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SG LUI REPRESENTATIVE BASIN REPORT NO.1 FOR 197172 TO 197374

1977

JABATAN PENGAIRAN DAN SALIRAN
KEMENTERIAN PERTANIAN MALAYSIA

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KEMENTERIAN PERTANIAN
BAHAGIAN PARIT DAN TALIAIR

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CONTENTS

SUMMARY

Analyses of previous data has afforded an understanding of major hydrological parameters related to the Sungei Lui representative basin; area 68 sq. km.

For the study period December 1971 to June 1974, flow from the catchment varied from 10.6 to 361 litre/sec/sq. km with a mean discharge for the two years of complete record of 25.8 litre/sec/sq. km. The base flow component of runoff; 84% of the total runoff, is high and typical for catchments with granitic geology. Maximum groundwater storage is greater than 180 mm.

Hydrograph analysis gave a mean time of rise to peak discharge of 5.75 hours and a basin lag of 5.9 hours.

INTRODUCTION

This report presents results from analyses of hydrological records observed for the Sg. Lui representative basin during the period December 1971 to June 1974.

1. PROJECT DETAILS

1.1 Basin Details

The Sg. Lui basin (Fig. 1) is situated approximately 20 km west of Kuala Lumpur city between longitudes 101° 52′ to 101° 59′ and latitudes 3° 6′ to 3° 13′. Representative of the Kuala Kerai – Ulu Langat hydrological region (Goh 1974); classification L_1 W_2, the basin drains the western flank of Gunong Hitam (1210m) and is a major tributary of the Sg. Langat.

Relevant physiographical details of the basin are as follows:–

Table 1 : Sg. Lui basin physiographical details

Area (sq. km)	68.1
Basin perimeter (km)	34
Maximum length of catchment (km)	12
Maximum width of catchment (km)	8
Range of elevation (m)	76 to 1210
Median elevation (m)	282

1.2 Basin History

At the initiative of the Drainage and Irrigation Department (DID) the basin was established in November 1959 to serve as a "standard catchment" representing the west coast rainfall type and steep jungle areas. One streamflow recorder and eight raingauges were installed in the catchment and rainfall and streamflow observations continued until 1963 when the basin was temporarily abandoned. Results for this period were published in DID Research Station Memorandum Nos. 78 and 78A (1965).

In July 1964 the basin was reopened and three automatic rainfall recorders were installed at Lawin, Sekolah and Lallang (Fig. 1). The streamflow site was reinstrumented and recording continued until April 1965 when observation ceased and the results published (Tan H.T. 1965).

At the request of Miss Low Kwai Sim (then of the University of Hull, England) the basin was again reopened in July 1968 and instrumented in accordance with her research objectives. An additional rainfall recorder was sited at Sawah and two additional streamflow stations were sited upstream of the previous recording station. To study forest interception, three manual raingauges were installed at ground level beneath the forest canopy at Lawin. Recording continued until October 1969, and analytical results from observations during this period were reported in a very comprehensive Doctorate thesis by Low (1971).

Following nomination as a representative basin in early 1971, a broad crested weir was constructed about 150 m upstream from the previous streamflow station. The water level recorder was resited and recording recommenced in December 1971.

1.3 Research Objectives

Research objectives for the period 1959 to 1970 were summarised by Goh (1973) as follows:—

(a) to determine the rainfall-runoff relations for catchments with the west coast type rainfall and on steep jungle areas,

(b) to investigate the water balance of a humid tropical rain forest catchment,

(c) to study the relationship between storm rainfall and runoff for flood protection purposes in steep forested areas,

(d) to indicate ways to reduce the damaging effects of man on the environment and on the water resources.

Following selection as a representative basin for the Kuala Kerai-Ulu Langat hydrological region the research objectives have been modified as follows:—

(a) forecasting of low and mean flows within a region,

(b) study of hydrological processes,

(c) development of mathematical models describing the hydrological regimen.

2. SURVEYS

2.1 Land use, Geology and Soils

A comprehensive review of land use, geology and soils is included in a previous study (Low 1971). A summary presented by Low K.S. is included in Table 2.

Table 2 : Distribution of land use, geology and soil

	Type	% catchment area
Land use	Forest	83
	Rubber	13
	Padi	2
	Orchard and Kampong	2
Geology	Granite	66
	Granitic-schist	34
Soils	Steepland	77
	Rengam (sandy clay loam)	7
	Tavy-Bangor	14
	Local alluvium-colluvium	2

3. INSTRUMENTATION AND OBSERVATION

3.1 Climate

A climate station has been proposed for the basin but is yet to be sited and instrumented. The nearest fully instrumented station is at Subang International Airport, Kuala Lumpur, approximately 38 km west of the basin. Besides Subang, evaporation using standard class A pan (painted black) is also recorded daily at Ampang Research Station (46 m m.s.l.), approximately 15 km west of the Sg. Lui Basin respectively (Fig. 1).

3.2 Rainfall

Rainfall is recorded at four sites; Sekolah, Lallang, Sawah and Lawin (Fig. 1) by means of Kent natural syphon recording raingauges. In January 1974 the gauge at Sekolah was replaced by a Capricorder and 0.5 mm Hattori tipping bucket raingauge. Except for Lawin the recorders are equipped with standard windshields and installed with the rim of the gauge about 1.2 m above ground level. Storage gauges sited near the automatic recording gauges serve as check gauges.

At Lawin the collecting funnel of the raingauge is installed at the top of a tree and about the level of the surrounding forest canopy. Collected rainfall runs down a plastic tube to the automatic recorder sited at the base of the tree. Frequent checks are necessary to ensure that the funnel and tube do not become blocked with forest litter.

