SOMALI DEMOCRATIC REPUBLIC
STATE PLANNING COMMISSION

MOGAMBO IRRIGATION PROJECT

Supplementary Feasibility Study

ANNEX 1
Hydrology and Climate
ANNEX 2
Soils

SIR M MACDONALD & PARTNERS LIMITED
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Demeter House, Cambridge CB1 2RS, United Kingdom

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SUPPLEMENTARY FEASIBILITY STUDY

This report comprises the following volumes:-

Main Report	
Annex 1	Hydrology and Climate
Annex 2	Soils
Appendix to Annex 2	Soil and Land Class Maps
Annex 3	Agriculture
Annex 4	Livestock
Annex 5	Engineering
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ANNEX 1

HYDROLOGY AND CLIMATE

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CHAPTER 1

INTRODUCTION

Three rivers (Gestro, Genale and Dawa) rise in the Ethiopian highlands and flow south-east to meet near the village of Dolo, just inside Somalia, to form the Juba river. The total catchment area is about 140 000 km^2 above Dolo, with annual average rainfalls ranging from about 200 mm to 1 600 mm. Below Dolo, the Juba river flows south-eastwards through the Juba basin and reaches the sea at Kismayo (Figure 1.1).

Areas upstream of Dolo are remote from centres of population and the terrain is generally unfavourable for the development of large irrigation schemes. These areas are thus relatively undeveloped and long-term consumptive uses are likely to remain low. Potential is believed to exist for hydro-power development and a limited amount of water will be required for drinking purposes.

Most of the development of irrigated agriculture will take place below Dolo. Technital (1975) identified a total area of about 160 000 ha which could be suitable for irrigation.

River flows vary considerably from year to year and within each year. The minimum annual flow recorded is about 3 600 Mm^3 in 1955 compared with a maximum of 9 900 in 1961 (Selchozpromexport, 1973). Low flows generally persist from early January to mid-April when they can increase up to 100 m^3/s or more in a matter of days. These high flows continue until early January when they fall to 20 m^3/s or less. On at least three occasions in the last forty years the flow in the Juba river has virtually dried up.

Flooding in the Juba basin occurs in most years, usually during October and November in the der season when floods are often of considerable volume with multiple peaks. River banks are overtopped in many places, sometimes resulting in extensive flooding and attenuation of flood peak flows. Flows of more than 1 000 m^3/s have been recorded on several occasions at Lugh Ganana. The flood problem is discussed in more detail in Chapter 2 of this annex.

The Mogambo project is situated in the Lower Juba basin. The climate is semi-arid and annual average rainfall is only about 500 mm per year. Almost all crop water requirements will thus be met from the Juba river. Chapter 3 summarises crop water requirements for the Mogambo project and other developments planned for the next 10 years and gives incremental water usages expected in the immediate, short and medium terms.

An analysis of river flows expected in each month at various locations is reported in Chapter 4. These water availabilities are compared with incremental future water uses, which take account of all medium-term development on the Juba, to give the net availabilities at Mogambo.

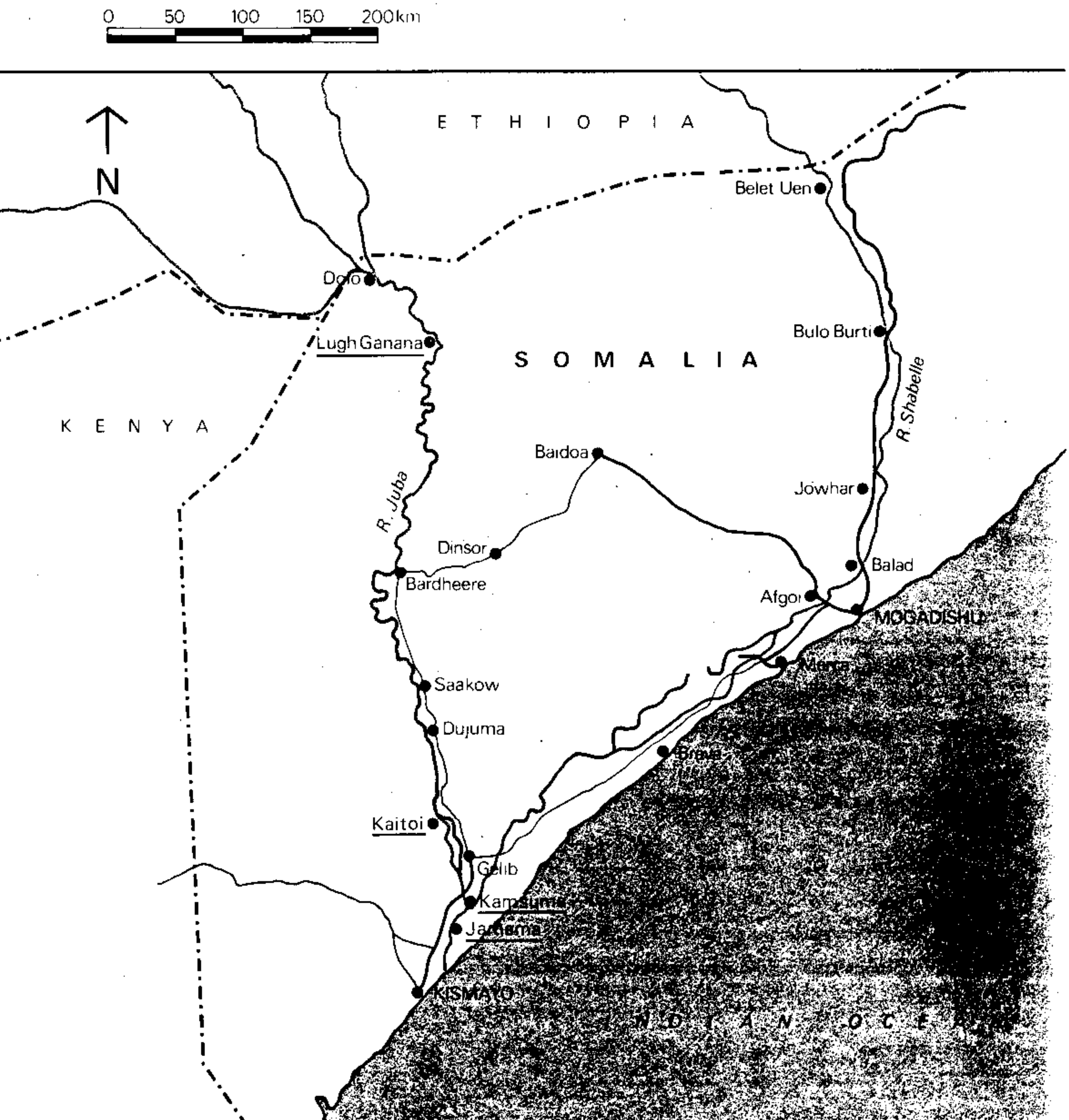
Drainage rates from cropped areas are discussed in Chapter 5, using daily water balances and allowing for rainfall, infiltration and evaporation.

Surfaced road

Unsurfaced road

Juba river gauging stations

1.1



CHAPTER 2

FLOOD HAZARDS

2.1 Introduction

High river flows in the Juba river can occur in May, during the gu season, but these are usually comparatively small. The highest flows and worst flooding usually occur in October or November, during the der season, when floods are often of considerable volume with multiple peaks. River banks are overtopped in many places between Bardheere and Kamsuma causing extensive areas of flooding on both sides of the river. The river flood plain is often lower than the river banks and considerable volumes of water enter storage, causing appreciable attenuation of peak flows. The worst flooding occurs when two floods occur close together: the first peak fills local depressions and drainage channels and the second peak causes widespread sheet flooding.

A very large flood occurred in November 1977 and observations made at that time have been used as a general basis for assessing flooding hazards in the Mogambo project area. However, insufficient information is available directly to assign return periods to flood flows and levels at Mogambo: only the Lugh Ganana gauging station, some 400 km to the north of Mogambo, has a sufficiently long record to assign reliable return periods to peak flows. There is also considerable attenuation of flood flows between Lugh Ganana and Mogambo. Section 2.2 describes how this attentuation has been estimated, first for the reach between Lugh Ganana and Kaitoi, which has a reasonable length of record, and second for the reach between Kaitoi and Kamsuma, the gauging station nearest to Mogambo. The estimated relationships between peak flows are used in Section 2.3 to estimate return periods of flows at Kamsuma. Observations on the 1977 floods are used in Section 2.4 with the results of backwater curve calculations to assign return periods to various river levels at Mogambo. These river levels are the dominant factor in flooding of the project area at the present time, before the proposed bunding of the river between Kaitoi and Kamsuma takes place. The possible effects of this upstream bunding are discussed in Section 2.5.

2.2 Flow Relationships

(a) Lugh Ganana and Kaitoi

Selchozpromexport (1965) has carried out a correlation analysis between flows at Lugh Ganana and Kaitoi, using concurrent data for 1963 and 1964. Those results have been updated using concurrent data for the period 1972 to 1975 (Booker-McConnell, 1976) and the following observations of peak river stages at Kaitoi and Lugh Ganana:-

(i) in 1977

(ii) in 1961, as reported by Selchozpromexport (1965).

Unfortunately, no measurements of river flow at Kaitoi have been made at high stage and extrapolation of the stage-discharge curve is therefore uncertain. Different extrapolations are given by Selchozpromexport (1965) and Booker-

McConnell (1976) but these have not been substantiated. Use of the two rating curves gives different estimates of peak flows observed at Kaitoi. Table 2.1 summarises concurrent high flows at Lugh Ganana and Kaitoi and Figure 2.1 shows the correlation obtained. The Selchozpromexport (1965) correlation greatly overestimates high flows at Kaitoi when flows at Lugh Ganana exceed about 500 m^3/s. It is to be expected however that storage effects within the reach will attenuate flows exceeding the capacity of the main river channel. For flows exceeding 500 m^3/s the relationship shown is to be preferred although it must be stressed that this relationship is not well defined by the data available (equation (1) below).

TABLE 2.1

High Flows at Lugh Ganana and Kaitoi (m^3/s)

Date	Flow at Lugh Ganana	Flow at Kaitoi	
Oct 1972	487	472	
Oct/Nov 1972	562	547	
Aug 1973	485	413	
Oct 1973	613	577	
Jun 1974	399	278	
Jul 1974	461	333	
Sep 1974	510	437	
Aug 1975	496	460	
Oct 1975	566	443	
1961	1 325	830(1)	1 210(2)
1977	2 120	800(1)	1 115(2)

Notes: (1) According to Selchozpromexport's extrapolation of rating curve

(2) According to Booker-McConnell's extrapolation of rating curve

Source: 1972 - 1975: Booker-McConnell, 1976

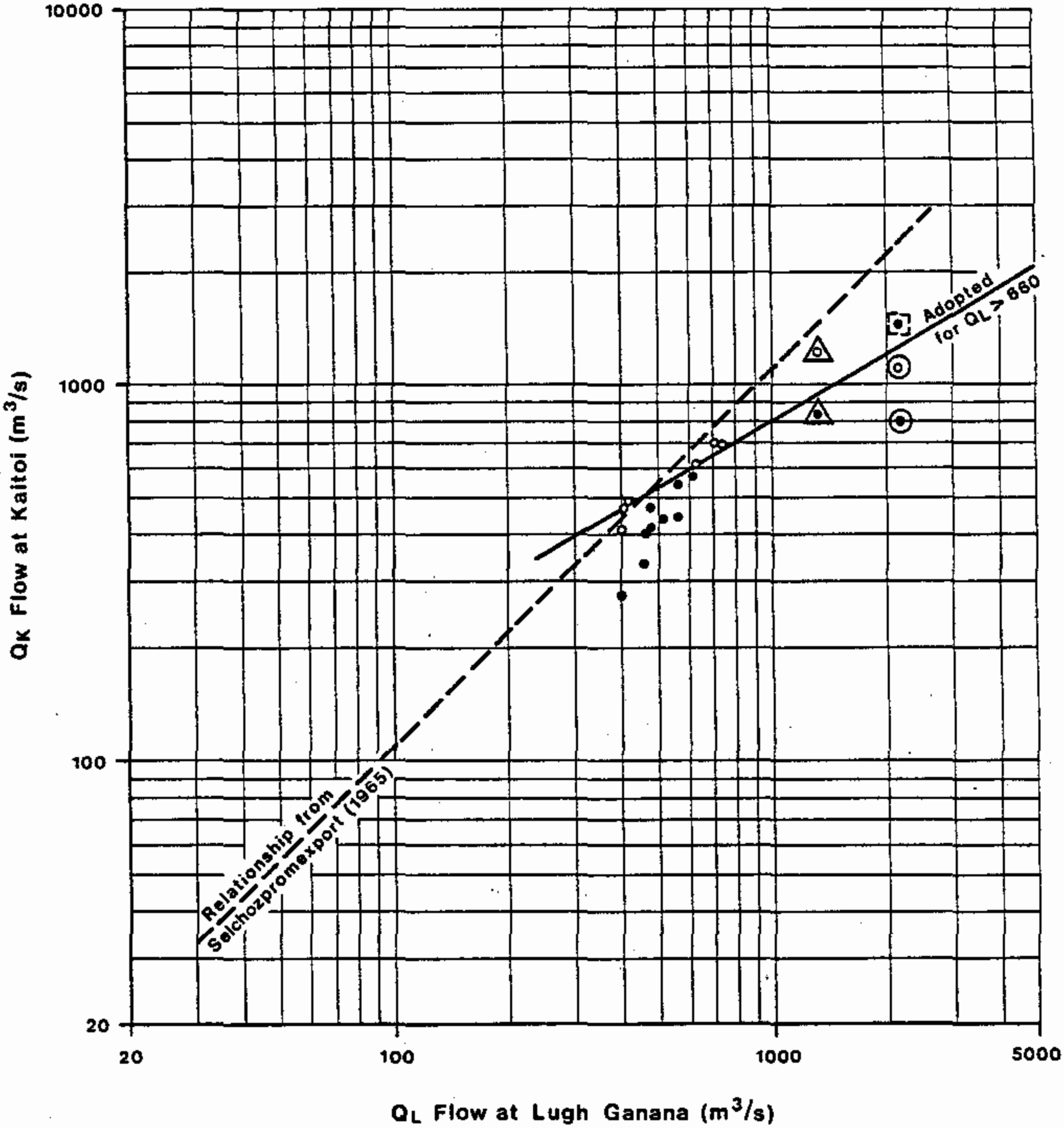
1961: Selchozpromexport, 1965

1977 (Lugh): MMP, 1978

1977 (Kaitoi): Ministry of Agriculture

The observed peak flow at Saakow (MMP, 1978) is shown on Figure 2.1 for comparison purposes. The Juba river flows in a comparatively narrow flood plain as far as Saakow and most attenuation will therefore take place within the Saakow to Kaitoi reach with its much wider flood plain. For these reasons, the flow at Kaitoi must have been lower than that observed at Saakow (lateral inflow is negligible) and the adopted relationship assumes at attenuation of 200 m^3/s between Saakow and Kaitoi. It should be noted that high flows at Lugh Ganana are

Relationship between flows at Kaitoi and Lugh Ganana 2.1



- ○ Estimated from graph in Selchozpromexport (1965) [for $Q_L > 400$ only]
- ● 1972 – 75 data from Booker – Mc Connell (1976)
- 1961, 1977 } Using Selchozpromexport (1963) rating curve for Kaitoi
- 1961, 1977 } Using Booker – Mc Connell (1976) rating curve for Kaitoi

believed to be overestimated (see Section 2.3) and the apparent attenuation of nearly 200 m^3/s between Lugh Ganana and Saakow is likely to be much smaller. The estimated relationship can be written as:-

$$Q_K = 16.0 \; Q_L^{\;0.569} \qquad : Q_L \quad 660 \qquad\qquad (1)$$

where Q_L = flow at Lugh Ganana (m^3/s)
Q_K = flow at Kaitoi (m^3/s)

It is considered that equation (1) is acceptable although its use may overestimate flows at Kaitoi, particularly when flows at Lugh Ganana exceed 1 000 m^3/s.

(b) Kaitoi to Kamsuma

Very little information is available to estimate attenuation of high flows between Kaitoi and Kamsuma, Kamsuma being the nearest permanent gauging station to the Mogambo project area. A graphical correlation has been carried out by Lockwood/FAO (1968) for Kaitoi and Jamama, which is about 52 km downstream of Kamsuma, but gives only a slight attenuation of high flows. This slight attenuation is considered insufficient. In 1977, for example, the flooded area covered a large area on the west bank of the Juba, inundating a large part of the Juba Sugar project area. Flooding also occurred on the east bank, where the Kamsuma to Gelib road was overtopped. However, the bridge at Kamsuma was not overtopped and only limited flooding occurred on the west bank of the river downstream of Kamsuma. Kamsuma bridge can pass about 750 m^3/s before water reaches the bridge soffit and it therefore appears likely that flows reaching Kamsuma did not exceed about 750 m^3/s. This conclusion is supported by the river profile and water levels shown in Figure 2.2. This has been prepared from:-

(i) new measurements of river cross-sections between Kamsuma and Jamama (Arara bridge) made during the present study (see Figure 2.3);

(ii) two sets of river stages observed at each new section of 8th to 10th March and 17th April 1979 when the estimated flows at Jamama were 155 and 65 m^3/s respectively;

(iii) the stage-discharge curve at Jamama (Arara bridge) given by Lockwood/FAO (1968), extended to cover high stages and adjusted to the same datum (Gelib) as the survey data.

Backwater curve calculations were made with various values of Mannings 'n' for each river reach defined by the new cross-section data, until calculated stages agreed with those observed between 8th and 10th March, using a river flow of 155 m^3/s. The final values of 'n' were then used with a flow of 65 m^3/s to calculate river stages at each new section. It was found that calculated and observed stages were in good agreement. Backwater curves were then calculated for higher discharges and adjusted to take account of estimated overbank spillage under existing conditions. Such spillage occurs at several points along the reach, for example at Mogambo flood relief channel, Farta Buud Buud and on the left bank between Kobon and Arara bridge, all of which occurred in the 1977 flood. It can be seen that a flow of 750 m^3/s the river overflows at several places downstream of Kamsuma bridge, assuming that present river bank levels remain unchanged, and the water level at the bridge is almost equal to the bridge soffit.

A more detailed discussion of the effects of flooding on the project area is given in Chapter 1 of Annex 5. It should be noted that the 1977 flood did not cause overtopping of the main road south of Mogambo and this is confirmed by the levels shown on Figure 2.2.

Figure 2.4 shows the available information relating flows at Kaitoi with those at Kamsuma and Jamama (Giamama). The relationship given by Lockwood/FAO (1968) for Kaitoi/Jamama allows for a slight attenuation of flow but not sufficient to agree with the argument above that high flows at Kamsuma (and therefore Jamama) will rarely exceed 750 m^3/s. A similar objection applies to the Booker-McConnell (1976) data. For these reasons, it is considered that the relationship shown for Kaitoi flows above 700 m^3/s is more appropriate. The relationship used to relate flows at Kaitoi with those at Kamsuma can be written as:-

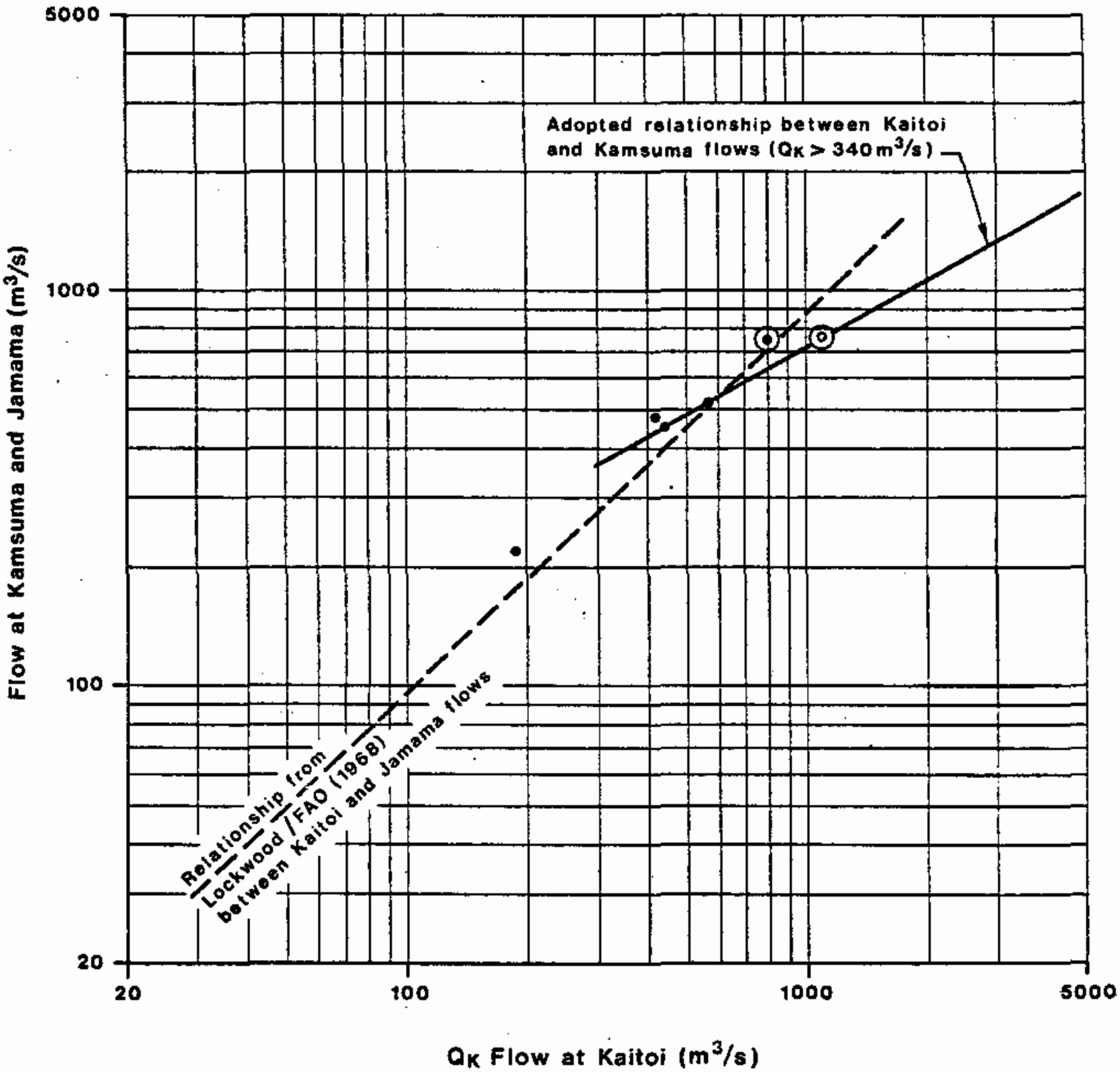
$$Q_{KAM} = 13.850 Q_K^{0.569} \quad m^3/s \; : \; Q_K > 340 \qquad (2)$$

2.3 Flood Peaks and Return Periods

A sufficient length of record for estimating return periods is available only for Lugh Ganana. Other records are too short. Previous frequency analyses of annual maximum flows at Lugh Ganana (MMP, 1977 and 1978) have used data published by Selchozpromexport (1965), augmented by the 1977 extreme flood in the case of the 1978 analysis. A more recent report by Selchozpromexport (1973) gives revised data for 1951-64 and new data for 1965-67 and 1970-72. No adequate explanations are given but Selchozpromexport must have had good reasons for changing its previously published figures and its latest figures have therefore been used here. A further source of data is the flow hydrograph published by Booker-McConnell (1976) covering the years 1972-75 and giving observed peak flows for 1972 to 1975. Table 2.2 compares the present data with those previously used. A Type 1 extremal (Gumbel) distribution was fitted by the method of moments to give the results shown in Figure 2.5. It can be seen that the observed peak flow in 1977 has an estimated return period of about 100 years.

A previous comparison of flows at Lugh Ganana and Saakow (MMP, 1978) suggests that the rating curve for Lugh Ganana overestimates flows at high river stage. The suggestion is based on hydrographs covering the large 1977 flood, when substantial volumes of water apparently entered flood plain storage downstream of Lugh Ganana but did not reappear during the falling stage at Saakow. The river valley between the two locations is relatively incised and the flood plain is only about 1 km wide. Some water would be lost by percolation and evaporation and some return flow would be delayed by bank storage. Nevertheless, most of the apparent losses should reappear at Saakow during the flood recession and it is likely, therefore, that high flows at Lugh Ganana are overestimates. It should be noted that the method of analysis used to relate Lugh Ganana and Kaitoi flows will automatically allow for estimation of Lugh Ganana flows, assuming that Kaitoi flows are reasonably correct.

Relationship between flows at Kaitoi and Kamsuma / Jamama 2.4



- Booker – Mc Connell (1976) data for Kaitoi and Kamsuma
- ⦿ 1977 flood using Selchozpromexport (1963) rating curve for Kaitoi
- ◎ 1977 flood using Booker – Mc Connell (1976) rating curve for Kaitoi

TABLE 2.2

Annual Maximum Flows at Lugh Ganana (m^3/s)

Year	Previously used by MMP(1)	Revised record(2)
1951	1 034	1 050
1952	351	860
1953	651	646
1954	982	994
1955	672	672
1956	1 423	1 500
1957	704	704
1958	855	784
1959	1 254	1 200
1960	668	1 300
1961	1 301	1 340
1962	598	592
1963	751	756
1964	771	788
1965		1 220
1966		386
1967		1 130
1968		n.a.
1969		n.a.
1970		1 190
1971		960
1972		783
1973		613
1974		520
1975		566
1976		n.a.
1977		2 120

Sources:- (1) Selchozpromexport, 1965

(2) 1951 - 1971 : Selchozpromexport, 1973
1972 - 1975 : Booker-McConnell, 1976
1977 : MMP, 1978

Insufficient data are available to estimate directly return periods of high flows at Kaitoi and Kamsuma. Use is therefore made of the high flow/return period relationship for Lugh Ganana and equations (1) and (2) to estimate corresponding downstream flows. The results are shown in Table 2.3 and Figure 2.5. The effects on these flows of proposed river bunding of schemes upstream of Mogambo are discussed in Section 2.5.

TABLE 2.3

High Flows and Return Periods

Return period (years)	Flow (m^3/s) Lugh Ganana	Kaitoi	Kamsuma
2	880	760	600
10	1 450	1 000	710
25	1 730	1 100	750
50	1 950	1 192	780
100	2 160	1 260	800

It should be noted that return periods for Lugh Ganana are well defined by available data and a reasonable case can be made in support of the relationship (equation (1)) between Lugh Ganana and Kaitoi flows. However, the relationship (equation (2)) between Kaitoi and Kamsuma flows cannot be wholly substantiated by the information available and the Kamsuma flows given in Table 2.3 should be viewed with caution.

