World Bank
Government of the People's Republic of Bangladesh

FAP-5

Gumti Phase II
Sub-Project Feasibility Study

FAP-5

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DRAFT FINAL REPORT

ANNEX B

HYDROLOGY AND HYDRAULIC MODELLING

June, 1993

Mott MacDonald Limited
in association with
Nippon Koei Company Limited
House of Consultants Limited
Desh Upodesh Limited

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ACKNOWLEDGEMENTS

The Gumti Phase II hydrology and hydraulic modelling team acknowledge the co-operation and assistance of the people of the area; their contribution to our understanding of the hydrology and hydraulics of the area cannot be over-estimated. The contribution of other members of the Gumti Phase II team is also gratefully acknowledged.

The help and assistance given by the staff of the Surface Water Modelling Centre (SWMC) was invaluable in the development and application of the hydraulic model of the area.

In addition we acknowledge the aid, experience and wisdom of government and non-government organisations and individuals who contributed to our studies. In particular we wish to thank FPCO, BWDB, FAP-2, FAP-4, FAP-5 and FAP-25.

B.1 Introduction

B.1.1 Objectives

The hydrological and hydraulic studies have a central role in the assessment of the impact of the river and drainage engineering proposals in the Gumti Phase II area. These studies involve the use of the computer based hydrological model NAM and the hydraulic model MIKE11. The model studies are not an end in themselves but should be viewed as a tool to provide quantitative predictions of the changes in flow patterns, rates and levels that may arise from the implementation of the engineering proposals. The modelling also provides parameters for the design of the engineering works.

The objectives of the hydrodynamic modelling in the project are threefold,

i) to assess the nature and extent of the existing flood problem, and to provide the basis for quantifying present flood-depth-area-frequency relationships, which can be used in project planning and evaluation;

ii) to provide the basis for assessing the impacts of flood mitigation measures both inside the areas to be protected and on unprotected areas, and for comparing pre- and post-development conditions;

iii) to provide design characteristics in the form of peak flood levels, discharges and velocities, for flood mitigation measures.

The hydrodynamic model provides a simulation of water levels and discharges, at each node in the schematisation of the river system, in response to a set of boundary conditions which effectively comprise upstream flows and downstream water level controls.

B.1.2 Study Area Location, Climate and Hydrology

The Gumti Phase II project area lies to the north-west of Comilla. It is bounded to the south by the Gumti River, to the west by the Meghna River, to the north by the Titas (or Pagla) River and to the east by the border with India.

The project area is approximately 141,000 hectares in size and land levels generally vary between 2.5 and 6 metres above sea level. An exception is a small area of relatively high land, rising to 9 m above sea level (asl), just north of Comilla.

The project area experiences a typical monsoon climate, with hot wet summers from May to September and cooler dry winters. The mean annual rainfalls at Comilla and Nabinagar are 2,387 and 2,047 mm respectively. Evapotranspiration exceeds rainfall for the months of November to March, and boro rice requires irrigation. An analysis of rainfall records shows that even in the wet season (April to September) there are, in most years, several dry periods of five days or more, when supplemental irrigation of aus and aman crops could be beneficial. Several major cyclones have crossed the project area, but damage is limited to that caused by high winds rather than tidal surges.

The project area is drained by the Upper Meghna River, which forms the western boundary. Other significant rivers are the Gumti River (forming the southern boundary) and the Titas, with its tributaries Buri, Salda, Gunghur and Bijni. In the western half of the area the rivers generally have flat slopes and come under tidal influence. In the eastern half of the area, the channels draining the Tripura hills (eg Gumti and Salda) are steeper and more liable to flash flooding. The Gumti River is being fully embanked over about three quarters of its length from the Indian border under the ongoing Gumti Phase I Flood Control and Drainage project. Although alleviating flash floods in the east, this existing embankment is likely to increase flood depths in the west of the Gumti Phase II area, downstream of the embankment.

The flooding regimes in the area are directly related to the river diversions. The low lying western areas are subject to deep flooding from the Meghna as it rises whilst the higher land in the east, although not deeply inundated for long periods, is vulnerable to damaging flash floods. Between the two is a transition area of medium elevation which is unable to evacuate either the run-off from internal rainfall or the run-off it receives from the east, as long as the Meghna levels remain high. It is clear that any flood control and drainage proposals therefore have to take account of these distinct flooding problems.

B.1.3 Scope of Work

This Annex covers the hydrological and hydraulic studies carried out during the Gumti Phase II study. A description is given of the methodology used in these studies. The development and calibration of the hydraulic model is described. The application of these models to investigate existing conditions and future conditions with imposed developments is presented.

The annex does not cover the assessment of any non-hydraulic impacts of the various options and scenarios studies, they are described in the main report and other annexes.

B.1.4 Report Structure

Following this chapter which gives an introduction to the hydrological and hydraulic studies there are two chapters which describe respectively the hydrometeorology and the drainage conditions. Chapter B.4 outlines the modelling methodology and Chapter B.5 describes the model development and calibration. Chapters B.6 to B.8 describe the baseline testing, the investigation of development options and the final option testing respectively. Chapter B.9 describes the modelling of developments which have been recommended previously for the Gumti Phase II area. Chapter B.10 draws conclusions and gives recommendations for future investigations.

B.2 Hydrometeorology

B.2.1 General

The hydrometeorology of the study area has been described to some degree in several general publications covering the climate of Bangladesh as a whole. The most note worthy are "The Agro-Climatic Survey of Bangladesh" by Manalo (Ref 2.1), and "Net Irrigation Requirement of Rice and Evapotranspiration of Wheat and Potato for Different Locations in Bangladesh" by Karim and Akland (Ref 2.2). A considerable amount of analysis was included in the South East Regional Study (Ref 2.3), and this has been the source of much of the material presented here. The analysis of rainfall reported in the Regional Study has been extended with updated data sets, and some more specific data quality control checks carried out. The analysis of basic climatic data has been based on the readily available published data for stations in the project area, generally covering the period 1965-80. It is very disappointing that the last ten years of climatic data were unavailable.

The monsoonal climate which affects the Gumti Project Area, and indeed the whole of Bangladesh, is part of a system which affects the whole of the Indian sub-continent. There are three main seasons:

i) the south-west monsoon: lasting approximately from May to October, and producing the main rainy season; almost 90% of the annual rainfall total in the study area occurs during this period, when both temperatures and relative humidity are high;

ii) the north-east monsoon: extending from November through to March, establishes the cool dry season of winter; only occasional rainfall occurs, associated with weak cyclonic disturbances;

iii) a short hot season: this precedes the south-west monsoon and can extend from late March through till May; the highest maximum daily temperatures can occur at this time, and the season is associated with variable convective storm activity which can occasionally develop into severe cyclonic storms; during this season, flash flooding from the rivers draining the Tripura hills to the east of the region can be a problem.

The study area can also be affected by severe tropical cyclones which develop in the Bay of Bengal. Cyclones most commonly occur in the periods before and after the main monsoon season in the months of May and October. In recent times, severe cyclones have affected the region in 1970, 1985 and 1991. Tropical cyclones are generally accompanied by very strong winds, high rainfall, and storm surge, which in coincidence with high tides can have disastrous consequences in coastal regions.

B.2.2 Climatic Norms

The climate stations of relevance to the study are at Comilla and Chandpur. Data at each station date from 1965, although there is some variability in the parameters recorded, and the completeness of records. The key parameters of temperature, relative humidity and wind speed are recorded at each station. Neither hours of bright sunshine nor radiation are recorded, however, and reference has been made to data for the stations at Dhaka and Chittagong. This is a limitation in the existing network.

