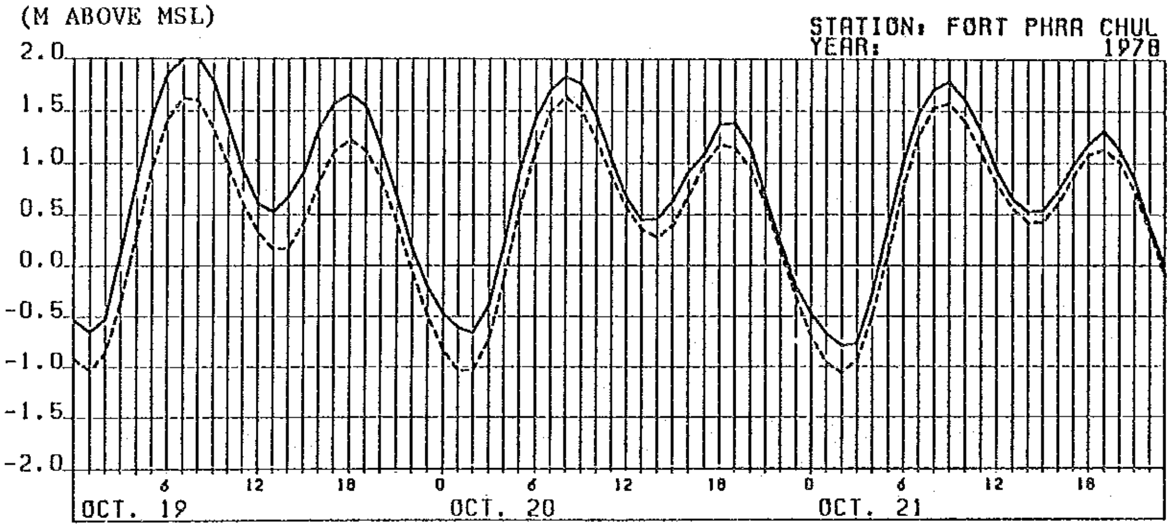
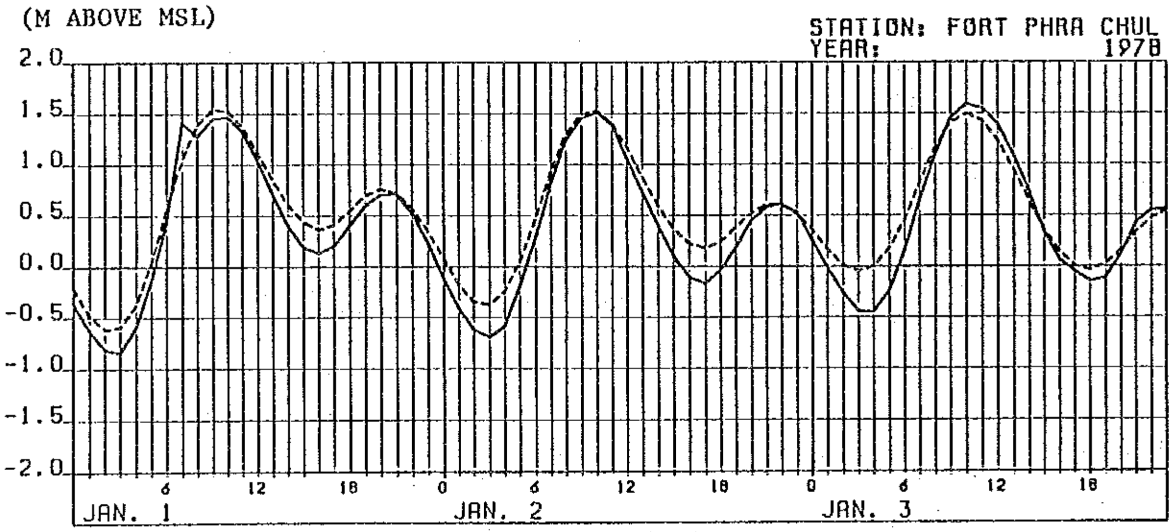


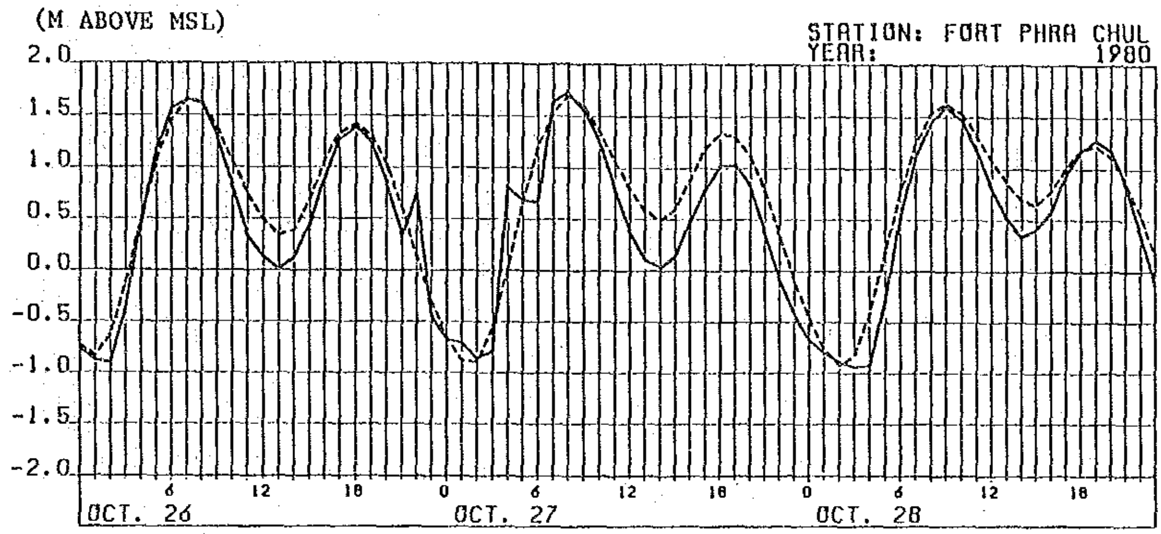


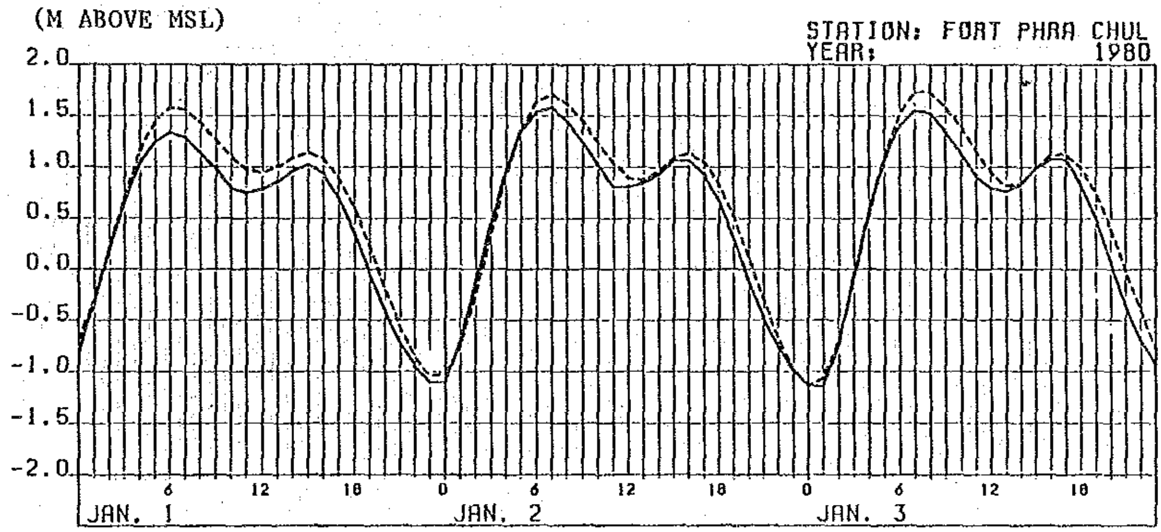
LEGEND

——— : OBSERVED

------ : PREDICTED

Fig. 2-28(1/3). HOURLY VARIATION OF TIDAL LEVEL IN 1978	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY





LEGEND

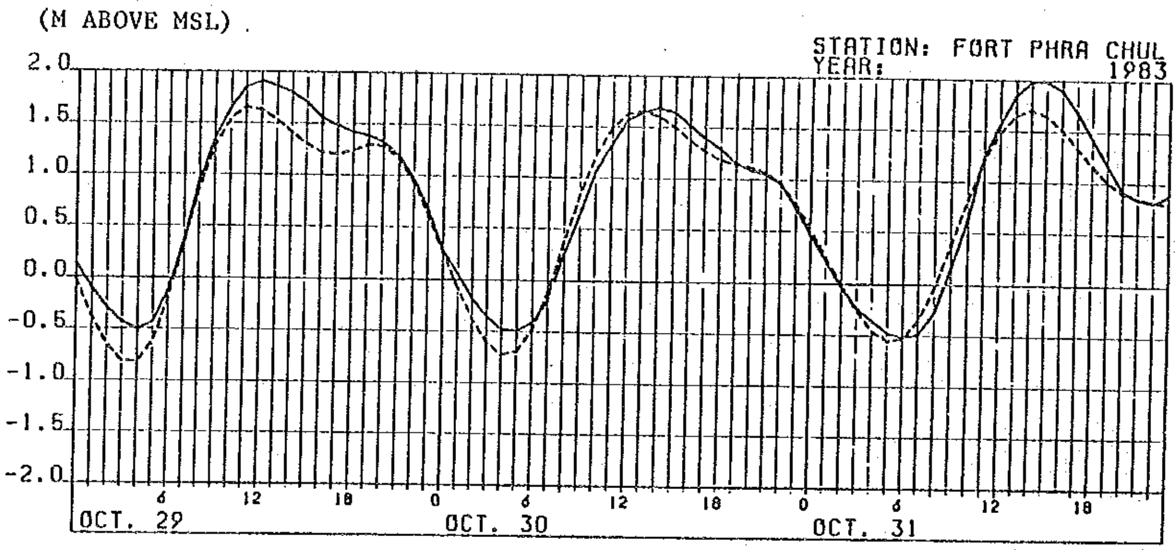
——— : OBSERVED

----- : PREDICTED

Fig. 2-28(2/3). HOURLY VARIATION OF TIDAL LEVEL IN 1980

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY



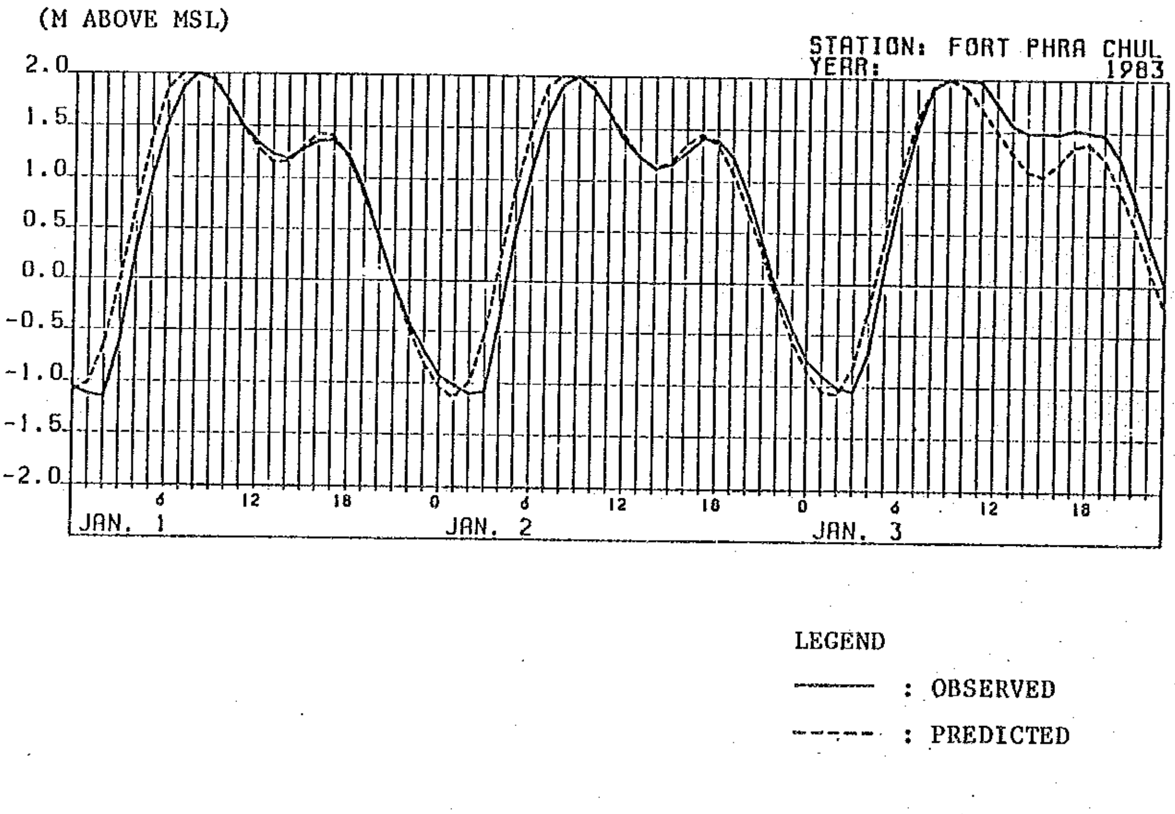


Fig. 2-28(3/3). HOURLY VARIATION OF TIDAL LEVEL IN 1983

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

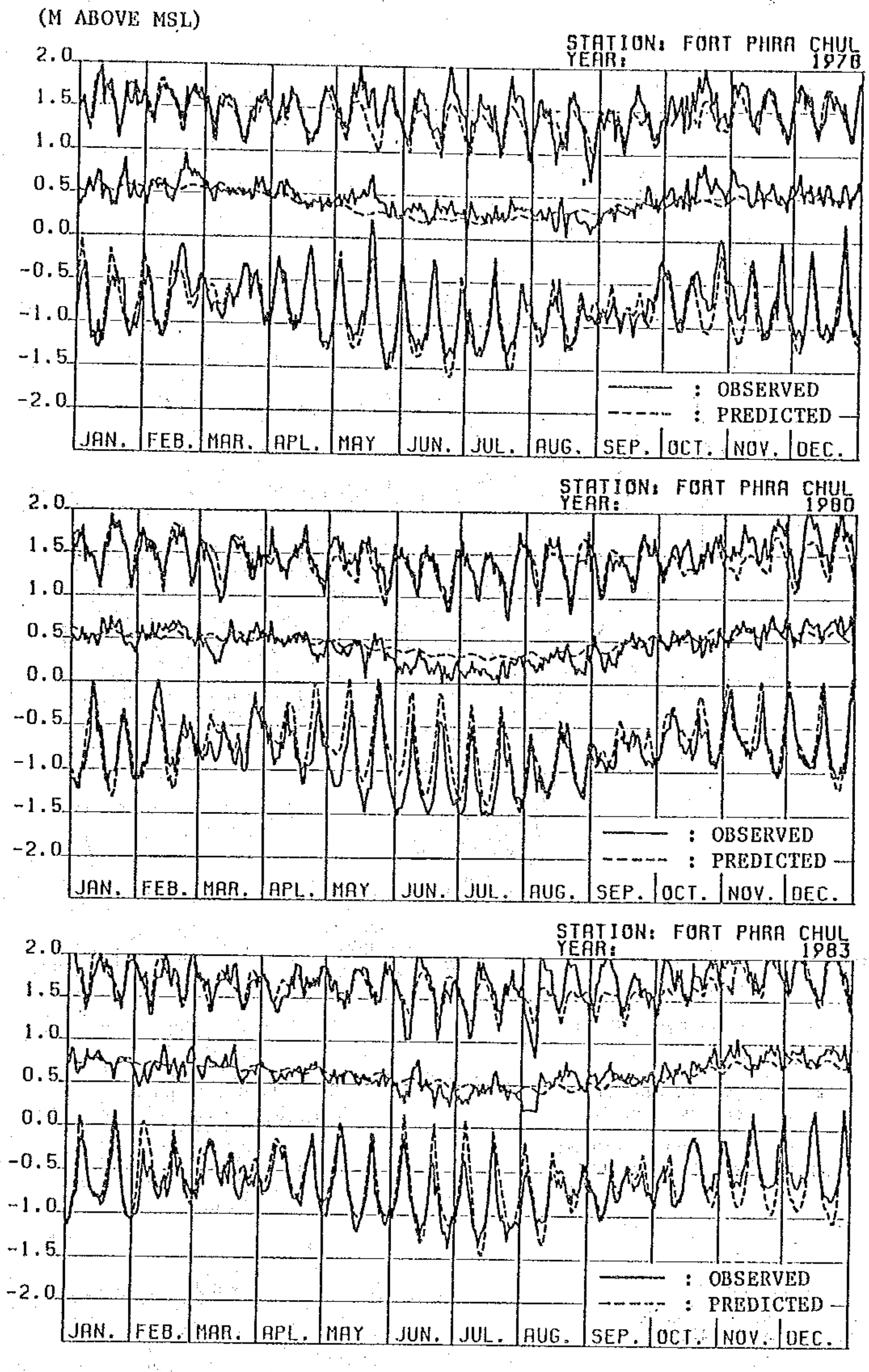


Fig. 2-29. DAILY VARIATION OF ONE-DAY MAXIMUM, AVERAGE AND MINIMUM TIDAL LEVEL	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY

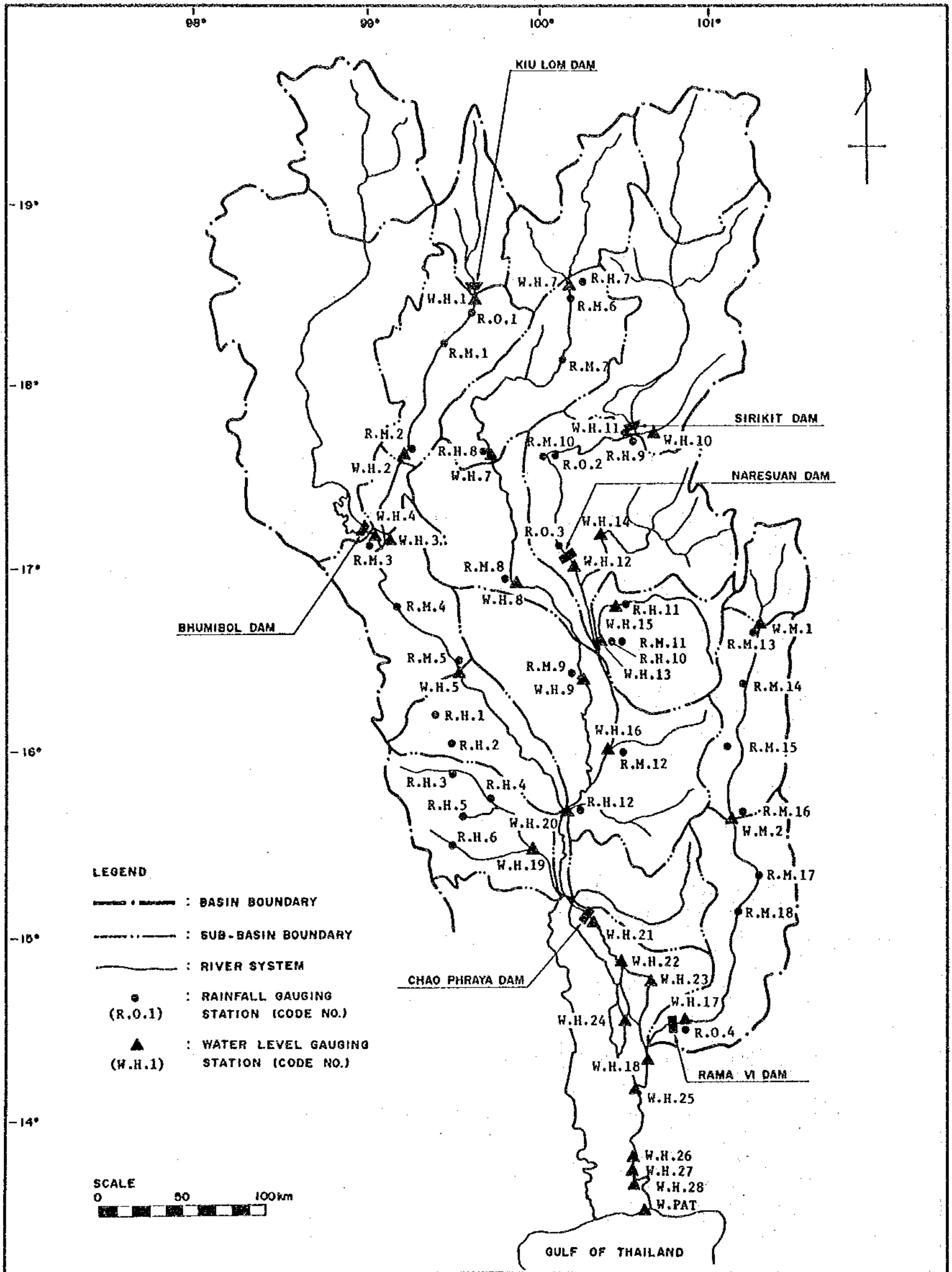
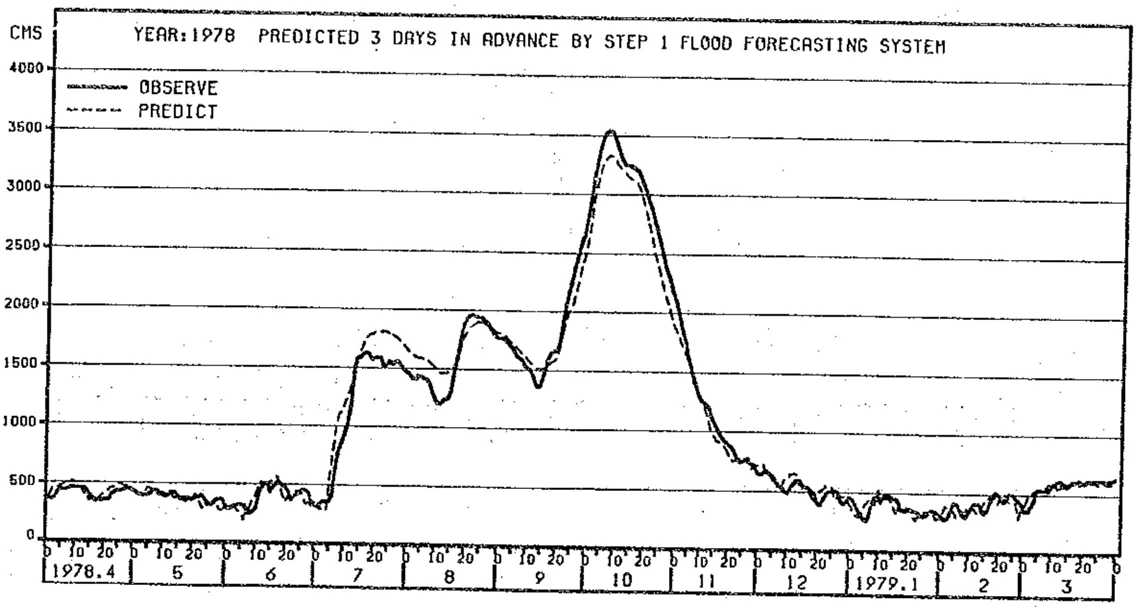


Fig. 2-30. HYDROLOGICAL GAUGING STATIONS (STEP 1)

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY



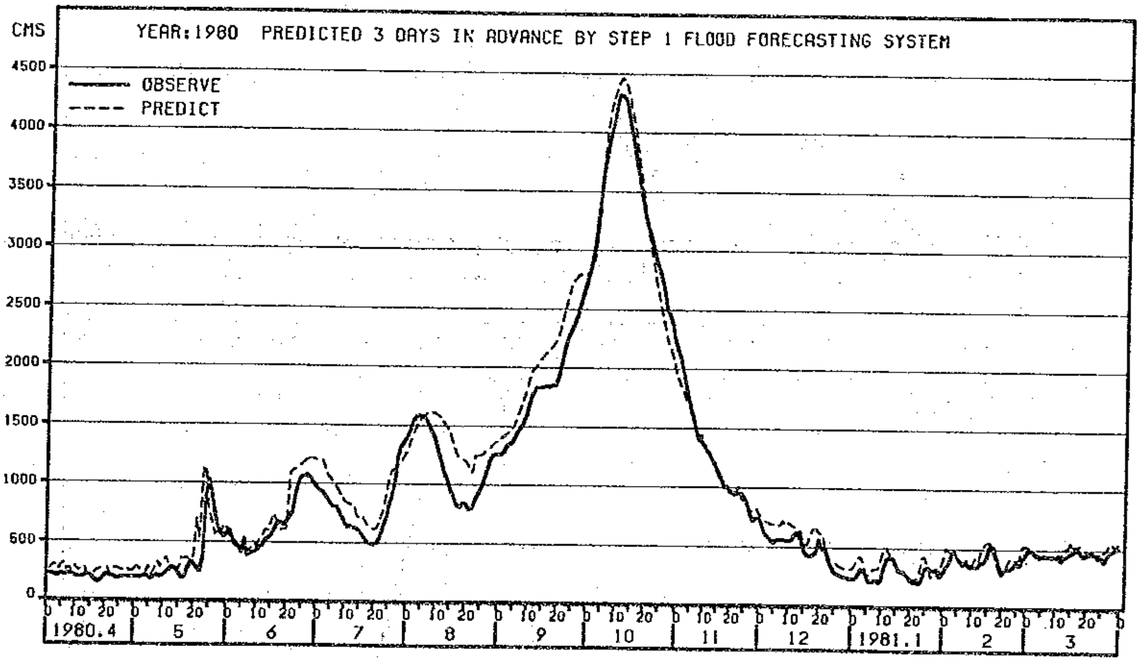


Fig. 2-31(1/3). DISCHARGE HYDROGRAPH PREDICTED 3 DAYS IN ADVANCE AT NAKHON SAWAN (STEP 1)

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

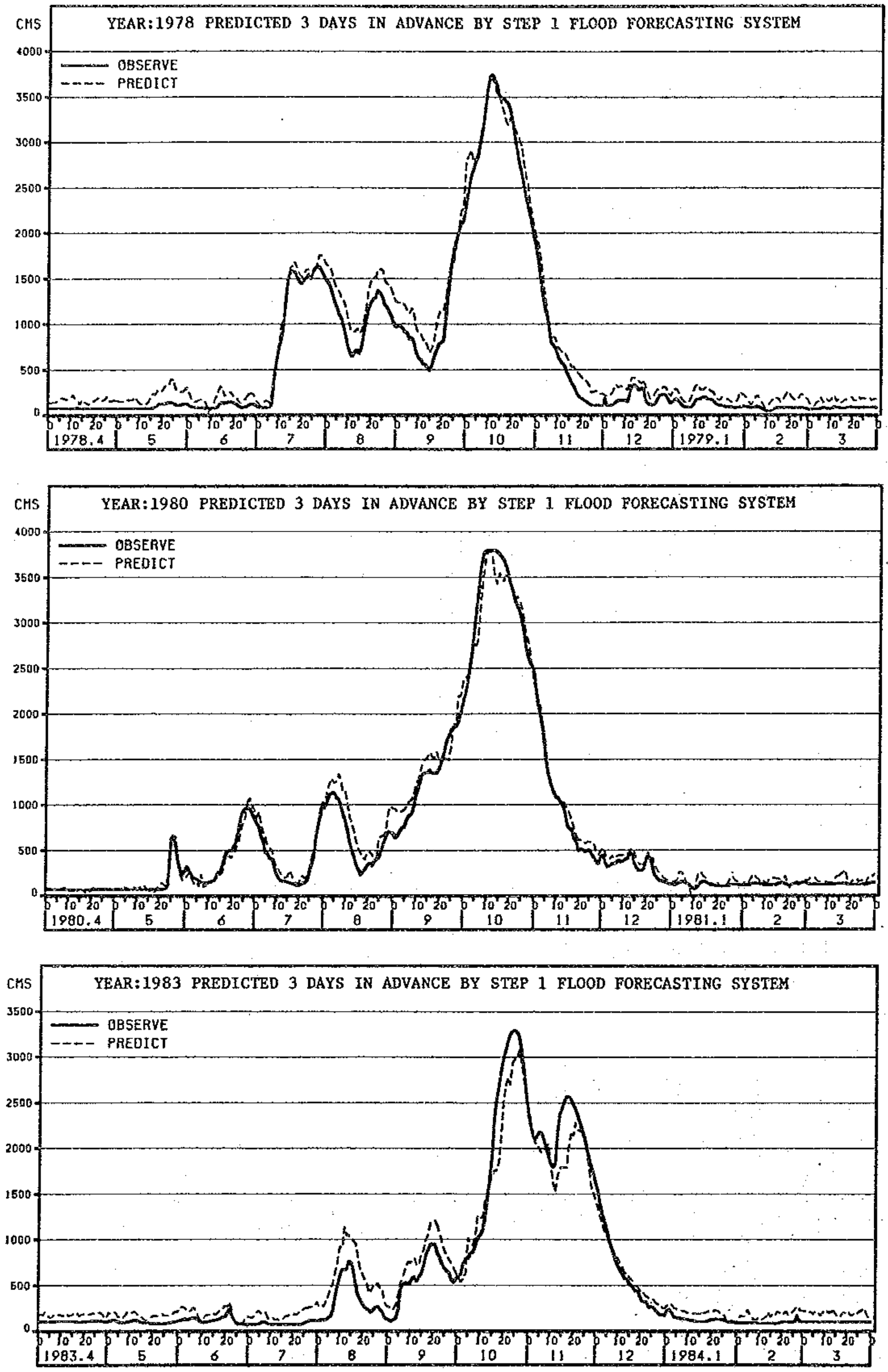
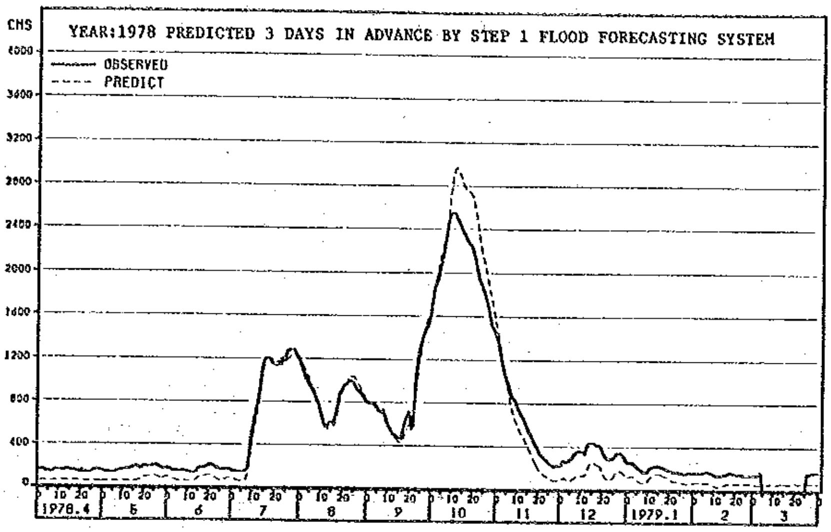
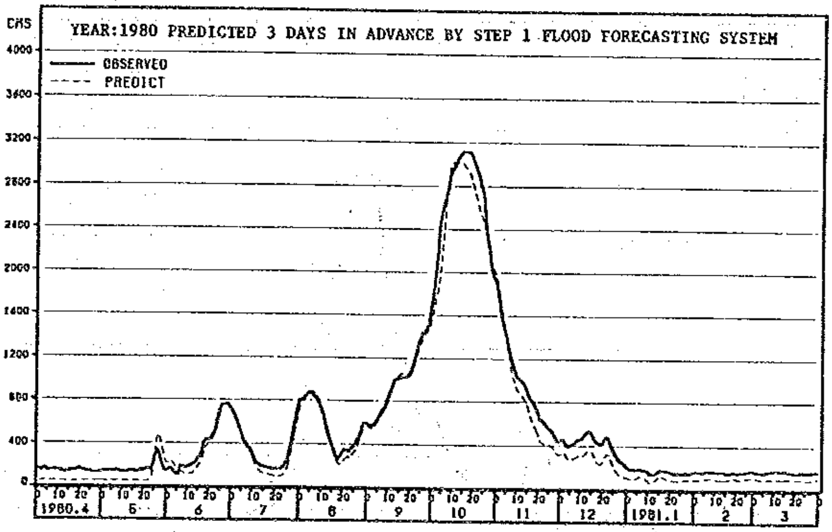


