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REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF HOUSING BUILDING
PLANNING AND URBAN DEVELOPMENT (CIPTA KARYA)

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TECHNICAL MEMORANDUM NO.4

DRAINAGE- PRINCIPAL RIVERS AND RAINFALL ANALYSIS

MAY 1979

MEDAN URBAN DEVELOPMENT, HOUSING, WATER SUPPLY AND SANITATION PROJECT

MEDAN URBAN DEVELOPMENT, HOUSING, WATER SUPPLY AND SANITATION PROJECT
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Our ref.: 79/1070/MUDS/313 May 12, 1979

Director General Cipta Karya
Ministry of Public Works
Jalan Pattimura 20
Kebayoran Baru
Jakarta Selatan

Subject: Technical Memorandum No. 4 - Drainage - Principals Rivers and Rainfall Analysis

Dear Sir:

Attached are 15 copies of the Subject Technical Memorandum for your information and review.

Yours faithfully,

John M. McGill
Project Representative

c.c.: Ir. Ruslan Diwiryo, Director of City & Regional Planning
Ir. Susanto Mertodiningrat, Director of Sanitary Engineering
Ir. Sunaryo, Head Sub-Directorate Town Planning
Ir. K. Pohan, Project Manager, MUDS
AID - Jakarta, attn. P. Thorne, Project Officer
ES - Arcadia
Dacrea - Jakarta
Sinotech - Taipei

JM/y

LIST OF TECHNICAL MEMORANDA PREVIOUSLY SUBMITTED

Report No.	T i t l e	Date Submitted
1.	Preliminary Site Selection Criteria for Perumnas Medan III, SSCH/LCH Project.	March, 1979
2.	Work plan for water supply and sanitation master plans and feasibility studies.	April, 1979
3.	Policy Issues for Project Guidance	March, 1979

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1. RUNOFF PROJECTION

1.1 Outline of Principal Rivers within Study Area

1.1.1 General Description

The principal rivers in study area include the Deli River, Percut River, Belawan River, Babura River, and River Sikambing. Most rivers within study area have little slope and frequently meander to a great extent. The basins along these rivers vary in their degree of improvement or drainage channels. In the densely populated middle and lower portion of the catchment areas of some rivers, there are channel improvements and bridges. Some dikes have been constructed along the Deli River.

1.1.2 Catchment Areas

The Deli River has a catchment area of about 390 square km. and a total length of about 80 km of which 42 km of the middle and lower reaches it run through the study area.

The Belawan River has a catchment area of about 270 square km. and a total length of about 66 km of which only 26 km of the lower part of the middle reach run through the study area.

The Percut River has a catchment area about 210 square km. and a total length of about 78 km. About 8 km of the lower part of middle reach run through the study area.

1.1.3 Characteristics of the Basins and Rivers

The river of most concern to the project is the Deli River and its branches the Sikambing and Babura Rivers. The average slope of the reaches of these rivers which are located in mountainous and hilly areas in steeper than 1/200 - 1/100, corresponding with the presence of rapids. The characteristics of these basins and rivers are indicated in Fgiures 1 and 2.

1.2 Rainfall Analysis

1.2.1 Rainfall Characteristics

The equatorial location and low elevation of Medan (3°35'N) largely determines the tropical climate of the region. Although

rainfall, temperatures and sunshine show some seasonal periods, these seasons are not as distinctly marked as in Java and many other areas of Asia. Two rainy periods occur during the fall and spring rather than during the more typical "monsoon" seasons which occurs over much of Asia. These vague periods more closely resemble those in southern India, Sri Lanka, and Equatorial Africa.

Medan rainfall has been recorded since 1879 at three stations (different recording periods) and is summarized in several reports (US 6,7,8,9,13 and 14). These reports and monthly records for 935 months in an 84 years period have been summarized to focus on the major storms which will affect drainage planning. During the period of record, annual rainfall has varied from 1352 to 2873 mm with 10 percent above 2400 mm and 10 percent below 1600 mm. About 50 percent of the annual rainfall records ranged from 2000 to 2400 mm, and the average annual rainfall for 40 years is about 2050 mm.

The distribution of rainfall throughout the year shows two high rain months: October and May, although the long "rainy season" extends from September to January. Of the 935 months of rainfall records, 80 percent of the months have rainfall between 60 and 300 mm, while about eight percent have rainfalls from 300 to 400 mm and two percent (six months) had rainfalls greater than 400 mm per month.

The three stations in Medan had three different days with 250 to 290 mm of rain in 24 hours. Although these storms occured in December or January, they occured at widely different years: 1907, 1931, and 1956, and these storms coincide with high rainfall months (more than 300 mm storm) but not with highest rainfall years. Such temporal distribution indicates that the storms were of limited areal extent and period and that rainfall quickly decreased beyond the intense center of rain. Comparisons with twelve other northern North Sumatra stations (below 50 m elevation) show average annual rainfall varied from 1800 to 3177 mm. Monthly averages for daily maxima varied from 26 to 85 mm, while storms of record ranged from 112 - 309 mm/during 10-20 years. Most records showed the

storms of I/1931 and XI/1956 to have been most widespread with limited local centers of high rainfall.

The rainfall daily maxima for Sibolangit were 130 to 140 mm are similar to the secondary maxima in the more northern, lower stations. This difference between primary maxima indicates that the very high rainfall came from local thunder-storms. A 1931 daily maximum at Binjei would further indicates that some frontal activity could provide widespread heavy rains and local thunderstorms produce very heavy rains.

Diurnal rainfall (US 14) show a strong tendency towards afternoon and night rains and relatively dry morning periods. For a 15 year period, rainfall of more than 5 mm/hr during January to September generally occur between 12:00 to 01:00, while during the "rainy season" rains continued from 12:00 or 15:00 to 06:00 the next morning (adding 50 percent to the total rain period). These records indicate that periods of 6 to 12 hours separate daily rainy periods and thereby allow runoff and drainage before the next day's rains.

The same diurnal rain records (US 14) indicated that the higher hourly rainfalls of 16 to 30 mm most commonly occured between 18:00 and 22:00 during March to September and between 23:00 and 01:00 during the rainy period of October to December. Maximum hourly rainfalls during January to March fell below 15 mm.

Rainfall records for 1879 to 1941 have been summarized (US 6) for 15 sections within the regional drainage basin of Medan (or the Deli Regency). These records clearly indicate the increase of annual rainfall with elevation:

Average Annual Rain (mm)		Elevation (m)
1773 - 2036	Mabar	6 - 12
2065 - 2269	Medan	28 - 38
2298 - 3098	Two Rivers, Deli Tua	60 - 101
3127 - 3978	Petani	129 - 174
4520	Sibolangit	565
5279 - 6676	Bandar Baru	864 - 928

A comparison of monthly rainfall at Sibolangit and Medan showed the same high rainfall during October and May, but in Sibolangit, the rainy period extended from August through May with more than 250 mm of rain per month. Rainfall in the river basins above Medan is generally higher because of longer daily and seasonal rains rather than more intense rains.

1.2.2 Rainfall Data

Rainfall data from 1961 to 1941 and 1953 to 1976 were obtained from Hydrology Design Unit, Provincial Department of Public Works Medan, and the data will be published in the near future.

