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THE GOVERNMENT OF THE KINGDOM OF THAILAND

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

EXECUTIVE SUMMARY

JUNE 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

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IN THE CHAO PHRAYA
RIVER BASIN

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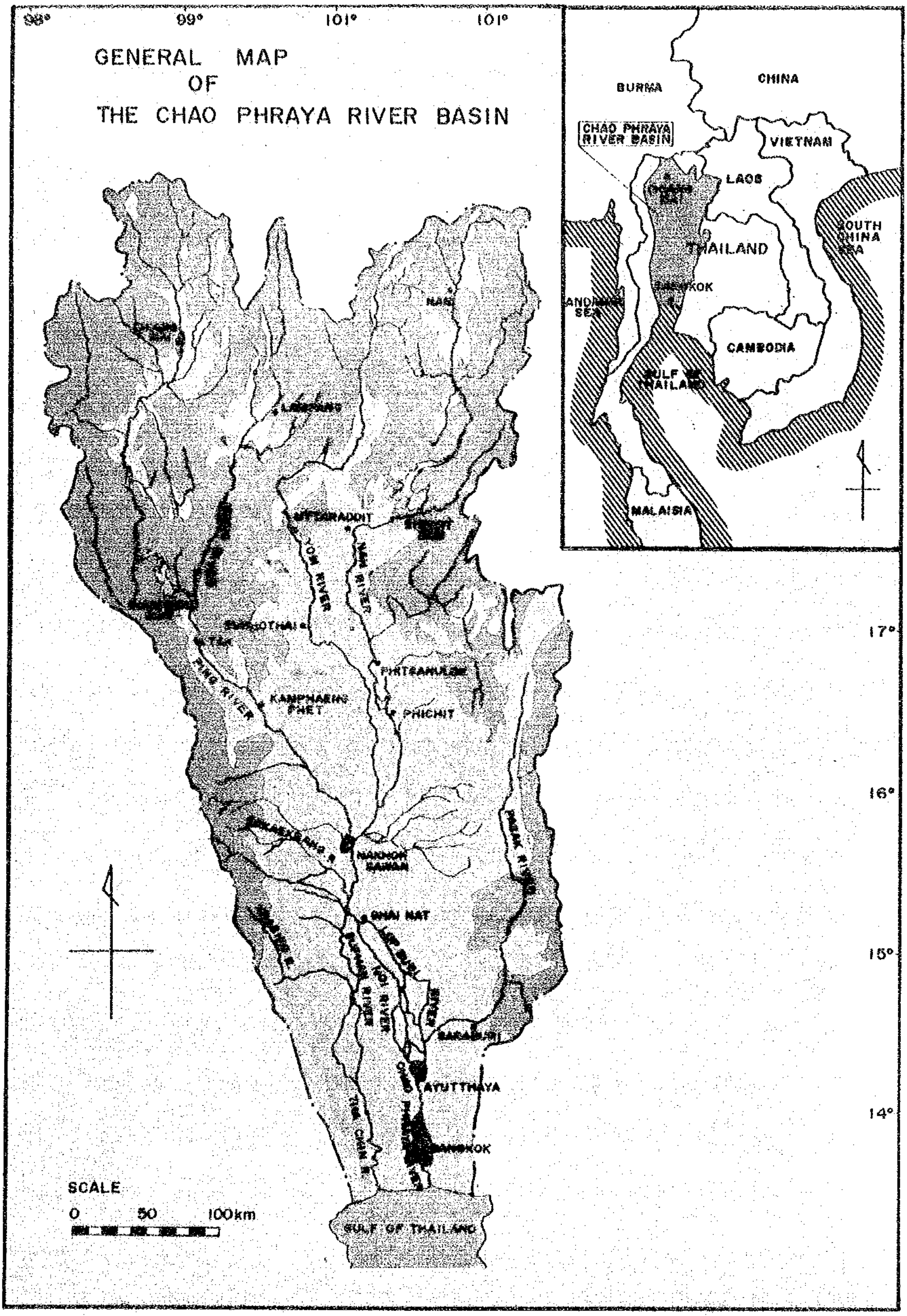
GENERAL MAP
OF
THE CHAO PHRAYA RIVER BASIN
98°
99°
101°
101°
BURMA
CHINA
CHAO PHRAYA
RIVER BASIN
VIETNAM
LAOS
THAILAND
SOUTH
CHINA
SEA
CAMBODIA
MALAISIA
NAN
UTTARADIT
YOM RIVER
NAN RIVER
TAK
PING RIVER
PHITSANULOK
KAMPHAENG
PHET
PHICHIT
NAKHON
SAWAN
CHAI NAT
KOI RIVER
AYUTTHAYA
GULF OF THAILAND
SCALE
0
50
100km
17°
16°
15°
14°

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN

EXECUTIVE SUMMARY

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1. General Description

The Chao Phraya River, which has the catchment area of 162,000 km^2, rises among the northern mountains of the country. It flows through fertile rice fields and after passing through Bangkok Metropolis, pours finally into the Gulf of Thailand.

The basin, particularly the delta in the downstream, has long been enjoying much agricultural production and urban development. However, the massive agricultural and urbanization developments have brought a decrease in the basins's inherent flood retarding capacity, and Bangkok Metropolis experiences serious land subsidence due to excessive groundwater extraction. These circumstances have aggravated the flood damage condition in the basin.

To mitigate flood damage, flood control works such as dam construction, river improvement, diversion channel construction, etc., are essential. However, it will take a long time and require an enormous construction cost to realize a flood control plan due to the large area of the basin. Under this situation, the formulation of a flood forecasting system was requested to cope urgently with the flood damage problem.

2. Objectives of the Study

The study objectives are as follows:

(1) To formulate the flood forecasting system in the following two steps:

Step 1: Flood forecasting system utilizing existing facilities with the introduction of supplemental equipment.

Step 2: Flood forecasting system with updated facilities having high reliability of flood prediction results.

(2) To carry out the preliminary design and cost estimates of the above two systems.

3. Study and Target Areas

3.1 Study Area

Situated in central and northern Thailand, the Chao Phraya River Basin can be divided broadly into two (2) basins at Nakhon Sawan from the aspect of river channel system. These are the mostly mountainous upper reaches covering 70% of the total basin area and the lower reaches consisting of flat land, as shown in the General Map.

Some of the plains scattered in the upper reaches such as Chiang Mai, Sukothai and Phitsanulok have developed into urban areas. The rest is agricultural land which sometimes function as retarding basin during flood time.

In the flat land of the lower reaches, the Chao Phraya River forms a complex watercourse network of diversion channels and canals. A vast agricultural land, as well as the urban areas of Bangkok, Ayutthaya, Chai Nat and others, exists in this flat land area. The agricultural land that is divided into districts by local ring levees, roads, railway lines, etc., also functions as retarding pond for the inland waters in the districts and the flood waters from the main tributaries during flood time. The riverbed gradient of this portion varies between 1/10,000 and 1/50,000.

The Chao Phraya River Basin is located in the tropical monsoon region which has distinct dry and rainy seasons. The annual rainfall in the basin ranges from 1,000 mm in the western area to 1,400 mm in the northeastern area. About 85 percent of the annual rainfall occurs during the rainy season from April to

October and during a tropical cyclone, one day precipitation sometimes exceeds 100 mm. Temperature ranges from 27 to 32°C during the rainy season, while it fluctuates between 20 and 27°C during the dry season.