Fig. 2-31(2/3). DISCHARGE HYDROGRAPH PREDICTED 3 DAYS IN ADVANCE AT CHAI NAT (STEP 1)

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY





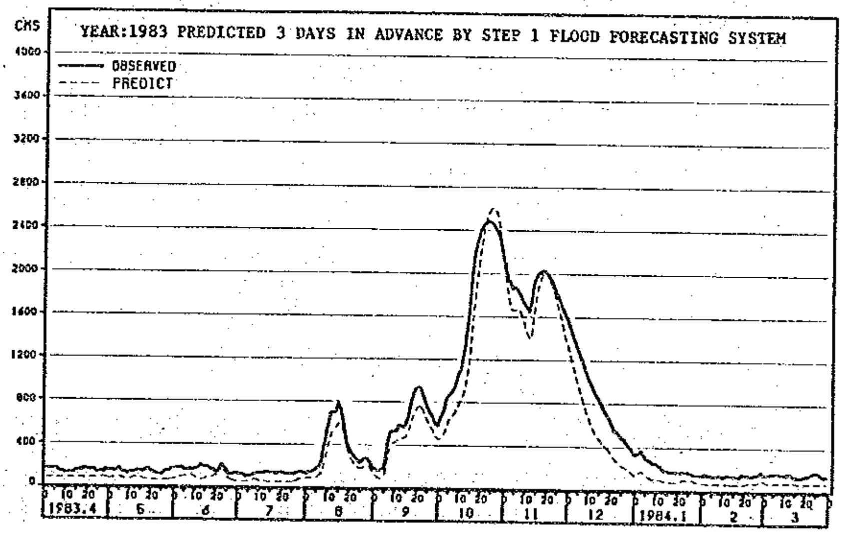


Fig. 2-31(3/3). DISCHARGE HYDROGRAPH PREDICTED 3 DAYS IN ADVANCE AT ANG THONG (STEP 1)	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY

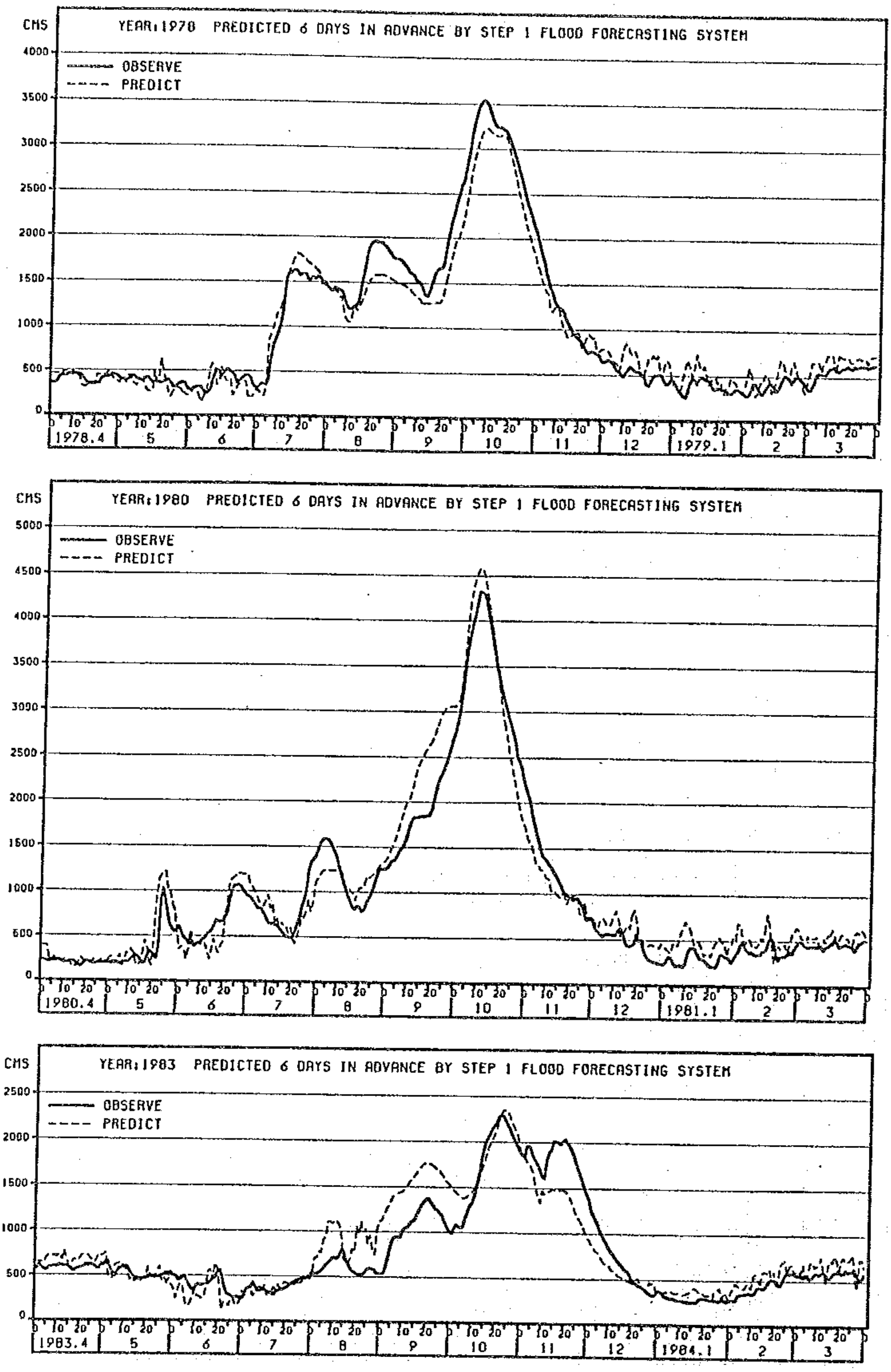
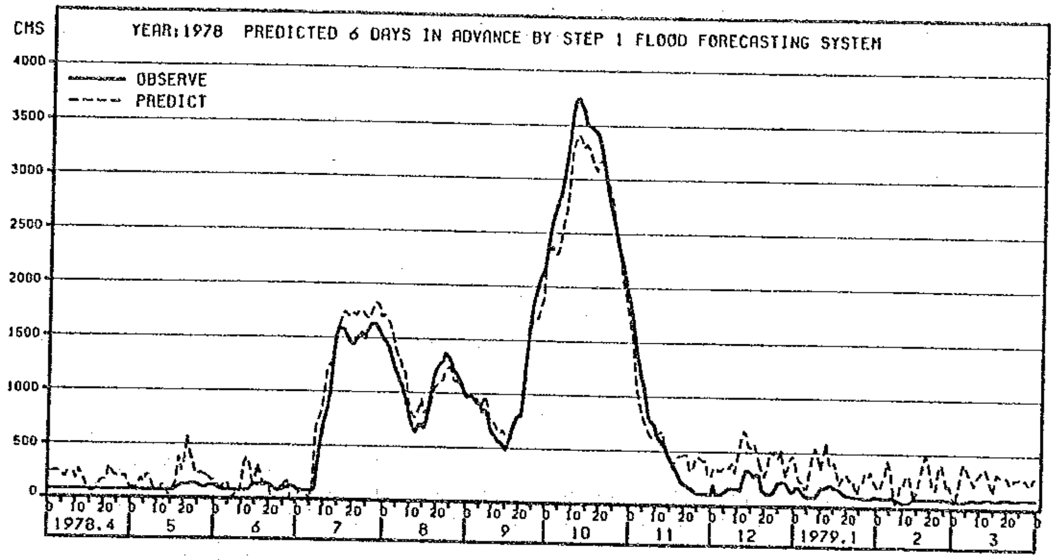
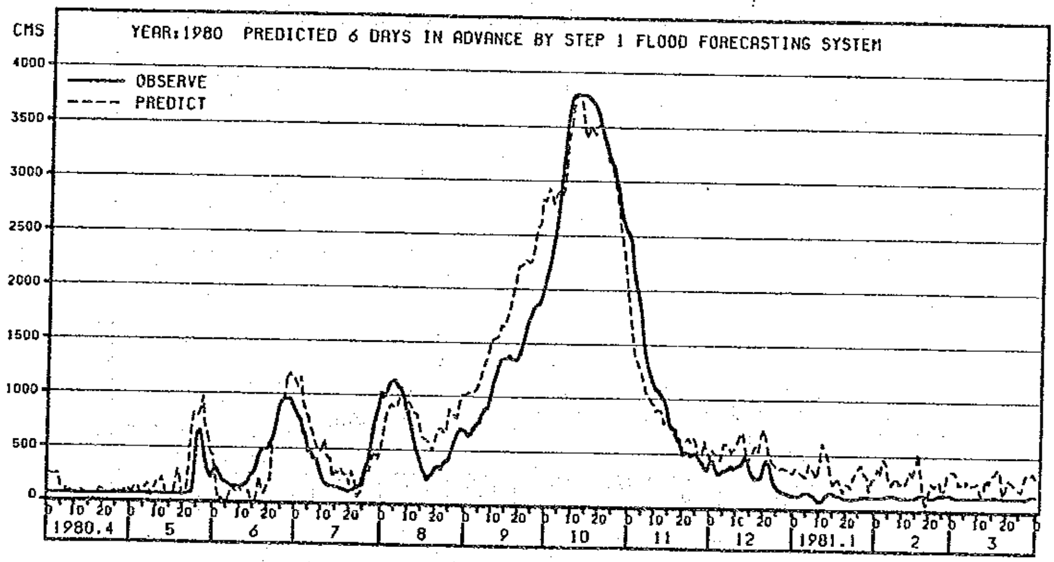


Fig. 2-32(1/3). DISCHARGE HYDROGRAPH PREDICTED 6 DAYS IN ADVANCE AT NAKHON SAWAN (STEP 1)

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY





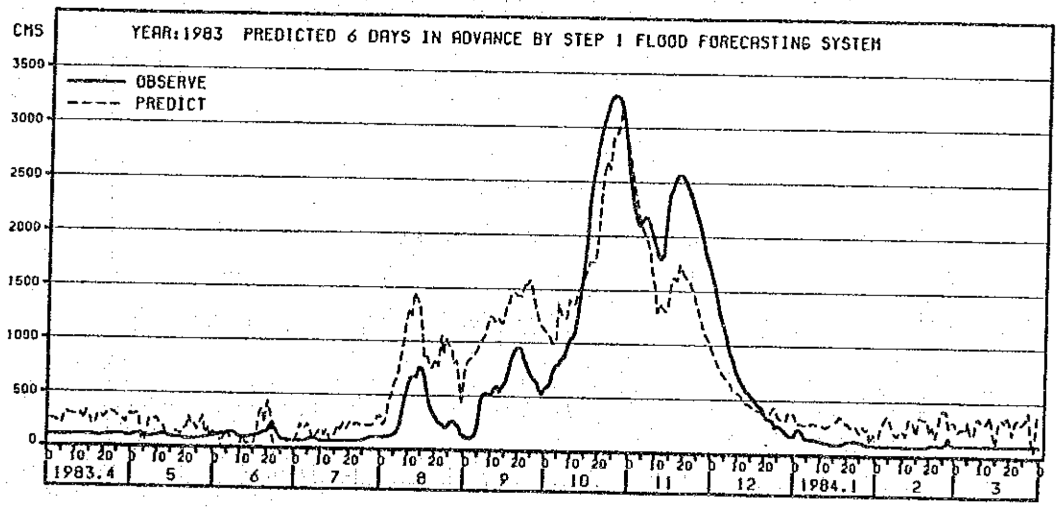


Fig. 2-32(2/3). DISCHARGE HYDROGRAPH PREDICTED 6 DAYS IN ADVANCE AT CHAI NAT (STEP 1)	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY

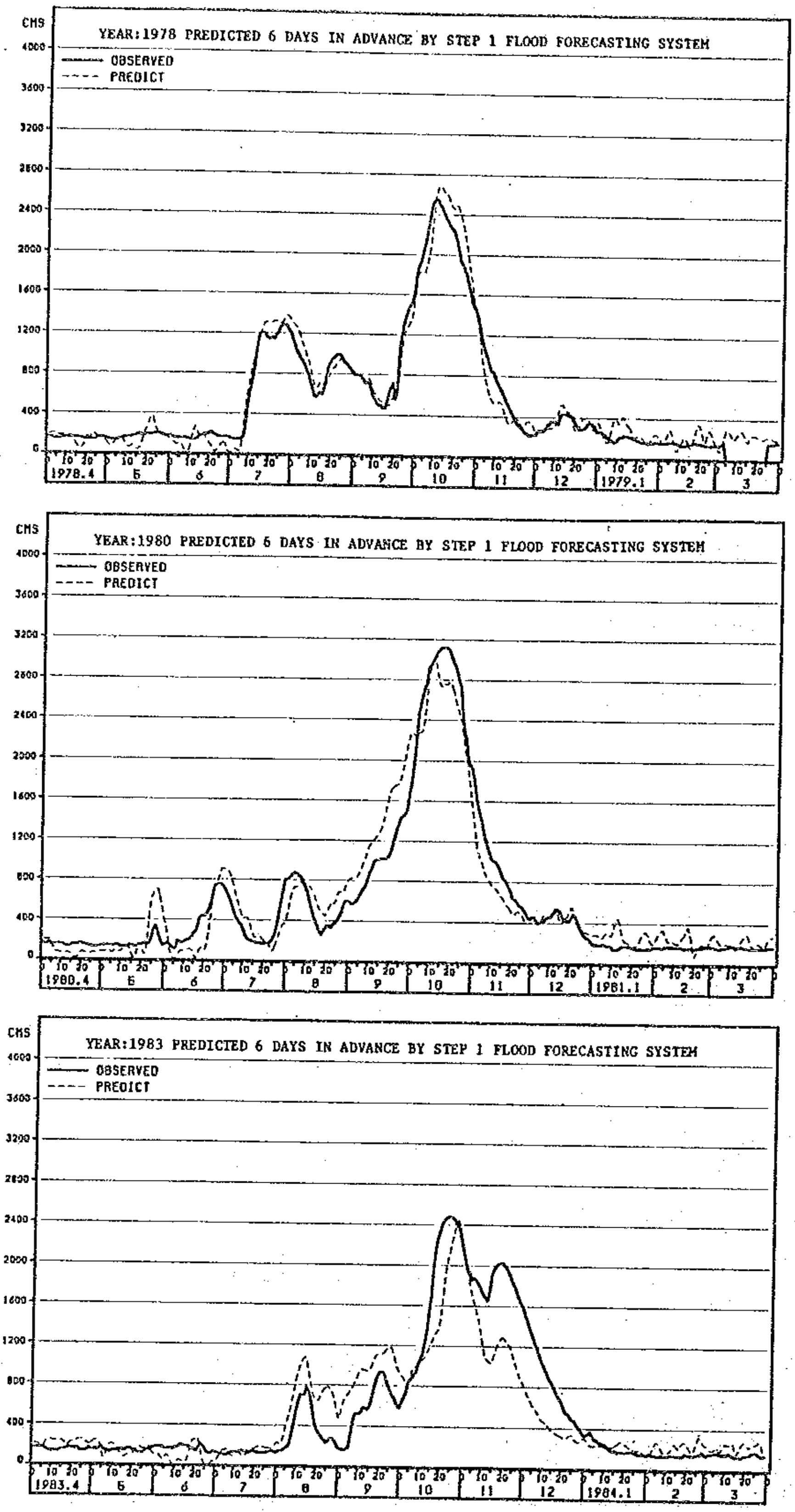


Fig. 2-32(3/3). DISCHARGE HYDROGRAPH PREDICTED 6 DAYS IN ADVANCE AT ANG THONG (STEP 1)

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

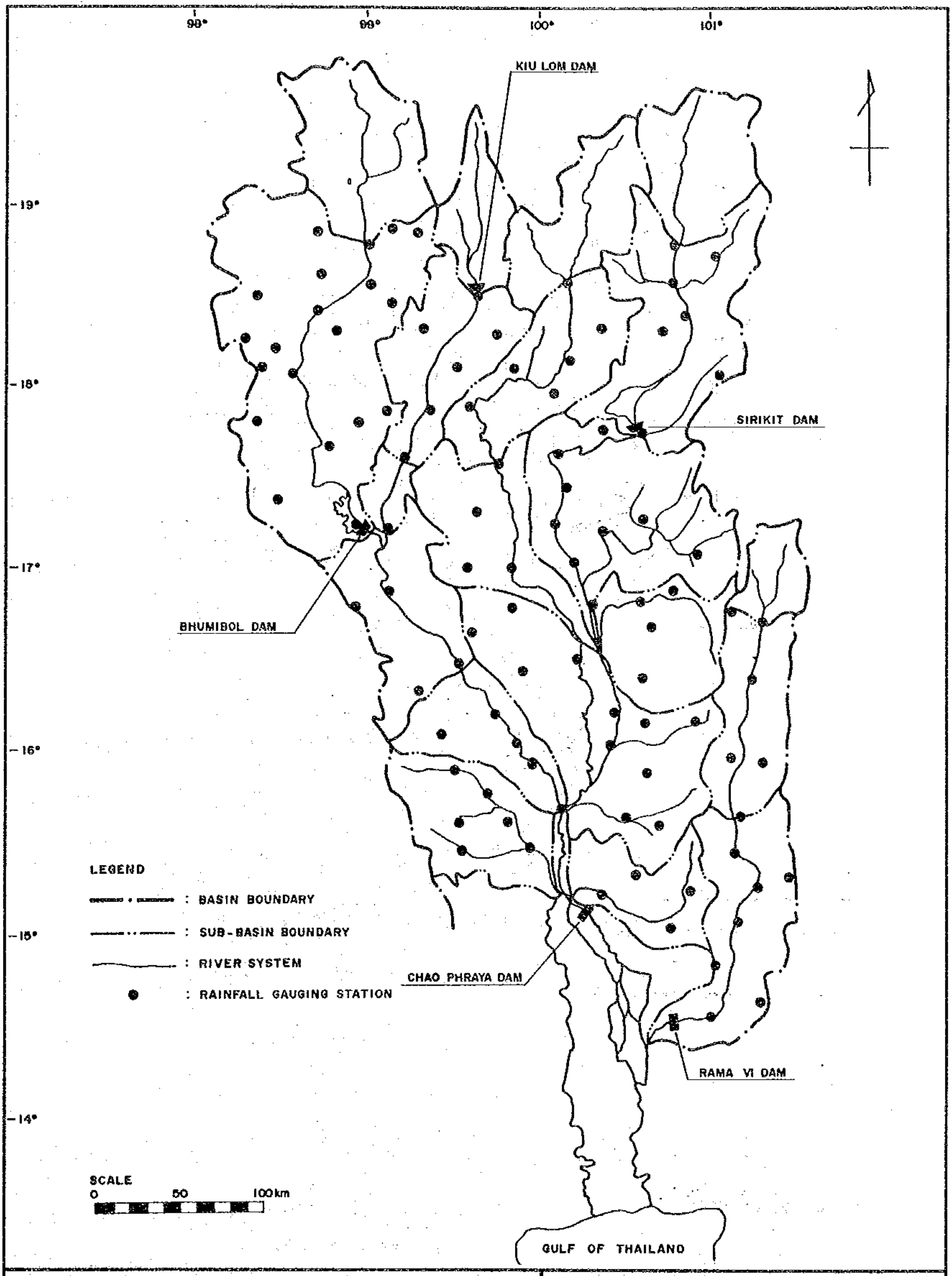


Fig. 2-33(1/5). RAINFALL GAUGING POINTS COVERING EVERY 1000 SQUARE KILOMETER	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY

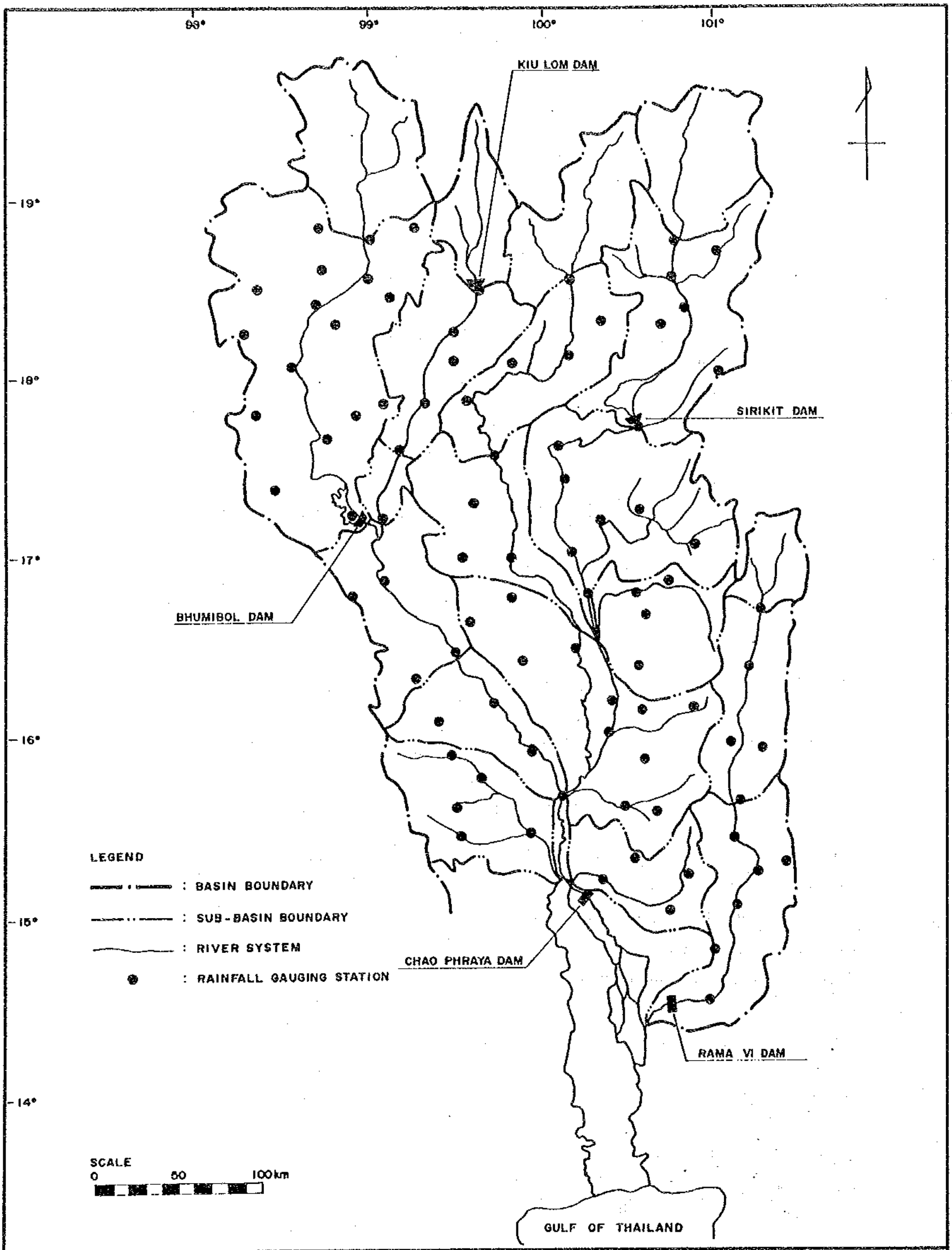


Fig. 2-33(2/5). RAINFALL GAUGING POINTS COVERING EVERY 1200 SQUARE KILOMETER

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

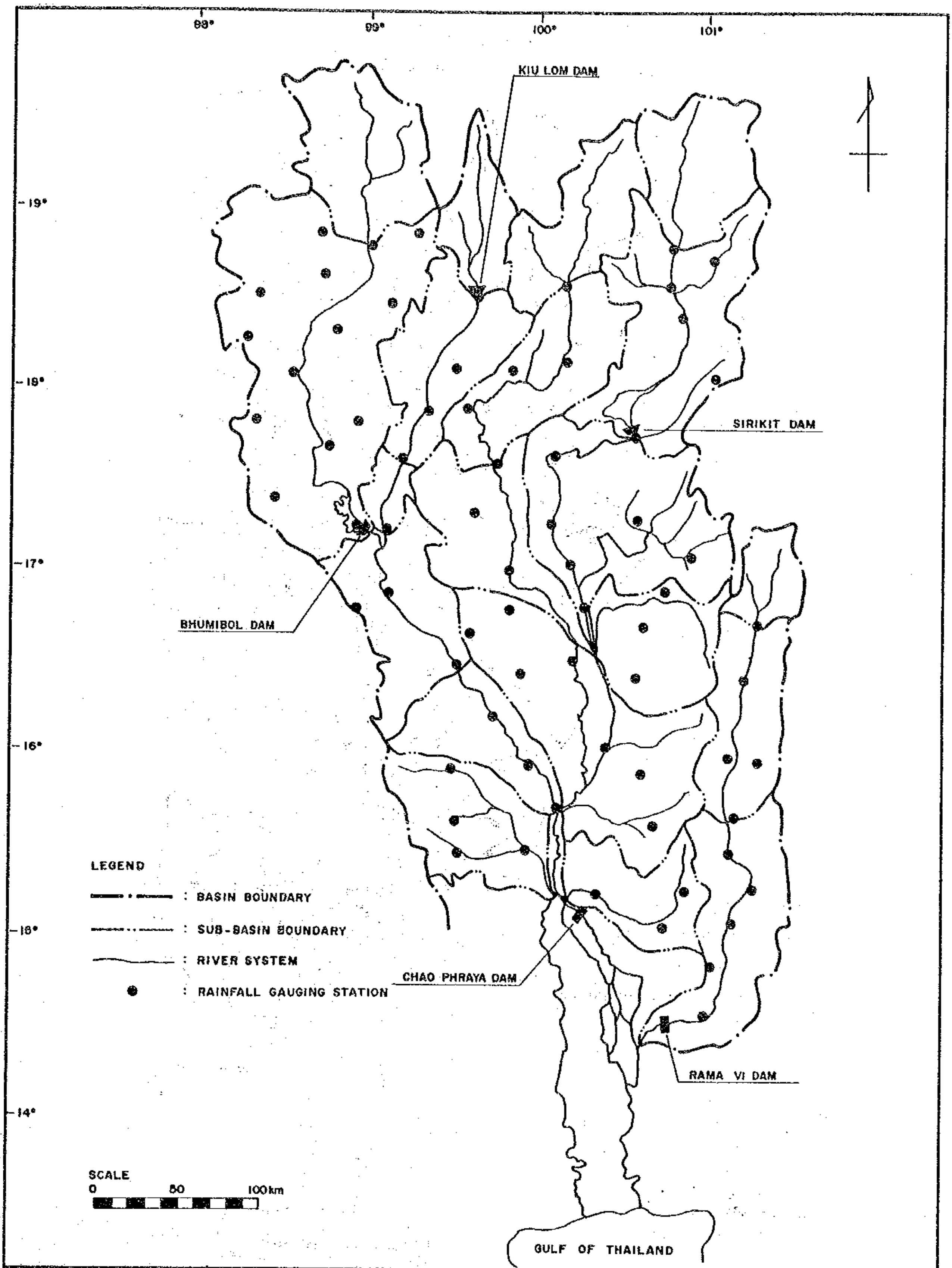


Fig. 2-33(3/5). RAINFALL GAUGING POINTS COVERING EVERY 1400 SQUARE KILOMETER

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

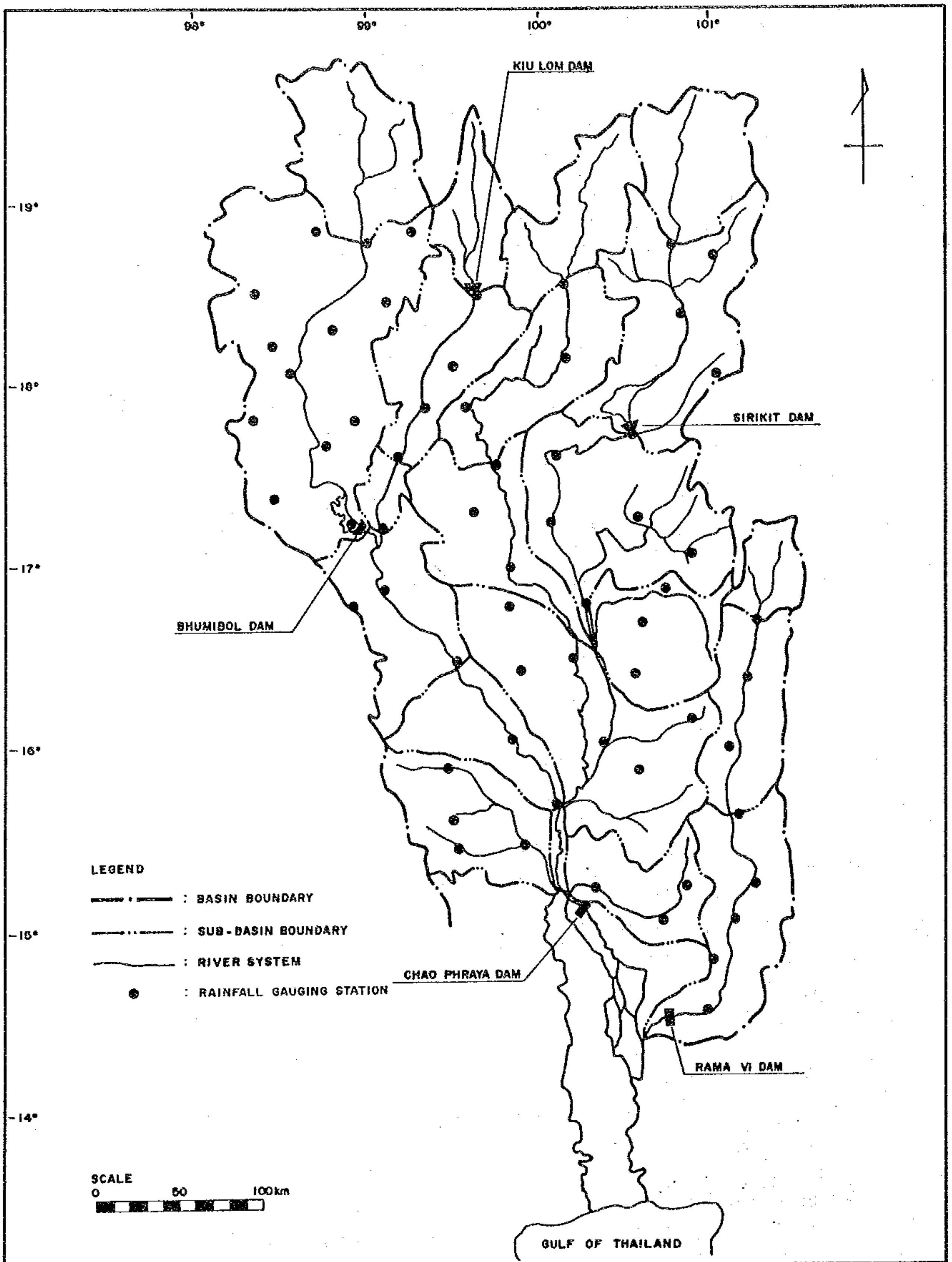


Fig. 2-33(4/5). RAINFALL GAUGING POINTS COVERING EVERY 1600 SQUARE KILOMETER	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY

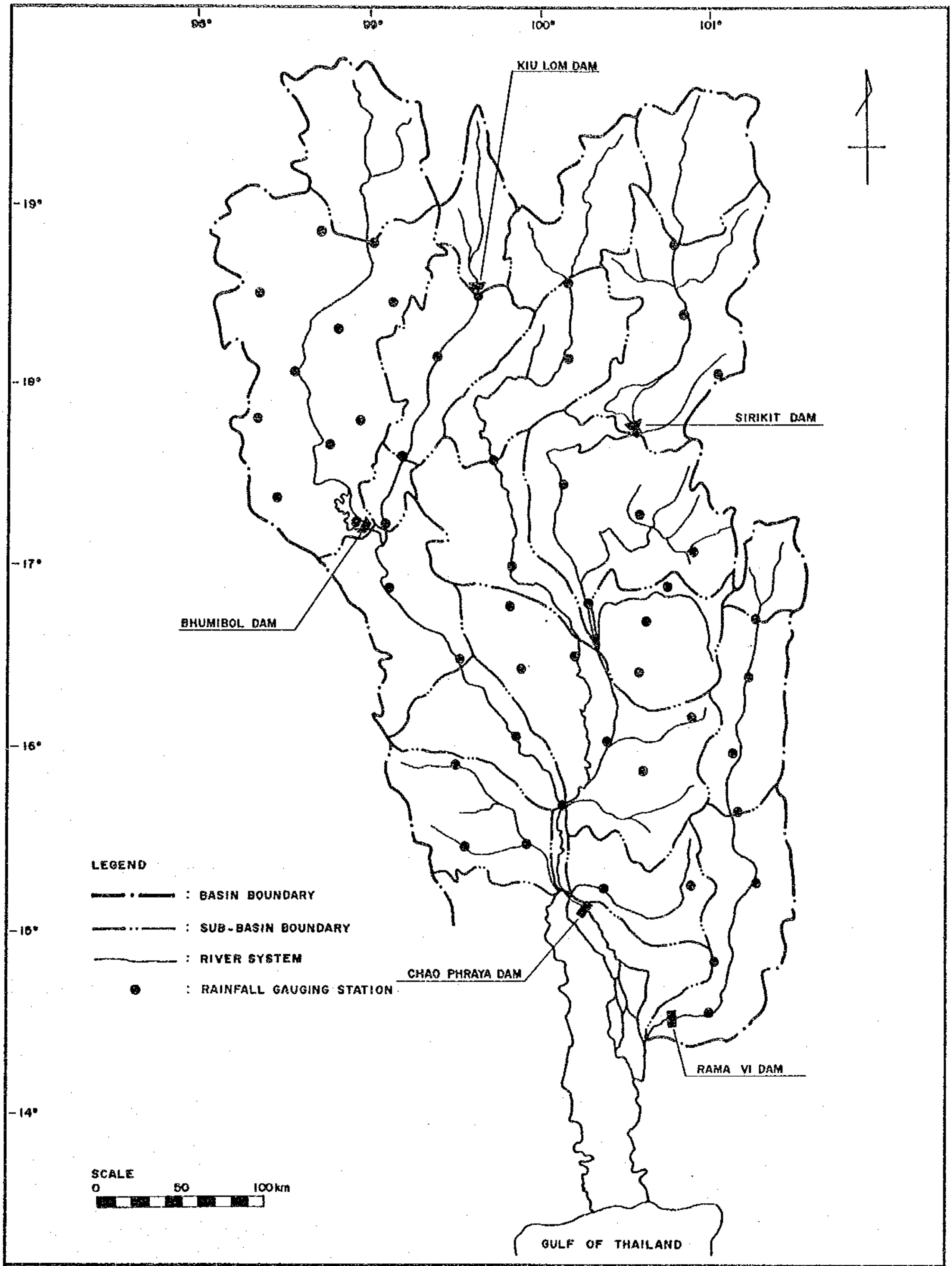


Fig. 2-33(5/5). RAINFALL GAUGING POINTS COVERING EVERY 1800 SQUARE KILOMETER	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY

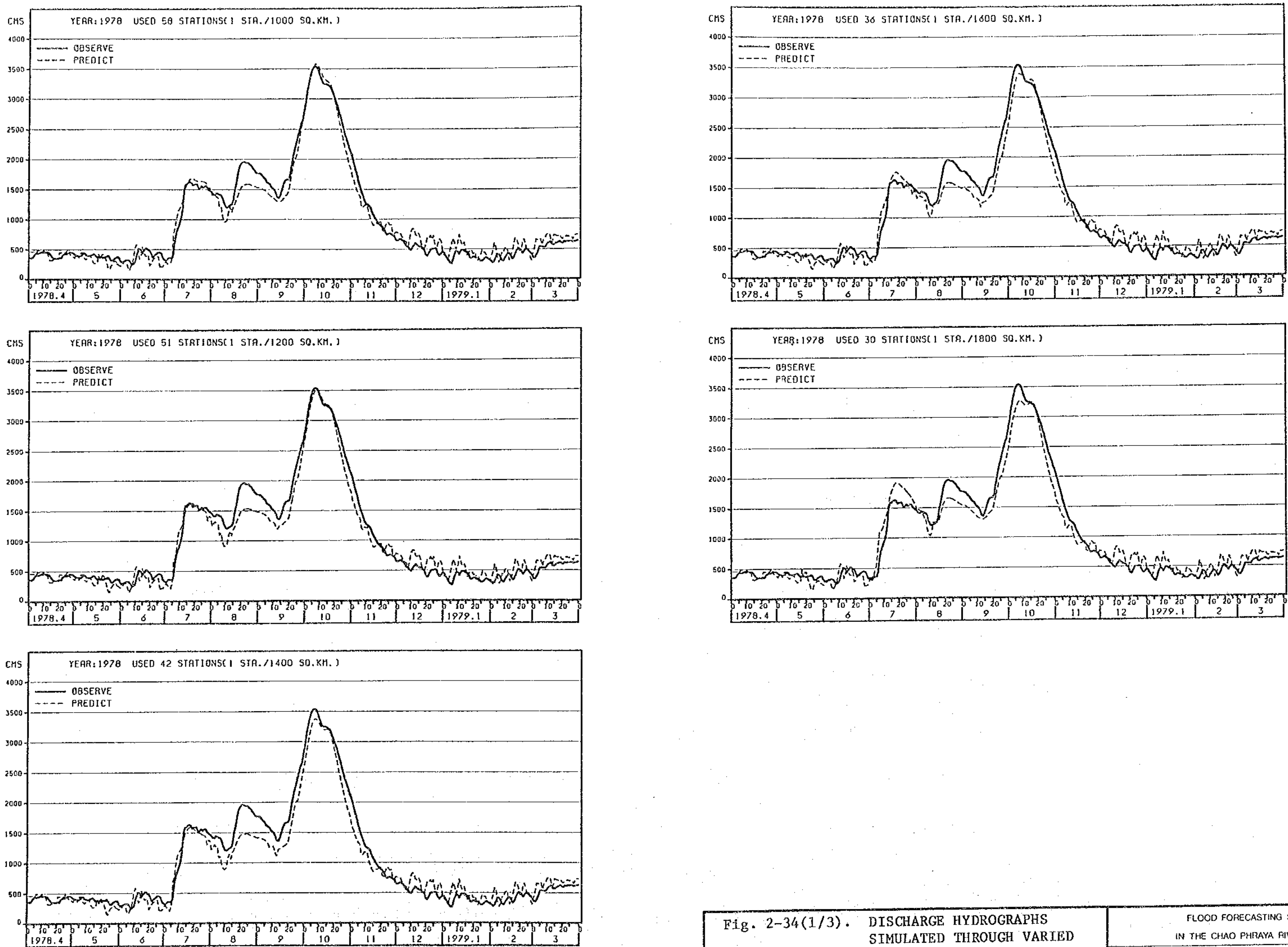
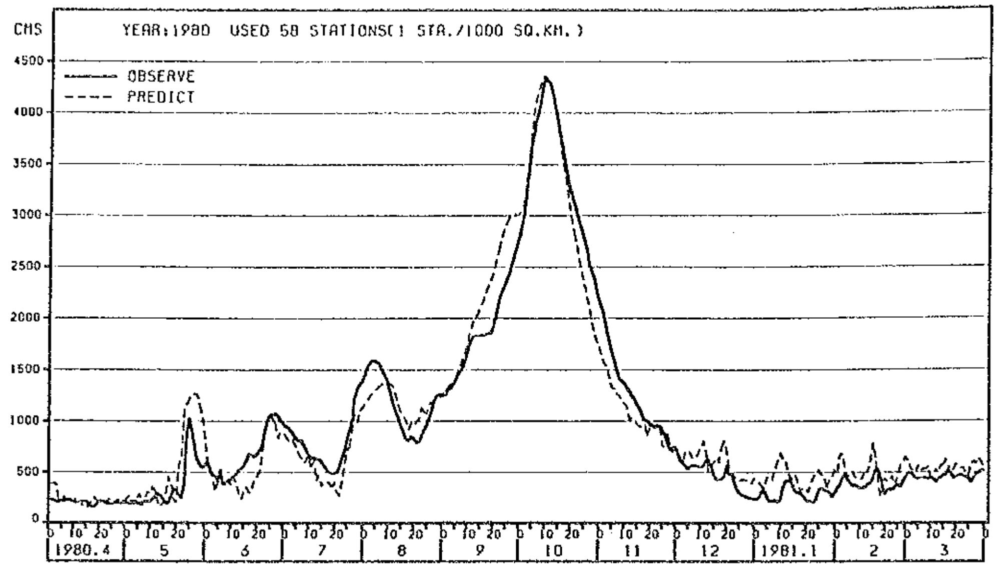
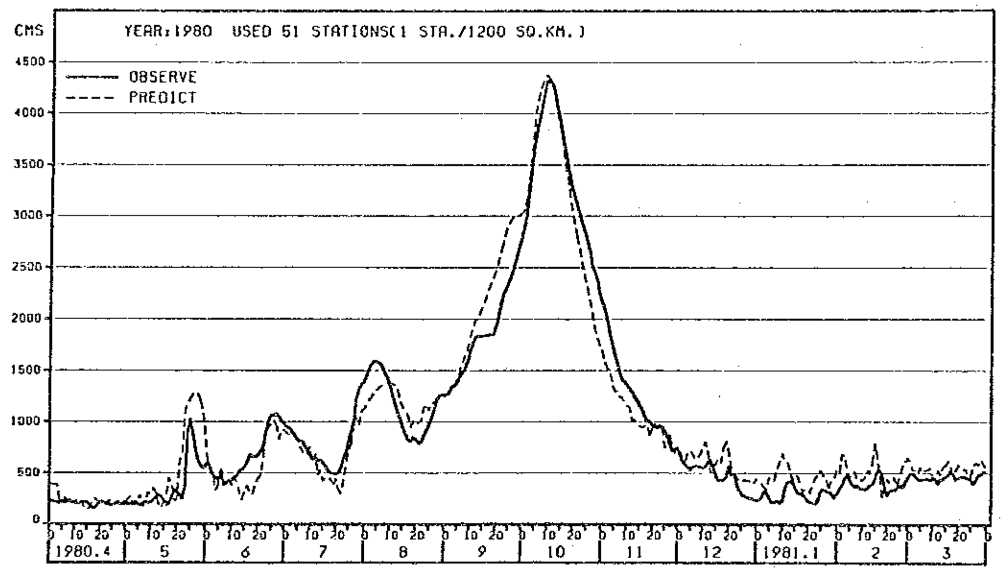


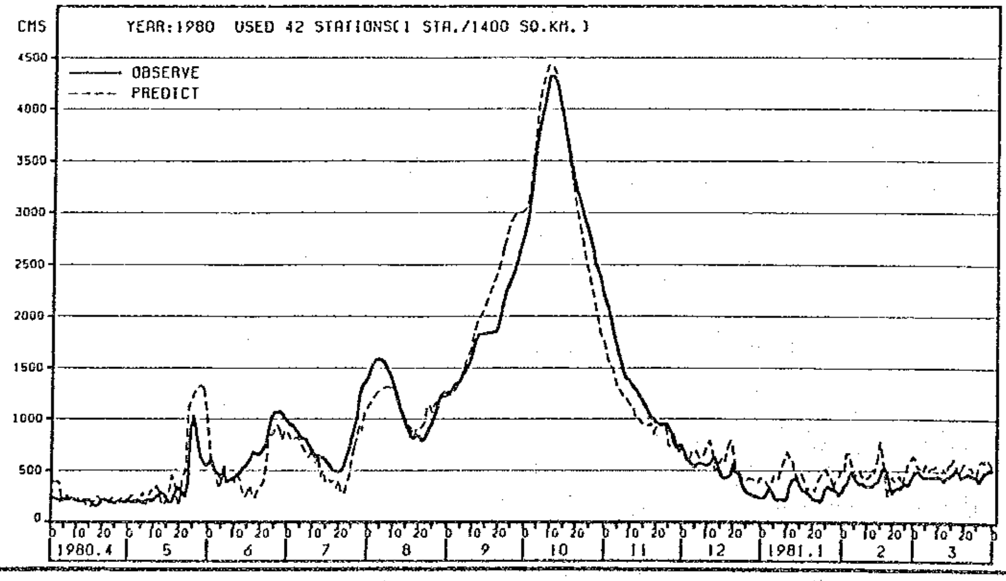
Fig. 2-34(1/3). DISCHARGE HYDROGRAPHS SIMULATED THROUGH VARIED RAINFALL GAUGING STATIONS

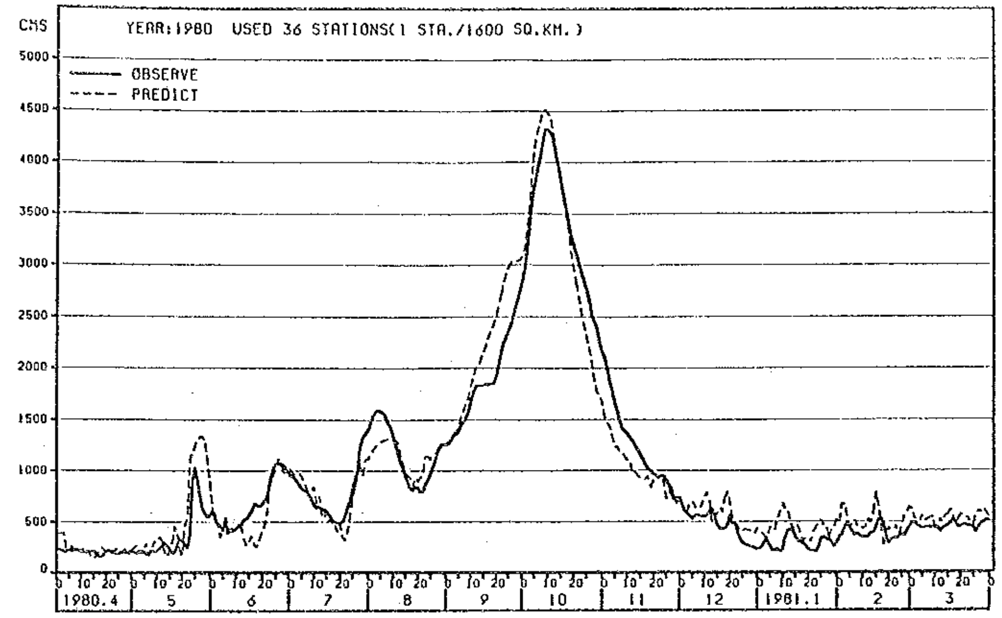
FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY









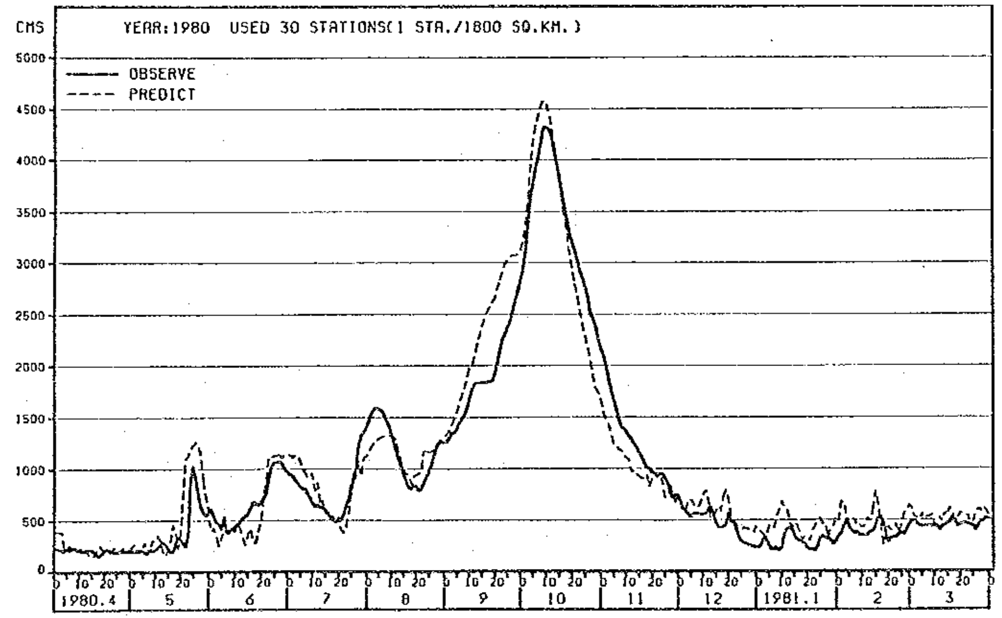


Fig. 2-34(2/3). DISCHARGE HYDROGRAPHS SIMULATED THROUGH VARIED RAINFALL GAUGING STATIONS

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

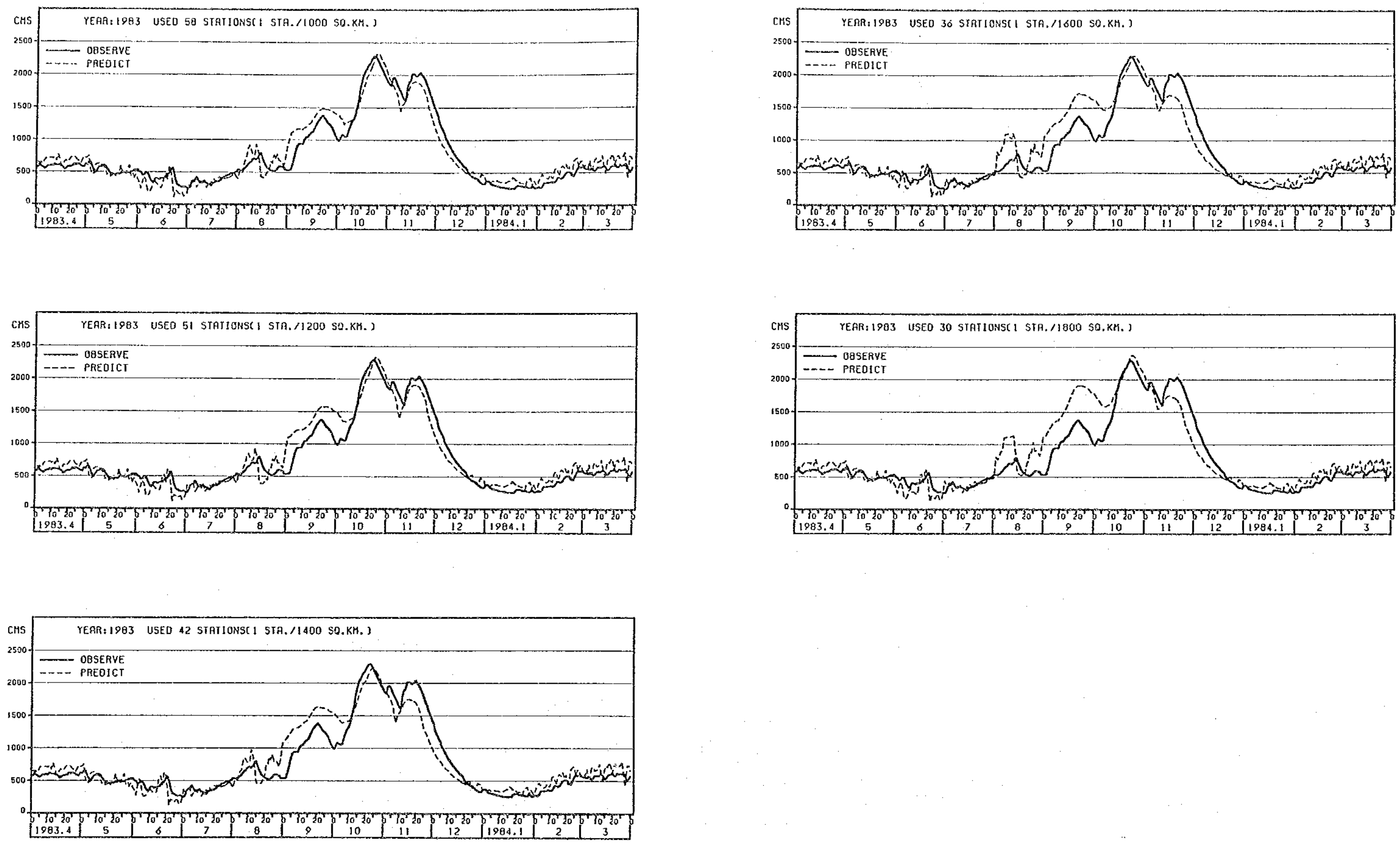


Fig. 2-34(3/3). DISCHARGE HYDROGRAPHS SIMULATED THROUGH VARIED RAINFALL GAUGING STATIONS

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

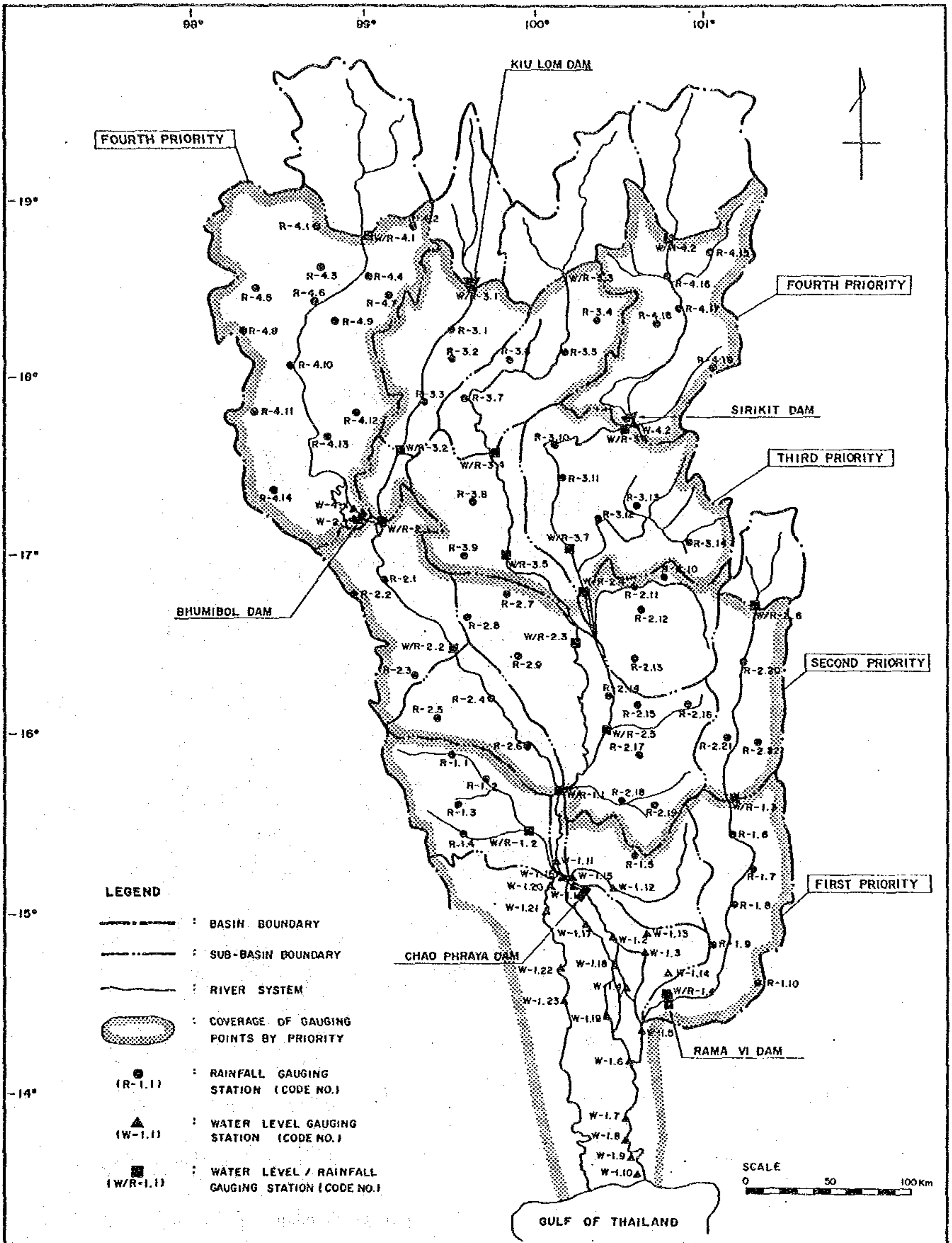


Fig. 2-35. HYDROLOGICAL GAUGING STATIONS FOR STEP 2 FLOOD FORECASTING SYSTEM	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN
	JAPAN INTERNATIONAL COOPERATION AGENCY

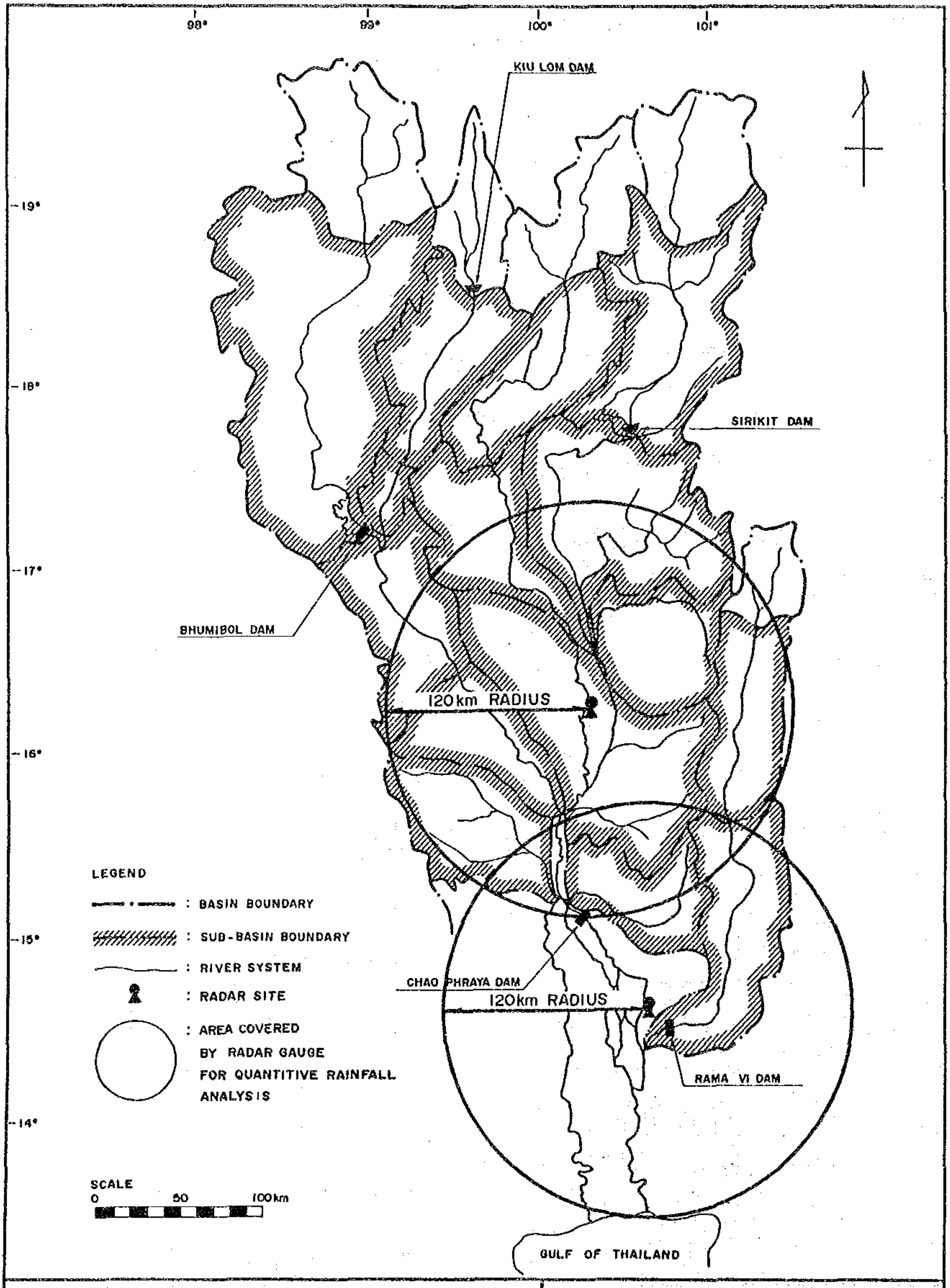
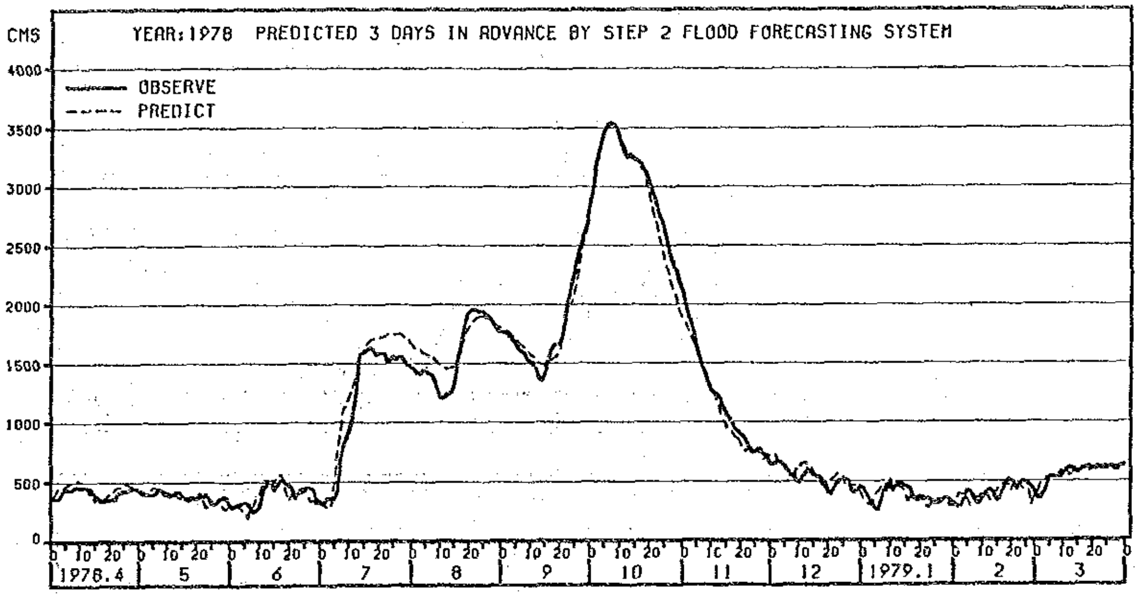


Fig. 2-36. PROPOSED RADAR SITES AND AREAS COVERED (STEP 2)	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY



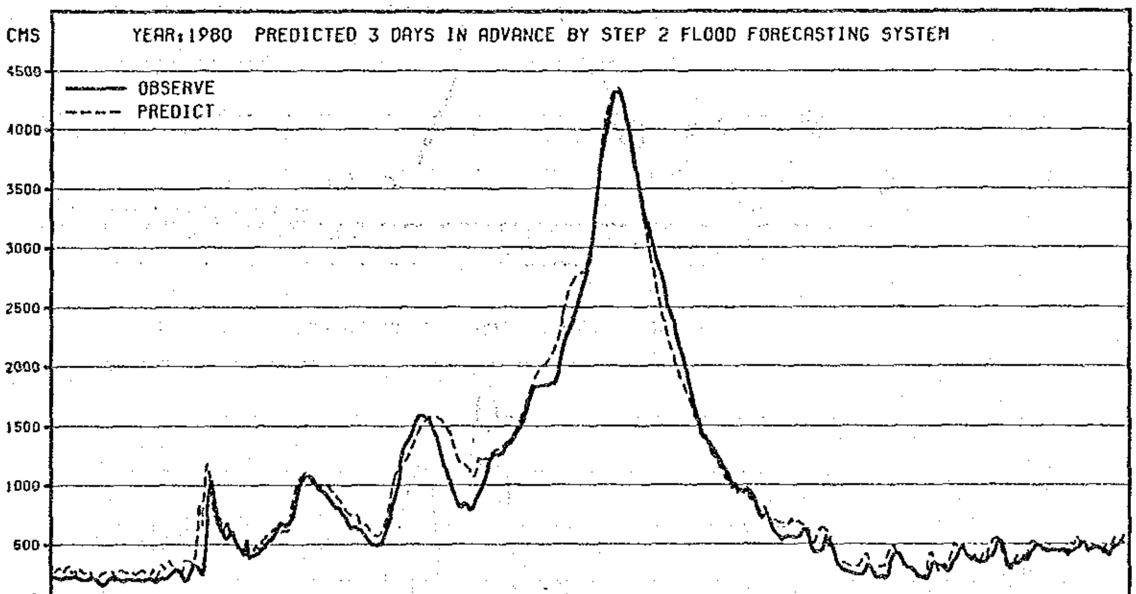
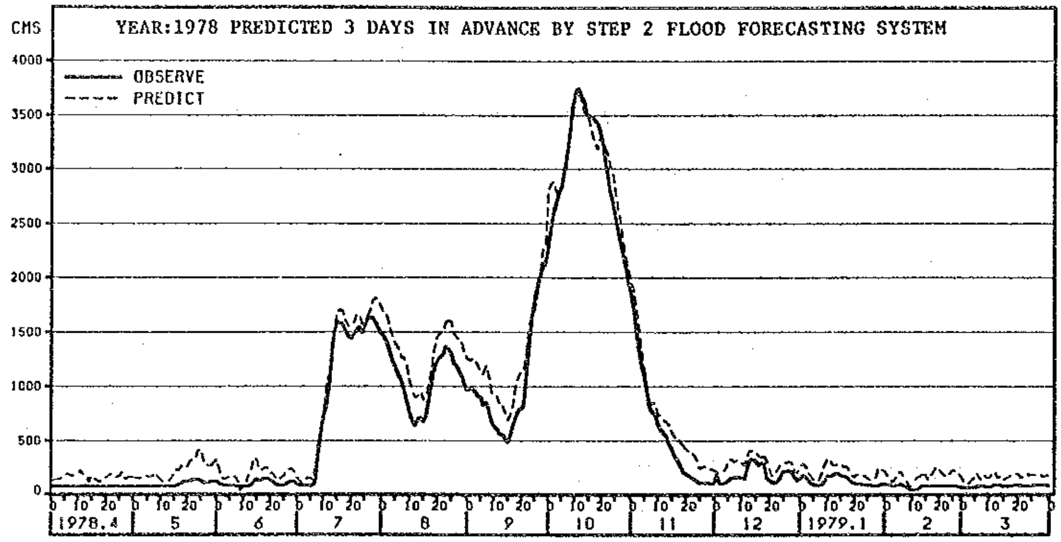
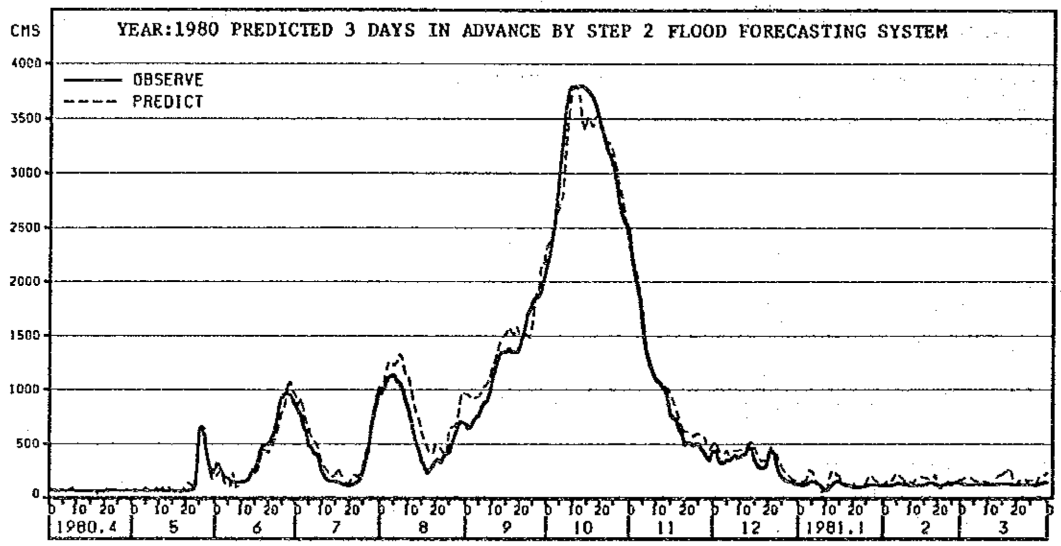


Fig. 2-37(1/3). DISCHARGE HYDROGRAPH PREDICTED 3 DAYS IN ADVANCE AT NAKHON SAWAN (STEP 2)	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY





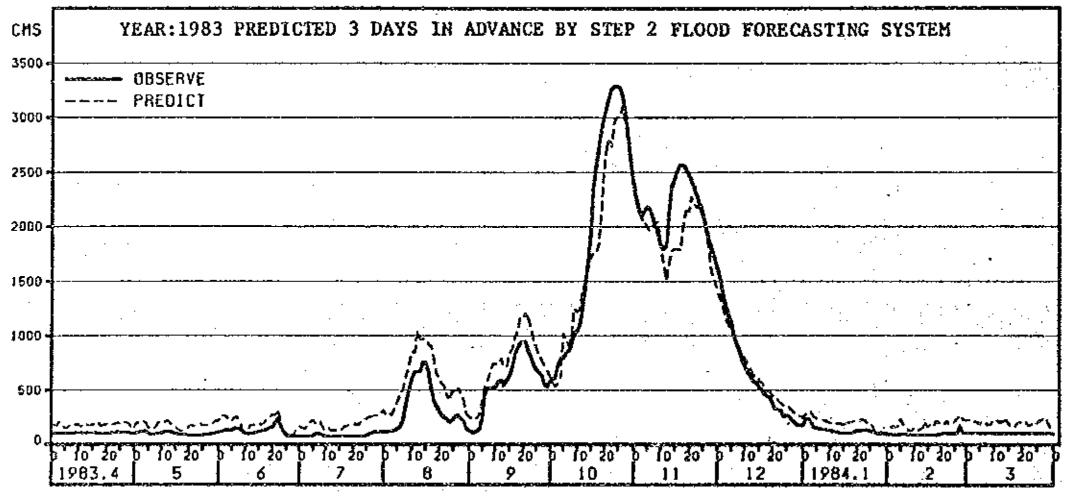


Fig. 2-37(2/3). DISCHARGE HYDROGRAPH PREDICTED 3 DAYS IN ADVANCE AT CHAI NAT (STEP 2)

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

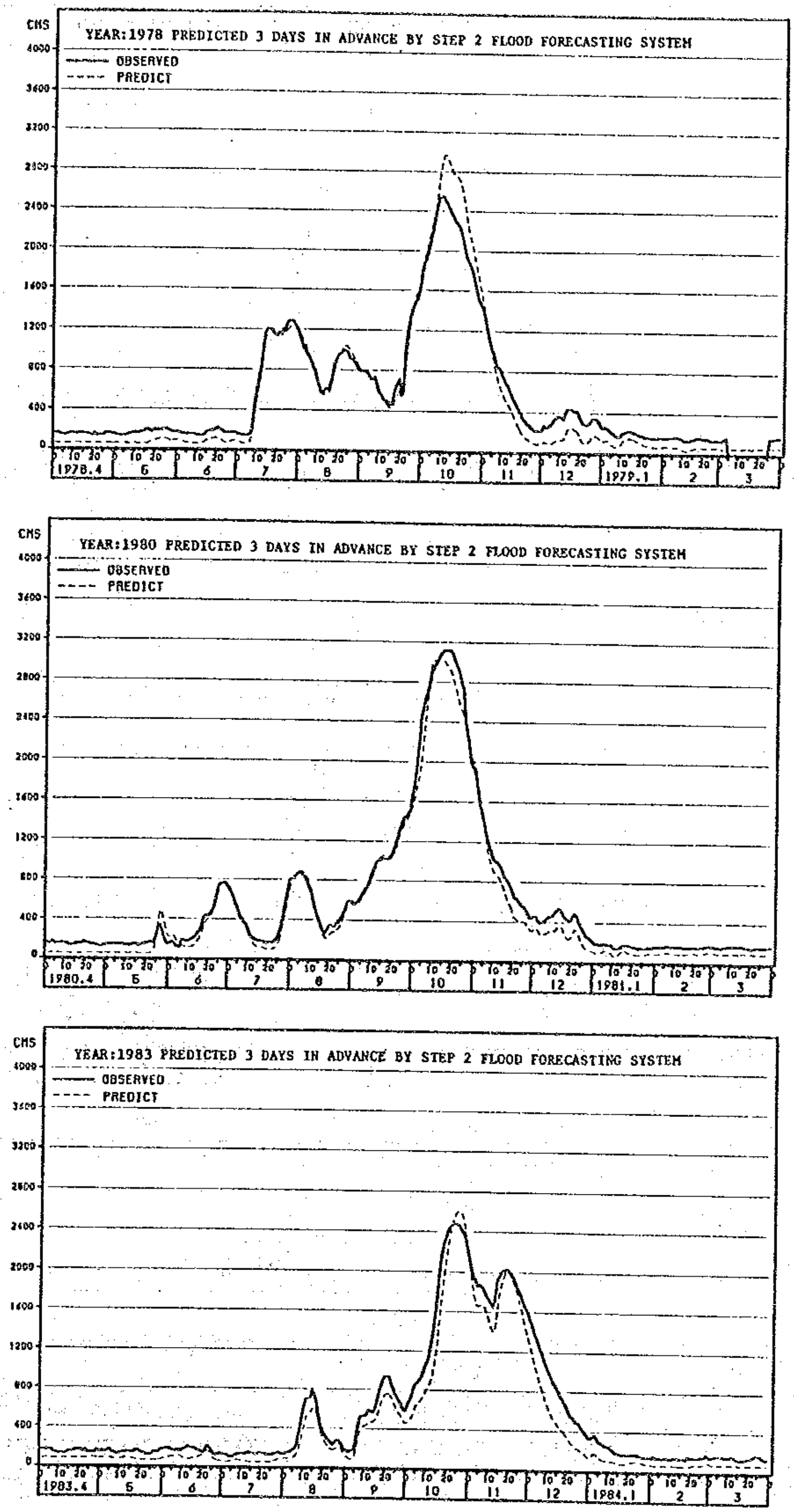
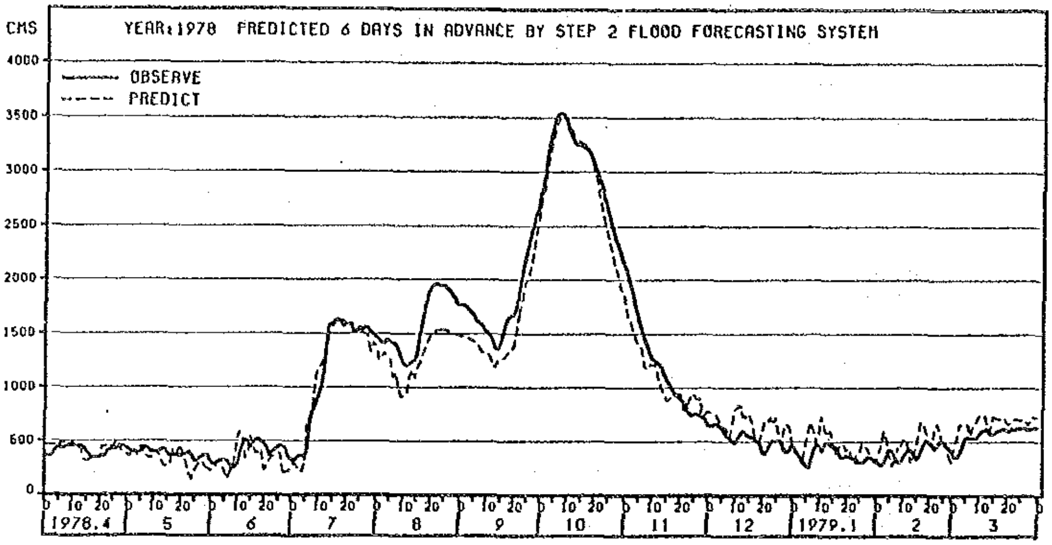
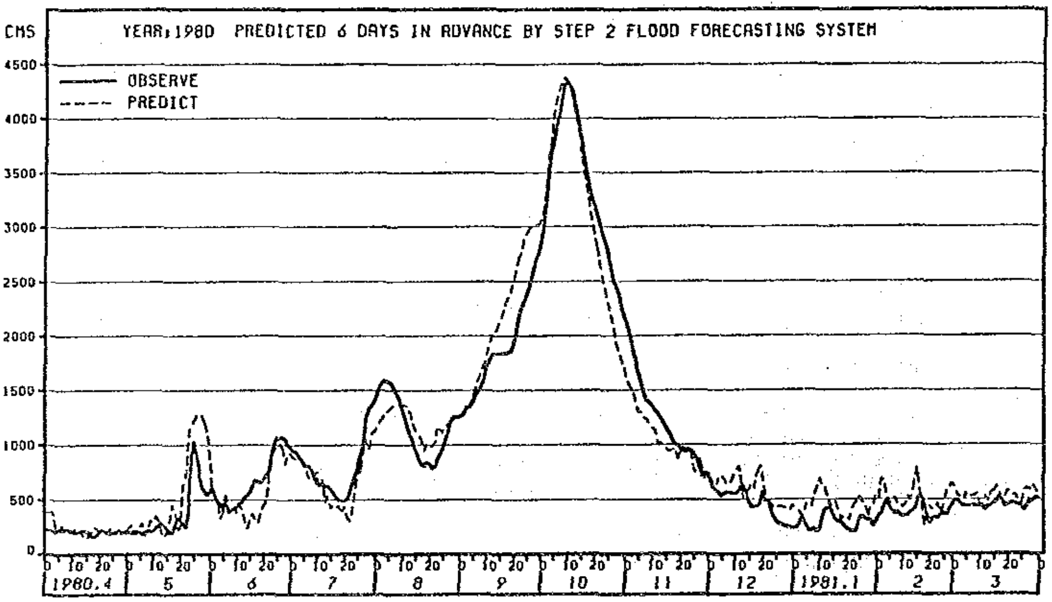


Fig. 2-37(3/3). DISCHARGE HYDROGRAPH PREDICTED 3 DAYS IN ADVANCE AT ANG THONG (STEP 2)

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY





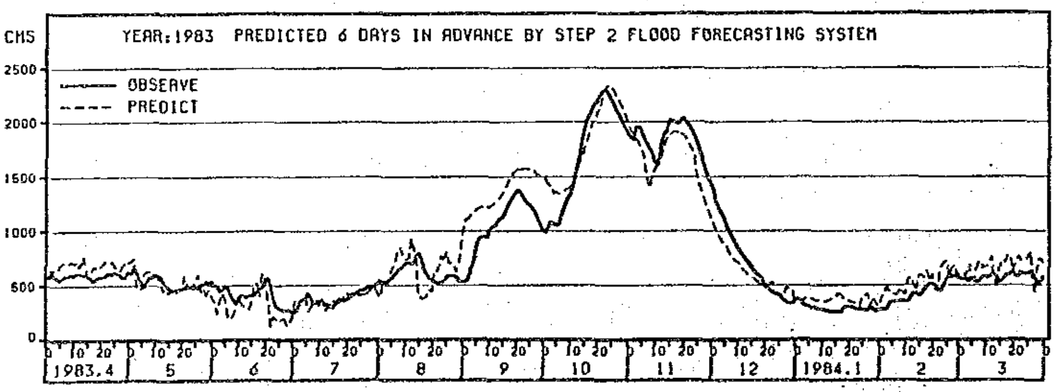


Fig. 2-38(1/3). DISCHARGE HYDROGRAPH PREDICTED 6 DAYS IN ADVANCE AT NAKHON SAWAN (STEP 2)	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY

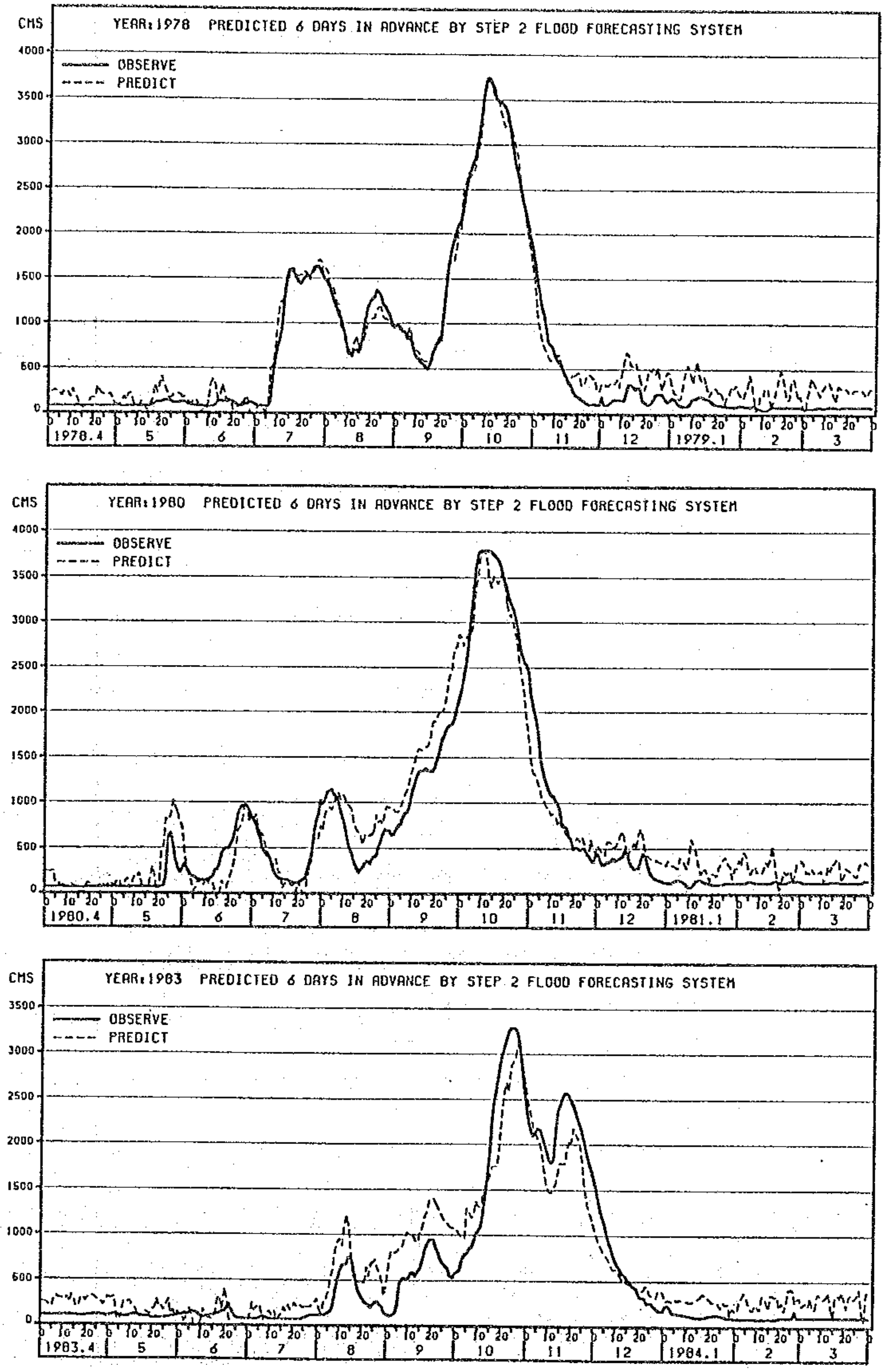


Fig. 2-38(2/3). DISCHARGE HYDROGRAPH PREDICTED 6 DAYS IN ADVANCE AT CHAI NAT (STEP 2)

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

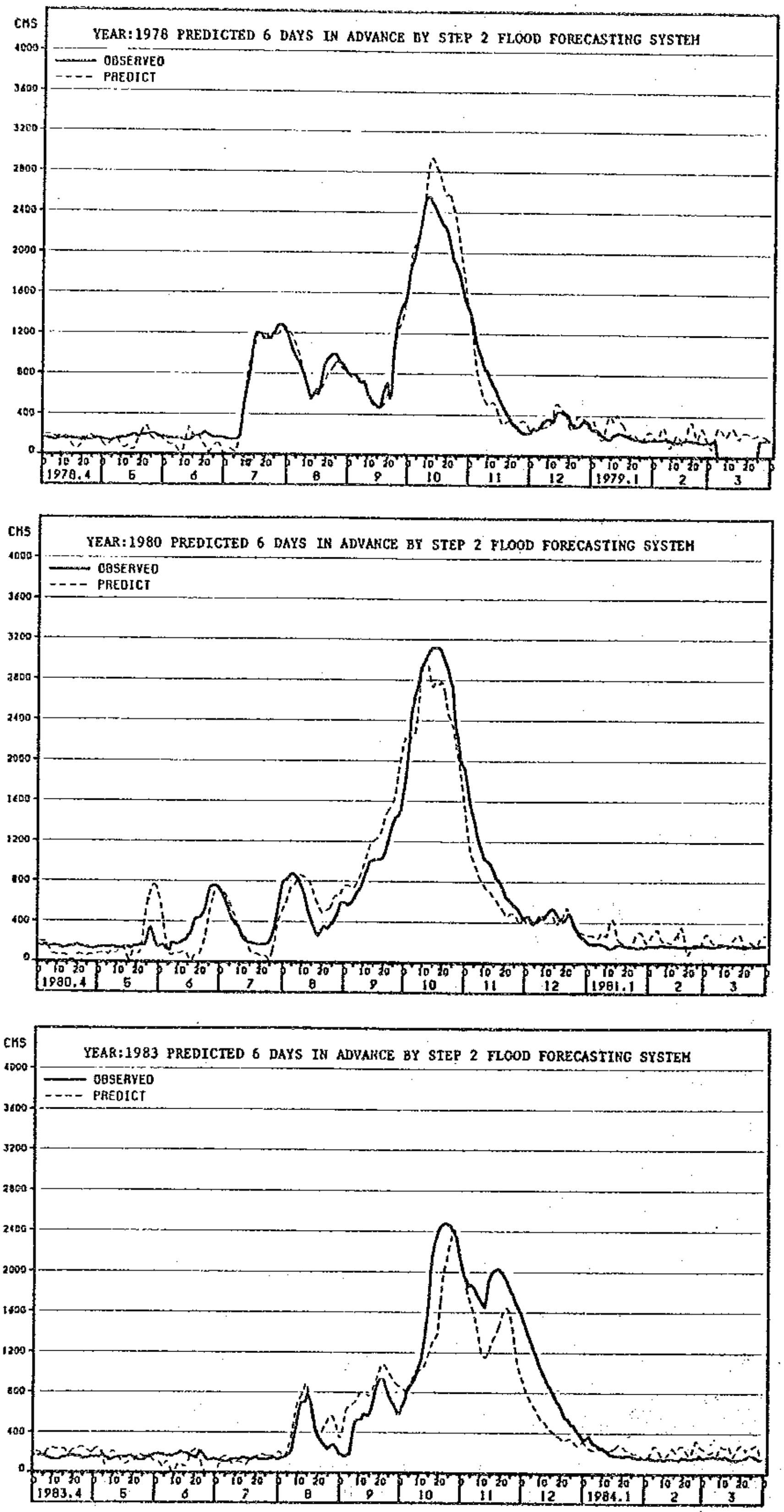


Fig. 2-38(3/3). DISCHARGE HYDROGRAPH PREDICTED 6 DAYS IN ADVANCE AT ANG THONG (STEP 2)	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY

3. TELECOMMUNICATION

SUPPORTING REPORT
ON
TELECOMMUNICATION SYSTEM

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Page

3. SUPPORTING REPORT ON TELECOMMUNICATION SYSTEM

1. General

The telecommunication system to collect and disseminate the necessary data for flood forecasting is formulated in consideration of the availability of the existing telecommunication network. In this sector of the Supporting Report, the study results on the formulation of the optimum telecommunication network are compiled, together with the investigation results on the existing telecommunication network.

2. Existing Telecommunication Network and Facilities

The agencies related to this Study such as RID, EGAT, BMA, MD, etc., have their own telecommunication network in the Chao Phraya River Basin. The conditions of the existing telecommunication networks managed by these agencies are described, with emphasis on that of RID.

(1) RID

RID has 12 regional offices all over the country and Regional Office No. 1, 2, 3, 7 and 8 are in the Chao Phraya River Basin. Each regional office is divided into project offices which, in principle, have control over the gauging stations (refer to Fig. 3-1).

RID's telecommunication system is used to operate river and irrigation structures, collect hydrological data from gauging stations to the head office, transmit administrative messages among the various offices, and serve ordinary telecommunications. Communication between the head office in Bangkok and the regional offices is made by voice communication of the one-way HF/SSB, while that between regional offices and project offices is by the one-way HF/SSB radio link and/or the one-way VHF link. Radio and magneto telephones are used for the communication between project offices and some of the gauging stations. Aside from the above, TOT's public dial telephone system is also installed at the RID Head Office, its regional offices, project offices and important gauging stations.

The telecommunication network is illustrated in Figs. 3-1 and 3-2, and the configuration of RID's telecommunication system is shown in Fig. 3-3. The present situation of radio equipment employed by the RID network is as follows:

(a) Quantity of Radio Equipment (Refer to Table 3-1)

- HF/SSB: 90 sets
- VHF/FM: 55 sets (base station)
  63 sets (mobile)
  146 sets (handy-talky)

(b) Frequency Used

- HF/SSB: 4810, 5830, 7855 and 7990 kHz
- VHF/FM: 139.050, 139.100 and 141.000 MHz

(c) Power Output of the Radio Equipment

- HF/SSB: 100 watts
- VHF : 100 watts or 60 watts for regional office

(d) Antenna for VHF Radio Equipment

Places	Antenna Type	Height of Antenna Tower
RID Head Office	Colinear	300 feet
Regional Office	Colinear	300 feet
Project Office	Colinear	150 - 200 feet

Some communication by magneto telephone is not clear because the lines are superannuated and sometimes involve interference and noise due to bad weather. In general, voice communication through the VHF radio link is clear in short distance communication; thus, the VHF radio link is considered available for the communication between ragional offices and project offices.

The talking condition of the HF/SSB link connecting the head office with the regional offices is practically good even in flood time, though interference and noise are sometimes involved in communicatiion in between. The HF/SSB radio equipment has been used for more than 10 to 15 years and the VHF for more than 5 to 10 years; some old equipment being repaired or replaced with new ones. The detailed talking conditions of the above are presented in Tables 3-2 and 3-3.

(2) MD

The telecommunication network of MD is illustrated in Fig. 3-4. It consists of HF/SSB radio links among the head office, gauging stations and radar stations. The system is used to collect meteorological data from the gauging and radar stations.

The number of observatories are 26 in the northern part, 19 in the middle part and 27 in the southern part. The meteorological data from observatories are collected every 3 hours in normal days, but every 1 hour during flood time, by means of one-way HF/SSB radio telephone with frequencies of 6,550 kHz and 6,660 kHz. The power output of the HF/SSB equipment is 150 or 130 watts and its talking condition is good.

The collected data received by voice communication are typed and punched into the paper tape and processed by computer. Data output for RID is delivered by hand.

(3) EGAT

The telecommunication system of EGAT, which consists of microwave radio links and powerline carrier telephone links, is used for the maintenance of power facilities, control of power distribution, data collection and communication of administrative matters. The network links the head office, the hydropower stations, and the substations, as shown in Fig. 3-5.

Hydrological data are transmitted by voice communication from the gauging stations at Bhumibol Dam, Sirikit Dam, and so on, to the head office in Bangkok. Since there is no definite connection line between EGAT and RID, data to the RID Head Office are transmitted by the TOT telephone cable or delivered by hand.

The telephone line of TOT is used between power stations and the head office. Electrical information such as watt and voltage values are sent from power stations and substations to the head office by a telemetering system.

EGAT has a plan to expand its microwave system to cope with the present shortage of connection channel. The microwave radio presently in use utilizes the 900 MHz band and the talking condition is good. Communication is kept in good condition even in flood time.

(4) BMA

The Bangkok Metropolitan Administration (BMA) has pumping stations for flood protection works. Communication between the pumping stations and the BMA Head Office is carried out by means of a one-way VHF radio network (150 MHz band, 4 channels), but this is restricted to Bangkok. This network is used for the transmission of hydrological data, operation of drainage pumps and general administration. In flood time, communication between the pumping stations and the BMA Head Office is not a problem.

Besides the above, BMA has a facsimile communication link system with RID and MD. The facsimile is used to transmit hydrological data in flood time.

To upgrade the communication condition among offices concerned, improvement of the telecommunication system has been formulated by JICA and are presently being planned to be implemented.

(5) LAD

The Local Administration Department (LAD) under the Ministry of Interior has a function to take countermeasures against natural disasters and so on. It has various means of communication with provincial offices in emergency situations.

The present telecommunication facilities between LAD and the provincial offices are as follows:

(a) TOT telephone line (exclusive use of its channel);

(b) One-way VHF radio for communication within 100 km in distance; and

(c) One-way HF/SSB radio for long distance communication.

The telecommunication network is not revealed for security reasons. At present, the communication between the RID Head Office and LAD is carried out by the TOT telephone.

(6) TOT

TOT has a long distance microwave radio network and a telephone cable network covering the whole country for commercial business. The microwave network in the Chao Phraya River Basin is as shown in Fig. 3-6. The average distance between TOT's repeater stations is about 40 km.

According to the information by TOT, it is possible for RID to utilize this microwave network for the required number of channels of the flood forecasting system. However, it is necessary to submit the network plan to TOT for investigation and approval. It is noted that some parts of the telephone cable in Bangkok sometimes could not be used due to inundation in the rainy season, especially during a big flood lasting for several days.

(7) CAT

CAT has a satellite earth station network using the transponders of INTELSAT, as shown in Fig. 3-7. The master station of the CAT network is located in Siraca near Bangkok. Satellite earth stations on the Chao Phraya River Basin are located at Bangkok, Nakhon Sawan, Phitsanulok, Lampang and Chiang Mai as substations.

CAT has a commercial telecommunication business by means of satellite communication and the UHF radio network for telephone as well as data transmission. The talking condition of the system is good even in flood time.

