Work Items	Unit	Q'ty	1st Year	2nd Year	3rd Year	4th Year	5th Year
A. River Improvement Works							
1. Itajai River							
(1) Riverbed dredging	cu.m	8,156,000					
(2) Levee embankment	cu.m	743,900					
(3) Parapet wall construction	cu.m	19,700					
2. Floodway Construction							
(1) Excavation, common	cu.m	4,343,200					
(2) Dredging	cu.m	3,006,800					
(3) Excavation, rock	cu.m	150,000					
(4) Levee embankment	cu.m	140,000					
(5) Riverbed protection	sq.m	5,400					
(6) Slope protection	sq.m	5,200					
(7) Road relocation (BR-470)	lin.m	2,100					
(8) Bridge construction, newly	set	2					
(9) Jetty, dredging seabed	cu.m	480,000					
(10) Jetty, embankment (core, filter & armor stone)	cu.m	1,123,000					
(11) Jetty, tetrapod, 16 t	pcs	3,675					
3. Itajai Mirim River							
(1) Riverbed dredging	cu.m	151,400					
(2) Exca., channel & short-cut cha	cu.m	180,400					
(3) Levee embankment	cu.m	725,400					
(4) Heightening existing bridges	set	4					
4. Itajai Mirim Short-cut Channel							
(1) Riverbed dredging	cu.m	227,100					
(2) Excavation, channel	cu.m	53,200					
(3) Levee embankment	cu.m	137,900					
(4) Parapet wall construction	lin.m	320					
B. Urban Drainage Works							
1. Regulation Ponds							
(1) Excavation	cu.m.	258,000					
(2) Embankment	cu.m	28,000					
2. Sluiceway in Regulating Ponds							
(1) Excavation	cu.m	3,000					
(2) Foundation piling	-	L.S.					
(3) Concreting	cu.m	280					
(4) Revetment/Gabion	sq.m	1,550					
(5) Flap gate	-	L.S.					
3. New Drainage System							
(1) Channel exca., Murta river	cu.m	85,000					
(2) Filling low land area	cu.m	210,000					
(3) Concreting	cu.m	3,800					
4. Pumping Station							
(1) Civil works	lot						
(2) Electro-mechanical works	lot			(Manufacturing)			
(3) Building works	lot						

Fig. VIII.2.4 CONSTRUCTION TIME SCHEDULE FOR LOWER ITAJAI RIVER IMPROVEMENT PROJECT

ANNEX IX.

STUDY ON FLOOD FORECASTING AND WARNING SYSTEM

ANNEX IX. STUDY ON FLOOD FORECASTING AND WARNING SYSTEM

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ANNEX IX. STUDY ON FLOOD FORECASTING AND WARNING SYSTEM

1. BACKGROUND OF THE STUDY

The Itajai river basin has a long history of flooding and large scale floods took place in 1983 and 1984. These floods caused damage in the whole basin. Inundation along the Itajai river and its tributaries extended over the territory of 18 municipalities. The inundated area reached 270 km^2, which accounts for about 2% of the total catchment area (15,220 km^2) of the Itajai river basin. The sum of flood damages in the entire Santa Catarina state, caused by these floods, was about Cr$ 715 billion in 1983 and Cr$ 323 billion in 1984.

DNAEE installed a flood forecasting and warning system (herein called FFWS) in the Itajai river basin and started its preliminary operation in August 1984. The existing system is being operated using meteo-hydrological data observed at five rainfall and water level gauging stations which are located at Taio, Ituporanga, Ibirama, Apiuna and Blumenau. Prediction of flood occurrence is made only for Blumenau city based on the observed data at present.

The master plan recommended reinforcement of the current hydrological network which is insufficient for grasping the hydrological condition of such a large catchment area of the Itajai river basin. In line with this recommendation, DNOS and Santa Catarina state government requested JICA to study the improved flood forecasting and warning procedures and methods, required facilities including radar rain gauge system and investment cost for this system on the preliminary study level.

2. NATURAL CONDITIONS IN THE ITAJAI RIVER BASIN

2.1 Topographic Condition

The Itajai river basin shown in Fig. IX.2.1 is surrounded by mountains of EL.1,000 m to EL.1,800 m and has a catchment area of about 15,220 km^2.

The Itajai river, originating in the mountain range with altitude of 1800 m in the southwestern part of the basin, flows northward as the Itajai do Sul river and joins the Itajai do Oeste river at Rio do Sul city. After joining the Itajai do Oeste river, it is named the Itajai river and flows down changing its direction northeastwards. After flowing down for a distance of about 20 km along its course, it joins the Itajai do Norte river near Ibirama city. Afterwards, the Itajai river flows down northeastwards passing Ascurra and Indaial cities, and changes its direction to the east. The Itajai river flows about 10 km long cascaded river course to Blumenau city, the largest city in the basin, and after passing through a V-shaped meandering river stretch along the Blumenau city, it flows down through a remarkably gentle sloped river course collecting several small tributaries. Near Itajai city, the Itajai river joins the Itajai Mirim river and finally it debouches into the Atlantic Ocean. The total river length is about 250 km.

Catchment areas of major tributaries are as follows;

	Name of Tributary	Catchment Area (km^2)
1)	Itajai do Sul river	2,166
2)	Itajai do Oeste river	3,050
3)	Itajai do Norte river	3,360
4)	Benedito river	1,521
5)	Testo river	405
6)	Luis Alves river	590
7)	Itajai Mirim river	1,699
8)	Other small tributaries	2,429
	Total	15,220

2.2 Hydrological Condition

2.2.1 Rainfall characteristics

According to the isohyetal map as shown in Fig. IX.2.2 which was prepared based on the rainfall records for the period from 1941 to 1984 at the existing rainfall gauging station, the annual mean rainfall in the Itajai river basin is estimated at about 1,600 mm, ranging from 1,300 mm in the center of the basin to 1,700 mm in the mountainous area.

Monthly rainfall distributions at the existing rainfall gauging stations in the major tributaries are illustrated in Fig. IX.2.3 and that in 1983 when the large scale flood corresponding to 50-year probable flood occurred, is also given in the same Figure for its comparison.

Fig. IX.2.4 shows the isohyetal map of the rain storms in 1978, 1980, 1983 and 1984 which caused large scale floods after construction of the Oeste dam in 1972 and Sul dam in 1975. Heavy rainfall occurred in the mountainous areas of the main tributaries which are the Benedito, the Itajai do Norte, the Itajai do Oeste, the Itajai do Sul and the Itajai Mirim rivers. Especially during the 1984 flood, intensive daily rainfall of around 150 mm took place in the Itajai Mirim river basin. The rainfall characteristics of these rain storms are summarized as follows:

Rain Storm	Basin Mean Rainfall (mm)		Duration (days)
	1-day	Total	
Dec. 1978	110	124	2
Dec. 1980	65	138	3
Jul. 1983	64	324	7
Aug. 1984	110	210	3

According to hourly rainfall distribution recorded in July 1983 and August 1984 as shown in Fig. IX.2.5, a maximum hourly rainfall in a range of 10 to 25 mm/hour was observed in 1983 and 1984 in the basin. Those rainfalls are not so intensive but they lasted for more than 3 days.

2.2.2 Flood runoff characteristics

Flood peak discharge at 6 stations during the floods in December 1978, December 1980, July 1983 and August 1984 are listed as follows:

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. IX.2.6 have the rising rim of 1 to 2 days and tail-off of 3 to 4 days. The flood in 1983 is characterized by the long duration time of the flood peak.

2.3 Flood Damage

Most of the major cities and municipalities located in the basin as listed in Table IX.2.1 were damaged due to inundation by the 1983 and 1984 floods.

Total area inundated reached 270 km^2 which is about 2% of the catchment area (15,220 km^2) of the Itajai river basin as described in the foregoing Chapter 1. Total population and houses inundated reached 141,711 and 31,692 in the Itajai river basin, respectively. The sum of flood damages caused by these floods in the entire Santa Catarina state was about Cr$ 715 billion in 1983 and Cr$ 323 billion in 1984.

3. EXISTING FLOOD FORECASTING AND WARNING SYSTEM

The existing FFWS shown in Fig. IX.3.1 was installed by DNAEE, which was established after the flood in 1984. DNAEE is responsible for river and water resources management of the Itajai river. However, the responsibility was handed over to the state government of Santa Catarina in 1989.

The operational organization and installed equipment/facilities are described in the following Sections.

3.1 Organization and Its Functions

The organization of the existing FFWS is shown in Fig. IX.3.2. It is controlled by the Santa Catarina State Government and Departamento Nacional de Agua e Energia Eletrica (National Department for Water and Hydropower: DNAEE), Ministry of Mining and Energy (MME).

DNAEE established the Central Operation Station (CEOPS) in Blumenau in the Itajai river basin, and DNAEE's regional office in Curitiba in Parana State which exercises jurisdiction over the Itajai river basin. CEOPS has the key role of control, processing and analysis of data and information and forecasting.

Santa Catarina State Government organized the Coordination of Civil Defense (CEDEC) in 1973 and has responsibility for public information and relief action against disasters such as flooding, violent wind, etc. CEDEC also gives flood warnings based on its criteria, receiving several kinds of data and information from agencies concerned.

The announcement of flood warning to the inhabitants along the river is basically done by the Municipal Commission for Civil Defense (COMDEC), which is subordinate to CEDEC and organized by each municipal unit, and emergency relief action is taken also by COMDEC. At present, 53 COMDECs are organized in the Itajai river basin.

CEDEC also has a Committee for Coordination of Disaster Activity (Grupo de Atividaded Coordenadas: GRAC) which is composed of private and public agencies concerned. This committee aims at integrating the defense and relief activities to be carried out by each agency.

3.2 Existing Facilities for Flood Forecasting and Warning

3.2.1 Hydrological observation network

The existing FFWS is operated by a simple telemetering system which consists of five rainfall and water level gauging stations equipped with a data transmission system by telephone line, located at Taio on the Itajai do Oeste river, Ituporanga on the Itajai do Sul river, Ibirama on the Itajai do Norte river, Apiuna and Blumenau along the Itajai main stream. In addition, the stations also have a voice and observer channel of communication with CEOPS for checking data sent by the existing FFWS and for sending emergency information.

The observed data at each station are transmitted by the telephone and telex system to CEOPS. CEOPS receives the data at 7:00, 10:00, 15:00 and 17:00 in normal periods and every two hours in case of rising of water levels. At each station, the data are recorded by an automatic recorder and periodically sent to CEOPS in Blumenau.

3.2.2 Flood forecasting and warning method

(1) Flood forecasting

CEOPS has been developing the forecasting method based on the rainfall and water level records transmitted by the hydrological observation system. Current flood forecasting is worked out based mainly on correlation and regression analyses between water level/water level and/or water level/rainfall by a computer separately from the existing data transmission system.

(2) The existing flood control dams

The existing three dams, Sul, Oeste and Norte dams, were constructed by DNOS solely for flood control in the Itajai river basin. These dams have an over-flow non-gated spillway and gated discharge valves at the bottom of the dam as shown in Table IX.3.1 and these gates are operated as follows:

a) Discharge valves are fully opened in the normal condition.
b) All the valves are closed in principle, when a rain storm is observed at the dam site or when the reservoir water depth reaches 10 m from riverbed.

The information about water levels up/downstream of the dam and released discharge from spillway are sent through DNOS to CEDEC in Florianopolis by telephone or HF/SSB radio communication system owned by the 14th DNOS office. CEOPS independently obtains the information about dam operation from the dam site office by telephone according to water level at Blumenau.

(3) Warning criteria and target area

The warning and critical water levels of each city are as follows:

Target Area	Water Level		
	Attention (m)	Warning (m)	Critical (m)
Taio	4.00	6.00	7.00
Ituporanga	2.50	3.00	4.00
Rio do Sul	4.00	6.00	7.00
Ibirama	3.00	3.50	4.30
Indaial	3.50	4.30	5.20
Blumenau	5.00	6.00	8.50

Water level indicates the gauge reading measured at each water level gauging station.

3.2.3 Evacuation system

The evacuation system has been developed for each city taking into account inundation area due to the probable flood water level and the existing road network in the city area, however evacuation times and locations have not yet been examined in this system. Training for flood protection and evacuation has never been executed in the inundated cities of the flood prone area.

3.2.4 Telecommunication system

The existing telecommunication system is as follows:

Description	Communication Method
Hydrological observation station and CEOPS	HF/SSB Radio system (5.4, 7.5 and 10.5 MHz)
CEOPS and CEDEC	Telex
CEDEC and COMDEC	Telephone

CEDEC has been developing the data and information collecting system (Curso Basico de Defensa Civil para Radioamador) by connecting the HF and VHF radio of CEDEC

Florianopolis with the private radio users in Santa Catarina State. At present, about 1,000 users are registered in this system.

3.3 Extension Plan Contemplated by Governmental Organization Concerned

Santa Catarina State Government and Fraiburgo-Fruit-Growers Cooperative which consists of eight private companies planting apple trees and is located at 280 km west of the Itajai are constructing a radar at Fraiburgo where elevation is about EL.1,000 m so as to detect hail clouds and break them up by chemical dispersion with rockets. The location of Fraiburgo is illustrated in Fig. IX.4.4.

The radar system is made in the Soviet Union and is named "MRL-5 Model". Radar can detect the occurrence of hail within a 300 km radius.

CEDEC intends to utilize this radar system for FFWS in the Itajai river basin and CEOPS in Blumenau has proposed to the MME to use this system and to finance the additional equipments such as data transmission line from Fraiburgo and computer system analyzing the data transmitted. Total project cost is estimated at Ncz$ 4,924,958 including radar installation.

4. INTEGRATED FLOOD FORECASTING AND WARNING SYSTEM

4.1 Basic Concept for FFWS

4.1.1 Necessity of the Integrated FFWS

The Itajai river basin has a flood forecasting and warning system established by DNAEE, which consists of five rainfall and water level gauges and a computer for forecasting flood occurrence at the municipalities along the Itajai river and tributaries. The existing hydrological observation system, however, is considered to be insufficient to cover the whole Itajai river basin and to predict flooding at the target areas spreading in the basin. Besides, since the transmission of the information and data is made by telephone and telex, it is feared that this communication system may be interrupted by onrushing flood.

Such related agencies as DNOS and the State Government have independently developed their communication system. Their system may be insufficient to timely transmit and analyze the information on hydrological condition in the basin and to disseminate flood warning to the inhabitants along the river course.

From the above-mentioned, it is required to establish the integrated FFWS system and its organization for the sake of; 1) obtaining sufficient data and information on rain storms such as instantaneous rainfall amount and its movement, development and attenuation of rainy area; 2) forecasting flood occurrence based on these data; and 3) quickly and effectively disseminating the flood warning to the inhabitants along the Itajai river and its tributaries.

4.1.2 Target area

FFWS to be studied aims at issuing flood forecasting and warning to inhabitants in 18 municipalities as listed in Table IX.2.1 along the Itajai river and tributaries widely spread in the basin. The targeted municipalities are summarized as follows:

	River Basin	Number of Target Municipalities	Municipality
1.	Itajai do Sul river	3	Ituporanga, Agronomica, Aurora
2.	Trombudo river	1	Trombudo Central
3.	Itajai do Oeste river	1	Taio
4.	Itajai do Norte river	1	Ibirama
5.	Benedito river	1	Timbo
6.	Itajai Mirim river	1	Brusque
7.	Along the Itajai river	10	Rio do Sul, Ascurra, Rodeio, Apiuna, Indaial, Blumenau, Gaspar, Ilhota, Itajai, Navegantes
	Total	18	

4.1.3 Flood forecasting method and required information

Flood forecasting is to predict the extent of the oncoming flood and its arrival time at target areas based on the meteorological and hydrological information.

There are two methods of flood forecasting, namely, mathematical flood simulation model method based on rainfall data and statistical model method established by correlation and regression analyses of meteo-hydrological data.

CEOPS established the forecasting model in the existing system only for estimate of flood water level at Blumenau applying the latter method based on the water level data at Blumenau and Apiuna gauging stations. CEOPS has an intention to extend this method for all the foregoing target areas. But application of this method will be limited only for a certain target area where there is no large tributaries between the envisaged target area and key gauging station and lag-time of flood flow is comparatively long to evacuate the inhabitants in the target area from the onrushing floods. According to the water level records and result of hearing to inhabitants in the target areas, rising time of water level from the warning water level to critical water level in CEDEC's criteria is so short as being 2 or 3 hours in tributary area and 6 to 8 hours in target areas along the main stream of Itajai river for floods in 1983 and 1984. Besides this method is not suitable to apply to the target areas along low Itajai river downstream of Blumenau since that river stretch is affected by tide wave and inundation and consequently it is not considered that the forecasted result has a high accuracy.

To carry out flood forecasting with high accuracy and to derive a sufficient evacuation time, the mathematical flood simulation model method based on rainfall data is proposed.

The proposed forecasting model requires instantaneous rainfall data covering the whole basin to simulate flood discharge. It is required for this purpose to observe such rainfall characteristics as rainfall amount, its movement and attenuation of rainy area with high accuracy in the basin on the real time basis. The forecasting model also requires water level data at the up/downstream of the existing dam sites and in the target areas to establish the model and to monitor actual water level and the forecasted results. To obtain the rainfall and water level data at real time, it is proposed to establish the flood forecasting system with telemetering rainfall and water level gauging stations in the basin.

It is predicted to increase the population in the urban areas with an annual growth rate of about 3% in the basin area. It will be needed to obtain the flood forecasted result with higher accuracy and to derive longer evacuation time with an increase in flood damage potential due to increase in population and extension of urban area. Then, it will be necessary to detect the area rainfall in addition to the spot rainfall and change of rainy area. To meet this requirement, the flood forecasting system with a radar rain gauge system will be proposed. However, since the radar rain gauge requires long-term and sufficient rainfall data to establish the model showing the relation between radar echo and rainfall, its installation will be made after the establishment of data base of rainfall and water level records obtained from the telemetered gauges..

In consideration of the foregoing situations, it is herein proposed to proceed with the flood forecasting method dividing into the following three stages;

(1) 1st stage; It is intended to improve the existing system for the purpose of;

a) Obtaining the meteo-hydrological data at the mountainous area and existing damsites on real time basis, and
b) Monitoring flood water level in the target areas.

To meet these purposes, the existing observation stations will be improved by means of telemetering system and additional telemetered rainfall gauges at the mountainous areas upstream of the existing dams and telemetered water level gauges at up and downstream of the existing damsites and at the flood prone areas will be installed. This system will be used not only for flood forecasting by means of statistical method by correlation of meteo-hydrological data but also for obtaining the fundamental data for establishment of simulation model based on rainfall data.

