5. WATER RESOURCES STUDY

5.1 Probable Minimum Rainfall

Using the rainfall data, the probable minimum annual rainfall for the following 5 rainfall stations are analysed for 2-year, 5-year, and 10-year events by the Log Pearson III method.

Station	Probable Minimum Annual Rainfall (mm) 2-yr.	5-yr.	10-yr.
Black River town	1,184	973	874
Burnt Savannah	1,537	1,340	1,247
Holland	1,913	1,640	1,495
Lacovia	1,662	1,387	1,261
Mountainside	1,255	1,017	905

The irrigation planning necessitates distribution of rainfall as well as annual rainfall. A bimodel peak in May and October is observed in the project area as mentioned in previous sections. A monthly rainfall record for each year of data period was extracted and the results were subjected to frequency analysis. The probable minimum monthly rainfall are shown in Table B-13.

5.2 Probable Low Flow

5.2.1 Black and Y.S. Rivers

Irrigation of the main development areas within the project area is to be based on diversions from the Black River and Y.S. River.

A 25-day and 20-day dependable daily mean discharge in a month were studied for each year of data period for the Black and Y.S. Rivers. For the Black River at Lacovia the data period extended from 1964-82 and for the U.S. River Near Middle Quarters 1959-82. These results were then subjected to frequency analysis from which the probable low flow was determined. In addition, a 360-day and 355-day dependable daily mean discharge in a year were studied for each year of data for the two rivers, and the results were also subjected to frequency

analysis. The minimum 5-year, 20-day low flows, were assessed to be 6.9 m^3/s (131 x 10^6igpd) in April in the Black River and 0.24 m^3/s (4 x 10^6 igpd) in March in the Y.S. River, as shown in Table B-14.

5.2.2 Broad and Middle Quarters Rivers

The Broad River and the Middle Quarters River are possible sources of irrigation water for the Pedro Plains and Luana areas, respectively. Both areas immediately adjoin the Project area.

The few measured data available on the flow in these rivers were not sufficient to allow the determination of dependable low flows. Mean monthly flows were inferred from the water balance study (Section 4.2.5 above). The estimated flows are shown in Table B-8.

A net inflow of sea water upstream of the Broad River at Salt Spring bridge December to February indicated a need for the construction of river-bed structures to control sea water intrusion. A maximum flow of 4.9 m^3/s in August and mean annual flow of 1.4 m^3/s were estimated.

Mean annual flow in the Middle Quarters River was assessed to be 0.29 m^3/s, with surface inflow from the adjoining Y.S. River catchment and/or sea water intrusion being important in low flow months.

5.3 Suitability of Water Quality

The waters of both the Black River and Y.S. River at the points proposed for diversion were classified as C2 - S1 according to the standards of the United States Department of Agriculture. This classification indicated excellent water quality for irrigation with respect to alkalinity and salinity. Nutrient levels in the Black River should have a beneficial effect on the proposed cultivations, a factor that should be considered when deciding fertilizer needs.

The background chemical quality of both the Broad and Middle Quarters Rivers is similar to that of the Y.S. River and therefore well suited for use as sources for irrigation. However, the control of seawater intrusions in both rivers will be a necessary prerequisite in order to prevent the effects of saline contamination.

6. FLOOD STUDY

6.1 Basic Concept of Analysis

Flood records are available for the Y.S. River since 1955 to 1982 and for the Black River since 1964 to 1982. It is very risky however to use such data for flood control planning without cross checking with results obtained by other methods. A rating curve is generally developed from the results of discharge measurements during medium or low flow periods from which the peak discharge can be extrapolated. Records of more than 20 to 30 years are usually needed for a reliable frequency analysis since the return period of a design flood for flood control planning is currently taken as about 50 years.

Accordingly, the probable flood had to be estimated from probable rainfall of which the recording period was longer than that of runoff. In this study, the unit hydrograph method was employed for the conversion of rainfall into runoff and the estimated flood discharge was compared with that derived from the records to determine the design flood discharge.

6.2 The Y.S. River

6.2.1 Flood records

Flood records are available since 1955. An automatic water level recorder has been operated at Near Middle Quarters since 1959. Annual maximum peak discharges estimated from peak water levels vary from 16 m^3/sec. to 52 m^3/sec. as shown in Table B-15.

Frequency analyses were made by Log Pearson Type III method. The resulting frequency data and curves are plotted on log-frequency paper as shown on Fig. B-15 and below.

Unit: m^3/sec. (cusec)

Return Period	Peak Discharge
2	28 (990)
5	36 (1,270)
10	41 (1,450)
50	55 (1,940)
100	61 (2,160)

6.2.2 Probable maximum rainfall

Major floods on the Y.S. River occur due to more than two days of continuous rainfall as shown in Table B-16. Accordingly, two days continuous rainfall is adopted to estimate the design peak flood discharges.

Four rainfall stations are located on the Y.S. River catchment area. Recorded annual two days continuous rainfalls on each station are calculated from the daily rainfall records as shown on Table B-17. The probable annual two days rainfall are estimated by Log Pearson Type III method for each station. The arithmetic mean of these is adopted for estimation of the probable peak flood discharge.

The results are shown below.

unit : mm

Station	Return Period					
	2	5	10	25	50	100
Maggoty	122	177	226	302	372	455
New Market	196	317	420	579	720	883
Quickstep	165	213	245	287	319	352
Y. S.	124	167	195	230	256	282
Average	152	219	272	350	417	493

6.2.3 Flood hydrograph analysis

1) Unit hydrograph

Taking into account the availability of runoff and rainfall records, the unit hydrograph method may be appropriate for the present flood study. Fig. B-16 shows the representative major flood hydrographs observed at Near Middle Quarters, which includes the largest flood which occurred in October, 1973.

Out of these, three flood hydrographs are converted into the dimensionless ones as shown on Fig. B-17. Judging from the shape of these hydrograph though there is no great difference except for the time of the pre-peak caused by previous rainfall; the hydrograph of October 1973 is adopted for the present study. From this dimensionless hydrograph, the unit hydrograph is derived defining the flood concentration time and the effective rainfall.

2) Flood concentration time

The flood concentration time is given by the summation of the time required for a flood to flow out into the river course from the farthest point in the catchment area and the time required for flood to flow down through the river course upto the point to be considered. Several empirical formulae have been proposed for the estimation of the flood concentration time. Most of these, however, are only valid in the specific region where it was developed. For example, the flood concentration time is estimated at 3 hours by Ruziha's formula as shown below.

$$T = L/(72\ (H/L)^{0.6}) \quad \ldots\ldots\ldots\ldots \quad (6\text{-}1)$$

where, T is flood concentration time in hours,

L is length of river course in km (15 km), and

H is difference of elevation between the point to be considered and farthest point in km (0.2 km)

Judging from the observed hydrograph, 3 hours of flood concentration time is short. From observation, it is obvious that a peak flood discharge is usually caused by the rainfall on the previous day on the Y.S. River. The flood concentration time is therefore assumed to be 12 hours for the present study.

3) Effective rainfall

The effective rainfall is that part of total rainfall, from which surface runoff is derived. The total amount of surface runoff of the major floods and areal rainfall were estimated from the recorded hydrograph shown on Fig. B-16. The total catchment area is at 160 km^2 on the Y.S. River.

	Flood time		
	11th June '60	28th June '66	18th Oct. '73
Surface runoff (m^3)	7 x 10^6	10 x 10^6	18 x 10^6
Areal rainfall			
Date	10 - 11	27 - 28	17 - 18
Depth (mm)	186	197	195
Volume (m^3)	29 x 10^6	31 x 10^6	31 x 10^6
Effective ratio (%)	24	32	58

Taking into consideration that the annual runoff coefficient is estimated at 0.38 in Section 4.1.3, though the above results have large dispersion, the effective ratio is assumed to be 0.5 in this study.

As the flood concentration time and effective ratio are given, the dimensionless hydrograph can be converted into the unit hydrograph for the unit effective rainfall depth of 1 mm.

4) Hyetograph

In order to determine a rainfall pattern for design, observed hyetographs of major storm rainfalls are necessary. Though an automatic rainfall recorder has been operated at Elim Meteorological station since 1981, only a few data have been obtained which do not

include any major storm rainfall at all nor are they reliable because of improper calibration of equipment. The following formula is employed to estimate the rainfall intensity.

$$t = R_{24}/Rt \times (t/24)^k \quad \ldots\ldots\ldots \quad (6\text{-}2)$$

where R_t is rainfall intensity during t hours (mm/hr),

R_{24} is rainfall during 24 hours (mm),

t is time in hours, and

k is coefficient (=1/2)

The above equation is extrapolated to apply to the probable two days rainfall in this study.

5) Probable flood hydrograph

Using the unit hydrograph constructed and assumed hyetograph in the previous sections, the probable flood hydrographs with a return period of 50-year and 10-year are obtained as shown in Fig. B-18.

6) Design flood

The estimated flood discharge by the unit hydrograph and the one derived from the records are compared as shown below.

	Return period	
	10	50
by the unit hydrograph (m^3/ sec.)	34	52
by the frequency analysis of the records (m^3/sec.)	41	55

The data period of the flood records is similar to the period of rainfall records. The unit hydrograph method in this study necessitated many assumptions due to the shortage of data. Taking the above conditions into account, the design flood discharge on the Y.S. River is taken to be 41 and 55 m^3/sec. in 10-year and 50-year return period respectively.

6.3 The Black River

6.3.1 Flood records

Automatic water stage recorders have been operated on the Black River at Newton and at Lacovia since 1966 and 1963 respectively. Annual maximum peak discharges estimated from peak water levels are shown on Table B-15. The frequency analyses were made on both Newton and Lacovia by Log Pearson Type III method. The resulting data and curves are plotted on log-frequency paper as shown on Fig. B-15 and below.

unit : m^3/sec. (cusec)

Return period	Black River at Newton	Black River at Lacovia
2	50 (1,770)	53 (1,870)
5	70 (2,470)	65 (2,300)
10	86 (3,040)	73 (2,580)
50	130 (4,590)	90 (3,180)
100	153 (5,410)	96 (3,390)

The peak discharge of the major floods at Lacovia was decreased by the large storage effect of the Upper Morass. However, it is significant that this storage effect has now been eliminated by the diking of the Black River of the Upper Morass Development Project.

6.3.2 Probable maximum rainfall

Major floods on the Black River are caused by more than three days of continuous rainfall as shown in Table B-18. Accordingly, three days of continuous rainfall is adopted to estimate the design peak flood discharges.

Recorded annual three days' continuous rainfall at 8 stations located in the Black River catchment area were calculated from the daily rainfall records as shown on Table B-19. The probable annual three days rainfall are estimated by Log Pearson Type III method for each station. The arithmetic mean of these is adopted to estimate the probable peak flood discharge.

The results are shown below.

unit : mm

Station	Return period 2	5	10	25	50	100
Maggoty	147	211	267	356	438	534
Raheen	160	216	260	322	374	432
Quickstep	190	246	282	326	358	389
Troy	132	170	201	247	287	332
Wait a bit	190	244	278	322	353	385
Warsop	157	215	254	304	342	381
Craighead	212	300	366	460	539	624
Mile Gully	158	243	308	399	474	556
Average	168	231	277	342	396	454

6.3.3 Flood hydrograph analysis at Newton

1) Unit hydrograph

Taking into account the availability of runoff and rainfall records, the unit hydrograph method may be appropriate for the present flood study. Fig. B-19 shows the 1973 October flood hydrograph as observed at Newton. This is the largest flood that has been observed since 1966. No other major flood hydrographs are available or reliable. Accordingly, the 1973 October flood hydrograph is adopted for the study. The 1973 October flood hydrograph is converted into a dimensionless one as shown on Fig. B-20. From this dimensionless hydrograph, the unit hydrograph is derived defining the flood concentration time and the effective rainfall.

