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SUNGAI TEKAM EXPERIMENTAL BASIN CALIBRATION REPORT FROM JULY 1977 TO JUNE 1980

1982

JABATAN PENGAIRAN DAN SALIRAN
KEMENTERIAN PERTANIAN MALAYSIA

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CALIBRATION REPORT FROM
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Bahagian Parit dan Tali Air
Kementerian Pertanian
Malaysia

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Contributing Agencies:

Drainage and Irrigation Department (Chairman)
Federal Land Development Authority
Soil and Analytical Services Branch of Agricultural Department
Forest Research Institute of Forestry Department
Geography Department of the University of Malaya
Division of Environment

BAHAGIAN PARIT DAN TALI AIR
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SUMMARY

The Sungai Tekam Experimental Basin was initiated in 1973 to study the effects of cultural change on the hydrological regime. Instrumentation for hydrological and climatic observation was completed in early 1977.

The study consists of three periods namely the calibration period, transition period and the evaluation period. This report covers specifically the calibration period from July 1977 to June 1980. The base-line data collected during this period are presented in this report together with results of the geomorphorlogical and botanical surveys and some preliminary analyses in hydrology, water quality and sedimentation.

Analyses of rainfall and runoff data show that the flow duration curves and master depletion curves of catchments A and B are very similar, whereas the unit hydrograph of catchment A and C are alike. The unit hydrograph for catchment B is rather flat due to backwater effect experienced at the flow measuring structure. The water balance analyses reveal an unaccounted "loss" of 475mm annually. A study on the groundwater flow characteristics together with the installation of another evaporation pan to verify present recorded values are recommended. More high flow gaugings and sediment sampling for a wider range of streamflow are also recommended. Generally the water in the basin is suitable for irrigation, municipal water supply and the propagation of fish and other aquatic wild life.

The study is now in the midst of the transition period which is scheduled to end by June 1983. The evaluation period will follow thereafter until June 1987.

1. INTRODUCTION

The Sungai Tekam Experimental Basin Study was initiated in September 1973 to study the effects of cultural change on the hydrological regime. However due to problems of field installation and instrumentation actual basin calibaration did not commence until July 1977.

The study consists of three periods, namely the calibration period from July 1977 to June 1980 involving the collection of base-line data; the transition period from July 1980 to June 1983 involving jungle felling, burning and initial crop establishment; and the evaluation period thereafter involving crop establishment. The evaluation period is scheduled from July 1983 to June 1987.

This report covers specifically the calibration period during which a number of activities such as base-line data collection, geomorphorlogical and botanical surveys including some premilinary analyses in hydrology, water quality and sedimentation have been carried out.

2. PROJECT DETAILS

2.1 Objectives

Due to the limited availability of suitable coastal land, most of the recent agricultural development has been confined to the inland undulating areas. The development of these areas involves the felling of extensive tracts of jungle, followed by burning, stacking and reburning of the felled trees and eventual replanting of the crops.

The Sungai Tekam Experimental Basin study is therefore conducted with the following objectives in mind:

(a) to study the effects of landuse changes on the hydrology of the basin focussing particularly on the various components namely streamflow, storage in the upper soil layers and groundwater storage beyond the root zone; and the magnitudes of high and low flows, as well as catchment yield in water resources.

(b) to study the effects of landuse changes on soil fertility resulting from various rates and patterns of chemical weathering, soil detachment and erosion.

(c) to study the effects of landuse changes on water quality as a measure of environmental pollution resulting from the various stages of agricultural development.

2.2 Project Organisation

The Sungai Tekam Experimental Basin Project is jointly operated by the Drainage and Irrigation Department (D.I.D.) of the Ministry of Agriculture and the Federal Land Development Authority (FELDA). Other agencies participating include the Soils and Analytical Services Branch of the Department of Agriculture, Forest Research Institute (F.R.I.) of the Forestry Department, Geography Department of the University of Malaya and the Division of Environment (D.O.E.). The Malaysian Meteorological Service (M.M.S.) was involved in the initial stages of the study.

2.3 Basin Description

The Sungai Tekam Experimental Basin is located in an area of selectively logged forest within the Tekam Forest Reserve of the Pusat Penyelidikan Pertanian Tun Razak, in Jerantut District, Pahang. It lies between latitude 3° 53′ 45″ N to 3° 55′ 00″ N and longitude 102° 31′ 30″ E, to 102° 33′ 00″ E, about 209 km by road due north-east of Kuala Lumpur. (Fig. 2.1).

The basin consists of three catchments namely catchments A, B, and C (Plate 2.1). Catchment A is a part of a larger catchment B, both of which are classified as operational catchments. These two catchments will be logged after an initial period of calibration and replanted with agricultural crops. Catchment C will retain its forested condition to serve as a control catchment for comparative purposes; this being an essential feature in the concept of experimental basin studies (Toebes and Ouryvaev, 1970).

For each catchment, the area and mean elevation were obtained based on a 2 metre contour map and are tabulated in Table 2.1.

TABLE 2.1—AREA AND MEAN ELEVATION OF EACH CATCHMENT.

Catchment	*Area (ha)*	*Mean Elevation (m)*
A	37.7	72.5
B	96.9	68.5
C	56.2	70.0

The catchments have good access with the old logging tracks providing passage for vehicles to all raingauges and flow recorder sites.

In the early stages, the streams have to be realigned and bunds have to be constructed near the flow measuring structures to enable measurement of the expected range of flows (Fig. 2.2, 2.3 and 2.4).

3. INSTRUMENTATION AND DATA COLLECTION

3.1 Rainfall

The basin is equipped with a network of five rainfall stations (Fig. 2.1) comprising four weekly automatic rainfall recorders with checkgauges and one storage gauge. These raingauges have their orifices at a distance of 1.37m (4′ 6″) above ground level, a D.I.D. standard practice for reason of easy operation and maintenance. Details of the rainfall stations are given in Table 3.1 below:

TABLE 3.1—DETAILS OF RAINFALL STATIONS.

Station No.	*D.I.D. Station No.*	*Type of Equipment*	*Data Commencement*
1	3825001 ..	Hattori Weekly Automatic	8/74
2	3925001 ..	OTA Weekly Automatic	10/74
3	3925002 ..	203mm Storage Gauge	9/73
4	3925003 ..	OTA Weekly Automatic	8/74
5	3925004 ..	Hattori Weekly Automatic	8/74

Prior to the erection of fencing and the installation of equipment, it was necessary to clear the vegetation at all the stations so as to ensure adequate exposure conditions. A distance of four times the height of the nearest obstruction is provided, where posibble, at each of these stations.

Plate 3.1 shows a typical rainfall station while Plate 3.2 shows a typical automatic rainfall recorder used.

Rainfall data is also being recorded at a climatic station situated about 2¼ km. from the Sungei Tekam Experimental Basin. This station has been in operation since March 1969 and is operated by FELDA staff. In addition to a manual raingauge and a Hattori weekly recording raingauge, other instruments installed include a cup anemometer; maximum, minimum, wet and dry bulb thermometers; a U.S. Class A white galvanised iron evaporation pan; and a sunshine recorder. Mean monthly climatic data are available from July 1973 onwards.

3.2 Streamflow

In late 1973, flow meaurements for the catchments were carried out by installing automatic pressure bulb water level recorders and supplemented by streamflow gaugings. However current meter gauging was not sensitive enough for measuring low flows and as such, it was recognized that suitable flow measuring structures were necessary to obtain reliable flow records.

A. 1.22m (4ft.) HL flume with concrete wingwalls was contstructed in early 1976 for this purpose. At the same time, pressure bulb recorders were replaced with Capricorder punch tape recorders.

While these additional works improved the flows measurements under normal and low flow conditions, flood flows were severely affected by backwater effects. Since the theoretical rating for the flume is based on free flow conditions, stream alignment works were carried out to improve the flow conditions.

In 1976, due to prolonged periods of dry weather, the extremely low streamflow levels fell below the level of the intake pipe of the recorder thereby exposing it. Therefore to enable the measurement of extreme low flows and to improve the sensitivity of the flume it was decided to replace the front portion with a 120°V—notch plate. These modifications were completed in March 1977, prior to the commencement of the Calibration Period. (Plate 3.3).

3.3 Water Quality

The collection of water quality samples began in April 1974 and is carried out once in every two weeks. All samples are taken from midstream at the surface upstream of each weir site, and sent to the Chemistry Department in Petaling Jaya for laboratory analysis as soon as practicable. The analysis covers physical parameters including suspended sediment, chemical parameters as well as BOD and COD.

4. CLIMATOLOGY

The mean monthly climatic data collected at the climate station in Pusat Penyelidikan Pertanian Tun Razak is given in Table 4.1.

It is observed that the average air temperature is 27.0°C with a maximum at 34.5°C and a minimum at 19.4°C. Relative humidity varies from an average of 98.2% measured at 7.30 a.m. in the morning to 62.6% measured at 1.30 p.m. in the afternoon. An average of 5.5 sunshine hours per day was recorded. Windrun varies from a maximum of 76 km/day to a minimum of 7 km/day. The rainfall and evaporation distributions are described in Chapter 8

5. GEOMORPHOLOGY AND SOILS

5.1 Geomorphological Description

5.1.1 *Slope Forms*

Hillslope form constitutes the basic land surface component which collectively gives expression to the morphometry of drainage basins. It also constitutes the basic response unit for the operation of drainage basin processes.

The Sungai Tekam drainage basin is locatetd in a landform region which is described by Eyles (1968) as consisting of low convex hills.Frequency analyses of slope angle in the three catchments give an average of 6°—8°. Typical profiles of valleyside slopes are characterised by slope segments rising abruptly from valley floors and immediately reaching its maximum slope before proceeding upslope to interfluve crests of gentle convexity. Maximum segments of valley-side slopes have been observed to rise up to as much as 25°. However, these are limited in occurrence. Asymmentry of valley cross-sections is noted to occur. Valley-head slopes of the three catchments are found to be different in form from valley-side slopes. Generally, such slopes consists of moderately steep rectilinear basal sections and interfluve crests of gentle convexity. A notable feature is the limited occurrence of concave slope sections in the cathments.

5.1.2 **Morphometry**

The influence of morphometric properties of drainage basins on denudational and hydrological processes of drainage basins has been generally accepted. Four morphometric parameters have been derived, namely, hypsometric integral, drainage density constant of channel maintenance and the lenght of overland flow (Table 5.1). Owing to the smallness of the three cathments (being drained only by second order streams), certain morphometric parameters such as bifurcation rations could not be computed.

The hypsometric integral provides a quantitative measure of the stage of dessection that a drainage basin has undergone. The numerical value of the integral indicates the amount of material above local base level that still remains to be removed by the denudational processes. In catchments A, B and C, similar values of the hypsometric integral were derived indicating the similar level of dissection which has been reached by the three catchments. The similarity of these integrals is significant in the sense that it justified the choice of catchments A, B and C as experimental catchments as the very concept of experimental basin necessitate that all physical parameters be similar so as to validate comparisons between control and operational catchments.

Drainage density is the total length of all the streams in the basin divided by the area. It is thus the average length of stream channel for each unit area. The constant of channel maintenance is the reciprocal of drainage density, which empirically indicates the area required to maintain each unit length of stream (Schumm, 1956). Half the value of the constant of channel maintenance gives the average horizontal distance between all the watersheds and streams within the basin. This is generally termed the length of overland flow. The speed of the unconcentrated flow overland is very much lower than when concentrated in a channel. It follows that the smaller the value of the length of overland flow, the quicker surface runoff will enter the streams. In a relatively homogeneous area, therefore, less rainfall is required to contribute a significant volume of surface runoff to stream discharge when the value of the length of overland flow is small than when it is large. This concept is used to explain partially the flashy nature of streamflow in small watersheds. The lower value of the length of overland flow in catchment B suggests a faster response to runoff should all other factors remain equal.

5.2 **Geology**

A reconnaissance geological survey of the Jengka Triangle area was done by the Geological Survey Department. The dominant rock types found in the area are andesitic tuft and andesites which occur interbedded with sedimentary rocks. These rocks are believed to be Permian in age.

The western half of the study although also consisting of amdesites and andestic tufts have been modified subsequent to their formotion by proclastic activity. The most extensive rock type is a coarse grained andesite. This is a dark greenish-grey rock. Occasionally quartz andesites are also present. The tufts have a similar composition to the andesite.

The eastern part of the study area is underlain by a variety if shales which range from iron-poor to iron rich. However ferruginous shales seem to dominate this area.

5.3 Soil Types

A total of 6 soil types have been identified as shown in Fig. 5.1. The areas and percentage of these soil types in the basin are shown below:

Soil Series	*Hectares*	*% of Study Area*
Munchong Series	190.9	53.7
Segamat Series	67.8	19.1
Katong Series	63.4	17.9
Local Alluvium	21.3	6.0
Durian Series	6.8	1.9
Chat Series	5.1	1.4
	355.3	100.0

5.3.1 Munchong Series

This type of soil is derived from iron rich shales and have a distinct oxic horizon, strong brown colour, clayey to sandy texture and moderate structure. The Munchong Series found in the Experimental Basin also has a band of fine iron concretions present at a depth of about 72-130 cm.

5.3.2 Segamat Series

This is a deep, reddish or yellowish red soil derived from andesite. It is friable, moderately fine to medium subangular blocky structure, which on crushing breaks down into a stable crumb aggregation. Despite its high clay content (normally 80-90%) it is freely-drained. Like the Munchong Series, the Segamat Series also has a high water holding capacity.

5.3.3 Katong Series

The soils have brown to dark brown, fine sandy-clay loam A horizons and yellowish brown to strong clayey B horizon. They also have a friable consistency.

5.3.4 Local Alluvium

These soils of alluvial origin but which do not have the characteristics of either Telemong or Akob are mapped as Local Alluvium. Their textures are highly varied. These are usually found on low terraces no longer subject to deposition. They may have a pale, yellowish to grey A horizon. These soils are mottled in the lower part of the profile indicating imperfect drainage.

5.3.5 Durian Series

These soils are derived from shales and silt stones and have a varied textured topsoil which grades into a heavy clay B horizon (usually having 65-85% clay) with a moderately developed medium blocky structure but frim to very firm consistency. The colour is yellow or brownish yellow in the upper part frequently becoming redder with depth. Generally Durian Series have a substantially lower field capacity than that of Munchong Series. The Durian Series, also has a smaller effective soil depth for plant growth than Segamat Series or Munchong Series. The presence of highly-weathered rocks and/or lateritic bands may limit root penetration.