(2) 2nd stage; The flood forecasting by means of mathematical flood simulation model method will be made for all the target areas in the basin. To meet this requirement, telemetered rainfall gauges will be additionally installed at the mountainous areas.

(3) 3rd stage; The radar rain gauge system to obtain area rainfall data in addition to spot rainfall will be installed not only to identify the movement of rain cloud timely also to utilize this information for dam operation for flood regulation.

4.1.4 Flood warning and dissemination procedures

Flood warning has been issued by CEDEC to the municipal governments by telephone based on the criteria described in Chapter 3 and forecasted results and hydrological information sent from CEOPS. Dissemination of flood warning is made by newspaper, radio and television through COMDEC in the existing FFWS. In the current dissemination manner, there is a possibility that immediate action may be difficult against flood which occurs suddenly and/or at night time.

The proposed flood warning system is planned to apply the existing criteria for issuing the flood warning although the review for this criteria is necessary in a further stage. The existing dissemination method, however, may be insufficient to timely inform flood onrushing to all the inhabitants in the target areas. Therefore, the following procedures are planned to be applied to supplement the existing manner:

a) Flood warning to inhabitants in urban area of Blumenau, Rio do Sul, Itajai and Brusque municipalities will be made by loud speaker to give clear information.

b) Flood warning to inhabitants in other target areas will be made by patrol cars and motorcycles equipped with speakers, warning light and walkie-talkie, which are distributed at Blumenau, Rio do Sul, Itajai and Brusque. These mobiles will carry out the dissemination of information to the municipal governments and inhabitants along the Itajai river and its tributaries within one hour by car distributed at the said four cities.

4.1.5 System components

The proposed FFWS requires the following five components to smoothly carry out flood forecasting and warning activities and evacuation of the inhabitants:

(1) Hydrological observation network which enable to carry out observation on real time basis. It consists of;

a) Telemetric rain gauges, which enable to observe rainfall on real time basis and which will be used for estimation of basin mean rainfall at a base point and also for calibration of the radar rain gauge system.

b) Telemetric water level gauges, which enable to monitor water level in the target areas and to check the accuracy of forecasted results.

c) Radar rain gauge which detects rainfall amount based on the relationship between echo strength and rainfall intensity and movement and attenuation of rainy area.

(2) Telemetering system required for sending data from gauging stations and receiving them for processing and analyzing.

(3) Data processing system, mainly consisting of a computer system for processing and analyzing data transmitted by the telemetering system, and for forecasting flood based on these data.

(4) Flood warning system to inform flood oncoming to the inhabitants along the Itajai river and tributaries in the target areas.

(5) Communication system for communication between the related agencies/offices so as to exchange information and manage FFWS.

4.1.6 Organization for FFWS

(1) Executing agency

DNOS, Ministry of Agriculture, has responsibility for flood control in the Itajai river basin and therefore has carried out such flood control work as flood control dam construction, river improvement including drainage works, operation and maintenance of these works, etc.

FFWS is one of the measures for flood prevention and is required to be consistent with flood control plan in the basin. DNOS, therefore, will function as a executing agency for establishment of the proposed FFWS.

(2) Organization for the proposed FFWS

The State Government has responsibility for management of the Itajai river basin, and issuance of flood warning and its dissemination are made by the municipal government at present. To effectively utilize the function of newly established FFWS, the following organizations are considered to be concerned with this system;

a) Federal Government
   - DNOS, Ministry of Agriculture
b) Santa Catarina State Government
   - Coordination of Civil Defense (CEDEC)
c) Municipal Government (18 municipalities)
d) Other organization
   - Police
   - Military

Fig. IX.4.1 shows the proposed organization for management, operation and maintenance of this system. As shown in this Figure, the following new offices and stations are organized for the proposed FFWS:

a) FFWS Central Office (Florianopolis)
b) FFWS Control Center (Blumenau)
c) Master Station (Rio do Sul)
d) Monitor Station (Itajai)
e) Gauging stations (at 48 sites)
f) Warning stations (at 16 sites)
g) VHF repeater stations (at 7 sites)
h) UHF repeater stations (at 4 sites)

Required activities of this organization are summarized in Table IX.4.1 and Fig. IX.4.2 shows the schematic relation between these offices and stations.

4.1.7 Work flow of FFWS

The work flow for FFWS in each organization is shown in Fig. IX.4.3. As indicated in this Figure, the flood warning will be issued based on the results of flood forecasting executed at the FFWS Control Center in Blumenau. When the river water level at a warning point is forecasted to rise up to a certain warning level by means of flood runoff simulation, the system will immediately issue a warning in accordance with the final instruction sent from the

Central Office. The FFWS Control Center will send warnings and flood information to the inhabitants in the target areas through warning stations and by patrol cars.

4.2 System Design

The preliminary design of the major equipment for the proposed FFWS is made on the basis of the standard specifications established by the Ministry of Construction, Japan, International Radio Consultative Committee and International Telegraph and Telephone Consultative Committee.

4.2.1 Hydrological observation network

(1) Rainfall gauging station

In the flood simulation study in the master planning, existing 26 rainfall gauges in and around the Itajai river basin were selected in due consideration of the rainfall characteristics in the basin and data availability for basin mean rainfall estimate. Six out of 26 gauges are located in the mountainous area outside of the Itajai river basin. The locations and numbers of these rainfall gauges are reviewed. Based on the result of this review, telemetered rain gauges to be newly installed are determined on the basis of the following criteria:

a) Telemetered rain gauge should be set at or near the existing 20 rainfall gauges within the basin area. To obtain the rainfall data at mountainous areas located at boundary of the basin area, data at 6 rain gauges outside of the basin area were incorporated in the study in this time. It is proposed to shift these 6 rain gauges within the basin area in consideration of convenience of their operation and maintenance. The telemetered rain gauge should be also installed for these shifted 6 rain gauges.

b) To estimate the basin mean rainfall with high accuracy, the telemetered rain gauge should be additionally installed at 5 places in mountainous areas in main tributaries, where rain gauges are not installed at present.

c) If the existing rain gauge is not accessible by car, its location should be moved to a place near the existing road considering the convenience of the operation and maintenance.

The selected locations for the telemetered rainfall gauges are shown in Table IX.4.2 and Fig. IX.4.8 and summarized as follows:

	River Basin	Catchment Area (km^2)	Number
1)	Itajai do Sul river	2,166	5
2)	Itajai do Oeste river	3,050	6
3)	Itajai do Norte river	3,360	7
4)	Benedito river	1,521	3
5)	Testo river	405	1
6)	Luis Alves river	590	1
7)	Itajai Mirim river	1,699	4
8)	Other small tributaries	2,429	4
	Total	15,220	31

(2) Radar rainfall gauge

1) Possibility of utilization of the radar system being constructed at Fraiburgo

CEDEC and CEOPS wish to utilize the radar rain gauge being constructed at Fraiburgo as previously mentioned. The possibility of utilization of the Fraiburgo radar in FFWS in the Itajai river basin was studied from the view points of topographic and operational conditions and equipment performance. However, it was clarified that there is no possibility of using it for this system due to the following reasons;

Topographic condition

Fig. IX.4.4 shows the location of the Fraiburgo radar site and the Itajai river basin. As indicated in the Figure, there exists a mountainous area of EL.1,200 to 1,400 m which screens off the Itajai river basin from the radar installed at Fraiburgo which is located at an altitude of about 1,000 m. Fig. IX.4.5 shows the relation among the altitude of mountain range, distance from the radar site and radar beam angle for the direction which covers as much Itajai river basin area as possible. It is clarified in this figure that the angle of the radar beam is restricted at 0.4 degree at least due to interruption of the high mountain range. While a blight band which is defined as a boundary zone changing from hail to rain is generally 2,000 to 9,000 m at an altitude. Assuming the minimum blight band of 2,000 m, the range which can detect the rainfall in the Itajai river basin area by the radar beam is considered to be at least 80 km, though this radar has a function of detecting hail cloud within 300 km in radius.

Operational condition

The main purpose of the Fraiburgo radar is to detect hail clouds, which are produced by convection phenomena and exist at high altitude. Fraiburgo radar has to be operated changing its angle to detect hail clouds. While, the radar for FFWS requires operation at a fixed low angle continuously to detect rainfall. Also, full-time operation is necessary to detect sudden rain storms and for long-term data collection. Thus this radar cannot be used for FFWS unless the activity to detect hail cloud is deleted.

Equipment performance

The radar should have a function to reject ground clutters reflected by mountains in order to accurately measure rainfall. But such function is not considered in the Fraiburgo radar system because of the observation of hail clouds at high altitude.

From the above conditions and constraints, it is judged that the existing Fraiburgo radar is unsuitable for FFWS in the Itajai river basin. The radar rain gauge, suitable for purposes of FFWS in the Itajai river basin is studied in the following.

2) Proposed radar rain gauge

Possible observation range depends on the capacity of the radar system. Generally an area within a radius of 40 km to 50 km can be covered by a small radar and 100 km to 120 km by a medium-sized radar. If a medium-sized radar is installed in the center of the basin area, it could cover the whole project area.

The proposed location of the radar site is set in Rio do Sul which is almost the center of the Itajai river basin and electric power is available for the system equipment. The elevation of radar site is approximately 722 m above sea level. The scale of the radar equipment required to observe rainfall in the basin would have 120 km radius to enable the analysis of a quantity of rainfall. A location map of the proposed radar site is shown in Fig. IX.4.6.

The proposed radar rain gauge equipment consists of an antenna with radome, wave guide dehydrator, antenna control equipment, radar control and supervision equipment, transmitter/receiver, indicator, signal (data) processor, communication interface equipment, analysis and image process computer, etc. The analysis and image process computer will be installed at the radar site in Rio do Sul to facilitate operation and effective data processing.

(3) Water level gauging station

Water level gauges are planned to be newly installed for monitoring water level in the target areas and checking the reliability of forecasted results by simulation model. The selected location of water level gauges is shown in Table IX.4.3 and Fig. IX.4.8 and summarized as follows:

	River Basin	Number of Stations
1.	Itajai do Sul river	3
2.	Itajai do Oeste river	4
3.	Itajai do Norte river	3
4.	Itajai Mirim river	1
5.	Benedito river	1
6.	Others along Itajai river	4
7.	Tide water level gauge	1
	Total	17

4.2.2 Telemetering system

The main purposes of a telemetering system is to receive data from the hydrological observation network at the Master Station and send them to the Control Center for data processing. The hydrological condition in the project area will be easily recognized on a real time basis by the telemetering system.

There are two kinds of data collection system; namely one is a "polling system" in which measured data at a gauging station are sent out in response to a calling signal from the Control Center; and the other is a "event recording system" in which measured data are sent out without any reference when a change of status takes place. However, in case that the measured data at a certain station and those at other station are transmitted concurrently, both data will be deleted as improper information. Such possibility of overlapping for data transmission will take place frequently in case that there are many gauging stations and/or a rain storm widely covers the basin. Among two systems, the former system is recommended in view of such advantages as i) high reliability of data collection, ii) possibility of incremental gauge installation, iii) possibility of arbitrary data collection and iv) possibility of checking the observation condition at gauging stations.

4.2.3 Data processing system

For operation of the planned FFWS, the computer system will have varied functions. The collected data will be analysed and processed by the computer system and storage equipment through a magnetic disk filing system in which data could be used when the need arises.

In this FFWS, the observed data are collected both at the Master Station and the Control Center, and the control and management of the telemetering system are executed from the Control Center. These two main stations, the Control Center and the Master Station, are planned to be connected with a 800 MHz multiplex radio link for data and voice communication purposes.

The data processing equipment aided by a computer are required for the Control Center and the Master Station for conducting the following functions:

a) Exchanging the data through the 800 MHz multiplex radio link at real time and non-real time
b) Processing the gauging data received at the Control Center for display on CRT screens and for starting flood analysis calculation
c) Flood forecasting analysis at the Control Center using the received gauging data, and
d) Processing the data sent from the radar rain gauge at the Master Station for display on CRT screen.

4.2.4 Flood warning system

Flood warning system comprises the following equipment:

a) Warning control equipment consisting of a radio transmitter and receiver and operating console with necessary station selection switches, a microphone, indicators, etc. installed at Control Center in Blumenau.
b) Terminal equipment for receiving signals from the Control Center, amplifier and loud speaker for broadcasting and microphone to pick up the warning notice and re-transmitting system installed at warning stations.
c) Mobile warning facilities such as patrol cars and motor cycles furnished with speakers and hand speaker sets, which are under control of Central Office in Blumenau and distributed to local authorities at Rio do Sul, Itajai and Brusque.

The quantities for the flood warning equipment are as follows:

Location	Warning Station	Patrol Car	Motorcycle
Blumenau	7	5	2
Rio do Sul	3	3	1
Itajai	5	3	2
Brusque	1	1	1
Total	16	12	6

4.2.5 Communication system

Communication system has a role of connecting the FFWS offices and stations by multiplex and simplex exclusive lines to inform the forecasted result and flood warning to related agencies. The proposed telecommunication system is illustrated in Figs. IX.4.7 and IX.4.8 and its content is as follows;

(1) 150 MHz VHF network

A radio wave band of 70 MHz or 150 MHz is usually used for sending and receiving signals between gauging stations, remote stations and their control station (Master Stations). The 150 MHz band is selected for the communication network for the project due to difficulty in obtaining allocation of available frequencies in the 70 MHz band.

The required number of communication channels for the proposed system is 12 channels. However an allocation of 20 channels is recommended at this stage to secure future extension of the project.

(2) 800 MHz UHF network

The 800 MHz UHF network is selected for the multi-channel communication network among the Control Center, Master Station, Central Office and Monitor Station, since the communication equipment cost of this frequency is comparatively lower than the systems with higher frequencies such as 2 GHz or more and the 800 MHz band has a capacity of up to 24 channels which are enough for the planned communication system and for future extension use.

The normal range of a UHF communication path from one station to another is usually about 50 km. The distance between the Control Center in Blumenau and the Master

Station in Rio do Sul is about 80 km on the map. Taking the above limit of range and radio wave propagation condition into consideration, construction of two repeater stations is required between Blumenau and Rio do Sul. Based on the map route study and site reconnaissance the repeater station sites were selected at Apiuna and Montanha do Cachorro between the Control Center and the Master Station, and Limeira Alta and Morro do Lagoa between the Control Center and the Central Office.

The 800 MHz network will enable to; 1) transmit control signals from the Control Center to the Master Station; 2) transmit simulation results on flood forecasting and others; and 3) communicate between the FFWS offices by telephone and facsimile. The required number of channels is given below:

- Telemetering	:	2 channels
- Telephone & Facsimile	:	10 channels
- Computer exclusive line	:	4 channels
- Radar exclusive line	:	2 channels

Actual channel requirement is 18 channels in the present plan, however, 24 channels will be required for future extension of the system.

(3) Voice Communication

The press-to-talk voice communication channel will be provided for communication among the Master Station, Control Center, Central Office and Monitor Station for necessary communication during the operation and maintenance period.

(4) Automatic Exchanges

Two electronic type private automatic exchanges of about 30 circuit capacity will be provided at the Control Center and Master Station to facilitate telephone communication between the stations and for other related facilities in or near the premises. By providing outgoing trunks, connection with the public system is possible. Two small scale telephone exchanges (Key telephone) will also be provided at the Central Office and Monitor Station.

4.2.6 Major equipment of the system

Based on the foregoing system design, major equipment required at the proposed FFWS offices and stations are selected. The selected equipment are listed in Table IX.4.4.

4.3. Implementation Program

4.3.1 Stage-wise development plan

It has been proposed to level up the flood forecasting procedures in the integrated FFWS by dividing into three stages. The implementation plan in these three stages is as follows;

(1) 1st Stage

The system construction in 1st stage consists of;

a) Improvement of the existing manual hydrological observation situation for rain and water level gauges by means of telemetering systems,

b) Reinforcement of the existing hydrological gauge system by installing additionally the telemetered rain gauges at the mountainous area upstream of the existing dams and telemetered water level gauges at up and downstream of the existing dams and at the flood prone areas.

c) Construction of the Control Center in Blumenau and Master Station in Rio do Sul.

The forecasting of flood water level will be carried out for Blumenau applying the existing method and issuance of flood warning will be disseminated to inhabitant in the municipal of Blumenau by current method.

(2) 2nd Stage

The system construction in 2nd stage comprises;

a) Additional installation of telemetered rain gauges at the mountainous area

b) Installation of telemetered tide water level gauge at Itajai

c) Construction of Central Office in Florianopolis and Monitor Station in Itajai.

The flood forecasting method will be converted from conventional correlation method of meteo-hydrological data into flood simulation method to expand the flood forecasting method to all the proposed target areas.

(3) 3rd stage

The radar rain gauge system will be introduced in Rio do Sul to raise accuracy of the flood forecasting result by changing the observation data from spot rainfall to the area rainfall.

4.3.2 System component of each stage

System component of each stage is shown in Fig. IX.4.9 and summarized as follows:

Stage	Major Component	Number
1st stage	- Telemetered rainfall gauging station	: 15 nos.
	- Telemetered water level gauging station	: 16 nos.
	- Control Center in Blumenau	
	- Master Station in Rio do Sul	
	- UHF repeater station	: 2 nos.
	- VHF repeater station	: 7 nos.
	- Telemetering system between stations and office	
	- Multiplex communication system between Blumenau and Rio do Sul	
2nd stage	- Telemetered rainfall gauging station	: 16 nos.
	- Telemetered tide water level gauge	: 1 no.
	- Central Office in Florianopolis	
	- Monitor Station in Itajai	
	- Expansion of multiplex communication system for the Control Center, Central Office and Monitor Station	
	- UHF repeater station	: 2 nos.
	- Installation of warning equipment	
3rd stage	- Installation of radar rain gauge system including data processing equipment and soft at Master Station in Rio do Sul	

Implementation schedule of the proposed system is shown in Fig. IX.4.10. The construction period including detailed design and operation/maintenance is 10 years comprising 4 years for prerequisite works, 2 years for the 1st stage, 1.5 year for the 2nd stage and one year for the 3rd stage and one year for training for 3rd stage.

4.4 Required Cost

4.4.1 Conditions for cost estimate

The following conditions and assumptions are set for cost estimate:

a) The construction work of the proposed system is executed by a contract system.
b) Unit prices of equipment and materials are estimated based on the price level in September 1989.
c) The cost is estimated in US$ equivalent using the exchange rate of US$1 = ¥140 = NCz$3.78.
d) The cost is estimated by dividing into direct cost, indirect cost and contingency. The indirect cost includes administration cost and engineering service cost.
e) Physical contingency is estimated at 10% for foreign and local currency portions.

