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THE MASTER PLAN STUDY
ON
THE EROSION AND SEDIMENT CONTROL
IN
THE PILOT RIVER BASIN, CHOLOMA, SAN PEDRO SULA, CORTES
IN
THE REPUBLIC OF HONDURAS

FINAL REPORT

SUPPORTING REPORT

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ABBREVIATIONS

CABEI	Central American Bank for Economic Integration
COHDEFOR	Corporation Hondurena de Desarrollo Forestal (Honduran Forestry Development Corporation)
COPECO	Comite Permanente de Emergencia y Contingencia (Permanent Committee of Emergency and Contingency)
DGOP	Direccion General de Obras Publicas de SECOPT (General Direction of Public Works of SECOPT)
DIMA	Division Municipal de Aguas de San Pedro Sula (Municipal Water Division of San Pedro Sula)
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GNP	Gross National Product
GOH	Government of Honduras
GOJ	Government of Japan
HARZA-CINSA	Consortium of consultants that carried out the Master Plan for the Sula Valley from 1976 to 1979
INA	Instituto Nacional Agrario (National Agricultural Institute)
IDB	Inter-American Development Bank
JICA	Japan International Cooperation Agency
JRD	Junta Regional de Desarrollo (Regional Development Committee)
SECPLAN	Secretaría de Planificacion, Coodinacion y Presupuesto (Ministry of Planification, Coordination and Budget)

SECOPT	Secretaría de Comunicaciones, Obras Publicas y Transporte (Ministry of Communications, Public Works and Transportation)
SHC	Servicio Hidrologico Climatologico (Climatic, Hydrologic Division)
SMN	Servicio Meteorologico Nacional (National Meteorological Division)
TRRC	Tela Railroad Co.
UNDP	United Nations Development Program

SUPPORTING REPORT A

HYDROLOGY

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SUPPORTING REPORT A HYDROLOGY

1. INTRODUCTION

The objectives of the hydrological study are to grasp the hydrological characteristics of the study area, to provide useful information necessary for the formulation of the flood, erosion and sediment control plan. The study includes the following activities.

- Collection of existing hydrological data
- Assessment of the rainfall and run-off characteristics
- Hydrological analysis for an estimation of probable rainfall
- Flood run-off analysis using mathematical model

2. CONDITIONS OF THE STUDY AREA

2.1 Climate

The climate of this study area is classified as a savanna type, characterized by two seasons: rainy and dry. The rainy season is from June to December. Annual rainfall is about 1,200 mm at La Mesa, and 2,800 mm at Puerto Cortes. Average monthly temperatures vary from 24 degrees centigrade in December to January to 28 degrees centigrade in May to June (*Table* A.2.1).

2.2 Rivers

The study area consists of steep mountains, alluvial fans/cones and alluvial plains. The mountain area rises from the Sula Valley to a maximum height of 1,700 meters and has developed very steep slopes. According to this topographic condition the river channels are very steep in the mountain area, but become suddenly gentle in the alluvial plain area (*Fig*. A.2.1).

In the study area there are several tributaries of the Rio Chamelecon. Among them, the major tributaries are the Rio Choloma, the Rio Blanco and the Rio El Sauce (*Fig*. A.2.2).

2.3 Major Flood

The major floods were mainly caused by the hurricanes that were recorded in 1897, 1916, 1935, 1954, 1969, 1974, 1976, 1979 and 1990. In 1974 the hurricane Fifi caused the most severe damage to the study area. The flood condition and damage are described in Supporting Report C "Flood Damage Survey and Analysis."

3. AVAILABLE DATA

The available hydrological data are very limited. There are several rainfall gauging stations in and around the study area, but La Mesa is the only rainfall station within the study area and no river water level gauging station is located in the study area.

3.1 Rainfall Data

The rainfall data of 34 gauging stations have been collected from the Servicio Meteorologia Nacional (SMN), Ministerio de Recursos Naturales (MRN) and Tela Railroad Co. Nine (9) stations are managed by the government (SMN, MRN) and twenty-five (25) stations are managed by the Tela Railroad Co. The rainfall gauging stations and the available data are listed and shown in *Table* A.3.1. The gauging stations nearby are shown in *Fig*. A.3.1.

Among the gauging stations, La Mesa is the only station which has a comparatively long observation period from 1944 to 1991 and located in the study area, and considered as a representative gauging station for the study.

3.2 River Water Level and Discharge Data

River water level and discharge data are only available along the Rio Chamelecon and the Rio Ulua, but not at the Rio Choloma, the Rio Blanco nor the Rio El Sauce. The locations of the gauging stations are shown in *Fig*. A.3.1 and their observation periods are listed as follows:

Table River Water Level Gauging Stations (Observation period and data)

Gauging Station	Period	Data
(Rio Ulua)		
Puente Pimienta:	1966 - 1988, 1991 - 1992	Discharge and/or River Water Level
Santiago:	1992	River Water Level
Guanacastales:	1992	River Water Level
(Rio Chamelecon)		
Puente Chamelecon	1966 - 1973, 1980 - 1989	Discharge and/or River Water Level
Pacmar:	1992	River Water Level

Note: The river water level data of the Puente Pimienta and Puente Chamelecon are useless for estimating flood water level, because of lack of their datum elevations.

The annual maximum river water level and discharges during the observation period are shown in *Table* A.3.2.

3.3 Rainfall Amount and River Water Level During the Hurricane Fifi

The hurricane Fifi's storm struck through the study area from September 18 to 19, 1974. Recorded rainfall amount during the storm is shown in *Table* A.3.3 and the maximum flood water levels along the Rio Ulua are shown in *Fig.* A.3.2

4. RAINFALL ANALYSIS

4.1 Average Rainfall

Annual and monthly average rainfall amounts are calculated for La Mesa, El Modelo, Puerto Cortes and Omoa. The stations of La Mesa and El Modelo are located at inland areas and Puerto Cortes and Omoa at coastal areas. The results of the calculations are shown in the *Table* A.4.1 to A.4.4

Results are summarized as follows:

- La Mesa and El Modelo have almost the same rainfall amount.
- Puerto Cortes and Omoa have almost the same rainfall amount.
- Puerto Cortes and Omoa areas seem to have twice as much as the rainfall amount at La Mesa and at El Modelo

4.2 Maximum Rainfall

The annual and monthly maximum daily rainfalls (6:00 am to 6:00 am) at La Mesa and Puerto Cortes are prepared and shown in *Tables* A.4.5 and A.4.6. The tables show that the maximum daily rainfall was recorded during the hurricane Fifi (September 18, 1974), and that amount is 340 mm at La Mesa and 283.2 mm at Puerto Cortes, but the maximum 6 hours' rainfall at La Mesa is 154.4 mm recorded on June 10, 1991 (see *Table* A.4.7). The maximum 6 hours' rainfall during Fifi is 140 mm.

The hourly rainfall record sheets are not available for all stations. The rainfall record charts of La Mesa have been collected for only 15 years. Recorded maximum hourly and two hours' rainfall is shown in *Table* A.4.8.

4.3 Frequency Analysis

The frequency analysis was conducted for daily rainfalls at La Mesa and Puerto Cortes. Moreover, 6 hours' rainfall, 2 hours' rainfall and one hour rainfall frequency analysis were also conducted at La Mesa. The method of frequency analysis applied are those of Iwai, Thomas, Hazen, and Gumbel.

4.3.1 Daily Rainfall

The frequency analysis for daily rainfall was conducted at La Mesa and Puerto Cortes. The results are shown in *Table* A.4.9 and *Figs*. A.4.1 and A.4.2.

The table shows that the result by the Gumbel method shows comparatively high rainfall amount and the rainfall amount of Puerto Cortes is more than 1.5 times as that of La Mesa in the same return period.

4.3.2 Six Hours Rainfall

The frequency analysis for six hours' rainfall was conducted at La Mesa. The results are shown in *Table* A.4.10 and *Fig*. A.4.3.

4.3.3 One Hour and Two Hours Rainfall

The frequency analysis for one hour's and two hours' rainfall was conducted at La Mesa. The results are shown in *Table* A.4.11.

To check the adequacy of the calculation, one hour's rainfall amount was estimated from the results of the daily rainfall's analysis because the calculation was conducted by the limited data. The following formula was used for the estimation and comparison table is shown below.

$$r_t = r_{24}\left(\frac{t}{24}\right)^{\frac{1}{3}}$$

where, t : Duration in hr.
r_{24} : Daily rainfall amount
r_t : Rainfall amount within the duration time

Table Comparison between Calculation and Estimation

Return Period	Result by collected data	Estimated from daily rainfall
1/100	81.3	87.1
1/50	73.2	77.2
1/30	67.1	69.9
1/10	53.9	53.9
1/5	45.2	43.3

Note : The results of the Gumbel method were used.

The table shows that the calculated rainfall amount is almost the same value of the estimated one. Therefore, the calculated rainfall amount will be used in the study.

4.4 Recorded Rainfall Pattern

4.4.1 Hurricane Fifi

The rainfall record sheets of the Hurricane Fifi are only available for Tela, but not for La Mesa nor Puerto Cortes. The hourly rainfall distribution of Fifi at Tela is shown in *Fig*. A.4.4.

The hourly rainfall distribution of the Hurricane Fifi has been estimated based on that of Tela, because the two rainfall gauging stations seemed to have a similar curves of rainfall distribution ratios during the hurricane Fifi as shown in the cumulative rainfall and time duration curves of *Fig*. A.4.5.

Though hourly rainfall distribution of Fifi at La Mesa was estimated based on that of Tela, 6 hours' rainfall amount was adjusted to the record of La Mesa. *Fig*. A.4.6 shows the estimated hourly rainfall distribution of Fifi at La Mesa.

4.4.2 Recorded Rainfall Pattern of La Mesa and El Modelo

The available rainfall patterns at La Mesa and El Modelo will be used for analysis of storm rainfall patterns. Since the annual average rainfall amounts at La Mesa is almost the same as those of El Modelo which is located about 5 km toward the East from the study area, the two stations seem to have a similar rainfall pattern; however, they have only a few available rainfall data.

The following storms which have over 70 mm rainfall amount were selected from the records and were used for the analysis.

Table List of Selected Rainfall (La Mesa)

Year/Month/Date	Total Rainfall	Duration
1965/Oct./30	121.5 mm	16 hrs
1966/June/4	102.9 mm	30 hrs
1967/Oct./18	133.4 mm	11 hrs
1968/May/25	104.2 mm	10 hrs
1970/Sept./21	73.7 mm	7 hrs

Table List of Selected Rainfall (El Modelo)

Year/Month/Date	Total Rainfall	Duration
1986/Oct./27	81.9 mm	7 hrs
1988/Dec./2	125.2 mm	21 hrs

The Rainfall patterns are shown in *Figs.* A.4.7 and A.4.8. The relationship between the cumulative rainfall depth and the rainfall duration data is shown in *Fig.* A.4.9.

According to the Figures, there are two types of rainfall distribution: long duration with low rainfall intensity and short duration with a high rainfall intensity.

4.5 Rainfall Intensity and Time Duration

4.5.1 Probable Rainfall Depth and Time Duration

Probable rainfall depth of La Mesa Gauging station is shown in table below.

Table Probable Rainfall Depth (Gumbel Method)

Time Duration	Return Period (Year)					
(min.)	100	50	30	10	5	2
60	81.3	73.2	67.1	53.9	45.2	32.0
120	104.7	93.5	85.3	67.1	53.2	37.1
360	160.4	143.7	131.3	104.2	86.2	59.1
1440	251.1	222.7	201.6	155.5	124.9	78.8

Unit : mm

4.5.2 Rainfall Intensity and Time Duration Curve

Rainfall Intensity and Time Duration Curve are closely resembled by the following formula.

$$r = \frac{a}{t^n + b}$$

where, r : rainfall intensity (mm/hr)
t : time duration
a,b and n : constant

The value of n was assumed in range of 0.5 to 0.8 and constants a and b were calculated for every n value by the method of least squares. The deviation between estimated values and actual ones were also calculated. The sum of square deviation (s) is used for the judgment of most fitted one. The results for 1 in 50 year return period are shown in Table A.4.12 and summarized as follows.

Table *Results of Calculation*

	Constant		Sum. of Deviation
n	a	b	s
0.5	350	-3.16	17.3
0.6	743	-1.67	2.8
2/3	1212	1.26	0.7
0.7	1554	3.74	1.8
3/4	2214	9.38	5.8
0.8	3169	18.33	12.5

As shown in the above table, n=2/3 has the minimum deviation. Therefore, the formula for rainfall intensity and time duration for 1 in 50 year return period was decided as follows:

$$r = \frac{1212}{t^{2/3} + 1.26}$$

The constants a and b for the other return periods were also calculated using n=2/3. The results are shown in the following table.

Table *Constants of the formulas*

	a	b	n
1/100	1365	1.49	2/3
1/50	1212	1.26	2/3
1/30	1099	1.07	2/3
1/10	850	0.48	2/3
1/5	681	-0.06	2/3
1/2	439	-1.63	2/3

Fig. A.4.10 shows the rainfall intensity and time duration curve by calculation.

4.6 Evaluation of Hurricane Fifi

On the basis of the collected rainfall data and the analysis, the hurricane Fifi is assessed as follows:

- The maximum daily rainfall of 340 mm at La Mesa is estimated to be in a scale of a storm larger than once in 200-year frequency; however, the rainfall amount of 280 mm at Puerto Cortes is estimated to be in a scale of a storm once in 20 - 30 years' frequency.
- The six (6) hours' rainfall amount of 140 mm at La Mesa is estimated to be in a scale of a storm about once in 50-year frequency.
- The daily rainfall amount is estimated to be in a scale larger than once in 200 years. Though the hurricane storm caused serious debris flows and floods in the Sula Valley, the maximum hourly rainfall intensity is estimated to be about 66 mm at La Mesa and that was estimated to be in a scale of a storm once in 30-year frequency.

5. FLOOD RUN-OFF ANALYSIS FOR THE MASTER PLAN STUDY

5.1 Run-off Analysis Method

For flood run off analysis, the Rational Formula, the Unit Hydrograph Method and the Storage Function Method have been studied and the Nakayasu's Unit Hydrograph Method that is developed in Japan, will be applied for the study with the following reasons:

- The pilot river basins have a similar topographic condition to Japan, and the Unit Hydrograph Method is widely used.
- By using the Unit Hydrograph Method, it is possible to estimate a peak discharge and shape of hydrograph.
- The Rational Formula is also useful for estimation of a peak discharge from a comparatively small basin, which means less than 200 sq. km.

- The Storage Function Method is likely useful for the study, but there are no discharge data necessary to calibrate the hydrograph estimated by the method.

The details of Nakayasu's Unit Hydrograph Method are described in the following.

5.1.1 Characteristic Values of Unit Hydrograph

The characteristic values of the unit hydrograph are divided into three categories: by its shapes such as Maximum Discharge, Discharge at the Time of Rising Limb and that of Falling Limb of Unit Hydrograph (see *Fig*. A.5.1) and the discharge at each category is calculated by the following formula.

Maximum discharge:

$$Q\max = \frac{1}{3.6} \cdot A \cdot Ro / (0.3T_1 + T_{0.3})$$

Discharge for rising unit hydrograph:

$0<t<T_1$ $$Qa = Q\max\left(\frac{t}{T_1}\right)^{2.4}$$

Discharge for falling unit hydrograph:

$1 > Qd/Q\max > 0.3$	$Qd = 0.3^{(t-T_1)/T_{0.3}}$
$0.3 > Qd/Q\max > 0.3^2$	$Qd = 0.3^{(t-T_1+0.5T_{0.3})/1.5T_{0.3}}$
$0.3^2 > Qd/Q\max$	$Qd = 0.3^{(t-T_1+1.5T_{0.3})/2.0T_{0.3}}$

where,

$Q\max$	:	Maximum discharge of unit hydrograph (m^3/s)
Qa, Qd	:	Discharge at the time of rising and falling limb of unit hydrograph (m^3/s)
A	:	Catchment Area (km^2)
R_0	:	Unit Rainfall (mm)
T_1	:	Time from start of run-off to maximum discharge
$T_{0.3}$	:	Time required until the discharge recesses to 0.3 times the maximum discharge

5.1.2 Relation between Shape of Catchment Area and Time Lag

The unit hydrograph concluded that T_1 and $T_{0.3}$. T_1 and $T_{0.3}$ are expressed as a function of the catchment characteristics that were found based on measured values:

Relation between catchment shape and $T_{0.3}$:

$$T_{0.3} = 0.47\ (A*L)^{0.25}$$

Time of occurrence of peak discharge T_1:

T_l = tg + 0.8 tr

tg : Time lag
for L<=15 km tg = 0.21 $L^{0.7}$
L>15 km tg = 0.4 + 0.058L
L : Maximum length of watercourse
tr : Duration of unit rainfall to be used

As a result of the above calculations, the unit hydrograph can be determined by the characteristic value of the basin alone, therefore, the run-off calculations can be made using this unit hydrograph.

5.1.3 Effective Rainfall

To calculate the effective rainfall for run-off calculation, the following functions are used. Because there are no actual values measured loss curve which indicates the relationship between the accumulated rainfall depth and storm loss.

$$R < 100mm : R_L = R(1 - 3.6 \times 10^{-4} \times R^{1.5})$$
$$R \geq 100mm : R_L = 64mm$$

5.2 Division of Drainage Basin

The study area was divided into twenty-two (22) sub-drainage basins. They are summarized in *Table* A.5.1 and *Fig*. A.5.2. River system models for the existing river system and the alternative river system are shown in *Fig*. A.5.3 and A.5.4 respectively.

5.3 Rainfall Pattern for Run-off Analysis

The following three rainfall patterns were created for every return period from the rainfall intensity and time duration formula that was calculated in Section 4.5.

Pattern A : Maximum rainfall intensity occurs at the beginning of the rainfall
Pattern B : Maximum rainfall intensity occurs at the middle of the rainfall
Pattern C : Maximum rainfall intensity occurs at the end of the rainfall

Considering the basin run-off characteristics, calculation time unit was settled for one hour. *Fig*. A.5.5 shows how to make the rainfall pattern from the formula and the created rainfall patterns of 50-years return period are shown in *Fig*. A.5.6.

5.4 Probable Discharge Distribution

Three (3) rainfall patterns that were described in Section 5.3 and six (6) return periods (100, 50, 30, 10, 5, 2-year) of daily rainfall depth were applied for the run-off simulation. The results of the simulation by the unit hydrograph method are shown in *Table* A.5.2 to A.5.7. Among the three storm patterns, the rainfall pattern C shows the maximum peak discharge at every point. The probable discharges of Pattern C for present and alternative river system were summarized in *Tables* A.5.8 and A.5.9 and shown *Figs.* A.5.7 and A.5.8 respectively.

Fig. A.5.9 to A.5.11 show the shape of hydrograph for different rainfall patterns, probable flood hydrograph at the Junction of the Rio Choloma and the Canal San Roque and at the river mouth of the Rio El Sauce and the difference of flood hydrograph between existing river conditions and alternative river conditions.

5.5 Simulation of Fifi's Flood

The flood of hurricane Fifi was simulated by using the estimated rainfall pattern with total rainfall of 376 mm. The flood peak discharge and the simulated flood hydrograph is shown in *Table* A.5.10 and *Fig.* A.5.12.

The following findings were found by comparing the Fifi's flood with probable discharges that were calculated in Section 5.4.

- Peak discharge of Fifi at the most downstream of the basin is bigger than that of peak discharge calculated by once in 50-year return period daily rainfall.
- Peak discharge of Fifi at the middle reaches of the basin are equal as that of peak discharge calculated by 30 to 50-year return period daily rainfall.
- Peak discharges of Fifi at the upper reaches of the basin are less than that of peak discharge calculated by 30-year return period daily rainfall.

The peak discharge at the upper reaches is mainly affected by short duration rainfall intensity, but that of the lower reaches is mainly affected by total rainfall amount. The maximum hourly rainfall intensity, 6 hours' rainfall amount and daily rainfall amount of Fifi are 66 mm, 140 mm and 340 mm, that are assessed as a once in 30-, 50- and more than 200-year return period respectively. Therefore, the simulation results show the above conditions.

Consequently, the Fifi's flood was assessed at the same scale of the flood that was calculated by once in 50-year return period daily rainfall for the whole basin.

5.6 Design Peak Discharge Distribution

The once in 50-year return period rainfall with the rainfall pattern C was selected for the design storm of the Master Plan. *Figs.* A.5.13 and A.5.14 show the peak discharge distribution for each alternative by 1/50 flood.

The reasons of selection of design rainfall pattern and design scale were described in Supporting Report F "Flood Mitigation Study" and Supporting Report I "Project Evaluation" respectively.

6 RUN-OFF ANALYSIS FOR THE FEASIBILITY STUDY

The Rio Choloma basin was selected as the area for the feasibility study based on the economic evaluation. In the Master Plan study, the once in 50-year return period flood was selected for the design scale.

6.1 Run-off Analysis Method

The unit hydrograph method that is applied to downstream basin from the Choloma Bridge and the Rational formula that is applied to upstream basin, is used for the calculation of discharge from the Rio Choloma basin. The reasons of application of the each method are as follows.

At the downstream basin, it is necessary to require not only the peak discharge but also the flood hydrograph because there is some possibility to consider the flood storage facilities and calculate the sedimentation. Therefore the unit hydrograph method is applied because it is possible to estimate a peak discharge and a hydrograph.

On the other hand, at the upstream basin, there are some debris and erosion control facilities and they have comparatively small basin. To simplify the plan, with a peak discharge needed, rather than a hydrograph for designing these facilities, the rational formula is applied.

6.2 Division of Drainage Basin (Rio Choloma Basin)

For the feasibility study, the Rio Choloma basin was divided into 8 sub-basins from the view point of river planning, erosion control plan and sediment control plan as shown in *Fig.* A.6.1 and the river system model for run-off analysis is shown in *Fig.* A.6.2

6.3 Run-off Analysis for the Upstream Basin

6.3.1 Rational Formula

The Rational formula is as follows:

$$Q_P = \frac{1}{3.6} f \cdot r \cdot A$$

where, Q_p : Peak Discharge (qu.m/sec)
f : Run-off Coefficient
r : Average Rainfall Intensity within the Time of Flood Concentration (mm/hr)
A : Catchment Area (km^2)

The calculation point of peak discharge is shown in *Fig.* A.6.1.

1) Run-off Coefficient

The run-off coefficient is settled by considering the geological, topographical and ground surface conditions of the basin. The coefficient of the Rio Choloma basin was divided into three values.

- Mountain with steep slope: 0.80
- Mountainous area: 0.70
- Undulated land: 0.55

The run-off coefficient for each calculation point which was calculated by weighted average method is shown in *Table* A.6.1.

2) Time of Flood Concentration (T)

The time of flood concentration (T) is defined as the period of time required until the rainfall reaches the exit of the basin. "T" is determined as the sum of the period of time elapsed until rainwater enters into the relevant channel (time of inlet: T1) and the period of time elapsed until rainwater flows down to the downstream end through the channel (time of flow: T0).

$$T = T1 + T0$$

a) Time of inlet (T1)

Time of inlet is controlled by many elements such as the form and area of the basin, slope of the ground surface, etc. Considering the above conditions, 30 min. for most upstream 2 km^2 is used in this study.

b) Time of flow (T0)

The time of flow means the period of time elapsed that the rainwater entered into a watercourse at its upstream end reaches the point for which the discharge calculations are to be made.

The time of flow is calculated using average velocity formula such as Kraven's and Razia's formula. In this study, the Kraven's formula was applied because the ground surface slope is too steep (steeper than 1/20) to apply the Razia's formula. The Kraven's formula is as follows.

$T0 = L / W$

L : Length of watercourse
W : Average flood velocity

The average velocity of the flood flow is divided into the following three values by slope of water course:

Table Average velocity for Kraven's formula

I	over 1/100	1/100 - 1/200	less 1/200
W (m/sec.)	3.5	3.0	2.1

I : Slope of watercourse

Table A.6.1 shows the time of flood concentration for every calculation point.

6.3.2 Rainfall Intensity and Flood Peak Discharge

The rainfall intensity within the time of flood concentration is calculated by using the formula of rainfall intensity and time duration that is described in the section 4.5. The rainfall intensity of 50-year return period rainfall and the results of the estimation of 50-year flood peak discharge is shown *Table* A.6.1.

6.4 Run-off Analysis for the Downstream Basin

The unit hydrograph method was applied for the calculation of discharge at the downstream basin. The calculation points are shown in *Fig.* A.6.1. The calculation conducted at every calculation point using the rainfall pattern C which has the amount of once in 50-year return rainfall. The results are shown in *Table* A.6.2 and simulated flood hydrographs are shown in *Fig*. A.6.3.

6.5 Design Peak Discharge Distribution

The peak discharge at the Choloma bridge is 647 m^3/s by Rational formula. It can be said that this value is almost the same as that of 612 m^3/s by unit hydrograph because of the result of the Rational method which has a tendency to show a big amount of peak discharge compared to the other method. Therefore the result of flood peak discharge calculation for upstream basin by Rational formula is adequate for the study. The design flood peak discharge distribution of the Rio Choloma is shown in *Fig*. A.6.4.

TABLES

TABLE A.2.1 MONTHLY AVERAGE TEMPERATURE (LA MESA)

YEAR	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1965	22.9	25.1	26.0	27.5	27.8	28.0	27.0	27.2	27.6	26.2	25.3	24.5
1966	23.0	23.5	23.8	26.8	27.0	26.6	26.6	26.7	26.5	25.7	22.7	22.3
1967	22.8	23.4	24.4	26.0	26.5	26.7	26.1	26.7	26.8	25.4	23.8	23.9
1968	22.8	22.5	23.3	24.9	26.7	26.7	26.1	26.0	26.3	25.4	23.8	23.4
1969	23.6	24.1	25.3	27.0	27.7	27.5	26.6	27.8	28.7	26.6	23.9	23.2
1970	23.9	22.4	25.4	27.2	26.3	27.1	26.7	26.8	26.5	26.2	22.6	23.3
1971	23.2	23.9	24.6	25.1	26.9	26.9	26.6	26.8	27.0	26.2	25.0	24.0
1972	23.9	23.6	25.2	26.9	27.5	27.6	26.5	25.4	26.7	25.1	25.3	22.9
1973	24.6	23.4	27.3	28.3	28.5	28.0	27.3	27.5	27.8	26.5	25.4	22.3
1974	24.5	23.9	26.0	27.3	28.8	28.3	26.9	26.9	27.1	24.9	24.0	23.7
1975	23.9	24.6	26.5	27.1	28.8	28.3	27.6	27.3	26.9	25.6	23.4	22.4
1976	21.8	22.1	25.3	25.6	27.5	26.7	26.6	26.9	27.2	26.0	24.1	23.6
1977	23.1	24.9	26.2	25.6	26.9	26.8	26.8	27.7	27.5	26.3	25.1	24.4
1978	23.3	22.6	24.9	26.8	29.6	27.3	26.5	27.0	27.0	25.9	25.2	24.4
1979	23.8	23.6	26.1	27.8	28.3	27.4	27.8	26.8	26.9	26.3	24.3	23.5
1980	24.1	24.2	26.0	26.1	28.4	26.6	26.8	27.3	27.5	26.3	24.6	22.4
1981	22.0	23.8	26.4	26.5	28.2	27.0	27.0	27.3	27.0	26.3	24.0	23.9
1982	24.6	25.2	26.0	27.5	27.8	28.6	26.5	26.7	27.0	26.8	24.6	24.3
1983	23.8	24.8	26.8	28.0	28.9	29.2	27.0	27.7	27.6	26.6	25.9	25.1
1984	23.1	24.3	26.1	28.0	28.4	27.4	28.1	28.2	27.8	27.9	24.8	24.9
1985	24.2	25.4	27.5	28.2	28.8	29.0	28.3	28.6	28.4	28.2	26.9	25.4
1986	23.6	26.3	26.1	27.6	29.3	29.2	28.0	28.6	28.0	27.4	27.0	25.8
1987	24.1	26.2	28.4	26.8	29.1	30.3	28.5	28.8	29.7	26.5	25.9	26.0
1988	25.0	25.4	26.8	29.2	30.1	30.5	29.0	29.2	29.1	25.9	27.2	24.4
1989	25.3	24.8	26.1	28.3	29.3	29.0	28.7	28.7	28.3	27.0	28.0	24.2
1990	26.9	27.0	27.4	29.5	31.2	29.7	29.9	29.3	29.1	27.3	24.6	25.1
1991	25.8	25.5	27.7	29.5	30.0	29.3	28.1	27.4	27.9	27.5	25.0	25.0
	23.8	24.3	26.0	27.2	28.3	28.0	27.3	27.5	27.6	26.4	24.9	24.0

(°C)

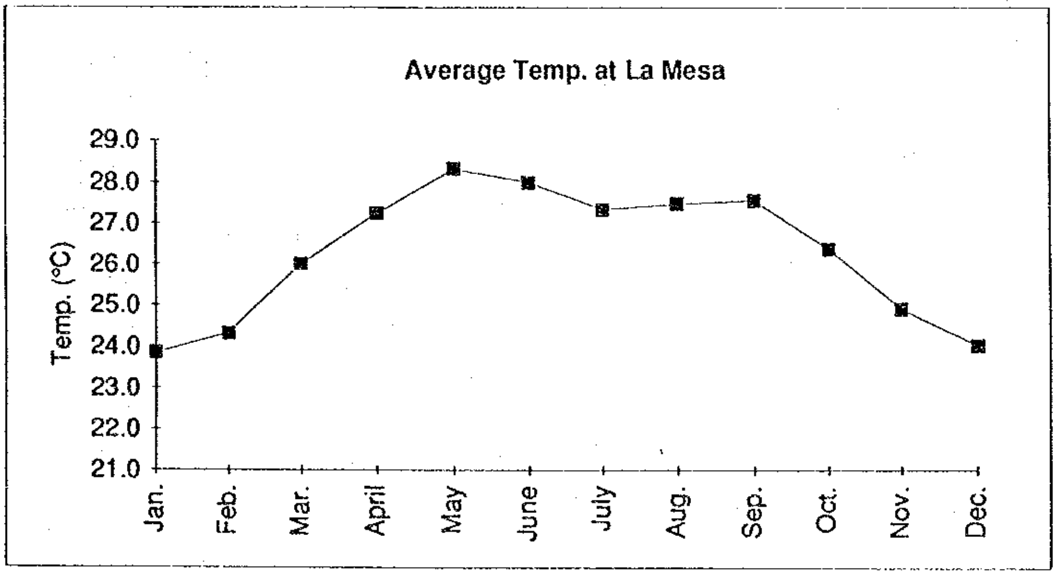


TABLE A.3.1 (1) AVAILABLE DAILY RAINFALL DATA

Station Name	Available Period	Managed By
La Mesa	1994 - 1991	SMN
El Modelo	1975 - 1990	MRN
Puerto Cortes	1945 - 1950 1962 - 1980	SMN
Omoa	1987 - 1991	SMN
Guaymas	1978-1990	MRN
Peña Blanca	1956-1977	SMN
Morazan	1966-1981	MRN
Quimistan	1968-1981 1986-1990	MRN
Finca 3	1969-1974	TRRC.
Santiago	1969-1974	TRRC.
Bejuco	1979-1981	TRRC.
Barranco	1969-1980	TRRC.
Oliva	1969-1980	TRRC.
Llano	1969-1980	TRRC.
Higuerito Central	1969-1977	TRRC.
Garroba	1975-1980	TRRC.
Blanco	1969-1980	TRRC.
Progreso	1969-1978	TRRC.
Buena Vista	1969-1988	TRRC.
Cobb	1969-1988	TRRC.
Las Flores	1969-1988	TRRC.
Naranjo Chino	1969-1988	TRRC.
Los Indios	1969-1988	TRRC.
Monterrey	1969-1988	TRRC.
Breck	1969-1988	TRRC.
Palomas	1969-1988	TRRC.
Birichiche	1979-1981	TRRC.
La Fragua	1969-1988	TRRC.
Guanacastales	1969-1972	TRRC.
La Lima	1969-1980	TRRC.
Guarumas	1974-1988	TRRC.
Omonita	1975-1988	TRRC.

