WATER RESOURCES PUBLICATION NO. 3

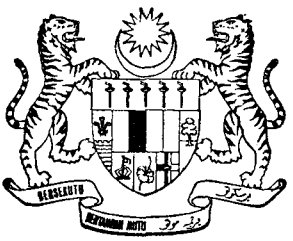
SUNGEI TEKAM EXPERIMENTAL BASIN ANNUAL REPORT NO. 1 FOR 1973 - 1974

JABATAN PENGAIRAN DAN SALIRAN
KEMENTERIAN PERTANIAN MALAYSIA

Bahagian Parit dan Taliair Water Resources Publication No. 3

SUNGEI TEKAM EXPERIMENTAL BASIN ANNUAL REPORT NO. 1 FOR 1973-1974

KEMENTERIAN PERTANIAN DAN PEMBANGUNAN LUAR BANDAR
MALAYSIA



SUNGEI TEKAM EXPERIMENTAL BASIN ANNUAL REPORT NO. 1 FOR 1973-1974

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MINISTRY OF AGRICULTURE AND RURAL DEVELOPMENT

ACKNOWLEDGEMENTS

The Sg. Tekam experimental basin study is a conjunct study between the Drainage and Irrigation Division (DID) of the Ministry of Agriculture and Rural Development and the Federal Land Development Authority (FELDA).

The Engineering Export Association of New Zealand Inc. (ENEX) works in association with the DID on this project and similarly the UN Food and Agricultural Organisation (FAO) is associated with FELDA.

The study objectives and research programme are reviewed regularly by a Technical Committee, the members of which are listed in the body of the report.

The data collected for the results reported here have been collected by Federal and State Offices of the DID and FELDA and the supply of climate data from the Malaysian Meteorological Services and the chemical analysis of water quality samples by the Chemistry Department are acknowledged.

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Summary and Conclusions

Analyses of flow and rainfall records to date have clearly demonstrated the suitability of these catchments for experimental basin studies. Flow duration analyses indicate that the daily runoff distribution is similar for all three catchments. Significant runoff events correspond directly to a rainfall event, and water balance data indicate no major loss to deep percolation. The lack of significant base flow suggests that little groundwater storage exists.

It is to be noted that the method adopted for deriving the mean daily basin rainfall totals assumes that if rainfall occurred at the automatic raingauge at FELDA office, then a proportional amount of rainfall also occurred in the experimental catchments. Considering the character of rainfall in Peninsular Malaysia, this assumption is likely to be incorrect and there are instances whereby significant runoff events result from insignificant rainfall events.

It is planned to install rainfall recorders in each of the three catchments for a period to study these apparent anomalies.

CONTENTS

1. INTRODUCTION

This report outlines the objectives of research for the Sungei Tekam Experimental Basin and summarises hydrological measurements to 31st August, 1974.

2. PROJECT DETAILS

2.1 Problems and objectives

Extensive areas of logged lowland tropical forest on the gently sloping lands of the Temerloh region are currently being converted to oil palm, rubber and cocoa crops. Little is known of the hydrological effects resulting from such a land management change.

Toebes and Goh (1973) postulated that development from previously logged forest to oil palm will result in:

— an immediate increase in annual water yield following clearing, brought about by the sharp reduction in interception and evapotranspiration. In addition, because of the destruction of the humic layers and compaction by heavy machinery a reduction in the rate of infiltration is expected with an associated greater flow variability—flood hydrographs with a shorter time of concentration, higher peak discharges and a greater volume of storm runoff. As the oil palm crop matures (6-8 years) annual water yield is expected to return to less than the pretreatment level.

— an increase in suspended sediment concentration and discharge and a deterioration in water quality.

Approximately 420 ha (1040 ac) of cut-over forest have been set aside near FELDA Research Station at Sungei Tekam for the establishment of an experimental basin project with the following research objectives.

— to study the hydrological effects of converting a forested catchment to oil palm.

— to study how the soil moisture status can be improved to increase palm oil production and whether oil palm is the most suitable crop considering the hydrological conditions.

— to study different planting patterns and management techniques in relation to soil moisture behaviour and production.

— to train local personnel in experimental basin studies.

2.2 Project organisation and acknowledgements

By formal agreement, the experimental basin project is to be operated jointly by the Drainage and Irrigation Division (DID) of the Ministry of Agriculture and Rural Development (MARD) and the Federal Land Development Authority (FELDA). Other agencies assisting including Forestry Department, Soils Branch of MARD, Malaysian Meteorological Services (MMS), Food and Agricultural Organisation (FAO), and the Geography Department of the University of Malaya.

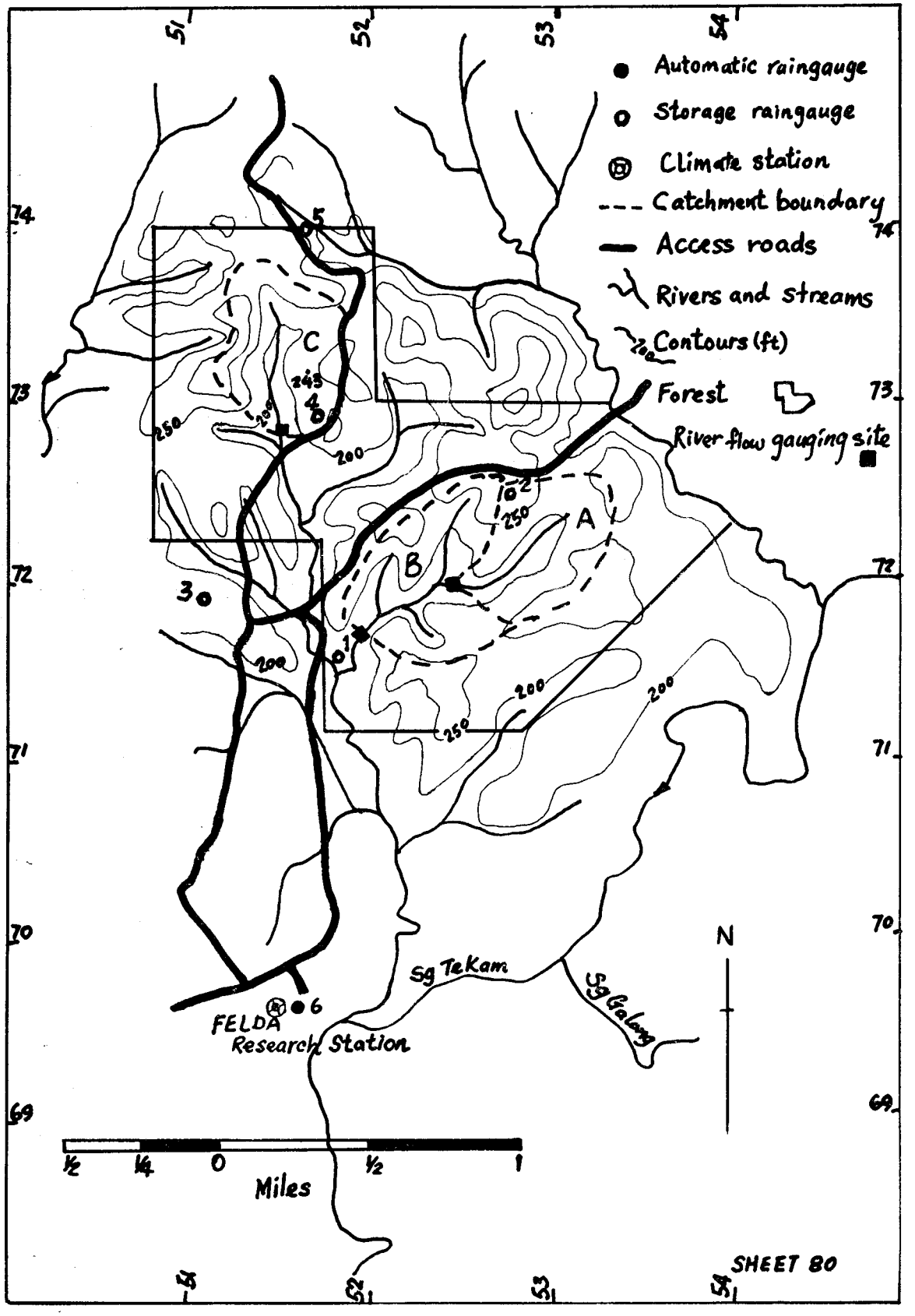


FIG. 1: SG. TEKAM EXPERIMENTAL BASINS LOCATION MAP

Members of the Sg. Tekam Experimental Basin Technical Committee are given in Appendix 1. This report is compiled from information supplied by participating staff of FELDA, DID and MMS.

