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MALAYSIA

ON

PROMOTION OF MANUFACTURING INDUSTRY

PART 2

WARSHIP AND BOAT

SUPPORTING INDUSTRY

JANUARY 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO, JAPAN

FEDERATIVE REPUBLIC OF BRAZIL

FINAL REPORT
ON
THE ITAJAI RIVER BASIN
FLOOD CONTROL PROJECT

PART I

MASTER PLAN STUDY

SUPPORTING REPORT

JANUARY 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO, JAPAN

ABBREVIATION

JICA	:	Japan International Cooperation Agency
ACARESC	:	Associacao de Credito e Assistencia Rural de Santa Catarina
CASAN	:	Companhia Catarinense de Aguas e Saneamento
CEDEC	:	Coordenacao Estadual de Defesa Civil
CELESC	:	Centrais Eletricas de Santa Catarina
CEPA	:	Instituto de Planejamento e Economia Agricola de Santa Catarina
CIDASC	:	Companhia Integrada de Desenvolvimento Agricola de Santa Catarina
DNAEE	:	Departamento Nacional de Agua e Energia Eletrica
DNER	:	Departamento Nacional de Estradas de Rodagem
DER	:	Departamento de Estradas de Rodagem
DNOS	:	Departamento Nacional de Obras de Saneamento
EMATER	:	Empresa de Assistencia Tecnica e Extencao Rural
EMBRAPA	:	Empresa Brasileira de Pesquisa Agropecuaria
EMATER	:	Empresa de Assistencia Tecnica
EMPASC	:	Empresa de Pesquisa Agropecuaria ria de Santa Catarina
FATMA	:	Fundacao de Amparo a Tecnologia e Meio Ambiente
FGV	:	Fundacao Getulio Vargas
GAPLAN	:	Gabinete de Planejamento e Coordenacao Geral
IBDF	:	Instituto Brasileiro de Desenvolvimento Florestal
IBGE	:	Instituto Brasileiro de Geografia e Estatistica
IBRD	:	Internatinal Bank for Reconstruction and Development
ITAG	:	Instituto Tecnico de Administracao e Gerencia
MA	:	Ministerio da Agricultura
MDUMA	:	Ministerio do Desenvolvimento Urbano e Meio Ambiente
PORTOBRAS	:	Empresa Brasileira de Portos
SAMAE	:	Servico Autonomo Municipal de Agua e Esgoto
SUDEPE	:	Superintendencia do Desenvolvimento da Pesca

ABBREVIATION OF MEASUREMENT

Length

mm	:	millimeter
cm	:	centimeter
m	:	meter
km	:	kilometer

Area

cm^2	:	square centimeter
m^2	:	square meter
ha	:	hectare
km^2	:	square kilometer

Volume

cm^3	:	cubic centimeter
l	:	liter
m^3	:	cubic meter

Weight

g	:	gram
kg	:	kilogram
ton	:	metric ton

Time

s or sec	:	second
min	:	minute
h or hr	:	hour
d	:	day
y or yr	:	year

Others

%	:	percent
°C	:	degree centigrade
10^3	:	thousand
10^6	:	million
10^9	:	billion

Derived Measure

m^3/s	:	cubic meter per second
kwh	:	kilowatt hour

Money

Cz$	:	Cruzado
Cr$	:	Cruzeiro
US$	:	US dollar

Exchange Rate (in March 1986)

US$ 1	:	Cz$ 13.80

ABBREVIATION OF ECONOMIC TECHNICAL TERMS

GDP	:	Gross Domestic Product
GRDP	:	Gross Regional Domestic Product
GVA	:	Gross Value Added
VA	:	Value Added
PV	:	Production Value

SUPPORTING REPORT

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ANNEX I. TOPOGRAPHIC SURVEY

I. TOPOGRAPHIC SURVEY

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1. INTRODUCTION

The topographic survey for the study includes;

- Collection and check of available topographic data,
- Arrangement of topographic data for use of master plan study, and
- Execution of additional river cross sectional survey.

The topographic data such as topographic maps, aerial photographs, river profile and cross sections were collected from DNOS and organizations concerned.

The collected data were reviewed and arranged for master planning uses. From the result of review, the additional river cross sectional survey were executed in cooperation with DNOS's surveying staff under instruction by the JICA TEAM.

2. DATA COLLECTION AND THEIR REVIEW

2.1 Available Data

The topographic maps of several kind of scale were collected from IBGE and main cities through DNOS. These maps are divided into the national base maps and the city planning topographic maps. The list of collected maps is shown in Table I.1.1.

The stereoscopic aerial photographs with a scale of 1:25,000 which were shot in 1978 and 1979 and cover along the Itajai river were borrowed from FATMA. These photographs were used for planning of master plan.

The river profile and cross sectional data were collected. These data were prepared for use of the river improvement plan of the Itajai river by DNOS. The list of collected cross sectional data is shown in Table I.1.2.

The data of horizontal and vertical national ground control points were obtained from IBGE for the purpose of an additional river cross sectional survey and photogrammetric mapping in the feasibility study.

2.2 Review of Available Data

2.2.1 Topographic maps

(1) National base map

National base map on a scale of 1:50,000 covering the east of longitude 50° W at the Itajai river basin, were collected from IBGE. The map consists of 29 sheets of colour printed maps with 20 m contour interval which were prepared in 1981. Since national base map of 1:50,000 in the west of longitude 50° W at the project area is not yet published, the map on a scale of 1:100,000 which was prepared in 1973 was collected. This map consists of 3 sheets of colour printed and 50 m contour interval.

The datum of these national base maps are;

(i) Vertical : Imbituba, Santa Catarina

(ii) Horizontal : SAD - 69.(South American data in 1969)

(iii) Projection : Universal Transverse Mercator (referred as UTM)

The index map of the national base maps is shown in Fig.I.1.1.

(2) Large scale topographic maps

(i) Scale of 1:2,000

Large scale topographic maps in Blumenau and Brusque cities on a scale of 1:2,000 with 1 m contour interval were obtained. These maps were prepared by the aerial photogrammetric method and cover whole city area. The horizontal and vertical datum of map is the same as national base map. However, since they were made more than ten years ago, namely 1972 in Blumenau and 1975 in Brusque,

it is necessary to consider the change of social infrastructures and geographical features for use of planning.

(ii) Scale of 1:4,000 and 1:5,000.

The topographic map on a scale of 1:4,000 and 1:5,000 were collected. They are scale of 1:4,000 with 5 m contour interval in Timbo city, a scale of 1:5,000 with 2 m contour interval in Picarras city and with 5 m contour interval in Rio do Sul city.

These maps have not the coordinates and the datum of altitude is not clear, therefore, they can not be used for master planning.

(iii) Scale of 1:10,000

The scale of 1:10,000 topographic maps in Blumenau, Brusque and Gaspar cities were collected. The contour interval is 5 m in Blumenau and Gaspar, and 10 m in Brusque. The datum of map is the same as the national base map.

The maps in Blumenau and Brusque were reduced and compiled from the map with a scale of 1:2,000 in 1972 and 1975. In case of Gaspar, they were prepared in 1978 by aerial photogrammetric method but did not cover the whole city.

Besides, the same scale of topographic maps along the upstream of the Itajai river, the Benedito and the Itajai do Norte, Oeste and Sul rivers were obtained. These maps were prepared in 1959 by the aerial photogrammetric method and covers about 1 km in width in both sides of the river. The projection of map is U.T.M, but coordinates are local system. The datum of altitude is the same as national base map. Therefore, these maps are only available for check up of topographic feature.

The index map of the above collected large scale topographic maps is illustrated in Fig.I.1.2.

2.2.2 Aerial photographs

The aerial photographs which were borrowed from FATMA were shot in 1978 and 1979 by whole Santa Catarina aerial photography program. These monochrome photographs on a scale of 1:25,000 were shot by means of 60% stereoscopic overlap and 30% sidelap in average.

Aerial camera which is used for R.M.K. is a wide angle of format 23cm x 23cm, and the attached pleogon is a distortion free lens. The negative films are stored in the aerial photographed firm under the regulation.

2.2.3 River profile and cross sectional data

(1) The Itajai river

(i) Barra - Blumenau

The river profile and cross sectional survey data from Barra to Blumenau were collected. These data were prepared for use of study for river improvement in the downstream of Blumenau by DNOS in 1983 to 1984. The surveyed river cross sections are in about 45 km in distance with 200 m interval, and they are drawn in a scale of 1:1,000 in horizontal and 1:100 in vertical. The datum of vertical is the same as national base map.

The drawings of profile were plotted only height of cross section's base points on a scale of 1:2,000 in horizontal and 1:100 in vertical but the height of riverbed and banks are not shown.

(ii) Salto Pilao - Rio do Sul

The same kind of data for Salto Pilao to Rio do Sul were collected. These data were prepared in 1984 and they are being used for planning by DNOS for river improvement in the downstream of Rio do Sul. The surveyed river cross sections are about 24 km in distance with 400 m interval. The drawing of cross sections were plotted on a scale of 1:2,000 in horizontal and 1:200 in vertical. Scale and presenting condition for the drawings of profile are the same as (a).

(2) The tributaries

(i) The Itajai do Oeste and Sul rivers

The river profile and cross sectional data of the Itajai do Oeste and Sul rivers were obtained. The distance of the surveyed data are about 5 km from the confluence with the Itajai main stream to the Oeste and 3 km in the Sul river. They are prepared by DNOS.

(ii) The Itajai Mirim river

The cross sectional data of the Itajai Mirim river were collected from DNOS. The surveyed data are 41 km in total distance from the confluence of the Itajai river to Brusque city.

(iii) Floodway

The cross sectional data for the proposed floodway route were collected. These data were compiled based on the topographic map, not by actual survey work, because of refusal on entrance permission for the sugar cane fields.

3. ADDITIONAL RIVER CROSS SECTIONAL SURVEY

As the result of review on collected river cross sectional data, more than 60 additional river cross sections were surveyed in this stage in cooperation with DNOS's surveying staff.

The additional river cross sections are listed in Table I.1.3 and the index map of river cross sections is shown in Fig.I.1.3.

The drawings of survey data were plotted on a scale of 1:1,000 in horizontal and 1:100 in vertical.

(1) The Itajai river

(i) Itajai - Barra

The bathymetric data of the river mouth were collected from PORTOBRAS. The datum of PORTOBRAS is not same as national base map, therefore, the data were converted to the datum of national base map.

The additional survey were executed for the river stretch from 7 km upstream to 30 km from river mouth. The surveyed data were connected to national bench marks in Itajai city and along the national route.

(ii) Blumenau - Salto Pilao

The river stretch along the flood prone areas in the Indaial and Ascurra cities was surveyed in short interval of about 500 m, and the remaining stretch was surveyed in an interval of 5 km. The cross section at the water gauging station located at Indaial, Warnow and Apiuna cities was also surveyed. The surveyed data were tied with national bench marks in the main cities and on the Route BR - 470.

(2) The tributaries

(i) The Itajai do Norte river

The surveys were executed in the confluence of the Itajai river to upper Ibirama city and connected with national bench marks in Ibirama city and on the BR - 470.

(ii) The Itajai do Sul river

The seven cross sections at Ituporanga and Aurora cities were surveyed. The surveyed data were connected to the record of topographic map, because there was no national bench mark in this area.

(iii) The Itajai do Oeste and the Trombudo river

At the close by the confluence of two rivers, each one cross section was surveyed and connected to national bench mark.

(iv) The Benedito river

At the downstream of the Benedito river, three cross sections were surveyed and connected to national bench marks in Indaial city.

Tables

Table I.1.1 COLLECTED TOPOGRAPHIC MAPS

Area	Scale	Contour Interval (m)	Coordinates Interval (km)	Projection	Datum	Mapping	Remarks
Itajai river basin (East of long. 50 W)	1/50,000	20	2	UTM	National	1981	
Itajai river basin (West of long. 50 W)	1/100,000	50	5	UTM	National	1973	
Blumenau city	1/2,000	1	0.2	UTM	National	1972	
Blumenau city	1/10,000	5	1	UTM	National	1972	
Itajai city	1/10,000	5	0.2	UTM	National	-	
Rio do Sul city	1/5,000	5	None	-	-	1983	Partial area
Brusque city	1/2,000	1	0.2	UTM	National	1975	
Brusque city	1/10,000	10	1	UTM	National	1975	
Gaspar city	1/10,000	5	1	UTM	National	-	Partial area
Picarras city	1/5,000	2	None	-	-	1978	
Timbo city	1/4,000	5	None	-	-	1975	
Itajai river (Blumenau-Rio do Sul)	1/10,000	10	1	UTM	Local	1959	
Itajai do Norte, Sul ar	1/10,000	10	1	UTM	Local	1959	

Table I.1.2 COLLECTED RIVER CROSS SECTIONS

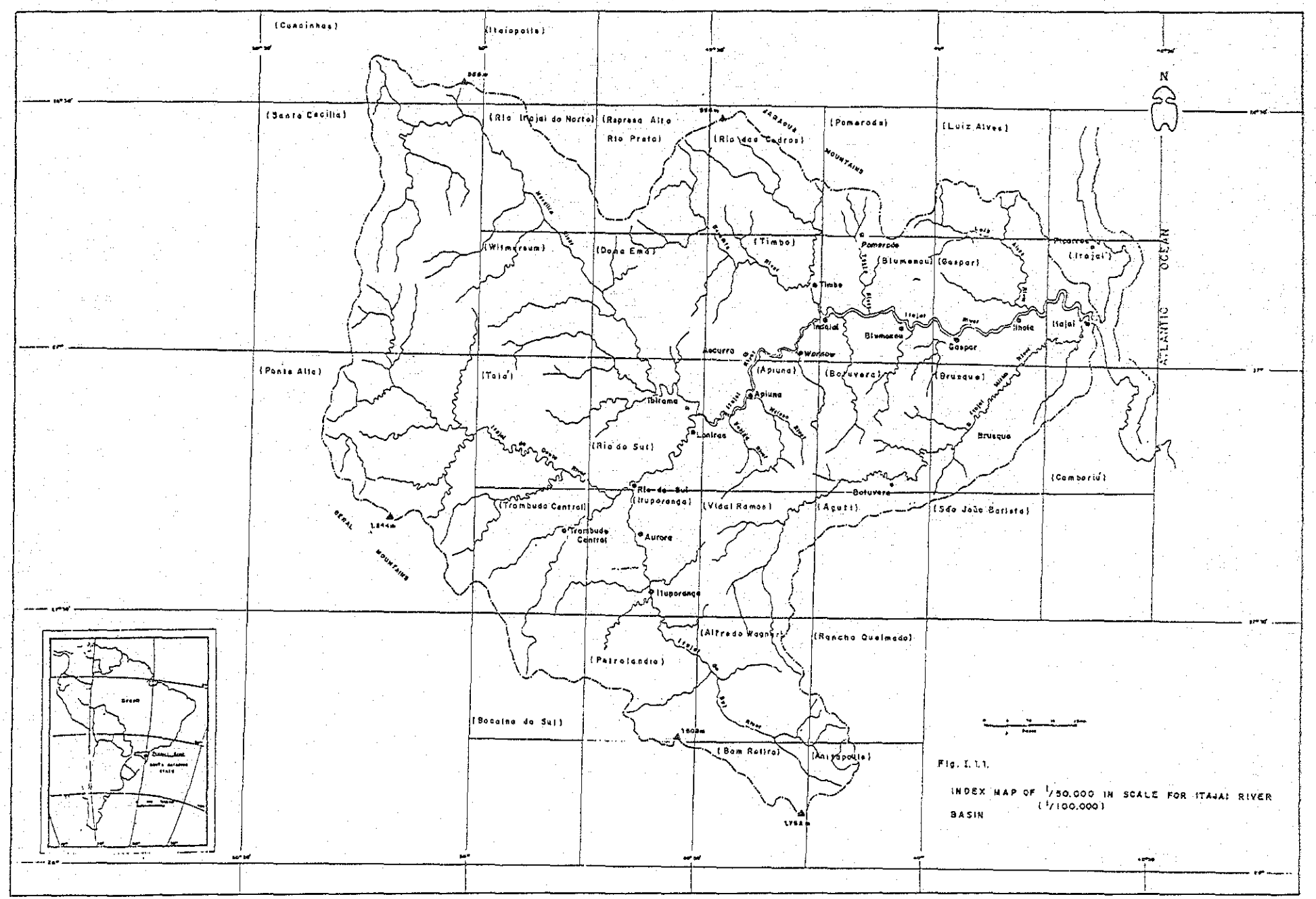
Name of River	Section	Distance (km)	Interval (m)	Scale H	Scale V	Remarks
Itajai	Barra-Blumenau	45	200	1/1,000	1/100	
Itajai	Salto Pilao-Rio do Sul	24	400	1/2,000	1/200	
Itajai do Oeste	Rio do Sul	5	400	1/2,000	1/200	
Itajai do Sul	Rio do Sul	3	400	1/2,000	1/200	
Itajai Mirim	Itajai-Brusque	41	1000	1/200	1/100	
Picarras floodway	Picarras-Barra	10	200	1/1,000	1/100	Planning route

Table I.1.3 ADDITINAL RIVER CROSS SECTIONS

Name of River	Section	Distance (km)	Interval (km)	Scale H	Scale V	Remarks
Itajai	Itajai-Barra	30	1	1/1,000	1/100	
Itajai	Blumenau-Indaial	25	0.5 - 5	1/1,000	1/100	
Itajai	Indaial-Ascurra	20	0.5 - 4	1/1,000	1/100	
Itajai	Ascurra-Salto Pilao	40	4 - 5	1/1,000	1/100	
Itajai do Norte	Itajai Acu-Ibirama	6	2 - 4	1/1,000	1/100	
Itajai do Sul	Aurora, Ituporanga	4	0.5 - 1	1/1,000	1/100	
Itajai do Oeste	Rio do Sul	2	2	1/1,000	1/100	
Benedito	Indaial	1	0.5 - 0.8	1/1,000	1/100	
Trombudo	Trombudo	0.5	0.5	1/1,000	1/100	

Note : H : Horizontal V : Vertical

Figures


(Cuncinhas)
(Itaiopolis)
(Santa Cecilia)
(Rio Itajai do Norte)
(Represa Alta Rio Preto)
(Rio dos Cedros)
(Pomerode)
(Luiz Alves)
N
ATLANTIC OCEAN
(Witmarsum)
(Dona Ema)
(Timbo)
Pomerode
(Blumenau)
(Gaspar)
(Itajai)
Timbo
Indaial
Blumenau
Ilhota
Itajai
Gaspar
Warnow
Ascurra
(Apiuna)
(Botuvera)
(Brusque)
(Ponte Alta)
(Taio)
Ibirama
Apiuna
Lontras
(Rio do Sul)
Brusque
(Camboriú)
Rio do Sul
(Ituporanga)
(Vidal Ramos)
Botuvera
(Trombudo Central)
(Agutt)
(São João Batista)
Trombudo Central
Aurora
Ituporanga
(Alfredo Wagner)
(Rancho Queimado)
(Petrolandia)
(Bocaina do Sul)
(Bom Retiro)
(Anitapolis)
Fig. I.1.1.
INDEX MAP OF 1/50.000 IN SCALE FOR ITAJAI RIVER BASIN
(1/100.000)

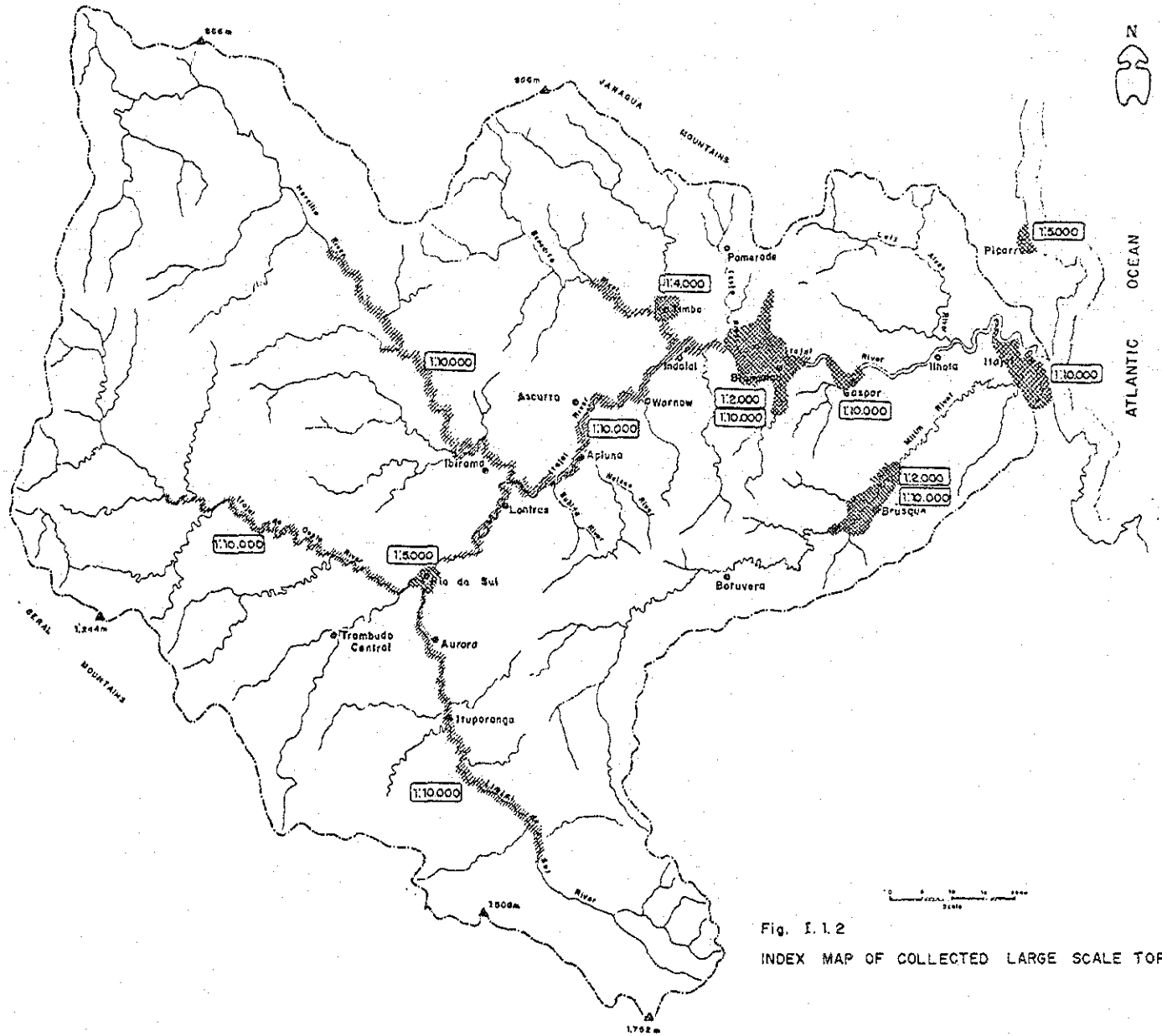


Fig. I.1.2

INDEX MAP OF COLLECTED LARGE SCALE TOPOGRAPHIC MAPS

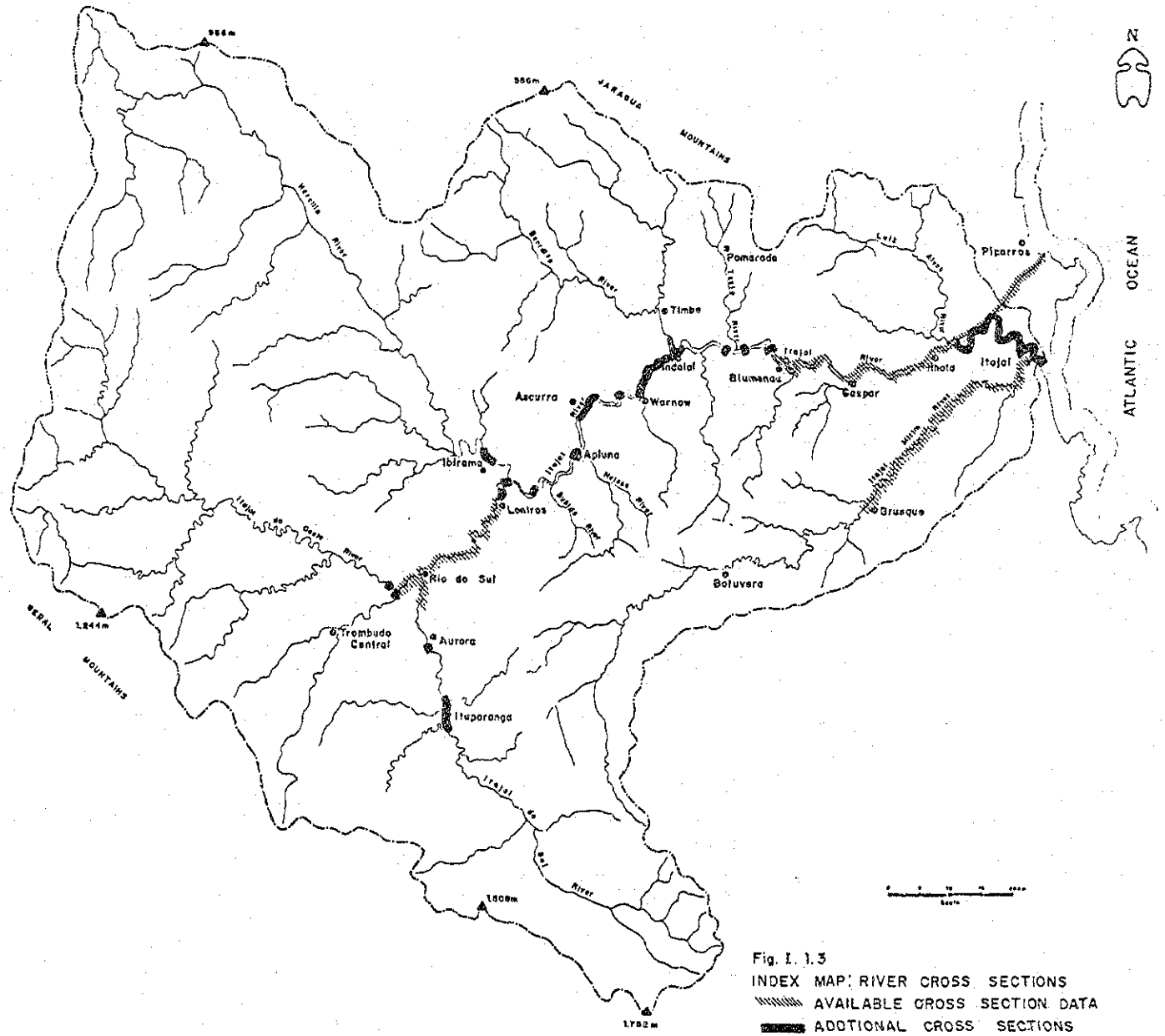


Fig. I. 1.3
INDEX MAP: RIVER CROSS SECTIONS
AVAILABLE CROSS SECTION DATA
ADDITIONAL CROSS SECTIONS

ANNEX II. HYDROLOGY

II. HYDROLOGY

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1. INTRODUCTION

Hydrological analysis aims at grasping hydrological characteristics and formulating the probable flood discharge distribution under present condition and with flood prevention works proposed in the flood control plan through the basic hydrological analysis and flood runoff analysis using the mathematic simulation model which is able to evaluate the effect of the river improvement and flood control facility for the reduction of flood peak discharge.