Climatic norms for Comilla and Chandpur are summarised in Figures B.2.1 and B.2.2, and in Tables B.2.1 and B.2.2. From these, the general characteristics in climate described in the introduction above are obvious. Very similar patterns are observed at both stations. Wind speeds are lowest in the north-east monsoon period, but then pick up during the pre-monsoon hot season when Nor'westers and localised storm activity can occur. Wind speeds tend to level off during the south-west monsoon. The South East Regional Study (SERS) has noted that discrepancies exist in the units of wind speed measurement are several stations, and has recommended that original records at the existing climate stations are completely standardised. The mean monthly wind speeds are significantly higher than those recorded in some other parts of the country. Particular problems are thought to exist with the records for Comilla.

Mean daily temperatures are fairly constant between the months of April and September, and show little variation across the region, being of the order of 28°C. From October, temperatures begin to decline, and mean daily temperatures reach a minimum of about 19-19.5°C in January. In April, maximum daily temperatures in the region can often exceed 35°C, while in January, minimum daily values can be below 10°C. Increased cloud cover during the south-west monsoon period prevents extremes of temperature when the sun is at its maximum declination. This is reflected clearly from the plots of sunshine hours. There is a dramatic fall in the hours of bright sunshine during the main monsoon period.

Relative humidity is high throughout the year. Maximum values occur in July, when the mean is of the order of 87.5% throughout the region. February generally produces the lowest values of 71% at Chandpur, and about 67% at Comilla.

Potential evapotranspiration has been calculated using the modified Penman Method, and these estimates are included in Tables B.2.1 and B.2.2. Pan evaporation measurements are made at a number of stations in Bangladesh, but must be treated with caution. There are few countries in which practical use can be made of pan measurements. A comparison of potential evapotranspiration estimates for Comilla is presented in Table B.2.3. The pan estimates (taken from Ref 2.1) are clearly inappropriate. Differences between those estimates prepared under the present study and those of the Water Balance Study (Ref. 2.4) and Karim & Akland (Ref. 2.2) are partly attributable to differences in the length of available data base, but wind speed data quality is a problem. Differences in the dry season are of rather more significance than differences in the wet season when irrigation is not required. The reliability that can be attached to the potential evapotranspiration estimates is not particularly high. In view of the size of differences noted in Table B.2.3, serious efforts should be made to rationalise the data base. A comparison of potential evapotranspiration estimates for Brahmanbaria is presented in Table B.2.4. It is stressed, however, that there is a need for upgrading climate stations in the region, for standardising measurement units, and for making data up to 1990 available.

In an average year, potential evapotranspiration exceeds rainfall between the months of October an March throughout the region. Rainfall in the early and late monsoon periods is highly variable, however, and the average conditions do not give a representative indication of requirements for irrigation. It is clear from Figures B.2.1 and B.2.2 that there is a requirement for irrigation between the months of October and April, even under average rainfall conditions. Rainfall and effective rainfall for agriculture are considered in greater detail in sections B.2.3 and B.2.4.