1.2.3 Probable Rainfall

Rainfall data have been analysed by the Hydrology Design Unit who have prepared rainfall intensity duration and frequency curves for Medan using the following methodology: Horner's formula.

$$i = \frac{A}{(t + d)^n}$$

where

i = rainfall intensity, in mm/hour

t = rainfall duration time, in hours

A, d and n are regional coefficients and exponents

The rainfall intensity for 2.33 - 50 - 10 - 20 - 50 - and 100-year return period are listed in table 1, and the rainfall intensity duration curves are shown in Figure 3.

Table 1. Rainfall Intensity for Various Return Period

Return period T (year)	Rainfall intensity i (mm/hour)
2.33	$i = \frac{83}{(t + 0.28)^{0.95}}$
5	$i = \frac{101}{(t + 0.28)^{0.95}}$
10	$i = \frac{115}{(t + 0.30)^{0.95}}$
20	$i = \frac{134}{(t + 0.31)^{0.95}}$

50 $$i = \frac{161}{(t + 0.34)^{0.95}}$$

100 $$i = \frac{187}{(t + 0.36)^{0.95}}$$

1.2.4 Runoff Coefficients and Runoff Curves

(1) Runoff Coefficient Estimation

The runoff coefficient using in North American Communities Japan and Taiwan are listed in Table 2. According to the study area conditions we adopt the various runoff coefficients as shown in Table 3.

Table 2.

Land Use	Runoff Coefficient		
	North American (a)	Japan (b)	Taiwan (c)
Commercial area	0.5 - 0.95	0.6 - 0.7	0.6 - 0.95
Residential area	0.25- 0.75	0.3 - 0.5	0.3 - 0.75
Industrial area	0.5 - 0.90	0.4 - 0.6	0.5 - 0.8
Park and green belt	0.1 - 0.25	0.1 - 0.2	0.1 - 0.25
Unimproved land	0.1 - 0.30	---------	0.1 - 0.3

Table 3. Land use and runoff coefficient

Land Use	Runoff Coefficient
Commercial area	0.70
Residential area	0.60
Industrial area	0.55
School, park and green area	0.25
Agriculture and undevelopment area	0.10

Note: (a) Am. Soc. Civil Engrs. Manuals of Engineering Practice, No.37, P.48 (1960).
(b) Japan Assn. Sewage Works Design Guide and Description. P.44 (1972).
(c) China Engineers Assn.Engineer's Handbook. P.4-7 (1974).

(2) Runoff Curves

2. 83-year frequency storm runoff

$$i = \frac{83}{(t + 0.28)^{0.95}}$$

Time of concentration t (minute)	Rainfall intensity i (mm/hour)	Storm runoff* (cms/ha) C	R	I	S	A
10	179	0.347	0.298	0.273	0.124	0.050
20	132	0.257	0.220	0.202	0.092	0.037
30	105	0.204	0.175	0.161	0.073	0.029
40	87	0.170	0.146	0.134	0.060	0.024
50	75	0.146	0.125	0.114	0.052	0.021
60	66	0.127	0.109	0.100	0.046	0.018

* C - Commercial area R - Residential area
I - Industrial area S - School park and green area
A - Agriculture and undevelopment area

5-year frequency storm runoff

$$i = \frac{101}{(t + 0.28)^{0.95}}$$

Time of Concentration t (minute)	Rainfall Intensity i (mm/hour)	Storm runoff (cms/ha) C	R	I	S	A
10	217	0.422	0.362	0.332	0.151	0.063
20	160	0.311	0.267	0.244	0.111	0.044
30	128	0.249	0.213	0.196	0.089	0.036
40	106	0.206	0.177	0.162	0.074	0.029
50	91	0.177	0.152	0.139	0.063	0.025
60	80	0.156	0.133	0.122	0.056	0.022

10-year frequency storm runoff

$$i = \frac{115}{(t + 0.30)^{0.95}}$$

Time of concentration t (minute)	Rainfall intensity i (mm/hour)	Storm runoff (cms/ha)				
		C	R	I	S	A
10	237	0.461	0.395	0.362	0.165	0.066
20	177	0.344	0.295	0.270	0.123	0.049
30	142	0.276	0.237	0.217	0.099	0.039
40	119	0.231	0.198	0.182	0.083	0.031
50	102	0.198	0.170	0.156	0.071	0.028
60	90	0.175	0.150	0.137	0.062	0.025

20-year frequency storm runoff

$$i = \frac{134}{(t + 0.31)^{0.95}}$$

Time of concentration t (minute)	Rainfall intensity i (mm/hour)	Storm runoff (cms/ha)				
		C	R	I	S	A
0.5	164	0.319	0.273	0.251	0.114	0.046
1	104	0.202	0.173	0.159	0.072	0.029
2.5	50	0.097	0.083	0.076	0.034	0.014
5	27	0.052	0.045	0.041	0.019	0.007
10	15	0.029	0.025	0.023	0.010	0.004
15	10	0.019	0.016	0.015	0.007	0.003
20	8	0.015	0.013	0.012	0.006	0.002

50-year frequency storm runoff

$$i = \frac{161}{(t + 0.34)^{0.95}}$$

Time of concentration t (minute)	Rainfall intensity i (mm/hour)	Storm runoff (cms/ha)				
		C	R	I	S	A
0.5	190	0.369	0.317	0.290	0.132	0.053
1	122	0.237	0.203	0.186	0.085	0.034
2.5	60	0.117	0.100	0.092	0.042	0.017
5	33	0.064	0.055	0.050	0.023	0.009
10	17	0.033	0.028	0.026	0.012	0.005
15	12	0.023	0.020	0.018	0.008	0.003
20	9	0.017	0.015	0.013	0.006	0.002

The runoff curves are shown in Fig. 4 to Fig. 8

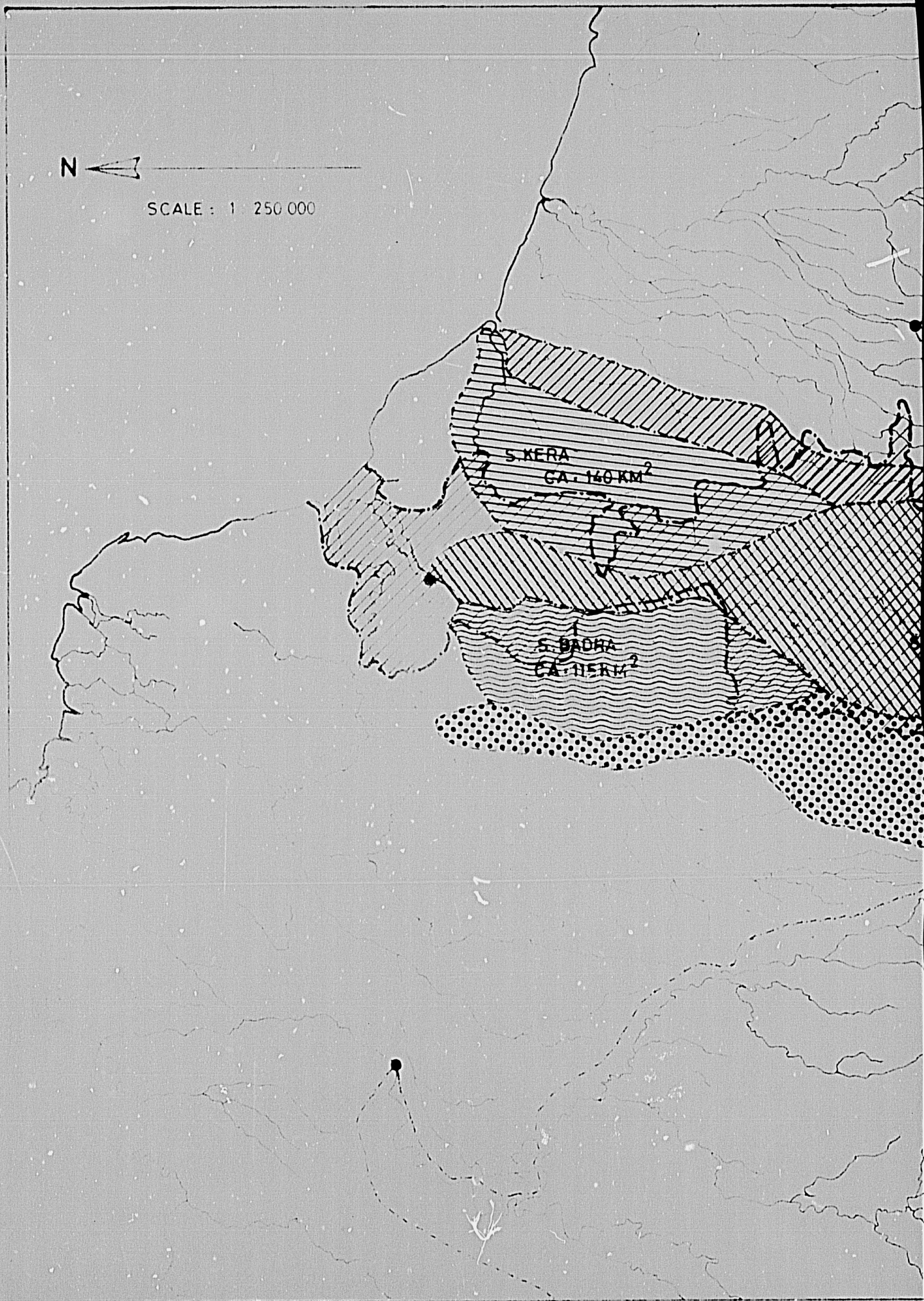
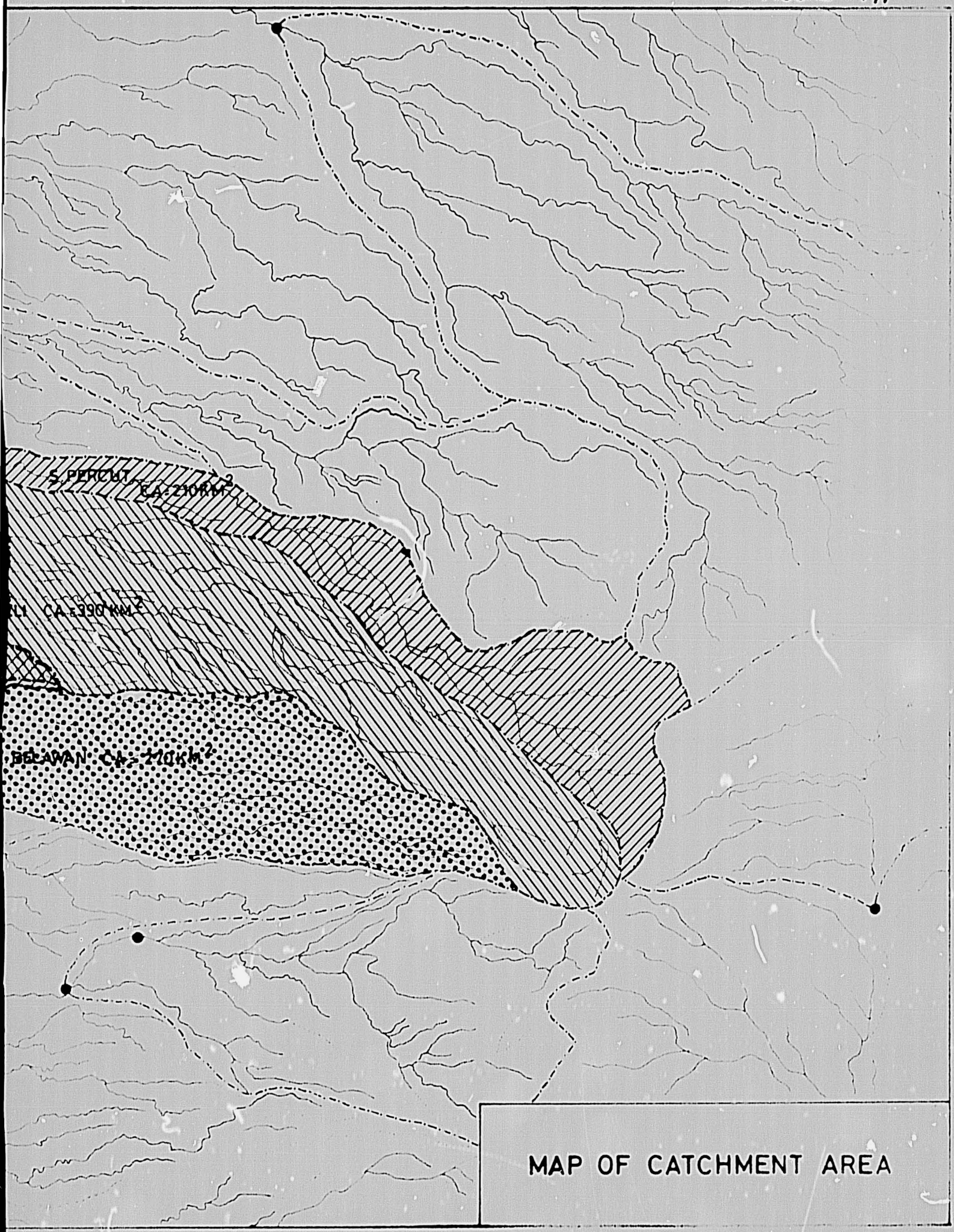