5.3.6 **Chat Series**

The soils have brown to yellowish brown clay to clay-loam A horizons. The B horizons are deep and uniform with deep brown colours and clayey textures. At lower depths (71-118cm) the colour may inter-grade into yellowish red. Iron concretions were also found at greater depths. The structures are weak to moderate, medium subangular blocky with friable consistency and patchy to discontinuous clayskins on ped surfaces.

6. BOTANICAL SURVEY

6.1 Objectives

The Forestry Department and the Forest Research Institute carried out a botanical survey in catchments A, B and C before felling and in catchment B after clear felling.

The main objective of this survey is to gather information on the location, stocking, composition, distribution and condition of the standing and residual crop; and the total volume of wood in catchment B after clear felling.

6.2 Methodology

A base-line was established across each catchment and the distance marked in chains. Then, sampling lines are placed perpendicular to the base line at 5 chains apart and numbered accordingly. Along each sumpling line, sample plots were arranged in systematic order at 6 chains intervals between plot centres (Fig. 6.1).

In each plot the following diameter classes were enumerated:

(*a*) 3 × 1 chain (60.3 × 20.1m) plots ... 12″ (305mm) dbh above (big trees)
(*b*) 1 × 1 chain (20.1 × 20.1m) plots ... 6″ (152mm) to 12″ (305mm) dbh (big poles)
(*c*) ½ × ½ chain (10.1 × 10.1m) plots ... 2″ (51mm) to 6″ (152mm) dbh (small poles)
(*d*) ¼×¼ chain (5×5m) plots ... ... 5′ (1525mm) ht to 2″ (51mm) dbh (saplings)
(*e*) Linear Sampling Milliacre (LSM) ¹⁄₁₀×¹⁄₁₀ chain (2×2m) plots 6″ (152mm) ht to 5′ (1525mm) ht (seedlings)

It was found that catchment A has 48 plots (13%), catchment B 68 plots (9.3%) and catchment C 48 plots (14.7%). In catchment B where clear feeling was carried out, at 5 chain (100.5m) × 1 chain (20.1m) undisturbed plot from any burning or other activities was selected. In the plot, measurements of diameter and length were taken on logs of 5cm diameter and above. (Note: It is recognized that the boundaries for botanical survey differ slightly from the actual catchment boundaries).

6.3 Results

Results of the botanical survey in catchment A, B and C are presented in the following figures and table.

Fig. 6.2—Graph of the stocking distribution in catchment A for dipterocarps and non-dipterocarps.

Fig. 6.3—Graph of the stocking distribution in catchment B for dipterocarps and non-dipterocarps.

Fig. 6.4—Graph of the stocking distribution in catchment C for dipterocarps and non-dipterocarps.

Fig. 6.5—Graph of the stocking distribution in the 3 catchment areas for the bigger size classes for dipterocarps and non-dipterocarps.

Table 6.1—Summary sheet for stocking distribution in the 3 catchment areas.

Further, for catchment B, results are obtained as follows:

(a) Volume of wood after felling	972.0 cu. m.
(b) Volume of logs extracted	3,607.5 cu. m.
(c) Total volume of log and wood in catchment B	4,579.5 cu. m.

6.4 Description of the Vegetation

Plate 6.1 shows the typical vegetation of the basin. The forest is typically logged-over and therefore the stocking differs from the virgin condition. Most of the big trees of merchantable quality have been removed leaving behind trees mostly in the diameter size classes of 6″ (152mm) dbh. to 18″ (457mm) dbh.The majority of trees from the main canopy.There are ten times more seedlings belonging to the non dipterocarp group than that of the dipterocarps, and these seedlings from the major ground cover. Only in times of a major seed fall of the dipterocarp species could the abundance of these seedlings occur.

The survey also indicates that in every plot, there are two or more trees of diameter greater than 18″ (457mm) but less than 4 trees with diameter greater than 12″ (305mm). Apparently this shows an abundance of tall relic trees although the main canopy is scattered and broken. The stock distributions for the three catchments are some what similar.

7. SOIL FERTILITY STUDY

The objective of this study is to obtain quantitative information on the extent of the change in soil fertility resulting from chemical weathering and soil erosion when a forest is converted to a cropped area. The parameters chosen for this study include the change in soil chemical content, rate of soil erosion and rate of organic matter returned to the soil.

7.1 Soil Chemical Analysis

Soil samples were taken twice yearly for chemical analysis from the major soil series from catchments B and C. These samples were taken from soil series depths 0-5, 5-15, 15-30 and 30-60cm. The date measured include PH, organic carbon, Cation Exchange Capacity (CEC), N, P, and exchangeable K, Mg, Ca and Na. Monitoring of these data will be continued until the crop (oil palm) planted in the catchment B has reached its second year of production i.e. about Mild 1987. A comparative technique will be employed to assess the change in chemical content when a forest is converted to a cropped area.

7.2 Soil Erosion Study

A soil erosion study is being carried out for Munchong and Segamat series on four different slopes (4, 9, 16 and 25%) under the forested and deforested conditions. The deforested condition is of an area of felled trees which are then burnt, mechanically stacked, re-burnt and eventually planted with cover crop and oil palm. A pin method is employed for this study. The plot size is 10 × 15m consisting of 24 pins separated 2m apart. The plot size will be monitored will the crop in catchment B has reached its second year of production.

7.3 Organic Matter Study

Several wire nets of one metre square are used to collect the organic matter fallen to the ground from the forecast canopy in catchment A, B and C. In the case of catchment B after planting with cover crop and oil palm, the leaf litter will be hand-picked from a pre-marked one metre square area. The parameter measured include dry matter, ash, carbon, nitrogen, phosphorus, potassium, magnesium and calcium. The rates of organic matter returned from the forest and crop canopies will be monitored till the oil palm in catchment B has reached its second year of production.

8. PRELIMINARY ANALYSES

8.1 Hydrology

8.1.1 Rainfall

Maximum rainfall intensities for 15 minutes to 30 days duration for the water year 1977/78, 1978/79 and 1979/80 for each of the automatic rainfall recorders were extracted and presented in Table 8.1.

In computing the catchment rainfall, the existing network of stations does not warrant the use of the Thiessen or Isohyetal method. Instead the Arithmetic Mean method is adopted where the mean rainfall total of gauges 1 and 2 is use for catchment B, and the mean of gauges 4 and 5 is used for catchment C. For catchment A, rainfall total is represented by that recorded at gauge 2 only. The mean monthly rainfall totals for all the three catchments are given in Tables 8.2, 8.3 and 8.4.

8.1.2 Rating Curves

The stage discharge rating curves for catchments A, B and C were established by field gauging data. For catchment A and C, a single curve stage-discharge relationships were found to be adequate. However, for catchment B, as a result of significant channel storage and backwater effect, a loop type stage-discharge relationship was necessary.

Based on these rating curves, the daily discharge values were obtained. The monthly total discharge for the three catchments are also presented in Tables 8.2, 8.3 and 8.4.

8.1.3 Flow Duration Curves

Flow duration curves show the percentage of time that certain values of discharge were equalled or exceeded. For comparison purposes, the flow (specific discharge in l/s/ha) duration curves for catchment A, B and C were drawn (Fig. 8.1). It is interesting to note that the curves for catchments A and B run fairly close together whereas the curve for catchment C is comparatively higher.

8.1.4 Unit Hydrographs

The average one-hour unit hydrographs for catchments A, B and C were derived from the simple flood hydrographs. The 1979 flood which is the largest recorded flood for the basin is excluded due to its complexity and possible inundation with backwater effects. The unit hydrographs were shown in Fig. 8.2.

It is observed that the unit hydrographs for catchment A and C show a peak discharge of 0.166 l/s and 0.180 l/s, and a time of concentration of 3½ hours and 2½ hours respectively. The unit hydrogarph of catchment B has a much smaller peak discharge of 0.078 l/s. and a longer time of concentration of 7 hours. This is due to the backwater effect experienced at the flow measuring structure in catchment B.

8.1.5 Master Depletion Curves

Based on flow data over the three years, the method of super-positioning of the recession limb of flow hydrographs of varying magnitudes on semi-log paper was used to obtain the master depletion curves for catchments A, B and C. Their linear plots are shown in Fig. 8.3. The equations of master depletion curve for the three catchments are listed below:

Catchment A	$q_t = q_o e^{-0.181t}$
Catchment B	$q_t = q_o e^{-0.184t}$
Catchment C	$q_t = q_o e^{-0.108t}$

Again it is observed that the curves for catchments A and B show the same characteristics whereas the curve for catchment C is more gentle.

8.1.6 Monthly Water Balance

Using a pan coefficient of 0.8 (Scarf 1976), monthly forest evapotranspiration values were obtained from observed pan evaporation values. The monthly water balance based only on rainfall, runoff and forest evapotranspiration was computed as shown in Tables 8.2, 8.3 and 8.4. The average monthly water balance over the three years is given in Table 8.5.

From these tables, it is observed that the average annual total rainfall for catchments A, B and C are 1751mm, 1798mm and 1791mm respectively, while the average annual total discharge are 277mm, 290mm and 350.7mm respectively. The average annual total evapotranspiration for all three catchments is 999mm. The average monthly rainfall and discharge distribution follows a similar cycle over the year, with the maximum occuring in the months of October and November and the minimum occurring in the month February and August. On some occasions such as July/77, August/77 and September/77, the streams dried up. The average monthly evapotranspiration reaches a miximum in the month of March and a minimum in the months of November, December and January For the average monthly water balance, the maximum surplus is encountered in the month of ctober while the maximum deficit occurs in the month of February.

Is it apparent that an average of 475mm, 509mm and 441mm of water was unaccounted for yearly in Catchment A, B, and C respectively. Some of the possible reasons for such losses are the existence of deep percolation, lateral seepage and also the underestimation of forest evapotranspiration. The last reason is suspected because previous studies on evaporation (Scarf, 1976) shows that the annual open water evaporation and annual potential forest evapotranspiration at Sungai Tekam are 1890mm and 1650mm respectively.

8.2 Water Quality

Results of the analyses of water quality are shown in Table 8.6, 8.7 and 8.8. Table 8.9 summarises the mean values of the parameters measured during the periods 1977/1978, 1978/1979 and 1979/1980.

In general, the waters of the three catchments A, B and C are clean and unpolluted with respect to the suggested stream standards (Table 8.9). Statistical analysis, by the one way analysis of variance, of the data showed that there was no significant difference ($\propto = 0.05$) in the quality of water between the three catchments for the parameters-conductivity, Biochemical Oxygen Demand (B.O.D.), chemical Oxygen Demand (C.O.D.), dissloved solids, suspended solids, phosphate, ammonia, nitrate, alkalinity, chloride, iron, magnesium, sodium, manganese, silica and calcium.

pH was significantly different at $\propto = 0.05$ but was not significant at $\propto = 0.01$. In general waters of the three catchments were acidic showing mean values ranging from 5.8 to 6.7. This characteristic, however, is normal of rivers in Peninsular Malaysia.

Sulphate content of water between the three catchments was significantly different at $\propto = 0.01$. This difference is likely to be attributed to errors in sampling, as examination of the data revealed extremely high values for some of the samples.

Iron content of water from all the three catchments was found to be high-mean over the period 1977/1980 ranged from 3.1 mg/1 to 4.2 mg/1. The high values are to be expected in view of the peculiar geological reatures reminiscent of Peninsular Malaysia, where soils are generally rich in iron. Such waters when used for potable purposes may cause problems of taste and discoloration.

8.3 Sedimentation

In the measurement of stream sediment loads and yields, sampling from a wide range of flow conditions is essential. For the three catchments A, B and C sediment samples were taken from flows ranging from 0.21 liters/sec. to 160 litres/sec.

Suspended sediment concentrations were low (less than 112 mg/1) with a range of 21-112 mg/1, 31-110 mg/1 and 28-90 mg/1 for catchment A, B and C respectively. The concentration of dissolved solids ranging from 19-66 mg/1, 41-72 mg/1 and 25-65 mg/1 for catchment A, B and C respectively were on the average lower than those of suspended sediment.

Suspended sediment load was higher than dissolved load in each of the catchments, comprising 58%, 65% and 59% of the total sediment load transported in catchments A, B and C respectively. This suggests the relatively greater significance of mechanical over chemical denudation. Nevertheless, dissolved solids constitute approximately 35-42% of the total sediment load and must be taken into account in any study of stream sediment yield.

Sediment data for catchments A, B and C are given in Table 8.7, 8.8 and 8.9 respectively.

9. EVALUATION AND RECOMMENDATION

9.1 Hydrology

In the monthly water balance analysis, it was found that about 475 mm of water was "lost" annually. To account for this "loss", the establishment of deep groundwater wells and the installation of another evaporation pan are recommended. The deep groundwater wells are essential for an understanding of some characteristics of groundwater flow in the catchments. On the other hand, an additional evaporation pan is necessary to verify the present recorded values, which are well below the values obtained from D.I.D. Water Resources Publication No. 5 (Scarf, 1976).

It is also recommended that studies on infiltration and erosion for the three catchments be carried out to determined the changes (if any) in infiltration and erosion rates before and after logging.

High streamflow gaugings should be carried out on a continuous basis (i.e. from rising to falling) to enhance the reliability of the rating curves.

9.2 Water Quality

Generally, water in the Basin is suitable for irrigation municipal water supply and the propagation of fish and other aquatic wild life.

Continuous monitoring of water quality is recommended to confirm the suitability of water in the Basin. In addition, sampling errors which might be the cause of the erratic sulphate content of water in the three catchments, should be minimised.

9.3 Sedimentation

Sediment sampling should be carried out in a wide range of streamflow conditions, especially during lowflow and highflow conditions, simply to ensure that the data collected are more representative.