Figure B.2.1
Climatic Norms at Comilla

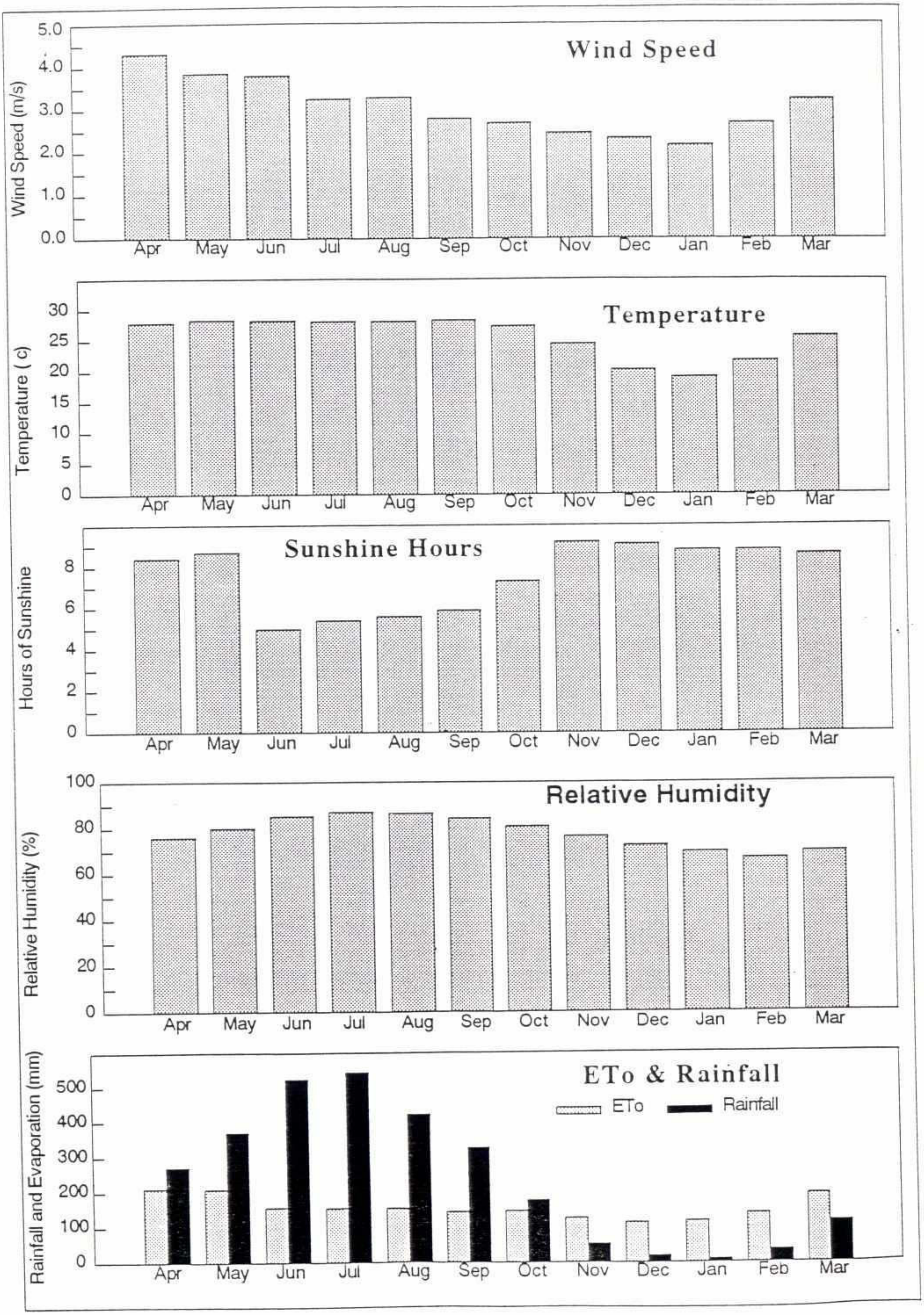


Figure B.2.2

Climatic Norms at Chandpur

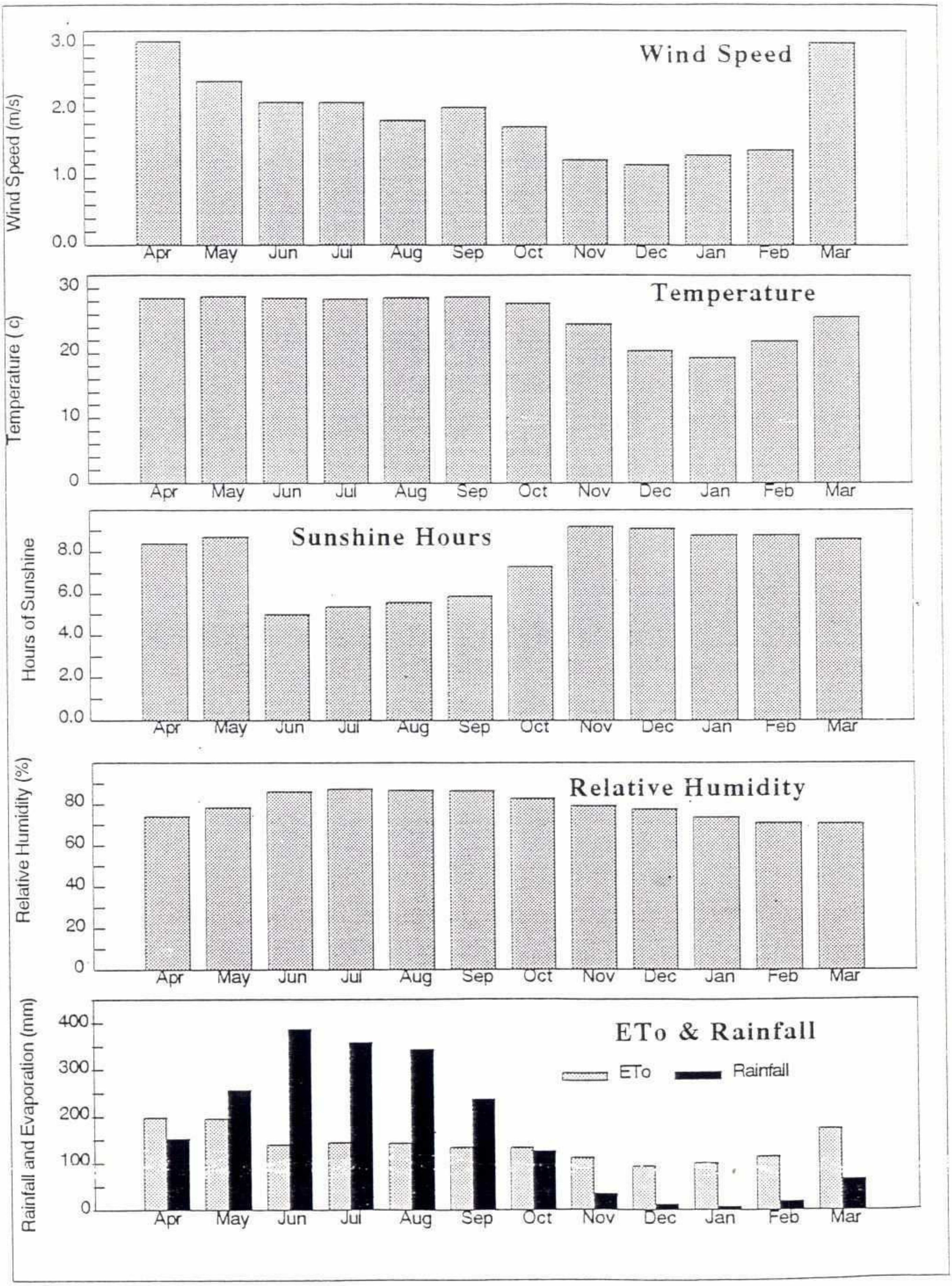


TABLE B.2.1

Climatic Norms at Comilla

Parameter	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Annual
Mean Temperature	27.9	28.3	28.2	28.1	28.1	28.3	27.3	24.4	20.2	19.0	21.6	25.6	25.6
Relative Humidity	76.1	80.1	85.3	87.1	86.4	84.3	80.9	76.4	72.4	69.6	66.8	69.7	77.9
Windspeed (m/s)	4.3	3.8	3.8	3.2	3.3	2.8	2.7	2.4	2.3	2.2	2.7	2.2	3.0
Sunshine (hrs/day)	8.4	8.7	5.0	5.4	5.6	5.9	7.3	9.2	9.1	8.8	8.8	8.6	7.6
Penman Eto (mm)	212	210	157	156	155	145	147	126	113	117	139	195	1872
Rainfall (mm)	192	325	416	455	368	261	174	59	38	10	29	60	2387

TABLE B.2.2

Climatic Norms at Chandpur

Parameter	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Annual
Mean Temperature	28.5	28.8	28.5	28.4	28.6	28.7	27.7	24.5	20.4	19.3	21.9	25.7	25.9
Relative Humidity	74.1	78.3	86.2	87.4	86.7	86.5	82.9	79.2	77.6	73.8	71.0	70.7	79.5
Windspeed (m/s)	3.0	2.5	2.1	2.1	1.9	2.1	1.8	1.3	1.2	1.3	1.4	3.0	2.0
Sunshine (hrs/day)	8.4	8.7	5.0	5.4	5.6	5.9	7.3	8.8	9.1	8.8	8.8	8.6	7.5
Penman Eto (mm)	198	196	140	145	143	134	134	97	94	100	115	174	1670
Rainfall (mm)	152	257	387	358	343	237	126	7	12	7	18	66	1970

TABLE B.2.3

Comparison of Potential Evapotranspiration at Comilla

Method	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Annual
Pan	146	150	100	107	90	98	92	79	62	67	94	134	1219
Karim & Akland	165	177	133	135	133	123	117	96	80	85	106	149	1499
Water Balance Study	178	173	135	143	136	134	140	117	92	96	110	155	1609
SERS	212	210	157	156	155	145	147	126	113	117	139	195	1872

TABLE B.2.4

Comparison of Potential Evapotranspiration at Brahmanbaria

Method	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Annual
Pan	108	110	89	79	83	89	97	81	66	61	68	107	1038
Manalo	139	136	91	101	106	105	99	73	57	67	76	115	1165

The peak rainfall months are June, July and August. During these three months, about 55-60% of the annual rainfall total can be expected.

B.2.3 Regional Rainfall

B.2.3.1 General

The locations of rain gauges in or close to the study area are shown in Figure B.2.3. The availability of daily data for these stations is summarised in Table B.2.5. With the exception of station nos. R-101, R-105, R-110, R-131 and R-132, all of which are to the north of the project area, the continuity of records is fairly good, and the length of the available records adequate to permit a reasonable level of reliability in most forms of statistical analysis. A total of 5 daily gauges have been used on the study. The data base created has a common record period of covering the 1962-1990 water years.

B.2.3.2 Data Reliability

Rainfall data quality was assessed as part of the SERS using both cross correlation analysis and double mass techniques. Stations R-357, R-365 and R-366 were found to have suspect data quality. Similar conclusions were drawn in the 1990 Feasibility Study (Ref. 2.5) with regard to stations R-351, R-357 and R-366.

The SERS concluded, as did the 1990 study, that station R-357 should not be used in any analysis. Annual rainfall at R-357 is about 30% higher than at other stations within 20 km of it. Station R-365 only contains 2 full years of data, some of it suspect, and Station R-366 includes obvious years of anomalous record, and without full investigation of station history, should not be included in analysis. The exclusion of these three stations is unfortunate as they should be representative of the south western part of the project area. The 1990 study also excluded station R-351 from analysis, as the annual totals at this station were lower than at neighbouring stations. They are, however, consistent with station R-367. There have been long gaps in the record at R-367 and rainfall is a lot lower that at R-103 which is nearby. At R-076, the annual rainfall totals are very much higher than at any surrounding stations, and the records are apparently anomalous.

The indications were therefore that stations R-076, R-357, R-365 and R-366 should be excluded from analysis. Double mass plots for R-076, R-357 and R-366 against a group of control stations are shown in Figures B.2.4 and 2.5. Apparent anomalies in the records are obvious. It was not worth carrying out the exercise for R-365 as there was an insufficient number of entire year station records for comparison. The remaining rain gauges of relevance to the study are R-103,R-351, R-367, R-362 and R-356. At R-366, the availability of data is poorer than at the other stations, with records from only 1968.

