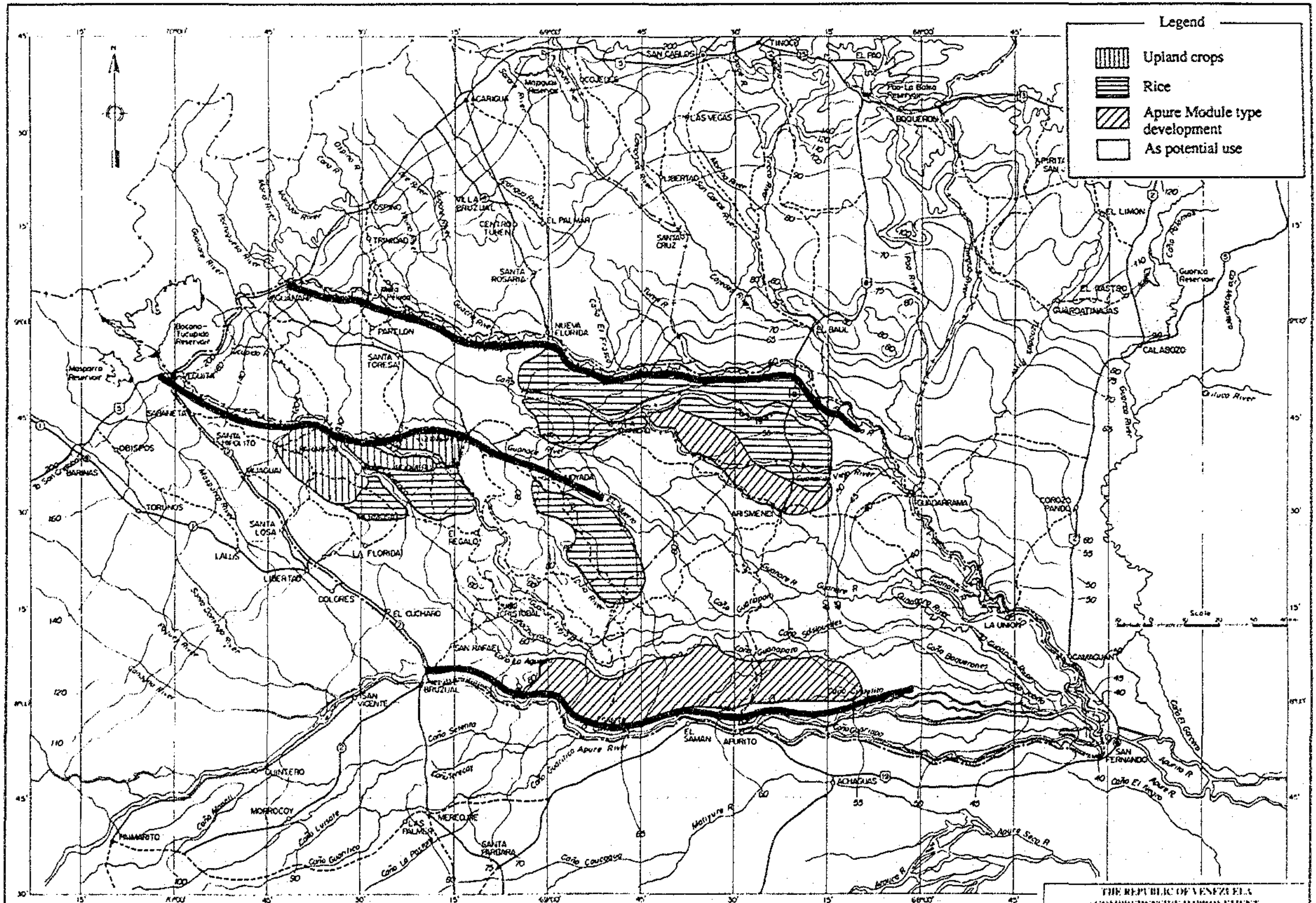

Fig. 2.4.5 Proposed Land Use in Areas Protected by Dikes

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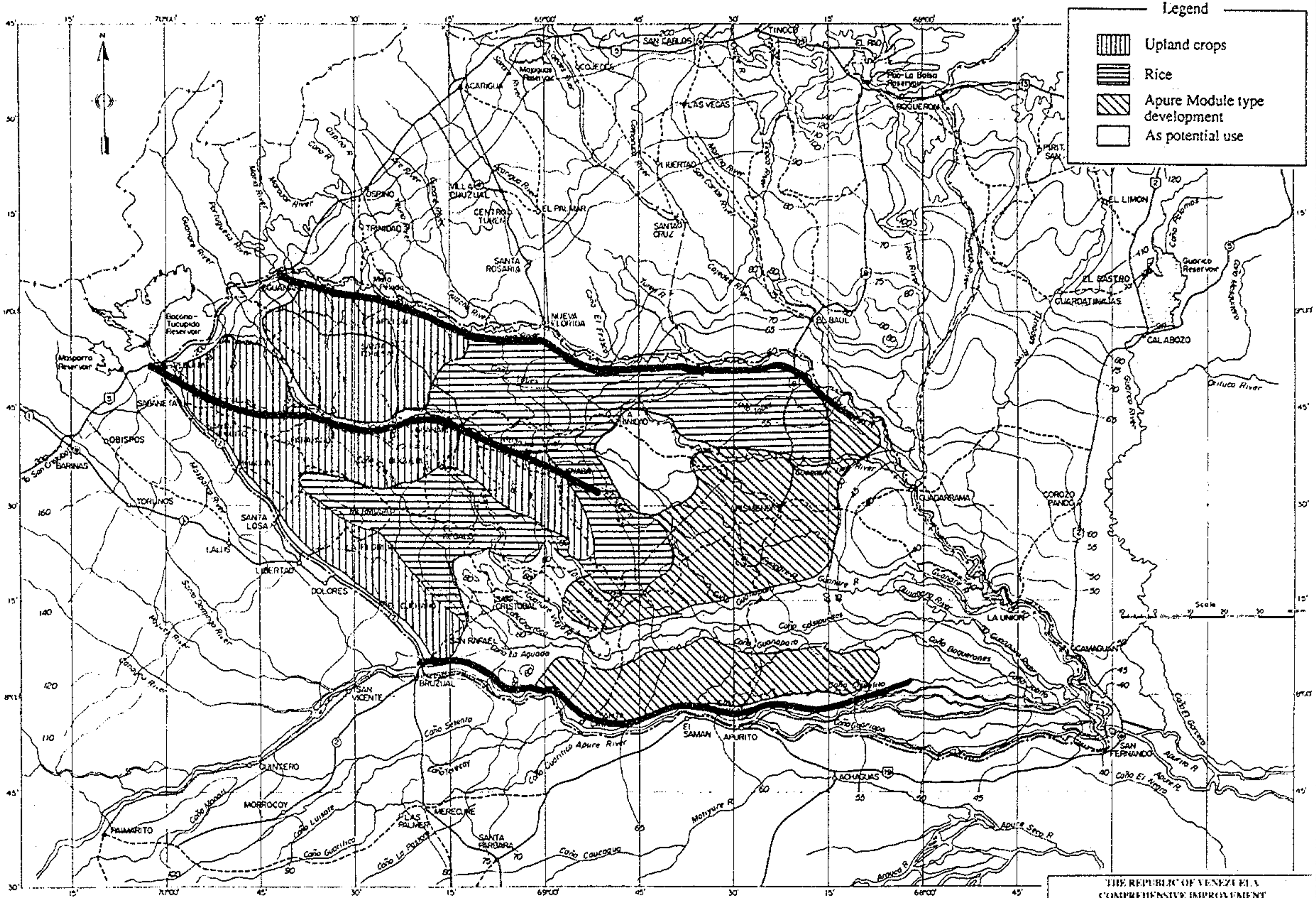

Fig. 2.4.6 Proposed Land Use With Dike Project, Drainage and Irrigation Projects

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OF THE APURE RIVER BASIN
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PART-D

HYDROLOGICAL AND HYDRAULIC STUDIES

STUDY ON COMPREHENSIVE IMPROVEMENT
OF
THE APURE RIVER BASIN

FINAL REPORT

VOLUME III : SUPPORTING REPORT
PART-D : HYDROLOGICAL AND HYDRAULIC STUDIES

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I. INTRODUCTION

The objectives of the hydrological and hydraulic studies are to provide basic data and information to be required for the study on channel stabilization plan and the study on flood management plan.

The studies consist of the following major items.

1) Meteo-hydrological observations to get field data and information for the study
2) Flood runoff analysis to get probable hydrographs for the flood management plan
3) Flood inundation analysis to grasp the effect of flood management plan
4) Channel flow analysis to get basic data and information for the channel stabilization plan

II. METEOROLOGICAL CONDITIONS

2.1 Basin and River System

The Apure river basin is the largest tributary of the Orinoco river. The area is located in 7° to 10° north latitude and 66° to 73° west longitude (Fig. 2.1.1).

The basin is bounded by the Coastal mountains on the north and the Andes mountains on the west. The Coastal mountains extend from east to west ranging in altitude from 2,000 m to 3,000 m. MSL and the Andes mountains run from southwest to northeast ranging in altitude from 3,000 m to 5,000 m MSL. Mt. Bolivar which is the height mountain in Venezuela is one of the peaks of the Andes mountains.

A vast flat plain called as Venezuelan Llanos exists between the Orinoco river and the Andes/Coastal mountains. It extends 1,000 km from east to west and 200 km to 400 km from north to south located in the central part of Venezuela. The plain is divided into western, central and eastern Llanos. The Apure river basin covers major part of the western Llanos and a part of the central Llanos having elevation ranging from 140 m to 40 m MSL.

The Apure river originates near the border to Colombia at the northwest point of the Andes mountains in Venezuela. The catchment area is 111,800 km^2 at San Fernando or 145,000 km^2 at confluence with the Orinoco river. Length of the main Apure river is 681 km from the confluence of the Orinoco river to Remolino bridge near Guasdualito.

The major tributaries of the Apure are the Guarico river from the coastal mountains; the Portuguesa, Masparro, Pagüey, Canagua, Suripa, Caparo, Uribante, and Sarare rivers from the Andes mountains; and the Guaritico river from the right bank plain area. The tributaries from the south eastern slope of the Andes mountains transport a lot of sediment and form large complex alluvial fans at the outlet of the mountainous area.

The area from the confluence of the Apure and Portuguesa rivers to the Orinoco river is the lowest in the basin. In this area an inland delta is formed.

2.2 Meteorology

Climate of the study area falls, as a whole, under the tropical savanna climate by Koppen's classification as shown in Fig. 2.2.1. General features of the climate of the study area are described hereinafter.

(1) Rainfall

Rainfall is most distinctive to the climate of the study area. Annual rainfall ranges from 1,200 mm to 1,600 mm in the plain area and amounts to 2,800 mm in the mountain area. Isohyetal map developed by an annual rainfall data is presented in Fig. 2.2.2.

Monthly rainfall pattern is shown in Fig. 2.2.3. The period from April to November is rainy season. In the rainy season, the rainfall depth reaches approximately 90 % of the annual rainfall.

(2) Temperature

Fluctuation of air temperature in the basin is relatively small. Daily mean temperature ranges between 17° and 20°C in the mountain area, and between 25° and 29°C in the plain area (Arismendi) as shown in Fig. 2.2.3.

The hottest month is March or April (end of dry season), while the coldest month is December or January (end of rainy season).

(3) Relative humidity

Relative humidity is observed in the basin ranging between 60 % and 90 %. At Bruzual, the daily mean relative humidity varies from 60 % in March to 85 % in August as shown in Table 2.2.3.

(4) Evaporation

Daily evaporation is measured by A-pan in the basin. Maximum evaporation is recorded in March as well as the temperature and the minimum in June at every year.

Annual mean daily evaporation is 3.1 mm at El Paradero in the mountain area, and 5.8 mm at Arismendi in the plain area. Annual variation of evaporation is shown in Fig. 2.2.3.

(5) Wind

Prevailing wind direction is the southwest from the northeast during the period from January to June and the northwest from the southeast during the period from July to December.

Annual variation of wind velocity is shown in Fig. 2.2.3. Monthly mean wind velocity at Bruzual fluctuates between 5.5 km/h and 11.5 km/h and annual mean velocity is about 8 km/h.

(6) Sunshine duration

Annual mean daily sunshine duration is 4 to 6 hours in the basin. The longest duration is seen in January and shortest in June.

Daily sunshine duration ranges between 4.1 hours in June and 8.2 hours in January at Arismendi as shown in Fig. 2.2.3.

III. METEO-HYDROLOGICAL OBSERVATION

3.1 Existing Observatories

Observation, maintenance and data compilation works of the meteorological and hydrological stations are shared by the field and central offices of the Directorate of Hydrology and Meteorology (Dirección de Hidrologia y Meteorologia) as follows:

1) Gauging station: Observation,management and maintenance of the station.

2) Provincial office: Preparation of daily and monthly reports and deliver to the central office , and providing recording paper and other logistical support to the station.

3) Central office: Compilation of daily and monthly reports, and encoding for data bank system. Daily and monthly data are stored in the form of floppy disk and hourly data in the form of document.

3.2 Available Data

3.2.1 Meteorological Data

There are two (2) types of meteorological stations by the difference of measurement items. All the measuring equipment are automatic recording type except for the evaporation pan. Location of these stations is shown in Fig. 3.2.1.

1) Type-C1: Measurement of seven (7) items for precipitation, evaporation, wind direction and velocity, radiation, humidity and temperature.

2) Type-C2: Measurement of four (4) items for precipitation, evaporation, wind direction and velocity.

3.2.2 Rainfall Data

Arrangement of raingauge network in the study area was started on since 1944 and there are 167 stations at present. Location of these stations is shown in Fig. 3.2.1. As seen in the figure, rainfall stations are densely located in the high land and mountainous area and are sparse in the plain area (Los Llanos). Automatic recording gauge is used for the all stations. Two (2) month continuous recording gauge is used and gauge keeper checks the gauge twice a month. Availability of rainfall data of respective stations is shown in Table 3.2.1.

3.2.3 Stream Data

Arrangement of gauging network along the Apure river and its tributaries was started on since 1970. There are 36 stations at present. According to the measurement items, the stream gauging stations are classified into six (6) types as follows:

1) Type 11 : WL by RG + Q + S : 28 stations
2) Type 12 : WL by SG + Q + S : 5 stations
3) Type 13 : WL by RG : no station
4) Type 14 : WL by SG + S : no station
5) Type 15 : WL by SG : 2 station
6) Type 16 : Q with WL + S : 1 station

where WL: water level, RG: recording gauge, SG: staff gauge, Q: water discharge, S: sediment

At most stream gauging stations, discharge rating curves were prepared based on the discharge measurements. Location of these gauging stations is shown in Fig. 3.2.2 and the period of available data is summarized in Table 3.2.2.

3.2.4 Water Quality Data

Water quality data were collected at Bruzual, El Saman, Camaguan and San Fernando for the period from 1987 to 1991 as shown in Table 3.2.3.

3.3 Installation of the Gauges

3.3.1 Rain Gauges

(1) General

Existing rainfall gauging stations are densely arranged in the mountain area, while sparsely in the low land where the area for the flood control study is situated.

In order to supplement the sparse distribution of the rainfall stations in the low land area as much as possible, installation of eight (8) rain gauges was planned by the JICA Study Team. Equipment were provided by JICA and installation and susequent observation are conducted by MARNR.

(2) Proposed Installation Sites

Proposed installation sites were selected by mesh method referring to the representative rainfall stations used in " SIMULACION HIDROGICA DE LA CUENCA DEL RIO APURE HASTA SAN FERNANDO DE APURE EN 1983 ".

According to the said study, one station covers the area of about 2,300 km^2 on average, so that the area of a mesh was set at 2,500 km^2 as shown in Fig. 3.3.1. Finally, the following eight (8) sites were selected.

1) La Union
2) Nueva Florida
3) El Regalo
4) Hato La Cruz
5) Santa Ana
6) Almoradero
7) Maporal
8) Quintero

3.3.2 Installation of Water Level Gauges

(1) General

As shown in Fig. 3.2.2, some water level gauging stations exist on the Apure river and tributaries in the study area. However, the number of stations are not sufficient to carry out more accurate hydrological analysis, so that the installation of five (5) more stations were planned by the JICA Study Team. Equipment were provided by JICA and installation and susequent observation are conducted by MARNR.

(2) Proposed Installation Sites

Based on the review of the present water level gauging station network, the following five(5) sites were selected.

1) Santa Rosalia (Suripa river)
2) Suripa (Apure river)
3) Guanalito (Guanare river)
4) Los Caballos (Guanare river)
5) Mangas Coveras (Apurito river)

3.4 Inundation Observation

The inundation observation was carried out from May to November, 1992 to know behavior of inundation in the study area.

In order to observe inland water levels, staff gauges were installed by MARNR at the following seven (7) sites shown in Fig. 3.3.3 and observation was made daily in principle by MARNR.

1) La Union
2) San Antonio
3) La Capilla 1 (East)
4) La Capilla 2 (West)
5) Costa de Guanare
6) Igues
7) Coco de Mono

Besides the above staff gauge observation, observation by car and boat crossing the subject area was carried out weekly at four routes shown in Fig. 3.3.3. The observation work was carried out by Venezuelan firm under JICA Study Team. According to the observation, inundation depth is estimated at 0.5 m to 2 m.

In parallel with the above inundation observation on ground, reconnaissance by airplane was carried out in May and June and August, 1992 to suppliment the ground observation.

Though the observation results were reflected to inundation analysis and flood management planning, it was difficult to know the inundation condition through this observation because of vast survay area, complicated inundation and poor accessibility.

3.5 Channel Observation

3.5.1 Observation Program

(1) Generals

Channel observation aims to investigate actual changes of river channel during eleven (11) months from June 1992 to April 1993 including a rainy season.

The changes of river channel are observed directly by river survey and indirectly by the changes of channel roughness. The channel roughness is worked out by non-uniform flow calculation based on water levels observed at the upper and lower ends of the channel stretch subject to the study, channel cross sections and corresponding channel discharge.

For the channel observation, following field works were undertaken:

1) Channel survey
2) Discharge measurement
3) Sediment observation
4) Water level observation

(2) Observation Sites

The following three sites were selected considering the importance of channel improvement and difference in channel characteristics:

1) Guasdualito site of the upper Apure river
2) Bruzual site of the middle Apure river
3) San Fernando site of the lower Apure river
4) Camaguan site of the middle Portuguesa river

Location of the observation sites are shown in Fig. 3.5.1.

3.5.2 River Survey

Cross-sectional survey and longitudinal sounding were carried out by JICA Team and partly by MARNR at the selected sites in Guasdualito, Bruzual, and Camaguan.

(1) Site of Survey

1) Guasdualito site of Sarare/Apure river from Remolino bridge toward downstream for about 22 km at the intervals of 500 m approximately.

2) Bruzual site of Apure river from San Vicente town toward downstream for about 25 km at the intervals of 500 m approximately.

3) Camaguan site of Portuguesa river from Camaguan town toward upstream for about 10 km at the intervals of 200 m approximately.

(2) Survey Works

	Description	Guasdualito	Bruzual	Camaguan
1)	Stretch	22 km	23 km	10 km
2)	1st Survey	Jun.'92	Jun./Jul.'92	Jul.'92
	a) Interval of section survey	500 m	500 m	200 m
	b) Longitudinal sounding	Done	Done	Done
3)	2nd Survey	Sep.'92	Sep.'92	Sep.'92
	a) Longitudinal sounding	Done	Done	Done
4)	3rd Survey	Jan./Feb.'93	Feb.'93	Jan./Feb.'93
	a) Interval of section survey	500 m	500 m	200 m
	b) Longitudinal sounding	Done	Done	Done

3.5.3 Discharge Measurement

Discharge measurements were carried out at the existing four (4) stations in collaboration with MARNR staff using current meter and float as follows:

Measurement by	P.Remolino (Jun.19'92)	Bruzual (Jun.9'92)	S.Fernando (Jul.14'92)	Camaguan (Jul.15'92)
1) JICA current meter	All	All	-	All
2) MARNR current meter	Partial	Partial	All	-
3) Float/Surface (nos)	10	15	-	-
4) Rod float/50 cm (nos)	10	15	-	-
5) Rod float/100 cm (nos)	10	Partial(5)	-	-

Results of discharge measurement are shown in Table 3.5.1 and Fig. 3.5.2.

(1) Comparison of Measurement Method

The following meters were used for discharge measurement:

1) JICA current meter: Electro-magnetic current meter
2) MARNR current meter: Propeller type current meter
3) Float: Three (3) types of standard floats developed by Ministry of Construction, Japan as follows:
    a) Surface float : vm/vf = 0.85
    b) 50 cm long rod float : vm/vf = 0.88
    c) 100 cm long rod float : vm/vf = 0.91

where vm and vf are vertical mean and float velocity, respectively.

Measurement results of different methods are compared below:

Method	Remolino Br.	Bruzual	S.Fernando	Camaguan
1) JICA current meter(m^3/s)	574.0	972.7	-	962.8
2) MARNR current meter(m^3/s)	-	-	3571.8	-
3) Surface float (m^3/s)	547.1	1,050.8	-	-
(Rate to 1)	(0.95)	(1.08)	-	-
4) Rod float/50 cm (m^3/s)	554.0	1016.5	-	-
(Rate to 1)	(0.97)	(1.05)	-	-
5) Rod float/100 cm (m^3/s)	573.2	-	-	-
(Rate to 1)	(1.00)	-	-	-

From the above measurements, the followings are considered:

1) Results of float method are also accurate enough, resulting in the range from 95 % to 108 % of the JICA meter depending on the rod length. Principally various sizes of rod floats should be used in combination for a section depending on the depth of measurement vertical.

