Institute of Hydrology

Natural Environment Research Council

Studies of Hydrology of the Lesotho Highlands Water Project for Royalties Assessment

Progress Report No. 11

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1. Introduction

This eleventh monthly progress report covers the period 1 June to 1 July 1994. Work has continued in several areas with the overall aim of finalising the datasets and stochastic model as far as possible with the current information available. This report describes the current position with regards to the three main areas defined in the Terms of Reference, namely the rainfall data, the flow data and the stochastic model.

2. Key dates

To date

14/06/93	Project begins
15/06/93	Project team arrives in Maseru
12/07/93	First progress report issued
03/08/93	Second progress report presented verbally to JPTC
10/08/93	Project team returns to UK
17/09/93	Third progress report issued
15/10/93	Fourth progress report issued
27/10/93	Working paper 1 despatched from UK
10/11/93	Working paper 2 despatched from UK
15/11/93	Fifth progress report issued
09/12/93	Working paper 3 despatched from UK
14/12/93	Sixth progress report issued
01/02/94	Seventh progress report issued
01/03/94	Eight progress report issued
30/03/94	Meeting with all parties in Maseru
15/04/94	Ninth progress report issued
01/06/94	Tenth progress report issued

Planned

Following discussions with LHDA, our plan is to continue only with background work until the agreed flow dataset for Whitehill has been received for possible inclusion in the core stochastic model. We will therefore not issue any further progress reports until one month after this dataset has been received (for example; if the dataset is finalised by mid-August, our next progress report will be issued in mid-September). A draft final report will be prepared as soon as possible thereafter describing the final version of the stochastic model and presenting our results for the Royalty flow sequences.

3. Work completed

The following work has been completed in the current reporting period:

1. The additional rainfall data for the RSA stations (as mentioned in the LHDA comments on our Working Paper 1) was received at the end of May. The data have been evaluated and the annual rainfall database used in the core stochastic model has been updated where appropriate. This database has also been modified to include the changes to the rainfall data recommended in Progress Report 9. Appendix A of this report describes this work and Appendix D presents the revised datasets. Provided all parties agree, this completes our evaluation of the raw rainfall data.

2. The agreed flow data for the Marakabei and Paray Crump weirs were also received at the end of May. Again, the data have been evaluated and a revised correction method has been developed for Marakabei. This work is described in Appendix B.1 and the revised datasets are presented in Appendix D. As agreed at the meeting in Maseru on 30/3/94, the correction scheme makes the basic assumption that the Crump weir flows are the best possible estimate of the true flow and so the rated section flows are adjusted to match the Crump weir flows.

3. A formal response has been prepared to all the comments received on our Working Paper 3 - Flow Analyses. This includes comments from LHDA (regarding rating equations, discharge measurements, individual flow values), BKS/DWAF (regarding the Seaka/Oranjedraai water balance, drag corrections, individual flow values) and WEMMIN (general points). This work is described in Appendices B.2, B.3 and B.4 of this report.

4. Work has continued on evaluating the results from the stochastic model. The aim has been to develop more objective ways of judging the results from different configurations of the model; for example, different choices of raingauges or different transformations. The proposed transposition scheme has also been modified assuming that Whitehill may be included as a key station in the core stochatic model and suggested values have now been estimated for the various coefficients to be used in both the transposition and monthly disaggregation schemes. This work is described in Appendix C of this report. One additional change to the model has been to make the code run more efficiently, to try and reduce run times when using the model on a personal computer. A 30% improvement in run times has been achieved so far.

Appendix A - Rainfall Data

This Appendix describes the work performed to complete our evaluation of the raw rainfall data. The project rainfall database has now been updated according to the recommendations made in Progress Report 9. Details of the amended data are contained in Table A.1 and printouts of the amended monthly rainfall series for these stations are provided in Appendix D.1. Also, the additional rainfall records for stations in RSA have been evaluated and final annual series have been prepared for use with the stochastic model. The map of annual rainfall ratios (pre/post 1966) has also been updated and improved.

A.1 EVALUATION OF ADDITIONAL SOUTH AFRICAN RAINFALL DATA

Monthly rainfall data for nine additional stations in South Africa were provided by RSA DWAF. The latitude, longitude and period of rainfall record of each of these stations is listed in Table A.2 whilst their locations are shown in Figure A.1. Figure A.1 also shows the locations of South African rainfall stations for which data have already been received and examined.

The annual rainfall data of each of the nine stations was examined for consistency using the basic techniques adopted previously in this study. This involved comparison with the annual data series of nearby stations in both South Africa and Lesotho by way of scaled time series and cumulative mass plots.

Examination of the data showed that in only one of the nine annual rainfall series, that of station 297721, is there a possible break in consistency. In this data series annual rainfall is higher from the late 1950s on as shown by the break in slope of the mass plot at this point in time (see Figure A.2). Nearby stations do not appear to exhibit a similar increase in annual rainfall and the break in slope is apparent in, for instance, the double mass plot of 297721 with station 298244 (see Figure A.3). On the basis of these findings it has been decided that rainfall data for station 297721 will not be used in the stochastic model.

The data for the remaining eight stations, however, are of satisfactory quality and may be used as additional rainfall inputs to the stochastic model. Of these, two stations appear to be particularly useful, having either relatively long records or being located some way from gauges previously included in the model. In addition a third station, number 237606, provides a much more complete record for the Sani Pass area than is true of the nearby station in Lesotho (station number 26). The decision to use the rainfall records of the remaining five stations will depend on an assessment of the extent to which they can yield additional information of use to the model. A summary of the potential of each data set for use in the stochastic model is given in Table A.3.

A.2 ANNUAL RAINFALL SERIES

The annual rainfall series for stations which are likely to be used as inputs to the stochastic model are presented in Appendix D for the period 1930-91. Two tables of annual rainfall series are presented. As discussed in Progress Report 9, there are 4 stations in the project area which potentially have useful long term records, 7 around the borders of Lesotho and

Location of additional and existing RSA rainfall stations

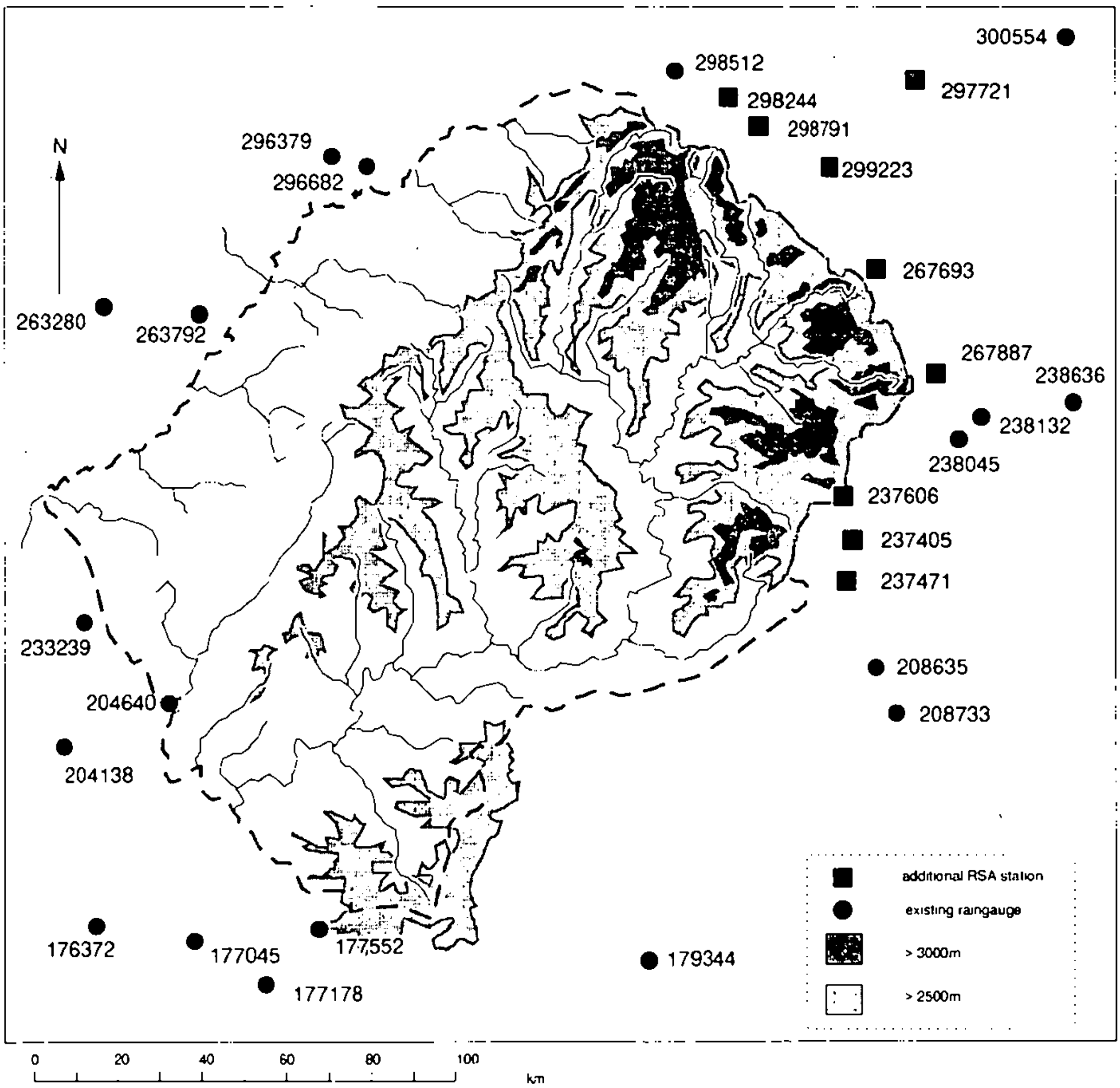


Figure A.1

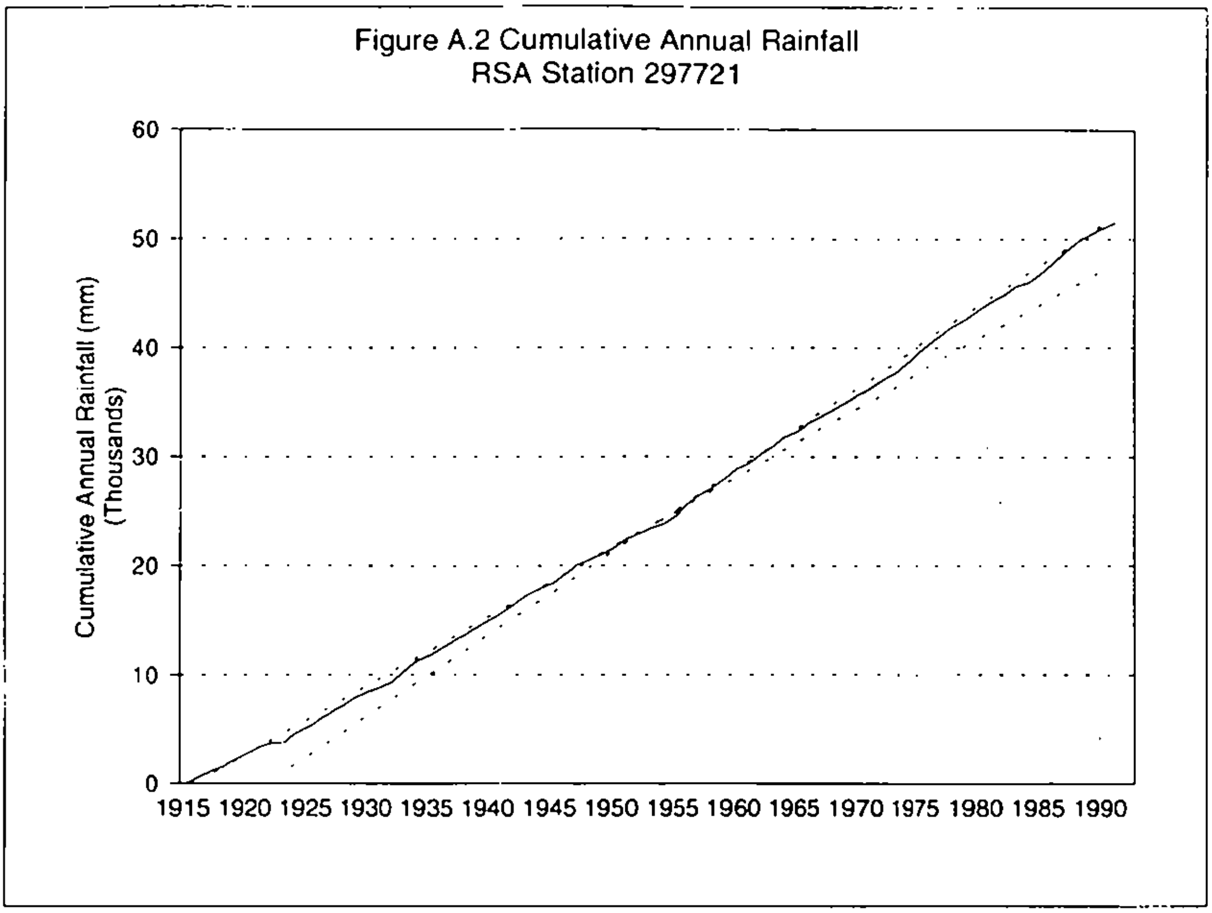


Figure A.2 Cumulative Annual Rainfall
RSA Station 297721
Cumulative Annual Rainfall (mm)
(Thousands)
60
50
40
30
20
10
0
1915 1920 1925 1930 1935 1940 1945 1950 1955 1960 1965 1970 1975 1980 1985 1990

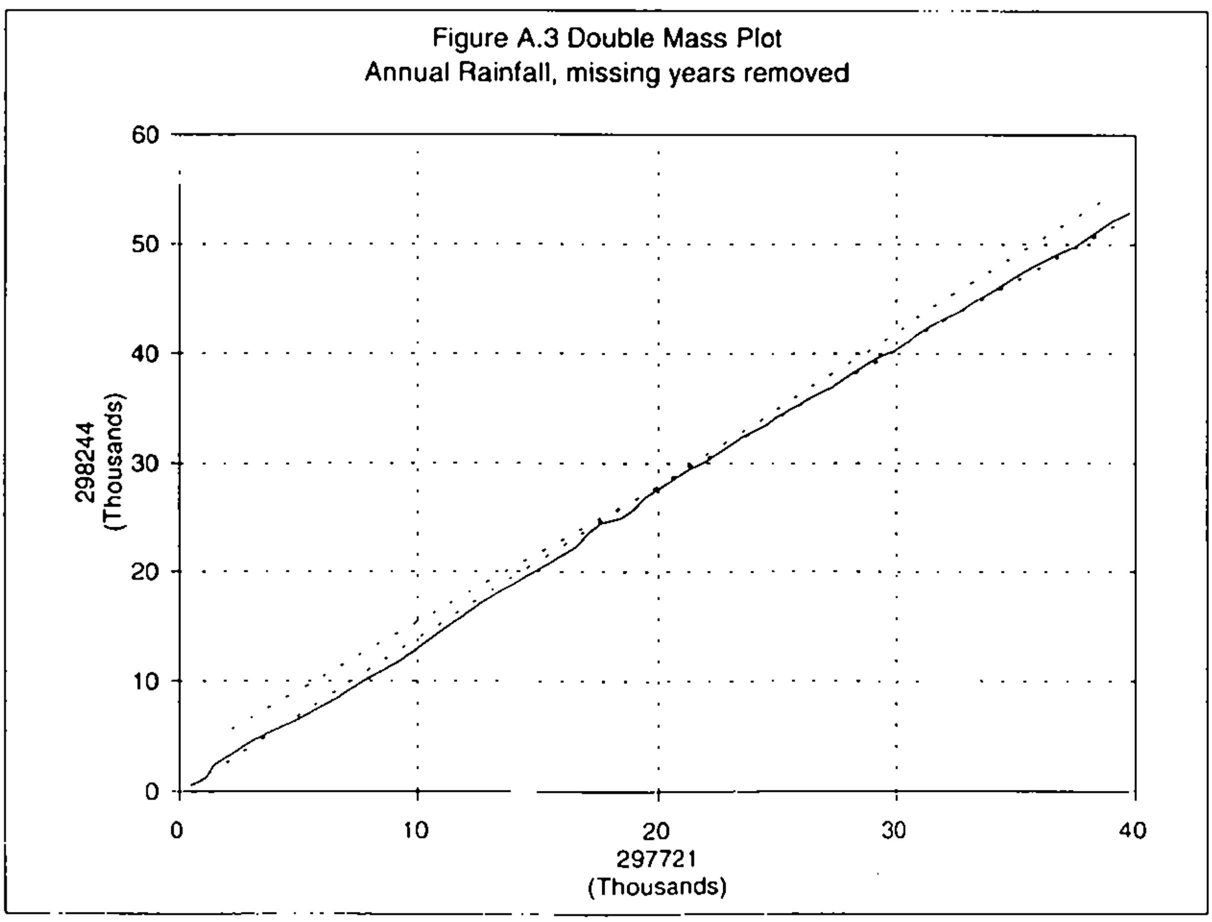


Figure A.3 Double Mass Plot
Annual Rainfall, missing years removed
298244
(Thousands)
60
50
40
30
20
10
0
0
10
20
30
40
297721
(Thousands)

(now) 25 in South Africa.

Table A1 Details of amendments to the project rainfall database

Station	Date	Daily Rainfall (mm)		Monthly Rainfall (mm)		Annual Rainfall (mm)	
		Old	Updated	Old	Updated	Old	Updated
21	11 Nov 1966	131	13.1	214	95	1163	959
21	6 Apr 1967	95	9.5	186	101	1163	959
25	23 Jan 1980	10.2	102	26	118	missing	missing
26	Oct 1976	-	-	19	120	missing	missing
60	Nov 1982	-	-	2.4	missing	missing	missing
64	Jun 1991	-	-	73	15	809	751
73	May 1977	-	-	222	6	1011	795
76	Sep 1987	-	-	246	64	838	1020
84	Dec 1978	-	-	216	180	822	786

Table A2 Details of additional South African rainfall stations

Station Number	Station Name	Latitude*	Longitude*	Period
237/405	Drakensburg Garden	29°45	29°14	1963-92
237/471	Bergview	29°51	29°16	1935-88
237/606	Sani Pass pol.	29°36	29°21	1968-93
267/887	Giants Castle	29°17	29°30	1947-93
267/693	Monk's Cowl	29°03	29°24	1962-93
297/721	Clarence pol.	28°31	28°25	1916-93
299/223	Olivia	28°43	29°08	1948-86
298/791	Royal Natal Park	28°41	28°57	1948-93
298/244	Caledonia	28°34	28°39	1920-82

* as given in DWA/BKS, Nov 1988

Table A3 *Summary of potential of additional South African rainfall data*

Station	Potential	Comment
237405	Useful	Short record near existing stations
237471	Very useful	Long record away from existing stations
237606	Very useful	More complete record than Sani Pass in Lesotho
267693	Useful	Short record near existing stations
267887	Very useful	Relatively distant from existing stations
297721	Do not use	Break in consistency in late 1950s
298244	Useful	Long record but close to existing stations
298791	Useful	Relatively long record but close to existing stations
299223	Useful	Patchy record but relatively distant from existing stations

Appendix D.2 lists annual totals over the water year running from October to September and differs only slightly from the data previously presented in Working Paper 1. These differences are due to the amendments listed in Table A.1 and the addition of the eight South African stations described in Section A.1.

Appendix D.3 lists annual totals over the water year running from August to July, this being the format required by the stochastic model. It should be noted that annual rainfall totals are not given for any years in which there are one or more missing months of data. Work is in progress to refine upper and lower bounds for the annual rainfall totals of these years in order to finalise the input series for the stochastic model.

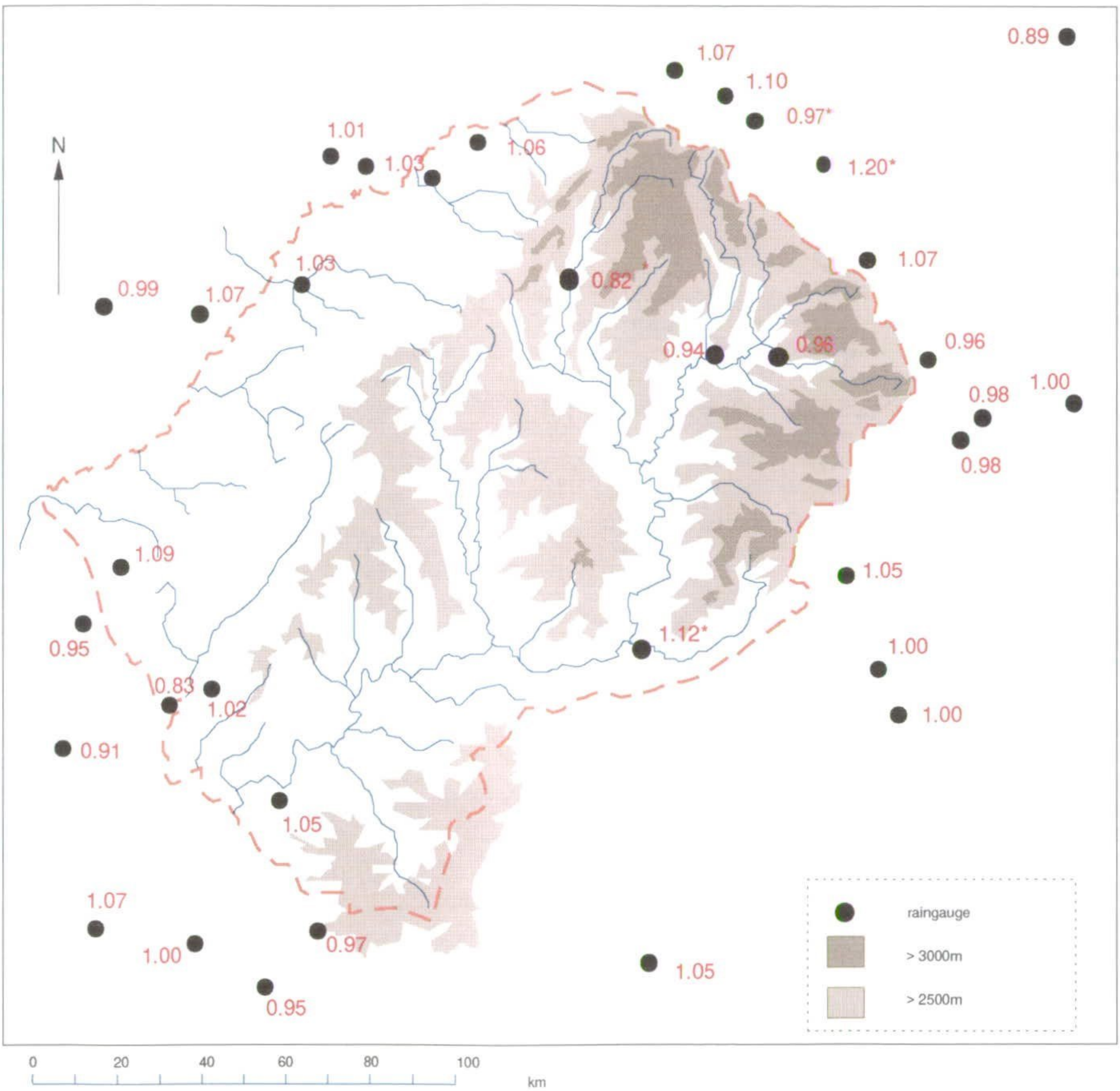
A.3 NOTE ON MEAN ANNUAL RAINFALL RATIO 1930-66/1967-92

Figure A.3 in Progress Report 10 shows the ratio of mean annual rainfall in the periods 1930-66 and 1967-92 for stations with long term data in Lesotho and South Africa. The value for station 9, Tsoelike, appears high in relation to those calculated for other stations and this has prompted a re-examination of the data for this gauge.

A crude infilling technique was used to fill in missing months of data by simply averaging the maximum and minimum rainfall recorded at Tsoelike in the relevant months. This allowed the estimation of annual totals to provide a more complete annual rainfall series. Recalculation of the mean annual rainfall ratio 1930-66/1967-92 gives a figure of 1.00 compared to the value of 1.12 calculated from the raw data alone.

The result of this exercise suggests that the high ratio of 1.12 for Tsoelike is largely a function of missing data. It is noticeable that annual totals for several wet years in the period 1967-92 are missing due to incomplete monthly data, thereby biasing the calculation of the ratio. The data for this station is consistent and is retained for input to the stochastic model. The rainfall ratio map has been updated to include this value and those for the additional RSA gauges and is shown in Figure A.4.

Ratio of mean annual rainfalls in the periods 1930 - 1966 and 1967 - 1992 (based on infilled annual records)



* Insufficient annual values for reliable long term means

Figure A.4

Appendix B - Flow data

This appendix describes our recent work on various issues regarding the raw flow dataset. Appendix B.1 presents an evaluation of the new agreed flow records for the Marakabei and Paray Crump weirs and Appendices B.2, B.3 and B.4 give our response to the comments made by LHDA, BKS/DWAF and WEMMIN respectively on our Working Paper 3 - Flow analyses. For convenience, Working Paper 3 is referred to as WP3 in the following discussions.

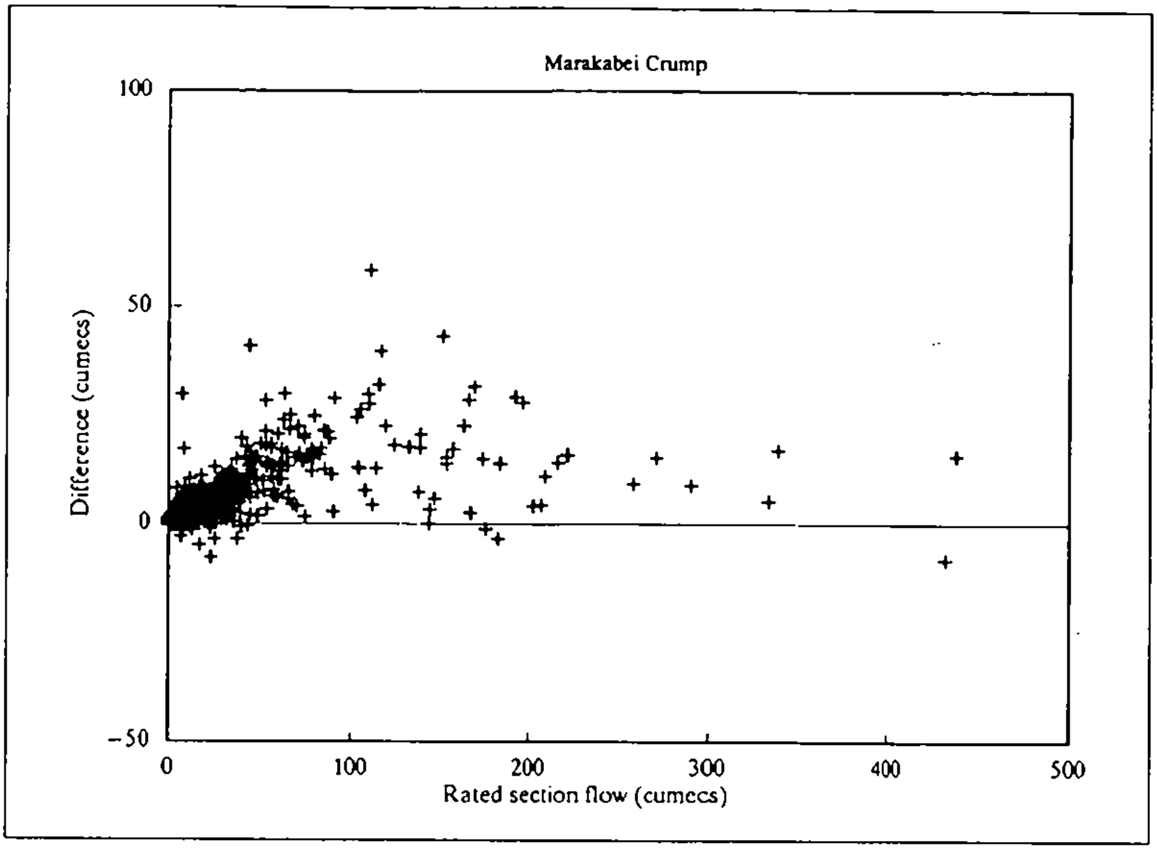
B.1 REVISED CRUMP WEIR DATA

One of the actions agreed at the meeting in Maseru on 30/3/94 was that LHDA and DWAF would combine their records for the Crump weir sites at Marakabei and Paray into single agreed records for each site covering the whole period of operation. We received these revised datasets at the end of May in the form of two ASCII datafiles (MARA1.DLY and PARA1.DLY). The data covered the period Dec 1985 to Jan 1994 for both sites. Each file contained two columns of data and we were informed that the first column (although marked LHDA data) was in fact the agreed record in both cases. On the assumption that adequate checks were performed by LHDA and DWAF during the intercomparison exercise, we have not performed any further validation tests on these data; for example, comparisons of daily flows with flows at the rated sections or other nearby stations.

The revised datasets are given in Appendix D.4 of this report and Table B.1 lists the periods in which these records differ from those presented in Appendix B of WP3. Figure B.1 shows the updated versions of Figures 4.3 and 4.9 from WP3, based on the new agreed Crump weir records and the original rated section records presented in Appendix B of WP3. These comparisons only cover the period up to Dec 1992 since we have not received any data for the rated section beyond this time. As before, our conclusions are that there seems to be a systematic error in the ratings for one or both sections at Marakabei, but no discernible error for Paray. A revised correction function is therefore required only for Marakabei.

In WP3 we recommended a polynomial correction function which peaked at a flow of about 200 cumecs and dropped off to zero for flows above 420 cumecs. LHDA have since informally suggested that a logarithmic polynomial correction function might be more suitable (in terms of the distribution of the residuals) and we have also thought of other possible functions which it might be possible to fit in a more objective manner. Our conclusion from evaluating these various functions is that the form of the function used makes little difference to the estimated annual total flows, provided that a good fit is obtained in the medium flow range (say 10-200 cumecs), since it is flows in this range which make the main contribution to the overall total flow. However, an unsatisfactory aspect of all these methods is that a subjective choice must be made both in the form of function used and the numerical procedures used to fit the function to the data. These considerations have led us to seek a more objective method which eliminates these uncertainties. The new method we propose is to develop an apparent 'synthetic' rating for the rated section based on simultaneous measurements of instantaneous levels at the rated section and instantaneous flows at the Crump weir. Effectively, this uses the Crump weir as a continuously operated gauging station for the rated section site.

Daily differences between Crump and rated section data 1985-1992 (revised Crump weir data)



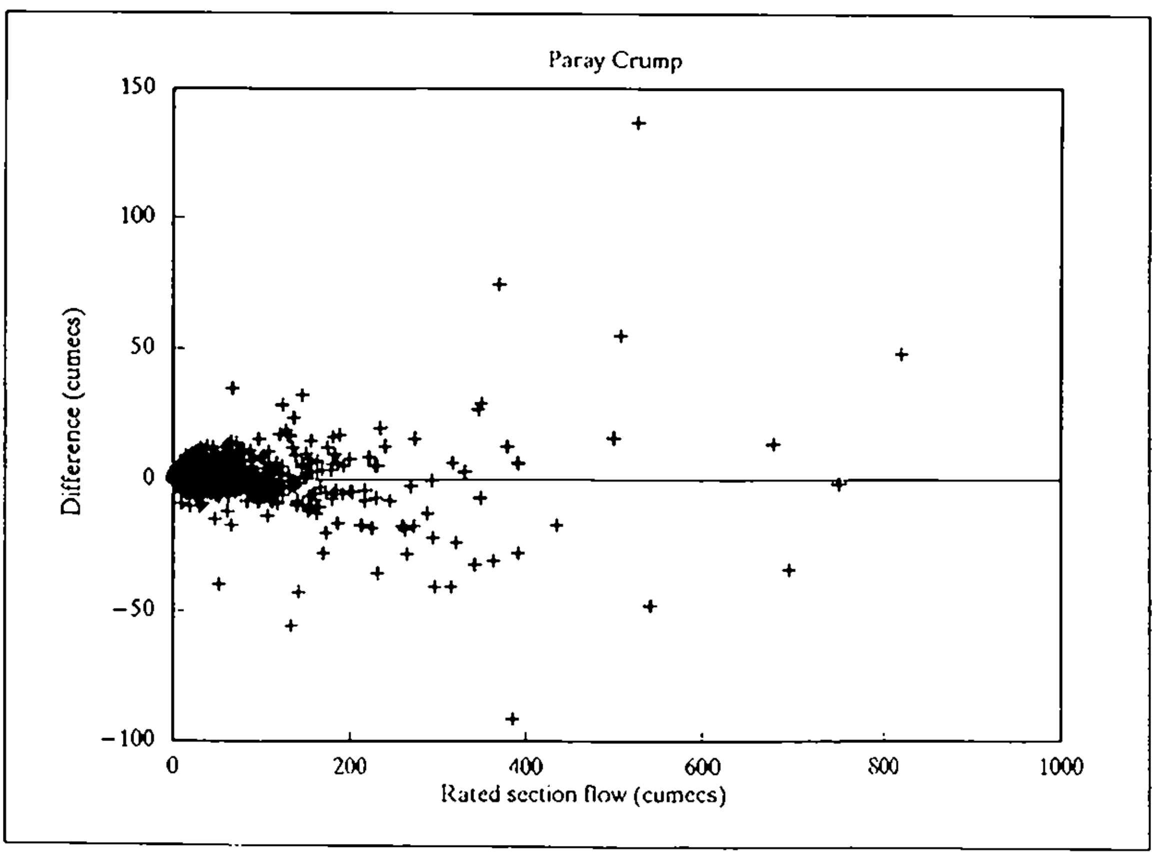


Figure B.1

Table B.1 *Periods in which revised Crump weir records differ from those given in Working Paper 3 (differences > 1 cumec)*

Marakabei	Paray
20/12/85-26/12/85	01/06/89-06/06/89
03/10/86	07/02/90-10/02/90
30/10/86-15/11/86	12/02/90-22/02/90
22/11/86-24/11/86	07/03/90
09/09/87	09/03/90
22/09/87-05/10/87	11/03/90-12/03/90
07/10/87	20/03/90-21/03/90
10/10/87-11/10/87	26/03/90
14/10/87	
08/11/87-04/12/87	
06/12/87-08/12/87	
18/12/87-20/12/87	
24/12/87-27/12/87	
15/01/88-16/01/88	
23/02/88-04/04/88	
13/04/88	
19/09/88	
22/11/88	
12/02/89	
15/02/89-16/02/89	
18/02/89	
01/06/89-02/06/89	
02/11/89-05/11/89	
14/11/89-21/11/89	
23/11/89-25/11/89	
27/11/89-28/11/89	
28/06/90	
16/08/90-17/08/90	
10/10/90-12/10/90	
16/10/90-17/10/90	
06/06/91-08/02/91	

To use this approach, some account needs to be taken of the finite lag time between the Crump and rated section sites. This can be estimated using the measurements of mean velocity which are made routinely during discharge measurements at the rated section. Figure B.2 shows the velocity/stage relationship for the rated section at Marakabei implied by the discharge measurements listed in WP3. The relationship is almost linear over the whole flow range and approximates to U=0.65h, where U is velocity (in m/s) and h is stage (in m). According to a recent survey by LHDA (see WP3), the Crump weir is about 1860 m upstream of the rated section, so the required lag time is approximately 1860/(0.65h) seconds. As a guide, the lag varies from about 1 ½ hours for flows of 1 cumec to less than 1/2 hour for flows greater than 100 cumecs.

Assuming these lag times, a synthetic rating was developed by sampling LHDA's digitised chart records for the Crump weir and rated section. The period chosen was all the hydrological years for which full records were available on our version of the LHDA database i.e. Oct 1986 to Sep 1992. For each day, the highest and lowest levels recorded at the rated section were noted, together with the appropriate lagged flow at the Crump weir (i.e. earlier in time). The digitising interval throughout this period was 30 minutes so in all cases the lag was estimated to the nearest 15 minutes. After this initial sampling, the five largest and five smallest flows in each month were selected in order to reduce the number of level/flow 'readings' to a more manageable quantity. Also, all values in the periods indicated in Table B.1 were deleted, on the assumption that, in these periods, there must be some doubt about LHDA's digitised chart levels for the Crump weir, since the flows obtained by converting these records were amended after comparison with DWAF's records.. Similarly, to account for the previous inter-comparison work (LHDA April 1992) several additional periods were deleted where the daily flows reported in WP3 (for Crump and rated sections) did not agree with those re-computed from the digitised levels.

The end result of this work was a set of some 318 synthetic discharge measurements for the rated section at Marakabei. These are shown in Figure B.3. With the exception of a few outliers, the values generally lie reasonably close to a straight line. The only exception was for flows less than about 1 cumecs, where there was a lot of scatter in the 'data'. The outlying values could arise from measurement errors (e.g. in the chart recorders or from timing/magnitude problems in the subsequent digitisations) or from errors in the estimated lag times. These values were excluded from the analysis. The large scatter at low flows probably results both from measurement errors and from errors in the estimated lag times, which probably become large at low flows. Flow values below 1 cumec were therefore also excluded. Using the remaining values, a synthetic rating was produced using the standard 'Fit Rating' option in the HYDATA database system used by LHDA. The resulting rating is shown in Table B.2 together with the original rating for this site derived during the Interim Hydrology. To estimate low flows with the new rating, the lowest portion of the Interim rating has been retained for levels up to 0.37 m. The main advantage of this method is that, once the rating has been developed, the revised flow record can be computed simply by reconverting the digitised chart levels for the rated section. However, before discussing the revised flows, it is interesting to compare the correction function implied by this new rating with that proposed in WP3. This implied function can be estimated by comparing the differences between the two rating equations shown in Table B.2 and is shown in Figure B.4. Encouragingly, for low to medium flows, the old and new functions are very similar and it is only at high flows that they diverge. High flows, of course, only make a small contribution to total runoff.

