OVERSEAS DEVELOPMENT ADMINISTRATION
MINISTRY OF AGRICULTURE, GOVERNMENT OF SOMALIA

HYDROMETRY PROJECT - SOMALIA

Second Progress Report
Phase 3
September 1988 - February 1989

Mott MacDonald Consultants
Demeter House, Station Road, Cambridge CB1 2RS
United Kingdom

in association with

Institute of Hydrology
Wallingford, Oxon 0X10 8BB

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SUMMARY

This report describes work on the Somalia Hydrometry Project between September 1988 and February 1989. Work has continued satisfactorily during this period, though it was slightly restricted in the last two months due to health problems.

Daily water level data has been received regularly from the nine gauging stations; this has been processed manually and also entered onto the database. A bulletin about the river flows has been produced every ten days and published in cooperation with the Food Early Warning Project.

During the period a total of 21 discharge measurements have been taken at seven river gauging stations, divided between the two rivers. These have generally shown reasonable agreement with the existing rating curves.

Data from the automatic water level recorders at Bardheere and Lugh Ganana has been collected regularly during the period and the recorders have been operating successfully. However, the other recorders at Kamsuma and Beled Weyn have not been working. The latter should become operational shortly.

An observer was appointed for the new gauging station at Kamsuma, thus re-establishing the regular return of data from the lower Jubba. A reasonable rating curve has been derived from the discharge measurements made since July, together with two in 1984.

Historic data for Balcad, Mareere, Kaitoi and Kamsuma has been entered to the computer database, together with discharge measurements from which rating curves have been derived. It is planned to use this data to infill periods of missing data at other stations.

Numerous requests for data have been received by the Hydrology Section and appropriate advice and information has been given to various local and international organisations. Close cooperation has been maintained with the National Water Centre and the river level and flow data has been copied to their computer to form part of their data archive.

The historic data already entered to the computer for Lugh, Bardheere and Afgoi has been carefully checked against the original records; many minor discrepancies and a few major errors were corrected. The checking of data for the remaining stations is now underway.

Throughout the period specific items of work have been treated as training exercises for the counterpart staff. Several unsupervised field trips were carried out. The staff are generally making good progress in both office and field work. One of the staff members is under consideration for a period of training at a UK university in 1989/90.

In the next six months work will continue on all aspects of the project, including water quality measurement which has received little attention to date. Subject to the prevailing river levels before the onset of the Gu flood it is intended that a number of staff gauge installations will be renovated. In contrast to the period under review there will be a major input by the Programmer in addition to the Resident Hydrologist.

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1. INTRODUCTION

This Progress Report describes work on the Somalia Hydrometry Project during the period from September 1988 to February 1989. In order that it can be read without the need for immediate reference to the previous reports, much of the Introduction and some other general sections and points from the first Progress Report have been repeated here. The report comprises a brief summary of progress during the period together with a series of appendices covering fieldwork and other aspects in greater detail. This is the third report produced during Phase 3 of the project and follows the Inception Report and the first Progress Report. There will be a further progress report in October 1989 followed by the Final Report at the conclusion of Phase 3. The latter will be accompanied by the publication of a revised Data Book so that the most up-to-date estimates of historic river flows will be available to assist in the future development of water use in Somalia.

The project aims to assist the Government of Somalia in the day-to-day management of the Jubba and Shebelli rivers, and to improve the reliability of the hydrometric database for both current and historic data. This work is the responsibility of the Hydrology Section of the Directorate of Irrigation and Land Use in the Ministry of Agriculture (MOA). The scheduled two year duration of Phase 3 follows work by the Consultants over a period of about two and a half years between 1983 and 1986.

Appendix A describes the state of the river flows in 1988 and includes hydrographs for each of the primary stations. Appendix B contains the reports on fieldwork. Appendix C details the entry of additional data and Appendix D reviews the performance of the automatic water level recorders.

2. STAFFING

2.1 Expatriate Staff

Five expatriate staff members (three from Mott MacDonald Consultants - previously Sir M MacDonald and Partners - and two from the Institute of Hydrology) were scheduled to work on the project in Somalia; two of them have made inputs during this period. One staff member, the Programmer/ hydrologist, has worked on the project in the UK during this period, and there has also been intermittent Head Office backup when required.

2.2 Staff Movements

The Field Hydrologist (Mr P F Ede, MM) left Somalia on leave on September 15th and arrived back in Somalia on October 16th following a brief period working in the Consultant's Head Office. He was in Somalia for the remaining time except for two weeks' sick leave in February. Mr P H W Bray, Project Coordinator (MM), visited Somalia in February and worked briefly on the project.

The Programmer/hydrologist (Dr K J Sene, IH) is due to start his next visit to Somalia in March. Dr J R Meigh (IH) has completed his input to the project and the final expatriate staff member, the Consultant Hydrologist (Mr T E Evans, MM), will be making a visit to the project shortly.

2.3 Local Staff

The main members of the local staff have been as follows:

Zakia Abdissalam Alim	(on maternity leave from October)	
Ali Yusuf Wayrax		
Ibrahim Abdullahi Sheikh Ahmed		
Marian Sharif Ahmed		
Maxamuud Maxamed Saiid	(until October)	Driver
Ahmed Nur Garash	(from October)	Driver

The driver has been employed by the Project; the remaining staff are employed by the Ministry of Agriculture to work in the Hydrology Section. The work of the Section comes under the overall direction of Mohamoud Mohamed Ali, Director of Irrigation and Land Use.

In connection with the project one Technical Cooperation (TC) award is available from British Council funds to enable one of the local staff to receive training at a UK university. The Director, supported by the resident hydrologist, recommended that Ibrahim should be considered for this scholarship. Various procedures have to be gone through before this can be confirmed, but it is hoped that Ibrahim will be able to attend a postgraduate course of between six and twelve months' duration in Britain during the 1989/90 academic year. This experience should assist the work of the Hydrology Section, particularly after the end of the project.

2.4 Supervision

The British Development Division in East Africa (BDDEA) has maintained a close interest in the progress of the project. The Hydrologist had discussions with Mr B Jackson, Engineering Advisor, at BDDEA in February. Mr Jackson had previously visited Somalia in September while the hydrologist was on leave; he discussed the project with the Director of Irrigation and Land Use and the local staff. The British Embassy in Mogadishu has continued to provide support and communication with BDDEA in Nairobi.

3. WORK UNDERTAKEN

3.1 General

Following the groundwork undertaken during the first six months of Phase 3 the regular work of the Hydrology Section has continued, both in the office and on field visits to all stations on the two rivers. The work programme has been planned by the Field Hydrologist to achieve the objectives of the Project, maintaining an appropriate balance between office and field work. This work is described in more detail in the sections below and in the Appendices.

3.2 Fieldwork

Introduction

The primary work of the Field Hydrologist has consisted of a regular programme of field visits to the gauging stations operated by the Hydrology Section on the Jubba and Shebelli rivers. This work is planned to achieve the following main points:

(a) Early identification of any problems with staff gauges, observers etc;
(b) Regular collection of data from the observers and where appropriate from the automatic recorders;
(c) Discharge measurements in order to identify any change in the established stage/discharge rating;
(d) Water quality monitoring;
(e) Training in fieldwork for Hydrology Section staff.

The Terms of Reference for the project envisaged a programme of fieldwork such that all stations would be visited once a month. In practice visits have been slightly less frequent than this because of leave, illness and the need to maintain office work. To visit all stations requires a minimum of 11 days (almost half the working month) of arduous travelling and fieldwork, and probably 13 days in practice if discharge measurements are to be undertaken at all sites. It is considered that it is probably beneficial for staff productivity to make major trips slightly less frequently than originally planned; this should not cause any significant reduction in the amount of useful fieldwork.

Availability of reliable transport is critical to the success of the Section's work because most of the gauging stations are very remote from Mogadishu and the journeys include sections of very rough road. The Land Rover provided by ODA under Phase 3 has performed extremely well to date, with no mechanical breakdowns and few punctures despite having covered about 20 000 km during the period. There have been no problems with the availability of fuel.

One minor and two major field trips were undertaken by the counterpart staff on their own. On each occasion this was because the Field Hydrologist was unavailable, but such trips are in any case valuable because they provide a good opportunity for the staff to demonstrate their understanding of hydrological procedures learnt on previous trips. In most respects these field trips were successful.

3.2.2 Data Collection

The graphs in Appendix A showing the river discharges for 1988 show that the return of data has been good since the resumption of the project (or the recruitment of observers in the case of Kamsuma and Kurten Waarey). This is primarily due to the regular field visits during which recent data has been collected. From some sites data cards are delivered by the observer or coordinator on visits to Mogadishu, but where the local postal service has been used there have often been considerable delays. From a few sites more immediate information on river levels has been obtained via the MOA radio network.

The automatic water level recorders at Lugh and Bardheere on the Jubba have operated well since the initial visits in July and data has been retrieved on subsequent visits. However, the other two recorders have not been operational. A review of the performance of the recorders is presented in Appendix D. It is planned that the existing recorders should be maintained as far as possible, but the provision of additional recording installations is not recommended. This is partly because of the varied performance levels of the existing recorders, but primarily because the standard of data collected from observers has substantially improved since the start of the project.

3.2.3 Discharge Measurements

The regular measurement of river discharge at each station is important in order to check the validity of the existing rating curve, and if necessary to derive a new equation. During this period a total of 21 measurements have been made; these are listed in Table 1. Most measurements have been reasonably close to the rating curves, though there is a problem with the cableway equipment at Bardheere (operated by the Ministry of Jubba Valley Development) which means that measurements there are of limited value. Low flows at Lugh were considerably below the rated values, but because of the shifting river bed such variations are inevitable and do not necessarily mean that the existing rating curve has to be amended.

3.2.4 Water Quality Measurement

Unfortunately it has not been possible to undertake regular measurements relating to water quality. Occasional spot measurements of electrical conductivity have been made by the Section, but it is considered that it would be best to place the conductivity meters at two of the main stations and make arrangements with the MOA observers for daily readings to be taken. Sediment sampling will be started as soon as possible, though it may prove difficult to arrange full testing of samples.

3.2.5 Field Trip Reports

Reports have been written on all fieldwork undertaken on a monthly basis. These have provided an ongoing record of work carried out and have also enabled the section to keep the Director of Irrigation and Land Use fully informed of progress. These reports, which expand on the points outlined above, are reproduced in Appendix B.

3.3 Office Work

Office work has been centred on the computer, primarily the use of the HYDATA package for the entry and checking of data. Training has also been given in the use of Lotus spreadsheets, primarily for the calculation of discharges from current meter measurements and for producing the river flow bulletins.

TABLE 1

Discharge Measurements Carried Out During the Period

Date	Station	Gauge height[a] (m)	Velocity (m/s)	Area (m^2)	Discharges Measured (m^3/s)	Discharges Equation (m^3/s)	% error
3/ 9/88	Lugh	2.90	0.72	351.4	254.0	271.9	-7
8/ 9/88	Kamsuma[c]	4.05	0.78	309.8	241.9	-	
2/10/88[e]	Afgoi	4.84	0.67	123.2	82.7	88.6	-7
26/10/88	Lugh	4.60	1.08	674.0	730.4	780.3	-6
2/11/88	Kamsuma[c]	6.24	1.02	474.6	484.9	-	
9/11/88	Afgoi	4.965[b]	0.67	127.6	84.9	91.9	-8
16/11/88	Beled Weyn	1.40	0.88	70.0	61.9	56.8	+9
17/11/88	Mahaddey	3.99	0.66	116.7	76.9	93.6	-18
30/11/88	Bardheere	1.255	0.52	310.9	161.6	119.8	+35
1/12/88	Lugh	2.03	0.31	270.3	83.3	108.6	-23
11/12/88	Kamsuma	2.31	0.46	173.6	79.3	-	
18/12/88	Beled Weyn	0.65	0.46	44.6	20.5	20.2	+2
18/12/88	Bulo Burti	1.48	0.72	27.7	19.9	15.5	+28
19/12/88	Mahaddey	2.03	0.37	54.9	20.3	23.6	-14
5/ 1/89[e]	Lugh	1.49	-	205.5	Equipment faulty		
11/ 1/89	Bardheere[d]	0.555	0.15	235.3	35.3	41.5	-15
12/ 1/89	Lugh	1.42	0.15	170.0	25.5	36.1	-29
26/ 1/89	Afgoi	1.83[b]	0.46	27.2	12.5	16.4	-24
8/ 2/89[e]	Beled Weyn	0.47	0.36	34.2	12.3	13.7	-10
8/ 2/89[e]	Bulo Burti	1.205	0.65	20.6	13.4	8.6	+55
9/ 2/89[e]	Mahaddey	1.63	0.33	37.9	12.5	15.1	-17

Notes:

[a] Mean gauge height during measurement period.

[b] Equivalent Gauge Height at Afgoi calculated from bridge dip measurement using revised datum difference of 7.42 m.

[c] The results for Kamsuma cannot be compared to the existing rating curve because the current gauge zero has not yet been related to that used for measurements in the period 1972 to 1976.

[d] It is believed that there is an error in the distance measuring equipment at the Bardheere cableway which results in a significant over-estimation of area and hence discharge.

[e] Discharge measurement carried out by counterpart staff without supervision.

It was noted in the previous report that work was severely affected by breaks in the mains electricity supply. The general unreliability of the Mogadishu supply continued, but the problems in the office were largely overcome by the installation of a line from the Ministry generator - although the generator was not always available when wanted. A new supply line was also installed for the air conditioner which makes working conditions more pleasant and satisfactory (for both staff and equipment) when the mains supply is available.

No progress has been made on the faulty items of computer equipment. The external disk drive was sent back to the UK for repair but when it was returned it was again found that its installation prevented operation of the computer. No further attempts to get this working are envisaged. It is still hoped that something can be done about the Uninterruptible Power Supply unit, but to date discussions about this with the suppliers have not borne fruit.

During the period the backlog of data entry for the primary stations was completed and historic data was entered for several additional stations. This was done to facilitate later infilling of missing data for the primary stations. The stations concerned were Balcad on the Shebelli (data for 1963-80) and Kaitoi (1963-64 and 1972-80), Mareere (1977 to date) and Kamsuma (1972-76) on the Jubba. The data for Kamsuma extends the record of the recently rehabilitated primary station; Balcad was originally a primary station and the other two are considered as secondary stations. Some of this data will be particularly valuable because it covers periods when no data is available for the primary stations on the Jubba.

For Balcad the original twice daily staff gauge data was entered, while for the Jubba stations mean daily levels were taken from reports published by the Ministry of Jubba Valley Development and from data sheets provided by the Jubba Sugar Project at Mareere. For all stations discharge measurements were analysed and rating curves derived. This work is described in detail in Appendix C.

3.4 Liaison With Other Organisations

The close links established with the FEWS project have been maintained. Data received via the MOA radio network set up under that project has been made available to the Hydrology Section and in return summary tables and analysis are produced every ten days for the regular bulletin on rainfall, river flows and crop conditions.

The informal links with the National Water Centre (NWC) have been extended following an agreement between the respective Ministries about the use of data collected by the Hydrology Section. NWC has purchased the database package HYDATA from the Institute of Hydrology; this will be used for rainfall and climate data as well as river flows. The data from the MOA computer was transferred to the NWC computer so that it is available for use by NWC staff. They will not be publishing the data themselves without further agreement with MOA. At appropriate intervals updated copies of the MOA data files will be transferred to NWC so that their record is kept up to date with new data and with corrections made to the historic data. In the event of breakdown of the project computer this backup facility at NWC would be invaluable to enable the work of the Section to continue.

Many requests have been received for data regarding one or both rivers; advice has been given as freely as possible because the provision of validated data sets is one of the major objectives of the project. Information has been given to a number of local organisations and to Consultants and other international organisations studying particular projects related to either of the rivers. In addition, advance warnings of the October flood on the Jubba were passed to the Fanoole and Mogambo projects. The Der flood on the Shebelli was not particularly high, but the Director was kept fully informed of the situation so that he was able to make appropriate decisions regarding the operation of the Jowhar Offstream Reservoir and the Duduble Flood Relief Channel.

4. FUTURE PROSPECTS

The outlook for the progress of the project over the next six months looks reasonably favourable. The Field Hydrologist will be resident through this period except for leave in June/July. The Programmer/hydrologist will be visiting Somalia for a period of about two months, starting in March. It is hoped that the Consultant Hydrologist will make a short visit in May during which the work programme for the remainder of the project period will be discussed with the other two expatriate staff and the Director of Irrigation and Land Use.

The priorities for the next six months will be to continue the programme of regular field visits to all stations, including the introduction of sediment sampling, and to complete checking the historic data so that infilling of some of the gaps in the data can be carried out.

APPENDIX A

RIVER LEVEL AND FLOW DATA FOR 1988

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APPENDIX A

RIVER LEVEL AND FLOW DATA FOR 1988

A1 INTRODUCTION

This appendix presents the discharge hydrographs for 1988 for the primary gauging stations operated by the Hydrology Section (with the exception of one station - Kurten Waarey - where the graph shows river level because no rating curve is available). The pattern of river flows during the year is described in general terms and specific comments are made on the data for individual stations.

A2 STATE OF RIVER FLOWS IN 1988

A2.1 River Jubba

A2.2.1 General

In overall terms the 1988 river flows were a little above the long-term normal levels. The Gu flood was a little shorter and lower than usual, but this shortfall was more than made up by the Der flood season. The latter started early and rose to a peak of around 950 cumecs at Lugh in late October - a value only exceeded in the last ten years by the floods in 1981 and 1987. The year as a whole showed the typical pattern with a number of minor flood peaks from April to October and very steady recession in the rest of the year.

A2.1.2 Lugh Ganana

The flows at Lugh (Figure A1) have been derived from staff gauge readings up to July 20th and from the automatic water level recorder thereafter. In general the observer appears to be reliable, though there have been some questionable SG values. Discharge measurements have been made on each visit to Lugh, including one of about 730 cumecs shortly after the October flood peak. This is one of the highest discharges actually measured in Somalia, exceeded only by one measurement in 1977 and five made during the 1981 flood. The rating curve established earlier in the project has been used; the five DMs made between July 1988 and January 1989 have shown reasonable agreement with that curve, though the measured discharges have tended to be somewhat below those calculated from the equation. The rating curve will be reassessed later in the project.

A2.1.3 Bardheere

As at Lugh, the flows at Bardheere (Figure A2) have been derived from the automatic recorder data from its installation in July. However, the recorder data for December was erroneously erased so the staff gauge data was used. The observer appears to be conscientious. Plots comparing the flows at Lugh and at Bardheere showed close correspondence except for one peak at Bardheere when very heavy local rainfall was reported.

Discharge measurements at low levels have been made by using the Ministry of Jubba Valley Development cableway. Unfortunately, there appears to be some error in the distance measuring equipment so the results are of little value. However, following the work in 1985-86 the rating curve is thought to be reliable.

A2.1.4 Kamsuma

The installation of the gauging station at Kamsuma was completed in April 1986. However, no observer could be appointed by the Ministry at that time so the only data available is from two short periods of operation of the automatic water level recorder. Furthermore, in the absence of check readings of the staff gauge even these values must be treated with caution. There were again difficulties in finding an observer in 1988 with the result that regular observations are only available for November and December. Additional spot readings were taken during four visits to the lower Jubba earlier in the year.

The installation in 1986 consisted of the automatic recorder and stilling pipe together with staff gauges covering the range 0-8 m which were attached to the brackets holding the pipe. In April 1988 it was found that the pipe and gauges below about 4.3 m had been washed away, probably during the very large flood in 1987. By the end of the year the remainder of the pipe and SG were far from secure, so readings have been made from the bridge dip point (MB) on the bridge (which is equivalent to a level of 9.96 m on the SGs). These readings can be seriously affected by the wind, particularly at low river levels, though the observer understands the problem and does not record the dip reading unless conditions allow the dip tape to be approximately vertical.

The hydrograph (Figure A3) shows the recession from the year's peak flow which is thought to have occurred on November 2nd. The flow values have been obtained from a rating equation derived from the available discharge measurements related to the established MB. There were two such DMs in 1984 and six from July 1988 to March 1st 1989. These eight points cover the full range of river levels at Kamsuma and show little scatter; the rating is therefore considered to be reasonable, but further check measurements will be made and the rating revised if necessary. A very large number of measurements were made when the station was previously in use from 1972 to 1976, but no information is available from which the gauge heights for that period can be related to the new gauge zero. However, the exponent of the new rating curve is fairly similar to that in the earlier equation which lends some additional confidence to the new rating. Details of the rating curve derivation are given in Appendix C.

A2.2 River Shebelli

A2.2.1 General

The overall average discharge in the Shebelli in 1988 was a little above the long-term normal, but there were substantial seasonal variations from that normal pattern. The peak of the Gu flood was of approximately normal magnitude, but the flood period was very short. This was followed by much lower flows than usual during the hagai period from late May to mid July; this caused considerable problems for farmers. The Der flood, by contrast, was of much longer duration than normal with a sustained flow of over 150 cumecs from Beled Weyn to Mahaddey Weyn and bank-full conditions at Afgoi and Audegle for many weeks. The flood peak, however, was not especially high. The recession from the peak level in early November was exceptionally rapid, with the flow at Beled Weyn dropping from over 230 cumecs to under 90 in seven days.

A2.2.2 Beled Weyn

The hydrograph for Beled Weyn (Figure A4) clearly shows the very short Gu flood and the sustained Der flood. This data is derived entirely from staff gauge readings because the automatic recorder failed to produce any data, despite extensive efforts to make it operational (see Appendix D). For much of the year only one reading was made each day - in some cases the observer only recorded one value while at other times the absence of variation suggests that one value was copied to the other two reading times.

Three discharge measurements have been made at low and medium flows and there is no evidence that the existing rating curve is inadequate. However, it was suggested in an earlier report that a multi-segment rating curve might be better than the existing one part curve and this will be considered before the end of Phase 3.

A2.2.3 Bulo Burti

The hydrograph in Figure A5 shows the extent of available information - no data was available for the early months of the year because the level was below the bottom of the existing staff gauge range and the observer had no bridge dipper. The latter shortcoming was overcome so that data should be available throughout the next low flow season, but the provision of an additional staff gauge depends on the river drying up in March/April - a situation which seems unlikely to occur in 1989. Bridge dip data also had to be used in place of SG data for levels above 5 m because the top gauge had been washed away. This should be replaced in 1989.

Evidence gathered during the year suggests that the observer is less reliable than those at some other stations; it seems likely that he rarely makes more than one genuine reading each day, and the bridge dip data shows unexpectedly large variations. Discharge measurements have been made at low flows, but to date these are insufficient for an assessment of the accuracy of the rating curve.

A2.2.4 Mahaddey Weyn

The hydrograph for Mahaddey Weyn (Figure A6) indicates the typical flat- topped shape resulting from out-of-bank spillage further upstream. This period of near constant flows in the Der season was substantially longer than usual. During the Gu season the river just reached this level but it was not maintained.

The observer for Mahaddey has often been unavailable because he usually travels to Jowhar each day. However, this does not imply that the data is poor; the river level is only recorded twice each day, but as the observer reads the gauge on his way to and from Jowhar it is believed that these are both genuine readings, in contrast to the situation at some stations.

A number of discharge measurements have been made during the second half of the year and all have indicated that the existing rating equation may overstate actual discharges. This is thought to be partly due to an obstruction round an old staff gauge stand which traps debris and results in an area of very low velocities. The rating will be reviewed in due course.

A2.2.5 Afgoi

As at Mahaddey Weyn the hydrograph for Afgoi (Figure A7) shows the characteristic shape during the Der season, though there is a little variation. The discharge measurements have shown satisfactory agreement with the rating curve, though with a tendency for the results to be below the rating. There may be some small errors in the recorded river levels because of uncertainty in converting from bridge dip readings when the gauge is obscured. It is hoped to iron these out, but in any case they are not considered to be significant.

The observer is considered to be reasonably reliable as evidenced by a substantial number of check readings when the Hydrology Section team has been travelling to or from fieldwork at other stations.

The jilaal period from January to March and again in December clearly shows an unnatural flow pattern. During this period the river discharge is being maintained by releases from the reservoir at Jowhar and the fluctuations are believed to be caused by the weekly pattern of irrigation abstractions between Jowhar and Afgoi. River levels at Afgoi usually peak each Friday and are at a minimum on Mondays.

A2.2.6 Audegle

Audegle has proved to be one of the most problematical stations on the network. The hydrograph in Figure A8 shows the current best estimate of discharges, but these tend to overstate actual flows because of the dam effect of the collapsed old bridge. This is particularly significant at low levels. It is hoped that further study of the data and comparison with that from Afgoi will permit some improvement in the estimates by adjustment of the rating curve. No discharge measurements have been made, but it is hoped that some may be possible at low levels. Some data has been obtained from bridge dip readings, but because these are from the new bridge some distance downstream there is considerable uncertainty about the correct conversion calculation. The earlier plans to relocate the staff gauges near to the new bridge in March/April 1989 seem likely to be frustrated by unusually high dry season flows.

In addition to the difficulties resulting from the old bridge and the remoteness of the dip readings, considerable doubt was cast on the reliability of the observer when a number of check readings made on visits to Audegle showed substantial variation from the observer's recorded data. He has frequently been unavailable, though he does appear to arrange a deputy when he is absent. The weekly fluctuations at Afgoi are repeated here after a time lag of one or two days.

A2.2.7 Kurten Waarey

The station at Kurten Waarey was established in April 1986, but no arrangements for regular observations were made until the barrage attendant was appointed to be the observer in July 1988. The station consists of staff gauges covering a range of 1-6 m. The river level is below the 1 m point for a considerable part of the year - in this case up to April 22nd (presumably from the start of the year) and also from mid December. The lowest part of the river bed at the section containing the staff gauges is slightly below the overall gauge zero. In most years the river at Kurten Waarey dries up completely by April, just prior to the arrival of the Gu flood, and it is intended that an additional gauge will be installed to cover the 0-1 m range; however, the relatively high flows in the Shebelli in early 1989 mean that this may not be practicable this year.

The hydrograph for Kurten Waarey (Figure A9) is presented as gauge heights because no discharge measurements are available. It should be possible to make low flow gaugings by wading, but there is no easy way to measure the flow with the level above about 1 m. An attempt was made in November to measure velocities in the upstream approach to the barrage, and also to calculate the discharge through the gates from theoretical considerations using the size of gate openings and the head difference, but it is clear that such methods will only give a very approximate estimate of discharge. For the time being, therefore, only gauge heights are available for Kurten Waarey.

Apart from one isolated observation in April the available data runs from July 27th to December 13th. It should be noted that the level is dependent on the barrage gate settings so there can be unnatural changes in level, such as that on November 23rd when the level fell sharply before rising again when the operator found that his initial gate adjustment had been too great for the required change upstream.

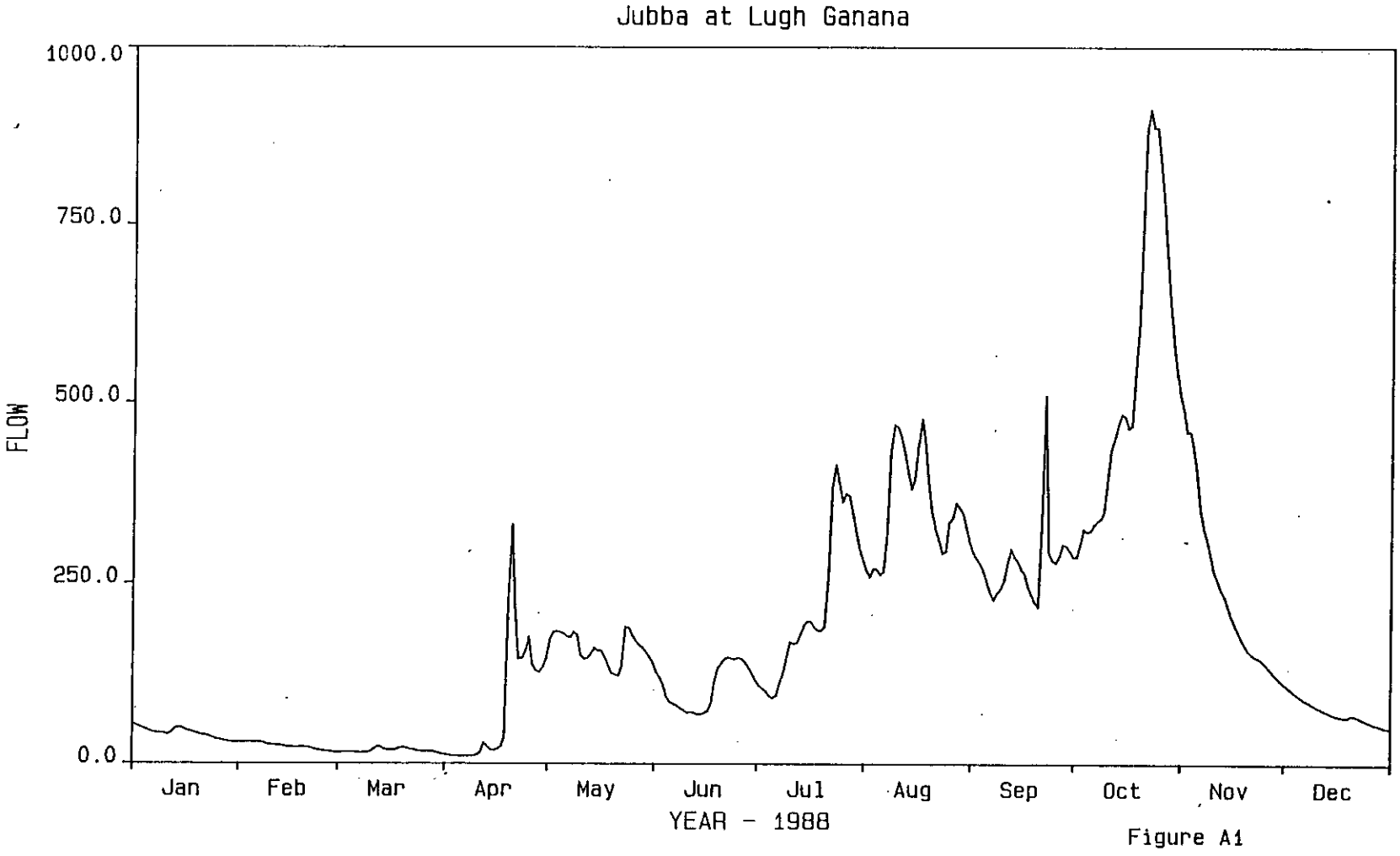
Jubba at Lugh Ganana
1000.0
750.0
500.0
250.0
0.0
FLOW
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
YEAR - 1988

Figure A1

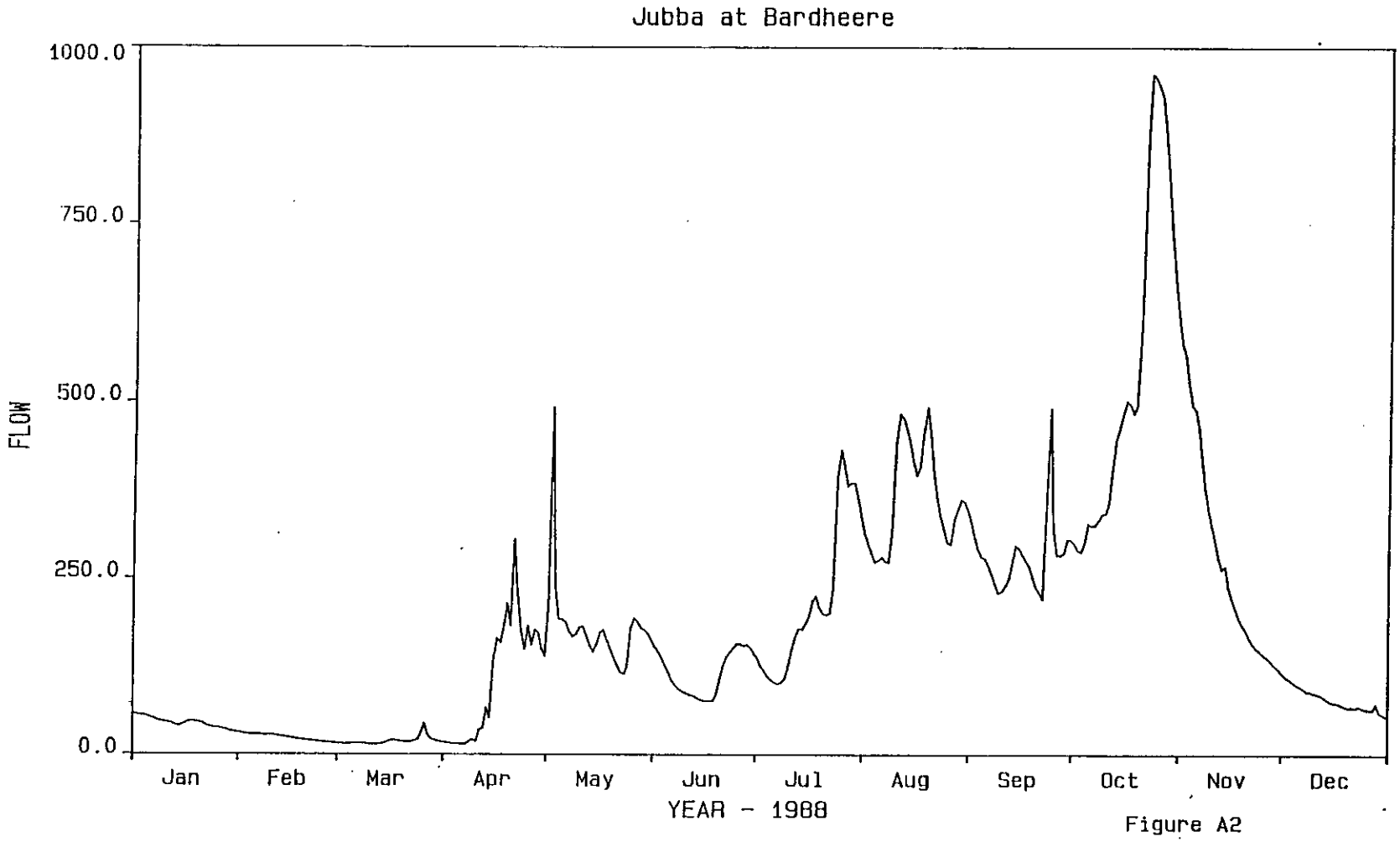
Jubba at Bardheere
1000.0
750.0
500.0
250.0
0.0
FLOW
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
YEAR - 1988

