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THE REPUBLIC OF INDONESIA
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
MINISTRY OF PUBLIC WORKS

THE MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS

FINAL REPORT
(SUPPORTING REPORT)

NOVEMBER 1993

JAPAN INTERNATIONAL COOPERATION AGENCY

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DATA BOOK

The cost estimate was based on July 1992 price level and expressed in Rupiah according to the exchange rate of US$1.00 = Indonesian Rupiah 2,033 and Japanese Yen 1.00 = Indonesian Rupiah 16.20 as of July 1992.

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CHAPTER 1 GENERAL

The study area lies between latitude 110°10'E to 110°31'E and longitude 6°56'S to 7°11'S in Jawa Island. It includes Semarang City which is the capital of Central Jawa Province as shown in Fig. I.1.1.

The northern side of the study area, which is the center of the city, is located in a coastal plain along Jawa Sea. Semarang City is bounded on the west by Kabupaten Kendal and on the east by Kabupaten Demak. About 23 km south of the city is Mt. Ungaran which rises to an elevation of 2,050 m. Six (6) objective rivers flow generally toward north. They are from east to west, Babon River, East Floodway, West Floodway/Garang River, Silandak River, Bringin River and Blorong River. The total catchment area of the six rivers is approximately 510 km^2.

As shown in Fig. I.1.2, the study area is under the influence of northwest and southeast trade winds. Climate is divided into two (2) seasons, namely, rainy season and dry season. The rainy season lasts between November and April with wet northwest winds from the Jawa Sea bringing rainfall, while the dry season lasts between May and October with southeast winds.

CHAPTER 2 CLIMATE

2.1 Existing Observatory

An inventory of meteorological and rainfall gauging stations in the study area and neighboring areas is given in Table I.2.1. The location of these stations is indicated in Fig. I.1.1.

There are three (3) meteorological stations in the study area, namely, two stations (Semarang and Ungaran stations) operated by the Institute of Meteorology and Geophysics (BMG) and one station at Semarang Ahmad Yani (Semarang Airport) for the observation of temperature, sunshine duration, wind velocity, hourly and daily rainfall, and evaporation.

There are 52 rainfall stations in the study area. Forty-one (41) of these stations are maintained by the Ministry of Public Works (DPU) and they include the four stations for daily rainfall observation in relation to the Jratunseluna Project. Three (3) rainfall stations are maintained by the Institute of Hydraulic Engineering (IHE) for the observation of hourly rainfall, and eight (8) other stations send daily rainfall data to BMG. The rainfall data were therefore collected from the DPU, the BMG and the IHE.

Two (2) water level gauging stations in Garang River and Blorong River are maintained by the IHE. The daily discharge data and annual maximum hydrographies of the two stations were collected from the IHE.

Meteorological data collected at the Semarang Airport station and the Ungaran station are relatively more reliable than those of other stations.

2.2 Climatic Characteristics

Climate

The Semarang station is located in the coastal plain. Temperature at the Semarang Airport station ranges between 21°C and 35°C and average annual temperature is 27.4°C. Average annual humidity is 76% and mean annual wind velocity is 4 knots.

The Ungaran station is located 300 m above mean sea level. Temperature ranges between 18°C and 35°C and average annual temperature is 26.2°C. Average annual humidity is 78%.

The climatic conditions are shown in Tables I.2.2 and I.2.3.

Rainfall

In rainy seasons rainfall is generally brought about by northwest wet winds blowing from Jawa Sea. Rainfall continues for approximately 2 to 12 hours, starting in the afternoon until midnight in general. Annual rainfall amounts to 2,460 mm at Semarang Airport station and 2,065 mm at Ungaran station. Isohyetal maps of daily rainfall for the major rainfalls from 1972 to 1990 are shown in Fig. I.2.1.

River Discharge

Annual average discharge observed at the Garang River Gauging station (C.A. = 185 km^2) and the Blorong

River Gauging station (C.A. = 158km^2) are listed in Table I.2.4. Annual average flow (Q) is 10.7 m^3/s at Garang River Gauging Station and 8.0 m^3/s at Blorong River Gauging station.

At Simongan Weir, annual maximum water levels were observed from 1961 to 1990. The annual maximum peak discharges were then estimated, as shown in Table I.2.5. Maximum discharge is 901 m^3/s in 1963 and 1990.

CHAPTER 3 RAINFALL ANALYSIS

3.1 Selection of Representative Rainfall Station

The distribution of rainfall depth is different in every rainfall. In the storm on January 25, 1990 which caused a big flood, rainfall at the mountainous areas was recorded at more than 200 mm/day, while that at Semarang City was only 35 mm/day. In consideration of the above condition, it is important to analyze rainfall in the coastal plain area and in the mountainous area.

Among the rainfall gauging stations, two stations can provide data for the study. These are the Semarang Meteorological Station (BMG) located in Semarang City and the Kaligading Automatic Rainfall Gauging Station (IHE) located on the foot of Mt. Ungaran.

The Semarang Meteorological Station (BMG) can provide rainfall intensity observed for short and long time durations ranging from five minutes to two days. Kaligading Automatic Rainfall Gauging Station (IHE) can provide rainfall intensity observed for a long time duration of one hour to two days.

3.2 Rainfall Intensity-Duration Curves

Two (2) types of rainfall intensity-duration curve were developed according to ranges of rainfall for the urban drainage plan and the flood control plan, as follows.

(1) Short Duration Curves

The curves were developed on the basis of annual maximum rainfall intensities observed for the duration of less than 120 minutes and preferably used for planning urban drainage where the run-off concentration time is less than 120 minutes. The rainfall intensity data of the Semarang Meteorological Station were used for this analysis [refer to Table I.3.1(1/2)].

(2) Long Duration Curves

The curves of two stations were developed on the basis of annual maximum rainfall intensities observed for time ranges of one hour to a few days preferably used for run-off analysis of hourly hydrographies in the flood control plan. In this study, the curves of Semarang Meteorological Station were applied to the planning of pump drainage for the Urban Drainage Plan. That of the Kaligading Automatic Rainfall Gauging Station was applied to the run-off analysis for the flood control plan. Those curves were used to estimate the probable run-off hydrographies. The data are shown in Table I.3.1.

3.3 Probable Rainfall Intensities

The recurrence probability analysis on point rainfall intensity of various durations was made by Gumbel Method using the annual maximum rainfall intensity series observed at Semarang and Kaligading gauging stations. As the results of the analysis, the probable point rainfall intensity for rainfall durations ranging from 5 minutes up to 48 hours were estimated as shown in Table I.3.2 and Fig. I.3.1.

3.4 Equations and Curves to Express Rainfall Intensity-Duration-Frequency

The following equations are generally applied to express the relationship between rainfall intensity and duration:

(a) Talbot Type Equation : $I = a / (T + b)$
(b) Sherman Type Equation : $I = a / T^n$
(c) Kuno Type Equation : $I = a / (T^{0.5} + b)$
(d) Horner Type Equation : $I = a / (T + b)^n$

where,

I : *Rainfall Intensity*
T : *Rainfall Duration*
a, b, n: *Constants*

The probable rainfall intensities were estimated from the equations and compared with the values estimated from the observed data as shown in Table I.3.3. Constants of the rainfall intensity-duration-frequency equations were estimated by least-square regression analysis for the relation between the probable rainfall intensities and corresponding rainfall duration. The equations for each station and each type are shown in Table I.3.4.

The Horner Type Equation which shows the smallest difference between observed data and estimated data is the most applicable equation to express the rainfall intensity-duration curves as shown in Fig. I.3.2. In the report of Semarang Drainage Project (May 1982), rainfall intensity curves were estimated for the records of 13 years (1959-1981) and these curves show nearly the same numerical values as those presented in this report.

3.5 Model Hyetograph of Point Rainfall

The model hyetographs showing distribution of point rainfall intensities of the study area were developed taking the following major factors into consideration.

(1) Entire Rainfall Duration

The standard value of the entire rainfall duration is an important factor for the model hyetograph run-off analysis of river basins. In this connection, surveyed were the actual rainfall continuation times of the 12 major storms recorded at the Semarang Meteorological Station for the period from 1979 to 1991, and 11 major storms recorded at the Kaligading Automatic Gauging Station for the period from 1980 to 1990. Consequently, the entire rainfall duration of the model hyetograph is assumed at 12 hours, which is the dominant rainfall continuation time in the past major storms, as shown in Fig. I.3.3.

(2) Time Distribution of Rainfall Depth

The time when the peak rainfall depth occurred in each storm was analyzed on the basis of the hourly rainfall depth observed in the above 23 major storms. As a result of the analysis, it is assumed that the model hyetograph has such a pattern that the rainfall depth gradually increases at regular time intervals until it reaches the peak at midpoint of the entire rainfall duration and then, gradually decreases at regular intervals. The assumption of rainfall depth is made as follows:

Rainfall Depth Distributed at Intervals of "dt"	Time of Occurrence
(a) Highest = $F(dt) \times dt/60$	Tc (mid. of duration)
(b) 2nd Highest = $F(dt \times 2) \times dt \times 2/60 - F(dt) \times dt/60$	$Tc + dt$
(c) 3rd Highest = $F(dt \times 3) \times dt \times 3/60 - F(dt \times 2) \times dt \times 2/60$	$Tc - dt$
(d) 4th Highest = $F(dt \times 4) \times dt \times 4/60 - F(dt \times 3) \times dt \times 3/60$	$Tc + dt \times 2$
(e) 5th Highest = $F(dt \times 5) \times dt \times 5/60 - F(dt \times 4) \times dt \times 4/60$	$Tc - dt \times 2$

where,

F = *rainfall intensity expressed by function of rainfall duration (dt x 1, 2, 3,...)*

dt= *time interval of model hyetograph*

Tc= *midpoint time in entire duration of model hyetograph*

The model hyetographs were developed on the basis of factors (1) and (2) above and the rainfall intensity-duration equation described in Section 3.4. As an example, Table I.3.5 presents the model hyetographs of 5-minute and 1-hour intervals which were developed from the Horner Type Rainfall Intensity-Duration Equation.

CHAPTER 4 FLOOD RUN-OFF ANALYSIS

Flood run-off analysis has been carried out to provide the standard design discharge for the formulation of the Flood Control Plan for the six (6) objective rivers; Babon River, East Floodway, West Floodway/Garang River, Silandak River, Bringin River and Blorong River. The six rivers flow down generally toward north, and the features of each river basin are as follows:

River	Catchment Area (km2)	Reference Point	Length of Stream (km)	Highest Elevation (EL. m)
Babon River	77.0	Pucanggading Weir	30.0	375
East Floodway	29.7	Kaligawe Bridge	12.0	250
West Floodway/ Garang River	204.0	Simongan Weir	32.0	2,050
Silandak River	8.5	Confluence of Channel	11.0	175
Bringin River	32.1	Bringin Bridge	15.5	225
Blorong River	157.0	Pengilon Weir	60.0	725

4.1 Procedure of Run-off Analysis

Garang River is the only river in the study area with complete data such as hourly discharge data of several major floods, hourly rainfall data of same floods, isohyetal maps of the same days and annual maximum discharge data for estimation of probable peak discharge. Therefore, the run-off analysis was made focusing on Garang River by the following procedure:

(1) The run-off model for Garang River is established by the storage function model with actual rainfall and discharge data, and it will be applied to the other five (5) rivers.

(2) Probable peak discharge at a reference point of Simongan Weir is estimated from actual discharge data.

(3) Area reduction factor for the Garang river basin is calculated to convert point rainfall into average rainfall in the river basin. The area reduction factor for Garang River is estimated by the probable peak discharge at Simongang Weir and the model hyetograph. The area reduction factors for the other five (5) river basins are estimated based on the their catchment areas (km^2) and the area reduction factor for Garang River.

(4) The probable peak discharge of the other rivers are calculated by storage function model with the area reduction factors estimated for each river basin.

4.2 Storage Function Model

4.2.1 Method of Storage Function Model

In order to calculate the flood discharges for each river, it is necessary to estimate the model hydrograph from the model hyetograph by run-off analysis. The storage function model is employed to simulate the design floods in this study, because various experimental values for the constants have been developed for this model and it is suitable to be applied for river basins with a few data for verification.

Storage Function Model for River Basin

The storage function model has been developed to express non-linear characteristics of run-off phenomena introducing the following function between the storage volume ($S1$) of a basin or a river channel and the discharge ($Q1$) from the same:

$$S1 = K \cdot Q1^{p} \qquad (1)$$

where, K and p are constants.

This equation is used with the equation of motion which expresses run-off as proportional to the exponent of storage volume. In this equation, the run-off phenomenum is considered to be similar to the run-off from the notch of a container filled with water.

Run-off calculation is performed in combination with the following equation of continuity for a basin.

$$\frac{dS_1}{dt} = \frac{1}{3.6} \cdot f \cdot r_{ave} \cdot A - Q1 \qquad (2)$$

where,

S_1	:	*apparent storage volume in the basin*($m^3/s/hr$)
f	:	*inflow coefficient*
r_{ave}	:	*basin's average rainfall (mm/hr)*
A	:	*area of the basin* (km^2)
$Q1=Q(t+T1)$	:	*direct run-off height with lag time* (m^3/s)
$T1$	:	*lag time (hr)*

Run-off calculations for a basin are generally made by dividing the above two basic equations (1) and (2) by the area of a basin in order to express them by the storage height *s (mm)* and run-off height *q (mm/hr)*. Accordingly, the basic equations are expressed as follows:

$$s_1 = k \cdot q_1^p \qquad (3)$$

$$\frac{dS_1}{dt} = f \cdot r_{ave} - q1 \qquad (4)$$

The constant f in the above equation is to estimate the effective rainfall. In the storage function model, the coefficient f is not related to rainfall but to the drainage area A; namely, it is assumed that in the early stages of rainfall, f is f_1 (termed the primary run-off rate) and that run-off occurs only from the area f_1A (called the run-off area). When accumulated rainfall exceeds R_{sa} (saturation rainfall), then $f=1$ (this is termed the saturated run-off rate), and the run-off occurs also from the remaining part $(1-f_1)A$ (infiltration area) due to the rainfall after R_{sa}.

In this model, run-off from both the run-off area and the infiltration area is calculated separately by equations (3) and (4) until the end of the flood. The total run-off from the whole basin is given by the sum of run-off from both areas plus the base flow, as shown in the following equation.

$$Q = \frac{1}{3.6} \cdot f1 \cdot A \cdot q1 + \frac{1}{3.6} \cdot (1 - f1) \cdot A \cdot q_{sat} + Q1 \qquad (5)$$

where,

f1	:	*primary run-off rate*
q1	:	*run-off height caused by total rainfall (mm/hr)*
q_{sat}	:	*run-off height caused by rainfall after saturation (mm/hr)*
Q1	:	*base flow* (m^3/s)
A	:	*total drainage basin* (km^2)

Storage Function Model for River Channel

The storage function of the river channel is expressed as follows:

$$dS/dt = Qi(t) - Qo(t+T1) \quad (6)$$

$$S = k \cdot Qo(t+T1)^p \quad (7)$$

where,

BS	:	*storage volume in the river channel* ($m^3/s/hr$)
Qi(t)	:	*inflow discharge of the channel* (m^3/s)
Qo(t+t1)	:	*outflow discharge of the channel* (m^3/s)
k, pf	:	*constant*
T1	:	*lag time (hr)*

4.2.2 Model for Simulation

In the storage function model, the basin is divided into sub-basins with catchment areas of 10 to 1,000 km^2; mostly less than 300 km^2. In this study, the river basins are divided into 23 sub-basins with catchment areas ranging from 1.3 to 70.9 km^2 and containing 22 river channels, as illustrated in Fig. I.4.1.

As for the data on flood hydrograph at Garang River from 1986 to 1990, hourly rainfall hyetographs at Kaligading and daily rainfall data in Garang River are available only for 1987 and 1990 as shown in Fig. I.4.2. Hourly rainfall in the basin is calculated proportionately between the daily data of Kaligading and the average rainfall of the Garang river basin estimated from isohyetal maps as shown in Fig. I.2.1(4/4).

4.2.3 Constants of Storage Function Model

Constants for River Basin

The basin's storage function is expressed as below (refer to Subsection 4.2.1):

$$S1 = K \cdot Q1^{p}$$

Constants K and p are determined as follows:

$$K = 5.5 \cdot A^{0.14}$$

$$p = 0.6$$

$$T1 = 0.95 \cdot A^{0.14} \cdot r_e^{-0.4}$$

where,

A : *catchment area* (km^2)

r_e : *height of net supply rainfall calculated from peak discharge volume* (Q_p); $r_e = 3.6 \cdot Q_p / A$

Constants for River Channel

The river channel's storage function is expressed as:

$$S = K \cdot Q1(t + T1)^{p}$$

as explained above. Constant K is expressed in the form of:

$$K = L \cdot B^{0.4} \cdot (n/I^{0.5})^{0.6} / 3.6$$

where,

B	:	*average channel width (m)*
L	:	*channel length (km)*
n	:	*Manning's roughness coefficient*
I	:	*average channel slope*

The constant "p" takes the value of 0.6 from the Manning's Formula for Steady Flow.

The lag time Tl is expressed by the following equation:

$$Tl = L \cdot k \cdot p_c / I_*^{1-p_c}$$

where,

L	:	*catchment length (km)*
k	:	$(N/s^{0.5})^p$
N	:	*roughness coefficient*
p_c	:	*0.6*
I_*	:	*maximum inflow volume* (m^3/s)

The constants were decided as shown in Table I.4.1 after some trial calculations. The results of the simulation show almost the same values as the observed data at Garang River Gauging Station as shown in Fig. I.4.3.

4.3 Probable Peak Discharge at Simongan Weir

The probable peak discharge at Simongan Weir is estimated by the Gumbel Method from the annual maximum discharge data for 1961 to 1990 (refer to Table I.2.5). The estimated amounts of probable peak discharge are as shown in Table I.4.2.

4.4 Area Reduction Factor

In the calculation of the model hydrograph of 5 to 100-year return period at Simongan Weir by the Storage Function Model, the results of the model hyetograph were multiplied by the area reduction factors decided temporarily. This calculation is repeated until the results become almost the same as the probable peak discharge calculated from the observed data. The probable peak discharges at Simongan Weir shown in Fig. I.4.4 and the area reduction factors were estimated as follows:

Probable Peak Discharge at Simongan Weir

Return Period (year)	Probable Peak Discharge (m3/s)	Reduction Factor
5	520	0.44
10	630	0.46
25	770	0.47
50	880	0.47
100	980	0.49

The area reduction factors were estimated from area average rainfall divided by maximum rainfall on the isohyet of rainfall. The area reduction factors from actual rainfall records are shown in Fig. I.4.5. The adequacy of the area reduction factors of 0.44 to 0.49 for the Garang river basin (C.A. = 204 km^2) is verified by plotting in Fig. I.4.5.

The area reduction factor curves are drawn between point zero (0) to the points on the chart as shown in Fig. I.4.5. Fig. I.4.5 gives the basin rainfall reduction factors for 5-year to 100-year return periods as follows:

	Garang River	Babon River	East Floodway	Silandak River	Bringin River	Blorong River
Area(km2)	204.0	77.0	29.7	8.5	32.1	157.0
Return Period			Reduction Factor			
5	0.44	0.66	0.78	0.84	0.77	0.50
10	0.46	0.70	0.82	0.89	0.81	0.54
25	0.47	0.70	0.82	0.89	0.81	0.53
50	0.47	0.70	0.83	0.89	0.82	0.53
100	0.49	0.73	0.86	0.93	0.85	0.55

The area reduction factors given in the report prepared by THE STUDY ON URBAN DRAINAGE WASTE WATER DISPOSAL PROJECT IN THE CITY OF JAKARTA (MARCH 1982) show nearly the same numerical values as those given in this study report.

4.5 Model Hydrograph and Peak Discharge

The probable peak discharges of the other rivers were decided in the same way as West Floodway/Garang River. Each river basin was divided into several sub-basins and river channels as illustrated in Fig. I.4.1. The constants of the storage function model for each sub-basin and river channel were estimated as shown in Table I.4.1. The probable peak discharges of 5 to 100-year return period for five (5) rivers were estimated from the model hyetograph (refer to Table I.3.5) as follows:

Return Period (Year)	Probable Peak Discharge (m3/s)*					
	Garang River	Babon River	East Floodway	Silandak River	Bringin River	Blorong River
5	520	407	199(130)	68	195	431
10	630	494	240(157)	84	237	549
20	740	552	267(175)	94	264	628
25	770	578	280(183)	99	277	664
50	880	630	306(201)	110	315	739
100	980	710	342(225)	120	342	845

* Peak discharge at reference point
( ) Peak discharge of East Floodway in front of confluence with Bajak River

The probable flood run-off hydrographs of 20, 25, 50 and 100-year return period for the six (6) rivers are shown in Fig. I.4.6. The peak discharge of the six (6) rivers plotted and published by DPU in 1984 in the Maximum Record Floods in Indonesia are as shown in Fig. I.4.7. The peak discharges are distributed in appropriate range compared with the maximum records of other rivers in Indonesia.

4.6 Probable Peak Discharge at Proposed Dam Site for Master Plan

A master plan of flood control is proposed for four (4) dam sites. Design flood discharge at the dam site is necessary to be decided for further study. The probable peak discharge of 100-year return period at the dam site is calculated to provide the design flood discharge as follows:

Dam	Jatibarang	Mundingan	Kedung Suren	Babon
Area(km2)	53.00	45.70	146.50	51.90
A.R.F	0.82	0.84	0.58	0.82
P.P.D (m3/s)	569.00	500.00	864.00	545.00

A.R.F : Area Reduction Factor at dam site
P.P.D : Probable Peak Discharge

4.7 Probable Maximum Precipitation (PMP) and Probable Maximum Flood (PMF) for Jatibarang Dam

The probable maximum precipitation (PMP) and the corresponding probable maximum flood (PMF) for Jatibarang Dam were estimated to determine the design flood water level (DFWL) and the spillway design discharge for the dam.

(1) Probable Maximum Precipitation (PMP)

Since climatic records of dewpoint and wind velocity in and/or around the dam catchment area are not available, it is virtually difficult to carry out a comprehensive study on the PMP based on the climatic storm maximization. Under the circumstances, the PMP was estimated by the simple statistical Hershfield method using a series of annual maximum precipitation observed at Kaligading Rainfall Station. The entire duration of PMP is herein assumed at one (1) day, in due consideration of the past storm durations recorded at the gauging station.

The Hershfield method is recommended by the World Meteorological Organization (WMO) for areas where rainfall record is available but other climatic records are hardly obtained. The following equation has been developed as the principal approach of the Hershfield method:

$$Xpmp = Xn + Km \cdot Sn \qquad \text{(Eq. I.4.1)}$$

where,

Xpmp : *Point PMP*

Xn : *Adjusted average of a series of the annual maximum precipitation.*

Sn : *Adjusted standard deviation of a series of the annual maximum precipitation.*

Km : *Statistical Coefficient*

The adjusted average and standard deviation values (*Xn* and *Sn*) in the above equation (Eq. I.4.1) are estimated from:

(a) The unadjusted average and standard deviation values of the observed annual maximum precipitation, multiplied by

(b) The adjustment factors developed by Hershfield (refer to Table I.4.3 and Fig. I.4.8).

The statistical coefficient (*Km*) in the equation (Eq. I.4.1) is also estimated from the relationship of the *Km* and *Xn* values developed by Hershfield (refer to Fig. I.4.9).

The point PMP could be estimated through the above Eq. I.4.1, and converted into the aerial average PMP using the area reduction factor curves. The area reduction curves were developed by the World Meteorological Organization (WMO) based on average values obtained from the depth-area-duration (DAD) analysis of major general-type storms in the world (refer to Fig. I.4.10). The estimated area average PMP with time durations of 1, 6 and 24 hours are as shown in Table I.4.3, corresponding to 1.65 to 2.66 times the 100-year point probable rainfall, as follows:

(1) Rainfall Duration	(2) 100-year Rainfall	(3) PMP	(4) Multiplier [(2)/(3)]
1-hour	120 mm	198 mm	1.65
6-hour	197 mm	424 mm	2.15
24-hour	260 mm	691 mm	2.66

The aerial average one-day PMP estimated for Jatibarang Dam is, further, compared with the PMP estimated for other dams in Indonesia as shown in Fig. I.4.11, from which the PMP for Jatibarang Dam is evaluated to be within an appropriate range. The PMP for Jatibarang and adjacent dams are given below:

Dam	Catchment Area (km2)	One-day PMP (mm)
Jatibarang	53	691
Jragung	94	690
Maung	213	459
Kedung Ombo	614	580
Glapan	796	548

(2) Probable Maximum Flood (PMF)

The model hyetograph for PMP was developed as follows, based on the rainfall intensity-duration curve and hourly rainfall distribution pattern:

(a) The rainfall intensity-duration curve for the PMP was developed, as shown in Fig. I.4.12, from the above 1, 6, and 24-hour PMP using the Horner Type Equation.

(b) The hourly rainfall distribution was assumed to have a pattern such that the one-hour rainfall intensity gradually increases until it reaches the peak at the midpoint of the entire rainfall duration, and then gradually decreases.

The model hydrograph for the PMF was developed from the model hyetograph through the flood run-off calculation. The flood run-off calculation was made by the Storage Function Model.

The model hyetograph and hydrographs for PMF developed as above are shown in Table I.4.4 and Fig. I.4.13. The peak discharge in the model hydrograph of PMF for Jatibarang Dam is about 1,800 m^3/s which could be within the proper limits of the PMF enveloped curve for all dams in Indonesia (refer to Fig. I.4.14). The peak discharge of PMF for Jatibarang Dam is compared with the PMF peak discharge for adjacent dams as below:

(1) Dam	(2) Catchment Area (km2)	(3) Peak PMF (m3/s)	(4) Specific Peak PMF (m3/s/km2)
Jatibarang	53	1,800	34
Jragung	94	3,000	32
Maung	213	6,000	28
Kedung Ombo	614	8,000	13
Glapan	796	10,000	13

4.8 Probable Peak Discharge at Jatibarang Dam Site

Jatibarang Dam has been proposed as a priority project for the Feasibility Study. The design flood discharge at the dam site is necessary to be decided in designing the dimensions of the auxiliary spillway. The probable peak discharge of each return period at the dam site is calculated to provide the design flood discharge as shown below:

Return Period (year)	2	100	200	5,000	10,000
Discharge (m3/s)	254	569	636	865	911

4.9 Evaluation of January 1993 Flood

In January 1993, a powerful monsoon storm hit most parts of Jawa Island, particularly Central Jawa. The storm occurred quite recently during the later part of the Master Plan Study, and its hydrological conditions could not be incorporated into the Master Plan Study. Therefore, a supplementary hydrological study was carried out during the Feasibility Study to review the detailed storm conditions based on the recorded hydrological data.

The probable rainfall intensities were estimated with the supplementary data recorded until 1993 and the results of estimation for the probable rainfall intensities are shown in Table I.4.5. The recurrence probabilities of rainfall intensities for shorter durations of less than 12 hours were estimated at 5-year to 25-year return periods at Semarang Meteorological Station and shorter durations less than 6 hours are less than 10-year, 12 hours is less than 20-year at Kaligading Gauging Station. However, the rainfall intensities for longer durations of 1 day and 2 days show longer return periods of about 20- and 70-year return period, respectively, at both stations.

The flood hydrograph in the January 1993 flood is substantially attributed to one-day rainfall. The maximum one-day rainfall of the January 1993 flood is recorded at 232 mm, which corresponds to about 20-year return period.

The peak flow at Simongan Weir is determined at around 700 m^3/s judging from the field reconnaissance and the records of the Garang Automatic Gauging Station. The recurrence probability is estimated at the scale of about 20-year return period.

The design scales adopted for the flood control master plan are 20 to 100-year return periods, exceeding the above recurrence probability of the January 1993 flood. Accordingly, further study on design scales of the Master Plan will not be necessary despite the recent recurrence of flood in January 1993.

CHAPTER 5 INUNDATION ANALYSIS

5.1 Objectives and Procedure of Inundation Analysis

Inundation analysis for the six (6) rivers was carried out to estimate the flood damage area of flooding conditions of 5-year to 100-year return period. Results of the inundation analysis were used for the flood damage calculation and economic evaluation of the improvement plan for the six (6) rivers.

For the inundation analysis, the computer simulation model was established based on the field survey. As for the field survey, flood mark survey for the six (6) rivers was carried out by the JICA Study Team to confirm the inundation area as well as the water depth of the flood on January 26, 1990, as shown in Fig. I.5.1.

The inundation model was established to simulate the probable inundation area both without- and with-the-project conditions.

5.2 Field Survey for Inundation Model

From the field survey, the features of flooding in the inundation area are given as follows:

(1) The flood area is flat with a slight slope towards the sea along the river stretches. (Refer to Figs. I.5.2 to I.5.7)

(2) Overbank flow spreads along the river course in the upper reaches.

(3) Overbank flow spreads to the shoreline area in the lower reaches.

Considering the above features, flooding in the area shows the storage type and the flow/diffusion type. Therefore, the Two Dimensional Unsteady Flow Model is employed.

5.3 Establishment of Inundation Model

The flood inundation model for each river was established with the following conditions:

(1) The whole inundation area is divided into mesh blocks of 200 m by 200 m as shown in Figs. I.5.2 to I.5.7.

(2) The average ground height of each mesh is obtained using the topographic map with a scale of 1/10,000 prepared in this Study.

(3) Structures such as roads and railways which may hamper the smooth flow of inundation water are taken into consideration assuming them as barriers between mesh blocks.

5.4 Simulation by Inundation Model

The maximum inundation depth and inundation area were examined under the probable flood discharge of 5-year, 10-year, 25-year, 50-year, 100-year return period. As the initial condition for computation, it was necessary to give the overflow discharge to the inundation area and the overflow section. The following initial conditions were taken into account:

(1) The overflow sections selected are of the poor flow capacity sections determined by the non-uniform calculation method (refer to Fig. V.2.6). The overflow sections of each return period are marked with arrows on the mesh map as shown in Figs. I.5.2 to I.5.7.

(2) It is assumed that in the probable flood hydrograph, the surplus discharge over the flow capacity overflows at the overflow section. The overflow discharge (dQ) at the overflow section is given by the surplus discharge (Q) minus the flow capacity (q) at the overflow section in the hydrograph as follows:

$$dQ = Q - q$$

5.5 Results of Simulation

Hydrographs and flood marks of the 1990 flood in the Garang river basin are available. The simulation model of Garang River is adequate to the inundation record of the flood in 1990 based on the flood mark survey on Garang River as shown in Fig. I.5.1.

The probable inundation area and water depth which correspond to the probable flood of the six (6) rivers are shown in Figs. I.5.2 to I.5.7, and the inundation areas occasioned on each return period are shown in the following table. The inundation duration is less than 24 hours in all cases.

Return Period (Year)	Inundation Area (km2)					
	West Floodway	Babon River	East Floodway	Silandak River	Bringin River	Blorong River
			Inundation Area Without Project			
5	-	10.0(1.1)	-	2.3(0.1)	8.6(1.6)	27.2(2.2)
10	1.6(0.0)	12.2(5.8)	3.4(0.2)	2.3(0.1)	8.8(2.0)	29.3(6.0)
25	3.4(0.4)	12.8(6.8)	4.5(0.3)	2.6(0.2)	8.8(3.0)	30.9(8.7)
50	5.0(0.6)	13.9(7.3)	5.0(0.5)	2.6(0.3)	8.9(3.7)	31.4(10.0)
100	7.0(2.1)	15.8(8.0)	18.2(0.8)	2.6(0.6)	9.0(4.5)	32.5(12.6)
			Inundation Area With Project			
25	-	-	-	-	-	30.9(8.7)
50	0.6(0.0)	13.9(7.3)	5.0(0.5)	2.6(0.3)	8.9(3.7)	31.4(10.0)
100	1.3(0.4)	15.8(8.0)	18.2(0.8)	2.6(0.6)	9.0(4.5)	32.5(12.6)

( ) Inundation area of depth more than 50 cm

CHAPTER 6 LOW FLOW ANALYSIS

6.1 Daily Rainfall Analysis

(1) Selection of Rainfall Station

There are 52 rainfall stations in and around the study area as mentioned in CHAPTER 2. These stations have different observation periods and reliability of records. Taking the length of observation period, amount of missing data and areal distribution into account, 12 rainfall stations are selected. The location of the selected stations is shown in Fig. I.6.1 and the annual rainfall of each station for 33 years is summarized in Table I.6.1.