2) Flood concentration time

A detailed explanation of the flood concentration time have been given above in Section 6.2.3 2). Eight hours is given by Ruziha's formula, but from observation, it is too short. The flood concentration times observed vary from one day to two days. Accordingly, it is assumed to be 36 hours for the present study.

3) Effective rainfall

The effective rainfall is that part of total rainfall, from which surface runoff is derived. The total amount of surface runoff of the major floods and areal rainfall were estimated from the recorded hydrograph shown on Fig. B-19. The total catchment area is at 400 km^2 on the Black River.

Flood on 19th Oct. 1973	
Surface runoff (m^3)	51 x 10^6
Areal rainfall	
Date 15 - 18	15 - 18
Depth (mm)	270
Volume (m^3)	108 x 10^6
Effective Ratio (%)	47

Taking into consideration that the annual runoff coefficient is estimated at 0.38 in Section 4.1.3 and the above result shows 47% of effective ratio, the effective ratio is assumed at 50% in this study.

As the flood concentration time and effective ratio are given, the dimensionless hydrograph can be converted into the unit hydrograph for the unit effective rainfall depth of 1 mm.

4) Hyetograph

As mentioned in Section 6.2.3 4), the equation (6-2) is extrapolated to apply to the three days rainfall in this study.

5) Probable flood hydrograph at Newton

Using the unit hydrograph constructed and assumed hyetograph in the previous sections, the probable flood hydrographs with a return period of 50-year and 10-year are obtained.

The peak discharge of the 10-year flood is estimated to be 87 m^3/sec. and the one of the 50-year flood is 128 m^3/sec.

The above results are similar to the peak discharges derived from the frequency analysis of the recorded data in Section 6.3.1. The data period of rainfall, however, is longer than that of discharged records. Therefore, the probable hydrograph estimated by the unit hydrograph method is adopted for further study.

6.3.4 Post Upper Morass Development Project

Implementation of the Upper Morass Project is expected to significantly modify the flood hydrograph of the Black River at Lacovia and within the Lower Morass. The diking of the Black River between Newton and Lacovia to contain a 50-year flood has effectively eliminated the previous storage effect of the flooding of the Upper Morass. Flood peaks are also accentuated by inflows from pumping stations which drain the Upper Morass behind the dikes (total capacity 65 m^3/s).

Estimates of post-project 10 and 50-year flood peak levels and peak discharges at Lacovia and upstream of Frenchman in the Lower Morass, have been reported by Hydrology Consultants (1981). The Holland dikes within the Lower Morass was subsequently rebuilt to contain the predicted 10-year flood peak.

The estimates developed by Hydrology Consultants were checked and incorporated in the Study. The procedures used to synthesize the post-project hydrographs and estimate new peak flood discharges are presented in the Section 1) and 2) below.

1) Synthesized Flood Hydrograph (Black River at Lacovia)

Flood hydrograph for the 10 and 50-year events for the Black River at Newton, Grass, Island and New Rivers pumping stations were developed utilizing the assumption that they are of the same form as that recorded for the 1973 flood at each of the specific sites.

The development of the hydrograph for the Black River at Lacovia incorporated a time lag for the flood wave, as it moved from Newton to Lacovia. The time lag determined by Hydrology Consultants (1981) assumed the same flow rate (2 km/hour) as that measured between the Appleton and Newton gauging stations on the Black River. Newton is 9 km downstream of Appleton. This rate, together with the respective distances to Lacovia were used to derive the following time lags.

Black River at Newton	7.3 hours
Grass River Pumping Station	5.5 hours
Island River Pumping Station	4.1 hours
New River Pumping Station	3.9 hours

These time lags were tentatively applied to the hydrographs for the Black River at Newton, Grass, Island and New Rivers.

The synthesized 10 and 50-year flood hydrographs are presented as Fig. B-21.

2) Peak Flood Discharges (Black River at Lacovia)

The post Upper Morass Development Project synthesized 10 and 50-year peak discharges in the Black River at Lacovia were determined to be 133 m^3/s (4,700 cusecs) and 193 m^3/s (6,800 cusecs) respectively.

These post-project peak flood discharges are therefore expected to be 60 m^3/s and 103 m^3/s higher than the pre-project 10 and 50-year events.

7. IMPACT OF THE LOWER MORASS DEVELOPMENT

7.1 Impact of the Irrigation Diversion and Drainage

A specific agricultural development plan for the Lower Morass has been decided. The 3,800 ha (34%) of the 11,450 ha project area is to be utilised. The development area consists essentially of the left and right banks of the Black and Broad Rivers. The development area will be protected by dikes on either side of the Black and Broad Rivers and a series of pumping stations to control the water level behind the dikes.

The Y.S. River Basin, the Middle Quarters River Basin and the Broad River catchment downstream of the Salt Spring bridge are not proppsed for agricultural development due to the marginal suitability for agriculture.

These areas are shown on Fig. B-22.

At this stage, it is possible only to provide qualitative indicators of the likely impact of the proposed irrigation and drainage system on the hydrology of the Lower Morass.

7.2 Impact on Streamflow

The Black River will be channelised between Hatfield and Frenchman (5 km). The rise of flood storage in the Styx River Basin (and occasionally within the Broad River Basin) is expected to account for 7 and 14% of post-BRUMDEC project 10 and 50 year peak flood discharges (Hydrology Consultants, 1981).

The ground water inflow into the Broad River would not be affected by the proposed diking but slightly higher post-project flood peaks may be produced by the artificial draining of the land behind the dike. The extent of possible diversions from the Broad River to the Pedro Plains is not known at this time and was therefore not considered.

The Y.S. River and Middle Quarters River would be only slightly affected by the anticipated diversion of a small quantity of flow. Surface storage capacity within the Y.S. River, Middle quarters

River and lower Broad River Basin would be unaffected by this proposed developments.

A Mean annual flow of 2 m^3/s is to be diverted from the Black and Y.S. Rivers for irrigation. Drainage pumping into the river system is expected to be an average 1.8 m^3/s (ANNEX H, Drainage), an amount approximately equal to that diverted for irrigation.

The net effect on surface outflows in the Black River would be for the Lower Morass Development Project to produce slightly higher peak flows, lower intermediate flows and little change in low flows.

7.3 Effect on Water Balance

Surface and sub-surface inflows into the Lower Morass would be largely unaffected by the proposed irrigation and drainage systems.

Diversion for irrigation would serve to reduce surface outflow while on the other hand drainage would tend to increase surface outflow. As discussed in the previous section the mean annual diversion for irrigation is approximately equal to the amount being pumped for drainage, and would therefore produce no net change in surface outflow.

The cultivation of rice require the flooding of paddy fields to create post-project conditions which are very similar to the present swamp conditions. PCJ (1983) has determined mean annual swamp evapotranspiration of 5.3 mm/day which is approximately equivalent to the 5.5 mm/day recommended for paddy by FAO (Irrigation and Drainage Paper No. 24). No significant change in evapotranspiration is therefore expected to occur.

No net change in surface and sub-surface inflows and outflows are likely to result from implementation of the Lower Morass Development Project.

7.4 Water Quality

The reduction in intermediate flows has implication for sea water intrusion of the river system for slightly longer periods than presently obtains. The extent of sea water intrusion is expected to essentially be the same.

The increased use of fertilizers within the development areas could see irrigation return-flows increasing the nutrient loads of the rivers. The impact on the nutrient poor Broad River could be significant. A similar situation would obtain with the large scale use of pesticides and other toxic chemicals.

8. REFERENCES

1) FOOD AND AGRICULTURE ORGANIZATION (FAO), 1971 : Groundwater Survey in Two Areas of the Interior, Jamaica. Appraisal Report of the Pedro Plains, Appendix III - Hydrology, Appendix IV, water quality, Rome, 1971.
AGL : SF/JAM 3, Technical Reports 1/A III, IV.

2) HARZA OVERSEAS ENGINEERS CO and HUE LYEW CHIN (HARZA, et al 1977) : Black River Upper Morass Feasibility Report Volume 2, Appendix A - Hydrology, Appendix B - Drainage Appendix H - Environmental Assessment.

3) HYDROLOGY CONSULTANTS LTD. (Hydrocon) 1981 : Determination of the likely Magnitude of Flood Peaks in the Black River Lower Morass subsequent to the completion of the Black River Upper Morass Project.

4) DONALDSON, L.A. and WALTERS, M.O. (1981) : Hydrologic Aspects of June 12, 1979 Flood Rains on the Newmarket Sub-basin. Journal of the Geological Society of Jamaica, Volume XX, 1981.

5) JONES, E (1981) : Geomorphological Implications of the June 12 Floods - A preliminary review. Journal of the Geological Society of Jamaica, Volume XX, 1981.

6) NATURAL RESOURCES CONSERVATION DEPARTMENT (NRCD) and TRAVERSE GROUP INC (1981) : Final Report, Environmental Feasibility Study of the Jamaica Peat Resources Utilisation Project. Volume II - Technical Reports.

7) PETROLEUM CORPORATION OF JAMAICA (PCJ) and UNIVERSITY OF LUND, SWEDEN (1983) : Summary, Environmental Feasibility Study of Peat Mining in Jamaica. Prepared by Sven Bjork, October 1983.

8) WATER RESOURCES DIVISION : Upper Black River Basin, St. Elizabeth, Upper Morass and Essex Valley Inventory Of Groundwater Resources.

9) METEOROLOGICAL SERVICES : The Climate of Jamaica, 1973

10) PETROLEUM CORPORATION OF JAMAICA : Estimation of Evaporation Losses from Negril and Black River Swamps. Prepared by Swedish Meteorological and Hydrological Institute.

11) PUBLIC WORKS RESEARCH INSTITUTE, MINISTRY OF CONSTRUCTION, JAPAN : Technical Memorandums of Density-Current at River Estuary (Japanese)

Table B-1 AVERAGE MONTHLY RAINFALL (1969-1980)

(Unit:mm)

NO.	STATION	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1 .	Bartons	82	73	96	185	277	139	151	229	218	247	100	65	1862
2 .	Bethlehem	67	56	81	138	155	82	63	121	180	224	105	93	1365
3 .	Black River	55	55	60	62	147	106	87	161	146	149	97	52	1177
4 .	Burnt Savannah	68	59	94	163	269	109	103	198	224	248	108	51	1694
5 .	Elim Farm	80	65	74	228	332	135	89	200	256	277	73	40	1849
6 .	Holland	71	71	73	169	266	153	189	245	245	283	86	61	1912
7 .	Lacovia	66	66	72	166	217	122	126	241	226	257	98	46	1703
8 .	Maggoty	108	106	95	211	295	199	188	295	335	319	105	45	2301
9 .	Mt. Charles	56	62	77	115	210	146	142	202	216	235	70	52	1583
10.	Mountainside	50	57	55	117	132	109	86	175	153	169	116	67	1286
11.	New Market	70	90	74	184	293	253	284	290	309	309	337	126	2619
12.	Pedro	31	20	29	64	84	48	34	55	80	137	63	33	678
13.	Raheen	72	69	93	269	379	156	152	246	309	357	113	40	2255
14.	Santa Cruz	58	59	94	163	269	109	103	198	224	248	108	51	1684
15.	Spur Tree	75	51	81	179	192	114	64	146	195	244	95	89	1525
16.	Thatchfield	45	31	46	72	100	74	52	94	108	134	76	37	869
17.	Y.S.	93	91	105	208	372	176	217	286	289	301	123	70	2331
18.	Quickstep	91	90	107	213	330	232	210	268	320	379	157	81	2478
19.	Troy	71	116	94	196	315	150	170	282	276	393	187	89	2339
20.	Wait a Bit	84	110	82	200	344	158	102	240	251	309	168	93	2161
21.	Warsop	72	107	87	196	360	199	178	286	340	368	168	117	2478
22.	Flamsted	117	92	112	246	384	347	253	368	396	506	176	110	3107
23.	Craighead	94	58	132	252	435	174	138	246	277	354	178	84	2422
24.	Mile Gully	80	51	80	211	305	170	110	187	222	249	89	59	1813