2) The current meter gives higher accurate results in general but there is a possibility of damages due to floating logs and other materials during measurement. But, the float method is not affected much by the floating materials and the measurement works are relatively easy and safe. The method shall be selected considering the conditions of the flow and site to be measured.

For the main Apure and Portuguesa rivers, the current meter seems to be applicable even for flood season measurements, since the rise and fall of flood water level are very gradual, flow velocity is not so rapid, and the floating materials are few. The float method would be effective for the flood discharge measurement of tributaries in hilly and mountainous areas.

(2) Stage-Discharge Curves

PROA has prepared stage-discharge curve at each discharge measurement sites. The curves are shown in Fig. 3.5.3 together with results of our measurement.

Measurement results by the JICA Team accord well with the PROA stage-discharge curves of PROA, and the PROA curves are applicable to the present study without any modification.

3.5.4 Sediment Observation

Suspended load and bed load were sampled at the same time with the discharge measurement as follows:

Measurement Item	Remolino Br. (Jun.19'92)	Bruzual (Jun.9'92)	S.Fernando (Jul.14'92)	Camaguan (Jul.15'92)
1) Integrated suspended load samples (nos)	4	5	-	3
2) Bed load sampling (nos)	3	3	3	3

The samples were analyzed in the laboratory of DHM. Results are summarized in Table 3.5.2. Grading curves of the sampled bed loads are shown in Fig. 3.5.4.

3.5.5 Water Level Observation

Water levels at the upper and lower ends of the selected sites were observed by MARNR daily since June, 1992, to provide data necessary for the channel studies. The following sites and gauges were selected for the water level observation:

1) Guasdualito site: Upper reaches of Apure river
    a) Remolino bridge: Existing recording gauge
    b) Santos Luzardo port: Existing staff gauge
2) Bruzual site: Middle reaches of Apure river
    a) San Vicente: Existing staff gauge
    b) Bruzual bridge:Existing recording gauge
3) San Fernando site: Lower reaches of Apure river
    a) San Fernando: Existing recording gauge
    b) El Negro: Existing staff gauge
4) Camaguan site: Middle reaches of Portuguesa river
    a) Camaguan: Existing recording gauge
    b) Camaguan Town: Existing staff gauge

3.6 Water Quality Test

Field water quality test was carried out at the sites as shown in Fig. 3.3.5 by portable tester and chemical agents in May, June and July, 1992 and February 1993. The test items are dissolved oxygen, PH, conductivity, turbidity, Mn, Fe and Cu.

Test sites are as follows:

(1) Camaguan (portuguesa river)
(2) La Union (portuguesa river)
(3) San Fernando (Apure river)
(4) El Saman (Apure river)
(5) Caño Corozal (Caño Corozal)
(6) El Baul (Cojedes river)
(7) Arismendi (Guanare river)
(8) Bruzual (Apure river)
(9) Guasdualito (Apure river)
(10) Upstream of Guanaparo river confluence (Apure river)
(11) Downstream of Garzas river confluence (Apure river)

The results are summarized below.

(1)	Temperature	26.6 - 32.3°C
(2)	Dissolved Oxygen	6.3 - 8.0 mg/l
(3)	PH	5.3 - 7.8
(4)	Conductivity	0.0 - 0.3 ms/cm
(5)	Turbidity	27 - 292 mg/l
(6)	Mn	0.0 - 0.5 mg/l
(7)	Fe	0.0 - 5.0 mg/l
(8)	Cu	0.0 - 1.0 mg/l

IV. PRELIMINARY ANALYSIS

4.1 Basin Analysis

4.1.1 Available Basin Map

In order to analyze the river system, basin boundary, and basin and channel conditions, the following topographic maps and photos were collected.

(1) Topographic maps published by Dirección de Cartografia

1) Scale of 1/1,000,000 for the study area
2) Scale of 1/500,000 for the study area
3) Scale of 1/250,000 for the study area
4) Scale of 1/100,000 for the area along the main Apure and the Portuguesa rivers
5) Scale of 1/25,000 for the area along the main Apure and the Portuguesa rivers

(2) Topographic maps published by Servicio Autonomo de Geografia y Cartografia Nacional: Scale of 1/10,000 for the area along the main Apure river excluding a stretch of 30 km downstream from Apurito

(3) Photos taken by CVS from airplane continuously along river course

1) Photos taken on March 14,1989 for the stretch from Guasdualito to Bruzual
2) Photos taken on March 29,1989 for the stretch from Bruzual to confluence of the Orinoco
3) Photos taken on October 13,1989 for the stretch from Guasdualito to Bruzual

4.1.2 River System

The Apure river originates near the border to Colombia at the northwest point of the Andes mountains in Venezuela. The catchment area is 111,800 km^2 at San Fernando. Length of the main Apure river is 681 km from the confluence of the Orinoco river to Remolino bridge near Guasdualito.

The major tributaries of the Apure are the Guarico river from the Coastal mountains; the Portuguesa, Masparro, Paguey, Canagua, Suripa, Caparo, Uribante, and Sarare rivers from the Andes mountains; and the Guaritico river from the right bank plain area. The tributaries from the south eastern slope of the Andes mountains transport a lot of sediment and form large complex alluvial fans at the outlet of the mountainous area.

4.1.3 Basin and Sub-basin

Basin and sub-basin boundaries were drawn on the topographic map of scale 1/500,000 for the major points of interest (basic stations) and the basin areas were measured. In drawing the boundary, the topographic map of scale 1/250,000 and the satellite image are also referred for the detailed topography and the latest channel conditions.

Basin and sub-basin boundaries are shown in Fig. 4.1.1 and their areas are summarized below:

	Base Station	Catchment Area (km^2)
1.	Main Apure River	(111,800 km^2 at San Fernando)
	1) Remolino Br.	8,400
	2) Bruzual	40,000
	3) El Saman	48,000
	4) San Fernando	111,800
2.	Portuguesa River	(54,600 km^2 at Junction with Apure river)
	1) El Baul	13,200
	2) El Jobalito	23,300
	3) Camaguan	54,400

As seen in Fig. 4.1.2, drainage areas of the main Apure (57,200 km^2) and the Portuguesa (54,600 km^2) are almost equal at their confluence, although their river features are quite different. River channel of the main Apure is wider and braided in places, while that of the Portuguesa is narrower and meandered.

4.2 Rainfall Analysis

Monthly rainfall was studied for the selected stations. Monthly mean, maximum and minimum rainfalls were worked out and shown in Fig. 4.2.1.

Annual rainfall patterns of the basin are characterized by the distinct rainy season which starts from April or May and ends in October or November. Within the rainy season the rainfall distributes rather uniformly with single or double peaks as summarized below.

Station	Situation	Rainy Season	Month of Rain Peak
1. San Cristobal/Estanque	High land, west	Apr.to Nov.	July
2. El Corozo/Palmita	High land, central	Apr.to Nov.	June/Oct.
3. Las Vegas/Charcot	High land, east	Apr.to Oct.	June
4. El Baul/Carretera	High land, east	May to Oct.	June/Aug.
5. Santa Lucia	Low land,central	May to Oct.	July
6. El Saman de Apure	Low land, east	Apr.to Oct.	June/Aug.

Basin mean monthly rainfall was also studied to estimate runoff rate. Seven (7) sub-basins were selected for the calculation of basin mean monthly rainfall. They are basins upstream of Remolino Br., Bruzual, El Saman and San Fernando stations along the main Apure river and El Baul, El Jobalito and Camaguan stations along the Portuguesa river.

Thirty nine (39) rainfall stations were selected for the preliminary study considering the available period of data and location of the stations in and around the basins (Fig. 4.2.2). Lack of records is complemented estimating from records of adjacent stations by means of correlation. Method of arithmetical mean was adopted to work out the basin mean rainfall.

Basin mean annual rainfalls thus estimated for 24 years from 1967 to 1990 (Table 4.2.1) are summarized below.

Basic Station	Ave. (mm/yr)	Max. (mm/yr)	Min. (mm/yr)
1. Main Apure River			
1) Remolino Br.	2,082	2,532	1,614
2) Bruzual	1,892	2,323	1,456
3) El Saman	1,851	2,282	1,442
4) San Fernando	1,608	2,003	1,282
2. Portuguesa River			
5) El Baul	1,310	1,677	1,018
6) El Jobalito	1,505	1,963	1,180
7) Camaguan	1,423	1,790	1,134

The annual basin mean rainfall of the main Apure river is 1,851 mm (at El Saman), while that of the Portuguesa is only 1,423 mm (at Camaguan) which is 3/4 of the main Apure.

4.3 Water Level and Discharge

Characteristics of water levels and discharges of the Apure river and water levels of the Orinoco river at Caicara Station are discussed herein based on the past records.

(1) Water Level

Monthly changes of water levels of the Apure and Portuguesa rivers are shown in Fig. 4.3.1, illustrating the average, maximum and minimum monthly water levels. Water level of the Orinoco river at Caicara station was also studied to provide data for the study on the influence of the Orinoco river to the Apure river and for determining design water level at the mouth of the Apure river. Water levels of the Apure river and Orinoco river are summarized below.

	Station	Lowest Mon.	W.L. (m)	Highest Mon.	W.L. (m)	Difference (m)	Rising Period (months)
1.	Main Apure River						
	Remolino Br.	Jan.	127.93	Jun.	130.58	2.65	5
	Bruzual	Feb.	74.86	Jul.	78.70	3.84	5
	El Saman	Mar.	60.07	Aug.	64.65	4.58	5
	San Fernando	Mar.	38.05	Sep.	44.11	6.06	6
2.	Portuguesa River						
	El Baul	Mar.	1.29	Aug.	5.11	3.82	5
	El Jobalito	Mar.	1.90	Aug.	8.83	6.93	5
	Camaguan	Mar.	41.46	Sep.	48.04	6.58	6
3.	Orinoco River						
	Caicara	Mar	23.74	Aug.	35.09	11.35	5

From the above, it is seen that the water level peaks of the stations located in the lower reaches occurs later than those located in the upper reaches with longer rising period, probably owing to the runoff retardation due to flooding. It is also noteworthy that the peak of the Portuguesa river appears later than that of the Apure river.

In order to grasp the short term fluctuation, daily water level hydrographs are shown in Fig. 4.3.2 for the year of 1990 for example.

(2) Discharge

Monthly changes of discharge of the Apure and Portuguesa rivers are shown in Fig. 4.3.3, illustrating the average, maximum and minimum monthly discharges. The monthly changes are similar to those of water level.

Daily discharge hydrographs of the stations located in the upper, middle and lower reaches is shown comparatively in Fig. 4.3.4. Flattering process of the runoff hydrograph is seen in the figure. In the mountainous upper reaches the runoff hydrograph shows fluctuations of short duration reflecting rainfall patterns. Then, as going downstream, the hydrograph fluctuates weekly, monthly or longer.

Annual maximum, minimum and mean discharges are shown in Table 4.3.1 for the above seven (7) stations.

4.4 Runoff Characteristics

Runoff characteristics of the main Apure and Portuguesa river basins were studied based on the past record.

(1) Annual Runoff Ratio

Annual runoff ratios of four (4) stations in the Apure river and three (3) stations in the Portuguesa river were estimated by the annual basin mean rainfall and recorded annual runoff as shown in Table 4.4.1. The result of the estimation is summarized in Fig. 4.4.1.

Average runoff ratio of the main Apure river varies from 0.84 at Remolino Br. to 0.41 at San Fernando, decreasing toward downstream. The runoff ratio of the Portuguesa river varies from 0.14 at El Baul to 0.20 at Camaguan, increasing toward downstream.

Runoff ratio of the Portuguesa river is remarkably small. This may come from small basin rainfall and losses due to evaporation and possibly groundwater movement.

(2) Discharge Correlation

Correlation of discharges between adjacent gauging stations were studied in order to verify the records and to provide basic data for discharge distribution. The correlation graphs are shown in Fig. 4.4.2.

In the figure, discharges of the downstream station were plotted on the horizontal axis. A line to show drainage area ratio is also illustrated on the figure. If the runoff is proportional to the drainage area, the correlation plots would be located on the drainage area line. Correlation plots of a year formed a clockwise loop line, except for correlation between Camaguan and San Fernando stations where counterclockwise loops were seen for some years.

From the pattern of the correlation line, the runoff characteristics of the stretch between two stations under consideration could be considered. Patterns of correlation lines are generally classified into three as follows and their typical cases are illustrated in Fig. 4.4.3:

1) Concave line : Increment of Qd (discharge at the downstream station) is increasing relatively to Qu (discharge at the upstream station), as the discharge is getting larger.
2) Linear line : Increment of Qd is equal to Qu.
3) Convex line : Increment of Qd is decreasing relatively to Qu, as the discharge is getting larger.

(3) Low Flow Discharge

Based on the daily discharge records since 1975, low flow conditions were studied. The data available for the study are as follows:

1) Main Apure River

a) Remolino Br. station : 4 years of 1979, 1981, 1982, and 1990
b) Bruzual station : 14 years from 1975 to 1986, and 1989 to 1990
c) El Saman station : 7 years from 1975 to 1978, 1980, and 1989 to 1990
d) San Fernando station : 11 years from 1975 to 1982,1986, and 1989 to 1990

2) Portuguesa River

a) El Baul station	:	14 years from 1975 to 1977, and 1980 to 1990
b) El Jobalito station	:	15 years from 1975 to 1977, and 1979 to 1990
c) Camaguan station	:	14 years from 1975 to 1981, 1983 to 1987, and 1989 to 1990

Among the above stations, Bruzual station would be the basic station for the main Apure river and El Jobalito station for the Portuguesa river, since these stations have relatively long period of discharge records and they are located close to the river stretches which might have navigation problems.

Average flow duration of respective stations are shown in Fig. 4.4.4 and Table 4.4.2. Features of the average flow duration are summarized below.

Station	Basin (km^2)	Minimum (m^3/s)	Maximum (m^3/s)	Max/Min
1. Main Apure River				
1) Remolino Br.	8,000	83	1,060	13
2) Bruzual	40,000	148	3,442	23
3) El Saman	48,000	217	3,954	18
4) San Fernando	111,800	289	5,744	20
2. Portuguesa River				
1) El Baul	13,200	9	229	25
2) El Jobalito	23,300	31	458	15
3) Camaguan	54,400	57	1,034	18

Coefficient of river regime which is defined as a ratio of annual maximum discharge to the minimum discharge (Max/Min) ranges from 13 to 25 for the main Apure and Portuguesa rivers. In order to look into detailed features of the low flow discharges the following significant figures were examined:

1) Daily discharges of the 1st, 10th and 30th order from the minimum: shown in Table 4.4.3
2) Order of the significant discharges from the minimum: shown in Table 4.4.4

Regarding the basic stations of Bruzual and El Jobalito, the significant low flow discharges are summarized as follows:

	Description	Bruzual Ave. (Range)	El Jobalito Ave.(Range)
1)	Ordinal discharge (m^3/s)		
	Annual min.	148 (40 to 267)	31 (8 to 63)
	10th from min.	167 (67 to 304)	33 (9 to 64)
	30th from min.	203 (119 to 362)	37 (11 to 68)
2)	Significant low flow discharge (m^3/s)		
	Max. of ann. min.	267	63
	Ave. of ann. min.	148	31
	5-yr. low flow	93	11
3)	Nos. of days less than significant discharge (days)		
	Max. of ann. min.	59 (0 to 107)	101 (0 to 185)
	Ave. of ann. min.	14 (0 to 47)	8 (0 to 65)
	5-yr. low flow	1 (0 to 15)	2 (0 to 28)

V. FLOOD RUNOFF ANALYSIS

5.1 General

Objective of the flood runoff analysis is to estimate the probable flood runoff for flood management planning.

As a general characteristics, the Apure river basin is roughly divided into mountainous area where the rapid runoff is observed and low plain area where significant retarding of the runoff from upper basin is observed. Due to this characteristics, it is difficult to well simulate the actual phenomena of the whole basin by an ordinary hydrological method only. Therefore, a flood inundation analysis was employed for the low plain area as a hydraulic method as well as a hydrological analysis. In this chapter, the flood runoff analysis by the storage function method is described, and the flood inundation analysis by the pond model method is in the next Chapter VI.

Fig. 5.1.1 shows the general procedure of the flood runoff analysis. According to this procedure, the flood runoff analysis consists of the following three (3) substantial works.

1) Construction of basin and river system model,
2) Rainfall analysis and,
3) Flood runoff analysis.

5.2 Basin and River System Model

The basin and river system model is a necessary tool for the flood runoff calculation with an aid of electronic computer. The model comprises all the elements of flood runoff mechanism such as river basins, channels and dam/reservoirs. These elements are linked together by the subbase points. The subbase points, at which the flood runoff is calculated, were determined at locations where significant changes in flood runoff peak are expected such as :

1) Junction of tributaries,
2) Runoff gauging stations and,
3) Points where the channel capacity changes.

Base points, which are selected among the subbase points, are the principal points for estimating the flood runoff and for determing the flood distribution along the river. The base points are located principally at the following points:

1) River mouth,
2) Junction of main river and major tributaries
3) Major runoff gauging stations and,
4) Dam/reservoirs.

The Apure river basin is largely divided into the main Apure river basin, and the Portuguesa river basin, a major tributary of the Apure river. They are further divided into sub-basins for the flood runoff analysis taking into account the topography, river system, base points, etc.

The sub-basins divided are shown in Fig. 5.2.1 and their principal features are presented in Table 5.2.1 and 5.2.2. Catchment areas of the main Apure (57,200 km^2) and the Portuguesa (54,600 km^2) rivers are almost equal at their confluence, although their river features are quite different. River channel of the main Apure river is wider and braided in places, while that of the Portuguesa river is narrower and meandered. The catchment areas of the major base points are summarized as follows:

Base Point	Catchment Area (km^2)
1. Main Apure River	(111,800 km^2 at San Fernando)
1) Guasdualito	8,400
2) Bruzual	40,000
3) El Saman	48,000
4) San Fernando	111,800
2. Portuguesa River	(54,600 km^2 at Junction with Apure river)
1) El Baul	13,200
2) El Jobalito	23,300
3) Camaguan	54,400

5.3 Rainfall Analysis

5.3.1 Design Rainfall Duration

Design rainfall duration is normally determined based on the following factors such as : (1) size of basin area, (2) rainfall characteristics, (3) flood runoff characteristics, etc. These factors in the Apure river basin summarized are presented as follows:

1) Size of basin area : Rather big (about 120,000 km^2)
2) Rainfall characteristics : Rainfall amount in rainy season from April to November is a major cause of habitual inundation in the downstream area due to insufficient riverflow capacities.
3) Flood runoff characteristics : Duration of inundation in the downstream is generally four (4) months from June to September, and maximum flood water level is recorded on July or August every year.

From the above, the design rainfall duration was decided to be eight (8) months from April to November.

5.3.2 Hourly Rainfall Distribution

Hourly rainfall distribution was assumed to have a center concentrated pattern due to limited available hourly rainfall data. This pattern is derived from the rainfall intensity duration curve using the recorded hourly rainfall data.

To obtain this pattern, the hourly rainfall increments are alternately distributed before and after the central increment so that the rainfall intensity of continuous rainfall around the center could accord with the rainfall intensity duration curve. This procedure was adopted for 24 hours using the rainfall intensity duration curve data at Campo Elias as shown in Table 5.3.1 and Fig. 5.3.1, which is located in the upstream of Rio Guanare. Ratio of hourly maximum rainfall amount against the 24 hours rainfall (0.41) as shown in Fig. 5.3.2 was judged reasonable by comparing the actual rainfall data of the other rainfall stations.

5.3.3 Representative Rainfall Stations

In order to estimate yearly basin mean rainfalls (from April to November) in the Apure river basin, Portuguesa river basin and the whole basin, 61 rainfall stations shown in Fig. 5.3.3 were selected as the representative stations. Number of rainfall station (61) said above was determined by the following procudures.

1) Relationships between basin mean rainfalls estimated by all the station data and N-number station data in the Rio Cojedes basin (CA=13,200 km^2) were examined.

2) One(1) station data was judged necessary at least to obtain an accurate basin mean rainfall for the area of 2,200 km^2 having an error within 5% from Fig. 5.3.4.

3) From the above , 54 station data should be taken up for the whole Apure river basin (CA=118,000 km^2).

4) Taking into account that the rainfall depth in the mountain area is rather higher than that of lower plain area , seven (7) station data was additionally selected. Consequently, 61 station data were utilized to estimate the basin mean rainfall in the whole basin.

As for the estimation of the basin mean rainfalls for the following latest big floods, the following numbers of rainfall stations were used depending on the data availability (See Figs. 5.3.5 and 5.3.6).

Flood	Number of Rainfall Station
1976 Flood	47
1981 Flood	39

5.3.4 Basin Mean Rainfall

Basin mean rainfall was estimated from the recorded rainfall by an areal weight of Thiessen polygon method as follows:

$$Rm = \sum Ri\,Fi$$

where, Rm : Basin mean rainfall (mm),
Ri : Point rainfall (mm) and
Fi : Areal weight

The areal weight of Thiessen polygon method for the yearly basin mean rainfalls, and the basin mean rainfalls for the 1976 flood and 1981 flood for the Apure river basin, Portuguesa river basin , and the whole basin (from April to November) estimated are presented in Tables 5.3.2 to 5.3.4.