(2) Calculation of Basin Rainfall

All stations, even though they are selected on the above-mentioned criteria, have plenty of missing data as shown in Table I.6.1. Judging from the difficulty and inaccuracy to interpolate the missing data among these records, the following procedure was adopted to estimate the basin rainfall which means average depth over a catchment:

(a) Daily basin rainfall is calculated by the Polygon Method (refer to Fig. I.6.1) using the records of 12 rainfall stations in 1980 where whole data are complete;

(b) Representative station is selected for river basins showing the highest correlation between daily point and basin rainfall in 1980;

(c) Missing data of representative station records are interporated by the linear regression method from simultaneous records at nearby stations; and

(d) Basin rainfall for 33 years are calculated on a daily basis by the linear regression method using the filled-in records of the representative station.

Fig. I.6.2 shows the relationship of daily rainfall and regression coefficient between point rainfall at the representative station and basin rainfall based on the records in 1980. Table I.6.2 presents calculation results of basin monthly rainfall in the Babon, Garang and Blorong river basins, respectively.

6.2 Low Flow Analysis

(1) River Flow Condition

There are three water level stations under operation in the study area, namely, Pucanggading Weir station in Babon River, Panjangan station in Garang River and Pucung station in Blorong River. Their locations are shown in Fig. I.6.1.

Flow regime and balance in observed records are summarized in Table I.6.3 and the flow-duration curves are presented in Fig. I.6.3. Calculated annual loss in Table I.6.3 varies widely, but the reliable range of annual loss seems to be from 1,000 mm to 1,400 mm in comparison with annual loss and run-off ratio.

(2) Low Flow Model

The Tank Model is one of the notable models, so-called distributed conceptual models, which has been devised for the synthesis of streamflow data.

The Tank Model is defined as a single basin model encompassing basins covered by existing water level stations. In this case, rainfall data input into this model is daily basin rainfall which is calculated in CHAPTER 3, Rainfall Analysis, as described before.

Amount of evaporation is also input into this model, and this value is equivalent to the annual run-off loss. As described before, the average run-off loss approximately ranges from 1,000 to 1,400 mm based on the observed streamflow records. On the other hand, the value of pan evaporation at Semarang Meteorology Station is 1,740 mm/year. Actual value of evaporation commonly ranges from 60 to 70% of pan evaporation, therefore, the daily loss is determined from the monthly variation pattern of pan evaporation, and all values are scaled down to 60%.

(3) Model Calibration

The parameters of the Tank Model as shown in Fig. I.6.4 are determined by the trial and error method until the calculated daily hydrograph shows well fitness to the observed one. The observed and calculated hydrographs are compared as shown in Fig. I.6.5.

(4) Synthesis of Streamflow Data

The daily discharge at three stations for 30 years are estimated by Tank Model simulation. The calculated flow regime are given in Table I.6.4, and the typical flow-duration curves by the respective rivers are presented in Fig. I.6.6.

CHAPTER 7 TIDAL ANALYSIS

7.1 Observed Tidal Data

Tidal level in the study area has been continuously observed by an automatic water level gauge at Semarang Harbor which is located between the river mouths of West Floodway and East Floodway, and the observation period extends more than ten (10) years. The automatic water level gauge was, however, replaced once during the harbor improvement project and the tidal data observed before replacement of the gauge has not been preserved. The present available data that could be furnished from the Harbor is limited to the hourly tidal level from January 1989 to April 1992.

The tidal level data observed by the old automatic gauge was supplemented from the Report on the "Study of Drainage and River Improvement, Ministry of Public Works, July 1985." In the Report, described are the annual mean high water level (MHWL), mean sea level (MSL) and mean low water level (MLWL) at Semarang Harbor. The year adopted to estimate these annual mean tidal levels is not explained in the Report, but could be assumed to be, at least, before 1985, the completion year of the Report.

7.2 Chart Datum of Observed Tidal Level

The chart datum of the old automatic water level gauge was set at 0.506 m below the annual mean sea level (MSL) of Jakarta Harbor (Tanjung Priok) which was observed in 1925 and thereafter used as the datum plane of first order leveling for all topographic surveys in Jawa and also, for all elevations in this study.

On the other hand, the chart datum of the new automatic water level gauge has not yet been related to the MSL of Jakarta Harbor. Therefore, the tidal level observed by the new automatic gauge is not converted into the absolute elevation. To cope with this problem, leveling survey was carried out by the JICA Study Team and it was confirmed that the chart datum of the new automatic water level recorder is 0.90 m below MSL of Jakarta Harbor.

7.3 Annual Mean Tidal Level

Based on the tidal data observed and the chart datum clarified as stated above, the annual mean tidal level at Semarang Harbor was estimated in terms of the elevation above MSL of Jakarta Harbor as below (refer to Table I.7.1).

(Unit: EL. m)

Item	Before 1985	1989	1990	1991
MHWL	0.54	0.59	0.58	0.60
MSL	0.09	0.05	0.07	0.09
MLWL	-0.33	-0.44	-0.39	-0.37

Recently, tidal inundation has occurred frequently at the low-lying coastal areas leading to serious flood damage, particularly, in Semarang City. The related government agencies had tried to trace the causes of inundation, presuming that one of the possible causes was the recent upward tendency of the tidal level.

As shown above, however, the annual mean tidal levels of the recent three (3) years have the difference of less than 10 cm as compared with those observed before 1985. This proves that no definite long-term transition or upward tendency of the tidal level has occurred.

The MHWL will be used to determine the design high water level for the flood control plan. Therefore, the long-term transition of tidal level is not required to be incorporated into the determination of the design high water level.

TABLES

Table I.2.1 INVENTORY OF RAINFALL GAUGING STATION

No	Code	Station Name	Organization Data Collected	Year of Record (50 · 60 · 70 · 80 · 90)
		(1) DAILY RAINFALL DATA		
1	22	Babadan	DPU.BMG	B A B B B B B B B B B B B B B B B B B B B B B B B A B A A A A B B B B B B A A B
2	23	Bojong	DPU.BMG	B A B B B A B B B A B B B A B B B A B B B A B B B B B A A A A B B B B B B A A B
3	25	Ketapang	DPU.BMG	B A B B B A B B B B B B B B B B B A B B B A B B B A A B A A A B B B B B B A A B
4	25 a	Brongsang	DPU.BMG	B B B B B B B B B B B B B B B B B B A A A A A A B A B B B B B B B
5	25 b	Sikopek	DPU.BMG	B A B B B B B B B B B B B B B B B B B B B A B B B A A A A A A A A B B A B A B B
6	25 c	Tambakboto	DPU.BMG	B A B B B A B B B B B B B B B B B A B B B A B B B A A A A A A A A B B B B B B B
7	25 d	Podowaras	DPU.BMG	B A B B B A B B B B B B B B B B B B B B B B B B B B A A A A A A A B B A B A B B
8	25 e	Blorok	DPU.BMG	B A B B B B B B B B B B B B B B B A B B B A B B B A A A A A A A A B B B B B B B
* 9	25 f	Kebonadem	DPU.BMG	A B B B B B B B B B B B A B B B A A A A A A A A A A A A B B A A A A A A A A A A B A A
10	25 g	Kd.Pucung	DPU.BMG	A B B B A B B B B B A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A B
11	26	Trompo	DPU.BMG	B B B B B B B B B B B B B A B B B B B B B A B B B B B A B A A B B B B B B A A B
12	27	Langenharjo	DPU.BMG	A B B B B B B B B B B B A B B B B B B B A A B B B B B B A A B
13	28	Pegandon	DPU.BMG	B A B B B A B B B A B B A A B B B B B B B B B B B A A A A A A B B B B B B A A B
14	30	Puguh	DPU.BMG	B A B B B B B B B B B B B A B B B B B B B A B B B B A A B A A B B B B B B A A B
15	32 e	Plantaran	DPU.BMG	B B B B B B B B B B B B B B B B B B B B B B B B A B B B A A A B A B A A B B B B A A B
16	33	Kaliwungu	DPU.BMG	B B B B B B B B B B B B B B B B B B B B B A B B B A A A A A A B A B B A B A B B
17	33 a	Plumbon	DPU.BMG	B B A B B B B B B B B B B B A B B B A A A A A A A A B B A B A B B
18	33 b	Gambilangu	DPU.BMG	B B B A B B B B B B B B B B B B B B B B B B B A B B B B A A A A A A A B B A B A B B
19	33 d	Panggung	DPU.BMG	B B B B B B B A B B B A B B B B B B B B B B B A B B B A A A B A A A A B B B B B B B
20	33 e	Gambilangu (BB)	BMG	B B B B B B B B B B B B A B B B A A A A A A B B B B B B B A B
* 21	33 f	Karangtengah	DPU.BMG	A B B B B B B B A B B B B B B B B A A A A A A A A A A A A A A A A A A A A A A A A A A
22	33 g	Babad	DPU.BMG	A B B B A B B B B B B B B B B B B B B B B B B B A B B B A A A B A A A A B B B B A A B
* 23	34	Ngareanak/Singorejo	DPU.BMG	B B B B B A B B B A B B B B A A A A A A A A B A A A A A A A A A A A A A A A B B
* 24	37	Boja	DPU.BMG	B A A A A A A A B B A B B A A B A A B B B
* 25	39	Limbangan	DPU.BMG	B B B B B B B B B B B B B B A A A A A A B A B B A A B B B A A A A A A A A B A A
26	41	Tugu	DPU.BMG	B B B B B A B B B A B B B A A A B A A A A B B A B B B
27	41 a	A. Yani Airport	AYA	B B A B B B B A B B B A B B B B A A A B B B B B B B A B B
28	41 c	Mangkangwaduk	BMG	B B B B B B B B B B A B B B A B B B A A A A A A A A B B B B A B B
* 29	41 d	Bringinmangkang	BMG	B B A A A A A A A A A A A A A A A A A A A A A A A B A A
30	41 e	Sta.klimetologi smg	BMG	B A A A A A A B A A A A A A B A A A A B A A A
31	42	Simongan	DPU.BMG	B B B B A B B B A B B B B A A A A B A A B B A B A B B
32	42 a	Kalisari	DPU.BMG	B A B B B B B B B B B B A A B B B A A A A B A A B B A B A B B
* 33	44	Mijen	DPU.BMG	B B A A B B B A A A A A A A A B A A B A A A A A A A A A A A A A A
34	46	Gunungpati	DPU.BMG	B B B B B A B A B
35	49 a	Meteo Maritim	BMG	B B B B B B A B B A A B B B B B B B B
36	52	Pandeanlamper	BMG	B B B
* 37	59	Candi	BMG	B B A B A A A B A A A A A A A A A A A A A A A B A B B A A A B
38	63 b	Kd.Banbkong	PU.BMG	A A A B B B B B A B A B
39	64	Susukan	BMG	B B A B B B B B B B B B B B A B B B A A A A B B B B B B B B A B B
40	65	Ungarang	BMG	A A A A A A A A A A A A A A A A
* 41	65 c	Sumurjurang	PU.BMG	B B B B A B A A B A A A A B A B B A A B A B A B A B A A A B A A A B B A A A A
* 42	68 b	Klepu(kendal)	BMG	B A B B B B B A A B A A A A B A B A B B B B B B B B A A A A B A B B B B B B B
43	93	Sayung/Purwosari	PU.BMG	B B B B B B B B B B B B B B B B B B A A A A B B A B B B B B A B
44	94	Genuk	PU.BMG	B B B B B B B B B B B A B B A B B B A A A A B A B B B A B A B
45	96	Brumbung (Mranggen)	PU.BMG	B B A B B B B B B B A B B B A B B B B A A A A B A B B B A B A A B
* 46	97	Plamongan	PU.BMG	A A A A A A B A A B A A A A A A A A A A A A A A A A A A A A A A A
47	98	Pucanggading	PU.BMG	B B B B B B B B B B B B B B B B B B A A A A B B A B B A B A B
* 48	99	Banyumeneng	PU.BMG	A A A A B A B A A A A B A B A A B A A A A A A A A A A A A A A A A A A
49	Smg32	Jimbaran(NL2)	JSP	A A A A B A A B A B A A A A A A B
50	Smg33	Karangjati	JSP	A A A A A B B A B A A A B B
51	Smg34	Barangan	JSP	B A A A A A A A A A A A B B B
52	Smg35	Sabiroto	JSP	B A A A A A A A A A B A A A A A B
		(2) HOURLY RAINFALL DATA		
* 53	41 e	Sta.klimetologi smg	BMG	A A A B A A A A B A A A
54	41 a	A., Yani Airport	AYA	B B B A B B B B
* 55	5	Kaligading	IHE	B A A A A B A A B B A
56	9	Jragung	IHE	B B A B B B B A A B B B
57	11	Juwero	IHE	B B B A B B B A A

Notes
- * :Selected Station for Rainfall & Runoff Analysis
- DPU :Pekerjaan Umum (Public Works)
- BMG :Badan Meteorologi dan Geofisika (Institute of Meteorogy and Geophysics)
- AYA :A.Yani
- JSP :Jratunseluna River Basin Development Project
- IHE :Institute of Hydraulic Engineering

A : Complete Data
B : Incomplete with missing

Table I.2.2 (1/3) GENERAL CLIMATOLOGICAL DATA OF SEMARANG AHMAD YANI

Monthly Mean Temperature (°C)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1980	26.5	26.6	26.9	27.5	28.3	27.7	27.4	27.5	28.0	28.3	27.7	26.7	27.4
1981	25.9	26.1	27.5	27.9	27.7	27.8	26.9	27.9	27.9	28.7	27.3	26.8	27.4
1982	25.7	26.2	26.8	27.6	27.7	27.4	26.8	26.6	26.9	28.6	28.9	27.7	27.2
1983	27.0		28.1	27.9	27.8	27.7	27.1	27.1	28.3				27.6
1984	26.1	26.1	26.7	27.7	27.9	27.1	27.0	27.3	27.1	28.0	27.7	26.5	27.1
1985	26.8	27.0	26.9	27.3	27.8	27.2	26.8	27.3	27.6	28.3	27.7	26.8	27.3
1986	26.1	26.3	26.7	27.7	28.2	27.6	27.0	26.8	27.6	28.0			27.2
1987				28.6	28.5	28.2	27.9	27.2	28.7	29.2	28.6	27.1	28.2
1988	27.3	27.1	27.5										
1989													
1990													
Average	26.4	26.5	27.1	27.8	28.0	27.6	27.1	27.2	27.8	28.4	28.0	26.9	27.4

Monthly Maximum Temperature (°C)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Max.
1980	30.2	30.6	31.5	32.2	33.6	33.1	32.4	33.4	34.3	33.7	33.0	30.8	34.3
1981	29.2	29.8	32.1	32.6	32.6	32.8	32.4	33.5	33.4	34.1	31.7	30.5	34.1
1982	29.4	29.8	30.9	32.6	33.3	33.2	33.4	33.7	34.1	35.0	34.3	31.7	35.0
1983	32.2	-	32.1	32.3	32.3	33.2	33.6	34.4	34.8	-	-	-	34.8
1984	29.8	30.0	30.7	32.1	32.5	32.8	32.7	33.1	32.7	33.1	32.6	30.4	33.1
1985	30.7	31.0	31.1	31.8	33.2	32.4	32.0	33.2	33.2	32.3	30.3	30.8	33.2
1986	29.7	30.4	30.7	32.4	33.8	32.6	33.0	32.8	33.4	32.8	-	-	33.8
1987	-	-	-	33.4	33.3	33.6	33.6	34.3	34.8	34.7	33.1	30.6	34.8
1988	30.7	31.0	31.6	-	-	-	-	-	-	-	-	-	
1989													
Maximum	32.2	31.0	32.1	33.4	33.8	33.6	33.6	34.4	34.8	35.0	34.3	31.7	35.0

Monthly Minimum Temperature (°C)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Min
1980	23.5	23.4	23.2	23.6	24.0	23.1	23.7	22.7	22.9	23.4	23.5	23.5	22.7
1981	23.2	23.1	24.0	24.1	23.8	23.6	22.8	22.8	23.5	23.6	23.7	23.6	22.8
1982	23.3	23.2	23.0	23.5	23.6	23.4	22.4	21.5	22.3	23.5	24.2	24.3	21.5
1983	24.2		24.9	24.9	25.1	23.3	22.1	22.7	23.6				22.1
1984	23.5	23.4	23.5	24.4	24.3	21.5	23.1	23.0	23.5	23.9	23.7	23.3	21.5
1985	26.7	23.9	23.8	24.0	24.3	23.3	22.7	22.4	23.1	23.9	23.8	23.6	22.4
1986	23.6	23.4	23.7	24.3	24.3	24.0	22.9	22.2	23.6	23.7			22.2
1987				24.9	24.6	24.2	23.6	21.3	23.5	24.6	24.9	24.2	21.3
1988	24.5	24.1	24.7										
1989													
Minimum	23.2	23.1	23.0	23.5	23.6	21.5	22.1	21.3	22.3	23.4	23.5	23.3	21.3

Monthly Rainfall (mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1980			340		190	17	120	191	33	80	276	321	-
1981	824	576	199	355	71	134	137	47	162	89	195	534	3323
1982	726	374	112	261	66	108	13	2			201	155	-
1983	299		79	94	304	15	8	0	3				
1984	391	301	364	204	109	60	87	10	321	176	301	615	2939
1985	283	554	243	219	256	126	92	165	60	241	178	60	2477
1986	521	161	216	131	43	216	66	66	173	150			
1987				81	133	79	9	12	0	32	145	246	-
1988	423	305	463										
1989													
Average	495	379	252	192	147	94	67	62	107	128	216	322	2460

Table I.2.2 (2/3) GENERAL CLIMATOLOGICAL DATA OF SEMARANG AHMAD YANI

Duration of Bright Sunshine (%)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1980	47	62	76	72	87	87	92	90	93	85	74	44	76
1981	36	54	77	73	75	91	73	95	83	88	45	64	71
1982		60	63	71	86	86				92	89	65	77
1983	63		77	67	65	93	92	96	98				81
1984	50	56	60	74	75	88	94	88	78	90	78	54	74
1985	73	64	69	69	86	86	90	97	92	86	72	62	79
1986	38	73	63	80	93	82	90	89	82	86			78
1987				84	90	86	97	99	96	97	75	56	87
1988	53	65	62										
1989													
Average	51	62	68	74	82	87	90	93	89	89	72	58	76

Monthly Mean Atmospheric Pressure (+1,000mb)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1980	9.9	11.0	11.5	10.6	11.2	11.7	12.2	12.9	12.9	12.0	11.0	10.0	11.4
1981	11.0	10.7	12.4	11.4	10.3	11.5	11.0	12.3	11.8	12.0	10.4	11.4	11.4
1982	10.8	10.6	10.8	11.2	11.4	12.8	13.2	13.6	14.0	12.8	11.7	11.3	12.0
1983	12.5		11.9	10.6	10.9	11.8	12.4	13.0	12.6				12.0
1984	9.9	9.0	11.0	10.3	10.3	11.4	11.2	11.9	11.6	12.7	11.3	9.5	10.8
1985	11.7	7.5	10.4	9.5	9.6	11.5	12.1	12.1	12.4	12.2	11.1	10.9	10.9
1986	9.9	11.2	10.1	10.6	10.6	10.4	12.5	11.9	12.9	12.8			11.3
1987				11.9	12.1	12.0	13.4	13.5	13.5	12.7	11.5	11.8	12.5
1988	10.5	10.6	9.1										
1989													
Average	10.8	10.1	10.9	10.8	10.8	11.6	12.3	12.7	12.7	12.5	11.2	10.8	11.4

Monthly Mean Humidity (%)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1980	84	82	79	79	72	70	74	68	66	69	75	81	75
1981	83	84	78	76	77	76	77	70	72	68	78	82	77
1982	86	86	82	80	74	73	71	67	68	63	71	80	75
1983	83		81	79	78	69	65	62	62				72
1984	82	83	81	77	74	72	75	73	78	75	78	82	78
1985	82	82	81	80	77	77	74	71	72	72	77	81	77
1986	85	82	83	78	74	78	74	70	74	75			77
1987				75	74	74	70	67	63	67	75	84	72
1988	83	83	82										
1989													
Average	84	83	81	78	75	74	73	69	69	70	76	82	76

Monthly Mean Force of Wind (knots)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1980	6	5	2	3	4	4	4	5	4	4	3	3	4
1981	7	5	4	6	4	4	4	5	4	4	3	4	5
1982	6	4	4	5	3	4	5	4	4	4	4	3	4
1983	4		4	6	6	6	6	5	6				5
1984	5	5	5	5	4	3	3	3	3	3	3	2	4
1985	2	3	2	4	4	4	4	3	3	3	2	2	3
1986	4	3	2	3	3	3	3	3	3	2			3
1987				2	3	3	3	4	4	4	3	3	3
1988	2	3	4										
1989													
Average	5	4	3	4	4	4	4	4	4	3	3	3	4

Table I.2.2 (3/3) GENERAL CLIMATOLOGICAL DATA OF SEMARANG AHMAD YANI

Direction of Wind

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1980	NW	NW	NW	NW	E	E	E	E	E	E	E	W
1981	SW	W	NW	E	E	E	E	E	W	E	NW	W
1982	W	W	W	E	E	E	E	E	NW	NW	E	NW
1983	SW	-	W	NW	SE	SE	E	SE	NW	-	-	-
1984	NW	NW	NW	N	SE	SE	SE	NW	N	N	NW	NW
1985	NW	NW	NW	N	SE	SE	SE	SE	NW	NW	N	N
1986	W	W	NW	N	SE	SE	E	E	SE	N	-	-
1987	-	-	-	E	N	E	SE	E	E	NW	N	W
1988	N	NW	W	-	-	-	-	-	-	-	-	-
1989												

Monthly Maximum Force of Wind (knots)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Max.
1980	23	22	17	15	20	15	16	17	20	18	19	20	23
1981	28	23	20	15	17	15	16	17	13	15	18	47	47
1982	25	20	17	15	13	16	16	15	15	17	45	15	45
1983	18		16	15	20	17	17	17	15				20
1984	15	15	12	10	13	10	20	12	12	15	15	22	22
1985	11	25	18	17	10	12	13	13	12	14	10	14	25
1986	16	29	15	12	12	15	12	18	16	12			29
1987				7	11	12	12	14	15	15	15	16	16
1988	14	20	13										
1989													
Maximum	28	29	20	17	20	17	20	18	20	18	45	47	47

Monthly Evaporation (mm) (Semarang Climatological Station)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1982	88	96	113	119	144	138	167	186	191	211	177	127	1756
1983	108	110	134	113	109	148	172	204	211	161	137	123	1731

Table I.2.3 (1/2) GENERAL CLIMATOLOGICAL DATA OF UNGARAN STATION

Monthly Mean Temperature (°C)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1980	24.8	25.3	25.3	25.9	26.9	26.5	26.2	26.3	27.2	27.5	27.0	25.9	26.2
1981									26.9				26.9
1982													
1983													
1984													
1985			24.7	25.6	26.0	25.7	25.7	26.5	26.4	27.3	27.1	26.4	26.1
1986	25.4	25.8	26.1	26.4	26.9	26.5		26.5	26.3	26.4	26.5	26.1	26.3
1987	25.5	25.7	26.0	26.1	26.6	26.4	26.4	26.3	27.4	28.3	27.4	25.1	26.4
1988	25.4	25.5	26.0	26.7	26.3	25.8	25.0	26.2	27.3		25.8	26.9	
1989	25.5	24.4	25.1	24.9	26.2	25.8					26.2		
1990													
Average	25.3	25.3	25.5	25.9	26.5	26.1	25.8	26.4	26.9	27.4	26.7	26.1	26.2

Monthly Maximum Temperature (°C)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Max.
1980	28.4	28.6	30.3	30.7	31.5	31.7	31.7	31.5	33.4	32.3	31.7	29.8	33.4
1981	-	-	-	-	-	-	-	-	31.2	-	-	-	31.2
1982													
1983													
1984													
1985													
1986													
1987	28.4	28.3	29.0	29.2	29.9	29.9	30.0	30.6	33.4	34.6	32.3	29.1	34.6
1988	28.0	30.5	30.7	31.4	31.9	32.0	32.0	32.2	31.8	-	30.3	28.4	32.2
1989	29.5	27.6	29.0	30.3	30.8	30.3	-	-	-	-	30.5	-	30.8
Maximum	29.5	30.5	30.7	31.4	31.9	32.0	32.0	32.2	33.4	34.6	32.3	29.8	34.6

Monthly Minimum Temperature (°C)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Min.
1980	22.5	21.8	22.0	22.9	22.9	23.1	22.9	22.8	24.1	23.4	22.5	22.7	21.8
1981									22.3				22.3
1982													
1983													
1984													
1985			22.2	22.7	23.1	23.1	22.5	22.8	22.2	22.3	22.1	21.7	21.7
1986	21.6	21.7	21.6	27.8	22.5	22.0		22.2	22.3	22.1	21.9	21.9	21.6
1987	21.1	21.6	21.8	22.2	22.4	22.4	22.6	22.3					21.1
1988						19.1	19.0	19.2	18.9		18.6	18.4	18.4
1989	19.8	20.4	19.9	19.3	18.2	18.2					18.9		
Minimum	19.8	20.4	19.9	19.3	18.2	18.2	19.0	19.2	18.9	22.1	18.6	18.4	18.2

Monthly Rainfall (mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1980		427	280	279	104	12	93	26	3	147	334	622	
1981									169				
1982													
1983													
1984													
1985			194	298	215	54	85	70	116	219	123	239	
1986	431	150	283	143	26	132		52	98	156	197	257	
1987	332	390	145	108	54	35	18		0	23	191	370	
1988	293	388	254	243	170	52	40	79	73		45	362	
1989	138	46	103	84	63	242					261		
Average	299	280	210	193	105	88	59	57	77	136	192	370	2065

Table I.2.3 (2/2) GENERAL CLIMATOLOGICAL DATA OF UNGARAN STATION

Duration of Bright Sunshine (%)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1980	49	53	62	61	82	82	76	79	79	68	69	50	68
1981									77				77
1982													
1983													
1984													
1985			51	53	75	81	86	93	76	73	67	61	72
1986	29	47	36	46	63	47		71	51				49
1987													
1988													
1989											87		
Average	39	50	50	53	73	70	81	81	71	71	74	56	64

Monthly Mean Atmospheric Pressure (+1,000mb)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1980													
1981													
1982													
1983													
1984													
1985			2.3	2.0	1.9	2.0	1.9	2.7	2.1	2.1	2.0	1.7	2.1
1986	1.0	1.0		1.0				1.8	1.4	1.4	1.0		1.2
1987													
1988													
1989	3.1	2.8	2.5	2.6	2.9								
Average	2.1	1.9	2.4	1.9	2.4	2.0	1.9	2.3	1.8	1.8	1.5	1.7	2.0

Monthly Mean Humidity of Air (%)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1980	83	82	82	83	75	75	76	72	66	71	76	83	77
1981									74				74
1982													
1983													
1984													
1985			83	82	78	74	75	68	74	73	78	80	77
1986	84	83	84	83				70	72	73	77	78	78
1987	84	83	79	74	74	70	73	70	63	66	75	84	75
1988	87	88	86	82	84	82	82	80	80		84	87	
1989	85	87	86	84	84	83							
Average	85	85	83	81	79	77	77	72	72	71	78	82	78

Table I.2.4 MONTHLY DISCHARGE AND ANNUAL MAXIMUM PEAK DISCHARGE AT AUTOMATIC WATER LEVEL RECORDER

(Garang River Gauging Station A=185.2km2) Unit : m3/sec

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Anual Max Peak Dis.	Specific Runoff
1986	28.9	34.5	35.3	37.2	5.2	8.1	5.1	3.6	3.9	3.2	8.1	11.1	480.0	2.59
1987	23.1	29.7	24.7	12.1	6.4	5.1	3.5	2.5	1.9	2.1	3.8	8.9	318.0	1.72
1988	16.2	20.7	22.7	10.7	6.7	2.9	2.5	1.7	1.8	3.5	4.2	11.4	368.0	1.99
1989	9.9	49.1	16.5	10.6	9.4	10.2	3.9	3.0	1.9	4.1	7.4	15.2	549.0	2.96
1990	17.5	12.5	12.7	7.8	7.1	5.2	3.6	3.1	2.2	1.7	2.6	13.5	1022.0	5.52
Average	19.1	29.3	22.4	15.7	6.9	6.3	3.7	2.8	2.3	2.9	5.2	12.0		

Annual Averag 10.7 m3/sec
(Specific Runoff 0.057 m3/sec/km2)

(Blorong River Gauging Station A=157.9km2) Unit : m3/sec

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Anual Max Peak Dis.	Specific Runoff
1980	13.6	9.4	15.3	11.5	9.0	3.2	2.5	2.9	1.5	2.4	4.0	9.7	268.5	1.70
1981	27.8	21.7	14.3	14.8	10.8	7.9	10.5	2.8	2.8	1.8	3.1	19.3	193.9	1.23
1982	27.6	23.6	13.8	14.7	4.0	2.7	2.0	1.1	0.9	0.8	1.0	3.5	196.8	1.25
1983	15.6	10.4	7.9	9.3	13.1	4.2	1.8	1.1	0.7	3.9	8.0	7.6	141.7	0.90
1984	11.5		14.9		5.9				6.6	2.7	4.0		130.7	0.83
1985	26.8			13.5	7.1	6.1	3.7	2.0	2.1	4.1			265.7	1.68
1986			20.9	13.5	5.9	6.1			2.2	1.4	6.6	6.7	126.0	0.80
1987	13.4	14.6	12.8	7.6	5.9	2.7	2.7	1.0	0.7	0.7	1.5	6.2	115.0	0.73
1988	7.3	11.1	9.5	6.9	4.6	2.8	2.2	1.7	1.3	3.2	3.6	13.6	177.0	1.12
1989	10.0	22.6	11.6	13.8	9.0	8.3	4.7	2.5	1.5	3.2	6.1	32.5	93.8	0.59
1990	23.9	13.3	9.4	5.6	6.9	3.9	2.8	3.5	1.7	1.1	1.1	6.0	101.0	0.64
Average	17.7	15.8	13.0	11.1	7.5	4.8	3.6	2.1	2.0	2.3	3.9	11.7		

Annual Averag 8.0 m3/sec
(Specific Runoff 0.051 m3/sec/km2)