Marakabei - velocity/stage relationship for rated section

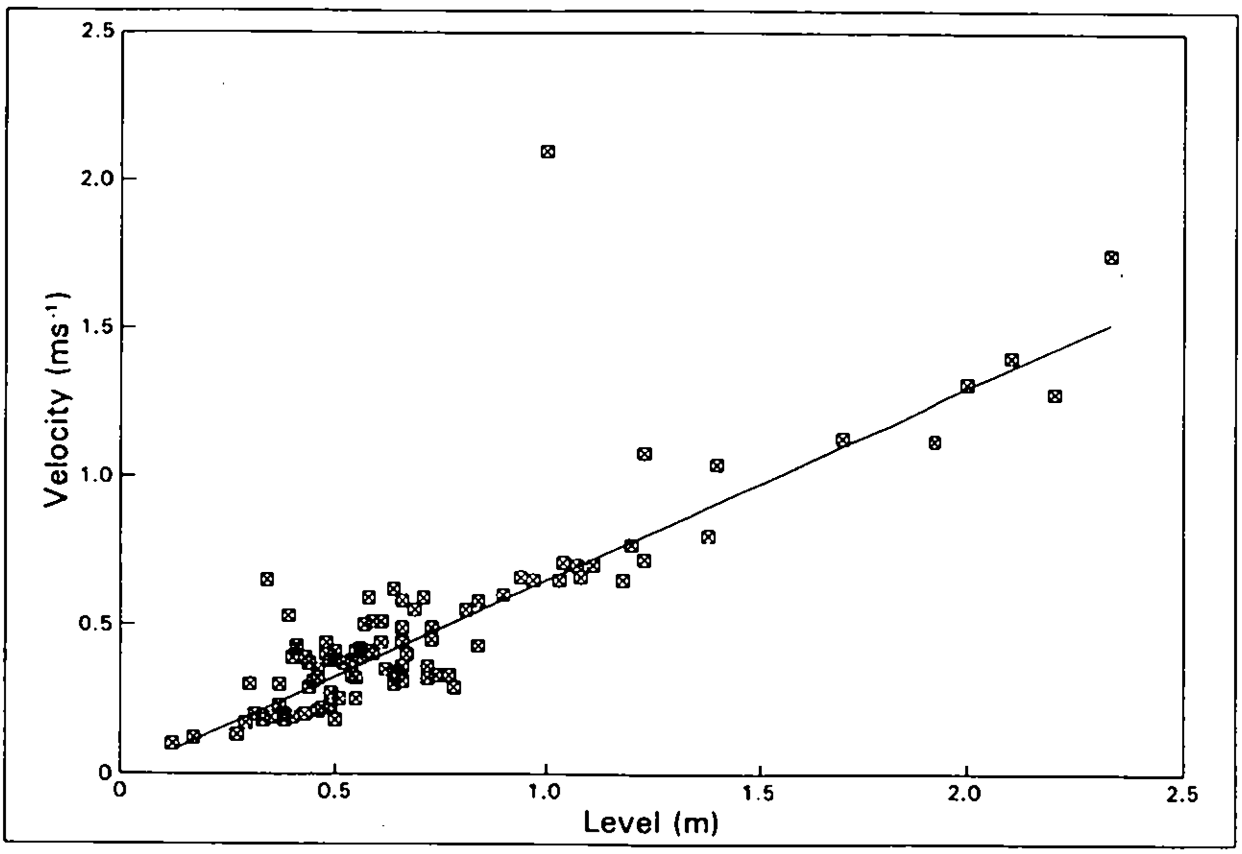


Figure B.2

Marakabei - synthetic rating using data for the period 1986-1992

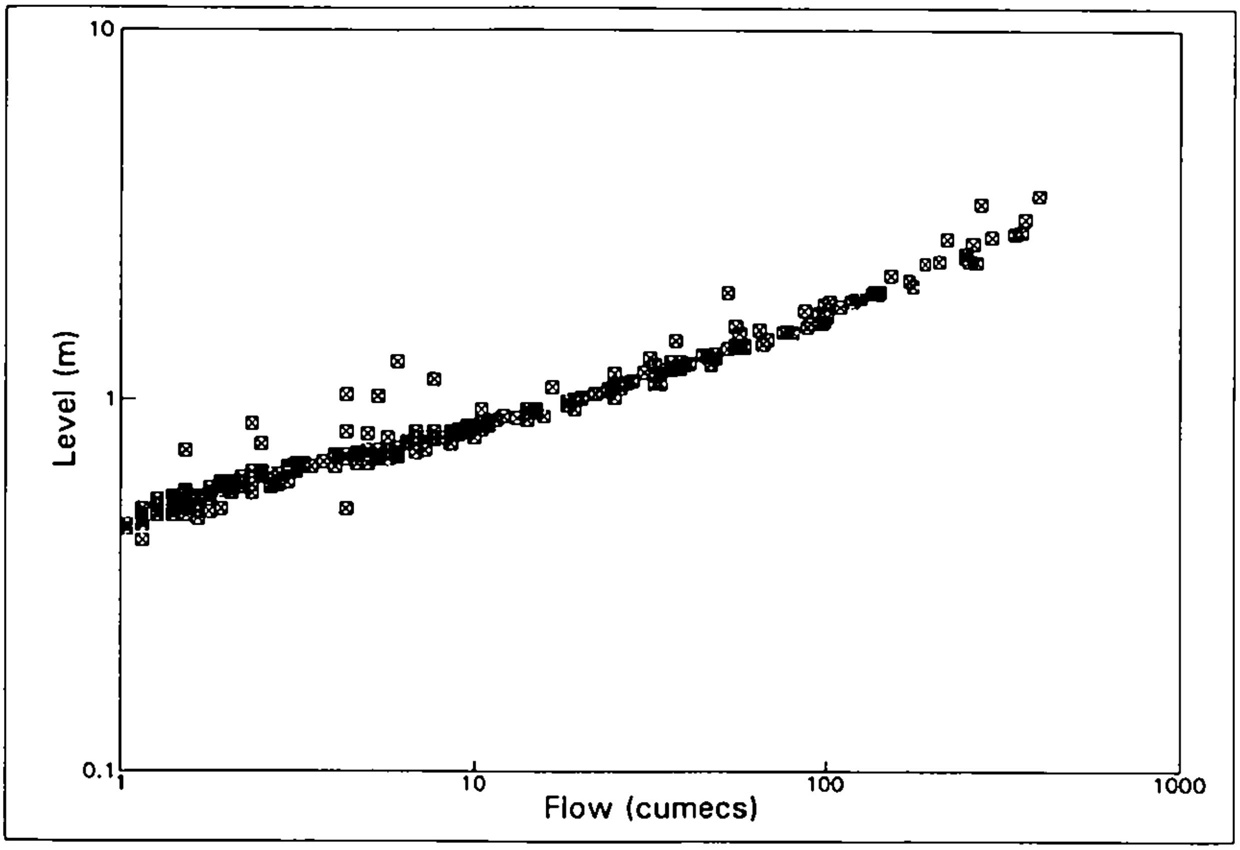


Figure B.3

Marakabei - comparison of implied correction from synthetic rating with that presented in Working Paper 3

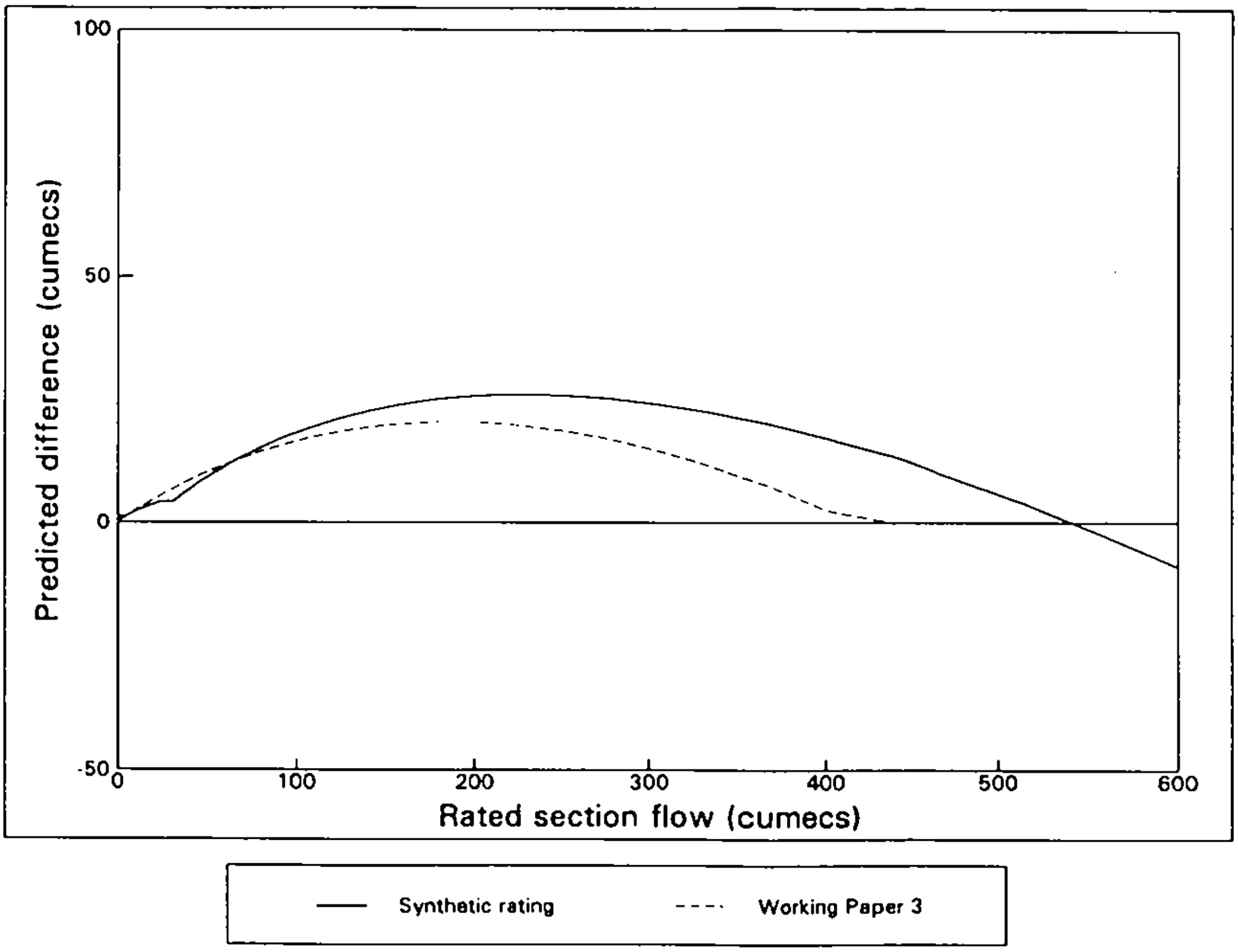


Figure B.4

Table B.2 Comparison of Synthetic and Interim Hydrology ratings for Marakabei

	a	b	c	h_{max}
Synthetic	5.086	2.394	-0.030	0.370
	17.894	4.000	0.015	1.100
	56.425	2.023	-0.410	10.000
Interim Hydrology	5.086	2.394	-0.030	0.486
	17.969	4.000	-0.030	1.127
	20.349	2.657	-0.030	5.000

Figure B.5 compares the estimated monthly Crump weir flows (computed from the rated section levels and the synthetic rating) with the measured Crump weir flows for Marakebei. The agreement is generally good and the errors vary randomly about zero. The only exception is for the hydrological year 1987 where the estimated flows are consistently too low. However, the earlier intercomparison report (LHDA April 1992) showed that, in much of this period, the original LHDA rated section flows were either deleted or replaced using DWAF records which suggests a possible problem with the LHDA digitised chart record in some of this period. We are therefore not concerned by these large differences in just this period.

The final revised flow record for Marakabei was computed using the synthetic rating up to Dec 1985 and the new agreed Crump weir flows thereafter. As agreed at the meeting in Maseru on 30/3/94, the Crump weir flows are taken as the best possible estimate of the true flows at Marakebei; consequently, no attempt has been made to derive a weighted version of the rated and Crump weir records as suggested in WP3. Also, as in WP3, missing periods in the rated section record were infilled using watchman records where available and provided that the infilling would not have a large effect on the annual total flows. The final monthly flow record is shown in Table B.3 and the annual values are plotted in Figure B.6. The resulting annual total flows are similar to those presented in WP3 and, as shown in Table B.4., differ by at most 1% from those presented in WP3.

For general interest, a synthetic rating was also derived for the rated section at Paray using the revised Crump weir data for Paray. A zero lag time was assumed since we did not have the distance between the Crump and rated sections readily to hand. Table B.5 compares the resulting synthetic rating with that currently used at Paray; the differences are small over the whole flow range which is additional confirmation that there appears to be no discernible systematic error in the rating for the rated section at Paray. A revised monthly record for Paray has therefore been generated using the values from WP3 up to Dec 1985 and the revised Crump weir record thereafter. These values are tabulated in Table B.6 and the resulting updated long term averages are shown in Table B.4.

Marakabei - comparison of predicted & observed Crump weir flows 1985-1992

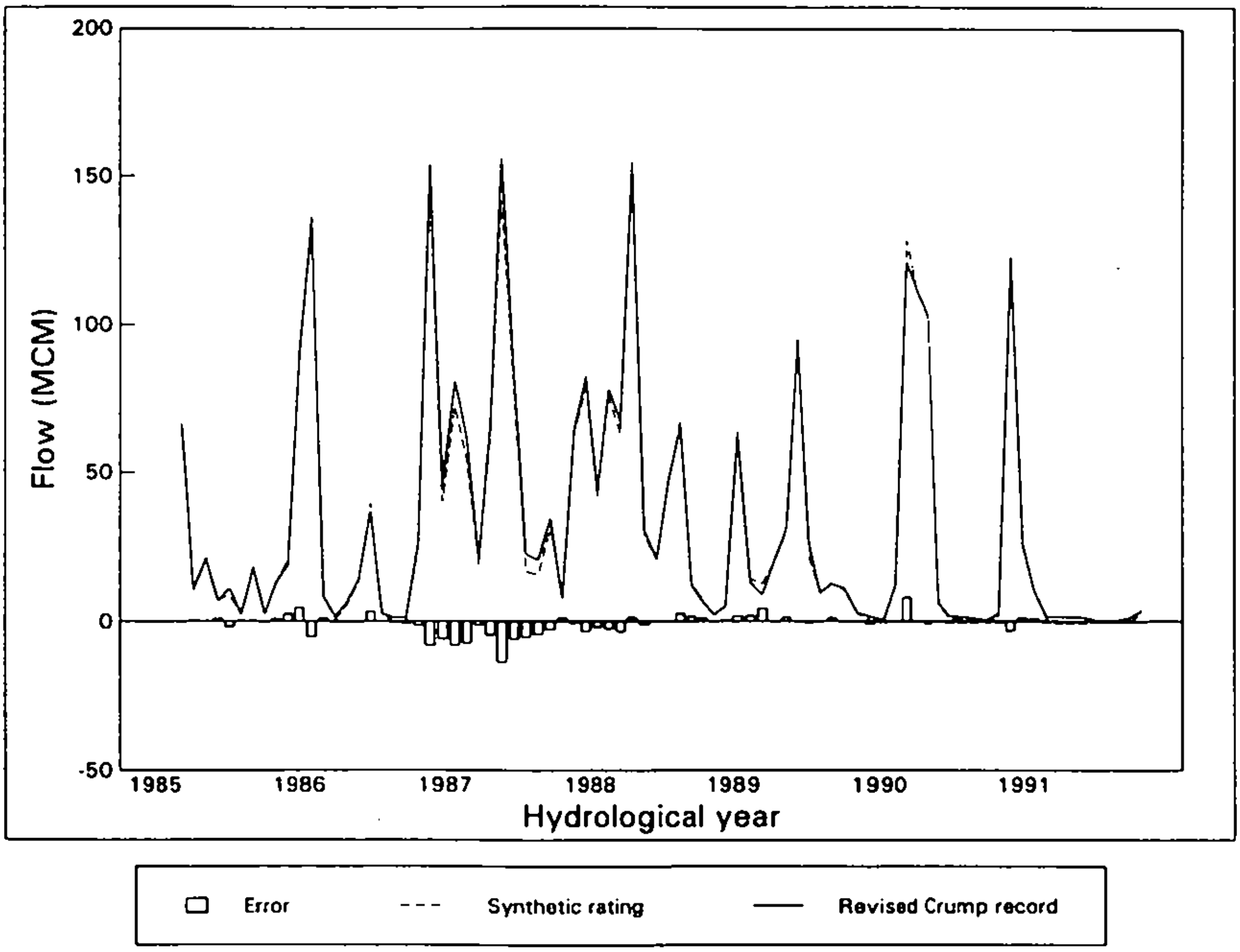


Figure B.5

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Summary of monthly data - Flow

Station number : 17004 Name : Marakabei (revised June 1994)

Basin no. : 0 Latitude : 0: 0: 0 N Longitude : 0: 0: 0 E Altitude : .0
Area : 1.0

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Total
1963/64	-	-	-	-	-	-	24.2	.8	.8	.4	.5	.8	-
1964/65	-	-	-	-	-	-	-	-	10.9	11.7	17.1	20.9	-
1965/66	21.9	42.1	18.1	103.0	133.3	13.6	9.0	8.9	5.0	1.9	1.0	1.3	358.9
1966/67	2.8	18.1	13.9	119.0	-	29.1	84.2	40.6	75.2	27.2	26.0	18.0	-
1967/68	4.5	139.0	28.6	5.7	1.9	9.3	19.9	57.8	9.6	12.2	4.8	3.6	296.8
1968/69	10.2	3.1	36.1	1.8	1.0	18.0	-	-	10.8	3.7	6.5	3.2	-
1969/70	58.9	21.1	8.7	11.7	22.0	2.4	.9	1.1	.8	.9	1.0	11.7	141.1
1970/71	34.4	14.4	60.4	66.0	53.3	26.7	31.0	22.3	1.5	.4	1.1	.4	312.0
1971/72	1.4	3.5	21.8	111.4	60.2	79.6	19.4	40.2	11.9	5.5	2.0	1.4	358.4
1972/73	16.9	32.1	3.0	1.3	72.5	19.7	21.6	4.2	1.9	1.6	57.8	11.1	243.6
1973/74	9.4	12.0	34.7	91.6	111.6	20.0	26.2	9.6	8.0	4.0	16.9	15.1	359.2
1974/75	4.0	124.2	28.1	64.1	97.1	117.2	16.7	9.8	2.6	9.2	1.9	23.1	498.2
1975/76	27.7	143.5	62.7	135.6	140.1	168.6	62.0	35.1	35.9	6.4	2.9	35.3	855.7
1976/77	166.4	84.6	6.2	26.1	73.7	154.5	16.1	9.0	4.1	3.0	2.2	17.4	563.4
1977/78	66.4	27.6	24.6	170.0	17.9	30.5	197.2	9.5	3.8	1.9	2.3	40.2	591.8
1978/79	35.0	13.6	94.0	13.3	22.7	7.2	1.8	8.5	5.0	37.2	99.4	24.7	362.6
1979/80	93.6	34.1	41.0	12.2	21.6	10.2	7.2	2.9	1.4	.9	1.0	12.9	239.1
1980/81	8.5	33.0	41.5	169.1	45.8	71.3	34.6	18.7	32.1	3.6	47.0	33.8	539.0
1981/82	7.2	63.6	52.3	11.5	28.0	11.7	95.9	16.4	4.2	4.0	2.5	2.5	299.8
1982/83	44.6	120.1	14.7	7.1	7.6	6.4	4.4	5.3	3.3	4.0	5.1	2.4	225.0
1983/84	5.1	59.5	27.4	39.3	4.3	9.6	8.9	41.0	3.0	7.6	3.7	13.5	222.7
1984/85	7.1	16.4	10.6	8.8	25.6	43.0	14.3	2.1	.8	.5	.2	.1	129.6
1985/86	2.3	15.1	66.6	10.6	21.6	6.9	11.0	2.5	18.4	2.3	13.1	18.8	189.2
1986/87	87.5	136.5	8.1	1.5	6.5	14.6	37.0	2.7	1.1	1.4	26.8	154.0	477.6
1987/88	46.5	80.9	61.6	20.6	64.1	156.0	85.3	22.7	20.5	34.5	7.5	64.3	664.6
1988/89	82.6	44.0	78.0	67.2	156.2	30.4	21.2	47.2	65.7	12.0	6.7	2.4	613.5
1989/90	5.2	62.6	13.0	8.9	20.9	31.3	95.3	26.0	9.7	12.5	11.3	3.0	299.5
1990/91	1.6	.6	12.2	121.1	112.3	102.9	6.1	1.7	1.5	1.0	.6	2.7	364.1
1991/92	123.0	25.8	10.1	1.6	1.3	1.2	1.2	.3	.4	.3	1.1	3.5	169.8
1992/93	14.1	61.7	4.8	9.4	58.7	28.2	66.6	6.9	2.0	1.3	2.1	-	-
Mean	35.3	51.2	31.5	50.3	50.7	43.6	36.4	16.2	11.7	7.1	12.4	18.7	365.2
Median	14.1	33.0	24.6	13.3	27.8	20.0	19.9	9.0	4.1	3.6	2.9	11.7	
Maximum	166.4	143.5	94.0	170.0	154.8	168.6	197.2	57.8	75.2	37.2	99.4	154.0	
Minimum	1.4	.6	3.0	1.3	1.0	1.2	.9	.3	.4	.3	.2	.1	
St. dev.	42.1	44.8	24.7	55.1	46.3	50.3	43.2	16.5	18.3	9.7	21.4	30.0	
CV	1.19	.88	.78	1.09	.91	1.15	1.19	1.02	1.56	1.36	1.73	1.61	

Total monthly flow in million cubic metres

Data flags

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Printed on 1/ 7/1994

Table B.3 Revised monthly flow record for Marakabei

Marakabei - revised annual flows 1963-1992

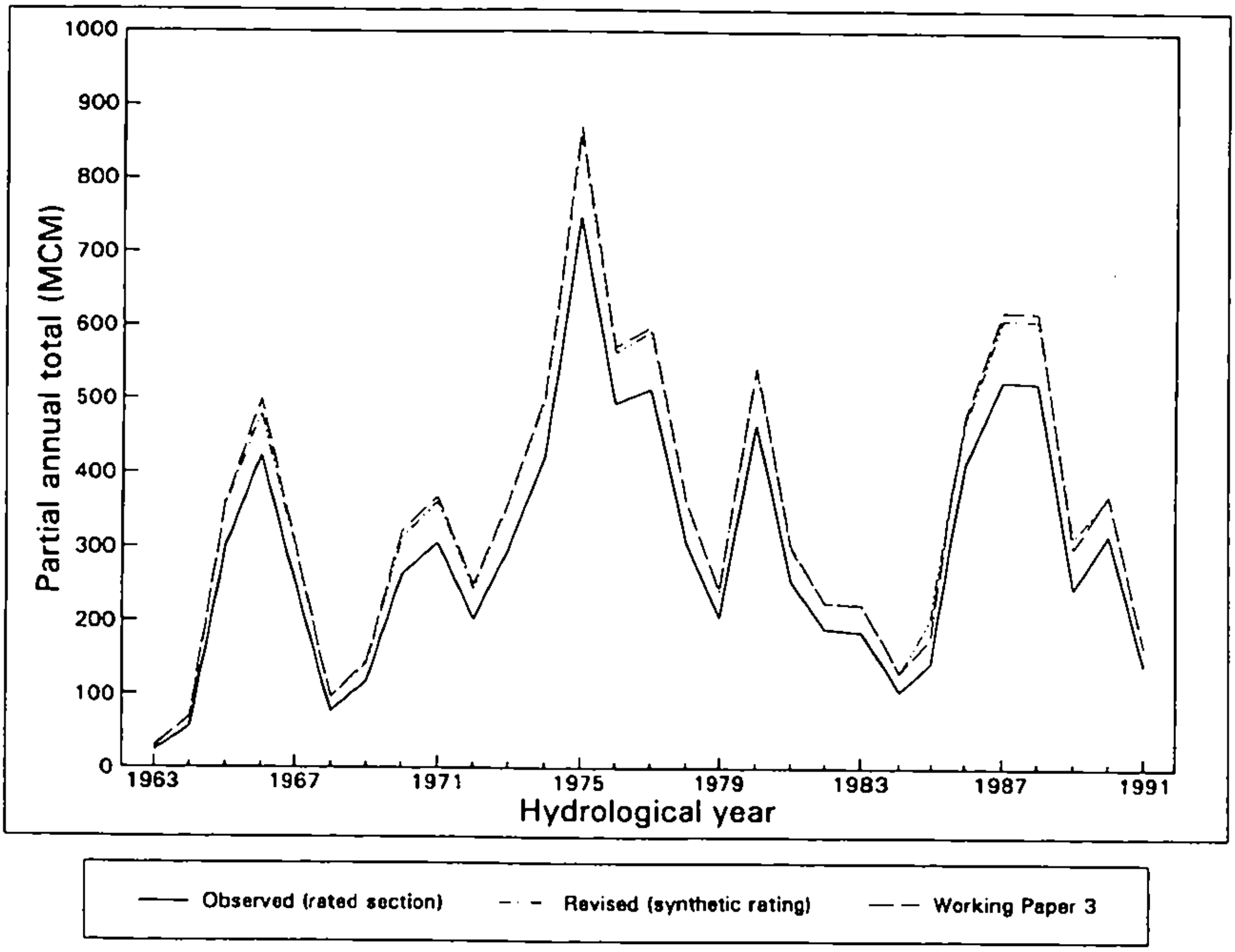

Figure B.6

Institute of Hydrology
Summary of monthly data - Flow

Station number : 8004 Name : Paray (revised June 1994)

Basin no. : 0 Latitude : 0: 0: 0 N Longitude : 0: 0: 0 E Altitude : .0
Area : 1.0

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Total
1965/66	-	-	-	-	-	-	-	-	-	-	-	-	-
1966/67	-	-	-	126.4	-	-	119.5	37.3	66.0	18.4	14.4	26.0	-
1967/68	2.6	127.6	95.8	22.2	7.8	34.7	34.1	114.2	11.6	9.1	4.9	9.8	474.3
1968/69	17.1	15.8	82.1	8.3	7.0	37.3	75.2	39.9	34.8	7.6	6.0	3.7	334.8
1969/70	105.4	41.4	55.1	54.2	63.5	4.9	2.9	2.3	1.2	1.2	1.3	27.3	360.8
1970/71	124.6	57.6	106.8	142.6	76.5	58.9	97.8	26.6	5.1	4.5	2.1	.9	704.0
1971/72	2.3	14.8	33.7	141.4	133.9	213.5	28.2	34.5	9.2	3.2	2.1	2.2	618.9
1972/73	19.6	65.8	5.4	1.0	138.7	46.8	38.4	7.1	3.2	1.8	71.2	47.7	446.6
1973/74	43.9	34.2	85.1	148.4	204.6	31.4	59.6	20.4	24.6	11.1	14.9	16.0	694.3
1974/75	5.0	306.6	-	152.0	-	-	29.4	13.8	4.5	7.3	2.8	78.7	-
1975/76	120.8	-	155.4	-	-	316.5	-	43.3	38.7	11.4	6.3	38.0	-
1976/77	363.5	340.4	18.9	80.4	181.8	275.6	39.2	11.2	4.4	3.4	2.2	9.7	1330.6
1977/78	165.8	57.2	20.5	348.4	71.4	63.6	324.0	24.6	6.4	4.3	4.0	93.7	1183.7
1978/79	84.6	35.5	225.7	44.3	35.6	36.9	5.1	10.6	13.6	41.6	233.3	164.8	931.7
1979/80	174.8	86.4	183.1	48.6	93.0	25.5	6.0	4.3	2.4	1.2	1.0	32.6	658.8
1980/81	34.2	88.7	72.0	337.7	81.9	113.4	84.7	34.3	51.4	5.8	46.6	52.3	1002.9
1981/82	10.3	78.8	149.1	16.1	14.6	19.0	135.8	32.8	6.1	4.3	3.3	4.7	474.9
1982/83	69.5	225.0	19.2	6.5	14.4	24.5	17.9	22.8	10.2	4.0	7.0	4.8	425.8
1983/84	33.8	72.4	-	-	8.0	17.4	18.3	28.3	3.5	2.6	1.3	24.8	-
1984/85	16.5	53.4	25.5	15.6	136.1	71.2	14.4	2.5	1.0	1.2	.2	.2	337.8
1985/86	29.3	126.6	256.6	31.9	80.1	17.7	43.1	10.3	29.7	5.1	14.7	50.3	695.6
1986/87	177.3	354.1	29.7	22.9	23.8	28.1	66.2	6.2	1.9	1.7	60.6	434.8	1207.4
1987/88	309.5	158.2	128.9	88.7	94.0	538.1	81.7	24.7	26.1	28.4	17.5	148.9	1644.7
1988/89	117.3	145.6	198.4	115.0	370.8	90.9	48.1	65.3	143.3	48.7	14.0	6.3	1363.7
1989/90	20.2	193.8	75.5	22.8	67.3	66.1	171.1	68.1	13.5	22.8	40.8	14.5	776.4
1990/91	13.4	7.1	21.8	123.1	215.3	121.4	17.7	3.0	2.1	1.7	.7	4.2	531.6
1991/92	186.1	74.8	37.0	14.5	4.0	7.3	3.4	1.3	.5	.4	1.2	14.1	344.6
1992/93	21.6	168.8	26.8	19.1	76.9	55.8	99.9	14.1	4.0	2.2	4.4	1.4	495.0
Mean	87.3	117.2	87.8	85.3	90.9	92.7	63.9	26.1	19.2	9.4	21.4	48.6	749.8
Median	34.2	78.8	72.0	48.6	75.9	46.8	39.2	22.8	6.4	4.3	4.9	16.0	
Maximum	363.5	354.1	256.6	348.4	367.5	538.1	324.0	114.2	143.3	48.7	233.3	434.8	
Minimum	2.3	7.1	5.4	1.0	3.9	4.9	2.9	1.3	.5	.4	.2	.2	
St. dev.	95.5	99.5	72.9	93.3	85.5	122.9	69.0	25.1	30.0	12.4	46.4	88.3	
CV	1.09	.85	.83	1.09	.94	1.33	1.08	.96	1.56	1.31	2.16	1.82	

Total monthly flow in million cubic metres

Data flags

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Printed on 1/ 7/1994

Table B.6 Revised monthly flow record for Paray

Table B.4 *Comparison of revised annual total flows for Marakabei and Paray*

	Table 5.1b WP3	Revised
Marakabei		
1967-1985	350	345
1964-1983	382	377
1963-1992	371	365
Paray		
1967-1985	684	683
1966-1982	731	731
1966-1992	762	750

Table B.5 *Comparison of Synthetic and Interim Hydrology ratings for Paray*

	a	b	c	h_{max}
Synthetic	24.800	2.463	0.115	10.000
Interim Hydrology	30.508	2.275	0.050	10.000

B.2 LHDA COMMENTS ON WP3 (UNTITLED REPORT PRESENTED TO IH ON 28/3/94)

LHDA's comments on Working Paper 3 are grouped by gauging station. Each sub-section comments on the discharge measurements shown in WP3, the revised rating equations and the resulting estimates of mean annual runoff. The following responses to these comments reflect this format.

Senqu River at Seaka Bridge, G3

Comment: *The IH(1993) database has the following measurements that are not available in the LHDA database. Their respective original measurement notes cannot be found in DWA/Natural Resources thus 326, 327, 328, 329, 330, 331, 333 and 345 from IH(1993) database.*

Reply: These measurements were not written on the WEMMIN discharge measurement summary sheet, but original field notes were located at WEMMIN's offices during the project team visit between 15/06/93 and 10/08/93. We have copies of these field notes.

Comment: *Measurement number 207 has the IH(1993) adjusted value more conservative than the LMC 1986 correction.*

Reply: The adjusted value of 1072.2 cumecs given in WP3 is incorrect. The value should be 1102.076 (i.e. less conservative than the LMC corrected value of 1078.12). This new value has been taken into consideration when re-determining the rating equations for this station (see Section B.3).

Comment: *Rating equation J is valid from 23/02/73 to 09/02/74 for stage greater than 2.30 m.*

Reply: Rating equation J is valid from 23/02/73 (not 23/03/72) as written in Appendix A) for all stage measurements.

Comment: *Rating equation 36.629(h+0.363)^2.269 in the appendix A of WP3 should be verified against the rating equation 36.630(h+0.363)^2.208 in the IH(1993) database.*

Reply: This is the upper part of rating J. In the text of Appendix A this equation has been typed incorrectly. As noted by LHDA it should be as it is written in Table A.3 of the Appendix and as it is entered on the IH(1993) database i.e. 36.630(h+0.363)^2.208.

Comment: *IH(1993) rating increases mean annual runoff between 1972 and 1992 by +5%.*

Reply: Noted - see discussion in Section B.3.

<u>Senqu River at Whitehill, G04</u>

Comment: *Measurements numbers 150 and 151 dated 27/02/87 are to be corrected in the LHDA database and IH(1993) database prior to adjustment according to the original summary sheets.*

Reply: Noted. Measurements changed in our version of the IH(1993) database. Rating equations recalculated after they had been changed.

Comment: *Measurements that have the IH(1993) adjusted values significantly different from the original values by more than 2.0 m^3/s: 162 (diff = 15.91 m^3/s) and 163 (diff = 15.21 m^3/s).*

Reply: The original discharge measurements were those on the LHDA database. No corrections had been applied during either the LMC(1986) study or the Interim Hydrology study. The IH(1993) adjusted values have been checked and are confirmed as being correct as written in Appendix A of WP3.

Comment: *The measurement dated 6/02/92 has been omitted in the IH(1993) and LHDA databases.*

Reply: Now added to our version of the IH(1993) database. This measurement has insignificant impact on the calculated rating.

Comment: *The rating equations are okay, the IH(1993) rating is consistently high at stage greater than 4.5 m*

Reply: Noted. To be explored when the revised Crump weir data for Whitehill has been received.

Comment: *IH(1993) rating increases mean annual runoff between 1964 and 1992 by +28%.*

Reply: This increase is primarily caused by applying the Crump weir correction discussed in WP3 which will soon be revised. However, a small part of the increase arises because two new discharge measurements were made at high flows (Q > 1175 m^3s^{-1}) after the Interim Hydrology study (on 24/09/87) and enable the upper part of this rating curve to be fitted with more confidence than previously. The IH(1993) rating is consistently higher at stages greater than 2.0 m (see Fig. A.7 in Appendix A).

Comment: *This station should be used as a key station for all the hydrological studies of the LHWP. The available Crump weir data can improve the reliability of the historical data at this site.*

Reply: This point will be explored once the revised Crump weir data for Whitehill has been received.

<u>Senqu River at Koma Koma, G05</u>

Comment: *Measurement 185 has the IH(1993) adjusted value more conservative than the LMC(1986) adjusted value.*

Reply: Measurement 185 was corrected by the velocity area method (discussed in reply to the next comment) and the value thus obtained was 1028.0, which as noted is more conservative than the LMC(1986) adjusted value of 1183.3.

Comment: *The adjustment of measurements by the velocity area method gives very conservative results when compared with the IH(1993) methodology. The adoption of this methodology to only three stations, Paray G08, Koma-Koma (G05), and Marakabei (G17) is not acceptable or it is questionable. Further application of this methodology without a well defined channel cross-section normally leads to less accurate results especially when applied to peak flows (instantaneous) flows that contribute significantly to the MAR (Mean Annual Runoff).*

Reply: As discussed in WP3, there are often considerable difficulties in obtaining reliable discharge measurements at high flows. Considerable error can occur in these measurements and it is sometimes difficult to treat them with a high degree of confidence. In the IH(1993) study, all discharge measurements were initially corrected only using the IH(1993) drag correction, which is explained in detail in WP3. However, at three stations (Koma-Koma, Paray and Marakabei), high flow measurements used to fix the upper part of the rating caused the ratings to look very unrealistic (exponents greater than or equal to 4). For this reason and after careful consideration of subcatchment water balances, high discharge measurements at these three stations were estimated using the velocity-area method instead.

Comment: *The correction of the rating curves by IH(1993) were noted. IH(1993) rating consistently higher than LHDA (1987) for stage greater than 6.0 m.*

Reply: The IH(1993) correction is different to that of LMC(1986) as discussed in WP3. This is why the IH(1993) rating equation differed from the LHDA(1987) ratings.

Comment: *The rating equation Q = 2.536(h+0.220)^3.642 should be Q = 2.535(h+0.220)^3.642 in Appendix A.*

Reply: This is the LHDA rating T. The difference is a typing error in Appendix A; the correct value was used in generating the flows.

Comment: *IH(1993) rating and data decreases the mean annual runoff between 1972 and 1992 by 4%.*

Reply: Noted - see also the comments in Section B.3 of this report.

Comment: *The reduction in the monthly total of March 1975/76 from 1171.0 (LHDA, 1987) to 642.9 IH(1993) which is an 82% reduction on the basis of the IH(1993) Appendix C is not acceptable because there is digitized stage data for the whole month including the three days 20, 21 and 22nd March 1976. There were floods all over the country for the period. This was an extremely wet year.*

Reply: Agreed. These values were deleted because they seemed unusually high and were a long way above the highest discharge measurement ever made at this station. However, we are happy to include data for this period if LHDA are confident in the chart digitisations (see also Appendix B.3). As a comparison, the peak daily mean flow recorded at Paray during this event was about 900 cumecs and the peak daily mean flow at Oranjedraai was about 5400 cumecs.

Senqu River at Mokhotlong, G06

Comment: *Flow measurements that are missing from the IH(1993) database yet they are available in the LHDA database (19/05/87, 25/06/88, 02/08/91, 08/08/91 and 04/09/91).*

Reply: These are all very low flow measurements with measured velocities below the calibrated minimum of the current meter. They were removed inadvertently from the IH(1993) database, but have now been replaced. The effect of omitting these measurements was negligible in terms of the rating equation for Mokhotlong.

Tsoelike River at Tsoelike Bridge, G07

Comment: *The flow of the original measurement No. 95 should be adjusted to 3.786 m^3s^{-1} in the LHDA database (measurement 94 in the IH(1993) database).*

Reply: Noted. LHDA action required.

Comment: *No problems with the IH(1993) change of rating dates. The IH(1993) rating is consistently high for stage greater than 2.5 m.*

Reply: Noted. No action required.

Comment: *IH(1993) ratings and data decreases the mean annual runoff between 1965 and 1992 by 6%, when compared to the LHDA ratings.*

Reply: Noted. We believe the revised rating provides an improved estimate of the mean annual runoff

Malibamatso River at Paray, G08

Comment: *The adjustment of the measurement made on 25/01/81 by the velocity-area method gives very conservative results when compared with IH(1993) methodology. The adoption of this methodology to only three stations, Paray (G08), Koma-Koma (G05), and Marakabei (G17) is not acceptable or it is questionable. Further application of this methodology without a well defined channel cross-section normally leads to less accurate results especially when applied to peak flows (instantaneous) flows that contribute significantly to the MAR.*

Reply: See reply to the same comment made for Koma-Koma, G05.

Comment: *The IH(1993) rating is considerably higher for stages greater than 4.0 m than the LHDA rating.*

Reply: In fact, when considering the whole flow range, the IH(1993) ratings and data decreases the mean annual runoff between 1966 and 1992 by 2%, when compared to the LHDA ratings and data. Since the IH(1993) rating is higher at all stages, this reduction is a consequence of the IH cleaning up of the raw data.

Senqunyane River at Marakabei, G17

Comment: *The adjustment of the measurement made on 29/01/77 results in the corrected value being more conservative than the LMC 1986 correction. Further, the adjustment of measurements by the velocity-area method gives very conservative results when compared with other methodologies. Its application to ill-defined channel cross-section normally leads to less accurate results especially when applied to peak flows that contribute significantly to the Mean Annual Runoff.*

Reply: See comments made to this point previously.

Comment: *The IH(1993) equation is consistently high for stage greater than 3.0 m.*

Reply: Noted. Revised rating recommended.

Comment: *The IH(1993) rating to be corrected in Appendix A and Table A.3.*

Reply: This was a typing error. The upper part of the rating, written as $Q = 43.410(h+0.280)^{2.870}$ in Appendix A and Table A.3 should be $Q = 43.410(h-0.280)^{2.870}$.

Comment: *The LHDA(1987) rating to be corrected in appendix A.*

Reply: This is another typing error. The middle part of the LHDA(1987) rating written as $Q = 17.969(h-0.030)^{\mathbf{2.120}}$ in Appendix A, should be written as $Q = 17.969(h-0.030)^{\mathbf{4.000}}$.

Comment: *IH(1993) ratings and data increases the mean annual runoff between 1963 and 1992 by 18%, when compared to the LHDA ratings.*

Reply: This is mainly due to the correction applied to account for the recent Crump weir data for Marakabei (see Section B.1 of this report).

<u>Senqunyane River at Nkaus, G32</u>

Comment: *Has the IH(1993) drag correction been applied to the original observed measurements as reflected in the LMC(1986) feasibility study or to the LMC(1986) adjusted values as reflected in the LHDA database ?*

Reply: The IH(1993) drag correction has been applied to the original observed measurements not the LMC(1986) adjusted measurements. This is why the IH(1993) corrected flows are greater than the LMC(1986) corrected flows.

Comment: *The IH rating is consistently high for stage greater than 4.0 m.*

Reply: This is because the IH(1993) drag correction is smaller than that previously applied by LMC(1986).

Comment: *IH(1993) ratings and data increases the mean annual runoff between 1967 and 1979 by 1.7%, when compared to the LHDA ratings.*

Reply: Noted. The revised ratings are believed to provide an improved estimate of mean annual runoff.