Figure A2

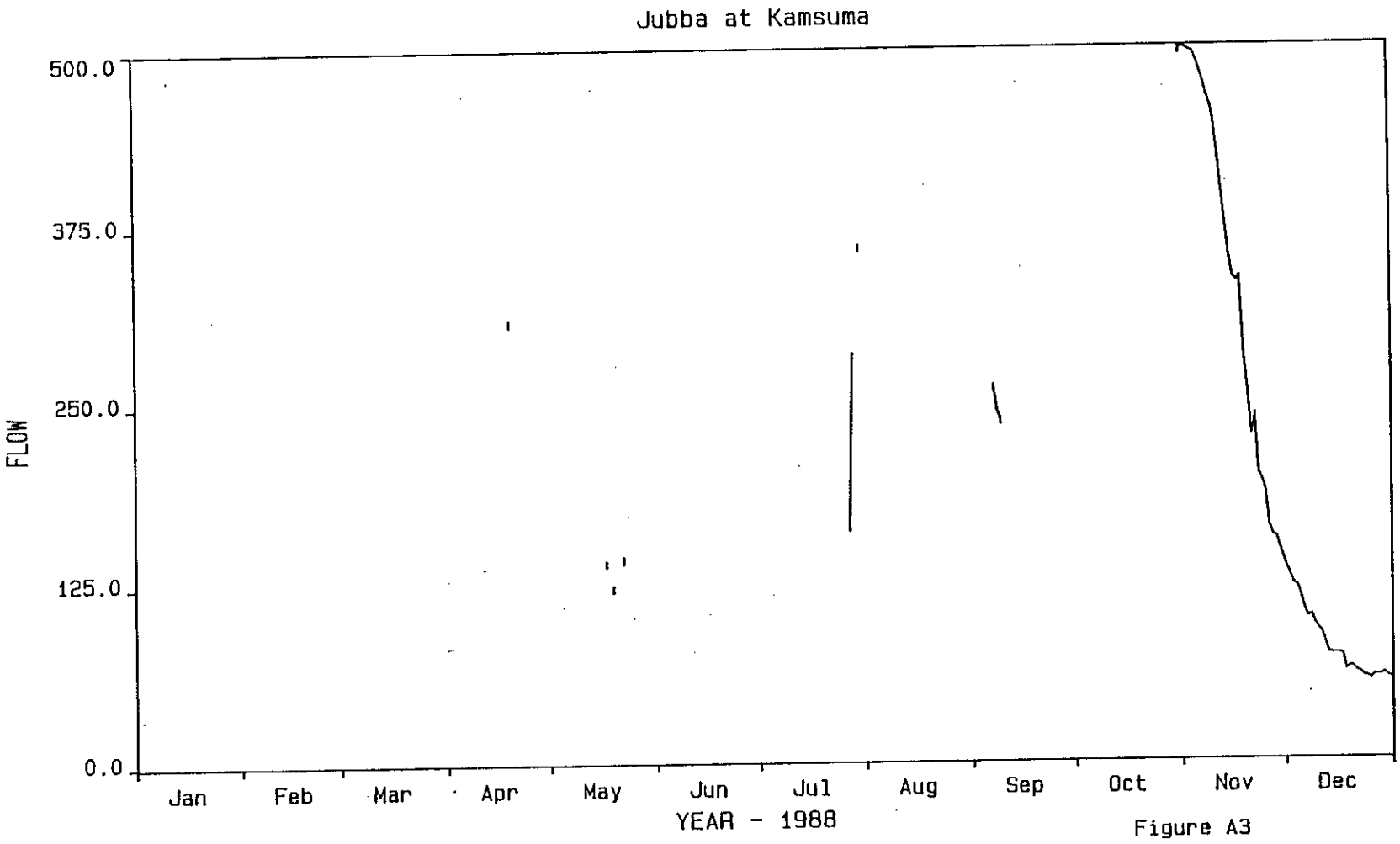
Jubba at Kamsuma
500.0
375.0
250.0
125.0
0.0
FLOW
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
YEAR - 1988

Figure A3

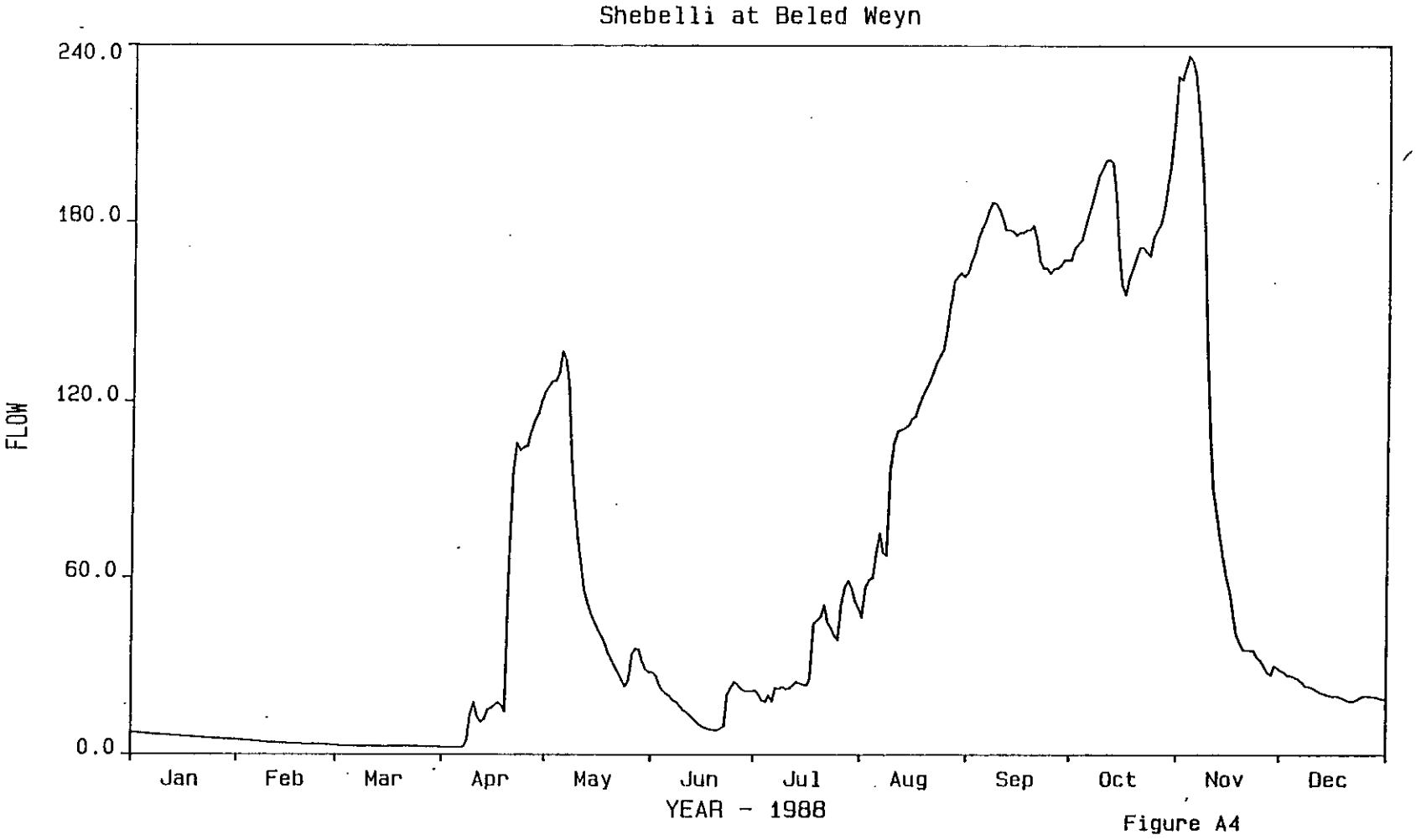
Shebelli at Beled Weyn
240.0
180.0
120.0
60.0
0.0
FLOW
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
YEAR - 1988

Figure A4

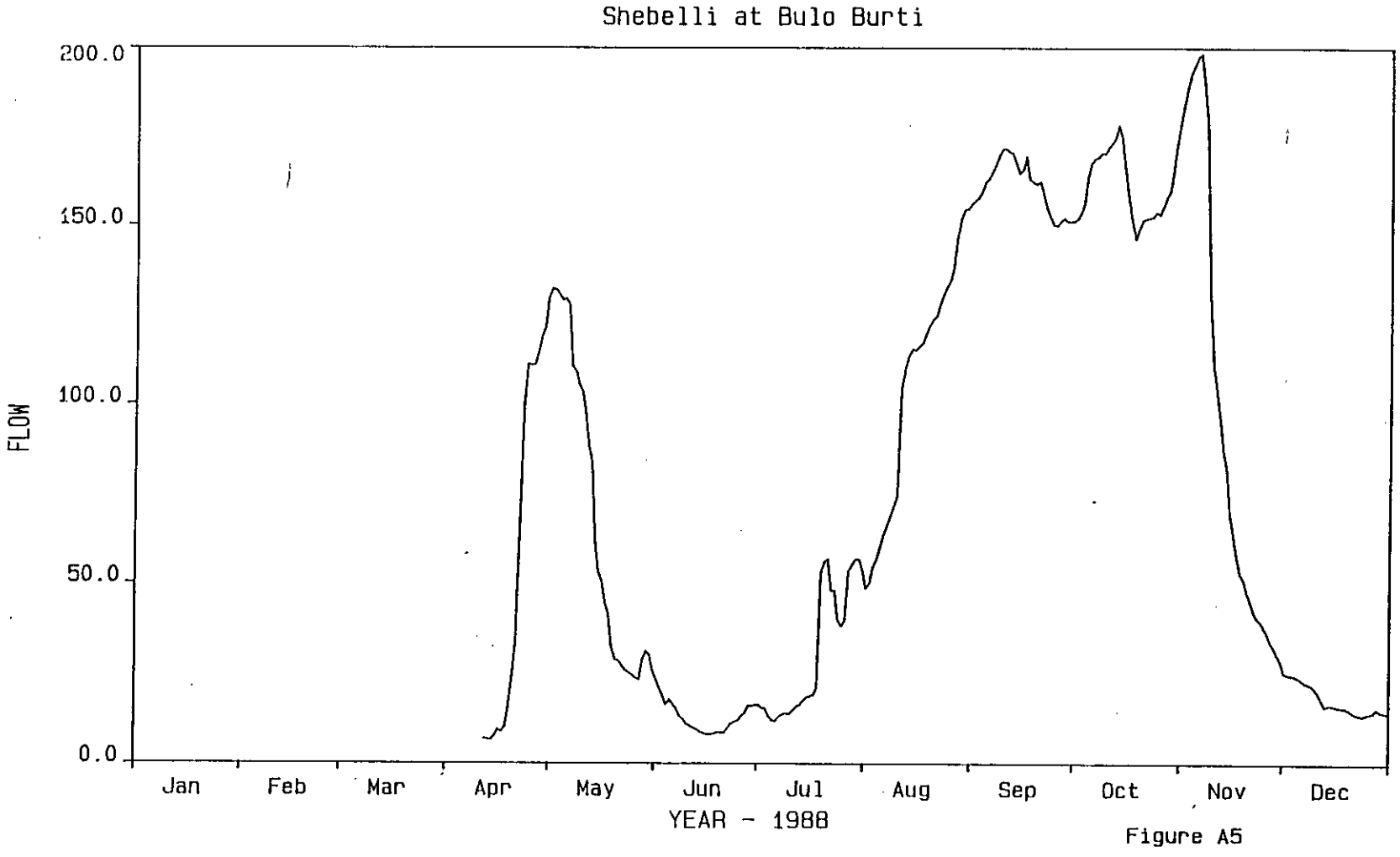
Shebelli at Bulo Burti
200.0
150.0
100.0
50.0
0.0
FLOW
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
YEAR - 1988

Figure A5

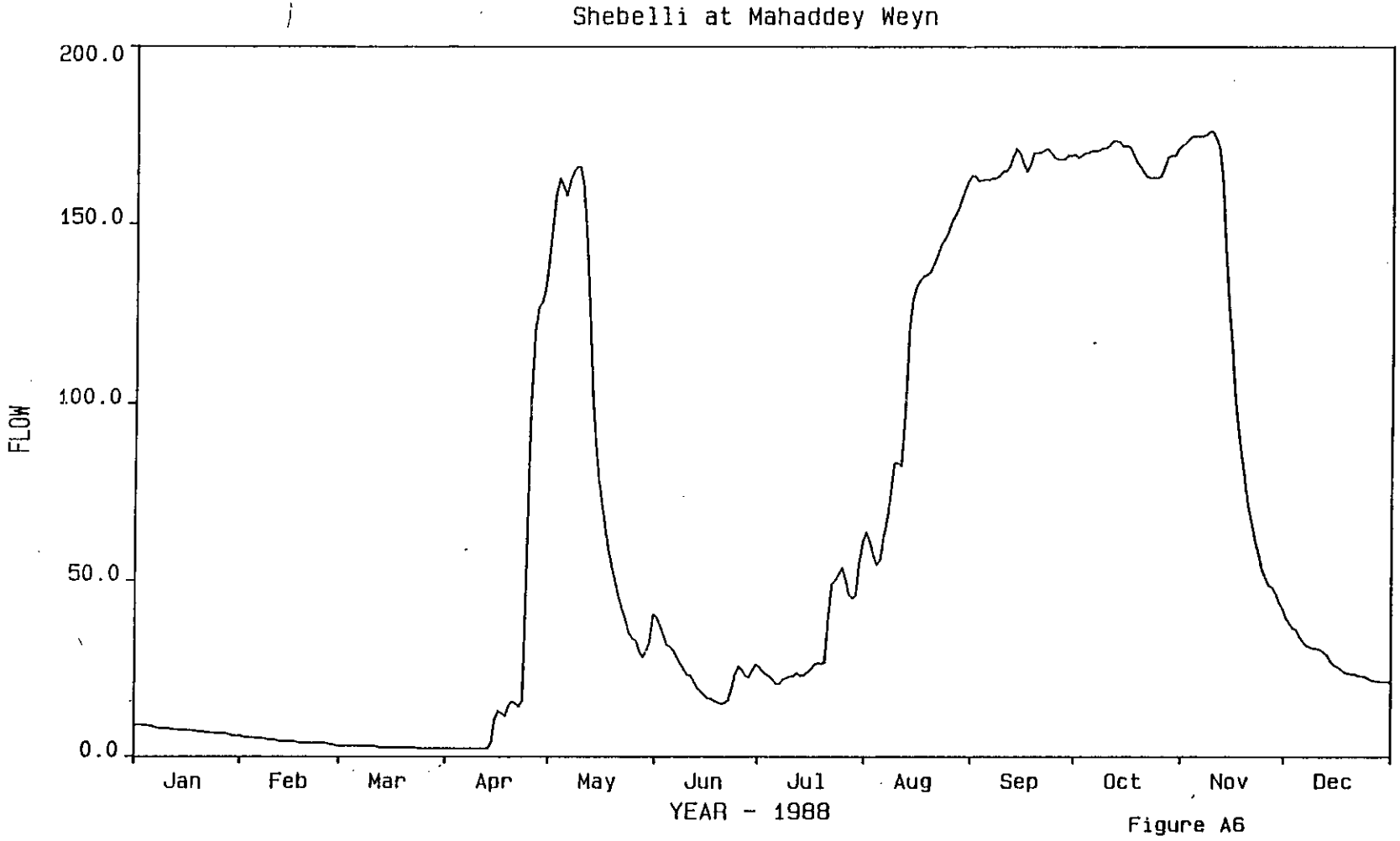
Shebelli at Mahaddey Weyn
200.0
150.0
100.0
50.0
0.0
FLOW
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
YEAR - 1988

Figure A6

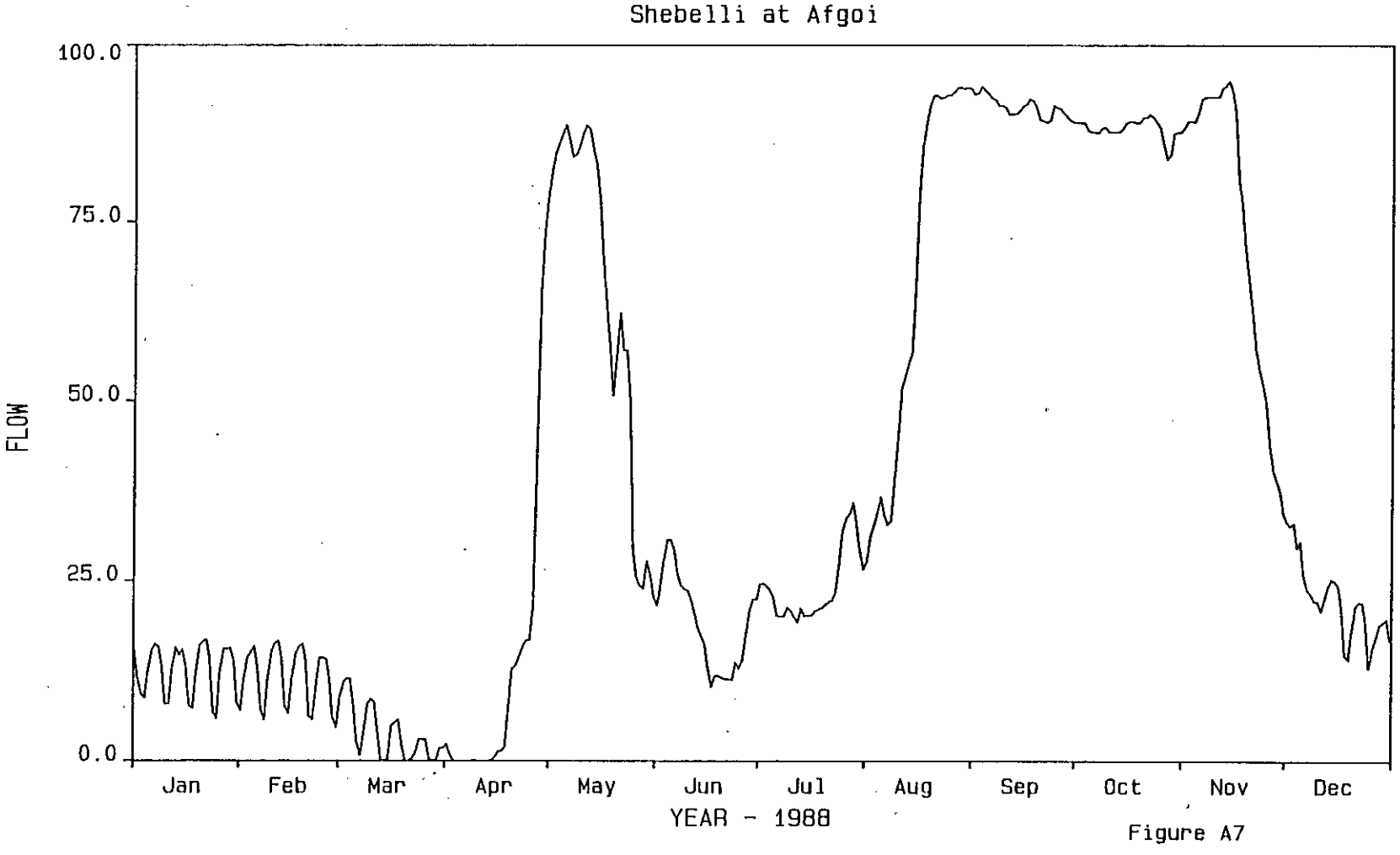
Shebelli at Afgoi
100.0
75.0
50.0
25.0
0.0
FLOW
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
YEAR - 1988

Figure A7

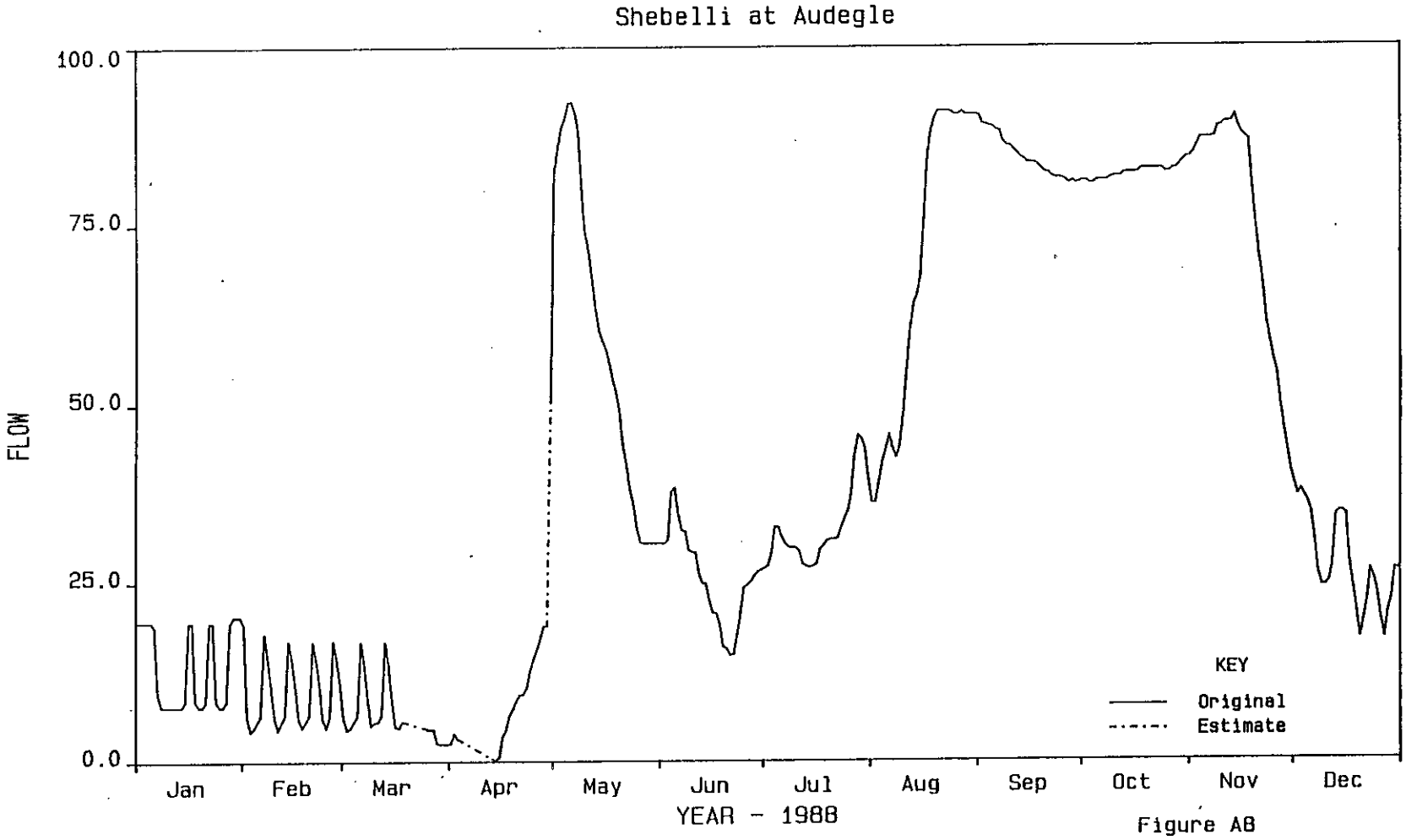
Shebelli at Audegle
100.0
75.0
50.0
25.0
0.0
FLOW
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
YEAR - 1988
KEY
Original
Estimate

Figure A8

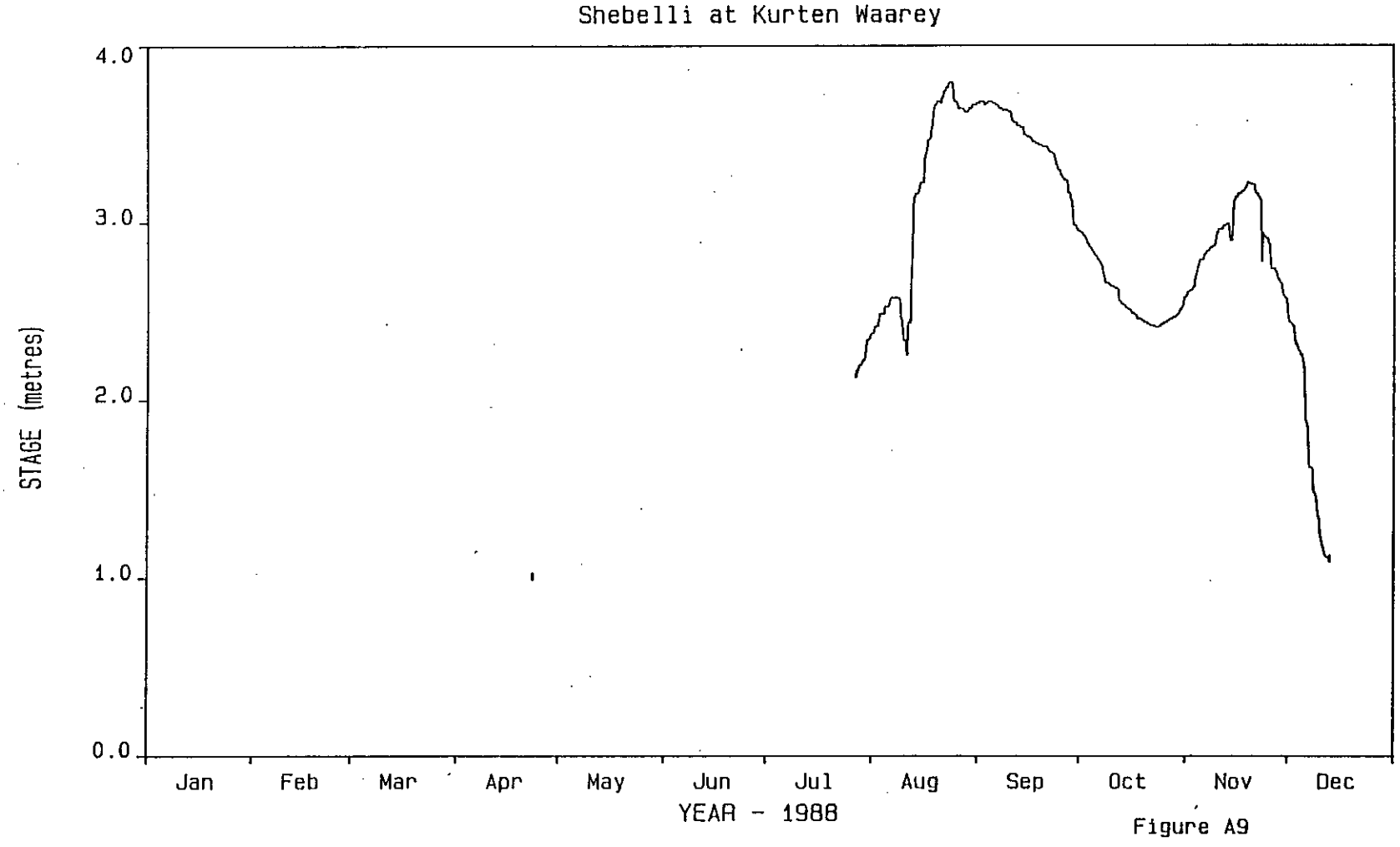
Shebelli at Kurten Waarey
4.0
3.0
2.0
1.0
0.0
STAGE (metres)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
YEAR - 1988

Figure A9

APPENDIX B

FIELD TRIP REPORTS

This appendix contains copies of the field trip reports produced during this period, brought together in a single document. The discharge measurement calculation sheets are included at the end of the appendix rather than after each particular report.

CONTENTS

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SECTION B1	FIELDWORK UNDERTAKEN DURING SEPTEMBER 1988	B1
SECTION B2	FIELDWORK UNDERTAKEN DURING OCTOBER 1988	B4
SECTION B3	FIELDWORK UNDERTAKEN DURING NOVEMBER 1988	B6
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SOMALIA HYDROMETRY PROJECT

B1 FIELDWORK UNDERTAKEN DURING SEPTEMBER 1988

2nd - 4th September	Bardheere and Lugh Ganana
7th - 9th September	Lower Shebelli and Lower Jubba

Participants (both trips):

Peter Ede
Ali
Ibrahim
Marian
Maxamuud

Upper Jubba Field Trip 2nd - 4th September 1988

Bardheere

Arrived Bardheere at 1520 on 2nd September and met the observer. At 1540 the SG reading was about 2.30 m and the bridge dip 5.72 m (EGH = 2.27 m). The automatic water level recorder was still working and showed a reading of 2.34 m which is acceptably close to the observed level. The data was copied to the data retriever and was also examined to check the flood peaks in July and August - the highest being 3.08 m on August 19th. Considerable trouble had been encountered in recharging the spare batteries in Mogadishu; a voltage check of those and the battery in place indicated that it would be best to leave the same battery until the next visit. This was brand new in July and should last for several months. Thereafter, new permanent batteries will be used. The recorder was restarted on the same battery at 1620 with the level 2.30 m.

On September 3rd at 0755 the SG reading was about 2.25 m and the AWLR showed 2.252 m. Bridge dip was 5.77 m. Some data was collected from the observer and a supply of data cards given to him. For some time he has only been recording on the monthly sheets because he has had no cards - it seems that cards despatched via the Coordinator did not reach him. We also gave the observer a bridge dipper which may well be needed at times because of debris catching on the trash rack and obscuring the staff gauge.

Lugh Ganana

Arrived at Lugh at 1305 on September 3rd. A discharge measurement was carried out. Verticals were spaced at 4 m intervals rather than the 8 m previously because of the considerable variation in depth and velocity observed in July. The results were as follows:

Staff gauge	2.90 m
Discharge	254.0 cumecs
Mean velocity	0.72 m/s

This result is about 7 % below the rating equation. The detailed results show that there has been a considerable shift in the river bed since the measurement in July - shallower towards the left bank and deeper towards the right bank. The velocity distribution across the section was broadly similar. A recalculation using only the verticals at 8 m intervals resulted in a significantly lower discharge; it is therefore likely that the measurement in July underestimated the actual discharge.

At 1715 the automatic recorder showed 2.925 m when the SG was about 2.90 m - certainly as close as can reasonably be expected because the staff gauge readings both before and after the period of recording are only accurate to within 1 or 2 cm. The data was transferred to the retriever and examined. The highest level was 3.70 m on August 17th and the time of travel of this flood peak to Bardheere was about 46 hours. As at Bardheere it was considered best to reset the recorder using the same battery (it was also being used for the first time). This was done at 1740 with the level 2.90 m. On 4th September at 0700 the SG level was about 2.89 m and the AWLR showed 2.885 m.

Afgoi

At 0815 on September 2nd the SG reading was approximately 5.03 m. On 4th September at 1545 the gauge was partly obscured, but the level had clearly dropped slightly to just under 5.00 m.

Lower Shebelli and Lower Jubba Field Trip 7th - 9th September 1988

Kurten Waarey 7th September 1988

At 1040 the SG reading (after the observer had swum out to clear weeds round the gauge) was approximately 3.64 m - only accurate to +/- 3 cm in the fast flowing water. Data was collected for 27th July to 2nd September except for one weekly card which could not be found in the office. The observer is keen and seems to be competent. The letter from MOA confirming his allowance for being the observer was delivered.

Kamsuma

The level was just below the broken staff gauge - bridge dip 5.72 m (EGH = 4.24 m) at 1655 on 7th September. The level dropped slightly during our stay, reaching a bridge dip of 5.95 m by 0745 on 9th September. A discharge measurement was made on 8th September in the afternoon - results as follows:

Bridge Dip (start)	5.89 m
Bridge Dip (end)	5.93 m
Mean EGH	4.05 m
Discharge	241.9 cumecs
Mean velocity	0.78 m/s

Velocities were measured at 2 m intervals over the right part of the section and for one part towards the left bank because of the substantial variation in velocity. This allowed a more exact check of the reverse flow section observed in July. However, it appears that the use of 4 m intervals does not significantly impair the accuracy of the measurement.

The main reason for this visit to the lower Jubba was to meet and train the observer for Kamsuma. The coordinator for the Jamamme district had responded to our request by finding a potential observer and we had given him the letter with details of salary and allowances (subject to the man being found to be suitable). Unfortunately, the coordinator was not in Jamamme and other MOA employees said that he lived in Kismayu (70 km away) and rarely came to the Jamamme office. Apparently he has not passed on salaries and allowances to the Jamamme staff for the last four months.

We decided to go to Kismayu in search of the coordinator. We failed to find him but we did meet the proposed observer who also lives in Kismayu. It is considered impracticable to accept this novel arrangement because a round trip of 180 km would be required for a single water level observation.

Mogambo

On 7th September at 1715 the staff gauge was found to be silted to a level of about 10.9 m. The water level was guessed to be around 10.7 m. By the following evening the water had dropped to the top of the lower gauge stand - level approx. 10.52 m at 1730. At 0730 on 9th September the reading was 10.49 m.

Audegle 9th September 1988

The Shebelli was extremely full and there was extensive minor flooding. The road between Janaale and Audegle (on the left bank) had been breached by floodwater but it was just possible to get through. At 1450 the readings at Audegle were 5.44 m (SG) and 1.75 m (Dip). Once again we were unable to find the observer. The comments in an earlier report by Rod Hawnt that the Audegle observer was the most conscientious of all now seem a little wide of the mark.

Afgoi

On 7th September at 0740 the bridge dip reading was 2.52 m (EGH=4.90 m). By 1555 on 9th September the river had risen very slightly to a dip reading of 2.49 m (SG approx. 4.94 m).

Peter Ede
18th October 1988

B2 FIELDWORK UNDERTAKEN DURING OCTOBER 1988

2nd October Afgoi
25th - 27th October Bardheere and Lugh Ganana

Participants:

	2	25-27
Peter Ede		y
Ali	y	y
Ibrahim	y	y
Marian	y	y
Maxamuud	y	
Ahmed		y

Afgoi 2nd October 1988

This trip was undertaken by the counterparts alone during the absence of the Hydrologist on leave in England. It was planned as part of the regular programme of field visits for data collection and river gauging, and was also seen as a good test of the ability of the counterpart staff to do fieldwork on their own by applying the methods which had been learnt on previous trips. The trip may be adjudged a success on both counts. The summary below is based on the field notes made by Marian and Ibrahim.

Arrived at Afgoi at 7.30. The discharge was measured using the regular procedure of verticals at 2 m intervals. The river dropped slightly from 4.85 m to 4.83 m during the measurement. Results were as follows:

Mean staff gauge	4.84 m
Mean bridge dip	2.59 m
Discharge	82.7 cumecs
Mean velocity	0.67 m/s

The measured discharge was about 7 % below that calculated from the rating equation - certainly a satisfactory result. Monthly data sheets and weekly cards were collected from the observer.

Upper Jubba Field Trip 25th - 27th October

Bardheere

Arrived at about 5 p.m. on October 25th - the road was much worse than previously because of recent rain. The SG level was 4.48 m (a little below the peak of the flood), and the bridge dip was 3.59 m. The automatic water level recorder was still working on the battery originally installed in July and showed a level of 4.42 m. The clock was about 4 minutes slow. The discrepancy in level is a bit larger than previously, but the data should still be useful. The data showed a flat flood peak of 4.48 m (i.e. SG about 4.54 m) during the night of 23rd/24th October. The data was transferred to the retriever and the logger restarted using a new Duracell battery at 1735 with the level 4.48 m (this was only an approximate SG reading because of waves). Some recent data was collected from the observer.

On October 26th at 0635 the SG reading was a steady 4.46 m. The recorder was adjusted from 4.48 to 4.46.