4.4.2 Project cost

The project cost for the proposed system divided into 3 stages is estimated as shown in Table 4.5 and summarized as follows:

(Unit: US$ thousand)

Cost Item	1st Stage		2nd Sage		3rd Sage		Total
	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	
(1) Direct cost (Construction cost including preliminary works)	6,975	1,712	6,334	1,348	6,476	220	23,065
(2) Indirect cost (Administration and engineering service costs)	1,395	776	1,267	654	1,295	379	5,766
(3) Contingency (Physical contingency)	837	249	760	220	777	60	2,883
Total	9,207	2,737	8,361	2,202	8,548	659	31,714
	(11,944)		(10,563)		(9,207)		

Note; F.C. ; Foreign currency portion
L.C. ; Local currency portion

The figures in bracket show total of F/C and L/C in each stage.

This table shows that the disbursement in each stage is almost balanced.

Tables

Table IX.2.1 LIST OF CITIES AND MUNICIPALITIES INUNDATED BY 1983 AND 1984 FLOODS

	Inundated City/Municipality	River Basin
1.	Ituporanga	Itajai do Sul river
2.	Agronomica	Itajai do Sul river
3.	Aurora	Itajai do Sul river
4.	Trombudo Central	Trombudo river
5.	Taio	Itajai do Oeste river
6.	Rio do Sul	Itajai river
7.	Ibirama	Itajai do Norte river
8.	Ascurra	Itajai river
9.	Rodeio	Itajai river
10.	Apiuna	Itajai river
11.	Timbo	Benedito river
12.	Indaial	Itajai river
13.	Blumenau	Itajai river
14.	Gaspar	Itajai river
15.	Ilhota	Itajai river
16.	Itajai	Itajai river
17.	Navegantes	Itajai river
18.	Brusque	Itajai Mirim river

Table IX.3.1 MAIN FEATURES OF SUL, OESTE AND NORTE DAMS

Item	Unit	Sul	Oeste	Norte
1. Reservoir				
a) Name of river		Itajai do Sul	Itajai do Oeste	Itajai do Norte
b) Location (distance from river mouth)	km	330	263	193
c) Catchment area	km2	1,290	860	2,318
d) Flood control space	Million cu.m.	97.5	83	357
e) Flood water level	El.m	399	360	302.5
2. Dam				
a) Type		Rockfill	Concrete gravity type	Rockfill
b) Crest elevation	El.m	410	363	309.5
c) Crest length	m	367.5	311	365.0
d) Height	m	43.5	25	65
e) Dam volume	Thousand cu.m.	678	85	2,200
f) Dam slope (upstream/downstream)		1:2.5, 1:2.0	1:0.03, 1:0.7	1:2.5, 1:2.0
3. Spillway				
a) Type		Non-gated overflow	Non-gated overflow	Non-gated overflow
b) Crest length	m	65.0	98	300
4. Outlet valves				
a) Type		Gated conduit	Gated conduit	Non-gated conduit
b) Scale		1.5m x 3m x5 lanes	1.5m x 7 lanes	1.5m x 5 lanes Gated conduit 2.6m x 2.6m x 2 lanes
5. Completed time		Nov. 1975	Mar. 1972	To be completed in Dec. 1987

Table IX.4.1 ROLE AND FUNCTION OF ORGANIZATIONS FOR FFWS

FFWS Control Center in Blumenau	FFWS Master Station in Rio do Sul
- To collect the observed data from gauges. - Flood forecasting. . Itajai river . Itajai Mirim river . Other tributaries - To transmit forecasted flood information to Central Office and Monitor Station - To inform flood warning to Municipal Government Offices. - To supervise the warning activities in project area. - To dispatch patrol crew to the site. - To collect information on floods and flood damage through Municipal Government Offices. - To decide terminating flood warning. - To disseminate flood warning under request from Municipal Government Offices. - To compile the observed data in a specified format. - To improve the forecasting method.	- To collect the observed data from gauges and radar data. - To transmit the collected data to Control Center - To send necessary/required information to FFWS Control Center. - To dispatch patrol crew to the site. - To collect information on dam discharge from Dam Control Offices. - To transmit data of dam discharge to Control Center. - To improve radar data. - To compile the observed data in a specified format, in case that UHF radio link is out of order.
FFWS Central Office in Florianopolis	**FFWS Monitor Station in Itajai**
- To receive information on floods from the Control Center. - To decide/issue flood warning to FFWS Control Center. - To collect information on floods and flood damage from related government offices/agencies. - To supervise the warning activities in project area through the Control Center. - To monitor the observed hydrological data from the Control Center.	- To monitor the forecasted flood and receive necessary information from FFWS Control Center. - To disseminate flood warning to Municipal Governmental Offices. - To collect information on floods and flood damage from related government. offices/agencies. - To send information on floods and flood damage to the Control Center. - To dispatch patrol crew to the site.

Table IX.4.2
LIST OF TELEMETRIC RAINFALL GAUGING STATIONS
AND RADAR RAIN GAUGE

No.	Location	River Basin	Construction Period
1st Stage			
1.	Ituporanga	Itajai do Sul River	1st stage
2.	Sul dam	Itajai do Sul River	1st stage
3.	Morro do Torombudo	Itajai do Sul River	1st stage
4.	Rio do Campo	Itajai do Oeste river	1st stage
5.	Taio	Itajai do Oeste river	1st stage
6.	Trombudo Central	Itajai do Oeste river	1st stage
7.	Nova Cultura	Itajai do Norte river	1st stage
8.	Norte dam	Itajai do Norte river	1st stage
9.	Ibirama	Itajai do Norte river	1st stage
10.	Dr. Pedrinho	Benedito river	1st stage
11.	Timbo	Benedito river	1st stage
12.	Vidal Ramos	Itajai Mirim river	1st stage
13.	Brusque	Itajai Mirim river	1st stage
14.	Apiuna	along Itajai river	1st stage
15.	Blumenau	along Itajai river	1st stage
1.	Serra dos Alves	Itajai do Sul River	2nd stage
2.	Sao Leonardo	Itajai do Sul River	2nd stage
3.	Colonia Sao Jaco	Itajai do Oeste river	2nd stage
4.	Barra do Rio de Trass	Itajai do Oeste river	2nd stage
5.	Serril	Itajai do Oeste river	2nd stage
6.	Colonia Rodeiozinho	Itajai do Norte river	2nd stage
7.	Moema	Itajai do Norte river	2nd stage
8.	Barra do Plata	Itajai do Norte river	2nd stage
9.	Catangara	Itajai do Norte river	2nd stage
10.	CELESC dam site	Benedito river	2nd stage
11.	Pomerode	Testo river	2nd stage
12.	Luis Alves	Luis Alves river	2nd stage
13.	Torre TELESC	Itajai Mirim river	2nd stage
14.	Botuvera	Itajai Mirim river	2nd stage
15.	Rio do Sul	along Itajai river	2nd stage
16.	Nova Russia	along Itajai river	2nd stage
1.	Radar Rain Gauge at Rio do Sul	along Itajai river	3rd Stage

Table IX.4.3 LIST OF TELEMETRIC WATER LEVEL GAUGING STATIONS

No.	Location	River Basin	Construction Period
1.	Upstream of Sul dam	Itajai do Sul river	1st stage
2.	Downstream of Sul dam	Itajai do Sul river	1st stage
3.	Ituporanga	Itajai do Sul river	1st stage
4.	Upstream of Oeste dam	Itajai do Oeste river	1st stage
5.	Downstream of Oeste dam	Itajai do Oeste river	1st stage
6.	Taio	Itajai do Oeste river	1st stage
7.	Trombudo Central	Itajai do Oeste river	1st stage
8.	Rio do Sul	Itajai river	1st stage
9.	Upstream Norte dam	Itajai do Norte river	1st stage
10.	Downstream Norte dam	Itajai do Norte river	1st stage
11.	Ibirama	Itajai do Norte river	1st stage
12.	Apiuna	Itajai river	1st stage
13.	Timbo	Benedito river	1st stage
14.	Indaial	Itajai river	1st stage
15.	Blumenau	Itajai river	1st stage
16.	Brusque	Itajai Mirim river	1st stage
17.	Sea water level gauge	River mouth	2nd stage

Table IX.4.4 MAJOR EQUIPMENT REQUIRED FOR OFFICES AND STATIONS FOR FFWS

FFWS Control Center in Blumenau	FFWS Master Station in Rio do Sul	FFWS Central Office in Florianopolis
- Telemetering equipment . Operation console . Telemetering supervision/control equipment - Communication control equipment - Computer system . Host computer . Color display (CRT) with keyboard . Floppy & hard disk drive . Graphic printer - Graphic and data panels - Facsimile - Telephone - Patrol cars and motorcycles - Warning equipment . Operation console . Warning supervision/control equipment	- Telemetering equipment . Operation console . Telemetering supervision/control equipment - Communication control equipment - Computer system . Inteligent terminal . Color display (CRT) with keyboard . Floppy & hard disk drive . Graphic printer - Antenna tower and equipment - Facsimile - Telephone	- Communication control equipment - Computer system . Inteligent terminal . Color display (CRT) with keyboard . Floppy & hard disk drive . Graphic printer - Graphic and data panels - Facsimile - Telephone
FFWS Monitor Station in Itajai	UHF Repeater Station (Montanha doCachorro and Lemeira Alta	UHF Repeater Station (Morro do Costa do Lagoa and Apiuna)
- Multiplex communication equipment . Radio equipment . Antenna tower and equipment . FDM multiplex terminal equipment . Supervisory/control equipment - Radio communication equipment . Radio telephone (Base) . AC power supply . Desk top microphone . Antenna equipment . Radio telephone (mobile) . Whip antenna . Antenna mast - Facsmile equipment - Telephone facilities	- Multiplex radio equipment . Antenna tower and equipment . Supervisory/control equipment . Power supply equipment - Radio Communication equipment . Repeater equipment . Radio equipment . Antenna equipment	- Multiplex radio equipment . Antenna tower and equipment . Supervisory/control equipment . Power supply equipment
VHF Repeater Station	Water Level Gauging Station	Rainfall Gauging Sation
- Repeater equipment - Radio equipment - Antenna equipment - Power supply equipment - Antenna mast	- Water level gauge equipment - Repeater equipment - Radio equipment - Antenna equipment - Power supply equipment - Antenna mast	- Rainfall gauge equipment - Repeater equipment - Radio equipment - Antenna equipment - Power supply equipment - Antenna mast
Water Level and Rainfall Gauging Station	Radar Rain Gauge	Warning Station
- Rainfall gauge equipment - Water level gauge equipment - Repeater equipment - Radio equipment - Antenna equipment - Power supply equipment - Antenna mast	- Weather radar system equipment . Radome . Antenna control equipment . Transmitter/receiver . Signal processor . Display monitor . Power controler . Dehydrator . Operation supervisory equipment . Automatic voltage regulator - Radar data processing soft	- Warning equipment - Radio equipment - Antenna mast and equipment - Loudspeaker equipment - Microphone - Power supply equipment

Table IX.4.5 PROJECT COST

(Unit : US$ thousand)

Description	1st Stage		2nd Stage		3rd Stage		Amount	
	F/C	L/C	F/C	L/C	F/C	L/C	F/C	L/C
I. Direct Construction Cost								
a) Equipment and materials								
1) Control Center at Blumenau	3,096	164	592	14	-	-	3,688	178
2) Master Station at Rio do Sul	563	114	214	7	1,790	43	2,567	164
3) Monitor Station at Itajai	-	-	464	50	-	-	464	50
4) Central Office at Florianopolis	-	-	1,341	29	-	-	1,341	29
5) UHF Repeater Station at Montanha do Cachorro	563	50	-	-	-	-	563	50
6) UHF Repeater Station at Lemeira Alta	328	7	-	-	-	-	328	7
7) UHF Repeater Station at Morro do Costa do Lagoa	-	-	535	14	-	-	535	14
8) UHF Repeater Station at Apiuna	-	-	328	7	-	-	328	7
9) Radar Rain Gauge System at Rio do Sul	-	-	-	-	3,638	86	3,638	86
10) Rainfall Gauging Station	178	36	642	128	-	-	820	164
11) Water Level and Rainfall Gauging Station	571	71	57	7	-	-	628	78
12) Water Level Gauging Station	214	36	43	7	-	-	257	43
13) VHF Telemeter Repeater Station (7 sites)	449	50	-	-	-	-	449	50
14) Warning Station	-	-	1,027	114	-	-	1,027	114
15) Patrol Cars and Motorcycles	-	-	64	278	-	-	64	278
16) Spare Parts	228	21	264	14	271	-	763	35
17) Maintenance Tools and Instrument	71	7	71	7	71	-	213	14
Sub-total	6,262	556	5,642	678	5,770	128	17,674	1,362
b) Civil and Building Work								
1) Control Center at Blumenau	-	250	-	-	-	-	-	250
2) Master Station at Rio do Sul	-	271	-	-	-	71	-	342
3) Monitor Station at Itajai	-	-	-	71	-	-	-	71
4) Central Office at Florianopolis	-	-	-	136	-	-	-	136
5) UHF Repeater Station at Montanha do Cachorro	-	121	-	-	-	-	-	121
6) UHF Repeater Station at Lemeira Alta	-	50	-	-	-	-	-	50
7) UHF Repeater Station at Morro do Costa do Lagoa	-	-	-	78	-	-	-	78
8) UHF Repeater Station at Apiuna	-	-	-	50	-	-	-	50
9) Radar Rain Gauge System at Rio do Sul	-	-	-	-	-	-	-	-
10) Rainfall Gauging Station	-	14	-	64	-	-	-	78
11) Water Level and Rainfall Gauging Station	-	107	-	14	-	-	-	121
12) Water Level Gauging Station	-	57	-	14	-	-	-	71
13) VHF Telemeter Repeater Station	-	29	-	-	-	-	-	29
14) Warning Station	-	-	-	57	-	-	-	57
15) Spare Parts	-	43	-	21	-	-	-	64
c) Preliminary Works including Design, Documentation, O/M Guidance, etc.	713	214	692	164	706	21	2,111	399
Sub-total	-	942	-	506	-	71	-	1,519
Total (a+b+c)	6,975	1,712	6,334	1,348	6,476	220	19,785	3,280
II. Indirect Cost								
a) Administration Cost (5% of Direct Cost)	-	434	-	384	-	335	-	1,153
b) Engineering Service Cost (20 % of Direct Cost)	1,395	342	1,267	270	1,295	44	3,957	656
Sub-total	1,395	776	1,267	654	1,295	379	3,957	1,809
Total (I+II)	8,370	2,488	7,601	2,002	7,771	599	23,742	5,089
III. Contingency (10% of total of Items I and II)	837	249	760	200	777	60	2,374	509
Grand Total	9,207	2,737	8,361	2,202	8,548	659	26,116	5,598

Figures

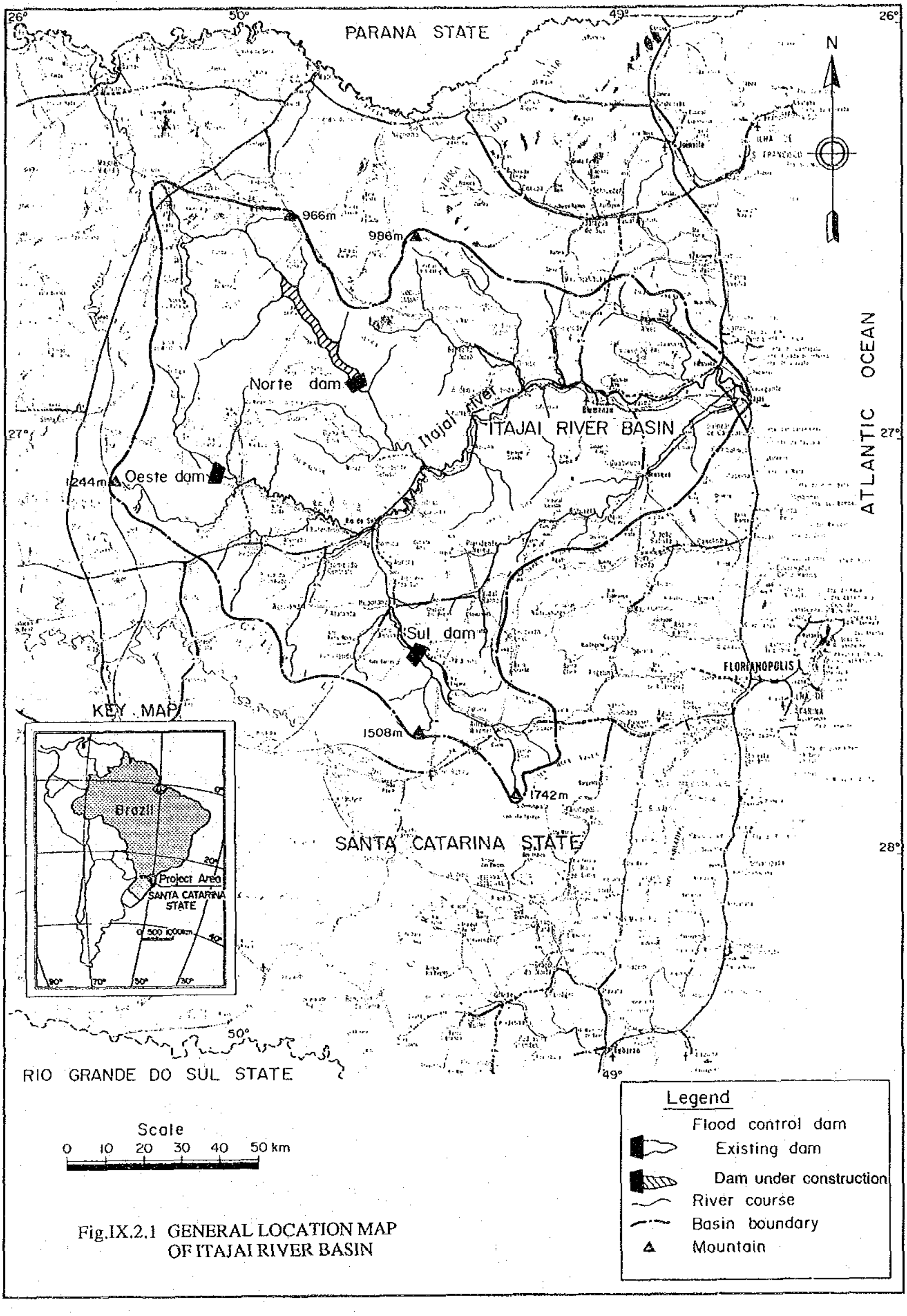
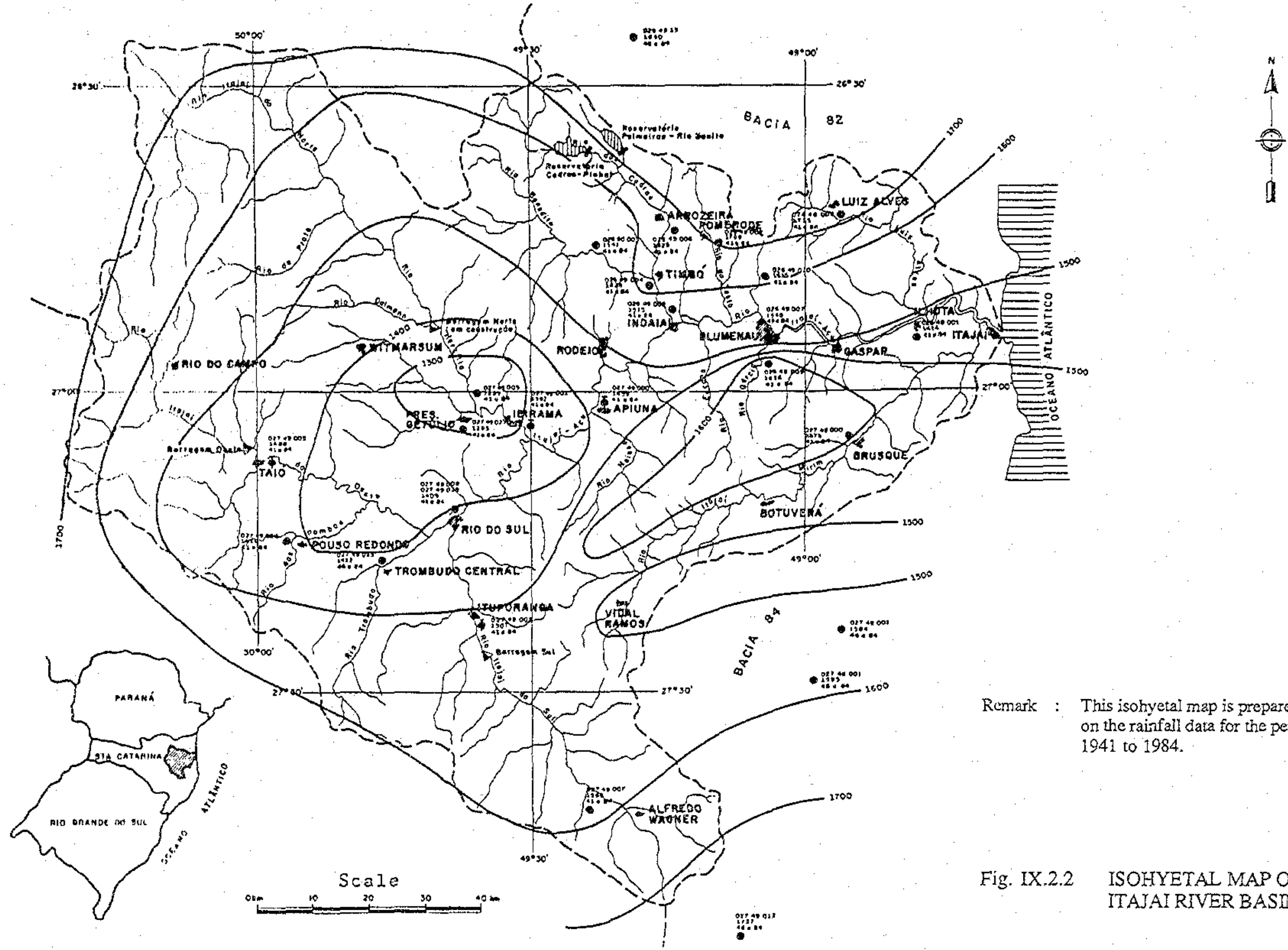