Therefore, the following studies were carried out in the hydrological analysis;

- hydrological data collection such as meteorological records, rainfall data, discharge data including hydrograph records, and tide water level records which affects the flood water level in the river channel,

- rainfall analysis comprising basin mean rainfall and probable rainfall estimates against design rainfall duration time,

- establishment of simulation model being able to express the relation between rainfall and runoff, and

- estimate of probable flood discharge and establishment of design flood discharge distribution againt the selected retern period.

2. METEO-HYDROLOGICAL DATA

(1) Meteorological data

Meteorological observation such as a temperature, relative humidity, evaporation, wind velocity and atmospheric pressure have been carried out at 9 meteorological observatories as shown in Fig.II.2.1 by INMET and EMPASC since 1911 in and around the Itajai river basin. Table II.2.1 shows the observation period in each meteorological observatory.

(2) Rainfall data

There exists 69 rainfall gauging stations in and around the Itajai river basin at which the daily rainfall amount has been observed at 7 o'clock every morning by DNOS, DNAEE, INMET, CELESC, EMPASC and SOUZA CRUZ. The location of the above stations is shown in Fig.II.2.1.

As shown in Fig.II.2.1, 19 stations are located around the basin and other 50 stations are densely distributed along the Itajai river and its tributaries in the basin.

Among the above 69 stations, 6 stations were installed in 1930's, and 20 stations in 1940's, and most of others in 1970's. And then, the observation at 12 gauging stations were discontinued.

Hourly rainfall observation was commenced at Indaial city in 1970 and 15 stations are installed in the Itajai river basin at present. 11 stations were constructed after the large flood in July, 1983.

Figs.II.2.2 and II.2.3 show the observation period of daily/hourly rainfall respectively.

(3) Water level and discharge

Water level observation and discharge measurement were commenced in 1920 and 36 water level gauging stations in Fig.II.2.1 which are operated by DNAEE, DNOS and CELESC, are installed along the Itajai river and its tributaries at present.

Water level at the above stations is observed twice a day at seven o'clock in the morning and five o'clock in the evening. Water level observation by an automatic recorder was commenced at Apiuna on August, 1971. At present , 7 stations, namely, Apiuna, Rio do Sul Novo, Brusque, Taio, Ituporanga, Ibirama, and Blumenau are installed and operated.

Discharge measurement is carried out about 10 times a year using current-meter by the preceding organization. Discharge rating curve for converting water level to discharge is made periodically by using the discharge measurement records.

Figs.II.2.4 and II.2.5 show the observation period of daily/hourly water level and discharge respectively.

(4) Tidal data

The lower reach downstream from Blumenau city has gentle river bed slope of around 1/15,000. Therefore, the fluctuation of tide water level affects the flood water level along the lower reach.

The tide water level fluctuation is recorded at the Itajai harbor by PORTBRAS since 1983. The location of the observation site is shown in Fig.II.2.1.

(5) Sediment data

Sediment concentration of suspended load on the Itajai river and its tributaries are observed several times a year after 1976 at Rio do sul, Apiuna, Indaial, Barra do Prata and Brusque by DNAEE. However, in regard of wash and bed loads, no observation has been carried out up to present.

3. METEO-HYDROLOGICAL CONDITION OF THE ITAJAI RIVER BASIN

3.1 Climate

The climatic records are shown in Table II.3.1.

The annual mean temperature in the Itajai river is 19.7oC at Itajai and 20.1oC at Blumenau in the lower area, and 18.4oC at Ituporanga in the mountainous area.

The minimum temperature is 13.2oC at Ituporanga in June and the maximum is 25.5oC at Timbo in January.

The basin mean annual evaporation amount is estimated to be around 800mm in the Itajai river basin which is corresponding to the evaporation rate of 2.2 mm/day.

The maximum monthly evaporation amount is 104 mm at Itajai and Timbo which is corresponding to the evaporation rate of 3.3 mm/day.

Annual mean relative humidity is 85.7% at Itajai and 77.0% at Indaial which are the maximum and the minimum in the basin. The monthly mean relative humidity from June to August is higher than other months.

Fig.II.3.1 shows the isohyetal map of annual mean rainfall in the Itajai river basin for the period from 1976 to 1985. The basin mean annual rainfall is estimated to be 1630 mm ranging from 1,500 mm in the mountainous area of the upstream of the Benedito river and Sul river to 1,800 mm along the main Itajai river.

3.2 Low Flow

Monthly discharges for the period from 1976 to 1985 at the water level gauging station of Rio do Sul and Indaial in the main Itajai river, Timbo in the Benedito river, Ibirama in the Itajai do Norte river, Ituporanga in the Itajai do Sul river, Taio in the Itajai do Oeste river and Brusque in the Itajai Mirim river are shown in Table II.3.2.

As shown in this table, monthly mean discharge from July to December is larger than the annual mean discharge at each station. From this fact, it can be said that a wet season is from July to December, and a dry season is from January to June in a year. Monthly mean discharges for the above periods and annual mean discharge are summarized as below.

Name of Station	Discharge (m^3/sec) Jan.-Jun.	Jul.-Dec.	Annual Mean
Rio do sul	104.7	162.9	135.1
Indaial	205.8	347.2	286.3
Timbo	40.7	50.8	47.7
Ibirama	55.7	100.6	80.5
Ituporanga	39.3	58.8	50.9
Brusque	25.3	35.4	31.5

The runoff coefficient at Indaial water level gauging station is estimated to be 0.48 from the runoff depth of 786 mm at Indaial and basin mean annual rainfall amount of 1,630 mm.

3.3 Flood Flow and Rain Storm

According to the flood records at Indaial in Table II.3.3 and Blumenau in Table II.3.4, four large scale floods after construction of Sul and Oeste dams occurs on December 1978, December 1980, July 1983 and August 1984. Flood peak discharge at 6 stations are listed up as below.

Name of Station	Flood Peak Discharge (m^3/sec)			
	Dec.1978	Dec.1980	Jul.1983	Aug.1984
Rio do sul Novo	720	850	1,970	1,860
Ibirama	1,010	1,380	2,480	2,070
Timbo	560	690	760	860
Apiuna	2,300	3,690	4,310	4,320
Indaial	2,900	3,500	4,740	5,030
Brusque	550	320	540	-

Flood hydrographs in 1978,1980 and 1984 shown in Fig.II.4.11 have the rising rimb of 1 to 2 days and depression of 3 to 4 days. The flood in 1983 is characterized by the long duration time of flood peak.

Rain storm which causes the flood is characterized by regional and hourly rainfall distribution. According to the isohyetal map of the rain storm as shown in Fig.II.3.2, the heavy rainfall occurs in the entire Itajai river basin and it is intensive in the mountainous area of main tributaries which are the Benedito river, the Itajai do Norte river, the Itajai do Oeste river, the Itajai do Sul river, the Itajai Mirim river. Especially, the rainfall of around 150 mm a day falls in the Itajai Mirim river basin.

Basin mean 1-day maximum rainfall and rainfall amount of rain storm are 110 mm and 124 mm in 1978, 65 mm and 138 mm in 1980, 64 mm and 324 mm in 1983 , and 110 mm and 210 mm in 1984 respectively. Rain storm in 1983 is characterized by the great quantity of rainfall amount of 324 mm.comparing with the other storms.

According to hourly rainfall distribution recorded in July 1983 and August 1984 as shown in Fig.II.3.3, the maximum hourly rainfall in a range of 10 to 25 mm/hour is observed in 1983 and 1984 in the basin and those are seemed to be not intensive. Hourly rainfall records in 1978 and 1981 are not available in this study.

3.4 Tide Water Level

Tide water level at the Itajai harbor is shown in Table II.3.5. Mean monthly highest / lowest tide water level and mean tide water level are summarized as below:

- Mean monthly highest tide water level 1.01 m
- Mean monthly lowest tide water level -0.60 m

- Mean tide water level 0.20 m

The fluctuation of tide water level is in a range of around 0.8 m.

3.5 Sedimentation

According to the sediment concentration records of suspended load in Table II.3.6 and Fig.II.3.4,the relation between flow discharge and suspended load is described by the following formula.

$$Qs = 0.334\ Q^{1.651}$$

where, Qs : Suspended load (ton / day)
Q : Flow discharge (m^3/sec)

Based on the above formula and daily mean discharge at Rio do Sul, Apiuna, Indaial, Ibirama and Brusque, the specific sediment loads are estimated to be 65, 113, 135, 59 and 30 m^3/km^2/year as shown Table II.3.7 respectively.

4. FLOOD RUNOFF ANALYSIS

4.1 General Procedures

In the Itajai river basin, there exists the Sul and the Oeste dams as a flood control dam. Besides, the Norte dam is under construction and the river improvement works along the reach of the Itajai river between Gaspar and Blumenau cities, and lower reach of Itajai Mirim river are under execution at present. DNOS has a dam construction plan for prevention of large scale flood such as serious flood in 1983 and 1984.

Flood runoff analysis aims at the following objects:

- to evaluate the flood scale of the past maximum flood,
- to grasp the retardation effect for flood peak discharge by existing dams, on-going dam and proposed dams, and
- to formulate probable flood discharge distribution under present condition and with flood control works proposed by this Study.

For establishing the above objectives, the following study on flood runoff analysis is needed so as to simulate flood hydrograph at major site in the Itajai river basin.

- modelling of the river basin and channel,
- construction of a river system model in which the river basins and channels are linked,
- rainfall analysis for determining the design rainfall duration, rainfall amount and pattern, and
- runoff calculation for the present river condition and with proposed flood control works using the river system constructed and results of rainfall analysis.

Fig.II.4.1 shows the general procedures in flood runoff analysis.

4.2 Methodology

4.2.1 Simulation model

Probable flood discharge are estimated from probable rainfall using the storage function model developed in Japan because it is required to work out the flood hydrograph for evaluation of simulation of the retardation effect for flood control dams, river improvement works and other flood prevention facilities.

Detailed methods and procedures are mentioned as follows.

(1) Base point and sub-base point

Base point, which are evaluation point of flood probability, is decided at the river mouth of the Itajai river because this flood control plan objects to prevent from the flood occurring in the entire Itajai river basin.

Sub-base points which are the site for estimating the probable flood discharge are distributed at the following site.

- Before/after the confluence with the major tributaries
- Proposed/existing dam site
- Proposed/existing flood diversion site
- Beginning/ending point of river stretches divided from the flood control plan.

(2) Construction of river system model

The Itajai river basin and its river course are divided into sub-basins and river channels taking into account the base point and sub-base points.

River system model is a flow diagram of flood discharge in which sub-basin and river channels are linked on the basis of topo-map of 1/50,000 for present condition and flood control plan.

(3) Flood runoff from sub-basin

Flood runoff from each sub-basin is estimated by means of storage function method. The basic formula of storage function method is expressed by the following equation.

$S = KQP$

$dS/dt = (1/3.6)\ f.r.A - Q$

Where, S : Basin storage (m^3)

Q : Runoff from basin (m^3/ sec)

K,P : Constants

t : Time (sec)

f : Runoff coefficient

r : Basin mean rainfall (mm/hr)

A : Catchment area (km^2)

Constants of K, P and lag-time in the equation are initially estimated by means of the following empirical formula which are described by average river bed slope in sub-basin. And then, those are calibrated using the flood records.

$K = 118.84\ .\ i0.3$

$P = 0.175\ .\ i-0.235$

where, i: Average river bed slope.

In the study, lag-time in sub-basin is roughly estimated by the following empirical formula.

$Tl = L\ /\ V$

where, Tl: Basin lag-time (hour)

L : River length (km)

V : Flow velocity (m/sec)

$V = 3.5$ m/sec $\quad i > 1/100$

$V = 3.0$ m/sec $\quad 1/200 < i < 1/100$

$V = 2.1$ m/sec $\quad i < 1/200$

i : Average river bed slope

(4) River channel model

River channel has a retardation effect for flood peak discharge due to the rise of water level in case that the river bed slope is gentle or that water level is affected by tidal effect.

The storage function of river channel is estimated from the river cross-section, river bed slope, and length using the non-uniform flow or uniform flow calculation method.

The basic formula of storage function is shown as follows:

$S = K Q P$

where, S : Storage volume (m^3/sec.)

Q : Flood discharge (m^3/sec.)

K, P : Constant

Lag-time of river channel model is estimated from the preceding empirical formula.

(5) River structure model

(i) Dam/reservoir

The retardation effect of flood control dam is simulated based on the relation between reservoir water level, storage volume and outflow from the spillway and outlet facilities using the following equation.

$ds/dt = I - O$

where, S : Storage volume (m^3)

I : Inflow into reservoir (m^3/sec)

O : Outflow from reservoir (m^3/sec)

(ii) Floodway

Flood discharge just before the floodway site is distributed to the floodway and to the downstream reach from the floodway site based on distribution ratio which is expressed as follows.

$R = (Qp - Qcp) / Qcp$

where, R : Flood distribution ratio,

Qp : Flood peak discharge just before the floodway site, and

Qcp : Discharge carrying capacity of the downstream reach designed by flood control plan.

4.2.2 Runoff coefficient

Runoff coefficient for flood runoff (R) is examined at major water level gauging station using the rainfall and flood records.

R = (Flood runoff volume)/ (Rainfall amount)

4.2.3 Base flow

Base flow for examining runoff coefficient is defined as the discharge just before flood occurs, and that for probable flood is determined from mean monthly discharge for the wet season.

4.2.4 Converting flood runoff to water level

It is needed to convert the flood peak discharge to water level at the major points along the Itajai river and its main tributaries for examination of simulation model which is able to evaluate the inundation during flood.

Rating curves for the conversion is used for the analysis in accordance with the following procedures:

(1) The rating curve based on the results of discharge measurement is prepared.

(2) For the site at which discharge measurement is not carried out, the rating curve is prepared by mean of uniform flow calculation based on the river cross-section, assuming that the roughness coefficient is 0.035 in river channel and 0.050 in the flood plain.

4.2.5 Rainfall analysis

(1) Basin mean rainfall

Basin mean daily rainfall is estimated by means of Thiesen's method. However, the daily records in Itajai do Norte river basin are available after 1977. But it is required for estimation of basin mean probable rainfall to use annual maximum basin mean rainfall more than 30 years. Therefore, the correlation analysis is carried out for grasping the relation between basin mean rainfall estimated by using the records in the Itajai do Norte river basin and rainfall except Itajai river basin. Results of correlation analysis is applied to estimation of basin mean rainfall before 1977.

(2) Basin mean probable rainfall

Basin mean probable rainfall is estimated by means of log-normal distribution method, Gumbel method and Pearson III type distribution method. The most suitable method among the above is applied for estimation of probable rainfall comparing the results with the plotting position by Thomas method.

(3) Duration time and pattern of probable rainfall

Design duration time and pattern of probable rainfall is decided on the basis of the observed rainfall duration time and patterns.

4.3 Results of Study

4.3.1 Simulation model

(1) Basin division and river system model

The Itajai river basin having a catchment area of 15,221 km2 and its river course are divided into 42 sub-basins and 26 river channels in consideration with the base point and sub base points as shown in Figs.II.4.2 and II.4.3. The Itajai river is also divided into 26 river channel which have a retarding effect for flood peak reduction judging from the river bed slope and shape of river cross section. Sub-basins and river channels are linked by the river system model for the flood routing as described in Fig.II.4.4.

(2) Runoff coefficient

Runoff coefficient is estimated from flood volume and rainfall amount. Flood volume is calculated from discharge hydrograph converted from water level by discharge rating curve. Fig.II.4.5 shows the discharge rating curves at major water level gauging stations which are made by DNAEE on the basis of results of discharge measurement. However, the discharge measurement records at high water level in each station are not sufficient. In this study, the discharge rating curves at high water level are checked by uniform / non-uniform flow calculation as sown in Fig.II.4.5. Table II.4.1 shows the flood peak discharges based on the DNAEE's and JICA's rating curves. As seen in the table, the difference except at Rio do Sul are less than 20 % against DNAEE's value and the rating curves are judged to be applicable. Rating curve at Rio do Sul gauging station are revised by JICA's curve based on uniform flow calculation.

Table II.4.2 shows the flood volume, rainfall amount and runoff coefficients of large floods recorded on Dec. 1978, Dec. 1980,Jul. 1983 and Aug. 1984. Runoff coefficient changes from 0.5 against rainfall amount up to 200 mm to 0.7 against rainfall amount more than 200 mm. From this result, it can be said that runoff coefficients are reasonable values and that rating curves are applicable for converting water level to discharge.

Fig.II.4.6 shows the relation between flood runoff depth and rainfall amount. As seen in the figure, the saturated rainfall which is turning point from preliminary runoff coefficient is 200 mm.

From the above, runoff coefficient in this simulation is modelled as below.

Runoff coefficient : 0.5 (R < 200 mm)

1.0 (R > 200 mm)

(3) Base flow

The Itajai river have wet and dry seasons and flood usually occurs in a wet season. Base flow in a wet season is considered to be large because of occurrence of frequent rainfall. The following table shows the monthly mean discharge and its specific discharge at the principle station.

Name of Station	Catchment Area (km^2)	Monthly Mean Discharge (m^3/sec)	Specific Discharge ($m^3/sec/km^2$)
Rio do sul	5,230	162.9	0.031
Indaial	11,491	347.2	0.030
Timbo	1,450	50.8	0.035
Taio	1,585	52.2	0.033
Ibirama	3,341	100.6	0.030
Ituporanga	1,461	58.8	0.040
Brusque	1,220	35.4	0.029
Mean			0.033

Base flow in sub-basin in the simulation model is estimated from the specific discharge of 0.033 $m^3/sec/km^2$.

4.3.2 Rainfall analysis

(1) Duration time of probable rainfall

Fig.II.4.7 shows the relation against basin mean daily rainfall in 1978 and 1980, and mathematic average of hourly rainfall in 1983 and 1984. Rainfall more than 70 % of total amount falls within 4 days. Table II.4.3 shows the basin mean annual maximum rainfall of 4 days / 7 days from 1951 to 1984. As seen in the table, the duration time of 7 days of the rain storm on December 1983 is abnormal and rain storm having a duration time of 4 days is normally occurred in the basin in consideration with the past rain storms.

Judging from the above mentioned, the duration time of 4 days are adopted as a design duration time of probable rainfall.

(2) Hourly rainfall distribution

It is not sufficient for estimation of basin mean hourly rainfall to use the Thiesen's method because the hourly rainfall availability is limited. However, the recorded hourly rainfall distribution as shown in Fig.II.3.4 is very similar in each rain storm. Therefore, the average of the recorded hourly rainfall pattern is adopted as a basin mean hourly rainfall in sub-basin for the rain storm in 1983 and 1984 in which hourly rainfall data are available. Hourly rainfall distribution for 1978 and 1980 flood is estimated from hourly records more than 50 mm of daily amount in 1983 and 1984 because of lack of hourly rainfall records and daily rainfall amount is calculated by thiessen method. Estimated hourly rainfall pattern in a day is shown Fig.II.4.8. Fig.II.4.9 shows the estimated basin mean hourly rainfall distribution in 1978, 1980, 1983 and 1984 floods. Hourly rainfall distribution of probable rainfall is worked out by multiplying the following enlarging ratio to recorded hourly rainfall distribution.

n = 4-day probable rainfall / 4-day observed rainfall

where, n : Enlarging ratio

(3) Probable Rainfall

Basin mean 4-day probable rainfall will be estimated on the basis of annual maximum basin mean rainfall which are worked out by means of Thiesen's method and the correlation analysis. Thiessen polygon and its weight are described in Fig.II.4.10. The frequency curve by means of Pearson III type distribution is shown in Fig.II.4.11, and probable rainfall and enlarging ratio are listed in Table II.4.4.

4.3.3 Formulation and Calibration of Simulation Model

Formulation and calibration of simulation model is carried out by using observed rainfall distribution and simulation model. In the calibration, storage function of all the sub-basins are changed by multipling the ratio as below.

$$K = a\ K_1$$

where, K_1 : Coefficient estimated by empirical formula.
a : constant

Other factor and storage function of river channels are fixed in the study. Finaly, constants of strage function in sub-basins are taken up by multipling 1.3 times to the initial K-value estimated by the preceding empirical formula.

The storage functions of sub-basins and river channels are listed up in Tables II.4.5 and II.4.6, and the simulated and observed hydrographs are shown in Fig.II.4.12. The fitness of the model is considered to be sufficient judging from availability of hourly rainfall records. Fig.II.4.13 shows the result of non-uniform flow calculation and flood marks in 1983 flood. Judging from the results, the simulation model is able to express the hydrological characteristics in the Itajai river basin and is applicable for the flood control study.

4.3.4 Dam/Reservoir Operation Study during Flood

Dam and reservoir operation study is carried out for discharging the inflow into reservoir from dam smoothly. In this study, the following methods are examined.

(1) Without flood control dam for evaluating the flood control effect of the existing dams against the floods.

(2) Existing operation method with / without Norte dam

Existing reservoir operation method is mentioned as below.

- Conduit valves are fully opened in normal condition.
- All the valves are closed in principle, when rain storm is observed at dam site.
- All the valves are closed in principle, when reservoir water level is over 10 m depth from river bed.

(3) All the conduit valves are closed, when discharge at Blumenau over 1,000m3/sec.

(4) All the existing conduit valves are fully opened, and when reservoir water level is over the crest elevation of spillway, outflow from

spillway based on the rating curve is added to the discharge from the conduit valves.

(5) Additional outlet for the Sul dam is installed since the existing conduits have small discharge capacity against a large flood such as in 1983. It is difficult for Oeste and Norte dams to install the additional outlet judging from topographic and geological condition. The feature of additional outlet is decided from the discharge capacity of 800 m3/sec at Ituporanga city.

- Outlet tunnel diameter 6.7 m, 1 lane

(6) Additional spillway gates to heighten the flood water level to the following maximum flood water level are installed. When reservoir water level is over maximum flood water level, outflow corresponding to inflow is discharged from spillway under the condition that all the existing conduit valves are fully opened.

- Sul dam EL.406.2 m (3.8 m below dam crest)
- Oeste dam El.362.4 m (1.8 m below dam crest)
- Norte dam El.306.5 m (3.0 m below dam crest)

The above maximum water levels are decided by adding free board 1.5 m (concrete dam type 1.0 m) to wave height. The feature of spillway gates are as below.

- Sul dam Width 7.50 m @ 6 Nos.
- Oeste dam Width 7.55 m @ 10 Nos.
- Norte dam Width 12.4 m @ 20 Nos.

Fig.II.4.14 shows the flood peak discharges at major sites and flood hydrographs at Blumenau city. As seen in the results, the effect of the additional conduit and spillway gates are corresponding to the flood peak reduction less than 200 m3/sec at Blumenau and they are not effective for flood peak reduction considering the cost effectiveness. Flood peak discharge of method (1) to method (4) at Blumenau are summarized as below.

Method	Flood Peak Discharge (m3/sec) 1978	1980	1983	1984
(1)	2,920	4,310	5,930	5,730
(2) (without Norte dam)	2,770	3,890	5,100	5,170
(2) (with Norte dam)	2,260	2,930	5,070	4,220
(3)	2,480	3,110	5,060	4,340
(4)	2,490	3,360	4,850	4,620

In the above table, since flood pattern in 1978, 1980 and 1984 have the duration time less than 4 days, the retardation volume in the reservoir contributes to the flood peak reduction. In flood pattern in 1983 which has a large flood volume, the existing method is not so effective and method

(4) is better than existing one. However,the flood in 1983 seems to be abnormal case because its duration period lasts about 7 days, while majority of floods except 1983's flood have a duration time of 4 days. Therefore, the existing method is proposed in this study.

4.3.5 Probable Flood Discharge Distribution

Probable flood discharge distribution is worked out by the probable flood hydrographs estimated at the base point and sub-bases point by simulation study using the probable rainfall , and is studied under the present river condition with the Norte dam and under the existing reservoir operation method. And probable flood discharge without the existing flood control dams is examined for comparing the past flood records.

Fig.II.4.15 shows the probable flood discharge distribution without the existing flood control dams, which is selected as a maximum value comparing with flood peak discharge among four flood patterns in Table II.4.7. The probable flood peak discharge at Blumenau is compared with flood discharge converted from the water level records using rating curves based on the non-uniform flow calculation and shown in Fig.II.4.16. The estimated probable flood discharges are fit for the plotted flood records with return period more than 10 years. But the estimated values less than 10 years probability are greater than the observed flood. This difference is considered to be caused by the reason why the selected four flood patterns are grearter than 2 years flood. From the mentioned, the results of this study is applicable for making the flood control plan.

Fig.II.4.17 and Table II.4.8 show the probable flood discharge distribution and probable flood peak discharge of four patterns with the existing three dams.

Flood peak discharges at Blumenau with/without flood control dams are summarized as below.

Return Period	Peak Discharge (m3/sec) Without F.C.D	With F.C.D
2-year	3,300	2,300
5-year	4,100	2,800
10-year	4,700	3,200
25-year	5,400	3,800
50-year	6,200	4,900
80-year	6,600	5,200
100-year	7,000	5,500

Note : F.C.D means the existing flood control dams.

From the above table, the flood peak reduction of 1,000 to 1,500 m3/sec is expected by the existing dams against the flood peak discharge without flood control dams. Fig.II.4.18 shows the probable flood hydrographs with/without the existing flood control dams.