10. REFERENCES

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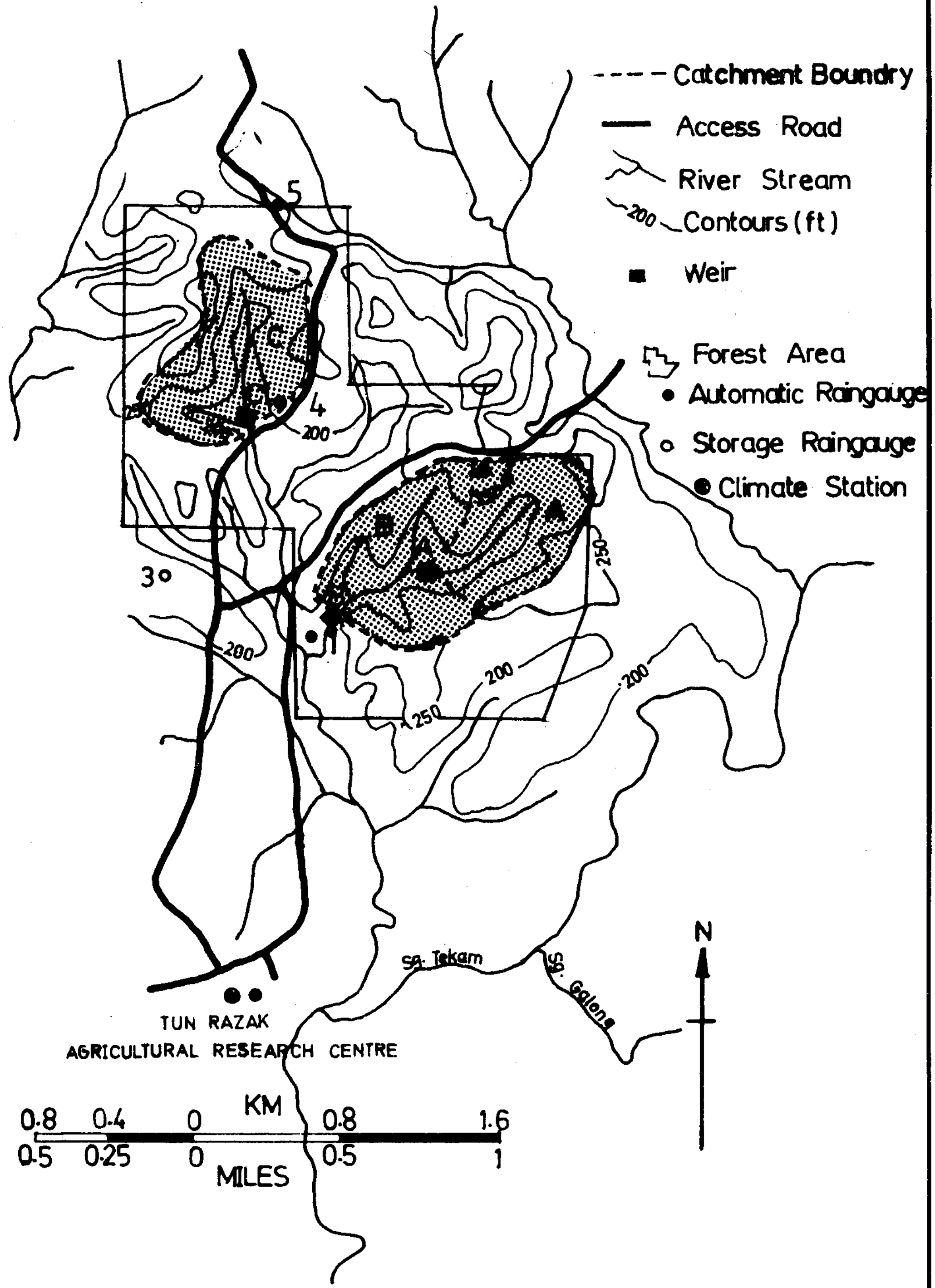


FIG. 2·1 SG.TEKAM EXPERIMENTAL BASIN LOCATION MAP

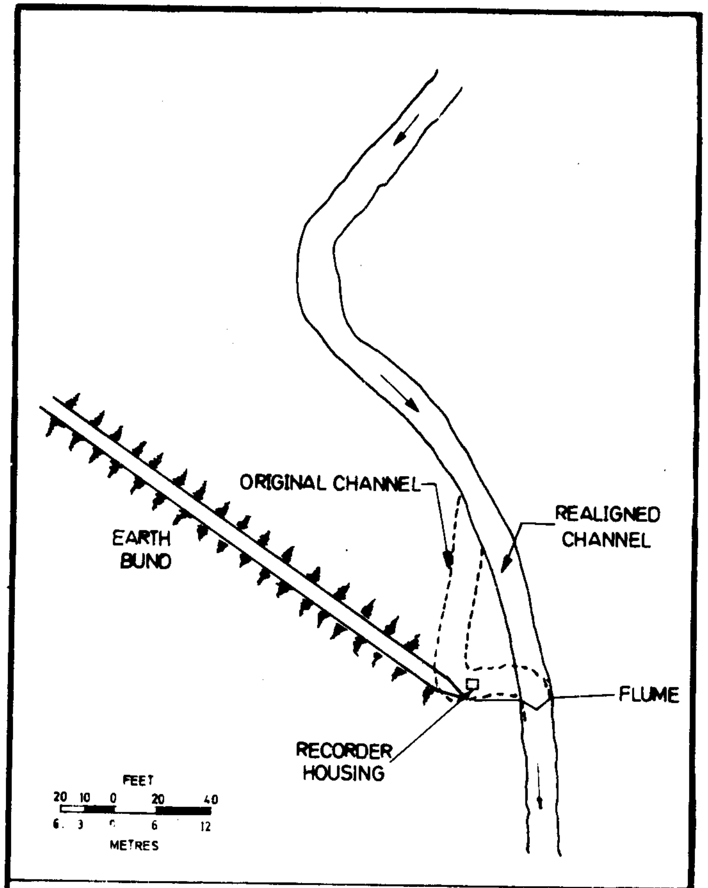


Fig. 2.2 LOCATION MAP
CHANNEL DEVIATION
BASIN A, SG.TEKAM

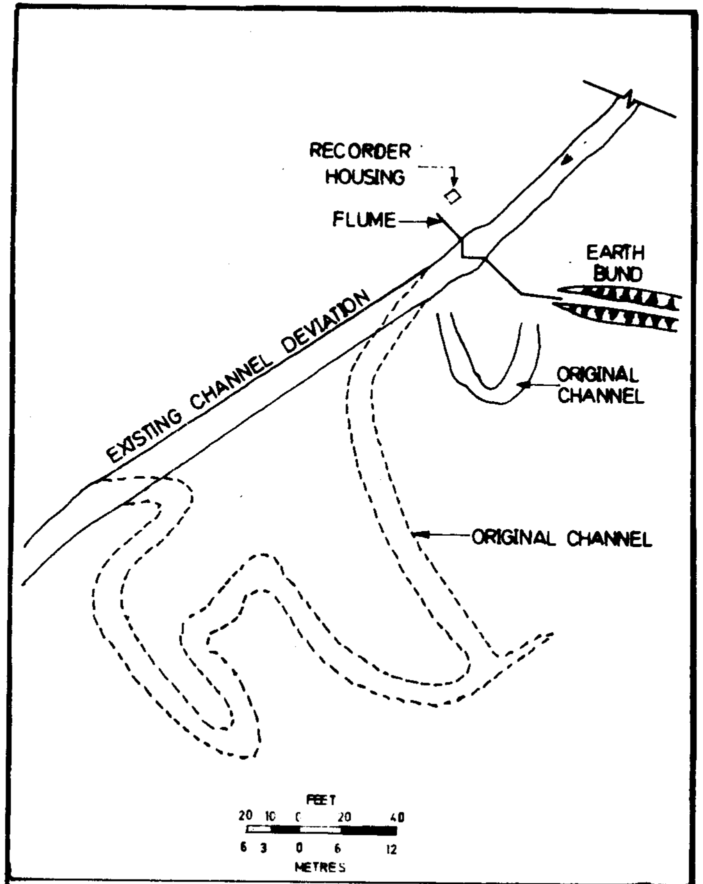


Fig. 2.3 LOCATION MAP
CHANNEL DEVIATION
BASIN B, SG.TEKAM

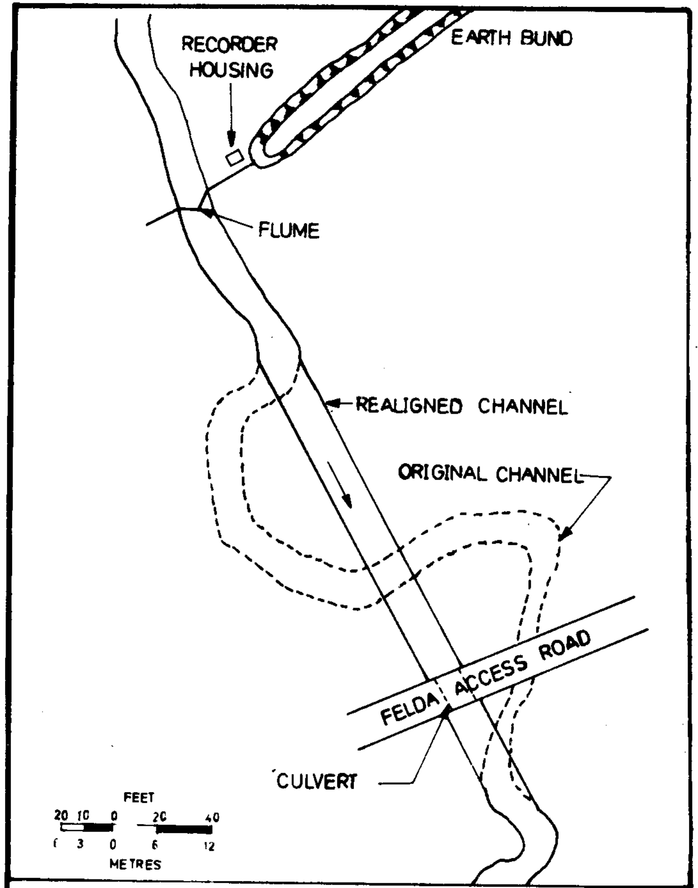
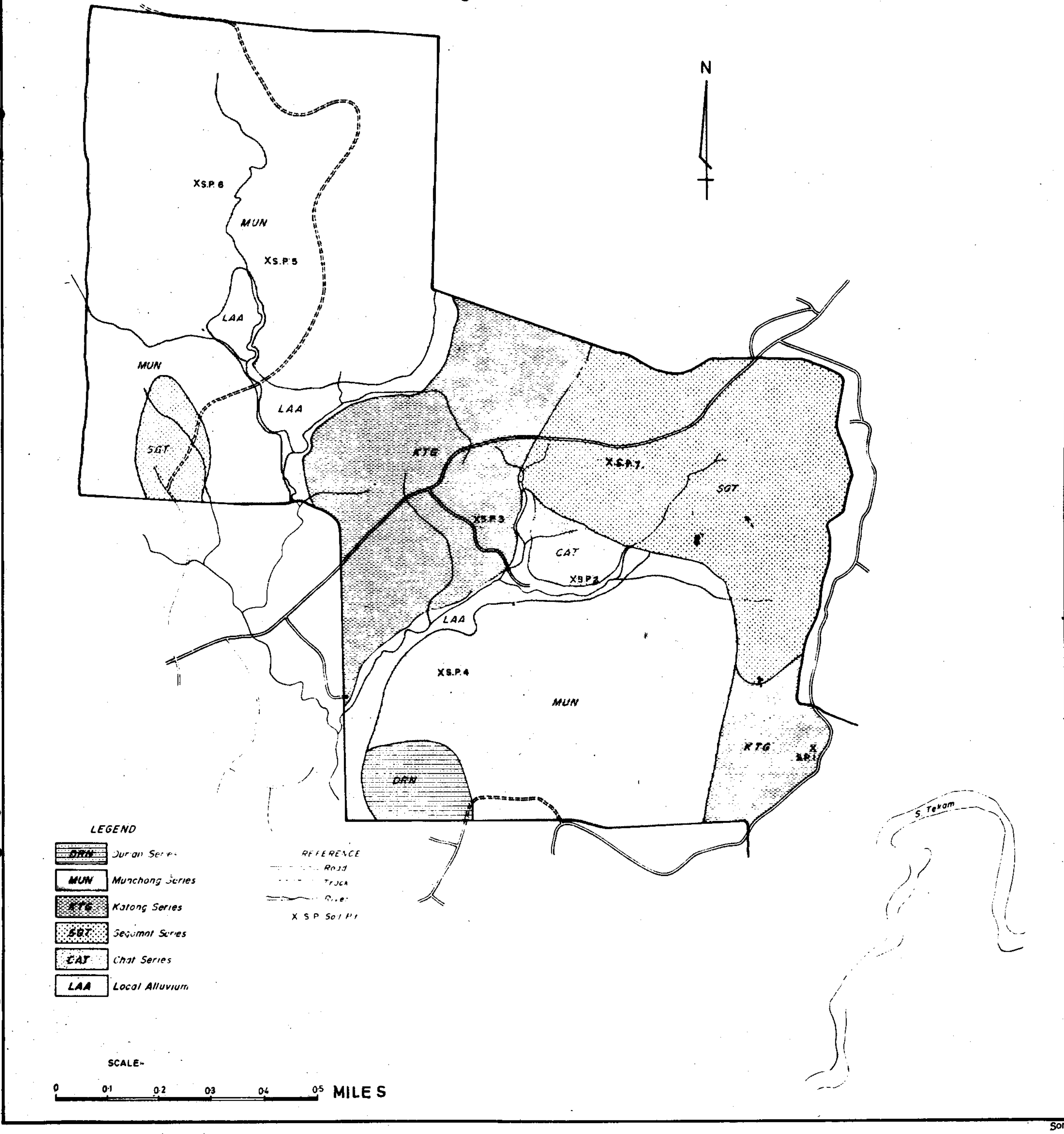