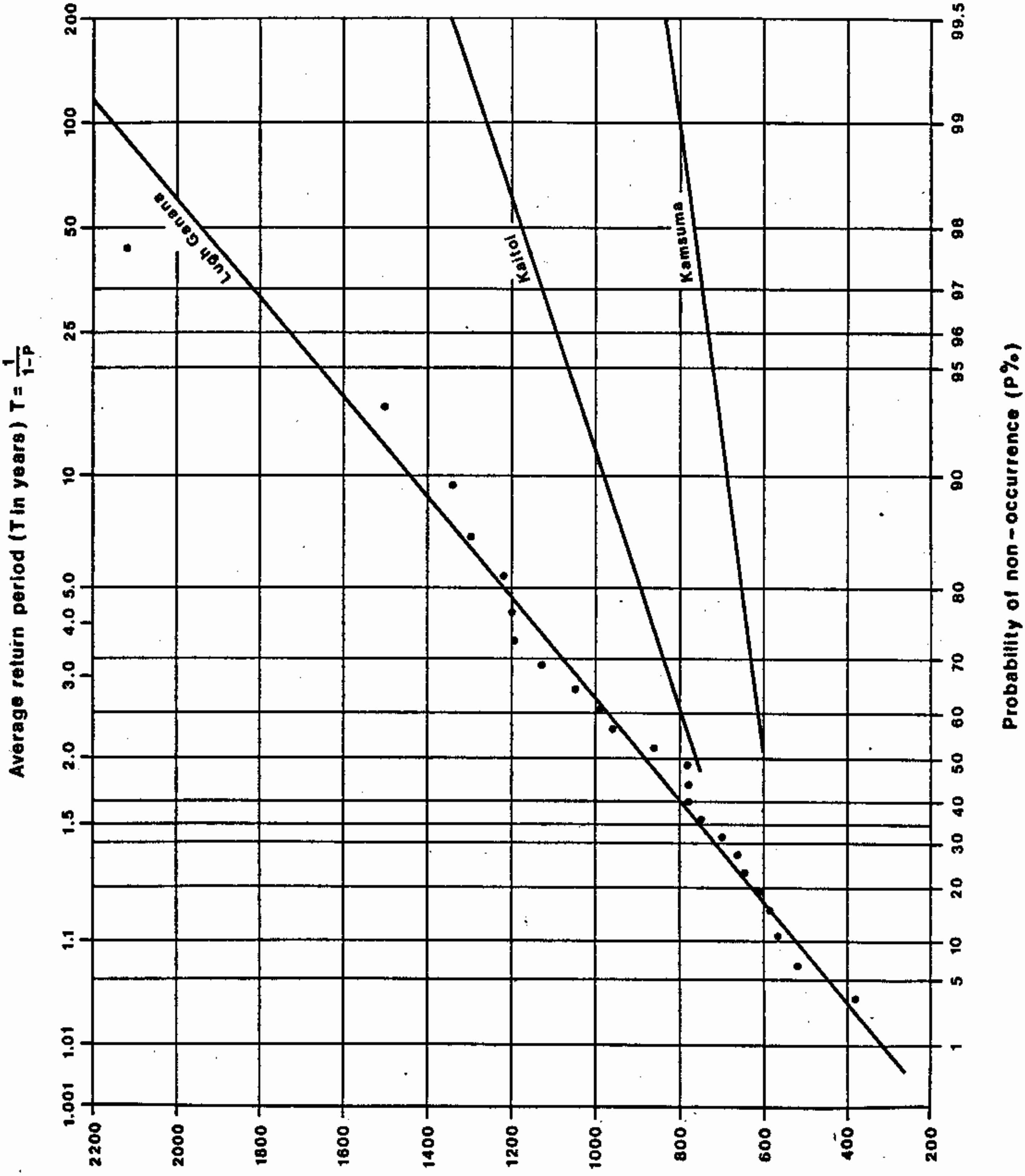
2.4 Flood Levels under Present Conditions

During the severe flooding of November 1977 it was observed that water overtopped the closed gates at the head of the Bulo Yaag channel and flowed west and north away from the Mogambo project area. It is therefore clear that flood levels within the project are mainly dependent on water levels in the Juba river at Bulo Yaag, which in turn are dependent on flows at Kamsuma. Figure 2.6 gives the relationship between flows at Kamsuma and water levels at Bulo Yaag. It can be seen that the channel gates are expected to overtop at a Kamsuma flow of 530 m^3/s.

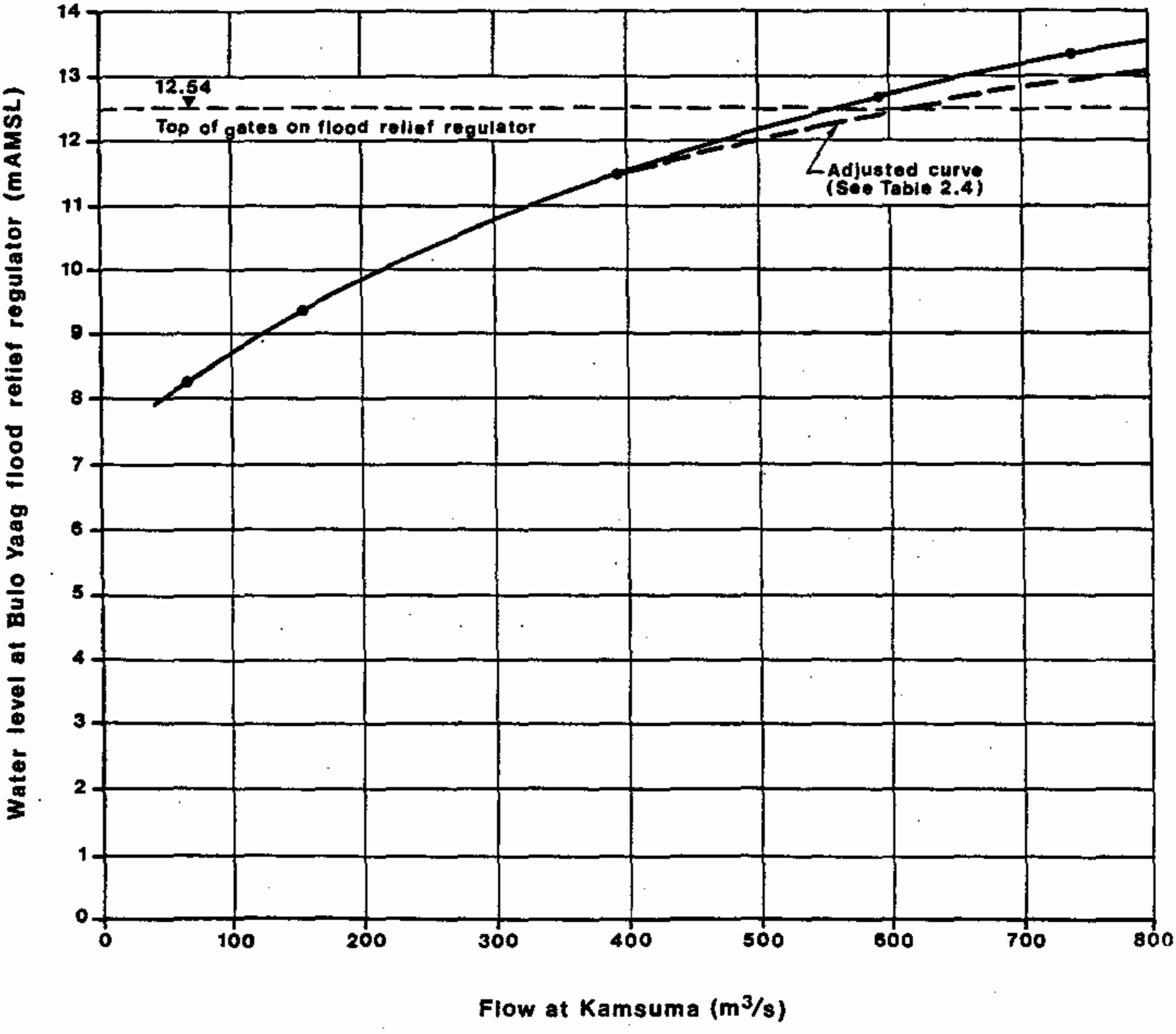
In 1977, the peak flow at Kamsuma was about 750 m^3/s (see Section 2.2.). Field observations at that time showed that flood water levels did not exceed the level of the road at Mogambo, which has a lowest level of about 13.0 m AMSL some 2 km north of Mogambo. However, Figure 2.6 suggests that a flow of 750 m^3/s at Kamsuma will give a water level of 13.3 m AMSL, some 0.3 m higher than the maximum level in 1977. The available evidence therefore indicates that Figure 2.6 overestimates Bulo Yaag water levels when Kamsuma flows exceed about 600 m^3/s.

Field observations indicate that overtopping of the Bulo Yaag flood gates, corresponding to a water level of 12.5 m AMSL, occurs fairly infrequently at intervals of (say) 10 years. However, Figure 2.6 suggests that overtopping occurs in most years. Also, it is clear that flooding will occur along the river between Kamsuma and Bulo Yaag when flows at Kamsuma exceed 750 m^3/s. This flooding will tend to attenuate flood peaks and result in lower water levels at Bulo Yaag. It is therefore concluded that the return periods shown in Table 2.4 are conservative. Accordingly the table contains adjusted levels which represent what is considered a truer estimate for the stated return period.

Return periods of flows in Juba river



Water levels at Bulo Yaag



Note:- Data points obtained from backwater curve calculations (See Figure 2.2) and direct field observations

TABLE 2.4

Return Periods of Bulo Yaag Water Levels Under Present Conditions

Return period (years)	Flows at Kamsuma (m^3/s)	Water level at Bulo Yaag (m AMSL)	
		Calculated	Adjusted
2	600	12.7	12.3
10	710	12.9	12.5
25	750	13.3	12.9
50	780	13.4	13.0
100	800	13.5	13.1

2.5 Conclusions

Under present conditions (with no new bunds constructed upstream of Kamsuma) the water levels of Table 2.4 are considered to be sufficiently accurate for planning flood protection of the project. This protection can be obtained by two alternative methods which are discussed briefly below and in more detail in Annex 5.

(a) Cutting a new flood relief channel through the north of the project area and providing flood bunds on both banks of this channel and along the northern and western boundaries of the project area. The top of the northern bund would be equal to the level shown in Table 2.4 for a specified return period. The western bunded level depends on calculations of water depth in the natural drainage channel to the west. A comparison has been made between water levels shown in Figure 2.2 and ground levels along the east of the project area to check if additional bunds are required.

(b) Closing off the flood relief channel and bunding along the north to a level of about 11.0 m AMSL to protect against flood water originating from areas to the north of the project area. As in (a) above, a check has been made for additional bunds required in the east. This alternative will increase water levels downstream of Bulo Yaag. If the flood relief channel has a capacity of 100 m^3/s (the calculated design discharge), then Figure 2.2 shows that this increase will be about 1 m for Kamsuma flows of 600 m^3/s. It is certain that this solution will lead to more frequent flooding of the banana plantations along the river.

Flood levels shown in Table 2.4 have been estimated assuming that upstream conditions remain unchanged in the future. However, flood protection works are under construction for the Juba Sugar project and are planned for the Fanoole project, involving bunding of a large proportion of the left and right banks of the river between Kaitoi and Kamsuma. Peak flows at Kamsuma will increase substantially when these bunds are completed. For example, flood peaks at Kaitoi and Kamsuma are given in Table 2.3 as 1 000 and 710 m^3/s respectively for a

10-year return period. If the Juba Sugar and Fanoole flood bunds are constructed then the flood peak at Kamsuma could increase to 900 m^3/s or more. Reference to Figure 2.6 suggests that the corresponding level at Bulo Yaag could rise to about 14.0 m AMSL, or 0.5 m higher than the 100-year flood under present conditions. In practice, Figure 2.6 is not strictly applicable to Kamsuma flows exceeding about 750 m^3/s, the maximum capacity of Kamsuma bridge and the downstream channel. Nevertheless, it is clear that the proposed upstream bunds will greatly reduce the return periods of flood levels shown in Table 2.4.

It is understood that Bardheere dam could be completed within the next eight years although no definite decision has yet been made. Previous work (Technital, 1977 and Hunting Technical Services, 1968) has shown that with Bardheere dam the annual risk of floods exceeding 750 m^3/s can be reduced to 1% (i.e. return period of 100 years). The corresponding flood peak at Kamsuma will be about 600 m^3/s (from Figure 2.4) assuming no attenuation between Bardheere and Kaitoi and no new flood bunds downstream of Kaitoi. If new flood bunds are constructed, the flow at Kamsuma will increase to about 700 m^3/s, causing minor flooding only. For shorter return periods with lower peak flows, it is clear that the risk of flooding is reduced to a very low level, and that bunding of the Mogambo project will probably not be required.

CHAPTER 3

IRRIGATION WATER REQUIREMENTS FOR PROJECTS ON THE JUBA RIVER

3.1 Introduction

Several changes in planned irrigation developments have occured since the Fanoole Settlement Report (HTS, 1978) which considered water requirements for potential development areas throughout the Juba basin. These changes have required revisions of water requirements for most projects and the opportunity has been taken to include planning horizons of 1985 and 1990 in addition to an evaluation of the situation which will occur in the immediate future.

3.2 Crop Water Requirements

The method of Doorenbos and Pruitt (1977) has been used to evaluate monthly values of reference crop evapotranspiration (ETo) which allow for observed greater wind effects than Penman's potential crop evapotranspiration (Eo). It should be noted that values of ETo are about 10% higher than values of reference crop evapotranspiration (Et) used by Huntings Technical Services (HTS) (1977 and 1978). Effective rainfall was calculated by applying the criteria of the US Bureau of Reclamation, as used by Lockwood/FAO (1968), to monthly rainfall occuring with an 80% probability of exceedence.

Table 3.1 gives values of ETo and effective rainfall (Re) calculated for three climatic zones, using climatological and rainfall data published by HTS (1977) and Fantoli (1965). Values of ETo include an increase of 8% to allow for above average evaporation in extreme years.

TABLE 3.1

Reference Crop Evaporation, ETo, and Effective Rainfall, Re for Three Climatic Zones (mm/month)

Month	Bardheere-Gelib		Gelib		Ionte-Gelib	
	ETo	Re	ETo	Re	ETo	Re
January	233	0	211	0	179	0
February	214	0	203	0	170	0
March	238	0	233	0	195	0
April	175	46	168	58	157	17
May	159	29	152	47	145	22
June	157	11	134	21	129	36
July	174	8	137	15	132	32
August	195	2	160	5	147	8
September	198	0	173	0	157	0
October	190	2	176	1	160	0
November	171	16	157	18	147	0
December	192	7	177	10	161	0
Year	2 296	121	2 081	175	1 879	115

Note: Effective rainfalls are quoted with an 80% probability of exceedence

Irrigation areas above Kaitoi were assumed to lie within the Bardheere-Gelib climatic zone, with ETo and Re obtained by averaging values at Bardheere and Gelib. All other areas except Mogambo were assumed to lie within the Gelib zone, with ETo and Re obtained from recorded data at Gelib. Jamama cotton and Ionte areas (see following section) strictly fall within the Ionte zone but were included within the Gelib zone for convenience: any errors caused to overall irrigation requirements are very small. The Mogambo project lies between Ionte and Gelib and average ETo values for these locations were used. Effective rainfalls for Ionte-Gelib zone were calculated from rainfall records at Jamama because of the short published length of record for Ionte.

Crop calendars and crop coefficients have been taken from the HTS (1978) report. Crop coefficients were calculated in accordance with the method of Doorenbos and Pruitt (1975) except for:-

(a) perennial crops given constant coefficients throughout the year

(b) paddy rice, assumed to have a coefficient 30% higher than for upland rice

(c) miscellaneous crops (for example, fodder) under continuous cultivation, which are assigned a constant coefficient of 0.8.

Coconuts, not considered in the HTS report, have been arbitrarily assigned a constant coefficient of 1.0.

Table 3.2 gives crop coefficients applying to all zones and Table 3.3 gives net crop requirements for the Gelib zone, including an allowance of 8% for annual variations from average values. Net requirements for the Bardheere-Gelib and Ionte-Gelib zones can be calculated from Tables 3.1 and 3.2.

The crop water requirements for the Mogambo project have been calculated separately using the method of Doorenbos and Pruitt (1977). Full details of the project crop water requirements calculations are in Chapter 5 of Annex 3. The irrigation requirements have been summarised in Table 3.4.

3.3 Future Irrigation Development

Three planning horizons have been used when estimating future development of schemes other than Mogambo. The first horizon (1980) which includes present development and that due for immediate implementation. The other planning horizons (1985 and 1990) indicate the short and medium term development considered likely in the light of present plans. Table 3.5 summarises the likely irrigated areas at each of the three planning horizons.

Irrigated areas in Table 3.5 are based on previous reports plus up-to-date appraisal of likely progress. In the case of the Ionte area it is reported that only 100 ha of coconuts have been planted and soils problems will prevent implementation of the previously planned rice project. It should be noted that the time horizons should be interpreted as indicating the immediate, short and medium-term development, rather than the actual dates shown.

TABLE 3.2

Crop Coefficients for All Areas other than Mogambo

Crop		Season	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Banana		Continuous	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sugar		Continuous	1.09	1.05	1.11	1.30	1.32	1.30	1.17	1.11	1.14	1.20	1.27	1.20
Citrus		Continuous	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55
Maize	1	Apr-Aug				0.13	0.55	1.02	0.97	0.26				
Maize	2	Sep-Jan	0.29								0.12	0.46	1.04	1.06
Rice	1	Apr-Aug				0.35	0.82	1.00	0.94	0.37				
Rice	2	Aug-Dec								0.38	0.89	1.03	0.97	0.40
Cotton	1	Apr-Sep				0.16	0.74	1.05	1.09	0.98	0.44			
Cotton	2	Aug-Jan	0.44							0.16	0.74	1.05	1.09	0.98
Sesame		Sep-Oct									0.15	0.73	0.99	0.45
Pulses	1	Apr-Jul				0.14	0.65	0.80	0.46					
Pulses	2	Oct-Jan	0.18									0.15	0.79	0.90
Groundnuts	1	Apr-Aug				0.42	0.81	1.01	0.83	0.09				
Groundnuts	2	Oct-Feb	0.91	0.10								0.43	0.85	1.11
Sorghum	1	Apr-Aug				0.13	0.51	0.96	0.91	0.27				
Sorghum	2	Oct-Feb	1.02	0.36								0.13	0.59	1.09
Miscellaneous		Continuous	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Coconuts		Continuous	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Note: Crop coefficients for rice are for upland rice

Source: HTS (1978), except for coconuts

TABLE 3.3

Net Crop Requirements for the Gelib Zone (mm)

Crop		Season	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Banana		Continuous	211	203	233	110	105	113	122	155	173	175	139	167
Sugar		Continuous	230	213	258	160	153	153	145	172	197	210	181	202
Citrus		Continuous	116	111	128	34	36	52	60	83	95	95	68	87
Maize	1	Apr-Aug					36	115	117	36				
Maize	2	Sep-Jan	61								20	80	145	177
Rice	1	Apr-Aug					77	113	113	54				
Rice	2	Aug-Dec								55	154	180	134	60
Cotton	1	Apr-Sep					65	119	134	151	76			
Cotton	2	Aug-Jan	92							20	128	183	153	163
Sesame		Sep-Dec									25	127	137	69
Pulses	1	Apr-Jul					51	86	48					
Pulses	2	Oct-Jan	38									25	106	149
Groundnuts	1	Apr-Aug				12	76	114	98	9				
Groundnuts	2	Oct-Feb	192	20								74	115	186
Sorghum	1	Apr-Aug					30	107	109	38				
Sorghum	2	Oct-Feb	215	73								21	74	182
Miscellaneous		Continuous	168	162	186	76	74	86	94	123	138	139	107	131
Coconuts		Continuous	211	203	233	110	105	113	122	155	173	175	139	167

Notes: 1. Requirements for upland rice are shown above
Requirements for paddy rice are 1.30 times those for upland rice

2. Effective rainfall used in preparation of this table has an 80% probability exceedence

TABLE 3.4

Summary of Irrigation Requirements for Mogambo Project

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Evapotranspiration, ETo (mm)	179	170	195	157	145	129	132	147	157	160	147	161
Effective rainfall, Re (mm)	0	0	0	17	22	36	32	8	0	0	0	0
Field requirements (mm)(1)												
Rotation A: surface irrigation												
Rice (3 300 ha)(2)	-	-	-	230	444	320	244	21	-	-	-	-
Maize (2 300) ha	45	-	-	-	-	-	-	-	213	173	245	237
Rotation B: overhead irrigation												
Rice (1 000 ha)(2)	-	-	-	-	148	124	151	171	16	-	-	-
Maize (1 000 ha)	96	-	-	-	-	-	-	-	-	184	137	221
Cotton (1 100 ha)	40	-	-	-	-	-	56	135	103	184	212	199
Maize (1 000 ha)	36	-	-	-	-	-	-	-	171	139	196	189
Main canal head flow (m^3/s)	1.13	-	-	3.18	6.54	4.95	4.13	1.57	3.31	3.75	4.74	4.76

Notes: (1) Field requirement = net requirement divided by field efficiency

(2) Rice grown under overhead irrigation is upland rice. Surface irrigated rice is paddy rice.

TABLE 3.6

Gross Irrigation Requirements in 1980 for Other Schemes (Mm^3)

CROP	AREA HA.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
SMALL SCHEMES ABOVE FANOLE (TECHNITAL)														
PULSES	480	0.00	0.00	0.00	0.00	0.79	1.22	0.77	0.00	0.00	0.00	0.00	0.00	2.78
PULSES	420	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	1.11	1.55	3.30
MAIZE	400	0.00	0.00	0.00	0.00	0.52	1.33	1.43	0.43	0.00	0.00	0.00	0.00	3.71
SORGHUM	230	0.00	0.00	0.00	0.00	0.27	0.71	0.77	0.26	0.00	0.00	0.00	0.00	2.01
SORGHUM	200	1.06	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.39	0.90	2.78
SESAME	160	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.49	0.55	0.28	1.42
GRDNUTS	80	0.38	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.23	0.37	1.15
BANANAS	30	0.16	0.14	0.16	0.09	0.09	0.10	0.11	0.13	0.13	0.13	0.10	0.12	1.45
SUB-TOTAL		1.98	0.52	0.16	0.09	1.67	3.36	3.08	0.82	0.24	1.10	2.37	3.22	18.59
DUJUMA SETTLEMENT														
PULSES	40	0.00	0.00	0.00	0.00	0.07	0.10	0.06	0.00	0.00	0.00	0.00	0.00	0.23
PULSES	40	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.11	0.15	0.31
SUB-TOTAL		0.04	0.00	0.00	0.00	0.07	0.10	0.06	0.00	0.00	0.02	0.11	0.15	0.55
SMALL SCHEMES BELOW FANOLE (TECHNITAL)														
BANANAS	4000	20.71	19.02	21.16	11.47	11.56	12.98	14.76	17.16	17.60	16.71	13.78	16.44	193.33
CITRUS	80	0.23	0.21	0.23	0.09	0.10	0.13	0.16	0.19	0.19	0.18	0.14	0.18	2.03
MAIZE	950	0.00	0.00	0.00	0.00	1.23	3.15	3.39	1.03	0.00	0.00	0.00	0.00	8.80
SORGHUM	700	3.70	1.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	1.32	3.15	9.72
RICE 1	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.39	0.43	0.33	0.16	1.47
RICE 2	180	0.00	0.00	0.00	0.14	0.56	0.77	0.82	0.37	0.00	0.00	0.00	0.00	2.66
PULSES	40	0.00	0.00	0.00	0.00	0.07	0.10	0.06	0.00	0.00	0.00	0.00	0.00	0.23
PULSES	120	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.32	0.44	0.94
SESAME	90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.27	0.31	0.16	0.80
COTTON	50	0.00	0.00	0.00	0.00	0.10	0.17	0.20	0.21	0.10	0.00	0.00	0.00	0.79
GRDNUTS	40	0.00	0.00	0.00	0.02	0.09	0.13	0.12	0.01	0.00	0.00	0.00	0.00	0.38
SUB-TOTAL		24.75	20.43	21.39	11.72	13.71	17.44	19.51	19.12	18.34	18.02	16.19	20.52	221.14

TABLE 3.6 (cont.)

GELIB														
MAIZE	540	0.00	0.00	0.00	0.00	0.44	1.39	1.41	0.44	0.00	0.00	0.00	0.00	3.68
MAIZE	240	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.43	0.77	0.95	2.59
GRDNUTS	180	0.00	0.00	0.00	0.05	0.30	0.46	0.39	0.04	0.00	0.00	0.00	0.00	1.24
GRDNUTS	180	0.77	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.46	0.75	2.36
RICE 1	240	0.00	0.00	0.00	0.00	0.41	0.60	0.61	0.29	0.00	0.00	0.00	0.00	1.92
RICE 1	240	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.82	0.96	0.72	0.32	3.12
SESAME	300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.85	0.92	0.46	2.40
COTTON	60	0.00	0.00	0.00	0.00	0.09	0.16	0.18	0.20	0.10	0.00	0.00	0.00	0.73
COTTON	120	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.34	0.49	0.41	0.44	1.98
PULSES	120	0.00	0.00	0.00	0.00	0.14	0.23	0.13	0.00	0.00	0.00	0.00	0.00	0.50
PULSES	60	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.14	0.20	0.42
MISC.	60	0.23	0.22	0.25	0.10	0.10	0.11	0.13	0.16	0.18	0.19	0.14	0.18	1.99
SUB-TOTAL		1.62	0.30	0.25	0.16	1.48	2.95	2.85	1.48	1.73	3.25	3.56	3.29	22.92
JUBBA SUGAR PROJECT														
SUGAR	2000	10.22	9.47	11.49	7.13	6.83	6.81	6.46	7.67	8.77	9.34	8.06	9.00	101.25
SUB-TOTAL		10.22	9.47	11.49	7.13	6.83	6.81	6.46	7.67	8.77	9.34	8.06	9.00	101.25
IONTE														
COCONUTS	100	0.47	0.45	0.52	0.24	0.23	0.25	0.27	0.34	0.38	0.39	0.31	0.37	4.24
SUB-TOTAL		0.47	0.45	0.52	0.24	0.23	0.25	0.27	0.34	0.38	0.39	0.31	0.37	4.24
TOTAL		39.1	31.2	33.8	19.3	24.0	30.9	32.2	29.4	29.5	32.1	30.6	36.5	368.7

TABLE 3.7

Gross Irrigation Requirements in 1985 for Other Projects (Mm^3)

CROP	AREA HA.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
SMALL SCHEMES ABOVE FANOOLE (TECHNITAL)														
PULSES	550	0.00	0.00	0.00	0.00	0.91	1.40	0.88	0.00	0.00	0.00	0.00	0.00	3.19
PULSES	500	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	1.32	1.84	3.93
MAIZE	500	0.00	0.00	0.00	0.00	0.65	1.66	1.79	0.54	0.00	0.00	0.00	0.00	4.63
SORGHUM	300	0.00	0.00	0.00	0.00	0.35	0.93	1.00	0.34	0.00	0.00	0.00	0.00	2.62
SORGHUM	250	1.32	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.47	1.12	3.47
SESAME	200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.61	0.68	0.35	1.77
GRONUTS	100	0.47	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.29	0.46	1.44
BANANAS	50	0.26	0.24	0.26	0.14	0.14	0.16	0.18	0.21	0.22	0.21	0.17	0.21	2.42
SUB-TOTAL		2.52	0.71	0.26	0.14	2.05	4.15	3.85	1.09	0.35	1.41	2.94	3.98	23.47
SAAKOW SCHEME (IL NUOVO CASTORO)														
MAIZE	3000	0.00	0.00	0.00	0.00	3.90	9.94	10.72	3.25	0.00	0.00	0.00	0.00	27.80
PULSES	3000	0.00	0.00	0.00	0.00	4.96	7.64	4.80	0.00	0.00	0.00	0.00	0.00	17.40
SESAME	3000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.98	9.11	10.22	5.29	26.61
RICE 2	3000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.24	15.31	16.84	13.30	6.19	57.88
SUB-TOTAL		0.00	0.00	0.00	0.00	8.85	17.58	15.52	9.48	17.29	25.95	23.52	11.48	129.69
DUJUMA SETTLEMENT														
PULSES	40	0.00	0.00	0.00	0.00	0.07	0.10	0.06	0.00	0.00	0.00	0.00	0.00	0.23
PULSES	40	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.11	0.15	0.31
SUB-TOTAL		0.04	0.00	0.00	0.00	0.07	0.10	0.06	0.00	0.00	0.02	0.11	0.15	0.55
SMALL SCHEMES BELOW FANOOLE														
BANANAS	7000	32.82	31.58	36.24	17.11	16.33	17.58	18.98	24.11	26.91	27.22	21.62	25.98	296.49
CITRUS	100	0.26	0.25	0.28	0.08	0.08	0.12	0.13	0.18	0.21	0.21	0.15	0.19	2.15
MAIZE	1150	0.00	0.00	0.00	0.00	0.94	2.96	3.01	0.94	0.00	0.00	0.00	0.00	7.84
SORGHUM	850	4.07	1.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	1.41	3.46	10.72
RICE 1	150	0.00	0.00	0.00	0.00	0.26	0.38	0.38	0.18	0.00	0.00	0.00	0.00	1.20
RICE 1	200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.68	0.80	0.60	0.27	2.60
PULSES	50	0.00	0.00	0.00	0.00	0.06	0.10	0.05	0.00	0.00	0.00	0.00	0.00	0.21
PULSES	150	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.35	0.50	1.06
SESAME	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.28	0.31	0.15	0.80
COTTON	50	0.00	0.00	0.00	0.00	0.07	0.13	0.15	0.17	0.08	0.00	0.00	0.00	0.61
GRONUTS	50	0.00	0.00	0.00	0.01	0.08	0.13	0.11	0.01	0.00	0.00	0.00	0.00	0.35
SUB-TOTAL		37.27	33.21	36.53	17.20	17.82	21.38	22.82	25.84	27.95	29.02	24.44	30.55	324.03

TABLE 3.7 (cont.)