Fig.IX.2.1 GENERAL LOCATION MAP OF ITAJAI RIVER BASIN



Remark : This isohyetal map is prepared based on the rainfall data for the period from 1941 to 1984.

Fig. IX.2.2 ISOHYETAL MAP OF THE ITAJAI RIVER BASIN

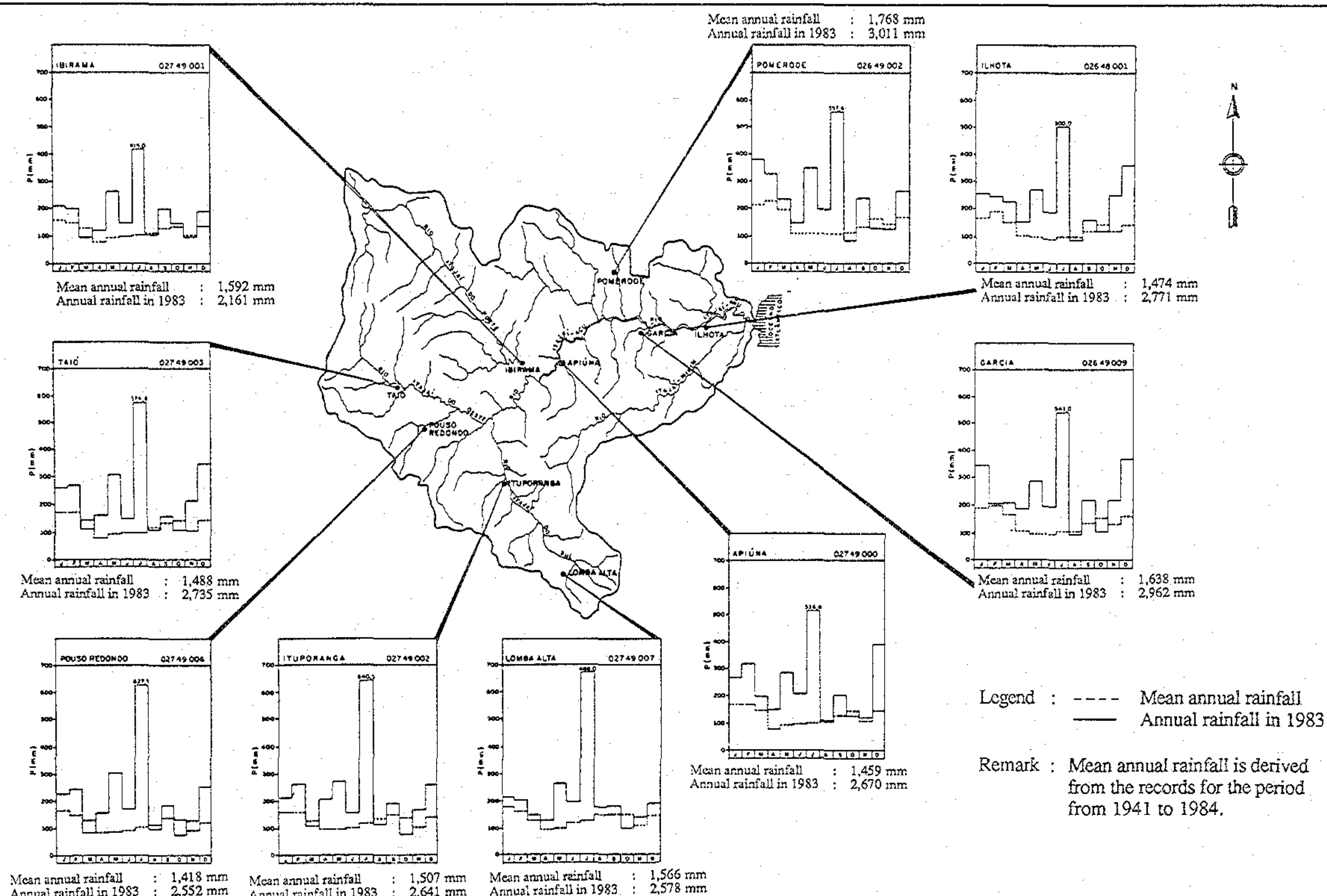


Fig. IX.2.3 MONTHLY RAINFALL DISTRIBUTION IN THE ITAJAI RIVER BASIN

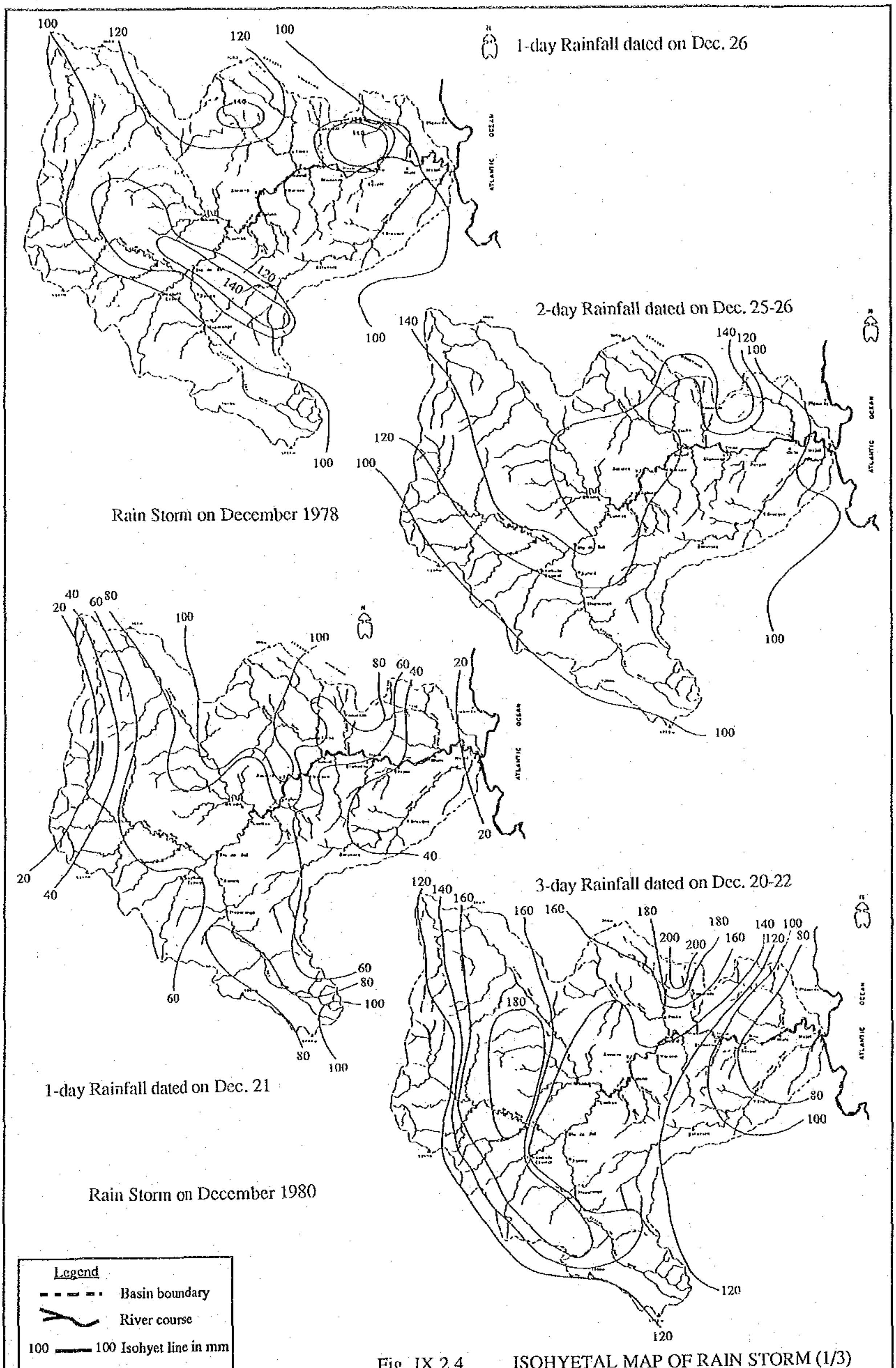


Fig. IX.2.4 ISOHYETAL MAP OF RAIN STORM (1/3)

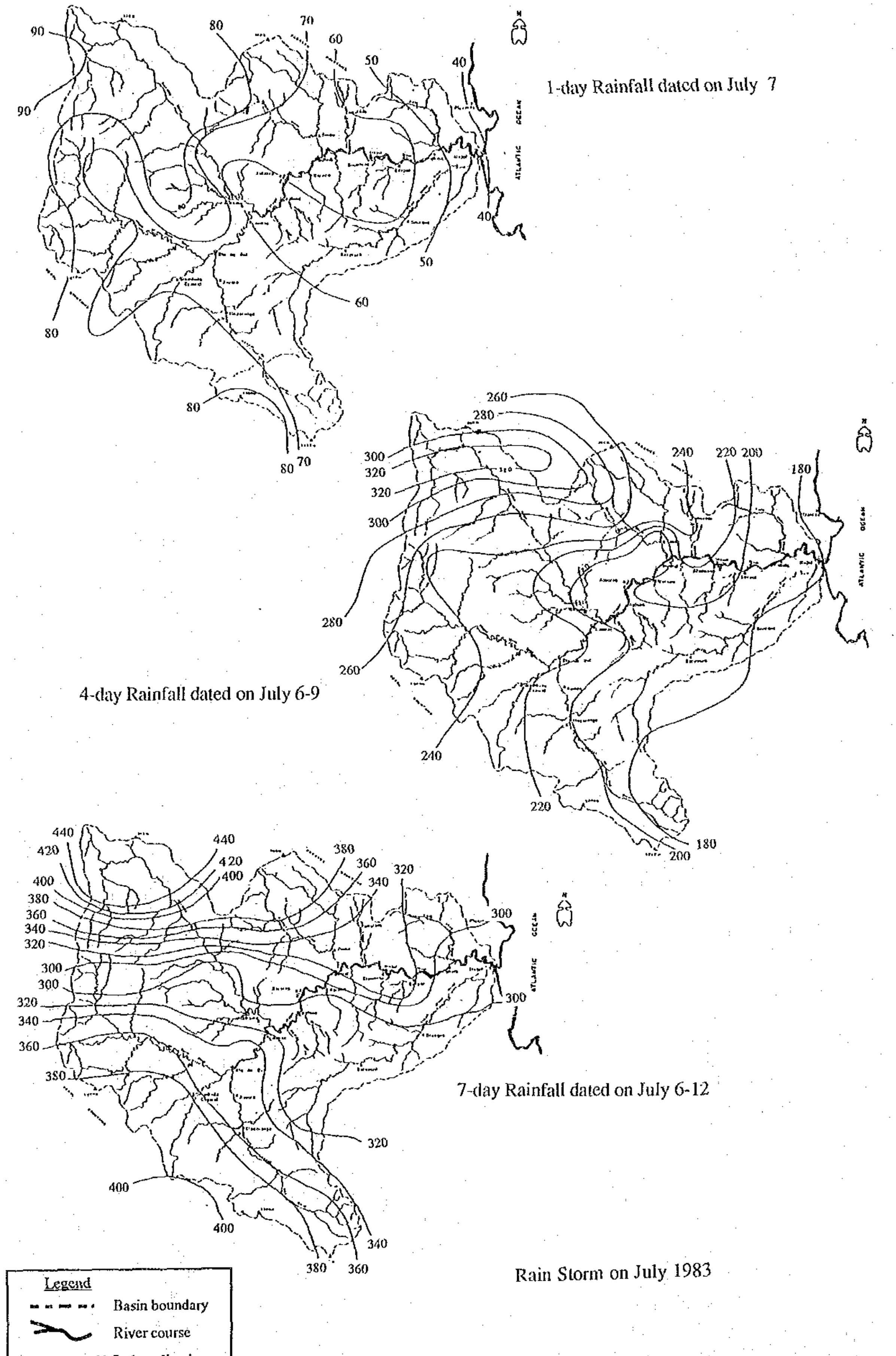


Fig. IX.2.4 ISOHYETAL MAP OF RAIN STORM (2/3)

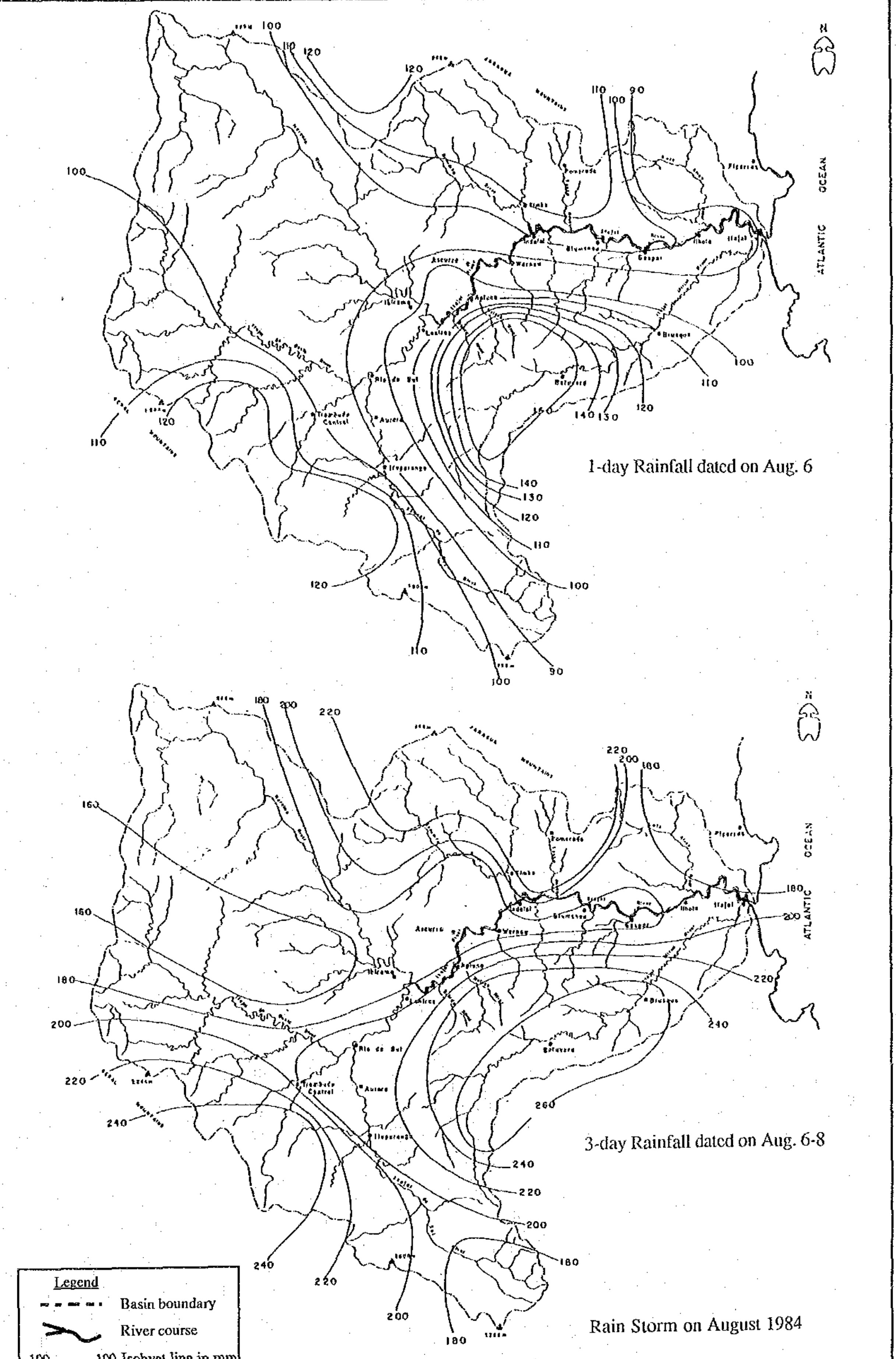


Fig. IX.2.4 ISOHYETAL MAP OF RAIN STORM (3/3)