Tables

Table II.2.1 LIST OF METEOROLOGICAL OBSERVATORIES IN AND AROUND THE ITAJAI RIVER BASIN

Name of Station	Observatin Period	Institution
Blumanau	1911-1969	INMET
Brusque	1911-1966	INMET
Camboriu	1912-1983	INMET
Curitibanos	1913-1958	INMET
Indaial	1971-up to present	INMET
Itajai	1980-up to present	EMPASC
Ituporanga	1979-up to present	INMET/EMPASC
Lages	1925-up to present	EMPASC
Timbo	1955-1969	INMET

Table II.3.1 MONTHLY METEOROLOGICAL DATA

(1) TEMPERATURE

Unit: °C

Name of Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Indaial	24.5	24.7	23.8	21.0	18.9	15.6	15.8	16.9	17.9	20.1	21.8	23.8	20.4
Itajai	24.0	24.6	22.9	20.2	18.2	15.3	15.4	15.9	16.7	19.2	21.5	22.9	19.7
Ituporanga	22.8	23.4	21.9	18.8	17.0	13.8	13.2	14.6	15.2	17.7	20.2	21.8	18.4
Lages	20.3	20.1	18.8	15.8	13.1	11.2	19.9	12.2	13.7	15.5	17.4	19.3	15.7
Timbó	25.5	24.4	23.3	20.9	17.5	15.7	15.5	16.6	18.1	20.4	21.9	23.2	20.1
Curitibanos	19.4	19.1	18.1	15.3	12.8	11.1	10.6	12.2	13.5	15.0	16.9	18.4	15.2
Blumenau	24.5	24.4	23.2	21.0	18.1	16.3	15.5	16.4	17.9	19.6	21.5	23.4	20.1
Brusque	24.4	24.1	23.2	20.5	17.8	15.7	15.1	16.0	17.6	19.3	21.2	23.0	19.8
Camboriú	23.5	23.8	23.1	20.6	17.9	16.0	15.0	15.7	17.0	18.0	20.5	22.3	19.5

(2) EVAPORATION

Unit: mm

Name of Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Indaial	97	75	71	67	63	50	57	59	61	79	89	94	868
Itajai	104	82	79	58	60	61	53	41	68	77	82	94	860
Ituporanga	-	-	-	-	-	-	-	-	-	-	-	-	-
Lages	68	52	58	44	40	34	41	49	48	55	65	74	628
Timbo	104	86	76	64	59	44	50	58	57	77	90	97	863
Curitibanos	57	46	43	36	32	33	43	58	49	55	61	62	576
Blumenau	59	50	54	43	38	31	34	38	39	47	53	61	544
Brusque	75	58	63	45	41	34	38	40	37	50	62	68	716
Camboriu	83	72	73	64	58	46	50	55	58	73	74	91	797

(3) RELATIVE HUMIDITY

Unit: %

Name of Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Indaial	73.7	77.7	76.7	77.7	77.4	79.5	80.2	77.6	77.8	76.7	75.1	73.9	77.0
Itajai	83.2	85.6	85.0	87.3	87.8	88.1	89.4	87.9	84.8	82.5	82.8	83.7	85.7
Ituporanga	-	-	-	-	-	-	-	-	-	-	-	-	-
Lages	77.5	80.0	80.4	81.4	82.4	83.5	80.8	80.4	81.0	79.7	76.6	75.2	79.9
Timbó	79.4	81.4	83.4	84.3	85.1	86.6	86.9	84.9	85.3	82.8	80.1	80.2	83.3
Curitibanos	81.9	83.1	84.4	85.7	85.6	85.7	82.8	80.0	82.5	81.4	78.7	79.1	82.6
Blumenau	82.1	83.7	84.3	85.1	85.8	87.2	86.2	85.2	85.2	83.5	81.2	81.0	84.2
Brusque	83.1	84.3	84.8	86.1	86.5	87.4	87.2	86.5	86.9	85.7	83.9	82.8	85.4
Camboriú	85.1	86.1	86.5	86.8	87.5	88.3	88.1	87.9	87.6	85.8	84.5	84.3	86.5

Data Source: EMPASC

Table II.3.2 MONTHLY MEAN DISCHARGE (1/2)

YEAR	Runoff (cms) Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean	Runoff Depth (mm)
Rio do Sul (Catchment area : 5,230 sq.km)														
1976	176.0	65.9	144.0	45.9	128.0	191.0	83.0	234.0	122.0	92.0	65.2	24.5	114.3	686.1
1977	281.0	255.0	125.0	87.3	45.4	29.1	36.3	255.0	89.7	284.0	203.0	77.7	147.4	884.8
1978	67.6	55.2	82.2	24.0	16.2	24.3	53.4	34.8	115.0	46.4	90.3	121.0	60.9	365.4
1979	49.7	29.2	38.5	45.3	133.0	61.7	56.8	60.2	72.4	355.0	168.0	124.0	99.5	597.2
1980	101.0	51.3	177.0	58.6	63.2	55.1	167.0	324.0	256.0	151.0	126.0	333.0	155.3	932.1
1981	175.0	110.0	45.9	40.2	31.3	29.7	43.3	33.7	68.3	68.7	60.3	97.3	67.0	402.1
1982	42.2	188.0	98.6	53.6	40.8	88.4	123.0	98.4	57.6	167.0	354.0	140.0	121.0	726.2
1983	190.0	185.0	265.0	132.0	339.0	337.0	939.0	379.0	216.0	135.0	122.0	182.0	285.1	1711.5
1984	110.0	73.2	107.0	85.1	110.0	206.0	174.0	504.0	159.0	178.0	176.0	100.0	165.2	991.7
1985	64.0	23.9	106.0	120.0	64.5	-	-	-	-	-	-	-	-	-
Mean	125.7	103.7	118.9	69.2	97.1	113.6	186.2	213.7	128.4	164.1	151.6	133.3	135.1	810.8
Indaial (Catchment area :11,491 sq.km)														
1976	353.0	166.0	323.0	135.0	293.0	466.0	216.0	444.0	253.0	198.0	192.0	390.0	285.8	784.2
1977	460.0	369.0	274.0	239.0	93.7	70.9	95.2	401.0	163.0	642.0	385.0	173.0	280.5	769.8
1978	153.0	138.0	219.0	60.8	45.6	57.5	117.0	101.0	252.0	152.0	172.0	285.0	146.1	400.9
1979	107.0	69.6	78.5	110.0	403.0	131.0	142.0	134.0	196.0	126.0	421.0	349.0	188.9	518.5
1980	239.0	168.0	383.0	143.0	123.0	119.0	391.0	585.0	520.0	324.0	303.0	702.0	333.3	914.8
1981	384.0	284.0	140.0	99.1	78.0	67.1	91.0	73.3	122.0	171.0	170.0	271.0	162.5	446.1
1982	110.0	373.0	212.0	130.0	110.0	236.0	315.0	213.0	131.0	363.0	748.0	340.0	273.4	750.4
1983	406.0	434.0	583.0	270.0	766.0	67.3	2026.0	724.0	503.0	332.0	241.0	401.0	562.8	1544.5
1984	216.0	173.0	234.0	182.0	227.0	396.0	310.0	1134.0	322.0	336.0	379.0	209.0	343.2	941.8
1985	-	-	-	-	-	-	-	-	-	-	-	-		-
Mean	242.8	217.5	244.7	136.9	213.9	179.0	411.5	423.3	273.6	293.8	334.6	346.7	286.3	785.7
Timbo (Catchment area :1,450 sq.km)														
1976	56.2	47.1	77.7	32.8	54.8	67.4	38.8	49.6	37.6	32.5	34.2	36.4	47.1	1024.2
1977	54.7	49.1	61.4	52.8	25.9	18.0	15.1	27.0	19.2	91.5	56.1	36.5	42.3	919.4
1978	32.8	40.0	57.4	16.7	11.6	12.6	16.1	19.4	35.0	24.8	26.8	45.7	28.2	614.2
1979	17.6	14.5	18.2	24.0	65.5	23.2	24.9	18.6	28.4	77.8	72.3	49.6	36.2	787.7
1980	43.7	53.2	55.5	29.9	20.4	17.9	53.9	55.8	56.0	52.4	54.6	105.0	49.9	1084.4
1981	77.6	68.8	41.6	30.0	21.3	14.9	19.9	13.1	14.5	42.0	43.3	58.8	37.2	808.0
1982	28.7	67.7	50.6	33.9	32.7	41.9	43.4	32.4	23.0	50.6	87.1	52.8	45.4	987.4
1983	72.5	77.1	87.7	46.3	116.0	91.9	240.0	86.9	81.2	61.2	43.8	81.2	90.5	1967.9
1984	42.2	35.4	48.7	41.1	40.1	45.9	39.7	139.0	51.7	46.1	70.4	31.1	52.6	1144.4
1985	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mean	42.6	45.3	49.9	30.8	38.8	37.1	54.6	49.1	38.5	53.2	54.3	55.2	47.7	1037.5
Ibirama (Catchment area :3,341 sq.km)														
1976	72.5	33.5	63.9	37.2	80.2	142.0	57.0	116.0	80.9	54.1	64.0	81.6	73.6	694.5
1977	105.0	36.2	62.0	65.2	20.1	14.7	21.9	60.8	32.6	153.0	79.6	40.2	57.6	543.8
1978	24.0	21.7	61.2	12.6	10.1	14.5	41.2	35.8	69.0	41.0	43.6	80.4	37.9	358.0
1979	26.4	17.6	15.4	27.5	151.0	40.6	49.7	39.5	75.7	226.0	138.0	112.0	76.6	723.2
1980	79.5	50.2	106.0	39.6	35.3	40.5	167.0	166.0	142.0	87.7	80.5	205.0	99.9	943.4
1981	97.7	17.0	35.6	25.4	20.7	17.9	24.3	20.7	31.3	42.5	48.9	99.9	40.2	379.1
1982	34.4	90.9	58.6	33.6	33.3	91.9	124.0	70.9	44.1	126.0	233.0	131.0	89.3	843.0
1983	103.0	117.0	163.0	65.5	222.0	201.0	653.0	154.0	130.0	87.6	50.0	85.7	169.3	1598.2
1984	38.8	34.4	59.7	41.8	51.4	105.0	79.2	259.0	81.7	76.6	97.2	40.4	80.4	759.2
1985	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mean	58.1	41.9	62.5	34.8	62.4	74.2	135.3	102.5	76.4	99.4	92.8	97.4	80.5	760.2

Table II.3.2 MONTHLY MEAN DISCHARGE (2/2)

YEAR	Runoff (cms) Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean	Runoff Depth (mm)
Ituporanga (Catchment area :1,461 sq.km)														
1976	55.6	16.0	32.9	11.8	41.0	46.3	31.9	86.1	31.8	23.5	22.7	63.9	38.6	833.7
1977	64.5	103.0	22.7	22.9	10.0	7.9	12.0	88.8	31.2	66.7	75.7	23.5	44.1	951.3
1978	23.8	27.7	23.9	6.8	5.5	6.5	12.8	8.7	30.7	15.0	22.0	36.3	18.3	395.2
1979	16.0	11.7	8.5	11.3	23.6	15.4	14.8	24.5	19.7	128.0	48.6	34.2	29.7	641.0
1980	31.1	16.8	41.2	15.5	17.2	12.6	40.3	116.0	81.6	43.0	31.0	100.0	45.5	982.7
1981	63.5	29.6	12.8	10.0	8.2	8.9	16.0	11.0	18.7	26.1	15.6	16.1	19.7	425.4
1982	8.5	34.1	15.7	7.8	7.3	23.5	26.3	23.2	12.5	49.1	96.5	37.8	28.5	615.7
1983	42.2	42.4	54.2	42.4	101.0	121.0	309.0	157.0	64.7	29.7	31.2	67.1	88.5	1910.1
1984	33.4	19.3	17.3	20.4	24.4	68.2	82.4	193.0	57.7	45.4	36.9	28.7	52.3	1128.0
1985	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mean	33.9	30.1	22.9	14.9	23.8	34.5	60.6	78.7	38.7	47.4	42.2	45.3	40.6	875.9
Taio (Catchment area :1,585 sq.km)														
1976	63.7	30.7	57.5	16.4	49.7	76.5	23.7	56.8	42.5	34.7	29.0	86.7	47.3	941.6
1977	110.0	57.2	59.8	37.6	12.9	9.6	10.9	74.8	26.6	119.0	50.0	25.0	49.5	983.9
1978	24.2	16.8	37.0	7.8	4.9	6.3	20.4	15.0	41.2	26.7	27.6	39.0	22.2	442.4
1979	14.6	10.4	25.0	19.4	81.2	22.8	22.1	24.1	33.1	132.0	61.4	54.1	41.7	829.4
1980	34.9	20.1	93.2	17.1	19.9	20.2	60.0	95.6	79.8	50.0	36.8	120.0	54.0	1073.7
1981	63.7	50.5	16.9	15.9	10.5	10.2	13.6	12.7	29.3	25.8	26.5	44.2	26.7	530.2
1982	18.2	97.5	59.3	27.1	22.6	43.5	57.6	39.9	23.1	69.9	152.0	60.8	56.0	1113.4
1983	90.1	97.5	87.4	41.9	126.0	113.0	332.0	122.0	77.1	50.9	47.0	64.0	104.1	2070.7
1984	34.6	24.6	52.2	39.7	49.4	68.6	35.8	156.0	43.8	55.1	78.7	37.9	56.4	1121.5
1985	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mean	45.4	40.5	48.8	22.3	37.7	41.2	64.0	66.3	44.1	62.7	56.6	59.1	50.9	1011.9
Brusque (Catchment area :1,220 sq.km)														
1976	47.6	28.5	37.0	20.0	40.5	51.0	36.3	58.4	29.4	22.5	27.2	31.2	35.8	925.4
1977	38.5	55.4	27.1	25.6	12.3	9.2	10.7	51.0	29.0	63.8	53.3	26.2	33.5	866.1
1978	25.3	21.2	22.5	9.5	8.1	10.3	12.6	8.8	22.8	17.8	18.6	38.2	18.0	464.6
1979	14.3	12.3	10.2	23.7	31.8	15.7	14.9	12.8	22.9	61.7	35.7	22.7	23.2	600.3
1980	20.9	16.9	24.7	19.3	12.6	10.7	31.4	47.0	40.1	36.3	30.1	62.2	29.4	758.7
1981	34.3	23.3	21.4	16.1	13.2	12.3	13.1	10.9	11.1	33.0	23.9	28.6	20.1	519.6
1982	16.9	43.9	25.0	19.8	17.2	23.2	22.8	20.7	15.0	28.7	49.1	25.5	25.7	663.0
1983	52.9	50.1	57.8	37.4	83.8	66.7	197.0	83.3	54.7	36.5	30.7	59.2	67.5	1745.0
1984	38.0	33.7	27.7	22.7	22.6	30.4	30.8	-	47.0	43.0	43.3	27.1	30.5	789.0
1985	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mean	28.9	28.5	25.3	19.4	24.2	25.5	41.1	32.5	30.2	38.1	34.7	35.7	31.5	814.6

Table II.3.3 RECORDED ANNUAL MAXIMUM DISCHARGE AT INDAIAL

Year	Date	Flood Discharge (cms)	Year	Date	Flood Discharge (cms)
1934	Apr.26	1,037	1971	Jun. 9	2,356
1935	Sep.24	2,684	1972	Aug.28	2,340
1936	Aug. 6	1,913	1973	Aug.29	2,900
1937	Oct.16	1,279	1974	Jan. 9	1,244
1938	Jun.27	1,995	1975	Oct. 2	2,980
1939	Nov.26	2,590	1976	May.29	1,830
1940	Aug.26	1,256	1977	Nov.12	1,995
1941	Nov.18	996	1978	Dec.26	2,830
1942	Feb.20	1,410	1979	Oct. 9	2,308
1943	Aug. 3	2,220	1980	Dec.21	3,700
1944	Mar.14	645	1981	Dec.23	1,197
1945	Feb.20	849	1982	Nov.15	1,920
1946	Feb. 2	1,755	1983	Jul. 9	4,791
1947	Oct.26	1,256	1984	Aug. 7	5,026
1948	Aug. 2	2,372	1985	Jun.16	1,380
1949	Jun.12	760			
1950	Oct.17	2,308			
1951	Oct.19	1,545			
1952	Sep. 7	1,332			
1953	Nov. 1	2,724			
1954	May.18	1,845			
1955	May.19	3,060			
1956	Sep.20	1,079			
1957	Aug.18	5,468			
1958	Mar.19	1,545			
1959	Sep. 2	1,126			
1960	Aug.18	1,425			
1961	Nov. 2	2,468			
1962	Sep.20	1,740			
1963	Sep.29	2,010			
1964	May. 2	795			
1965	Aug.21	1,965			
1966	Feb.10	2,180			
1967	Feb.27	1,256			
1968	Dec.25	760			
1969	Feb.20	1,560			
1970	Jul. 2	1,338			

Table II.3.4 PAST LARGE FLOOD WATER LEVEL AT BLUMENAU

Year	Date	Water Level (m)	Year	Date	Water Level (m)
1852	Nov.16	16.00	1954	May.18	8.90
1855	Nov.20	13.00	1954	Oct.22	11.84
1864	Sep.17	10.00	1955	May.19	9.96
1868	Nov.28	13.00	1957	Jul.21	8.68
1869	Jul.22	11.00	1957	Aug.20	12.42
1870	Nov.10	10.00	1961	Sep.13	9.52
1880	Sep.23	16.80	1961	Sep.30	8.98
1891	Jun.18	13.50	1961	Nov. 1	11.70
1898	May. 3	12.00	1962	Sep. 9	8.64
1898	Dec.24	11.00	1963	Sep.30	8.58
1900	Jun. 2	12.50	1966	Feb.13	9.42
1911	Oct. 2	16.60	1967	Feb.18	10.20
1911	Oct.30	9.56	1969	Apr. 6	9.00
1925	May.15	9.80	1971	Jun. 9	9.50
1925	May.24	10.00	1972	Aug.16	10.40
1926	Jan.13	9.70	1972	Aug.29	10.65
1927	Nov. 9	12.00	1973	Jun.25	10.55
1928	Jun.18	11.46	1973	Jul.22	8.70
1928	Aug.15	10.52	1973	Aug.29	11.84
1928	Sep.17	10.00	1975	Oct.3	12.15
1930	Feb.16	9.05	1976	May.29	10.55
1931	Apr. 1	10.90	1978	Dec.26	11.05
1931	May. 2	10.44	1979	May.10	9.30
1931	Sep.14	10.62	1979	Oct. 9	9.78
1931	Nov.17	12.30	1980	Dec.22	12.95
1932	May.25	8.90	1983	Mar. 4	9.95
1933	Oct. 4	10.90	1983	May.20	12.06
1935	Sep.24	10.60	1983	Jul.8-18	15.37
1939	Nov.27	11.08	1983	Aug. 2	11.20
1943	Aug. 3	9.82	1983	Sep.24	11.10
1946	Feb. 2	8.80	1984	Aug.6-9	15.46
1948	May.18	11.20			
1950	Oct.17	8.80			
1953	Nov. 1	9.30			

Source : " Bacia do Rio Itajai " , DNAEE

Table II.3.5 TIDE WATER LEVEL AT ITAJAI HARBOR

Monthly Highest Tide Water Level

Unit : El.m

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
						Month							
1983						1.16	1.96	1.17	1.16	-	-	0.96	1.28
1984	1.02	0.88	-	1.14	1.32	1.06	1.29	1.11	1.11	0.92	0.71	0.91	1.04
1985	0.81	-	-	-	-	-	-	0.86	0.96	0.97	0.77	0.86	0.87
1986	0.62	0.77	0.91										0.77
Mean monthly highest tide water level													1.01

Monthly Lowest Tide Water Level

Unit : El.m

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
						Month							
1983						-0.34	-0.14	-0.44	-0.44	-	-	-0.39	-0.35
1984	-0.44	-0.62	-	-0.54	-0.20	-0.48	-0.53	-0.49	-0.69	-0.74	-0.62	-0.49	-0.53
1985	-0.81	-	-	-	-	-	-	-0.84	-0.95	-0.79	-0.94	-0.76	-0.87
1986	-0.64	-0.74	-0.79										-0.72
Mean monthly lowest tide water level													-0.60

Monthly Mean Tide Water Level

Unit : El.m

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
						Month							
1983						0.44	0.73	0.34	0.28	-	-	0.13	0.38
1984	0.16	0.16	-	0.35	0.47	0.45	0.37	0.40	0.11	0.04	0.12	0.10	0.25
1985	0.03	-	-	-	-	-	-	0.11	0.05	0.12	0.04	0.02	0.06
1986	0.06	0.09	0.01										0.05
Mean tide water level													0.20

Table II.3.6 SEDIMENT CONCENTRATION RECORDS

(1) Apiuna

Date	Gage Height (m)	Discharge (cms)	Sediment Concentration (ppm)
Mar.20 '81	0.58	62.3	49.9
Jun.16	0.50	44.7	45.8
Sep.21	0.58	56.2	37.8
Dec.27	1.30	280.0	52.5
Jan.16 '82	0.58	64.6	29.9
Mar.17	0.69	84.3	9.1
Jul.8	0.90	142.0	50.3
Sep.8	0.85	129.0	35.8
Nov.19	1.90	553.0	31.6
Apr.25 '83	1.36	298.0	68.8
Jun.22	1.58	344.0	39.1
Oct.21	1.12	208.0	180.9
Jan.20 '84	1.06	177.0	244.7
Mar.2	1.48	317.0	144.0
Jul.21	1.50	351.0	56.5
Jan.25 '85	0.62	67.0	41.0
Oct.20	1.08	178.0	81.8

(2) Barra do Prata

Date	Gage Height (m)	Discharge (cms)	Sediment Concentration (ppm)
May.19 '79	1.55	35.8	15.6
Mar.19 '81	0.97	8.0	109.0
Jun.9 '81	0.81	4.0	53.2
Sep.27	1.63	43.4	268.5
Dec.26	1.48	28.8	18.9
Jan.12 '82	1.37	23.1	43.8
Mar.23	1.50	28.7	93.3
Sep.15	1.18	14.9	44.2
Nov.31	2.03	89.0	49.2
Apr.29 '83	1.35	24.1	22.4
Jun.29	1.94	61.5	46.4
Oct.23	1.88	62.0	251.3
Jan.17 '84	1.20	14.5	108.4
Jan.22	1.26	16.5	138.5
Apr.23	1.30	19.4	18.1
Jul.20	0.90	5.1	13.1
Jul.21	1.52	34.4	28.4
Oct.17	1.26	17.7	18.4

(3) Brusque

Date	Gage Height (m)	Discharge (cms)	Sediment Concentration (ppm)
Apr.22 '77	1.31	19.5	23.7
Aug.29	1.47	27.0	46.0
Oct.19	2.36	71.6	183.1
Aug.7 '78	0.98	7.8	20.2
Oct.6	1.05	10.1	29.3
Dec.8	1.21	15.8	53.0
Mar.8 '79	0.99	8.1	64.7
Feb.21 '81	1.41	24.0	159.7
May.12	1.09	11.9	44.2
Aug.24	0.99	7.9	78.1
Nov.27	1.14	11.8	43.7
Feb.19 '82	1.54	32.0	253.0
Jun.11	1.19	14.6	43.9
Aug.6	1.18	15.2	38.4
Oct.8	2.90	125.0	820.8
Dec.4	1.63	43.2	136.3
Dec.22 '83	2.28	81.2	203.9
Feb.21 '84	1.41	22.1	21.3
May.12	1.26	15.9	42.8
May.25	2.30	64.7	169.1
Nov.23	1.71	38.1	80.6
May.23 '85	1.04	16.6	32.8
Aug.25	0.78	9.0	23.6

(4) Rio do Sul Novo

Date	Gage Height (m)	Discharge (cms)	Sediment Concentration (ppm)
Feb.26 '79	0.87	22.3	91.2
May.5	1.68	82.4	25.1
Mar.17 '81	1.06	32.3	57.1
Jun.11	1.06	32.3	65.9
Sep.23	1.68	82.4	35.1
Dec.10	1.40	57.7	54.7
Jan.14 '82	1.14	38.0	18.2
Mar.24	2.22	122.0	90.2
Sep.9	1.45	62.7	176.8
Nov.22	3.72	303.0	58.4
Jan.24 '83	1.80	92.0	26.4
Mar.15	1.17	43.3	32.9
Apr.26	2.30	126.0	63.2
Jun.27	4.39	433.0	32.3
Jul.17	3.70	268.0	83.6
Oct.23	2.40	130.0	120.6
Oct.9 '84	5.70	522.0	324.3
Jan.15 '85	1.08	34.3	70.1

(5) Indaial

Date	Gage Height (m)	Discharge (cms)	Sediment Concentration (ppm)
Oct.27 '76	1.75	223.0	79.9
Dec.9	3.15	849.0	282.0
Dec.12	3.04	784.0	120.4
May.17 '77	1.27	84.0	35.2
Sep.21	1.49	138.0	45.8
Nov.17 '78	1.26	82.0	23.2
Mar.17 '79	1.15	62.0	7.0
May.29	1.56	161.0	22.5
Mar.22 '81	1.30	90.0	57.8
Jun.17	1.16	72.0	62.8
Sep.20	1.06	50.0	37.5
Dec.5	1.47	140.0	37.5
Jan.9 '82	1.40	123.0	33.9
Mar.16	1.44	132.0	15.8
Sep.22	1.30	106.0	62.2
Nov.18	3.05	854.0	71.6
Apr.18 '83	1.98	312.0	105.3
Jun.18	2.40	485.0	113.8
Oct.20	2.10	348.0	104.2
Jan.18 '84	1.70	212.0	459.7
Mar.24	1.98	310.0	96.0
Jul.23	2.29	398.0	224.3
Oct.22	1.62	181.0	116.0
Jan.26 '85	1.26	70.5	86.1
Jan.11	1.45	135.0	109.4

Table II.3.7 ANNUAL SEDIMENT LOAD

(Unit : Million cm)

Year	Station				
	Rio do Sul	Apiuna	Indaial	Ibirama	Brusque
1976	-	0.74	1.20	0.13	0.04
1977	-	0.84	1.26	0.11	0.04
1978	0.12	0.29	0.49	0.07	0.02
1979	0.25	0.69	1.03	0.17	0.02
1980	0.47	1.17	1.64	0.20	0.03
1981	0.11	0.26	0.46	0.06	0.02
1982	0.29	0.73	1.11	0.15	0.02
1983	0.66	3.59	4.86	0.69	0.12
1984	0.56	1.30	1.95	0.20	0.02
1985	0.27	-	-	-	-
Total	2.73	9.61	14.00	1.78	0.33
Mean	0.34	1.07	1.56	0.20	0.04
Catchment Area (km2)	5,230	9,487	11,491	3,341	1,220
Specific Sediment load (m3/km2/year)	65	113	135	59	30

Table II.4.1 COMPARISON OF FLOOD PEAK DISCHARGE BASED ON RATING CURVES BY DNAEE AND JICA TEAM

Name of Station	Gage Height (m)	Flood Peak Discharge DNAEE	Flood Peak Discharge JICA	Difference (cms)	Difference (%)
Dec. 1978					
Rio do Sul	6.80	720	700	20	(2.8)
Ibirama	4.43	1,010	1,070	-60	(5.9)
Apiuna	5.47	2,300	2,100	200	(8.7)
Timbo	6.46	560	470	90	(16.1)
Indaial	5.92	2,900	2,400	500	(17.2)
Brusque	7.58	550	490	60	(10.9)
Dec. 1980					
Rio do Sul	7.57	850	860	-10	(1.2)
Ibirama	7.30	2,480	2,950	-470	(19.0)
Apiuna	7.70	3,690	3,250	440	(11.9)
Timbo	7.28	690	590	100	(14.5)
Indaial	6.60	3,500	2,900	600	(17.1)
Brusque	5.45	320	290	30	(9.4)
Jul. 1983					
Rio do Sul	13.28	1,970	2,560	-590	(29.9)
Ibirama	7.30	2,480	2,950	-470	(19.0)
Apiuna	8.64	4,310	3,900	410	(9.5)
Timbo	-	-	-	-	-
Indaial	7.78	4,760	4,200	560	(11.8)
Brusque	7.54	540	480	60	(11.1)
Aug. 1984					
Rio do Sul	12.80	1,860	2,370	-510	(27.4)
Ibirama	6.56	2,070	2,430	-360	(17.4)
Apiuna	8.66	4,320	3,950	370	(8.6)
Timbo	8.26	860	800	60	(7.0)
Indaial	8.02	5,030	4,500	530	(10.5)
Brusque	-	-	-	-	-

