OLLSCOIL NA hÉIREANN, GAILLIMH
NATIONAL UNIVERSITY OF IRELAND, GALWAY

International Postgraduate Hydrology Courses

M.Sc. Degree (Hydrology) - Summer Examination 2000

Applied Hydrology II - STOCHASTIC

Examiners: Professor P.E. O'Connell
Professor C. Cunnane

Time allowed is *three* hours

Attempt *five* questions.

1. (a) Hydrological frequency analysis deals with maxima and minima of hydrological variables. Give a brief outline of extreme value theory and explain how it has influenced the development of hydrological analysis. *[10 marks]*

   (b) A series of annual maximum flows has an extreme value type 1 (EV1) distribution with location and scale parameters, $u = 200$ and $\alpha = 100$, respectively. What are the parameters of the distribution of the corresponding decade maxima? *[10 marks]*

2. A series of peaks over a threshold data have the following probability weighted moment statistics, in m^3/s, $M_{100} = 171.88$, $M_{110} = 101.32$, $M_{120} = 74.59$.

   The series consists of 48 values over a 32 year period.

   (a) Find a relationship between flood magnitude and return period using

   (i) an exponential distribution *[5 marks]*

   (ii) a generalised Pareto distribution *[7 marks]*

   (b) Display these relationships in graphical form on a standardised exponential base with a return period scale shown alongside. *[8 marks]*

3. (a) Starting with the following sequence of groups of random digits generate/simulate a sample of five values from a Generalised Logistic Distribution with parameters $\xi = 100$, $\alpha = 50$, $k = -0.10$.
   Random digits: 3106 4977 0701 0418 8644 *[6 marks]*

   (b) State two uses for such simulation in the context of hydrological frequency analysis. *[4 marks]*

Question 3 continued overleaf.../

(c) Using a selection of the random digits in (a) generate three annual flows for a river whose annual flows follow an AR(1) process, where mean $\bar{Q} = 400\ m^3/s$, standard deviation $\sigma = 150\ m^3/s$, and first order serial correlation $r_1 = 0.2$. Use $Q = 600\ m^3/s$ as a start up value. *[5 marks]*

(d) Explain briefly the differences between auto-regressive (AR), moving average (MA) and ARMA models. *[5 marks]*

4. (a) (i) What is understood by a homogeneous region in the context of flood frequency analysis. *[4 marks]*

(ii) Outline the principle categories of methods used to determine homogeneous regions *[4 marks]*

(iii) How can a region be verified as homogeneous. *[4 marks]*

(b) Using the following data demonstrate how to obtain a regional growth curve X_T - T relation, $X_T = Q/Qbar$, assuming a GEV distribution of magnitudes.

Site	1	2	3
No Years M_{100}	18 41.424	25 6.283	32 18.011
M_{101} M_{110}	13.325 28.099	2.314 3.969	6.723 11.288
M_{102} M_{120}	6.822 21.596	1.284 2.939	3.746 8.311

5. (a) In the context of a low demand flow of 20% of the long term mean flow the following annual volumes of deficit, in cumec days, were observed on a particular river:

199, 0, 84, 66, 0, 18, 195, 237, 18, 4, 0, 0, 10, 13, 0

Demonstrate any method of obtaining an estimate of the volume of deficit which has a 25 year return period and which takes into account the presence of zero values. *[10 marks]*

(b) In determining volumes of deficit how does the sequent peak method differ from the conventional mass flow (or Rippl diagram) method? *[2 marks]*

(c) Explain how simulation techniques are used to determine required reservoir capacity for a location where a long record of flow data is available. *[8 marks]*

Questions 6 and 7 overleaf.../

6. (a) (i) An annual maximum flow series is Pearson Type III distributed with mean = 140 m^3/s, standard deviation = 65 m^3/s and skewness = 2.45. Display the magnitude return period relationship on an EV1 base with a return period scale marked alongside. *[4 marks]*

(ii) Outline how the Pearson Type 3 frequency factor K_T may be determined using the standard functions available in a typical computer spreadsheet program. *[4 marks]*

(b) A sample of annual minimum flow values have the following values of probability weighted moments: $M_{100} = 4.703$, $M_{110} = 2.492$, $M_{101} = 1.580$.

Assuming a two parameter Weibull distribution for the annual minimum flows calculate an estimate of the 25 year return period low flow. *[6 marks]*

Why can it be assumed that the Weibull distribution is a reasonable choice of distribution for low flows? *[2 marks]*

7. (a) The attached figure, entitled "Data for Question 7(a)" shows 20 recent annual maximum flows and one large isolated flood which occurred in year 6. In all other years between year 1 and year 26 the annual maximum flows are known to be < 45 cumec but their individual values are unknown.