N
SCALE : 1 : 250 000
S. KERA
CA : 140 KM²
S. DADRA
CA : 115 KM²

FIGURE : 1 A



MAP OF CATCHMENT AREA

ENGINEERING SCIENCE - SINOTECH

FIGURE : 2 a

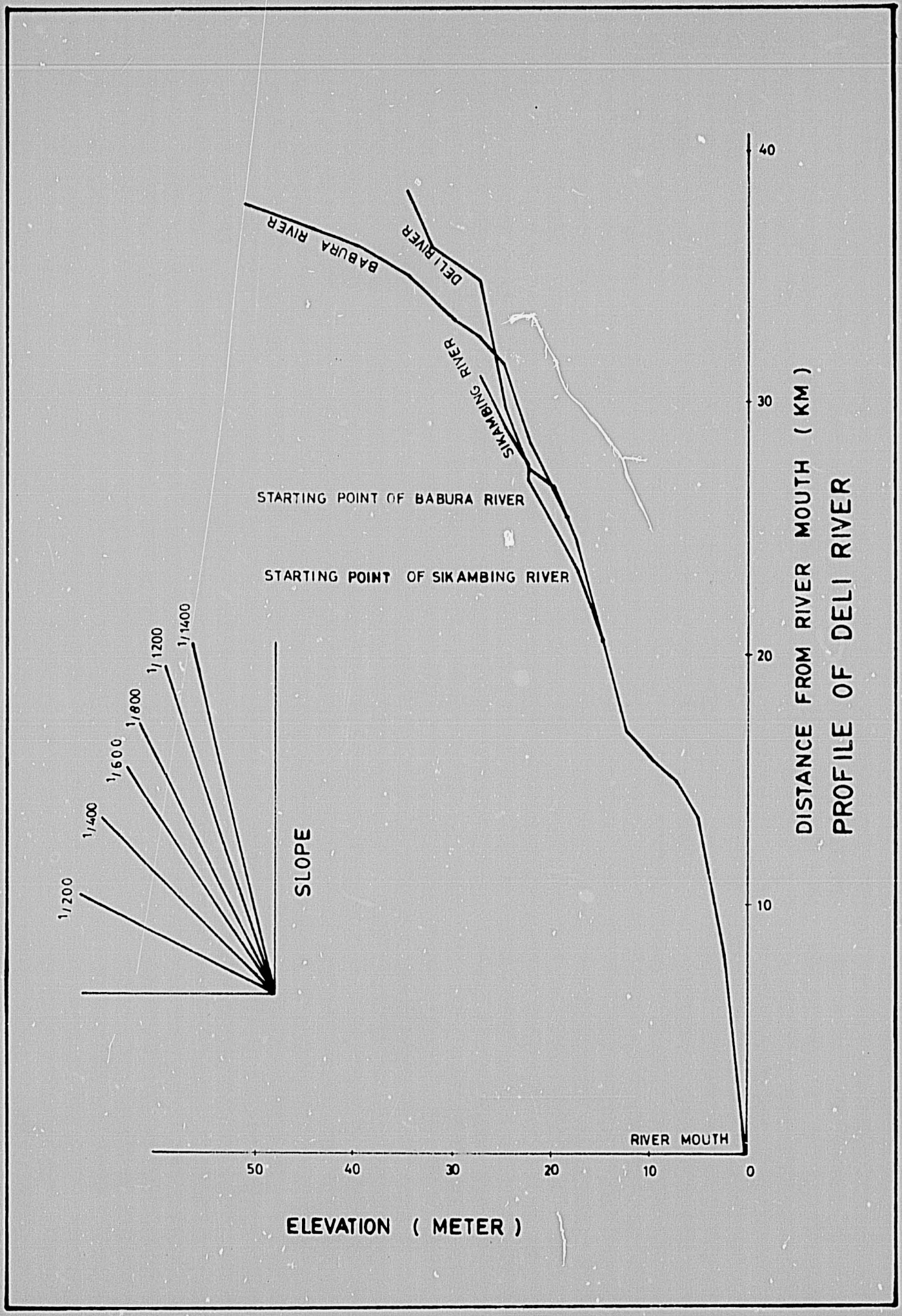

PROFILE OF DELI RIVER
DISTANCE FROM RIVER MOUTH (KM)
40
30
20
10
0
DELI RIVER
BABURA RIVER
SIKAMBING RIVER
STARTING POINT OF BABURA RIVER
STARTING POINT OF SIKAMBING RIVER
RIVER MOUTH
50
40
30
20
10
ELEVATION (METER)
SLOPE
1/200
1/400
1/600
1/800
1/1200
1/1400