Lugh

Lugh was reached at 1240 after 5 hours 40 minutes driving (cf 4:50 in September). At 1330 the SG was 4.61 m, nearly 50 cm below the peak a few days earlier. The results of the discharge measurement were as follows:

SG (start)	4.61 m
SG (finish)	4.59 m
Discharge	730.4 cumecs
Mean velocity	1.08 m/s

This result is about 6 % below the rating equation. In view of the dramatic shift in the bed profile compared to the previous measurements this is certainly an acceptable result. The measured discharge is almost double the largest previously recorded by the Project (at Kamsuma on 30th July) and is the seventh highest on record in Somalia. Most of the higher ones were measured at Lugh during the 1981 flood.

The automatic recorder showed 4.56 m at 1700 compared to 4.58 m on the SG. The clock had lost about 5 minutes. This is again satisfactory. The data showed a sharp peak of 5.05 m at 0600 on 22nd October. The data was transferred to the retriever and the recorder reset using a new battery with the level at 4.58 m. The new Duracell batteries used at Bardheere and Lugh should last for about two years.

The river level continued to fall and at 0745 on October 27th the SG reading was 4.46 m. The recorder showed 4.45 m.

Peter Ede
31st October 1988

B3 FIELDWORK UNDERTAKEN DURING NOVEMBER 1988

1st-3rd November	Kamsuma, Mogambo and Jilib
9th November	Afgoi
15th-17th November	Beled Weyn, Bulo Burti and Mahaddey Weyn
23rd November	Kurten Waarey
29th Nov.- 1st Dec.	Bardheere and Lugh Ganana

Participants:

	1-3	9	15-17	23	29-1
Peter Ede	y	y	y	y	y
Ibrahim	y	y	y	y	y
Ali	y	y	y	y	
Marian	y	y			y
Khadija		y	y	y	
Ahmed	y	y	y	y	y

Lower Jubba Field Trip 1st - 3rd November 1988

Kamsuma

As had been expected following the flood at Lugh, the river was extremely full throughout the lower Jubba. At Kamsuma the SG reading at 1545 on November 1st was approximately 6.23 m. It was difficult to read the gauge because of debris caught between the stilling well/staff gauge and the bridge pillar. It was also clear that this was putting great strain on the pipe with the possibility that the remaining sections could soon suffer the same fate as the lower parts. The bridge dip reading was 3.74 m (which is equivalent to SG = 6.22 m).

The river level changed only slightly during our visit - rising to a dip reading of 3.71 m by the morning of November 3rd. By then a large crack had appeared on one of the pipe connectors and failure appeared to be imminent. A full discharge measurement was carried out on November 2nd, with results as follows:

Bridge dip	3.72 m
Equivalent SG	6.24 m
Discharge	484.9 cumecs
Mean Velocity	1.02 m/s

The detailed results which are attached indicate that at this very high river level the section of reverse flow had been eliminated, though the velocities were very low at that point.

An observer (a lady named Hawa Abdi Mohamed) was recruited and trained to use the bridge dipper which we provided. In view of the state of the remaining part of the staff gauge there was no point in asking her to record SG levels as well.

Mogambo

The SG level at the Pump Station was 12.51 m at 1600 on November 1st. This also rose slightly overnight to 12.54 m. At this level there was no need for the pumps to be operated. The flood relief channel had been in operation for some days. The flow in the channel was obviously small compared to that in the river, but it was a significant contribution to the protection of the river bank further downstream.

Jilib

The main purpose of visiting Jilib was to collect any data that the Fanoole project had for Lugh in June and July 1985. The data recorded by the MOA observer was very suspicious - the hydrograph showed an unnatural arithmetical progression followed by a very sharp drop, and there was no such rise at Bardheere. The Fanoole data also looked of dubious quality, but examination of it in Mogadishu suggested that it was reasonable - and certainly better than the previous values.

The river level at Jilib (according to the observer) was 5.57 m. The actual gauge reading was 5.25 m, but the observer read this as 1.25 m and then added a constant of 4.32 m. The river was obviously very close to its bank-full level.

Afgoi 9th November 1988

A morning trip to Afgoi was undertaken to carry out a discharge measurement and also to check the current meter used for measurements against a spare one which had more recently come to light. The river had risen again to close to its "full" level - an EGH of 4.97 m compared to 4.83 m observed on November 1st on our way to Mogambo. The results of the main measurement were as follows:

Bridge dip (mean)	2.455 m
Equivalent SG (mean)	4.965 m
Discharge	84.9 cumecs
Mean velocity	0.67 m/s

This discharge is some 8 % below the rated value - a similar difference to those of most previous measurements at Afgoi this year. Afterwards vertical velocity profiles were measured at a point near the middle of the river, using a number of different combinations of current meter and impellor. The results showed that the combination used for all measurements since July 12th produced significantly lower velocities than other arrangements. No clear difference could be attributed to the meter, but the impellor did appear to give lower velocities with either meter than were observed with other impellors. There are signs of slight damage on this impellor which could have contributed towards the low readings. The results were not sufficiently consistent (or the experiment rigorously scientific) for a precise percentage error to be determined, but the indications are that the impellor used to date may have been under-recording the velocity by an amount of the order of 5 %. This impellor will not be used in the future unless the remaining ones should be damaged; when past results are analysed it may be useful to bear in mind that the discharges are probably under-estimates of the actual flow at the time.

Middle and Upper Shebelli Field Trip 15th-17th November 1988

Beled Weyn

The river had dropped very sharply in the previous ten days - from a peak of 3.57 m on November 4th to 1.45 m on our arrival at 1715 on November 15th. It fell further overnight before the discharge measurement was undertaken, results of which were as follows:

Staff gauge	1.40 m
Discharge	61.9 cumecs
Mean velocity	0.88 m/s

This discharge is about 9 % above that given by the rating equation - not as close as some previous measurements, but quite acceptable.

The automatic recorder was checked, but as had been expected the battery installed on the previous visit was flat and no data could be retrieved. Next time the recorder is used one of the "permanent" Duracell batteries will be used; there was no point in restarting the recorder on this visit because the water level was already below the bottom of the pipe, and is unlikely to rise above that level until the Gu season next year.

Bulo Burti

The readings at about 3 p.m. on November 15th were 2.88 m (SG) and approximately 7.26 m (bridge dip). We collected data from the coordinator and queried the absence of dip readings for the previous five days. On the next day the missing values had been filled in. The observer explained that he had copied them from another piece of paper at his house; this is possible, but the erratic nature of the values suggests that he is not taking readings regularly. (The wind and the high bridge do make this site difficult for accurate bridge dip measurements, but the inconsistencies between SG and dip data could not be fully explained by the wind.) The SG data also gives rise to suspicion that the observer is making only one reading and then inventing the other two. At 1330 on November 16th the SG was 2.78 m and the dip very approximately 7.37 m.

Mahaddey Weyn

On November 15th the SG was silted to a depth of about 4.6 m. The water level appeared to be about midway between that and the 4 m level. The bridge dip was 3.12 m at 1200 (EGH = 4.40). On the next day at 1600 the dip was 3.39 m and it was clear that the SG had been dug out that morning when the level must have been about 4.21 m. We left a message for the observer that we would be doing a discharge measurement the following morning.

The results of the discharge measurement were as follows:

SG (start)	4.00 m
SG (finish)	3.98 m
Discharge	76.9 cumecs
Mean velocity	0.66 m/s

This discharge is some 18 % below the rating equation - one of the larger differences from this year's measurements. There was again a section with very low velocities near the bed - when the river dries up it will be helpful to see whether there is some obstruction at this point. The observer helped with the measurement and confirmed that he had been digging out the SG in order to take readings.

Kurten Waarey Trip 23rd November 1988

The purpose of this trip was to collect data and to see whether there would be any possibility of measuring the discharge through the barrage (necessarily very approximately). A radio message had been sent via the Settlement Development Agency (SDA) to check that Ahmed Hassan would be at the MOA to meet us. Data was collected for 3rd September to 11th November, together with one missing card from August.

At the barrage (reached at about noon by a circuitous route because of flooding) it was seen that the upstream level was high (about 5 m on the old SG) while the level on the Project's SG downstream was 2.78 m. The observer explained that the level had dropped from 3.12 m that morning because he had adjusted the gates. One was almost fully open, three were very slightly open and four appeared to be completely closed. Velocity measurements were taken on the upstream side of the barrage in front of the open gate.

The surface velocity was around 1.1 m/s. From a depth of about 1.2 m the velocity increased rapidly to over 2.2 m/s at a depth of about 2.7 m. Below there it would have been too dangerous to take measurements because of the risk of the weight and meter being sucked through the gate opening. It was therefore not possible to determine the discharge, though the method might be suitable if the flow was distributed across more gate bays.

Measurements of water level (by bridge dip from the barrage deck) and gate positions were taken so that some theoretical estimate of flow could be made.

Upper Jubba Field Trip 29th November - 1st December 1988

Bardheere

At 1545 on November 29th the river level readings were as follows: staff gauge 1.28 m; Bridge dip 6.71 m (EGH = 1.28); Automatic recorder 1.36 m. The difference between the staff gauge and the recorder is larger than previously, but the recorder data should still be of some use. The data was copied to the retriever and the recorder re-initiallised at a level of 1.28 m. Data was also collected from the observer (who had travelled with us from Mogadishu - in his absence readings had been taken by the coordinator).

We met Mohamoud Sheikh Abdi Salaam who is employed by the Ministry of Jubba Valley Development (MJVD) to do discharge measurements using the cableway installed for the Bardheere Dam Project in 1985. He still does regular measurements and sends copies of the results sheets to MJVD in Mogadishu. He agreed to do a measurement the following morning.

The discharge measurement was carried out by Mohamoud and the MOA observer (Abdukadir) with some minor assistance from the Hydrometry team. Observing a measurement by cableway was good experience for the team because techniques are necessarily different from those used in gauging from a bridge. The procedure used was to first traverse the river measuring the depth at 6 m intervals and then to fix the current meter and return measuring the velocity at .2 and .8 of the depth at each point.

The reason for this is that the current meter is fixed directly to the weight and the observers have found that it tends to get clogged with mud if it is in place when the bed is sounded. The measurement of depth is less subjective than with the bridge derrick because a circuit is completed by the weight when it reaches the bed. Depths and distances are also measured to the nearest 1 cm rather than 10 cm. The observers were certainly competent in carrying out the work. River levels were as follows:

SG	1.26 m	/ 1.25 m
AWLR	1.260 m	/ 1.254 m
Dip	6.74 m	/ 6.75 m

No rating table for the current meter and propellor was available in Bardheere and the appropriate person at MJVD in Mogadishu is away; using the table previously applied to Bardheere measurements gave the following results:

Discharge	161.6 cumecs
Mean velocity	0.52 m/s

This result is 35 % above the rating equation value - indicating that there is almost certainly some error in the meter rating equation used. This will be checked with MJVD, along with other recent measurements.

Lugh Ganana

Because of the measurement at Bardheere, Lugh was reached too late to do the discharge measurement on that day. There was, however, time to check the automatic recorder. This read 2.067 m. Owing to an error (non Somali) in reading the staff gauge it was initially thought that the river level was 1.82 m which implied very poor performance from the recorder. Data was copied and the recorder reset at 1.82 m.

On seeing the observer the following morning it was found that the SG reading was actually 2.03 m. The confusion was due to an old SG which was very difficult to read. The level on that gauge had dropped by 1 cm overnight so the SG reading when the recorder was checked should have been 2.04 m - close to the recorder value. The recorder was corrected, but when data is retrieved the values for 1800 on 30/11 to 0800 on 1/12 should be raised by 0.22 m.

The discharge measurement was interesting because there was zero velocity over a substantial portion of the section towards the right bank. The results were as follows:

SG	2.03 m
Bridge dip	7.57 m
Discharge	83.2 cumecs
Mean velocity	0.31 m/s

This is about 23 % below the rated value. There had once again been a considerable change in the river bed profile. The changing profile will be examined in detail in a later report.

At Afgoi the bridge dip values were 4.68 m on November 29th and 4.95 m on December 1st.

B4 FIELDWORK UNDERTAKEN DURING DECEMBER 1988

10th-12th December Kamsuma, Mogambo and Jilib
17th-19th December Beled Weyn, Bulo Burti, Mahaddey Weyn and Jowhar
(some readings were also made at Kamsuma and Mogambo in late December)

Participants:

	10-12	17-19
Peter Ede	y	y
Ibrahim	y	
Ali		y
Marian		y
Khadija	y	
Ahmed	y	y

Lower Jubba Field Trip 10th - 12th December 1988

Kamsuma

The results of the discharge measurement on December 11th were as follows:

Bridge dip	7.65 m
Equivalent SG	2.31 m
Discharge	79.2 cumecs
Mean velocity	0.46 m/s

The 4 m marks and numbers were repainted, and intervening 2 m points marked to facilitate this and future measurements. Data was collected from the new observer - she appears to be doing a good job. At times the wind makes dip measurements very difficult, but she shows the necessary patience to wait for a lull in the wind. Later bridge dip readings were 8.10 m at 1630 on 26th December and 8.12 m at 1030 on 27th December.

Mogambo

The staff gauges were silted so no readings could be taken. Extensive efforts were being made to clear the accumulated silt so that the pumps were kept clear and to find the lower gauges. By December 24th the 7.5 to 9 m gauge was clear, but was slightly skew; this should be straightened and the level checked when the river drops further. The water level was approximately 8.08 m at 1815 on December 26th.

On 11th and 24th December some work was done to assess the discharge in the main Mogambo supply canal. This is described on attached sheets.

Jilib

A brief visit was made to the observer for the Fanoole project to supply a new observation book. For the moment this data is not being incorporated into the database, but it may be useful to infill gaps in the data for nearby Mareere - for example when the level there is below the SG range or gauges are silted (the gauges at Jilib are in the main river channel so are less likely to become silted up than those at Mareere which are in a side channel in front of the pumping station).

Middle and Upper Shebelli Field Trip 17th - 19th December 1988

Beled Weyn

The results of the discharge measurement on 18th December were as follows:

Staff gauge	0.65 m
Discharge	20.5 cumecs
Mean velocity	0.46 m/s

This discharge is very close to that given by the rating equation. It was reported on the radio the day after our visit that the staff gauge was broken. Fortunately it is apparently the upper staff gauge which is not needed for the current low levels. The damage will be assessed on the next visit so that repairs can be undertaken before the next Gu flood season. Data collected from the observer indicates that he rarely takes more than one reading per day. In the jilaal season this is of little consequence, but efforts will be made to achieve three separate readings when the river is higher.

Bulo Burti

For the first time this year a discharge measurement was carried out at this site. There were three main reasons why measurements had not been made on previous visits: firstly, it is always particularly difficult even to get permission to walk on the bridge to do a dip measurement and indications were that use of the gauging equipment would not be allowed; secondly, the bridge girders and the structure of the bridge sub-deck make it difficult to use the derrick; thirdly, time constraints have made it difficult to do work at all three Shebelli sites on the same trip. After considerable discussion permission was granted for the work on this occasion; measurements proved to be slightly less difficult than anticipated, and the low level of the river meant that the measurement at Beled Weyn was considerably quicker than earlier in the year, leaving adequate time for this one at Bulo Burti.

This measurement was therefore the first since 1984 and the results were as follows:

Staff gauge	1.48 m
Discharge	19.9 cumecs
Mean velocity	0.72 m/s

This discharge is significantly above the rated value; since it agrees closely with the results at the other sites on this trip it may be that the rating equation understates discharges at low river levels.

The base of the 1-3 m staff gauge is clearly silted so dip data will have to be used when the level drops another 10-20 cm. This gauge should be fully dug out next time. Replacement of the 5-7 m gauge (and possibly the 0-1 m) will be carried out towards the end of the dry season. The quality of the observer's data is often poor; it appears that he usually only makes one actual reading of the staff gauge. Dip readings are difficult because of the wind, but the discrepancies between dip and SG readings are sometimes too great to be explained by this.

Mahaddey Weyn

The results of the discharge measurement on 19th December were as follows:

SG	2.03 m
Discharge	20.3 cumecs
Mean velocity	0.37 m/s

This discharge is a little below the rated value, as has been the case with all measurements at Mahaddey this year. Comparison plots of Beled Weyn and Mahaddey Weyn for 1988 show slightly higher flows here than would be expected, supporting the suggestion that the equation is overstating actual flows.

Jowhar

Data was collected from Mr. Hajir at Jowhar and discussions were held about the possibility of joining forces for discharge measurements on the JOSR outlet canal - Mr. Hajir has access to a boat.

Discharge Measurement at Mogambo Irrigation Project on 11th December 1988

After testing of additional current meter equipment belonging to MMP, a set of equipment for discharge measurement by wading was taken to Mogambo for use by the Irrigation Engineer (Chris Brown of MMP). Some measurements were made by Peter Ede to test the procedure for measuring canal flows.

(1) Velocities were measured using a Braystoke BFM001 current meter. The site was the main canal just to the downstream (western) side of the main Jilib to Kismayu road. Measurements were in fact made by lowering the rod and meter from the concrete walkway rather than by wading. This would have been easier (and possibly more accurate) with an extension to the rods.

(2) Measurement of velocity over a vertical at the middle of the left bank (southern) channel section indicated virtually zero velocity in the bottom 0.2 m. Velocity then increased rapidly and from 0.4 m to the surface (1.26 m) there was relatively little change (range 0.50 to 0.57 m/s).

This indicates that the two point method (mean of velocities at 0.2 x depth and 0.8 x depth) would underestimate mean velocity while the single point method (0.6 x depth) would substantially overestimate.

Thus:

Mean velocity	= 0.42 m/s	
at 0.2 x depth vel.	= 0.52 m/s)	mean = 0.36 m/s
at 0.8 x depth vel.	= 0.21 m/s)	
at 0.6 x depth vel.	= 0.57 m/s	

(3) Across the section there was no significant change in velocity at 0.2 x depth from the middle to 0.1 m from the edge (the closest which the current meter could safely be positioned). With the total width of the section 1.8 m, the effective width can be assumed to be at least 1.7 m.

Hence, approximate discharge	= 0.42 x 1.26 x 1.7 x 2
(over both sections)	= 1.8 m/s

The discharge into the canal from the pump station was supposed to be around 2 m/s so the results seem reasonable, though a repeat measurement (perhaps also at a different section) would be advisable.

(4) To overcome the problem of the stagnant section near the bed the following initial guidelines are suggested:

> Take the effective depth to be 75 % of the total depth and take two or more measurements of velocity within the top 60 % of the depth. Assume that the mean of these velocities represents the top 75 % of flow with zero velocity for the bottom 25 %.

These should be revised when additional measurements are made.

Peter Ede
14/12/88

Discharge Measurement at Mogambo Irrigation Project on 24th December 1988

The discharge in the main canal was measured by wading at a site midway between the pump station and the main road. The canal was about 12 m wide and up to 1.14 m deep. The chest waders proved adequate and could be used in water another 10 or 15 cm deeper. Because of weed growth at the edge of the canal upstream of the section chosen, zero velocities were encountered for about 2 m near each edge. Over the rest of the section there was a smooth variation in velocity to a maximum at the surface near the middle of the section of 0.30 m/s. Near the bed the velocity increased very quickly, unlike the results at the road section (December 11th) when silt at the bottom produced a 'dead' section. The section may therefore be considered to be a good site for measuring discharge; either the one or two point method would be reasonable and acceptable results could be obtained with only a small number of verticals.

The velocities at the various points selected for measurement are given in the table, together with the mean velocity over each vertical. The overall measured discharge was 1.63 cumecs - slightly less than the crude estimate made on 11th December.

Peter Ede
7th January 1989

TABLE B1

Discharge Measurement at Mogambo Irrigation Project

Date: 24th December 1988

Location: Midway between pump station and main road

Observers: Peter Ede, Brian Jones, Mohamed Ali Mohamed and assistant

Equipment: Braystoke current meter with 8011 series propeller

Number of propeller revolutions in 50 seconds

Distance up from bed	(Distance across canal, m) 5.5	6	7	8	9	10	11	12	13	14	15	16	17	17.3
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.08					15	18	25	23	28					
0.1		4	1	17	19	29	32	35	32	19	16	3	1	
0.2		3	0	20	25	33	39	40	34	24	19	0		
0.5			2	33	36	38	44	44	42	35	22			
0.7			2	38	43	48	48	45	43	43	33			
0.8				40			48			39				
1.0					45	47	52	55	50					
Full depth	0.00	0.50	0.87	1.00	1.07	1.11	1.14	1.10	1.08	0.98	0.82	0.49	0.20	0.00

Velocity

Distance up from bed	5.5	6	7	8	9	10	11	12	13	14	15	16	17	17.3
0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.8					0.09	0.10	0.14	0.13	0.16					
0.1		0.03	0.00	0.10	0.11	0.16	0.18	0.19	0.18	0.11	0.09	0.00	0.00	
0.2		0.00	0.00	0.11	0.14	0.18	0.22	0.22	0.19	0.14	0.11	0.00		
0.5			0.00	0.18	0.20	0.21	0.24	0.24	0.23	0.19	0.13			
0.7			0.00	0.21	0.24	0.26	0.26	0.25	0.24	0.24	0.18			
0.8				0.22			0.26			0.22				
1.0					0.25	0.26	0.29	0.30	0.27					
Mean velocity (vertical)	0.00	0.01	0.00	0.17	0.19	0.21	0.24	0.24	0.22	0.18	0.13	0.00	0.00	0.00
Sections:														
Mean vel.	0.00	0.00	0.08	0.18	0.20	0.23	0.24	0.23	0.20	0.15	0.06	0.00	0.00	
Width	0.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.30	
Mean depth	0.25	0.69	0.94	1.04	1.09	1.13	1.12	1.09	1.03	0.90	0.66	0.35	0.10	
Area	0.13	0.69	0.94	1.04	1.09	1.13	1.12	1.09	1.03	0.90	0.66	0.35	0.03	
Discharge	0.00	0.00	0.08	0.18	0.22	0.25	0.26	0.25	0.20	0.14	0.04	0.00	0.00	

Mean velocity 0.16 m/s Maximum velocity = 0.30 m/s Area = 10.14 sq. m

Total discharge = 1.63 cumecs

B5 FIELDWORK UNDERTAKEN DURING JANUARY AND FEBRUARY 1989

3rd-5th January	Bardheere and Lugh
10th-12th January	Bardheere and Lugh
26th January	Afgoi
7th-9th February	Beled Weyn, Bulo Burti and Mahaddey Weyn

Participants:

	3-5	10-12	26	7-9
Peter Ede		y	y	
Ibrahim	y	y	y	y
Ali	y	y	y	y
Marian	y		y	y
Khadija			y	
Ahmed	y	y	y	y

Introduction

Because of illness affecting Peter Ede, the planned programme of fieldwork was somewhat restricted. The counterpart staff undertook two major trips alone, but no visit was made to the lower Jubba in either month.

Upper Jubba Field Trip 3rd - 5th January 1989

A report on this field trip was compiled by Ibrahim and is attached. The trip was not completely successful and a repeat visit was made the following week. Some comments on this first trip are contained in the report below.

Upper Jubba Field Trip 10th - 12th January 1989

Bardheere

Bardheere was reached at about 1600 on January 10th when the river level readings were as follows:

Staff gauge	0.56 m
Recorder	0.560 m
Bridge dip	7.43 m

The data on the recorder was copied to the retriever. This procedure was very quick because it contained only the past week's data; the previous period's data had obviously been erased. Since the data was also erased from the retriever before the return to Mogadishu (indeed before data was copied at Lugh) approximately five weeks' data has been lost. This is not too serious because the river level was steadily declining for most of the period and staff gauge data is available.

It is accepted that mistakes do happen (hopefully not to be repeated), but the fact that the staff were unaware that the erasure of data from both recorder and retriever (and the recorder at Lugh) had occurred is a matter of some concern. Erasure of data requires the entry of a special code so that it cannot happen accidentally, yet the staff had no recollection at all that the code had been entered at any time.

A small error in the recorder clock was corrected and the recorder reset at 0.560 m at 1615. At 0715 on January 11th this had dropped by 3 mm.

A discharge measurement using the cableway was undertaken by the MJVD and MOA staff in Bardheere with minor assistance from the Mogadishu team. The results were as follows:

SG/Recorder at start	0.56 / 0.557 m
SG/Recorder at finish	0.55 / 0.550 m
Mean SG level	0.555 m
Discharge	35.5 cumecs
Mean velocity	0.15 m/s

This discharge is actually slightly below that implied by the rating equation (41.5 cumecs), but it is substantially higher than that measured at Lugh on this trip. A similar discrepancy occurred on the November visit. It has been confirmed that the correct rating equation has been used for the current meter/propellor, but suspicion has arisen regarding the distance measuring counters.

The river widths measured on these two occasions are considerably higher than those for earlier measurements at similar river levels. If the horizontal distances are in error it may be expected that the same applies to the depths; overestimation of area and hence discharge will be proportional to the square of the excess in measurement of distance. The scale of this presumed error has not yet been determined.

Lugh Ganana

At Lugh the data from the recorder was copied to the retriever. The level at 1700 on January 11th was 1.421 m compared to 1.42 m on the staff gauge. As noted above, the previous data had been erased, though this was not remembered by the staff. However, this did not matter because it had been copied to the computer in Mogadishu after the previous trip. The clock was corrected slightly and the recorder reset at 1.420 m.

On the previous visit the counterparts had reported that the velocity of the river was zero; observation by eye on this visit showed that there was some movement, albeit extremely slow. The team had reported that the equipment was working (and that it was checked periodically during the attempted measurement), but it was found to be faulty on return to Mogadishu and was repaired. The results of this measurement were as follows:

Staff gauge	1.42 m
Discharge	25.8 cumecs
Mean velocity	0.13 m/s

This discharge is some 29 % below the rated value. This may seem to be a large difference, but the scouring of the river bed during each flood season make it very difficult to define an accurate rating for very low river levels.

Afgoi 26th January 1989

A discharge measurement was undertaken, though at the prevailing river level the water depths were rather low for accurate results using the bridge suspension method (the accurate measurement of depth is relatively difficult, and in any case it is only attempted to the nearest 0.1 m). Results were as follows:

Bridge dip	5.59 m
Equivalent GH	1.83 m
Discharge	12.5 cumecs
Mean velocity	0.46 m/s

The bridge dip was considered to be the most accurate measure of water level; the value was confirmed by observation of the staff gauge where the level was seen to be in the range 1.82 to 1.84 m. The measured discharge is about 24 % below the rated value; at low levels such a difference (amounting to less than 4 cumecs) is acceptable.

The river at Afgoi is now being maintained by the releases of water from the reservoir at Jowhar. Since mid-December the level has fluctuated between 1.40 m and 1.95 m on approximately a weekly cycle, apparently because of abstractions between Jowhar and Afgoi. During this time the levels upstream of Jowhar have declined very slowly.

Upper Shebelli Field Trip 7th - 9th February 1989

This trip was again undertaken by the counterparts without supervision (in the absence of Peter Ede in Nairobi); a report by Ibrahim is attached. The aims of the trip were to collect data, make discharge measurements and establish what repair work will be needed at Beled Weyn; the indications are that the trip was successful. The discharge measurement results were as follows:

	Discharge (cumecs)		%
	measured	equation	difference
Beled Weyn	12.3	13.7	-10
Bulo Burti	13.4	8.6	+55
Mahaddey Weyn	12.5	15.1	-17

These are minor differences except for that at Bulo Burti. The difference is similar to that observed on the previous measurement in December, thus supporting the suggestion that the rating equation is not very accurate at low levels.

Peter Ede
28th February 1989

Field Trip to Bardheere and Lugh 3rd - 5th January 1989

Participants

Ibrahim
Marian
Ali
Ahmed

Bardheere

Arrived Bardheere at 4.30 p.m. on January 3rd. The river level readings were as follows:

Staff gauge	0.64 m	
Automatic recorder	0.64 m	
Bridge dip	7.34 m	(EGH = 0.65)

This was the first time that the recorder reading has exactly agreed with the staff gauge (previously there has been a difference of between 2 and 8 cm). Data from the recorder was transferred to the retriever, but unfortunately when we returned to Mogadishu the data was found to be missing. It appears that the data was accidentally erased during the transfer of data at Lugh. However, the data should still be on the recorder at Bardheere and can be collected on the next visit.

Cards and monthly sheets were collected from the observer. We spoke to the cableway observer (Mohamoud Abdisalaam); no further discharge measurements have been made since the one on 30th November during our previous visit.

Lugh Ganana

Lugh was reached at 1400 on January 4th. The readings were as follows:

Staff gauge	1.50 m
Automatic recorder	1.51 m

The data from the recorder was transferred to the retriever on January 5th when the SG reading was 1.49 m; the difference of 1-2 cm between SG and recorder is insignificant. The recorder was corrected to 1.49 m. The data was successfully transferred to the computer on returning to Mogadishu. Data sheets and cards were collected from the observer.

A discharge measurement was carried out from the bridge between 7.45 and 9.30 a.m. on January 5th. Although the depth reached over 4 m in parts, no velocity was recorded at any of the more than 20 positions checked. The discharge expected for the observed river level would be more than 40 cumecs. The reason for the zero measured discharge is not clear.

Ibrahim Abdullahi Sheikh Ahmed
6th January 1989

Field Trip to Upper Shebelli 7th-9th February 1989

Participants

Ibrahim
Ali
Marian
Ahmed

Mahaddey Weyn

On the 7th February the observer was in Jowhar so we left new weekly cards with Mr. Hajir. He told us that the observer was still not sending the monthly sheets. We collected data cards from Hajir and when we were going to Beled Weyn left the observer a message with his family to wait for us when we come back to Mahaddey Weyn on 9th February. When we returned we collected monthly sheets from the observer. The river discharge was measured on 9th February. The staff gauge would be difficult to read between about 1.7-2.0 m because it is damaged.

Discharge measurement results:

Staff gauge	1.63 m
Discharge	12.5 cumecs
Mean velocity	0.33 m/s

Bulo Burti

Collected data from observer on the 8th February. The river discharge was measured. The observer takes dip readings, but not the staff gauge because it was out from the water. The staff gauge was silted to a little below 1.40 m.

Discharge measurement results:

Bridge dip (start)	8.91 m
Bridge dip (end)	8.90 m
Equivalent GH	1.205 m
Discharge	13.4 cumecs
Velocity	0.65 m/s

Beled Weyn

Reached Beled Weyn at 4:20 on the 7th February. Level was about 0.48 m. The river discharge was measured on the 8th February. After we took the measurements we went to the MOA office and collected data from the observer. The SG is broken between 1 and 2 m; the observer told us that to fix the broken staff gauge we have to bring the following: a 3 m wooden support, cement, paint and a new staff gauge.

Discharge measurement results:

Staff gauge	0.47 m
Discharge	12.3 cumecs
Mean velocity	0.36 m/s

Ibrahim Abdullahi Sheikh Ahmed
10th March 1989

B6 DISCHARGE MEASUREMENTS UNDERTAKEN DURING THE PERIOD

The following pages contain the calculation sheets for the discharge measurements carried out by the Project team. A total of 21 measurements were made, bringing the total during Phase 3 to 32, and these are listed below:

Date	River	Station
3rd September 1988	Jubba	Lugh Ganana
8th September	Jubba	Kamsuma
2nd October	Shebelli	Afgoi
26th October	JubbaLugh	Ganana
2nd November	Jubba	Kamsuma
9th November	Shebelli	Afgoi
16th November	Shebelli	Beled Weyn
17th November	Shebelli	Mahaddey Weyn
30th November	Jubba	Bardheere
1st December	Jubba	Lugh Ganana
11th December	Jubba	Kamsuma
18th December	Shebelli	Beled Weyn
18th December	Shebelli	Bulo Burti
19th December	Shebelli	Mahaddey Weyn
5th January 1989	Jubba	Lugh Ganana
11th January	Jubba	Bardheere
12th January	Jubba	Lugh Ganana
26th January	Shebelli	Afgoi
8th February	Shebelli	Beled Weyn
8th February	Shebelli	Bulo Burti
9th February	Shebelli	Mahaddey Weyn

DISCHARGE MEASUREMENT BY CURRENT METER

Station: Jubba at Lugh Ganana
Date: 3rd September 1988
Method: Suspension from bridge (d/s face) with 25kg weight
Origin: Left Bank
Observers: Ali/Ibrahim/Marian/Peter Ede
Meter: Braystoke BFM 001 No. 75-306 Impellor No. 8011-504

	Start	Finish
Time	1450	1650
Stage	2.90	2.90

Calculations made by method of mean velocity over section between two verticals. Two measurements at each vertical.

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
1	14.5	0.0	-	50	0	0.000	0.000					
								0.149	0.65	3.50	2.28	0.340
2	18.0	1.3	.6d	50	55	0.301	0.299					
			.6d	50	54	0.296		0.408	1.75	3.00	5.25	2.142
3	21.0	2.2	.8d	50	95	0.515	0.517					
			.2d	50	96	0.520		0.675	2.20	3.00	6.60	4.453
4	24.0	2.2	.8d	50	143	0.771	0.832					
			.2d	50	166	0.893		0.876	2.25	4.00	9.00	7.885
5	28.0	2.3	.8d	50	143	0.771	0.920					
			.2d	50	199	1.069		0.981	2.30	4.00	9.20	9.029
6	32.0	2.3	.8d	50	173	0.931	1.043					
			.2d	50	215	1.155		0.752	2.25	4.00	9.00	6.769
7	36.0	2.2	.8d	50	87	0.472	0.461					
			.2d	50	83	0.451		0.731	2.30	4.00	9.20	6.723
8	40.0	2.4	.8d	50	153	0.824	1.000					
			.2d	50	219	1.176		1.028	2.45	4.00	9.80	10.076
9	44.0	2.5	.8d	50	174	0.936	1.056					
			.2d	50	219	1.176		1.077	2.60	4.00	10.40	11.206
10	48.0	2.7	.8d	50	187	1.005	1.099					
			.2d	50	222	1.192		0.819	2.70	4.00	10.80	8.843
11	52.0	2.7	.8d	50	87	0.472	0.539					
			.2d	50	112	0.605		0.571	2.60	4.00	10.40	5.936
12	56.0	2.5	.8d	50	125	0.675	0.603					
			.2d	50	98	0.531		0.777	2.75	4.00	11.00	8.552
13	60.0	3.0	.8d	50	146	0.787	0.952					
			.2d	50	208	1.117		0.956	3.10	4.00	12.40	11.856
14	64.0	3.2	.8d	50	170	0.915	0.960					
			.2d	50	187	1.005		0.960	3.30	4.00	13.20	12.674
15	68.0	3.4	.8d	50	155	0.835	0.960					
			.2d	50	202	1.085		0.817	3.35	4.00	13.40	10.954
16	72.0	3.3	.8d	50	155	0.835	0.675					
			.2d	50	95	0.515		0.755	3.55	4.00	14.20	10.718
17	76.0	3.8	.8d	50	130	0.701	0.835					
			.2d	50	180	0.968		0.825	3.80	4.00	15.20	12.547
18	80.0	3.8	.8d	50	123	0.664	0.816					
			.2d	50	180	0.968						

(cont.)

(cont.)