Table II.4.2 RECORDED LARGE FLOOD IN THE ITAJAI RIVER BASIN

Date	Flood Characteristic		Water Level Gauging Station							
			Sul dam	Oeste dam	Rio do Sul	Ibirama	Apiuna	Timbo	Indaial	Brusque
	Catchment area	(sq.km)	1,290	860	5,230	3,341	9,487	1,450	11,491	1,220
1978	Flood discharge	(cms)	330	240	720	1,010	2,290	560	2,840	550
Dec.	Flood volume	(mil. m3)	44.7	38.0	181.0	149.0	369.5	69.8	465.5	56.0
25-31	Runoff depth	(mm)	(34.7)	(44.2)	(34.6)	(44.6)	(38.9)	(48.1)	(40.5)	(45.9)
	Basin mean rainfall	(mil. m3)	120.0	92.9	508.9	387.6	1,010.4	178.2	1254.8	176.0
	Rainfall amount	(mm)	(93.0)	(108.0)	(97.3)	(116.0)	(106.5)	(122.9)	(109.2)	(144.3)
	Runoff coefficient		0.37	0.41	0.36	0.38	0.37	0.39	0.37	0.32
1980	Flood discharge	(cms)	680	660	680	2,500	3,690	690	3,500	320
Dec.	Flood volume	(mil. m3)	94.8	137.1	395.8	326.7	744.4	131.2	-	54.8
19-28	Runoff depth	(mm)	(73.5)	(159.4)	(75.7)	(97.8)	(78.5)	(90.5)	-	(44.9)
	Basin mean rainfall	(mil. m3)	202.1	204.6	904.8	528.2	1,577.7	250.6	-	170.7
	Rainfall amount	(mm)	(156.7)	(237.9)	(173.0)	(158.1)	(166.3)	(172.8)	-	(139.9)
	Runoff coefficient		0.47	0.67	0.44	0.62	0.50	0.52	-	0.32
1983	Flood discharge	(cms)	1,470	940	1,970	2,480	4,310	-	4,740	540
Jul.	Flood volume	(mil. m3)	284.0	198.0	1,173.0	757.0	2,243.3	-	2,564.2	223.3
6-15	Runoff depth	(mm)	(220.2)	(230.2)	(224.3)	(226.6)	(236.5)	-	(223.1)	(183.0)
	Basin mean rainfall	(mil. m3)	471.1	278.6	1,889.1	1,090.2	3,275.9	-	3,979.3	412.8
	Rainfall amount	(mm)	(365.2)	(323.9)	(361.2)	(326.3)	(345.3)	-	(346.3)	(338.4)
	Runoff coefficient		0.61	0.71	0.62	0.70	0.68	-	0.64	0.54
1984	Flood discharge	(cms)	2,450	1,130	1,860	2,070	4,320	860	5,030	-
Aug.	Flood volume	(mil. m3)	195.7	114.1	804.1	379.6	1,448.7	187.1	1,615.9	-
5-15	Runoff depth	(mm)	(151.7)	(132.7)	(153.7)	(113.6)	(152.7)	(129.0)	(140.6)	-
	Basin mean rainfall	(mil. m3)	297.3	167.9	1,233.8	665.2	2,118.4	377.9	2,576.3	-
	Rainfall amount	(mm)	(230.5)	(195.2)	(235.9)	(199.1)	(223.3)	(260.6)	(224.2)	-
	Runoff coefficient		0.66	0.68	0.65	0.57	0.68	0.50	0.63	-

Table II.4.3 ANNUAL MAXIMUM BASIN MEAN
4 DAYS / 7 DAYS RAINFALL

Year	Date	4-day (mm)	Date	7-day (mm)	(7-day)-(4-day) (mm)	(4-day)/(7-day) %
1951	OCT. 15	90	OCT. 14	145	55	62.1
1952	SEP. 3	87	OCT. 13	103	16	84.5
1953	OCT. 28	93	OCT. 27	101	8	92.1
1954	MAR. 31	101	OCT. 16	137	36	73.7
1955	MAY. 16	115	MAY. 15	126	11	91.3
1956	SEP. 16	56	SEP. 14	94	38	59.6
1957	AUG. 16	118	AUG. 13	133	15	88.7
1958	MAR. 13	121	MAR. 13	152	31	79.6
1959	AUG. 30	88	AUG. 29	124	36	71.0
1960	JUL. 31	89	JUL. 30	97	8	91.8
1961	SEP. 9	138	SEP. 6	193	55	71.5
1962	SEP. 18	89	SEP. 17	100	11	89.0
1963	SEP. 26	138	SEP. 25	176	38	78.4
1964	APR. 28	57	OCT. 20	66	9	86.4
1965	AUG. 16	91	AUG. 16	104	13	87.5
1966	FEB. 9	121	FEB. 9	166	45	72.9
1967	SEP. 18	56	SEP. 18	86	30	65.1
1968	DEC. 22	103	DEC. 20	115	12	89.6
1969	FEB. 16	93	MAR. 30	110	17	84.5
1970	FEB. 2	69	FEB. 1	96	27	71.9
1971	MAY. 5	66	APR. 16	100	34	66.0
1972	AUG. 25	146	AUG. 22	165	19	88.5
1973	AUG. 26	108	AUG. 22	149	41	72.5
1974	JUL. 22	99	JUL. 19	115	16	86.1
1975	SEP. 30	102	SEP. 27	127	25	80.3
1976	MAY. 26	90	MAY. 23	108	18	83.3
1977	AUG. 15	125	AUG. 13	137	12	91.2
1978	DEC. 25	118	DEC. 24	122	4	96.7
1979	MAY. 7	106	MAY. 8	141	35	75.2
1980	DEC. 19	151	DEC. 18	164	13	92.1
1981	DEC. 21	99	DEC. 21	102	3	97.1
1982	FEB. 3	96	FEB. 4	111	15	86.5
1983	JUL. 6	216	JUL. 6	324	108	66.7
1984	AUG. 5	213	AUG. 2	259	46	82.2

Table II.4.4 PROBABLE RAINFALL AND ENLARGING RATIO

Return Period (year)	Probable Rainfall (mm)	Observed Rainfall (mm)			
		Dec.1978 118	Dec.1980 151	Jul.1983 216	Aug.1984 213 /1
2	110	0.932	0.728	0.509	0.516
5	140	1.186	0.927	0.648	0.657
10	160	1.356	1.060	0.741	0.751
25	185	1.568	1.225	0.856	0.869
50	210	1.780	1.391	0.972	0.986
100	230	1.949	1.523	1.065	1.080

Note : /1 Actual 4-day rainfall (mm)

Table II.4.5 STORAGE FUNCTION OF SUB-BASIN

Basin NO.	Catchment Area (sq.km)	River Length (km)	River Bed Slope	Coeff. of Storage Function K	Coeff. of Storage Function P	Lag-time (hour)
1	860.0	45.0	1/130	35.87	0.549	4.0
2	725.0	56.0	1/90	40.05	0.504	4.0
3	866.0	70.0	1/1,300	17.98	0.944	9.0
4	116.0	20.0	1/220	30.63	0.622	3.0
5	300.0	35.0	1/100	38.81	0.516	3.0
6	183.0	22.5	1/250	29.48	0.641	3.0
7	440.0	26.0	1/100	38.81	0.516	2.0
8	850.0	32.4	1/425	25.14	0.726	4.0
9	159.0	28.5	1/220	30.63	0.622	4.0
10	326.0	28.2	1/200	31.52	0.608	3.0
11	217.0	28.0	1/170	33.10	0.585	3.0
12	174.0	26.6	1/60	45.23	0.458	2.0
13	854.0	43.1	1/435	24.97	0.730	6.0
14	584.0	48.4	1/170	33.10	0.585	4.0
15	880.0	32.8	1/140	35.08	0.559	3.0
16	611.0	44.9	1/355	26.54	0.696	6.0
17	431.0	59.8	1/285	28.34	0.661	8.0
18	348.0	17.9	1/95	39.41	0.510	1.0
19	657.0	41.1	1/105	38.24	0.522	3.0
20	50.4	7.5	1/100	38.81	0.516	1.0
21	314.0	29.1	1/120	36.74	0.539	3.0
22	205.0	34.4	1/65	44.16	0.467	3.0
23	606.0	43.0	1/100	38.81	0.516	3.0
24	779.0	52.4	1/55	46.43	0.449	4.0
25	64.9	8.9	1/540	23.40	0.768	1.0
26	71.1	9.0	1/165	33.39	0.581	1.0
27	405.0	37.7	1/305	27.77	0.671	5.0
28	262.0	38.2	1/160	33.70	0.577	4.0
29	197.0	21.6	1/220	30.63	0.622	3.0
30	191.0	22.9	1/270	28.81	0.652	3.0
31	15.2	3.2	1/180	32.53	0.593	0.0
32	61.2	7.1	1/670	21.93	0.808	1.0
33	590.0	49.0	1/980	19.57	0.883	6.0
34	111.0	11.4	1/210	31.06	0.615	2.0
35	640.0	66.0	1/145	34.71	0.564	6.0
36	457.0	58.0	1/675	21.88	0.809	8.0
37	170.0	15.7	1/55	46.43	0.449	1.0
38	179.0	15.0	1/55	46.43	0.449	1.0
39	116.0	14.1	1/145	34.71	0.564	1.0
40	122.0	20.1	1/510	23.80	0.757	3.0
41	14.5	1.7	1/240	29.84	0.634	0.0
42	18.4	1.5	1/500	23.95	0.754	0.0

Total Catchment Area : 15,220.7 sq.km

Table II.4.6 STORAGE FUNCTION OF RIVER CHANNEL

Name of Stretch	River Length (km)	River Bed Slope	Coeff. of Storage Function K	P		Lag-time Tl (hr)
IT1	7.6	1/12,000	21.519	0.704	Q < 1,000	1.0
			0.677	1.204	Q > 1,000	
IT2	11.7	1/12,000	27.915	0.749	Q < 1,000	2.0
			0.581	1.307	Q > 1,000	
IT3	15.0	1/12,000	46.457	0.700	Q < 1,200	2.0
			0.329	1.398	Q > 1,200	
IT4	3.7	1/12,000	12.910	0.671	Q < 1,200	0.0
			0.403	1.160	Q > 1,200	
IT5	8.0	1/12,000	34.066	0.642	Q < 1,600	1.0
			0.512	1.211	Q > 1,600	
IT6	13.0	1/12,000	37.507	0.629	Q < 2,700	2.0
			0.662	1.140	Q > 2,700	
IT7	14.0	1/12,000	42.507	0.675	Q < 2,500	2.0
			1.307	1.120	Q > 2,500	
IT8	19.0	1/500	27.443	0.681		3.0
IT9	4.2	1/1050	6.261	0.669		1.0
IT10	18.0	1/1050	24.006	0.677		2.0
IT11	4.0	1/2,500	6.479	0.683	Q < 2,500	1.0
			2x10-7	2.870	Q > 2,500	
IT12	42.0	1/100	9.239	0.711		3.0
IT13	22.0	1/5,000	29.626	0.740	Q < 800	1.0
			0.141	1.540	Q > 800	
Benedito river			0.000			
BN1	8.6	1/1,000	10.531	0.657		1.0
Itajai do Norte river			0.000			
IN1	7.5	1/240	8.274	0.637		1.0
Itajai do Oeste river			0.000			
IO1	6.0	1/5,000	14.853	0.738	Q < 200	1.0
			0.777	1.317	Q > 200	
IO2	15.1	1/5,000	15.801	0.745	Q < 800	2.0
			0.060	1.578	Q > 800	
Itajai do Sul river			0.000			
IS1	12.0	1/4,000	20.552	0.781	Q < 700	2.0
			0.060	1.648	Q > 700	
IS2	13.0	1/1,000	12.898	0.669		2.0
IS3	3.4	1/600	5.262	0.683	Q < 800	1.0
			0.111	1.190	Q > 800	
Itajai Mirim river			0.000			
IM1	8.4	1/10,000	11.309	0.805	Q < 100	1.0
			0.040	2.032	Q > 100	
IM2	8.4	1/2,300	7.515	0.735	Q < 200	1.0
			0.001	2.341	Q > 200	
IM3	9.2	1/2,900	0.201	1.559	Q < 200	1.0
			0.077	1.740	Q > 200	
IM4	13.4	1/2,600	2.403	1.087	Q < 200	2.0
			1.104	1.234	Q > 200	
IM5	9.0	1/2,000	0.966	1.211	Q < 200	1.0
			0.250	1.466	Q > 200	
Luiz Alves river			0.000			
LA1	2.0	1/10,000	4.853	0.610	Q < 100	1.0
			0.001	2.810	Q > 100	

Table II.4.7 PROBABLE FLOOD PEAK DISCHARGES WITHOUT EXISTING DAMS

(Unit : cms)

Name of Stretch	Catchment Area (km2)	Return Period (Year) 2-Year 1978	1980	1983	1984	5-Year 1978	1980	1983	1984	10-Year 1978	1980	1983	1984	25-Year 1978	1980	1983	1984	50-Year 1978	1980	1983	1984	80-Year 1978	1980	1983	1984	100-Year 1978	1980	1983	1984
IT1	15,221	3,050	3,120	3,100	3,190	3,770	3,850	3,830	3,940	4,260	4,330	4,310	4,420	4,910	4,990	5,070	5,020	5,680	5,780	5,890	5,830	6,030	6,120	6,600	6,110	6,400	6,520	7,210	6,470
IT2	13,504	2,800	2,930	2,870	2,930	3,450	3,620	3,550	3,600	3,880	4,070	3,990	4,020	4,430	4,660	4,710	4,520	5,070	5,350	5,670	5,170	5,370	5,660	6,130	5,400	5,690	6,030	6,600	5,720
IT3	13,393	2,870	3,020	2,880	3,000	3,550	3,750	3,570	3,700	3,990	4,230	4,020	4,140	4,570	4,830	4,730	4,660	5,230	5,570	5,710	5,230	5,530	5,890	6,190	5,560	5,870	6,280	6,670	5,870
IT4	12,741	2,950	3,180	2,840	3,070	3,660	4,000	3,550	3,820	4,130	4,550	4,010	4,300	4,740	5,240	4,620	4,860	5,440	6,040	5,670	5,530	5,760	6,400	6,180	5,750	6,120	6,840	6,680	6,040
IT5	12,726	2,950	3,190	2,850	3,080	3,660	4,010	3,560	3,830	4,130	4,560	4,020	4,300	4,750	5,260	4,620	4,870	5,450	6,050	5,680	5,560	5,770	6,410	6,180	5,750	6,120	6,860	6,690	6,040
IT6	12,535	2,950	3,210	2,840	3,080	3,670	4,040	3,560	3,830	4,140	4,610	4,030	4,320	4,760	5,320	4,630	4,890	5,460	6,120	5,670	5,560	5,780	6,480	6,170	5,770	6,140	6,940	6,670	6,060
IT7	12,338	2,950	3,230	2,830	3,070	3,670	4,080	3,550	3,840	4,140	4,650	4,020	4,320	4,760	5,360	4,630	5,900	5,460	6,170	5,630	5,570	5,790	6,530	6,130	5,790	6,160	6,990	6,630	6,070
Garcia river	157	48	32	40	56	64	48	48	72	72	48	56	88	72	56	72	96	88	64	80	112	96	72	88	120	104	72	100	128
Itoupava river	93	28	18	21	32	35	21	21	43	39	25	32	50	46	28	43	57	53	35	50	67	53	35	50	71	57	39	57	75
Velha river	56	17	21	14	20	25	17	17	26	26	17	20	31	26	20	26	34	31	23	28	40	34	26	31	43	37	26	37	45
IT8	12,076	2,940	3,240	2,820	3,050	3,650	4,090	3,540	3,810	4,120	4,670	4,010	4,290	4,730	5,380	4,610	4,870	5,430	6,180	5,590	5,540	5,760	6,530	6,080	5,750	6,150	6,990	6,560	6,030
IT9	11,671	2,860	3,150	2,750	2,970	3,550	3,990	3,450	3,700	4,110	4,550	3,910	4,160	4,590	5,260	4,490	4,720	5,260	6,040	5,430	5,370	5,580	6,390	5,890	5,570	5,970	6,830	6,350	5,820
IT10	9,945	2,440	2,690	2,380	2,590	3,030	3,390	3,000	3,230	3,430	3,860	3,400	3,620	3,930	4,450	3,920	4,100	4,570	5,170	4,560	4,650	4,860	5,500	4,940	4,820	5,180	5,890	5,300	5,050
IT11	9,631	2,380	2,620	2,350	2,590	2,960	3,310	2,950	3,160	3,350	3,770	3,350	3,540	3,850	4,350	3,860	4,010	4,480	5,080	4,530	4,550	4,760	5,400	4,880	4,710	5,070	5,790	5,240	4,940
IT12	9,581	2,370	2,620	2,340	2,330	2,970	3,330	2,970	3,170	3,370	3,810	3,390	3,570	3,880	4,440	3,940	4,040	4,550	5,200	4,740	4,600	4,860	5,560	5,130	4,780	5,200	6,000	5,520	5,020
IT13	5,570	1,360	1,380	1,250	1,540	1,790	1,750	1,580	2,040	1,930	1,980	1,790	2,280	2,190	2,270	2,210	2,580	2,550	2,610	2,550	3,020	2,710	2,770	2,700	3,190	2,890	2,980	2,840	3,430
IM1+IM2	1,699	450	410	270	490	560	500	330	590	630	560	370	660	710	640	420	730	820	730	520	860	870	780	560	900	920	820	610	960
IM1		130	120	90	140	160	150	100	170	180	160	120	180	200	180	130	200	230	210	160	240	240	230	170	250	260	240	190	260
IM2		330	290	190	350	400	360	230	430	450	400	260	480	520	460	300	530	590	520	360	630	630	550	400	660	670	590	430	700
IM3	1,562	440	390	250	490	550	490	310	600	620	550	350	670	720	630	400	760	840	730	490	900	900	780	540	960	960	830	580	1,020
IM4	1,446	440	390	240	510	560	490	300	650	640	550	340	740	760	640	390	840	870	740	480	1,010	940	800	520	1,070	1,020	860	570	1,140
IM5	1,267	400	350	220	480	510	440	270	610	580	500	310	690	690	580	350	790	790	670	420	950	860	720	460	1,020	940	780	500	1,110
Mirim dam	640	210	160	110	290	270	210	140	380	320	240	160	450	400	280	180	520	470	310	210	620	520	330	220	650	550	350	230	710
		(210)	(160)	(110)	(290)	(270)	(210)	(140)	(380)	(320)	(240)	(160)	(450)	(400)	(280)	(180)	(520)	(470)	(310)	(210)	(620)	(520)	(330)	(220)	(650)	(550)	(350)	(230)	(710)
BN1	1,521	440	440	390	410	560	600	520	550	640	700	600	650	750	840	720	780	870	980	1,000	930	960	1,040	1,130	980	1,010	1,110	1,270	1,040
IN1	3,360	1,010	1,250	1,130	980	1,250	1,610	1,460	1,280	1,420	1,860	1,670	1,470	1,600	2,180	1,950	1,710	1,960	2,630	2,370	2,000	2,120	2,870	2,620	2,090	2,320	3,170	2,860	2,200
Norte dam	2,318	680	900	830	660	840	1,170	1,070	860	950	1,350	1,230	990	1,080	1,580	1,450	1,160	1,290	1,900	1,920	1,360	1,370	2,080	2,110	1,420	1,490	2,290	2,280	1,500
		(680)	(900)	(830)	(660)	(840)	(1,170)	(1,070)	(860)	(950)	(1,350)	(1,230)	(990)	(1,080)	(1,580)	(1,450)	(1,160)	(1,290)	(1,900)	(1,920)	(1,360)	(1,370)	(2,080)	(2,110)	(1,420)	(1,490)	(2,290)	(2,280)	(1,500)
IO1	3,050	860	840	780	1,000	1,080	1,120	1,000	1,270	1,220	1,280	1,130	1,440	1,400	1,480	1,310	1,660	1,640	1,750	1,510	1,920	1,760	1,880	1,620	2,000	1,910	2,050	1,740	2,150
IO2	599	160	150	140	210	200	190	180	270	220	210	210	310	250	240	230	360	290	280	280	420	310	290	310	450	340	310	340	490
Trombudo	300	70	80	70	120	90	100	90	160	110	120	110	190	120	140	130	220	140	160	160	260	140	170	170	270	150	180	180	290
dam (A)		(70)	(80)	(70)	(120)	(90)	(100)	(90)	(160)	(110)	(120)	(110)	(190)	(120)	(140)	(130)	(220)	(140)	(160)	(160)	(260)	(140)	(170)	(170)	(270)	(150)	(180)	(180)	(290)
Trombudo	116	40	30	30	50	50	40	40	60	60	50	40	70	70	50	50	80	70	60	70	90	80	60	70	90	90	70	80	110
dam (B)		(40)	(30)	(30)	(50)	(50)	(40)	(40)	(60)	(60)	(50)	(40)	(70)	(70)	(50)	(50)	(80)	(70)	(60)	(70)	(90)	(80)	(60)	(70)	(90)	(90)	(70)	(80)	(110)
Oeste dam	850	260	310	320	340	330	400	410	450	370	460	480	520	430	540	560	610	490	720	670	720	500	800	760	750	530	910	850	790
		(260)	(310)	(320)	(340)	(330)	(400)	(410)	(450)	(370)	(460)	(480)	(520)	(430)	(540)	(560)	(610)	(490)	(720)	(670)	(720)	(500)	(800)	(760)	(750)	(530)	(910)	(850)	(790)
IS1	2,166	550	560	530	770	770	770	870	930	780	810	1,080	1,050	870	920	1,300	1,200	1,040	1,040	1,470	1,420	1,100	1,080	1,550	1,520	1,190	1,140	1,620	1,650
IS2	1,992	530	540	510	740	660	690	890	960	750	790	1,090	1,100	850	920	1,330	1,270	1,060	1,050	1,540	1,510	1,140	1,100	1,620	1,610	1,240	1,190	1,720	1,740
IS3	1,775	500	490	500	680	620	630	860	880	700	720	1,040	1,000	790	840	1,280	1,160	1,010	900	1,490	1,370	1,080	1,010	1,570	1,450	1,180	1,060	1,660	1,570
Sul dam	1,290	400	370	440	500	490	470	760	650	560	540	900	750	630	630	1,120	880	860	720	1,290	1,020	910	760	1,370	1,100	1,000	800	1,450	1,210
		(400)	(370)	(440)	(500)	(490)	(470)	(760)	(650)	(560)	(540)	(900)	(750)	(630)	(630)	(1,120)	(880)	(860)	(720)	(1,290)	(1,020)	(910)	(760)	(1,370)	(1,100)	(1,000)	(800)	(1,450)	(1,210)

Note : ' ( ) ' means outflow discharge from dam.

Table II.4.8 PROBABLE FLOOD PEAK DISCHARGES WITH EXISTING DAMS

(Unit : cms)