Figure B.2.3

General Map of Main Drainage System and Data Collection Stations

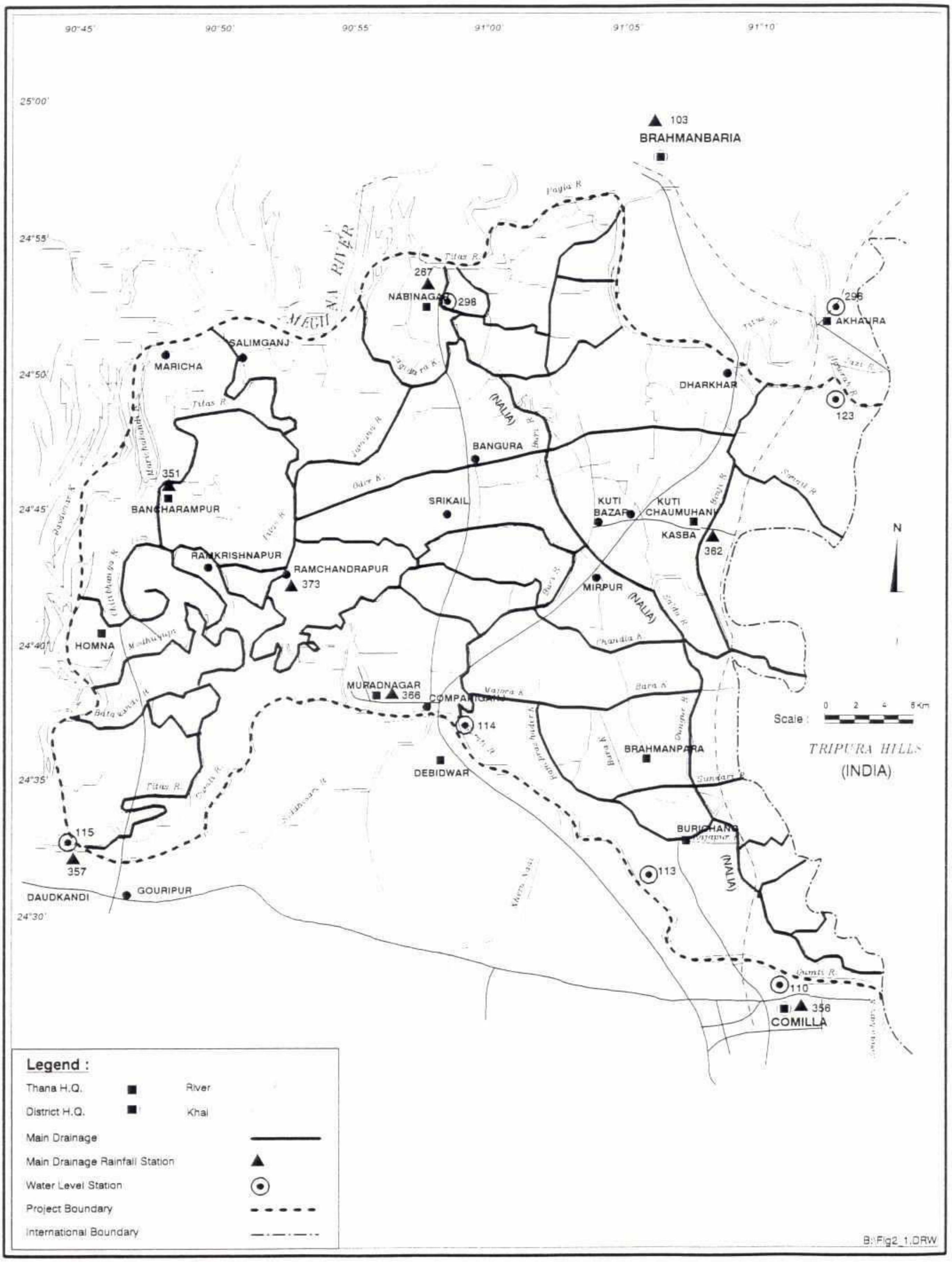


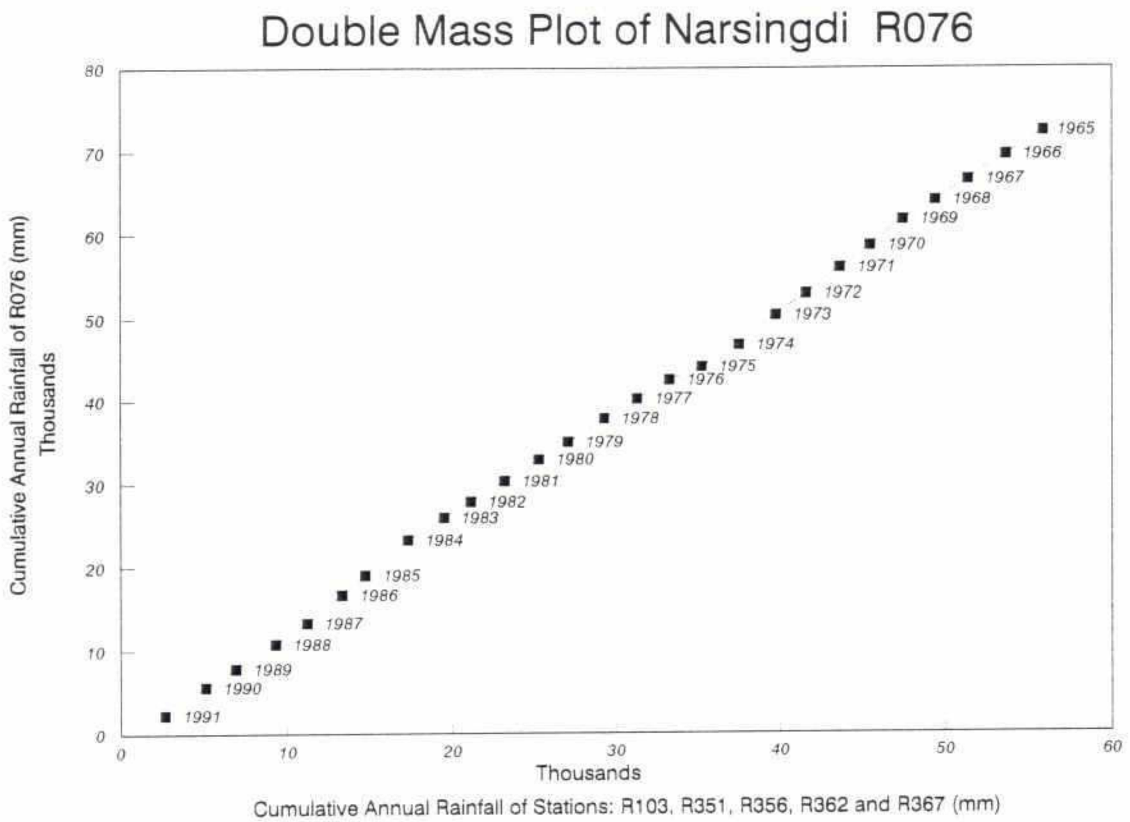
TABLE B.2.5

Daily Rainfall Data Availablily for Gumti Phase II

Station	Latitude		Longitude		Rainfall years: 59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91
R-076	23	57.3	90	42.0			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	░	░	■	■	■	■	■	■			
R-101	24	2.7	90	59.3				■	■	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	■	■	■	■	■	■	■		
R-103	23	58.7	97	7.0			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
R-105	24	7.9	91	29.1				■	■	■	■	■	■	■	░	░	░	░	░	░	░	░	░	░	░	░	░	░	■	■	■	■	■	■	■	■	■
R-110	24	22.0	91	25.5				■	■	■	■	■	■	■	░	░	░	░	░	░	░	░	░	░	░	░	░	░	■	■	■	■	■	■	■	■	■
R-111	24	8.1	91	23.0			■	■	■	■	■	■	■	■	■	■	■	?	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■
R-131	24	4.3	91	7.0			■	■	■	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	■	■	■	■	■	■	■		
R-132	24	11.8	91	12.0			■	■	■	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	■	■	■	■	■	■	■	■	
R-351	23	44.5	90	47.5			■	■	■	?	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
R-356	23	27.5	91	11.0				■	■	?	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
R-357	23	31.7	90	44.5				■	■	?	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■
R-362	23	45.4	91	8.9			■	■	■	?	■	■	■	■	■	■	?	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
R-365	23	33.1	90	32.2			■	?	■	?	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	░	░	■	■	■	■	■	■	■		
R-366	23	42.6	90	56.5				■	■	?	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
R-367	23	53.5	90	58.5			■	■	■	?	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	░	░	■	■	■	■	■	■	■	■	■