The satellite channel is rent out for public use. So far, it is used by companies and agencies located where the TOT line is not installed.

The UHF radio line and channels are limited and already fully occupied, so that they are not available for RID's use. Therefore, an approach link to the earth station must be provided by RID.

(8) PTD

PTD has the Domestic Satellite Communication Center (DSCC) in Bangkok, and the satellite channel is rented out for governmental and public communication only.

Satellite communication uses transponders rented from PALAPA of Indonesia. Transponders of 1-3/4 (700 voice channels) are already being used by TV stations, the army and other agencies, and additional transponders of 1/4 (100 voice channels) are also scheduled to be rented out.

Some facilities in the DSCC are Japanese made (NEC). Two radio towers are located in the center for approach link to other agencies; however, it is necessary for the user of a PTD satellite channel to provide a satellite earth station (SES) by itself, because PTD has no satellite earth station.

3. Study on Appropriate Telecommunication Network

3.1 Telecommunication Network for Step 1

3.1.1 Planning Conditions

(1) Quantity of Hydrological Data for Flood Prediction

Hydrological data can be obtained on the daily basis at the 26 water level gauging stations on the upper reaches of Bang Sai and at the 34 rainfall stations on the whole basin. These data will be transmitted to the RID Head Office on the daily basis, including the water levels gauged on the hourly basis at the four (4) stations on the lower reaches of Bang Sai which include a tidal level gauging station. The data processed at the RID Head Office will be disseminated to the related agencies, as well as to RID's internal offices.

(2) Proposed Telecommunication Network

Hydrological data observed at the gauging stations under RID's O&M Division are transmitted to this division through the Communications Division, and those of MD and EGAT are collected at their head offices in Bangkok by their own telecommunication systems. Planning of a new telecommunication network will be done on the concept that the above-said existing systems would be utilized to the maximum extent. Thus, the line to be connected in the system will cover the portions between RID's Head Office and the following:

(a) Hydrological gauging stations managed by RID's Hydrology Division, for data collection;

(b) Head office of related agencies, for collection of data and dissemination of prediction results; and

(c) Tidal gauging stations of PAT, for data collection (refer to the Study on Telecommunication Network mentioned later).

The telecommunication line to be newly connected in this system is studied from the aspect of applicable facilities and communication lines.

3.1.2 Applicable Facilities

The applicable facilities are classified into two categories from the viewpoint of intermediation of manpower, the updated on-line system and the existing off-line system. The telecommunication system for the Step 1 Flood Forecasting System will utilize the existing off-line system as far as applicable.

For comparison, the applicability of the off-line system has been studied from three aspects: transmission link, transmission media and frequency, as shown in the following table. The suitable facilities were selected on the basis of certain considerations as described hereinafter.

Item	Alternative Cases
Transmission Line	a. Wired Line b. Radio
Transmission Media	a. Voice Communication b. Data Transmission
Radio Equipment	a. VHF use b. HF use

(1) Transmission Link

Comparison between the wired line and the radio shows that the radio has an advantage in view of its reliability during flood time. The wired line is subject to accidental interruption due to heavy rainfall or strong wind. In this connection, the TOT line which includes wired line in its network is not applicable to this flood forecasting system.

(2) Transmission Media

Voice communication has an economical advantage over the data transmission system. The latter costs more because of the additional facilities with a new HF frequency. In this context, voice communication will be applied as the transmission media for Step 1.

(3) Radio Equipment

The superiority of the VHF or HF/SSB is generally dependent on the distance of communication, i.e., HF/SSB is suitable for long distance communication and VHF for short distance communication from the technical point of view. The turning point appears at about 30 km in terms of the required cost, as shown in Fig. 3-8; namely, HF/SSB is selected for communication of more than 30 km, while VHF is for less than 30 km distance, although it must be recognized that the distance of this turning point varies according to topographic conditions.

3.1.3 Study on Telecommunication Network

The study on the telecommunication link is mainly regarding the transmission of data managed by RID's Hydrology Division. This link is firstly discussed hereunder.

The existing telecommunication network of RID is provided primarily for communication among its head office, regional offices and project offices. To effectively utilize the existing telecommunication network and save on initial investment, the study was firstly made on the possibility of installing additional facilities to link the hydrological observation stations on the nearest project office.

In connection with the above study, it is pointed out that the reliability of data transmitted, as well as operation and maintenance costs, is influenced by the number of relay points. Therefore, to keep the reliability of transmitted data higher and at the same time save on operation and maintenance costs, a telecommunication network directly connecting the observation stations to the regional office concerned or the RID Head Office, regardless of the distance, has also been considered.

In the above consideration, alternatives are provided to select the proposed telecommunication network, as follows (refer to Table 3-4 and Fig. 3-9):

Case 1: Telecommunication network connecting the hydrological observation stations to the nearest project office in each RID region.

Case 2: Telecommunication network connecting the hydrological observation stations to the nearest RID regional office.

Case 3: Telecommunication network connecting the hydrological observation stations directly to the RID Head Office.

Table 3-5 shows the results of comparison among the three alternatives. In view of economical superiority and higher reliability of transmitted data, Case 3 is selected as the suitable telecommunication network for data collection and transmission of hydrological data.

The head office of other related agencies (MD, EGAT, LAD and BMA) and the RID Head Office will be directly connected with each other, because there is no other applicable method. As for the tidal gauging station under PAT, it is more practical to transmit the tidal data directly to the RID Head Office than transmitting them by way of PAT's Head Office, because there exists only one station that is related to the proposed flood prediction system and that no radio communication is available between this station and PAT's Head Office.

3.1.4 Proposed Telecommunication Network

On the basis of the aforementioned study results, a new telecommunication network for the Step 1 system is proposed as tabulated herein and illustrated in Fig. 3-10.

Related Agencies	Portions of Network				
	Gauging Station	======	Head office of Related Agency	==========	Head Office of RID
MD	HF/SSB*			VHF**	Data collection /2
PAT			VF/SSB** /1		- do -
RID (O&M Division)	VHF; HF/SSB*			VHF: HF/SSB*	- do -
RID (Hydrology Division)			HF/SSB** /1		- do -
LAD				VHF**	Dissemination /2
BMA				VHF**	- do -
EGAT				VHF**	Data Collection/ Dissemination /2

Note: * Existing; ** Proposed
/1 Direct connection between gauging station and RID Head Office.
/2 Contents of communication.

In addition to the above network, the existing telecommunication lines of RID connecting the RID Head Office, the regional offices and the project offices will also be utilized for the purpose of collecting hydrological data, disseminating the results of flood prediction, instructing the necessary countermeasures, and so on.

3.1.5 Preliminary Design

The major telecommunication facilities comprise radio equipment and housing, as outlined hereunder.

(1) Radio Equipment

The diagrams of equipment to be installed at VHF and HF radio stations are shown in Figs. 3-11 and 3-12. The specifications of equipment required are as follows:

(a) VHF Radio Equipment

RF Output Power	:	10 watts
Frequency Range	:	136-150 MHz
Antenna	:	3-element YAGI
Antenna Height	:	20 m or less

(b) HF Radio Equipment

RF Output Power	:	10 watts
Frequency Coverage	:	3-15 MHz
Antenna	:	Dipole
Antenna Height	:	15 m or less

(2) Housing

The general scheme of housing for the VHF and HF facilities is preliminarily designed in Figs. 3-13, 3-14 and 3-15. The housing to be newly constructed shall have an area of 3.24 m^2 for the installation of radio equipment and operation.

3.2 Telecommunication Network for Step 2

3.2.1 Planning Conditions

For the establishment of telecommunication network for Step 2 flood forecasting system, the following factors were considered as planning conditions.

Hydrological Data for Flood Prediction

(1) Data to be Collected from Gauging Stations to RID Flood Forecasting Center (FFC)

(a) At One-Hour Interval

- Water level data from 4 gauging stations

(b) At 6-hour Interval

- Water level data from 22 gauging stations
- Rainfall data from 65 gauging stations
- Water level/rainfall data from 19 gauging stations

(c) At 5-minute Interval

- Rainfall data from 2 radar gauging stations

(2) Data to be Disseminated from FFC to Related Agencies

(a) At 6-hour Interval

- Data processed at FFC

Communication Facilities

The principal features of communication facilities for the flood forecasting system are as follows:

(1) The ratio transmission link for exclusive use is employed to assure reliability and speed of data transmission;

(2) The on-line system with data transmission by digital signals is used to prevent the occurrence of error due to manual intervention; and

(3) The mutual exchange of information and instruction will be made by means of voice communication.

Telecommunication Network and Number of Channels

(1) Formation of Telecommunication Network

Since there are a considerable number of hydrological stations which cover the whole Chao Phraya River Basin, it is advisable to divide the basin into several areas and to provide substations to collect and manage the hydrological data from gauging stations in each area. For convenience in operating and maintaining the facilities, the substations are installed at every RID regional office.

The telecommunication network for this flood forecasting system is composed of trunk lines and branch lines for data collection and data dissemination. The trunk lines will be provided between FFC and substations, and the branch lines for data collection will be installed between substations and hydrological gauging stations, including rainfall radar gauges. Branch lines for data dissemination will be provided between FFC and related agencies. (Refer to Fig. 3-16.)

(2) Number of Channels

(a) Trunk Lines

Two channels will be provided for use in the communication between FFC and the substations; one for data transmission and one for telephone communication. For data dissemination or instruction by telephone/facsimile, FFC will be connected by an additional channel each to Regional Office Nos. 7 and 8; and, two channels for the radar gauge will be used between FFC and Regional Office Nos. 3 and 8. The number of channels for the trunk lines are shown in Table 3-6.

(b) Branch Lines

One channel is employed to each branch line connecting substations to hydrological gauging stations, except the radar raingauges, since the polling system is applied for the data collection. Four channels are provided on each branch line to connect radar raingauge stations with substations for data transmission, supervision, maintenance, etc. Two channels are employed on each branch line for data dissemination between FFC and related agencies; namely, BMA, LAD and EGAT.

3.2.2 Study on Transmission System

The transmission system of each line is explained below according to the flow of data.

(1) Branch Line for Data Collection

(a) Local Telemetering Line for Gauging Station

- Calling System

Calling is to be made by polling system, in which the substation calls the gauging station sequentially one by one to collect data individually responding to the calling signal. The advantage of this system is that the substation, without attendant, can collect data automatically from many gauging stations.

- Communication System and Channel

  Communication is by the simplex radio system of one channel. During maintenance work, voice communication can be done by changeover.

- Radio Frequency

  Generally, the frequency bands available for telecommunication are classified into four categories; namely, the HF band (3 MHz and 30 MHz), the VHF band (30 MHz to 300 MHz), the UHF band (300 MHz to 3 GHz) and the SHF band (3 GHz to 30 GHz).

  Among the above frequency bands, the VHF band is generally used for local telemetering systems from the aspects of stability, reliability and low cost of communication. In this study, the VHF band of 150 MHz, which is in the middle of the VHF band, is selected in consideration of the geographical condition of the study area.

(b) Data Transmission Line for Radar Raingauge Station

- Communication System and Channel

  The multiplex system is employed for use of the following channels:

  Channel 1: Receive power data
  Channel 2: Brightness plane parallel indication (PPI) data
  Channel 3: Supervisory information
  Channel 4: Voice channel for maintenance

- Frequency

  The UHF band (1.5 GHz) which is economically and technically suitable to this multiplex radio link is applied.

(2) Trunk Line

The trunk line is designed to directly link each substation with FFC, to be used exclusively for the flood forecasting purpose by RID.

It would be better for RID if it can utilize the available channels of the existing commercial radio line as the main line portion of the trunk line. It will only provide approach lines to connect substations and FFC to the commercial line for use as private/ exclusive lines. In this case, the trunk line will be composed of the following three portions, as shown in Fig. 3-16.

Approach Line (in Region)

This is the line provided by RID to connect RID substations to the nearest terminal station of the existing commercial line in the region.

Main Line

This is the section of the existing commercial line between each terminal station in the region and the terminal station in Bangkok, the channels of which will be rented by RID for exclusive use.

Approach Line (in Bangkok)

This approach line is the line provided by RID to connect FFC with the terminal station of the existing commercial line in Bangkok.

The communication system is separately discussed for the approach line portion and the main line portion hereunder.

(a) Approach Line Portion in Region

- Communication System and Channel

  The approach line from each substation to the nearest terminal station is a multiplex communication system to use 2 to 5 channels for the respective substation as shown in Fig. 3-18.

- Radio Wave Frequency

  UHF frequency band (300 MHz to 3 GHz) is applicable for the approach line from the aspects of high reliability, but the lower part of this frequency band is much crowded in communication being used for mobile telephone. So the higher part of the band (1.5 GHz, 2 GHz) is recommendable.

  In this case, 1.5 GHz band is selected because the facility for 2 GHz is relatively costlier than that for 1.5 GHz.

(b) Main Line Portion

For the radio line to be used for the main line portion of the trunk line, not only the on-land communication network of TOT but also the satellite communication lines of CAT and PTD are considered referring to the availability of these lines stated in Section 2.

The selection of radio frequency of the main portion is not the matter of RID and has to be decided by the owner of the line.

(c) Approach Line Portion in Bangkok

- Communication System and Channel

  The approach line between FFC and terminal station in Bangkok is also a multiplex communication system using 16 channels in total for all substations.

- Radio Frequency

  The same frequency band of the approach lines for the substation in the region, i.e., 1.5 GHz band, is applied using the same equipment for the convenience of operation and maintenance of the system.

  In addition to the above, the case that RID will newly provide a trunk line to connect substations directly to FFC is also considered.

(3) Branch Line for Data Dissemination

(a) Communication System and Channel

For the transmission of prediction results from FFC to related agencies, the multi-directional system, comprising one master station at FFC and remote stations at each agency, is employed for the multiplex line to each agency using 3 channels for all lines, in view of the following reasons:

- The construction cost is less than the cost for construction of independent point to point system.
- Not many frequencies are required, because the same frequencies are used for lines to all remote stations by time division method.
- The addition of remote station is easy using the master station commonly.

All the related agencies are located in the Bangkok area within less than 30 km from FFC which is the distance applicable for the multi-directional system.

(b) Radio Frequency

The same frequency band of 1.5 GHz as of the approach lines is used.

3.2.3 Study on Telecommunication Network

A comparative study was done on the composition of the telecommunication network putting more emphasis on the trunk lines taking up several possible alternatives. Regarding the branch lines, no comparative study was conducted, selecting an appropriate system with consideration on the limitations of location and distance as explained later.

Trunk Line

For comparative study, the following four cases are considered for the trunk line from the aspect of applicable line.

Case 1: Use of TOT long distance telephone line voice channel.

Case 2: Use of private radio line provided by RID.

Case 3: Use of CAT satellite line voice channel.

Case 4: Use of PTD satellite line voice channel.

(1) Case 1: Trunk Line Based on the TOT Long Distance Telephone Line

The TOT network uses multiplex radio lines of the UHF or SHF band in most portions. The telecommunication network using the TOT line as trunk line is shown in Fig. 3-17(1/4).

The voice channel of the TOT multiplex radio line is to be rented for exclusive use on flood forecasting as a direct voice circuit, bypassing the connecting points where the TOT line is connected with an intermediate exchanger.

The TOT line to be rented by RID is the section linking Chiang Mai to Bangkok via the following cities where the TOT terminal stations will be connected with the substation by RID's approach line in the respective region.

RID Office (Substation and FFC)	Terminal Station of TOT Line
Regional Office No. 1	Chiang Mai
Regional Office No. 2	Lampang
Regional Office No. 3	Phitsanulok
Regional Office No. 7	Chai Nat
Regional Office No. 8	Lop Buri
Head Office (FFC)	Bangkok

With this line connection, RID will be released from the burden of high initial investment, as well as operation and maintenance cost, though RID has to pay the rental charge of the TOT line.

(2) Case 2: Trunk Line Provided by RID

This network is established with new private microwave circuits provided by RID as shown in Fig. 3-17(2/4).

RID Head Office is connected with the five regional offices up to Chiang Mai (Regional Office), without approach line. The network consists of 6 terminal stations and 18 relay stations.

The radio link route is selected from the economical viewpoint among the several alternative cases which are considered from the topographic condition.

For the reason stated in the transmission system, UHF band (2 GHz) is selected for this line.

Multiplex transmission system is adopted to provide two or more channels for voice communication and data transmission. It is also to be considered that the data from the radar raingauge stations will also be transmitted through these trunk lines.

Since this trunk line is operated and managed by RID itself, maintenance and repair is assured, together with its future expansion. However, RID should bear the high initial investment, as well as operation and maintenance cost for the whole line.

(3) Case 3: Trunk Line Based on the CAT Satellite

As shown in Fig. 3-17(3/4), the network is planned to lease the voice channels of the CAT satellite communication system as trunk line. CAT has one master station and five SESs in the Chao Phraya River Basin as stated in item (7) of Section 2.

Using these satellite stations, RID Head Office is connected with the SES in Bangkok, and Regional Office No. 1, No. 2 and No. 3 are connected with the SES in Chiang Mai, Lampang and Phitsanulok, respectively, by approach lines provided by RID.

However, Regional Office No. 7 and No. 8 are connected with the same SES of CAT at Nakhon Sawan, using the TOT telephone line separately as a part of the main line portion of the trunk line.

Each satellite line from substation to FFC is relayed at the master station of CAT at Siraca. Regarding the economical aspect, RID is released from the burden of high initial investment cost and operation and maintenance cost of the trunk line by the application of the CAT satellite line as in the case of application of the TOT long distance telephone line.

(4) Case 4: Trunk Line Based on the PTD Satellite Line

As shown in Fig. 3-17(4/4), the network is planned to utilize the voice channel of the PTD satellite communication system, which uses by lease the voice channel of the transponder of the PALAPA Satellite of Indonesia.

The Domestic Satellite Communication Center (DSCC) of PTD in Bangkok can be used for the telecommunication, connecting RID Head Office by approach line, but the SES to be used at each regional office should be newly provided by RID at the respective locations.

Although the SES can be located at substations without any approach line, RID must bear the initial investment cost for the construction of these five SESs and approach line in Bangkok and operation and maintenance cost, in addition to the rental charge of the voice channel of the PTD satellite line. Since the rental system of PTD satellite lines is still being developed, this system includes several uncertain factors such as rental charge of the line and allocation of available channels of the satellite.

(5) Comparison of Four Proposals

In general, satellite communication has the advantages of not requiring a ground repeater station even for long distance comunication and reliability in communication over a very wide area. However, it also has the disadvantage of increased propagation loss in heavy rains and communication interruption during solar eclipses in spring and summer.

On the other hand, the on-land communication has the advantage in cheaper investment cost and easier operation and maintenance of the communication facilities, which are only arranged on the ground, compared with the satellite communication.

The results of comparison of construction cost and operation/maintenance cost of the trunk line of telecommunication network in the four alternatives are summarized below, the details of which are shown in Table 3-7.

(US$103)

Alternative	Construction Cost	O&M Cost	Total
Case 1 (TOT)	3,169	1,531	4,700
Case 2 (RID)	12,504	2,986	15,490
Case 3 (CAT)	3,305	6,865	10,170
Case 4 (PTD)	4,537	2,360	6,897

As the results of comparison, the trunk line based on the TOT line is selected as the optimum one from the following reasons.

(a) The trunk line based on the TOT line has economical advantages over the other cases and the TOT on-land communication system has acquired sufficient experience in long time operation with reliable performance.

(b) Although satellite communication may be further developed in the near future, the PTD satellite line, which has the secondary advantage in cost comparison, includes still uncertain factors for the planning and does not have long time experience compared with the on-land communication of the TOT line.

Branch Line

The study on branch lines is featured as below.

(1) Branch Line for Local Telemetering Connecting Gauging Stations with Substation

The radio line route for branch line in this section is basically subject to the location of repeater station which is decided mainly from the topographic condition. Thus, the radio line is preliminarily selected as shown in Fig. 3-17.

(2) Branch Line for Data Dissemination Connecting FFC with Related Agencies

Since the communication distance for this section is very short, the radio line route is decided to directly connect both stations without any repeater station. The same transmission system and frequency band selected in item (1) and (3) of Subsection 3.2.2 are commonly used for each branch line in the four cases of trunk line.

3.2.4 Proposed Telecommunication Network

On the basis of the aforementioned study results, the telecommunication network for Step 2 based on the TOT line is proposed as illustrated in Fig. 3-18.

3.2.5 Stagewise Extension of Telecommunication Network

As mentioned in the implementation schedule, the Step 2 Flood Forecasting System will be stagewisely provided dividing the whole construction work into five stages. In this connection, it is proposed to extend the telecommunication network also, keeping pace with the stepwise implementation schedule in accordance with the study results of hydrology, as shown in Fig. 3-19(1/5 to 5/5).

3.2.6 Preliminary Design

(1) Facilities to be Provided in Gauging Station

(a) Equipment

The telecommunication equipment in rainfall gauging stations, water level gauging stations and rainfall/water level gauging stations are as shown in Figs. 3-20 to 3-22. The specifications of equipment in each station are stated below.

- Raingauge

Type	:	tipping bucket type with recorder
Diameter of Inlet	:	200 mm
Measuring Unit	:	1 mm

- Water Level Gauge

Type	:	float type with recorder
Measuring Range	:	0 - 10 m
Measuring Unit	:	1 cm

- Telemetering Equipment

Code Format	:	BCD code with parity bit per digit Water Level: 4 digits Rainfall : 3 digits
Transmission Speed	:	50 bps
Data Input Interface	:	1 sheet

- Radio Equipment

Frequency Band	:	150 MHz
RF Output Power	:	10 W

- Antenna

Type	:	3-element YAGI

- Power Supply

  Solar Cell : 12 V, 8.5 W

  Battery Capacity : DC 12 V, 40 AH

For rainfall/water level gauging stations, one more additional sheet of data input interface will be provided to the telemetering equipment.

(b) Housing and Tower

The typical schemes of housing for rainfall gauging station, water level gauging station and rainfall/water level gauging station which will be newly constructed are shown in Figs. 3-23 to 3-25. The space of housing required is more than 3 m^2, considering the size of equipment and space for maintenance activity. A tower of about 20 m in height is installed in each station, and the antenna is set on the top of tower.

(2) Facilities to be Provided in Radar Site

(a) Equipment

The telecommunication equipment in radar sites for the radar raingauge system is as shown in Fig. 2-26. The main specifications of equipment in radar sites are given below.

- Radar Transmitter/Receiver

  Transmitting Frequency : 5300 MHz band

  Transmitting Power : 250 kW or more

- Antenna

  Antenna Size : 3 m dia. parabola

- Radome

  Diameter : 7 m dia.

- Signal Processor

  Quantization for Range : 3 km

  Quantization for Azimuth : 2.8° (within 120 km)/1

  1.4° (beyond 120 km)

  (Note /1: The available coverage of one radar gauge is estimated at about 120 km radius judging from the topographic conditions of the Chao Phraya River Basin. Thus, two radar sites will be required to cover the gauging area specified in the hydrological study (refer to the sector of Hydrology.)

- Radar Supervisory/Controller

  Items for Supervision and Control : 40

- Monitor

  Display : raw video display

- Communication Control Unit

  Transmission Speed : 1200 bps or more

  Data Transmission : every 5 min.

- Power Supply Equipment

  Output Voltage : AC 220 V, 50 Hz

  Output Capacity : 200 kVA

- Multiplex Radio Equipment

  Frequency Band : 1.5 GHz band

  RH Output Power : 1.0 W

- Multiplex Terminal Equipment

  Channel Capacity : 4 ch

- Antenna for Data Transmission

  Type : 8-element YAGI

(b) Housing

The typical scheme of housing for radar sites is shown in Fig. 3-27. The housing is designed as a 3-storey building, so that the radio wave of the radar can reach the maximum extent from the top of the building, and the space beneath is required for operation and maintenance. The antenna for data transmission will be installed at the side of the building.

(3) Facilities to be Provided in Repeater Station

(a) Equipment

The telecommunication equipment in repeater stations is as shown in Fig. 3-28. The major specifications of equipment in the station are shown as follows:

- Repeater Equipment

Type	:	Hot/Standby automatic changeover and remote changeover
Repeater	:	VHF-VHF Repeater

- Radio Equipment

Frequency	:	150 MHz
RF Output Power	:	10 W

- Antenna Equipment

Type	:	3-stage Colinear

- Power Supply Equipment

Solar Cell	:	12 V, 20 W
Battery Capacity	:	DC 12V, 80 AH

(b) Housing and Tower

The typical scheme of housing for repeater stations is shown in Fig. 3-29. A tower of about 30 m in height is installed in each repeater station, and the antenna is installed at the top of the tower.

(4) Facilities to be Provided in Substation (RID Regional Office)

(a) Equipment

The telecommunication equipment in substations is shown in Fig. 3-30. The equipment consists of those for trunk lines and those for branch lines, which is connected to gauging stations or radar sites. The major specifications of the equipment are shown below:

<u>For Trunk Line (Approach Line)</u>

- Multiplex Radio Equipment

  Frequency Band : 1.5 GHz band

  RF Output Power : 1.0 W

- Multiplex Terminal Equipment

  Channel Capacity : 3 ch or less

- Antenna for Data Transmission

  Type : 8-element YAGI

<u>For Branch Line for Collecting Hydrological Data</u>

- Telemetering Supervisory Equipment

  Code Format : BCD code with parity bit per digit

  Water Level: 4 digits
  Rainfall : 3 digits

Transmission Speed	:	50 bps
Measuring Capacity	:	30 stations

- Radio Equipment

Frequency Band	:	150 MHz
RF Output Power	:	10 W

- Antenna Equipment

Type	:	3-stage Colinear

- Operating Unit/Console

Operation	:	Gauging station selection, calling interval setting, voice communication for maintenance
Display	:	Received data, received failure, date and time

- Typewriter

Carriage Width	:	27 inches or less
Printing Speed	:	100 characters/sec or more

<u>For Branch Line for Collecting Radar Raingauge Data (Regional Office No. 3 and No. 8)</u>

- Radar Supervisory/Controller

Supervisor	:	20 items or more
Controller	:	20 items or more

- Brightness Monitor

Display	:	19 inch, color

- Typewriter for Supervision

Carriage Width	:	13 inches
Printing Speed	:	15 characters/sec
Character	:	64 kinds

- Multiplex Radio Equipment

  Frequency Band : 1.5 GHz band

  RF Output Power : 1.0 W

- Multiplex Terminal Equipment

  Channel Capacity : 3 ch or less

- Antenna Equipment

  Type : 8-element YAGI

Common Facility

- Power Supply Equipment

  Output Voltage : AC 220 V, 50 Hz

  Output Capacity : 75 kVA or more

(b) Housing and Tower

The typical schemes of housing which will be newly constructed for substations in each regional office are shown in Fig. 3-31. The required space is about 100 m^2, considering the size of equipment and space for operation and maintenance activity. A tower of about 30 m in height is installed on each substation, and the antenna equipment is set on top of the tower.

(5) Facilities to be Provided in TOT Terminal Station

(a) Telecommunication Equipment

The specifications of the proposed equipment in the TOT terminal stations are as stated below (refer to Fig. 3-32), on condition that TOT will provide as part of the rental charge the electric power and the installation space, and the connection of exclusive line will be carried out for TOT's equipment to transmit without a telephone exchanger.

- Multiplex Radio Equipment

  Frequency Band : 1.5 GHz

  RF Output Power : 1.0 W

- Multiplex Terminal Equipment

  Channel Capacity : 3 ch or less

- Antenna Equipment

  Type : 8-element YAGI

(6) Facilities to be Provided in FFC (RID Head Office)

(a) Equipment

The equipment in FFC consists of those for telecommunication, data management and data dissemination, as shown in Fig. 3-33. The major specifications of the facilities are stated below.

Telecommunication Facility

For Trunk Line:

- Multiplex Radio Equipment

  Frequency Band : 1.5 GHz band

  RF Output Power : 1.0 W

- Multiplex Terminal Equipment

  Channel Capacity : 16 ch

- Antenna Equipment

  Type : 8-element YAGI

- Communication Control Unit

  Input Data : Hydrological data, radar rainfall data

  Output Data : Dissemination data

- Data Conversion Unit for Radar Rainguage

  Memory : 200 kB or more

- Magnetic Disk Unit

  Capacity : 10 MB or more

- Magnetic Tape Unit

  Density : 1600 bit/inch or less

  Transfer Speed : 20 kB/sec

For Branch Line for Collecting Hydrological Data:

- Telemetering Supervisory Equipment

  Code Format : BCD code with parity bit per digit

  Water Level: 4 digits
  Rainfall : 3 digits

  Transmission Speed : 50 bps

  Measuring Capacity : 30 stations

- Radio Equipment

  Frequency Band : 150 MHz

  RF Output Power : 10 W

- Antenna Equipment

  Type : 3-stage Colinear

- Operating Unit/Console

  Operation : Gauging station selection, calling interval setting, voice communication for maintenance

  Display : Received data, received failure, date and time

- Typewriter

  Carriage width : 27 inches or less

  Printing Speed : 100 characters/sec or more

For Branch Line for Data Dissemination to Related Agencies:

- Multiplex Radio Equipment (Multi-Directional Type)

  Frequency Band : 1.5 GHz band

  RF Output Power : 1.0 W

- Multiplex Terminal Equipment (Multi-Directional Type)

  Channel Capacity : 3 ch for each station

- Antenna for Data Transmission

  Type : 3-stage colinear

Common Facility:

- Power Supply Equipment

  Output Voltage : AC 220 V, 50 Hz

  Output Capacity : 200 kVA or more

<u>Data Management and Data Dissemination Facility</u>

- Engineering Work Station

  CPU : 32 bit

  Memory : 5 MB

  CRT Graphic Display : 19 inch, color

- Hard Disk Drive

  Capacity : 100 MB or more

- Magnetic Disk Drive

  Density : 1600 byte/inch

  Transfer Speed : 120 kB/sec

- Printer

  Printing Width : 132 characters/line

  Printing Speed : 180 characters/sec

- Video Projector

  Size : 100 inch

- Facsimile

  Type : GII, GIII

(b) Housing and Tower

The typical scheme of housing which will be newly constructed for FFC in the RID Head Office is shown in Fig. 3-34. The required space is about 600 m^2, considering the size of equipment and space for operation and maintenance. A tower of about 30 m in height is installed in FFC, and the antenna is set on top of the tower.

(6) Facilities to be Provided in Related Agencies

The proposed equipment in BMA, LAD, EGAT consist of those for dissemination, as shown in Fig. 3-35. The equipment is designed on the condition that electric power and space will be provided by the agencies themselves.