Fig. 2.4 LOCATION MAP
STREAM REALIGNMENT
BASIN C, SG.TEKAM

Fig. 5.1 SOIL MAP OF SG. TEKAM EXPERIMENTAL BASIN



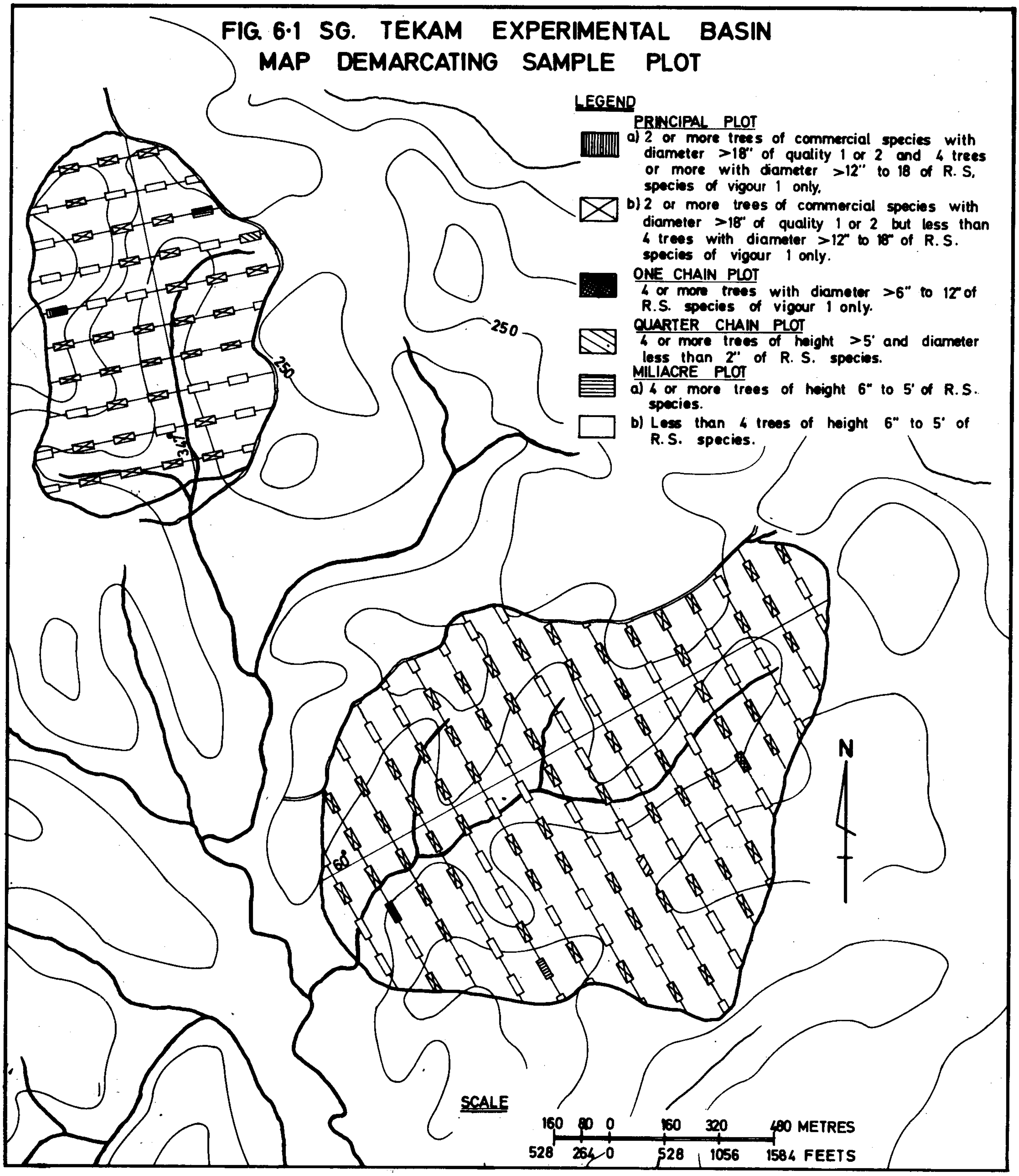


FIG. 6·1 SG. TEKAM EXPERIMENTAL BASIN
MAP DEMARCATING SAMPLE PLOT
LEGEND
PRINCIPAL PLOT
a) 2 or more trees of commercial species with diameter >18" of quality 1 or 2 and 4 trees or more with diameter >12" to 18 of R. S. species of vigour 1 only.
b) 2 or more trees of commercial species with diameter >18" of quality 1 or 2 but less than 4 trees with diameter >12" to 18" of R. S. species of vigour 1 only.
ONE CHAIN PLOT
4 or more trees with diameter >6" to 12" of R.S. species of vigour 1 only.
QUARTER CHAIN PLOT
4 or more trees of height >5' and diameter less than 2" of R. S. species.
MILIACRE PLOT
a) 4 or more trees of height 6" to 5' of R. S. species.
b) Less than 4 trees of height 6" to 5' of R. S. species.
250
250
347°
60°
N
SCALE
160 80 0 160 320 480 METRES
528 264 0 528 1056 1584 FEETS

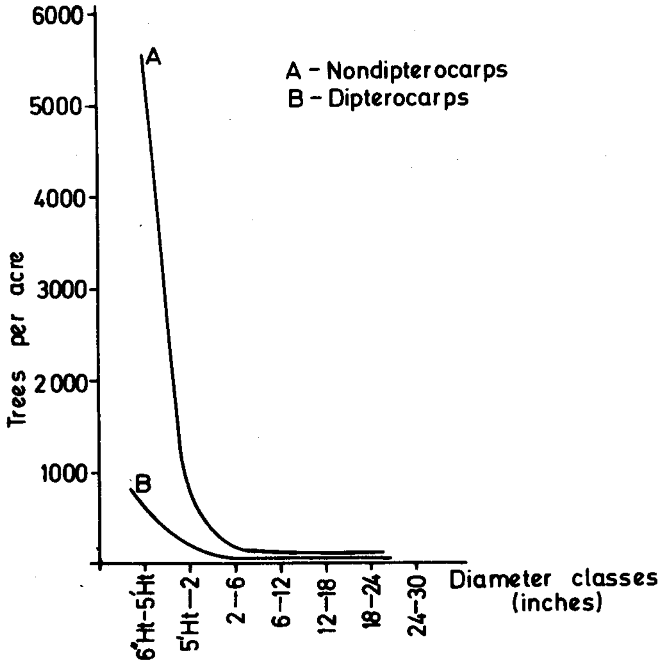


Fig.6·2 Stocking distribution in Catchment A for dipterocarps and nondipterocarps

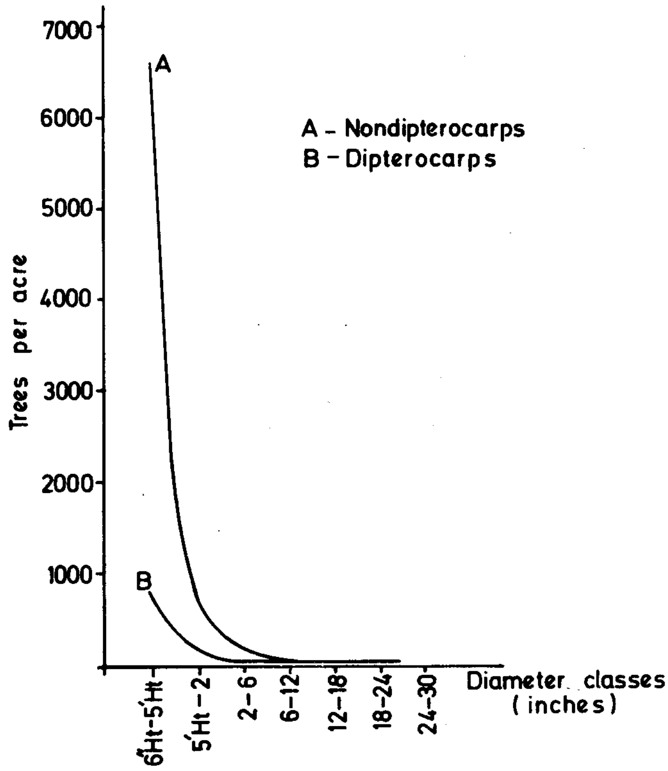


Fig.6·3 Stocking distribution in Catchment B for dipterocarps and nondipterocarps

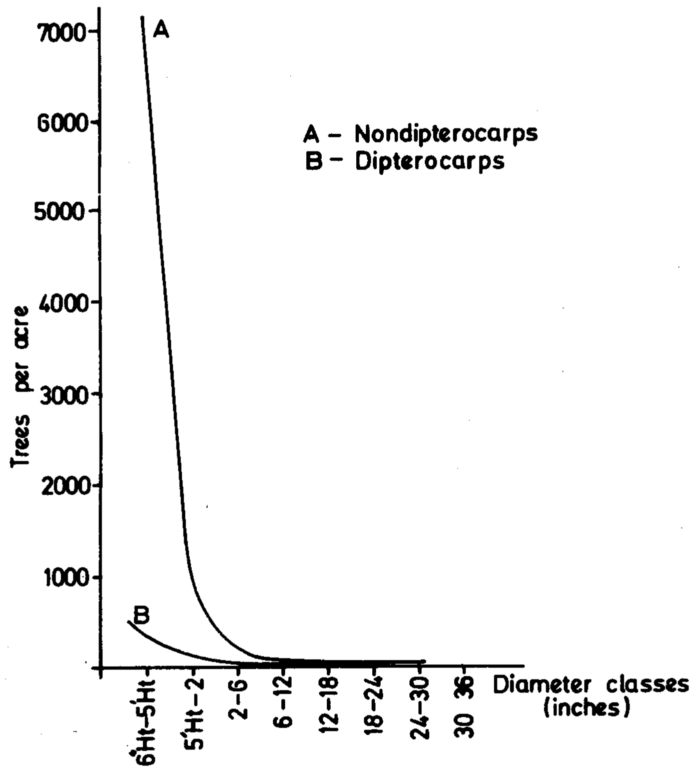


Fig.6·4 Stocking distribution in Catchment C for dipterocarps and nondipterocarps

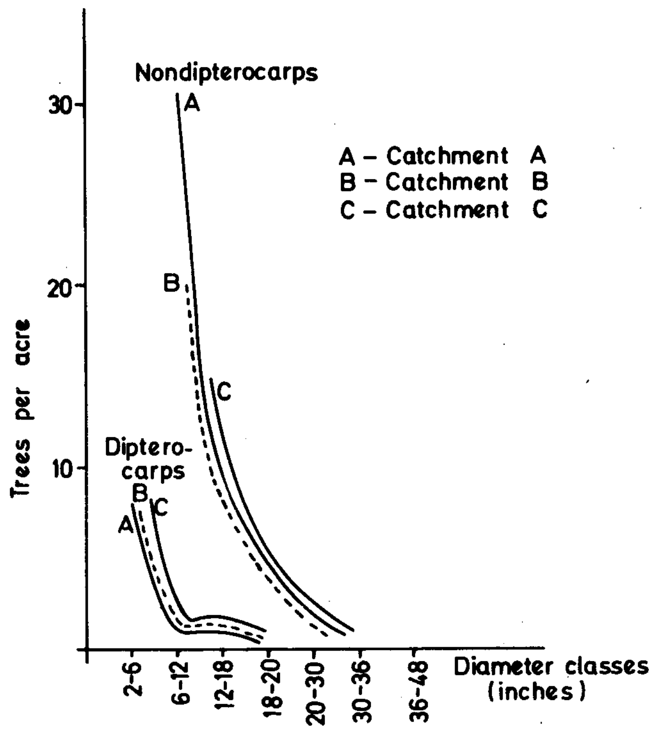


Fig.6·5 Stocking distribution in the 3 catchment areas for the bigger size classes for dipterocarps and nondipterocarps

FIG.8·1 FLOW DURATION CURVES FOR CATCHMENTS A,B,C.

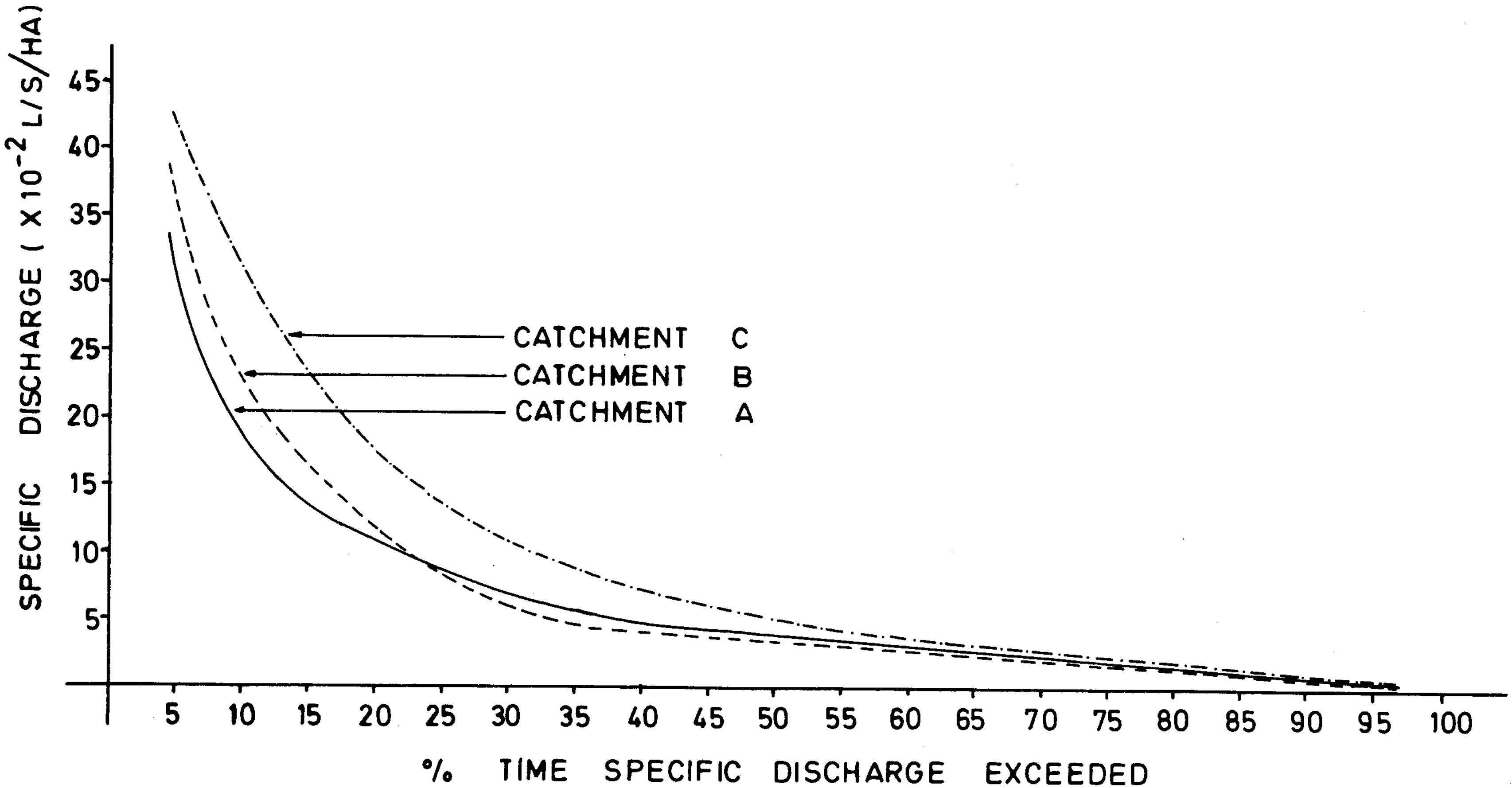


FIG. 8·2 1 HOUR UNIT HYDROGRAPHS OF CATCHMENTS A, B, C.