Yeary basin mean rainfalls (from April to November) obtained by the method above is shown in Table 5.3.5, and the basin mean rainfalls for each flood event are summarized as follows:

(Period : 1967 - 1990)

Item	Basin Mean Rainfall from April to November		
	Apure Basin	Portuguesa Basin	Whole Basin
Average of			
Yearly Mean Rainfall	1,678	1,334	1,508
1976 Flood	1,715	1,437	1,580
1981 Flood	2,004	1,623	1,818

5.3.5 Probable Basin Mean Rainfall

Probable basin mean rainfalls were calculated by using a series of estimated yearly basin mean rainfall (from April to November) for the Apure river basin, Portuguesa river basin, and the whole basin. Frequency analysis was performed by the Gumbel method, because the results obtained from this method fit well the rainfall data plotted by the Hazen method as shown in Figs. 5.3.7 to 5.3.9.

The probable basin mean rainfalls (from April to November) for the Apure river basin, Portuguesa river basin, and the whole basin estimated are tabulated in Table 5.3.6. The 10-year probable basin mean rainfalls for the whole basin was estimated at 1,742 mm, which is 0.959 times of the latest maximum flood in 1981 (1,818 mm).

5.4 Flood Runoff Analysis

5.4.1 Storage Function Method

A storage function method was employed for calculation of flood runoff from each sub-basin and river channel. In general, there are some differences in runoff characteristics among basins. The parameters of storage function method can express those differences based on topographic data. Schemetic diagram of the basin and river channel model is illustrated in Fig. 5.4.1

(1) Basin Runoff Model

The storage function of basin is expressed by the following equations :

$$Sl = KQ_l^P$$

$$\frac{1}{3.6} f\, r_{ave} A - Ql = \frac{dSl}{dt}$$

Where, Sl : apparent storage in basin (m^3)
Ql (t) = Q (t + Tl) : Direct runoff from basin with lag Time (m^3/sec)
K, P : constants
t : time intterval (sec)
f : runoff ratio
rave : average basin rainfall (mm/hr)
A : catchment area (km^2)
Tl : lag time (sec)

Constants of K and P in the equation were estimated employing the following empirical formula :

$$K = k\, 43.4 \cdot C \cdot L^{1/3} \cdot i^{-1/5}$$
$$P = 1/3$$

where, C : reserve constant (= 0.12)
L : river length (km)
i : average river bed slope
k : parmenters determined by try and error

Flood runoff from sub-basin was adjusted taking lag time into consideration. The lag time was estimated by empirical formula expressed below.

$$Tl = 0.047 \cdot L - 0.56$$

where, Tl : lag time in basin (hr)
L : river length (km)

(2) River Channel Model

Flood runoff through a river channel was estimated by the following equations :

$$Sl = KQ_l^P$$

$$I - Ql = \frac{dt}{dSl}$$

where, Sl : apparent storage volume in river channel (m^3)
K, P : constants
I : inflow to river channel (m^3 sec)
Ql (t) = Ql (t + Tl) : discharge at lower boundary of channel with lag time (m^3/sec)
Tl : lag time (sec)

Constants of K and P were estimated by uniform flow calculation, the river cross section, river bed gradient and river length.

The lag time in river channel was estimated by the empirical formula expressed below.

$$Tl = (7.36 \times 10^{-4}) \cdot L \cdot i^{-0.5}$$

where, Tl : lag time in river channel(hr)
L : river length (km)
i : average river bed slope

5.4.2 Selected Flood Data

(1) Selected Flood Event

The annual maximum daily mean discharges of four major points in the Apure river basin are given in Table 5.4.1 for the period from 1975 to 1990. As seen in the table, the recorded maximum discharges are as follows:

Point	Max. Discharge	Occurrence Year
Bruzual	3,962	1983
El. Saman	4,824	1976
San Fernando	8,645	1981
Camaguan	1,238	1981

Based on the above, the bigger floods occurred in 1976 and 1981 were selected for calibration. The observed hydrographs of the both floods are shown in Figs. 5.4.2 and 5.4.3 and the related daily rainfalls in Fig. 5.4.4.

(2) Selected Flood Hydrographs

In the whole Apure and Portuguesa river basins, there are 36 water level gauging stations. Of these, 26 stations (Type 11, and/or 12, see Chapter III) were selected as shown in Fig. 5.4.5. Then, reliable flood hydrographs for the calibration were selected based on the following criteria.

(a) Flood hydrograph in 1976 or 1981 is available.
(b) Long period data (around 10 years) is available, and there is a few lack of data (Reliability of data is considered to be high).
(c) No effect of existing dam/reservoir is expected.
(d) Reliable rainfall data in and around the runoff gauging basin is available.
(e) Data which has a reliable runoff coefficient is available
(f) No discrepancies between rainfall duration pattern and shape of hydrograph are observed.

Of these above, by using the selection criteria (a) to (d), the following 13 stations were firstly selected.

No.	St.No.	Name	Catchment Area (km^2)	Basin	Remarks
1	0005	Acarigua	970	Portuguesa	For flood runoff analysis
2	0022	San Fernando	111,800	Apure	For Flood inundation analysis
3	0039	El Cambur	480	- do -	For flood runoff analysis
4	0120	Puente Doradas	630	- do -	- do -
5	0124	Puente El Molino	660	- do -	- do -
6	0317	El Baul	13,200	Portuguesa	- do -
7	0320	El Paso	880	Apure	- do -
8	0395	Tinaco	650	Portuguesa	- do -
9	0405	Paso Viboral	1,490	- do -	- do -
10	0705	Bruzual	40,000	Apure	- do -
11	0710	EL Saman	48,000	- do -	For Flood inundation analysis
12	0890	Camaguan	54,400	Portuguesa	- do -
13	0895	Jobalito	23,300	- do -	- do -

Then, the runoff coefficient using data from April to November for the 13 stations above were examined in Table 5.4.2. From this table, following study results were obtained.

(a) Data of the Sta. No.0124, No. 0320, and 1976 data of the Sta.No. 0005, No. 0039 were discarded due to unreasonable runoff coefficients derived from unreliable rainfall or runoff data.

(b) 1981 data of the Sta. No.0317 and No. 0405 were discarded due to the discrepancies between the rainfall duration patterns and the shape of hydrographs.

Consequently, nine (9) hydrographs of the seven (7) runoff stations were selected for the flood runoff analysis, and eight (8) hydrographs of the four (4) stations located in the downstream plain area for the flood inundation analysis.

5.4.3 Calibration of Parameters

The parameters in the flood runoff model were calibrated by the actual floods. The calibration was carried out according to the procedure shown in Fig. 5.1.1.

Primary runoff coefficient (f1) and saturated rainfall (Rsa) were estimated on Fig. 5.4.6. This figure shows that the primary runoff coefficient of the upstream area of El Baul (Sta. No. 0395 and No.0405) is quite low (f1 = 0.15) due to the basin geology (Meta Volcanic Rock and/or porlas sand stone is widely distributed). On the other hand, the f1 of the upstream Apure river basin (Sta. No. 0039 and No.0120) is high (f1 = 0.75). The f1 of the Portuguesa river basin and right tributary areas of the Portuguesa river (Sta. No. 0005) indicates an intermidiate value against those above (f1 = 0.45).

From the figures above, the primary runoff coefficient (f1) and saturated rainfall (Rsa) were determined as below. The f1 and Rsa of the Rio Cojedes basin were assumed to be 0.030, which is located between Rio Sn. Carlos basin where Sta. No. 0405 exists and Rio Acarigua basin where Sta. No. 0005 exists.

	Basin	f1	Rsa (mm)
1.	Apure river basin	0.75	2,400
2.	Upstream area of El. Baul	0.15	2,500
3.	Portuguesa river basin and right tributary areas	0.45	1,800
4.	Rio Cojedes basin	0.30	2,500

The constants of K, P and lag time(Tl) for each sub-basin and river channel estimated are tabulated in Table 5.4.3 and 5.4.4.

Figs. 5.4.7 and 5.4.8 show the comparison of the observed and simulated flood runoffs for the selected nine(9) hydrographs. As seen in the figures, both observed and simulated flood hydrographs coincide well. Therefore, the parameters of the model were judged applicable.

Besides, the parameters of the model were verified by the comparison of the observed and simulated flood runoff volume. Both observed and simulated flood runoff volume also coincide well as shown below.

				1976 Flood			1981 Flood		
No.	St.No.	Name	Catchment Area (km^2)	Observed Qo(Bil. m^3)	Simulated Qs(Bil. m^3)	Ratio Qs/Qo	Observed Qo(Bil. m^3)	Simulated Qs(Bil. m^3)	Ratio Qs/Qo
1	0005	Acarigua	970				1.38	1.46	1.06
2	0039	El Cambur	480				1.08	1.04	0.96
3	0120	Puente Doradas	630	1.50	1.41	0.94	1.59	1.36	0.86
4	0317	EL Baul	13,200				5.09	5.30	1.04
5	0395	Tinaco	650	0.18	0.17	0.94			
6	0405	Paso Viboral	1,490	0.31	0.32	1.03			
7	0705	Bruzual	40,000	43.5	51.6	1.19	52.6	52.4	0.99

Moreover, specific flood runoff peaks of the 1981 flood estimated at the existing and proposed damsites were verified by the available data. Based on Fig. 5.4.9 obtained from Tables 5.4.5, 5.4.6 and 5.4.7, the specific flood runoff peaks of the 1981 flood estimated by the model were judged reasonable as shown in Table 5.4.8.

The flood hydrographs of inflow rivers for Pond Model Method of floods in 1976 and 1981 are shown in Figs. 5.4.10 and 5.4.11.

5.4.4 Probable Flood Runoff

Based on the probable rainfalls and flood runoff model developed in the previous section, the probable flood runoff at the respective base points, which become inputs for the Pond Model Method are given in Fig. 5.4.12. The 10-year probable flood peak distribution under the present condition (with existing dam), under without existing dams condition and under with existing and proposed dams condition are presented in Figs. 5.4.13 to 5.4.15.

On the other hand, probable daily mean discharges at base points were calculated as given in Table 5.4.9 based on the recorded annual maximum daily mean discharges from 1975 to 1990. The flood in 1976 and 1981 were evaluated as 5-year and 20-year return periods at San Fernando, respectively. In case of evaluation by probable water level from 1942 to 1992, those floods are evaluated as 7-year and 40-year return periods, respectively.

5.4.5 Flood Discharge Confined in River Channel

The flood management study area has a vast inundation area and flooding occurs here and there. For this, it may be difficult to confine all the inundation water in the river channel formed by dikes. However, in order to know the degree of flood concentration under the said condition the flood discharge confined in the river channel was calculated by the storage function method for the actual floods in 1976 and 1981 in the Portuguese river basin assuming that the present river channels remain as it is and dikes are constructed on both banks with 10 km wide in the downstream reaches.

The results are shown in Figs. 5.4.16 and 5.4.17.

VI. FLOOD INUNDATION ANALYSIS

6.1 General

As mentioned in the previous Chapter V, most of the flood management study area have inundation and flooding problems and therefore the flood runoff phenomena in such area cannot be simulated by an ordinary hydrological runoff calculation method.

Accordingly, a Pond Model Method was employed to hydraulically simulate the flood runoff in the flood management study area as flood inundation analysis.

6.2 Basin and River System Model

For the flood inundation analysis by the pond model method, the objective area was divided into mesh blocks as shown in Fig. 6.2.1.

The objective area is 23,900 km^2 and divided into 495 mesh blocks. A mesh block has a size of 10 km x 10 km in principle, but the mesh block for river channel has smaller size. Fig. 6.2.2 gives average ground elevation of each mesh divided.

6.3 Flood Inundation Analysis

6.3.1 Pond Model

In order to express two dimensional movement of flood flow in the inundation area, a sequential pond model was adopted. This model simulates the flood flow propagation between divided mesh blocks by solving the movement and continuity equations given below;

$$\frac{L}{g} \cdot \frac{dv}{dt} = (h_1 + Z_1) - (h_2 + Z_2) - L \frac{n^2 |v| v}{h^{4/3}}$$

$$F \frac{dH}{dt} = Q_{in} - Q_{out}$$

Where, L : interval between mesh blocks (m)
g : acceleration of gravity (m/sec^2)
v : flow velocity (m/sec)

t : time (sec)
h : water depth of mesh (m)
z : average ground elevation (m)
n : coefficient of roughness
F : area of mesh block (m^2)
H : water level of mesh (m)
Q_i : inflow into mesh (m^3/sec)
Q_o : outflow from mesh (m^3/sec)

6.3.2 Input Data of the Model

The input for the objective area covered by the pond model consists of runoff from the surrounding rivers calculated by the storage function method and rain directly falling on the objective area. The runoff said above are shown in Fig. 5.4.12 as probable flood hydrographs of inflow rivers for pond model.

Rainfalls of the respective mesh blocks are given by the basin mean rainfall in the inundation area shown in Fig. 6.3.1 and 6.3.2.

Evaporation from the inundation area was estimated based on the data of Arismendi and Bruzual meteorological stations located in the inundation area. Average value of the daily mean evaporation in each month from June to September was calculated by the reduction ratio of 0.9, which is normally used as an average ratio for pan evaporation value applicable the plain area in Venezuela. In the calculation, the value of 4.1 mm/day was used.

Station	June	July	Aug.	Sept.
Arismendi (mm/month)	134.3	137.1	140.0	138.8
Bruzual (mm/month)	139.5	143.4	150.0	144.0
Ave. above (mm/month)	136.9	140.3	145.0	141.4
(mm/day)	4.6	4.5	4.7	4.7
Ave. above x 0.9 (mm/day)	4.1	4.1	4.2	4.2

6.3.3 Calibration of Parameter

It is rather difficult to make an accurate simulation by the pond model for the objective area due to complicated flow and vast area, however the calibration of parameters in the pond model was made by qualitative examination of inundation and check of runoff at El Saman, San Fernando, Jobalito and Camaguan gauging stations, which are located in the lower plain area. The floods used for calibration are 1976 flood and 1981 flood. Their hydrographs as the input for the pond model are shown in Figs. 5.4.10 and 5.4.11.

The calculation was made for 4 months from June to September and time intervals of each calculation step was 30 seconds. Roughness coefficient was taken as 0.2 for savanna and 0.035 - 0.05 for river channel based on the trial and error method though the actual roughness coefficient in the hydraulic calculation will be smaller than those values.

Figs. 6.3.3 and 6.3.4 shows the results of simulation calculation. As seen in the figures, simulated hydrograph of 1976 at San Fernando is over the observed hydrograph, while that of 1981 lowers the observed one. At the other base points, the hydrographs simulated almost coincide with the observed ones. Therefore, it was judged that the established pond models are applicable for the present flood management study as averaged one.

6.3.4 Probable Inundation Depth

Using the calibrated pond model, simulation for the probable flood runoff was carried out under the present condition of the objective area.

The result of simulation for the 10-year probable flood which was selected as an design flood for flood management study is shown in Fig. 4.3.1 in this Supporting Report : Part-F as maximum inundation.

6.3.5 Inundation Depth for Respective Flood Management Plans

In relation with the flood management study, the flood inundation simulation under the different flood management plans were carried out by the pond model method.

The simulation was made for the following cases with 10-year probable flood.

No.	Plan	Condition
1	A1	Construction of dike for Portuguesa rever
2	B1	Construction of dike for Guanare river
3	B2A	Plan B1 + Inprovement of Guanare Viejo river (25 m wide)
4	B2B	Plan B1 + Improvement of guanare Viejo river (50 m wide)
5	C1	Construction of dike for Apure river
6	C2	Construction of dike for Apure river (shorter)
7	D1A	Modification of existing floodway
8	D1B	Plan D1A + construction of diversion channel
9	D2	Retarding basin by Apure type module
10	Overall	Plan A1 + Plan B1 + Plan C1

Results of the simulations for respective plans are shown in Figs. 4.3.2 to 4.3.12, 4.5.2 and 4.5.3 in this Supporting Report : Part-F.

Furthermore, the following simulations were made for further analysis and economic evaluation of flood management plan. The results are complied in Data Book II.

Plan A1	-	2-yr and 5-yr return periods
Plan B1	-	2-yr, 5-yr and 50-yr return periods
Plan C1	-	2-yr and 5-yr return periods
Plan C2	-	50-yr return period
Overall (Plans A1 + B1 + C1)	-	2-yr and 5-yr return periods

VII. CHANNEL FLOW ANALYSIS

7.1 Construction of Channel Flow Model

(1) Water Level at River Mouth of Apure

The confluence of Apure and Orinoco rivers is located at about 730 km upstream from the sea (mouth of the Orinoco) and the Caicara station is located at about 27 km downstream from the Apure confluence.

Water level at the river mouth of the Apure was estimated based on the water level records at Caicara station. Water level gauging station next to Caicara station upstream of the Orinoco river is far away in Los Caracaros at about 80 km upstream from the Apure confluence. The slope of NAB (low water datum) was used to estimate the water level at the confluence of the Apure river. The NAB is the water level datum for navigation specified by INC based on the recorded lowest water levels at major stations.

The river bed profile along the navigation route of the Orinoco river is shown in Fig. 7.1.1. The NAB slope is 1/18,400 for the stretch of 27 km from Caicara to Apure confluence. The monthly mean water level at Apure confluence was estimated from the water level at Caicara adding 1.47 m as follows:

Month	Caicara (m MSL)	Apure (m MSL)	Month	Caicara (m MSL)	Apure (m MSL)
Jan.	25.46	26.93	Jul.	34.02	35.49
Feb.	24.18	25.65	Aug.	35.09	36.56
Mar.	23.74	25.21	Sep.	34.52	35.99
Apr.	24.77	26.24	Oct.	32.54	34.01
May	28.25	29.72	Nov.	30.55	32.02
Jun.	31.53	33.00	Dec.	28.17	29.64

(2) Flow Model of Apure River

River sections surveyed in March 1992 by PROA were used for channel flow calculation, supplementing some additional sections with INC sounding results as shown in Table 7.1.1. Forty nine (49) sections were incorporated with the channel flow model for the entire stretch of 681 km from river mouth of the Apure (Orinoco river) to Remolino Br. as follows:

PROA section : 28 sects.
INC and others : 21 sects.
Total : 49 sects.

Water level and discharge records are available at four (4) stations of San Fernando, El Saman, Bruzual and Remolino Br. Discharge distribution for the flows calculation was determined based on the discharges at four stations, location of confluences of tributaries, and basin area.

Channel roughness was estimated by the trial and error procedures so that the calculated water levels should be on the stage-discharge rating curve at the upper end station of sub-stretch for calculation. Therefore the roughness varies depending on the channel discharges, and the roughness represents all the unknown factors included in the flow model as well as channel roughness.

As an example, water level on June 1, 1992 was simulated by non-uniform flow for calibration of the model and shown in Fig. 7.1.2.

According to the calculation, channel roughness was estimated to be 0.015 in the lowest reaches and 0.042 in the uppermost reaches. The water level calculated was judged to be reasonable comparing with observed water levels and ground elevations.

(3) Flow Model of Portuguesa River

Channel sections reported in EVALUACION PRELIMINAR DE LA PREFACTIBILIDAD DE NAVEGACION DEL RIO PORTUGUESA (Preliminary Evaluation of Pre-feasibility of Navigation in Portuguesa River), April 1990, were used for the study. Thirty nine (39) sections are available in total over the stretch of about 249 km from river mouth (Apure river) to El Baul port. All of these section are the sounding result surveyed from water surface and are not related to the MSL-datum. These sections were surveyed on October 2 to 4 in 1989 and the water level was still high.

In order to construct channel flow model for the evaluation of navigation capacity under various channel discharges, river bed profile was assumed and channel roughness was estimated as follows:

1) Water level at the lowest end of the Portuguesa river was adjusted to be same as water level of the Apure river on October 3, 1989.

2) River sections were aligned so that the water surface should be linear. Water surface slope in the lower reaches was estimated assuming the channel roughness to be 0.015 which was used in the lower reaches of the Apure river.

3) In the upper reaches, the channel roughness was adjusted so that the water surface should be close to the assumed linear surface slope.

The estimated river bed profile is shown in Fig. 7.1.3. The profile was estimated only for the present study based on the data as available. River profile for further channel flow study should be prepared based on the actual longitudinal profile survey.

7.2 Extent of Influence of Orinoco River

Extent of influence of the Orinoco river to the Apure river was studied using the channel flow model under the following various flow conditions:

1) Rainy season flow: August
   a) Channel flow of the Apure river: Average discharge of August
   b) Water level of the Orinoco river:
      Case-1: Normal depth at the lowest end of the Apure river
      Case-2: Highest monthly water level of the Orinoco river in August
      Case-3: Lowest monthly water level of the Orinoco river in August

2) Dry season flow: March
   a) Channel flow of the Apure river: Average discharge of March
   b) Water level of the Orinoco river:
      Case-1: Normal depth at the lowest end of the Apure river
      Case-2: Highest monthly water level of the Orinoco river in March
      Case-3: Lowest monthly water level of the Orinoco river in March

The extent of hydraulic influence of the Orinoco river could be estimated in comparison with water levels of cases-1 and 2, and the extent of influence due to water level changes of the Orinoco river could be estimated in comparison with water levels of cases-2 and 3.