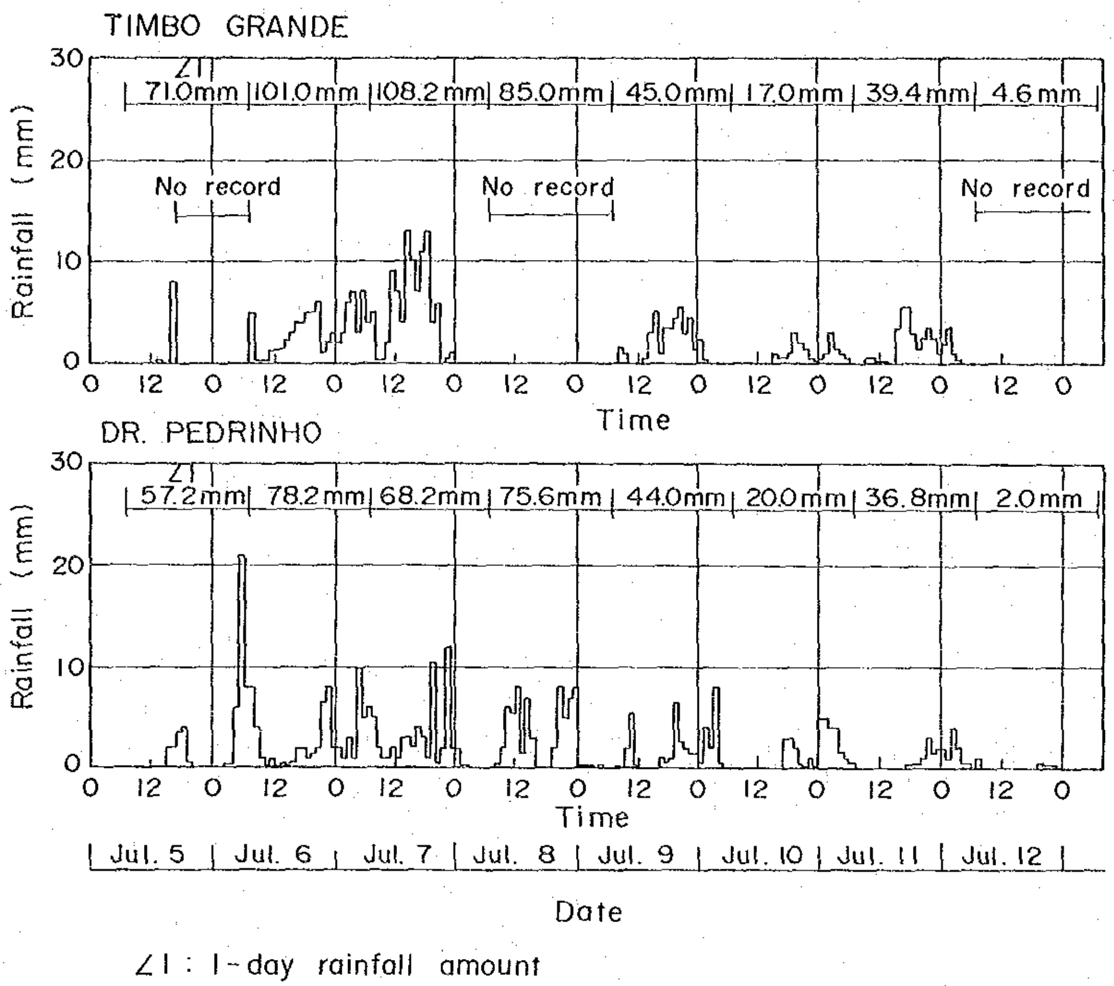
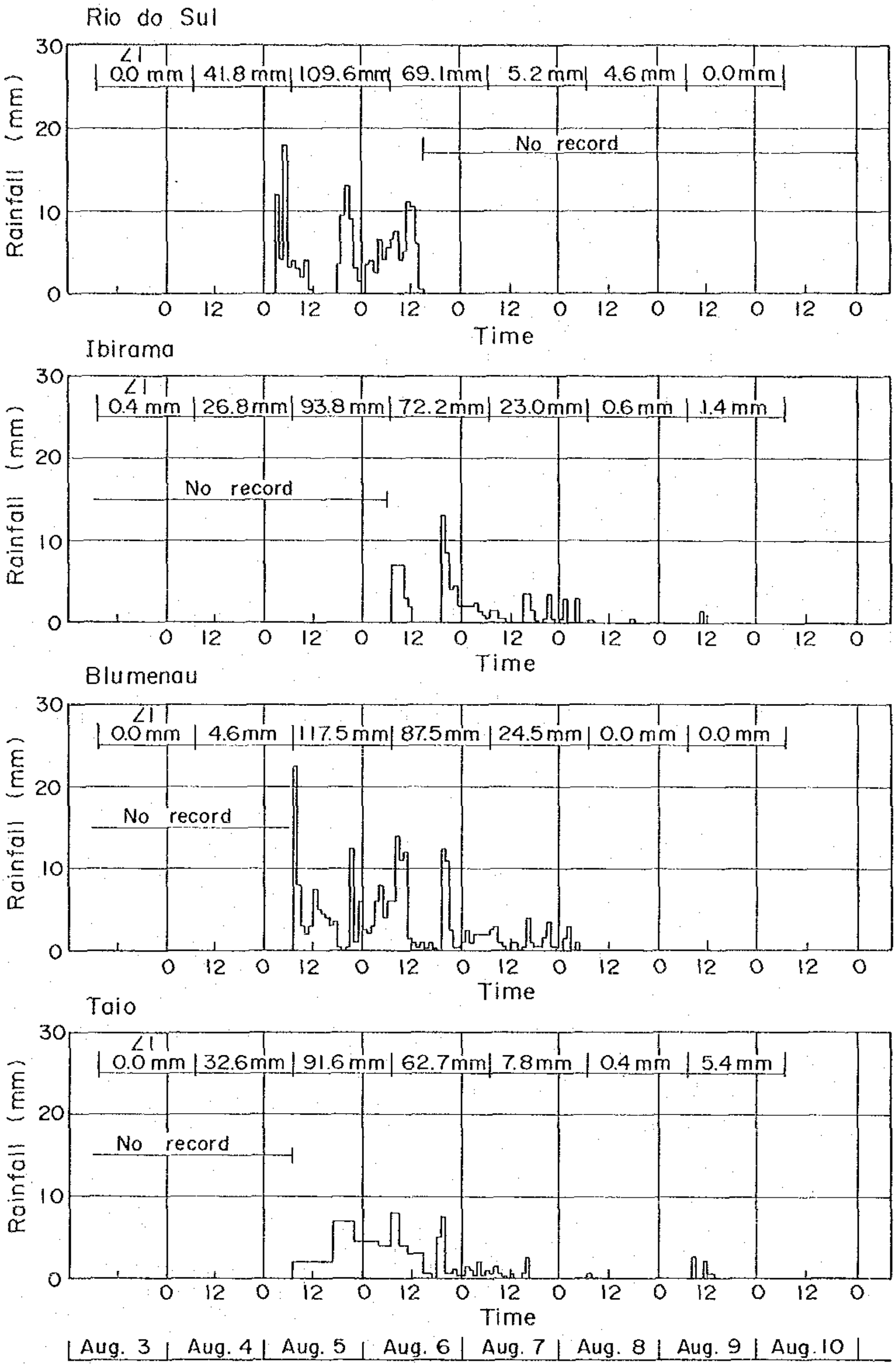


Fig. IX.2.5 HOURLY RAINFALL DISTRIBUTION (1/3)
(Rain Storm in July 1983)



∠1 : 1-day rainfall amount

Fig. IX.2.5 HOURLY RAINFALL DISTRIBUTION (2/3)
(Rain Storm in August 1984)

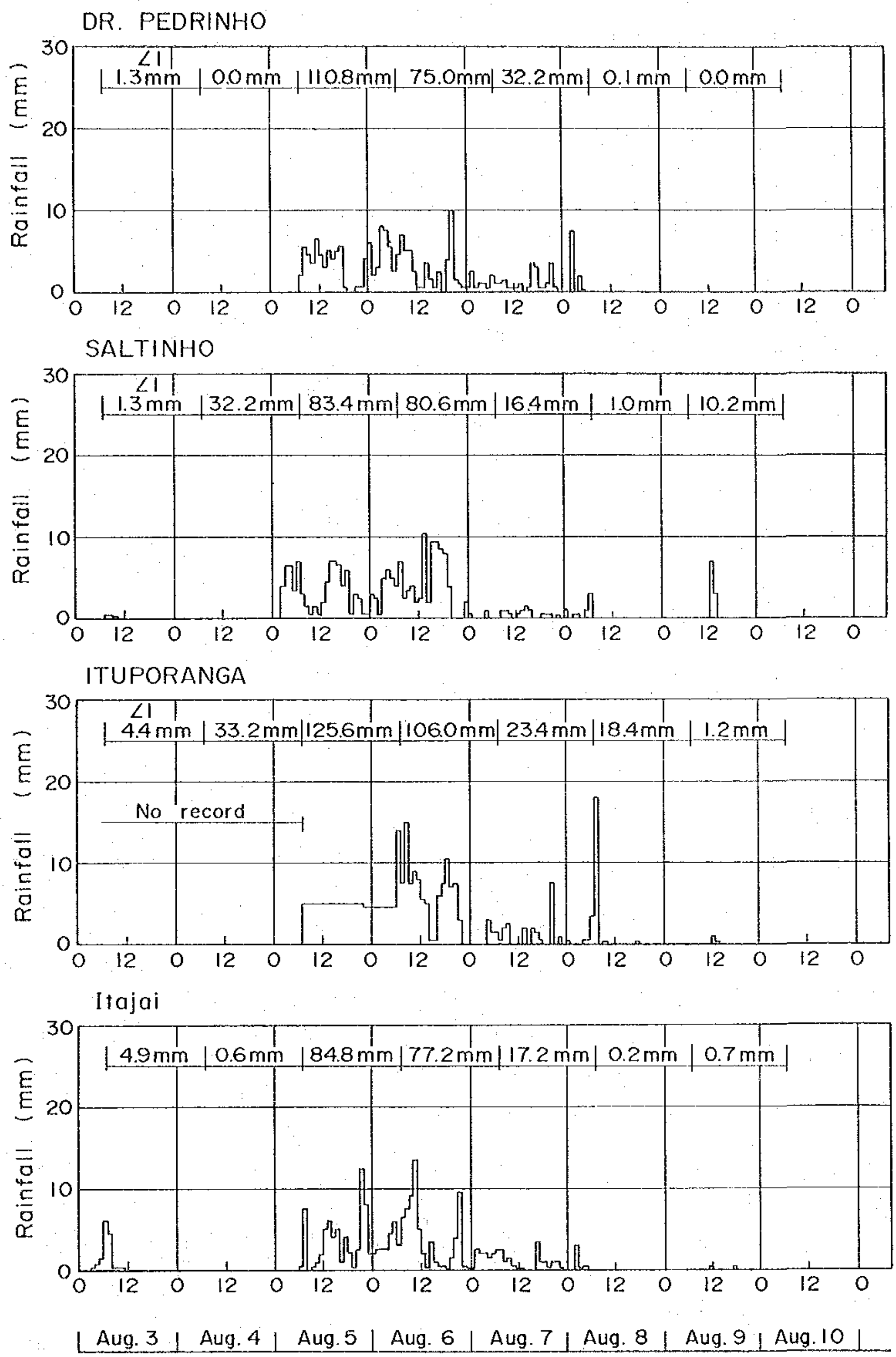


Fig. IX.2.5 HOURLY RAINFALL DISTRIBUTION (3/3)
(Rain Storm in August 1984)

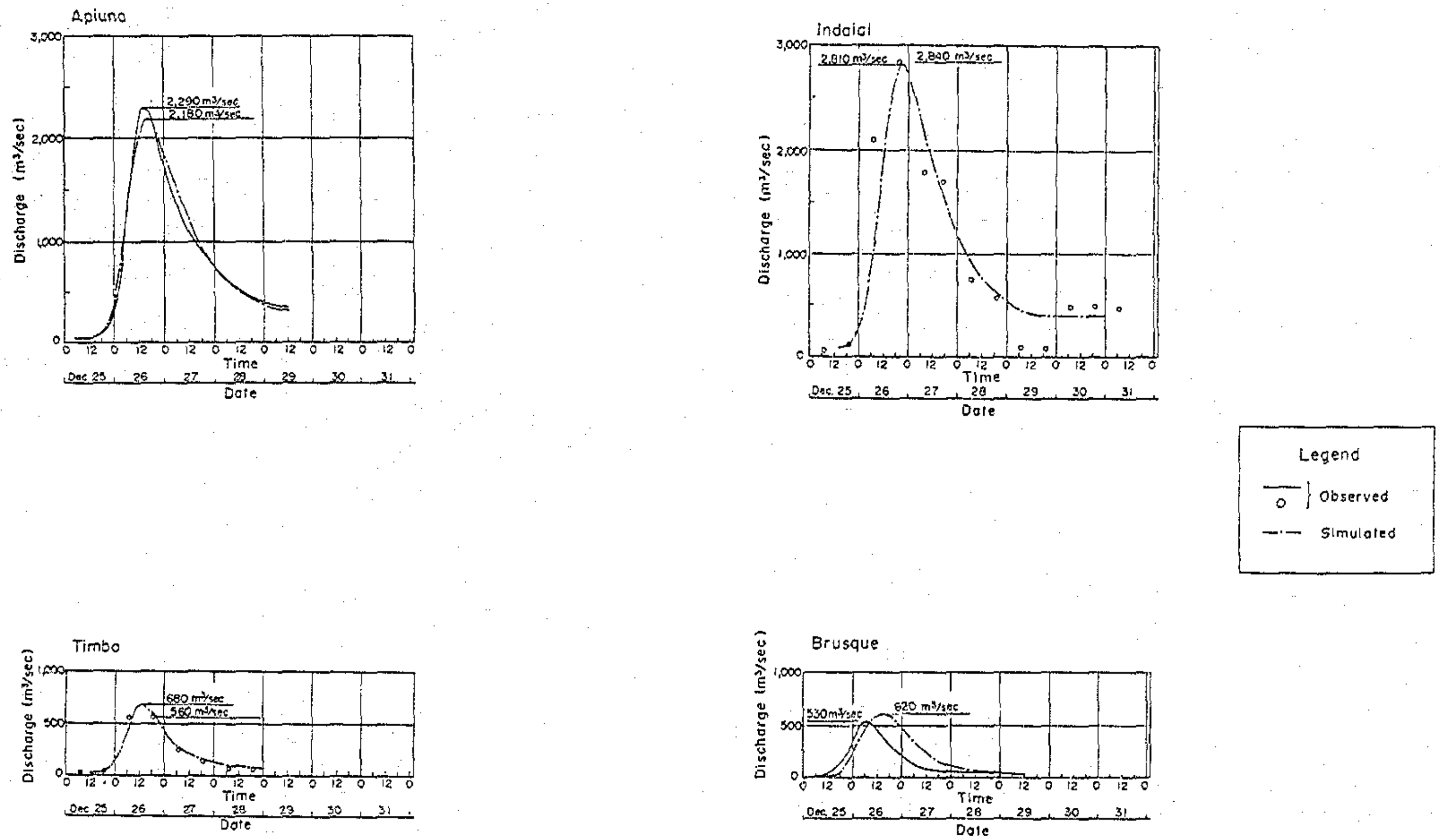


Fig. IX.2.6 OBSERVED AND SIMULATED FLOOD HYDROGRAPH (1/4)
(Flood in December 1978)

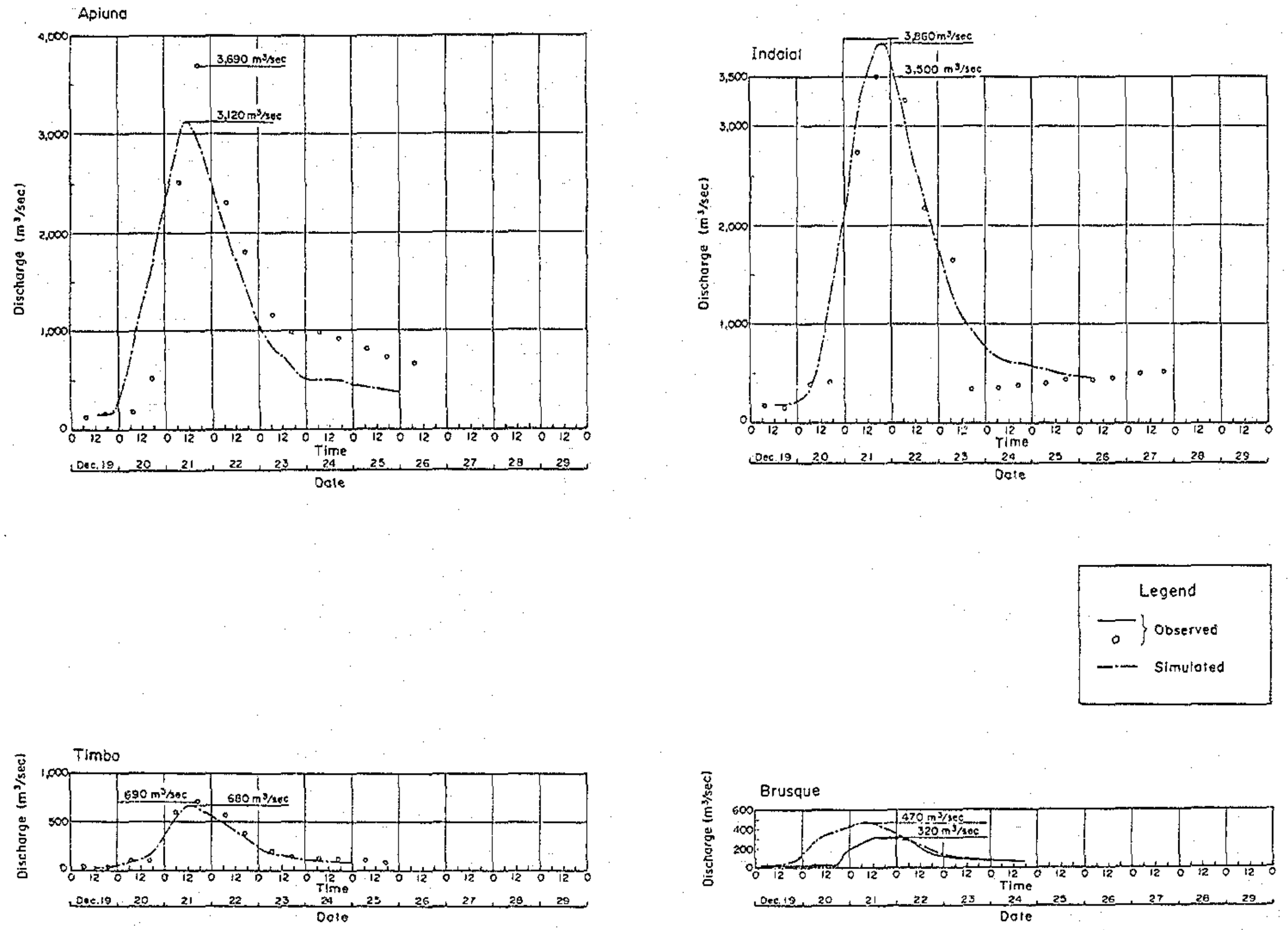


Fig. IX.2.6 OBSERVED AND SIMULATED FLOOD HYDROGRAPH (2/4)
(Flood in December 1980)