Legend: ? - availability uncertain ■ - full record ░ - incomplete record

Figure B.2.4
Double Mass Plots



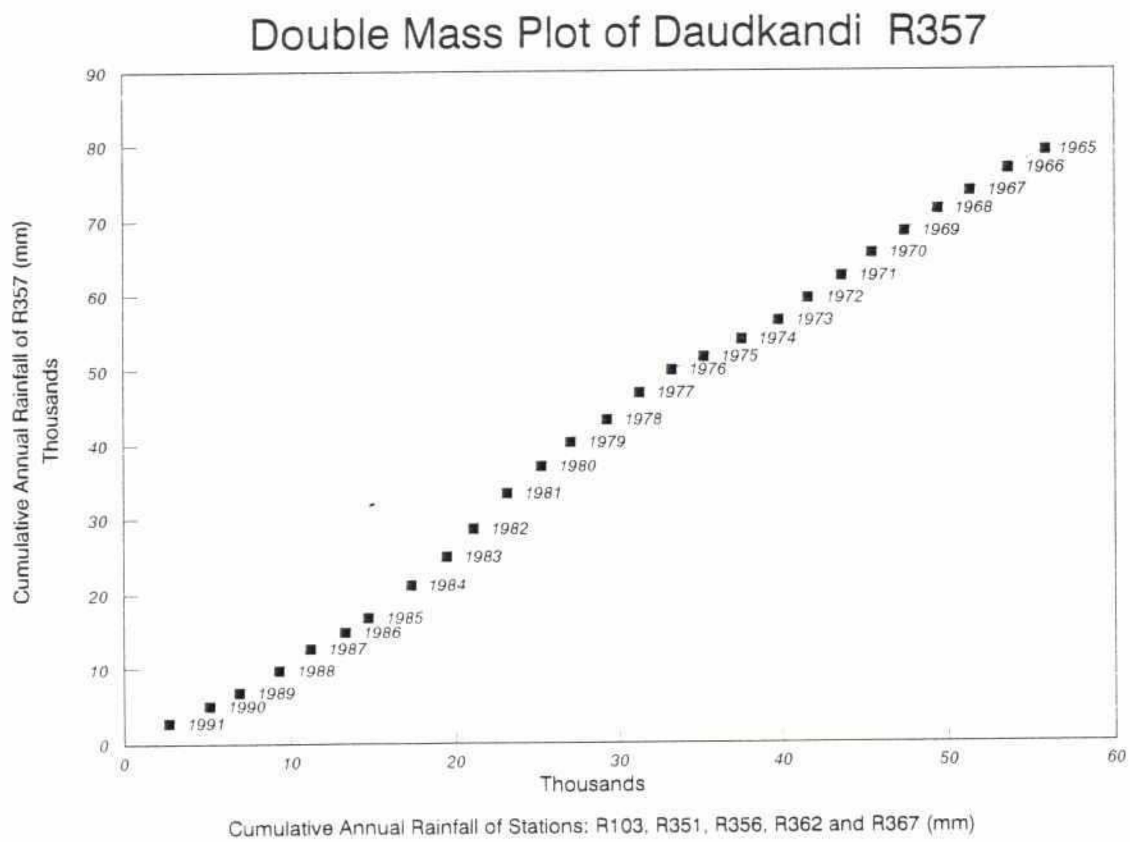
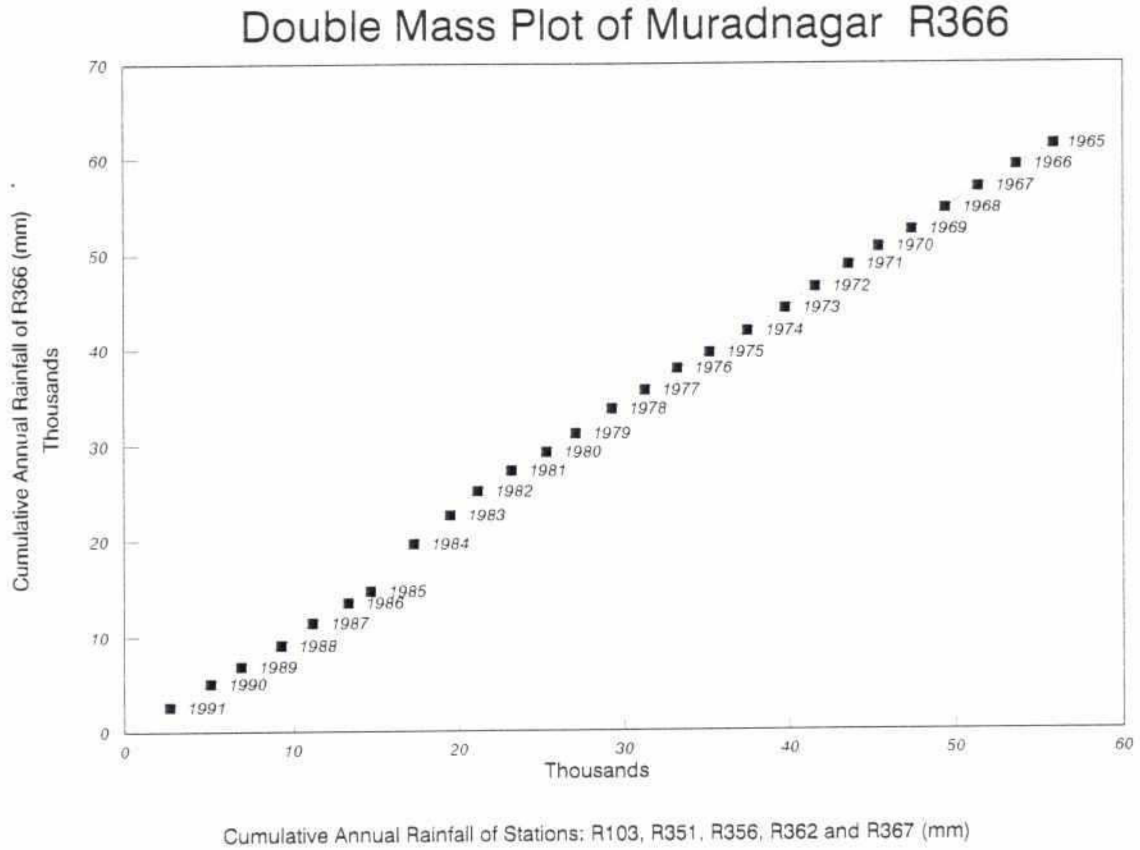


Figure B.2.5
Double Mass Plots



B.2.3.3 Time Series Analysis

Time series analysis has been carried out on the annual rainfall data for stations R-103 and R-356. The results of the analysis are presented in Table B.2.6.

There is evidence of weak persistence at station R-103, but no evidence of trend in either of the records. The data are, however, rather short for any conclusions to be drawn with regard to long term trends.