Name of Stretch	Catchment Area (km2)	Return Period (Year) 2-Year 1978	2-Year 1980	2-Year 1983	2-Year 1984	5-Year 1978	5-Year 1980	5-Year 1983	5-Year 1984	10-Year 1978	10-Year 1980	10-Year 1983	10-Year 1984	25-Year 1978	25-Year 1980	25-Year 1983	25-Year 1984	50-Year 1978	50-Year 1980	50-Year 1983	50-Year 1984	80-Year 1978	80-Year 1980	80-Year 1983	80-Year 1984	100-Year 1978	100-Year 1980	100-Year 1983	100-Year 1984
IT1	15,221	2,450	2,320	2,260	2,570	3,050	2,870	2,780	3,190	3,430	3,230	3,110	3,560	3,940	3,700	3,940	4,040	4,530	4,250	5,160	4,690	4,810	4,490	5,650	4,920	5,100	4,790	6,110	5,220
IT2	13,504	2,130	2,110	2,020	2,220	2,610	2,580	2,480	2,730	2,940	2,890	2,810	3,050	3,350	3,280	3,690	3,440	3,810	3,730	4,800	3,930	4,040	3,940	5,200	4,110	4,280	4,200	5,580	4,360
IT3	13,393	2,170	2,170	2,010	2,280	2,680	2,660	2,470	2,810	3,010	2,990	2,880	3,140	3,450	3,390	3,750	3,550	3,920	3,840	4,860	4,060	4,150	4,050	5,240	4,230	4,410	4,320	5,610	4,470
IT4	12,741	2,180	2,240	1,930	2,290	2,710	2,770	2,390	2,830	3,040	3,120	2,900	3,170	3,490	3,570	3,760	3,600	3,970	4,050	4,900	4,100	4,190	4,260	5,220	4,260	4,440	4,530	5,530	4,480
IT5	12,726	2,190	2,240	1,930	2,290	2,710	2,770	2,390	2,830	3,040	3,120	2,900	3,180	3,490	3,580	3,760	3,610	3,970	4,050	4,910	4,100	4,200	4,260	5,230	4,270	4,450	4,530	5,530	4,490
IT6	12,535	2,180	2,240	1,910	2,280	2,700	2,770	2,360	2,820	3,030	3,130	2,890	3,170	3,480	3,600	3,750	3,610	3,960	4,070	4,900	4,100	4,170	4,280	5,210	4,260	4,420	4,550	5,510	4,470
IT7	12,338	2,160	2,230	1,870	2,260	2,660	2,760	2,320	2,800	3,000	3,130	2,890	3,150	3,450	3,610	3,730	3,600	3,930	4,080	4,880	4,090	4,130	4,290	5,190	4,250	4,390	4,550	5,490	4,460
Garcia river	157	48	32	40	56	64	48	48	72	72	48	56	88	72	56	72	96	88	64	80	112	96	72	88	120	104	72	104	128
Itoupava river	93	28	18	21	32	35	21	21	43	39	25	32	50	46	28	43	57	53	35	50	67	53	35	50	71	57	39	57	75
Velha river	56	17	21	14	20	23	17	17	26	26	17	20	31	26	20	26	34	31	23	28	40	34	26	31	43	37	26	37	45
IT8	12,076	2,120	2,200	1,820	2,220	2,620	2,740	2,270	2,750	2,950	3,120	2,860	3,100	3,380	3,620	3,690	3,550	3,860	4,070	4,830	4,060	4,060	4,260	5,130	4,210	4,340	4,520	5,420	4,410
IT9	11,671	2,030	2,120	1,750	2,120	2,490	2,630	2,190	2,630	2,800	3,000	2,790	2,960	3,200	3,470	3,600	3,370	3,630	3,890	4,700	3,840	3,830	4,090	4,990	3,980	4,110	4,350	5,270	4,170
IT10	9,945	1,580	1,660	1,380	1,720	1,900	2,020	1,810	2,110	2,130	2,290	2,360	2,360	2,430	2,630	3,120	2,680	2,810	2,950	4,050	3,020	3,020	3,110	4,290	3,140	3,240	3,310	4,530	3,320
IT11	9,631	1,510	1,590	1,330	1,660	1,820	1,940	1,790	2,040	2,040	2,190	2,310	2,280	2,320	2,570	3,060	2,610	2,710	2,840	3,960	2,920	2,900	3,000	4,200	3,030	3,110	3,200	4,430	3,250
IT12	9,581	1,510	1,580	1,330	1,650	1,810	1,920	1,780	2,030	2,020	2,170	2,300	2,270	2,300	2,480	3,060	2,560	2,700	2,830	3,970	2,920	2,900	2,990	4,220	3,030	3,110	3,200	4,450	3,190
IT13	5,570	840	880	790	1,040	1,030	1,100	1,300	1,300	1,160	1,240	1,710	1,470	1,320	1,420	2,160	1,670	1,600	1,710	2,510	1,960	1,790	1,880	2,650	2,140	1,990	2,100	2,790	2,430
IM1+IM2	1,699	450	410	270	490	560	500	330	590	630	560	370	660	710	640	420	730	820	730	520	860	870	780	560	900	920	820	610	960
IM1		130	120	90	140	160	150	100	170	180	160	120	180	200	180	130	200	230	210	160	240	240	230	170	250	260	240	190	260
IM2		330	290	190	350	400	360	230	430	450	400	260	480	520	460	300	530	590	520	360	630	630	550	400	660	670	590	430	700
IM3	1,562	440	390	250	490	550	490	310	600	620	550	350	670	720	630	400	760	840	730	490	900	900	780	540	960	960	830	580	1,020
IM4	1,446	440	390	240	510	560	490	300	650	640	550	340	740	760	640	390	840	870	740	480	1,010	940	800	520	1,070	1,020	860	570	1,160
IM5	1,267	400	350	220	480	510	440	270	610	580	500	310	690	690	580	350	790	790	670	420	950	860	720	460	1,020	940	780	500	1,110
Mirim dam	640	210	160	110	290	270	210	140	380	320	240	160	450	400	280	180	520	470	310	210	620	520	330	220	650	550	350	230	710
		(210)	(160)	(110)	(290)	(270)	(210)	(140)	(380)	(320)	(240)	(160)	(450)	(400)	(280)	(180)	(520)	(470)	(310)	(210)	(620)	(520)	(330)	(220)	(650)	(550)	(350)	(230)	(710)
BN1	1,521	440	440	390	410	560	600	520	550	640	700	600	650	750	840	720	780	870	980	1,000	930	960	1,040	1,130	980	1,010	1,110	1,270	1,040
IN1	3,360	540	570	520	510	640	680	620	610	700	760	690	680	770	860	800	760	940	990	1,300	870	1,020	1,060	1,380	900	1,120	1,160	1,720	940
Norte dam	2,318	680	900	830	660	840	1,170	1,070	860	950	1,350	1,230	990	1,080	1,580	1,450	1,160	1,290	1,900	1,920	1,360	1,370	2,080	2,110	1,420	1,490	2,290	2,280	1,500
		(220)	(240)	(260)	(220)	(240)	(260)	(290)	(240)	(250)	(270)	(320)	(250)	(270)	(290)	(500)	(260)	(280)	(310)	(950)	(270)	(290)	(320)	(1,020)	(280)	(300)	(330)	(1,240)	(280)
IO1	3,050	630	610	510	710	790	760	640	890	880	860	770	1,010	1,000	990	1,050	1,160	1,220	1,280	1,340	1,340	1,330	1,480	1,470	1,390	1,460	1,720	1,590	1,550
IO2	599	160	150	140	210	200	190	180	270	220	210	210	310	250	240	230	360	290	280	280	420	310	290	310	450	340	310	340	490
Trombudo	300	70	80	70	120	90	100	90	160	110	120	110	190	120	140	120	220	140	160	160	260	140	170	170	270	150	180	180	290
dam (A)		(70)	(80)	(70)	(120)	(90)	(100)	(90)	(160)	(110)	(120)	(110)	(190)	(120)	(140)	(120)	(220)	(140)	(160)	(160)	(260)	(140)	(170)	(170)	(270)	(150)	(180)	(180)	(290)
Trombudo	116	40	30	30	50	50	40	40	60	60	50	40	70	70	50	50	80	70	60	70	90	80	60	70	90	90	70	80	110
dam (B)		(40)	(30)	(30)	(50)	(50)	(40)	(40)	(60)	(60)	(50)	(40)	(70)	(70)	(50)	(50)	(80)	(70)	(60)	(70)	(90)	(80)	(60)	(70)	(90)	(90)	(70)	(80)	(110)
Oeste dam	860	260	310	320	340	330	400	410	450	370	460	480	520	430	540	560	610	490	720	670	720	500	800	760	750	530	910	850	790
		(0)	(0)	(70)	(0)	(0)	(70)	(180)	(20)	(0)	(180)	(250)	(50)	(40)	(300)	(340)	(110)	(60)	(510)	(520)	(260)	(90)	(570)	(570)	(200)	(130)	(670)	(630)	(370)
IS1	2,166	170	230	470	300	220	300	830	390	250	340	1,030	440	450	400	1,250	520	770	460	1,420	870	830	480	1,490	970	910	530	1,560	1,100
IS2	1,992	150	200	470	260	180	260	840	330	240	290	1,030	370	450	340	1,240	510	730	390	1,410	870	840	420	1,490	1,000	940	510	1,560	1,150
IS3	1,775	110	140	450	180	130	180	800	240	220	210	980	270	430	240	1,170	460	700	330	1,330	800	810	390	1,400	920	900	460	1,470	1,050
Sul dam	1,290	400	370	440	500	490	470	760	650	560	540	900	750	630	630	1,120	680	840	720	1,290	1,020	910	760	1,370	1,100	1,000	800	1,450	1,210
		(50)	(50)	(390)	(50)	(100)	(50)	(710)	(120)	(170)	(90)	(850)	(200)	(350)	(160)	(1,010)	(350)	(590)	(250)	(1,140)	(600)	(690)	(300)	(1,210)	(700)	(780)	(350)	(1,270)	(800)

Note : ' ( ) ' means outflow discharge from dam.

Figures

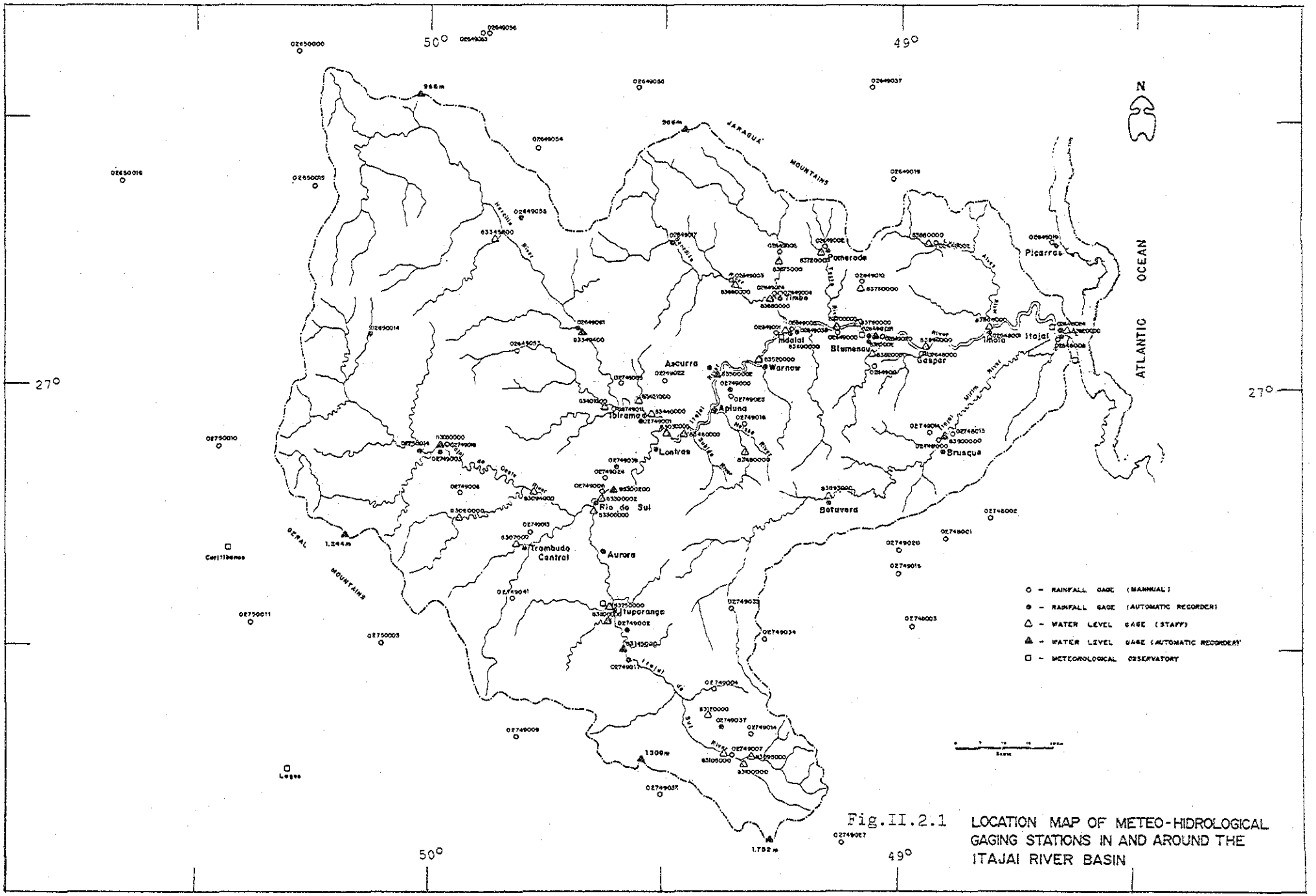
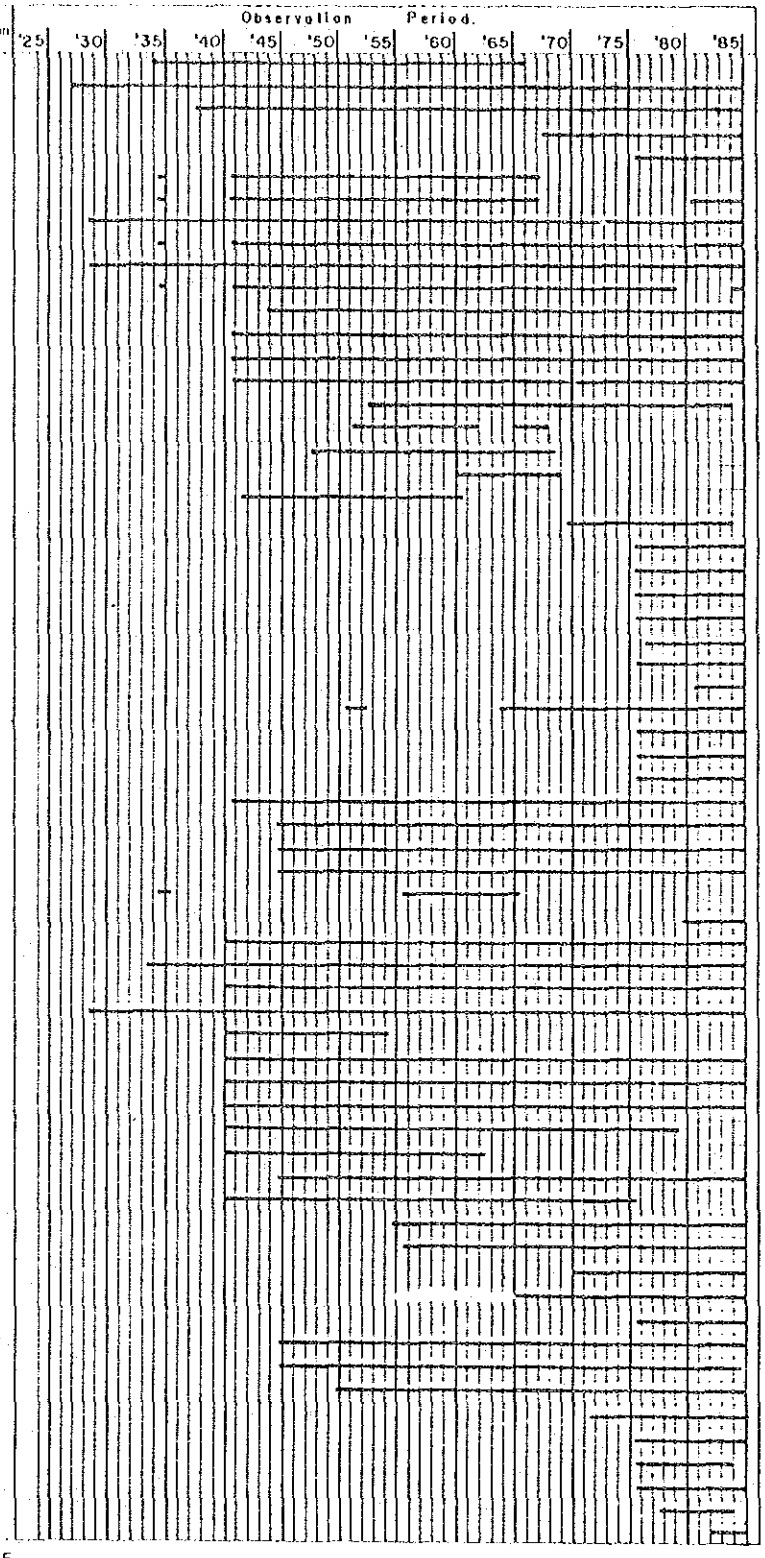


Fig.II.2.1 LOCATION MAP OF METEO-HIDROLOGICAL GAGING STATIONS IN AND AROUND THE ITAJAI RIVER BASIN

Fig. II.2.2 AVAILABLE DAILY RAINFALL RECORDS IN AND AROUND THE ITAJAI RIVER BASIN (1/2)

Name of Station	ID. Number	Institution (L1)
Gaspar	02648000	01
Ilhota	02648001	01
Luiz Alves	02648002	01
Itajai	02648008	02
Piçarras	02648019	01
Passo Manso	02649000	01
Warnow	02649001	01
Pomerode	02649002	01
Benedito Novo	02649003	01
Timbo	02649004	01
Indaial	02649005	01
Blumenau	02649007	01
Rio dos Cedros	02649008	01
Garcia	02649009	01
Itoup Central	02649010	01
Dr. Pedrinho	02649017	01
Massaranduba	02649019	02
Blumenau	02649020	05
Timbo	02649024	05
Jaragua do Sul	02649037	01
Indaial	02649038	05
Witmarsum	02649053	01
Itaiopolis	02649054	01
Rio Negrinho	02649055	01
Itaiopolis	02649056	01
Barra do Prata	02649058	01
Barragem Norte	02649061	02
Itaiopolis	02649013	02
Papanduva	02650000	01
Rio do Campo	02650014	01
Monte Castelo	02650015	01
Santa Cecilia	02650016	01
Brusque	02748000	01
Major Gerciao	02748001	01
Nova Trento	02748002	01
Angelina	02748003	01
Brusque	02748014	05
Brusque	02748015	29
Indaial	02749000	01
Ibirama	02749001	01
Ituporanga	02749002	01
Taio	02749003	02
Alfredo Wagner	02749004	01
Nova Bremen	02749005	01
Pouso Redondo	02749006	01
Lomba Alta	02749007	01
Rio do Sul	02749008	01
Pres. Getulio	02749011	01
Tromb. Central	02749013	01
Barracao	02749014	01
Faz.Boa Esper.	02749015	01
Neisse Central	02749016	01
Barragem Sul	02749017	02
Barragem Oeste	02749018	01
Rancho Queimado	02749020	01
Ibirama	02749022	15
Rio do Sul	02749024	15
Apiuna	02749025	15
Anitapolis	02749027	01
Vidal Ramos	02749033	01
Leoberto Leal	02749034	01
Saltinho	02749037	01
Rio do Sul Novo	02749039	01
Agrolandia	02749041	01

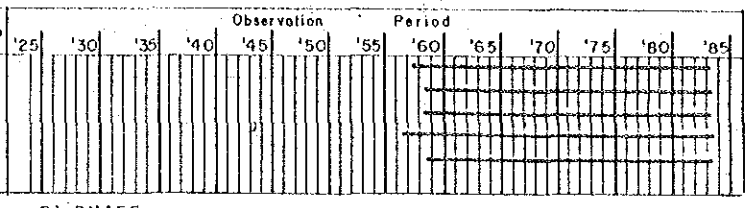


L1. Institution

01	DNAEE
02	DNOS
05	INMET
15	CELESC
29	SOUZA CRUZ

Fig. II.2.2 AVAILABLE DAILY RAINFALL RECORDS IN AND AROUND THE ITAJAI RIVER BASIN (2/2)

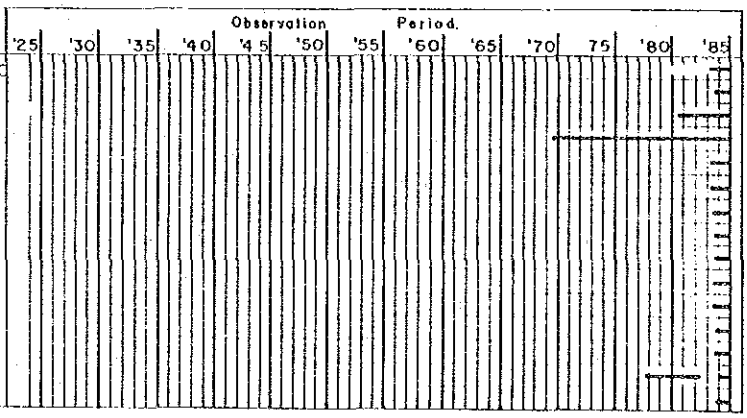
Name of Station	ID. Number	Institution (LI)
Lages	02750003	01
Lages	02749009	01
Curitibanos	02750010	01
Ponte Alta	02750011	01
Bom Retiro	02749032	01



LI Institution 01 DNAEE

Fig. II.2.3 AVAILABLE HOURLY RAINFALL RECORDS IN THE ITAJAI RIVER BASIN

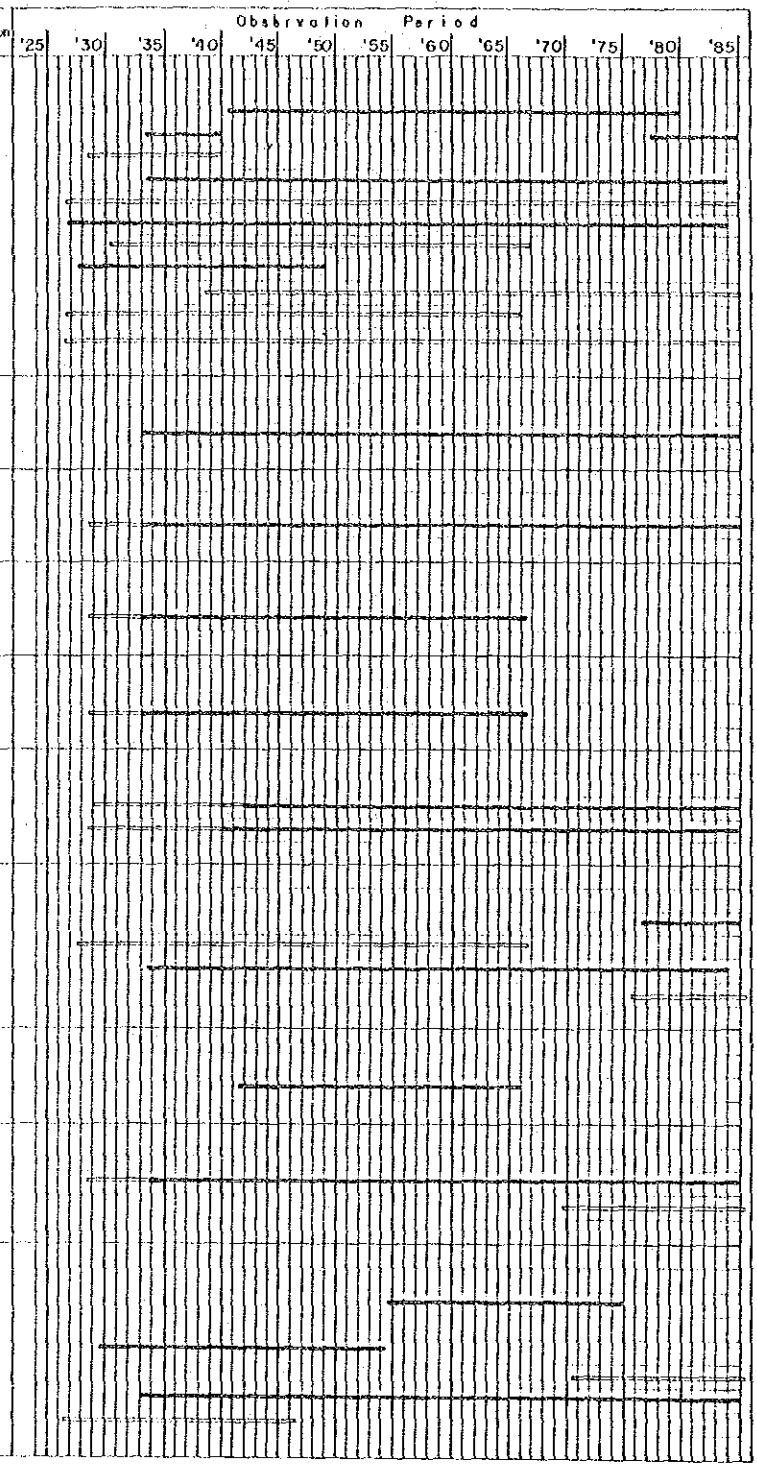
Name of Station	ID. Number	Institution
Itajaí	02648024	EMPASC
Blumenau	02649007	01
Doutor Pedrinho	02649017	01
Indaial	02649038	05
Barra do Prata	02649058	01
Barragem Norte	02649061	01
Rio do Campo	02650014	01
Apiúna	02749000	01
Ibirama	02749001	01
Ituporanga	02749002	01
Taió	02749003	01
Barragem Sul	02749017	01
Saltinho	02749037	01
Rio do Sul	02749039	01
Barragem Oeste	02749018	01



Institution 01 DNAEE
05 INMET

Fig. II.2.4 AVAILABLE DAILY WATER LEVEL / DNSCHARGE IN THE ITAJAI RIVER BASIN (1/2)

Name of Station	ID. Number	L.I. Institution
a) Itajaí river		
Rio do Sul	83300002	01
Rio do Sul Novo	83300200	01
Subida	83460000	01
Apiúna	83500002	01
Warnow	83520000	01
Indaial	83690000	01
Passo Manso	83700000	01
Itoupava Seca	83780000	01
Blumenau	83800002	01
Gaspar	83840000	01
Ilhota	83860000	01
b) Itajaí Mirim river		
Brusque	83900000	01
c) Luiz Alves river		
Luiz Alves	83880000	01
d) Testo river		
Rio do Testo	83720000	01
e) Garcia river		
Garcia	83820000	01
f) Benedito river		
Benedito Novo	83660000	01
Timbó	83680000	01
g) Itajaí do Norte river		
Barra do Prata	83345000	01
Nova Bremen	83421000	01
Ibirama	83440000	01
Barragem Norte	83349400	02
h) Neisse river		
Neisse Central	8348000	01
i) Itajaí do Oeste river		
Taió	83050000	01
Barragem Oeste	83030000	02
j) Itajaí do Sul river		
Barracão	83100000	01
Saltinho	83105000	01
Jararaca	83120000	01
Barragem Sul	83145000	02
Ituporanga	83250000	01
Rio do Sul	83300000	01

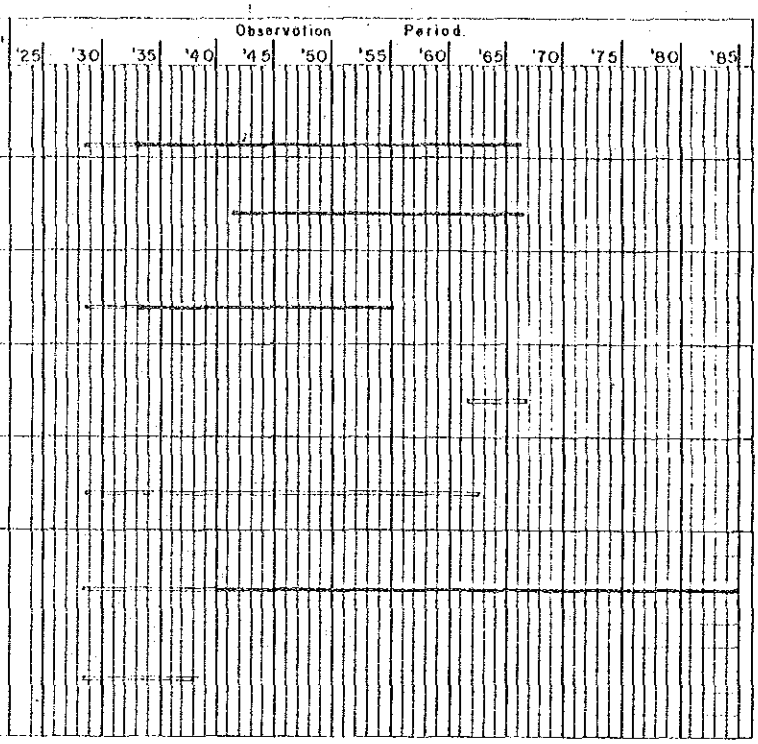


Legend
- Daily water level / discharge
- Daily water level

L.I. Institution
- 01 DNAEE
- 02 DNOS

Fig. II.2.4 AVAILABLE DAILY WATER LEVEL/ DISCHARGE IN THE ITAJAI RIVER BASIN (2/2)

Name of Station	ID Number	Institution
k) Pombas river		
Pouso Redondo	83060000	01
l) Trombudo river		
Trombudo Central	83070000	01
m) Adaga river		
Barracão	83095000	01
n) Perimbo river		
Barra do Perimbo	83200000	01
o) Kranel river		
President Getúlio	83401000	01
p) Cedros river		
Arrozeira	83675000	01
q) Itoupava river		
Itoupava	83760000	01



Legend

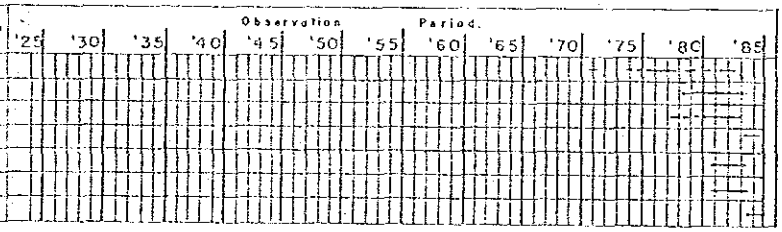
Daily water level / Discharge

Daily water level

I1 Institution 01 DNAEE 02 DNOS

Fig. II.2.5 AVAILABLE HOURLY WATER LEVEL RECORDS IN THE ITAJAI RIVER BASIN.