The river flow discharge shows a seasonal variation in accordance with the aforesaid distinctive precipitation in the rainy and dry seasons. According to the records of the stream gauging station at Nakhon Sawan, the maximum discharge was observed after construction of the Bhumibol and the Sirikit dams, at 4,355 m^3/s in 1975 and at 4,320 m^3/s in 1980. Among the recently recorded floods, those that occurred in 1975, 1978, 1980 and 1983 had inflicted severe damage especially in the downstream. The inundation areas of the 1983 flood are shown in Fig. 1 as an example.

The tidal compartment is regarded approximately until Bang Sai on the Chao Phraya River and the Rama VI Dam on the Pasak River. Mean high water and mean low water spring tides are approximately 2.2 m and -1.8 m above MSL, which are observed at the river mouth.

3.2 Target Areas

The target areas of the study cover the following (refer to Fig. 2):

(1) Bangkok Metropolis and urban areas in Nakhon Sawan, Chai Nat, Sing Buri, Lop Buri, Ang Thong and Ayutthaya; and

(2) The agricultural areas along the Chao Phraya River between Ang Thong and Ayutthaya, and along the Pasak River between Ayutthaya and Rama VI Dam.

Among these areas, top priority for the establishment of a flood forecasting system is given to Bangkok Metropolis in view of its significant economic and political role in Thailand.

4. Step 1 Flood Forecasting System

4.1 Function and Facilities

The Step 1 Flood Forecasting System consists of four works: data collection, data transmission, data management and data dissemination. Utilized for data collection are the existing 31 water level gauging stations that include a tidal gauging station and the 34 rainfall gauging stations located in the lower reaches of Bhumibol Dam and Sirikit Dam (refer to Fig. 3). Most of the gauging stations are managed by RID and the rest by MD and PAT.

As for data transmission, hydrological data observed at gauging stations under RID's Regional Offices are transmitted through RID's Communication Division to RID's O&M Division, and those of MD are collected at its head office in Bangkok by its own telecommunication system. Therefore, the telecommunication network to be newly connected to this system covers the portion between RID's Head Office and (a) the hydrological gauging stations managed by RID's Hydrology Division, for data collection; (b) the head offices of related agencies, for collection of data and/or dissemination of prediction results; and (c) the tidal gauging station of PAT, for data collection.

The telecommunication system to be newly established is by means of the radio line and voice communication that utilizes the VHF and/or the HF/SSB band of the simplex line. The proposed telecommunication network is summarized as follows and illustrated in Fig. 4.

Related Agencies	Portions of Network: Gauging Station =====	Head Office of Related Agency ======	Head Office of RID
MD	HF/SSB*	VHF**	Data collection /2
PAT	HF/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.

For the management of data concerned, such as rainfall, water level, flood damage, etc., the system is equipped with functions such as data filing and processing by manual operation, flood prediction, hydrological analysis, and displaying computation results. The required equipment for this system is the engineering work station (EWS) and its peripherals such as data storage equipment, printer, color hard copy unit and video projector.

The flood prediction results consist of the daily and the hourly water stages during flood prediction time at the flood prediction points. Aside from RID's Regional Office Nos. 7 and 8, the information will be disseminated daily to the related government agencies such as LAD, BMA and EGAT.

4.2 Justification of the Proposed System

The Step 1 Flood Forecasting System can perform short term flood prediction 5.3 days in advance, which is the minimum time necessary for the flood forecasting works such as processing of predicted flood water level and flood fighting. The accuracy of the short term flood prediction results is not so high, with errors ranging approximately from 10 cm to 30 cm; however, flood prediction by the system is practically feasible. The maximum error of 30 cm occurred in the prediction for Sathu Pradit on October 21, 1978.

4.3 Implementation Schedule

The flood forecasting system can be broadly classified into two phases, namely, installation of flood forecasting system and development of the system. The total implementation time required for the proposed project is 36 months, as shown in Fig. 5.

The establishment of the flood forecasting system, which includes detailed design, pre-construction, construction/ installation, preparation of operation and maintenance manual, and flood prediction programming, will require 12 months.

The development of the system including training of the staff concerned will further require 24 months. This development phase shall cover calibration and modification of flood prediction models, on-the-job training and overseas training.

4.4 Cost Estimates

The total cost of the proposed system is estimated at US$2,786,000 composed of the cost of establishment of the system and the cost of developing it amounting to US$1,731,000 and US$1,055,000, respectively. (Refer to Table 1.)

5. Step 2 Flood Forecasting System

5.1 Function and Facilities

Since it may take quite a long time to establish the system with updated facilities that will cover the whole basin, the project is proposed to be executed stepwisely in accordance with the priority of the target area.

Rainfall data collection shall be undertaken by gauging measures which are roughly classified into two types, i.e., the point rainfall gauge type and the radar gauge type. The point rainfall gauging network shall be primarily established prior to the radar gauge network. Succeedingly, the radar gauge network will be installed to supplement the accuracy of areal annual rainfall estimation, subject to the real-time calibration of point rainfall gauges.

Eighty-four (84) point rainfall gauging stations shall be installed all over the whole basin of the Chao Phraya River. Two (2) radar gauge stations shall be installed at approximately 14°40'N latitude and 100°30'E longitude (south of Lop Buri) and at 16°15'N latitude and 100°15'E longitude (near Taphan Hin) to grasp the rainfall condition over the downstream area.

Forty-five (45) water level gauging stations including a tidal gauging station shall also be set up in this system. The installation of gauging stations is divided into five stages in accordance with the priority of the target area and the work volume, as shown in Table 2 and in Figs. 6 to 7.

For data transmission and communication, the facilities for the flood forecasting system shall include the following:

(a) Radio transmission link for exclusive use to assure reliability and speed of data transmission;

(b) On-line system with character transmission for data transmission to prevent occurrence of errors due to manual intervention; and

(c) Off-line system with voice communication for easier communication of comments and instructions.

The telecommunication network for Step 2 Flood Forecasting System is composed of trunk lines and branch lines. The trunk lines, which will utilize the TOT UHF microwave line, shall be provided between the Flood Forecasting Center (FFC) at the RID Head Office and the substations in RID's Regional Offices. To connect the substation and FFC to the terminal station of TOT, an approach line with no exchanger will be installed.

The branch lines between the substations and the gauging stations will be newly installed in this system, utilizing the VHF band of the simplex line. The branch line between FFC and the related agencies is newly installed as well, utilizing the UHF microwave band. The proposed telecommunication network is illustrated in Fig. 8.

Regarding data management, the functions reinforced from those of Step 1 Flood Forecasting System are real-time data filing and processing, real-time flood prediction, displaying visual information, and monitoring basin conditions. The composition of the required facilities for this system is the same as that of Step 1, but the capacity and quality of some of the facilities such as the EWS and the display equipment are upgraded.

5.2 Justification of the Proposed System

The short term prediction time required for the Step 2 Flood Forecasting System is assumed to be 3 days for flood mitigation. The 3-day prediction will minimize errors to less than 20 cm on all prediction points.

As for the long term prediction time, 10-day prediction for Bangkok Metropolis and 6-day prediction for other target areas are the maximum prediction times estimated on the basis of the flood lag time. Errors of the 10-day and 6-day predictions are also within 20 cm, except in the prediction at Memorial Bridge in the 1983 flood where the error is 30 cm.

Under the above circumstances, flood prediction by the Step 2 Flood Forecasting System is also practically feasible.

5.3 Implementation Schedule

The required implementation period for this system is 11 years. This consists of 1.5 years for the integrated study, 1.5 years for the acquisition of necessary funds, 0.5 year for the procurement of consultant, 2.0 years for the detailed design, 0.5 year for the pre-construction, and 5.0 years for the construction of facilities and installation of equipment. (Refer to Fig. 9.)

As for the construction and installation, the works shall be implemented in five phases according to the priority of the target areas in consideration of the large work volume. The required period for each phase of construction/installation works is estimated at 12 months, which include the period of 8.0 months for the procurement of equipment, 8.0 months for the construction of civil works, and 4.0 months for the installation and adjustment of equipment.

5.4 Cost Estimates

The total cost of the proposed Step 2 system is estimated at US$55,947,500 consisting of US$3,882,800 for Detailed Design, US$11,582,000 for Phase 1 Works, US$5,249,500 for Phase 2 Works, US$5,212,400 for Phase 3 Works, US$5,222,500 for Phase 4 Works, and US$24,798,300 for Phase 5 Works. (Refer to Table 3.)

6. Socio-Economic Impact

The Chao Phraya River and its tributaries have caused serious flood damage in the past to immovable and movable properties, business activities and traffic. With the flood forecasting system, hydrological data covering the vast area of the Chao Phraya River Basin are collected and processed in a more precise manner with a longer quantity and a higher quality. It will practically be possible to predict flood discharge and water stage at target points, and based on such prediction, damage caused by flood is expected to be remarkably reduced.

In addition to the above damage mitigation, the proposed telecommunication network for Step 2 Flood Forecasting System can be utilized for common administration and communication in a more expeditious manner.

7. Recommendation

(a) In this study, the Step 2 Flood Forecasting System is formulated in a manner of master plan study stage for the installation of updated facilities. Since the study on water management system where some of the facilities will be utilized in common with the flood forecasting system is still under way, adjustment between both studies may be finally necessary. In this connection, it is recommended that further study of this flood forecasting system be commenced as early as possible after completion of the water management system study.

(b) To cope urgently with the flooding problems, a flood forecasting system utilizing the existing facilities is formulated as the Step 1 system. This system can directly proceed to the detailed design and construction phase and it requires only one (1) year for it to be established, though its effectiveness is not so high compared with Step 2.

Aside from promoting the study on the Step 2 system, it is recommended that the Step 1 system be executed with the least lapse of time to fulfill the objectives of flood forecasting until the Step 2 system is established.

Table 1. TOTAL COST OF THE PROPOSED SYSTEM (STEP 1)

Cost Item	Amount (US$)
Establishment of the System	
Telecommunication Facilities	960,360
Data Management Facilities	203,120
Engineering Services	179,300
- Local Engineers (19 M/M)	
- Foreign Engineers (4 M/M)	
Programming of Flood Prediction Model Including Preparation of O&M Manual	231,000
Sub-Total	1,573,780
Contingency	157,220
Total	1,731,000
Development of the System	
Calibration/Modification of the Flood Prediction Model	805,200
- Local Engineer (12 M/M)	
- Foreign Engineers (24 M/M)	
Training	154,000
Sub-Total	959,200
Contingency	95,800
Total	1,055,000
Grand Total	2,786,000

Note: US$1.00 = 25.5 Baht = ¥130 (1987 December)

Table 2. INSTALLATION PRIORITY OF GAUGING STATIONS (STEP 2)

Priority	Gauging Purpose	Coverage of Gauging Network to be Expanded	Number of Gauging Station			
			Water Level Gauging Station	Water Level/ Rainfall Gauging Station	Rainfall Gauging Station	Radar Gauging Station
1.	(1) Short Term Prediction for target areas except Nakhon Sawan	(1) Chao Phraya River Basin upto Nakhon Sawan (Sta. C2) including Sake Krang River Basin (2) Pasak River Basin upto Wichian Buri	23	4	10	0
2.	(1) Long Term Prediction for target areas except Nakhon Sawan (2) Short Term Prediction for Nakhon Sawan	(1) Ping River Basin upto Bhumibol Dam (Stas. P12 and W4A) (2) Yom River Basin upto Sam Ngam (Sta. Y17) (3) Nan River Basin upto Phitsanulok (Sta. N5A) (4) Pasak River Basin upto Lop Buri	1	6	22	0
3.	(1) Long Term Prediction for all target areas	(1) Wang River Basin upto Chae Hom (Sta. W10A) (2) Yom River Basin upto Ngao Sak (Sta. Y20) (3) Nan River Basin upto Sirikit Dam (Sta. N12A)	0	7	14	0
4.	(1) Long Term Prediction for all target areas (2) Flood mitigation effect for respective target areas through effective use of potential flood control functions attached to Bhumibol and Sirikit Dam.	(1) Catchment area of Bhumibol Dam upto Chiang Mai (Sta. P1) (2) Catchment area of Sirikit Dam upto Nan (Sta. N1)	2	2	19	0
5.	(1) Facilitating the rainfall prediction measures (2) Improving the accuracy of areal average rainfall estimated from the point rainfall gauging data	(1) Most of Pasak and Sakae Krang River (2) Lower reaches of Ping, Yom and Nan River Basin	0	0	0	2

Note: "Short Term Prediction" is proposed to be done 3 days in advance, while "Long Term Prediction" is to be done 6 to 10 days in advance.

Table 3. TOTAL COST OF THE PROPOSED SYSTEM (STEP 2)

Cost Item	Amount (US$)
1. Telecommunication Facilities	
Gauging Station	16,954,700
Substation	4,544,600
TOT Terminal Station	813,000
Flood Forecasting Center	5,291,700
Related Agencies	330,000
Sub-Total	27,934,000
2. Data Management and Dissemination Facilities	
Substation	101,000
Flood Forecasting Center	1,034,800
Related Agencies	123,900
Sub-Total	1,259,700
3. Engineering Services	
Detailed Design	3,134,800
Construction Supervision	5,634,500
Development of the System	1,422,000
Sub-Total	10,191,300
4. Training	600,000
Total of 1 to 4	39,985,000
5. Physical Contingency	3,998,500
Total of 1 to 5	43,983,500
6. Price Contingency	11,964,000
Grand Total	55,947,500

Note: US$1.00 = 25.5 Baht = ¥130 (1987 December)

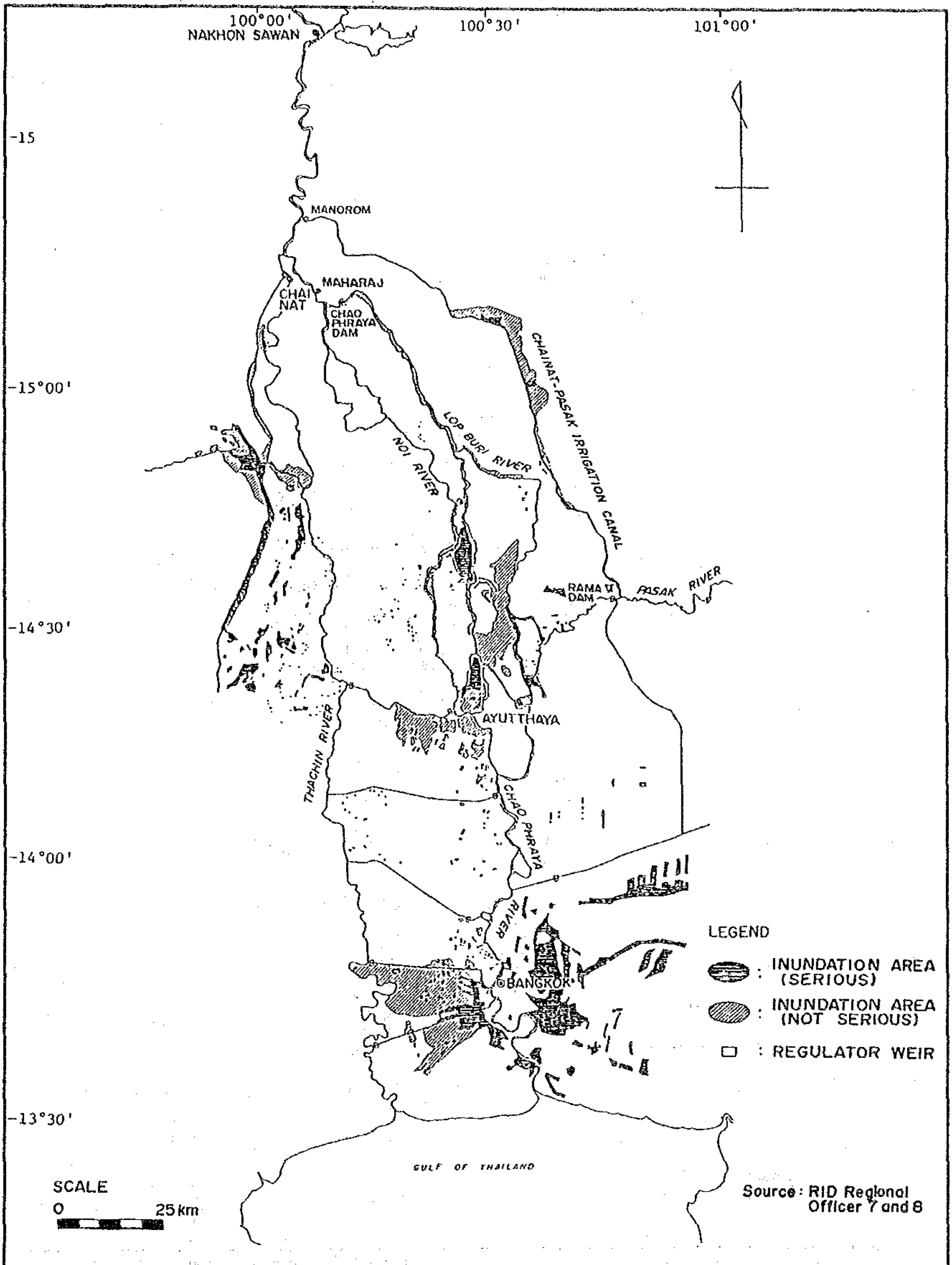

Fig. 1. FLOOD INUNDATION AREA (1983 FLOOD)	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN
	JAPAN INTERNATIONAL COOPERATION AGENCY

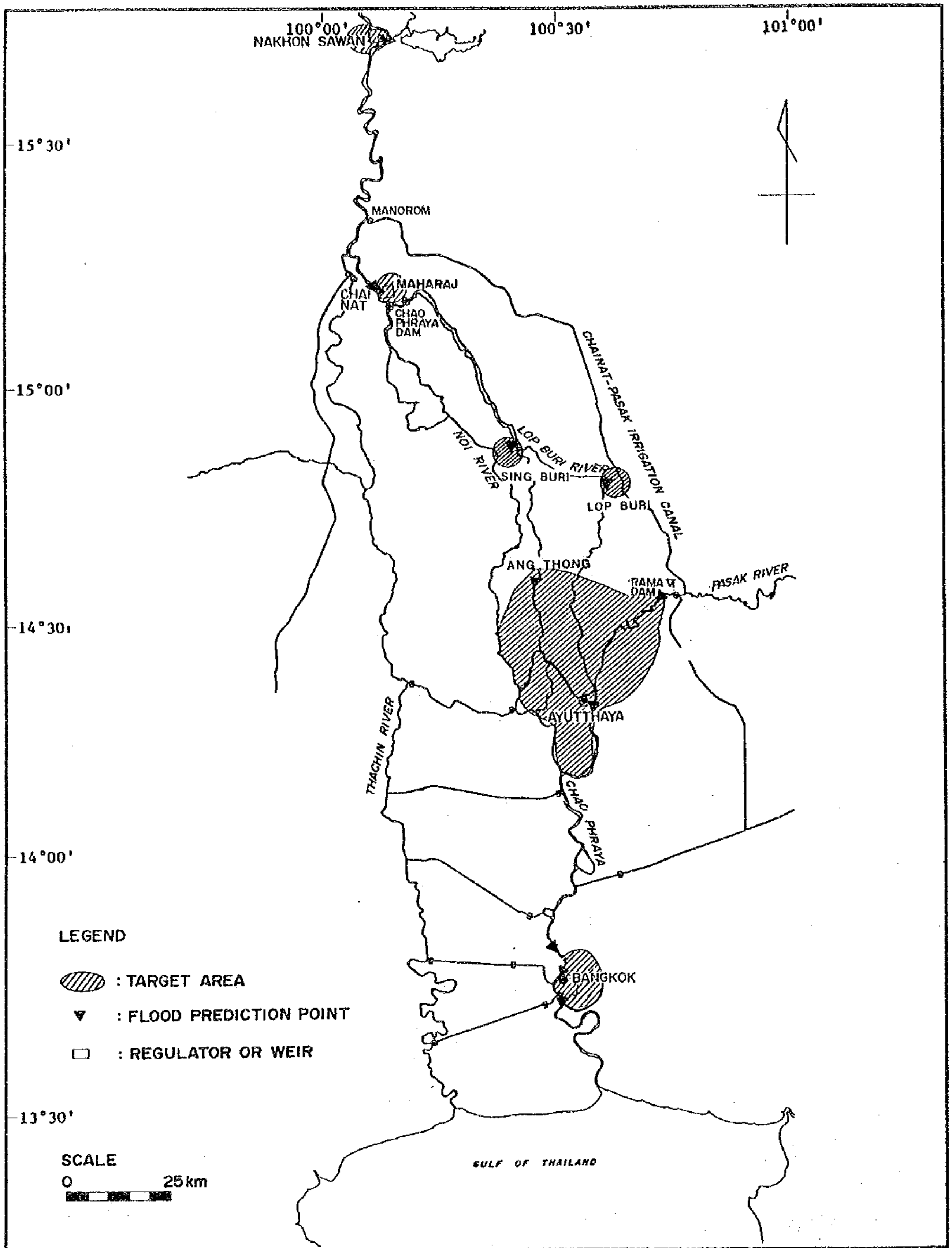

Fig. 2. TARGET AREA AND FLOOD PREDICTION POINT	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY

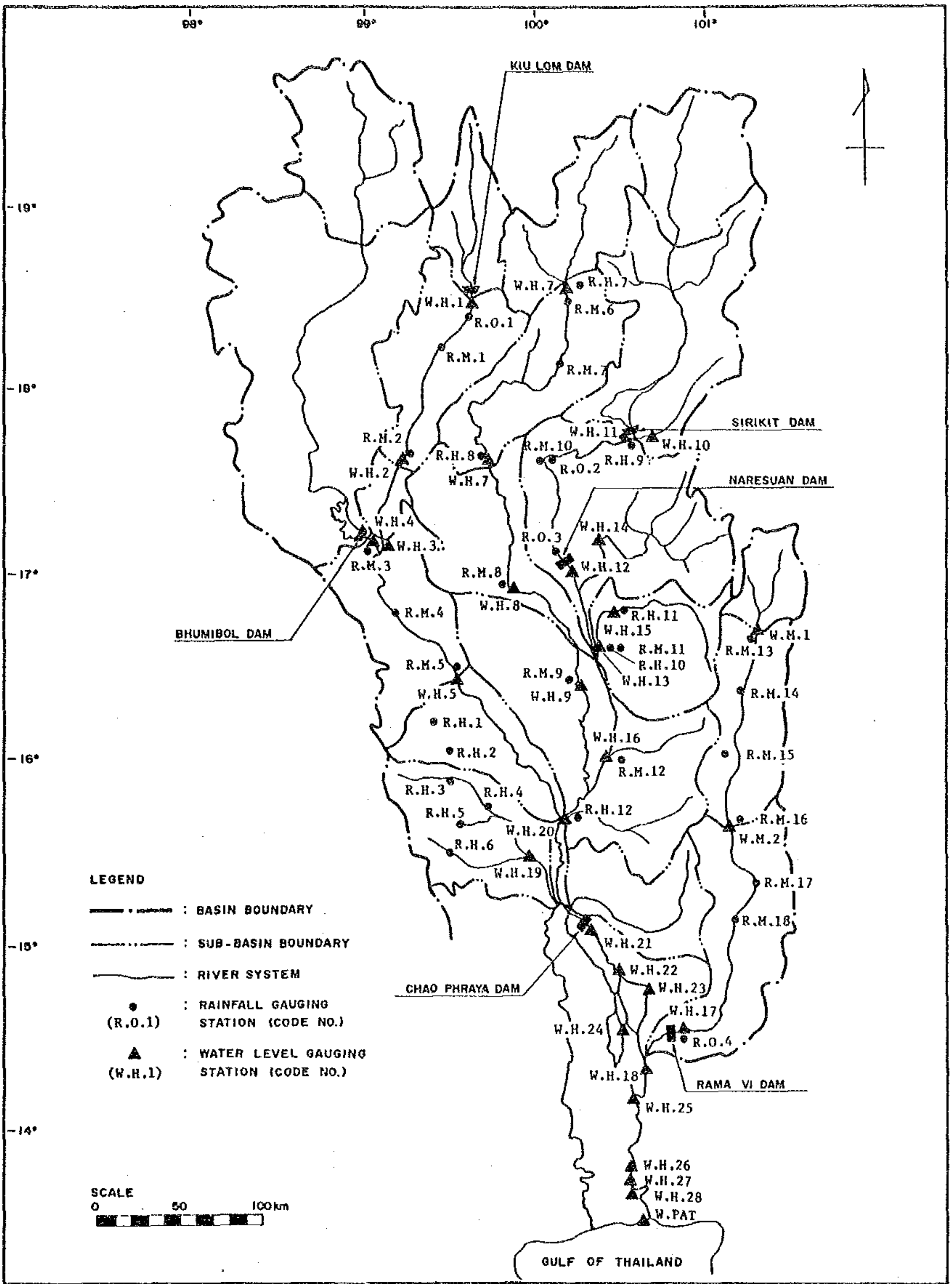

Fig. 3. PROPOSED GAUGING STATIONS (STEP 1)

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

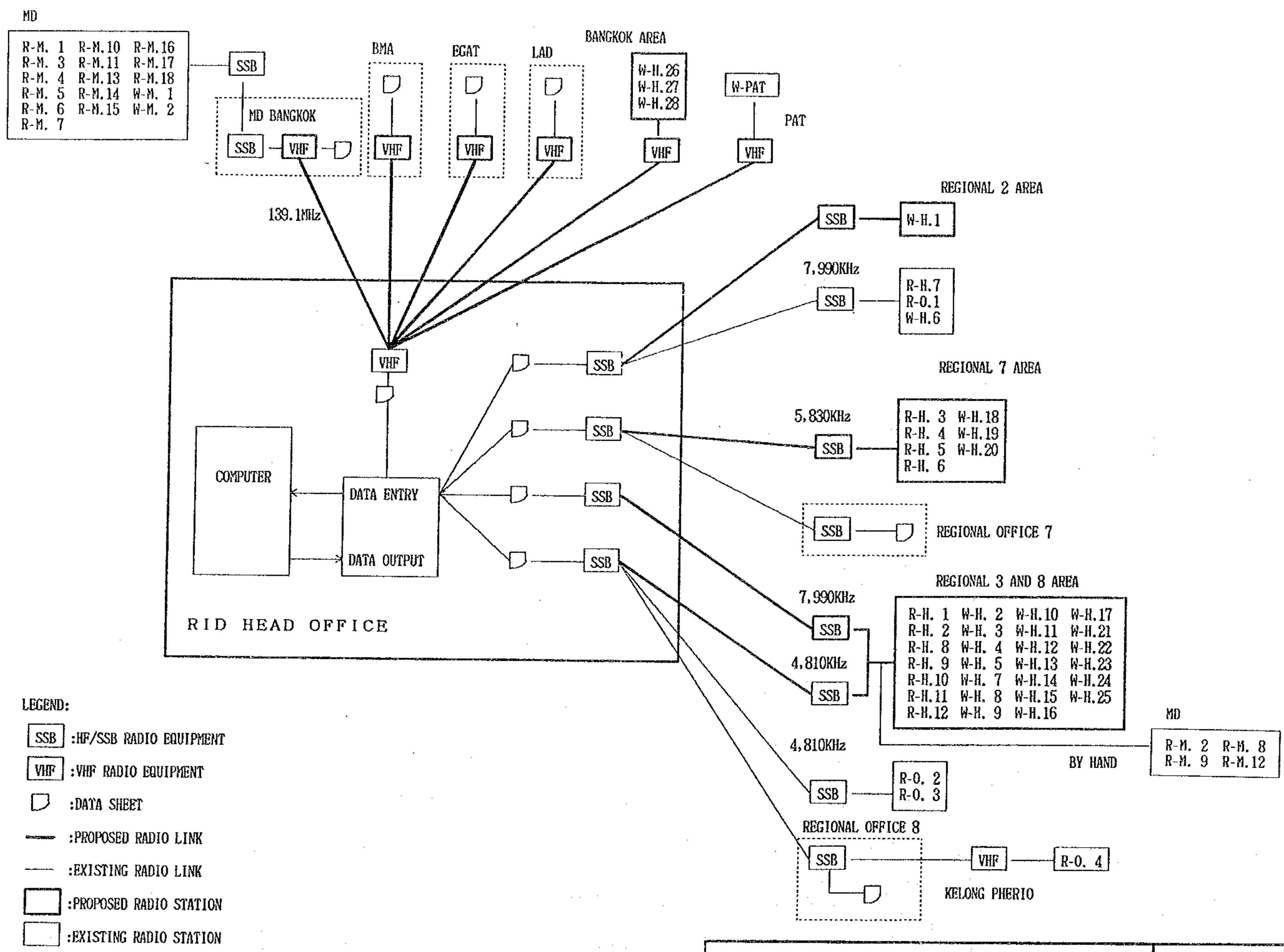

Fig. 4. PROPOSED TELECOMMUNICATION NETWORK (STEP 1)

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

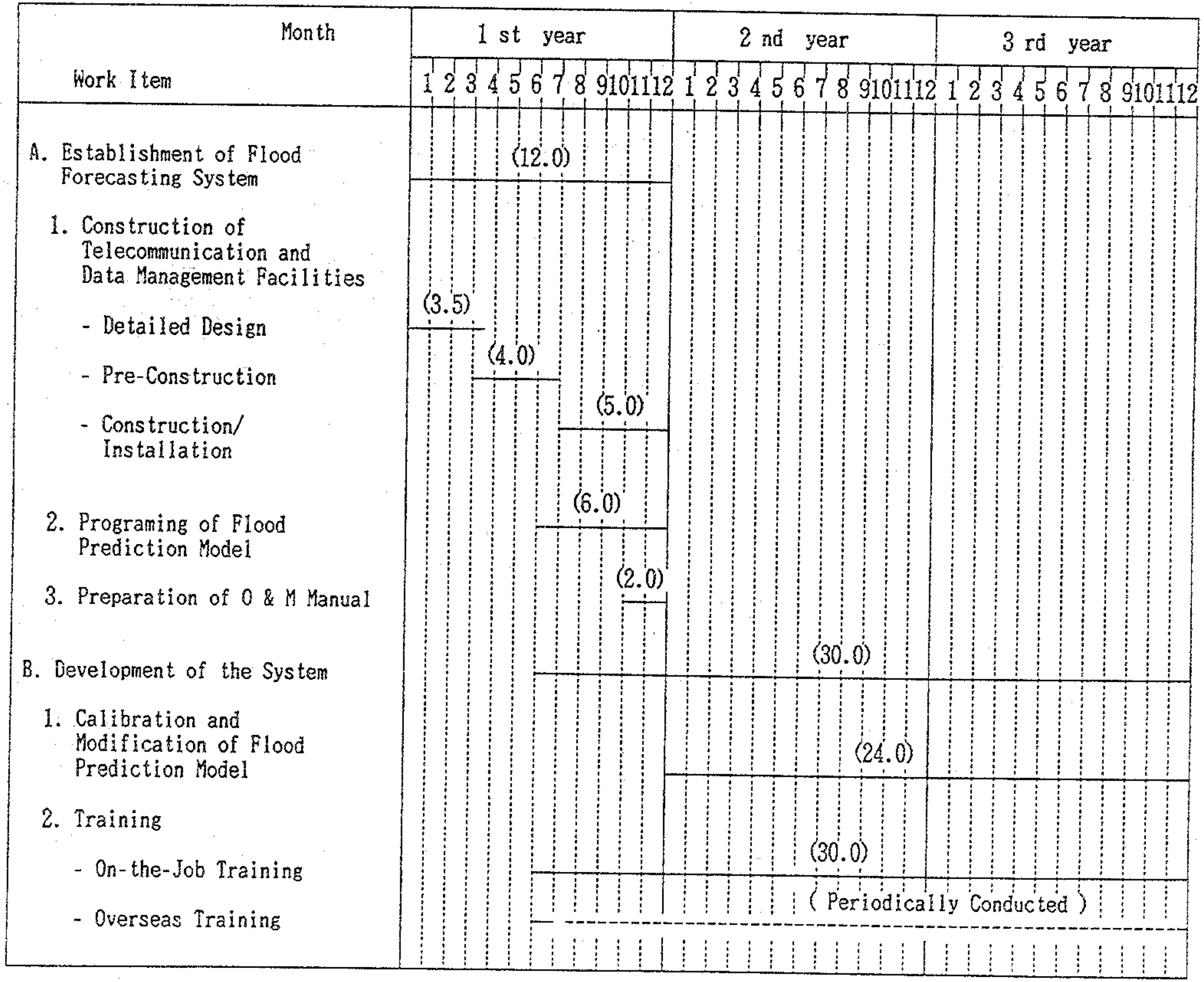

Fig. 5. IMPLEMENTATION SCHEDULE (STEP 1)

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

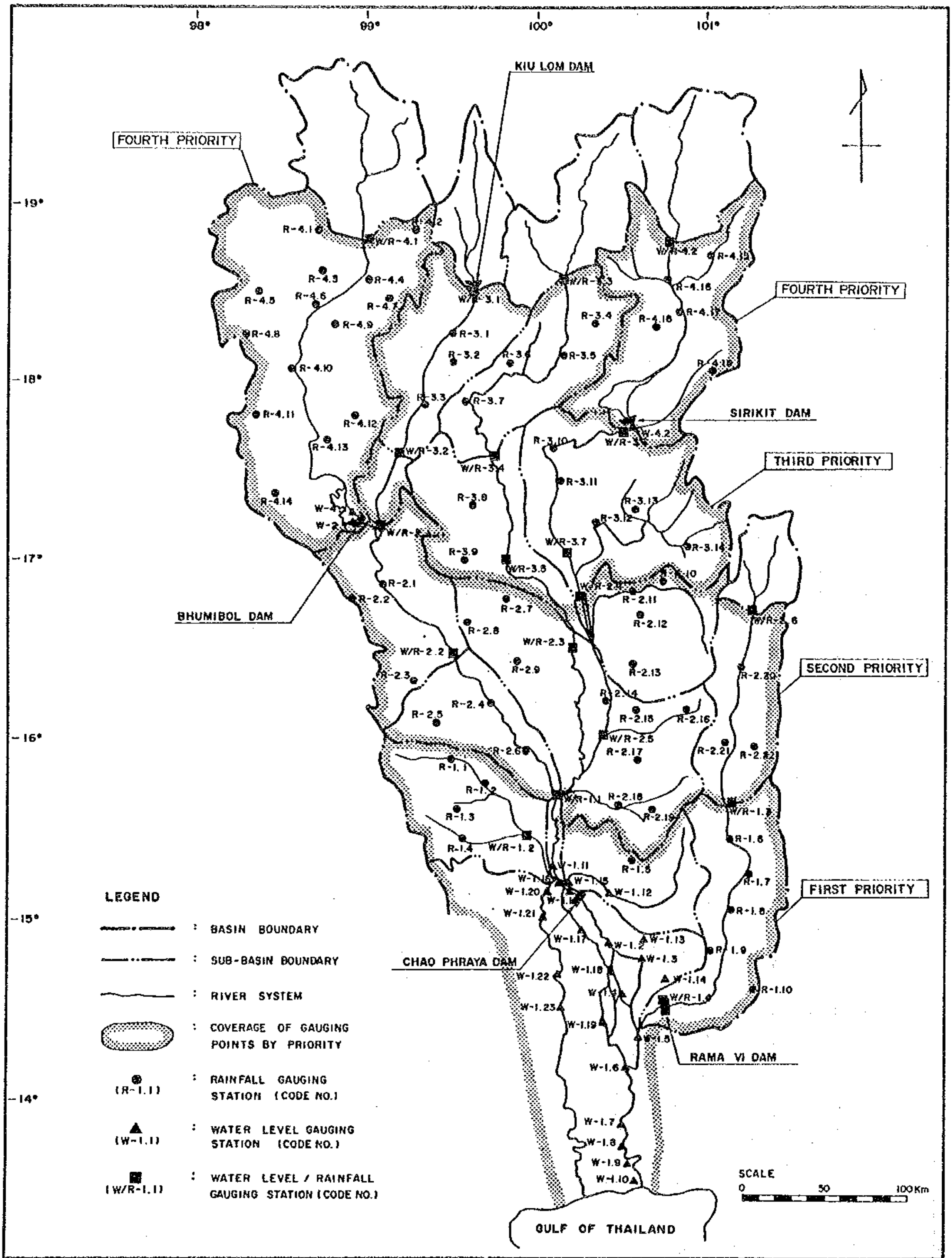

Fig. 6. PROPOSED POINT GAUGING STATIONS (STEP 2: FIRST TO FOURTH INSTALLATION PRIORITY)	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY

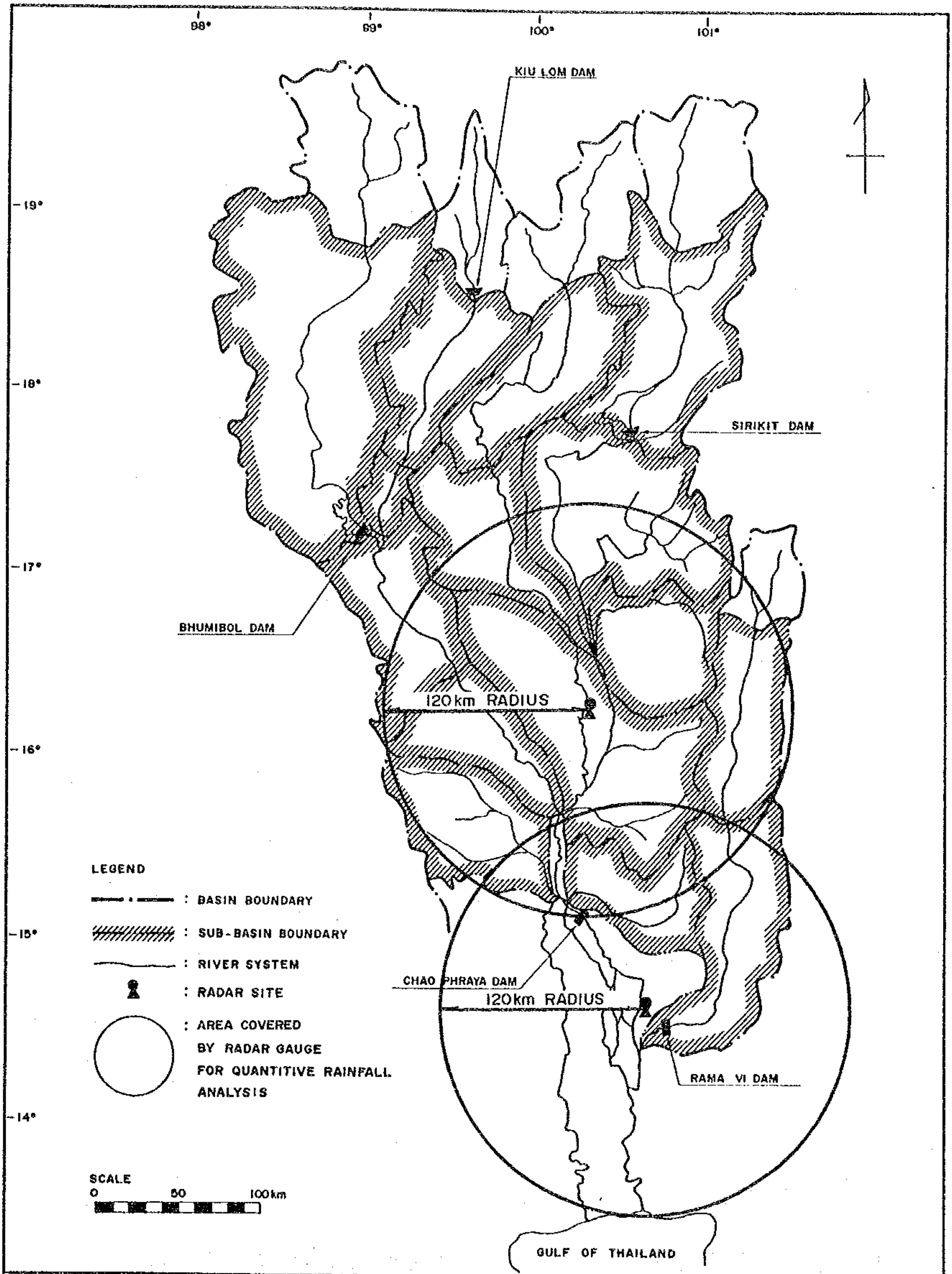

Fig. 7. PROPOSED RADAR GAUGING STATIONS (STEP 2: FIFTH INSTALLATION PRIORITY)

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

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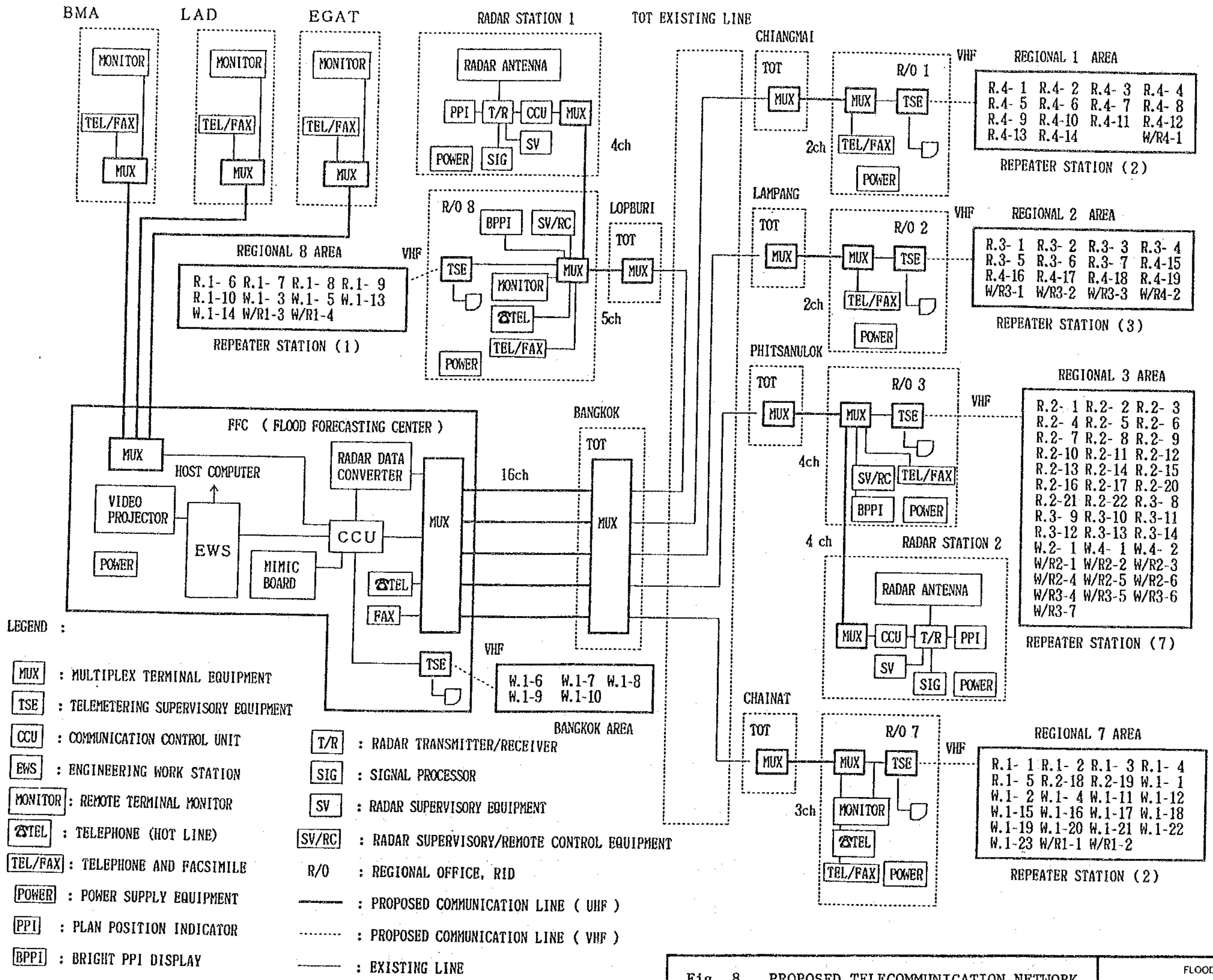

Fig. 8. PROPOSED TELECOMMUNICATION NETWORK (STEP 2)

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

Work Item \ Year	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th
A. Integrated Study	(1.5)										
B. Acquisition of Necessary Funds			(1.5)								
C. Procurement of Consultant				(0.5)							
D. Detailed Design					(2.0)						
E. Pre-Construction						(0.5)					
F. Construction										(5.0)	
1. Phase 1							(1.0)				
2. Phase 2								(1.0)			
3. Phase 3									(1.0)		
4. Phase 4										(1.0)	
5. Phase 5											(1.0)
G. Training	(Periodically Conducted)										

Fig. 9. IMPLEMENTATION SCHEDULE (STEP 2)

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

APPENDICES

COMPARISON BETWEEN CONTENTS OF STEP 1 AND STEP 2 SYSTEM

Particulars	Step 1	Step 2
(1) Concept	° Realization of urgent flood forecasting system based on existing facilities	° Accomplishment of required flood forecasting system through introduction of updated facilities
(2) System Composition		
(a) Data Collection	° 34 rainfall gauging stations ° 31 water level gauging stations including one tidal gauging station	° 84 rainfall gauging stations ° 45 water level gauging stations including one tidal gauging station ° 2 radar raingauges
(b) Data Transmission	° Off-line system ° Voice communication ° VHF and HF simplex radio line	° On-line telemetering system ° Character transmission ° UHF multiplex and VHF simplex radio line
(c) Data Management	° Off-line system	° On-line system
(d) Data Dissemination	° Voice communication	° Facsimile
(3) Effectiveness of Flood Prediction	° Maximum error of 30 cm in short-term prediction for tidal compartment ° Maximum error of 300 m^3/s (15 cm) in short-term prediction for Nakhon Sawan and Chai Nat	° Maximum error of less than 20 cm in short-term and long-term prediction for tidal compartment ° Maximum error of less than 100 m^3/s (5 cm) in short-term and long-term prediction for Nakhon Sawan and Chai Nat
(4) Implementation Period	° 3 years in total - 1 year for installation - 2 years for system development	° 11 years in total - 3.5 years for integrated study, acquisition of necessary funds and procurement of consultants - 2.5 years for detailed design and pre-construction - 5.0 years for construction of facilities and installation of equipment
(5) Total Cost	US$2,786,000	US$55,947,500

PRINCIPAL FEATURES OF THE PROPOSED SYSTEM

A. STEP 1 SYSTEM

1. Hydrological Gauging Station

Existing

(a) Rainfall Gauging Station	(RID)	16 places
	(MD)	18 places
Total		34 places
(b) Water Level Gauging Station	(RID)	27 places
	(MD)	2 places
	(PAT)	1 place
Total		30 places

New Installation

(a) Water Level Gauging Station	(RID)	1 place

2. Telecommunication

Existing

(a) HF Radio Station for Gauging Station (RID)	4 places
Frequency Band	3-15MHz
RF Output Power	100W
Antenna	Dipole
Power Supply (Commercial)	220V, 50Hz
(b) HF Radio Station for Gauging Station (MD)	20 places
Frequency Band	6MHz
RF Output Power	150W or 130W
Antenna	Dipole
Power Supply (Commercial)	220V, 50Hz

New Installation

(a) HF Radio Station for Gauging Station with Housing	30 places
Frequency Band	3-15MHz
RF Output Power	100W
Antenna	Dipole
Power Supply (Engine Generator)	2 kVA
Housing Space (Floor Area)	3 m^2

(b) VHF Radio Station for Gauging Stations with Housing — 3 places

Frequency Band	150MHz
RF Output Power	10W
Antenna	3-element Yagi
Power Supply (Engine Generator)	0.5 kVA
Housing Space	3 m^2

(c) VHF Radio Station for Agencies Concerned — 4 places

Frequency Band	150MHz
RF Output Power	10W
Antenna	3-element Yagi

3. Data Management

New Installation

Engineering Work Station with CRT Display (32 bit CPU, 5 MB main memory)	1 unit
Hard Disk Drive (100 MB memory capacity)	1 unit
Magnetic Tape Drive (2,400 ft; 1,600 BPI)	1 unit
Line Printer	1 unit
Video Projector	1 unit
CVCF (3 kVA capacity)	1 unit
Operating System Software	1 set
Application Program	1 set

B. STEP 2 SYSTEM

1. Hydrological Gauging Station

New Installation

(a) Rainfall Gauging Station	65 places
(b) Water Level Gauging Station	26 places
(c) Rainfall/Water Level Gauging Station	19 places
(d) Radar Raingauge	2 places

2. Telecommunication

New Installation

(a) VHF Radio Station for Gauging Station with Housing — 110 places

Frequency Band	150MHz
RF Output Power	10W
Antenna	3-element Yagi

Power Supply	12V, 8.5W (solar cell); and DC 12V, 40AH (battery)
Housing Space (Floor Area)	3 m^2
Tower Height	20 m

(b) UHF Radio Station for Radar Raingauge with Housing — 2 places

Frequency Band	1.5GHz
RF Output Oower	1 Watt
Channel Capacity	4 ch
Antenna	8-element Yagi
Power Supply (Commercial Power)	AC 200V, 50 Hz,
Power Supply (Engine Generator)	200 kVA
Housing Space (Floor Area)	300 m^2

(c) VHF Repeater Station with Housing — 15 places

Frequency Band	150MHz
RF Output Power	10W
Antenna	3-Stage Colinear
Power Supply	12V, 20W (solar cell); and DC 12V, 80AH (battery)
Housing Space	3 m^2
Tower Height	30 m

(d) Substation with Housing — 5 places

For VHF Radio Station to collect hydrological data — 5 places

Frequency Band	150MHz
RF Output Power	10W
Antenna	3-Stage Colinear

For UHF Radio Station to collect radar raingauge data — 2 places

Frequency Band	1.5 GHz
RF Output Power	1 Watt
Antenna	8-element Yagi

For UHF Radio Station to connect TOT Terminal Station — 5 places

Frequency Band	1.5 GHz
RF Output Power	1 Watt
Antenna	8-element Yagi
Channel Capacity	3 ch or less

Common Use for VHF, UHF Radio Station

Power Supply (Commercial Power)	AC 220V, 50Hz
Power Supply (Engine Generator)	75 kVA
Housing Space (Floor Area)	100 m^2
Tower Height	30 m

(e) Terminal Station of TOT without Housing — 6 places

Frequency Band	1.5GHz
RF Output Power	1 Watt
Antenna	8-element Yagi
Channel Capacity	3 ch or less

(f) Flood Forecasting Center

For VHF Radio Station to connect Gauging Station — 1 place

Frequency Band	150MHz
RF Output Power	10W
Antenna	3-Stage Colinear

For UHF Radio Station to connect Substations — 1 place

Frequency Band	1.5GHz
RF Output Power	1 Watt
Channel Capacity	16 ch
Antenna	8-element Yagi

For UHF Radio Station to connect Agencies Concerned — 1 place

Frequency Band	1.5GHz
RF Output Power	1 Watt
Channel Capacity	9 ch
Antenna	3-Stage Colinear

Common Use for VHF and UHF Radio Stations

Power Supply (Commerical Power)	AC 220V, 50Hz
Power Supply (Engine Generator)	200 kVA
Housing Space (Floor Area)	600 m^2
Tower Height	30 m

(g) UHF Radio Station for Data Dissemination without Housing — 3 places

Frequency Band	1.5GHz
RF Output Power	1 Watt
Channel Capacity	3 ch
Antenna	8-element Yagi

3. Data Management

New Installation

Engineering Work Station (32 bit CPU, 5 MB main memory)	3 units
Hard Disk Drive (100 MB memory capacity)	3 units
Magnetic Tape Drive	1 unit
Line Printer	1 unit
Color Hard Copy	1 unit
Video Projector	1 unit
Mimic Board	1 unit
Electronic Filing System	1 set
Video Tape Recorder	1 set
Telephone	13 sets
Facsimile	9 sets
Remote Terminal Monitor	5 sets

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