Table I.2.5 ANNUAL MAXIMUM DISCHARGE AT SIMONGAN WEIR

Year	Annual Max. Water Level (EL. m)	Water Depth (h1) (m)	Velo-city Head (h2) (m)	Overflow Head (H=h1+h2) (m)	** Discharge Flowing over Fixed Weir: C1 (Co-efficient)	** Discharge Flowing over Fixed Weir: Q1 (m3/s)	*** Discharge Passing through Gates: C2 (Co-efficient)	*** Discharge Passing through Gates: Q2 (m3/s)	Total Discharge (Q1+Q2) (m3/s)
1961	7.9	2.3	0.08	2.38	1.52	362	0.52	96	458
1962	7.3	1.7	0.07	1.77	1.50	228	0.51	87	315
1963	9.4	3.8	0.12	3.92	1.57	785	0.53	116	901
1964	6.9	1.3	0.07	1.37	1.48	153	0.50	80	233
1965	7.4	1.8	0.07	1.87	1.50	249	0.51	88	337
1968	6.6	1.0	0.07	1.07	1.46	103	0.47	72	175
1969	7.1	1.5	0.07	1.57	1.49	189	0.50	83	272
1970	7.0	1.4	0.07	1.47	1.48	170	0.50	82	252
1971	7.0	1.4	0.07	1.47	1.48	170	0.50	82	252
1972	6.9	1.3	0.07	1.37	1.48	153	0.50	80	233
1973	6.9	1.3	0.07	1.37	1.48	153	0.50	80	233
1974	7.8	2.2	0.08	2.28	1.52	338	0.51	94	433
1975	6.9	1.3	0.07	1.37	1.48	153	0.50	80	233
1976	7.9	2.3	0.08	2.38	1.52	362	0.52	96	458
1977	7.5	1.9	0.08	1.98	1.51	270	0.51	90	360
1978	7.5	1.9	0.08	1.93	1.50	260	0.51	89	349
1979	7.2	1.6	0.07	1.67	1.49	208	0.51	85	293
1980	6.7	1.1	0.07	1.17	1.46	119	0.48	75	194
1981	8.1	2.5	0.09	2.59	1.53	412	0.52	99	510
1982	7.7	2.1	0.08	2.18	1.51	315	0.51	93	408
1983	7.4	1.8	0.07	1.87	1.50	249	0.51	88	337
1984	7.3	1.7	0.07	1.77	1.50	228	0.51	87	315
1985	8.2	2.6	0.09	2.69	1.53	437	0.52	100	537
1986	7.4	1.8	0.07	1.87	1.50	249	0.51	88	337
1987	7.7	2.1	0.08	2.18	1.51	315	0.51	93	408
1988	7.8	2.2	0.08	2.23	1.52	327	0.51	94	420
1989	7.6	2.0	0.08	2.08	1.51	292	0.51	92	384
1990	9.4	3.8	0.12	3.92	1.57	785	0.53	116	* 901 (1022)

Note : Discharges were estimated from observed annual maximum water level

* ; ( ) Peak discharge recorded at Garang River Water Level Gauging Station in upstream of Simongan Weir

** ; Q1 = C1 x B1 x H**1.5

*** ; Q2 = C2 x B2 x (2g x h1)**0.5

where;

C1, C2: Coefficient

B1 : Fixed Weir Width (=64.6 m)

B2 : Gate Weir Width (=11.8 m)

Table I.3.1 (1/2) ANNUAL MAXIMUM RAINFALL INTENSITIES

(Semarang Meteorological Station : BMG)

(1) Rainfall Depth — Unit : mm

No.	Year	5'	10'	15'	30'	45'	60'	120'	180'	360'	720'	1Day	2Days
		Duration (Minutes)											
1	1959	20	25	30	50	53	53	55	55	55	55	75	-
2	1960	18	22	32	46	46	47	51	57	67	71	87	115
3	1961	21	26	28	40	43	44	50	66	87	116	124	-
4	1962	11	20	25	30	35	38	45	52	73	76	100	-
5	1963	22	-	25	38	40	40	44	62	70	118	120	-
6	1964	21	31	42	62	78	80	89	91	98	100	100	-
7	1965	11	15	18	28	38	40	41	44	91	125	166	270
8	1966	27	30	34	43	50	54	72	80	90	91	-	-
9	1976	17	20	32	43	59	75	107	107	135	183	206	249
10	1978	17	25	36	60	72	85	98	102	115	115	115	149
11	1979	15	24	29	37	50	56	99	114	126	126	126	126
12	1980	14	28	62	82	82	91	175	185	192	192	192	192
13	1981	20	40	50	65	70	80	113	120	204	228	253	260
14	1982	10	10	16	47	-	69	80	103	131	131	157	247
15	1983	18	36	54	73	-	93	93	96	96	96	96	116
16	1984	16	27	35	47	61	67	79	83	85	91	91	128
17	1985	15	25	35	55	71	96	149	149	149	247	253	282
18	1986	31	46	62	72	-	100	105	123	129	130	130	130
19	1987	27	32	37	60	-	88	93	93	96	138	138	155
20	1988	15	26	36	51	71	81	102	101	117	174	174	198
21	1989	16	26	30	44	55	80	100	100	108	142	142	226
22	1990	10	21	31	52	59	59	65	68	81	100	115	123
23	1991	12	20	31	41	48	50	62	89	130	137	137	185
24	1992	16	22	32	58	80	85	92	100	103	104	104	135
25	1993	24	32	43	80	90	98	116	118	151	211	276	429
	MAX	31	46	62	82	90	100	175	185	204	247	276	429

(2) RAINFALL INTENSITY — Unit : mm/hr

No.	Year	5'	10'	15'	30'	45'	60'	120'	180'	360'	720'	1Day	2Days
		Duration (Minutes)											
1	1959	240	150	120	100	71	53	27	18	9	5	3	-
2	1960	218	132	128	92	61	47	26	19	11	6	4	2
3	1961	247	154	111	80	57	44	25	22	15	10	5	-
4	1962	130	120	101	60	47	38	23	17	12	6	4	-
5	1963	266	-	100	76	53	40	22	21	12	10	5	-
6	1964	250	187	166	125	103	80	45	30	16	8	4	-
7	1965	132	88	73	57	51	40	21	15	15	10	7	6
8	1966	318	178	137	86	67	54	36	27	15	8	-	-
9	1976	204	120	126	86	79	75	53	36	22	15	9	5
10	1978	204	147	144	120	96	85	49	34	19	10	5	3
11	1979	182	141	116	74	67	56	49	38	21	11	5	3
12	1980	166	167	248	163	109	91	88	62	32	16	8	4
13	1981	240	240	200	130	93	80	56	40	34	19	11	5
14	1982	119	57	65	95	-	69	40	34	22	11	7	5
15	1983	218	218	218	145	-	93	46	32	16	8	4	2
16	1984	193	161	140	94	82	67	39	28	14	8	4	3
17	1985	180	150	140	109	94	96	75	50	25	21	11	6
18	1986	371	278	247	144	-	100	53	41	22	11	5	3
19	1987	329	192	146	120	-	88	47	31	16	12	6	3
20	1988	180	155	144	101	94	81	51	34	20	15	7	4
21	1989	192	156	120	88	73	80	50	33	18	12	6	5
22	1990	125	124	124	103	78	59	33	23	14	8	5	3
23	1991	149	122	125	81	64	50	31	30	22	11	6	4
24	1992	192	132	128	116	107	85	46	33	17	9	4	3
25	1993	288	192	172	160	120	98	58	39	25	18	12	9
	MAX	371	278	248	163	120	100	88	62	34	21	12	6

Data of 1992 and 1993 are supplemented for the evaluation on scale of January 1993 flood.

Table I.3.1 (2/2) ANNUAL MAXIMUM RAINFALL INTENSITIES

(Kaligading Automatic Rainfall Gauging Station)

(1) Rainfall Depth — Unit : mm

No.	Year	Duration (Minutes) 5'	10'	15'	30'	45'	60'	120'	180'	360'	720'	1Day	2Days
1	1980						98	103	103	113	113	216	226
2	1981						69	108	133	145	145	201	234
3	1982						64	80	115	143	143	158	270
4	1983						97	129	130	163	175	175	193
5	1984						75	95	101	113	144	144	171
6	1985						71	96	97	97	156	159	192
7	1986						77	85	87	90	109	113	173
8	1987						58	87	106	117	126	126	218
9	1988						63	63	-	-	-	-	-
10	1990						66	94	98	139	150	150	170
11	1991						89	121	127	128	128	128	128
12	1992						54	90	90	90	90	90	120
13	1993						41	61	87	158	219	232	440
	MAX						98	129	133	163	219	232	440

(2) Rainfall Intensity — Unit : mm/hr

No.	Year	Duration (Minutes) 5'	10'	15'	30'	45'	60'	120'	180'	360'	720'	1Day	2Days
1	1980						98	51	34	19	9	9	5
2	1981						69	54	44	24	12	8	5
3	1982						64	40	38	24	12	7	6
4	1983						97	64	43	27	15	7	4
5	1984						75	48	34	19	12	6	4
6	1985						71	48	32	16	13	7	4
7	1986						77	42	29	15	9	5	4
8	1987						58	44	35	19	11	5	5
9	1988						63	63	-	-	-	-	-
10	1990						66	47	33	23	12	6	4
11	1991						89	61	42	21	11	5	3
12	1992						54	45	30	15	8	4	3
13	1993						41	31	29	26	18	10	9
	MAX						98	64	44	27	15	9	6

Data of 1991,1992 and 1993 are supplemented for the evaluation on scale of January 1993 flood.

Table I.3.2 PROBABLE POINT RAINFALL INTENSITIES
BY GUMBEL METHOD

(Short Duration) Unit : mm/hr
Semarang Meteorological Station

Return Period (Year)	Rainfall Duration						
	5 min.	10 min.	15 min.	30 min.	45 min.	60 min.	120 min.
2	200.0	148.2	133.1	96.7	72.7	64.7	40.0
3	227.8	168.4	153.0	108.2	80.5	73.1	47.0
5	258.7	190.9	175.1	120.9	89.1	82.4	54.8
8	285.2	210.2	194.2	131.9	96.5	90.3	61.5
10	297.5	219.1	203.0	137.0	100.0	94.0	64.5
20	334.7	246.2	229.7	152.3	110.4	105.2	73.9
25	346.5	254.8	238.1	157.2	113.7	108.8	76.9
30	356.1	261.8	245.0	161.2	116.4	111.7	79.3
50	382.9	281.2	264.2	172.2	123.9	119.7	86.1
70	400.5	294.0	276.8	179.5	128.8	125.0	90.5
80	407.4	299.1	281.8	182.3	130.8	127.1	92.2
100	419.0	307.5	290.1	187.1	134.0	130.6	95.1
150	440.1	322.8	305.2	195.8	139.9	136.9	100.5
200	455.0	333.7	315.9	202.0	144.1	141.4	104.2
300	476.0	348.9	331.0	210.7	150.0	147.7	109.5

(Long Duration) Unit : mm/day
Semarang Meteorological Station

Return Period (Year)	Rainfall Duration		
	12 hours	1 day	2 days
2	242.4	132.0	88.8
3	283.2	153.6	100.8
5	328.8	177.6	115.2
8	367.2	196.8	127.2
10	384.0	206.4	132.0
20	439.2	232.8	148.8
25	456.0	242.4	153.6
30	470.4	249.6	158.4
50	508.8	268.8	170.4
70	532.8	283.2	177.6
80	544.8	288.0	180.0
100	561.6	297.6	187.2
150	590.4	312.0	196.8
200	612.0	324.0	201.6
300	643.2	338.4	211.2

(Long Duration) Unit : mm/day
Kaligading Rainfall Gauging Station

Return Period (Year)	Rainfall Duration		
	12 hours	1 day	2 days
2	278.4	156.0	98.4
3	297.6	168.0	105.6
5	321.6	184.8	115.2
8	343.2	196.8	122.4
10	350.4	204.0	124.8
20	379.2	223.2	134.4
25	388.8	228.0	136.8
30	396.0	232.8	139.2
50	417.6	247.2	146.4
70	429.6	254.4	151.2
80	434.4	259.2	153.6
100	444.0	264.0	156.0
150	458.4	273.6	160.8
200	470.4	283.2	165.6
300	487.2	292.8	170.4

Table I.3.3 (1/3) CONFORMITY OF EQUATIONS DEVELOPED FOR RAINFALL INTENSITY-DURATION CURVES

Semarang Meteorological Station
(Rainfall Duration : less than 120 minutes)

Return Period (Year)	Rainfall Duration (min)	Rainfall Intensities Estimated: (1) Observed Data (mm/hr)	(2) Eq. of Talbot (mm/hr)	(3) Eq. of Sherman (mm/hr)	(4) Eq. of Kuno (mm/hr)	(5) Eq. of Horner (mm/hr)	Difference of Rainfall Intensities: (1)-(2) (mm/hr)	(1)-(3) (mm/hr)	(1)-(4) (mm/hr)	(1)-(5) (mm/hr)
2	5.0	200.0	185.5	215.0	212.7	192.4	14.5	15.0	12.7	7.6
	10.0	148.2	157.9	152.3	151.9	156.3	9.7	4.1	3.7	8.1
	15.0	133.1	137.5	124.5	124.6	133.0	4.4	8.6	8.5	0.1
	30.0	96.7	99.0	88.2	88.6	94.6	2.3	8.5	8.1	2.1
	45.0	72.7	77.4	72.1	72.6	75.1	4.7	0.6	0.1	2.4
	60.0	64.7	63.5	62.5	62.9	63.0	1.2	2.2	1.8	1.7
	120.0	40.0	37.0	44.3	44.6	40.1	3.0	4.3	4.6	0.1
	Average						5.7	6.2	5.6	3.2
5	5.0	258.7	238.8	274.6	273.2	257.2	19.9	15.9	14.5	1.5
	10.0	190.9	203.5	195.2	195.4	199.2	12.6	4.3	4.5	8.3
	15.0	175.1	177.2	159.9	160.3	166.6	2.1	15.2	14.8	8.5
	30.0	120.9	127.8	113.6	114.1	118.0	6.9	7.3	6.8	2.9
	45.0	89.1	99.9	93.1	93.4	94.9	10.8	4.0	4.3	5.8
	60.0	82.4	82.0	80.8	81.0	80.9	0.4	1.6	1.4	1.5
	120.0	54.8	47.8	57.4	57.5	54.4	7.0	2.6	2.7	0.4
	Average						8.5	7.3	7.0	4.1
10	5.0	297.5	274.6	314.3	314.0	299.7	22.9	16.8	16.5	2.2
	10.0	219.1	233.8	223.6	224.3	227.3	14.7	4.5	5.2	8.2
	15.0	203.0	203.6	183.3	183.9	188.9	0.6	19.7	19.1	14.1
	30.0	137.0	146.7	130.4	130.8	133.9	9.7	6.6	6.2	3.1
	45.0	100.0	114.6	106.9	107.1	108.3	14.6	6.9	7.1	8.3
	60.0	94.0	94.1	92.8	92.9	92.8	0.1	1.2	1.1	1.2
	120.0	64.5	54.8	66.0	65.9	63.5	9.7	1.5	1.4	1.0
	Average						10.3	8.2	8.1	5.4
20	5.0	334.7	308.9	352.2	353.1	340.4	25.8	17.5	18.4	5.7
	10.0	246.2	263.0	250.8	252.0	253.9	16.8	4.6	5.8	7.7
	15.0	229.7	228.9	205.6	206.6	210.2	0.8	24.1	23.1	19.5
	30.0	152.3	164.9	146.4	146.9	149.2	12.6	5.9	5.4	3.1
	45.0	110.4	128.8	120.1	120.2	121.1	18.4	9.7	9.8	10.7
	60.0	105.2	105.7	104.3	104.3	104.3	0.5	0.9	0.9	0.9
	120.0	73.9	61.5	74.3	73.9	72.3	12.4	0.4	0.0	1.6
	Average						12.5	9.0	9.1	7.0
25	5.0	346.5	319.8	364.2	365.5	353.1	26.7	17.7	19.0	6.6
	10.0	254.8	272.2	259.4	260.8	262.4	17.4	4.6	6.0	7.6
	15.0	238.1	237.0	212.7	213.8	217.0	1.1	25.4	24.3	21.1
	30.0	157.2	170.6	151.6	152.0	154.1	13.4	5.6	5.2	3.1
	45.0	113.7	133.3	124.3	124.4	125.3	19.6	10.6	10.7	11.6
	60.0	108.8	109.4	108.0	107.9	107.9	0.6	0.8	0.9	0.9
	120.0	76.9	63.7	76.9	76.5	75.0	13.2	0.0	0.4	1.9
	Average						13.2	9.2	9.5	7.5
50	5.0	382.9	353.5	401.2	404.0	392.6	29.4	18.3	21.1	9.7
	10.0	281.2	300.8	286.0	288.0	288.4	19.6	4.8	6.8	7.2
	15.0	264.2	261.7	234.6	236.0	237.9	2.5	29.6	28.2	26.3
	30.0	172.2	188.4	167.2	167.7	169.2	16.2	5.0	4.5	3.0
	45.0	123.9	147.2	137.2	137.2	137.9	23.3	13.3	13.3	14.0
	60.0	119.7	120.7	119.2	119.0	119.2	1.0	0.5	0.7	0.5
	120.0	86.1	70.3	85.0	84.3	83.5	15.8	1.1	1.8	2.6
	Average						15.4	10.4	10.9	9.0
100	5.0	419.0	387.0	438.2	442.4	431.3	32.0	19.2	23.4	12.3
	10.0	307.5	329.2	312.4	315.1	314.4	21.7	4.9	7.6	6.9
	15.0	290.1	286.4	256.3	258.1	259.0	3.7	33.8	32.0	31.1
	30.0	187.1	206.0	182.8	183.2	184.3	18.9	4.3	3.9	2.8
	45.0	134.0	160.9	149.9	149.9	150.5	26.9	15.9	15.9	16.5
	60.0	130.6	131.9	130.3	130.0	130.3	1.3	0.3	0.6	0.3
	120.0	95.1	76.8	92.9	92.1	91.8	18.3	2.2	3.0	3.3
	Average						17.5	11.5	12.3	10.5
200	5.0	455.0	420.5	474.9	480.6	470.0	34.5	19.9	25.6	15.0
	10.0	333.7	357.5	338.7	342.0	340.1	23.8	5.0	8.3	6.4
	15.0	315.9	311.0	278.0	280.1	279.9	4.9	37.9	35.8	36.0
	30.0	202.0	223.6	198.3	198.8	199.3	21.6	3.7	3.2	2.7
	45.0	144.1	174.5	162.7	162.6	163.1	30.4	18.6	18.5	19.0
	60.0	141.4	143.1	141.4	140.9	141.4	1.7	0.0	0.5	0.0
	120.0	104.2	83.2	100.9	99.8	100.0	21.0	3.3	4.4	4.2
	Average						19.7	12.6	13.8	11.9

Table I.3.3 (2/3) CONFORMITY OF EQUATIONS DEVELOPED FOR RAINFALL INTENSITY-DURATION CURVES

Semarang Meteorological Station
(Rainfall Duration : from 2 to 48 hours)

Return Period (Year)	Rainfall Duration (min)	Rainfall Intensities Estimated					Difference of Rainfall Intensities			
		(1) Observed Data (mm/hr)	(2) Eq. of Talbot (mm/hr)	(3) Eq. of Sherman (mm/hr)	(4) Eq. of Kuno (mm/hr)	(5) Eq. of Horner (mm/hr)	(1)-(2) (mm/hr)	(1)-(3) (mm/hr)	(1)-(4) (mm/hr)	(1)-(5) (mm/hr)
2	60.0	64.7	58.7	66.2	77.9	67.5	6.0	1.5	13.2	2.8
	120.0	40.0	41.9	39.1	35.7	38.9	1.9	0.9	4.3	1.1
	180.0	29.2	32.5	28.8	25.2	28.5	3.3	0.4	4.0	0.7
	360.0	17.3	19.5	17.0	15.2	16.8	2.2	0.3	2.1	0.5
	720.0	10.1	10.8	0.1	9.7	10.0	0.7	0.0	0.4	0.1
	1,440.0	5.5	5.7	6.0	6.4	6.0	0.2	0.5	0.9	0.5
	2,880.0	3.7	2.9	3.5	4.3	3.6	0.8	0.2	0.6	0.1
	Average						2.1	0.5	3.7	0.8
5	60.0	82.4	76.5	87.5	103.4	86.6	5.9	5.1	21.0	4.2
	120.0	54.8	55.0	51.8	47.4	51.9	0.2	3.0	7.4	2.9
	180.0	38.9	42.9	38.1	33.5	38.3	4.0	0.8	5.4	0.6
	360.0	22.7	25.8	22.6	20.0	22.7	3.1	0.1	2.5	0.0
	720.0	13.7	14.4	13.4	12.9	13.4	0.7	0.3	0.8	0.3
	1,440.0	7.4	7.6	7.9	8.5	7.9	0.2	0.5	1.1	0.5
	2,880.0	4.8	3.9	4.7	5.8	4.7	0.9	0.1	1.0	0.1
	Average						2.1	1.4	5.6	1.2
10	60.0	94.0	88.3	1.5	120.6	99.2	5.7	7.5	26.6	5.2
	120.0	64.5	63.6	0.6	55.1	60.5	0.9	4.4	9.4	5.0
	180.0	45.3	49.6	44.2	38.9	44.8	4.3	1.1	6.4	0.5
	360.0	26.3	30.0	26.2	23.4	26.6	3.7	0.1	2.9	0.3
	720.0	16.0	46.7	15.5	14.9	15.6	0.7	0.5	1.1	0.4
	1,440.0	8.6	8.9	9.2	9.9	9.2	0.3	0.6	1.3	0.6
	2,880.0	5.5	4.6	5.4	6.7	5.4	0.9	0.1	1.2	0.1
	Average						2.4	2.0	7.0	1.6
20	60.0	105.2	99.8	115.1	137.3	111.4	5.4	9.9	32.1	6.2
	120.0	73.9	71.9	68.1	62.6	68.7	2.0	5.8	11.3	5.2
	180.0	51.4	56.2	29.7	44.1	51.0	4.8	1.3	7.3	0.4
	360.0	29.8	33.9	29.7	26.5	30.3	4.1	0.1	3.3	0.5
	720.0	18.3	18.9	17.6	16.9	17.8	0.6	0.7	1.4	0.5
	1,440.0	9.7	10.1	0.4	11.2	10.4	0.4	0.7	1.5	0.7
	2,880.0	6.2	5.2	6.2	7.6	6.0	1.0	0.0	1.4	0.2
	Average						2.6	2.6	8.3	2.0
25	60.0	108.8	103.5	119.4	142.8	115.2	5.3	10.6	34.0	6.4
	120.0	76.9	74.6	70.7	64.9	71.3	2.3	6.2	12.0	5.6
	180.0	53.4	58.3	52.0	45.8	53.0	4.9	1.4	7.6	0.4
	360.0	30.9	35.2	30.8	27.5	31.5	4.3	0.1	3.4	0.6
	720.0	19.0	19.7	18.2	17.6	18.4	0.7	0.8	1.4	0.6
	1440.0	10.1	10.4	10.8	11.6	10.7	0.3	0.7	1.5	0.6
	2880.0	6.4	5.4	6.4	7.9	6.2	1.0	0.0	1.5	0.2
	Average						2.7	2.8	8.8	2.0
50	60.0	119.7	114.6	132.6	159.1	127.3	5.1	12.9	39.4	7.6
	120.0	86.1	82.7	78.5	72.2	79.3	3.4	7.6	13.9	6.8
	180.0	59.4	64.7	57.8	50.9	59.0	5.3	1.6	8.5	0.4
	360.0	34.3	39.1	34.2	30.5	35.1	4.8	0.1	3.8	0.8
	720.0	21.2	21.9	20.2	19.5	20.5	0.7	1.0	1.7	0.7
	1,440.0	11.2	11.6	12.0	12.9	11.9	0.4	0.8	1.7	0.7
	2,880.0	7.1	6.0	7.1	8.7	6.9	1.1	0.0	1.6	0.2
	Average						3.0	3.4	10.1	2.4
100	60.0	130.6	125.6	145.5	174.9	139.1	5.0	14.9	44.3	8.5
	120.0	59.1	90.8	86.2	79.5	87.2	4.3	8.9	15.6	7.9
	180.0	65.4	71.1	63.5	56.1	65.1	5.7	1.9	9.3	0.3
	360.0	37.7	43.1	37.6	33.6	38.7	5.4	0.1	4.1	1.0
	720.0	23.4	24.1	22.3	21.5	22.7	0.7	1.1	1.9	0.7
	1,440.0	12.4	12.8	13.2	14.2	13.2	0.4	0.8	1.8	0.8
	2,880.0	7.8	6.6	7.8	9.6	7.6	1.2	0.0	1.8	0.2
	Average						3.2	4.0	11.3	2.8
200	60.0	141.4	136.9	458.7	191.7	150.7	4.5	17.3	50.3	9.3
	120.0	104.2	98.9	93.9	86.7	95.1	5.3	10.3	17.5	9.1
	180.0	71.3	77.4	69.1	61.0	71.1	6.1	2.2	10.3	0.2
	360.0	41.0	46.8	40.9	36.6	42.3	5.8	0.1	4.4	1.3
	720.0	25.5	26.2	24.2	23.3	24.7	0.7	1.3	2.2	0.8
	1,440.0	13.5	13.9	14.3	15.4	14.3	0.4	0.8	1.9	0.8
	2,880.0	8.4	7.2	8.5	10.4	8.2	1.2	0.1	2.0	0.2
	Average						3.4	4.6	12.7	3.1

Table I.3.3 (3/3) CONFORMITY OF EQUATIONS DEVELOPED FOR RAINFALL INTENSITY-DURATION CURVES

Kaligading Automatic Rainfall Gauging Station
(Rainfall Duration : from 1 to 48 hours)

Return Period (Year)	Rainfall Duration (min)	Rainfall Intensities Estimated (1) Observed Data (mm/hr)	(2) Eq. of Talbot (mm/hr)	(3) Eq. of Sherman (mm/hr)	(4) Eq. of Kuno (mm/hr)	(5) Eq. of Horner (mm/hr)	Difference of Rainfall Intensities (1)-(2) (mm/hr)	(1)-(3) (mm/hr)	(1)-(4) (mm/hr)	(1)-(5) (mm/hr)
2	60.0	71.5	66.1	75.8	89.3	74.7	5.4	4.3	17.8	3.2
	120.0	45.5	47.5	44.9	41.0	45.0	2.0	0.6	4.5	0.5
	180.0	35.1	37.0	33.0	29.0	33.3	1.9	2.1	6.1	1.8
	360.0	20.1	22.3	19.5	17.4	19.7	2.2	0.6	2.7	0.4
	720.0	11.4	12.4	11.5	11.1	11.6	1.0	0.1	0.3	0.2
	1,440.0	6.5	6.6	6.8	7.4	6.8	0.1	0.3	0.9	0.3
	2,880.0	4.1	3.4	4.0	5.0	4.0	0.7	0.1	0.9	0.1
	Average						1.9	1.2	4.7	0.9
5	60.0	83.6	76.9	87.8	103.3	87.5	6.7	4.2	19.7	3.9
	120.0	53.3	55.2	52.0	47.5	52.0	1.9	1.3	5.8	1.3
	180.0	39.7	43.0	38.3	33.6	38.3	3.3	1.4	6.1	1.4
	360.0	23.6	25.9	22.7	20.2	22.7	2.3	0.9	3.4	0.9
	720.0	12.9	14.4	13.4	12.9	13.4	1.5	0.5	0.0	0.5
	1,440.0	7.7	7.7	8.0	8.6	8.0	0.0	0.3	0.9	0.3
	2,880.0	4.8	3.9	4.7	5.8	4.7	0.9	0.1	1.0	0.1
	Average						2.4	1.2	5.3	1.2
10	60.0	91.6	84.1	95.8	112.8	95.5	7.5	4.2	21.2	3.9
	120.0	58.4	60.3	56.7	51.8	56.8	1.9	1.7	6.6	1.6
	180.0	42.7	47.0	41.8	36.6	41.8	4.3	0.9	6.1	0.9
	360.0	26.0	28.3	24.7	22.1	24.8	2.3	1.3	3.9	1.2
	720.0	13.9	15.7	14.6	14.1	14.6	1.8	0.7	0.2	0.7
	1,440.0	8.5	8.3	8.7	9.3	8.7	0.2	0.2	0.8	0.2
	2,880.0	5.2	4.3	5.1	6.3	5.1	0.9	0.1	1.1	0.1
	Average						2.7	1.3	5.7	1.2
20	60.0	99.3	91.0	103.5	121.8	103.1	8.3	4.2	22.5	3.8
	120.0	63.3	65.2	61.3	56.0	61.4	1.9	2.0	7.3	1.9
	180.0	45.6	50.8	45.1	39.6	45.2	5.2	0.5	6.0	0.4
	360.0	28.3	30.6	26.7	23.8	26.8	2.3	1.6	4.5	1.5
	720.0	14.9	17.0	15.8	15.3	15.8	2.1	0.9	0.4	0.9
	1,440.0	9.3	9.0	9.4	10.1	9.4	0.3	0.1	0.8	0.1
	2,880.0	5.6	4.6	5.5	6.8	5.5	1.0	0.1	1.2	0.1
	Average						3.0	1.3	6.1	1.2
25	60.0	101.7	93.3	106.1	124.9	105.5	8.4	4.4	23.2	3.8
	120.0	64.9	66.7	62.8	57.3	62.8	1.8	2.1	7.6	2.1
	180.0	46.5	52.0	46.2	40.5	46.3	5.5	0.3	6.0	0.2
	360.0	29.0	31.2	27.3	24.3	27.4	2.2	1.7	4.7	1.6
	720.0	15.2	17.4	16.2	15.6	16.2	2.2	1.0	0.4	1.0
	1440.0	9.5	9.2	9.6	10.3	9.6	0.3	0.1	0.8	0.1
	2880.0	5.7	4.7	5.7	7.0	5.6	1.0	0.0	1.3	0.1
	Average						3.0	1.4	6.3	1.3
50	60.0	109.2	100.1	113.6	133.7	112.9	9.1	4.4	24.5	3.7
	120.0	69.7	71.6	67.2	61.4	67.3	1.9	2.5	8.3	2.4
	180.0	49.4	55.7	49.5	43.4	49.6	6.3	0.1	6.0	0.2
	360.0	31.2	33.5	29.3	26.1	29.4	2.3	1.9	5.1	1.8
	720.0	16.2	18.6	17.3	16.7	17.4	2.4	1.1	0.5	1.2
	1,440.0	10.3	9.9	10.3	11.1	10.3	0.4	0.0	0.8	0.0
	2,880.0	6.1	5.1	6.1	7.5	6.0	1.0	0.0	1.4	0.1
	Average						3.4	1.4	6.6	1.3
100	60.0	116.6	106.8	121.0	142.7	120.6	9.8	4.4	26.1	4.0
	120.0	74.5	76.3	71.6	65.4	71.7	1.8	2.9	9.1	2.8
	180.0	52.2	59.4	52.7	46.2	52.8	7.2	0.5	6.0	0.6
	360.0	33.4	35.6	31.2	27.8	31.2	2.2	2.2	5.6	2.2
	720.0	17.1	19.8	18.4	17.8	18.5	2.7	1.3	0.7	1.4
	1,440.0	11.0	10.5	10.9	11.8	10.9	0.5	0.1	0.8	0.1
	2,880.0	6.5	5.4	6.5	8.0	6.4	1.1	0.0	1.5	0.1
	Average						3.6	1.6	7.1	1.6
200	60.0	124.0	113.5	128.4	151.3	127.8	10.5	4.4	27.3	3.8
	120.0	79.3	81.1	76.0	69.5	76.1	1.8	3.3	9.8	3.2
	180.0	55.0	63.1	56.0	49.1	56.1	8.1	1.0	5.9	1.1
	360.0	35.6	37.9	33.1	29.5	33.2	2.3	2.5	6.1	2.4
	720.0	18.1	21.1	19.6	18.9	19.6	3.0	1.5	0.8	1.5
	1,440.0	11.8	11.2	11.6	12.5	11.6	0.6	0.2	0.7	0.2
	2,880.0	6.9	5.7	6.9	8.5	6.9	1.2	0.0	1.6	0.0
	Average						3.9	1.8	7.5	1.8

Table I.3.4 EQUATIONS DEVELOPED FOR RAINFALL INTENSITY-DURATION CURVE

Semarang Meteorological Station
(Applicalbe Range of Rainfall Duration : less than 120 minutes)