Source: UPPER BLACK RIVER BASIN,ST. ELIZABETH, Upper Morass and Essex Valley, Inventory of Groundwater Resources, Water Resources Division

Table B-2 WEIGHED COEFFICIENT OF THIESSEN POLYGONS

(Unit: %)

Rainfall Station	Black River at Newton (400 km2)	Black River at Lacovia (830 km2)	Y.S. River at Near Middle Quarters (160 km2)	Black River at Black River (1,200 km2)
1. Bartons	3.3	4.5	-	3.2
2. Bethlehem	-	11.0	-	7.5
3. Black River	-	-	-	2.7
4. Burnt Savannah	-	1.0	-	4.2
5. Elim Farm	-	8.6	-	5.9
6. Holland	-	-	1.3	3.1
7. Lacovia	-	1.9	-	4.1
8. Magotty	12.4	6.4	15.7	6.5
9. Mt. Charles	-	-	-	2.6
10. Mountainside	-	0.2	-	1.7
11. New Market	-	-	11.9	2.5
12. Pedro	-	1.3	-	0.9
13. Raheen	17.9	9.1	-	6.2
14. Santa Cruz	-	10.6	-	7.2
15. Spur Tree	-	11.6	-	7.8
16. Thatchfield	-	-	-	0.2
17. Y.S.	-	-	39.0	6.2
18. Quickstep	16.9	8.1	10.1	6.9
19. Troy	13.9	6.7	-	4.6
20. Wait a bit	3.5	1.7	-	1.2
21. Warsop	1.8	0.8	-	0.6
22. Flamsted	-	-	22.0	2.9
23. Craighead	12.4	5.9	-	4.1
24. Mile Gully	17.9	10.6	-	7.2
Total	100.0	100.0	100.0	100.0

Table B-3 (1/3) MONTHLY RAINFALL

Station; BLACK RIVER — Unit; mm

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1950	58	18	68	107	208	92	51	184	202	675	54	36	1753
1951	19	24	16	56	31	81	59	266	137	194	23	19	925
1952	0	9	52	-	-	-	-	124	111	97	49	20	462
1953	106	40	150	24	167	87	59	64	109	72	202	38	1118
1954	41	172	130	67	61	116	150	152	217	201	178	26	1511
1955	44	58	29	35	147	124	45	126	119	128	29	114	998
1956	57	11	134	80	107	200	80	186	184	283	151	90	1563
1957	16	86	76	107	139	-	-	-	245	50	-	-	719
1958	-	-	-	-	246	0	-	-	198	335	121	49	-
1959	-	10	-	42	194	-	128	35	104	123	236	83	-
1960	90	36	57	152	259	317	120	138	51	100	170	45	1535
1961	22	24	116	242	157	53	161	162	208	405	43	61	1654
1962	64	37	9	228	170	112	70	47	146	167	34	43	1127
1963	34	109	124	41	122	178	46	186	141	219	92	114	1406
1964	1	28	17	321	161	82	93	154	103	107	87	33	1187
1965	36	0	16	48	107	43	81	237	82	76	50	10	796
1966	35	0	27	57	127	476	147	60	142	165	117	0	1353
1967	0	120	28	101	106	149	56	164	73	175	88	0	1060
1968	4	35	11	13	133	81	164	131	81	194	223	0	1070
1969	53	0	17	88	294	8	26	219	100	256	52	58	1171
1970	146	109	215	45	241	227	81	108	197	115	157	96	1737
1971	52	51	119	30	184	80	57	82	110	114	56	41	976
1972	105	67	67	67	105	69	117	214	295	77	77	46	1306
1973	101	29	29	20	89	115	70	151	148	336	168	20	1276
1974	20	41	80	180	60	4	82	171	125	59	149	2	901
1975	1	57	55	40	186	6	129	255	106	146	82	50	1113
1976	49	50	60	15	121	63	50	179	170	110	100	65	1032
1977	0	122	18	128	181	13	180	294	51	110	55	71	1223
1978	59	48	10	22	147	77	117	1	138	307	113	19	1058
1979	0	60	30	155	112	550	56	153	223	99	94	38	1570
1980	73	25	19	20	41	59	80	98	78	57	62	117	729
1981	-	131	50	11	97	-	153	206	-	259	-	335	-
1982	15	86	10	114	211	41	147	-	142	104	64	26	-
1983	26	59	9	38	200	39	54	116	107	127	64	47	885

Station; BURNT SAVANNAH — Unit; mm

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1967	-	122	76	138	138	181	119	119	142	281	60	22	1398
1968	-	-	76	74	-	-	152	-	150	377	322	99	1250
1969	81	0	28	167	313	67	55	111	171	252	60	67	1372
1970	113	53	298	45	298	102	98	153	161	253	81	87	1742
1971	112	77	96	76	371	49	131	227	122	201	72	100	1634
1972	99	153	63	198	73	90	20	298	414	236	217	88	1949
1973	84	36	129	168	302	131	97	192	165	364	136	77	1881
1974	3	75	141	159	86	0	88	222	165	142	152	7	1240
1975	1	48	84	86	110	62	230	261	148	169	143	34	1376
1976	102	56	57	17	59	33	78	233	241	267	56	34	1233
1977	1	35	22	374	248	64	229	251	110	159	22	58	1573
1978	115	100	76	199	157	90	72	126	159	332	189	0	1615
1979	0	78	70	137	204	395	101	93	364	117	146	30	1735
1980	100	60	52	127	231	140	61	162	163	48	60	84	1288
1981	-	149	143	152	-	-	130	298	-	562	-	-	1434
1982	-	81	-	122	-	-	109	179	273	177	14	-	955
1983	-	51	25	165	259	21	40	158	165	203	40	101	1228

to be continued

TABLE B-3 (2/3) MONTHLY RAINFALL

Station; Holland Unit; mm

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1948	92	7	0	246	239	326	326	189	173	159	121	77	1782
1949	10	38	125	227	526	130	159	155	208	245	158	63	2044
1950	29	37	49	264	355	183	134	186	222	753	86	50	2348
1951	33	33	34	86	241	104	88	395	152	211	75	43	1495
1952	32	61	95	214	266	181	285	232	159	255	0	25	1805
1953	133	64	29	63	351	193	144	171	142	113	264	46	1713
1954	31	174	131	309	192	149	192	247	187	280	278	8	2178
1955	77	26	72	71	153	147	166	111	300	263	58	104	1548
1956	31	31	185	163	327	253	95	304	196	367	162	108	2222
1957	22	206	44	115	154	49	155	280	320	107	25	111	1588
1958	92	7	5	59	350	231	179	405	296	476	163	54	2317
1959	13	55	89	219	196	18	270	153	137	120	286	99	1655
1960	98	27	102	128	234	350	420	179	308	227	234	65	2372
1961	64	35	278	132	346	89	256	215	213	305	96	59	2088
1962	54	71	51	289	277	133	242	173	207	279	77	87	1940
1963	29	87	170	59	320	270	147	195	219	371	192	73	2132
1964	37	43	30	376	296	158	79	186	142	165	142	88	1742
1965	94	4	66	117	351	49	202	271	263	163	115	42	1737
1966	102	46	131	138	242	333	159	59	186	190	71	46	1701
1967	66	172	141	346	222	197	54	115	149	391	127	34	2014
1968	14	59	61	79	163	114	151	226	118	344	91	29	1449
1969	109	0	27	214	324	47	74	299	289	264	72	43	1762
1970	116	0	7	78	347	367	273	148	316	280	77	47	2056
1971	58	80	90	90	420	153	319	206	138	364	57	36	1921
1972	142	71	179	372	146	126	185	298	295	242	172	67	2228
1973	67	43	112	193	203	148	205	200	297	421	58	22	1969
1974	60	89	126	294	183	62	187	316	275	316	151	77	2136
1975	7	35	18	78	322	100	323	352	185	264	55	12	1751
1976	11	82	106	54	122	62	85	193	218	141	44	66	1184
1977	28	29	0	174	358	67	184	324	342	305	57	153	2021
1978	176	105	41	203	480	263	207	216	165	358	51	19	2284
1979	10	219	105	197	137	393	84	213	299	234	145	83	2119
1980	62	51	38	78	159	38	138	169	223	217	84	101	1358
1981	22	160	299	322	328	635	154	258	0	385	0	-	2563
1982	85	0	86	293	394	151	199	399	255	151	0	42	2017
1983	84	84	10	89	311	44	23	193	139	269	107	147	1500

to be continued

Table B-3 (3/3) MONTHLY RAINFALL

Station; Lacovia — Unit; mm

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	TOTAL
1950	16	29	80	325	179	130	111	166	266	518	27	40	1897
1951	33	73	24	-	76	-	-	-	196	-	-	-	-
1956	-	-	-	-	338	227	145	344	279	478	154	133	2198
1957	22	-	86	212	-	-	-	250	282	-	-	146	998
1958	82	4	-	45	402	-	54	371	489	-	130	70	1697
1959	-	47	122	230	219	73	163	96	190	84	401	104	1729
1960	147	14	-	147	154	293	305	320	237	202	262	-	2081
1969	104	15	37	190	281	54	76	260	252	231	74	51	1625
1970	100	77	46	79	285	316	155	211	136	193	216	20	1834
1971	62	89	62	18	293	80	53	262	51	241	33	27	1271
1972	48	98	181	516	80	111	148	260	341	253	175	52	2263
1973	46	38	32	32	88	109	72	139	221	331	89	28	1225
1974	54	74	103	263	186	69	179	206	250	355	155	79	1973
1975	0	31	5	75	330	48	309	468	280	263	59	0	1868
1976	45	24	66	74	138	49	102	356	271	199	50	68	1442
1977	31	30	0	243	179	66	71	266	210	259	105	27	1447
1978	168	77	137	174	468	169	177	179	265	318	78	0	2210
1979	27	175	182	195	93	341	74	171	224	280	72	46	1374
1980	100	54	35	121	183	43	94	153	212	162	61	98	1316
1981	-	162	132	43	330	-	124	219	-	363	-	581	1954
1982	101	55	94	303	380	114	186	0	239	-	-	-	1199
1983	67	73	24	145	237	45	32	235	183	251	12	107	1411

Station; MOUNTAINSIDE — Unit; mm

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1967	60	-	124	50	59	92	-	-	124	143	-	-	625
1968	-	-	-	206	-	-	-	-	40	-	-	-	246
1969	55	37	44	123	243	90	83	115	129	176	82	64	1241
1970	99	54	35	57	245	231	136	62	131	115	91	108	1364
1971	44	33	91	116	90	33	103	769	54	156	84	79	1652
1972	101	90	86	101	100	108	55	120	206	127	74	89	1257
1973	94	15	43	119	115	160	99	228	170	306	183	66	1598
1974	5	89	53	163	74	0	73	169	204	89	103	14	1036
1975	7	12	35	73	108	16	166	170	92	118	120	70	987
1976	96	50	46	42	42	14	39	63	151	157	81	53	834
1977	4	51	47	249	189	41	82	125	81	181	97	62	1209
1978	40	113	136	177	91	158	77	62	163	256	248	5	1526
1979	0	84	31	108	163	347	72	81	386	244	109	54	1679
1980	48	57	8	65	111	124	44	127	62	94	120	36	896
1981		137	79	91	165	-	-	291	-	366	-	619	1748
1982	69	-	61	97	293	16	46	137	132	202	50	10	993
1983	23	48	11	170	130	174	175	179	263	230	163	161	1727