<u>Khubelu River at Tlokoeng, G36</u>

Comment: *Clarification required: Omission of 4 measurements dated 3rd December 1971 (i.e. numbers 37, 38, 39 and 40 in the LHDA database) because they were determined on the steep recession of the hydrograph require explanation. It is worth noting that these flow measurements are very high measurements compared to the other recorded measurements for the station.*

Reply: When all the discharge measurements are plotted on a linear scale three of those made on 3/12/71 appear as outliers (see Figure B.7). From the order in which they appear in the LHDA database it would seem that stage decreased from 1.69 m to 1.05 m and velocity from 1.258 ms^{-1} to 0.894 ms^{-1} between the first and last measurement made on this date (unfortunately the original field sheets could not be located at WEMMIN). This suggests that

Khubelu River at Tlokoeng: discharge measurements omitted

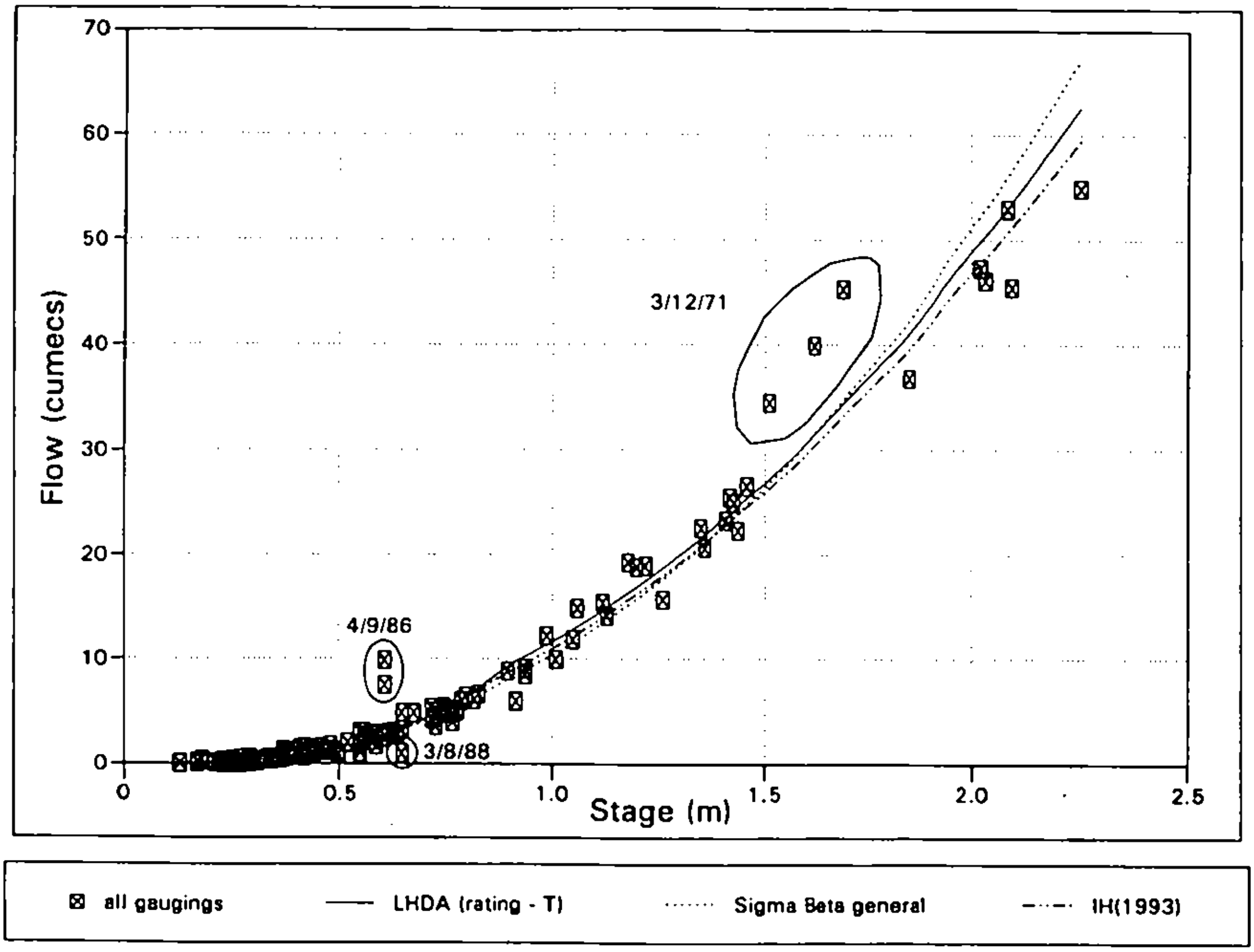

Figure B.7

the measurements were made during a period of steep recession when discharge was changing rapidly. Under such circumstances accurate flow gauging is extremely difficult and since these measurements appear to be outliers it was decided to omit them from the analysis.

Comment: *Measurement of 19th May 1993 is to be corrected in the LHDA database according to the original one. Refer to the IH(1993) report.*

Reply: Noted. Action by LHDA required.

Comment: *The IH(1993) rating is lower than the Interim Hydrology rating (1987) for stage greater than 3.0 m.*

Reply: This is only a very small difference between the two ratings, probably caused by the omission of the measurements discussed above.

Comment: *IH(1993) ratings and data decreases the mean annual runoff between 1969 and 1988 by 2.7%, when compared to the LHDA ratings.*

Reply: Noted. The revised ratings are believed to provide an improved estimate of mean annual runoff.

<u>Bokong River at Bokong, G41</u>

Comment: *The IH adjusted measurement made on 15/04/87 is different from the original measurement by a value greater than 2.0 m^3s^{-1}. The difference is 3.23 m^3s^{-1}.*

Reply: The IH adjustment or drag correction for this measurement has been checked and is confirmed as being correct.

Comment: *The Interim Hydrology rating R has been revised for high flows and the IH(1993) rating gives conservative results.*

Reply: The LHDA rating R was based solely on low flow discharge measurements and considerably over-estimates flow.

Comment: *IH(1993) ratings and data decreases the mean annual runoff between 1971 and 1992 by 6%, when compared to the LHDA ratings.*

Reply: Noted. The revised rating is believed to provide an improved estimate of mean annual runoff.

<u>Matsoku River at Ha Seshote, G42</u>

Comment: *The IH(1993) equation is consistently higher for medium to high flows.*
Reply: The IH(1993) rating is a two-part rating that we feel gives a slightly better fit than the LHDA single part rating across the range of discharge measurements.

Comment: *The IH(1993) ratings and data leave the mean annual runoff between 1970 and 1992 exactly the same, when compared to the LHDA ratings.*

Reply: Noted. No action required.

Malibamatso River at Ha Lejone, G4

Comment: *For the 7 measurements dated 15/04/87, two measurements at stage of 2.85 m were observed, the measurement of 251.16 m^3s^{-1} was selected.*

Reply: The measurement selected was that on the WEMMIN discharge measurement summary sheet.

Comment: *For the 7 measurements dated 15/04/87, two measurements at stage of 3.10 m were observed, the measurement of 292.17 m^3s^{-1} was selected.*

Reply: The measurement selected was that on the WEMMIN discharge measurement summary sheet.

Comment: *The adjusted discharge measurements 135, 139 and 141 (all made on 15/04/87) are different from the original measurements by more than 2.0 m^3s^{-1}.*

Reply: The original field sheets obtained from WEMMIN for all the measurements made on 15/04/87 have been checked. From these it is clear that in some cases the measurements had a drag correction applied before they were entered onto the WEMMIN discharge summary sheet. The IH drag correction was applied inadvertently to all the measurements and so in some cases a correction was applied twice. This occurred in the case of measurements 138, 139, 140 and 141. The correct values for these discharge measurements (i.e. when the IH correction is applied to uncorrected flows) are:

138:	250.4 m^3s^{-1},	139:	299.4 m^3s^{-1},
140:	222.5 m^3s^{-1},	141:	289.6 m^3s^{-1}

The IH drag correction was applied correctly to measurements 135, 136 and 137. These revisions are sufficiently small that we do not feel that there is any need to revise the ratings recommended in WP3.

Comment: *On table 3.3 the date of the second measurement (i.e. 101.7 m^3s^{-1}) should be corrected to 13/01/76.*

Reply: This is a typing error and is noted.

Comment: *The LHDA(1987) rating has been revised for medium to high flows due to the availability of flow measurements. The IH(1993) rating gives reasonable results for high flows. The IH(1993) ratings and data decrease the mean annual runoff between 1972 and 1992 by 7.6% when compared to the LHDA ratings.*

Reply: Noted. The revised ratings are believed to give an improved estimate of the mean annual runoff.

General

There are a few other minor typing errors in Appendix A of WP3 that were not noted by LHDA. These errors and their corrections are listed below:

Seaka (03):

'Period until 22/02/72' should be 'Period until 22/02/73'

Koma Koma (05):

Period until 22/03/76 - the third part of the rating:

$Q = 1.230(h-0.553)^{3.962}$ should be $Q = 1.230(h+0.553)^{3.962}$

Period from 23/03/76 - the second part of the rating:

$Q = 28.061(h+0.100)^{1.784}$ should be $Q = 28.061(h-0.270)^{1.784}$

Tsoelike (07):

In Table A.3 of WP3: 17.04.75 should be 17.04.76

Nkaus (32):

Period from 10/02/73 until 18/03/75 - the first part of the rating:

$Q = 15.490(h+0.092)^{1.940}$ should be $15.940(h+0.092)^{1.940}$

Note: the multiplier also needs changing in table A.3.

Bokong (41):

Period from 26/02/72 until 21/03/76 - the first part of the rating:

$Q = 68.710(h-0.284)^{1.560}$ should be $Q = 68.710(h-0.284)^{2.458}$

Period from 22/03/76 until 19/06/78 - the first part of the rating:

$Q = 58.200(h-0.202)^{1.140}$ should be $Q = 58.200(h-0.202)^{2.770}$

Period from 20/06/78 - the first part of the rating:

$Q = 66.490(h-0.255)^{1.100}$ should be $Q = 66.490(h-0.255)^{2.550}$

B.3 BKS/DWAF COMMENTS ON WP3 (REPORT TITLED "COMMENTS ON THE LHDA REPORT TITLED STUDIES OF HYDROLOGY OF THE LESOTHO HIGHLANDS WATER PROJECT ROYALTIES ASSESSMENT WORKING PAPER 3 - FLOW ANALYSES", BKS INC REPORT NO. P4564/02/10, JAN 1994)

BKS/DWAF prepared an extensive report commenting on the issues discussed in Working Paper 3. The comments mainly concerned aspects of the methodology used, rather than specific data values. The main questions raised in the Conclusions and Executive Summary concerned:

(a) The drag corrections applied to the raw discharge measurements
(b) The correction to be applied to the historic Marakabei data
(c) The water balance between Seaka and Oranjedraai
(d) Miscellaneous plants (e.g. the record for Koma Koma)

The main recommendations concerning the Marakabei data were that the LHDA and RSA records should be merged into a single record and that a decision should be taken about whether the Crump weir flows should be regarded as 'correct' or whether a weighted average of Crump and rated section flows should be used instead. These issues were resolved at the meeting in Maseru on 30/3/94 and the revised Marakabei record is discussed in Section B.1 of this report. The remaining issues are discussed in detail below:

<u>Drag corrections (Section 3.3 of BKS/DWAF report)</u>

When making discharge measurements, a drag correction is required to allow for the curvature of the cable caused by the current meter being swept downstream, resulting in an over-estimate of the true depth and hence of the true flow. In WP3, we presented a revised drag correction method based on recent actual measurements of cable deflection angle. The resulting corrections were generally much smaller than the theoretical correction factors derived by LMC at the time of the Stage 2B studies. We believe that the new corrections are more realistic since they are based on field data rather than theoretical estimates. In future, the need for a drag correction could be avoided altogether by a change in measurement procedures; for example by using heavier sinker weights in fast flowing water or by the more difficult method of 'casting' the current meter upstream of the suspension point so that it drifts back to touch the river bed immediately beneath the suspension point.

To answer some of the points made by BKS/DWAF, it is perhaps helpful to explain why it was necessary to develop a new correction method. On arriving in Maseru at the start of the project, we quickly realised that a large number of discharge measurements had been made since the time of the Interim Hydrology. It was therefore important to include these in our review of the rating equations for the project area stations. However, both of the main data collection agencies (LHDA and WEMMIN) were of the opinion that the Stage 2B drag corrections were larger than necessary, and were no longer applying these corrections to new discharge measurements. LHDA had reached this view after requesting Dr Reg Herschy to review the Stage 2B correction method, whilst WEMMIN had, with the assistance of a UN consultant, developed a new correction method based on direct measurements of the cable deflection angle. In his visit report, Herschy outlined a new method for making the wet-line correction, although at that time he did not have access to the measurements of cable deflection made by WEMMIN. We simply took his suggested method one step further by developing an empirical relationship between deflection angle and the mean stream velocity.

The resulting correction function gave similar results to that developed by WEMMIN. However, in view of the comments made by BKS/DWAF, we have again reviewed the various assumptions made in deriving these revised corrections. Perhaps one of the main reasons that the corrections are smaller than the Stage 2B values is that they do not include an 'air-line' component. This is because it is generally agreed that WEMMIN have always zeroed the depth meter after the current meter has been immersed at the water surface. This was noted by LMC themselves in their original report and is confirmed again in WEMMIN's comments on our WP3 (i.e. "Natural Resources DWA have always zeroed the depth meter when the water is at the horizontal axis of the current meter-sinker assemblage.."). In fact, the assumption of an identically zero air-line correction is not strictly correct because the deflection angle may change as the current meter assemblage is lowered from the surface to the river bed. This leads to a small additional error as indicated in Figure B.8, which can be either positive or negative, depending on the relative magnitudes of the drag forces on the immersed sinker and immersed cable. A rough estimate for this term can be obtained by taking moments about the suspension point, and ignoring the curvature of the cable. These calculations suggest that, for the Lesotho highlands, this correction is unlikely to be more than a few percent in the worst case of deep, fast flowing water, when the drag on the immersed cable is likely to be a maximum. However, to derive these estimates, many assumptions must be made about the magnitude of the drag force, the shape of the cable, the precise measuring technique and the velocity profile in the river. Also, WEMMIN evidently did not feel this error term was a significant factor when developing their correction method using direct field observations of the deflection angle. For the future, better estimates of this term could be obtained by measuring the true length of the submerged cable with the aid of markers attached to the cable at, say, 10 cm intervals.

A second assumption in the IH method is that the mean deflection angle gives a reasonable measure of the total correction; in fact, this is confirmed by comparisons with the WEMMIN field data, in which WEMMINS's estimated corrections are based on an integration of the correction factor for each flow panel across the stream width, and give similar results to a function based on the mean deflection angle. This is shown by Figure B.9, which compares the WEMMIN correction, the revised (WP3) correction and the original Stage 2B correction for those discharge measurements for which WEMMIN have made direct measurements of the cable deflection angle (see Table 3.2 of WP3). The only differences between the WEMMIN and WP3 corrections are for flows greater than about 1500 cumecs, and are only of the order 1-2%.

In their comments, BKS/DWAF also make several useful observations about the corrections applied to specific measurements. One such measurement is that made on 25/1/81 at Koma Koma; the problem here is that this measurement was made using a 100 kg sinker weight, whilst the revised correction was only developed from data collected using the 25 kg and 50 kg sinker weights. The revised correction therefore seems inconsistent when compared with the Stage 2B correction. However, given that the correction is only 2% when assuming a 50 kg sinker weight, there would only be a small effect on the rating for Koma Koma if the correction was modified to allow for the heavier sinker weight. Also, an inspection of the Stage 2B and subsequent data shows that the 100 kg weight has apparently only ever been used on three occasions in the Lesotho highlands - all at the Koma Koma site. Another point made by BKS/DWAF is that, in WP3, five of the measurements were estimated using the area-velocity method rather than by applying the revised correction, and that the resulting values seem very close to those obtained using the LMC drag correction. These five measurements are discussed in more detail in Section B.2; however, our belief is that the measurements themselves are in error since they do not fit in with the pattern indicated by

Sketch showing the small additional air-line correction to account for drag as the cable is submerged

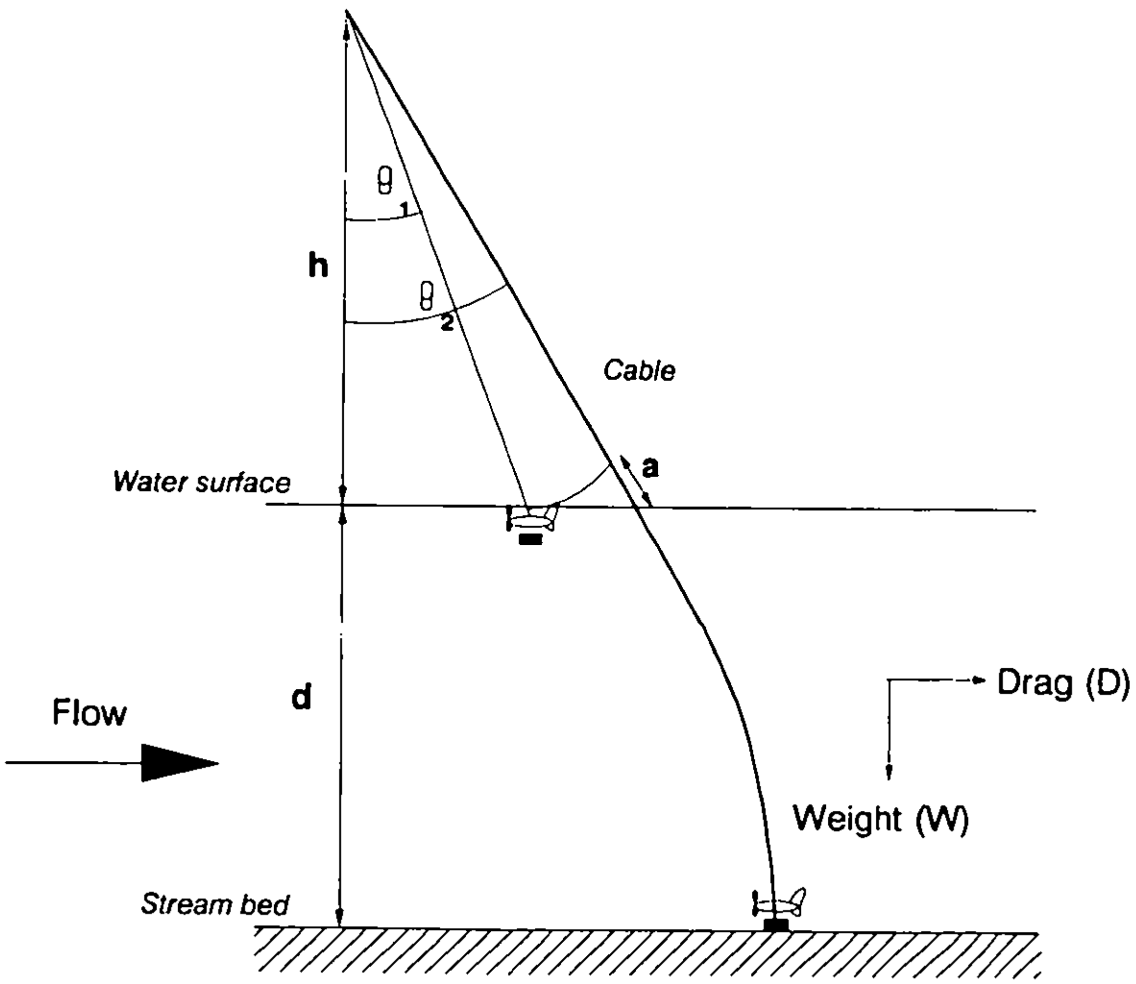

Figure B.8

Comparison of drag correction methods
(when cable deflection angle was known)

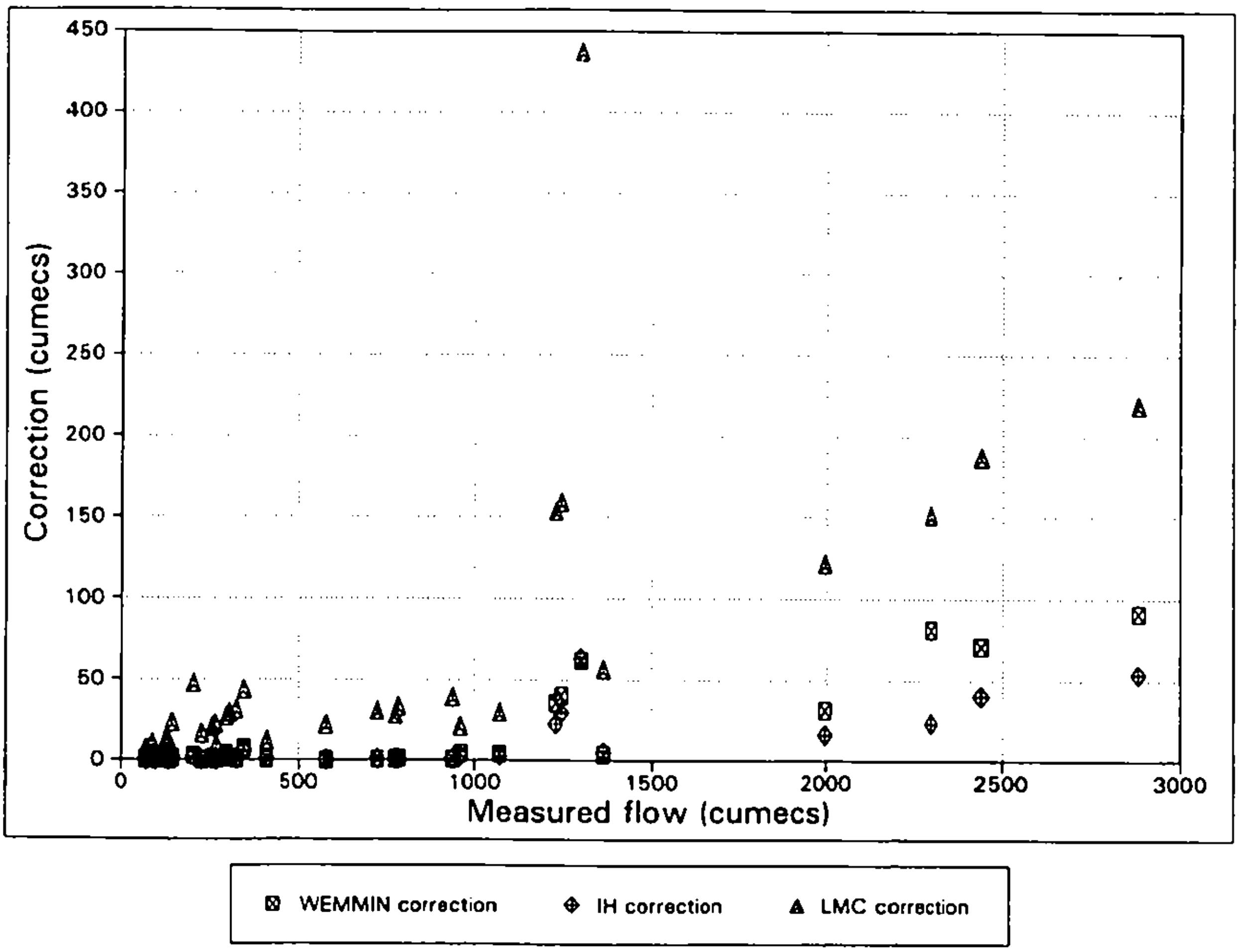

Figure B.9

the other measurements at these sites. Another suggestion made by BKS/DWAF in their report was that LMC's original calculation files should be consulted for further information. In fact, we obtained the bulk of these informally whilst we were preparing Working Paper 3. The notes consist mainly of earlier drafts and worked examples similar to the final text presented in the LMC (1985) report and do not contain any significant additional data or information. They do however confirm that the full air-line correction was included in the calculations and that, apparently, the shape of the submerged cable was approximated as a parabola.

Overall, we believe that the revised drag corrections provide a reasonable estimate of the true correction and may in any case be small in comparison to some of the other errors inherent in making discharge measurements by current meter. Also, even if the drag correction was in error at the highest flows, the impact on annual total flows at a given station is likely to be small, since the highest flows only make a small contribution to annual runoff. The rating at Seaka provides a good example of this point (see next section).

<u>Seaka-Oranjedraai water balance (Section 3.5 of BKS/DWAF report)</u>

One of the conclusions from WP3 was that there were some problems with the water balance in the reach between Seaka and Oranjedraai, with a suspiciously low mean annual runoff and consistently small or negative incremental flows since 1987. BKS/DWAF make the points that (a) the revised drag corrections have raised flows at Seaka, (b) the water balance to Whitehill is suspect and (c) that additional RSA flow data (Hendrik Verwoerd, Kraai, Caledon) may help in resolving this issue. We plan to re-work the overall water balance once the revised flow records for Whitehill have been received; in the meantime, we present some observations on the discharge tables for Seaka and Oranjedraai.

The first point is that LHDA have noted that the IH(1993) drag correction was applied incorrectly to discharge measurement 207 at Seaka (see Section B.2). This has been rectified and the rating equations recalculated. The new ratings, which are given in Table B.7 are virtually indistinguishable from those previously determined, and the revised annual total flows are within 1% of the values presented in WP3.

We now consider the issue of the effect of the revised drag corrections. In order to determine the sensitivity of the fitted ratings to the correction applied, and consequently the impact on the calculated flows, rating equations were fitted to discharge measurements to which the following drag corrections had been applied:

i) No correction applied
ii) LMC(1986) correction applied
iii) H(1993) correction applied

For this comparison exercise, all the ratings were fitted to discharge measurements made after 14/10/77, which was the last time there was definitely a shift in the rating curve, and were all two-part ratings with the switch-point at 1.52 m. The resulting rating equations were:

i) $Q = 73.53(h - 0.056)^{1.649}$ hmax = 1.52 m
$Q = 52.69(h + 0.036)^{2.080}$ hmax = 10.00 m

ii) $Q = 73.01(h - 0.057)^{1.640}$ hmax = 1.52 m
$Q = 56.53(h - 0.005)^{2.024}$ hmax = 10.00 m

iii) $Q = 73.52(h - 0.056)^{1.649}$ $hmax = 1.52$ m
$Q = 55.58(h + 0.005)^{2.049}$ $hmax = 10.00$ m

Table B.7 Revised rating equations for Seaka

Period until 22/02/73:

$Q = 67.90(h + 0.020)^{1.737}$ $hmax = 1.90$ m

$Q = 55.58(h + 0.005)^{2.049}$ $hmax = 10.00$ m

Period from 23/02/73 until 09/02/74:

$Q = 64.03(h - 0.077)^{1.959}$ $hmax = 2.30$ m

$Q = 55.58(h + 0.005)^{2.049}$ $hmax = 10.00$ m

Period from 10/02/74 until 06/02/77:

$Q = 49.22(h + 0.127)^{2.102}$ $hmax = 2.50$ m

$Q = 55.58(h + 0.005)^{2.049}$ $hmax = 10.00$ m

Period from 07/02/77 until 13/10/77.

$Q = 87.82(h + 0.010)^{1.434}$ $hmax = 2.10$ m

$Q = 55.58(h + 0.005)^{2.049}$ $hmax = 10.00$ m

Period from 14/10/77 until 15/03/88:

$Q = 73.52(h - 0.056)^{1.649}$ $hmax = 1.52$ m

$Q = 55.58(h + 0.005)^{2.049}$ $hmax = 10.00$ m

Period from 15/03/88:

$Q = 35.87(h + 0.097)^{2.577}$ $hmax = 1.80$ m

$Q = 55.58(h + 0.005)^{2.049}$ $hmax = 10.00$ m

Figure B.10 shows a comparison of these three rating curves as both a linear and a log-log plot. Also shown is the Interim Hydrology rating (Rating T):

iv) $Q = 5.208(h + 0.080)^{2.018}$

which was applied from 25/10/77 in the original work. However, in this case, it was applied from 14/10/77 in order to compare it directly with the other rating equations. Figure B.10(a) shows that for stages greater than 4.0 m the IH(1993) rating is slightly greater than both the LMC(1986) rating and rating-T whilst, for stages greater than 5.0 m, rating-T is lower than even the rating determined by applying the LMC(1986) correction to all the data presently available (i.e. last discharge measurement in June 1992). However, for stages less than 0.3 m, rating T is slightly higher than the other fitted ratings so it is clear that the two-part ratings produce a better fit to the low flow discharge measurements. Between stages of 0.3 m and 4.0 m all the ratings are very similar. In order to compare the rating equations in a quantitative way and to ascertain the impact on long-term mean annual flows, a cumulative total (MCM) was calculated for the period 10/77 to 09/92 using each of the rating equations. To determine the total, the raw LHDA stage data were used. The table below gives the cumulative totals derived from the different rating equations and the percentage changes

Senqu at Seaka: comparison of discharge measurements and rating equations

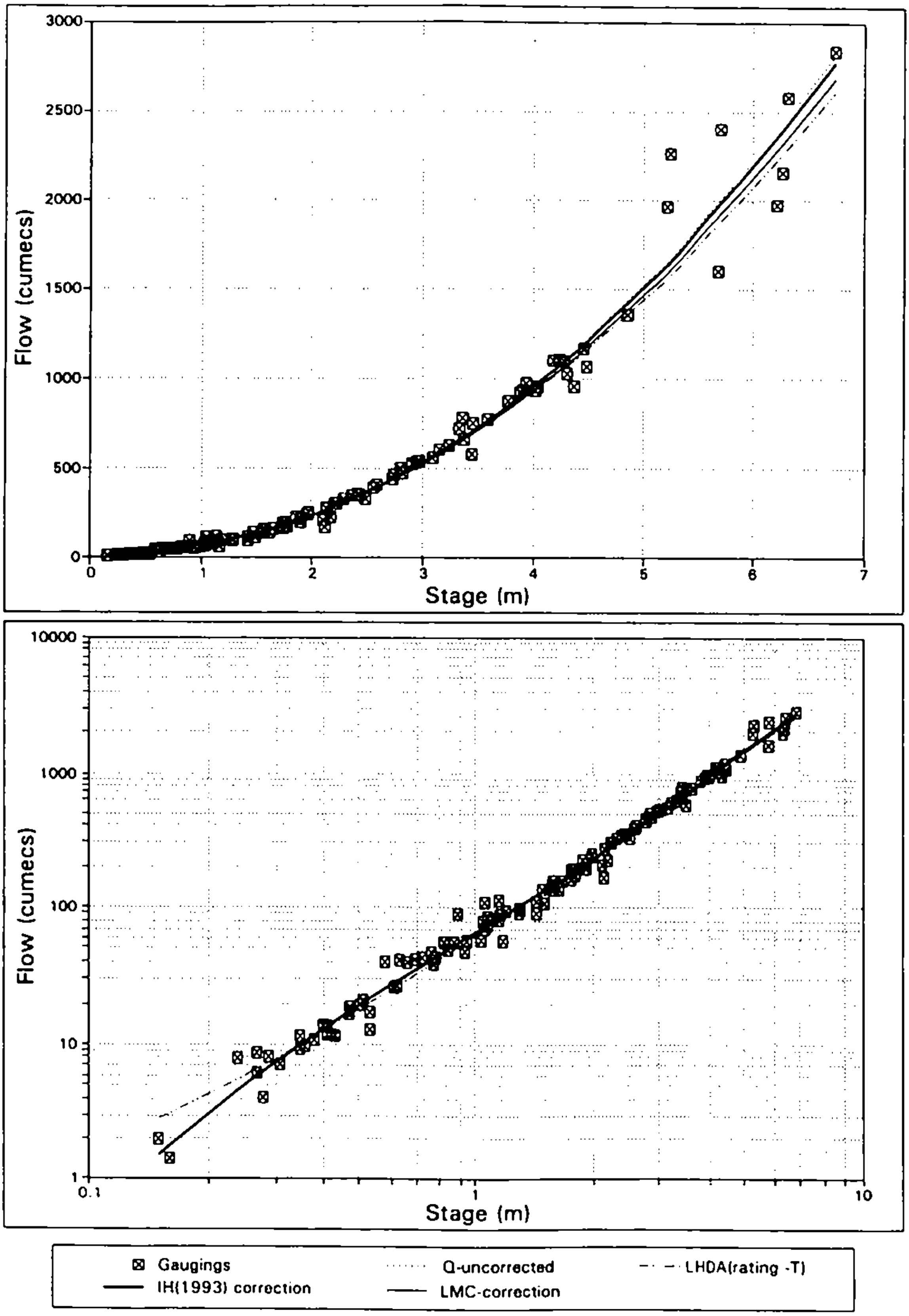

Figure B.10

relative to the IH(1993) rating:

Rating (IH(1993) correction applied):	42019.9 MCM	
Rating (no correction applied):	42113.0 MCM	+0.2 %
LHDA(1987) rating T:	41576.8 MCM	-1.1 %
Rating (LMC correction applied):	41429.9 MCM	-1.4 %

These results allow direct comparison of the influence of the different rating equations and consequently the effect of the correction applied to the current meter measurements. The results clearly demonstrate that over a representative period the different rating equations do not significantly change the flow. This must be because the stage at Seaka lies predominantly between 0.3 m and 4.0 m and consequently there are relatively few periods when the rating equations are significantly different. Certainly these differences alone are not enough to explain the discrepancy between the Oranjedraai and Seaka flows, which assuming the flows at Oranjedraai are correct, would require a decrease in the flow at Seaka of between 8 and 14%. As a further check, Figure B.11(a-c) shows the monthly total incremental flows between Oranjedraai and Seaka computed on the basis of these different rating equations. These confirm that the different Seaka ratings result in very similar patterns of incremental flow and so clearly the negative flows cannot be explained solely by the magnitude of the drag correction applied to the discharge measurements at Seaka.

Since it is particularly noticeable that, in the period after water year 1987, the incremental flows are zero or negative, this period was investigated in more detail. It is possible that a major flood between 13 and 14 March 1988 shifted the lower part of the rating at Seaka as it did at several other stations in the Lesotho Highlands (e.g. G45, Malibamatso at Pelaneng). In Appendix A of WP3 it was stated that there was insufficient evidence to prove that a change in rating had actually occurred, because only 11 discharge measurements have been made since this date and only one of these has been made at a stage less than 1.00 m. Consequently, no new rating was fitted. However, it is possible that the rating did shift and the few discharge measurements that have been made do suggest that this might be the case (see Figure A.1 in WP3). To investigate the effect of this apparent change, the new rating was fitted for the period from 15/03/88 using the discharge measurements available. These were first corrected for drag using the IH(1993) methodology and it was assumed that no change occurred in the upper part of the rating. The equation fitted is:

$$Q = 35.87(h + 0.097)^{2.577} \qquad hmax = 1.80 \text{ m}$$
$$Q = 55.58(h + 0.005)^{2.049} \qquad hmax = 10.00 \text{ m}$$

Figure B.11(d) indicates that this does improve the incremental flows for the period after March 1988, but there are still several near zero and some negative values.

Our overall conclusions from this work are that the near zero and negative incremental flows between Oranjedraai and Seaka cannot be explained solely by errors in the rating fitted at Seaka. The magnitude of the drag correction applied to the current meter measurements made at Seaka has little effect on the rating derived and consequently the calculated flows at Seaka. Over a representative period the difference between having no correction and the largest possible correction (i.e. the LMC correction) is less than 2%. The suggested new rating for stages up to 1.80 m improves the incremental flows between Seaka and Oranjedraai from 15/03/88. However, this rating is based on only eleven discharge measurements and our recommendation that is to make every effort to confirm it through current meter measurements as soon as possible. This new rating also does not fully explain the observed

Comparison of monthly total flows (10/77 to 12/92)
Oranjedraai - Seaka

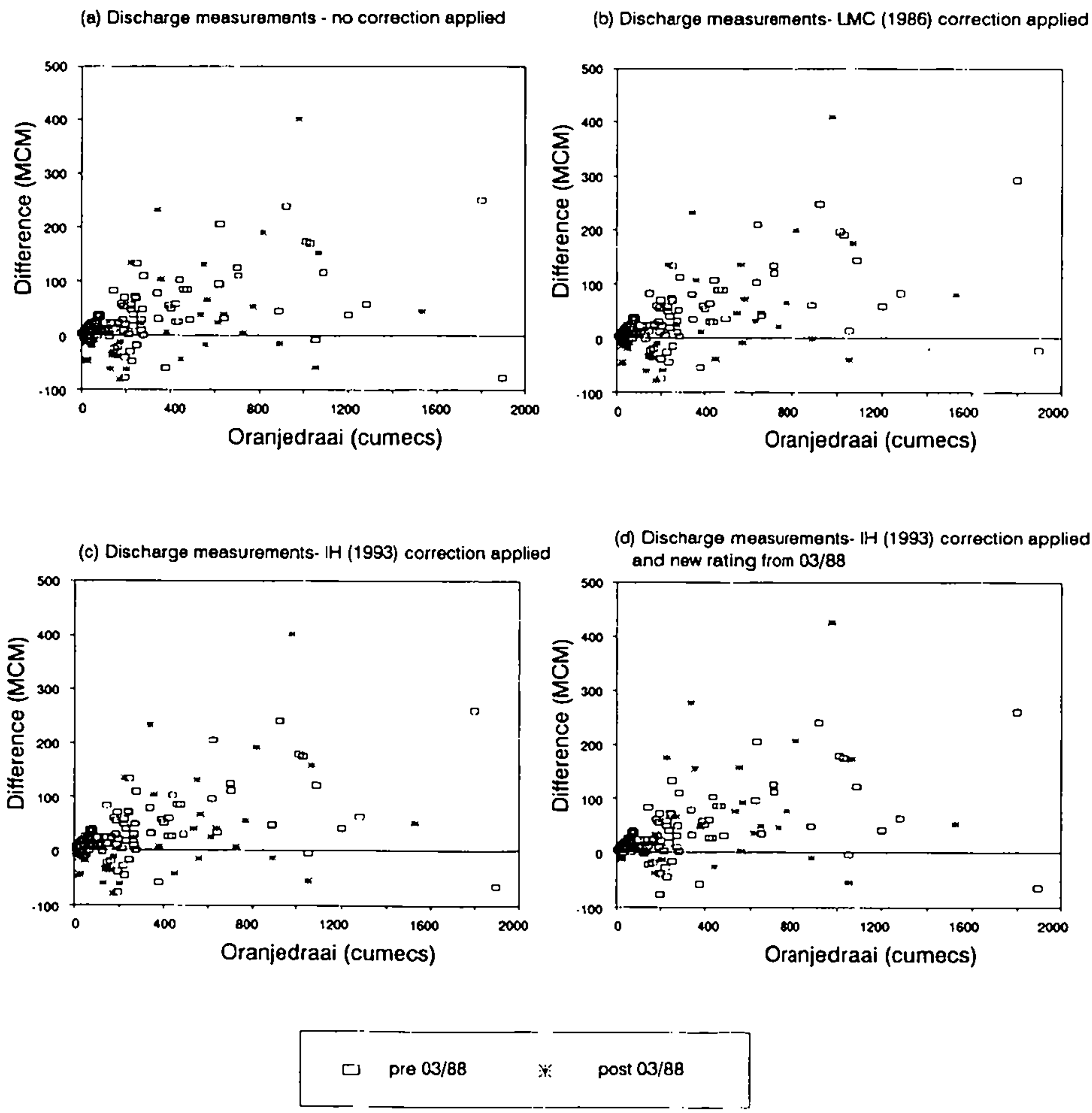

Figure B.11

discrepancies.

One further possibility was examined. Since there was a change in the discharge table used by DWAF for Oranjedraai in August 1989 and this corresponds to the period during which the water-balance between Seaka and Oranjedraai is particularly prone to being close to zero, the effect of this switch was investigated. Discharge table 28 (DT28) was used from 21/10/60 to 29/04/87. Discharge table 30 was used from 08/08/87 to 29/08/89 and discharge table 33 (DT33) has been used since. As DT30 was used for just two years we have not looked at this rating but have concentrated on the other two. Using data from the discharge tables, rating curves corresponding to each table were fitted. Using the daily flow data from 01/09/89 to 31/08/92 an "effective mean daily stage" was calculated using the DT33 rating. The flow was then re-computed using the DT28 rating. This allows direct comparison of the two discharge tables. The results indicate that while there are differences on a day to day basis, the monthly totals are very similar and not sufficiently different to cause the water balance problem between Seaka and Oranjedraai. Recent stream gauging made on 13/01/94 at Oranjedraai lie within the error band of gauging at the site and confirm the rating. However, we note that they are different from the rating in the positive sense (i.e. suggest a slightly higher flow at Oranjedraai). As for Seaka the only real solution is to make more discharge measurements. It is also hoped that re-working the overall water balance may help towards resolving this issue.

Miscellaneous points

Koma Koma record (p4.3-4.5)

BKS/DWAF note that the revised flows for Koma Koma are some 3% lower than their own estimates, whereas a higher value would be expected in view of the revised drag correction. Examining individual years, the values are higher in the first 10 years of record and lower thereafter. This difference almost certainly arises from a revision of the rating equations rather than from the revised drag corrections. The recommended ratings (Figures A.9 and A.10 of WP3) give higher flows up to 1976 and lower flows thereafter when compared to the Interim Hydrology ratings. The shift in 1976 was linked to the flood of 21.3.76.

BKS/DWAF also discuss several monthly values for which there are large differences with previous estimates. We agree that two of these values seem inconsistent when compared with the values for nearby stations; for Nov. 68, the problem arises because, during the period 5/11-18/11, flows at Koma Koma were estimated as zero whilst a flow of a few cumecs was recorded at Paray. Similar monthly totals were obtained for Paray and Whitehill suggesting that the records for Koma Koma are incorrect for this month. This will be corrected in the final database. The low value for Mar. 76 is in fact an estimate based on an incomplete month of data. In Section B.2, we mention that LHDA recommend reinstating 3 of the missing daily high flow values, which would raise the total for this month by about 615 MCM. Estimated values should really be flagged and this will be done in the final printouts; note however that this has no effect on the annual totals used in the stochastic model since these are calculated directly from the daily data.

Non-zero in rating equations (p3.6)

In this study, rating equations are expressed in the form $Q=a(h+c)^b$, where Q is flow, h is level and a,b and c are constants. BKS/DWAF point out that a non-zero value for c can result in discontinuities at intersections in multi-art ratings. Whilst in principle we agree with this comment, the use of a non-zero c is in line with current practice at both WEMMIN and LHDA and also with ISO guidelines. Applying a retrospective correction to all digitised stage values might also cause confusion. We feel that the ratings developed so far are certainly sufficient to provide a satisfactory estimate of the monthly and annual total flows required as input to the stochastic model.

B.4 COMMENTS BY WEMMIN ON WP3 (3 NOTES PRESENTED TO IH ON 28/3/94)

WEMMIN provided three sets of comments on WP3 in letters dated 14/1/94 (ref: WR/557/01), 25/1/94 (ref: NR/WA/A/16) and 25/2/94 (ref: NR/WA/C/22). Two of these letters included comments on Working Papers 1 and 2, but only those comments relating to WP3 are discussed below.