TABLE A.3.1 (2) AVAILABLE DAILY RAINFALL DATA

Station Name	Available Period	Managed By
San Juan	1969-1988	TRRC.
La Curva	1970-1988	TRRC.
Tacamiche	1969-1988	TRRC.
Copen	1969-1988	TRRC.
Corozal	1969-1988	TRRC.
Mopala	1969-1988	TRRC.
Santa Rosa	1969-1988	TRRC.
Ceibita	1969-1988	TRRC.
Indiana	1969-1988	TRRC.
Caimito	1969-1988	TRRC.
Limones	1969-1988	TRRC.
Laurel	1969-1988	TRRC.
Lupo	1969-1988	TRRC.
Mercedes	1969-1982	TRRC.
Tibombo	1969-1988	TRRC.

TABLE A.3.2 ANNUAL MAXIMUM WATER LEVEL AND DISCHARGE (RIO ULUA AND RIO CHAMELECON)

Rio Ulua at Puente Pimienta

	Period					Month	Date	Water Level (m)	Discharge (qu. m/sec)
1	May	1966	-	April	1967	Sep.	15	4.58	1,042.00
2	May	1967	-	April	1968	Oct.	12	3.36	981.20
3	May	1968	-	April	1969	Sep.	21	5.00	1,200.00
4	May	1969	-	April	1970	Sep.	3	8.50	2,735.00
5	May	1970	-	April	1971	Aug.	28	4.60	998.00
6	May	1971	-	April	1972	Oct.	9	4.46	943.00
7	May	1972	-	April	1973	Aug.	29	4.16	845.00
8	May	1973	-	April	1974	Aug.	29	5.58	1,370.00
9	May	1974	-	April	1975	Sep.	19	7.30	2,170.00
10	May	1975	-	April	1976	Sep.	24	5.94	1,550.00
11	May	1976	-	April	1977	June	13	6.92	2,269.00
12	May	1977	-	April	1978	June	1	4.64	1,400.00
13	May	1978	-	April	1979	Sep.	6	6.13	2,104.20
14	May	1979	-	April	1980	June	9	6.52	1,756.00
15	May	1980	-	April	1981	Sep.	13	7.50	2,681.00
16	May	1981	-	April	1982	Sep.	25	7.36	1,687.22
17	May	1982	-	April	1983	June	13	6.04	1,545.94
18	May	1983	-	April	1984	Sep.	29	6.62	1,827.15
19	May	1984	-	April	1985	Sep.	3	6.18	1,653.26
20	May	1985	-	April	1986	Sep.	28	4.60	1,043.43
21	May	1986	-	April	1987	Sep.	13	4.82	982.84
22	May	1987	-	April	1988	Sep.	24	4.90	1,495.17
							Max.	8.50	2,735.00

Rio Chamelecon at Puente Chamelecon

	Period					Month	Date	Water Level (m)	Discharge (qu. m/sec)
1	May	1966	-	April	1967	Nov.	21	4.94	341.60
2	May	1967	-	April	1968	Oct.	19	5.66	561.50
3	May	1968	-	April	1969	Sep.	25	4.60	552.00
4	May	1969	-	April	1970	Sep.	3	6.20	833.00
5	May	1970	-	April	1971	Sep	24	4.10	465.00
6	May	1971	-	April	1972	Nov.	21	3.32	322.00
7	May	1972	-	April	1973	July	28	1.58	62.70
8	May	1980	-	April	1981	Oct.	7	5.00	483.00
9	May	1981	-	April	1982	June	23	5.44	902.71
10	May	1982	-	April	1983	Sep.	24	4.78	701.69
11	May	1983	-	April	1984	Nov.	16	5.06	821.66
12	May	1984	-	April	1985	Sep.	3	5.00	429.28
13	May	1985	-	April	1986	Sep.	27	3.04	205.48
14	May	1986	-	April	1987	Sep.	29	3.35	349.45
15	May	1987	-	April	1988	Sep.	21	2.74	218.18
							Max.	6.20	902.71

Note: Water level is no an elevation at the station.

TABLE A.3.3 RAINFALL REGISTERED DURING HURRICANE FIFI
(In mm.)

Station Name	Date					Total
	16	17	18	19	20	
La Mesa	0.1	43.0	340.0	100.1	0.0	483.2
Zapotal	1.3	10.0	250.9	16.4	0.0	278.6
Santa Ana	0.0	150.7	190.9	0.5	0.0	342.1
Las Palmas	4.8	59.6	211.8	53.7	0.0	329.9
Piedras Negras	3.8	60.5	419.5	0.0	0.0	483.8
Olanchito	0.3	69.6	140.6	9.7	0.2	220.4
La Ceiba	1.0	167.1	288.9	4.5	0.5	462.0
Tela	6.4	91.2	154.2	11.7	0.0	263.5
Morazan	1.0	30.7	336.5	66.6	8.2	443.0
Quimistan	1.6	20.3	76.2	75.5	2.8	176.4
La Entrada	0.8	39.5	72.1	13.6	3.8	129.8

(unit : mm)

Source: Obras de Protección contra inundaciones
Informe Principal por Sir William Halcrow & Partners
September 1975

TABLE A.4.1 AVERAGE MONTHLY RAINFALL AT LA MESA

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1944	-	-	27.2	30.0	35.1	158.2	148.6	177.8	150.6	275.3	69.1	131.6	-
1945	77.5	35.3	18.8	21.1	70.1	99.3	111.5	-	-	146.6	284.2	54.4	-
1946	8.9	73.2	3.0	38.1	12.7	9.9	72.4	31.0	43.7	21.3	28.4	15.0	357.6
1947	44.7	34.0	68.1	7.1	17.0	74.7	261.1	175.5	152.4	40.1	64.3	69.6	1,008.6
1948	96.5	189.2	10.9	16.5	176.8	96.5	193.3	115.6	217.2	60.7	98.3	80.8	1,352.3
1949	79.2	4.3	19.1	14.0	2.0	70.4	95.5	87.4	161.3	75.9	137.9	228.6	975.6
1950	161.3	68.8	85.1	-	-	233.7	96.0	66.8	85.1	172.7	135.9	79.0	-
1951	23.1	19.1	0.0	0.0	101.9	136.1	113.3	96.5	49.0	-	6.1	10.9	-
1952	38.6	62.0	6.1	73.7	39.9	215.4	162.8	-	232.2	159.0	153.7	233.9	-
1953	92.2	48.8	30.7	4.6	213.1	191.3	152.4	140.7	106.7	178.6	210.1	97.3	1,466.5
1954	128.5	22.9	47.5	81.0	55.4	242.6	108.0	122.9	312.2	263.4	145.8	92.2	1,622.4
1955	65.5	68.1	7.4	6.9	2.3	36.6	172.5	136.1	222.0	186.7	150.9	206.0	1,261.0
1956	43.4	20.8	30.7	48.0	132.8	181.4	81.0	167.1	231.4	293.4	269.7	218.2	1,717.9
1957	126.5	31.5	131.8	3.0	99.1	139.2	276.9	213.4	85.3	78.7	60.5	138.2	1,384.1
1958	47.5	16.5	98.3	3.6	65.5	299.5	377.2	175.8	137.4	175.8	68.3	46.5	1,511.9
1959	57.4	6.9	37.1	92.7	28.4	305.3	88.4	77.7	169.9	237.7	161.0	63.8	1,326.3
1960	53.8	41.7	75.7	80.8	38.1	249.9	143.8	86.1	236.2	147.3	205.7	121.9	1,481.0
1961	181.1	74.7	45.7	17.5	23.6	63.8	251.7	64.3	108.2	148.6	103.4	74.4	1,157.0
1962	71.4	25.6	84.1	117.3	45.5	218.4	127.5	87.6	134.6	297.9	72.6	55.9	1,338.4
1963	34.3	133.1	112.5	4.8	33.5	69.8	66.5	141.5	271.8	141.0	114.8	118.6	1,242.2
1964	31.0	61.5	2.0	34.5	51.6	263.4	83.8	59.9	160.0	127.2	88.9	245.6	1,209.4
1965	52.6	-	17.5	8.1	15.7	49.0	329.4	125.5	49.0	63.8	318.5	127.3	-
1966	51.3	172.7	77.5	48.0	62.0	306.3	88.1	145.8	145.0	143.0	129.5	81.0	1,450.2
1967	136.4	98.6	14.7	20.6	20.8	205.7	50.8	83.8	156.7	247.4	222.5	122.9	1,380.9
1968	34.8	32.3	44.5	2.5	262.1	123.2	118.6	86.1	221.7	158.5	146.1	150.6	1,381.0
1969	47.5	9.4	52.8	7.6	152.2	84.8	154.4	133.6	174.8	11.4	274.1	66.6	1,169.2
1970	47.2	54.6	1.5	0.3	30.7	61.7	121.7	96.0	201.9	69.1	124.5	160.5	969.7
1971	83.8	25.4	24.9	27.4	45.7	35.0	52.4	37.8	74.2	46.3	184.6	48.4	685.9
1972	34.8	149.4	30.0	3.5	12.4	151.3	65.8	112.6	103.6	27.5	15.7	59.1	765.7
1973	13.6	25.6	4.2	77.1	83.0	51.6	119.5	145.8	65.4	37.6	108.6	15.0	747.0
1974	17.8	22.4	5.9	5.5	17.0	314.5	41.6	71.4	549.2	430.5	90.8	62.4	1,629.0
1975	6.1	1.4	0.0	0.0	22.4	11.9	6.6	105.0	53.9	106.7	119.9	92.8	526.7
1976	266.5	24.6	0.5	76.8	62.4	159.0	60.2	16.3	24.7	155.8	189.1	141.0	1,176.9
1977	42.8	53.8	13.3	55.9	79.8	176.9	67.3	88.6	58.5	100.2	92.1	112.6	941.8
1978	113.2	31.8	78.4	0.3	199.5	145.8	112.7	113.8	140.9	134.6	170.5	138.4	1,379.9
1979	51.2	88.5	15.1	44.7	66.3	110.1	90.0	165.5	245.5	164.0	257.7	177.6	1,476.2
1980	22.4	61.9	2.4	149.9	41.6	201.5	79.9	71.4	309.6	242.8	181.0	92.6	1,457.0
1981	68.4	219.1	28.6	9.9	26.0	243.7	121.6	156.3	146.6	253.6	53.6	216.5	1,543.9
1982	103.2	98.4	44.6	9.2	68.9	93.8	94.1	90.6	170.7	159.1	92.9	68.7	1,094.2
1983	79.9	9.6	13.7	91.1	13.5	118.5	93.1	152.9	85.3	34.5	98.7	175.2	966.0
1984	82.5	34.6	46.6	3.3	57.0	169.3	204.1	172.4	145.6	65.2	105.0	105.2	1,190.8
1985	45.0	18.7	11.5	46.9	78.9	109.0	138.9	99.5	97.5	38.7	28.1	72.8	785.5
1986	81.1	10.5	45.9	1.8	67.7	84.8	195.9	96.8	109.6	181.1	46.7	86.0	1,007.9
1987	74.9	10.8	65.7	4.5	0.0	64.6	245.0	103.6	93.8	68.3	231.9	221.8	1,184.9
1988	138.2	93.6	34.5	25.0	79.9	146.4	189.6	211.5	152.1	327.0	36.7	253.2	
1989	86.6	70.9	6.7	12.4	49.4	88.6	84.4	78.0	184.2	137.8	128.2	129.3	
1990	44.1	16.0	51.4	1.3	52.6	232.2	35.2	107.2	89.7	75.5	157.2	93.1	955.5
1991	60.0	46.4	44.7	48.3	63.2	68.5	53.9	114.3	101.5	59.0	424.7	67.9	1,152.4
Ave.	71.2	54.8	35.8	31.4	63.3	145.1	129.1	113.2	153.6	144.0	138.7	115.0	1,185.8

(unit : mm)

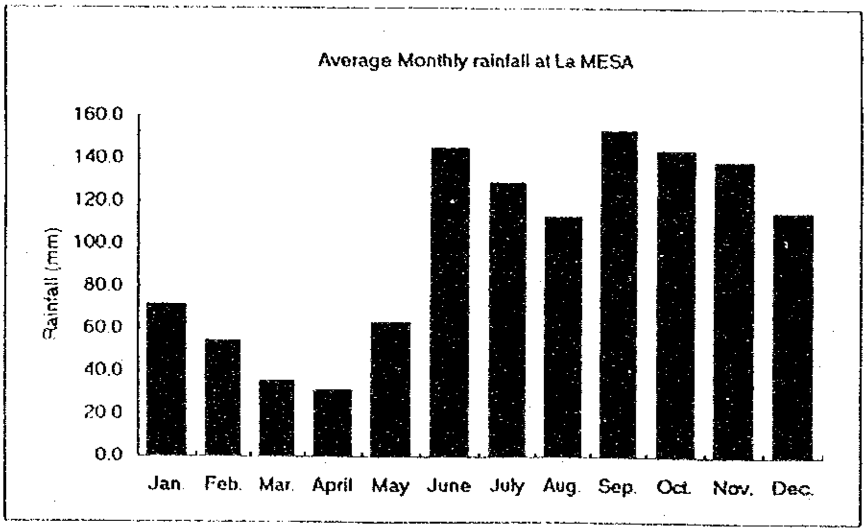


TABLE A.4.2 AVERAGE MONTHLY RAINFALL AT EL MODELO

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1975	82.4	7.6	57.7	2.7	2.9	42.2	48.1	76.1	87.4	76.3	102.6	72.5	-
1976	199.3	21.4	2.1	40.3	160.5	138.5	118.8	92.8	90.3	196.4	198.5	136.6	1,395.5
1977	50.6	55.7	13.7	63.2	107.5	395.6	74.5	157.7	-	42.2	119.1	82.6	-
1978	75.0	134.7	86.5	3.2	165.4	135.6	174.7	101.0	203.0	-	178.0	141.3	1,398.4
1979	53.7	80.5	26.6	17.6	-	-	-	-	-	-	-	-	-
1982	137.4	132.5	35.7	61.6	84.3	120.0	61.3	-	-	-	72.9	58.0	-
1984	77.3	30.4	-	-	108.9	-	258.4	179.0	-	65.7	69.2	103.4	-
1985	55.9	28.7	12.9	50.0	53.9	71.4	209.7	100.8	171.7	24.9	46.0	53.4	879.3
1986	89.2	11.8	36.0	0.7	78.4	100.2	201.7	123.2	122.4	190.0	58.7	78.9	1,091.2
1987	82.4	7.6	57.7	2.7	2.3	87.3	213.1	153.9	110.7	62.0	210.2	209.6	1,199.5
1988	107.3	94.8	40.5	29.5	63.5	144.4	217.6	118.4	155.2	267.3	47.0	209.0	1,494.5
1989	87.9	56.5	7.3	4.9	59.3	91.8	46.0	151.3	162.1	112.7	-	-	-
1990	-	-	-	-	-	-	-	132.0	104.8	20.1	173.9	24.4	-
Ave.	91.5	55.2	34.2	25.1	80.6	132.7	147.6	126.0	134.2	105.8	116.0	106.3	1,243.1

(unit : mm)

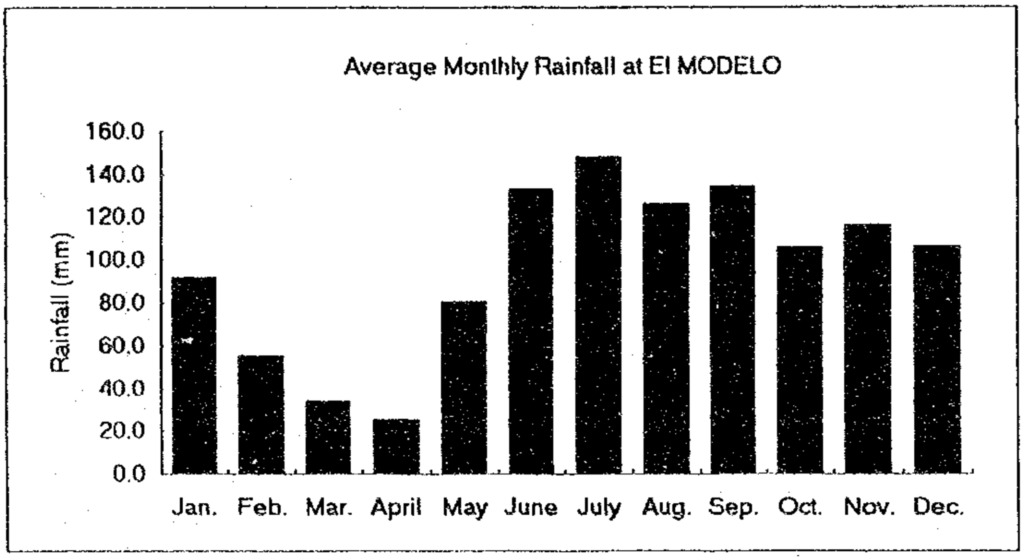


TABLE A.4.3 AVERAGE MONTHLY RAINFALL AT PUERTO CORTES

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1945	-	23.9	8.9	0.0	204.2	90.7	188.5	380.0	602.7	-	-	-	-
1946	225.3	92.5	78.0	25.4	9.4	138.4	117.1	103.9	109.5	430.3	589.0	390.1	2,308.9
1947	110.2	295.1	201.7	92.7	34.5	99.8	-	-	128.5	216.4	284.7	577.6	-
1948	660.4	165.9	35.3	50.5	104.1	153.2	147.8	117.3	172.2	450.1	235.5	237.0	2,529.3
1949	162.6	19.3	24.4	48.0	18.0	47.2	115.6	125.5	76.7	246.9	447.5	570.7	1,902.4
1950	144.8	170.4	21.3	27.2	1.3	252.2	256.5	169.9	110.0	777.5	-	-	-
1962	-	-	25.1	-	68.6	-	293.6	117.1	309.6	427.8	390.9	253.0	-
1963	146.3	185.7	322.6	49.3	72.9	54.4	62.5	137.4	241.8	591.1	528.6	387.1	2,779.7
1964	142.7	191.5	-	5.1	23.6	243.8	117.1	286.8	163.8	408.7	409.4	503.7	-
1965	374.4	188.0	68.1	62.0	34.3	169.9	178.3	211.3	158.2	646.4	509.8	501.9	3,102.6
1966	467.4	574.3	243.8	28.2	91.2	454.7	176.5	94.7	94.2	631.7	-	-	-
1967	387.1	301.2	79.2	121.4	127.3	243.8	193.3	157.7	221.7	467.4	525.5	156.7	2,982.3
1968	195.1	196.1	113.7	22.6	100.3	82.8	143.0	278.6	138.7	413.5	457.2	587.5	2,729.1
1969	254.0	72.1	327.9	10.4	242.3	244.9	111.8	78.0	507.0	340.9	807.7	312.4	3,309.4
1970	294.9	242.6	50.3	25.4	115.1	223.3	134.1	87.4	258.1	252.7	385.3	432.6	2,501.8
1971	244.1	179.6	131.8	25.4	35.3	96.5	86.6	244.4	146.3	112.0	498.6	312.4	2,113.0
1972	211.3	459.0	47.8	46.5	95.0	242.8	193.3	209.6	268.0	181.4	111.0	320.8	2,386.5
1973	77.0	232.9	131.8	-	242.3	-	-	160.7	242.0	178.7	263.4	211.3	-
1974	83.9	89.1	32.0	25.0	85.8	155.3	120.0	153.7	578.5	697.9	210.8	171.0	2,403.0
1975	170.7	34.8	0.0	1.8	35.3	78.5	67.4	159.9	182.6	579.8	547.3	438.9	2,297.0
1976	458.5	130.9	8.1	156.5	105.9	242.8	185.7	217.6	155.6	656.6	742.8	470.2	3,531.2
1977	121.5	210.2	50.5	210.6	171.2	155.8	170.6	131.6	77.3	251.1	249.8	311.1	2,111.3
1978	349.0	153.8	543.6	20.4	78.0	128.5	150.4	301.0	171.8	316.6	492.7	623.3	3,329.1
1979	220.9	374.1	93.9	52.8	247.0	261.6	137.6	403.1	288.0	539.7	1,118.4	327.3	4,064.4
1980	189.7	178.2	162.6	-	-	-	-	-	-	-	-	-	-
Ave.	247.5	198.4	116.8	50.3	97.6	175.5	152.2	188.1	225.1	426.7	466.9	385.6	2,728.3

(unit : mm)

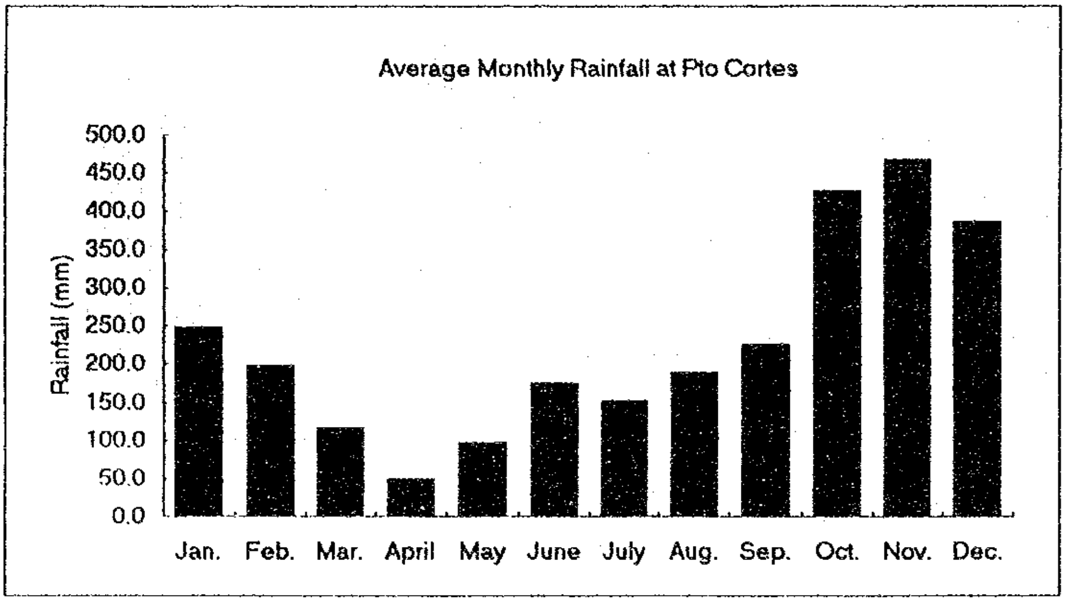


TABLE A.4.4 AVERAGE MONTHLY RAINFALL AT OMOA

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1987	140.6	140.9	126.7	55.7	2.7	37.7	214.1	232.1	210.7	216.6	505.1	429.2	2,312.1
1988	459.6	511.6	144.0	116.3	9.4	179.8	253.7	183.5	107.0	1,008.4	180.7	559.8	3,713.8
1989	252.4	136.3	14.5	11.0	15.9	16.9	142.5	100.0	156.3	492.0	706.7	428.2	2,472.7
1990	277.6	241.3	244.8	-	82.8	144.4	254.0	406.5	564.9	226.5	1,031.0	238.8	-
1991	147.7	14.7	94.1	9.9	267.5	91.5	147.4	167.1	257.6	163.1	693.9	189.7	2,244.2
Ave.	255.6	209.0	124.8	48.2	75.7	94.1	202.3	217.8	259.3	421.3	623.5	369.1	2,685.7

(unit : mm)

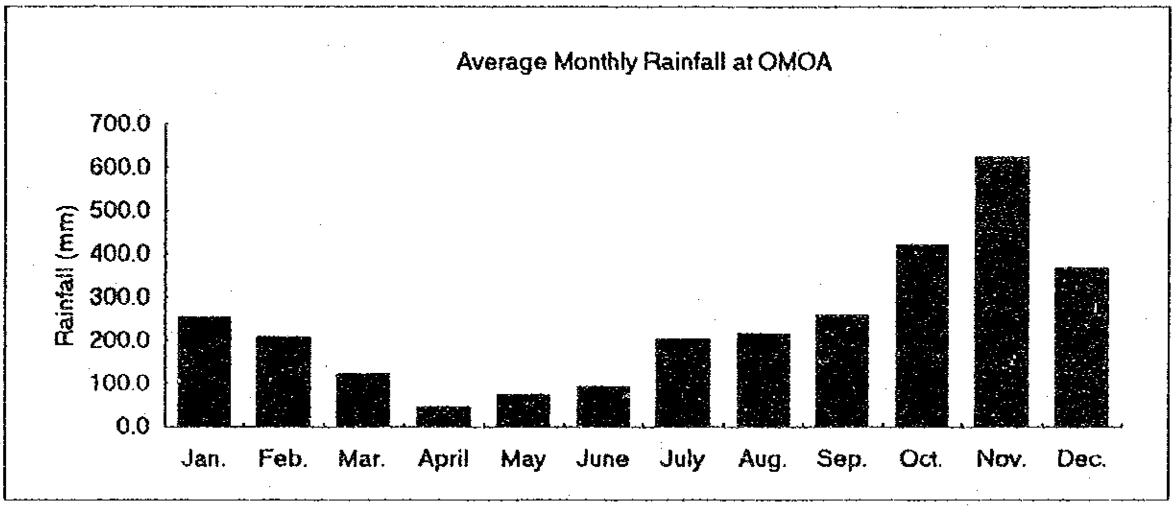


TABLE A.4.5 (1) MONTHLY MAXIMUM ONE DAY RAINFALL AT LA MESA

		Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Max.
1944	Date	-	-	9	3	31	17	27	25/27	3/21	25	9	1	
	Rainfall			10.9	30.0	32.0	52.1	21.1	33.0	52.1	53.1	17.0	30.0	53.1
1945	Date	2	25	10	6	21	17	17	-	-	27	23	10	
	Rainfall	11.9	8.9	9.9	9.9	23.1	52.1	24.4			37.1	48.0	20.1	52.1
1946	Date	24	15	9/10	19	5	16/17/26/28	28	12	20	3	27	4	
	Rainfall	3.0	45.0	10.2	25.9	8.9	2.0	58.9	23.9	14.0	4.1	14.0	9.9	58.9
1947	Date	9	14	16	27	9	16	8	1	6	5	1	6	
	Rainfall	13.0	8.1	52.1	4.1	11.9	11.9	97.0	24.9	32.0	22.1	35.1	20.1	97.0
1948	Date	9	2/3	13	3	25	10/21	18	3	24	3	11	30	
	Rainfall	27.9	52.1	10.9	16.0	55.9	21.1	42.9	22.1	52.1	13.0	35.1	52.1	55.9
1949	Date	11	10	20	6	22	22	25	12	26	11	13	25	
	Rainfall	17.3	2.3	9.9	14.0	2.0	23.1	34.0	18.0	45.0	30.0	43.9	34.0	45.0
1950	Date	21	2	30	-	-	28	16	29	14	25	13	11	
	Rainfall	36.1	11.9	48.0			50.0	23.4	50.0	39.9	56.9	19.3	22.1	56.9
1951	Date	25	3			28	23	23	23	9	-	18	17/27	
	Rainfall	9.1	6.4			53.3	97.3	26.4	40.6	21.1		2.8	2.0	97.3
1952	Date	13	27	7	27	12	7	19	-	30	8	27	11	
	Rainfall	10.4	17.0	6.1	34.5	15.2	42.4	57.4		48.3	31.0	23.9	45.2	57.4
1953	Date	24	18	27	22	27	23	26/27	15	25	30	9	31	
	Rainfall	53.3	13.0	12.7	3.3	61.0	48.3	26.7	12.7	24.6	88.9	61.0	31.8	88.9
1954	Date	7	18	4	22	12	14	18	15	27	3	3	15	
	Rainfall	32.0	10.4	25.7	23.9	15.5	45.0	51.3	30.0	148.6	55.4	61.7	17.5	148.6
1955	Date	31	15	28	16	31	21	3	30	2	31	10	16	
	Rainfall	33.0	13.5	2.5	2.5	1.3	10.9	25.7	39.6	56.4	51.6	56.4	68.1	68.1
1956	Date	4	29	25	11	25	10	6	24	15	27	10	27	
	Rainfall	17.5	14.0	14.2	24.6	26.7	33.8	16.5	36.1	50.3	137.2	64.8	49.0	137.2
1957	Date	18	11	26	15	7	21	29	15	11	25	9	9	
	Rainfall	23.6	10.7	71.9	1.8	45.7	34.3	49.8	52.3	38.6	37.8	22.4	36.1	71.9
1958	Date	4/16	3	15	13	16	12	11	10	27	20	3	21	
	Rainfall	10.7	7.6	70.4	3.3	33.8	80.5	37.1	48.8	36.1	43.7	28.4	16.5	80.5
1959	Date	16	2	9	15	31	20	19	6	22	25	28	24	
	Rainfall	12.7	4.8	18.8	31.5	17.8	58.2	13.5	32.8	34.3	62.0	28.4	36.3	62.0
1960	Date	8	26	5	11	23	9	9	28	10	23	25	13	
	Rainfall	13.0	22.6	29.5	41.9	16.0	77.7	31.0	48.0	36.8	31.2	55.4	35.1	77.7
1961	Date	17	4	9	20	25	18	23	14	4	16	5	30	
	Rainfall	56.9	29.2	21.6	9.9	11.7	16.3	102.9	17.5	29.5	34.3	28.4	14.7	102.9
1962	Date	17	12	6	17	2	11	5	14	27	4	25	30	
	Rainfall	24.9	12.2	51.3	49.0	14.0	52.3	18.5	12.4	39.1	94.7	23.1	15.0	94.7
1963	Date	31	20	23	15	20	12	28	17	24	11	2	17	
	Rainfall	8.9	81.5	42.7	3.0	9.1	33.5	20.6	47.0	66.8	23.4	30.2	21.6	81.5
1964	Date	10	29	31	17	31	6	29	13	13	20	7	7	
	Rainfall	16.5	25.9	2.0	15.0	30.5	47.2	17.3	14.7	41.1	37.3	38.1	143.3	143.3
1965	Date	-	25	5	29	1	10	17	15	21	30	5	9	
	Rainfall		17.5	8.1	9.4	31.8	48.8	42.2	13.2	12.7	120.4	39.9	43.9	120.4
1966	Date	26	4	14	10	30	4	6	17	30	25	20	11	
	Rainfall	15.5	75.4	29.0	18.8	26.9	80.0	21.1	40.9	20.3	54.1	34.0	25.9	80.0
1967	Date	29	24	10	4	24	19	16	30	26	19	6	23	
	Rainfall	34.3	35.3	6.4	12.2	10.7	46.0	9.1	39.4	36.3	75.4	51.8	61.0	75.4

(unit : mm)