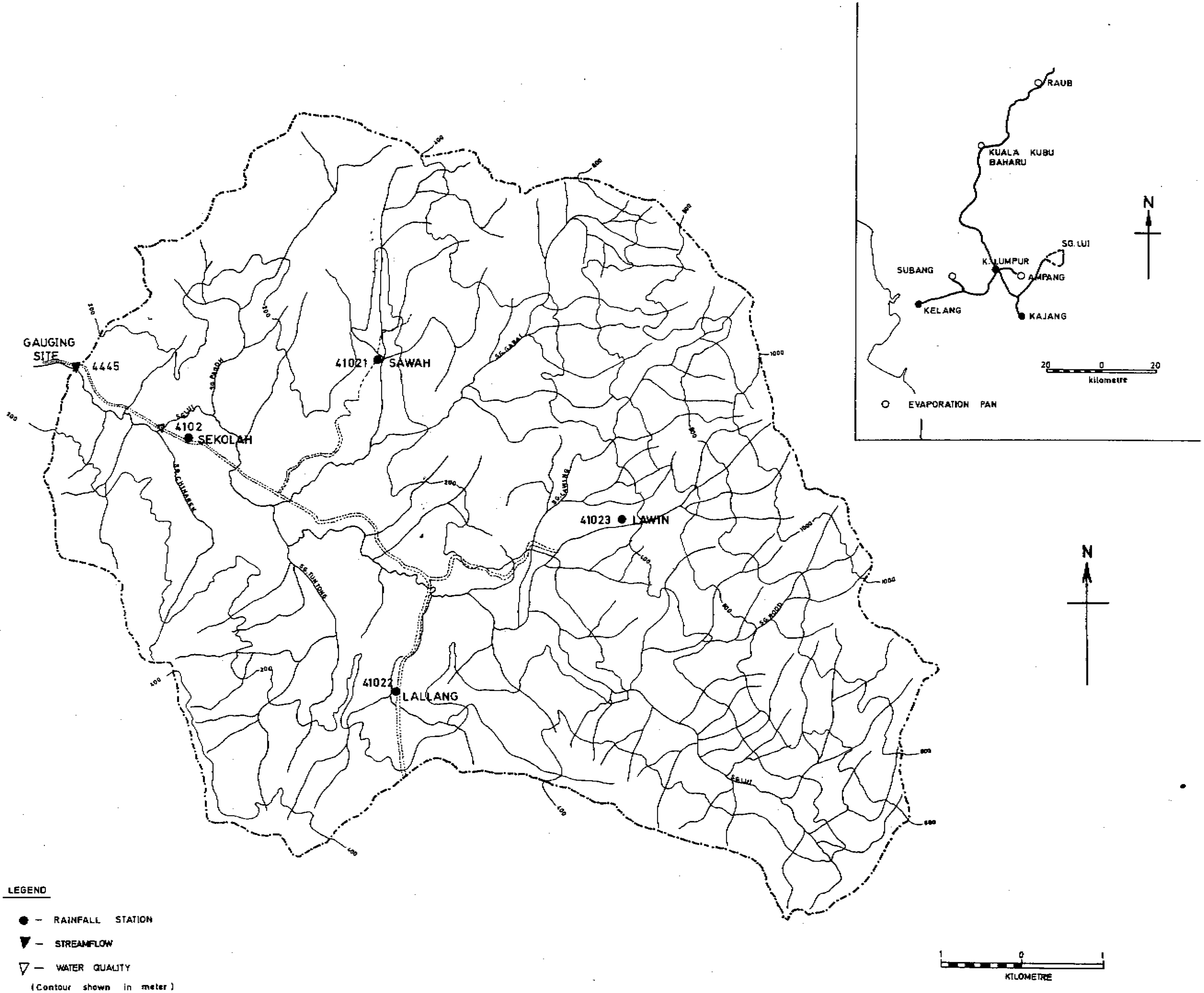


FIG-1:— BASIN AND LOCALITY MAP FOR SUNGAI LUI AND RIVER GAUGING SITE

30-5-1974

Frequent clock stoppages, due to the wet humid operating conditions, were responsible for many periods of missing record. Since the installation of the tipping bucket raingauge at Sekolah records for that site have been continuous.

3.3 Flow

The streamflow gauging site (Fig. 1) is controlled by a board crested weir (Fig. 2) and runoff is recorded by means of a 0 to 1.5 m range Stevens automatic strip chart recorder (6 cm per day).

Set at a level of 76.2 m reduced level (R.L.), the intake pipe of the stilling well is 0.305 m (1 ft) below the level of the central weir (76.5 m R.L.). This has led to silting problems around the intake pipe and in the stilling well and there is a need to check and possibly flush the recording structure after every major flood event.

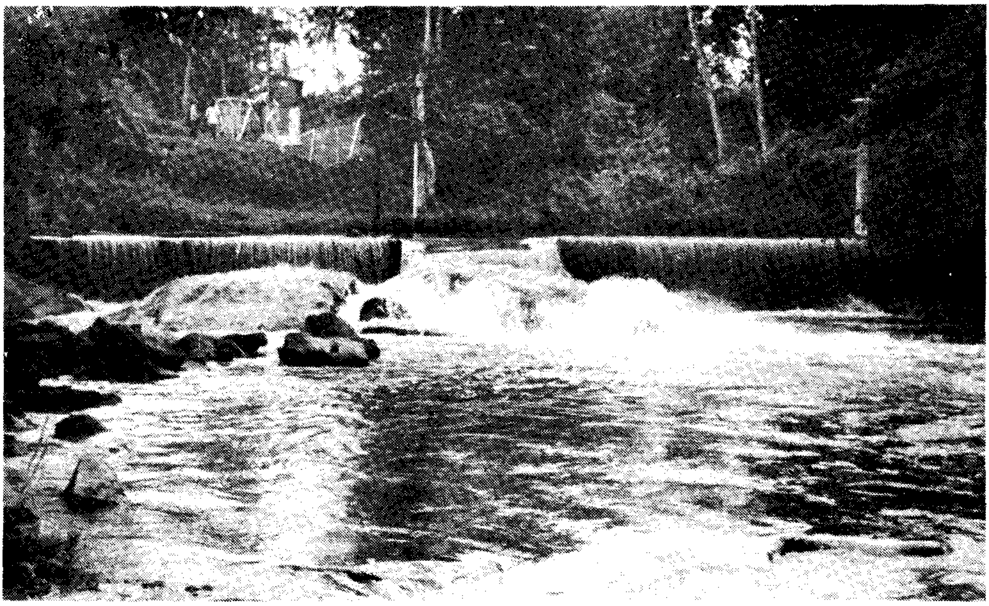
The broad crested weir was model rated at Ampang Research Station; the stage-discharge relationship conforming to a theoretical rating obtained previously by the U.S. Geological Survey (DID Memo. 157, 1972). River discharge measurements using a current meter to check the field rating of the constructed weir have yet to be carried out. However it is considered unlikely that the field and model ratings will differ by more than ± 5%. The rating used in subsequent analysis of flow data is given in Appendix 1.

4. DATA PROCESSING

4.1 Climate

The climate is considered to be typical of Peninsular Malaysia characterised by uniform temperature, high humidity and high rainfall. Average annual temperature is approximately 26° C for altitudes less than 150m m.s.l. whilst for areas above 900m average annual temperature would be approximately 21.5° C estimated from climate data observed at Maxwell's Hill (1040m).

A summary of climate data observed at Subang Airport, Kuala Lumpur is given in Table 3.



(a) Elevation Looking Upstream

(b) Elevation From Bank

Fig. 2 : Sg. Lui Broad Crested Weir

Table 3 : Summary of climate data at Subang Airport, Kuala Lumpur.

Year		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean Annual
1972	Mean temperature ^{0}C	25.4	26.2	26.4	26.3	26.8	26.6	26.8	26.8	26.4	26.2	26.2	25.8	26.3
	Relative humidity %	80.3	83.0	81.7	86.4	85.6	85.3	81.3	80.3	84.4	86.0	87.3	88.3	84.2
	Sunshine hrs/day	7.1	6.9	7.2	6.6	7.1	6.6	7.2	6.7	5.3	5.8	5.7	5.0	6.4
	Wind knots	1.2	1.5	1.3	0.9	1.2	2.1	2.5	2.5	2.3	1.1	1.2	0.7	1.5
1973	Mean temperature ^{0}C	26.3	27.1	26.9	26.8	26.8	27.1	26.7	26.4	26.3	26.0	26.1	25.3	26.5
	Relative humidity %	83.1	80.7	83.4	87.1	86.6	85.3	83.6	84.9	85.4	87.3	86.7	86.2	85.0
	Sunshine hrs/day	6.6	7.2	6.7	6.4	6.9	5.7	6.6	5.9	5.2	5.9	4.6	4.1	6.0
	Wind knots	0.7	0.9	1.0	0.9	0.8	0.4	0.7	0.5	0.7	0.7	1.0	0.4	0.7
1974	Mean temperature ^{0}C	25.4	25.7	26.4	26.5	26.4	26.5							
	Relative humidity %	83.7	82.8	79.9	85.8	86.0	84.1							
	Sunshine hrs/day	5.1	5.9	7.5	5.9	5.9	6.4							
	Wind knots	0.4	0.7	0.8	0.4	1.1	1.7							

Average monthly and annual evaporation[¤] data recorded at Ampang Research Station is summarised in Table 4.

Table 4 : Average monthly and annual evaporation[¤] data (mm)

Site	Years of Record	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Annual
Ampang	10	162	163	150	154	147	147	167	171	191	178	173	157	1960

[¤] The evaporation data are recorded by a Class A (black) pan. From correlation studies carried out previously, monthly evaporation recorded by Class A Pan = 0.9 monthly evaporation recorded by Class A pan painted black (D.I.D. R.S. Memorandum No. 19).

4.1.1. Evapotranspiration

Using data observed at Subang International Airport the average monthly and annual evapotranspiration were calculated using the Penman procedure (Scarf 1976). An albedo r = 0.18 for deciduous forest has been assumed and results are shown in Table 5.