B.2.3.4 Annual Rainfall Distribution

Following the exclusion of stations to the southwest of the project area, it is rather difficult to prepare isohyets. It would appear that annual rainfall over the project area varies from about 2300 mm in the south to about 2100 mm at Brahmanbaria. At 80 % exceedance probability, annual rainfall drops to about 2000 mm at Comilla, and to about 1700 mm at Brahmanbaria. Ten day rainfall at each of the relevant stations are included in Appendix B.I.

B.2.4 Decad Rainfalls at 80% Exceedance

Decad rainfalls at 80 per cent exceedance probability have been evaluated for each of the relevant stations and are presented in Table B.2.7. Distributions have not been fitted to the data. The tabulated values are simply interpolated between ranks to give the chosen exceedance probability. There are therefore occasional large jumps between values in adjacent decads in the wet season. A common data period between 1965 and 1989 has been used in the analysis, excluding 1971.

It is clear from Table B.2.7 that there is no effective rainfall for agriculture in the project area between mid October and the end of April. Supplemental irrigation will often be required even into May.

B.2.5 Drainage Design Rainfalls

Frequency analyses have been carried out on the records of each of the rain gauges of relevance to the project. The objective has been to provided the basic data for drainage design purposes. EV1 (Gumbel) distributions have been fitted to the annual maximum series rainfalls of the following durations:

- 1 day;
- 2 day;
- 3 day;
- 4 day;
- 5 day;
- 7 day;
- 10 day.

2⁰

TABLE B.2.6

Statistical Tests on Annual Rainfall

Statistical Test	R-103 Expected	R-103 Observed	R-356 Expected	R-356 Observed
Randomness				
Median Crosses	11 +/- 6	14	10 +/- 6	9
Turning Points	14 +/- 3	12	11 +/- 3	10
Persistence				
First Order Serial Correlation	-0.05+/-0.44	-0.43	-0.05+/-0.44	-0.08
Spearman Rank	-0.05+/-0.44	-0.92	-0.06+/-0.47	-0.67
Trend				
Rank Order	-0.05+/-0.41	-0.35	-0.05+/-0.43	-0.41
Mann-Whitney U Test	66 +/- 32	53	55+/-28	51
Wald-Wolfowitz Runs Test	12 +/- 5	15	11+/-4	15

The seasonality of rainfall extremes is also important and forms part of the drainage design process. This is to account for the different stages of crop growth that are likely at different times of the year, as well as the influence different drainage conditions in terms of main river levels and outfall controls. In accordance with practice in Bangladesh, rainfall extremes have been evaluated at each of the above durations for the following periods:

- pre-monsoon (April to June inclusive);
- mid-monsoon (July and August);
- post-monsoon(September and October).

The results of the analysis are summarised in Table B.2.8, and are included in full in Appendix B.II.

The analysis has been based on common record periods between 1965 and 1989, and with the exception of R-362, at which data were not available for 1990, the results are generally consistent. Extremes in the north of the project area may be expected to be higher than in the south of the project area.

TABLE B.2.8

Annual Maximum Rainfalls (mm)

Duration	1 Day			3 Day			5 Day		
Return Period	2	5	10	2	5	10	2	5	10
Station									
R-103	155	193	218	252	324	372	314	405	465
R-351	128	175	207	215	306	366	271	375	443
R-356	125	165	192	213	270	308	267	331	374
R-362	124	167	195	214	281	326	267	342	392
R-367	125	171	202	208	312	382	259	366	437

TABLE B.2.7

Precipitation Equalled or Exceeded in 80% Years

Station	Apr			May			Jun			Jul			Aug			Sep			Oct			Nov			Dec			Jan			Feb			Mar			80% ANN	ANN MEAN
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3		
R−103	0	10	19	14	52	31	55	96	17	39	52	51	34	34	45	27	31	15	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1884	2165
R−351	0	6	6	10	14	13	15	48	31	18	31	31	28	24	30	29	24	7	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1289	1754
R−356	0	15	21	17	20	29	51	67	67	55	39	71	38	43	70	47	33	15	16	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2067	2349
R−362	0	7	3	24	31	34	40	41	29	30	54	28	15	23	32	23	31	14	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1696	1994
R−367	0	2	22	0	48	29	19	56	55	37	35	49	31	17	57	41	42	8	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1772	2243

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2d

B.2.6 NAM Model of the South East Region

B.2.6.1 Introduction

The NAM hydrological model allows runoff (discharge) to be estimated from a knowledge of rainfall, evaporation and groundwater abstraction.

It is required to provide discharge hydrographs for input into the hydrodynamic model, MIKE11. NAM is used to generate lateral inflows along different reaches of the main rivers, runoff in the flood storage areas and discharge hydrographs at discharge boundaries in the hydrodynamic model where discharge observations are not available.

NAM input is most important in areas where the flood regime depends on the river flows, rather than being as a result of backwater effects from the main rivers.

Set-up, calibration and verification of the NAM model was carried out by the SWMC (Ref. 5.1).

B.2.6.2 Model Set-up

For the purposes of the NAM modelling the South East Region was divided into 24 catchments. The catchment boundaries are delineated on what may be loosely considered watersheds, along natural topographic features or artificial embankments. At least one rainfall station and one groundwater observation well with a continuous record were available for each sub-catchment.

B.2.6.3 Model data

Rainfall data

A total of 24 rainfall stations were used in the NAM modelling. A Thiessen polygon was constructed connecting all the rainfall stations in the region with the weightage of each station being used to compute the mean areal rainfall. Missing data are covered by increasing the weightage of the neighbouring stations.

Evaporation data

Evaporation data is only available at the Brahmanbaria climatological station. This is in fact pan evaporation with a pan coefficient of 0.7. The Brahmanbaria station was assumed to be representative of the entire region.

Groundwater abstractions

There is no direct reliable data available on groundwater abstractions. The estimated abstractions were based on an estimate of the number of tubewells on a thana basis and a assumed average abstraction rate per working day.

B.2.6.4 Model Calibration

Model calibration was carried out over the hydrological years 1986, 1987 and 1988. The parameter values in the model were changed until a good match was achieved between the simulated and observed groundwater level hydrographs. There are no discharge gauging stations in the region against which the runoff estimates from NAM can be calibrated.

Details of the calibration results and an assessment of the calibration can be found in the South East Region Model Verification Report 1990 which was produced by the SWMC in November 1991 (Ref. 5.1).

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B.2.6.5 Verification

The model was verified from April 1989 to March 1991. The verification was good in areas where the water level fluctuations were accurately recorded.

B.2.6.6 25 year NAM simulation

In order to provide discharges for the 25 year hydrodynamic model simulations a 25 year NAM simulation is required. This simulation was carried out for the period 1965 to 1989.

Missing rainfall data was infilled by using the 'Normal Ratio' method. Data quality was initially checked by serial correlation of monthly values among the surrounding stations. Where the correlation was poor stations were checked by the Double Mass Method. Inconsistent data was made consistent and reviewed.

Since the annual variation in evaporation is small the same set of evaporation data was used for each year of NAM calculation.

For the purposes of the 25 year NAM simulation the most recent estimate of groundwater abstraction rate was used for each year of NAM calculation.

The NAM 25 year simulation was run for the period 1965 to 1989 in two blocks, the first consisting of 15 years and the second 10 years.