Table B-4 METEOROLOGICAL RECORD AT HYDROMETEOROLOGICAL STATION (PCJ)

Year: 1983

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Temperature (°C)												
Mean Max.	-	-	32.4	32.1	32.7	33.4	34.3	33.7	33.7	-	-	-
Mean Min.	-	-	20.3	20.9	22.7	24.5	23.6	23.6	23.4	-	-	-
Absolute Max.	-	-	35.1	34.5	35.5	35.9	35.8	35.2	35.0	-	-	-
Absolute Min.	-	-	20.0	20.9	22.7	24.5	23.6	23.6	23.4	-	-	-
Relative Humidity (%)												
Mean Max.	-	-	-	96	96	94	96	96	95	-	-	-
Mean Min.	-	-	-	50	53	52	47	49	49	-	-	-
Absolute Max.	-	-	-	97	97	97	97	97	97	-	-	-
Absolute Min.	-	-	-	37	43	39	39	42	35	-	-	-
Wind Speed (m/s)	-	-	2.4	2.3	2.3	2.1	-	-	-	-	-	-
Evaporation (mm/day)												
from floating evaporimeter	-	-	6.0	5.9	5.3	5.7	5.3	5.5	5.2	4.0	4.6	4.0
from sunken evaporimeter with water surface above peat surface	-	-	5.1	5.0	5.0	5.0	5.1	5.8	6.1	4.7	5.9	5.5
from sunken evaporimeter with water surface below peat surface	-	-	-	-	-	-	-	-	10.8	10.4	10.9	9.4
Global Solar radiation (MJm^2)	-	-	21.6	21.7	21.4	19.5	-	20.8	-	-	-	-
Albedo	-	-	0.13	0.13	0.12	-	-	-	-	-	-	-
Rainfall (mm)	-	-	-	44.3	293.5	27.2	53.8	194.9	96.0	157.4	87.2	71.7
Rainy Day (days)	-	-	-	7	22	7	9	13	10	19	6	11

Source: "Estimation of Evaporation Losses from Negril and Black River Swamp", Petroleum Corporation of Jamaica

Table B-5 METEOROLOGICAL RECORD AT CRAWFORD PRIMARY SCHOOL

Station: Crawford Altitude: 50 ft., Period: 1974-1982

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Temperature (°F)													
Mean Max.	87.3	85.8	86.8	87.2	88.0	89.4	89.9	89.0	88.4	88.9	88.5	87.3	88.0
Mean Min.	66.4	62.7	66.6	68.2	70.2	71.3	69.8	70.2	71.1	70.0	69.6	67.8	68.7
Absolute Max.	91	90	91	90	92	95	95	95	92	92	90	91	92
Absolute Min.	57	60	60	63	64	66	65	67	68	65	63	55	62
Relative Humidity (%)													
at 7.00	87	89	89	87	88	85	88	90	91	91	90	89	89
at 13.00	63	65	63	63	63	65	64	63	64	63	62	61	63
Sunshine Hours (hrs/day)	7.8	7.8	7.9	8.1	8.1	7.3	8.1	7.5	6.6	7.6	7.3	7.6	7.6
Wind Runs (nautical mile)	48	61	55	57	58	68	53	48	41	36	40	49	51
Class-A Pan Evaporation (inches/day)	0.19	0.20	0.22	0.24	0.25	0.24	0.22	0.22	0.21	0.20	0.17	0.17	0.21
Rainfall (inches)	1.26	2.09	2.63	2.27	4.62	4.11	4.11	7.35	5.02	5.89	2.83	2.38	44.56

Note: Wind runs is observed at 6 ft. height above ground surface.

Table B-6 (1/2) MONTHLY MEAN DISCHARGE

River; Black Station; Newton Unit;m^3/sec

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	AVERAGE
1966	7.05	4.06	3.89	5.40	16.49	19. 9	26.26	14.14	14.36	17.89	16.82	8.82	12.83
1967	5.69	4.64	5.34	12.40	15.76	13.02	10.13	7.30	12.01	22.93	23.63	11.92	11.92
1968	5.52	3.78	2.94	3.24	4.22	3.75	5.71	10.08	13.88	18.34	17.24	8.13	8.13
1969	5.46	3.38	2.88	9.18	31.36	22.95	11.2	12.29	18.25	24.61	14.36	7.42	13.61
1970	7.13	5.29	4.28	5.46	16.18	24.61	14.50	15.06	16.43	24.24	26.37	12.74	14.35
1971	7.75	5.53	5.25	6.39	22.14	19.46	9.46	15.68	15.23	18.95	15.79	9.11	12.38
1972	5.76	4.98	6.38	15.42	17.16	7.36	8.03	15.76	18.95	15.45	29.37	8.93	12.72
1973	5.93	4.08	5.92	4.59	10.02	14.19	8.87	19.51	15.43	42.00	26.09	13.10	14.14
1974	8.62	5.85	7.14	8.98	7.25	7.75	9.12	11.64	20.18	22.76	20.77	9.24	11.61
1975	5.01	3.78	3.72	2.57	10.69	9.52	10.03	16.38	19.48	19. 6	17.24	8.34	10.53
1976	5.93	3.94	3.52	2.24	4.09	3.94	2.88	8.90	17.44	24.38	10.78	6.32	7.86
1977	3.78	3.19	2.07	11.25	28.81	15. 4	13.21	13.16	16.57	27.41	16.91	10.55	13.28
1978	11.56	6.88	5.94	10.72	17.24	17. 5	14.81	11.29	12.34	25.11	17.47	9.26	13.35
1979	5.26	4.25	4.67	6.21	11.28	30.32	18.81	18.22	19.57	21.81	14.56	7.86	13.57
1980	5.74	3.78	3.05	5.23	12.12	12.85	8.97	10.03	11.26	15.96	13.07	9.52	9.15
1981	4.25	3.14	2.73	2.41	13.19	8.21	17.72	15.03	18.31	31.41	18.37	9.93	12.14
1982	10.07	7.95	4.55	6.38	25.46	12.66	9.39	8.24	16.84	14.79	12.15	8.05	11.38
Mean (1966-1982)	6.47	4.61	4.36	6.94	15.32	14.26	11.61	13.10	16.27	23.44	15.01	9.32	11.94

River; Black Station ; Lacovia Unit;m^3/sec

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	AVERAGE
1963				12.26	24.41	39.65	23.59	23.79	27.67	52.68	50.13	34.27	32.28
1964	20.73	10.11	12.94	25.94	22.68	20.84	18.01	21.18	27.07	28.32	19.14	15.63	20.76
1965	11.50	10.28	9.63	10.99	45.60	20.99	15.41	17.93	28.07	26.31	22.17	13.51	19.40
1966	11.27	9.20	9.32	10.62	22.46	21.78	40.78	19.94	20.99	23.28	25.57	14.22	19.20
1967	11.19	9.54	10.45	26.14	26.05	23.70	17.50	12.15	17.45	28.60	35.40	16.17	19.54
1968	10.93	7.99	6.80	7.90	8.81	8.38	9.80	15.66	19.46	24.44	25.40	14.61	13.37
1969	10.25	7.56	7.42	14.53	35.97	39.93	19.09	24.10	29.74	40.50	25.09	15.21	22.51
1970	13.79	10.25	8.86	11.61	24.95	38.80	22.32	25.54	28.29	39.65	41.63	20.28	23.87
1971	13.42	10.82	11.21	11.36	33.42	35.12	15.83	24.64	26.82	25.57	29.45	15.55	21.16
1972	9.60	12.21	16.71	29.74	30.59	14.53	16.45	21.04	28.89	40.78	28.60	15.83	22.26
1973	10.62	8.86	9.97	9.66	18.38	20.48	15.63	24.61	21.30	45.60	37.95	18.97	20.25
1974	15.43	13.03	14.50	17.78	14.81	13.57	14.13	17.42	28.60	29.74	18.97	13.40	17.62
1975	9.06	8.61	8.69	7.96	17.73	14.37	14.90	21.41	28.89	26.79	26.65	12.89	16.54
1976	8.50	7.39	7.08	5.24	6.97	7.73	7.90	16.91	29.45	35.68	14.87	10.73	13.20
1977	7.93	7.00	5.89	17.95	38.52	24.16	19.54	19.80	27.13	36.53	28.01	15.83	20.76
1978	17.33	11.10	10.82	18.29	28.04	28.15	19.80	18.44	19.65	35.40	31.15	13.71	21.04
1979	9.88	8.52	9.88	11.87	18.15	42.76	24.75	21.86	30.87	29.45	26.08	14.73	20.79
1980	11.78	9.06	8.07	11.95	17.25	21.16	11.55	14.98	17.59	21.38	18.18	12.77	14.64
1981	9.57	8.27	8.55	7.39	15.94	32.34	23.00	21.58	24.95	46.25	32.00	15.38	18.89
1982	10.17	15.63	11.19	11.47	34.81	18.44	17.87	13.51	28.01	25.06	19.94	13.00	18.27
Mean (1964-1982)	11.73	10.08	9.85	13.17	24.27	23.53	18.12	19.61	25.42	32.07	26.64	14.86	19.16

(To be continued)

Table B-6 (2/2) MONTHLY MEAN DISCHARGE

River; Y.S. Station; Near Middle Quarters Unit m^3/sec

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	AVERAGE
1955	1.35	1.04	0.78	2.13	2.30	10.53	4.73	3.03	5.01	9.28	2.94	1.54	3.72
1956	0.97	0.61	0.93	4.64	18.42	11.40	3.99	8.80	11.01	16.10	5.63	5.03	7.30
1957	2.00	1.44	2.02	6.99	6.62	4.13	5.43	8.74	7.24	4.27	1.77	1.23	4.33
1958	1.55	0.72	0.43	0.39	2.09	8.97	3.71	11.57	10.24	16.61	2.97	1.94	5.19
1959	1.05	0.62	0.58	6.31	11.10	4.90	8.07	6.53	3.48	5.63	4.98	3.45	4.75
1960	1.99	1.25	1.24	8.63	12.31	12.28	8.57	6.82	4.81	7.02	6.40	3.57	6.25
1961	1.40	1.75	3.40	4.84	7.98	5.63	8.69	9.99	11.94	14.77	5.26	2.38	6.54
1962	1.42	0.83	0.59	1.51	5.77	8.46	7.47	8.43	9.76	8.49	4.56	1.75	4.95
1963	1.05	0.67	0.83	0.83	6.28	12.20	11.12	8.94	9.99	13.67	7.53	4.55	6.51
1964	2.54	0.94	0.57	8.69	7.73	6.76	6.37	7.95	6.74	5.83	3.93	2.53	5.07
1965	1.00	0.55	0.30	1.12	11.97	5.04	3.65	8.04	7.90	9.14	2.83	1.13	4.41
1966	1.02	0.69	1.11	2.19	11.09	10.58	10. 4	4.16	5.41	5.74	6.65	1.49	5.07
1967	0.94	1.41	1.67	6.05	10.05	5.15	4.64	4.50	6.42	9.62	5.69	2.24	4.87
1968	1.04	0.44	0.43	1.17	2.03	1.88	3.45	4.53	6.99	9.14	5.74	2.05	3.25
1969	1.68	0.64	0.41	3.37	11.15	6.34	2.73	8.29	7.90	9.31	4.73	1.12	4.84
1970	1.16	0.58	0.57	0.41	7.81	9.03	9.17	7.84	8.04	12.02	9.82	1.82	5.72
1971	1.31	1.39	1.65	1.43	8.32	6.00	4.13	8.32	10.33	7.39	6.94	2.66	5.01
1972	1.34	1.65	2.36	6.82	6.82	2.28	2.83	7.67	10.13	8.74	3.96	2.01	4.73
1973	1.31	0.69	1.57	0.74	3.17	5.55	5.09	8.63	6.23	19.05	8.83	2.94	5.35
1974	1.21	0.84	1.61	5.41	2.24	1.56	6.14	8.21	10.67	7.56	4.87	2.83	4.44
1975	0.82	0.34	0.43	0.16	5.63	6.65	6.28	8.18	9.11	11.40	6.94	2.19	4.87
1976	0.77	0.29	0.33	0.16	1.66	2.10	1.31	7.78	10.39	9.88	1.51	1.07	3.14
1977	0.46	0.42	0.17	4.47	9.23	4.08	6.62	7.58	7.75	9.91	4.39	2.14	4.81
1978	2.83	1.14	1.40	5.15	7.44	8.35	8.26	3.25	5.63	15.62	6.76	2.25	5.72
1979	0.82	0.79	0.75	4.58	7.84	21.37	5.41	7.08	7.95	6.57	3.85	1.87	5.74
1980	0.73	0.42	0.19	1.41	5.97	4.81	2.38	5.43	5.38	6.99	5.74	2.63	3.51
1981	1.39	1.10	0.52	0.50	3.67	3.38	9.17	6.59	5.34	12.58	5.20	1.76	4.27
1982	1.19	3.68	1.50	3.48	10.64	4.19	4.27	4.41	7.50	6.96	4.44	1.81	4.50
Mean (1955-1982)	1.30	0.92	1.01	3.34	7.39	6.91	5.86	7.18	7.83	9.97	5.17	2.28	4.95
Mean (1964-1982)	1.24	0.94	0.92	3.01	7.07	6.05	5.38	6.76	7.67	9.65	5.41	2.02	4.70