Return Period (Year)	(1) Talbot Type Equation	(2) Sherman Type Equation	(3) Kuno Type Equation	(4) Horner Type Equation
2	I= 5,314 /(T+23.65)	I= 479 /T^ 0.50	I= 493 /(T^0.5+0.08)	I= 1,400 /(T+10.19)^0.73
5	I= 6,867 /(T+23.75)	I= 607 /T^ 0.49	I= 635 /(T^0.5+0.09)	I= 1,000 /(T+ 4.49)^0.60
10	I= 7,874 /(T+23.68)	I= 693 /T^ 0.49	I= 727 /(T^0.5+0.08)	I= 968 /(T+ 2.93)^0.57
20	I= 8,838 /(T+23.61)	I= 775 /T^ 0.49	I= 815 /(T^0.5+0.07)	I= 973 /(T+ 1.96)^0.54
25	I= 9,148 /(T+23.61)	I= 800 /T^ 0.49	I= 843 /(T^0.5+0.07)	I= 980 /(T+ 1.73)^0.54
30	I= 9,395 /(T+23.58)	I= 822 /T^ 0.49	I= 866 /(T^0.5+0.07)	I= 989 /(T+ 1.58)^0.53
50	I= 10,086 /(T+23.53)	I= 881 /T^ 0.49	I= 929 /(T^0.5+0.06)	I= 1,012 /(T+ 1.18)^0.52
100	I= 11,010 /(T+23.53)	I= 961 /T^ 0.49	I= 1,014 /(T^0.5+0.06)	I= 1,060 /(T+ 0.82)^0.51
200	I= 11,936 /(T+23.38)	I= 1,041 /T^ 0.49	I= 1,097 /(T^0.5+0.05)	I= 1,109 /(T+ 0.53)^0.50

Semarang Meteorological Station
(Applicalbe Range of Rainfall Duration : from 1 to 48 hours)

Return Period (Year)	(1) Talbot Type Equation	(2) Sherman Type Equation	(3) Kuno Type Equation	(4) Horner Type Equation
2	I= 8,734 /(T+88.60)	I= 1,472 /T^ 0.70	I= 211 /(T^0.5-5.03)	I= 1,313 /(T + 5.40)^0.74
5	I= 11,705 /(T+93.01)	I= 1,929 /T^ 0.76	I= 281 /(T^0.5-5.03)	I= 2,050 /(T + 2.95)^0.76
10	I= 13,599 /(T+93.90)	I= 2,245 /T^ 0.70	I= 326 /(T^0.5-5.05)	I= 2,600 /(T + 7.20)^0.78
20	I= 15,436 /(T+94.70)	I= 2,545 /T^ 0.70	I= 369 /(T^0.5-5.06)	I= 3,136 /(T +10.31)^0.78
25	I= 16,014 /(T+94.76)	I= 2,646 /T^ 0.70	I= 382 /(T^0.5-5.07)	I= 3,346 /(T +11.64)^0.79
30	I= 16,516 /(T+95.20)	I= 2,714 /T^ 0.70	I= 394 /(T^0.5-5.06)	I= 3,450 /(T +11.91)^0.79
50	I= 17,823 /(T+95.40)	I= 2,931 /T^ 0.70	I= 425 /(T^0.5-5.08)	I= 3,832 /(T +13.36)^0.79
100	I= 19,680 /(T+96.60)	I= 3,197 /T^ 0.70	I= 468 /(T^0.5-5.07)	I= 4,324 /(T +15.15)^0.80
200	I= 21,357 /(T+96.00)	I= 3,510 /T^ 0.70	I= 507 /(T^0.5-5.10)	I= 4,984 /(T +17.65)^0.80

Kaligading Automatic Rainfall Gauging Station
(Applicalbe Range of Rainfall Duration : from 1 to 48 hours)

Return Period (Year)	(1) Talbot Type Equation	(2) Sherman Type Equation	(3) Kuno Type Equation	(4) Horner Type Equation
2	I= 10,103 /(T+92.90)	I= 1,685 /T^ 0.76	I= 243 /(T^0.5-5.03)	I= 1,852 /(T + 4.60)^0.77
5	I= 11,739 /(T+92.72)	I= 1,935 /T^ 0.76	I= 282 /(T^0.5-5.01)	I= 1,966 /(T + 0.76)^0.76
10	I= 12,770 /(T+91.82)	I= 2,120 /T^ 0.76	I= 308 /(T^0.5-5.02)	I= 2,165 /(T + 1.02)^0.76
20	I= 13,797 /(T+91.54)	I= 2,287 /T^ 0.76	I= 333 /(T^0.5-5.01)	I= 2,350 /(T + 1.30)^0.76
25	I= 14,067 /(T+90.74)	I= 2,357 /T^ 0.76	I= 340 /(T^0.5-5.03)	I= 2,438 /(T + 1.62)^0.76
30	I= 14,337 /(T+90.68)	I= 2,404 /T^ 0.76	I= 346 /(T^0.5-5.03)	I= 2,508 /(T + 2.05)^0.76
50	I= 15,089 /(T+90.79)	I= 2,515 /T^ 0.76	I= 364 /(T^0.5-5.02)	I= 2,612 /(T + 1.83)^0.76
100	I= 16,043 /(T+90.17)	I= 2,684 /T^ 0.76	I= 388 /(T^0.5-5.03)	I= 2,740 /(T + 1.00)^0.76
200	I= 17,063 /(T+90.34)	I= 2,837 /T^ 0.76	I= 412 /(T^0.5-5.02)	I= 2,914 /(T + 1.30)^0.76

Table I.3.5 MODEL HYETOGRAPH

Semarang Meteorological Station
(5-Minute Interval)

Time	Rainfall Distribution in Return Period								
(min)	2-year (mm)	5-year (mm)	10-year (mm)	20-year (mm)	25-year (mm)	30-year (mm)	50-year (mm)	100-year (mm)	200-year (mm)
5	1.1	2.0	2.3	2.9	3.0	3.1	3.4	3.8	4.3
10	1.2	2.1	2.5	3.0	3.1	3.3	3.6	4.0	4.5
15	1.3	2.2	2.6	3.2	3.3	3.5	3.8	4.2	4.7
20	1.4	2.4	2.8	3.4	3.5	3.7	4.0	4.4	5.0
25	1.6	2.6	3.0	3.6	3.8	3.9	4.2	4.7	5.3
30	1.8	2.8	3.2	3.9	4.1	4.2	4.6	5.1	5.6
35	2.0	3.1	3.6	4.3	4.5	4.6	5.0	5.5	6.1
40	2.4	3.5	4.0	4.7	5.1	5.1	5.5	6.1	6.7
45	3.0	4.1	4.6	5.4	5.9	5.8	6.3	6.9	7.6
50	3.9	5.1	5.6	6.5	7.3	6.9	7.4	8.1	8.9
55	5.6	6.8	7.4	8.4	10.3	8.9	9.5	10.3	11.2
60	10.0	11.9	12.7	14.0	29.2	14.6	15.3	16.5	17.7
65	16.0	21.6	24.8	28.4	14.0	30.4	32.7	36.0	39.3
70	7.2	8.6	9.2	10.3	8.4	10.8	11.4	12.4	13.4
75	4.6	5.8	6.3	7.3	6.5	7.7	8.2	9.0	9.9
80	3.4	4.5	5.0	5.9	5.4	6.3	6.8	7.4	8.2
85	2.7	3.8	4.3	5.1	4.8	5.4	5.8	6.5	7.1
90	2.2	3.3	3.8	4.5	4.3	4.8	5.2	5.8	6.4
95	1.9	2.9	3.4	4.1	3.9	4.4	4.8	5.3	5.9
100	1.7	2.7	3.1	3.8	3.6	4.1	4.4	4.9	5.4
105	1.5	2.5	2.9	3.5	3.4	3.8	4.1	4.6	5.1
110	1.4	2.3	2.7	3.3	3.2	3.6	3.9	4.3	4.8
115	1.2	2.1	2.5	3.1	3.0	3.4	3.7	4.1	4.6
120	1.2	2.0	2.4	2.9	2.9	3.2	3.5	3.9	4.4
Total	80.3	110.7	124.7	145.5	146.6	155.5	167.1	183.8	202.1

Semarang Meteorological Station
(1-Hour Interval)

Time	Rainfall Distribution in Return Period								
(hour)	2-year (mm)	5-year (mm)	10-year (mm)	20-year (mm)	25-year (mm)	30-year (mm)	50-year (mm)	100-year (mm)	200-year (mm)
1	2.8	3.7	3.9	4.7	4.5	4.7	5.2	5.3	6.2
2	3.3	4.4	4.6	5.6	5.4	5.6	6.3	6.4	7.5
3	4.0	5.4	5.7	7.0	6.8	7.1	7.9	8.2	9.6
4	5.2	7.2	7.8	9.6	9.5	9.8	11.0	11.4	13.4
5	7.7	11.5	13.0	16.3	16.3	16.8	19.0	20.1	23.9
6	68.0	88.0	97.6	113.7	114.5	117.7	128.7	136.5	153.2
7	10.6	17.8	21.1	26.8	27.1	28.1	31.8	34.2	40.6
8	6.2	8.8	9.7	12.0	11.9	12.3	13.8	14.5	17.1
9	4.5	6.1	6.6	8.1	7.9	8.2	9.2	9.5	11.1
10	3.6	4.8	5.1	6.2	6.1	6.2	7.0	7.2	8.4
11	3.1	4.0	4.2	5.1	4.9	5.1	5.7	5.8	6.8
12	2.7	3.5	3.6	4.4	4.2	4.4	4.9	4.9	5.8
Total	121.7	165.2	182.8	219.8	219.2	226.0	250.5	264.2	303.7

Kaligading Automatic Rainfall Gauging Station
(1-Hour Interval)

Time	Rainfall Distribution in Return Period								
(hour)	2-year (mm)	5-year (mm)	10-year (mm)	20-year (mm)	25-year (mm)	30-year (mm)	50-year (mm)	100-year (mm)	200-year (mm)
1	3.0	3.5	3.9	4.2	4.4	4.5	4.7	4.9	5.2
2	3.6	4.1	4.6	5.0	5.2	5.3	5.5	5.8	6.2
3	4.4	5.1	5.6	6.1	6.4	6.6	6.8	7.1	7.6
4	6.0	6.8	7.5	8.1	8.4	8.7	9.1	9.4	10.1
5	9.8	10.7	11.8	12.9	13.4	13.9	14.4	15.0	16.0
6	74.8	86.7	95.2	102.9	106.4	108.9	113.7	120.5	127.6
7	15.4	16.2	17.9	19.6	20.5	21.3	22.1	22.7	24.3
8	7.4	8.2	9.1	9.9	10.3	10.6	11.0	11.5	12.3
9	5.1	5.8	6.4	7.0	7.2	7.5	7.8	8.1	8.6
10	4.0	4.6	5.0	5.5	5.7	5.9	6.1	6.4	6.8
11	3.3	3.8	4.2	4.6	4.7	4.9	5.1	5.3	5.7
12	2.8	3.3	3.6	3.9	4.1	4.2	4.4	4.6	4.9
Total	139.6	158.8	174.8	189.7	196.7	202.3	210.7	221.3	235.3

Table I.4.1 CONSTANTS FOR STORAGE FUNCTION MODEL

Constants for Sub-Basin

River Sub-Basin	K	p	Tl (hr)	Fl	A (km2)	Base Flow (m3/s)
Babon R.						
BAB-1	9.20	0.60	0.39	0.86	38.80	2.0
BAB-2	7.90	0.60	0.34	0.86	13.10	0.7
BAB-3	8.60	0.60	0.37	0.86	25.10	1.3
East Floodway						
EAB-1	8.40	0.60	0.33	0.86	19.80	1.1
EAB-2	7.60	0.60	0.30	0.86	9.90	0.5
Garang R.						
GAB-1	10.00	0.60	0.54	0.86	70.90	3.4
GAB-2	8.00	0.60	0.43	0.86	14.00	0.9
GAB-3	9.00	0.60	0.48	0.86	34.00	1.8
GAB-4	5.90	0.60	0.32	0.86	1.60	0.1
GAB-5	9.40	0.60	0.50	0.86	45.70	2.4
GAB-6	7.30	0.60	0.39	0.86	7.30	0.5
GAB-7	7.60	0.60	0.41	0.86	10.40	0.6
GAB-8	5.70	0.60	0.31	0.86	1.30	0.1
GAB-9	8.30	0.60	0.45	0.86	18.80	0.6
Silandak R.						
SIB-1	7.40	0.60	0.27	0.86	8.50	0.4
Bringin R.						
BRB-1	7.80	0.60	0.31	0.86	12.00	0.6
BRB-2	7.80	0.60	0.31	0.86	11.90	0.6
BRB-3	7.40	0.60	0.30	0.86	8.20	0.4
Blorong R.						
BLB-1	9.50	0.60	0.51	0.86	50.50	3.0
BLB-2	9.40	0.60	0.59	0.86	46.50	2.6
BLB-3	8.40	0.60	0.45	0.86	20.40	1.0
BLB-4	8.70	0.60	0.47	0.86	29.10	1.3
BLB-5	7.90	0.60	0.42	0.86	10.50	0.6

Constants for River Channel

River Channel	K	P	Tl (hr)
Babon R.			
BAR-1	2.13	0.60	0.13
BAR-2	6.04	0.60	0.28
BAR-3	3.91	0.60	0.18
East Floodway			
EAR-1	4.81	0.60	0.28
Garang R.			
GAR-1	4.73	0.60	0.24
GAR-2	5.85	0.60	0.24
GAR-3	2.80	0.60	0.17
GAR-4	2.47	0.60	0.13
GAR-5	4.83	0.60	0.24
GAR-6	4.01	0.60	0.16
GAR-7	1.45	0.60	0.05
GAR-8	0.93	0.60	0.02
GAR-9	7.26	0.60	0.17
Silandak R.			
SIR-1	1.74	0.60	0.20
Bringin R.			
BRR-1	2.28	0.60	0.16
BRR-2	1.11	0.60	0.08
BRR-3	2.48	0.60	0.17
Blorong R.			
BLR-1	4.18	0.60	0.25
BLR-2	10.93	0.60	0.14
BLR-3	2.74	0.60	0.26
BLR-4	11.45	0.60	0.77
BLR-5	4.11	0.60	0.16

Table I.4.2 PROBABLE RUN-OFF DISCHARGE BASED ON OBSERVED DATA AT SIMONGAN WEIR

Return Period (Year)	Probable Discharge (m3/s)
2	350
5	520
10	630
20	740
25	770
30	800
40	840
50	880
70	920
80	940
100	980
150	1,040
200	1,080
300	1,140
500	1,220

Table I.4.3 PROBABLE MAXIMUM PRECIPITATION (PMP) FOR JATIBARANG DAM CATCHMENT AREA ESTIMATED BY HERSHFIELD METHOD

Description		1-hour Rainfall	6-hour Rainfall	24-hour Rainfall
1. Annual Maximum Point Rainfall Observed	Year			
at Kaligading Gauging Station	1980	98 mm	113 mm	216 mm
	1981	69 mm	145 mm	201 mm
	1982	64 mm	143 mm	158 mm
	1983	97 mm	163 mm	175 mm
	1984	75 mm	113 mm	144 mm
	1985	71 mm	97 mm	159 mm
	1986	77 mm	90 mm	113 mm
	1987	58 mm	117 mm	126 mm
	1990	66 mm	139 mm	150 mm
	1991	89 mm	128 mm	128 mm
2. Average of Observed Annual Maximum Point Rainfall				
2.1 For all observed data series (Xn, n=10)		76.40 mm	124.80 mm	157.00 mm
2.2 Exclude the highest observed data (Xm, m= 9)		74.00 mm	120.56 mm	150.44 mm
2.3 Xm/Xn		0.97	0.97	0.96
3. Adjustment of Xn				
3.1 Adjustment factor effected by the highest observed data		1.05	1.05	1.04
3.2 Adjustment factor effected by the observed data length		1.05	1.05	1.05
3.3 Adjusted Xn ((2.1) x (3.1) x (3.2))		84.23 mm	137.59 mm	171.44 mm
4. Standard Deviation of Observed Annual Maximum Point Rainfall				
4.1 For all observed data series (Sn, n=10)		13.18 mm	21.76 mm	31.15 mm
4.2 Exclude the highest observed data (Sm, m= 9)		11.63 mm	18.60 mm	25.46 mm
4.3 Sm/Sn		0.88	0.85	0.82
5. Adjustment of Sn				
5.1 Adjustment factor effected by the highest observed data		1.07	1.03	1.00
5.2 Adjustment factor effected by the observed data length		1.30	1.30	1.30
5.3 Adjusted Sn ((4.1) x (5.1) x (5.2))		18.33 mm	29.13 mm	40.49 mm
6. Point PMP				
6.1 Statistical Coefficient Km		6	10	13
6.2 Unadjusted Point PMP ((3.3) + (6.1) x (5.3))		194 mm	429 mm	698 mm
6.3 Adjustment for fixed observational time interval		1.13	1.02	1.01
6.4 Adjusted Point PMP ((6.2) x (6.3))		219 mm	437 mm	705 mm
7. Areal Average PMP for Jatibarang Dam Watershed				
7.1 Areal Reduction Factor (53 km2)		0.90	0.97	0.98
7.2 Areal Average PMP ((6.4) x (7.1))		198 mm	424 mm	691 mm

Table I.4.4 HOURLY DISTRIBUTION OF PROBABLE MAXIMUM PRECIPITATION (PMP) AND PROBABLE MAXIMUM FLOOD RUNOFF DISCHARGE (PMF)

Time (hour)	Probable Maximum Rainfall (mm/hr)	Probable Maximum Flood (m3/s)	Time (hour)	Probable Maximum Rainfall (mm/hr)	Probable Maximum Flood (m3/s)
1	10	4	25	-	147
2	11	11	26	-	104
3	12	36	27	-	73
4	13	76	28	-	55
5	14	109	29	-	43
6	15	140	30	-	35
7	17	176	31	-	28
8	20	215	32	-	24
9	25	264	33	-	20
10	32	335	34	-	17
11	51	479	35	-	15
12	198	1429	36	-	14
13	76	1777	37	-	12
14	39	1092	38	-	11
15	28	702	39	-	10
16	22	509	40	-	9
17	19	399	41	-	8
18	16	336	42	-	8
19	15	284	43	-	7
20	13	253	44	-	7
21	12	225	45	-	6
22	11	206	46	-	6
23	11	189	47	-	6
24	10	175	48	-	6

Table I.4.5 (1/2) PROBABLE POINT RAINFALL INTENSITIES BY GUMBEL METHOD

(Short Duration)
Semarang Meteorological Station

Unit : mm/hr

Return Period (Year)	Rainfall Duration						
	5 min.	10 min.	15 min.	30 min.	45 min.	60 min.	120 min.
2	202.5	148.9	134.0	99.5	75.8	66.5	40.8
3	229.8	168.5	153.2	111.6	84.6	75.0	47.6
5	260.1	190.4	174.7	125.0	94.4	84.5	55.2
8	286.2	209.3	193.1	136.6	102.8	92.6	61.7
10	298.2	218.0	201.6	141.9	106.7	96.4	64.7
20	334.8	244.4	227.5	158.1	118.4	107.7	73.9
25	346.4	252.7	235.7	163.3	122.2	111.4	76.8
30	355.9	259.5	242.3	167.4	125.2	114.3	79.1
50	382.2	278.5	260.9	179.1	133.7	122.5	85.7
70	399.4	290.9	273.1	186.7	139.2	127.8	90.0
80	406.3	295.9	278.0	189.8	141.4	130.0	91.7
100	417.7	304.1	286.0	194.8	145.1	133.5	94.6
150	438.3	319.1	300.6	204.0	151.8	140.0	99.7
200	453.0	329.6	311.0	210.5	156.5	144.5	103.4
300	473.7	344.5	325.6	219.6	163.1	151.0	108.5
1993	282.0	192.6	171.2	160.5	119.8	98.0	57.8
Scale	<8-year	<8-year	<5-year	<25year	<25year	<20year	<8year

(Long Duration)
Semarang Meteorological Station

Unit : mm/hr

Return Period (Year)	Rainfall Duration						
	1 hr.	2 hr.	3 hr.	6 hr.	12 hr.	1-day	2-day
2	66.5	40.8	29.7	17.5	10.3	5.7	3.8
3	75.0	47.6	34.1	20.1	12.0	6.6	4.5
5	84.5	55.2	39.1	22.9	13.9	7.7	5.3
8	92.6	61.7	43.3	25.3	15.6	8.6	5.9
10	96.4	64.7	45.3	26.4	16.3	9.1	6.3
20	107.7	73.9	51.2	29.9	18.6	10.4	7.2
25	111.4	76.8	53.1	30.9	19.3	10.8	7.5
30	114.3	79.1	54.7	31.8	19.9	11.1	7.7
50	122.5	85.7	59.0	34.3	21.6	12.0	8.4
70	127.8	90.0	61.8	35.9	22.7	12.6	8.9
80	130.0	91.7	62.9	36.5	23.1	12.9	9.0
100	133.5	94.6	64.8	37.6	23.8	13.3	9.3
150	140.0	99.7	68.1	39.5	25.1	14.0	9.9
200	144.5	103.4	70.5	40.9	26.0	14.6	10.2
300	151.0	108.5	73.9	42.8	27.3	15.3	10.8
1993	98.0	57.8	39.2	25.1	17.5	11.5	8.9
Scale	<20-year	<8-year	<8-year	<8-year	<20-year	<50-year	=70-year

Table I.4.5 (2/2) PROBABLE POINT RAINFALL INTENSITIES BY GUMBEL METHOD

(Long Duration)
Kaligading Rainfall Gauging Station

Unit : mm/hr

Return Period (Year)	Rainfall Duration 1 hr.	2 hr.	3 hr.	6 hr.	12 hr.	1-day	2-day
2	68.2	45.0	34.5	20.1	11.3	6.7	4.1
3	75.1	49.1	36.8	21.8	12.5	7.3	4.9
5	82.8	53.6	39.4	23.8	13.8	8.0	5.7
8	89.4	57.6	41.6	25.5	14.9	8.7	6.4
10	92.4	59.4	42.6	26.3	15.4	9.0	6.7
20	101.7	64.9	45.8	28.6	17.0	9.8	7.6
25	104.6	66.6	46.8	29.4	17.5	10.1	8.0
30	107.0	68.1	47.6	30.0	18.0	10.4	8.2
50	113.7	72.0	49.8	31.7	19.0	11.0	8.9
70	118.0	74.6	51.3	32.8	19.7	11.4	9.4
80	119.8	75.7	51.9	33.3	20.0	11.6	9.5
100	122.7	77.4	52.8	34.0	20.5	11.8	9.9
150	127.9	80.5	54.6	35.3	21.4	12.3	10.4
200	131.6	82.7	55.9	36.3	22.0	12.7	10.8
300	136.8	85.8	57.6	37.6	22.9	13.2	11.3
1993	41.0	30.5	28.8	26.3	18.1	9.7	9.2
Scale	<2-year	<2-year	<2-year	=10-year	<50-year	<20-year	<70-year

Table I.6.1 ANNUAL RAINFALL AT SELECTED RAINFALL GAUGING STATIONS

(Unit : mm)

Year	Rainfall Station Code											
	25	33	34	37	39	41	44	59	65	68	97	99
1958	1,579 *	1,254 *	1,077 *	0 *	1,591 *	1,427 *	1,412 *	2,379 *	3,469	3,264	2,615	3,143
1959	733 *	1,001 *	1,241 *	0 *	1,583 *	787 *	1,389 *	1,711 *	2,861	2,569	2,209	2,755
1960	2,373	2,006 *	2,391	0 *	2,596 *	0 *	2,652	1,508	3,081 *	1,378 *	1,383	1,792 *
1961	1,523 *	1,332 *	1,581 *	0 *	519 *	0 *	1,593	1,766 *	1,901	1,376	2,152	1,865
1962	1,517 *	2,282 *	3,475 *	0 *	1,425 *	0 *	1,429 *	1,833	3,375	2,300	2,650	2,903 *
1963	174 *	1,673 *	775 *	0 *	1,087 *	0 *	790 *	1,322	2,377	1,502	1,747	1,545
1964	2,204	1,524 *	2,421 *	0 *	2,105 *	0 *	1,688 *	1,671	2,563	1,988	594 *	2,590
1965	1,490	1,733	2,302	0 *	2,437	1,492	2,047	1,240 *	2,774 *	1,513 *	1,822	2,626
1966	1,693	1,905	2,879	0 *	3,239	853 *	2,204	1,756	2,818	2,010	2,407	2,068
1967	1,967	2,253	3,437	0 *	3,467	750 *	2,318	1,461	1,938 *	1,261 *	1,017 *	633 *
1968	2,598	3,026	4,267	0 *	4,996	2,040	3,593	2,489	2,761 *	2,625	2,572 *	3,521
1969	1,261	1,402	2,664	2,506 *	3,374	1,564	2,000	1,095	3,725	853 *	1,476	748 *
1970	2,149	2,152	2,908	5,401	4,316	814 *	2,515	1,851	3,567	1,579 *	1,635	2,978
1971	2,972	2,516	4,128	3,247	3,807 *	1,675	2,351	2,217	3,422 *	1,357 *	2,881	3,222
1972	2,149	2,270	2,003	2,401	2,728	1,350	2,137	1,892	2,217	1,095 *	2,022	2,057 *
1973	3,287	3,034	2,542 *	3,128	3,134 *	2,075	1,971 *	2,442	1,809 *	2,049 *	2,626	3,262
1974	2,870	2,134	3,537	3,676	7,236 *	1,878	3,789	2,538	3,205	1,634 *	2,361	3,293
1975	910 *	1,534	3,375	0 *	3,384	1,838	2,606	0 *	2,775 *	566 *	2,523	4,110
1976	2,876 *	2,140	2,644	0 *	2,273	1,459	2,776 *	0 *	2,753	1,803 *	2,243	1,746
1977	2,338	1,340	2,204	2,459	1,760 *	1,632	2,361	1,506	2,497 *	1,084	1,966	1,200
1978	3,165	2,282	3,815	2,815 *	0 *	2,751	2,995	1,981	2,856	1,819	2,309	2,825
1979	1,967	1,934	2,593	2,685	3,495 *	2,226	2,324	1,909	3,206	1,716	1,702	2,666
1980	1,622	1,896	2,476	3,222	3,718	2,036	2,215	2,396	3,387	1,613	1,839	1,941
1981	2,875	3,387	3,811	4,465 *	4,294	3,184	2,937	2,265	1,354 *	872 *	2,597	2,620
1982	1,769	1,643	1,989	2,439 *	3,007	1,847	1,926	1,623 *	2,152	1,269	1,749	1,686
1983	2,187	1,842	2,428	3,632	3,976	1,781	1,989	2,344	2,265	751 *	1,792	1,799
1984	2,846	2,659	3,993	4,052	4,039	2,304	2,991	2,811 *	2,495	1,235 *	2,373	2,902
1985	2,668	1,830	2,168	1,969 *	4,091	1,619	2,445	1,938 *	713 *	1,354 *	2,045	2,690
1986	2,844	2,232	2,742	3,177	4,258	1,851	3,092	2,706	2,021 *	1,561 *	2,079	2,714
1987	1,844	1,179	1,962	1,294	3,304	1,144	2,250	2,998	3,057	606 *	1,439	2,363
1988	2,253 *	2,173	2,181	31 *	2,560 *	1,685 *	2,130	2,833	4,871	0 *	1,781	2,403
1989	2,755	2,127	0 *	0 *	2,635	2,144	2,650	2,642	3,981	0 *	2,031	2,827
1990	2,275	2,356	0 *	0 *	2,752	2,324	2,728	1,764 *	2,713	0 *	1,666	2,985

Note

* : including missing or unreliable data

Station Name : 25; Kebonadem 33; Karangtengah 34; Ngareanak 37; Boja
39; Limbangan 41; Bringinmangkang 44; Mijen 59; Candi
65; Sumurjurang 68; Klepu 97; Plamongan 99; Banyumeneng

Table I.6.2(1/3) MONTHLY BASIN RAINFALL BABON RIVER BASIN

Year	1	2	3	4	5	6	7	8	9	10	11	12	Annual Rainfall (mm)
	Monthly Rainfall (mm)												
1958	294	590	304	250	170	107	217	154	60	140	167	234	2,687
1959	337	324	350	210	187	90	177	10	50	137	47	347	2,266
1960	420	514	394	227	220	77	53	33	60	77	244	130	2,449
1961	537	150	220	120	214	0	30	0	37	10	140	194	1,652
1962	364	570	324	404	227	40	43	63	30	60	187	257	2,569
1963	697	254	330	190	27	7	0	0	0	87	50	154	1,796
1964	314	287	180	277	140	80	13	77	63	227	163	127	1,948
1965	634	303	520	150	40	43	7	33	0	27	120	227	2,104
1966	404	364	410	210	63	83	10	0	53	217	117	214	2,145
1967	304	417	297	367	70	0	0	0	0	13	90	340	1,898
1968	497	280	273	300	200	227	164	110	77	43	200	274	2,645
1969	344	530	564	570	20	67	43	0	13	127	170	334	2,782
1970	340	234	334	274	194	137	120	0	97	90	294	577	2,691
1971	590	390	347	320	167	227	23	0	43	210	247	227	2,791
1972	490	254	414	60	117	13	0	0	0	0	137	180	1,665
1973	383	170	260	177	157	87	107	17	113	247	297	247	2,262
1974	417	197	507	240	117	13	33	57	77	284	163	334	2,439
1975	290	197	427	267	170	50	0	20	217	207	337	210	2,392
1976	697	330	490	53	17	27	3	13	0	50	207	173	2,060
1977	324	240	467	163	120	87	0	0	0	0	120	350	1,871
1978	580	354	334	73	83	110	67	33	163	107	114	200	2,218
1979	454	474	330	357	200	97	33	17	83	87	163	127	2,422
1980	544	244	247	310	190	0	53	93	27	130	287	427	2,552
1981	307	290	70	0	144	83	150	0	0	0	50	320	1,414
1982	274	204	464	394	0	0	0	0	0	0	97	190	1,623
1983	330	163	150	230	267	17	0	0	0	267	220	70	1,714
1984	177	394	187	104	50	57	70	40	320	70	184	304	1,957
1985	53	190	124	167	27	0	73	63	87	160	194	224	1,362
1986	450	194	430	160	57	180	37	73	97	73	117	147	2,015
1987	564	480	220	43	93	40	53	0	0	7	223	564	2,287
1988	427	440	347	257	143	27	27	53	23	167	154	657	2,722
1989	287	934	390	264	187	170	93	10	40	120	260	274	3,029
1990	564	187	230	127	73	127	43	60	40	40	140	464	2,095
Average	415	338	331	222	126	72	53	31	57	105	173	276	2,198

Table I.6.2(2/3) MONTHLY BASIN RAINFALL GARANG RIVER BASIN

Year	Monthly Rainfall (mm) 1	2	3	4	5	6	7	8	9	10	11	12	Annual Rainfall (mm)
1958	308	621	319	277	173	111	228	160	63	150	182	262	2,854
1959	349	344	362	224	192	94	181	9	52	146	54	384	2,391
1960	437	531	415	251	237	78	62	36	63	83	261	139	2,593
1961	554	158	238	127	224	0	35	0	37	12	146	214	1,745
1962	384	596	348	423	237	48	44	67	32	65	201	275	2,720
1963	725	267	345	210	27	6	0	0	0	91	51	168	1,890
1964	330	301	190	288	144	86	15	78	72	238	174	128	2,044
1965	664	317	549	156	45	46	9	38	0	29	129	245	2,227
1966	432	386	418	215	70	87	9	0	59	229	127	227	2,259
1967	318	432	312	381	69	0	0	0	0	15	93	357	1,977
1968	517	306	285	304	217	238	176	113	83	45	212	293	2,789
1969	353	556	578	592	23	68	44	0	15	136	177	344	2,886
1970	359	246	343	281	205	142	124	0	102	92	301	599	2,794
1971	614	404	354	336	173	239	24	0	44	218	254	247	2,907
1972	509	261	432	65	122	15	0	0	0	0	139	195	1,738
1973	402	177	279	178	160	92	109	18	117	257	317	254	2,360
1974	437	211	531	249	122	19	42	58	86	292	172	348	2,567
1975	297	206	436	284	180	45	0	24	231	213	362	229	2,507
1976	730	348	517	59	18	27	3	15	0	54	219	182	2,172
1977	346	258	496	169	120	93	0	0	0	0	120	371	1,973
1978	586	370	347	77	92	112	78	33	169	118	127	208	2,317
1979	477	499	346	369	212	101	32	18	88	91	174	129	2,536
1980	564	250	264	321	203	0	55	98	29	139	302	442	2,667
1981	326	296	76	0	164	91	164	0	0	0	57	330	1,504
1982	286	214	480	407	0	0	0	0	0	0	103	204	1,694
1983	352	172	155	238	279	18	0	0	0	286	231	77	1,808
1984	196	416	195	111	56	55	78	44	336	77	194	319	2,077
1985	64	198	133	175	33	0	76	65	90	172	215	253	1,474
1986	476	209	445	173	58	182	43	84	107	80	123	156	2,136
1987	583	502	226	47	100	39	58	0	0	6	234	591	2,386
1988	450	466	366	268	155	27	27	59	28	181	165	689	2,881
1989	297	978	406	275	202	182	100	12	41	131	272	285	3,181
1990	592	204	241	130	83	138	47	66	45	45	162	482	2,235
Average	434	355	346	232	133	75	56	33	60	112	183	292	2,312