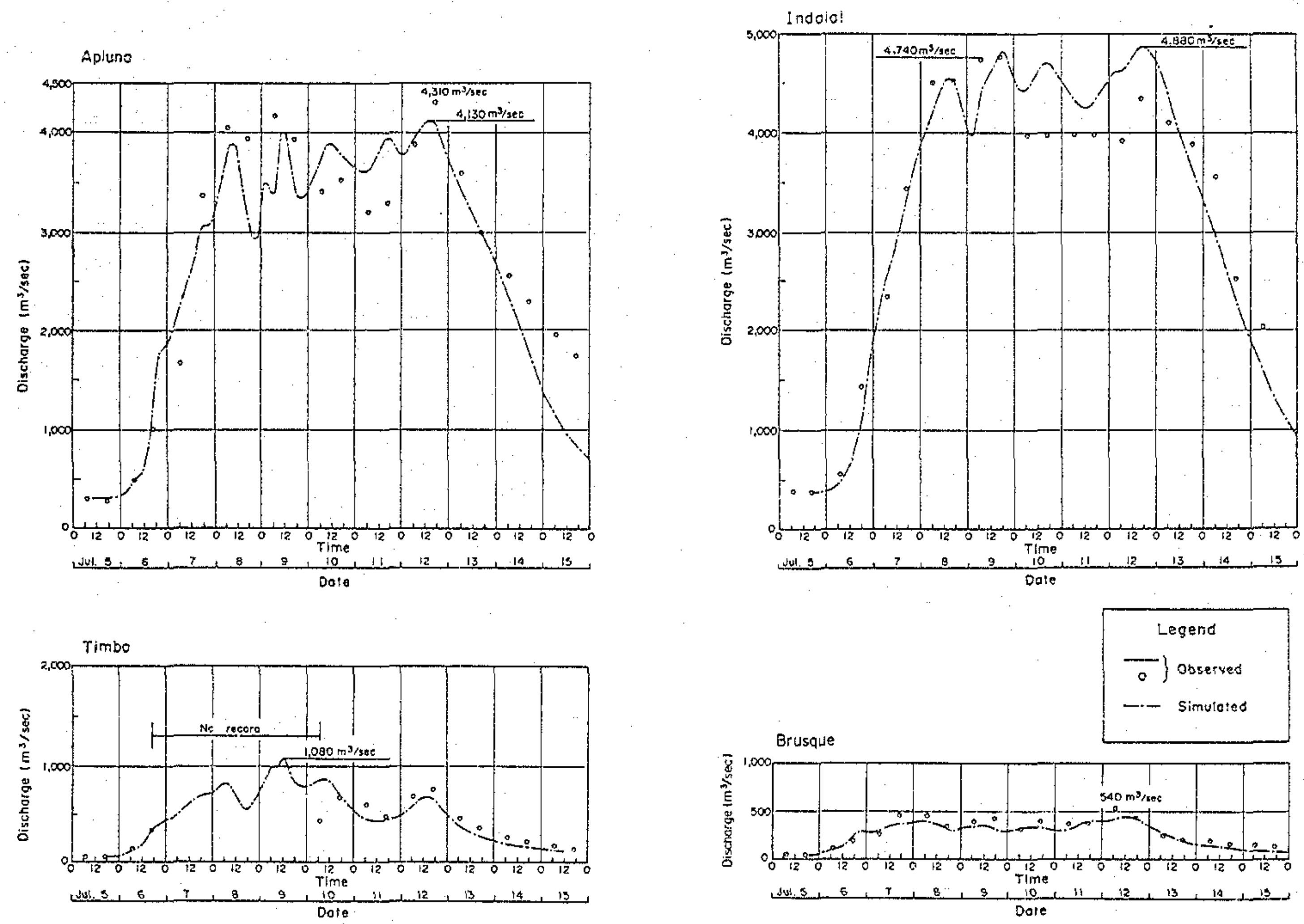


Fig. IX.2.6 OBSERVED AND SIMULATED FLOOD HYDROGRAPH (3/4)
(Flood in July 1983)

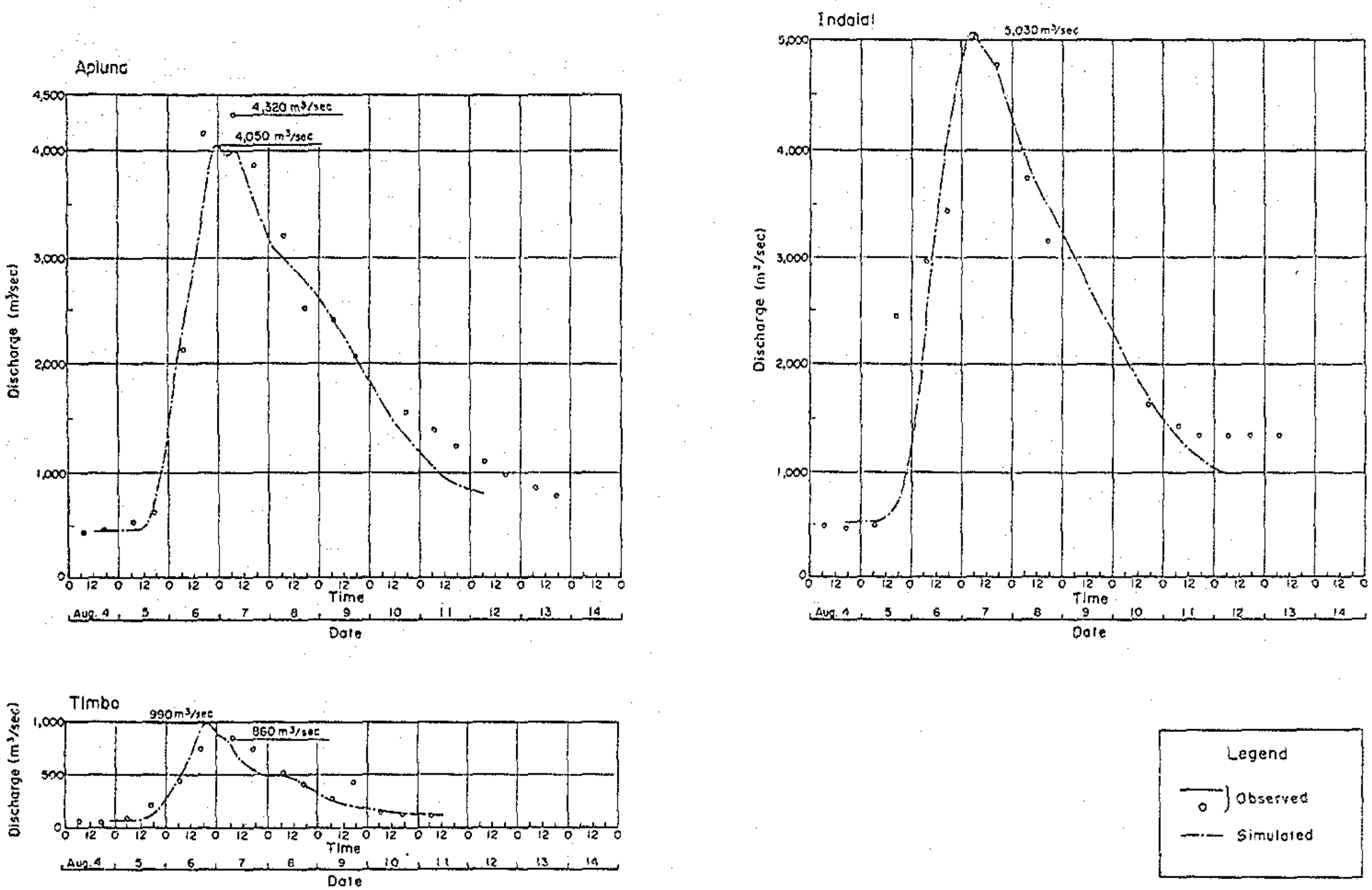


Fig. IX.2.6 OBSERVED AND SIMULATED FLOOD HYDROGRAPH (4/4)
(Flood in August 1984)

