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Bangladesh

1. COUNTRY: BANGLADESH

2. DESIGNATED RIVER BASIN

2.1 Basin name and area: Ganges (within Bangladesh)
600,000 km^2 and 20,000 km^2 in Bagladesh

2.2 Location:

Lat.	24°40' N	23° N
Long.	88° E	91°E

2.3 Topographical map of the basin showing the boundary of the basin, rivers, towns etc. attached (Fig. 1)

2.4 Index map (1:1,000,000) showing the location of the basin and the main rivers.

For this the above map will do (Fig. 1).

2.5 General description of the basin:

i) Topography and Geology:

Bangladesh, a deltaic country, is occupying a very unique and important place in the land of rivers. It lies roughly between 21°30' - 26°40' in north latitude and 88° - 92°40' in the east longitude. Being one of the biggest deltaic countries of the world; it consists of the flood plains of the Ganges, the Brahmaputra and the Meghna rivers and their large number tributaries and distributaries.

The general characteristic of the topography is of extreme flatness with only a few hills in the South- East and North-East. Generally the land slopes from north to south, from 250 ft above mean sea level at the northern boundary of Dinoypur District to 10 ft or less near the sea coast. The highest areas of the country lie in the Chittagong Hill Track where elevations range up to app. 4,000 ft. Most of the area of the country lies between 50 ft to 20 ft contours.

The rivers Ganges and Brahmputra join together near Goalando and flows as Padma River, the river Meghna joining the Padma near Chandpur flows to the Bay of Bengal as Meghna River. These river system together, drain one of the heaviest rainfall areas in the world. Their total catchment area is app. 600,000 sq miles (1,500,000 sq km) of only which 75% lies in Bangladesh. About 75% of the total quantity of water reaching Bangladesh in from outside by these main river system. Most of the rivers of Bangladesh are charactrized by limited depth due to depositions. All the rivers are tidal near the sea with a maxm tide range of 22 ft. The rivers Ganges, Brahmputra and Meghna together discharge a flood which can exceed 5,000,000 cfs (140,000 m^3/sec) and they carry sediment in the order of 2,400 million tons annually.

ii) Meteorology (including causes of main floods):

With respect to meteorology and climate, the country has two distinct seasons, dry season from November to May and wet season from June to October, over 80% of the rainfall occurs during the monsoon or rainy season when flood invariably occurs. The normal rainfall varies from app. 56" (1,700 mm) at Rajshahi Pabna, Bogra, Kushtia, Jessore, Faridpur District and 216" (5,500 mm) around Sylhet District. Long periods of steady rainfall for several days are common during monsoon season, but sometimes local high intensity rainfall of short duration occurs. The sky remains cloudy for long period, high humidity persists, and the maxm temperatures stays in more than 100 °(F) 40 °(C) at some places. The rivers begin to rise steadily on the on-set of the monsoon and reach their peak levels from July, Aug. and September when flooded area covers about 10,000 sq miles (2,5000 sq km) in normal years. Flash floods occur on the small rivers of steep slope in high intensity areas like Syhet and Chittagong Hill Track areas. Overflooding becomes severe when the high floods in the main rivers - the Ganges, the Brahmputra and the Meghna coincides. Floods in the principal rivers occur in the monsoon season with such remarkable regularly in timing, duration and magnitude that they have determined the way of life for the people here over many centuries. In fact, the agriculture practice and cropping pattern have adjusted itself to the normal conditions of rainfall and inundation. About 10,000 sq mile (25,000 km^2) of this intensity cultivated and thickly population region is "normally" flooded every year with a flooding height of 3 ft (1 meter) to 12 ft (4 meters). When there is abnormal flooding principally due to synchronization of flood peaks of the Ganges, the Brahmputra with simultaneous heavy rainfall in the catchments, the maxm flooded area may rise to over 20,000 sq mile (50,000 km^2) as occurred in the year 1974 with the flooding depth of 15 ft (5 meters), and above in the low lying areas of Mymensingh, Sylhet and Commilla District.

Causes of Main Floods:

On the basis of extensive data collected over a number of years, investigation and model studies the following factors have been identified responsible, in general, for floods in Bangladesh.

a) Low general topography:

Topographically Bangladesh is a low area, half of the land is lying with 25 ft (5 m) contour line with respect to mean sea level. Flood water spills from the rivers and accumulates in the plains. (Fig. 2)

b) High monsoon flood through the principal channels:

The drainage from a catchment area about 600,000 sq miles (1,500,000 km^2) which is drenched by one of the heaviest monsoon rainfalls in the world leads to a concentration of large discharge in the main rivers in the monsoon months. As a result these channels are over loaded with the quantum of flow, flooding the low lying areas. (Fig. 3)

c) Siltation of the off-take of the principal distribution of the Ganges and Brahmputra:

Due to Earthquake of 1950, there has been marked changes in the behaviours of off-takes of the principal distributeries of the Ganges and Brahmputra. These were one sufficiently deep to function efficiently but are now badly silted up. This has resulted in the concentration of flood in the South-Eastern of the country instead of being more proportionately distributed over land area.

d) Over bank spilling of the rivers:

Simultaneous heavy discharges of the upland streams, high waters in the estuaries low topography of the country, river bed siltation account for the bank spilling of rivers in Bangladesh.

e) Effect of flood control measures in the upper reaches of the Ganges, Brahmputra, Teesta:

During the last few years, INDIA has constructed several thousand miles of embankment in the upper reaches of Brahmputra. This leads to a quicker flow of large flood waters into Bangladesh resulting the rise of flood water level within country.

f) High rainfall within the country:

Annual rainfall within country is mainly caused by the south-western monsoon. Heavy rainfall of more than 200 inches (5,500 mm) a year occurs in the North-Eastern Corner. Since 80% of precipitation occurs in monsoon months, the large rainfall run-off coincides with heavy discharges in the rivers and causes the typical floods. Besides, locally concentrated rainfall sometimes leads to a local flood of severe intensity of short duration. (Fig. 4)

g) Strong back water effects of tides of the Bay of Bengal:

Back water effects of the tide, specially spring tides of the Bay of Bengal retard drainage of the flood water in the Bay of Bengal and thereby causing monsoon flooding of low areas in the coastal region. (Fig. 5)

h) Rise of mean sea level:

Rise in the mean sea level by about 2 ft (0.70 m) in the monsoon due to the effect of south-westerly winds also adversly affect the drainage and raises the flood levels near the coast.

i) Back water effect of the principal rivers on one another at their confluence:

High water level in the principal rivers slows down the flow of their tributeries. They also affect the discharge of each other. River Dharla and the Teesta in Rangpur District are backed up the river Brahmputra, thereby increasing the flood heights in Kurigram in Rangpur District. Backing up by the Ganges and in Brahmputra during coincidence increasing flooding in Pabna, Bogra and Faridpur District. The backing up of the drainage of the Sylhet, Mymensingn, Haor (depressed areas) through the Meghna due to the high waters Bevailing in the lowers Meghna at Chandpur is a wellknown phenomenon.

j) Topographic features controlled by geological factors:

A series of geological fault has created depression in the North-West (Rajshahi, Pabna, Bogra), North-East (Sylhet, Mymensingh Haor areas) and in the South(Beel areas of Khulna, Faridpur, Barisal). These areas are inundated with the advant of monsoon and remain water logged upto November or even upto December. (Fig. 6)

k) Peak-flood synchronization in the Ganges and the Brahmputra:

In some years both the Ganges and the Brahmputra recorded peak floods simultaneously and thereby aggravated floods situation in the country, though the rivers have different behaviour with respect to their peak flood records.

iii) Population:

As per 1981 census the total population is 90,000,000 out of which 46 million male, 44 million female. Growth rate 2.5% per annual.

Sex ratio 107 males per 100 females.

The urban population 10% and rural 90%.

Density 1,550 per square mile, the total area 56,000 sq mile i.e. 640 per km^2 perhaps the largest population density of the world.

iv) Economy (Land use, agriculture, industry, traffic etc.)

Out of 35 million acres (14.4 million hectars) of total land area of the country 24.5 million acres (9.92 million hectars) are cultivable for cultivation. 16% is under forest, 18% is not available for cultivation and there is only 2% cultivable waste of the cultivable area. 62% is single cropped, 34% is double cropped area and 4% is triple cropped. The average per capita income is $80.00 (eighty) only.

Principal crops: Jute, Rice, Tea, Tobacco, Sugarcane, Pulses, Oilseads, Wheat.

Principal fruits: Mango, Jackfruits, Banana, Coconuts.

Principal industries: Jute, Cotton, Tea, Paper, Neos print, Cement, Fertilizer, Electric Cables.

Principal minerals: Natural Gas, Lignite and Limestones.

Principal exports: Jute, Jute manufactures, Tea, Hides and Skins, Newsprint, Fish.

Sea ports: Chittagong and Chalna.

Airports: Dacca (International), Chittagong, Jessore, Ishurdi, Sylhet, Commilla, Cox's Bazar, Thakurgaon and Syedpur (Rangpur District).

Radio stations: Dacca, Chittagong, Rajshahi, Khilna, Rangpur and Sylhet.

Television stations: Dacca, Chittagong, Sylhet, Khilna, Natore (Rajshahi District), Mymenshingn and Rangpur.

Satellite station: Betunia (for international telecommunication through tel-set).

Total length of metalled road is 3,000 miles (4,800 km) by National Road Agency. Total length of metalled road by Local Bodies 4,500 miles (7,200 km).

Total railway net work is 1,800 miles (2,800 km).

Total no of telephone sets: 80,000 nos.

Total no of T.V. set: 35,000 nos.

v) Others:

Present Bangladesh came into being after 1971 with bloodshed, being separated from Pakistan. And Pakistan from INDIA in the year 1947 by the British. Due to member of transition Bangladesh could not go ahead as desired. Bangladesh has got her best fertile lands best could not produce enough food for her 90,000,000 people. Under Buraucratic administration system (colonial way as the British) no national programme for the people virtually could not be launched.

During monsoon, due to excess water, flood occurs and during winter and summer there is shortage of water for irrigation purposes. I am confident that Bangladish can be built up as one of the best agricultural country as Japan has been built by her hard working and sincere people and by the honest leaderships.

2.6 Past floods and damage: date, magnitude, loss of lives and property, social effect, etc:

Sufficient records of flood in the pre-independence days (1947) are not available.

In 1787 there was a devastating floods in the District of Bogra, Dinajpur and Rangpur from Teesta River.

In 1926 a major flood occurred in Bogra District.

The shifting of Brahmputra flows to the Jamuna from 1787 to 1830 had caused recurrent floods in Rangpur, Bogra and Pabna District.

In 1938, floods also affected the district of Mymensingh along the Old Brahmputra.

Since 1947 as many as 12 floods occurred in Bangladesh. In 1954, 1955, 1956, 1974 floods caused extensive damages with wide spread losses of lives and properties. The country was again in the grip of severe floods in 1962, 1963, 1964, 1966, 1968, 1971, 1977, 1978, 1980. (Fig. 12, 13)

GANGES BASIN ONLY (Major floods)

	year	population affected	loss of lives	loss of live-stocks	crops (ton)	Total in Taka	1$=2,000 Tk.
Floods	1965	2,000,000	4	300	20,000	400,000,000	20,000,000
cyclone	1965	3,000,000	20,000	100,000	100,000	40,000,000,000	2,000 000,000
cyclone	1970	3,000,000	300,000	200,000	100,000	100,000,000,000	5,000,000,000
Floods	1974	1,000,000	1,000	50,000	140,000	60,000,000,000	3,000,000,000
Floods	1977	1,000,000	10	1,000	20,000	300,000,000	15,000,000
Floods	1980	1,000 000	100	10,000	100,000	600,000,000	30,000,000

3. FLOOD PROTECTION AND RELATED WORKS IN THE BASIN

3.1 Map (1:1,000,000) showing the location of hydraulic works such as embankment, dams, flood retarding basins, diversion channels, flood gates, drainage pumping, etc.

Map of 1:1,000,000 is attached showing major project and works. (Fig. 7, 7a)

3.2 Dams:

There is no dam or barrage for storage. But in the coastal belt in Jessore, Khulna, Barisal, Patuakhali some closure dams have executed for arresting astronomical tides and saline water intrusion.

3.3 General description of other works:

a) Before entering the boarder of Bangladesh from INDIA Farraka Barrage has been constructed by INDIA. The Barrage is operated during dry season by JOINT RIVER COMMISION.

b) Ganges Kobadak Project covering 1,500,000 acs (600,000 hec) has been programmed for comprehensive flood control, irrigation and drainage. The whole project has been phased out as Kurhtia unit, Jessore unit. Khulna unit. The Kurhtia unit has already completed. The western part by River Gorai has been protected from floods. But eastern embankment are not maintained. Wave actions erodes the loss. The completed works provide flood protection to 117,000 ha of land.

c) Coastal embankment project:
The whole coastal belt of Khulna, Barisal Patuakhali and Jessore have been completed in the Phase I under this project 86 polders which provides protection to about 1,000,000 hectares of land. The physical works consist of 3,620 km of embankment and 800 sluices.

d) Barisal irrigation project:
Under the Phase I Progamme the project provide irrigation to 60,000 hectares of land with all flood control and drainage facilities. Under this scheme 1,000 km excavation and re-excavation canal systems, 750 sluices and 2,600 nos low lift pumps.

e) Ganges Barrage project:
The preliminary works for the project is on programme. This scheme will provide flood protection to entire basin area in the District of Pabna, Kurhtia, Jessore, Faridpur, Khulna coupled with irrigation facilities.

f) Special canal digging programme:
Under this programme old channels are being re-excavated to retard flood water and use these water for winter irrigation.

3.4 General procedure for operating works during floods:

Entire Ganges basin is under one chief engineer as zonal head of south-western zone. Under this zone the project official HO lying as below;

The G.K. Project at Kurhtia, the Coastal Embankment Project, Khulna, Barisal, there are divisional HO under individual project. There is a separate Hydrological Divn. with zonal HO. This Hydrological Divn. has got unit and subunit offices for observing water stages, discharges, rainfall data and their computation.

All over the basin there are observing stations for collecting these basic datas and communicated to project HOs and zonal HO.

Generally rising of water levels starts from July and keeps rising upto Sept.. During the entire period timely communication of stages is maintained by project HO officials and published through dailies.

For Ganges basin, water stages at the upper reachs within INDIA are exchanged under JOINT RIVER COMMISSION by wireless system specially installed for flood forecasting in the entire basin. Important structures, sluices, embankments are gauged by people employed for the operation of these works.

4. EXISTING FLOOD FORECASTING AND WARNING SYSTEM:

4.1 Map (1:250,000 if possible) showing the system and data transmission network: Fig. 8

A map of scale 1:1,000,000 is attached showing the system and data transmission network for cyclone and hydrological datas separately.

4.2 General information:

a) Purpose of the system:

Describe the reason for the establishment of the system, target area to be protected by the system etc.

In 1956, the Services of a United Nations Technical Assistance Mission (KRUG Mission) was obtained for the study of the problems of floods and water resources development of this region. Again in 1964 eminent expert like General Hardin and Professor Theijee (Netherland) examined the problems independently. In the meantime World Bank studied the possibilities of agriculture and water development programme in Bangladesh.

As recommended by the world body and expert opinions, the hydrological organization, headed by a chief engineer under water Dev. Board, Ministry of Power, Water Resources and Flood Control has been working for collection processing, computation and publication of data in the field of surface water hydrology, ground water hydrology, river morphology and flood covering the whole Bangladesh.

As for Ganges basin, much of floods coming from INDIA. Special observation teams are working both in INDIA and BANGLADESH under JOINT RIVER COMMISION. Water levels, discharge observation and rainfall in the upper reaches of the Ganges are regularly exchanged and communicated.

For Ganges Basin, one full Divn. HO and Faridpur and zonal offices in the District HOs and unit offices at sub-division HOs are maintaining and communicating to HO, Dacca for final computation and forecasting.

Most of the cyclone casualties and damages are caused by storm surges which are associated with cyclones. Bagladesh government have drawn extensive action plan for prevention for disasters caused by cyclones. Under this plan a cyclone warning system has been developed. Meteorology Department has been given responsibility to collect weather data through some ground stations, weather radar and weather satellites launched by U.S.A. and Japan, to analyse them and to forecast weather conditions through National Radio and T.V. network and news papers. Cyclone Preparedness Programme has offices in the coastal areas and in the off shore islands connected by wireless network.

b) History of the system: Describe the development of the system:

For hydrological studies and data collection, processing etc. separate directorate of hydrology headed by a chief engineer. This office has got three deputy directors for processing under chief engineer, there are four directors as; Surface Water Hydrology - I, Surface Water Hydrology - II, Ground Water, River Morphology, Research and Training. Under these four Directors, there are 19 nos Deputy Directors working for zonal and District HO. Under these 19 Deputy Directors, there 100 nos unit offices. Under these unit offices, field people take the hydraulic and hydrological observations and communicate them to the zonal HOs and control HO at Dacca. Commonly stage datas are maintained with respect to mean sea level and manually. Bench marks are established by skilled technicians. Discharge observations are taken by rising current meters commonly and calculated by imprical formulas.

Bangladesh faced number of disasters during last two decades. In the year of 1961, 1963, 1965 and 1970 have got severe devastating cyclones. In the year of 1970 as good as 300,000 people lost their lives and not to speak of livestocks. As countermeasures, Meteorological Dept. collect weather datas through some ground stations, weather radar and weather satellites launched by U.S.A. and Japan. Cyclone Preparedness Programme (CPP) has offices in the coastal area and off shore islands connected by wireless network. Also 3,600 km of coastal embankments with 800 nos sluices have been completed to prevent initial impact of storm surges.

c) Resources of the forecasting centre:

i) Organization:

Hydrology directorate under Water Development Board is operating the system. For the Ganges basin two Divns. one at Pabna and another at Faridpur are working. These two Divisions have got 12 nos hydrologist, 12 nos telecommunication staff and 300 nos field staffs.

ii) Computer facilities:

In the "Flood forecasting and warning" Project under execution through technical and financial assistance of UNDP Project Document No.BGD/76/008, there is a provision for installation of a telemetering network with 16 nos telemetering raingauges, 14 nos telemetering water level recorders, 4 nos teleprint machines, 20 nos auto rainfall recorders and 9 nos auto water level recorders including central terminal station, for flood forecasting and warning in Bangladesh.

Under another project UNDP-BGD/76/006, there is a provision for installation of 66 nos SSB wireless sets at different places throughout the country for obtaining real-time data on rainfall and water level for flood forecasting and warning. In both two projects, there is a provision for processing computors for using in flood forecasting and data processing.

iii) Operating costs:

Average budget in recent years. For hydrological activities and flood forecasting and warning total approached allocation 130,000,000 TK (6,500,000 US $) for 2nd five year plan.

4.3 Data collection system for precipitation, water level, stream flow, discharge released from dam gates and other data:

a) Rainfall stations (Ganges basin)

No.	Name	Location	Altitude	Duration of record	Type - ordinary of self recording	Other information if any
1.1	Rajshahi	Rajshahi	20 m	From 1954	Ordinary	Attached here with statement showing annual rain fall at some principal stations in Bangladesh. Fig. 9a, 9b.
1.2	Kushtia	Kushtia	15 m	From 1954	Ordinary	
1.3	Jhenidah	Jessore	10 m	From 1954	Ordinary	
1.4	Jessore	Jessore	8 m	From 1954	Ordinary	
1.5	Khulna	Khulna	3.5 m	From 1954	Ordinary	
1.6	Barisal	Barisal	2.0 m	From 1954	Ordinary	

b) Water level stations (Ganges basin)

No.	Name	Location	Altitude of the datum	Distance from the river mouth	Duration of record	Type - staff only or self recording	Other information if any
2.1	Rajshahi	Rajshahi	20 m	288 km*	From 1919	Staff only	Attached statement of flood levels of the major rivers during last five years with project.
2.2	Harding Bridge	Kurshtia	15.50 m	225 km*	From 1910	Staff only	
2.3	Goraikly Bridge	Kurshtia	15.00 m	205 km*	From 1948	Staff only	
2.4	Goalonda ghat	Faridpur	9.5 m	130 km*	From 1954	Staff only	
2.5	Faridpur	Faridpur	7.5 m		From 1954	Staff only	
2.6	Chandpur	Commilla	6.0 m	0 km	From 1954	Staff only	

* from Chandpur as '0' km.

c) Stream flow stations:

No.	Name	Location	Distance from river mouth	Duration of record	Type flood or current water	Frequency of observation	Other information if any
3.1	Rajshahi	Rajshahi	288 km	From 1954	Current water	Every 7 days	Discharge of Ganges River from (1934-62) average, month wide is attached Fig. 11.
3.2	Harding Bridge	Kurshtia	225 km	From 1934	Current water	Every 7 days	
3.3	Goraikly ghat	Kurshtia	205 km	From 1954	Current water	Every 7 days	
3.4	Goalonda ghat	Foridpur	130 km	From 1934	Current water	Every 7 days	
3.5	Chandpur	Commilla	0 km	From 1934	Current water	Every 7 days	

d) Data transmission system:

Station number	Telephone	Telegraph	SSB MZ	Telemeter MZ	Others
Rajshahi	Local wireless		Under execution	Under execution	
Harding Bridge	Local wireless				
Goalonda ghat	Local wireless				
Chandpur	Local wireless				

4.4 Data processing system for checking and processing the incoming data as input to the forecasting model:

Datas of water stage, rainfall, flow discharges are plotted in the unit offices for local use. Also these datas are sent to Decca central flood forecasting center operated by Hydrological Divn. under Water Dev. Board. In the central office these datas are checked with previous records and computed and draw day to day hydrographs.

4.5 Receipt and use of meteorological forecasts:

4.6 Forecasting model:

4.7 Warning system:

4.8 Storm surge:

If the basin is affected by storm surges, describe how their effect is introduced into the forecast.

Meteorological Department is responsible for meteorological data collection through some ground stations weather radar and weather satellites launched by U.S.A. and Japan, to analyse them and to forecast weather conditions through man media. Whenever cyclone is formed in the Bay of Bengal Meteorological Department starts issuing warning through radio, television, news papers at interval depending on the intensity of the storm. Storms generally occur in Bangladesh in the months of April - May and October - November (early part). The Meteorological Department uses separate codes of signals for storm warnings at maritime and miver ports. These codes are given below in abbreviated form.

It should be noted that the signal members in the two codes do not carry the same significance and, in particular that higher signal members within the "danger" and "great danger" maritime group indicate differences in storm location not differences in storm intensity.

Storm warning signals for use at maritime ports:

a) Distant signals:

(I) Cautionary: There is a region of squally weather in which a storm may be found.

(II) Warning: A storm has formed.

b) Local signals:

(III) Cautionary: Port is threatened by squally weather.

(IV) Port is threatened by a storm, but danger, not yet sufficiently great to justify extreme precautionary measures.

(V)-(VII) Danger: Port will experience severe weather from a storm of slight or moderate intensity.

(VIII)- (X) Great danger: Port will experience severe weather from a storm of great intensity.

Storm warning signals for use at river ports:

(I) Cautionary: Area threatened by squally winds. Look out for further developments.

(II) Warning: A storm or north -western is likely to strike the area.

(III) Danger: A storm will soon strike the area. All vessels seek shellter immediately.

(IV) Great danger: A violent storm will soon strike the area.

Wind speed estimation over land in Bangladesh according to Beaufort scale.

No.	Name	Indication	Wind speed (at 10 meter) KMPH
2	Light breeze	Wind felt on face, windvane moves.	6 - 11
4	Moderate breeze	Dust and loose papers raised.	19 - 26
7	Moderate gale	Whole trees sway. Difficult to walk against wind.	50 - 60
9	Strong gale	Branchs broken off trees, slight structural damge to buildings.	75 - 85
11	Storm	Widespread damage to trees and property	85 - 95
12	Hurricane	Do -	about 100

4.9 Problems with the system:

a) For flood forecasting, for computation of flood discharges etc. and observation of high discharges at the entry to Bangladesh and high rainfall datas, should be finely communicated. Automatic rain gauges, water stage gauges at important locations, computor facilities for computation should be set up. Skilled technical persanals should be trained wellahead of execution of operation of the system. Co-operation from INDIA, NEPAL, BURMA will be sincerely required.

b) For storm surge or cyclone forecasting, skill technical personals should be trained to operate the ground station and satellite system launched by USA and Japan. More weather data collection centers should be opened for uniform circulation.

4.10 Plans for improving the existing system:

In the "Flooding forecasting and warning" project under execution through technical and financial assistance of UNDP. There is a provision for installation of a telemetering network with 16 nos telemetering raingauges, 14 nos telemetering water level recorders, 4 nos teleprint machines, 20 nos auto rainfall recorders and 9 nos auto water level recorders including central terminal station, for flood forecasting and warning in Bangladesh, Ganges basin included.

Under another project by UNDP, there is a provision for installation of 66 nos SSB wireless at different places throughout the country for obtaining real time data on rainfall and water-level for flood forecasting and warning. In both the projects, there is a provision for procurring computors for using in flood forecasting and data processing.

5. ASSOCIATED STATION NETWORK:

5.1 Map: Showing all rainfall, water level, discharge stations including those reported. Attached (See Fig.).

5.2 Number of hydrometric stations. (For Ganges basin)

a) Discharge stations: 12

b) Stage only: 14

5.3 Number of rainfall stations:

a) Ordinary: 12

b) Self recording: -

c) Others: -

5.4 Other stations: Satellite sation at Betbunia at Cox's Bazar (Chittaongong)

FLOOD LOSS PREVENTION PLANNING

1. INTRODUCTION:

Bangladesh being a flood plain at confluence of the mighty rivers Ganges-Brahampulna, Meghna it has got complex hydrological and geomorphological situation.

The catchment area of the above rivers is app. 950,000 km^2 of which only 7.5% lies in Bangladesh. About 75% of the total quantity of water reaching Bangladesh is brought in from outside by these river system. Most of the rivers of Bangladesh are characterized by limited depth due to deposition. All the rivers are tidal near the sea with a maxm. tide range of 7 m.

The rivers Ganges, Brahmpulra and Meghna together discharge a flood which can exceed 150,000 m^3/sec and they carry sediment in the order of 2,400 mil tons annually.

2. CAUSES OF FLOODS:

Before planning flood losses, causes should be identified in short;

a) Low general topography, half of the land is lying within 6 m contour line from M.S.L.
b) High monsoon flood through the above main three rivers out of 950,000 km^2 only 7.5% lying in Bangladesh.
c) Siltation of the off-take of the principal distributaries from the Ganges and Brahampulra due to earthquake 1950 and due to sedimentation.
d) Effects of flood control measures in the upper reaches of rivers by India.
e) High rainfall within country. More than 80% of precipitation (1,400 mm) occurs in the monsoon months, the large rainfall run-off coincides with the heavy discharges in the rivers.
f) Strong back water effects of the tides of the Bay of Bengal.
g) Peak-flood synchronization in the Ganges and the Brahampulra.
h) Topographic features controlled by geological factors. A series of geological faults has created depression in the North-West, North-East and in the South.

3. During monsoon when water requirement is less for agriculture, abandoned water is available and flooding damages crops and properties, again when water requirement is high, the availability of water is less.

These circumstances necessitate Bangladesh for flood control and irrigation synchronization.

4. FLOOD LOSS PREVENTION PLANNING:

Flood loss prevention is classified as (i) structural measures (ii) non-structural measures.

A) Structural Measures

a) Construction of Reservoirs:

Detention of the flood waters in the Himalayan slopes is apparently interesting, as it also indicates the possibilities of increased low water discharges in the Ganges, Brahmpulra and Meghna. This will also minimize silt load in river beds. This is essentially dependent on the diplomatic relation between India and Bangladesh. The scheme is under consideration by the two Govts. through JOINT RIVER COMMISSION.

A barrage can be constructed at Hardindge Bridge 225 km up the '0' km at Chandpur (outfall to Bay of Bengal.) This scheme is under model study.

A barrage can be constructed over Brahmpulra at Bahadurabad Ghat separating discharges which can be used for the irrigation also.

b) River Diversions:

South diversion is possible only in the case of discharge of Ganges by Farrack Barrage to divert the flood flow of the Ganges to the Bay of Bengal through the Bhagirathy-Hooghy in west Bengal in India.

c) Channel Improvements:

Channel improvement for reduction of peak stage by increased effeciency of the channels.

This is very expensive and can be executed in limited scale. Channels are dredged only for navigational facilities.

But by improvement of the months of distributaries and tributaries floods can be diverted to certain extent.

In the Ganges basin, the month of Garai, the month of Mathabhanga, Bhairab, Chilra can be economically improved during high stages at the Ganges. Also by generating velocities, the river bed can easily be eroded to dominant section. This water again can be used for irrigation lifting.

d) Retarding Ponds:

Road side ditches, low lying beel areas can be used as run-off retarding-basins. Also people may be encouraged to have individual retarding ponds for his own homesteads. This will retard the run-off during high stages.

e) Levees and Dyke Construction:

Construction of properly designed flood dikes along the major river and the coast line, so as to divide the entire country into a number of polder or protected areas. The drainage channels within each polder will be improved for draining these area during monsoon by sluice gates or pumping station.

First phase of these programme, contour of coasted dykes have been completed by contour of 3,200 km of dikes and 800 nos of sluice.

The Ganges river embankments have been constructed up to Kushrina town for arresting flood to Kushrina, Jessore and Khulna District. Under the Project, named Brahampulra Flood Embankment with 220 km dike has been completed.

f) Contour of Closure Dam:

Closing all the estuaries of Bangladesh from Cox's Bazar to Khulna in combination with a system of sufficiently high coastal dikes protected against wave attacks, and provision of tidal sluices to drain out the upland water. This measure will deal with both the flood and storm surges problems.

B) Non-structural Flood for Prevention:

a) Concept of non-structural measures:

We can not fully protect ourselves from the adverse effects of flood overnight. Also structural measures are very much costly. Designing and execution of structural measures of flood prevention takes time. Non-structural measures is not to protect rivers but to protect country and people from flood disaster and to maintain public safety. For immediate benefit to public, non-structural measures accomplished at a much small cost may be undertaken. Non-structural measures can be regarded as complementary to the structural measures. Even after completion of structural method, for the safety of costly structures against impending dangers of flood and hazards which may fall on general means should build up non-structural measures.

The concept of non-structural measures should be clearly understood.

While structural measures is a most appropriate adjustment in many cases, it has many disadvantages too. For example erosion frequently occurs along dikes and natural banks as a result of the construction of flood control and river training works. As a consequence dikes often have to be rebuilt. In addition, flood defension reservoirs sometimes accumulates large volume of sediment, thus reducing their storage capacity and impairing the economics of their development and is very likely common for Bangladesh.

To ensure the flood loss potential reduced is most key sense of non-structural countermeasures.

This concept of non-structural measures are sometimes known to my country, but the very concept is not clearly identified and understood in the light that flood protection is not to protect rivers, but "to protect the country, people and to maintain public safety."

b) Classification:

Japan has developed the concept of non-structural measures very successfully and been able to minimize the extent devastations caused by floods and natural calamities.

Non-structural measures have several alternative adjustments or combinations of adjustments from which to choose. Basically, the adjustment can be classified as below;

(A) Flood plain management
(B) Structural change
(C) Flood proofing
(D) Emergency measures
(E) Redistribute losses
(F) Bear the loss.

The above broad classifications can be elaborated as below;

(A) Flood plain management;

(1) Land use regulation, there are two basic approaches to the regulation of the land use of the basin areas,

(i) location of housing and industry itself is to be restricted or guided,

(ii) though no restrictions are to be placed on location, the locating body is to be obliged to take measures so as not to reduce (or lower) its own or other's safety in terms of flood control.

(2) Zoning ordinance

(3) Building code; to reduce the flood damages and the danger to life four measures are incorporated in the building codes;

(1) Control the elevation of the building site

(2) Control of building materials

(3) Control of the height of the ground floor and provision of refuge rooms

(4) Prohibition of houses, hotels, boarding houses within a certain distance from the sea or river, the purpose to preserve life and properties away from dangerous areas

(4) Govt purchased of land and property

(5) Subsidised reallocation

(6) Floood risk mapping

(B) Structural change:

(1) Use of impervious materials for basement and walls, closure of low-level windows. In some cases building can be built up on stilts for storing moveable materials

(2) Land elevation

(3) Control of high-floor houses, such as killas. These killas have been constructed in the coastal belt as countermeasures against storm surge and cyclone.

(C) Flood proofing:

(i) Permanent closure of low level windows and other openings

(ii) Water proofing interiors

(iii) Stove counters on wheels

(iv) Underpinning buildings

(v) Installation of removal covers

(vi) Closing of sewer values

(vii) Anchoring machineries

(viii) Plastic sheets coverings machines

(ix) Seepage control

Flood proofing offers considerable opportunities for reducing flood losses, also it places part of responsibilities for taking action on the shoulders of the individual. This is important.

(D) Emergency measures:

(i) Flood forecasting and warning:

This component is one of the most important countermeasures against flood loss prevention and management activities. For flood forecasting a good network of hydrological stations connected with telemetering gauges or by telecommunication or teleprint links with the control forecasting and zonal forecasting centers are required.

Bangladesh is developing forecasting and warning systems under UNDP and using weather satellites launched by U.S.A. and

Japan. Water Development Board and Meteorological Dept. jointly forecasing floods and warning are issued through National Radio, T.V. networks regularly.

As big rivers have got their catchment areas outside Bangladesh as stated earlier we need cooperation between India and Nepal. Datas on rivers, rainfall and snowfall in the upper catchment areas are exchanged regularly with India under JOINT RIVER COMMISSION between the two neighbouring countries.

(ii) Flood fighting and evacuation:

Floods are forecast and people in danger zone are warned before it on mesh, thereby providing them opportunities for evacuation, removal of properties to safer places well ahead.

Local Flood Control Office with local leaders and local civil administrators will undertake measures for flood fighting and evacuation.

Under this programme, spreading of the knowledge of disaster preparedness among local leaders and residents is an important pre-requisite.

(E) Redistributed losses:

(i) Disaster relief by the Government and local bodies and institutions

(ii) Financial aids to recoupe agricultural or manufacturing production

(iii) Tax write offs: Flood affects areas may be identified and land tax may be exempted. It is in practice in Bangladesh.

(iv) Flood insurance: This conception is new. This is one of most important countermeasures maybe imposed on very vulnerable places by Govt. Law.

(F) Bear the losses:

Bearing the loss is still the major adjustment for large numbers of food plain occupants in developing countries. Rescheduling and land use restrictions may be useful in this case.

FLOOD RISK MAPPING 1

1. BASIC CONCEPT (attached one geomorphological map)

The present land form has been formed by climatic condition and other factors. The relationship between disasters and the land form is important in the sense that it is a container in which the water and sediment flow and deposit and also in the sense that those natural hazards which occurred in the past may be deducted from the land form.

Thus the geomorphological condition has a clear relation with flooding and proide a clue to the estimation of those places prone to disasters and their types.

2. IMPORTANCE OF FLOOD RISK MAPPING:

Flood forecast or cyclone forecast will be useless, no matter how accurately they are disseminated; unless they lead to appropriate actions of the people concerned; in fact , lot of damages may result. Not only for preparation and planning of any flood control or drainage worxs, flood risk map must be prepared considering all geomorphological, hydrological aspects of the area, but for the education and preparedness of the residents and local administration.

So flood risk maps are equally useful to hydrologist, geomorphologist, civil engineer and local administrater and the resident.

COMPILATION OF FLOOD RISK MAP:

This flood risk maps should be prepared by a working group including topographer, hydrologist and civil engineers on the basis of topographical and hydrological datas.

For this four approaches can be used by adjustments among the approaches.

a) Geomorphological approach:-

For compilation of flood rist map by this approach requires geomorphological maps, geographical maps airial photographs, historic inundation datas from residents.

By this approach, we are considering the shape, genesis, period and material of area concern.

b) Approach based on historic flood data:

For compilation of flood rist map we should put in the following datas and materials

i) Past flood datas inundated area, depth as are left from residents of the area.

ii) Geographical map

iii) Rainfall and discharge data for designing & analysis.

iv) River plain and flood plain cross-section

v) Longitudinal profile of the channel with this approach over-lapping with-geomorphological approach very useful flood rist map is possible.

c) Hydraulic-hydrological approach:

For compilation of flood rist map by this approach, all the basic materials for the previous approaches are required.

But this approaches efficiently calculate and work out the runoff model, inundation model, rainfall model.

By saying hydraulic, hydrological we are using the basic sense and conception of geomorphology of the channel and the basin itself.

d) Hydraulic hydrological-damage approach:

For compilation of flood risk map, all the materials as stated in approach based on historical flood data and hydraulic hydrological approach should be used. In addition to that approaches, damage rating curves to inundation depth.

FLOW CHART FOR EASY COMPILATION OF
FLOOD RISK MAP

Base map (1:25,000 or 1:50,000)

Contour map (1:25,000 or 1:50,000)   Field checks — Preliminary Flood risk map

Geomorphological map (1:25,000 or 1:50,000)

|

hydraulic hydrological calculations

|

Final check

|

Final map of flood risk

MAP OF BANGLADESH

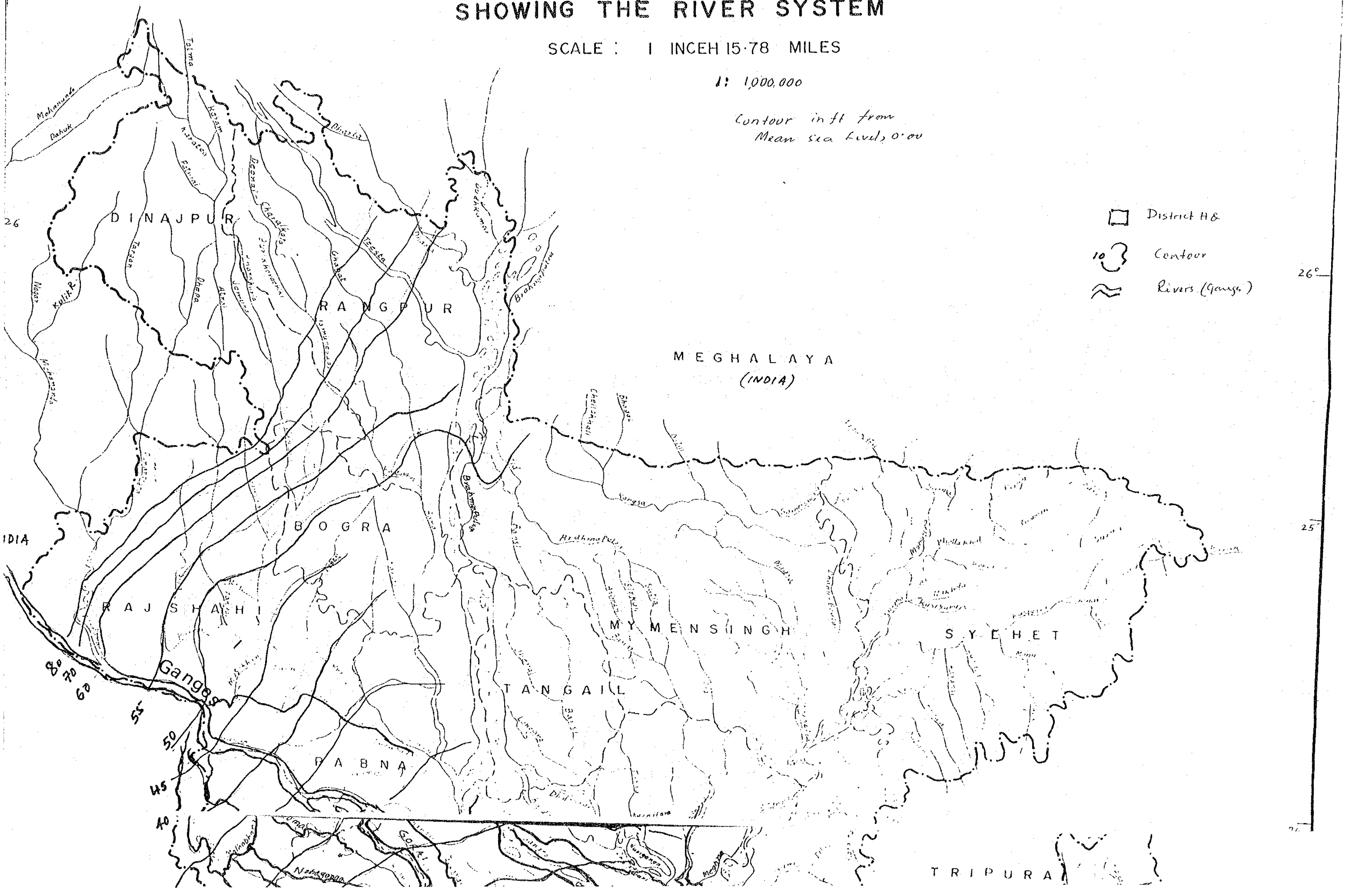
SHOWING THE RIVER SYSTEM

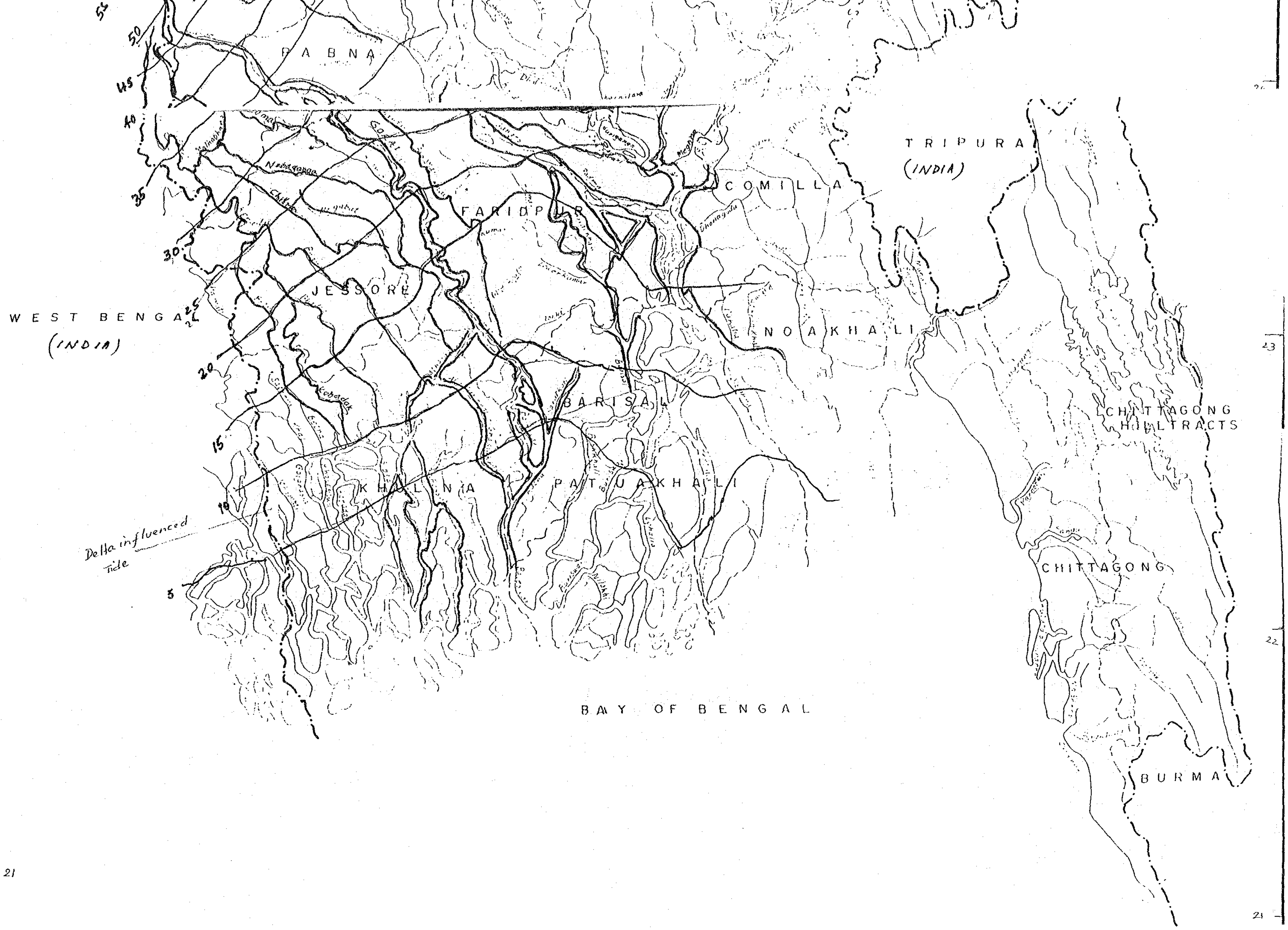
SCALE : 1 INCEH 15·78 MILES

1: 1,000,000

Contour in ft from Mean sea Level, 0·00

FIG-1




PABNA
TRIPURA
(INDIA)
COMILLA
FARIDPUR
JESSORE
WEST BENGAL
(INDIA)
NOAKHALI
BARISAL
CHITTAGONG
HILLTRACTS
KHULNA
PATUAKHALI
Delta influenced Tide
CHITTAGONG
BAY OF BENGAL
BURMA
55
50
45
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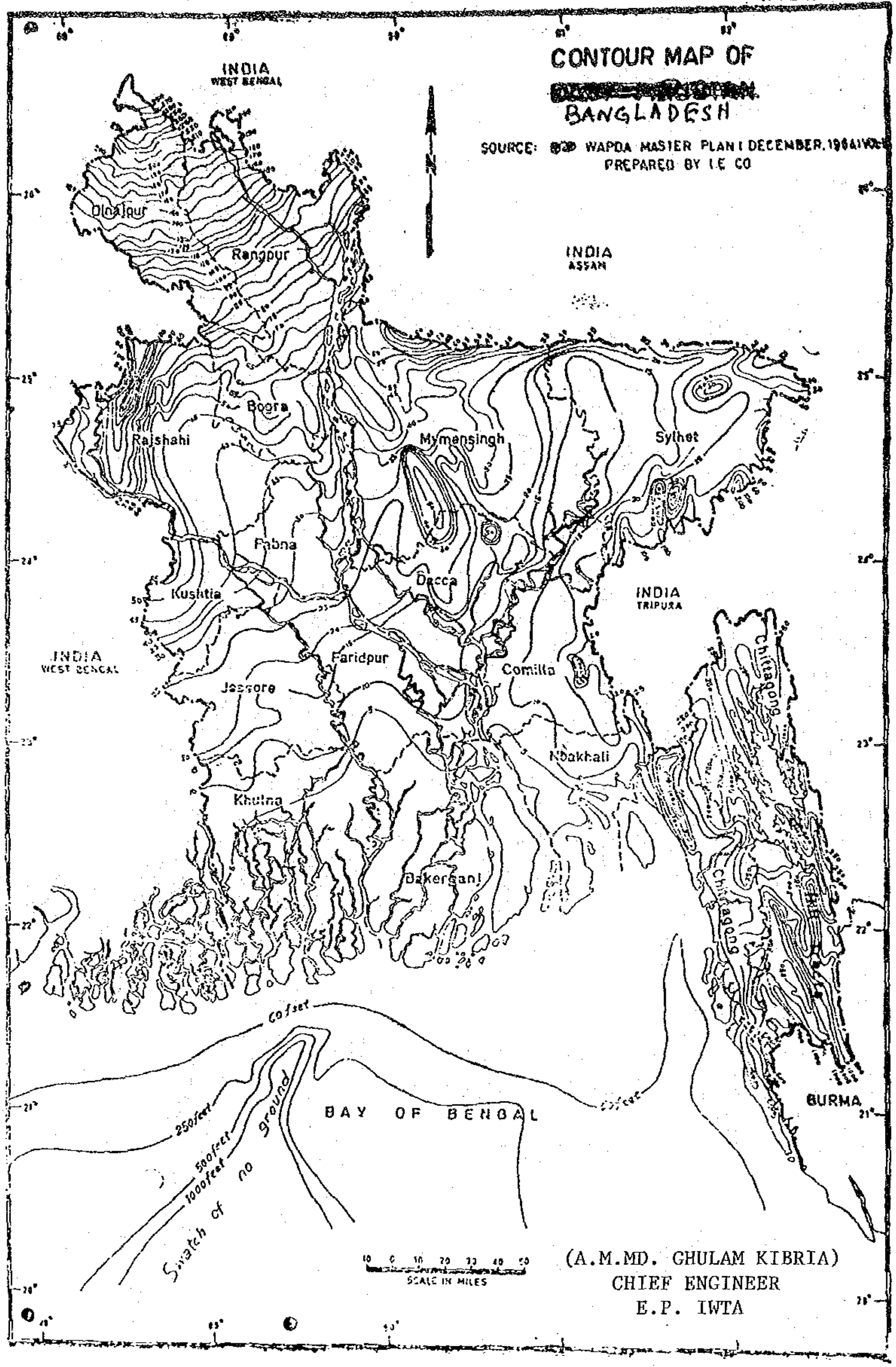
21

APPENDIX NO 1



(A.M.MD. GHULAM KIBRIA)
CHIEF ENGINEER
E.P. IWTA

Fig. 2

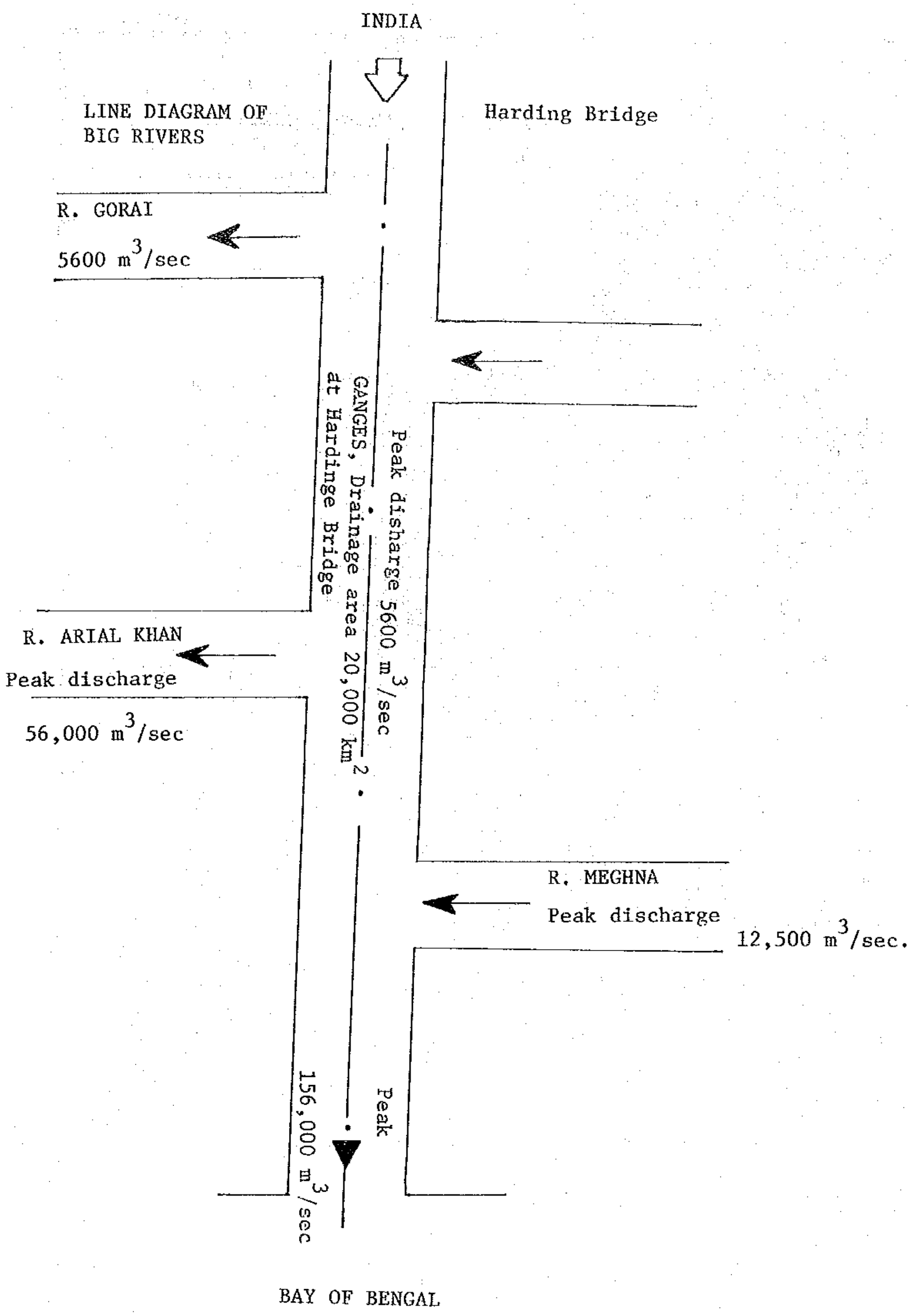
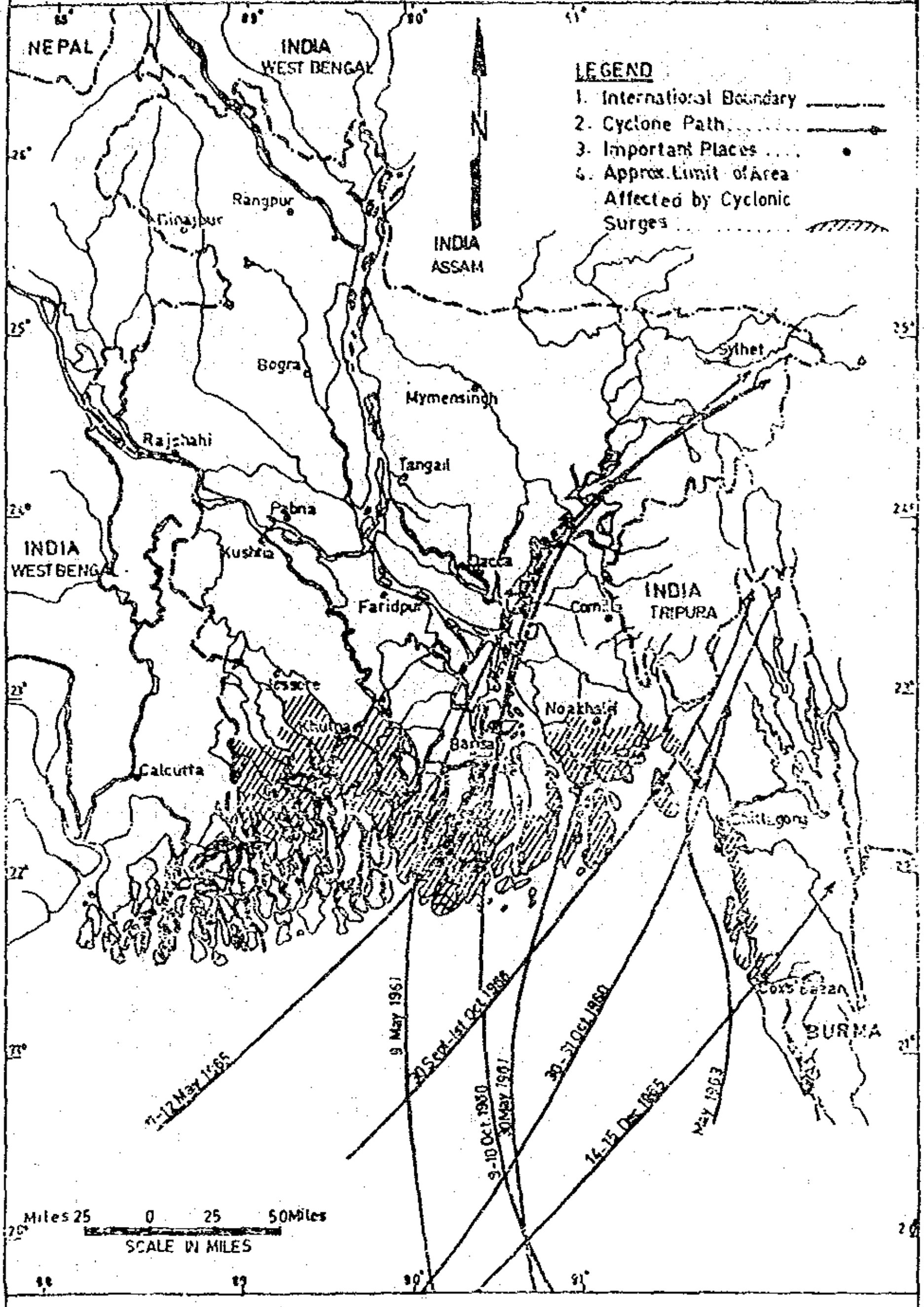

INDIA
LINE DIAGRAM OF BIG RIVERS
Harding Bridge
R. GORAI
5600 m3/sec
Peak dishharge 5600 m3/sec
GANGES, Drainage area 20,000 km2 at Hardinge Bridge
R. ARIAL KHAN
Peak discharge
56,000 m3/sec
R. MEGHNA
Peak discharge
12,500 m3/sec.
Peak
156,000 m3/sec
BAY OF BENGAL

Fig. 3

TYPICAL CYCLONE PATHS IN [redacted] BANGLADESH

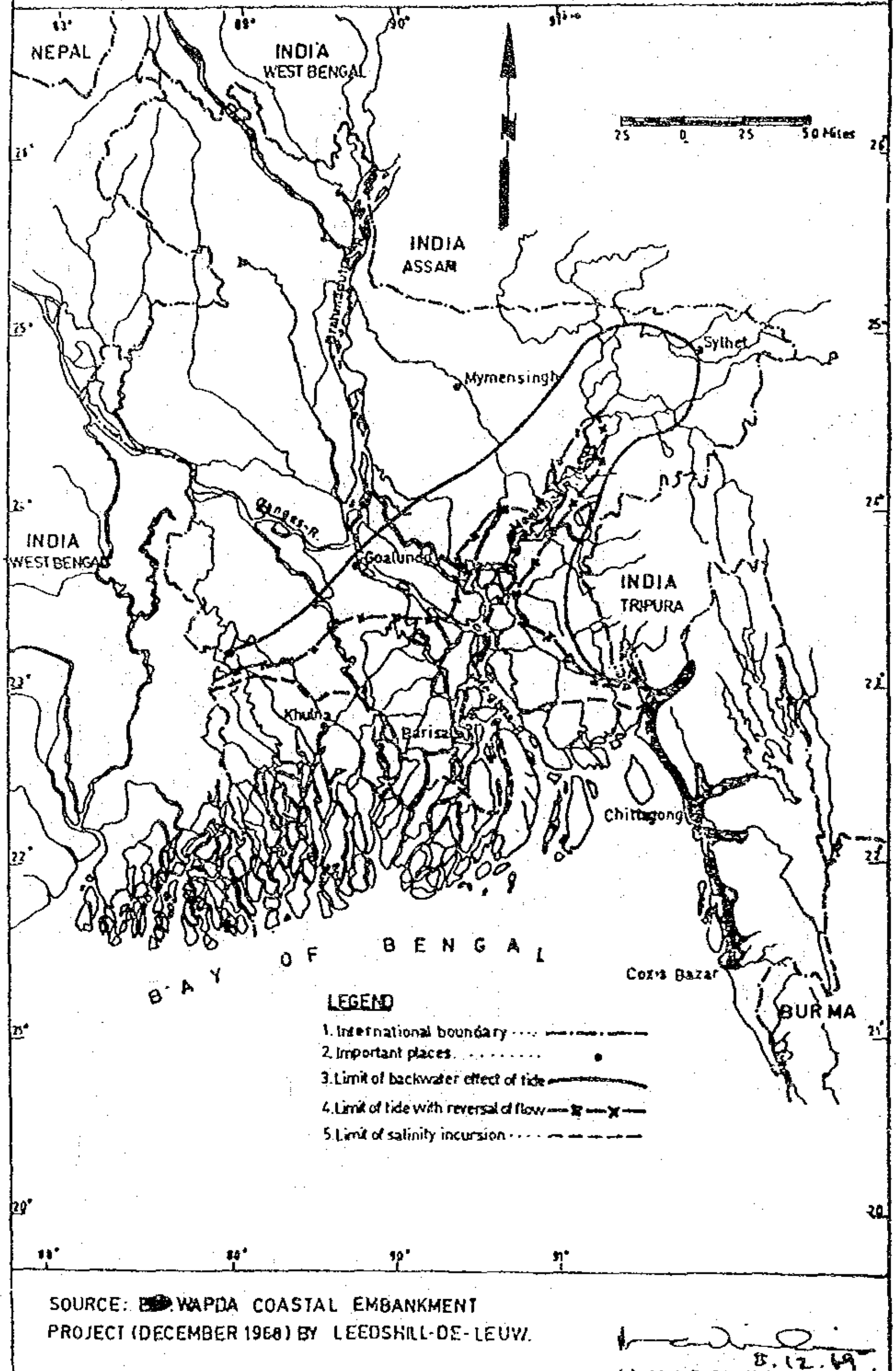


SOURCE: [redacted] WAPDA COASTAL EMBANKMENT PROJECT (DECEMBER 1968) BY LEEDSHILL-DE-LEUW.

8.12.69
(A. M. MD. GHULAM KIBRIA)
CHIEF ENGINEER
E.P. IWTA.

Fig. 4

LIMIT OF TIDAL EFFECTS IN [redacted] BANGLADESH



SOURCE: [redacted] WAPDA COASTAL EMBANKMENT PROJECT (DECEMBER 1968) BY LEEDSHILL-DE-LEUW.

8.12.69
(A.M.MD.GHULAM KIBRIA)
CHIEF ENGINEER
E.P.IWTA.

Fig. 5

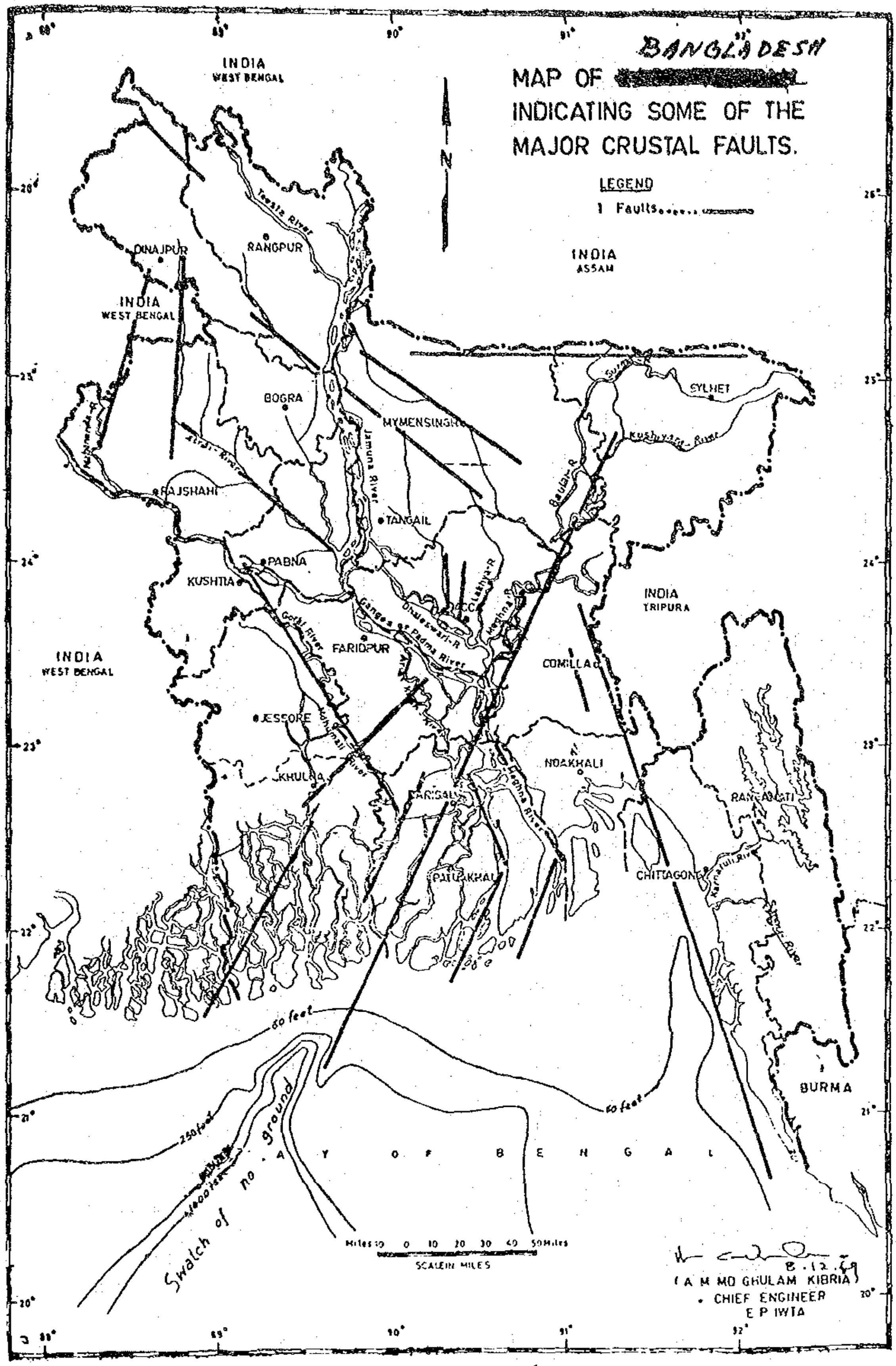

BANGLADESH
MAP OF [redacted]
INDICATING SOME OF THE
MAJOR CRUSTAL FAULTS.
LEGEND
1 Faults
N
INDIA
WEST BENGAL
INDIA
ASSAM
INDIA
TRIPURA
BURMA
DINAJPUR
RANGPUR
BOGRA
MYMENSINGH
SYLHET
RAJSHAHI
TANGAIL
PABNA
KUSHTIA
FARIDPUR
COMILLA
JESSORE
KHULNA
NOAKHALI
BARISAL
PATUAKHALI
CHITTAGONG
RANGAMATI
Teesta River
Jamuna River
Atrai River
Kushiyara River
Gorai River
Ganges or Padma River
Meghna River
Karnafuli River
Sangu River
50 feet
250 feet
1600 feet
Swatch of no ground
BAY OF BENGAL
Miles 10 0 10 20 30 40 50 Miles
SCALE IN MILES
8.12.69
(A M MD GHULAM KIBRIA)
CHIEF ENGINEER
E P IWTA

Fig. 6

STATEMENT SHOWING ANNUAL RAINFALL (IN INCHES) AT SOME PRINCIPAL STATIONS
IN BANGLADESH FOR THE YEAR 1954-1955 AND 1962-1977
AND ALSO THE NORMAL ANNUAL RAINFALL

St. No.	NAME OF STATIONS	1954	1955	1962	1963	1964	1965	1966	1967	1968	1969	1970
1.	BARISAL	77.92	74.14	74.51	77.69	65.65	77.94	73.45	78.34	91.96	107.45	110.04
2.	BOGRA.	72.08	80.48	50.15	62.52	74.38	75.55	55.39	64.61	63.45	75.49	69.94
3.	CHITTAGONG	129.16	111.89	97.17	137.24	121.84	159.48	120.29	83.66	119.95	120.99	121.99
4.	COMILLA	110.25	85.89	69.56	*88.52	109.31	96.68	81.51	90.30	88.77	96.90	67.39
5.	DACCA	73.38	50.11	71.91	75.27	117.87	82.72	79.38	68.12	68.16	61.24	73.59
6.	DINAJPUR	*34.48	72.62	52.25	*63.81	77.30	60.92	61.38	69.10	83.63	99.73	66.72
7.	JESSORE	69.66	44.93	50.35	62.93	71.42	71.73	50.03	66.50	80.47	69.99	*86.96
8.	KHULNA	65.39	62.74	65.88	61.60	61.41	71.83	60.32	68.51	75.43	76.73	*95.51
9.	NYMENSINGH	78.78	102.49	86.92	79.94	98.36	104.56	77.65	83.54	90.39	85.52	89.60
10.	PABNA	49.19	N.A.	*53.75	48.80	68.15	54.91	40.80	57.19	57.89	69.06	82.85
11.	RAJSHAHI	44.73	47.83	44.85	47.84	70.59	70.16	56.81	40.11	48.36	68.71	56.95
12.	RANGPUR	88.53	94.22	60.94	*71.77	77.82	63.95	54.29	76.50	82.94	144.41	81.69
13.	SYLHET	129.86	136.57	122.18	145.66	195.24	157.85	154.11	138.43	165.42	148.74	187.57

Fig. - 9 a

St. No.	NAME OF STATIONS	1971	1972	1973	1974	1975	1976	1977
1.	BARISAL	84.67	55.97	123.82	111.00	75.99	76.15	85.48
2.	BOGRA	*41.70	49.82	107.82	70.00	48.29	73.53	85.26
3.	CHITTAGONG	*72.63	77.68	96.02	171.95	111.35	144.28	116.50
4.	COMILLA	83.81	54.42	N.A.	117.59	83.43	89.40	85.87
5.	DACCA	73.21	72.04	87.11	N.A.	83.67	83.58	85.23
6.	DINAJPUR	N.A.	33.69	80.30	N.A.	64.46	80.76	82.31
7.	JESSORE	*79.54	41.19	66.98	88.35	48.24	50.66	65.51
8.	KHULNA	81.57	53.51	70.79	75.85	75.70	74.25	72.39
9.	NYMENSINGH	*74.35	67.53	110.39	123.30	94.71	100.21	106.88
10.	PABNA	*60.11	44.97	71.41	61.11	65.48	64.14	72.10
11.	RAJSHAHI	*50.96	41.02	74.10	N.A.	56.66	47.09	63.78
12.	RANGPUR	91.85	50.25	116.62	N.A.	70.64	94.06	95.46
13.	SYLHET	115.10	*177.54	182.43	209.94	154.59	199.7	179.94

N.A. -- Not available.

* -- Incomplete data.

Fig. - 9 b

COMPERATIVE STATEMENT OF FLOOD LEVELS OF THE MAJOR RIVERS
AT IMPORTANT STATIONS IN BANGLADESH DURING THE LAST FIVE YEARS.

St. No.	District	River	Station	Danger level	Recorded highest water level with the year	Highest flood level for the last five years				
						1973	1974	1975	1976	1977
1.	Rangpur	Teesta	Kaunia	96.50	110.13 (1968)	99.65	98.38	98.48	98.78	98.97
2.	Mymensingh	Brahmaputra	Bahedurabad	63.50	65.00 (1958)	65.25	65.60	63.65	65.20	65.60
		Old Brahma-putra	Mymensingh	42.00	45.99 (1954)	42.33	44.20	40.90	41.40	42.75
		Meghna	Bhairab Bazar	21.50	25.10 (1955 & 74)	21.25	25.10	21.25	23.05	21.55
3.	Rajshahi	Ganges	Rampur Boalia	60.00	65.60 (1919)	59.85	60.85	60.55	61.95	59.10
4.	Sylhet	Surma	Sylhet	37.00	39.10 (1959)	36.95	37.30	37.45	38.70	35.18
		Kushiyara	Shoola	43.00	46.40 (1975 & 76)	45.40	45.40	46.40	46.40	45.70
		Kushiyara	Fenchuganj	32.50	36.38 (1959)	34.50	34.60	34.35	36.15	34.10
		Khowai	Habiganj	26.00	27.90 (1975)	27.65	27.55	27.90	26.40	27.80
		Monu	Moulvi Bazar	38.00	40.38 (1960)	38.40	38.10	37.20	39.97	38.85

Fig. - 10 a

St. No.	District	River	Station	Danger level	Recorded highest water level with the year	Highest flood level for the last five years				
						1973	1974	1975	1976	1977
5.	Pabna	Brahmaputra	Serajgunj	44.50	46.70 (1973 & 74)	46.70	46.70	44.67	44.16	45.60
		Gauges	Hardinge-Bridge	44.50	49.35 (1910)	46.51	47.20	40.95	48.05	46.30
6.	Aushtia	Gorai	Gorai Rly. Bridge	40.50	44.56 (1948)	42.67	42.95	41.95	43.10	41.85
7.	Faridpur	Kumar	Faridpur	24.50	28.35 (1954)	25.12	25.80	24.17	22.50	24.35
		Ganges	Goalundo	27.50	31.25 (1954)	29.20	30.40	29.30	27.80	28.66
8.	Dacca	Buriganga	Dacca	20.00	23.25 (1955)	19.30	21.70	17.80	16.95	18.45
		Lakhya	Narayanganj	18.00	20.45 (1974)	18.10	20.45	17.60	16.95	17.95
9.	Comilla	Gumti	Comilla	36.50	42.80 (1968)	40.20	38.60	40.16	40.70	37.76
		Meghna	Chandpur	13.00	17.54 (1955)	16.30	17.20	15.55	14.40	14.90
10.	Noakhall	Munuri	Parahuram	38.00	46.80 (1966)	42.60	42.65	44.00	45.50	42.80
11.	Chittagong	Halda	South Sun-derpur	27.00	41.18 (1975)	27.50	36.45	41.18	36.80	34.45
		Sangu	Dohazari	24.00	29.72 (1960)	18.80	22.80	20.50	26.20	18.80
		Metemuhuri	Chiringe	16.00	20.50 (1965)	18.90	23.00	19.80	21.20	17.40

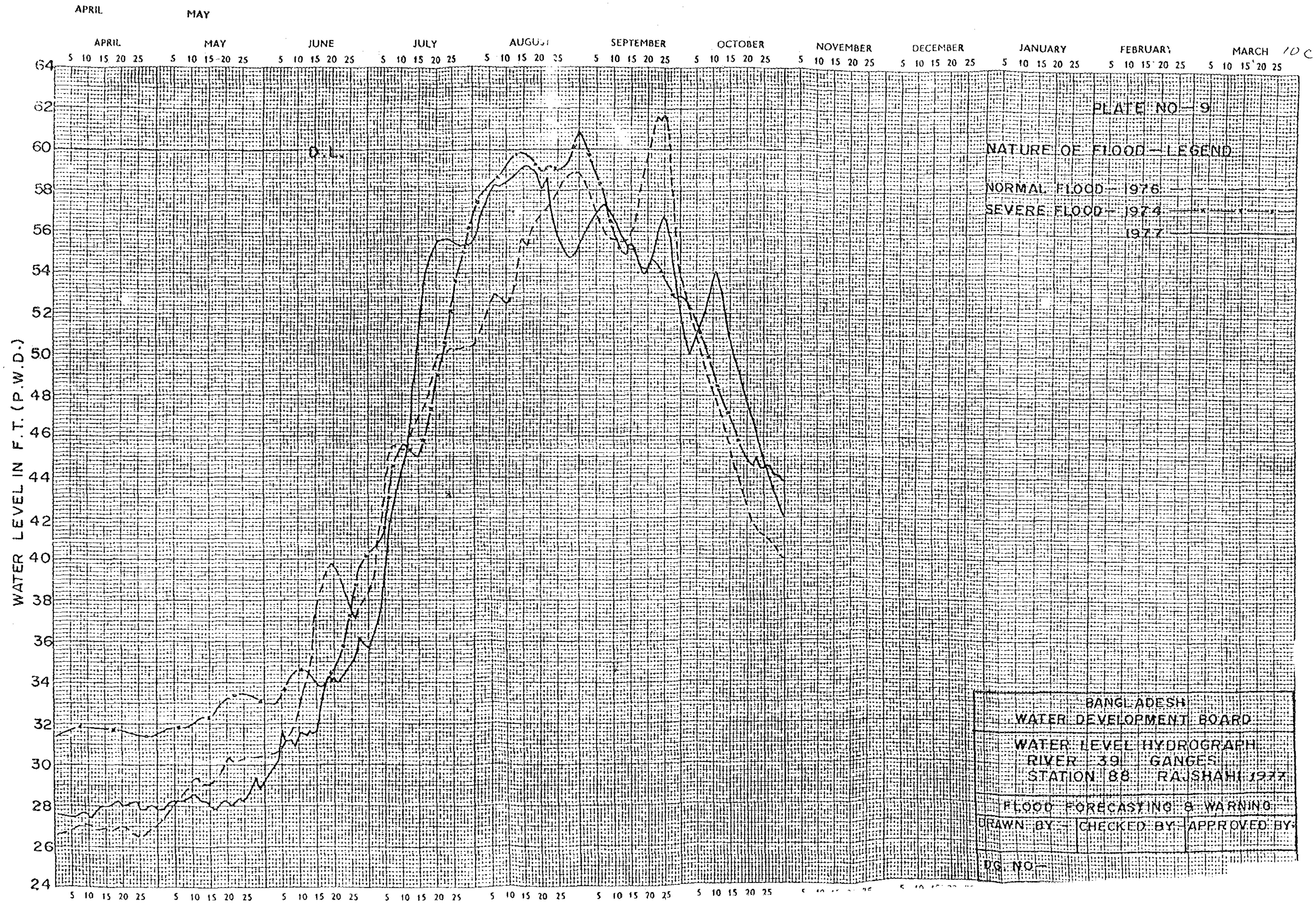
Fig. - 10 b

Bangladesh discharge of Ganges River at
Hardrige Bridge

Source: UN water rescurces series No. 29, 1966)
(Period 1934-62)

Month	Maximum		Minimum		Maximum	
	m3/5	cfs	m 3/5	cfs	m3/5	cfs
January	3,680	130,000	2,065	73,000	3,110	110,000
February	4,750	168,000	1,895	67,000	2,740	97,000
March	3,600	127,000	1,600	57,000	2,350	83,000
April	2,970	105,000	1,273	45,000	2,040	72,000
May	3,140	111,000	1,388	49,000	2,120	75,000
June	9,680	342,000	2,350	83,000	4,360	154,000
July	29,700	1,050,000	10,750	380,000	18,070	639,000
August	52,600	1,860,000	23,600	834,000	39,400	1,390,000
Sept.	56,000	1,980,000	25,000	804,000	36,500	1,290,000
October	42,200	1,490,000	8,350	295,000	17,700	626,000
November	16,500	584,000	4,390	155,000	7,190	254,000
December	67,400	238,000	2,860	101,000	4,190	148,000
Annual	16,350	578,000	7,810	276,000	11,650	412,000

Fig. - 11



10 C
APRIL
MAY
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
5 10 15 20 25
WATER LEVEL IN F.T. (P.W.D.)
64
62
60
58
56
54
52
50
48
46
44
42
40
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36
34
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26
24
D.L.
PLATE NO - 9
NATURE OF FLOOD - LEGEND
NORMAL FLOOD - 1976
SEVERE FLOOD - 1974
1977
BANGLADESH
WATER DEVELOPMENT BOARD
WATER LEVEL HYDROGRAPH
RIVER 39 GANGES
STATION 88 RAJSHAHI 1977
FLOOD FORECASTING & WARNING
DRAWN BY - CHECKED BY - APPROVED BY -
DG. NO -

Fig 10C

APRIL MAY

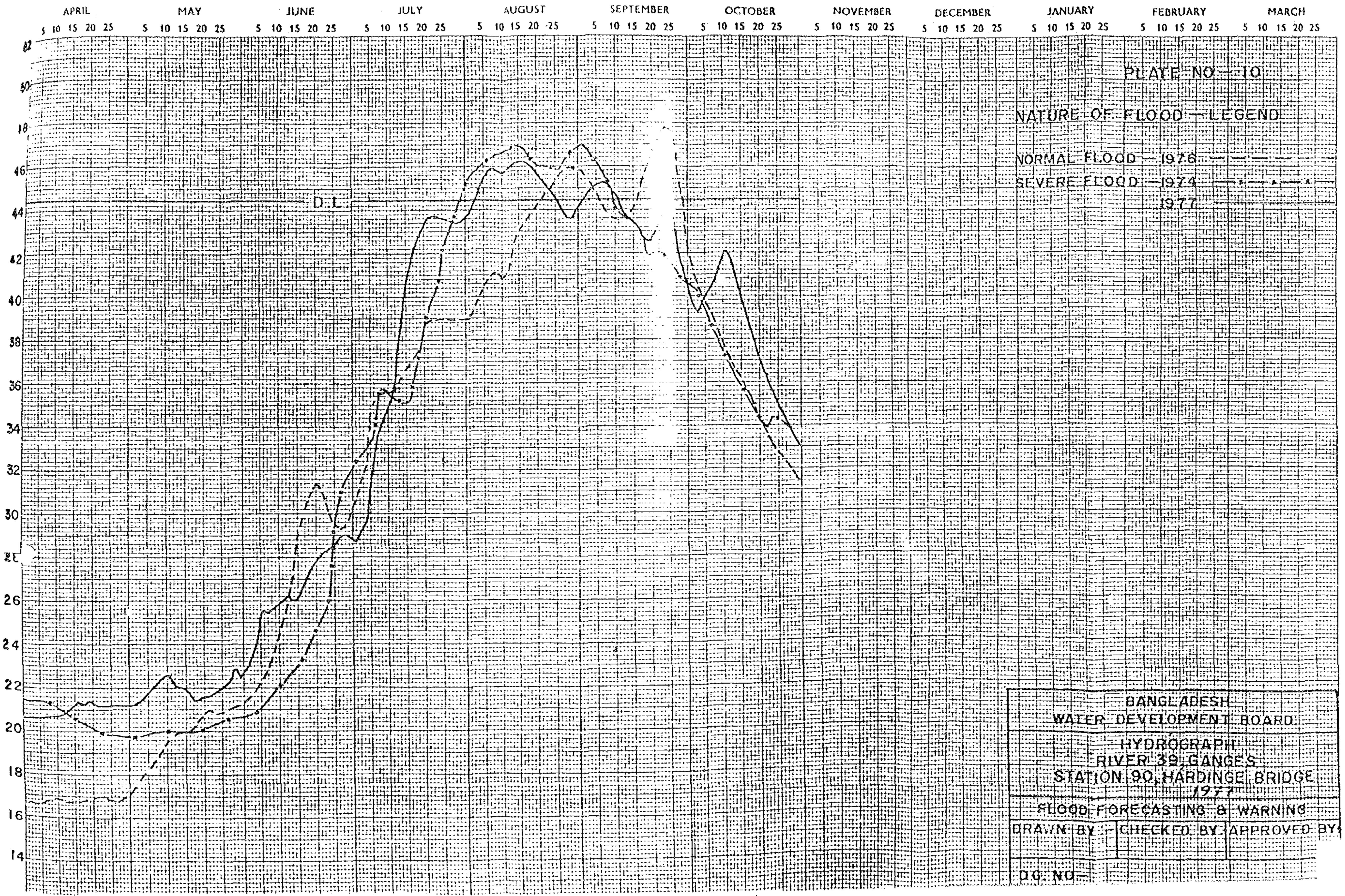


Fig 10d

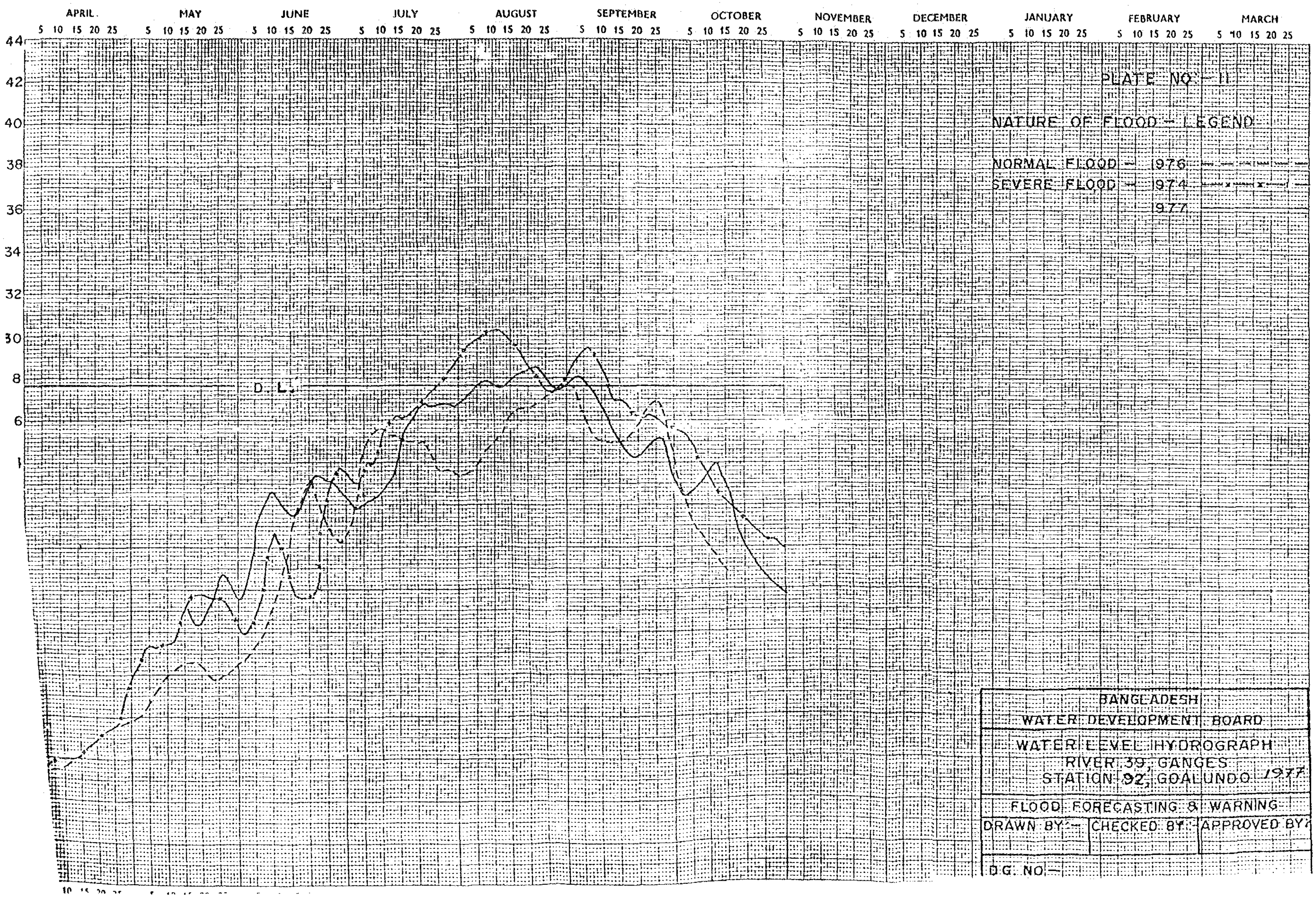

APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH
PLATE NO - 11
NATURE OF FLOOD - LEGEND
NORMAL FLOOD - 1976
SEVERE FLOOD - 1974
1977
D. L.
BANGLADESH
WATER DEVELOPMENT BOARD
WATER LEVEL HYDROGRAPH
RIVER 39, GANGES
STATION 92, GOALUNDO 1977
FLOOD FORECASTING & WARNING
DRAWN BY:- CHECKED BY:- APPROVED BY:
D.G. NO-

Fig 10 e

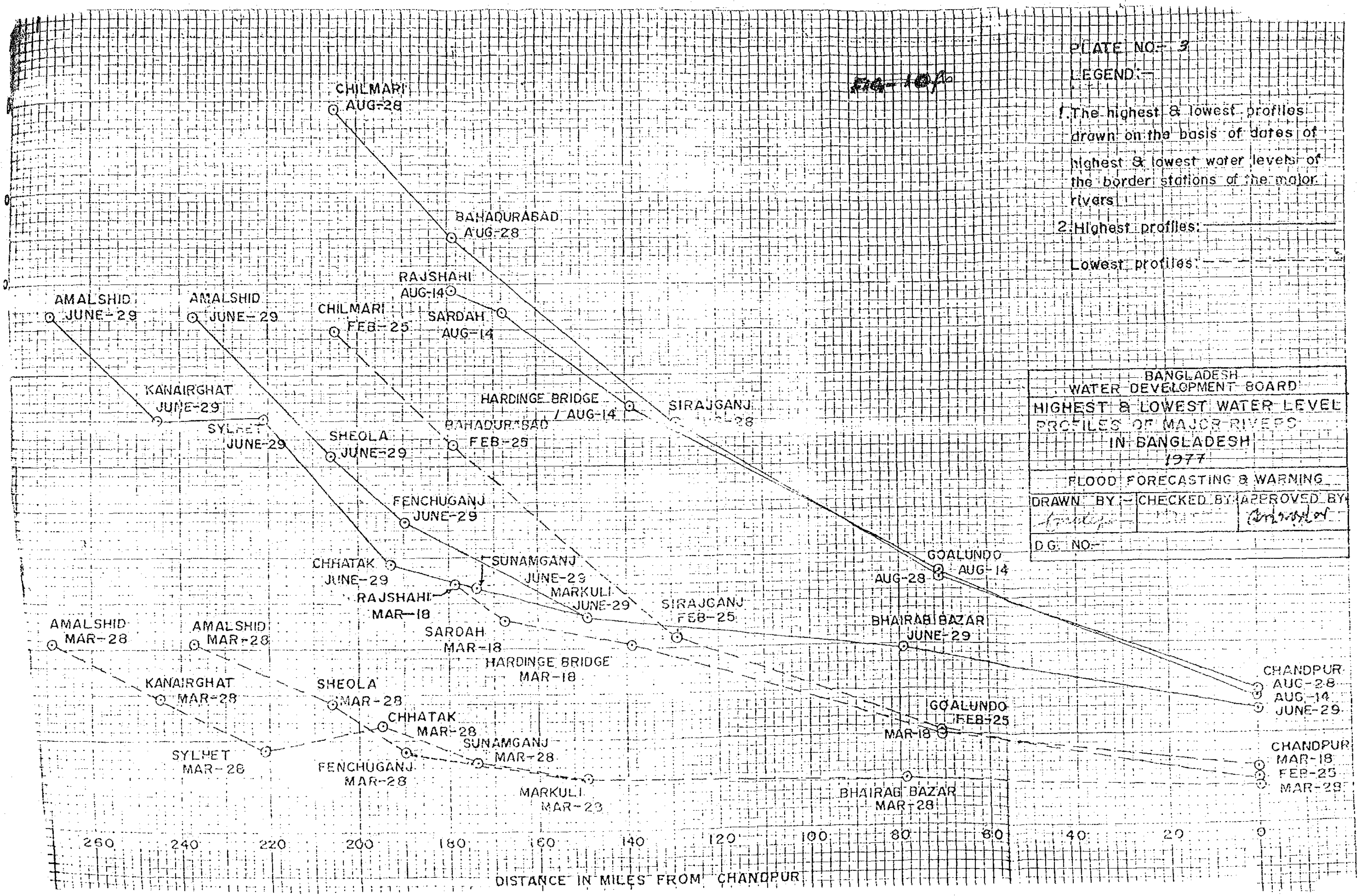


PLATE NO:- 3
Fig-10f
LEGEND:-
1. The highest & lowest profiles drawn on the basis of dates of highest & lowest water levels of the border stations of the major rivers.
2. Highest profiles:
Lowest profiles:
BANGLADESH
WATER DEVELOPMENT BOARD
HIGHEST & LOWEST WATER LEVEL PROFILES OF MAJOR RIVERS IN BANGLADESH
1977
FLOOD FORECASTING & WARNING
DRAWN BY:-
CHECKED BY
APPROVED BY
D.G. NO:-
CHILMARI AUG-28
BAHADURABAD AUG-28
RAJSHAHI AUG-14
SARDAH AUG-14
HARDINGE BRIDGE AUG-14
SIRAJGANJ
AMALSHID JUNE-29
CHILMARI FEB-25
KANAIRGHAT JUNE-29
SYLHET JUNE-29
SHEOLA JUNE-29
BAHADURABAD FEB-25
FENCHUGANJ JUNE-29
CHHATAK JUNE-29
SUNAMGANJ JUNE-29
RAJSHAHI MAR-18
MARKULI JUNE-29
SIRAJGANJ FEB-25
SARDAH MAR-18
HARDINGE BRIDGE MAR-18
GOALUNDO AUG-14
AUG-28
BHAIRAB BAZAR JUNE-29
CHANDPUR AUG-28 AUG-14 JUNE-29
AMALSHID MAR-28
KANAIRGHAT MAR-28
SHEOLA MAR-28
CHHATAK MAR-28
SUNAMGANJ MAR-28
SYLHET MAR-28
FENCHUGANJ MAR-28
MARKULI MAR-28
GOALUNDO FEB-25
MAR-18
BHAIRAB BAZAR MAR-28
CHANDPUR MAR-18 FEB-25 MAR-28
260 240 220 200 180 160 140 120 100 80 60 40 20 0
DISTANCE IN MILES FROM CHANDPUR

Fig 10 f

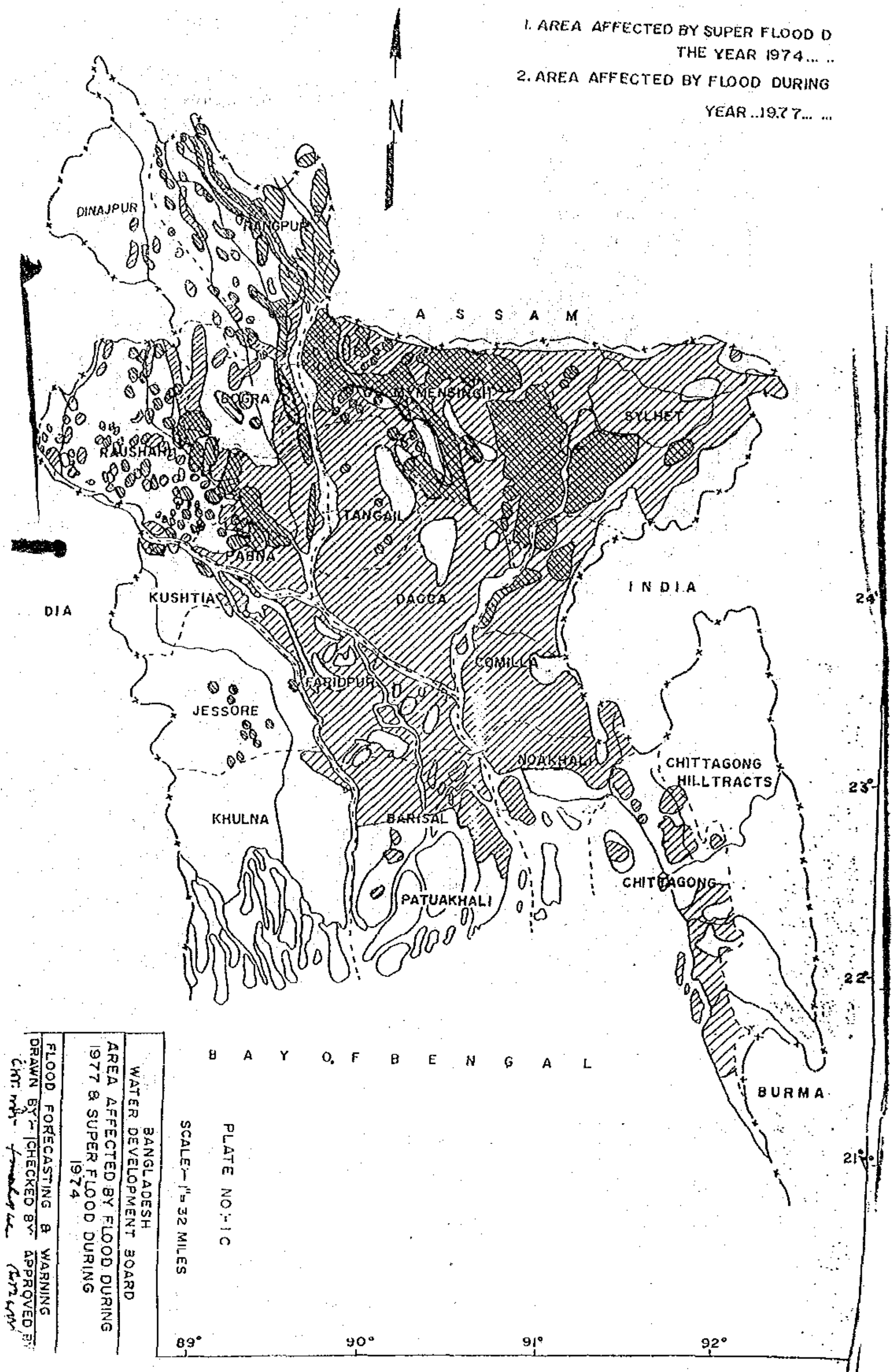

1. AREA AFFECTED BY SUPER FLOOD D
THE YEAR 1974......
2. AREA AFFECTED BY FLOOD DURING
YEAR ..19.7 7... ...
N
DINAJPUR
RANGPUR
ASSAM
ROGRA
MYMENSINGH
SYLHET
RAJSHAHI
TANGAIL
PABNA
KUSHTIA
DIA
DACCA
INDIA
COMILLA
FARIDPUR
JESSORE
NOAKHALI
CHITTAGONG
HILLTRACTS
KHULNA
BARISAL
PATUAKHALI
CHITTAGONG
BAY OF BENGAL
BURMA
24°
23°
22°
21°
89°
90°
91°
92°
PLATE NO:-1C
SCALE—1"= 32 MILES
BANGLADESH
WATER DEVELOPMENT BOARD
AREA AFFECTED BY FLOOD DURING
1977 & SUPER FLOOD DURING
1974
FLOOD FORECASTING & WARNING
DRAWN BY:- CHECKED BY:- APPROVED BY:

Fig. 12

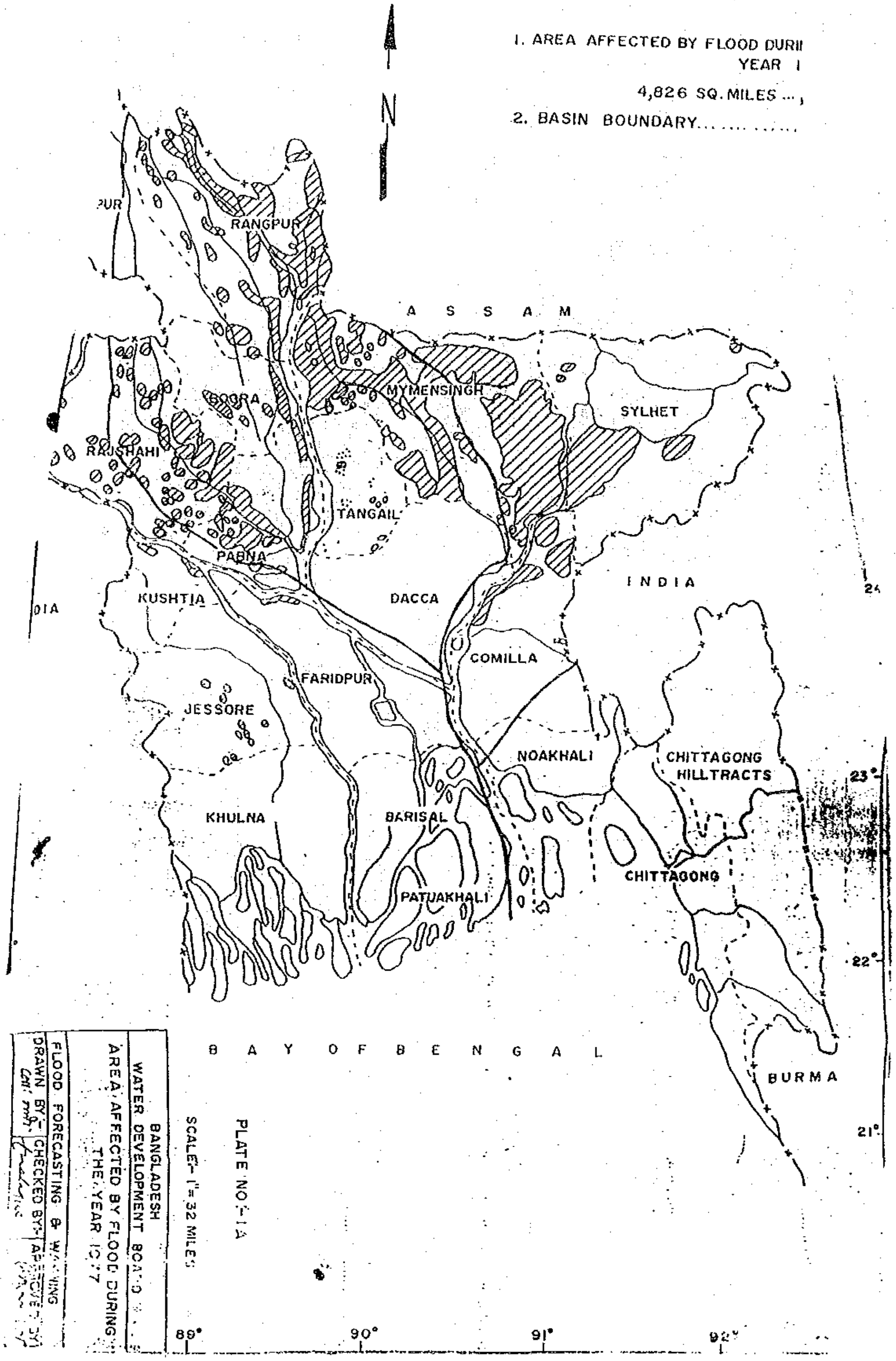

1. AREA AFFECTED BY FLOOD DURI
YEAR
4,826 SQ. MILES
2. BASIN BOUNDARY
N
RANGPUR
ASSAM
BOGRA
MYMENSINGH
SYLHET
RAJSHAHI
TANGAIL
PABNA
INDIA
KUSHTIA
DACCA
COMILLA
FARIDPUR
JESSORE
NOAKHALI
CHITTAGONG HILLTRACTS
KHULNA
BARISAL
CHITTAGONG
PATUAKHALI
BAY OF BENGAL
BURMA
23°
22°
21°
89°
90°
91°
BANGLADESH
WATER DEVELOPMENT BOARD
AREA AFFECTED BY FLOOD DURING
THE YEAR
FLOOD FORECASTING & WARNING
DRAWN BY
CHECKED BY
SCALE- 1"= 32 MILES
PLATE NO.

Fig. 13

By: Chung Hyo Sang
Korea

1. COUNTRY: REPUBLIC OF KOREA

2. DESIGNATED RIVER BASIN

2.1 Basin name and area

1) Anyang River ; 286 km^2 (tributary river)
2) Han River ; 26,219 km^2 (main river)

2.2 Location

Lat.: 37°20' N and 37°32' N. Long.: 126°47' E and 127°04' E

2.3 Map: see Fig. 1 & 2

2.4 Index map : see the map of river basin in Korea

2.5 General description of the basin

1) Topography and geology

The Anyang River basin area is about 286 km^2. The southern part of this basin has a lot of mountainous area surrounded with Mt. Chonggye (height; 500 m), Mt. Soorhi (height; 474.8 m) and also the slope of that area is too steep and rough. The northern part of this basin area is passed through Seoul city partialy surrounded with Mt. Kwanak (height; 629.1 m), while the rest of basin belongs to Kyungki province.

2) Economy

Recently, it was expanded quickly the land use for industrial, residental and urbanized area after having built up the highway throughout this region.

As resulted, forest and agricultural area was decreased contradistinctively. Approximately the four hundreds of small and large factories and companies were contained on Anyang River basin at the end of 1977, continued the economical acts so very badly because of the merits and benefits to access easily on Seoul.

Land use management in this area was classified as follow

Forest area	; 143.7 km^2	(50.3%)
Agricultural area	; 72.3 km^2	(25.3%)
Housing area	; 26.7 km^2	(9.3%)
Urbanized area	; 36.8 km^2	(12.8%)
Factory area	; 6.5 km^2	(2.3%)

2.6 Past flood and damage

These rainfall records in this basin obtained by the Ministry of Construction were located in Nammyun, Siheung-Koon in Kyungki province, and also in Youngdeungpo, Seoul and Anyang city.

The city municipal office of Seoul, Inchon and Kimpo, which are near the basin had observations at there, standard meteorological stations include the records of rainfall, wind, temperature and so on.

The followed table 1 shows the datum about the rainfall stations.

Table 1

Station	River basin	Period of record	Type of observation	Existing maximum daily rainfall
Nammyun	Anyang river	From July 1st 1962 to present	Daily rainfall	Aug. 19, 1972 . ; 325.3 mm
Youngdeungpo	"	Not available	"	July 8, 1977 . ; 328.0 mm
Siheung-Koon	"	"	"	July 8, 1977 . ; 366.7 mm
Anyang Cityhall	"	"	"	July 8, 1977 . ; 454.5 mm
Kimpo	Near by	From 1962 to 1971	"	Aug. 8, 1972 . ; 340.8 mm
C.M.O. (SEOUL)	"	From 1907 to present	"	Aug. 2, 1920 . ; 354.7 mm

The amount of rainfall in the Anyang River basin on July 8, 1977 registered a unpreceedented record breacking rainfall of magnitude of 454.5 mm/day (99.5 mm hourly), so that concentrated heavy rainfall caused river and streams to flood embankments broke and roads were washed away in various location. The followed table 2 shows the datum about the lost values by flood.

Table 2 (US.1000 DLS: ₩ 485/1 DL)

Region	Damage of peoples			Damage of house-holds	Damage of factory	Damage of agricul-turals	Damage of pubric facility	Damage of others	Total
	Killed	Missed	Hurted						
Seoul	63	19	58	0.07	22.28	0.42	0.93	0.04	23.74
Anyang	103	17	310	2.79	27.95	0.26	1.61	-	32.61
Siheung	42	13	52	0.67	17.23	1.77	2.30	0.42	22.39
Total	208	49	420	3.53	67.42	2.44	4.85	0.46	78.74

3. FLOOD PROTECTION AND RELATED WORKS IN THE BASIN

3.1 Map: See Fig. 3 & 4

3.2 Dams; None

3.3 General Description of other works

In Anyang River basin, all of agrarian land must be established up the supply water system at both sides, and also the width of land road executed more than 5 meters in a straight line, after the flood had occurred. Furthermore the inhabitants in which their houses were located on the riskful hilly side and the low river basin was evacuated mostly to the safe places where have been built up 20 houses as a group.

3.4 General procedure for operating works during floods

This river basin and streamways are very narrow and winding the river's width and path, and also small size of hydraulic and crossing structure. The steep slope of the upper basin shape makes the flood larger originally because of simultaneous arriving time of the storm.

Anyway, the poor forestation allows the heavy sediment transportation and landslide. After the unpreceedent flood, local authorities concerned are accomplishing the prevention against landslide and building up not only the pumping stations, embankments, public facilities and etc. more than at that time, but also planting for the control of erosion.

4. EXISTING FLOOD FORECASTING AND WARNING SYSTEM

4.1 Map: See Fig. 5, 6, 7 & 8

4.2 General information

a) Purpose of the system: Not available.

b) History of the system: Not available.

c) Resources of the forecasting centre: Not available.

4.3 Data collection system for precipitation, water level, stream flow, discharge released form dam gates and other data.

a) Rainfall stations

No. Name	Location	Altitude	Duration of record	Type ordinary or self-recording	other inform
1.1 Anyang City Hall	Unconfirmed	-	-	ordinary type	-
1.2 Nammyun	126.57' E 37.21' N	40 M	July 1st, 1962	self-recording type	-
1.3 Ojung	Unconfirmed	-	-	ordinary type	-
1.4 Youngdeungpo	Unconfirmed	-	-	ordinary type	-

b) Water level stations: None

c) Streamflow stations: None

4.4 Data transmission system

As regard to Fig. 4, there are 4 rainfall stations within Anyang River basin, but were uncertainly the connection with telemetering system on the main Han River control office.

4.5 Data-processing system for checking and processing the incoming data as input to the forecasting model.

Not available.

4.6 Receipt and use of meteorological forecasts

The occurence of a heavy concentrated rainfall's expected the overflow of small river basin with a steep slopes or downstream ways along the levee where there are equipped poorly the structures for drainage, and the lag time between the peak rainfall and water stage is high up rapidly at very short-term.

So the ordinary flood forecast system cann't be applicable and useful, because of most time is spent for collecting the hydrogical data, preparing forecast and dissemenation of that forecast.

It is neccessary to figure out the meteorological conditions which are present status of heavy rainfall, flooding and the prospect of future.

4.7 Forecasting model

The following forecast warnings are utilized by a regional forecast based upon the meteorological and hydrogical conditions as shown in table 3.

Office name	Classification	Kinds	Detailed standard of announcement
Meteorological office	Advisory	Heavy rainfall & flood	Expected the considerable rainfall and damage. Expected the river's overflow by the considerable rainfall.
	Warning	Heavy rainfall & flood	Expected the severe rainfall and disaster by flood. Expected the rapid increment of water level and the possibility of serious flood by rainfall.
Meteorological office & Ministry of Construction	Advisory	Riverflood	If the water level of observation point designated river for flood forecasting exceeds the warning level and expect the danger of flood
	Warning	Riverflood	If the water level of observation point designated river for flood forecasting exceeds the warning level and expect the risk of serious disaster by flood.
Ministry of Construction	Warning	Flood prevention & fighting	If the rivers designated by Ministry of Construction will be expected the overflow of the embankment and the loss of human being, properties, public facilities and so on, also the neccessity of evacuation of residents and national economicals by the severe flood.

4.8 Warning system

The Han River control centre issue the advisory and warning of flood in Han River basin as following.

38 telemetric raingage stations (hourly rainfall data recording)

12 telemetric water level stations (hourly water height data recording)

5 telemetric dam water level stations (hourly dam water height data recording)

→ 3 telemetric relay stations

↓

Main control centre (graphic display panel)

1) direct to observe & monitor.

2) print to data by T.T.Y.

↓

Mini-computer ; 1700
(assort and analysis of collecting data)

↓

Main-computer ; 3170
(rain forecast, runoff & runoff forecast, dam data and water level data)

↓

Determine the possibility of flood, as that result

↓

Calculation of flood magnitude

↓

Decide by Director of Disaster Prevention Centre

↓

Flood advisory & warning issue by D. P. C.

↓

Notice of authorities concerned

Mass-com

Han River control centre

↓

Flood advisory & warning issue by 5 stations (Yeoju, Kwangjang, Ddukdo, Indogyo, Yanghwa)

4.9 Storm surge

Not available.

4.10 Problem with the system

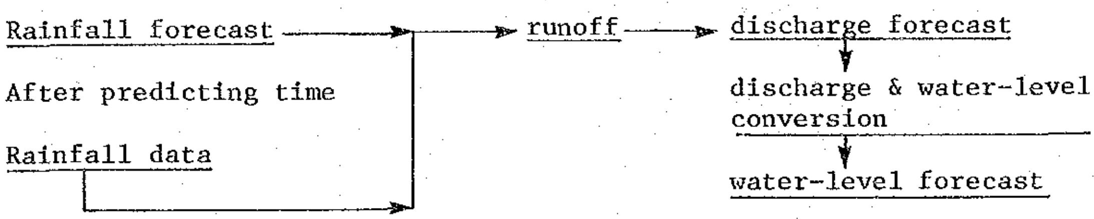
Not available.

4.11 Plans for improving the existing system

1) Improvement of flood forecast system

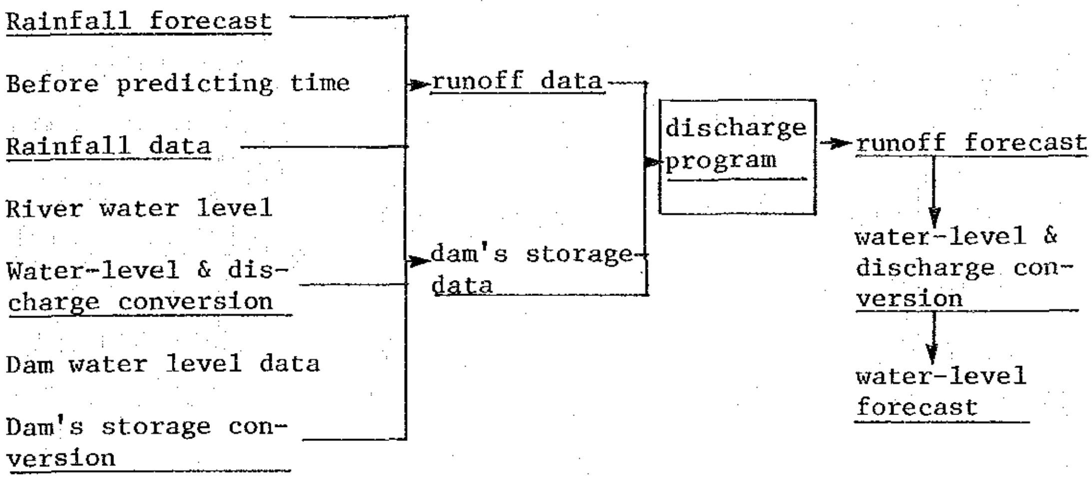
At present

Before predicting time



In future

After predicting time



2) Level up of computer capacity

3) Reanalysis of constant or frequency and discharge of flood warning.

Priority No.	River name	Catchment area	River length	Remarks
1	Sum River basin	1,479.2 km^2	101.5 km	survey at 1980
2	Hongchun River basin	1,553.0 "	140.8 "	
3	Pyungchang River basin	2,430.9 "	180.0 "	
4	Youngweol River basin	2,428.2 "	178.5 "	
5	Dalchun River basin	1,602.1 "	125.2 "	

5. ASSOCIATED STATION NETWORK

5.1 Map

See Fig. 9, 10, 11, 12.

5.2 Number of hydrometric stations including thouse reported under 4.

a) Discharge stations: 6 stations (sediment discharge too)

b) Stage only

5.3 Number of rainfall stations including those reported under 4:

a) Ordinary : 6 stations

b) Self-recording : 33 stations

c) Others : Not available

5.4 Other stations

Not available.

6. FLOOD RISK STUDIES AND MAPS

6.1 Basin map with contour lines, river channel and flood plain cross section, and longitudinal profile of the river channel.

Not available.

6.2 Hydrographs and hyetographs of recorded flood events at the gauging station, with inundation and without inundation

Not available.

6.3 Longitudinal profiles of the maximum flood stage and the maximum flooding area of the recorded flood events with inundation as many possible.

Not available.

6.4 Geomorphological map or aerial photographs of the basin including areas subject to flooding.

Not available.

6.5 Information on major channel works and reservoir constructions and reports of the assesment of their effects on the decrease of inundation areas.

Not available.

6.6 The result of statistical analysis of return period on flood discharge and rainfall.

Not available.

BRIEF REPORT

COUNTRY: REPUBLIC OF KOREA

BASIN NAME AND AREA: Anyang River basin -- 286 km^2 (tributary)

GENERAL CONDITION:

In Anyang River basin there are only 4 raingage stations, no streamflow station, no waterlevel station and no sediment station, there is no operating process system in Han River control centre.

Anyang River basin has been used to urbanize near the municipality of Seoul. But now we have worked only the ordinary action for flood control, so we must equip or construct 2 formal raingage stations, 1 waterlevel station, 1 streamflow station and 1 sediment station which should belong the operating process system in Han River control centre.

In most of agrarian land must be established up the supply water system at both sides, and also the width of land road executed more than 5 meters in a straight line.

Furthermore the inhabitants in which their houses were located on the riskful hilly side and the low river basin were evacuated mostly to the safe places have been built up 20 houses as a group.

THE REPORT OF CASE STUDY BASED ON GEOMORPHOLOGICAL APPROACHES FOR FLOOD RISK MAPPING

Geomorphological mapping about flood risk area is one of principle method which can estimate to select the riskful zone occurred by flood. This method must be done and worked by experts, having a lot of experiences, because we can improve the flood risk area with comparison to historical approaches, but it may be too difficult to compile the geomorphological map for flood control for the beginner.

CASE STUDY

Hino River begins to flow from Mt. Kagami, Mikami and Yukino. At the beginning of the river there are numerous tributaries, which if we make any measuring of formulation of mountain, it will be shown as in Fig. 1.

When it rains at the peak of mountainous area, generally, the rainwater will flow down through the hilly side to the foot of mountain.

As that result of the high latent dynamical energy of the stream, that rain-water will cause the land-slides at the fragile point of that's surface of hilly

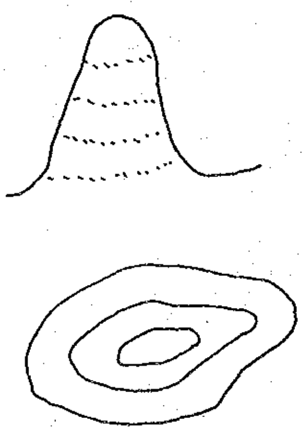


Fig. 1

steep area and carry with it as erroded some ingredients to the foot of mountain.

Continuing this geomorphological phenomenon for long-term periods, it will form the coarse valley as like the water-channel, step by step.

So we can look at and show the formation using contour lines map. In this way, most of mountainous area have taken the formation of a lot of tributaries as shown Fig. 2. In case of Hino River also it may be a reason which it has taken numerous tributaries in this mountain area. In the views of geomorphological sense, it has been classified, at the river beginning from its peak area, it trenches to carry some materials which it deposits heavy ingredienacts at one place, there are some mild gradients as deposition of fans or river terraces.

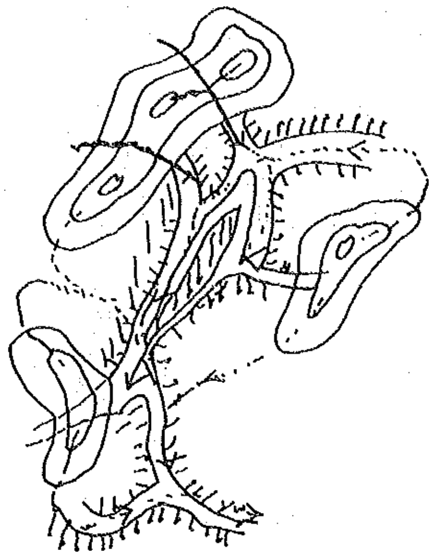


Fig. 2

After such a process, natural levees have been developped well along the riverways or embankments except in some mountainous area, but its levee area was very small and narrow than lowland. Therefore this water-level is probably increasing up highly, suddenly when the heavy rainstorm falls in, so that lowland area is too dangerous against the flood except limited natural levee or hilly area because of discharge water flowing down the river basin directly and expand fastly, having not enough time for flood prevention or fighting chance.

The acurate flood forecast is the best method for lessening the losses by the flood, and also has enough time for remove some raw materials, high major facilities and inhabitants to safe places or the other hilly zone, not being submerged by the inundation.

FLOW CHART

Survey of catchment area (landuse, population, hydro-hydraulic equipments and contour lines map up-to-date)

Collection of all related historical, geomorphological referrence and original water channel.

Sellection of natural levees, dunes, past inundated region and etc. with topographical, geomorphological views.

Preparation of aerial photographs of catchment area.

Analysis and arrangement of geomorphological area classification according to the aerial photographs.

Precompilation of geomorphological map for flood control.

Comparison to the manuscript compilation of geomorphological map for flood control with topographical and geomorphological map.

Final geomorphological map for flood control.

THE CHECK LIST OF COUNTERMEASURES

THE IMPROVEMENT OF EXACTNESS OF FLOOD FORECAST

I think that I must collect and use the historical records inundated, which can survey the chracteristics of flood, so try to endeavor the improvement of flood forecast with high accuracy. That's very effective and economical method to do and accomplish easily the flood prevention under our situation.

LAND-USE REGULATION

I suppose that government's law or local governer's regulation must be acted to control the land-use for preventing the flood and lessening the loss occurred by flood.

In an instance everyhouses may be built up only the designated area by the law, so as provided there is just reason for it, we can save the residents, raw materials and major equipments safely from submerged in water, or have some enough time for flood fighting or control.

CONTINUATION TO PLANT FOR THE WEALTHY FORESTATION

I mean this method also has a highly effective way which can manage the prevention of flood, landslide and drought. Furthermore it gives us to bring forth the cover of green shape at mountain and supply with solid fuel as wood, puts us at the rest psychologically.

CONCLUSION

A flood has been occurred any river basin in which can easily overflow or breach out the embankments and cause the landslide too. Anyang River basin is growing in popularity and requires setting up the scheme for decision making in water control. By establishing such kinds of station as mentioned above, we can control this river basin which is destined for more intensive urbanization.

Several factors suggest, however, that this approach is gradually being abandoned in favor of management of flood plain lands to minimize the toll of losses, so the increasing impact of flood losses on the economics of the country and the increasing knoweledge that it is possible to reduce such losses.

The human implication of the provision of flood protection, anyway may be even more significant than the physical consequence. The essential effect of flood protection is to reclaim land which would possibly not be used intensively without it. A consequence is that it fosters increased flood plain occupancy, not all of which may be very rational. Such type of countermeasures mentioned above must also be adopted to ensure the flood loss potential is reduced rather than increased.

Pasak River Basin

By: Sutat Chantrapornlert
Thailand

1. COUNTRY: THAILAND

2. DESIGNATED RIVER BASIN

2.1 The basin name: Pasak River Basin.
Area: 16,120 km^2

2.2 The main river: Choa Phraya River

2.3 Location:
Lat. 14°21' N. and 17°15' N.
Long. 100°35' E. and 101°30' E.

2.4 Topographical map of the basin. (in Fig. 1)

2.5 Index map. (in Fig. 2)

2.6 General description of the basin.

i) Geographically, Pasak river basin is located in the center of upper Thailand at latitudes between 14°21' N. and 17°15' N. and longitudes between 100°35' E. and 101°30' E. The Pasak river with its total length of about 320 km is one of the Chao Phraya river's tributaries joining the Chao Phraya River at Ayutthaya Province. The river basin has a banana shape and drain an area of about 16,120 km^2 from the eastern slope of Phetchabun mountain range and the western slope of Korat marginal mountain into the Central Plain.

ii) Meteorology:
The climate in the basin is somewhat like that of the country which is under the influence of the northeast and southwest monsoon wind regime. Widespread rainfall is obtained during the southwest monsoon season. Atmospheric disturbances in the form of depression originated in the West Pacific Ocean and the South China Sea usually affect upper Thailand, including the Pasak river basin during July to October. Flooding condition from depression superimposed on normal storm rainfall usually occurs in the lower reaches of the Pasak river basin. Such cases were experienced in 1964 and 1978 which resulted in severe damaged to rice crops and other public utilities.

iii) Population and Economy:
Based on the Phetchabun Province's population growth rate about 2.41 percent, the number of people living in the Pasak river basin is expected to be around 1 million by the end of 1980. The economic growth rate for the Pasak river basin, based on 1977 figured, is about 9.27 percent with gross provincial product of about 4,019.6 million baht and per capita income of 5,479.4 baht.

SOURCES: National Economic and Social Development Boards (NESDB)

Key Figures (1977)

Province	Area sq.km	Population person	GPP M/Baht	Per Capita Baht	Birth Rate percent
Ayutthaya	2,556.6	612,826	5,215.0	8,509.7	0.92
Saraburi	3,576.5	452,332	5,099.9	11,247.6	1.64
Lopburi	6,199.8	612,929	4,241.7	6,920.3	2.45
Phetchabun	12,668.4	733,583	4,019.6	5,479.4	2.41
The Whole Kingdom	513,115.0	44,272,693	370,445.0	8,412.0	2.61

2.7 Past floods and damage

Severe flooding was observed in September-October 1978. The seasonal rainfall in the basin as a result of active southeast monsoon was higher than normal. Continuous rainfall was observed at the upper stations during September with 23 to 27 rainy days. Intense rainfall due to depression "Kit" entering the country during 27-29 September generated a surplus runoff from the upper basin cause severe flood damage along the flood plain from Saraburi down to Ayutthaya. The maximum peak discharge of 3,200 m^3/sec at Kaeng Khoi station located at the head of the flood plain was about 3 times greater than normal peak flow. The river stage at RAMA VI Barrage of +10.90 m (msl) was the maximum recorded since 1914.

The flood event was recorded as the most severe in the history of the basin and caused intensive damage to paddy field, houses and public facilities. As regards the damage by flood, it was reported by the Center of Assistance of Flood Victims under the Ministry of Interior that within two provinces, Saraburi and Ayutthaya, 47,921 families suffer, 11 persons died and 1,207 sq km of agricultural land were completely damage.

3. FLOOD PROTECTION AND RELATED WORKS IN THE BASIN

3.1 Map. Shown in Fig. 1

3.2 Dam. Not available.

3.3 General procedure of other works. Not available.

3.4 General procedure for operating works during floods. Not available.

4. EXISTING FLOOD FORECASTING AND WARNING SYSTEM

4.1 Map. Not available.

4.2 General information.

a) Purpose of the system. Information is not available.

b) History of system.

Flood forecast is issued by the Weather Forecasting Center of Meteorology Department usually 24 hours in the advance base on the field data from six rainfall/water stage stations in the middle and upper reaches of the basin. A simple stage correlation method is currently employed for the flood forecasting for the upper part of the Pasak river basin. Flood information is communicated to the community level by the commercial telephone via provincial or district offices in the addition to the radio broadcasting.

Following items may be proposed as guidelines for the implementation of a flood forecast and warning system. Development of more accurate flood simulation model equipped with telemetric telecommunication network may be considered in the future if necessary.

(1) Study characteristics of rainfall patterns in relation to the track of storms (including typhoons and tropical depressions). This will be helpful in issuing flood forecast well in advance as soon as storm information is available.

(2) Improve the stage correlation method by introducing rainfall data into the model as a new parameter in addition to the water stage data upstream.

(3) Improve data transmission system from the field stations to the Center in Bangkok. Presently, three stations are sending data by SSB.

(4) Improve warning and emergency operation system. Setting up an interagency organization for emergency operation, installation of exclusive communication line between the Center and local offices, designation of places for evacuation may be considered for this purpose.

c) Resources of the Forecasting Center,

(1) Organization: Meteorological Department

(2) Computer facilities: Not available

(3) Operation cost: Not available

4.3 Data collection system for precipitation, water level, streamflow, discharge released from dam gates and other data:

a) Rainfall stations

No.	Name	Location	Altitude	Duration of record	Type	Other
1.1	Lom Sak	16°46'25"N 101°14'58"E	-	-	self-recording	-
1.2	Wichian Buri	15°39'25"N 101°06'30"E	-	-	self-recording	-
1.3	Bua Chum	15°15'50"N 101°11'30"E	-	-	self-recording	-
1.4	Nong Phai	15°59'30"N 101°04'00"E	-	-	ordinary	-

b) Water level station.

No.	Name	Location	Altitude of staff datum	Distance from the river mouth	Duration of record	Type
2.1	Lom Sak	16°46'25"N 101°14'58"E	-	-	-	self-recording
2.2	Wichian Buri	15°39'25"N 101°06'30"E	-	-	-	self-recording
2.3	Bua Chum	15°15'50"N 101°11'30"E	-	-	-	self-recording
2.4	Nong Phai	15°59'30"N 101°04'00"E	-	-	-	staff

c) Streamflow station

No.	Name	Location	Distance from the river mouth	Duration of record	Type-flood	Frequency
3.1	Phetchabun	-	-	-	-	-
3.2	Lom Sak	-	-	-	-	-
3.3	Wichian Buri	-	-	-	-	-
3.4	Bua Chum	-	-	-	-	-
3.5	Kaeng Khoi	-	-	-	-	-

- Not available

4.4 Data transmission system: Not available

4.5 Data-processing system for checking and processing: Not available

4.6 Receipt and use of meteorological forecasts: Not available

4.7 Forecasting model: Not available

4.8 Warning system: Information is not available.

4.9 Storm surge: Not available

4.10 Problem of the system: Information is not available.

4.11 Plans for improving the existing sytem

1) Study characteristics of rainfall patterns in relation to the track of storms (including typhoon and tropical depressions).

This will be helpful in issuing flood forecast well in advance as soon as storm information is available.

2) Improve the stage correlation method by introducing rainfall data into the model as a new parameter in addition to the water stage data upstream.

3) Improve data transmission system from the field stations to its Center in Bangkok. Presently, three stations are sending data by SSB.

4) Improve warning and emergency operation system. Setting up an interagency organization for emergency operation, installation of exclusive communication line between the Center and local offices, designation of places for evacuation may be considered for this purpose.

5. ASSOCIATED STATION NETWORK

5.1 Shown in Fig. 1

5.2 Number of Hydrometric stations.

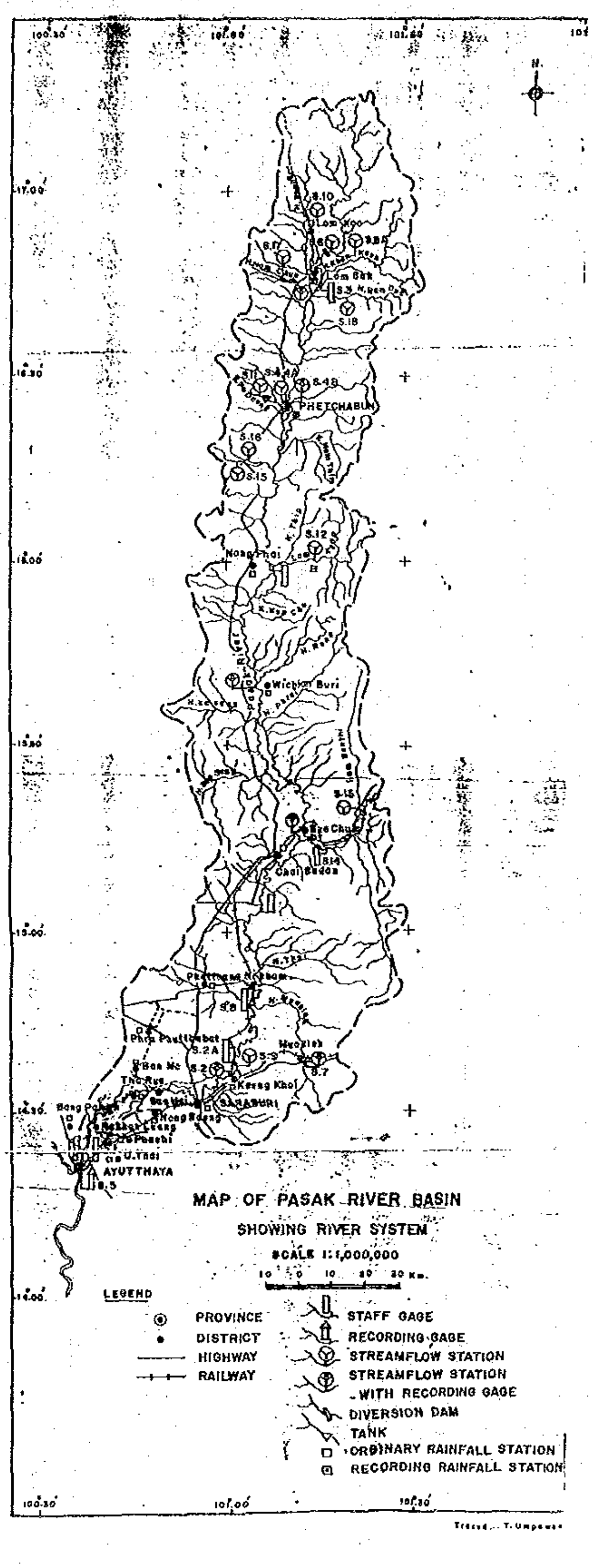
a) Discharge stations: 18 stations

b) Stage only: Not available

5.3 Number of rainfall stations

a) Ordinary: 15 stations

b) Self-recording: 6 stations


MAP OF PASAK RIVER BASIN
SHOWING RIVER SYSTEM
SCALE 1:1,000,000
10 0 10 20 30 Km.
LEGEND
PROVINCE
DISTRICT
HIGHWAY
RAILWAY
STAFF GAGE
RECORDING GAGE
STREAMFLOW STATION
STREAMFLOW STATION WITH RECORDING GAGE
DIVERSION DAM
TANK
ORDINARY RAINFALL STATION
RECORDING RAINFALL STATION
PHETCHABUN
AYUTTHAYA
SARABURI
Wichian Buri
N.

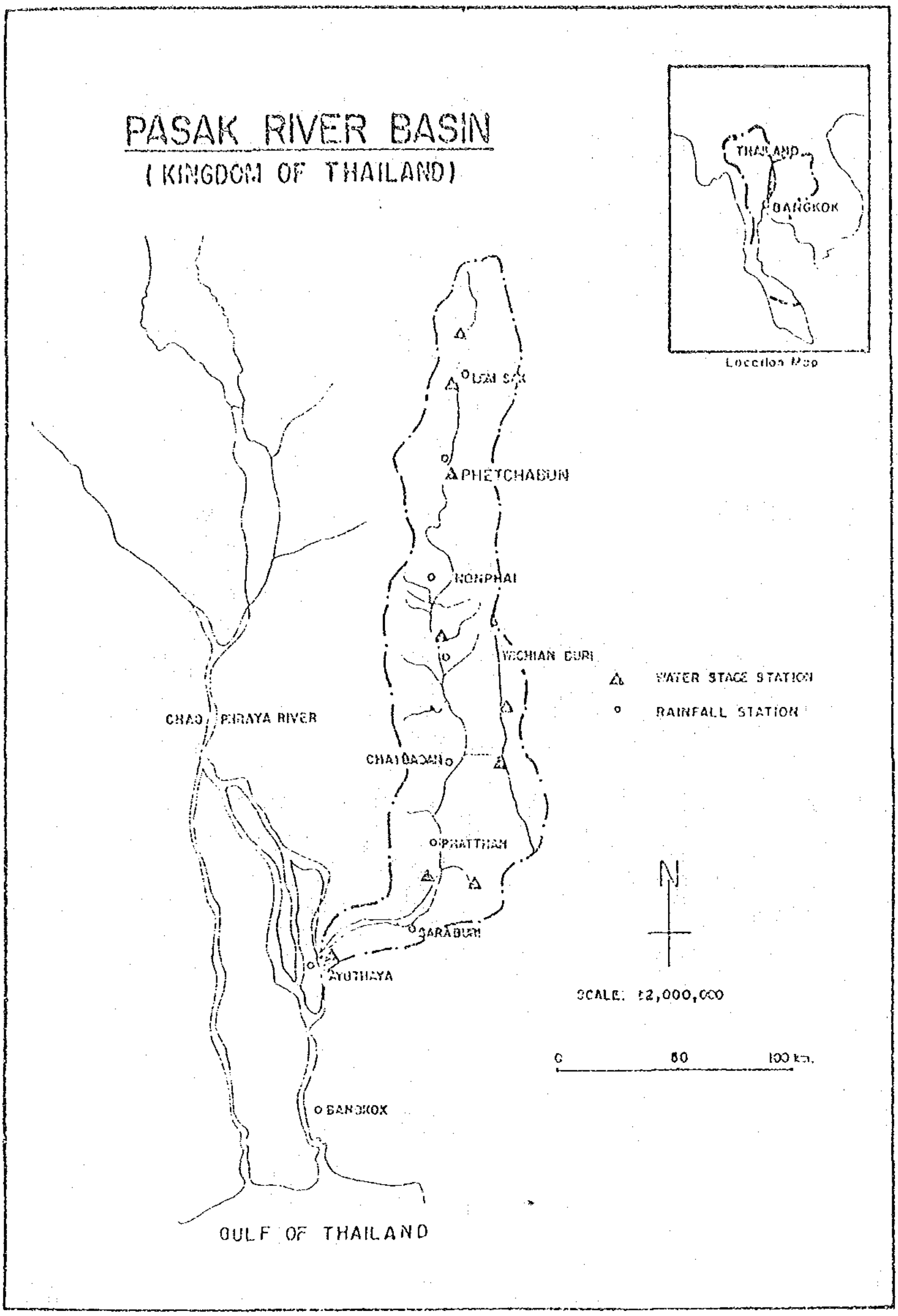

PASAK RIVER BASIN
(KINGDOM OF THAILAND)
THAILAND
BANGKOK
Location Map
PHETCHABUN
NONPHAI
WICHIAN BURI
WATER STAGE STATION
RAINFALL STATION
CHAI BADAN
SARABURI
AYUTHAYA
BANGKOK
GULF OF THAILAND
N
SCALE: 1:2,000,000
0
50
100 km.

Fig. 2

PILOT RIVER - PASAK RIVER

By:

Thailand

1. Outline of the Pilot River Basin

1.1 Topography

The Pasak river is a major tributary of the Chao Phraya river joining the Chao Phraya at Ayuthaya. The basin has a long shape draining the eastern slope of the Phetchabun mountain range and the wester of the Korat marginal mountain. The upper part of the basin upstream from Saraburi province is hilly while the power part from Saraburi to Ayuthaya is a fertile flood plain suitable for rice cultivation. The total length of the river is about 320 kilimeters and the catchment area above Kaeng Khoi stream gauging station is about 14,520 sq.km. The river basin covers part of the areas of four provinces namely Phetchabun, Lopburi, Saraburi and Ayuthaya.

1.2 Climate

The climate of the Pasak river basin is similar to climate of the country which is under the influence of the northeast and southwest monsoons. During the northeast monsoon lasting from November to February, dry and cool conditions prevail over the country. The sourhwest monsoon lasting from May to October is moist and warm. Wedespread rainfall occurs during the southwest monsoon season. Atmospheric disturbances in the form of depressions originate in West Pacific and South China Sea usually affect Thailand during July to October. Sometimes depression-caused rainfall is superimposed on the normal storm rainfall over the basin. This condition produces the most serious flood potential in the central plain. Such cases occurred in 1964 and 1978 which resulted in severe damage to rice crop and other public facilities.

2. The Hydrological Observation System and Floods

Observation of climatic data is carried out by the Meteorological Department. Rain gauges were installed at each district or provincial office and the data transmission is made by telegram and postal services. A synoptic station is located at Phetchabun provincial office. Flow measurements at Lom Sak, Wichianburi and Bua Chum are also carried out by the Meteorological Department while the station at Kaeng Kkoi is operated by the Royal Irrigation Department. The transmission of data from those stations is made by SSB except at Kaeng Khoi. Observation of river stage in the flood plain area is carried out by the Royal Irrigation Department. Irrigation development in the flood plain areas has been made with the Rama VI diversion dam built at Tha Luang and supplies water for rice cultivation in the left bank area. Additional development in the upper flood plain area near Saraburi Province has also been implemented. Normal flooding conditions with small depth in the lower flood plain areas has normally been experienced in wet years and is sufficient for rice cultivation. Severe flooding condition is likely to occur whenever the widespread and continuous torrential rainfall from a depression occurs.

Severe flooding was observed in September - October 1978.

The seasonal rainfall in the basin as a result of active southwest monsoon was higher than normal. Continuous rainfall was observed at the upper basin stations during September with 23 to 27 rainy days. Intense rainfall due to depression "Kit" entering the country during 27 - 29 September generated a surplus runoff from the upper basin causing severe flood damage along the flood plain from Saraburi down to Ayuthaya. The maximum peak discharge of 3,200 m^3/sec. at Kaeng Khoi station located at the head of flood plain was about 3 times greater than normal peak flow. The river stage at Rama VI Barrage of +10.90 m (msl) was the maximum recorded since 1914.

The flood event was recorded as the most severe in the history of the basin and caused extensive damage to paddy fields, houses and public facilities. As regards the damage by flood it was reported by the Center of Assistance of Flood Victims under the Ministry of Interior that within two provinces, Saraburi and Ayuthaya, 47,921 families suffered, 11 persons died and 754,375 rai (1,207 sq. km) of agricultural lands were completely damaged.

3. The Impression of Comprehensive Flood Loss Prevention and Management

The concept of the comprehensive flood loss prevention had been developed in the United States about 15 years earlier than it was started in Japan.

Experience in many countries has shown that large investment in flood control measures have not resulted in an overall reduction in flood losses. Even though the flood control structures have operated according to their design, larger flood losses have resulted from an expanding economic growth and many times unwise land use in flood-prone regions.

Flood control reservoirs function on the principle that all or at least a major part of flood volume is captured in the previously empty reservoir space and released soon after the flood at non-damaging rates of discharge. Obviously a flood control reservoir is ineffective for floods occurring when the reservoir is already filled. When the volume of floods are much larger than the storage volume of the reservoir, the potential of serious flood losses still exist downstream. Damaging flood downstream may also be created when the reservoir gates are opened suddenly or when they are opened when tributaries downstream are already at flooding stages.

Flood levees or bunds were probably the first flood control structures built by man. Levees or bunds are constructed from earth and must have a wide base to be stable against washouts. The slopes facing the stream are often protected by rip rap, masonry or concrete facing. When there is insufficient land space for a wide levee, concrete or masonry flood walls are used to limit the spread of the flood water. Levees fail to prevent flood loss when the flood is even a small amount higher that the design stage when they are overtopped and after fail catastrophically. Levees are always subject to erosion damage at places where high velocity currents happen to impinge against them. The flow patterns are transient and are often unpredictable. To be dependable, levees require continuing maintenance and their conditions must be continuously monitored during times of flood to ensure that timely emergency repairs can be made when needed.

It can be shown that many flood losses can be reduced through non-structural flood control measures. Furthermore the optimum benefit to society results when there is a comprehensive and coordinated combination of both structural and non-structural measures to migitate recurring flood losses. This coordinated plan is referred to as Comprehensive Flood Loss Prevention and Management.

4. Non Structural Measures

A great extent of flooding in the low-lying area along the Pasak river from Saraburi to Ayuthaya has been recognized which caused especially severe damages during the flood in 1978. The flow which overtopped the bank in the upstream reaches from Saraburi inundated the flat plain near the city. The canals and embankments are assumed to have some role to change the inundated flow direction and flood-prone pattern on the plain.

The water stage on the flood plain usually rises slowly to its maximum level over several days, which provides enough time to evacuate inhabitants and domestic animals in this area. Accordingly, the flood risk warning given to the dwellers as well as new comers or developers has a great effect on the flood loss prevention. In view of this characteristics, the following three items are to be proposed for the study of this area.

1) Improvement of flood forecasting procedure

2) Flood risk evaluation

3) Other recomendations

4.1 Improvement of Flood Forecasting Procedure

Flood forecast is issued by the Weather Forecasting Center of Meteorological Department usually 24 hours in advance based on field data from six rainfall/water stage stations in the middle and upper reaches of the basin. A simple stage correlation method is currently employed for the flood forecasting for the upper part of the Pasak river basin. Flood information is communicated to the community level by commercial telephone via provincial or district offices in addition to the radio broadcasting.

Following items may be proposed as guidelines for the implementation of a flood forecasting and warning system. Development of more accurate flood simulation model equipped with the telemetric telecommunication network may be considered in the future if necessary.

1) Study characteristics of rainfall patterns in relation to the track of storms (including typhoons and tropical depressions). This will be helpful in issuing flood forecast well in advance as soon as storm information is available.

2) Improve the stage correlation method by introducing rainfall data into the model as a new parameter in addition to the water stage data upstream.

3) Improve data transmission system from the field stations to the Center in Bangkok. Presently, three stations are sending data by SSB, while

the others send by data telegram.

4) Improve warning and emergency operation system. Setting up an inter-agency organization for emergency operation, installation of exclusive communication line between the center and local offices, designation of places for evacuation may be considered for this purpose.

4.2 Flood Risk Evaluation

The following studies are recommended for future activities regarding flood risk evaluation.

1) Estimation of flood prone area along the lower reaches of the Pasak river from Saraburi to Ayuthaya would be carried out on the basis of a field survey and collection of past flood data.

2) Implementation of hydraulic studies on the flooding phenomena particularly affected by the canals, embankment as well as highways and roads.

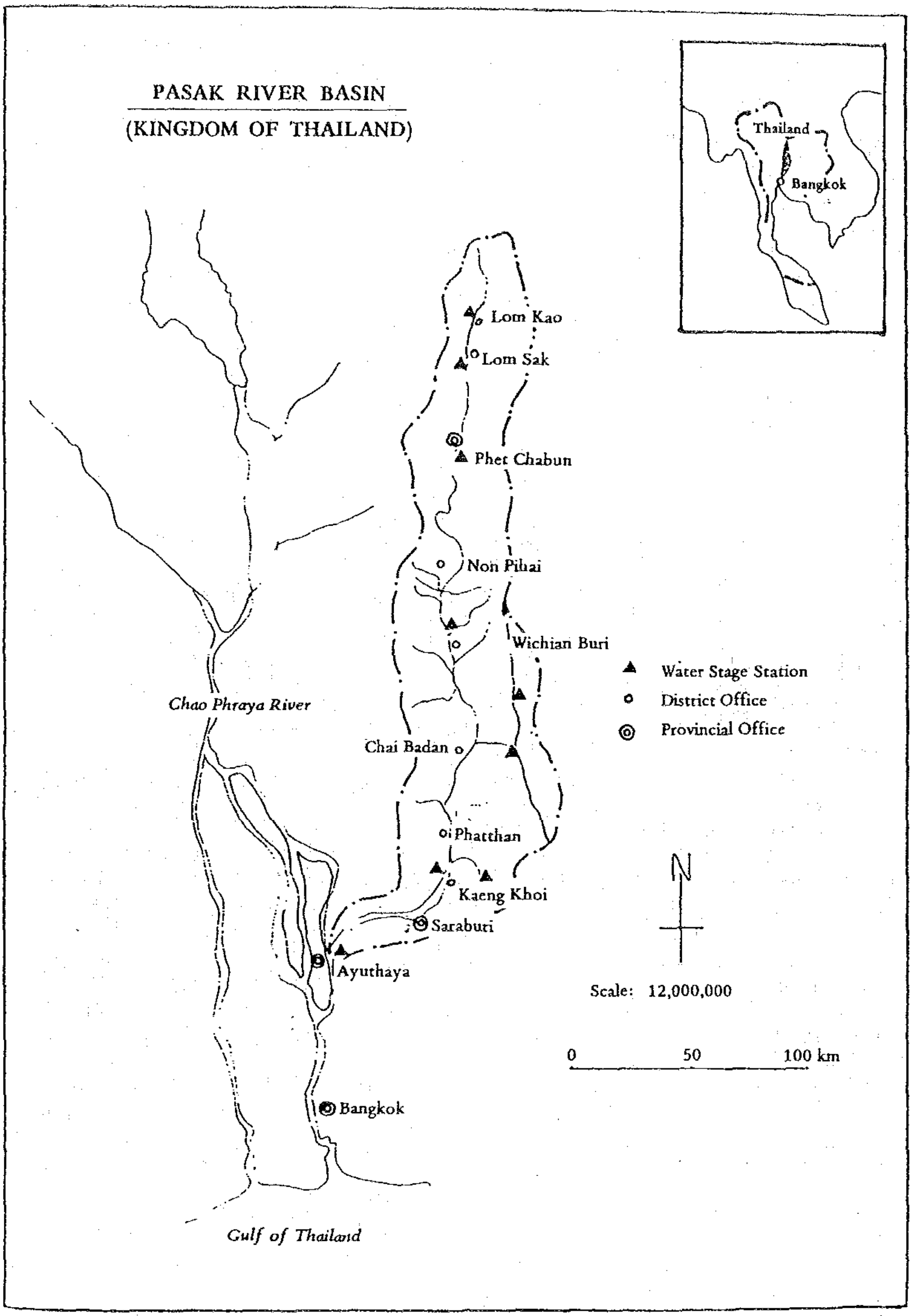
3) Establishment of tentative survey team to make survey of flood marks as soon as possible when a large flood has occurred.

4) Frequency analysis of flood magnitudes to evaluate quantitative flood risk.

4.3 Institutional Matters

It was noted that the functions of meteorological forecasting, stream forecasting for irrigation operations and remarkable degree of flood migitation is achieved through the present operations of the Royal Irrigation Department and the Meteorological Department. The full benefits of comprehensive flood loss prevention and magnagement will not occur to the nation until the responsibilities for comprehensive flood loss prevention are clearly defined and assigned to one of the existing agencies in Thailand. Accordingly it is recommended that:

1) The responsibilities for promoting comprehensive flood loss prevention and management be specifically assigned to an agency of the Government of Thailand, and that cooperation between all concerned agencies be encouraged.



PASAK RIVER BASIN
(KINGDOM OF THAILAND)
Thailand
Bangkok
Lom Kao
Lom Sak
Phet Chabun
Non Pihai
Wichian Buri
Water Stage Station
District Office
Provincial Office
Chao Phraya River
Chai Badan
Phatthan
Kaeng Khoi
Saraburi
Ayuthaya
Scale: 12,000,000
0
50
100 km
Bangkok
Gulf of Thailand