TABLE A.4.5 (2) MONTHLY MAXIMUM ONE DAY RAINFALL AT LA MESA

		Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Max.
1968	Date	13	19	17	11	25	6	31	12	24	18	19	23	
	Rainfall	18.3	15.7	17.8	1.8	101.3	39.9	33.8	11.9	95.5	42.9	50.8	42.7	101.3
1969	Date	5	3	31		17	5	12	28	2	31	6	11	
	Rainfall	22.1	6.1	17.8		48.5	19.8	27.9	27.9	60.2	13.2	62.2	14.5	62.2
1970	Date	6	21	14	11	16	10	13	3	21	30	23	6	
	Rainfall	11.4	10.7	1.0	0.3	21.3	16.8	35.3	36.6	71.1	26.2	22.6	38.6	71.1
1971	Date	20	9	4	6	14	11	28	30	10	21	11	23	
	Rainfall	34.3	12.4	19.8	19.1	20.3	11.0	12.7	26.2	33.7	16.5	62.1	30.0	62.1
1972	Date	16	4	11	2	19	20	8/19	12	2	10	8	16	
	Rainfall	14.9	54.4	13.2	3.3	6.6	31.0	14.0	23.6	45.7	11.4	4.4	29.7	54.4
1973	Date	12	4	17	28	14	20	18	31	18	11	6	7	
	Rainfall	2.6	9.3	2.2	52.9	33.8	23.1	16.5	28.2	14.2	10.6	28.6	5.5	52.9
1974	Date	3	26	8	17	20	25	26	25/31	18	22	12	1	
	Rainfall	11.0	18.6	3.3	2.8	12.3	113.4	8.0	23.0	340.0	80.4	22.1	31.7	340.0
1975	Date	20	13/24			23	13	22	13	11	31	23	7	
	Rainfall	3.0	0.5			11.0	5.0	2.9	22.1	12.0	37.9	43.0	26.7	43.0
1976	Date	9	1	17	26	17	3	5	1	3	10	7	16	
	Rainfall	95.9	6.1	0.5	49.0	18.8	37.4	20.9	5.2	8.0	46.0	46.1	31.3	95.9
1977	Date	17	16	1	23	3	6	13	21	22	13	11	21	
	Rainfall	24.1	36.0	4.2	31.4	30.9	32.1	20.0	28.0	23.2	44.9	50.1	32.1	50.1
1978	Date	28	21	27	14	28	22	25	24	18	19	19	13	
	Rainfall	50.9	16.8	21.5	0.3	100.3	20.3	33.6	50.0	26.9	46.8	73.0	56.3	100.3
1979	Date	9	8	15	17	7	23	22	29	3	11	29	25	
	Rainfall	12.1	23.5	6.9	38.0	22.2	24.0	30.5	36.5	42.5	34.6	83.2	50.6	83.2
1980	Date	4	3	15	17	22	15	27	3	13	5	5	13	
	Rainfall	10.8	14.3	1.4	93.0	39.4	34.8	21.5	18.2	96.4	78.7	44.2	25.0	96.4
1981	Date	10	14	17	18	4	1	12	17	9	18	2	5	
	Rainfall	13.8	56.2	16.4	6.3	16.9	37.2	38.8	43.1	35.4	102.6	26.4	62.8	102.6
1982	Date	11	26	1	30	28	13	4	28	14	4	2	2	
	Rainfall	36.9	33.8	28.6	28.1	12.8	42.0	32.7	19.8	44.0	65.1	43.7	47.4	65.1
1983	Date	11	26	11	16	29	14	31	26	15	25	16	25	
	Rainfall	30.6	3.8	10.3	44.5	13.5	31.3	11.1	27.4	21.2	7.5	61.8	65.6	65.6
1984	Date	15	5	20	5	30	15	29	25	10	26	21	7	
	Rainfall	35.4	24.2	24.7	2.1	14.7	57.5	51.9	33.9	28.6	27.8	33.2	46.0	57.5
1985	Date	22	12	6	2	6	13	4	17	22	16	23	25	
	Rainfall	22.5	12.6	5.8	41.2	46.2	40.0	35.4	37.7	20.0	13.6	12.2	14.8	46.2
1986	Date	19	13	21	21	25	7	19	22	11	28	14	6	
	Rainfall	28.3	3.6	18.9	1.8	17.6	17.8	40.3	17.3	41.2	50.6	10.5	23.2	50.6
1987	Date	11	7	4	27		9	10	25	1	29	11	30	
	Rainfall	36.9	7.8	21.8	1.7		23.5	31.4	32.9	31.0	22.6	69.3	50.5	69.3
1988	Date	11	21	15	11	30	20	29	24	29	12	22	2	
	Rainfall	34.4	39.8	20.7	14.0	67.6	69.6	48.0	65.5	38.1	54.1	14.6	146.0	146.0
1989	Date	21	22	7	18	12	19	23	20	11	11	30	13	
	Rainfall	26.4	19.5	3.3	4.8	30.4	17.4	46.7	20.3	55.0	53.8	31.2	43.7	55.0
1990	Date	25	12	20	27	23	17	30	11	27	25	29	4	
	Rainfall	23.9	31.8	32.4	25.6	14.2	20.0	13.5	15.0	36.4	34.4	104.5	46.9	104.5
1991	Date	7	15	10	1	26	9	4	6	20	19	25	14	
	Rainfall	18.1	6.5	37.2	1.2	17.0	154.4	14.2	26.3	20.4	19.4	37.5	20.3	154.4

(unit : mm)

TABLE A.4.6 MONTHLY MAXIMUM ONE DAY RAINFALL AT PUERTO CORTES

		Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Max.
1945	Date	-	3	22		25	20	2	31	28	-	-	-	
	Rainfall		12.7	3.6		66.0	43.4	63.0	154.9	160.5				160.5
1946	Date	25	5	5	28	5	11	18	21	2	30	28	5	
	Rainfall	86.4	21.6	21.6	11.4	8.4	54.9	21.3	35.8	18.0	154.2	180.8	121.9	180.8
1947	Date	24	26	17	17	9	13	-	-	13	21	28	23	
	Rainfall	38.1	76.2	70.4	48.3	24.1	34.8			42.7	80.0	85.1	123.2	123.2
1948	Date	31	3	12	18	21	25	8	19	17	20	12	30	
	Rainfall	120.9	64.8	23.1	28.2	35.1	76.2	31.2	48.5	41.9	97.8	94.7	100.3	120.9
1949	Date	12	2	1	6	23	20	30	31	6	15	1	25	
	Rainfall	47.8	5.3	12.7	22.4	16.3	17.0	40.9	41.9	22.9	15.2	70.9	153.2	153.2
1950	Date	22	17	31	7	8	9	11	12	22	25	-	-	
	Rainfall	30.0	44.2	17.8	25.1	1.0	56.9	73.2	37.3	36.8	163.1	43.9	34.0	163.1
1962	Date	-	-	17	-	6	-	17	2	21	3	11	14	
	Rainfall			17.0		18.5		41.9	48.3	178.8	154.9	152.4	118.4	178.8
1963	Date	21	14	23	4	30	24	14	16	24	5	18	17	
	Rainfall	33.0	70.1	118.6	24.1	36.3	29.0	16.0	55.6	40.6	77.2	214.9	103.4	214.9
1964	Date	10	28	-	16	15	21	20	22	16	20	8	1	
	Rainfall	40.6		69.9	5.1	7.9	51.1	37.1	52.1	38.1	85.1	76.2	150.6	150.6
1965	Date	17	25	4	30	2	9	13	30	14	30	6	8	
	Rainfall	125.0	80.0	31.8	30.5	15.2	64.0	57.7	30.7	31.8	143.5	136.7	83.3	143.5
1966	Date	6	4	30	6	10	4	8	1	9	29	-	-	
	Rainfall	171.2	157.7	71.9	17.3	27.7	207.0	74.9	22.9	34.8	175.3			207.0
1967	Date	29	12	31	5	23	21	24	20	9	9	5	23	
	Rainfall	101.6	71.1	34.3	100.1	71.1	51.1	34.3	63.2	73.4	80.0	83.8	43.2	101.6
1968	Date	16	5	22	6	5	20	5	12	24	24	19	7	
	Rainfall	22.4	74.4	44.5	14.7	127.0	25.4	50.8	119.9	34.3	130.8	127.0	139.7	139.7
1969	Date	19	4	3	2	28	28	19	26	2	24	19	12	
	Rainfall	82.6	53.3	127.3	7.9	81.3	81.3	20.1	29.2	144.8	92.7	157.7	88.9	157.7
1970	Date	9	1	13	3	16	8	11	22	7	20	14	5	
	Rainfall	74.9	34.3	16.8	24.6	50.8	62.0	35.3	12.7	97.0	33.3	81.3	46.2	97.0
1971	Date	16	9	4	3	15	5	5	29	11	13	20	12	
	Rainfall	49.5	66.0	43.2	24.6	18.8	50.8	13.0	50.8	50.8	50.8	102.6	88.9	102.6
1972	Date	17	3	10	2	31	11	19	15	27	3	8	17	
	Rainfall	59.7	114.8	25.9	26.7	59.7	74.9	33.3	39.6	45.7	62.0	33.5	123.2	123.2
1973	Date	28	4	3	-	28	-	-	8/9	2	25	29	7	
	Rainfall	24.6	50.8	45.0		81.3			40.1	49.5	43.4	48.3	113.5	113.5
1974	Date	8	28	13	5	22	28	9	31	18	10	12	17	
	Rainfall	12.7	52.1	19.3	7.1	71.6	43.2	55.9	45.2	283.2	136.7	59.7	87.9	283.2
1975	Date	27	13		4	13	28	1	17	29	28	23	26	
	Rainfall	39.1	11.2		1.0	25.7	46.2	41.9	35.3	46.0	107.2	103.4	91.2	107.2
1976	Date	9	23	5	25	18	4	23	6	12	20	23	23	
	Rainfall	131.3	44.7	4.3	94.0	49.8	78.7	88.9	27.2	33.0	165.9	231.1	101.6	231.1
1977	Date	18	16	23	23	31	1	2	7	17	14	25	21	
	Rainfall	40.6	68.8	36.6	50.8	78.2	58.4	37.1	21.1	17.8	83.1	62.2	132.1	132.1
1978	Date	29	4	4	14	19	16	20	6	4	31	19	11	
	Rainfall	113.0	53.8	108.0	6.4	43.2	20.3	26.4	43.7	41.9	58.9	152.4	209.8	209.8
1979	Date	2	11	26	15	27	30	22	7	24	2	29	25	
	Rainfall	120.9	148.6	24.1	28.4	165.6	51.8	37.3	83.8	50.8	83.3	229.9	95.3	229.9
1980	Date	23	3	2	-	-	-	-	-	-	-	-	-	
	Rainfall	115.8	57.2	6.3										115.8

(unit : mm)

TABLE A.4.7 (1) MONTHLY MAXIMUM 6 HOURS RAINFALL AT LA MESA

		Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Max.
1956	Date	4	29	25	26	25	10	6	24	15	27	10	27	
	Rainfall	8.9	14.0	10.9	16.0	26.7	33.8	16.3	36.1	48.8	66.0	35.6	22.9	66.0
1957	Date	11	11	26	15	7	21	29	15	11	25	9	9	
	Rainfall	18.8	10.7	27.7	1.8	45.2	26.2	49.8	50.3	38.6	36.8	22.4	32.5	50.3
1958	Date	29	3	15	13	16	12	11	10	27	20	3	21	
	Rainfall	9.1	5.1	66.0	3.3	33.5	80.5	36.3	47.2	36.1	42.7	28.4	6.4	80.5
1959	Date	16	2	9	15	31	20	19	6	22	25	6.	24	
	Rainfall	12.7	4.8	17.8	27.9	17.0	58.2	12.7	30.7	33.0	38.9	23.1	30.5	58.2
1960	Date	9	26	5	11	23	9	9	28	10	24	25	13	
	Rainfall	6.6	22.6	13.7	17.0	16.0	52.8	29.7	45.5	36.8	17.8	44.5	17.8	52.8
1961	Date	17	4	9	2	25	18	23	14	4	16	5	3	
	Rainfall	23.6	25.1	21.6	6.4	7.1	16.3	40.6	15.7	22.4	26.2	27.7	9.4	40.6
1962	Date	23	12	6	16	2	11	5	14	27	4	25	30	
	Rainfall	11.2	8.9	50.0	30.5	14.0	35.6	18.5	12.4	20.8	64.3	17.5	7.6	64.3
1963	Date	31	20	23	15	23	12	28	17	24	11	2	17	
	Rainfall	6.6	28.2	25.7	3.0	9.1	33.5	20.3	45.7	66.8	22.9	23.6	20.3	66.8
1964	Date	10	29	31	17	31	6	29	10/13	22	21	7	7	
	Rainfall	15.0	15.0	1.3	12.7	30.5	47.2	15.0	13.5	32.3	20.6	33.0	53.3	53.3
1965	Date	14	25	5	29	1	10	17	17	21/25	30	5	9	
	Rainfall	10.2	8.4	3.8	9.4	14.7	48.3	37.8	8.9	10.7	82.8	24.9	16.8	82.8
1966	Date	26	4	14	10	30	5	6	17	30	25	29	11	
	Rainfall	10.4	35.6	25.7	18.8	26.9	44.7	21.1	38.4	20.3	51.6	15.2	22.4	51.6
1967	Date	20	12	10	4	24	17	2	30	26	19	10	23	
	Rainfall	22.1	24.9	6.4	12.2	8.9	51.8	7.4	31.0	35.8	66.0	46.5	35.6	66.0
1968	Date	14	19	17	11	25	6	31	25	24	18	30	24	
	Rainfall	10.7	15.2	15.0	1.8	98.6	30.7	33.8	8.6	84.8	37.8	25.1	23.9	98.6
1969	Date	5	3	4	1	17	5	12	28	15	4	20	11	
	Rainfall	20.8	5.8	10.2	7.6	48.5	19.8	27.9	27.9	34.8	3.0	33.0	12.4	48.5
1970	Date	7	22	14	11	17	10	13	3	21	30	28	6	
	Rainfall	11.4	5.8	1.0		15.0	16.8	33.0	29.0	71.1	24.9	20.6	20.3	71.1
1971	Date	20	9	5	6	15	10	28	31	10	14	11	23	
	Rainfall	19.6	5.8	19.8	8.9	20.3	10.2	12.7	26.2	21.3	11.4	25.4	26.2	26.2
1972	Date	17	4	11	2	20	20	8/19	12	2	10	30	16	
	Rainfall	14.7	21.1	12.7	3.3	6.6	31.0	14.0	23.6	45.7	11.4	3.8	13.5	45.7
1973	Date	12	28	1	28	15	20	19	31	17	17	6	8	
	Rainfall	3.0	3.3	2.0	26.2	33.5	21.6	16.4	19.1	11.2	10.4	27.0	5.5	33.5
1974	Date	3	26	8	6/17	21	25	26	25	19	23	12	1	
	Rainfall	11.0	12.0	3.3	2.6	11.9	110.4	8.0	21.0	140.0	80.0	22.0	23.3	140.0
1975	Date	21	24			23	13	7	13	12	31	23	7	
	Rainfall	3.0	0.5			11.0	5.0	2.0	22.1	9.1	36.0	21.2	16.4	36.0
1976	Date	9	2	17	26	17	3	25	1	3	10	7	15	
	Rainfall	46.0	6.1	0.5	37.0	18.8	30.0	18.0	5.2	8.0	36.0	22.7	26.0	46.0
1977	Date	17	16	1	24	4	18	14	27	23	13	11	21	
	Rainfall	16.0	16.1	5.0	29.0	26.7	23.2	20.0	14.7	23.2	25.3	30.0	27.5	30.0
1978	Date	28	21	5	15	28	13	25	25	19	6	20	13	
	Rainfall	32.6	12.4	15.4	0.3	80.0	18.8	33.6	30.0	20.8	23.4	34.4	50.0	80.0
1979	Date	9	19	7	18	7	23	22	29	20	5	14	25	
	Rainfall	11.8	17.0	4.3	38.0	22.2	21.3	30.3	36.5	34.0	22.0	28.1	27.8	38.0

(unit : mm)

TABLE A.4.7 (2) MONTHLY MAXIMUM 6 HOURS RAINFALL AT LA MESA

		Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Max.
1980	Date	4	3	15	17	22	15	27	3	13	6	5	13	
	Rainfall	6.2	12.4	1.4	30.0	33.2	34.6	13.1	16.0	96.4	37.2	40.5	12.2	96.4
1981	Date	11	13	17	18	4	16	12	17	9	19	2	5	
	Rainfall	9.3	33.0	14.2	6.3	16.9	36.1	25.8	42.9	34.4	62.0	20.5	24.0	62.0
1982	Date	9	27	2	12	1	13	4	28	22	4	2	13	
	Rainfall	25.5	33.8	25.6	9.0	27.9	39.0	30.2	19.7	41.9	64.2	43.5	22.4	64.2
1983	Date	12	26	11	16	30	14	31	26	15	14	16-	30	
	Rainfall	30.6	1.9	8.4	37.5	12.1	24.0	9.4	21.0	19.0	5.3	35.0	60.5	60.5
1984	Date	15	5	21	6	28	16	29	2/25	10	26	22	7	
	Rainfall	15.2	10.0	17.5	1.2	11.6	57.5	51.2	23.6	25.2	22.3	28.5	25.3	57.5
1985	Date	22	12	6	2	7	13	4	17	22	16	23	14	
	Rainfall	10.0	12.1	5.1	38.0	46.2	40.0	35.4	33.7	20.0	10.0	12.2	8.2	46.2
1986	Date	20	3	21	21	28	7	23	18	12	28	14	3	
	Rainfall	13.0	3.5	14.9	1.8	14.5	17.5	31.5	16.0	41.0	47.6	7.4	22.1	47.6
1987	Date	12	7	13	27		9	10	25	1	30	11	17	
	Rainfall	34.7	3.6	16.0	1.6		23.5	28.1	23.2	30.0	10.0	60.0	27.0	60.0
1988	Date	22	21	15	11	30	20	27	24	29	12	22	2	
	Rainfall	22.1	20.2	9.6	9.0	67.2	43.8	38.1	43.0	35.6	30.4	11.9	60.2	67.2
1989	Date	21	22	7	12	12	19	23	20	12	11	30	14	
	Rainfall	15.9	14.6	2.2	3.4	30.0	17.3	46.1	20.3	36.0	51.9	27.7	32.2	51.9
1990	Date	26	12	21	28	27	17	31	11	28	25	29	5	
	Rainfall	23.9	19.7	20.2	25.6	13.3	20.0	13.5	12.0	24.4	28.5	50.8	38.1	50.8
1991	Date	7	16	10	2	27	10	4	6	2	19	25	4	
	Rainfall	18.0	4.1	29.0	0.9	17.0	154.4	14.2	26.3	26.8	11.8	16.2	15.5	154.4

(unit : mm)

TABLE A.4.8 YEARLY MAXIMUM ONE HOUR AND 2 HOURS RAINFALL AT LA MESA

Year	1 hour	2 hour
1966	38.1	40.6
1967	41.9	55.9
1968	-	-
1969	35.6	36.8
1970	27.9	31.8
1971	14.0	19.1
1972	25.4	26.7
1973	22.9	26.7
1974	-	-
1975	21.2	25.0
1976	-	-
1977	-	-
1978	-	-
1979	-	-
1980	54.0	82.1
1981	31.5	36.0
1982	52.5	57.0
1983	33.0	38.0
1984	43.0	49.5
1985	46.2	46.2
1986	-	-
1987	-	-
1988	-	-
1989	-	-
1990	-	-
1991	18.9	20.0

(Unit : mm)

Note : Record sheets are partially lacked.

TABLE A.4.9 RESULT OF FREQUENCY ANALYSIS
(ONE DAY RAINFALL AT LA MESA AND PUERTO CORTES)

STATION NAME: **La Mesa** 1 day Rainfall

RETURN PERIOD	IWAI METHOD	THOMAS METHOD	HAZEN METHOD	GUMBEL METHOD
2	75.4	78.4	78.4	78.8
5	107.6	110.9	108.8	124.9
10	132.1	132.9	129.1	155.5
20	157.9	154.4	148.7	184.8
30	173.8	166.9	160.0	201.6
50	194.6	182.7	174.3	222.7
70	209.0	193.2	183.8	236.5
100	224.7	204.4	193.8	251.1
150	243.2	217.3	205.3	267.6
200	256.9	226.5	213.6	279.4
500	302.9	256.5	240.2	316.7
1000	340.7	279.9	260.9	344.9

Unit : mm

STATION NAME: **Puerto Cortes** 1 day Rainfall

RETURN PERIOD	IWAI METHOD	THOMAS METHOD	HAZEN METHOD	GUMBEL METHOD
2	149.3	151.8	151.8	152.2
5	199.1	206.1	199.1	209.1
10	233.5	241.8	229.4	246.8
20	267.3	276.0	257.9	283.0
30	287.1	295.6	274.1	303.8
50	312.2	320.2	294.3	329.8
70	329.1	336.4	307.4	346.8
100	347.1	353.6	321.3	364.8
150	367.8	373.2	337.1	385.3
200	382.8	387.2	348.3	399.8
500	431.5	432.1	383.9	445.8
1000	469.8	466.7	411.0	480.7

Unit : mm

Note : To calculate the probable rainfall, 1962 - 1980 rainfall data are used.

TABLE A.4.10 RESULT OF FREQUENCY ANALYSIS
(6 HOURS RAINFALL AT LA MESA)

STATION NAME: **La Mesa** 6 hous Rainfall

RETURN PERIOD	IWAI METHOD	THOMAS METHOD	HAZEN METHOD	GUMBEL METHOD
2	58.4	58.7	58.7	59.1
5	81.1	82.9	81.0	86.2
10	96.6	99.2	95.9	104.2
20	111.6	115.2	110.2	121.4
30	120.4	124.5	118.5	131.3
50	131.5	136.2	128.9	143.7
70	138.9	144.0	135.8	151.8
100	146.8	152.3	143.1	160.4
150	155.9	161.9	151.4	170.1
200	162.4	168.7	157.4	177.0
500	183.5	190.9	176.7	199.0
1000	200.0	208.3	191.7	215.6

Unit : mm

TABLE A.4.11 RESULT OF FREQUENCY ANALYSIS (ONE HOUR AND 2 HOURS RAINFALL AT LA MESA)

STATION NAME: **La Mesa** 1 hour Rainfall

RETURN PERIOD	IWAI METHOD	THOMAS METHOD	HAZEN METHOD	GUMBEL METHOD
2	32.5	31.5	31.5	32.0
5	43.7	46.0	43.8	45.2
10	50.4	56.0	52.0	53.9
20	56.4	65.8	59.9	62.3
30	59.7	71.6	64.5	67.1
50	63.7	79.0	70.3	73.2
70	66.2	84.0	74.1	77.1
100	68.9	89.3	78.2	81.3
150	71.9	95.4	82.9	86.1
200	74.0	99.8	86.2	89.4
500	80.5	114.3	97.0	100.1
1000	85.3	125.7	105.4	108.2

Unit : mm

STATION NAME: La Mesa 2 hours rainfall

RETURN PERIOD	IWAI METHOD	THOMAS METHOD	HAZEN METHOD	GUMBEL METHOD
2	37.4	36.5	36.4	37.1
5	51.8	54.0	51.3	55.2
10	60.7	66.2	61.4	67.1
20	69.0	78.5	71.2	78.6
30	73.6	85.7	76.9	85.3
50	79.2	94.9	84.2	93.5
70	82.9	101.1	88.9	98.9
100	86.7	107.8	94.1	104.7
150	91.1	115.5	99.9	111.2
200	94.1	121.1	104.1	115.8
500	103.7	139.4	117.8	130.4
1000	111.0	153.9	128.4	141.5

Unit : mm

TABLE A.4.12 RESULTS OF THE ESTIMATION OF CONSTANTS FOR FORMULA OF RAINFALL INTENSITY AND TIME DURATION

Calculation of Constants a and b / **Calculation of Deviation**

n= 0.5

N	Rainfall Duration t (min.)	Rainfall Amount R (mm)	Rainfall Intensity r (mm/hr)	t^n	r*t^n	r^2	r^2*t^n	Calculated Rainfall Intensity	Deviation s	s^2
1	60.0	73.2	73.2	7.7	567.0	5,358.2	41,504.7	76.4	-3.2	10.3
2	120.0	93.5	46.8	11.0	512.1	2,185.6	23,941.6	45.0	1.8	3.2
3	360.0	143.7	24.0	19.0	454.4	573.6	10,883.3	22.2	1.8	3.2
4	1,440.0	222.7	9.3	37.9	352.1	86.1	3,267.4	10.1	-0.8	0.6
Total (Σ)			153.2		1,885.7	8,203.5	79,597.1			17.3

a = (Σr*Σ(r^2*t^n)-Σ(r^2)*Σ(r*t^n)) / ((Σr)^2-N*Σ(r^2)) = 350
b = (N*Σ(r^2*t^n)-Σr*Σ(r*t^n)) / ((Σr)^2-N*Σ(r^2)) = -3.16

n= 0.6

N	Rainfall Duration t (min.)	Rainfall Amount R (mm)	Rainfall Intensity r (mm/hr)	t^n	r*t^n	r^2	r^2*t^n	Calculated Rainfall Intensity	Deviation s	s^2
1	60.0	73.2	73.2	11.7	853.9	5,358.2	62,504.7	74.3	-1.1	1.3
2	120.0	93.5	46.8	17.7	826.6	2,185.6	38,643.1	46.4	0.3	0.1
3	360.0	143.7	24.0	34.2	818.6	573.6	19,606.2	22.9	1.1	1.2
4	1,440.0	222.7	9.3	78.5	728.7	86.1	6,761.4	9.7	-0.4	0.1
Total (Σ)			153.2		3,227.8	8,203.5	127,515.4			2.8

a = (Σr*Σ(r^2*t^n)-Σ(r^2)*Σ(r*t^n)) / ((Σr)^2-N*Σ(r^2)) = 743
b = (N*Σ(r^2*t^n)-Σr*Σ(r*t^n)) / ((Σr)^2-N*Σ(r^2)) = -1.67

n= 0.666666667

N	Rainfall Duration t (min.)	Rainfall Amount R (mm)	Rainfall Intensity r (mm/hr)	t^n	r*t^n	r^2	r^2*t^n	Calculated Rainfall Intensity	Deviation s	s^2
1	60.0	73.2	73.2	15.3	1,121.9	5,358.2	82,121.4	73.1	0.1	0.0
2	120.0	93.5	46.8	24.3	1,137.4	2,185.6	53,172.1	47.4	-0.6	0.4
3	360.0	143.7	24.0	50.6	1,212.0	573.6	29,027.7	23.4	0.6	0.3
4	1,440.0	222.7	9.3	127.5	1,183.3	86.1	10,979.8	9.4	-0.1	0.0
Total (Σ)			153.2		4,654.5	8,203.5	175,301.0			0.7

a = (Σr*Σ(r^2*t^n)-Σ(r^2)*Σ(r*t^n)) / ((Σr)^2-N*Σ(r^2)) = 1212
b = (N*Σ(r^2*t^n)-Σr*Σ(r*t^n)) / ((Σr)^2-N*Σ(r^2)) = 1.26

n= 0.7

N	Rainfall Duration t (min.)	Rainfall Amount R (mm)	Rainfall Intensity r (mm/hr)	t^n	r*t^n	r^2	r^2*t^n	Calculated Rainfall Intensity	Deviation s	s^2
1	60.0	73.2	73.2	17.6	1,285.9	5,358.2	94,130.0	72.5	0.7	0.5
2	120.0	93.5	46.8	28.5	1,334.2	2,185.6	62,372.1	47.8	-1.1	1.2
3	360.0	143.7	24.0	61.6	1,474.7	573.6	35,320.2	23.6	0.3	0.1
4	1,440.0	222.7	9.3	162.5	1,507.9	86.1	13,991.7	9.3	0.0	0.0
Total (Σ)			153.2		5,602.7	8,203.5	205,814.0			1.8

a = (Σr*Σ(r^2*t^n)-Σ(r^2)*Σ(r*t^n)) / ((Σr)^2-N*Σ(r^2)) = 1544
b = (N*Σ(r^2*t^n)-Σr*Σ(r*t^n)) / ((Σr)^2-N*Σ(r^2)) = 3.74

n= 0.75

N	Rainfall Duration t (min.)	Rainfall Amount R (mm)	Rainfall Intensity r (mm/hr)	t^n	r*t^n	r^2	r^2*t^n	Calculated Rainfall Intensity	Deviation s	s^2
1	60.0	73.2	73.2	21.6	1,578.1	5,358.2	115,514.3	71.6	1.6	2.6
2	120.0	93.5	46.8	36.3	1,695.0	2,185.6	79,240.9	48.5	-1.8	3.2
3	360.0	143.7	24.0	82.6	1,979.4	573.6	47,406.5	24.1	-0.1	0.0
4	1,440.0	222.7	9.3	233.8	2,169.1	86.1	20,127.5	9.1	0.2	0.0
Total (Σ)			153.2		7,421.6	8,203.5	262,289.1			5.8

a = (Σr*Σ(r^2*t^n)-Σ(r^2)*Σ(r*t^n)) / ((Σr)^2-N*Σ(r^2)) = 2214
b = (N*Σ(r^2*t^n)-Σr*Σ(r*t^n)) / ((Σr)^2-N*Σ(r^2)) = 9.38

n= 0.8

N	Rainfall Duration t (min.)	Rainfall Amount R (mm)	Rainfall Intensity r (mm/hr)	t^n	r*t^n	r^2	r^2*t^n	Calculated Rainfall Intensity	Deviation s	s^2
1	60.0	73.2	73.2	26.5	1,936.6	5,358.2	141,756.6	70.8	2.4	6.0
2	120.0	93.5	46.8	46.1	2,153.4	2,185.6	100,671.9	49.2	-2.5	6.0
3	360.0	143.7	24.0	110.9	2,656.7	573.6	63,628.7	24.5	-0.6	0.3
4	1,440.0	222.7	9.3	336.3	3,120.3	86.1	28,954.0	8.9	0.3	0.1
Total (Σ)			153.2		9,867.0	8,203.5	335,011.1			12.5

a = (Σr*Σ(r^2*t^n)-Σ(r^2)*Σ(r*t^n)) / ((Σr)^2-N*Σ(r^2)) = 3169
b = (N*Σ(r^2*t^n)-Σr*Σ(r*t^n)) / ((Σr)^2-N*Σ(r^2)) = 18.33

TABLE A.5.1 CATCHMENT AREA OF SUB-BASIN

		Catchment/River	
		C.A. (sq. km)	L (km)
I	**Rio Choloma, Rio Blanco, Canal San Roque, Canal S. R.- C. and Canal C.- H.- C. Basin**		
C-1	River Mouth of the Basin	**420.15**	**48.4**
C-2	Choloma, Blanco, San Roque, Canal San Roque - Cuabanos, C-H-C Basin	**366.45**	**42.1**
	i Canal Copen-Higuero-Cuabanos	33.43	9.6
	ii Choloma, Blanco and San Roque	333.02	42.1
C-3	Rio Choloma, Rio Blanco and S.R. Basin	**297.13**	**37.4**
RC-1	Rio Choloma Basin	**106.89**	**20.7**
RC-2	i at Choloma Bridge	71.64	13.6
RC-3	ii at Jutosa (Junction of Rio La Jutosa)	55.02	9.4
C-4	Rio Blanco - Canal San Roque Basin	**190.24**	**37.4**
RB-1	Rio Blanco Basin	**137.98**	**31.0**
RB-2	i Outlet of Laguna El Carmen	107.41	22.7
RB-3	ii Inlet of Laguna El Carmen	83.72	19.2
RB-4	iii Prop. Diversion Point	71.35	15.7
RB-5	iv Rio del Zapotal and Rio de Armenta	43.90	12.2
II	**Rio El Sauce and Rio El Sauce (viejo) - Chotepe Basin**		
S-1	River Mouth of Rio El Sauce	**215.70**	**29.9**
RS-1	Rio El Sauce Basin	**118.33**	**29.7**
RS-2	i Mid. of Rio El Sauce	79.98	21.8
RS-3	ii Jct. of Prop. Diversion	75.33	18.1
RS-4	iii Rio Santa Ana and Rio Piedras	72.16	15.4
RSB-1	iv Rio Santa Ana Basin (at National Road)	37.63	13.4
RSP-1	v Rio Piedras Basin (at National Road)	30.87	12.6
RSV-1	Rio El Sauce (viejo) - Chotepe Basin	**97.37**	**22.9**

Note: Retention effect of Laguna El Carmen is not considered in this calculation

C.A. : Catchment Area of the Basin (sq. km) L : Maximum River Length of the Basin (km)
S.R. : Canal San Roque S.R.-C : Canal San Roque Cuabanos
C-H-C : Canal Copen-Higuero-Cuabanos

TABLE A.5.2 RESULT OF RUN-OFF SIMULATION BY UNIT HYDROGRAPH METHOD (100-YEAR RETURN PERIOD)

		Catchment/River		Peak Discharge (qu. m / sec.)		
		C.A.	L	Rainfall Pattern		
		(sq. km)	(km)	A	B	C
I	**Rio Choloma, Rio Blanco, Canal San Roque, Canal S.R.-C and Canal C-H-C Basin**					
C-1	River Mouth of the Basin	**420.15**	**48.4**	**1023.6**	**1,793.4**	**2,285.9**
C-2	Choloma, Blanco, S.R. ,S.R.-C ,C-H-C Basin	**366.45**	**42.1**	**896.0**	**1,612.4**	**2,114.5**
	i Canal Copen-Higuero-Cuabanos	33.43	9.6	126.3	303.1	387.3
	ii Choloma, Blanco and San Roque	333.02	42.1	822.5	1,487.4	1,949.6
C-3	Rio Choloma, Rio Blanco and S.R. Basin	**297.13**	**37.4**	**764.7**	**1,394.5**	**1,826.7**
RC-1	Rio Choloma Basin	**106.89**	**20.7**	**330.2**	**678.3**	**888.3**
RC-2	i at Choloma Bridge	71.64	13.6	250.1	543.5	688.1
RC-3	ii at Jutosa (Junction of Rio La Jutosa)	55.02	9.4	198.6	458.1	596.7
C-4	Rio Blanco - Canal San Roque Basin	**190.24**	**37.4**	**517.1**	**964.6**	**1,250.1**
RB-1	Rio Blanco Basin	**137.98**	**31.0**	**383.1**	**741.9**	**998.7**
RB-2	i Outlet of Laguna El Carmen	107.41	22.7	325.9	663.4	872.4
RB-3	ii Inlet of Laguna El Carmen	83.72	19.2	270.1	568.1	733.9
RB-4	iii Prop. Diversion Point	71.35	15.7	244.9	527.2	671.2
RB-5	iv Rio del Zapotal and Rio de Armenta	43.90	12.2	165.4	375.3	463.7
II	**Rio El Sauce and Rio El Sauce (viejo) - Chotepe Basin**					
S-1	River Mouth of Rio El Sauce	**215.70**	**29.9**	**575.0**	**1,087.7**	**1,474.7**
RS-1	Rio El Sauce Basin	**118.33**	**29.7**	**336.8**	**663.3**	**885.7**
RS-2	i Mid. of Rio El Sauce	79.98	21.8	252.3	528.1	684.6
RS-3	ii Jct. of Prop. Diversion	75.33	18.1	249.4	530.0	680.2
RS-4	iii Rio Santa Ana and Rio Piedras	72.16	15.4	248.3	534.8	680.7
RSB-1	iv Rio Santa Ana Basin (at National Road)	37.63	13.4	141.4	322.4	397.4
RSP-1	v Rio Piedras Basin (at National Road)	30.87	12.6	119.8	278.7	339.8
RSV-1	Rio El Sauce (viejo) - Chotepe Basin	**97.37**	**22.9**	**297.6**	**611.1**	**800.5**

Note: Retention effect of Laguna El Carmen is not considered in this calculation
C.A. : Catchment Area of the Basin (sq. km) L : Maximum River Length of the Basin (km)
S.R. : Canal San Roque S.R.-C : Canal San Roque Cuabanos
C-H-C : Canal Copen-Higuero-Cuabanos

Rainfall Pattern
A : Maximum intensity of rainfall occures at the beginning of the rain.
B : Maximum intensity of rainfall occures at the midlle of the rain.
C : Maximum intensity of rainfall occures at the end of the rain.

Runoff(100)

TABLE A.5.3 RESULT OF RUN-OFF SIMULATION BY UNIT HYDROGRAPH METHOD (50-YEAR RETURN PERIOD)

		Catchment/River		Peak Discharge (qu. m / sec.)		
		C.A.	L	Pattern		
		(sq. km)	(km)	A	B	C
I	**Rio Choloma, Rio Blanco, Canal San Roque, Canal S.R.-C and Canal C-H-C Basin**					
C-1	River Mouth of the Basin	**420.15**	**48.4**	**851.9**	**1,514.6**	**2,010.9**
C-2	Choloma, Blanco, S.R. ,S.R.-C ,C-H-C Basin	**366.45**	**42.1**	**744.6**	**1,360.5**	**1,862.1**
	i Canal Copen-Higuero-Cuabanos	33.43	9.6	100.3	252.4	345.6
	ii Choloma, Blanco and San Roque	333.02	42.1	683.9	1,255.3	1,717.6
C-3	Rio Choloma, Rio Blanco and S.R. Basin	**297.13**	**37.4**	**634.3**	**1,177.5**	**1,610.7**
RC-1	Rio Choloma Basin	**106.89**	**20.7**	**271.3**	**564.8**	**787.7**
RC-2	i at Choloma Bridge	71.64	13.6	202.6	453.2	611.9
RC-3	ii at Jutosa (Junction of Rio La Jutosa)	55.02	9.4	159.6	381.2	531.6
C-4	Rio Blanco - Canal San Roque Basin	**190.24**	**37.4**	**424.7**	**806.7**	**1,104.1**
RB-1	Rio Blanco Basin	**137.98**	**31.0**	**313.6**	**620.6**	**883.7**
RB-2	i Outlet of Laguna El Carmen	107.41	22.7	267.6	552.3	773.4
RB-3	ii Inlet of Laguna El Carmen	83.72	19.2	220.8	473.3	651.5
RB-4	iii Prop. Diversion Point	71.35	15.7	198.8	439.5	596.6
RB-5	iv Rio del Zapotal and Rio de Armenta	43.90	12.2	132.4	313.3	413.1
II	**Rio El Sauce and Rio El Sauce (viejo) - Chotepe Basin**					
S-1	River Mouth of Rio El Sauce	**215.70**	**29.9**	**472.7**	**918.0**	**1,302.9**
RS-1	Rio El Sauce Basin	**118.33**	**29.7**	**276.0**	**551.9**	**784.2**
RS-2	i Mid. of Rio El Sauce	79.98	21.8	206.7	439.9	607.6
RS-3	ii Jct. of Prop. Diversion	75.33	18.1	203.2	441.7	604.2
RS-4	iii Rio Santa Ana and Rio Piedras	72.16	15.4	201.6	445.8	605.0
RSB-1	iv Rio Santa Ana Basin (at National Road)	37.63	13.4	113.0	269.2	354.1
RSP-1	v Rio Piedras Basin (at National Road)	30.87	12.6	95.8	232.8	303.0
RSV-1	Rio El Sauce (viejo) - Chotepe Basin	**97.37**	**22.9**	**244.6**	**508.8**	**709.9**

Note: Retention effect of Laguna El Carmen is not considered in this calculation

C.A. : Catchment Area of the Basin (sq. km) L : Maximum River Length of the Basin (km)
S.R. : Canal San Roque S.R.-C : Canal San Roque Cuabanos
C-H-C : Canal Copen-Higuero-Cuabanos

Rainfall Pattern

A : Maximum intensity of rainfall occures at the beginning of the rain.
B : Maximum intensity of rainfall occures at the midlle of the rain.
C : Maximum intensity of rainfall occures at the end of the rain.

RUNOFF(1/50)

TABLE A.5.4 RESULT OF RUN-OFF SIMULATION BY UNIT HYDROGRAPH METHOD (30-YEAR RETURN PERIOD)

		Catchment/River		Peak Discharge (qu. m / sec.)		
		C.A.	L	Pattern		
		(sq. km)	(km)	A	B	C
I	**Rio Choloma, Rio Blanco, Canal San Roque, Canal S.R.-C and Canal C-H-C Basin**					
C-1	River Mouth of the Basin	**420.15**	**48.4**	**724.7**	**1,305.3**	**1,800.9**
C-2	Choloma, Blanco, S.R. ,S.R.-C ,C-H-C Basin	**366.45**	**42.1**	**631.6**	**1,171.2**	**1,669.5**
	i Canal Copen-Higuero-Cuabanos	33.43	9.6	83.7	213.5	313.9
	ii Choloma, Blanco and San Roque	333.02	42.1	579.1	1,080.8	1,540.5
C-3	Rio Choloma, Rio Blanco and S.R. Basin	**297.13**	**37.4**	**536.7**	**1,014.2**	**1,445.8**
RC-1	Rio Choloma Basin	**106.89**	**20.7**	**227.3**	**478.4**	**711.2**
RC-2	i at Choloma Bridge	71.64	13.6	168.7	384.2	553.9
RC-3	ii at Jutosa (Junction of Rio La Jutosa)	55.02	9.4	132.8	322.3	482.2
C-4	Rio Blanco - Canal San Roque Basin	**190.24**	**37.4**	**360.2**	**695.4**	**992.8**
RB-1	Rio Blanco Basin	**137.98**	**31.0**	**265.0**	**534.5**	**796.0**
RB-2	i Outlet of Laguna El Carmen	107.41	22.7	224.5	467.8	698.0
RB-3	ii Inlet of Laguna El Carmen	83.72	19.2	184.1	401.0	588.9
RB-4	iii Prop. Diversion Point	71.35	15.7	165.5	372.5	539.8
RB-5	iv Rio del Zapotal and Rio de Armenta	43.90	12.2	110.7	265.8	374.6
II	**Rio El Sauce and Rio El Sauce (viejo) - Chotepe Basin**					
S-1	River Mouth of Rio El Sauce	**215.70**	**29.9**	**399.7**	**790.2**	**1,172.0**
RS-1	Rio El Sauce Basin	**118.33**	**29.7**	**232.6**	**473.5**	**706.9**
RS-2	i Mid. of Rio El Sauce	79.98	21.8	172.6	372.7	549.0
RS-3	ii Jct. of Prop. Diversion	75.33	18.1	169.0	374.3	546.3
RS-4	iii Rio Santa Ana and Rio Piedras	72.16	15.4	167.8	377.9	547.5
RSB-1	iv Rio Santa Ana Basin (at National Road)	37.63	13.4	94.5	228.4	321.2
RSP-1	v Rio Piedras Basin (at National Road)	30.87	12.6	79.8	197.5	275.1
RSV-1	Rio El Sauce (viejo) - Chotepe Basin	**97.37**	**22.9**	**204.9**	**430.9**	**640.9**

Note: Retention effect of Laguna El Carmen is not considered in this calculation

C.A. : Catchment Area of the Basin (sq. km) L : Maximum River Length of the Basin (km)
S.R. : Canal San Roque S.R.-C : Canal San Roque Cuabanos
C-H-C : Canal Copen-Higuero-Cuabanos

Rainfall Pattern

A : Maximum intensity of rainfall occures at the beginning of the rain.
B : Maximum intensity of rainfall occures at the midlle of the rain.
C : Maximum intensity of rainfall occures at the end of the rain.

RUNOFF(1/30)

TABLE A.5.5 RESULT OF RUN-OFF SIMULATION BY UNIT HYDROGRAPH METHOD (10-YEAR RETURN PERIOD)

		Catchment/River		Peak Discharge (qu. m / sec.)		
		C.A.	L	Pattern		
		(sq. km)	(km)	A	B	C
I	**Rio Choloma, Rio Blanco, Canal San Roque, Canal S.R.-C and Canal C-H-C Basin**					
C-1	River Mouth of the Basin	**420.15**	**48.4**	**454.5**	**836.1**	**1,304.4**
C-2	Choloma, Blanco, S.R. ,S.R.-C ,C-H-C Basin	**366.45**	**42.1**	**394.6**	**746.4**	**1,213.0**
	i Canal Copen-Higuero-Cuabanos	33.43	9.6	46.5	124.1	238.9
	ii Choloma, Blanco and San Roque	333.02	42.1	361.3	689.1	1,120.5
C-3	Rio Choloma, Rio Blanco and S.R. Basin	**297.13**	**37.4**	**333.3**	**647.4**	**1,054.5**
RC-1	Rio Choloma Basin	**106.89**	**20.7**	**135.2**	**302.7**	**528.9**
RC-2	i at Choloma Bridge	71.64	13.6	97.9	232.6	416.0
RC-3	ii at Jutosa (Junction of Rio La Jutosa)	55.02	9.4	75.2	190.8	364.9
C-4	Rio Blanco - Canal San Roque Basin	**190.24**	**37.4**	**221.1**	**445.0**	**727.8**
RB-1	Rio Blanco Basin	**137.98**	**31.0**	**160.8**	**340.6**	**587.2**
RB-2	i Outlet of Laguna El Carmen	107.41	22.7	133.8	297.4	518.4
RB-3	ii Inlet of Laguna El Carmen	83.72	19.2	108.8	249.6	439.6
RB-4	iii Prop. Diversion Point	71.35	15.7	96.6	227.3	404.7
RB-5	iv Rio del Zapotal and Rio de Armenta	43.90	12.2	62.6	157.1	283.4
II	**Rio El Sauce and Rio El Sauce (viejo) - Chotepe Basin**					
S-1	River Mouth of Rio El Sauce	**215.70**	**29.9**	**245.6**	**502.3**	**860.2**
RS-1	Rio El Sauce Basin	**118.33**	**29.7**	**140.2**	**302.1**	**522.7**
RS-2	i Mid. of Rio El Sauce	79.98	21.8	102.2	233.0	409.5
RS-3	ii Jct. of Prop. Diversion	75.33	18.1	99.5	230.9	408.7
RS-4	iii Rio Santa Ana and Rio Piedras	72.16	15.4	97.9	230.5	410.5
RSB-1	iv Rio Santa Ana Basin (at National Road)	37.63	13.4	53.3	135.0	243.1
RSP-1	v Rio Piedras Basin (at National Road)	30.87	12.6	44.5	116.8	208.9
RSV-1	Rio El Sauce (viejo) - Chotepe Basin	**97.37**	**22.9**	**121.9**	**272.8**	**476.5**

Note: Retention effect of Laguna El Carmen is not considered in this calculation
C.A. : Catchment Area of the Basin (sq. km) L : Maximum River Length of the Basin (km)
S.R. : Canal San Roque S.R.-C : Canal San Roque Cuabanos
C-H-C : Canal Copen-Higuero-Cuabanos

Rainfall Pattern
A : Maximum intensity of rainfall occures at the beginning of the rain.
B : Maximum intensity of rainfall occures at the midlle of the rain.
C : Maximum intensity of rainfall occures at the end of the rain.

RUNOFF(1/10)

TABLE A.5.6 RESULT OF RUN-OFF SIMULATION BY UNIT HYDROGRAPH METHOD (5-YEAR RETURN PERIOD)

		Catchment/River		Peak Discharge (qu. m / sec.)		
		C.A.	L	Pattern		
		(sq. km)	(km)	A	B	C
I	**Rio Choloma, Rio Blanco, Canal San Roque, Canal S.R.-C and Canal C-H-C Basin**					
C-1	River Mouth of the Basin	**420.15**	**48.4**	**284.4**	**505.7**	**916.1**
C-2	Choloma, Blanco, S.R. ,S.R.-C ,C-H-C Basin	**366.45**	**42.1**	**244.9**	**447.3**	**853.6**
	i Canal Copen-Higuero-Cuabanos	33.43	9.6	26.4	74.0	173.8
	ii Choloma, Blanco and San Roque	333.02	42.1	223.6	412.6	789.1
C-3	Rio Choloma, Rio Blanco and S.R. Basin	**297.13**	**37.4**	**204.5**	**387.7**	**743.9**
RC-1	Rio Choloma Basin	**106.89**	**20.7**	**78.7**	**179.8**	**378.0**
RC-2	i at Choloma Bridge	71.64	13.6	55.7	138.2	299.5
RC-3	ii at Jutosa (Junction of Rio La Jutosa)	55.02	9.4	42.7	112.6	264.2
C-4	Rio Blanco - Canal San Roque Basin	**190.24**	**37.4**	**133.6**	**266.6**	**515.3**
RB-1	Rio Blanco Basin	**137.98**	**31.0**	**95.7**	**202.4**	**417.4**
RB-2	i Outlet of Laguna El Carmen	107.41	22.7	78.2	176.7	370.3
RB-3	ii Inlet of Laguna El Carmen	83.72	19.2	62.6	148.3	315.2
RB-4	iii Prop. Diversion Point	71.35	15.7	55.0	135.1	291.0
RB-5	iv Rio del Zapotal and Rio de Armenta	43.90	12.2	35.6	93.5	205.0
II	**Rio El Sauce and Rio El Sauce (viejo) - Chotepe Basin**					
S-1	River Mouth of Rio El Sauce	**215.70**	**29.9**	**148.1**	**298.3**	**609.5**
RS-1	Rio El Sauce Basin	**118.33**	**29.7**	**82.9**	**179.5**	**372.1**
RS-2	i Mid. of Rio El Sauce	79.98	21.8	59.0	138.4	293.3
RS-3	ii Jct. of Prop. Diversion	75.33	18.1	56.9	137.2	293.4
RS-4	iii Rio Santa Ana and Rio Piedras	72.16	15.4	55.7	137.0	295.2
RSB-1	iv Rio Santa Ana Basin (at National Road)	37.63	13.4	30.4	80.3	176.1
RSP-1	v Rio Piedras Basin (at National Road)	30.87	12.6	25.4	69.5	151.7
RSV-1	Rio El Sauce (viejo) - Chotepe Basin	**97.37**	**22.9**	**71.0**	**162.1**	**340.6**

Note: Retention effect of Laguna El Carmen is not considered in this calculation
C.A. : Catchment Area of the Basin (sq. km) L : Maximum River Length of the Basin (km)
S.R. : Canal San Roque S.R.-C : Canal San Roque Cuabanos
C-H-C : Canal Copen-Higuero-Cuabanos

Rainfall Pattern
A : Maximum intensity of rainfall occures at the beginning of the rain.
B : Maximum intensity of rainfall occures at the midlle of the rain.
C : Maximum intensity of rainfall occures at the end of the rain.

RUNOFF(1/5)

TABLE A.5.7 RESULT OF RUN-OFF SIMULATION BY UNIT HYDROGRAPH METHOD (2-YEAR RETURN PERIOD)

		Catchment/River		Peak Discharge (qu. m / sec.)		
		C.A.	L	Pattern		
		(sq. km)	(km)	A	B	C
I	**Rio Choloma, Rio Blanco, Canal San Roque, Canal S.R.-C and Canal C-H-C Basin**					
C-1	River Mouth of the Basin	**420.15**	**48.4**	**95.2**	**177.5**	**338.7**
C-2	Choloma, Blanco, S.R. ,S.R.-C ,C-H-C Basin	**366.45**	**42.1**	**81.8**	**157.7**	**316.0**
	i Canal Copen-Higuero-Cuabanos	33.43	9.6	9.2	28.1	65.8
	ii Choloma, Blanco and San Roque	333.02	42.1	74.6	145.6	292.3
C-3	Rio Choloma, Rio Blanco and S.R. Basin	**297.13**	**37.4**	**68.2**	**136.7**	**275.9**
RC-1	Rio Choloma Basin	**106.89**	**20.7**	**26.7**	**63.5**	**141.5**
RC-2	i at Choloma Bridge	71.64	13.6	19.2	50.5	112.7
RC-3	ii at Jutosa (Junction of Rio La Jutosa)	55.02	9.4	14.8	42.3	99.8
C-4	Rio Blanco - Canal San Roque Basin	**190.24**	**37.4**	**44.6**	**93.9**	**191.5**
RB-1	Rio Blanco Basin	**137.98**	**31.0**	**32.0**	**71.6**	**155.6**
RB-2	i Outlet of Laguna El Carmen	107.41	22.7	26.4	62.4	138.5
RB-3	ii Inlet of Laguna El Carmen	83.72	19.2	21.4	52.6	118.2
RB-4	iii Prop. Diversion Point	71.35	15.7	18.9	48.9	109.4
RB-5	iv Rio del Zapotal and Rio de Armenta	43.90	12.2	12.3	35.0	77.4
II	**Rio El Sauce and Rio El Sauce (viejo) - Chotepe Basin**					
S-1	River Mouth of Rio El Sauce	**215.70**	**29.9**	**49.4**	**105.6**	**226.7**
RS-1	Rio El Sauce Basin	**118.33**	**29.7**	**27.8**	**63.4**	**138.9**
RS-2	i Mid. of Rio El Sauce	79.98	21.8	20.1	48.9	109.9
RS-3	ii Jct. of Prop. Diversion	75.33	18.1	19.5	49.1	110.1
RS-4	iii Rio Santa Ana and Rio Piedras	72.16	15.4	19.2	49.7	110.9
RSB-1	iv Rio Santa Ana Basin (at National Road)	37.63	13.4	10.5	30.1	66.5
RSP-1	v Rio Piedras Basin (at National Road)	30.87	12.6	8.8	26.1	57.4
RSV-1	Rio El Sauce (viejo) - Chotepe Basin	**97.37**	**22.9**	**24.1**	**57.2**	**127.5**

Note: Retention effect of Laguna El Carmen is not considered in this calculation

C.A. : Catchment Area of the Basin (sq. km) L : Maximum River Length of the Basin (km)
S.R. : Canal San Roque S.R.-C : Canal San Roque Cuabanos
C-H-C : Canal Copen-Higuero-Cuabanos

Rainfall Pattern

A : Maximum intensity of rainfall occures at the beginning of the rain.
B : Maximum intensity of rainfall occures at the midlle of the rain.
C : Maximum intensity of rainfall occures at the end of the rain.

RUNOFF(1/2)

TABLE A.5.8 PROBABLE FLOOD PEAK DISCHARGE OF RAINFALL PATTERN C (PRESENT RIVER SYSTEM)

		Catchment/River		Peak Discharge (qu. m / sec.)					
		C.A.	L	Return Period					
		(sq. km)	(km)	2-year	5-year	10-year	30-year	50-year	100-year
I	**Rio Choloma, Rio Blanco, Canal San Roque, Canal San Roque-Cuabanos and Canal Copen-Higuero-Cuabanos Basin**								
C-1	River Mouth of the Basin	**420.15**	**48.4**	**338.7**	**916.1**	**1,304.1**	**1,800.9**	**2,010.9**	**2,285.9**
C-2	Choloma, Blanco, S.R. ,S.R.-C ,C-H-C Basin	**366.45**	**42.1**	**316.0**	**853.6**	**1,213.0**	**1,669.5**	**1,862.1**	**2,114.5**
	i Canal Copen-Higuero-Cuabanos	33.43	9.6	65.8	173.8	238.9	313.9	345.6	387.3
	ii Choloma, Blanco and San Roque	333.02	42.1	292.3	789.1	1,120.5	1,540.5	1,717.6	1,949.6
C-3	Rio Choloma, Rio Blanco and S.R. Basin	**297.13**	**37.4**	**275.9**	**743.9**	**1,054.5**	**1,445.8**	**1,610.7**	**1,826.7**
RC-1	Rio Choloma Basin	**106.89**	**20.7**	**141.5**	**378.0**	**528.9**	**711.2**	**787.7**	**888.3**
RC-2	i at Choloma Bridge	71.64	13.6	112.7	299.5	416.0	553.9	611.9	688.1
RC-3	ii at Jutosa (Junction of Rio La Jutosa)	55.02	9.4	99.8	264.2	364.9	482.2	531.6	596.7
C-4	Rio Blanco - Canal San Roque Basin	**190.24**	**37.4**	**191.5**	**515.3**	**727.8**	**992.8**	**1,104.1**	**1,250.1**
RB-1	Rio Blanco Basin	**137.98**	**31.0**	**155.6**	**417.4**	**587.2**	**796.0**	**883.7**	**998.7**
RB-2	i Outlet of Laguna El Carmen	107.41	22.7	138.5	370.3	518.4	698.0	773.4	872.4
RB-3	ii Inlet of Laguna El Carmen	83.72	19.2	118.2	315.2	439.6	588.9	651.5	733.9
RB-4	iii Prop. Diversion Point	71.35	15.7	109.4	291.0	404.7	539.8	596.6	671.2
RB-5	iv Rio del Zapotal and Rio de Armenta	43.90	12.2	77.4	205.1	283.4	374.6	413.1	463.7
II	**Rio El Sauce and Rio El Sauce (viejo) - Chotepe Basin**								
S-1	River Mouth of Rio El Sauce	**215.70**	**29.9**	**226.7**	**609.5**	**860.2**	**1,172.0**	**1,302.9**	**1,474.7**
RS-1	Rio El Sauce Basin	**118.33**	**29.7**	**138.9**	**372.1**	**522.7**	**706.9**	**784.2**	**885.7**
RS-2	i Mid. of Rio El Sauce	79.98	21.8	109.9	293.3	409.5	549.0	607.6	684.6
RS-3	ii Jct. of Prop. Diversion	75.33	18.1	110.1	293.4	408.7	546.3	604.2	680.2
RS-4	iii Rio Santa Ana and Rio Piedras	72.16	15.4	110.9	295.2	410.5	547.5	605.0	680.7
RSB-1	iv Rio Santa Ana Basin (at National Road)	37.63	13.4	66.5	176.1	243.1	321.2	354.1	397.4
RSP-1	v Rio Piedras Basin (at National Road)	30.87	12.6	57.4	151.7	208.9	275.1	303.0	339.8
RSV-1	Rio El Sauce (viejo) - Chotepe Basin	**97.37**	**22.9**	**127.5**	**340.6**	**476.5**	**640.9**	**709.9**	**800.5**

Note: Retention effect of Laguna El Carmen is not considered in this calculation

C.A. : Catchment Area of the Basin (sq. km) L : Maximum River Length of the Basin (km)

S.R. : Canal San Roque S.R.-C : Canal San Roque Cuabanos C-H-C : Canal Copen-Higuero-Cuabanos

TABLE A.5.9 PROBABLE FLOOD PEAK DISCHARGE OF RAINFALL PATTERN C (ALTERNATIVE RIVER SYSTEM)

		Catchment/River		Peak Discharge (qu. m / sec.)					
		C.A.	L	Return Period					
		(sq. km)	(km)	2-year	5-year	10-year	30-year	50-year	100-year
I	**Rio Choloma, Rio Blanco, Canal San Roque, Canal San Roque-Cuabanos and Canal Copen-Higuero-Cuabanos Basin**								
C-1	River Mouth of the Basin	**348.80**	**32.7**	**326.9**	**881.5**	**1,249.8**	**1,714.1**	**1,909.7**	**2,166.0**
C-2	Choloma, Blanco, S.R. ,S.R.-C ,C-H-C Basin	**295.10**	**26.4**	**303.0**	**815.5**	**1,152.8**	**1,574.1**	**1,751.2**	**1,983.5**
	i Canal Copen-Higuero-Cuabanos	33.43	9.6	65.8	173.8	238.9	313.9	345.6	387.3
	ii Choloma, Blanco and San Roque	261.67	26.4	274.8	739.1	1,043.8	1,423.2	1,582.6	1,791.7
C-3	Rio Choloma, Rio Blanco and S.R. Basin	**225.78**	**21.7**	**257.1**	**690.1**	**971.9**	**1,319.2**	**1,465.7**	**1,657.3**
RC-1	Rio Choloma Basin	**106.89**	**20.7**	**141.5**	**378.0**	**528.9**	**711.2**	**787.7**	**888.3**
RC-2	i at Choloma Bridge	71.64	13.6	112.7	299.5	416.0	553.9	611.9	688.1
RC-3	ii at Jutosa (Junction of Rio La Jutosa)	55.02	9.4	99.8	264.2	364.9	482.2	531.6	596.7
C-4	Rio Blanco - Canal San Roque Basin	**118.89**	**21.7**	**152.4**	**407.6**	**570.9**	**769.2**	**852.5**	**961.8**
RB-1	Rio Blanco Basin	**66.63**	**15.3**	**104.1**	**276.8**	**384.7**	**512.5**	**566.2**	**636.8**
II	**Rio El Sauce and Rio El Sauce (viejo) - Chotepe Basin**								
S-1	River Mouth of Rio El Sauce	**287.05**	**30.1**	**285.6**	**769.1**	**1,088.1**	**1,487.6**	**1,655.7**	**1,876.0**
RS-1	Rio El Sauce Basin	**189.68**	**29.9**	**204.1**	**548.3**	**773.1**	**1,051.6**	**1,168.5**	**1,321.9**
RS-2	i Mid. of Rio El Sauce	151.33	22.0	184.9	495.3	695.3	939.8	1,042.4	1,177.1
RS-3	ii Upstream of Jct. of Prop. Diversion	75.33	18.1	110.1	293.4	408.7	546.3	604.2	680.2
RS-4	iii Rio Santa Ana and Rio Piedras	72.16	15.4	110.9	295.2	410.5	547.5	605.0	680.7
RSB-1	iv Rio Santa Ana Basin (at National Road)	37.63	13.4	66.5	176.1	243.1	321.2	354.1	397.4
RSP-1	v Rio Piedras Basin (at National Road)	30.87	12.6	57.4	151.7	208.9	275.1	303.0	339.8
RB-4	iii Prop. Diversion Point	71.35	15.7	109.4	291.0	404.7	539.8	596.6	671.2
RB-5	iv Rio del Zapotal and Rio de Armenta	43.90	12.2	77.4	205.1	283.4	374.6	413.1	463.7
RSV-1	Rio El Sauce (viejo) - Chotepe Basin	**97.37**	**22.9**	**127.5**	**340.6**	**476.5**	**640.9**	**709.9**	**800.5**

Note: Retention effect of Laguna El Carmen is not considered in this calculation

C.A. : Catchment Area of the Basin (sq. km) L : Maximum River Length of the Basin (km)

S.R. : Canal San Roque S.R.-C : Canal San Roque Cuabanos C-H-C : Canal Copen-Higuero-Cuabanos

TABLE A.5.10 SIMULATED PEAK DISCHARGE OF HURRICANE FIFI

		Catchment/River		Discharge
		C.A. (sq. km)	L (km)	Q (qu.n/sec)
I	**Rio Choloma, Rio Blanco, Canal San Roque, Canal S.R.-C and Canal C-H-C Basin**			
C-1	River Mouth of the Basin	**420.15**	**48.4**	**2,079.0**
C-2	Choloma, Blanco, San Roque, Canal S.R.-C ,C-H-C Basin	**366.45**	**42.1**	**1,838.3**
	i Canal Copen-Higuero-Cuabanos	33.43	9.6	297.4
	ii Choloma, Blanco and San Roque	333.02	42.1	1,686.0
C-3	Rio Choloma, Rio Blanco and S.R. Basin	**297.13**	**37.4**	**1,559.0**
RC-1	Rio Choloma Basin	**106.89**	**20.7**	**668.3**
RC-2	i at Choloma Bridge	71.64	13.6	514.7
RC-3	ii at Jutosa (Junction of Rio La Jutosa)	55.02	9.4	453.1
C-4	Rio Blanco - Canal San Roque Basin	**190.24**	**37.4**	**1,039.7**
RB-1	Rio Blanco Basin	**137.98**	**31.0**	**767.7**
RB-2	i Outlet of Laguna El Carmen	107.41	22.7	658.3
RB-3	ii Inlet of Laguna El Carmen	83.72	19.2	546.9
RB-4	iii Prop. Diversion Point	71.35	15.7	500.3
RB-5	iv Rio del Zapotal and Rio de Armenta	43.90	12.2	351.8
II	**Rio El Sauce and Rio El Sauce (viejo) - Chotepe Basin**			
S-1	River Mouth of Rio El Sauce	**215.70**	**29.9**	**1,159.4**
RS-1	Rio El Sauce Basin	**118.33**	**29.7**	**676.3**
RS-2	i Mid. of Rio El Sauce	79.98	21.8	510.8
RS-3	ii Jct. of Prop. Diversion	75.33	18.1	504.6
RS-4	iii Rio Santa Ana and Rio Piedras	72.16	15.4	507.5
RSB-1	iv Rio Santa Ana Basin (at National Road)	37.63	13.4	301.9
RSP-1	v Rio Piedras Basin (at National Road)	30.87	12.6	259.8
RSV-1	Rio El Sauce (viejo) - Chotepe Basin	**97.37**	**22.9**	**602.4**

Note: Retention effect of Laguna El Carmen is not considered in this calculation
C.A. : Catchment Area of the Basin (sq. km) L : Maximum River Length of the Basin (km)
S.R. : Canal San Roque S.R.-C : Canal San Roque Cuabanos
C-H-C : Canal Copen-Higuero-Cuabanos

TABLE A.6.1 RESULT OF RUN-OFF CALCULATION OF UPSTREAM OF THE RIO CHOLOMA BASIN (RATIONAL FORMULA)

Calculation Point	Catchment Area (sq.km) A	Run-off Coefficient f	Time of Flood Concentration (hour)			Rainfall Intensity (mm/hr) R	Peak Discharge (cu.m/sec.) Qp
			Time of Inlet T1	Time of Flow T0	Total T		
Choloma Bridge (RC-2)	71.64	0.64	0.5	1.29	1.79	50.8	647
Rio La Jutosa (J-1)	20.39	0.67	0.5	0.69	1.19	65.6	249
Rio Majaine and Rio Ocotillo (M-2)	34.63	0.67	0.5	0.83	1.33	61.2	394
Rio Majine (M-1)	12.91	0.73	0.5	0.44	0.94	75.9	199
Rio Ocotillo (O-1)	13.51	0.70	0.5	0.26	0.76	86.4	227