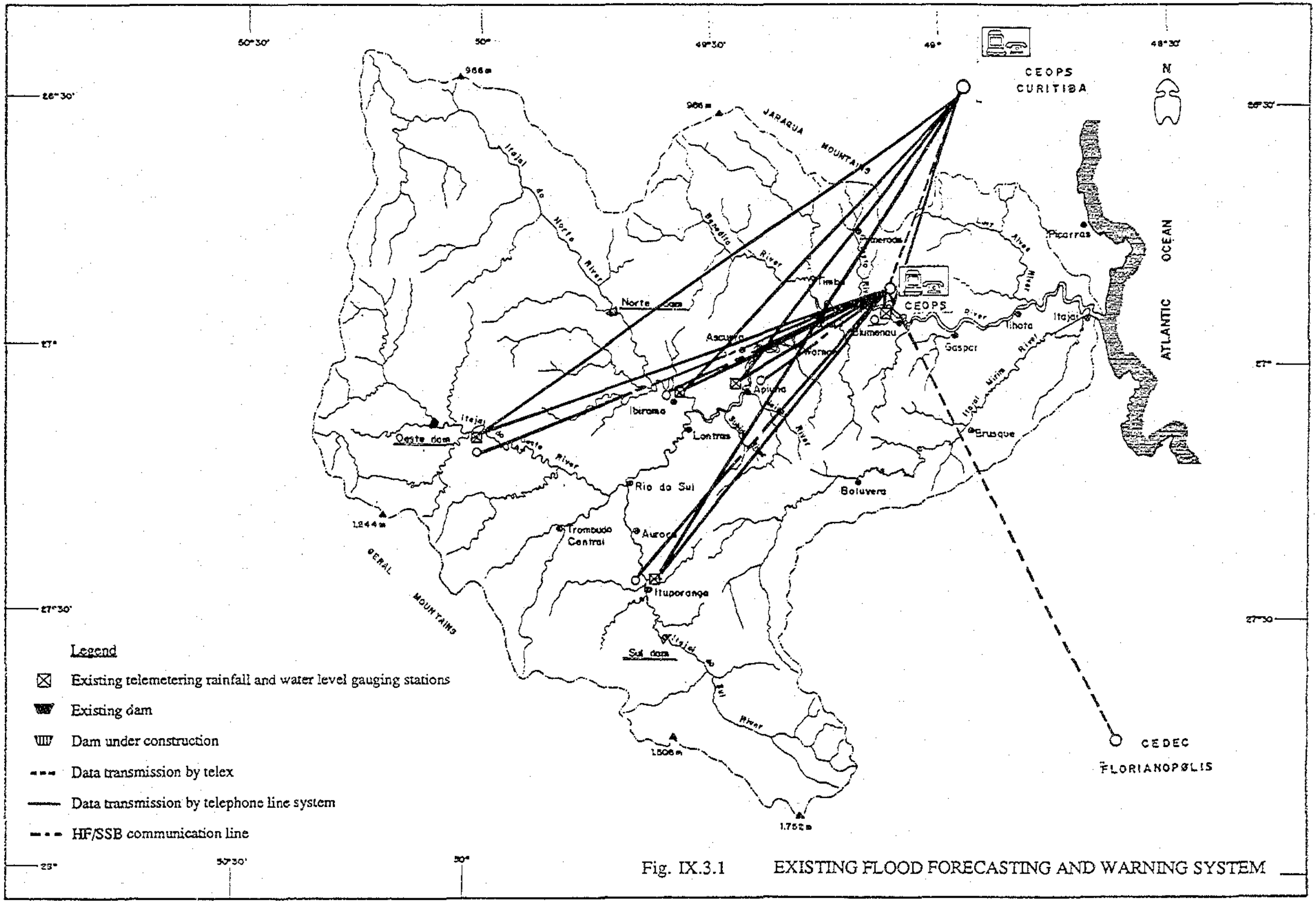


Fig. IX.3.1 EXISTING FLOOD FORECASTING AND WARNING SYSTEM

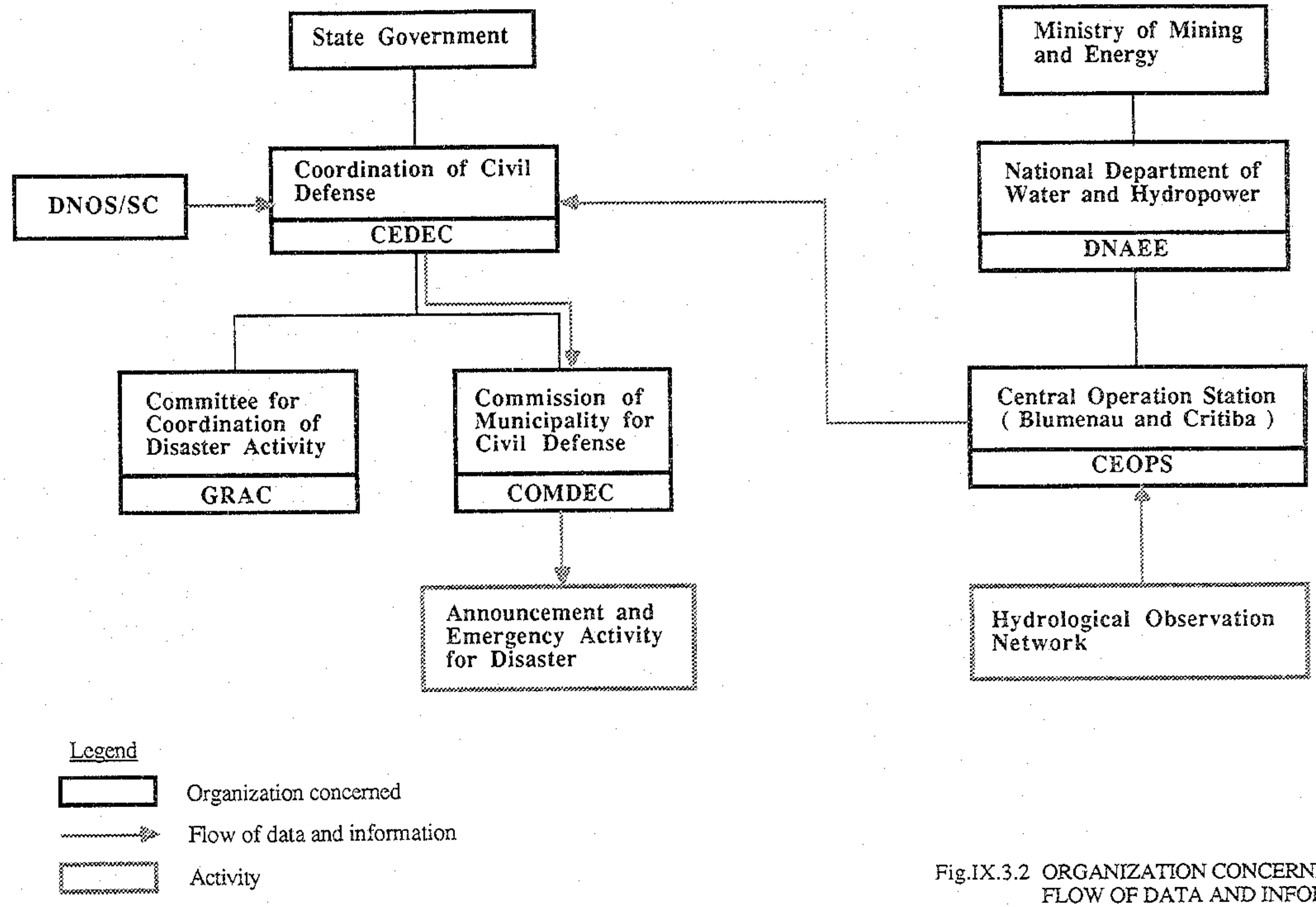


Fig.IX.3.2 ORGANIZATION CONCERNED AND FLOW OF DATA AND INFORMATION

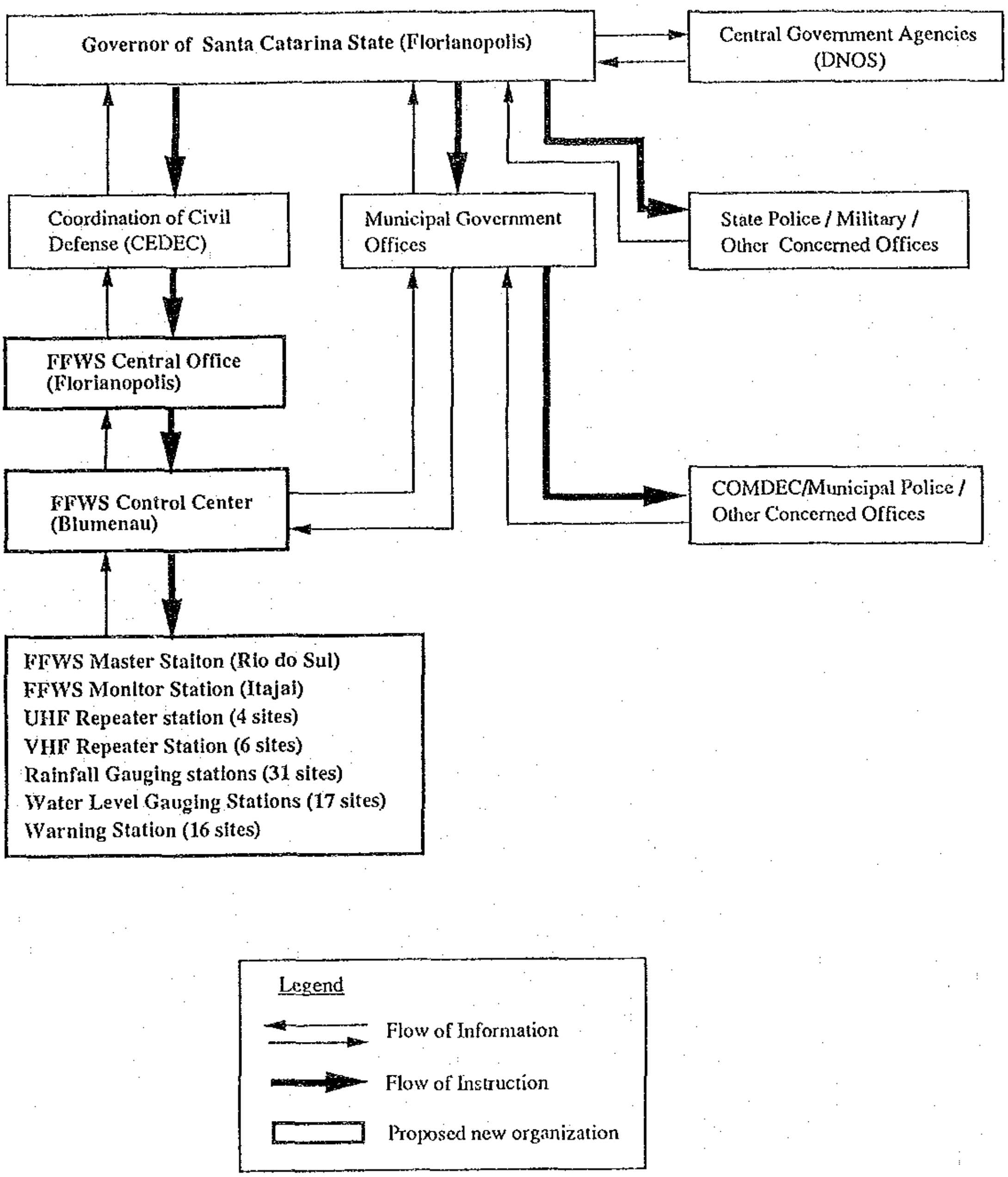


Fig.IX.4.1 PROPOSED ORGANIZATION FOR FFWS

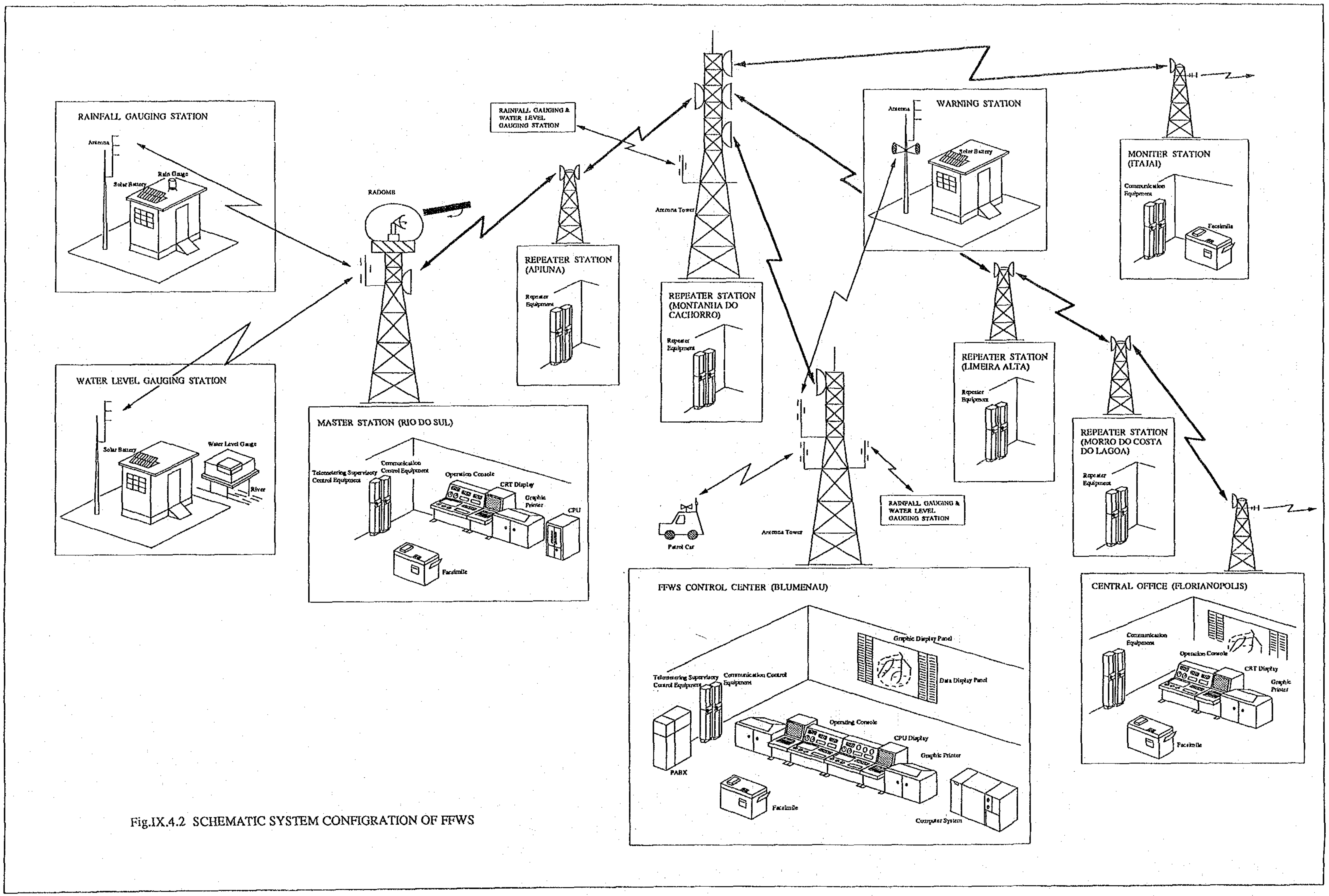


Fig.IX.4.2 SCHEMATIC SYSTEM CONFIGRATION OF FFWS

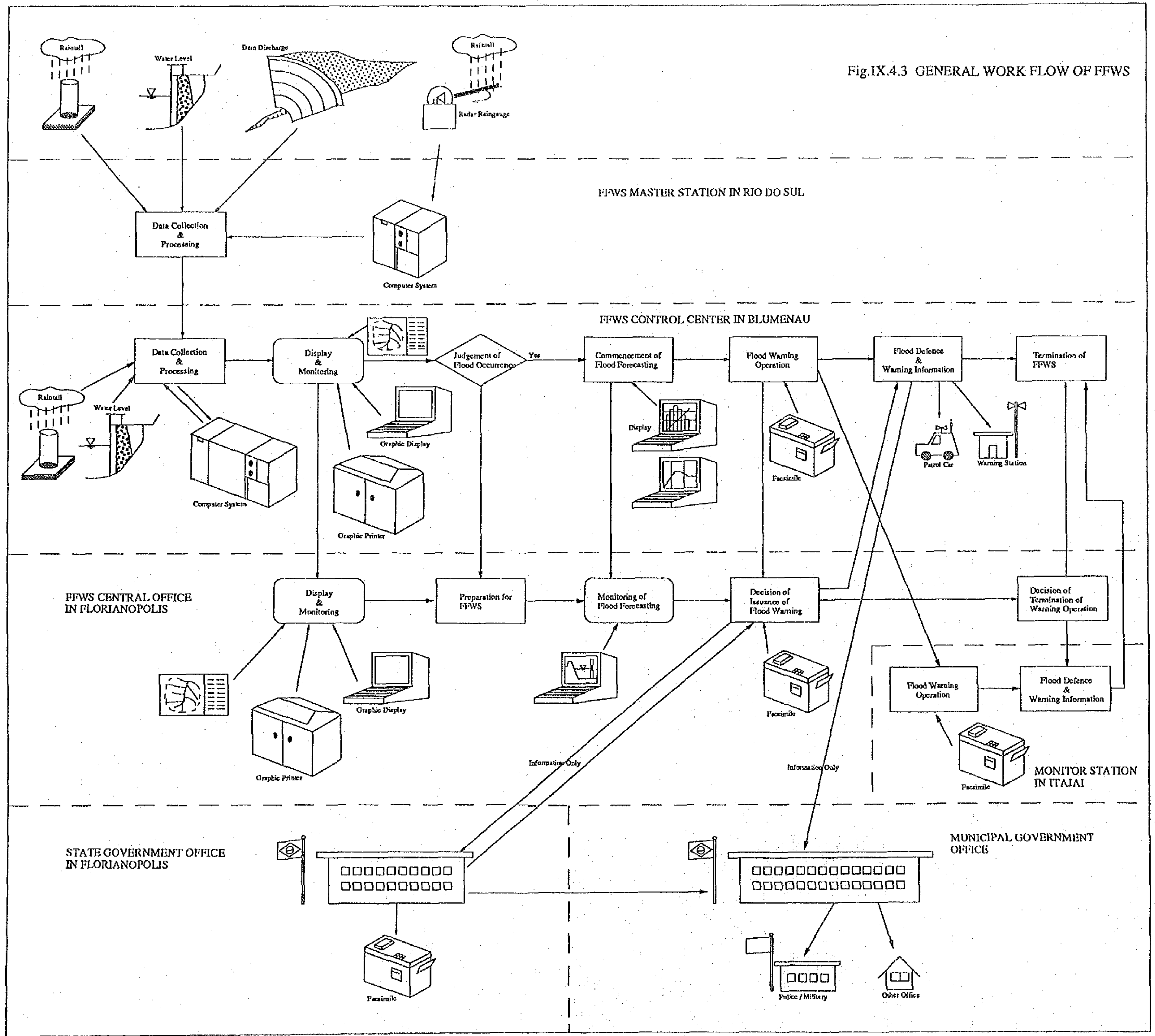


Fig.IX.4.3 GENERAL WORK FLOW OF FFWS

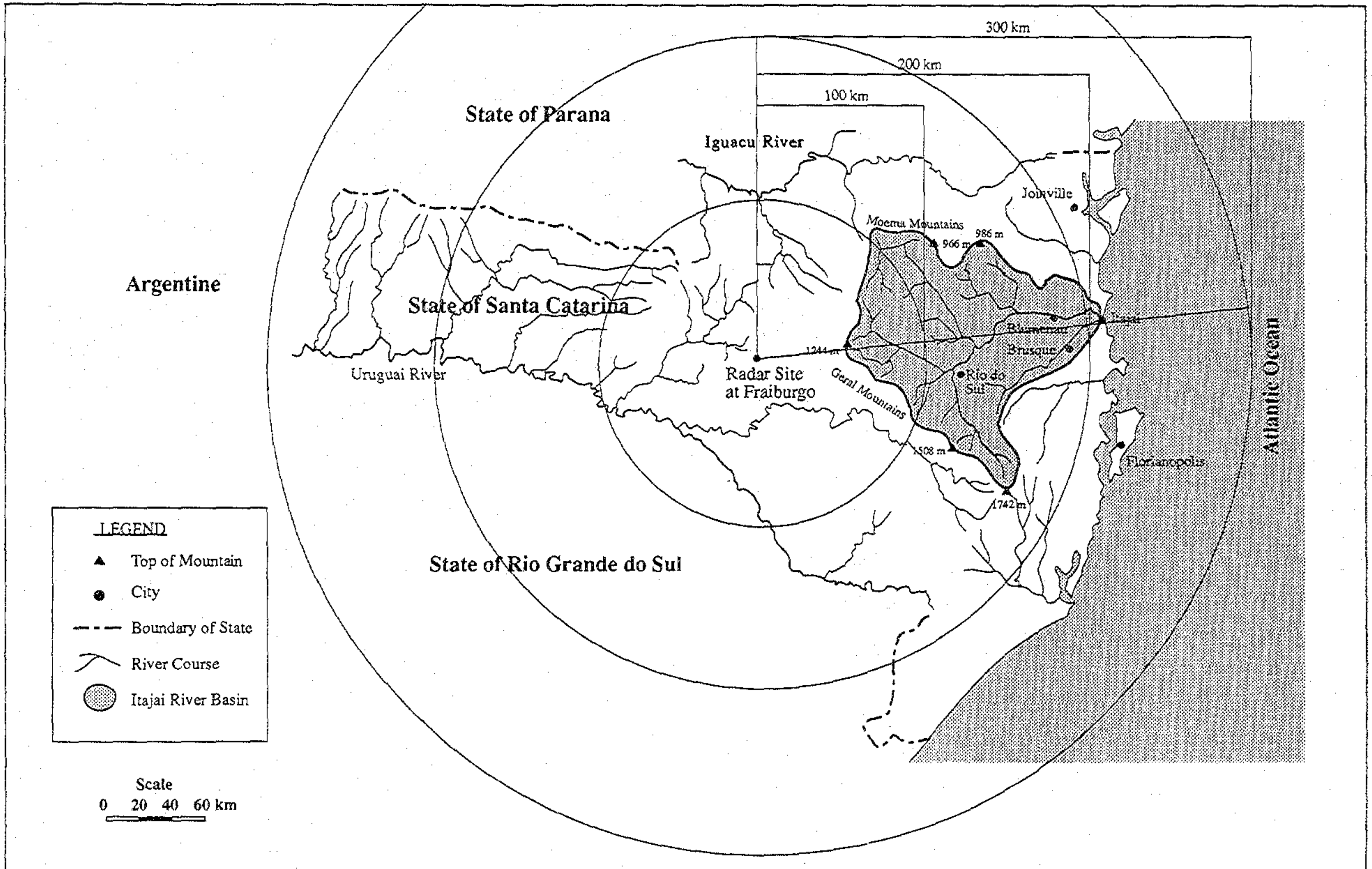
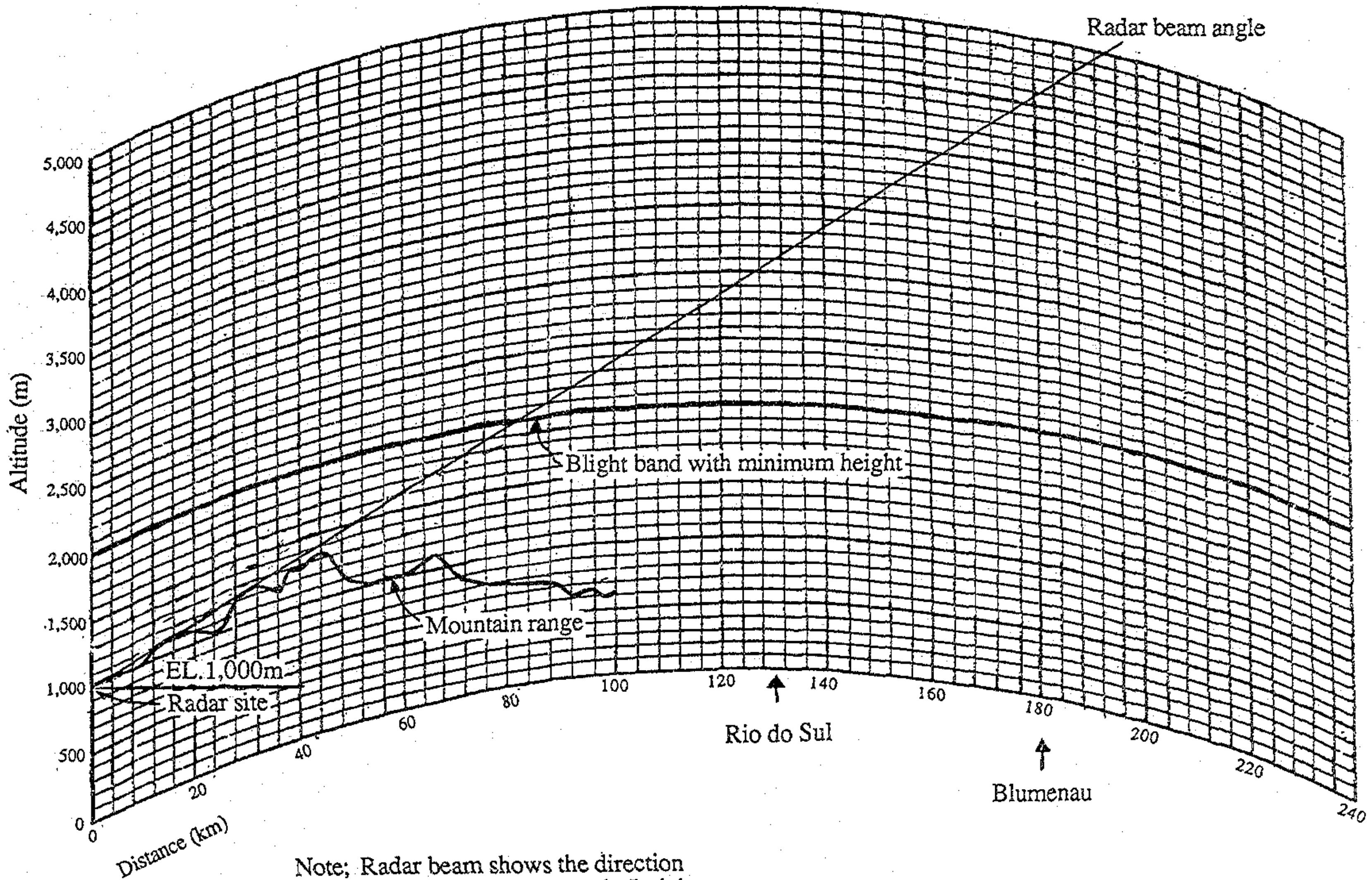


Fig. IX.4.4 LOCATION OF RADAR RAIN GAUGE AT FRAIBURGO



Note; Radar beam shows the direction which covers as much Itajai river basin area as possible.