The extent of influence was estimated as a length of stretch where the difference of calculated water levels is more than 0.01 m. The result of estimation is as follows (Fig. 7.2.1):

	(Rainy season)	(Dry season)
1) Cases-1 and 2	Near Danta Flaca at 94 km from mouth	Near La Maciera at 64 km from mouth
2) Cases-2 and 3	Near El Sausal at 89 km from mouth	Near La Maciera at 64 km from mouth

The influence of the Orinoco river extends up to 94 km from river mouth (near Danta Flaca about 29 km downstream from Arichuna). The Apure river channel downstream from Arichuna is deemed to be formed under the influence of the Orinoco river.

On the other hand, the influence due to water level changes of the orinoco river extends up to 89 km from river mouth (near El Sausal) just downstream of anabranch reaches.

7.3 Bankful Channel Capacity

Bankful carrying capacity of the Apure river was estimated by the channel flow model. Conditions for the channel flow calculation are as follows:

1) Channel discharge: Assumed various discharges

2) Water level at the lowest end: Water level estimated from Caicara water level using relationship shown in Fig. 7.3.1 corresponding to respective channel discharges. Fig. 7.3.1 shows the relationship between monthly discharge at San Fernando station and monthly water level at Caicara station. Although these two (2) stations are located in different river the relationship is rather definite.

3) Other conditions such as channel sections and channel roughness are same as those used for the channel flow model for Q210d.

Estimated bankful capacity of the Apure river is shown in Table 7.3.1 and Fig. 7.3.2. The result is summarized as follows:

Stretches (km from mouth)	Bankful capacity (m^3/s) Average	Minimum	Remarks
0 - 70	2,290	2,210	Lowest reaches
70 - 130	2,480	1,750	Anabranch reaches
	(1,760)	(1,110)	(Main Apure only)
130 - 195	4,140	2,990	Between anabranches
195 - 275	3,150	3,150	Anabranch reaches
	(1,380)	(1,380)	(Main Apure only)
275 - 450	3,380	2,500	El Saman - Bruzual
450 - 520	2,080	1,800	Bruzual - Suripa R.
520 - 680	910	600	Suripa -Guasdualito

Channel capacity of the Portuguesa river was not studied because of lack of channel section data up to river banks.

7.4 Sediment Flow Features

In order to grasp the sediment transport characteristics of the Apure river, annual sediment transport capacity was estimated as presented in the ensuing subsections. Sediment studies for the Portuguesa river were not made because of lack of channel section data.

(1) Bed Materials

Results of bed materials and bore hole investigation conducted by the Study Team were used to clarify the characteristics of the bed materials. Locations of the investigation sites are shown in Fig. 7.4.1.

Boring logs along the Apure and Portuguesa rivers are shown in Fig. 7.4.2 and significant grain sizes of bed materials and bore hole samples are presented in Table 7.4.1.

Grading of river bed samples differ much depending on the place of sampling. Moreover, the grading at a place differ much in a vertical depending on the layer of sampling as shown in Fig. 7.4.3. The samples are clearly classified into sandy soils and clayey soils. According to the boring logs, the sandy and clayey soil layers are placed alternately. The sandy soils are transported probably by the flood flow and the clayey soils are the deposit during the recession period of flood.

Sandy soils were taken up for sediment transport study. Average grading of sandy soils at respective sites were calculated and shown in Table 7.4.1 and Fig. 7.4.4. Longitudinal change of grain size along the river is not clear. Average grading of the whole stretch of the Apure was worked out as follows:

Specified size	d25	d50	d65	d75
Grain size (mm)	0.15	0.26	0.34	0.41

The sorting coefficient defined as square root of (d75/d25) of the sandy soil is 1.68 on average ranging from 1.33 to 2.68.

The sediment load was calculated by segment particle sizes. The grain sizes used for the calculation are shown in Table 7.4.2.

(2) Type of Sediment Flow

The runoff hydrographs of the Apure river form single annual cycle and the river water flows over lands for long period as 2 to 4 months. Therefore, the dominant discharge for the river channel formation is deemed to be the bankful channel discharge.

According to the empirical diagrams for classifications of sediment flows and bed forms shown in Figs. 7.4.5 and 7.4.6, types of sediment flow in the Apure and Portuguesa rivers were studied under the bankful channel discharge conditions. Results of study are shown in Table 7.4.3. Sediment flow and bed forms of the Apure and Portuguesa rivers are classified as follows:

1) Suspended load is the dominant sediment transport.

2) Regarding the medium scale bed configuration, the Apure and Portuguesa rivers fall under the condition of semi bars and alternate bars.

(3) Sediment Transport Capacity

Sediment transport capacity of the Apure river were estimated for various discharges using the sediment transport formula adjusting with the sediment observation records by PROA as follows:

1) Relationship between channel discharge and sediment load observed by PROA is shown in Fig. 7.4.7.

2) Sediment discharge was calculated as a sum of bed load and suspended load. These loads were calculated for various segment sizes of bed materials.

3) Sato-Kikkawa-Ashida's formula was adopted for estimation of the bed load, and Brown's formula for the suspended load. The Brown's formula was modified based on the observed data.

4) The suspended loads calculated by the Brown's formula was compared, on the average, with the observed data by stretches as shown in Fig. 7.4.8. The calculated loads (Qsc) were adjusted to meet with the observed load (Qso) as follows:

   a) River mouth to San Fernando : Qso/Qsc = 25.3
   b) San Fernando to El Saman : " 3.57
   c) El Saman to Bruzual : " 3.88
   d) Bruzual to Suripa R. : " 2.88
   e) Suripa R. to Remolino Br. : " 3.16

   The adjustment ratios are similar along the Apure river ranging from 2.88 to 3.88, except for the downstream reaches of San Fernando.

Results of calculations are shown in Fig. 7.4.9 for various discharges.

(4) Annual Sediment Transport

Multiplying the sediment transport capacity by the flow duration, annual sediment transport capacity was estimated as an average for each river stretch. The result is presented below in brief.

Stretches	Annual Sediment Load (mil.m^3/yr)	Stretch Length (km)	Approx. Channel Width (m)
River mouth to S.Fernando	14.7	167.3	340
S.Fernando to El Saman	15.2	180.8	342
El Saman to Bruzual	14.5	94.1	522
Bruzual to Suripa R.	13.0	81.4	501
Suripa R. to Remolino Br.	14.3	139.8	265

TABLES

Table 3.2.1 AVAILABILITY OF RAINFALL RECORDS (1/6)

Number	Type	State	Station	1940							1950										1960										1970										1980										1990		
				3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2
3097	PR	TACHIRA	PREGONERO																																	○	○	○	○	○	○	○	○	○	○	○	○	○	○				
4012	PC	TACHIRA	UREN-A																									○	○	○	○	○	○	○	○	○	○	○	○	○	○		○	○	○		○	○	○	○	○	○		
4018	PR	TACHIRA	LOS LAURELES																									○	○	○	○	○	○	○	○	○	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○		
4026	PR	TACHIRA	ZORCA																									○	○	○	○	○	○	○	○	○	○	○	○	○	○		○	○	○	○	○		○	○	○	○		
4027	PC	TACHIRA	PALMIRA																									○	○	○	○	○	○	○	○	○	○	○	○	○	○		○	○	○					○		○		
4037	PR	TACHIRA	SAN CRISTOBAL-ESTANQUE									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
4045	PR	TACHIRA	LA COPE																									○	○	○	○	○	○	○	○	○	○	○	○	○	○		○	○	○		○	○	○	○	○	○		
4057	PR	TACHIRA	DORADAS																									○	○	○	○	○	○	○	○	○	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○		
4058	PR	TACHIRA	LAS COLORADAS																				○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
4059	PR	TACHIRA	NAVAY																									○	○	○	○	○	○	○	○	○	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○		
4072	C2	TACHIRA	PARAMO EL ZUMBADOR																																				○	○		○	○	○	○	○	○	○	○	○	○		
4082	PR	TACHIRA	SANTA FE																										○	○	○	○	○	○		○	○	○	○	○		○	○	○	○	○	○	○	○	○	○		
4083	C1	TACHIRA	PUENTE SALOM																										○		○	○	○	○		○	○	○	○	○		○	○	○	○	○	○	○	○	○	○		
4085	PR	TACHIRA	URIBANTE-SITIO DE PRESA																													○	○	○	○	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○		
4089	PR	BARINAS	HACIENDA LOS CHAGUARAMOS																																							○	○	○	○	○	○	○	○	○	○		
4090	PR	TACHIRA	EL NULA																													○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
4091	PR	TACHIRA	LA HONDA																																	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○		
4092	PR	TACHIRA	LA HORMIGA																																	○	○	○	○	○		○	○	○	○	○		○	○	○	○		
4093	PR	TACHIRA	LOS PAUJILES																																○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
4097	PR	TACHIRA	LA POTRERA																																										○	○	○	○	○	○	○		
4098	PR	TACHIRA	SAN CRISTOBAL-TORBES																																										○	○	○	○	○				
8066	PR	TACHIRA	PARAMO EL BATALLON																										○	○	○	○	○	○		○	○	○	○	○		○	○	○	○	○	○	○	○	○	○		
8067	PR	TACHIRA	HACIENDA VALLE NEGRO																																○	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○		
9006	PR	TACHIRA	SAN VICENTE-REVANCHA																										○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
9060	C1	TACHIRA	EL PARADERO																																○	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○		
3001	PR	MERIDA	CAPURI																																						○				○	○	○	○	○	○	○		
3005	PR	MERIDA	PARAMO EL QUEMADO																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
3023	PR	MERIDA	EL MOLINO																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		

Table 3.2.1 AVAILABILITY OF RAINFALL RECORDS (2/6)

Number	Type	State	Station	1940							1950										1960										1970										1980										1990		
				3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2
3027	PR	MERIDA	PARAMO LA CULATA																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
3030	PR	MERIDA	GUARAQUE-LA QUINTA																								○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
3072	PR	MERIDA	MUCUBAJI																											○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
3089	PR	MERIDA	LA CULATA																											○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
3098	PR	MERIDA	LA MESA DE ARACAY																											○	○	○	○	○	○	○	○	○	○	○	○	○	○	○									
3112	PR	MERIDA	PARAMO PICO AGUILA																									○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
3114	PR	MERIDA	SANTO DOMINGO																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
3115	PR	MERIDA	LA MITISUS																													○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○				
3133	PR	MERIDA	MUCUCHACHI																												○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
3134	PR	MERIDA	CANAGUA																											○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
3138	PR	MERIDA	CHACANTA																												○	○	○	○	○			○	○	○	○	○	○	○	○	○	○	○	○	○	○		
3141	C2	MERIDA	TOVAR																											○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
3161	PR	MERIDA	LAS PLANTIOS																											○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
3195	PR	MERIDA	LAS MESAS																																	○	○	○	○	○	○	○	○	○	○	○	○	○	○				
3197	PR	MERIDA	EL PEROL																													○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
3087	PR	BARINAS	EL CELOSO																											○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
3090	PR	BARINAS	CALDERAS																											○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
3120	PR	BARINAS	PEN~A LARGA-ZONA																							○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
3126	PR	BARINAS	BARINITAS		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
3128	PR	BARINAS	BARRANCAS																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
3136	PR	BARINAS	QUEBRADA SECA																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
3149	PR	BARINAS	ALTAMIRA-BARINAS																																	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
3158	PR	BARINAS	TORUNOS																										○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
3160	PR	BARINAS	SAN RAFAEL CANAGUA																																			○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
3162	PR	BARINAS	EL COROZO-PALMITA																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
3173	PR	BARINAS	SAN SILVESTRE										○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
3180	C2	BARINAS	LA QUINTA																																				○	○	○	○	○	○	○	○	○	○	○				
3184	C2	BARINAS	SANTA BARBARA																												○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		

Table 3.2.1 AVAILABILITY OF RAINFALL RECORDS (3/6)

Number	Type	State	Station	1940							1950										1960										1970										1980										1990		
				3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2
3185	PR	BARINAS	CURBATI																												○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
3186	PR	BARINAS	PEDRAZA LA VIEJA																												○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
3188	PR	BARINAS	QUIU																																	○	○	○	○	○	○	○	○	○							○		
3189	PR	BARINAS	MAPORALITO																												○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
3190	PR	BARINAS	LA ACEQUIA																												○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
3191	PR	BARINAS	BUM-BUM																												○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
3192	PR	BARINAS	SURIPA																												○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
3193	PR	BARINAS	SAI-SAI																												○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
3200	PR	BARINAS	LIBERTAD																																			○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
3212	PR	BARINAS	SABANETA																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
3222	PR	BARINAS	SAN HIPOLITO																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
3230	PR	BARINAS	SINIGUIS																																																○		
3254	PR	BARINAS	MIJAGUAL																							○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
3261	PR	BARINAS	EL REAL																									○	○	○	○	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○		
3283	PR	BARINAS	SANTA LUCIA																									○	○	○	○	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2170	PR	PORTUGUESA	GUAFAS																○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
2171	PR	PORTUGUESA	SURUGUAPO																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2173	PR	PORTUGUESA	LA CONCEPCION																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2239	PR	PORTUGUESA	AGUA BLANCA																																	○	○	○	○	○	○	○	○	○	○	○	○	○	○				
2246	PR	PORTUGUESA	HACIENDA CAMBURITO																										○	○	○	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2253	PR	PORTUGUESA	HACIENDA GUACHE																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2259	PR	PORTUGUESA	PAYARA																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2260	PR	PORTUGUESA	POTRERITOS																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2261	PR	PORTUGUESA	CHABASQUEN																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2265	PR	PORTUGUESA	OSPINO																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2266	PR	PORTUGUESA	OSPINO-LA ESTACION									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
2267	PR	PORTUGUESA	PIRITU																																	○	○	○	○	○	○	○	○	○	○	○	○	○	○				
2269	PR	PORTUGUESA	CORDOBA																																						○	○	○	○	○	○	○	○	○	○	○		

Table 3.2.1 AVAILABILITY OF RAINFALL RECORDS (4/6)

Number	Type	State	Station	1940							1950										1960										1970										1980										1990		
				3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2
2273	PR	PORTUGUESA	BISCUCUY																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2281	C1	PORTUGUESA	MESA DE CAVACAS																																				○	○	○	○	○	○	○	○	○	○	○				
2282	PR	PORTUGUESA	DESEMBOCADERO																									○	○	○	○	○	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2286	PR	PORTUGUESA	HACIENDA SAN RAFAEL									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
2295	PR	PORTUGUESA	CAMPAMENTO LAS MARIAS																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2300	C1	PORTUGUESA	EXPERIMENTAL LAS MAJAGUAS																																				○	○	○	○	○	○	○	○	○	○	○	○	○		
2331	PR	PORTUGUESA	SAN RAFAEL DE ONOTO				○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
2342	PR	PORTUGUESA	SANTA TERESA																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2357	PR	PORTUGUESA	GUABINAS																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
3214	PR	PORTUGUESA	PUERTO LAS ANIMAS													○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
3216	PR	PORTUGUESA	SIPORORO																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
3241	PR	PORTUGUESA	BANCO DE LOS CEDROS																																				○	○	○	○	○	○	○	○	○	○	○				
3272	PR	PORTUGUESA	GUANARITO																																			○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
3273	PR	PORTUGUESA	PAPELON																																			○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2303	PR	COJEDES	LA SIERRA																												○	○	○	○		○	○	○		○	○	○		○	○	○	○	○	○	○		
2308	PR	COJEDES	VALLECITO										○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
2311	C1	COJEDES	SAN CARLOS-UNELLEZ																																						○	○	○	○	○	○	○	○	○	○		
2316	PR	COJEDES	TINAQUILLO																									○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2336	PR	COJEDES	TINACO																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2338	PR	COJEDES	EL PAO PLANTA																																	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2348	PR	COJEDES	MORITA-CASERIO																									○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2349	PR	COJEDES	EL PAO-OFICINA								○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
2350	PR	COJEDES	GALERA																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2358	PR	COJEDES	EL RETAZO																												○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2364	PR	COJEDES	LAS VEGAS-CHARCOTE												○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
2378	PR	COJEDES	CAN-O BENITO											○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
2461	PR	COJEDES	SAN JOSE DE CHIRGUA																																			○		○	○	○	○	○	○	○	○	○	○	○	○		
3303	PR	COJEDES	PALO QUEMADO																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		

Table 3.2.1 AVAILABILITY OF RAINFALL RECORDS (5/6)

Number	Type	State	Station	1940							1950										1960										1970										1980										1990		
				3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2
3304	PR	COJEDES	HATO LAS BABAS																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
3309	PR	COJEDES	EL BAUL-CARRETERA																			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
3331	C2	COJEDES	ARISMENDI																													○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
3332	PR	COJEDES	JOBALITO																														○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
2419	PR	GUARICO	LA PALMITA																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2426	PR	GUARICO	LA YEGUERA																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2427	PR	GUARICO	HATO PARADERO																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2430	PR	GUARICO	PARAPARA																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2431	PR	GUARICO	RIO VERDE																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
2448	PR	GUARICO	ORTIZ																									○	○	○	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2492	PR	GUARICO	GUARDATINAJAS																											○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
3403	PR	GUARICO	LOS NARANJOS										○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
3416	PR	GUARICO	EL MANGUITO																												○	○	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	○	○		
3454	PR	GUARICO	COROZO-PANDO										○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
4140	PR	APURE	LA PORFIA																										○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
4171	PR	APURE	PUERTO INFANTE																																		○	○	○	○	○	○	○	○	○	○	○	○	○	○				
4175	PR	APURE	LA VICTORIA																												○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
4194	PR	APURE	EL AMPARO																										○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
4201	PR	APURE	LA TRINIDAD DE ORICHUNA																																		○	○	○	○	○	○	○	○	○	○	○	○	○	○				
4292	C1	APURE	BRUZUAL																										○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
4294	PR	APURE	MATA DE CUBARRO																											○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
4296	C1	APURE	MANTECAL																										○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
4298	PR	APURE	EL CEDRAL																										○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○	○	○	○		○
4302	PR	APURE	EL SAMAN DE APURE																										○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
4303	PR	APURE	ACHAGUAS																												○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
4406	PR	APURE	SAN JUAN DE PAYARA																										○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
4408	PR	APURE	ARICHUNA																															○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
4409	PR	APURE	LOS ALGARROBOS																															○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○

Table 3.2.1 AVAILABILITY OF RAINFALL RECORDS (6/6)

Number	Type	State	Station	1940							1950										1960										1970										1980										1990		
				3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2
2166	PR	TRUJILLO	EL JARILLO															○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
2196	PR	TRUJILLO	LAS MESITAS																						○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
2199	PR	TRUJILLO	NIQUITAO																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○	○	○		
7142	C2	TRUJILLO	HACIENDA SAN GILISTO																														○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
1220	PR	LARA	ARUA NEGRA																									○	○	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
1221	PR	LARA	LAS TABLAS																									○	○	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
1222	PR	LARA	EL ZANCUDO																									○	○	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2208	PR	LARA	MAPORAL																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2219	PR	LARA	MIRACUY																											○	○	○	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2221	PR	LARA	CUZ MACHADERA																										○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
2227	C2	LARA	PASO ANGOSTURA																										○	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2229	PR	LARA	SARARE																										○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2231	PR	LARA	CASPITO																										○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
2233	PR	LARA	LA CRUZ																										○	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2237	PR	LARA	RIECITO																											○	○	○	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2245	PR	LARA	GUARICO																									○	○	○	○	○	○	○		○	○			○	○	○	○	○	○	○	○	○	○	○	○		
2252	PR	LARA	LA MESA																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2287	PR	LARA	LAS CUMBRES																										○	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2288	PR	YARACUY	LAS DELICIAS																										○	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
1297	C3	YARACUY	EL RODEO-EXPERIMENT OCCIDENTE								○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
1373	PR	YARACUY	NIRGUA								○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
1385	PR	YARACUY	MIRANDA-LA TRINIDAD																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2275	PR	YARACUY	LA RIUERA																																									○	○			○	○	○	○		○
6357	PR	YARACUY	LOS COGOLLOS																									○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
6360	PR	YARACUY	PASO UAQUIRA																												○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
0491	PR	CARABOBO	LAS DOS BOCAS								○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
2404	PB	CARABOBO	MAWUARE																○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		

Table 3.2.2 AVAILABILITY OF WATER LEVEL RECORDS (1/2)

Number	Type	River	Station	1940							1950										1960										1970										1980										1990		
				3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2
0005	11	ACARIGUA	PUENTE ACARIGUA																																		○	○	○	○	○	○	○	○	○	○	○	○	○	○			○
0214	11	ACEQUIA	PUENTE LA ACEQUIA																																	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
0022	12	APURE	SAN FERNANDO			○	○		○	○	○	○	○	○	○					○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
0705	12	APURE	BRUZUAL																																	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
0710	12	APURE	EL SAMAN																																	○	○	○	○	○	○	○	○	○	○	○		○	○	○	○		○
0344	11	ARAURE	ARAURE																																																		
0589	11	BOCONO	LA CAVITA																																															○	○		
0039	11	CALDERAS	EL CAMBUR																											○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
0041	11	CANAGUA	CANAGUA																																																		
0050	11	CAPARO	PUENTE JUNIN																																	○	○													○	○		
0390	11	CAPARO	LOS TORUNOS																																																		
0485	11	CAPARO	PUNTA DE PIEDRA																																																		
0595	11	CARACHE	PTE. CARACHE																																																○		
0317	11	COJEDES	PUENTE EL BAUL																																	○	○	○			○	○	○	○	○	○	○	○	○	○	○		○
0120	11	DORADAS	PUENTE DORADAS																															○	○	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○		
0124	11	EL MOLINO	PUENTE EL MOLINO																																	○	○		○				○	○	○	○	○	○	○	○	○		
0202	15	GUANARE	ARISMENDI																																						○	○											
0241	11	MARURIA	PASO LAS GLORES																																	○	○	○	○	○								○	○	○	○		
0165	11	MUCUCHACHI	PUENTE MUCUCHACHI																																																		
0172	11	NAVAY	PUENTE NAVAY																																					○	○	○	○	○	○					○	○		
0310	11	OSPINO	PASO LA ESTACION																																	○	○	○		○	○	○	○										
0320	11	PAGUEY	EL PASO																																	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
0197	11	PAITO	CHARCO LARGO																																	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
0335	11	PAO	PASO LA BALSA																																						○	○	○	○	○	○	○						○
0895	15	PORTUGUESA	JOBALITO																																	○	○	○		○	○	○	○	○	○	○	○	○	○	○	○		○
0591	11	PORTUGUESA	NUEVA FLORIDA																																															○	○		○
0890	12	PORTUGUESA	CAMAGUAN-SAMAN GACHO																																	○	○	○	○	○	○	○		○	○	○	○	○	○	○	○		○
0354	12	QUINIMARY	BUENOS AIRES																																																		

Table 3.2.2 AVAILABILITY OF WATER LEVEL RECORDS (2/2)

Number	Type	River	Station	1940							1950										1960										1970										1980										1990		
				3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2
0529	16	SAN ANTONIO	PUENTE SAN ANTONIO																																																		
0338	11	SANTA BARBARA	LA BALSERA																																					○	○	○	○	○	○	○	○	○	○	○	○		
0370	11	SARARE	SARARE																																		○	○	○	○	○	○	○	○	○	○	○	○	○				
0900	11	SARARE	PUENTE REMOLINO																																					○		○	○	○	○						○		○
0339	11	SURIPA	PUENTE SURIPA																													○	○	○	○	○		○		○	○	○	○	○	○	○	○	○	○	○	○		
0395	11	TINACO	PUENTE TINACO																																		○	○			○		○	○	○	○		○	○	○	○		
0405	11	TIRGUA	PASO VIBORAL																																		○	○		○	○	○	○	○	○	○	○	○	○	○	○		○
0485	11	URIBANTE	PUENTE URIBANTE																																○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○

Table 3.2.3 WATER QUALITY IN THE PROJECT AREA (1/2)

		'87	'88					'89			'90		'91	
		Sep.	Apr.	Jul.	Sep.	Oct.	Dec.	Apr.	Jun.	Oct.	Mar.	Jun.	Dec.	
Item	Station	17	14	7	19	6	22	12~13	21~22	4	13~19	19~25	12~18	
Color	Bruzual	-	55	250	350	300	150	-	-	-	1400	375	-	Unit : Unid Pt-Co
	El Saman	-	-	-	-	-	200	-	-	-	675	250	-	
	Camaguan	200	-	250	-	90	150	-	-	-	225	110	-	
	San Fernando	200	55	450	-	250	250	-	-	-	625	350	-	
Conductivity	Bruzual	-	138	-	132	-	158	180	141	-	76	101	158	Unit : uohm/cm
	El Saman	-	-	130	-	110	101	183	142	-	105	83	115	
	Camaguan	187	-	277	-	261	280	379	287	-	262	217	295	
	San Fernando	95	205	119	-	138	153	199	230	130	120	149	270	
Temperature	Bruzual	-	30.0	-	27.6	-	24.6	30.0	28.1	-	26.2	28.2	27.8	Unit : ℃
	El Saman	-	-	27.5	-	28.4	28.6	28.2	28.0	-	27.0	28.4	34.2	
	Camaguan	29.6	-	28.5	29.2	-	27.8	28.4	29.2	-	29.0	28.4	25.6	
	San Fernando	29.8	30.8	28.0	-	28.8	27.8	28.2	28.2	27.6	27.2	28.2	23.8	
Bicarbonate	Bruzual	-	61.0	-	48.8	-	73.2	85.4	61.0	-	36.6	61.0	73.2	Unit : mg/L
	El Saman	-	-	61.0	-	36.6	48.8	85.4	61.0	-	48.8	48.8	48.8	
	Camaguan	85.4	-	85.4	-	79.3	134.2	134.2	109.8	-	134.2	109.8	134.2	
	San Fernando	48.8	85.4	61.0	-	48.8	73.2	97.6	109.8	61.0	48.8	97.0	109.8	
Charcoal	Bruzual	-	0	-	-	-	-	-	-	-	-	-	-	Unit : mg/L
	El Saman	0	-	0	-	-	-	-	-	-	-	-	-	
	Camaguan	-	-	-	-	-	-	-	-	-	-	-	-	
	San Fernando	0	0	0	-	-	-	-	-	-	-	-	-	
Fluoride	Bruzual	-	1	-	14	-	18	-	11	-	15	-	-	Unit : mg/L
	El Saman	-	-	-	-	07	22	-	35	-	18	-	-	
	Camaguan	-	-	-	-	12	14	-	15	-	05	-	-	
	San Fernando	-	3	-	-	15	32	-	21	25	08	-	-	
CaCO3	Bruzual	-	50	-	40	-	60	70	50	-	30	50	60	Unit : mg/L
	El Saman	-	50	-	-	30	40	70	50	-	40	40	40	
	Camaguan	70	-	70.1	-	65	110	110	90	-	110	90	110	
	San Fernando	-	70	50	40	40	60	80	90	50	40	80	90	
pH	Bruzual	-	7.4	-	6.9	-	7.3	7.4	7.0	-	7.4	7.1	7.1	Unit:
	El Saman	-	-	7.1	-	6.5	7.2	7.5	7.2	-	7.4	7.0	7.0	
	Camaguan	6.7	-	-	7.1	6.9	6.9	7.6	7.2	-	8.2	7.2	7.0	
	San Fernando	6.7	7.5	7.1	-	6.9	7.3	7.7	6.9	7.0	7.7	7.1	7.2	
Solid	Bruzual	-	-	-	87	-	110	-	-	-	-	-	-	Unit : mg/L
	El Saman	-	-	-	-	73	67	-	-	-	-	-	-	
	Camaguan	125	-	-	-	172	195	-	-	-	-	-	-	
	San Fernando	65	-	-	-	91	101	-	-	-	-	-	-	
Na	Bruzual	-	4.6	-	1.9	-	2.3	2.3	2.3	-	-	2.3	14.0	Unit : mg/L
	El Saman	-	-	2.3	-	2.3	2.3	4.6	2.3	-	-	2.3	6.9	
	Camaguan	2.3	-	6.9	-	3.2	6.3	9.2	6.9	-	6.9	2.3	16.1	
	San Fernando	2.3	6.9	2.3	-	2.3	2.3	4.6	2.3	2.3	-	2.3	33.1	
Mg	Bruzual	-	3.6	-	9.6	-	9.6	3.6	4.8	-	1.2	4.8	4.8	Unit : mg/L
	El Saman	-	-	4.8	-	6.0	6.0	4.8	4.8	-	1.2	4.8	6.0	
	Camaguan	6.0	-	2.4	-	6.0	4.8	18.0	4.8	-	13.2	3.6	10.1	
	San Fernando	3.6	7.2	3.6	-	6.0	7.2	7.2	9.6	2.4	3.6	2.4	4.8	

Table 3.2.3 WATER QUALITY IN THE PROJECT AREA (2/2)

		'87	'88					'89			'90		'91	
		Sep.	Apr.	Jul.	Sep.	Oct.	Dec.	Apr.	Jun.	Oct.	Mar.	Jun.	Dec.	
Item	Station	17	14	7	19	6	22	12~13	21~22	4	13~19	19~25	12~18	
	San Fernando	0.0	0.0	9.6	-	14.4	4.8	0.0	0.0	0.0	0.0	0.0	35.1	
Chlorine	Bruzual	-	7.1	-	7.1	-	10.6	7.1	3.5	-	7.1	3.5	7.1	Unit : mg/L
	El Saman	-	-	10.6	-	10.6	7.1	10.6	3.5	-	7.1	3.5	10.6	
	Camaguan	7.1	-	10.6	-	10.6	14.4	10.6	10.6	-	10.6	7.1	7.1	
	San Fernando	7.1	7.1	7.1	-	7.1	7.1	7.1	7.1	10.6	7.1	7.1	10.6	
Potacium	Bruzual	-	0.0	-	3.9	-	3.9	0.0	3.9	-	0.0	0.0	2.3	Unit : mg/L
	El Saman	-	-	3.9	-	0.0	0.0	0.0	3.9	-	0.0	0.0	1.6	
	Camaguan	0.0	-	3.9	-	0.0	7.1	0.0	0.0	-	0.0	3.9	3.5	
	San Fernando	0.0	0.0	3.9	-	3.9	0.0	0.0	3.9	3.9	3.9	3.9	3.5	
Calcium	Bruzual	-	18	-	12	-	12	18	18	-	10	8	12	Unit : mg/L
	El Saman	-	-	12	-	12	12	18	16	-	16	8	8	
	Camaguan	26	-	40	-	40	38	30	44	-	26	34	30	
	San Fernando	12	22	18	-	14	22	22	20	18	14	22	18	

Table 3.5.1 RESULT OF DISCHARGE MEASUREMENT (1/2)

SITE: BRUZUAL(APURE RIVER)
DATE: Jun.9'92
W.L : 6.38m(76.88m,MSL)
JICA-CURRENT METER

No.	x (m)	dx (m)	h (m)	v (m/s)	Q (m3/s)	A (m2)	hs (m)	As (m2)
V1	6	15.0	2.25	0.73	24.6	33.8	2.4	36.0
V2	24	18.0	4.68	1.11	93.5	84.2	4.8	86.4
V3	42	18.0	4.77	1.12	96.2	85.9	4.6	82.8
V4	60	18.0	4.45	1.35	108.1	80.1	4.4	79.2
V5	78	18.0	4.55	1.41	115.5	81.9	4.6	82.8
V6	96	18.0	4.60	1.47	121.7	82.8	4.4	79.2
V7	114	18.0	4.64	1.40	116.9	83.5	5.2	93.6
V8	132	19.0	5.10	1.27	116.6	91.8	3.8	68.4
V9	150	18.0	4.98	1.21	108.5	89.6	4.0	72.0
V10	168	18.0	4.90	0.99	87.3	88.2	3.6	64.8
V11	186	18.0	3.81	0.63	43.2	68.6	3.4	61.2
V12	204	18.0	4.01	0.52	37.5	72.2	1.8	32.4
V13	222	18.0	3.54	0.47	29.9	63.7	1.4	25.2
V14	240	18.0	1.25	0.67	15.1	22.5	1.4	25.2
V15	258	23.0	1.14	0.61	16.0	26.2	0.8	18.4
	272							
Total		272.0			1,130.7	1,055.0		907.6

FLOAT

No.	x	dx	h	Surface vs	Qs	0.5 m v0.5	Q0.5	1.0 m v1.0	Q1.0
	(m)	(m)	(m)	(m/s)	(m3/s)	(m/s)	(m3/s)	(m/s)	(m3/s)
V1	6	15.0	2.25	0.87	29.4	1.01	34.1		
V2	24	18.0	4.68	1.18	99.4	1.02	85.9		
V3	42	18.0	4.77	1.25	107.3	1.21	103.9		
V4	60	18.0	4.45	1.44	115.3	1.36	108.9		
V5	78	18.0	4.55	1.31	107.3	1.47	120.4		
V6	96	18.0	4.60	1.29	106.8	1.54	127.5		
V7	114	18.0	4.64	1.37	114.4	1.40	116.9		
V8	132	18.0	5.10	1.15	105.6	1.24	113.8		
V9	150	18.0	4.98	1.29	115.6	0.99	88.7		
V10	168	18.0	4.90	1.05	92.6	0.75	66.2		
V11	186	18.0	3.81	0.82	56.2	0.84	57.6		
V12	204	18.0	4.01	0.87	62.8	0.86	62.1		
V13	222	18.0	3.54	0.88	56.1	0.90	57.3		
V14	240	18.0	1.25	0.88	19.8	0.80	18.0		
V15	258	23.0	1.14	1.25	32.8	0.77	20.2		
	272								
Total		272.0			1,221.5		1,181.6		

SITE: PUENTE REMOLINO/SARARE R.
DATE: Jun.19'92
W.L : 4.72m(129.93m,MSL)
JICA-CURRENT METER

No.	x (m)	dx (m)	h (m)	v (m/s)	Q (m3/s)	A (m2)	hs (m)	As (m2)
V1	4	12.5	2.95	1.27	46.8	36.9	1.20	15.0
V2	21	17.0	4.57	1.20	93.2	77.7	3.20	54.4
V3	38	17.0	3.82	1.21	78.6	64.9	5.40	91.8
V4	55	17.0	3.98	1.13	76.5	67.7	4.50	76.5
V5	72	17.0	3.60	1.15	70.4	61.2	4.30	73.1
V6	89	17.0	3.00	1.26	64.3	51.0	4.00	68.0
V7	106	17.0	2.90	1.09	53.7	49.3	4.20	71.4
V8	123	17.0	2.08	1.07	37.8	35.4	3.90	66.3
V9	140	17.0	1.55	0.89	23.5	26.4	2.60	44.2
V10	157	13.5	1.40	0.90	17.0	18.9	1.90	25.7
V11	167	9.0	2.20	0.62	12.3	19.8	2.30	20.7
	171							
Total		171.0			574.0	509.1		607.1

FLOAT

No.	x	dx	h	Surface vs	Qs	0.5 m v0.5	Q0.5	1.0 m v1.0	Q1.0
	(m)	(m)	(m)	(m/s)	(m3/s)	(m/s)	(m3/s)	(m/s)	(m3/s)
V1	4	12.5	2.95	1.06	39.1	1.10	40.6	1.26	46.5
V2	21	17.0	4.57	1.22	94.8	1.19	92.5	1.23	95.6
V3	38	17.0	3.82	1.25	81.2	1.22	79.2	1.23	79.9
V4	55	17.0	3.98	1.33	90.0	1.26	85.3	1.30	88.0
V5	72	17.0	3.60	1.06	64.9	1.22	74.7	1.26	77.1
V6	89	17.0	3.00	1.04	53.0	1.05	53.6	1.16	59.2
V7	106	17.0	2.90	1.09	53.7	1.02	50.3	1.08	53.2
V8	123	17.0	2.08	0.90	31.8	0.98	34.7	0.95	33.6
V9	140	17.0	1.55	0.79	20.8	0.78	20.6	0.72	19.0
V10	157	13.5	1.40	0.46	8.7	0.59	11.2	0.55	10.4
V11	167	9.0	2.20	0.46	9.1	0.59	11.7	0.55	10.9
	171								
Total		171.0			547.1		554.0		573.2

Table 3.5.1 RESULT OF DISCHARGE MEASUREMENT (2/2)

SITE: SAN FERNANDO(APURE RIVER)
DATE: Jul.14'92
W.L : 7.62m(43.86m,MSL)
MARNR-CURRENT METER

No.	x (m)	dx (m)	h (m)	v (m/s)	Q (m3/s)	A (m2)	hs (m)	As (m2)
V1	45	60.0	5.25	1.20	378.0	315.0	4.4	264.0
V2	75	30.0	4.95	1.04	154.4	148.5	4.0	120.0
V3	105	30.0	4.55	1.04	142.0	136.5	3.8	114.0
V4	135	30.0	4.10	1.00	123.0	123.0	3.6	108.0
V5	165	30.0	4.25	1.00	127.5	127.5	3.8	114.0
V6	195	30.0	4.15	0.94	117.0	124.5	3.8	114.0
V7	225	30.0	4.55	1.10	150.2	136.5	4.2	126.0
V8	255	30.0	4.90	1.02	149.9	147.0	4.6	138.0
V9	285	30.0	5.35	1.10	176.6	160.5	4.8	144.0
V10	315	30.0	5.25	0.94	148.1	157.5	5.4	162.0
V11	345	30.0	6.15	1.04	191.9	184.5	5.8	174.0
V12	375	27.5	6.15	1.02	172.5	169.1	6.2	170.5
V13	400	27.5	6.85	1.12	211.0	188.4	7.0	192.5
V14	430	30.0	9.15	1.11	304.7	274.5	9.8	294.0
V15	460	30.0	11.45	1.12	384.7	343.5	12.2	366.0
V16	490	30.0	11.60	1.18	410.6	348.0	11.2	336.0
V17	520	23.5	11.90	0.84	234.9	279.7	11.2	263.2
V18	537	26.5	10.35	0.78	213.9	274.3	8.6	227.9
	555							
Total		555.0			3,790.9	3,638.4		3,428.1

SITE: CAMAGUAN(PORTUGUESA RIVER)
DATE: Jul.15'92
W.L : 10.00m(48.54m,MSL)
JICA-CURRENT METER

No.	x (m)	dx (m)	h (m)	v (m/s)	Q (m3/s)	A (m2)	hs (m)	As (m2)
V1	2	5.5	2.60	0.39	5.6	14.3	2.5	13.8
V2	9	7.0	7.45	1.10	57.4	52.2	5.5	38.5
V3	16	7.0	11.10	1.14	88.6	77.7	10.0	70.0
V4	23	7.0	10.80	1.11	83.9	75.6	11.9	83.3
V5	30	7.0	9.30	1.08	70.3	65.1	11.7	81.9
V6	37	7.0	9.30	1.12	72.9	65.1	11.5	80.5
V7	44	7.0	9.35	1.02	66.8	65.5	10.8	75.6
V8	51	7.0	8.90	1.10	68.5	62.3	10.5	73.5
V9	58	7.0	8.55	1.02	61.0	59.9	9.9	69.3
V10	65	7.0	8.70	1.02	62.1	60.9	9.5	66.5
V11	72	7.0	7.90	1.05	58.1	55.3	9.2	64.4
V12	79	7.0	7.50	1.03	54.1	52.5	8.9	62.3
V13	86	7.0	7.30	1.01	51.6	51.1	8.4	58.8
V14	93	7.0	7.15	0.91	45.5	50.1	8.0	56.0
V15	100	7.0	6.75	0.76	35.9	47.3	6.0	42.0
V16	107	8.5	4.70	0.29	11.6	40.0	3.2	27.2
	112							
Total		112.0			893.9	894.6		963.6

ADJUSTMENT TO FLOW AREA

Qadj = (Q/A) x As
A : Flow area measured by current meter
As : Flow area measured by echo sounder
Q/A: Mean velocity

	Q (m3/s)	A (m2)	Q/A (m/s)	As (m2)	As/A	Qadj (m3/s)
1) P. Remolino					*	*
	574.0	509.1	1.13	607.1	1.19	684.5
2) Bruzual						
	1,130.7	1,055.0	1.07	907.6	0.86	972.7
3) San Fernando						
	3,790.9	3,638.4	1.04	3,428.1	0.94	3,571.8
4) Camagnan						
	893.9	894.6	1.00	963.6	1.08	962.8

*: Discharge measured at P. Remolino was not adjusted, since As was unreasonably large.

Table 3.5.2 PHYSICAL ANALYSIS OF SEDIMENT LOAD

1.LOCATION: PUENTE REMOLINO
2.SAMPLING DATE: June 19, 1992
3.SEDIMENT CONCENTRATION
1)Air temperature : 31.4 deg.C
2)Water temperature: 27.1 deg.C
3)Water level : 4.33 m
4)Sample

No.	Sampling place	Concentration (ppm) >63mm	<63mm	Total
V2:	21m from left bank	283	288	571
V5:	72m - do -	294	287	581
V8:	123m - do -	348	281	629
V10:	157m - do -	245	301	546

4.GRADING OF BED LOAD
1)Grading

Diameter(mm)	Percentage of finer particles Left(V2)	Center(V5)	Right(V8)
2.00	-	99.8	99.8
0.85	99.8	98.1	99.5
0.425	95.9	65.9	94.4
0.25	74.2	18.2	46.6
0.18	41.9	7.4	21.4
0.15	16.5	3.3	7.5
0.075	1.1	0.3	0.5

2)Specific size

	Diameter (mm) Left	Center	Right	Ave.
d75	0.26	0.51	0.35	0.36
d65	0.22	0.42	0.30	0.30
d50	0.19	0.35	0.26	0.26
d25	0.15	0.27	0.18	0.19
SQRT(d75/d25)	1.32	1.37	1.39	1.38

1.LOCATION: BRUZUAL
2.SAMPLING DATE: June 9, 1992
3.SEDIMENT CONCENTRATION
1)Air temperature : 32.0 deg.C
2)Water temperature: 29.4 deg.C
3)Water level : 6.40 m
4)Sample

No.	Sampling place	Concentration (ppm) >63mm	<63mm	Total
V2:	24m from left bank	130	260	390
V5:	78m - do -	113	245	358
V8:	132m - do -	197	382	579
V11:	186m - do -	444	381	825
V14:	240m - do -	195	381	576

4.GRADING OF BED LOAD
1)Grading

Diameter(mm)	Percentage of finer particles Left(V5)	Center(V8)	Right(V11)
2.00	99.6	99.0	-
0.85	93.2	97.9	-
0.425	23.5	68.2	99.8
0.25	1.5	18.7	98.6
0.18	0.5	5.8	88.0
0.15	0.3	2.9	64.3
0.075	0.1	0.6	9.7

2)Specific size

	Diameter (mm) Left	Center	Right	Ave.
d75	0.70	0.51	0.16	0.39
d65	0.63	0.41	0.15	0.34
d50	0.55	0.36	0.12	0.29
d25	0.44	0.27	0.090	0.22
SQRT(d75/d25)	1.26	1.37	1.33	1.33

1.LOCATION: SAN FERNANDO
2.SAMPLING DATE: July 14, 1992
3.SEDIMENT CONCENTRATION: Not Sampled

4.GRADING OF BED LOAD
1)Grading

Diameter(mm)	Percentage of finer particles Left	Center	Right
2.00	99.8	99.9	99.9
0.85	99.0	97.7	98.1
0.425	84.0	55.8	78.1
0.25	34.4	11.4	36.9
0.18	12.8	2.0	15.9
0.15	4.6	0.8	8.4
0.075	0.5	0.2	0.7

2)Specific size

	Diameter (mm) Left	Center	Right	Ave.
d75	0.39	0.59	0.41	0.46
d65	0.35	0.50	0.36	0.40
d50	0.29	0.40	0.29	0.32
d25	0.21	0.29	0.19	0.23
SQRT(d75/d25)	1.36	1.43	1.47	1.41

1.LOCATION: CAMAGUAN
2.SAMPLING DATE: July 15, 1992
3.SEDIMENT CONCENTRATION
1)Air temperature : 27.0 deg.C
2)Water temperature: 27.6 deg.C
3)Water level : 10.0 m
4)Sample

No.	Sampling place	Concentration (ppm) >63mm	<63mm	Total
V4:	23m from left bank	119	34	153
V9:	58m - do -	126	46	172
V13:	86m - do -	130	99	229

4.GRADING OF BED LOAD
1)Grading

Diameter(mm)	Percentage of finer particles Left	Center	Right
2.00	96.9	-	-
0.85	64.7	99.8	-
0.425	5.1	98.6	99.7
0.25	2.1	21.7	93.4
0.18	1.3	4.6	42.4
0.15	1.0	2.7	14.3
0.075	0.7	0.5	1.6

2)Specific size

	Diameter (mm) Left	Center	Right	Ave.
d75	1.20	0.36	0.21	0.45
d65	0.86	0.33	0.20	0.38
d50	0.71	0.30	0.18	0.34
d25	0.53	0.25	0.16	0.28
SQRT(d75/d25)	1.50	1.20	1.15	1.27

Table 3.6.1 RESULTS OF WATER QUALITY TEST (1/2)

			1992							1993
Station	Test Item	Unit	May-11	May-12	May-14	May-15	Jun-09	Jul-14	Jul-15	Feb.16
Camaguan	Temperature	C	29.2						26.9	28.7
	Disolved Oxygen	mg/l	7.1						6.7	7.4
	PH		7.7						6.9	7.7
	Coductivity	ms/cm	0.0						0.0	0.2
	Turbidity	mg/l	31.0						80.0	140.0
	Mn	mg/l	0.0						0.0	0.3
	Fe	mg/l	0.0						1.0	0.0
	Cu	mg/l	0.5						0.5	0.1
San Fernando	Temperature	C		29.4				26.6		27.3
	Disolved Oxygen	mg/l		7.5				8.6		7.3
	PH			7.6				7.1		7.7
	Coductivity	ms/cm		0.0				0.0		0.0
	Turbidity	mg/l		220.0				145.0		90.0
	Mn	mg/l		0.0				0.0		0.0
	Fe	mg/l		0.0				1.0		0.2
	Cu	mg/l		0.5				0.5		0.0
El. Saman	Temperature	C		31.1						
	Disolved Oxygen	mg/l		7.3						
	PH			7.6						
	Coductivity	ms/cm		0.0						
	Turbidity	mg/l		145.0						
	Mn	mg/l		0.0						
	Fe	mg/l		0.5						
	Cu	mg/l		0.0						
Cano Corozal	Temperature	C			27.2					
	Disolved Oxygen	mg/l			82.7					
	PH				6.7					
	Coductivity	ms/cm			0.0					
	Turbidity	mg/l			33.0					
	Mn	mg/l			0.5					
	Fe	mg/l			5.0					
	Cu	mg/l			1.0					
El Baul	Temperature	C				28.7				
	Disolved Oxygen	mg/l				6.6				
	PH					7.6				
	Coductivity	ms/cm				0.3				
	Turbidity	mg/l				480.0				
	Mn	mg/l				0.0				
	Fe	mg/l				1.0				
	Cu	mg/l				0.5				
Arismendi	Temperature	C				32.3				
	Disolved Oxygen	mg/l				6.1				
	PH					7.4				
	Coductivity	ms/cm				0.0				
	Turbidity	mg/l				27.0				
	Mn	mg/l				0.0				
	Fe	mg/l				1.0				
	Cu	mg/l				0.0				

Table 3.6.1 RESULTS OF WATER QUALITY TEST (2/2)

			1992		1993	
Station	Test Item	Unit	Jun-09	Jun-19	Feb. 12	Feb.16
Bruzual	Temperature	C	29.1		30.0	
	Disolved Oxygen	mg/l	8.0		6.3	
	PH		7.5		7.1	
	Coductivity	ms/cm	0.0		0.0	
	Turbidity	mg/l	292.0		138.0	
	Mn	mg/l	0.5		0.0	
	Fe	mg/l	1.0		0.2	
	Cu	mg/l	0.5		0.0	
Guasdualito	Temperature	C		27.1	26.7	
	Disolved Oxygen	mg/l		7.6	4.1	
	PH			7.1	5.3	
	Coductivity	ms/cm		0.0	0.0	
	Turbidity	mg/l		165.0	102.0	
	Mn	mg/l		0.5	0.0	
	Fe	mg/l		2.0	0.2	
	Cu	mg/l		0.5	0.5	
Upstream of Guanaparo R.	Temperature	C				27.6
	Disolved Oxygen	mg/l				6.8
	PH					7.8
	Coductivity	ms/cm				0.0
	Turbidity	mg/l				190.0
	Mn	mg/l				0.0
	Fe	mg/l				0.3
	Cu	mg/l				0.4
Downstream of Garzas R.	Temperature	C				27.9
	Disolved Oxygen	mg/l				7.3
	PH					7.8
	Coductivity	ms/cm				0.0
	Turbidity	mg/l				100.0
	Mn	mg/l				0.0
	Fe	mg/l				0.2
	Cu	mg/l				0.5
La Union	Temperature	C				28.9
	Disolved Oxygen	mg/l				6.5
	PH					7.6
	Coductivity	ms/cm				0.1
	Turbidity	mg/l				318.0
	Mn	mg/l				0.0
	Fe	mg/l				1.0
	Cu	mg/l				0.5

Table 4.2.1 BASIN MEAN ANNUAL RAINFALL

(Unit: mm)

Year	Puente Remolino	Bruzual	El Saman	San Fernando	El Baul	Jobalito	Camaguan
1967	2153.8	1833.5	1788.3	1545.4	1227.1	1446.8	1376.7
1968	2099.0	1784.7	1724.6	1458.5	1188.7	1363.0	1255.6
1969	1732.5	1841.3	1845.6	1740.8	1464.8	1692.9	1678.0
1970	2183.2	1845.6	1826.7	1662.1	1502.0	1560.5	1519.9
1971	2094.2	1804.4	1752.5	1455.7	1194.6	1321.7	1241.5
1972	2118.1	2054.3	1996.8	1723.2	1544.0	1722.2	1494.3
1973	1784.2	1562.8	1539.0	1383.3	1092.2	1244.3	1245.1
1974	1614.4	1455.9	1442.0	1282.3	1082.1	1190.4	1192.8
1975	1792.7	1660.2	1627.4	1486.4	1392.1	1479.8	1389.7
1976	2243.1	1995.3	1949.7	1737.4	1437.4	1658.5	1566.2
1977	1953.7	1841.2	1817.9	1543.1	1242.8	1454.3	1288.1
1978	2208.6	2174.1	2099.0	1756.7	1283.7	1570.4	1501.3
1979	2294.7	2242.3	2191.6	1834.1	1282.4	1596.7	1587.6
1980	1926.8	1876.3	1862.3	1666.4	1260.4	1611.3	1510.5
1981	2345.9	2322.9	2281.9	2003.3	1677.2	1963.4	1789.6
1982	2393.8	2112.3	2047.5	1717.5	1392.8	1609.3	1458.0
1983	2179.1	2103.5	2044.6	1799.4	1637.3	1756.0	1609.1
1984	1978.3	1582.0	1541.9	1390.7	1177.1	1311.5	1250.9
1985	1955.2	1718.2	1681.2	1459.1	1037.5	1346.6	1236.6
1986	2531.7	2146.4	2111.8	1789.4	1440.6	1658.4	1540.8
1987	2234.8	1813.8	1791.5	1569.0	1297.5	1459.6	1362.6
1988	2095.4	1870.4	1834.7	1583.7	1286.7	1417.6	1391.4
1989	1853.8	1696.8	1625.0	1324.3	1017.9	1179.5	1133.6
1990	2208.1	2065.4	1994.6	1672.6	1270.7	1516.1	1520.2
Ave	2082.3	1891.8	1850.7	1607.7	1309.6	1505.4	1422.5
Max	2531.7	2322.9	2281.9	2003.3	1677.2	1963.4	1789.6
Min	1614.4	1455.9	1442.0	1282.3	1017.9	1179.5	1133.6

Note : Basin mean rainfall is based on data of selected 39 stations

Table 4.3.1 DISCHARGE OF APURE RIVER

YEAR		APURE RIVER								PORTUGUESA RIVER					
		P.REMOLINO		BRUZUAL		EL SAMAN		S.FERNANDO		EL BAUL		JOBALITO		CAMAGUAN	
		(M3/S)	DATE	(M3/S)	DATE	(M3/S)	DATE	(M3/S)	DATE	(M3/S)	DATE	(M3/S)	DATE	(M3/S)	DATE
1975	MIN.	-	-	163	02/25	193	02/17	122	03/03	7	04/24	28	04/24	16	03/01
	MAX.	-	-	2529	07/20	3012	07/21	3606	09/18	155	10/01	394	09/29	882	10/02
	AVE.	-	-	1064	-	1338	-	1686	-	56	-	180	-	365	-
1976	MIN.	-	-	267	02/24	272	02/26	285	02/26	9	03/12	35	04/03	29	03/04
	MAX.	-	-	3662	07/08	4824	07/28	6416	08/09	304	07/20	521	07/20	1090	08/07
	AVE.	-	-	1546	-	1842	-	2525	-	93	-	224	-	479	-
1977	MIN.	-	-	130	03/14	177	03/10	333	03/14	13	04/30	33	05/02	28	03/16
	MAX.	-	-	3592	07/25	4196	08/08	5428	09/17	207	09/13	453	09/14	996	09/25
	AVE.	-	-	1383	-	1602	-	2258	-	68	-	201	-	441	-
1978	MIN.	-	-	130	03/24	151	03/23	258	03/27	-	-	-	-	31	03/29
	MAX.	-	-	3676	06/30	4308	07/18	5626	09/04	-	-	-	-	1046	08/15
	AVE.	-	-	1552	-	1838	-	2570	-	-	-	-	-	508	-
1979	MIN.	75	03/01	93	03/05	-	-	338	03/03	-	-	27	03/24	43	03/21
	MAX.	968	07/17	3592	07/20	-	-	6522	08/20	-	-	479	07/20	1074	08/12
	AVE.	474	-	1572	-	-	-	2710	-	-	-	243	-	563	-
1980	MIN.	-	-	119	04/17	171	04/13	254	04/19	18	04/14	28	04/14	44	04/17
	MAX.	-	-	3592	07/14	4421	07/25	7132	08/27	299	08/21	496	08/29	1224	08/25
	AVE.	-	-	1571	-	1920	-	2864	-	117	-	250	-	583	-
1981	MIN.	67	02/13	177	04/06	-	-	289	02/19	21	04/03	36	04/06	70	04/09
	MAX.	1039	06/16	3933	06/21	-	-	8645	07/19	340	09/16	501	06/18	1238	07/07
	AVE.	512	-	1794	-	-	-	3441	-	173	-	296	-	616	-
1982	MIN.	86	12/20	134	03/23	-	-	254	03/27	21	03/21	31	03/29	-	-
	MAX.	1148	06/28	3918	03/13	-	-	6840	08/21	223	08/12	492	08/16	-	-
	AVE.	531	-	1671	-	-	-	2770	-	95	-	231	-	-	-
1983	MIN.	-	-	76	03/27	-	-	-	-	13	04/05	9	04/01	63	04/05
	MAX.	-	-	3962	08/14	-	-	-	-	325	07/04	521	08/27	1217	09/08
	AVE.	-	-	1722	-	-	-	-	-	132	-	281	-	606	-
1984	MIN.	-	-	40	04/11	-	-	-	-	10	03/22	45	03/22	85	04/09
	MAX.	-	-	2952	07/25	-	-	-	-	244	09/08	501	10/22	985	10/31
	AVE.	-	-	1335	-	-	-	-	-	67	-	206	-	438	-
1985	MIN.	-	-	104	03/26	-	-	-	-	1	05/01	38	04/24	43	03/20
	MAX.	-	-	3270	08/30	-	-	-	-	134	08/31	421	11/03	940	09/24
	AVE.	-	-	1434	-	-	-	-	-	44	-	189	-	420	-
1986	MIN.	-	-	146	03/18	-	-	-	-	2	04/15	39	03/20	49	03/24
	MAX.	-	-	3861	07/17	-	-	-	-	207	10/18	514	08/11	1062	08/24
	AVE.	-	-	1942	-	-	-	-	-	81	-	284	-	611	-
1987	MIN.	-	-	-	-	-	-	352	03/20	5	03/18	63	04/16	122	03/16
	MAX.	-	-	-	-	-	-	5005	09/17	213	09/13	475	08/18	1002	09/28
	AVE.	-	-	-	-	-	-	2201	-	62	-	223	-	492	-
1988	MIN.	-	-	-	-	-	-	-	-	3	02/04	41	05/22	-	-
	MAX.	-	-	-	-	-	-	-	-	271	09/03	451	09/28	-	-
	AVE.	-	-	-	-	-	-	-	-	69	-	168	-	-	-
1989	MIN.	-	-	234	04/25	249	04/26	336	04/29	3	12/31	11	05/03	93	04/20
	MAX.	-	-	2835	08/10	3377	08/15	3569	08/18	63	10/09	180	07/15	629	08/18
	AVE.	-	-	1252	-	1396	-	1637	-	22	-	71	-	310	-
1990	MIN.	103	01/16	263	03/04	309	03/10	358	03/09	2	02/16	8	03/10	82	03/12
	MAX.	1086	05/28	2855	07/06	3567	06/28	4439	09/04	218	08/27	465	08/25	1087	08/31
	AVE.	551	-	1459	-	1761	-	2323	-	52	-	182	-	541	-

REMARKS: Date,"xx/xx" indicates "month/day".

Table 4.4.1 ANNUAL RUNOFF RATIO

Year	Station	Puente Remolino	Bruzual	El Saman	San Fernando	El Baul	Jobalito	Camaguan
	Serial No.	900	705	710	022	317	895	890
	Area(Km2)	8,400	40,000	48,000	111,800	13,200	23,300	54,400
1975	AVG. Runoff (m3/s)	-	1,064	1,338	1,686	56	180	365
	Runoff Height (mm)	-	838.9	879.1	475.6	133.8	243.6	211.6
	Rainfall (mm)	-	1,660.2	1,627.4	1,486.4	1,392.1	1,479.8	1,389.7
	Runoff Ratio	-	0.51	0.54	0.32	0.10	0.16	0.15
1976	AVG. Runoff (m3/s)	-	1,546	1,842	2,525	93	224	479
	Runoff Height (mm)	-	1,218.9	1,210.2	712.2	222.2	303.2	277.7
	Rainfall (mm)	-	1,995.3	1,949.7	1,737.4	1,437.4	1,658.5	1,566.2
	Runoff Ratio	-	0.61	0.62	0.41	0.15	0.18	0.18
1977	AVG. Runoff (m3/s)	-	1,383	1,602	2,258	68	201	441
	Runoff Height (mm)	-	1,090.4	1,052.5	636.9	162.5	272.0	255.7
	Rainfall (mm)	-	1,841.2	1,817.9	1,543.1	1,242.8	1,454.3	1,288.1
	Runoff Ratio	-	0.59	0.58	0.41	0.13	0.19	0.20
1978	AVG. Runoff (m3/s)	-	1,552	1,838	2,570	-	-	508
	Runoff Height (mm)	-	1,223.6	1,207.6	724.9	-	-	294.5
	Rainfall (mm)	-	2,174.1	2,099.0	1,756.7	-	-	1,501.3
	Runoff Ratio	-	0.56	0.58	0.41	-	-	0.20
1979	AVG. Runoff (m3/s)	474	1,572	1,856	2,710	-	243	563
	Runoff Height (mm)	1,779.5	1,239.4	1,219.4	764.4	-	328.9	326.4
	Rainfall (mm)	2,294.7	2,242.3	2,191.6	1,834.2	-	1,596.7	1,587.6
	Runoff Ratio	0.78	0.55	0.56	0.42	-	0.21	0.21
1980	AVG. Runoff (m3/s)	-	1,571	1,920	2,864	117	250	583
	Runoff Height (mm)	-	1,238.6	1,261.4	807.9	279.5	338.4	338.0
	Rainfall (mm)	-	1,876.3	1,862.3	1,666.5	1,260.4	1,611.3	1,510.5
	Runoff Ratio	-	0.66	0.68	0.48	0.22	0.21	0.22
1981	AVG. Runoff (m3/s)	512	1,794	2,322	3,441	173	296	616
	Runoff Height (mm)	1,922.2	1,414.4	1,525.6	970.6	413.3	400.6	357.1
	Rainfall (mm)	2,345.9	2,322.9	2,281.9	2,003.4	1,677.2	1,963.4	1,789.6
	Runoff Ratio	0.82	0.61	0.67	0.48	0.25	0.20	0.20
1982	AVG. Runoff (m3/s)	531	1,671	-	2,770	95	231	-
	Runoff Height (mm)	1,993.5	1,317.4	-	781.3	227.0	312.7	-
	Rainfall (mm)	2,393.8	2,112.3	-	1,717.5	1,392.8	1,609.3	-
	Runoff Ratio	0.83	0.62	-	0.45	0.16	0.19	-
1983	AVG. Runoff (m3/s)	-	1,722	-	-	132	281	606
	Runoff Height (mm)	-	1,357.6	-	-	315.4	380.3	351.3
	Rainfall (mm)	-	2,103.5	-	-	1,637.3	1,756.0	1,609.1
	Runoff Ratio	-	0.65	-	-	0.19	0.22	0.22
1984	AVG. Runoff (m3/s)	-	1,335	-	-	67	206	438
	Runoff Height (mm)	-	1,052.5	-	-	160.1	278.8	253.9
	Rainfall (mm)	-	1,582.0	-	-	1,177.1	1,311.5	1,250.9
	Runoff Ratio	-	0.67	-	-	0.14	0.21	0.20
1985	AVG. Runoff (m3/s)	-	1,434	-	-	44	189	420
	Runoff Height (mm)	-	1,130.6	-	-	105.1	255.8	243.5
	Rainfall (mm)	-	1,718.2	-	-	1,037.5	1,346.6	1,236.6
	Runoff Ratio	-	0.66	-	-	0.10	0.19	0.20
1986	AVG. Runoff (m3/s)	-	1,942	-	-	81	284	611
	Runoff Height (mm)	-	1,531.1	-	-	193.5	384.4	354.2
	Rainfall (mm)	-	2,146.4	-	-	1,440.6	1,658.4	1,540.8
	Runoff Ratio	-	0.71	-	-	0.13	0.23	0.23
1987	AVG. Runoff (m3/s)	-	-	-	2,201	62	223	492
	Runoff Height (mm)	-	-	-	620.8	148.1	301.8	285.2
	Rainfall (mm)	-	-	-	1,569.0	1,297.5	1,459.6	1,362.6
	Runoff Ratio	-	-	-	0.40	0.11	0.21	0.21
1988	AVG. Runoff (m3/s)	-	-	1,726	2,071	69	168	-
	Runoff Height (mm)	-	-	1,134.0	584.2	164.8	227.4	-
	Rainfall (mm)	-	-	1,834.7	1,583.7	1,286.7	1,417.6	-
	Runoff Ratio	-	-	0.62	0.37	0.13	0.16	-
1989	AVG. Runoff (m3/s)	-	1,252	1,396	1,637	22	71	310
	Runoff Height (mm)	-	987.1	917.2	461.8	52.6	96.1	179.7
	Rainfall (mm)	-	1,696.8	1,625.0	1,324.3	1,017.9	1,179.5	1,133.6
	Runoff Ratio	-	0.58	0.56	0.35	0.05	0.08	0.16
1990	AVG. Runoff (m3/s)	551	1,459	1,761	2,323	52	182	541
	Runoff Height (mm)	2,068.6	1,150.3	1,157.0	655.3	124.2	246.3	313.6
	Rainfall (mm)	2,208.1	2,065.4	1,994.6	1,672.6	1,270.7	1,516.1	1,520.2
	Runoff Ratio	0.94	0.56	0.58	0.39	0.10	0.16	0.21

Table 4.4.2 AVERAGE FLOW DURATION

ORDINAL DAYS	APURE RIVER				PORTUGUESA RIVER		
	P.REMOLINO (M3/S)	BRUZUAL (M3/S)	EL SAMAN (M3/S)	S.FERNANDO (M3/S)	EL BAUL (M3/S)	JOBALITO (M3/S)	CAMAGUAN (M3/S)
1	83	148	217	289	9	31	57
5	88	158	225	302	10	32	59
10	92	167	239	322	11	33	63
20	97	188	251	362	11	35	67
30	104	203	270	391	12	37	72
40	113	224	292	422	13	39	77
50	122	248	319	466	14	41	82
60	137	276	346	511	15	43	89
70	154	308	380	554	16	47	98
80	176	341	410	606	18	51	106
90	208	380	449	669	20	57	120
100	246	445	506	749	22	62	135
110	287	523	561	856	24	73	154
120	319	586	629	961	26	82	179
130	350	673	705	1,103	29	91	210
140	385	762	812	1,273	31	105	239
150	424	890	961	1,469	35	119	275
160	449	1,059	1,095	1,698	39	139	339
170	482	1,289	1,255	1,940	47	167	386
180	514	1,490	1,376	2,164	57	190	438
190	537	1,621	1,536	2,357	65	212	497
200	563	1,759	1,715	2,582	73	233	560
210	599	1,849	1,886	2,839	80	254	613
220	623	1,948	2,041	3,083	87	273	663
230	656	2,033	2,198	3,258	94	289	705
240	677	2,163	2,345	3,454	103	308	747
250	707	2,263	2,448	3,609	111	324	786
260	743	2,375	2,576	3,742	118	343	833
270	775	2,479	2,714	3,904	128	367	872
280	802	2,580	2,847	4,066	142	388	907
290	838	2,667	2,978	4,256	151	401	934
300	874	2,783	3,134	4,427	162	412	954
310	905	2,911	3,280	4,691	172	421	964
320	922	3,014	3,452	4,925	183	428	979
330	938	3,105	3,570	5,147	193	436	990
340	963	3,183	3,646	5,357	202	443	1,000
350	1,003	3,296	3,768	5,581	211	449	1,016
360	1,037	3,422	3,903	5,701	223	456	1,029
365	1,060	3,442	3,954	5,744	229	458	1,034

Table 4.4.3 LOW WATER DISCHARGE

		ANNUAL VALUES (M3/S)																DISCHARGE(M3/S)			Q5YR	
STATION	ORDER	1975	'76	'77	'78	'79	'80	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90	AVG.	MAX.	MIN.	m3/s	ORDER
PUENTE	MIN.	-	-	-	-	75	-	67	86	-	-	-	-	-	-	-	103	83	103	67	67	1st
REMOLINO	10TH	-	-	-	-	78	-	72	97	-	-	-	-	-	-	-	121	92	121	72		
/APURE	30TH	-	-	-	-	84	-	81	106	-	-	-	-	-	-	-	147	104	147	81		
BRUZUAL	MIN.	163	267	130	130	93	119	177	134	76	40	104	146	-	-	234	263	148	267	40	93	3rd
/APURE	10TH	172	304	142	142	101	134	186	146	140	67	115	154	-	-	234	299	167	304	67		
	30TH	186	362	159	182	119	159	214	186	159	126	140	182	-	-	314	348	203	362	119		
EL SAMAN	MIN.	193	272	177	151	-	171	-	-	-	-	-	-	-	-	249	309	217	309	151	151	1st
/APURE	10TH	201	322	184	170	-	190	-	-	-	-	-	-	-	-	265	342	239	342	170		
	30TH	223	374	201	196	-	208	-	-	-	-	-	-	-	-	291	396	270	396	196		
PUENTE	MIN.	7	9	13	-	-	18	21	21	13	10	1	2	5	3	3	2	9	21	1	2	3rd
EL BAUL	10TH	8	10	14	-	-	20	22	21	16	12	6	3	6	3	6	2	11	22	2		
/COJEDES	30TH	9	12	15	-	-	23	25	28	17	13	8	4	7	4	8	2	12	28	2		
JOBALITO	MIN.	28	35	33	-	27	28	36	31	9	45	38	39	63	41	11	8	31	63	8	11	3rd
/PORTUGUESA	10TH	29	35	34	-	29	31	39	33	11	47	40	42	64	42	12	9	33	64	9		
	30TH	31	37	36	-	31	35	45	44	15	54	43	45	68	45	13	11	37	68	11		
CAMAGUAN	MIN.	16	29	28	31	43	44	70	-	63	85	43	49	122	-	93	82	57	122	16	29	3rd
/PORTUGUESA	10TH	20	33	30	33	45	52	74	-	76	101	49	57	126	-	97	84	63	126	20		
	30TH	25	46	37	44	52	61	91	-	89	118	54	74	135	-	99	87	72	135	25		
SAN	MIN.	122	285	333	258	338	254	289	254	-	-	-	-	352	-	336	358	289	358	122	254	2nd
FERNANDO	10TH	140	338	358	313	350	281	305	313	-	-	-	-	391	-	352	398	322	398	140		
/APURE	30TH	178	441	399	374	399	338	370	466	-	-	-	-	459	-	398	484	391	484	178		

REMARKS:
5YR: Annual minimum discharge which corresponds to (n/5)th order from the minimam, where n is sample size or years of available data.

Table 4.4.4 ORDER OF SIGNIFICANT LOW WATER DISCHARGES

STATION	DISCHARG (M3/S)	NUMBER OF DAYS LOWER THAN THE SIGNIFICANT DISCHARGES(DAYS) 1975	'76	'77	'78	'79	'80	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90	AVG. DAYS
PUENTE	Q5yr 67	-	-	-	-	0	-	0	0	-	-	-	-	-	-	-	0	0
REMOLINO	Qave 83	-	-	-	-	27	-	31	0	-	-	-	-	-	-	-	0	15
/APURE	Qmax 103	-	-	-	-	62	-	54	24	-	-	-	-	-	-	-	0	35
BRUZUAL	Q5yr 93	0	0	0	0	0	0	0	0	2	15	0	0	-	-	0	0	1
/APURE	Qave 148	0	0	15	11	47	21	0	11	13	40	31	2	-	-	0	0	14
	Qmax 267	79	0	107	69	87	70	53	55	60	87	85	63	-	-	13	4	59
EL SAMAN	Q5yr 151	0	0	0	0	-	0	-	-	-	-	-	-	-	-	0	0	0
/APURE	Qave 217	21	0	38	42	-	39	-	-	-	-	-	-	-	-	0	0	20
	Qmax 309	88	7	103	77	-	62	-	-	-	-	-	-	-	-	36	0	53
PUENTE	Q5yr 2	0	0	0	-	-	0	0	0	0	0	2	0	0	0	0	0	0
EL BAUL	Qave 9	21	0	0	-	-	0	0	0	0	0	0	107	47	84	58	94	29
/COJEDES	Qmax 21	152	83	120	-	-	17	0	0	52	108	152	134	145	165	188	144	104
JOBALITO	Q5yr 11	0	0	0	-	0	0	0	0	6	0	0	0	0	0	0	28	2
/PORTUGUESA	Qave 31	21	0	0	-	28	9	0	0	65	0	0	0	0	0	0	0	8
	Qmax 63	132	94	134	-	96	87	72	63	92	73	104	92	0	149	185	137	101
CAMAGUAN	Q5yr 29	45	0	4	0	0	0	0	-	0	0	0	0	0	-	0	0	4
/PORTUGUESA	Qave 57	108	70	85	40	40	17	0	-	0	0	34	9	0	-	0	0	29
	Qmax 122	137	106	140	104	85	75	65	-	66	37	100	90	0	-	72	106	85
SAN	Q5yr 254	61	0	0	0	0	0	0	0	-	-	-	-	0	-	0	0	6
FERNANDO	Qave 289	70	2	0	6	0	11	0	6	-	-	-	-	0	-	0	0	9
/APURE	Qmax 358	99	11	7	27	12	37	24	16	-	-	-	-	1	-	15	0	23

REMARKS:

1) Q5yr: Annual minimum discharge which corresponds to (n/5)th order from the minimum, where n is number of years of available data.

2) Qave, Qmax,: Average and maximum values of annual minimum discharge at respective stations.

Table 5.2.1 PRINCIPAL FEATURES OF SUB-BASIN OF APURE RIVER BASIN

River Basin	Catchment Area (km2)	River Length (km)	River Gradient	River Basin	Catchment Area (km2)	River Length (km)	River Gradient
B-A- 1	660	35	1/20	B-P- 1	730	80	1/55
B-A- 2	680	30	1/25	B-P- 2	30	15	1/80
B-A- 3	2,485	70	1/65	B-P- 3	785	45	1/30
B-A- 4	150	30	1/25	B-P- 4	602	55	1/55
B-A- 5	480	30	1/75	B-P- 5	278	40	1/75
B-A- 6	330	25	1/90	B-P- 6	305	60	1/54
B-A- 7	1,205	95	1/1,600	B-P- 7	80	20	1/1,300
B-A- 8	1,730	180	1/210	B-P- 8	1,295	110	1/98
B-A- 9	680	50	1/5,000	B-P- 9	205	25	1/5,000
B-A-10	1,600	165	1/2,400	B-P-10	900	55	1/550
B-A-11	3,800	115	1/2,300	B-P-11	335	30	1/35
B-A-12	390	100	1/35	B-P-12	440	20	1/55
B-A-13	1,530	30	1/30	B-P-13	195	30	1/80
B-A-14	1,170	110	1/38	B-P-14	435	25	1/100
B-A-15	1,150	50	1/210	B-P-15	1,115	65	1/930
B-A-16	910	135	1/2,200	B-P-16	625	70	1/4,800
B-A-17	3,235	115	1/430	B-P-17	500	60	1/3,000
B-A-18	1,400	85	1/45	B-P-18	44	10	1/30
B-A-19	260	35	1/1,200	B-P-19	1,446	50	1/50
B-A-20	810	90	1/34	B-P-20	905	75	1/940
B-A-21	600	40	1/15	B-P-21	650	50	1/59
B-A-22	350	55	1/45	B-P-22	985	20	1/360
B-A-23	330	45	1/820	B-P-23	605	40	1/720
B-A-24	165	30	1/1,200	B-P-24	4,325	125	1/74
B-A-25	770	85	1/1,700	B-P-25	100	10	1/40
B-A-26	630	75	1/1,100	B-P-26	1,560	40	1/90
B-A-27	1,025	115	1/430	B-P-27	915	55	1/280
B-A-28	975	95	1/28	B-P-28	690	65	1/3,300
B-A-29	1,400	105	1/1,800	B-P-29	155	30	1/1,500
B-A-30	420	20	1/15	B-P-30	820	50	1/2,000
B-A-31	320	80	1/35	B-P-31	1,245	80	1/4,800
B-A-32	480	55	1/30	B-P-32	1,300	80	1/1,000
B-A-33	780	120	1/1,800	B-P-33	1,000	120	1/4,800
B-A-34	880	60	1/25	B-P-34	960	80	1/5,000
B-A-35	2,055	125	1/1,800	B-P-35	1,380	95	1/320
B-A-36	1,605	135	1/190	B-P-36	1,170	15	1/750
B-A-37	595	45	1/43	B-P-37	940	20	1/20
B-A-38	500	45	1/20	B-P-38	1,760	20	1/50
B-A-39	1,245	125	1/2,300	B-P-39	1,380	105	1/1,300
B-A-40	220	55	1/2,200	B-P-40	580	50	1/2,500
B-A-41	2,695	95	1/4,800	B-P-41	390	40	1/2,500
B-A-42	3,280	215	1/4,300	B-P-42	1,770	70	1/3,500
B-A-43	2,280	50	1/4,500	B-P-43	1,490	40	1/70
B-A-44	2,300	70	1/5,000	B-P-44	1,560	85	1/1,100
B-A-45	1,825	105	1/2,600	B-P-45	1,570	90	1/2,500
B-A-46	775	50	1/2,500	B-P-46	2,020	105	1/33
B-A-47	1,440	70	1/4,500	B-P-47	400	55	1/1,100
B-A-48	2,650	100	1/5,000	B-P-48	1,377	90	1/50
				B-P-49	33	10	1/70
				B-P-50	670	40	1/1,300
				B-P-51	640	75	1/1,900
				B-P-52	250	50	1/2,500
				B-P-53	1,040	110	1/3,600
				B-P-54	1,250	110	1/3,600
				B-P-55	600	105	1/33
				B-P-56	2,740	130	1/3,800
				B-P-57	1,780	70	1/10,000
				B-P-58	1,050	50	1/6,000
				B-P-59	690	60	1/45,000

Note : B-A-1;Sub-basin in Apure river basin except Portuguesa river basin
B-P-1; Sub-basin in Portuguesa river basin

Table 5.2.2 PRINCIPAL FEATURES OF RIVER CHANNEL

River	River Length (km)	River Gradient	River	River Length (km)	River Gradient
C-A- 1	15	1/60	C-P- 1	15	1/80
C-A- 2	70	1/65	C-P- 2	40	1/800
C-A- 3	30	1/75	C-P- 3	40	1/75
C-A- 4	25	1/90	C-P- 4	20	1/1,300
C-A- 5	95	1/1,600	C-P- 5	25	1/5,000
C-A- 6	50	1/5,000	C-P- 6	20	1/4,800
C-A- 7	130	1/4,300	C-P- 7	20	1/55
C-A- 8	50	1/310	C-P- 8	55	1/90
C-A- 9	135	1/2,200	C-P- 9	25	1/100
C-A-10	35	1/1,200	C-P-10	65	1/930
C-A-11	20	1/1,000	C-P-11	70	1/4,800
C-A-12	55	1/45	C-P-12	60	1/4,800
C-A-13	45	1/820	C-P-13	75	1/65
C-A-14	15	1/1,000	C-P-14	75	1/940
C-A-15	30	1/3,000	C-P-15	20	1/360
C-A-16	55	1/5,000	C-P-16	50	1/720
C-A-17	105	1/1,800	C-P-17	40	1/2,000
C-A-18	25	1/5,000	C-P-18	55	1/280
C-A-19	65	1/40	C-P-19	40	1/90
C-A-20	120	1/1,800	C-P-20	65	1/3,300
C-A-21	125	1/1,800	C-P-21	30	1/1,500
C-A-22	20	1/5,000	C-P-22	25	1/1,300
C-A-23	125	1/2,300	C-P-23	20	1/2,900
C-A-24	100	1/6,500	C-P-24	120	1/4,800
C-A-25	50	1/45,000	C-P-25	35	1/5,000
C-A-26	150	1/8,300	C-P-26	15	1/750
C-A-27	70	1/4,500	C-P-27	20	1/65
C-A-28	100	1/5,000	C-P-28	105	1/1,300
			C-P-29	50	1/2,500
			C-P-30	40	1/3,500
			C-P-31	40	1/23,000
			C-P-32	85	1/1,100
			C-P-33	85	1/2,500
			C-P-34	25	1/25,000
			C-P-35	55	1/1,100
			C-P-36	40	1/1,300
			C-P-37	10	1/70
			C-P-38	75	1/1,900
			C-P-39	110	1/3,600
			C-P-40	130	1/3,800
			C-P-41	70	1/10,000
			C-P-42	25	1/28,000
			C-P-43	45	1/45,000

Note : C-A-1; River channel in Apure river basin except Portuguesa river basin
C-P-1; River channel in Portuguesa river basin

Table 5.3.1 RAINFALL INTENSITY CURVE

Station : Campo Elias

Year	Rainfall Intrensity (mm)					
	1hr	3hrs	6hrs	9hrs	12hrs	24hrs
1964	36	51	76	78	78	93
	(0.39)	(0.55)	(0.82)	(0.84)	(0.84)	(1.00)
1965	46	58	62	68	70	89
	(0.52)	(0.65)	(0.70)	(0.76)	(0.79)	(1.00)
1966	29	81	82	82	82	95
	(0.31)	(0.85)	(0.86)	(0.86)	(0.86)	(1.00)
1967	36	55	73	82	89	94
	(0.38)	(0.59)	(0.78)	(0.87)	(0.95)	(1.00)
1968	72	90	97	103	103	103
	(0.70)	(0.87)	(0.94)	(1.00)	(1.00)	(1.00)
1969	42	53	80	87	88	89
	(0.47)	(0.60)	(0.90)	(0.98)	(0.99)	(1.00)
1970	32	51	89	100	102	103
	(0.31)	(0.50)	(0.86)	(0.97)	(0.99)	(1.00)
1971	51	73	77	77	77	90
	(0.57)	(0.81)	(0.86)	(0.86)	(0.86)	(1.00)
1972	39	52	75	92	113	113
	(0.35)	(0.46)	(0.66)	(0.81)	(1.00)	(1.00)
1973	31	48	68	69	71	75
	(0.41)	(0.64)	(0.91)	(0.92)	(0.95)	(1.00)
1974	46	54	64	79	80	80
	(0.58)	(0.68)	(0.80)	(0.99)	(1.00)	(1.00)
1975	29	64	72	72	73	86
	(0.34)	(0.74)	(0.84)	(0.84)	(0.85)	(1.00)
1976	38	67	82	90	90	90
	(0.42)	(0.74)	(0.91)	(1.00)	(1.00)	(1.00)
1977	23	57	68	99	102	105
	(0.22)	(0.54)	(0.65)	(0.94)	(0.97)	(1.00)
1978	42	51	61	67	77	105
	(0.40)	(0.49)	(0.58)	(0.64)	(0.73)	(1.00)
1979	70	73	105	117	121	125
	(0.56)	(0.58)	(0.84)	(0.94)	(0.97)	(1.00)
1980	41	96	109	121	121	122
	(0.34)	(0.79)	(0.89)	(0.99)	(0.99)	(1.00)
1981	38	73	116	135	151	156
	(0.24)	(0.47)	(0.74)	(0.87)	(0.97)	(1.00)
1982	32	60	78	81	81	96
	(0.33)	(0.63)	(0.81)	(0.84)	(0.84)	(1.00)
1983	35	49	66	73	76	81
	(0.43)	(0.60)	(0.81)	(0.90)	(0.94)	(1.00)
Ave.	(0.41)	(0.64)	(0.81)	(0.89)	(0.92)	(1.00)

Note : Value in parenthesis indicates ratio (Ri/R24)

Table 5.3.2 AREAL WEIGHT OF THIESSEN POLYGON METHOD FOR BASIN MEAN RAINFALL

Station no.	491	1297	1373	2166	2170	2196	2208	2221	2231	2246	2260	2261	2266
Apure	-	-	-	-	-	0.004	-	-	-	-	-	-	-
Portuguesa	0.019	0.024	0.012	0.014	0.019	0.012	0.018	0.018	0.012	0.023	0.013	0.014	0.029
Whole Basin	0.009	0.012	0.006	0.007	0.009	0.008	0.009	0.009	0.006	0.011	0.006	0.007	0.014

Station no.	2286	2308	2316	2331	2336	2349	2364	2378	2404	2426	2427	2431	2448
Apure	-	-	-	-	-	-	-	-	-	-	-	-	-
Portuguesa	0.042	0.021	0.021	0.039	0.018	0.026	0.041	0.035	0.011	0.010	0.013	0.030	0.005
Whole Basin	0.020	0.010	0.010	0.019	0.009	0.013	0.020	0.017	0.006	0.005	0.006	0.015	0.003

Station no.	2492	3030	3072	3087	3120	3126	3133	3173	3185	3186	3189	3191	3214
Apure	-	0.027	0.015	0.012	0.013	0.021	0.030	0.063	0.028	0.060	0.044	0.061	0.004
Portuguesa	0.034	-	-	0.001	0.024	-	-	-	-	-	-	-	0.065
Whole Basin	0.017	0.014	0.008	0.007	0.018	0.011	0.015	0.033	0.014	0.031	0.023	0.031	0.034

Station no.	3254	3283	3304	3309	3331	3332	3403	3454	4037	4058	4090	4140	4175
Apure	0.038	0.063	-	-	0.007	-	-	0.005	0.030	0.041	0.033	0.068	0.025
Portuguesa	0.000	-	0.071	0.032	0.092	0.042	0.013	0.042	-	-	-	-	-
Whole Basin	0.019	0.033	0.035	0.016	0.048	0.020	0.006	0.023	0.015	0.021	0.017	0.035	0.013

Station no.	4194	4292	4294	4296	4302	4303	4406	6360	9006	Total
Apure	0.040	0.071	0.043	0.042	0.034	0.040	0.018	-	0.020	1.000
Portuguesa	-	0.014	-	-	0.017	-	0.002	0.011	-	1.000
Whole Basin	0.020	0.043	0.022	0.021	0.026	0.021	0.010	0.005	0.010	1.000

Table 5.3.3 AREAL WEIGHT OF THIESSEN POLYGON METHOD FOR 1976 FLOOD (1/2)

(Apure River Basin)