B.3 Drainage Conditions

B.3.1 Introduction

A general map of the drainage system in the project area is presented in the previous chapter in Figure B.2.3. The entire region is bounded to the west by the River Meghna, and it is this that dominates drainage of the greater part of the region. The mean annual flow at Bhairab Bazar is of the order of 4600 m^3/s, but seasonally the discharge varies between a mean monthly minimum of 260 m^3/s in February and a mean monthly maximum of 12,400 m^3/s in August. The Meghna is joined by the Padma about 100 km downstream of Bhairab Bazar. The Padma carries the combined discharges of the Ganges and Jamuna (Brahmaputra) Rivers. The mean annual runoff in the Padma is of the order of 30,000 m^3/s, and on average varies between 75,000 m^3/s in August and 6000 m^3/s in February. There are backwater influences in the Meghna upstream of its confluence with the Padma, and the project area is thus affected by the major river systems. The coincidence of seasonal rainfall with peak flood discharges in the Meghna does, however, exacerbate internal drainage problems. Figure B.3.1 shows hydrographs of mean monthly discharges in the Padma and Meghna Rivers, along with mean monthly rainfalls over the project area. The basic parameters of the internal drainage problem of the region, are the same as those for the country as a whole.

The Meghna is the outfall water level control on drainage for the entire project area. The seasonal range in Meghna water levels reduces in a southerly direction towards the Bay of Bengal. Seasonal water surface profiles between Bhairab Bazar and Satnal are shown in Figure B.3.2. The profiles shown are for 1981, but the chosen year is of no significance. At Bhairab Bazar, the seasonal range of water levels is of the order of three metres, and there is very little tidal influence in the dry season. At Satnal the seasonal range in water levels is of the order of 2.5 m, and the dry season tidal range of the order of 300 mm. There is a notable change in water surface slope in the Meghna between wet and dry seasons.

General topography of the project area is indicated in Figure B.3.3. Comparison with Figure B.3.2 gives an indication of the areas most susceptible to flooding, particularly close to the Meghna. Figure B.3.3 is at a macro level and is included only to help illustrate the general problems.

There are areas of relatively deep flooding in the project area close to the Meghna. Drainage in these areas is complex, with a series of interconnected channels and remnants of former main river courses. It is difficult to identify any singularly important main rivers, other than perhaps the Hawrah which flows into the Buri and Titas Rivers, and the Salda River. Some of the channels in the area had formerly been fed by spills from the Gumti River, prior to completion of embankments and the construction of a regulator at the head of the Buri Nadi River. The area does receive inflows from a number of rivers draining the western slopes of the Tripura Hills. These catchments and their areas are given in Table B.3.1. These are referred to as external catchments.

The area in Bangladesh between the Bhairab to Comilla railway and the Gumti River is about 1400 km^2. Thus about 50% of the drainage through the project area is generated in external catchments. Flash floods in these rivers can cause serious damage.