<u>Letter dated 14/1/94</u>

Comment: *The fact that there is no balance in flows between Seaka and Oranjedraai suggests further investigation into measurements upstream of Oranjedraai. If the Whitehill data is very suspect then the water balance downstream at Seaka will also be affected. One would expect that the Oranjedraai weir data is more reliable than the Seaka rated section data.*

Reply: Some further investigation of the water balance in the Seaka-Oranajedraai is presented in Section B.3 of this report. The Whitehill-Seaka balance will be reviewed once the agreed flow records for the Whitehill Crump weir have been received.

Comment: *Whitehill and Marakabei flow data has been investigated in great detail the past few years. There is a great amount of information available from both Lesotho and RSA authorities on the measuring structures. Both sets of data should be used if found to be suitable.*

Reply: One of the recommendations from the meeting in Maseru on 30/3/94 was that the LHDA and RSA Crump weir records for Marakabei and Paray should be merged into single agreed records for the whole observational period. This exercise has now been completed and Section B.1 of this report presents a review of these data. A similar exercise for Whitehill is currently underway.

Comment: *The method of determining the mean annual rainfall in Chapter 5.4 is very dependent on the choice of a straight line (see fig 5.7). A small change in the slope of the line will result in a big change of the annual rainfall since the catchment areas, used as a multiplier in the equation, are very big. The use of the same MAR straight line relationship for the areas FA and CG in fig 5.8 is questionable. All these factors may contribute to the differences between Seaka and Oranjedraai.*

Reply: We agree that the mean annual rainfall estimates presented in Working Paper 1 are only approximate and are sensitive to the rainfall-altitude relationships assumed. However, we believe that they are as good as can be achieved at present with the current rainfall dataset and raingauge network density. The MAR estimates were only one of several factors which led us to question the water balance in this reach; similar conclusions are reached from a comparison of flows alone. Section B.3 of this report discusses some of these issues in more detail.

Letter dated 25/1/94

Comment: *1. Proper naming of the gauging stations. The old names it not relate to the actual location of the site but to the home of the nearest European in the area.*

Reply: We have adopted the naming system used by LHDA and during the Stage 2B and Interim Hydrology to avoid confusion. We agree that some of the stations may be known locally by different names.

Comments: *Imbalances between the rises and falls of water levels in the river and in the stilling, especially during flashy floods. Has this been addressed in any of the previous studies?*

Reply: This is yet another of the uncertainties inherent in measurements of river levels using chart recorders. Detailed comments on possible problems appear on many of the original chart records and in the Stage 2B reports. We have assumed that, where these problems have occurred, the resulting values have either been corrected or not loaded onto the LHDA database. Consequently, our primary validation checks were on the daily mean flows (e.g. Figure 2.3 of WP3).

Comment: *The watchmen (most of) tend to record the upstream level of the water on the gage plate. Debris may have built up against the gage plate.*

Reply: Again, we assumed that, where watchman records were used for infilling, gross errors due to this problem could be spotted by inter-station comparisons of daily mean flows.

Comment: *The gauge height may change drastically during a discharge measurement, and estimating the weighted mean gauge height may be in error if no intermediate gage readings are not available in between the start and end of the measurement.*

Reply: Agreed. This is yet another of the uncertainties in making discharge measurements by current meter - however, there is little prospect of correcting the historical measurements for this effect.

Comment: *Joint and independent discharge measurements are available made by DWA and LHDA*

Reply: With the assistance of LHDA and WEMMIN staff, we believe that we located all of the discharge measurements made up to 1993 during our time in Maseru (6/93-8/93).

Comment: *Early in the 1970 discharge measurements included velocity profiles. Time taken used to miss the crest and hence DWA resorting to 0.6 depth and 0.2 and 0.8 depth.*

Reply: For future assessments of the accuracy of discharge measurements, it would be very interesting to locate a write-up on this work. Presumably, the 0.2/0.8 depth method was adopted on the basis of these trials.

Comment: *DWA zeros the depth meter when the water cuts the horizontal axis of the current meter - sinker assemblage.*

Reply: This is the basic assumption made in the revised drag corrections developed by ourselves and WEMMIN.

Comment: *The average value of Cd, the drag coefficient of the cable and meter assemblage of equation 3.2 on page 8 is not given.*

Reply: This was not required since a purely empirical relationship was developed between velocity and cable deflection.

Comment: *A deflection angle of 30° may be an overestimate. The measurements made with the angle measuring device show small angles. However it depends on the sinker weight used by the hydrometrist.*

Reply: Agreed. Many hydrometric technicians would be suspicious of readings taken with such a large deflection; in part because of the difficulties of placing the meter accurately at the 0.2/0.8 depths and because the meter is several meters downstream of the suspension point. These are some of the reasons why discharge measurements at high flows must be treated with caution.

Comment: *It was not until the mid-1980s that DWA changed from* $Q=a(h)^b$ *to* $Q=a(h-c)^b$.

Reply: Some comments on this point are given in Section B.3.

Comment: *Cableway site at Koma Koma has some rapids upstream especially at mid to high flows; thus affecting the surface of the flow.*

Reply: Noted.

Comment: *Crump weirs were drowned and by-passed by the 1988 floods. For very high flows the cableway site does not confine the flow in the first banks on the right hand side.*

Reply: It is not clear which site(s) this comment refers to.

Comment: *Table 3.2 should read: "Some" discharge measurements by WEMMIN....cable angle are available. And "Mokhare (G22)" should read "Maseru (G22)". As stated before "Pelaneng" should be "Lejone's".*

Reply: Noted.

Comment: *Tlokoeng: Page 13: During the 1988 floods the minihydropower was still under construction and plans/designs had already been completed for the contractor to move the station to the new site because the backwater of the 5 m dam was going to flood it.*

Reply: Noted.

Comment: *Paray (page 21): 2000 m^3/s the Crump weir is drowned and by-passed. Flow is over the banks at the cableway section.*

Reply: Agreed. At high flows, errors in the ratings may be large for both the Crump weirs and rated sections.

APPENDIX C - Additional work on the stochastic model

In Progress Report 10, we described our current thinking on ways of validating the output from the core stochastic model. Since then, we have been trying to develop more objective ways of choosing between the results produced by different configurations of the model, such as different choices of raingauges or different transformations. Our general approach is described in Section C.1 whilst some examples of the types of test being used are presented in Section C.2. We have also started to implement the transposition and monthly disaggregation schemes which were outlined in Working Paper 2 and Section C.3 discusses the general approach we are taking.

C.1 GENERAL APPROACH TO VALIDATION OF THE MODEL

Each run of the stochastic model generates several hundred annual flow sequences for the 5 (or 6) key sites and for the incremental catchment areas immediately upstream of each site. The model can also be configured to use different combinations of raingauges, different key sites and different transformations between flow and rainfall. Also, as discussed in Progress Report 10, the model can be run in three different modes of operation according to the intended application. Before describing specific validation tests, it is therefore worth reviewing what it is hoped to achieve using each configuration of the model. Figure C.1 shows the current preferred configuration of the model, which allows for the possibility of including Whitehill as a key site.

As described in the Terms of Reference, there are two main objectives to this study:

(a) to generate annual flow sequences for the Royalty hydrology and

(b) to generate longer term annual flow sequences for use in the Phase 1B design studies.

The Royalty flows will be a set of flow sequences which individually are all plausible estimates of the flows which really occurred in the Lesotho Highlands in the period 1930/31 to 1982/83. The number of sequences required to estimate the Royalty payments will only become apparent by running each sequence through the Royalty calculation program but will probably be of the order 10-20. The form of the model ensures that the actual recorded flows appear in all sequences in periods where these flows are available (i.e. the 'flow-data' period, which begins in the 1960s). By contrast, the design flow sequences are completely synthetic and span an arbitrary period, which at present is set to equal the entire observational period for rainfall, which dates from about 1886. Also, many more sequences will be required for reliable yield estimates; typically, in reservoir design, several hundred sequences with durations of 50-100 years might be used. In Progress Report 10, it was mentioned that the core stochastic model has already been configured to work in both the Royalty mode (Mode 1) and the design flow mode (Mode 3).

These different requirements ((a) and (b) above) lead naturally to slightly different testing procedures. In stochastic modelling, the conventional test is to ensure that the generated sequences have the same statistical flavour as the shorter original observed flow sequences.

Revised subdivision of the basin

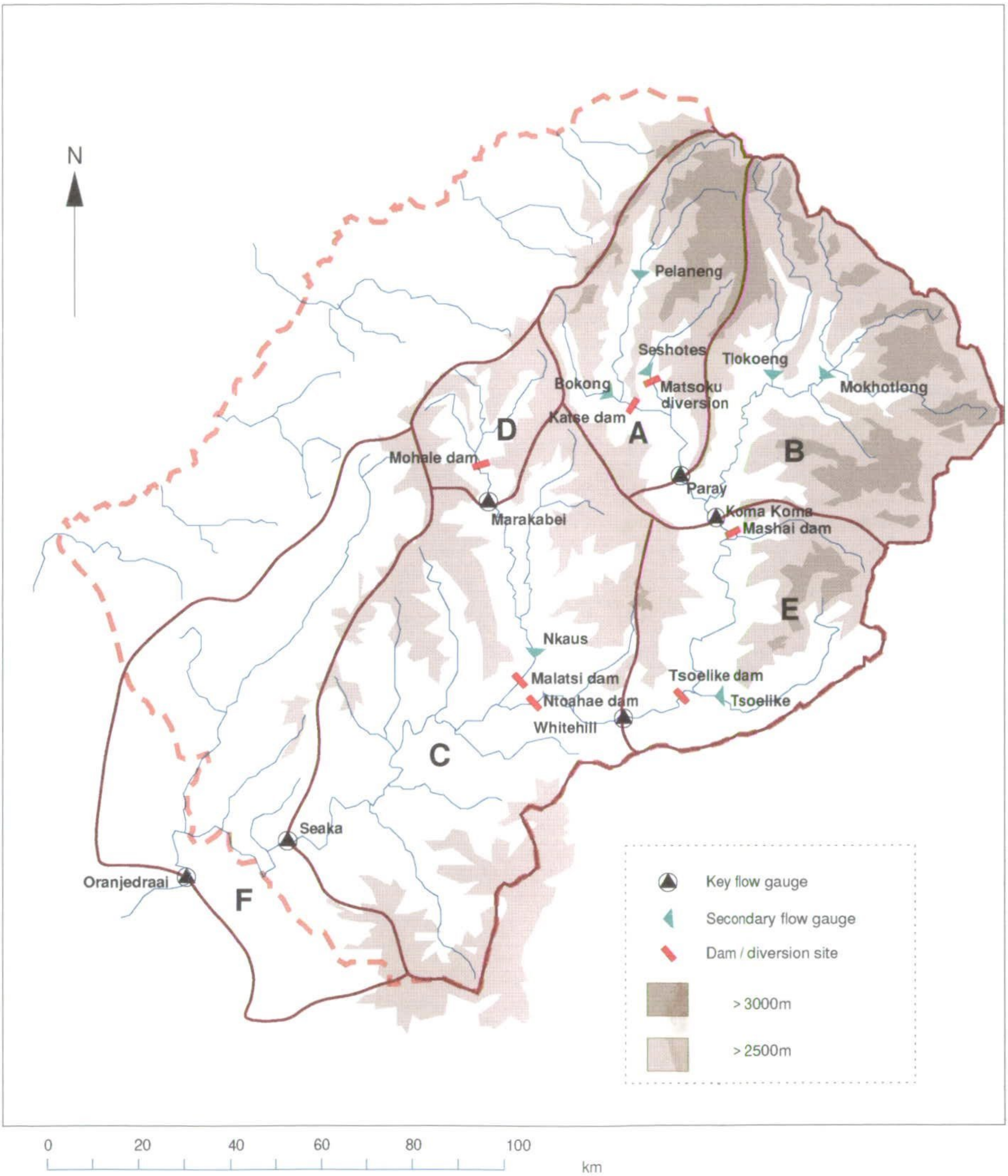

Figure C.1

For reservoir yield studies, the flow sequences should have not only the correct mean, standard deviation, serial and cross correlations, but also the correct storage related characteristics, such as minimum run sums and maximum deficits. However, for the Royalty sequences, it only makes sense to apply these tests to the 'flow-data' period. This is because the longer term rainfall data (Figure C.2) shows that this period would be expected to have noticeably different statistical characteristics to the earlier part of the Royalty period, with apparently a higher serial correlation, higher variability and longer low flow deficits. A two stage validation procedure is therefore required, checking first that, for the 'flow-data' period, the flows generated by the model have the same statistical characteristics as the observed flows and then, for the full Royalty period, that the generated flows behave in the way suggested by the observed rainfall data, and by other indicators of flow variability, such as estimates of the flow at Aliwal North and flows estimated by other modelling procedures, such as the Pitman rainfall-runoff model. To perform the first of these tests, it is necessary to use the model in an additional mode of operation, in which the flows in the 'flow-data' period are generated using rainfall data alone, and the fact that the flows are really known is ignored. This is called Mode 2 in Progress Report 10.

For the design flow sequences, more conventional stochastic modelling validation tests will be appropriate. So far in this study, we have not presented any results using this mode of operation, although the model is configured to run in this mode and all of the required validation testing procedures are in place. These procedures include all the conventional tests on the statistics of the generated flows and on various storage related statistics. Some example results from this mode of operation are shown later. In this mode of operation, flows will still be generated using rainfall data as a guide, although the rainfall data will now be generated as well. It is at this stage that the issues of cycle and trend become important since, if they are significant, they should be built into the rainfall generation process. However, our preliminary conclusion (see Working Paper 2 and previous Progress Reports) is that, in this study, these factors will not be significant in terms of reservoir yield and reliability.

C.2 EXAMPLES OF VALIDATION TESTS

We now present some examples of the types of statistical tests being used to validate the model when it is being used in the Royalty and design flow modes of operation. These are in addition to the various comparisons of time series shown in Progress Report 10. To illustrate the methods, five different combinations of raingauges and rainfall-flow transformations have been used as shown in Table C.1. We must emphasise that the following discussion is intended only to give some examples of the validation procedures being developed and the results presented should not be interpreted as representative of the final Royalty flow sequences. We will not take any final decisions on the optimum configuration of the model until the revised flow records for Whitehill have been received.

In these tests, the parameters of the transformations applied to individual flow and rainfall series have been selected separately. Models 1, 2 and 3 each used identical sets of transformations for the flow and rainfall, while for Models B-3 and U-3 the same sets of upper bounds were used in both models. In the case of Models 3, B-3 and U-3 the same combinations of raingauges and catchments were used: however, note that the selection of raingauges was made after assessing several variants of Model 3, but that such a selection is not necessarily appropriate for the other models because of the different effects of the transformations in these cases. For the time being, Model 3 is regarded as our 'best' model, with the others being presented as an illustration of the effects of various changes to the

Comparison of long term rainfall and flow records for the Royalty period

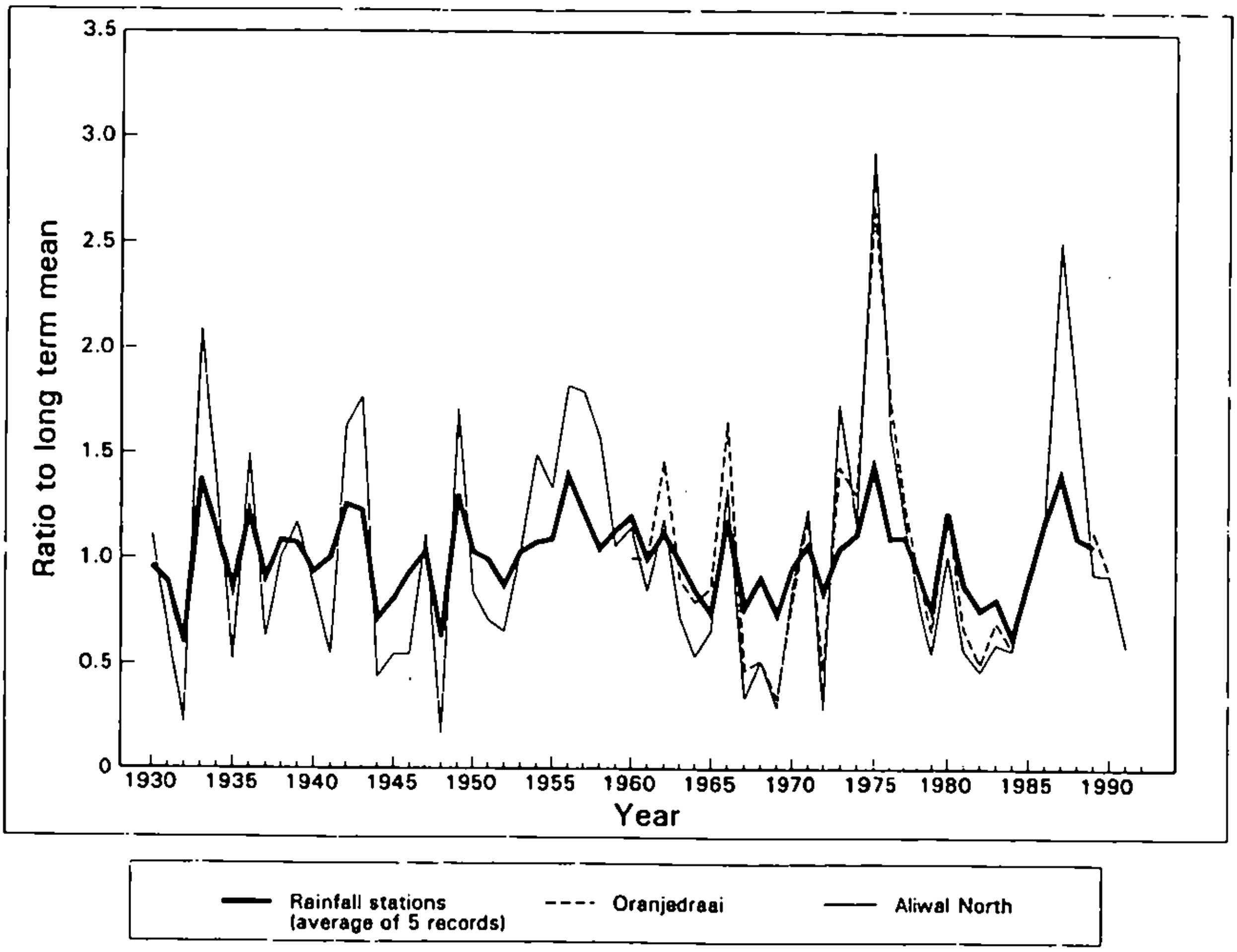

Figure C.2

model configuration.

Table C.2 presents a comparison of the results of the different models in regard to the probability distributions which summarise the models' best estimates of what the actual mean annual flow over the Royalty period might have been. Entries in the table consist of the mean (upper figure) and the standard deviation of the distributions of these means, where flows are expressed in units of million cubic metres. As expected, there is a consistent decrease in the uncertainties with which the mean flows are known as more use is made of the information available in the rainfall data in passing from Model 1 to 2 and then to 3. A similar comparison for the sample standard deviation is shown in Table C.3. In this case, the variability in the standard deviation typically decreases as more information about rainfall is used: this would be expected since the range of variation of rainfall during the Royalty period is smaller than that experienced during the period when both flow and rainfall data are available. For Models B-3 and U-3, the flows are forced to lie below a finite upper bound and thus smaller standard deviations might be expected, but such an effect is not apparent in Table C.3 which presumably indicates that the bounds are not tight enough to cause such a problem.

Table C.1 Summary of model configurations

Model	Treatment of rainfall-runoff modelling	Flow and rainfall transformations
1	Rainfall information ignored	Logarithm/linear
2	Each catchment regressed on the average of the same set of gauges	Logarithm/linear
3	Each catchment regressed on the average a different set of gauges	Logarithm/linear
B-3	Each catchment regressed on the average a different set of gauges	Logit, with selected upper and lower bounds
U-3	Each catchment regressed on the average a different set of gauges	Logit, with selected upper bounds, all lower bounds set to zero.

Table C.4 gives an indication of the strengths of the relationships between rainfall and flow built into the models. The table shows, in the upper figure, the mean standard deviation of the model relating flow to rainfall and past flows and, in the lower figure, the ratio of this value to the mean standard deviation of the flows themselves. Note that the standard deviations here are in transformed units, so that, although direct comparisons of standard deviations can be made between Models 1,2 and 3, those of Models B-3 and U-3 each relate to different scales. The values given in Table C.4 give one possible guide to the best choice of raingauges for use in the final model runs; for example, on the basis of these tests, Model 3 appears to give the best results. By contrast, the results reported in Tables C.2 and C.3 relate primarily to the generated Royalty sequences rather than the performance of the model. It is therefore not sensible to use these tables to try to choose between competing versions of the model by, for example, directly seeking to minimise the uncertainty with which the Royalty period mean flows are known. Instead, we suggest using the mean residual standard deviation (Table C.4) to select which raingauges are to be included in the rainfall-runoff component of the model, although this is itself closely related to the standard deviation of the mean flow.

In any case, these statistics are by themselves not sufficient to provide guidance as to the appropriateness or adequacy of the model. The results presented in Tables C.1 to C.4 all relate to the Royalty mode (Mode 1) of operation. As indicated in Section C.1 above, we also need to consider the performance of the model in other modes of operation, especially Mode 2, when estimating the Royalty flows. The previous report gave some examples of comparisons made using this mode, and a more extensive set of comparisons is now presented here. The box plots presented in Progress Report 10 were in fact a summary of just part of the information presented in a much more comprehensive set of plots which are now generated routinely by the model after each model run. Figures C.3 to C.6 give examples of these plots for the 'Model 3' configuration shown in Table C.1. Each of the example plots corresponds to a different sample statistic (mean, standard deviation, ordinary cross correlation, rank-based cross-correlation (Spearman rho)) calculated foı four different data periods and for the three different run-modes (including the design mode, Mode 3). Note that in Mode 1 of operation, the simulated series reproduce whatever flow observation was made in a given year, if available; also, infilled values obey bounds where these are available. The results presented consist of box-plots constructed from 400 sets of simulated series, where the points marked are the minimum and maximum and the 5, 25, 50, 75 and 95 percent points. The four different data periods considered are:

(a) All data period	1886 to 1991;
(b) Royalty period	1930 to 1982;
(c) Flow-data period	1960 to 1991;
(d) Site-data period	different for each site/unit.

Table C.2. *Mean and standard deviation of the distribution of the actual mean annual flow over the Royalty Period (Mm^3)*

Site/Unit	Model 1	Model 2	Model 3	Model B-3	Model U-3
Paray (A)	817	858	843	860	879
	76	51	31	49	32
Unit B	705	738	646	658	697
	97	87	58	64	55
Unit C	1676	1743	1709	1749	1729
	182	151	117	115	119
Marakabei (D)	390	418	399	409	409
	32	23	19	18	16
Unit F	632	680	666	662	666
	99	83	73	72	70
Oranjedraai	4221	4437	4263	4338	4381
	384	267	185	203	192
Seaka	3589	3757	3596	3676	3714
	311	228	161	173	161
Koma Koma	1522	1595	1489	1518	1576
	161	123	73	91	74

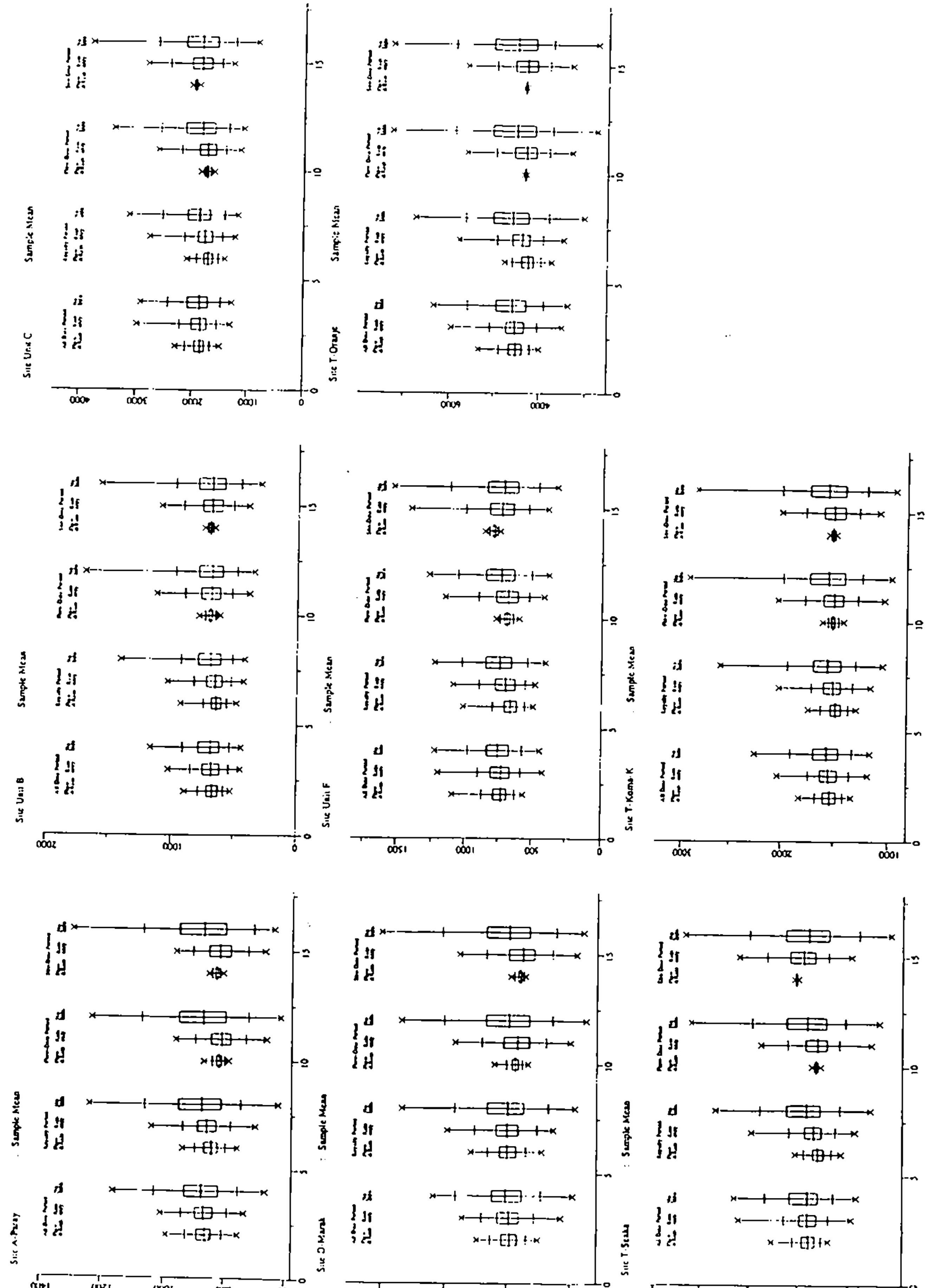

Figure C.3

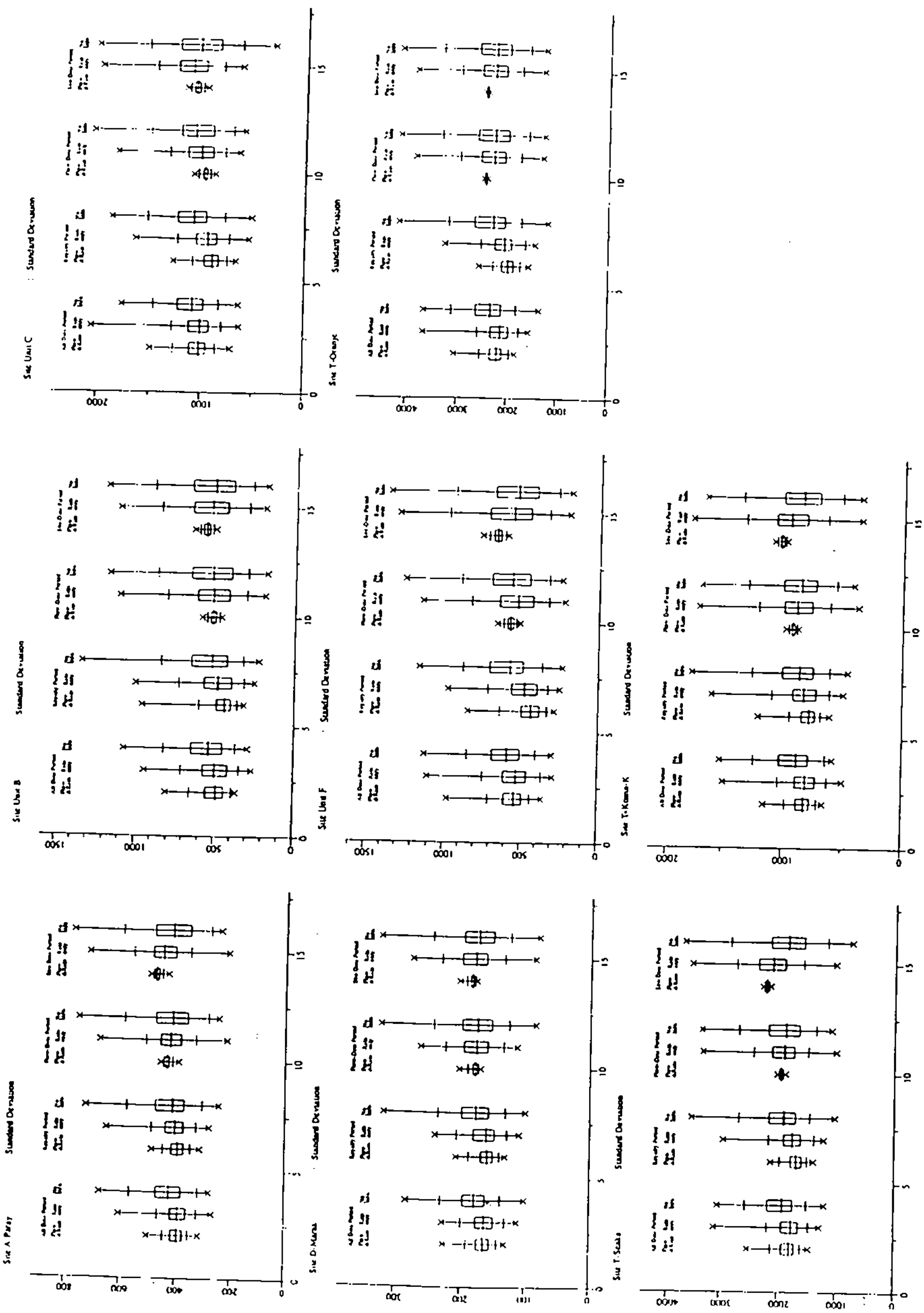

Figure C.4

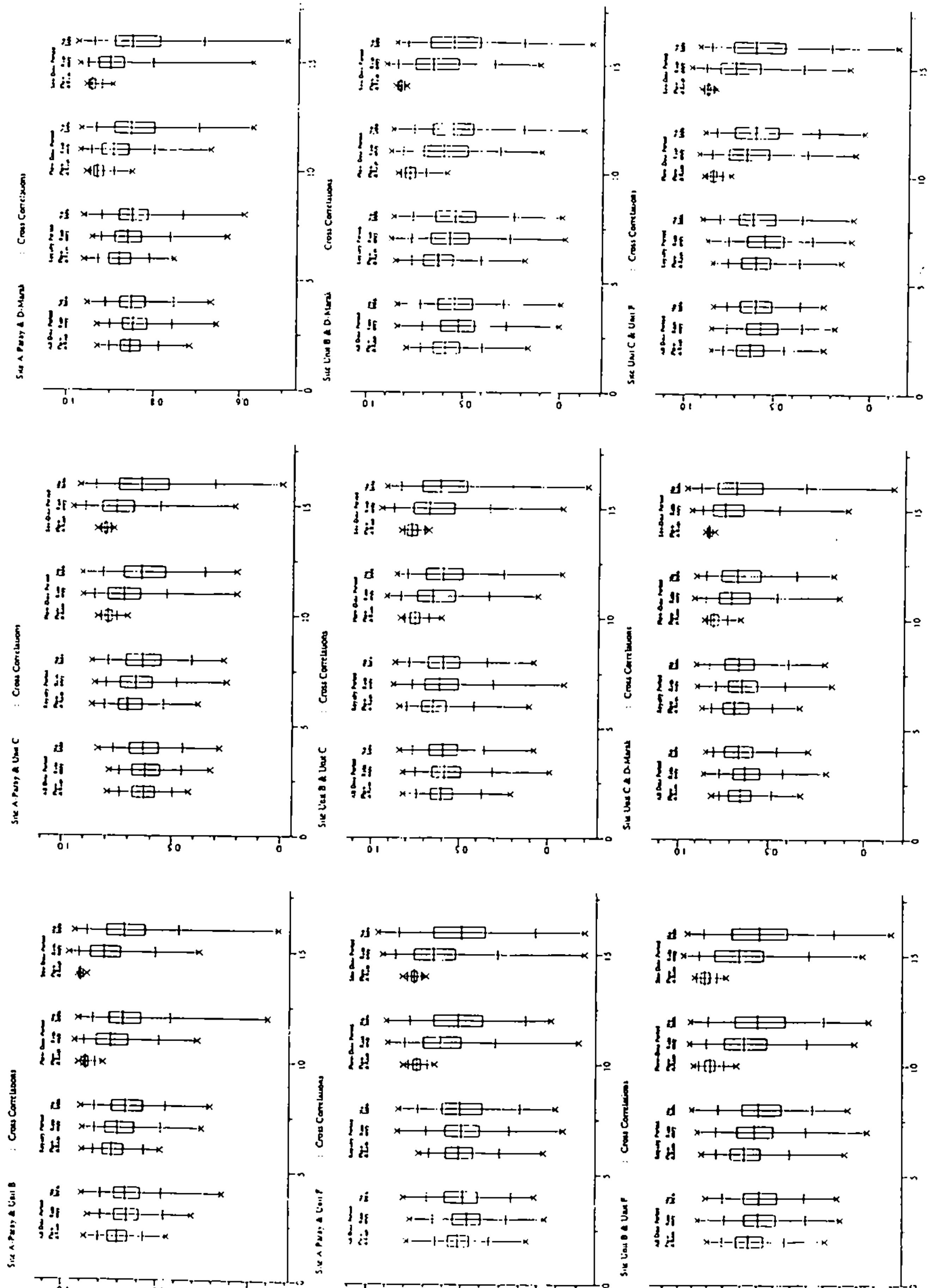

Figure C.5

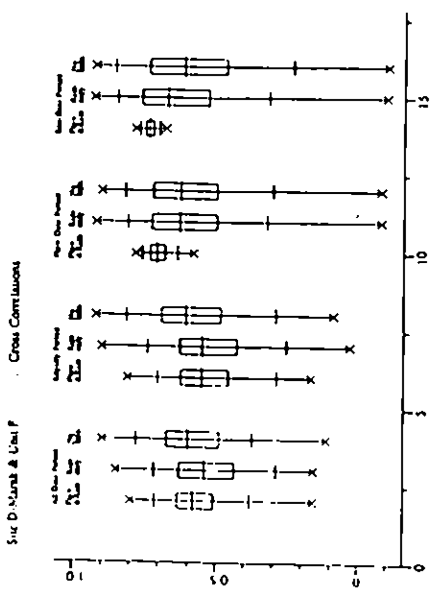

Figure C.5 cont.

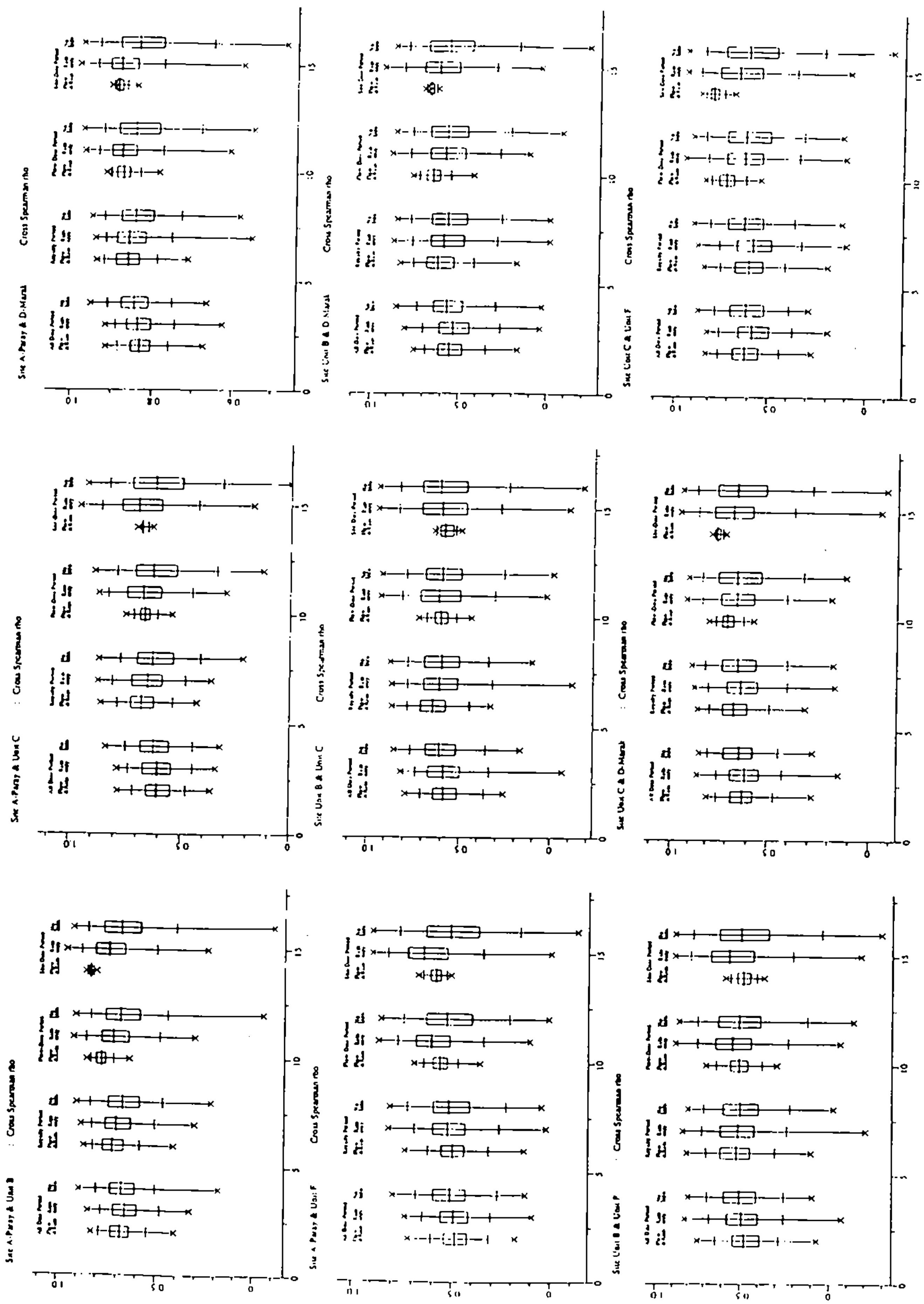

Figure C.6

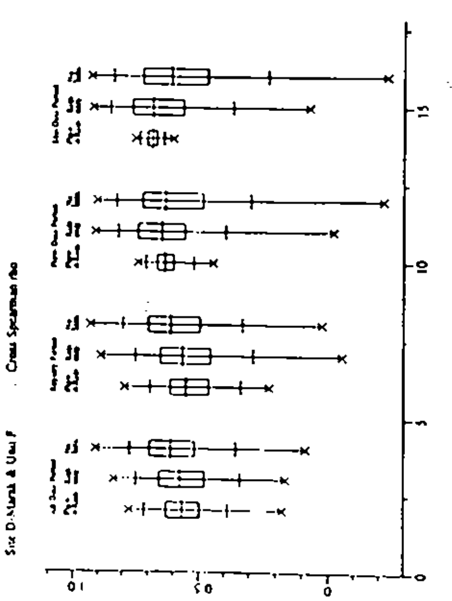

Figure C.6 cont.