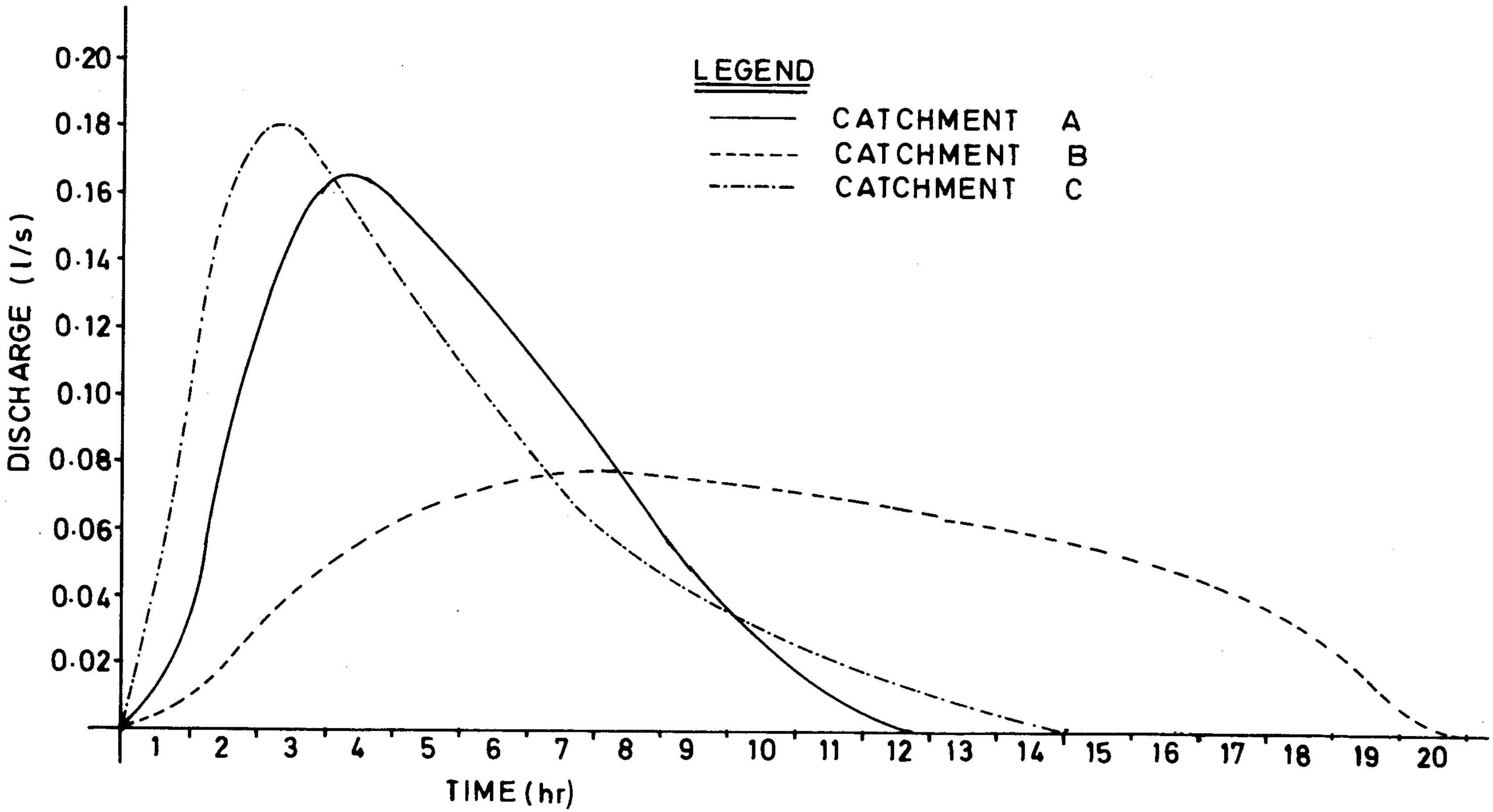


FIG 8·3 MASTER DEPLETION CURVES FOR CATCHMENTS A,B,C.

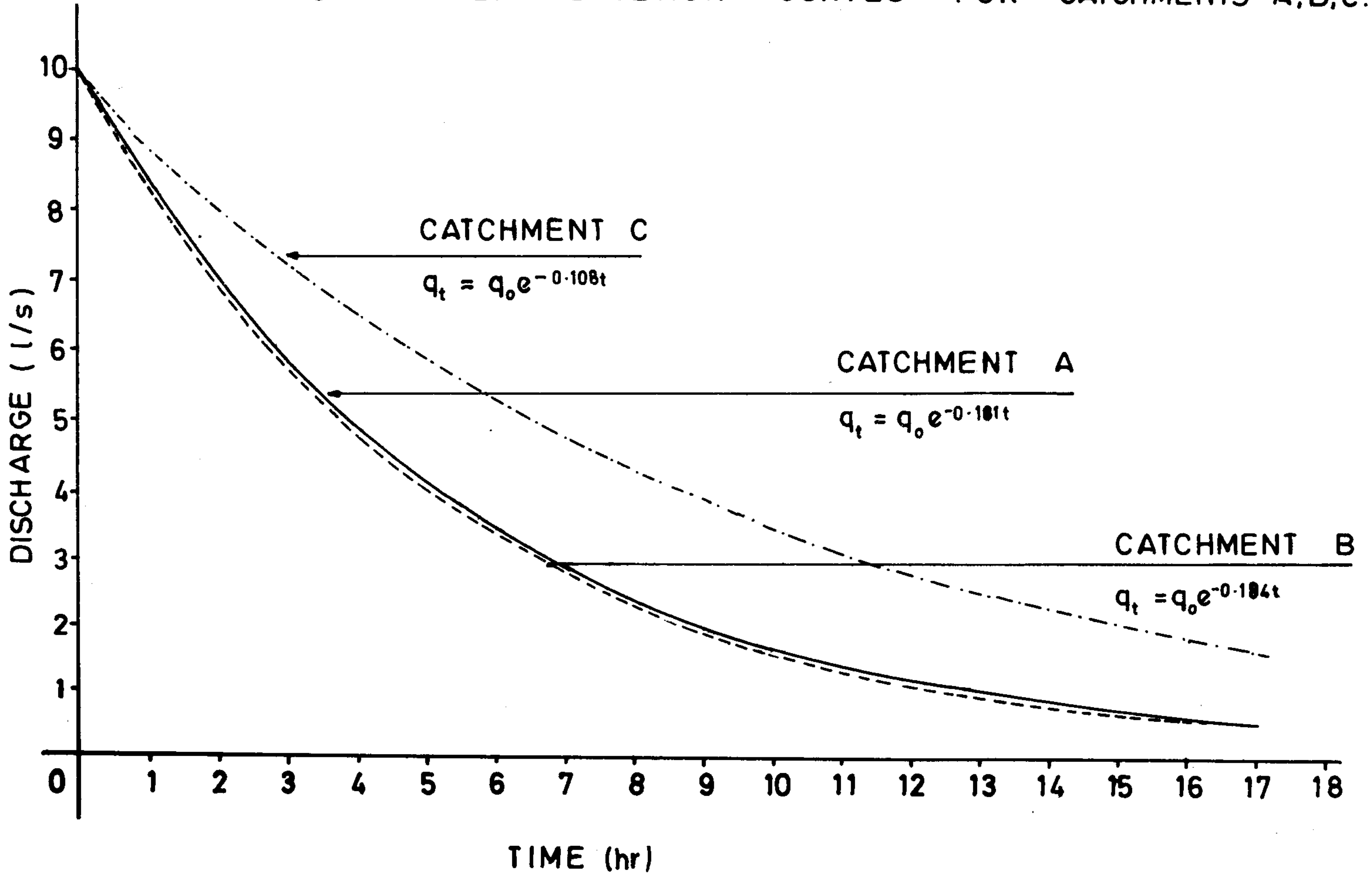


PLATE 2.1—Aerial View of Sungei Tekam Experimental Basin

Showing Catchment A (right foreground)
Catchment B (left foreground)
Catchment C (left background)

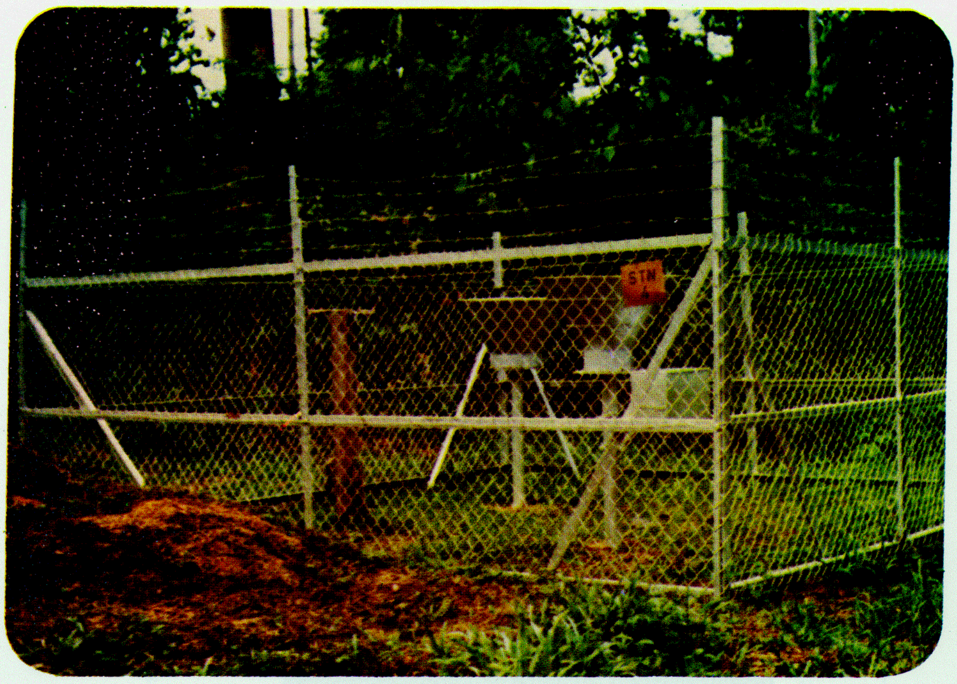


PLATE 3.1—A Typical Rainfall Station

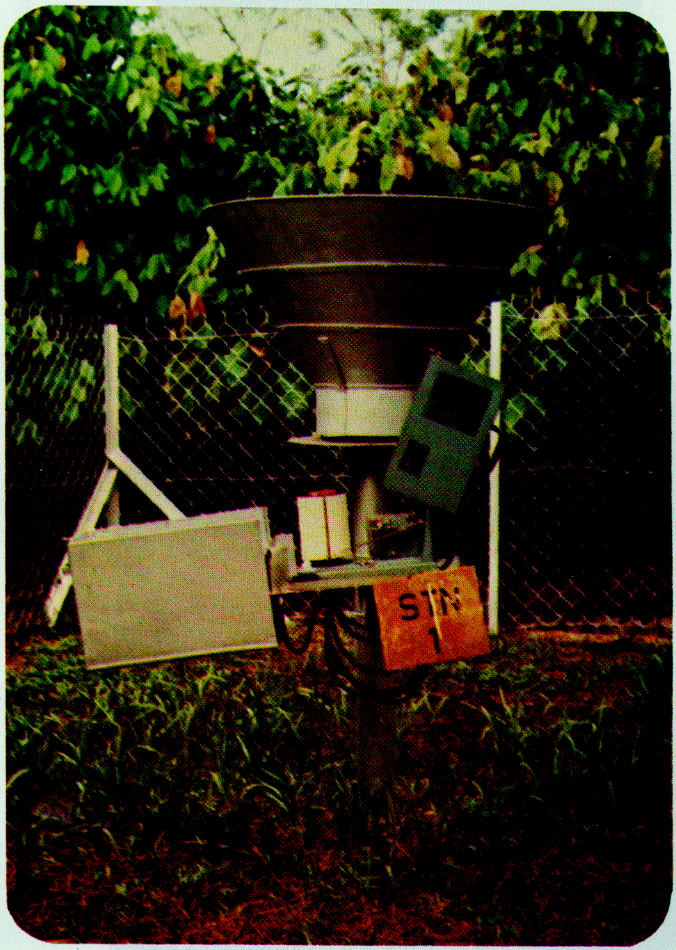


PLATE 3.2—A Typical Automatic Rainfall Recorder

PLATE3.3—A TYPICAL GAUGING STATION
(CALIBRATION BY VOLUMETRIC METHOD IN PROGRESS)

PLATE 6.1—Typical Vegetation of the Basin
(View of Site a Looking Towards Site B)

TABLE 4.1

MEAN MONTHLY CLIMATIC DATA (PPPTR)

Month/Year	Air Temperature, °C Max	Min	Mean	Wet and Dry Bulb Temperature 7.30 a.m. Wet	Dry	RH%	1.30 p.m. Wet	Dry	RH%	Total Sunshine Hours	Average Sunshine hr/day	Rainfall Mean (mm)	Windurn (km/day)	E. Pan (mm)
7/77	33.7	21.5	27.6	22.8	23.1	97	25.5	32.5	55	207.9	6.7	18.7	76	129.5
8/77	32.7	21.3	27.0	23.3	23.6	97	24.8	30.6	61	165.2	5.3	193.1	67	133.1
9/77	32.9	21.6	27.2	22.8	22.9	99	25.2	31.1	57	150.6	5.0	127.8	59	108.8
10/77	32.0	22.0	27.0	23.2	23.5	97	25.8	31.3	63	178.2	5.7	252.5	64	120.4
11/77	30.8	21.1	25.9	22.8	23.1	97	25.4	29.6	70	118.4	3.9	227.2	60	84.7
12/77	30.9	21.0	25.9	22.0	22.2	98	25.1	29.7	67	152.9	4.9	120.6	66	87.9
1/78	30.8	20.7	25.7	21.5	21.7	98	25.1	29.6	68	144.6	4.7	171.5	64	80.4
2/78	32.2	20.4	26.3	21.1	21.3	98	25.0	30.9	61	195.7	7.0	108.1	76	93.3
3/78	33.6	21.9	27.7	22.8	22.9	99	25.9	32.6	57	215.1	6.9	159.3	68	159.8
4/78	33.8	22.3	28.0	23.1	23.3	98	26.1	32.7	58	224.5	7.4	522.1	67	125.7
5/78	33.0	23.1	28.0	23.8	23.9	99	26.8	30.7	73	178.6	5.8	150.3	56	97.1
6/78	33.0	22.5	27.7	23.3	23.4	99	26.2	32.1	66	153.6	5.1	120.9	53	95.5
7/78	32.0	21.7	26.8	22.5	22.6	99	25.8	31.0	65	153.6	4.9	174.0	53	103.7
8/78	31.7	22.1	26.9	22.8	22.9	99	25.7	30.8	65	121.7	3.9	47.5	48	82.3
9/78	32.4	21.5	26.9	22.7	22.9	98	25.7	31.5	61	165.9	5.5	125.3	58	102.7
10/78	32.2	21.3	26.7	22.9	23.0	99	25.5	31.0	63	151.0	4.9	203.1	61	101.0
11/78	31.7	21.6	26.6	22.9	23.1	98	25.6	30.6	66	150.3	5.0	231.9	56	90.7
12/78	30.4	20.1	25.2	21.9	22.0	99	24.9	29.2	69	162.2	5.2	256.5	54	73.9
1/79	31.4	19.4	25.4	20.9	21.0	99	25.1	30.1	65	198.7	6.4	64.9	58	84.1
2/79	33.2	20.9	27.0	21.6	21.8	98	26.0	31.9	61	175.8	6.3	42.0	69	97.3
3/79	34.5	20.7	27.6	22.0	22.2	98	25.9	33.0	55	185.9	6.0	40.9	67	129.1
4/79	33.7	22.6	28.1	23.3	23.4	99	26.6	32.1	63	155.5	5.2	132.7	61	110.5
5/79	34.2	22.5	28.3	23.4	23.7	97	26.6	32.7	61	201.8	6.5	140.1	54	119.8
6/79	32.8	22.4	27.6	23.1	23.3	98	26.3	31.7	64	169.2	5.6	187.6	54	116.8
7/79	32.3	22.0	27.1	22.6	22.7	99	25.8	30.8	66	156.7	5.0	251.4	53	104.4
8/79	33.4	21.6	27.5	23.0	23.1	99	25.9	32.3	58	193.8	6.2	69.3	53	112.9
9/79	32.6	21.6	27.1	22.8	23.0	98	25.7	31.5	61	161.0	5.4	148.8	52	105.8
10/79	32.2	21.7	26.9	23.1	23.3	98	25.9	31.3	63	125.1	4.0	392.8	40	114.7
11/79	30.2	22.4	26.3	23.1	23.3	98	25.3	28.8	75	83.9	2.8	345.5	33	66.2
12/79	31.3	20.2	25.7	21.3	21.5	98	24.4	30.1	61	168.9	5.4	36.2	35	81.0
1/80	31.8	20.2	26.0	20.9	21.1	98	24.3	30.6	57	182.3	5.9	65.4	32	93.3
2/80	32.8	20.6	26.7	21.2	21.4	98	24.6	31.4	55	151.3	5.4	48.3	48	99.8
3/80	33.5	21.6	27.5	22.2	22.3	99	25.7	33.5	52	189.8	6.1	163.6	34	134.6
4/80	33.4	21.7	27.5	23.2	23.3	99	26.2	31.8	63	171.0	5.7	268.9	18	107.4
5/80	33.8	22.8	28.3	24.1	24.3	98	26.9	32.1	65	192.9	6.2	92.9	7	108.0
6/80	33.3	22.9	28.1	23.7	24.1	97	26.9	32.0	65	155.4	5.2	63.2	10	90.9

TABLE 5.1

MORPHOMETRIC PROPERTIES OF SUNGEI TEKAM EXPERIMENTAL BASIN

Catchment	*Drainage Density (m/ha)*	*Hypsometric Integral*	*Constant of Channel Maintenance*	*Lenght of overland flow (m)*
A	43.34	0.36	230	115
B	46.55	0.26	214	107
C	36.98	0.38	270	135

TABLE 8.1

RAINFALL INTENSITY (mm)

Station No. Year	3825001			3925001			3925003			3925004		
	77/78	78/79	79/80	77/78	78/79	79/80	77/78	78/79	79/80	77/78	78/79	79/80
Duration												
15 min	29	19	18	40	49	29	41	27	30	40	31	28
30 min	43	31	31	56	49	42	46	41	42	46	42	38
1 hour	66	58	50	72	59	49	65	69	54	68	65	60
2 hour	82	70	70	92	60	69	84	71	75	82	72	72
3 hour	87	71	72	94	60	77	88	72	84	83	72	79
6 hour	91	71	76	101	60	83	98	72	102	91	73	96
12 hour	93	71	90	101	60	88	99	72	109	100	73	106
24 hour	104	99	93	108	86	91	115	94	111	103	102	108
48 hour	107	108	123	109	90	127	116	104	127	107	114	127
72 hour	129	108	155	121	91	160	116	105	159	113	122	150
5 days	132	123	175	140	100	186	119	118	184	118	135	199
7 days	132	151	218	141	117	220	139	128	247	138	142	228
14 days	200	188	330	228	178	248	188	166	371	216	168	268
30 days	314	273	475	327	258	372	291	275	500	296	281	382

TABLE 8.2

MONTHLY WATER BALANCE JULY 1977-JUNE 1978

Catchment	Month / Parameter	July	August	September	October	November	December	January	February	March	April	May	Jun	Annual Total
A	P	24.5	184.5	127.5	225.5	225.5	114.5	165.5	103.5	162.5	190.0	119.0	120.5	1763.0
	Q	0.0	0.0	0.0	17.4	38.7	19.4	25.1	12.2	12.1	14.7	11.9	7.5	159.0
	E	103.6	106.5	87.0	96.3	67.8	70.3	64.3	74.6	127.8	100.6	77.7	76.4	1052.9
	P-Q-E	−79.1	78.0	40.5	111.8	119.0	24.8	76.1	16.7	22.6	74.7	29.4	36.6	551.1
B	P	16.0	188.0	145.0	282.5	228.5	114.0	162.0	94.0	155.0	202.1	142.0	106.7	1835.8
	Q	0.0	0.1	0.0	16.5	35.1	13.1	26.8	7.3	13.7	15.3	15.3	2.2	145.3
	E	103.6	106.5	87.0	96.3	67.8	70.3	64.3	74.6	127.8	100.6	77.7	76.4	1052.9
	P-Q-E	−87.6	81.4	58.0	169.7	125.6	30.6	70.9	12.1	13.5	86.2	49.0	28.1	637.6
C	P	15.0	203.5	108.5	225.0	224.9	123.9	173.0	106.5	150.7	162.5	172.3	126.2	1792.0
	Q	0.0	0.0	0.0	23.7	74.2	21.9	38.3	14.0	26.6	37.1	50.4	13.2	299.4
	E	103.6	106.5	87.0	96.3	67.8	70.3	64.3	74.6	127.8	100.6	77.7	76.4	1052.9
	P-Q-E	−88.6	97.0	21.5	105.0	82.9	31.7	70.4	17.9	−3.7	24.8	44.2	36.6	439.7

P—precipitation (mm).
Q—runoff (mm).
E—forest evapotranspiration (mm).

TABLE 8.3

MONTHLY WATER BALANCE JULY 1978-JUNE 1979

Catchment	*Month* / *Parameter*	*July*	*August*	*September*	*October*	*November*	*December*	*January*	*February*	*March*	*April*	*May*	*Jun*	*Annual Total*
A	P	169.0	44.0	107.5	204.0	267.2	174.5	55.0	30.5	30.6	126.5	85.0	182.0	1475.8
	Q	19.9	8.0	1.3	13.2	27.0	49.3	30.2	16.5	3.2	0.0	0.0	3.2	171.8
	E	83.0	65.8	82.2	80.8	72.6	59.1	67.3	77.8	103.3	88.4	95.8	93.4	969.5
	P-Q-E	66.1	−29.8	24.0	110.0	167.6	66.1	−42.5	−63.8	−75.9	38.1	−10.8	85.4	334.5
B	P	184.0	44.5	106.5	202.5	225.5	249.5	60.5	25.5	58.1	138.5	106.5	208.5	1610.1
	Q	19.8	2.9	0.2	6.7	33.6	75.3	37.3	5.0	0.4	0.1	0.0	6.3	187.6
	E	83.0	65.8	82.2	80.8	72.6	59.1	67.3	77.8	103.3	88.4	95.8	93.4	969.5
	P-Q-E	81.2	−24.2	24.1	115.0	119.3	115.1	−44.1	−57.3	−45.6	50.0	10.7	108.8	453.0
C	P	158.5	44.7	122.7	203.0	220.0	265.2	68.2	45.5	44.0	162.4	113.7	204.3	1652.1
	Q	13.2	10.4	6.6	15.4	27.8	57.7	32.6	8.4	2.4	1.9	4.5	12.1	193.0
	E	83.0	65.8	82.2	80.8	72.6	59.1	67.3	77.8	103.3	88.4	95.8	93.4	969.5
	P-Q-E	62.3	−31.5	33.9	106.8	119.6	148.4	−31.7	−40.7	−61.7	72.1	13.4	98.7	489.6

P—precipitation (mm).
Q—runoff (mm).
E—forest evapotranspiration (mm).

TABLE 8.4

MONTHLY WATER BALANCE JULY 1979-JUNE 1980

Catchment	*Month* / *Parameter*	*July*	*August*	*September*	*October*	*November*	*December*	*January*	*February*	*March*	*April*	*May*	*Jun*	*Annual Total*
A	P	272.8	75.0	120.5	391.0	366.5	33.0	85.0	48.0	177.5	280.0	95.0	69.5	2013.8
	Q	12.9	1.7	5.8	64.5	264.9	59.3	31.7	3.8	10.3	24.2	13.2	6.8	499.1
	E	83.5	90.3	84.6	91.8	53.0	64.8	74.6	79.8	107.7	85.9	86.4	72.7	975.1
	P-Q-E	176.4	−17.0	30.1	234.7	48.6	−91.1	−21.3	−35.6	59.5	169.9	−4.6	−10.0	539.6
B	P	270.5	59.9	141.0	418.0	336.0	42.0	57.5	57.5	160.0	256.5	73.0	76.0	1947.5
	Q	27.5	0.9	3.3	100.6	331.4	30.7	8.0	0.6	2.0	24.2	7.4	0.3	536.9
	E	83.5	90.3	84.6	91.8	53.0	64.8	74.6	79.8	107.7	85.9	86.4	72.7	975.1
	P-Q-E	159.5	−31.7	53.1	225.6	−48.4	−53.5	−25.1	−22.9	50.3	146.4	−20.8	3.0	435.5
C	P	237.6	77.05	147.7	379.7	343.9	30.0	61.2	50.2	188.2	256.0	86.0	70.7	1928.2
	Q	35.3	11.6	14.9	152.9	234.8	57.4	13.5	0.4	0.6	27.3	10.9	0.1	559.7
	E	83.5	90.3	84.6	91.8	53.0	64.8	74.6	79.8	107.7	85.9	86.4	72.7	975.1
	P-Q-E	118.8	−24.9	48.2	135.0	56.1	−92.2	−26.9	−30.0	79.9	142.8	−11.3	−2.1	393.4

P—precipitation (mm)

Q—runoff (mm)

E—forest evapotranspiration (mm)

TABLE 8.5

AVERAGE MONTHLY WATER BALANCE JULY 1977-JUNE 1980

Catchment	Month / Parameter	July	August	September	October	November	December	January	February	March	April	May	Jun	Annual Total
A	P	155.4	101.2	118.5	273.5	286.4	107.3	101.8	60.7	123.5	198.8	99.7	124.0	1750.8
	Q	10.9	3.2	2.4	31.7	110.2	42.7	29.0	10.8	8.5	13.0	8.4	5.8	276.6
	E	90.0	87.5	84.6	89.6	64.5	64.7	68.7	77.4	112.9	91.6	86.6	80.8	998.9
	P-Q-E	54.5	10.4	31.5	152.2	111.7	−0.1	4.1	−27.5	2.1	94.2	4.7	37.3	475.0
B	P	156.8	97.3	130.8	301.0	263.3	135.2	93.3	59.0	124.4	199.0	107.2	130.4	1797.7
	Q	15.8	1.3	1.2	41.3	133.4	39.7	24.0	4.3	5.4	13.2	7.6	2.9	290.1
	E	90.0	87.5	84.6	89.6	64.5	64.7	68.7	77.4	112.9	91.6	86.6	80.8	998.9
	P-Q-E	51.0	8.5	45.1	170.1	65.5	30.7	0.6	−22.7	6.1	94.2	13.0	46.6	508.7
C	P	137.0	108.4	126.3	269.2	262.9	139.7	100.8	67.7	127.6	193.6	124.0	133.7	1790.6
	Q	16.2	7.3	7.2	64.0	112.3	45.7	28.1	7.6	9.9	22.1	21.9	8.5	350.8
	E	90.0	87.5	84.6	89.6	64.5	64.7	68.7	77.4	112.9	91.6	86.6	80.8	998.9
	P-Q-E	30.8	13.5	34.5	115.6	86.2	29.3	3.9	−17.6	4.8	79.9	15.4	44.4	440.7

P—precipitation (mm).
Q—runoff (mm).
E—forest evapotranspiration (mm).