Jubba at Lugh Ganana 3rd September 1988

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point (m/s)	Velocity Mean (m/s)	Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
18	80.0	3.8	.8d	50	123	0.664	0.816					
			.2d	50	180	0.968		0.840	3.80	4.00	15.20	12.770
19	84.0	3.8	.8d	50	140	0.755	0.864					
			.2d	50	181	0.973		0.651	3.55	4.00	14.20	9.241
20	88.0	3.3	.8d	50	101	0.547	0.437					
			.2d	50	60	0.328		0.600	3.50	4.00	14.00	8.401
21	92.0	3.7	.8d	50	119	0.643	0.763					
			.2d	50	164	0.883		0.757	3.70	4.00	14.80	11.210
22	96.0	3.7	.8d	50	124	0.669	0.752					
			.2d	50	155	0.835		0.752	3.70	4.00	14.80	11.131
23	100.0	3.7	.8d	50	127	0.685	0.752					
			.2d	50	152	0.819		0.413	3.25	4.00	13.00	5.367
24	104.0	2.8	.8d	50	18	0.104	0.074					
			.2d	50	6	0.043		0.386	2.90	4.00	11.60	4.480
25	108.0	3.0	.8d	50	105	0.568	0.699					
			.2d	50	154	0.829		0.729	3.05	4.00	12.20	8.899
26	112.0	3.1	.8d	50	129	0.696	0.760					
			.2d	50	153	0.824		0.764	3.10	4.00	12.40	9.475
27	116.0	3.1	.8d	50	127	0.685	0.768					
			.2d	50	158	0.851		0.513	3.05	4.00	12.20	6.263
28	120.0	3.0	.8d	50	64	0.349	0.259					
			.2d	50	30	0.168		0.501	2.95	4.00	11.80	5.916
29	124.0	2.9	.8d	50	118	0.637	0.744					
			.2d	50	158	0.851		0.760	2.95	4.00	11.80	8.969
30	128.0	3.0	.8d	50	123	0.664	0.776					
			.2d	50	165	0.888		0.627	2.95	4.00	11.80	7.396
31	132.0	2.9	.8d	50	67	0.365	0.477					
			.2d	50	109	0.589		0.412	2.05	4.00	8.20	3.379
32	136.0	1.2	.6d	50	65	0.355	0.347					
			.6d	50	62	0.339		0.173	0.60	3.40	2.04	0.354
33	139.4	0.0	-	50	0	0.000	0.000					

Total Area (sq.m) = 351.37	Total discharge (cumecs) = 253.95	Mean Velocity (m/s) = 0.72

DISCHARGE MEASUREMENT BY CURRENT METER

			Start	Finish
Station:	Jubba at Kamsuma			
Date:	8th September 1988			
Method:	Suspension from bridge (d/s face) with 25kg weight	Time	1345	1540
Origin:	Right Bank	Bridge dip	5.89	5.93
Observers:	Ali/Ibrahim/Marian/Peter Ede	Equivalent SG	4.07	4.03
Meter:	Braystoke BFM 001 No. 75-306 Impellor No. 8011-504			

Calculations made by method of mean velocity over section between two verticals. Two measurements at each vertical.

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Velocity Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
1	8.5	0.0	-	50	0	0.000	0.000					
								0.056	1.30	3.50	4.55	0.255
2	12.0	2.6	.8d	50	24	0.136	0.112					
			.2d	50	15	0.088		0.373	3.55	2.00	7.10	2.652
3	14.0	4.5	.8d	50	82	0.445	0.635					
			.2d	50	153	0.824		0.837	4.95	2.00	9.90	8.291
4	16.0	5.4	.8d	50	180	0.968	1.040					
			.2d	50	207	1.112		1.061	5.15	2.00	10.30	10.933
5	18.0	4.9	.8d	50	175	0.941	1.083					
			.2d	50	228	1.224		1.112	5.00	2.00	10.00	11.121
6	20.0	5.1	.8d	50	181	0.973	1.141					
			.2d	50	244	1.309		1.183	4.95	2.00	9.90	11.710
7	22.0	4.8	.8d	50	186	1.000	1.224					
			.2d	50	270	1.448		0.739	4.85	2.00	9.70	7.166
8	24.0	4.9	.8d	50	48	0.264	0.253					
			.2d	50	44	0.243		0.151	4.70	2.00	9.40	1.417
9	26.0	4.5	.8d	50	5	0.038	0.048					
			.2d	50	9	0.058		-0.055	4.85	2.00	9.70	-0.530
10	28.0	5.2	.8d	50	-29	-0.163	-0.157					
			.2d	50	-27	-0.152		-0.131	4.85	2.00	9.70	-1.272
11	30.0	4.5	.8d	50	-10	-0.063	-0.105					
			.2d	50	-26	-0.147		0.284	5.05	2.00	10.10	2.864
12	32.0	5.6	.8d	50	151	0.813	0.672					
			.2d	50	98	0.531		1.003	5.60	2.00	11.20	11.231
13	34.0	5.6	.8d	50	244	1.309	1.333					
			.2d	50	253	1.358		1.285	5.55	2.00	11.10	14.269
14	36.0	5.5	.8d	50	204	1.096	1.237					
			.2d	50	257	1.379		1.183	5.40	4.00	21.60	25.549
15	40.0	5.3	.8d	50	181	0.973	1.128					
			.2d	50	239	1.283		1.087	5.35	4.00	21.40	23.258
16	44.0	5.4	.8d	50	167	0.899	1.045					
			.2d	50	222	1.192		0.885	4.75	4.00	19.00	16.823
17	48.0	4.1	.8d	50	121	0.653	0.725					
			.2d	50	148	0.797		0.815	3.95	4.00	15.80	12.873
18	52.0	3.8	.8d	50	137	0.739	0.904					
			.2d	50	199	1.069						

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Jubba at Kamsuma 8th September 1988

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
18	52.0	3.8	.8d	50	137	0.739	0.904					
			.2d	50	199	1.069		0.940	3.90	4.00	15.60	14.666
19	56.0	4.0	.8d	50	165	0.888	0.976					
			.2d	50	198	1.064		0.943	3.90	4.00	15.60	14.707
20	60.0	3.8	.8d	50	142	0.765	0.909					
			.2d	50	196	1.053		0.911	3.65	4.00	14.60	13.297
21	64.0	3.5	.8d	50	149	0.803	0.912					
			.2d	50	190	1.021		0.707	3.65	2.00	7.30	5.159
22	66.0	3.8	.8d	50	83	0.451	0.501					
			.2d	50	102	0.552		0.571	3.70	2.00	7.40	4.223
23	68.0	3.6	.8d	50	129	0.696	0.640					
			.2d	50	108	0.584		0.721	3.75	2.00	7.50	5.411
24	70.0	3.9	.8d	50	120	0.648	0.803					
			.2d	50	178	0.957		0.788	4.00	2.00	8.00	6.305
25	72.0	4.1	.8d	50	116	0.627	0.773					
			.2d	50	171	0.920		0.708	3.30	4.00	13.20	9.347
26	76.0	2.5	.8d	50	99	0.536	0.643					
			.2d	50	139	0.749		0.599	2.35	4.00	9.40	5.628
27	80.0	2.2	.8d	50	87	0.472	0.555					
			.2d	50	118	0.637		0.501	1.95	4.00	7.80	3.911
28	84.0	1.7	.8d	50	72	0.392	0.448					
			.2d	50	93	0.504		0.224	0.85	3.50	2.98	0.666
29	87.5	0.0	-	50	0	0.000	0.000					

Total Area (sq.m) = 309.83 Total discharge (cumecs) = 241.93 Mean Velocity (m/s) = 0.78

DISCHARGE MEASUREMENT BY CURRENT METER

Station: Shebelli at Afgoi
Date: 2nd October 1988
Method: Suspension from bridge (d/s face) with 25kg weight
Origin: Left Bank
Observers: Ibrahim/Ali/Maxamuud/Said/Marian
Meter: Braystoke BFM 001 No. 75-306 Impellor No. 8011-504

	Start	Finish
Time	0845	1020
Stage	4.85	4.83

Calculations made by method of mean velocity over section between two verticals. Two measurements at each vertical.

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
1	0.0	0.0	-	50	0	0.000	0.000					
								0.119	0.65	2.00	1.30	0.154
2	2.0	1.3	.6d	50	47	0.259	0.237					
			.6d	50	39	0.216		0.313	1.65	2.00	3.30	1.034
3	4.0	2.0	.8d	50	95	0.515	0.389					
			.2d	50	48	0.264		0.507	2.30	2.00	4.60	2.331
4	6.0	2.6	.8d	50	121	0.653	0.624					
			.2d	50	110	0.595		0.732	2.75	2.00	5.50	4.026
5	8.0	2.9	.8d	50	158	0.851	0.840					
			.2d	50	154	0.829		0.844	3.10	2.00	6.20	5.233
6	10.0	3.3	.8d	50	149	0.803	0.848					
			.2d	50	166	0.893		0.861	3.55	2.00	7.10	6.116
7	12.0	3.8	.8d	50	156	0.840	0.875					
			.2d	50	169	0.909		0.807	3.60	2.00	7.20	5.809
8	14.0	3.4	.8d	50	103	0.557	0.739					
			.2d	50	171	0.920		0.744	3.75	2.00	7.50	5.581
9	16.0	4.1	.8d	50	143	0.771	0.749					
			.2d	50	135	0.728		0.855	4.20	2.00	8.40	7.180
10	18.0	4.3	.8d	50	155	0.835	0.960					
			.2d	50	202	1.085		0.931	4.35	2.00	8.70	8.098
11	20.0	4.4	.8d	50	137	0.739	0.901					
			.2d	50	198	1.064		0.836	4.30	2.00	8.60	7.190
12	22.0	4.2	.8d	50	111	0.600	0.771					
			.2d	50	175	0.941		0.727	4.15	2.00	8.30	6.032
13	24.0	4.1	.8d	50	85	0.461	0.683					
			.2d	50	168	0.904		0.576	4.15	2.00	8.30	4.781
14	26.0	4.2	.8d	50	73	0.397	0.469					
			.2d	50	100	0.541		0.447	4.25	2.00	8.50	3.797
15	28.0	4.3	.8d	50	107	0.579	0.424					
			.2d	50	49	0.269		0.547	4.15	2.00	8.30	4.538
16	30.0	4.0	.8d	50	125	0.675	0.669					
			.2d	50	123	0.664		0.669	3.95	2.00	7.90	5.288
17	32.0	3.9	.8d	50	120	0.648	0.669					
			.2d	50	128	0.691		0.509	3.65	2.00	7.30	3.719
18	34.0	3.4	.8d	50	62	0.339	0.349					
			.2d	50	66	0.360						

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Shebelli at Afgoi 2nd October 1988

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Velocity Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
18	34.0	3.4	.8d	50	62	0.339	0.349					
			.2d	50	66	0.360		0.325	2.50	2.00	5.00	1.627
19	36.0	1.6	.8d	50	55	0.301	0.301					
			.2d	50	55	0.301		0.151	0.80	1.50	1.20	0.181
20	37.5	0.0	-	50	0	0.000	0.000					

Total Area (sq.m) = 123.20 Total discharge (cumecs) = 82.72 Mean Velocity (m/s) = 0.67

DISCHARGE MEASUREMENT BY CURRENT METER

Station: Jubba at Lugh Ganana
Date: 26th October 1988
Method: Suspension from bridge (d/s face) with 25kg weight
Origin: Left Bank
Observers: Ali/Ibrahim/Marian/Peter Ede
Meter: Braystoke BFM 001 No. 75-306 Impellor No. 8011-504

	Start	Finish
Time	1340	1610
Stage	4.61	4.59

Calculations made by method of mean velocity over section between two verticals. Two measurements at each vertical.

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
1	10.9	0.0	-	50	0	0.000	0.000					
								0.095	0.60	2.10	1.26	0.119
2	13.0	1.2	.6d	50	40	0.221	0.189					
			.6d	50	28	0.157		0.347	1.80	3.00	5.40	1.872
3	16.0	2.4	.8d	50	78	0.424	0.504					
			.2d	50	108	0.584		0.495	3.20	4.00	12.80	6.333
4	20.0	4.0	.8d	50	75	0.408	0.485					
			.2d	50	104	0.563		0.828	4.70	4.00	18.80	15.568
5	24.0	5.4	.8d	50	212	1.139	1.171					
			.2d	50	224	1.203		1.145	5.55	4.00	22.20	25.430
6	28.0	5.7	.8d	50	149	0.803	1.120					
			.2d	50	268	1.438		1.292	6.00	4.00	24.00	31.012
7	32.0	6.3	.8d	50	231	1.240	1.464					
			.2d	50	315	1.688		1.123	6.45	4.00	25.80	28.968
8	36.0	6.6	.8d	50	115	0.621	0.781					
			.2d	50	175	0.941		1.113	7.05	4.00	28.20	31.400
9	40.0	7.5	.8d	50	215	1.155	1.446					
			.2d	50	324	1.736		1.480	7.60	4.00	30.40	44.998
10	44.0	7.7	.8d	50	242	1.299	1.515					
			.2d	50	323	1.731		1.506	7.90	4.00	31.60	47.574
11	48.0	8.1	.8d	50	224	1.203	1.496					
			.2d	50	334	1.790		0.971	8.25	4.00	33.00	32.036
12	52.0	8.4	.8d	50	97	0.525	0.445					
			.2d	50	67	0.365		0.673	8.25	4.00	33.00	22.223
13	56.0	8.1	.8d	50	261	1.400	0.901					
			.2d	50	74	0.403		1.147	8.25	4.00	33.00	37.845
14	60.0	8.4	.8d	50	199	1.069	1.392					
			.2d	50	320	1.715		1.347	8.05	4.00	32.20	43.368
15	64.0	7.7	.8d	50	193	1.037	1.301					
			.2d	50	292	1.566		1.325	7.35	4.00	29.40	38.970
16	68.0	7.0	.8d	50	226	1.213	1.350					
			.2d	50	277	1.486		1.156	6.50	4.00	26.00	30.060
17	72.0	6.0	.8d	50	190	1.021	0.963					
			.2d	50	168	0.904		1.089	6.10	4.00	24.40	26.583
18	76.0	6.2	.8d	50	192	1.032	1.216					
			.2d	50	261	1.400						

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Jubba at Lugh Ganana 26th October 1988

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Velocity Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
18	76.0	6.2	.8d	50	192	1.032	1.216					
			.2d	50	261	1.400		1.205	5.95	4.00	23.80	28.690
19	80.0	5.7	.8d	50	178	0.957	1.195					
			.2d	50	267	1.432		1.184	5.50	4.00	22.00	26.051
20	84.0	5.3	.8d	50	171	0.920	1.173					
			.2d	50	266	1.427		1.189	4.85	4.00	19.40	23.076
21	88.0	4.4	.8d	50	188	1.011	1.205					
			.2d	50	261	1.400		1.195	4.40	4.00	17.60	21.029
22	92.0	4.4	.8d	50	192	1.032	1.184					
			.2d	50	249	1.336		1.184	4.55	4.00	18.20	21.551
23	96.0	4.7	.8d	50	201	1.080	1.184					
			.2d	50	240	1.288		1.112	4.65	4.00	18.60	20.686
24	100.0	4.6	.8d	50	168	0.904	1.040					
			.2d	50	219	1.176		0.601	4.10	4.00	16.40	9.863
25	104.0	3.6	.8d	50	40	0.221	0.163					
			.2d	50	18	0.104		0.632	3.70	4.00	14.80	9.355
26	108.0	3.8	.8d	50	181	0.973	1.101					
			.2d	50	229	1.229		1.092	3.70	4.00	14.80	16.164
27	112.0	3.6	.8d	50	177	0.952	1.083					
			.2d	50	226	1.213		1.075	3.50	4.00	14.00	15.047
28	116.0	3.4	.8d	50	172	0.925	1.067					
			.2d	50	225	1.208		0.933	3.40	4.00	13.60	12.695
29	120.0	3.4	.8d	50	129	0.696	0.800					
			.2d	50	168	0.904		0.944	3.60	4.00	14.40	13.595
30	124.0	3.8	.8d	50	179	0.963	1.088					
			.2d	50	226	1.213		1.077	3.95	4.00	15.80	17.024
31	128.0	4.1	.8d	50	170	0.915	1.067					
			.2d	50	227	1.219		1.089	4.05	4.00	16.20	17.649
32	132.0	4.0	.8d	50	189	1.016	1.112					
			.2d	50	225	1.208		0.773	3.40	4.00	13.60	10.519
33	136.0	2.8	.8d	50	69	0.376	0.435					
			.2d	50	91	0.493		0.373	1.85	4.00	7.40	2.763
34	140.0	0.9	.6d	50	57	0.312	0.312					
			.6d	50	57	0.312		0.156	0.45	4.40	1.98	0.309
35	144.4	0.0	-	50	0	0.000	0.000					

Total Area (sq.m) = 674.04 Total discharge (cumecs) = 730.42 Mean Velocity (m/s) = 1.08

DISCHARGE MEASUREMENT BY CURRENT METER

			Start	Finish
Station:	Jubba at Kamsuma			
Date:	2nd November 1988			
Method:	Suspension from bridge (d/s face) with 25kg weight	Time	1050	1340
Origin:	Right Bank	Bridge dip	3.72	3.72
Observers:	Marian/Ibrahim/Ali/Peter Ede	Equivalent SG	6.24	6.24
Meter:	Braystoke BFM 001 No. 75-306 Impellor No. 8011-504			

Calculations made by method of mean velocity over section between two verticals. Two measurements at each vertical.

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
1	6.4	0.0	-	50	0	0.000	0.000					
								0.116	1.20	2.60	3.12	0.362
2	9.0	2.4	.8d	50	24	0.136	0.232					
			.2d	50	60	0.328		0.565	3.70	3.00	11.10	6.276
3	12.0	5.0	.8d	50	88	0.477	0.899					
			.2d	50	246	1.320		0.960	6.00	2.00	12.00	11.521
4	14.0	7.0	.8d	50	131	0.707	1.021					
			.2d	50	249	1.336		1.179	7.30	2.00	14.60	17.211
5	16.0	7.6	.8d	50	234	1.256	1.336					
			.2d	50	264	1.416		1.348	7.30	2.00	14.60	19.683
6	18.0	7.0	.8d	50	240	1.288	1.360					
			.2d	50	267	1.432		1.387	6.95	2.00	13.90	19.277
7	20.0	6.9	.8d	50	243	1.304	1.414					
			.2d	50	284	1.523		1.408	7.00	2.00	14.00	19.714
8	22.0	7.1	.8d	50	220	1.181	1.403					
			.2d	50	303	1.624		1.169	7.05	2.00	14.10	16.490
9	24.0	7.0	.8d	50	115	0.621	0.936					
			.2d	50	233	1.251		0.582	6.70	2.00	13.40	7.797
10	26.0	6.4	.8d	50	10	0.063	0.228					
			.2d	50	72	0.392		0.243	6.55	2.00	13.10	3.186
11	28.0	6.7	.8d	50	16	0.093	0.259					
			.2d	50	78	0.424		0.716	6.90	2.00	13.80	9.882
12	30.0	7.1	.8d	50	151	0.813	1.173					
			.2d	50	286	1.534		1.362	7.30	2.00	14.60	19.878
13	32.0	7.5	.8d	50	272	1.459	1.550					
			.2d	50	306	1.640		1.468	7.75	2.00	15.50	22.757
14	34.0	8.0	.8d	50	222	1.192	1.387					
			.2d	50	295	1.582		1.378	7.80	2.00	15.60	21.489
15	36.0	7.6	.8d	50	221	1.187	1.368					
			.2d	50	289	1.550		1.390	7.50	2.00	15.00	20.843
16	38.0	7.4	.8d	50	245	1.315	1.411					
			.2d	50	281	1.507		1.366	7.35	2.00	14.70	20.073
17	40.0	7.3	.8d	50	218	1.171	1.320					
			.2d	50	274	1.470		1.342	7.30	2.00	14.60	19.586
18	42.0	7.3	.8d	50	240	1.288	1.363					
			.2d	50	268	1.438						

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Jubba at Kamsuma 2nd November 1988

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Velocity Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
18	42.0	7.3	.8d	50	240	1.288	1.363					
			.2d	50	268	1.438		1.346	7.40	2.00	14.80	19.913
19	44.0	7.5	.8d	50	228	1.224	1.328					
			.2d	50	267	1.432		0.981	7.10	2.00	14.20	13.937
20	46.0	6.7	.8d	50	113	0.611	0.635					
			.2d	50	122	0.659		0.904	6.35	2.00	12.70	11.482
21	48.0	6.0	.8d	50	209	1.123	1.173					
			.2d	50	228	1.224		1.213	5.85	2.00	11.70	14.198
22	50.0	5.7	.8d	50	222	1.192	1.253					
			.2d	50	245	1.315		1.212	5.65	2.00	11.30	13.697
23	52.0	5.6	.8d	50	204	1.096	1.171					
			.2d	50	232	1.245		1.189	5.60	4.00	22.40	26.644
24	56.0	5.6	.8d	50	207	1.112	1.208					
			.2d	50	243	1.304		1.127	5.80	4.00	23.20	26.142
25	60.0	6.0	.8d	50	174	0.936	1.045					
			.2d	50	215	1.155		1.003	5.90	4.00	23.60	23.666
26	64.0	5.8	.8d	50	159	0.856	0.960					
			.2d	50	198	1.064		0.763	5.70	2.00	11.40	8.695
27	66.0	5.6	.8d	50	104	0.563	0.565					
			.2d	50	105	0.568		0.763	5.50	2.00	11.00	8.390
28	68.0	5.4	.8d	50	167	0.899	0.960					
			.2d	50	190	1.021		0.956	5.70	2.00	11.40	10.900
29	70.0	6.0	.8d	50	154	0.829	0.952					
			.2d	50	200	1.075		0.928	5.90	2.00	11.80	10.952
30	72.0	5.8	.8d	50	144	0.776	0.904					
			.2d	50	192	1.032		0.847	5.15	4.00	20.60	17.443
31	76.0	4.5	.8d	50	136	0.733	0.789					
			.2d	50	157	0.845		0.715	4.35	4.00	17.40	12.437
32	80.0	4.2	.8d	50	113	0.611	0.640					
			.2d	50	124	0.669		0.515	3.95	4.00	15.80	8.133
33	84.0	3.7	.8d	50	74	0.403	0.389					
			.2d	50	69	0.376		0.209	2.65	4.00	10.60	2.215
34	88.0	1.6	.8d	50	1	0.009	0.028					
			.2d	50	7	0.048		0.014	0.80	3.70	2.96	0.042
35	91.7	0.0	-	50	0	0.000	0.000					

Total Area (sq.m) = 474.58 Total discharge (cumecs) = 484.91 Mean Velocity (m/s) = 1.02

DISCHARGE MEASUREMENT BY CURRENT METER

			Start	Finish
Station:	Shebelli at Afgoi			
Date:	9th November 1988			
Method:	Suspension from bridge (d/s face) with 25kg weight	Time	0855	1010
Origin:	Left Bank	Bridge dip	2.45	2.46
Observers:	Marian/Ibrahim/Ali/Khadija/Peter Ede/Ahmed	Equivalent SG	4.97	4.96
Meter:	Braystoke BFM 001 No. 75-306 Impellor No. 8011-504			

Calculations made by method of mean velocity over section between two verticals. Two measurements at each vertical.

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
1	0.0	0.0	-	50	0	0.000	0.000					
								0.133	0.85	2.00	1.70	0.227
2	2.0	1.7	.8d	50	59	0.323	0.267					
			.2d	50	38	0.211		0.328	1.95	2.00	3.90	1.279
3	4.0	2.2	.8d	50	78	0.424	0.389					
			.2d	50	65	0.355		0.521	2.50	2.00	5.00	2.607
4	6.0	2.8	.8d	50	126	0.680	0.653					
			.2d	50	116	0.627		0.760	2.95	2.00	5.90	4.485
5	8.0	3.1	.8d	50	158	0.851	0.867					
			.2d	50	164	0.883		0.841	3.35	2.00	6.70	5.638
6	10.0	3.6	.8d	50	141	0.760	0.816					
			.2d	50	162	0.872		0.868	3.70	2.00	7.40	6.424
7	12.0	3.8	.8d	50	169	0.909	0.920					
			.2d	50	173	0.931		0.833	3.85	2.00	7.70	6.417
8	14.0	3.9	.8d	50	97	0.525	0.747					
			.2d	50	180	0.968		0.735	4.10	2.00	8.20	6.025
9	16.0	4.3	.8d	50	119	0.643	0.723					
			.2d	50	149	0.803		0.840	4.25	2.00	8.50	7.141
10	18.0	4.2	.8d	50	150	0.808	0.957					
			.2d	50	206	1.107		0.965	4.20	2.00	8.40	8.110
11	20.0	4.2	.8d	50	167	0.899	0.973					
			.2d	50	195	1.048		0.899	4.25	2.00	8.50	7.640
12	22.0	4.3	.8d	50	120	0.648	0.824					
			.2d	50	186	1.000		0.685	4.35	2.00	8.70	5.963
13	24.0	4.4	.8d	50	68	0.371	0.547					
			.2d	50	134	0.723		0.484	4.35	2.00	8.70	4.211
14	26.0	4.3	.8d	50	68	0.371	0.421					
			.2d	50	87	0.472		0.437	4.35	2.00	8.70	3.805
15	28.0	4.4	.8d	50	117	0.632	0.453					
			.2d	50	50	0.275		0.519	4.25	2.00	8.50	4.409
16	30.0	4.1	.8d	50	128	0.691	0.584					
			.2d	50	88	0.477		0.612	4.10	2.00	8.20	5.019
17	32.0	4.1	.8d	50	102	0.552	0.640					
			.2d	50	135	0.728		0.512	3.60	2.00	7.20	3.687
18	34.0	3.1	.8d	50	70	0.381	0.384					
			.2d	50	71	0.387						

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Shebelli at Afgoi 9th November 1988

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Velocity Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
18	34.0	3.1	.8d	50	70	0.381	0.384					
			.2d	50	71	0.387		0.351	2.30	2.00	4.60	1.613
19	36.0	1.5	.6d	50	58	0.317	0.317					
			.6d	50	58	0.317		0.159	0.75	1.50	1.13	0.179
20	37.5	0.0	-	50	0	0.000	0.000					

Total Area (sq.m) = 127.63 Total discharge (cumecs) = 84.88 Mean Velocity (m/s) = 0.67

DISCHARGE MEASUREMENT BY CURRENT METER

Station: Shebelli at Beled Weyn
Date: 16th November 1988
Method: Suspension from bridge (d/s face) with 25kg weight
Origin: Left Bank
Observers: Ali/Ibrahim/Peter/Khadija
Meter: Braystoke BFM 001 No. 75-306 Impellor No. 8011-503

	Start	Finish
Time	0840	1030
Stage	1.40	1.40

Calculations made by method of mean velocity over section between two verticals. Two measurements at each vertical.

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
1	7.0	0.0	-	50	0	0.000	0.000					
								0.332	0.40	2.4	0.96	0.319
2	9.4	0.8	.6d	50	124	0.669	0.664					
			.6d	50	122	0.659		0.679	0.85	1.0	0.85	0.577
3	10.4	0.9	.6d	50	126	0.680	0.693					
			.6d	50	131	0.707		0.637	1.10	2.0	2.20	1.402
4	12.4	1.3	.6d	50	106	0.573	0.581					
			.6d	50	109	0.589		0.699	1.45	2.2	3.19	2.229
5	14.6	1.6	.8d	50	140	0.755	0.816					
			.2d	50	163	0.877		0.783	1.80	2.4	4.32	3.382
6	17.0	2.0	.8d	50	132	0.712	0.749					
			.2d	50	146	0.787		0.821	2.25	2.7	6.07	4.990
7	19.7	2.5	.8d	50	148	0.797	0.893					
			.2d	50	184	0.989		0.916	2.60	2.2	5.72	5.240
8	21.9	2.7	.8d	50	167	0.899	0.939					
			.2d	50	182	0.979		0.944	2.90	2.3	6.67	6.297
9	24.2	3.1	.8d	50	171	0.920	0.949					
			.2d	50	182	0.979		0.963	3.05	2.4	7.32	7.048
10	26.6	3.0	.8d	50	172	0.925	0.976					
			.2d	50	191	1.027		1.004	2.95	2.0	5.90	5.924
11	28.6	2.9	.8d	50	188	1.011	1.032					
			.2d	50	196	1.053		1.056	2.65	2.0	5.30	5.597
12	30.6	2.4	.8d	50	200	1.075	1.080					
			.2d	50	202	1.085		1.069	2.35	2.3	5.40	5.780
13	32.9	2.3	.8d	50	195	1.048	1.059					
			.2d	50	199	1.069		1.020	2.25	2.1	4.73	4.820
14	35.0	2.2	.8d	50	170	0.915	0.981					
			.2d	50	195	1.048		0.953	1.95	2.3	4.48	4.276
15	37.3	1.7	.8d	50	165	0.888	0.925					
			.2d	50	179	0.963		0.821	1.65	2.3	3.80	3.117
16	39.6	1.6	.8d	50	115	0.621	0.717					
			.2d	50	151	0.813		0.390	1.45	1.5	2.18	0.849
17	41.1	1.3	.6d	50	11	0.068	0.063					
			.6d	50	9	0.058		0.032	0.65	1.4	0.91	0.029
18	42.5	0.0	-	50	0	0.000	0.000					

Total Area (sq.m) = 70.00 Total discharge (cumecs) = 61.88 Mean Velocity (m/s) = 0.88

DISCHARGE MEASUREMENT BY CURRENT METER

			Start	Finish
Station:	Shebelli at Mahaddey Weyn			
Date:	17th November 1988			
Method:	Suspension from bridge (d/s face) with 25kg weight	Time	0835	1025
Origin:	Left Bank	Stage	4.00	3.98
Observers:	Khadija/Ali/Ibrahim/Peter/Ahmed			
Meter:	Braystoke BFM 001 No. 75-306 Impellor No. 8011-503			

Calculations made by method of mean velocity over section between two verticals. Two measurements at each vertical.

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
1	0.0	0.0	-	50	0	0.000	0.000					
								0.071	1.35	2.8	3.78	0.267
2	2.8	2.7	.8d	50	32	0.179	0.141					
			.2d	50	18	0.104		0.300	2.90	1.3	3.77	1.131
3	4.1	3.1	.8d	50	93	0.504	0.459					
			.2d	50	76	0.413		0.540	3.20	1.6	5.12	2.765
4	5.7	3.3	.8d	50	115	0.621	0.621					
			.2d	50	115	0.621		0.653	3.45	1.6	5.52	3.607
5	7.3	3.6	.8d	50	135	0.728	0.685					
			.2d	50	119	0.643		0.728	3.70	2.3	8.51	6.196
6	9.6	3.8	.8d	50	140	0.755	0.771					
			.2d	50	146	0.787		0.769	3.80	2.3	8.74	6.725
7	11.9	3.8	.8d	50	138	0.744	0.768					
			.2d	50	147	0.792		0.796	3.90	2.4	9.36	7.451
8	14.3	4.0	.8d	50	142	0.765	0.824					
			.2d	50	164	0.883		0.831	4.00	2.3	9.20	7.643
9	16.6	4.0	.8d	50	137	0.739	0.837					
			.2d	50	174	0.936		0.816	4.10	2.4	9.84	8.030
10	19.0	4.2	.8d	50	134	0.723	0.795					
			.2d	50	161	0.867		0.747	4.00	2.1	8.40	6.273
11	21.1	3.8	.8d	50	107	0.579	0.699					
			.2d	50	152	0.819		0.759	4.00	1.9	7.60	5.767
12	23.0	4.2	.8d	50	140	0.755	0.819					
			.2d	50	164	0.883		0.765	4.10	1.3	5.33	4.080
13	24.3	4.0	.8d	50	102	0.552	0.712					
			.2d	50	162	0.872		0.581	3.75	1.1	4.12	2.398
14	25.4	3.5	.8d	50	38	0.211	0.451					
			.2d	50	128	0.691		0.479	3.55	1.2	4.26	2.039
15	26.6	3.6	.8d	50	38	0.211	0.507					
			.2d	50	149	0.803		0.607	3.70	1.2	4.44	2.694
16	27.8	3.8	.8d	50	123	0.664	0.707					
			.2d	50	139	0.749		0.681	3.60	1.3	4.68	3.189
17	29.1	3.4	.8d	50	107	0.579	0.656					
			.2d	50	136	0.733		0.592	3.15	1.7	5.35	3.171
18	30.8	2.9	.8d	50	80	0.435	0.528					
			.2d	50	115	0.621						

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Shebelli at Mahaddey Weyn 17th November 1988

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Velocity Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
18	30.8	2.9	.8d	50	80	0.435	0.528					
			.2d	50	115	0.621		0.505	2.65	1.6	4.24	2.143
19	32.4	2.4	.8d	50	73	0.397	0.483					
			.2d	50	105	0.568		0.388	2.00	1.5	3.00	1.164
20	33.9	1.6	.8d	50	50	0.275	0.293					
			.2d	50	57	0.312		0.147	0.80	1.8	1.44	0.211
21	35.7	0.0	-	50	0	0.000	0.000					

Total Area (sq.m)	= 116.71	Total discharge (cumecs) =	76.94	Mean Velocity (m/s)	= 0.66

DISCHARGE MEASUREMENT BY CURRENT METER

Station: Jubba at Bardheere
Date: 30th November 1988
Method: Cableway
Origin: Left Bank
Observers: Mohamoud/Abdukadir (from Bardheere); ass. by Peter/Marian/Ibrahim
Meter: SIAP 4002 No. 601036 Impellor type 7404

	Start	Finish
Time	0730	1020
Stage	1.26	1.25

Calculations made by method of mean velocity over section between two verticals. Two measurements at each vertical.