GELIB														
MAIZE	2870	0.00	0.00	0.00	0.00	2.33	7.38	7.52	2.33	0.00	0.00	0.00	0.00	19.57
MAIZE	1640	2.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76	2.91	5.29	6.47	17.67
GRDNUTS	1230	0.00	0.00	0.00	0.34	2.08	3.13	2.70	0.26	0.00	0.00	0.00	0.00	8.50
GRDNUTS	1230	5.25	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.04	3.16	5.10	16.10
RICE 1	1640	0.00	0.00	0.00	0.03	2.83	4.12	4.15	1.98	0.00	0.00	0.00	0.00	13.10
RICE 1	1640	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.03	5.61	6.57	4.89	2.22	21.33
SESAME	1230	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71	3.48	3.76	1.90	9.85
COTTON	410	0.00	0.00	0.00	0.00	0.60	1.09	1.22	1.38	0.69	0.00	0.00	0.00	4.99
COTTON	1640	3.38	0.00	0.00	0.00	0.00	0.00	0.00	0.75	4.67	6.70	5.58	5.96	27.04
PULSES	1640	0.00	0.00	0.00	0.00	1.89	3.14	1.75	0.00	0.00	0.00	0.00	0.00	6.78
PULSES	410	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.97	1.36	2.90
MISC.	410	1.54	1.48	1.70	0.70	0.68	0.79	0.86	1.12	1.26	1.27	0.98	1.20	13.57
SUB-TOTAL		12.75	2.03	1.70	1.07	10.41	19.64	18.20	9.85	13.70	23.21	24.63	24.21	161.39
HONBOY IRRIGATION SCHEME														
MAIZE	2250	0.00	0.00	0.00	0.00	1.83	5.78	5.89	1.83	0.00	0.00	0.00	0.00	15.34
PULSES	2250	0.00	0.00	0.00	0.00	2.59	4.31	2.40	0.00	0.00	0.00	0.00	0.00	9.30
SESAME	2250	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.30	6.37	6.87	3.48	18.03
COTTON	2250	4.64	0.00	0.00	0.00	0.00	0.00	0.00	1.03	6.40	9.19	7.66	8.17	37.09
SUB-TOTAL		4.64	0.00	0.00	0.00	4.42	10.09	8.30	2.86	7.70	15.56	14.53	11.66	79.76
JUBBA SUGAR SCHEME														
SUGAR	10000	51.11	47.37	57.47	35.64	34.14	34.04	32.29	38.36	43.83	46.71	40.31	44.98	506.25
SUB-TOTAL		51.11	47.37	57.47	35.64	34.14	34.04	32.29	38.36	43.83	46.71	40.31	44.98	506.25
TRANSJUBBA SCHEME														
MISC.	300	1.13	1.08	1.24	0.51	0.50	0.57	0.63	0.82	0.92	0.93	0.72	0.88	9.93
SUB-TOTAL		1.13	1.08	1.24	0.51	0.50	0.57	0.63	0.82	0.92	0.93	0.72	0.88	9.93
JAHAMA														
COTTON	2000	4.13	0.00	0.00	0.00	0.00	0.00	0.00	0.92	5.69	8.17	6.81	7.26	32.97
SUB-TOTAL		4.13	0.00	0.00	0.00	0.00	0.00	0.00	0.92	5.69	8.17	6.81	7.26	32.97
IONTE .														
COCONUTS	100	0.47	0.45	0.52	0.24	0.23	0.25	0.27	0.34	0.38	0.39	0.31	0.37	4.24
SUB-TOTAL		0.47	0.45	0.52	0.24	0.23	0.25	0.27	0.34	0.38	0.39	0.31	0.37	4.24
TOTAL		114.0	84.9	97.7	54.8	78.5	107.8	101.9	89.6	117.8	151.4	138.3	135.5	1272.3

TABLE 3.8

Gross Irrigation Requirements in 1990 for Other Projects (Mm^3)

CROP	AREA HA.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
SMALL SCHEMES ABOVE FANOOLE (TECHNITAL)														
PULSES	550	0.00	0.00	0.00	0.00	0.91	1.40	0.88	0.00	0.00	0.00	0.00	0.00	3.19
PULSES	500	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	1.32	1.84	3.93
MAIZE	500	0.00	0.00	0.00	0.00	0.65	1.66	1.79	0.54	0.00	0.00	0.00	0.00	4.63
SORGHUM	300	0.00	0.00	0.00	0.00	0.35	0.93	1.00	0.34	0.00	0.00	0.00	0.00	2.62
SORGHUM	250	1.32	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.47	1.12	3.47
SESAME	200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.61	0.68	0.35	1.77
GRDNUTS	100	0.47	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.29	0.46	1.44
BANANAS	50	0.26	0.24	0.26	0.14	0.14	0.16	0.18	0.21	0.22	0.21	0.17	0.21	2.42
SUB-TOTAL		2.52	0.71	0.26	0.14	2.05	4.15	3.85	1.09	0.35	1.41	2.94	3.98	23.47
SAAKOW SCHEME (IL NUOVO CASTORO)														
MAIZE	3000	0.00	0.00	0.00	0.00	3.90	9.94	10.72	3.25	0.00	0.00	0.00	0.00	27.80
PULSES	3000	0.00	0.00	0.00	0.00	4.96	7.64	4.80	0.00	0.00	0.00	0.00	0.00	17.40
SESAME	3000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.98	9.11	10.22	5.29	26.61
RICE 2	3000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.24	15.31	16.84	13.30	6.19	57.88
SUB-TOTAL		0.00	0.00	0.00	0.00	8.85	17.58	15.52	9.48	17.29	25.95	23.52	11.48	129.69
DUJUMA SETTLEMENT														
PULSES	40	0.00	0.00	0.00	0.00	0.07	0.10	0.06	0.00	0.00	0.00	0.00	0.00	0.23
PULSES	40	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.11	0.15	0.31
SUB-TOTAL		0.04	0.00	0.00	0.00	0.07	0.10	0.06	0.00	0.00	0.02	0.11	0.15	0.55
SMALL SCHEMES BELOW FANOOLE														
BANANAS	7000	32.82	31.58	36.24	17.11	16.33	17.58	18.98	24.11	26.91	27.22	21.62	25.98	296.49
CITRUS	100	0.26	0.25	0.28	0.08	0.08	0.12	0.13	0.18	0.21	0.21	0.15	0.19	2.15
MAIZE	1150	0.00	0.00	0.00	0.00	0.94	2.96	3.01	0.94	0.00	0.00	0.00	0.00	7.84
SORGHUM	850	4.07	1.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	1.41	3.46	10.72
RICE 1	150	0.00	0.00	0.00	0.00	0.26	0.38	0.38	0.18	0.00	0.00	0.00	0.00	1.20
RICE 1	200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.68	0.80	0.60	0.27	2.60
PULSES	50	0.00	0.00	0.00	0.00	0.06	0.10	0.05	0.00	0.00	0.00	0.00	0.00	0.21
PULSES	150	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.35	0.50	1.06
SESAME	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.28	0.31	0.15	0.80
COTTON	50	0.00	0.00	0.00	0.00	0.07	0.13	0.15	0.17	0.08	0.00	0.00	0.00	0.61
GRDNUTS	50	0.00	0.00	0.00	0.01	0.08	0.13	0.11	0.01	0.00	0.00	0.00	0.00	0.35
SUB-TOTAL		37.27	33.21	36.53	17.20	17.92	21.38	22.32	25.84	27.95	29.02	21.44	30.55	324.03

TABLE 3.8 (cont.)

GELIB														
MAIZE	2870	0.00	0.00	0.00	0.00	2.33	7.38	7.52	2.33	0.00	0.00	0.00	0.00	19.57
MAIZE	1640	2.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76	2.91	5.29	6.47	17.67
GRDNUTS	1230	0.00	0.00	0.00	0.34	2.08	3.13	2.70	0.26	0.00	0.00	0.00	0.00	8.50
GRDNUTS	1230	5.25	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.04	3.16	5.10	16.10
RICE 1	1640	0.00	0.00	0.00	0.03	2.83	4.12	4.15	1.98	0.00	0.00	0.00	0.00	13.10
RICE 1	1640	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.03	5.61	6.57	4.89	2.22	21.33
SESAME	1230	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71	3.48	3.76	1.90	9.85
COTTON	410	0.00	0.00	0.00	0.00	0.60	1.09	1.22	1.38	0.69	0.00	0.00	0.00	4.99
COTTON	1640	3.38	0.00	0.00	0.00	0.00	0.00	0.00	0.75	4.67	6.70	5.58	5.96	27.04
PULSES	1640	0.00	0.00	0.00	0.00	1.89	3.14	1.75	0.00	0.00	0.00	0.00	0.00	6.78
PULSES	410	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.97	1.36	2.90
MISC.	410	1.54	1.46	1.70	0.70	0.68	0.79	0.86	1.12	1.26	1.27	0.98	1.20	13.57
SUB-TOTAL		12.75	2.03	1.70	1.07	10.41	19.64	18.20	9.85	13.70	23.21	24.63	24.21	161.39
HOMBOY IRRIGATION SCHEME														
MAIZE	4500	0.00	0.00	0.00	0.00	3.66	11.57	11.79	3.66	0.00	0.00	0.00	0.00	30.68
PULSES	4500	0.00	0.00	0.00	0.00	5.18	8.62	4.80	0.00	0.00	0.00	0.00	0.00	18.60
SESAME	4500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.59	12.75	13.74	6.96	36.05
COTTON	4500	9.28	0.00	0.00	0.00	0.00	0.00	0.00	2.06	12.80	18.38	15.31	16.35	74.18
SUB-TOTAL		9.28	0.00	0.00	0.00	8.84	20.19	16.59	5.72	15.40	31.13	29.06	23.31	159.51
JUBBA SUGAR SCHEME														
SUGAR	15000	66.70	61.81	75.00	46.52	44.56	44.43	42.13	50.05	57.19	60.96	52.60	58.70	660.65
SUB-TOTAL		66.70	61.81	75.00	46.52	44.56	44.43	42.13	50.05	57.19	60.96	52.60	58.70	660.65
TRANSJUBBA SCHEME														
MISC.	600	2.25	2.17	2.49	1.02	0.99	1.15	1.26	1.64	1.85	1.86	1.43	1.75	19.86
SUB-TOTAL		2.25	2.17	2.49	1.02	0.99	1.15	1.26	1.64	1.85	1.86	1.43	1.75	19.86
JAMAMA														
COTTON	2000	4.13	0.00	0.00	0.00	0.00	0.00	0.00	0.92	5.69	8.17	6.81	7.26	32.97
SUB-TOTAL		4.13	0.00	0.00	0.00	0.00	0.00	0.00	0.92	5.69	8.17	6.81	7.26	32.97
IONTE														
COCONUTS	100	0.47	0.45	0.52	0.24	0.23	0.25	0.27	0.34	0.38	0.39	0.31	0.37	4.24
SUB-TOTAL		0.47	0.45	0.52	0.24	0.23	0.25	0.27	0.34	0.38	0.39	0.31	0.37	4.24
TOTAL		135.4	100.4	116.5	66.2	93.8	128.9	120.7	104.9	139.8	182.1	165.8	161.8	1516.4

TABLE 3.9(a)

Water Use by River Reach in 1980 (Mm^3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Above Kaitoi												
Small schemes	2.0	0.5	0.2	0.1	1.7	3.4	3.1	0.8	0.2	1.1	2.4	3.2
Dujuma	0				0.1	0.1	0.1			0	0.1	0.2
Sub-total	2.0	0.5	0.2	0.1	1.8	3.5	3.2	0.8	0.2	1.1	2.5	3.4
Kaitoi to Kamsuma												
Small schemes	24.8	20.4	21.4	11.7	13.7	17.4	19.5	19.1	18.3	18.0	16.2	20.5
Fanoole-Gelib	1.6	0.3	0.3	0.2	1.5	3.0	2.9	1.5	1.7	3.3	3.6	3.3
Juba Sugar	10.2	9.5	11.5	7.1	6.8	6.8	6.5	7.7	8.8	9.3	8.1	9.0
Sub-total	36.6	39.2	33.2	19.0	22.0	27.2	28.9	28.3	28.8	30.6	27.9	32.8
Below Kamsuma												
Ionte	0.5	0.5	0.5	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.3	0.4
Kismayo water	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sub-total	0.6	0.6	0.6	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.4	0.5
TOTAL	39.2	34.3	34.0	19.4	24.1	31.1	32.5	29.5	29.5	32.2	30.8	36.7

TABLE 3.9(b)

Water Use by River Reach in 1985 (Mm^3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Above Kaitoi												
Small schemes	2.5	0.7	0.3	0.1	2.1	4.2	3.9	1.1	0.4	1.4	2.9	4.0
Saakow					8.9	17.6	15.5	9.5	17.3	26.0	23.5	11.5
Dujuma	0				0.1	0.1	0.1			0	0.1	0.2
Sub-total	2.5	0.7	0.3	0.1	11.1	21.9	19.5	10.6	17.7	27.4	26.5	15.7
Kaitoi to Kamsuma												
Small schemes	37.3	33.2	36.5	17.2	17.8	21.4	22.8	25.8	28.0	29.0	24.4	30.6
Fanoole-Gelib	12.8	2.0	1.7	1.1	10.4	19.6	18.2	9.9	13.7	23.2	24.6	24.2
Fanoole-Homboy	4.6				4.4	10.1	8.3	2.9	7.7	15.6	14.5	11.7
Juba Sugar	51.1	47.4	57.5	35.6	34.1	34.0	32.3	38.4	43.8	46.7	40.3	45.0
Sub-total	105.8	82.6	95.7	53.9	66.7	85.1	81.6	77.0	93.2	114.5	103.8	111.5
Below Kamsuma												
Trans-Juba	1.1	1.1	1.2	0.5	0.5	0.6	0.6	0.8	0.9	0.9	0.7	0.9
Mogambo	2.6			8.2	17.5	12.0	10.5	4.1	8.8	9.5	12.2	12.6
Jamama cotton	4.1							0.9	5.7	8.2	6.8	7.3
Ionte	0.5	0.5	0.5	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.3	0.4
Kismayo water	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Residual flow	26.8	24.4	26.8	25.9	26.8	25.7	26.8	26.8	25.9	26.8	25.9	26.8
Sub-total	35.2	26.1	28.6	34.9	45.1	38.7	38.3	33.0	41.8	45.9	46.0	48.1
TOTAL	143.5	109.4	124.6	88.9	122.9	145.7	139.4	120.6	152.7	187.8	176.3	175.3

TABLE 3.9(c)

Water Use by River Reach in 1990 (Mm^3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Above Kaitoi												
Small schemes	2.5	0.7	0.3	0.1	2.1	4.2	3.9	1.1	0.4	1.4	2.9	4.0
Saakow					8.9	17.6	15.5	9.5	17.3	26.0	23.5	11.5
Dujuma	0				0.1	0.1	0.1			0	0.1	0.2
Sub-total	2.5	0.7	0.3	0.1	11.1	21.9	19.5	10.6	17.7	27.4	26.5	15.7
Kaitoi to Kamsuma												
Small schemes	37.3	33.2	36.5	17.2	17.8	21.4	22.8	25.8	28.0	29.0	24.4	30.6
Fanoole-Gelib	12.8	2.0	1.7	1.1	10.4	19.6	18.2	9.9	13.7	23.2	24.6	24.2
Fanoole-Homboy	9.3				8.8	20.2	16.6	5.7	15.4	31.1	29.1	23.3
Juba Sugar	66.7	61.8	75.0	46.5	44.6	44.4	42.1	50.1	57.2	61.0	52.6	58.7
Sub-total	126.1	97.0	113.2	64.8	81.6	105.6	99.7	91.5	114.3	144.3	130.7	136.8
Below Kamsuma												
Trans-Juba	2.3	2.2	2.5	1.0	1.0	1.2	1.3	1.6	1.9	1.9	1.4	1.8
Mogambo	2.6			8.2	17.4	12.0	10.4	4.1	8.8	9.5	12.2	12.6
Jamama cotton	4.1							0.9	5.7	8.2	6.8	7.3
Ionte	0.5	0.5	0.5	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.3	0.4
Kismayo water	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Residual flow	26.8	24.4	26.8	25.9	26.8	25.9	26.8	26.8	25.9	26.8	25.9	26.8
Sub-total	36.4	27.2	29.9	35.4	45.5	39.5	38.9	33.8	42.8	46.9	46.7	49.0
TOTAL	165.0	124.9	143.4	100.3	138.2	167.0	158.1	135.9	174.8	218.6	203.9	2 01.5

TABLE 3.10

Incremental Water Use on Juba River to 1990 (Mm^3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(a) by 1980												
Above Kaitoi	0.4	0.1	0	0	0.3	0.7	0.6	0.2	0	0.2	0.5	0.6
Kaitoi-Kamsuma	16.8	13.9	16.1	9.6	11.0	13.3	13.3	13.0	14.2	16.2	14.9	6.6
Kamsuma-Mogambo	0	0	0	0	0	0	0	0	0	0	0	0
Below Mogambo	0.6	0.6	0.6	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.4	0.5
Total	17.8	14.6	16.7	9.9	11.6	14.4	14.3	13.6	14.7	16.9	15.8	7.7
(b) by 1985												
Above Kaitoi	0.9	0.3	0.1	0	9.6	19.1	16.9	10.0	17.5	26.5	24.5	12.9
Kaitoi-Kamsuma	86.0	66.3	78.5	44.5	55.7	71.2	66.0	61.7	78.6	100.1	90.8	85.3
Kamsuma-Mogambo	1.1	1.1	1.2	0.5	0.5	0.6	0.6	0.8	0.9	0.9	0.7	0.9
Mogambo	2.6	0	0	8.2	17.5	12.0	10.5	4.1	8.8	9.5	12.2	12.6
Below Mogambo	31.5	25.0	27.4	26.2	27.2	26.3	27.2	28.1	32.1	35.5	33.1	34.6
Total	122.1	92.7	107.3	79.4	110.5	129.4	121.2	104.7	137.9	172.5	161.3	146.3
(c) by 1990												
Above Kaitoi	0.9	0.3	0.1	0	9.6	19.1	16.9	10.0	17.5	26.5	24.5	12.9
Kaitoi-Kamsuma	106.3	80.7	96.1	55.4	70.6	91.7	84.1	76.2	99.7	129.9	117.7	110.6
Kamsuma-Mogambo	2.3	2.2	2.5	1.0	1.0	1.2	1.3	1.6	1.9	1.9	1.4	1.8
Mogambo	2.6	0	0	8.2	17.5	12.0	10.5	4.1	8.8	9.5	12.2	12.6
Below Mogambo	31.5	25.0	27.4	26.2	27.1	26.3	27.3	28.1	32.1	35.5	33.1	34.6
Total	143.6	108.2	126.1	90.8	125.8	150.3	140.1	120.0	160.0	203.3	188.9	172.5

CHAPTER 4

RIVER FLOW AVAILABILITY

4.1 Introduction

The principal gauging station on the River Juba within Somalia is at Lugh Ganana. The use of records from this station to estimate flows in the coastal area suffers from the long length of river, some 680 km, between Lugh Ganana and the sea. Although reasonably accurate assessments can be made of the higher flows which occur during the main rainfall seasons, low flows during the period January to March/April are extremely difficult to estimate. Past studies (see Section 4.2) have made use of correlations obtained between Lugh Ganana flows and short period records at stations on the coastal plain. Even so the low flows derived by such procedures are subject to a wide range of error and have indicated that the river fluctuates between reaches from effluent to influent conditions. Such fluctuations during the dry season are more likely to reflect deficiencies in the rating curves at low flow and/or the poor reliability obtained from fitting regression equations to the derived flows. As a result, flows at Kamsuma have been estimated employing all the available data and making full use of previous studies. In particular, the correlation of low flow data has been assessed separately from the complete data set.

The use of monthly flows to calculate water availability is suitable for most months in the year: the exception is April when the river starts to rise following the gu season rains. The use of a monthly mean flow for April tends to hide the fact that flows at the beginning of April are generally much lower than at the end of the month.

In view of the proposed cropping patterns and the importance of water availability for planting rice in April, a probability study of the timing of the gu flood has been made.

Future irrigation requirements upstream of Kamsuma will increase substantially with the completion of ongoing and planned projects. Comparisons are made of future requirements and water availabilites for the unregulated river. Previous work on Bardheere reservoir is also reviewed and it is concluded that the reservoir can supply sufficient water to meet all irrigation development in the Juba basin for the foreseeable future.

4.2 Existing Flow Estimates

In the Inter-Riverine Agricultural Study (HTS, 1977), Juba river flows published by Selchozpromexport (1965) were adopted since the alternative data (Lockwood/FAO, 1968) were suspect due to an apparent anomalous extension to the rating curve for Lugh Ganana. Signficant differences arose between the two data sets for flows in excess of 400 m^3/s, with the Selchozpromexport (1965) data giving higher values (p 14 - 16, Annex A, HTS, 1977). However, recent flow measurements (MMP, 1978) indicate that the rating curve at Lugh Ganana prepared by Selchozpromexport (1965 & 1973) overestimates flow at high stages. In view of this and other factors discussed later in this section, it was decided to analyse both the Selchozpromexport and the Lockwood/FAO results before arriving at estimates of low flow reliability at Kamsuma.

TABLE 4.1

Monthly River Juba Flows at Lugh Ganana in Mm^3 (after Selchozpromexport, 1965)

AR	JAN.	FEB.	MAR.	APR.	MAY.	JUNE.	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
51	214.54	77.90	40.98	808.70	1564.19	593.57	401.76	878.52	572.83	1556.15	1236.38	648.17	8593.68
52	158.83	21.55	9.64	145.67	597.28	208.66	270.52	618.71	982.37	1609.72	787.97	98.57	5509.47
53	22.23	8.23	8.30	67.39	436.58	166.15	645.49	1173.14	414.72	610.68	865.73	141.42	4560.05
54	39.37	8.23	7.50	549.50	519.61	378.43	723.17	1315.09	1327.10	1574.90	352.51	213.47	7008.88
55	39.37	32.18	9.91	66.87	227.40	29.03	129.10	519.61	694.66	1119.57	482.11	114.64	3464.44
56	55.44	29.06	10.98	214.88	642.82	261.79	369.62	841.02	2210.98	2073.08	730.94	160.70	7601.31
57	44.73	20.08	130.17	136.86	1039.22	705.02	602.64	602.64	393.98	524.97	686.88	441.94	5329.12
58	71.78	87.58	49.82	57.80	324.09	173.40	878.52	1226.71	1132.70	1285.63	886.46	506.22	6680.70
59	151.60	20.32	13.12	67.65	565.14	544.32	519.61	557.11	1181.95	1518.65	1397.09	261.14	6797.71
60	80.35	308.19	950.83	80.87	13.12	412.13	358.91	412.47	585.79	760.67	406.94	40.71	4410.98
61	48.48	30.24	32.94	448.42	610.68	443.23	613.35	1382.05	1054.94	1700.78	2073.60	1253.49	9692.21
62	212.40	48.38	34.55	129.86	514.25	103.68	192.31	468.72	642.82	1325.81	733.54	313.37	4719.68
63	85.71	29.76	29.46	720.58	1347.23	383.62	353.55	404.44	321.41	495.50	489.89	704.42	5365.56
64	214.27	71.66	33.75	97.46	201.68	254.53	263.55	723.17	637.63	1365.98	-999.00	-999.00	-999.00
AN	102.79	56.67	97.28	256.61	614.52	332.68	451.58	794.53	868.13	1251.58	856.16	376.79	6133.37
V	0.70	1.35	2.55	1.02	0.70	0.59	0.48	0.44	0.58	0.39	0.56	0.90	0.29
EW	0.69	3.09	3.64	1.29	1.05	0.35	0.41	0.61	1.53	-0.33	1.55	1.58	0.55

SUM OF MONTHLY MEANS = 6059.31

NOTE: -999 INDICATES A MISSING VALUE

TABLE 4.1 (cont.)