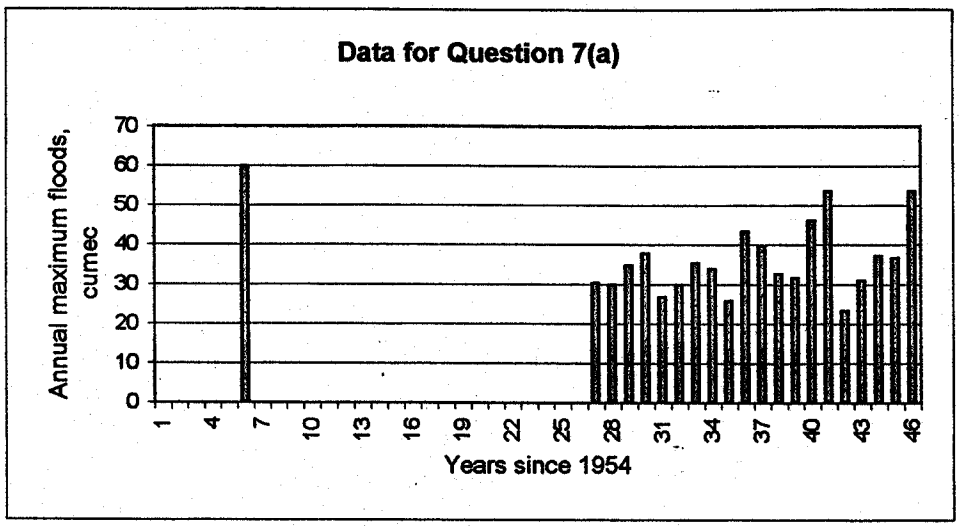
Outline a scheme which uses all this information to estimate the 100 year flood. *[8 marks]*

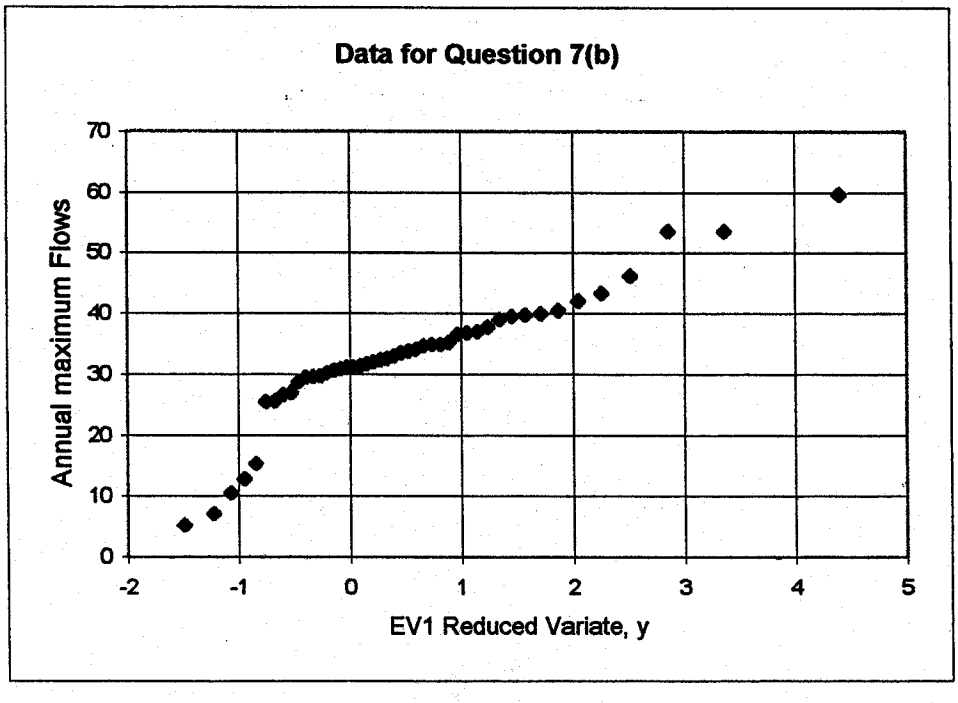
(b) The figure, entitled "Data for Question 7(b), shows an annual maximum flood series which contains what might be termed low outliers.

(i) What harmful effect might these low outliers have on flood frequency analysis [2 marks]

(ii) Explain how censored sample estimation methods could be used which would exclude these outliers [6 marks]

(iii) What were Wang's (1990) findings about the effect on $\hat{Q}_{100}$ of so omitting low outliers. [4 marks]


Data for Question 7(a)
Annual maximum floods, cumec
0
10
20
30
40
50
60
70
1
4
7
10
13
16
19
22
25
28
31
34
37
40
43
46
Years since 1954


Data for Question 7(b)
Annual maximum Flows
0
10
20
30
40
50
60
70
-2
-1
0
1
2
3
4
5
EV1 Reduced Variate, y