The main specifications of the facilities are shown below:

- Multiplex Radio Equipment (Multi-Directional Type)

  Frequency Band : 1.5 GHz band

  RF Output Power : 1.0 W

- Multiplex Terminal Equipment (Multi-Directional Type)

  Channel Capacity : 3 ch for each station

- Antenna Equipment

  Type : 8-element YAGI

- Monitor : 14 inch or more, color

- Facsimile

  Type : GII, GIII

TABLES

Table 3-1. RADIO EQUIPMENT OF RID

Office	HF/SSB	VHF/FM		
		Base	Mobile	Handy Talkie
Head Office	7 sets	7 sets	11 sets	27 sets
Regional Office No. 1	17	8	13	29
Regional Office No. 2	22	13	12	24
Regional Office No. 3	25	11	22	24
Regional Office No. 7	13	12	5	25
Regional Office No. 8	6	4	-	17
Total	90 sets	55 sets	63 sets	146 sets

Table 3-2. RADIO CONDITION BETWEEN RID HEAD OFFICE AND REGIONAL OFFICES

Regional Office		Frequency	Condition /1
<u>From RID Head Office to Regional Office</u>			
1	Chiang Mai	HF/SSB (7855/7990 kHz)	1
2	Lam Pang	HF/SSB (7855/7990 kHz)	2
3	Phitsanulok	HF/SSB (4810 kHz)	3
7	Chai Nat	HF/SSB (5830 kHz)	3
8	Lop Buri	HF/SSB (4810 kHz)	3 or 4
<u>From Regional Office to RID Head Office</u>			
1	Chiang Mai	HF/SSB (7855/7990 kHz)	2
2	Lam Pang	HF/SSB (7855/7990 kHz)	1
3	Phitsanulok	HF/SSB (4810 kHz)	3
7	Chai Nat	HF/SSB (5830 kHz)	3
8	Lop Buri	HF/SSB (4810 kHz)	3

Note: /1 Radio condition:

1 = very sensitive
2 = good sensitivity
3 = fairly sensitive
4 = fairly sensitive but interference and noise often occur

Table 3-3(1/2). RADIO CONDITION FROM REGIONAL OFFICE TO PROJECT OFFICE

	Project Office	Frequency	Distance (km)	Condition /1	
				HF/SSB	VHF/FM
REGION 1					
1	Nam Yuan	HF/SSB	130	4	-
2	Mae Sao	HF/SSB	140	4	-
3	Tractori	HF/SSB; VHF/FM	20	1	4
4	Mae Kuang	HF/SSB; VHF/FM	20	1	1
5	Huai Hong Kari	VHF/FM	20	-	1
6	Mae Hong Son	HF/SSB	120	1	-
7	Mae Tub	HF/SSB; VHF/FM	100	1	4
8	Jsok	VHF/FM	10	-	4
9	Chomtaeng	HF/SSB; VHF/FM	20	1	4
10	Faek	VHF/FM	30	-	4
11	Mae Ngat	HF/SSB; VHF/FM	40	1	4
12	Nong Krating	VHF/FM	60	-	4
13	Maeon	VHF/FM	25	-	1
14	Huai Rong	VHF/FM	50	-	2
15	Phai Poi Noi	VHF/FM	65	-	4
REGION 2					
1	Kiu Lom	VHF/FM	30	-	1
2	Mae Wan	VHF/FM	40	-	2
3	Mae Lao	HF/SSB	160	2	-
4	Mae Yom	HF/SSB	80	3	-
5	Mae Song	HF/SSB	80	3	-
6	Phayao	HF/SSB; VHF/FM	100	3	2
7	Mae Tam	HF/SSB	90	4	-
8	Mae Man	VHF/FM	70	-	4
9	Phrae	HF/SSB		4	-
10	Denchai	VHF/FM	60	2	4
11	Namngae	HF/SSB	150	3	-
12	Mae Kung No. 1	VHF/FM	120	-	2
13	Chiang Rai	HF/SSB	230	3	-
14	Dong Mada	HF/SSB	190	4	-
15	Mae Prum	HF/SSB	130	3	-
16	Huai Chang	HF/SSB	290	3	-
17	Phaisamun	HF/SSB	170	3	-
18	Mae Sai	HF/SSB	300	1	-

Note: /1 Radio condition:

1 = very sensitive
2 = good sensitivity
3 = fairly sensitive
4 = fairly sensitive but interference and noise often occur

Table 3-3(2/2). RADIO CONDITION FROM REGIONAL OFFICE TO PROJECT OFFICE

	Project Office	Frequency	Distance (km)	Condition /1	
				HF/SSB	VHF/FM
REGION 3					
1	Phrom Phiram	HF/SSB; VHF/FM	35	1	1
2	Nampat	HF/SSB	200	3	-
3	Huai Padaeng	HF/SSB; VHF/FM	140	2	4
4	Namrid	HF/SSB; VHF/FM	110	2	4
5	Nakhon Sawan	HF/SSB; VHF/FM	130	2	4
6	Tak	HF/SSB; VHF/FM	100	3	3
7	Phichit	VHF/FM	50	-	1
8	Wang Sri Sup	HF/SSB	130	2	-
9	Kamphaeng Phet	HF/SSB; VHF/FM	100	2	3
10	Sawang Khalok	VHF/FM	80	-	2
11	Thabua	VHF/FM	70	-	2
12	Maesot	HF/SSB	260	2	5
13	Chabun	HF/SSB	130	2	-
14	Sukhothai	HF/SSB; VHF/FM	57	1	1
15	Wangbua	HF/SSB	100	2	-
	(Note: VHF/FM = 139.100 MHz)				
REGION 7					
1	Chanasute	HF/SSB	60	1	-
2	Chaochet	HF/SSB	140	2	-
3	Bangbal	HF/SSB	125	2	-
4	Phrayabanlue	VHF/FM	180		
5	Phakhai	HF/SSB	80	1	-
6	Phase Charoen	HF/SSB	200	2	-
7	Banglen	VHF/FM	120	-	4
8	Phophaya	VHF/FM	70	-	2
9	Thabote	VHF/FM	25	-	1
10	Phonlathep	VHF/FM	15	-	2
11	Thap Salao	HF/SSB	50	1	-
12	Donchedi	VHF/FM	50	-	2
13	Phraphimol	HF/SSB	180	2	-
14	Kraseio	VHF/FM	50	-	1
15	Samchuk	VHF/FM	45	-	1
	(Note: HF/SSB = 5830 kHz; VHF/FM = 139.100 MHz)				
REGION 8					
1	Khlong Pure	VHF/FM	45	-	1
2	Pasak Thai	VHF/FM	30	-	3
3	Chongkae	HF/SSB	50	1	-
4	Maharaj	VHF/FM	30	-	2
5	Rangsit North	VHF/FM	70	-	3
6	Nakorn Luang	VHF/FM	70	-	2
7	Manorom	VHF/FM	60	-	4
8	Khlong Dan	HF/SSB	160	4	-
9	Rangsit South	HF/SSB	80	4	-
	(Note: VHF/FM = 141.000 MHz)				

Table 3-4(1/3). TELECOMMUNICATION NETWORK BETWEEN RID HEAD OFFICE AND HYDROLOGICAL OBSERVATION STATION (Step 1: Case 1)

Gauging Station	Gauging Station to Project Office		Project Office to Regional Office		Regional Office to Head Office	
	Method of Transmission	Project Office	Method of Transmission	Regional Office	Method of Transmission	Head Office
1 W-H1	VHF(New)	Kiu Lom	HF(Existing)	R2	HF(Existing)	
2 W-H2 R-M2	HF(New)	Tak	HF(Existing)	R3	HF(Existing)	RID Head Office
3 W-H3	HF(New)					
4 W-H4	HF(New)					
5 R-H8 W-H7	HF(New)	Wang Sri Sup	HF(Existing)			
6 R-H9 W-H11	HF(New)					
7 W-H10	HF(New)					
8 W-H8 R-M8	VHF(New)	Sukhothai	HF(Existing)			
9 W-H12	VHF(New)	Phrom Phiram	VHF(Existing)			
10 W-H14	VHF(New)					
11 R-H10 W-H13	VHF(New)	Sawan Khalok	VHF(Existing)			
12 R-H11 W-H15	VHF(New)					
13 W-H5	VHF(New)	Wang Bua	HF(Existing)			
14 R-H1	HF(New)					
15 R-H2	HF(New)					
16 R-H12 W-H20	VHF(New)	Nakhon Sawan	HF(Existing)			
17 W-H9 R-M9	VHF(New)	Phichit	HF(Existing)			
18 W-H16 R-M12	VHF(New)	Tha Bua	HF(Existing)			
19 R-H3	HF(New)	Thap Salao	HF(Existing)	R7	HF(Existing)	
20 R-H4	HF(New)					
21 R-H5	VHF(New)					
22 R-H6	VHF(New)					
23 W-H18	VHF(New)	Bang Bal	HF(Existing)			
24 W-H19	VHF(New)	Phonlathep	VHF(Existing)			
25 W-H21	VHF(New)	Borommathat	VHF(Existing)			
26 W-H22	VHF(New)	Maharaj	VHF(Existing)	R8	HF(Existing)	
27 W-H23	VHF(New)	Pasak Tai	VHF(Existing)			
28 W-H17	VHF(New)	Khlong Pure	HF(Existing)			
29 W-H24	VHF(New)	Yang Manee	VHF(Existing)			
30 W-H25	HF(New)					
31 W-H26	VHF(New)					
32 W-H27	VHF(New)					
33 W-H28	VHF(New)					
34 W-PAT	VHF(New)					

Table 3-4(2/3). TELECOMMUNICATION NETWORK BETWEEN RID HEAD OFFICE AND HYDROLOGICAL OBSERVATION STATION (Step 1: Case 2)

Gauging Station		Gauging Station to Regional Office		Regional Office to Head Office	
		Method of Transmission	Regional Office	Method of Transmission	Head Office
1	W-H1	VHF(New)	R2	HF(Existing)	RID Head Office
2	W-H2 R-M2	HF(New)	R3	HF(Existing)	
3	W-H3	HF(New)			
4	W-H4	HF(New)			
5	R-H8 W-H7	HF(New)			
6	R-H9 W-H11	HF(New)			
7	W-H10	HF(New)			
8	W-H8 R-M8	HF(New)			
9	W-H12	HF(New)			
10	W-H14	VHF(New)			
11	R-H10 W-H13	VHF(New)			
12	R-H11 W-H15	VHF(New)			
13	W-H5	HF(New)			
14	R-H1	HF(New)			
15	R-H2	HF(New)			
16	R-H12 W-H20	HF(New)			
17	W-H9 R-M9	HF(New)			
18	W-H16 R-M12	HF(New)			
19	R-H3	HF(New)	R7	HF(Existing)	
20	R-H4	HF(New)			
21	R-H5	HF(New)			
22	R-H6	HF(New)			
23	W-H18	HF(New)			
24	W-H19	HF(New)			
25	W-H21	VHF(New)			
26	W-H22	VHF(New)	R8	HF(Existing)	
27	W-H23	VHF(New)			
28	W-H17	HF(New)			
29	W-H24	VHF(New)			
30	W-H25	HF(New)			
31	W-H26	VHF(New)			
32	W-H27	VHF(New)			
33	W-H28	VHF(New)			
34	W-PAT	VHF(New)			

Table 3-4(3/3). TELECOMMUNICATION NETWORK BETWEEN RID HEAD OFFICE AND HYDROLOGICAL OBSERVATION STATION (Step 1: Case 3)

Gauging Station		Gauging Station to Head Office	
		Method of Transmission	Head Office
1	W-H1	HF(New)	RID Head Office
2	W-H2 R-M2	HF(New)	
3	W-H3	HF(New)	
4	W-H4	HF(New)	
5	R-H8 W-H7	HF(New)	
6	R-H9 W-11	HF(New)	
7	W-H10	HF(New)	
8	W-H8 R-M8	HF(New)	
9	W-H12	HF(New)	
10	W-H14	HF(New)	
11	R-H10 W-H13	HF(New)	
12	R-H11 W-H15	HF(New)	
13	W-H5	HF(New)	
14	R-H1	HF(New)	
15	R-H2	HF(New)	
16	R-H12 W-H20	HF(New)	
17	W-H9 R-M9	HF(New)	
18	W-H16 R-M12	HF(New)	
19	R-H3	HF(New)	
20	R-H4	HF(New)	
21	R-H5	HF(New)	
22	R-H6	HF(New)	
23	W-H18	HF(New)	
24	W-H19	HF(New)	
25	W-H21	HF(New)	
26	W-H22	HF(New)	
27	W-H23	HF(New)	
28	W-H17	HF(New)	
29	W-H24	HF(New)	
30	W-H25	HF(New)	
31	W-H26	VHF(New)	
32	W-H27	VHF(New)	
33	W-H28	VHF(New)	
34	W-PAT	VHF(New)	

Table 3-5. COMPARISON OF COST, RELAY POINTS AND COMMUNICATION VOLUME AMONG ALTERNATIVES

Comparison Item	Case 1	Case 2	Case 3
Construction Cost and O&M Cost (US$$10^3$)	1,048	1,036	1,029
- Construction Cost	935	948	960
- O&M Cost for 10 years	113	88	69
Repeat Point	2	1	0
Communication Volume (Transmitted Data Volume/Day) /1	104	74	41

Note: /1 One unit of communication volume is one hydrological data transmitted from one place to another, i.e., from hydrological observation station to project office, from project office to regional office, etc.

TABLE 3-6. REQUIRED NUMBER OF CHANNEL FOR DATA COLLECTION

Section	No of Channel				
	Date Transmission	Tel/Fax	Telephone	Radar	Total
FFC - R1	1	1			2
FFC - R2	1	1			2
FFC - R3	1	1		2	4
FFC - R7	1	1	1		3
FFC - R8	1	1	1	2	5

Table 3-7. COST COMPARISON OF ALTERNATIVES

Cost Item	Amount (US$ 10^3)			
Construction Cost	TOT	RID	CAT	PTD
1. Trunk Line	1,645	10,980	1,781	3,013
- Sub-station	678	1,115	678	2,723
- Terminal Station (TOT, CAT, PTD)	813	-	949	136
- Repeater Station (UHF)	-	9,407	-	-
- Flood Forecasting Center	154	458	154	154
2. Branch Line	1,524	1,524	1,524	1,524
- Radar Ganging Station	171	171	171	171
- Repeater Station	1,182	1,182	1,182	1,182
- Sub-station	171	171	171	171
Sub Total	3,169	12,504	3,305	4,537
O&M Cost for 10 years				
1. Rental Fee for Line	309	-	5,619	818
2. Personnel for O&M	682	853	682	768
3. Maintenance Cost for Materials	540	2,133	564	774
Sub-Total	1,531	2,986	6,865	2,360
Grand Total	4,700	15,490	10,170	6,897

FIGURES

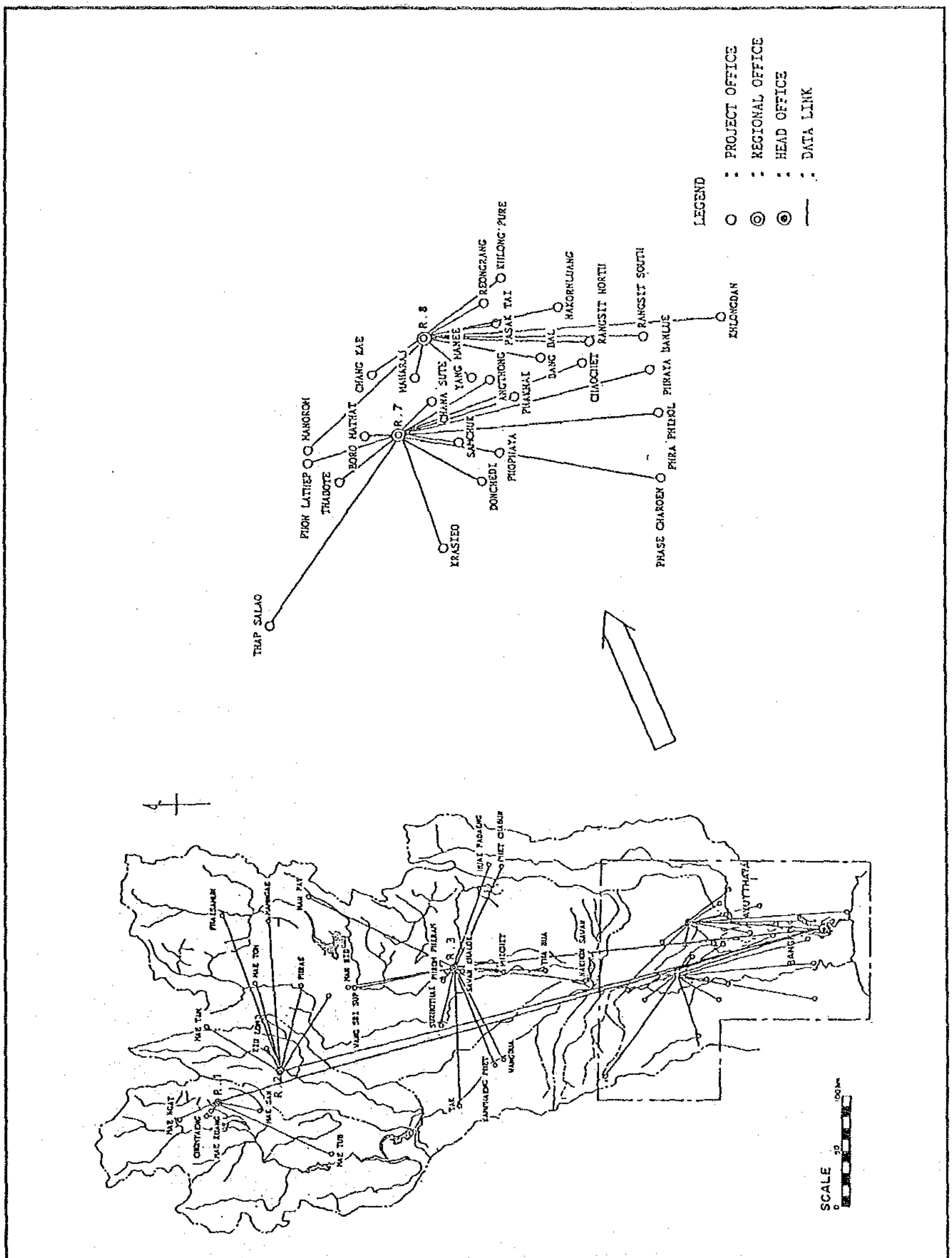


Fig. 3-1. LOCATION OF RID REGIONAL AND PROJECT OFFICES

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

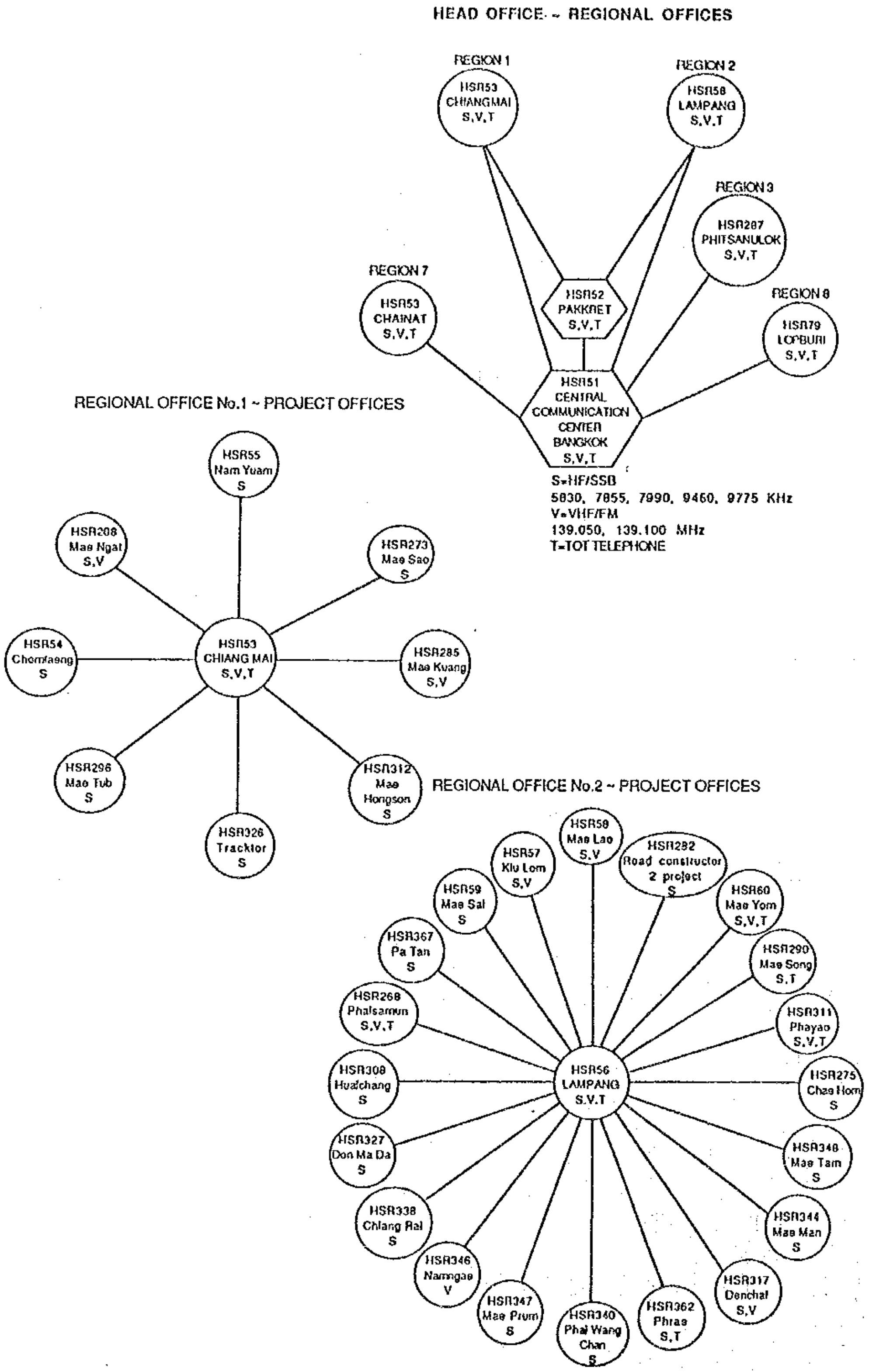


Fig. 3-2(1/2). RID TELECOMMUNICATION NETWORK	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN
	JAPAN INTERNATIONAL COOPERATION AGENCY

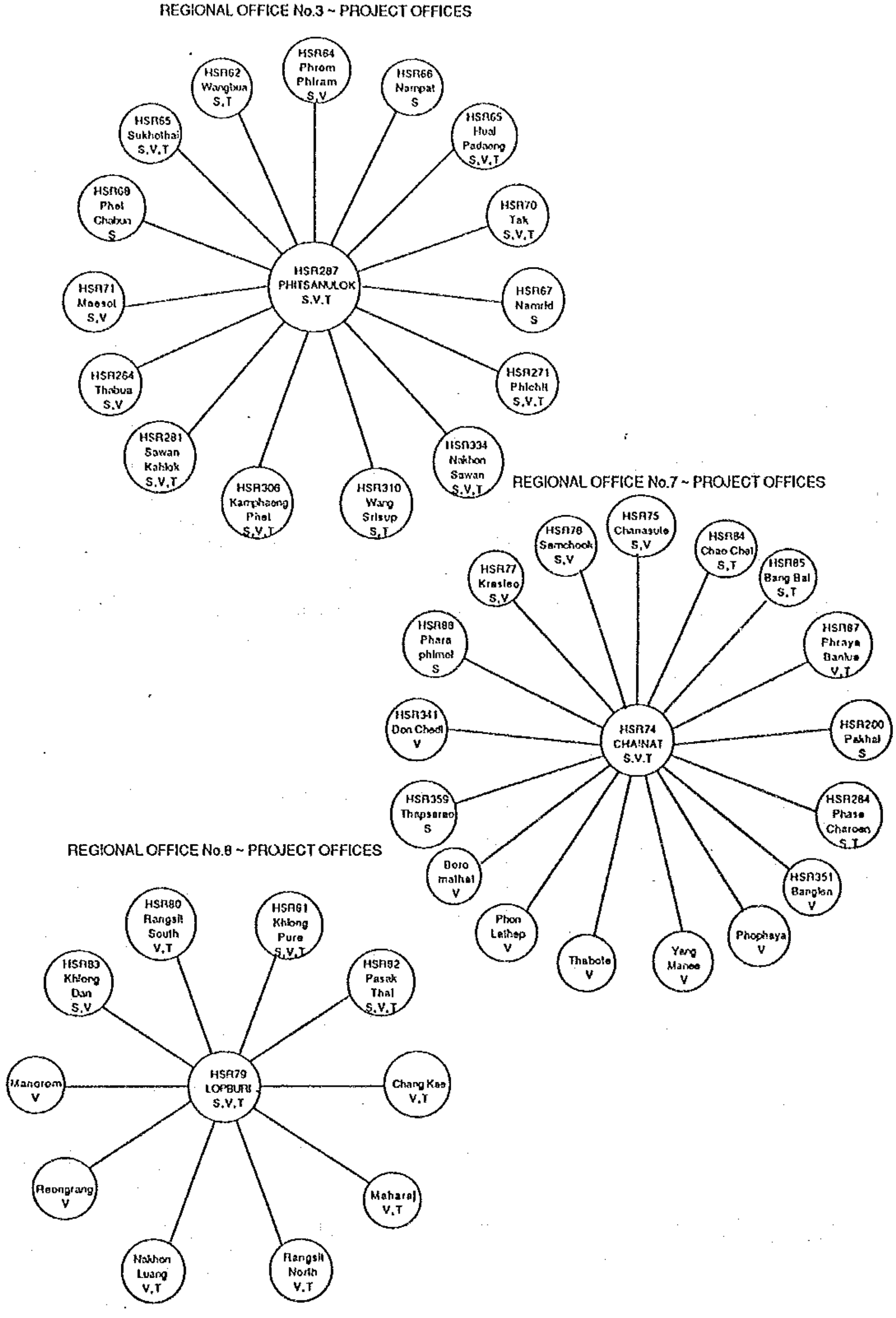


Fig. 3-2(2/2). RID TELECOMMUNICATION NETWORK	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN
	JAPAN INTERNATIONAL COOPERATION AGENCY