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
1	18.22	0.00	-	50	0	0.000	0.000					
								0.175	0.91	6.0	5.46	0.954
2	24.22	1.82	0.36	50	76	0.390	0.350					
			1.46	50	60	0.309		0.377	2.22	6.0	13.32	5.023
3	30.22	2.62	0.52	50	89	0.455	0.405					
			2.09	50	69	0.355		0.382	2.56	6.0	15.36	5.869
4	36.22	2.50	0.50	50	82	0.420	0.360					
			2.00	50	58	0.299		0.376	2.34	6.0	14.04	5.277
5	42.22	2.18	0.44	50	73	0.375	0.392					
			1.74	50	80	0.410		0.470	2.12	6.0	12.72	5.975
6	48.22	2.06	0.41	50	131	0.665	0.547					
			1.65	50	84	0.430		0.532	2.45	6.0	14.67	7.809
7	54.22	2.83	0.57	50	109	0.555	0.517					
			2.26	50	94	0.480		0.500	3.06	6.0	18.33	9.161
8	60.22	3.28	0.66	50	87	0.445	0.482					
			2.62	50	102	0.520		0.509	3.38	6.0	20.28	10.313
9	66.22	3.48	0.70	50	103	0.525	0.535					
			2.78	50	107	0.545		0.584	3.58	6.0	21.45	12.520
10	72.22	3.67	0.73	50	147	0.745	0.632					
			2.94	50	102	0.520		0.670	3.72	6.0	22.32	14.956
11	78.22	3.77	0.75	50	156	0.790	0.708					
			3.02	50	123	0.625		0.683	3.65	6.0	21.90	14.948
12	84.22	3.53	0.71	50	144	0.730	0.658					
			2.82	50	115	0.585		0.679	3.62	6.0	21.69	14.724
13	90.22	3.70	0.72	50	151	0.765	0.700					
			2.96	50	125	0.635		0.634	3.69	6.0	22.14	14.031
14	96.22	3.68	0.74	50	142	0.720	0.567					
			2.94	50	81	0.415		0.627	3.65	6.0	21.90	13.742
15	102.22	3.62	0.72	50	162	0.820	0.688					
			2.90	50	109	0.555		0.599	3.58	6.0	21.45	12.842
16	108.22	3.53	0.71	50	105	0.535	0.510					
			2.82	50	95	0.485		0.432	3.20	6.0	19.20	8.298
17	114.22	2.87	0.57	50	63	0.325	0.355					
			2.30	50	75	0.385		0.268	2.73	6.0	16.38	4.393
18	120.22	2.59	0.52	50	26	0.139	0.182					
			2.07	50	43	0.224		0.091	1.30	6.4	8.26	0.751
19	126.60	0.00	-	50	0	0.000	0.000					

Total Area (sq.m) = 310.87 Total discharge (cumecs) = 161.59 Mean Velocity (m/s) = 0.52

DISCHARGE MEASUREMENT BY CURRENT METER

Station: Jubba at Lugh Ganana
Date: 1st December 1988
Method: Suspension from bridge (d/s face) with 25kg weight
Origin: Left Bank
Observers: Marian/Ibrahim/Peter/Ahmed
Meter: Braystoke BFM 001 No. 75-306 Impellor No. 8011-503

	Start	Finish
Time	0815	0950
Staff gauge	2.03	2.03
Bridge dip	7.57	7.57

Calculations made by method of mean velocity over section between two verticals. Two measurements at each vertical.

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
1	18.7	0.0	-	50	0	0.000	0.000					
								0.039	0.75	3.30	2.48	0.097
2	22.0	1.5	.6d	50	14	0.083	0.078					
			.6d	50	12	0.073		0.129	1.80	2.00	3.60	0.463
3	24.0	2.1	.8d	50	23	0.131	0.179					
			.2d	50	41	0.227		0.209	2.10	4.00	8.40	1.759
4	28.0	2.1	.8d	50	36	0.200	0.240					
			.2d	50	51	0.280		0.279	2.50	4.00	10.00	2.787
5	32.0	2.9	.8d	50	39	0.216	0.317					
			.2d	50	77	0.419		0.234	3.10	4.00	12.40	2.899
6	36.0	3.3	.8d	50	42	0.232	0.150					
			.2d	50	11	0.068		0.322	3.15	4.00	12.60	4.054
7	40.0	3.0	.8d	50	75	0.408	0.493					
			.2d	50	107	0.579		0.523	3.00	4.00	12.00	6.273
8	44.0	3.0	.8d	50	93	0.504	0.552					
			.2d	50	111	0.600		0.601	3.35	4.00	13.40	8.059
9	48.0	3.7	.8d	50	110	0.595	0.651					
			.2d	50	131	0.707		0.441	4.25	4.00	17.00	7.504
10	52.0	4.8	.8d	50	45	0.248	0.232					
			.2d	50	39	0.216		0.240	5.10	4.00	20.40	4.900
11	56.0	5.4	.8d	50	76	0.413	0.248					
			.2d	50	14	0.083		0.378	5.15	4.00	20.60	7.777
12	60.0	4.9	.8d	50	65	0.355	0.507					
			.2d	50	122	0.659		0.511	4.35	4.00	17.40	8.887
13	64.0	3.8	.8d	50	76	0.413	0.515					
			.2d	50	114	0.616		0.507	3.80	4.00	15.20	7.702
14	68.0	3.8	.8d	50	71	0.387	0.499					
			.2d	50	113	0.611		0.367	3.55	4.00	14.20	5.207
15	72.0	3.3	.8d	50	55	0.301	0.235					
			.2d	50	30	0.168		0.340	3.20	4.00	12.80	4.353
16	76.0	3.1	.8d	50	71	0.387	0.445					
			.2d	50	93	0.504		0.377	2.95	4.00	11.80	4.453
17	80.0	2.8	.8d	50	54	0.296	0.309					
			.2d	50	59	0.323		0.259	2.75	4.00	11.00	2.846
18	84.0	2.7	.8d	50	18	0.104	0.208					
			.2d	50	57	0.312						

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Jubba at Lugh Ganana 1st December 1988

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point (m/s)	Velocity Mean (m/s)	Velocity Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
18	84.0	2.7	.8d	50	18	0.104	0.208					
			.2d	50	57	0.312		0.176	2.20	4.00	8.80	1.549
19	88.0	1.7	.8d	50	20	0.115	0.144					
			.2d	50	31	0.173		0.098	1.70	4.00	6.80	0.666
20	92.0	1.7	.8d	50	0	0.000	0.052					
			.2d	50	18	0.104		0.085	1.70	4.00	6.80	0.576
21	96.0	1.7	.8d	50	18	0.104	0.117					
			.2d	50	23	0.131		0.074	1.85	4.00	7.40	0.544
22	100.0	2.0	.8d	50	3	0.026	0.030					
			.2d	50	4	0.033		0.015	1.40	4.00	5.60	0.083
23	104.0	0.8	.6d	50	0	0.000	0.000					
			.6d	50	0	0.000		0.002	0.90	4.00	3.60	0.008
24	108.0	1.0	.6d	50	1	0.009	0.004					
			.6d	50	0	0.000		-0.027	0.85	4.00	3.40	-0.092
25	112.0	0.7	.6d	50	-9	-0.058	-0.058					
			.6d	50	-9	-0.058		-0.029	0.60	4.00	2.40	-0.070
26	116.0	0.5	-	50	0	0.000	0.000					
								0.000	0.50	4.00	2.00	0.000
27	120.0	0.5	-	50	0	0.000	0.000					
								0.000	0.65	4.00	2.60	0.000
28	124.0	0.8	.6d	50	0	0.000	0.000					
			.6d	50	0	0.000		0.000	0.70	4.00	2.80	0.000
29	128.0	0.6	-	50	0	0.000	0.000					
								0.000	0.50	4.00	2.00	0.000
30	132.0	0.4	-	50	0	0.000	0.000					
								0.000	0.20	4.30	0.86	0.000
31	136.3	0.0	-	50	0	0.000	0.000					

Total Area (sq.m) = 270.34 Total discharge (cumecs) = 83.28 Mean Velocity (m/s) = 0.31

DISCHARGE MEASUREMENT BY CURRENT METER

			Start	Finish
Station:	Jubba at Kamsuma			
Date:	11th December 1988			
Method:	Suspension from bridge (d/s face) with 10kg weight	Time	0955	1200
Origin:	Right Bank	Bridge Dip	7.65	7.65
Observers:	Ibrahim/Khadija/Peter/Ahmed	Equivalent SG	2.31	2.31
Meter:	Braystoke BFM 001 No. 75-306 Impellor No. 8011-503			

Calculations made by method of mean velocity over section between two verticals. Two measurements at each vertical.

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
1	10.8	0.0	-	50	0	0.000	0.000					
								0.038	1.40	3.2	4.48	0.172
2	14.0	2.8	.8d	50	24	0.136	0.077					
			.2d	50	2	0.017		0.325	3.15	2.0	6.30	2.048
3	16.0	3.5	.8d	50	86	0.467	0.573					
			.2d	50	126	0.680		0.591	3.25	2.0	6.50	3.840
4	18.0	3.0	.8d	50	78	0.424	0.608					
			.2d	50	147	0.792		0.597	2.95	2.0	5.90	3.525
5	20.0	2.9	.8d	50	60	0.328	0.587					
			.2d	50	157	0.845		0.569	2.95	2.0	5.90	3.359
6	22.0	3.0	.8d	50	73	0.397	0.552					
			.2d	50	131	0.707		0.388	3.00	2.0	6.00	2.329
7	24.0	3.0	.8d	50	14	0.083	0.224					
			.2d	50	67	0.365		0.135	2.70	2.0	5.40	0.730
8	26.0	2.4	.8d	50	1	0.009	0.046					
			.2d	50	14	0.083		-0.005	2.75	2.0	5.50	-0.027
9	28.0	3.1	.8d	50	-4	-0.033	-0.056					
			.2d	50	-13	-0.078		-0.049	3.20	2.0	6.40	-0.316
10	30.0	3.3	.8d	50	-7	-0.048	-0.043					
			.2d	50	-5	-0.038		0.113	3.45	2.0	6.90	0.780
11	32.0	3.6	.8d	50	81	0.440	0.269					
			.2d	50	17	0.099		0.573	3.60	2.0	7.20	4.129
12	34.0	3.6	.8d	50	158	0.851	0.877					
			.2d	50	168	0.904		0.856	3.50	2.0	7.00	5.993
13	36.0	3.4	.8d	50	142	0.765	0.835					
			.2d	50	168	0.904		0.801	3.45	2.0	6.90	5.530
14	38.0	3.5	.8d	50	126	0.680	0.768					
			.2d	50	159	0.856		0.756	3.60	2.0	7.20	5.444
15	40.0	3.7	.8d	50	124	0.669	0.744					
			.2d	50	152	0.819		0.683	3.65	2.0	7.30	4.984
16	42.0	3.6	.8d	50	88	0.477	0.621					
			.2d	50	142	0.765		0.655	3.55	2.0	7.10	4.649
17	44.0	3.5	.8d	50	108	0.584	0.688					
			.2d	50	147	0.792		0.479	3.15	2.0	6.30	3.016
18	46.0	2.8	.8d	50	33	0.184	0.269					
			.2d	50	65	0.355						

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Jubba at Kamsuma 11th December 1988

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Velocity Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
18	46.0	2.8	.8d	50	33	0.184	0.269					
			.2d	50	65	0.355		0.307	2.40	2.0	4.80	1.472
19	48.0	2.0	.8d	50	56	0.307	0.344					
			.2d	50	70	0.381		0.459	2.25	2.0	4.50	2.064
20	50.0	2.5	.8d	50	85	0.461	0.573					
			.2d	50	127	0.685		0.600	2.50	2.0	5.00	3.000
21	52.0	2.5	.8d	50	106	0.573	0.627					
			.2d	50	126	0.680		0.615	2.45	2.0	4.90	3.012
22	54.0	2.4	.8d	50	98	0.531	0.603					
			.2d	50	125	0.675		0.589	2.45	2.0	4.90	2.888
23	56.0	2.5	.8d	50	92	0.499	0.576					
			.2d	50	121	0.653		0.577	2.55	2.0	5.10	2.945
24	58.0	2.6	.8d	50	97	0.525	0.579					
			.2d	50	117	0.632		0.551	2.50	2.0	5.00	2.754
25	60.0	2.4	.8d	50	83	0.451	0.523					
			.2d	50	110	0.595		0.520	2.30	2.0	4.60	2.392
26	62.0	2.2	.8d	50	82	0.445	0.517					
			.2d	50	109	0.589		0.509	2.00	2.0	4.00	2.038
27	64.0	1.8	.8d	50	83	0.451	0.501					
			.2d	50	102	0.552		0.311	1.90	2.0	3.80	1.183
28	66.0	2.0	.8d	50	3	0.026	0.121					
			.2d	50	39	0.216		0.231	1.90	2.0	3.80	0.879
29	68.0	1.8	.8d	50	68	0.371	0.341					
			.2d	50	57	0.312		0.377	1.80	2.0	3.60	1.359
30	70.0	1.8	.8d	50	66	0.360	0.413					
			.2d	50	86	0.467		0.388	1.80	2.0	3.60	1.397
31	72.0	1.8	.8d	50	59	0.323	0.363					
			.2d	50	74	0.403		0.312	1.55	2.0	3.10	0.967
32	74.0	1.3	.8d	50	33	0.184	0.261					
			.2d	50	62	0.339		0.216	0.95	2.0	1.90	0.410
33	76.0	0.6	.6d	50	31	0.173	0.171					
			.6d	50	30	0.168		0.144	0.50	4.0	2.00	0.288
34	80.0	0.4	(.6d)	50	20	0.115	0.117					
			(.6d)	50	21	0.120		0.059	0.20	3.4	0.68	0.040
35	83.4	0.0	-	50	0	0.000	0.000					

Total Area (sq.m) = 173.56 Total discharge (cumecs) = 79.27 Mean Velocity (m/s) = 0.46

DISCHARGE MEASUREMENT BY CURRENT METER

			Start	Finish
Station:	Shebelli at Beled Weyn			
Date:	18th December 1988			
Method:	Suspension from bridge (d/s face) with 10kg weight	Time	0800	0925
Origin:	Left Bank	Stage	0.65	0.65
Observers:	Ali/Marian/Peter/Ahmed			
Meter:	Braystoke BFM 001 No. 75-306 Impellor No. 8011-503			

Calculations made by method of mean velocity over section between two verticals.
Two measurements at each vertical.

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
1	9.6	0.0	-	50	0	0.000	0.000					
								0.136	0.35	3.7	1.30	0.176
2	13.3	0.7	.6d	50	51	0.280	0.272					
			.6d	50	48	0.264		0.309	0.85	2.2	1.87	0.579
3	15.5	1.0	.6d	50	62	0.339	0.347					
			.6d	50	65	0.355		0.335	1.10	1.8	1.98	0.663
4	17.3	1.2	.8d	50	61	0.333	0.323					
			.2d	50	57	0.312		0.380	1.45	2.0	2.90	1.102
5	19.3	1.7	.8d	50	78	0.424	0.437					
			.2d	50	83	0.451		0.437	1.80	1.9	3.42	1.496
6	21.2	1.9	.8d	50	65	0.355	0.437					
			.2d	50	96	0.520		0.476	2.05	2.5	5.13	2.440
7	23.7	2.2	.8d	50	95	0.515	0.515					
			.2d	50	95	0.515		0.504	2.25	2.3	5.18	2.609
8	26.0	2.3	.8d	50	84	0.456	0.493					
			.2d	50	98	0.531		0.515	2.25	2.3	5.18	2.664
9	28.3	2.2	.8d	50	92	0.499	0.536					
			.2d	50	106	0.573		0.560	1.90	2.7	5.13	2.873
10	31.0	1.6	.8d	50	108	0.584	0.584					
			.2d	50	108	0.584		0.571	1.60	2.4	3.84	2.192
11	33.4	1.6	.8d	50	95	0.515	0.557					
			.2d	50	111	0.600		0.532	1.50	2.0	3.00	1.596
12	35.4	1.4	.8d	50	74	0.403	0.507					
			.2d	50	113	0.611		0.497	1.20	2.1	2.52	1.253
13	37.5	1.0	.6d	50	87	0.472	0.488					
			.6d	50	93	0.504		0.405	0.95	1.8	1.71	0.693
14	39.3	0.9	.6d	50	60	0.328	0.323					
			.6d	50	58	0.317		0.192	0.75	1.1	0.83	0.158
15	40.4	0.6	.6d	50	12	0.073	0.061					
			.6d	50	7	0.048		0.030	0.30	2.0	0.60	0.018
16	42.4	0.0	-	50	0	0.000	0.000					

Total Area (sq.m)	= 44.57	Total discharge (cumecs) =	20.51	Mean Velocity (m/s)	= 0.46

DISCHARGE MEASUREMENT BY CURRENT METER

Station: Shebelli at Bulo Burti
Date: 18th December 1988
Method: Suspension from bridge (d/s face) with 10kg weight
Origin: Left Bank
Observers: Peter/Marian/Ali/Ahmed
Meter: Braystoke BFM 001 No. 75-306 Impellor No. 8011-503

	Start	Finish
Time	1410	1520
Stage	1.48	1.48

Calculations made by method of mean velocity over section between two verticals.
Two measurements at each vertical.

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
1	10.9	0.0	-	50	0	0.000	0.000					
								0.277	0.25	4.9	1.23	0.340
2	15.8	0.5	.6d	50	103	0.557	0.555					
			.6d	50	102	0.552		0.627	0.60	2.0	1.20	0.752
3	17.8	0.7	.6d	50	134	0.723	0.699					
			.6d	50	125	0.675		0.704	0.75	2.4	1.80	1.267
4	20.2	0.8	.6d	50	130	0.701	0.709					
			.6d	50	133	0.717		0.771	0.95	1.8	1.71	1.318
5	22.0	1.1	.8d	50	146	0.787	0.832					
			.2d	50	163	0.877		0.813	1.10	2.0	2.20	1.790
6	24.0	1.1	.8d	50	135	0.728	0.795					
			.2d	50	160	0.861		0.803	1.15	2.3	2.65	2.123
7	26.3	1.2	.8d	50	138	0.744	0.811					
			.2d	50	163	0.877		0.792	1.30	2.1	2.73	2.162
8	28.4	1.4	.8d	50	123	0.664	0.773					
			.2d	50	164	0.883		0.763	1.55	2.5	3.88	2.956
9	30.9	1.7	.8d	50	112	0.605	0.752					
			.2d	50	167	0.899		0.787	1.55	1.7	2.64	2.073
10	32.6	1.4	.8d	50	141	0.760	0.821					
			.2d	50	164	0.883		0.824	1.25	1.8	2.25	1.854
11	34.4	1.1	.8d	50	148	0.797	0.827					
			.2d	50	159	0.856		0.781	1.05	1.8	1.89	1.477
12	36.2	1.0	.6d	50	137	0.739	0.736					
			.6d	50	136	0.733		0.663	0.90	1.5	1.35	0.895
13	37.7	0.8	.6d	50	109	0.589	0.589					
			.6d	50	109	0.589		0.573	0.80	1.1	0.88	0.505
14	38.8	0.8	.6d	50	107	0.579	0.557					
			.6d	50	99	0.536		0.279	0.40	3.2	1.28	0.357
15	42.0	0.0	-	50	0	0.000	0.000					

Total Area (sq.m) = 27.67 Total discharge (cumecs) = 19.87 Mean Velocity (m/s) = 0.72

DISCHARGE MEASUREMENT BY CURRENT METER

			Start	Finish
Station:	Shebelli at Mahaddey Weyn			
Date:	19th December 1988			
Method:	Suspension from bridge (d/s face) with 10kg weight	Time	0835	1010
Origin:	Left Bank	Stage	2.03	2.03
Observers:	Peter/Marian/Ali/Ahmed			
Meter:	Braystoke BFM 001 No. 75-306 Impellor No. 8011-503			

Calculations made by method of mean velocity over section between two verticals. Two measurements at each vertical.

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Velocity Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
1	2.4	0.0	-	50	0	0.000	0.000		-			
								0.067	0.50	1.0	0.50	0.033
2	3.4	1.0	.6d	50	20	0.115	0.133					
			.6d	50	27	0.152		0.196	1.20	1.6	1.92	0.376
3	5.0	1.4	.8d	50	53	0.291	0.259					
			.2d	50	41	0.227		0.344	1.60	2.3	3.68	1.266
4	7.3	1.8	.8d	50	66	0.360	0.429					
			.2d	50	92	0.499		0.424	1.90	2.3	4.37	1.853
5	9.6	2.0	.8d	50	66	0.360	0.419					
			.2d	50	88	0.477		0.455	2.10	2.4	5.04	2.292
6	12.0	2.2	.8d	50	81	0.440	0.491					
			.2d	50	100	0.541		0.488	2.30	2.3	5.29	2.582
7	14.3	2.4	.8d	50	77	0.419	0.485					
			.2d	50	102	0.552		0.477	2.40	2.4	5.76	2.750
8	16.7	2.4	.8d	50	78	0.424	0.469					
			.2d	50	95	0.515		0.468	2.25	2.3	5.18	2.422
9	19.0	2.1	.8d	50	78	0.424	0.467					
			.2d	50	94	0.509		0.451	2.00	2.3	4.60	2.073
10	21.3	1.9	.8d	50	63	0.344	0.435					
			.2d	50	97	0.525		0.437	2.10	1.6	3.36	1.470
11	22.9	2.3	.8d	50	70	0.381	0.440					
			.2d	50	92	0.499		0.295	2.15	1.6	3.44	1.015
12	24.5	2.0	.8d	50	42	0.232	0.150					
			.2d	50	11	0.068		0.113	1.90	0.8	1.52	0.171
13	25.3	1.8	.8d	50	25	0.141	0.075					
			.2d	50	1	0.009		0.077	1.75	1.4	2.45	0.188
14	26.7	1.7	.8d	50	14	0.083	0.078					
			.2d	50	12	0.073		0.185	1.85	1.2	2.22	0.410
15	27.9	2.0	.8d	50	62	0.339	0.291					
			.2d	50	44	0.243		0.299	1.85	1.3	2.41	0.718
16	29.2	1.7	.8d	50	50	0.275	0.307					
			.2d	50	62	0.339		0.261	1.25	1.6	2.00	0.523
17	30.8	0.8	.6d	50	39	0.216	0.216					
			.6d	50	39	0.216		0.108	0.40	2.8	1.12	0.121
18	33.6	0.0	-	50	0	0.000	0.000					

Total Area (sq.m)	= 54.85	Total discharge (cumecs) =	20.26	Mean Velocity (m/s)	= 0.37

DISCHARGE MEASUREMENT BY CURRENT METER

			Start	Finish
Station:	Jubba at Lugh Ganana			
Date:	5th January 1989			
Method:	Suspension from bridge (d/s face) with 10kg weight	Time	0740	0930
Origin:	Left Bank	Stage	1.49	1.49
Observers:	Ali/Ibrahim/Marian			
Meter:	Braystoke BFM 001 No. 75-306 Impellor No. 8011-503			

Calculations made by method of mean velocity over section between two verticals. Two measurements at each vertical.

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point (m/s)	Velocity Mean (m/s)	Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
1	19.0	0.0	-	50	0	0.000	0.000					
								0.000	0.45	3.0	1.35	0.000
2	22.0	0.9	.6d	50	0	0.000	0.000					
			.6d	50	0	0.000		0.000	1.25	2.0	2.50	0.000
3	24.0	1.6	.8d	50	0	0.000	0.000					
			.2d	50	0	0.000		0.000	1.70	4.0	6.80	0.000
4	28.0	1.8	.8d	50	0	0.000	0.000					
			.2d	50	0	0.000		0.000	2.05	4.0	8.20	0.000
5	32.0	2.3	.8d	50	0	0.000	0.000					
			.2d	50	0	0.000		0.000	2.50	4.0	10.00	0.000
6	36.0	2.7	.8d	50	0	0.000	0.000					
			.2d	50	0	0.000		0.000	2.60	4.0	10.40	0.000
7	40.0	2.5	.8d	50	0	0.000	0.000					
			.2d	50	0	0.000		0.000	2.50	4.0	10.00	0.000
8	44.0	2.5	.8d	50	0	0.000	0.000					
			.2d	50	0	0.000		0.000	2.75	4.0	11.00	0.000
9	48.0	3.0	.8d	50	0	0.000	0.000					
			.2d	50	0	0.000		0.000	3.65	4.0	14.60	0.000
10	52.0	4.3	.8d	50	0	0.000	0.000					
			.2d	50	0	0.000		0.000	4.50	4.0	18.00	0.000
11	56.0	4.7	.8d	50	0	0.000	0.000					
			.2d	50	0	0.000		0.000	3.70	16.0	59.20	0.000
12	72.0	2.7	.8d	50	0	0.000	0.000					
			.2d	50	0	0.000		0.000	2.65	4.0	10.60	0.000
13	76.0	2.6	.8d	50	0	0.000	0.000					
			.2d	50	0	0.000		0.000	2.35	4.0	9.40	0.000
14	80.0	2.1	.8d	50	0	0.000	0.000					
			.2d	50	0	0.000		0.000	1.55	8.0	12.40	0.000
15	88.0	1.0	.6d	50	0	0.000	0.000					
			.6d	50	0	0.000		0.000	0.50	42.0	21.00	0.000
16	130.0	0.0	-	50	0	0.000	0.000					

Total Area (sq.m) = 205.45 Total discharge (cumecs) = 0.00 Mean Velocity (m/s) = 0.00

Note: The observers reported that the equipment was checked during the measurement and found to be working, but a break in the cable was found on returning to Mogadishu.
Although the velocity under the bridge is very slow at this river level it clearly cannot be zero.

DISCHARGE MEASUREMENT BY CURRENT METER

Station: Jubba at Bardheere
Date: 11th January 1989
Method: Cableway
Origin: Left Bank
Observers: Mohamoud/Abdukadir (from Bardheere)
Meter: SIAP 4002 No. 601036 Impellor type 7404

	Start	Finish
Time	0745	1015
Stage	0.56	0.55

Calculations made by method of mean velocity over section between two verticals. Two measurements at each vertical.

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
1	21.27	0.00	-	50	0	0.000	0.000					
								0.006	0.56	6.00	3.33	0.020
2	27.27	1.11	0.22	50	3	0.024	0.012					
			0.89	50	0	0.000		0.037	1.45	6.00	8.70	0.320
3	33.27	1.79	0.36	50	14	0.079	0.062					
			1.43	50	7	0.044		0.065	1.74	6.00	10.44	0.682
4	39.27	1.69	0.34	50	17	0.094	0.069					
			1.35	50	7	0.044		0.089	1.51	6.00	9.06	0.807
5	45.27	1.33	0.27	50	26	0.139	0.109					
			1.06	50	14	0.079		0.129	1.41	6.00	8.46	1.093
6	51.27	1.49	0.30	50	34	0.179	0.149					
			1.19	50	22	0.119		0.155	1.85	6.00	11.07	1.721
7	57.27	2.20	0.44	50	38	0.199	0.162					
			1.76	50	23	0.124		0.163	2.44	6.00	14.64	2.386
8	63.27	2.68	0.54	50	29	0.154	0.164					
			2.14	50	33	0.174		0.206	2.76	6.00	16.56	3.404
9	69.27	2.84	0.57	50	54	0.279	0.247					
			2.27	50	41	0.214		0.224	2.83	6.00	16.95	3.803
10	75.27	2.81	0.56	50	41	0.214	0.202					
			2.25	50	36	0.189		0.228	2.76	6.00	16.53	3.770
11	81.27	2.70	0.54	50	54	0.279	0.254					
			2.16	50	44	0.229		0.247	2.74	6.00	16.44	4.059
12	87.27	2.78	0.56	50	54	0.279	0.239					
			2.22	50	38	0.199		0.222	2.91	6.00	17.46	3.873
13	93.27	3.04	0.61	50	48	0.249	0.204					
			2.43	50	30	0.159		0.197	3.00	6.00	17.97	3.536
14	99.27	2.95	0.59	50	41	0.214	0.189					
			2.36	50	31	0.164		0.155	2.93	6.00	17.55	2.729
15	105.27	2.90	0.58	50	26	0.139	0.122					
			2.32	50	19	0.104		0.093	2.77	6.00	16.62	1.544
16	111.27	2.64	0.53	50	13	0.074	0.064					
			2.11	50	9	0.054		0.084	2.36	6.00	14.13	1.189
17	117.27	2.07	0.41	50	22	0.119	0.104					
			1.66	50	16	0.089		0.052	1.76	6.00	10.56	0.550
18	123.27	1.45	0.29	50	0	0.000	0.000					
			1.16	50	0	0.000		0.000	0.73	3.87	2.81	0.000
19	127.14	0.00	0	50	0	0.000	0.000					

Total Area (sq.m) = 229.28 Total discharge (cumecs) = 35.49 Mean Velocity (m/s) = 0.15

DISCHARGE MEASUREMENT BY CURRENT METER

			Start	Finish
Station:	Jubba at Lugh Ganana			
Date:	12th January 1989			
Method:	Suspension from bridge (d/s face) with 10kg weight	Time	0735	0855
Origin:	Left Bank	Stage	1.42	1.42
Observers:	Peter/Ibrahim/Ali/Ahmed			
Meter:	Braystoke BFM 001 No. 75-306 Impellor No. 8011-503			

Calculations made by method of mean velocity over section between two verticals. Two measurements at each vertical.

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
1	19.7	0.0	-	50	0	0.000	0.000					
								0.016	0.70	4.30	3.01	0.048
2	24.0	1.4	.8d	50	0	0.000	0.032					
			.2d	50	10	0.063		0.044	1.55	4.00	6.20	0.271
3	28.0	1.7	.8d	50	6	0.043	0.056					
			.2d	50	11	0.068		0.084	1.90	4.00	7.60	0.638
4	32.0	2.1	.8d	50	15	0.088	0.112					
			.2d	50	24	0.136		0.101	2.35	4.00	9.40	0.947
5	36.0	2.6	.8d	50	22	0.125	0.089					
			.2d	50	8	0.053		0.111	2.55	4.00	10.20	1.137
6	40.0	2.5	.8d	50	14	0.083	0.134					
			.2d	50	33	0.184		0.183	2.50	4.00	10.00	1.829
7	44.0	2.5	.8d	50	37	0.205	0.232					
			.2d	50	47	0.259		0.228	2.75	4.00	11.00	2.508
8	48.0	3.0	.8d	50	28	0.157	0.224					
			.2d	50	53	0.291		0.161	3.65	4.00	14.60	2.347
9	52.0	4.3	.8d	50	26	0.147	0.097					
			.2d	50	7	0.048		0.088	4.50	4.00	18.00	1.590
10	56.0	4.7	.8d	50	22	0.125	0.079					
			.2d	50	4	0.033		0.162	4.55	4.00	18.20	2.954
11	60.0	4.4	.8d	50	40	0.221	0.245					
			.2d	50	49	0.269		0.231	3.80	4.00	15.20	3.507
12	64.0	3.2	.8d	50	34	0.189	0.216					
			.2d	50	44	0.243		0.199	3.20	4.00	12.80	2.543
13	68.0	3.2	.8d	50	22	0.125	0.181					
			.2d	50	43	0.237		0.120	2.95	4.00	11.80	1.413
14	72.0	2.7	.8d	50	9	0.058	0.058					
			.2d	50	9	0.058		0.116	2.65	4.00	10.60	1.227
15	76.0	2.6	.8d	50	25	0.141	0.173					
			.2d	50	37	0.205		0.152	2.40	4.00	9.60	1.459
16	80.0	2.2	.8d	50	22	0.125	0.131					
			.2d	50	24	0.136		0.088	2.15	4.00	8.60	0.757
17	84.0	2.1	.8d	50	2	0.017	0.045					
			.2d	50	12	0.073		0.025	1.60	4.00	6.40	0.159
18	88.0	1.1	.8d	50	0	0.000	0.004					
			.2d	50	1	0.009						

(cont.)

(cont.)

Jubba at Lugh Ganana 12th January 1989

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
18	88.0	1.1	.8d	50	0	0.000	0.004					
			.2d	50	1	0.009		0.027	1.10	4.00	4.40	0.119
19	92.0	1.1	.8d	50	12	0.073	0.050					
			.2d	50	3	0.026		0.040	1.10	4.00	4.40	0.176
20	96.0	1.1	.8d	50	6	0.043	0.030					
			.2d	50	2	0.017		0.022	1.20	4.00	4.80	0.104
21	100.0	1.3	.8d	50	3	0.026	0.013					
			.2d	50	0	0.000		0.007	0.70	4.00	2.80	0.018
22	104.0	0.1	-	50	0	0.000	0.000					
								0.000	0.20	4.00	0.80	0.000
23	108.0	0.3	-	50	0	0.000	0.000					
								0.000	0.15	5.60	0.84	0.000
24	113.6	0.0	-	50	0	0.000	0.000					

Total Area (sq.m) = 201.25 Total discharge (cumecs) = 25.75 Mean Velocity (m/s) = 0.13

DISCHARGE MEASUREMENT BY CURRENT METER

			Start	Finish
Station:	Shebelli at Afgoi			
Date:	26th January 1989			
Method:	Suspension from bridge (d/s face) with 10kg weight	Time	0905	1000
Origin:	Left Bank	Stage	1.83	1.83
Observers:	Ibrahim/Ali/Peter/Marian/Khadija			
Meter:	Braystoke BFM 001 No. 75-306 Impellor No. 8011-503			

Calculations made by method of mean velocity over section between two verticals. Two measurements at each vertical.

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
1	0.0	0.0	-	50	0	0.000	0.000					
								0.020	0.30	2.5	0.75	0.015
2	2.5	0.6	.6d	50	7	0.048	0.041					
			.6d	50	4	0.033		0.171	0.70	1.5	1.05	0.180
3	4.0	0.8	.6d	50	57	0.312	0.301					
			.6d	50	53	0.291		0.416	0.85	1.5	1.28	0.530
4	5.5	0.9	.6d	50	92	0.499	0.531					
			.6d	50	104	0.563		0.596	1.05	1.5	1.58	0.939
5	7.0	1.2	.8d	50	92	0.499	0.661					
			.2d	50	153	0.824		0.563	1.30	1.5	1.95	1.097
6	8.5	1.4	.8d	50	74	0.403	0.464					
			.2d	50	97	0.525		0.532	1.45	1.5	2.18	1.157
7	10.0	1.5	.8d	50	114	0.616	0.600					
			.2d	50	108	0.584		0.657	1.50	1.5	2.25	1.479
8	11.5	1.5	.8d	50	99	0.536	0.715					
			.2d	50	166	0.893		0.729	1.45	1.5	2.18	1.586
9	13.0	1.4	.8d	50	113	0.611	0.744					
			.2d	50	163	0.877		0.571	1.45	1.5	2.18	1.241
10	14.5	1.5	.8d	50	62	0.339	0.397					
			.2d	50	84	0.456		0.388	1.40	1.5	2.10	0.815
11	16.0	1.3	.8d	50	58	0.317	0.379					
			.2d	50	81	0.440		0.329	1.15	1.5	1.73	0.568
12	17.5	1.0	.6d	50	51	0.280	0.280					
			.6d	50	51	0.280		0.268	1.00	1.5	1.50	0.402
13	19.0	1.0	.6d	50	47	0.259	0.256					
			.6d	50	46	0.253		0.312	1.05	1.5	1.58	0.491
14	20.5	1.1	.8d	50	75	0.408	0.368					
			.2d	50	60	0.328		0.441	1.05	1.5	1.58	0.695
15	22.0	1.0	.6d	50	96	0.520	0.515					
			.6d	50	94	0.509		0.523	1.00	1.5	1.50	0.784
16	23.5	1.0	.6d	50	101	0.547	0.531					
			.6d	50	95	0.515		0.399	0.85	1.3	1.11	0.441
17	24.8	0.7	.6d	50	44	0.243	0.267					
			.6d	50	53	0.291		0.133	0.35	1.4	0.49	0.065
18	26.2	0.0	-	50	0	0.000	0.000					

Total Area (sq.m)	= 26.95	Total discharge (cumecs) =	12.49	Mean Velocity (m/s)	= 0.46

DISCHARGE MEASUREMENT BY CURRENT METER

			Start	Finish
Station:	Shebelli at Beled Weyn			
Date:	8th February 1989			
Method:	Suspension from bridge (d/s face) with 10kg weight	Time	0800	0940
Origin:	Left Bank	Stage	0.47	0.47
Observers:	Ali/Marian/Ibrahim/Ahmed			
Meter:	Braystoke BFM 001 No. 75-306 Impellor No. 8011-503			

Calculations made by method of mean velocity over section between two verticals.
Two measurements at each vertical.