Table 5 : Summary of Penman evapotranspiration data (mm)

Year	Years of Record	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Annual
1971/72	1	122	116	124	127	114	101	124	123	139	130	130	123	1473
1972/73	1	131	132	124	123	117	107	123	123	137	131	128	117	1493
1973/74	1	124	121	120	122	109	100	110	110	141	125	120	122	1424
1964–1974	11	123	125	125	122	114	109	121	121	139	134	130	123	1486

4.2 Rainfall

Daily rainfall totals (midnight to midnight) were abstracted from recorder charts for all stations, Sekolah, Sawah, Lawin and Lallang. For periods of missing records an approximate daily record was prepared based on the check gauge total and automatic recorder chart records from other stations operating.

In general it was found that the time of occurrence of rainfall events at Sawah and Sekolah were similar. The same observation applied to Lawin and Lallang. Thus in correcting for missing records at Lawin for example, the check gauge total at Lawin was apportioned according to the automatic recorder chart record observed at Lallang.

Daily rainfall records for all stations are held on file and the monthly and annual totals only are included in Table 6.

Table 6 : Monthly and annual rainfall totals (mm) for Sg. Lui rainfall stations

Station	Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Annual Total
Sekolah	71/72						460	62	216	249	327	247	87	
Sawah	71/72						510	106	210	159	402	240	126	
Lawin	71/72						772	129	471	206	628	332	73	
Lallang	71/72						427	114	174	162	410	231	138	
Sekolah	72/73	145	83	319	347	349	177	86	100	216	294	505	155	2776
Sawah	72/73	131	122	284	298	312	169	71	74	318	330	502	185	2796
Lawin	72/73	118	85	349	280	182	138	32	153	241	388			
Lallang	72/73	130	79	292	291	381	147	98	95	228	295	461	182	2679
Sekolah	73/74	79	265	259	324	354	295	32	168	185	233	381	188	2765
Sawah	73/74	76	296	293	352	355	289	20	184	150	189	380	167	2751
Lawin	73/74	39	53	124	251	445	295	48	161	78	201	142	105	1942
Lallang	73/74	55	317	286	223	407	263	24	156	163	215	280	99	2488

4.3 Flow

Recorder charts have been digitised using a digitizer and stage-time data are stored on magnetic tape. A printout of daily mean discharge indicated a few anomalies and some manual checking from the original charts was found necessary. Errors in computer storage resulted from a few suspect staff gauge readings and silting of the inlet and stilling well.

Missing records resulting from clock failure were prepared from maxima and minima on charts aided by the mean basin rainfall record and basin lag information.

5. DATA ANALYSES

5.1 Rainfall

Daily mean basin rainfall was derived using the Theissen method, the weighting factors for each rainfall site being as follows:–

Sekolah	0.173	Lawin	0.387
Sawah	0.237	Lallang	0.203

Table 7a: TABULATION OF DAILY RAINFALL AND RUNOFF FOR WATER YEAR 1971–72

RECORDS BEGIN IN 1–12–1971

Date	December		January		February		March		April		May		June	
	P	Q	P	Q	P	Q	P	Q	P	Q	P	Q	P	Q
1	–		6.6	3.46	23.5	2.68	0.1	1.78	28.3	1.86	–		16.2	3.51*
2	53.3		0.1	3.32	3.5	2.43	29.3	3.53	0.9	2.88	40.9		2.4	3.72*
3	132.9		–	2.88	9.3	2.22	–	3.08	57.9	2.07	1.0		–	2.49*
4	28.9		–	2.72	17.0	2.89	–	1.88	38.8	9.44	16.3		–	2.24*
5	18.9	10.33	–	2.62	–	2.21	–	1.70	5.3	3.31	12.1		1.6	2.10*
6	3.7	5.90	16.8	3.42	–	1.71	–	1.61	0.6	2.79	0.1		–	1.95*
7	–		0.6	3.32	50.6	6.39	–	1.53	–		0.1		0.5	1.88
8	1.7		–	3.13	6.0	4.06	–	1.48	0.1		–	No record	0.4	1.79
9	3.7		–	2.63	7.4	2.59	2.6	1.52	4.3		4.5		–	1.75
10	9.2		–	2.50	5.3	2.72	–	1.41	28.5		5.2		–	1.75
11	12.7		–	2.41	0.3	2.11	–	1.43	14.7		–		0.7	1.74
12	3.2		–	2.34	–	1.83	40.0	2.86	75.3		–		0.4	1.74
13	33.6		–	2.29	–	1.71	–	2.22	5.3		–		–	1.68
14	13.9		–	2.20	–	1.65	–	1.52	35.5		10.0		45.5	2.15
15	47.2		–	2.14	–	1.56	21.0	1.84	0.2		6.3		–	2.87
16	0.3		–	2.07	–	1.47	25.2	5.14	0.1		30.7		2.1	1.89
17	2.2		–	2.01	–	1.41	–	2.98	8.8		11.5	3.71	9.1	1.88
18	8.5		0.8	1.97	–	1.40	0.1	1.87	3.4		4.2	3.22	0.1	1.84
19	0.2		1.0	1.90*	–	1.61	0.2	1.78	0.1		11.4	3.16*	19.0	2.55
20	33.7	No record	0.2	1.88*	0.6	1.66	25.3	2.13	36.3	No record	9.3		0.1	2.44
21	2.3		–	1.87*	12.1	1.78	2.5	2.15	5.9		4.9		1.9	2.21
22	–		–	1.84*	1.7	1.57	–	1.62	0.2		0.2		1.2	2.31
23	4.0		–	1.81*	31.2	2.76	7.5	1.75	12.7		58.5		–	2.08
24	–		–	1.78*	90.0	4.90	4.7	1.59	2.3		0.3		–	1.93
25	91.8		5.6	1.87*	0.8	3.61	–	1.56	47.9		17.7	No record	–	1.85
26	6.1		10.1	2.10	0.6	2.01	–	1.38	17.8		–		–	1.79
27	35.1		1.5	1.77	–	1.76	0.8	1.33	–		–		–	1.72
28	–		–	1.67	45.0	3.03	5.1	1.32	27.5		24.7		–	1.64
29	39.0		–	1.60	–	2.74	19.1	1.38	2.7		3.8		–	1.60
30	–		–	1.54			4.4	1.97	16.5		1.4		–	1.55
31	–		65.7	3.03			5.5	1.59			–			
Total	586		109	72.09	305	70.47	193	60.93	478		275		101	62.64

* Short term missing records prepared from chart maxima and minima and rainfall and basin lag information.

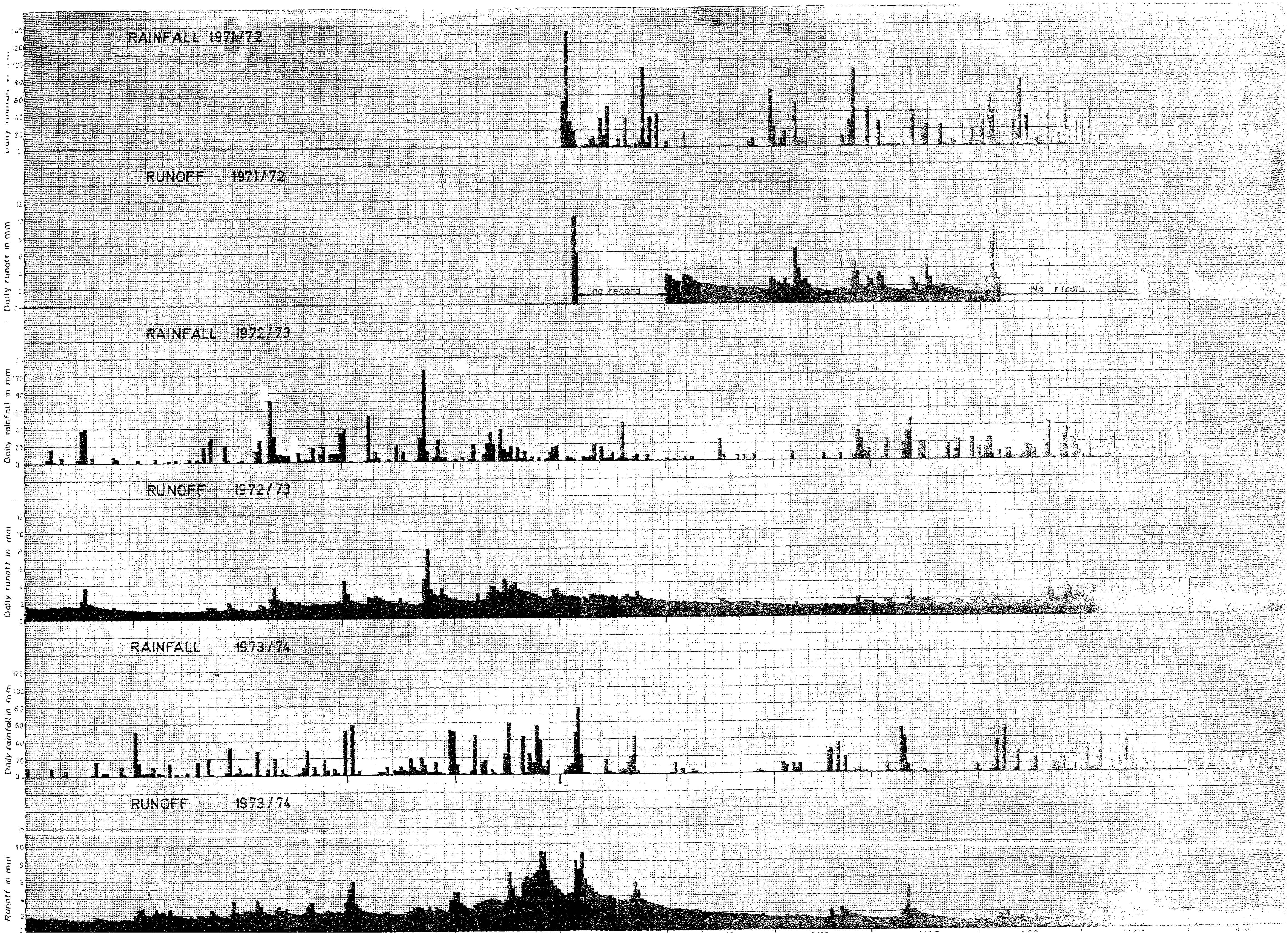
All values in mm
– indicates no rain

Table 7b: TABULATION OF DAILY RAINFALL AND RUNOFF FOR WATER YEAR 1972/73

Date	July		August		September		October		November		December		January		February		March		April		May		June		Date
	P	Q	P	Q	P	Q	P	Q	P	Q	P	Q	P	Q	P	Q	P	Q	P	Q	P	Q	P	Q	
1	–	1.51	–	1.08	2.6	1.23	–	2.84	3.5	2.23	1.4	2.64	2.2	1.78	–	1.40	–	1.65	16.9	1.53	2.9	2.14	4.7	4.29	1
2	–	1.47	3.8	1.07	0.3	1.14	1.7	2.17	0.2	2.09	–	2.46	0.6	1.74	–	1.39	–	1.40	2.9	1.96	–	1.92	–	2.89	2
3	–	1.44	–	1.08	–	1.11	–	2.02	5.2	2.09	5.8	2.40	1.6	1.75	–	1.36	0.4	1.32	14.0	1.49	23.3	2.02	7.6	2.58	3
4	0.3	1.39	–	1.06	0.1	1.09	–	1.88	–	2.03	2.9	2.55	–	1.74	0.1	1.33	3.3	1.34	24.9	1.75	0.7	3.25	12.4	2.88	4
5	–	1.38	–	1.11	13.0	1.16	–	1.73	2.4	1.94	2.1	2.46	0.6	1.67	–	1.34	24.0	1.87	9.7	2.46	–	2.25	15.9	2.79	5
6	0.1	1.36	–	1.07	25.7	1.70	1.3	1.66	19.4	2.03	–	2.40	3.3	1.70	8.8	1.34	–	1.95	–	2.03	11.7	2.46	11.9	3.14	6
7	4.0	1.42	4.7	1.02	–	1.46	53.2	2.54	0.6	2.86	–	2.32	0.8	1.68	–	1.60	–	1.41	9.5	1.69	16.0	2.60	9.2	2.79	7
8	16.5	1.54	–	1.02	–	1.23	3.0	2.36	–	2.01	5.4	2.36	4.4	1.70	–	1.36	–	1.32	–	1.61	17.4	2.44	4.2	2.85	8
9	1.7	1.54	–	1.00	71.6	2.28	11.5	2.63	9.2	2.18	4.9	2.29	–	1.70	–	1.31	–	1.29	11.7	1.50	29.8	3.17	–	2.48	9
10	–	1.41	0.5	0.97	30.7	3.65	4.6	2.43	20.5	2.89	6.3	2.63	–	1.63	–	1.29	19.7	1.40	–	1.74	29.5	2.42	–	2.28	10
11	6.4	1.59	2.0	0.97	6.8	2.26	–	2.13	34.3	3.63	18.7	2.79	–	1.57	–	1.26	33.4	2.18	2.9	1.49	6.3	3.12	9.5	2.19	11
12	–	1.61	0.3	0.98	9.7	2.02	0.1	1.93	18.8	3.62	–	2.46	0.2	1.55	0.2	1.25	46.7	3.08	2.9	1.51	4.0	2.62	1.0	2.21	12
13	0.2	1.55	3.4	1.04	7.2	1.90	2.3	1.87	–	3.24	16.3	2.60	–	1.52	–	1.24	–	2.09	4.5	1.50	5.0	2.19	33.3	2.91	13
14	–	1.54	–	1.04	7.7	1.99	–	1.79	36.8	2.99	3.6	2.47	0.2	1.52	–	1.22	0.3	1.67	9.1	1.48	23.5	2.17	–	2.46	14
15	–	1.51	0.1	0.95	–	1.82	18.6	1.79	13.4	4.49	3.5	2.35	0.1	1.52	7.4	1.22	20.8	1.79	17.0	1.67	11.8	2.24	–	2.10	15
16	4.2	1.53	0.6	0.93	–	1.67	–	2.36	10.9	3.47	9.9	2.56	25.6	1.91	1.6	1.38	22.0	1.86	15.4	2.00	12.2	2.65	–	1.99	16
17	37.1	2.20	3.8	0.98	11.2	1.91	10.3	1.80	17.0	3.75	0.6	2.33	5.7	2.14	1.0	1.29	–	2.07	11.7	1.71	9.1	2.42	–	1.92	17
18	38.8	3.65	–	1.01	–	1.63	1.8	1.87	2.1	4.10	2.8	2.14	–	1.76	–	1.29	–	1.61	1.4	1.70	9.0	2.58	–	1.89	18
19	–	1.86	3.7	1.00	1.9	1.57	–	1.67	15.9	3.31	45.4	2.35	–	1.63	–	1.24	–	1.49	–	1.53	13.2	2.22	–	1.89	19
20	6.4	1.75	1.6	0.99	3.4	1.50	–	1.60	2.5	3.21	3.1	2.67	–	1.56	6.6	1.24	–	1.44	20.4	1.62	0.9	2.25	12.8	2.12	20
21	–	1.60	17.7	1.08	16.6	1.78	2.5	1.56	12.0	3.02	2.3	2.30	5.8	1.61	0.3	1.28	–	1.36	41.7	3.17	6.3	2.32	0.2	1.87	21
22	–	1.50	0.1	1.31	–	1.69	27.4	1.76	0.8	3.06	5.1	2.33	–	1.67	–	1.21	2.7	1.30	2.4	2.71	0.9	2.41	30.7	2.23	22
23	–	1.39	27.1	1.39	–	1.46	105.7	4.46	4.9	2.80	6.7	2.93	5.7	1.60	–	1.18	18.2	1.45	1.6	1.92	27.7	2.43	2.2	2.37	23
24	–	1.31	–	1.32	17.7	1.64	11.5	8.07	0.3	2.72	–	2.45	–	1.69	5.3	1.29	0.5	1.56	7.5	1.77	0.2	2.52	3.7	1.96	24
25	–	1.24	–	1.19	0.1	1.70	–	3.34	3.9	2.47	–	2.19	–	1.50	34.3	2.24	11.7	1.70	26.9	2.06	25.2	2.56	–	2.02	25
26	7.7	1.42	–	1.14	–	1.52	5.2	2.63	–	2.39	6.6	2.05	6.3	1.52	25.2	1.46	22.8	1.82	35.9	3.64	0.5	2.66	9.2	2.02	26
27	4.6	1.26	18.5	1.18	8.9	1.69	25.4	2.62	3.5	2.31	0.5	2.10	–	1.65	9.7	1.79	–	1.65	–	3.31	4.8	2.41	–	1.90	27
28	–	1.21	3.2	1.93	9.6	1.92	5.4	3.43	10.3	2.40	–	1.97	–	1.46	12.8	1.73	–	1.40	24.3	2.14	66.6	3.22	–	1.84	28
29	–	1.17	–	1.35	33.4	1.77	5.2	2.64	16.0	3.25	0.2	1.90	–	1.42			–	1.33	14.9	3.29	27.2	4.02	–	1.80	29
30	–	1.15	–	1.21	38.7	4.39	0.3	2.39	18.2	3.37	–	1.91	–	1.41			25.1	1.75	9.1	2.52	14.2	3.20	–	1.77	30
31	–	1.15	1.2	1.19			0.9	2.23			–	1.83	0.8	1.39			0.8	2.04			66.9	4.03			31
Total	128	47.65	92	34.66	317	55.88	298	76.20	283	85.95	154	73.19	464	50.69	113	38.53	252	51.59	339	60.50	467	80.91	168	70.43	Total

Total rainfall for year 2675 mm
Total runoff for year 724.2 mm
All values in mm.
– indicates no rain.

Date	July		August		September		October		November		December		January		February		March		April		May		June		Date
	P	Q	P	Q	P	Q	P	Q	P	Q	P	Q	P	Q	P	Q	P	Q	P	Q	P	Q	P	Q	
1	9.8	2.04	50.4	2.03	2.5	2.44	–	2.93	12.1	4.52	0.4	4.25	–	2.45	–	1.47	–	1.32	1.8	1.15	4.9	1.66	–	1.52	1
2	–	1.86	14.8	2.66	3.6	2.43	50.8	5.76	1.7	3.28	4.8	4.09	0.9	2.42	–	1.44	–	1.28	–	0.99	31.5	2.20	–	1.47	2
3	–	1.82	3.3	2.77	3.1	2.47	–	3.34	1.6	2.86	9.1	4.39	12.5	2.45	12.0	1.46	–	1.24	0.5	0.94	4.3	2.71	0.1	1.43	3
4	–	1.78	3.1	2.07	–	2.37	4.7	2.75	0.3	2.64	11.9	4.31	–	2.49	8.2	1.64	–	1.23	2.9	0.95	11.1	2.29	–	1.37	4
5	–	1.76	4.6	1.96	29.4	3.73	–	2.57	4.6	2.53	48.0	8.03	4.8	2.40	0.1	1.57	10.3	1.22	7.7	1.08	25.8	2.23	–	1.32	5
6	–	1.75	10.2	2.25	1.3	3.08	–	2.36	46.5	2.99	77.1	6.91	–	2.35	10.4	1.52	1.0	1.39	36.9	1.34	43.8	5.27	22.7	1.70	6
7	–	1.72	–	2.65	0.2	2.34	–	2.26	0.3	3.23	22.6	8.89	0.6	2.24	5.4	1.61	3.5	1.32	1.5	1.71	1.9	4.15	–	1.53	7
8	8.3	1.83	3.9	2.28	7.4	2.27	–	2.17	14.5	3.26	1.6	5.88	5.3	2.27	11.1	1.50	0.1	1.25	53.3	1.60	13.4	3.05	–	1.36	8
9	–	1.74	1.8	2.44	–	2.06	0.6	2.10	16.1	3.41	1.8	5.11	1.6	2.36	–	1.60	51.7	2.26	0.1	1.90	12.1	3.71	1.1	1.34	9
10	–	1.68	–	2.00	19.7	2.55	3.9	2.05	0.1	3.41	–	4.72	0.1	2.23	–	1.46	41.3	2.56	–	1.35	1.0	3.63	–	1.35	10
11	0.6	1.65	14.5	2.64	–	2.89	3.1	2.15	6.2	3.44	–	4.42	–	2.14	–	1.41	9.4	4.97	3.6	1.21	15.0	3.45	–	1.26	11
12	6.4	1.70	–	2.16	7.7	2.47	8.7	2.38	2.5	3.42	–	4.15	–	2.04	–	1.36	2.1	2.91	24.5	1.28	0.1	3.55	–	1.20	12
13	–	1.62	1.4	1.97	3.0	2.61	0.1	2.07	–	3.30	–	3.95	0.4	2.01	–	1.34	–	2.29	0.4	1.48	43.7	3.55	13.3	1.26	13
14	–	1.58	0.2	1.89	0.7	2.31	–	1.96	1.4	3.19	16.3	3.93	–	1.99	–	1.31	–	1.88	–	1.24	6.0	4.23	1.1	1.32	14
15	0.2	1.55	0.2	1.79	–	2.18	4.7	1.97	23.8	3.51	2.8	3.99	–	1.98	–	1.31	0.2	1.67	0.6	1.15	26.4	4.38	11.9	1.31	15
16	–	1.53	4.3	1.72	0.9	2.11	9.2	2.09	59.6	6.53	0.7	3.70	–	1.94	24.4	1.39	3.2	1.61	1.9	1.09	3.2	4.76	7.4	1.54	16
17	–	1.52	0.2	1.83	3.0	2.05	5.3	2.05	0.6	4.90	–	3.53	–	1.90	27.9	2.30	–	1.56	16.4	1.38	2.6	4.28	9.1	1.38	17
18	–	1.50	–	1.69	8.8	2.22	3.6	2.21	0.2	4.09	5.0	3.49	–	1.88	0.4	1.59	–	1.43	–	1.27	1.0	3.85	17.9	1.96	18
19	0.1	1.47	15.7	2.01	29.4	3.02	19.0	2.31	0.6	3.85	5.7	3.46	–	1.82	34.7	1.59	–	1.35	–	1.15	7.0	4.15	0.5	2.07	19
20	0.7	1.46	–	2.07	–	3.44	9.2	2.68	44.0	5.62	13.5	3.47	–	1.79	1.4	2.55*	–	1.28	0.1	1.09	0.1	3.69	0.7	1.65	20
21	16.8	1.84	–	1.74	10.3	2.28	5.3	2.75	2.2	6.28	19.7	3.94	–	1.77	18.8	2.23*	–	1.23	–	1.06	8.4	3.75	16.1	1.68	21
22	–	1.82	20.1	2.07	2.3	2.25	18.6	2.73	24.8	6.19	43.0	5.49	–	1.78	0.5	1.97*	–	1.19	10.8	1.08	–	2.31	1.7	1.81	22
23	4.5	1.67	1.4	2.55	–	2.11	11.0	2.42	13.4	6.60	3.1	4.63	0.4	1.73	–	1.68*	–	1.15	9.8	1.33	–	2.08	2.9	1.66	23
24	4.1	1.56	0.2	2.08	18.9	2.33	2.1	2.93	57.6	7.08	–	3.74	–	1.70	4.3	1.62*	–	1.12	4.3	1.34	0.7	2.01	1.0	1.64	24
25	–	1.56	–	1.91	5.1	2.46	2.9	2.49	39.8	9.18	–	3.49	–	1.65	4.8	1.55*	–	1.08	16.1	1.43	1.9	1.95	0.2	1.54	25
26	0.1	1.50	–	1.80	0.1	2.38	14.3	2.69	9.0	9.10	–	3.28	0.4	1.64	–	1.44*	–	1.06	0.3	1.53	0.8	1.87	0.1	1.51	26
27	0.3	1.47	4.1	1.83	8.0	2.24	2.6	2.59	16.2	6.97	–	3.14	3.8	1.66	2.1	1.40*	–	1.03	0.2	1.30	0.7	1.79	9.6	1.62	27
28	11.6	1.53	32.7	2.16	3.2	2.38	1.2	2.38	0.6	5.68	–	3.01	2.2	1.68	–	1.36*	–	0.99	9.3	1.34	0.5	1.73	0.3	1.42	28
29	2.5	1.59	1.6	3.59	–	2.16	–	2.25	–	5.15	–	2.86	0.5	1.59			–	0.98	0.3	1.75	–	1.67	–	1.35	29
30	1.2	1.59	2.8	2.34	51.5	3.40	51.4	3.47	0.1	4.76	–	2.74	–	1.54			–	0.98	3.0	1.73	–	1.62	14.8	1.43	30
31	0.6	1.56	9.5	2.18			49.8	4.47			–	2.57	0.2	1.51			9.0	0.97				1.57			31
Total	68	51.25	201	67.13	220	75.03	282	81.33	400	140.97	287	133.56	34	61.40	167	44.67	132	47.80	206	39.24	268	93.14	133	45.00	Total