FIGURE : 2 b

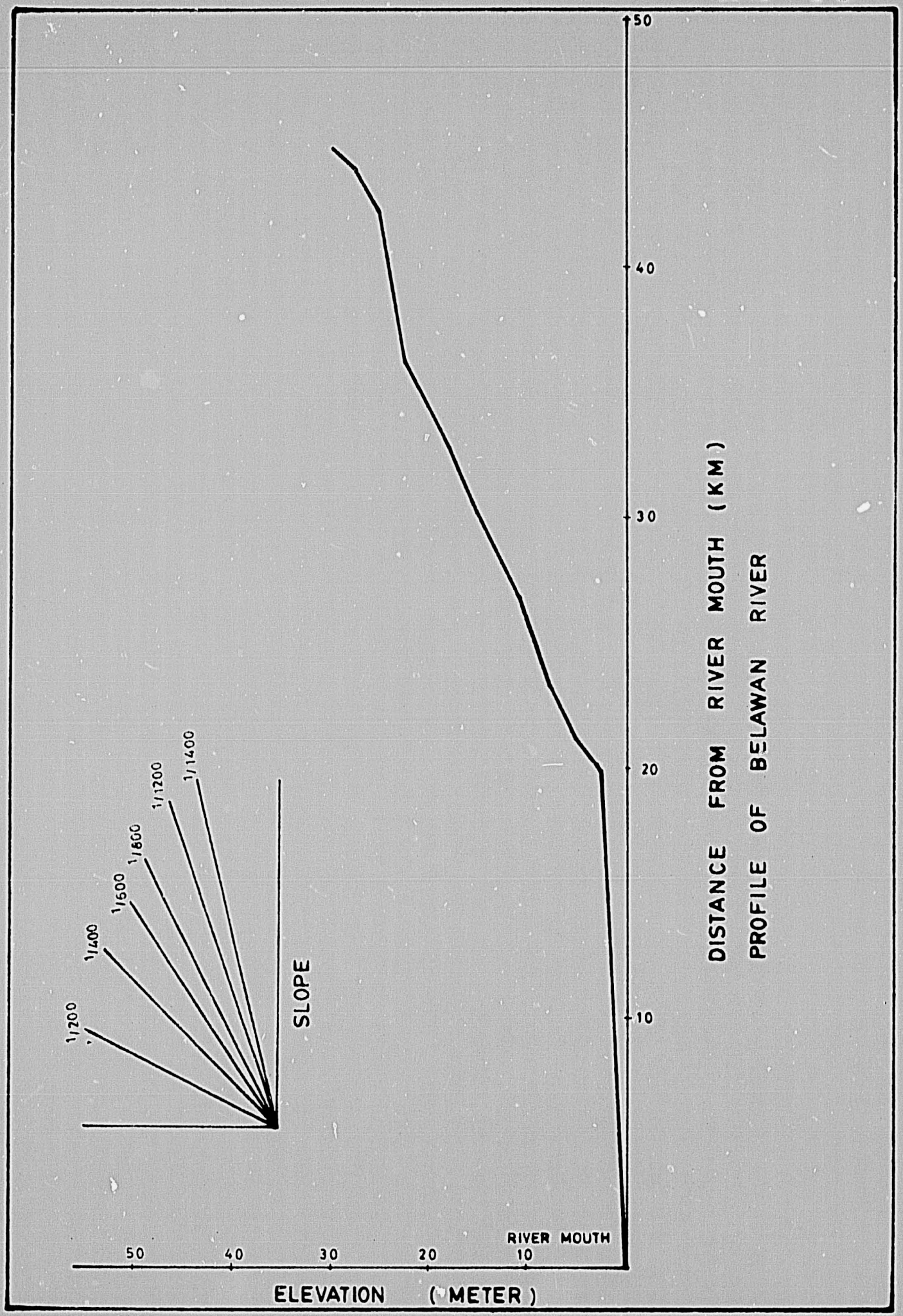
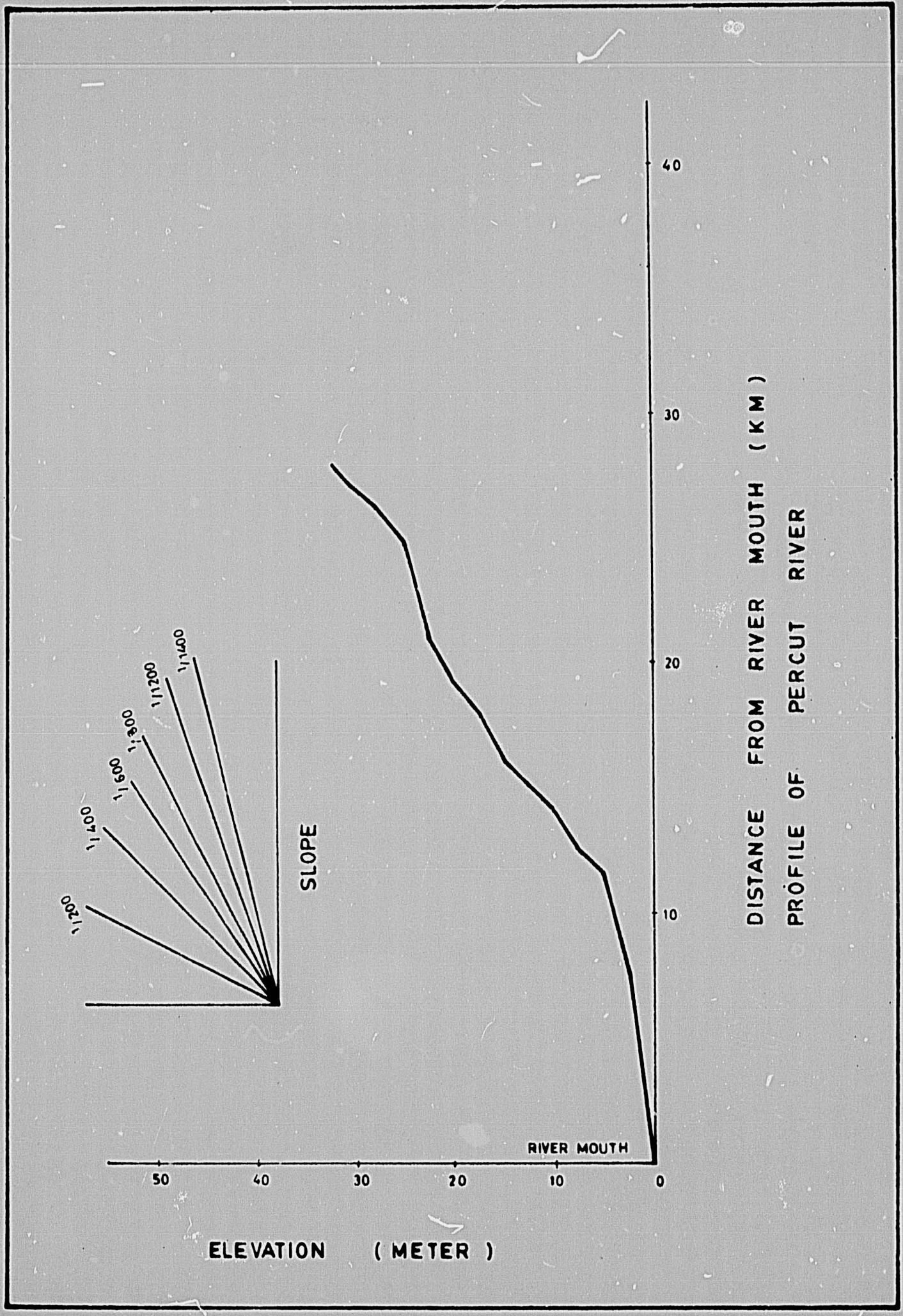
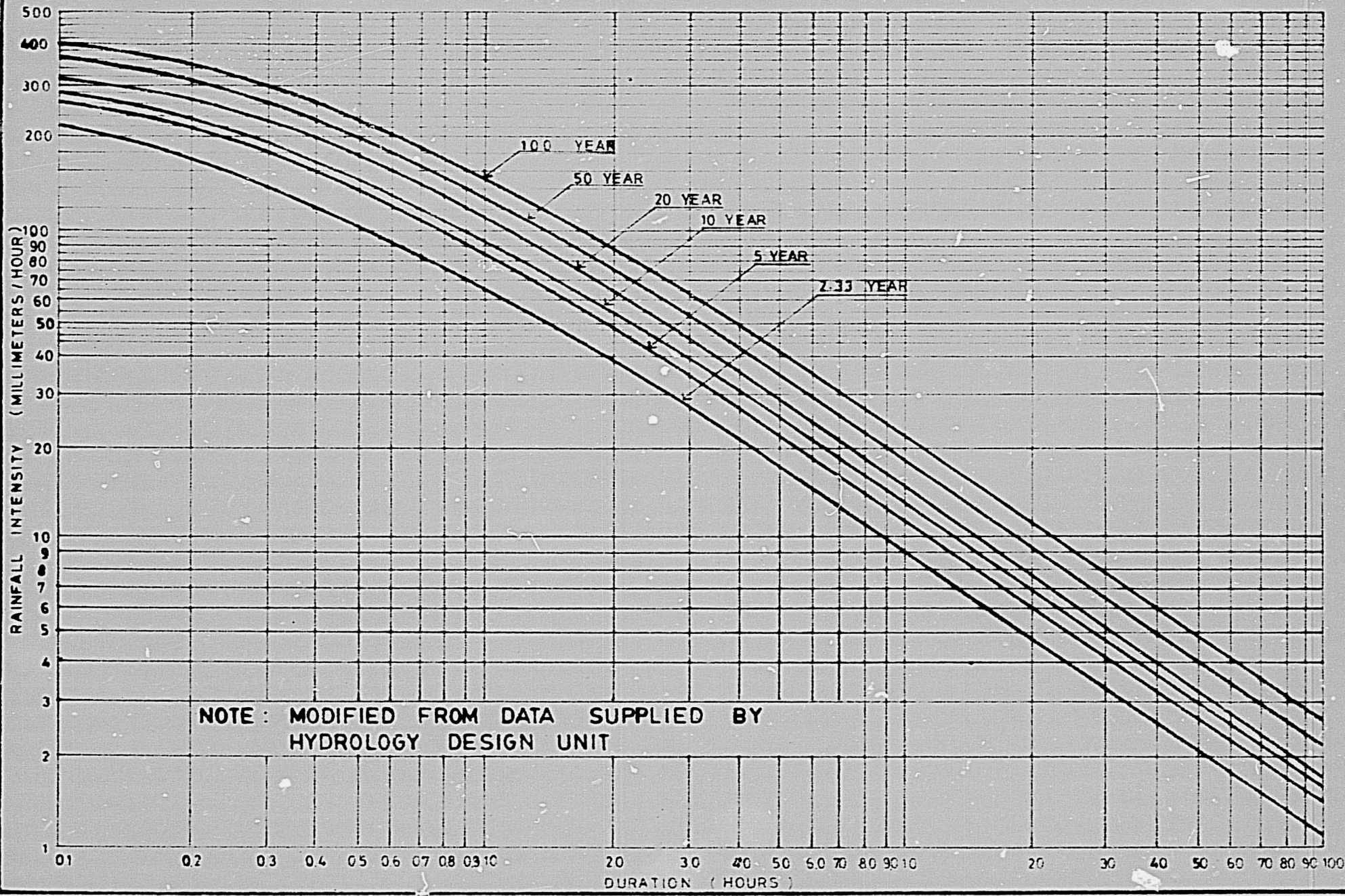