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Velocity Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
1	3.0	0.0	-	50	0	0.000	0.000					
								0.117	0.30	2.8	0.84	0.099
2	5.8	0.6	.6d	50	44	0.243	0.235					
			.6d	50	41	0.227		0.237	0.90	2.2	1.98	0.470
3	8.0	1.2	.8d	50	43	0.237	0.240					
			.2d	50	44	0.243		0.279	1.40	1.4	1.96	0.546
4	9.4	1.6	.8d	50	54	0.296	0.317					
			.2d	50	62	0.339		0.337	1.70	1.8	3.06	1.032
5	11.2	1.8	.8d	50	56	0.307	0.357					
			.2d	50	75	0.408		0.364	1.85	1.6	2.96	1.078
6	12.8	1.9	.8d	50	66	0.360	0.371					
			.2d	50	70	0.381		0.371	2.00	1.5	3.00	1.112
7	14.3	2.1	.8d	50	65	0.355	0.371					
			.2d	50	71	0.387		0.383	2.10	2.7	5.67	2.170
8	17.0	2.1	.8d	50	71	0.387	0.395					
			.2d	50	74	0.403		0.399	1.90	1.5	2.85	1.136
9	18.5	1.7	.8d	50	70	0.381	0.403					
			.2d	50	78	0.424		0.420	1.55	2.5	3.88	1.628
10	21.0	1.4	.8d	50	78	0.424	0.437					
			.2d	50	83	0.451		0.443	1.20	2.0	2.40	1.063
11	23.0	1.0	.6d	50	82	0.445	0.448					
			.6d	50	83	0.451		0.436	1.05	2.0	2.10	0.916
12	25.0	1.1	.8d	50	73	0.397	0.424					
			.2d	50	83	0.451		0.413	0.85	2.0	1.70	0.703
13	27.0	0.6	.6d	50	71	0.387	0.403					
			.6d	50	77	0.419		0.201	0.30	5.3	1.59	0.320
14	32.3	0.0	-	50	0	0.000	0.000					

Total Area (sq.m) = 33.99	Total discharge (cumecs) = 12.27	Mean Velocity (m/s) = 0.36

DISCHARGE MEASUREMENT BY CURRENT METER

			Start	Finish
Station:	Shebelli at Bulo Burti			
Date:	8th February 1989			
Method:	Suspension from bridge (d/s face) with 10kg weight	Time	1430	1600
Origin:	Left Bank	Bridge Dip	8.91	8.90
Observers:	Marian/Ibrahim/Ali/Ahmed	Equivalent GH	1.20	1.21
Meter:	Braystoke BFM 001 No. 75-306 Impellor No. 8011-503			

Calculations made by method of mean velocity over section between two verticals.
Two measurements at each vertical.

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
1	12.4	0.0	-	50	0	0.000	0.000					
								0.335	0.35	8.6	3.01	1.007
2	21.0	0.7	.6d	50	124	0.669	0.669					
			.6d	50	124	0.669		0.701	0.85	1.6	1.36	0.954
3	22.6	1.0	.6d	50	136	0.733	0.733					
			.6d	50	136	0.733		0.745	1.05	2.4	2.52	1.878
4	25.0	1.1	.8d	50	134	0.723	0.757					
			.2d	50	147	0.792		0.767	1.10	4.0	4.40	3.374
5	29.0	1.1	.8d	50	129	0.696	0.776					
			.2d	50	159	0.856		0.753	1.15	2.5	2.88	2.166
6	31.5	1.2	.8d	50	114	0.616	0.731					
			.2d	50	157	0.845		0.761	1.05	1.5	1.58	1.199
7	33.0	0.9	.6d	50	147	0.792	0.792					
			.6d	50	147	0.792		0.803	0.85	1.2	1.02	0.819
8	34.2	0.8	.6d	50	155	0.835	0.813					
			.6d	50	147	0.792		0.751	0.80	1.8	1.44	1.081
9	36.0	0.8	.6d	50	129	0.696	0.688					
			.6d	50	126	0.680		0.511	0.75	2.0	1.50	0.766
10	38.0	0.7	.6d	50	66	0.360	0.333					
			.6d	50	56	0.307		0.167	0.35	2.9	1.01	0.169
11	40.9	0.0	-	50	0	0.000	0.000					

Total Area (sq.m) = 20.72 Total discharge (cumecs) = 13.41 Mean Velocity (m/s) = 0.65

DISCHARGE MEASUREMENT BY CURRENT METER

Station: Shebelli at Mahaddey Weyn
Date: 9th February 1989
Method: Suspension from bridge (d/s face) with 10kg weight
Origin: Left Bank
Observers: Marian/Ali/Ibrahim/Ahmed
Meter: Braystoke BFM 001 No. 75-306 Impellor No. 8011-503

	Start	Finish
Time	0915	1110
Stage	1.63	1.63

Calculations made by method of mean velocity over section between two verticals. Two measurements at each vertical.

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
1	0.0	0.0	-	50	0	0.000	0.000					
								0.119	0.50	2.5	1.25	0.148
2	2.5	1.0	.6d	50	44	0.243	0.237					
			.6d	50	42	0.232		0.245	0.95	1.0	0.95	0.233
3	3.5	0.9	.6d	50	46	0.253	0.253					
			.6d	50	46	0.253		0.279	1.20	1.5	1.80	0.502
4	5.0	1.5	.8d	50	46	0.253	0.304					
			.2d	50	65	0.355		0.368	1.55	2.0	3.10	1.141
5	7.0	1.6	.8d	50	70	0.381	0.432					
			.2d	50	89	0.483		0.456	1.60	1.2	1.92	0.876
6	8.2	1.6	.8d	50	83	0.451	0.480					
			.2d	50	94	0.509		0.485	1.55	1.8	2.79	1.354
7	10.0	1.5	.8d	50	79	0.429	0.491					
			.2d	50	102	0.552		0.489	1.50	1.2	1.80	0.881
8	11.2	1.5	.8d	50	77	0.419	0.488					
			.2d	50	103	0.557		0.476	1.55	1.8	2.79	1.328
9	13.0	1.6	.8d	50	80	0.435	0.464					
			.2d	50	91	0.493		0.463	1.60	1.5	2.40	1.111
10	14.5	1.6	.8d	50	77	0.419	0.461					
			.2d	50	93	0.504		0.455	1.60	1.5	2.40	1.091
11	16.0	1.6	.8d	50	75	0.408	0.448					
			.2d	50	90	0.488		0.443	1.50	1.7	2.55	1.129
12	17.7	1.4	.8d	50	75	0.408	0.437					
			.2d	50	86	0.467		0.432	1.25	1.0	1.25	0.540
13	18.7	1.1	.8d	50	72	0.392	0.427					
			.2d	50	85	0.461		0.367	1.05	1.3	1.37	0.501
14	20.0	1.0	.6d	50	57	0.312	0.307					
			.6d	50	55	0.301		0.229	1.30	2.0	2.60	0.596
15	22.0	1.6	.8d	50	33	0.184	0.152					
			.2d	50	21	0.120		0.091	1.40	1.5	2.10	0.191
16	23.5	1.2	.8d	50	4	0.033	0.030					
			.2d	50	3	0.026		0.054	1.30	1.3	1.69	0.091
17	24.8	1.4	.8d	50	16	0.093	0.078					
			.2d	50	10	0.063		0.111	1.50	1.0	1.50	0.167
18	25.8	1.6	.8d	50	34	0.189	0.144					
			.2d	50	17	0.099						

(cont.)

(cont.)

Shebelli at Mahaddey Weyn 9th February 1989

Vertical number	Distance (m)	Depth (m)	Depth of observation	Time (s)	Revs	Velocity Point	Velocity Mean (m/s)	Velocity Section	Mean depth (m)	Width (m)	Area (sq.m)	Discharge (cumecs)
18	25.8	1.6	.8d	50	34	0.189	0.144					
			.2d	50	17	0.099		0.191	1.40	1.2	1.68	0.320
19	27.0	1.2	.8d	50	37	0.205	0.237					
			.2d	50	49	0.269		0.217	0.95	1.2	1.14	0.248
20	28.2	0.7	.6d	50	33	0.184	0.197					
			.6d	50	38	0.211		0.099	0.35	2.1	0.74	0.073
21	30.3	0.0	-	50		0.000	0.000					

Total Area (sq.m) = 37.81	Total discharge (cumecs) = 12.52	Mean Velocity (m/s) = 0.33

APPENDIX C

HISTORIC DATA FOR ADDITIONAL STATIONS

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APPENDIX C

HISTORIC DATA FOR ADDITIONAL STATIONS

C1 INTRODUCTION

During the earlier stages of the Project work was concentrated on the eight primary gauging stations which were established in 1963 by the FAO (Lockwood) project and which are still in use. It was, however, noted in earlier reports that there was some additional data for other stations which had either not been part of the primary network or had been discontinued, and that some of this data could be useful in the overall analysis of river flows. It was therefore decided to add some of this data to the computer database. The sections below detail the work carried out on a station-by-station basis.

C2 BALCAD, RIVER SHEBELLI

C2.1 Available Data

When the river gauging network was established in 1963 there were six primary stations on the river Shebelli. These stations remain in use today with the exception of that at Balcad (some 50 km upstream of Afgoi); this was used until 1980 when the FAO Consultant B.A.P. Gemmell found that the river level and the stage-discharge relationship were being affected by a barrage a short distance downstream which became operational early in 1980. River level records continue until December 1980, but the readings in that year cannot be converted to discharge with any degree of reliability.

The date when barrage operation commenced is quoted by Gemmell as April 4th 1980, but the exact date when the presence of the barrage started to affect the river at Balcad is not clear. Gemmell reported on 29th March (the date of the second discharge measurement of the year) that it "appears that the barrage is holding the water level"; by 2nd April he was certain ("This barrage will affect all future water levels."). On May 5th 1980 he noted that the station would no longer be a gauged site (though some later measurements were made) and the station was finally abandoned in April 1981. The two discharge measurements in February and March 1980 displayed lower velocities than indicated by the rating which would be consistent with a backwater effect from the barrage. Although that observation does not provide conclusive evidence, when taken together with the fact that there were no regular water level observations in January and February 1980 it seems sensible to take the end of 1979 as the cut-off date for flow data.

When Gemmell surveyed the gauges in 1980 he found an overlap of 8 cm between the 0-2 m and the 2-4 m gauges. Unfortunately there is no record of any changes in the gauge zero (eg following gauge replacement), so it is not possible to state with certainty the period for which the observed values should be adjusted. However, inspection of the hydrographs for 1978 and 1979 showed some clear jumps at the 2 m level in 1979 but generally smooth changes in 1978. It was therefore concluded that the overlap is most likely to have arisen in early 1979.

As a consequence of this inspection, SG readings of below 2 m in the period March 1979 to December 1980 were increased by 8 cm. The same adjustment was made to the observed gauge height for discharge measurements during this period.

Although the record for Balcad for the period 1963 to 1979 is far from complete it does include data for certain periods where information is sparse for some of the other Shebelli stations. The data may therefore be useful for the infilling of missing data as well as for the checking of recorded data. All the available SG data was taken from the monthly record sheets compiled by the observer (or in some cases what appear to be fair copies made out in the MOA office).

C2.2 Discharge Measurements

Although the stage data alone are of some value it is necessary to convert them to discharges to obtain maximum benefit for the purposes of inter- station correlation and data infilling. A total of 57 discharge measurements (DMs) by current meter were available from 1962 to 1982. Although the

first of these was made before the FAO staff gauges were set up in 1963, the recorded water level was referenced to a local benchmark so that the equivalent post-1963 gauge height could be determined.

An initial examination of a few discharge measurement observation sheets showed some errors in the computations, so all results were recalculated from the original sheets. (Most of the original calculations had of course been done long before the days of calculators or computers.) Current meter rating tables were not available, so the velocities entered for recorded numbers of propellor revolutions could not be fully checked; however, it is considered that this is likely to be only a minor source of potential error. Some minor corrections resulted to the list of measured discharges in the FAO period (1963-65), but thereafter many major errors were corrected. The DM on 7th February 1972 was omitted because the available record appeared to be incomplete (possibly a second sheet was missing).

Once a full list of DMs had been obtained they were further examined to see if any should be omitted from the rating curve derivation process. All the measurements are shown in Figure C1. It was immediately clear that the eight DMs in 1980-82 after the construction of the barrage should be left out. Plots of velocity and discharge against stage confirmed that the previous section control no longer applied (see Figure C2 which compares these DMs to the derived rating curve); Gemmell's notes also indicated that attempts at some other measurements had been abandoned because of negligible velocities, even at high river stages. Three further DMs (two in 1967 and one in 1971) were omitted from the derivation process because they were very clear outliers and it is assumed that a faulty meter or incorrect rating was used. All these measurements are marked with a "?" on the DM list (Table C1); the three identified as outliers are clearly apparent as such on the graphs when compared to the derived rating curve (Figure C3). Furthermore, the original sheet for the DM on 15th May 1967 was labelled "Not satisfactory", though no reason is given for this.

Following this recalculation and checking procedure a total of 45 DMs were available for analysis to derive a rating curve. Most of these were from the years 1963-64 and 1970-72; no measurements were available from 1973 to 1979. The plots of DMs show a certain amount of scatter at both low and high levels. However, there was no apparent temporal pattern to this variation so a single curve was derived to cover the whole period. The graphs also suggested that a one part equation would be appropriate and this was derived using the best-fit least squares procedure in HYDATA. The resulting equation is as follows:

$$Q = 10.08 \, (\, h + 0.10 \,)^{1.330}$$

Attempts at fitting a two or three part rating did not produce any significant improvement in the fit of the rating curve to the DMs. The zero flow intercept of GH = -0.10 m seems reasonable because SG data indicates that the river level occasionally dropped below the lowest staff gauge, but only for short periods.

C2.3 River Discharges

The derived equation was used to obtain daily mean discharges from the twice daily staff gauge readings. The resulting mean monthly discharges are shown in Table C2. Comparison plots of Balcad flows with those for Mahaddey Weyn and Afgoi show a good degree of agreement, though this checking process did identify some periods of very doubtful data at individual stations. The majority of the annual hydrographs also display the typical form for stations in the middle and lower Shebelli - clear Gu and Der flood seasons with flows usually staying approximately constant for a considerable period, separated by a fairly short period of medium to low flows (hagai) and followed by a long recession to very low or zero flows at the end of the jilaal season.

C3 MAREERE, RIVER JUBBA

C3.1 Available Data

River levels have been recorded at the Jubba Sugar Project (JSP) at Mareere since 1977. The completeness of the record is generally good, particularly when compared to the MOA stations (Lugh, Bardheere and Jamamme) which have long gaps in the periods 1977-79 and 1982-83. The staff of

JSP made available sheets showing the mean daily water level for 1977-88 and agreed to forward future data to the MOA. These daily values had been derived from twice daily SG readings. Some copies of original sheets have been received in Mogadishu; in some cases these could not easily be reconciled with the mean daily values because the sheets do not always note which SG was being read or the appropriate gauge zero. It was felt that the prepared mean daily values would be adequate and that it would not be worthwhile to examine all the original sheets at Mareere in order to enter twice daily values. The main purpose of entering this data is to provide comparison with other stations and possibly some approximate infilling; at other stations much of the data is itself effectively only one reading per day (where the subsequent readings have simply duplicated the morning one) so the quality of the data entered for Mareere should not suffer by comparison.

Despite strenuous efforts by the staff of JSP, their record is not complete because of the difficulty of fixing SGs for very low levels; however, these occurrences are clearly marked on the data sheets. Nevertheless, the 95 % of data available compares very favourably with other Jubba stations for the same period (Lugh 83 %, Bardheere 56 % and Jamamme 44 %, the latter for the period up to the station being abandoned in 1985).

C3.2 Discharge Measurements

Unfortunately, the availability of discharge measurements at Mareere is rather limited in both time and range of river level. A total of 15 DMs were available but all were taken within 5 months in 1979/80. There is no bridge so measurements must be made from a boat; this probably explains the lack of measurements at high stages, together with the fact that the magnitudes of flood discharges are of little interest to JSP who are concerned with the ability to maintain pumping at low levels. The available measurements are listed in Table C3; the highest measured discharge of 34 cumecs is very low when compared to the estimated "bank-full" discharge of about 550-600 cumecs. The DM data was taken directly from the report referred to below.

K. Jacobi, Consultant Hydrologist at the Ministry of Jubba Valley Development (MJVD) in 1983/85 included the Mareere data in his study of river levels and flows in the Jubba. He derived a rating curve from the available measurements which shows an acceptable degree of fit in that range. He extrapolated this rating to cover the full range of data; this procedure is obviously questionable, but Jacobi found that the resulting discharges showed reasonable correlation with those at other stations. A similar procedure has therefore been adopted for the MOA database, **but it must be stressed that high discharges are approximate estimates only and may be substantially inaccurate. Furthermore, any change in the section control before or after the period of measurements cannot be identified.** The best-fit procedure fails to produce an acceptable rating equation (the exponent would be over 3, resulting in ridiculously high discharges on extrapolation of the curve), so Jacobi's zero flow intercept has been adopted. The derived rating equation is shown below and is plotted together with the DMs in Figure C4. The graph shows the potential range of river levels and clearly indicates the extent of the extrapolation from the available measurements.

$$Q = 17.87 (h - 4.55)^{1.903}$$

Note: because HYDATA cannot accept a gauge zero correction of more than 9.99 m, all data values (which are initially metres above mean sea level) were reduced by 10 m; the equation refers to the adjusted values.

C4 KAITOI, RIVER JUBBA

C4.1 Available Data

A gauging station was established at Kaitoi in 1963 at about the same time as the rest of the network. However, records stopped after less than two years and did not resume until 1972. Good records of river level are available from then until 1988, but the station ceased to be of value for discharges after 1980 because of the effect of the Fanoole barrage a short distance downstream. Daily mean gauge heights have been taken from Jacobi's MJVD report; some of the original observation sheets have also been checked at the Fanoole Project office at Jilib. The records are almost complete from July 1972 to December 1980.

C4.2 Discharge Measurements

A total of 171 discharge measurements were available; nine were in 1963 and the remainder in 1972-76. Values were taken directly from Jacobi's report. These measurements are listed in Table C4 and plotted in Figure C5 together with the best-fit rating curve derived from them. The final measurement was omitted from the derivation process because it was an obvious outlier and it was not possible to check the original measurement sheet or calculations; it is clearly seen on the graph, being much further from the rating curve than any other gauging. There is little scatter and a single segment curve was considered appropriate for the whole period; the equation is as follows:

$$Q = 35.12 (h + 0.29)^{1.614}$$

C5 KAMSUMA, RIVER JUBBA

C5.1 Available Data

The Russian (Selchozpromexport) study in the early to mid 1970's recorded extensive quantities of data at various stations on the Jubba, including a very large number of discharge measurements. This was done at some of the existing stations as well as several new stations. Some of the latter apparently had very temporary staff gauges, but the station at Kamsuma (midway between Jilib and Jamamme) appeared to be well established and consequently provides good quality data.

In view of the problems associated with the MOA station at Jamamme it was decided during Stage 1 of this project to reestablish the station at Kamsuma as a long-term replacement for Jamamme (see Stage 1 Final Report). An automatic water level recorder and staff gauges were installed in 1985/86, but regular readings did not commence until November 1988 because of difficulties in appointing a gauge reader. Furthermore, the recorder and SGs were seriously damaged in the large 1987 flood so readings are currently taken by using a bridge dipper.

The Russian data was available as mean daily gauge heights for a continuous period of approximately four years (1972-76) as presented by Jacobi's MJVD report; original data sheets were not available. This data is said to be referenced to a gauge zero of 6.00 m amsl, but there is no record of the benchmark used. When the station was re-established by this project it was therefore not possible to use the same gauge zero; the new gauges were related to the MB (bridge dip point) set at the 32 m mark on the downstream face of the bridge. The records entered to the database for the two periods are for different gauge zeros and are therefore not directly comparable, though in due course it should be possible to deduce the difference between the gauge zeros.

C5.2 Discharge Measurements

A total of 98 discharge measurements were available from the period 1972-75, the majority occurring in 1974. These are presented in Table C5, together with measurements made during this project referenced to the new gauge zero (9.96 m below the MB). Figure C6 indicates that the 98 DMs show relatively little scatter. There is no indication of a change in rating during the period, nor of the need for a multi-segment rating equation. The DM data was again taken from the MJVD report by Jacobi. The rating derived by the best fit least squares procedure, and plotted in Figure C6, was as follows:

$$Q = 45.76 (h - 2.33)^{1.405}$$

The preponderance of measurements in 1974 (including 15 in one period of 18 days) could introduce bias to the estimation procedure. The DM data set was therefore reduced to 75 measurements by selecting not more than 4 measurements in each month (taking the highest and lowest in the month together with two others selected at random). However, the resulting rating equation was so nearly identical to that given above that it was considered that bias was not a problem.

Where data was available for Jamamme it was found that comparison plots of daily discharges showed a good degree of agreement.

For the data from the new MB (occasional readings from 1986 and regular readings from November 1988) it was necessary to derive a rating equation from measurements made during the project. 8 DMs were available from 1984 to early 1989; from these the following equation was derived:

$$Q = 35.02 (h - 0.50)^{1.521}$$

The slope of this line is reasonably close to that for the earlier period of data which lends some confidence to it. When further measurements are available the rating will be reviewed and revised if appropriate. Figure C7 shows this rating curve together with the eight measured discharges. The first discharges calculated using this rating equation are shown in the 1988 hydrograph in Appendix A.

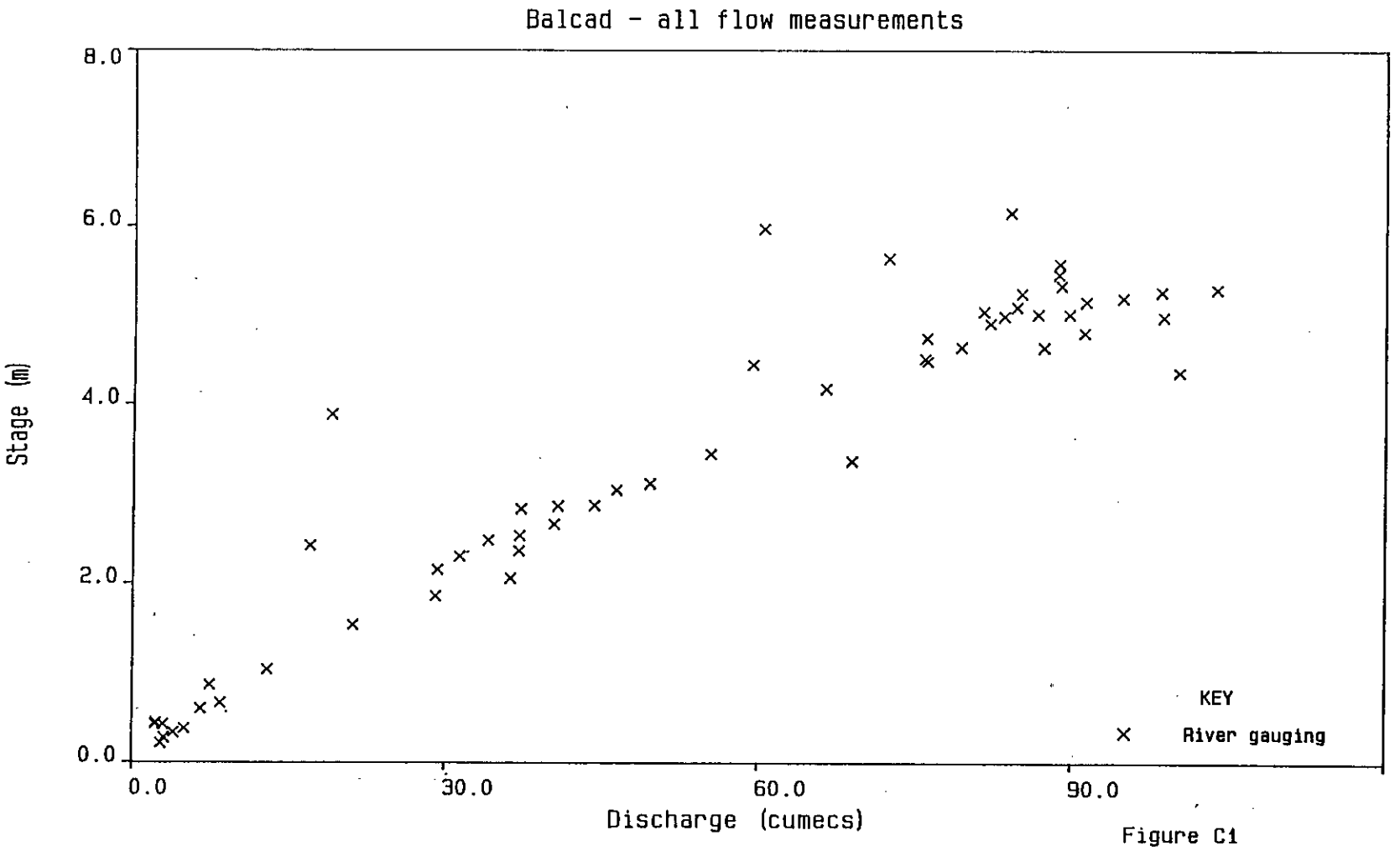
Balcad - all flow measurements
8.0
6.0
4.0
2.0
0.0
Stage (m)
0.0
30.0
60.0
90.0
Discharge (cumecs)
KEY
River gauging

Figure C1

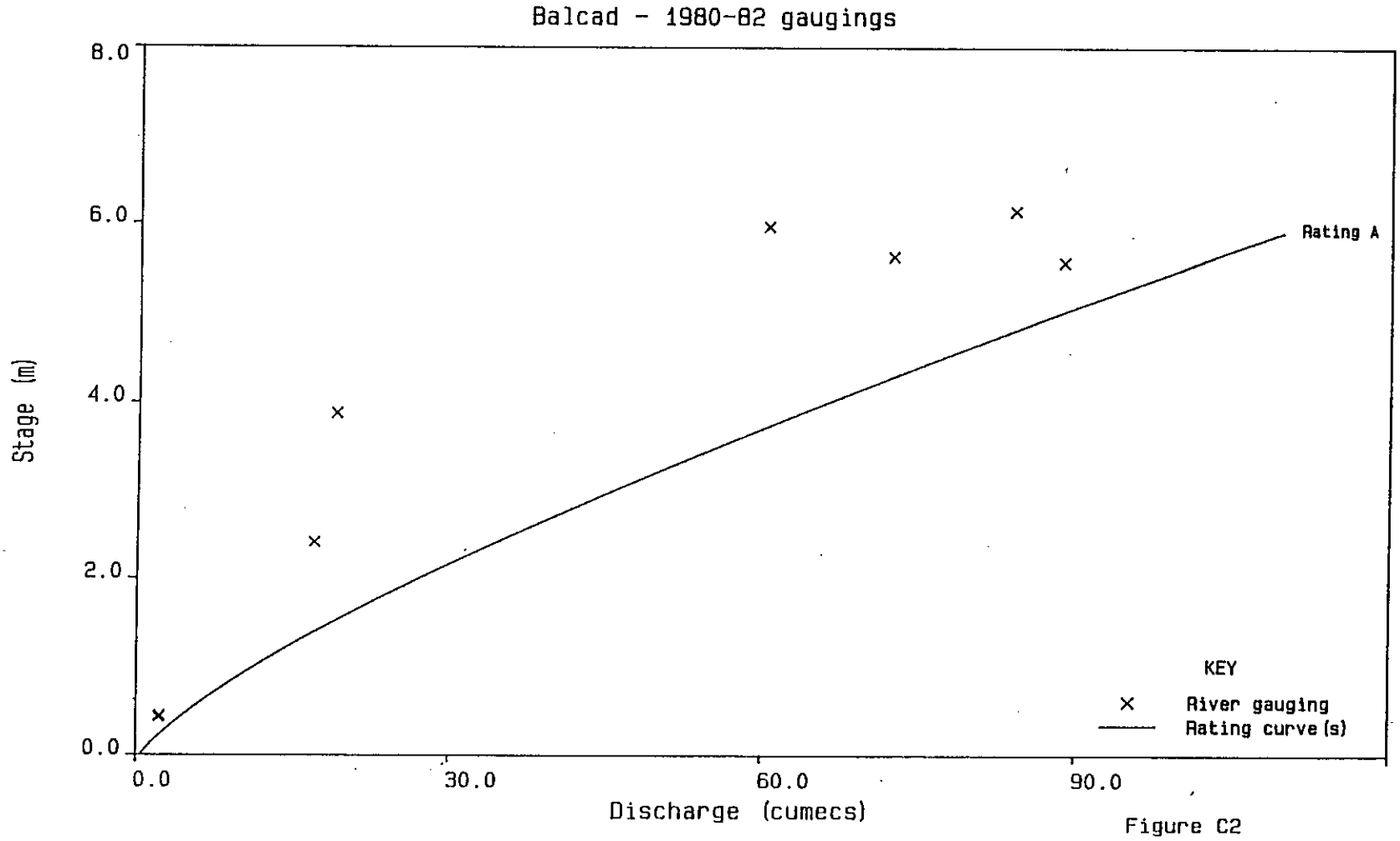
Balcad - 1980-82 gaugings
8.0
6.0
4.0
2.0
0.0
Stage (m)
0.0
30.0
60.0
90.0
Discharge (cumecs)
Rating A
KEY
River gauging
Rating curve(s)

Figure C2

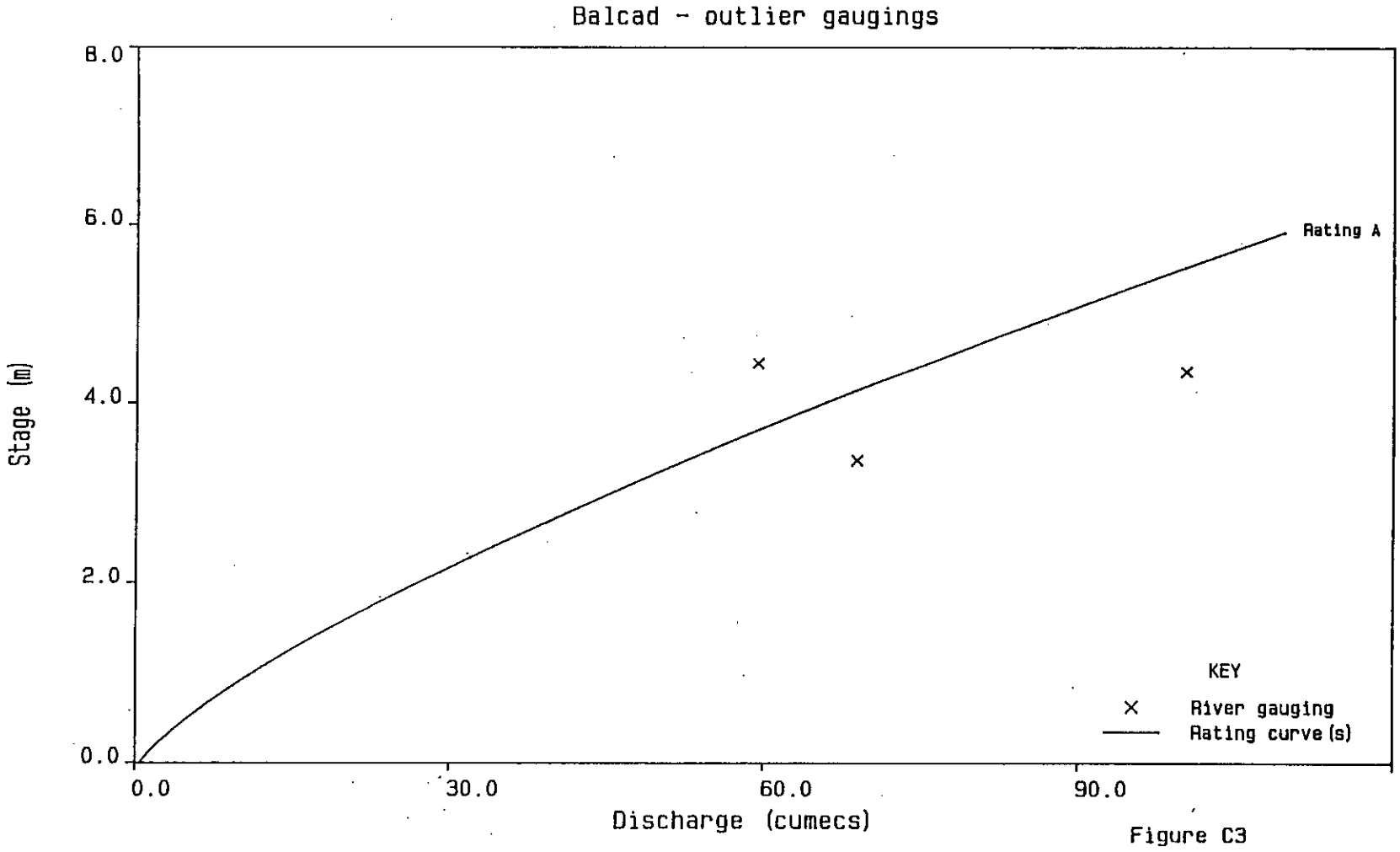
Balcad - outlier gaugings
8.0
6.0
4.0
2.0
0.0
Stage (m)
0.0
30.0
60.0
90.0
Discharge (cumecs)
Rating A
KEY
River gauging
Rating curve(s)