TABLE

WATER QUALITY DATA

Parameter / Sampling Date	Total Solids (mg/l)	Suspended Solid (mg/l)	Dissolved Solid (mg/l)	Conductivity (Umhos/cm)	pH	Alkalinity (ppm $CaCO_3$)
2-11-77	149	12	137	160	5.8	15
1-12-77	155	5	150	90	5.4	19
7-12-77	134	25	109	90	5.8	17
28-12-77	120	11	109	85	5.5	25
14-1-78	168	3	165	70	5.7	19
14-2-78	118	15	103	90	6.0	32
22-2-78	163	39	124	95	6.4	30
23-3-78	142	22	120	75	5.9	36
29-3-78	113	7	106	100	6.1	48
5-4-78	124	30	94	85	5.6	33
26-4-78	168	32	136	80	6.1	24
3-5-78	194	23	171	65	5.2	24
24-5-78	161	47	114	65	5.9	26
28-6-78	155	6	149	100	6.3	28
MEAN VALUE	147.4	19.8	127.6	89.3	5.8	28.9
5-7-78	143	40	103	70	6.2	25
9-8-78	162	45	117	70	6.2	45
23-8-78	196	104	95	50	7.4	39
25-10-78	185	55	130	46	6.1	72
8-11-78	215	200	15	55	5.2	31
9-11-78	210	15	195	38	5.9	28
6-12-78	125	20	105	33	6.0	38
27-12-78	95	15	80	38	5.4	30
21-2-79	95	15	80	68	5.6	58
9-3-79	105	30	75	58	6.3	46
25-4-79	220	40	180	69	5.6	16
13-6-79	185	40	145	90	6.2	9
MEAN VALUE	161.3	51.6	109.7	57.1	6.0	36.4
8-8-79	125	50	75	86	5.6	28
26-9-79	205	69	136	77	5.5	40
3-10-79	139	34	105	87	6.5	27
7-11-79	128	46	82	35	5.8	28
12-12-79	99	11	88	46	6.4	19
26-12-79	97	11	86	48	6.7	24
9-4-80	210	23	187	44	6.6	47
4-5-80	172	70	102	35	7.0	90
MEAN VALUE	146.9	39.3	107.6	57.3	6.3	37.9

8.6

FOR CATCHMENT A

Bod (mg/l)	Cod (mg/l)	Ammonia (mg/l)	Chloride (mg/l)	Phosphate (mg/l)	Iron (mg/l)	Nitrate (mg/l)	Sulphate (mg/l)
—	—	—	2	0.08	—	2.2	17.2
—	—	—	1	0.08	—	3.1	10.3
—	—	—	3	0.08	—	1.1	2.5
—	—	—	2	0.08	—	1.5	1.1
—	—	—	3	0.08	—	1.3	2.5
—	—	—	1	3.10	—	5.2	2.5
—	—	—	2	3.00	—	2.6	2.1
—	—	—	3	0.12	—	1.8	2.2
—	—	—	4	0.08	—	2.3	2.3
—	—	—	5	0.06	—	2.3	2.1
—	—	—	3	0.38	—	2.1	2.5
—	—	—	4	0.08	—	1.8	2.3
—	—	—	2	0.06	—	1.3	2.5
—	—	—	3	0.06	—	1.1	2.4
—	—	—	2.7	0.52	—	2.1	3.9
—	—	—	3	0.06	—	0.7	1.9
—	—	—	4	0.24	—	0.7	1.4
—	—	—	3	0.06	—	1.0	0.5
—	—	—	3	0.48	—	1.4	45.0
—	—	—	3	2.08	—	0.5	0.6
—	—	—	3	0.16	—	1.8	0.5
—	—	—	3	0.16	—	1.5	0.5
—	—	—	2	0.06	—	7.9	0.6
—	—	—	10	0.14	—	1.6	0.1
—	—	—	2	0.04	—	1.8	0.5
0.2	26	0.00	2	0.12	—	0.2	8.3
0.4	21	0.06	31	0.04	—	0.5	18.5
0.3	23.5	0.03	5.8	0.30	—	1.6	6.5
0.9	40	0.19	5	0.07	6.70	1.0	6.9
0.8	27	0.28	16	0.22	3.40	1.2	10.6
1.1	17	7.30	8	0.84	2.30	2.5	6.9
0.4	23	0.03	2	0.04	4.30	0.1	10.0
0.8	20	0.06	3	0.03	1.60	0.4	0.0
0.4	18	0.12	4	0.08	3.40	0.2	0.0
2.8	32	0.03	6	0.12	3.00	0.1	0.0
0.7	32	0.03	2	0.13	5.40	0.0	0.1
1.0	26.1	0.89	5.8	0.19	3.7	0.7	4.3

WATER QUALITY DATA

Parameter / Sampling Date	Colour (Hazen Units)	Turbidity (Fullers Earth)	Manganese (mg/l)	Fluoride (mg/l)
2-11-77	75	175	—	—
1-12-77	300	300	—	—
7-12-77	260	260	—	—
28-12-77	240	240	—	—
14-1-78	325	96	—	—
14-2-78	150	58	—	—
22-2-78	200	48	—	—
23-3-78	300	82	—	—
29-3-78	350	105	—	—
5-4-78	250	74	—	—
26-4-78	175	67	—	—
3-5-78	275	101	—	—
24-5-78	275	77	—	—
28-6-78	225	82	—	—
MEAN VALUE	242.9	126.1	—	—
5-7-78	275	62	—	—
9-8-78	200	72	—	—
23-8-78	250	53	—	—
25-10-78	200	91	—	—
8-11-78	300	101	—	—
9-11-78	200	96	—	—
6-12-78	250	53	—	—
27-12-78	200	38	—	—
21-2-79	200	34	0.00	0.05
9-3-79	175	48	0.20	0.08
25-4-79	25	60	0.08	0.07
13-6-79	30	58	0.21	0.05
MEAN VALUE	192.1	63.8	0.12	0.06
8-8-79	10	28	0.43	0.04
26-9-79	15	40	0.05	0.06
3-10-79	50	27	0.06	0.10
7-11-79	70	28	0.06	0.06
12-12-79	30	19	0.05	0.00
26-12-79	35	34	0.06	0.00
9-4-80	40	47	0.03	0.06
4-5-80	45	90	0.11	0.04
MEAN VALUE	36.9	37.9	0.11	0.05

8.6

FOR CATCHMENT A

Silica (mg/l)	*Calcium (mg/l)*	*Magnesium (mg/l)*	*Sodium (mg/l)*	*Potassium (mg/l)*
44	9.2	5.1	2.9	0.7
40	5.6	4.3	2.8	0.4
36	6.4	3.6	2.7	0.4
36	6.0	2.9	2.0	0.2
32	4.8	2.6	2.5	0.2
18	8.0	2.1	2.6	1.0
16	7.6	2.9	5.2	1.1
14	5.2	2.1	2.2	0.9
18	7.2	2.6	2.1	0.6
14	6.4	2.6	1.0	0.7
14	6.4	2.4	2.5	1.4
16	4.8	1.4	2.3	0.5
14	7.6	2.1	2.4	0.6
14	4.6	4.4	2.0	0.7
23.3	6.4	2.9	2.5	0.7
16	4.8	1.9	2.1	0.5
24	6.0	2.9	2.3	0.5
—	60	2.6	1.6	0.6
31	—	—	2.9	0.5
31	4.0	2.3	1.9	0.5
31	3.6	1.9	1.8	0.4
21	4.0	1.7	1.9	0.3
21	4.6	2.8	2.0	0.2
21	7.2	8.4	2.6	0.4
31	7.0	3.4	2.3	0.4
10	6.0	3.4	3.3	0.5
21	8.4	4.1	2.3	1.2
23.4	5.6	3.2	2.3	0.5
16	9.6	3.9	3.2	0.7
12	7.6	3.2	3.1	0.6
10	8.0	4.6	3.3	1.0
10	3.2	1.7	2.7	0.6
10	5.6	0.7	1.8	0.4
12	5.6	2.2	2.3	0.4
10	5.2	0.7	2.9	1.5
21	3.6	1.5	2.2	0.3
12.6	6.1	2.3	2.7	0.7

Table 8.7
WATER QUALITY DATA FOR CATCHMENT B

Parameter / Sampling Date	Total Solid (mg/l)	Suspended Solid (mg/l)	Dissolved Solid (mg/l)	Conductivity (Umhos/cm)	pH	Alkalinity (ppm $CaCO_3$)	Bod (mg/l)	Cod (mg/l)	Ammonia (mg/l)	Chloride (mg/l)	Phosphate (mg/l)	Iron (mg/l)	Nitrate (mg/l)	Sulphate (mg/l)
2-11-77	158	35	123	125	6.5	31	—	—	—	5	0.04	—	3.1	2.5
1-12-77	163	38	125	95	6.1	30	—	—	—	1	0.08	—	3.7	42.3
7-12-77	181	89	92	90	6.4	25	—	—	—	2	0.14	—	1.5	1.5
28-2-77	134	38	96	90	6.2	32	—	—	—	2	0.08	—	1.3	0.3
14-1-78	—	—	—	3	1.5	—	11.0	170	—	32	4.80	0.30	6.2	181.0
14-2-78	110	4	106	100	6.4	41	—	—	—	1	0.12	—	4.2	1.5
22-2-78	140	25	115	90	6.6	33	—	—	—	2	0.26	—	2.1	1.4
23-3-78	143	15	128	75	6.3	45	—	—	—	5	0.16	—	1.3	1.3
29-3-78	113	21	92	145	6.7	89	—	—	—	5	0.08	—	1.3	1.5
5-4-78	115	8	107	100	5.9	44	—	—	—	4	0.16	—	1.5	1.5
26-4-78	148	47	101	60	6.0	26	—	—	—	2	0.46	—	1.8	1.8
3-5-78	162	33	129	75	5.8	36	—	—	—	9	0.06	—	1.8	2.1
24-5-78	132	29	103	80	6.3	31	—	—	—	2	0.06	—	1.8	2.6
28-6-78	204	67	137	100	6.3	30	—	—	—	3	0.10	—	0.6	2.8
Mean Value	136.0	34.5	101.5	87.7	5.9	39.9	11.0	170	—	5.4	0.47	0.30	2.4	17.5
5-7-78	104	23	81	90	6.5	37	—	—	—	4	0.06	—	1.4	2.5
9-8-78	151	44	107	85	6.4	44	—	—	—	3	0.04	—	0.7	2.1
23-8-78	83	9	74	63	7.6	44	—	—	—	2	0.02	—	1.5	0.5
25-10-78	155	25	130	60	6.5	5	—	—	—	3	1.60	—	0.6	20.0
8-11-78	135	130	5	42	5.7	40	—	—	—	4	0.24	—	0.5	0.8
9-11-78	195	15	180	52	6.7	41	—	—	—	3	0.24	—	2.1	0.6
6-12-78	120	25	95	41	5.9	39	—	—	—	4	0.20	—	1.5	0.8
27-12-78	95	15	80	36	5.7	32	—	—	—	2	0.20	—	15.8	1.1
21-2-79	95	15	80	56	5.9	43	—	—	—	10	0.18	4.00	2.3	0.1
8-3-79	115	10	105	62	6.6	42	—	—	—	2	0.08	5.50	1.7	0.3
13-6-79	130	30	100	68	6.3	31	1.2	37	0.19	4	0.08	5.60	0.5	2.8
Mean Value	125.3	31.0	94.3	59.5	6.3	36.2	1.2	37	0.2	3.7	0.30	5.03	2.60	2.9
25-7-79	220	60	160	48	6.6	20	0.3	24	0.00	2	0.12	8.40	0.5	2.0
8-8-79	112	43	69	84	5.9	43	1.0	33	0.20	5	0.30	6.50	1.4	0.9
26-9-79	189	49	140	68	6.4	25	0.9	36	0.09	22	0.14	4.90	1.6	4.4
7-11-79	148	44	104	31	6.9	24	0.3	12	0.01	3	0.07	2.60	0.4	0.8
12-12-79	85	10	75	39	6.4	19	0.6	12	0.03	5	0.04	1.30	0.5	0.0
26-12-79	69	10	59	39	7.1	20	0.5	9	0.01	4	0.08	0.70	0.5	0.0
9-4-80	219	31	188	40	6.8	17	0.9	47	0.03	5	0.07	6.30	0.2	0.3
13-5-80	135	41	94	64	6.9	31	0.6	22	0.03	2	0.03	5.10	0.5	0.0
21-5-80	148	53	95	53	7.3	27	0.9	26	0.01	2	0.13	3.80	0.4	0.0
Mean Value	147.2	37.9	109.3	57.9	6.7	25.1	0.7	24.6	0.05	5.6	0.11	4.40	0.7	0.9

TABLE 8.7—(*Continued*)

Parameter / *Sampling Date*	*Silica (mg/1)*	*Calcium (mg/1)*	*Magnesium (mg/1)*	*Sodium (mg/1)*	*Potassium (mg/1)*	*Turbidity (Fullers Earth)*	*Manganese (mg/1)*	*Fluoride (mg/1)*	*Colour (Hazen Units)*
2-11-77	45	6.8	4.3	2.9	1.0	115	—	—	300
1-12-77	40	7.2	3.8	3.1	0.6	72	—	—	360
7-12-77	40	7.2	4.1	3.1	0.6	72	—	—	300
28-12-77	40	6.8	3.4	2.7	0.4	72	—	—	250
14-1-78	2.0	0.2	75.0	26.0	—	108	—	—	350
14-2-78	16	8.8	2.6	5.4	1.1	77	—	—	225
22-2-78	14	5.2	3.4	6.1	1.9	53	—	—	225
23-2-78	16	5.2	2.6	2.1	0.6	110	—	—	300
29-2-78	16	12.0	3.1	4.4	1.8	96	—	—	350
5-4-78	14	7.6	2.4	1.0	0.9	72	—	—	250
26-4-78	14	4.8	0.9	2.6	1.4	96	—	—	225
3-5-78	16	6.4	1.4	3.0	0.6	91	—	—	250
24-5-78	14	6.4	3.8	3.2	0.8	82	—	—	275
28-6-78	16	4.8	1.7	2.0	1.1	58	—	—	250
MEAN VALUE	21.6	6.4	8.0	4.8	0.9	83.6	—	—	279.3
5-7-78	16	6.8	1.7	2.5	1.0	53	—	—	250
9-8-78	24	6.8	2.9	2.9	0.8	58	—	—	200
23-8-78	—	7.6	3.2	2.0	1.1	38	—	—	200
25-10-78	31	—	—	2.5	1.2	62	—	—	250
8-11-78	31	4.8	1.5	2.6	0.7	58	—	—	150
9-11-78	31	4.8	2.7	2.5	0.7	96	—	—	250
6-12-78	31	4.0	1.9	2.7	0.5	58	—	—	250
27-12-78	16	4.0	2.4	2.5	0.2	43	—	—	150
21-2-79	21	6.4	5.0	2.7	0.6	38	0.00	0.05	225
8-3-79	31	7.4	3.8	2.5	0.8	48	0.10	0.05	225
13-6-79	12	7.2	3.2	2.4	2.3	53	0.24	0.05	70
MEAN VALUE	22.2	5.4	2.6	2.5	0.9	55	0.03	0.05	201.8
25-7-79	12	4.8	2.2	3.1	0.8	70	0.06	0.07	25
8-8-79	16	11.2	2.7	4.0	1.4	16	0.55	0.10	50
26-9-79	10	7.6	1.9	3.1	1.4	54	0.03	0.08	25
7-11-79	8	4.0	0.5	3.2	0.6	26	0.05	0.05	60
12-12-79	12	3.6	1.2	1.9	0.6	18	0.03	0.00	10
26-12-79	10	4.4	1.7	2.8	0.6	19	0.01	0.00	15
9-4-80	8	4.8	1.0	2.4	0.9	52	0.02	0.05	30
13-5-80	8	8.4	2.2	3.4	0.8	55	0.04	0.05	30
21-5-80	25	5.2	2.9	2.9	0.7	76	0.04	0.04	40
MEAN VALUE	12.1	6	1.8	3.0	0.9	42.9	0.09	0.05	31.7