Table I.6.2(3/3) MONTHLY BASIN RAINFALL BLORONG RIVER BASIN

Year	Monthly Rainfall (mm)												Annual Rainfall (mm)
	1	2	3	4	5	6	7	8	9	10	11	12	
1958	296	417	306	306	202	158	257	249	122	168	207	256	2,944
1959	331	176	320	384	187	143	143	12	114	97	114	386	2,407
1960	454	431	356	324	286	121	48	39	63	110	507	229	2,968
1961	620	373	244	168	259	33	50	3	0	25	160	203	2,138
1962	351	545	465	386	246	109	174	128	36	122	235	436	3,233
1963	608	250	356	222	66	94	0	11	11	70	168	194	2,050
1964	313	251	170	209	223	116	74	34	137	445	151	318	2,441
1965	623	194	240	102	47	31	48	0	0	0	113	300	1,698
1966	358	376	328	206	162	77	6	0	56	137	277	318	2,301
1967	306	496	404	300	51	0	0	0	0	79	311	492	2,439
1968	314	523	616	264	307	282	196	121	58	28	301	509	3,519
1969	360	349	397	445	51	82	36	0	17	125	377	137	2,376
1970	413	531	540	391	51	111	0	0	69	107	491	336	3,040
1971	522	326	285	312	201	201	87	3	0	402	274	358	2,971
1972	495	228	457	170	233	0	0	0	0	26	119	197	1,925
1973	334	384	259	289	366	171	34	19	244	194	261	231	2,786
1974	410	264	270	252	185	98	136	182	303	219	276	335	2,930
1975	368	324	286	164	170	18	61	47	331	264	279	217	2,529
1976	321	190	288	199	69	11	4	45	0	93	262	254	1,736
1977	269	175	270	146	56	247	0	0	8	19	162	225	1,577
1978	382	197	291	145	182	185	124	145	221	177	138	330	2,517
1979	248	309	313	499	178	165	28	34	177	113	246	422	2,732
1980	354	261	509	213	238	0	109	18	26	155	337	428	2,648
1981	544	291	287	371	210	155	302	62	171	82	132	464	3,071
1982	515	344	247	457	37	53	9	4	0	0	160	299	2,125
1983	501	392	309	256	347	47	0	0	0	268	454	228	2,802
1984	404	485	323	203	115	88	80	58	318	133	188	482	2,877
1985	342	462	452	324	212	42	61	35	61	374	240	299	2,904
1986	469	280	563	287	156	174	150	11	125	122	322	362	3,021
1987	433	307	383	211	136	33	15	0	16	58	214	532	2,338
1988	309	242	528	34	90	39	23	19	0	239	210	310	2,043
1989	332	565	163	272	261	123	105	60	104	168	270	282	2,705
1990	949	239	201	123	147	32	28	39	35	22	106	512	2,433
Average	420	339	346	262	174	98	72	42	86	141	244	330	2,552

Table I.6.3 FLOW REGIME AND BALANCE IN OBSERVED RECORDS

River	Year	No. of Records	Flow Regime (m3/s) Maximum	25%	50%	75%	95%	99%	Minimum	Mean Discharge (m3/s)	Annual Run-off (mm)	Annual Rainfall (mm)	Annual Loss (mm)	Run-off Ratio
Babon	1985	365	14.00	2.34	1.42	0.89	0.11	0.00	0.00	1.85	758	1,362	604	0.557
(C.A= 77.0km2)	1986	364	11.00	2.11	0.88	0.59	0.25	0.11	0.04	1.58	647	2,015	1,368	0.321
	1987	334	39.50	2.45	1.09	0.22	0.00	0.00	0.00	2.83	1,159	2,287	1,128	0.507
	1988	350	163.20	2.14	0.95	0.30	0.01	0.00	0.00	2.53	1,039	2,722	1,683	0.382
	1989	272	35.30	1.84	0.99	0.25	0.00	0.00	0.00	1.46	598	3,029	2,431	0.197
	1990	363	354.06	1.78	0.97	0.37	0.06	0.01	0.01	4.27	1,749	2,095	346	0.835
Garang	1987	357	99.20	10.50	5.12	2.45	1.77	1.64	1.50	9.65	1,643	2,386	743	0.689
(C.A=185.2km2)	1988	344	123.00	10.70	4.37	2.10	1.44	1.16	0.38	8.54	1,458	2,881	1,423	0.506
	1990	341	74.40	9.14	5.56	2.50	1.40	1.30	1.30	6.88	1,172	2,235	1,063	0.524
Blorong	1980	351	31.50	8.11	4.68	2.10	1.20	1.02	1.00	6.34	1,083	2,648	1,565	0.409
(C.A=157.0km2)	1981	342	47.30	14.40	6.64	2.62	1.49	1.15	1.07	10.01	1,705	3,071	1,366	0.555
	1982	349	65.00	11.20	2.13	0.99	0.67	0.55	0.52	6.77	1,153	2,125	972	0.543
	1983	352	39.00	9.06	4.53	1.61	0.70	0.59	0.57	6.62	1,127	2,802	1,675	0.402
	1984	328	49.20	7.84	4.36	2.29	1.48	1.21	1.07	6.91	1,180	2,877	1,697	0.410
	1985	329	67.50	10.60	5.68	2.93	1.28	0.98	0.89	7.64	1,301	2,904	1,603	0.448
	1986	331	44.90	10.80	5.38	2.61	1.16	0.92	0.85	7.89	1,344	3,021	1,677	0.445
	1987	359	42.40	8.20	3.05	1.03	0.51	0.43	0.40	5.77	983	2,338	1,355	0.420
	1988	349	53.90	7.72	3.60	1.86	1.03	0.85	0.35	5.58	953	2,043	1,090	0.466
	1989	322	93.80	10.20	8.20	2.50	1.28	1.22	1.22	9.32	1,587	2,705	1,118	0.587
	1990	344	57.20	8.92	3.92	2.02	0.78	0.57	0.54	6.50	1,107	2,433	1,326	0.455

Note : Annual Run-off=Mean Discharge(m3/s)x365or366(day)x86,400/C.A(km2)/1,000

Table I.6.4 (1/3) FLOW REGIME CALCULATED BY TANK MODEL SIMULATION BABON RIVER : PUCANGGADING WEIR (C.A=77.0km2)

Year	Flow Regime (m3/s)														Annual Rainfall
	Maximum	5%	15%	25%	35%	45%	50%	55%	65%	75%	85%	95%	99%	Minimum	Mean	(mm)
1961	24.75	6.02	3.23	2.43	2.12	2.00	1.77	1.52	1.10	0.64	0.34	0.13	0.09	0.09	2.15	1,652
1962	21.55	7.95	5.41	4.10	3.08	2.50	2.36	2.22	1.86	1.51	1.12	0.85	0.82	0.80	3.18	2,569
1963	79.73	6.75	4.43	2.82	2.33	2.03	1.75	1.48	1.08	0.59	0.25	0.11	0.09	0.07	2.61	1,796
1964	14.31	5.20	3.26	2.29	1.56	1.37	1.24	1.16	0.95	0.68	0.61	0.56	0.39	0.21	1.81	1,948
1965	26.38	10.64	4.60	2.94	2.23	1.87	1.64	1.48	1.04	0.69	0.30	0.13	0.08	0.07	2.76	2,104
1966	15.28	6.54	4.24	2.96	2.17	1.90	1.79	1.62	1.23	0.88	0.63	0.47	0.40	0.38	2.38	2,145
1967	50.65	6.46	4.17	2.90	2.22	1.90	1.72	1.65	1.20	0.71	0.23	0.00	0.00	0.00	2.38	1,898
1968	28.09	7.45	4.52	3.51	2.73	2.22	2.07	2.03	1.92	1.62	1.49	1.21	1.16	1.15	3.10	2,645
1969	32.57	12.25	7.03	5.02	3.55	3.20	2.99	2.77	2.27	1.75	1.36	1.16	1.11	1.09	4.24	2,782
1970	30.26	7.04	5.18	4.22	3.49	3.05	2.79	2.57	2.40	2.04	1.61	1.26	1.15	1.11	3.48	2,691
1971	19.71	10.79	7.18	5.60	4.61	3.61	3.49	3.30	2.93	2.41	2.04	1.68	1.63	1.62	4.47	2,791
1972	35.44	7.85	4.86	2.96	2.62	2.35	2.09	1.86	1.30	0.83	0.40	0.20	0.10	0.08	2.73	1,665
1973	25.54	5.53	3.53	2.55	1.88	1.55	1.46	1.43	1.32	1.09	0.90	0.68	0.65	0.64	2.19	2,262
1974	20.21	8.32	5.35	4.12	3.02	2.59	2.40	2.19	1.87	1.56	1.27	1.15	1.01	0.96	3.24	2,439
1975	18.19	6.75	4.77	3.86	3.08	2.58	2.51	2.41	2.09	1.79	1.53	1.34	1.27	1.26	3.07	2,392
1976	35.42	10.86	5.60	3.60	3.06	2.55	2.29	2.05	1.55	1.09	0.71	0.47	0.38	0.37	3.38	2,060
1977	18.54	6.65	3.75	2.52	1.94	1.76	1.57	1.41	1.06	0.63	0.27	0.04	0.00	0.00	2.13	1,871
1978	18.86	7.61	4.20	2.64	2.07	1.83	1.77	1.66	1.42	1.14	0.98	0.86	0.79	0.78	2.59	2,218
1979	23.77	8.37	5.52	4.18	3.18	2.71	2.52	2.33	1.90	1.42	1.18	1.01	0.97	0.95	3.30	2,422
1980	67.97	7.24	5.07	3.83	2.93	2.38	2.27	2.13	1.84	1.48	1.19	0.80	0.62	0.61	3.23	2,552
1981	11.05	5.16	3.29	2.45	1.95	1.67	1.60	1.44	1.33	0.81	0.35	0.00	0.00	0.00	1.88	1,414
1982	27.35	6.78	3.43	2.02	1.72	1.38	1.18	1.00	0.61	0.25	0.02	0.00	0.00	0.00	1.89	1,623
1983	14.89	5.06	2.97	1.87	1.45	1.21	1.08	0.99	0.80	0.46	0.23	0.02	0.00	0.00	1.58	1,714
1984	8.64	4.96	3.15	1.91	1.34	1.25	1.12	1.05	0.85	0.69	0.54	0.48	0.34	0.33	1.68	1,957
1985	15.64	3.43	1.66	1.16	1.09	1.00	0.93	0.85	0.55	0.45	0.26	0.10	0.00	0.00	1.11	1,362
1986	25.45	6.38	3.75	2.63	1.95	1.71	1.64	1.54	1.28	0.99	0.75	0.62	0.58	0.56	2.30	2,015
1987	29.87	9.15	5.17	3.32	2.11	1.89	1.76	1.61	1.22	0.84	0.33	0.00	0.00	0.00	2.87	2,287
1988	24.40	9.90	6.20	4.48	3.32	2.65	2.52	2.29	1.86	1.42	1.02	0.77	0.72	0.72	3.54	2,722
1989	41.07	11.36	6.67	5.15	4.31	3.66	3.43	3.30	2.92	2.40	1.94	1.58	1.54	1.51	4.70	3,029
1990	33.28	6.68	4.70	3.39	2.78	2.53	2.42	2.28	1.91	1.48	1.05	0.71	0.64	0.60	3.04	2,095
Average	27.96	7.50	4.56	3.25	2.53	2.16	2.01	1.85	1.52	1.14	0.83	0.61	0.55	0.53	2.77	2,171

Table I.6.4 (2/3) FLOW REGIME CALCULATED BY TANK MODEL SIMULATION GARANG RIVER : PANJANGAN (C.A=185.2km2)

Year	Flow Regime (m3/s)															Annual Rainfall (mm)
	Maximum	5%	15%	25%	35%	45%	50%	55%	65%	75%	85%	95%	99%	Minimum	Mean	
1961	64.23	16.19	9.62	7.46	5.80	4.35	3.92	3.43	2.53	1.55	0.88	0.01	0.00	0.00	5.69	1,745
1962	55.85	22.08	15.79	12.15	9.37	7.17	6.04	5.07	4.34	3.51	2.33	1.64	1.54	1.51	8.68	2,720
1963	199.58	19.34	12.63	8.74	5.47	4.36	3.86	3.37	2.25	1.18	0.33	0.00	0.00	0.00	6.80	1,890
1964	38.20	14.73	9.80	6.82	5.00	3.53	3.06	2.81	2.21	1.59	1.18	0.99	0.63	0.25	4.98	2,044
1965	70.60	29.37	13.83	8.89	4.85	4.20	3.86	3.42	2.47	1.49	0.70	0.03	0.00	0.00	7.38	2,227
1966	42.29	19.09	12.38	9.47	6.75	4.60	4.13	3.77	3.04	2.25	1.29	0.82	0.54	0.53	6.54	2,259
1967	61.90	17.38	12.24	8.76	6.55	4.65	4.16	3.53	2.34	1.17	0.26	0.00	0.00	0.00	6.01	1,977
1968	71.38	21.43	13.60	10.18	8.14	6.71	6.14	5.61	4.55	4.06	3.43	2.89	2.41	2.36	8.56	2,789
1969	84.40	33.89	19.90	14.23	9.96	7.26	6.73	6.15	5.09	3.97	2.97	2.23	2.08	2.05	10.97	2,886
1970	78.50	19.27	14.22	11.92	9.76	8.42	7.88	7.05	5.78	4.46	3.49	2.45	2.10	2.01	9.16	2,794
1971	50.49	28.90	19.07	15.21	12.53	9.83	8.60	7.74	6.56	5.56	4.45	3.43	3.14	3.08	11.45	2,907
1972	89.45	20.86	13.74	7.68	5.59	4.84	4.46	3.95	2.80	1.81	0.84	0.14	0.00	0.00	6.76	1,738
1973	66.12	15.05	10.35	7.76	6.01	5.01	4.46	3.98	2.96	2.53	1.84	1.26	1.14	1.13	6.10	2,360
1974	52.74	22.16	15.51	11.39	8.93	6.43	5.52	5.15	4.38	3.58	2.89	2.32	1.96	1.87	8.53	2,567
1975	46.42	18.38	13.48	10.82	8.94	7.54	6.73	6.04	5.04	4.38	3.52	2.61	2.41	2.35	8.18	2,507
1976	92.01	29.07	16.07	10.72	6.55	5.62	5.02	4.51	3.42	2.26	1.35	0.66	0.49	0.49	8.62	2,172
1977	46.98	18.69	11.53	7.43	5.65	4.02	3.68	3.42	2.38	1.40	0.41	0.00	0.00	0.00	5.82	1,973
1978	47.91	21.14	12.64	8.09	5.38	4.30	4.03	3.73	3.40	2.85	2.18	1.79	1.72	1.70	6.94	2,317
1979	62.37	23.04	15.90	12.19	9.20	7.63	5.68	5.15	4.22	3.31	2.45	1.96	1.83	1.79	8.81	2,536
1980	169.50	20.03	13.90	11.05	8.74	7.08	5.91	5.28	4.34	3.42	2.54	1.36	1.01	0.98	8.59	2,667
1981	29.07	14.27	9.92	7.36	5.20	3.85	3.45	3.20	2.66	1.65	0.54	0.00	0.00	0.00	4.94	1,504
1982	68.58	19.02	10.76	6.90	4.10	3.27	2.76	2.28	1.42	0.47	0.00	0.00	0.00	0.00	5.18	1,694
1983	39.96	15.23	9.06	6.58	4.93	3.65	2.95	2.61	2.04	1.14	0.47	0.00	0.00	0.00	4.68	1,808
1984	25.52	14.91	9.78	6.65	4.42	3.09	2.74	2.54	2.11	1.70	1.28	1.01	0.74	0.65	4.87	2,077
1985	40.64	11.02	5.45	3.80	2.83	2.36	2.23	2.08	1.64	1.12	0.71	0.09	0.00	0.00	3.25	1,474
1986	64.33	19.12	11.24	8.23	5.68	4.17	3.84	3.55	3.01	2.35	1.95	1.43	1.26	1.21	6.37	2,136
1987	77.52	25.91	15.33	10.52	5.90	4.25	3.92	3.57	2.78	1.66	0.49	0.00	0.00	0.00	7.78	2,386
1988	64.33	29.53	17.72	13.64	10.12	7.37	5.55	5.05	4.20	3.32	2.44	1.60	1.37	1.34	9.68	2,881
1989	103.96	32.66	17.87	14.02	11.80	9.96	9.44	8.54	6.55	5.38	4.14	3.20	3.08	3.05	12.34	3,181
1990	83.92	18.89	12.85	9.78	7.67	6.25	5.59	5.15	4.24	3.33	2.40	1.43	1.25	1.14	7.94	2,235
Average	69.63	21.02	13.21	9.61	7.06	5.53	4.88	4.39	3.49	2.62	1.79	1.18	1.02	0.98	7.39	2,282

Table I.6.4 (3/3) FLOW REGIME CALCULATED BY TANK MODEL SIMULATION BLORONG RIVER : PUCUNG (C.A=157.0km2)

Year	Flow Regime (m3/s)														Annual Rainfall (mm)
	Maximum	5%	15%	25%	35%	45%	50%	55%	65%	75%	85%	95%	99%	Minimum	Mean	
1961	74.06	19.32	12.48	9.41	6.79	5.10	4.69	4.35	3.55	2.83	2.23	1.71	1.64	1.63	7.27	2,138
1962	72.54	20.39	14.42	12.38	9.89	7.93	7.21	6.65	5.03	4.17	3.50	2.95	2.87	2.81	9.12	3,233
1963	143.19	16.91	11.74	9.25	7.25	5.42	4.63	4.30	3.58	2.78	2.08	1.78	1.73	1.68	7.05	2,050
1964	56.60	15.84	10.15	7.29	5.63	4.49	4.08	3.75	2.93	2.67	2.24	1.87	1.70	1.61	5.97	2,441
1965	48.59	17.51	9.80	6.46	4.66	3.48	3.17	2.94	2.40	1.69	0.96	0.36	0.15	0.09	5.31	1,698
1966	33.85	15.12	10.20	7.92	5.90	4.39	3.47	2.95	2.45	1.86	1.31	0.78	0.69	0.69	5.38	2,301
1967	48.98	17.19	12.06	9.07	6.89	4.71	3.70	3.38	2.75	1.96	1.35	0.75	0.60	0.60	6.39	2,439
1968	60.64	24.01	16.67	12.99	10.87	9.06	8.13	7.48	6.19	5.00	4.27	3.47	3.12	3.03	10.25	3,519
1969	61.53	20.05	14.71	11.10	8.24	5.80	5.41	5.05	4.46	3.92	3.10	2.55	2.25	2.20	8.18	2,376
1970	58.74	24.09	16.45	13.23	9.19	6.90	6.02	5.17	4.62	3.78	2.99	2.36	2.25	2.24	9.11	3,040
1971	44.79	18.72	14.35	11.80	10.14	8.70	7.97	7.47	6.29	4.81	4.08	3.23	2.86	2.78	9.20	2,971
1972	35.95	19.42	13.14	9.13	6.58	5.06	4.69	4.30	3.56	2.90	2.07	1.50	1.40	1.39	6.88	1,925
1973	50.54	17.42	11.70	9.39	7.74	6.51	5.98	5.45	4.61	3.62	2.97	2.45	2.33	2.28	7.30	2,786
1974	53.58	16.63	12.13	9.87	8.51	7.26	6.72	6.18	5.12	4.30	3.89	3.56	3.41	2.93	8.01	2,930
1975	37.89	15.82	11.79	9.70	8.27	7.12	6.76	6.44	5.66	4.53	4.02	3.41	3.21	3.18	7.81	2,529
1976	30.75	12.53	8.84	7.66	6.56	5.41	4.43	4.09	3.33	2.47	1.86	1.44	1.39	1.38	5.49	1,736
1977	23.62	10.44	7.14	5.75	4.65	2.94	2.77	2.65	2.37	1.67	0.96	0.43	0.30	0.25	3.98	1,577
1978	31.72	12.57	8.39	6.45	5.23	4.55	4.16	3.86	3.31	2.87	2.39	2.23	2.18	2.14	5.32	2,517
1979	47.45	16.95	12.71	10.16	8.24	6.81	6.17	5.51	4.30	3.81	3.21	2.71	2.51	2.43	7.82	2,732
1980	56.61	17.51	12.31	10.22	8.66	7.23	6.29	5.70	4.30	3.80	3.17	2.45	2.32	2.24	7.79	2,648
1981	61.62	18.28	14.06	12.21	10.47	8.68	7.87	7.25	5.67	4.76	4.25	3.70	3.55	3.50	9.29	3,071
1982	58.99	18.96	13.86	10.78	8.04	5.49	5.14	4.79	3.99	3.19	2.39	1.68	1.60	1.59	7.69	2,125
1983	47.60	20.23	13.79	10.95	9.19	7.46	6.51	5.61	4.03	3.26	2.59	1.84	1.61	1.57	8.11	2,802
1984	35.72	18.75	14.69	10.53	8.24	6.95	6.22	5.45	4.17	3.63	3.20	2.97	2.89	2.85	8.06	2,877
1985	49.63	19.15	14.63	12.16	10.21	8.76	8.05	7.11	5.38	4.88	4.26	3.45	3.16	3.07	9.21	2,904
1986	49.61	19.82	15.71	12.29	9.89	8.05	7.16	6.60	5.66	5.04	4.28	3.77	3.60	3.51	9.35	3,021
1987	69.31	19.16	14.41	11.02	8.80	6.73	5.75	4.93	4.22	3.35	2.54	1.97	1.86	1.84	7.95	2,338
1988	42.90	14.35	10.51	8.01	5.78	4.30	4.00	3.79	3.35	2.81	2.17	1.44	1.15	1.07	6.00	2,043
1989	72.48	16.78	11.80	9.25	7.43	6.30	5.62	5.10	3.92	3.52	2.97	2.42	2.28	2.27	7.30	2,705
1990	88.15	24.09	12.09	8.95	6.43	4.47	4.16	3.90	3.19	2.48	1.95	1.36	1.30	1.30	7.72	2,433
Average	54.92	17.93	12.56	9.85	7.81	6.20	5.56	5.07	4.15	3.41	2.78	2.22	2.06	2.00	7.48	2,530

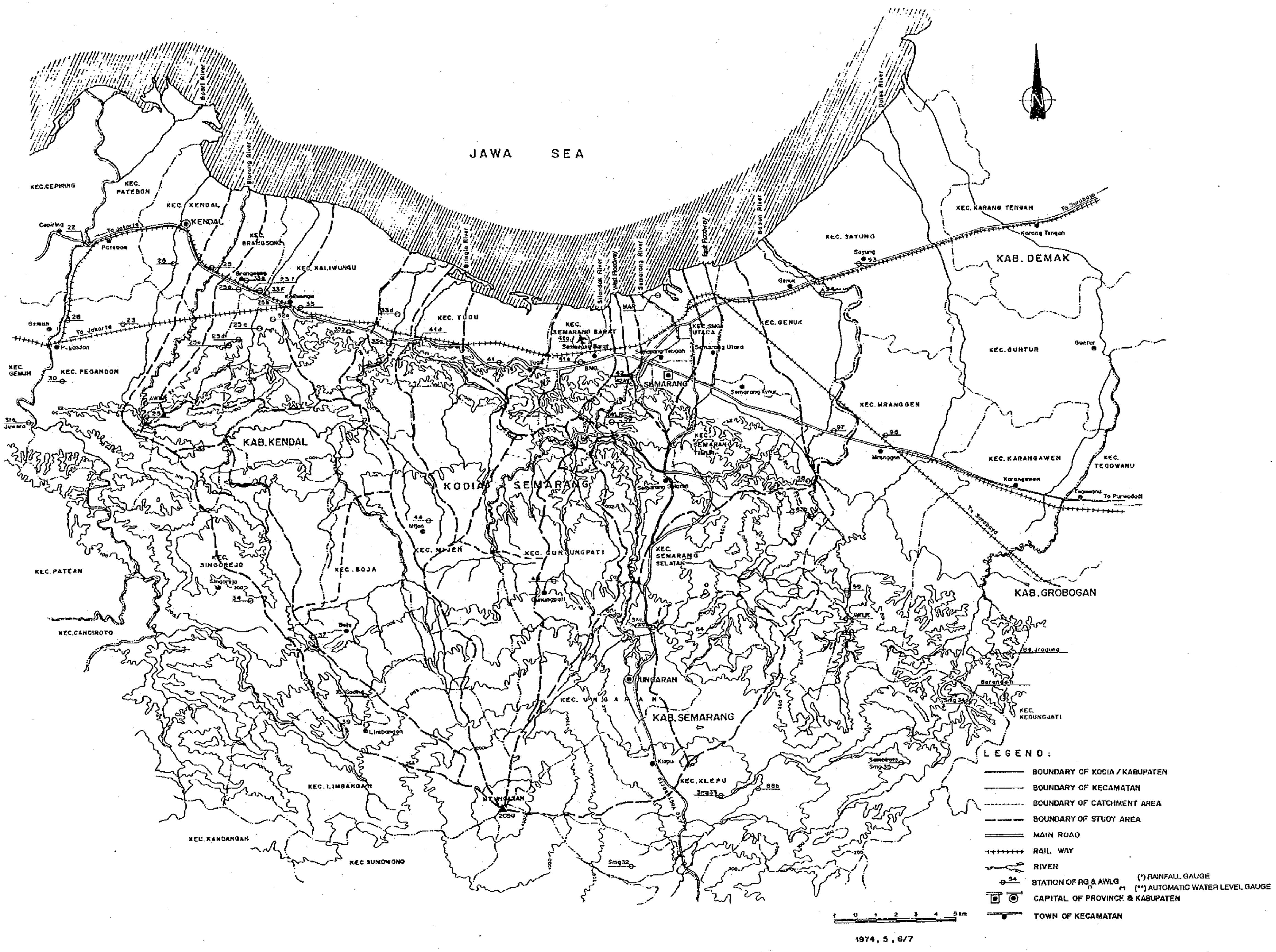
Table I.7.1 MONTHLY AND ANNUAL TIDAL LEVEL OBSERVED AT SEMARANG HARBOR

(Unit: EL.m)

	Year: 1989			Year: 1990			Year: 1991			Year: 1992		
	HWL	LWL	MSL	HWL	LWL	MSL	HWL	LWL	MSL	HWL	LWL	MSL
Jan.	0.56	-0.47	0.00	0.54	-0.50	0.04	0.59	-0.39	0.03	0.50	-0.30	0.06
Feb.	0.49	-0.40	-0.04	0.52	-0.30	0.07	0.56	-0.27	0.07	0.52	-0.34	0.04
Mar.	0.56	-0.42	0.00	0.50	-0.36	-0.01	0.68	-0.30	0.14	0.60	-0.31	0.09
Apr.	0.54	-0.58	0.00	0.69	-0.40	0.09	0.67	-0.39	0.11	0.65	-0.36	0.12
May	0.68	-0.48	0.10	0.68	-0.38	0.10	0.71	-0.42	0.19			
Jun.	0.62	-0.35	0.14	0.63	-0.40	0.14	0.65	-0.36	0.13			
Jul.	0.60	-0.44	0.11	0.56	-0.37	0.09	0.62	-0.44	0.08			
Aug.	0.55	-0.37	0.08	0.56	-0.37	0.10	0.52	-0.33	0.04			
Sep.	0.56	-0.38	0.06	0.56	-0.31	0.09	0.48	-0.34	0.03			
Oct.	0.62	-0.46	0.05	0.58	-0.39	0.07	0.59	-0.38	0.08			
Nov.	0.69	-0.46	0.08	0.60	-0.46	0.07	0.62	-0.44	0.08			
Dec.	0.61	-0.43	0.06	0.59	-0.42	0.03	0.65	-0.42	0.10			
Ave.	0.59	-0.44	0.05	0.58	-0.39	0.07	0.61	-0.37	0.09	0.57	-0.33	0.08
Annual Max. & Min.	0.69	-0.58		0.69	-0.50		0.71	-0.44		0.65	-0.36	0.08

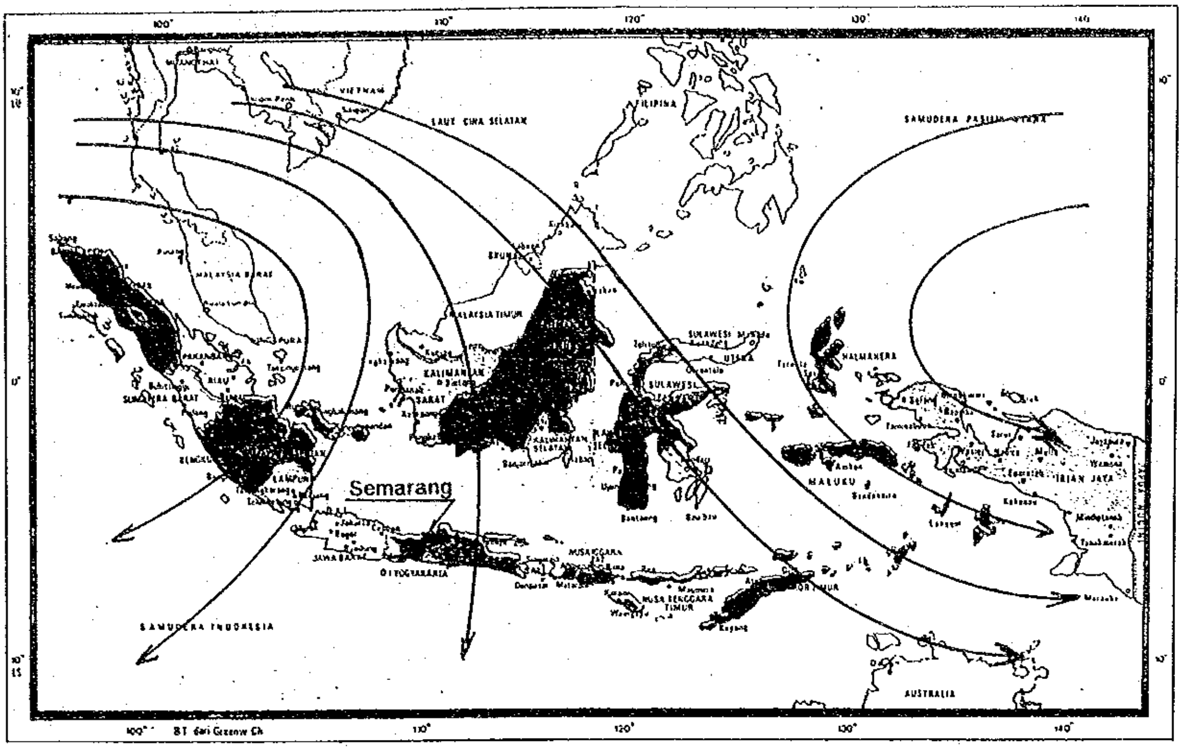
Note: (1) HWL: Monthly and annual highest tidal level.
(2) LWL: Monthly and annual lowest tidal level.
(3) MSL: Monthly and annual average tidal level.
(4) All tidal levels are presented as the elevation above MSL observed at Jakarta Harbour (Tanjung Priok) in 1925.