2.3 **Basin details**

Three catchments have been selected for study. Basins A (a nested catchment of Basin B) and B are both classified as operational catchments and scheduled for conversion following a suitable calibration period (3 years minimum). It is proposed to convert Basin A to oil palm and Basin B (excluding Basin A) to oil palm or cocoa. Basin C is to be retained in a forest cover to serve primarily as a control catchment.

The forest block surrounding the control catchment is to be left in its present cover and the forest block surrounding catchment B is to be planted in oil palm/cocoa at the same time as catchment B is developed to prevent the so called "oasis effect".

Consideration will be given to introduce different planting patterns and management techniques within catchment B.

Details of catchment location and areas are shown in Fig. 1 and are tabulated in Table 1:

TABLE 1

BASIN DETAILS

Catchment	*Approximate Catchment Area (ha)*	*Approximate Mean Elevation (m)*	*Map Reference Series 1:63,360*
Basin A	49.4	72.5	80:524720
Basin B	98.4	68.5	80:519716
Basin C	44.1	70.0	80:515728

3. LAND MANAGEMENT

3.1 **Roading**

The basins have good access with roads skirting along part of the catchment boundaries. Old logging tracks supply partial access to raingauge and flow recording sites. Tracks to the latter will need to be cleared and extended to facilitate construction of the permanent flow recording structures.

The main access route from the FELDA Research Centre office block to the basins is not entirely flood free, notably during the North-East monsoon (Nov.-Dec.), but it is doubtful whether any major inconvenience will result.

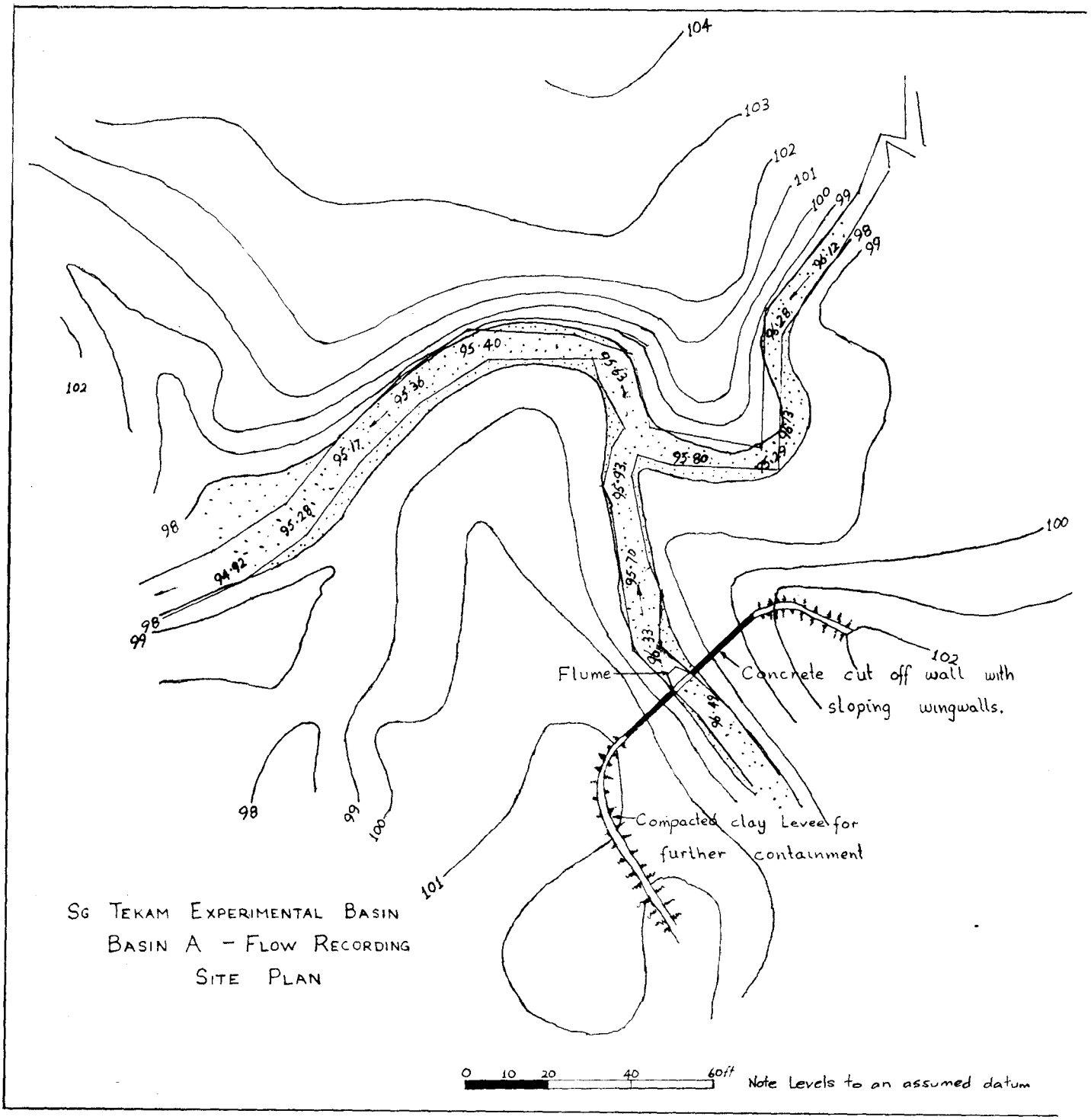
3.2 **Channel clearing**

A contract has been let to clear the main channels of dead logs and debris, disturbing as little as possible the natural riparian vegetation and channel regime.

4. SURVEYS

4.1 **Flow structure site survey**

Chain and level surveys at all three proposed flow structure sites have been carried out by DID staff. Whilst the site for catchment A can be contained for the expected flow range (*see* Fig. 2), the same cannot be said for the sites at catchments B and C and further site selection and, or, surveying will be required.



SG TEKAM EXPERIMENTAL BASIN
BASIN A - FLOW RECORDING
SITE PLAN

FIG. 2: SG. TEKAM BASIN A FLOW RECORDING SITE PLAN

PLATE 1: BASIN C
Site survey for flow recording station.

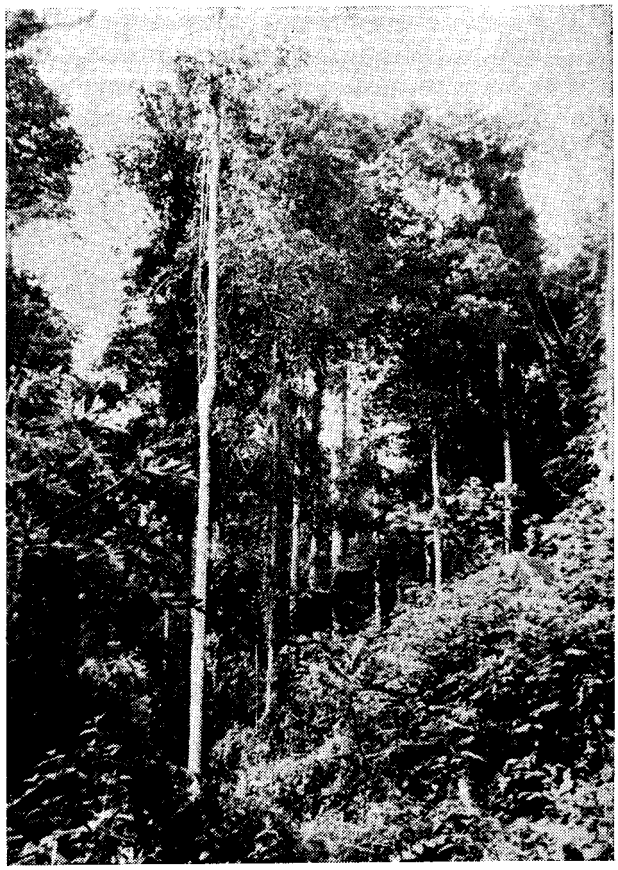


PLATE 2: BASIN C
Typical forest vegetation.

5. INSTRUMENTATION

5.1 Rainfall

The basins are currently equipped with five 200 mm diameter storage gauges, with a 0.5 mm Hattori tipping bucket weekly automatic rainfall recorder at the climate observation station at FELDA Research Centre some 2½ km south of the basin (Fig. 1). Only storage gauges 2 and 4 are within the forested area, the remaining gauges are sited just outside the forest boundary. Whilst it would be desirable to have more gauges within the catchment boundaries, suitable sites for ground level gauges are limited under the existing forest land use.

Storage gauge totals are observed weekly and basin rainfall records are available since 21st September, 1973.

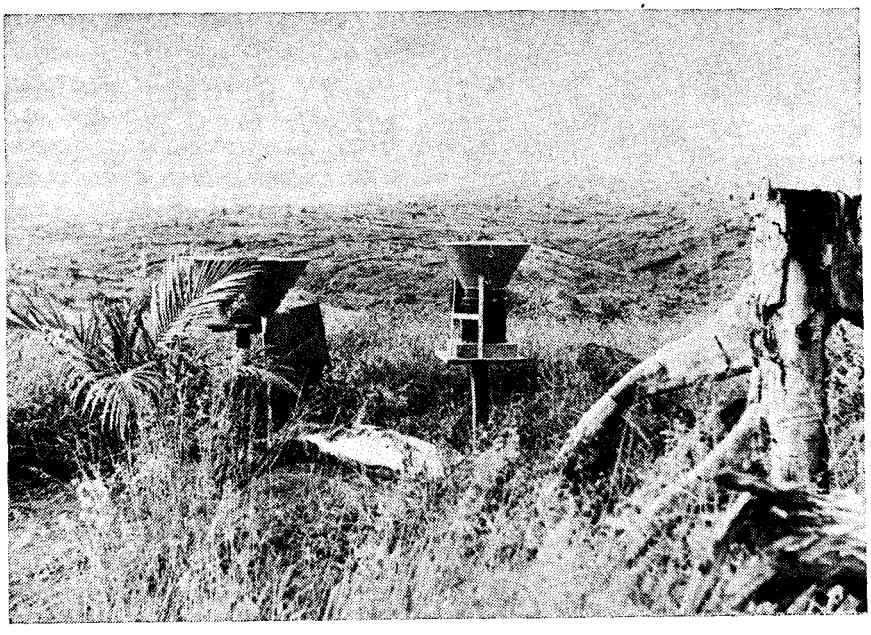


PLATE 3: BASIN C
Raingauge site No. 5 after installation of automatic rainfall recorder on 10th September, 1974.

PLATE 4: BASIN B
Raingauge site No. 1 after installation of automatic rainfall recorder on 10th September, 1974.

5.2 Flow

To date runoff has been recorded by means of a 0-6 m range Negretti and Zambra pressure bulb recorder. Flows less than about 0.2 m stage are channelled through a timber sluice to improve the sensitivity of low flow recording. An approximate stage-discharge relationship (Appendix 2) has been obtained by regular current meter gauging. Approximate overall channel slopes are 0.07, 0.04 and 0.04 for catchments A, B and C respectively. At the gauging sites the slopes are very flat causing velocities in the low flow regime to be very low making current meter gauging difficult. Thus the accuracy of the stage-discharge rating in this range is questionable.

Flow records are available since 24th September, 1973.

5.3 Climate

The climate station situated near the main FELDA office has been equipped by the Malaysia Meteorological Services with the following instruments:

1 manual raingauge, 125 mm capacity (5 inch),

1 standard Stevenson screen containing maximum, minimum, wet and dry bulb thermometers,

1 sunshine recorder,

1 recording raingauge; Hattori 0.5 mm tipping bucket, weekly chart (DID, *see* 5.1).

Observation and recording, since March 1969, has been carried out by FELDA staff.

5.4 Water Quality

Samples for water quality analyses are collected during each flow recorder visit. The sampling programme commenced on 2nd April, 1974. Analyses are performed by the Chemistry Department.

PLATE 5: BASIN C

Site showing staff gauge, timber sluice and pressure bulb for the flow recorder.

PLATE 6: BASIN B

Water quality sampling at existing flow recording station.

6. DATA PROCESSING

6.1 Rainfall

Weekly rainfall observations from the storage gauges were used to derive the mean basin rainfall, the daily totals being apportioned according to the daily rainfall recorded by the automatic raingauge at the climate station.

The existing network was not considered sufficient to adopt the Thiessen or isohyetal methods, and the mean basin rainfall was derived by using the arithmetic mean of totals recorded at gauges 1 and 2 for both Basin A and Basin B, and gauges 3, 4 and 5 for Basin C.

Results are tabulated in tables 2, 3 and 4 and plotted in Fig. 3.

PLATE 7: BASIN A

Raingauge site No. 2.

TABLE 2

BASIN A—TABULATION OF DAILY

1973

	September		*October*		*November*		*December*		*January*		*February*	
	P	*Q*	*P*	*Q*	*P*	*Q*	*P*	*Q*	*P*	*Q*	*P*	*Q*
1			25.0	3.90*	1.5	1.64	0.0	0.37	0.0		1.5	
2			0.5	1.30*	0.0	1.04	6.0	1.21	0.0		23.5	
3			3.5	0.75	17.5	8.08	0.0	0.47	0.0		29.0	
4			0.0	0.40	0.0	1.87	14.5	0.82	0.5		15.5	
5			9.5	0.22	0.0	1.56	0.0	1.11	0.0		0.0	
6			0.0	0.27	12.5	1.06	2.5	0.38	0.0		0.0	
7			0.0	0.20	0.0	0.80	45.0	21.65	0.0		0.0	
8			0.0	0.18	0.0	0.61	165.0		2.0		0.0	
9			0.0	0.27	5.5	0.57	19.0		0.0		0.0	
10			37.5	5.12	0.0	0.71	5.0		0.0		3.0	
11			9.0	2.49	4.5	0.95	3.5		0.0		0.0	
12			0.5	1.00	0.0	0.76	0.0		0.0		0.0	
13			0.0	0.39	0.0	0.53	6.5		0.0		2.0	
14			0.0	0.19	0.0	0.37*	2.0		0.0		0.0	
15			0.0	0.18*	9.0	0.69*	5.0		0.0		2.0	
16			15.0	0.34	6.5	0.69	5.5		0.0		3.0	
17			0.0	0.18	0.0	0.58	6.5		0.0		51.5	
18			0.0	0.18	0.0	0.46	0.0		5.5		10.0	
19			20.0	6.67	0.0	0.40	14.5	No. records	0.0	No. records	4.0	No. records
20			14.0	1.58	3.0	0.48	0.0		0.0		0.0	
21	4.0	—	4.0	1.93	11.5	2.33	0.0		0.0		3.0	
22	0.0	—	1.0	0.69*	0.0	1.14	2.0		0.0		0.0	
23	0.0	—	5.0	0.36*	9.5	0.89	1.5		0.0		8.0	
24	40.0	13.02	0.0	0.78	0.5	1.14	0.0		0.0		0.0	
25	0.0	5.87	0.0	0.29	0.0	0.75	10.0		0.0		1.5	
26	0.0	1.45	0.0	0.18*	0.5	0.65	4.5		0.0		0.0	
27	1.0	0.78	0.5	0.13*	7.5	0.69	1.5		16.5		1.5	
28	0.5	0.53	0.0	0.13*	10.5	1.34	2.0		15.5		0.0	
29	0.0	0.53	25.0	0.15*	1.0	0.87	0.0		0.0		—	
30	0.0	0.45*	62.5	5.11*	4.0	0.37	0.0		0.0		—	
31	—	—	0.0	11.52	—	—	0.0		0.0		—	
TOTAL ..	—	—	232.5	47.1	105.0	34.0	322.0		40.0		159.0	

RAINFALL AND RUNOFF DATA (mm)

1974

March		*April*		*May*		*June*		*July*		*August*	
P	*Q*	*P*	*Q*	*P*	*Q*	*P*	*Q*	*P*	*Q*	*P*	*Q*
0.0		3.0	1.88	0.5	2.94	0.0	0.26	0.0	0.08	74.5	21.05
0.0		4.0	0.94	4.5	3.07	0.0	0.23	0.0	0.07*	20.5	3.25
0.0		6.5	1.31	2.0	1.45	0.0	0.20	0.0	0.05*	0.0	2.31
0.0		14.0	1.70	0.5	0.72	0.0	0.18	0.0	0.04*	0.0	0.59
3.0		17.5	1.05	0.0	0.39	0.0	0.16	0.0	0.04*	0.0	0.28
9.5		1.0	0.37	12.5	0.32	0.0	0.14	0.0	0.03*	0.0	
0.0		5.0	0.30*	8.0	0.22*	0.0	0.13	0.0	0.02*	0.0	
0.0		16.0	0.24*	0.0	0.18*	0.0	0.11	0.0	0.02*	7.0	
1.5		1.0	0.20*	4.5	0.16*	7.0	0.09	0.0	0.02*	0.0	
0.0		30.0	1.05	0.5	0.14*	0.0	0.08	48.5		0.0	
0.0		6.5	1.86*	0.0	0.13*	0.0	0.08	0.0		0.0	
4.5	0.18	25.5		3.5	0.20*	0.5	0.07	27.0		0.0	
0.0	0.15	0.0		2.5	0.22*	0.0	0.18	0.0		0.0	
0.0	0.11	0.0		6.0	3.32	9.0	1.48	34.5		0.0	
0.0	0.10	4.0		0.0	1.90	0.0	0.08	0.0		0.0	
0.0	0.10	28.5	2.78*	3.5	0.35	3.0	0.07	14.5		0.0	
0.0	0.09	12.0	5.54	0.0	0.29	0.5	0.06	0.0	1.62*	0.0	
0.0	0.09	5.5	1.73	0.0	0.12	0.0	0.05	13.5	1.03	0.0	
0.0	0.08	4.0	1.55	9.0	0.14	0.0	0.05	0.0	0.79	41.0	
0.0	0.07	1.5	1.35	0.0	0.09	0.0	0.05	0.0	0.18	16.0	
0.0	0.07	1.5	1.32	8.0	0.29	12.5	0.05	0.0	0.17	11.0	
0.0	0.06	11.0	1.20	0.0		2.5	0.09	0.0	0.15	0.0	
0.0	0.05	0.0	0.79	25.0		0.5	0.08	3.0	0.14	4.5	
0.0	0.05	5.5	0.85	6.5		0.0	0.08	2.0	0.13	11.5	
0.0	0.04	5.5	0.64	0.0		56.0	1.38	3.0	0.12	0.0	
0.0	0.04	0.0	0.37*	1.0		3.0	12.39	0.0	0.11	2.0	
0.0	0.03	0.0	0.30*	0.0		1.5	0.16	0.5	0.09	0.0	
18.0	0.03	58.5		0.0		0.0	0.08	0.0	0.08	0.0	
18.0	0.15	2.5		0.0		2.0	0.07	8.0	0.08	18.0	
15.0	1.14	0.5		8.0		9.0	0.17	1.0	0.08	0.0	
18.0	2.09*	—		0.0	0.37	—	—	0.0	0.09	3.5	
87.5	—	270.0		106.0		107.0	18.3	155.5		209.5	

No. records

No. records

No. records

No. records

No. records

TABLE 3

BASIN B—TABULATION OF DAILY

1973

	September		October		November		December		January		February	
	P	*Q*	*P*	*Q*	*P*	*Q*	*P*	*Q*	*P*	*Q*	*P*	*Q*
1			25.0	3.62*	1.5	1.91	0.0	0.44	0.0		1.5	
2			0.5	2.85*	0.0	1.21	6.0	1.01	0.0		23.5	
3			3.5	1.01	17.5	6.44	0.0	0.78	0.0		29.0	
4			0.0	0.90	0.0	1.60	14.5	0.65	0.5		15.5	
5			9.5	0.58	0.0	0.83	0.0	1.33	0.0		0.0	
6			0.0	0.75	12.5	1.57	2.5	0.73	0.0		0.0	
7			0.0	0.59	0.0	0.93*	45.0	23.33	0.0		0.0	
8			0.0	0.53	0.0	0.80*	165.0		2.0		0.0	No. records
9			0.0	0.44	5.5	0.93*	19.0		0.0		0.0	
10			37.5	2.75	0.0	0.93*	5.0		0.0		3.0	
11			9.0	3.11	4.5	0.80*	3.5		0.0		0.0	
12			0.5	1.30	0.0	0.71*	0.0		0.0		0.0	
13			0.0	0.66	0.0	0.71*	6.5		0.0		2.0	
14			0.0	0.54	0.0	0.71	2.0		0.0	No. records	0.0	
15			0.0	0.24	9.0	0.80*	5.0		0.0		2.0	
16			15.0	0.76	6.5	0.93*	5.5		0.0		3.0	
17			0.0	0.29	0.0	0.80*	6.5		0.0		51.5	
18			0.0	0.11	0.0	0.71*	0.0		5.5		10.0	
19			20.0	3.94	0.0	0.71*	14.5		0.0		4.0	
20			14.0	1.93	3.0	0.71	0.0		0.0		0.0	
21	4.0	—	4.0	2.23	11.5	1.80	0.0		0.0		3.0	
22	0.0	—	1.0	0.94	0.0	0.78	2.0	No. records	0.0		0.0	0.76*
23	0.0	—	5.0	0.77	9.5	0.62	1.5		0.0		8.0	0.52
24	40.0	8.86	0.0	1.29	0.5	0.81	0.0		0.0		0.0	0.76
25	0.0	9.15	0.0	0.78	0.0	0.53	10.0		0.0		1.5	0.52
26	0.0	1.23	0.0	0.33	0.5	0.29	4.5		0.0		0.0	0.48
27	1.0	0.94	0.5	0.16	7.5	0.61	1.5		16.5		1.5	0.44
28	0.5	0.83	0.0	0.26	10.5	1.01	2.0		15.5		0.0	0.30
29	0.0	0.71	25.0	0.45	1.0	0.86	0.0		0.0		—	—
30	0.0	0.71	62.5	5.96	4.0	0.61	0.0		0.0		—	—
31	—	—	0.0	15.77	—	—	0.0		0.0		—	—
TOTAL ..			232.5	55.8	105.0	32.7	322.0		40.0		159.0	

RAINFALL AND RUNOFF DATA (MM)

1974

March		*April*		*May*		*June*		*July*		*August*	
P	*Q*	*P*	*Q*	*P*	*Q*	*P*	*Q*	*P*	*Q*	*P*	*Q*
0.0	0.15	3.0	2.21	0.5	1.59	0.0	0.33	0.0	0.04	74.5	18.23
0.0	0.15	4.0	1.01	4.5	1.37	0.0	0.27	0.0	0.03	20.5	4.64
0.0	0.12	6.5	0.45	2.0	0.98	0.0	0.25	0.0	0.02	0.0	5.88
0.0	0.09	14.0	0.62	0.5	1.04	0.0	0.20	0.0	0.01	0.0	1.95
3.0	0.09	17.5	0.76	0.0	0.79	0.0	0.15	0.0	0.00	0.0	0.70
9.5	0.09	1.0	0.99	12.5	0.59	0.0	0.13	0.0	0.00	0.0	0.52
0.0	0.09	5.0	0.27	8.0	0.58	0.0	0.11	0.0	0.00	0.0	0.37
0.0	0.09*	16.0	0.10	0.0	0.40	0.0	0.10	0.0	0.00	7.0	0.31
1.5	0.08*	1.0	0.14	4.5	0.17	7.0	0.09	0.0	0.00	0.0	0.20
0.0	0.08*	30.0	0.61	0.5	0.16	0.0	0.08	48.5	5.40	0.0	0.15
0.0	0.07*	6.5	1.43	0.0	0.14	0.0	0.07	0.0	1.35	0.0	0.12
4.5	0.05	25.5	6.87	3.5	0.54	0.5	0.06	27.0	0.70	0.0	0.09
0.0	0.04	0.0	2.09	2.5	0.52*	0.0	0.04	0.0	10.01	0.0	0.07
0.0	0 02	0.0	0.64	6.0	2.85*	9.0	0.70	34.5	3.70	0.0	0.04
0.0	0.01	4.0	0.19	0.0	3.30	0.0	0.03	0.0	3.78	0.0	0.03
0.0	0.01	28.5	13.53	3.5	0.77	3.0	0.02	14.5	2.13	0.0	0.02
0.0	0.01	12.0	4.84	0.0	0.61	0.5	0.02	0.0	1.97	0.0	0.01
0.0	0.01	5.5	1.23	0.0	0.43	0.0	0.01	13.5	1.34	0.0	0.00
0.0	0.01	4.0	0.71	9.0	0.36	0.0	0.01	0.0	1.73	41.0	2.93
0.0	0.01	1.5	0.82	0.0	0.30	0.0	0.00	0.0	0.93	16.0	1.47
0.0	0.01	1.5	1.00	8.0	0.62	12.5	0.00	0.0	0.73	11.0	6.08
0.0	0.00	11.0	0.82	0.0	0.57	2.5	0.03	0.0	0.44	0.0	0.59
0.0	0.00	0.0	0.37	25.0	1.14	0.5	0.02	3.0	0.36	4.5	0.07
0.0	0.00	5.5	0.25	6.5	0.69	0.0	0.01	2.0	0.30	11.5	0.05
0.0	0.00	5.5	0.17	0.0	0.52	56.0	0.02	3.0	0.25	0.0	0.06
0.0	0.00	0.0	0.13	1.0	0.44	3.0	10.20	0.0	0.20	2.0	0.03*
0.0	0.00	0.0	0.09	0.0	0.36	1.5	0.24	0.5	0.12	0.0	0.02*
18.0	0.00	58.5	0.31	0.0	0.30	0.0	0.02	0.0	0.09	0.0	0.02*
18.0	0.05	2.5	38.22	0.0	0.25	2.0	0.01	8.0	0.09	18 0	0.56*
15.0	0.80	0.5	3.31	8.0	0.55*	9.0	0.06	1.0	0.08	0.0	0.43*
18.0	1.82	—	—	0.0	0.36	—	—	0.0	0.08	3.5	0.20*
87.5	4.0	270.5	74.2	106.0	23.3	107.0	13.3	155.5	35.9	209.5	45.8

TABLE 4

BASIN C—TABULATION OF DAILY

1973

	September		*October*		*November*		*December*		*January*		*February*	
	P	*Q*	*P*	*Q*	*P*	*Q*	*P*	*Q*	*P*	*Q*	*P*	*Q*
1			13.5	0.96*	1.0	1.07	0.0	0.46	0.0		1.5	
2			0.5	0.58*	0.0	0.86	6.0	2.23	0.0		23.5	
3			2.0	0.46*	13.0	9.69	0.0	0.98	0.0		29.0	
4			0.0	0.33*	0.0	1.96	15.0	0.64	0.5		15.5	
5			5.0	0.30*	0.0	1.64	0.0	0.98	0.0		0.0	
6			0.0	0.33*	13.5	1.56	2.5	0.73	0.0		0.0	
7			0.0	0.19*	0.0	2.35	47.5		0.0		0.0	
8			0.0	0.20	0.0	1.64	174.0		2.0		0.0	
9			0.0	0.24	6.5	1.20	20.0		0.0	No. records	0.0	No. records
10			41.0	4.98	0.0	0.71	5.0		0.0		2.5	
11			9.5	1.95	5.0	1.04	4.0		0.0		0.0	
12			0.5	0.52	0.0	0.69	0.0		0.0		0.0	
13			0.0	0.37	0.0	0.62	7.0		0.0		2.0	
14			0.0	0.26	0.0	0.56	2.0		0.0		0.0	
15			0.0	0.20	8.0	0.50	5.0		0.0		2.0	
16			19.0	0.50	6.5	1.07	5.5		0.0		2.5	
17			0.0	0.21	0.0	0.59	7.0		0.0		45.0	
18			0.0	0.15	0.0	0.46	0.0	No. records	9.0	2.50	8.5	
19			25.0	5.50	0.0	0.33	15.0		0.0	1.09	3.5	
20			16.5	0.74	4.5	0.35	0.0		0.0	0.73	0.0	
21	3.5	—	5.0	0.83	17.0	0.67	0.0		0.0	0.59	3.5	
22	0.0	—	1.5	0.82	0.0	0.33	2.5		0.0	0.53	0.0	0.72*
23	0.0	—	6.0	0.76	14.5	0.25	2.0		0.0	0.40	9.0	0.74
24	38.0	14.05	0.0	0.84	0.5	0.18	0.0		0.0	0.33	0.0	1.54
25	0.0	1.41	0.0	0.45	0.0	0.16	10.5		0.0	0.26*	1.5	0.91
26	0.0	1.00	0.0	0.22	1.0	0.15	5.0		0.0	0.20*	0.0	0.73
27	1.0	0.61	0.5	0.34	11.5	0.33	2.0		27.0		2.0	0.46
28	0.5	0.35	0.0	0.29	16.0	8.59*	2.0		15.5		0.0	0.33
29	0.0	0.33*	30.0	0.29	1.0	3.79*	0.0		0.0		—	—
30	0.0	0.30*	52.0	2.97	4.5	0.59	0.0		0.0		—	—
31	—	—	0.0	7.08	—	—	0.0		0.0		—	—
TOTAL ..	—	—	227.5	33.9	124.0	43.9	339.5		54.0		151.5	

RAINFALL AND RUNOFF DATA (mm)

1974

March		*April*		*May*		*June*		*July*		*August*		
P	*Q*	*P*	*Q*	*P*	*Q*	*P*	*Q*	*P*	*Q*	*P*	*Q*	
0.0	0.26	2.5	0.81	0.0	0.86	0.0	0.17	0.0	0.10	63.0	8.64	
0.0	0.20	3.5	0.46	4.0	0.57	0.0	0.15	0.0	0.08	17.5	2.25	
0.0	0.17*	5.5	0.64	1.5	0.32	0.0	0.12	0.0	0.06	0.0	2.51	
0.0	0.14*	11.5	0.49	0.0	0.36	0.0	0.10	0.0	0.04	0.0	0.67	
3.5	0.12*	14.0	0.40	0.0	0.17	0.0	0.08	0.0	0.02	0.0	0.46	
10.5	0.36*	0.5	0.61	10.0	0.15*	0.0	0.07	0.0	0.01	0.0	0.33	
0.0	0.26*	4.0	0.51	6.5	0.12*	0.0	0.07	0.0	0.01	0.0	0.26	
0.0	0.20*	13.0	0.49	0.0	0.10*	0.0	0.07	0.0	0.00	6.0	0.20	
2.0	0.17*	1.0	0.34*	4.0	0.09*	10.5	0.21	0.0	0.00	0.0	0.15	
0.0	0.14*	22.5	0.41*	0.5	0.07*	0.0	0.26	40.0	1.77	0.0	0.10	
0.0	0.13*	5.0	0.46	0.0	0.06*	0.0	0.20	0.0	0.24	0.0	0.07	
1.5	0.11	19.0	2.16	2.5	0.30*	0.5	0.15	22.5	0.05	0.0	0.05	
0.0	0.10	0.0	0.73	2.0	0.66*	0.0	0.17	0.0	0.87	0.0	0.04	
0.0	0.09	0.0	0.40	6.0	1.59	9.0	0.56	28.5	2.72	0.0	0.02	
0.0	0.08	4.0	0.13	0.0	1.22	0.0	0.07	0.0	1.14	0.0	0.02	
0.0	0.06	28.0	5.67	3.5	0.46	3.0	0.06	12.0	0.73	0.0	0.02	
0.0	0.05	12.0	5.53	0.0	0.26	0.5	0.05	0.0	0.47	0.0	0.01	
0.0	0.03	5.5	1.59	0.0	0.15	0.0	0.05	13.0	0.35	0.0	0.01	
0.0	0.02	4.0	0.86	9.0	0.10*	0.0	0.04	0.0	0.45	40.5	6.60	
0.0	0.02	1.5	0.86	0.0		0.0	0.02	0.0	0.27	15.4	2.18	
0.0	0.01	1.5	0.79	8.0		14.5	0.01	0.0	0.20	11.0	5.47	
0.0	0.01	11.0	0.66	0.0		2.5	0.02	0.0	0.17	0.0		
0.0	0.01	0.0	0.59	25.0		0.5	0.06	3.0	0.12	4.0		
0.0	0.00	5.5	0.52	6.5		0.0	0.02	2.0	0.10	11.5		
0.0	0.00	5.5	0.39*	0.0		47.5	0.03	3.0	0.08	0.0		
0.0	0.00	0.0	0.33*	1.0		2.5	8.57	0.0	0.07	1.5		
0.0	0.00	0.0	0.29*	0.0		1.0	0.13	0.5	0.06	0.0		
15.0	0.03	58.0	1.69*	0.0		0.0	0.03	0.0	0.05	0.0		
15.0	0.08	2.5	37.31*	0.0		2.0	0.02	8.0	0.04	17.5		
12.5	0.80	0.5	1.31*	8.0		7.5	0.26	1.0	0.04	0.0		
15.0	0.81	—	—	0.0	0.23*	—	—	0.0	0.03	3.5		
75.0	4.5	241.5	67.4	98.0		101.5	11.8	133.5	10.3	191.5		

No. records

No. records

6.1.1 **Rainfall Intensity**

Maximum rainfall intensities recorded to date at the FELDA Research Centre are as follows:

TABLE 5

RAINFALL INTENSITIES

Date	*Maximum rainfall (mm) recorded in*			
	1 hr	*2 hr*	*6 hr*	*24 hr*
24-9-73	17	—	—	—
1-10-73	24	—	—	—
10-10-73	19	—	—	—
8-12-73	18	34	51	138
28-4-74	21	—	—	—
25-6-74	38	—	—	—
1-8-74	35	42	47	—
19-8-74	30	33	—	—

6.2 **Flow**

From chart records and the appropriate rating table, daily runoff totals for each basin have been calculated and are tabulated in Tables 2, 3 and 4 and plotted in Fig. 3. For days when chart records were "lost" due to clock failure or "drowning out" of the site during high flood conditions, the daily runoff totals given in the tables are marked with an asterisk. The accuracy of the tabulated runoff data is probably no better than ± 15%.

Flow duration curves for the study period are shown in Fig. 4.

6.3 **Climate**

Mean monthly climate data are tabulated in Table 6.

TABLE 6

MEAN MONTHLY CLIMATE DATA

Month	*Air Temperature °C*			*Wet and Dry Bulb Temperature °C*						*Sun shine hours total*	*Rain-fall mm*
				1.30 p.m.			*7.30 a.m.*				
	max	*min*	*mean*	*wet*	*dry*	*RH†%*	*wet*	*dry*	*RH†%*		
July 1973 ..	33.3	21.7	27.7	26.5	32.4	61	22.8	23.0	98	176	49
August	33.3	21.7	27.7	26.1	32.1	61	22.7	22.9	98	169	192
September ..	32.8	22.2	27.6	26.1	31.8	62	22.8	23.2	96	156	189
October ..	32.8	22.2	27.5	26.1	31.4	64	23.2	23.5	97	163	148
November ..	31.1	21.1	26.1*	25.4	30.0	68	22.4	22.9	95	67	129
December ..	30.6	21.1	26.1	24.7	29.8	64	21.6	22.0	96	78	304
January 1974 ..	31.7	20.0	25.6	24.2	30.5	57	21.1	21.4	97	159	12
February ..	31.7	20.6	26.1	24.4	29.6	64	21.7	21.9	98	128	157
March	33.3	20.6	26.8	24.9	31.1	59	21.2	21.7	95	234	84
April	—	—	27.9*	26.1	31.5	64	22.8	23.5	93	138	271*
May	—	—	26.8	24.9	31.7	63	21.2	21.7	95	234	106*
June	—	—	28.4	25.4	31.7	59	22.8	23.3	95	193	109
July	33.1*	22.6*	27.7	25.6	31.8	59	22.3	22.5	97	202	102
August	33.3*	23.0*	28.2	25.7	31.6	61	23.0	23.3	97	154	169

* monthly records not complete; results subject to MMS revision.
† derived from relative humidity tables.

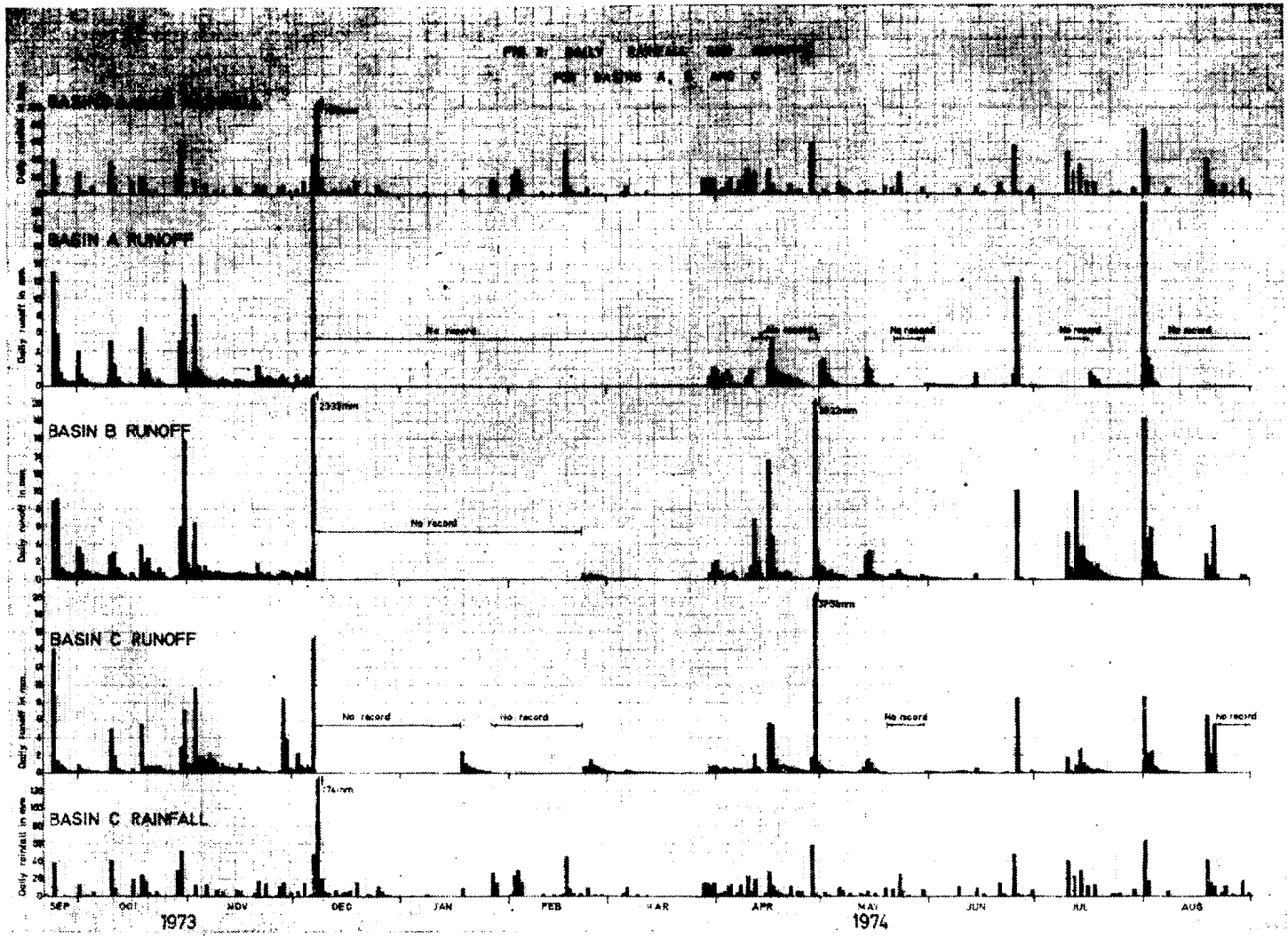


FIG. 3 DAILY RIANFALL AND RUNOFF FOR BASINS A, B, AND C

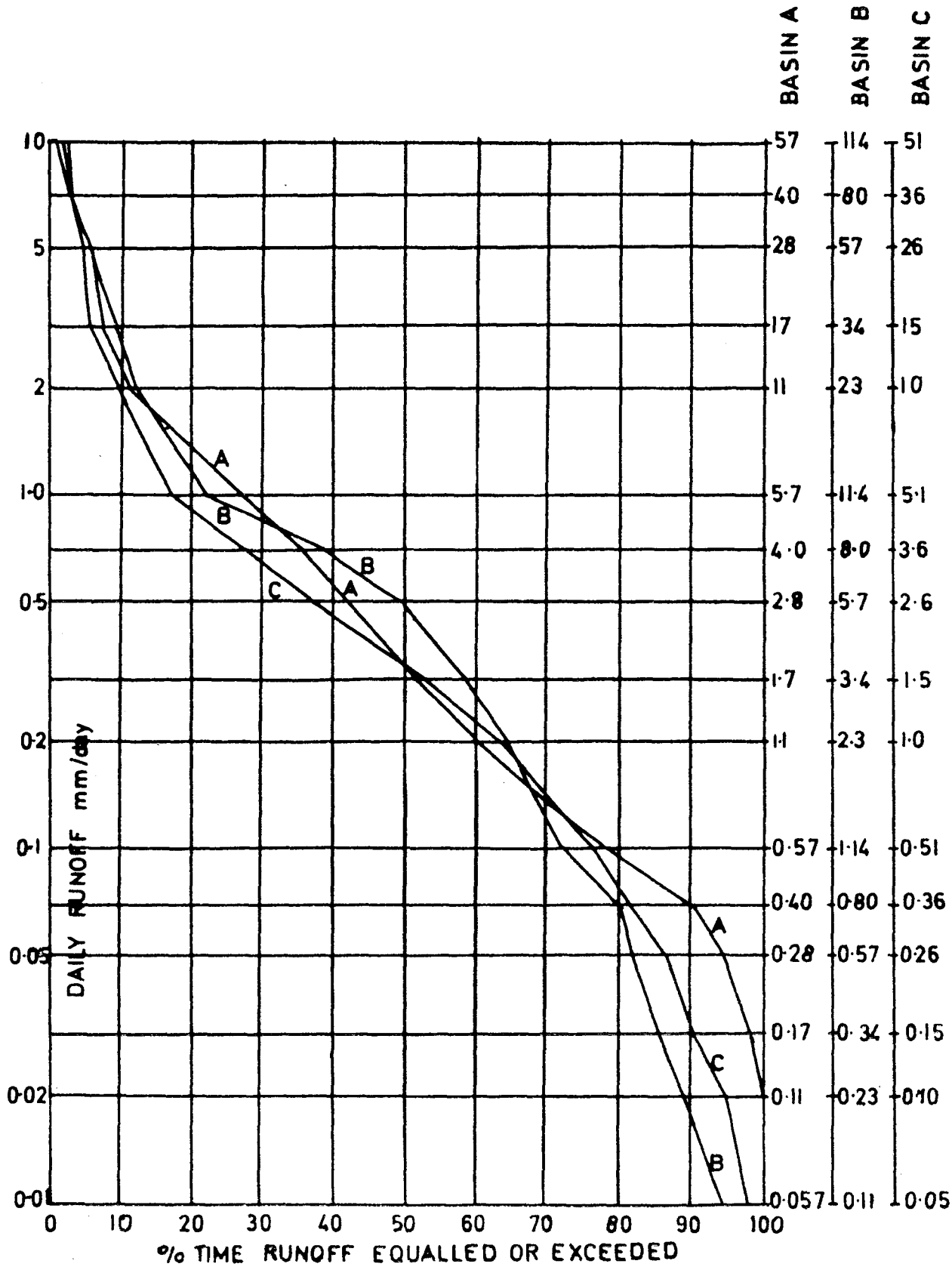


FIG. 4: FLOW DURATION CURVES FOR SG. TEKAM BASINS A, B AND C. 1973/1974.

Annual rainfall totals for the district have been recorded since 1969. The original site near Kg. Karong was closed down in April, 1971 and the raingauge moved to the Tekam Research Centre. In April, 1973 this site was also closed and the gauge resited at the existing climate station. Annual totals recorded, irrespective of the site were as follows:

Water Year (1st July–31st June)	*Annual Rainfall mm*
1969/1970	2268
1970/1971	2565
1971/1972	2139
1972/1973	1629
1973/1974	1750*

* Result subject to MMS revision.

6.3.1 Potential Evapotranspiration

Monthly evapotranspiration data have been derived using the climate data (6.3) and the Penman procedure assuming conversion factors for sunshine hours to radiation of a = 0.22 and b = 0.54 and an albedo r = 0.18. The wind speed was assumed to be 0.82 m/sec at a height of 13.5 m.

TABLE 7

MONTHLY POTENTIAL EVAPOTRANSPIRATION TOTALS (MM)

	1973						*1974*						
	Jul.	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*June*	*Total*
PE ..	126	127	129	127	95	96	115	117	147	125	137	133	1,474

6.4 Water balance

Monthly water balance data for Basins B and C are tabulated in Table 8. Data for Basin A is excluded because of incomplete monthly runoff totals resulting from flow recorder failure.

TABLE 8

MONTHLY WATER BALANCE (mm)

Month	*1973*			*1974*							
	Oct.	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*June*	*July*	*Aug.*
BASIN B											
Precipitation P	233	105	322	40	159	88	271	206	107	156	210
Runoff Q	56	33	*	*	*	4	84	23	13	36	46
Potential Evapotranspiration											
PE	127	95	96	115	117	147	125	137	133	133	126
P - Q - PE	+50	−23				−63	+62	+46	−39	−13	+38
BASIN C											
Precipitation P	228	124	340	54	152	75	242	98	102	134	192
Runoff Q	34	44	*	*	*	5	67	*	12	10	*
Potential Evapotranspiration											
PE	127	95	96	115	117	147	125	137	133	133	126
P - Q - PE	+67	−15				−77	+50		−43	−9	

* Incomplete flow data.

6.5 Water Quality

Four samples from each flow recording site have been analysed to date and the results are presented in Table 9. Comment on the data is reserved until a future research report when additional information will be available.

TABLE 9

WATER QUALITY ANALYTICAL RESULTS

	Basin A				*Basin B*				*Basin C*			
Sampling date	2-4-74	30-4-74	12-6-74	20-6-74	4-7-74	22-7-74	31-7-74	13-8-74	4-7-74	22-7-74	31-7-74	13-8-74
Discharge (l/sec)	2.1	28	1.0	0.5	0.1	4.1	1.7	4.1	0.2	1.0	0.5	0.2
Temperature °C	—	—	—	—	—	25.5	24.6	—	—	25.0	24.5	—
Conductivity (umho/cm)	39	40	60	70	50	40	50	40	50	40	40	40
Hardness (mg/l $CaCO_3$)	20	—	29	37	21	20	27	21	18	17	24	23
pH	6.8	6.5	6.7	6.4	6.9	6.5	6.8	6.9	7.0	6.6	6.8	6.2
Total solids (mg/l)	95	75	63	76	74	75	62	77	69	71	76	98
Suspended solids (mg/l)	15	11	13	8	20	31	16	21	9	8	15	36
Dissolved solids (mg/l)	80	64	50	68	54	44	46	56	60	63	61	62
Calcium Ca++ (mg/l)	4.0	11.0	—	—	6.8	6.0	5.2	6.8	6.4	5.2	5.2	4.8
Magnesium Mg++ (mg/l)	2.5	7.0	—	—	0.97	1.2	3.4	0.97	0.49	1.0	2.6	2.6
Sodium Na+ (mg/l)	—	—	1.7	2.86	3.6	3.5	2.5	3.7	3.6	3.8	3.2	4.2
Potassium K+ (mg/l)	—	—	1.0	1.3	1.3	0.8	0.8	0.4	1.5	1.0	1.3	1.0
Ammonia NH_4+_4 (mg/l)	0.02	—	—	0.1	—	—	—	—	—	—	—	—
Nitrate NO_3-- (mg/l)	—	—	—	—	—	—	—	—	—	—	—	—
Phosphate PO_4-- (mg/l)	—	—	—	—	—	—	—	—	—	—	—	—
Chloride Cl− (mg/l)	1.0	3.0	1.0	1.0	1.0	1.0	2.0	1.0	1.0	2.6	2.0	1.0
Sulphate SO_4-- (mg/l)	2.25	1.0	0.4	0.35	0.5	0.35	0.33	0.62	0	0.31	6.38	0.70

7. REFERENCE

Toebes, C; Goh Kiam Seng. Nov. 1973: Water Resources Development Project No. 4; Sg. Tekam Experimental Basin Research proposal. DID Internal Report; 475/6/3/4.

APPENDIX 1

Members of the Sg. Tekam Experimental Basin Technical Committee:

Mr C. Toebes	ENEX of New Zealand
Mr Goh Kiam Seng	DID
Mr Salleh bin Mohd. Noor	Forestry Department
Mr Poh Kok Kian	FELDA
Mr Law Wei Min	Agriculture Department
Mr David Abrahim	MMS
Mr Liew See Peng	MMS
Dr Low Kwai Sim	Geography Department, University of Malaya

APPENDIX 2

TEMPORARY STAGE-DISCHARGE RATING TABLES

SG. TEKAM—BASIN A (Discharge in 1/sec)

Stage (m)	*0.0*	*0.01*	*0.02*	*0.03*	*0.04*	*0.05*	*0.06*	*0.07*	*0.08*	*0.09*
0.1	—	—	—	—	—	—	0.05	0.10	0.18	0.30
0.2	0.48	0.74	1.0	1.5	2.1	3.0	3.9	5.1	6.5	8.2
0.3	10.5	13	16	19	23	28	32	38	43	49
0.4	55	62	70	78	88	95	100	107	114	122
0.5	130	137	144	152	160	170	180	190	200	210
0.6	225	235	245	260	270	280	290	305	320	335
0.7	350	365	380	400	415	430	450	470	490	510
0.8	530	550	570	590	610	630	650	670	690	720
0.9	750	780	800	820	840	870	—	—	—	—

Conversion factor: Daily mean discharge (1/sec) to runoff (mm) multiply by 0.175.

SG. TEKAM—BASIN B (Discharge in 1/sec)

Stage (m)	*0.0*	*0.01*	*0.02*	*0.03*	*0.04*	*0.05*	*0.06*	*0.07*	*0.08*	*0.09*
1.1	—	—	0.2	0.5	1.0	1.7	2.8	4.1	5.9	8.0
1.2	10.6	13.6	17	21	26	31	37	43	50	57
1.3	66	73	80	87	95	103	112	120	130	140
1.4	150	160	170	180	190	202	215	227	240	250
1.5	265	280	295	310	320	335	350	365	380	400
1.6	420	435	450	465	480	505	520	540	560	580
1.7	600	620	640	660	680	700	720	740	760	790
1.8	820	840	870	890	910	940	960	990	1,020	1,040

Conversion factor: Daily mean discharge (1/sec) to runoff (mm) multiply by 0.088.

SG. TEKAM—BASIN C (Discharge in 1/sec)

Stage (m)	*0.0*	*0.01*	*0.02*	*0.03*	*0.04*	*0.05*	*0.06*	*0.07*	*0.08*	*0.09*
0.0	—	—	0.03	0.06	0.12	0.24	0.5	1.0	1.7	3.0
0.1	4.4	6.7	10	14	19	26	34	42	50	59
0.2	68	78	90	102	117	130	145	162	180	200
0.3	220	245	270	295	320	350	380	410	440	480
0.4	520	560	600	645	690	740	790	840	900	960
0.5	1,020	1,080	1,140	1,200	1,270	1,340	1,420	1,500	1,600	1,700
0.6	1,800	—	—	—	—	—	—	—	—	—

Conversion factor: Daily mean discharge (1/sec) to runoff (mm) multiply by 0.196.

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WATER RESOURCES PUBLICATION PREVIOUSLY PUBLISHED

1.	..	Surface Water Resources Map (Provisional) of Peninsular Malaysia ..	1974
2.	..	Hydrological Regions of Peninsular Malaysia	1975