Table C.3. *Mean and standard deviation of the distribution of the actual standard deviation of the annual flows over the Royalty Period (Mm^3)*

Site/Unit	Model 1	Model 2	Model 3	Model B-3	Model U-3
Paray (A)	407	393	395	452	399
	64	45	31	40	25
Unit B	533	542	456	477	478
	126	114	77	57	45
Unit C	987	969	910	896	891
	161	150	102	92	86
Marakabei (D)	186	175	161	163	158
	28	17	14	13	11
Unit F	501	497	449	454	441
	141	119	92	70	65
Oranjedraai	2298	2204	2014	2064	2063
	393	280	163	157	143
Seaka	1901	1843	1702	1747	1736
	300	226	144	131	117
Koma Koma	891	882	790	846	828
	171	141	82	75	59

Table C.4. *Mean standard deviation of the residuals of the model relating flow to rainfall and past flows (transformed units), and proportion of the overall standard deviation not explained.*

Site/Unit	Model 1	Model 2	Model 3	Model B-3	Model U-3
Paray (A)	179	109	69	0.82	0.30
	0.81	0.51	0.34	0.47	0.32
Unit B	269	213	169	0.74	0.56
	0.85	0.66	0.56	0.53	0.54
Unit C	123	82	63	0.47	0.45
	0.81	0.57	0.45	0.44	0.45
Marakabei (D)	224	116	103	0.43	0.30
	0.79	0.45	0.44	0.41	0.40
Unit F	263	177	172	0.68	0.59
	0.80	0.56	0.56	0.56	0.57

For the purposes of model assessment one would ideally seek an 'observed' value of some statistic to compare with a statistical distribution of similar values generated from the fitted model. In the present situation, there is no single 'observed' value available because, in some years, values are missing and sometimes only bounds are available rather than the exact values. Instead, what arises is a statistical distribution of what the observed statistic for the particular period might have been, and this distribution is slightly affected by the particular model being assessed since it is derived from values infilled using the model. One is therefore left with the problem of comparing two statistical distributions in order to assess the performance of the model.

In order to use a consistent assessment procedure across all cases we suggest using the 'Flow-data' period comparisons since for these the spread of the 'observed' distributions is reasonably small and, as mentioned earlier, we suggest comparing the 'observed' distribution with the distribution from the 'rainfall only' case (Mode 2). Similar comparisons were made in Progress Report 10 using the 'site data' period; however, using the 'flow-data' period has the advantage of using an identical number of years in each comparison. For a particular model configuration to fit well, one would expect the 'observed' distribution (possibly taking the median of this distribution as representative) to be a not-unusual outcome of the fully simulated distribution. In an attempt to quantify this agreement, a numerical summary of the match between observations and model has been defined in the following way. First, the median of the observed (Mode 1) flow distribution is found, and then the proportion of the simulated (Mode 2) values which are more extreme than this is calculated, where 'more extreme' is counted in the direction away from the median of the simulated values. This proportion (which must be less than or equal to one-half) is then converted to a measure of fit by setting the outcome identically equal to 1.0 if the proportion has a value greater than x, say, and otherwise by multiplying the proportion by 1.0/x. This procedure results in the outcome being a continuous function of the proportion, taking values between 0.0 and 1.0. The value x allows for the fact that only a finite number of simulations has been performed, and would be 0.5 for an infinite number of simulations. For the test results shown below, we have used a value of $x=0.4$ to allow for the fact that the distributions are the result of only 400 simulations and thus the counts are subject to sampling error. Once the medians are in agreement to that extent there is little merit in expecting to achieve a closer match. A sample-size based criterion is not used here because the samples are not independent and thus the expected discrepancy is not easily quantified.

This proposed measure of fit yields a single value for each site, or combination of sites, for each statistic chosen. If required, these values can also be averaged across sites and types of statistic to yield a final overall measure of fit. Some example results of this procedure are presented in Table C.5: here a value of 1.0 represents a perfect fit, while 0.0 is very poor. As well as the conventional statistics such as mean and standard deviation, this table also includes a set of storage based statistics which are calculated separately for each flow unit, and also for the three major flow observation sites which appear in Tables C.2 and C.3. Furthermore, for each site the statistics are calculated for a number of different design yields. Similarly, the Minimum run-total statistics are calculated for a number of different run-lengths. For the five example model configurations shown, in the case of the medians and standard deviations, the observed and simulated distributions might be expected to be in close agreement, since these statistics are closely related to ones which play an intrinsic part in the model-fitting procedure and are therefore to some extent reproduced automatically. For other variables, such as the storage based tests, there is no in-built constraint at all on the generated values, so the measures of fit shown are a genuine guide to the performance of the model.

From these comparisons, the poorest agreement is for the cross-correlation statistics, although it is still satisfactory (the lowest value of 0.39 is well above the 5% limit). It is worth considering the reasons for this in more detail. The ability of the model to reproduce the observed cross-correlations is affected by two factors.

(a) The structure of the model is such that it is the cross-correlation of the model-residuals which play a primary role. These are residuals from the model relating flow to both rainfall and past flows. Even in the case of Model 1, where rainfalls are not used, the model structure still relates flow for a unit to the flow in the previous year for the same unit.

(b) The model structure assumes that, after the logarithm/linear or logit transformation, the flows and rainfall are jointly Normally distributed. One aspect of this requirement is that when one transformed variable is related to another, there should be a constant conditional variance: broadly speaking the spread of the points about a regression line should be the same for all values of the 'dependent' variable. At least for the data-sets being used at present, it does not seem possible to find transformations of the flow variates which work well at achieving simultaneously both marginal Normality, and bivariate Normality. It seems therefore that some compromise between these must be made. Transformations which have been evaluated include the log-normal and the logit (SB3) transformation favoured by BKS/DWAF in some cases.

When the same type of assessment procedures as reported here are applied to cross-correlations evaluated from the transformed-values, it is found that there is much closer agreement between the observations and the model results. Also, higher scores are obtained using rank based correlation tests, such as Spearman's rho, which are also shown in Table C.5. We are therefore not concerned by the lower scores achieved so far in tests of cross-correlation compared to tests of the other statistical variables.

C.3 TRANSPOSITION AND DISAGGREGATION SCHEMES

The core stochastic model generates annual flows at the key gauging stations in the project area. To estimate monthly flows at the dam sites, two further sub-models are required to transpose the estimated annual flows to the dam sites and to disaggregate these flows into monthly values. To avoid duplicating work, we have deliberately delayed implementing these schemes in detail until the final rainfall and flow sequences have been agreed.

The general approach to be used is outlined in Working Paper 2. However, now that we have a good idea of how the final dataset will appear (in terms of data availability/gaps in the records) we have identified some minor modifications which will be required to the proposed methods. These are discussed briefly below.

Transposition

The transposition scheme is required to estimate flows at the dam sites from the flows generated at the key sites (see Figure C.1). The main change since producing Working Paper 2 is the possibility of including Whitehill as a key station in the core stochastic model. This would affect the proposed transposition scheme for the Tsoelike, Mashai, Malatsi and Ntoahae dam sites. The general approach would remain the same but the coefficients in the model would of course change from those derived using the earlier 5 unit scheme. In fact,

Statistic	Model 1	Model 2	Model 3	Model B-3	Model U-3
Sample mean	1.00	1.00	1.00	1.00	0.99
Standard deviation	0.98	0.97	0.97	0.89	0.80
Sample Minimum	0.87	0.89	0.89	0.68	0.81
Sample Maximum	0.98	0.98	0.98	0.82	0.54
Serial Correlations	0.69	0.69	0.90	0.92	0.89
Cross correlations	0.59	0.46	0.39	0.35	0.51
Maximum Deficit	0.86	0.94	0.89	0.89	0.87
Duration of max deficit	0.72	0.72	0.70	0.65	0.61
Duration of depletion	0.70	0.73	0.72	0.71	0.72
Minimum run-totals	0.84	0.87	0.84	0.78	0.83
Serial Spearman rho	0.79	0.73	0.86	0.83	0.71
Cross spearman rho	0.99	0.99	0.88	0.86	0.88
Overall measure of fit	0.83	0.83	0.84	0.78	0.76

Table C.5. Overall Measure of Fit

for Tsoelike and Ntoahae, it will be much easier to derive reliable estimates for these coefficients, since both dam sites are only a short distance from the Whitehill station.

For all of the dam sites, we proposed in Working Paper 2 to base the transposition coefficients on the areas and mean rainfalls for the incremental catchments. From the Interim Hydrology data, there appeared to be a unique relationship between mean runoff and mean rainfall for the whole project area (Figure 5.8 of WP2). The most recent data suggest that this may be an oversimplification, and that for some of the lower catchments, the transposition scheme might safely be based on catchment area alone. Our main change to the scheme proposed in Working Paper 2 is therefore to update Figure 5.8 of WP2 using the final flow and rainfall datasets and to use these new relationships in transferring the generated flows to the dam sites. One additional change may be to simplify the proposed transposition scheme for the Paray basin by merging the flows at Bokong and Pelaneng into a single record. This would then reduce the number of records for this basin from four to three, which should make it simpler to preserve the required cross correlation between the generated flows at Paray and the flows at Katse dam and the Matsoku diversion.

Monthly disaggregation

Disaggregation of generated annual flows to monthly values will be undertaken by a modification of the method of fragments, which is that used in the current BKS stochastic models. The method has been described very effectively by McMahon and Mein (1986)[1], and uses standardised observed monthly flows for each year as scalars for the generated annual flows. For each year of the historical record at each of the six key stations of the core model, the annual flows are ranked from lowest to highest and their corresponding monthly flows are expressed as proportions of the annual total. The generated annual totals are then compared to the historical flows for the appropriate site, and disaggregated using the standardised monthly scalars from whichever historical year is closest to the generated annual total.

This method will however have to be modified in two important respects, one for all modes of operation of the stochastic model, and the other solely for Mode 1, where the Royalty period is being modelled. The first modification of the model is required because of the frequent gaps in the historical data, with only a relatively small number of years with complete monthly historical data being available at most sites. The valid samples of monthly distributions may be rather too limited for application of the method without some sort of adjustment of the method. A suitable extension of the method has not yet been finalised and work is continuing on this topic.

The second modification is required for computation of flows for the Royalty period, where in the later years observed or bounded flows make up the bulk of the flow series. It will be necessary to make some slight adjustments to the disaggregation model for years with bounded flows so that only months with missing data are estimated, with observed data being allowed to stand unaltered. In such circumstances, care will have to be taken to ensure that the generated proportion of the annual flow is sensibly distributed over months with missing data. Work is again continuing on this point.

[1] McMahon T.A. and Mein R.G., 1986, River and reservoir yield. Water Resources Publications, Littleton, Colorado.

Appendix D.1 - Amended monthly rainfall data

Institute of Hydrology
Summary of monthly data - Rainfall

Station number : 21 Name : ST JOHN (MARAKABEI)

Basin no. : 0 Latitude : 29:33: 0 S Longitude : 28: 7: 0 E Altitude : 2240.0

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Total
63/64	-	-	159.	135.	70.	199.	57.	13.	35.	0.	27.	39.	-
1964/65	140.	36.	112.	98.	59.	20.	100.	2.	58.	27.	57.	18.	727.
1965/66	61.	84.	43.	207.	80.	55.	58.	31.	8.	0.	17.	3.	647.
66/67	59.	95.	118.	277.e	70.	99.	101.	53.	38.	11.	24.	14.	959.
967/68	94.	139.	75.	74.	5.	134.	66.	79.	10.	29.	14.	24.	743.
1968/69	69.	57.	116.	100.	85.	154.	76.	75.	5.	6.	28.	15.	786.
69/70	154.	35.	79.	78.	65.	48.	15.	12.	15.	13.	29.	75.	618.
970/71	100.	56.	152.	145.	68.	103.	55.	68.	5.	33.	3.	7.	795.
1971/72	68.	52.	239.	171.	155.	223.	43.	35.	28.	6.	28.	29.	1077.
72/73	63.	69.	33.	121.	176.	95.	57.	15.	1.	11.	78.	50.	769.
73/74	16.	129.	113.	162.	231.	54.	30.	22.	20.	0.	48.	29.	854.
1974/75	33.	166.	96.	113.	125.	121.	28.	11.	17.	3.	6.	101.	820.
75/76	55.	196.	151.	175.	139.	179.	55.	26.	37.	0.	0.	138.	1151.
76/77	190.	57.	50.	166.	87.	175.	48.	21.	10.	0.	6.	88	898.
1977/78	142.	-	98.	158.	115.	193.	88.	0.	12.	2	31.	98.	-
78/79	31.	55.	165.	59.	74.	24.	19.	48.	3.	65.	41.	22.	606.
79/80	104.	95.	157.	115.	159.	93.	31.	22.	0.	1.	1.	-	-
1980/81	-	162.	-	-	149.	135.	56.	31.	42.	0.	106.	27.	-
81/82	52.	106.	62.	118.	84.	80.	105.	7.	20.	16.	0.	14.	664.
82/83	175.	86.	-	117.	33.	69.	58.	46.	19.	37.	0.	25.	-
1983/84	74.	86.	116.	71.	39.	45.	19.	38.	-	0.	57.	5.	-
84/85	85.	57.	82.	89.	120.	76.	58.	-	-	-	-	-	-
85/86	92.	74.	147.	-	-	-	-	-	-	-	-	-	-
1986/87	-	-	-	34.	54.	44.	18.	0	6.	-	-	-	-
87/88	-	82.	-	54.	-	219.	59.	-	34.	-	-	-	-
n	88.	90.	113.	123.	97.	110.	54.	30.	19.	12.	29.	41.	807.
Median	74.	82.	113.	117.	84.	95.	56.	22.	15.	6.	27.	25.	
aximum	190.	196.	239.	277.	231.	223.	105.	79.	58.	65.	106.	138.	
imum	16.	35.	33.	34.	5.	20.	15.	0.	0.	0.	0.	3.	
St. dev.	48.	44.	49.	55.	53.	63.	26.	24.	16.	17.	28.	38.	
CV	.54	.49	.44	.45	.54	.57	.49	.79	.81	1.37	.98	.93	

Total monthly rainfall in millimetres

Data flags

Missing flag "-" Original - no flag set Estimate - flag "e"

nted on 22/ 6/1994

Institute of Hydrology
Summary of monthly data - Rainfall

Station number : 25 Name : Mashai

Basin no. : 0 Latitude : 29:41: 0 S Longitude : 28:48: 0 E Altitude : 1830 0

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Total
1965/66	-	-	-	-	50.	25.	0.	18.e	0.	0.	20.	0.	-
1966/67	32.	30.	90.	-	12.	41.	30.	0.	0.	0.	0.	0.	.
1967/68	60.	30.	61.	25.	38.	45.	6.	18.	0.	11.	0.	28.	322.
1968/69	6.	15.	56.	31.	12.	62.	40.	34.	0.	0.	14.	9.	279.
1969/70	87.	21.	78.	43.	50.	14.	0.	-	-	-	37.	57.	-
1970/71	44.	38.	63.	130.	71.	14.	26.	-	-	-	-	-	-
1971/72	28.	13.	88.	40.	61.	47.	10.	15.	0.	6.	8.	38.	354.
1972/73	40.	97.	-	48.	100.	36.	34.	0.	0.	4.	82.	30.	-
1973/74	7.	61.	89.	90.	143.	42.	16.	2.	12.	-	-	-	-
1974/75	1.	132.	71.	99.	74.	71.	18.	3.	3.	9.	1.	80.	562.
1975/76	19.	131.	74.	180.	62.	124.	15.	37.	0.	0.	0.	51.	693.
1976/77	97.	51.	40.	131.	53.	84.	26.	0.	2.	0.	1.	22.	507.
1977/78	87.	26.	41.	149.	60.	21.	59.	0.	0.	0.	23.	52.	518.
1978/79	30.	37.	98.	19	86.	50.	12.	6.	0.	22.	59.	10.	429.
1979/80	41.	70.	26.	118.	27.	16.	4.	0.	0.	0.	0.	-	-
1980/81	18.	-	29.	113.	81.	-	-	1.	12.	0.	21.	0.	-
1981/82	18.	45.	28.	-	-	67.	46.	0.	7.	-	0.	8.	-
1982/83	-	64.	15.	122.	21.	77.	20.	1.	4.	22.	0.	6.	-
1983/84	54.	90.	-	84.	29.	25.	13.	-	1.	-	22.	2.	-
1984/85	55.	27.	36.	51.	71.	8.	3.	0.	0.	0.	0.	0.	251.
1985/86	139.	87.	90.	26.	62.	72.	13.	0.	36.	0.	43.	12.	580.
1986/87	-	86.	11.	34.	49.	76.	36.	-	0.	3.	-	141.	-
1987/88	31.	59.	-	47.	72.	50.	-	0.	31.	2.	0.	57.	-
1988/89	41.	53.	82.	-	-	-	-	20.	17.	0.	-	0.	-
1989/90	39.	100.	-	-	-	-	-	-	25.	-	13.	0.	-
1990/91	18.	13.	87.	141.	54.	37.	0.	0.	-	-	-	32.	-
1991/92	115.	36.	-	-	-	-	-	1.	0.	0.	-	-	-
Mean	46.	56.	60.	82.	58.	48.	19.	7.	6.	4.	16.	28.	431.
Median	39.	51.	63.	84.	60.	45.	15.	1.	0.	0.	8.	12.	
Maximum	139.	132.	98.	180.	143.	124.	59.	37.	36.	22.	82.	141.	
Minimum	1.	13.	11.	19.	12.	8.	0.	0.	0.	0.	0.	0.	
St. dev.	36.	35.	28.	49.	30.	28.	16.	11.	11.	7.	22.	34.	
CV	.77	.62	.47	.60	.51	.59	.83	1.61	1.70	1.76	1.37	1.24	

Total monthly rainfall in millimetres

Data flags

Missing - flag "-" Original - no flag set Estimate - flag "e" .

Printed on 22/ 6/1994

Institute of Hydrology
Summary of monthly data - Rainfall

Station number : 26 Name : Sani Pass

Basin no. : 0 Latitude : 29:35: 0 S Longitude : 29:17: 0 E Altitude : 2440.0

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Total
75/76	-	-	258.	304.	228.	316.	-	-	-	-	19.	7.	-
1976/77	120.	41.	-	182.	125.	-	58.	0.	0.	0.	0.	71.	-
977/78	95.	74.	122.	248.	86.	84.	52.	0.	0.	11.	25.	66.	863.
78/79	-	62.	-	-	218.	-	25.	22.	-	16.	-	-	-
1979/80	-	-	-	-	-	-	-	-	-	-	-	-	-
980/81	-	-	-	-	-	-	-	-	-	-	-	-	-
81/82	-	-	-	-	-	-	-	-	-	-	-	-	
1982/83	-	-	-	-	-	-	-	.	-	-	-	-	-
1983/84	-	-	-	-	-	-	-	-	-	-	-	-	-
84/85	-	-	-	-	-	-	-	-	-	-	-	-	-
1985/86	196.	145.	179.	130.	76.	85.	31.	0.	23.	8.	32.	107.	1012.
1986/87	117.	118.	101.	88.	66.	55.	-	-	5.	0.	84.	58.	-
87/88	103.	56.	106.	209.	-	-	15.	-	-	-	0.	55.	-
1988/89	31.	106.	109.	116.	.	149.	81.	-	8.	5.	0.	0.	-
1989/90	105.	136.	116.	-	90.	79.	51.	5.	13.	7.	12.	4.	-
90/91	38.	-	-	115	-	-	-	-	-	-	-	-	-
ean	101.	92.	142.	174.	127.	128.	45.	5.	8.	7.	22.	46.	896.
Median	103.	74.	116.	130.	90.	84.	51.	0.	5.	7.	12.	55.	
ximum	196.	145.	258.	304.	228.	316.	81.	22.	23.	16.	84.	107.	
nimum	31.	41.	101.	88.	66.	55.	15.	0.	0.	0.	0.	0.	
St. dev.	52.	39	58.	75	68.	97.	23.	10.	9.	6.	28.	38.	
	.51	.42	.41	.43	.54	.76	.50	1.76	1.08	.86	1.31	.84	

Total monthly rainfall in millimetres

Data flags

Missing - flag "-" Original - no flag set Estimate - flag "e"

inted on 22/ 6/1994

Institute of Hydrology
Summary of monthly data - Rainfall

Station number : 76 Name : Sehlabathebe

Basin no. : 0 Latitude : 29:53: 0 S Longitude : 29: 4: 0 E Altitude : 2250.0

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Total
44/45	64.	93.	40.	131.	155.	123.	18.	0.	0.	0.	3.	8.	635.
1945/46	29.	14.	37.	98.	88.	104.	21.	22.	0.	1.	1.	7.	422.
1946/47	63.	126.	59.	99.	90.	77.	-	1.	61.	9.	4.	19.	-
47/48	-	137.	126.	146.	157.	121.	17.	17.	0.	0.	0.	4.	-
1948/49	35.	19.	56.	158.	102.	53.	56.	9.	0.	3.	4.	30.	525.
1949/50	48.	84.	125.	154.	157.	162.	25.	29.	0.	5.	97.	12.	898.
50/51	35.	77.	118.	98.	-	-	-	-	-	-	-	-	-
1951/52	-	-	-	-	-	-	-	-	-	-	-	-	-
1952/53	-	-	-	-	-	-	-	-	-	-	-	-	-
53/54	-	-	-	-	-	-	-	-	-	-	-	-	-
1954/55	-	-	-	-	-	-	-	-	-	-	-	-	-
1955/56	-	-	-	-	-	-	-	-	-	-	-	-	-
56/57	-	-	-	-	-	-	-	-	-	-	-	-	-
1957/58	-	-	-	-	-	-	-	-	-	-	-	-	-
1958/59	-	-	-	-	-	-	-	-	-	-	-	-	-
59/60	-	-	-	-	-	-	-	-	-	-	-	-	-
960/61	-	-	-	-	-	-	-	-	-	-	-	-	-
1961/62	-	-	-	-	-	-	-	-	-	-	-	-	-
62/63	-	-	-	-	-	-	-	-	-	-	-	-	-
63/64	-	-	-	-	-	-	-	-	-	-	-	-	-
1964/65	-	-	-	-	-	-	-	-	-	-	-	-	-
65/66	-	-	-	-	-	-	-	-	-	-	-	-	-
66/67	-	-	-	-	-	-	-	-	-	-	-	-	-
1967/68	-	-	-	-	-	-	-	-	-	-	-	-	-
68/69	-	-	-	-	-	-	-	-	-	-	-	-	-
69/70	-	-	-	-	-	-	-	-	-	-	-	-	-
1970/71	-	-	-	-	-	-	-	-	-	-	-	-	-
71/72	-	-	-	-	-	-	-	-	-	-	-	-	-
72/73	-	-	-	-	-	-	-	-	-	-	-	-	-
1973/74	-	-	-	-	-	-	-	-	-	-	-	-	-

Institute of Hydrology
Summary of monthly data - Rainfall

Station number : 76 Name : Sehlabathebe

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Total
1974/75	-	-	-	-	.	-		32.	-	10.		78.	-
1975/76	37.	130.	235.	285.	165.	280.	44.	30.	3.	-	-	43.	
1976/77	101.	37.	125.	142.	106.	90.	16.	4.	0.	0.	2.	39.	662.
1977/78	119.	-	102.	151.	77.	85.	-	-	-	-	35.	96.	-
1978/79	17.	79.	114.	100.	225.	81.	29.	7.	5.	42.	27.	41.	767.
1979/80	15.	-	114.	109.	225.	195.	19.	34.	1.	0.	0.	86.	-
1980/81	44.	85.	87.	140.	132.	33.	43.	18.	11.	1.	40.	23.	657.
1981/82	41	87.	111.	111.	56.	115.	67.	5.	13.	14.	0.	34.	654.
1982/83	138.	93.	41.	75.	89	82.	42.	8.	0.	65.	5.	17.	655.
1983/84	58.	95.	-	62.	78.	145.	58.	16.	19.	33.	26.	27.	-
1984/85	71.	74.	54.	158.	307.	22.	14.	2.	0.	4	11.	7.	724.
1985/86	117.	-	-	207.	89.	61.	33.	0.	33.	0.	31.	40.	-
1986/87	139.	97.	104.	87.	132.	86.	33.	0.	32.	8.	56.	246.	1020.
1987/88	89.	75.	86.	114.	189.	-	-	29.	12.	27.	21.	37.	-
1988/89	-	-	-	34.	-	48.	48.	22.	-	-	1	8.	-
1989/90	51.	199.	112.	194.	44.	82.	42.	-	22.	6.	34.	5.	-
1990/91	49.	20.	111.	-	133.	123.	10.	9.	6.	0.	2.	28.	-
1991/92	-	-	-	-	-	-	-	0.	0.	0.	-	-	-
Mean	65.	85.	98.	130.	133.	103.	33.	13.	10.	11.	19.	41.	742.
Median	51.	85.	104.	114.	132.	86.	33.	9.	3.	4.	5.	28.	
Maximum	139.	199.	235.	285.	307.	280.	67.	34.	61.	65.	97.	246.	
Minimum	15.	14.	37.	34.	44.	22.	10.	0.	0.	0.	0.	4.	
St. dev.	38.	45.	45.	54.	64.	58.	17.	12.	16.	17.	24.	52.	
	.59	.52	.46	.41	.48	.56	.50	.89	1.51	1.58	1.28	1.27	

Total monthly rainfall in millimetres

Data flags

Missing - flag "-" Original - no flag set Estimate - flag "e"

Printed on 30/ 6/1994

Institute of Hydrology
Summary of monthly data - Rainfall

Station number : 84 Name : ST MARTINS

Basin no. : 0 Latitude : 29:17: 0 S Longitude : 28:45: 0 E Altitude : 2270.0

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Total
1971/72	90.	61.	86.	163.	140.	112.	26.	27.	10.	12.	11.	40.	778.
1972/73	87.	98.	42.	77.	153.	82.	40.	5.	2.	16.	67.	42.	711.
1973/74	23.	110.	110.	155.	195.	49.	51.	24.	26.	6.	29.	27.	805.
1974/75	37.	143.	111.	103.	-	99.	34.	8.	3.	22.	13.	184.	-
1975/76	59.	177.	106.	116.	93.	159.	67.	27.	22.	0.	6.	59.	891.
1976/77	159.	107	55.	186.	-	119.	20.	19.	2.	0.	4.	56.	-
1977/78	95.	-	67.	168.	85.	69.	95.	0.	0.	0.	27.	95.	-
1978/79	83.	34.	180.	61.	94.	60.	38.	40.	5.	90.	47.	54.	786.
1979/80	71.	124.	129.	73.	-	50.	11.	24.	0.	0.	0.	72.	-
1980/81	39.	131.	126.	139.	98.	26.	73.	17.	28.	3.	67.	27.	774.
1981/82	29.	103.	113.	103.	58.	74.	114.	5.	0.	19.	0.	15.	633.
1982/83	125.	66.	47.	130.	63.	104.	34.	21.	0.	26.	0.	26.	642.
1983/84	102.	100.	124.	131.	65.	51.	32.	62.	1.	0.	64.	7.	739.
1984/85	85.	82.	74.	94.	145.	37.	33.	5.	0.	0.	0.	2.	557.
1985/86	144.	69.	150.	167.	87.	59.	78.	0.	53.	1.	59.	52.	919.
1986/87	204.	106.	51.	76.	88.	71.	61.	3.	-	9.	81.	251.	-
1987/88	54.	111.	79.	141.	146.	132.	52.	52.	11.	25.	19.	44.	866.
1988/89	111.	126.	-	-	252.	64.	27.	74.	-	2.	7.	7.	-
1989/90	64.	-	-	-	36.	-	119.	7.	31.	-	17.	1.	-
1990/91	-	22.	95.	93.	-	94.	5.	-	-	-	-	-	-
1991/92	-	-	-	-	-	-	-	0.	0.	0.	-	-	-
Mean	87.	98.	97.	121.	112.	80.	51.	21.	11.	12.	27.	56.	773.
Median	85.	103.	95.	116.	93.	71.	38.	17.	2.	3.	17.	42.	
Maximum	204.	177.	180.	186.	252.	159.	119.	74.	53.	90.	81.	251.	
Minimum	23.	22.	42.	61.	36.	26.	5.	0.	0.	0.	0.	1.	
Std dev.	47.	38.	38.	38.	56.	35.	32.	21.	15.	21.	28.	63.	
CV	.54	.39	.39	.31	.50	.43	.63	1.02	1.40	1.73	1.02	1.13	

Total monthly rainfall in millimetres

Data flags

Missing - flag "-" Original - no flag set Estimate - flag "e"

Printed on 22/ 6/1994

Institute of Hydrology
Summary of monthly data - Rainfall

Station number : 60 Name : Leribe (RAINDAT)

Basin no. : 0 Latitude : 0: 0: 0 N Longitude : 0: 0: 0 E Altitude : 0

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Total
86/87	-		-	53.	90.	149.	65.	69.	3.	31.	38.	4.	-
87/88	36.	46.	104.	161.	199.	207.	150.	25.	0.	34.	33.	31.	1026.
1888/89	89.	66.	70.	161.	91.	86.	60.	-	0.	0.	19.	38.	-
89/90	111.	86.	60.	64.	143.	56.	51.	0.	17.	14.	18.	0.	620.
90/91	63.	85.	85.	235.	56.	175.	78.	119.	60.	28.	34.	2.	1020.
1891/92	29.	144.	128.	91.	149.	102.	17.	15.	12.	0.	49	61.	797.
92/93	130.	82.	107.	289.	57.	71.	36.	5.	1.	13.	0.	83.	874.
93/94	77.	135.	114.	141.	185.	182.	51.	21.	28.	0.	34.	-	-
1894/95	87.	-	103.	84.	133.	167.	54.	30.	0.	0.	0.	27.	-
95/96	19.	90.	171.	110.	51.	29.	122.	64.	28.	0.	53.	28.	765.
96/97	4.	32.	308.	114.	49.	180.	15.	9.	0.	0.	13.	3.	727.
1897/98	121.	4.	69.	415.	47.	147.	18.	38.	0.	0.	13.	11.	883.
98/99	57.	73.	135.	152.	84.	137.	99.	37.	19.	105.	39.	15.	952.
9/00	64.	71.	89.	207.	115.	34.	61.	0.	36.	23.	80.	0.	780.
1900/01	37.	71.	94.	125.	154.	173.	91.	1.	1.	-	-	-	-
901/02	-	-	-	-	-	-	-	-	-	-	-	-	-
2/03	-	-	-	-	-	-	-	-	-	-	-	-	-
1903/04	-	-	-	-	-	-	-	-	-	-	-	-	-
904/05	-	-	-	-	-	-	-	-	2.	0.	11.	60.	-
5/06	16.	115.	103.	231.	68.	141.	32.	19.	5.	0.	0.	81.	811.
1906/07	115.	171.	171.	248.	142.	102.	127.	69.	2.	8.	0.	76.	1231.
1907/08	126.	139.	147.	108.	73.	173.	9.	5.	50.	10.	33.	64.	937.
8/09	89.	122.	90.	394.	267.	130.	53.	85.	0.	5.	16.	56.	1307.
1909/10	19.	77.	242.	240.	215.	84.	26.	31.	14.	4.	2.	71.	1025.
1910/11	192.	48.	73.	86.	103.	216.	85.	73.	6.	31.	22.	34.	969.
1/12	83.	128.	43.	55.	383.	32.	139.	76.	29.	8.	1.	1.	978.
1912/13	51.	35.	190.	81.	106.	134.	30.	3.	3.	9.	23.	36.	701.
1913/14	119.	83.	5.	56.	104.	70.	73.	21.	8.	0.	33.	18.	590.
4/15	95.	105.	111.	171.	144.	39.	8.	26.	1.	42.	4.	40.	786.
1915/16	84.	210.	85.	129.	75.	84.	108.	21.	0.	3.	0.	11.	810.

Institute of Hydrology
Summary of monthly data - Rainfall

Station number : 60 Name : Leribe (RAINDAT)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Total
916/17	66.	53.	137.	153.	99.	57.	66.	5.	44.	24.	31.	27.	762.
17/18	37.	157.	103.	129.	97.	94.	0.	9.	1.	26.	50.	56.	759.
1918/19	35.	47.	107.	126.	25.	72.	58.	11.	3.	8.	6.	67.	565.
919/20	13.	142.	33.	136.	123.	141.	39.	9.	2.	0.	18.	43.	699.
20/21	131.	54.	49.	86.	170.	199.	61.	28.	1.	0.	1.	46.	826.
1921/22	35.	158.	147.	190.	95.	56.	5.	0.	77.	8.	31.	16.	818.
922/23	65.	148.	118.	104.	80.	98.	76.	52.	59.	18.	32.	1.	851.
23/24	33.	116.	49.	114.	98.	169.	18.	7.	3.	2.	5.	80.	696.
1924/25	80.	167.	134.	71.	155.	251.	144.	22.	2.	6.	1.	64.	1097.
925/26	86.	79.	39.	94.	115.	168.	5.	23.	14.	0.	0.	70.	693.
26/27	86.	186.	147.	143.	95.	120.	15.	8.	0.	23.	16.	2.	841.
1927/28	85.	49.	151.	199.	83.	102.	28.	0.	2.	0.	3.	34	736.
928/29	147.	117.	114.	237.	40.	177.	19.	46.	55.	29.	17.	173.	1171.
29/30	50.	131.	188.	166.	107.	172.	84.	15.	0.	4.	15.	10.	942.
1930/31	36.	74.	125.	177.	107.	90.	190.	8.	3.	39.	0.	0.	849.
1931/32	58	101.	68.	90.	169.	89.	3.	15.	1.	0.	0.	15.	609.
32/33	34.	72.	102.	36.	91.	118.	48.	12.	9.	15.	0.	6.	543.
1933/34	14.	306.	246.	330.	67.	175.	69.	89.	3.	46.	30.	6.	1381.
1934/35	81.	257.	136.	155.	54.	121.	38.	49.	0.	0.	17.	12.	920.
35/36	31.	61.	121.	88.	22.	87.	22.	74.	1.	2.	0.	3.	512.
1936/37	100.	227.	112.	210.	196.	89.	28.	9.	0.	6.	0.	28.	1005.
1937/38	41.	44.	90.	145.	206.	16.	90.	27.	39.	7.	44.	21.	770.
38/39	67.	39.	124.	212.	219.	59.	25.	38.	1.	23.	50.	24.	881.
1939/40	77.	144.	84.	63.	147.	61.	95.	41.	15.	8.	1.	88.	824.
1940/41	18.	106.	165.	158.	174.	26.	75.	0.	0.	14.	0.	53.	789.
41/42	123.	5	21.	130.	117.	125.	59.	22.	36.	0.	67.	13.	718.
942/43	98.	109.	165.	136.	55.	103.	117.	89.	0.	92.	38.	7.	1009.
1943/44	137.	234.	219.	70.	165.	134.	4.	79.	72.	0.	0.	71.	1185.
44/45	113.	158.	27.	81.	210.	136.	51.	28.	0	1.	0.	4.	809.
945/46	74.	54.	49.	145.	76.	99.	28.	66.	0.	3.	0.	9.	603.

Institute of Hydrology
Summary of monthly data - Rainfall

Station number : 60 Name : Leribe (RAINDAT)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Total
1946/47	133.	74.	63.	82.	90.	82.	107.	18.	6.	9.	2.	67.	733.
1947/48	87.	81.	261.	96.	111.	218.	55.	9.	0.	0.	2.	0.	920.
1948/49	81.	54.	28.	110.	79.	173.	38.	36.	9.	4.	1.	30.	643.
1949/50	81.	141.	150.	147.	120.	210.	111.	68.	9.	15.	80.	18.	1150.
1950/51	47.	51.	174.	134.	178.	147.	53.	28.	11.	4.	32.	13.	872.
1951/52	154.	36.	56.	134.	142.	52.	22.	14.	6.	21.	8.	30.	675.
1952/53	30.	78.	125.	48.	184.	53.	38.	19.	4.	0.	8.	10.	597.
1953/54	107.	105.	112.	136.	117.	141.	36.	40.	3.	1.	0.	1.	799.
1954/55	29.	119.	98.	176.	252.	43.	93.	56.	10.	0.	0.	0.	876.
1955/56	67.	129.	172.	171.	108.	131.	55.	67.	0.	6.	0.	24.	930.
1956/57	104.	107.	271.	169.	98.	127.	62.	10.	30.	19.	36.	131.	1164.
1957/58	232.	105.	134.	172.	95.	105.	98.	44.	2.	0.	0.	62.	1049.
1958/59	41.	77.	126.	111.	39.	49.	86.	113.	8.	46.	0.	15.	711.
1959/60	87.	118.	151.	98.	190.	146.	67.	0.	0.	9.	29.	49.	944.
1960/61	54.	97.	115.	121.	37.	106.	107.	55.	48.	18.	9.	20.	787.
1961/62	8.	126.	76.	79.	146.	65.	62.	4.	0.	0.	7.	19.	592.
1962/63	42.	95.	36.	170.	126.	124.	118.	31.	15.	14.	2.	5.	778.
1963/64	56.	105.	102.	52.	55.	113.	42.	7.	0.	0.	14.	52.	593.
1964/65	136.	45.	133.	148.	31.	13.	92.	0.	20.	12.	15.	12.	657.
1965/66	39.	62.	39.	175.	69.	40.	43.	14.	13.	0.	2.	11.	507.
1966/67	39.	69.	98.	305.	216.	114.	84.	45.	0.	0.	4.	4.	978.
1967/68	85.	53.	93.	25.	30.	139.	66.	64.	0.	10.	17.	6.	588.
1968/69	58.	30.	95.	66.	111.	138.	59.	86.	7.	1.	9.	9.	669.
1969/70	113.	38.	124.	69.	24.	15.	19.	13.	20.	25.	22.	41.	523.
1970/71	60.	41.	158.	128.	84.	42.	46.	51.	0.	5.	2.	5.	622.
1971/72	60.	58.	65.	120.	167.	103.	50.	16.	13.	0.	0.	0.	652.
1972/73	59.	67.	20.	44.	169.	49.	51.	0.	0.	16.	64.	34.	573.
1973/74	5.	21.	107.	171.	84.	112.	41.	9.	8.	0.	11.	0.	569.
1974/75	18.	187.	49.	95.	135.	112.	28.	-	0.	15.	13.	78.	-
1975/76	50.	136.	100.	87.	121.	69.	38.	21.	19.	-	-	73.	-

Institute of Hydrology
Summary of monthly data - Rainfall

Station number : 60 Name : Leribe (RAINDAT)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Total
1976/77	73.	48.	55.	168.	94.	136.	6.	8.	0.	0.	.	-	-
77/78	-	-	-	-	-	-	-	-	-	-	-	-	-
1978/79	-	-	-	-	-	-	-	26.	8.	-	-	-	-
1979/80	-	-	-	-	-	60.	24.	7.	2.	0.	1.	108.	-
80/81	12.	116.	69.	287.	67.	79.	46.	12.	23.	0.	43.	15.	769.
1981/82	27.	92.	105.	96.	79.	57.	161.	8.	13.	8.	0.	2.	648.
1982/83	89.	-	76.	45.	67.	45.	39.	.	5.	11.	0.	20.	-
83/84	59.	122.	91.	83.	35.	74.	51.	34.	1.	4.	51.	0.	605.
1984/85	41.	93.	39.	56.	100.	34.	0.	0.	1.	0.	0.	1.	365.
1985/86	64.	63.	90.	49.	104.	51.	47.	0.	52.	0.	50.	14.	584.
86/87	174.	95.	38.	30.	96.	116.	78.	0.	0.	9.	60.	157.	853.
1987/88	39.	94.	88.	147.	259.	185.	89.	40.	14.	-	12.	62.	-
1988/89	91.	45.	116.	128.	137.	69.	50.	54.	32.	3.	7.	0.	732.
89/90	48.	146.	50.	55.	102.	130.	130.	28.	23.	16.	24.	0.	752.
ean	71.	98.	108.	136.	116.	108.	59.	30.	12.	11.	17.	32.	800.
Median	64.	90.	103.	128.	104.	103.	51.	21	3.	5.	11.	19.	
ximum	232.	306	308.	415.	383.	251.	190.	119.	77.	105.	80.	173.	
inimum	4.	4.	5.	25.	22.	13.	0.	0.	0.	0.	0.	0.	
St. dev.	43.	55.	57.	74.	62.	53.	39.	28.	17.	17.	20.	35.	
V	.60	.56	.53	.55	.53	.49	.66	.93	1.45	1.54	1.15	1.08	

Total monthly rainfall in millimetres

Data flags

Missing - flag "-" Original - no flag set Estimate - flag "e"

inted on 22/ 6/1994

Institute of Hydrology
Summary of monthly data - Rainfall

Station number : 64 Name : Butha Buthe (RAINDAT)

Basin no. : 0 Latitude : 0: 0: 0 N Longitude : 0: 0: 0 E Altitude : .0

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Total
1890/91	-	-	-	-	-	-	94.	60.	24.	11.	38.	1.	-
1891/92	-	141.	-	-	121.	157.	11.	18.	11.	0.	32.	81.	-
1892/93	113.	81.	107.	213.	87.	69.	25.	1.	35.	7.	3.	69.	810.
1893/94	75.	198.	114.	148.	103.	74.	31.	31.	41.	0.	25.	67.	907.
1894/95	74.	74.	90.	87.	117.	106.	67.	27.	0.	12.	0.	25.	679.
1895/96	32.	129.	145.	77.	80.	47.	86.	9.	10.	0.	39.	26.	680.
1896/97	12.	68.	214.	114.	103.	114.	11.	29.	0.	0.	10.	30.	705.
1897/98	80.	5.	59.	376.	55.	75.	37.	41.	0.	0.	14.	27.	769.
1898/99	82.	102.	90.	117.	109.	151.	87.	35.	18.	97.	35.	18.	941.
1899/00	59.	86.	64.	199.	130.	63.	74.	0.	38.	30.	82.	0.	825.
1900/01	68.	88.	148.	-	-	-	-	-	-	-	-	-	-
1901/02	-	-	-	-	-	-	-	-	-	-	-	-	-
1902/03	-	-	-	-	-	-	-	-	-	-	-	-	-
1903/04	-	-	-	-	-	-	-	-	-	-	-	-	-
1904/05	-	-	-	-	-	-	-	-	-	-	-	-	-
1905/06	-	-	-	-	-	-	-	-	-	-	-	-	-
1906/07	-	-	-	-	-	-	-	-	-	-	-	-	-
1907/08	-	-	-	-	-	-	-	-	-	-	-	-	-
1908/09	-	-	-	-	-	-	-	-	-	-	-	-	-
1909/10	-	-	-	-	-	-	-	-	-	-	-	-	-
1910/11	-	-	-	-	-	-	-	-	-	-	-	-	-
1911/12	-	-	-	-	-	-	-	-	-	-	-	-	-
1912/13	-	-	-	-	-	-	-	-	-	-	-	-	-
1913/14	-	-	-	-	-	-	-	-	-	-	-	-	-
1914/15	-	-	-	-	-	-	-	-	-	-	-	-	-
1915/16	-	-	-	-	-	-	-	-	-	-	-	-	-
1916/17	-	-	-	-	-	-	-	-	-	-	-	-	-
1917/18	-	-	-	-	-	-	-	-	-	-	-	-	-
1918/19	-	-	-	-	-	-	-	-	-	-	-	-	-
1919/20	-	-	-	-	-	-	-	-	-	-	-	-	-

Institute of Hydrology
Summary of monthly data - Rainfall

Station number : 64 Name : Butha Buthe (RAINDAT)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Total
1920/21	112.	68.	67.	105.	148.	157.	54.	21.	0.	0.	0.	55.	787.
1921/22	20.	117.	116.	243.	29.	44.	0.	32.	30.	0.	39.	0.	670.
1922/23	76.	157.	123.	126.	61.	30.	96.	47.	65.	23.	32.	2.	838.
1923/24	40.	101.	59.	132.	100.	196.	19.	3.	4.	0.	7.	118.	779.
1924/25	102.	218.	128.	52.	127.	219.	110.	49.	2.	0.	5.	44.	1056.
1925/26	63.	107.	30.	145.	99.	126.	2.	15.	26.	3.	0.	65.	681.
1926/27	123.	146.	133.	97.	138.	101.	27.	4.	0.	38.	11.	2.	820.
1927/28	94.	35.	191.	122.	200.	84.	22.	0.	3.	0.	3.	20.	774.
1928/29	101.	87.	149.	144.	89.	126.	20.	16.	68.	30.	21.	126.	977.
1929/30	45.	127.	196.	227.	107.	126.	103.	14.	2.	0.	14.	2.	963.
1930/31	28.	44.	122.	120.	86.	129.	157.	4.	0.	26.	0.	0.	716.
1931/32	58.	102.	44.	77.	189.	159.	17.	8.	0.	0.	0.	19.	673.
1932/33	27.	92.	122.	35.	85.	76.	29.	15.	4.	3.	0.	11.	499.
1933/34	27.	214.	232.	304.	122.	147.	90.	0.	76.	61.	48.	6.	1327.
1934/35	82.	231.	99.	97.	37.	94.	32.	36.	3.	0.	14.	12.	737.
1935/36	56.	54.	109.	85.	103.	100.	28.	63.	0.	0.	0.	0.	598.
1936/37	90.	189.	100.	232.	154	134.	16.	5.	0.	5.	1.	0.	926.
1937/38	50.	47.	76.	193.	188.	5.	54.	28.	57.	8.	76.	47.	829.
1938/39	91.	41.	91.	109.	203.	49.	0.	49.	6.	17.	35.	37.	728.
1939/40	87.	145.	81.	99.	75.	82.	109.	38.	7.	0.	0.	59.	782.
1940/41	4.	126.	139.	121.	127.	65.	75.	9.	0.	18.	0.	46.	730.
1941/42	110.	4.	77.	145.	126.	137.	75.	26.	0.	0.	51.	46.	797.
1942/43	114.	90.	167.	132.	71.	127.	63.	78.	1.	87.	42.	18.	990.
1943/44	139.	179.	216.	131.	144.	95.	4.	26.	53.	0.	0.	82.	1071.
1944/45	96.	111.	28.	59.	113.	179.	62.	28.	0.	0.	0.	0.	676.
1945/46	45.	44.	65.	150.	67.	98.	34.	66.	0.	3.	0.	8.	580.
1946/47	152.	166.	71.	84.	105.	75.	104.	11.	4.	7.	0.	54.	833.
1947/48	104.	117.	188.	104.	74.	208.	97.	13.	0.	0.	4.	8.	917.
1948/49	77.	-	18.	131.	86.	203.	102.	20.	3.	5.	8.	5.	-
1949/50	25.	9.	88.	101.	125.	103.	115.	82.	4.	18.	61.	12.	743.