FIGURES

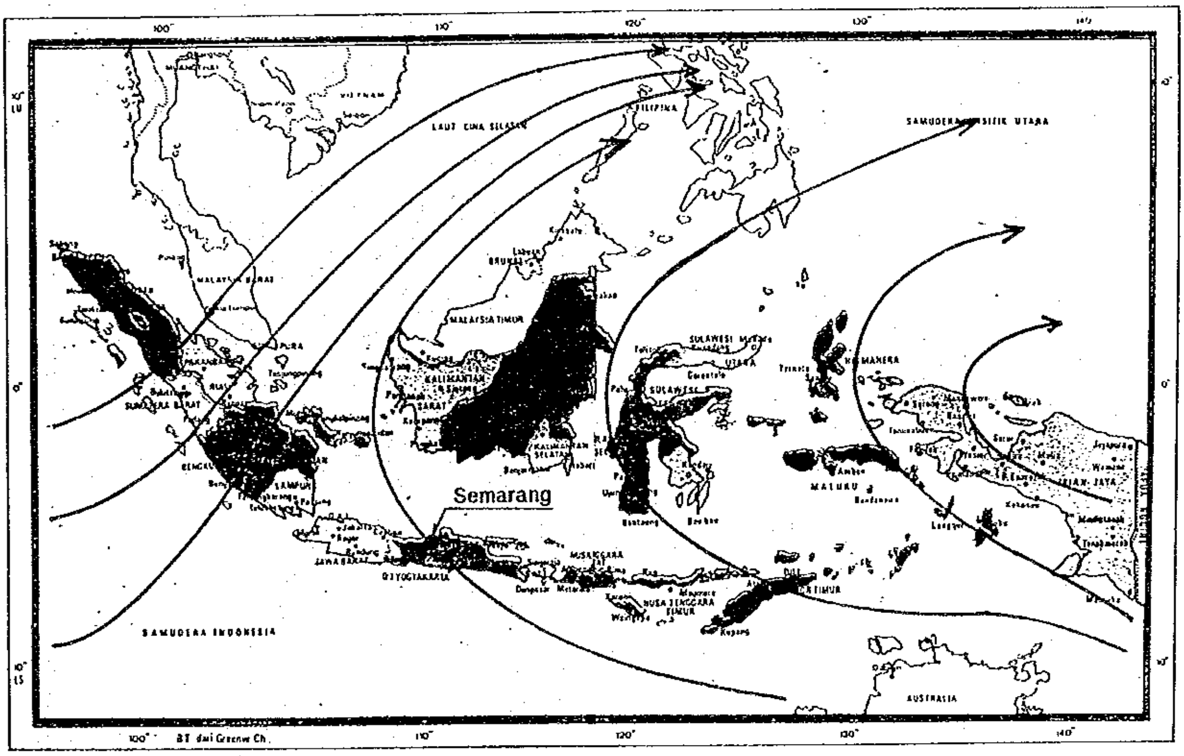


MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.1.1 LOCATION MAP OF METEOROLOGICAL AND WATER LEVEL GAUGING STATION
JAPAN INTERNATIONAL COOPERATION AGENCY	

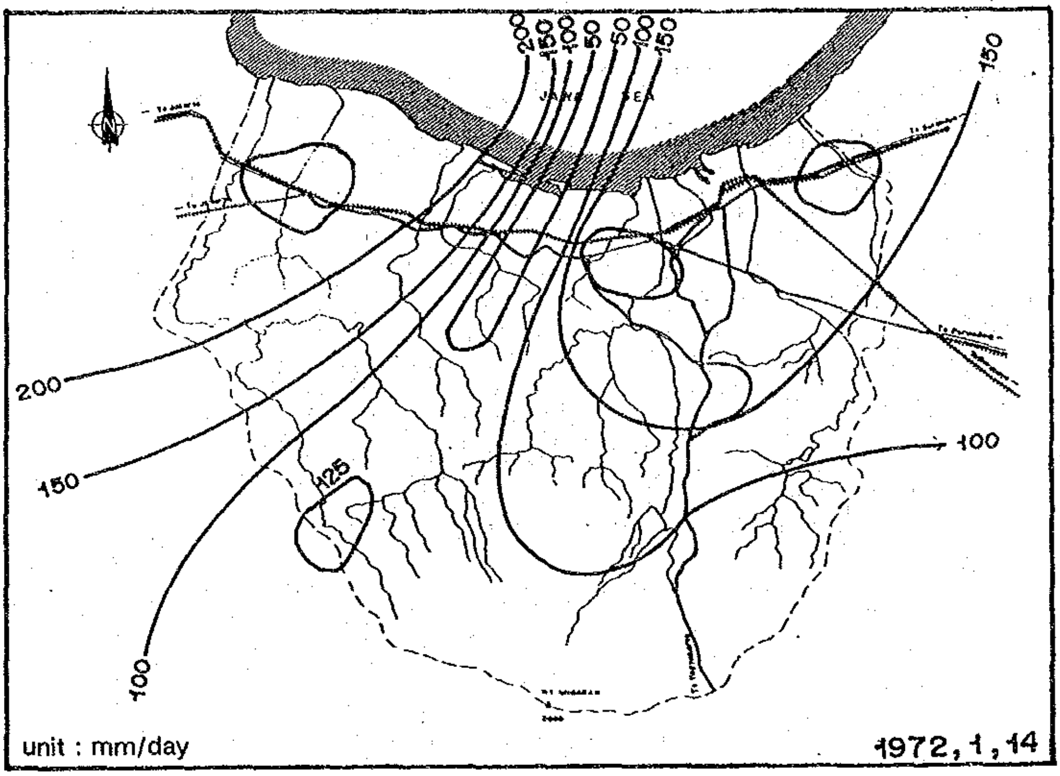
RAINY SEASON (NOVEMBER - APRIL)

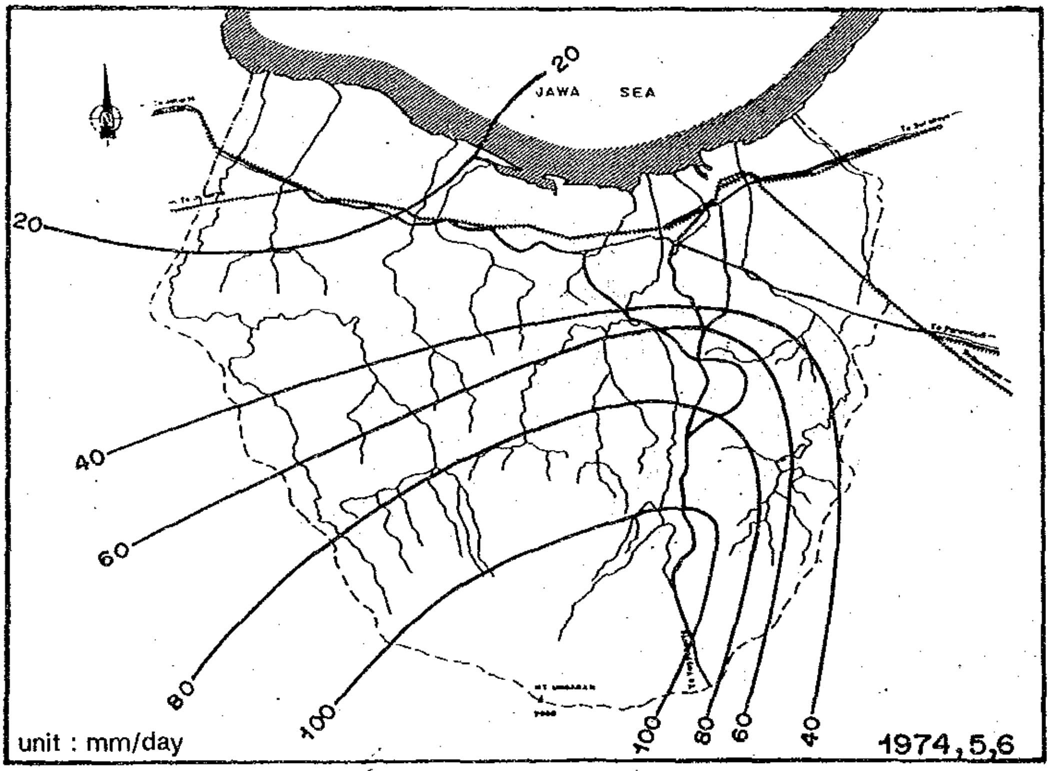


DRY SEASON (MAY - OCTOBER)

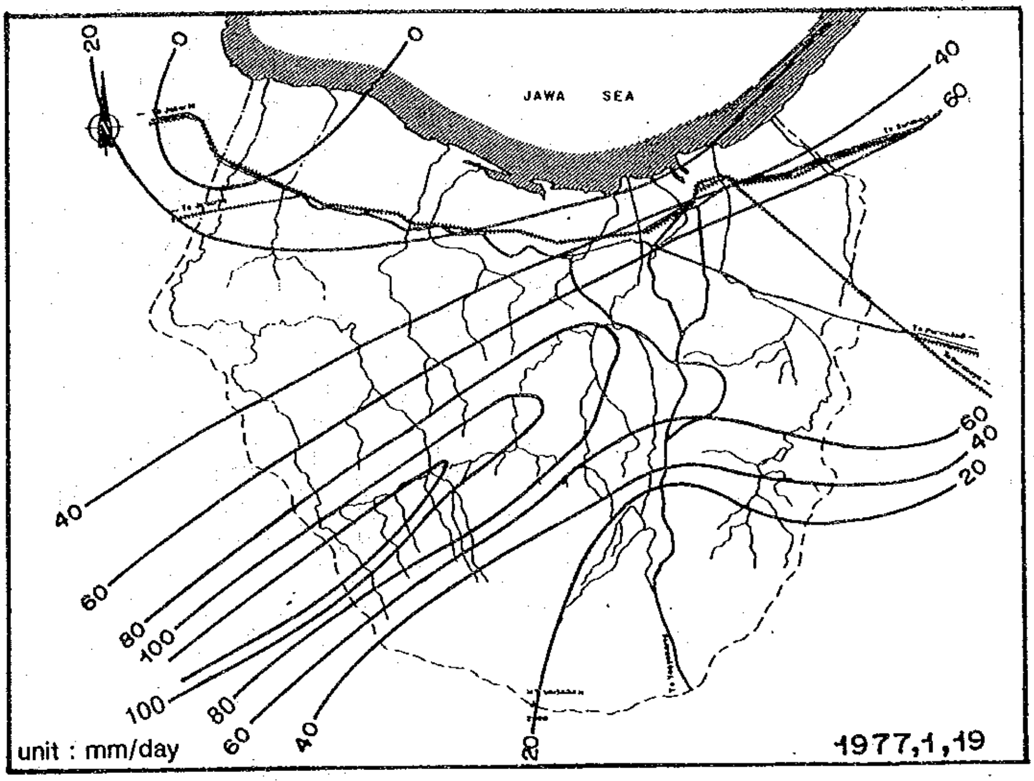


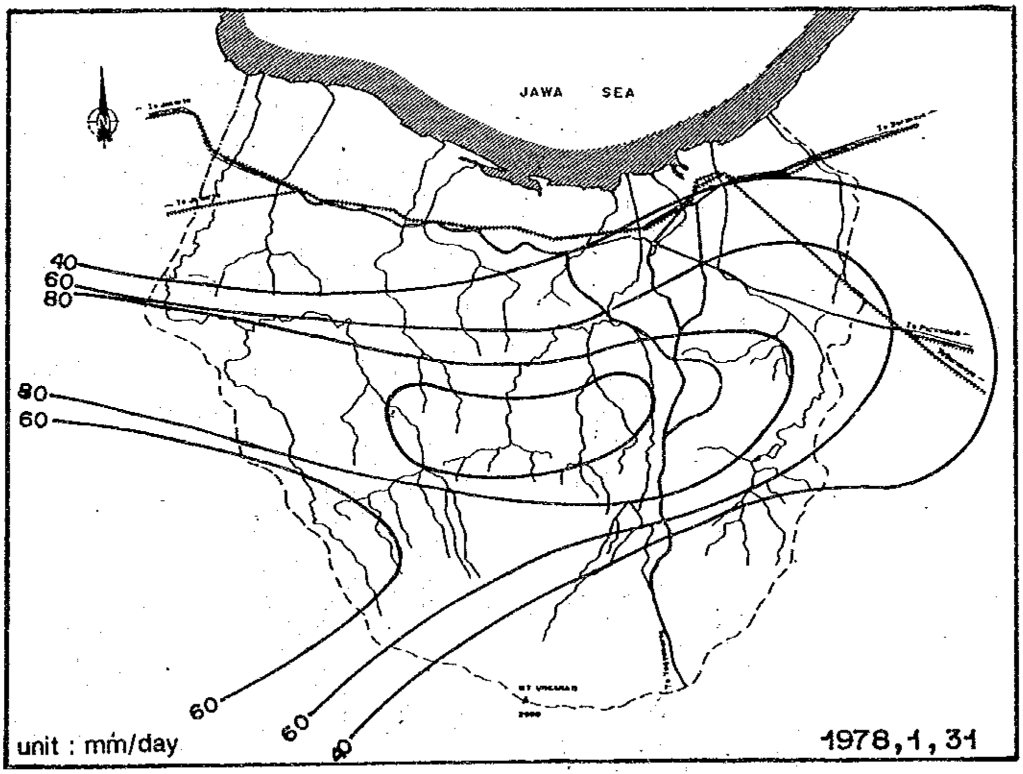
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.1.2 DIRECTION OF TRADE WIND
JAPAN INTERNATIONAL COOPERATION AGENCY	



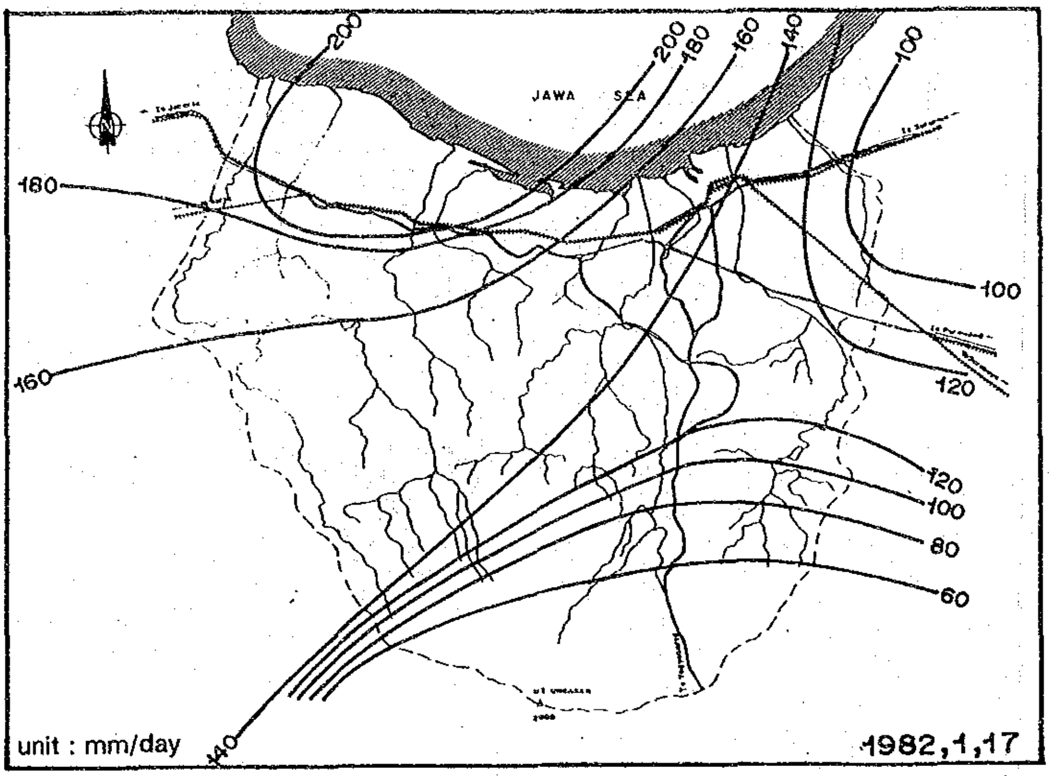


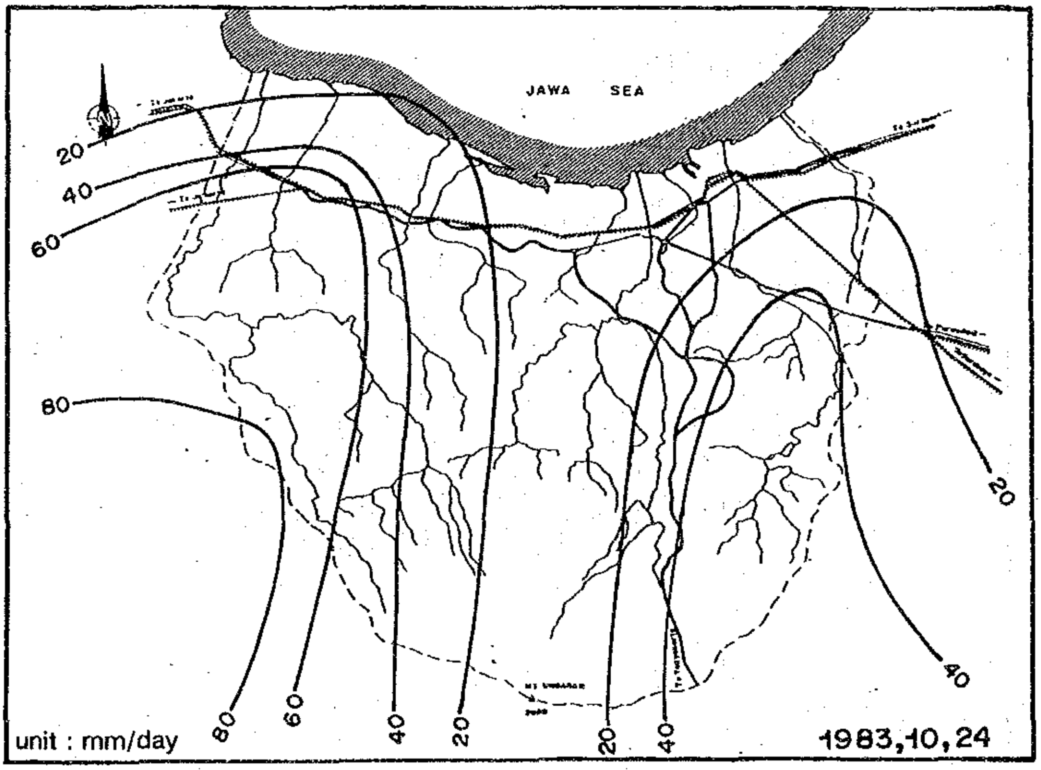
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.2.1 (1/4) ISOHYETAL MAPS OF DAILY RAINFALL FOR MAJOR RAINFALL
JAPAN INTERNATIONAL COOPERATION AGENCY	



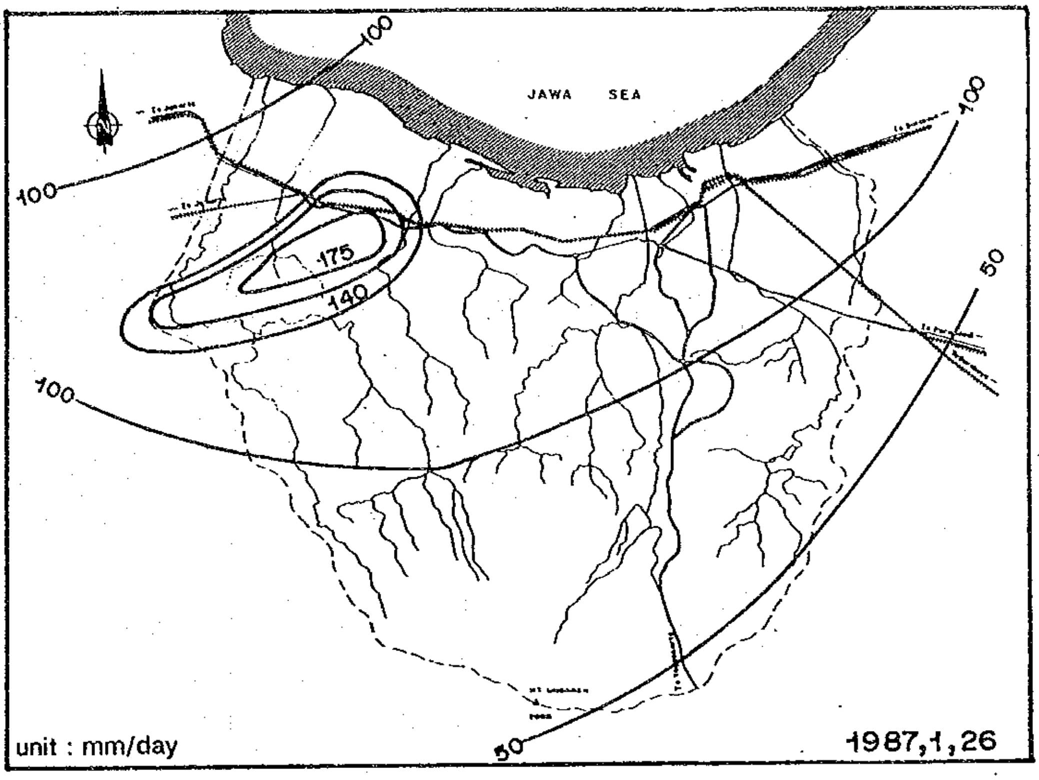


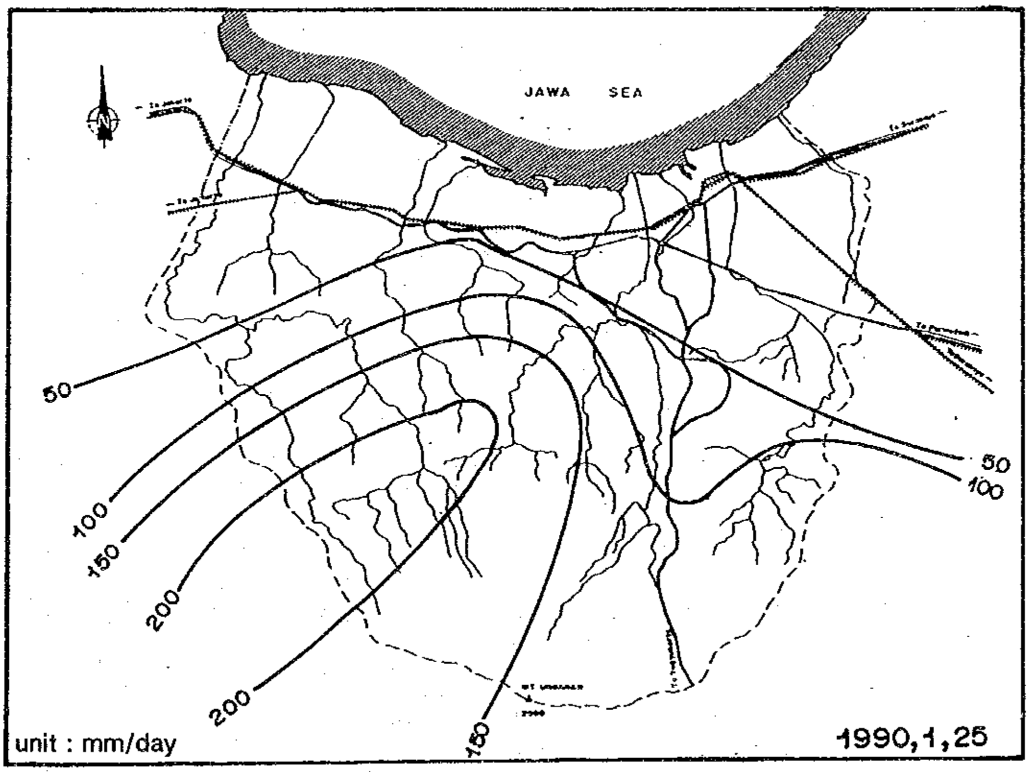
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. I.2.1 (2/4) ISOHYETAL MAPS OF DAILY RAINFALL FOR MAJOR RAINFALL



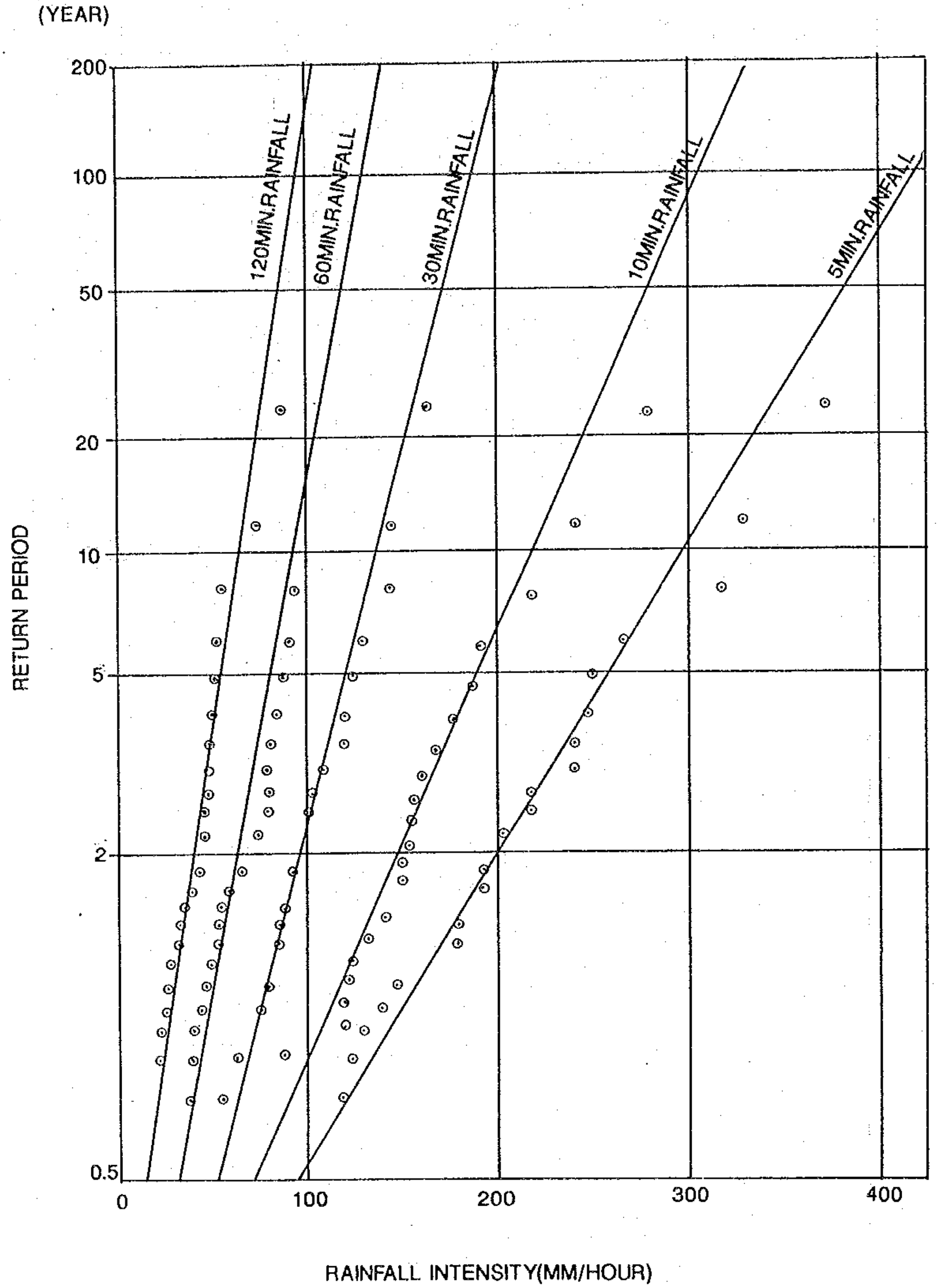


MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. I.2.1 (3/4) ISOHYETAL MAPS OF DAILY RAINFALL FOR MAJOR RAINFALL

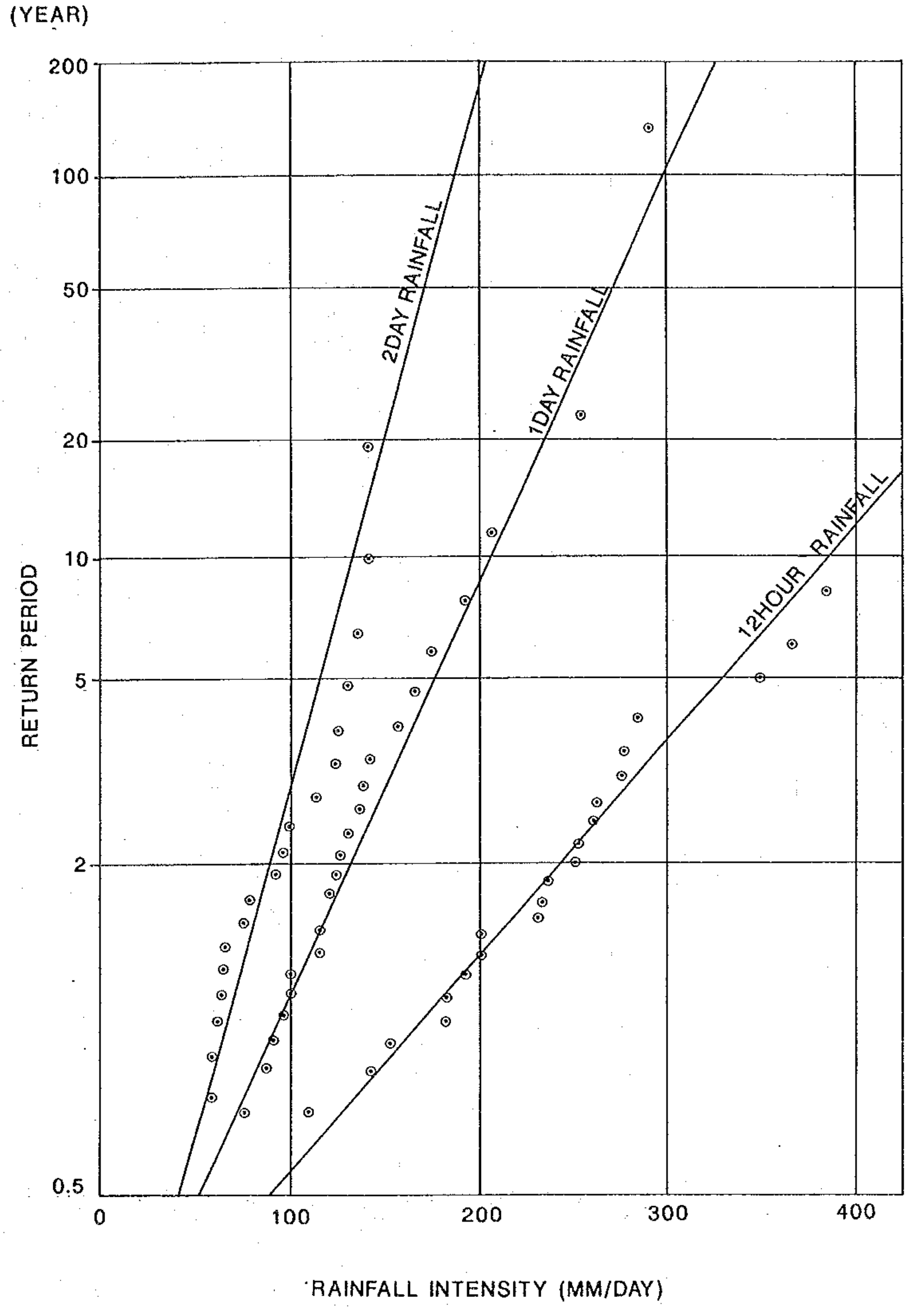




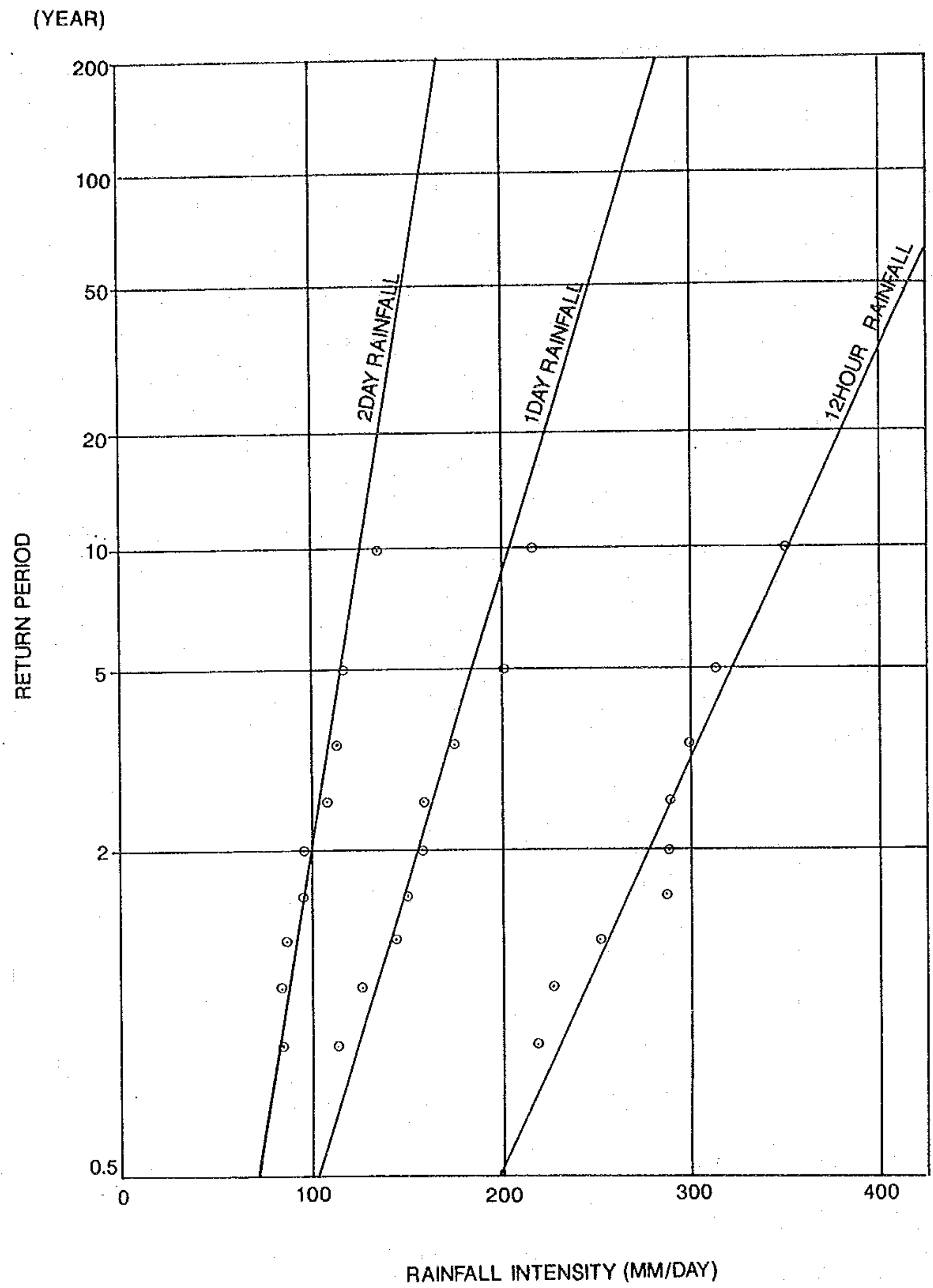
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.2.1 (4/4) ISOHYETAL MAPS OF DAILY RAINFALL FOR MAJOR RAINFALL
JAPAN INTERNATIONAL COOPERATION AGENCY	



MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.3.1 (1/3) PROBABLE POINT RAINFALL INTENSITIES (SHORT DURATION AT SEMARANG METEOROLOGICAL STATION)
JAPAN INTERNATIONAL COOPERATION AGENCY	

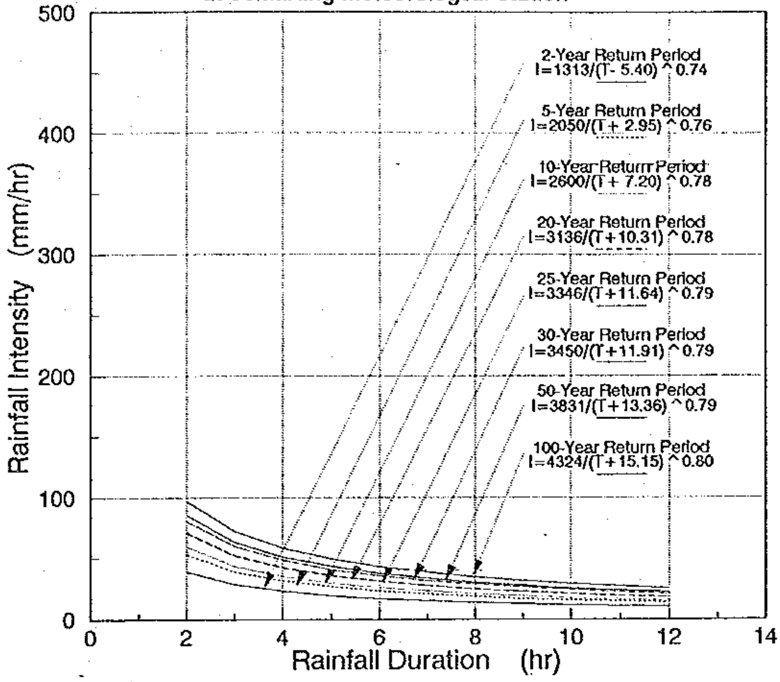


MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.3.1 (2/3) PROBABLE POINT RAINFALL INTENSITIES (LONG DURATION AT SEMARANG METEOROLOGICAL STATION)
JAPAN INTERNATIONAL COOPERATION AGENCY	

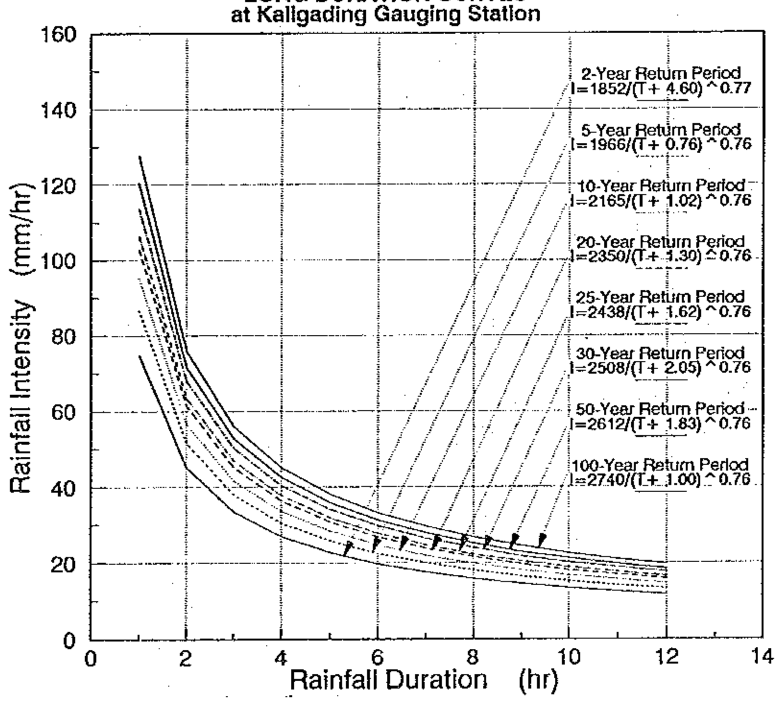


MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.3.1 (3/3) PROBABLE POINT RAINFALL INTENSITIES (LONG DURATION AT KALIGADING GAUGING STATION)
JAPAN INTERNATIONAL COOPERATION AGENCY	

RAINFALL INTENSITY-DURATION CURVE
LONG DURATION CURVES
at Semarang Meteorologcal Station

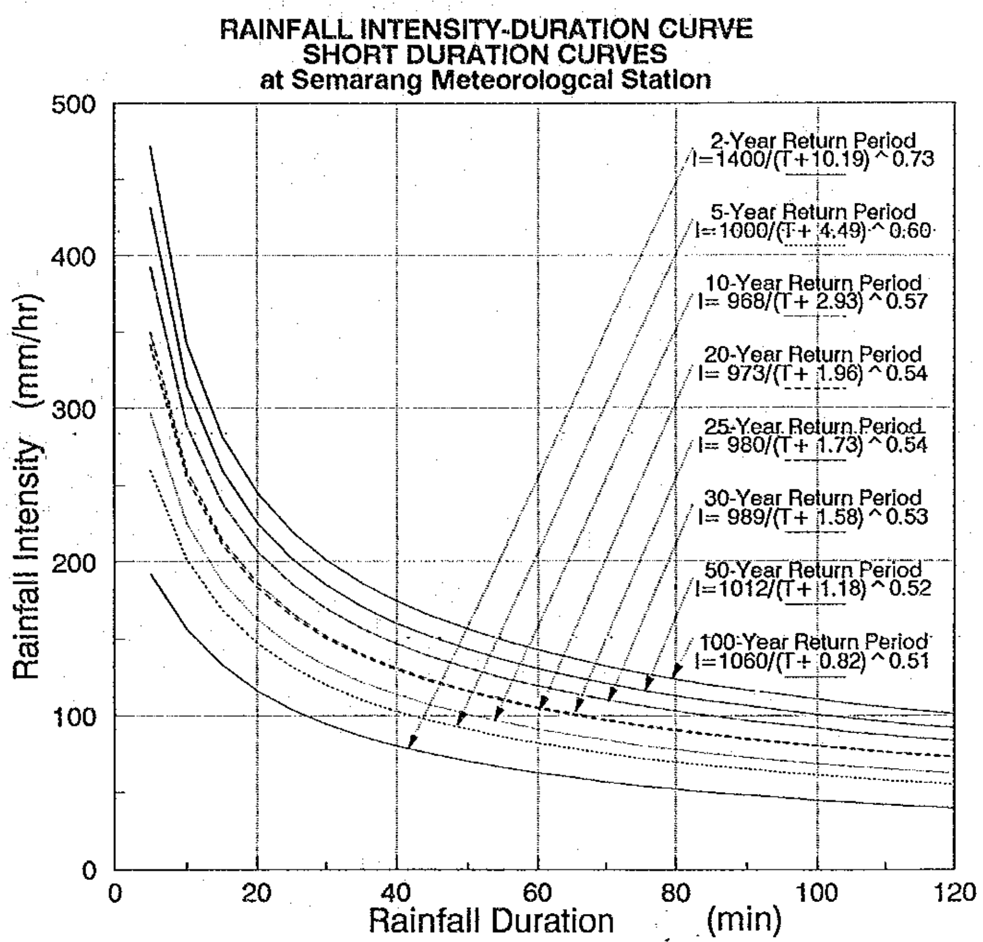


RAINFALL INTENSITY-DURATION CURVE
LONG DURATION CURVES
at Kaligading Gauging Station



Note : Horner Type Equation

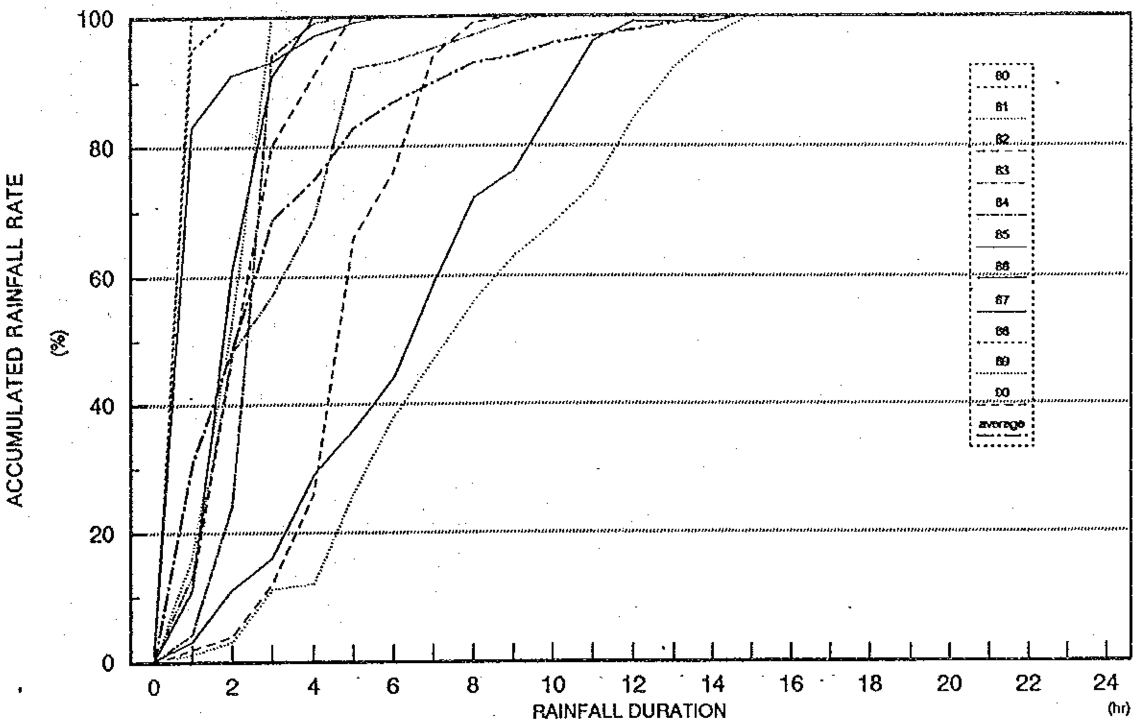
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. I.3.2 (1/2) RAINFALL INTENSITY-DURATION CURVE (LONG DURATION)



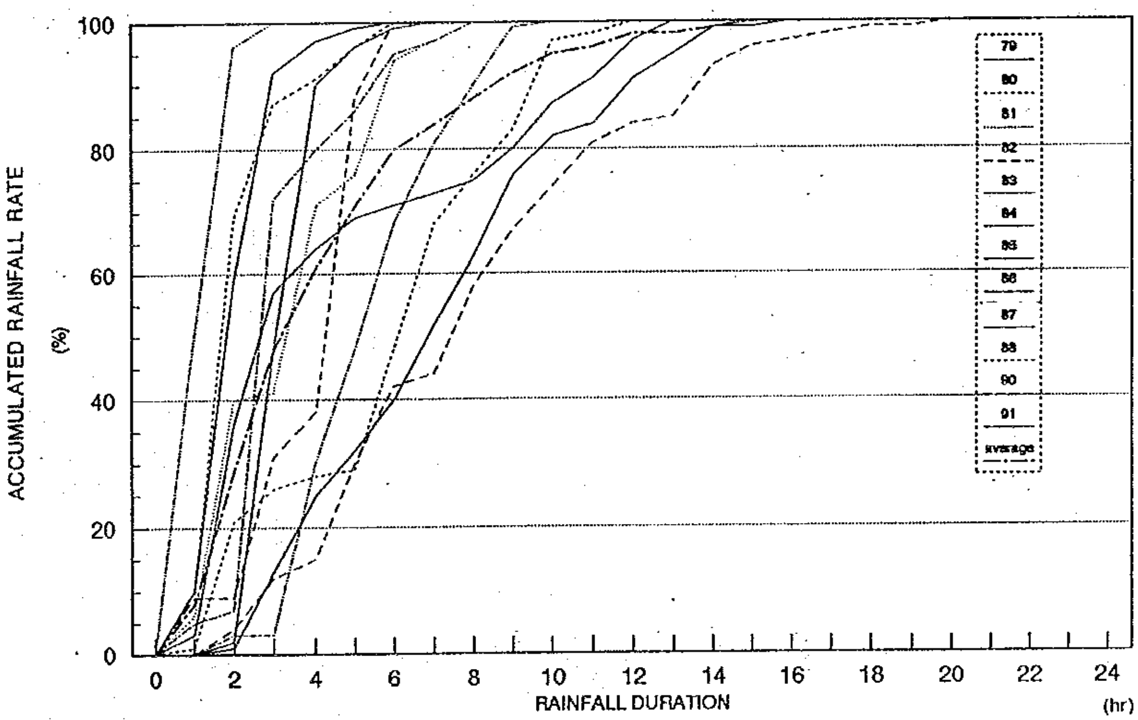
Note : Horner Type Equation

MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.3.2 (2/2) RAINFALL INTENSITY-DURATION CURVE (SHORT DURATION)
JAPAN INTERNATIONAL COOPERATION AGENCY	

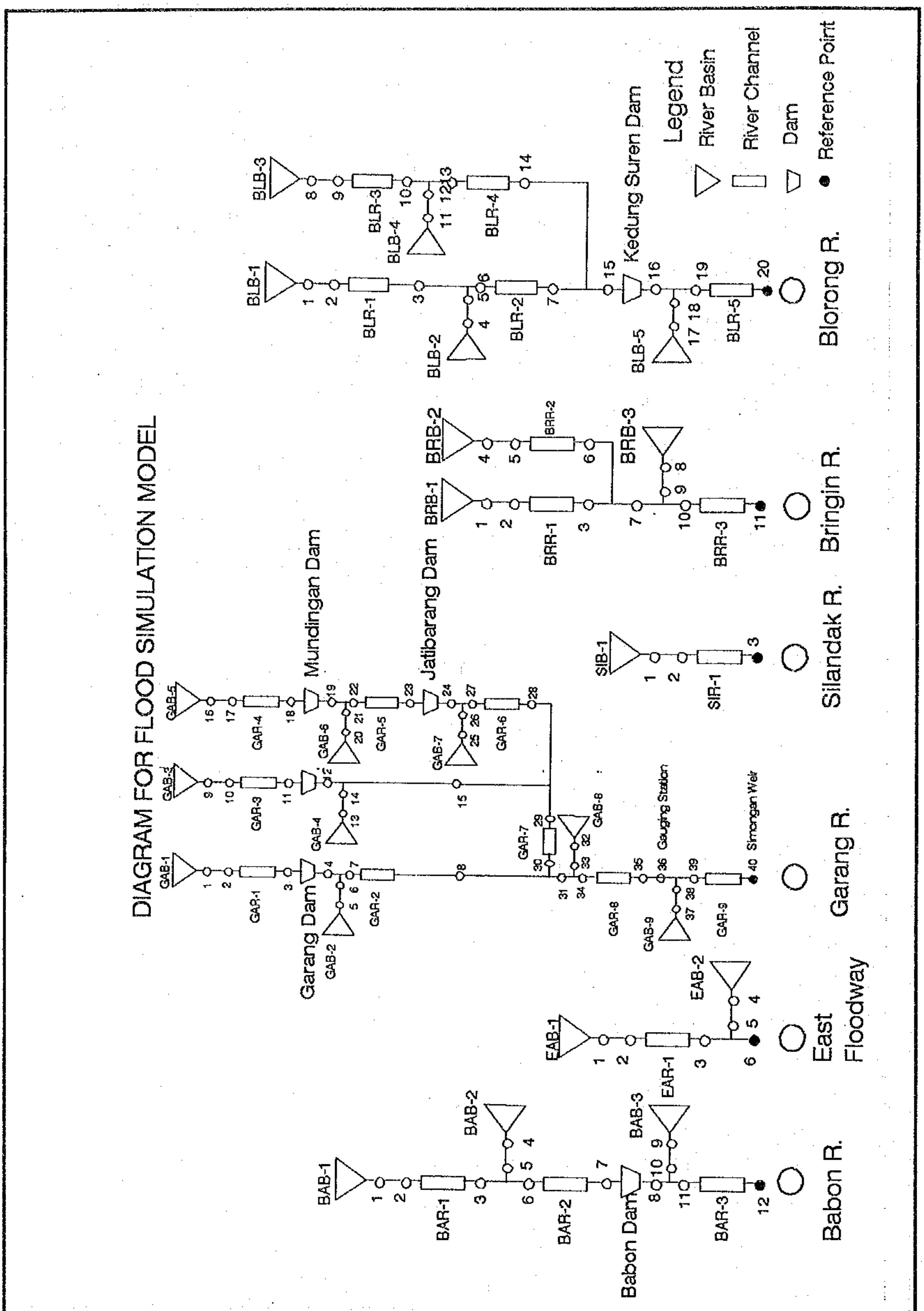
KALIGADING AUTOMATIC RAINFALL GAUGING STATION



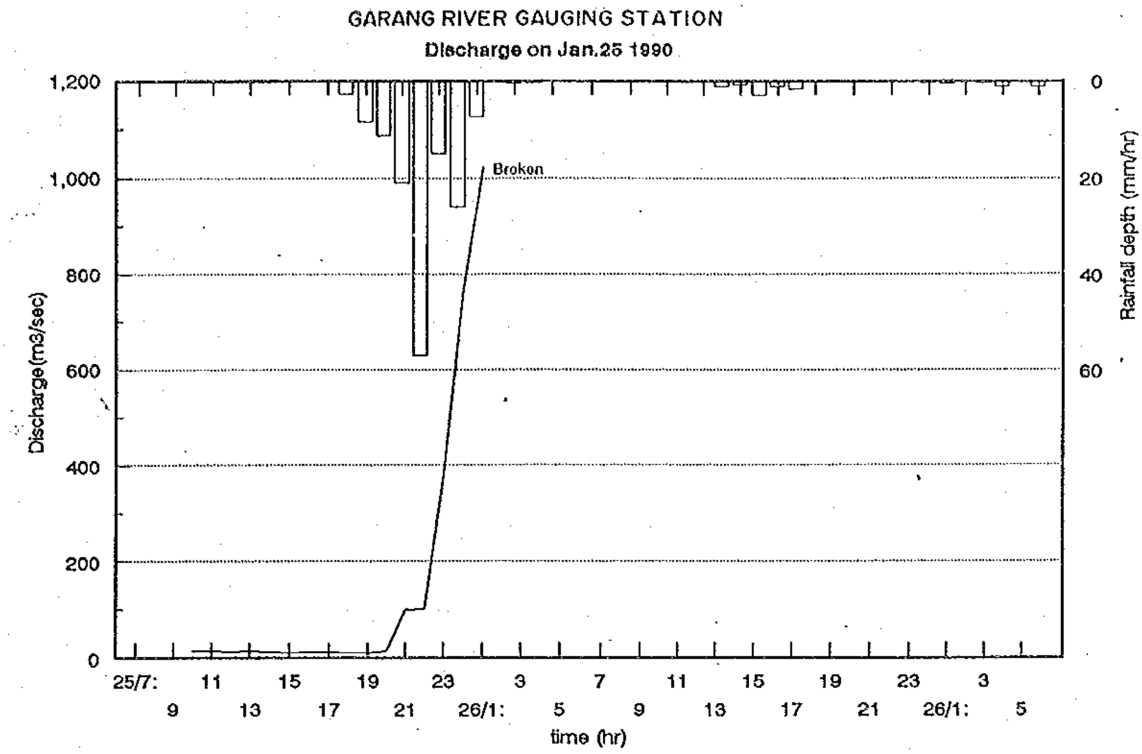
SEMARANG METEOROLOGICAL STATION

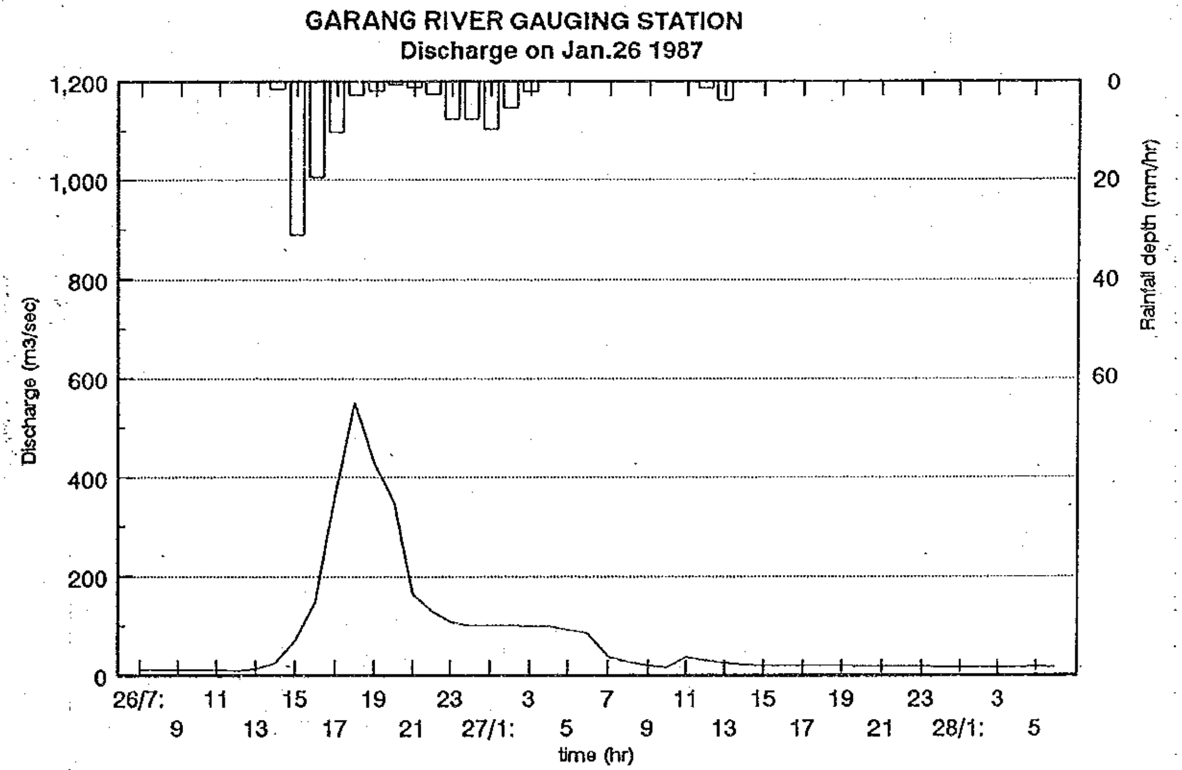


MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.3.3 RAINFALL DURATION AND ACCUMULATED RAINFALL RATE OF ANNUAL MAXIMUM RAINFALL
JAPAN INTERNATIONAL COOPERATION AGENCY	



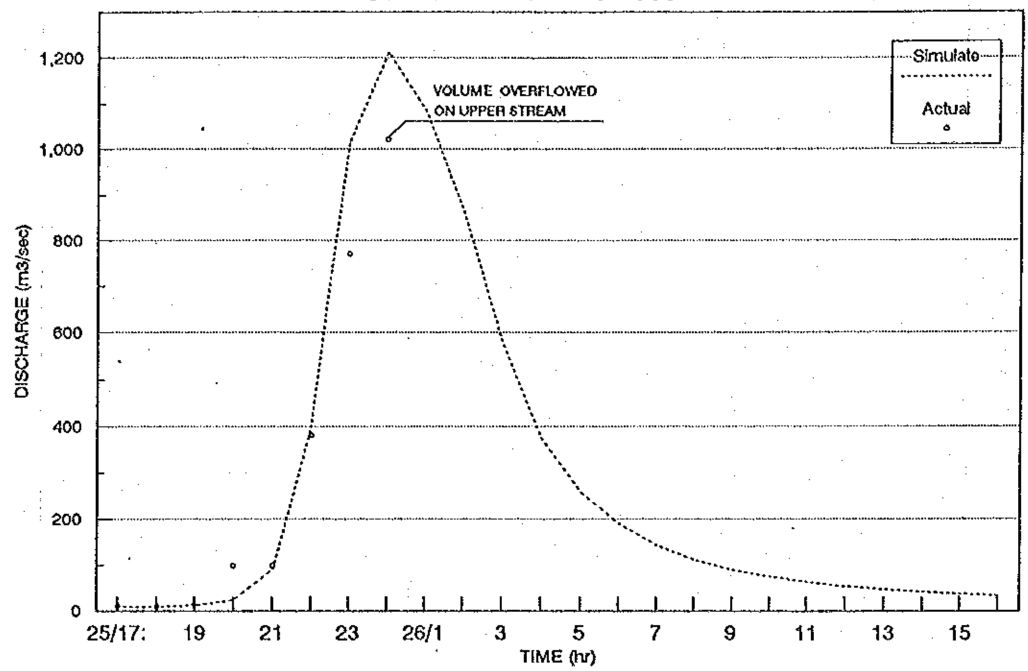
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.4.1 MODEL DIAGRAM FOR STORAGE FUNCTION MODEL SIMULATION
JAPAN INTERNATIONAL COOPERATION AGENCY	



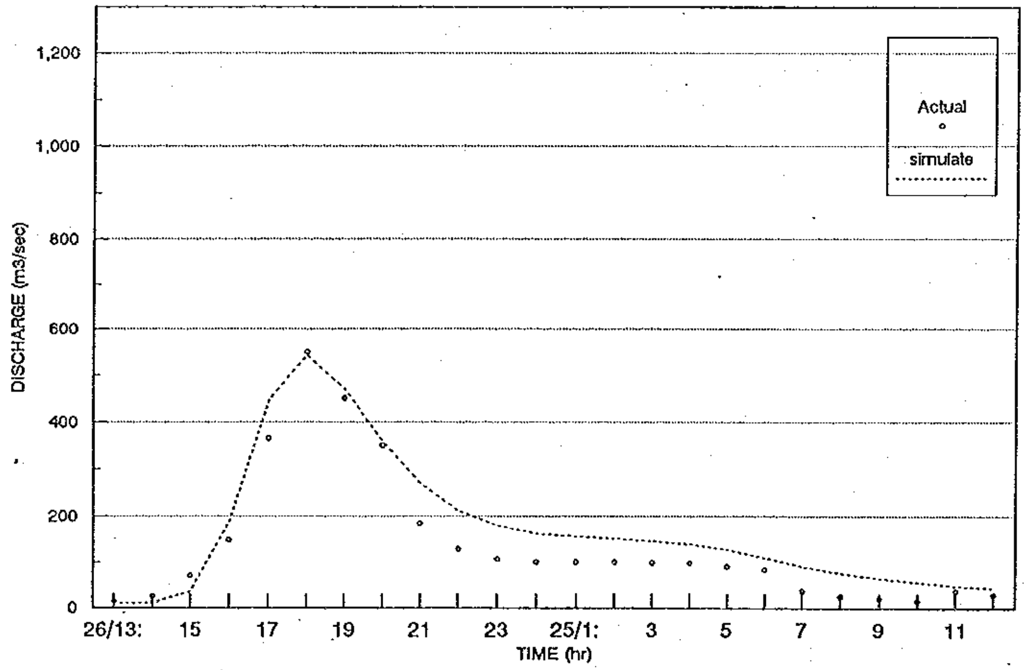


MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.4.2 AVAILABLE ACTUAL HYDROGRAPH AND HYETOGRAPH FOR SIMULATION
JAPAN INTERNATIONAL COOPERATION AGENCY	