Name of Station	ID. Number	Institution
Apiuna	83500002	01
Rio do Sul Novo	83300500	01
Brusque	83900000	01
Taió	83050000	01
Ituporanga	83250000	01
Ibirama	83440000	01
Blumenau	83600000	01



Institution 01 DNAEE
05 INMET

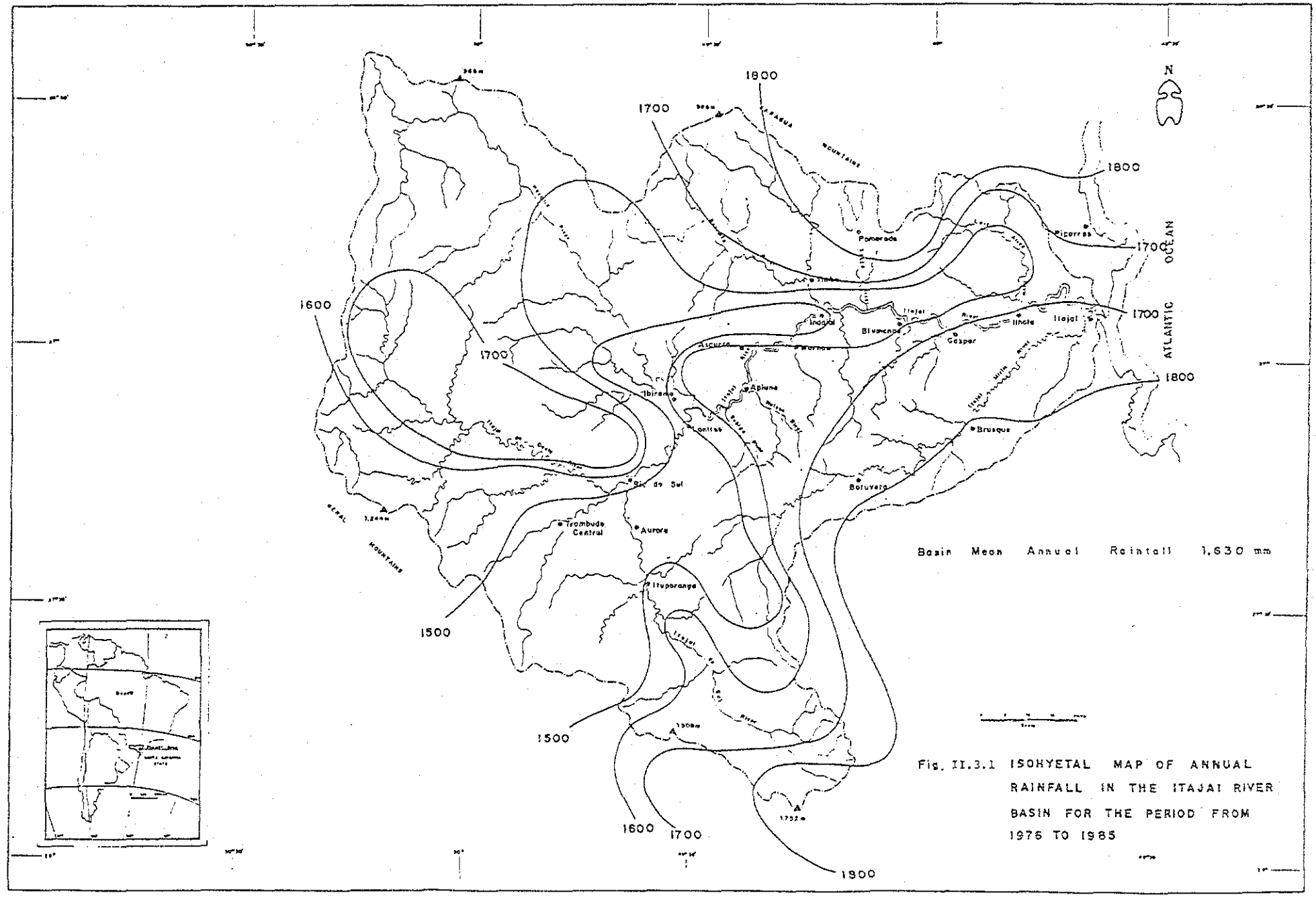
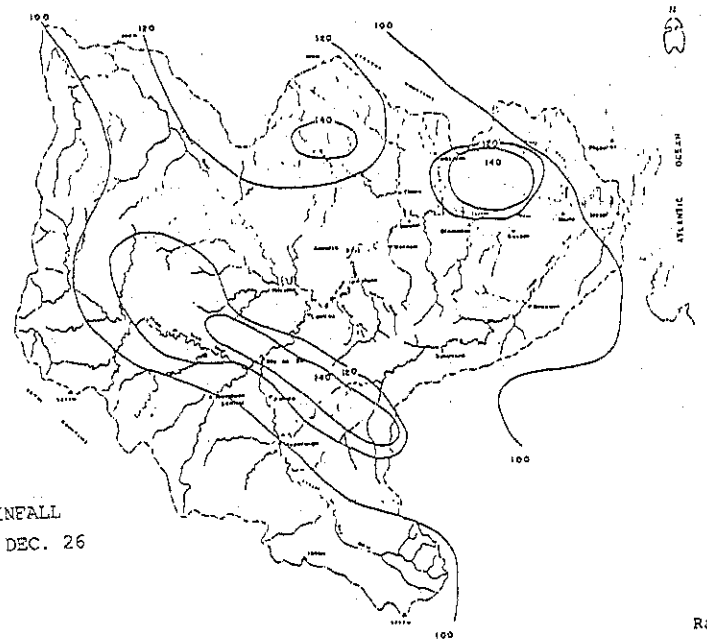
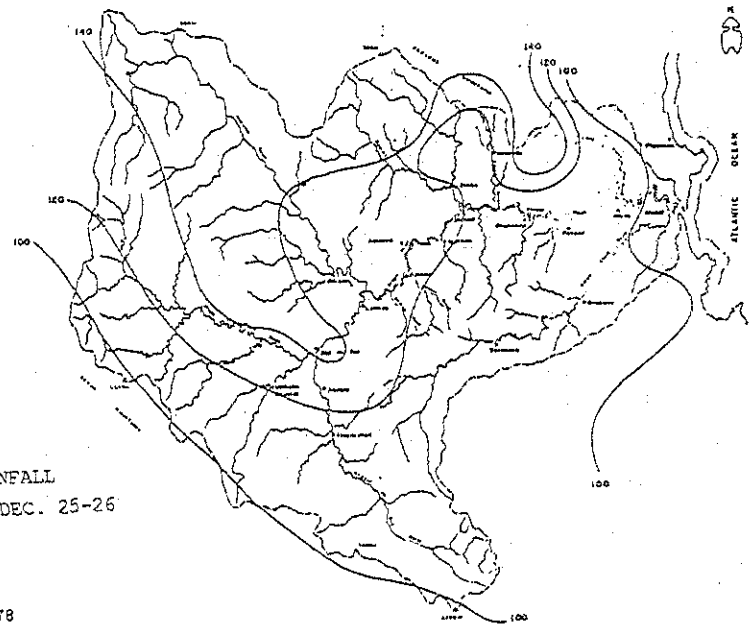
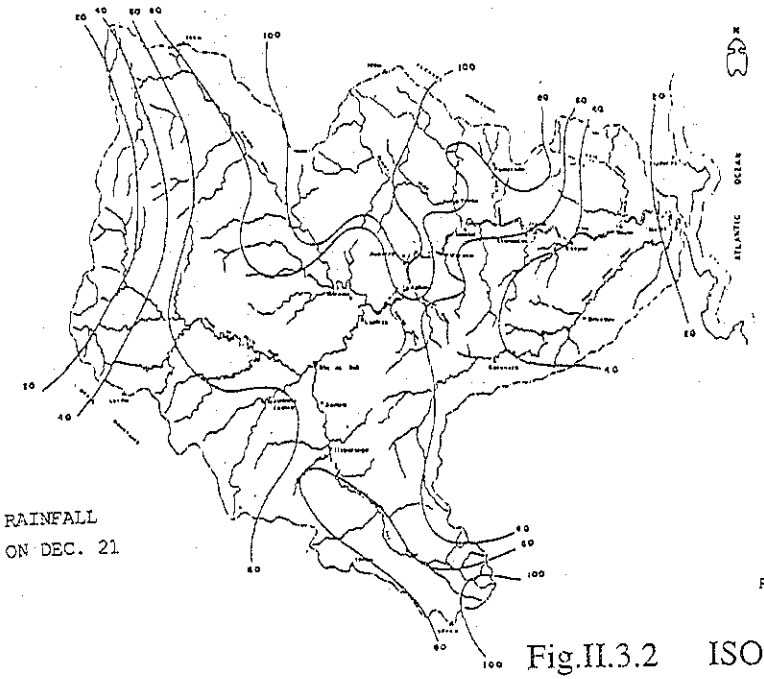


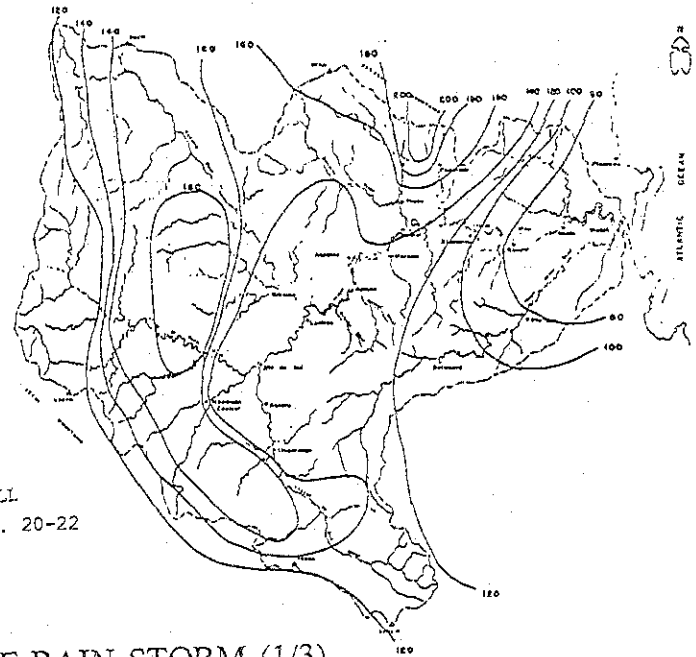
Fig. II.3.1 ISOHYETAL MAP OF ANNUAL RAINFALL IN THE ITAJAI RIVER BASIN FOR THE PERIOD FROM 1976 TO 1985





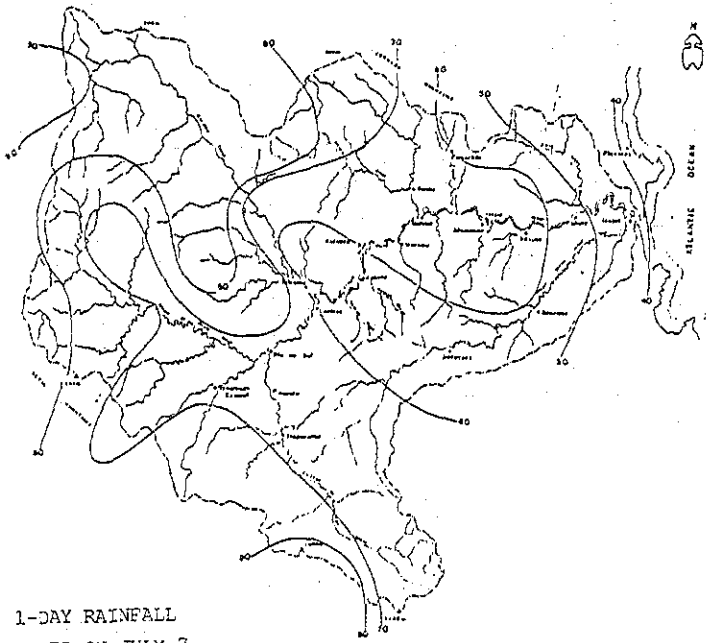
Rain storm on Dec. 1978

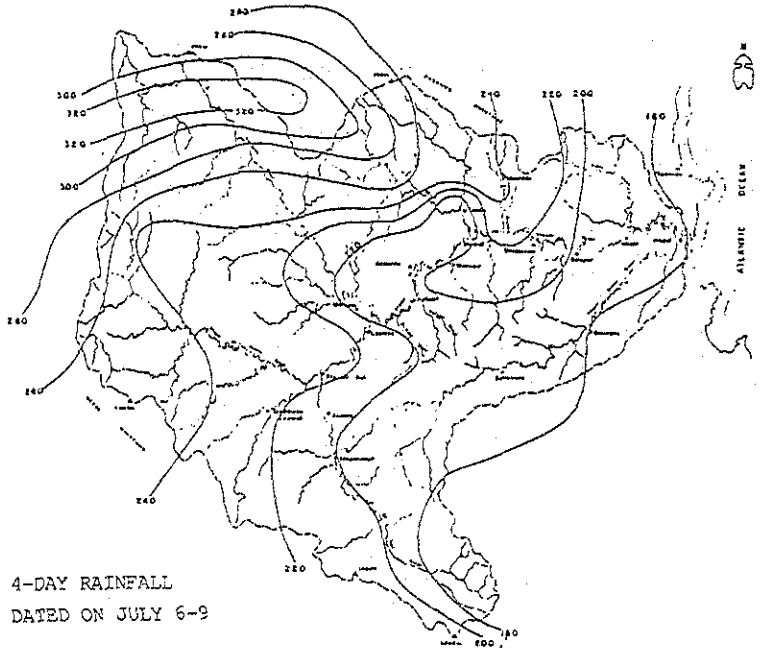


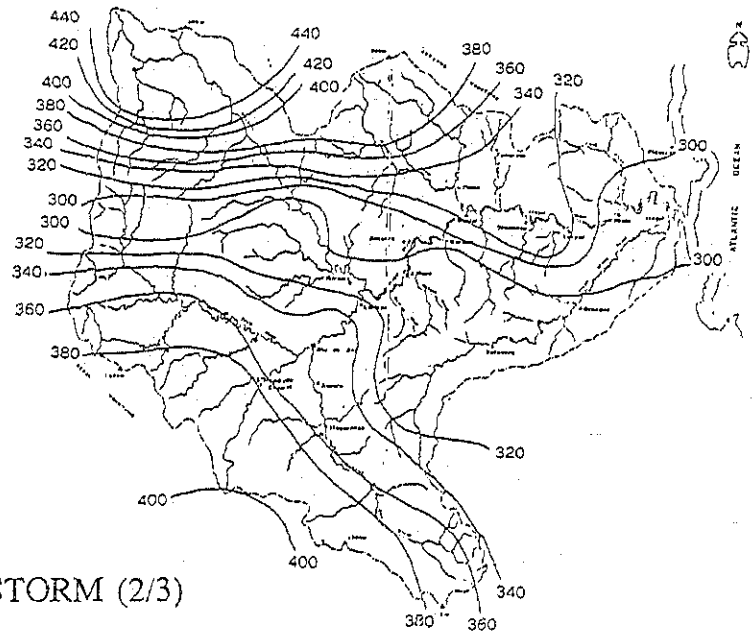


Rain storm on Dec. 1980

Fig.II.3.2 ISOHYETAL MAP OF RAIN STORM (1/3)

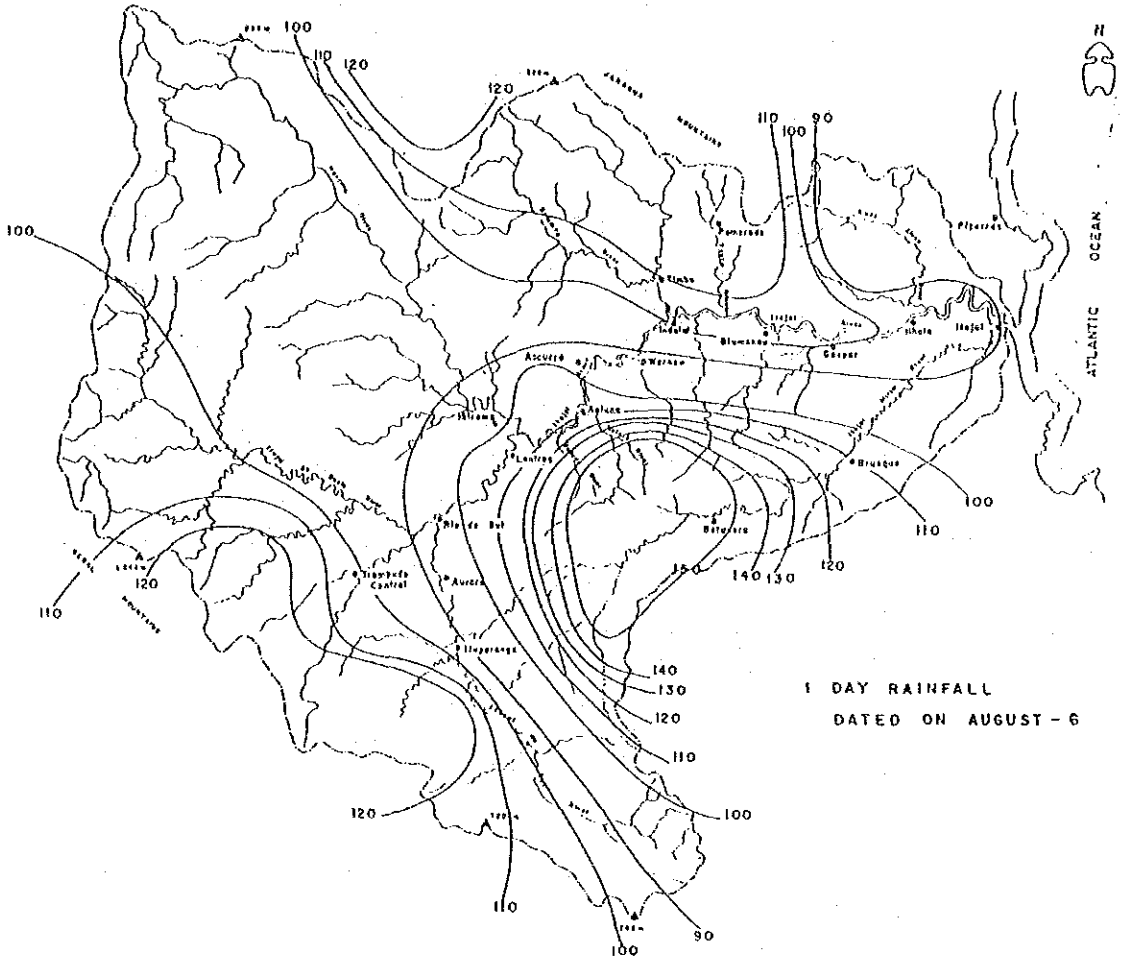


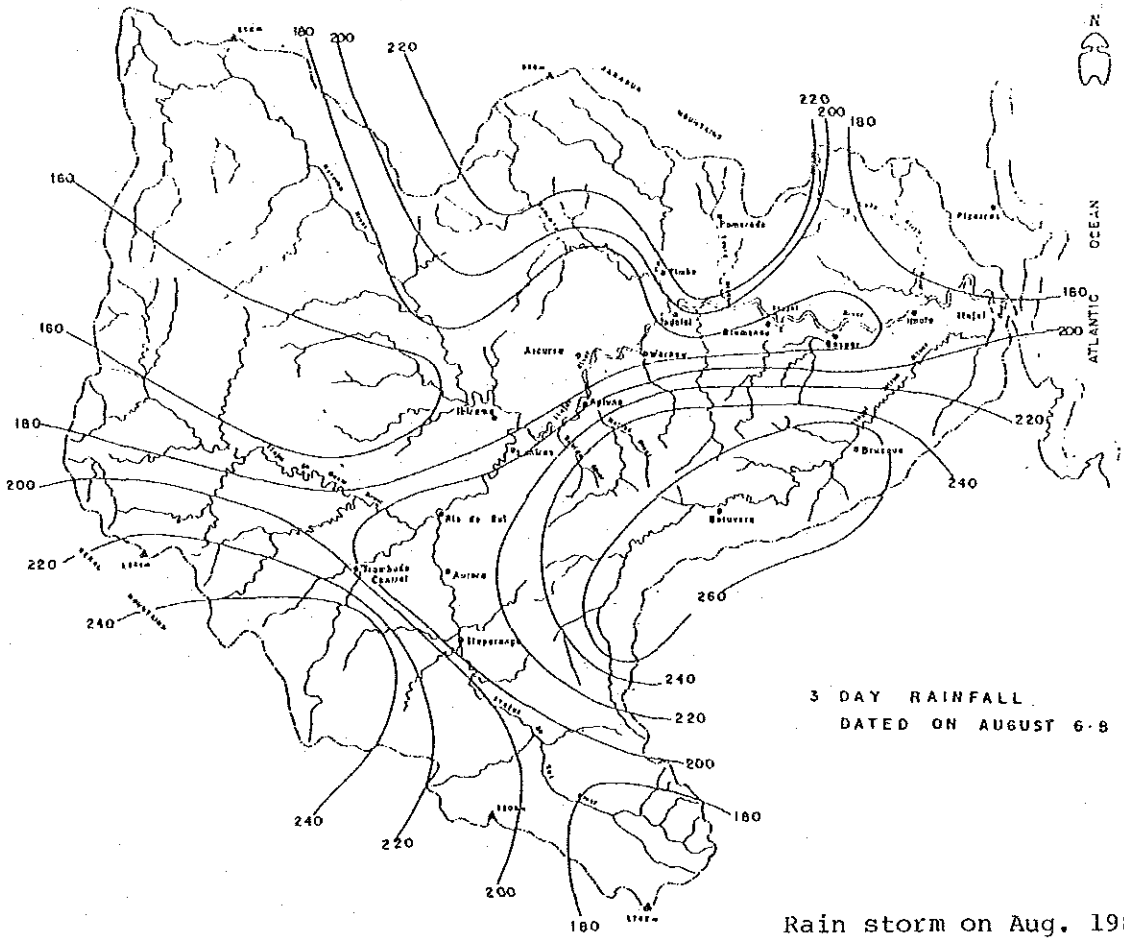




Rain storm on Jul. 1983

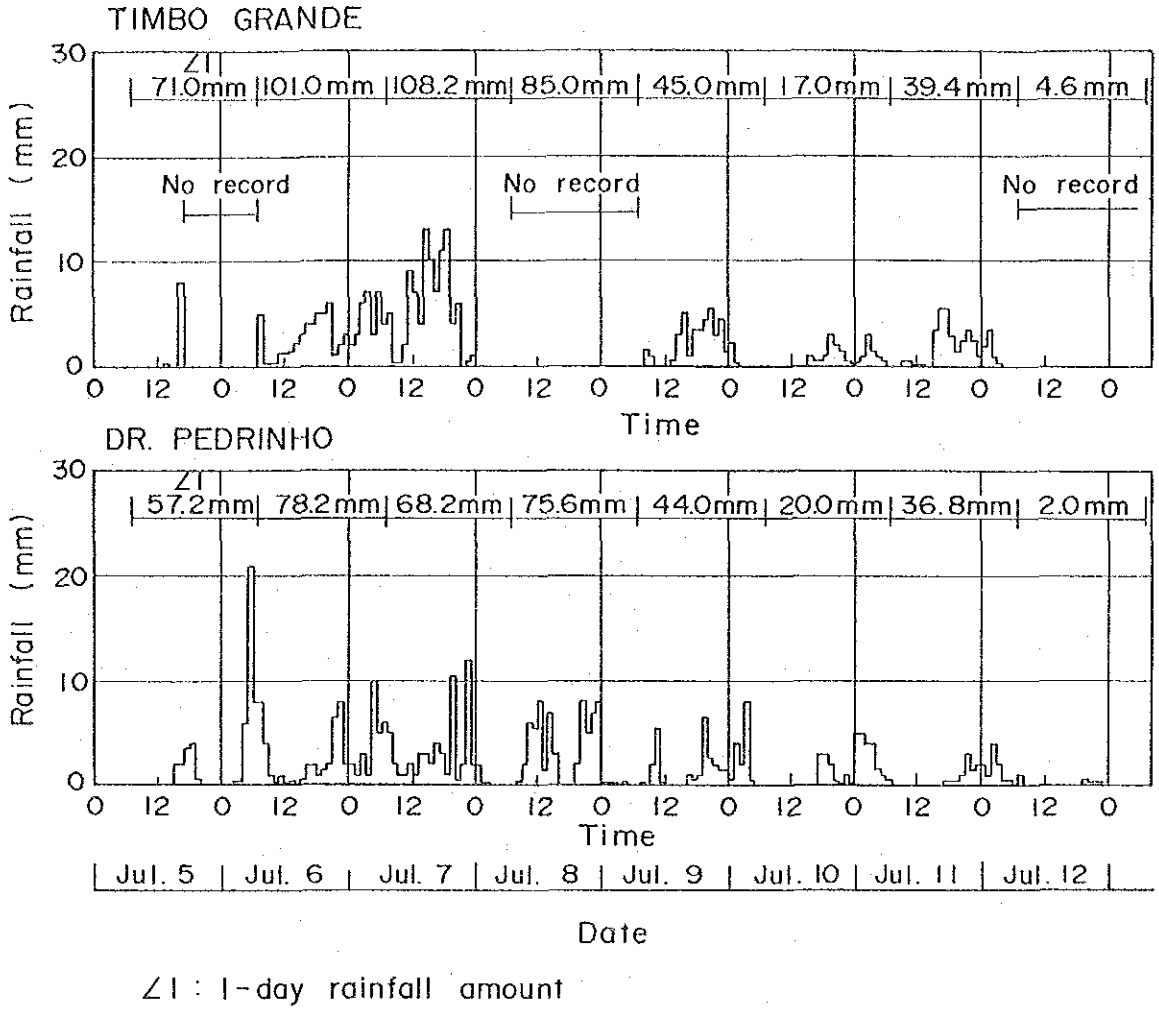
Fig.II.3.2 ISOHYETAL MAP OF RAIN STORM (2/3)





Rain storm on Aug. 1984

Fig. II.3.2 ISOHYETAL MAP OF RAIN STORM (3/3)



ΣI : 1-day rainfall amount

Fig. II.3.3 HOURLY RAINFALL DISTRIBUTION (1/3)
(July 1983)