Institute of Hydrology
Summary of monthly data - Rainfall

Station number : 64 Name : Butha Buthe (RAINDAT)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Total
1950/51	39.	46.	185.	131.	92.	92.	75.	34.	16.	1.	30.	21.	762.
51/52	213.	35.	86.	82.	205.	90.	55.	9.	2.	36.	16.	21.	850.
1952/53	36.	85.	100.	59.	183.	38.	41.	17.	3.	0.	6.	11.	579.
1953/54	105.	59.	141.	149.	94.	103.	36.	26.	7.	0.	0.	12.	732.
54/55	18.	87.	76.	216.	196.	52.	64.	55.	6.	6.	0.	5.	781.
1955/56	58.	135.	133.	42.	116.	32.	66.	40.	0.	3.	0.	20.	645.
1956/57	109.	142.	213.	117.	96.	208.	42.	4.	32.	27.	35.	154.	1179.
57/58	219.	84.	81.	199.	44.	53.	67.	36.	8.	0.	0.	53.	844.
1958/59	69.	98.	105.	68.	35.	18.	98.	120.	6.	51.	0.	9.	677.
1959/60	111.	78.	172.	54.	168.	164.	58.	31.	5.	13.	28.	34.	916.
60/61	99.	145.	151.	147.	75.	107.	97.	58.	48.	14.	8.	36.	985.
1961/62	11	160.	87.	64.	180.	84.	68.	5.	0.	0.	8.	7.	674.
1962/63	44.	86.	25.	168.	87.	125.	106.	34.	14.	25.	10.	5.	729.
63/64	77.	106.	93.	143.	79.	174.	33.	10.	33.	0.	19.	24.	791.
1964/65	124.	52.	148.	115.	20.	3.	73.	0.	8.	21.	0.	15.	579.
1965/66	66.	102.	11.	186.	51.	35.	26.	23.	11.	0.	6.	6.	523.
66/67	62.	78.	69.	303.	93.	96.	86.	48.	0.	0.	7.	9.	851.
1967/68	56.	96.	69.	41.	34.	130.	59.	76.	0.	11.	13.	6.	591.
1968/69	56.	59.	83.	47.	59.	113.	47.	89.	14.	0.	9.	-	-
69/70	-	-	136.	98.	65.	50.	15.	5.	34.	26.	23.	32.	-
70/71	30.	62.	168.	138.	83.	115.	65.	61.	2.	18.	0.	6.	748.
1971/72	37.	65.	103.	159.	131.	133.	29.	20.	0.	0.	9.	8.	694.
72/73	48.	103.	8.	66.	139.	71.	55.	7.	0.	17.	84.	89.	687.
73/74	17.	100.	140.	177.	107.	86.	28.	15.	18.	0.	8.	11.	707.
1974/75	52.	235.	44.	140.	141.	128.	49.	33.	3.	14.	5.	78.	922.
75/76	47.	195.	112.	113.	141.	252.	67.	29.	19.	0.	3.	56.	1034.
76/77	134.	140.	71.	161.	50.	153.	16.	8.	0.	0.	0.	60.	793.
1977/78	102.	19.	88.	167.	66.	188.	92.	5.	6.	5.	16.	44.	798.
78/79	53.	35.	165.	107.	137.	64.	11.	29.	7.	48.	126.	49.	831.
79/80	94.	108.	89.	61.	91.	41.	4.	14.	9.	0.	6.	100.	617.

Institute of Hydrology
Summary of monthly data - Rainfall

Station number : 64 Name : Butha Buthe (RAINDAT)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Total
1980/81	9.	108.	124.	237.	87.	86.	56.	10.	35.	0.	54.	8.	814.
1981/82	8.	111.	122.	90	23.	62.	133.	11.	19.	17.	0.	29.	625.
1982/83	131.	102.	49.	63.	84.	84.	44.	17.	25.	32.	0.	18.	649.
1983/84	68.	121.	-	71.	-	-	-	50.	9.	-	53.	16.	-
1984/85	71.	77.	74.	76.	83.	54.	26.	0.	0.	1.	0.	2.	464.
1985/86	82.	107.	151	71	71.	38.	87.	0.	35.	0.	51.	13.	706.
1986/87	-	135.	43.	65.	100.	65.	74.	0.	2.	8.	91.	187	-
1987/88	36.	80.	87.	146.	140.	219.	61.	41.	18.	16.	10.	35.	889.
1988/89	94.	72.	125.	130.	147.	104.	47.	50.	47.	0.	6.	2.	824.
1989/90	72.	166.	13.	20.	160.	118.	136.	8.	15.	17.	18.	0.	743.
1990/91	35.	18.	73.	284.	149.	114.	5.	3.	15.	0.	0.	55.	751.
1991/92	120.	22.	115.	53.	71.	85.	12.	0.	0.	3.	74.	74.	629.
Mean	73.	101.	106.	126.	106.	104.	56.	27.	14.	12.	19.	33.	778.
Median	69.	98.	100.	117.	100.	98.	55.	20.	6.	3.	8.	20.	
Maximum	219.	235.	232.	376.	205.	252.	157.	120.	76.	97.	126.	187.	
Minimum	4.	4.	8.	20.	20.	3.	0.	0.	0.	0.	0.	0.	
. dev.	42.	53.	51.	67.	45.	53.	36.	24.	18.	19.	26.	37.	
	.58	.52	.48	.53	.42	.51	.64	.91	1.32	1.60	1.34	1.11	

Total monthly rainfall in millimetres

Data flags

Missing - flag "-" Original - no flag set Estimate - flag "e"

Printed on 22/ 6/1994

Institute of Hydrology
Summary of monthly data - Rainfall

Station number : 73 Name : Teyateyaneng (RAINDAT)

Basin no. : 0 Latitude : 0: 0: 0 N Longitude : 0: 0: 0 E Altitude : .0

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Total
95/96	-	-	-	34.	74.	36.	74.	61.	21.	0.	80.	6.	-
1896/97	13.	54	273.	131.	78.	133.	24.	11.	0	0.	5.	3.	725.
1897/98	66.	1.	72.	343.	87.	82.	28.	49.	0.	1.	1.	11.	741.
98/99	89.	86.	75	135.	102.	91.	103.	31.	27.	86.	47.	10.	882.
1899/00	64.	36.	139.	186.	134.	78.	47.	0.	26.	16.	47.	0.	773.
1900/01	69.	38.	142.	120.	146.	206.	85.	0.	0.	4.	44.	33.	887.
01/02	113.	86.	102.	160.	66.	244.	91.	3.	29.	17.	5.	79.	995.
1902/03	73.	28.	63.	52.	108.	8.	125.	34.	0.	0.	0.	0.	491.
1903/04	61.	83.	52.	164.	103.	43.	42.	27.	54.	0.	1.	16.	646.
04/05	28.	63.	81.	147.	180.	176.	33.	0.	8.	0.	16.	61.	793.
1905/06	16.	56.	77.	124.	93.	106.	29.	15.	6.	0.	0.	62.	584.
1906/07	77.	95.	104	151.	98.	156.	131.	74.	0.	0.	0.	37.	923.
07/08	65.	136.	149.	88.	73.	96.	24.	3.	49.	14.	31.	52.	780.
1908/09	84.	64.	115.	280.	252.	54.	65.	87.	0.	0.	5.	65.	1071.
1909/10	28.	61.	207.	267.	79.	83.	21.	25.	10.	5.	0.	50.	836.
10/11	146.	35.	42.	74.	27.	123.	71.	49.	9.	28.	23.	16.	643.
1911/12	70.	110.	72.	75.	193.	60.	79.	51.	18.	6.	0.	0.	734.
1912/13	29.	25.	92.	82.	74.	182.	64.	2	6.	8.	15.	35.	614.
13/14	84.	54.	0.	98.	86.	41.	83.	34.	5.	0.	32.	20.	537.
1914/15	60.	85.	142.	219.	118.	16.	13.	25.	3.	40.	6.	43.	770.
1915/16	76.	179.	92.	114.	47.	64.	49.	10.	0.	5.	0.	15.	651.
16/17	95.	48.	122.	178.	104.	83.	42.	9.	16.	17.	74.	26.	814.
17/18	26.	115.	107.	137.	77.	130.	1.	12.	1.	45.	40.	51.	742.
1918/19	42.	60.	114.	174.	24.	97.	50.	8.	3.	7.	11.	51.	641.
19/20	28.	119	20.	132.	112.	170.	26.	17.	0.	5.	5.	40.	674.
20/21	99.	38.	36.	91.	190.	196.	45.	32.	0.	0.	0.	24.	751.
1921/22	40.	115.	219.	116.	69.	30.	2.	20.	27.	5.	12.	12.	667.
22/23	74.	143.	72.	127.	105.	42.	63.	22.	38.	24.	26.	1.	737.
23/24	37.	79.	22.	80.	79.	173.	11.	9.	1.	1.	1.	70.	563.
1924/25	65.	144.	94.	48.	118.	204.	86.	66.	1.	4.	2.	39.	871.

Institute of Hydrology
Summary of monthly data - Rainfall

Station number : 73 Name : Teyateyaneng (RAINDAT)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Total
1925/26	78.	58.	54.	93.	66.	134.	6.	19.	15.	0.	0.	32.	555.
1926/27	67.	91.	61.	76.	83.	146.	2.	0	0.	31.	24.	3.	584.
1927/28	100.	13.	134.	198.	88.	70.	24.	0.	7.	0.	2.	4.	640.
1928/29	73.	84.	106.	141.	22.	137.	29.	24.	46.	15.	14.	84.	775.
1929/30	36.	80.	141.	49.	93.	112.	54.	15.	1.	0.	12.	1.	594.
1930/31	49	39.	64.	81.	87.	80.	175.	1.	1.	46.	0.	0.	623.
1931/32	49.	151.	23.	80.	94.	117.	5.	21.	0.	0.	0.	22.	562.
1932/33	16.	62.	70.	24.	34.	48.	28.	11.	7.	6.	0.	13.	319.
1933/34	9.	199.	196.	340.	104.	90.	119.	80.	0.	30.	30.	13.	1212.
1934/35	58.	146.	75.	64.	99.	153.	60.	32.	10.	1.	9.	11.	718.
1935/36	60.	94.	124.	66.	77.	114.	21.	56	0.	1.	0.	2.	615.
1936/37	101.	218.	107.	167.	78.	78.	32	7.	0.	5.	2.	23.	818.
1937/38	40.	99.	63.	122.	128	17.	68	15.	23.	13.	20.	13.	621.
1938/39	72.	69.	102.	156.	117.	40	12.	32.	3	23.	45.	17	688.
1939/40	98.	103.	52.	54.	106.	63.	68.	46.	6.	7.	0.	65.	668.
1940/41	14.	71.	123.	102.	117.	42.	92.	0.	0	11.	0.	62.	634.
1941/42	94.	6	28.	100.	73.	114.	62.	19.	2.	0.	46.	28.	572.
1942/43	83.	130.	117.	70.	27.	70.	78.	63.	1.	68.	40.	24.	771.
1943/44	118.	222.	134.	57.	94.	70.	5.	48.	55.	0.	0.	42.	845
1944/45	89.	56.	14.	57.	82.	146.	9.	30.	0.	0.	0.	0.	485
1945/46	20.	48.	50.	149.	17.	159.	37.	42.	3.	0.	0.	5.	530.
1946/47	156.	63.	77.	45.	75.	76.	71.	7.	0.	0.	0.	37.	607.
1947/48	98.	38.	111.	85.	65.	198.	74.	31.	0.	4.	2.	0.	706.
1948/49	35.	16.	11.	130.	89.	66.	19.	26.	7.	7.	1.	18.	425.
1949/50	55.	96.	114.	70.	117.	160.	154.	74.	13.	41.	80.	7.	981.
1950/51	30.	80.	171.	132.	56.	76.	86.	32.	9.	1.	10.	22.	705.
1951/52	154.	88.	34.	110.	99.	75.	17.	8.	20.	35.	13.	32.	685.
1952/53	57.	101.	122.	147.	177.	68.	95.	15.	2.	0.	14.	13.	811.
1953/54	129.	115.	97.	94.	108.	142.	18.	55.	4.	0.	0.	6.	768.
1954/55	4.	72.	74.	277.	160.	62.	57.	50.	19.	17.	0.	0.	792.

Institute of Hydrology
Summary of monthly data - Rainfall

Station number : 73 Name : Teyateyaneng (RAINDAT)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Total
1955/56	60.	88.	156.	74.	174.	136.	30.	26.	5.	7.	0.	18.	774.
1956/57	102.	46.	240.	123.	72.	84.	52.	12.	26.	16.	50.	145.	968.
1957/58	218.	107.	111.	171.	141.	86.	94.	73.	2.	0.	0	39.	1042.
1958/59	22.	118.	83.	160.	91.	79	113.	89.	2.	52.	0.	6.	815.
1959/60	58.	33.	179.	95.	107.	145.	74.	9.	10	10.	40.	32.	792
1960/61	76.	155.	115.	132.	60.	105.	96.	52.	55.	12.	12.	1.	871.
1961/62	1.	128.	87.	45.	230.	79	58.	7.	0.	0	0.	8.	643.
1962/63	30.	153.	35.	165.	83.	98.	123.	33.	15.	18.	1.	4.	758.
1963/64	48.	146.	80.	51.	74.	199.	25.	0.	31.	0.	8.	16.	678.
1964/65	199.	69.	140.	132.	28.	19.	82.	4.	25.	9.	22.	24.	753.
1965/66	40.	111.	21.	173.	76.	59.	31.	16.	8.	0.	6.	0.	541.
1966/67	28.	19.	113.	248.	116.	61.	106.	54	5.	1.	5.	7.	763.
1967/68	40.	51.	80.	45.	43.	115.	81.	82.	0.	13.	10.	6.	566.
1968/69	24.	13.	66.	71	108.	116.	56.	84.	9	0.	28.	12.	587.
1969/70	98.	23.	52.	80.	40.	25.	29.	7.	19.	17.	-	69.	-
1970/71	-	-	-	-	18.	52.	37.	71.	0.	12.	0.	3.	-
1971/72	45.	65.	74.	181	163.	182.	49.	14	27.	0.	7.	14.	821.
1972/73	78.	107.	17.	39.	236	41.	0.	0.	3	6.	79.	40.	646.
1973/74	48.	50.	90.	-	68.	156.	58.	14.	5.	0.	-	-	-
1974/75	25.	215.	60.	160	173.	142.	47.	22.	9.	19.	2.	6.	880.
1975/76	29.	168.	166.	179.	174.	175.	80.	32.	21.	0.	2.	0.	1026.
1976/77	121.	78.	44.	101.	139.	101.	139.	6	60.	6.	0.	0.	795.
1977/78	-	-	80.	172.	22.	129.	126.	1.	18.	12.	29.	46.	-
1978/79	37.	36.	188.	75.	64.	37.	41.	0.	-	-	90.	84.	-
1979/80	99.	113.	91.	38.	48.	83.	28.	1.	0.	0.	2.	0.	503.
1980/81	8.	135.	92.	362.	178.	102.	43.	37.	25.	0.	73.	9.	1064.
1981/82	40.	87.	112.	54.	57.	24.	117.	0.	17.	10.	0.	34.	552.
1982/83	35.	125.	47.	19.	69.	0.	44.	30.	28	32.	5.	2.	436.
1983/84	54.	150.	63.	87.	16.	39.	15.	79	0.	0.	0.	0.	503.
1984/85	36.	30.	46.	63.	101.	60.	29.	0.	0.	0.	0.	0.	365.

Institute of Hydrology
Summary of monthly data - Rainfall

Station number : 73 Name : Teyateyaneng (RAINDAT)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Total
1985/86	50.	-	-	42.	-	92	54.	0.	45.	1.	54.	21.	-
1986/87	168.	113.	39.	17.	60.	58.	75.	0.	1.	9.	54.	-	-
1987/88	16.	145.	124.	56.	-	132.	121	30.	18.	-	10.	30.	-
1988/89	141.	49.	108.	63.	203.	89.	75.	69.	20.	1.	12.	6.	836.
1989/90	50.	139	23.	169.	83.	108.	106.	4.	26.	5.	25.	0.	738.
Mean	65.	88.	93.	119.	97.	98.	58.	27.	12.	10.	16.	24.	709.
Median	58.	84.	87.	102.	88.	89.	54.	21.	6.	5.	5.	16.	
Maximum	218.	222.	273.	362.	252.	244.	175.	89.	60.	86.	90.	145.	
Minimum	1.	1.	0.	17.	16.	0.	0.	0.	0.	0.	0.	0.	
St. dev.	42.	50.	53.	71.	50.	53.	38.	25.	15.	16.	23.	26.	
	.65	.56	.56	.60	.52	.53	.66	.93	1.23	1.51	1.38	1.08	

Total monthly rainfall in millimetres

Data flags

Missing - flag "-" Original - no flag set Estimate - flag "e"

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Appendix D.2 - Finalised annual rainfall (October-September water year)

Table A3.1 Annual rainfall 1930-91 for stations included in the stochastic model
October-September water year

	Stations in Lesotho					
	9 Tsoelike	41 Pelaneng	42 Lelingoana	71 Mokhotlong	44 Quthing	60 Leribe
1930				572	756	849
1931				435	705	612
1932	343	464		469	424	546
1933	674	830	705	635	843	1381
1934	740	817	639	624	875	921
1935	483	494	477	453	637	510
1936	636	809	761	636	779	1005
1937	532	606	554	559	647	773
1938	633	678	547	595	852	880
1939	653	726	681		921	826
1940	505	600	619	555	709	789
1941	414	660	469	458	646	717
1942	538	964	675	572	830	1010
1943	762	883	715	727	871	1184
1944	488	456	524	484	447	810
1945	391	495	300	437	619	602
1946	521	583	490	580	535	733
1947	672	661	516	522	622	921
1948	459	416	413	403	461	642
1949	949	907	574	772	984	1147
1950	458	450	360	436	802	871
1951	499	525	389	544	761	680
1952	464	479	393	505	658	596
1953	512	521	370	495	792	800
1954	590	616	475	517	712	875
1955	669		475	556	853	928
1956			742	822	996	1163
1957						1050
1958					723	707
1959						945
1960	459				904	789 #
1961				683	746	592 #
1962				655	829	777 #
1963	743			742	635	595 #
1964	556				610	654 #
1965	409	626		420	486	509 #
1966	633	703		619	879	981 #
1967	403	681		503	495	587 #
1968	363	476		441	677	668 #
1969	316				481	519 #
1970					709	622 #
1971				664	776	652 #
1972	413		545	622	560	573 #
1973			555	611	797	569 #
1974	514		722	699	751	
1975	723		810	788	1023	
1976	584		527		819	
1977	616		522		867	
1978	463		660		504	
1979	503		501		537	
1980	490		508	510	782	769 #
1981	448		487	383		648 #
1982	267		379	452	549	
1983	525		554	739		605 #
1984			313	477	532	365 #
1985	805			729	624	584 #
1986	601		691	773		853 #
1987			695	570		
1988	564			582		732 #
1989			461	535	850	752 #
1990				497		
1991						

Data judged inconsistent - of limited use

Table A3.1 (cont)
October-September water year

	Stations in Lesotho (cont)				
	63 Qacha's Nek	64 Butha Buthe	70 Mafeteng	72 Mohale's Hoek	73 Teyateyaneng
1930	893	717	673	716	623
1931	696	673	645	607	564
1932	560	500	455	469	318
1933	1076	1327	801	818	1213
1934	1023	738	888	832	720
1935	620	599	586	653	614
1936	935	925	886	1007	818
1937	846	831	586	604	621
1938	1050	728	838	817	689
1939	967	780	743	766	668
1940	769	729	703	614	635
1941	973	769	863	776	572
1942	1306	990	854	1103	771
1943	1186	1071	789	842	872
1944	788	676	524	460	485
1945	710	578	638	563	528
1946	1136	836	792	608	607
1947	1271	916		769	706
1948	943			466	425
1949		744	935	1048	981
1950	944	763	720	738	705
1951	927	850	676	623	686
1952	1049	578	529	565	812
1953	974	733	690	737	768
1954	910	782		848	790
1955	950	646	861	797	771
1956	1202	1178	906	1003	967
1957	873	849	748	898	1040
1958	1058	678	681	882	815
1959		920	631	959	790
1960		987	831	737	872
1961	690 #	680	751	784	645
1962	898 #	734	843	878	760
1963	738 #	796	685	759	677
1964	876 #	593	571	531	752
1965	712 #	521	486	645	536
1966	802 #	850	880	914	761
1967	538 #	589	546	582	567
1968	634 #			684	585
1969	705 #		484	616	
1970	732 #	748	700	627	
1971		694		802	821
1972		687	592	565	646
1973	868 #	707	844	689	
1974		922	695	797	880
1975		1034	1050		1026
1976		793	875	677	795
1977	840 #	798	793	743	
1978	816 #	831		727	
1979	813 #	617			503
1980	750 #	814			1064
1981	632 #	625	696	668	552
1982	335 #	649	452	662	436
1983	689 #		543	680	503
1984	513 #	464	334	579	365
1985	934 #	706	529	753	
1986				858	
1987		889		1196	
1988		824		762	836
1989	496 #	743	745	754	738
1990		751			
1991		629			

Data judged inconsistent - of limited use

Table A3.1 (cont)
October-September water year

	Stations in South Africa				
	176372	177045	177178	177552	179344
1930	743	689	689	703	1225
1931		763	529	743	1057
1932	411	535	370	532	845
1933	1172	973	735	851	1317
1934	907	1049	696	868	1077
1935	730	665	515	518	821
1936	770	872	637	724	1248
1937		857	595	868	1137
1938	915	1182	595	945	1431
1939	787	923	486	891	
1940	595	870	544	856	1068
1941	624	850	474	780	1081
1942		1049	671	1030	1334
1943		1074	770	912	1269
1944	371	560	412	438	831
1945	715	895	549	773	912
1946		842	564	708	1108
1947		868	672	839	1135
1948		652	360	575	807
1949		1222	713	933	1059
1950			615	927	1089
1951		650	565	716	893
1952		543	492	796	1194
1953	810	768	301	822	1155
1954	801	1014	295	935	1510
1955	795	986	358	976	1048
1956	913	1137	763	817	1559
1957	834	1093	703	935	1084
1958	738	1054	796	900	1274
1959	678	937	643	891	859
1960	796	1043	860	928	903
1961	777	756	663	702	960
1962	978		784	918	1290
1963	597	792	578	725	1356
1964	673	713	594	590	980
1965	484		414	697	1032
1966	809	1045	717	987	1152
1967	400	481	362	522	823
1968	652	661	649	770	928
1969	459	568	410	510	1118
1970	669	901	709	845	1057
1971	617	913	630	810	870
1972	442	662	454	660	1148
1973	1169	1283	937	993	1375
1974	642	1019	594	1034	1026
1975	928	1270	896	1136	1855
1976	718	844	638	813	1039
1977	708	964	720	1022	949
1978	719 $	831	525	808	724
1979	495 $	782	593	811	1164 $
1980	714 $	967	530	756	1136
1981	685	843	581 $	779	1077
1982	634 $	913	528 $	740 $	645
1983	490	658	364	743	
1984	602	685	464 $	563	1126 $
1985	657	902	756	902	1337 $
1986	797 $	943	640	849	1358 $
1987	877	1239	821	1093	1148
1988	883	954	804	947	1403
1989	564	1005	681	1081	
1990	724	849	635	707	
1991	679	416	557	857	

$ Flagged unreliable by RSA DWA
Note that although listed in RSA DWA files, annual totals are not given where one or more month of data is missing

Table A3.1 (cont)
October-September water year

	Stations in South Africa (cont)				
	204138	204640	208635	208733	233239
1930	727		895	834	643
1931	517		770	794	450
1932	326		697	734	430
1933	775	786	1055		808
1934	740		880	917	
1935	651	590	756	801	620 $
1936	723	781		862	926
1937	686		765	751	624
1938	777		1038	1072	814
1939		749	1019	986	635
1940	809		939	841	564
1941	564	543		827	592 $
1942	1099		1238	1283	924
1943	851	739	1069	1009	624
1944	309	419	751	700	508
1945	563	564		667	612
1946	609	561	741	888	591
1947	720	716	867 $	944	787
1948	379	441	640 $	672	392
1949	872		915	924	838
1950	755	624	832	821	
1951	552	593	675	604	
1952			694		648
1953			823	905	691
1954			997	1101	689
1955			703	706	713
1956			907	1059	779
1957			767	777	
1958			1055	1136	
1959	842	817	651	669	795
1960	927	756	870	898	667
1961	701		656	737	610
1962	829	823	837	1002	981
1963	560	624	891	1068	685
1964	502	481	978 $	904	583
1965	530	522	798	833	517
1966	992	766	969	1002	766
1967	487	486	626	740	486
1968	580	501	781	700	678
1969	424	339	737		492
1970	686		905	839	703
1971	777	776	962	881	882
1972	467	436	779	1019	520
1973	1170	847	816	1139	850
1974	713	675	755	805	704
1975	1078	1236	1122	1224	1066
1976	620	649	636	866	732
1977	785	957	842	1017	919
1978	553 $	664 $	988	903	764 $
1979	391 $	578	532 $	673	535
1980	619	753 $	740	672	796
1981	560	600 $	691	717	563
1982	578	734	648	495	549
1983	513	567	884	893	631
1984	614	522	744	652	554
1985	778	840	1203	1041	660
1986	688	788 $	1018	1138	718 $
1987	1153	1113	1296	942	1117
1988	808	854	866	825	777
1989	599	569	953	893	570
1990	762	731	865	727	675
1991	532	503	782	745	398

$ Flagged unreliable by RSA DWA
Note that although listed in RSA DWA files, annual totals are not given where one or more month of data is missing

Table A3.1 (cont)
October-September water year

	Stations in South Africa (cont)				
	237405	237471	237606	238045	238132
1930					876
1931					779
1932					694
1933				982	1040
1934					905
1935				722	756
1936		1290		823	815
1937		1130		874	939
1938				1153	
1939		1322		939	978
1940				923	
1941		1139		1064	999
1942		1407		1348	1389
1943		1572		1126	1033
1944		987		806	855
1945		1005		687	587
1946		1024		868	945
1947		1332			894
1948		920		924	731
1949		1231		844	994
1950		1051		920	908
1951		1081		880	909
1952					
1953		1226		876	1091
1954		1204		892	998
1955		1077		868	879
1956		1663		1299	1219
1957		1057		809	980
1958		1261		1034	1149
1959		1108		734	
1960		1114		1010	1001
1961		954		947	1111
1962		1391		1038	1083
1963		1376		1034	1107
1964				1018	994
1965		1234		839	768
1966		1311		910	1001
1967	786	984		724	783
1968	943	928		773	747
1969		934	992	944	977
1970		1206	1097	1014	840
1971		1369	1378	1021	886
1972	1260	1111	1054	998	753
1973	1574	1452	1616	1000	1064
1974		1004	1073	883	901
1975	1689	2034	1820	1391	1377
1976	1197	1151	981	709	868
1977	1440	1314	1375 $	925	968
1978	1206	1156	1154	1006	953
1979	1061 $	1110	1315	948	852 $
1980	1015	1019	1141	905	925
1981	1017	839 $	1101	755	751
1982	756	702	815	531	650
1983	1285	1247	1337	953 $	1181
1984	1077 $	886 $	1072	694 $	780
1985	1243	1293	1316	910 $	1195 $
1986	1502		1295	1357	1389
1987	1543		1501	1478	1242
1988	1370		1148	791	1076
1989	1290		1140	998	1018
1990	1023		1094	994	909
1991	1168		935	824	796

$ Flagged unreliable by RSA DWA
Note that although listed in RSA DWA files, annual totals are not given where one or more month of data is missing

Table A3.1 (cont)
October-September water year

	Stations in South Africa (cont)				
	238636	263280	263792	267693	267887
1930	794				
1931	863	643	708		
1932	719	312	348		
1933	1341	934	1118		
1934	1163	597	683		
1935	860		608		
1936	848	846	807		
1937	937	580	610		
1938	1432	758	715		
1939	1206	831	802		
1940			649		
1941	1111	805	615		
1942	1661	993	924		
1943	1105	872	917		
1944	817	558	496		
1945	712	780	542		
1946	1162	738	696		
1947	926	763 $	823		
1948	759	366	398		691
1949	991	869	939		1111
1950	1032	504	623		769
1951	851	568	636		861
1952	927	661	785		1090
1953	883	656	602		1086
1954	924		701		1181
1955	819	715	840		964
1956	1491	874	1014		1310
1957	869	746	924 $		962
1958	1141	655	680		962
1959	750		747		1058
1960	979	730	829		889
1961	985	624	765		1043 $
1962	1043		807 $		915
1963	1089	684	742	1408	1078
1964	995		562	1534	1051
1965	744		501	1274	834
1966	1010		775	1882	1371
1967	804	603	613	790	790
1968	574	677	519	1369	975
1969	717		529	1241	997
1970	1033	617	702	1373	963
1971	1302	734	738	1375	1002
1972	1217	469	439	1429	
1973	938	743	654	1916	1390
1974	915	764	724	2480	
1975	1294	880	992	2372	1387
1976	973	862	738	1428	871 $
1977	755	891	944	1454	1028
1978	1084	619	620	1534	1141
1979	748 $	577	508	1151	947
1980	1007 $	885	872	1482	1164
1981	753	727	678	1192	790
1982	608 $	510		914	918
1983	1232	621	615	1432	1159
1984	992	521	507	880	896 $
1985	1348	640	715	1408	1088
1986	1367	781	872	1673	1401 $
1987	1219	1030	863	1607	1292
1988	1021	682	738	1385	963
1989	1028	748	735	1159	886
1990	1091	594	606	1302	1096
1991	737	519	400	1145	1029

$ Flagged unreliable by RSA DWA
Note that although listed in RSA DWA files, annual totals are not given where one or more month of data is missing

Table A3.1 (cont)
October-September water year

	Stations in South Africa (cont)					
	296379	296682	298244	298512	298791	299223
1930	699	894		835		
1931	496	614		675		
1932	403	417	648	472		
1933	1098	1064	1178	1050		
1934	674	641	1222	881		
1935	615	546	623	547		
1936	752	819	785	838		
1937	672	680		759		
1938	756	759		897		
1939	706	689	1143	1070		
1940	563	585	940	766		
1941	706	655	966			
1942	990	1011	1255	988		
1943	927	940	1036	1231		
1944	593	560		703		
1945	586	456	654	469		
1946	685	606	1121			
1947	827	750	1061	674		
1948	404	491	587	588		
1949	990	1020	1210		1471	913
1950	562 $	759	916		1058	919
1951	615	776		603	1185	914
1952	560	551		544	1312	1002
1953		688	830		1084	840 $
1954	754	720	1007		1395	
1955	675	786	1098	953	1315	987
1956		1150	1450	1411	1888	1401
1957	831	989	908	850	1297	1101
1958	698	684	988	881		941
1959	822	790	1209	944	1256	935
1960	731	727	1006	793	1389	960
1961		437	786	724	1093	782
1962		680	1014			903
1963	638	680	921	909	1227	789
1964	544	610	856	703	1328	952
1965	471	550	743			741
1966	906	944	1284	829		1118
1967	691	620	690	507	1011	581
1968	644	712	534	564		753
1969	473		860	698	1288	837
1970	650		1033	615	1372	963
1971	726		797	373 $	1268	804
1972	469	660	777	423 $	1139	877
1973	644	763	883	648	1785	1040
1974	809	896	1074	1055	1674	1004
1975	1038	999		1124	1981	
1976	695	665	1095	983	1535	
1977	835	994	945	678	1368	
1978	727	717	850 $	730	1413 $	126
1979	646	626 $	971 $	635	1193	1055 $
1980	747	822 $	1193 $	698	1429 $	
1981	659	631	840	502	875 $	
1982	490	551		511	827	
1983	583	687		743	1305	
1984	575	497		645	1155	705 $
1985	710	690		820 $	1186 $	
1986	807	865		991	1711	
1987	923	882		1167	1632	
1988	763	774		851		
1989	795	827		771	1350	
1990	666	712		792	1103	
1991	430	458		666		

$ Flagged unreliable by RSA DWA
Note that although listed in RSA DWA files, annual totals are not given where one or more month of data is missing

Appendix D.3 - Finalised annual rainfall (August-July water year)

Table A3.2 Annual rainfall 1930-91 for stations included in the stochastic model
August - July water year

	Stations in Lesotho					
	9 Tsoelike	41 Pelaneng	42 Lelingoana	71 Mokhotlong	44 Quthing	60 Leribe
1930					792	874
1931				421	659	594
1932				478	462	552
1933	659	806		616	836	1351
1934	729	821	681	612	820	927
1935	517	522	633	478	696	538
1936	632	797	503	645	792	980
1937	506	556	759	503	615	733
1938	614	690	504	617	803	872
1939	624	678	561	692	879	809
1940	581	641	643		741	825
1941	381	643	665	453	678	691
1942	552	914	466	574	820	1044
1943	725	935	649	713	894	1159
1944	545	534	731	542	494	876
1945	402	476	576	442	585	598
1946	472	563	299	511	471	673
1947	719	706	433	585	717	987
1948	436	369	570	373	448	614
1949	901	828	372	717	888	1083
1950	476	543	564	502	829	925
1951	496	503	395	500	740	682
1952	449	505	340	538	708	617
1953	571	529	427	518	816	816
1954	594	651	405	521	734	877
1955	664		484	548	840	906
1956			463	689	803	1021
1957			610			1154
1958					728	758
1959						
1960	462				976	
1961				709	768	
1962				663	771	
1963				702	667	
1964	567				613	
1965	408	645			507	
1966	660	692		638	869	
1967	350	699		499	466	
1968	399	492		453	689	
1969	238				409	
1970					792	
1971				617	797	
1972	397			614	505	
1973			455	657	783	
1974	461		627	598	723	
1975	738		647	878	1039	
1976	624		890		821	
1977	588		516	708	860	
1978	481		514		506	
1979	497		614		587	
1980	486		514	575	746	
1981	676		533	395		
1982	290		529	459	542	
1983	500		386	702		
1984			518	522	558	
1985	744		354	658	551	
1986	622			581	757	
1987			515	792		
1988	604		877	619		
1989				525	837	
1990				452		
1991						

Table A3.2 (cont)
August - July water year

	Stations in Lesotho (cont)				
	63 Qacha's Nek	64 Butha Buthe	70 Mafeteng	72 Mohale's Hoek	73 Teyateyaneng
1930	981	732	685	740	636
1931	667	654	595	558	540
1932	582	507	503	517	328
1933	1068	1284	781	806	1182
1934	992	765	855	789	741
1935	668	624	627	697	633
1936	901	925	896	1021	795
1937	828	707	546	584	613
1938	1023	779	824	759	659
1939	940	795	709	747	665
1940	864	743	758	691	637
1941	881	746	830	715	560
1942	1326	1027	857	1128	781
1943	1185	1049	788	851	867
1944	862	758	602	515	527
1945	718	572	628	540	525
1946	1098	787	730	552	575
1947	1305	959		844	741
1948	911			457	408
1949		683	826	941	913
1950	974	784	765	799	760
1951	971	864	659	578	672
1952	994	599	588	642	829
1953	1050	737	716	734	789
1954	936	788		876	798
1955	931	630	871	787	756
1956	1039	1010	751	790	791
1957	1063	980	917	1107	1198
1958	1035	721	702	906	848
1959		863	576	874	726
1960		1003	875	802	930
1961		703	767	802	648
1962		729	838	874	761
1963		763	679	753	659
1964		607	552	529	731
1965		526	515	667	581
1966		847	860	887	757
1967		588	522	578	562
1968		586		679	563
1969			432	522	430
1970		797	789	745	
1971		683		811	803
1972		531	497	477	548
1973		861	905	724	
1974		858	668	775	
1975		1058	1035		1032
1976		792	839	686	797
1977		798	852	762	
1978		716		672	
1979		686			675
1980		858	647	805	984
1981		658			600
1982		660	472	691	463
1983			492	622	510
1984		531	403	651	365
1985		644	457	693	
1986				699	615
1987		1122		1349	
1988		861		793	858
1989		733	735	739	731
1990		714			
1991		536			