DISTANCE FROM RIVER MOUTH (KM)
PROFILE OF BELAWAN RIVER
50
40
30
20
10
SLOPE
1/1200
1/1400
1/1600
1/1800
1/1200
1/1400
RIVER MOUTH
50
40
30
20
10
ELEVATION (METER)

FIGURE : 2 C


DISTANCE FROM RIVER MOUTH (KM)
PROFILE OF PERCUT RIVER
40
30
20
10
0
RIVER MOUTH
50
40
30
20
10
ELEVATION (METER)
SLOPE
1/200
1/400
1/600
1/800
1/1000
1/1200
1/1400

RAINFALL INTENSITY - DURATION CURVES



NOTE: MODIFIED FROM DATA SUPPLIED BY HYDROLOGY DESIGN UNIT

FIGURE : 3

FIGURE 4

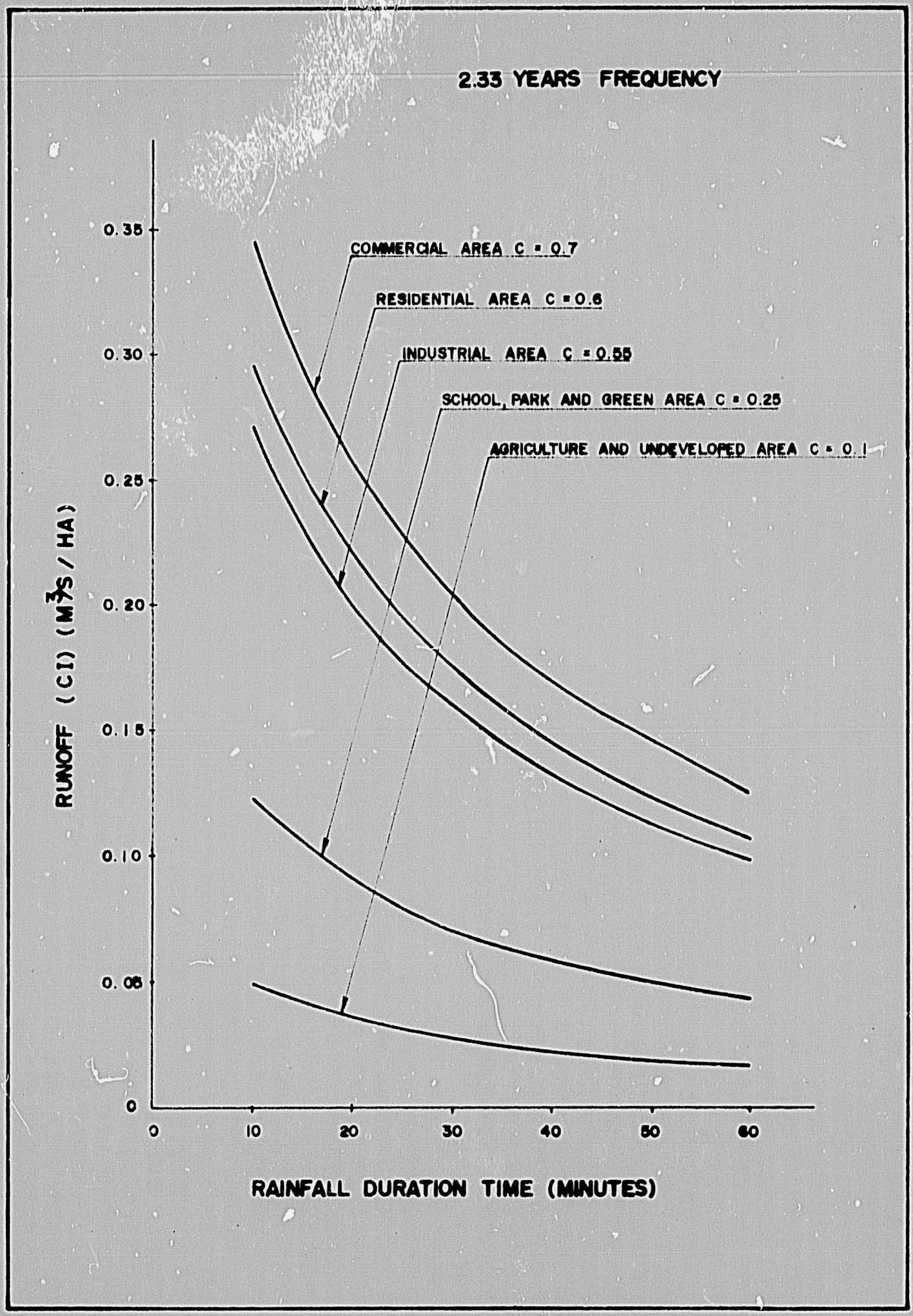

2.33 YEARS FREQUENCY
COMMERCIAL AREA C = 0.7
RESIDENTIAL AREA C = 0.6
INDUSTRIAL AREA C = 0.55
SCHOOL, PARK AND GREEN AREA C = 0.25
AGRICULTURE AND UNDEVELOPED AREA C = 0.1
RUNOFF (CI) (M³/S / HA)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0
0
10
20
30
40
50
60
RAINFALL DURATION TIME (MINUTES)