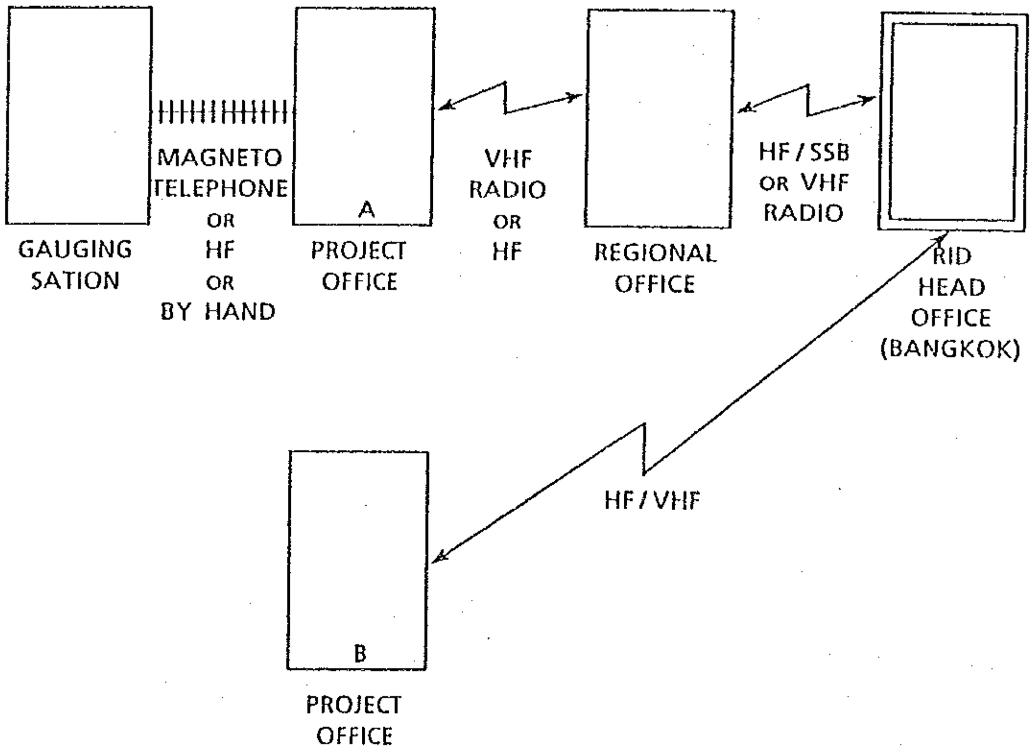


Fig. 3-3. CONFIGURATION OF RID TELECOMMUNICATION NETWORK

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

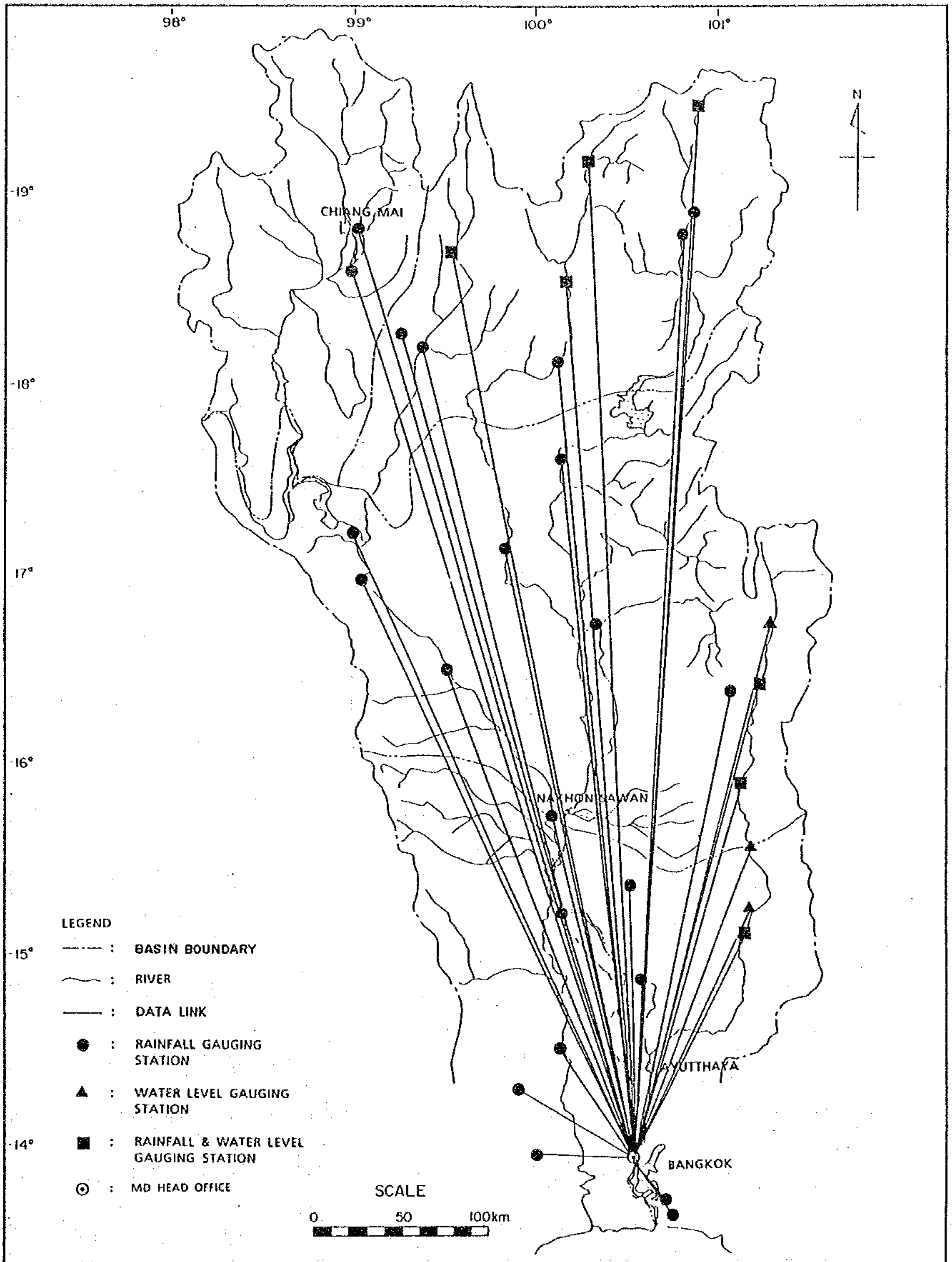


Fig. 3-4. MD TELECOMMUNICATION NETWORK

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

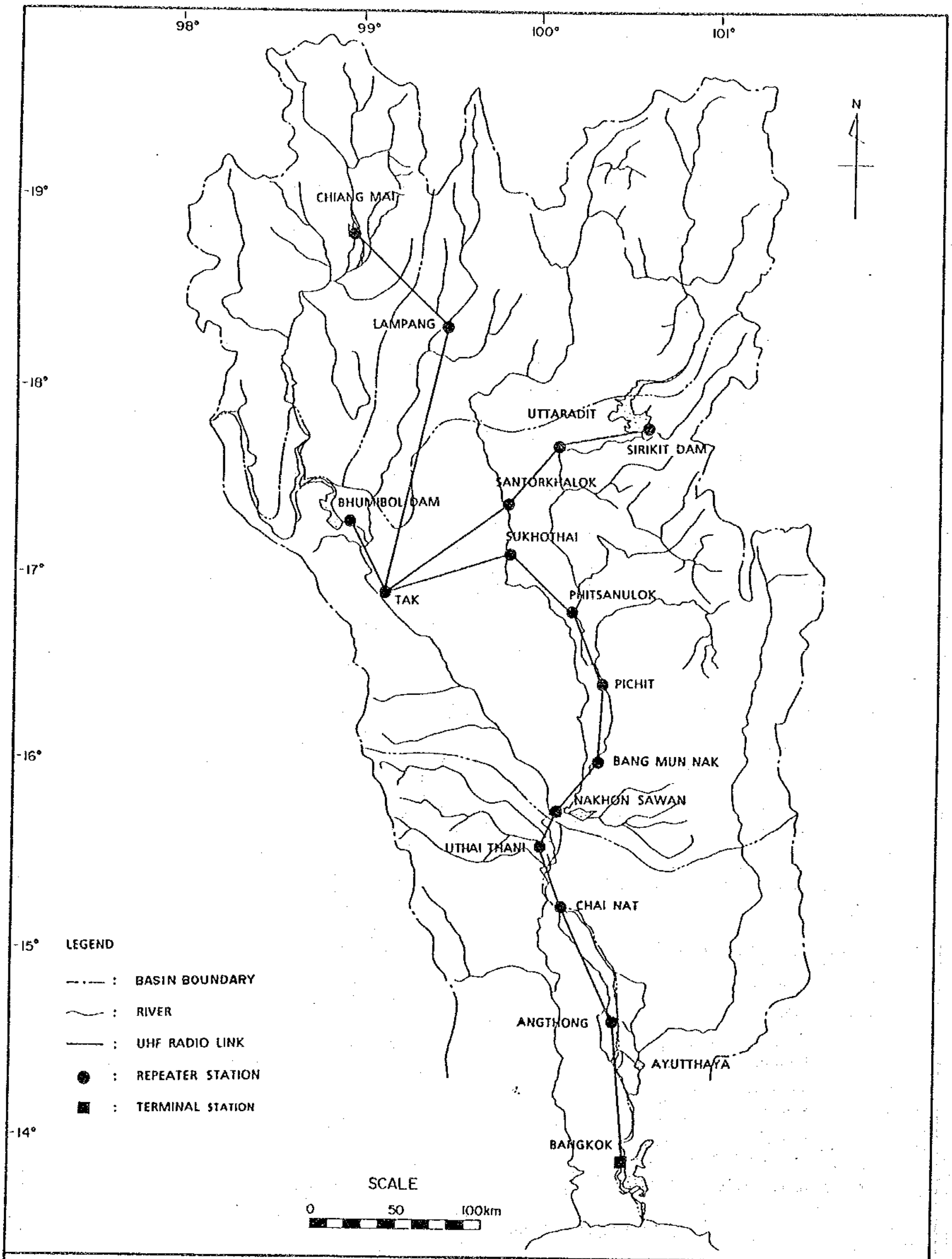


Fig. 3-5. EGAT MICROWAVE NETWORK

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

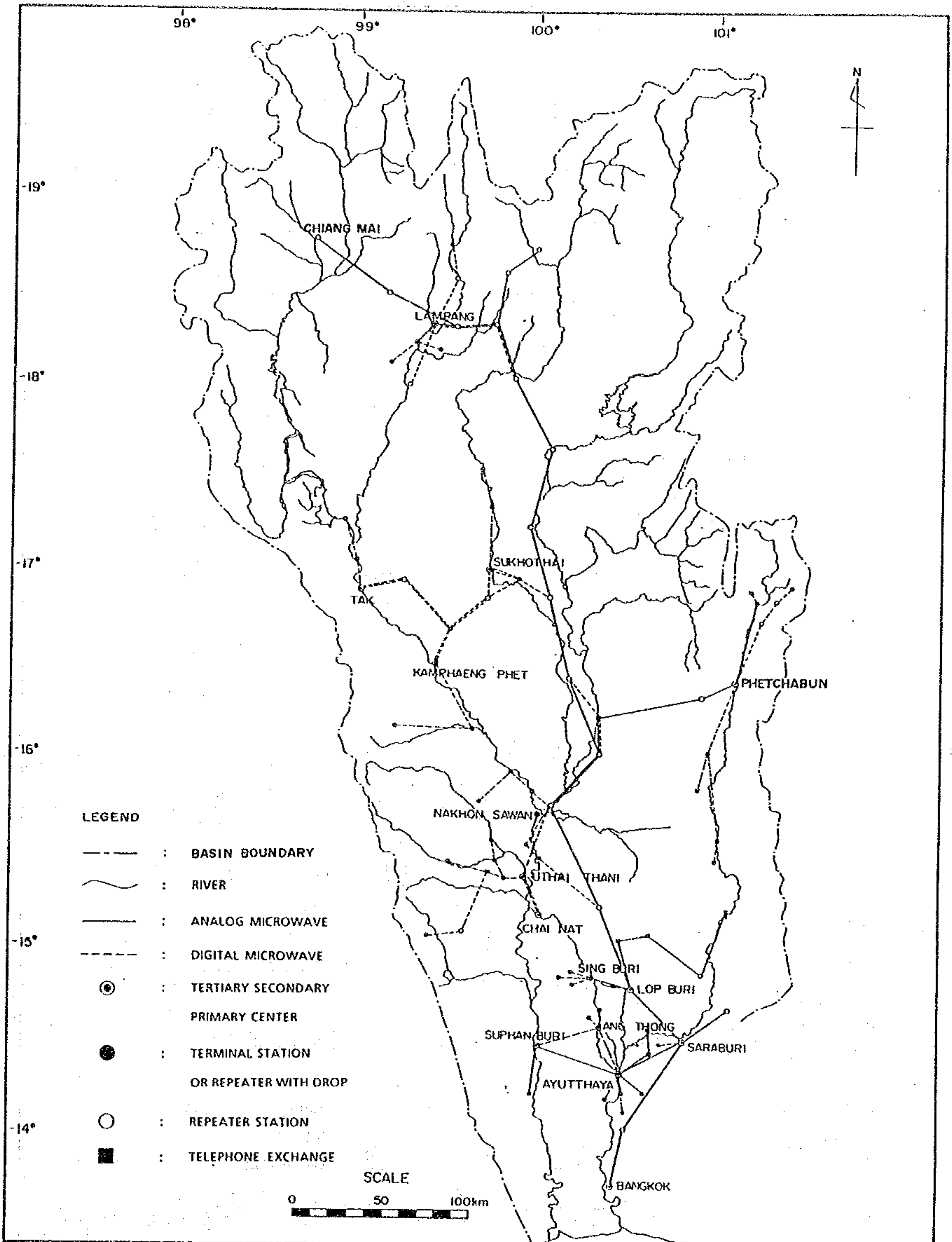


Fig. 3-6. TOT MICROWAVE NETWORK

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

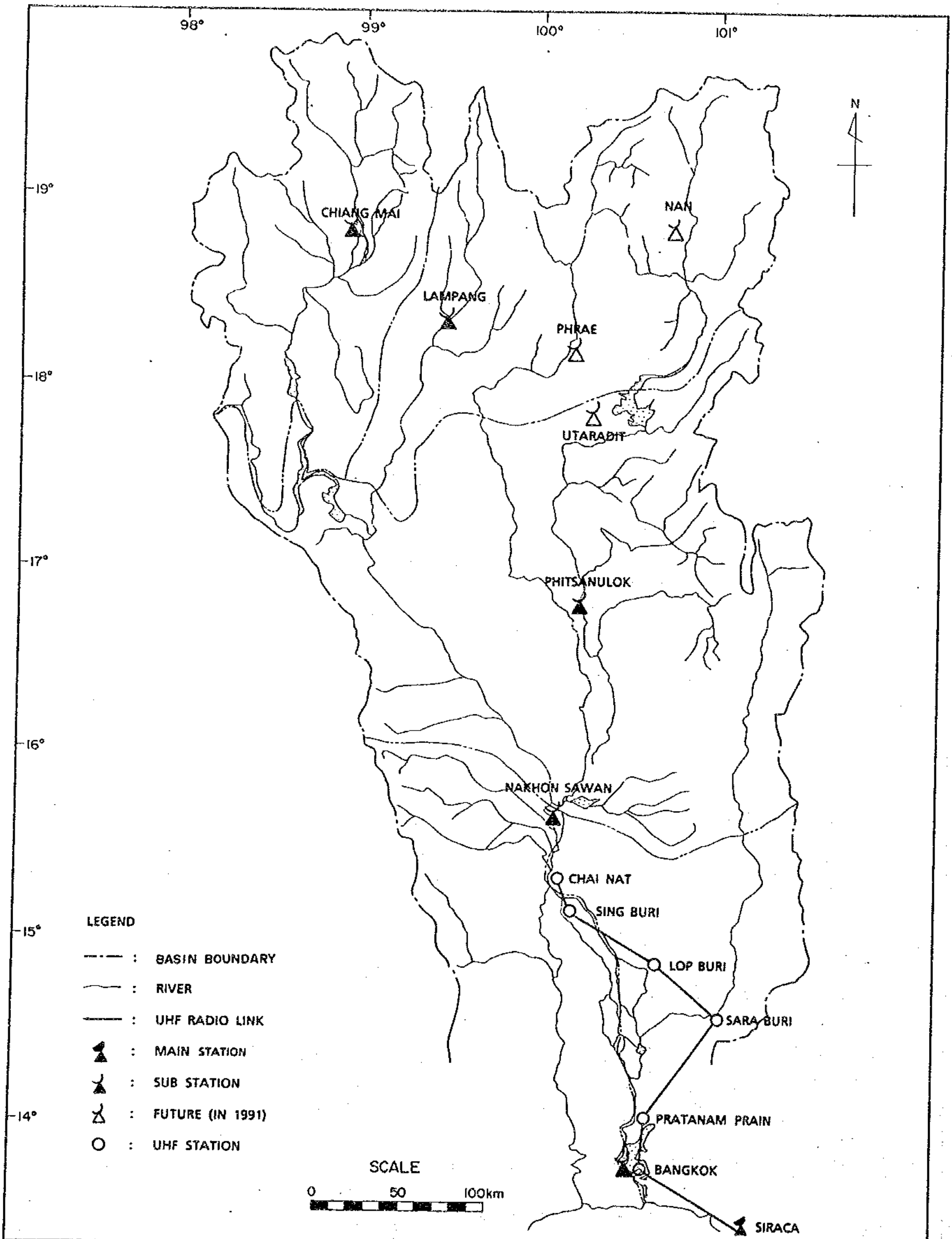


Fig. 3-7. CAT TELECOMMUNICATION NETWORK	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN
	JAPAN INTERNATIONAL COOPERATION AGENCY

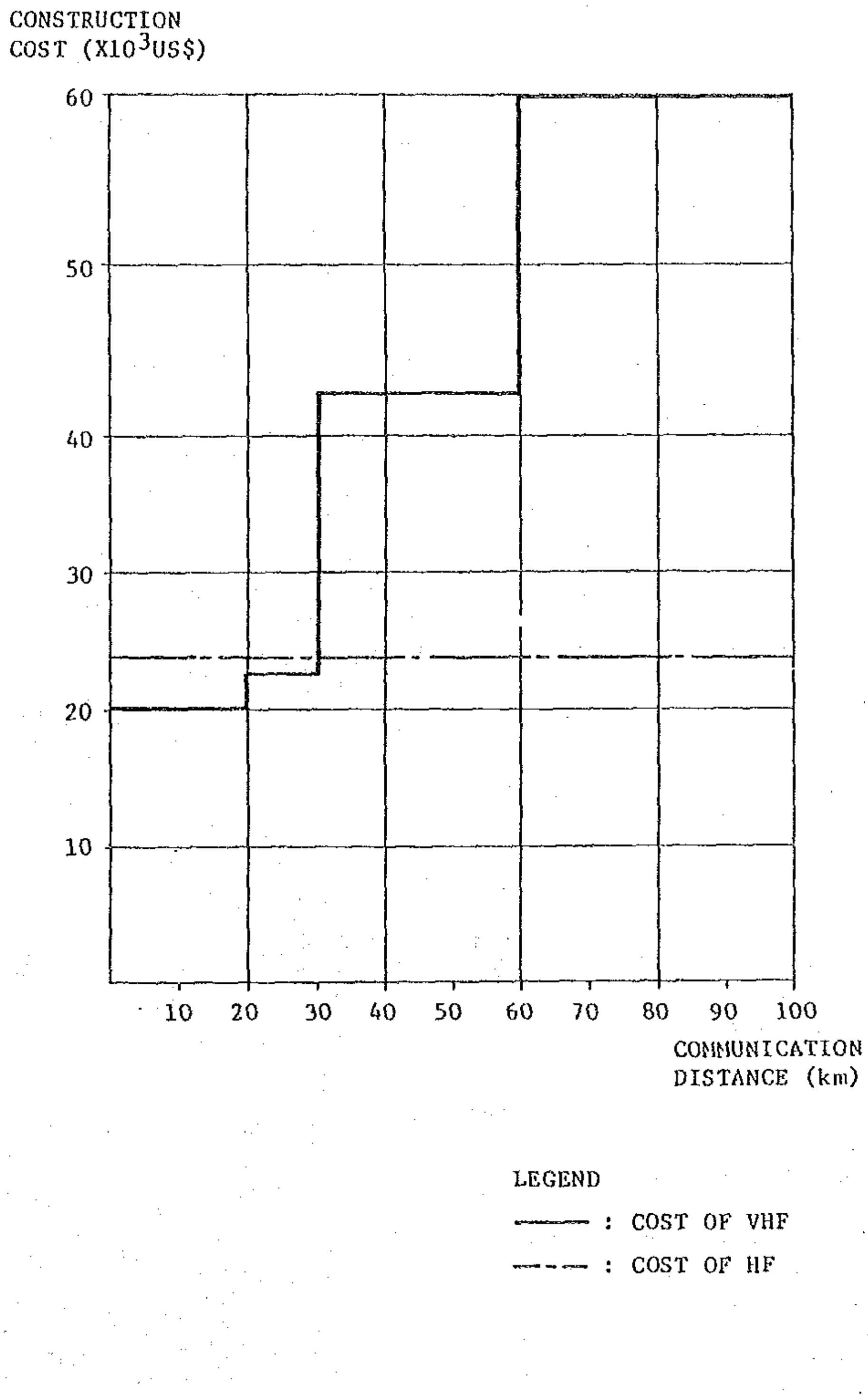


Fig. 3-8. RELATION BETWEEN COST AND COMMUNICATION DISTANCE

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

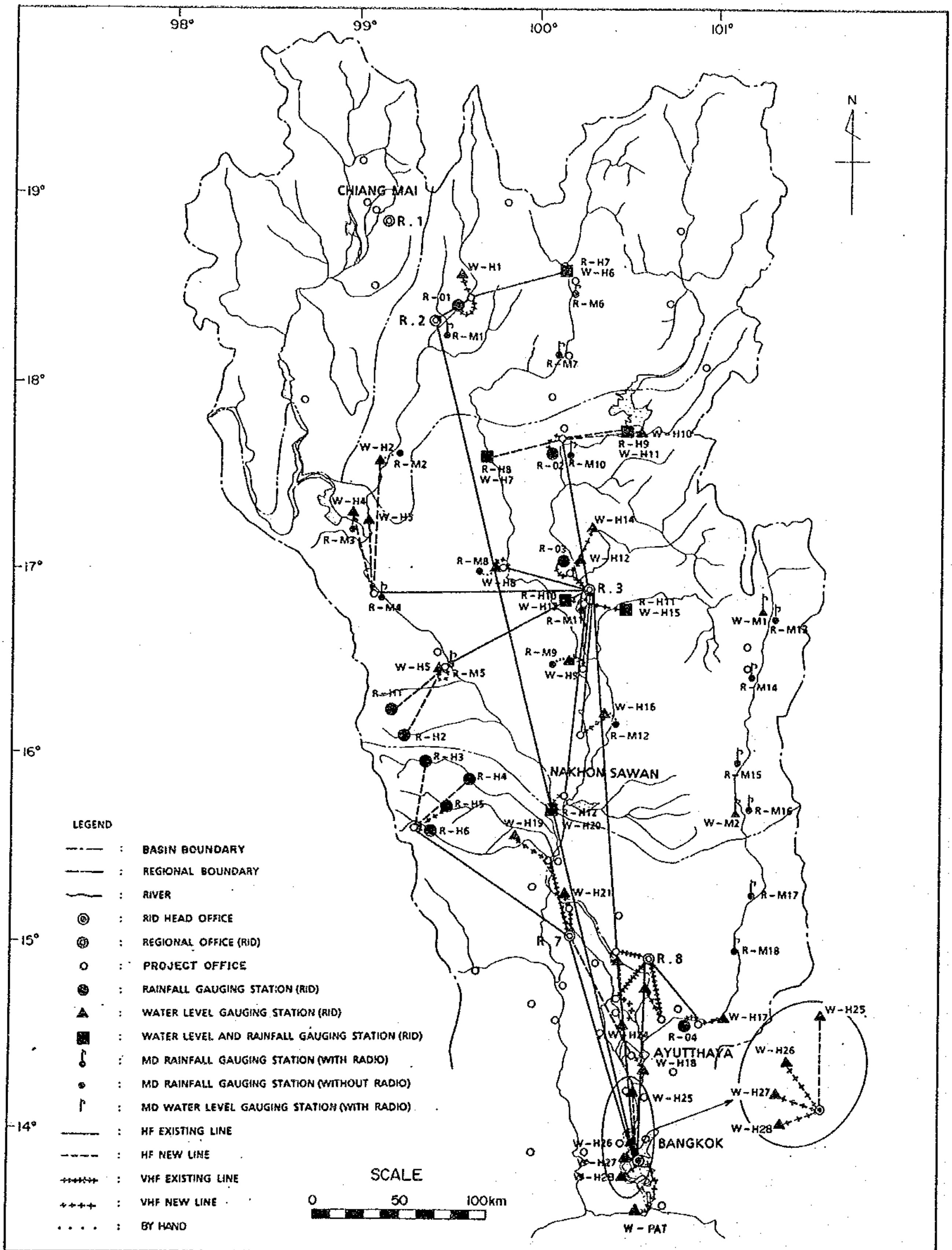


Fig. 3-9(1/3). TELECOMMUNICATION NETWORK (STEP 1: ALTERNATIVE CASE 1)

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

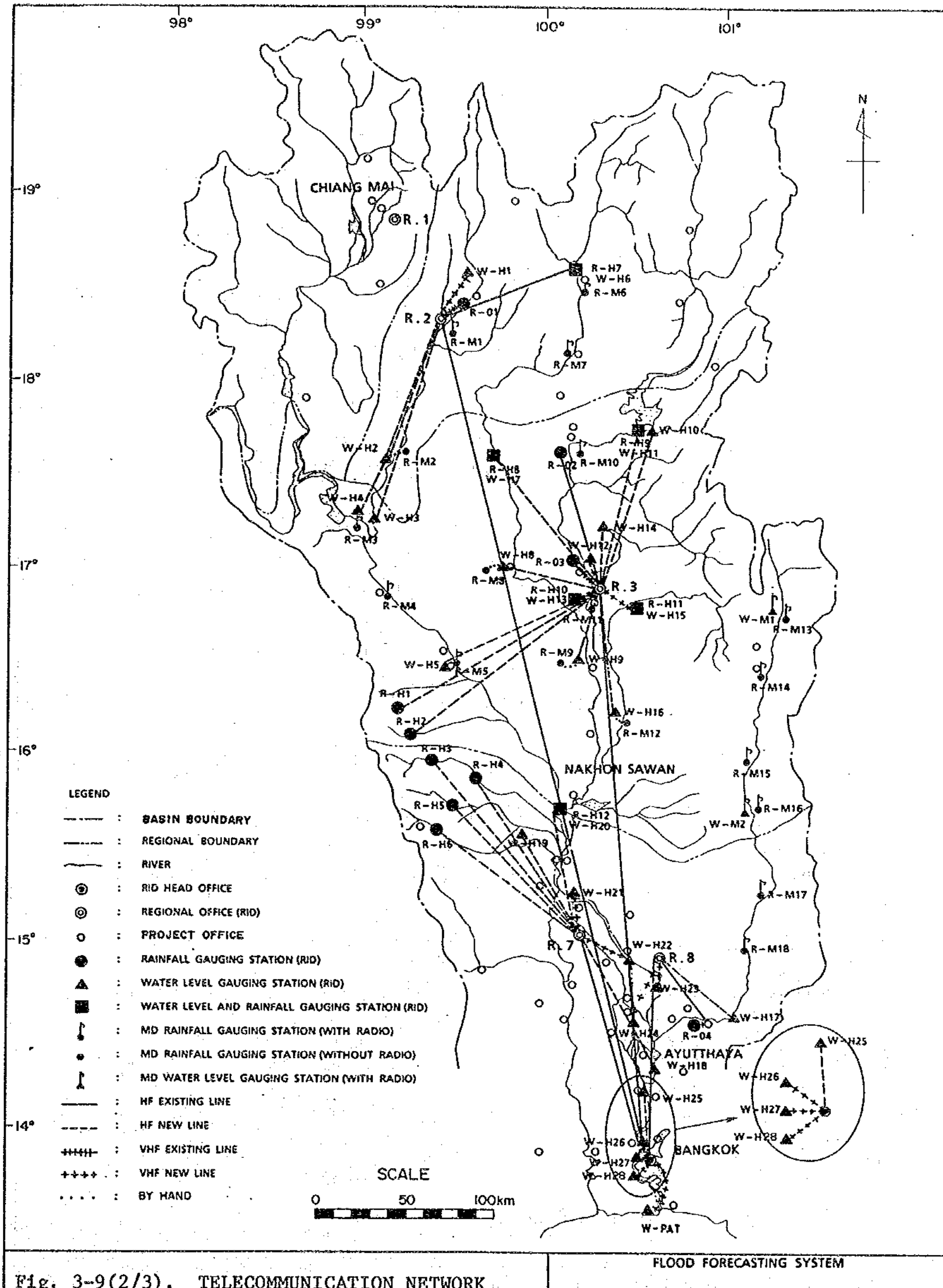


Fig. 3-9(2/3). TELECOMMUNICATION NETWORK (STEP 1: ALTERNATIVE CASE 2)	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY

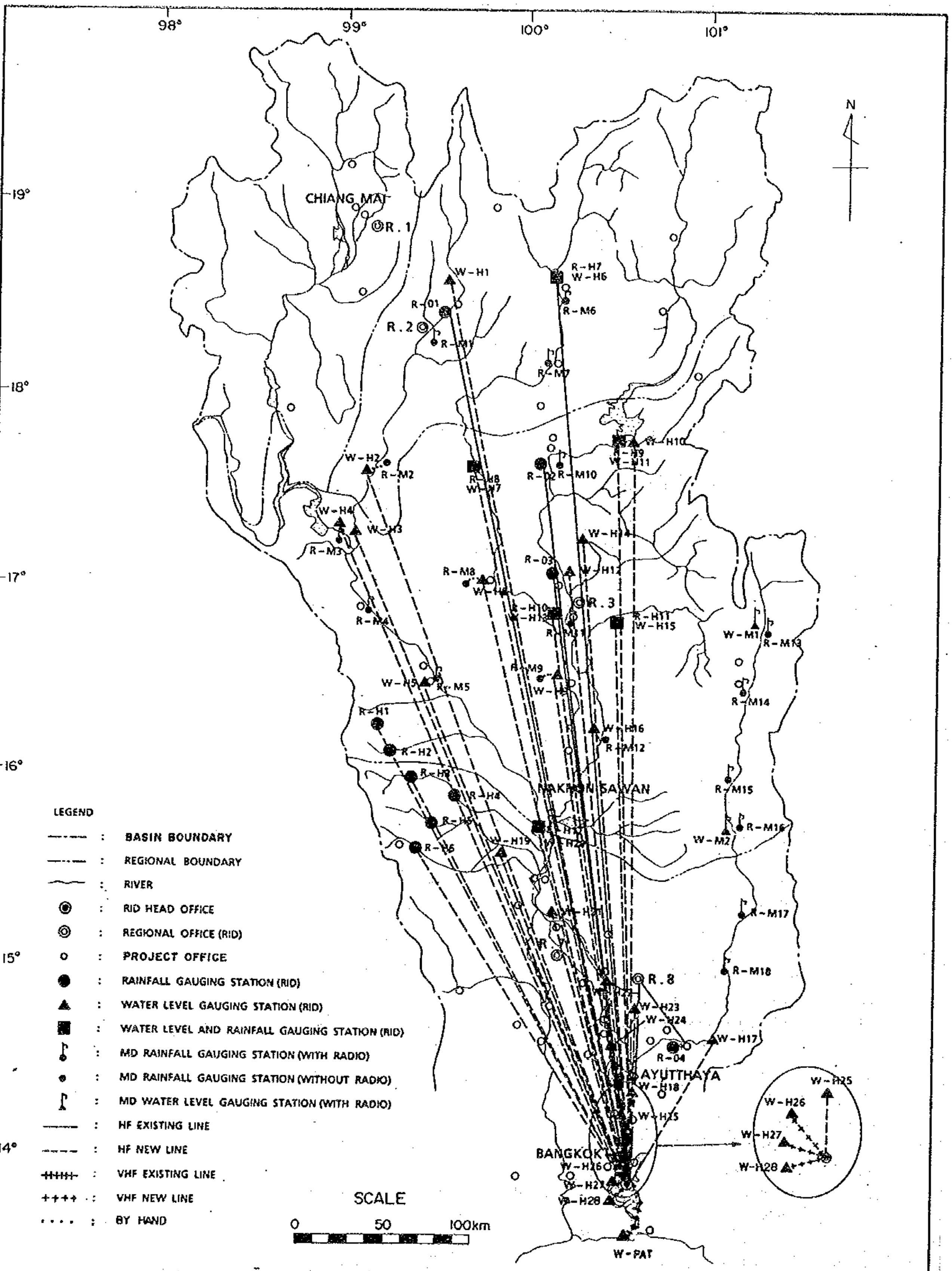


Fig. 3-9(3/3). TELECOMMUNICATION NETWORK (STEP 1: ALTERNATIVE CASE 3)	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN
	JAPAN INTERNATIONAL COOPERATION AGENCY

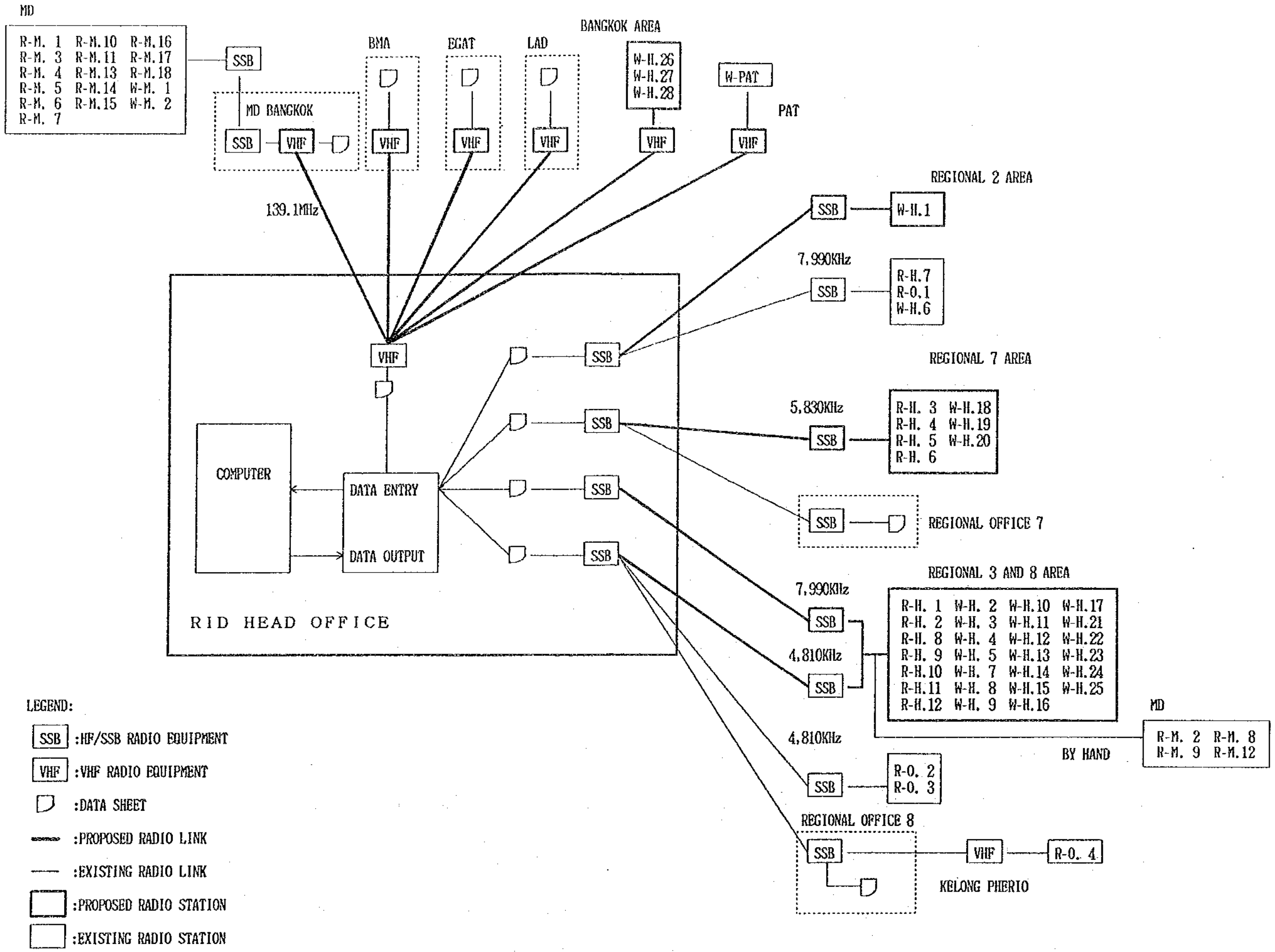


Fig. 3-10. PROPOSED TELECOMMUNICATION NETWORK (Step 1)

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

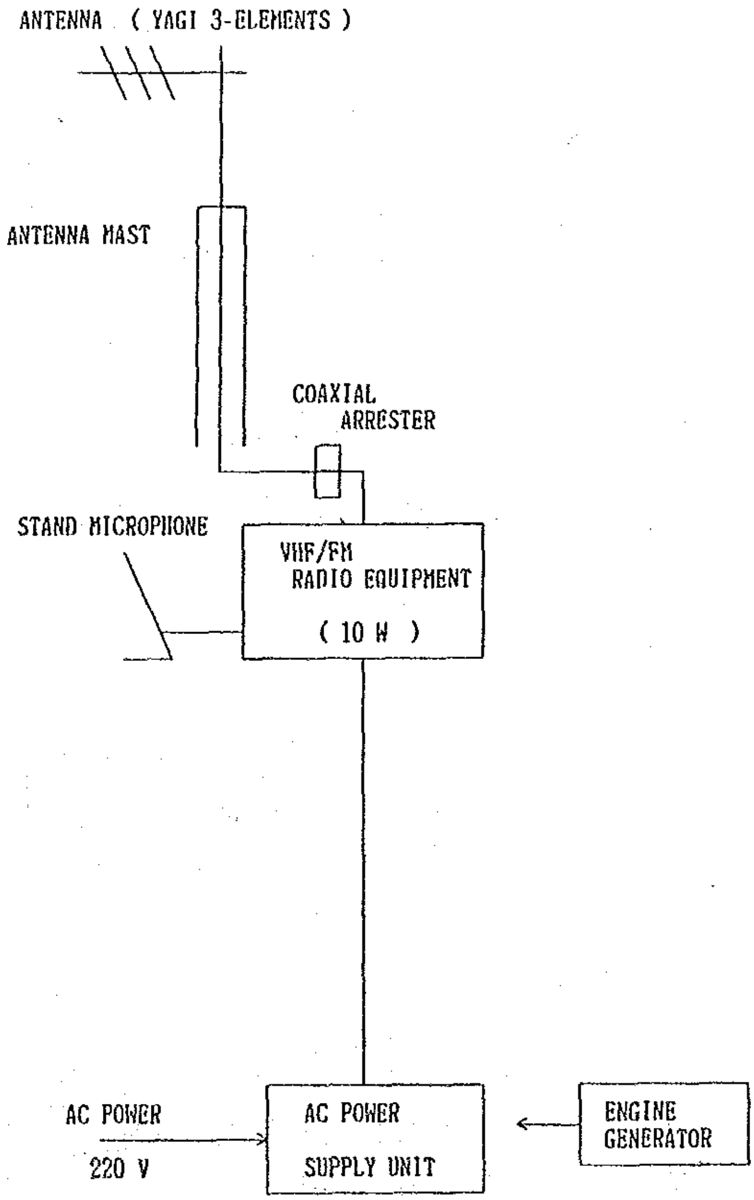


Fig. 3-11. DIAGRAM OF VHF/FM RADIO STATION	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY

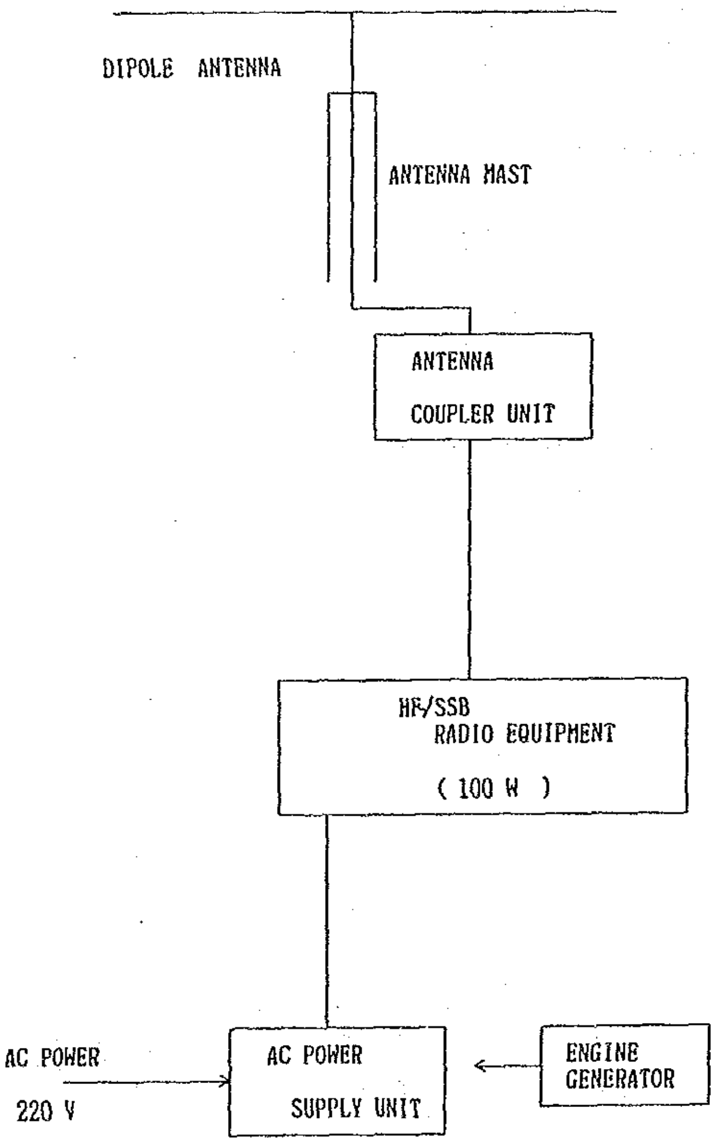


Fig. 3-12. DIAGRAM OF HF/SSB RADIO STATION

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

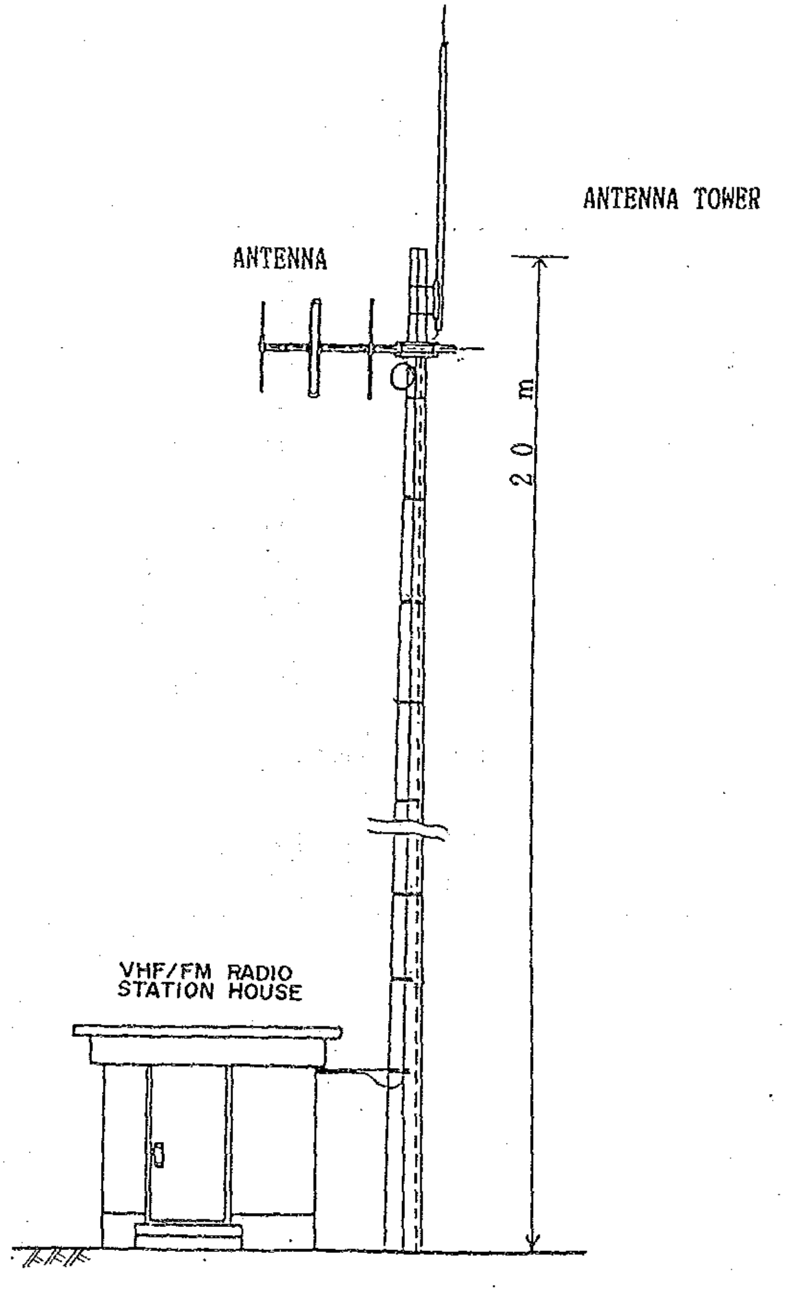


Fig. 3-13. STANDARD DRAWING OF VHF/FM RADIO STATION

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

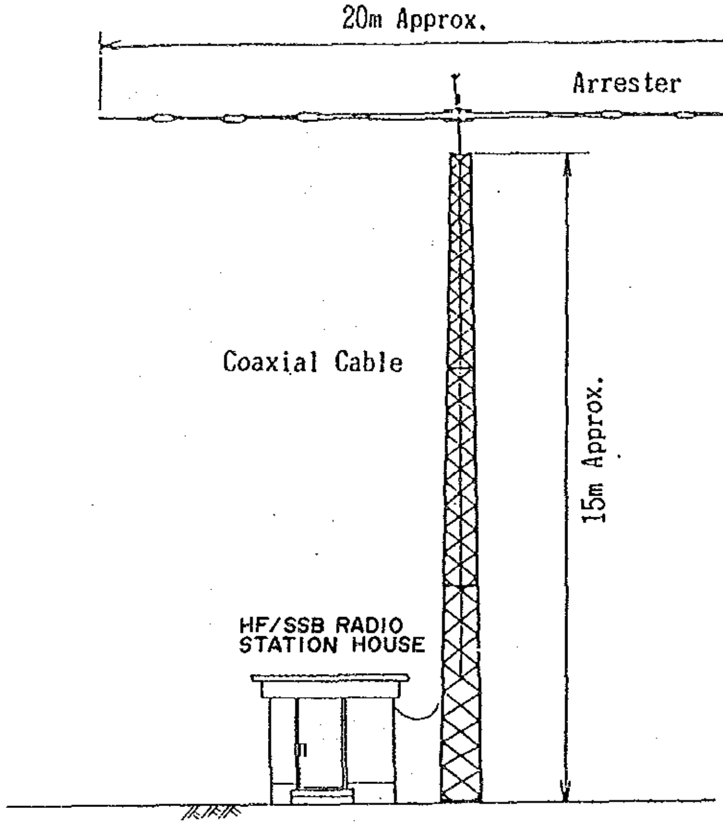


Fig. 3-14. STANDARD DRAWING OF HF/SSB RADIO STATION

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

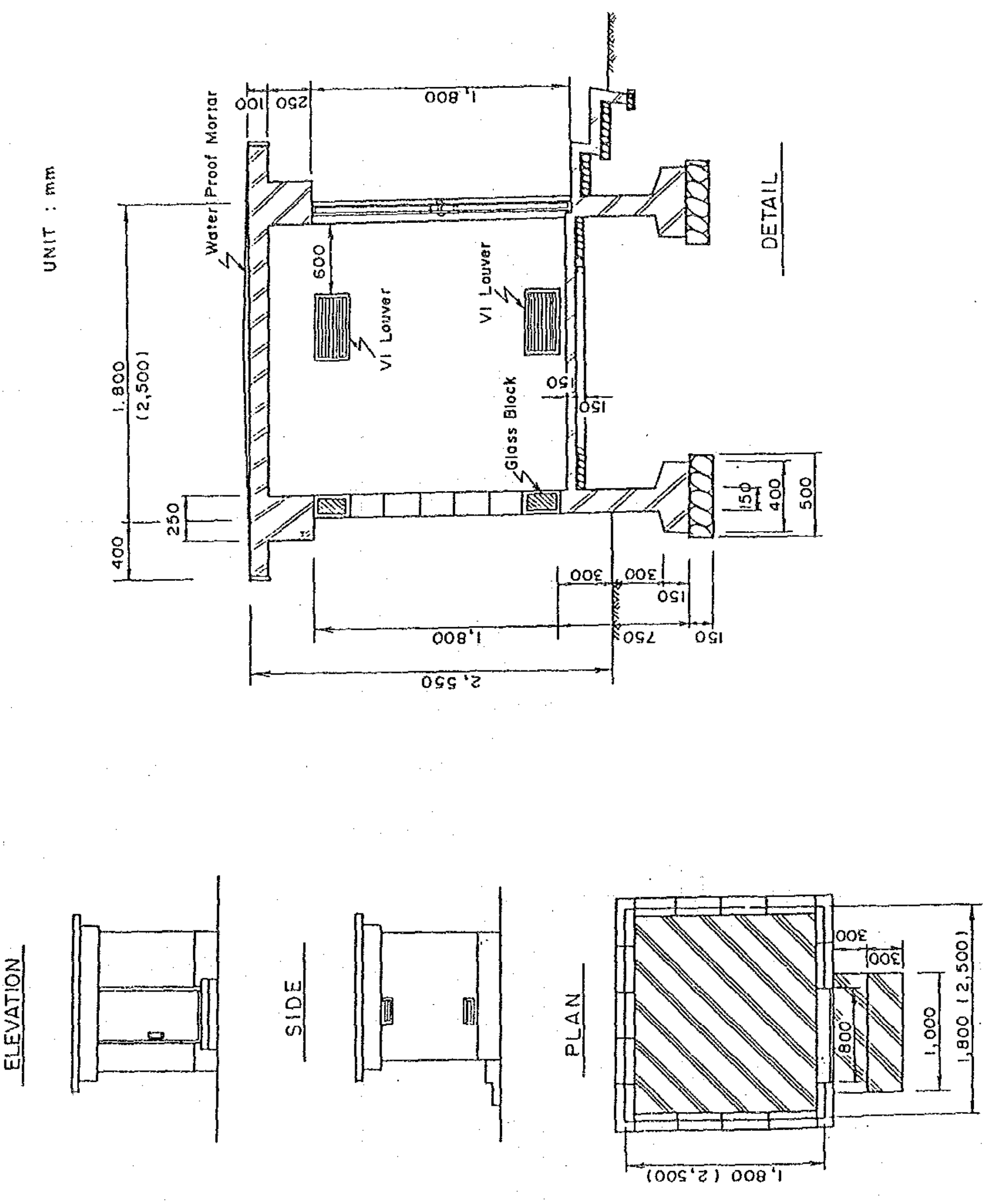


Fig. 3-15. STANDARD DRAWING OF RADIO STATION HOUSING

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

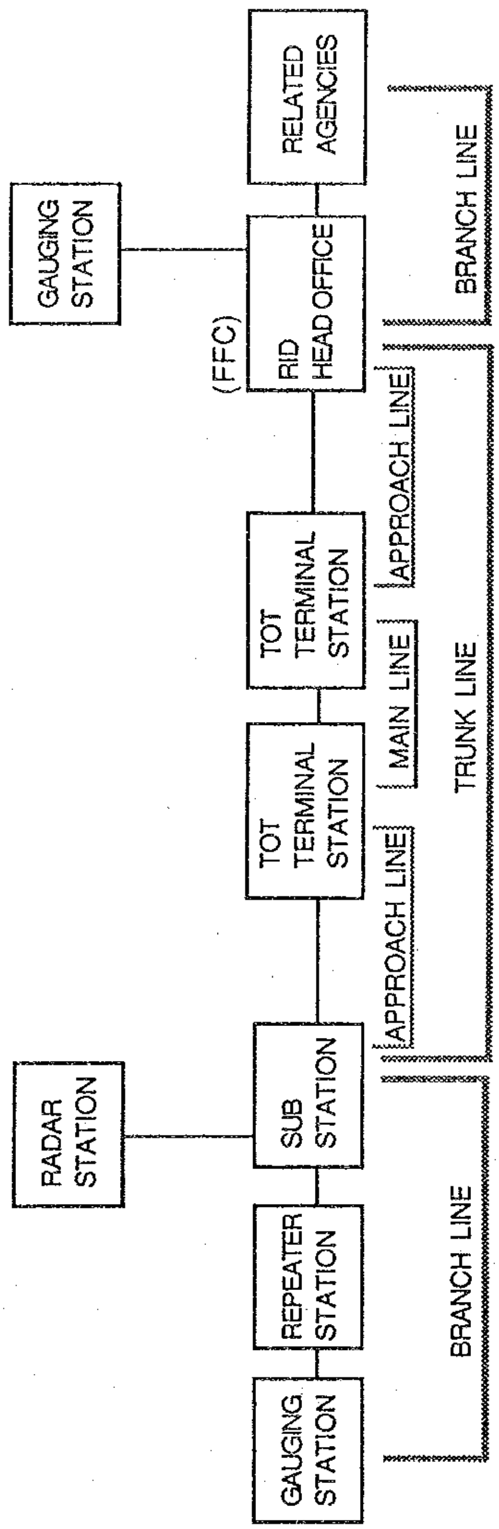


Fig. 3-16. FORMATION OF TELECOMMUNICATION NETWORK

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

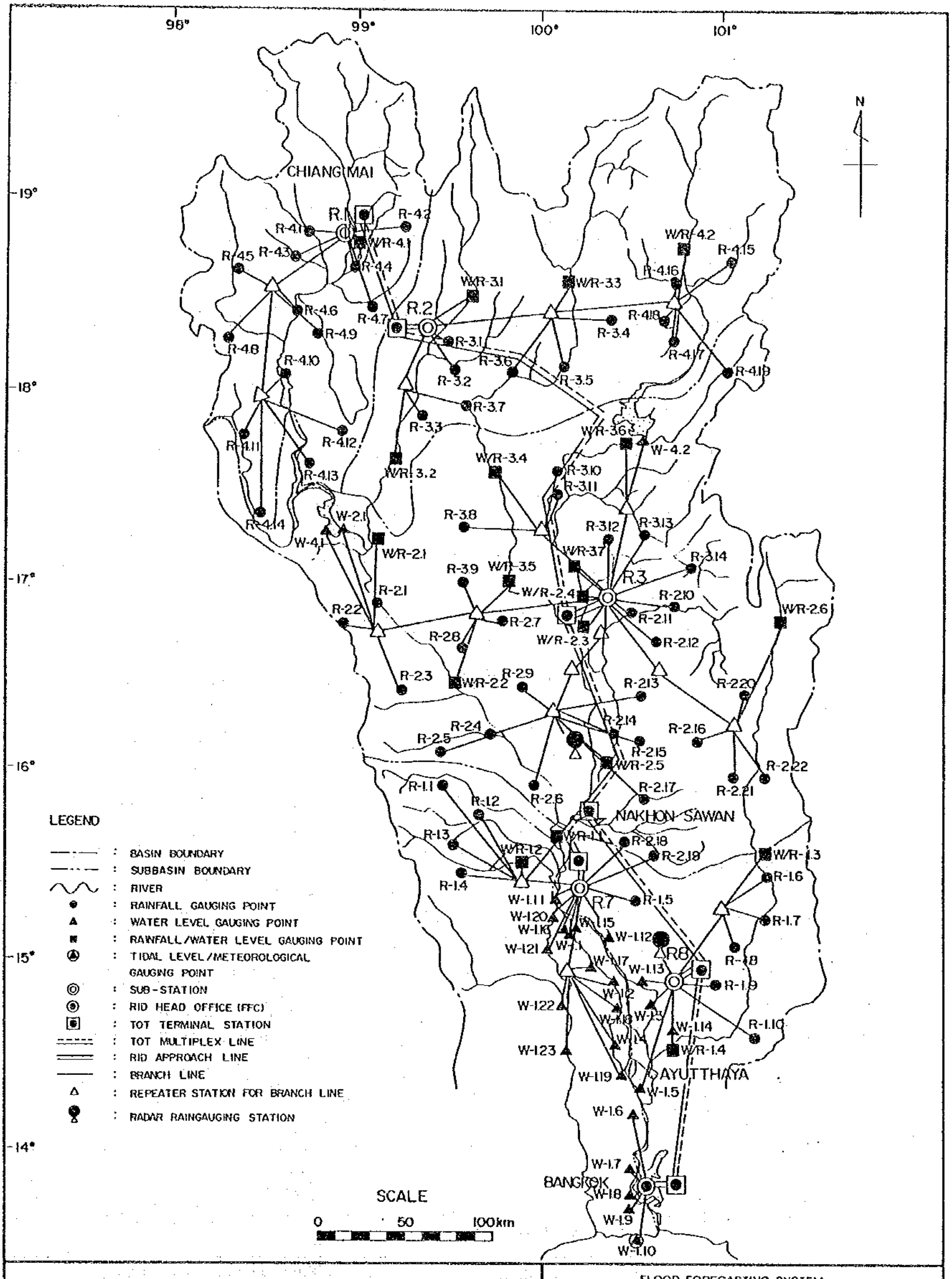


Fig. 3-17(1/4). TELECOMMUNICATION NETWORK (STEP 2: ALTERNATIVE CASE 1)

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

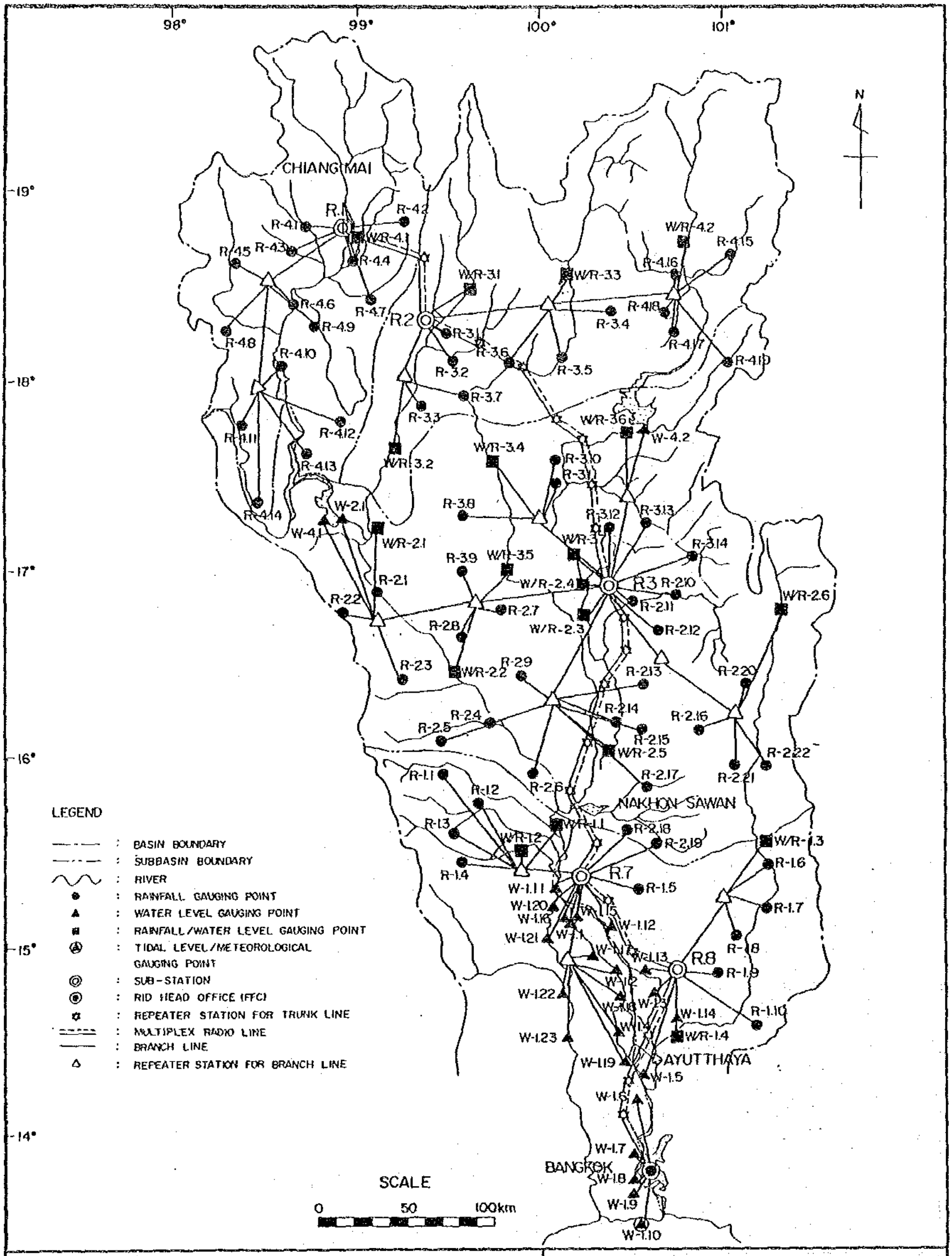


Fig. 3-17(2/4). TELECOMMUNICATION NETWORK (STEP 2: ALTERNATIVE CASE 2)	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY

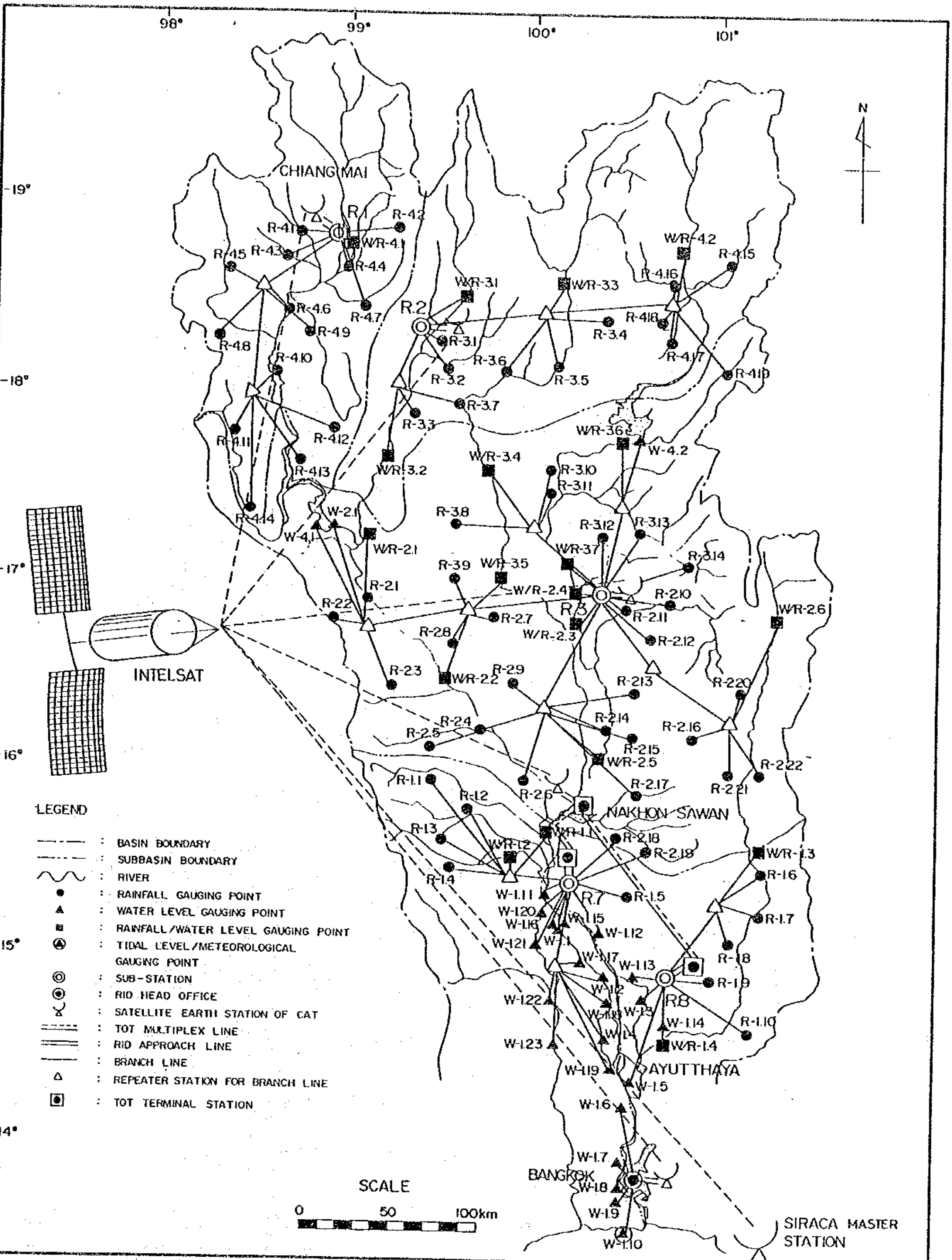


Fig. 3-17(3/4). TELECOMMUNICATION NETWORK (STEP 2: ALTERNATIVE CASE 3)

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

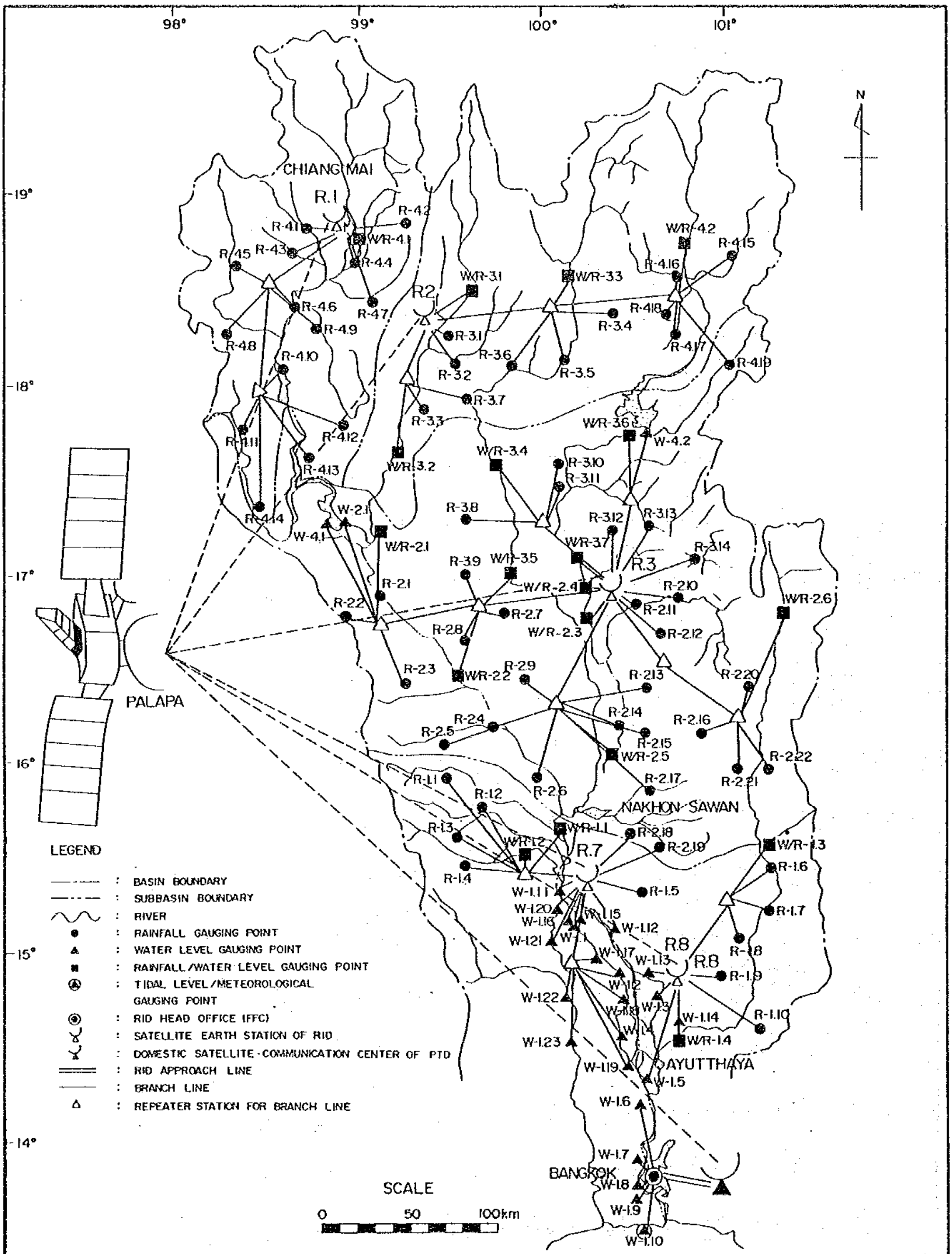


Fig. 3-17(4/4). TELECOMMUNICATION NETWORK (STEP 2: ALTERNATIVE CASE 4)

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY