 28	66	DI	2	4,6	Smartt Syndicate Dam
D2M01°	29 43	26 59	Caledon	13521	13421	3680	3,71	34 01 03	42	u	u	5*	*K_e' = 4,6
D4	26 43	22 28	Kuruman	17545	15155	900	2,03	74 03	(90)	SA	2	2,8	"Aansluit"

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period
Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DØ = dam outflow
Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : K_e' = K_e at site

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km^2) gross A	effective A_e	FLOOD PEAK Q (m^3/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRESENTATIVE PERIOD N(yr)	METHOD OF MEASUREMENT	ACCURACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
D5	31 01	20 35	Sak	19099	19099	1810	2,63	61 03 28	27	u	2	4	"Bleskrans"
D2	30 21	26 33	Caledon	19512	19512	5850	3,98	88 02 22	63	SA	1	5*	"Delta"; $*K_e' = 4,6$
D4	25 27	23 43	Molopo	23189	20650	80	-1,12	88 02	(40)	SA	1	<2,8	"Abington", Bray
D6°	29 36	23 00	Brak	33792	30657	2040	2,34	74 03 05	(20)	SA	1	4	near to the Prieska- Douglas road
D1M03°	30 41	26 43	Orange	37075	37075	10000	4,17	34 01 03	74	G	u	5	
D5	29 43	21 04	Sak	46231	35036	1760	2,03	61 03 31	27	u	u	3,4*	"Jagddrift" ; $*K_e' = 2,8$
D3R02	30 37	25 30	Orange	70749	70749	11600	3,86	88 02 22	54	DI	1	5	H.F. Verwoerd Dam
D5R01	29 24	21 12	Hartbees	72335	41740	1790	1,87	61 04 01	55	DI	2	3,4*	Rooiberg Dam; $*K_e' = 2,8$
D3M03°	29 39	24 12	Orange	94765	90230	11200	3,59	25 03 24	75	SA	2	4*	$*K_e' = 4,3$
D7M08°	29 02	22 11	Orange	342967	268150	16200	3,04	25 03 26	63	SA	2	4*	*d/s of Boegoeberg Dam; $*K_e' = 3,7$
D8M03	28 45	17 44	Orange	850530	404000	10200	1,68	25 03 30	63	SA	2	3,4 *	$*K_e' = 2,8$
E3	30 30	19 30	Klein Rooiberg	17	17	90	4,03	85 09 08	(200)	C	2	3,4	Sishen- Saldanha railway
E2M06°	33 09	19 22	Kruis	40	40	67	3,48	45 06 21	49	G	2	4,6	
E4M01	31 29	19 47	Oorlogskloof	970	970	204	2,64	25 06 19	21	G	u	4	
E1M01°	32 03	18 49	Olifants	2659	2659	1640	3,91	25 06 19	31	G	u	4,6	
E2M04°	32 19	19 35	Tankwa	6426	6426	1420	3,20	25 06 19	19	SA	2	4	

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period
Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DΘ = dam outflow
Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : $K_e' = K_e$ at site

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km²) gross A	effective A_e	FLOOD PEAK Q (m³/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRE-SENTATIVE PERIOD N(yr)	METHOD OF MEASURE-MENT	ACCU-RACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
E2M02	32 30	19 32	Doring	6903	6903	2120	3,58	25 06 17	65	G	u	4,6	
E3°	31 35	18 24	Sout (or Hol)	17167	17167	1470	2,48	61 04 10	27	u	u	4	u/s of Olifants River confluence
E2M03	31 51	18 41	Doring	24044	24044	1900	2,48	57 07 15	61	G	u	4	
E3	31 47	18 37	Olifants	26977	26977	3630*	3,16	25 06 19	100	B + VA**	u	4	**velocity-area at railway bridge; *HFL was 3m above the 1888 level
F5M01	30 50	18 07	Swart Doring	2349	2349	47	0,65	67 06 13	< 10	G	1	3,4	

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period
Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DΘ = dam outflow
Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : K_e' = K_e at site

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km^2) gross A	effective A_e	FLOOD PEAK Q (m^3/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRE-SENTATIVE PERIOD N(yr)	METHOD OF MEASURE-MENT	ACCU-RACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
G1M15°	33 49	19 04	Kasteelkloof	1,9	1,9	11	3,58	76 07 25	21	G	1	5	
G2M08°	33 59	18 57	Jonkershoek	20	20	74	3,83	55 02 18	37	G	1	5	
G1M03°	33 54	19 05	Franschhoek	46	46	370	4,58	85 06 13	39	G	1	5	
G1M04°	33 56	19 04	Berg	70	70	466	4,59	51 06 27	37	G	u	5	
G4°	34 09	19 02	Palmiet	106	106	490	4,46	1899 8 1	89	SA	u	5	Grabouw, railway bridge site
G2	33 56	18 40	Kuils	137	137	139	3,42	45 07 08	(10)	SA	2	5	near Sarepta railway station
G1M02	33 08	19 04	Vier en Twintig	187	187	771	4,57	54 05 19	37	G	u	5	
G1M12	33 28	18 44	Diep	244	244	164	3,26	74 07 05	20	G	1	5	
G4M06°	34 24	19 36	Klein	600	600	203	2,93	74 08 22	25	G	1	4,6	
G5M05°	34 34	20 07	Kars	658	658	530	3,68	57 10 03	7	G	1	4,6	
G1M07°	33 38	18 59	Berg	713	713	2130	4,84	54 05 18	37	G	u	5	
G5°	34 42	19 55	Nuwejaars	730	645	664	3,88	78 07 25	10	SA	2	4,6	"South Bush"

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period

Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DO = dam outflow

Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : $K_e' = K_e$ at site

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km²) gross A	effective A_e	FLOOD PEAK Q (m³/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRESENTATIVE PERIOD N(yr)	METHOD OF MEASUREMENT	ACCURACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
H4°	33 47	19 56	Droog Kloof	10	10	176	4,64	29 09 05	59	SA	u	5	Robertson
H1M14°	33 26	19 24	Vals	18	18	140	4,29	77 05 31	23	G	2	5	
H4	33 47	19 52	Willem Nels	32	32	588	5,03	81 01 25	(> RMF)	SA	2	5	near Robertson
H6M08°	34 04	19 04	Riviersonderend	38	38	270	4,44	73 07 04	24	G	2	5	
H1M07°	33 34	19 09	Wit	84	84	587	4,68	53 04 18	38	G	u	5	
H9M02	34 01	21 12	Vet	89	89	270	4,10	81 01 25	25	G	2	5	
H3	33 41	20 02	Keisie	120	120	673	4,64	81 01 25	(100)	SA	2	5	d/s of Pietersfontein Dam
H8R01	34 00	20 57	Duivenshoks	148	148	194	3,63	81 01 25	12	DΘ	1	5	Duivenshoks Dam
H4°	33 47	19 47	Vink	194	194	1450	5,03	81 01 25	(> RMF)	SA	2	5	"Noree"
H6M01°	34 02	19 13	Riviersonderend	280	280	680	4,30	64 05 26	(30)	G	u	5	
H4R02	33 35	19 42	Nuy	377	377	948	4,43	81 01 25	48	DI	2	5	Keerom Dam
H7M03	34 00	20 40	Buffeljags	450	450	600	3,97	81 01 25	39	G	2	5	
H2M03°	33 36	19 31	Hex	718	718	737	3,91	57 07 14	38	G	u	5	
H1M06°	33 25	19 16	Breë	753	753	1140	4,26	55 08 03	66	G	u	5	
H3	33 48	20 05	Kogmanskloof	999	999	1460	4,33	81 01 25	63	B	2	5	"Loftus Bridge", Montagu-Robertson road
H6M09°	34 05	20 09	Riviersonderend	1510*	1510*	1450	4,11	86 08 30	24	SA	2	5	*d/s of Theewaterskloof Dam
H4M06	33 43	19 28	Breë	2942	2942	1580	3,82	57 07 14	31	G	u	5	
H5M02	33 54	20 01	Breë	6684	6684	1910	3,49	57 07 15	10	G	u	5	

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period

Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DΘ = dam outflow

Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : $K_e' = K_e$ at site

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km²) gross A	effective A_e	FLOOD PEAK Q (m³/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRE-SENTATIVE PERIOD N(yr)	METHOD OF MEASURE-MENT	ACCU-RACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
J2M06	33 30	21 30	Wilgehout	25	25	250	4,54	81 01 25	27	G	2	5	
J2°	32 28	22 19	Klein Sand	41	41	394	4,67	48 01 28	40	SA	2	5	28 km SW of Beaufort West
J2	32 32	21 14	Dwyka	74	74	320	4,30	81 01 25	(40)	Dθ	u	5	"Rietvalley" farm dam
J3M05°	33 47	22 19	Klip	95	95	425	4,40	31 12 31	21	G	u	5	
J2°	32 21	22 35	Gamka	355	355	708	4,22	41 04 06	47	B	2	5	near Beaufort West
J1	33 09	20 47	Wilgehout	361	361	1230	4,65	81 01 25	(100)	SA	2	5	"Zoutkloof"
J3M03°	33 20	22 32	Groot	426	426	667	4,09	28 01 08	46	G	u	5	
J1R01	33 31	20 45	Prins	757	757	1030	4,17	81 01 25	72	DI	2	5	Prinsrivier Dam
J3M01°	33 40	22 25	Kammanassie	1484	1484	2760	4,70	16 05 04	72	G	u	5	
J2R02°	32 37	22 00	Leeu	2088	2088	1100	3,68	67 05 27	68	SA	2	5	u/s of Leeugamka Dam
J3M02	33 23	23 07	Traka	3039	3039	2130	4,08	21 12 29	76	SA	u	5	
J1M04°	33 12	20 51	Buffels	3070	3070	5680	5,02	81 01 25	(>RMF)	B	1	5	at railway bridge
J2	32 46	21 58	Gamka	3237	3237	1790	3,88	21 12 29	(15)	SA	u	5	Fraserburg Road
J1R03	33 17	21 00	Buffels	4001	4001	5740	4,90	81 01 25	(200)	DI	1	5	Floriskraal Dam
J1	33 42	21 10	Touws	5803	5763	3650	4,25	81 01 25	(45)	SA	2	5	"Ockertskraal"
J2M01°	33 05	21 56	Gamka	10292	10292	4450	4,10	21 12 29	77	SA	2	5	"Klipfontein"
J3	33 39	22 11	Olifants	10295	10295	3820	3,94	32 01 01	56	W*	u	5	near Oudtshoorn; *weir
J1	33 44	21 24	Groot	12466	12466	11000	4,98	81 01 26	(200)	SA	2	5	"Conradie"
J2R06	33 18	21 38	Gamka	17046	17046	5700	4,04	81 03 26	67	DI	2	5	Gamkapoort Dam
J4M02	33 59	21 39	Gouritz	43451	43451	11400	4,22	81 01 26	(40)	SA	2	5	

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period

Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; Dθ = dam outflow

Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : $K'_e = K_e$ at site

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km^2) gross A	effective A_e	FLOOD PEAK Q (m^3/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRESENTATIVE PERIOD N(yr)	METHOD OF MEASUREMENT	ACCURACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
K1M02	33 56	22 08	Beneke	3,8	3,8	18	3,61	64 09 16	25	G	1	5,2	
K4M02	33 53	22 50	Karatara	22	22	195	4,43	81 05 29	27	G	2	5,2	
K8M01°	33 59	24 01	Kruis	26*	26*	136	4,13	64 09 16	24	G	2	5,2**	*largely forest plantation; **K_e' = 5
K7M01°	33 57	23 38	Bloukrans	57	57	360	4,48	81 03 26	27	G	2	5,2	
K3M05	33 57	22 57	Touws	78	78	400	4,44	81 05 29	19	SA	2	5,2	
K2M02°	34 02	22 13	Groot Brak	131	131	1000	4,90	64 09 16	(200)	G	u	5,2	
K5M02	33 54	23 02	Knysna	133	133	560	4,47	81 05 29	18	G	u	5,2	
K4°	34 02	22 57	Gouwkama	220	220	2000	5,23	17 10	(>RMF)	SA	u	5,2	at railway bridge
K9R01°	34 00	24 30	Krom	357	357	434	3,83	71 08 22	40	DΘ	1	5,4	Kromrivier Dam
K6M02	33 56	23 22	Keurbooms	764	764	1070	4,19	81 05 29	27	SA	u	5,2	

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period
Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DΘ = dam outflow
Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : K_e' = K_e at site

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km^2) gross A	effective A_e	FLOOD PEAK Q (m³/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRE-SENTATIVE PERIOD N(yr)	METHOD OF MEASURE-MENT	ACCU-RACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
L8M01°	33 52	23 50	Wabooms	21	21	165	4,34	81 05 30	23	G	2	5,2	
L8M02	33 44	23 18	Haarlemspruit	52	52	210	4,15	81 05 30	18	G	1	5,2	
L9M01°	33 52	25 02	Loerie	147	147	1750	5,27	81 03 26	(200)	DI	2	5,4	Loerie Dam
L9	33 48	24 54	Klein	170	170	987	4,79	81 03 26	(65)	SA	2	5,4	near Hankey
L8	33 35	24 10	Baviaanskloof	1217	1217	924	3,83	32 01 01	(15)	SA	u	5,2	
L6M01°	33 12	24 14	Heuningklip	1290	1290	2960	4,83	50 03 15	63	u	u	5,2	
L8 °	33 40	24 23	Cougha	2538	2538	4250	4,84	32 01 01	56	SA	u	5,2	u/s of Baviaanskloof River confluence
L1M01	32 10	23 03	Sout	3938	3938	2240	3,98	88 02 22	55	SA	2	5	
L2M04°	32 14	23 25	Buffels	5584	5584	2070	3,69	61 63 27	27	G	2	5	
L7M02°	33 19	24 21	Groot	25730	25730	4390	3,43	71 08 23	60	G	u	5,2*	*K_e' = 4,6
L9	33 46	24 40	Gamtoos	33800	33800	7080	3,81	32 01 02	56	SA	2	5,4*	"Mistkraal" ; *K_e' = 5

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period
Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DΘ = dam outflow
Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : $K_e' = K_e$ at site

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km²) gross A	effective A_e	FLOOD PEAK Q (m³/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRE-SENTATIVE PERIOD N(yr)	METHOD OF MEASURE-MENT	ACCU-RACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
M2°	33 59	25 39	Shark	8,7	8,7	218	4,80	68 09 01	(100)	SA	2	5,4	Port Elizabeth
M1R02	33 48	25 10	Bulk	34	34	550	4,96	81 03 26	(180)	DΘ	2	5,4	Bulkrivier Dam
M2	33 55	25 35	Papenkuils	39	39	555	4,92	81 03 25	(140)	SA	2	5,4	Port Elizabeth, Everite
M1R03	33 44	25 06	Sand	51	51	600	4,88	81 03 26	(100)	DΘ	2	5,4	Sandrivier Dam
M2°	33 58	25 37	Baakens	67	67	707	4,90	08 11 16	80	SA	u	5,4	Port Elizabeth
M2	33 55	25 12	Van Stadens	74	74	1110	5,18	81 03 26	(200)	SA	2	5,4	Van Stadens Pass
M1R01	33 41	25 16	Swartkops	261	261	625	4,26	81 03 26	(15)	DΘ	1	5,4	Groendal Dam
M1M04	33 48	25 18	Elands	400	400	1800	4,92	81 03 26	(110)	SA	2	5,4	
M1	33 46	25 23	Swartkops	900	900	2130	4,71	81 03 26	(50)	B	2	5,4	Uitenhage, Niven Bridge
N3°	32 38	25 14	Blyde	130	130	1170	5,02	22 01 11	66	SA	2	5,2	near Pearston
N4R01	33 22	25 40	White	196	196	610	4,37	79 07 21	33	DΘ	2	5,2	Slagboom Dam
N4°	33 26	25 42	Coerney	324	324	902	4,45	79 07 21	(40)	SA	2	5,2	"Swanepoelskraal"
N3M01°	32 59	25 11	Vogel	1597	1597	1980	4,37	41 10 30	19	G	u	5	
N1M07	32 25	24 17	Camdebo	1669	1669	1100	3,81	32 01 01	20	SA	u	5	
N1M02°	32 10	24 33	Gats	1811	1811	1140	3,79	?	(15)	SA	u	5	

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period
Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DΘ = dam outflow
Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : $K_e' = K_e$ at site

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km²) gross A	effective A_e	FLOOD PEAK Q (m³/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRE-SENTATIVE PERIOD N(yr)	METHOD OF MEASURE-MENT	ACCU-RACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
N1R01	32 14	24 32	Sundays	3681	3681	2070	3,95	32 01 01	56	DI	2	5	Vanryneveldspas Dam
N2R01	33 13	25 09	Sundays	16826	16826	5400	3,99	32 01 01	56	DI	2	5	Mentz Dam
P1M02	33 15	26 22	New Years	124	124	161	3,58	51 01 16	5	G	2	5,2	
P1M03°	33 20	26 05	Bushmans	1476	1476	925	3,72	71 08 22	22	G	u	5,2	
Q3M02°	32 05	25 35	Jenkins Spruit	289	289	606	4,19	33 12 22	6	G	2	5	
Q1	31 30	25 01	Kleinbrak	386	386	780	4,26	74 03 03	(45)	SA	u	5	near Middelburg
Q9M11°	32 34	26 41	Kat	539	539	555	3,82	53 10 22	37	G	u	5,2	
Q6M01	32 34	25 57	Baviaans	694	694	895	4,09	32 01 01	19	G	u	5,2	

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period
Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DO = dam outflow
Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : K_e' = K_e at site

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km^2) gross A	effective A_e	FLOOD PEAK Q (m^3/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRE-SENTATIVE PERIOD N(yr)	METHOD OF MEASURE-MENT	ACCU-RACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
Q3°	32 03	25 25	Pauls	873	873	2500	4,86	74 03 03	(200)	SA	2	5	"Spitskop"
Q8	32 42	25 28	Little Fish	1114	1114	2000	4,55	32 01 01	56	SA	2	5,2	Skietrug damsite
Q9M02°	32 43	26 18	Koonap	1245	1245	1610	4,30	74 03 03	52	SA	2	5,2	
Q2M01	31 55	25 25	Great Fish	1702	1702	1560	4,11	32 01 01	56	G	u	5	
Q1M01	31 54	25 29	Great Fish	9091	8161	2640	3,69	74 03 01	70	SA	2	5	
Q3	32 08	25 37	Great Fish	11032	10102	5700	4,38	74 03 01	(70)	SA	2	5	Cradock
Q9M06	33 10	26 50	Great Fish	28937	27831	8730	4,21	74 03 05	56	SA	2	5,2	
R2°	32 45	27 18	Buffalo	38*	38*	207	4,26	22 11 05	26	DΘ	1	5,2**	Maden Dam; *largely forest plantation; **K_e' = 5
R2M08°	32 46	27 22	Quencwe	61*	61*	496	4,68	71 08 21	36	G	u	5,2	*70% forest plantation, scattered settlements
R2M07°	32 47	27 23	Zele	82	82	259	4,11	54 10 23	23	G	u	5,2	
R2M09°	32 55	27 23	Ngqokweni	103	103	255	4,00	48 04 20	24	G	u	5,4	
R2M11	32 56	27 29	Yellowwoods	197	197	747	4,52	70 08 28	31	G	2	5,4	
R2M05	32 52	27 23	Buffalo	411	411	1050	4,47	70 08 28	41	G	1	5,4	
R3R01°	32 54	27 48	Nahoon	473	473	2390	5,08	70 08 28	(200)	DI	2	5,4	Nahoon Dam
R1M02°	32 50	27 00	Keiskamma	665	665	994	4,20	48 04 19	12	G	u	5,2	

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period
Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DΘ = dam outflow
Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : $K_e' = K_e$ at site

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km²) gross A	effective A_e	FLOOD PEAK Q (m³/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRESENTATIVE PERIOD N(yr)	METHOD OF MEASUREMENT	ACCURACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
R2R03	32 59	27 44	Buffalo	1176	1176	3260	4,95	70 08 28	(125)	DΘ	1	5,4	Bridle Drift Dam
R1M13°	33 01	26 57	Keiskamma	1515	1515	2750	4,69	70 08 27	(100)	G	u	5,2	
S3°	31 32	26 46	Kleinvlei	31	31	365	4,72	?	(200)	u	u	5	east of Sterkstroom
S6M01°	32 35	27 22	Kubusi	90*	90*	150	3,68	85 11 02	(10)	G	1	5	*50% forest plantations
S6M03°	32 31	27 31	Toise	215	215	700	4,43	85 11 02	(40)	SA	2	5,2	
S6M02	32 35	27 38	Kubusi	491	491	920	4,28	85 11 02	40	G	u	5,2	
S3R01	32 17	26 51	Klipplaat	603	603	653	3,90	76 03 20	30	DI	1	5	Waterdown Dam
S3M02°	31 45	26 35	Klaas Smits	796	796	906	4,03	50 05 18	25	G	u	5	
S7°	32 30	27 58	Great Kei	19690	19690	15000	5,08	1874 12 8	114	SA	u	5,2	at railway bridge

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period
Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DΘ = dam outflow
Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : $K_e' = K_e$ at site

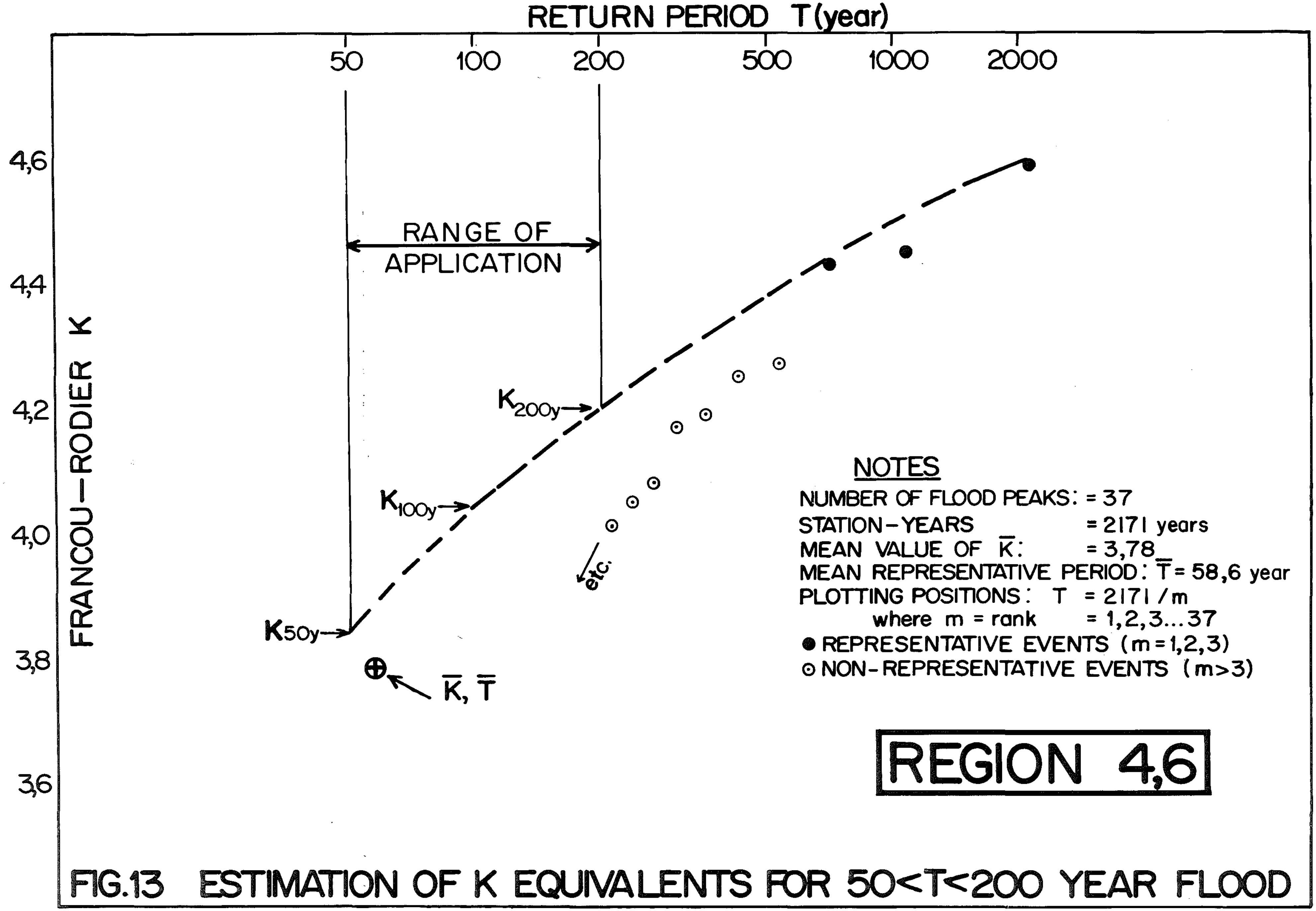

FIG.13 ESTIMATION OF K EQUIVALENTS FOR 50<T<200 YEAR FLOOD PEAKS IN SOUTH AFRICA

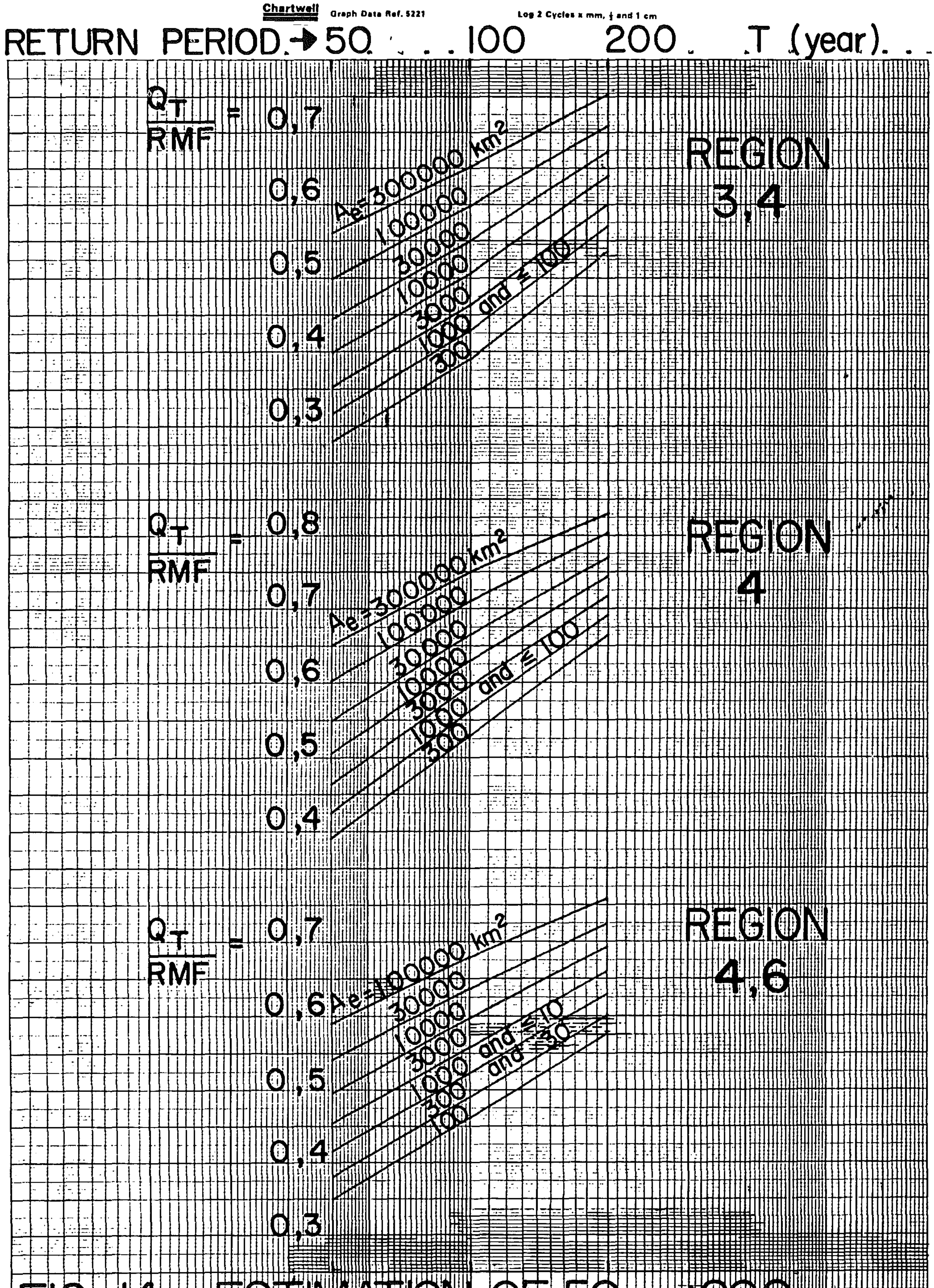

FIG. 14a ESTIMATION OF 50-yr → 200-yr FLOOD PEAKS (Q_T) FROM RMF IN SOUTH AFRICA

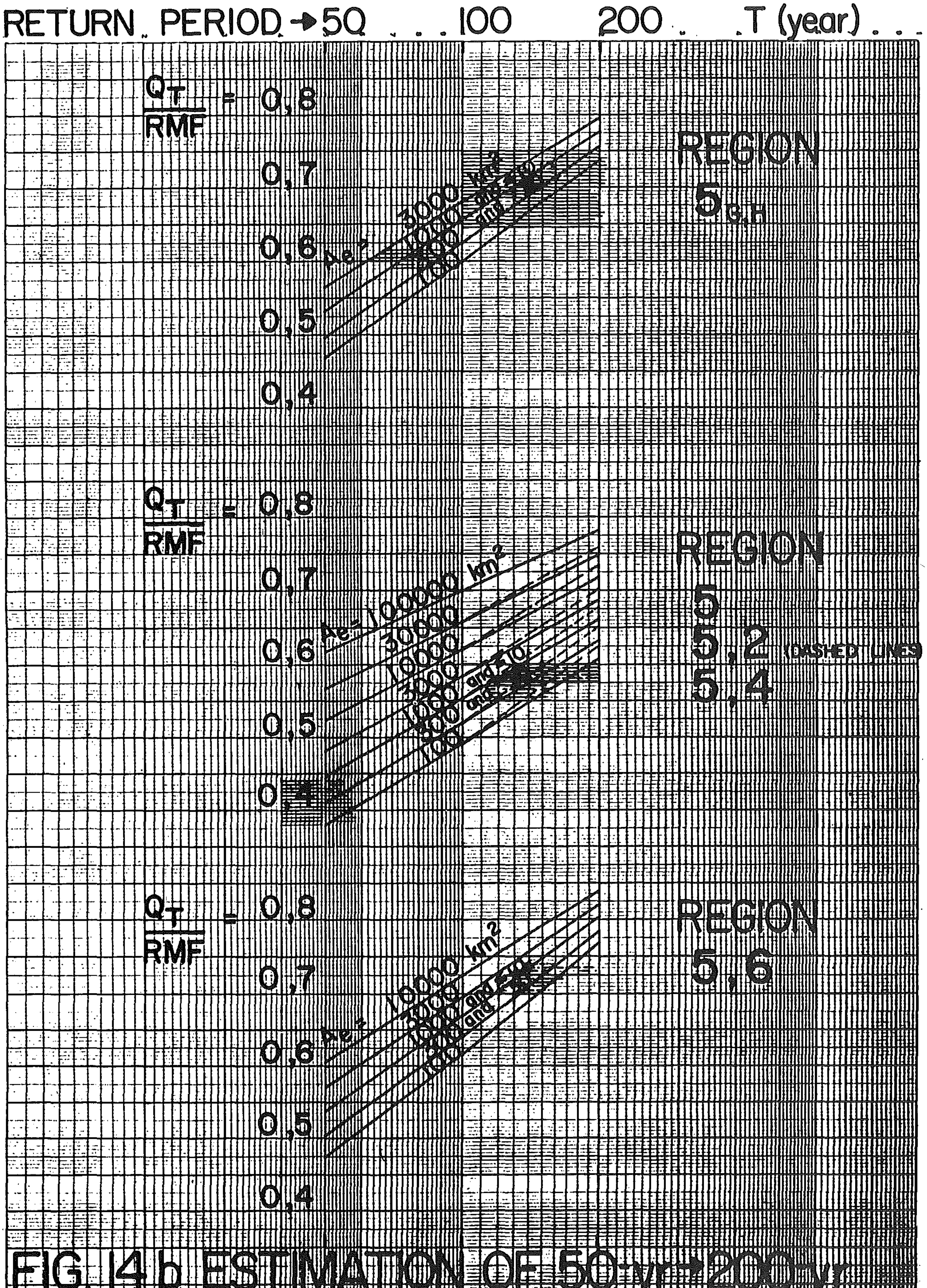

FIG. 14 b ESTIMATION OF 50-yr → 200-yr FLOOD PEAKS (Q_T) FROM RMF IN SOUTH AFRICA, LESOTHO AND SWAZILAND

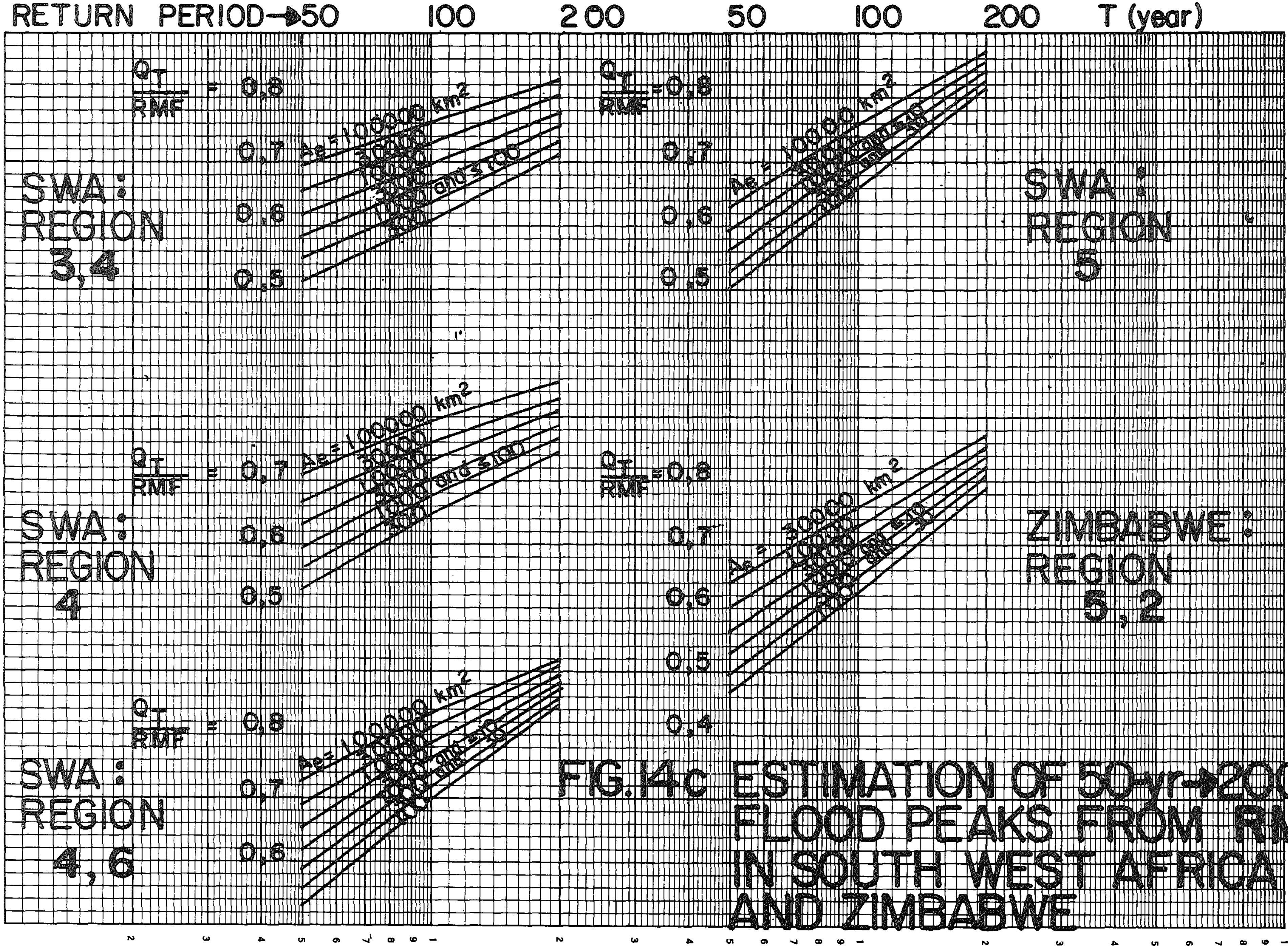

FIG.14c ESTIMATION OF 50-yr→200-yr FLOOD PEAKS FROM RMF IN SOUTH WEST AFRICA AND ZIMBABWE

APPENDIX 1: CATALOGUE OF MAXIMUM PEAK DISCHARGES RECORDED IN SOUTH AFRICA, LESOTHO AND SWAZILAND

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km^2) gross A	effective A_e	FLOOD PEAK Q (m^3/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRESENTATIVE PERIOD N(yr)	METHOD OF MEASUREMENT	ACCURACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
A2°	25 46	28 13	Waterkloofspruit	5,0	5,0	141	4,73	35 12	53	u	u	5	
A7°	23 03	29 40	Tributary: Sand	9,1	9,1	106	4,35	83 01 04	(30)	C	2	5	near Mara
A2M24°	26 09	27 36	Brandvlei	13	13	160	4,49	70 12 27	30	G	u	5	
A7	23 29	29 55	Dwars	24	24	179	4,34	58 01 04	30	SA	u	5	near Soekmekaar
A2	25 42	28 12	Noord- en Suid-spruit	29	29	252	4,50	78 01 28	(70)	B	1	5	Pretoria, Wonderboom Suid
A2	25 41	28 17	Hartbeesspruit	33	33	222	4,36	78 01 28	(45)	B	1	5	Pretoria, Cullinan road
A6M11°	24 46	28 21	Groot Nyl	73	73	123	3,63	78 01 05	22	G	u	4,6	
A2	25 44	28 18	Moreletaspruit	83	83	361	4,34	78 01 28	(55)	B	2	5	Pretoria, Silverton
A8	22 55	29 55	Marandanyombe	104	104	326	4,17	58 01 04	30	SA	u	5	Williespoort
A6°	23 44	28 36	Wydhoekspruit	130	130	700	4,64	75 12 25	(200)	B	2	5	
A2M04	24 52	28 16	Plat	137	137	126	3,35	09 01 09	37	G	2	4,6	
A2M16°	25 45	27 29	Sterkstroom	140	140	397	4,19	28 12 12	60	G	u	5	
A2M07°	25 44	28 10	Apies	142	142	454	4,28	09 01 09	79	G	2	5	
A2°	25 48	27 46	Scheerpoort	155	155	840	4,71	29 02 04	59	SA	u	5	at railway bridge
A2M28	25 39	28 19	Hartbeesspruit	156	156	520	4,34	78 01 28	(60)	B	2	5	"Kameeldrif"
A2°	25 45	28 22	Pienaars	243	243	1250	4,83	78 01 28	83	B	2	5	N4 road bridge
A9M04°	22 46	30 32	Mutale	320	320	650	4,20	72 01 29	25	G	u	5,2	
A7°	23 27	29 44	Dwars	381	381	1310	4,68	58 01 04	(200)	SA	u	5	
A6	23 36	28 32	Klein Mogalakwena	400	400	700	4,16	75 12 25	(25)	B	2	5	Marken- Potgietersrus road
A2M03°	25 46	27 16	Hex	495	495	709	4,06	14 12 17	25	G	u	5	
A7	23 02	29 35	Dorps	570	570	1100	4,36	58 01 04	30	SA	u	5	near Mara
A2	25 27	28 16	Apies	650	650	682	3,90	78 01 28	28	SA	1	5	u/s of station A2M26

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period
Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DO = dam outflow; u = unknown
Col. 11 : 1 = error < 10% ; 2 = error < 30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : $K'_e = K_e$ at site

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	GEOGRAPHIC POSITION Long. ° '	RIVER	CATCHMENT AREA (km^2) gross A	CATCHMENT AREA (km^2) effective A_e	FLOOD PEAK Q (m^3/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRESENTATIVE PERIOD N(yr)	METHOD OF MEASUREMENT	ACCURACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
A2R09	25 37	28 22	Pienaars	684	684	1510	4,54	78 01 28	74	DI	2	5	Roodeplaat Dam
A2R07°	25 29	26 41	Elands	704	704	594	3,74	76 03 20	40	DI	1	4,6	Lindleyspoort Dam
A6°	24 14	28 47	Sterk	707	707	1880	4,71	46 02 02	(200)	u	u	5	"Rooiwal"
A6M02°	24 41	28 38	Nyl	738	738	646	3,78	41 12	47	u	u	4,6	
A2M05	25 50	28 08	Hennops	808	808	359	3,24	09 01 22	46	G	u	5	partly dolomitic catchment
A4M04°	24 09	27 29	Matlabas	1046	980	566	3,52	67 01 22	26	G	u	4,6	
A3M01°	25 32	26 06	Klein Marico	1165	1165	1160	4,05	?	(110)	u	u	4,6*	60% dolomitic catchment; * $K_e' = 4,3$
A2M02°	25 44	27 51	Magalies	1207	1207	1760	4,40	?	(70)	u	u	5	
A9°	22 54	30 41	Luvuvhu	1600	1600	1830	4,29	76 01 31	(25)	B	2	5,2	Louis Trichardt - Kruger National Park road
A5M05°	23 37	28 09	Palala	2331	2331	2400	4,34	69 12 08	(60)	G	u	5	
A4°	24 11	28 00	Mokolo	2603	2603	2020	4,12	43	45	SA	u	5	"Klipspruit"
A2M01°	25 44	27 52	Krokodil	2909	2909	3320	4,54	18 02 15	84	G	u	5	partly dolomitic catchment
A3	25 02	26 25	Groot Marico	4170	4170	1930	3,80	?	(45)	u	u	4,6	"Nooitgedacht"
A9°	22 25	31 13	Luvuvhu	5110	5110	2880	4,08	76 01 31	(25)	B	2	5	Kruger National Park
A7M01	22 54	29 37	Sand	7703	7466	2550	3,72	58 01 04	30	SA	u	5	"Waterpoort"
A3M07°	24 52	26 27	Marico	8685	8685	2470	3,58	?	(140)	u	u	4	
A6M09°	22 36	28 53	Mogalakwena	14773	14206	1900	2,93	67 02 04	28	G	u	4,6*	*$K_e' = 4$
A2M25	24 56	27 33	Krokodil	21349	21349	2120	2,72	67 02 07	29	G	2	4,6*	*$K_e' = 4$
A7M04°	22 13	29 59	Limpopo	201000	185000	17000*	3,52	09 01*	79	u	u	5**	Beit Bridge; *Source: F.E. Canthack, 1928; **$K_e' = 4$

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period

Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DΘ = dam outflow

Col. 11 : 1 = error$<$10% ; 2 = error$<$30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : $K_e' = K_e$ at site

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km^2) gross A	effective A_e	FLOOD PEAK Q (m^3/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRE-SENTATIVE PERIOD N(yr)	METHOD OF MEASURE-MENT	ACCU-RACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
B8°	23 55	30 14	Tamara	26	26	123	4,06	60 11 09	(15)	u	u	5,2	
B7M02°	24 05	30 16	Ngwabitsi	58	58	530	4,75	56 02 17	40	G	u	5,2	
B6M03°	24 41	30 49	Treur	92*	92*	269	4,09	67 04 16	26	G	u	5**	*more than 50% forest plantation; **K_e' = 4,8
B7M01°	24 33	31 02	Klaserie	137*	137*	793	4,71	39 02 05	49	G	u	5,2	*50% forest plantation
B4M05°	25 02	30 13	Waterval	188	188	85	2,89	61 12 06	27	G	1	4,6	
B8M14	23 53	30 05	Great Letaba	294*	294*	380	3,82	72 01 29	18	G	u	5,2**	*70% forest plantation; **K_e' = 5
B6M01°	24 41	30 48	Blyde	518*	518*	477	3,72	15 02 13	49	G	2	5**	*80% dolomitic catchment; **K_e' = 4,6
B7M08°	24 00	30 40	Selati	832	832	2150	4,75	58 01 05	(130)	SA	u	5,2	
B8M09°	23 53	30 22	Great Letaba	861	861	973	4,05	60 12 20	28	G	u	5,2	
B3M07°	25 16	29 11	Moses	971	971	865	3,89	81 01 14	(60)	SA	2	4,6	
B2M01°	25 48	28 46	Bronkhorst	1594	1594	1030	3,77	36 05 24	47	G	u	4,6	
B6M05	24 31	30 50	Blyde	2204	2204	1080	3,63	60 02 02	28	G	u	5	partly dolomitic catchment
B8°	23 19	30 41	Klein Letaba	3230	3230	3510	4,53	81 02 03	(50)	B	2	5,2	near Giyani
B1M01°	25 48	29 20	Olifants	3989	3989	1330	3,46	09 03 03	47	G	u	4,6	
B7M07°	24 11	30 40	Olifants	46583	43434	1810	1,85	58 01 05	30	SA	u	5,2*	*K_e' = 4

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period
Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DΘ = dam outflow
Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : K_e' = K_e at site

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km²) gross A	effective A_e	FLOOD PEAK Q (m³/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRE-SENTATIVE PERIOD N(yr)	METHOD OF MEASURE-MENT	ACCU-RACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
C2°	26 37	27 53	Kwagga	15	15	203	4,59	84 11 05	(200)	C	u	4,6	near Vereeniging
C2M28°	26 15	27 36	Rietfonteinspruit	31*	31*	21	2,81	76 02 12	27	G	2	4,6**	*dolomitic catchment; **K_e' = 4
C5	29 07	26 13	Bloemspruit	36	36	(453)*	(4,81)*	04 01 17	(>RMF)*	u	u	4,6	*dam-break wave
C2	26 39	27 53	Kwagga	58	58	308	4,37	84 11 05	(200)	C+W*	2	4,6	in Vereeniging; *weir
C5M07	29 09	26 19	Renosterspruit	348	348	800	4,33	88 02 21	65	G	2	4,6	
C2°	26 55	27 43	Kromellenboog	518	518	850	4,19	36 11 18	52	SA	2	4,6	"Wolwehoek"
C[illegible]M65°	27 22	26 21	Leeudoringspruit	860	860	720	3,80	76 01 14	17	G	u	4	
C8	27 52	28 19	Tierkloof	879	879	1020	4,08	88 03 11	(125)	SA	1	4,6	"Zamenkomst"
C5R01°	29 25	26 08	Kaffir	922	922	1300	4,27	88 02 21	54	DI	2	4,6	Tierpoort Dam
C5	29 25	26 08	Kaffir	932	932	(7100)*	(5,73)*	88 02 21	(>RMF)*	SA	2	4,6	at N1 bridge; *dam break wave
C5R03	29 16	26 37	Modder	940	940	2300*	4,75*	88 02 21	(200)	DI	2	5	*corrected for surges, original Q = 3100m³ /s
C1M06°	26 47	29 33	Blesbokspruit	1094	1094	1280	4,17	75 02 15	(170)	G	2	4,6	
C2°	26 44	27 07	Loop	1096	1096	539	3,41	?	(75)	u	u	4	near Potchefstroom
C5	29 30	25 58	Kaffir	1295	1295	(5700)*	(5,41)*	88 02 21	(>RMF)*	SA	2	4,6	"Spitskop"; *dam brake wave
C6	27 40	27 13	Blomspruit	1315	1315	1060	3,91	88 03 12	(60)	B	2	4,6	Odendaalsrus- Kroonstad road
C2M21°	26 25	28 05	Klip	1720	1720	1080	3,77	44 02 03	44	SA	u	4,6	at railway bridge
C1M08	26 52	28 53	Watervals	2212	2212	682	3,20	75 02 17	22	SA	1	4,6	
C5	29 36	25 55	Riet	2685	2685	3900	4,73	88 02 21	(200)	SA	2	5	"Mooihoek"
C8°	27 52	28 19	Liebenbergsvlei	2709	2709	2200	4,18	88 03 12	(175)	SA	1	4,6	"Wilgerhof"
C5M05°	29 02	26 25	Modder	3088	3088	2560	4,25	20 03 03	83	u	u	4,6	
C2°	26 40	26 36	Skoonspruit	3160*	1210*	380	3.04	15 02 18	83	u	u	4	*partly dolomitic catchment
C5	29 41	25 32	Krommelenboog	3367	3367	2300	4,10	88 02 21	(30)	SA	2	5	"Gleniffer"

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ;
Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DO = dam outflow
Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ;
Col. 9 : ( ) estimated period
Col. 12 : K_e = regional envelope value of K ; Col. 13 : K_e' = K_e at site

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km²) gross A	effective A_e	FLOOD PEAK Q (m³/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRESENTATIVE PERIOD N(yr)	METHOD OF MEASUREMENT	ACCURACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
C2M01°	26 39	27 05	Mooi	3595*	1925*	129	1,75	15 01 29	84	SA	2	4**	*75% dolomitic; **K_e' = 3,4
C4R01	28 17	27 09	Sand	3665	3665	2110	3,97	88 03 12	63	DI	1	4,6	Allemanskraal Dam
C1°	26 50	29 48	Vaal	3781	3781	1860	3,83	?	(77)	?	u	4,6	"De Langesdrif"
C1M02°	27 10	29 14	Klip	4152	4152	1220	3,35	23 01 29	69	G	2	4,6	
C7M01	27 16	27 10	Renoster	5227	5212	1490	3,40	34 01 03	25	G	2	4,6	
C3	26 46	25 33	Harts	5450	4135	521	2,51	76 01 19	(65)	B	2	3,4	Delareysville- Ottosdal road
C4M01°	28 28	26 40	Groot Vet	5590	5590	4380	4,45	52 11 06	65	SA	u	4,6	at railway bridge
C5	29 34	25 29	Riet	5648	5425	(9200)*	(5,23)*	88 02 22	(>RMF)*	SA	2	5	"Jagersfontein"; *influenced by dam break wave
C6M01°	27 27	26 59	Vals	5674	5624	2560	3,90	24 11 05	75	G	u	4,6	
C1M01°	26 56	29 16	Vaal	8193	8193	2290	3,54	11 01 12	83	G	1	4,6	
C3R01°	27 10	25 20	Harts	9219	6339	900	2,74	76 01 19	53	DI	2	3,4	Schweizer Reneke Dam
C3M04°	27 34	24 42	Dry Harts	10165	6900	1320	3,08	88 02 22	(200)	SA	2	3,4	
C5R02	29 30	25 13	Riet	10268	9473	(12000)*	(5,23)*	88 02 22	(>RMF)*	DI	u	5	Kalkfontein Dam; *influenced by dam break wave
C5	29 30	25 12	Riet	10579	9584	6100*	4,49*	88 02 22	(100)*	SA	2	4	"Kalkfontein"; *possibly slightly influenced by dam break wave; **K_e' = 5
C3M03	27 35	24 45	Harts	10990	7875	1100	2,79	88 02 22	65	B	2	3,4	downstream of station
C4°	28 02	26 17	Vet	14829	14700	4050	3,76	88 03 13	63	B	2	4	Bultfontein- Wesselsbron road
C5M13°	28 59	25 05	Modder	15011	8346	2710	3,71	in 1881	107	SA	u	4	at railway bridge
C8M01°	27 16	28 29	Wilge	15673	15673	3120	3,41	57 09 27	74	G	2	4,6	
C3R02	28 08	24 30	Harts	26914	18139	2430	3,01	88 02 22	(200)	DI	2	3,4	Spitskop Dam
C3M14	28 23	24 18	Harts	30910	18630	3200*	3,31*	88 02 23	(200)*	SA	2	3,4	*influenced by dam break wave
C5°	29 01	24 30	Riet	31675	18785	5350	3,90	88 02 24	76	SA	2	4*	"De Krans"; *K_e' = 4,3
C1R01	26 53	28 07	Vaal	38505	38505	5470	3,38	57 09 27	65	DI	2	4,6	Vaal Dam

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period
Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DO = dam outflow
Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : K_e' = K_e at site

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km^2) gross A	effective A_e	FLOOD PEAK Q (m^3/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRE-SENTATIVE PERIOD N(yr)	METHOD OF MEASURE-MENT	ACCU-RACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
C2M07°	27 01	26 42	Vaal	63437	61112	7310	3,35	Feb 1894	94	u	u	4	Coalminedrift
C9R02	27 40	25 37	Vaal	107911	96070	6140	2,67	88 03 15	94	DI	1	4	Bloemhof Dam
C9M03°	28 31	24 42	Vaal	120902	97867	5410	2,47	Feb 1894	94	u	u	3,4	Kimberley Water Works
C9M07°	29 03	23 50	Vaal	193842	139647	7800*	2,62*	88 02 25	94	SA	2	4**	just u/s of Douglas; *possibly slightly influenced by dam breaks; **$K_e' = 3,4$
D1°	31 23	26 29	Spioenkop	13	13	90	4,12	?	(20)	u	u	5	NE of Molteno
D1*°	28 43	28 37	Tsehlanyane	57	57	146	3,86	70 12	30	G	1	5	*Lesotho, G11
D1*	28 50	28 42	Motete	67	67	334	4,37	67 01 31	26	G	u	5	*Lesotho, G14
D4M03	26 43	20 02	Swartbas	70	70	15	2,16	47 04 26	7	G	u	2,8	
D1*	29 26	27 54	Makhaleng	86	86	99	3,40	78 03 31	24	G	1	5	*Lesotho, G19
D6	31 26	22 46	Meltonwoldspruit	127	127	453	4,33	61 03 27	67	DI	1	4,6	Aspeling Dam
D1*°	30 24	27 42	Qomoqomong	208	208	325	3,86	74 02	16	G	u	5	*Lesotho, G40
D7°	28 32	21 12	Donkerhoekspruit	241	241	163	3,26	48 04 17	40	u	u	4	south of Upington
D1M08*	28 47	28 37	Malibamatso	277	277	710	4,33	67 01 31	29	G	2	5	*Lesotho, G10
D6R01	31 24	23 06	Dorpspruit	280	280	312	3,69	61 03 27	27	DI	1	4,6	Victoria West Dam
D7	29 24	22 07	Marydalespruit	382	382	214	3,23	88 02	(30)	B	2	4	Marydale

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period

Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DΘ = dam outflow

Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K = regional envelope value of K ; Col. 13 : K' = K at site

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km^2) gross A	effective A_e	FLOOD PEAK Q (m^3/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRE-SENTATIVE PERIOD N(yr)	METHOD OF MEASURE-MENT	ACCU-RACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
T5	29 59	29 48	Nkonzo	32	32	396	4,76	59 05 17	39	SA	u	5,2	Creighton
T5M06	30 42	30 16	Mzimkulwana	534	534	1110	4,41	59 05 17	39	u	u	5,4	
T5M04°	29 46	29 28	Mzimkulu	545	545	651	3,95	76 03 05	39	SA	u	5	
T4M01°	30 44	29 49	Mtamvuna	715	715	2270	4,86	59 05 18	(190)	SA	u	5,2	
T5M02	30 24	29 54	Bisi	867	867	1300	4,30	59 05 17	54	SA	2	5,2	
T1M01	31 40	28 06	Xuka	956	956	907	3,94	59 05 17	13	SA	u	5,2	
T3M04°	30 34	29 26	Mzimhlava	1029	1029	759	3,74	59 05 18	41	G	u	5	
T4°	31 03	30 11	Mtamvuna	1557	1557	3170	4,80	59 05 18	(75)	SA	2	5,4	near Port Edward
T3M05°	31 02	28 53	Tina	2597	2597	1900	4,07	76 03 21	37	G	1	5,2	
T5M07	30 15	29 57	Mzimkulu	3586	3586	3800	4,55	59 05 17	57	SA	2	5,2	
T3M06	31 14	28 51	Tsitsa	4268	4268	1700	3,66	76 03 21	28	SA	2	5,2	
T1M04	31 55	28 27	Bashee	4828	4828	3400	4,27	59 05 17	33	SA	2	5,2	
T5	30 42	30 25	Mzimkulu	6630	6630	6520	4,77	59 05 18	57	SA	u	5,4	Port Shepstone

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period
Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DΘ = dam outflow
Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : K_e' = K_e at site

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km^2) gross A	effective A_e	FLOOD PEAK Q (m^3/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRESENTATIVE PERIOD N(yr)	METHOD OF MEASUREMENT	ACCURACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
U5	29 14	31 22	Zinkwazi	28	28	400	4,81	87 09 29	(85)	SA	2	5,4	"Hollydays Hoek"
U2M10°	29 37	30 14	Msindusaan	30	30	255	4,49	24 12 29	24	u	u	5	
U2°	29 36	30 24	Dorpspruit	69	69	340	4,37	47 01 14	41	SA	u	5,2	Pietermaritzburg
U6°	29 55	30 57	Mhlatuzana	119*	119*	750*	4,73	76 03 21*	(55)	u	u	5,4	Durban; * source: C.G. Schmidt
U5	29 17	31 22	Nonoti	157	157	1160	4,94	87 09 29	(120)	SA	2	5,4	"Chateloupe"
U8°	30 26	30 37	Fafa	225	225	1000	4,69	85 02 10	29	SA	2	5,4	near mouth
U3M01°	29 33	31 08	Tongati	318*	318*	2100*	5,13	18 02 16*	(200)	u	u	5,4	at railway bridge; * source: C.G. Schmidt
U3R01	29 36	31 03	Mdloti	377	377	1830	4,95	87 09 28	(125)	DI	1	5,4	Hazelmere Dam
U8	30 36	30 33	Mzumbe	536*	536*	1320*	4,54	59 05 17	(30)	u	u	5,4	near mouth; * source: J.E. Perry
U8	30 17	30 45	Mpambanyoni	548	548	1230	4,47	59 05 17	29	u	u	5,4	near mouth
U8	30 28	30 36	Mtwalume	565	565	992	4,28	59 05 17	29	SA	u	5,4	at South-Coast road
U6R01	29 53	30 44	Mlazi	781	781	1500	4,47	87 09 29	30	DΘ	2	5,4	Nshongweni Dam
U2M22	29 39	30 38	Msunduze	877	877	1440	4,38	87 09 29	40	SA	2	5,2	u/s of station
U7M02	30 05	30 49	Lovu	936	936	2000	4,63	76 03 21	30	u	u	5,4	
U2R03°	29 26	30 26	Mgeni	1644	1644	2530	4,57	87 09 29	(60)	DI	1	5,2	Albert Falls Dam
U4M05°	29 20	31 11	Mvoti	2473	2473	5000	5,01	87 09 29	(170)	SA	2	5,4	d/s of station
U2M15	29 42	30 49	Mgeni	4023	4023	5500	4,86	87 09 29	70	DΘ	2	5,4	Inanda dam-wall (in construction)
U1M06°	30 11	30 46	Mkomanzi	4375	4375	7000	5,06	1856 4 16*	132	SA	2	5,4	"Umlazi"; * source: E. Beesley

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period
Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DΘ = dam outflow
Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : K_e' = K_e at site

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km^2) gross A	effective A_e	FLOOD PEAK Q (m^3/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRESENTATIVE PERIOD N(yr)	METHOD OF MEASUREMENT	ACCURACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
V1M22°	28 59	29 15	Mazongwana VI	0,62	0,62	7,9	3,78	66 02 03	24	G	2	5	
V2R01	29 10	30 17	Mnyamvubu	152	152	377	4,12	87 09 29	25	DI	1	5	Craigie Burn Dam
V7M12°	29 00	29 53	Little Bushmans	196	196	1050	4,78	30 03 08	58	SA	u	5	
V3M11°	27 54	30 35	Bloed	543	543	1200	4,45	84 01 31	(80)	B	u	5	
V3M05	27 26	29 59	Slang	676	676	400	3,43	84 01 31	33	G	2	5	
V1M10	28 49	29 33	Little Tugela	782	782	630	3,73	79 03 03	(17)	G	1	5	
V3R01°	27 57	29 57	Ngagane	830	830	1270	4,30	64 10 29	24	DI	1	5	Chelmsford Dam
V7	28 57	29 55	Bushmans	1100	1100	2030	4,57	30 03 08	58	SA	u	5	"Elmwood"
V2°	29 09	30 06	Mooi	1186	1186	1380	4,17	87 09 29	54	SA	2	5	"Riverside"
V1M38°	28 34	29 45	Klip	1644	1644	2200	4,44	23 02 12	65	SA	2	5	Ladysmith
V1M26°	28 43	29 22	Tugela	1894	1894	1400	3,96	79 03 03	21	G	2	5	
V2	28 46	30 34	Mooi	2482	2482	2000	4,14	87 09 29	54	SA	2	5	
V1M01	28 44	29 49	Tugela	4176	4176	3400	4,36	76 03 21	28	G	2	5	
V3M01	28 15	30 30	Buffels	7930	7930	2380	3,60	39 02 08	18	u	u	5	
V6M02°	28 45	30 26	Tugela	12862	12862	4610	4,00	43 04 25	41	G	u	5	
V5M02°	29 10	31 24	Tugela	28490	28490	15100	4,86	25 03	71	SA	2	5,2	

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period
Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DΘ = dam outflow
Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : K_e' = K_e at site

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km^2) gross A	effective A_e	FLOOD PEAK Q (m^3/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRESENTATIVE PERIOD N(yr)	METHOD OF MEASUREMENT	ACCURACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
W1R02	28 54	31 27	Mlalazi	14	14	132	4,34	87 09 29	10	DI	1	5,6	Eshowe Dam
W2M07	27 58	31 12	Bizamkulu	78	78	585	4,71	84 01 31	23	SA+B	1	5,6	
W5M08°	26 29	30 38	Bonnie Brook	119	119	178	3,67	60 12 03	31	G	u	4,6	
W2°	28 30	32 09	Mzinduzi	179	179	1330	5,00	25 03	63	SA	u	5,6	at railway bridge
W5M06	27 07	30 50	Swartwater	180	180	600	4,39	84 01 30	37	B	2	5,2	
W6M03*	26 23	31 32	White Imbuluzi	223	223	785	4,51	84 01 30	23	SA+G	1	5,6	*Swaziland, GS 10
W1	28 55	31 41	Mlalazi	230	230	930	4,62	87 09 29	(20)	SA	2	5,6	
W2M08	27 56	31 12	Black Mfolozi	238	238	2180	5,27	84 01 31	(110)	SA	2	5,6	
W2R01	27 51	30 49	White Mfolozi	340	340	1090	4,58	84 01 31	(65)	DI	2	5,2	Klipfontein Dam
W4	27 18	31 15	Mozane	426	426	3020	5,31	84 01 30	(125)	SA	2	5,6	"Tobolsk"
W1°	28 42	32 01	Nseleni	547	547	4250	5,49	87 09 29	(200)	SA	2	5,6	1,5 km u/s of N2 bridge
W1	29 05	31 33	Matigulu	583	583	3170	5,23	87 09 29	(90)	SA	2	5,6	Dunn's Reserve
W1	28 42	31 39	Mfule	618	618	3300	5,24	87 09 29	(95)	SA	2	5,6	Mfule Estate
W6M01*	26 10	31 35	Black Imbuluzi	723	723	1660	4,59	84 01 30	29	G+DI	1	5,6	*Swaziland, GS 3
W3R01°	28 07	32 11	Hluhluwe	734	734	3060	5,10	63 07 04	63	SA+F*	2	5,6	Hluhluwe Dam ; *float
W5M05°	26 50	30 44	Hlelo	804*	804*	709	3,82	51 12 30	37	G	u	5	*30% forest plantation
W4	27 31	30 49	Bivane	878	878	1060	4,12	84 01 30	38	B	2	5,2	"Uitval"
W5M22	27 04	31 00	Assegaai	1191*	1191*	1320	4,15	84 01 31	20	SA	2	5,2	*d/s of Heyshope Dam
W1R01	28 46	31 29	Mhlatuze	1273	1273	3650	5,02	87 09 29	(40)	DI	1	5,6	Goedertrouw Dam
W3M01	27 40	31 40	Mkuze	1467	1467	3320	4,87	63 07 04	(25)	G	u	5,6	
W1	28 51	31 55	Mhlatuze	1494*	1494*	3900	5,01	87 09 29	(40)	SA	2	5,6	N2 bridge; *d/s of Goedertrouw Dam
W2°	28 04	31 33	Black Mfolozi	1635	1635	7500	5,56	84 01 31	(200)	SA	2	5,6	just u/s of station W2M06

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period
Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DO = dam outflow
Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : K'_e = K_e at site

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km^2) gross A	effective A_e	FLOOD PEAK Q (m^3/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRE-SENTATIVE PERIOD N(yr)	METHOD OF MEASURE-MENT	ACCU-RACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
W4	27 06	32 04	Ngwavuma	1660	1660	4250	5,04	84 01 31	(45)	SA	1	5,6	"Mbuzini"
W4	27 19	30 54	Pongolo	1731	1731	2750	4,62	84 01 31	(75)	B	2	5,2	"Mooiplaats"
W3M02	27 36	32 01	Mkuze	2647	2647	5500	5,06	84 01 31	60	SA	2	5,6	
W5M17*	26 34	31 05	Great Usutu	2680	2680	1100	3,60	84 01 30	26	G+SA	1	5	*Swaziland, GS 9
W5M15*	26 42	31 05	Ngwempisi	3147	3147	> 1525	> 3,74	84 01 30	26	G	u	5	*Swaziland, GS 5
W2	28 16	31 51	Black Mfolozi	3396	3396	10000	5,52	84 01 31	(200)	SA	2	5,6	Umfolozi Game Reserve
W5	26 42	31 26	Mkondvo (Assegaai)	3844	3844	4900	4,77	84 01 30	(25)	SA	2	5,6	Swaziland, Sidvokodvo
W2M05	28 20	31 23	White Mfolozi	3939	3939	7500	5,18	84 01 31	(75)	SA	2	5,6	
W4M03	27 25	31 31	Pongolo	5788	5788	9200	5,19	84 01 31	(80)	G	1	5,6	
W4R01	27 25	32 04	Pongolo	7831	7831	13000	5,41	84 01 31	(200)	DI	2	5,6	Pongolapoort Dam
W2	28 27	32 06	Mfolozi	9216	9216	16000	5,55	84 01 31	(200)	SA	2	5,6	5 km u/s of N2 bridge
W5°	26 51	31 54	Great Usutu	15350	15060	13500	5,11	84 01 31	(200)	SA+G	1	5,6*	Swaziland, near Big Bend; $*K_e' = 5,2$

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period
Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DO = dam outflow
Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : $K_e' = K_e$ at site

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km^2) gross A	effective A_e	FLOOD PEAK Q (m^3/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRE-SENTATIVE PERIOD N(yr)	METHOD OF MEASURE-MENT	ACCU-RACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
X2M26°	25 17	30 35	Research Tributary	14*	14*	46	3,67	72 01 17	17	G	1	5**	*forest plantation; $**K_e' = 4,6$
X2	25 44	31 03	Hysloop Creek	43	43	200	4,19	84 01 30	(35)	C	u	5	"The Thorns"
X2M01°	25 17	31 00	White	103*	103*	258	4,01	39 02 05	20	G	2	5**	*92% forest plantation; $**K_e' = 4,6$
X2M10°	25 37	30 53	Noordkaap	126*	126*	200	3,72	67 02 18	36	G	2	5	*45% forest plantation
X3M01°	25 05	30 47	Sabie	174*	174*	112	3,14	58 01 06	37	G	1	5**	$**K_e' = 4,6$ *83% forest plantation, 30% dolomitic catchment;
X1°	26 02	30 24	Buffelspruit	205	205	560	4,28	76 01 15	16	B	2	5	Carolina - Badplaas road
X2M09°	25 44	30 59	Suidkaap	280*	280*	443	3,96	51 12 14	18	G	2	5	*40% forest plantation
X2	25 44	31 00	Queens	320	320	700	4,26	84 01 30	40	SA	2	5	"Daisy Koppie"
X2M11°	25 39	30 17	Elands	402	402	400	3,70	82 01 07	30	G	2	5	
X2M18°	25 17	31 38	Mbyamiti	618	618	1080	4,31	72 03 26	24	G	u	5,2	
X1	25 46	31 26	Mlumati	642	642	1800	4,71	84 01 30	(25)	SA	1	5,6	Swaziland, Horo
X3M06°	25 02	31 08	Sabie	766*	766*	890	4,04	60 02 02	30	G	u	5,2**	$**K_e' = 5$ *80% forest plantation, 15% dolomitic catchment;
X3M08°	24 46	31 23	Sand	1064	1064	658	3,60	71 01 21	21	G	u	5,2	
X2M22	25 33	31 19	Kaap	1639	1639	1370	4,02	84 01 30	28	SA	2	5,2	
X1M01°	26 02	31 00	Komati	5499	5499	3420	4,21	39 02 07	49	G	2	5	
X2M16	25 22	31 57	Crocodile	10365	10365	1800	3,11	84 01 31	28	SA	2	5,2	
X1	25 29	31 58	Komati	10785	10785	3100	3,68	84 01 30	(15)	SA	2	5,6*	"Grimman"; $*K_e' = 5,2$
X2°	25 26	32 00	Komati	21600	21600	7800	4,25	37 02	51	SA	2	5,2	Mozambique, Ressano Garcia, E 23

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period
Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DO = dam outflow
Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : $K_e' = K_e$ at site

APPENDIX 2: CATALOGUE OF MAXIMUM PEAK DISCHARGES RECORDED IN SOUTH WEST AFRICA

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km²) gross A	effective A_e	FLOOD PEAK Q (m³/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRESENTATIVE PERIOD N(yr)	METHOD OF MEASUREMENT	ACCURACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
2982°	22 29	17 03	No Name	2,6		51	4,35	42 03 01	54	DI	1	5	Nubuamis Dam
2951°	19 41	15 04	No Name	8,3		30	3,61	81 03	(15)	u	u	4	Kamanjab, km 125
3121°	22 48	16 50	Oanob tributary	12,5		200	4,64	34 01	54	DI	u	5	Claratal Haus Dam
0492°	24 38	18 00	No Name	20		200	4,48	84 04	(70)	SA	2	4,6	Kauchas
2961°	20 38	16 39	Otjiwarongo	46		345	4,54	50 01	38	u	u	4,6	
0499	27 16	17 58	Small	59		58	3,20	74 01 28	14	SA	u	4	Einoog
0496°	26 27	18 05	Aub	90		305	4,18	74 01 28	(50)	u	u	4,6	Gellap Ost
3121°	22 51	16 47	Oanob tributary	100		900	4,92	63 01	(200)	DI	u	5	Claratal Haus, Stengel Dam
2532°	20 43	17 13	Ombatjipuro		100	31	2,49	83 11 27	5	SA	2	3,4	Tevrede
2982°	22 34	17 08	Avis	102		685	4,72	34 04	54	u	u	5	Avis Dam
2986°	21 45	15 35	Khan tributary	110		600	4,59	49	(200)	u	u	4,6	Ameib
0492	24 23	17 35	Zamnarib	130		430	4,28	44 01 31	44	u	u	4,6	
2986°	21 40*	15 51*	Okawoyo	141		350	4,09	85 02 06	(45)	SA	2	4,6	Spes Bona; *approximate position
0493°	25 00	17 17	Riet	150		600	4,47	44 01 13	44	u	u	4,6	Haribes
3111°	22 00	17 35	Black Nossob	220		243	3,61	49	39	u	u	4	Hummelshain
2991M04°	23 12	16 09	Djab	231		68	2,61	78 02 10	11	G	2	4	
0497	26 38	18 47	Loewen tributary	270		270	3,59	74 01	(60)	u	u	4	Braus
0483°	28 02	18 40	Satco	340		400	3,79	74 01	(200)	DΘ	2	4	Bondelsdam
0492°	24 32	17 58	Aub	350		390	3,75	77 02	54	B	2	4,6	road bridge
2971°	21 21*	16 02*	Okandju	357		550	4,02	64 01 19	(35)	u	u	4,6	Kompanene; *guess
0493°	24 46	17 20	Tsub	380		810	4,30	34	73	u	u	4,6	Voigtsgrund
0497°	27 20	18 17	Gab	385		320	3,55	85 12 02	(60)	SA	2	4	Arbeit

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period

Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DΘ = dam outflow ; u = unknown,

Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : K_e = K_e at site

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km^2) gross A	effective A_e	FLOOD PEAK Q (m^3/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRESENTATIVE PERIOD N(yr)	METHOD OF MEASUREMENT	ACCURACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
C°	17 54	30 50	Marimba	202		733	4,50	31 11	57	u	u	5	source: T.B. Mitchell
C15°	19 19	30 00	Que Que White-Waters	326		619	4,15	52 02	30	G	u	5	
C83°	17 37	30 37	Gwebi	362		810	4,32	78 03	(50)	G	2	5	
C3°	17 59	31 04	Hunyani	793		809	3,94	63 02	29	G	u	5	
C70°	18 15	30 46	Umfuli	1210		1110	3,99	74 02	11	G	u	5	
C°	17 58	30 56	Hunyani	1410		2440	4,61	26 03	62	u	u	5	source: T.B. Mitchell
C47°	19 04	30 21	Sebakwe	1554		1300	4,00	58 02	24	G	1	5	
C18	18 49	30 19	Umniati	2631		2270	4,23	53 01	35	u	u	5	source: T.B. Mitchell
C	18 11	30 21	Umfuli	5000		1880	3,66	26 03	62	u	u	5	source: T.B. Mitchell
C°	18 40	29 49	Umniati	5880		5660	4,69	53 01	(200)	SA+W*	2	5	source: T.B. Mitchell ; *weir
C74	17 05	30 18	Hunyani	6110		2630	3,88	77 03	9	G	u	4,6	
C59	17 30	29 24	Sanyati	37500		3850	2,95	69 03	9	G	1	4	
D°	17 50	31 01	Avondale Vlei	28		354	4,73	45 02	43	u	u	5	source: T.B. Mitchell
D4°	17 34	31 00	Dassura	73		257	4,15	41 01	47	G	2	5	
D47°	18 01	32 09	Nyagadzi	233		456	4,07	74 01	(15)	G	u	5,2*	*guess
D	17 20	30 59	Umrodzi	699		1020	4,20	26 03	62	u	u	5	source: T.B. Mitchell

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period
Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DΘ = dam outflow
Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : $K'_e = K_e$ at site

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km²) gross A	effective Ae	FLOOD PEAK Q (m³/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRE-SENTATIVE PERIOD N(yr)	METHOD OF MEASURE-MENT	ACCU-RACY	RMF REGION Ke	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
D	17 25	31 33	Umwindisi	1090		1950	4,54	26 03	62	u	u	5,2	source: T.B. Mitchell
D6°	17 38	31 36	Shawanoya	1170		1920	4,49	52 02	31	G	u	5,2	
D44°	17 16	31 33	Poti	1215		1180	4,04	78 03	12	G	u	5,2	
D25	17 16	31 37	Mazoe	4520		2290	3,92	26 03	62	u	u	5,2	source: T.B. Mitchell
D°	17 30	31 35	Inyagni	5280		4900	4,60	26 03	62	u	u	5,2	source: T.B. Mitchell
E	19 45	30 58	Mpako	44		383	4,62	46 01	42	SA	u	5,2	source: T.B. Mitchell
E°	19 40	31 06	Munendi	130		1400	5,15	46 01	(200)	SA	2	5,2	source: T.B. Mitchell
E°	18 54	32 35	Umtali	236		612	4,29	26 01	55	u	u	5	source: T.B. Mitchell
E46°	20 24	31 11	Lower Tsjibaka	430		1090	4,49	62 12	10	G	1	5,2	
E10 + 136	18 33	32 07	Lesapi	635		908	4,15	77 02	30	G	u	5	
E4°	20 51	31 18	Umtilikwe	803*		2970	5,04	73 12	(200)	G	1	5,2	*catchment excludes Bangala Dam
E*	20 05	31 00	Umtilikwe	844		2490	4,87	46 01	(100)	SA	2	5,2	*at Mashvingo - Birchenough road; source: T.B. Mitchell
E108	20 29	31 32	Chiredzi	1040		3110	4,97	73 12	(150)	G	u	5,2	
E112°	20 01	30 24	Tokwe	1197		1190	4,06	73 12	15	G	1	5	
E51 + 52	20 45	31 14	Umtilikwe	1980*		2900	4,60	73 12	20	G	1	5,2	*catchment excludes Kyle Dam

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period
Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DO = dam outflow
Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : $K_e' = K_e$ at site

APPENDIX 3: CATALOGUE OF MAXIMUM PEAK DISCHARGES RECORDED IN ZIMBABWE

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km^2) gross A	effective A_e	FLOOD PEAK Q (m^3/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRE-SENTATIVE PERIOD N(yr)	METHOD OF MEASURE-MENT	ACCU-RACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
A12	20 23	27 48	Tegwani	72		124	3,64	55 02	29	G	2	4,6	
A24	20 01	28 32	Umgusa	474		432	3,68	70 12	24	G	u	4,6	
A61°	19 39	29 22	Shangani	622		777	4,03	73 12	(30)	G	u	5	
A27	18 15	25 57	Matetsi	1740		1304	3,94	62 12	22	G	u	4,6	
A32	18 55	28 52	Shangani	5900		611	2,40	64 12	20	G	u	4	
A22	18 22	27 03	Gwai	38600		2510	2,38	58 03	25	G	1	4	
B36°	20 19	29 00	Bumani	21		122	4,15	69 01	21	G	1	5	
B32°	20 21	28 29	Nicholson Spruit	21		199	4,46	66 02	(50)	G	1	5	
B14°	20 36	29 35	Nuanetsi	260		433	3,98	62 12	9	G	2	5	
B12°	21 03	28 26	Shashane	666		583	3,75	55 02	19	G	2	5	
B7°	20 58	28 48	Mtsheleli	1810		1331	3,94	53 02	20	G	2	5	
B20	20 36	29 11	Umzingwane	2530		1390	3,78	62 12	27	G	u	5	
B86°	21 42	28 47	Shashani	2770		3300	4,56	72 01	(130)	G+SA	2	5	
B91°	21 46	29 39	Umzingwane	11100		4310	4,02	76 12	12	G	2	5	
B37	22 02	31 27	Nuanetsi	13000		4370	3,93	72 01	28	G	1	5	

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period
Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DO = dam outflow; u = unknown ,
Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : K_e = K_e at site

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km^2) gross A	effective A_e	FLOOD PEAK Q (m^3/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRE-SENTATIVE PERIOD N(yr)	METHOD OF MEASURE-MENT	ACCU-RACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
0492°	24 30*	17 57*	Dabib	390		800	4,27	68 03 29	(80)	u	u	4,6	near Hardap; *guess
0497	26 50	18 33	Loewen tributary	426		(3000)*	(5,30)*	54 03 07	34	SA	u	4	Uachanaris; *unreliable
2982M03°	22 27	16 58	Arataragas	430		595	3,99	48 02 28	16	G	2	5	Gammans III
2961°	20 25	16 28	Omatjenne	780		850	3,99	42 02 23	54	DI	2	4,6	Omatjenne Dam
2987°	21 47	15 30	Aroab	900		700	3,75	85 02 05	(25)	SA	2	4,6	Usakos
0491M06	23 49	16 37	Kam	1080		>351	>3,04	85 02 03	15	G	1	4,6	
2971M03°	21 15	16 15	Omaruru	1320		764	3,61	84 02 09	14	G	1	4	
3022M01°	24 31	15 46	Tsauchab	1480		222	2,44	86 01 28	10	SA	2	3,4	
0492M02	24 21	17 35	Packriem	1520		499	3,15	84 04 03	12	G	1	4,6	
2954M01°	20 29	14 35	Aba-Huab	1570		259	2,53	83 01 10	(10)	G	1	4	
2991M03°	23 01	16 22	Kuiseb	1900		1260	3,86	63 01 23	54	u	2	4,6	
3112R01°	22 17	17 57	White Nossob	2070		500	2,95	87 02 14	19	DI	1	4	Otjivero silt Dam
0482M01°	28 09	19 15	Ham	2470		1010	3,50	74 01 21	(50)	G	u	4	
2992M02°	23 29	15 46	Gaub	2490		306	2,37	75 03 12	14	G	u	3,4	
2921°	18 02	13 29	Hoarusib	2540		450	2,72	84 04 10	(35)	SA	u	3,4	Oute
3121M01	23 20	17 03	Oanob	2730		522	2,81	86 02 05	18	G	u	4,6	
2983	22 01	16 54	Swakop	3000		2000	4,03	34	54	u	u	4,6	near Okahandja
0491M02°	24 12	17 02	Kam	3450		819	3,08	78 03 30	12	G	1	4,6	
3126M01	22 53	17 57	Olifants	3650		5	-1,95	82 12 06	12	G	u	<3,4	De Duine
2986M01	21 50	15 58	Khan	4010		987	3,16	85 02 05	21	G+SA	1	4,6	
2940°	20 12	13 12	Unjab	4060		770	2,91	82	(60)	u	2	3,4	mouth
2531M01°	21 13	17 06	Omatako	4970		435	2,19	63 01 04	27	G	u	3,4	

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period
Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; Dθ = dam outflow
Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : $K_e' = K_e$ at site

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km^2) gross A	effective A_e	FLOOD PEAK Q (m^3/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRESENTATIVE PERIOD N(yr)	METHOD OF MEASUREMENT	ACCURACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
2991M01°	23 17	15 48	Kuiseb	6520		840	2,65	63 01 16	27	G	1	3,4	
0497R01	26 56	17 56	Loewen	8630		2200	3,46	74 02 21	26	DI	1	4	Naute Dam
2934M01	19 11	13 35	Hoanib	11000		600	1,86	82	12	SA	2	3,4	Sesfontein
0493°	25 28	17 40	Lewer	11400		4750	4,11	74 02	(45)	u	2	4,6	Gelukwater
2972M01°	21 55	14 29	Omaruru	11500		1100	2,49	85 02 06	(20)	u	2	3,4	
0492R02°	24 30	17 52	Fish	13600		6100	4,27	72 03 16	25	DI	2	4,6	Hardap Dam
2926	18 47	12 56	Hoarusib	13600		1500	2,70	84 04 11	(30)	SA	u	3,4	Lower Purros
2962M03	20 25	15 28	Ugab	14200*	9200	417	1,63	85 02 05	21	G	1	4**	*partly dolomitic catchment; **K_e' = 3,4
2994M01	23 11	14 39	Kuiseb	14700		406	1,15	63 01 17	27	u	u	<3,4	
2985	22 27	15 39	Swakop	16000		4750	3,88	34 01 04	75	u	u	4,6	Nudis
3124M01	25 01	18 54	Aoub	19600		38	-1,92	74 02 02	16	G	2	<2,8	near Gochas
2962	21 05	13 48	Ugab	28900*	23900	258	0,09	85 02 05	12	G	2	3,4**	Ugab Stab; *partly dolomitic catchment; **K_e' = 2,8
2988°	22 41	14 32	Swakop	29000		3800	3,16	34 01 05	75	u	u	3,4	Swakopmund
0496M01	26 49	17 48	Fish	46400		8300	3,76	72 03 18	27	G	2	4,6	
0499M02°	27 55	17 29	Fish	63300		5460	2,93	72 03 19	27	FV*	2	3,4	Ai-Ais; *float-velocity
2520M01	17 58	20 48	Cuito	72000*		596	-0,26	68 02	39	A**	u	<2,8	Dirico; *estimate; **synthetic record
2811M01	17 20	14 15	Cunene	84000*		1524	0,84	63 03	27	G	u	<2,8	Ruacana; *estimate
2511M01	17 52	19 45	Okavango	137000*		947	-0,56	68 03	43	G	1	<2,8	Rundu; *estimate
2512M04	18 02	21 25	Okavango	270000*		1590	-0,89	53 04	39	G	1	<2,8	Mukwe; *estimate
2300M01	17 25	24 12	Zambezi	326000		8440	1,66	58 03 03	81	G	1	2,8	Katima Mulilo

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period
Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DΘ = dam outflow
Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : K_e' = K_e at site

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	Long. ° '	RIVER	CATCHMENT AREA (km^2) gross A	effective A_e	FLOOD PEAK Q (m^3/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRE-SENTATIVE PERIOD N(yr)	METHOD OF MEASURE-MENT	ACCU-RACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
E61°	18 55	32 25	Odzi	2450		3710	4,73	29 01	59	u	u	5	source: T.B. Mitchell
E133	20 37	30 27	Lundi	5390		2760	4,00	73 12	10	G	2	5,2	
E101	21 03	31 10	Tokwe	7700		3600	4,06	73 12	15	G	1	5,2	
E21°	19 13	32 01	Sabi	11000		2020	3,19	77 03	25	G	2	5	
E74	21 08	31 16	Lundi	23000		11700	4,69	73 12	(50)	G	u	5,2	
E43°	21 11	32 17	Sabi	43000		7500	3,69	72 02 04	28	G	1	5	source: W.G. Wannell
ZGP1	17 53	25 50	Zambezi	360000		9340	1,69	58 03 04	80	G	1	2,8	
Z1	16 22	28 52	Zambezi	525000		16140	2,14	58 03 05	80	DΘ	1	3,4	

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period
Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DΘ = dam outflow
Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : K_e' = K_e at site

APPENDIX 4: CATALOGUE OF MAXIMUM PEAK DISCHARGES RECORDED IN BOTSWANA

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	GEOGRAPHIC POSITION Long. ° '	RIVER	CATCHMENT AREA (km²) gross A	CATCHMENT AREA (km²) effective Ae	FLOOD PEAK Q (m³/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRESENTATIVE PERIOD N(yr)	METHOD OF MEASUREMENT	ACCURACY	RMF REGION Ke	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
2511	24 41	25 40	Kolobeng	120		55	2,81	85 01 16	10	G	u	4	Kumakwane
5111	21 00	26 45	Mosupe	516		107	2,49	85 01 18	17	G	u	4	Matsitama
4511	21 00	27 25	Tati	570		1010	4,28	72 01 26	17	G	u	5	Tati weir
3121	23 06	26 58	Taupye	630		236	3,03	85 02 07	3	G	u	4	Bondungwe Hill
4411	21 00	27 33	Ntshe	800		1610	4,52	72 01 26	17	G	u	5	Ntshe weir
3221	23 03	26 49	Mahalapye	840		335	3,15	77 03 06	16	G	u	4	Madiba
5211	20 38	26 11	Mosetse	1090		190	2,50	73 12 30	18	G	u	3,4	Mosetse Old Bridge
3111	23 18	26 44	Bonwapitse	1125		57	1,42	86 02 07	3	G	u	4	Selekwane Hill
4361	21 11	27 21	Shashe	2500		438	2,70	86 04 19	14	G	u	5	Mooke weir
2411	24 27	26 05	Metsemotlhabe	3400		272	2,02	87 12 13	11	G	u	4	Morwa
3331	22 34	27 09	Lotsane	3815		96	0,91	77 03 08	16	G	u	4	Palapye
4321	21 34	27 44	Shashe	7810		1750	3,29	72 01 18	17	G	u	5	Lower Shashe
4121	21 53	28 01	Motloutse	8400		1150	2,79	87 12	19	G	u	4,6	Tobane
5311	20 12	26 11	Nata	22500		1070	1,85	72 01 30	17	G	u	2,8	Nata Old Bridge

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period

Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DΘ = dam outflow ; u = unknown,

Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : K_e = K_e at site

APPENDIX 5: **CATALOGUE OF MAXIMUM PEAK DISCHARGES RECORDED IN MOZAMBIQUE**

DRAINAGE REGION OR STATION No.	GEOGRAPHIC POSITION Lat. ° '	GEOGRAPHIC POSITION Long. ° '	RIVER	CATCHMENT AREA (km²) gross A	CATCHMENT AREA (km²) effective A_e	FLOOD PEAK Q (m³/s)	FRANCOU RODIER K	DATE OF PEAK Y M D	REPRESENTATIVE PERIOD N(yr)	METHOD OF MEASUREMENT	ACCURACY	RMF REGION K_e	NOTES
1	2		3	4	5	6	7	8	9	10	11	12	13
E85	20 05	33 07	Lucite	1980		7990	5,54	74 02 26	(200)	G	2	5,6	
E65	18 34	33 16	Pungoé	3100		2920	4,38	76 03 14	28	G	2	5,6	
E10	26 12	32 08	Umbeluzi	3250		6150	5,07	84 01 31	(50)	G	2	5,6	Goba
E8	26 03	32 20	Umbeluzi	5600		8200	5,09	84 01 31	(55)	G	2	5,6	Boane
E66	19 01	34 11	Pungoé	15046		2960	3,39	77 03 18	18	G	2	4,6	
E23	25 26	32 00	Incomati	21600		7800	4,25	37 02	51	SA	2	5,2	Ressano Garcia
E188	19 57	34 09	Búzi	26314		6590	3,91	74 02 28	26	G	2	4,6	
E6	26 48	32 28	Maputo	31600		16000	4,87	84 01 31	(200)	SA	2	5,2	Madubula
E43	25 02	32 39	Incomati	37600		2200	2,24	84 02 02	(20)	G	1	?	Magude
	23 46	32 05	Elefantes	67540	64390	5410	2,90	77 02 09	30	DI	2	5*	Massingir Dam; $*K_e' = 4,6$
E47	21 06	34 41	Save	101966		13840	3,79	73 12 30	(30)	G	2	?*	$*K_e' = 4,6$
E33	23 28	32 26	Limpopo	257200	241000	8740	2,14	77 02 11	22	G	2	?*	Combomune; $*K_e' = 3,4$
E35	24 30	33 00	Limpopo	342000	326000	7800	1,52	55 02 18	33	G	2	?*	Chokwé $*K_e' = 2,8$