FIGURE : 5

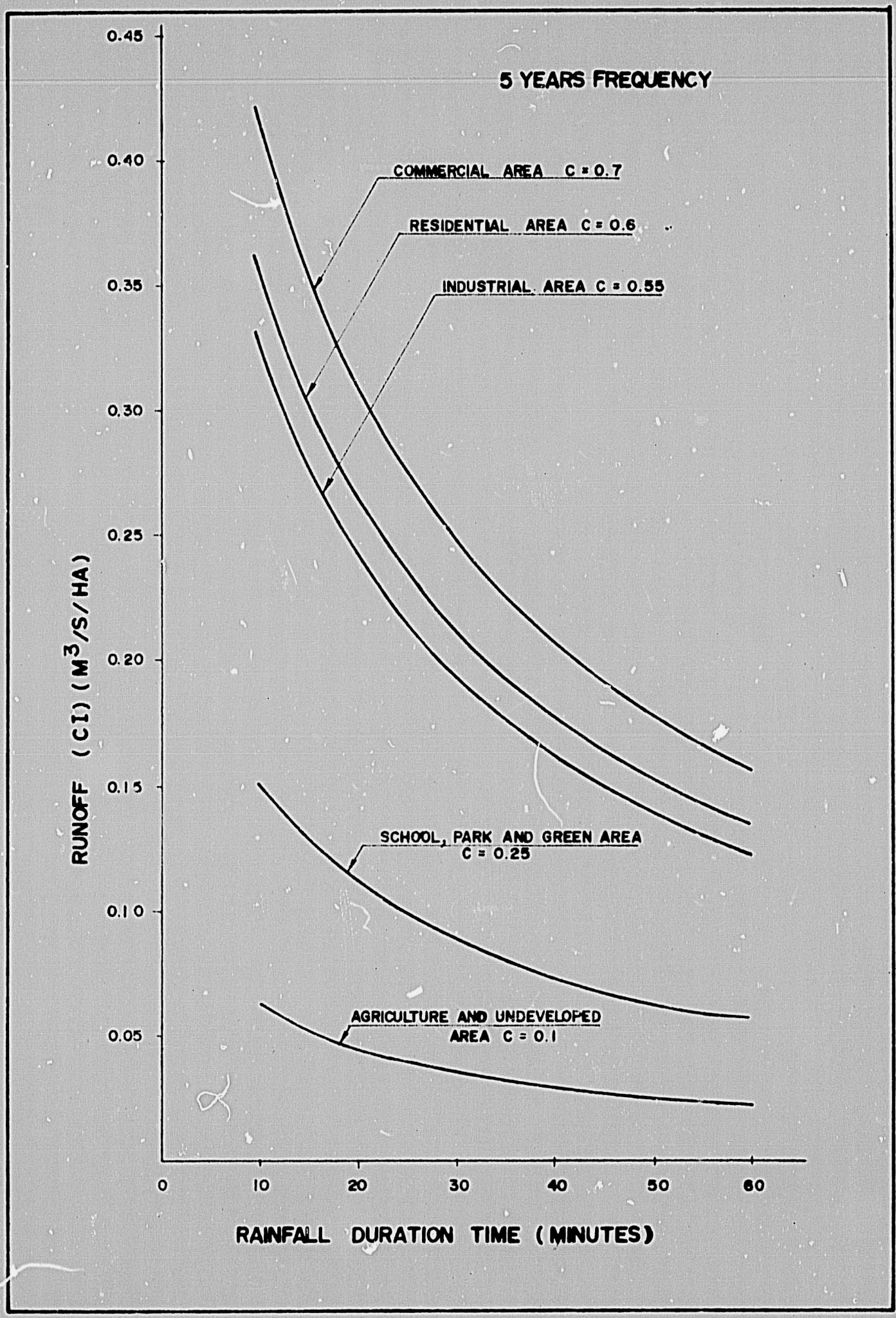
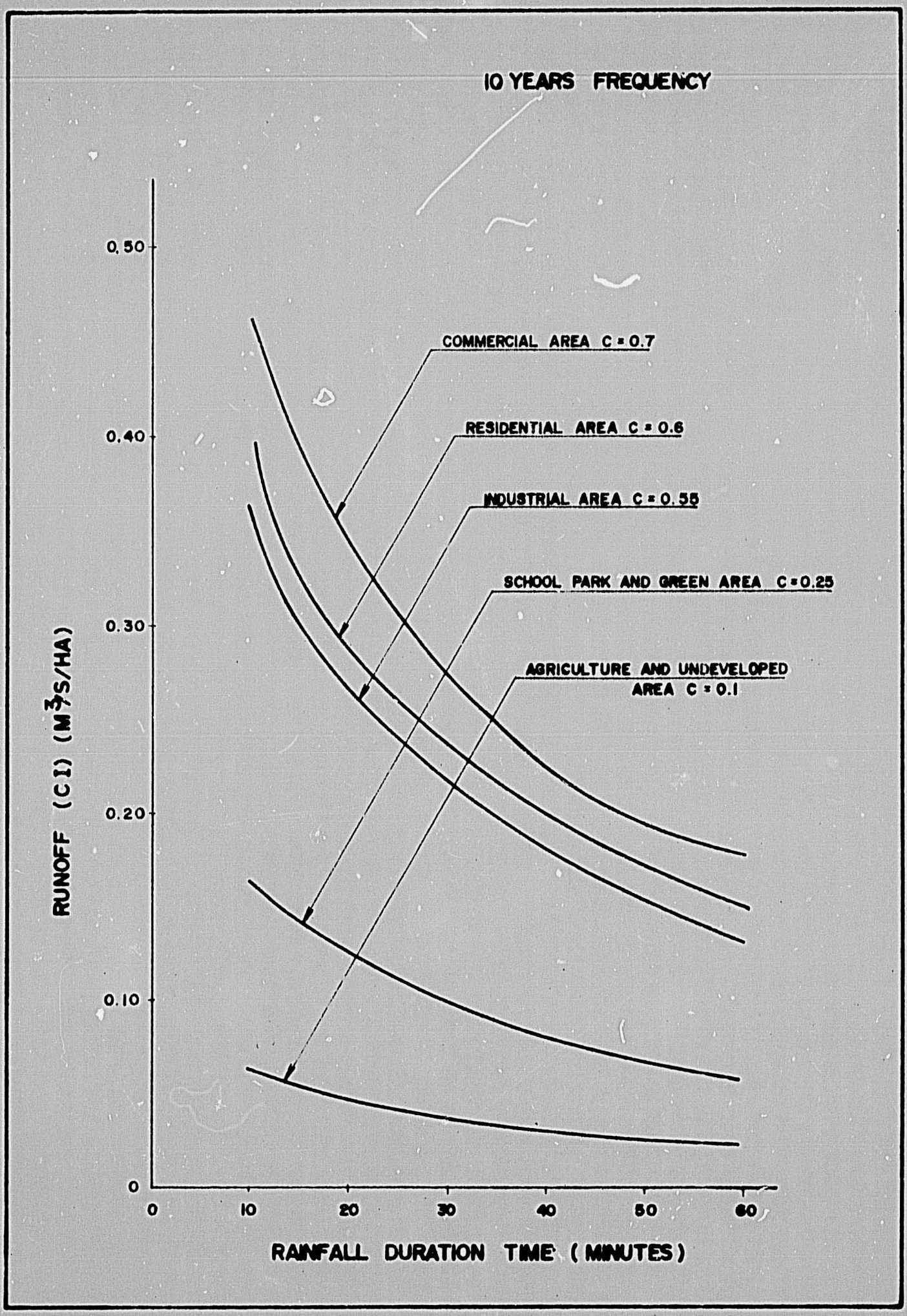

5 YEARS FREQUENCY
COMMERCIAL AREA C = 0.7
RESIDENTIAL AREA C = 0.6
INDUSTRIAL AREA C = 0.55
SCHOOL, PARK AND GREEN AREA C = 0.25
AGRICULTURE AND UNDEVELOPED AREA C = 0.1
RUNOFF (CI) (M3/S/HA)
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0
10
20
30
40
50
60
RAINFALL DURATION TIME (MINUTES)