Table A3.2 (cont)
August - July water year

	Stations in South Africa				
	176372	177045	177178	177552	179344
1930	799	758	766	779	1359
1931		653	476	671	989
1932	480	606	401	576	871
1933	1187	1004	757	864	1354
1934	836	962	640	796	1007
1935	787	726	549	578	881
1936	779	901	657	743	1217
1937	538	800	574	829	1129
1938	-	1134	572	900	1307
1939	781	921	493	886	
1940	642	923	555	915	1116
1941	569	774	412	677	1022
1942		1070	712	1075	1219
1943		1058	726	950	1284
1944	478	699	506	497	1024
1945		849	542	715	894
1946		790	491	677	1094
1947		962	750	930	1164
1948		633	348	563	768
1949		1085	654	783	987
1950			629	1008	1040
1951		639	542	693	1000
1952		640	552	816	1089
1953	853	787	316	895	1271
1954	800	994	294	932	1500
1955	777	984	320	950	1086
1956	763		670	645	1417
1957	992		813	1138	1225
1958	753		805	911	1223
1959	626		594	792	845
1960	816	1072	874	940	962
1961	809	808	711	777	949
1962	953		775	922	1346
1963	620		567	687	1260
1964	667	721	596	604	969
1965	491		418	704	1028
1966	795	1049	728	983	1248
1967	386	438	335	470	762
1968	651	642	648	786	956
1969	369		343	439	993
1970	776	983	793	947	1176
1971	632	930	647	818	898
1972	410	610	437	635	1091
1973	1108	1225	898	953	1446
1974	691	1037	585	1012	884
1975	901		896	1119	1906
1976	698	860	632	856	1019
1977	711	922	705	977	1015
1978	767	839	567	842	700
1979	494	802	614	829	1027
1980	656	899	486	723	1225
1981	789	961	655	864	1108
1982	601	901	488	710	722
1983	491	655	363	726	983
1984	636	729	491	628	
1985	592	795	689	774	1248
1986	651	838	601	800	1064
1987	1014	1273	860	1089	1461
1988	912	1096	856	1086	1488
1989	573	1000	686	1103	804
1990	627	850	613	681	
1991	743	377	570	814	

Table A3.2 (cont)
August - July water year

	Stations in South Africa (cont)				
	204138	204640	208635	208733	233239
1930	748		999	920	660
1931	457		752	755	395
1932	381		703	763	484
1933	771	780	1037		775
1934	675		870	898	
1935	709	633	772	809	679
1936	736			881	923
1937	667		717	707	602
1938	741		994	1006	780
1939			1054	1065	
1940	865		981	858	635
1941	531			838	550
1942	1111		1197		917
1943	845	732	1084	1092	621
1944	380	479	829	768	589
1945	542	540		672	597
1946	541	494	714	878	520
1947	809	805	883	966	875
1948	363	431	603	633	374
1949	805		862	853	760
1950	783	678	845	845	
1951	506	565	724	675	
1952			636		717
1953			890	946	717
1954			999	1106	688
1955			681	685	695
1956			781	935	592
1957			912	943	
1958			1030	1115	
1959	747	715	633	655	716
1960	996	846	908	905	727
1961	726		649	755	625
1962	813	809	872	1012	973
1963	570	623	896	1050	690
1964	482	472	884	864	577
1965	559	541	802	784	532
1966	959	736	1058	1125	752
1967	500	497	564	670	481
1968	575	487	824	746	663
1969	342	282	623		400
1970	776		1007	974	832
1971	798	785	957	891	878
1972	401	346	763	976	435
1973	1166	901	840	1188	890
1974	726	639	687	748	695
1975	1070	1200	1160	1247	1041
1976	591	675	651	849	709
1977	824	973	827	1013	954
1978	525	662	992	943	721
1979	429	589	490	636	593
1980	560	715		687	759
1981	618	663	710	752	620
1982	592	744	677	509	570
1983	480	528	847	885	574
1984	674	584	777	678	630
1985	717	782	1142	969	580
1986	578	662	657	816	632
1987	1164	1217	1700	1320	1191
1988	942	940	889	856	
1989	605	542	909	822	
1990	712	732	894	758	678
1991	567	494	788	753	417

Table A3.2 (cont)
August - July water year

	Stations In South Africa (cont)				
	237405	237471	237606	238045	238132
1930					944
1931					754
1932					710
1933					1010
1934					906
1935				722	748
1936		1312		832	842
1937		1098		836	889
1938				1118	
1939		1359		967	1048
1940				974	
1941		1076		1024	968
1942		1387		1298	1322
1943		1556		1125	1054
1944		1065		892	933
1945		1024		677	582
1946		986		860	924
1947		1362			914
1948		869		888	695
1949		1211		807	960
1950		1063		929	890
1951		1088		931	969
1952		-1			
1953		1275		890	1111
1954		1206		912	1014
1955		1084		844	855
1956		1543		1219	1111
1957		1155		920	1116
1958		1295		1013	1139
1959		1075		716	
1960		1097		1032	1018
1961		989		918	1062
1962		1419		1091	1165
1963		1361		999	1067
1964				977	960
1965		1251		857	770
1966		1396		972	1069
1967	732	929		646	740
1968	1010	937		819	780
1969		866	882	806	813
1970		1256	1191	1125	967
1971		1400	1365	1057	921
1972		1056	965	943	679
1973	1614	1535	1763	1062	1158
1974		941	973	790	785
1975	1758	2073	1895	1473	1449
1976	1103	1101	929	679	844
1977	1441	1297	1303	882	956
1978	1252	1195	1219	1050	978
1979	1017	1071	1278	883	792
1980	1039	1035	1136	947	952
1981	1078	903	1164	791	805
1982	758	707	846	547	633
1983	1272	1244	1344	950	1186
1984	1097	877	1057	709	813
1985	1195	1245	1267	842	1126
1986	1160		998	988	1017
1987	1901		1793	1903	1674
1988	1426		1244	795	1092
1989	1229		1086	970	960
1990	1019		991	995	926
1991	1216		1058	854	817

Table A3.2 (cont)
August - July water year

	Stations in South Africa (cont)				
	238636	263280	263792	267693	267887
1930	867				
1931	833	600	670		
1932	749	347	382		
1933	1281	912	1084		
1934	1199	587	691		
1935	852		636		
1936	870	824	787		
1937	900	573	612		
1938	1292	707	669		
1939	1359	864	798		
1940			681		
1941	1065	751	583		
1942	1573	992	890		
1943	1164	924	984		
1944	901	603	538		
1945	707	767	531		
1946	1143	702	679		
1947	959	812	852		
1948	713	337	377		632
1949	973	819	865		1074
1950	973		698		795
1951	932	526	593		899
1952	887	690	831		1005
1953	928	679	615		1166
1954	947		690		1209
1955	780	700	842		924
1956	1350	732	839		1159
1957	1057	844	1079		1139
1958	1097	699	707		976
1959	748		698		1039
1960	979	762	875		877
1961	992	629	771		1053
1962	1082		813		952
1963	1030	691	730	1281	968
1964	1024		560	1498	1059
1965	702		523	1362	856
1966	1057		771	1937	1438
1967	772	575	563	770	771
1968	622	674	535	1305	936
1969	512		500	1168	850
1970	1153	691	759	1489	1091
1971	1384	728	727	1394	1072
1972	1083	383	340	1197	
1973	1082	793	734	2179	1591
1974	803	753	704	2314	
1975	1272	891	989	2394	1497
1976	1028	807	729	1490	847
1977	772	918	955	1459	1009
1978	1089	635	609	1471	1107
1979	670	525	513	1122	938
1980	1044	876	846	1524	1165
1981	815	817	740	1240	861
1982	620	525	-1	969	923
1983	1238	556	576	1376	1151
1984	1013	597	556	930	925
1985	1290	572	638	1356	994
1986	957	615	723	1319	1049
1987	1677	1195	1035	1988	1711
1988	1033	736	794	1444	1009
1989	982	757	717	1090	772
1990	1107	533	570	1315	1168
1991	750	539	430	1157	1055

Table A3.2 (cont)
August - July water year

	Stations in South Africa (cont)					
	296379	296682	298244	298512	298791	299223
1930		927		881		
1931	480	598		646		
1932	415		664	496		
1933	1088	1047	1126			
1934	660	643	1258	937		
1935	641	569	649	561		
1936	726	800	789	837		
1937	666	652		680		
1938	735	747	1020	917		
1939	693	637		1033		
1940	604	665	961	827		
1941	668	610	944			
1942	991	1036	1299	968		
1943	940	934	939	1222		
1944	651	616		785		
1945	583	452	641	465		
1946	647	559	1044			
1947	868	802	1130			
1948	391	463	576	570		
1949	930	964	1147		1448	928
1950	603	803	962		1024	853
1951	619	779			1264	998
1952	570	574		553	1316	1022
1953		696	814	482	1052	805
1954	745	723	1047		1462	
1955	658	767	1078	927	1271	952
1956		988	1132	1108	1616	1157
1957	957	1117	1151	1110	1545	1325
1958	744	728	1094	948		992
1959	783	742	1100	882		884
1960	761	772	1065	830	1410	977
1961		442	792	719	1117	794
1962		688	1060			933
1963	620	664	852	846	1152	716
1964	540	615	870	684	1216	875
1965	491	560	772			857
1966	902	944	1254	852		1147
1967	662	605	705	496	976	532
1968	663	717	549	584		779
1969	426		773	596	1163	754
1970	712		1112	703	1491	1051
1971	733		808	389	1304	828
1972	364	559	655		947	728
1973	724	851	998	681	1963	1190
1974	748	831	986	930	1545	940
1975	1035	1004			2051	
1976	699	675	1116	951	1436	
1977	873	1016	902	694	1452	
1978	646	634	740	622	1311	
1979	671	645	1057	710	1269	1066
1980	784	882	1191	688	1401	
1981	695	675	905	558	1002	
1982	505	562	691	525	814	
1983	547	648		679	1269	
1984	618	542		733	1212	790
1985	651	616		773	1111	719
1986	625	688		753	1313	
1987	1108	1081		1414	2024	
1988	816	820		889		
1989	766	789		740	1290	
1990	640	726		788	1130	
1991	420	398		639		

Appendix D.4 - Revised Crump weir records for Marakabei & Paray (June 1994)

Institute of Hydrology
Annual summary of daily data - Flow

Station number : 9171 Name : Marakabei Crump (file MARA1.DLY)

Basin no. : 0 Latitude : 0: 0: 0 N Longitude : 0: 0: 0 E Altitude : .0
Area : 1.0

Year : 1985/1986

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	-	-	13.4	7.4	4.5	1.4	.9	3.1	.4	1.3	.4	38.9
2	-	-	9.0	6.4	5.8	1.2	.8	2.7	.4	1.2	.4	25.4
3	-	-	6.4	10.0	5.0	1.1	.7	2.3	.6	1.1	.4	17.6
4	-	-	37.7	11.1	41.4	.9	.6	2.1	34.7	1.2	.4	13.3
5	-	-	28.5	12.2	45.8	.9	.5	1.8	30.7	1.5	.3	10.5
6	-	-	22.8	9.3	20.3	1.7	.5	1.4	22.9	1.3	.3	8.6
7	-	-	22.1	6.6	16.4	2.3	.4	1.3	16.6	1.1	.3	6.9
8	-	-	16.1	5.0	15.9	1.9	.4	1.2	13.3	1.0	.3	5.7
9	-	-	13.4	4.2	12.1	1.3	.4	1.1	10.5	1.0	.3	4.9
10	-	-	10.8	3.4	6.7	1.2	5.4	1.0	8.7	.9	.3	4.2
11	-	-	7.9	3.0	5.1	1.7	6.1	.9	7.6	.9	.3	3.8
12	-	-	6.0	2.8	4.2	2.3	3.7	.8	8.9	.9	.3	3.5
13	-	-	4.7	2.5	3.2	2.3	3.0	.8	8.6	.9	.3	3.1
14	-	-	6.4	2.1	2.6	2.2	12.3	.7	7.1	.9	.3	3.4
15	-	-	15.9	1.7	2.2	2.5	23.4	.6	6.0	.9	.3	7.8
16	-	-	19.6	1.3	4.1	9.7	13.3	.6	5.1	.9	.3	10.8
17	-	-	13.2	1.3	12.5	9.3	9.6	.6	4.4	.9	.3	7.6
18	-	-	10.1	1.4	6.9	6.5	7.4	.5	3.5	.9	.3	6.1
19	-	-	12.9	1.5	4.3	5.0	5.7	.5	3.1	.9	.3	5.0
20	-	-	27.1	1.4	3.1	3.9	4.6	.5	2.7	.8	.3	4.2
21	-	-	60.8	1.5	2.6	3.3	3.7	.5	2.5	.7	.3	3.7
22	-	-	85.7	1.2	3.2	2.7	3.1	.4	2.3	.7	.3	3.3
23	-	-	69.3	1.0	5.2	2.2	2.7	.4	2.0	.7	.3	3.2
24	-	-	50.3	1.1	5.1	2.0	2.4	.4	1.8	.7	.3	3.2
25	-	-	50.2	3.5	3.4	2.1	2.1	.4	1.7	.7	.3	2.6
26	-	-	39.4	5.6	2.6	1.8	2.2	.4	1.6	.5	.3	2.2
27	-	-	42.2	3.3	2.1	1.4	2.8	.4	1.5	.4	.3	2.1
28	-	-	28.1	2.7	1.7	1.3	2.5	.4	1.4	.4	.3	1.9
29	-	-	18.7	3.4		1.2	2.8	.3	1.3	.4	.7	1.8
30	-	-	13.1	2.8		1.1	3.8	.4	1.3	.4	76.2	2.3
31	-		9.5	1.9		.9		.4		.4	65.6	
Mean	-	-	24.871	3.9438	8.8525	2.5673	4.2556	.93245	7.1045	.87139	4.8759	7.2447
Maximum	-	-	85.7	12.223	45.808	9.734	23.387	3.107	34.739	1.457	76.187	38.913
Minimum	-	-	4.704	1.023	1.715	.869	.365	.311	.365	.447	.281	1.83
R/off mm	-	-	-	-	-	-	-	-	-	-	-	-

Flows in cubic metres per second

Insufficient data for annual statistics

Possible data flags

Missing - flag "-" Original - no flag set Estimate - flag "e"

Printed on 1/ 7/1994

Institute of Hydrology
Annual summary of daily data - Flow

Station number : 9171 Name : Marakabei Crump (file MARA1.DLY)

Basin no. : 0 Latitude : 0: 0: 0 N Longitude : 0: 0: 0 E Altitude : .0
Area : 1.0

Year : 1986/1987

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	3.1	156.7	9.6	1.2	.1	2.6	5.8	2.3	.5	.6	.5	5.8
2	3.2	73.2	7.1	.9	.1	3.6	4.4	2.1	.5	.6	.4	5.2
3	71.4	41.6	6.7	.7	.1	2.1	3.3	1.9	.5	.6	.4	7.2
4	71.9	28.0	6.4	.6	.1	1.6	2.6	1.7	.5	.5	.4	13.4
5	74.3	22.6	5.1	.6	.1	1.4	2.2	1.6	.5	.5	.4	14.5
6	47.1	52.7	5.0	.5	.1	12.2	1.9	1.5	.5	.4	.3	11.9
7	35.8	93.6	4.5	.5	.1	4.7	1.7	1.3	.5	.4	.4	10.4
8	24.2	300.6	3.5	.4	.5	2.8	1.5	1.2	.4	.4	.3	39.6
9	17.3	221.6	2.9	.4	.9	1.9	1.4	1.2	.4	.4	.4	78.1
10	20.2	108.4	2.5	.3	.7	1.5	10.0	1.1	.4	.4	.4	38.2
11	17.4	74.4	5.2	.3	.9	1.2	7.2	1.1	.4	.4	.3	25.2
12	13.7	48.4	4.0	.6	.6	1.0	5.9	1.2	.4	.3	.3	17.8
13	10.9	32.9	3.1	1.2	1.2	.8	6.2	1.1	.4	.4	.3	14.5
14	8.8	23.3	2.8	.9	3.5	.7	10.0	1.1	.4	.3	.3	12.3
15	7.2	17.5	2.3	.6	3.8	.6	169.2	1.0	.4	.3	.4	9.0
16	6.9	13.4	1.9	.4	7.3	.7	69.5	.9	.4	.3	30.8	7.2
17	6.0	11.6	2.1	1.1	3.6	.9	32.7	.8	.4	.3	41.1	6.1
18	6.6	10.3	2.6	1.3	2.1	1.2	20.4	.7	.4	.3	32.2	5.7
19	7.0	8.9	2.1	.8	1.6	18.2	14.5	.7	.4	.3	32.2	5.0
20	8.8	8.1	1.8	.6	2.0	12.5	11.1	.7	.4	.5	28.0	5.0
21	7.0	10.0	1.4	.6	1.5	7.9	8.7	.6	.3	.8	25.1	8.5
22	5.7	74.4	1.1	.5	1.1	9.2	7.0	.6	.3	.8	21.1	455.0
23	4.7	38.3	1.0	.5	17.0	16.9	5.8	.5	.3	.9	17.2	357.0
24	5.2	26.8	.9	.4	5.8	17.5	4.8	.5	.3	.9	13.7	142.1
25	9.9	19.5	.8	.3	6.3	11.2	4.0	.5	.3	.8	11.7	78.8
26	36.8	14.5	.9	.3	5.5	8.7	3.5	.5	.4	.7	10.6	50.8
27	39.6	15.9	1.7	.2	4.9	6.6	3.3	.4	.4	.7	10.0	61.4
28	30.3	12.5	1.2	.2	3.6	5.3	3.5	.5	.5	.6	9.1	68.4
29	145.1	9.3	1.0	.1		4.3	3.1	.5	.5	.6	8.3	119.9
30	87.5	10.3	1.2	.1		3.6	2.6	.5	.6	.6	7.1	108.3
31	179.7		1.4	.1		5.5		.5		.5	6.5	
Mean	32.682	52.645	3.0238	.55997	2.6761	5.4449	14.261	.99352	.43017	.52319	10.004	59.41
Maximum	179.71	300.65	9.639	1.322	16.986	18.163	169.24	2.29	.61	.93	41.123	455.0
Minimum	3.08	8.142	.785	.083	.055	.631	1.383	.447	.285	.289	.276	4.998
Runoff mm	-	-	-	-	-	-	-	-	-	-	-	-

Flows in cubic metres per second

Annual statistics

Maximum 455.000 Minimum .055 Mean 15.144 cubic metres per second
Total 477.576 million cubic metres Runoff .000 millimetres

Possible data flags

Missing - flag "-" Original - no flag set Estimate - flag "e"

Printed on 1/ 7/1994

Institute of Hydrology
Annual summary of daily data - Flow

Station number : 9171 Name : Marakabei Crump (file MARA1.DLY)

Basin no. : 0 Latitude : 0: 0: 0 N Longitude : 0: 0: 0 E Altitude : .0
Area : 1.0

Year : 1987/1988

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	87.6	14.4	45.2	5.1	2.6	45.4	3.2	14.6	17.3	4.9	3.4	7.9
2	62.0	12.5	26.5	4.0	2.2	40.6	2.8	12.4	15.0	5.6	3.1	6.5
3	39.5	19.2	20.4	3.3	2.0	42.2	3.1	10.9	13.8	26.0	2.9	48.6
4	30.4	15.3	13.8	2.9	1.6	47.6	4.6	9.3	14.0	55.3	2.8	55.7
5	23.9	13.0	12.2	2.6	1.5	46.9	13.4	8.4	14.5	40.6	2.4	32.4
6	17.7	11.8	23.7	2.2	1.4	137.8	40.6	7.6	13.9	28.1	2.2	22.2
7	16.6	11.2	21.0	2.1	3.7	86.4	58.5	6.9	12.7	22.1	2.1	16.5
8	15.4	8.1	15.7	2.3	2.8	52.6	186.0	6.5	13.6	17.2	2.1	13.0
9	15.1	6.7	11.0	2.0	2.6	39.5	84.4	6.1	12.2	14.0	2.0	10.1
10	23.9	9.5	8.3	1.9	3.1	131.9	47.2	5.8	10.7	13.8	2.0	8.0
11	17.9	7.1	6.7	1.7	2.2	231.0	31.9	5.2	9.6	13.5	1.9	6.4
12	12.8	195.2	10.7	1.8	1.8	425.0	23.5	4.7	8.5	12.8	2.1	5.4
13	10.8	104.5	9.0	2.3	1.6	139.6	17.2	4.2	8.3	13.5	1.8	4.7
14	11.2	127.7	6.7	2.1	7.4	91.2	14.0	3.9	7.3	14.4	1.8	5.0
15	9.5	68.9	6.0	26.1	9.5	58.0	15.4	3.5	6.5	13.4	1.7	31.0
16	7.6	41.7	11.9	19.6	6.4	39.1	17.6	3.4	5.8	12.7	1.6	160.0
17	7.0	27.4	13.2	10.9	31.9	28.7	19.7	3.5	5.7	10.3	1.6	87.4
18	5.8	20.7	38.7	8.2	22.1	21.9	19.7	3.7	5.0	9.9	1.5	58.5
19	4.8	37.0	23.9	6.0	13.8	16.9	40.0	3.5	4.7	8.8	1.5	38.1
20	4.7	35.2	15.5	22.4	10.7	13.7	28.6	4.5	3.9	8.1	1.5	28.7
21	6.7	24.0	11.0	21.3	8.3	11.4	20.5	5.4	3.7	7.2	1.5	21.6
22	14.8	17.3	11.4	17.5	45.2	10.4	15.7	4.2	3.4	6.2	1.5	16.5
23	12.5	13.0	189.0	10.6	43.0	9.3	16.9	3.4	3.0	5.8	1.5	13.2
24	10.2	19.3	55.4	7.9	25.5	5.5	13.6	3.2	2.8	5.4	1.6	10.6
25	11.8	18.6	31.6	15.1	18.8	5.2	79.8	2.9	2.7	5.0	1.6	8.9
26	10.4	10.3	22.4	11.6	47.1	5.2	60.0	2.7	2.7	4.7	1.6	7.2
27	13.7	7.4	16.7	7.8	220.8	5.2	39.2	2.7	2.8	4.6	1.7	6.2
28	10.4	5.8	11.9	5.9	147.9	4.7	29.3	20.4	3.9	4.2	1.7	5.5
29	8.1	8.0	9.3	4.8	74.2	5.4	22.8	39.8	4.8	3.7	6.3	4.7
30	6.6	25.3	7.6	3.8		4.3	18.3	28.3	4.8	3.5	15.7	4.0
31	9.0		6.3	2.9		3.5		21.7		3.5	10.4	
Mean	17.362	31.204	22.985	7.6948	26.264	58.262	32.918	8.4924	7.921	12.862	2.8045	24.816
Maximum	87.63	195.16	189.0	26.057	220.8	425.0	186.0	39.835	17.333	55.341	15.7	160.0
Minimum	4.653	5.81	6.011	1.663	1.402	3.55	2.85	2.681	2.675	3.496	1.46	4.019
R/off mm	-	-	-	-	-	-	-	-	-	-	-	-

Flows in cubic metres per second

Annual statistics

Maximum 425.000 Minimum 1.402 Mean 21.070 cubic metres per second
Total 666.298 million cubic metres Runoff .000 millimetres

Possible data flags

Missing - flag "-" Original - no flag set Estimate - flag "e"

Printed on 1/ 7/1994

Institute of Hydrology
Annual summary of daily data - Flow

Station number : 9171 Name : Marakabei Crump (file MARA1.DLY)

Basin no. : 0 Latitude : 0: 0: 0 N Longitude : 0: 0: 0 E Altitude : .0
Area : 1.0

Year : 1988/1989

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	3.5	31.3	19.5	23.7	13.4	10.0	8.6	22.8	238.0	14.0	1.9	1.4
2	3.0	26.5	17.7	27.4	9.2	9.3	7.0	19.4	168.1	13.0	2.0	1.4
3	2.7	34.2	16.2	26.0	10.5	8.5	6.2	15.5	71.1	10.2	3.9	1.3
4	2.5	27.4	16.1	21.9	15.2	6.3	5.3	14.3	44.1	8.2	3.7	1.2
5	2.3	19.9	20.1	22.2	17.2	4.9	4.4	23.9	30.7	7.0	3.0	1.1
6	2.1	14.4	16.7	31.5	17.6	4.2	3.8	21.6	22.4	5.9	2.6	1.0
7	2.1	11.2	12.9	57.9	31.3	3.7	3.5	17.7	17.6	5.3	2.4	.9
8	1.9	9.3	11.3	49.0	22.0	3.6	4.0	14.7	14.7	4.7	2.2	.9
9	1.8	17.8	11.1	46.4	17.2	3.2	7.2	12.3	12.2	4.4	2.0	.9
10	3.0	12.8	19.5	32.6	21.3	2.8	8.5	10.7	10.1	4.4	1.9	.9
11	3.4	9.8	13.7	29.7	29.8	2.4	7.1	9.2	8.5	3.9	1.7	.8
12	6.6	8.2	10.4	31.8	195.4	2.3	6.6	7.6	7.3	3.6	1.7	1.0
13	21.6	8.5	9.0	25.8	144.0	4.0	7.0	6.3	6.4	3.3	1.7	1.4
14	66.9	9.9	12.2	18.5	70.8	41.3	6.8	5.5	5.6	3.0	1.7	1.5
15	95.7	9.4	9.7	49.7	287.0	44.5	6.4	4.9	5.1	2.8	2.9	1.3
16	106.6	9.0	9.4	28.9	340.0	22.3	12.0	24.6	4.6	2.7	4.7	1.1
17	98.5	8.5	15.9	30.3	207.0	15.7	16.5	21.8	4.1	2.5	4.2	.9
18	76.6	9.2	12.2	32.3	117.0	11.4	13.7	15.6	3.8	3.3	3.4	.8
19	46.1	9.1	12.2	29.0	66.6	8.8	10.9	11.9	3.6	5.2	3.2	.9
20	33.2	7.0	19.2	20.7	38.7	7.5	8.5	9.3	3.4	4.0	3.0	.8
21	29.7	7.6	16.6	18.8	25.8	6.8	7.2	7.7	3.2	3.4	2.8	.8
22	48.1	9.8	12.1	21.1	19.6	14.5	7.5	6.6	3.1	3.2	2.7	.8
23	37.7	7.8	9.4	14.5	16.6	13.5	15.7	5.6	3.0	3.0	2.6	.7
24	26.1	9.2	9.8	12.7	14.1	12.6	12.9	4.9	5.9	2.8	2.4	.5
25	19.4	14.4	156.5	10.8	12.8	16.6	10.2	4.5	11.6	2.5	2.3	.6
26	19.8	13.5	142.1	9.8	11.2	16.1	8.4	7.3	11.8	2.4	2.1	.5
27	14.4	20.3	95.3	8.4	10.3	15.5	7.1	81.0	9.9	2.3	2.0	.4
28	64.0	58.0	53.9	8.9	10.4	11.4	6.5	50.6	8.2	2.2	1.9	.4
29	57.2	46.8	48.0	10.2		8.6	6.4	34.7	8.1	2.0	1.8	.4
30	34.9	28.0	39.6	10.3		7.7	9.6	26.1	13.7	1.9	1.7	.4
31	24.4		34.6	16.9		11.9		27.6		1.9	1.5	
Mean	30.837	16.962	29.13	25.082	64.0	11.355	8.1777	17.618	25.332	4.4839	2.4967	.9151
Maximum	106.61	58.008	156.53	57.926	340.0	44.5	16.5	81.0	238.0	13.981	4.73	1.47
Minimum	1.847	7.046	8.989	8.35	9.164	2.35	3.47	4.53	2.983	1.92	1.517	.365
R/off mm	-	-	-	-	-	-	-	-	-	-	-	-

Flows in cubic metres per second

Annual statistics

Maximum 340.000 Minimum .365 Mean 19.410 cubic metres per second
Total 612.117 million cubic metres Runoff .000 millimetres

Possible data flags

Missing - flag "-" Original - no flag set Estimate - flag "e"

Printed on 1/ 7/1994

Institute of Hydrology
Annual summary of daily data - Flow

Station number : 9171 Name : Marakabei Crump (file MARA1.DLY)

Basin no. : 0 Latitude : 0: 0: 0 N Longitude : 0: 0: 0 E Altitude : .0
Area : 1.0

Year : 1989/1990

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	.4	3.3	17.8	1.8	3.6	2.9	93.7	49.1	2.0	12.4	3.5	1.9
2	.3	3.6	14.6	2.3	5.8	2.0	94.2	33.2	1.9	10.0	3.3	1.8
3	.3	94.3	16.7	3.2	11.0	1.5	47.5	24.2	1.9	8.2	3.0	1.8
4	.3	51.1	12.8	2.8	8.1	1.3	92.8	20.1	1.8	8.5	2.7	1.8
5	.3	27.0	8.7	1.9	6.7	1.5	93.6	16.2	2.5	9.9	2.8	1.7
6	.2	20.9	6.2	1.3	6.4	12.1	61.2	13.3	2.9	8.5	4.7	1.7
7	.3	24.0	4.7	1.1	8.8	49.6	38.7	11.2	2.3	7.1	8.6	1.5
8	.3	27.0	4.5	1.4	7.9	21.8	27.3	9.3	2.0	6.0	10.6	1.5
9	.3	22.1	7.1	1.0	7.9	12.7	20.3	7.9	1.8	5.2	10.3	1.5
10	.6	17.0	5.5	1.9	5.6	8.8	16.9	7.6	1.6	4.7	8.9	1.4
11	1.1	12.5	4.0	3.1	25.6	6.3	14.1	9.6	1.5	4.1	7.7	1.4
12	.9	11.4	4.7	2.0	16.1	4.7	11.3	8.5	1.4	3.6	6.6	1.3
13	.8	17.4	4.0	1.6	10.8	3.7	10.7	10.6	1.3	3.3	6.3	1.3
14	.5	17.1	3.3	1.6	9.1	3.4	15.8	10.0	1.3	3.0	5.4	1.2
15	.4	31.1	4.0	1.5	24.1	4.7	13.3	8.6	1.3	2.6	5.2	1.1
16	.4	101.0	4.8	2.3	22.1	7.1	10.8	7.1	1.2	2.6	3.9	1.0
17	.4	55.9	3.6	6.7	15.0	28.5	8.7	6.4	1.2	3.0	3.7	1.1
18	.5	31.9	3.1	4.1	10.3	21.9	7.2	5.8	1.2	4.0	4.2	1.0
19	.4	21.8	2.6	2.5	7.1	13.9	6.4	5.1	1.1	4.6	3.4	.9
20	.5	15.8	2.2	2.4	5.3	15.9	5.5	4.6	1.1	3.6	3.1	.9
21	.8	11.5	1.9	3.3	4.3	32.3	4.7	4.3	1.2	3.0	2.9	.8
22	3.3	9.9	1.5	3.2	3.4	20.5	4.3	3.9	1.7	2.8	2.6	.8
23	3.5	9.5	1.3	2.7	2.9	14.0	4.4	3.4	1.8	2.6	2.4	.7
24	3.5	7.8	1.1	3.0	2.5	10.7	5.3	3.0	1.5	2.4	2.1	.7
25	8.5	6.1	1.0	7.6	2.2	12.3	22.5	2.9	1.5	2.2	2.0	.7
26	8.7	5.2	.9	9.5	1.9	11.0	129.0	2.8	1.3	2.0	1.9	.6
27	6.2	5.7	1.8	7.6	1.8	8.5	72.6	2.7	1.9	1.9	1.8	.6
28	4.5	9.7	1.0	5.5	3.1	6.9	42.9	2.5	23.2	1.8	1.7	.6
29	3.4	31.6	.9	5.4		5.6	57.0	2.3	27.5	2.0	1.5	.5
30	4.3	21.6	1.5	4.4		4.9	69.9	2.2	16.9	4.1	1.8	[illegible]
31	4.2		2.3	4.6		11.4		2.2		4.3	2.0	
Mean	1.9358	24.161	4.8361	3.3357	8.5517	11.697	36.749	9.7018	3.7304	4.649	4.2189	1.1458
Maximum	8.658	101.0	17.8	9.53	25.6	49.646	129.0	49.116	27.5	12.409	10.6	1.91
Minimum	.23	3.33	.87	1.02	1.784	1.342	4.309	2.193	1.066	1.8	1.544	.534
R/off mm	-	-	-	-	-	-	-	-	-	-	-	-

Flows in cubic metres per second

Annual statistics

Maximum 129.000 Minimum .230 Mean 9.492 cubic metres per second
Total 299.347 million cubic metres Runoff .000 millimetres

Possible data flags

Missing - flag "-" Original - no flag set Estimate - flag "e".

Printed on 1/ 7/1994

Institute of Hydrology
Annual summary of daily data - Flow

Station number : 9171 Name : Marakabei Crump (file MARA1.DLY)

Basin no. : 0 Latitude : 0: 0: 0 N Longitude : 0: 0: 0 E Altitude : .0
Area : 1.0

Year : 1990/1991

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	.5	.3	.0	1.6	65.0	4.4	6.1	.9	.4	.5	.2	.2
2	.5	.5	.0	1.0	36.4	3.7	5.2	.9	.4	.5	.2	.1
3	.5	.8	1.3	.6	26.8	3.6	4.6	.8	.4	.5	.3	.2
4	.5	.8	2.6	.4	25.0	4.6	4.0	.8	.4	.4	.3	.2
5	.6	.6	1.5	.3	169.3	3.7	3.5	.8	.4	.4	.2	.2
6	.7	.5	19.5	.3	150.0	3.0	3.3	.8	.4	.4	.2	.5
7	.7	.4	30.5	.4	127.0	3.9	4.3	.8	.4	.4	.2	.4
8	.8	.4	16.9	5.1	90.6	5.2	3.9	.7	.4	.4	.2	.4
9	1.6	.4	9.7	15.3	59.3	11.2	3.2	.7	.4	.4	.2	.3
10	.3	.3	6.5	9.3	38.8	7.0	2.8	.7	.4	.4	.2	.3
11	.3	.3	4.8	6.8	33.8	5.3	2.5	.7	.5	.4	.2	.2
12	.3	.2	3.6	4.4	23.3	6.2	2.3	.6	.4	.4	.2	.2
13	.3	.2	3.3	3.1	18.1	81.5	2.1	.6	.4	.4	.2	.4
14	.3	.2	4.5	2.3	15.7	116.0	2.0	.6	.4	.4	.2	5.1
15	.7	.2	3.0	1.7	17.8	52.0	1.9	.6	.5	.4	.2	3.0
16	2.0	.2	4.5	1.4	17.6	37.2	1.7	.6	.5	.4	.2	1.7
17	1.6	.1	6.9	1.8	26.8	27.8	1.6	.6	.5	.3	.2	1.2
18	1.0	.1	4.4	3.2	34.4	201.0	1.5	.6	.5	.3	.2	.9
19	.7	.1	3.4	4.1	118.0	175.0	1.5	.5	.8	.3	.2	.6
20	.5	.1	2.5	3.2	66.0	101.0	1.4	.5	1.4	.3	.2	.6
21	.5	.1	2.0	17.4	38.9	66.5	1.3	.6	1.1	.3	.2	.5
22	.5	.0	1.5	63.2	25.6	72.8	1.3	.5	.9	.3	.2	.4
23	.4	.0	1.3	70.9	18.8	51.0	1.2	.5	.8	.3	.2	.4
24	.4	.0	1.1	153.0	14.3	35.4	1.1	.5	.7	.3	.2	.4
25	.3	.0	1.0	98.3	10.6	29.1	1.1	.5	.6	.3	.2	.4
26	.3	.0	.9	88.1	8.1	22.0	1.0	.5	.6	.3	.2	.5
27	.3	.0	.7	198.0	6.5	18.2	1.0	.4	.5	.3	.2	.4
28	.3	.0	.5	148.0	5.3	14.4	1.0	.4	.5	.3	.2	.4
29	.3	.0	.5	212.0		11.5	.9	.4	.5	.3	.2	6.2
30	.3	.0	.7	170.0		9.3	.9	.4	.5	.2	.2	4.9
31	.2		1.6	116.0		7.4		.4		.2	.2	
Mean	.59961	.2326	4.5558	45.21	45.994	38.416	2.344	.63271	.56873	.35694	.20613	1.0278
Maximum	2.0	.83	30.455	212.0	169.26	201.0	6.13	.93	1.426	.534	.268	6.198
Minimum	.24	.0	.019	.31	5.34	3.01	.93	.447	.41	.22	.157	.103
Runoff mm	-	-	-	-	-	-	-	-	-	-	-	-

Flows in cubic metres per second

Annual statistics

Maximum 212.000 Minimum .000 Mean 11.513 cubic metres per second
Total 363.082 million cubic metres Runoff .000 millimetres

Possible data flags

Missing - flag "-" Original - no flag set Estimate - flag "e"

Printed on 1/ 7/1994

Institute of Hydrology
Annual summary of daily data - Flow

Station number : 9171 Name : Marakabei Crump (file MARA1.DLY)

Basin no. : 0 Latitude : 0: 0: 0 N Longitude : 0: 0: 0 E Altitude : .0
Area : 1.0

Year : 1991/1992

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	3.3	43.6	1.8	1.5	.2	1.3	1.4	.2	.1	.1	.1	13.7
2	2.6	29.3	1.5	1.5	.6	.9	.7	.2	.1	.1	.2	6.3
3	2.5	24.3	1.3	1.4	1.0	.8	.5	.2	.1	.1	.2	3.9
4	2.3	19.2	1.3	1.3	.8	1.0	.4	.2	.1	.2	.2	2.6
5	2.0	15.6	1.9	1.1	.5	.8	.6	.2	.2	.2	.2	2.0
6	1.6	12.8	3.0	.9	.4	.6	1.1	.2	.2	.1	.3	1.6
7	1.4	9.9	2.5	.8	.3	.5	.6	.1	.2	.1	.4	1.2
8	1.2	7.8	2.0	.6	.3	.4	.4	.1	.2	.1	.4	1.1
9	1.1	7.4	2.6	.6	.2	.3	.4	.1	.2	.1	.4	.9
10	1.1	9.5	3.7	.5	.2	.3	.4	.1	.2	.1	.4	.8
11	1.1	7.8	4.5	.4	.3	.2	.4	.1	.2	.1	.4	.7
12	1.2	6.2	5.8	.4	.3	.2	.6	.1	.2	.1	.4	.6
13	5.7	5.7	3.7	.4	.3	.1	.5	.1	.2	.1	.3	.5
14	20.1	21.8	2.9	1.3	.3	.1	.4	.1	.2	.2	.3	.5
15	94.6	14.0	2.3	.4	.2	.1	.4	.1	.2	.2	.3	.4
16	43.8	9.9	2.7	.4	.2	.1	.3	.1	.2	.2	.2	.4
17	25.0	7.4	4.7	.4	.1	.1	.3	.1	.2	.2	.2	.3
18	17.5	6.0	4.8	.4	.1	.1	.3	.1	.2	.2	.2	.3
19	34.6	5.6	4.4	.4	.1	.1	.3	.1	.2	.2	.2	.3
20	93.3	5.8	15.1	.4	.2	.1	.3	.1	.2	.2	.2	.2
21	224.5	5.1	11.5	.4	2.7	.2	.3	.1	.2	.2	.2	.2
22	267.8	4.1	7.4	.4	1.7	.2	.3	.1	.2	.2	.2	.2
23	174.9	3.3	5.2	.4	1.3	.3	.5	.1	.2	.2	.2	.2
24	90.7	2.8	3.9	.3	.8	.6	.6	.1	.2	.2	.1	.2
25	53.1	2.4	3.1	.3	.6	.6	.5	.1	.2	.1	.1	.2
26	44.3	2.1	2.5	.2	.5	.5	.4	.1	.1	.1	.1	.2
27	32.1	1.8	2.4	.2	.4	.8	.3	.1	.1	.1	.1	.2
28	25.5	1.9	3.2	.2	.4	.8	.3	.1	.1	.1	.1	.2
29	20.8	2.5	2.2	.2	.6	.6	.3	.1	.1	.1	.1	.2
30	61.5	2.2	1.8	.2		.6	.2	.2	.1	.1	.9	.2
31	72.1		1.5	.3		.9		.2		.1	5.6	
Mean	45.922	9.9353	3.777	.5851	.54034	.45239	.46373	.12365	.1428	.129	.42152	1.3324
Maximum	267.84	43.555	15.056	1.512	2.745	1.29	1.437	.22	.157	.157	5.556	13.654
Minimum	1.11	1.805	1.272	.164	.101	.055	.22	.101	.101	.101	.101	.156
Runoff mm	-	-	-	-	-	-	-	-	-	-	-	-