UES EQUALLED OR EXCEEDED 50.PERCENT OF THE TIME (NOT AN HOMOGENEOUS SEQUENCE)

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
)	76	30	31	133	542	320	386	671	669	1346	734	261	5509

UES EQUALLED OR EXCEEDED 75.PERCENT OF THE TIME (NOT AN HOMOGENEOUS SEQUENCE)

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
)	44	20	10	68	318	173	270	516	563	751	487	133	4670

UES EQUALLED OR EXCEEDED 80.PERCENT OF THE TIME (NOT AN HOMOGENEOUS SEQUENCE)

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
)	41	20	10	67	249	168	265	480	450	644	482	115	4564

UES EQUALLED OR EXCEEDED 90.PERCENT OF THE TIME (NOT AN HOMOGENEOUS SEQUENCE)

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
)	36	8	8	65	164	89	180	411	379	519	391	81	4127

Monthly River Juba Flows at Lugh Ganana in Mm^3 (after Selchozpromexport, 1973)

R	JAN.	FEB.	MAR.	APR.	MAY.	JUNE.	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1	205.17	95.32	75.80	793.15	1561.51	572.83	383.01	841.02	565.06	1558.83	1226.02	645.49	8523.19
2	172.22	49.36	34.02	156.63	591.93	203.99	260.34	610.68	982.37	1612.40	785.38	117.05	5578.34
3	53.30	30.00	31.34	81.91	433.90	173.92	640.14	1167.76	409.54	599.96	852.77	153.74	4628.29
4	68.30	29.76	29.19	546.91	516.93	362.88	720.49	1309.74	1321.92	1577.58	347.33	216.68	7047.70
5	70.98	59.27	33.75	84.24	233.02	59.10	135.53	506.22	689.47	1119.57	471.74	124.81	3587.70
6	85.17	58.88	34.28	226.28	634.78	255.83	361.58	843.70	886.46	2105.22	728.35	165.53	6386.07
7	75.53	48.38	149.99	149.82	996.36	697.25	589.25	680.31	381.02	522.29	676.51	439.26	5405.98
8	96.96	100.64	76.07	71.80	318.73	1734.05	873.16	1274.92	1171.58	1240.10	819.07	618.71	8395.78
9	166.06	47.66	40.71	102.38	554.43	528.77	508.90	565.14	1179.36	1499.90	1371.17	264.63	6829.10
0	103.12	438.48	1151.71	102.64	40.71	456.19	645.49	455.33	580.61	749.95	990.14	597.28	6311.66
1	79.55	60.00	65.09	585.79	602.64	422.50	602.64	1379.36	1052.35	1698.11	2094.34	1256.17	9898.53
2	210.52	71.37	60.53	145.15	506.22	119.75	193.38	463.36	609.12	1360.63	728.35	308.02	4776.40
3	48.75	38.71	55.71	733.54	1341.88	453.60	340.16	391.05	316.22	487.47	489.89	696.38	5393.34
4	216.68	92.96	65.09	149.04	203.02	251.16	265.70	677.64	635.04	1365.98	816.48	374.98	5113.76
5	340.16	90.72	23.44	28.25	80.62	35.51	66.42	131.51	234.58	1671.32	1283.04	524.97	4510.53
6	136.33	75.48	86.78	195.44	562.46	391.39	337.48	495.50	899.42	691.03	715.39	259.80	4846.51
7	79.28	56.61	69.91	211.77	677.64	131.67	447.29	1020.47	868.32	1848.10	2034.72	854.41	8300.16
8	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00
9	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	430.27	154.54	-999.00
0	163.11	136.93	281.23	629.86	503.54	855.36	458.01	658.89	969.41	1730.25	1353.02	195.79	7935.39
1	97.23	66.77	73.66	156.30	522.29	422.50	610.68	567.82	637.63	1596.33	1052.35	329.44	6132.98
2	138.21	118.26	143.56	292.90	822.27	562.46	586.57	685.67	596.16	881.19	1065.31	361.58	6254.15
3	143.56	76.69	51.96	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00
[illegible]	130.96	87.73	125.42	272.29	585.24	434.54	451.31	736.30	749.28	1295.81	968.17	412.35	6292.77
	0.54	0.97	1.93	0.88	0.64	0.86	0.46	0.46	0.41	0.37	0.48	0.70	0.26
[illegible]	1.34	3.82	4.19	1.18	1.13	2.31	-0.01	0.57	0.15	-0.40	1.12	1.43	0.53

UM OF MONTHLY MEANS = 6249.39

OTE: -999 INDICATES A MISSING VALUE

TABLE 4.2 (cont.)

S EQUALLED OR EXCEEDED 50.PERCENT OF THE TIME (NOT AN HOMOGENEOUS SEQUENCE)

JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
103	67	65	157	538	407	453	668	664	1433	819	329	6194

S EQUALLED OR EXCEEDED 75.PERCENT OF THE TIME (NOT AN HOMOGENEOUS SEQUENCE)

JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
78	49	34	102	369	187	297	500	572	807	703	186	4963

S EQUALLED OR EXCEEDED 80.PERCENT OF THE TIME (NOT AN HOMOGENEOUS SEQUENCE)

JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
74	48	34	92	269	150	263	477	476	716	607	161	4806

S EQUALLED OR EXCEEDED 90.PERCENT OF THE TIME (NOT AN HOMOGENEOUS SEQUENCE)

JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
61	34	30	76	130	83	159	417	342	553	451	139	4558

Pre-1963 flows published by Selchozpromexport (1965) for Kaitoi were based on a correlation between 1963/64 flows at Lugh Ganana and Kaitoi which was then used to process pre-1963 flows recorded at Lugh Ganana. The linear regression equation relating flows at Kaitoi and Lugh Ganana was:-

$$Q_K = 1.14\, Q_L + 0.46\ m^3/s \quad \text{(HTS, 1977)}$$

A summary table of monthly flows at Kaitoi has been published by HTS (1977) (Table 2.2, Annex A of the HTS report)

Since then a further report (Selchozpromexport, 1973) has become available in which the original data for Lugh Ganana (1951/62) are superseded resulting in substantial increases in low flows during the months of January to April (see Tables 4.1 and 4.2). Derived Kaitoi flows using these later data are included in the report, HTS (1978), together with recorded data for 1963/65 and 1972/75. The derived data, 1951/62 and 1966/71 were based on a linear regression equation fitted to 33 measured monthly river flows at Kaitoi and Lugh Ganana:-

$$Q_K = 0.99\, Q_L + 8.49\ m^3/s$$

A comparison between the mean, minimum and maximum monthly flows at Kaitoi published by HTS (1977) and HTS (1978) is given in Table 4.3

TABLE 4.3

Previous Estimates of Flows at Kaitoi Based on Data Prepared by Selchozpromexport (1965 and 1973) (Mm^3)

Flow statics	Jan	Feb	Mar	Apr	Source
Mean	114	66	99	241	HTS (1977)
Maximum	265	350	1 090	925	
Minimum	26	9	9	25	
Mean	143	94	130	263	HTS (1978)
Maximum	340	438	1 152	807	
Minimum	35	23	22	25	

The differences in flow exhibited in Table 4.3 are predominantly due to changes in flow at Lugh Ganana introduced by Selchozpromexport (1973).

The reason for Selchozpromexport's re-evaluation of flow at Lugh Ganana is not known but there is no apparent change in the rating curve published in both reports. Without information additional to that provided in the reports it is not possible to comment on the validity of the changes.

Because of the importance of low flows to the viability of the Mogambo scheme and the uncertainties introduced in the existing flow estimates, low flows at Kamsuma have been calculated using the Lockwood/FAO (1965) results and recently collected data, as well as that published by Selchozpromexport.

4.3 Estimation of Flows at Kaitoi and Kamsuma

(i) Selchozpromexport (1973) Data

Selchozpromexport (1973) has published monthly flows at Kaitoi for the periods January 1963 to March 1965 and August 1972 to March 1973 based on separate rating curves. The two rating curves are almost identical, suggesting that changes in the bed have been minimal over the intervening period.

To extend the data base, flows at Kaitoi were correlated with those from Lugh Ganana (see also HTS, 1978). The revised analysis contained in this report allows for the fitting of a separate regression equation to flows below 50 m^3/s. The data suggest that during periods of low flow, losses occur as the river flows through the coastal plain to the sea. The three regression equations fitted to the two data sets were:-

$$Q_K = 1.33\, Q_L - 13.3\ (m^3/s) \text{ for } Q_L < 90\ m^3/s$$

$$Q_K = 0.943\, Q_L + 22.0\ (m^3/s) \text{ for } 90 \leq Q_L \leq 660\ m^3/s$$

$$Q_K = 16.0\, Q_L^{0.569} \text{ for } Q_L > 660$$

The relationships for the low flow data set suggest that losses of the order of 10 m^3/s occur at extreme low flows between Lugh Ganana and Kaitoi. This amount seems rather high as monthly irrigation abstractions above Kaitoi are small and unlikely to exceed 1 m^3/s, whilst evaporation/transpiration losses from the water surface and the fringe vegetation are estimated to amount to less than 7 m^3/s. A plot of the data set and low flow regression equations is given in Figure 4.1, whilst the derived flows at Kaitoi, using the above regression equations, are given in Table 4.4.

A similar exercise was undertaken to relate flows at Kaitoi to those at Kamsuma. Recorded monthly flows at Kaitoi and Kamsuma (Selchozpromexport, 1973) for the period September 1972 to March 1973 were correlated and regression equations fitted to concurrent values. The two regression equations obtained were:-

$$Q_{KAM} = 1.13\, Q_K - 3.3\ (m^3/s) \text{ for } Q_K < 340\ m^3/s$$

$$Q_{KAM} = 13.85\, Q_K^{0.569}\ (m^3/s) \text{ for } Q_K \geq 340$$

The implications are that losses occur in low flow between Kaitoi and Kamsuma. In this case the loss is about 3 m^3/s and this is reasonably consistent when compared with irrigation abstractions in this stretch of the River Juba.

Use has been made of the two regression equations to convert the Kaitoi flows given in Table 4.4 to flows at Kamsuma (see Table 4.6 and Figure 4.2).

Monthly River Juba Flows at Kaitoi in Mm^3 (based on regression equations shown in Figure 4.1)

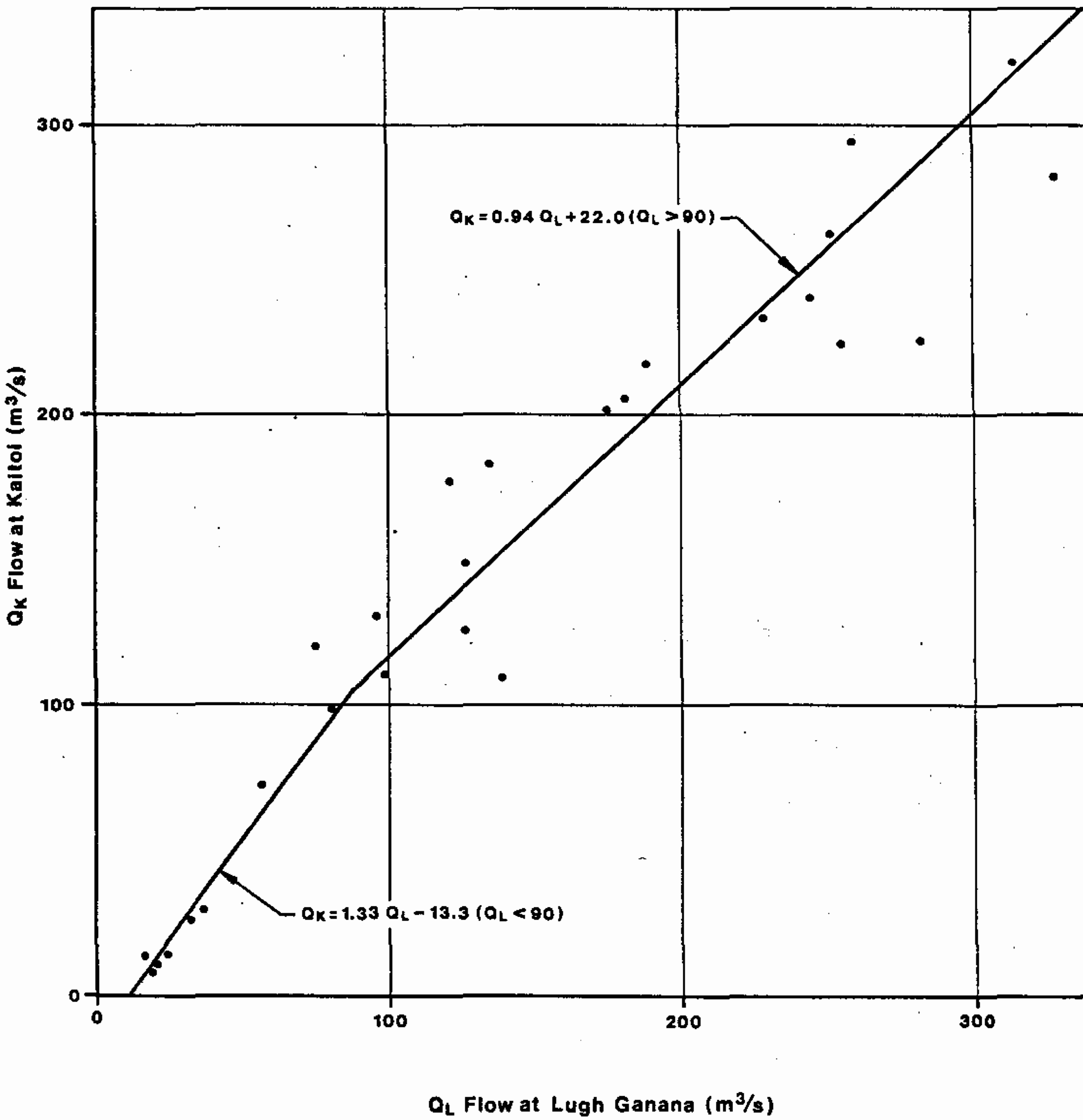
AR	JAN.	FEB.	MAR.	APR.	MAY.	JUNE.	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
51	237.76	94.81	65.33	804.97	1531.43	597.20	420.11	852.00	589.86	1528.91	1213.16	667.62	8603.14
52	193.86	32.40	9.64	176.90	617.10	237.35	304.43	634.76	983.40	1579.40	797.64	120.31	5687.22
53	35.33	7.74	6.05	74.62	468.08	197.28	662.58	1160.15	443.23	624.68	861.19	169.22	4710.16
54	55.34	7.40	3.21	572.75	546.39	399.22	738.35	1294.01	1303.59	1546.59	384.55	253.14	7104.55
55	58.90	46.74	9.27	77.73	274.91	44.22	144.95	536.30	707.20	1114.67	501.89	130.68	3647.46
56	77.81	45.08	9.99	267.08	657.52	298.26	399.91	854.52	892.97	1903.22	743.85	184.92	6335.12
57	64.98	32.25	164.24	165.16	998.51	714.54	614.59	700.45	416.33	551.43	694.97	473.14	5590.57
58	93.53	101.90	65.70	61.15	359.49	1680.42	882.32	1261.18	1161.84	1228.34	829.41	642.36	8367.63
59	185.64	31.28	18.56	101.92	581.75	555.65	538.81	591.85	1169.15	1473.33	1350.02	308.47	6906.42
60	101.75	468.62	1144.99	102.25	18.56	487.22	667.62	488.30	604.53	766.13	990.74	622.17	6462.88
61	70.33	47.73	51.05	609.43	627.20	455.44	627.20	1359.69	1049.40	1660.23	1870.98	1243.50	9672.19
62	244.91	62.87	44.97	156.94	536.30	125.06	222.07	495.88	631.41	1342.01	743.85	349.37	4957.65
63	73.66	31.45	30.53	583.20	1537.40	520.99	396.40	460.68	456.19	549.07	562.02	787.45	5989.05
64	264.63	75.67	38.57	187.14	321.41	336.96	294.62	701.74	622.08	1274.92	832.03	291.95	5241.71
65	334.80	77.41	37.50	3.11	71.75	12.78	52.82	139.60	278.23	1634.98	1266.92	553.97	4463.86
66	146.03	68.37	79.98	225.97	589.33	426.10	377.17	526.17	905.18	710.55	731.64	303.92	5090.40
67	69.96	43.21	57.48	247.72	697.94	140.95	480.72	1021.22	875.86	1767.26	1840.50	864.64	8107.46
68	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00
69	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	462.78	170.29	-999.00
70	181.73	150.28	324.14	650.98	533.75	863.63	490.82	680.26	971.17	1690.55	1332.94	225.28	8095.52
71	93.88	56.75	62.46	173.79	551.43	455.44	634.78	594.39	658.32	1564.27	1049.40	369.59	6264.50
72	148.52	124.23	155.67	333.23	834.32	587.42	612.07	608.00	614.30	760.67	1073.09	484.79	6336.30
73	158.56	63.14	27.32	25.06	112.33	226.46	275.45	639.28	783.82	1042.51	641.00	222.66	4217.60
74	64.01	26.88	22.20	266.79	272.69	432.60	395.63	464.35	675.92	501.37	408.24	128.21	3658.90
75	34.55	22.81	23.76	66.43	312.52	316.82	396.40	807.32	746.94	764.82	609.82	299.28	4401.47
IN	130.02	74.74	106.64	256.10	567.48	439.65	462.17	733.57	762.65	1199.13	908.02	411.12	6083.11
	0.63	1.24	2.23	0.88	0.68	0.78	0.43	0.42	0.35	0.38	0.45	0.68	0.27
W	0.93	3.75	4.18	1.13	1.25	2.20	-0.01	0.64	0.28	-0.21	1.01	1.38	0.46

UM OF MONTHLY MEANS = 6053.28

OTE: -999 INDICATES A MISSING VALUE

Mar 1973-1975 (Booker-McConnell, 1976)

Relationship between flows at Kaitoi and Lugh Ganana (low flows) 4.1



Data derived from rating curves 1963/65 and 1972/73
(Selchozpromexport 1973)

TABLE 4.4 (cont.)

.UES EQUALLED OR EXCEEDED 50.PERCENT OF THE TIME (NOT AN HOMOGENEOUS SEQUENCE)

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
l)	94	48	39	177	546	426	420	639	707	1275	814	306	5989

.UES EQUALLED OR EXCEEDED 75.PERCENT OF THE TIME (NOT AN HOMOGENEOUS SEQUENCE)

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
:)	66	32	19	82	314	229	318	528	606	761	623	201	4757

.UES EQUALLED OR EXCEEDED 80.PERCENT OF THE TIME (NOT AN HOMOGENEOUS SEQUENCE)

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
)	64	31	10	75	276	198	295	497	590	712	573	174	4470

UES EQUALLED OR EXCEEDED 90.PERCENT OF THE TIME (NOT AN HOMOGENEOUS SEQUENCE)

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
)	49	18	8	50	100	101	199	463	435	551	452	130	4050

TABLE 4.6

Monthly River Juba Flows at Kamsuma in Mm^3 (based on regression equations shown in Figure 4.2)

AR	JAN.	FEB.	MAR.	APR.	MAY.	JUNE.	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
51	259.94	99.24	65.09	901.16	1374.63	666.38	465.99	954.02	658.08	1373.35	1187.06	745.67	8750.59
52	210.33	23.44	2.17	191.45	688.59	259.74	335.28	708.57	1053.39	1398.95	892.87	127.22	5897.00
53	31.18	0.87	0.00	75.87	520.20	214.46	739.99	1173.73	492.40	697.16	964.69	182.48	5093.02
54	53.81	0.43	0.00	638.77	608.69	442.66	825.62	1248.99	1236.64	1382.35	426.10	277.32	7141.44
55	57.83	44.92	1.74	79.39	301.91	41.52	155.08	597.28	790.69	1147.32	558.68	138.93	3915.30
56	79.20	42.77	2.54	293.36	734.26	328.59	443.17	956.88	997.14	1555.59	832.11	200.24	6465.85
57	64.68	28.55	176.85	176.17	1077.68	798.98	685.75	782.79	462.00	614.37	776.87	525.90	6172.61
58	96.96	107.27	65.51	60.65	397.50	1428.87	988.28	1230.86	1158.23	1212.51	928.79	717.14	8392.57
59	201.04	27.46	12.24	106.71	648.65	619.44	600.12	660.06	1162.36	1344.69	1261.50	339.84	6984.11
60	106.25	521.37	1165.00	107.10	12.24	542.12	745.67	543.05	674.67	857.01	1057.85	694.32	7026.63
61	70.74	46.04	48.96	680.22	700.00	506.19	700.00	1284.67	1093.05	1439.26	1518.91	1221.00	9309.03
62	268.03	63.17	42.08	171.15	597.28	132.87	242.21	551.62	705.05	1275.13	832.11	386.06	5266.75
63	74.49	27.65	25.77	650.57	1377.66	580.27	439.20	511.84	507.05	611.72	626.64	881.09	6313.94
64	290.28	77.35	34.85	203.03	354.46	372.31	324.19	784.24	694.50	1238.46	931.75	321.17	5626.59
65	369.59	79.59	33.64	0.00	72.34	5.99	50.94	149.03	305.93	1426.76	1216.71	617.26	4327.79
66	156.28	69.36	81.64	246.89	657.20	473.04	417.48	585.85	1004.87	794.20	818.32	334.69	5639.81
67	70.33	40.93	56.22	271.46	779.95	150.83	534.47	1091.58	981.28	1491.33	1504.79	968.32	7941.50
68	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00
69	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	514.49	183.71	-999.00
70	196.62	161.94	357.54	727.16	594.42	967.44	545.88	759.97	1045.92	1454.16	1252.40	245.82	8309.27
71	97.36	56.25	61.84	187.95	614.37	506.19	708.57	662.93	735.45	1391.32	1093.05	408.91	6524.19
72	159.10	132.22	167.19	368.09	934.04	655.34	682.91	678.30	694.66	827.63	1122.34	565.14	6986.94
73	171.15	62.17	22.90	5.44	115.09	238.98	274.13	690.68	870.91	1033.86	728.35	249.09	4462.77
74	104.46	45.96	26.78	305.86	321.41	518.40	460.68	530.32	754.27	605.32	482.11	176.77	4332.35
75	69.64	29.03	8.04	49.25	385.69	401.76	452.65	878.52	855.36	846.37	689.47	275.83	4941.65
AN	141.71	77.96	106.89	282.60	602.97	471.84	513.84	783.29	823.21	1131.25	925.75	449.33	6340.07
[illegible]	0.64	1.34	2.28	0.91	0.59	0.67	0.44	0.36	0.30	0.29	0.33	0.65	0.24
W	0.98	3.79	4.07	1.11	0.57	1.19	-0.04	0.17	-0.20	-0.47	0.25	1.08	0.26

UM OF MONTHLY MEANS = 6310.64

OTE: -999 INDICATES A MISSING VALUE

Mar 73-Dec 75 (Booker-McConnell, 1976)

TABLE 4.5

Data Sources for Deriving Juba Flows at Kaitoi and Kamsuma

River gauging station	Period (inclusive)	Data	Source
Lugh Ganana	Jan 1951 - Dec 1967 Nov 1969 - Mar 1973	Average monthly river flows	Selchozpromexport, 1973
	Nov 1969 - Mar 1973	Average monthly river flows	Selchozpromexport, 1973
Kaitoi	Feb 1963 - Mar 1965	Average monthly river flows	Selchozpromexport, 1973
	Aug 1972 - Mar 1973	Average monthly river flows	Selchozpromexport, 1973
	Mar 1973 - Dec 1975	Daily river flows	Booker - McConnell, 1976
Kamsuma	Mar 1973 - Dec 1975	Daily river flows	Booker - McConnell, 1976

(ii) Lockwood/FAO (1968) Data

As an alternative approach to the use of Selchozpromexport 1973 data, flows estimated by Lockwood/FAO (1968) for Jamama have been analysed to prepare a record of flow at Kamsuma. Before 1963 no water level data were available for Jamama and Lockwood/FAO (1968) constructed a 'discharge relations' curve correlating flows at Lugh Ganana with those at Jamama. Flows at Jamama were derived by Lockwood/FAO (1968) for the period January 1951 to December 1965. To up-date this record, available river stage data for the period 1966-1976 were reduced using the stage/discharge relationship from Lockwood/FAO (1968) to give daily and monthly mean flow. Table 4.7 summarises the sources of the composite record which is reproduced in Table 4.8.

TABLE 4.7

Data Sources for Deriving Juba Flow at Jamama

River gauging station	Period (inclusive)	Data	Source
Jamama (Giamama)	Jan 1951 - Dec 1964	Average monthly flows	Lockwood/FAO, 1968
	Jan 1965 - Dec 1965 Apr 1970 - Oct 1970 Jun 1976 - Dec 1976	Daily gauge levels	Ministry of Agriculture
	Jan 1973 - Dec 1975		Selchozpromexport
	Jan 1972 - Dec 1972		Unknown

TABLE 4.6 (cont.)

ALUES EQUALLED OR EXCEEDED 50.PERCENT OF THE TIME (NOT AN HOMOGENEOUS SEQUENCE)

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
(I)	104	46	35	191	609	473	466	709	791	1238	911	337	6314

ALUES EQUALLED OR EXCEEDED 75.PERCENT OF THE TIME (NOT AN HOMOGENEOUS SEQUENCE)

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
(I)	70	29	9	85	360	243	351	588	678	831	706	220	5126

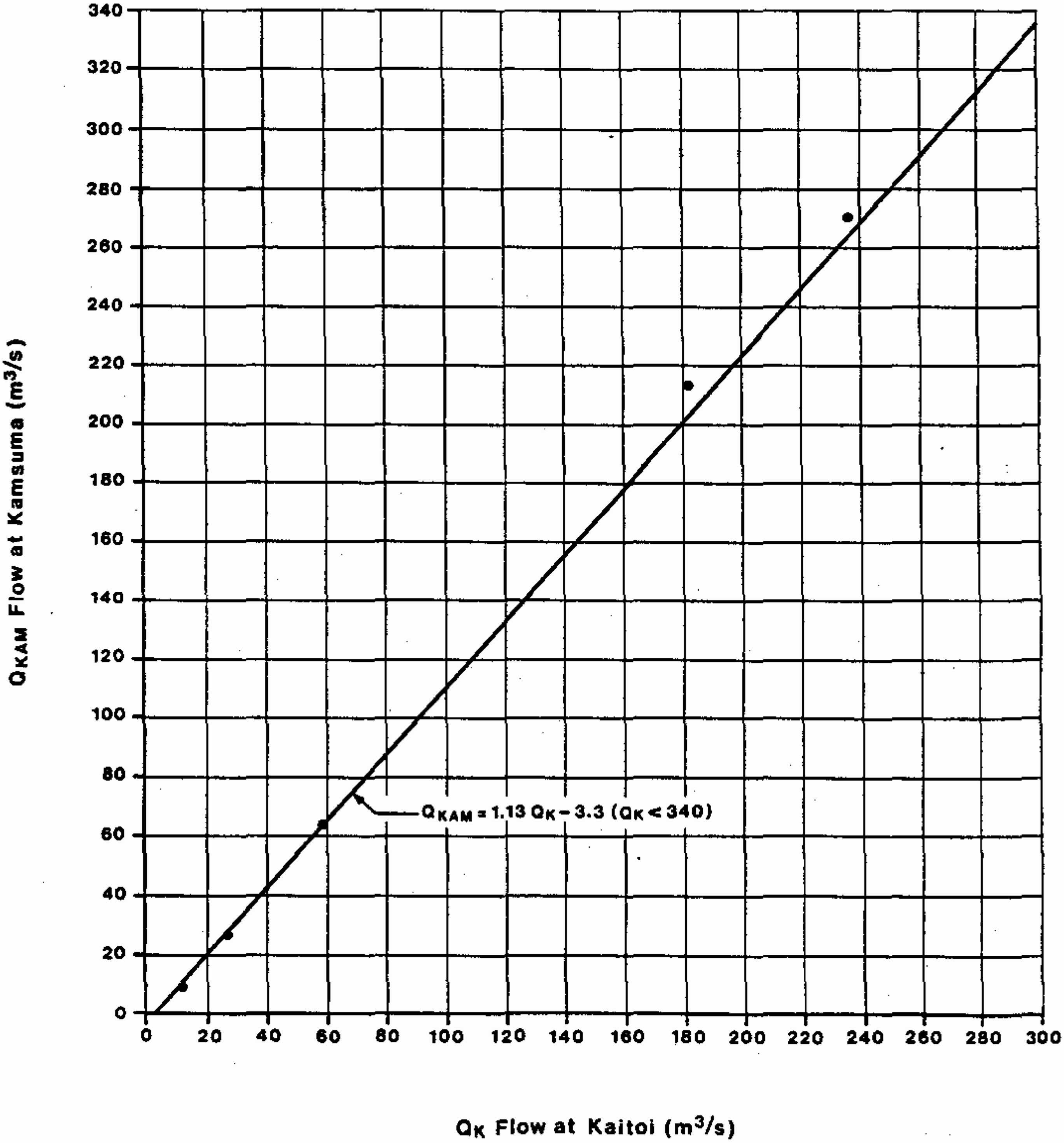
ALUES EQUALLED OR EXCEEDED 80.PERCENT OF THE TIME (NOT AN HOMOGENEOUS SEQUENCE)

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
(I)	70	28	3	76	322	215	324	552	658	795	641	187	4945

ALUES EQUALLED OR EXCEEDED 90.PERCENT OF THE TIME (NOT AN HOMOGENEOUS SEQUENCE)

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
(I)	57	19	1	36	102	105	216	525	483	614	508	169	4331

Relationship between flows at Kaitoi and Kamsuma (low flows) 4.2



Data source Selchozpromexport (1973)

TABLE 4.8

Monthly River Juba Flows at Jamama in Mm^3 (based on Lockwood/FAO, 1968 and reduced daily stage records for 1965-76)

R	JAN.	FEB.	MAR.	APR.	MAY.	JUNE.	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1	308.00	96.00	30.00	679.00	1027.00	761.00	436.00	740.00	621.00	933.00	1005.00	780.00	7416.00
2	255.00	24.00	8.00	75.00	566.00	362.00	241.00	569.00	845.00	1070.00	862.00	240.00	5117.00
3	17.00	6.00	6.00	18.00	461.00	228.00	559.00	911.00	498.00	535.00	820.00	292.00	4351.00
4	44.00	6.00	6.00	444.00	547.00	425.00	596.00	1057.00	993.00	1191.00	537.00	338.00	6184.00
5	46.00	27.00	7.00	37.00	314.00	34.00	134.00	461.00	680.00	894.00	582.00	208.00	3424.00
6	65.00	25.00	9.00	97.00	630.00	397.00	371.00	700.00	838.00	987.00	871.00	270.00	5260.00
7	49.00	14.00	151.00	200.00	793.00	777.00	537.00	695.00	467.00	446.00	767.00	535.00	5431.00
8	123.00	78.00	89.00	15.00	388.00	273.00	629.00	1087.00	972.00	978.00	899.00	396.00	5927.00
9	270.00	19.00	7.00	7.00	454.60	500.00	551.00	601.00	693.00	836.00	1049.00	421.00	5408.00
0	103.00	192.00	699.00	212.00	7.00	392.00	462.00	395.00	579.00	562.00	849.00	787.00	5239.00
1	157.00	23.00	26.00	270.00	708.00	448.00	569.00	1022.00	937.00	864.00	1169.00	1100.00	7293.00
2	365.00	111.00	18.00	136.00	535.00	151.00	271.00	428.00	663.00	985.00	878.00	403.00	4944.00
3	34.00	6.00	13.00	393.00	1143.00	555.00	420.00	443.00	470.00	477.00	459.00	727.00	5140.00
4	290.00	94.00	24.00	158.00	322.00	306.00	284.00	604.00	604.00	992.00	780.00	303.00	4761.00
5	367.50	81.96	34.71	19.26	151.01	68.22	95.86	185.45	298.81	823.18	1187.65	683.77	3997.36
	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00
	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00
	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00
	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00
	-999.00	-999.00	-999.00	521.56	1049.50	607.12	782.76	664.48	979.26	1222.48	-999.00	-999.00	-999.00
	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00	-999.00
	221.45	113.48	134.72	159.36	903.24	799.42	641.34	689.90	740.79	867.72	1128.87	609.15	7009.44
	199.59	83.68	37.52	17.68	135.47	276.33	313.35	745.18	938.07	1066.78	843.18	286.70	4943.53
	106.33	53.08	17.76	297.41	321.62	529.88	451.69	540.82	760.10	641.05	498.93	180.90	4399.57
	65.14	21.10	0.80	41.08	378.59	400.88	478.09	898.47	888.28	896.22	-999.00	-999.00	-999.00
	-999.00	-999.00	-999.00	-999.00	1272.13	915.26	647.45	647.80	630.50	435.13	619.23	435.13	-999.00
	162.42	56.54	69.40	189.87	576.50	438.39	450.98	670.72	718.85	842.98	831.83	473.45	5346.94
	0.73	0.89	2.28	1.01	0.60	0.54	0.40	0.35	0.27	0.28	0.26	0.52	0.20
	0.46	1.12	3.87	1.20	0.46	0.30	-0.34	0.11	-0.28	-0.44	-0.08	1.02	0.51

TABLE 4.8 (cont.)

ALUES EQUALLED OR EXCEEDED 50.PERCENT OF THE TIME (NOT AN HOMOGENEOUS SEQUENCE)

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
(I)	123	27	18	147	535	401	462	664	693	894	849	403	5190

ALUES EQUALLED OR EXCEEDED 75.PERCENT OF THE TIME (NOT AN HOMOGENEOUS SEQUENCE)

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
(I)	52	19	7	27	322	275	304	516	596	616	647	288	4738

ALUES EQUALLED OR EXCEEDED 80.PERCENT OF THE TIME (NOT AN HOMOGENEOUS SEQUENCE)

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
(I)	47	15	7	19	319	256	279	454	549	552	590	274	4409

ALUES EQUALLED OR EXCEEDED 90.PERCENT OF THE TIME (NOT AN HOMOGENEOUS SEQUENCE)

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
(I)	37	6	6	16	143	110	188	412	469	462	510	218	4068

The Jamama gauge is sited some 26 km below Mogambo whilst the Kamsuma gauge is about 20 km upstream of Mogambo.

Monthly flows at Kamsuma for the period September 1972 to December 1975 (Booker-McConnell, 1976) were correlated with flows at Jamama and a linear regression equation obtained:

$$Q_{KAM} = 0.962Q_J - 0.4 \, (m^3/s)$$

$$\text{Coefficient of determination } (r^2) = 0.996$$

An inspection of the fit of the low flow in the above correlation indicated that there was little justification in adjusting the Jamama data to obtain estimates of flow at Kamsuma. In fact at low flows the regression equation would suggest a slight increment in flow between Kamsuma and Jamama. Although river abstractions in this reach (46 km) are small, some loss of flow would be expected during the low flow season of January to March/April.

It is suggested therefore that the low flows at Jamama provide as reasonable an estimate of Kamsuma flows as it is possible to make using the Lockwood/FAO data and recent stage information.

(iii) Conclusions

The hydrometric data available for estimating low flows at Mogambo are not sufficiently accurate or sensitive enough to provide reliable results. In these circumstances a range of low flows is presented from which it is speculative to decide which specific values should be given most credence.

The most reliable hydrometric data would appear to be those collected at Lugh Ganana. Indeed, this is the only station with water level records collected on a regular basis prior to 1963. However, the unexplained differences between low flows at Lugh Ganana quoted by Selchozpromexport (1965) and their subsequent report in 1973 throws some doubt on their validity. Despite this qualification, one approach to obtaining systematic and consistent results for low flows at locations between Lugh Ganana and the sea, is to reduce low flows recorded at Lugh Ganana during the recession period, to allow for losses due to direct abstractions and evapotranspiration.

This approach has an additional advantage in that the station is above the area of direct irrigation abstractions, so no allowance need to be made to adjust records to account for variations in abstractions during the period of the records.

Table 4.9 summarises the low flows estimated by the various approaches for monthly exceedence probabilities of 50, 75 and 80%. Cases I and II show the two sets of estimated flows at Lugh Ganana prepared by Selchozpromexport (1965 and 1973). Between Lugh Ganana and Kamsuma it is estimated, albeit rather crudely, that losses based on evapotranspiration and abstractions could be of the order of 20 Mm^3 per month during the period January to March. This amount can be compared with the maximum losses of around 33 Mm^3 deduced from the correlations between Lugh Ganana/Kaitoi and Kaitoi/Kamsuma.

TABLE 4.9

Comparison between River Juba Low Flow Estimates for Exceedence Probabilities of 50, 75 and 80%

Case Nr	Source	Period	Location	Exceedence probability (%)	Monthly Flow (Mm^3) Nov	Dec	Jan	Feb	Mar	Apr	Comment
I	Selchozpromexport (1965)	1951 - 1963	Lugh Ganana	50	734	261	76	30	31	133	-
II	Selchozpromexport (1973)	1951 - 1973	Lugh Ganana	50	819	329	103	67	65	157	excluding 1968, 1969
III	Selchozpromexport (1973)	1951 - 1975	Kamsuma	50	814	306	94	48	39	177	Correlation Lugh Ganana/ Kaitoi and Kaitoi/Kamsuma
IV	Lockwood/FAO (1968)	1951 - 1976	Jamama/Kamsuma	50	849	403	123	27	18	147	Lockwood/FAO, 1967 Jamama flows
I	Selchozpromexport (1965)	1951 - 1963	Lugh Ganana	75	487	133	44	20	10	68	
II	Selchozpromexport (1973)	1951 - 1973	Lugh Ganana	75	703	186	78	49	34	102	
III	Selchozpromexport (1973)	1951 - 1975	Kamsuma	75	623	201	66	32	19	82	
IV	Lockwood/FAO (1968)	1951 - 1976	Jamama/Kamsuma	75	647	288	52	19	7	27	
I	Selchozpromexport (1965)	1951 - 1963	Lugh Ganana	80	482	115	41	20	10	67	
II	Selchozpromexport (1973)	1951 - 1973	Lugh Ganana	80	607	161	74	48	34	92	
III	Selchozpromexport (1973)	1951 - 1975	Kamsuma	80	573	174	64	31	10	75	
IV	Lockwood/FAO (1968)	1951 - 1976	Jamama/Kamsuma	80	590	274	47	15	7	19	

TABLE 4.10

Estimates of 80% Reliable River Juba Flows at Kamsuma

(see Table 4.9) (Mm^3)

Source (Record)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lugh Ganana (Selchozpromexport, 1965)	21[(1)]	0[(1)]	0[(1)]	67	249	168	265	480	450	644	482	115
Lugh Ganana (Selchozpromexpect, 1973)	54[(1)]	28[(1)]	14[(1)]	92	269	150	263	477	476	716	607	161
Kamsuma correlation method (Figures 4.1 and 4.2)	64	31	10	75	276	198	295	497	590	712	573	174
Jamama (Table 4.8)	47	15	7	19	319	256	279	454	549	552	590	274
Mean 80% reliable flow (Mm^3)	47	19	8	64	278	193	276	477	516	656	563	181

Note: (1) Lugh Ganana flow less 20 Mm^3

The deduction of 20 Mm^3 from the January to March monthly flows at Lugh Ganana for cases I and II provides two sets of estimates for flow at Kamsuma. Combining these estimates with those obtained from the correlation approach (case III) and the Lockwood/FAO (1968) data for Jamama (case IV), it is clear that at the 80% reliability level it is not possible to guarantee a supply for the 1985 planning horizon during the months of January, February and March.

4.4 Available Water in April

River Juba flows usually start to rise during April following the onset of the gu rains, though the flows appear to be more dependent on rainfall falling in the upper catchment than over Somalia. Before this event the river flow remains low and water availability in early April is similar to that in March. In Section 4.5 it is shown that by the early 1980s there will be insufficient water in March to satisfy demand with an 80% security. The onset of the gu flood is therefore particularly important for the early planting of rice crops on which the proposed cropping pattern depends.

The timing of the increase in flows in the Juba is generally similar along its lower reaches and hence it is immaterial which lower Juba station is chosen for analysis. For this analysis, Kaitoi flows were selected.

The daily river flows were estimated from the hydrograph at Lugh Ganana (Lockwood/FAO, 1968) for the period 1951 to 1965 inclusive. The discharges on specified days in April (1, 5, 10, 15, 10, 25 and 30th) were extracted and related directly to those at Kaitoi using the correlation equation:

$$Q_K = 1.333\,Q_L - 13.33\ (m^3/s) \quad \text{for } Q_L < 90.0$$

The daily flows were then ranked and plotted on log-normal probability graph paper using the Weibull plotting formula (Figure 4.3). The probability of meeting the demand at the proposed planning horizons on that particular date was then determined.

Because of the rapid increase in flow with the onset of the gu flood, there is little difference in the probability of meeting demand at the two planning horizons. Both indicate a severe shortage of water in the early part of the month, with the probability of meeting demand rising rapidly in the latter half of the month. By day 20, demand can be met in one year in two, whilst by the end of the month water is expected to be available in more than four years in five.

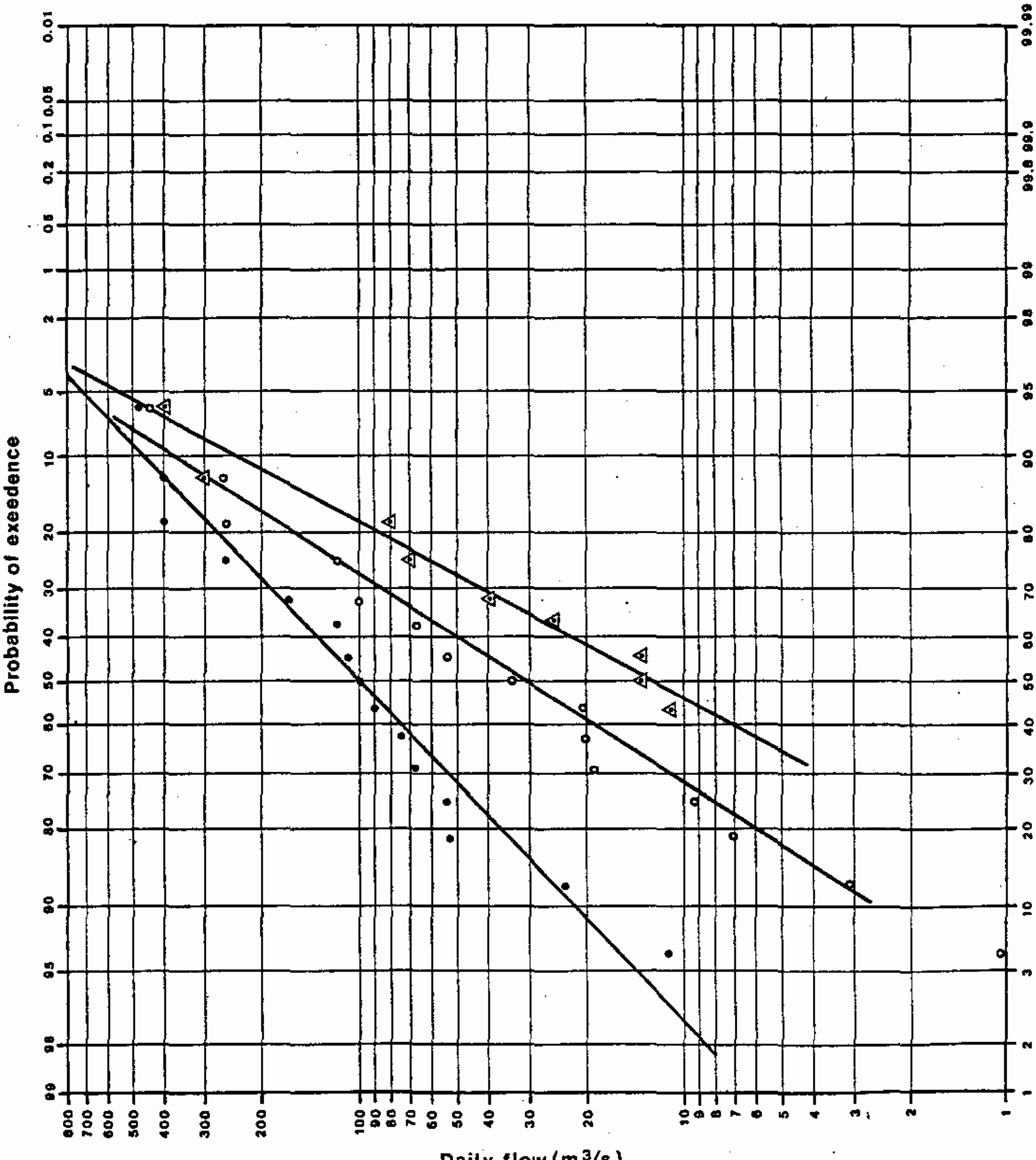
TABLE 4.11

Probability of Meeting Demand in April with River Juba Flows (%)

	Day					
Planning horizon	5	10	15	20	25	30
1985	14	35	40	50	72	85
1990	23	33	38	48	68	82

4.3

Probabilities of flows at Kaitoi for April



A similar analysis was carried out with April rainfall, which signifies the start of the gu season. It was assumed that a cumulative value of rainfall in excess of 50 mm falling over five consecutive days would be sufficient to start ploughing and planting rice.

The April daily rainfall records for Alessandra (Gelib) 1931 - 1939, 1953 - 1960 (Fantoli, 1965) were analysed and the first occurrence of a five-day rainfall in excess of 50 mm noted. The frequency of occurrence was then calculated and is shown in Table 4.12.

TABLE 4.12

Probability of 5-day Rainfall in Selected Periods in April in Excess of 50 mm (%)

	Day					
	1-5	6-10	11-19	16-23	21-25	26-30
Probability of occurrence	0	6	39	61	67	72

The indications are that there is insufficient rainfall in the early part of the month to commence planting, although by the third week there should be enough rain three years in five for rice planting to commence without Juba abstractions.

It has been shown that localised rain in the project area and the arrival of the gu season river flood occur randomly thoroughout April and hence can be considered as independent events. Thus, an upper limit may be placed to the probability of having enough water to commence planting by summing the probabilities of water availability from the two sources, rainfall or river flow.

This indicates that in four out of five years there will be enough water from either river flow or rainfall to carry out initial planting by the second week of April. However, it should be noted that the early gu rains are often very localised and hence this represents the most optimistic projection.

The most pessimistic assumption is to treat the start of the rains and the flood as being highly correlated, in which case sufficient water would not on average be available to plant rice with an 80% reliability until the last week in April.

4.5 Future Water Availabilities without River Regulation

Tables 4.13(a), (b) and (c) show future water availabilities for the immediate, short and medium-term planning horizons, designated by 1980, 1985 and 1990 respectively. In the immediate future, Table 4.13(a) shows present availabilities should satisfy demand except during March, and Tables 4.13(b) and (c) show that availabilities will be over-committed in the short-term, with large deficits occurring in the medium-term during months January to April inclusive.

TABLE 4.13 (a)

Future Water Availabilities at Mogambo without Regulation (a) by 1980 (Mm^3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Present availability at Kamsuma	47	19	8	64	278	193	276	477	516	656	563	181
Less incremental requirements above Kamsuma	17	14	16	10	11	14	14	13	14	16	16	8
Net availability at Kamsuma	30	5	0	54	267	179	262	464	502	640	549	173
Less requirements, Kamsuma to Mogambo	0	0	0	0	0	0	0	0	0	0	0	0
Net availability at Mogambo	30	5	0	54	267	179	262	464	502	640	549	173
Less Mogambo requirements	3	0	0	8	18	12	11	4	9	10	12	13
Net availability below Mogambo	27	5	0	46	249	167	251	460	492	630	537	160
Less requirements below Mogambo	1	1	1	0	0	0	0	0	1	1	0	1
Net surplus/deficit below Mogambo	26	4	0	46	249	167	251	460	492	629	537	159
Total surplus/deficit on Juba	26	4	-8	46	249	167	251	460	492	629	537	159

Notes:
1. Present water availabilities at Kamsuma from Table 4.10.
2. Water requirements taken from Chapter 3.
3. Water requirements and availabilities all based on 5-year return period.

TABLE 4.13 (b)

Future Water Availabilities at Mogambo without Regulation (b) by 1985 (Mm^3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Present availability at Kamsuma	47	19	8	64	278	193	276	477	516	656	563	181
Less incremental requirements above Kamsuma	87	66	79	45	66	90	83	72	97	127	116	98
Net availability at Kamsuma	0	0	0	19	212	103	193	405	419	529	447	87
Less requirements, Kamsuma to Mogambo	1	1	1	1	1	1	1	1	1	1	1	1
Net availability at Mogambo	0	0	0	18	211	102	192	404	418	528	446	83
Less Mogambo requirements	3	0	0	8	18	12	11	4	9	10	12	13
Net availability below Mogambo	0	0	0	10	193	90	181	400	409	518	434	70
Less requirements below Mogambo	32	25	27	26	27	26	27	28	32	36	33	35
Net surplus/deficit below Mogambo	0	0	0	0	166	64	154	372	377	482	401	35
Total surplus/deficit on Juba	-76	-73	-99	-16	166	64	154	372	377	482	401	35

Notes:
1. Present water availabilities at Kamsuma from Table 4.10.
2. Water requirements taken from Chapter 3.
3. Water requirements and availabilities all based on 5-year return period.

TABLE 4.13 (c)

Future Water Availabilities at Mogambo without Regulation (c) by 1990 (Mm^3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Present availability at Kamsuma	47	19	8	64	278	193	276	477	516	656	563	181
Less incremental requirements above Kamsuma	107	81	96	55	81	111	101	86	118	157	143	124
Net availability at Kamsuma	0	0	0	9	197	82	175	391	398	499	420	57
Less requirements, Kamsuma to Mogambo	2	2	2	1	1	1	1	2	2	2	1	2
Net availability at Mogambo	0	0	0	8	196	81	174	389	396	497	419	55
Less Mogambo requirements	3	0	0	8	18	12	11	4	9	10	12	13
Net availability below Mogambo	0	0	0	0	178	69	163	385	387	487	407	42
Less requirements below Mogambo	32	25	27	26	27	26	27	28	32	36	33	35
Net surplus/deficit below Mogambo	0	0	0	0	151	43	136	357	355	451	374	7
Total surplus/deficit on Juba	-97	-89	- 117	-26	151	43	136	357	355	451	474	7

Notes:
1. Present water availabilities at Kamsuma from Table 4.10.
2. Water requirements taken from Chapter 3.
3. Water requirements and availabilities all based on 5-year return period.

Little water is available for the Mogambo project during the first three/four months of the year by 1990, when the project is planned to become fully productive. This may delay the start of rice planting by up to one month and will affect the maturation of crops in the early part of the year. It is concluded that by 1990, without river regulation, the availability of water for irrigation would be severely restricted in the months January to April. This conclusion is in agreeement with that drawn by HTS (1978).

4.6 Future Water Availabilities with River Regulation from Bardheere Reservoir

Several previous studies have considered regulation of the Juba from the proposed Bardheere reservoir (Selchozpromexport, 1965, Technital, 1975 and 1977, HTS, 1978, and MMP, 1978. It is beyond the scope of this report to re-evaluate the operation of Bardheere reservoir and assess long-term water availabilities in the regulated reach of the river. The brief discussion which follows is therefore based primarily on the Bardheere reservoir review (MMP, 1978).

The Bardheere feasibility study (Technital, 1977) envisaged the reservoir with a spillway at 145 m AMSL and a gross storage of 4 100 Mm^3, although it was said that a smaller storage would probably suffice. Technital assumed that a second reservoir at Saakow would be constructed to provide secondary regulation of their large hydro-power releases from Bardheere reservoir. Saakow reservoir is shown by MMP (1978) to be unnecessary and their review considers regulation with Bardheere only.

The hydrology of Bardheere reservoir was studied by MMP using river flow records at Lugh Ganana and Bardheere, previously published by Selchozpromexport (1965 and 1973) and Lockwood/FAO (1968). These records are incompatible, the Lockwood data being rejected by MMP because of suspect rating curves for Lugh Ganana and Bardheere. Further sources of data were the 10-day records given by Technital (1977) and monthly records given by MMP (1978). Table 4.14 summarises the three data bases used.

TABLE 4.14

Data Bases used by MMP (1978) to Review Bardheere Reservoir

Data base	River gauging station	Period (inclusive)	Source
A	Lugh Ganana	Jan 1951 - Oct 1964	Selchozpromexport, 1965
	Bardheere	Jun 1963 - Oct 1964	Selchozpromexport, 1965
B	Lugh Ganana	Jan 1951 - Oct 1964	Selchozpromexport, 1965
	Lugh Ganana	Nov 1969 - Feb 1973	Selchozpromexport, 1965
	Bardheere	Jun 1963 - Oct 1964	Selchozpromexport, 1965
	Bardheere	Nov 1969 - Jun 1974	MMP, 1978(a)
C	Bardheere	Jan 1951 - Dec 1963	Technital, 1977

In the case of bases A and B, concurrent data at Lugh Ganana and Bardheere were correlated in the linear domain, to define the relationship between flows at the two locations, and a Thomas-Fiering model was used (also in the linear domain) to allow generation of synthetic data at Lugh Ganana. These synthetic data were transposed to Bardheere using the previous correlation between the two locations. In the case of base C, the Thomas-Fiering (logarithmic) model was applied directly to the Technital data. In each case, 10 sets of 50-year sequences were generated for Bardheere monthly inflows. These synthetic sequences were used with calculated upper and lower month-end operating levels for each data base, where:

(a) water above the upper operating level is discharged at a constant 750 m^3/s. These levels reduce the probability of uncontrolled spillage to 1%

(b) the lower operating levels represent minimum monthly storages required to meet demand with a 95% level of reliability.

MMP (1978) reassessed demand on Bardheere reservoir, using the most up-to-date information available at that time. Irrigation and other demands upstream of Bardheere are also quantified in an attempt to determine the long-term hydrology of Bardheere reservoir. Table 4.15 tabulates these demands.

TABLE 4.15

Long-term Water Requirements in the Juba Basin (after MMP, 1978)

Month	Irrigation	Other	Total	Irrigation	Others
Jan	146	40	186	56	
Feb	95	37	131	41	
Mar	103	40	144	40	
Apr	70	39	109	22	Increments of 50,
May	150	40	202	99	100 and 150 Mm^3
Jun	225	39	263	130	per month included
Jul	238	40	278	122	for water supply and
Aug	286	40	327	66	and reservoir losses
Sep	317	39	356	70	presently unquanti-
Oct	380	40	420	160	fied
Nov	237	39	376	94	
Dec	324	40	365	121	

Note: (1) Water supply and residual flow to sea
(2) Totals may not agree because of rounding

Demands were used with synthetic inflow sequences to Bardheere to calculate upper and lower operating levels and the maximum storage capacity required in the reservoir. The first case considered used downstream demands only, inflows to the reservoir being assessed in turn by each of three data bases. The largest storage capacities required varied from 1 922 $\pm$ 294 Mm^3 to 2 533 $\pm$ 961 Mm^3, compared with the capacity of 4 100 Mm^3 suggested by Technital (1977). Although the hydrological data and demands used are not well defined, it is clear that demands on Bardheere can be met with a very high level of reliability.

In order to evaluate the effect of water use above Bardheere, MMP (1978) used the synthetic inflow sequences defined on data base B, reduced by upstream irrigation demands shown in Table 4.15 together with increments of 50, 100 and 150 Mm^3 per month. Recalculated upper and lower operating levels showed that a gross Bardheere storage capacity of 4 100 Mm^3 should suffice to serve downstream flood control and regulation functions until upstream abstractions reach between 2 200 and 2 460 Mm^3 per year. This level of upstream use is equivalent to between 70% and 78% of the long-term downstream demand and it is clear that this situation will not arise for the foreseeable future.

CHAPTER 5

DRAINAGE RATES FROM CROPPED AREAS

5.1 Introduction

Areas with heavy basin soils will be used for flood irrigation of rice, followed by surface irrigation of a maize crop, in bunded and levelled fields. Areas of lighter levee soils will remain unlevelled and used to grow cotton and other crops irrigated by sprinklers. Drainage characteristics of the two areas will be different and have been assessed separately.

The nearest rainfall station with a sufficiently long record of daily rainfalls is located at Alessandra (Gelib). Data for this station are given by Fantoli (1963) for the periods 1930 to 1939 and 1953 to 1960. The annual average rainfall is 586 mm at Alessandra, compared with only 368 mm at Kismayo on the coast, based on records from 1943 to 1976 (TAMS/FINTECS 1977). However, annual averages can be misleading, particularly where records are short. TAMS/FINTECS show that average annual rainfalls at Kismayo and Jamama were 295 and 414 mm respectively, based on 11 years of data over the period 1930 to 1958. It should be noted that this figure for Kismayo is only 80% of that based on the period 1943 to 1976. If the same proportion is assumed for Jamama, then the true long-term annual average rainfall would be about 500 mm (414 divided by 0.8), which is slightly less than the average annual rainfall at Alessandra.

For drainage calculations, daily rainfalls are clearly of more importance than annual averages. Heavy rains are associated with movement of the inter-tropical convergence zone, generally causing rainy periods of up to about one week during the gu season. TAMS/FINTECS show that storm intensities usually decrease between Kismayo and Alessandra but this decrease is large only for intense storms.

It can be seen that use of Alessandra daily records will tend to underestimate the maximum annual run-off rates but overestimate the average annual run-off. In both cases the errors are likely to be fairly small.

5.2 Basin Soils: Surface Irrigation

The following distinct phases of cropping have been identified for basin soils:-

(a) April and May, when young rice seedlings must be protected against drowning

(b) May to August, when taller rice is irrigated to a depth of 150 mm, following a 9-day irrigation cycle

(c) September to January, when maize is grown.

Each phase has been considered separately, using a daily water balance based on daily rainfall records for Alessandra (Gelib) covering the periods 1930 to 1939 and 1953 to 1960 inclusive.

(a) Drainage Rates from Rice Seedlings

Under the proposed cropping pattern, rice will be planted over a one-month period, water being applied under a 9-day irrigation cycle. Thus, at the end of this one-month period, the area can be viewed as consisting of 9 equal sized blocks, with stages of growth varying from nil (for newly-seeded areas) to seedlings approximately 200 mm high and corresponding irrigation depths varying from nil to about 100 mm. In practice these blocks are not continuous: any given area will consist of rice in all stages of growth. It can be shown that the highest drainage rates (minimum field storage) will occur when the block with the median growth rice has just been irrigated. Under these conditions, and allowing for infiltration and evaporation (each assumed as 5 mm/d), the maximum storage allowed on each block can be calculated as shown in Table 5.1.

TABLE 5.1

Storage Depths in Irrigated Basins (mm)

	1	2	3	4	5	6	7	8	9
Seedling height	200	175	150	125	100	75	50	25	0
Irrigated depth	100	88	75	63	50	38	25	13	0
Days since irrigation	4	3	2	1	0	8	7	6	5
Water loss	40	30	20	10	0	38	25	13	0
Water depth	60	58	55	53	50	0	0	0	0
Available storage	140	118	95	73	50	75	50	25	0

Note : Block 1 corresponds to one-month old rice, the earliest areas to receive water, and block 9 corresponds to the newly watered areas with very young seedlings.

The available storage represents the difference between seedling height and water depth and indicates the short-term retention which can be allowed before seedlings are drowned. This storage will significantly reduce peak drainage rates. In practice, available storages in all blocks are affected by antecedent rainfall, irrigation and drainage quantities. The problem becomes extremely complex if all these variables are included and the following simplifying assumptions were made :-

(a) available storages at the beginning of a wet spell are always assumed as calculated above for median growth rice

(b) a wet spell is defined as the period of consecutive days when rainfall exceeds 10 mm/d, equal to the daily losses by infiltration and evaporation

(c) irrigation is stopped during a wet spell

(d) there is no run-off from a block until the block storage has been filled by rainfall.

Using the above assumptions together with rainfall at Alessandra, a daily water balance was carried out for the months April and May to calculate maximum run-offs for each wet period. Annual maximum run-offs were fitted to an extremal Type 1 (Gumbel) distribution to give the results shown in Table 5.2.

TABLE 5.2

Run-off Rates from Rice Fields

Return period (years)	Run-off rate (l/s/ha)
2	0.8
4	1.3
5	1.5

(b) Drainage Rates from Mature Rice

For mature rice (rice taller than 200 mm), irrigation depths are 150 mm compared with a minimum bund height between fields of 200 mm. Thus, at least 50 mm storage can be allowed on newly irrigated fields, increasing to 130 mm on fields irrigated eight days ago. Using these initial conditions and other assumptions as for rice seedlings, a daily water balance was carried out for months May to August to give the results shown in Table 5.3. It can be seen that drainage rates to be provided for rice seedlings are more than adequate for mature rice.

TABLE 5.3

Maximum Annual Drainage Rates for Mature Rice

Year	Maximum drainage rate (l/s/ha)	Year	Maximum drainage rate (l/s/ha)
1930	1.35	1953	0
1931	0	1954	0
1932	0	1955	0.3
1933	0	1956	0
1934	0	1957	0.3
1935	0	1958	0
1936	0	1959	0
1937	0.2	1960	0
1938	0.5		
1939	0		

TABLE 5.4

Maximum Annual Flood Depths and Durations: Maize on Basin Soils

Year	Maximum flood depth (mm)			Flood duration (days)		
	Q=1	Q=1.5	Q=2	Q=1	Q=1.5	Q=2
1930	13	9	5	1	1	1
1931	13	9	5	1	1	1
1932	34	30	25	2	2	1
1933	13	9	5	1	1	1
1934	5	1	0	1	1	0
1935	24	20	16	2	1	1
1936	73	69	65	4	3	2
1937	0	0	0	0	0	0
1938	20	16	12	2	2	1
1939	0	0	0	0	0	0
1953	23	18	14	1	1	1
1954	26	22	18	2	1	1
1955	24	20	16	2	1	1
1956	63	58	54	4	3	2
1957	32	25	21	4	2	1
1958	0	0	0	0	0	0
1959	0	0	0	0	0	0
1960	0	0	0	0	0	0

Note: Q = drainage rate in l/s/ha

(c) Drainage Rates from Maize Crop

Reduced yield or even loss of crops can result if flooding on this crop is deep and/or prolonged. Field storage of rainfall excess would normally not be allowed and would only occur if rainfall is greater than maximum drainage rates. The method used to assess flood depths and durations therefore uses a range of drainage rates in a daily water balance carried out for each sequence of rainfalls from September to January as given by Alessandra rainfall records. An infiltration rate of 10 mm/d was assumed, since the maize crop will not be grown under flooded conditions and soil cracking will occur between irrigations. Maximum annual flooding depths and durations are given in Table 5.4. It can be seen that for a drainage rate of 1.5 l/s/ha, the frequency of flooding lasting for longer than one day is such as to occur about 1 year in 5. This is considered acceptable since it will generally only occur in localised areas.

5.3 Levee Soils: Sprinkler Irrigation

This area, covering about 3 000 ha, was viewed as a small catchment for the purpose of estimating drainage rates due to rainfall. The method of the US Soil Conservation Service (1964) was used, where run-off (Q mm) is calculated according to :-

$$Q = \frac{(P - Ia)^2}{P + 4\,Ia} \qquad (1)$$

where
- Q = run-off (mm)
- P = daily rainfall value (mm)
- Ia = initial abstraction (mm) or the reduction in rainfall due to infiltration and retention

Values of Ia are determined by a curve number (CN) based on the type of cultivation, the hydrologic soil group and wetness of the soil. For sprinkler areas, a median CN of 84 was used corresponding to :-

(a) row crops with contoured fields
(b) poor hydrologic condition (conducive to run-off)
(c) group C of the hydrologic soil classification (a loamy soil)

The median CN applies to soil with median antecedent rainfall, referred to as antecedent moisture condition (AMC) class II. Curve numbers for other AMC classes and values of Ia are given in Table 5.5.

TABLE 5.5

Run-off Parameters for Levee Soils

Antecedent moisture condition	5-day antecedent rainfall (mm)	Curve number	Initial obstruction (mm)
Class I	0 - 35	68	23.9
Class II	35 - 52	84	9.7
Class III	greater than 52	93	3.8

Source: US Soil Conservation Service (1964)

The lowest rainfall causing run-off is therefore 3.8 mm, applying to the wettest soil condition. The whole rainfall record for Alessandra (Gelib) for the periods 1930-39 and 1953-60 was checked for days with rain in excess of 3.8 mm, and the 5-day antecedent rainfalls calculated. The corresponding AMC class and values of initial abstraction were assigned, daily values of run-off computed and annual maxima abstracted. These annual maxima were found to fit a log-normal distribution, which was used to estimate the run-off rates with various return periods, as shown in Table 5.6.

TABLE 5.6

Run-off Rates for Overhead Irrigation Areas

Return period (years)	Run-off rate (l/s/ha)
2	1.6
4	2.9
5	3.5

5.4 Design Rates

Run-off rates were calculated on the assumption that point rainfall at Alessandra falls uniformly over the project area but in practice this will not occur. During fieldwork for this present study it was observed that rainfall is very localised so parts of the area receive rain whilst other parts remain dry. The calculated run-off rates are therefore overestimates when considering the whole area although they will apply to small areas drained by small channels. Design drainage rates shown in Table 5.7 therefore assume reduction factors of 0.9 for main collector drains and a further 0.9 for main drains.

TABLE 5.7

Design Drainage Rates (l/s/ha) and Return Periods

	Return period (years)		
	2	4	5
(a) Basin Soils			
Collector drains	0.8	1.3	1.5
Main collector drains	0.7	1.2	1.4
Main drains	0.6	1.1	1.2
(b) Levee Soils			
Collector drains	1.6	2.9	3.5
Main collector drains	1.4	2.6	3.2
Main drains	1.3	2.3	2.8

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APPENDIX I

CLIMATE DATA

APPENDIX I

CLIMATE DATA

TABLE I.1

Climate Data for Ionte, 00° 08' 30"S 42° 30' 20"E altitude 8 m

Month	Temperature (°C)	Humidity (%)	Wind speed (km/d)
January	28.2	74	60
February	28.1	74	52
March	28.7	74	43
April	28.9	76	26
May	27.8	79	35
June	26.3	80	43
July	25.7	81	52
August	25.8	78	60
September	26.2	78	60
October	27.3	77	52
November	27.4	76	43
December	27.9	76	52
Year	27.4	77	48

TABLE I.2

Climate Data for Gelib (Alessandra) 00° 30' 00"N 42° 46' 00"E altitude 24 m

Month	Temperature (°C)	Humidity (%)	Wind speed (km/d)	Sunshine (h/d)
January	28.7	69	150	9.19
February	28.9	68	170	8.96
March	29.0	67	160	10.00
April	28.3	73	78	7.62
May	28.0	78	35	7.62
June	26.5	79	52	6.87
July	25.8	77	52	6.98
August	26.1	75	60	7.93
September	26.6	73	86	8.51
October	27.3	73	95	7.47
November	28.0	76	78	6.72
December	28.1	74	95	8.21
Year	27.6	74	93	8.01

Wind Speed Records

1. Marere (Juba Sugar Project)

Wind speed readings are available for the period August 1978 to July 1979. These take the form of maximum and minimum readings measured every half hour throughout the day and night. The records are in knots at a height of 10 m and these have been converted to m/s at a height of 2 m by multiplying by a factor of 0.40. Tables I.3 and I.14 show the results of an analysis of these wind speeds grouped into various speed bands for 2 hour periods.

Figure I.1 summarises the results graphically for the months of September and November (1978).

2. Fanoole State Farm

Wind speed records from the Fanoole state farm are available for 6 months. Each day at 7.00 am and 12.00 am, five instantaneous readings of wind speed were recorded. Each set of readings has been averaged and the maximum of these values and the monthly average are tabulated (Table I.15).

3. Alessandra

Monthly average wind speeds for 1953-1958 are tabulated (Table I.16).

TABLES I.3 to I.14

Analysis of Wind Speeds at Marere
(Juba Sugar Project)

TABLE I.3

Percentage Probability of Exceeding Given Wind Speed, August 1978

Wind speed at 2 m (m/s)	≥ 0		>0.4		>1.2		>2.4		>4.0		>6.0		>8.4 <10.4		Maximum windspeed at 2 m (m/s)
Time (hours)	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	
0.00 - 1.30	100	100	27	3	18	1	5	-	2	-	-	-	-	-	4.4
2.00 - 3.30	100	100	11	3	9	1	6	-	1	-	-	-	-	-	5.6
4.00 - 5.30	100	100	12	2	12	2	1	-	1	-	-	-	-	-	5.6
6.00 - 7.30	100	100	22	3	17	1	1	-	-	-	-	-	-	-	2.8
8.00 - 9.30	100	100	81	43	78	27	55	9	17	-	1	-	-	-	6.0
10.00 - 11.30	100	100	99	90	99	71	91	41	67	-	30	-	-	-	8.0
12.00 - 13.30	100	100	100	97	100	82	100	46	88	-	45	-	6	-	8.8
14.00 - 15.30	100	100	100	100	100	85	100	5.4	94	2	63	-	3	-	9.6
16.00 - 17.30	100	100	100	93	99	83	96	61	87	-	62	-	1	-	8.4
18.00 - 19.30	100	100	100	71	94	58	84	17	56	-	7	-	1	-	8.0
20.00 - 21.30	100	100	94	30	84	19	44	1	7	0	0	-	-	-	4.8
22.00 - 23.30	100	100	61	12	53	6	22	4	0	0	-	-	-	-	4.0

Note: NB only 17 days of data

TABLE I.4

Percentage Probability of Exceeding Given Wind Speed, September 1978

Wind speed at 2 m (m/s)	≥0		>0.4		>1.2		>2.4		>4.0		>6.0		>8.4 <10.4		Maximum windspeed at 2 m (m/s)
Time (hours)	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	
0.00 - 1.30	100	100	38	4	32	4	11	2	1	0	0	-	-	-	4.8
2.00 - 3.30	100	100	22	2	16	1	5	0	0	-	-	-	-	-	2.8
4.00 - 5.30	100	100	12	1	11	1	2	0	1	-	0	-	-	-	4.4
6.00 - 7.30	100	100	45	16	45	15	31	1	14	0	0	-	-	-	6.0
8.00 - 9.30	100	100	99	70	99	44	98	2	88	1	25	0	2	-	10.0
10.00 - 11.30	100	100	100	90	100	65	100	2	99	0	72	-	5	-	9.6
12.00 - 13.30	100	100	100	92	100	73	100	1	100	0	89	-	11	-	9.2
14.00 - 15.30	100	100	100	98	100	85	100	1.1	100	0	95	-	17	-	9.2
16.00 - 17.30	100	100	100	98	100	85	100	8	100	0	75	-	4	-	10.0
18.00 - 19.30	100	100	100	81	100	51	95	0	71	-	8	-	0	-	7.2
20.00 - 21.30	100	100	96	62	94	33	70	0	23	-	0	-	0	-	5.6
22.00 - 23.30	100	100	84	28	77	19	45	1	4	0	1	-	0	-	6.4

TABLE I.5

Percentage Probability of Exceeding Given Wind Speed, October 1978

Wind speed at 2 m (m/s)	≥ 0		> 0.4		> 1.2		> 2.4		> 4.0		> 6.0		> 8.4 < 10.4		Maximum windspeed at 2 m (m/s)
Time (hours)	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	
0.00 - 1.30	100	100	12	4	12	2	8	0	1	-	0	-	-	-	3.2
2.00 - 3.30	100	100	3	0	2	-	2	-	0	-	-	-	-	-	3.6
4.00 - 5.30	100	100	15	3	15	3	12	0	2	-	0	-	-	-	5.6
6.00 - 7.30	100	100	61	39	61	39	57	1	38	1	3	0	0	-	6.4
8.00 - 9.30	100	100	95	57	95	55	91	1	77	0	10	-	0	-	7.2
10.00 - 11.30	100	100	96	51	96	49	93	0	77	-	29	-	0	-	8.4
12.00 - 13.30	100	100	99	62	99	63	97	0	92	-	57	-	1	-	10.4
14.00 - 15.30	100	100	100	79	100	77	95	0	88	-	65	-	3	-	9.6
16.00 - 17.30	100	100	97	76	92	76	90	0	82	-	36	-	0	-	7.6
18.00 - 19.30	100	100	87	60	87	57	77	0	51	-	4	-	0	-	7.2
20.00 - 21.30	100	100	54	29	53	26	37	0	9	-	1	-	0	-	5.2
22.00 - 23.30	100	100	31	9	31	6	12	0	1	-	0	-	-	-	4.4

TABLE I.6

Percentage Probability of Exceeding Given Wind Speed, November 1978

Wind speed at 2 m (m/s)	≥ 0		> 0.4		> 1.2		> 2.4		> 4.0		> 6.0		> 8.4 < 10.4		Maximum windspeed at 2 m (m/s)
Time (hours)	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	
0.00 - 1.30	100	100	6	0	6	-	0	-	-	-	-	-	-	-	2
2.00 - 3.30	100	100	6	0	6	-	0	-	-	-	-	-	-	-	2.4
4.00 - 5.30	100	100	17	3	17	3	4	0	1	-	-	-	-	-	4.4
6.00 - 7.30	100	100	52	27	52	24	34	0	11	-	1	-	0	-	8.0
8.00 - 9.30	100	100	86	50	86	47	78	0	34	-	3	-	0	-	6.8
10.00 - 11.30	100	100	90	46	90	44	81	0	37	-	10	-	0	-	6.8
12.00 - 13.30	100	100	98	60	98	58	92	5	56	0	10	-	0	-	8.8
14.00 - 15.30	100	100	98	64	98	62	90	2	55	0	15	-	2	-	10.0
16.00 - 17.30	100	100	87	52	87	52	72	2	39	0	7	-	0	-	9.2
18.00 - 19.30	100	100	69	33	69	30	43	0	4	-	0	-	-	-	6.0
20.00 - 21.30	100	100	43	7	43	7	10	0	0	-	-	-	-	-	3.2
22.00 - 23.30	100	100	30	0	30	-	5	-	0	-	-	-	-	-	2.8

TABLE I.7

Percentage Probability of Exceeding Given Wind Speed, December 1978

Wind speed at 2 m (m/s)	$\geqslant 0$		> 0.4		> 1.2		> 2.4		> 4.0		> 6.0		> 8.4 < 10.4		Maximum windspeed at 2 m (m/s)
Time (hours)	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	
0.00 - 1.30	100	100	42	5	41	5	14	0	1	-	0	-	-	-	5.2
2.00 - 3.30	100	100	34	6	31	6	7	0	1	-	0	-	-	-	5.6
4.00 - 5.30	100	100	22	3	20	3	5	0	2	-	0	-	-	-	4.4
6.00 - 7.30	100	100	46	10	45	10	22	0	10	-	2	-	0	-	6.8
8.00 - 9.30	100	100	76	33	73	30	58	0	35	-	7	-	1	-	8.8
10.00 - 11.30	100	100	95	38	93	34	83	0	52	-	9	-	0	-	8.4
12.00 - 13.30	100	100	97	37	95	34	91	1	57	0	14	-	2	-	9.6
14.00 - 15.30	100	100	96	36	95	33	86	1	53	0	16	-	3	-	10.4
16.00 - 17.30	100	100	94	37	94	32	74	0	43	-	1	-	0	-	6.4
18.00 - 19.30	100	100	92	34	92	31	66	0	31	-	1	-	0	-	6.4
20.00 - 21.30	100	100	79	22	77	18	44	0	14	-	0	-	-	-	5.2
22.00 - 23.30	100	100	67	12	63	11	20	0	5	-	0	-	-	-	5.2

TABLE I.8

Percentage Probability of Exceeding Given Wind Speed, January 1979

Wind speed at 2 m (m/s)	≥0		>0.4		>1.2		>2.4		>4.0		>6.0		>8.4 <10.4		Maximum windspeed at 2 m (m/s)
Time (hours)	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	
0.00 - 1.30	100	100	57	17	53	4	23	0	1	-	0	-	-	-	4.8
2.00 - 3.30	100	100	53	11	46	6	13	0	1	-	-	-	-	-	4.4
4.00 - 5.30	100	100	33	4	30	1	9	-	1	-	-	-	-	-	4.0
6.00 - 7.30	100	100	23	4	22	1	4	-	-	-	-	-	-	-	3.2
8.00 - 9.30	100	100	73	31	69	21	47	5	21	2	2	1	0	0	6.8
10.00 - 11.30	100	100	94	54	92	43	77	10	44	4	6	4	0	0	6.8
12.00 - 13.30	100	100	98	60	96	45	84	7	47	4	7	4	0	0	6.4
14.00 - 15.30	100	100	98	60	92	48	79	12	52	2	5	0	1	-	9.6
16.00 - 17.30	100	100	97	74	97	64	89	20	73	2	12	0	1	-	8.8
18.00 - 19.30	100	100	97	70	96	62	87	12	55	0	5	-	0	-	8.0
20.00 - 21.30	100	100	92	48	89	30	71	5	25	0	0	-	-	-	6.0
22.00 - 23.30	100	100	82	38	74	19	49	3	11	2	0	0	-	-	5.6

TABLE I.9

Percentage Probability of Exceeding Given Wind Speed, February 1979

Wind speed at 2 m (m/s)	≥ 0		> 0.4		> 1.2		> 2.4		> 4.0		> 6.0		> 8.4 < 10.4		Maximum windspeed at 2 m (m/s)
Time (hours)	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	
0.00 - 1.30	100	100	80	32	66	13	34	1	3	0	0	-	-	-	4.8
2.00 - 3.30	100	100	61	22	50	6	15	0	2	-	0	-	-	-	5.2
4.00 - 5.30	100	100	49	16	36	2	11	0	1	-	0	-	-	-	4.8
6.00 - 7.30	100	100	37	12	27	2	14	1	1	0	0	-	-	-	5.2
8.00 - 9.30	100	100	82	62	79	41	66	9	32	1	1	0	0	-	6.8
10.00 - 11.30	100	100	100	82	100	59	94	10	60	0	1	-	0	-	6.4
12.00 - 13.30	100	100	98	82	98	58	87	18	56	0	2	-	0	-	6.4
14.00 - 15.30	100	100	100	83	99	64	89	14	58	0	8	-	0	-	7.2
16.00 - 17.30	100	100	100	91	100	75	98	47	81	0	10	-	0	-	6.8
18.00 - 19.30	100	100	100	96	100	77	98	32	67	0	6	-	0	-	7.2
20.00 - 21.30	100	100	97	72	96	41	90	5	32	0	0	-	-	-	5.2
22.00 - 23.30	100	100	91	61	89	32	59	3	13	0	0	-	-	-	5.2

TABLE I.10

Percentage Probability of Exceeding Given Wind Speed, March 1979

Wind speed at 2 m (m/s)	≥0		>0.4		>1.2		>2.4		>4.0		>6.0		>8.4 <10.4		Maximum windspeed at 2 m (m/s)
Time (hours)	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	
0.00 - 1.30	100	100	42	9	28	4	10	0	1	-	0	-	-	-	4.8
2.00 - 3.30	100	100	23	8	20	1	4	0	2	-	0	-	-	-	4.4
4.00 - 5.30	100	100	19	8	17	1	6	0	0	-	-	-	-	-	3.2
6.00 - 7.30	100	100	27	26	25	10	15	0	1	-	0	-	-	-	3.6
8.00 - 9.30	100	100	82	67	81	36	69	3	18	0	0	-	-	-	5.6
10.00 - 11.30	100	100	99	89	99	57	91	12	45	0	0	-	-	-	5.6
12.00 - 13.30	100	100	100	85	99	56	86	14	45	0	3	-	0	-	7.2
14.00 - 15.30	100	100	95	87	93	76	89	22	65	0	2	-	0	-	6.4
16.00 - 17.30	100	100	88	86	82	76	83	39	62	0	2	-	0	-	7.6
18.00 - 19.30	100	100	83	79	82	67	77	16	33	0	0	-	-	-	5.6
20.00 - 21.30	100	100	71	63	71	31	46	0	5	-	0	-	-	-	5.2
22.00 - 23.30	100	100	56	30	50	7	20	0	0	-	-	-	-	-	4.0

TABLE I.11

Percentage Probability of Exceeding Given Wind Speed, April 1979

Wind speed at 2 m (m/s)	≥0		>0.4		>1.2		>2.4		>4.0		>6.0		>8.4 <10.4		Maximum windspeed at 2 m (m/s)
Time (hours)	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	
0.00 - 1.30	100	100	11	-	10	-	3	-	-	-	-	-	-	-	3.2
2.00 - 3.30	100	100	7	3	7	1	5	-	1	-	-	-	-	-	3.2
4.00 - 5.30	100	100	15	5	15	5	9	1	-	-	-	-	-	-	4.8
6.00 - 7.30	100	100	21	6	18	3	10	-	-	-	-	-	-	-	4.0
8.00 - 9.30	100	100	65	15	63	8	43	3	12	-	-	-	-	-	4.8
10.00 - 11.30	100	100	89	43	87	33	72	11	25	-	-	-	-	-	6.4
12.00 - 13.30	100	100	90	62	86	39	78	12	35	-	2	-	-	-	7.6
14.00 - 15.30	100	100	84	59	82	47	70	17	41	2	4	-	-	-	8.8
16.00 - 17.30	100	100	82	68	73	57	60	19	25	2	2	-	-	-	6.0
18.00 - 19.30	100	100	65	33	55	28	33	11	5	-	-	-	-	-	6.0
20.00 - 21.30	100	100	24	13	22	11	7	2	-	-	-	-	-	-	4.0
22.00 - 23.30	100	100	8	3	7	1	4	-	-	-	-	-	-	-	3.2

TABLE I.12

Percentage Probability of Exceeding Given Wind Speed, May 1979

Wind speed at 2 m (m/s)	≥0		>0.4		>1.2		>2.4		>4.0		>6.0		>8.4 <10.4		Maximum windspeed at 2 m (m/s)
Time (hours)	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	
0.00 - 1.30	100	100	29	2	21	1	6	-	1	-	-	-	-	-	4
2.00 - 3.30	100	100	31	2	23	2	8	-	1	-	-	-	-	-	4
4.00 - 5.30	100	100	30	2	18	1	9	-	1	-	-	-	-	-	4
6.00 - 7.30	100	100	58	17	50	9	35	1	8	-	-	-	-	-	4.4
8.00 - 9.30	100	100	84	44	84	28	63	17	30	-	-	-	-	-	5.6
10.00 - 11.30	100	100	96	65	92	51	77	24	38	-	3	-	-	-	5.6
12.00 - 13.30	100	100	96	74	91	58	79	24	49	-	5	-	-	-	6.8
14.00 - 15.30	100	100	94	77	90	63	77	33	51	-	6	-	-	-	7.2
16.00 - 17.30	100	100	81	63	76	52	62	24	16	-	2	-	-	-	6.4
18.00 - 19.30	100	100	72	49	61	28	36	3	1	-	-	-	-	-	5.2
20.00 - 21.30	100	100	44	16	36	6	12	-	-	-	-	-	-	-	4.0
22.00 - 23.30	100	100	27	7	17	4	4	-	-	-	-	-	-	-	3.6

TABLE I.13

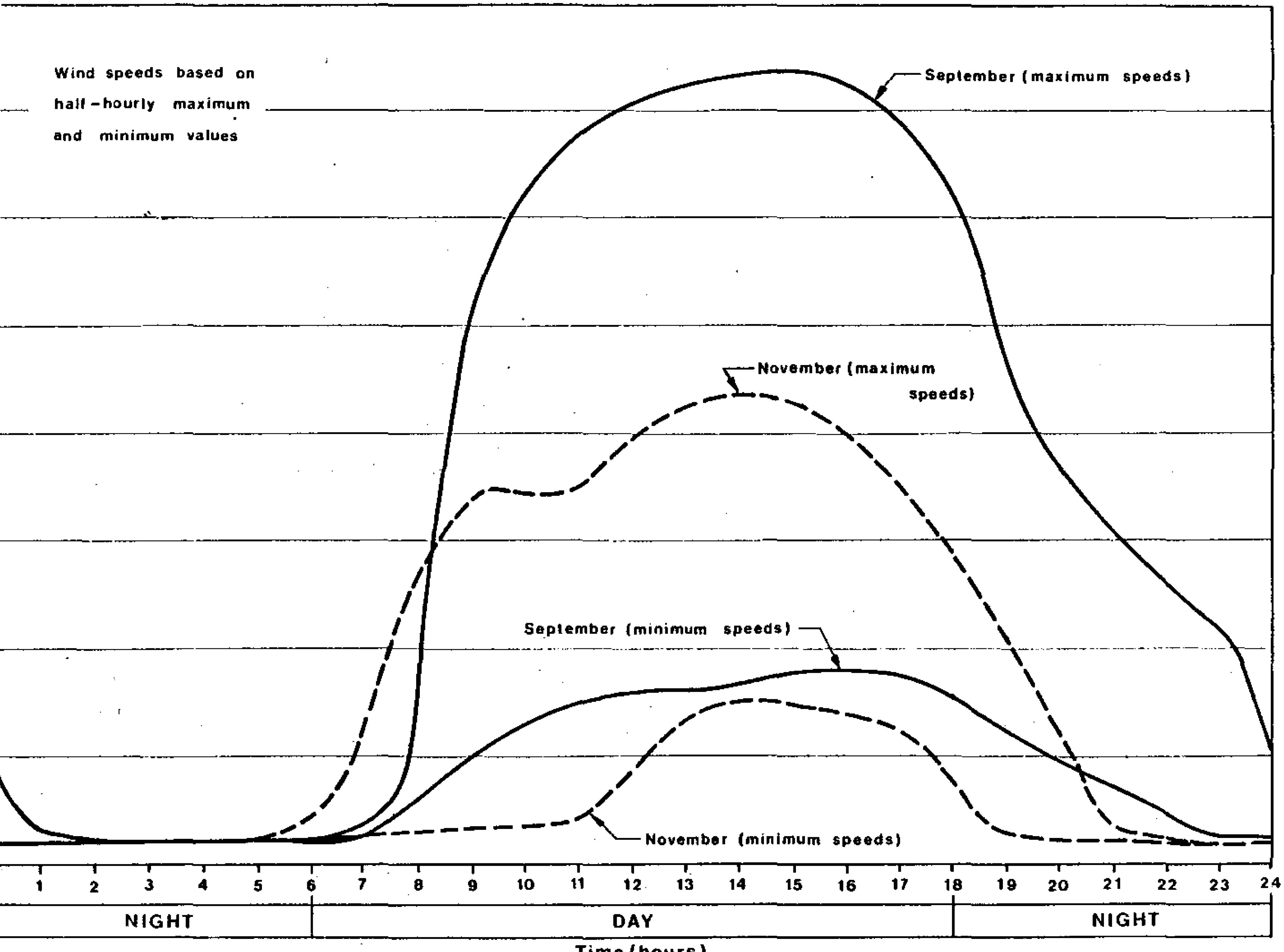
Percentage Probability of Exceeding Given Wind Speed, June 1979

Wind speed at 2 m (m/s)	≥ 0		≥ 0.4		> 1.2		> 2.4		> 4.0		> 6.0		> 8.4 < 10.4		Maximum wind speed at 2 m (m/s)
Time (hours)	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	
0.00 - 1.30	100	100	46	7	40	1	22	-	2	-	-	-	-	-	5.6
2.00 - 3.30	100	100	40	4	32	2	13	-	2	-	-	-	-	-	5.2
4.00 - 5.30	100	100	34	6	29	2	12	-	1	-	-	-	-	-	4.0
6.00 - 7.30	100	100	68	9	60	2	42	-	7	-	2	-	-	-	6.4
8.00 - 9.30	100	100	94	28	91	20	78	4	37	-	11	-	-	-	6.4
10.00 - 11.30	100	100	97	59	93	44	90	19	68	-	26	-	1	-	8.4
12.00 - 13.30	100	100	97	66	95	53	90	24	70	3	31	-	1	-	10.0
14.00 - 15.30	100	100	95	64	94	47	87	24	64	3	15	-	-	-	8.0
16.00 - 17.30	100	100	97	54	96	41	73	12	36	2	4	-	1	-	8.4
18.00 - 19.30	100	100	79	33	69	22	34	4	13	1	1	-	-	-	6.4
20.00 - 21.30	100	100	57	20	48	11	28	2	3	-	-	-	-	-	5.2
22.00 - 23.30	100	100	50	6	47	-	17	-	6	-	1	-	-	-	6.8

TABLE I.14

Percentage Probability of Exceeding Given Wind Speed, July 1979

Wind speed at 2 m (m/s)	≥ 0		> 0.4		> 1.2		> 2.4		> 4.0		> 6.0		> 8.4 < 10.4		Maximum windspeed at 2 m (m/s)
Time (hours)	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	
0.00 - 1.30	100	100	48	5	48	-	25	-	2	-	-	-	-	-	4.8
2.00 - 3.30	100	100	52	10	47	2	22	-	8	-	-	-	-	-	4.8
4.00 - 5.30	100	100	56	16	53	7	28	-	16	-	2	-	-	-	6.0
6.00 - 7.30	100	100	73	14	73	12	52	-	15	-	4	-	-	-	6.4
8.00 - 9.30	100	100	97	31	94	25	86	2	62	-	10	-	-	-	5.6
10.00 - 11.30	100	100	95	32	95	24	95	12	86	-	29	-	-	-	7.2
12.00 - 13.30	100	100	95	27	95	19	92	11	86	-	38	-	-	-	7.6
14.00 - 15.30	100	100	97	25	97	20	94	9	82	3	39	-	1	-	8.4
16.00 - 17.30	100	100	91	16	89	12	77	-	41	-	8	-	-	-	7.2
18.00 - 19.30	100	100	84	6	79	1	45	-	12	-	3	-	-	-	7.6
20.00 - 21.30	100	100	58	6	58	6	33	1	7	-	-	-	-	-	6.4
22.00 - 23.30	100	100	52	6	51	1	31	-	6	-	-	-	-	-	4.8



Wind speed patterns (Marere)

I.1

TABLE I.15

Wind Speeds at Fanoole (m/s)

Month	Wind speed at 0700		Wind speed at 1200	
	Average	Maximum(1)	Average	Maximum(1)
1978				
February	3.1	5.1	5.3	8.0
March	2.1	6.4	4.3	7.6
April	3.4	8.0	4.5	9.6
May	2.6	4.2	4.4	7.4
June (2)	2.4	7.0	5.1	8.0
Nov (3)	2.4	3.6	5.1	7.7

Notes: (1) Average of five instantaneous readings of wind velocity

(2) 20 days of readings only

(3) 7 days of readings only

TABLE I.16

Wind Speed at Alessandra (m/s)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year's average
1953	?	?	1.9	1.3	0.5	0.4	0.8	0.6	0.7	0.7	0.5	1.0	(0.8)
1954	1.7	1.9	1.9	0.7	0.4	0.6	0.6	0.8	0.9	1.0	1.0	1.1	1.0
1955	1.9	2.2	2.0	0.9	0.3	0.4	0.4	0.5	0.9	1.3	1.2	1.4	1.1
1956	1.9	2.3	2.0	1.2	0.6	0.5	0.7	0.9	1.0	1.0	0.8	1.3	1.4
1957	1.8	1.9	1.4	0.5	0.1	0.4	0.7	0.9	1.1	1.0	0.6	0.7	0.9
1958	1.3	1.7	1.9	0.8	0.4	0.3	0.6	0.7	1.2	1.3	1.4	1.4	1.1
Average	1.7	2.0	1.9	0.9	0.4	0.6	0.6	0.7	1.0	1.1	0.9	1.1	1.1

Source: Taken from Contributo alla climatologia della Somalia by Amilcare Fantoli.

RAINFALL RECORDS

1. Tables I.17 to I.34 give daily rainfall records for Alessandra for the years 1930 to 1939 and 1953 to 1960

2. Table I.35 gives monthly rainfall records for Alessandra

3. Table I.36 gives monthly rainfall records for Bardheere

4. Table I.37 gives monthly rainfall records for Jamama

SANDRA

RAINFALL IN MILLIMETRES

TABLE I.17

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
	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	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	1.00	0.00	0.00	0.00	19.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	1.20	0.00	0.00	6.40	0.00	0.00	0.00	6.20	0.00
	0.00	0.00	0.00	2.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	18.40	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	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	26.10	1.60	0.00	0.00	0.00	0.00	0.00	0.00	7.20	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.40	2.00
	0.00	0.00	0.00	11.80	0.00	0.00	0.00	0.00	0.00	0.00	1.40	0.00
	0.00	0.00	0.00	30.20	0.00	0.00	15.20	0.00	0.00	0.00	0.00	2.60
	0.00	0.00	0.00	14.20	101.00	0.00	6.00	0.00	0.00	0.00	3.80	0.00
	0.00	0.00	0.00	0.00	8.20	0.00	4.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	1.00	5.00	0.00	0.00	0.00	0.00	0.00	7.00	0.00
	0.00	0.00	0.00	0.00	10.60	0.00	2.00	0.00	0.00	0.00	2.00	0.00
	0.00	0.00	0.00	7.60	0.00	0.00	0.00	0.00	0.00	0.00	1.00	16.00
	0.00	0.00	0.00	38.40	0.00	0.00	7.00	4.00	0.00	0.00	10.00	0.00
	0.00	0.00	0.00	4.20	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	4.60	0.00	0.00	0.00	0.00	0.00	7.00	0.00
	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00
	0.00	0.00	0.00	58.60	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	0.00	0.00	0.00	0.00	2.00	0.00
	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	7.60	7.20	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	0.00	0.00	8.20	0.00	0.00
	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	12.00	0.00	0.00
	0.00	0.00	0.00	1.20	0.00	0.00	0.00	0.00	0.00	14.00	0.00	0.00
	0.00	0.00	0.00	0.00	4.60	0.00	0.00	0.00	2.20	36.80	0.00	0.00
	0.00	-----	0.00	2.00	16.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.50	-----	0.00	3.60	0.00	0.00	0.00	0.00	0.00	18.40	0.00	0.00
	0.00	-----	0.00	-----	0.00	-----	1.40	0.00	-----	6.00	-----	0.00
L	0.50	0.00	46.50	188.60	169.60	0.00	61.00	6.00	2.20	95.40	69.00	20.60
	0.02	0.00	1.50	6.29	5.47	0.00	1.97	0.19	0.07	3.08	2.30	0.66
	0.50	0.00	26.10	58.60	101.00	0.00	19.00	4.00	2.20	36.80	11.40	16.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1930 SUMMARY (365 DAYS) : TOTAL 659.4 MEAN 1.8

ESSANDRA

RAINFALL IN MILLIMETRES

AY	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
1	0.00	0.00	0.00	0.00	11.00	0.00	1.80	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.70
3	0.00	0.00	0.00	0.00	3.10	1.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	1.60	0.00	0.00	0.00	0.00	0.00	0.00	4.30
6	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.60	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	20.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	4.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	6.60	0.50	0.00	0.00	0.00	0.00	0.00	0.00
0	0.00	0.00	0.00	12.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	8.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
2	0.00	0.00	0.00	15.00	1.50	0.50	4.00	20.40	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.50	3.50	2.00	0.00	0.00	14.00	0.00
4	0.00	0.00	0.00	0.00	0.00	3.00	0.00	0.10	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	9.40	7.50	0.90	0.00	0.00	0.00	2.10	0.00	0.00
7	0.00	0.00	0.00	0.00	10.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	57.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	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	0.00	0.00	0.00	0.00	0.00	0.00	1.80	0.00	0.00	1.90	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.00	0.00	37.40	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	24.00	0.00	0.00
4	0.00	0.00	0.00	0.50	20.00	0.00	0.00	0.00	0.00	12.00	22.60	0.00
5	0.00	0.00	0.00	0.00	2.80	5.00	0.00	0.00	0.00	9.50	3.00	0.00
6	0.00	0.00	0.00	0.00	0.00	4.20	35.00	1.00	0.00	0.00	0.50	0.00
7	0.00	0.00	0.00	2.20	1.30	12.50	0.40	0.00	0.00	0.00	0.10	0.00
8	0.00	0.00	0.00	2.20	1.50	0.00	0.30	0.00	0.00	0.00	0.00	0.00
9	0.00	-----	0.00	5.50	0.00	0.50	0.00	0.00	0.00	0.00	7.50	0.00
0	0.00	-----	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	8.00	0.00
1	0.00	-----	0.00	-----	4.10	-----	0.00	0.00	-----	0.00	-----	0.00
TAL	0.00	0.00	0.00	54.80	156.90	29.00	47.40	24.10	1.00	86.90	55.70	13.00
AN	0.00	0.00	0.00	1.83	5.06	0.97	1.53	0.78	0.03	2.80	1.86	0.42
X.	0.00	0.00	0.00	15.00	57.70	12.50	35.00	20.40	1.00	37.40	22.60	8.70
N.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1931 SUMMARY (365 DAYS) : TOTAL 468.8 MEAN 1.3

TABLE I.18

TABLE I.19

SANDRA RAINFALL IN MILLIMETRES

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
	0.00	0.00	0.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	43.20	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	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	12.50	0.00	0.00	0.00	0.00	0.00	6.70
	0.00	0.00	0.00	0.00	7.30	0.00	0.00	4.00	0.00	0.00	14.60	5.70
	0.00	0.00	0.00	0.00	1.00	4.50	0.00	9.50	0.00	0.00	0.50	4.00
	0.00	0.00	0.00	0.00	26.50	0.00	0.00	8.50	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	11.50	0.00	0.00	0.00	0.00	0.00	0.00	5.50
	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	0.00	0.00	7.50	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	6.50	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	29.00	5.30	0.00	8.00	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	0.00	0.00	20.00
	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00
	0.00	0.00	0.00	0.00	7.00	3.70	0.00	0.00	0.00	0.00	0.00	57.60
	0.00	0.00	0.00	0.00	0.00	4.80	0.00	0.00	0.00	0.00	18.00	4.50
	0.00	0.00	0.00	0.00	3.00	0.00	0.00	2.00	0.00	0.00	3.70	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	1.20
	1.00	0.00	0.00	23.00	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	0.00	22.50	0.00	0.00	0.00	0.00	4.80
	0.00	0.00	0.00	0.00	0.00	4.70	0.00	0.00	0.00	0.00	0.00	4.80
	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	14.50
	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	5.60	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	4.50	0.00	0.00	0.00	0.00	4.30	0.00
	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	1.00	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	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50
	0.00	0.00	0.00	0.00	15.00	0.00	0.00	0.00	0.00	0.00	10.50	0.00
	0.00	-----	0.00	0.00	6.50	0.00	0.00	0.00	0.00	10.70	0.00	0.00
	0.00	-----	0.00	-----	0.00	-----	0.00	0.00	-----	0.00	-----	0.00
L	1.00	0.00	0.00	24.50	183.50	40.00	31.00	32.00	0.00	17.30	51.60	132.80
	0.03	0.00	0.00	0.82	5.92	1.33	1.00	1.03	0.00	0.56	1.72	4.28
	1.00	0.00	0.00	23.00	43.20	12.50	22.50	9.50	0.00	10.70	18.00	57.60
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1932 SUMMARY (366 DAYS) : TOTAL 513.7 MEAN 1.4

ESSANDRA

RAINFALL IN MILLIMETRES

AY	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	39.20	0.00	0.00	0.00	0.00	0.00	0.00	11.00
3	0.00	0.00	0.00	0.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	11.00	0.00	2.00	0.00	4.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	14.80	0.00	4.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	12.40	1.30	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	7.80	1.20	0.00	20.00	0.00	0.00	18.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.00
9	0.00	0.00	0.00	1.70	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.00
0	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	4.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	3.00	0.00	30.00	0.00	0.00	0.00	7.50	37.00
3	0.00	0.00	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.00	10.00	2.50
4	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	3.50	0.00	0.00	0.00	0.00	0.00
8	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	26.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	26.40	0.00	0.00	0.00	0.00	0.00	0.00	7.20	0.00
3	0.00	0.00	0.00	8.00	0.00	2.60	0.00	0.00	0.00	1.00	4.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	3.70	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	0.00
8	0.00	0.00	0.00	46.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	0.00
9	0.00	-----	0.00	17.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0.00	-----	0.00	14.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	-----	12.40	-----	0.00	-----	0.00	0.00	-----	0.00	-----	0.00
TAL	7.00	0.00	12.40	139.10	72.50	22.80	59.50	0.00	44.00	2.00	50.40	75.50
AN	0.23	0.00	0.40	4.64	2.34	0.76	1.92	0.00	1.47	0.06	1.68	2.44
X.	7.00	0.00	12.40	46.00	39.20	12.40	30.00	0.00	20.00	1.00	10.00	37.00
N.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1933 SUMMARY (365 DAYS) : TOTAL 485.2 MEAN 1.3

TABLE I.20

SANDRA

RAINFALL IN MILLIMETRES

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
	0.00	0.00	0.00	0.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	10.00
	0.00	0.00	0.00	0.00	2.50	0.00	4.00	8.00	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	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	9.00	0.00	2.00	1.20	0.00	0.00	0.50	9.50
	0.00	0.00	0.00	0.00	11.00	0.00	1.00	0.30	0.00	0.00	0.00	6.50
	0.00	0.00	0.00	0.00	51.00	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	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	13.00	0.00	0.00	2.40	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	4.50	0.00	0.00	0.00	3.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	9.60	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	0.00	0.00	0.00	0.00	1.00	5.00	3.00	1.00	0.00	0.00	0.00
	0.00	0.00	0.00	26.00	6.50	0.00	0.00	0.00	0.20	27.00	3.00	0.00
	0.00	0.00	0.00	12.00	0.00	3.50	6.00	0.00	0.00	4.80	0.00	0.00
	0.00	0.00	0.00	6.50	0.00	4.50	6.00	0.00	0.00	1.50	0.00	2.00
	0.00	0.00	0.00	9.50	0.00	6.00	34.00	0.00	0.00	0.00	0.00	1.00
	0.00	0.00	0.00	0.00	0.00	3.00	5.00	0.00	0.00	0.00	2.00	5.00
	0.00	0.00	0.00	0.00	0.00	0.00	1.00	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	0.00	0.00	0.00	11.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	29.00	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	0.00
	0.00	0.00	0.00	4.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	8.00	0.00	0.50	0.00	0.00	0.00	0.00	7.60	0.00
	0.00	0.00	0.00	4.20	0.00	0.00	0.00	4.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	8.00	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	11.00	0.50	0.00	0.00	0.00	2.10	0.00
	0.00	0.00	0.00	0.00	2.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	1.00	0.00
	0.00	-----	0.00	31.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	-----	0.00	24.00	26.50	9.00	0.00	0.00	0.00	0.00	1.00	0.00
	0.00	-----	0.00	-----	8.00	-----	0.00	0.00	-----	0.00	-----	0.00
L	0.00	0.00	0.00	133.40	134.00	50.50	71.00	18.90	6.20	62.30	26.80	45.00
	0.00	0.00	0.00	4.45	4.32	1.68	2.29	0.61	0.21	2.01	0.89	1.45
	0.00	0.00	0.00	31.00	51.00	11.00	34.00	8.00	3.00	29.00	9.60	11.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1934 SUMMARY (365 DAYS) : TOTAL 548.1 MEAN 1.5

TABLE I.21

RAINFALL IN MILLIMETRES

AY	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.00
2	0.00	0.00	0.00	0.00	0.00	7.00	0.00	0.00	0.00	0.00	0.00	10.00
3	0.00	0.00	0.00	0.00	0.00	15.00	0.00	0.00	0.00	0.00	48.00	0.00
4	0.00	1.00	0.00	0.00	0.00	14.00	0.00	5.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	1.00	6.00	0.00	8.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	2.00	27.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	43.00	0.00	0.00	25.00	0.00	0.00	0.00	0.00	0.00
9	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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	20.00	0.00	0.00	0.00	20.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	2.00	0.00	0.00	0.00	18.00	0.00	27.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	15.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	0.00	0.00	0.00	0.00	0.00	41.00	0.00	0.00	0.00	12.00	7.00	0.00
9	0.00	0.00	0.00	0.00	0.00	11.00	0.00	0.00	0.00	0.00	13.00	0.00
20	0.00	0.00	0.00	0.00	6.00	21.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	18.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	8.50	0.00	0.00	0.00	0.00	0.00	0.00	20.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	8.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	20.00	0.00	0.00	0.00	0.00	0.00	0.00	22.00	0.00
27	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	45.00	0.00	0.00
28	0.00	0.00	0.00	14.00	0.00	0.00	0.00	0.00	0.00	6.00	0.00	0.00
29	0.00	-----	0.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00	-----	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	-----	0.00	-----	0.00	-----	0.00	0.00	-----	0.00	-----	0.00
OTAL	0.00	9.50	0.00	103.00	41.00	142.00	33.00	46.00	20.00	105.00	100.00	17.00
AN	0.00	0.34	0.00	3.43	1.32	4.73	1.06	1.48	0.67	3.39	3.33	0.55
X.	0.00	8.50	0.00	43.00	27.00	41.00	25.00	20.00	20.00	45.00	48.00	10.00
N.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1935 SUMMARY (365 DAYS) : TOTAL 616.5 MEAN 1.7

TABLE I.22

SSANDRA RAINFALL IN MILLIMETRES

Y	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
	0.00	0.00	0.00	13.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	4.00	36.00	0.00	0.00	1.90	1.20	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.90	0.00	0.00	1.00
	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	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	6.00	45.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00
	1.00	0.00	0.00	0.00	0.00	0.00	1.20	0.00	0.00	0.00	18.00	0.00
	0.00	0.00	0.00	2.10	0.00	1.10	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	13.10	2.50	10.50	0.00	0.00	0.00	0.00	3.00	1.00
	0.00	0.00	0.00	8.00	5.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	14.50	0.00	0.00	9.00	0.00	0.00	13.00	0.00	0.00
	0.00	0.00	0.00	10.50	0.00	0.00	0.90	0.80	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	7.00	0.00	0.10	0.50	0.00	0.00	29.50	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	1.60	0.00	0.00	2.00	0.00	0.00	1.00
	0.00	0.00	0.00	6.00	0.00	3.00	0.10	0.00	1.00	0.00	0.00	0.00
	0.00	0.00	0.00	30.00	0.00	8.50	0.30	0.10	3.00	0.00	0.00	0.00
	0.00	0.00	0.00	2.00	0.00	1.20	0.30	0.00	47.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	4.00	0.00	0.00	10.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	5.80	0.00	0.00	97.00	0.00	6.50	0.00
	0.00	13.00	0.00	0.00	0.00	23.70	0.00	1.70	0.00	66.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	5.20	13.30	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	7.10	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	1.20	0.10	0.00	0.00	7.00	0.00
	0.00	0.00	0.00	0.00	0.00	3.00	1.00	8.60	0.00	0.00	2.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	12.00	3.00	0.00
	0.00	0.00	0.00	11.00	0.00	0.00	0.00	0.00	0.00	22.50	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	-----	0.20	-----	0.00	-----	0.00	0.00	-----	0.00	-----	0.00
AL	2.00	13.00	0.20	121.70	43.70	73.70	36.00	14.10	162.10	143.00	45.50	48:00
	0.06	0.45	0.01	4.06	1.41	2.46	1.16	0.45	5.40	4.61	1.52	1.55
	1.00	13.00	0.20	30.00	36.00	23.70	13.30	8.60	97.00	66.00	18.00	45.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1936 SUMMARY (366 DAYS) : TOTAL 703.0 MEAN 1.9

TABLE I.23

TABLE I.24

DAY	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
1	0.00	0.00	0.00	0.00	46.00	0.90	4.50	0.00	0.00	0.00	0.00	0.30
2	0.00	0.00	0.00	0.00	1.50	0.00	1.50	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.00	1.00
4	0.00	0.00	0.00	3.30	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	20.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	15.00	12.50	0.00	0.10	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	1.10	0.00	0.00	0.00	0.00	0.00	0.00	0.60
8	0.00	0.00	0.00	41.50	2.60	0.00	0.00	0.00	0.70	0.00	12.90	0.00
9	0.00	0.00	0.00	27.30	0.00	0.00	11.00	0.00	0.00	0.00	0.00	0.20
10	0.00	0.00	0.00	0.00	2.60	0.00	30.30	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	3.50	0.00	0.00	2.90	0.00	7.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.80	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.90	0.00	0.00	16.00
14	0.00	0.00	0.00	30.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	16.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.40	1.50	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	2.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	6.20	0.00	4.40	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.70	0.00	7.00	0.00	2.70	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	3.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	1.00	0.50	0.00	0.60	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	5.30	0.50	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	16.00	2.60	0.00	0.40	0.00	0.00	0.00	0.00
27	0.00	0.00	2.70	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.90	0.00
28	0.00	0.00	0.00	0.00	5.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00	-----	0.00	0.00	25.20	52.10	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00	-----	0.00	0.00	11.80	30.00	0.00	0.40	0.00	0.00	0.00	0.00
31	0.00	-----	1.20	-----	1.00	-----	0.00	0.00	-----	0.00	-----	0.00
TOTAL	0.00	0.00	3.90	146.50	140.40	94.70	57.10	6.60	16.40	0.00	15.80	34.10
MEAN	0.00	0.00	0.13	4.88	4.53	3.16	1.84	0.21	0.55	0.00	0.53	1.10
MAX.	0.00	0.00	2.70	41.50	46.00	52.10	30.30	2.70	7.80	0.00	12.90	16.00
MIN.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1937 SUMMARY (365 DAYS) : TOTAL 515.5 MEAN 1.4

SANDRA   RAINFALL IN MILLIMETRES

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
	0.00	0.00	0.00	0.00	0.00	0.00	80.00	0.00	0.00	0.00	44.00	0.00
	0.00	0.00	0.00	0.00	3.00	0.00	4.50	0.00	0.00	0.00	20.00	0.00
	0.00	0.00	0.00	0.00	45.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	47.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	7.50	0.00	0.00	0.00	0.00	0.00	10.00
	0.00	0.00	0.00	0.00	0.00	4.00	3.50	0.00	0.00	0.00	0.00	3.00
	0.00	0.00	0.00	6.00	15.00	1.80	1.00	1.60	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	2.00	2.00	1.00	0.00	14.20	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.00	0.00	0.00	0.00	4.00
	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	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	0.00	0.00	3.00
	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	0.00	0.00	0.00	0.00	0.80	1.00	0.00	0.00	0.00	0.00	15.00
	0.00	0.00	0.00	5.00	0.00	0.00	7.00	3.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	18.60	2.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	2.40	0.00	0.00	0.00	0.00	5.00
	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	1.00
	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	0.00	0.00	7.50	0.00	0.00	0.00	0.00	0.00	0.00	3.00	0.00
	0.00	0.00	0.00	3.50	0.00	4.00	0.00	0.00	0.00	0.00	12.00	0.00
	0.00	0.00	0.00	0.00	27.00	4.00	1.00	2.00	0.00	0.00	1.00	0.00
	0.00	0.00	0.00	0.00	8.50	0.00	0.00	0.00	0.00	0.00	5.00	20.00
	0.00	0.00	0.00	0.00	0.00	20.00	0.00	0.00	0.00	13.00	0.00	0.00
	0.00	0.00	0.00	0.00	5.50	1.00	1.00	0.00	0.00	22.50	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	3.50	5.00	0.00	0.50	0.00	0.00
	0.00	0.00	0.00	7.00	0.00	6.00	3.00	1.00	0.00	17.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	2.00	4.50	0.00	0.00	18.00	0.00	0.00
	0.00	-----	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.50	0.00	0.00
	0.00	-----	0.00	50.00	0.00	38.80	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
L	3.00	0.00	0.00	81.00	153.00	90.90	136.30	36.80	0.00	94.50	85.00	63.00
	0.10	0.00	0.00	2.70	4.94	3.03	4.40	1.19	0.00	3.05	2.83	2.03
	3.00	0.00	0.00	50.00	47.00	38.80	80.00	14.20	0.00	23.50	44.00	20.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1938 SUMMARY (365 DAYS) : TOTAL 743.5 MEAN 2.0

TABLE I.25

TABLE I.26

DAY	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
1	0.00	0.00	0.00	0.00	0.00	0.00	1.00	6.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.40	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	28.50	39.50	4.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	16.00	0.00	4.50	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	16.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	30.00	21.50	17.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	18.00	0.00	7.50	0.00	8.50	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	24.00	0.00	17.50	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	1.10	25.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	23.50	22.50	25.50	0.00	17.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	4.00	0.00	2.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	22.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.80	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	16.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	7.50	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00	-----	0.00	0.00	44.50	2.00	2.00	9.00	0.00	0.00	0.00	0.00
30	0.00	-----	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	-----	0.00	-----	0.00	-----	0.00	0.00	-----	0.00	-----	0.00
TOTAL	0.00	0.00	0.00	189.90	153.60	110.00	3.00	46.90	0.00	0.00	0.00	0.00
MEAN	0.00	0.00	0.00	6.33	4.95	3.67	0.10	1.51	0.00	0.00	0.00	0.00
MAX.	0.00	0.00	0.00	30.00	44.50	25.50	2.00	17.00	0.00	0.00	0.00	0.00
MIN.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1939 SUMMARY (365 DAYS) ! TOTAL 503.4 MEAN 1.4

SSANDRA

RAINFALL IN MILLIMETRES

Y	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
	0.00	0.00	0.00	0.00	5.00	5.10	0.00	0.00	0.30	0.00	0.00	0.40
	0.00	0.00	0.00	0.00	0.40	12.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	1.30	0.00	0.00	1.40	0.00	0.00	12.50
	0.00	0.00	0.00	0.00	14.00	4.30	6.10	0.00	7.90	0.00	5.70	0.50
	0.00	0.00	0.00	0.00	4.60	3.30	2.90	1.70	0.10	0.00	10.60	4.40
	0.00	0.00	0.00	0.00	0.00	0.00	7.30	4.80	0.80	0.00	0.00	0.10
	0.00	0.00	0.00	0.00	3.00	0.00	0.50	0.30	0.00	0.00	0.00	1.10
	0.00	0.00	0.00	0.00	3.80	0.00	1.80	0.00	0.00	0.00	46.20	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	2.00
	0.00	0.00	0.00	12.80	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.90	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.80	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	9.60	0.00	0.00	0.30	26.30	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	25.80	0.30	0.00	38.00	0.30	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	13.20	2.60	0.00	0.00	2.30	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	2.20	0.20	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.10	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.60	16.30	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	10.30	0.10	0.00	0.20	0.00	1.80
	0.00	0.00	0.00	0.00	0.00	0.00	5.20	6.50	0.00	5.20	8.10	0.00
	0.00	0.00	0.00	6.40	7.70	3.40	19.80	0.00	0.00	0.00	3.00	0.00
	0.00	0.00	0.00	1.80	0.20	0.50	0.60	2.50	0.00	0.00	3.80	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.40	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.30	0.00	0.00	14.10	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.90	10.00	0.00	0.00	0.50	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.60	0.00
	0.00	0.00	0.00	19.80	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00
	0.00	-----	0.00	6.80	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00
	0.00	-----	0.00	13.50	2.90	0.00	0.00	0.00	0.00	0.00	6.40	0.00
	0.00	-----	0.00	-----	4.30	-----	0.00	0.00	-----	0.00	-----	0.00
AL	0.00	0.00	0.00	63.10	45.90	29.90	107.10	34.20	10.50	45.10	156.60	22.80
N	0.00	0.00	0.00	2.10	1.48	1.00	3.45	1.10	0.35	1.45	5.22	0.74
.	0.00	0.00	0.00	19.80	14.00	12.00	25.80	10.00	7.90	38.00	46.20	12.50
.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1953 SUMMARY (365 DAYS) : TOTAL 515.2 MEAN 1.4

TABLE I.27

TABLE I.28

RAINFALL IN MILLIMETRES

AY	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
1	0.00	0.00	0.00	0.00	30.10	0.00	0.00	0.00	1.90	0.00	2.80	3.90
2	0.00	0.00	0.00	8.20	0.00	0.00	0.00	0.50	0.00	0.00	1.90	11.90
3	0.00	0.00	0.00	1.70	0.00	0.00	1.40	0.90	0.00	0.00	0.00	29.10
4	0.00	0.00	0.00	1.10	0.00	1.00	1.00	1.40	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	4.10	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	9.90	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.20	0.00	1.00	0.50	0.40	0.00	0.00	0.00	19.90
8	0.00	0.00	0.00	0.00	13.10	0.00	0.00	1.50	0.00	0.00	10.30	9.50
9	0.00	0.00	0.00	0.00	10.40	0.00	0.00	0.50	0.00	0.00	0.00	0.00
0	0.00	0.00	0.00	1.60	2.70	0.00	3.30	0.90	0.00	0.00	9.70	0.00
1	0.00	0.00	0.00	27.60	5.90	0.00	1.30	0.20	0.00	0.00	3.60	0.00
2	0.00	0.00	0.00	0.10	0.20	0.00	1.30	0.00	0.00	0.00	0.20	0.00
3	0.00	0.00	0.00	0.00	0.80	0.00	13.10	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	2.60	0.00	0.00	50.00	5.10	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00
6	0.00	0.00	0.00	3.70	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	2.10	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00
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
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.20	0.00	0.00
2	0.00	0.00	0.00	0.00	4.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	11.90	0.40	30.60	0.00	0.00	0.30	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.20	8.50	0.00	0.10	0.00	5.70	8.60	0.00
5	0.00	0.00	0.00	0.00	0.80	9.70	0.00	5.80	0.00	36.40	6.20	0.00
6	0.00	0.00	0.00	0.00	0.00	19.10	0.00	0.09	0.20	0.00	0.00	0.00
7	0.00	0.00	0.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	1.10	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00
9	0.00	-----	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.80	4.10	0.00
0	0.00	-----	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.90	0.00
1	0.00	-----	0.40	-----	0.00	-----	0.00	0.00	-----	0.00	-----	0.00
TAL	0.00	0.00	0.40	62.80	70.70	69.90	37.20	12.79	3.20	108.90	53.50	74.30
AN	0.00	0.00	0.01	2.09	2.28	2.33	1.20	0.41	0.11	3.51	1.78	2.40
X.	0.00	0.00	0.40	27.60	30.10	30.60	13.10	5.80	1.90	50.00	10.30	29.10
N.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1954 SUMMARY (365 DAYS) ! TOTAL 493.7 MEAN 1.4

SANDRA

RAINFALL IN MILLIMETRES

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
	0.00	0.00	0.00	0.00	0.00	3.90	7.10	0.00	0.00	0.00	0.10	0.00
	9.00	0.00	0.00	0.00	15.80	0.00	0.10	0.00	0.10	0.00	4.00	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
	0.00	0.00	0.00	0.00	0.00	0.00	2.10	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	1.00	6.90	0.00	0.00	1.00	0.00	40.00
	0.00	0.00	0.00	0.00	7.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	9.90	4.40	10.10	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	2.20	0.50	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.10	0.00	0.00	1.00	2.90	0.00	0.00	0.00	6.80
	0.00	0.00	0.00	25.10	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	46.60	2.30	0.00	19.50	0.00	0.00	0.00	2.90	0.00
	0.00	0.00	0.00	13.80	0.00	0.00	8.30	0.00	0.00	0.00	16.90	0.00
	0.00	0.00	0.00	19.60	0.00	1.90	0.00	0.00	0.00	0.00	0.00	14.00
	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.90	0.00	2.80
	0.00	0.00	0.00	0.30	0.00	2.30	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	4.20	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	1.80	1.60	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	35.40	0.00	1.70	0.00	0.00	0.00	1.50	0.00	0.00
	0.00	0.00	0.00	2.50	2.20	4.80	0.00	0.00	0.00	0.00	2.50	0.00
	0.00	0.00	0.00	0.00	3.80	5.80	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	2.90	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	4.20	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	1.00	6.90	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	0.10	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	1.20	0.00	0.00	1.80	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	7.50	0.00	0.00	0.10	10.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	60.20	4.00	0.00	0.00	0.00	0.00	0.00	0.00	15.60
	0.00	-----	0.00	0.40	11.30	19.00	1.20	0.00	0.00	0.00	0.00	20.50
	0.00	-----	0.00	0.00	73.90	5.20	0.00	0.00	0.00	0.00	0.00	2.30
	0.00	-----	0.80	-----	12.30	-----	0.00	0.00	-----	48.00	-----	0.00
L	10.50	0.00	0.80	217.90	152.30	59.00	60.60	13.40	0.10	51.40	26.40	102.00
	0.34	0.00	0.03	7.26	4.91	1.97	1.95	0.43	0.00	1.66	0.88	3.29
	9.00	0.00	0.80	60.20	73.90	19.00	19.50	10.00	0.10	48.00	16.90	40.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1955 SUMMARY (365 DAYS) : TOTAL 694.4 MEAN 1.9

TABLE I.29

ESSANDRA

RAINFALL IN MILLIMETRES

AY	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
1	0.00	0.00	0.00	1.50	0.00	0.00	0.00	0.00	0.00	0.50	7.60	0.00
2	0.00	0.00	0.00	6.50	2.20	0.00	0.00	0.00	0.00	0.00	0.00	7.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	1.90	0.00	0.00	0.00	0.00	11.90	0.00
7	0.00	0.00	0.00	0.00	1.90	4.80	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.00	2.20
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
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
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.90	0.00	0.00	35.50	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.50	0.00
5	0.00	0.00	0.00	0.10	8.60	0.00	0.00	0.00	0.00	0.00	0.00	1.10
6	0.00	0.00	0.00	33.00	4.40	30.50	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10	0.00	0.00	16.40	0.00
8	0.00	0.00	0.00	8.50	0.00	0.10	0.00	1.30	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00	15.90	0.00
0	0.00	0.00	0.00	57.00	0.40	0.00	0.00	0.00	0.00	0.00	3.10	0.00
1	0.00	0.00	0.00	4.80	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.30	0.00
3	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	33.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	21.40	0.00	0.00	0.00	0.00	0.00	11.50	0.00	0.00
6	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	86.40	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	6.10	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	37.00	1.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	35.30	0.20	0.00	0.00	0.00	0.00	18.50	0.00	0.00
0	0.00	-----	0.00	0.00	9.90	0.00	1.70	0.00	0.00	4.00	0.00	0.00
1	0.00	-----	6.60	-----	0.00	-----	2.30	0.00	-----	0.00	-----	0.00
TAL	0.00	0.00	6.60	241.50	30.70	43.40	4.60	5.10	0.00	120.90	111.20	10.30
AN	0.00	0.00	0.21	8.05	0.99	1.45	0.15	0.16	0.00	3.90	3.71	0.33
X.	0.00	0.00	6.60	57.00	9.90	30.50	2.30	1.90	0.00	86.40	35.50	7.00
N.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1956 SUMMARY (366 DAYS) : TOTAL 574.3 MEAN 1.6

TABLE I.30

ANDRA

RAINFALL IN MILLIMETRES

TABLE I.31

JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
0.00	0.00	0.00	0.00	0.20	0.00	10.90	0.00	0.00	0.00	0.00	9.30
0.00	0.00	0.00	0.00	1.80	0.00	0.00	0.00	0.00	0.00	0.00	10.20
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.90
0.00	0.00	0.00	0.00	1.60	0.00	0.00	0.00	0.00	0.00	0.00	14.30
0.00	0.00	0.00	0.00	1.20	0.00	19.30	0.00	4.50	0.00	8.10	0.00
0.00	0.00	0.00	0.00	3.80	0.00	31.50	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	1.30	0.00	7.40	0.70	0.00	0.00	1.00	0.80
0.00	0.00	0.00	0.00	20.60	0.00	6.20	0.00	0.00	0.00	0.00	4.70
0.00	0.00	15.20	0.00	0.00	4.10	1.10	1.70	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	11.80	0.00	0.00	0.00	0.00	6.10	0.20
0.00	0.00	0.00	0.00	11.70	6.70	0.00	0.00	0.00	0.00	0.00	5.60
0.00	0.00	0.00	8.50	25.80	0.70	0.00	0.00	0.00	0.00	2.00	9.70
0.00	0.00	0.00	44.50	0.80	1.50	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	50.20	77.40	0.00	0.00	0.10	0.00	0.00	0.00	0.00
0.00	0.00	0.00	33.60	8.90	4.80	10.00	0.00	3.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	3.80	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.80	1.30	0.00	0.00	0.00	0.00	4.20	0.00
0.00	0.00	0.00	0.00	38.80	0.00	0.00	0.00	0.10	0.00	2.70	0.00
0.00	0.00	0.00	0.00	3.50	0.00	1.50	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	62.50	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	19.70	0.00	0.00	0.00	0.00	0.00	22.90	10.70	0.00
0.00	0.00	0.00	10.90	0.10	0.00	0.80	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	15.40	2.80	1.00	1.20	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.90	0.00	0.50	0.00	0.00	0.00	0.00	0.80	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.30	0.00
0.00	0.00	0.00	3.70	0.00	0.60	0.00	0.00	0.00	6.60	0.00	0.00
0.00	0.00	0.00	22.20	0.00	0.50	0.00	0.00	0.00	0.70	0.00	0.00
0.00	0.00	0.00	11.00	0.00	0.00	0.00	0.00	0.00	23.00	18.40	0.00
0.00	-----	2.50	1.90	0.00	2.10	0.60	0.00	0.00	1.80	26.10	0.00
0.00	-----	0.00	1.10	0.00	0.00	0.00	5.70	0.00	2.30	53.10	0.00
0.00	-----	0.00	-----	0.00	-----	0.50	0.00	-----	20.00	-----	0.00
0.00	0.00	17.70	286.10	201.10	39.40	101.00	8.20	7.60	77.30	137.50	65.70
0.00	0.00	0.57	9.54	6.49	1.31	3.26	0.26	0.25	2.49	4.58	2.12
0.00	0.00	15.20	62.50	77.40	11.80	31.50	5.70	4.50	23.00	53.10	14.30
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1957 SUMMARY (365 DAYS) : TOTAL 941.6 MEAN 2.6

TABLE I.32

AY	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
1	0.00	0.00	0.00	0.00	1.50	1.50	0.00	13.90	2.80	0.00	0.00	12.80
2	0.00	0.00	0.00	0.00	0.40	21.20	0.00	1.90	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	37.90	15.80	0.00	1.50	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	1.20	6.00	0.50	0.00	0.00	0.00	0.00	1.10
5	0.00	0.00	0.00	0.00	6.00	7.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	30.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.90
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.50	0.00
0	0.00	0.00	0.00	0.00	0.00	0.00	1.30	0.00	0.00	0.00	0.00	5.00
1	0.00	0.00	0.00	0.00	0.00	0.00	3.40	0.80	0.00	0.00	5.50	7.50
2	0.00	0.00	0.00	0.00	0.00	0.50	0.20	1.90	0.00	0.00	0.00	4.30
3	0.00	0.00	0.00	0.00	0.00	5.60	9.50	0.00	0.00	0.00	0.00	20.10
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.90	0.00	0.00	0.00	0.00	0.00	0.00	5.80	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.40	0.00	0.00
0	0.00	0.00	0.00	2.40	26.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	28.30	0.00	0.00	0.00	14.50	0.00	0.00	11.00	0.00
2	0.00	0.00	0.00	1.30	0.10	0.00	0.00	0.70	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	25.40	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	12.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	1.00	0.00	0.80	0.00	0.00	0.00	0.00	3.50	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.10	1.10	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	2.80	0.10	2.30	0.20	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	1.70	2.80	0.00	0.00	0.00	0.00	0.00	0.00	4.00
9	0.00	-----	0.00	0.00	0.00	0.00	12.10	0.10	0.00	0.00	0.00	0.00
0	0.00	-----	0.00	0.90	2.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	-----	0.00	-----	27.80	-----	0.10	0.00	-----	0.00	-----	0.00
TAL	0.00	0.00	0.00	78.00	137.60	61.20	27.40	37.00	2.80	6.40	27.30	62.70
AN	0.00	0.00	0.00	2.60	4.44	2.04	0.88	1.19	0.09	0.21	0.91	2.02
X.	0.00	0.00	0.00	28.30	37.90	21.20	12.10	14.50	2.80	6.40	11.00	20.10
N.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1958 SUMMARY (365 DAYS) : TOTAL 440.4 MEAN 1.2

SANDRA

RAINFALL IN MILLIMETRES

TABLE I.33

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
	0.00	0.00	0.00	0.00	3.90	8.30	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	0.00	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	0.00	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
	0.00	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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	3.60	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	21.50	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	0.00	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	0.00	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	0.00
	0.00	0.00	0.00	9.80	0.00	0.00	0.00	25.20	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	1.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	61.00	11.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	14.70	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	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	60.00	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	0.00	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	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	24.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	16.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	22.30	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	0.00	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	0.00	0.00	0.00
	2.50	0.00	0.00	62.80	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	0.00	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	0.00	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	0.00
	0.00	-----	0.00	11.50	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	-----	0.00
L	2.50	4.60	0.00	247.20	74.20	8.30	0.00	25.20	0.00	0.00	0.00	0.00
	0.08	0.16	0.00	8.24	2.39	0.28	0.00	0.81	0.00	0.00	0.00	0.00
	2.50	3.60	0.00	62.80	22.30	8.30	0.00	25.20	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	0.00	0.00

1959 SUMMARY (365 DAYS) : TOTAL 362.0 MEAN 1.0

DAY	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
1	0.00	0.00	0.00	32.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	41.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	8.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	16.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	15.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	29.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	15.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	5.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00	-----	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	-----	0.00	-----	0.00	-----	0.00	0.00	-----	0.00	-----	0.00
TOTAL	0.00	0.00	0.00	185.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MEAN	0.00	0.00	0.00	6.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MAX.	0.00	0.00	0.00	41.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MIN.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1960 SUMMARY (366 DAYS) : TOTAL 185.8 MEAN 0.5

TABLE I.34

HLY RAINFALL AT GELIB(ALESSANDRA) - MILLIMETRES

TABLE I.35

JAN.	FEB.	MAR.	APR.	MAY.	JUNE.	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
7	0	5	145	111	24	57	10	50	224	28	91	752
11	0	66	143	88	22	111	5	6	299	105	87	943
-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
1	0	47	189	170	0	61	6	2	95	69	21	659
0	0	0	55	157	29	47	24	1	87	56	13	469
1	0	0	25	184	40	31	32	0	17	52	133	514
7	0	12	139	73	23	60	0	44	2	50	76	485
0	0	0	133	134	51	71	19	6	62	27	45	548
0	10	0	103	41	142	33	46	20	105	100	17	617
2	13	0	122	44	74	36	14	162	143	46	48	703
0	0	4	147	140	95	57	7	16	0	16	34	515
3	0	0	81	153	91	136	37	0	95	85	63	743
0	0	0	190	154	110	9	41	0	0	0	0	503
-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999

/1951

TABLE I.35 (continued)

TD.

R	JAN.	FEB.	MAR.	APR.	MAY.	JUNE.	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
2	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
3	0	0	0	63	46	30	107	34	11	45	157	23	516
4	0	0	0	63	71	70	37	22	3	109	54	74	502
5	11	0	1	218	152	54	66	13	0	3	74	102	694
6	0	0	7	169	93	54	2	5	0	121	111	10	572
7	0	0	18	286	201	39	101	8	5	77	138	66	939
8	0	0	0	78	138	61	27	37	3	6	27	63	440
9	3	5	0	236	76	72	0	0	25	0	0	0	415
0	0	0	0	186	0	0	0	0	0	0	0	0	186
N	2	1	8	138	111	54	52	18	18	75	60	48	586
	1.63	2.64	2.18	0.49	0.49	0.68	0.74	0.84	2.08	1.08	0.76	0.79	0.30
W	1.62	2.69	2.70	0.32	-0.29	0.67	0.54	0.48	3.48	1.35	0.56	0.46	0.26

UM OF MONTHLY MEANS = 586

OTE: -999 INDICATES A MISSING VALUE

UES EQUALLED OR EXCEEDED 80.PERCENT OF THE TIME (NOT AN HOMOGENEOUS SEQUENCE)

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
)	0	0	0	69	56	23	17	5	0	1	20	11	476

THLY RAINFALL AT BARDHEERE - MILLIMETRES

R	JAN.	FEB.	MAR.	APR.	MAY.	JUNE.	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
2	3	0	18	44	79	4	66	4	11	105	3	17	352
3	0	3	26	209	34	39	41	6	22	329	28	20	757
4	6	103	53	142	56	78	93	0	5	19	92	38	685
5	0	0	6	29	29	4	110	22	0	240	76	0	516
6	0	0	15	74	300	15	132	0	15	0	119	5	675
7	0	0	0	124	58	132	84	2	0	74	56	36	566
8	0	0	0	94	69	0	0	20	0	0	84	31	298
9	2	11	10	29	0	4	21	18	85	104	88	100	471
0	13	0	67	187	13	0	14	17	0	114	54	47	525
1	0	21	0	40	65	10	5	0	0	41	49	0	231
2	0	0	93	87	48	6	3	21	11	4	29	88	388
3	4	2	9	67	21	8	2	0	11	16	135	38	311
4	0	0	8	93	29	9	41	5	7	136	16	21	362
5	0	22	0	110	84	4	0	11	10	61	2	61	366
6	7	10	31	109	0	4	4	33	6	131	11	117	462
7	2	0	48	190	22	16	7	2	0	0	88	4	378
8	12	0	8	129	26	9	24	8	1	152	48	17	434
9	23	8	14	36	21	17	1	0	0	0	0	0	119
0	0	7	43	137	101	18	-999	0	0	53	15	15	-999
1	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
2	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
3	0	0	0	55	0	1	0	0	0	4	20	6	85
4	74	0	10	38	27	7	6	6	1	51	50	8	278
5	0	0	9	23	232	2	27	7	4	42	53	24	422
[illegible]	0	0	22	32	8	7	15	4	26	66	52	1	232
[illegible]	16	1	29	141	68	4	0	6	0	36	33	11	345
[illegible]	0	11	35	20	7	7	9	0	0	77	156	11	332
[illegible]	3	8	8	69	69	9	0	1	0	45	15	41	269
[illegible]	10	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999

/1951

LY RAINFALL AT JAMAAME (mm)

JAN.	FEB.	MAR.	APR.	MAY.	JUNE.	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
-999	-999	-999	-999	-999	-999	111	15	95	72	49	91	-999
0	0	58	82	362	88	87	-999	27	191	70	6	-999
0	0	1	0	215	41	-999	-999	-999	21	3	0	-999
0	0	-999	38	61	32	-999	-999	-999	-999	-999	-999	-999
12	0	0	70	26	62	94	26	23	0	0	0	313
0	0	0	69	99	86	48	89	7	4	0	0	402
0	0	0	34	23	141	41	25	8	4	16	32	323
0	33	0	91	4	140	31	15	188	-999	0	42	-999
-999	-999	-999	-999	8	111	146	41	0	0	0	0	-999
0	0	0	44	37	112	41	19	0	0	5	10	268
0	0	0	86	224	50	77	0	0	0	0	0	437
0	0	0	0	60	42	0	0	0	0	40	0	142
0	0	0	82	116	74	72	11	0	0	43	39	437
14	0	0	121	57	41	-999	-999	-999	-999	-999	-999	-999
0	0	47	92	110	77	37	36	145	5	93	104	745
0	10	9	270	271	79	61	98	11	0	0	7	816
0	0	0	9	-999	-999	-999	-999	-999	-999	-999	-999	-999
2	3	8	73	111	78	65	31	39	23	23	24	431
2.65	3.06	2.31	0.91	0.97	0.45	0.59	1.01	1.62	2.38	1.36	1.47	0.51
2.44	3.43	2.28	1.94	1.17	0.52	0.50	1.42	1.72	2.94	1.21	1.58	0.86

OF MONTHLY MEANS = 479

E: -999 INDICATES A MISSING VALUE

S EQUALLED OR EXCEEDED 80.PERCENT OF THE TIME (NOT AN HOMOGENEOUS SEQUENCE)

JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
0	0	0	19	24	41	37	9	0	0	0	0	278

TABLE I.37