River; Y.S. River Diversion Station; Near Middle Quarters Unit; m^3/sec

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	AVERAGE
1968	-	-	0.34	0.79	0.93	0.67	0.52	0.42	0.36	0.36	0.34	0.28	
1969	0.33	0.23	0.25	0.36	0.39	0.39	0.34	0.27	0.23	0.22	0.27	0.28	0.30
1970	0.26	0.20	0.28	0.27	0.63	0.58	0.50	0.42	0.34	0.34	0.31	0.31	0.37
1971	0.24	0.45	0.41	0.27	0.80	0.68	0.52	0.40	0.38	0.28	0.24	0.23	0.41
1972	0.24	0.16	0.14	0.28	0.32	0.26	0.21	0.18	0.14	0.14	0.20	0.25	0.21
1973	0.18	0.32	0.51	0.46	0.64	0.58	0.49	0.44	(0.31)	(0.28)	(0.23)	(0.27)	0.39
1974	0.58	0.38	0.61	0.44	0.59	0.57	0.50	0.38	0.34	0.39	0.27	0.41	0.50
1975	0.66	0.53	0.57	0.54	0.56	0.57	0.23	0.09	0.09	0.02	0.03	0.28	0.35
1976	0.63	0.55	0.66	0.40	0.54	0.63	0.55	0.48	0.54	0.52	0.44	0.59	0.54
1977	0.57	0.78	0.46	0.86	0.81	0.71	0.68	0.56	0.56	0.49	0.36	0.24	0.59
1978	0.48	0.57	0.57	0.72	0.62	0.49	0.42	0.33	0.36	0.29	0.23	0.18	0.44
1979	0.51	0.55	0.67	0.77	0.04	0.71	0.64	0.61	0.52	0.52	0.25	0.64	0.62
1980	0.77	0.65	0.57	0.62	0.71	0.68	0.20	0.06	0.05	0.04	0.02	0.08	0.37
1981	0.21	0.30	0.46	0.28	0.49	0.69	0.65	0.44	0.22	0.29	0.18	0.07	0.36
1982	0.20	0.26	0.37	0.60	0.54	0.41	0.34	0.33	0.25	0.10	0.08	0.04	0.29
Mean (1969-82)	0.41	0.42	0.45	0.54	0.63	0.57	0.45	0.36	0.31	0.28	0.23	0.27	0.41

Table B-7 SUMMARY OF WATER BALANCE COMPUTATION

(Unit: m^3/sec)

Year	I_B	I_Y	P_Y	P_U	I_S	I_G	I_P	I	O_B	E	O	ds
1974	17.6	4.4	14.1	7.1	2.0	2.9	3.1	30.0	25.3	3.9	29.2	+0.8
1975	16.5	4.8	10.9	6.4	1.1	1.7	2.9	27.0	25.1	3.7	28.8	-1.8
1976	13.2	3.1	9.8	5.2	1.4	2.1	2.5	22.3	20.8	4.0	24.8	-2.5
1977	20.7	4.8	14.0	6.4	1.7	2.5	3.0	32.7	28.2	3.9	32.1	+0.6
1978	21.0	5.7	13.9	7.6	1.2	1.7	3.5	33.1	28.9	3.9	32.8	+0.3
1979	20.7	5.7	14.9	8.4	1.8	2.7	3.7	34.6	28.9	3.7	32.6	+2.0
1980	14.6	3.5	9.2	4.3	0.9	1.5	2.3	22.8	22.1	3.8	25.9	-3.1
Average	17.8	4.6	12.4	6.5	1.4	2.2	3.0	29.0	25.6	3.8	29.4	-0.5

Table B-8 COMPUTATION OF RIVER RUNOFF ON THE BROAD AND MIDDLE QUARTERS RIVERS

Broad River:

	Rain-fall (mm)	Swamp Evapo. Trans. (mm)	Swamp Effect. Rainfall (mm)	Direct Flow (m^3/s)	Upland Surface Flow (m^3/s)	Total Surface Flow (m^3/s)	Ground Water Flow (m^3/s)	Total (m^3/s)
Jan.	1	138	-137	-1.176	0.005	-1.171	0.204	-0.967
Feb.	48	137	-89	-0.846	0.267	-0.579	0.330	-0.249
Mar.	84	177	-93	-0.798	0.421	-0.377	0.501	0.124
Apr.	86	163	-77	-0.683	0.446	-0.237	0.616	0.379
May	110	177	-67	-0.575	0.552	-0.023	2.448	2.425
June	62	179	-117	-1.038	0.321	-0.717	0.924	0.207
July	230	180	50	0.429	1.154	1.583	2.338	3.921
Aug.	261	174	87	0.747	1.309	2.056	2.888	4.944
Sept.	148	137	11	0.098	0.767	0.865	1.705	2.570
Oct.	169	185	-16	-0.137	0.848	0.711	2.387	3.098
Nov.	143	128	15	0.133	0.741	0.874	0.913	1.787
Dec.	34	134	-100	-0.859	0.170	-0.689	0.259	-0.430
Total	1,376	1,909	-533	-	-	-	-	-
Mean	-	-	-	-0.392	0.583	0.191	1.293	1.484

Middle Quarters River

	Rain-fall (mm)	Swamp Evapo. Trans. (mm)	Swamp Effect. Rainfall (mm)	Direct Flow (m^3/s)	Upland Surface Flow (m^3/s)	Total Surface Flow (m^3/s)	Ground Water Flow (m^3/s)	Total (m^3/s)
Jan.	7	138	-131	-0.292	0.007	-0.285	0.003	-0.282
Feb.	35	137	-102	-0.251	0.042	-0.209	0.042	-0.167
Mar.	18	177	-159	-0.354	0.019	-0.335	0.064	-0.271
Apr.	78	163	-85	-0.195	0.087	-0.108	0.078	-0.030
May	322	177	145	0.323	0.347	0.670	0.312	0.980
June	100	179	-79	0.182	0.111	-0.071	0.118	0.047
July	323	180	143	0.318	0.348	0.666	0.298	0.964
Aug.	352	174	178	0.396	0.379	0.775	0.368	1.143
Sept.	185	137	48	0.110	0.206	0.316	0.217	0.533
Oct.	264	185	79	0.176	0.284	0.460	0.304	0.764
Nov.	55	128	-73	-0.168	0.061	-0.107	0.116	0.009
Dec.	12	134	-122	-0.272	0.013	-0.259	0.033	-0.226
Total	1,751	1,909	-158	-	-	-	-	-
Mean	-	-	-	-0.033	0.159	0.126	0.163	0.289

Table B-9 RESULTS OF WATER QUALITY ANALYSES

Sample No.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
River:	Y.S.	Black	Black		Broad		Y.S.	Black	Broad
Site:	Near M.Q.	Lacovia	Town of Black R.	Holland Estate P.S.	Salt Spring Bridge	Swamp Salt Spring	Near M.Q.	Lacovia	Salt Spring Bridge
Date:	25/7/88	25/7/84	25/7/84	25/7/84	25/7/84	25/7/84	19/7/84	19/7/84	19/7/84
Calcium (Ca)	42	72	58	55	57	133	-	-	-
Magnesium (Mg)	6.3	5.3	33	8.35	10	71	-	-	-
Sodium (Na)	3.1	4.3	192	6.1	21	688	-	-	-
Potassium (K)	0.86	2.37	8.72	1.52	1.51	27	-	-	-
C.O.D.	7	12	26	5	17	217	41.76	0	-
DO/B.O.D.	7.8/0.9	5.4/1.2	5.2/1.2	3.8/1.1	4.6/0.5	3.8	-	-	-
Nitrates (NO_3)	2.3	2.7	1.8	2.1	1.5	0.8	3.5	1.98	2.32
Nitrites (NO_2)	0.03	0.06	0.04	0.06	0.04	0.04	-	-	-
Sulphate (SO_4)	3.6	9.6	0.4	10	5.5	41	-	-	-
Chlorides (Cl)	10	12	380	16	44	1,450	-	-	-
Phosphate Total (PO_4)	0.11	0.17	0.7	0.15	0.04	0.22	0.05	0.05	0.05
Ortho	0.06	0.08	0.04	0.05	0.02	0.02	-	-	-
EC m.mhos/cm	270	380	1,570	370	470	4,420	-	-	-
TDS	160	320	910	210	270	3,100	-	-	-
Hardness, Total	132	202	280	172	184	625	-	-	-
Alkalinity, Total	130	186	160	164	174	430	-	-	-
Alkaninity, Bicarbonate	130	186	160	164	174	430	-	-	-
Alkaninity, Carbonate	0	0	0	0	0	0	-	-	-
Alkaninity, Hydroxide	0	0	0	0	0	0	-	-	-
pH Value	7.85	7.34	7.39	7.12	7.29	7.62	7.3	7.2	7.0
Suspended Soils	-	-	-	-	-	-	29.4	25.8	3.6

Sample No. (1) - (6): Analysed by Montego Bay Laboratory, NWC
Sample No. (7) - (9): Analysed by Laboratory, NRCD

Table B-10 SEDIMENT TRANSPORTATION

Sample No.	Site	Date	G.H.	Discharge (m^3/sec)	Suspended Solids (ppm)	
					Above 200 micro m	0.4 micro m
1	Lacovia	12 July '84	5.66	13.6	21	0
2	Y.S.	12 July '84	3.83	8.2	43	1
3	Lacovia	16 July '84	6.24	15.6	27	0
4	Y.S.	16 July '84	3.58	6.8	106	0
5	Y.S.	25 July '84	3.34	5.7	115	2
6	M.Q. Div. Upstream	14 July '84	-	0.15	105	0
7	M.Q. Div. Midstream	14 July '84	-	-	7	0

Analysed by Montego Bay Laboratory, N.W.C.