Figure C3

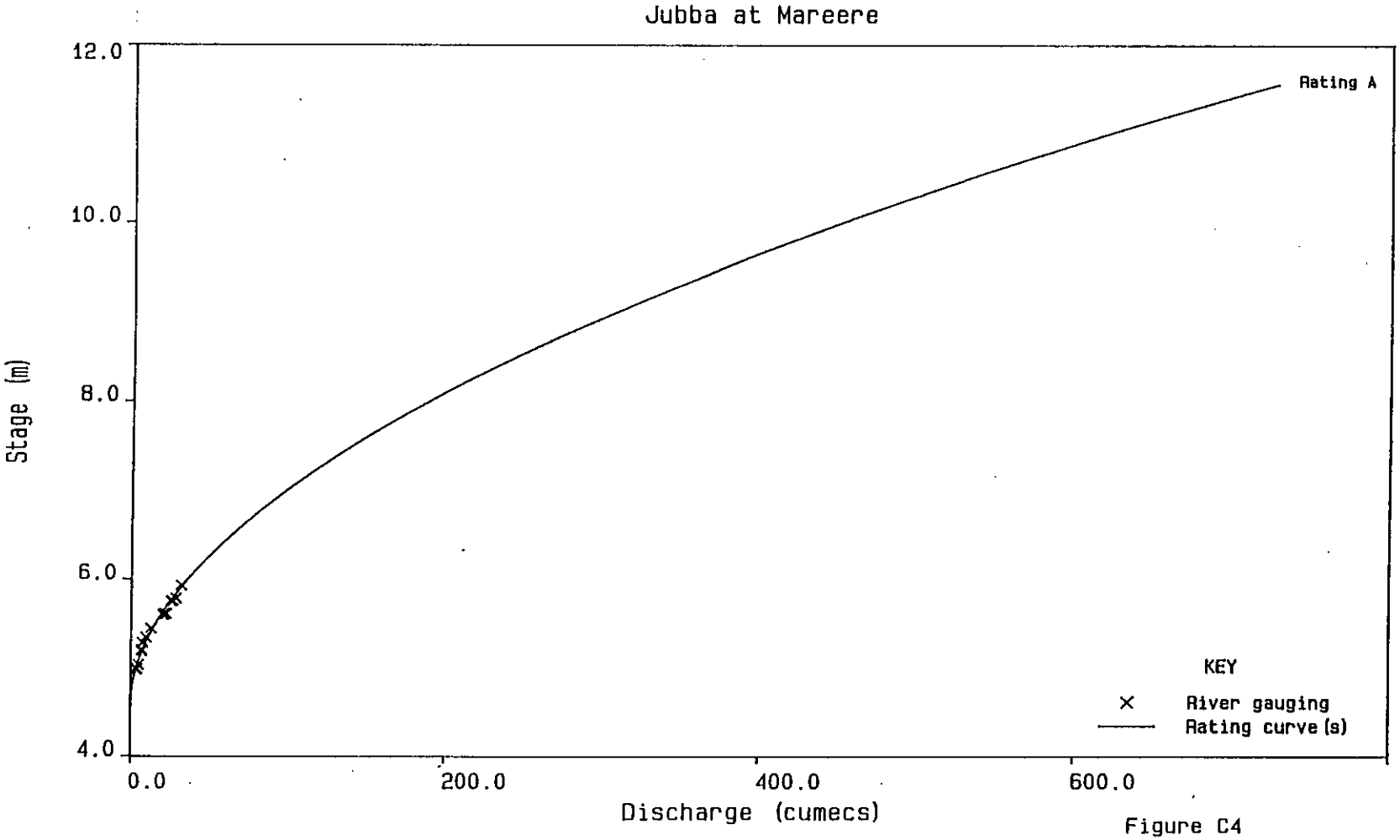
Jubba at Mareere
12.0
10.0
8.0
6.0
4.0
Stage (m)
0.0
200.0
400.0
600.0
Discharge (cumecs)
Rating A
KEY
River gauging
Rating curve (s)

Figure C4

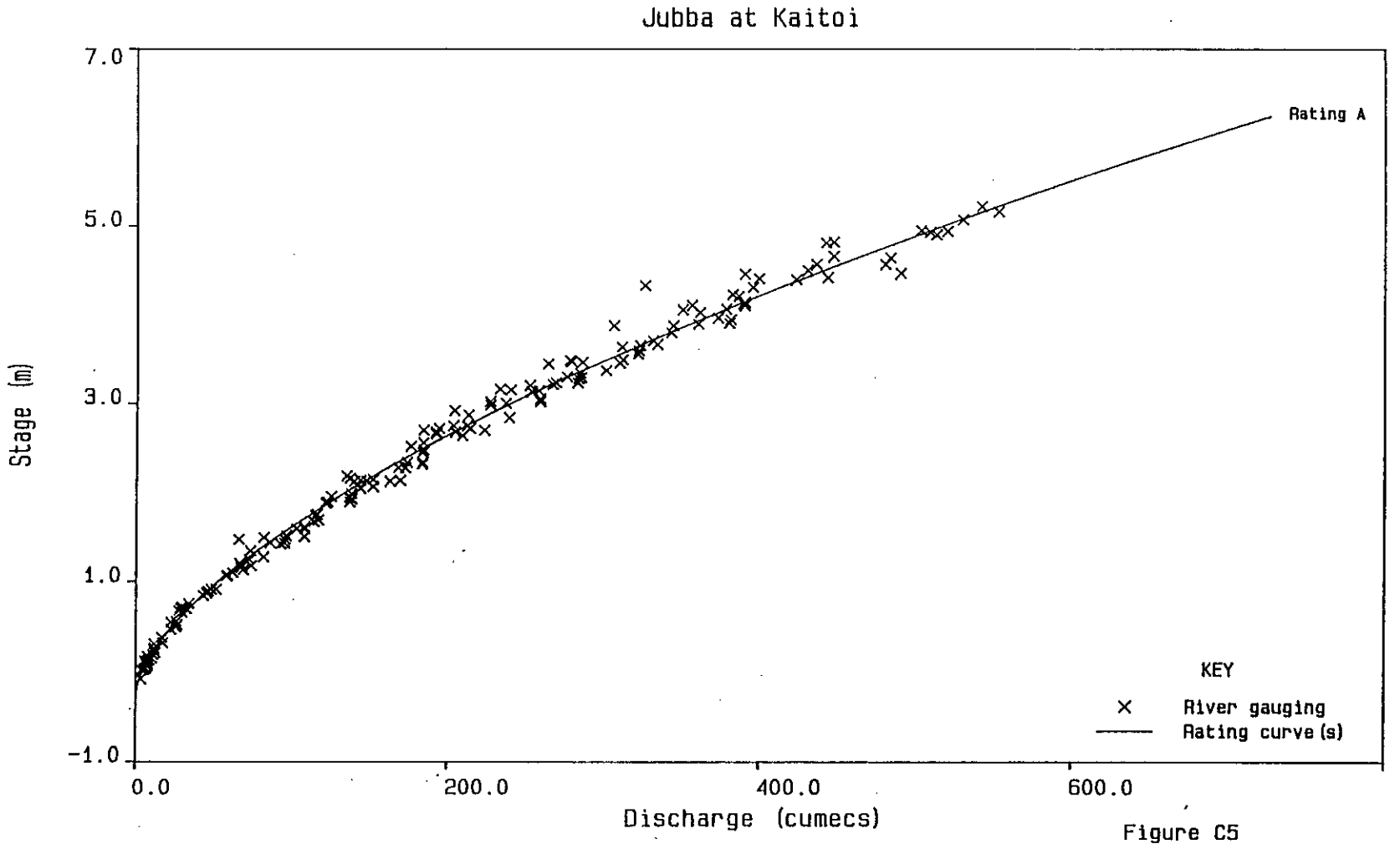
Jubba at Kaitoi
7.0
5.0
3.0
1.0
-1.0
Stage (m)
0.0
200.0
400.0
600.0
Discharge (cumecs)
Rating A
KEY
River gauging
Rating curve(s)

Figure C5

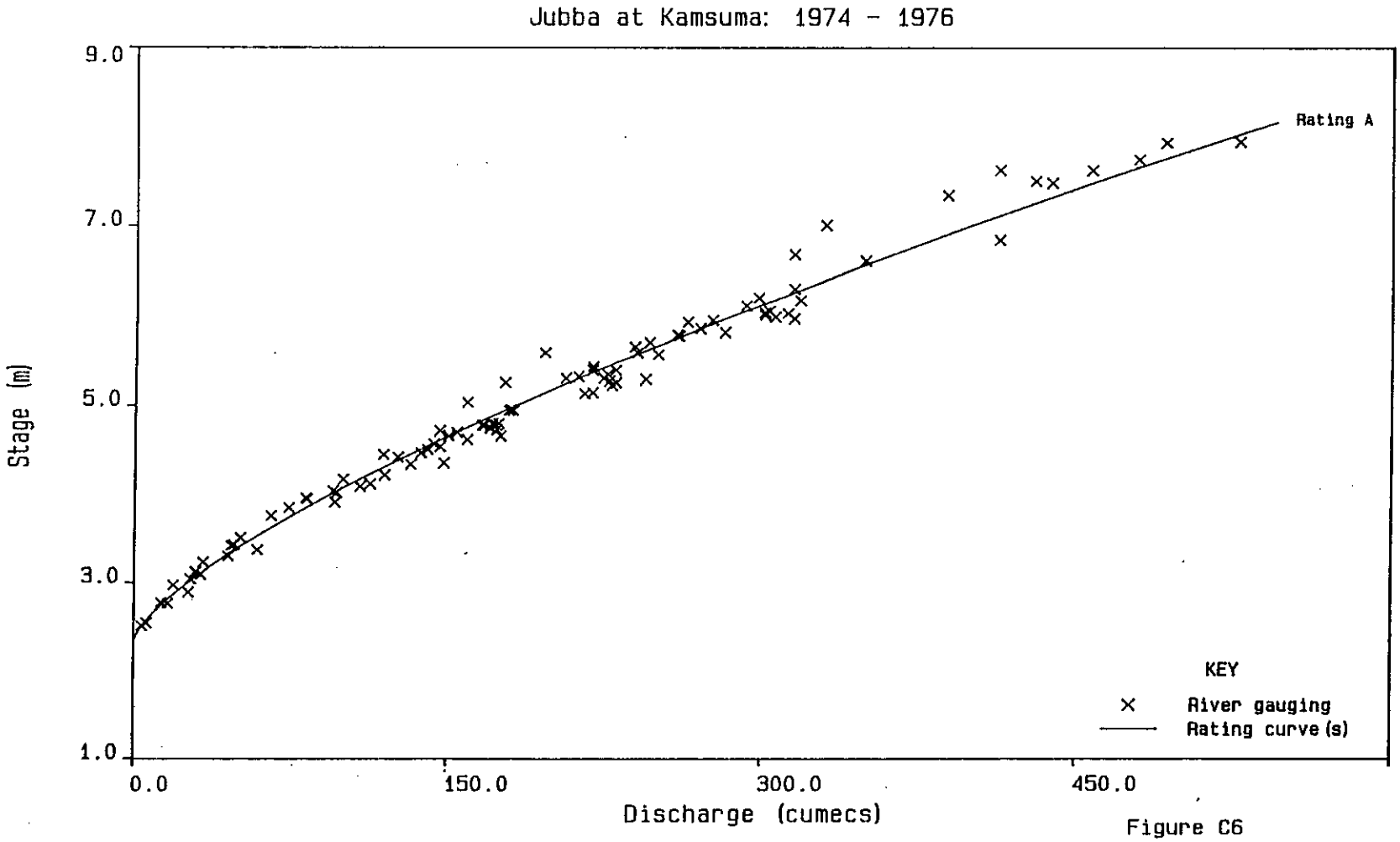
Jubba at Kamsuma: 1974 - 1976
9.0
7.0
5.0
3.0
1.0
Stage (m)
0.0
150.0
300.0
450.0
Discharge (cumecs)
Rating A
KEY
River gauging
Rating curve(s)

Figure C6

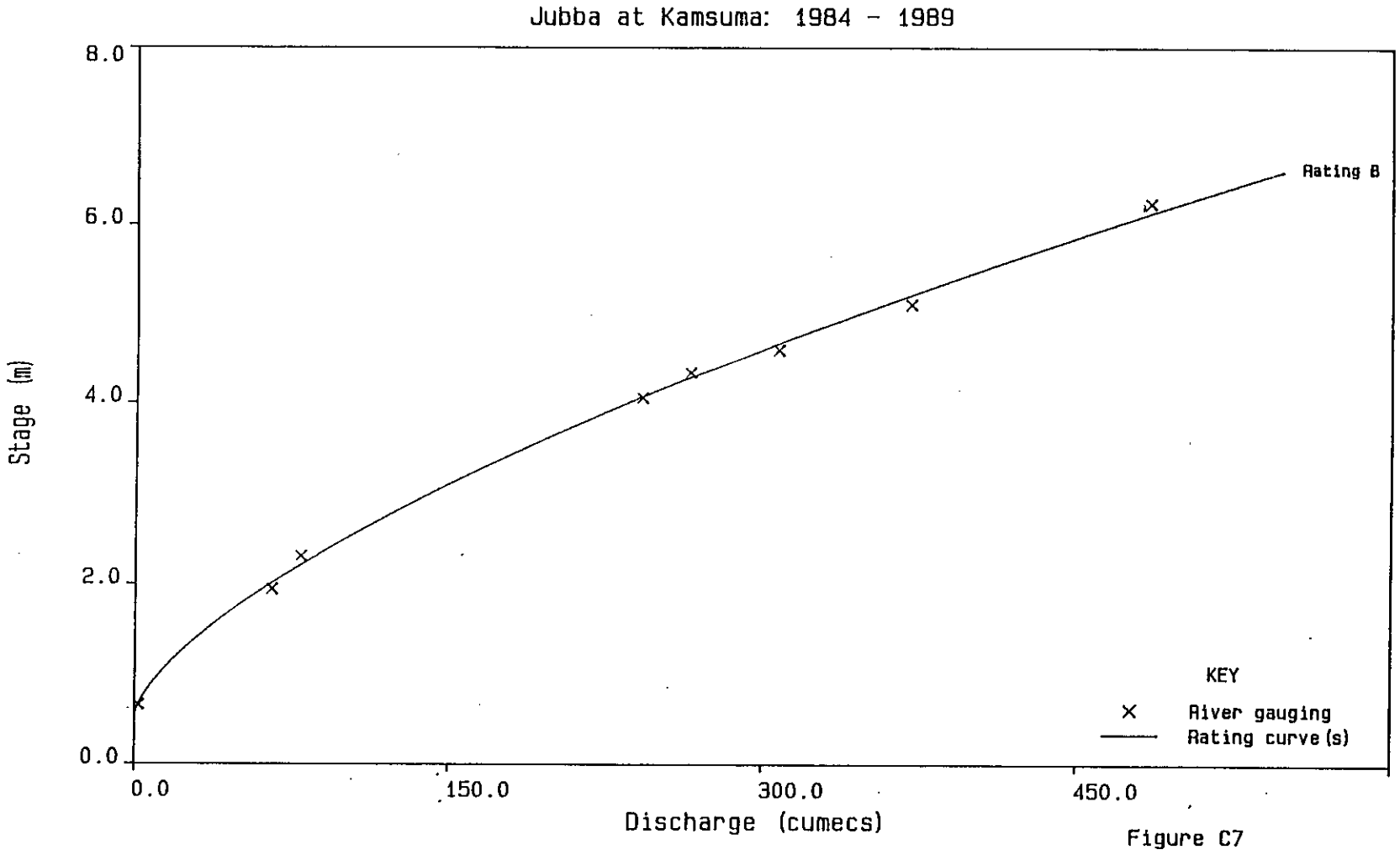
Jubba at Kamsuma: 1984 - 1989
8.0
6.0
4.0
2.0
0.0
Stage (m)
Rating 8
KEY
River gauging
Rating curve(s)
0.0
150.0
300.0
450.0
Discharge (cumecs)

Figure C7

Discharge measurements for station 13 : Shebelli at Balcad

Order Number	Date	Rating	Stage (m)	Velocity (m/s)	Area (sq m)	Discharge (cumecs)	--- Comparison --- Diff./Rat.	Plot
1	20 Sep 1962	A	4.650	0.800	99.14	79.314	0.03/A	->
2	2 May 1963	A	5.050	0.703	115.83	81.429	0.34/A	->>>
3	23 May 1963	A	4.915	0.706	116.24	82.062	0.17/A	->>
4	6 Jun 1963	A	4.750	0.718	105.82	75.982	0.28/A	->>>
5	27 Jun 1963	A	3.110	0.690	71.80	49.544	-0.10/A	<-
6	13 Jul 1963	A	2.860	0.696	58.49	40.709	0.10/A	->
7	23 Jul 1963	A	2.830	0.626	59.41	37.193	0.26/A	->>>
8	12 Aug 1963	A	4.520	0.746	101.70	75.870	0.06/A	->
9	1 Sep 1963	A	5.100	0.722	117.19	84.608	0.25/A	->>>
10	11 Oct 1963	A	4.490	0.749	101.55	76.059	0.02/A	-
11	13 Nov 1963	A	2.530	0.675	54.93	37.075	-0.03/A	<-
12	19 Dec 1963	A	4.810	0.794	114.73	91.097	-0.33/A	<<<<-
13	11 Jan 1964	A	2.480	0.625	54.51	34.067	0.08/A	->
14	20 Jan 1964	A	2.150	0.660	44.25	29.206	0.02/A	->
15	13 Feb 1964	A	1.030	0.545	23.74	12.941	-0.08/A	<-
16	29 Feb 1964	A	0.660	0.528	16.00	8.448	-0.12/A	<-
17	21 Apr 1964	A	2.300	0.696	45.04	31.347	0.05/A	->
18	17 May 1964	A	2.360	0.714	51.90	37.060	-0.20/A	<<-
19	5 Aug 1964	A	3.440	0.727	76.20	55.394	-0.06/A	<-
20	19 Oct 1964	A	5.000	0.717	116.34	83.416	0.20/A	->>
21	6 Nov 1964	A	5.020	0.756	114.60	86.640	0.08/A	->
22	8 Mar 1965	A	0.420	0.393	7.63	3.000	0.12/A	->
23	15 May 1967	?	4.450	0.719	82.61	59.394	0.75/A	->>>
24	29 May 1967	A	5.160	0.777	117.44	91.253	0.02/A	-
25	8 Aug 1967	?	3.360	0.737	93.45	68.869	-0.78/A	<<<<-
26	30 Nov 1969	A	1.855	0.564	51.47	29.028	-0.26/A	<<<-
27	17 Jan 1970	A	0.595	0.317	20.73	6.572	-0.03/A	<-
28	26 Jan 1970	A	0.330	0.320	12.47	3.989	-0.07/A	<-
29	29 Jan 1970	A	0.270	0.253	12.19	3.084	-0.04/A	<-
30	2 Feb 1970	A	0.210	0.199	13.79	2.745	-0.07/A	<-
31	7 Feb 1970	A	0.375	0.377	13.40	5.051	-0.12/A	<-
32	9 Feb 1970	A	2.055	0.619	58.57	36.255	-0.46/A	<<<<-
33	19 Mar 1970	A	2.660	0.582	69.41	40.399	-0.08/A	<-
34	28 Mar 1970	A	4.170	0.656	101.21	66.396	0.14/A	->>
35	8 Apr 1970	A	5.270	0.785	125.47	98.494	-0.18/A	<<-

TABLE C1 Discharge Measurements at Balcad

Discharge measurements for station 13 : Shebelli at Balcad

Order Number	Date	Rating	Stage (m)	Velocity (m/s)	Area (sq m)	Discharge (cumecs)	--- Comparison --- Diff./Rat.	Plot
36	13 Apr 1970	A	5.020	0.756	118.55	89.621	-0.05/A	<-
37	29 Apr 1970	A	5.200	0.757	125.23	94.797	-0.10/A	<-
38	6 May 1970	A	5.300	0.805	128.96	103.814	-0.38/A	<<<<-
39	10 Jun 1970	A	3.040	0.698	66.39	46.343	-0.01/A	-
40	28 Jun 1970	A	1.530	0.648	32.62	21.138	-0.12/A	<-
41	22 Apr 1971	A	2.870	0.708	62.49	44.240	-0.07/A	<-
42	8 Aug 1971	A	4.650	0.770	113.29	87.233	-0.32/A	<<<-
43	25 Sep 1971	?	4.360	0.700	143.18	100.227	-1.17/A	<<<<-
44	2 Oct 1971	A	5.338	0.685	129.72	88.856	0.30/A	->>:
45	4 Nov 1971	A	5.250	0.664	128.09	85.051	0.38/A	->>.
46	1 Jan 1972	A	0.860	0.337	21.99	7.412	0.17/A	->>
47	7 May 1972	A	4.990	0.740	133.35	98.679	-0.47/A	<<<<-
48	16 Sep 1972	A	5.465	0.709	124.96	88.594	0.44/A	->>:
49	21 Feb 1980	?	0.440	0.238	9.61	2.288		
50	29 Mar 1980	?	0.425	0.237	9.35	2.217		
51	21 Jun 1980	?	3.880	0.180	105.83	19.050		
52	21 Jul 1980	?	2.420	0.341	49.88	17.010		
53	23 Aug 1980	?	5.970	0.505	119.60	60.396		
54	6 Apr 1981	?	6.150	0.555	151.41	84.030		
55	23 Sep 1982	?	5.580	0.511	173.62	88.720		
56	5 Oct 1982	?	5.640	0.409	176.85	72.330		

Total number of gaugings = 56

TABLE C1 (continued)

Summary of monthly data - Flow

Station number : 13 Name : Shebelli at Balcad

Basin no. : 2 Latitude : 2: 9: 0 N Longitude : 45:23:42 E Altitude : 95.0
Area : 272700.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean
1963	-	-	-	-	88.5	69.2	43.4	79.9	90.5	78.9	40.7	73.2	-
1964	32.9	12.5	3.43	15.9	30.6	14.1	23.2	70.3	88.7	88.3	71.9	24.1	39.7
1965	43.6	11.4	2.58	-	41.0	-	-	-	-	-	-	-	-
1966	6.81	-	-	-	77.8	35.6	28.4	43.1	55.9	74.6	62.0	23.1	-
1967	-	-	-	-	-	65.9	21.1	63.5	92.2	87.5	84.8	83.3	-
1968	-	-	57.6	62.1	-	82.4	-	-	92.4	90.3	61.4	61.9	-
1969	22.6	18.3	73.5	91.6	85.0	59.4	48.2	76.6	95.1	81.3	-	-	-
1970	-	-	-	-	-	-	-	-	-	-	-	-	-
1971	9.52	4.33	-	27.4	72.6	-	30.6	43.8	52.9	85.3e	-	-	-
1972	8.74	10.4	18.4	21.6	93.0	70.4	57.3	96.0	98.4	91.6	74.7	24.7	55.6
1973	6.55	1.10e	1.52e	0.172e	36.5e	32.8	13.1	65.1	88.0	80.3	-	-	-
1974	-	-	-	-	41.1	55.2	55.7	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-	-	-	-	-	-
1976	-	-	-	-	81.5	83.5	57.2	87.2e	96.0	68.6	59.3	33.1	-
1977	-	-	-	-	-	58.8e	-	90.6	-	92.1	94.7	85.5	-
1978	30.2	-	55.0	44.2	80.6	34.3	37.6	97.0	96.7	95.0	85.0	37.6	-
1979	19.5	49.6	38.2	68.6	63.7	92.9	49.1	84.7	60.9	56.1	51.0	17.5	54.2
Mean	20.1	15.4	31.3	41.5	66.0	58.0	38.7	74.8	84.0	82.3	68.6	46.4	52.4
St.d	13.4	16.1	28.6	30.8	22.6	23.2	15.3	18.3	16.9	10.9	16.8	26.8	
CV	0.666	1.05	0.915	0.742	0.342	0.399	0.395	0.245	0.201	0.133	0.244	0.577	

Mean monthly flow in cubic metres per second

Data flags

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

Limit to missing daily data permissible [5]

Printed on 20/ 3/1989

TABLE C2 Monthly Mean discharges at Balcad

Discharge measurements for station 5 : Jubba at Mareere

Order Number	Date	Rating	Stage (m)	Velocity (m/s)	Area (sq m)	Discharge (cumecs)	--- Comparison --- Diff./Rat.	Plot
1	30 Dec 1979	A	5.930	0.410	78.05	32.000	0.02/A	->
2	6 Jan 1980	A	5.750	0.420	62.86	26.400	-0.03/A	<-
3	8 Jan 1980	A	5.750	0.430	59.07	25.400	-0.00/A	-
4	16 Jan 1980	A	5.600	0.430	52.33	22.500	-0.08/A	<-
5	19 Jan 1980	A	5.590	0.430	47.21	20.300	-0.03/A	<-
6	31 Jan 1980	A	5.430	0.340	37.35	12.700	0.04/A	->
7	9 Feb 1980	A	5.330	0.340	28.24	9.600	0.06/A	->
8	16 Feb 1980	A	5.270	0.310	24.19	7.500	0.09/A	->
9	23 Feb 1980	A	5.190	0.330	21.52	7.100	0.02/A	->
10	25 Feb 1980	A	5.180	0.330	20.61	6.800	0.03/A	->
11	13 Mar 1980	A	5.020	0.350	14.00	4.900	-0.04/A	<-
12	18 Mar 1980	A	4.970	0.260	12.69	3.300	0.01/A	-
13	18 Mar 1980	A	4.970	0.300	13.67	4.100	-0.04/A	<-
14	6 May 1980	A	5.600	0.380	56.05	21.300	-0.05/A	<-
15	7 May 1980	A	5.780	0.430	66.51	28.600	-0.05/A	<-

Total number of gaugings = 15

TABLE C3 Discharge Measurements at Mareere

Discharge measurements for station 4 : Jubba at Kaitoi

Order Number	Date	Rating	Stage (m)	Velocity (m/s)	Area (sq m)	Discharge (cumecs)	--- Comparison --- Diff./Rat.	Plot
1	28 Apr 1963	A	4.900	1.060	483.96	513.000	-0.07/A	<-
2	29 Apr 1963	A	4.950	1.030	488.35	503.000	0.04/A	->
3	26 May 1963	A	4.810	0.980	451.02	442.000	0.30/A	->>
4	4 Jun 1963	A	3.150	0.910	263.74	240.000	0.15/A	->>
5	11 Jun 1963	A	2.720	0.790	245.57	194.000	0.13/A	->>
6	22 Jun 1963	A	2.680	0.770	249.35	192.000	0.11/A	->
7	30 Jun 1963	A	2.160	0.700	195.71	137.000	0.13/A	->>
8	14 Jul 1963	A	2.190	0.700	192.86	135.000	0.18/A	->>
9	17 Jul 1963	A	1.960	0.640	195.31	125.000	0.05/A	->
10	11 Sep 1972	A	3.230	0.930	304.30	283.000	-0.12/A	<<-
11	20 Sep 1972	A	3.050	0.890	291.01	259.000	-0.11/A	<-
12	24 Sep 1972	A	2.840	0.840	284.52	239.000	-0.15/A	<<-
13	28 Sep 1972	A	2.700	0.860	213.95	184.000	0.20/A	->>
14	3 Oct 1972	A	2.480	0.860	213.95	184.000	-0.02/A	-
15	9 Oct 1972	A	2.920	0.870	234.48	204.000	0.24/A	->>
16	11 Oct 1972	A	4.570	1.160	375.86	436.000	0.10/A	->
17	12 Oct 1972	A	4.820	1.090	410.09	447.000	0.28/A	->>
18	14 Oct 1972	A	4.460	1.050	371.43	390.000	0.31/A	->>
19	15 Oct 1972	A	4.110	1.030	345.63	356.000	0.20/A	->>
20	17 Oct 1972	A	4.060	1.030	339.81	350.000	0.20/A	->>
21	19 Oct 1972	A	3.880	0.990	309.09	306.000	0.35/A	->>
22	24 Oct 1972	A	3.450	0.920	286.96	264.000	0.25/A	->>
23	1 Nov 1972	A	3.230	0.920	292.39	269.000	-0.01/A	-
24	3 Nov 1972	A	4.940	1.140	456.14	520.000	-0.08/A	<-
25	4 Nov 1972	A	5.160	1.190	464.71	553.000	-0.07/A	<-
26	5 Nov 1972	A	5.220	1.200	451.67	542.000	0.06/A	->
27	30 Nov 1972	A	3.880	0.990	347.47	344.000	0.06/A	->
28	6 Dec 1972	A	3.370	1.170	257.26	301.000	-0.12/A	<<-
29	17 Dec 1972	A	2.140	0.700	205.71	144.000	0.03/A	->
30	23 Dec 1972	A	1.760	0.630	184.13	116.000	-0.05/A	<-
31	28 Dec 1972	A	1.440	0.590	161.02	95.000	-0.12/A	<<-
32	9 Jan 1973	A	1.250	0.500	145.20	72.600	-0.03/A	<-
33	11 Jan 1973	A	1.180	0.480	140.21	67.300	-0.03/A	<-
34	14 Jan 1973	A	1.070	0.460	127.39	58.600	-0.01/A	-
35	23 Jan 1973	A	0.910	0.390	123.85	48.300	-0.02/A	-
36	27 Jan 1973	A	0.840	0.360	120.28	43.300	-0.01/A	-
37	3 Feb 1973	A	0.690	0.320	100.94	32.300	0.03/A	->
38	7 Feb 1973	A	0.650	0.290	101.72	29.500	0.04/A	->
39	21 Feb 1973	A	0.460	0.240	94.17	22.600	-0.01/A	-

TABLE C4 Discharge Measurements at Kaitoi

Discharge measurements for station 4 : Jubba at Kaitoi

Order Number	Date	Rating	Stage (m)	Velocity (m/s)	Area (sq m)	Discharge (cumecs)	--- Comparison --- Diff./Rat.	Plot
40	26 Feb 1973	A	0.370	0.200	83.50	16.700	0.03/A	->
41	4 Mar 1973	A	0.300	0.120	99.17	11.900	0.08/A	->
42	8 Mar 1973	A	0.250	0.160	74.37	11.900	0.03/A	->
43	12 Mar 1973	A	0.240	0.180	64.44	11.600	0.03/A	->
44	31 Mar 1973	A	0.160	0.120	65.00	7.800	0.06/A	->
45	7 Apr 1973	A	0.080	0.100	66.00	6.600	0.01/A	-
46	9 Apr 1973	A	0.030	0.090	63.33	5.700	-0.00/A	-
47	17 Apr 1973	A	0.020	0.090	61.11	5.500	-0.01/A	-
48	24 Apr 1973	A	0.110	0.120	62.50	7.500	0.02/A	-
49	30 Apr 1973	A	0.510	0.280	95.36	26.700	-0.04/A	<-
50	8 May 1973	A	0.890	0.390	119.23	46.500	-0.01/A	-
51	9 May 1973	A	1.900	0.640	192.19	123.000	0.02/A	-
52	10 May 1973	A	1.750	0.650	176.92	115.000	-0.05/A	<-
53	13 May 1973	A	1.620	0.620	174.19	108.000	-0.10/A	<-
54	23 May 1973	A	0.700	0.310	92.58	28.700	0.11/A	->
55	6 Jun 1973	A	2.050	0.820	175.61	144.000	-0.06/A	<-
56	9 Jun 1973	A	1.900	0.700	195.71	137.000	-0.13/A	<<-
57	12 Jun 1973	A	1.500	0.410	200.00	82.000	0.10/A	->
58	16 Jun 1973	A	1.180	0.540	137.04	74.000	-0.12/A	<-
59	21 Jun 1973	A	1.280	0.530	154.53	81.900	-0.12/A	<-
60	4 Jul 1973	A	1.480	0.420	156.90	65.900	0.29/A	->>>
61	10 Jul 1973	A	1.700	0.710	164.79	117.000	-0.12/A	<-
62	14 Jul 1973	A	1.480	0.620	154.03	95.500	-0.09/A	<-
63	18 Jul 1973	A	1.430	0.600	154.67	92.800	-0.11/A	<-
64	25 Jul 1973	A	1.510	0.660	163.64	108.000	-0.21/A	<<-
65	31 Jul 1973	A	3.020	0.940	241.49	227.000	0.13/A	->>
66	31 Jul 1973	A	3.020	0.940	275.74	259.200	-0.14/A	<<-
67	5 Aug 1973	A	3.300	0.920	300.11	276.100	0.00/A	-
68	11 Aug 1973	A	2.700	0.900	247.78	223.000	-0.15/A	<<-
69	14 Aug 1973	A	2.640	0.850	245.88	209.000	-0.09/A	<-
70	18 Aug 1973	A	2.750	0.870	243.68	212.000	-0.01/A	-
71	20 Aug 1973	A	2.720	0.870	245.98	214.000	-0.05/A	<-
72	26 Aug 1973	A	4.400	1.080	391.67	423.000	0.02/A	-
73	27 Aug 1973	A	4.140	1.040	375.00	390.000	-0.01/A	-
74	28 Aug 1973	A	3.900	1.040	346.25	360.100	-0.04/A	<-
75	29 Aug 1973	A	3.710	0.990	334.34	331.000	-0.01/A	-
76	30 Aug 1973	A	3.600	0.940	342.55	322.000	-0.06/A	<-
77	2 Sep 1973	A	4.110	1.090	357.80	390.000	-0.04/A	<-
78	3 Sep 1973	A	4.130	1.060	366.98	389.000	-0.02/A	-
79	5 Sep 1973	A	4.210	1.080	357.50	386.100	0.09/A	->
80	6 Sep 1973	A	4.070	1.040	363.46	378.000	0.00/A	-
81	11 Sep 1973	A	3.490	0.900	308.78	277.900	0.18/A	->>

TABLE C4 (continued)

Discharge measurements for station 4 : Jubba at Kaitoi

Order Number	Date	Rating	Stage (m)	Velocity (m/s)	Area (sq m)	Discharge (cumecs)	--- Comparison --- Diff./Rat.	Plot
82	13 Sep 1973	A	3.910	1.070	355.23	380.100	-0.17/A	<<-
83	16 Sep 1973	A	3.950	1.090	349.54	381.000	-0.14/A	<<-
84	19 Sep 1973	A	3.640	1.020	305.10	311.200	0.07/A	->
85	24 Sep 1973	A	3.210	0.910	293.19	266.800	-0.01/A	-
86	27 Sep 1973	A	3.140	0.910	283.52	258.000	-0.01/A	-
87	4 Oct 1973	A	3.670	1.040	321.15	334.000	-0.08/A	<-
88	8 Oct 1973	A	3.560	1.040	309.13	321.500	-0.09/A	<-
89	18 Oct 1973	A	3.970	1.070	348.60	373.000	-0.06/A	<-
90	24 Oct 1973	A	5.070	1.140	464.82	529.900	-0.01/A	-
91	4 Nov 1973	A	4.030	0.980	368.57	361.200	0.08/A	->
92	8 Nov 1973	A	3.800	0.960	357.08	342.800	-0.01/A	-
93	21 Nov 1973	A	2.680	0.800	255.38	204.300	-0.01/A	-
94	28 Nov 1973	A	2.340	0.790	232.15	183.400	-0.15/A	<<-
95	1 Dec 1973	A	2.130	0.770	211.17	162.600	-0.16/A	<<-
96	5 Dec 1973	A	1.930	0.720	191.94	138.200	-0.12/A	<-
97	10 Dec 1973	A	1.600	0.620	165.97	102.900	-0.06/A	<-
98	13 Dec 1973	A	1.440	0.540	159.26	86.000	-0.01/A	-
99	18 Dec 1973	A	1.160	0.480	140.42	67.400	-0.05/A	<-
100	20 Dec 1973	A	1.160	0.480	140.42	67.400	-0.05/A	<-
101	23 Dec 1973	A	1.060	0.450	129.33	58.200	-0.02/A	-
102	29 Dec 1973	A	0.910	0.430	119.77	51.500	-0.07/A	<-
103	31 Dec 1973	A	0.870	0.420	107.86	45.300	-0.01/A	-
104	9 Jan 1974	A	0.710	0.310	95.81	29.700	0.10/A	->
105	12 Jan 1974	A	0.670	0.290	95.17	27.600	0.10/A	->
106	28 Jan 1974	A	0.550	0.280	92.50	25.900	0.01/A	-
107	29 Jan 1974	A	0.540	0.260	86.92	22.600	0.07/A	->
108	7 Feb 1974	A	0.310	0.210	82.86	17.400	-0.05/A	<-
109	18 Feb 1974	A	0.140	0.140	73.57	10.300	-0.04/A	<-
110	25 Feb 1974	A	0.070	0.120	65.00	7.800	-0.03/A	<-
111	25 Feb 1974	A	0.050	0.110	66.36	7.300	-0.04/A	<-
112	2 Mar 1974	A	0.110	0.090	64.44	5.800	0.07/A	->
113	5 Mar 1974	A	0.030	0.100	63.00	6.300	-0.03/A	<-
114	16 Mar 1974	A	-0.090	0.060	56.67	3.400	-0.04/A	<-
115	18 Mar 1974	A	0.010	0.080	53.75	4.300	0.03/A	->
116	26 Mar 1974	A	0.010	0.070	55.71	3.900	0.04/A	->
117	8 Apr 1974	A	2.450	0.820	223.78	183.500	-0.04/A	<-
118	13 Apr 1974	A	2.140	0.810	209.01	169.300	-0.22/A	<<-
119	17 Apr 1974	A	2.320	0.810	226.17	183.200	-0.17/A	<<-
120	5 May 1974	A	1.130	0.510	135.10	68.900	-0.10/A	<-
121	27 May 1974	A	2.130	0.770	192.21	148.000	-0.02/A	-
122	28 May 1974	A	2.130	0.750	186.67	140.000	0.06/A	->