Flows in cubic metres per second

Annual statistics

Maximum 267.840 Minimum .055 Mean 5.371 cubic metres per second
Total 169.831 million cubic metres Runoff .000 millimetres

Possible data flags

Missing - flag "-" Original - no flag set Estimate - flag "e"

Printed on 1/ 7/1994

Institute of Hydrology

Annual summary of daily data - Flow

Station number : 9171 Name : Marakabei Crump (file MARA1.DLY)

Basin no. : 0 Latitude : 0: 0: 0 N Longitude : 0: 0: 0 E Altitude : .0

Area : 1.0

Year : 1992/1993

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	.1	1.2	4.7	.5	5.5	18.1	2.3	6.0	1.0	.8	.4	-
2	.1	1.8	3.7	.4	3.6	13.9	1.8	5.3	1.0	.7	.4	-
3	.1	6.8	3.1	.4	2.7	14.2	1.6	5.1	1.0	.7	.4	-
4	.1	5.7	2.6	2.0	4.4	46.2	2.8	5.2	1.1	.6	.4	-
5	.1	19.2	2.2	1.8	18.0	25.9	4.7	4.5	1.1	.6	.4	-
6	.1	29.5	1.9	.9	9.7	18.7	3.6	4.1	1.1	.6	.4	-
7	.1	15.1	1.8	.6	6.9	14.1	4.1	3.5	1.0	.6	.3	-
8	.1	17.0	1.7	.5	47.9	10.2	5.4	3.0	1.0	.5	.3	-
9	.1	76.9	1.6	.4	45.1	10.9	4.3	3.0	.9	.5	.3	-
10	2.6	147.8	1.6	.4	28.0	10.9	4.3	2.6	.9	.5	.3	-
11	4.0	65.7	1.8	.6	23.7	10.1	3.5	2.5	.8	.5	.3	-
12	71.6	66.4	2.3	1.5	28.4	11.9	3.8	2.4	.8	.5	.5	-
13	22.3	36.5	1.9	1.4	33.6	9.8	322.0	2.3	.8	.4	1.6	-
14	12.1	23.2	3.4	.9	40.3	10.0	88.7	2.0	.8	.4	3.2	-
15	7.6	18.0	3.1	.6	28.5	8.6	52.0	1.9	.8	.4	2.3	-
16	4.9	12.8	2.1	.5	26.2	9.1	33.1	2.4	.8	.4	1.8	-
17	3.3	9.2	1.5	.4	19.0	12.6	24.0	3.5	.8	.4	1.3	-
18	2.5	7.0	1.2	.4	56.4	9.7	19.2	2.8	.8	.4	1.0	-
19	1.8	-	1.0	.3	34.6	10.5	37.3	2.4	.7	.4	.9	-
20	1.5	-	.9	.3	30.9	9.0	30.5	2.1	.7	.4	.9	-
21	1.1	-	.8	.3	23.9	10.2	24.0	1.9	.7	.4	.8	-
22	1.0	-	.7	7.7	31.5	8.2	18.7	1.9	.6	.4	.7	-
23	.8	-	.8	25.7	20.9	6.2	14.6	1.7	.6	.4	.7	-
24	2.9	-	1.1	8.4	21.7	4.9	12.1	1.6	.6	.4	.6	-
25	7.3	-	1.6	5.1	18.6	4.0	10.2	1.5	.6	.4	.5	-
26	4.8	-	2.0	6.9	15.5	3.4	8.6	1.4	.5	.4	.5	-
27	3.3	-	1.3	7.3	21.4	2.9	7.5	1.3	.5	.4	.5	-
28	2.5	-	.9	8.4	26.8	2.5	7.3	1.2	.5	.4	.4	-
29	2.0	-	.8	10.1		2.1	7.5	1.1	.6	.4	.4	-
30	1.6	-	.8	6.8		2.2	7.9	1.1	.7	.4	.4	-
31	1.4		.6	7.0		3.2	7.0	1.1	.8	.4	.4	-
						3.0		1.0		.4	-	
Mean	5.2793	-	1.7874	3.5039	24.061	10.521	25.676	2.5901	.782	.48355	.7677	-
Maximum	71.646	-	4.69	25.7	56.4	46.2	322.0	6.042	1.11	.79	3.177	-
Minimum	.055	-	.64	.28	2.68	2.08	1.62	1.05	.51	.39	.289	-
Runoff mm	-	-	-	-	-	-	-	-	-	-	-	-

Flows in cubic metres per second

Insufficient data for annual statistics

Possible data flags

Missing - flag "-" Original - no flag set Estimate - flag "e"

Printed on 1/ 7/1994

Institute of Hydrology
Annual summary of daily data - Flow

Station number : 9081 Name : Paray Crump (file PARA1.OLY)

Basin no. : 0 Latitude : 0: 0: 0 N Longitude : 0: 0: 0 E Altitude : .0
Area : 1.0

Year : 1985/1986

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	-	-	42.3	29.2	15.7	5.3	2.2	14.1	1.2	2.8	.9	81.5
2	-	-	28.7	23.4	30.4	4.8	2.0	12.0	1.2	2.7	.9	60.3
3	-	-	18.2	25.0	31.7	4.0	1.9	10.0	1.2	2.6	.8	48.7
4	-	-	49.2	23.0	100.7	3.0	1.8	8.5	11.6	2.6	.8	39.2
5	-	-	139.9	28.9	195.1	3.0	1.6	7.2	51.1	2.5	.8	31.7
6	-	-	97.0	25.4	88.6	7.0	1.4	6.3	38.8	2.5	.8	25.7
7	-	-	116.5	18.7	72.6	8.1	1.3	5.5	29.2	2.5	.7	21.4
8	-	-	66.1	14.2	57.0	6.2	1.2	5.1	23.7	2.4	.7	17.8
9	-	-	54.4	11.8	42.6	6.7	1.1	4.6	19.5	2.3	.7	14.5
10	-	-	48.6	9.7	31.9	7.0	1.6	4.3	16.2	2.3	.7	12.5
11	-	-	37.8	8.1	24.9	8.9	2.1	3.8	14.3	2.2	.6	10.9
12	-	-	28.8	7.3	21.2	6.9	3.0	3.3	14.9	2.2	.6	9.7
13	-	-	22.7	6.1	16.8	6.0	3.3	3.0	13.7	2.2	.6	9.5
14	-	-	52.8	5.2	13.3	5.5	23.1	2.8	13.1	2.1	.6	9.7
15	-	-	107.5	4.6	16.8	5.5	129.2	2.7	11.8	2.1	.6	13.2
16	-	-	149.4	4.1	20.6	8.9	76.6	2.3	10.2	2.1	.5	27.1
17	-	-	107.0	3.7	22.3	12.8	45.4	2.2	9.0	1.9	.5	24.5
18	-	-	71.4	3.4	21.3	13.8	31.6	2.1	7.9	1.9	.5	19.3
19	-	-	76.4	4.5	14.1	12.6	24.0	2.0	7.1	1.9	.5	15.7
20	-	-	76.0	4.2	11.2	10.1	18.5	1.9	6.2	1.7	.5	13.4
21	-	-	120.2	4.0	9.7	8.4	15.5	1.9	5.7	1.6	.4	11.8
22	-	-	275.0	9.4	9.3	10.6	13.1	1.7	5.4	1.6	.4	10.4
23	-	-	229.4	6.0	10.2	6.7	11.2	1.6	4.9	1.4	.4	9.4
24	-	-	165.3	16.0	10.4	6.2	9.9	1.5	4.5	1.5	.4	8.7
25	-	-	212.8	9.8	9.8	5.4	11.7	1.4	4.2	1.3	.4	7.6
26	-	-	160.3	8.0	8.1	5.0	12.7	1.3	4.0	1.3	.4	6.4
27	-	-	148.7	6.7	6.9	4.3	13.1	1.4	3.6	1.2	.4	5.8
28	-	-	104.0	12.2	6.1	3.8	11.9	1.2	3.4	1.3	.4	5.3
29	-	-	72.0	11.1		3.3	12.1	1.3	3.1	1.1	.4	5.2
30	-	-	52.3	10.5		2.9	15.4	1.3	3.0	.9	19.2	5.0
31	-		39.0	15.2		2.6		1.2		.9	133.2	
Mean	-	-	95.795	11.915	32.829	6.6211	16.645	3.8599	11.457	1.9196	5.4766	19.394
Maximum	-	-	274.99	29.249	195.13	13.79	129.16	14.147	51.118	2.805	133.17	81.499
Minimum	-	-	18.23	3.445	6.08	2.581	1.095	1.183	1.155	.93	.365	5.023
Runoff mm	-	-	-	-	-	-	-	-	-	-	-	-

Flows in cubic metres per second

Insufficient data for annual statistics

Possible data flags

Missing - flag "-" Original - no flag set Estimate - flag "e"

Printed on 1/ 7/1994

Institute of Hydrology
Annual summary of daily data - Flow

Station number : 9081 Name : Paray Crump (file PARA1.DLY)

Basin no. : 0 Latitude : 0: 0: 0 N Longitude : 0: 0: 0 E Altitude : .0
Area : 1.0

Year : 1986/1987

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	5.6	445.5	18.9	8.4	3.4	9.2	10.1	6.3	.9	.7	.5	27.9
2	7.5	192.1	15.9	8.1	3.0	9.4	9.4	5.5	.9	.7	.5	29.6
3	50.8	121.4	14.0	7.1	2.6	7.9	7.8	4.8	.9	.7	.5	45.0
4	106.2	82.2	18.3	7.2	2.5	6.7	6.4	4.4	.9	.7	.4	82.9
5	120.6	272.2	15.9	6.9	6.0	5.5	5.3	3.9	.8	.7	.5	77.5
6	91.0	362.5	12.8	5.6	4.6	7.9	4.7	3.6	.7	.7	.5	56.3
7	67.6	293.8	11.6	4.7	7.3	20.4	4.1	3.2	.7	.7	.5	50.8
8	49.7	492.0	10.9	4.6	7.6	14.0	3.8	3.0	.7	.7	.5	135.8
9	38.4	561.7	9.3	4.5	13.3	10.3	3.5	2.7	.8	.7	.4	195.9
10	35.3	288.5	9.3	4.4	8.9	8.2	4.7	2.5	.7	.7	.4	127.3
11	30.3	185.8	14.6	4.7	7.3	6.6	8.9	2.3	.7	.7	.4	87.1
12	24.4	126.3	25.5	5.7	8.6	5.6	21.0	2.1	.7	.7	.4	64.3
13	19.9	87.8	16.9	5.8	8.3	4.7	17.7	2.1	.7	.6	.4	51.3
14	16.2	66.8	13.1	6.2	9.7	4.0	21.4	2.3	.7	.6	.4	41.6
15	13.5	50.3	14.9	5.5	16.1	3.5	194.3	2.1	.7	.6	.5	32.8
16	12.2	38.8	10.1	6.4	21.5	3.1	148.1	1.9	.7	.6	45.5	26.7
17	12.1	31.2	15.0	12.6	14.4	2.8	70.8	1.8	.7	.6	71.3	23.7
18	27.0	26.9	11.8	24.2	11.6	3.2	46.6	1.6	.7	.4	52.2	22.6
19	42.8	24.0	10.5	9.5	9.6	19.8	34.7	1.5	.7	.4	48.5	20.1
20	39.8	21.1	8.3	25.8	7.5	24.6	27.1	1.4	.7	.5	49.2	18.3
21	43.9	22.1	6.9	23.0	7.1	15.8	21.4	1.3	.6	.6	52.1	20.9
22	36.7	50.4	5.9	16.8	6.5	12.4	17.7	1.3	.6	.6	51.0	692.7
23	26.8	53.6	5.0	12.2	27.7	11.2	14.4	1.2	.6	.7	47.1	871.1
24	22.0	43.5	4.5	9.1	14.8	18.5	12.6	1.2	.6	.7	44.3	373.5
25	27.1	35.5	4.1	7.2	12.8	16.6	10.6	1.2	.6	.7	40.6	204.6
26	91.4	27.3	4.7	6.1	11.0	14.7	9.1	1.2	.6	.7	36.8	158.9
27	106.8	24.6	6.3	5.7	10.6	14.7	8.2	1.2	.7	.6	32.8	252.2
28	82.9	28.9	7.8	5.6	8.6	12.9	7.5	1.2	.7	.6	30.2	334.3
29	274.1	23.2	6.5	4.6		11.5	7.4	1.1	.6	.6	30.2	515.3
30	236.4	19.1	6.0	3.8		10.4	6.9	1.0	.7	.5	30.7	391.8
31	292.7		8.1	3.2		9.1		1.0		.5	31.8	
Mean	66.186	136.63	11.083	8.562	9.7518	10.488	25.532	2.3152	.72947	.64629	22.631	167.77
Maximum	292.73	561.73	25.53	25.841	27.743	24.575	194.25	6.313	.93	.723	71.288	871.09
Minimum	5.6	19.115	4.108	3.202	2.514	2.814	3.518	.984	.626	.447	.427	18.26
Runoff mm	-	-	-	-	-	-	-	-	-	-	-	-

Flows in cubic metres per second

Annual statistics

Maximum 871.090 Minimum .427 Mean 38.280 cubic metres per second
Total 1207.189 million cubic metres Runoff .000 millimetres

Possible data flags

Missing - flag "-" Original - no flag set Estimate - flag "e"

Printed on 1/ 7/1994

Institute of Hydrology
Annual summary of daily data - Flow

Station number : 9081 Name : Paray Crump (file PARA1.DLY)

Basin no. : 0 Latitude : 0: 0: 0 N Longitude : 0: 0: 0 E Altitude : .0
Area : 1.0

Year : 1987/1988

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	397.3	26.4	97.6	14.1	14.2	115.8	11.0	21.1	15.3	5.7	7.1	18.8
2	323.5	23.6	65.0	11.7	12.0	118.9	11.5	17.3	13.8	5.6	7.2	15.5
3	233.1	52.5	57.8	9.5	10.4	104.8	10.2	14.9	12.8	6.9	6.7	36.7
4	191.5	51.7	42.4	7.9	8.6	111.9	10.9	13.5	12.7	19.1	6.0	75.1
5	169.2	36.5	34.6	6.6	7.5	93.3	14.7	12.1	14.3	24.1	5.7	59.8
6	159.8	29.8	32.0	5.6	6.8	166.2	19.8	10.8	16.9	19.7	5.5	46.2
7	146.3	57.4	70.3	5.1	12.2	151.3	28.3	9.9	18.9	16.1	5.3	37.7
8	184.9	53.6	54.7	5.8	6.5	100.2	52.8	9.2	20.1	13.8	5.3	31.3
9	197.6	40.8	36.1	5.4	8.1	80.9	70.0	8.3	18.8	12.7	5.3	28.2
10	206.7	36.1	25.8	5.0	9.7	94.3	45.8	7.8	16.3	12.3	5.3	23.3
11	145.6	37.9	19.8	4.2	14.8	662.7	34.3	7.2	13.9	12.6	5.1	20.1
12	110.2	146.9	18.9	4.5	12.3	2804.1	29.8	6.8	12.6	12.1	5.0	16.5
13	96.5	145.2	21.1	4.4	9.4	-	28.6	6.7	11.2	10.8	5.0	13.7
14	81.2	153.1	16.9	5.0	9.1	-	27.9	6.3	10.3	11.2	4.8	13.0
15	72.6	106.7	13.6	8.2	24.7	-	27.2	5.8	9.4	11.7	4.7	25.3
16	60.9	71.6	13.8	49.6	36.7	-	26.7	5.4	8.4	11.9	4.6	378.7
17	51.8	51.7	18.4	32.0	56.3	85.1	26.7	5.4	7.8	10.7	4.4	241.2
18	44.7	41.5	73.5	21.3	39.4	67.7	26.7	5.1	7.0	10.2	4.4	154.0
19	38.7	181.0	65.9	20.8	28.8	53.5	25.9	5.0	6.4	10.0	4.3	107.9
20	39.5	113.2	43.0	109.1	22.2	42.5	26.1	5.0	5.9	9.5	4.1	79.2
21	59.7	77.3	38.6	171.9	17.6	35.3	25.6	5.3	5.7	9.1	4.1	61.9
22	99.7	57.9	49.3	128.3	33.6	29.7	24.6	5.7	5.4	8.5	4.2	48.9
23	94.3	45.0	206.5	74.2	74.0	25.7	24.4	5.2	5.1	8.0	4.5	40.1
24	76.8	39.8	107.2	52.5	49.5	22.2	23.1	4.8	4.7	7.5	5.1	33.6
25	62.5	37.9	65.1	66.6	45.1	19.7	49.0	4.5	4.5	7.2	5.7	28.3
26	51.3	32.7	47.5	57.6	72.5	18.2	92.3	4.2	4.3	7.1	6.3	23.4
27	50.4	24.6	51.0	42.0	151.0	16.0	58.8	3.8	4.1	7.1	6.8	20.0
28	41.6	19.7	38.2	32.7	208.4	14.0	38.8	6.0	4.8	6.8	6.8	17.1
29	35.3	18.3	28.2	26.2	115.6	13.5	29.7	19.9	5.3	6.8	8.2	14.9
30	31.5	20.3	21.3	21.8		13.4	24.1	23.8	5.5	6.8	20.9	13.1
31	27.7		17.9	17.4		11.7		19.0		6.9	23.7	
Mean	115.56	61.021	48.137	33.126	38.517	187.88	31.523	9.2136	10.086	10.596	6.525	57.453
Maximum	397.25	180.99	206.46	171.95	208.39	2804.1	92.289	23.811	20.088	24.07	23.734	378.72
Minimum	27.741	18.309	13.592	4.211	6.47	11.666	10.249	3.828	4.126	5.559	4.092	12.994
Runoff mm	-	-	-	-	-	-	-	-	-	-	-	-

Flows in cubic metres per second

Annual statistics

Maximum 2804.100 Minimum 3.828 Mean 49.475 cubic metres per second
Total 1564.527 million cubic metres Runoff .000 millimetres

Possible data flags

Missing - flag "-" Original - no flag set Estimate - flag "e"

Printed on 1/ 7/1994

Institute of Hydrology
Annual summary of daily data - Flow

Station number : 9081 Name : Paray Crump (file PARA1.DLY)

Basin no. : 0 Latitude : 0: 0: 0 N Longitude : 0: 0: 0 E Altitude : .0
Area : 1.0

Year : 1988/1989

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	11.5	52.3	69.4	58.2	34.5	72.3	25.0	40.0	236.0	56.6	4.9	4.2
2	10.2	48.0	54.0	48.0	27.8	70.5	19.7	42.6	418.0	66.3	5.0	4.0
3	8.9	48.5	56.3	42.5	39.2	62.8	16.9	37.2	185.0	56.3	5.6	3.7
4	8.2	60.6	74.2	37.6	120.6	48.5	15.0	32.0	119.0	42.7	6.0	3.5
5	7.3	45.2	102.8	36.2	110.9	38.9	13.2	35.8	89.1	31.9	5.7	3.2
6	6.6	35.6	85.7	37.0	96.6	31.9	11.7	36.0	69.4	27.0	5.1	3.1
7	6.1	29.5	65.0	56.7	90.5	26.9	10.3	31.2	53.2	23.0	4.9	2.9
8	5.7	25.5	55.6	84.1	74.6	25.5	9.7	26.6	45.0	22.2	4.5	2.8
9	5.7	35.9	47.8	81.8	57.9	23.3	11.1	23.1	38.0	20.3	4.1	2.7
10	5.7	36.1	50.0	62.1	55.9	19.1	12.1	20.8	32.2	19.3	4.0	2.6
11	6.0	26.4	38.2	47.1	67.0	15.6	10.4	18.7	27.7	17.3	3.8	2.6
12	8.7	21.7	29.9	43.7	134.5	13.3	10.7	16.2	24.1	15.7	3.7	2.6
13	13.5	26.6	25.4	54.8	309.8	13.6	11.1	13.9	21.4	15.0	3.7	2.8
14	18.1	22.6	23.0	43.9	151.0	40.1	11.5	12.7	19.1	13.5	3.6	2.7
15	25.8	40.4	23.8	60.1	242.6	76.6	10.2	11.2	16.6	12.1	4.4	2.4
16	39.1	86.7	20.5	43.5	661.1	52.4	10.3	13.1	14.5	10.7	6.3	2.3
17	81.8	61.4	50.0	53.4	747.0	36.3	27.5	19.3	13.1	10.1	7.5	2.0
18	111.2	56.8	51.1	47.1	341.4	28.0	36.2	20.0	12.1	10.9	7.3	2.1
19	75.8	51.7	42.2	41.0	198.1	22.5	28.5	17.2	11.3	11.4	6.6	2.0
20	61.3	38.9	54.8	35.1	133.2	22.7	23.3	15.1	10.5	10.0	5.9	2.0
21	66.0	47.5	51.7	33.2	94.2	20.2	19.5	13.4	9.7	8.6	5.7	2.0
22	100.4	52.2	40.6	32.1	73.7	23.1	17.0	12.5	9.2	7.7	5.7	2.0
23	94.0	78.4	31.5	29.7	72.8	35.2	25.8	11.5	8.8	7.4	5.7	2.0
24	63.8	64.4	26.5	23.6	63.0	34.1	36.8	10.4	12.7	7.1	5.8	1.9
25	47.9	57.2	196.3	23.0	61.4	36.7	28.7	9.5	18.2	6.8	5.5	1.7
26	40.9	63.0	297.3	21.7	56.7	34.1	23.6	9.3	22.9	6.4	5.4	1.7
27	32.7	84.8	256.3	17.9	54.9	30.9	20.2	35.8	24.6	5.9	5.4	1.5
28	75.2	153.6	131.1	26.7	83.1	29.3	17.8	52.8	21.6	5.7	5.3	1.5
29	158.6	139.0	97.3	30.0		23.8	18.0	44.1	24.6	5.6	4.9	1.4
30	95.5	94.5	75.5	33.6		20.1	25.4	36.3	51.3	5.0	4.8	1.2
31	65.0		71.9	45.5		23.4		37.2		5.1	4.7	
Mean	43.788	56.163	74.062	42.934	151.93	33.93	18.566	24.376	55.299	18.189	5.2154	2.442
Maximum	158.6	153.6	297.33	84.094	747.0	76.58	36.842	52.846	418.0	66.302	7.526	4.238
Minimum	5.708	21.652	20.517	17.945	27.759	13.338	9.682	9.31	8.822	5.022	3.648	1.219
Runoff mm	-	-	-	-	-	-	-	-	-	-	-	-

Flows in cubic metres per second

Annual statistics

Maximum 747.000 Minimum 1.219 Mean 43.138 cubic metres per second
Total 1360.397 million cubic metres Runoff .000 millimetres

Possible data flags

Missing - flag "-" Original - no flag set Estimate - flag "e"

Printed on 1/ 7/1994

Institute of Hydrology
Annual summary of daily data - Flow

Station number : 9081 Name : Paray Crump (file PARA1.DLY)

Basin no. : 0 Latitude : 0: 0: 0 N Longitude : 0: 0: 0 E Altitude : .0
Area : 1.0

Year : 1989/1990

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	1.2	12.4	98.2	9.7	13.8	6.1	44.1	132.2	5.0	15.2	11.5	9.3
2	1.1	13.1	74.4	9.8	18.1	6.0	103.9	91.8	4.7	12.0	10.4	8.4
3	1.0	84.7	69.8	8.8	23.5	5.4	76.7	68.4	4.5	10.0	9.6	7.1
4	1.0	253.9	58.5	8.4	14.0	10.8	80.2	55.1	4.2	9.1	8.9	6.8
5	.9	106.8	44.6	7.9	10.4	13.1	150.5	45.9	4.8	9.4	8.6	6.8
6	.8	70.9	35.0	9.5	10.7	19.4	102.2	37.9	5.2	10.0	20.3	6.8
7	.9	71.5	26.7	6.4	16.3	79.5	74.4	31.1	5.3	9.3	35.8	7.1
8	1.0	144.8	22.8	5.9	18.3	61.4	56.4	26.5	4.7	8.2	37.8	8.7
9	1.4	176.0	25.3	5.9	18.7	36.6	44.4	22.7	4.7	7.3	35.3	9.2
10	1.5	150.0	21.8	6.4	23.2	25.7	37.1	20.6	4.1	6.7	31.5	8.8
11	3.0	91.6	19.3	5.6	59.4	18.9	33.1	20.1	3.8	6.1	28.8	8.1
12	4.1	68.9	18.5	9.0	61.7	14.3	31.2	21.8	3.7	5.5	26.0	7.5
13	3.3	67.3	18.3	7.9	39.0	12.2	29.6	26.0	3.5	5.0	21.7	7.2
14	2.9	60.9	19.4	7.2	31.1	10.4	37.1	23.5	3.3	4.6	19.7	6.9
15	2.5	56.9	39.0	7.3	90.4	9.2	56.1	20.0	3.2	4.3	17.5	6.4
16	2.2	110.6	33.3	13.3	91.8	12.3	41.9	17.1	3.0	4.0	14.9	6.2
17	2.0	104.6	31.0	13.0	58.6	19.3	33.5	14.8	2.9	4.3	13.1	5.6
18	1.9	69.9	30.9	9.6	40.5	26.5	30.5	13.3	2.7	10.1	12.1	5.1
19	1.7	51.8	30.9	7.5	29.4	21.0	26.4	12.3	2.7	19.4	11.2	4.7
20	1.8	39.0	25.4	6.5	22.4	22.0	23.2	11.2	2.6	14.2	10.0	4.2
21	2.8	30.1	22.8	5.7	17.7	68.4	19.5	9.9	2.5	11.3	9.3	4.0
22	10.2	27.2	17.2	5.5	15.3	59.3	16.5	9.1	2.5	9.5	8.6	3.3
23	36.5	34.2	13.2	5.5	12.9	40.0	14.8	8.1	2.7	8.2	7.8	3.0
24	24.0	30.3	11.5	5.2	9.4	29.0	15.6	7.5	2.7	7.2	7.3	2.7
25	20.6	24.9	9.7	9.4	7.8	25.6	21.7	6.6	2.8	6.5	7.2	2.5
26	23.8	21.1	8.3	9.8	6.6	27.9	174.0	6.3	2.7	6.1	7.3	2.3
27	24.0	21.1	7.7	11.4	5.8	22.5	161.6	5.9	2.7	6.0	7.7	2.3
28	18.2	37.2	8.7	11.9	5.7	19.1	97.6	6.1	9.6	6.1	7.9	2.2
29	14.0	102.6	9.3	9.2		15.5	150.0	5.6	28.9	6.2	7.9	2.1
30	12.2	108.9	9.5	8.8		13.3	196.4	5.4	20.9	8.8	8.0	2.0
31	10.8		13.0	15.2		14.2		5.2		13.2	8.6	
Mean	7.5292	74.776	28.197	8.4933	27.587	24.671	66.003	25.415	5.2166	8.5103	15.236	5.5901
Maximum	36.547	253.95	98.192	15.166	91.8	79.507	196.4	132.16	28.9	19.4	37.8	9.334
Minimum	.841	12.36	7.656	5.167	5.708	5.4	14.756	5.159	2.521	4.03	7.201	1.97
Runoff mm	-	-	-	-	-	-	-	-	-	-	-	-

Flows in cubic metres per second

Annual statistics

Maximum 253.950 Minimum .841 Mean 24.602 cubic metres per second
Total 775.838 million cubic metres Runoff .000 millimetres

Possible data flags

Missing - flag "-" Original - no flag set Estimate - flag "e"

Printed on 1/ 7/1994

Institute of Hydrology
Annual summary of daily data - Flow

Station number : 9081 Name : Paray Crump (file PARA1.DLY)

Basin no. : 0 Latitude : 0: 0: 0 N Longitude : 0: 0: 0 E Altitude : .0
Area : 1.0

Year : 1990/1991

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	1.7	4.4	.5	3.5	141.0	17.5	19.3	1.7	.8	.8	.4	.2
2	1.6	5.8	.6	3.1	145.0	14.3	16.0	1.6	.8	.8	.4	.2
3	1.5	6.6	.6	2.6	97.1	12.8	13.5	1.5	.8	.7	.3	.2
4	1.4	8.6	.5	2.0	76.8	11.6	12.3	1.4	.8	.7	.4	.2
5	1.3	7.3	.6	1.6	91.1	11.6	11.2	1.6	.8	.7	.3	.2
6	1.3	6.6	1.3	1.3	84.6	11.3	10.3	1.3	.7	.8	.4	.3
7	1.2	5.9	13.0	1.3	87.2	12.5	9.7	1.3	.7	.8	.4	.3
8	1.2	4.9	27.0	5.8	117.7	11.6	9.2	1.3	.7	.8	.4	.4
9	1.2	4.1	16.3	31.9	106.9	11.9	8.8	1.2	.7	.7	.3	.4
10	1.3	3.6	11.8	23.2	81.9	10.6	8.0	1.3	.7	.7	.3	.4
11	1.4	3.1	8.7	15.8	68.5	10.7	7.5	1.2	.7	.7	.3	.4
12	2.1	2.7	7.5	11.3	56.3	10.3	6.9	1.2	.8	.7	.3	.4
13	2.4	2.4	21.7	8.1	46.0	17.4	6.4	1.2	.7	.7	.3	.6
14	2.3	2.0	14.3	6.1	40.4	135.4	6.1	1.2	.7	.7	.3	1.9
15	2.6	1.7	13.1	4.7	45.5	74.2	5.6	1.2	.8	.7	.3	6.5
16	16.1	1.5	14.0	3.8	50.6	51.2	5.2	1.1	.7	.6	.3	4.3
17	15.1	1.3	17.6	3.1	149.9	42.6	4.8	1.1	.7	.6	.3	3.0
18	10.7	1.2	17.9	3.5	125.0	73.6	4.4	1.0	.8	.6	.2	2.3
19	8.5	1.1	11.2	3.8	266.3	168.3	4.2	1.0	.8	.6	.2	1.8
20	6.7	.9	8.9	11.8	171.1	110.8	4.1	1.0	.8	.6	.2	1.5
21	6.2	.9	7.1	13.4	113.6	80.3	3.8	1.0	.8	.6	.2	1.4
22	5.7	.8	5.6	43.5	82.8	84.8	3.5	1.0	1.0	.5	.2	1.2
23	5.3	.7	4.6	58.0	61.1	84.1	3.5	.9	1.0	.6	.2	1.1
24	5.0	.7	4.2	138.0	47.7	70.2	3.3	.9	1.0	.5	.2	1.0
25	5.0	.7	4.0	116.0	38.1	57.6	3.2	.9	1.0	.5	.2	.9
26	10.6	.6	3.7	102.0	30.8	48.8	2.8	.9	.9	.5	.2	.8
27	10.4	.6	3.2	123.0	25.7	42.8	3.0	.8	.9	.4	.2	.9
28	8.1	.6	2.6	144.0	21.3	37.1	3.0	.8	.8	.4	.1	.9
29	6.7	.6	2.3	222.0		31.0	2.9	.8	.8	.4	.1	4.7
30	5.7	.5	4.2	169.0		26.1	2.6	.8	.8	.4	.2	10.2
31	4.9		3.2	148.0		22.6		.8		.4	.1	
Mean	5.0178	2.7429	8.1267	45.977	88.203	45.339	6.8402	1.1224	.8197	.63552	.25671	1.6165
Maximum	16.125	8.614	27.011	222.0	266.26	168.33	19.335	1.698	1.041	.825	.371	10.225
Minimum	1.235	.537	.534	1.28	21.334	10.309	2.558	.783	.723	.424	.138	.157
Runoff mm	-	-	-	-	-	-	-	-	-	-	-	-

Flows in cubic metres per second

Annual statistics

Maximum 266.260 Minimum .138 Mean 16.797 cubic metres per second
Total 529.720 million cubic metres Runoff .000 millimetres

Possible data flags

Missing - flag "-" Original - no flag set Estimate - flag "e"

Printed on 1/ 7/1994

Institute of Hydrology
Annual summary of daily data - Flow

Station number : 9081 Name : Paray Crump (file PARA1.DLY)

Basin no. : 0 Latitude : 0: 0: 0 N Longitude : 0: 0: 0 E Altitude : .0
Area : 1.0

Year : 1991/1992

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	7.4	74.8	7.8	12.1	2.7	1.3	1.2	1.0	.2	.2	.2	36.4
2	5.7	58.7	6.9	11.6	2.8	1.8	1.1	1.0	.2	.2	.2	26.1
3	4.7	47.5	6.3	12.8	2.4	14.3	1.3	.9	.2	.2	.2	18.8
4	3.9	56.7	6.2	11.0	1.8	12.9	1.6	.9	.2	.1	.2	18.8
5	3.5	49.7	6.9	10.2	1.5	8.5	1.4	.8	.2	.1	.2	13.0
6	2.8	44.8	9.6	14.3	1.5	6.0	1.3	.7	.2	.2	.2	9.9
7	2.4	38.5	9.1	18.4	1.2	4.9	1.1	.7	.2	.2	.2	7.7
8	2.0	31.1	7.7	10.1	1.6	3.7	1.4	.6	.2	.2	.3	6.6
9	1.9	25.0	7.0	7.7	.9	3.0	1.4	.6	.2	.2	.3	5.9
10	2.1	21.0	8.9	6.0	.9	2.5	1.4	.5	.2	.2	.4	5.1
11	2.1	18.7	9.5	4.9	.9	2.0	1.4	.5	.2	.2	.4	4.4
12	1.9	17.4	12.7	4.2	1.0	1.7	1.6	.5	.2	.2	.3	3.7
13	7.4	15.2	11.2	4.1	1.3	1.5	1.7	.5	.2	.2	.3	3.1
14	31.7	16.9	10.2	9.8	1.0	1.3	1.5	.4	.2	.2	.3	2.8
15	111.0	20.6	10.0	3.6	.9	1.2	1.3	.4	.2	.2	.3	2.4
16	83.6	16.6	12.7	3.6	.9	1.1	1.3	.4	.2	.2	.3	2.2
17	50.2	13.4	23.1	3.1	.9	1.0	1.3	.4	.2	.2	.3	1.9
18	35.1	11.1	25.8	2.6	1.0	1.0	1.1	.4	.2	.2	.2	1.7
19	33.0	19.6	20.5	2.1	1.3	2.8	1.0	.3	.2	.2	.2	1.6
20	114.0	66.3	29.1	1.8	2.1	.9	.9	.3	.2	.2	.2	1.3
21	333.0	55.6	28.1	1.6	4.1	.8	1.0	.4	.2	.2	.2	1.1
22	254.0	35.5	22.1	1.4	3.2	.9	1.1	.3	.2	.2	.2	.9
23	237.0	25.6	16.6	1.2	2.0	.8	1.2	.3	.2	.2	.2	.9
24	179.0	19.6	12.8	1.0	1.8	.9	1.2	.3	.2	.2	.2	.8
25	131.0	15.6	10.6	.9	1.7	1.1	1.6	.2	.2	.2	.2	.8
26	97.1	12.7	8.9	.8	1.5	1.1	2.0	.2	.2	.2	.2	.7
27	79.4	10.9	15.0	.7	1.3	1.3	1.7	.2	.2	.2	.2	.7
28	89.2	9.6	27.8	1.2	1.8	1.3	1.4	.2	.2	.2	.2	.6
29	84.7	8.6	19.6	1.0	1.2	1.1	1.2	.2	.2	.2	.2	.5
30	71.5	8.9	13.9	.9		1.0	1.1	.2	.2	.2	.2	.4
31	91.9		11.6	2.6		1.0		.2		.2	6.2	
Mean	69.488	28.868	13.814	5.4002	1.6253	2.7345	1.3081	.47029	.20673	.15548	.43313	5.4385
Maximum	333.0	74.772	29.099	18.426	4.082	14.252	2.02	1.041	.22	.157	6.171	36.387
Minimum	1.9	8.562	6.192	.747	.854	.834	.87	.22	.157	.111	.157	.447
Runoff mm	-	-	-	-	-	-	-	-	-	-	-	-

Flows in cubic metres per second

Annual statistics

Maximum 333.000 Minimum .111 Mean 10.899 cubic metres per second
Total 344.659 million cubic metres Runoff .000 millimetres

Possible data flags

Missing - flag "-" Original - no flag set Estimate - flag "e"

Printed on 1/ 7/1994

Institute of Hydrology
Annual summary of daily data - Flow

Station number : 9081 Name : Paray Crump (file PARA1.DLY)

Basin no. : 0 Latitude : 0: 0: 0 N Longitude : 0: 0: 0 E Altitude : .0
Area : 1.0

Year : 1992/1993

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	.4	8.0	21.4	3.8	26.1	18.2	5.9	11.3	2.1	1.0	.6	.9
2	.4	70.6	17.3	3.2	19.6	19.8	5.2	9.8	1.9	1.0	.6	.8
3	.3	105.5	13.5	3.4	13.6	24.5	5.2	8.9	1.9	1.1	.6	.8
4	.4	59.1	11.2	3.2	10.3	23.6	5.5	8.4	1.8	1.1	.6	.9
5	.3	48.2	9.4	2.6	12.8	20.0	5.9	7.9	2.0	1.0	.6	.9
6	.3	61.6	7.8	2.8	13.7	15.5	5.4	7.2	2.1	1.0	.5	.9
7	.3	42.8	7.2	3.3	13.2	17.6	4.9	6.3	2.1	1.0	.5	1.0
8	.4	36.7	7.1	2.7	13.6	23.4	4.7	5.7	2.0	1.0	.5	.9
9	.9	158.1	6.5	2.2	51.8	32.4	4.6	5.2	2.1	.9	.4	.9
10	1.8	314.6	7.4	2.0	62.0	26.7	3.8	4.9	1.9	.9	.4	.8
11	6.7	153.9	8.3	2.1	49.4	29.6	3.2	4.8	1.7	.9	.6	.7
12	35.5	102.4	14.9	1.9	52.5	35.9	300.2	5.0	1.6	.7	.8	.6
13	25.7	71.0	19.7	1.7	64.5	32.0	236.0	4.8	1.6	.8	2.5	.6
14	17.7	51.8	21.8	2.1	58.1	33.7	86.7	4.4	1.6	.8	7.0	.5
15	12.1	41.4	20.0	2.0	44.4	32.1	64.3	5.2	1.5	.7	5.3	.5
16	8.4	37.7	13.9	4.8	34.2	30.5	49.8	5.9	1.5	.7	4.1	.4
17	6.2	27.6	10.9	2.9	27.0	26.4	39.8	6.3	1.5	.7	3.2	.4
18	5.0	21.3	8.1	3.5	30.0	25.9	51.7	6.1	1.4	.7	2.7	.4
19	3.8	19.2	6.7	3.2	25.7	26.8	51.9	5.5	1.3	.7	2.4	.3
20	3.0	61.8	5.6	2.4	34.8	25.3	39.7	5.3	1.3	.7	2.1	.3
21	2.5	79.4	4.7	1.8	37.1	21.1	32.9	4.8	1.4	.7	1.9	.3
22	2.1	54.0	4.7	7.8	34.8	18.2	27.3	4.5	1.3	.7	1.7	.3
23	2.0	39.0	4.5	27.4	27.7	14.6	22.5	4.0	1.2	.6	1.4	.2
24	5.6	31.0	10.9	17.1	26.5	12.5	18.8	3.5	1.2	.7	1.4	.3
25	27.8	69.7	9.1	10.5	27.2	10.5	16.1	3.1	1.2	.7	1.4	.3
26	23.6	60.7	6.7	11.1	24.5	9.3	13.9	2.9	1.1	.7	1.2	.3
27	16.1	42.8	8.7	14.0	26.0	8.2	12.7	2.7	1.0	.7	1.2	.3
28	11.9	33.2	7.4	10.6	20.8	8.6	12.1	2.5	1.0	.7	1.1	.4
29	9.2	26.3	5.3	13.2		7.4	13.0	2.3	1.0	.6	1.0	.4
30	10.0	24.0	5.0	23.3		8.0	12.9	2.3	1.0	.6	1.0	.6
31	9.6		4.8	27.9		7.2		2.2		.6	1.1	
Mean	8.0646	65.119	10.015	7.113	31.503	20.82	38.549	5.2815	1.5467	.81623	1.6295	.5601
Maximum	35.536	314.61	21.755	27.913	64.511	35.906	300.16	11.314	2.102	1.139	6.962	.974
Minimum	.289	7.98	4.509	1.657	10.338	7.152	3.24	2.152	1.041	.626	.447	.22
Runoff mm	-	-	-	-	-	-	-	-	-	-	-	-

Flows in cubic metres per second

Annual statistics

Maximum 314.610 Minimum .220 Mean 15.675 cubic metres per second
Total 494.319 million cubic metres Runoff .000 millimetres

Possible data flags

Missing - flag "-" Original - no flag set Estimate - flag "e"

Printed on 1/ 7/1994