Table B-11 QUALITY OF WATER DISCHARGES FROM THE APPLETON SUGAR FACTORY AND RUM DISTILLERY

	Sugar Factory (Direct to Black River via Factory drain: Jan. 1975)	Rum Distillery (To N. Elim Spring via sinkhole: Jan. to June 1974)
Turbidity	43	more than 500
pH	7.2	5.5 - 6.4
Spec. Cond (micro mhos)	238	825 - 1,900
BOD (mg/l)	105.6	2,550 - 4,600
COD (mg/l)	144	4,450
Total N (mg/l)	N/D	28
NO_3-N (mg/l)	0.76	0.16
PO_4-P (mg/l)	0.15	5.5 - 9.0
Susp. Solids (mg/l)	190	320
Flow (mgd)	N/D	2.25

Source: Black River Upper Morass Feasibility Report
Vol. 3 Appendix H. Environmental Assessment

Table B-12 RESULT OF ELECTRICAL CONDUCTIVITY MEASUREMENTS

Site No.	Location	Sampling Depth (m)	Electrical Conductivity (micro mhos)	Equivalent to NaCl (ppm)
1	Black River Estuary	0	2,580	1,300
		1.0	2,420	1,300
		2.0	4,100	2,100
		2.25	5,880	3,200
2	Black River junction with Broad River	0	3,100	1,600
		1.0	2,780	1,500
		2.0	3,040	1,600
		2.75	3,420	1,800
3	Black River 3 km upstream from estuary	0	390	190
		1.0	350	170
		2.0	320	160
		3.0	370	180
		4.0	340	170
		5.0	370	180
		5.75	360	170
4	Broad River 2 km upstream from junction with Broad River	0	1,280	650
		1.0	1,280	640
		2.0	1,160	580
		2.5	2,030	1,050
		3.0	6,150	3,300
5	Broad River Salt Spring Bridge	0	570	280
		1.0	480	240
		2.0	600	290

Table B-13 PROBABLE MINIMUM RAINFALL IN THE LOWER MORASS

(Unit: mm)

Month	Black River Sample No. 21			Burnt Sabannah Sample No. 12			Holland Sample No. 33			Lacovia Sample No. 12			Mountainside Sample No. 12		
	2-yr	5-yr	10-yr	2-yr	5-yr	10-yr	2-yr	5-yr	10-yr	2-yr	5-yr	10-yr	2-yr	5-yr	10-yr
Jan.	24	4	2	32	4	1	47	22	14	69	21	8	32	7	3
Feb.	47	14	6	73	25	9	51	15	6	53	29	21	52	27	18
Mar.	34	16	11	72	40	30	72	20	8	58	14	5	50	26	17
Apr.	61	27	18	135	64	39	148	88	67	127	54	33	104	67	53
May	142	93	73	185	105	75	257	185	155	191	117	89	118	76	60
June	79	24	11	98	27	9	143	73	49	84	50	41	79	17	6
July	87	56	44	94	52	37	168	110	87	115	70	58	79	55	46
Aug.	157	102	77	189	136	112	221	154	122	218	168	150	109	72	62
Sept.	120	80	65	169	130	117	214	164	143	247	159	111	131	82	65
Oct.	135	87	70	214	128	90	256	178	146	254	207	185	154	111	95
Nov.	87	57	45	102	55	38	130	57	26	82	53	42	100	80	74
Dec.	23	6	3	54	15	6	57	31	21	34	8	2	60	26	14
Annual	1,184	973	874	1,537	1,340	1,247	1,913	1,640	1,495	1,662	1,387	1,261	1,255	1,017	905

Table B-14 PROBABLE MINIMUM 25-DAY AND 20-DAY FLOW IN A MONTH

(Unit: m^3/sec)

Month	Black R. at Lacovia			Y.S. R. at M.Q.			Black R. at Lacovia			Y.S. R. at M.Q.		
	2-yr	5-yr	10-yr	2-yr	5-yr	10-yr	2-yr	5-yr	10-yr	2-yr	5-yr	10-yr
	Minimum 25-day Flow:						Minimum 20-day Flow:					
Jan.	9.8	8.6	8.2	0.93	0.56	0.38	10.1	8.8	8.4	0.97	0.63	0.48
Feb.	8.6	7.0	6.4	0.53	0.37	0.31	9.1	7.6	7.1	0.61	0.42	0.35
Mar.	8.3	7.0	6.4	0.49	0.21	0.11	8.7	7.2	6.6	0.55	0.24	0.12
Apr.	8.4	6.6	5.9	0.52	0.19	0.11	9.3	6.9	6.1	0.84	0.29	0.16
May	14.3	9.6	7.8	2.35	0.91	0.51	17.6	11.6	9.2	3.49	1.79	1.20
June	15.1	10.3	8.5	2.79	1.66	1.24	16.6	11.2	9.1	3.27	1.93	1.46
July	13.7	10.1	8.6	3.10	1.80	1.33	15.1	10.8	9.1	3.82	2.20	1.59
Aug.	14.2	11.9	10.7	3.87	2.70	2.21	15.7	13.0	11.8	4.63	3.48	2.98
Sep.	19.2	16.2	14.7	4.45	3.45	3.03	21.5	18.0	16.4	5.33	4.09	3.57
Oct.	22.6	17.9	15.8	4.74	3.59	3.16	27.2	17.9	15.8	6.03	4.43	3.83
Nov.	19.8	16.1	14.3	2.97	2.20	1.80	22.2	17.5	15.4	3.55	2.60	2.13
Dec.	12.5	10.9	10.3	1.55	1.20	1.05	13.1	11.5	10.8	1.70	1.28	1.10
	Minimum 360-day Flow:						Minimum 355-day Flow:					
	7.9	6.6	5.9	0.37	0.15	0.09	8.1	6.7	6.0	0.42	0.17	0.09

Table B-15 RECORDED ANNUAL PEAK DISCHARGE

(Unit: m^3/sec)

Year	Black River at Newton		Black River at Lacovia		Y.S. River at Near Middle Quarters	
	Date	Discharge	Date	Discharge	Date	Discharge
1955					June 6	31
1956					May 25	31
1957					Apr. 16	16
1958					Oct. 28	41
1959					May 26	28
1960					June 11	41
1961					Oct. 20	28
1962					Oct. 14	22
1963					June 10	32
1964			Oct. 26	44	Apr. 23	26
1965			May 16	60	May 11	28
1966	June 29	81	July 1	64	June 28	46
1967	Nov. 17	45	Nov. 19	48	Oct. 21	25
1968	Oct. 15	38	Oct. 16	37	Oct. 15	38
1969	May 27	99	Oct. 21	74	May 31	27
1970	Nov. 13	63	Nov. 15	51	May 23	23
1971	May 12	45	June 1	66	May 31	29
1972	Oct. 7	52	Oct. 19	55	Aug. 13	22
1973	Oct. 19	117	Oct. 21	86	Oct. 18	52
1974	Nov. 21	36	Apr. 29	34	July 24	24
1975	Oct. 30	42	Nov. 1	45	Oct. 20	24
1976	Oct. 17	47	Oct. 18	44	Aug. 30	18
1977	May 20	47	Sep. 13	52	Sep. 25	29
1978	Oct. 11	41	June 1	45	Oct. 9	26
1979	June 13	60	June 15	56	June 13	51
1980	June 1	28	June 1	37	May 30	29
1981	Oct. 14	45	Oct. 15	57	Oct. 14	21
1982	May 19	67	Oct. 21	70	May 18	26

Table B-16 RAINFALL IN FLOOD TIME ON THE Y.S. RIVER

	Flood on 11th June, 1960				
	Date				
Station	7	8	9	10	11
Maggoty	-	-	-	-	-
Quickstep	50	28	56	79	36
New Market	38	39	368	234	22
Y.S.	22	0	54	117	72
Flamstead	-	-	-	-	-
	37	22	159	143	43

	Flood on 28th June, 1966				
	Date				
Station	24	25	26	27	28
Maggoty	0	0	81	166	15
Quickstep	9	0	51	96	76
New Market	0	0	0	56	155
Y.S.	0	0	0	92	131
Flamstead	-	-	-	-	-
	2	0	33	103	94

	Flood on 18th Oct., 1973				
	Date				
Station	14	15	16	17	18
Maggoty	2	69	142	152	47
Quickstep	0	76	89	152	38
New Market	-	-	-	-	-
Y.S.	0	61	122	97	41
Flamstead	67	61	137	131	121
	17	67	123	133	62

Table B-17 ANNUAL MAXIMUM 2 DAYS CONTINUOUS RAINFALL

(mm)

Station	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
Maggoty	345	97	-	96	89	93	199	89	156	119
New Market	246	638	-	218	334	199	211	216	255	303
Quickstep	-	-	-	-	134	216	211	154	232	163
Y.S.	-	-	-	-	-	-	-	64	137	160

Station	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Maggoty	102	113	122	124	135	128	248	118	123	122
New Market	602	372	231	135	112	95	211	128	150	140
Quickstep	182	147	135	117	112	138	172	135	210	-
Y.S.	189	95	127	91	127	120	223	132	166	127

Station	1970	1971	1972	1973	1978	1979	1980	1981	1982
Maggoty	75	-	-	295	-	-	-	-	214
New Market	-	-	-	-	-	-	-	-	106
Quickstep	-	197	107	241	-	312	75	-	143
Y.S.	109	-	153	218	110	124	-	-	-

Station	1983
Maggoty	88
New Market	96
Quickstep	59
Y.S.	-

Table B-18(1/2) RAINFALL IN FLOOD TIME ON THE BLACK RIVER

(mm)

Flood on 29th June, 1966	Date					Flood on 17th Nov., 1967	Date			
Station	25	26	27	28	29	13	14	15	16	17
Bartons	-	-	-	-	-	3	0	72	27	8
Maggoty	0	81	166	15	0	9	1	78	0	28
Raheen	89	34	10	0	0	18	52	113	0	3
Quickstep	0	51	96	76	0	14	53	24	0	0
Troy	-	-	-	-	-	-	-	-	-	-
Wait a bit	14	30	183	102	0	49	11	112	0	0
Warsop	0	47	254	55	0	51	0	0	0	0
Craighead	34	136	275	4	0	9	22	76	0	0
Mile Gully	0	119	222	15	0	4	47	5	0	0
Average	20	71	172	38	0	20	23	60	3	5

Flood on 27th May, 1969	Date					Flood on 13th Nov. 1970	Date			
Station	23	24	25	26	27	9	10	11	12	13
Bartons	13	79	0	22	0	0	37	0	0	0
Maggoty	10	61	61	25	0	-	-	-	-	-
Raheen	-	-	-	-	-	0	113	57	36	0
Quickstep	-	-	-	-	-	-	-	-	-	-
Troy	-	-	-	-	-	-	-	-	-	-
Wait a bit	-	-	-	-	-	-	-	-	-	-
Warsop	-	-	-	-	-	-	-	-	-	-
Craighead	81	0	25	17	116	3	135	0	48	0
Mile Gully	30	25	0	42	0	-	-	-	-	-
Average	34	41	22	27	29	1	95	19	28	0

Table B-18(2/2)

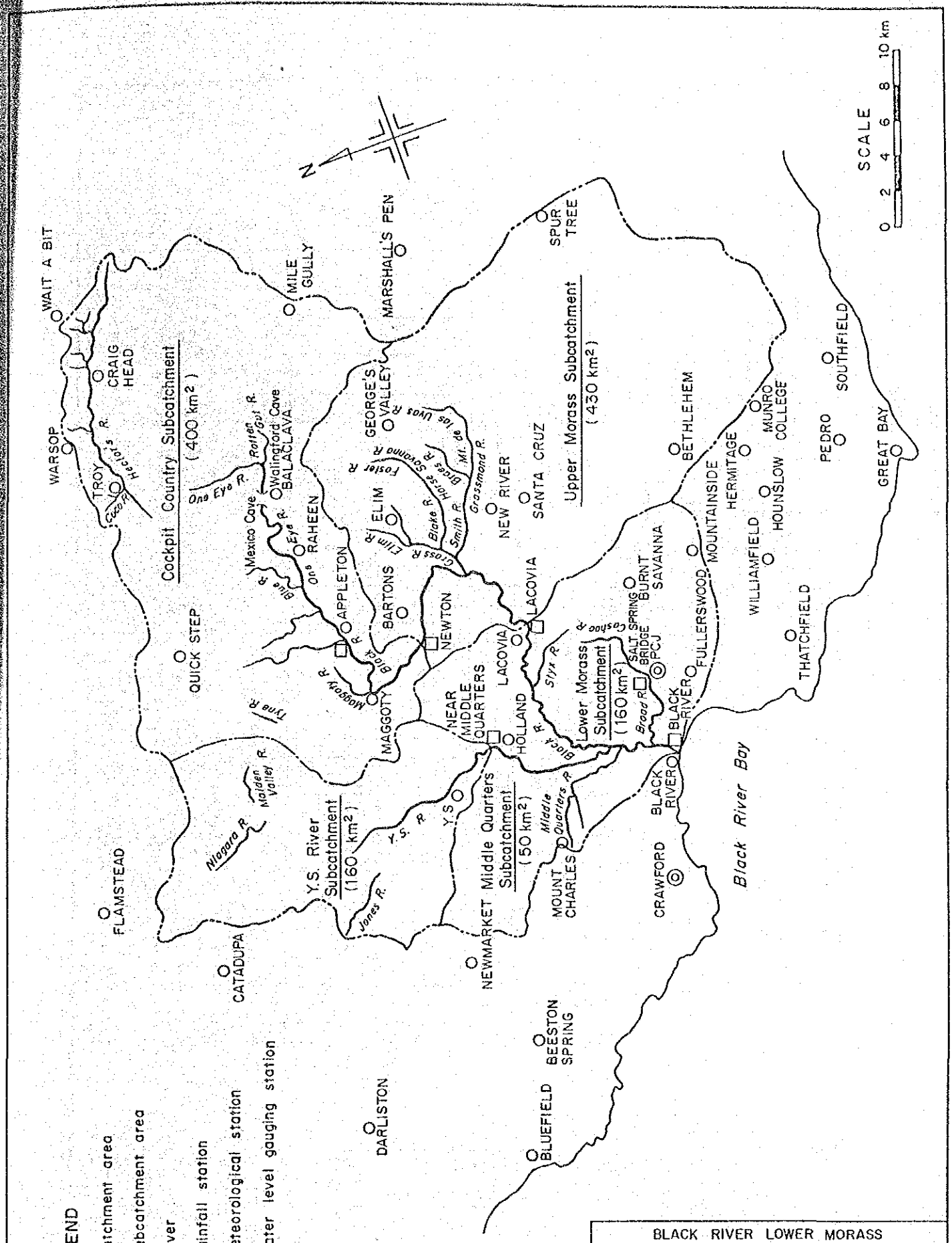
Station	Flood on 19th Oct., 1973 Date 14	15	16	17	18	19	Flood on 19th May, 1982 Date 15	16	17	18	19
Bartons	-	-	-	-	-	-	10	6	80	43	-
Maggoty	15	69	142	152	47	7	-	-	-	-	-
Raheen	0	12	99	135	37	15	30	42	44	9	1
Quickstep	0	89	152	38	20	0	-	-	-	-	-
Troy	48	10	76	109	0	0	66	56	0	190	0
Wait a bit	0	27	95	136	0	0	-	-	-	-	-
Warsop	0	21	86	59	5	16	-	-	-	-	-
Craighead	-	-	-	-	-	-	-	-	-	-	-
Mile Gully	-	-	-	-	-	-	45	53	31	64	0
Average	11	38	108	105	18	6	38	39	39	77	1

Table B-19 ANNUAL MAXIMUM 3 DAYS RAINFALL

Staion	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957
Maggoty	-	-	431	144	-	102	123	108	237	97
Raheen	197	109	459	155	121	129	146	109	146	136
Quickstep	-	-	-	-	-	-	155	259	211	167
Troy	-	-	-	128	137	-	-	131	105	122
Wait a bit	-	-	-	-	131	-	-	134	122	172
Warsop	-	-	124	193	182	139	125	88	201	198
Craighead	-	-	380	182	141	-	173	146	268	160
Mile Gully	-	-	-	-	-	-	139	62	110	119

Station	1958	1958	1960	1961	1962	1963	1964	1965	1966	1967
Maggoty	169	135	114	166	155	140	161	166	263	164
Raheen	176	191	185	169	152	194	148	169	241	212
Quickstep	290	175	278	205	164	117	128	170	223	-
Troy	-	-	-	109	142	-	-	-	-	-
Wait a bit	218	220	182	180	284	296	160	211	315	183
Warsop	135	229	119	139	168	279	174	174	356	127
Craighead	246	170	224	427	204	404	124	145	445	165
Mile Gully	306	171	93	100	117	307	137	171	357	148

Station	1968	1969	1970	1971	1972	1973	1982	1983
Maggoty	128	147	126	-	-	363	221	99
Raheen	180	-	206	166	-	272	144	81
Quickstep	210	-	-	197	111	318	-	-
Troy	-	-	-	-	-	187	246	-
Wait a bit	145	-	-	-	-	259	-	-
Warsop	77	225	-	-	-	166	-	95
Craighead	201	268	224	274	-	-	-	-
Mile Gully	340	324	135	236	-	-	147	117

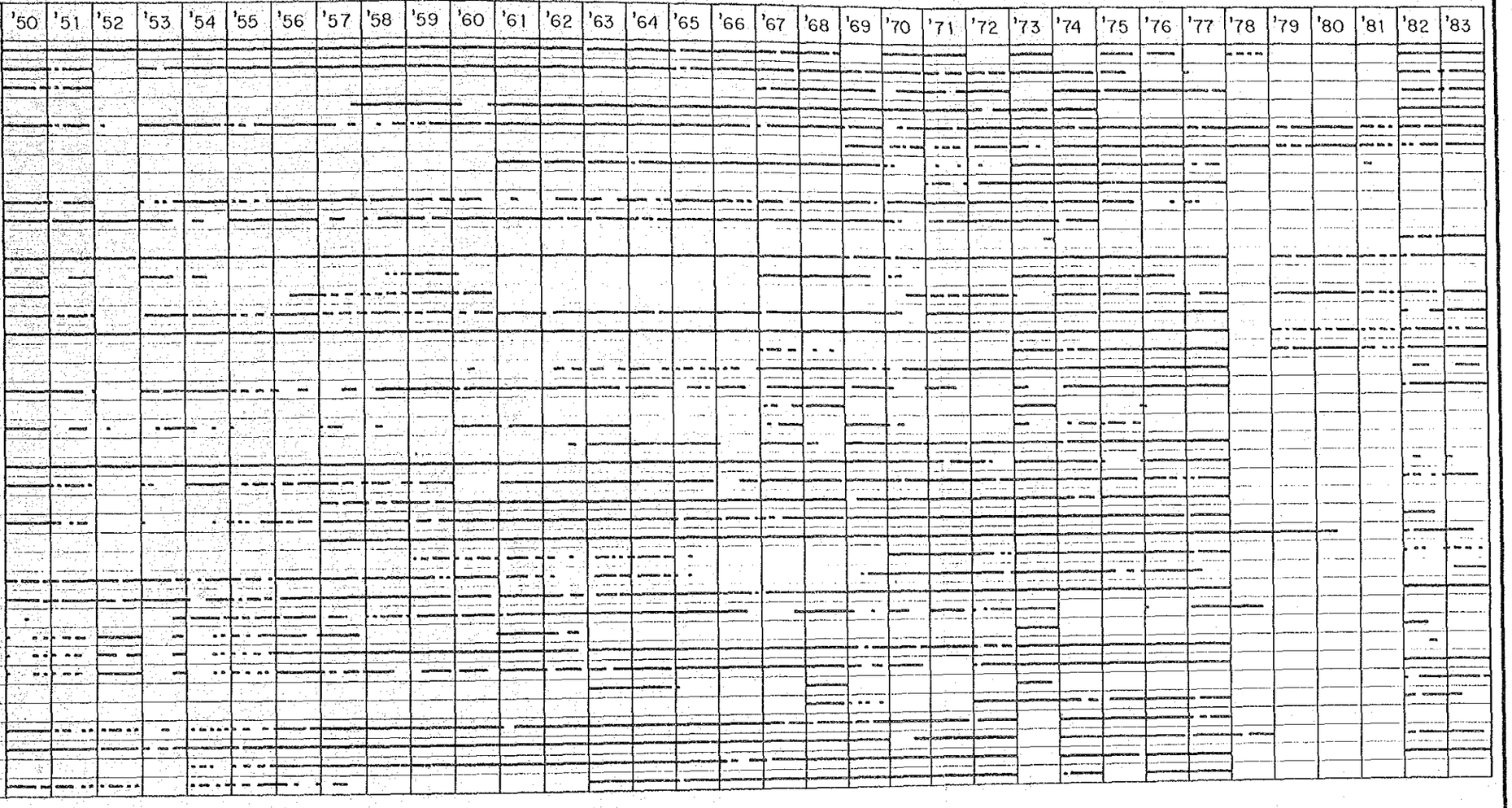


BLACK RIVER LOWER MORASS AGRICULTURAL DEVELOPMENT PROJECT

Fig. B-1 THE BLACK RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

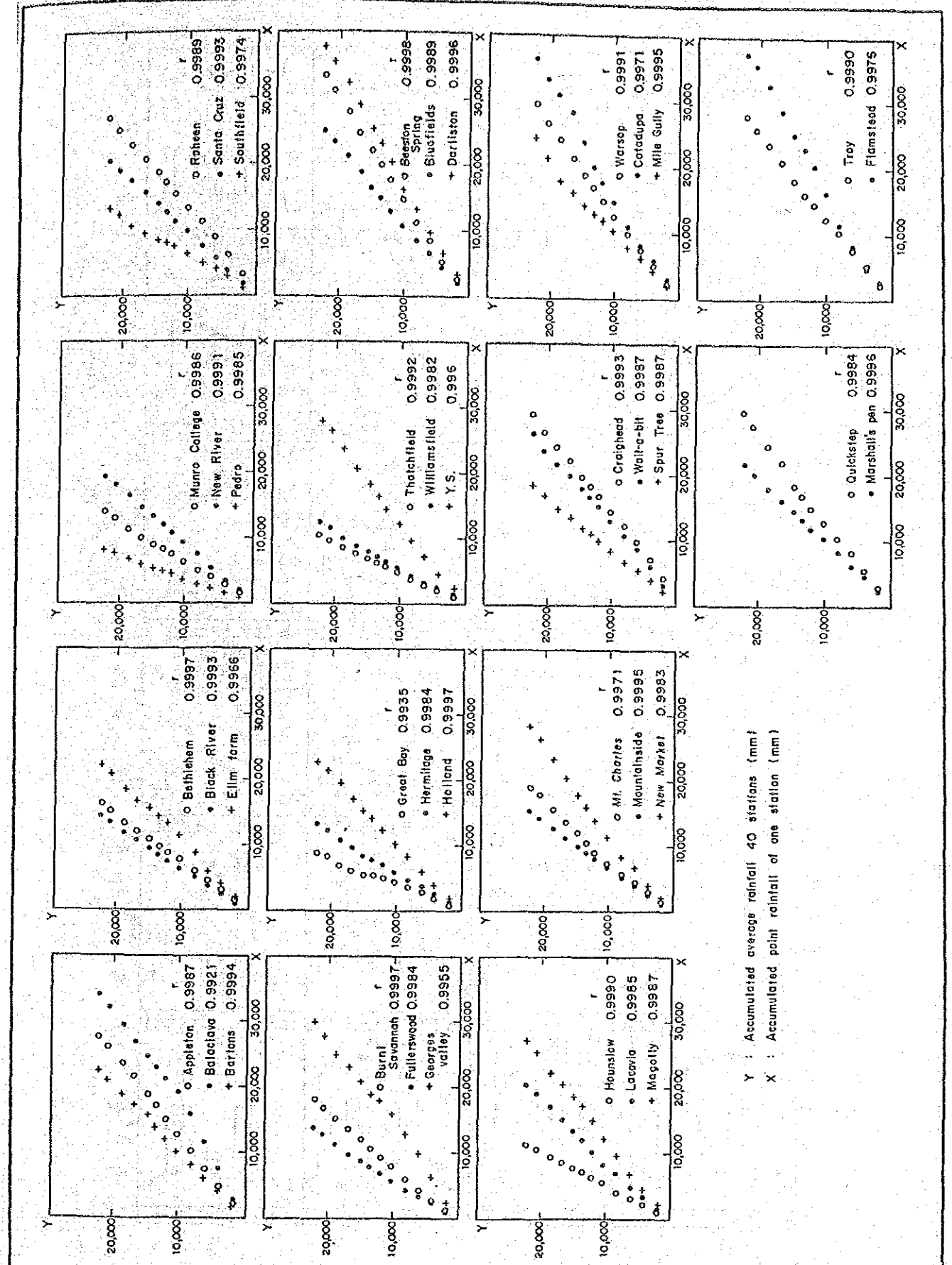
No.	Name of Station	Number
1.	Appleton	18177781
2.	Baloclave	18177682
3.	Bartons	18177762
4.	Bethlehem	17977684
5.	Black River	18077862
6.	Burnt Savannah	18077752
7.	Elim Farm	18177664
8.	Fullerswood	18077850
9.	George Valley	18177651
10.	Great Bay	17877781
11.	Hermitage	17977674
12.	Holland	18177850
13.	Hounslow	17977771
14.	Lacovia	18077782
15.	Magotty	18177773
16.	Mount Charles	18077893
17.	Mountainside	17977742
18.	Munroe College	17977664
19.	New Market	18177970
20.	New River	18077684
21.	Pedro I	17877791
22.	Raheen Estate I	18177683
23.	Santa Cruz	18177674
24.	Southfield	17877693
25.	Thatchfield	17977870
26.	Williamsfield	17977773
27.	Y.S.	18177861
28.	Beeston Spring	18177973
29.	Bluefields	18178081
30.	Darliston	18277963
31.	Quickstep	18277770
32.	Troy	18277670
33.	Wait a bit	18277570
34.	Warsop	18277583
35.	Catadupa	18277883
36.	Flamstead	18377861
37.	Graig Head	18277567
38.	Marshall's Pen	18077576
39.	Mile Gully	18177567
40.	Spur Tree	17977598



BLACK RIVER LOWER MORASS
AGRICULTURAL DEVELOPMENT PROJECT

Fig. B-2 AVAILABLE DAILY RAINFALL RECORDS

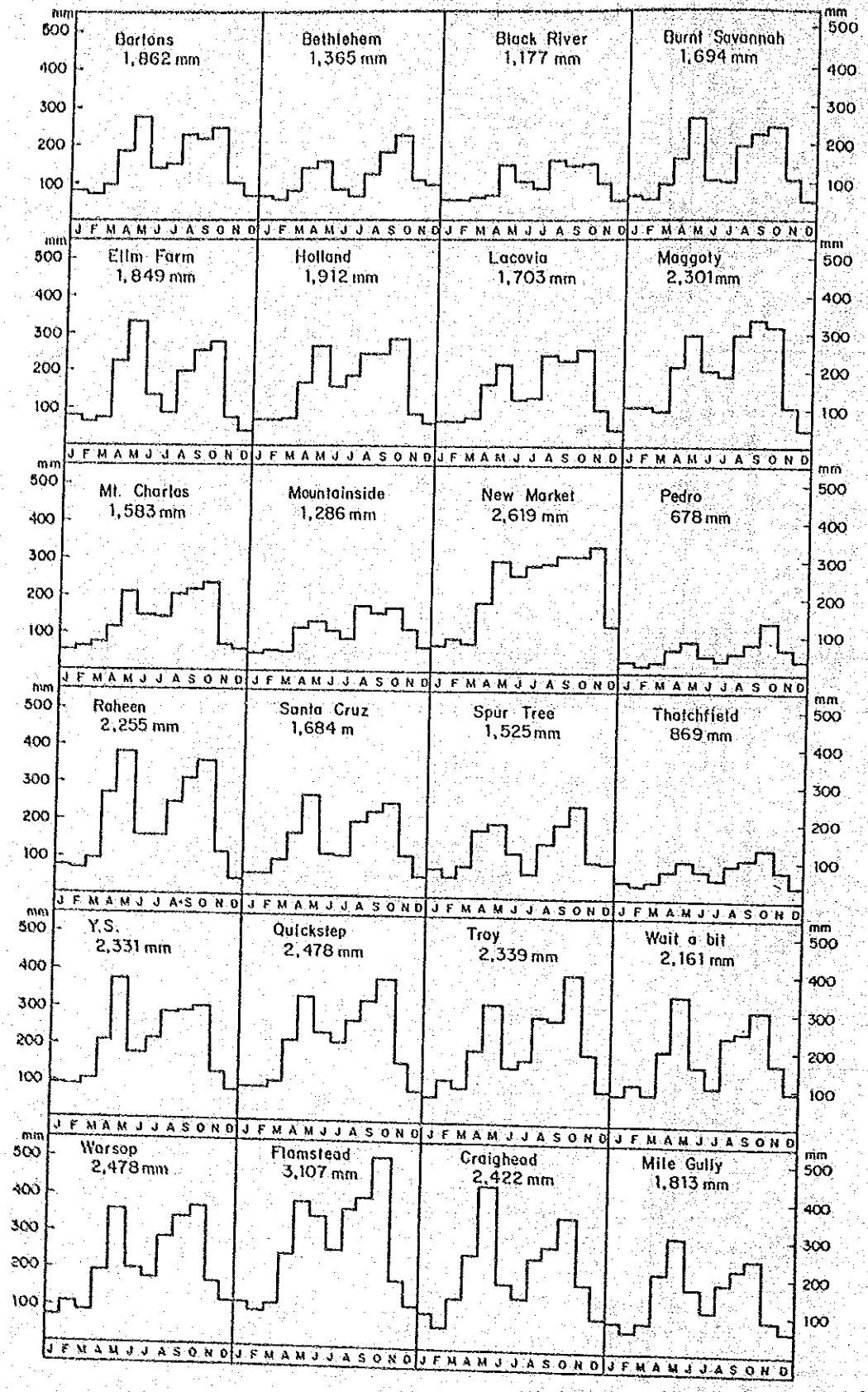
JAPAN INTERNATIONAL COOPERATION AGENCY



BLACK RIVER LOWER MORASS
AGRICULTURAL DEVELOPMENT PROJECT

Fig. B-3
DOUBLE MASS CURVE ANALYSES FOR RAINFALL RECORDS

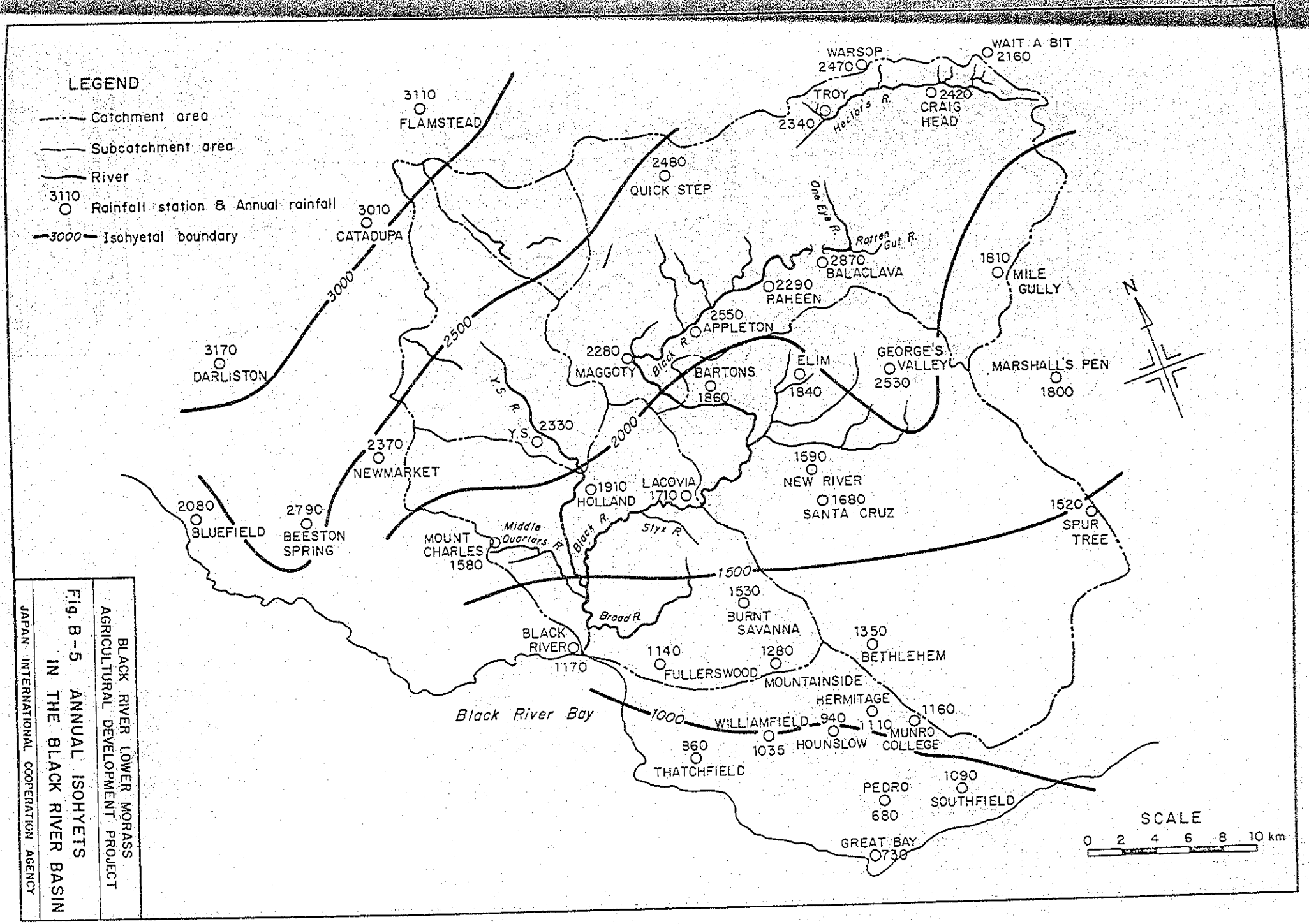
JAPAN INTERNATIONAL COOPERATION AGENCY



BLACK RIVER LOWER MORASS
AGRICULTURAL DEVELOPMENT PROJECT

Fig. B-4
MONTHLY RAINFALL HISTOGRAMS

JAPAN INTERNATIONAL COOPERATION AGENCY



BLACK RIVER LOWER MORASS AGRICULTURAL DEVELOPMENT PROJECT

Fig. B-5 ANNUAL ISOHYETS IN THE BLACK RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY