To achieve the above purposes, the following conditions are taken into account for the formulation of the Step 2 gauging system:

(1) To propose the most appropriate gauging measures in consideration of the latest models of gauging equipment;

(2) To propose the appropriate number and coverage of the hydrological gauging stations, the selection of which is made purely from the viewpoint of hydrological significance in location for flood simulation works and not necessarily related to the availability of existing gauging facilities; and

(3) To arrange the order of priority in the installation of gauging stations so as to propose the stepwise development plan in line with the staged extension programs of the target area (refer to Sector 1 of Supporting Report, Planning Condition).

6.1 Objectives of Gauging

Rainfall and water level are the essential items required in the calculations for the proposed flood prediction model. The objectives of gauging are as described below.

6.1.1 Objectives of Rainfall Gauge

The coverage of the Step 1 gauging network is limited within the lower reaches from the Bhumibol and Sirikit dams assuming that the discharge released from the dams are given to the flood prediction model as boundary conditions, while the Step 2 gauging network is expanded to the catchment areas of the two dams. Depending on the expansion of gauging coverage, a longer flood prediction time becomes possible for the downstream target areas. It is further expected that more effective use for potential flood control function is given to the dam operation in accordance with the real-time flood forecasting information so as to reduce the flood peak discharges in the target areas.

Consequently, the Step 2 gauging network covers the rainfall gauging area of about 100,000 km2, while the Step 1 gauging network covers the area of about 63,600 km2.

6.1.2 Objectives of Water Level Gauge

In addition to the items proposed in the Step 1 Flood Forecasting System, the gauging items related to the existing major river structures are newly proposed in the Step 2 Flood Forecasting System as described hereinafter.

Since the runoff discharge in the dam catchment area is included as an object of flood prediction, it is newly proposed to gauge the reservoir water level at the Bhumibol and the Sirikit dams and also to gauge the stream flow discharges along Ping and Nan rivers in the upper reaches from the dams. The proposed gauging items will provide the boundary conditions in terms of the runoff discharges observed in the upstream and to monitor the inflow discharges to the dam reservoirs.

It is further proposed to monitor the water level at existing regulators in the major canals which are related to the operation of the Chao Phraya Dam. In accordance with the gauging information, the results of flood prediction will reflect immediately to the integrated control for inflow and outflow discharges of these regulators, as well as the Chao Phraya Dam.

6.2 Gauging Measure

6.2.1 Rainfall Gauge Measure

Gauging measures are roughly classified into two types, that is, the point rainfall gauge type and the radar gauge type.

The point rainfall gauge type has been commonly applied, and this type is employed in the Step 1 gauging system. As described in Section 5, it was verified that large flood discharges of more than 3,000 m3/s can be accurately simulated at Nakhon Sawan on the basis of the point rainfall data with the rather sparse gauging density of about 1,000 km2 per station (refer to Table 2-8). This may be attributed to the wide hyetal region and the long flood traveling time. On the other hand, the reliability of point rainfall data with the said density tends to be low, simulating the runoff discharges of less than 2,000 m3/s at Nakhon Sawan. It is conjectured from the past rainfall records that the flood discharges not exceeding 2,000 m3/s at Nakhon Sawan are caused mostly from the rainfall areas of less than 50 km2. Thereby, it is virtually difficult to estimate the accurate areal average rainfall from the point rainfall gauges.

The radar gauge type is recently being developed with the advance of computer systems which can process a large amount of data scanned by the radar into the actual rainfall volume. The major advantages of radar are that one radar gauge has the potential to measure areal rainfall directly within a radius of about 120 km regardless of the size of the rainfall area. Radar gauging is, however, performed subject to the real-time calibration using the point rainfall gauge for the reason that the relationship between "the actual rainfall rate" and "the radar reflecting energy" is varied depending on the rainfall drop size, the intensity of precipitation, etc. Further, a rather long training period will be required to acquire the meteo-hydrological knowledge concerned in the operation of radar rainfall gauge. Facilities for one radar gauge system will also require an enormous cost.

In accordance with the above evaluation, it is recommended to apply both the point rainfall gauge and the radar gauge measures for the Step 2 hydrological gauging system, subject to the following conditions:

(1) The point rainfall gauging network shall be primarily established prior to the radar gauge network. The equipment of point rainfall gauge is herein assumed to be the tipping bucket type which is generally applied to the online data transmission system.

(2) Succeedingly, the radar gauge network shall be installed to supplement the accuracy of areal annual rainfall estimation, subject to the real-time calibration of point rainfall gauge.

6.2.2 Water Level Gauge Measure

It is desirable to select the appropriate gauging equipment for each gauging point among the various alternative types such as the float type, the pressure type and the lead switch type taking account of each river channel condition. However, the selection subject to the confirmation of the whole channel conditions in the Chao Phraya River Basin is virtually difficult during this study stage. Further, the alternative equipment types have neither an excessive difference in their installation and equipment costs nor an extreme change of the gauging data transmission network.

Due to the above conditions, the equipment for water level gauge is assumed equally to all gauging points as the float type which enables the most flexible installation for various river channel conditions.

6.3 Location and Number of Gauging Station

6.3.1 Rainfall Gauging Station

Rainfall gauging stations are to be installed in the proposed 14 subbasins where the basin runoff discharges are predicted through the simulation model (refer to Fig. 2-14). As stated before, it is recommended to establish the point rainfall gauge network, and afterwards the radar gauge network. The gauging stations for each network are selected as described hereinafter.

<u>Point Rainfall Gauging Station</u>

The necessary density of rainfall gauge point was primarily examined through simulations of rainfall discharges in 1978, 1980 and 1983. The simulation was made on the basis of the rainfall data and with their gauge densities varying from 1,000 km2 to 1,800 km2 per gauging station in the upper reaches of (1) Nakhon Sawan, (2) the Bhumibol Dam, and (3) Saraburi (Sta. S9 in the Pasak River Basin) (refer to Fig. 2-33). As the results of simulation, a substantial difference is detected in the observed and simulated discharge hydrographs when the rainfall gauging density is assumed to be more sparse than 1,200 km2 per station, as shown in Fig. 2-34. The difference is further clarified by the comparison of either the annual peak discharges or the annual discharge volumes, as shown in Table 2-25.

Due to the above verification, the installation density of gauging station is proposed to be about 1,200 km2 per station. Further, the location of gauging stations are arranged so as to be equally distributed in the respective subbasin, and also to be nearby the existing gauging stations as far as possible taking into account of the continuity of the gauging period. The exceptional manner of arrangement for gauging stations is, however, applied to the Tha Pla Pi Subbasin (Basin Code No. B-12), where the installation density of about 2,000 km^2 per station is available since the basin runoff discharges are simulated to scarcely contribute to the stream flow of the Chao Phraya River.

Based on the aforesaid arrangement, 84 rainfall gauging stations are selected to the Step 2 hydrological gauging network. The location and inventory of these gauging stations are as shown in Fig. 2-35 and Tables 2-26 and 2-27, respectively.

Among the selected gauging stations, 19 stations are to be used in common with the water level gauging stations, and another 65 stations are used purely for rainfall gauging. The estimation of basin average rainfall is made on the basis of the gauging stations classified in Table 2-28.

Radar Gauge Station

Among the 14 subbasins regarded as objects of the Basin Runoff Prediction Model, 6 subbasins (Basin Code Nos. BS-4, 9, 10, 11 and 12) are adjacent to the downstream target points (refer to Fig. 2-14). The 6 subbasins are located in the lower reaches of Ping, Yom, Nan, Pasak and Sakae Krang river basins, and specially characterized as below:

(1) Rainfall prediction for the subbasins is required to perform flood prediction of the target areas due to the short time difference between the occurrence of rainfall in the subbasin and the occurrence of the corresponding runoff discharges at the target points. The time difference is assumed to be less than 3 days in the proposed flood prediction model. Thereby, the radar gauge is useful to overview the movement of rainfall areas and to predict the time series trend of the rainfall intensity and hyetal region.

(2) Rainfall in the subbasins contributes to the runoff discharges at the target points more sensitively than the rainfall in the other upper subbasins. In this connection, it is desirable to apply the radar gauge so as to catch even the small scale rainfall which is not practically gauged by the point rainfall gauge station.

Due to the above characteristics, two radar gauge stations are proposed to cover the aforesaid 6 subbasins subject to the available coverage of one radar gauge station to be about 120 km in radius (refer to Fig. 2-36). The radar stations are to be located approximately in latitude 14°40'N and longitude 100°30'E (south of Lop Buri), and in latitude 16°15'N and longitude 100°15'E (near Taphan Hin).

6.3.2 Water Level Gauging Station

The water level gauging points were selected due to the following necessities of their gauging data:

(1) To monitor and calibrate the discharge and water level calculated through flood prediction model;

(2) To input the boundary conditions in terms of runoff discharges observed in the upper reaches;

(3) To accommodate the basic data for the tidal prediction in the Gulf of Thailand; and

(4) To monitor the inflow and outflow discharge of major canals at existing regulators.

Correspondingly, 45 water level gauging stations including one tidal gauging station were selected. The inventory and location of the selected gauging stations are shown in Tables 2-27 and 2-29 and Fig. 2-25, respectively. The selected gauging stations are further classified according to gauging purpose (refer to Tables 2-30, 2-31 and 2-32).

Among the water level gauging stations for the Step 2 system, 27 gauging stations are selected at the same locations as those of the Step 1 system for the reason of continuity of cumulative gauging data to be stored, as well as the hydrological significance in location for the calculation of flood prediction.

In addition to the above, the following gauging stations are newly proposed in the Step 2 system:

(1) Four (4) gauging stations in the upper reaches from the Bhumibol and the Sirikit dams, two of which are to gauge the water level of dam reservoirs and the other two, which are located at Chai Mai and Nan, to gauge the upstream runoff discharges; and

(2) Twelve (12) gauging stations in the lower reaches from the Chai Nat Dam, to gauge the water level of Chai Nat-Pasak Canal, Chai Nat-Ayutthaya Canal, Noi River and Suphan River so as to monitor the inflow and outflow discharge at major regulators (refer to Table 2-32).

6.4 Installation Priority of Gauging Stations

The installation priority of gauging stations was primarily conceived in accordance with the staged extension programs of the target areas and the expected flood prediction time (refer to Sector 1 of Supporting Report, Planning Condition). The priorities were further adjusted from the viewpoints of installation volumes.

Through the aforesaid conditions, the installation priorities are divided into five stages as below (refer to Table 2-23 and Fig. 2-35).

(1) As the first priority, it is proposed to install 37 gauging stations in the lower reaches from Nakhon Sawan along the main channel of the Chao Phraya River and in the lower reaches from Wichian Buri along the Pasak River (refer to the first priority stations in Fig. 2-35). These gauging stations will enable short term prediction (prediction time = 3 days) for the target areas except Nakhon Sawan.

(2) As the second priority, it is proposed to install 29 gauging stations in the lower reaches of Ping, Yom and Nan rivers and the upper reaches of Pasak River (refer to the second priority stations in Fig. 2-35). The gauging stations will enable short term prediction for Nakhon Sawan as well as 6-day prediction for other target areas.

(3) As the third priority, 21 gauging stations are to be installed in the upper reaches of Ping, Yom and Nan rivers, except the catchment areas of the Bhumibol and

Sirikit dams (refer to the third priority stations in Fig. 2-35). Provided that the dominant rainfall area covers the installation areas, the flood prediction will be done about 6 days in advance for Nakhon Sawan and more than 6 days in advance for other target areas.

(4) As the fourth priority, 23 gauging stations are to be installed in the catchment areas of the Bhumibol and Sirikit dams. Thereby, flood prediction will enable a longer flood prediction time and also a certain flood mitigation effect for the respective target areas through the effective use of flood control functions attached to the Bhumibol and Sirikit dams (refer to the fourth priority stations in Fig. 2-35).

(5) As the fifth priority, two radar stations are to be installed so as to facilitate the rainfall prediction measures and improve the accuracy of areal rainfall estimation (refer to Fig. 2-36).

6.5 Manner of Flood Prediction

Flood prediction at the respective prediction points is carried out through different combinations of flood prediction models by using the real-time gauged data. Thereby, the results of flood prediction are calculated in terms of either the daily average or the hourly average water levels/ discharges more than three days in advance for the respective prediction points. The calculations are to be done every six hours on the basis of the gauged data newly collected on the real-time basis so as to update the results of prediction (refer to Sector 1 of Supporting Report, Planning Condition). The details of the contents of flood prediction are described hereinafter.

Prediction of Daily Average Water Level and Discharge

Predictions are made for the target areas except Bangkok on the basis of real-time gauged data collected from the gauging stations in the upper reaches from Bang Sai. The gauged data are continuously and automatically input to the data processing unit, so that they are successively processed to the runoff discharges as well as areal average rainfall and stored by the data memory unit. The gauged data thus processed and stored are used for the calculation of flood prediction which is made every six hours through the combination of the Basin Runoff Prediction Model, the Channel Routing Model, and the Flood Plain Routing Model. Correspondingly, both water level and runoff discharge are predicted in terms of daily average values subject to the renewal of prediction results at every 6-hour interval.

Prediction of Hourly Average Water Level

The results of prediction are provided for the Bangkok Metropolitan area which is located along the estuary and strongly influenced by tidal fluctuation. The calculation for prediction is made every six hours through the Unsteady Flow Prediction Model by using the following initial condition and boundary conditions.

(1) The water level gauge data are collected on the real-time basis from the five (5) gauging stations located along the estuary from the river mouth up to Bang Sai. The collected water level gauge data are processed into the water level profile for tidal compartment which is used as the initial condition for the time before the start of model calculation.

(2) The upstream boundary conditions for the model calculation are given in terms of daily average runoff discharges predicted at Bang Sai.

(3) The hourly average tidal levels are predicted through the Harmonic Analysis, using the real-time gauged data

of tidal levels at the river mouth. The results of prediction are used as the downstream boundary conditions of the Unsteady Flow Prediction Model.

6.6 Effectiveness of Flood Prediction

The effectiveness of flood prediction was examined through simulations using the hydrological gauging data recorded in 1978, 1980 and 1983 at the gauging stations located nearby the gauging points to be selected for the Step 2 Flood Forecasting System. The simulation was carried out subject to the 3 and 6-day advanced predictions.

The 3-day prediction corresponds to the short term prediction primarily required of the Step 2 Flood Forecasting System. The prediction time longer than 6 days was not examined in this study, since such longer prediction time essentially requires rainfall prediction, the practical measure of which could not be developed during this study period, especially for the upstream prediction points such as Nakhon Sawan and Chai Nat. It is, however, noted that the advanced prediction time is possibly extended up to about 10 days for the prediction at Bangkok situated as the lowest prediction point due to the long flood lag time (refer to Table 2-24).

The results of simulation are shown in Tables 2-34 to 2-35 and Figs. 2-37 to 2-38. Compared with the results of flood prediction in the Step 1 Flood Forecasting System (refer to Tables 2-22 to 2-23 and Figs. 2-31 to 2-32), appreciable improvements were recognized for the Step 2 Flood Forecasting System, especially in the results of prediction at Nakhon Sawan and Bangkok. The details are described hereinafter.

6.6.1 Accuracy of Daily Average Discharge Prediction in the Upper Reaches from Bang Sai

The flood discharge hydrographs are predicted at Nakhon Sawan, Chai Nat and Ang Thong where the observed discharge records are available. The prediction was made through the combination of the Basin Runoff Prediction Model, the Channel Routing Model and the Flood Plain Routing Model. The results of prediction are shown in Figs. 2-37 to 2-38 and Table 2-34, and evaluated below.

Prediction for Nakhon Sawan

The results of both 3 and 6-day predictions well coincide with the observed hydrographs in the portion of more than 3,000 m^3/s which is in dangerous condition of overbanking and regarded as the primary object of prediction. However, it is rather difficult to predict the runoff discharges of less than 2,000 m^3/s, especially 6 days in advance. The difficulty is attributed to the errors of areal average rainfall estimated from the point rainfall gauge for the small hyetal regions.

Prediction for Lower Chai Nat Dam

As in the prediction for Nakhon Sawan, the results of 3 and 6-day predictions well coincide with the observed discharges, when the runoff discharges are over 2,000 m^3/s.

Prediction for Ang Thong

Compared with the prediction results for Nakhon Sawan and Chai Nat, the difference between the observed and predicted discharges is rather large. One of the causes is the reliability of observed discharges at Ang Thong where the period of field discharge measurement is quite limited. Accordingly, it is necessary to accumulate a sufficient data of field discharge measurement and make further verifications on the model's effectiveness.

6.6.2 Accuracy of Hourly Average Water Level Prediction for Tidal Compartment

The one-day maximum water levels were predicted through the Unsteady Flow Prediction Model for several points along the estuary and compared with the observed water levels shown in Table 2-35. In this prediction, the following premises are given:

(1) The dates for prediction are set on the days when the annual maximum discharges were observed at Bang Sai in 1978, 1980 and 1983.

(2) The upstream boundary conditions are given from the daily average discharges predicted at Bang Sai either 3 days or 6 days in advance. Thereby, the Step 2 Flood Forecasting System enables improvement of the accuracy of boundary conditions due to the increment of gauging points in the upper reaches from Bang Sai.

(3) The downstream boundary conditions are given from the hourly average tidal levels at Fort Phra Chul which are predicted through the Harmonic Analysis. Due to the real-time and online data collection system, the Step 2 Flood Forecasting System enables updating of the results of tidal prediction at short intervals so as to increase their accuracy. Table 2-36 shows the results of 6-day advanced tidal level prediction to be made subject to everyday updating of results which is assumed to be practical in the Step 2 Flood Forecasting System. The said results of prediction well coincide with the observed values compared with the other results of prediction which were made subject to the updating of results at one year interval (refer to Table 2-16).

In accordance with the aforesaid improvement, the Step 2 Flood Forecasting System improves the results of water level prediction for tidal compartment. As shown in Table 2-35, the 3-day prediction is derived to make the errors of less than 20 cm for all prediction points. As for the 6-day prediction, the errors are also within 20 cm, except in the prediction at Memorial Bridge on October 31, 1983 where the error of 30 cm was calculated.

TABLES

Table 2-1. ANNUAL MAXIMUM DISCHARGES ON CHAO PHRAYA RIVER (OBJECT YEARS: 1978 TO 1985)

Year	Discharge /1 Observation Point	Peak Discharge (m^3/s)	Date of Peak Discharge
1978	C2	3,540	07 OCT
	C13	3,740	11 OCT
1979	C2	1,390	02 OCT
	C13	1,158	02 OCT
1980	C2	4,320	10 OCT
	C13	3,795	13 OCT
1981	C2	1,663	18 AUG
	C13	1,282	13 AUG
1982	C2	1,596	09 OCT
	C13	932	06 OCT
1983	C2	2,290	23 OCT
	C13	3,290	25 OCT
1984	C2	1,249	27 OCT
	C13	584	24 OCT
1985	C2	2,137	28 OCT
	C13	2,066	26 OCT

Note: /1 Refer to Fig. 2-5 for the location of observation points C2 and C13. These observation points have the respective drainage areas of 110,569 km^2 and 120,693 km^2.

Table 2-2. TRANSITION OF FLOOD PEAK DISCHARGE ALONG PING, WANG, YOM AND NAN RIVERS

River System	Observation Point /1 (Sta. No.)	Distance (km)	1978 Flood Qmax (m^3/s)	1978 Flood Date	1978 Flood Time Differ-rence (days)	1980 Flood Qmax (m^3/s)	1980 Flood Date	1980 Flood Time Differ-ence (days)	1983 Flood Qmax (m^3/s)	1983 Flood Date	1983 Flood Time Differ-rence (days)
Ping/Wang	W10	355	140	27 SEP	5	NO FLOOD			NO FLOOD		
	W1A	315	150	27 SEP	5	NO FLOOD			NO FLOOD		
	W3A	212	460	27 SEP	5	160	03 OCT	1	180	19 OCT	1
	W4A	132	340	28 SEP	4	280	04 OCT	0	200	20 OCT	0
	P2A	65	550	30 SEP	2	410	04 OCT	0	600	20 OCT	0
	P7A	0	1,180	02 OCT	0	910	04 OCT	0	1,440	20 OCT	0
Yom	Y20	195	340	25 SEP	1	610	05 SEP	3	332	09 OCT	-3
	Y1	112	800	25 SEP	1	730	08 SEP	0	317	09 OCT	-3
	Y14	0	1,000	26 SEP	0	2,170	08 SEP	0	448	06 OCT	0
	Y6	-24	1,130	26 SEP	0	2,130	08 SEP	0	477	06 OCT	0
	Y3A	-45	1,200	26 SEP	0	1,240	08 SEP	0	472	06 OCT	0
	Y4	-92	470	27 SEP	-1	580	10 SEP	-2	NOT REPORTED		
	Y17	-197	490	CONSTANT/2		730	CONSTANT/2		NOT REPORTED		
Nan	N33	222	100	24 SEP	1	1,080	07 SEP	2	180	04 OCT	3
	N12A	211	300	20 SEP	5	990	07 SEP	2	200	04 OCT	3
	N26	128	630	24 SEP	1	1,710	08 SEP	1	300	06 OCT	1
	N5A	0	1,210	25 SEP	0	1,520	09 SEP	0	560	07 OCT	0
	N7	-76	1,340	08 OCT	-13	1,420	11 SEP	-2	660	10 OCT	-3
	N10A	-112	1,440	08 OCT	-13	1,520	23 SEP	-14	710	10 OCT	-3
	N8	-137	1,430	09 OCT	-15	1,520	26 SEP	-17	NOT REPORTED		

Note: /1 Refer to Fig. 2-5 for the location of observation points.
/2 Flood discharge is retarded to be almost a constant value.

Table 2-3. PEAK DISCHARGES OF 1978, 1980 AND 1983 FLOODS

Flood Year	River System	Discharge /1 Observation Point	Drainage Area (km^2)	Peak Discharge (m^3/s)	Peak Discharge Unit D.A. ($m^3/s/km^2$)
1978	Ping-Wang	P7A	42,700	1,178	2.8×10^{-2}
	Yom	Y17	21,415	480	2.2×10^{-2}
	Nan	N8	32,878	1,430	4.3×10^{-2}
	Chao Phraya	C2	110,569	3,540	3.2×10^{-2}
		C13	120,693	3,740	3.1×10^{-2}
	Pasak	S9	14,374	3,206	22.3×10^{-2}
1980	Ping-Wang	P7A	42,700	905	2.1×10^{-2}
	Yom	Y17	21,415	732	3.4×10^{-2}
	Nan	N8	32,878	1,520	4.6×10^{-2}
	Chao Phraya	C2	110,569	4,320	3.9×10^{-2}
		C13	120,693	3,795	3.1×10^{-2}
	Pasak	S9	14,374	886	6.2×10^{-2}
1983	Ping-Wang	P7A	42,700	1,439	3.4×10^{-2}
	Yom	Y3A	13,583	465	3.4×10^{-2}
	Nan	N10A	30,760	673	2.2×10^{-2}
	Chao Phraya	C2	110,569	2,290	2.0×10^{-2}
		C13	120,693	3,290	3.1×10^{-2}
	Pasak	S9	14,374	851	5.9×10^{-2}

Note: /1 Refer to Fig. 2-5 for the location of observation points.

Table 2-4. HYDROLOGIC BALANCE

River Basin	Discharge Observation Point Upper	Discharge Observation Point Lower	Catchment Area /1 (km²)	Hydrologic Year /2	Hydrologic Value (1) Rainfall (mm)	(2) Runoff Discharge (mm)	(3) Balance (1)-(2) (mm)
Wang	W10A	W3A	6,187	1978	1,067	215	852
				1979	935	76	859
				1980	956	108	848
				1981	-Data Missing-		
				1982	829	51	778
				1983	1,017	109	908
				1984	961	58	903
				1985	-Data Missing-		
				Average	961	103	858
Ping	W4A, P12	P7A	5,797	1978	1,401	361	1,040
				1979	1,129	192	937
				1980	1,563	400	1,163
				1981	1,319	235	1,084
				1982	1,103	259	844
				1983	-Data Missing-		
				1984	1,055	140	916
				1985	1,213	258	954
				Average	1,255	264	991
Yom	Y20	Y14	6,721	1978	1,373	255	1,118
				1979	1,019	77	942
				1980	1,324	192	1,132
				1981	1,364	286	1,078
				1982	978	79	898
				1983	1,118	137	981
				1984	1,163	108	1,054
				1985	1,343	150	1,193
				Average	1,210	161	1,049
Nan	N12A, N33	N5A	7,105	1978	1,503	507	996
				1979	1,040	160	880
				1980	1,610	459	1,151
				1981	1,345	301	1,044
				1982	1,100	189	911
				1983	1,319	222	1,097
				1984	-Data Missing-		
				1985	-Data Missing-		
				Average	1,320	306	1,014
Pasak	S4B	S9	10,808	1978	1,413	394	1,018
				1979	1,077	45	1,032
				1980	1,157	191	966
				1981	1,337	158	1,180
				1982	1,186	219	967
				1983	1,262	191	1,071
				1984	-Data Missing-		
				1985	-Data Missing-		
				Average	1,239	200	1,039

Note: /1 Balance between the catchment areas of lower and upper discharge observation points.

/2 From April in the subject year to March in the following year.

Table 2-5. RECORD OF PAN EVAPORATION

Location	Hydrologic Year	Monthly and Annual Pan Evaporation (mm)												
		APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	ANNUAL
Lampang	1978	192.0	141.3	148.8	120.9	113.0	106.9	103.2	94.7	88.6	95.2	110.0	182.7	1,497.3
	1979	204.7	171.3	145.4	141.1	115.3	112.8	114.3	110.4	93.6	(91.9)	126.1	156.4	1,583.3
Lat. N19°53'	1980	196.8	184.6	132.8	131.1	124.9	94.8	90.2	(98.3)	(85.2)	92.5	116.2	172.8	1,520.2
Long. E99°50'	1981	193.7	154.8	122.9	113.0	111.7	117.7	104.1	74.9	68.0	86.5	116.9	151.6	1,415.8
Elev. 241 m	1982	168.8	168.9	130.8	133.1	122.2	111.3	126.0	114.0	90.4	93.2	124.5	180.1	1,563.3
	Average	191.2	164.2	136.1	127.8	117.4	108.7	107.6	98.3	85.2	91.9	118.7	168.7	1,515.8
Phitsanulok	1978	166.2	157.0	140.1	128.7	130.5	102.6	147.9	123.0	129.4	121.0	135.5	204.2	1,686.1
	1979	206.4	199.6	152.4	171.4	128.0	127.2	137.5	139.0	118.1	113.4	139.5	183.9	1,816.4
Lat. N16°49'	1980	222.7	210.0	146.3	187.1	141.9	113.8	122.4	115.1	118.2	116.7	129.8	173.0	1,797.0
Long. E100°16'	1981	194.5	196.5	135.0	123.6	157.6	125.7	130.2	107.6	110.0	112.9	125.4	175.6	1,694.6
Elev. 44 m	1982	190.9	191.6	155.8	134.1	118.3	118.7	132.5	115.3	108.2	108.5	125.0	182.3	1,681.2
	Average	196.1	190.9	145.9	149.0	135.3	117.6	134.1	120.0	116.8	114.5	131.0	183.8	1,735.0
Phechabun	1978	214.8	161.4	151.9	102.4	101.1	95.4	131.6	126.4	143.5	138.8	141.3	179.9	1,688.5
	1979	201.3	166.9	117.2	157.3	109.9	116.0	147.3	151.5	141.2	130.6	159.6	191.9	1,790.7
Lat. N16°26'	1980	148.7	184.3	113.8	122.6	106.0	90.5	136.5	153.3	154.1	144.8	147.1	216.9	1,718.6
Long. E101°09'	1981	192.7	171.4	129.4	137.8	111.5	104.0	106.9	112.5	120.7	112.7	118.7	179.3	1,597.6
Elev. 118 m	1982	181.9	191.4	132.7	118.3	90.5	85.6	104.2	110.1	101.7	105.7	124.1	182.1	1,528.7
	Average	187.9	175.1	129.0	127.7	103.8	98.3	125.3	130.8	132.2	126.5	138.2	190.1	1,664.9

Note: Months with figures in parenthesis have the data missing, but were supplied with the average of the data of the other four years.

Source: Annual Meteorological Bulletin, Meteorological Department

Table 2-6. COMPARISON BETWEEN HYDROLOGIC BALANCE AND PAN EVAPORATION DATA

River Basin	Discharge Observation Point		Pan Evaporation Observation Point	Hydrologic Year /1	Comparison		
	Upper	Lower			(1) Hydrologic Balance (mm)	(2) Pan Evaporation (mm)	(3) Ratio (1)/(2) (%)
Wang	W10A	W3A	Lampang	1978	852	1,497	57
				1979	859	1,583	54
				1980	848	1,520	56
				1981	-Data Missing-		
				1982	778	1,563	50
				Average	834	1,541	54
Ping, No. P12	W4A	P7A	Phitsanulok	1978	1,040	1,686	62
				1979	937	1,816	52
				1980	1,163	1,797	65
				1981	1,084	1,695	64
				1982	844	1,681	50
				Average	1,014	1,735	58
Yom	Y20	Y14	Phitsanulok	1978	1,118	1,686	66
				1979	942	1,816	52
				1980	1,132	1,797	63
				1981	1,078	1,695	64
				1982	898	1,681	53
				Average	1,034	1,735	60
Nan	N12A	N5A	Phitsanulok	1978	996	1,686	59
				1979	880	1,816	48
				1980	1,150	1,797	64
				1981	1,044	1,695	62
				1982	910	1,681	54
				Average	996	1,735	57
Pasak	S4B	S9	Phetchabun	1978	1,018	1,689	60
				1979	1,032	1,791	58
				1980	966	1,719	56
				1981	1,180	1,598	74
				1982	967	1,529	63
				Average	1,033	1,665	62

Note: /1 From April in the subject year to March in the following year.

Table 2-7(1/2). CONSTANT PARAMETERS FOR BASIN RUNOFF CALCULATION

Parameter Items	Symbol	Basin No. BS-1 Ping River (20,031 km^2)	Basin No. BS-2 Wang River (6,187 km^2)	Basin No. BS-3 Ping River (5,797 km^2)	Basin No. BS-4 Ping River (5,162 km^2)	Basin No. BS-5 Yom River (6,721 km^2)	Basin No. BS-6 Yom River (4,320 km^2)	Basin No. BS-7 Nan River (8,521 km^2)
A. Multiplier								
1. 1st Tank								
- Runoff Hole (upper)	a1	0.111	0.200	0.060	-	0.120	-	-
- Runoff Hole (middle)	a2	0.022	0.040	0.040	0.040	0.040	0.034	0.031
- Runoff Hole (lower)	a3	0.020	0.035	0.035	0.040	0.035	0.030	0.027
- Infiltration Hole	ao	0.014	0.025	0.025	0.034	0.025	0.021	0.019
2. 2nd Tank								
- Runoff Hole	b1	0.006	0.010	0.010	0.014	0.010	0.009	0.007
- Infiltration Hole	bo	0.011	0.020	0.020	0.027	0.020	0.017	0.016
3. 3rd Tank								
- Runoff Hole	c1	0.002	0.002	0.002	0.003	0.002	0.002	0.002
- Infiltration Hole	co	0.001	0.004	0.004	0.005	0.004	0.003	0.003
4. 4th Tank								
- Runoff Hole	d1	0.001	0.001	0.001	0.001	0.001	0.001	0.001
B. Height of Runoff Hole (mm)								
1. 1st Tank								
- Upper	A1	130	130	130	-	130	-	130
- Middle	A2	100	100	100	100	100	100	100
- Lower	A3	80	80	80	80	80	80	80
2. 2nd Tank	B	60	60	60	60	60	60	60
3. 3rd Tank	C	50	50	50	50	50	50	50
4. 4th Tank	D	20	20	20	20	20	20	20
C. Initial Storage Height (mm)								
1. 1st Tank	X1	0	0	0	0	0	0	0
2. 2nd Tank	X2	0	0	0	0	0	0	0
3. 3rd Tank	X3	0	0	0	0	0	0	0
4. 4th Tank	X4	20	20	20	20	20	20	20

Table 2-7(2/2). CONSTANT PARAMETERS FOR BASIN RUNOFF CALCULATION

Parameter Items	Symbol	Basin No. BS-8 Nan River (9,568 km^2)	Basin No. BS-9 Nan River (5,478 km^2)	Basin No. BS-10 Nan/Yom River (15,488 km^2)	Basin No. BS-11 Sakae Krang River (5,775 km^2)	Basin No. BS-12 Tha Pla Pai River (4,349 km^2)	Basin No. BS-13 Pasak River (5,180 km^2)	Basin No. BS-14 Pasak River (8,124 km^2)
A. Multiplier								
1. 1st Tank								
- Runoff Hole (upper)	a1	-	-	-	0.060	-	-	0.110
- Runoff Hole (middle)	a2	0.034	0.044	0.026	0.050	0.040	0.018	0.036
- Runoff Hole (lower)	a3	0.029	0.039	0.023	0.050	0.040	0.007	0.014
- Infiltration Hole	ao	0.021	0.028	0.017	0.010	0.034	0.007	0.014
2. 2nd Tank								
- Runoff Hole	b1	0.008	0.011	0.007	0.010	0.014	0.004	0.009
- Infiltration Hole	bo	0.017	0.022	0.013	0.020	0.027	0.004	0.009
3. 3rd Tank								
- Runoff Hole	c1	0.002	0.002	0.001	0.002	0.003	0.002	0.002
- Infiltration Hole	co	0.003	0.004	0.002	0.004	0.005	0.002	0.002
4. 4th Tank								
- Runoff Hole	d1	0.001	0.001	0.001	0.001	0.001	0.0009	0.0009
B. Height of Runoff Hole (mm)								
1. 1st Tank								
- Upper	A1	-	-	-	200	130	-	200
- Middle	A2	100	100	100	80	100	100	100
- Lower	A3	80	80	80	60	80	80	80
2. 2nd Tank	B	60	60	60	40	60	60	60
3. 3rd Tank	C	50	50	50	30	50	50	50
4. 4th Tank	D	20	20	20	10	20	20	20
C. Initial Storage Height (mm)								
1. 1st Tank	X1	0	0	0	0	0	0	0
2. 2nd Tank	X2	0	0	0	0	0	0	0
3. 3rd Tank	X3	0	0	0	0	0	0	0
4. 4th Tank	X4	20	20	20	20	20	20	20

Table 2-8. COMPARISON OF EXTREME VALUES BETWEEN OBSERVED AND SIMULATED BASIN RUNOFF DISCHARGES

Subbasin Code No.	Upstream Discharge Observation Point	Downstream Discharge Observation Point	Year	Observed at Downstream Point		Simulated for Downstream Point		Lag Time
				Date	(m^3/s)	Date	(m^3/s)	(days)
BS-1 (Ping River)	Chiang Mai (P1)	Bhumibol Dam (Inflow)	1978	Jul.09	1,080	Jul.08	1,030	1.0
			1978	Aug.17	1,070	Aug.14	1,080	3.0
			1978	Oct.06	1,270	Oct.04	1,330	2.0
			1980	Sep.09	1,380	Sep.07	1,410	2.0
			1980	Oct.08	1,660	Oct.07	1,550	1.0
			1983	Oct.19	1,570	Oct.18	1,590	1.0
			1983	Nov.13	1,470	Nov.12	1,520	1.0
BS-2 (Wang River)	Chae Hom (W10A)	Thaen (W3A)	1978	Aug.15	640	Aug.14	650	1.0
			1980	Sep.07	420	Sep.06	430	1.0
			1983	Sep.16	350	Sep.14	350	2.0
BS-3 (Ping River)	Wang Kra Chai (P12) and Wang Khrai (W4A)	Kamphaeng Phet (P7A)	1978	Jul.12	780	Jul.10	770	2.0
			1978	Oct.02	1,180	Sep.29	1,190	3.0
			1978	Oct.15	630	Oct.13	770	2.0
			1980	May 23	1,530	May 22	1,540	1.0
			1980	Oct.04	910	Oct.02	920	2.0
BS-5 (Yom River)	Ngao Sak (Y20)	Si Satchanalai (Y14)	1978	Aug.15	1,550	Aug.13	1,550	2.0
			1978	Sep.26	1,000	Sep.23	1,180	3.0
			1980	Sep.02	990	Sep.01	970	1.0
			1980	Sep.08	2,170	Sep.07	2,150	1.0
			1983	Sep.16	710	Sep.14	860	2.0
BS-7 (Nan River)	Nan (N1)	Sirikit Dam (Inflow)	1978	Aug.15	1,320	Aug.14	1,020	1.0
			1978	Sep.14	1,150	Sep.13	960	1.0
			1980	Aug.25	1,070	Aug.25	1,000	0.0
			1980	Sep.06	2,260	Sep.05	2,330	1.0
			1983	Sep.19	1,070	Sep.18	1,020	1.0
BS-8 (Nan River)	Tha Pla (N12A)	Phitsanulok (N5A)	1978	Aug.16	1,410	Aug.13	1,320	3.0
			1978	Sep.25	1,210	Sep.23	1,210	2.0
			1980	Aug.01	1,240	Jul.30	1,280	2.0
			1980	Sep.09	1,520	Sep.07	1,530	2.0
			1980	Sep.20	1,230	Sep.18	1,220	2.0
			1983	Sep.09	660	Sep.07	780	2.0
BS-14 (Pasak River)	Wichian Buri	Saraburi (S9)	1978	Oct.03	3,210	Sep.30	3,260	3.0
			1980	Oct.05	890	Oct.01	850	4.0

Table 2-9. CONSTANT PARAMETERS ASSUMED AS FLOOD TRAVELLING TIME

River Stretch Code No.	River System	Travelling Time (days)
R1	Ping (Chiang Mai to Bhumibol Dam)	2.0
R2	Wang (Chae Hom (W10A) to Thoen (W3A))	1.0
R3	Wang (Thoen (W3A) to Wang Krai (W4A))	1.0
R4	Ping (Bhumibol Dam to Kamphaeng Phet (P7A))	2.0
R5	Ping (Downstream from Kamphaeng Phet (P7A))	1.0
R6	Yom (Ngao Sak (Y20) to Si Satchanalai (Y14))	2.0
R7	Yom (Downstream from Sam Ngam (Y17))	3.0
R8	Nan (Nan (N1) to Sirikit Dam)	1.0
R9	Nan (Sirikit Dam to Phitsanulok (N5A))	2.0
R10	Nan	1.0
R11	Yom/Nan	1.0
R12	Chao Phraya	1.0
R13	Tha Pla Pai	8.0
R14	Sakae Krang	6.0
R15	Chao Phraya	3.0
R16	Pasak (Lom Sak to Wichian Buri)	2.0
R17	Pasak (Wichian Buri to Rama VI Dam)	3.0

Table 2-10. CONSTANT PARAMETERS OF STORAGE FUNCTION FOR SUBDIVIDED RIVER STRETCH

(1) Upper Reaches from Nakhon Sawan

River Stretch Code No.	Constant Parameters			
	K	P	T1	T1z
S1	80.0	0.800	0.0	4.0
S2	80.0	0.800	0.0	0.0
S3	80.0	0.600	0.0	7.0
S4	80.0	0.800	0.0	0.0
S5	210.8	0.615	2.0	0.0

(2) Lower Reaches from Nakhon Sawan

River Stretch Code No.	Flow Capacity (m^3/s)	Constant Parameters /1 Less Than Flow Capacity		Constant Parameters /1 More Than Flow Capacity	
		K	P	K	P
S6	2,700	17.1	0.6	4.6×10^{-5}	2.2
S7	2,000	12.1	0.6	1.2×10^{-5}	2.4
S8	1,200	5.8	0.6	1.3×10^{-7}	3.1
S9	700	1.0	0.6	4.6×10^{-15}	5.6
S10	700	3.3	0.6	1.5×10^{-8}	3.5
S11	200	2.1	0.6	1.1×10^{-5}	3.0
S12	700	4.6	0.6	2.4×10^{-6}	2.8
S13	250	3.3	0.6	1.4×10^{-5}	2.8
S14	900	5.8	0.6	5.8×10^{-7}	3.0
S15	200	3.3	0.6	5.0×10^{-6}	3.1
S16	200	4.2	0.6	7.1×10^{-5}	2.7
S17	150	2.9	0.6	6.3×10^{-6}	3.1
S18	200	2.1	0.6	1.1×10^{-5}	3.0
S19	900	2.9	0.6	3.1×10^{-10}	4.0
S20	1,800	4.8	0.6	8.8×10^{-8}	3.0
S21	3,000	4.6	0.6	1.4×10^{-6}	2.5
S22		120.0	0.8	120.0	0.8

Note: /1 Zero value is assumed as parameters of "T1" and "T1z" for all river stretches in the lower reaches from Nakhon Sawan.

Table 2-11. FLOW CAPACITY OF SUBDIVIDED RIVER CHANNELS (CHAO PHRAYA RIVER AND TRIBUTARIES)

Name of River	River Stretch Code No.	Subdivided Channel Stretch		Length of Stretch (km)	Flow Capacity (m^3/s)
		From	To		
Chao Phraya	S6	Chao Phraya Dam	Sing Buri	50	2,700
-do-	S7	Sing Buri	Diversion Point to Bang Kaeo River	40	2,000
-do-	S8	Diversion Point to Bang Kaeo River	Diversion Point to Bang Luan River	20	1,200
-do-	S9	Diversion Point to Bang Luan River	Diversion Point to Bang Ban River	5	700
-do-	S10	Diversion Point to Bang Ban River	Ayutthaya	15	700
Noi	S11	Pakhai	Confluence Point with Bang Luan River	10	200
Noi (Bang Luan)	S12	Diversion Point from Chao Phraya River	Confluence Point with Bang Ban River	22	700
Noi (Bang Ban)	S13	Whole stretch		17	250
Noi	S14	Confluence Point with Bang Ban River	Confluence Point Chao Phraya River	20	900
Lop Buri	S15	Sing Buri	Lop Buri	20	200
-do-	S16	Lop Buri	Confluence Point with Bang Kaeo River	26	200
Bang Kaeo	S17	Whole stretch		13	150
Lop Buri	S18	Confluence Point with Bang Kaeo River	Ayutthaya	14	200
Pasak	S19	Rama VI Dam	Ayutthaya	45	900
Chao Phraya	S20	Ayutthaya	Confluence Point with Noi River	15	1,800
-do-	S21	Confluence Point with Noi River	Bang Sai	5	3,000

Table 2-12. COMPARISON OF OBSERVED AND SIMULATED ANNUAL PEAK DISCHARGES AND ANNUAL DISCHARGE VOLUME

Verification Point	Simulation Starting From	Year	Annual Peak Discharge				Annual Discharge Volume	
			Observed		Simulated		Observed	Simulated
			(m^3/s)	Date	(m^3/s)	Date	($10^6 m^3$)	($10^6 m^3$)
(1) Nakhon Sawan (C2)	Downstream points of Ping, Yom and Nan River /1	1978	3,540	Oct. 7	3,553	Oct. 7	31,215	31,779
		1980	4,320	Oct. 9	4,352	Oct. 9	29,709	30,255
		1983	2,290	Oct. 23	-	- /2	23,945	- /2
(2) Chai Nat (C13)	Nakhon Sawan (C2)	1978	3,741	Oct. 11	3,739	Oct. 7	19,727	23,370
		1980	3,795	Oct. 10	3,796	Oct. 10	20,725	22,036
		1983	3,290	Oct. 25	3,097	Oct. 27	16,889	18,560
(3) Angthong (C7A)	Chai Nat (C13)	1978	2,550	Oct. 12	2,967	Oct. 12	11,966	13,756
		1980	3,115	Oct. 13	3,024	Oct. 13	13,639	14,780
		1983	2,482	Oct. 25	2,604	Oct. 26	11,815	10,852

Note: /1 Kamphaeng Phet (P7A) of Ping River, San Ngam (Y17) of Yom River and Thaphan Hin (N10A).

/2 Simulation was not made due to the missing discharge data at Y17.

Table 2-13. EFFECTS OF MANNING'S ROUGHNESS COEFFICIENT ON COMPUTED STAGE FOR TIDAL COMPARTMENT

Date of Flood	Objective Point	Distance from River Mouth (km)	Observed and Computed Maximum Water Stage (m above MSL)					
			Observed	Computed by Varied Manning's (n) n=0.03	n=0.028	n=0.026	n=0.024	n=0.02
Oct 21 '78	Pak Nan	7	1.75	1.78	1.77	1.76	1.75	1.73
	Bangkok Port	27	1.73	1.92	1.87	1.83	1.80	1.75
	Satha Pradit	40	1.77	2.07	1.95	1.84	1.75	1.62
	Memorial Bridge	48	1.89	2.26	2.14	2.04	1.92	1.76
	RID Samsen	54	2.03	2.30	2.21	2.11	2.04	1.88
	Pakred	70	2.15	2.67	2.49	2.31	2.16	2.00
	Bang Sai	110	3.25	3.41	3.18	2.97	2.79	2.49
Oct 27 '80	Pak Nan	7	1.68	1.71	1.70	1.70	1.69	1.66
	Bangkok Port	27	1.77	1.78	1.73	1.70	1.66	1.61
	Satha Pradit	40	-	1.88	1.77	1.68	1.60	1.47
	Memorial Bridge	48	1.92	2.32	2.20	2.10	2.03	1.93
	RID Samsen	54	2.01	2.33	2.22	2.12	2.04	1.93
	Pakred	70	2.21	2.68	2.51	2.36	2.22	1.98
	Bang Sai	110	3.16	3.23	3.02	2.82	2.66	2.34
Oct 31 '83	Pak Nan	7	1.93	2.04	2.03	2.02	2.01	2.00
	Bangkok Port	27	1.97	2.14	2.11	2.10	2.08	2.06
	Satha Pradit	40	1.87	2.15	2.07	2.00	1.94	1.86
	Memorial Bridge	48	1.82	2.07	1.99	1.93	1.90	1.88
	RID Samsen	54	1.94	2.27	2.19	2.12	2.06	1.98
	Pakred	70	2.05	2.41	2.28	2.15	2.05	1.89
	Bang Sai	110	3.09	3.35	3.19	3.04	2.92	2.77

Table 2-14. CONSTANTS FOR TIDAL PREDICTION FORMULA AT FORT PHRA CHUL

CONSTITUENTS		CONSTANTS FOR 1978		CONSTANTS FOR 1980		CONSTANTS FOR 1983	
i	CYCLE Ti (HR)	AMPLETUDE Hi (M)	PHASE Ri (RAD)	AMPLETUDE Hi (M)	PHASE Ri (RAD)	AMPLETUDE Hi (M)	PHASE Ri (RAD)
1	8765.82422	0.16590	3.31894	0.12731	3.23874	0.14736	3.39769
2	4382.90625	0.04730	2.65788	0.04737	4.06928	0.04585	4.69960
3	661.30933	0.02141	0.32317	0.01360	3.20360	0.00880	0.04215
4	354.36694	0.00723	4.46429	0.01630	0.19595	0.00840	0.91319
5	327.85889	0.00299	0.64732	0.02234	3.32207	0.02680	2.51708
6	24.00000	0.02461	1.88119	0.03550	2.06727	0.04019	2.88921
7	23.93446	0.59835	2.72694	0.58481	2.85820	0.64441	2.88899
8	24.06589	0.19438	3.01946	0.18809	3.03100	0.17455	3.11989
9	24.13214	0.01141	-0.95539	0.01393	-0.51029	0.01045	-1.24002
10	23.86929	0.00591	0.25081	0.01776	-0.64174	0.05371	-0.73148
11	23.80447	0.01746	-1.06281	0.01929	-1.12477	0.01382	4.23182
12	24.84120	0.02206	3.21864	0.03302	-1.02316	0.01406	-1.00772
13	23.20695	0.00779	-0.77349	0.00973	3.99981	0.00100	4.53057
14	23.09848	0.02145	4.07350	0.01971	0.79343	0.02515	2.23615
15	24.70906	0.01022	0.20434	0.01322	4.22073	0.00653	3.49912
16	25.81934	0.35621	1.05281	0.30833	3.72591	0.40380	-1.40323
17	25.66812	0.03516	2.72095	0.07083	-1.26044	0.02798	0.27381
18	22.42018	0.04566	1.27614	0.03241	4.64898	0.04240	3.53555
19	22.30608	0.02352	1.18994	0.02426	-1.35951	0.03457	3.90042
20	26.72305	0.00890	-0.35848	0.01972	1.51319	0.01024	-0.49557
21	26.86836	0.05941	0.59283	0.06496	0.02463	0.06769	-0.14711
22	27.84839	0.00800	0.96843	0.01590	-0.41371	0.01236	2.50667
23	28.00623	0.00622	-0.45591	0.00432	4.16998	0.01114	1.17468
24	12.00000	0.28765	3.73524	0.28537	3.77340	0.27866	3.53473
25	12.01645	0.02955	-0.63727	0.02235	-0.53788	0.04117	4.26908
26	11.98360	0.02425	-0.59707	0.02011	0.23727	0.06404	-0.00376
27	11.96724	0.09187	-0.17670	0.09782	-0.04354	0.09812	-0.14813
28	12.19162	0.04106	4.70062	0.01659	-1.19211	0.03616	1.37229
29	12.22177	0.01581	-0.75972	0.01714	2.80822	0.01923	1.94738
30	11.78613	0.01372	1.01489	0.00444	0.22124	0.01305	-0.81790
31	11.75452	0.00604	0.68521	0.01733	-1.56307	0.00819	4.40608
32	12.42060	0.59429	1.25708	0.53392	4.13625	0.54115	-0.93723
33	11.60695	0.01450	2.57281	0.01649	-0.08596	0.01556	4.54853
34	12.45590	0.03833	3.60376	0.09276	1.32671	0.08650	1.42424
35	12.38551	0.02671	4.44754	0.06180	-0.81181	0.01146	-0.05445
36	12.65835	0.09054	0.62571	0.10215	0.29416	0.09382	0.03481
37	12.62600	0.01350	-0.91633	0.02769	1.87212	0.02491	-0.23624
38	12.87176	0.03148	1.09054	0.02000	0.19207	0.02200	3.02702
39	12.90538	0.02112	1.51821	0.02138	0.72540	0.01367	3.66487
40	13.12727	0.00623	0.83623	0.00482	0.76748	0.01129	4.53338
41	13.16671	0.00958	1.21399	0.01020	1.86399	0.01281	4.69037
42	7.99271	0.01554	-0.79450	0.01200	-0.74522	0.01399	-0.64518
43	8.17714	0.02026	2.74135	0.01452	-0.44397	0.01862	0.90648
44	8.19243	0.01452	3.92204	0.01286	0.41700	0.02110	1.80928
45	8.28041	0.00715	2.66405	0.00301	2.58846	0.00633	1.93824
46	8.38631	0.01964	1.88989	0.01600	0.79556	0.01699	3.67781
47	6.00001	0.00705	-0.78628	0.00761	-0.55556	0.00419	-0.47131
48	5.99180	0.00360	-0.28940	0.00290	0.71030	0.00494	0.04127
49	6.10334	0.02503	3.11459	0.02443	-0.27790	0.01928	0.98670
50	6.09485	0.00285	-1.20417	0.00662	1.25713	0.00317	1.04141
51	6.16020	0.00400	2.61011	0.00418	2.61111	0.00278	2.73232
52	6.21031	0.02853	0.85495	0.02442	0.03211	0.02392	2.74803
53	6.26918	0.01131	0.12316	0.00703	2.66009	0.00771	3.78920
54	4.04567	0.00313	4.15684	0.00465	1.34230	0.00688	2.35685
55	4.04194	0.00168	1.19847	0.00274	3.24459	0.00336	3.78235
56	4.09239	0.00994	1.85561	0.00836	1.28528	0.00554	3.81168
57	4.08857	0.00261	-1.46789	0.00343	3.56286	0.00053	-0.66542
58	4.11787	0.00395	1.65096	0.00184	3.64339	0.00135	-1.35679
59	4.14020	0.00741	-0.34896	0.00606	1.80641	0.00439	-0.71555
60	4.16628	0.00328	-0.65571	0.00305	3.52702	0.00297	0.16230
61	0.0	0.41679		0.47845		0.63102	

Note: /1 Constants for each year are estimated in the basin of tidal levels recorded for 357 days (1 Jan. to 23 Dec.) in the preceding year.

/2 Constant of 'Phase' is subject to the standard time at 0:00 AM on either 27th March in a non-leap year or 28th March in a leap year.

Table 2-15. MONTHLY AND ANNUAL EXTREME VALUES OF TIDAL LEVEL

Year	Month	Observed		Predicted	
		Maximum	Minimum	Maximum	Minimum
1978	JAN	1.95	-1.23	1.86	-1.32
	FEB	1.74	-1.16	1.81	-1.15
	MAR	1.69	-1.05	1.64	-0.99
	APR	1.75	-1.27	1.68	-1.30
	MAY	1.97	-1.51	1.63	-1.51
	JUN	2.04	-1.37	1.57	-1.59
	JUL	1.90	-1.34	1.55	-1.53
	AUG	1.72	-1.27	1.51	-1.26
	SEP	1.81	-1.10	1.48	-0.98
	OCT	2.04	-0.97	1.63	-1.07
	NOV	1.85	-1.11	1.73	-1.19
	DEC	1.83	-1.18	1.82	-1.28
	ANNUAL	2.04	-1.51	1.86	-1.59
1980	JAN	1.93	-1.22	1.85	-1.31
	FEB	1.78	-1.11	1.83	-1.22
	MAR	1.72	-1.01	1.71	-0.84
	APR	1.82	-1.15	1.66	-0.99
	MAY	1.70	-1.46	1.59	-1.12
	JUN	1.60	-1.50	1.52	-1.28
	JUL	1.75	-1.50	1.63	-1.45
	AUG	1.77	-1.30	1.69	-1.29
	SEP	1.75	-0.99	1.65	-0.94
	OCT	1.75	-0.94	1.69	-0.93
	NOV	1.94	-1.05	1.73	-1.02
	DEC	2.08	-1.06	1.77	-1.20
	ANNUAL	2.08	-1.50	1.85	-1.45
1983	JAN	2.12	-1.15	2.13	-1.14
	FEB	2.05	-1.03	1.96	-0.96
	MAR	1.90	-0.83	1.82	-0.81
	APR	1.90	-1.01	1.88	-0.88
	MAY	1.93	-1.19	1.86	-1.03
	JUN	2.17	-1.37	1.81	-1.31
	JUL	1.94	-1.32	1.75	-1.45
	AUG	2.09	-1.13	1.65	-1.33
	SEP	2.03	-1.05	1.62	-1.03
	OCT	2.13	-0.89	1.79	-0.87
	NOV	2.19	-0.65	2.00	-0.96
	DEC	2.25	-0.81	2.14	-1.07
	ANNUAL	2.25	-1.37	2.14	-1.45

Table 2-16. DIFFERENCES BETWEEN OBSERVED AND PREDICTED DAILY MAXIMUM TIDAL LEVEL (PREDICTED ONE YEAR IN ADVANCE)

Subject Year	Season	Maximum Difference (m)	Average Difference (m)	Occurrence of Difference in Daily Maximum Tidal Leve in One Year					
				Less than 0.1 m (day)	Less than 0.2 m (day)	Less than 0.3 m (day)	Less than 0.4 m (day)	Less than 0.5 m (day)	More than 0.5 m (day)
1978	Rainy Season	0.58	0.16	63	131	162	177	182	184
	Dry Season	0.32	0.09	128	165	180	181		
	Annual	0.58	0.12	191	296	342	358	363	365
1980	Rainy Season	0.38	0.11	97	158	178	184		
	Dry Season	0.45	0.13	83	141	171	179	182	
	Annual	0.45	0.12	180	299	349	363	366	
1983	Rainy Season	0.49	0.16	72	124	159	172	184	
	Dry Season	0.36	0.11	96	156	177	181		
	Annual	0.49	0.13	168	280	336	353	365	

Table 2-17. INVENTORY OF SELECTED WATER GAUGING STATIONS (STEP 1)

Code No.	River System	Station Number	Location: District	Location: Province	Location: Latitude	Location: Longitude	Type of Gauge /1	Administration Office /2
W-H.1	Wang	W10A	Chae Hon	Lampang	18°31'16"	99°37'52"	V	HyD
W-H.2	Wang	W3A	Thoen	Lampang	17°38'29"	99°14'04"	F	HyD
W-H.3	Wang	W4A	Sam Ngao	Tak	17°12'22"	99°06'08"	F	HyD
W-H.4	Ping	P12	Sam Ngao	Tak	17°14'30"	99°00'45"	F	HyD
W-H.5	Ping	P7A	Muang	Kamphaeng Phet	16°28'38"	99°31'06"	V	HyD
W-H.6	Yom	Y20	Song	Phrae	18°35'03"	100°09'17"	B	HyD
W-H.7	Yom	Y14	Si Satchanalai	Sukhotai	17°35'42"	99°43'08"	V	HyD
W-H.8	Yom	Y4	Muang	Sukhotai	17°00'18"	99°49'31"	V	HyD
W-H.9	Yom	Y17	Sam Ngam	Phichit	16°30'50"	100°12'40"	V	HyD
W-H.10	Nan	N33	Nam Pat	Uttaradit	17°43'05"	100°34'32"	F	HyD
W-H.11	Nan	N12A	Tha Pla	Uttaradit	17°44'10"	100°32'28"	F	HyD
W-H.12	Nan	N27A	Phrom Phiram	Phitsanulok	17°01'54"	100°11'05"	B	HyD
W-H.13	Nan	N5A	Muang	Phitsanulok	16°49'15"	100°15'49"	B	HyD
W-H.14	Nan	N40	Wat Bot	Phitsanulok	17°13'14"	100°21'10"	V	Hyd
W-H.15	Nan	N24	Wang Thong	Phitsanulok	16°50'35"	100°31'20"	B	HyD
W-H.16	Nan	N10A	Taphan Hin	Phichit	16°12'42"	100°25'01"	F	HyD
W-H.17	Pasak	S9	Kaeng Khoi	Saraburi	14°37'33"	101°01'00"	F	HyD
W-H.18	Pasak	S5	Muang	Ayutthaya	14°21'32"	100°35'02"	B	HyD
W-H.19	Sakae Krang	Ct8	Thap Than	Uthai Thani	15°29'30"	99°56'28"	V	HyD
W-H.20	Chao Phraya	C2	Muang	Nakhon Sawan	15°40'15"	100°06'45"	F	HyD
W-H.21	Chao Phraya	C13	Sanphaya	Chai Nat	15°09'57"	100°11'32"	V	HyD
W-H.22	Chao Phraya	C3	Muang	Sing Buri	14°53'44"	100°24'14"	V	HyD
W-H.23	Lop Buri	L2A	Muang	Lop Buri	14°47'37"	100°36'34"	V	HyD
W-H.24	Chao Phraya	C7A	Muang	Ang Thong	14°35'05"	100°27'12"	V	HyD
W-H.25	Chao Phraya	C29	Bang Sai	Ayutthaya	14°11'33"	100°30'23"	V	HyD
W-H.26	Chao Phraya	C22	Pakred /3	Nonthaburi	13°53'47"	100°29'39"	F	HyD
W-H.27	Chao Phraya	C12	Dasit /4	Bangkok	13°47'14"	100°30'56"	F	HyD
W-H.28	Chao Phraya	C4	Thon Buri	Bangkok	13°44'15"	100°29'55"	F	HyD
W-PAT	Chao Phraya	Fort Phra Chul	Pom Phra Chulachomklao	Bangkok	13°32'50"	100°34'58"	F	PAT
W-M1	Pasak	Lom Sak	Lom Sak	Phetchabun	16°46'25"	101°14'58"	V	MD
W-M2	Pasak	Wichian Buri	Wichian Buri	Phetchabun	15°39'25"	101°06'30"	V	MD

Note: /1 V = Vertical Staff Gauge; F = Recorder, Float Gauge; B = Recorder, Bubble Gauge
/2 HyD = Hydrology Division, RID; PAT = Port Authority of Thailand; MD = Meteorological Department
/3 RID Pakred Office
/4 RID Bangkok Office

Table 2-18. INVENTORY OF SELECTED RAINFALL GAUGING STATIONS (STEP 1)

Code No.	Location					Type of Gauge /1	Administration Office /2
	River Basin	District	Province	Latitude	Longitude		
R-H.1	Ping	Khlong Lan	Kamphaeng Phet	16°20'03"	99°16'29"	R	HyD
R-H.2	Ping	Khlong Khlung	Kamphaeng Phet	16°04'22"	99°24'18"	R	HyD
R-H.3	Ping	Khanu	Kamphaeng Phet	15°54'10"	99°28'45"	R	HyD
R-H.4	Sakae Krang	Lat Yao	Nakhon Sawan	15°47'01"	99°40'55"	NR	Hyd
R-H.5	Sakae Krang	Lat Yao	Nakhon Sawan	15°38'23"	99°32'20"	R	HyD
R-H.6	Sakae Krang	Lam Sak	Uthai Thani	15°31'38"	99°28'10"	R	HyD
R-H.7	Yom	Song	Phrae	18°35'03"	100°09'17"	R	HyD
R-H.8	Yom	Satchanalai	Sukhotai	17°35'42"	99°43'08"	R	HyD
R-H.9	Nan	Tha Pla	Uttaradit	17°44'10"	100°32'28"	R	HyD
R-H.10	Nan	Muang	Phitsanulok	16°49'15"	100°15'52"	R	HyD
R-H.11	Nan	Wang Thong	Phitsanulok	16°50'35"	100°31'20"	R	HyD
R-H.12	Ping/Yom/Nan	Muang	Nakhon Sawan	15°40'15"	100°06'45"	NR	HyD
R-O.1	Wang	Muang	Lampang	18°26'16"	99°38'04"	R	RO
R-O.2	Nan	Muang	Uttaradit	17°37'38"	100°06'33"	NR	RO
R-O.3	Nan	Phrom Phiram	Phitsanulok	17°02'50"	100°10'52"	NR	RO
R-O.4	Pasak	Khlong Phrieo	Saraburi	14°31'34"	100°56'08"	NR	RO
R-M.1	Wang	Muang	Lampang	18°17'23"	99°30'27"	R	MD
R-M.2	Wang	Thoen	Lampang	17°36'39"	99°13'08"	R	MD
R-M.3	Ping	Sam Ngae	Tak	17°14'30"	99°03'45"	R	MD
R-M.4	Ping	Muang	Tak	16°52'50"	99°07'36"	R	MD
R-M.5	Ping	Muang	Kamphaeng Phet	16°28'56"	99°31'26"	NR	MD
R-M.6	Yom	Song	Phrae	18°28'06"	100°11'11"	NR	MD
R-M.7	Yom	Muang	Phrae	18°08'44"	100°08'42"	R	MD
R-M.8	Yom	Muang	Sukhothai	17°00'21"	99°49'36"	NR	MD
R-M.9	Yom	Sam Ngam	Phichit	16°30'25"	100°12'23"	NR	MD
R-M.10	Nan	Muang	Uttaradit	17°37'32"	100°05'57"	R	MD
R-M.11	Nan	Muang	Phitsanulok	16°49'24"	100°15'45"	R	MD
R-M.12	Nan	Taphan Hin	Phichit	16°12'44"	100° 25'23"	NR	MD
R-M.13	Pasak	Lom Sak	Phetchabun	16°46'42"	101°14'45"	NR	MD
R-M.14	Pasak	Muang	Phetchabun	16°25'00"	101°09'35"	R	MD
R-M.15	Pasak	Nong Phai	Phetchabun	15°59'13"	101°03'53"	NR	MD
R-M.16	Pasak	Wichianburi	Phetchabun	15°39'20"	101°06'37"	R	MD
R-M.17	Pasak	Bua Chum	Lop Buri	15°15'50"	101°11'00"	R	MD
R-M.18	Pasak	Chai Badam	Lop Buri	15°02'12"	101°08'11"	NR	MD

Note: /1 R = Recording Raingauge; NR = Non-Recording Raingauge
/2 HyD = Hydrology Division, RID; RO = Regional Office, RID; MD = Meteorological Department

Table 2-19. WATER LEVEL GAUGING STATIONS TO MONITOR AND CALIBRATE THE RIVER FLOW DISCHARGE (STEP 1 FLOOD FORECASTING SYSTEM)

River System	Monitor and Calibration Items	Station Code No.	Location
Ping	Discharge	W-H.5	Kamphaeng Phet (P7A)
Wang	Discharge	W-H.2	Thoen (W3A)
Wang	Discharge	W-H.3	Wang Khrai (W4A)
Yom	Discharge	W-H.7	Si Satchanalai (Y14)
Yom	Discharge	W-H.8	Sukhotai (Y4)
Yom	Discharge	W-H.9	Sam Ngam (Y17)
Nan	Discharge	W-H.12	Lower Naresuan Dam (N27A)
Nan	Discharge	W-H.13	Phitsanulok (N5A)
Nan	Discharge	W-H.16	Thaphan Hin (N10A)
Sakae Krang	Discharge	W-H.19	Thap Than (Ct8)
Pasak	Discharge	W-M.2	Wichian Buri
Pasak	Discharge	W-H.17	Saraburi (S9)
Pasak	Water Level	W-H.18	Ayutthaya (S5)
Chao Phraya	Discharge/Water Level	W-H.20	Nakhon Sawan (C2)
Chao Phraya	Discharge/Water Level	W-H.21	Lower Chao Phraya Dam (C13)
Chao Phraya	Discharge/Water Level	W-H.22	Sing Buri (C3)
Lop Buri	Discharge/Water Level	W-H.23	Lop Buri (L2A)
Chao Phraya	Discharge/Water Level	W-H.24	Angthong (C7A)
Chao Phraya	Discharge/Water Level	W-H.25	Bang Sai (C29)
Chao Phraya	Water Level	W-H.26	Pakred (C22)
Chao Phraya	Water Level	W-H.27	RID Bangkok Office
Chao Phraya	Water Level	W-H.28	Memorial Bridge
Chao Phraya	Water Level	W-PAT /1	Fort Phra Chul (Gulf)

Note: /1 The observed water level is also used to predict the tidal level in the Gulf of Thailand.

Table 2-20. WATER LEVEL GAUGING STATIONS TO INPUT THE OBSERVED DISCHARGE AS BOUNDARY CONDITION (STEP 1 FLOOD FORECASTING SYSTEM)

Item of Prediction		Applied Gauging Station		
Prediction Time	Target Point	River System	Station Code No.	Location
Short	Bangkok Metropolis	(1) Chao Phraya	W-H25	Bang Sai (C29)
Short	Ayutthaya	(1) Chao Phraya	W-H21	Lower Chao Phraya Dam (C13)
		(2) Pasak	W-M2	Wichian Buri
Short	Chai Nat, Sing Buri, Lop Buri and Angthong	(1) Ping	W-H5	Kamphaeng Phet (P7A)
		(2) Yom	W-H9	Sam Ngam (Y17)
		(3) Nan	W-H16	Thaphan Hin (N10A)
Short	Nakhon Sawan	(1) Ping	W-H4	Lower Bhumibol Dam (P12)
		(2) Wang	W-H3	Wang Khrai (W4A)
		(3) Yom	W-H9	Sam Ngam (Y17)
		(4) Nan	W-H13	Phitsanulok (N5A)
		(5) Nan	W-H15	Kehk River (N24)
Long	All Target Points	(1) Ping	W-H4	Lower Bhumibol Dam (P12)
		(2) Wang	W-H1	Lower Kiu Lom Dam (W10A)
		(3) Yom	W-H6	Ngao Sak (Y20)
		(4) Nan	W-H11	Lower Sirikit Dam (N12A)
		(5) Nan	W-H10	Nan Pat River (N33)

Table 2-21. POINT RAINFALL GAUGING STATIONS APPLIED TO BASIN RUNOFF PREDICTION MODEL (STEP 1 FLOOD FORECASTING SYSTEM)

Objective Basin		Applied Gauging Station		
Basin Code No. /1	River System	Station Code No. /Location	Station Code No. /Location	Station Code No. /Location
BS-2	Wang	R-O.1/Lampang	R-M.1/Lampang	R-M.2/Thoen
BS-3	Wang/ Ping	R-M.3/Sam Ngam	R-M.4/Tak	R-M.5/Kamphaeng Phet
BS-4	Ping	R-M.5/Kamphaeng Phet R-H.1/Khlong Lan	R-H.2/Khlong Klung	R-H.12/Nakhon Sawan
BS-5	Yom	R-M.7/Phrae	R-H.8/Satchanalai	R-M.6/Song
BS-6	Yom	R-H.8/Satchanalai	R-M.8/Sukhothai	
BS-8	Nan	R-H.9/Tha Pla R-H.10/Phitsanulok (R-M.11/ Phitsanulok) /2	R-O.2/Uttaradit (R-M.8/ Uttaradit) /2	R-O.3/Phrom Phiram
BS-9	Nan	R-H.11/Wang Thong	R-H.10/Phitsanulok (R-M/11/Phitsanulok)	
BS-10	Nan/ Yom	R-M.8/Sukhotai R-M.9/Sam Ngam	R-M.12/Taphan Hin	R-H.12/Nakhon Sawan
BS-11	Sakae Krang	R-H.3/Khanu R-H.4/Lat Yao	R-H.5/Lat Yao	R-H.6/Lan Sak
BS-12	Tha Pla Pai	R-H.12/Nakhon Sawan		
BS-13	Pasak	R-M.10/Lom Sak	R-M.11/Phetchabun	R-M.12/Nong Phai
BS-14	Pasak	R-M.13/Wichian Buri R-M.14/Bua Chun	R-M.15/Chai Badam	R-O.4/Khlong Phrieo

Note: /1 Step 1 Flood Forecasting System does not cover the upper reaches of Bhumibol and Sirikit dams which correspond to Basin Code Nos. 1 and 7.

/2 Gauging station in parenthesis is applied as secondary station to supplement lacking data of the main station.

Table 2-22. ANNUAL PEAK DISCHARGE PREDICTED AT TARGET POINT THROUGH STEP 1 FLOOD FORECASTING SYSTEM

Target Point	Year	Observed		Predicted 3 Days in Advance		Predicted 6 Days in Advance	
		m^3/s	Date	m^3/s	Date	m^3/s	Date
Nakhon Sawan	1978	3,540	Oct. 07	3,329	Oct. 07	3,228	Oct. 08
Chai Nat	1978	3,741	Oct. 11	3,693	Oct. 10	3,408	Oct. 11
Angthong	1978	2,550	Oct. 10	2,996	Oct. 12	2,693	Oct. 12
Nakhon Sawan	1980	4,320	Oct. 09	4,461	Oct. 09	4,580	Oct. 09
Chai Nat	1980	3,795	Oct. 10	3,789	Oct. 10	3,796	Oct. 10
Angthong	1980	3,115	Oct. 15	3,024	Oct. 13	3,011	Oct. 11
Nakhon Sawan	1983	2,290	Oct. 23	- /1	- /1	2,348	Oct. 24
Chai Nat	1983	3,290	Oct. 25	3,079	Oct. 27	3,139	Oct. 27
Angthong	1983	2,482	Oct. 24	2,604	Oct. 26	2,477	Oct. 28

Note: /1 Prediction was not made because of the missing upstream observed discharge data at Y17.

Table 2-23. ONE-DAY MAXIMUM WATER LEVEL PREDICTED FOR TIDAL COMPARTMENT THROUGH STEP 1 FORECASTING SYSTEM

Observation/ Prediction Date /1	Objective Point		Observed		Predicted 3 Days in Advance		Predicted 6 Days in Advance	
	Location Name	Distance from River Mouth (km)	Water Level (m. MSL)	Time	Water Level (m. MSL)	Time	Water Level (m. MSL)	Time
Oct. 21 1978	Bangkok Port	27	1.73	10:00	1.56	11:00	1.52	11:00
	Satha Pradit	40	1.77	10:00	1.54	11:00	1.47	11:00
	Memorial Bridge	48	1.89	10:00	1.93	10:00	1.86	10:00
	RID Samsen	54	2.03	12:00	1.90	11:00	1.83	11:00
	Pakred	70	2.15	12:00	2.01	13:00	1.88	12:00
Oct. 27 1980	Bangkok Port	27	1.77	09:00	1.69	10:00	1.69	10:00
	Satha Pradit	40	Data Missing		1.63	11:00	1.65	11:00
	Memorial Bridge	48	1.92	10:00	1.97	10:00	2.06	10:00
	RID Samsen	54	2.01	10:00	1.98	11:00	2.00	11:00
	Pakred	70	2.21	11:00	2.26	12:00	2.30	12:00
Oct. 31 1983	Bangkok Port	27	1.97	15:00	1.76	16:00	1.72	16:00
	Satha Pradit	40	1.87	16:00	1.72	17:00	1.60	17:00
	Memorial Bridge	48	1.82	16:00	2.08	16:00	1.97	16:00
	RID Samsen	54	1.94	17:00	1.85	17:00	1.73	17:00
	Pakred	70	2.05	18:00	2.11	19:00	1.90	19:00

Note: /1 Date of observation of annual maximum discharge at Bang Sai.

Table 2-24. FLOOD LAG TIME

(1) Downstream Point	(2) Upstream Point	(3) Flood Year	(4) Date of Qmax Predicted at (2)	(5) Date of Qmax Observed at (2)	(6) Date of Qmax Observed at (1)	(7) Concentration time (5)-(4) (day)	(8) Traveling Time (6)-(5) (day)	(9) Flood Lag Time (6)-(4) (day)
Nakhon Sawan	Sta. W-H.5	1978	29 Sep	02 Oct	07 Oct	3	5	8
(Sta. W-H.20)	Ping River	1980	02 Oct	04 Oct	10 Oct	2	6	8
		1983	15 Oct /1	20 Oct	23 Oct	5	3	8
	Sta. W-H.7	1978	23 Sep	26 Sep	07 Oct	3	11	14
	Yom River	1980	07 Sep	08 Sep	10 Oct	1	31	32
		1983	04 Oct	06 Oct	23 Oct	2	18	20
	Sta. W-H.13	1978	23 Sep	25 Sep	07 Oct	2	12	14
	Nan River	1980	07 Sep	09 Sep	10 Oct	2	31	33
		1983	05 Oct	07 Oct	23 Oct	2	16	18
Chai Nat	Sta. W-H.14	1978	06 Oct	-	11 Oct	-	-	5
(Sta. W-H.21)	Sakae Krang River	1980	06 Oct /1	-	12 Oct	-	-	6
		1983	18 Oct /1	-	25 Oct	-	-	7
Ayutthaya (1)	Sta. W-H.17	1978	30 Sep	03 Oct	03 Oct	3	0	3
(Sta. W-H.17	Pasak River	1980	01 Oct	05 Oct	05 Oct	4	0	4
		1983	10 Oct /1	14 Oct	14 Oct	4	0	4
Ayutthaya (2)	Sta. W-H.21	1978	-	11 Oct	17 Oct /2	-	6	6
(Sta. W-H.18)	(Chai Nat Dam)	1980	-	13 Oct	28 Oct /2	-	15	15
	Chao Phraya River	1983	-	25 Oct	01 Nov /2	-	7	7
Bang Sai	Sta. W-H.21	1978	-	11 Oct	27 Oct	-	16	16
(Sta. W-H.24)	(Chai Nat Dam)	1980	-	13 Oct	01 Nov	-	20	20
	Chao Phraya River	1930	-	25 Oct	05 Nov	-	11	11

Note: /1 Date of the maximum one day rainfall is substituted.
/2 Date of the predicted discharge is substituted.

Table 2-25(1/3). ANNUAL PEAK DISCHARGE AND ANNUAL DISCHARGE VOLUME SIMULATED THROUGH VARIED POINT RAINFALL GAUGING NETWORK

Case of Observation and Simulation			Objective Basin: Upper Reaches from Bhumibol Dam (C.A. = 20,031 km^2) /1			
Year	Case No.	Density of Rainfall Gauging Network (km^2/station)	Number of Rainfall Stations	Annual Peak Discharge (m^3/s)	Annual Peak Discharge (Date)	Annual Discharge Volume ($10^6 m^3$)
1978	(1) Observation	-	-	1,267	Oct. 06	6,829
	(2) Simulation 1	1000	20	1,327	Oct. 05	6,771
	(3) simulation 2	1200	17	1,337	Oct. 05	6,797
	(4) Simulation 3	1400	13	1,431	Oct. 05	6,967
	(5) Simulation 4	1600	13	1,431	Oct. 05	6,967
	(6) Simulation 5	more than 1800	11	1,368	Oct. 05	6,167
1980	(1) Observation	-	-	1,662	Oct. 08	6,156
	(2) Simulation 1	1000	19	1,547	Oct. 08	6,214
	(3) Simulation 2	1200	17	1,587	Oct. 08	6,185
	(4) Simulation 3	1400	13	1,627	Oct. 08	5,939
	(5) Simulation 4	1600	12	1,635	Oct. 08	5,930
	(6) Simulation 5	more than 1800	10	1,805	Oct. 08	5,499
1983	(1) Observation	-	-	1,574	Oct. 19	4,939
	(2) Simulation 1	1000	20	1,593	Oct. 19	5,041
	(3) Simulation 2	1200	16	1,577	Oct. 20	5,013
	(4) Simulation 3	1400	14	1,670	Oct. 20	5,551
	(5) Simulation 4	1600	13	1,652	Oct. 20	5,547
	(6) Simulation 5	more than 1800	11	1,709	Oct. 20	5,285

Note: /1 Covering the sub-basin of Code No. BS-1.

Table 2-25(2/3). ANNUAL PEAK DISCHARGE AND ANNUAL DISCHARGE VOLUME SIMULATED THROUGH VARIED POINT RAINFALL GAUGING NETWORK

Case of Observation and Simulation			Objective Basin: Upper Reaches from Nakhon Sawan (C.A. = 58,721 km^2) /1			
Year	Case No.	Density of Rainfall Gauging Network (km^2/station)	Number of Rainfall Stations	Annual Peak Discharge (m^3/s)	(Date)	Annual Discharge Volume ($10^6 m^3$)
1978	(1) Observation	-	-	3,540	Oct. 07	31,215
	(2) Simulation 1	1000	59	3,579	Oct. 07	30,892
	(3) simulation 2	1200	49	3,514	Oct. 08	30,139
	(4) Simulation 3	1400	42	3,378	Oct. 08	28,477
	(5) Simulation 4	1600	37	3,390	Oct. 08	29,453
	(6) Simulation 5	more than 1800	33	3,268	Oct. 08	29,780
1980	(1) Observation	-	-	4,320	Oct. 09	29,085
	(2) Simulation 1	1000	57	4,360	Oct. 09	30,753
	(3) Simulation 2	1200	49	4,373	Oct. 09	30,959
	(4) Simulation 3	1400	40	4,434	Oct. 09	30,501
	(5) Simulation 4	1600	38	4,514	Oct. 09	31,081
	(6) Simulation 5	more than 1800	34	4,580	Oct. 09	31,663
1983	(1) Observation	-	-	2,290	Oct. 23	23,945
	(2) Simulation 1	1000	58	2,324	Oct. 24	24,831
	(3) Simulation 2	1200	48	2,332	Oct. 24	25,081
	(4) Simulation 3	1400	42	2,229	Oct. 24	24,962
	(5) Simulation 4	1600	37	2,304	Oct. 24	25,612
	(6) Simulation 5	more than 1800	32	2,372	Oct. 24	26,319

Note: /1 Covering the sub-basins of Code Nos. BS-2, 3, 4, 5 6, 7, 8, 9 and 10.

Table 2-25(3/3). ANNUAL PEAK DISCHARGE AND ANNUAL DISCHARGE VOLUME SIMULATED THROUGH VARIED POINT RAINFALL GAUGING NETWORK

Case of Observation and Simulation			Objective Basin: Pasak River Upper Reaches from Saraburi (S.9) (C.A. = 8,124 km^2) /1			
Year	Case No.	Density of Rainfall Gauging Network (km^2/station)	Number of Rainfall Stations	Annual Peak Discharge (m^3/s)	(Date)	Annual Discharge Volume (10^6m^3)
1978	(1) Observation	-	-	3,206	Oct. 03	5,186
	(2) Simulation 1	1000	-	-	-	-
	(3) simulation 2	1200	7	3,272	Oct. 03	5,318
	(4) Simulation 3	1400	-	-	-	-
	(5) Simulation 4	1600	5	3,305	Oct. 03	6,023
	(6) Simulation 5	more than 1800	3	3,309	Oct. 03	6,239
1980	(1) Observation	-		No Notable Flood		
	(2) Simulation 1	1000				
	(3) Simulation 2	1200				
	(4) Simulation 3	1400				
	(5) Simulation 4	1600				
	(6) Simulation 5	more than 1800				
1983	(1) Observation	-		No Notable Flood		
	(2) Simulation 1	1000				
	(3) Simulation 2	1200				
	(4) Simulation 3	1400				
	(5) Simulation 4	1600				
	(6) Simulation 5	more than 1800				

Note: /1 Covering the sub-basin of Code No. BS-14.

Table 2-26(1/2). INVENTORY OF POINT RAINFALL GAUGING STATIONS SELECTED FOR STEP 2 FLOOD FORECASTING SYSTEM

Installation Priority	Code No.	River Basin	Location	
			Latitude	Longitude
1	R-1.1	Sakae Krang	15°54'	99°28'
1	R-1.2	"	15°47'	99°41'
1	R-1.3	"	15°38'	99°32'
1	R-1.4	"	15°28'	99°34'
1	R-1.5	Chao Phraya	15°20'	100°32'
1	R-1.6	Pasak	15°28'	101°04'
1	R-1.7	"	15°13'	101°16'
1	R-1.8	"	15°04'	101°04'
1	R-1.9	"	14°51'	100°59'
1	R-1.10	"	14°37'	101°11'
2	R-2.1	Ping	16°52'	99°07'
2	R-2.2	"	16°46'	98°55'
2	R-2.3	"	16°20'	99°16'
2	R-2.4	"	16°12'	99°43'
2	R-2.5	"	16°03'	99°51'
2	R-2.6	"	15°56'	99°59'
2	R-2.7	Yom	16°49'	99°48'
2	R-2.8	"	16°39'	99°35'
2	R-2.9	"	16°27'	99°53'
2	R-2.10	Nan	16°52'	100°45'
2	R-2.11	"	16°50'	100°31'
2	R-2.12	"	16°42'	100°36'
2	R-2.13	"	16°25'	100°33'
2	R-2.14	"	16°12'	100°25'
2	R-2.15	Nan	16°10'	100°33'
2	R-2.16	"	16°11'	100°51'
2	R-2.17	"	15°51'	100°35'
2	R-2.18	"	15°38'	100°29'
2	R-2.19	"	15°35'	100°39'
2	R-2.20	Pasak	16°25'	101°09'
2	R-2.21	"	15°59'	101°03'
2	R-2.22	"	15°59'	101°14'

Table 2-26(2/2). INVENTORY OF POINT RAINFALL GAUGING STATIONS SELECTED FOR STEP 2 FLOOD FORECASTING SYSTEM

Installation Priority	Code No.	River Basin	Location	
			Latitude	Longitude
3	R-3.1	Wang	18°17'	99°30'
3	R-3.2	"	18°07'	99°31'
3	R-3.3	"	17°52'	99°20'
3	R-3.4	Yam	18°23'	100°22'
3	R-3.5	"	18°08'	100°08'
3	R-3.6	"	18°04'	99°50'
3	R-3.7	"	17°53'	99°36'
3	R-3.8	"	17°19'	99°33'
3	R-3.9	"	17°00'	99°34'
3	R-3.10	Nan	17°37'	100°05'
3	R-3.11	"	17°28'	100°07'
3	R-3.12	"	17°13'	100°21'
3	R-3.13	"	17°17'	100°33'
3	R-3.14	"	17°05'	100°50'
4	R-4.1	Ping	18°50'	98°58'
4	R-4.2	"	18°51'	99°17'
4	R-4.3	"	18°50'	98°44'
4	R-4.4	"	18°42'	99°02'
4	R-4.5	"	18°29'	98°21'
4	R-4.6	"	18°24'	98°40'
4	R-4.7	"	18°27'	99°08'
4	R-4.8	"	18°17'	98°19'
4	R-4.9	"	18°18'	98°49'
4	R-4.10	"	18°03'	98°38'
4	R-4.11	"	17°47'	98°21'
4	R-4.12	"	17°48'	98°57'
4	R-4.13	"	17°39'	98°46'
4	R-4.14	"	17°22'	98°29'
4	R-4.15	Nan	18°44'	101°01'
4	R-4.16	"	18°34'	100°45'
4	R-4.17	"	18°23'	100°51'
4	R-4.18	"	18°19'	100°43'
4	R-4.19	"	18°02'	101°01'

Table 2-27. INVENTORY OF POINT RAINFALL AND WATER LEVEL GAUGING STATIONS SELECTED FOR STEP 2 FLOOD FORECASTING SYSTEM

Installation Priority	Station Code No.	River System	Location		Existing /1 Gauging Station Located Nearby	Existing River Structure Located Nearby
			Latitude	Longitude		
1	W/R-1.1	Chao Phraya	15°40'	100°06'	C2 (RID)	-
1	W/R-1.2	Sakae Krang	15°29'	99°56'	-	-
1	W/R-1.3	Pasak	16°46'	101°14'	Wichian Buri (MD)	-
1	W/R-1.4	"	14°33'	100°45'	-	Upper Rama VI Dam Site
2	W/R-2.1	Ping	17°12'	99°06'	W4A (RID)	-
2	W/R-2.2	"	16°28'	99°31'	P7A (RID)	-
2	W/R-2.3	Yom	16°30'	100°12'	Y17 (RID)	-
2	W/R-2.4	Nan	16°49'	100°15'	N5A (RID)	-
2	W/R-2.5	"	16°12'	100°25'	N10A (RID)	-
2	W/R-2.6	Pasak	16°46'	101°14'	Lom Sak (MD)	-
3	W/R-3.1	Wang	18°31'	99°37'	W10A (RID)	Lower Kiu Lom Dam Site
3	W/R-3.2	"	17°38'	99°14'	W3A (RID)	-
3	W/R-3.3	Yom	18°35'	100°09'	Y20 (RID)	-
3	W/R-3.4	"	17°35'	99°43'	Y14 (RID)	-
3	W/R-3.5	"	17°00'	99°49'	Y4 (RID)	-
3	W/R-3.6	Nan	17°44'	100°32'	N12A (RID)	Lower Sirikit Dam Site
3	W/R-3.7	"	17°01'	100°11'	N27A (RID)	Upper Naresuan Dam Site
4	W/R-4.1	Ping	18°47'	99°00'	P1 (RID)	-
4	W/R-4.2	Nan	18°46'	100°46'	N1	-

Note: /1 The name in parenthesis means the office controlling the existing water level gauging station.

Table 2-28(1/2). POINT RAINFALL GAUGING STATIONS APPLIED TO BASIN RUNOFF PREDICTION MODEL (STEP 2 FLOOD FORECASTING SYSTEM)

Objective Basin		Applied Gauging Station		
Basin Code No.	River System	Station Code No. /Location	Station Code No. /Location	Station Code No. /Location
BS-1	Ping	W/R-4.1/Chiang Mai R-4.3/Mae Rim R-4.6/Chom Thong R-4.9/Hot R-4.12/Li	R-4.1/Samoeng R-4.4/Sarapi R-4.7/Mae Tha R-4.10/Ban Aen R-4.13/Ban Ko	R-4.2/Sam Kamphaeng R-4.5/Mae Chaem R-4.8/Huai Mae Ka R-4.11/Omkoi R-4.14/Ban San Mamuang
BS-2	Wang	W/R-3.1/Kiu Lom Dam R-3.3/Sop Prap	R-3.1/Lampang W/R-3.2/Thoen	R-3.2/Mae Tha
BS-3	Ping	W/R-2.1/Wang Khrai R-2.3/Khlong Lan	R-2.1/Tak W/R-2.2/Kamphaeng Phet	R-2.2/Doi Musae
BS-4	Ping	W/R-2.2/Kamphaeng Phet R-2.6/Banphot Phisai	R-2.4/Khlong Khlung W/R-1.1/Nakhon Sawan	R-2.5/Ban Pang Wai
BS-5	Yom	W/R-3.3/Ngao Sak R-3.6/Long	R-3.4/Rong Kwang R-3.7/Wang Chin	R-3.5/Phrae W/R-3.4/Si Satchanalai
BS-6	Yom	W/R-3.4/Si Satchanalai W/R-3.5/Sukhotai	R-3.8/Thung Saliam	R-3.9/Ban Dan Lan Hoi
BS-7	Nan	W/R-4.2/Nan R-4.17/Na Noi W-R-3.6/Tha Pla	R-4.15/Mae Charim R-4.18/Yan Sarang	R-4.16/Sa R-4.19/Nam Pat
BS-8	Nan	W/R-3.6/Tha Pla R-3.12/Ban Nong Bon W/R-3.7/Naresuan Dam	R-3.10/Uttaradit R-3.13/Chattrakan W/R-2.4/Phitsanulok	R-3.11/Thron R-3.14 Nakhon Thai
BS-9	Nan	W/R-2.4/Phitsanulok R-2.12/Nan Khek	R-2.10/Khao Krayang R-2.13/Wang Saiphum	R-2.11/Wang Nok Aen

Table 2-28(2/2). POINT RAINFALL GAUGING STATIONS APPLIED TO BASIN RUNOFF PREDICTION MODEL (STEP 2 FLOOD FORECASTING SYSTEM)

Objective Basin		Applied Gauging Station		
Basin Code No.	River System	Station Code No. /Location	Station Code No. /Location	Station Code No. /Location
BS-10	Nan/ Yom	R-2.7/Khirimat R-2.13/Wang Saiphum R-2.16/Chon Daen R-2.19/Phaisali	R-2.8/Phran Kratai R-2.14/Bang Mun Nak R-2.17/Nong Bua W/R-2.3/Sam Ngam	R-2.9/Sai Ngam R-2.15/Thap Khlo R-2.18/Thatako W/R-2.5/Taphan Hin
BS-11	Sakae Krang	R-1.1/Ban Pang Makha R-1.4/Lan Sak	R-1.2/Ban San Chao W/R-1.2/Uthai Thani	R-1.3/Khlong Pho
BS-12	Tha Pla Pi	R-1.5/Ban Mi		
BS-13	Pasak	W/R-2.6/Lom Sak R-2.22/Ban Wang Thadi	R-2.20/Phetchabun W/R-1.2/Wichian Buri	R-2.21/Nong Phai
BS-14	Pasak	W/R-1.3/Wichian Buri R-1.8/Chai Badam W/R-1.4/Rama VI Dam	R-1.6/Kok Saat R-1.9/Phatthana Nikhom	R-1.7/Ban Tha Ruak R-1.10/Kham Takhian

Table 2-29(1/2). INVENTORY OF WATER LEVEL GAUGING STATIONS SELECTED FOR STEP 2 FLOOD FORECASTING SYSTEM

Installation Priority	Station Code No.	River System	Location		Existing /1 Gauging Station Located Nearby	Existing River Structure Located Nearby
			Latitude	Longitude		
1	W-1.1	Chao Phraya	15°09'	100°11'	C13 (RID)	Chao Phraya Dam
1	W-1.2	"	14°53'	100°24'	C3 (RID)	-
1	W-1.3	Lop Buri	14°47'	100°36'	L2A (RID)	-
1	W-1.4	Chao Phraya	14°35'	100°27'	C7A (RID)	-
1	W-1.5	"	14°21'	100°35'	S5 (RID)	-
1	W-1.6	"	14°11'	100°30'	C29 (RID)	-
1	W-1.7	"	13°53'	100°29'	C22 (RID)	-
1	W-1.8	"	13°47'	100°30'	C12 (RID)	-
1	W-1.9	"	13°44'	100°29'	C4 (RID)	-
1	W-1.10	"	13°32'	100°34'	Phra Chul (PAT)	-
1	W-1.11	C-P Canal /2	15°20'	100°06'	-	Manorom Regulator
1	W-1.12	"	15°09'	100°25'	-	Chongkae Regulator
1	W-1.13	"	14°54'	100°36'	-	Kake Kathien Regulator
1	W-1.14	"	14°38'	100°45'	-	Reong Rang Regulator
1	W-1.15	C-A Canal /3	15°10'	100°10'	-	Maharaj Regulator
1	W-1.16	Noi	15°10'	100°09'	-	Borommathat Regulator
1	W-1.17	"	14°56'	100°17'	-	Chanasatr Regulator

Note: /1 The name in parenthesis means the office controlling the existing water level gauging station.

/2 Chai Nat - Pasak Canal.

/3 Chai Nat - Ayutthaya Canal.

Table 2-29(2/2). INVENTORY OF WATER LEVEL GAUGING STATIONS SELECTED FOR STEP 2 FLOOD FORECASTING SYSTEM

Installation Priority	Station Code No.	River System	Location		Existing /1 Gauging Station Located Nearby	Existing River Structure Located Nearby
			Latitude	Longitude		
1	W-1.18	Noi	14°45'	100°25'	-	Yang Manee Regulator
1	W-1.19	"	14°26'	100°23'	-	Pakhar Regulator
1	W-1.20	Suphan	15°13'	100°04'	-	Phonlathep Regulator
1	W-1.21	"	15°03'	100°01'	-	Thabote Regulator
1	W-1.22	"	14°46'	100°06'	-	Samchook Regulator
1	W-1.23	"	14°32'	100°08'	-	Phophya Regulator
2	W-2.1	Ping	17°14'	99°00'	P12 (RID)	Lower Bhumibol Dam Site
4	W-4.1	"	17°15'	98°50'	-	Upper Bhumibol Dam Site
4	W-4.2	Nan	17°46'	100°33'	-	Upper Sirikit Dam Site

Note: /1 The name in parenthesis means the office controlling the existing water level gauging station.

Table 2-30. WATER LEVEL GAUGING STATIONS TO MONITOR AND CALIBRATE THE RIVER FLOW DISCHARGE (STEP 2 FLOOD FORECASTING SYSTEM)

River System	Monitor and Calibration Items	Station Code No.	Location
Ping	Discharge	W-4.1	Upper Bhumibol Dam
Ping	Discharge	W/R-2.2	Kamphaeng Phet (P7A)
Wang	Discharge	W/R-3.2	Thoen (W3A)
Wang	Discharge	W/R-2.1	Wang Khrai (W4A)
Yom	Discharge	W/R-3.4	Si Satchanalai (Y14)
Yom	Discharge	W/R-3.5	Sukhotai (Y4)
Yom	Discharge	W/R-2.3	Sam Ngan (Y17)
Nan	Discharge	W-4.2	Upper Sirikit Dam
Nan	Discharge	W/R-3.7	Lower Naresuan Dam (N27A)
Nan	Discharge	W/R-2.4	Phitsanulok (N5A)
Nan	Discharge	W/R-2.5	Thaphan Hin (N10A)
Sakae Krang	Discharge	W/R-1.2	Thap Than (Ct8)
Pasak	Discharge	W/R-1.3	Wichian Buri
Pasak	Discharge	W/R-1.4	Upper Rama VI Dam
Chao Phraya	Discharge/Water Level	W/R-1.1	Nakhon Sawan (C2)
Chao Phraya	Discharge/Water Level	W-1.1	Lower Chao Phraya Dam (C13)
Chao Phraya	Discharge/Water Level	W-1.2	Sing Buri (C3)
Lop Buri	Discharge/Water Level	W-1.3	Lop Buri (L2A)
Chao Phraya	Discharge/Water Level	W-1.4	Angthong (C7A)
Chao Phraya	Discharge/Water Level	W-1.5	Ayutthaya
Chao Phraya	Discharge/Water Level	W-1.6	Bang Sai (C29)
Chao Phraya	Water Level	W-1.7	Pakred (C22)
Chao Phraya	Water Level	W-1.8	RID Bangkok Office (C12)
Chao Phraya	Water Level	W-1.9	Memorial Bridge
Chao Phraya	Water Level	W-1.10 /1	Fort Phra Chul (Gulf)

Note: /1 The observed water level is also used to predict the tidal level in the Gulf of Thailand.

Table 2-31. WATER LEVEL GAUGING STATIONS TO INPUT THE OBSERVED DISCHARGE AS BOUNDARY CONDITION (STEP 2 FLOOD FORECASTING SYSTEM)

Item of Prediction		Applied Gauging Station		
Prediction Time	Target Point	River System	Station Code No.	Location
Short	Bangkok Metropolis	(1) Chao Phraya	W-1.6	Bang Sai (C29)
Short	Ayutthaya	(1) Chao Phraya	W-1.1	Lower Chao Phraya Dam (C13)
		(2) Pasak	W/R-1.3	Wichian Buri
Short	Chai Nat, Sing Buri, Lop Buri and Angthong	(1) Chao Phraya	W/R-1.1	Nakhon Sawan (C2)
Short	Nakhon Sawan	(1) Ping	W/R-2.2	Kamphaeng Phet (P7A)
		(2) Yom	W/R-2.3	Sam Ngam (Y17)
		(3) Nan	W/R-2.4	Phitsanulok (N5A)
Long	All Target Points	(1) Ping	W-2.1	Lower Bhumibol Dam (P12)
		(2) Wang	W/R-3.1	Lower Kiu Lom Dam (W10A)
		(3) Yom	W/R-3.3	Ngao Sak (Y20)
		(4) Nan	W/R-3.6	Lower Sirikit Dam (N12A)
		(5) Pasak	W/R-2.6	Lom Sak
		(6) Ping	W/R-4.1	Chiang Mai (P1) /1
		(7) Nan	W/R-4.2	Nan (N.1) /1

Note: /1 Subject to flood prediction for upper reaches from Bhumibol and Sirikit dams.

Table 2-32. WATER LEVEL GAUGING STATIONS TO MONITOR THE CANAL FLOW DISCHARGE AT EXISTING REGULATOR (STEP 2 FLOOD FORECASTING SYSTEM)

Name of Canal	Name of Regulator	Station Code No.
Chai Nat-Pasak Canal	Manorom	W-1.11
Chai Nat-Pasak Canal	Chongkae	W-1.12
Chai Nat-Pasak Canal	Kake Kathiom	W-1.13
Chai Nat-Pasak Canal	Reong Rang	W-1.14
Chai Nat-Ayutthaya Canal	Maharaj	W-1.15
Noi River	Borommathat	W-1.16
Noi River	Chanasatr	W-1.17
Noi River	Yang Manee	W-1.18
Noi River	Pakhai	W-1.19
Suphan River	Phonlathep	W-1.20
Suphan River	Thabote	W-1.21
Suphan River	Samchook	W-1.22
Suphan River	Phophya	W-1.23

Table 2-33. INSTALLATION PRIORITY OF GAUGING STATIONS FOR STEP 2 FLOOD FORECASTING SYSTEM

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 2-34. ANNUAL PEAK DISCHARGE PREDICTED AT TARGET POINT THROUGH STEP 2 FLOOD FORECASTING SYSTEM

Target Point	Year	Observed		Predicted 3 Days Before		Predicted 6 Days Before	
		m^3/s	Date	m^3/s	Date	m^3/s	Date
Nakhon Sawan	1978	3,540	Oct. 07	3,527	Oct. 07	3,514	Oct. 08
Chai Nat	1978	3,741	Oct. 11	3,689	Oct. 11	3,709	Oct. 11
Angthong	1978	2,550	Oct. 10	2,966	Oct. 12	2,938	Oct. 12
Nakhon Sawan	1980	4,320	Oct. 09	4,356	Oct. 09	4,373	Oct. 09
Chai Nat	1980	3,795	Oct. 10	3,796	Oct. 10	3,796	Oct. 10
Angthong	1980	3,115	Oct. 15	3,024	Oct. 13	3,011	Oct. 11
Nakhon Sawan	1983	2,290	Oct. 23	- /1	- /1	2,332	Oct. 24
Chai Nat	1983	3,290	Oct. 25	3,097	Oct. 27	3,114	Oct. 27
Angthong	1983	2,482	Oct. 24	2,604	Oct. 26	2,425	Oct. 28

Note: /1 Prediction was not made because of the missing upstream observed discharge data at Sam Ngam (Sta. Y17)

Table 2-35. ONE-DAY MAXIMUM WATER LEVEL PREDICTED FOR TIDAL COMPARTMENT THROUGH STEP 2 FORECASTING SYSTEM

Observation/ Prediction Date /1	Objective Point		Observed		Predicted 3 Days Before		Predicted 6 Days Before	
	Location Name	Distance from River Mouth (km)	Water Level (m. MSL)	Time	Water Level (m. MSL)	Time	Water Level (m. MSL)	Time
Oct. 21 1978	Bangkok Port	27	1.73	10:00	1.70	11:00	1.67	11:00
	Satha Pradit	40	1.77	10:00	1.66	11:00	1.60	11:00
	Memorial Bridge	48	1.89	10:00	2.07	11:00	2.01	10:00
	RID Samsen	54	2.03	12:00	2.00	11:00	1.94	11:00
	Pakred	70	2.15	12:00	2.09	12:00	1.98	12:00
Oct. 27 1980	Bangkok Port	27	1.77	09:00	1.86	10:00	1.86	10:00
	Satha Pradit	40	Data Missing		1.76	10:00	1.75	10:00
	Memorial Bridge	48	1.92	10:00	2.04	10:00	2.02	10:00
	RID Samsen	54	2.01	10:00	2.05	10:00	2.07	10:00
	Pakred	70	2.21	11:00	2.24	12:00	2.27	11:00
Oct. 31 1983	Bangkok Port	27	1.97	15:00	1.93	17:00	1.89	17:00
	Satha Pradit	40	1.87	16:00	1.85	18:00	1.74	18:00
	Memorial Bridge	48	1.82	16:00	1.97	16:00	2.13	16:00
	RID Samsen	54	1.94	17:00	1.97	18:00	1.85	18:00
	Pakred	70	2.05	18:00	1.99	20:00	2.00	19:00

Note: /1 Date of observation of annual maximum discharge at Bang Sai.

Table 2-36. DIFFERENCES BETWEEN OBSERVED AND PREDICTED DAILY MAXIMUM TIDAL LEVEL (PREDICTED SIX DAYS IN ADVANCE)

Subject Year	Season	Maximum Difference (m)	Average Difference (m)	Occurrence of Difference in Daily Maximum Tidal Level in One Year					
				Less than 0.1 m (day)	Less than 0.2 m (day)	Less than 0.3 m (day)	Less than 0.4 m (day)	Less than 0.5 m (day)	More than 0.5 m (day)
1978	Rainy Season	0.45	0.11	105	157	175	182	184	
	Dry Season	0.38	0.10	115	168	177	181		
	Annual	0.45	0.11	220	325	352	363	365	
1980	Rainy Season	0.33	0.08	125	173	181	184		
	Dry Season	0.34	0.09	112	166	179	182		
	Annual	0.34	0.09	237	339	360	366		
1983	Rainy Season	0.62	0.11	95	162	180	182	182	184
	Dry Season	0.28	0.09	117	167	181			
	Annual	0.62	0.10	212	329	361	363	363	365

FIGURES

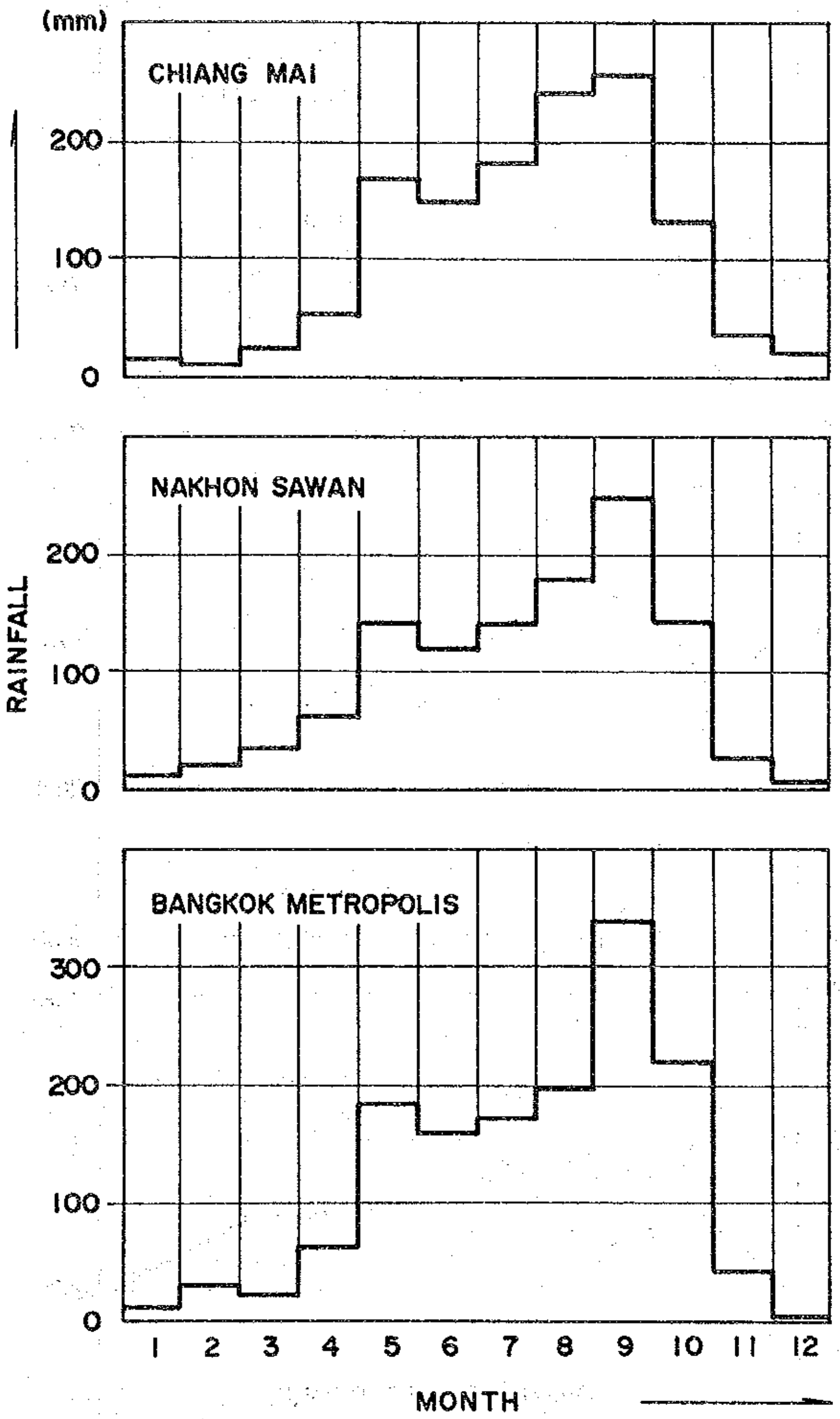


Fig. 2-1. MONTHLY VARIATION OF AVERAGE RAINFALL (1951 - 1980)

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

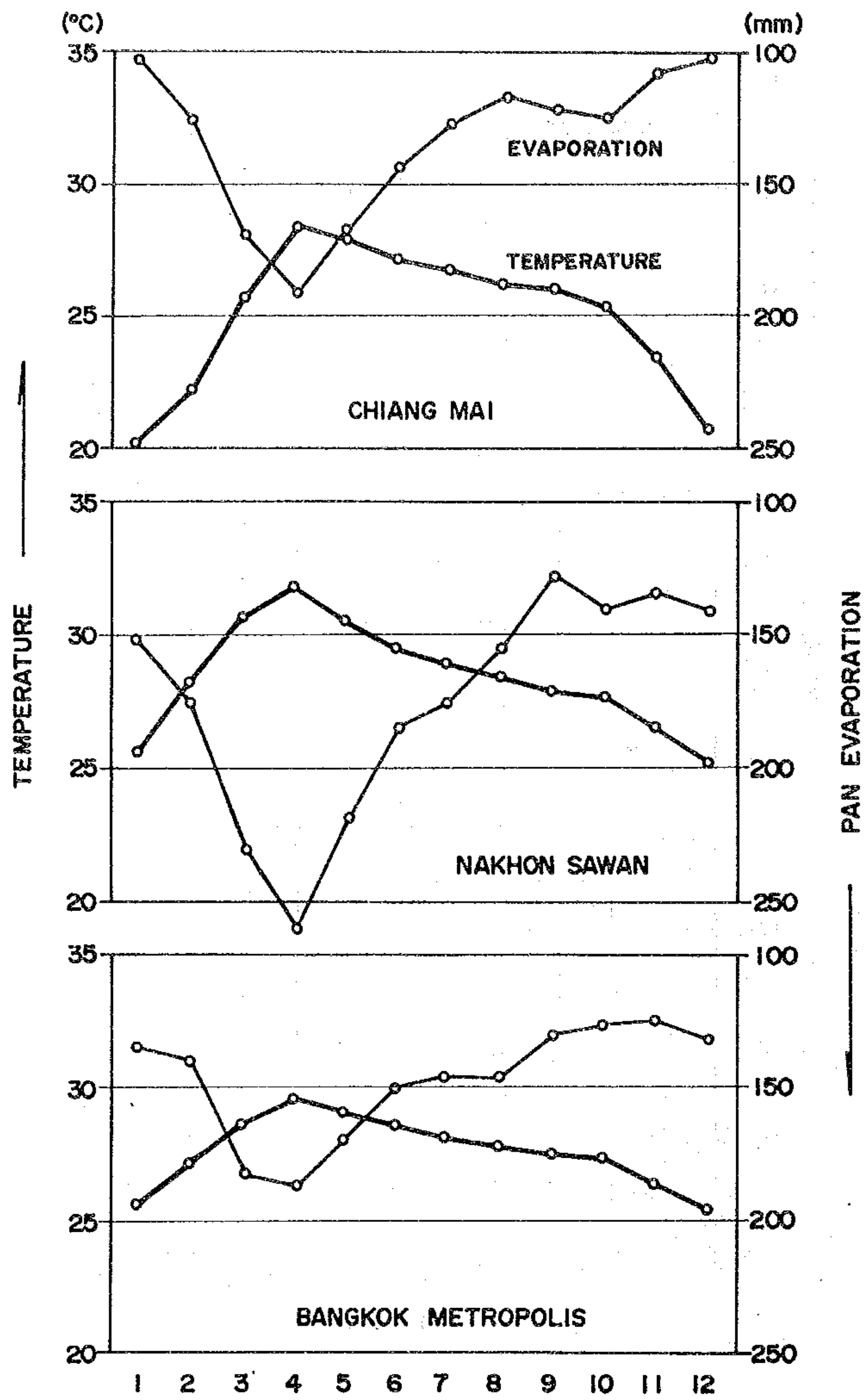


Fig. 2-2. MONTHLY VARIATION OF AVERAGE TEMPERATURE AND EVAPORATION (1951 - 1980)	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY

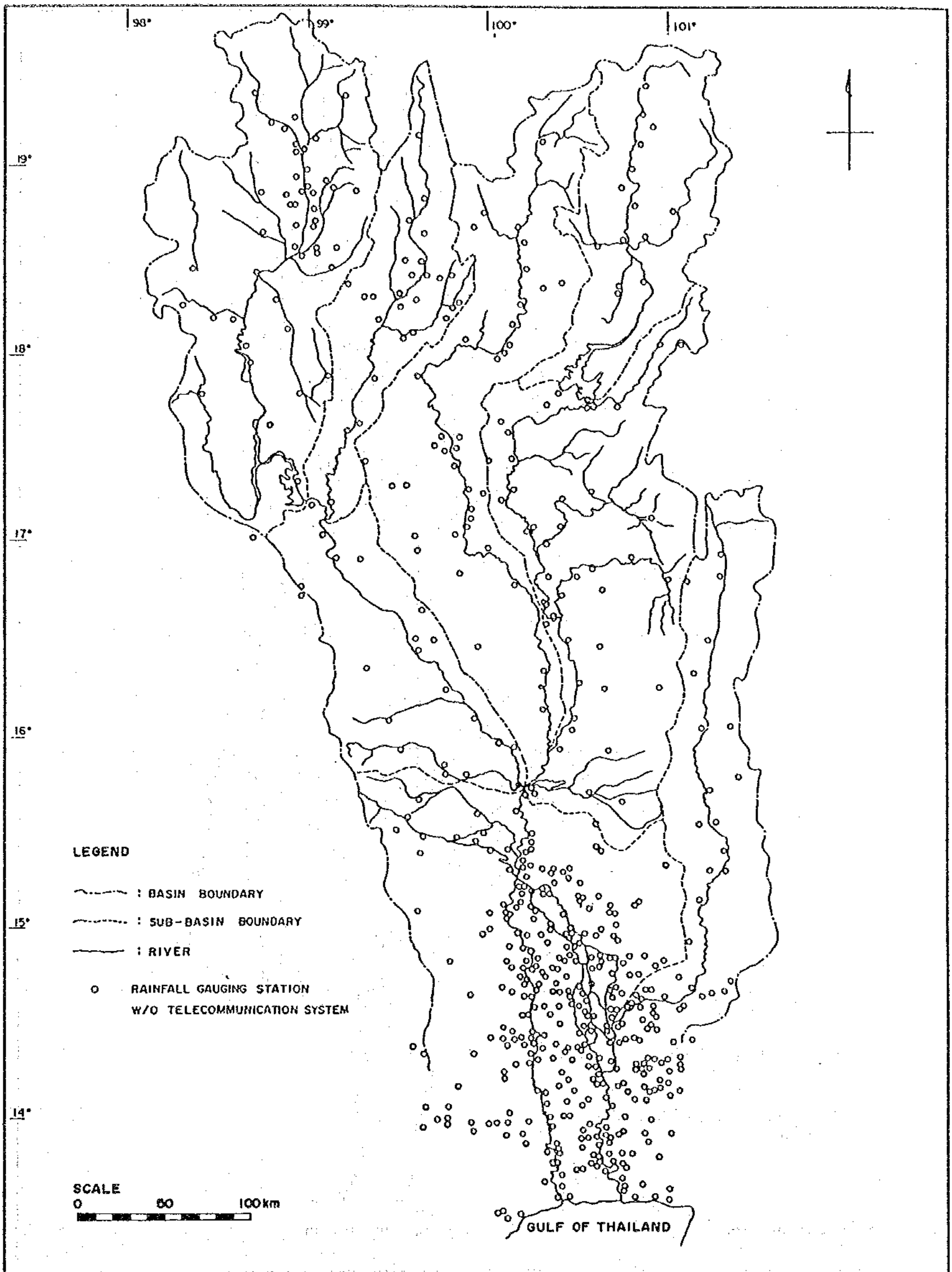


Fig. 2-3. LOCATION MAP OF EXISTING RAINFALL GAUGING STATIONS

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

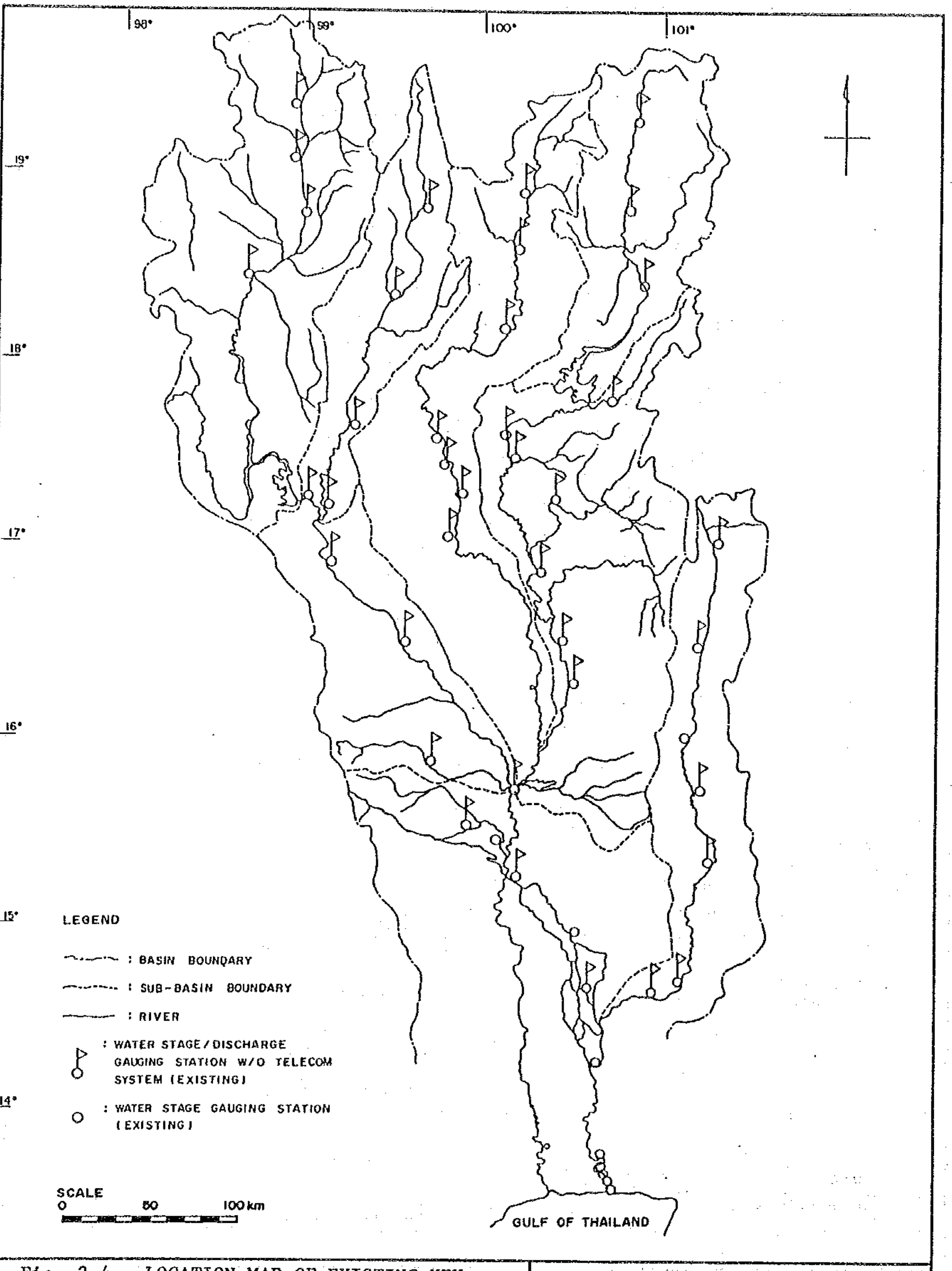


Fig. 2-4. LOCATION MAP OF EXISTING KEY WATER STAGE AND DISCHARGE GAUGING STATIONS	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY

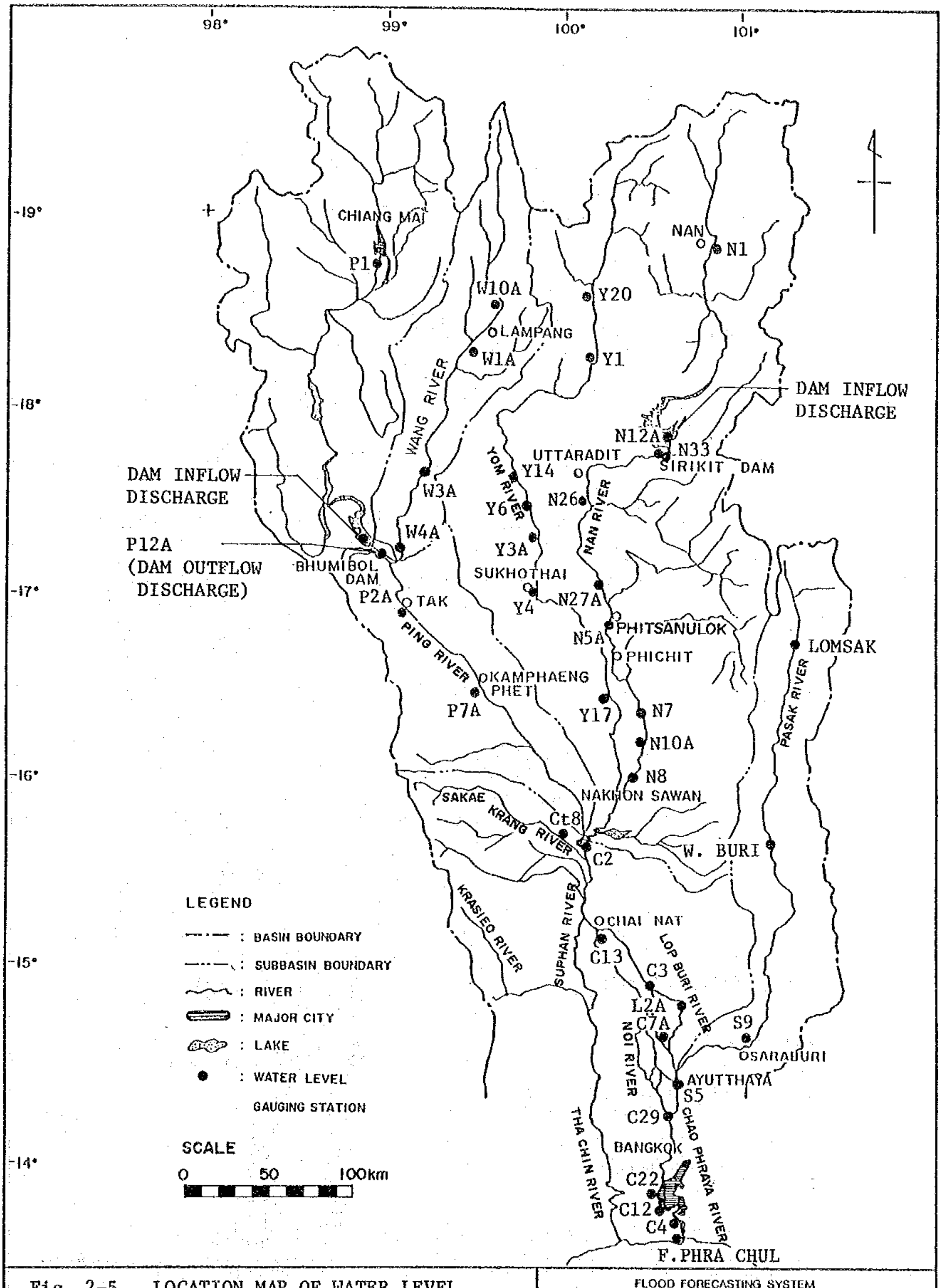


Fig. 2-5. LOCATION MAP OF WATER LEVEL GAUGING STATION SELECTED FOR HYDROLOGICAL STUDY

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

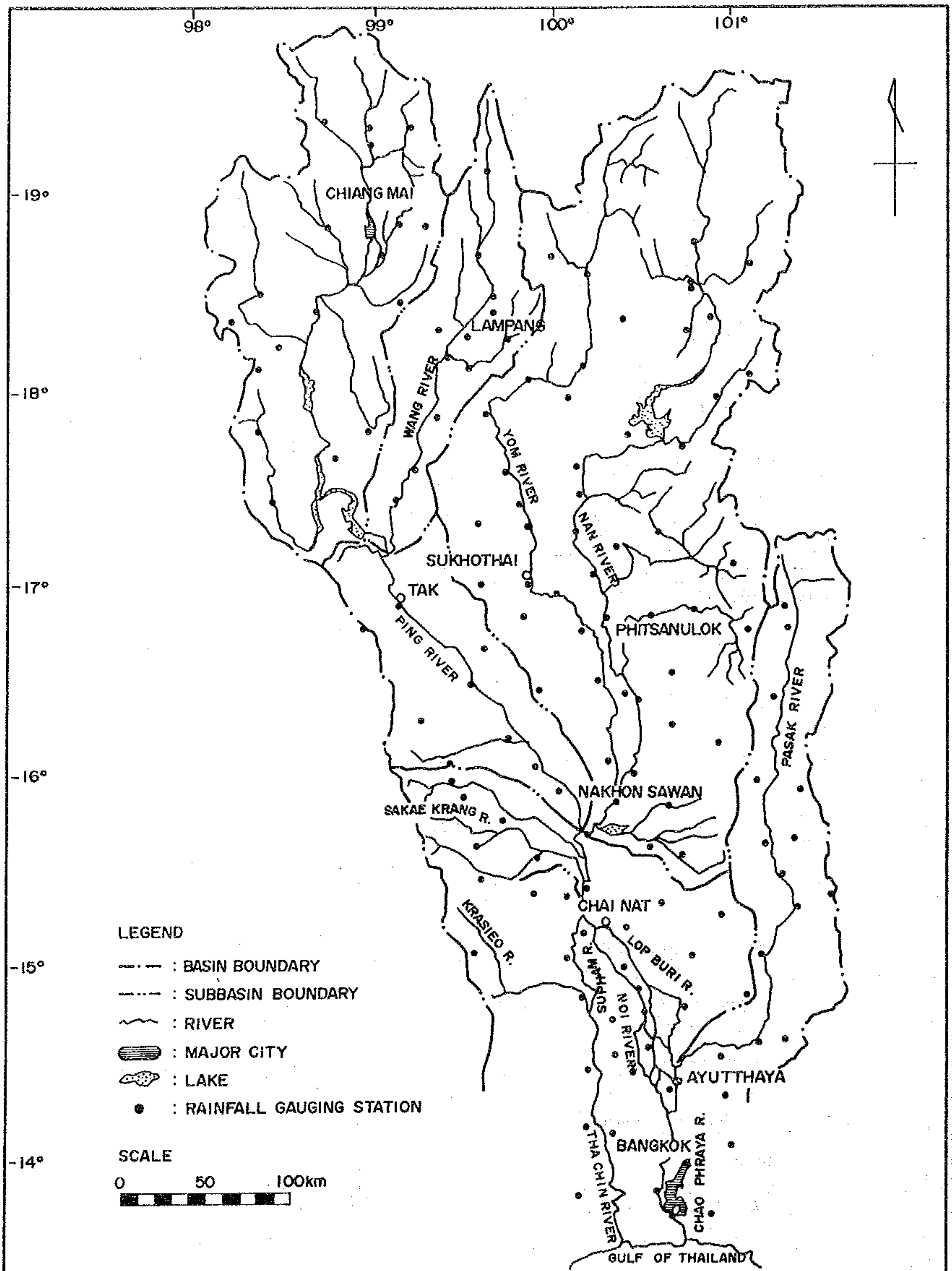


Fig. 2-6. LOCATION MAP OF RAINFALL GAUGING STATION SELECTED FOR HYDROLOGICAL STUDY	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY

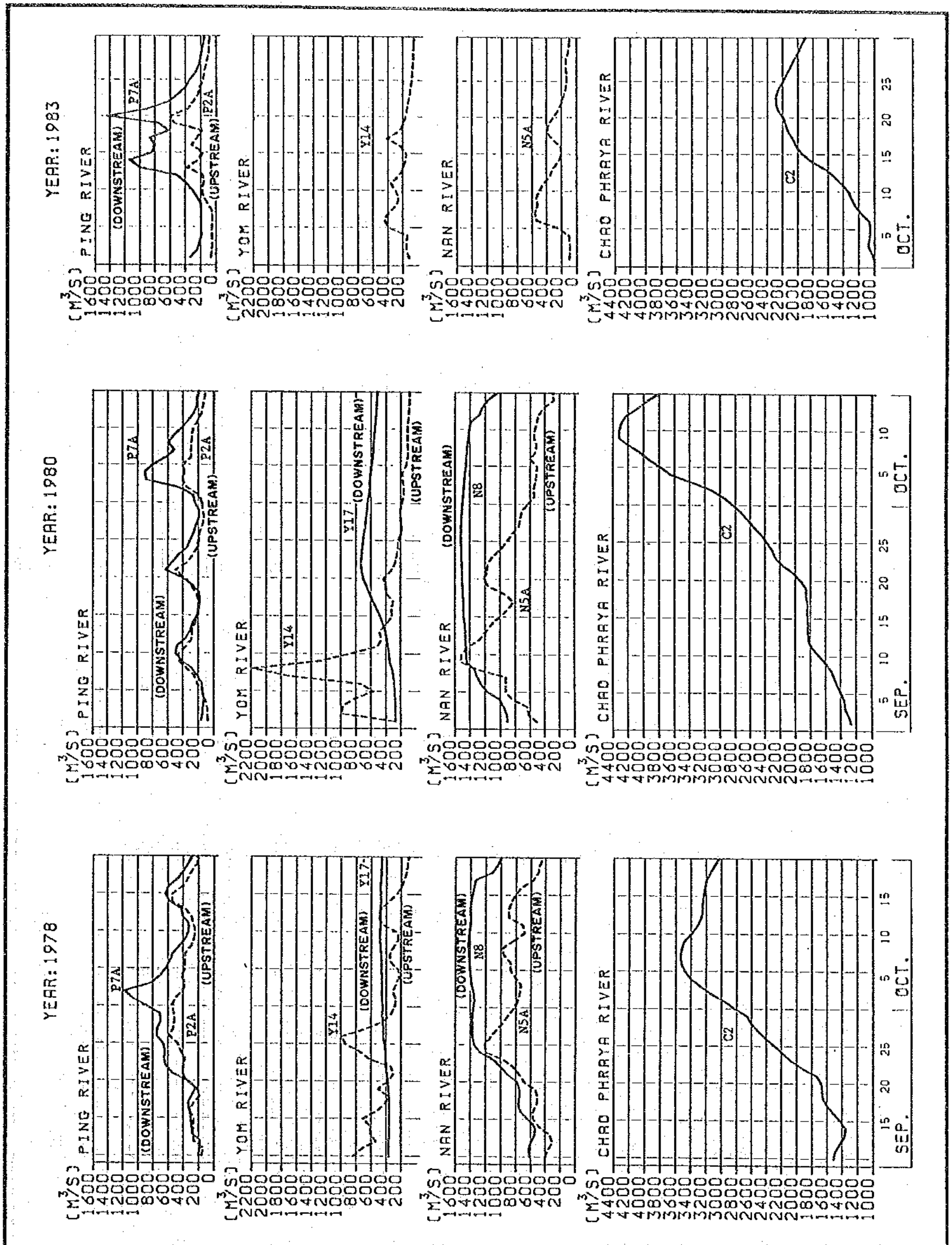


Fig. 2-7. TRANSITION OF FLOOD HYDROGRAPH FROM PING, YOM AND NAN RIVERS TO CHAO PHRAYA RIVER

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

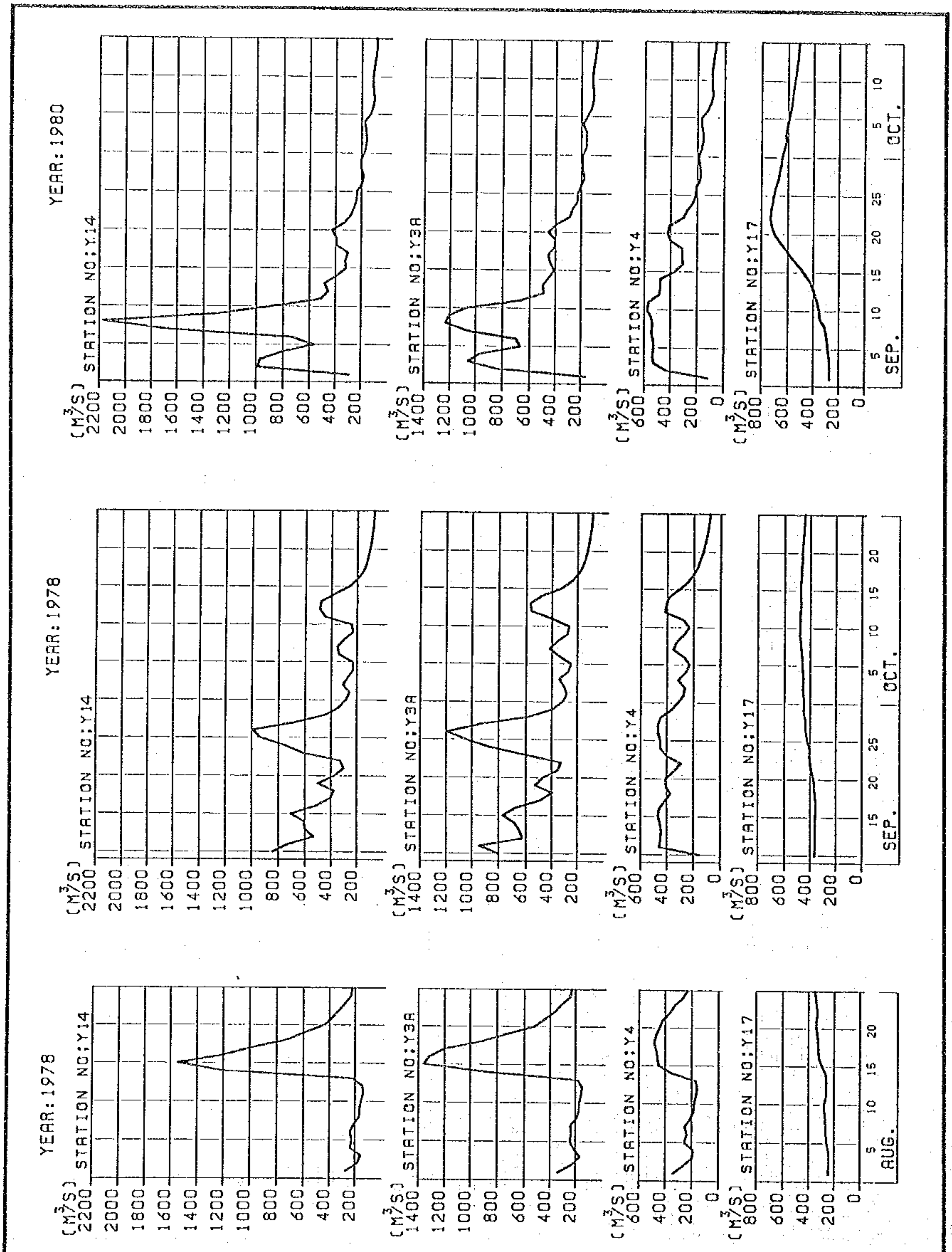


Fig. 2-8. TRANSITION OF FLOOD HYDROGRAPH ON YOM RIVER

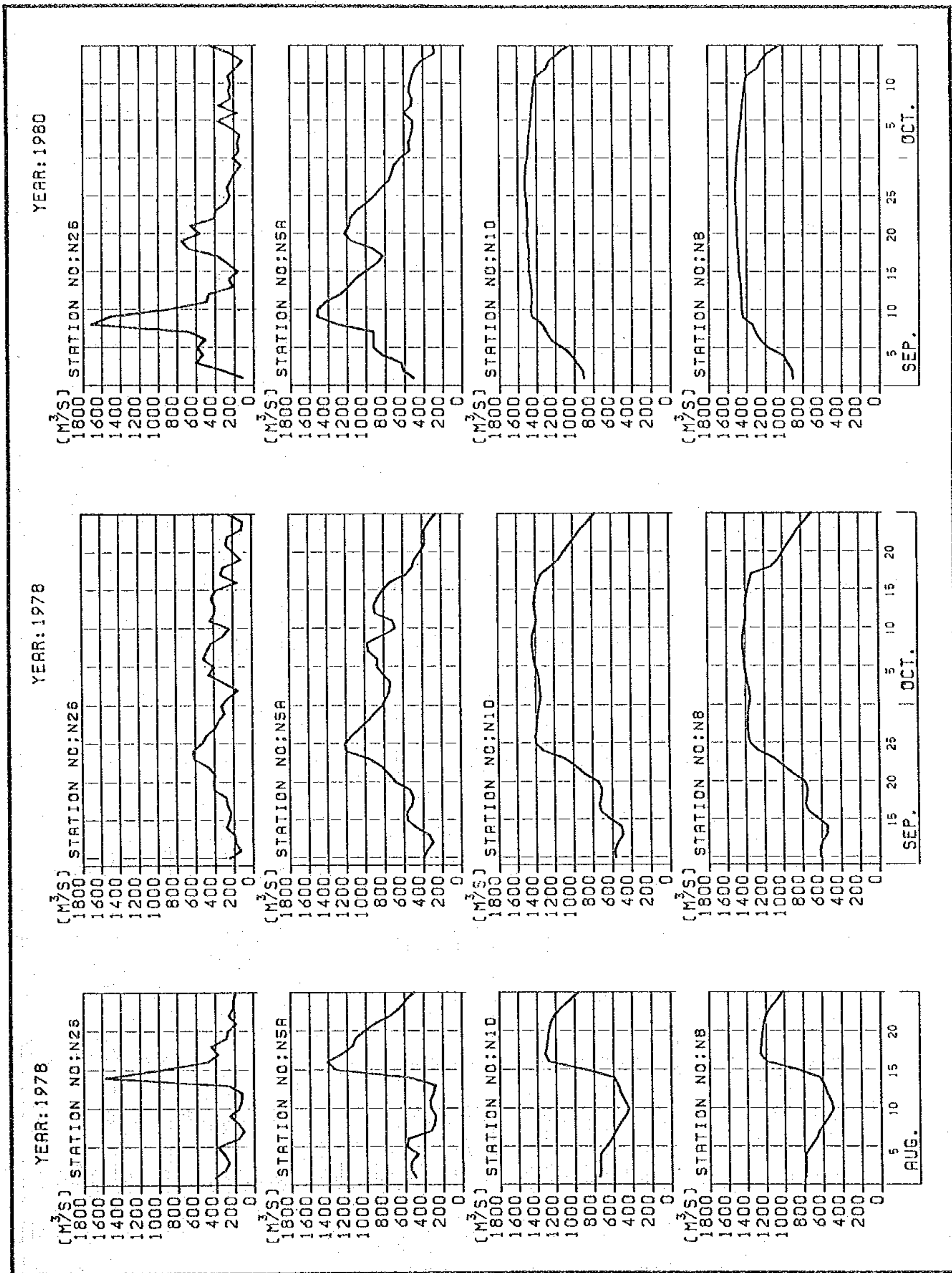


Fig. 2-9. TRANSITION OF FLOOD HYDROGRAPH ON NAN RIVER

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

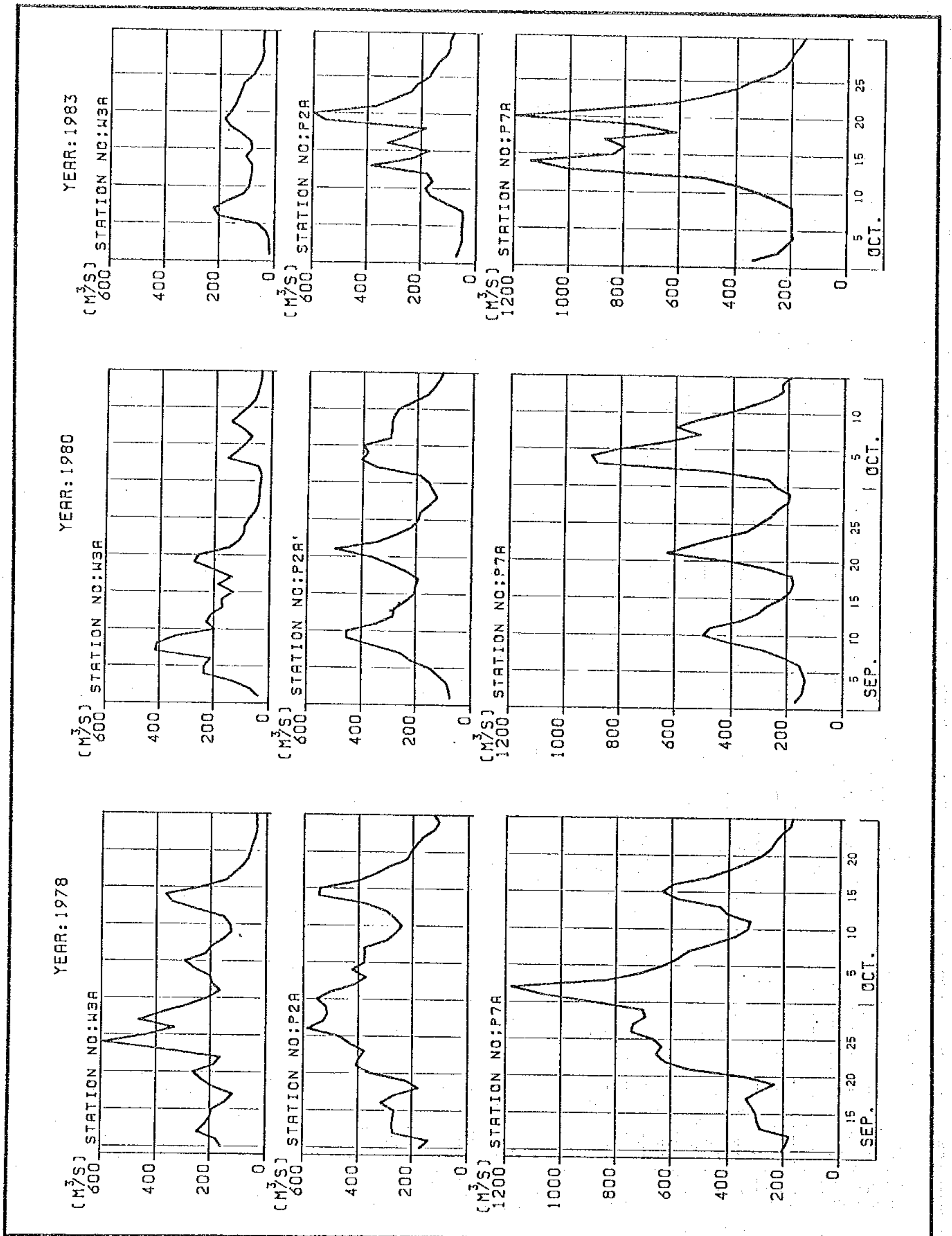


Fig. 2-10. TRANSITION OF FLOOD HYDROGRAPH ON WANG AND PING RIVERS

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

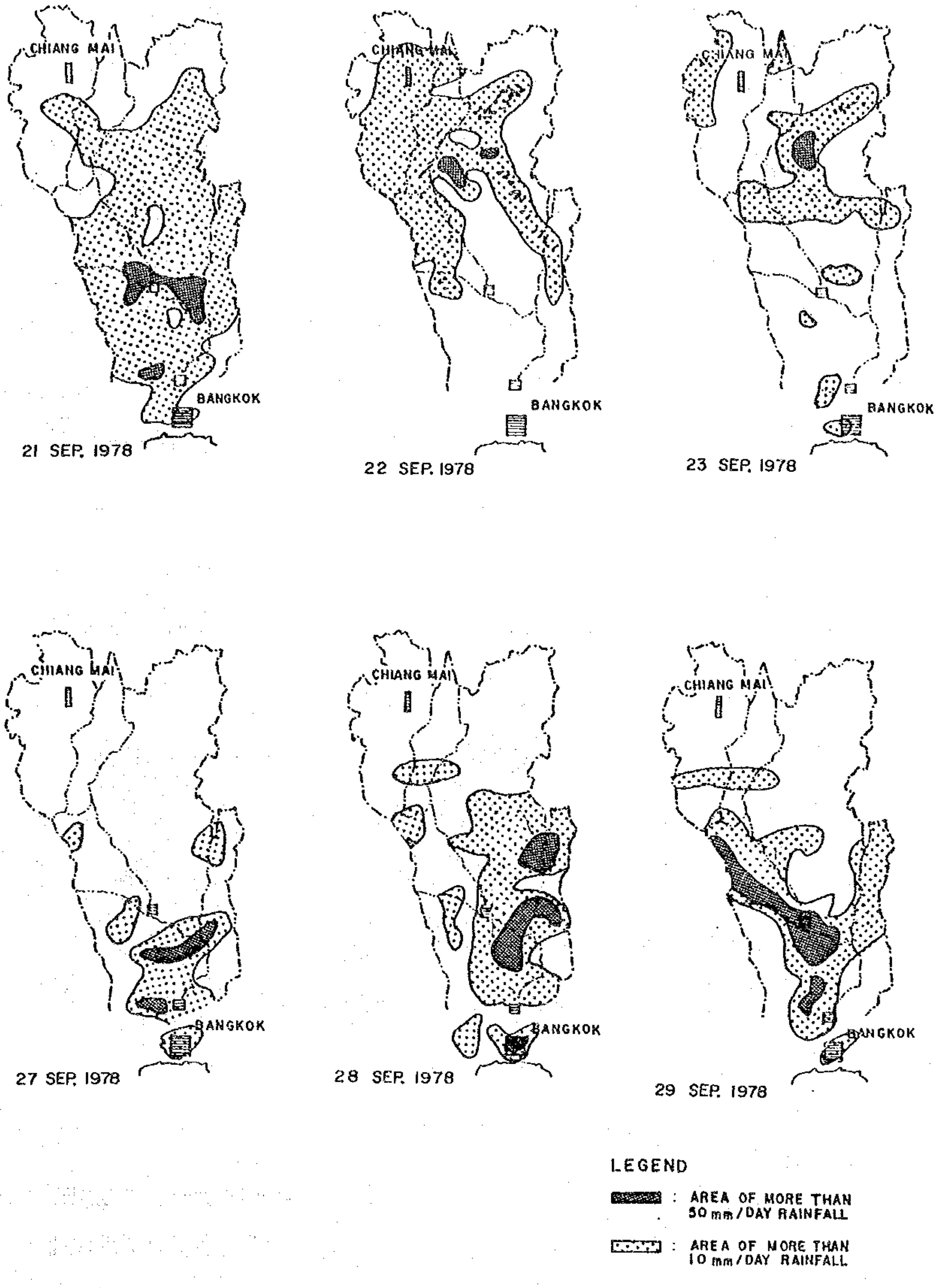


Fig. 2-11. DOMINANT RAINFALL AREA DURING 1978 FLOOD

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

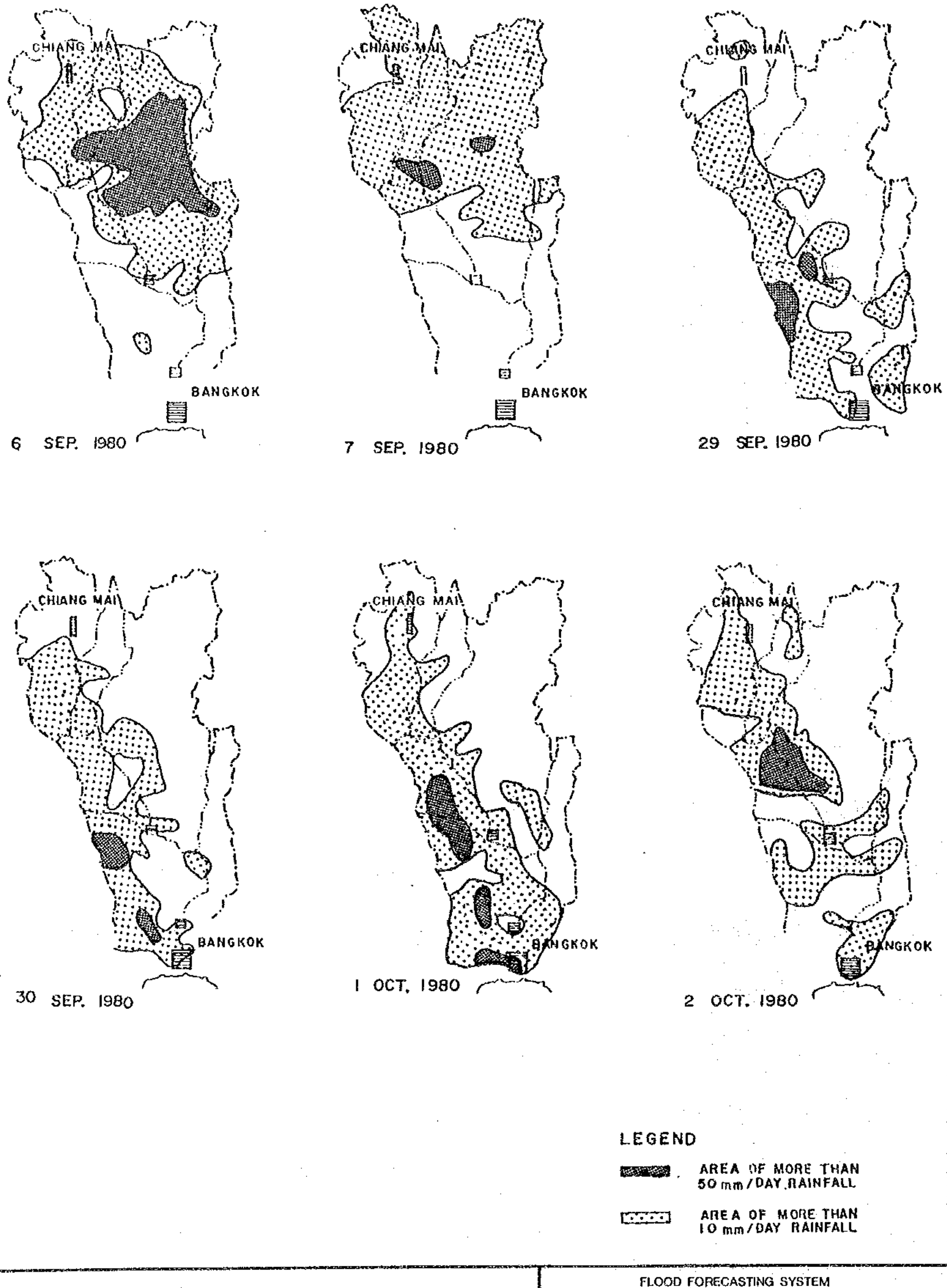


Fig. 2-12. DOMINANT RAINFALL AREA DURING 1980 FLOOD

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

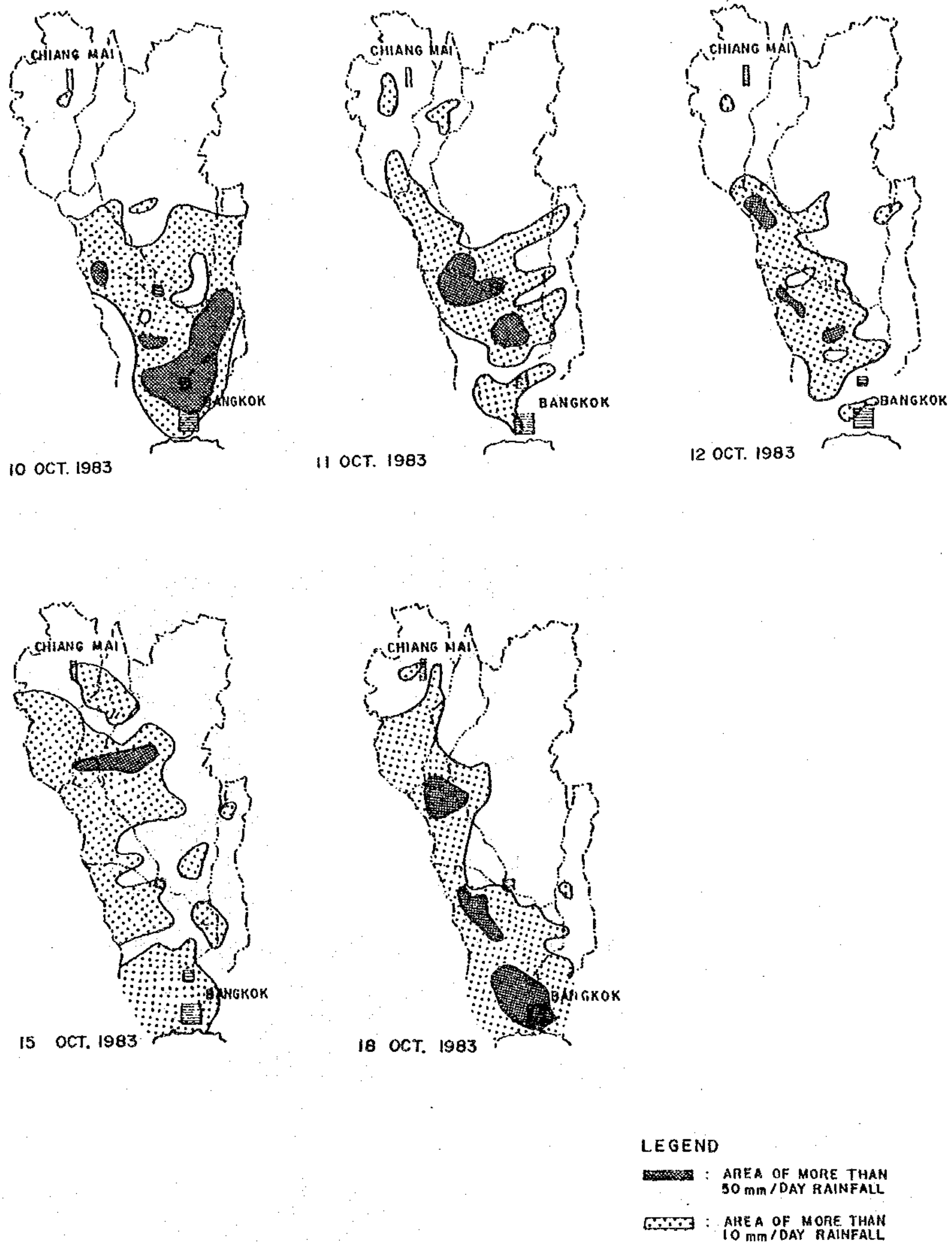


Fig. 2-13. DOMINANT RAINFALL AREA DURING 1983 FLOOD

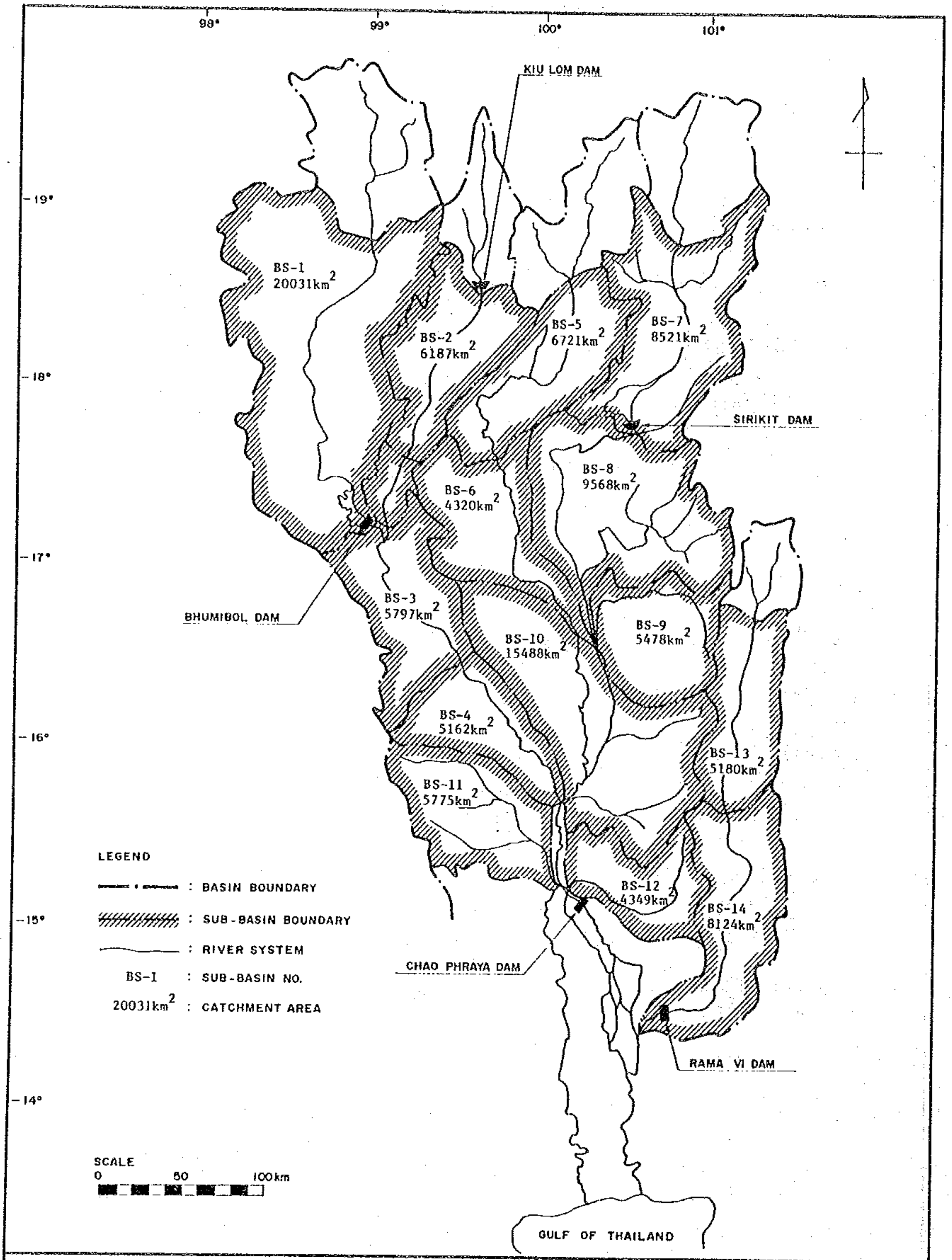


Fig. 2-14. SUB-BASIN BOUNDARY ASSUMED FOR FLOOD PREDICTION MODEL

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

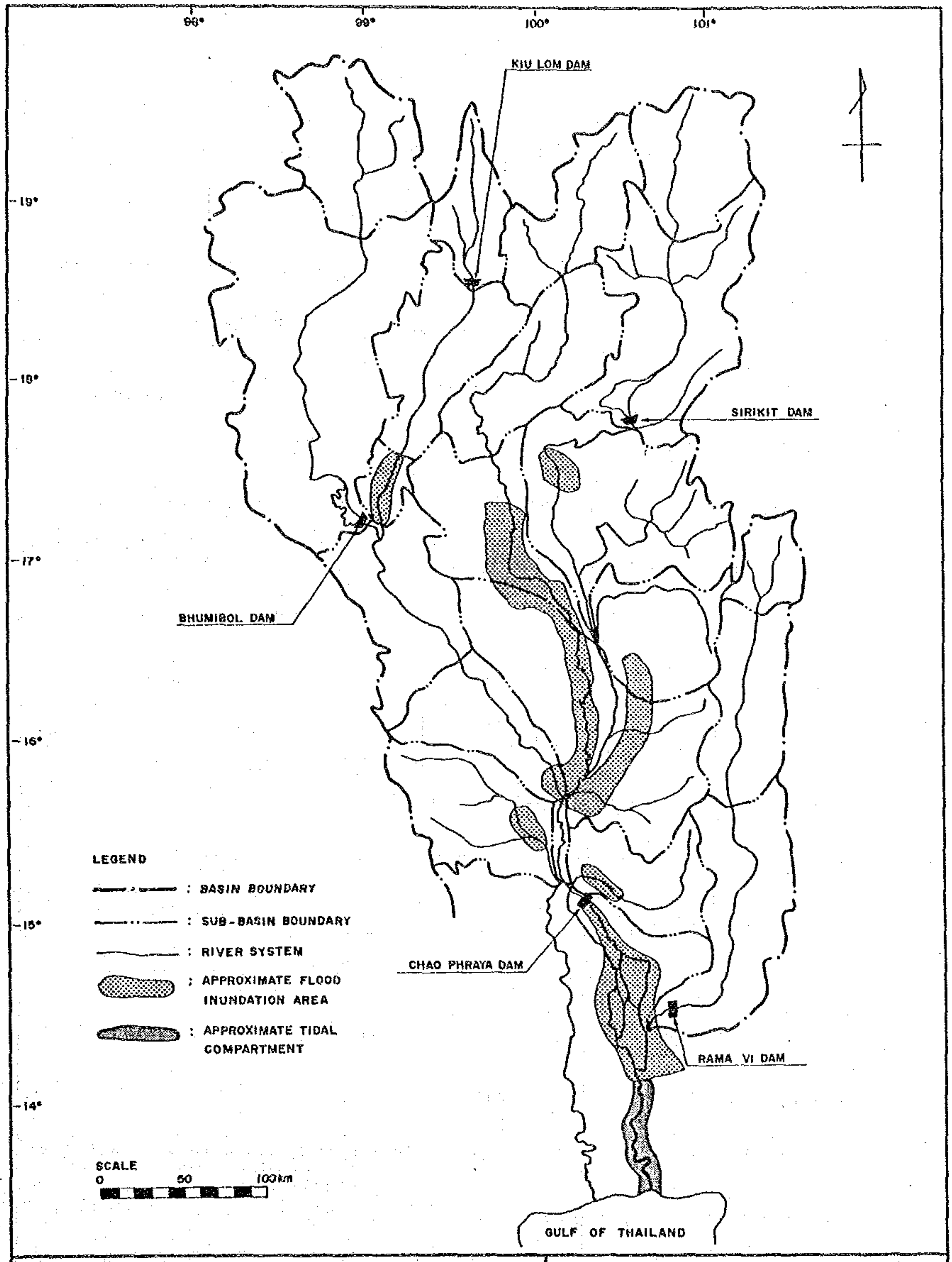


Fig. 2-15. FLOOD INUNDATION AREA AND TIDAL COMPARTMENT ASSUMED FOR FLOOD PREDICTION MODEL

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

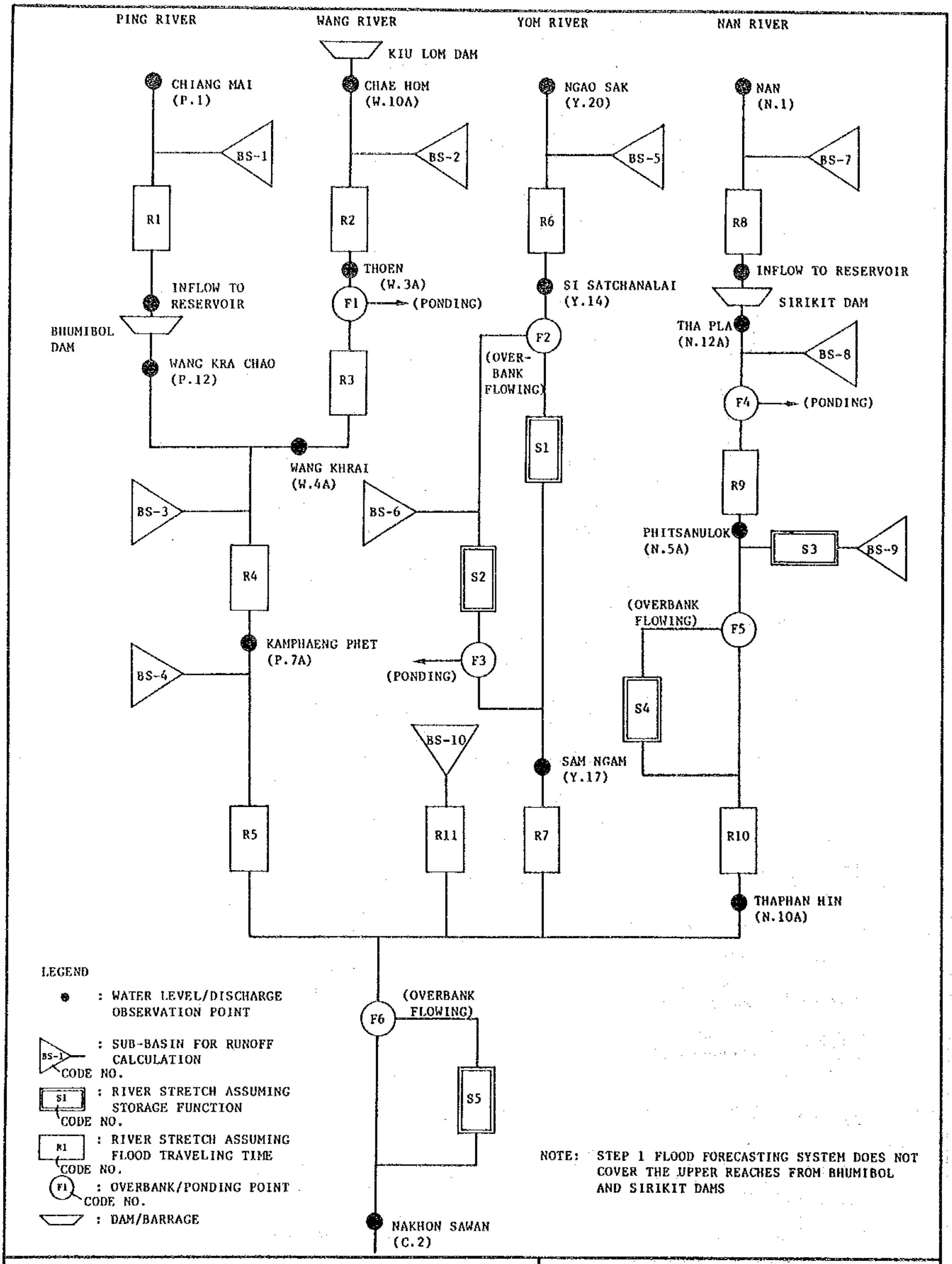


Fig. 2-16. FLOOD PREDICTION MODEL FOR UPPER REACHES FROM NAKHON SAWAN

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

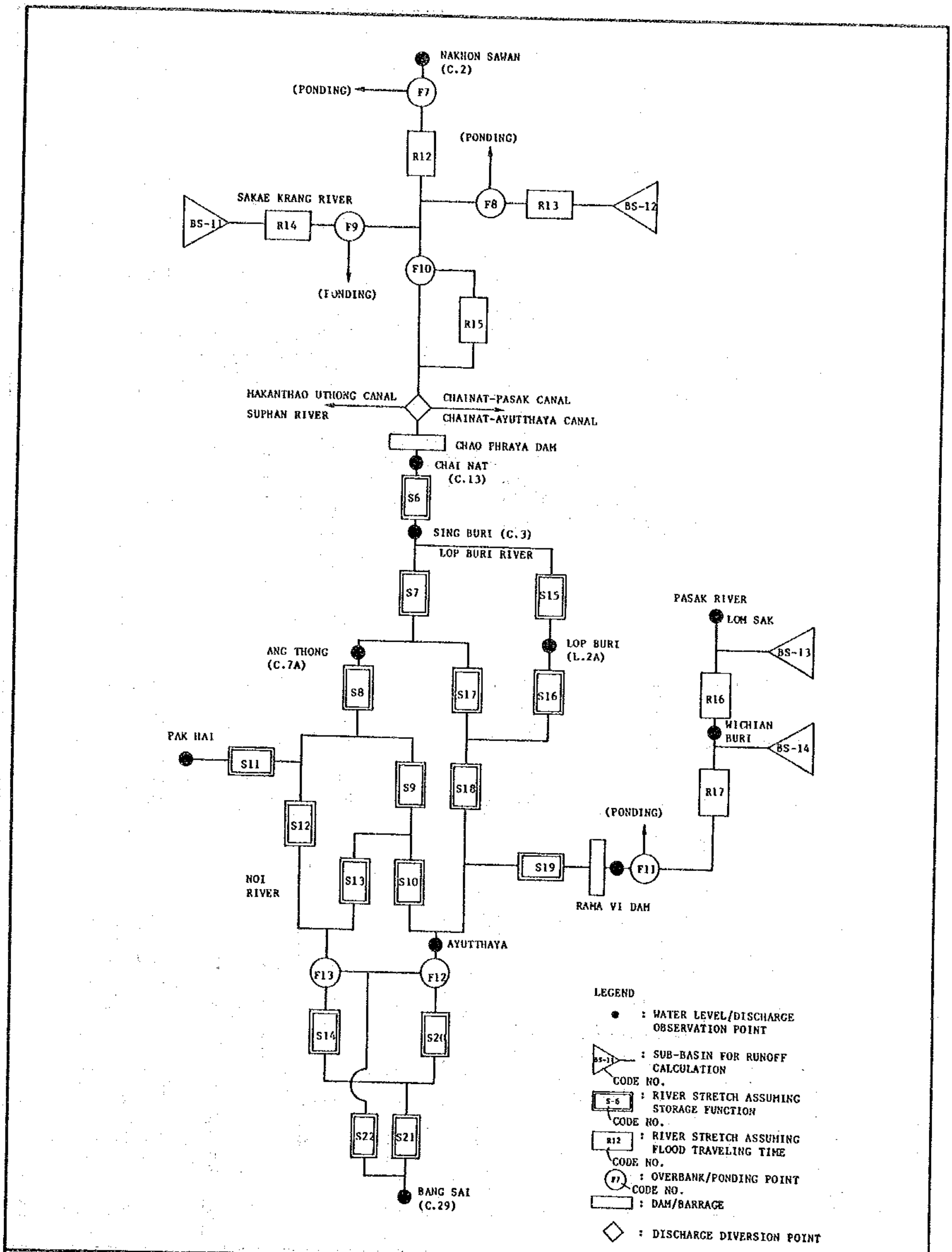


Fig. 2-17. FLOOD PREDICTION MODEL FROM NAKHON SAWAN TO BANG SAI

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

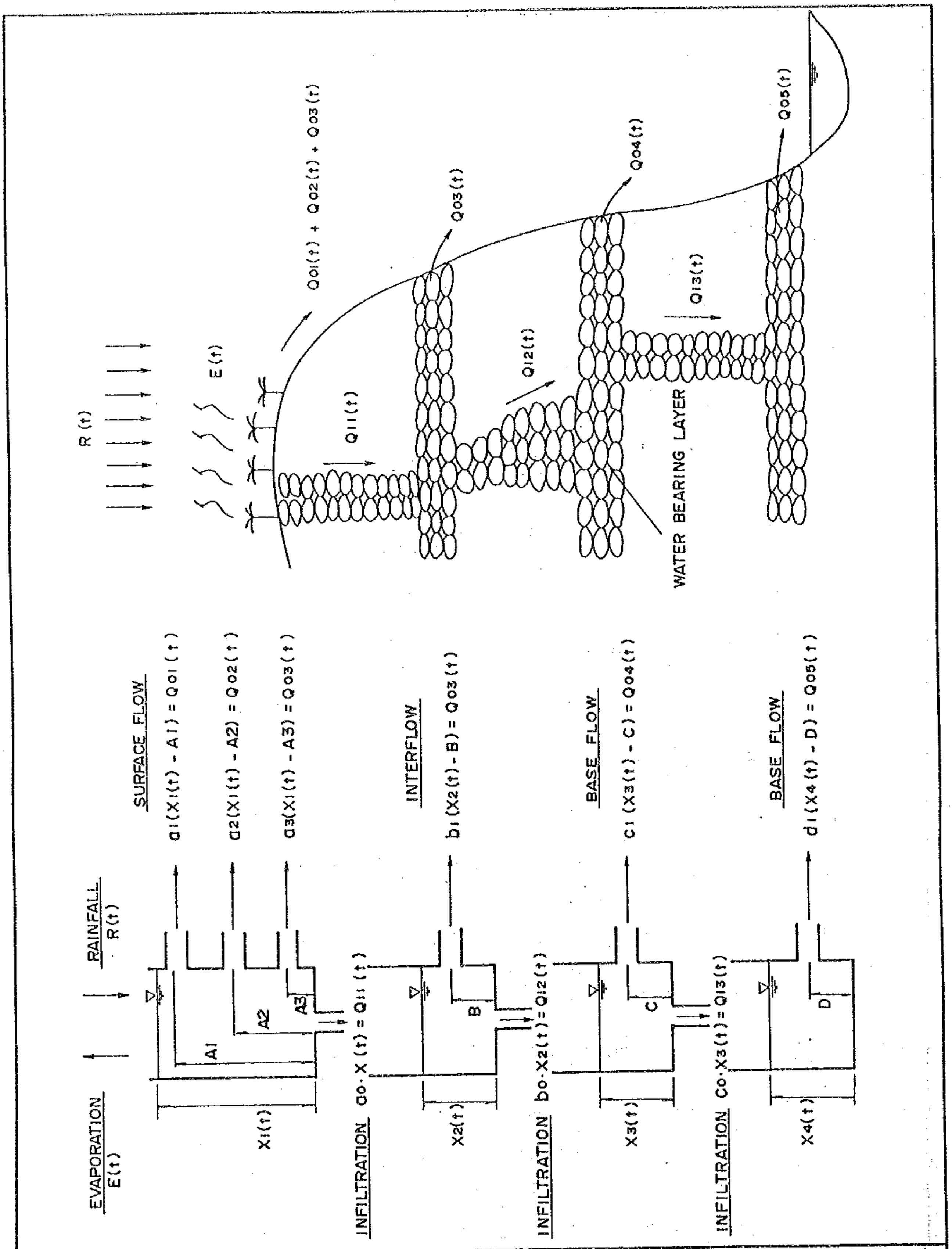
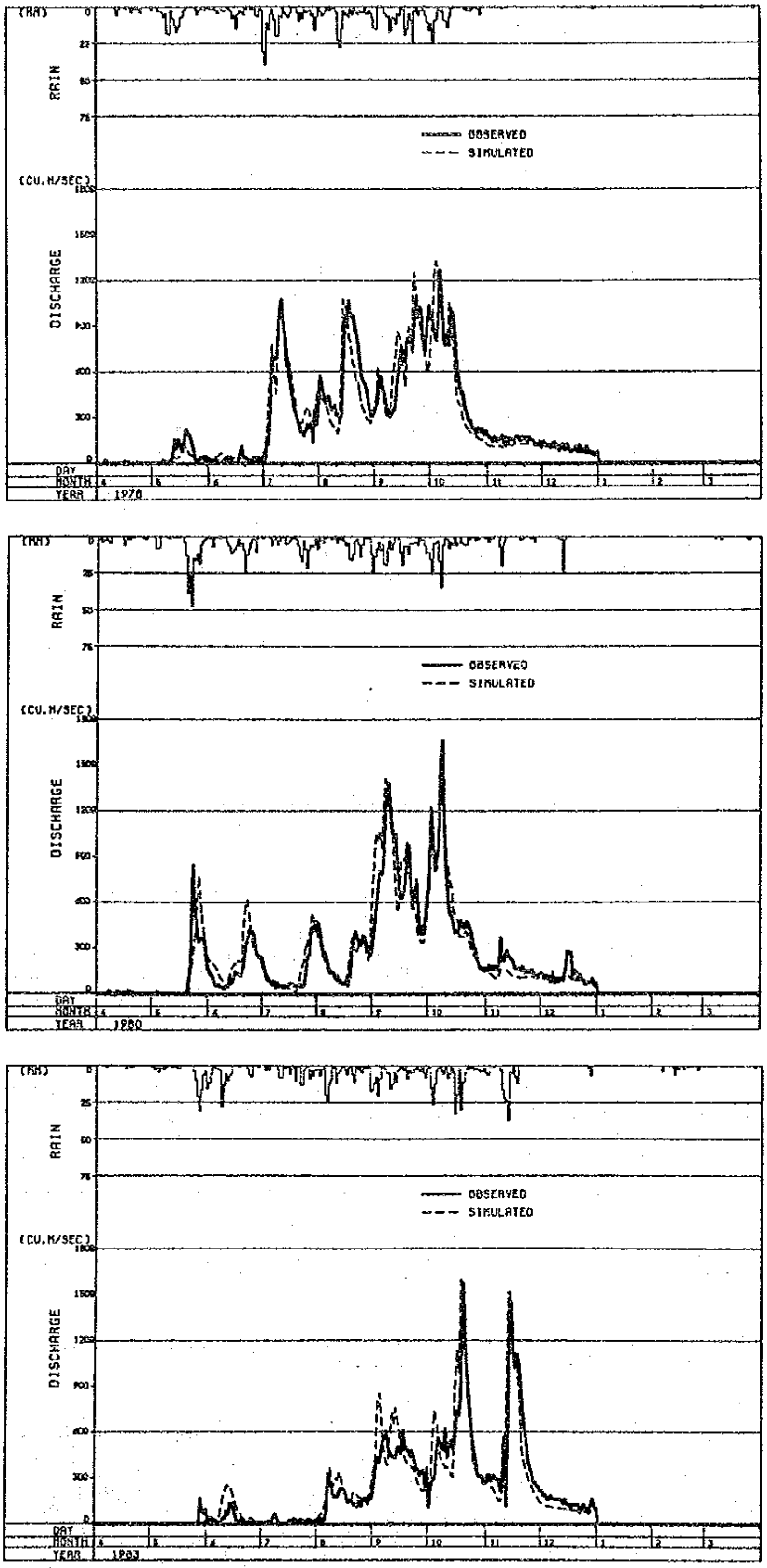
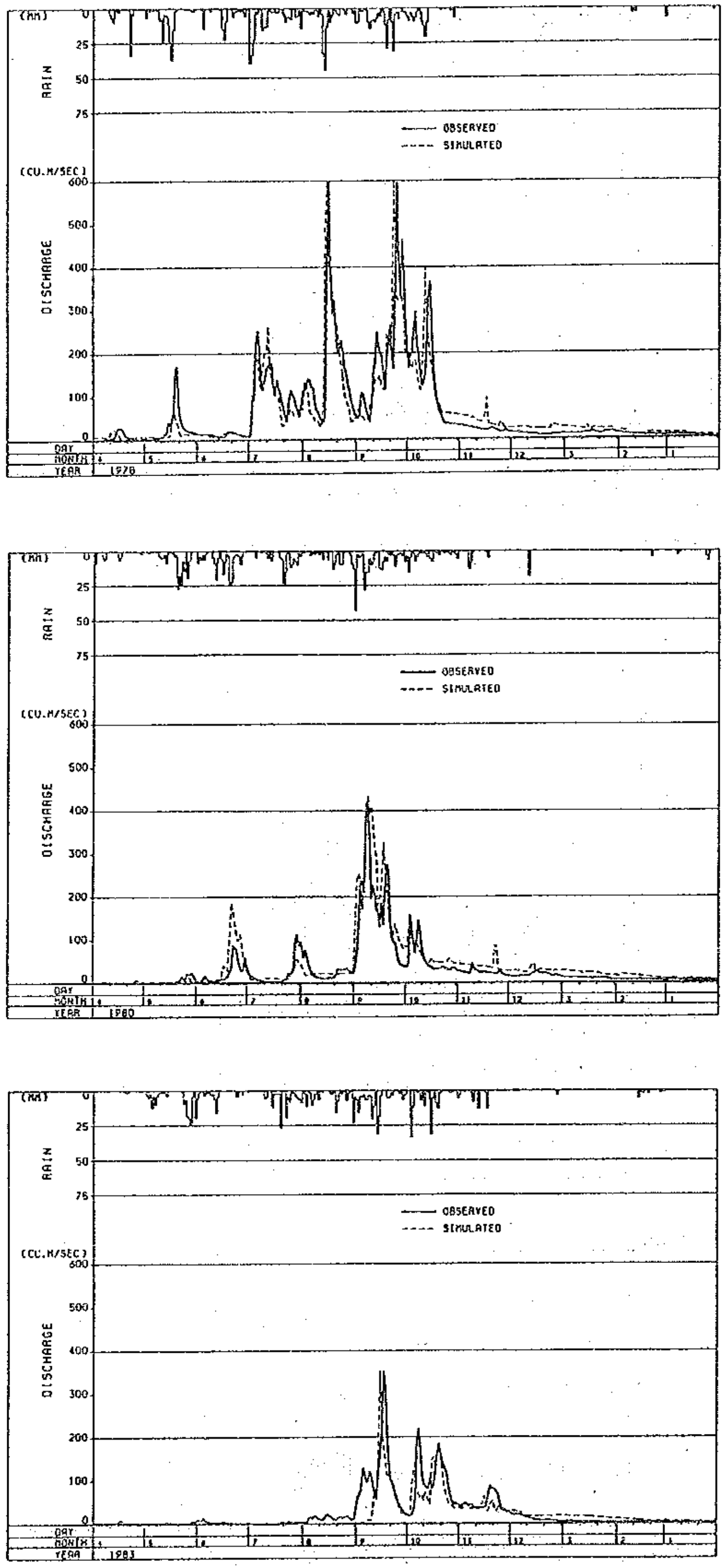


Fig. 2-18. SCHEMATIC DIAGRAM OF BASIN RUNOFF PREDICTION MODEL



BHUMIBOL DAM RESERVOIR IN PING RIVER BASIN

Fig. 2-19(1/8). DISCHARGE HYDROGRAPH SIMULATED BY BASIN RUNOFF PREDICTION MODEL	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN
	JAPAN INTERNATIONAL COOPERATION AGENCY

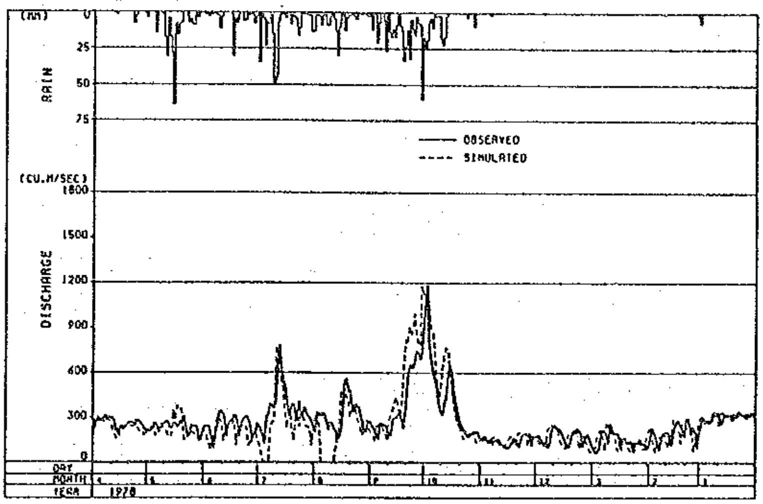


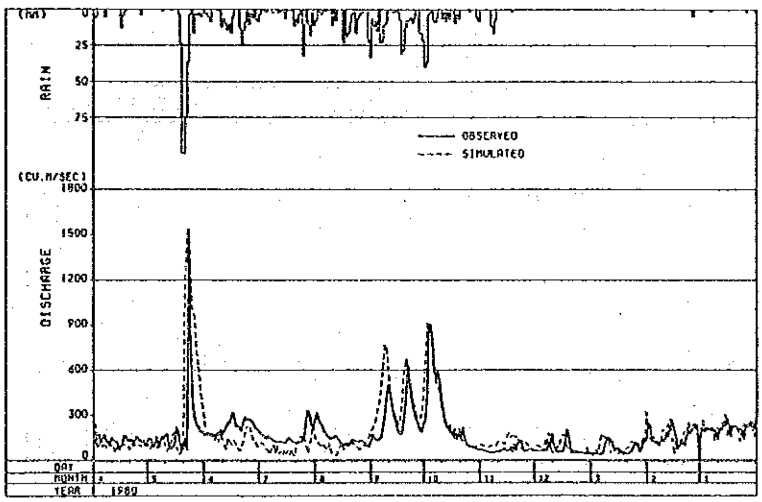
STA. W3A
IN WANG RIVER
BASIN

Fig. 2-19(2/8). DISCHARGE HYDROGRAPH SIMULATED BY BASIN RUNOFF PREDICTION MODEL

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN

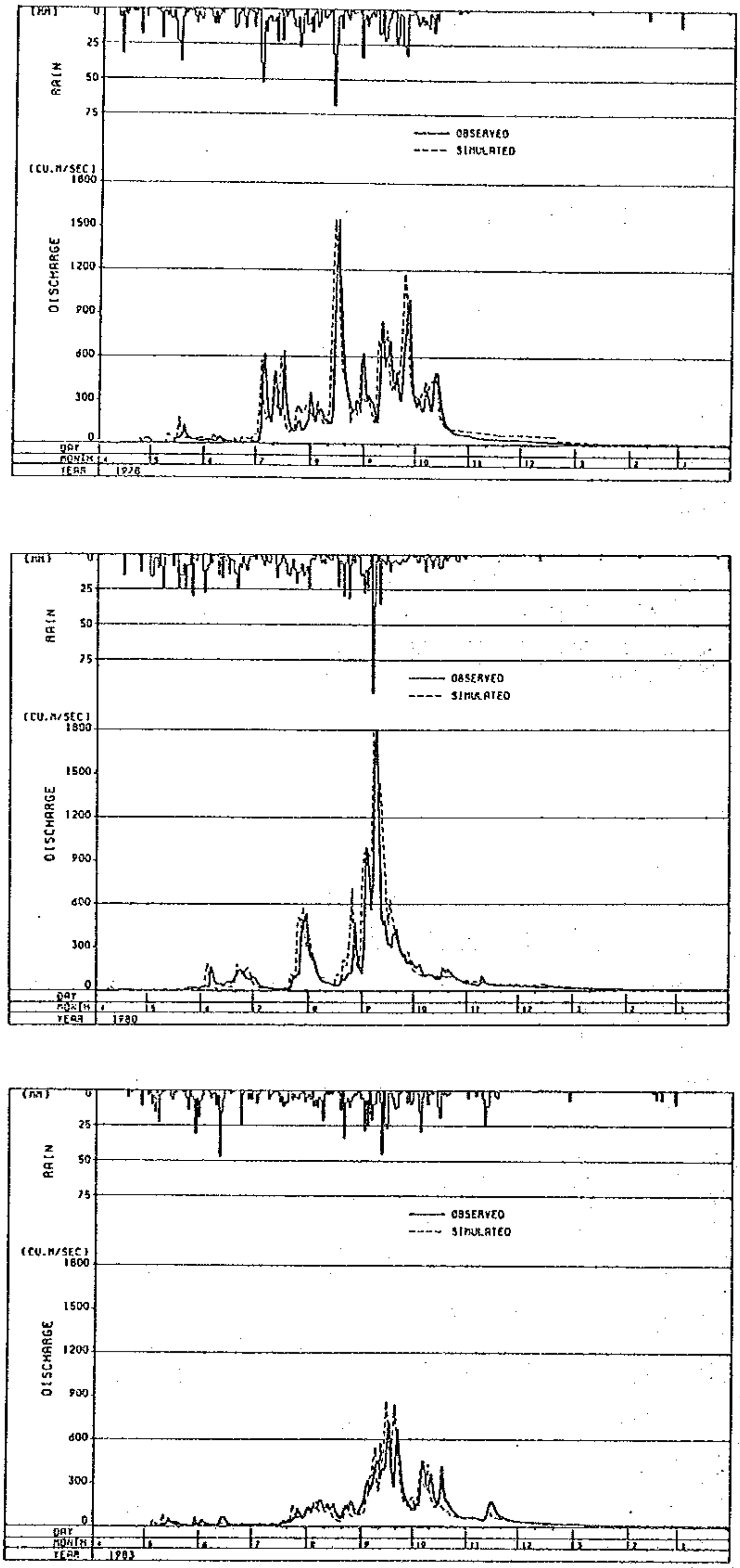
JAPAN INTERNATIONAL COOPERATION AGENCY





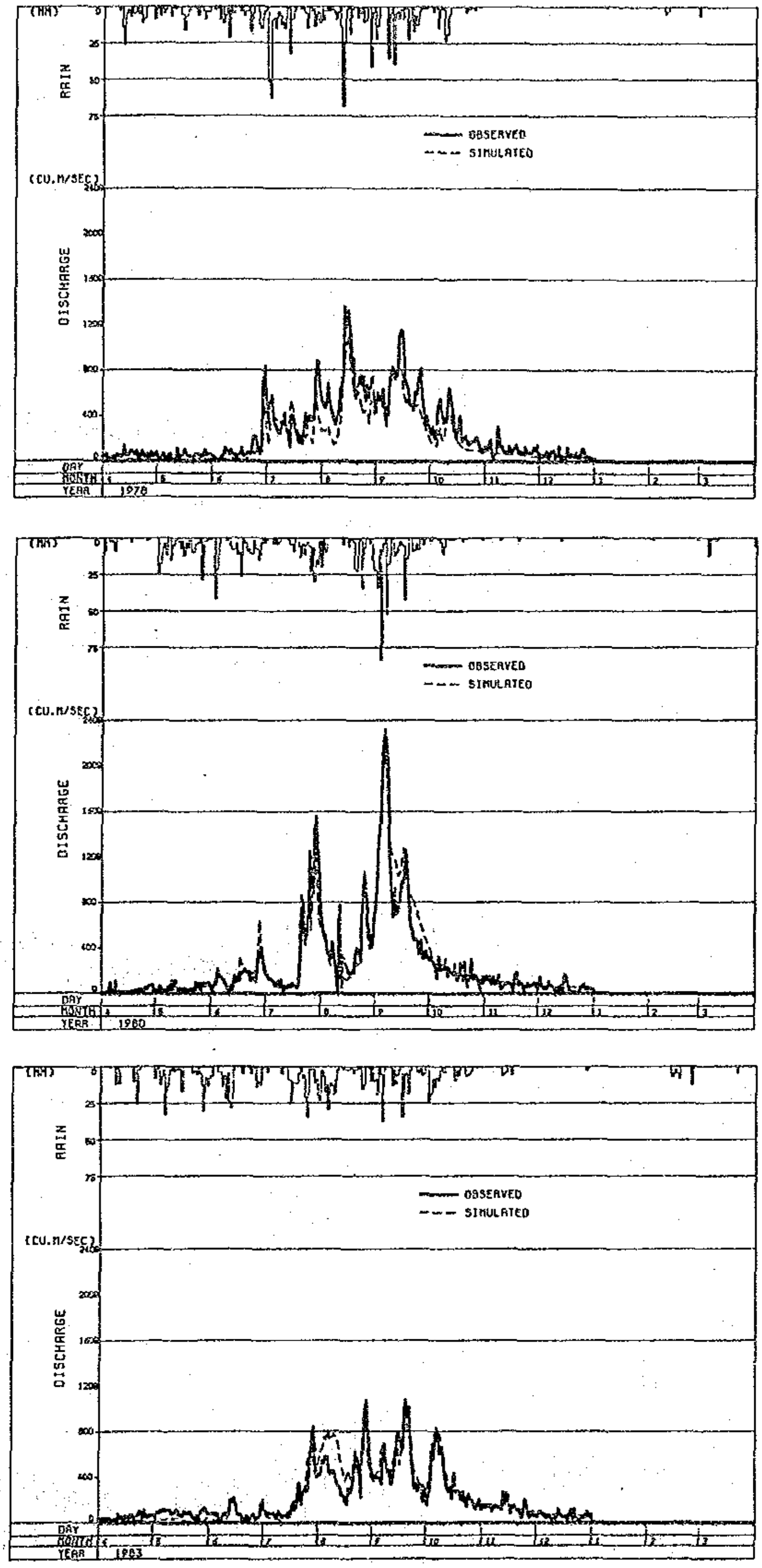
STA. P7A IN PING RIVER BASIN

Fig. 2-19(3/8). DISCHARGE HYDROGRAPH SIMULATED BY BASIN RUNOFF PREDICTION MODEL	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY



STA. Y14 IN YOM RIVER BASIN

Fig. 2-19(4/8). DISCHARGE HYDROGRAPH SIMULATED BY BASIN RUNOFF PREDICTION MODEL	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY

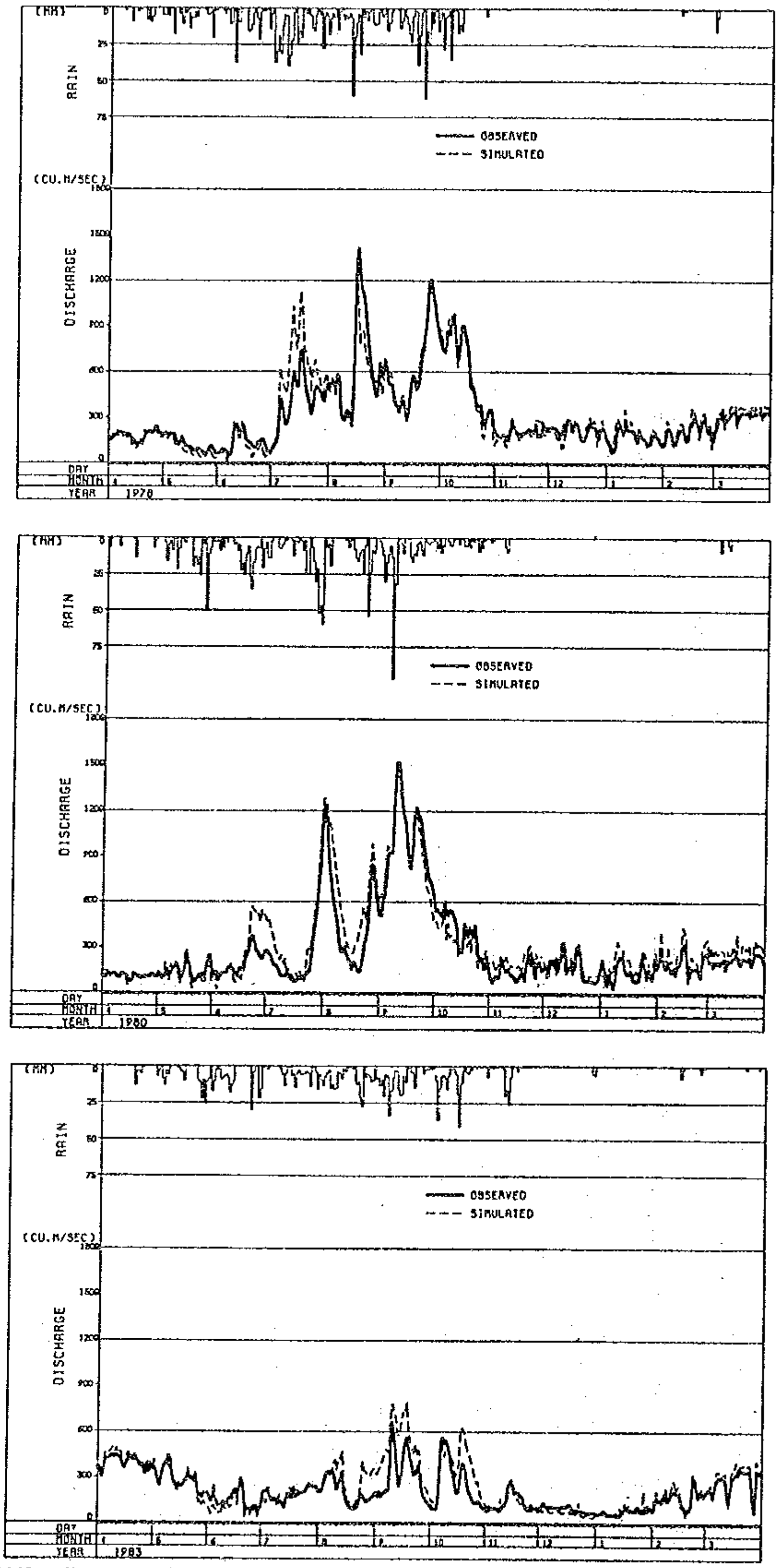


SIRIKIT DAM RESERVOIR IN NAN RIVER BASIN

Fig. 2-19(5/8). DISCHARGE HYDROGRAPH SIMULATED BY BASIN RUNOFF PREDICTION MODEL

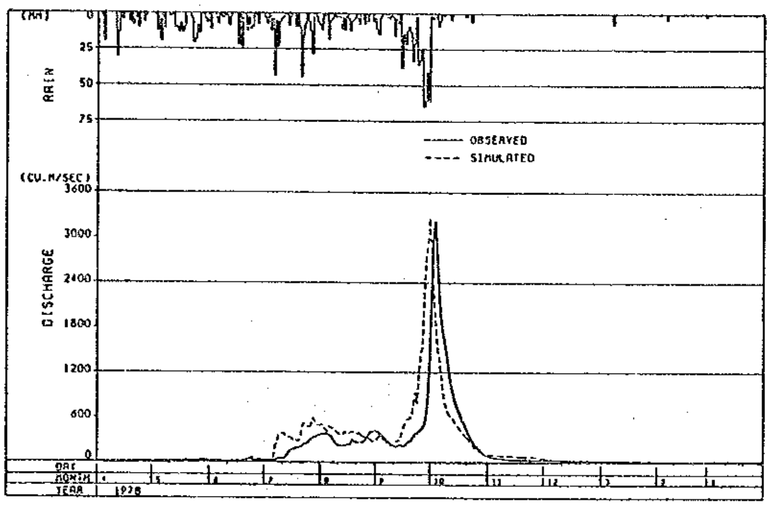
FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

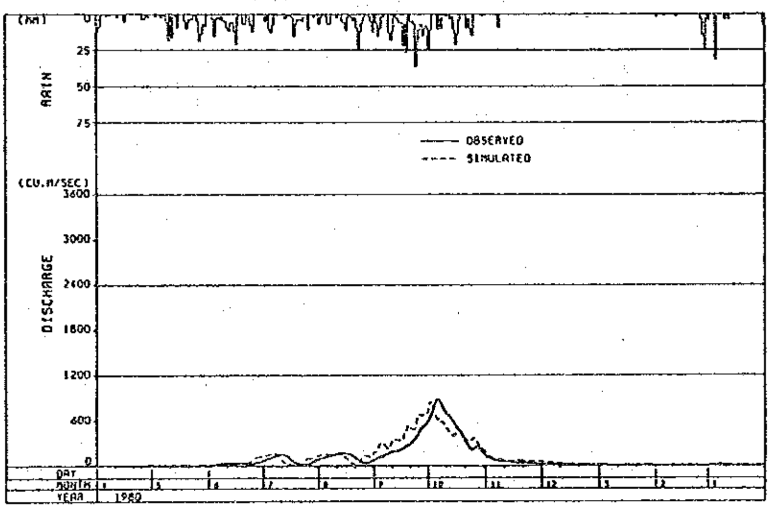
JAPAN INTERNATIONAL COOPERATION AGENCY



STA. N5A IN NAN RIVER BASIN

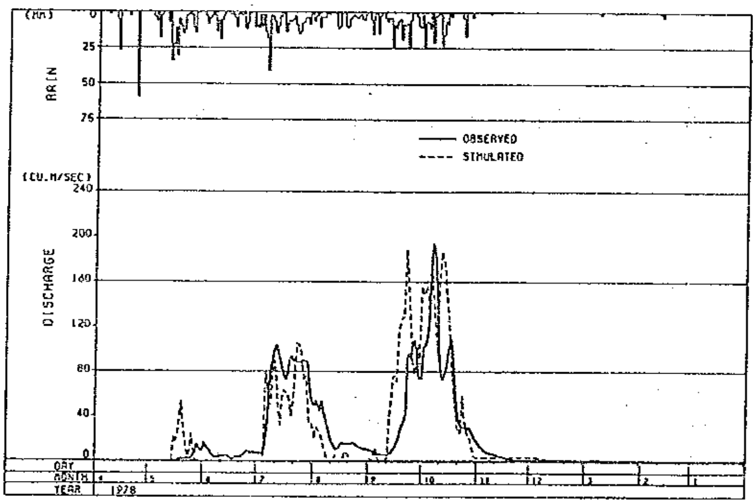
Fig. 2-19(6/8). DISCHARGE HYDROGRAPH SIMULATED BY BASIN RUNOFF PREDICTION MODEL	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY





STA. S9 IN PASAK RIVER BASIN

Fig. 2-19(7/8). DISCHARGE HYDROGRAPH SIMULATED BY BASIN RUNOFF PREDICTION MODEL	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY



STA. Ct8
IN SAKAE KRANG RIVER
BASIN

Fig. 2-19(8/8). DISCHARGE HYDROGRAPH SIMULATED BY BASIN RUNOFF PREDICTION MODEL

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

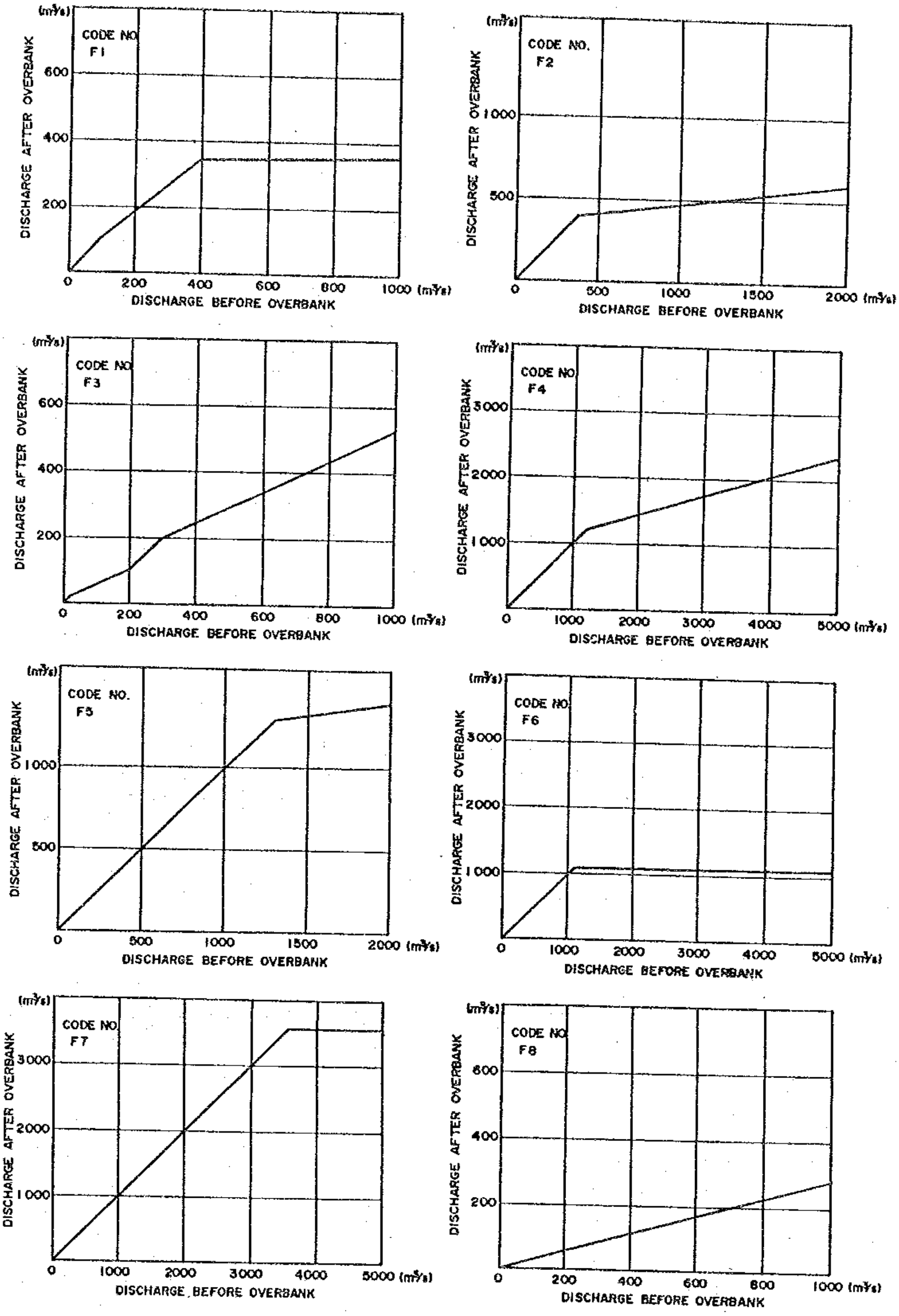


Fig. 2-20(1/2). RELATIONSHIP OF RIVER CHANNEL FLOW DISCHARGES BEFORE AND AFTER OVERBANK

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

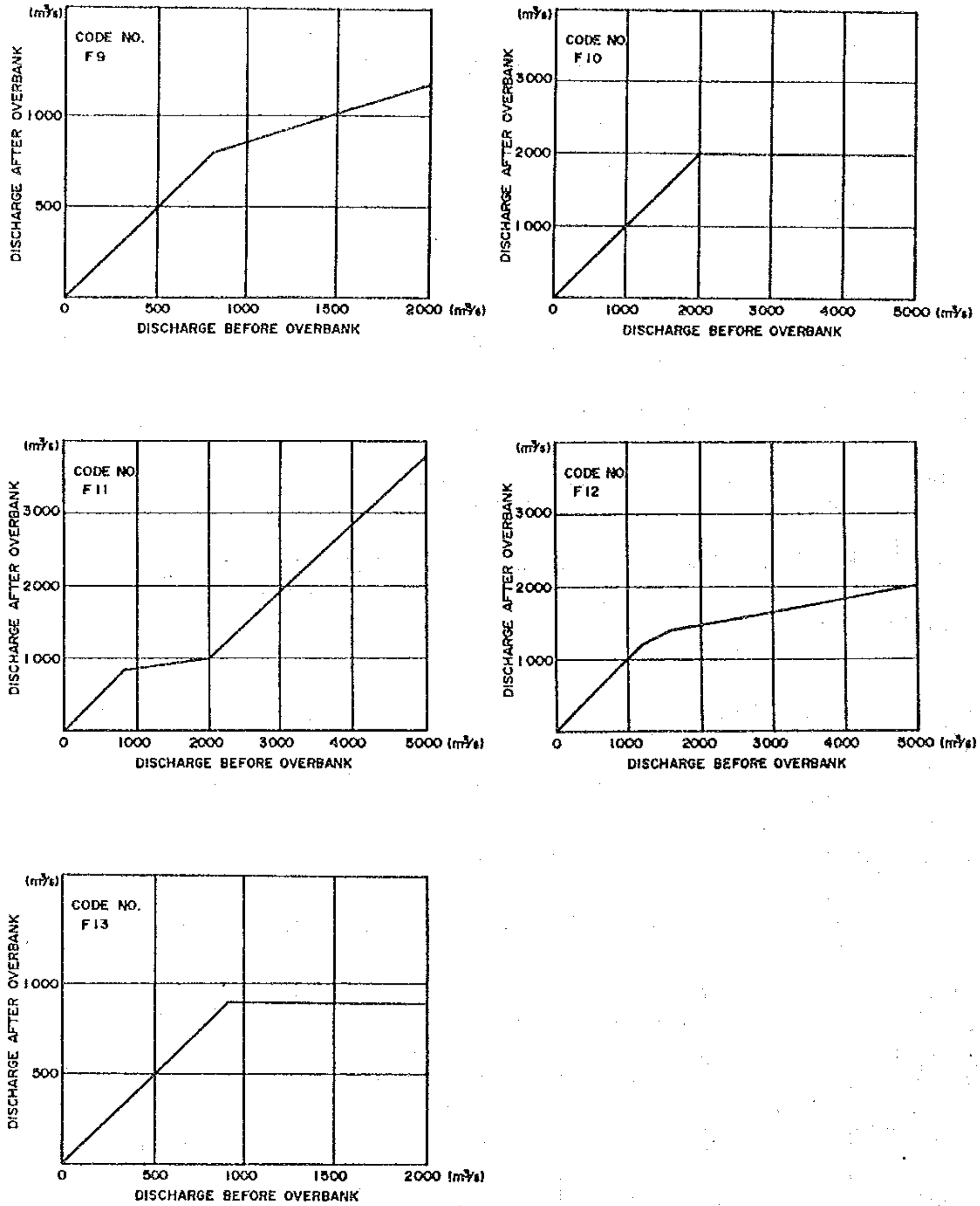


Fig. 2-20(2/2). RELATIONSHIP OF RIVER CHANNEL FLOW DIXCHARGES BEFORE AND AFTER OVERBANK

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

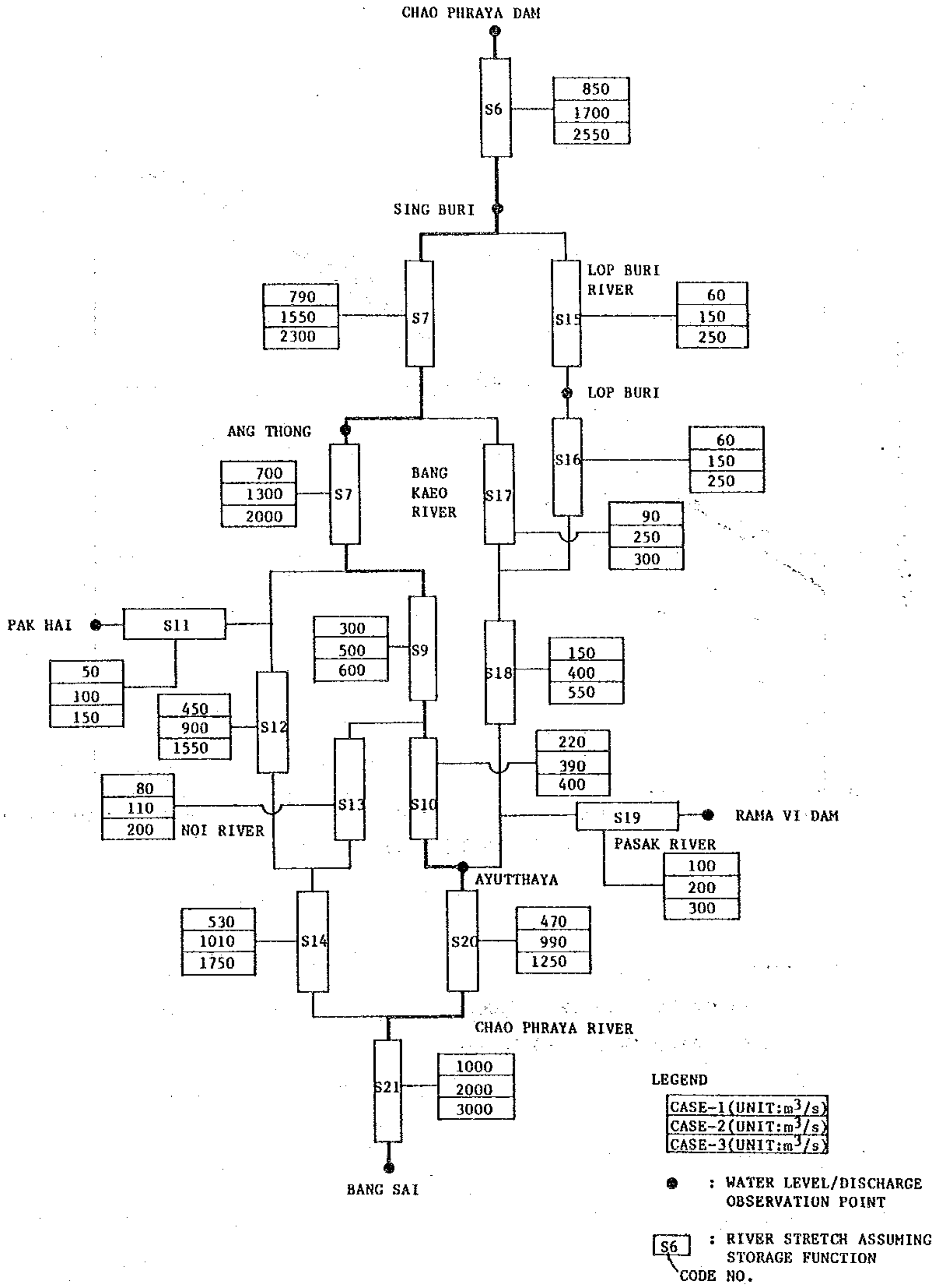


Fig. 2-21. DIVERSION RATIO OF FLOOD DISCHARGE AMONG SUBDIVIDED CHANNEL

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

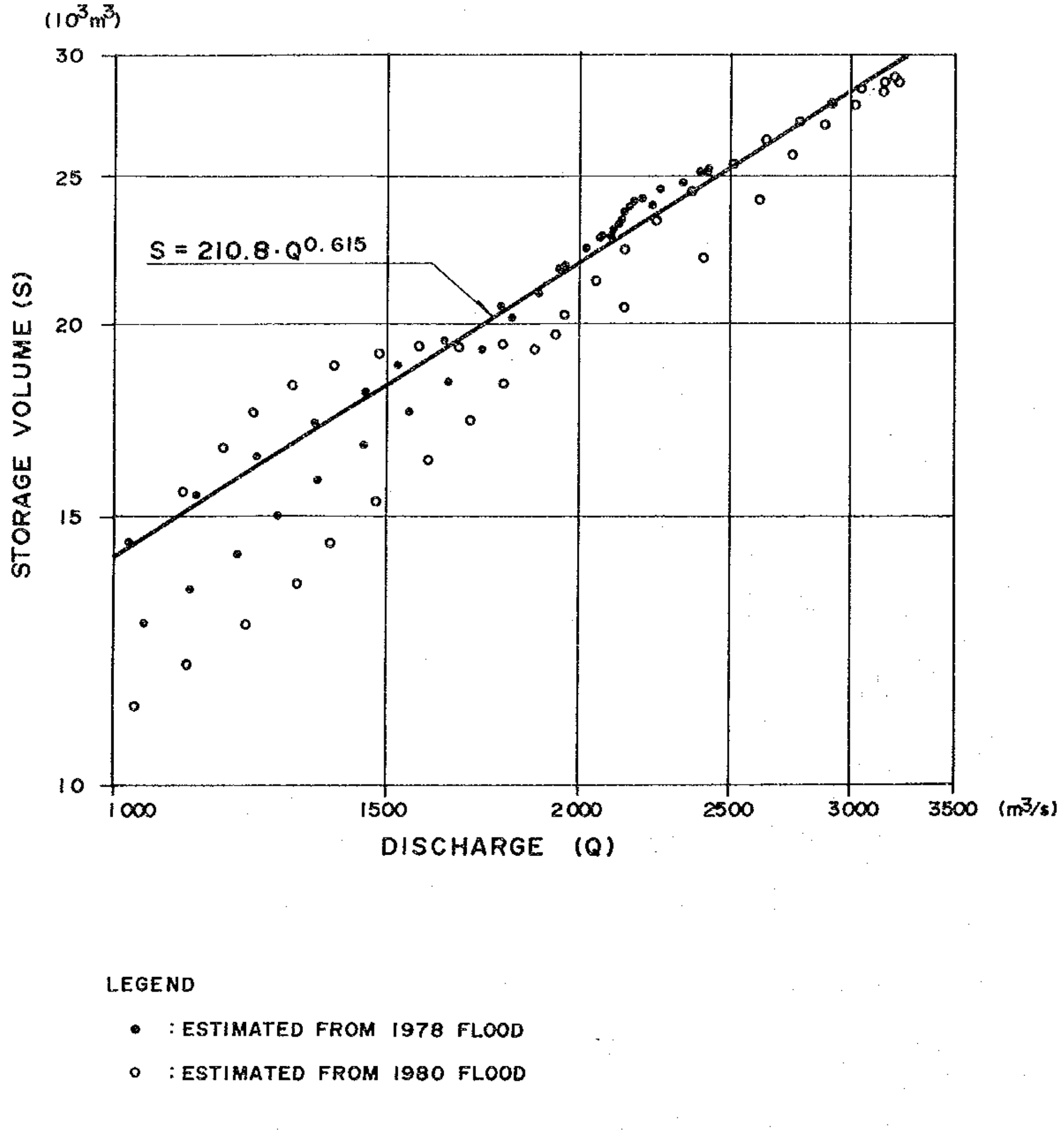


Fig. 2-22. RELATIONSHIP BETWEEN STORAGE VOLUME AND DISCHARGE AT CONFLUENCE OF PING AND NAN RIVER	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY

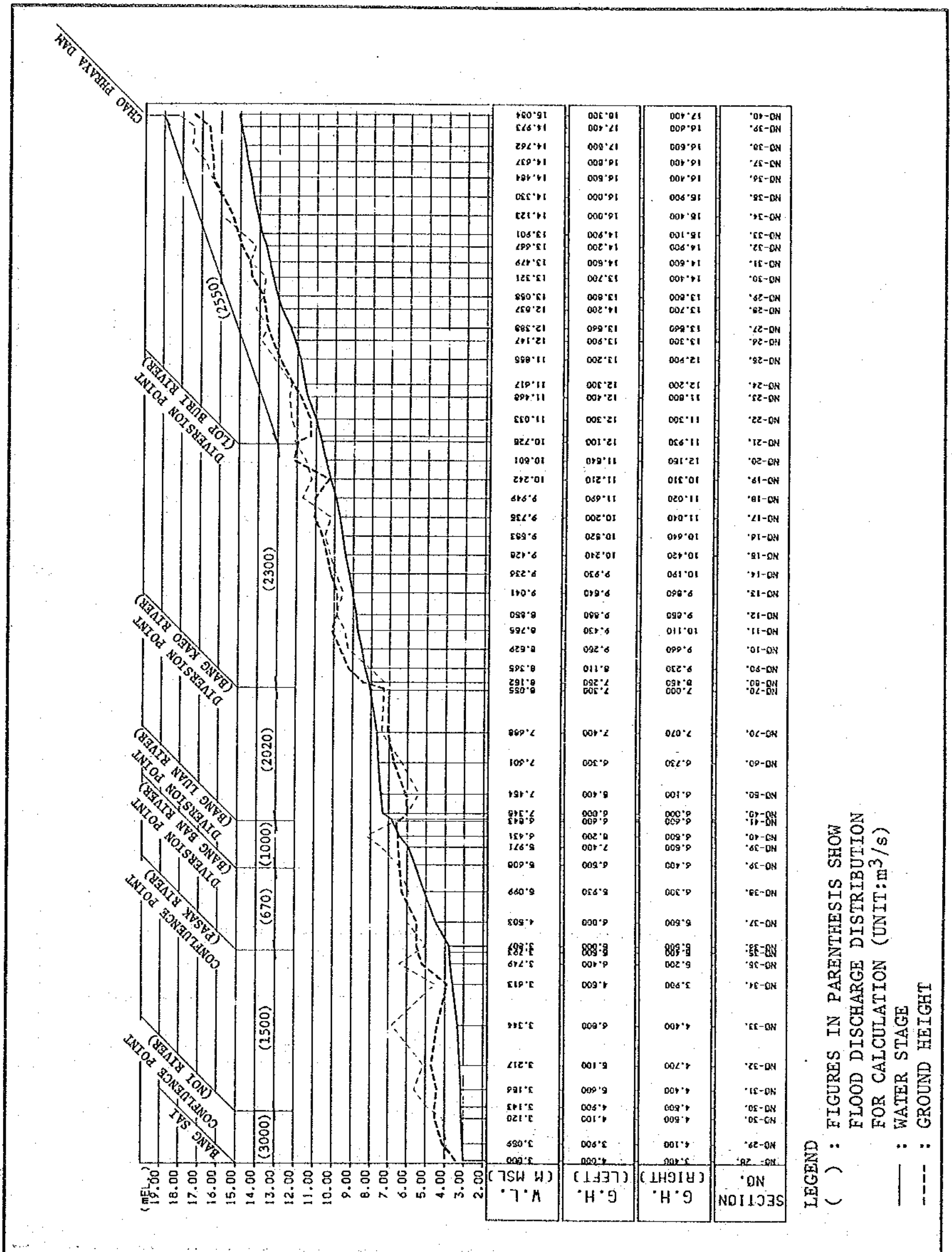
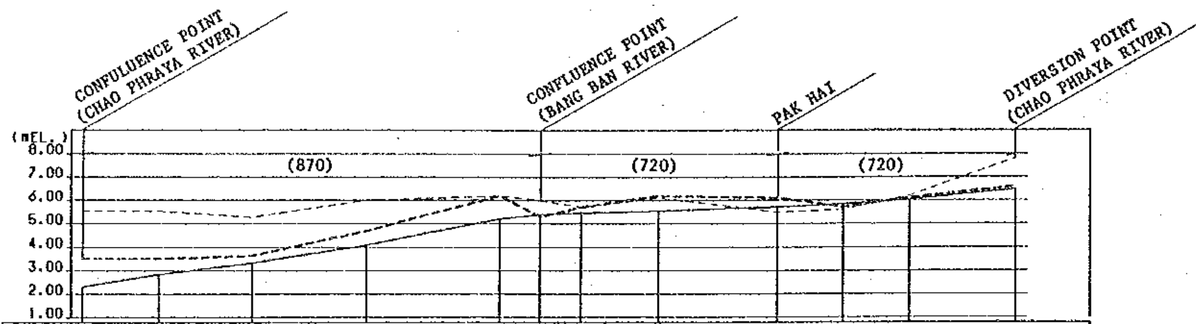
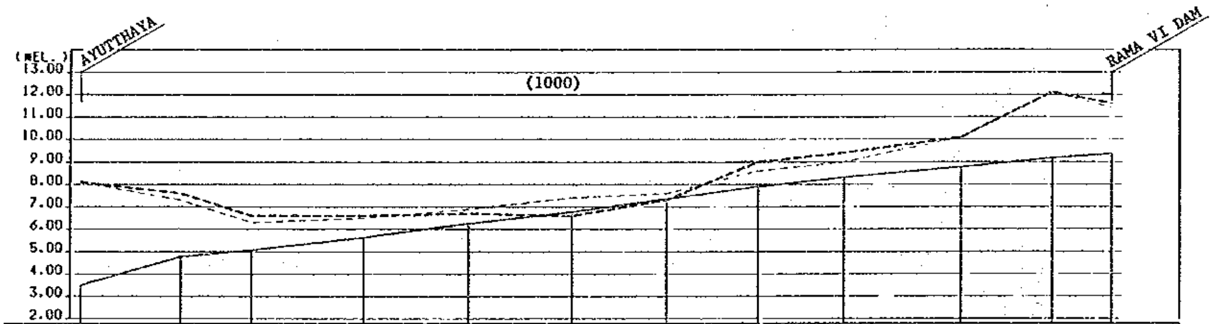


Fig. 2-23(1/2). NON-UNIFORM FLOW CALCULATION RESULT (CHAO PHRAYA RIVER)

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



W.L. (M MSL)	2.310	2.844	3.329	4.105	5.216	5.402	5.470	5.560	5.725	5.844	6.060	6.452
G.H. (LEFT)	5.540	5.540	5.280	6.000	6.200	6.000	5.700	6.100	5.600	5.600	6.200	7.600
G.H. (RIGHT)	3.610	3.610	3.630	4.700	6.200	5.300	5.700	6.200	6.100	5.700	6.100	6.650
SECTION NO.	NO- 10.	NO-10.	NO-20.	NO-30.	NO-40.	NO-40.	NO-50.	NO-60.	NO-70.	NO-10.	NO-20.	NO-30.



W.L. (M MSL)	3.500	4.769	5.077	5.650	6.264	6.787	7.360	7.910	8.323	8.777	9.180	9.370
G.H. (LEFT)	8.100	7.300	6.300	6.800	6.900	7.400	7.600	8.400	9.000	10.100	12.100	11.400
G.H. (RIGHT)	8.100	7.600	6.000	6.600	6.700	6.600	7.300	9.000	9.400	10.100	12.100	11.600
SECTION NO.	NO- 10.	NO-20.	NO-30.	NO-40.	NO-50.	NO-60.	NO-70.	NO-80.	NO-90.	NO-10.	NO-11.	NO-12.

LEGEND

( ) : FIGURES IN PARENTHESIS SHOW FLOOD DISCHARGE DISTRIBUTION FOR CALCULATION (UNIT:m^3/s)

—— : WATER STAGE

---- : GROUND HEIGHT

Fig. 2-23(2/2). NON-UNIFORM FLOW CALCULATION RESULT (NOI RIVER AND PASAK RIVER)

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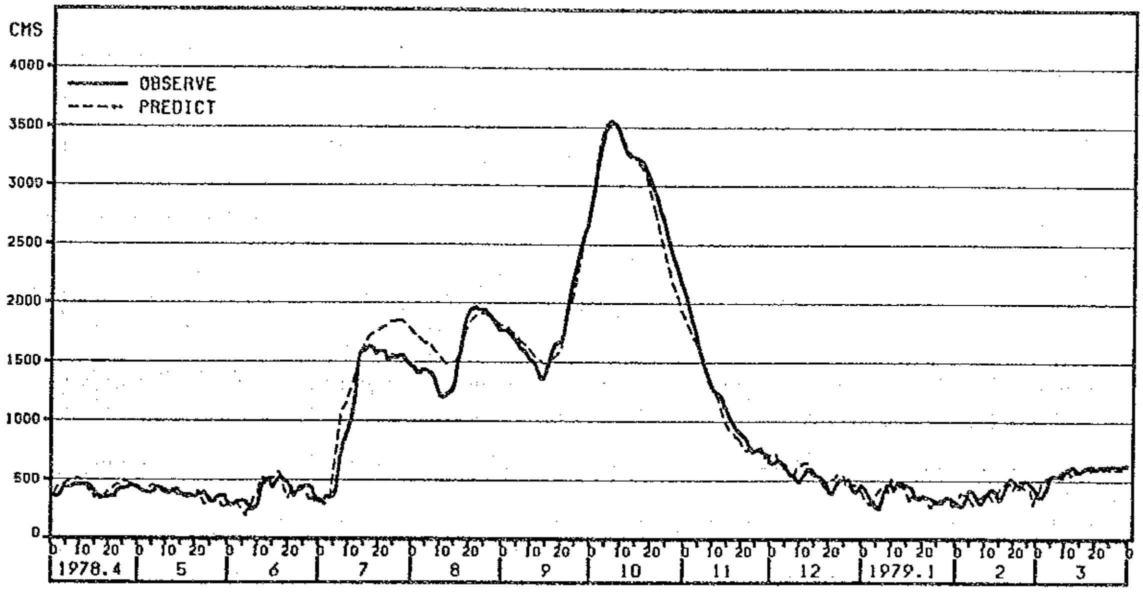

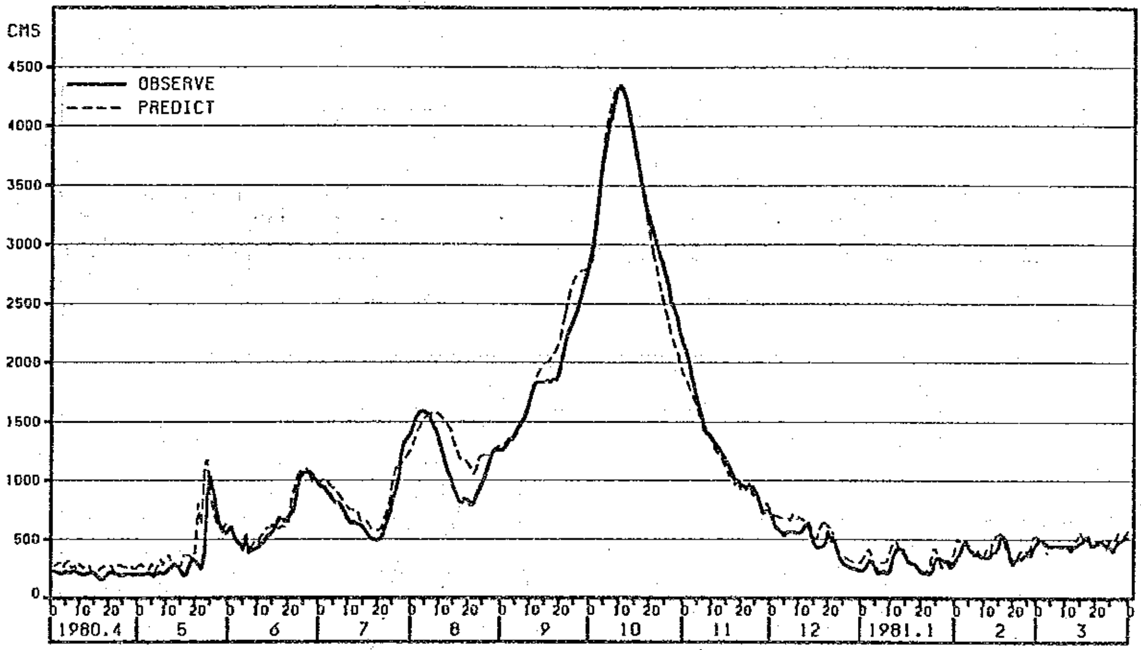

Fig. 2-24(1/4). DISCHARGE HYDROGRAPH SIMULATED AT NAKHON SAWAN

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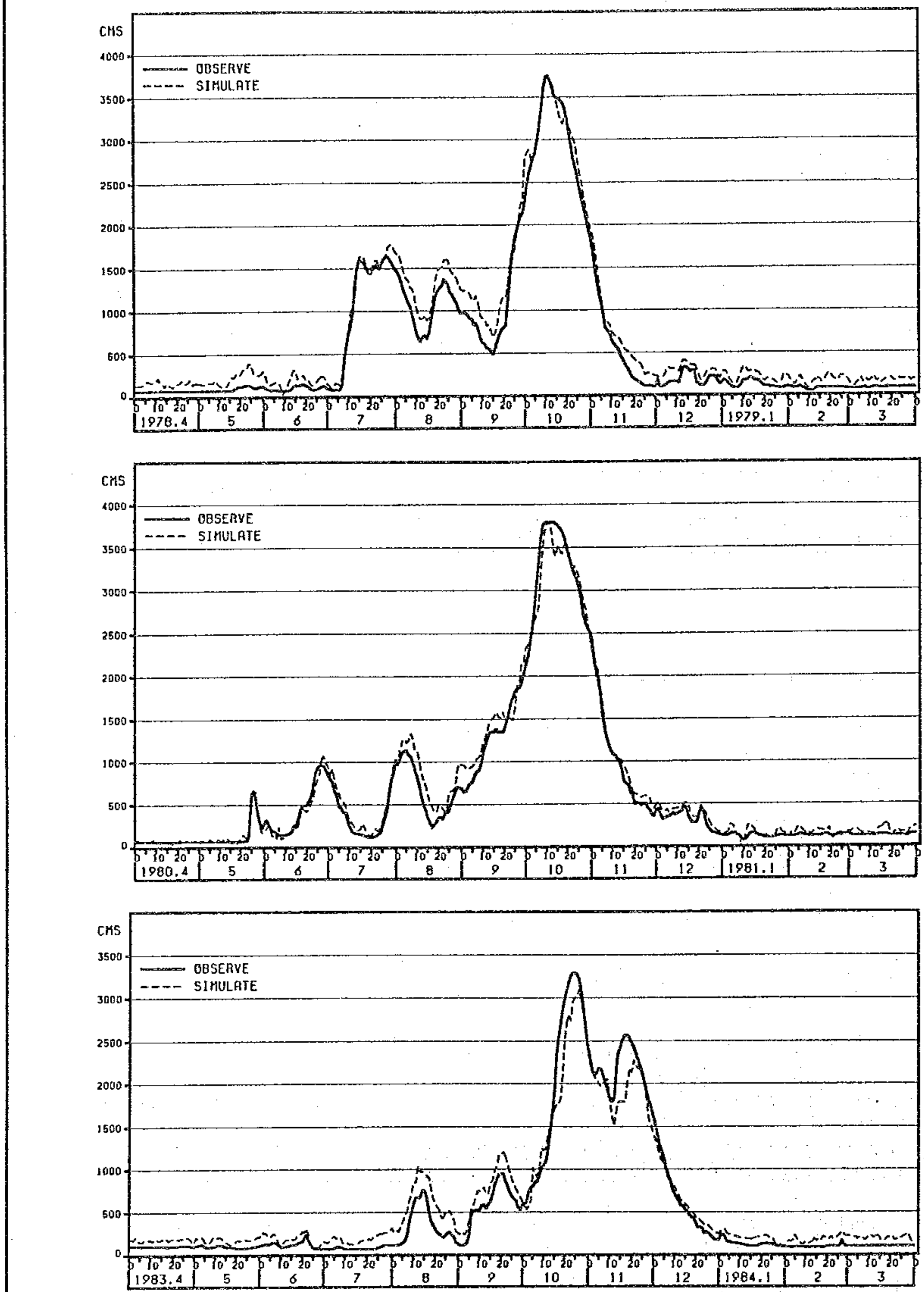

Fig. 2-24(2/4). DISCHARGE HYDROGRAPH SIMULATED AT CHAI NAT

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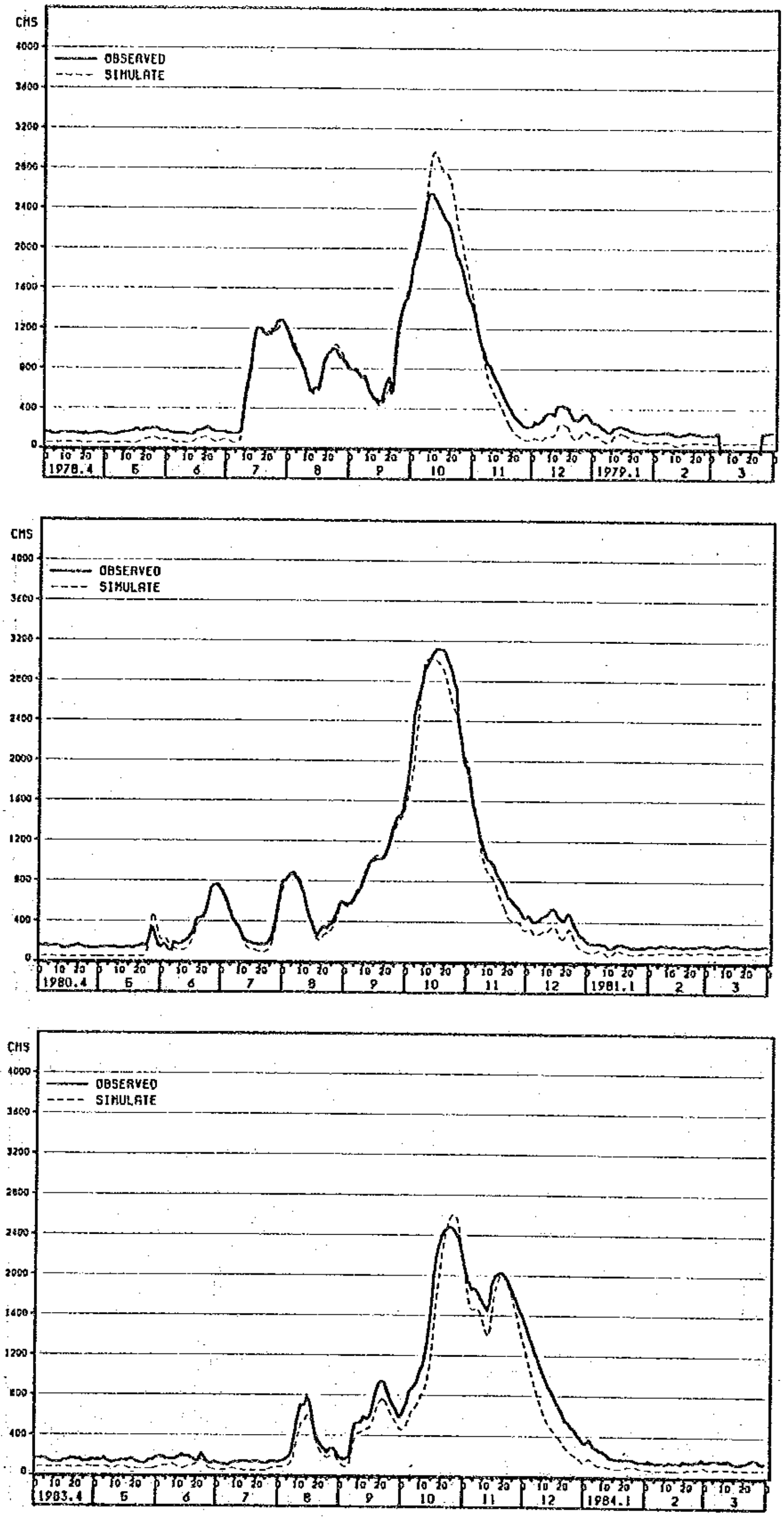

Fig. 2-24(3/4). DISCHARGE HYDROGRAPH SIMULATED AT ANG THONG

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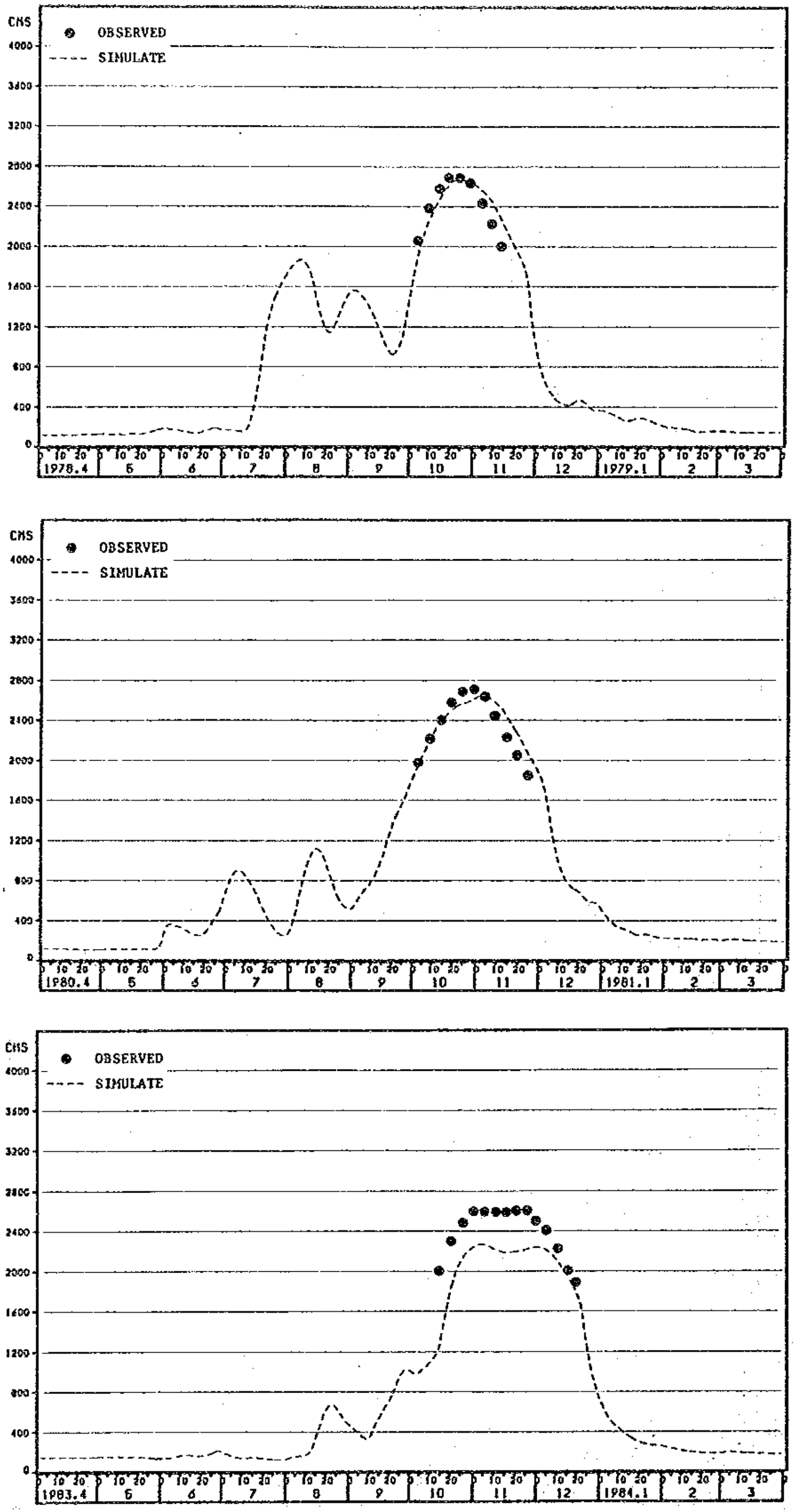

Fig. 2-24(4/4). DISCHARGE HYDROGRAPH SIMULATED AT BANG SAI

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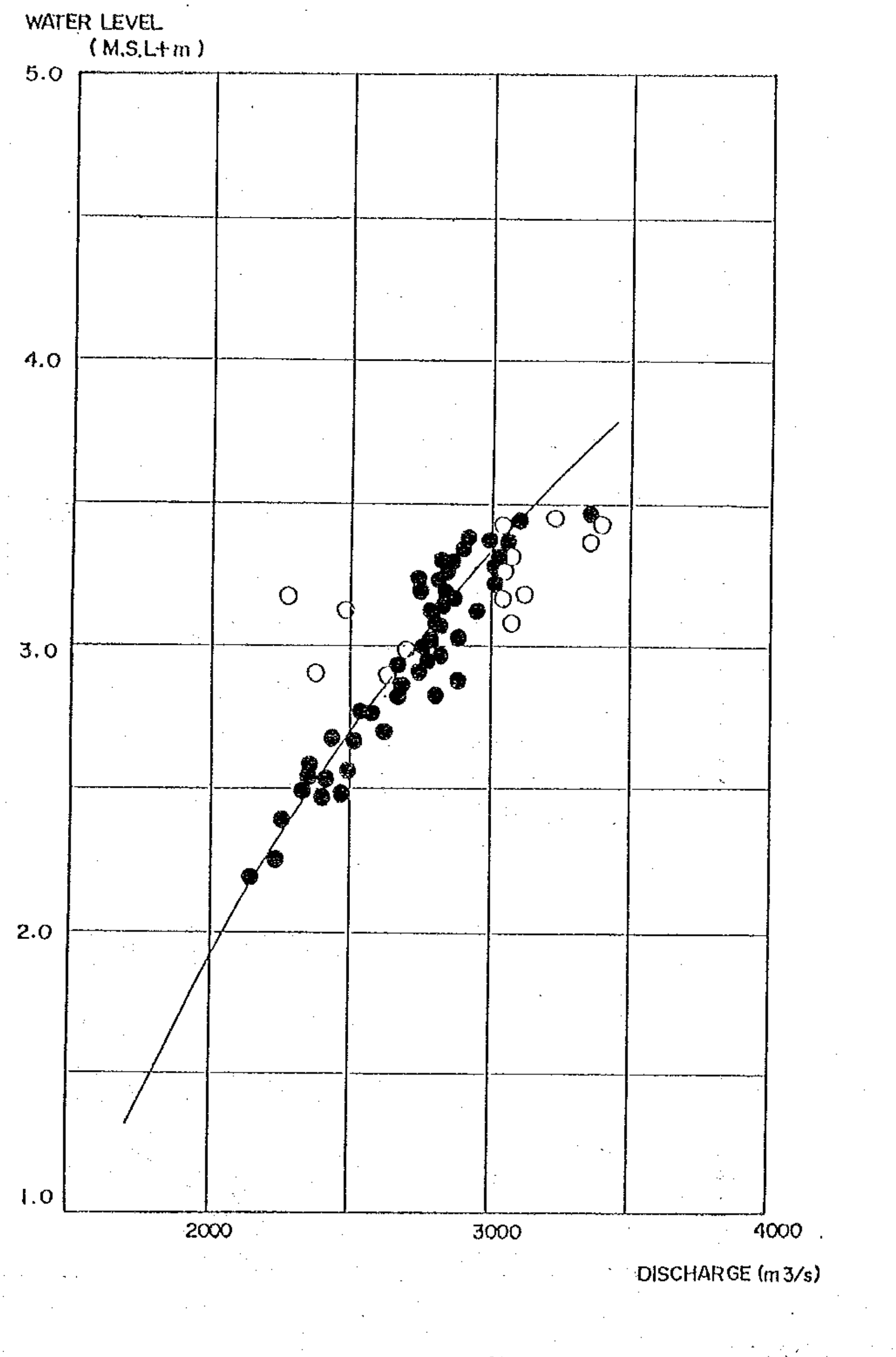

Fig. 2-25. RATING CURVE AT BANG SAI

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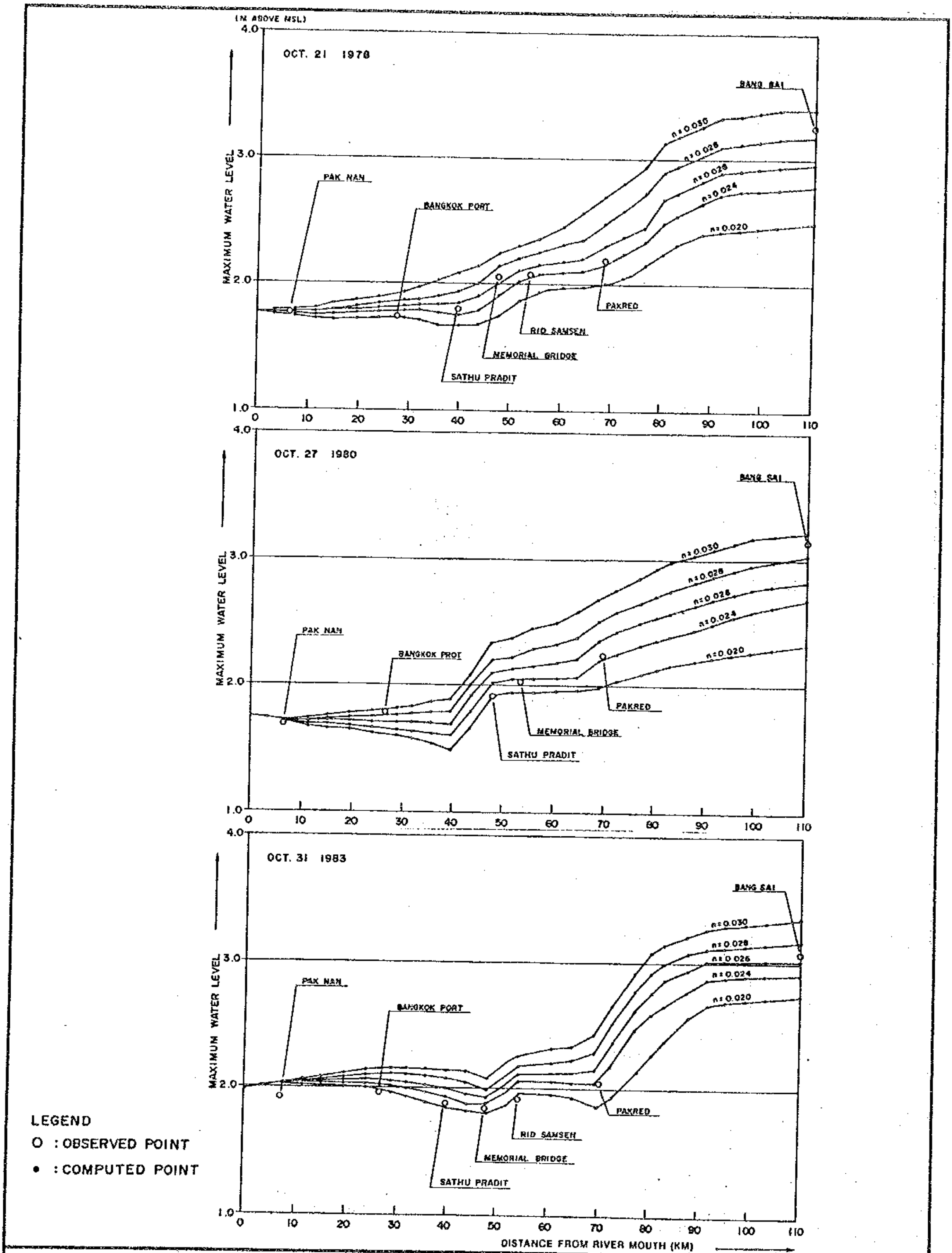

Fig. 2-26. EFFECTS OF MANNING ROUGHNESS COEFFICIENTS ON COMPUTED MAXIMUM WATER STAGE	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN
	JAPAN INTERNATIONAL COOPERATION AGENCY

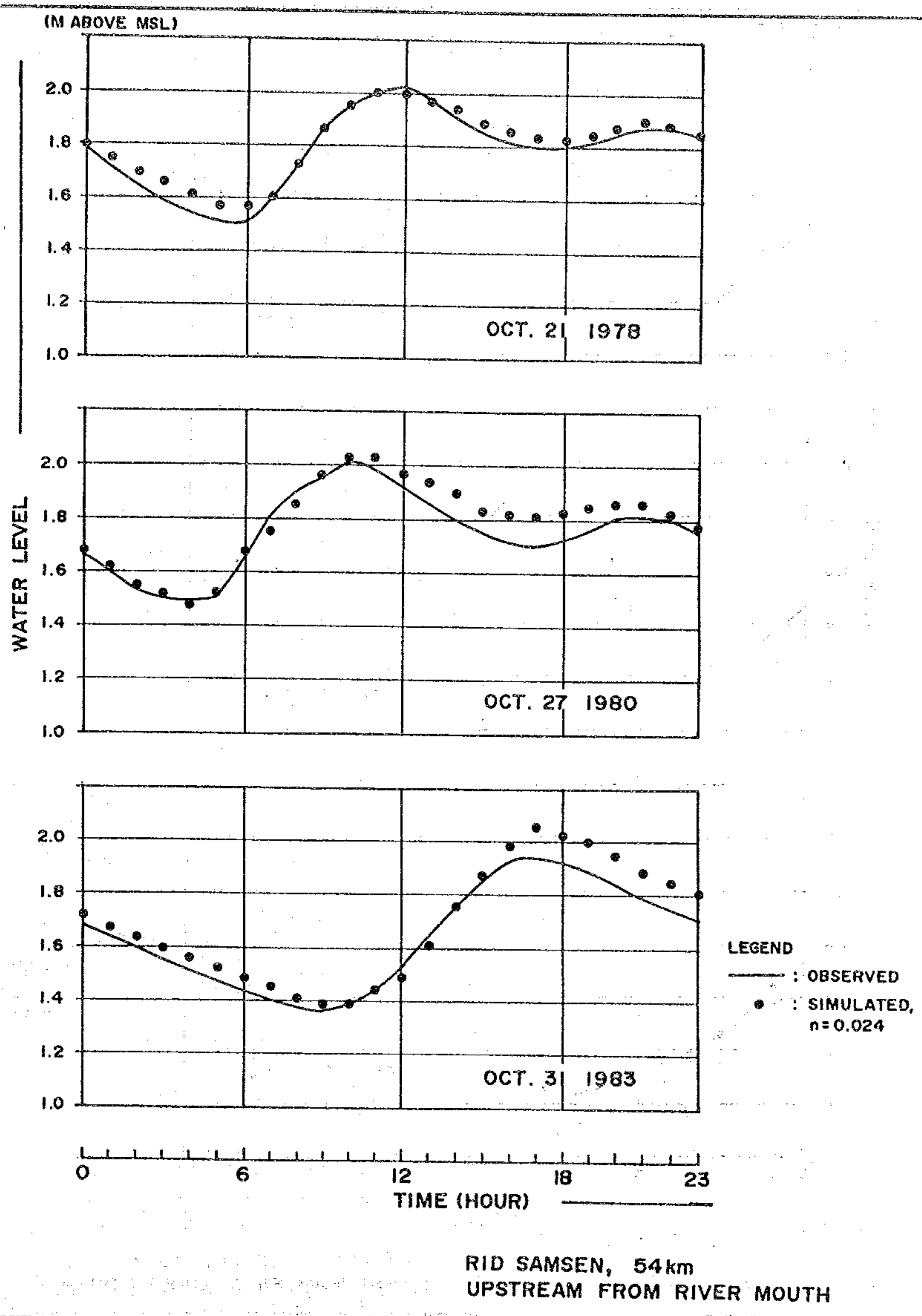

Fig. 2-27(1/3). OBSERVED AND SIMULATED WATER LEVEL HYDROGRAPH FOR TIDAL COMPARTMENT

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

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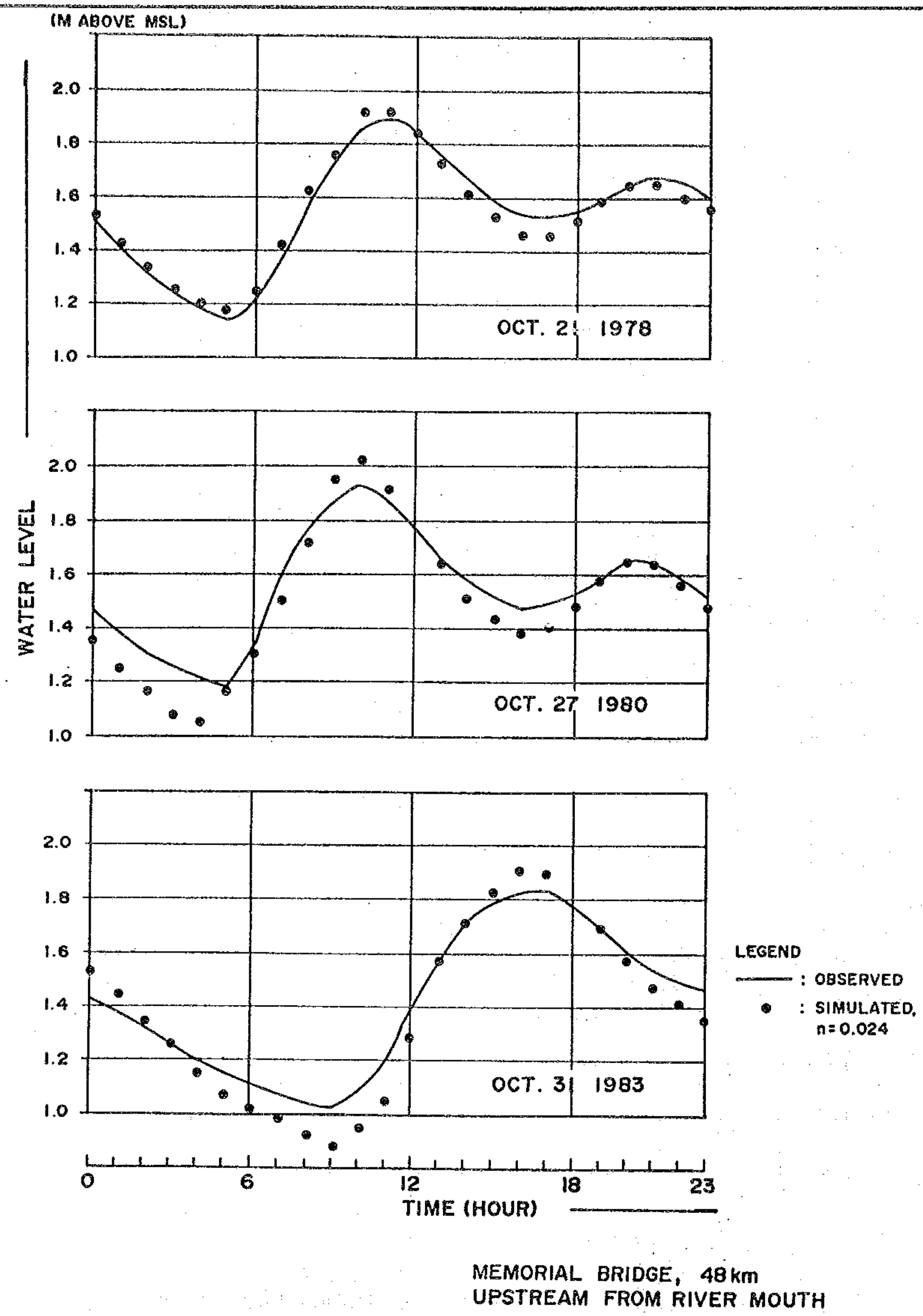

Fig. 2-27(2/3). OBSERVED AND SIMULATED WATER LEVEL HYDROGRAPH FOR TIDAL COMPARTMENT	FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY

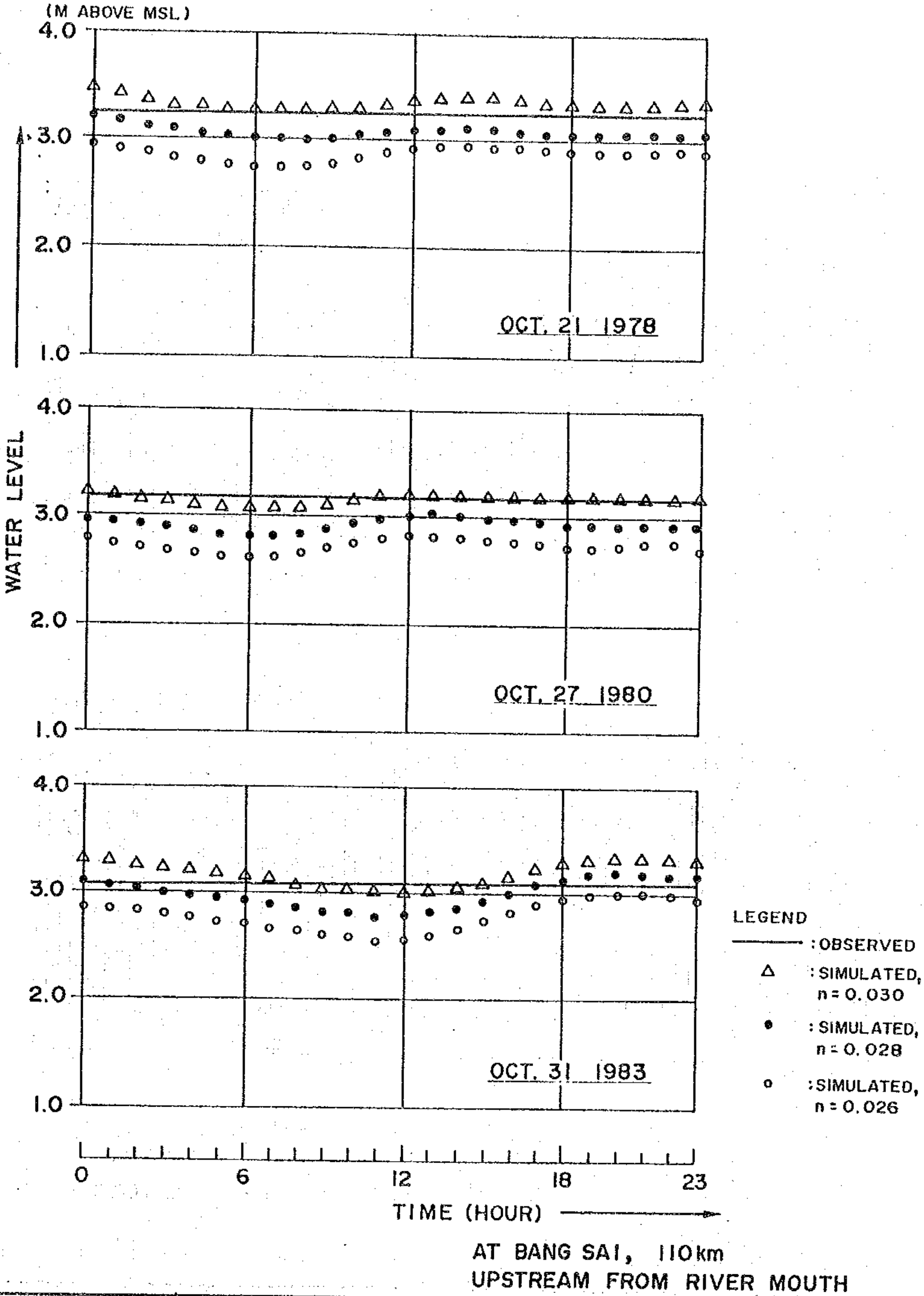

Fig. 2-27(3/3). OBSERVED AND SIMULATED WATER LEVEL HYDROGRAPH FOR TIDAL COMPARTMENT

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

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