Sub Basin	3023	3078	3090	3114	3120	3123	3134	3161	3181	3190	3216	3331	3332	4018	4027	4037	4082	4083	4085	4086	4292	4296	4303	9060
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
B - A - 1	0.69						0.31																	
B - A - 2	0.36													0.51										0.13
B - A - 3														0.16	0.09	0.01	0.3	0.12	0.11					0.13
B - A - 4																				0.56				0.44
B - A - 5																			0.47					0.53
B - A - 6																		0.76	0.24					
B - A - 7																		0.29	0.01	0.29				0.42
B - A - 8																	0.08	0.3		0.46				0.16
B - A - 9									0.82											0.18				
B - A - 10									0.39											0.47				0.15
B - A - 11									0.76	0.07											0.17			
B - A - 12																				1.00				
B - A - 13	0.03						0.71													0.26				
B - A - 14							0.46		0.49											0.04				
B - A - 15																				0.61				0.39
B - A - 16									0.79	0.05										0.16				
B - A - 17									0.93	0.03										0.04				
B - A - 18							0.02		0.1	0.88														
B - A - 19										1.0														
B - A - 20							0.04			0.96														
B - A - 21		0.21								0.79														
B - A - 22										1.0														
B - A - 23										1.0														
B - A - 24										0.95											0.05			
B - A - 25									0.36	0.51											0.13			
B - A - 26										0.6											0.4			
B - A - 27										0.82											0.18			
B - A - 28		0.25								0.75														
B - A - 29										0.29											0.71			
B - A - 30				1.0																				
B - A - 31		0.11	0.27	0.31		0.08		0.23																
B - A - 32			0.96	0.04																				
B - A - 33						0.62															0.38			
B - A - 34		0.09	0.15	0.13				0.21		0.41														
B - A - 35			0.06			0.35				0.36											0.23			
B - A - 36						0.44															0.56			
B - A - 37			0.31		0.12	0.57																		
B - A - 38			0.43			0.57																		
B - A - 39						0.68															0.32			
B - A - 40																					1.0			
B - A - 41									0.04													0.95		
B - A - 42									0.23												0.57	0.2		
B - A - 43																					0.47	0.43	0.1	
B - A - 44																							1.0	
B - A - 45						0.04					0.31										0.65			
B - A - 46											0.48										0.52			
B - A - 47																					0.88		0.12	
B - A - 48												0.18	0.03										0.79	

Table 5.3.3 AREAL WEIGHT OF THIESSEN POLYGON METHOD FOR 1976 FLOOD (2/2)

(Portuguesa River Basin)

Sub Basin	1297	2219	2229	2231	2233	2252	2253	2273	2286	2287	2303	2336	2349	2350	2364	2378	2404	2427	2431	2448	3090	3114	3120	3216	3309	3331	3332	3403	4292	4303	6357
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
B - P - 1				0.14		0.13		0.61																0.12							
B - P - 2									0.63															0.38							
B - P - 3								0.11	0.89																						
B - P - 4		0.03		0.26				0.04	0.67																						
B - P - 5									1.00																						
B - P - 6		0.15					0.22		0.63																						
B - P - 7									1.00																						
B - P - 8		0.22					0.45		0.32																						
B - P - 9									1.00																						
B - P - 10							0.89		0.11																						
B - P - 11		0.45		0.55																											
B - P - 12		0.15			0.63					0.23																					
B - P - 13		0.17			0.13		0.71																								
B - P - 14							1.00																								
B - P - 15							0.58								0.34										0.08						
B - P - 16							0.07		0.18						0.13										0.53	0.09					
B - P - 17															0.81										0.19						
B - P - 18																															1.00
B - P - 19											0.21				0.15																0.64
B - P - 20												0.08			0.88										0.05						
B - P - 21											0.43	0.38																			0.18
B - P - 22												0.90	0.07	0.02																	
B - P - 23												0.02		0.41	0.32	0.25															
B - P - 24	0.38		0.13	0.00	0.04					0.16	0.17																				0.12
B - P - 25			0.89							0.11																					
B - P - 26			0.48		0.04		0.30			0.07					0.11																
B - P - 27			0.24												0.76																
B - P - 28															0.86										0.14						
B - P - 29																									1.00						
B - P - 30															0.01	0.13									0.85						
B - P - 31															0.02										0.79		0.19				
B - P - 32									0.74															0.26							
B - P - 33									0.13																0.03	0.55	0.29				
B - P - 34																										0.53	0.47				
B - P - 35													0.09	0.06		0.26	0.01	0.03	0.54												
B - P - 36																0.17			0.56									0.26			
B - P - 37												0.06	0.12				0.72														0.10
B - P - 38											0.01	0.16	0.52				0.31														
B - P - 39												0.08	0.19	0.26		0.46															
B - P - 40																0.34									0.62		0.03				
B - P - 41																0.02									0.45		0.24	0.29			
B - P - 42																0.03									0.31		0.53	0.13			
B - P - 43																	0.70	0.45	0.24	0.12											
B - P - 44																			0.35	0.08								0.57			
B - P - 45																											0.35	0.65			
B - P - 46						0.02		0.27													0.34	0.05	0.25	0.07							
B - P - 47																							0.41	0.59							
B - P - 48						0.16		0.72															0.04	0.09							
B - P - 49																								1.00							
B - P - 50																							0.08	0.92							
B - P - 51									0.26															0.63					0.10		
B - P - 52									0.96															0.04							
B - P - 53																								0.04		0.96					
B - P - 54									0.01																	0.97			0.02		
B - P - 55																								0.34					0.66		
B - P - 56																										0.58			0.40	0.01	
B - P - 57																										0.78	0.22				
B - P - 58																											0.46	0.52		0.02	
B - P - 59																												0.25		0.75	

Table 5.3.4 AREAL WEIGHT OF THIESSEN POLYGON METHOD FOR 1981 FLOOD (1/2)

(Apure River Basin)

Sub Basin	3023	3072	3089	3090	3114	3134	3161	3180	3184	3191	3200	3222	3251	3331	4018	4027	4033	4058	4085	4086	4292	4296	9060
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
B - A - 1	0.90					0.10																	
B - A - 2	0.20					0.05									0.36				0.16	0.23			
B - A - 3															0.18	0.20	0.38		0.14				0.10
B - A - 4																			0.67	0.33			
B - A - 5																	0.10	0.13	0.27				0.50
B - A - 6																	0.80		0.11				0.09
B - A - 7																	0.20	0.80					
B - A - 8																	0.32	0.68					
B - A - 9									0.70									0.30					
B - A - 10									0.35									0.58		0.07			
B - A - 11									0.67	0.18											0.15		
B - A - 12																		0.18	0.10	0.72			
B - A - 13	0.01					0.57			0.16											0.26			
B - A - 14						0.32			0.44	0.17										0.07			
B - A - 15																		0.63	0.05	0.32			
B - A - 16									0.71	0.11								0.03		0.15			
B - A - 17									0.79	0.17										0.04			
B - A - 18									0.01	0.99													
B - A - 19										1.00													
B - A - 20										1.00													
B - A - 21		0.23								0.77													
B - A - 22										1.00													
B - A - 23										1.00													
B - A - 24										0.97	0.03												
B - A - 25									0.19	0.69	0.07										0.05		
B - A - 26										0.57	0.28										0.15		
B - A - 27										0.66	0.30										0.04		
B - A - 28		0.31								0.69													
B - A - 29								0.01		0.13	0.40										0.46		
B - A - 30			0.70		0.30																		
B - A - 31		0.11	0.03	0.30	0.23		0.27	0.06															
B - A - 32			0.08	0.92																			
B - A - 33								0.20			0.59		0.19								0.02		
B - A - 34		0.13		0.23	0.02		0.47			0.15													
B - A - 35				0.12				0.33		0.14	0.31		0.05								0.05		
B - A - 36				0.01				0.23			0.45	0.02	0.12								0.17		
B - A - 37				0.37				0.63															
B - A - 38				0.57				0.43															
B - A - 39								0.19			0.30	0.17	0.29								0.05		
B - A - 40											0.32										0.68		
B - A - 41									0.08												0.01	0.91	
B - A - 42									0.20	0.06											0.64	0.10	
B - A - 43														0.02							0.46	0.52	
B - A - 44														0.98							0.02		
B - A - 45											0.38	0.10	0.23								0.29		
B - A - 46											0.55	0.01	0.44										
B - A - 47											0.08			0.08							0.84		
B - A - 48														1.00									

Table 5.3.4 AREAL WEIGHT OF THIESSEN POLYGON METHOD FOR 1981 FLOOD (2/2)

(Portuguesa River Basin)

Sub Basin	1297	2219	2221	2231	2233	2255	2287	2300	2303	2311	2336	2349	2448	3089	3090	3180	3200	3216	3222	3251	3303	3331	4292	4296
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
B - P - 1				0.68														0.32						
B - P - 2																		1.00						
B - P - 3				0.11		0.08												0.81						
B - P - 4				0.51		0.49																		
B - P - 5						0.97												0.03						
B - P - 6		0.13				0.87																		
B - P - 7						0.60												0.40						
B - P - 8		0.18		0.04		0.78																		
B - P - 9						1.00																		
B - P - 10						1.00																		
B - P - 11		0.34		0.63	0.03																			
B - P - 12		0.30	0.16		0.42		0.12																	
B - P - 13		0.33				0.38		0.29																
B - P - 14						0.88		0.12																
B - P - 15						0.19		0.04													0.77			
B - P - 16						0.15															0.50	0.35		
B - P - 17																					1.00			
B - P - 18									1.00															
B - P - 19									0.98		0.02													
B - P - 20									0.01	0.06	0.14										0.79			
B - P - 21									0.54		0.46													
B - P - 22										0.59	0.41													
B - P - 23										1.00														
B - P - 24	0.40		0.13		0.03		0.12	0.02	0.30															
B - P - 25							0.42	0.58																
B - P - 26							0.10	0.79													0.11			
B - P - 27									0.06												0.94			
B - P - 28																					1.00			
B - P - 29																					0.50	0.50		
B - P - 30										0.84											0.12	0.04		
B - P - 31										0.03											0.17	0.80		
B - P - 32						0.08												0.64	0.02	0.26				
B - P - 33						0.08														0.04		0.88		
B - P - 34																						1.00		
B - P - 35												0.98	0.02											
B - P - 36												0.46	0.54											
B - P - 37									0.29		0.48	0.23												
B - P - 38											0.22	0.78												
B - P - 39										0.09	0.08	0.83												
B - P - 40										0.02		0.75										0.23		
B - P - 41												0.49										0.51		
B - P - 42										0.16		0.05										0.79		
B - P - 43												0.17	0.83											
B - P - 44													1.00											
B - P - 45													0.10									0.90		
B - P - 46				0.05										0.07	0.60	0.08		0.20						
B - P - 47																0.39		0.02	0.58	0.01				
B - P - 48				0.30											0.05			0.65						
B - P - 49																		1.00						
B - P - 50																0.01		0.69	0.30					
B - P - 51																	0.04	0.15	0.07	0.74				
B - P - 52																				1.00				
B - P - 53																				0.04		0.96		
B - P - 54																	0.05					0.95		
B - P - 55																	0.55			0.45				
B - P - 56																	0.05					0.60	0.35	
B - P - 57																						1.00		
B - P - 58																						1.00		
B - P - 59																						1.00		

Table 5.3.5 YEARLY 8-MONTH BASIN MEAN RAINFALL

(Unit : mm)

Year	Apure River Basin	Portuguesa River Basin	Whole Basin
1967	1,857	1,238	1,556
1968	1,776	1,204	1,497
1969	1,688	1,645	1,667
1970	1,658	1,405	1,535
1971	1,521	1,191	1,360
1972	1,751	1,335	1,549
1973	1,508	1,242	1,378
1974	1,333	1,099	1,219
1975	1,487	1,279	1,386
1976	1,715	1,437	1,580
1977	1,683	1,245	1,470
1978	1,862	1,479	1,675
1979	1,878	1,438	1,664
1980	1,771	1,506	1,642
1981	2,004	1,623	1,818
1982	1,878	1,376	1,634
1983	1,821	1,532	1,680
1984	1,459	1,236	1,350
1985	1,600	1,193	1,402
1986	1,822	1,378	1,606
1987	1,578	1,301	1,443
1988	1,678	1,228	1,459
1989	1,540	1,028	1,291
1990	1,687	1,384	1,539
Average	1,690	1,334	1,517

Note : 8 months from April to November

Table 5.3.6 PROBABLE 8-MONTH BASIN MEAN RAINFALL

(Unit : mm)

Year	Apure River Basin	Portuguesa River Basin	Whole Basin
2-Year	1,666	1,311	1,495
5-Year	1,832	1,471	1,644
10-Year	1,942	1,576	1,742
20-Year	2,047	1,677	1,836
30-Year	2,108	1,735	1,890
50-Year	2,184	1,808	1,958
80-Year	2,253	1,875	2,020
100-Year	2,286	1,906	2,049

Note : 8 months from April to November

Table 5.4.1 ANNUAL MAXIMUM DAILY MEAN DISCHARGES

(Unit: m^3/s)

Year	Base Point Bruzual (Apure R.)	El Saman (Apure R.)	Camaguan (Portuguesa R.)	San Fernando (Apure R.)
1975	2,529	3,012	882	3,606
1976	3,662	4,824	1,090	6,416
1977	3,592	4,196	996	5,428
1978	3,676	4,308	1,046	5,626
1979	3,592	4,523	1,074	6,522
1980	3,592	4,421	1,224	7,132
1981	3,933	4,744	1,238	8,645
1982	3,918	4,601	-	6,840
1983	3,962	4,283	1,217	-
1984	2,952	4,283	985	-
1985	3,270	3,740	940	-
1986	3,861	-	1,062	-
1987	2,895	4,358	1,002	5,005
1988	3,079	3,751	-	4,757
1989	2,835	3,377	629	3,569
1990	2,855	3,567	1,087	4,439

Table 5.4.2 RUNOFF COEFFICIENT (FROM APRIL TO NOVEMBER)

	Station	0005	0022	0039	0120	0124	0317	0320	0395	0405	0705	0710'	0890	0895
1970	R(mm)	-	-	2,203	-	-	-	-	-	-	-	-	-	-
	Q(mm)	-	-	1,662	-	-	-	-	-	-	-	-	-	-
	f	-	-	0.755	-	-	-	-	-	-	-	-	-	-
1971	R(mm)	-	-	1,650	-	-	-	-	-	-	-	-	-	-
	Q(mm)	-	-	1,318	-	-	-	-	-	-	-	-	-	-
	f	-	-	0.799	-	-	-	-	-	-	-	-	-	-
1972	R(mm)	-	-	2,319	-	-	-	-	-	-	-	-	-	-
	Q(mm)	-	-	(2,465)	-	-	-	-	-	-	-	-	-	-
	f	-	-	(1.063)	-	-	-	-	-	-	-	-	-	-
1973	R(mm)	-	-	1,851	-	-	-	-	-	-	-	-	-	-
	Q(mm)	-	-	1,376	-	-	-	-	-	-	-	-	-	-
	f	-	-	0.743	-	-	-	-	-	-	-	-	-	-
1974	R(mm)	-	-	1,741	1,814	-	-	1,656	-	-	-	-	-	-
	Q(mm)	-	-	1,592	1,348	-	-	-	-	-	-	-	-	-
	f	-	-	0.914	0.743	-	-	-	-	-	-	-	-	-
1975	R(mm)	-	1,386	1,722	1,968	-	1,235	1,627	-	-	1,542	1,526	1,279	1,322
	Q(mm)	-	422	1,522	1,642	-	113	(1,749)	-	-	734	774	189	211
	f	-	0.304	0.884	0.834	-	0.092	(1.075)	-	-	0.476	0.507	0.147	0.160
1976	R(mm)	1,942	1,600	2,526	3,208	998	1,354	2,040	1,453	1,071	2,128	1,809	1,437	1,483
	Q(mm)	1,724	641	(2,476)	2,381	(1,149)	203	(2,243)	275	205	1,084	1,082	259	270
	f	0.888	0.401	(0.980)	0.742	(1.151)	0.150	(1.100)	0.189	0.191	0.509	0.598	0.180	0.186
1977	R(mm)	1,602	1,470	2,280	2,460	1,288	1,144	2,147	1,014	965	1,758	1,719	1,245	1,330
	Q(mm)	742	572	1,625	1,936	624	144	1,683	170	179	1,016	974	234	245
	f	0.463	0.389	0.713	0.787	0.484	0.126	0.784	0.167	0.186	0.578	0.567	0.188	0.184
1978	R(mm)	1,928	1,675	2,795	-	-	-	2,365	-	-	1,970	1,926	1,478	-
	Q(mm)	1,576	658	2,118	-	-	-	(2,335)	-	-	1,122	1,118	273	-
	f	0.818	0.393	0.758	-	-	-	(0.987)	-	-	0.570	0.581	0.185	-
1979	R(mm)	1,903	1,664	2,601	2,611	1,368	-	2,335	-	-	1,942	-	1,438	1,493
	Q(mm)	985	674	2,193	2,314	(1,599)	-	-	-	-	1,112	-	294	295
	f	0.518	0.405	0.843	0.886	(1.169)	-	-	-	-	0.573	-	0.204	0.198
1980	R(mm)	1,786	1,642	2,690	2,057	-	1,247	2,447	1,077	1,033	1,808	1,792	1,505	1,497
	Q(mm)	1,179	730	1,902	1,998	-	248	2,208	262	261	1,141	1,147	302	305
	f	0.660	0.445	0.707	0.971	-	0.199	0.903	0.243	0.252	0.631	0.640	0.201	0.204
1981	R(mm)	2,154	1,818	2,679	3,484	-	1,856	1,739	2,041	2,490	2,335	2,060	1,623	1,718
	Q(mm)	1,422	904	2,247	2,526	-	384	(2,082)	-	427	1,314	1,368	309	366
	f	0.660	0.497	0.839	0.725	-	0.207	(1.197)	-	0.171	0.563	0.664	0.190	0.213
1982	R(mm)	1,963	1,634	2,359	2,764	-	1,286	2,178	1,103	1,200	2,014	-	1,376	1,481
	Q(mm)	1,387	715	2,163	2,450	-	199	(2,075)	302	308	1,233	-	-	278
	f	0.706	0.438	0.917	0.886	-	0.154	(0.952)	0.274	0.256	0.612	-	-	0.188
1983	R(mm)	1,826	1,680	2,627	2,349	1,338	1,514	2,462	1,254	1,451	1,916	1,859	1,532	1,589
	Q(mm)	(2,304)	-	2,226	(2,317)	1,009	292	2,145	427	386	1,277	1,311	317	353
	f	(1.262)	-	0.847	(0.986)	0.754	0.193	0.872	0.340	0.266	0.666	0.705	0.207	0.222
1984	R(mm)	1,404	1,350	2,010	2,127	1,155	1,185	1,802	1,030	994	1,534	-	1,235	1,286
	Q(mm)	651	-	1,339	1,380	519	139	1,443	159	190	934	-	181	233
	f	0.464	-	0.666	0.649	0.450	0.117	0.801	0.155	0.191	0.609	-	0.146	0.181
1985	R(mm)	1,540	1,402	2,170	2,011	1,224	1,049	1,893	1,011	1,144	1,693	-	1,193	1,216
	Q(mm)	-	-	1,765	(2,027)	492	91	1,580	214	168	1,015	-	213	220
	f	-	-	0.813	(1.008)	0.402	0.087	0.835	0.212	0.147	0.600	-	0.178	0.181
1986	R(mm)	2,138	1,606	2,737	2,445	-	1,241	2,261	1,070	1,145	1,896	-	1,378	1,444
	Q(mm)	1,121	-	2,151	(2,350)	-	179	2,029	-	244	1,411	-	303	335
	f	0.524	-	0.786	(0.961)	-	0.144	0.897	-	0.213	0.744	-	0.220	0.232
1987	R(mm)	1,426	1,443	2,024	2,293	1,203	1,189	1,887	857	1,097	1,605	-	1,300	1,312
	Q(mm)	-	540	1,582	(2,291)	637	136	1,742	207	213	-	-	245	257
	f	-	0.374	0.782	(0.999)	0.530	0.115	0.923	0.241	0.194	-	-	0.188	0.196
1988	R(mm)	1,617	1,459	2,336	2,584	1,535	1,178	-	1,120	1,228	-	1,745	-	1,283
	Q(mm)	-	507	2,068	(3,635)	978	155	-	254	-	-	790	-	196
	f	-	0.348	0.885	(1.407)	0.637	0.132	-	0.226	-	-	0.453	-	0.153
1989	R(mm)	1,266	1,254	2,150	1,988	1,019	876	1,898	868	836	-	1,509	1,028	980
	Q(mm)	-	388	1,734	(3,007)	616	40	1,651	94	103	-	789	147	81
	f	-	0.310	0.806	(1.512)	0.604	0.046	0.870	0.108	0.123	-	0.523	0.143	0.082
1990	R(mm)	1,891	1,493	2,918	2,367	1,319	1,140	2,462	1,117	1,068	1,719	1,679	1,363	1,381
	Q(mm)	-	570	(2,816)	(3,284)	808	119	(2,545)	189	153	982	1,002	279	230
	f	-	0.382	(0.965)	(1.387)	0.613	0.104	(1.034)	0.169	0.143	0.571	0.597	0.205	0.166
Average	R(mm)	1,834	1,545	2,266	2,312	1,120	1,228	2,099	1,065	1,143	1,831	1,762	1,360	1,388
	Q(mm)	1,199	610	1,810	1,997	631	174	1,810	232	236	1,106	1036	253	259
	f	0.653	0.395	0.799	0.864	0.564	0.142	0.862	0.218	0.207	0.604	0.588	0.186	0.186

Note : ▨ Selected data for flood model