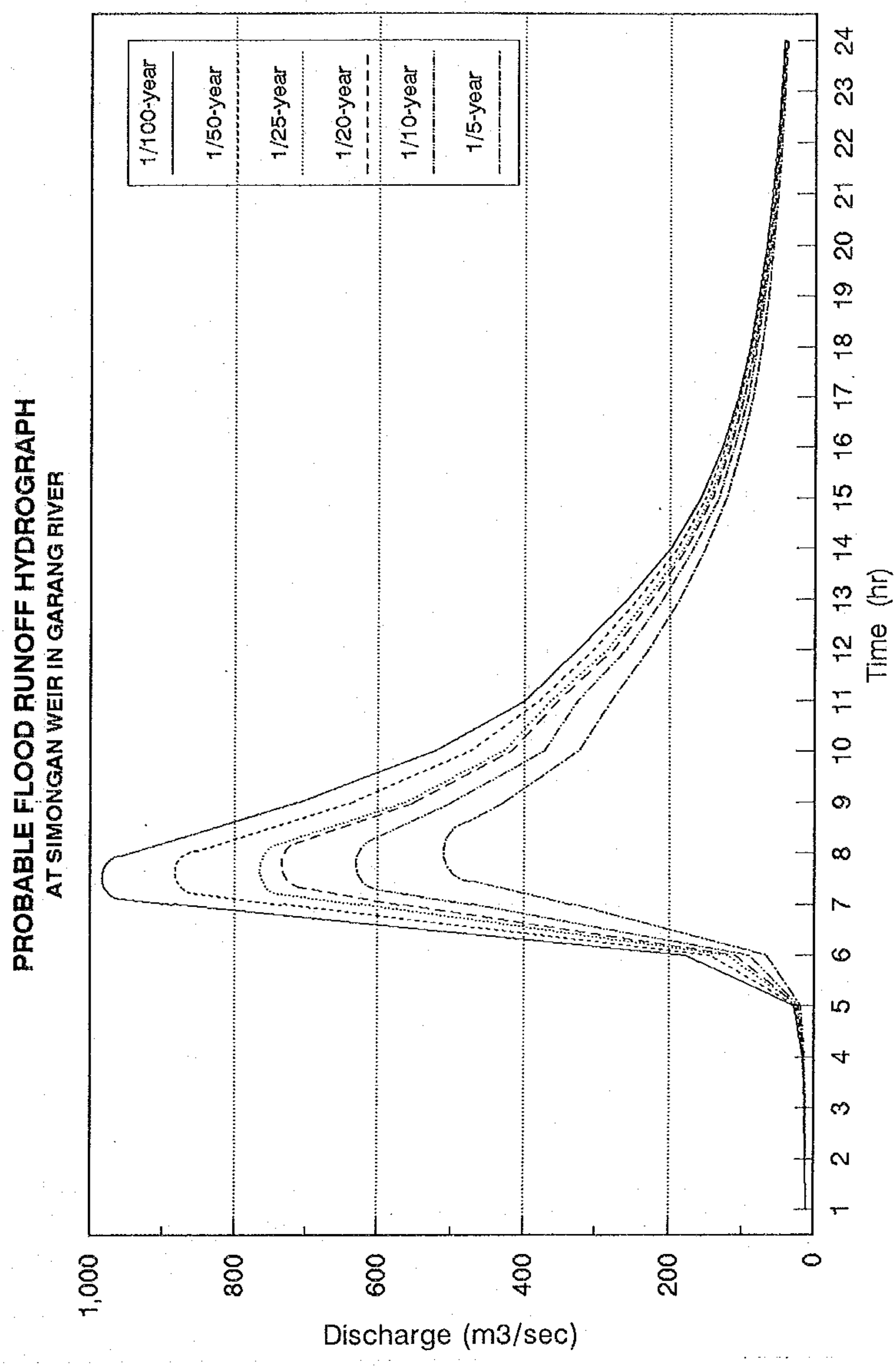
SIMULATED FLOOD OF THE GARANG RIVER GAUGING STATION ON JAN.25 1990



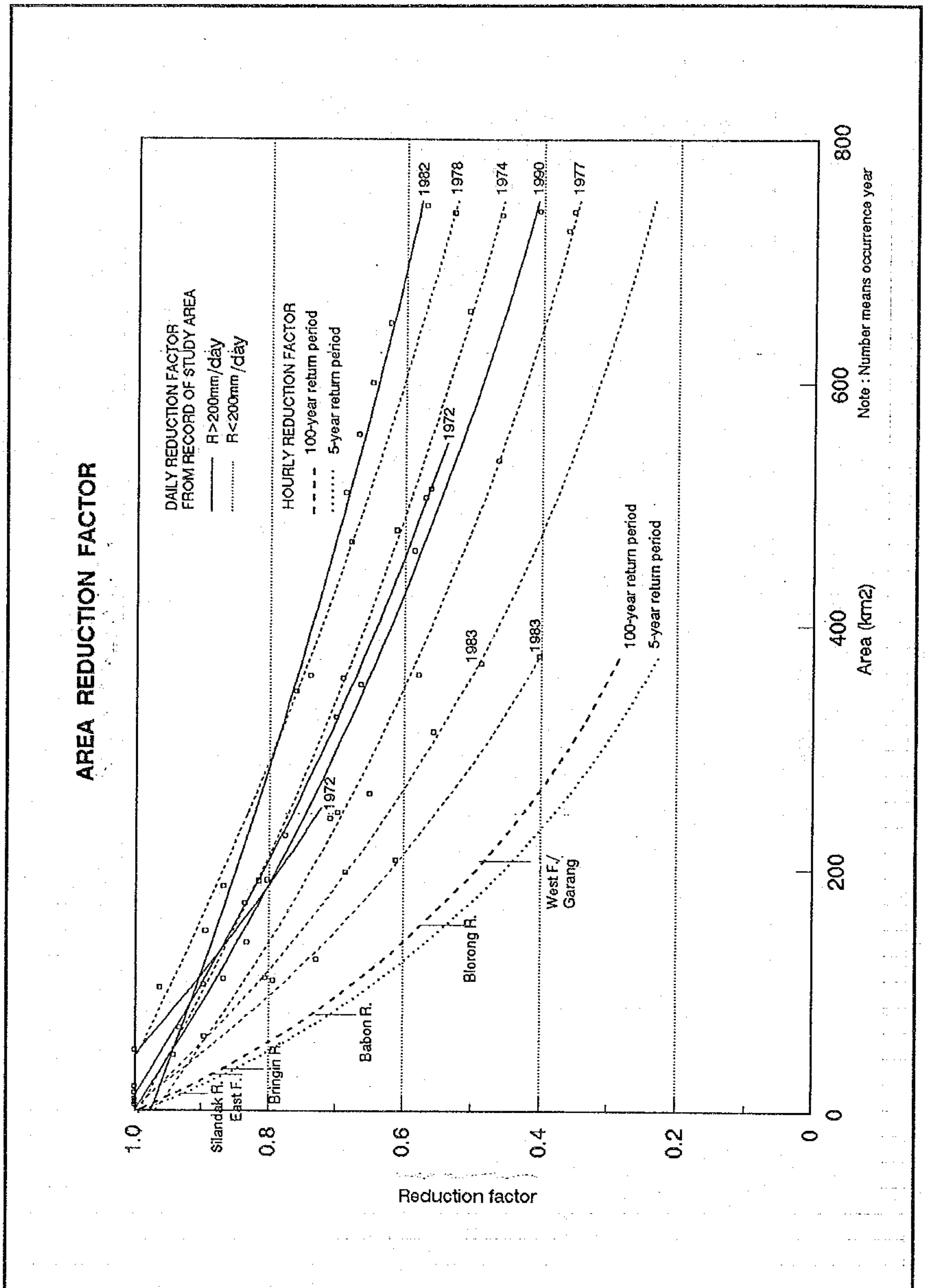
SIMULATED FLOOD OF THE GARANG RIVER GAUGING STATION ON JAN.26 1987



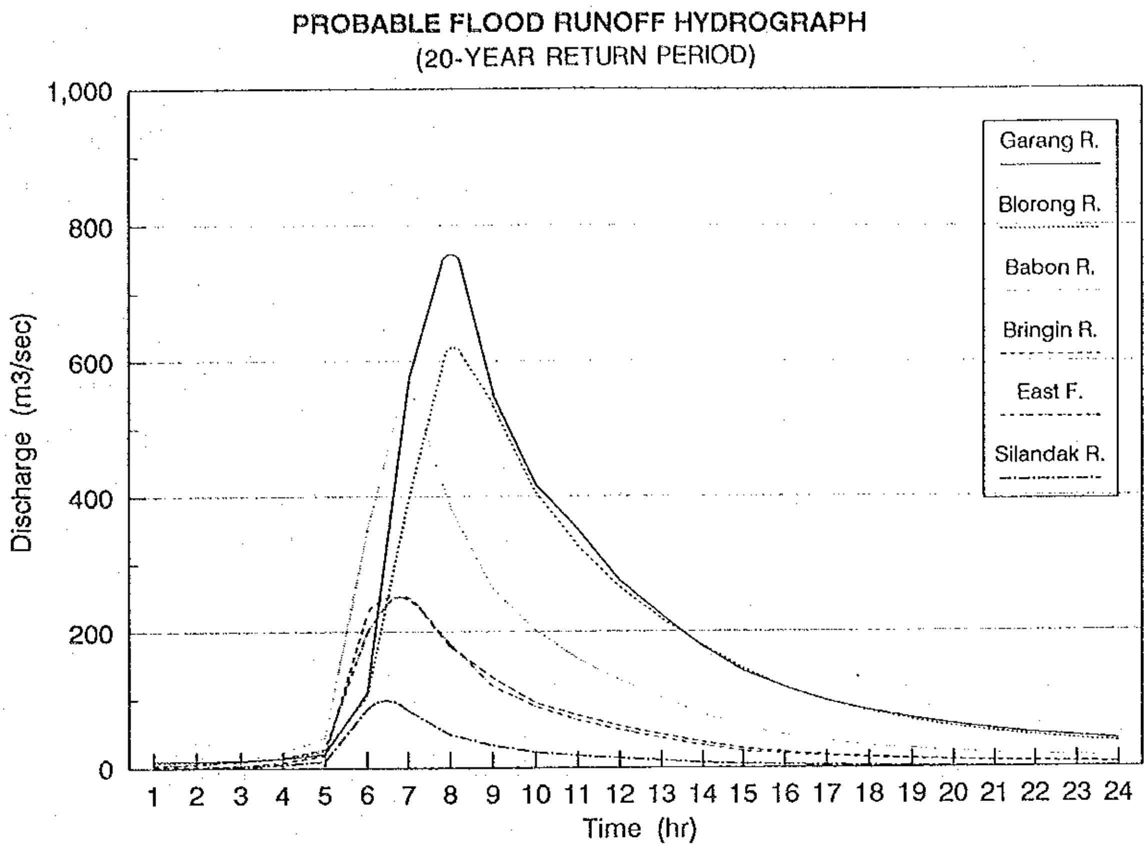
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.4.3
JAPAN INTERNATIONAL COOPERATION AGENCY	SIMULATED FLOOD OF THE GARANG RIVER GAUGING STATION

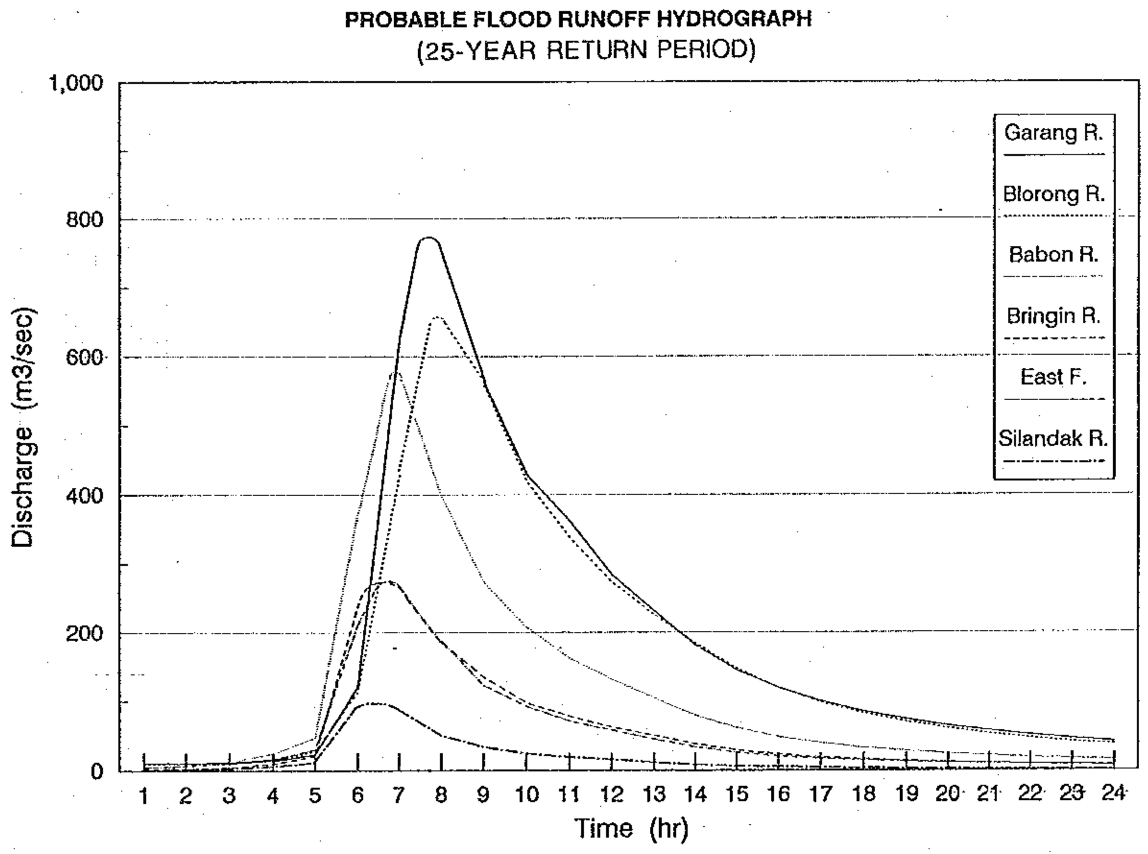


MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.4.4 PROBABLE FLOOD RUN-OFF HYDROGRAPH AT SIMONGAN WEIR
JAPAN INTERNATIONAL COOPERATION AGENCY	



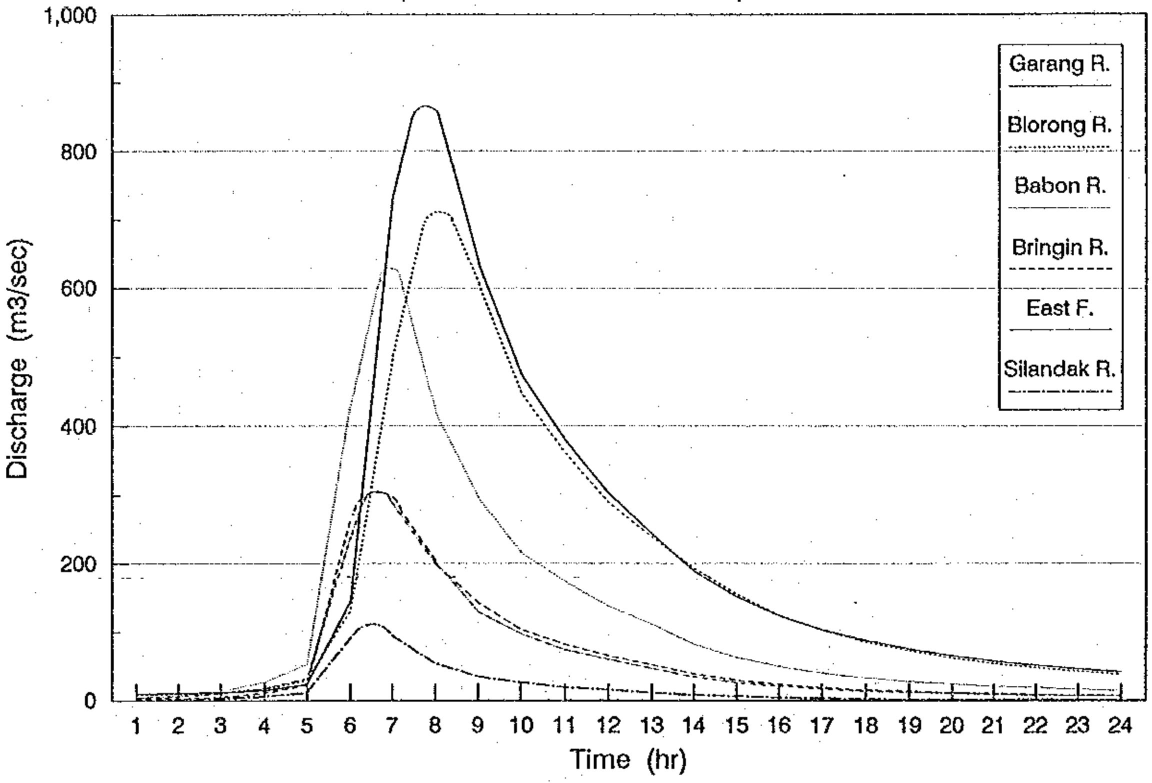
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.4.5 AREA REDUCTION FACTOR
JAPAN INTERNATIONAL COOPERATION AGENCY	



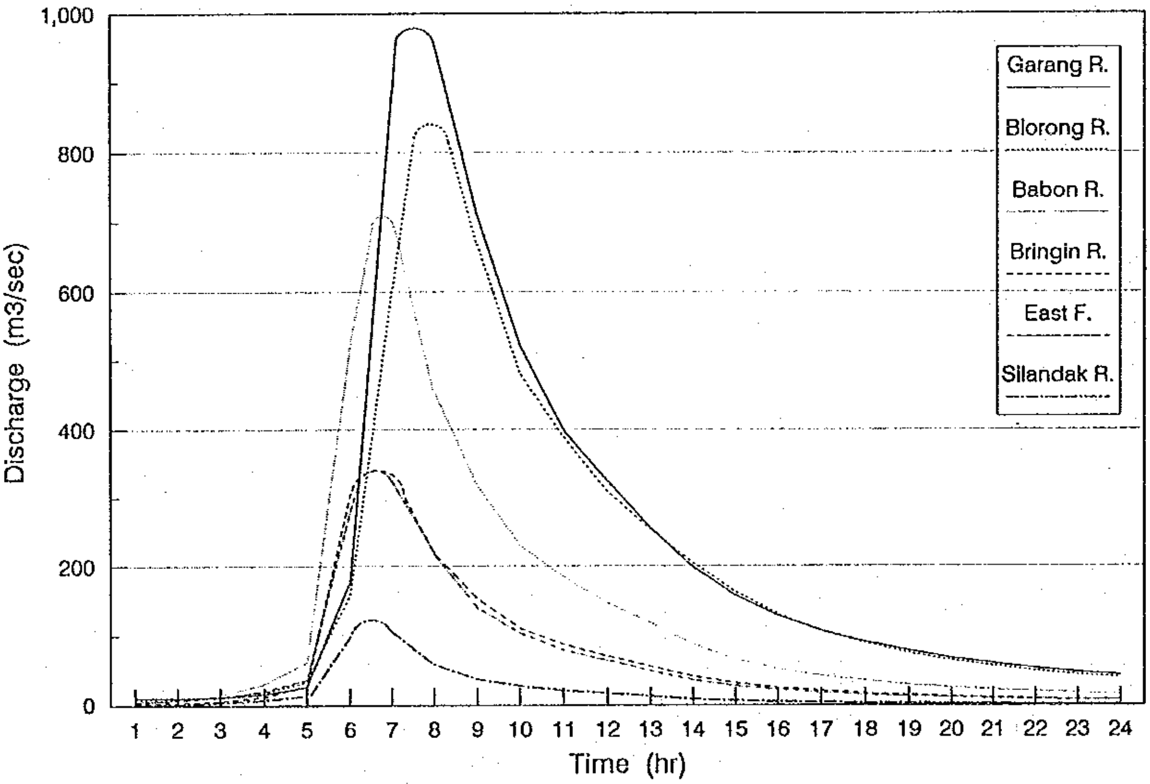


MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.4.6 (1/2) PROBABLE FLOOD RUN-OFF HYDROGRAPH
JAPAN INTERNATIONAL COOPERATION AGENCY	

PROBABLE FLOOD RUNOFF HYDROGRAPH
(50-YEAR RETURN PERIOD)

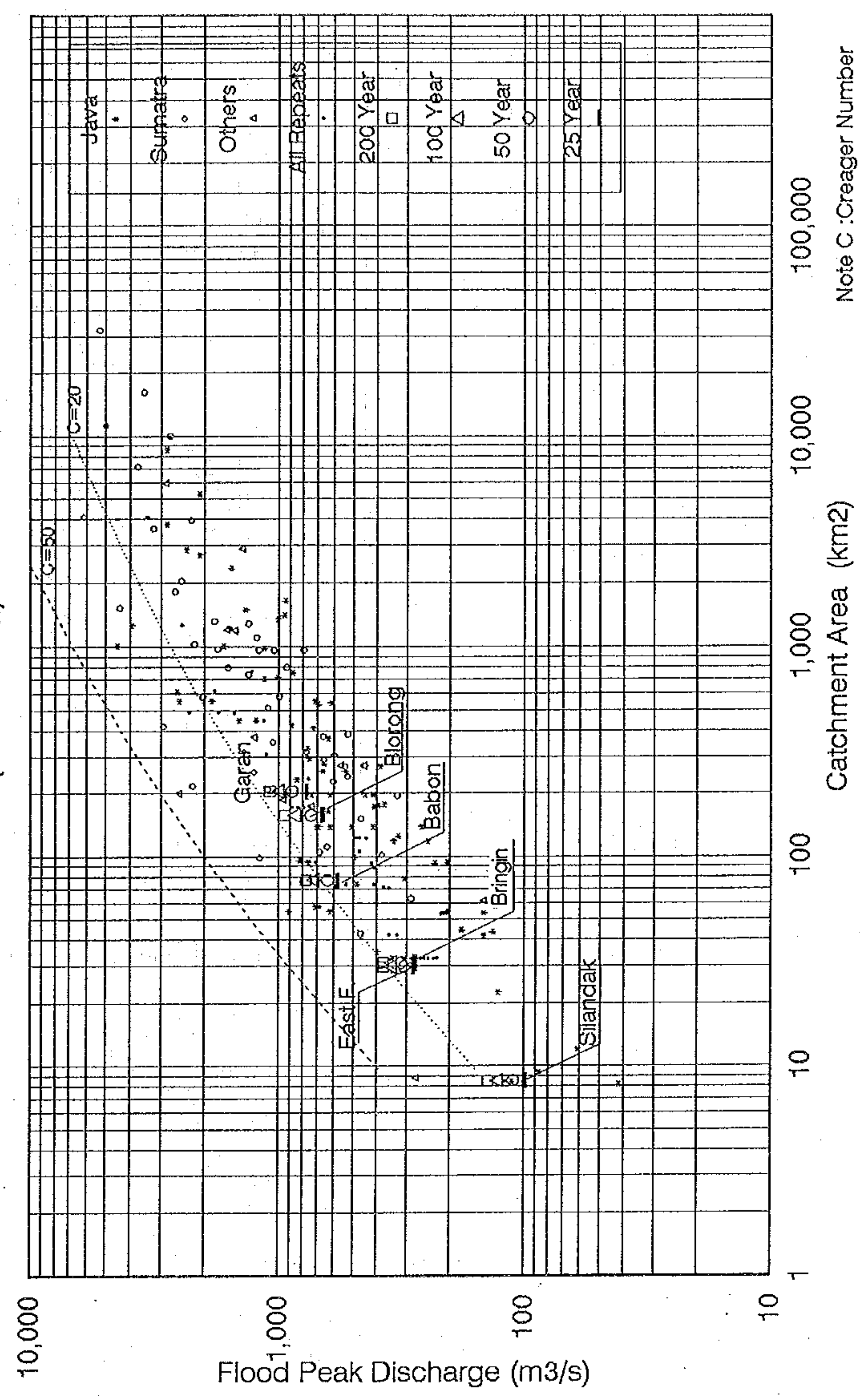


PROBABLE FLOOD RUNOFF HYDROGRAPH
(100-YEAR RETURN PERIOD)

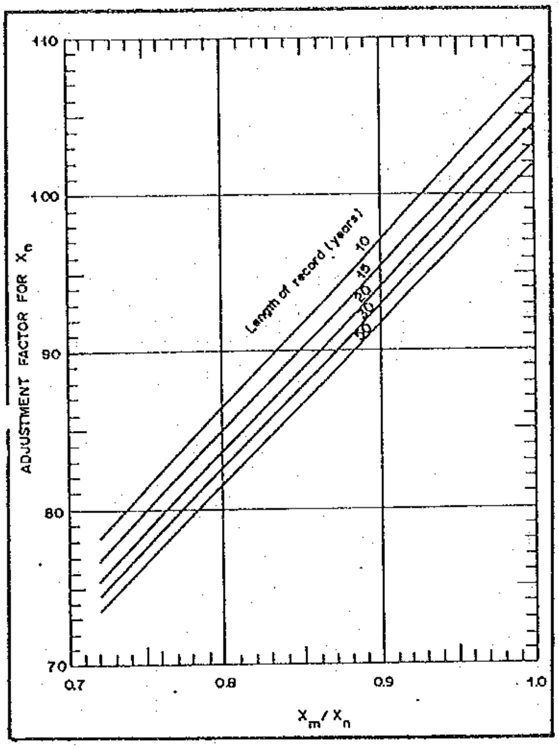


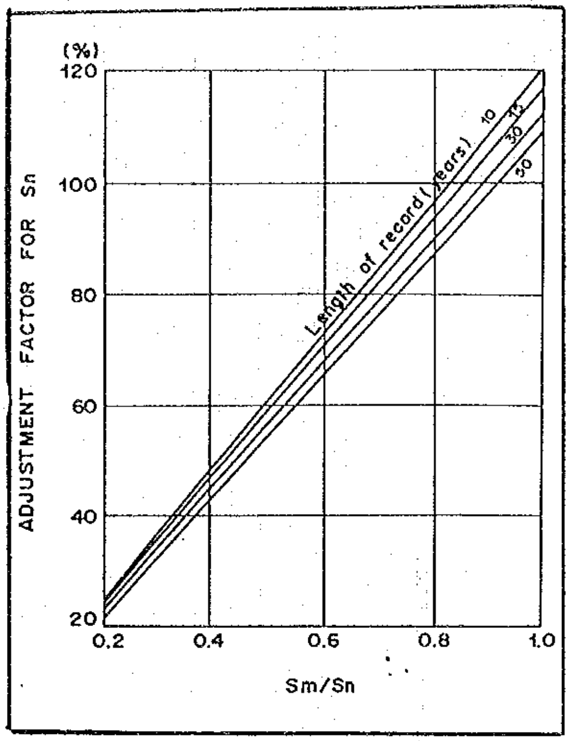
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.4.6 (2/2) PROBABLE FLOOD RUN-OFF HYDROGRAPH
JAPAN INTERNATIONAL COOPERATION AGENCY	

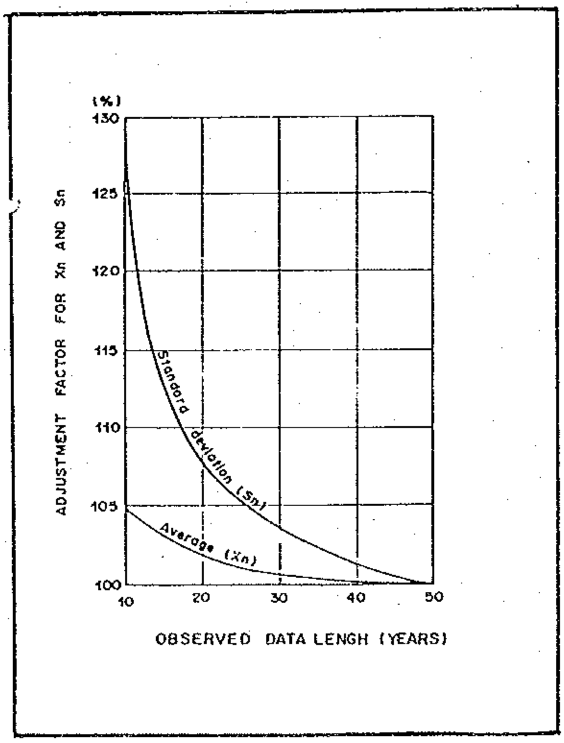
PEAK DISCHARGE AND MAXIMUM RECORDED FLOODS IN INDONESIA (1984 VERSION)



MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.4.7 PEAK DISCHARGE AND MAXIMUM RECORDED FLOODS IN INDONESIA
JAPAN INTERNATIONAL COOPERATION AGENCY	







NOTE:

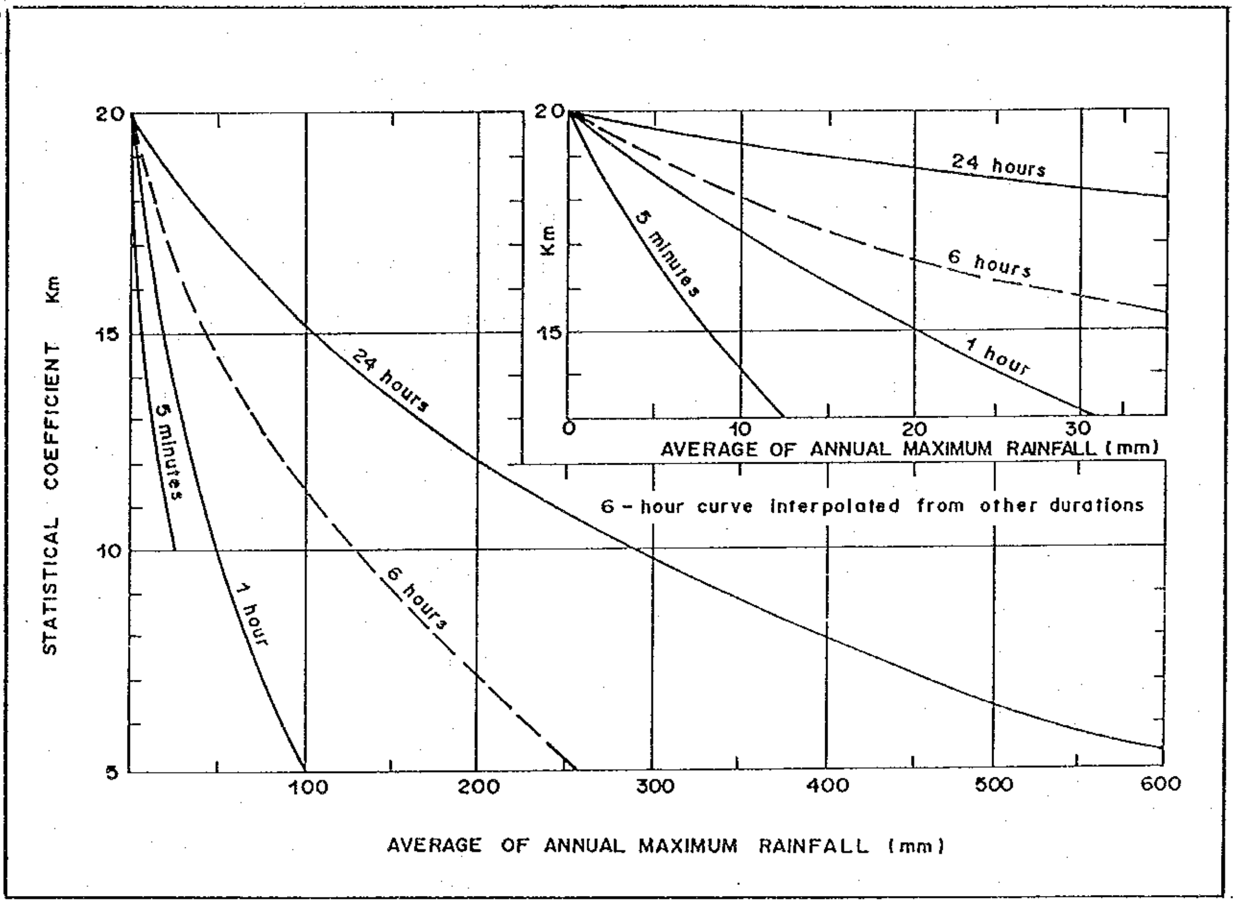
Xn : Unadjusted average of a series of annual maximum precipitation.

Xm : Unadjusted average of a series of annual maximum precipitation excluding the highest value.

Sn : Unadjusted standard deviation of a series of annual maximum precipitation.

Sm : Unadjusted standard deviation of a series of annual maximum precipitation excluding the highest value.

MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 1.4.8 ADJUSTMENT FACTORS DEVELOPED BY HERSHFIELD FOR ESTIMATION OF PMP



MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. I.4.9
STATISTICAL COEFFICIENT OF HERSHFIELD'S FORMULA FOR ESTIMATION OF PMP