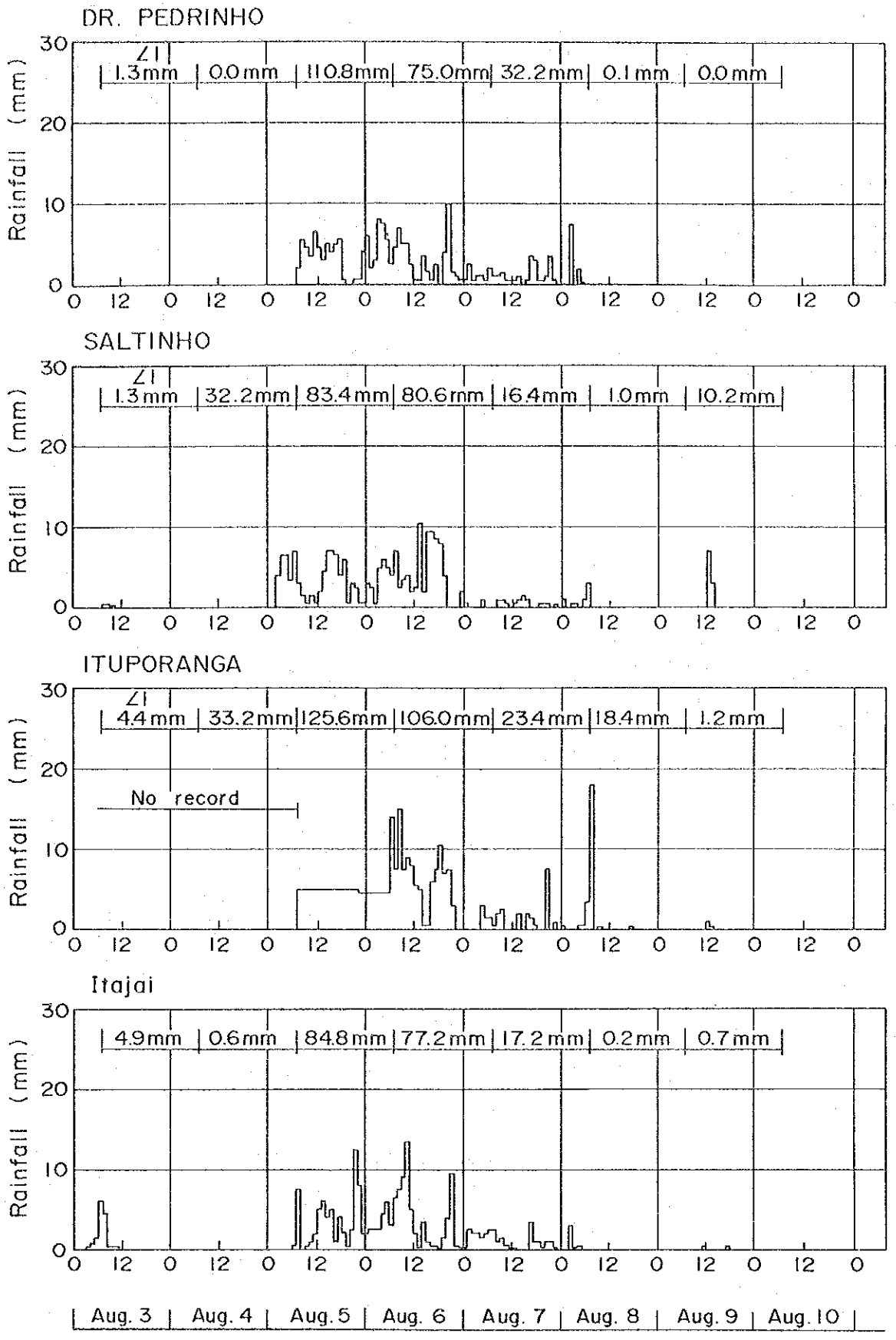
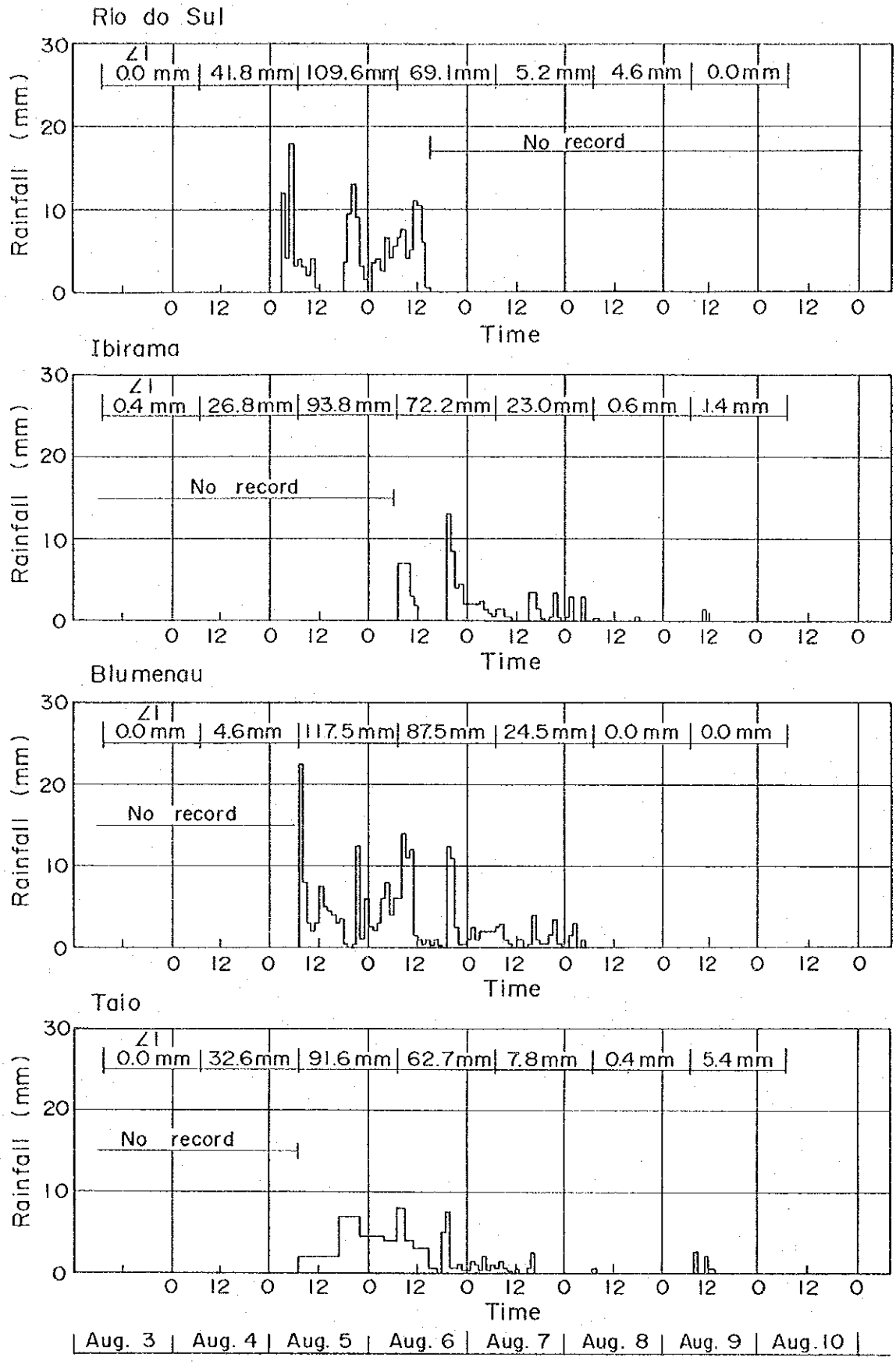


Fig. II.3.3 HOURLY RAINFALL DISTRIBUTION (2/3)
(August 1984)



∠I : 1-day rainfall amount

Fig. II.3.3 HOURLY RAINFALL DISTRIBUTION (3/3)
(August 1984)

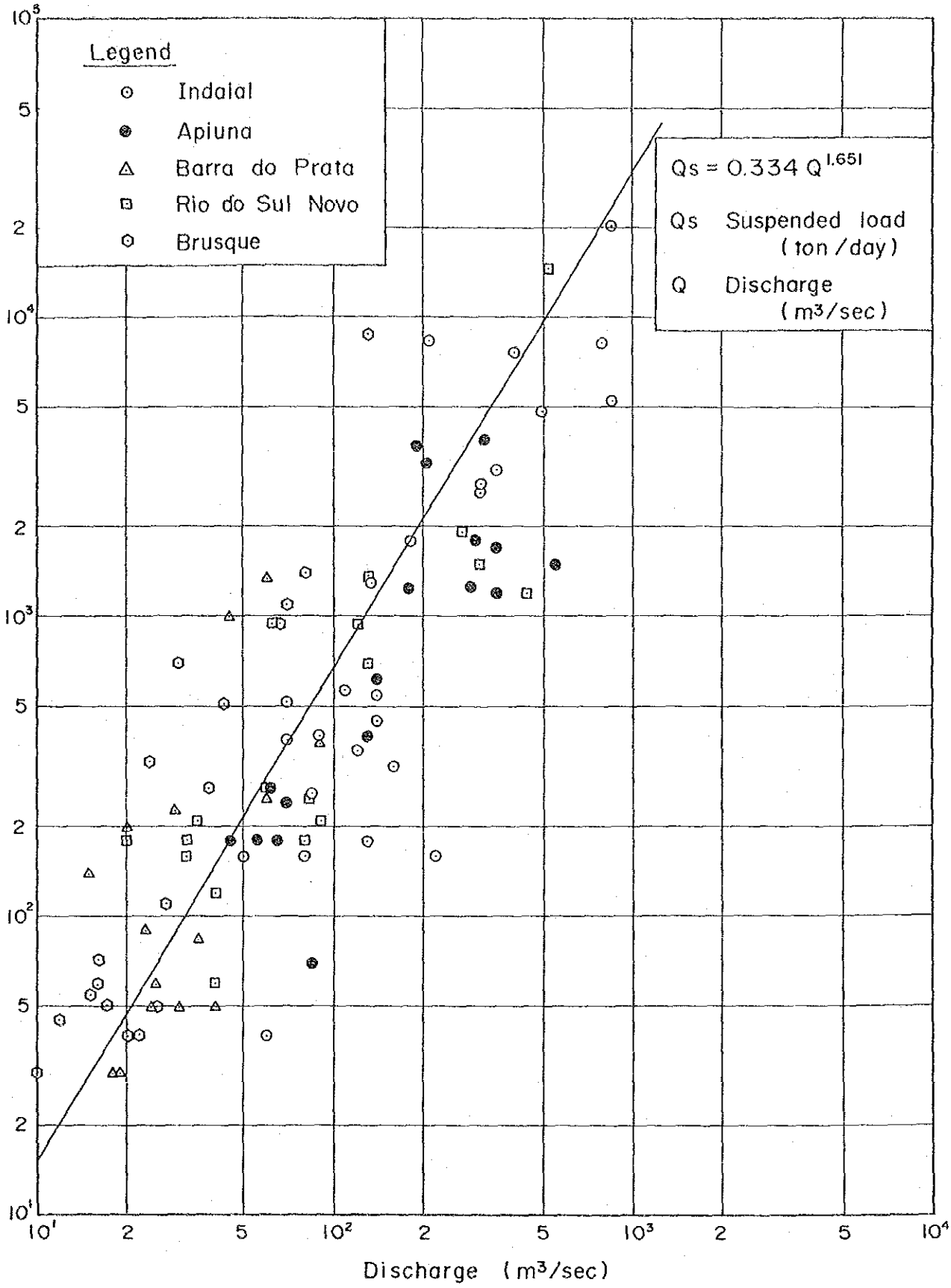
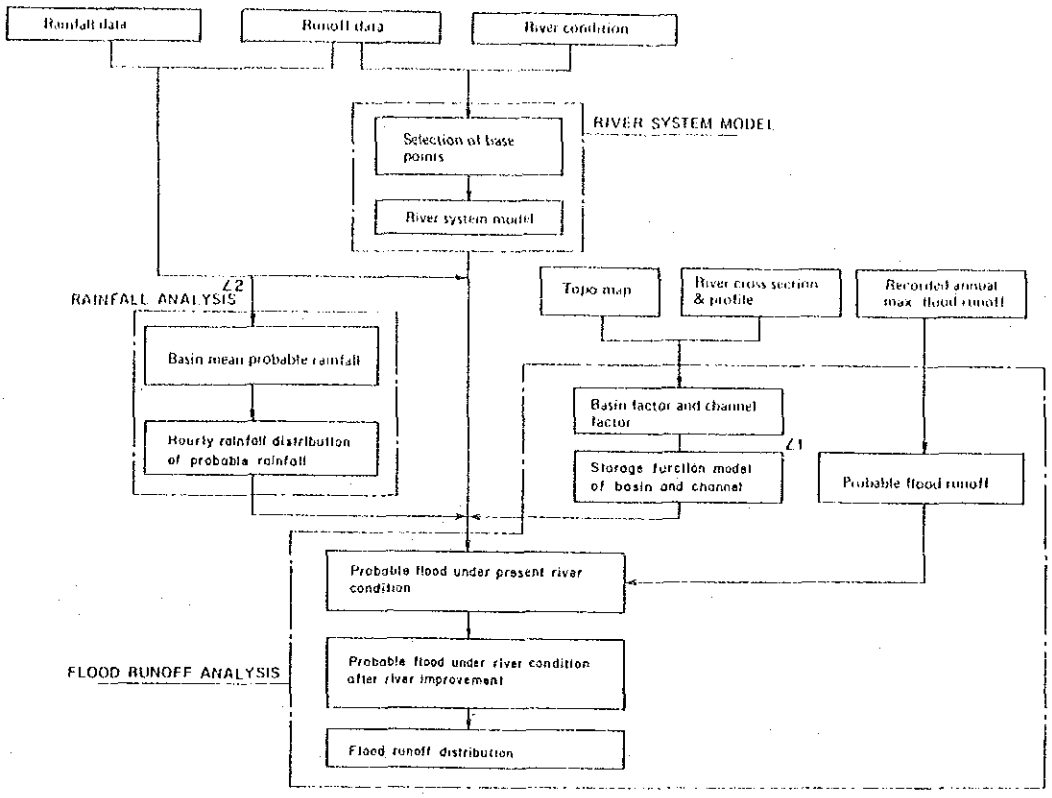
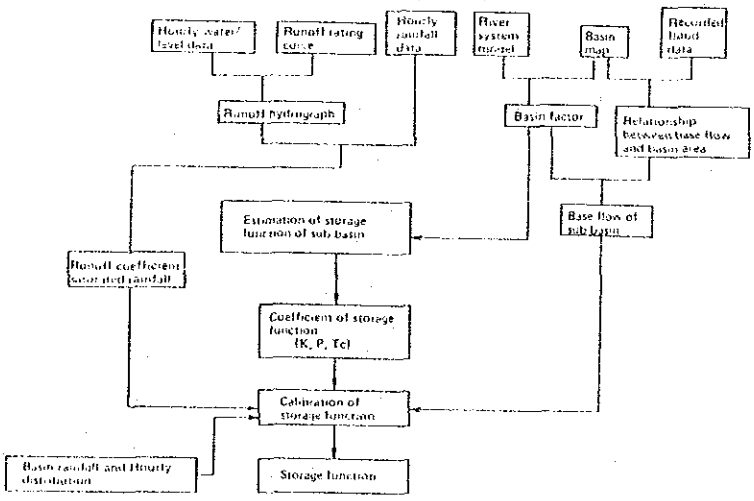


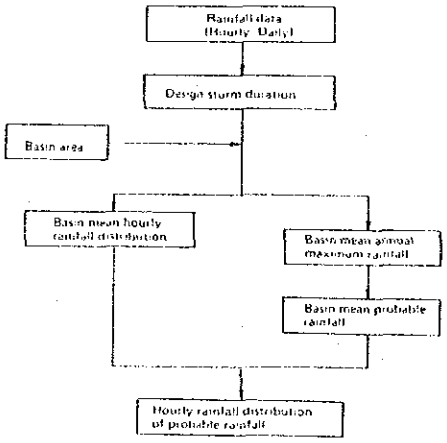
Fig. II.3.4 RELATION BETWEEN SUSPENDED LOAD AND DISCHARGE