TABLE C4 (continued)

Discharge measurements for station 4 : Jubba at Kaitoi

Order Number	Date	Rating	Stage (m)	Velocity (m/s)	Area (sq m)	Discharge (cumecs)	--- Comparison --- Diff./Rat.	Plot
123	8 Jun 1974	A	3.290	0.970	294.12	285.300	-0.08/A	<-
124	9 Jun 1974	A	3.340	0.980	290.51	284.700	-0.03/A	<-
125	10 Jun 1974	A	3.280	0.940	301.49	283.400	-0.08/A	<-
126	12 Jun 1974	A	3.460	0.990	313.13	310.000	-0.10/A	<-
127	16 Jun 1974	A	2.980	0.860	263.95	227.000	0.09/A	->
128	20 Jun 1974	A	2.340	0.800	217.00	173.600	-0.06/A	<-
129	23 Jun 1974	A	1.950	0.730	187.12	136.600	-0.08/A	<-
130	15 Jul 1974	A	1.520	0.630	152.86	96.300	-0.06/A	<-
131	29 Jul 1974	A	3.000	0.840	282.14	237.000	0.03/A	->
132	10 Aug 1974	A	2.280	0.800	210.00	168.000	-0.07/A	<-
133	22 Aug 1974	A	3.480	0.960	290.63	279.000	0.16/A	->>
134	23 Aug 1974	A	3.160	0.910	256.04	233.000	0.22/A	->>>
135	1 Sep 1974	A	1.990	0.730	189.04	138.000	-0.05/A	<-
136	2 Sep 1974	A	2.070	0.800	190.00	152.000	-0.12/A	<-
137	3 Sep 1974	A	2.150	0.780	194.87	152.000	-0.04/A	<-
138	10 Sep 1974	A	3.470	0.960	297.92	286.000	0.09/A	->
139	11 Sep 1974	A	3.660	1.040	310.58	323.000	-0.00/A	-
140	15 Sep 1974	A	4.660	1.140	392.11	447.000	0.12/A	->
141	16 Sep 1974	A	4.410	1.050	380.00	399.000	0.19/A	->>
142	17 Sep 1974	A	4.230	1.040	367.31	382.000	0.13/A	->>
143	10 Oct 1974	A	3.200	0.950	265.47	252.200	0.10/A	->
144	14 Oct 1974	A	2.750	0.840	241.79	203.100	0.07/A	->
145	15 Oct 1974	A	2.660	0.800	240.13	192.100	0.08/A	->
146	27 Oct 1974	A	1.950	0.730	187.67	137.000	-0.08/A	<-
147	28 Oct 1974	A	1.890	0.700	173.57	121.500	0.02/A	->
148	13 Nov 1974	A	2.870	0.860	247.67	213.000	0.11/A	->
149	19 Nov 1974	A	2.560	0.810	227.16	184.000	0.06/A	->
150	21 Nov 1974	A	2.280	0.830	207.59	172.300	-0.11/A	<-
151	26 Nov 1974	A	1.680	0.710	160.56	114.000	-0.10/A	<-
152	27 Nov 1974	A	1.600	0.680	158.82	108.000	-0.12/A	<-
153	2 Dec 1974	A	1.350	0.560	131.07	73.400	0.06/A	->
154	5 Dec 1974	A	1.210	0.540	123.15	66.500	0.01/A	-
155	8 Dec 1974	A	1.100	0.560	110.71	62.000	-0.03/A	<-
156	26 Dec 1974	A	0.750	0.410	82.68	33.900	0.06/A	->
157	25 Jan 1975	A	0.200	0.410	30.49	12.500	-0.04/A	<-
158	8 Feb 1975	A	0.490	0.330	77.88	25.700	-0.04/A	<-
159	11 Feb 1975	A	0.180	0.330	33.33	11.000	-0.02/A	-
160	13 Feb 1975	A	0.120	0.160	53.75	8.600	-0.01/A	-
161	23 Sep 1975	A	3.500	0.990	315.05	311.900	-0.08/A	<-
162	16 Oct 1975	A	4.470	1.160	422.41	490.000	-0.36/A	<<<<-
163	17 Oct 1975	A	4.570	1.140	421.05	480.000	-0.19/A	<<-

TABLE C4 (continued)

Discharge measurements for station 4 : Jubba at Kaitoi

Order Number	Date	Rating	Stage (m)	Velocity (m/s)	Area (sq m)	Discharge (cumecs)	--- Comparison --- Diff./Rat.	Plot
164	18 Oct 1975	A	4.420	1.120	395.54	443.000	-0.10/A	<-
165	19 Oct 1975	A	4.310	1.030	383.50	395.000	0.12/A	->>
166	16 May 1976	A	4.500	1.110	387.57	430.200	0.07/A	->
167	2 Aug 1976	A	3.130	0.910	278.46	253.400	0.02/A	-
168	14 Oct 1976	A	2.520	0.770	228.57	176.000	0.10/A	->
169	6 Nov 1976	A	4.930	1.200	424.17	509.000	-0.02/A	-
170	7 Nov 1976	A	4.640	1.130	427.70	483.300	-0.14/A	<<-
171	10 Nov 1976	?	4.330	0.850	383.41	325.900	0.65/A	->>>>

Total number of gaugings = 171

TABLE C4 (continued)

Discharge measurements for station 6 : Jubba at Kamsuma

Order Number	Date	Rating	Stage (m)	Velocity (m/s)	Area (sq m)	Discharge (cumecs)	--- Comparison --- Diff./Rat.	Plot
1	11 Jul 1972	A	5.150	0.900	243.33	219.000	-0.23/A	<<<-
2	17 Jul 1972	A	6.850	1.090	378.90	413.000	-0.27/A	<<<-
3	24 Jul 1972	A	5.790	0.790	329.11	260.000	0.02/A	-
4	14 Aug 1972	A	5.440	0.770	284.42	219.000	0.06/A	->
5	20 Aug 1972	A	6.220	0.880	338.64	298.000	0.09/A	->
6	3 Sep 1972	A	6.320	0.900	350.00	315.000	0.04/A	->
7	12 Sep 1972	A	6.020	0.910	330.77	301.000	-0.13/A	<<-
8	18 Sep 1972	A	5.960	0.840	328.57	276.000	0.04/A	->
9	21 Sep 1972	A	5.870	0.850	317.65	270.000	0.00/A	-
10	25 Sep 1972	A	5.600	0.830	236.14	196.000	0.45/A	->>>
11	4 Oct 1972	A	5.260	0.820	215.85	177.000	0.31/A	->>>
12	11 Nov 1972	A	7.480	1.130	387.61	438.000	0.16/A	->>
13	12 Nov 1972	A	7.500	1.090	394.50	430.000	0.24/A	->>>
14	14 Nov 1972	A	7.620	1.110	411.71	457.000	0.14/A	->>
15	15 Nov 1972	A	7.930	1.170	420.51	492.000	0.18/A	->>
16	16 Nov 1972	A	7.940	1.170	450.43	527.000	-0.09/A	<-
17	19 Nov 1972	A	7.740	1.130	423.89	479.000	0.09/A	->
18	21 Nov 1972	A	7.340	1.070	362.62	388.000	0.43/A	->>>
19	23 Nov 1972	A	7.620	1.070	385.98	413.000	0.50/A	->>>
20	16 Dec 1972	A	5.040	0.700	227.14	159.000	0.28/A	->>>
21	24 Dec 1972	A	4.450	0.690	172.46	119.000	0.15/A	->>
22	25 Dec 1972	A	4.420	0.670	188.06	126.000	0.03/A	->
23	7 Jan 1973	A	3.950	0.560	147.68	82.700	0.10/A	->
24	21 Jan 1973	A	3.510	0.450	113.11	50.900	0.10/A	->
25	4 Feb 1973	A	3.230	0.340	97.06	33.000	0.11/A	->
26	12 Feb 1973	A	3.120	0.350	84.57	29.600	0.06/A	->
27	22 Feb 1973	A	2.970	0.270	69.63	18.800	0.11/A	->
28	5 Mar 1973	A	2.770	0.210	61.43	12.900	0.03/A	->
29	2 Apr 1973	A	2.540	0.170	35.29	6.000	-0.03/A	<-
30	17 May 1973	A	3.420	0.470	99.57	46.800	0.07/A	->
31	21 May 1973	A	3.120	0.340	86.18	29.300	0.06/A	->
32	7 Jun 1973	A	4.720	0.720	202.78	146.000	0.11/A	->
33	17 Jun 1973	A	3.850	0.550	134.73	74.100	0.11/A	->
34	18 Jun 1973	A	3.760			65.600	0.14/A	->>
35	3 Jul 1973	A	4.220	0.650	184.31	119.800	-0.09/A	<-
36	9 Jul 1973	A	4.020	0.610	158.85	96.900	-0.02/A	-
37	16 Jul 1973	A	4.040	0.640	148.59	95.100	0.03/A	->
38	26 Jul 1973	A	4.120	0.690	163.77	113.000	-0.11/A	<-
39	29 Jul 1973	A	4.360	0.830	178.31	148.000	-0.28/A	<<<-
40	1 Aug 1973	A	5.720	0.890	276.40	246.000	0.08/A	->

TABLE C5 Discharge Measurements at Kamsuma

Discharge measurements for station 6 : Jubba at Kamsuma

Order Number	Date	Rating	Stage (m)	Velocity (m/s)	Area (sq m)	Discharge (cumecs)	--- Comparison --- Diff./Rat.	Plot
41	12 Aug 1973	A	5.310	0.820	251.22	206.000	0.06/A	->
42	25 Aug 1973	A	6.620	0.970	359.79	349.000	0.04/A	->
43	29 Sep 1973	A	6.130	0.910	320.88	292.000	0.06/A	->
44	1 Jan 1974	A	3.430	0.380	125.79	47.800	0.07/A	->
45	13 Feb 1974	A	2.760	0.190	85.26	16.200	-0.05/A	<-
46	6 Mar 1974	A	2.510			3.700	0.01/A	-
47	11 Apr 1974	A	5.300			244.300	-0.33/A	<<<<-
48	15 Apr 1974	A	4.730			173.000	-0.18/A	<<-
49	20 Apr 1974	A	4.700	0.720	213.89	154.000	-0.00/A	-
50	24 Apr 1974	A	4.510			140.000	-0.04/A	<-
51	28 Apr 1974	A	4.090			108.000	-0.08/A	<-
52	18 May 1974	A	4.470	0.710	192.96	137.000	-0.04/A	<-
53	25 May 1974	A	5.280	0.890	255.06	227.000	-0.18/A	<<-
54	26 May 1974	A	5.330	0.750	282.67	212.000	0.02/A	->
55	28 May 1974	A	4.800	0.740	235.14	174.000	-0.12/A	<-
56	29 May 1974	A	4.750	0.760	223.68	170.000	-0.13/A	<<-
57	9 Jun 1974	A	5.830	0.850	331.76	282.000	-0.15/A	<<-
58	10 Jun 1974	A	6.050	0.850	354.12	301.000	-0.10/A	<-
59	11 Jun 1974	A	6.040	0.890	350.56	312.000	-0.21/A	<<-
60	12 Jun 1974	A	6.070	0.870	348.28	303.000	-0.10/A	<-
61	13 Jun 1974	A	6.190	0.900	353.33	318.000	-0.12/A	<-
62	16 Jun 1974	A	5.940	0.800	330.00	264.000	0.13/A	->>
63	17 Jun 1974	A	5.800	0.810	319.75	259.000	0.03/A	->
64	18 Jun 1974	A	5.600	0.780	307.69	240.000	0.02/A	-
65	19 Jun 1974	A	5.350	0.810	279.01	226.000	-0.10/A	<-
66	20 Jun 1974	A	5.230	0.830	274.70	228.000	-0.24/A	<<<-
67	22 Jun 1974	A	4.950			181.000	-0.04/A	<-
68	23 Jun 1974	A	4.780	0.690	242.03	167.000	-0.06/A	<-
69	24 Jun 1974	A	4.660			150.000	0.00/A	-
70	25 Jun 1974	A	4.540	0.650	224.62	146.000	-0.07/A	<-
71	26 Jun 1974	A	4.570	0.690	207.25	143.000	-0.01/A	-
72	11 Jul 1974	A	3.960			82.000	0.12/A	->
73	18 Jul 1974	A	4.170	0.850	117.65	100.000	0.10/A	->
74	25 Jul 1974	A	6.690	0.890	353.93	315.000	0.41/A	->>>
75	17 Aug 1974	A	4.780	0.760	218.42	166.000	-0.05/A	<-
76	19 Aug 1974	A	4.960	0.750	240.00	180.000	-0.02/A	<-
77	24 Aug 1974	A	5.980	0.890	353.93	315.000	-0.30/A	<<<-
78	29 Aug 1974	A	5.140			215.000	-0.20/A	<<-
79	31 Aug 1974	A	4.800	0.740	231.08	171.000	-0.09/A	<-
80	2 Sep 1974	A	4.620	0.760	209.21	159.000	-0.14/A	<<-
81	4 Sep 1974	A	4.780	0.780	221.79	173.000	-0.13/A	<<-

TABLE C5 (continued)

Discharge measurements for station 6 : Jubba at Kamsuma

Order Number	Date	Rating	Stage (m)	Velocity (m/s)	Area (sq m)	Discharge (cumecs)	--- Comparison --- Diff./Rat.	Plot
82	10 Sep 1974	A	5.400	0.870	264.37	230.000	-0.09/A	<-
83	11 Sep 1974	A	6.000	0.990	309.09	306.000	-0.20/A	<<-
84	14 Sep 1974	A	7.010	1.020	323.53	330.000	0.60/A	->>>>
85	5 Oct 1974	A	5.580			250.000	-0.10/A	<-
86	19 Oct 1974	A	5.310			224.000	-0.12/A	<-
87	27 Oct 1974	A	4.660			175.000	-0.27/A	<<<-
88	11 Nov 1974	A	5.400			219.000	0.02/A	->
89	13 Nov 1974	A	5.670			239.000	0.10/A	->
90	20 Nov 1974	A	5.260			230.000	-0.23/A	<<<-
91	23 Nov 1974	A	4.950			179.000	-0.02/A	<-
92	28 Nov 1974	A	4.340	0.750	176.00	132.000	-0.12/A	<-
93	4 Dec 1974	A	3.910	0.610	157.38	96.000	-0.11/A	<-
94	22 Dec 1974	A	3.370			59.000	-0.16/A	<<-
95	28 Dec 1974	A	3.300			45.000	-0.02/A	-
96	6 Jan 1975	A	3.090			32.000	-0.02/A	-
97	9 Jan 1975	A	3.040			27.000	0.02/A	->
98	20 Jan 1975	A	2.890			26.000	-0.11/A	<-
99	13 Jun 1984	B	1.940	0.443	148.15	65.630	-0.07/B	<-
100	30 Oct 1984	B	4.340	0.874	303.18	264.980	0.06/B	->
101	28 Jul 1988	B	4.600	0.872	352.27	307.180	-0.07/B	<-
102	30 Jul 1988	B	5.110	0.923	401.25	370.350	-0.11/B	<-
103	8 Sep 1988	B	4.050	0.780	310.17	241.930	-0.01/B	-
104	2 Nov 1988	B	6.240	1.020	475.37	484.880	0.11/B	->
105	11 Dec 1988	B	2.310	0.460	172.07	79.150	0.10/B	->
106	1 Mar 1989	B	0.650	0.027	72.22	1.950	0.00/B	-

Total number of gaugings = 106

TABLE C5 (continued)

APPENDIX D

PERFORMANCE OF AUTOMATIC WATER LEVEL RECORDERS

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APPENDIX D

PERFORMANCE OF AUTOMATIC WATER LEVEL RECORDERS

D1 INTRODUCTION

This appendix describes the use of automatic water level recorders on the Jubba and Shebelli rivers in Somalia. The operational performance of the recorders installed earlier in this project is assessed: two are currently working well, but the other two have been almost totally unsuccessful. It is concluded that the data collection and management carried out by the Hydrology Section of the Directorate of Irrigation and Land Use would be best served by additional emphasis on the maintenance of staff gauge stations rather than allocating time and resources to an extension of the network of automatic recorders. However, the existing working recorders will continue to be maintained and used.

Many of the primary gauging stations set up in 1963 were equipped with automatic recorders in which a pen trace on a strip chart represented the water level in the stilling well; wells were located on the bank of the river with horizontal inlet pipes allowing water to enter from (or exit to) the river. The basic reasons for installing automatic recorders may be summarised as follows:

(a) By providing a continuous plot of the water level much more can be learnt about a flood event than from the records of a human observer who reads a staff gauge two or three times each day. This is particularly important in Somalia where the rivers can rise very rapidly - even by several metres in a day on the Shebelli.

(b) The use of automatic recorders should ensure greater accuracy and reliability of data by reducing the risks from observer error or non-reading.

The original recorders proved to be unsuitable for conditions in Somalia, primarily because of the high silt load in the rivers. Much of the data obtained from these recorders was therefore of doubtful value. (For more details on the original installations, and the problems associated with them, reference should be made to the Stage 1 Progress and Final Reports.)

D2 NEW AUTOMATIC RECORDERS

D2.1 Introduction

The Stage 1 reports recommended that a new network of solid state automatic recorders should be set up. These were to use new small diameter plastic stilling wells which would be attached to a bridge pillar or other suitable support. The advantages of this system over the previous arrangement were summarised as follows:

(a) There would be little or no siltation problem.

(b) The data could be automatically and easily transferred to the computer for storage and analysis; by comparison, the abstraction of data from chart records is laborious and time-consuming, and can easily introduce errors.

(c) Maintenance requirements would be much lower, and the recorders could if necessary be left unattended for many months at a time.

The importance of having automatic recording facilities was reinforced by the initial analysis of data during Stage 1. In addition to some long periods with no data, there were many instances of probable errors in the data (eg a sudden change in the water level at the beginning of a new month). A significant number of periods of complete data fabrication by the observers were discovered - including cases where a whole month's data was an exact copy of that for another month in the same or a previous year.

D2.2 Recorder Installation

The final report of Stage 1 recommended the purchase and installation of five automatic recorders, three to be on the Jubba and two on the Shebelli. It was intended that the installation work would be carried out during the period of minimum flows in early 1985 when access to the river bed is possible, but delays in the purchase and shipment of equipment meant that nothing could be done until May when the rivers were both very high. This unfortunate delay had a detrimental effect on Stage 2 of the project. Much more time than originally planned had to be spent on the installation work because it could only be done in stages as river levels permitted; this restricted the amount of office work which could be done on the entry and checking of data. Furthermore, and most importantly, the recorders were not fully operational until about April 1986 - only two months before the end of Stage 2 - so there was insufficient time for a proper test of their operation. There were also a number of teething problems with the recorders which might have been ironed out during Stage 2 if they had become operational earlier. The only useful data retrieved from the recorders was for three periods of only 10-15 days' duration at Beled Weyn, Bardheere and Kamsuma. In the months after the conclusion of the project the Section staff were unable to travel to the sites to attempt to retrieve data.

It had been intended that additional automatic recorders might be installed when the performance of the initial set was assessed. This appraisal had to wait until Stage 3 of the project which began in March 1988. The terms of reference for Stage 3 stated that additional recorders should be purchased and installed if the existing ones were found to be working satisfactorily. One of the purposes of this report is therefore to summarise the performance and to make further recommendations. The condition of each installation at the start of Stage 3, and the performance of those which worked, is discussed below.

D2.3 Recorder Operation

D2.3.1 Beled Weyn, River Shebelli

Although a little data had been retrieved from this recorder for May 1985, the installation seems to have been plagued with problems. Firstly, the recorder was inadvertently located above part of the bridge footing so the stilling well could not be extended to as low a level as had been hoped. It is therefore only able to measure medium and high flows. Secondly, there were two failures of the cable carrying the float and counterweight which resulted in the loss of the counterweight. Thirdly, the cable has several times been found to have come off the pulley wheel - a problem which has not occurred at the other sites.

An initial visit was made to Beled Weyn on April 5th and 6th 1988. Because of problems with the battery it was not possible to reactivate the recorder for the coming Gu season. However, it was set up on the next visit at the end of May - though the data would only be useful when the river rose in the Der season. On the next visit at the end of August no data could be retrieved, and the cable had again come off the pulley wheel. Further battery or recorder problems meant that no data was obtained on the following visit either. It is intended to restart the recorder in time for the 1989 Gu flood, though it must be feared that the pulley wheel problem will recur.

In conclusion, the Beled Weyn recorder installation has been unsatisfactory to date, and even if it operates in the future the data record from it cannot be complete. The staff gauge record is therefore likely to remain the primary source of data for this site.

D2.3.2 Kamsuma, River Jubba

The Kamsuma recorder was installed in two stages in July 1985 and April 1986, but hopes of obtaining data from it for the last part of Stage 2 were frustrated by a malfunction of the recorder. When the site was first visited in 1988 it was found that the bottom half of the stilling well had been washed away (presumably in the severe 1987 flood) so that the recorder was completely unusable. It has therefore been impossible to operate the recorder. The possibility of reinstalling the stilling well will be assessed later in the current low flow period which ends in April 1989.

D2.3.3 Bardheere, River Jubba

The Bardheere recorder was the first to provide any useful data in 1985, but it was not finished for the whole range of water levels until March 1986. The only attempt at retrieving data in the remainder of Stage 2 failed because of a malfunction of the portable retriever unit. Because of restrictions on fieldwork in the early months of Stage 3 (see the First Progress Report) it was not possible to visit this site until mid-July. However, the recorder installation was found to be in good order. Data was successfully retrieved on three subsequent visits in 1988, but December's data (although properly recorded) was lost from the portable retriever owing to human error. The quality of the data is discussed below.

D2.3.4 Lugh Ganana, River Jubba

The installation at Lugh was completed in April 1986, but for the same reasons as at Bardheere no data was retrieved before the end of Stage 2. The first visit in 1988 was in mid-July (visits to Lugh and Bardheere always being combined in one field trip) when the installation was found to be in good order. Data has been retrieved on each of five subsequent visits and there is every reason to hope that it will continue to operate without interruption. The quality of the data is discussed below.

D2.4 Quality of Recorder Data

In order to assess the quality of the recorder data it is necessary to make some comparison with the observed staff gauge readings. The most important check is the reading when the site is revisited in order to collect data. Ideally the reading on the recorder will correspond to that read from the staff gauge at that time; it is then reasonable to assume that the recorder has correctly followed the changes in level throughout the period. In practice there is usually some difference between the two values; a difference of a few centimetres would not necessarily indicate a recorder error because the individual SG readings could themselves be subject to such an error. If the difference is, say, 4 cm or more then there has probably been some slippage in the cable on the pulley wheel so that a vertical movement in the float has not been fully reflected in the digital display which depends on the conversion of the angular movement of the pulley wheel through the shaft encoder.

When recorder data is brought back to the office it is transferred to the main computer and can then be read into the database. The first procedure is to compare this data to the existing staff gauge data. Generally there has been good agreement between them. An example is shown in Figure D1; at the end of this period there was a difference of 8 cm between the SG and recorder levels (the largest error recorded to date). In such a case it is necessary to adjust the recorder data. There could be a sharp divergence between the curves, or (as in this case) it could be a gradual change; here the approximate date on which the divergence began was identified and the total shift of 8 cm was gradually applied from that point. By combining the two data sources in this way we expect to gain a more accurate record than would be the case from either one alone. Figure D2 shows another example (this time from Lugh) where there was very good agreement except for a period of intermittent SG readings from about August 20th. Enquiries revealed that at that time the observer was absent and a less able deputy was taking SG readings.

In conclusion, the quality of data from the recorders at Lugh and Bardheere has been good, though it is important to maintain the parallel staff gauge record.

D3 CONCLUSIONS AND RECOMMENDATIONS

After a long period without success (substantially due to the break between Stages 2 and 3), some good data has been obtained from the automatic recorders at Lugh and Bardheere on the Jubba. However, the other two recorders installed during Stage 2 have failed to produce any data - in one case due primarily to a succession of technical problems and in the other to the effects of the 1987 flood.

In drawing conclusions from the operation of the recorders it is necessary to address two main questions:

(a) Are the recorders capable of producing reasonably reliable and accurate data?

(b) Has the operation of the recorders brought about a significant improvement in the quality of data?

The answer to the first question is a clear "Yes" for two stations, but an equally clear "No" for the other two. The answer to the second question is perhaps less clear-cut; it can certainly be said that the data records from Lugh and Bardheere for the second half of 1988 are both more accurate and more complete than that which was typical before the project began at the end of 1983. However, there has been a marked improvement at most stations as a result of better and more frequent supervision of observers. The unreliability of the observers in the period before the start of the project was a prime reason for obtaining automatic recorders because it was felt that there was little prospect of a dramatic improvement in staff gauge records alone. In practice that dramatic improvement has come about. Since 1984 only one or two relatively short periods of data fabrication have been identified, and the amount of missing data has been substantially reduced.

As a result of the above assessment it is considered that it is not necessary to commit further resources to extending the network of automatic recorders; it would probably be more productive in the long term to concentrate on the staff gauge stations, particularly in the light of problems experienced when previous foreign projects have finished. As a further point it may be noted that the sites selected for the initial recorders were chosen because recorder and stilling well installation were expected to be relatively easy; extension to additional sites would involve more difficult construction problems, and in view of the problems at Kamsuma such work is not recommended. It is, however, recommended that every effort should be made to maintain the operation of the existing recorders.

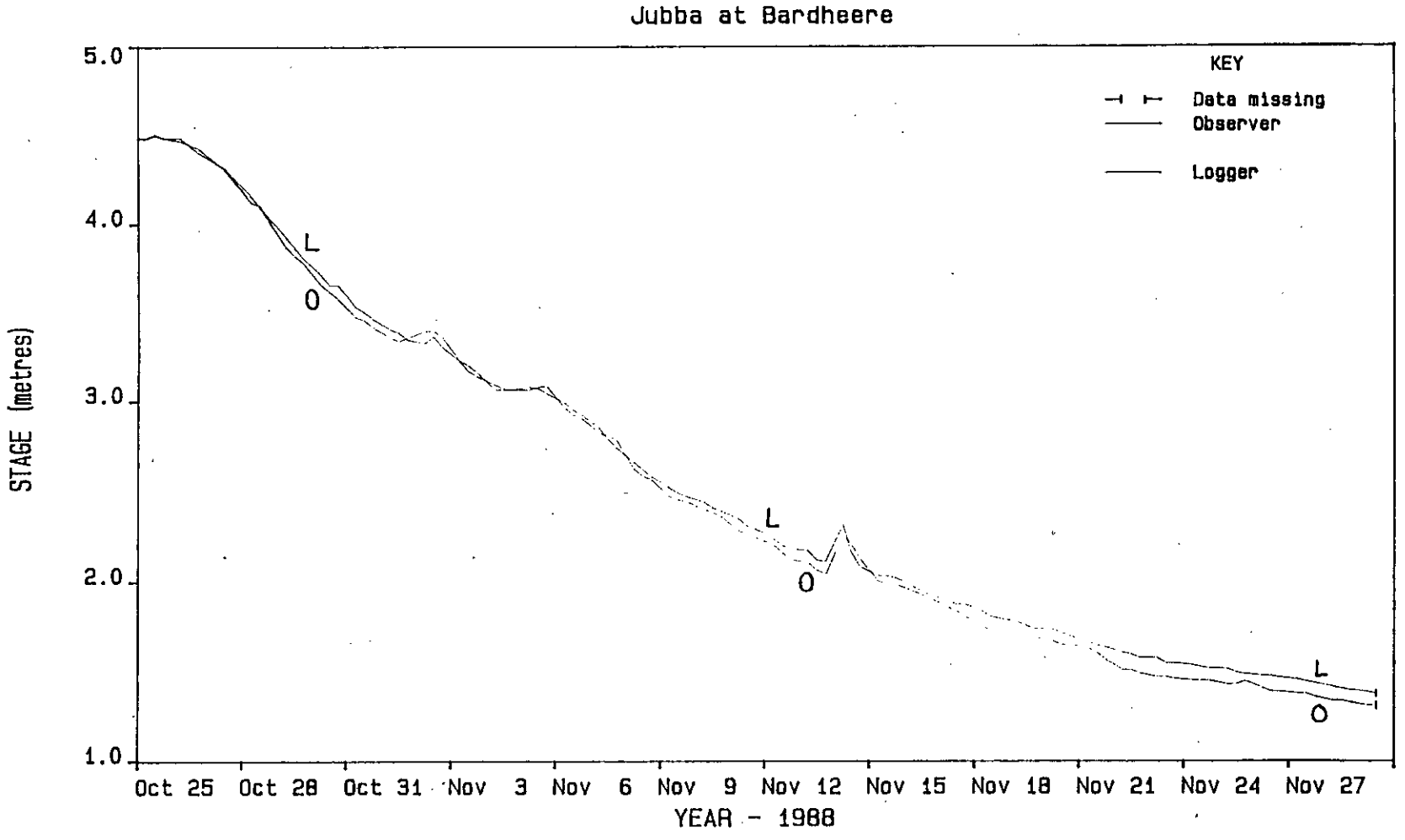
Jubba at Bardheere
KEY
Data missing
Observer
Logger
5.0
4.0
3.0
2.0
1.0
STAGE (metres)
L
O
L
O
L
O
Oct 25
Oct 28
Oct 31
Nov 3
Nov 6
Nov 9
Nov 12
Nov 15
Nov 18
Nov 21
Nov 24
Nov 27
YEAR - 1988

Figure D1

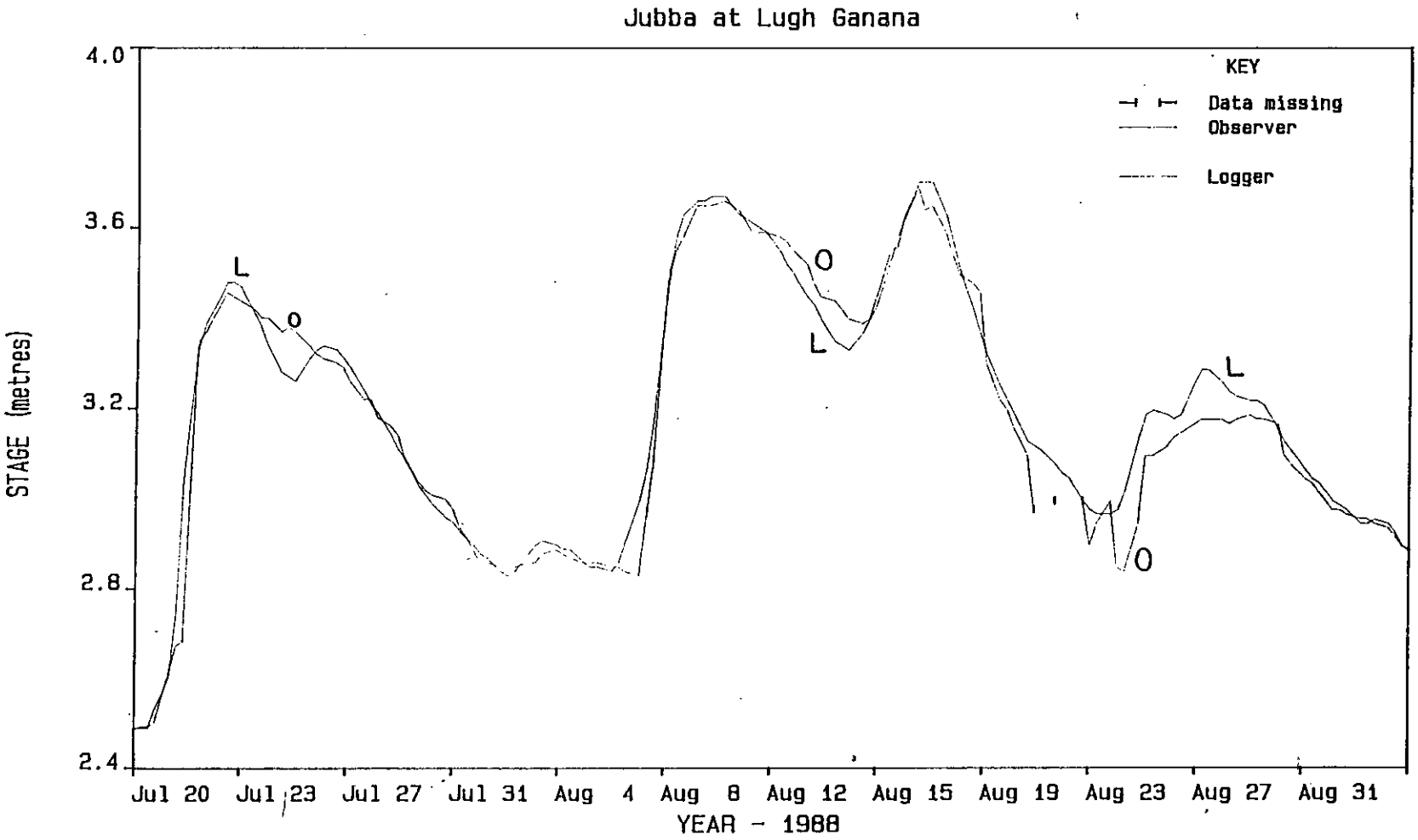
Jubba at Lugh Ganana
KEY
Data missing
Observer
Logger
STAGE (metres)
4.0
3.6
3.2
2.8
2.4
L
O
O
L
L
O
Jul 20
Jul 23
Jul 27
Jul 31
Aug 4
Aug 8
Aug 12
Aug 15
Aug 19
Aug 23
Aug 27
Aug 31
YEAR - 1988

Figure D2