TABLE A.6.2 RESULT OF RUN-OFF CALCULATION OF DOWNSTREAM OF THE RIO CHOLOMA BASIN (UNIT HYDROGRAPH METHOD)

	Calculation Point	Catchment/River		Peak Discharge (qu. m/sec.)					
		C.A.	L	Return Period					
		(sq. km)	(km)	2-year	5-year	10-year	30-year	50-year	100-year
RC-1	Rio Choloma Basin	106.89	20.7	141.5	378.0	528.9	711.2	787.7	888.3
i	Middle Reach of the Lower Stream	93.45	18.6	130.4	348.2	487.0	651.1	720.8	812.7
ii	Downstram of the Choloma town	82.22	15.1	124.1	330.6	460.9	613.9	678.9	764.6
RC-2	Choloma Bridge	71.64	13.6	112.7	299.5	416.0	553.9	611.9	688.1

C.A. : Catchment Area of the Basin (sq. km) L : Maximum River Length of the Basin (km)

FIGURES

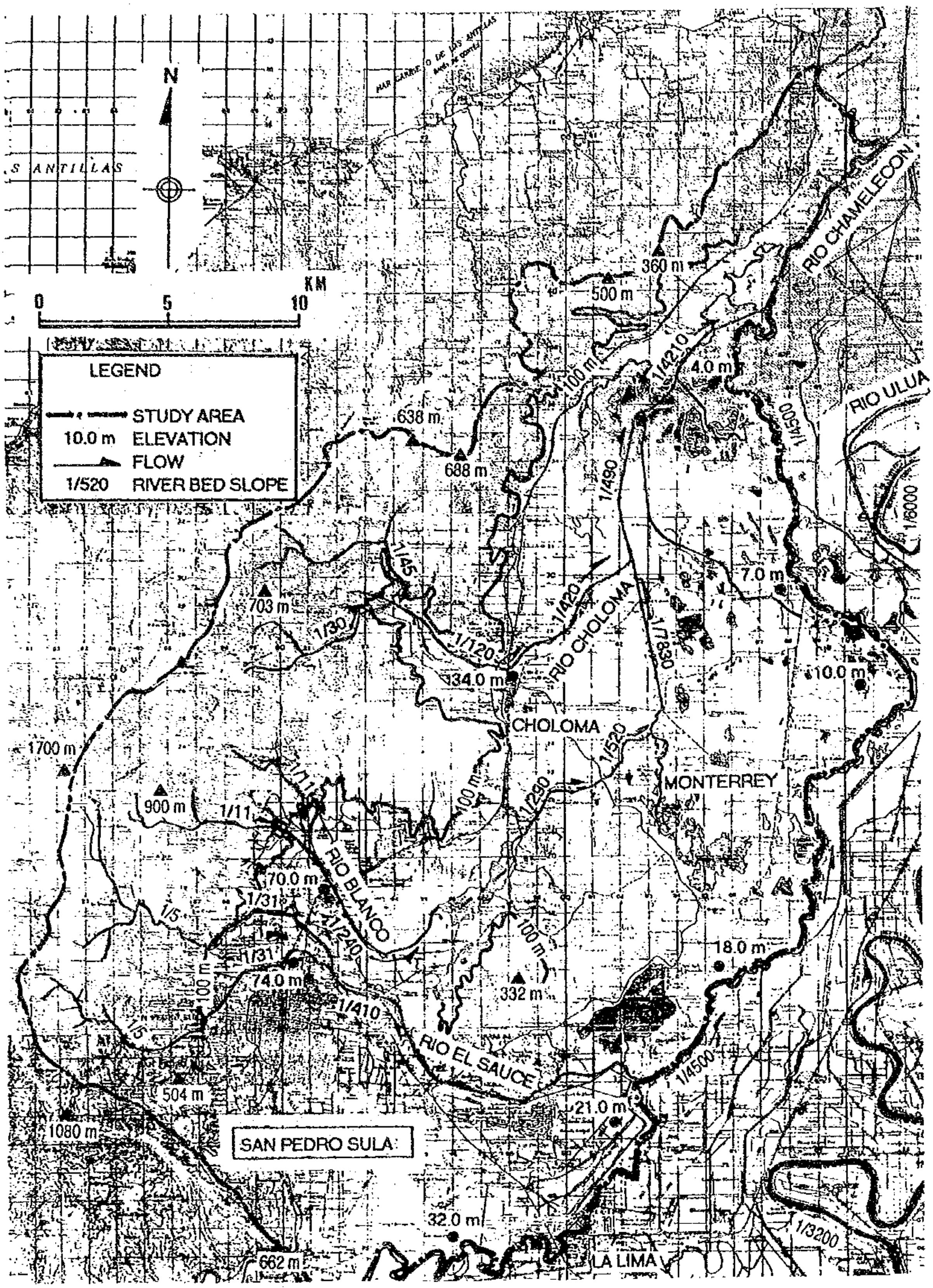


FIG. A.2.1 GENERAL TOPOGRAPHIC MAP OF THE STUDY AREA

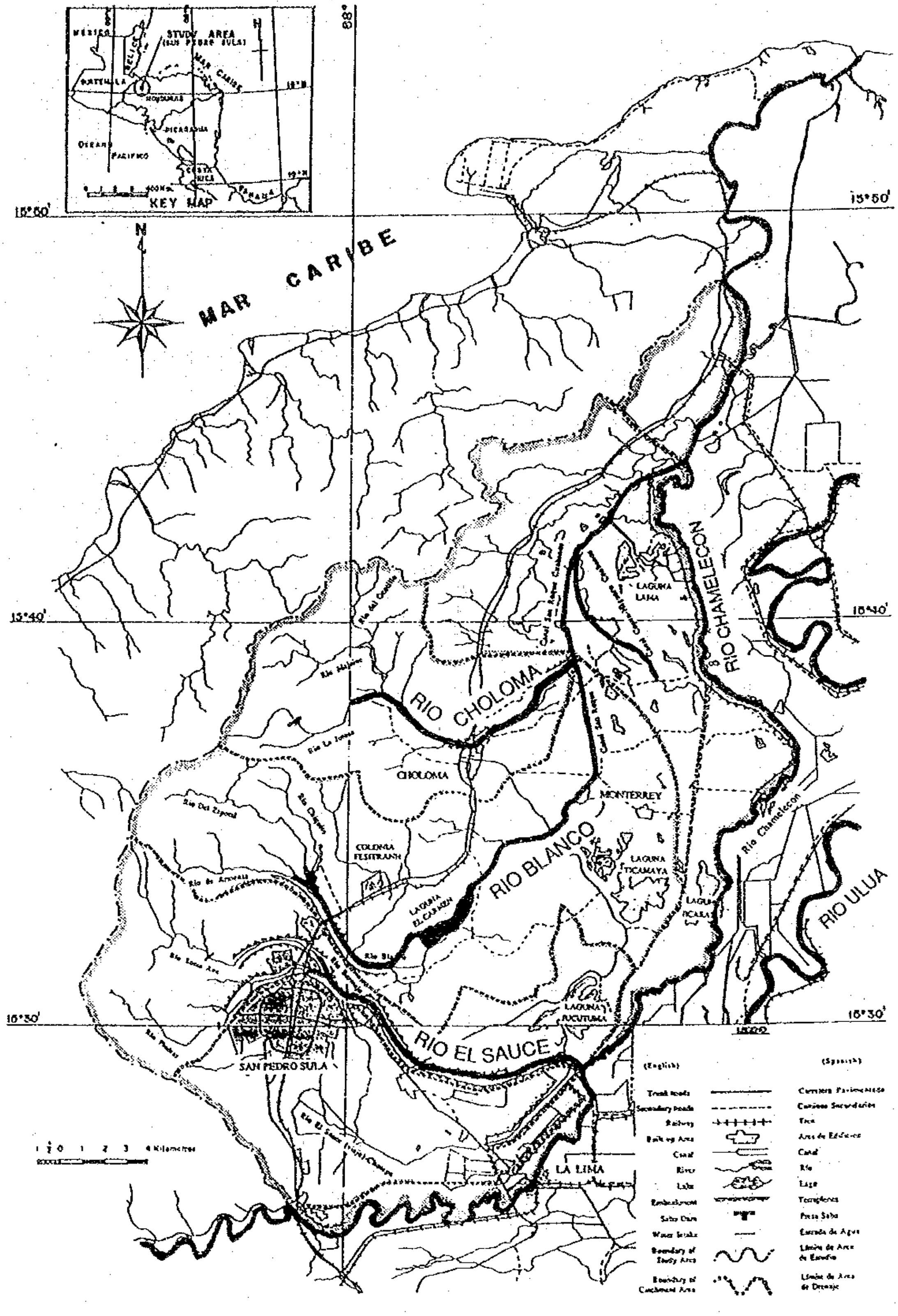


FIG. A.2.2 LOCATION OF THE RIVERS

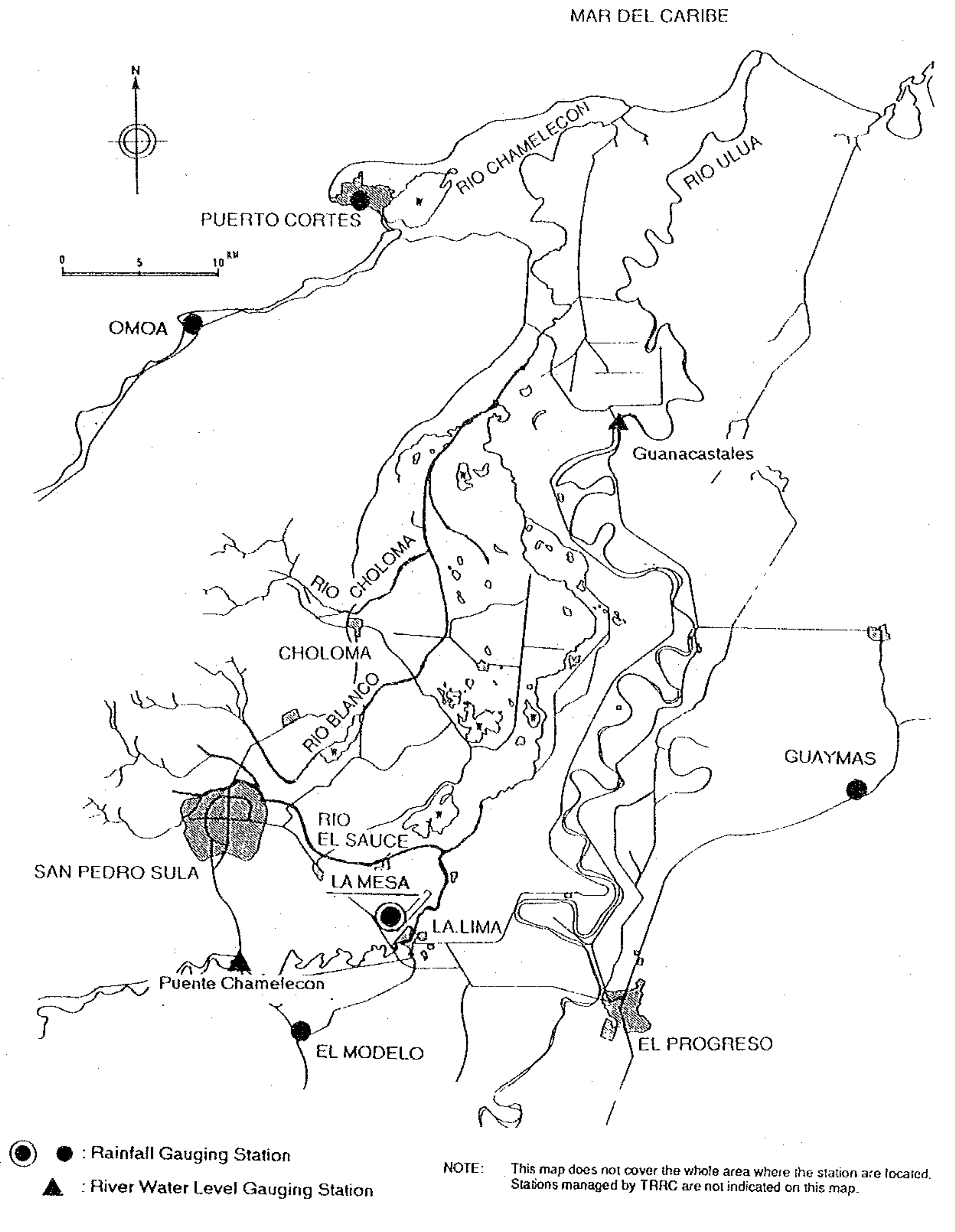
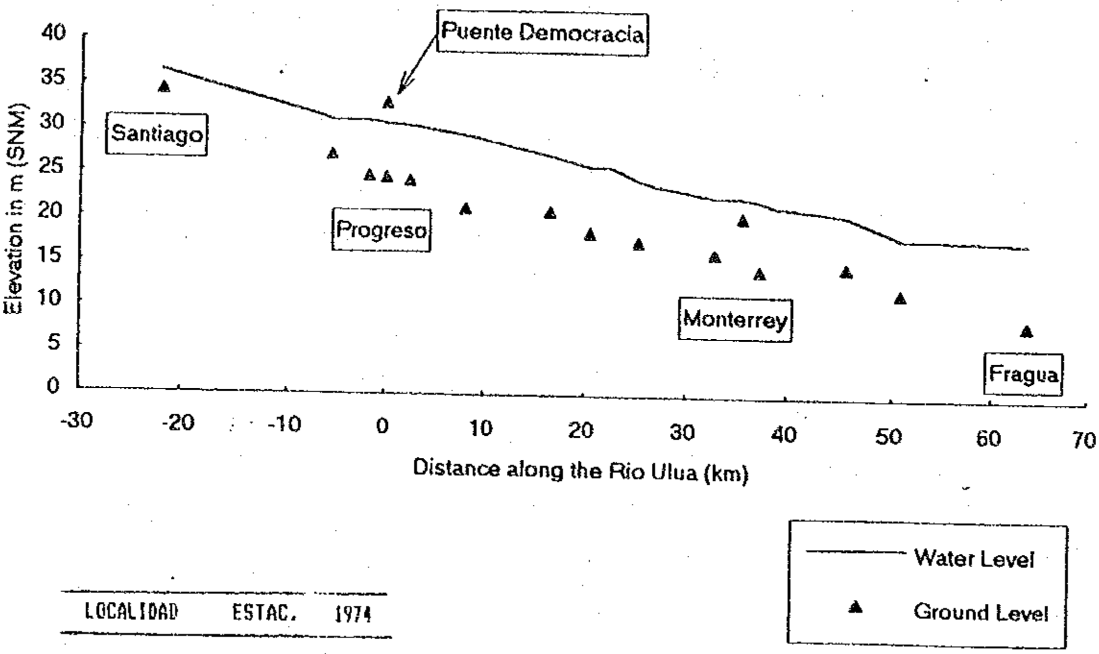


FIG. A.3.1 LOCATION MAP OF THE GAUGING STATIONS (RAINFALL AND RIVER WATER LEVEL)



LOCALIDAD	ESTAC.	1974
SANTIAGO	0.00	36.34
CAMPIN	11100.00	31.00
OMONITA	11900.00	30.92
PROGRESO	13100.00	30.63
BUENA VISTA	14600.00	30.45
COBB	18900.00	29.38
STA. ROSA	30900.00	27.13
CEIBITA	34400.00	25.81
N. CHINO	35800.00	25.81
CAIMITO	37500.00	24.41
LOS INDIOS	41200.00	23.76
LIMONES	45300.00	22.52
MONTERREY	46900.00	22.50
MERCEDES	49100.00	22.15
P. BLANCOS	52400.00	21.60
TIBOMBO	56300.00	20.65
MANACALITO	63100.00	18.18
FRAGUA	74600.00	17.70

RECORDED FLOOD WATER LEVEL

Source
Flood Water Level : Tela Railroad Company
Ground Elevation: 1:10,000 Topographical Map by SECOPT

FIG. A.3.2 MAXIMUM FLOOD STAGES ALONG THE RIO ULUA DURING THE HURRICANE FIFI

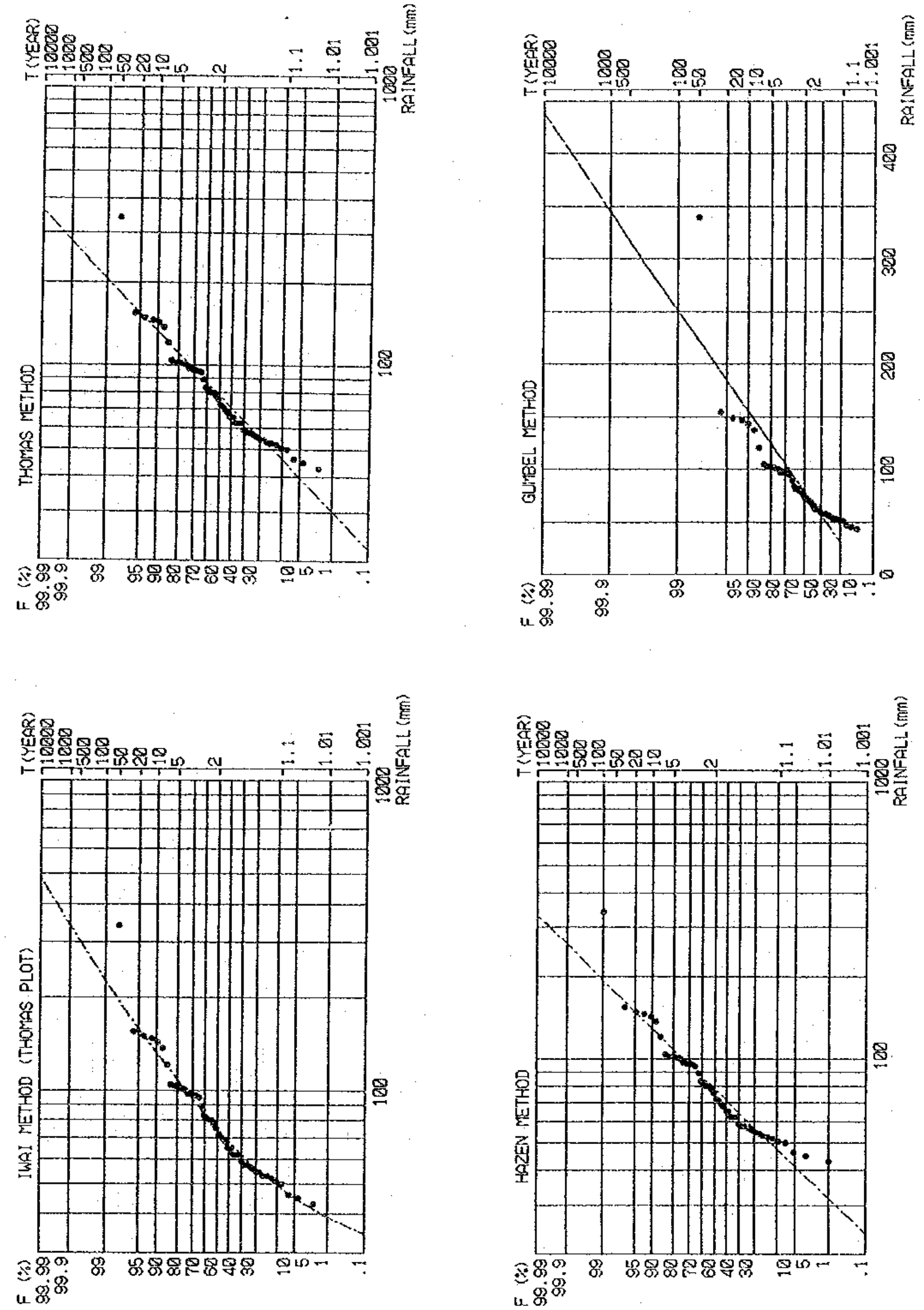


FIG. A.4.1 FREQUENCY ANALYSIS ON ONE DAY RAINFALL AT LA MESA

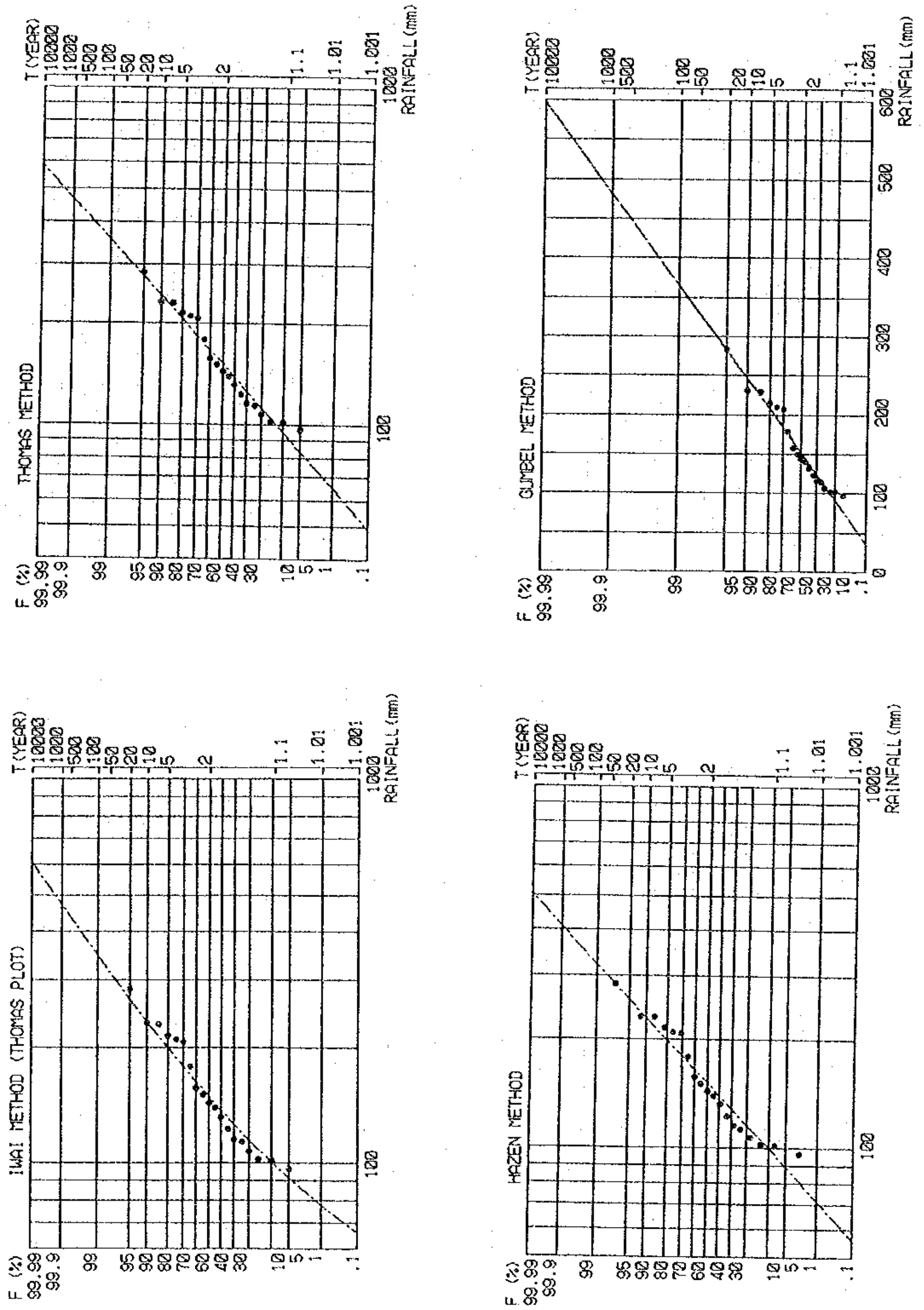


FIG. A.4.2 FREQUENCY ANALYSIS ON ONE DAY RAINFALL AT PUERTO CORTES

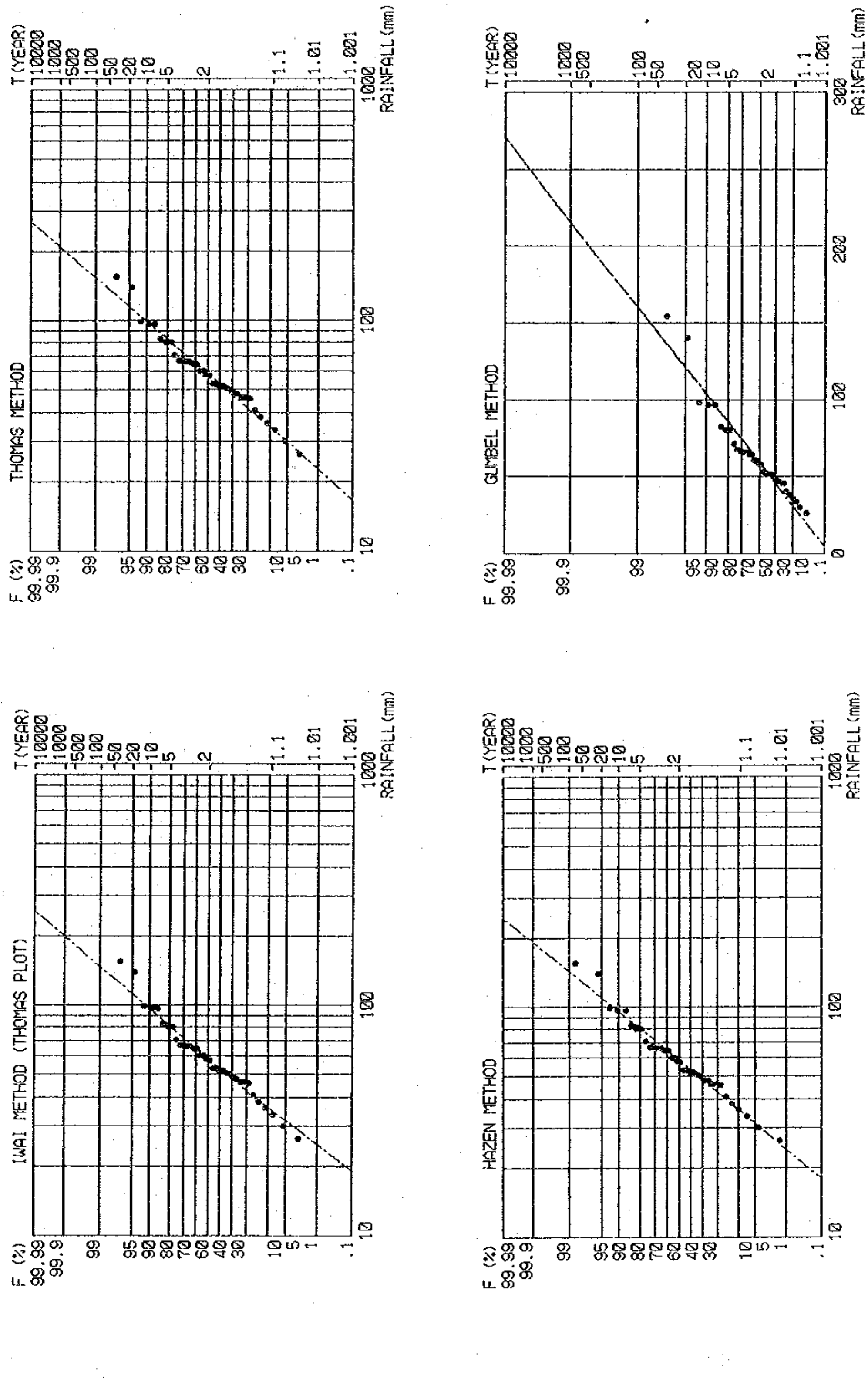
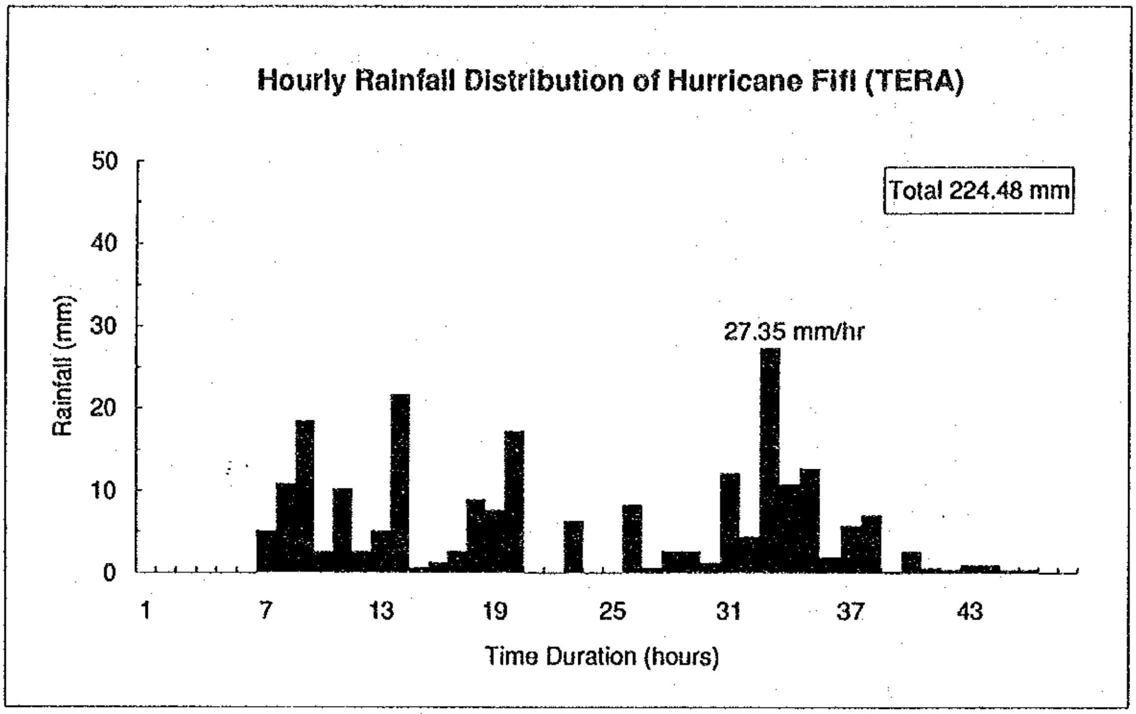
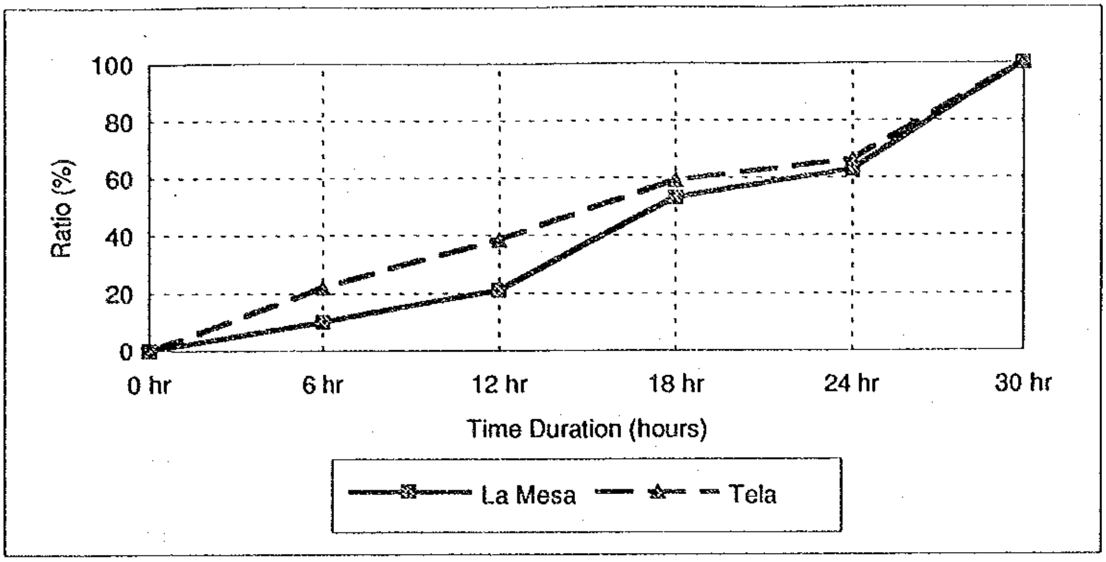


FIG. A.4.3 FREQUENCY ANALYSIS ON 6 HOURS RAINFALL AT LA MESA



hr	Rain (mm)	hr	Rain (mm)	hr	Rain (mm)	hr	Rain (mm)
1	0.00	13	5.09	25	0.00	37	5.73
2	0.00	14	21.63	26	8.27	38	7.00
3	0.00	15	0.64	27	0.64	39	0.13
4	0.00	16	1.27	28	2.55	40	2.55
5	0.00	17	2.55	29	2.55	41	0.64
6	0.00	18	8.91	30	1.27	42	0.32
7	5.09	19	7.64	31	12.09	43	0.96
8	10.82	20	17.18	32	4.46	44	0.96
9	18.45	21	0.00	33	27.35	45	0.32
10	2.55	22	0.00	34	10.82	46	0.32
11	10.18	23	6.36	35	12.73	47	0.00
12	2.55	24	0.00	36	1.91	48	0.00

FIG. A.4.4 HOURLY RAINFALL DISTRIBUTION OF THE HURRICANE FIFI AT TELA



Accumulative Rainfall Ratio

	6 hr	12 hr	18 hr	24 hr	30 hr
La Mesa	9.6	20.2	52.1	62.8	100.0
Tela	23.1	39.7	59.4	66.3	100.0

(Unit : %)

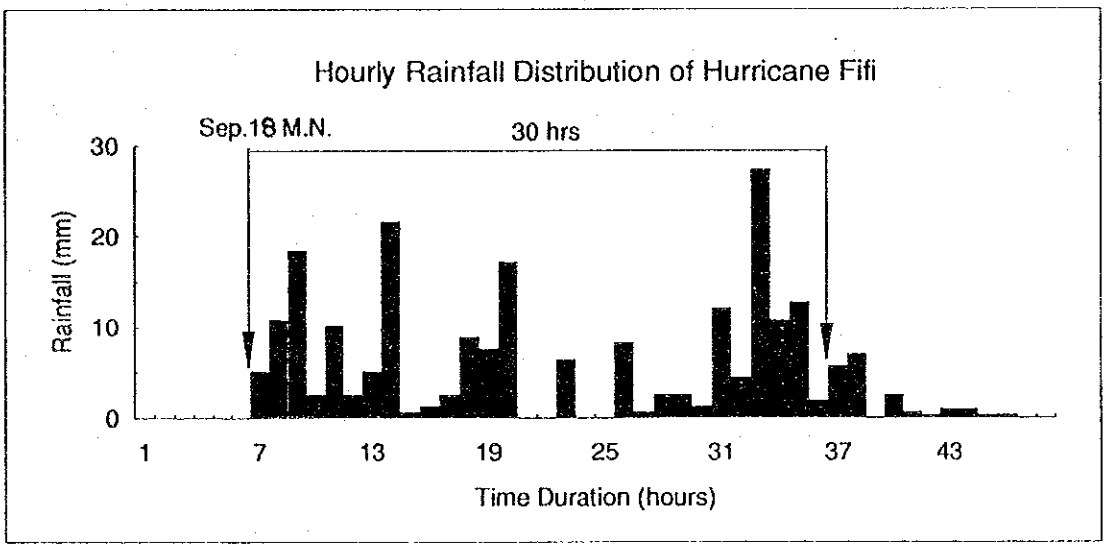
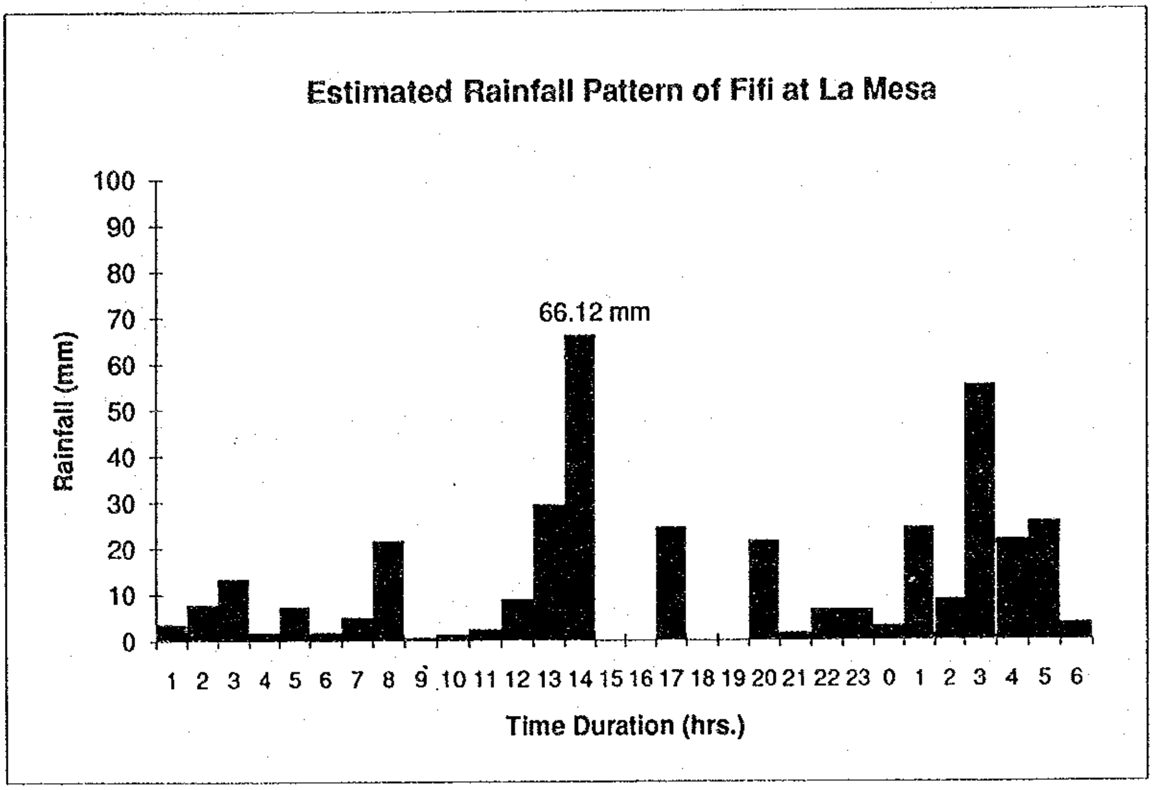
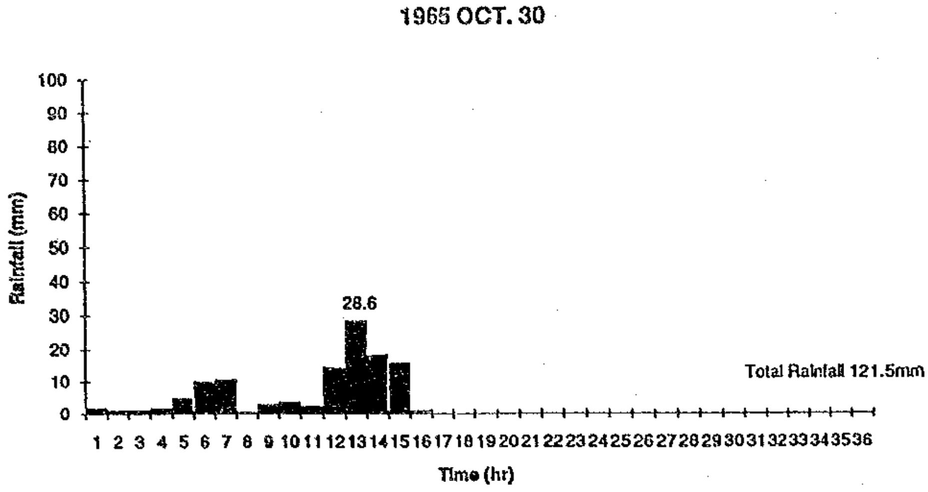


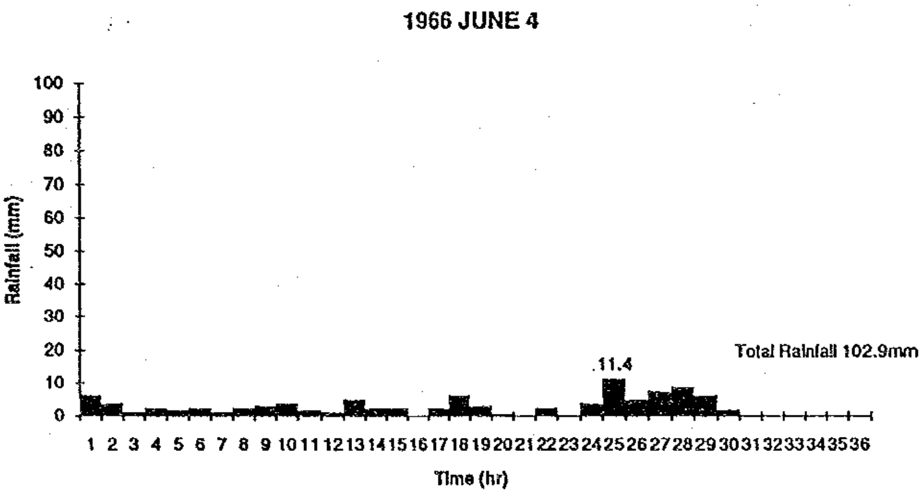
FIG. A.4.5 ACCUMULATIVE RAINFALL RATIO OF THE HURRICANE FIFI AT LA MESA AND TELA



	18 - Sept.				19-Sept.
	0 to 6	6 to12	12 to 18	18 to 24	0 to 6
1	3.69	5.08	29.40	0.00	24.40
2	7.85	21.58	66.12	21.65	9.00
3	13.38	0.64	0.00	1.67	55.21
4	1.85	1.27	0.00	6.68	21.84
5	7.38	2.54	24.48	6.68	25.69
6	1.85	8.89	0.00	3.32	3.86
Total	36.00	40.00	120.00	40.00	140.00

FIG. A.4.6 ESTIMATED HOURLY RAINFALL DISTRIBUTION OF THE HURRICANE FIFI AT LA MESA





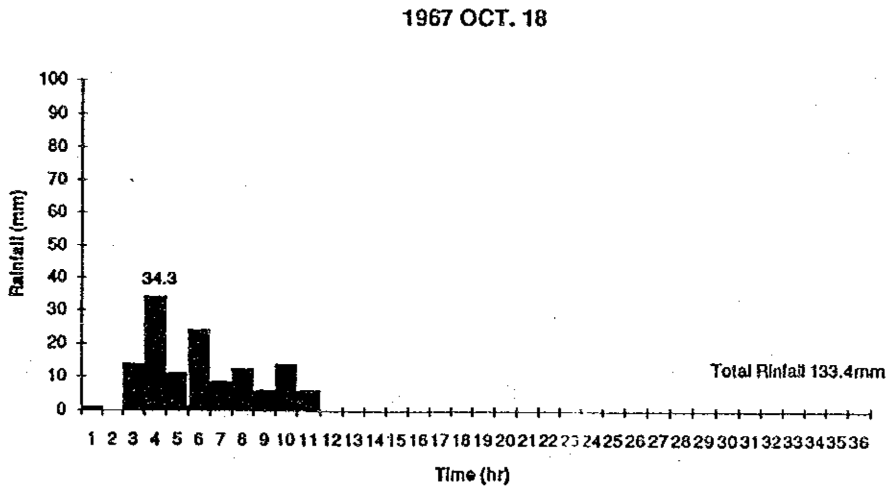
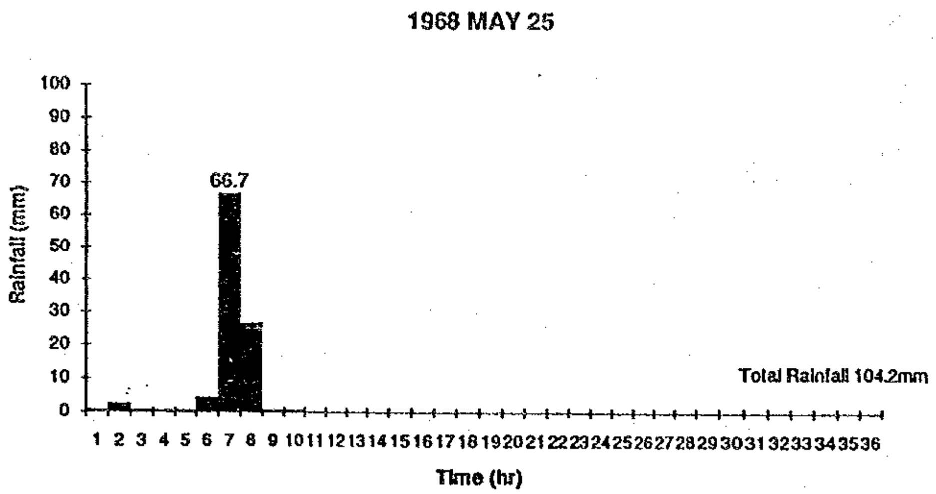


FIG. A.4.7 (1) HOURLY RAINFALL DISTRIBUTION RECORD AT LA MESA (1)



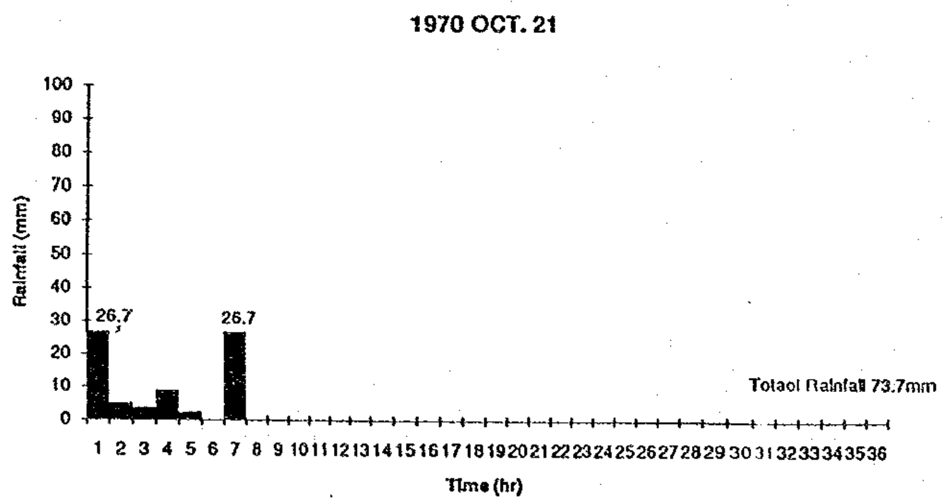
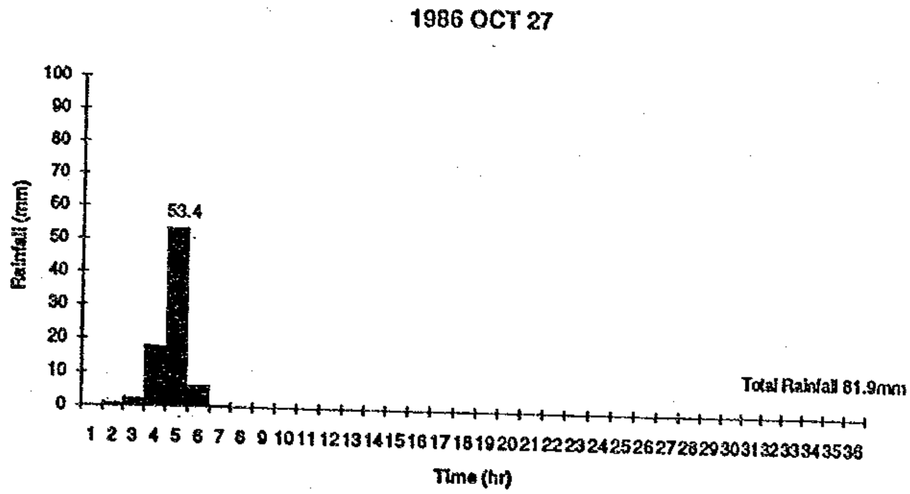


FIG. A.4.7 (2) HOURLY RAINFALL DISTRIBUTION RECORD AT LA MESA (2)



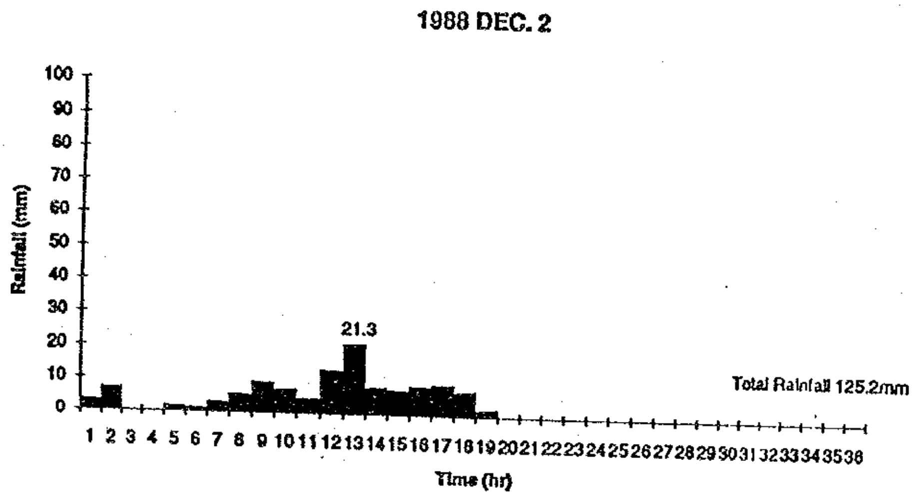


FIG. A.4.8 HOURLY RAINFALL DISTRIBUTION RECORD AT EL MODELO

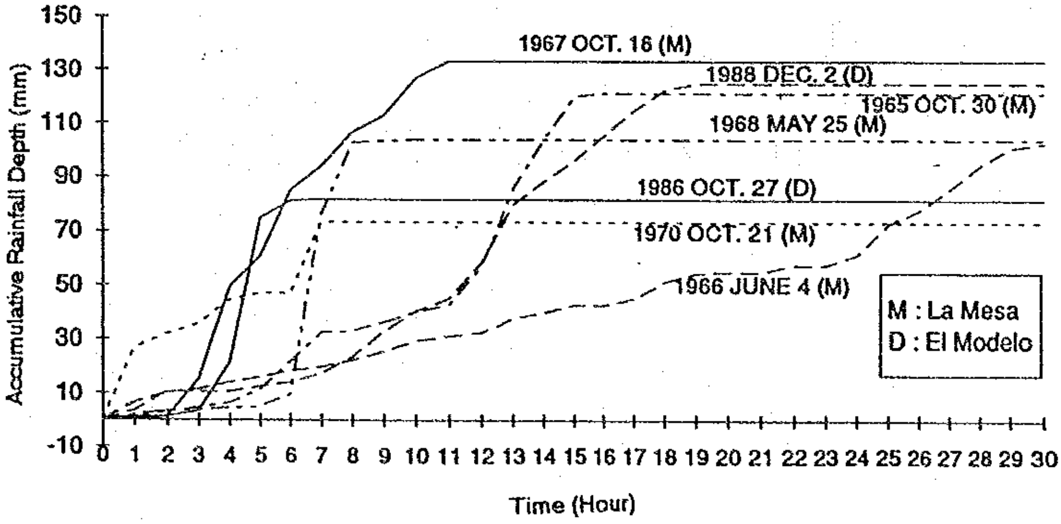


FIG. A.4.9 ACCUMULATIVE RAINFALL DEPTH AND DURATION CURVE

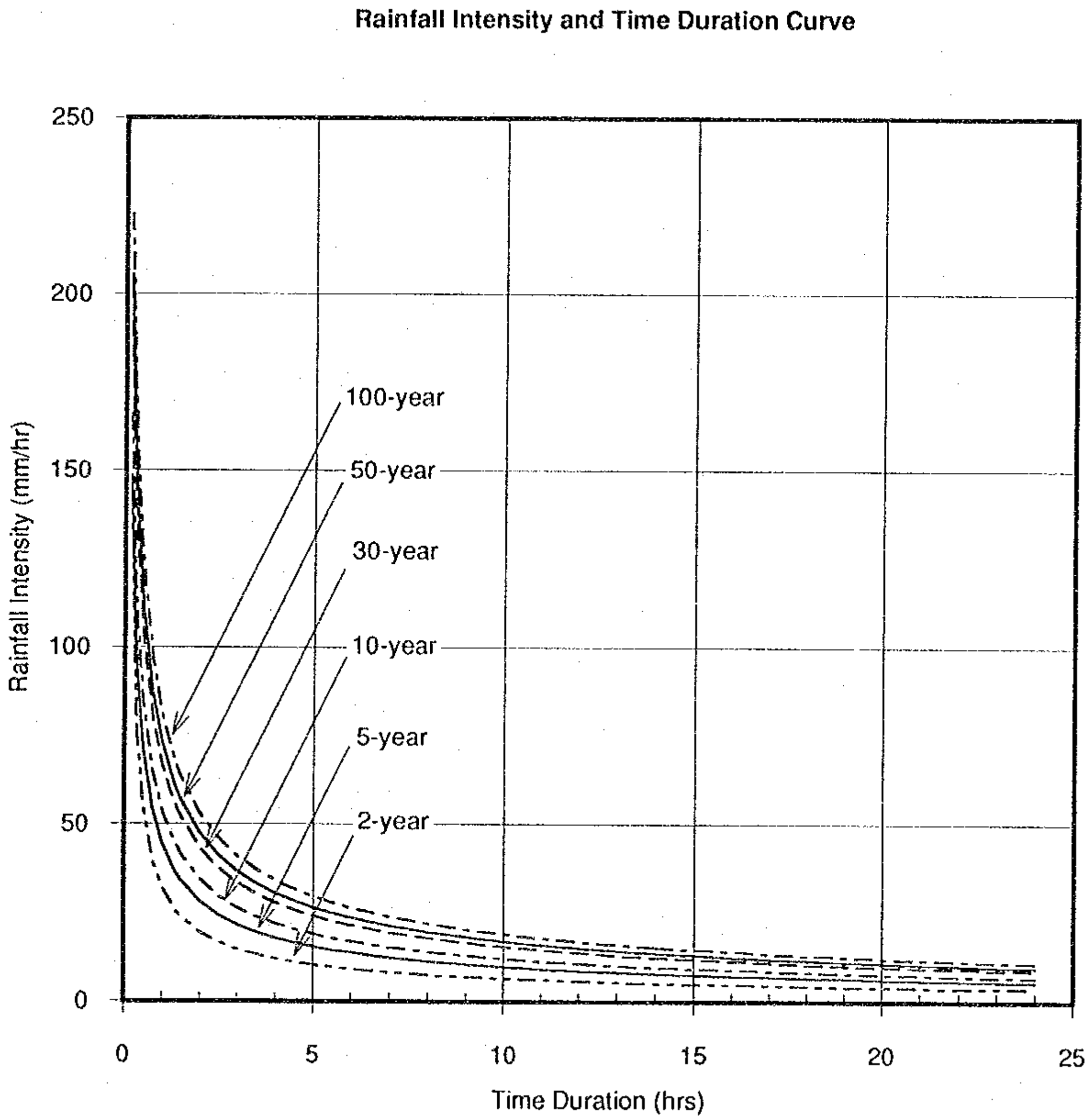
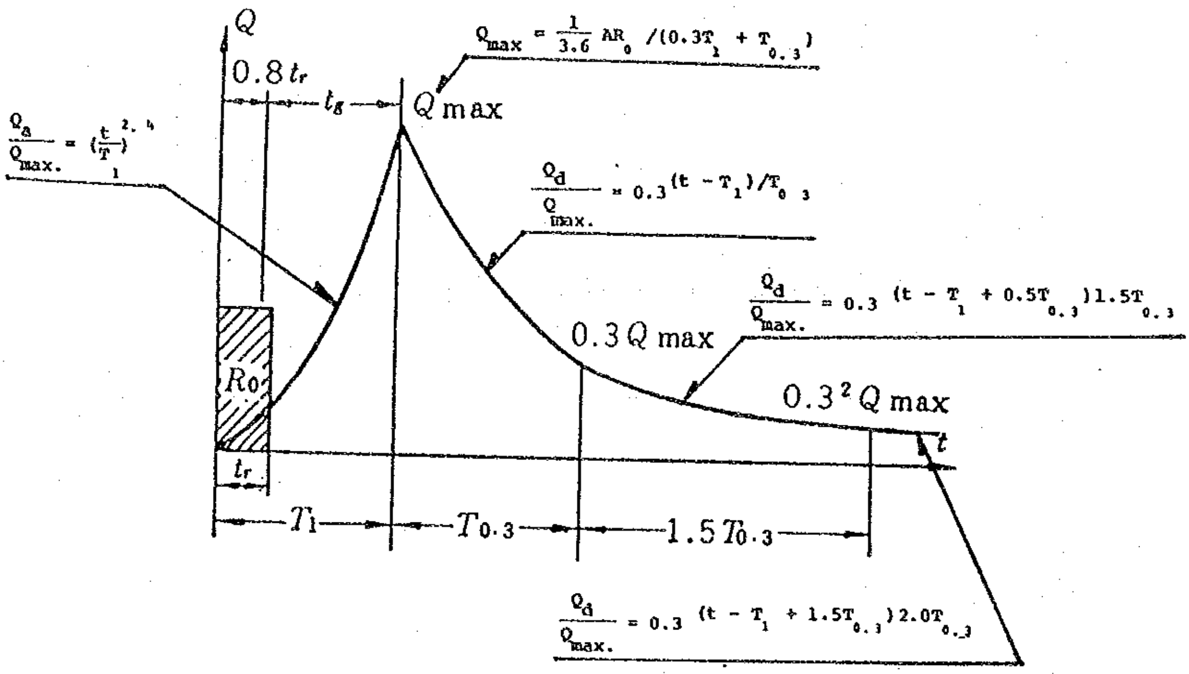


FIG. A.4.10 RAINFALL INTENSITY AND TIME DURATION CURVE



where, $Q_{max.}$: Maximum discharge of unit hydrograph (m^3/s)

Q_a, Q_d: Discharge at the time of rising and falling limb of unit hydrograph (m^3/s).

A : Catchment area (km^2)

R_0: Unit rainfall (mm)

T_1: Time from the start of run-off to maximum discharge

$T_{0.3}$: Time required until the discharge recesses to 0.3 times the maximum discharge

Relation between catchment shape and T :

$$T_{0.3} = 0.47 (A \cdot L)^{0.25}$$

Time of occurrence of peak discharge:

$$T_1 = t_g + 0.8\, t_r$$

where, t_r: Duration of unit rainfall to be used.

For $L \leq 15$ km

$$t_g = 0.26\, L_m^{0.7} = 0.21\, L^{0.7} = 0.235\, (L_m \cdot L)^{0.35}$$

For $L > 15$ km:

$$t_g = 0.4 + 0.077\, L_m = 0.4 + 0.058\, L$$

FIG. A.5.1 SHAPE OF NAKAYASU'S UNIT HYDROGRAPH

		Catchment/River	
		C.A. (sq. km)	L (km)
I	Rio Choloma, Rio Blanco, Canal San Roque, Canal S. R.- C. and Canal C.- H.- C. Basin		
C-1	River Mouth of the Basin	420.15	48.4
C-2	Choloma, Blanco, San Roque, Canal San Roque - Cuabanos, C-H C Basin	366.45	42.1
	I Canal Copen-Higuero-Cuabanos	33.43	9.6
	II Choloma, Blanco and San Roque	333.02	42.1
C-3	Rio Choloma, Rio Blanco and S.R. Basin	297.13	37.4
RC-1	Rio Choloma Basin	106.89	20.7
RC-2	I at Choloma Bridge	71.64	13.6
RC-3	II at Jutosa (Junction of Rio La Jutosa)	55.02	9.4
C-4	Rio Blanco - Canal San Roque Basin	190.24	37.4
RB-1	Rio Blanco Basin	137.98	31.0
RB-2	I Outlet of Laguna El Carmen	107.41	22.7
RB-3	II Inlet of Laguna El Carmen	83.72	19.2
RB-4	III Prop. Diversion Point	71.35	15.7
RB-5	IV Rio del Zapotal and Rio de Armenta	43.90	12.2
II	Rio El Sauce and Rio El Sauce (viejo) - Chotepe Basin		
S-1	River Mouth of Rio El Sauce	215.70	29.8
RS-1	Rio El Sauce Basin	118.33	29.7
RS-2	I Mid. of Rio El Sauce	79.93	21.8
RS-3	II Jct. of Prop. Diversion	75.33	18.1
RS-4	III Rio Santa Ana and Rio Piedras	72.16	15.4
RSB-1	IV Rio Santa Ana Basin (at National Road)	37.63	13.4
RSP-1	V Rio Piedras Basin (at National Road)	30.87	12.6
RSV-1	Rio El Sauce (viejo) - Chotepe Basin	97.37	22.9

Note: Retention effect of Laguna El Carmen is not considered in this calculation

C.A. : Catchment Area of the Basin (sq. km) L : Maximum River Length of the Basin (km)
S.R. : Canal San Roque S.R.-C : Canal San Roque Cuabanos
C-H-C : Canal Copen-Higuero-Cuabanos

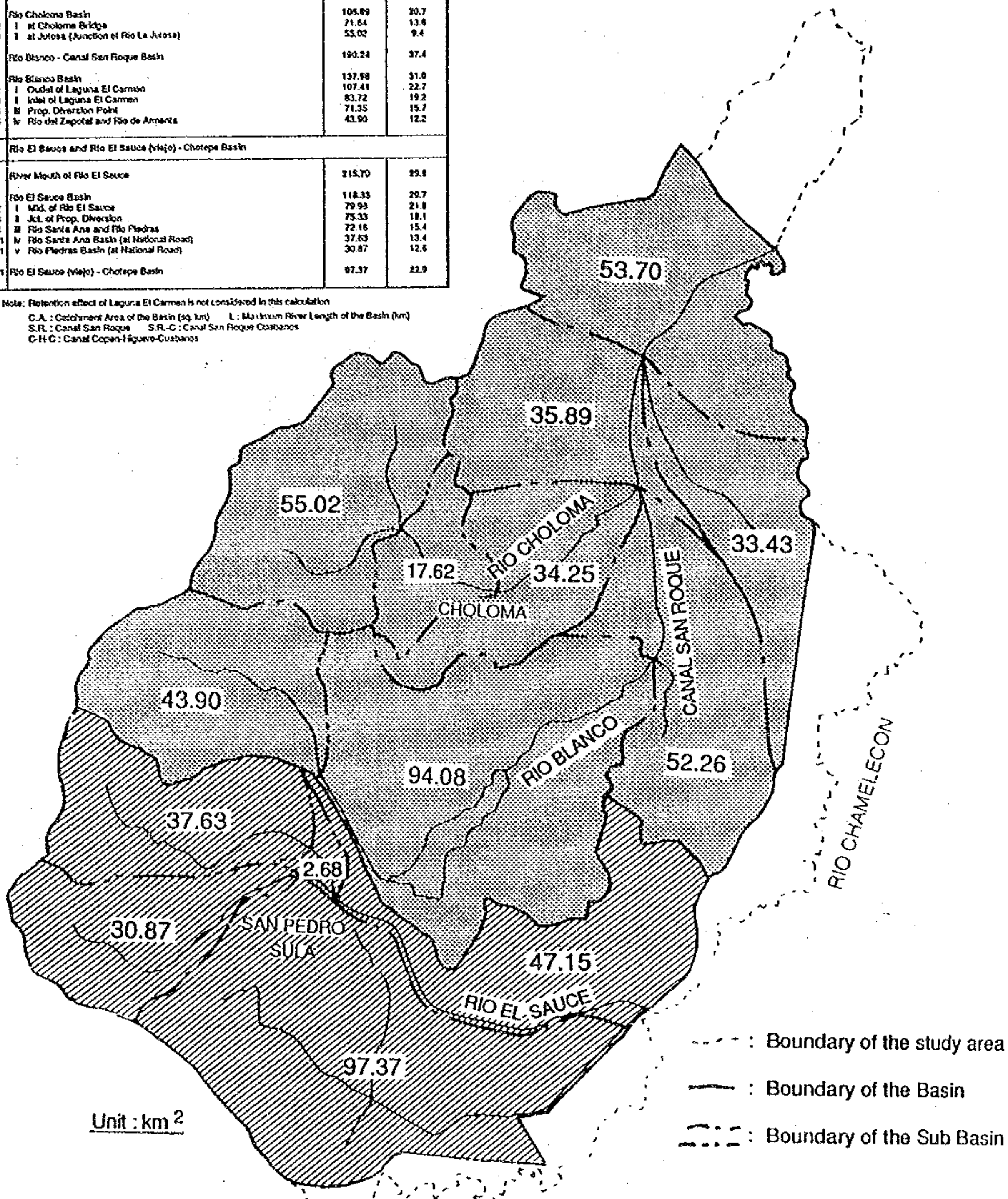


FIG. A.5.2 SUB-DIVISION OF THE DRAINAGE BASIN

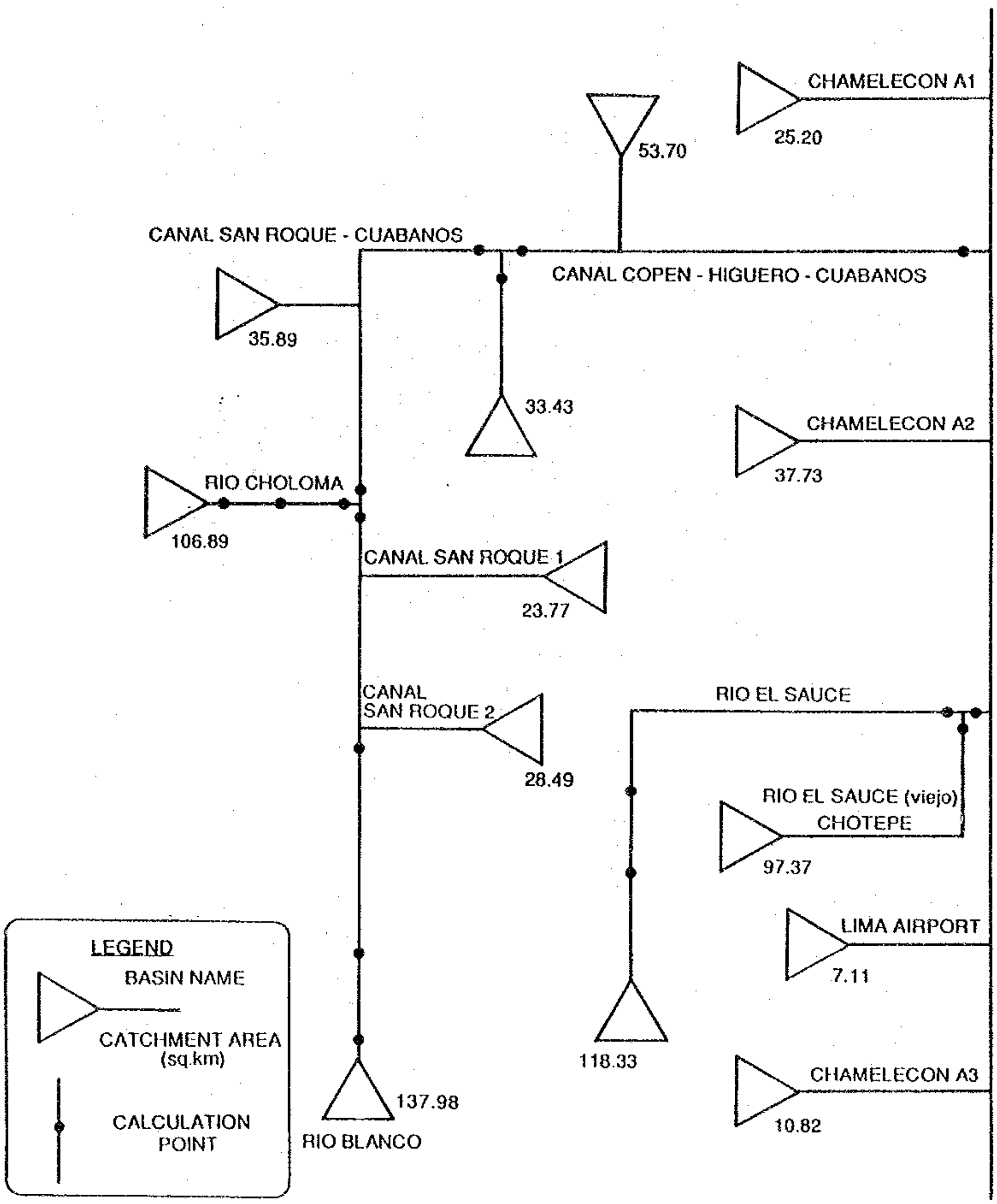


FIG. A.5.3 RIVER SYSTEM MODEL FOR RUN-OFF SIMULATION (PRESENT RIVER SYSTEM)

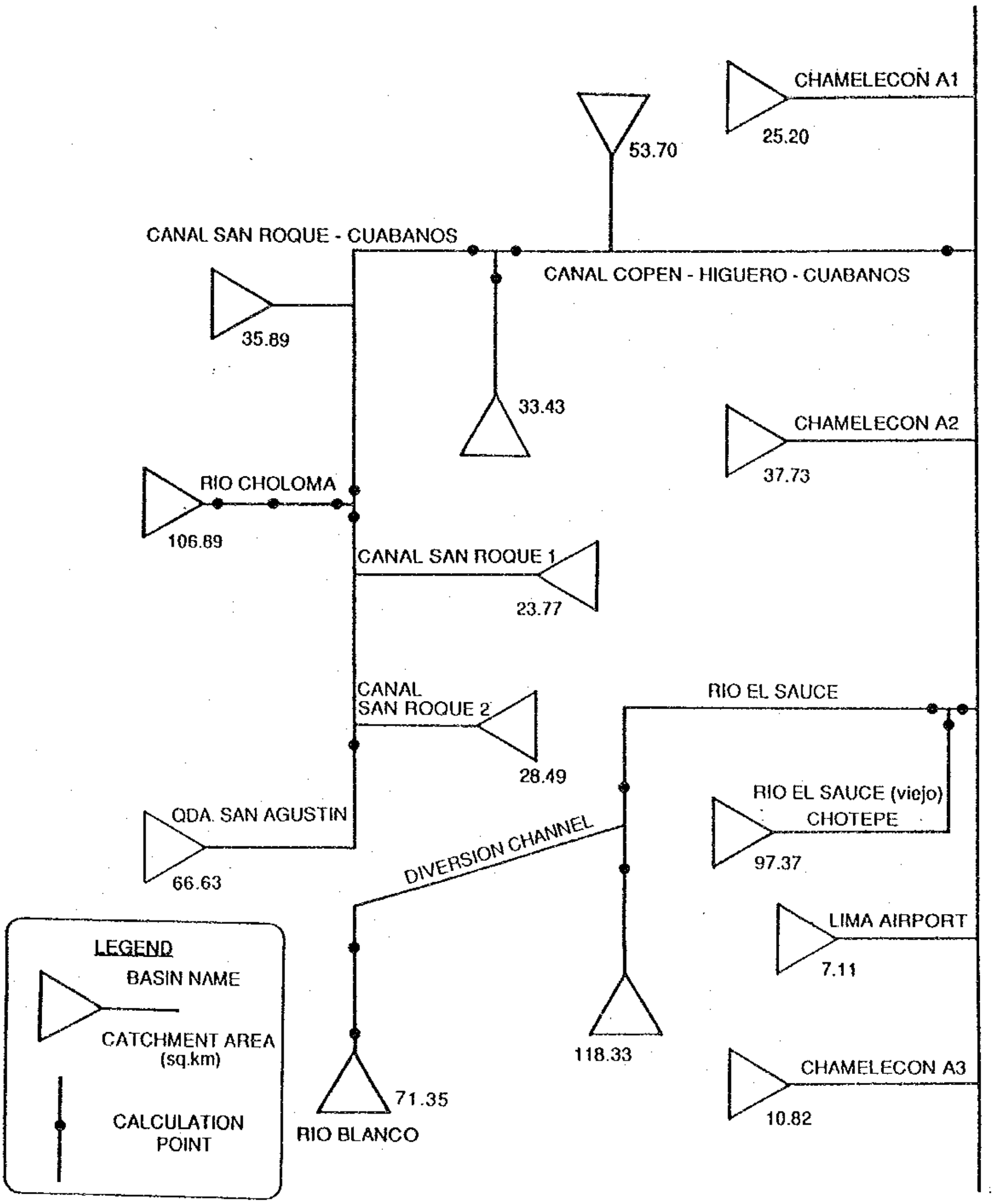
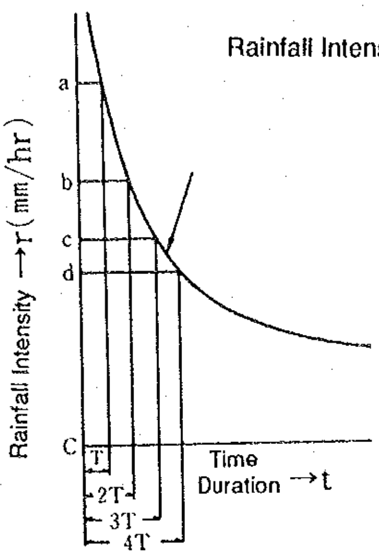
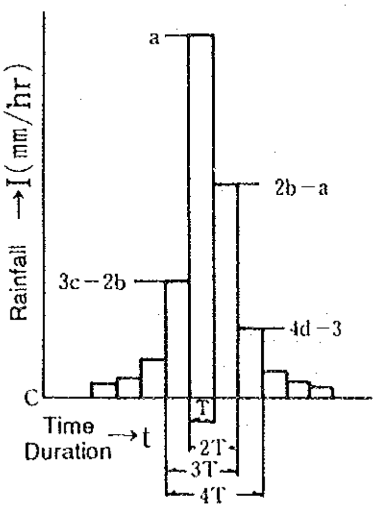


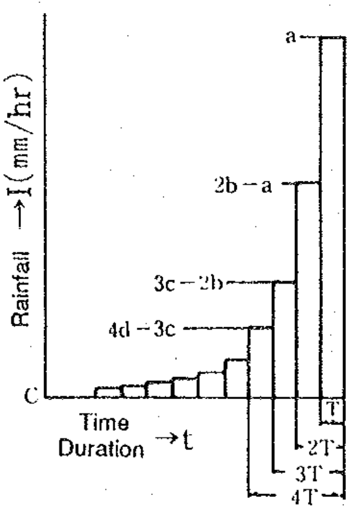
FIG. A.5.4 RIVER SYSTEM MODEL FOR RUN-OFF SIMULATION (ALTERNATIVE RIVER SYSTEM)



T : Calculation Time Unit



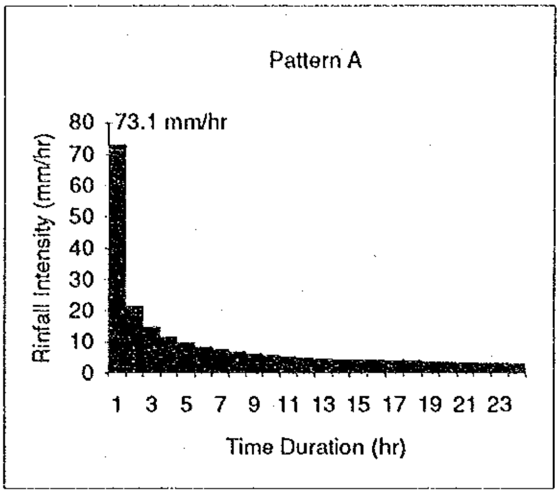
Maximum rainfall intensity occurs at the middle of the rain

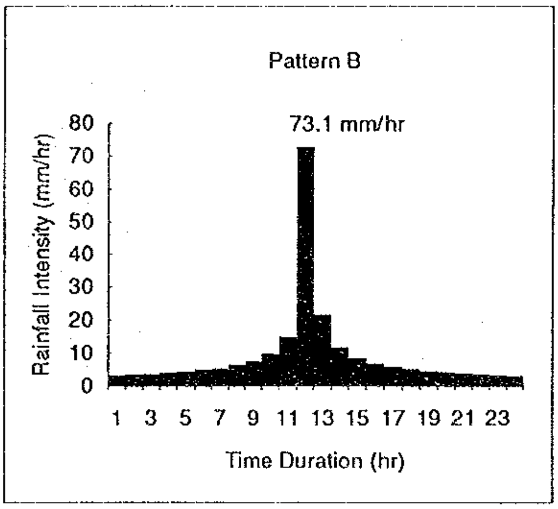


Maximum rainfall intensity occurs at the end of the rain

FIG. A.5.5 HOW TO CREATE THE RAINFALL PATTERN USING RAINFALL INTENSITY AND TIME DURATION CURVE

T (hr)	Rainfall Intensity (mm/hr)		
	Pattern A	Pattern B	Pattern C
1	73.1	3.3	3.2
2	21.7	3.6	3.3
3	15.0	3.8	3.4
4	11.8	4.1	3.6
5	10.0	4.5	3.7
6	8.7	5.0	3.8
7	7.7	5.6	4.0
8	7.0	6.5	4.1
9	6.5	7.7	4.3
10	6.0	10.0	4.5
11	5.6	15.0	4.7
12	5.3	73.1	5.0
13	5.0	21.7	5.3
14	4.7	11.8	5.6
15	4.5	8.7	6.0
16	4.3	7.0	6.5
17	4.1	6.0	7.0
18	4.0	5.3	7.7
19	3.8	4.7	8.7
20	3.7	4.3	10.0
21	3.6	4.0	11.8
22	3.4	3.7	15.0
23	3.3	3.4	21.7
24	3.2	3.2	73.1





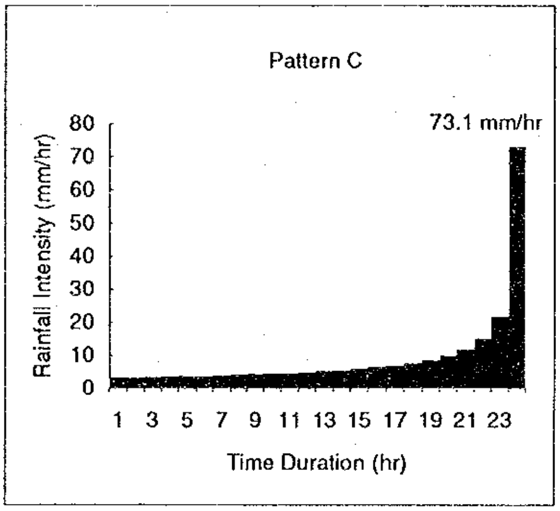


FIG. A.5.6 RAINFALL PATTERNS FOR RUN-OFF SIMULATION

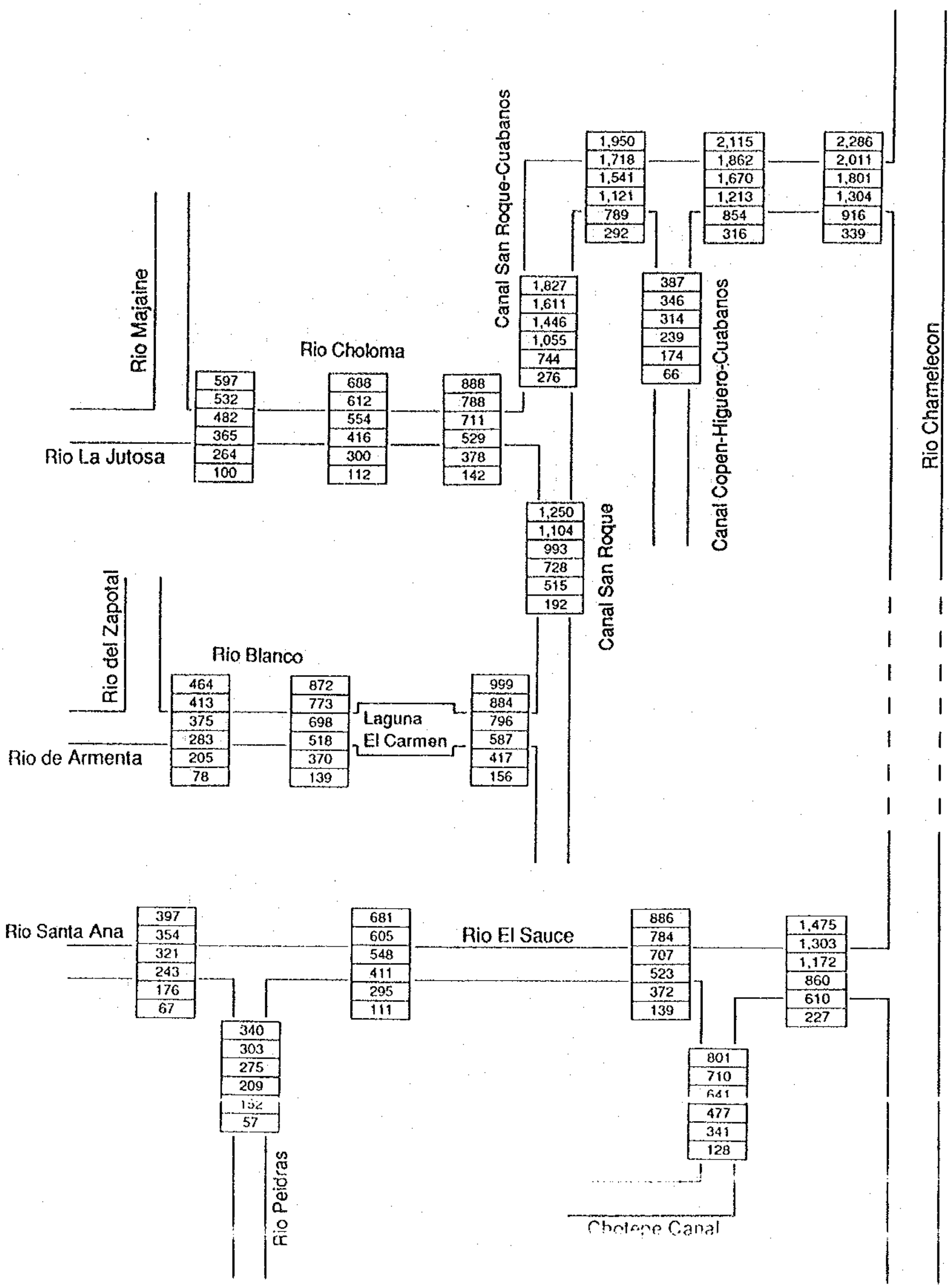


FIG. A.5.7 PROBABLE PEAK DISCHARGE DISTRIBUTION
- PRESENT RIVER SYSTEM (RAINFALL PATTERN C)

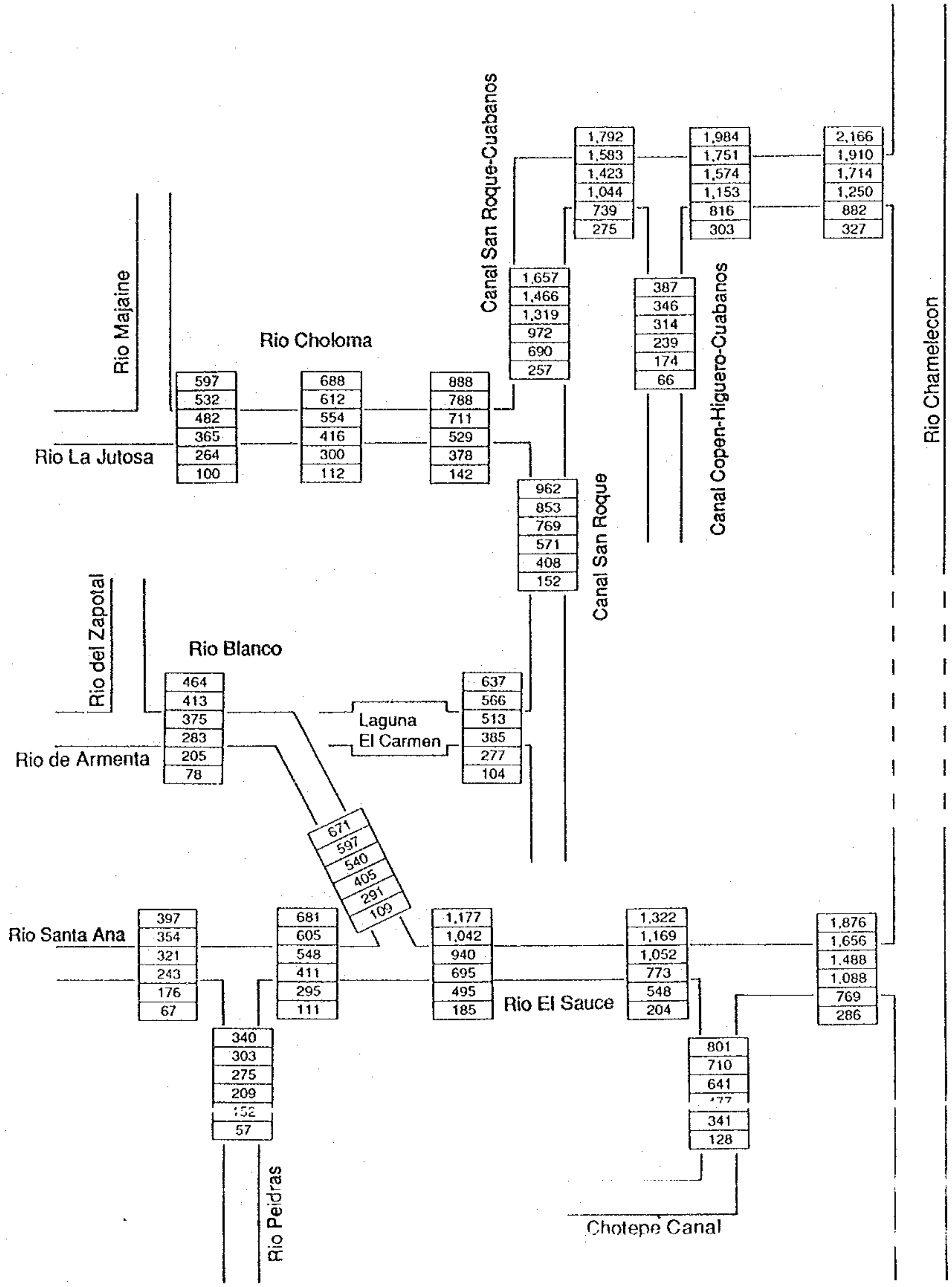
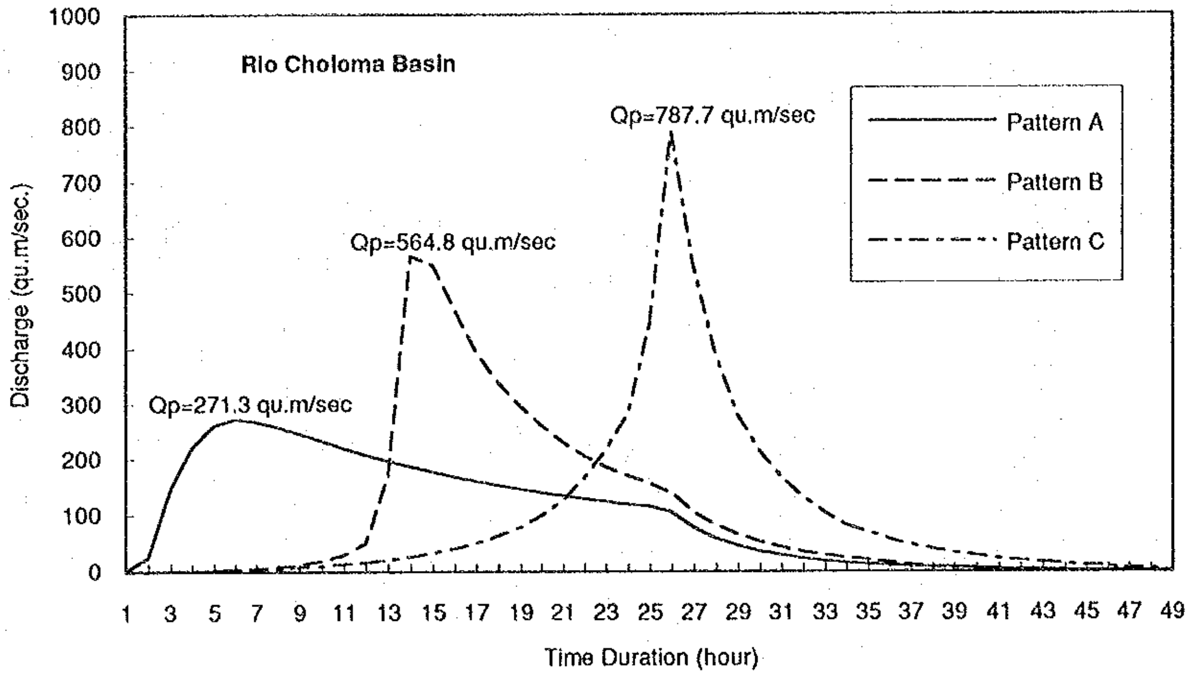


FIG. A.5.8 PROBABLE PEAK DISCHARGE DISTRIBUTION
- ALTERNATIVE RIVER SYSTEM (RAINFALL PATTERN C)



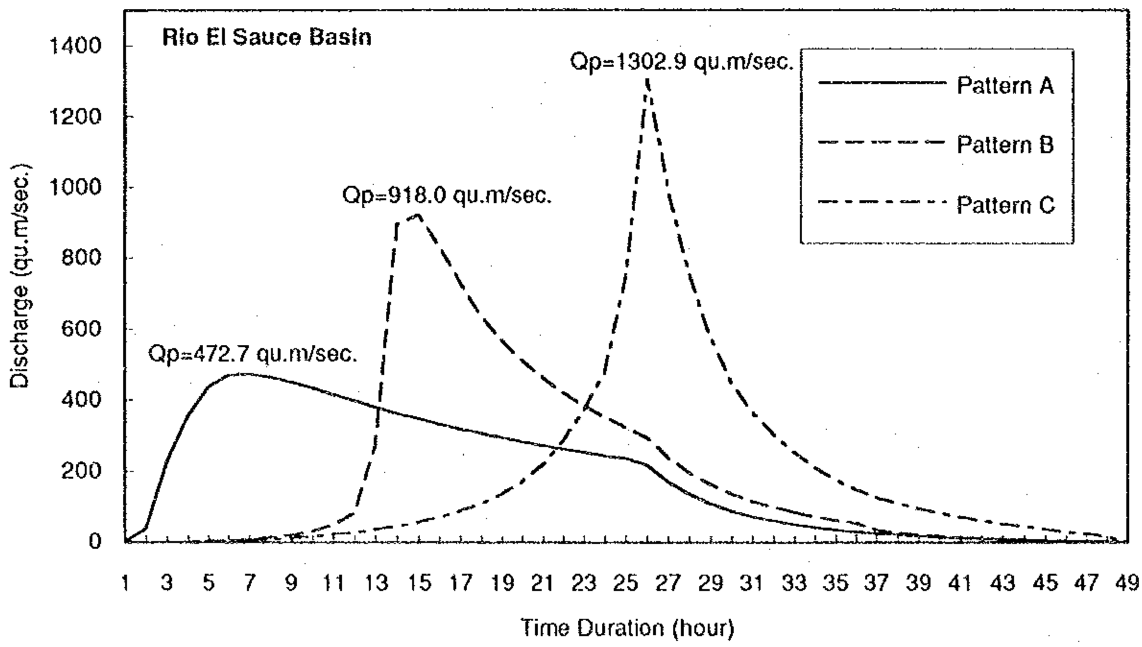
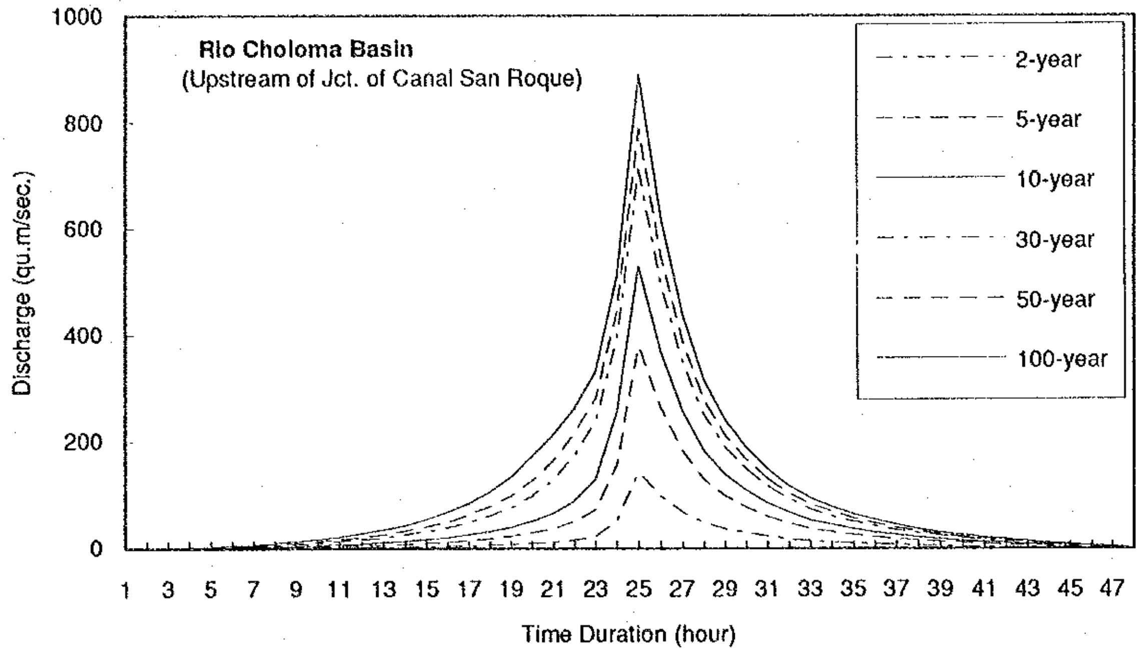


FIG. A.5.9 DIFFERENCE OF THE HYDROGRAPH BY RAINFALL PATTERN



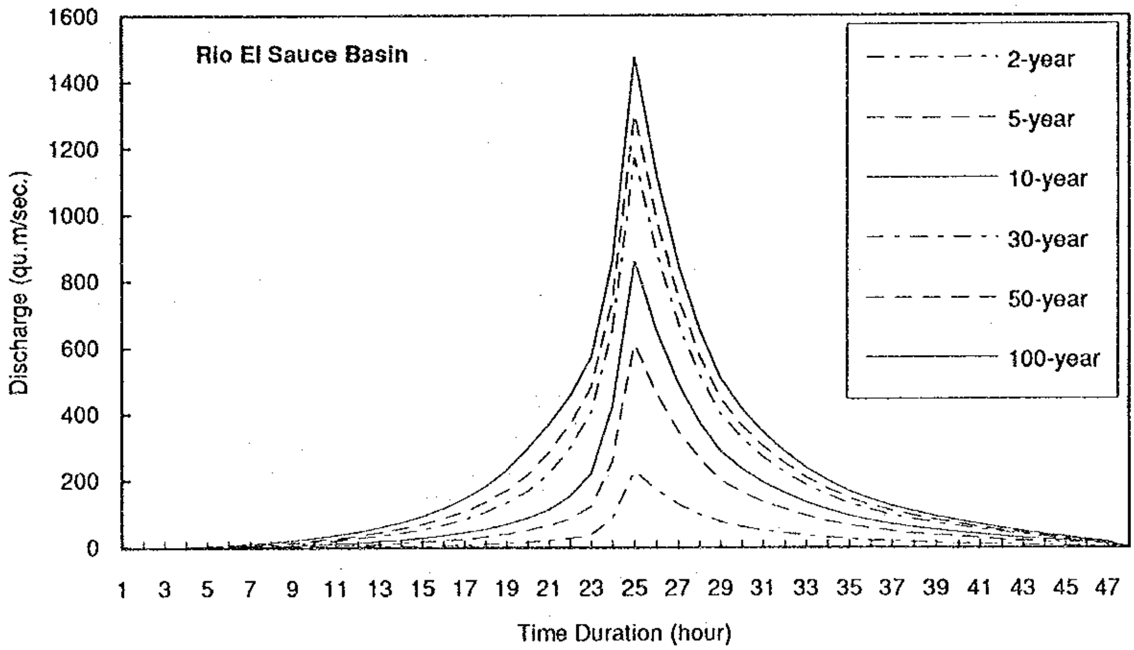
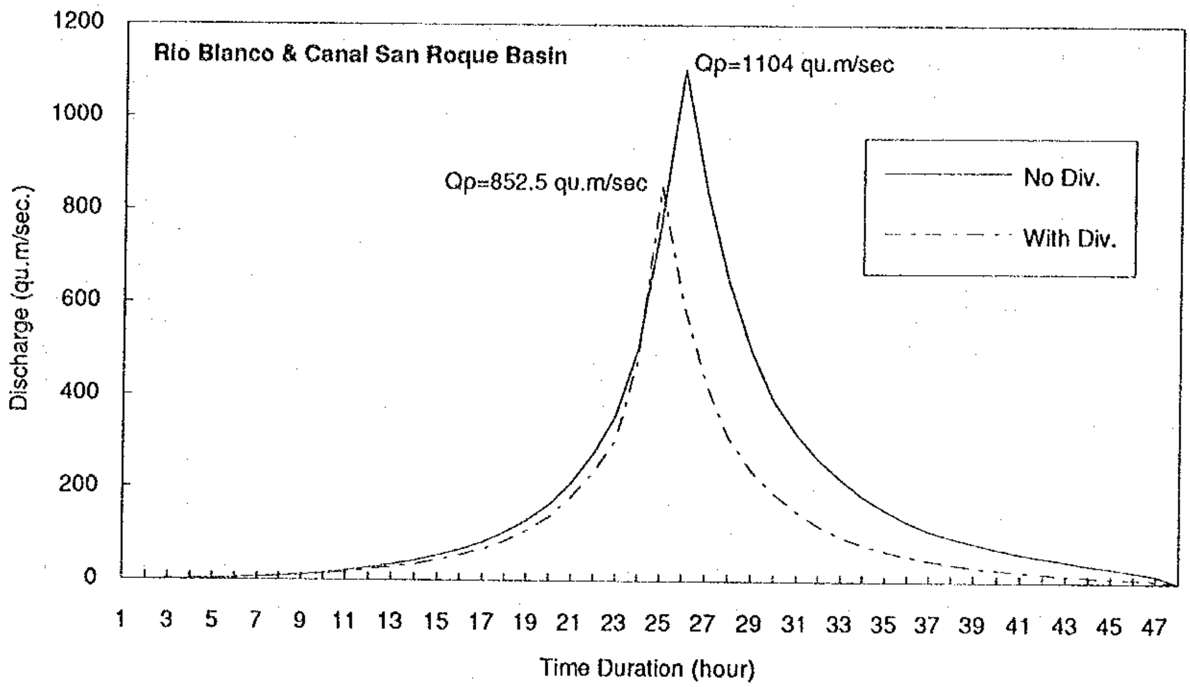


FIG. A.5.10 PROBABLE FLOOD HYDROGRAPH (RAINFALL PATTERN C)



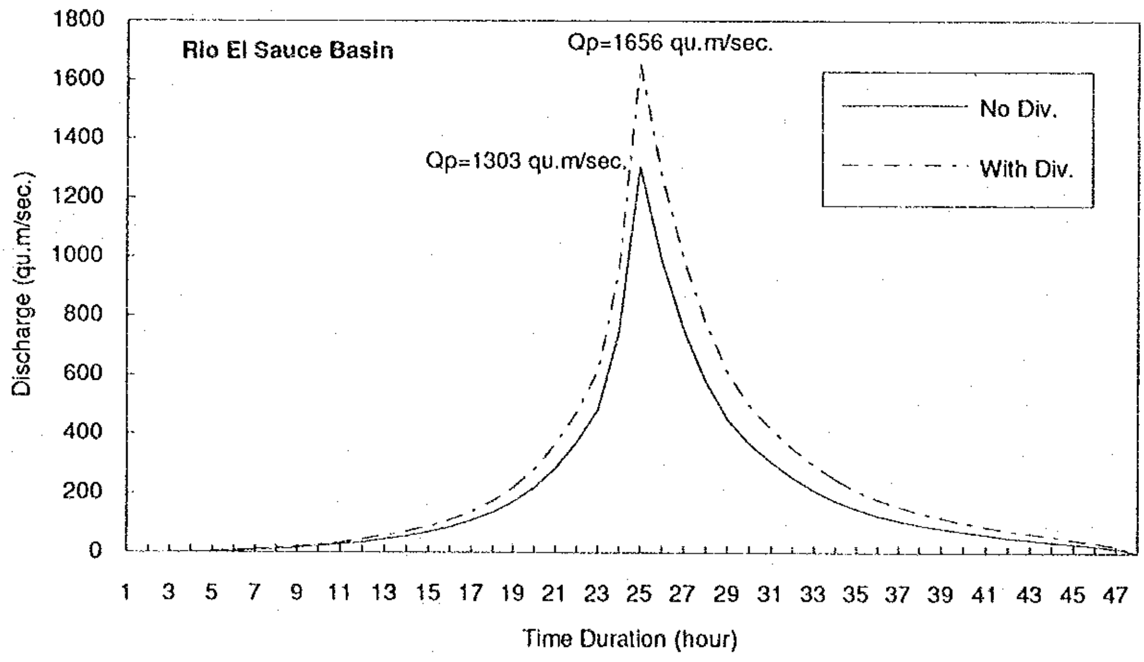


FIG. A.5.11 DIFFERENCE OF THE HYDROGRAPH BY ALTERNATIVES

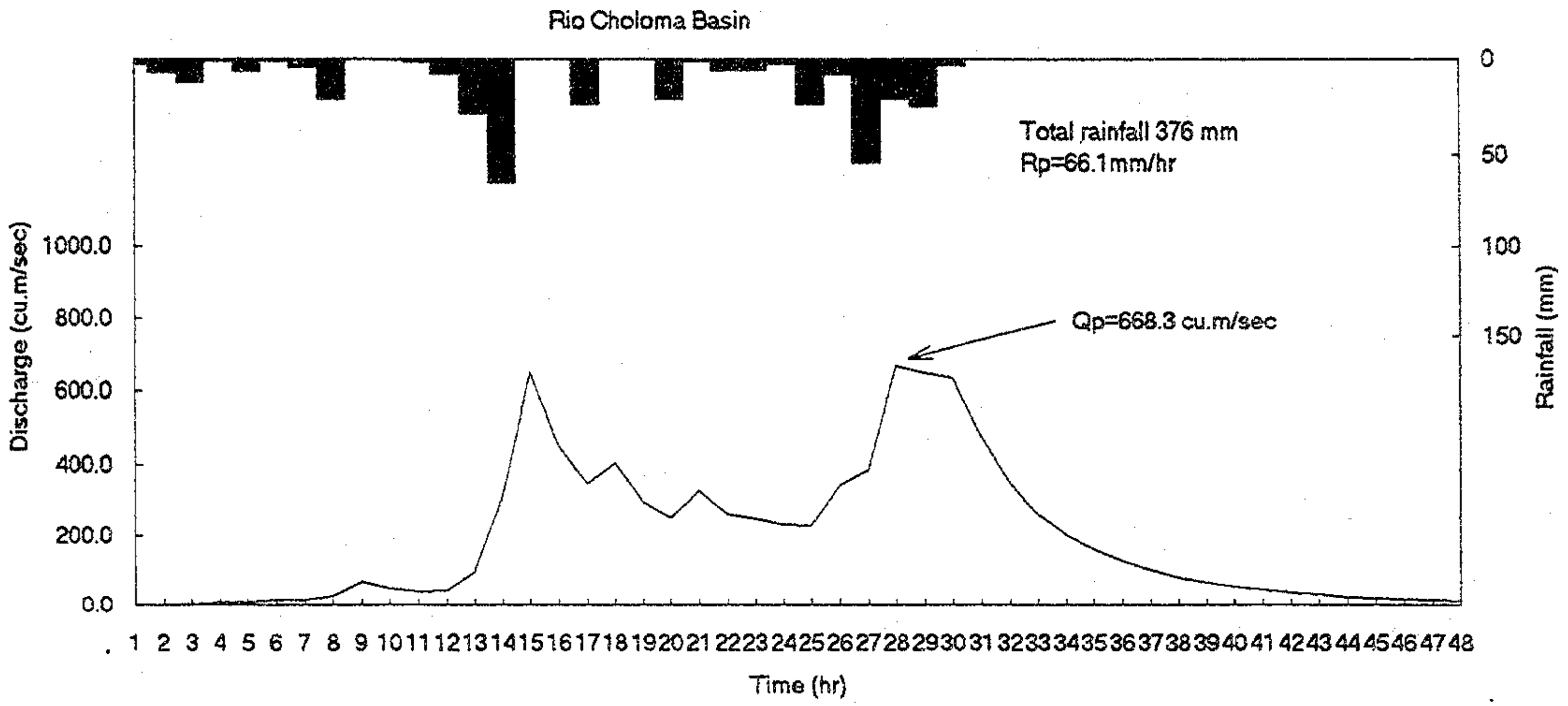


FIG. A.5.12 SIMULATED FLOOD HYDROGRAPH OF THE HURRICANE FIFI

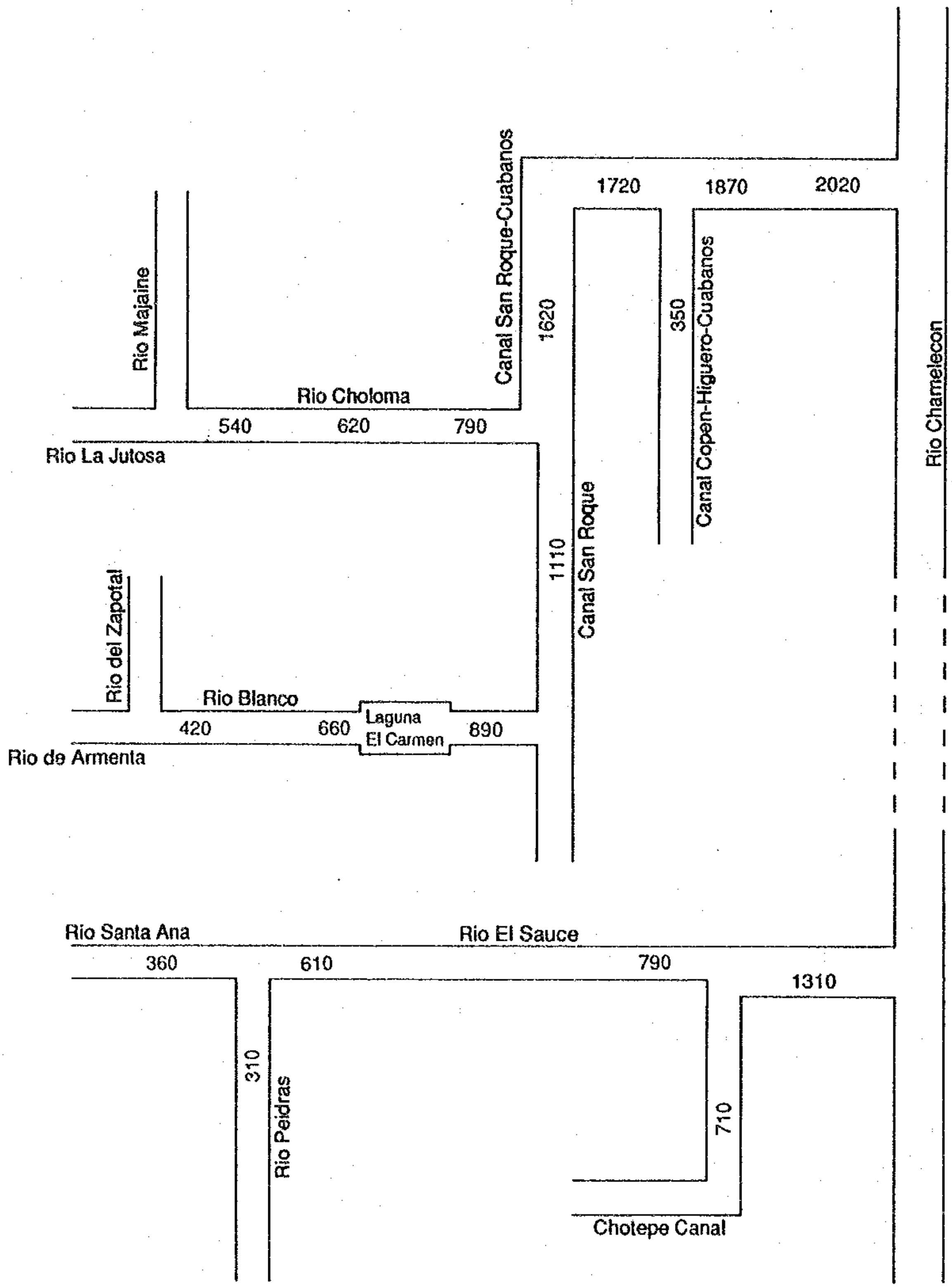


FIG. A.5.13 PEAK DISCHARGE DISTRIBUTION
(50-YEAR FLOOD / PRESENT RIVER SYSTEM)

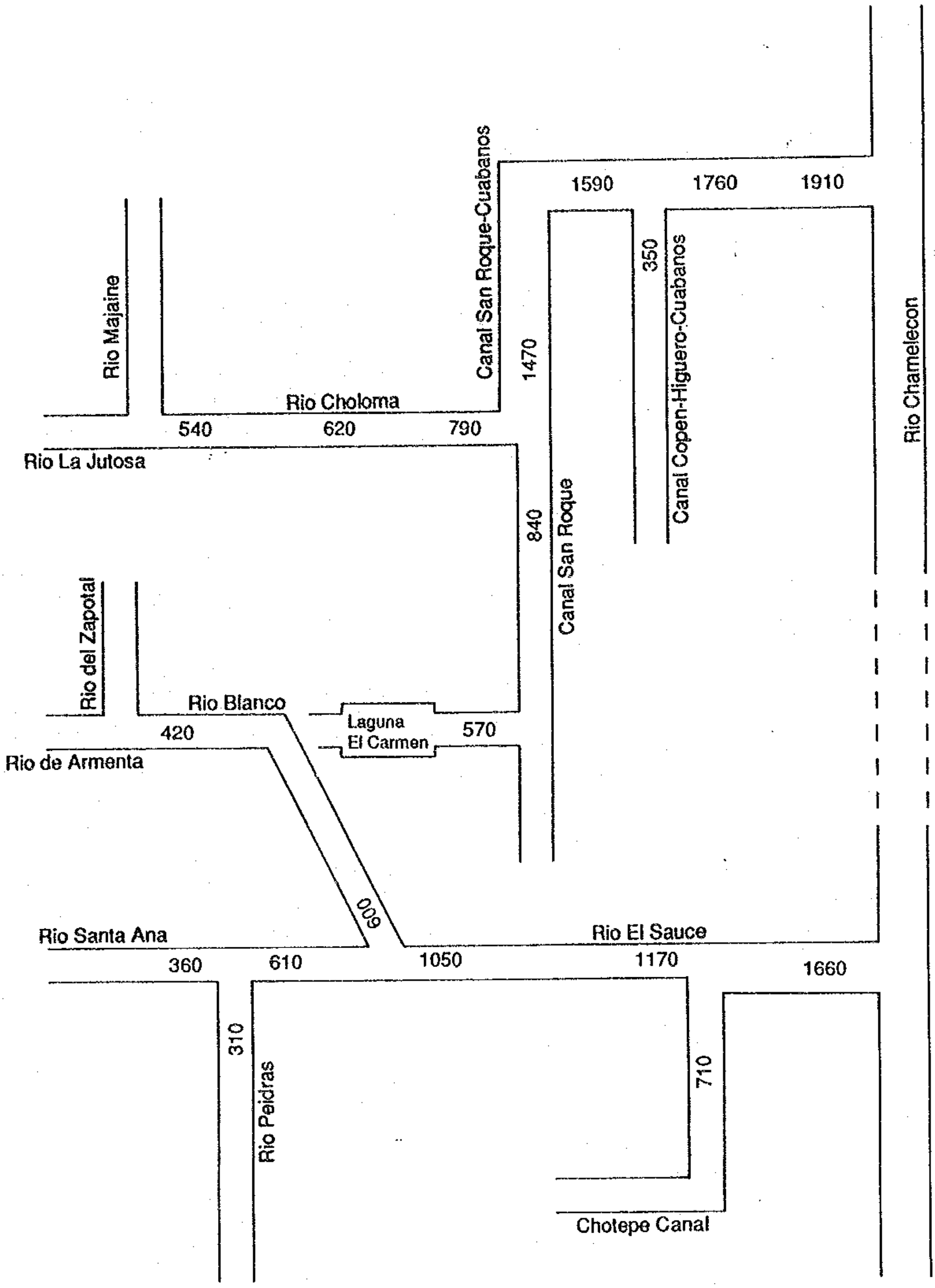


FIG. A.5.14 PEAK DISCHARGE DISTRIBUTION (50-YEAR FLOOD / ALTERNATIVE RIVER SYSTEM)

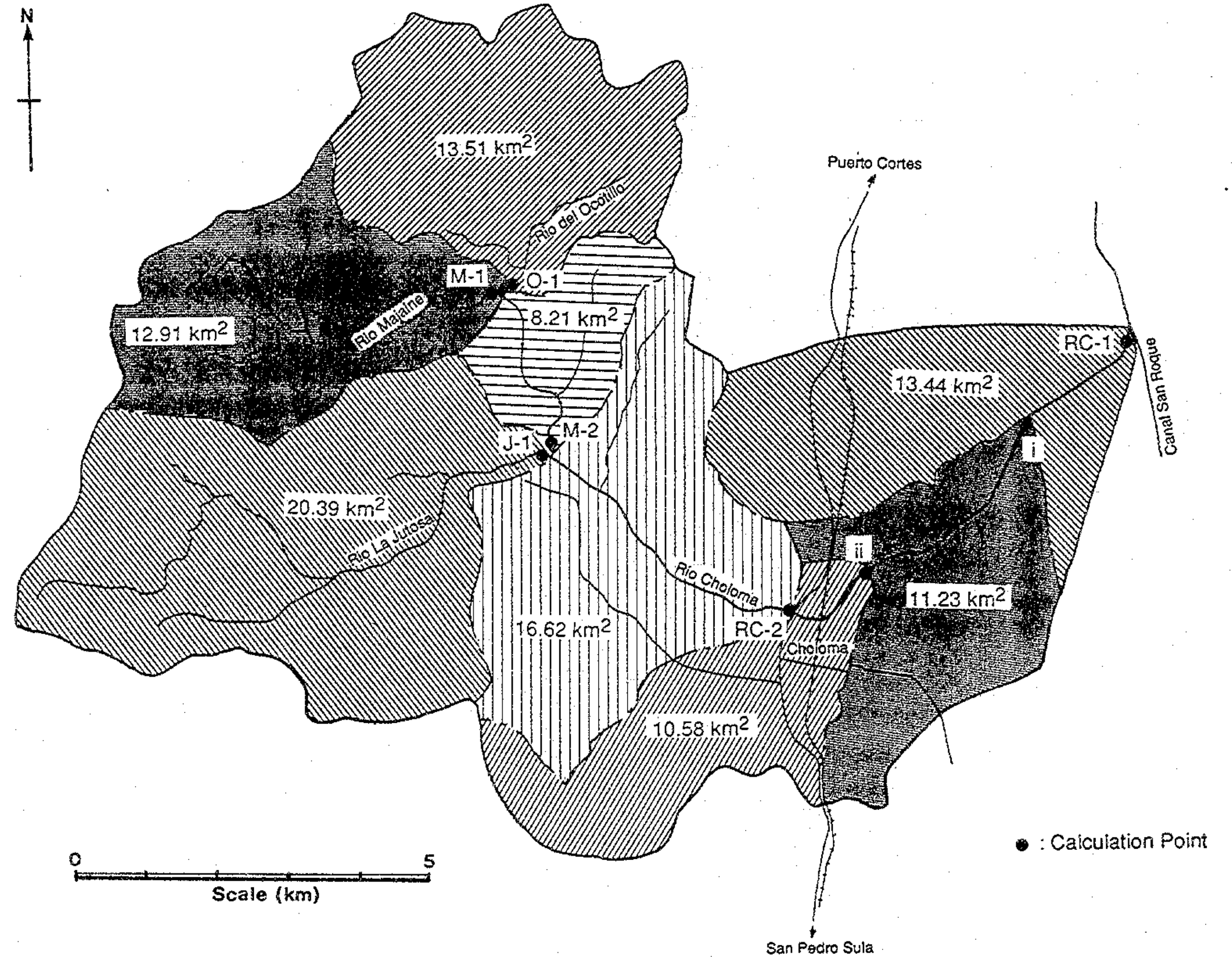


FIG. A.6.1 DIVISION OF THE RIO CHOLOMA BASIN

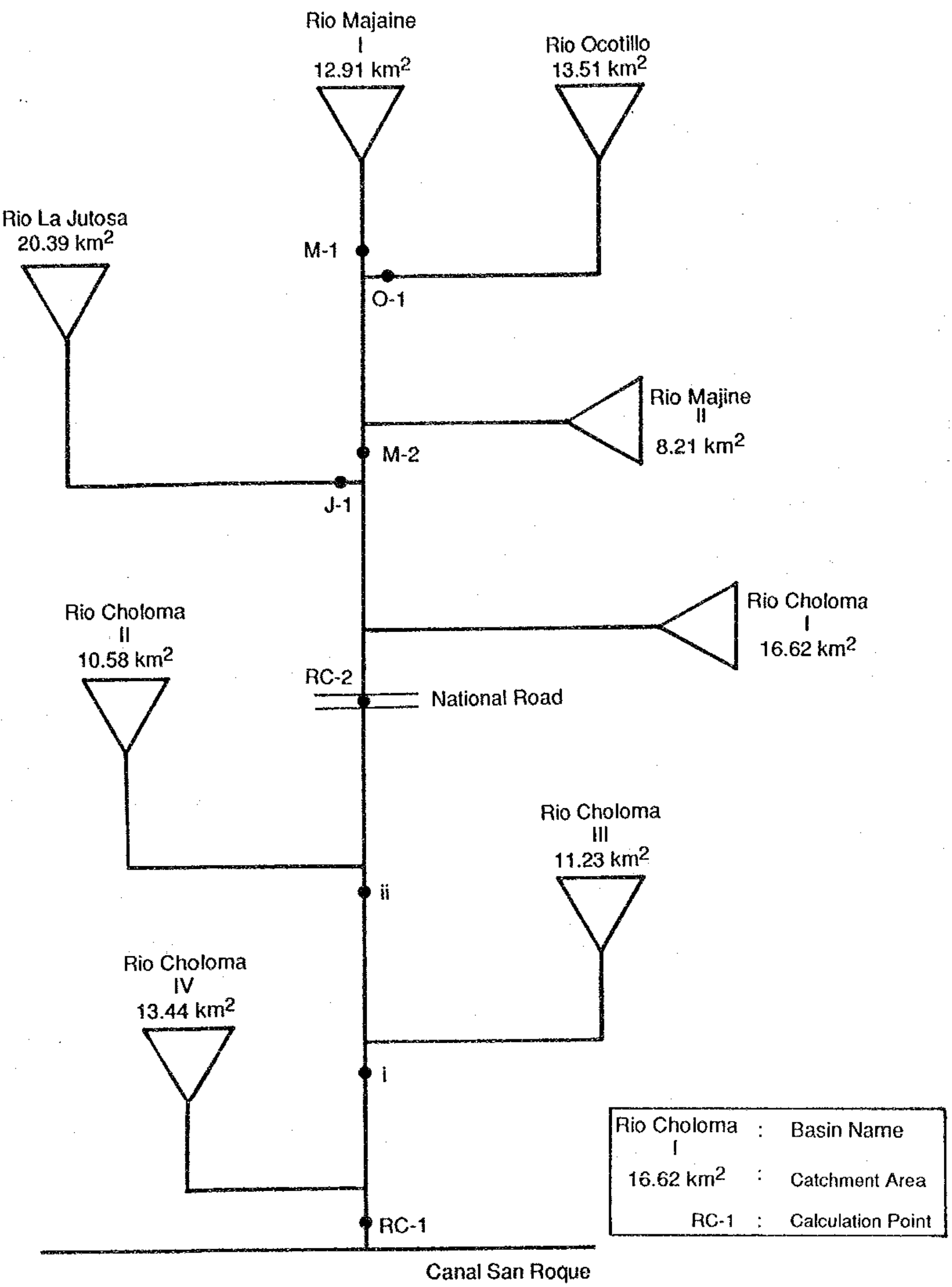


FIG. A.6.2 RIVER SYSTEM MODEL FOR THE RIO CHOLOMA BASIN

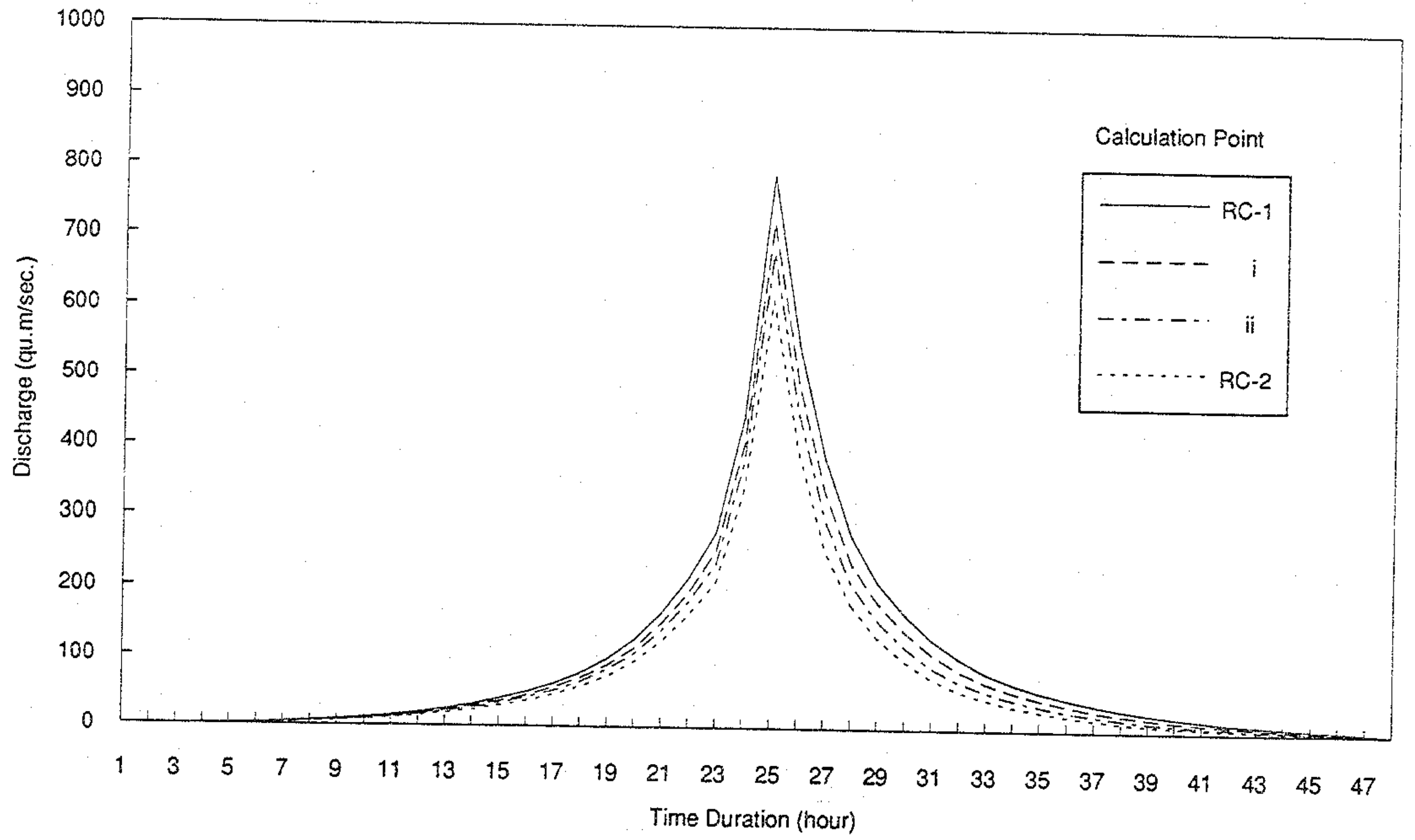


FIG. A.6.3 SIMULATED FLOOD HYDROGRAPH OF THE RIO CHOLOMA

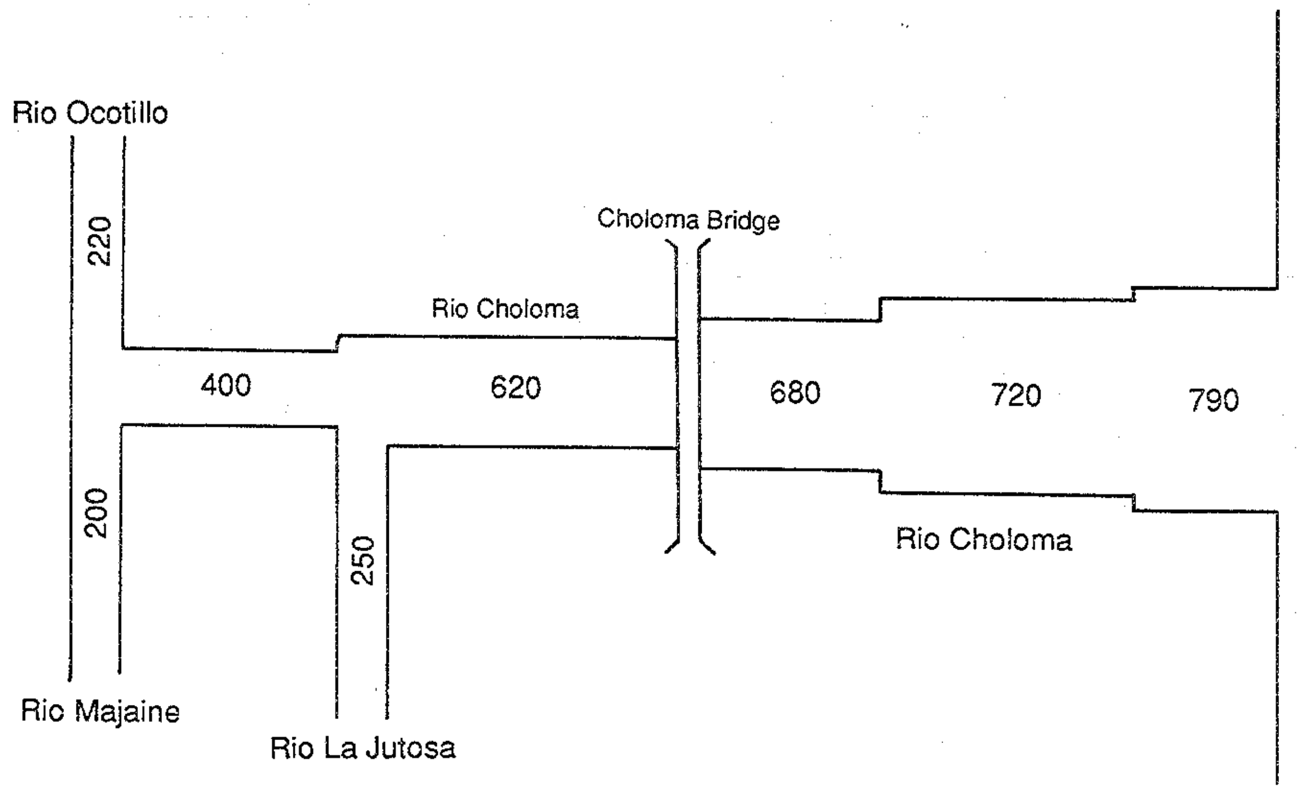


FIG. A.6.4 PEAK DISCHARGE DISTRIBUTION OF THE RIO CHOLOMA (50-YEAR FLOOD)