FIGURE - 6



PADCO - DACREA

ENGINEERING SCIENCE - SINOTECH

FIGURE : 7

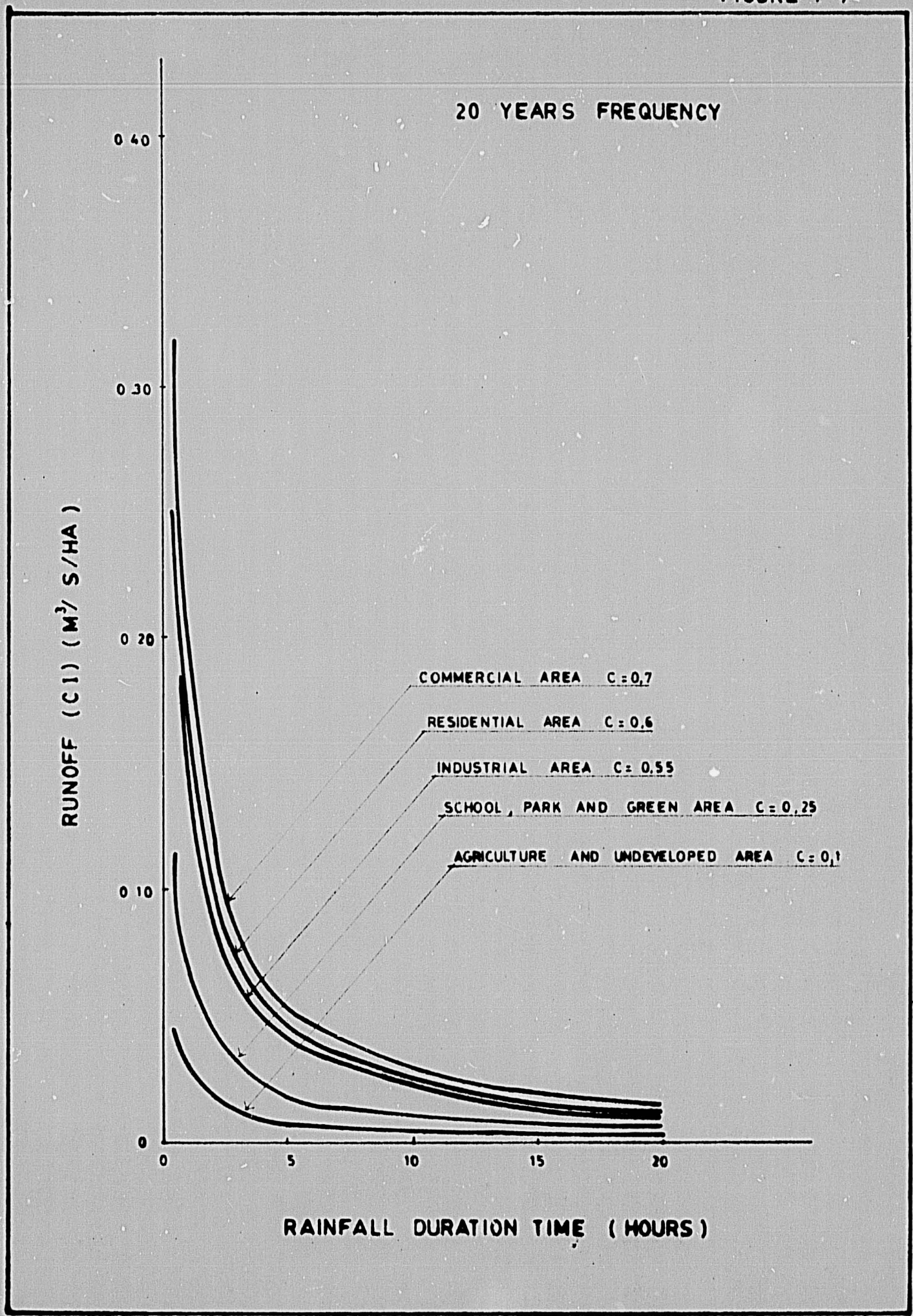
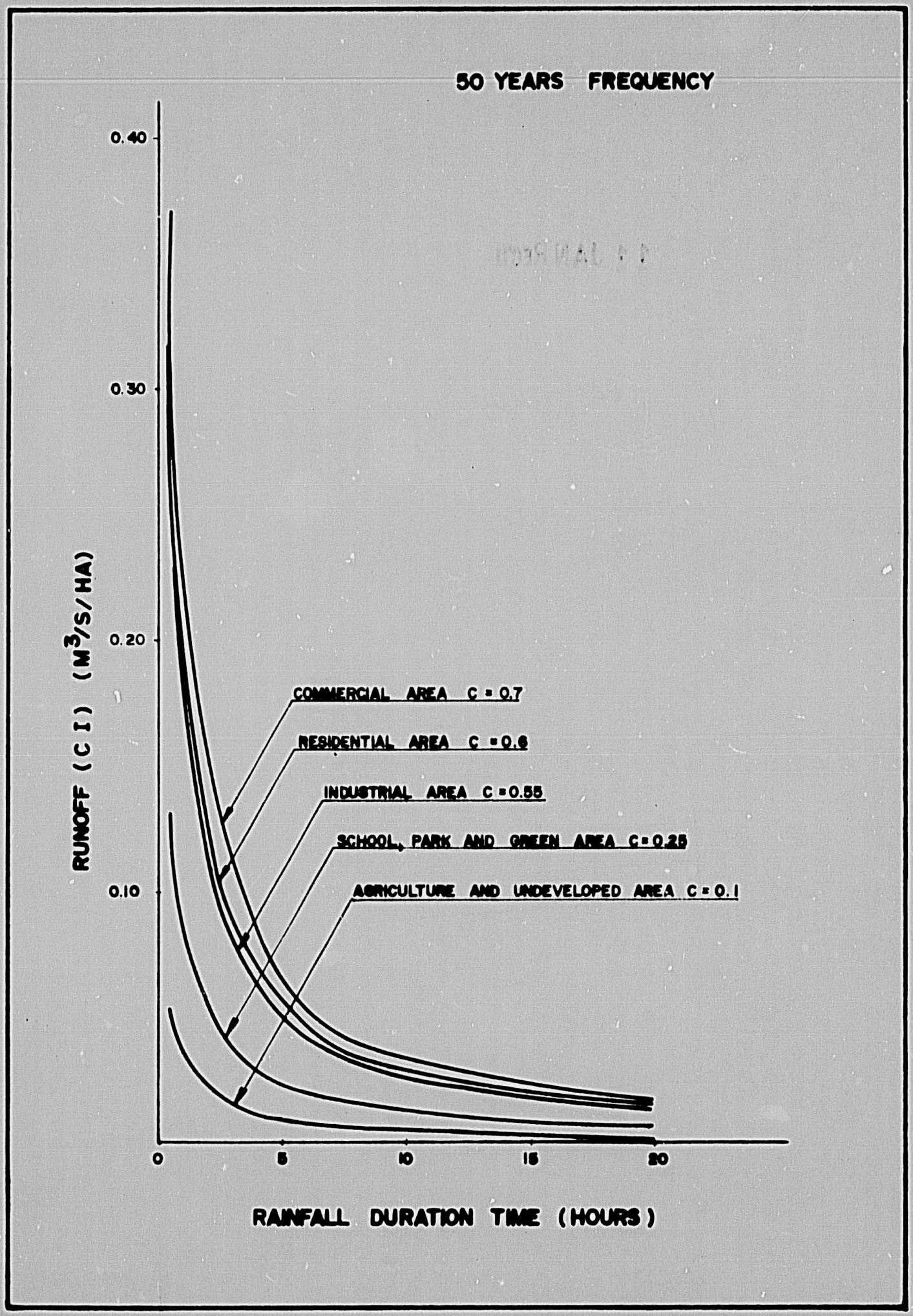

20 YEARS FREQUENCY
0 40
0 30
0 20
0 10
0
RUNOFF (C I) (M³/ S/HA)
COMMERCIAL AREA C = 0,7
RESIDENTIAL AREA C = 0,6
INDUSTRIAL AREA C = 0,55
SCHOOL, PARK AND GREEN AREA C = 0,25
AGRICULTURE AND UNDEVELOPED AREA C = 0,1
0
5
10
15
20
RAINFALL DURATION TIME (HOURS)

FIGURE - 8


50 YEARS FREQUENCY
0.40
0.30
0.20
0.10
RUNOFF (C I) (M3/S/HA)
COMMERCIAL AREA C = 0.7
RESIDENTIAL AREA C = 0.6
INDUSTRIAL AREA C = 0.55
SCHOOL, PARK AND GREEN AREA C = 0.25
AGRICULTURE AND UNDEVELOPED AREA C = 0.1
0
5
10
15
20
RAINFALL DURATION TIME (HOURS)