GENERAL FLOW CHART OF FLOOD ANALYSIS



∠1. STORAGE FUNCTION MODEL OF BASIN AND CHANNEL



∠2. RAINFALL ANALYSIS

Fig. II.4.1 GENERAL PROCEDURE

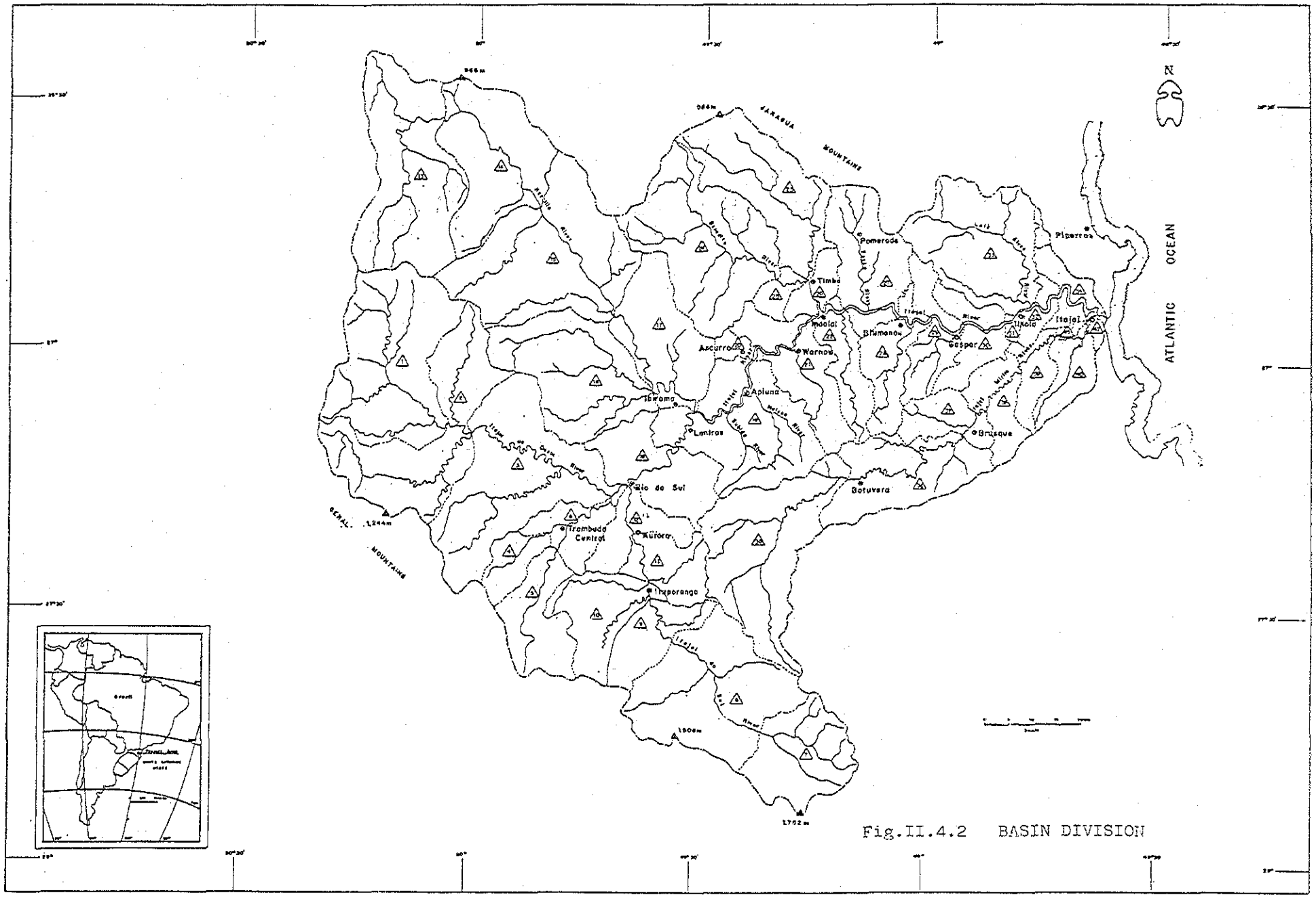


Fig.II.4.2 BASIN DIVISION

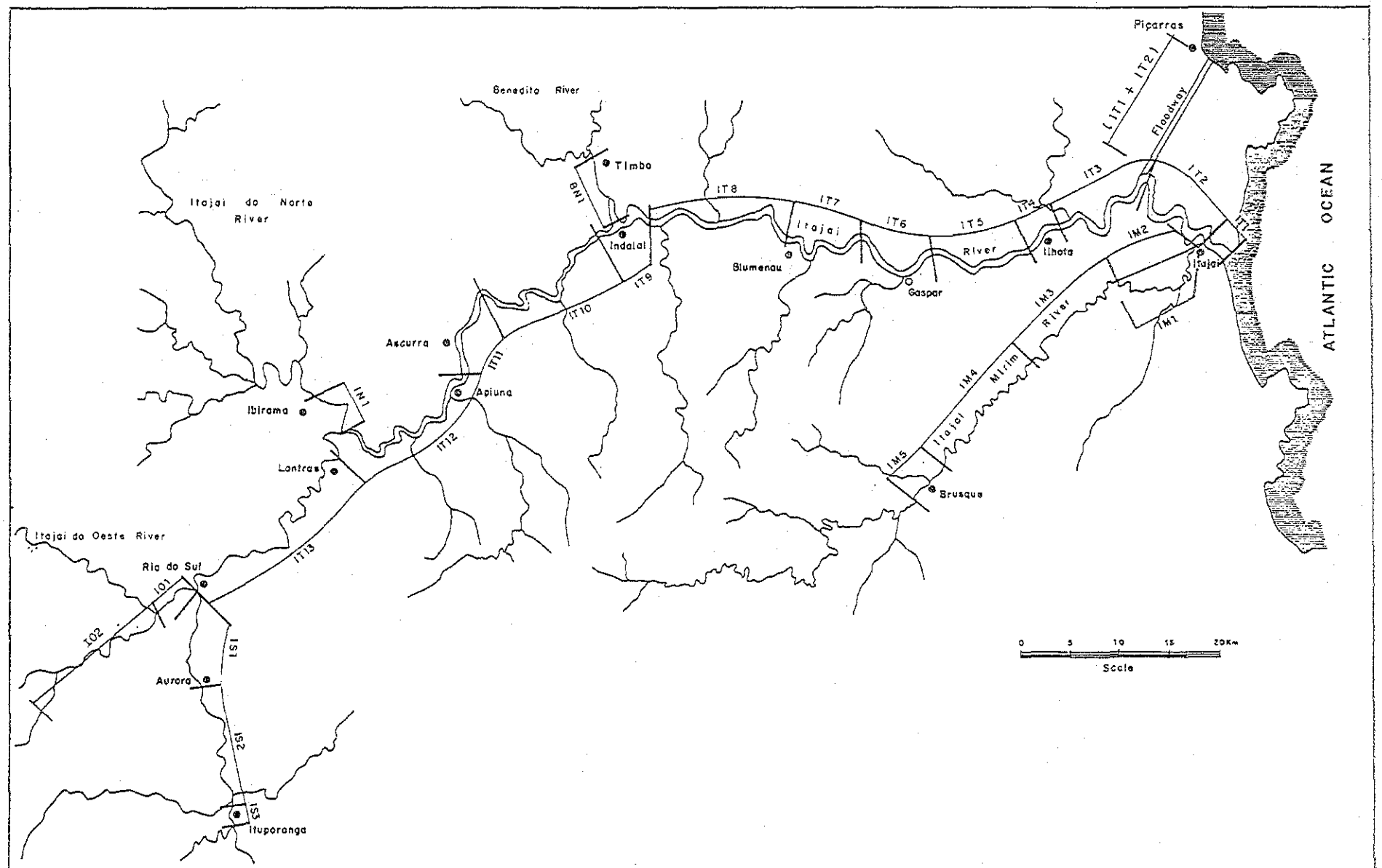


Fig. II.4.3 RIVER STRETCHES FOR FLOOD ANALYSIS

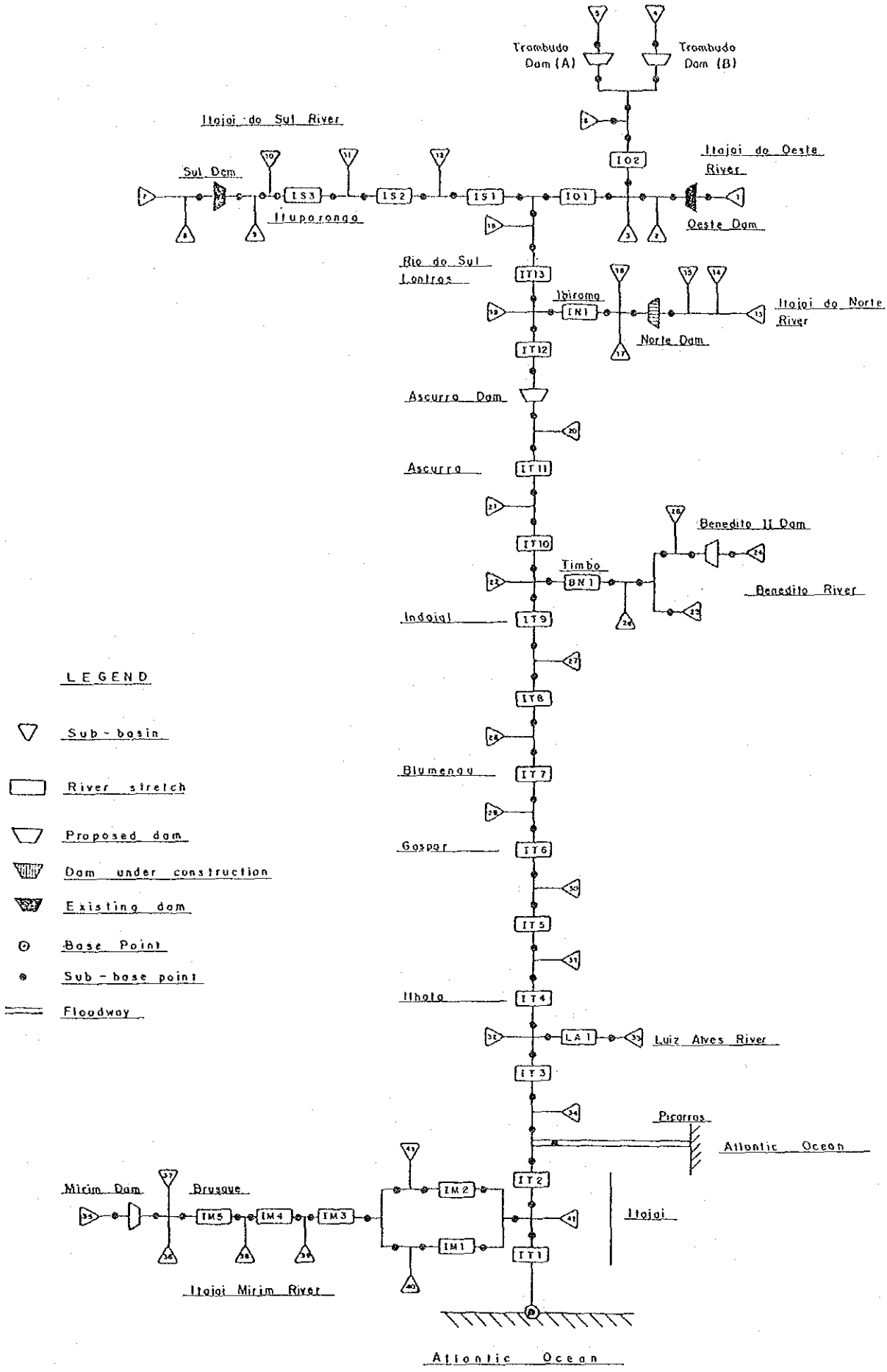


Fig. II.4.4 RIVER SYSTEM FOR FLOOD ROUTING

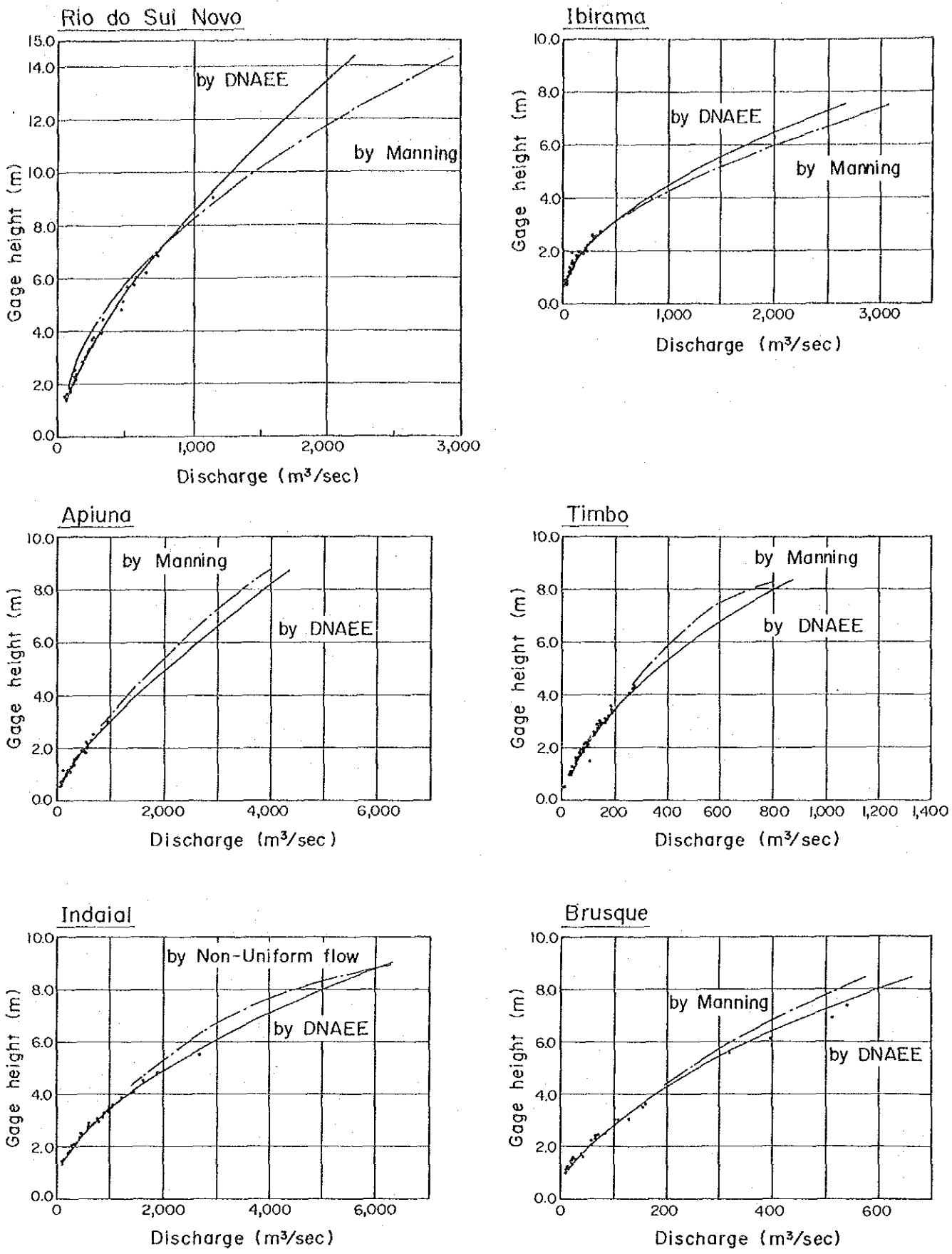


Fig. II.4.5 RELATION BETWEEN GAGE HEIGHT AND DISCHARGE

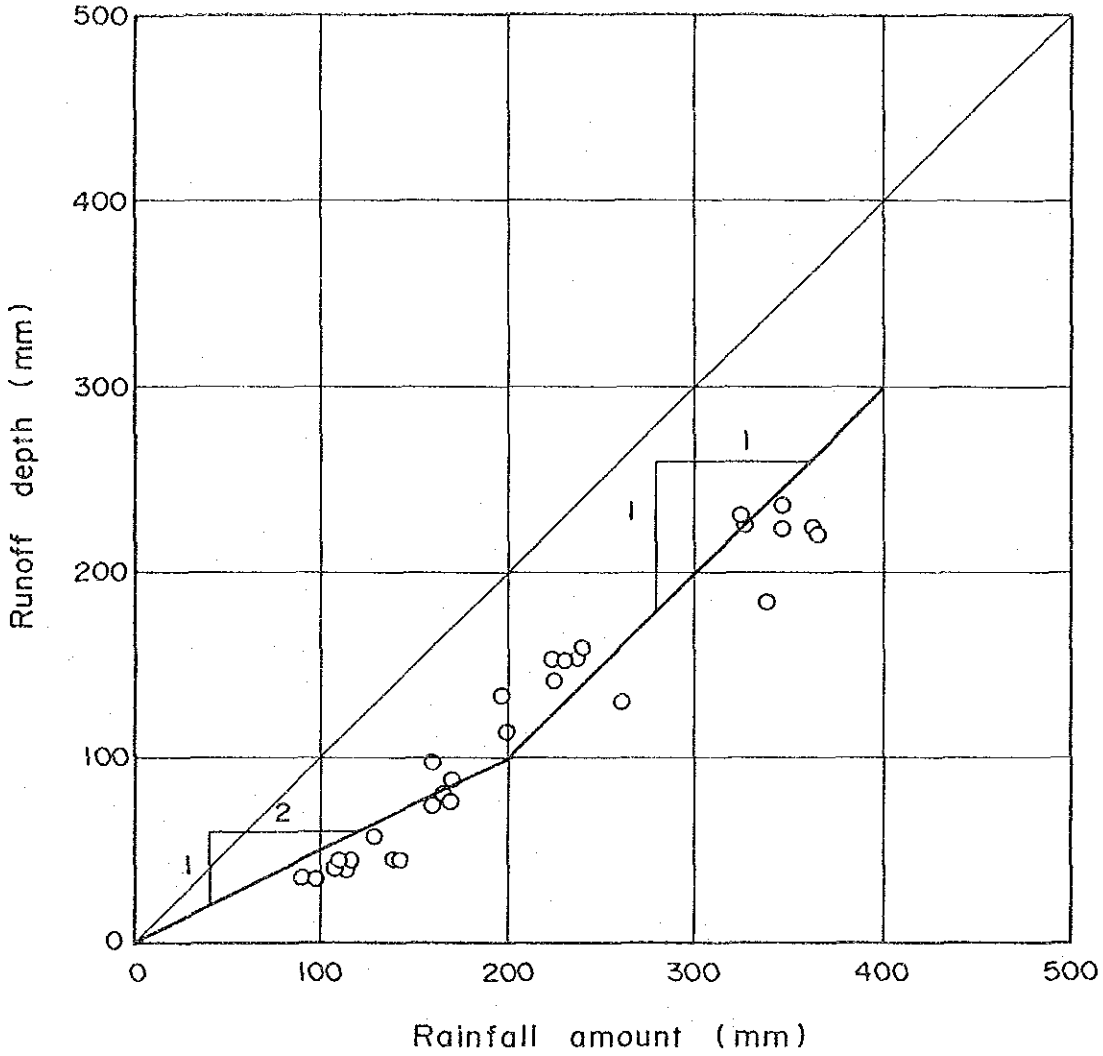


Fig. II.4.6 RELATION BETWEEN RAINFALL AMOUNT AND RUNOFF DEPTH

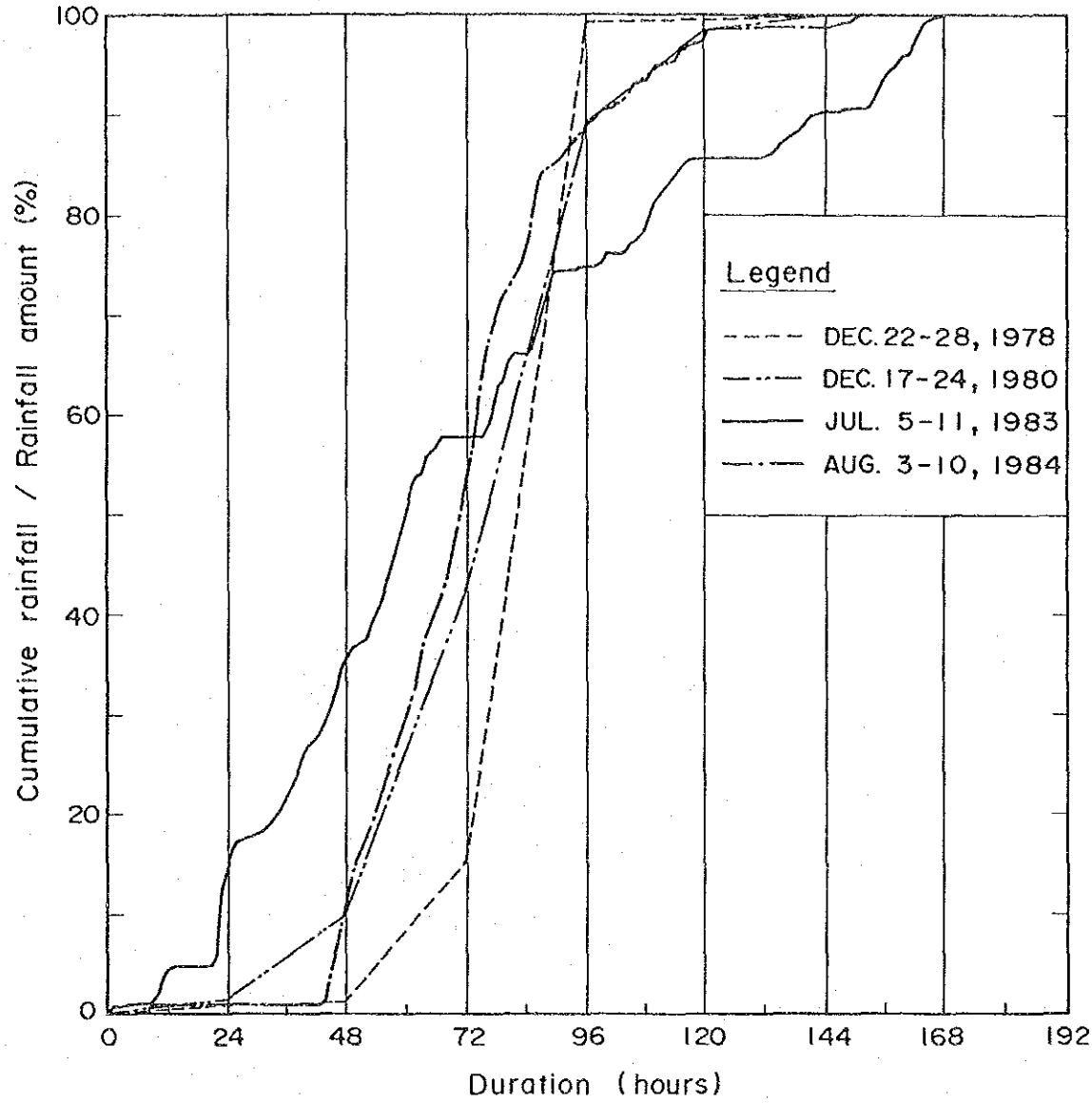


Fig. II.4.7 RELATION BETWEEN BASIN MEAN RAINFALL AND DURATION DURING RAIN STORM

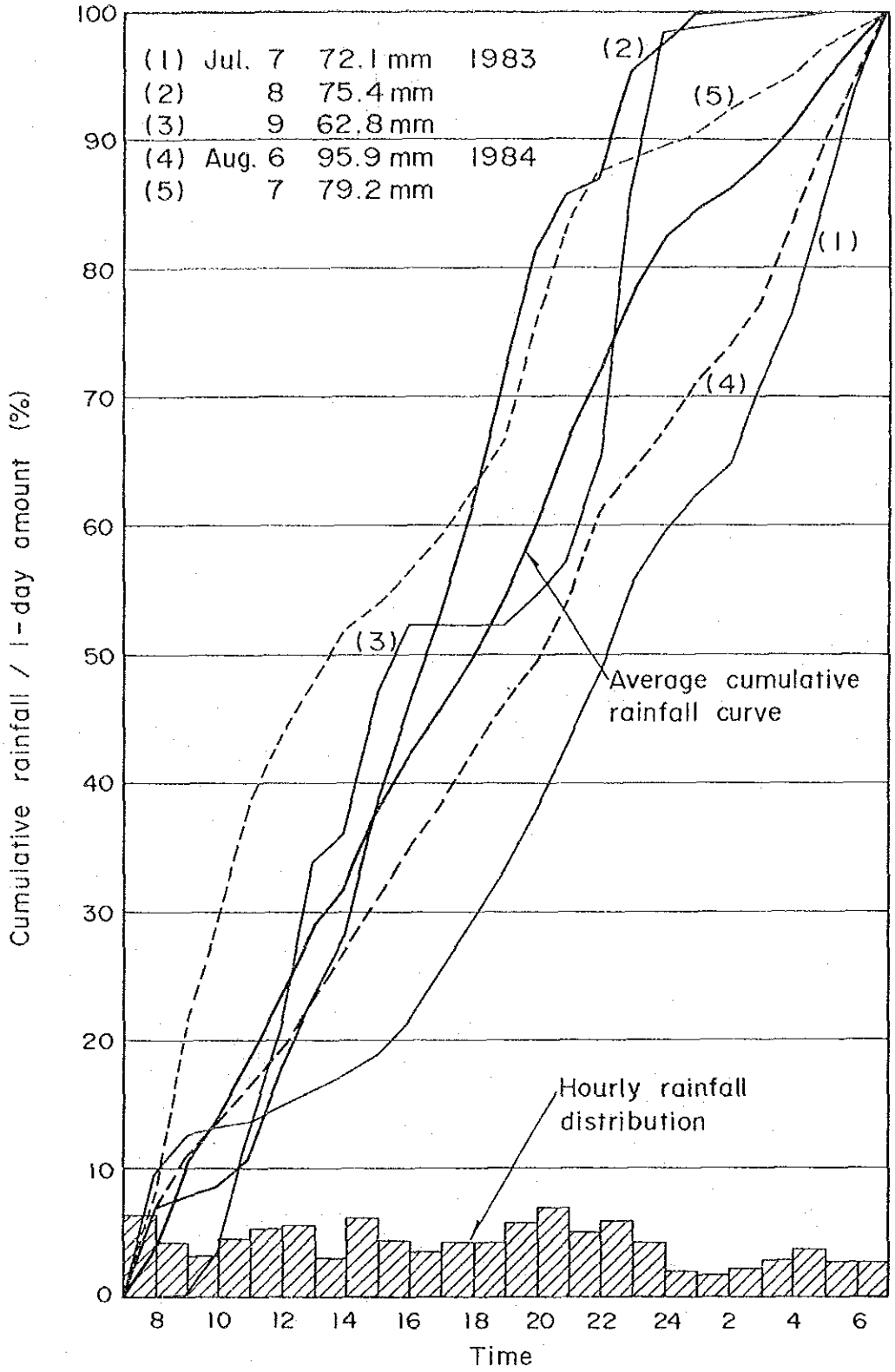


Fig. II.4.8 ESTIMATED DAILY RAINFALL PATTERN

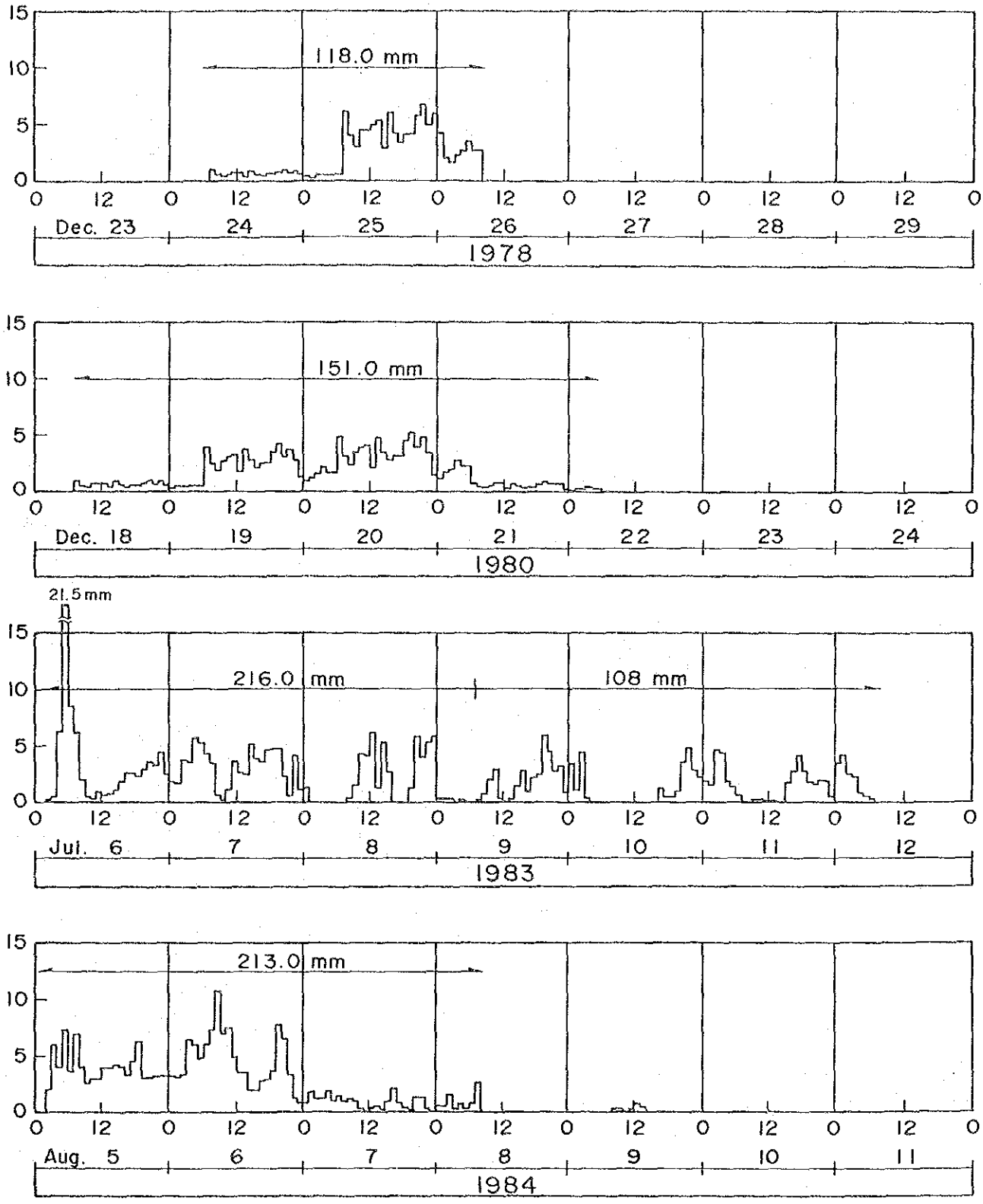


Fig. II.4.9 BASIN MEAN HOURLY RAINFALL DISTRIBUTION

NO.	Name of station	NO. of station	Thissen's Coefficient	Coefficient *
1	Witmarsum	2649053	0.041	-
2	Rio do Campo	2650014	0.084	-
3	Salt Canoinhas	2650000	0.023	-
4	Barragem Norte	2649061	0.032	-
5	Brusque	2748000	0.078	0.085
6	Barra do Prata	2649058	0.052	-
7	Itaiopolis	2649054	0.018	-
8	Pomerode	2649002	0.011	0.057
9	Picarras	2648019	0.021	-
10	Luiz Alvez	2648002	0.034	0.035
11	Bom Retiro	2749032	0.013	0.039
12	Ponte Alta	2750011	0.002	-
13	Lages	2749009	0.019	-
14	Trombudo Central	2749013	0.063	0.102
15	Anitapolis	2749027	0.005	-
16	Vidal Ramos	2749033	0.049	-
17	Apiuna	2749025	0.063	0.046
18	Rio dos Cedros	2649008	0.034	0.044
19	Garcia	2649009	0.042	0.059
20	Itoupava Central	2649010	0.021	0.062
21	Doutor Pedrinho	2649017	0.059	-
22	Ibirama	2749001	0.028	0.116
23	Ituporanga	2749002	0.054	0.042
24	Lomba Alta	2749007	0.042	0.065
25	Rio do Sul	2749024	0.039	0.082
26	Taio	2749003	0.073	0.111
	Total		1.000	

Note: Thiessen's coefficient is applied to estimation of basin mean rainfall from 1977 to 1984.
Coefficient * is applied for the period from 1951 to 1976.

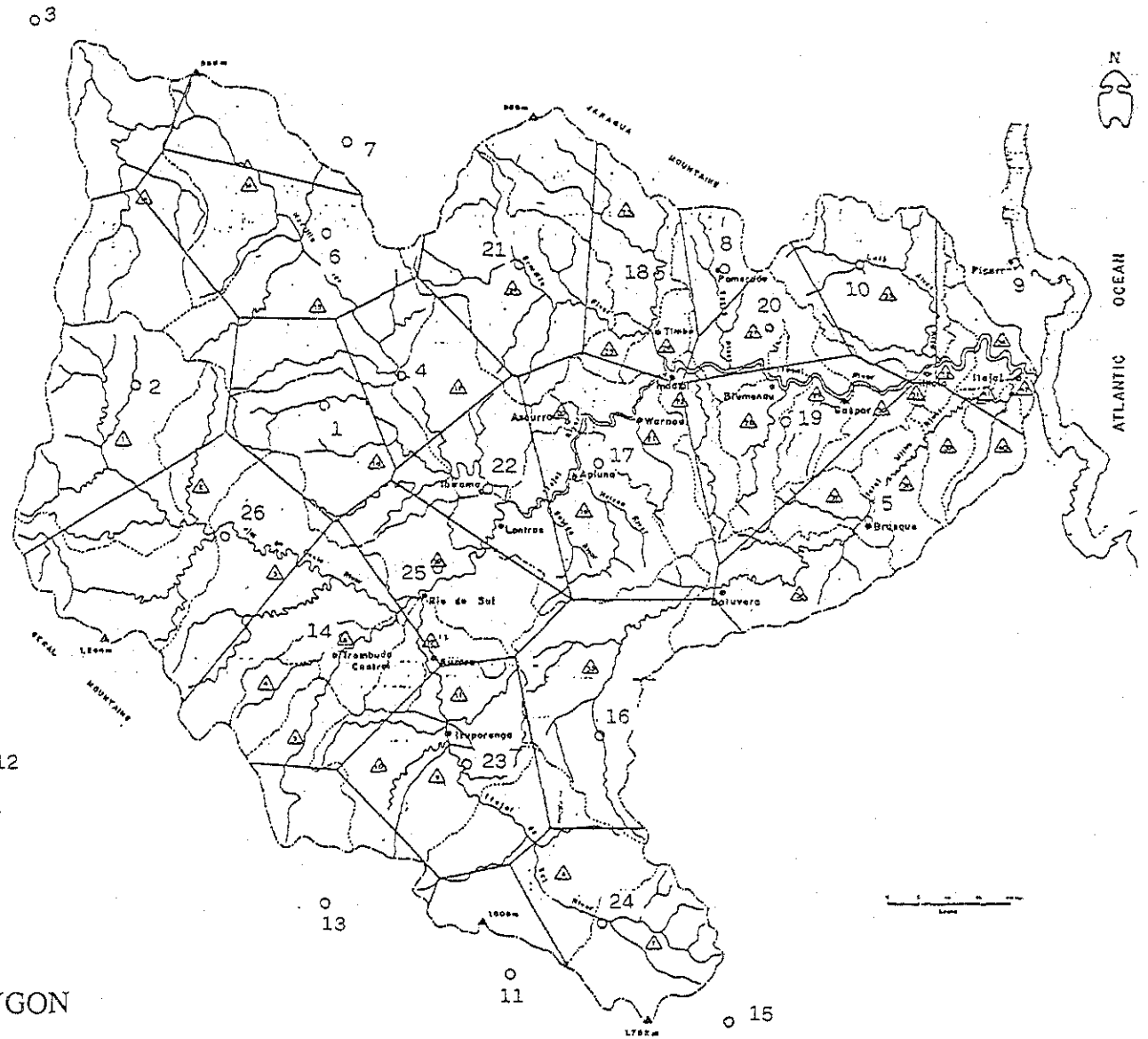


Fig.II.4.10 THIESSEN POLYGON

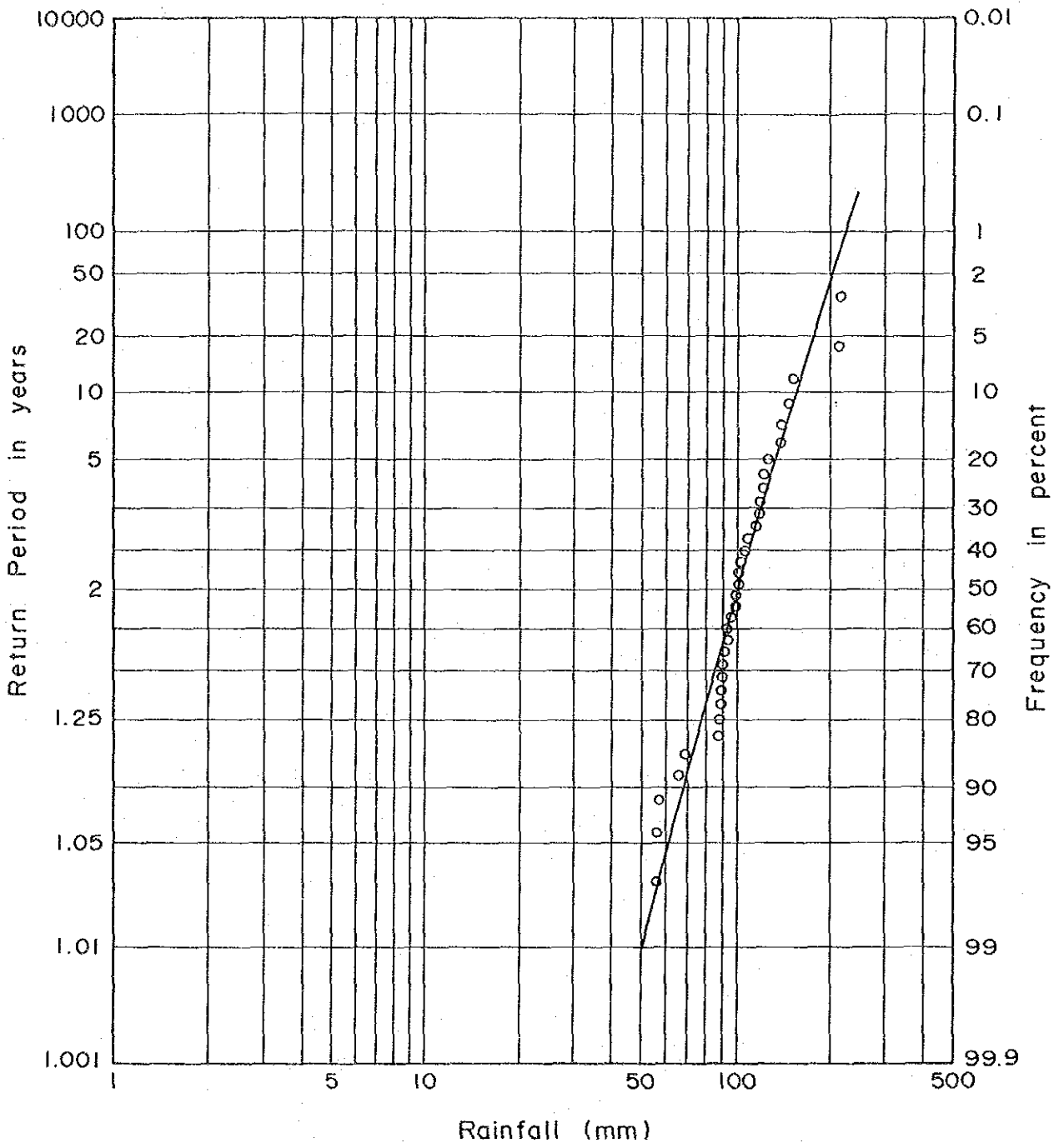


Fig. II.4.11 FREQUENCY CURVE OF ANNUAL MAX. 4-DAY RAINFALL