RAINFALL 1971/72
RUNOFF 1971/72
Daily runoff in mm
no record
No record
RAINFALL 1972/73
Daily rainfall in mm
RUNOFF 1972/73
Daily runoff in mm
RAINFALL 1973/74
Daily rainfall in mm
RUNOFF 1973/74
Runoff in mm

Results are shown in Tables 7(a), 7(b) and 7(c) and plotted in Fig. 3.

To evaluate the time distribution of daily rainfall a rainfall duration curve for the total study period was calculated and is shown in Fig. 4. This shows that the expected number of days when less than 1.0mm/day is recorded in the catchment is 49.1% of the time or 179 days/year. The percentage time when mean daily basin rainfall exceeds 50 mm /day is 2.44% (9 days/yr) and 20mm /day; 11.8% (43 days/yr).

During the study period, basic rainfall exceeded 100mm on only two occasions; on 3 Dec. 1971 (132.9mm) and 23 Oct. 1972 (105.7mm). Allowing that a daily rainfall of 1mm or less does not contribute significantly to runoff and can be considered rainless, the maximum number of consecutive rainless days was 18 in January 1972. Periods of 14 consecutive days were also recorded in June-July 1972 and March, 1974.

5.1.1 Rainfall Intensity

Convectional rainstorms, occurring often in the afternoon, are noted for their high rainfall intensity. Fortunately the storms tend to be localised, seldom extending over the entire catchment area and seldom exceeding one hour duration.

Table 8 lists several notable storm intensities that occured during the study period.

Table 8 : Rainfall intensities

Site	Date	Rainfall (mm)	Duration (hrs)	Intensity (mm/hr)
Lawin	24/ 2/72	160	1	160
Lallang	16/ 1/73	43	0.33	130
Sekolah	7/10/72	62	0.50	124
Sawah	14/ 6/72	21	0.17	123
Sekolah	21/10/73	20	0.17	118
Sekolah	16/11/73	56	0.50	112
Sawah	6/ 5/74	55	0.50	110
Lawin	23/ 2/73	53	0.50	106
Sawah	11/11/73	53	0.50	106

5.2 Flow

Daily runoff totals were calculated and are tabulated in Tables 7(a), 7(b) and 7(c) and plotted in Fig. 3. Average annual discharge for the two years of complete record is 1760 1/s (25.8 litre/sec/sq. km.).

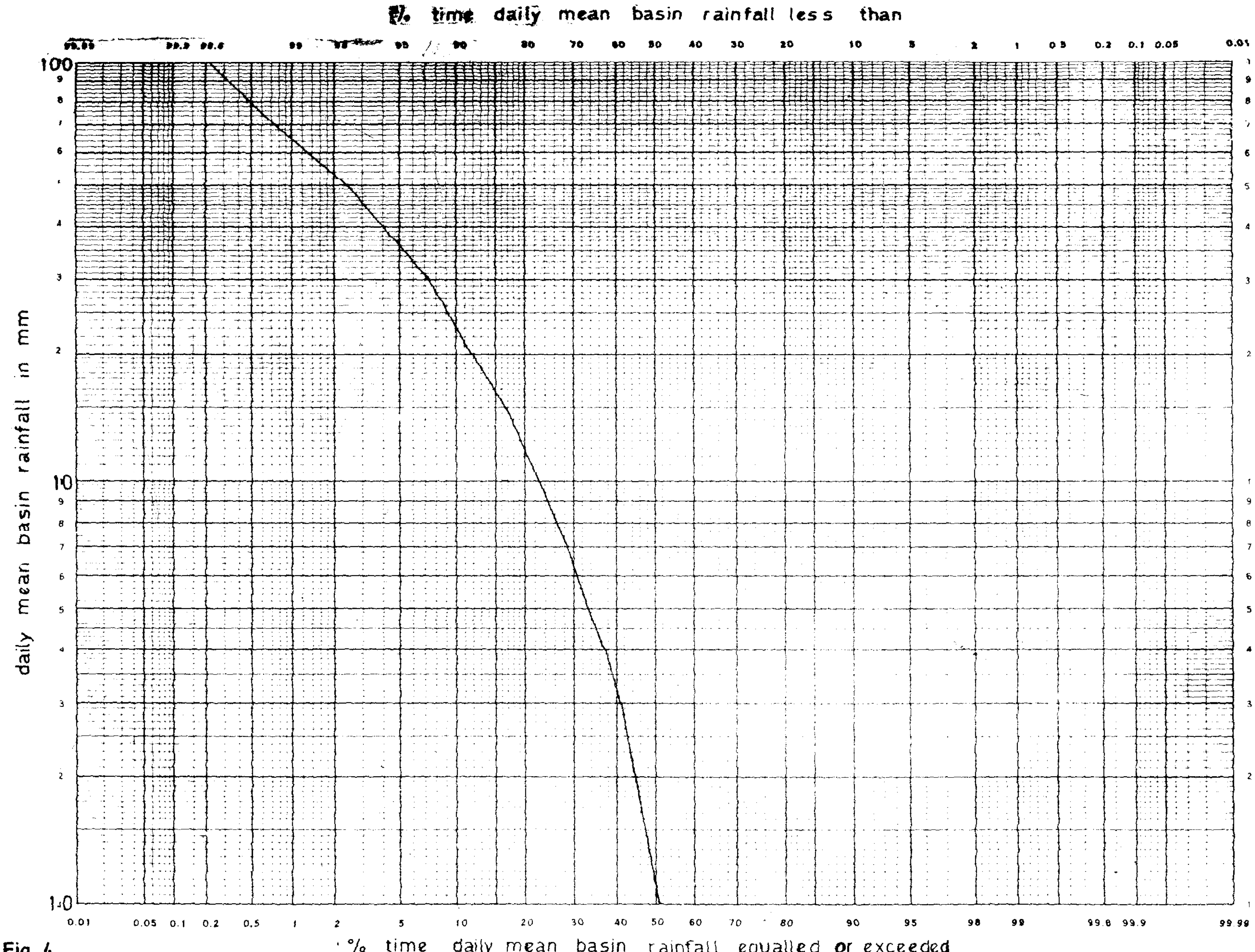

% time daily mean basin rainfall less than
daily mean basin rainfall in mm
% time daily mean basin rainfall equalled or exceeded

Fig. 4

From the tabulated runoff data flow duration curves are prepared and are plotted in Fig. 5.

5.2.1 Flood Discharges

Flood events exceeding 14,000 1/s during the study period are listed in Table 9.

Table 9 – Flood Discharges

Date of Flood event	Maximum flood discharge	
	1/s	1/s/sq.km
5.12.71	17,500	257
7. 2.72	24,600	361
23. 5.72	16,600	244
24.10.72	19,700	289
26.11.73	14,300	210

5.2.2 Low Flows

Minimum flows recorded for the 1972/73 and 1973/74 water years were 725 1/s (10.6 litre/sec/sq. km) in August 1972 and 745 1/s (10.8 litre/sec/sq.km) in April, 1974 respectively.

5.2.3 Base Flow Recession

Extended periods of base flow recession were plotted on log normal graph-paper and superimposed to construct a master base flow recession curve. The curve followed a double exponential decay of the form

$$q_t = q_o e^{-at^n}$$

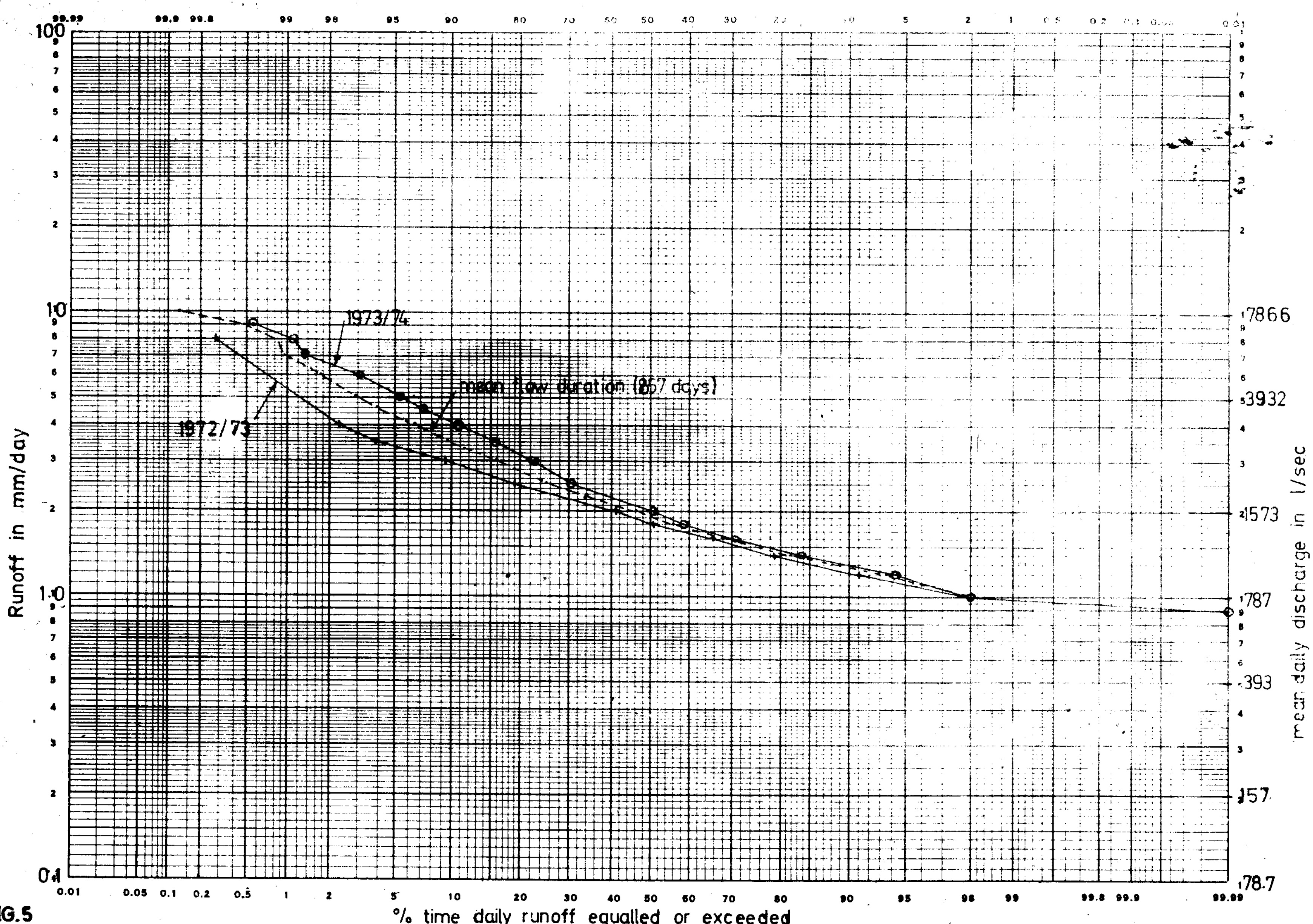
where q is discharge and t is the time in days. Regression analysis was used to determine the constants a and n giving a curve of best fit (Fig. 6):

$$q_t = q_o e^{-0.057t^{0.83}}$$

For computational purposes this curve can be approximated by two simple exponential decay curves of the form

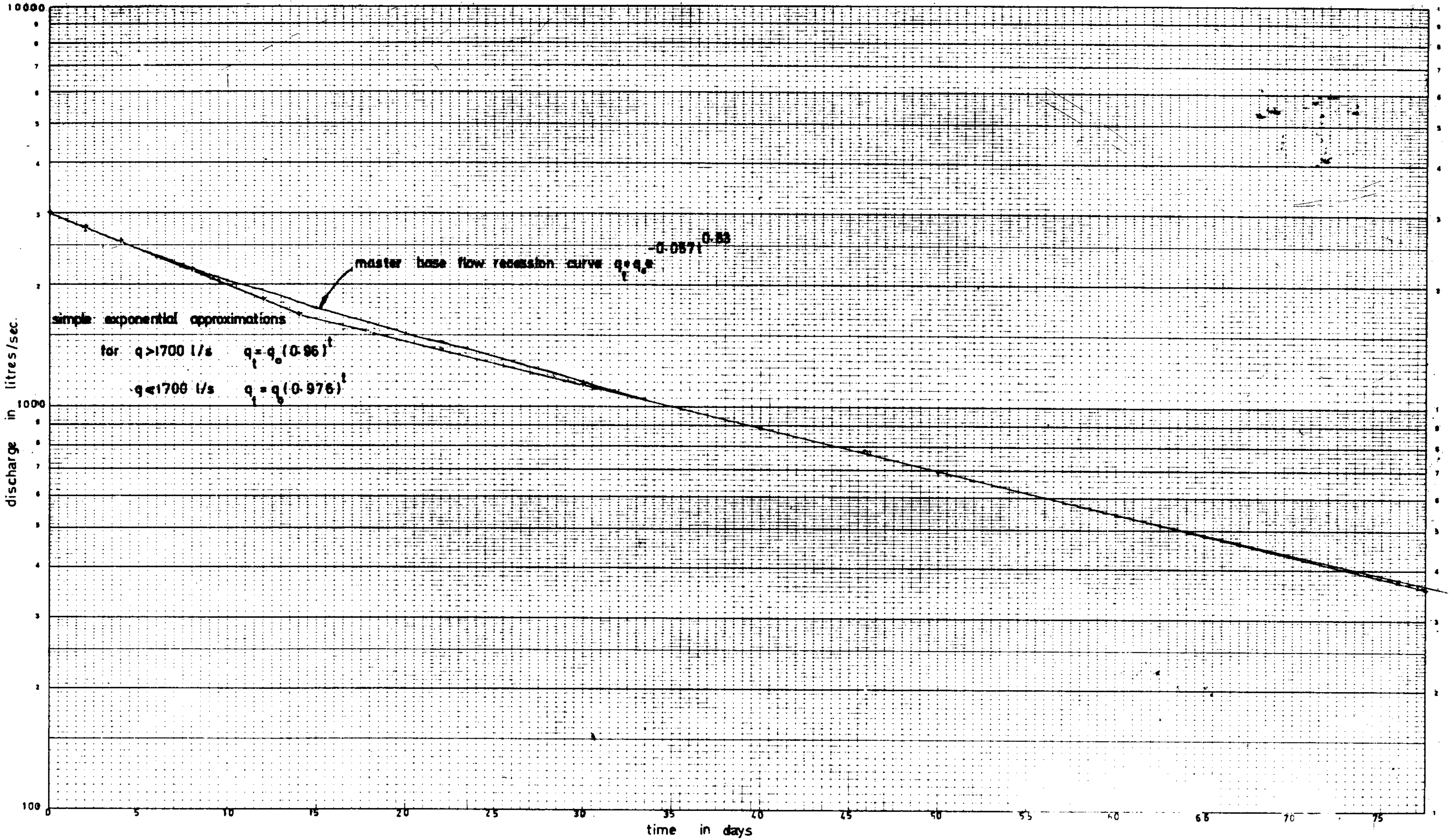
$$q_t = q_o e^{-at}$$

Where e^{-a} = K, the base flow recession constant. For flows:–



1973/74
mean flow duration (857 days)
1972/73
Runoff in mm/day
mean daily discharge in l/sec
7866
3932
1573
787
393
157
78.7
% time daily runoff equalled or exceeded

FIG.5



master base flow recession curve $q_t = q_o e^{-0.057t^{0.83}}$
simple exponential approximations
for q>1700 l/s $q_t = q_o(0.96)^t$
q<1700 l/s $q_t = q_o(0.976)^t$
discharge in litres/sec.
time in days

Fig. 6

(a) exceeding 1,700 1/s

$$q_t = q_o(0.96)^t$$

(b) less than 1,700 1/s

$$q_t = q_o (0.976)^t$$

Maximum error is less than ± 6%.

5.2.4 Base Flow Component of Runoff

Using the 1973/74 flow records the base flow component was abstracted using the standard plotting method and simple exponential equations given in 5.2.3. Results are summarised in Table 10.

Table 10 – Base flow component of runoff for 1973–74 water year

Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Annual
Total Runoff mm	51.3	67.1	75.0	81.3	141.0	133.6	61.4	44.7	47.8	39.2	93.1	45.0	880.5
Base flow runoff mm	49.9	58.9	62.5	65.4	106.6	115.1	60.1	40.3	38.7	33.8	67.9	41.0	740.2
Ratio: Base runoff / Total runoff	0.97	0.88	0.83	0.80	0.76	0.86	0.98	0.90	0.81	0.86	0.73	0.91	0.84

Base flow discharge reached a maximum on 7 Dec. 1973 with a flow of 4,275 1/s.

Integration of the base flow recession equation with respect to time and taking q_o = 5.36 mm/day (4275 1/s) gives an estimated 188 mm of base flow (groundwater) storage corresponding to this base flow discharge.

5.2.5 Time of Rise of Hydrograph

The time of rise, defined as the time interval between the beginning of rise and peak of the hydrograph, was abstracted for 124 flood events occuring during the study period.

Mean time of rise was 5.75 hours with a standard deviation of 1.5 hours.

5.2.6 Basin Lag

Basin lag is the time interval between the centre of mass of the effective rainfall hyetograph and the flood peak. Analysis of 10 storm events having a time of rise about 5.75 hours gave an average basin lag of 5.9 hours.

5.3 Water Balance

The Penman evapotranspiration estimate (Table 5) is used to establish the monthly and annual water balance for the study period. Results are tabulated in Table 11.

Table 11 – Monthly and annual water balance

1971/72	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Annual
Precipitation (mm) p						586	109	305	193	478	275	101	
Runoff (mm) Q						*	72	70	61	*	*	63	
Evapotranspiration (mm) E						101	124	123	139	130	130	123	
P–Q–E						*	–87	+112	– 7	*	*	–85	

* incomplete flow record

1972/73	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Annual
Precipitation (mm) P	128	92	317	298	283	154	64	113	252	339	467	168	2675
Runoff (mm) Q	48	35	54	76	86	73	51	39	52	61	81	70	724
Evapotranspiration (mm) E	131	132	124	123	117	107	123	123	137	131	128	117	1493
P–Q–E	–51	–75	+139	+99	+80	–26	–110	–49	+63	+147	+258	–19	+456

1973/74	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Annual
Precipitation (mm) P	68	201	220	282	400	287	34	167	132	206	268	133	2398
Runoff (mm) Q	51	67	75	81	141	134	61	45	48	39	93	45	881
Evapotranspiration (mm) E	124	121	120	122	109	100	110	110	141	125	120	122	1424
P–Q–E	–107	+13	+25	+79	+150	+53	–137	+12	–57	+42	+55	–34	+93

Whilst the annual P–Q–E totals of +456 and +93 mm respectively would indicate a small loss to deep percolation, it is more probable that the true evapotranspiration has been underestimated by the Penman procedure and the deep percolation loss is apparent rather than real. Continued recording and future analyses will clarify this point.

6. RECOMMENDATIONS FOR FUTURE INSTRUMENTATION AND RESEARCH

6.1 Instrumentation

There is a need to establish a station to study climatic conditions related to this basin, such data being required primarily for evapotranspiration assessment in the water balance equation. Thus it is recommended that the existing Capricorder at Sekolah be replaced with a nine-channel recorder; one channel recording rainfall as at present, and the remaining channels being used to record other climatic variables such as air temperature, wet and dry bulb temperature, wind velocity and radiation if suitable instruments are available.

The Capricorder from Sekolah together with a 0.5mm Hattori tipping bucket raingauge should replace the existing Kent rainfall recorder at Lawin. Because of the rainfall pattern prevailing in the Sg. Lui Basin (i.e. rainfall events at Lallang and Lawin occurring at similar time and the same for Sekolah and Sawah), it is considered that the automatic gauges at Lallang and Sawah could be replaced with storage raingauges without significant reduction in rainfall data quality. Visits to sites could then be reduced to once fortnightly.

It is further recommended that a series of gaugings be carried out to check the laboratory model rating with the actual field rating.

6.2 Research

Analyses of previous data has afforded an understanding of certain hydrological parameters relating to the Sg. Lui Basin. To evaluate the hydrological regimen further it is proposed that future research be aimed towards fitting a mathematical model to the existing data.

The success of such a model will not only assist in preparing missing records and evaluating long term water resources of the Sg. Lui, but may lead to accurate assessment of water resources for similar sized basins with granitic geology in the Kuala Kerai – Ulu Langat hydrological region.

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STAGE-DISCHARGE RATING TABLE FOR SG. LUI WEIR

Stage in m	0.00	0.02	0.04	0.06	0.08
	DISCHARGE IN CUMECS				
76.7	0.200	0.255	0.283	0.340	0.396
76.8	0.436	0.500	0.552	0.623	0.708
76.9	0.800	0.877	0.962	1.075	1.189
77.0	1.274	1.410	1.599	1.755	2.009
77.1	2.250	2.406	2.660	2.802	3.113
77.2	3.400	3.831	4.387	4.528	5.094
77.3	5.380	5.970	6.509	7.075	7.358
77.4	8.210	8.490	8.915	9.340	9.905
77.5	10.61	11.04	11.60	12.17	12.88
77.6	13.30	14.15	14.72	15.57	16.27
77.7	16.98	17.55	17.11	18.96	19.81
77.8	20.38	21.61	22.07	23.21	23.77
77.9	24.90	25.47	26.60	27.17	28.30
78.0	28.86	29.72	31.13	32.55	32.83
78.1	34.53	35.38	36.79	37.36	38.49
78.2	39.62	40.47	41.88	42.45	43.87
78.3	45.28	46.13	46.70	48.11	48.68
78.4	50.94	52.36	53.20	54.05	55.19
78.5	56.60	57.16	58.01	59.43	61.69
78.6	62.26	63.68	65.09	65.66	67.35
78.7	67.92	69.34	70.75	72.17	73.01
78.8	73.58	74.43	76.41	76.69	77.83
78.9	79.24	79.81	80.66	82.07	83.45
79.0	83.48				

WATER RESOURCES PUBLICATIONS PREVIOUSLY PUBLISHED

1. Surface Water Resources Map (Provisional) of Peninsular Malaysia (1974) $5.00

2. Hydrological Regions of Peninsular Malaysia (1974) $6.00

3. Sungei Tekam Experimental Basin Annual Report No. 1 For 1973–1974 (1975) $5.00

4. Notes on Some Hydrological Effects of Land Use Changes in Peninsular Malaysia (1975) $5.00

5. Evaporation in Peninsular Malaysia (1976) .. $5.00

6. Average Annual Surface Water Resources of Peninsular Malaysia (1976) $5.00