WATER QUALITY DATA

Parameter / Sampling Date	Total Solid (mg/l)	Suspended Solid (mg/l)	Dissolved Solid (mg/l)	Conductivity (Umhos/cm)	pH	Alkalinity (ppm $CaCO_3$)
2-11-77	210	32	178	100	6.3	23
1-12-77	177	12	165	85	6.2	26
7-12-77	216	47	169	70	6.3	18
28-12-77	130	16	114	80	6.0	34
14-1-78	194	8	186	65	6.1	29
14-2-78	82	4	78	90	6.5	37
22-2-78	130	12	118	90	6.6	35
23-3-78	138	17	121	70	6.1	35
29-3-78	100	3	97	105	6.5	63
5-4-78	134	13	121	75	6.1	38
26-4-78	115	9	106	55	6.0	22
3-5-78	145	27	118	55	5.0	29
24-5-78	90	5	85	70	6.4	34
28-6-78	103	5	98	95	6.5	27
MEAN VALUE	140.1	15	125.1	78.9	6.3	32.1
5-7-78	95	6	89	75	6.6	35
9-8-78	119	22	97	85	6.4	43
23-8-78	68	7	61	52	7.1	40
13-9-78	115	5	110	50	7.2	—
27-9-78	103	10	93	52	7.3	46
25-10-78	90	5	85	40	7.0	48
8-11-78	215	200	15	60	5.6	45
9-11-78	110	5	105	43	7.1	38
6-12-78	75	10	65	44	6.5	51
27-12-78	65	10	55	41	5.6	29
21-2-79	105	15	90	58	6.0	45
8-3-79	75	15	60	52	6.7	41
16-5-79	175	20	155	52	6.4	31
29-5-79	190	25	165	43	6.2	18
13-6-79	145	40	105	31	6.7	18
27-6-79	130	40	90	45	6.4	26
MEAN VALUE	117	27	90	50.8	6.6	37.6
8-8-79	75	21	54	45	6.1	28
5-9-79	168	110	58	45	6.1	28
26-9-79	125	13	112	44	7.3	29
7-11-79	87	25	62	37	6.8	28
12-12-79	77	3	74	46	6.7	22
26-12-79	62	5	57	41	6.9	22
2-4-80	228	46	182	35	6.4	15
13-5-80	126	47	79	50	7.1	25
21-5-80	146	102	44	50	7.2	28
MEAN VALUE	121.6	41.3	80.3	43.7	6.7	25

8.8

FOR CATCHMENT C

Bod (mg/l)	*Cod (mg/l)*	*Ammonia (mg/l)*	*Chloride (mg/l)*	*Phosphate (mg/l)*	*Iron (mg/l)*	*Nitrate (mg/l)*	*Sulphate (mg/l)*
—	—	—	1	0.06	—	1.7	1.8
—	—	—	1	0.14	—	3.7	48.8
—	—	—	2	0.14	—	1.3	1.2
—	—	—	2	0.14	—	1.5	0.6
—	—	—	3	0.14	—	2.1	0.2
—	—	—	2	1.40	—	5.2	0.3
—	—	—	1	0.86	—	3.9	0.2
—	—	—	2	0.16	—	1.3	0.4
—	—	—	5	0.06	—	1.5	0.3
—	—	—	5	0.08	—	1.0	0.5
—	—	—	3	0.50	—	1.3	0.3
—	—	—	4	0.14	—	1.5	0.3
—	—	—	3	0.00	—	1.8	0.3
—	—	—	5	0.10	—	0.4	0.3
—	—	—	2.8	0.28	—	2.0	4.0
—	—	—	3	0.14	—	1.0	0.3
—	—	—	3	0.00	—	1.0	0.1
—	—	—	4	0.08	—	1.4	2.2
—	—	—	4	0.00	—	0.7	0.3
—	—	—	4	0.24	—	1.4	0.0
—	—	—	3	0.48	—	1.7	0.8
—	—	—	2	0.24	—	4.9	0.3
—	—	—	2	0.04	—	2.1	0.1
—	—	—	3	0.14	—	2.1	0.1
—	—	—	1	0.10	—	13.2	0.3
—	—	—	9	0.68	2.00	2.3	0.1
—	—	—	3	0.04	2.50	1.6	0.1
—	—	—	1	0.18	4.50	0.4	0.8
0.5	20	0.01	0	0.06	0.50	0.9	1.8
0.4	51	0.03	3	0.04	3.00	0.4	0.0
0.8	30	0.00	6	0.14	2.90	0.2	0.0
0.6	33.7	0.01	3.2	0.16	2.6	2.2	0.5
0.3	23	0.00	4	0.00	2.20	1.0	1.0
1.6	41	0.64	12	0.25	5.10	3.5	0.0
0.8	25	0.02	21	0.09	3.60	0.6	0.0
0.3	6	0.01	1	0.06	1.10	0.4	0.9
0.5	5	0.06	4	0.04	0.00	0.2	0.0
0.7	10	0.01	5	0.12	0.70	0.5	0.0
0.7	36	0.06	4	0.13	6.50	0.1	1.3
0.5	20	0.03	2	0.03	2.80	0.2	0.0
0.9	42	0.01	3	0.30	6.20	0.2	0.0
0.7	23.1	0.09	6.9	0.19	3.5	0.8	0.4

WATER QUALITY DATA

Parameter / *Sampling Date*	*Silica (mg/l)*	*Calcium (mg/l)*	*Magnesium (mg/l)*	*Sodium (mg/l)*
2-11-77	50	8.4	4.6	4.1
1-12-77	45	6.0	3.8	3.6
7-12-77	40	5.2	2.4	3.4
28-12-77	32	6.4	2.1	2.9
14-1-78	30	6.0	1.9	3.0
14-2-78	14	8.0	1.4	5.5
22-2-78	14	7.6	1.2	6.3
23-3-78	14	5.2	2.4	2.7
29-3-78	16	8.8	1.4	5.4
5-4-78	16	6.8	0.7	1.3
26-4-78	14	44.0	0.9	2.7
3-5-78	14	5.2	1.2	3.0
24-5-78	14	6.4	0.9	3.4
28-6-78	16	5.2	1.2	3.0
MEAN VALUE	23.5	9.2	1.9	3.6
5-7-78	16	6.0	4.7	3.1
9-8-78	24	6.4	1.8	3.3
23-8-78	—	6.4	2.1	3.2
13-9-78	—	6.0	2.1	3.1
27-9-78	31	6.0	2.7	3.4
25-10-78	31	4.4	1.7	2.9
8-11-78	41	5.2	1.7	2.4
9-11-78	31	5.2	1.9	2.8
6-12-78	31	4.8	1.8	3.1
27-12-78	21	4.8	1.9	2.9
21-2-79	21	7.2	2.4	3.2
8-3-79	31	6.4	1.9	3.1
16-5-79	31	2.8	0.7	2.8
29-5-79	16	4.4	1.9	2.3
13-6-79	21	3.2	4.9	2.6
27-6-79	10	5.2	1.7	2.6
MEAN VALUE	22.3	5.3	2.2	2.9
8-8-79	14	6.8	1.0	3.0
5-9-79	12	6.8	1.9	3.5
26-9-79	8	5.6	1.7	3.3
7-11-79	12	4.8	0.5	3.9
12-12-79	14	4.8	0.7	2.5
26-12-79	14	4.8	1.0	3.3
2-4-80	8	3.2	1.5	2.2
13-5-80	10	6.4	1.2	3.3
21-5-80	33	6.8	0.7	3.4
MEAN VALUE	15.2	5.6	1.1	3.2

8.8—*(Continued)*

FOR CATCHMENT C

Potassium (mg/l)	*Colour (Hazen Units)*	*Turbidity (Fullers Earth)*	*Manganese (mg/l)*	*Fluoride (mg/l)*
1.4	260	122	—	—
0.6	300	77	—	—
0.5	325	124	—	—
0.7	275	74	—	—
0.4	260	86	—	—
1.9	275	34	—	—
1.9	150	36	—	—
1.0	200	86	—	—
1.3	300	43	—	—
0.6	150	36	—	—
1.8	225	67	—	—
0.6	150	48	—	—
0.8	150	36	—	—
0.7	125	43	—	—
1.0	220.4	65.1	—	—
0.6	125	26	—	—
0.6	75	31	—	—
0.7	150	14	—	—
0.9	179	24	—	—
1.2	125	29	—	—
0.6	100	19	—	—
0.7	275	120	—	—
0.7	175	38	—	—
0.6	150	29	—	0.01
0.6	80	19	—	—
0.8	125	24	—	0.06
0.8	125	31	0.09	0.04
0.6	75	77	0.05	0.08
0.6	50	76	0.05	0.04
0.8	60	72	0.06	0.05
0.6	80	43	0.15	0.08
0.7	121.6	42.0	0.02	0.02
0.6	35	21	0.05	0.05
1.0	35	29	0.15	0.06
1.0	35	32	0.04	0.06
0.8	10	8	0.04	0.05
0.9	5	5	0.01	—
0.8	10	9	0.01	—
0.5	30	56	0.04	0.04
0.8	30	52	0.07	0.04
1.0	50	170	0.23	0.04
0.8	26.7	42.4	0.07	0.04

Table 8.9

THE MEAN VALUE FOR SELECTED PARAMETERS IN CATCHMENTS A, B, AND C SUNGAI TEKAM (JULY 1977-JUNE 1980)

Parameter[1]	*A*			*B*			*C*			*Suggested Stream Standards*[2]		
	1977/78	*1978/79*	*1979/80*	*1977/78*	*1978/79*	*1979/80*	*1977/78*	*1978/79*	*1979/80*	*Portable Water Supply*	*Fish and Other Aquatic Life*	*Irrigation*
Colour (Hazen Unit)	242.9	192.1	36.9	279.3	201.8	31.7	220.4	121.6	26.7	—	—	—
Conductivity (Umhos/cm)	89.3	57.1	57.3	87.7	59.5	57.9	79.9	50.8	43.7	—	—	—
Turbidity (Fuller Earth)	121.1	63.8	37.9	83.6	55	42.9	65.1	42.0	42.4	—	—	—
Total Solids	147.4	161.3	146.9	136.0	125.3	147.2	140.1	117.2	121.6	—	—	—
Suspended Solids	19.8	51.6	39.3	34.5	31.0	37.9	15.0	27.2	41.3	—	—	—
Dissolved Solids	127.6	110.7	107.6	101.5	94.3	109.3	125.1	90.0	80.3	∠4000	∠1000	400 if there is poor drainage 1000 if there is good drainage
p^H	5.8	6.0	6.3	5.9	6.3	6.7	6.2	6.6	6.7	8.5	6.5-8.5	4.5-9.0
Alkalinity	28.9	36.4	37.9	39.9	36.2	25.1	32.1	37.6	2.5	—	—	—
Sulphate	3.9	6.5	4.3	17.5	2.9	0.9	17.5	0.5	0.4	—	—	—
Nitrate	2.1	1.6	0.7	2.4	2.6	0.7	2.0	2.2	0.7	—	—	—
BOD	—	0.3	0.9	—	1.2	0.7	—	0.6	0.7	—	—	—
COD	—	23.5	26.1	—	37.0	24.6	—	33.7	23.1	—	—	—
Iron	—	—	3.8	—	5.0	4.4	—	2.6	3.2	—	—	—
Ammonia	—	0.03	0.89	—	0.19	0.05	—	0.01	0.09	—	∠1	—
Chloride	27	5.8	5.8	5.4	3.7	5.6	2.8	3.2	6.2	∠1000	—	—
Flouride	—	0.06	0.05	—	0.01	0.05	—	0.02	0.04	—	1.5	—
Phosphate	0.5	0.3	0.2	0.5	0.3	0.1	0.5	0.2	0.7	—	0.05	—
Sodium Adsorption Ratio (SAR)	0.21	0.19	0.24	0.30	0.22	0.29	0.31	0.28	0.32	—	—	∠10 if there is poor drainage ∠18 if there is good drainage
Manganese	—	0.12	0.11	—	0.03	0.09	—	0.02	0.07	—	—	—
Silica	23.3	23.4	12.6	21.6	22.2	12.1	23.5	22.3	15.2	—	—	—
Calcium	6.4	5.6	6.1	6.4	5.4	6.0	9.2	5.3	5.6	—	—	—
Magnesium	2.9	3.2	2.3	8.0	2.6	1.8	1.9	2.2	1.1	—	—	—
Sodium	2.5	2.3	2.7	4.8	2.5	3.0	3.6	2.9	3.2	—	—	—
Potassium	0.7	0.5	0.7	0.9	0.9	0.9	1.0	0.7	0.8	—	—	—

[1] All values are expressed as mg/1 except pH or unless otherwise specified.

[2] *Source:* Pescod, M.B. (1973), Investigation of Rational Effluent and Stream Standards for Tropical Countries Asian Institute of Technology, Bangkok (Report No. FE-476-1 Interim).

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.	Sungai 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
7.	Sungei Lui Representative Basin Report No. 1 for 1971/72 to 1973/74 (1977) ..	$5.00
8.	Water Resources for Irrigation of Upland Crops in South Kelantan	$5.00
9.	Sungei Lui Representative Basin Report No. 2 for 1974/75 to 1975/76	$5.00
10.	Sungai Tekam Experimental Basin Report No. 2 for September, 1974 to March 1977 (1978)	$5.00
11.	Comparison of Performance of U.S. Class A Evaporation Galvanised Iron Pan and Aluminium Pan (1982)	$5.00
12.	Average Annual and Monthly Surface Water Resources of Peninsular Malaysia (1982)	$10.00