NOTES: Col. 1 : ° included in derivation of 50-yr to 200-yr peaks ; Col. 9 : ( ) estimated period
Col. 10 : G = gauging station; SA = slope-area; B = bridge contraction; C = culvert contraction; DI = dam inflow; DΘ = dam outflow; u = unknown,
Col. 11 : 1 = error<10% ; 2 = error<30% ; u = unknown error ; Col. 12 : K_e = regional envelope value of K ; Col. 13 : $K_e' = K_e$ at site

APPENDIX 6: Q_T/RMF RATIOS FOR DIFFERENT CATCHMENT AREAS IN SOUTH AFRICA, LESOTHO AND SWAZILAND

REGION	RETURN PERIOD T(years)	K_T	EFFECTIVE CATCHMENT AREA, A_e (km^2)									
			≤ 10*	30*	100	300	1000	3000	10000	30000	100000	300000
5,6	50	5,06	0,537	0,508	0,474	0,503	0,537	0,570	0,607			
	100	5,25	0,668	0,645	0,617	0,640	0,668	0,695	0,724			
	200	5,41	0,803	0,788	0,769	0,784	0,803	0,821	0,838			
5,4	50	4,70	0,447	0,416	0,380	0,411	0,447	0,482	0,523			
	100	4,89	0,556	0,525	0,492	0,523	0,556	0,588	0,623			
	200	5,04	0,661	0,635	0,607	0,633	0,661	0,687	0,716			
5,2	50	4,50	0,447	0,416	0,380	0,411	0,447	0,482	0,526	0,566		
	100	4,69	0,556	0,528	0,494	0,524	0,556	0,588	0,626	0,660		
	200	4,86	0,676	0,650	0,624	0,650	0,676	0,701	0,733	0,758		
5 (except in SW Cape)	50	4,30	0,447	0,416	0,380	0,411	0,447	0,482	0,525	0,567	0,617	
	100	4,48	0,550	0,521	0,488	0,517	0,550	0,582	0,619	0,657	0,699	
	200	4,64	0,661	0,636	0,608	0,633	0,661	0,687	0,718	0,748	0,780	
$5_{G,H}$ (SW Cape)	50	4,45	0,531	0,502	0,468	0,497	0,531	0,564				
	100	4,63	0,654	0,629	0,600	0,625	0,654	0,680				
	200	4,78	0,777	0,758	0,738	0,757	0,777	0,795				
4,6	50	3,84	0,416	0,385	0,350	0,381	0,416	0,453	0,496	0,541	0,591	
	100	4,04	0,524	0,495	0,462	0,491	0,524	0,558	0,597	0,636	0,679	
	200	4,20	0,629	0,603	0,576	0,602	0,629	0,660	0,692	0,724	0,758	
4	50	3,26	0,426	0,426	0,426*	0,390	0,426	0,463	0,506	0,548	0,602	0,651
	100	3,50	0,562	0,562	0,562*	0,529	0,562	0,595	0,631	0,666	0,710	0,749
	200	3,68	0,692	0,692	0,692*	0,665	0,692	0,718	0,745	0,771	0,804	0,831
3,4**	50	2,40	0,317	0,317	0,317*	0,281	0,317	0,353	0,398	0,444	0,500	0,560
	100	2,66	0,428	0,428	0,428*	0,391	0,428	0,463	0,506	0,549	0,598	0,651
	200	2,91	0,570	0,570	0,570*	0,536	0,570	0,600	0,638	0,672	0,710	0,753

* Guessed ratios

** Ratios of this region may be used also in region 2,8

APPENDIX 7: Q_T/RMF RATIOS FOR DIFFERENT CATCHMENT AREAS IN SOUTH WEST AFRICA AND ZIMBABWE

COUNTRY	REGION	RETURN PERIOD T(years)	K_T	EFFECTIVE CATCHMENT AREA, A_e (km²)								
				≤10*	30*	100	300	1000	3000	10000	30000	100000
SOUTH WEST AFRICA	5	50 100 200	4,50 4,70 4,85	0,562 0,708 0,841	0,534 0,686 0,828	0,501 0,661 0,813	0,529 0,683 0,826	0,562 0,708 0,841	0,594 0,732 0,855	0,631 0,759 0,871		
	4,6	50 100 200	4,14 4,34 4,48	0,589 0,741 0,871	0,561 0,721 0,860	0,530 0,699 0,848	0,558 0,719 0,860	0,589 0,741 0,871	0,620 0,763 0,883	0,654 0,787 0,895	0,690 0,811 0,909	0,727 0,835 0,920
	4	50 100 200	3,50 3,66 3,77	0,562 0,676 0,767	0,562 0,676 0,767	0,562* 0,676* 0,767*	0,529 0,648 0,746	0,562 0,676 0,767	0,595 0,703 0,788	0,631 0,731 0,809	0,666 0,759 0,829	0,710 0,793 0,856
	3,4	50 100 200	2,88 3,01 3,13	0,550 0,639 0,733	0,550 0,639 0,733	0,550* 0,639* 0,733*	0,517 0,610 0,711	0,550 0,639 0,733	0,585 0,669 0,758	0,619 0,698 0,779	0,656 0,729 0,803	0,696 0,762 0,828
ZIMBABWE**	5,2	50 100 200	4,65 4,86 5,03	0,531 0,676 0,822	0,502 0,652 0,807	0,468 0,625 0,791	0,497 0,649 0,806	0,531 0,676 0,822	0,564 0,702 0,838	0,603 0,731 0,855	0,640 0,759 0,871	

* Guessed ratios

** In region 5 use the same ratios as in South Africa

APPENDIX 8: REGIONAL SUMMARY OF PERTINENT STATISTICS ON INDEPENDENT FLOOD PEAKS

COUNTRY	RMF REGION	NUMBER OF PEAKS M	STATION - YEARS ΣN	MEAN REPR. PERIOD $\bar{N} = \Sigma N/M$	MEAN CATCHMENT AREA $\bar{A}_e$ (km²)	MAXIMUM K VALUE K_{max}	MEAN K VALUE $\bar{K}$	$\frac{K_{max}}{\bar{K}}$	COEFF. OF VARIATION C_K^{**}	50-YEAR EQVIVALENT K K_{50}	100-YEAR EQVIVALENT K K_{100}	200-YEAR EQVIVALENT K K_{200}
South Africa	3,4	7	625	89	74500	3,08	2,55	1,21	0,19	2,40	2,66	2,91
&	4	19	1090	57	26800	3,90	3,21	1,21	0,17	3,26	3,50	3,68
Lesotho	4,6	37	2171	59	3440	4,59	3,78	1,21	0,10	3,84	4,04	4,20
&	5	65	3991	61	2110	5,02	4,26	1,18	0,08	4,30	4,48	4,64
Swaziland	5_{GH}	15	782	52	304	5,03	4,37	1,15	0,09	4,45	4,63	4,78
	5,2	33	2147	65	3270	5,23	4,51	1,16	0,09	4,50	4,69	4,86
	5,4	13	1205	93	828	5,27	4,76	1,11	0,09	4,70	4,89	5,04
	5,6	4	526	132	774	5,56	5,29	1,05	0,05	5,06	5,25	5,41
South West Africa	3,4	10	295	30	12600*	3,16	2,64	1,20	0,11	2,88	3,01	3,13
	4	9	418	46	957*	3,79	3,31	1,15	0,14	3,50	3,66	3,77
	4,6	16	904	56	2130*	4,59	4,11	1,12	0,10	4,14	4,34	4,48
	5	5	378	76	129*	4,92	4,52	1,09	0,08	4,50	4,70	4,85
Zimbabwe	5	22	994	45	3930*	4,73	4,18	1,13	0,09	4,30	4,48	4,64
	5,2	7	530	76	1270*	5,15	4,55	1,13	0,09	4,65	4,86	5,03

NOTES: *mean gross catchment area, $\bar{A}$

**$C_K = S_K/\bar{K}$ where S_K is the standard deviation

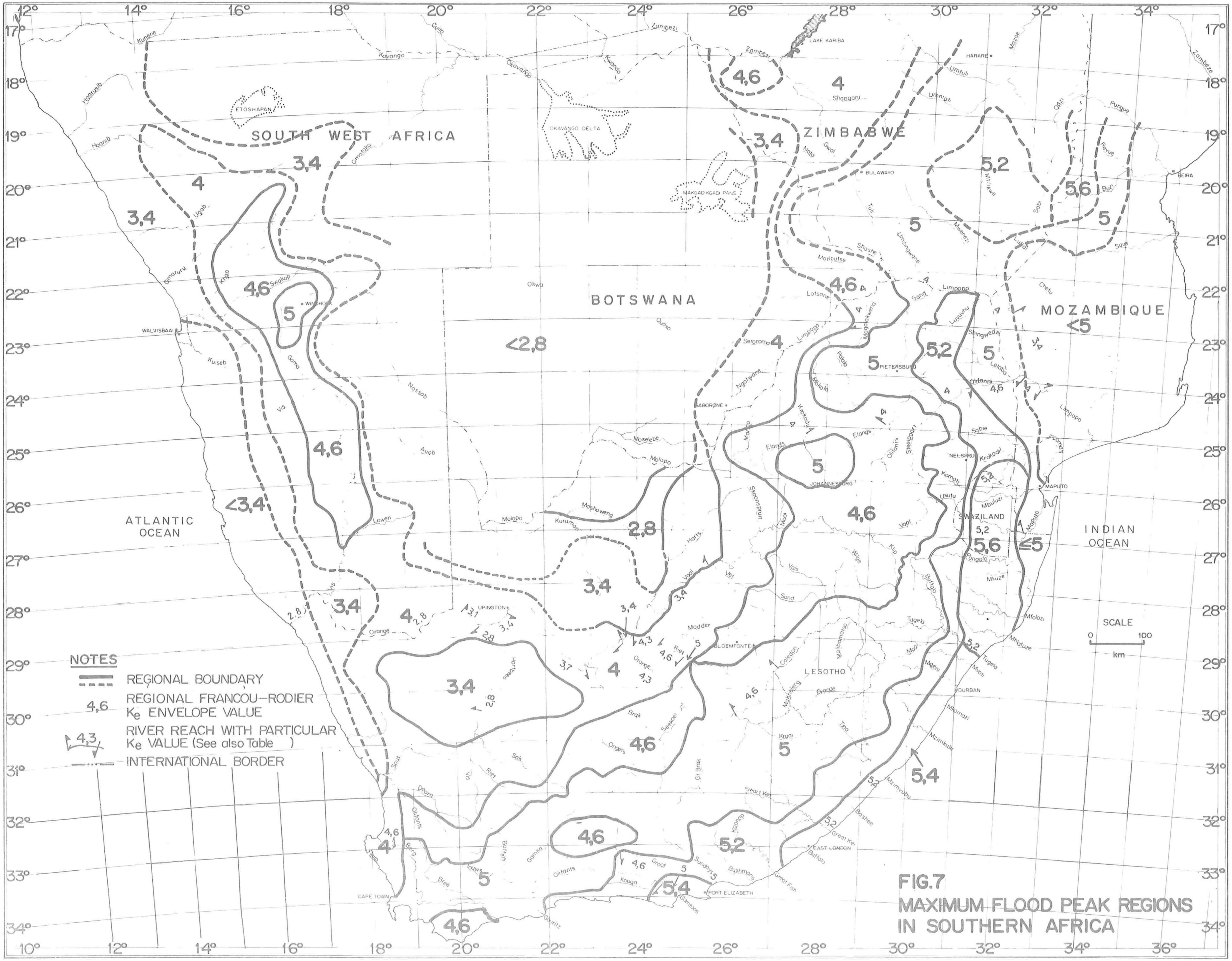

FIG.7
MAXIMUM FLOOD PEAK REGIONS IN SOUTHERN AFRICA