Fig.IX.4.5 TERRAIN PROFILE

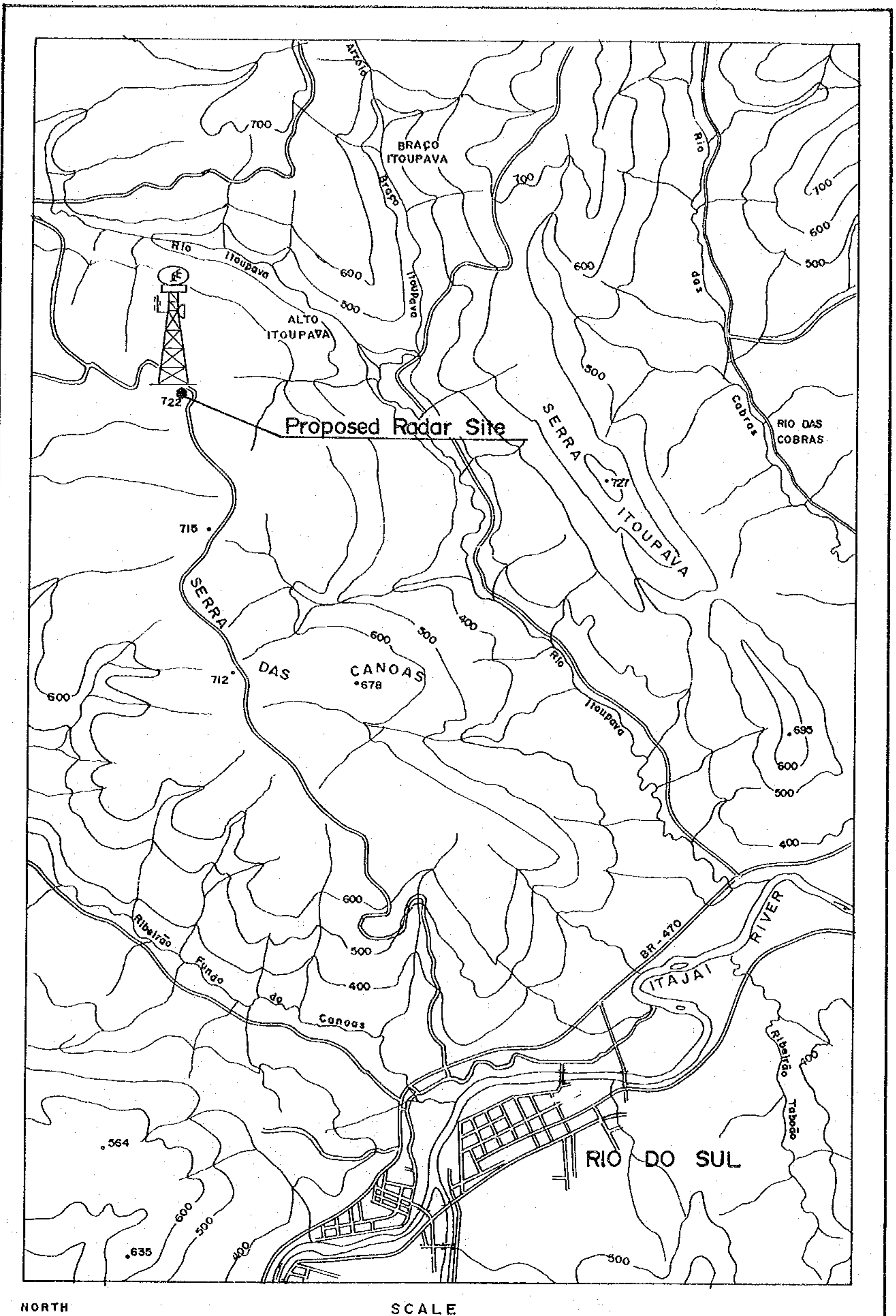


Fig.IX.4.6 LOCATION MAP OF PROPOSED RADAR SITE

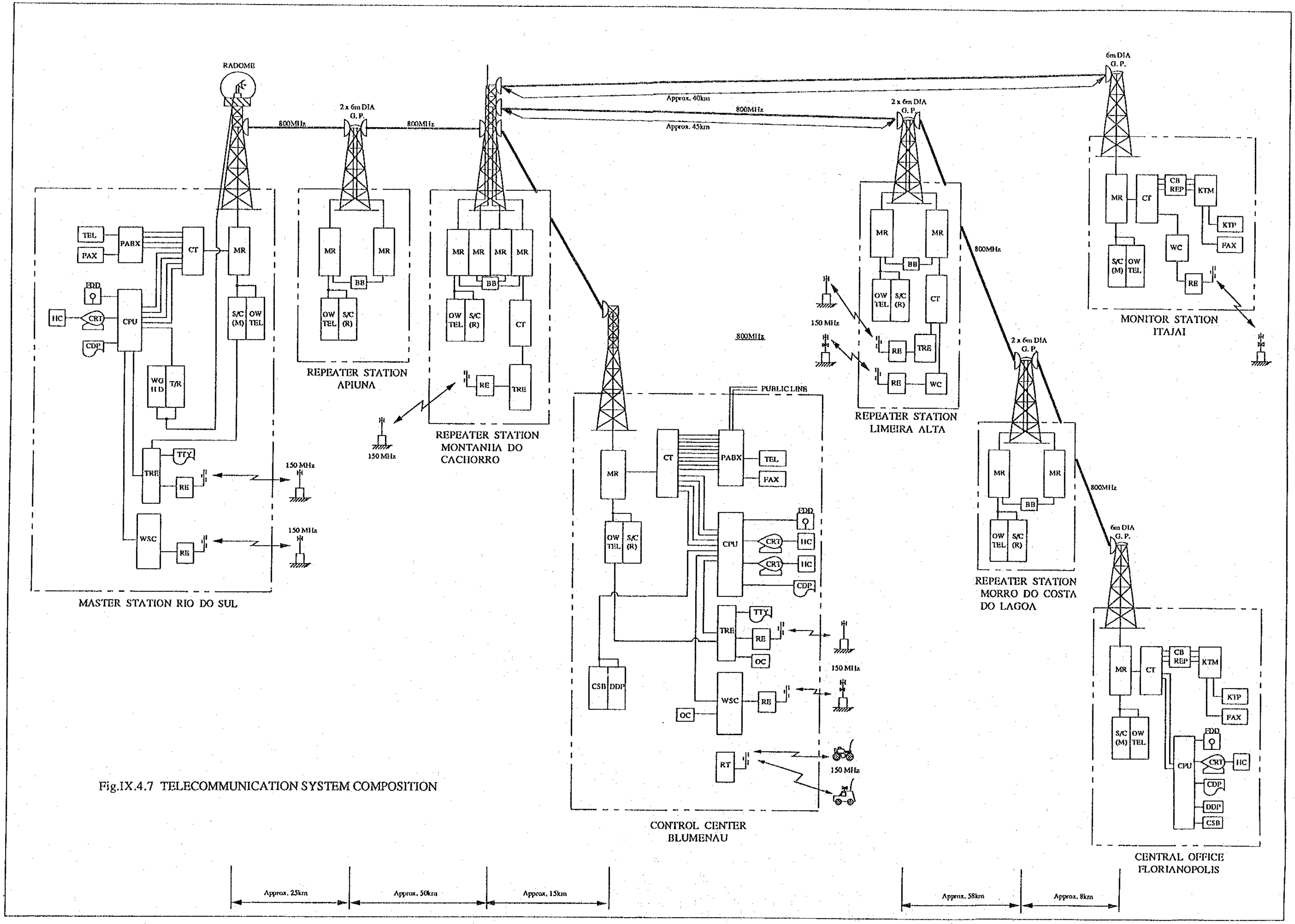


Fig.IX.4.7 TELECOMMUNICATION SYSTEM COMPOSITION

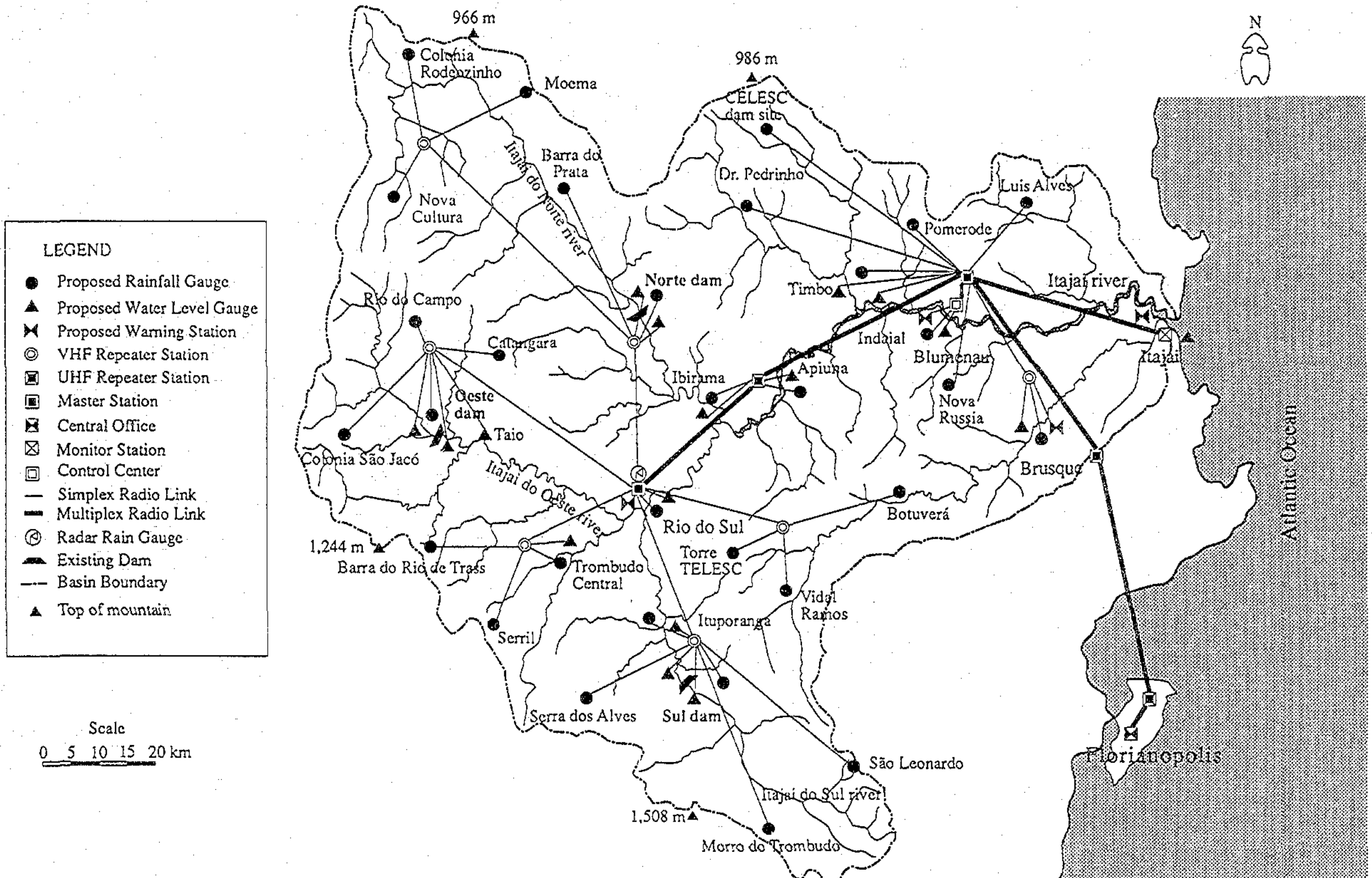


Fig.IX.4.8 OVERALL CHEME OF THE PROPOSED FFWS

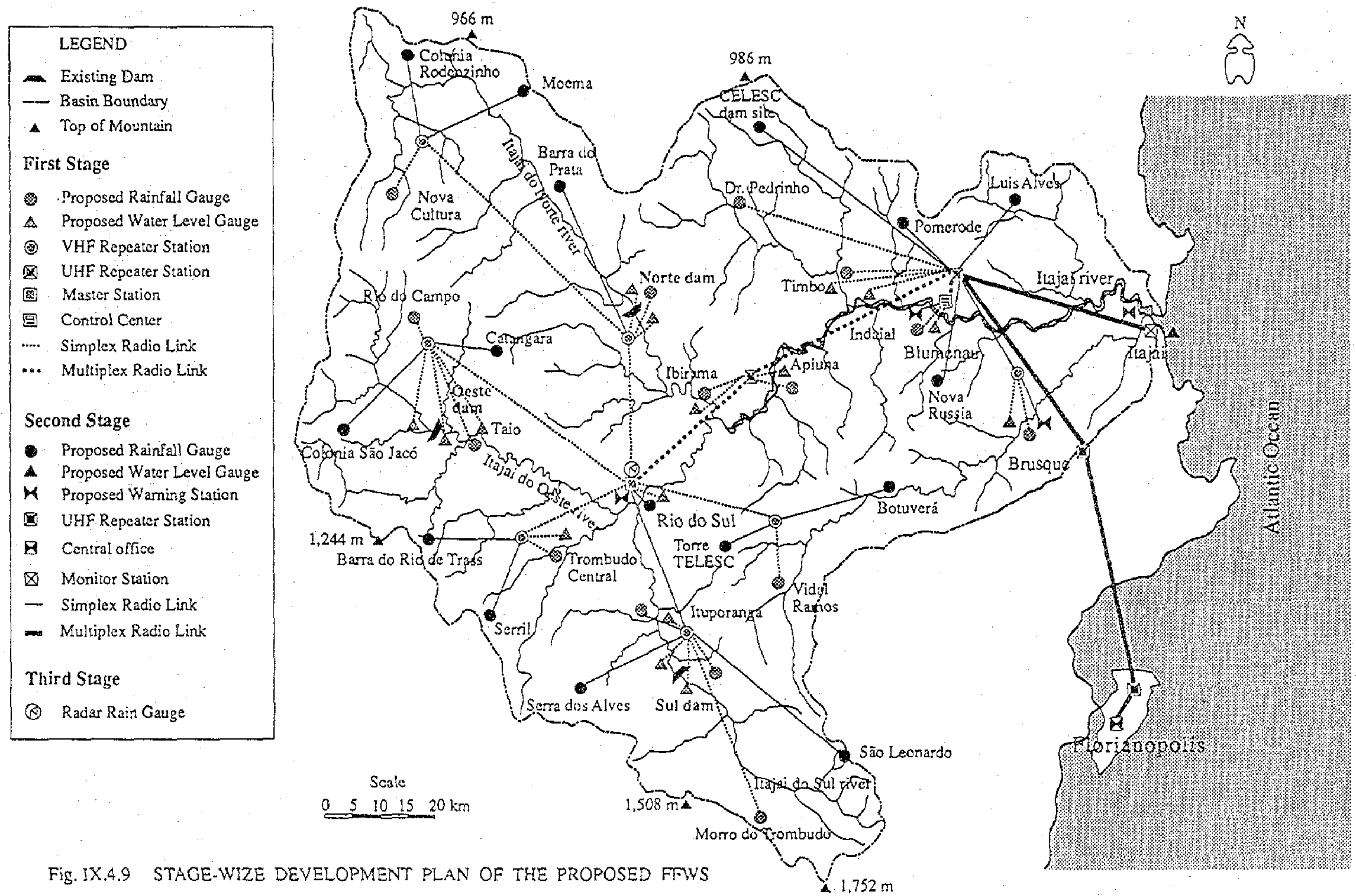


Fig. IX.4.9 STAGE-WIZE DEVELOPMENT PLAN OF THE PROPOSED FFWS

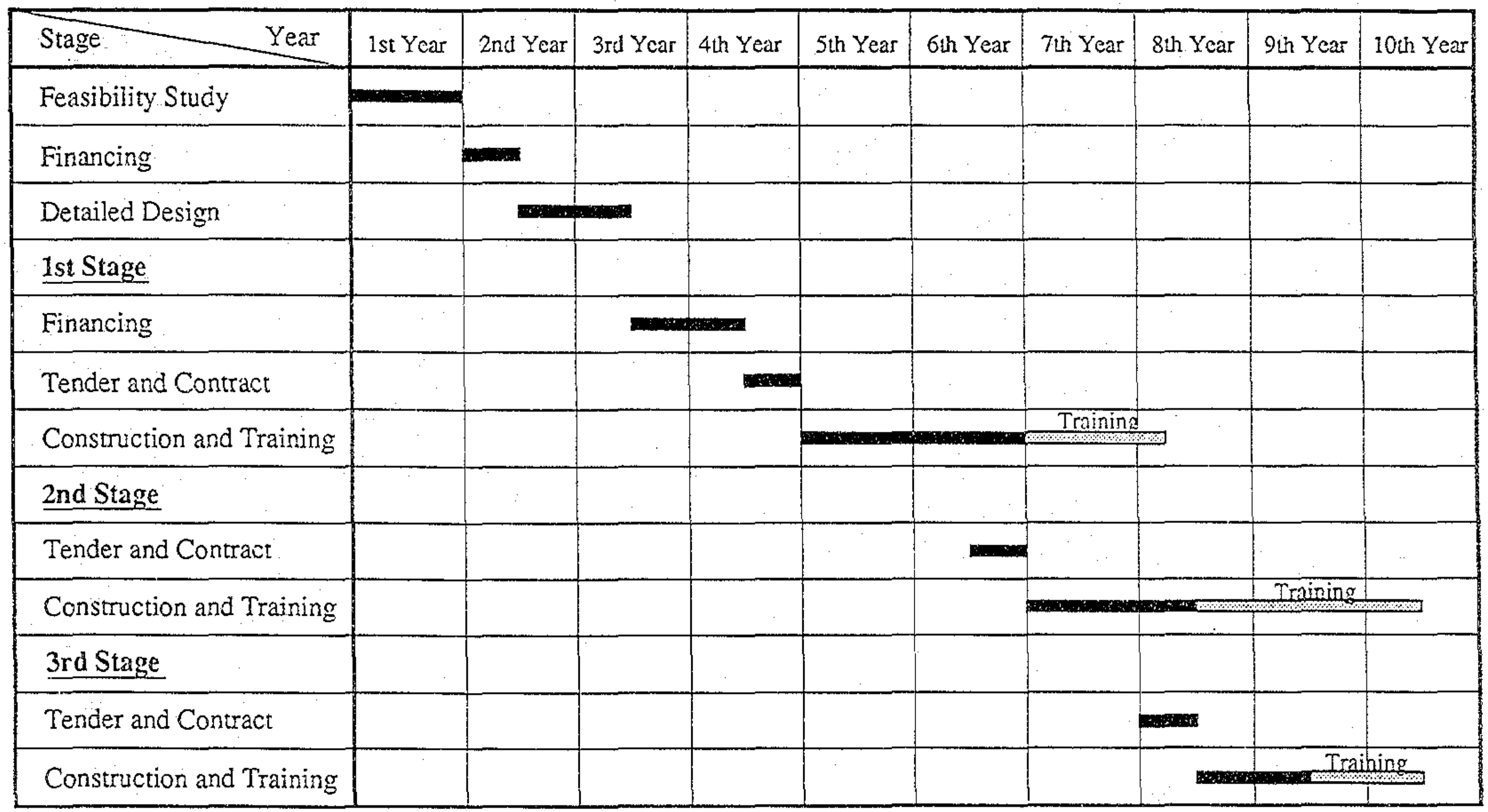


Fig.IX.4.10 IMPLEMENTATION SCHEDULE OF THE PROPOSED FFWS

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