Figure B.3.1
Relationship Between Crops, Rainfall and Floods

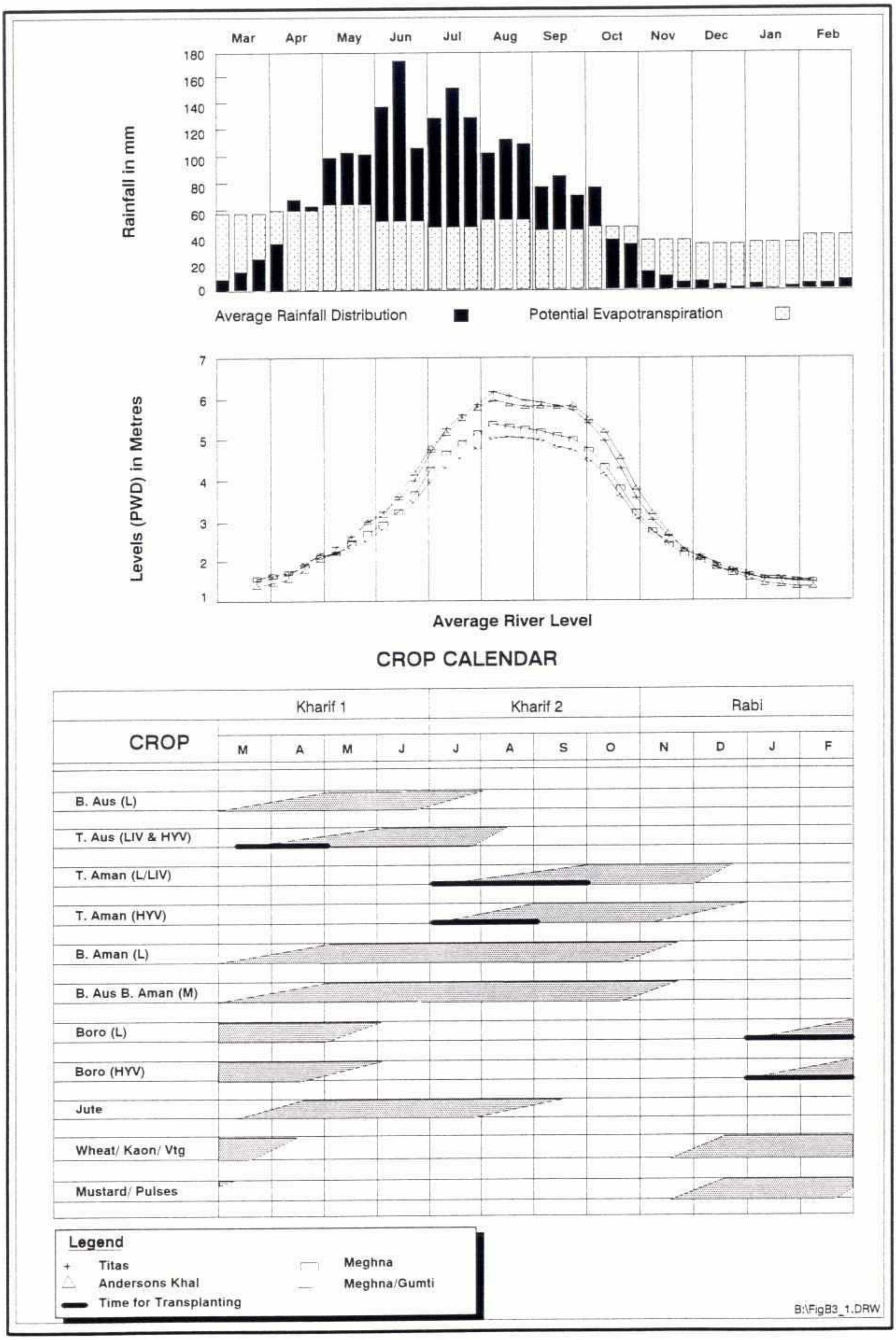

Figure B.3.2
Meghna Water Surface Profiles

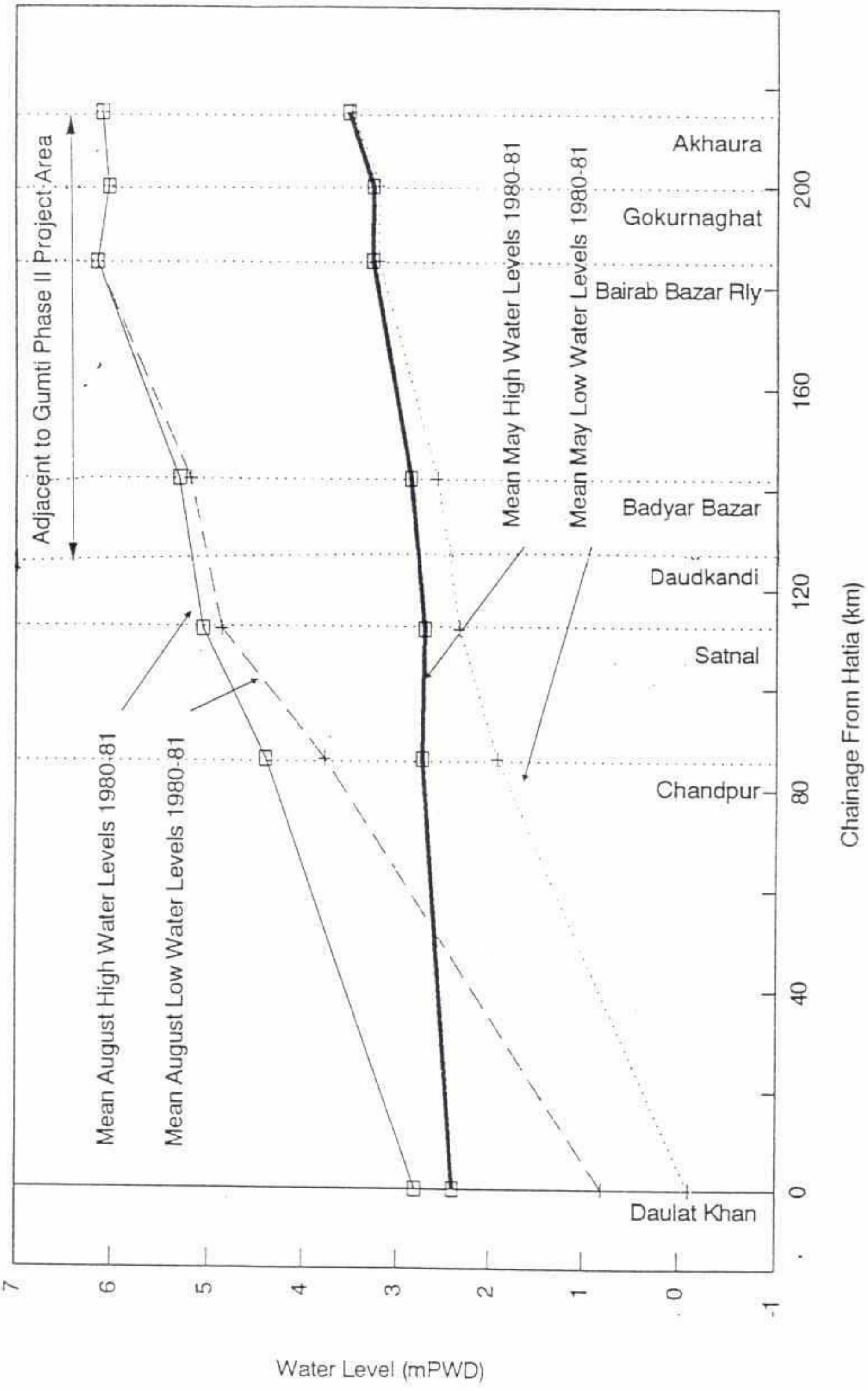

Figure B.3.3
Contour Map

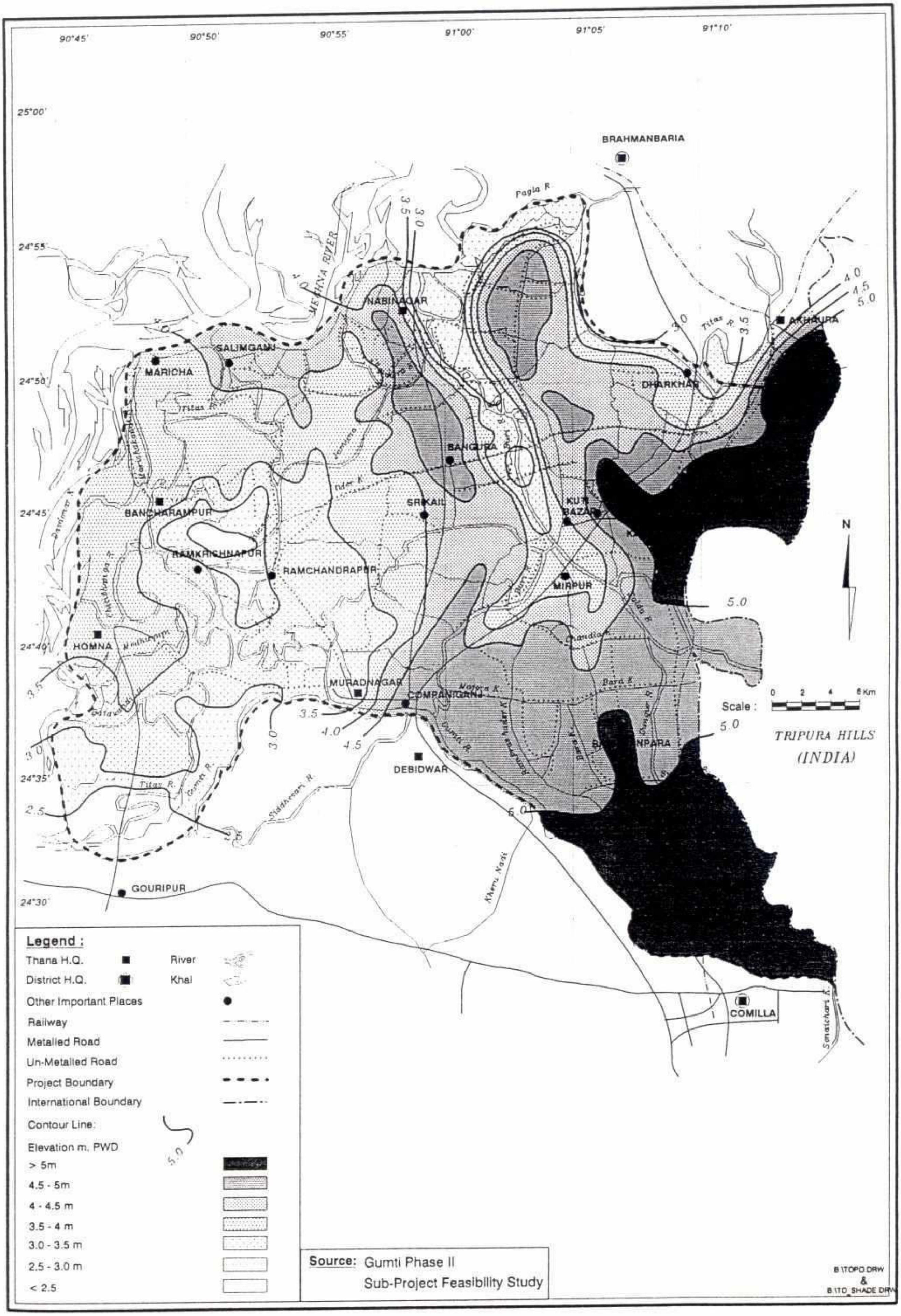

TABLE B.3.1

External Catchments North of the Gumti River

Catchment	Area (km^2)
Pagli	73
Ghungur	60
Salda	447
Sonai	176
Hawrah	496
Total	1252

The Gumti River forms the southern boundary of the project area. It is embanked through most of its length in Bangladesh. It can contribute to flooding in the south western part of the project area. At Comilla the Gumti has a catchment area of 1950 km^2. The Gumti is embanked from upstream of Comilla, almost to its confluence with the Meghna. The annual maximum mean daily flood in the Meghna at Comilla is 500 m^3/s. During times of flood, water levels in the Gumti are significantly higher than the surrounding land. Historically, the Gumti did spill through the project area through the Buri Nadi River. This is now controlled with a gated inlet from the Gumti.

B.3.2 The Present Flood Problems

B.3.2.1 Seasonal Flood Characteristics

Much of the land in the project area is regularly flooded. On the basis of the MPO flood phase classification system, only 15% of the area is flood free. The timing, rate of rise, and duration of flooding are, in addition to the flood peak attained, very important factors influencing agricultural damages and cropping patterns, fisheries, and indeed the general disruption caused. Seasonality of flooding is therefore a key variable.

In terms of seasonality, the flood problems are:

pre-monsoon : April-June	rapid rise in water level before boro crops are harvested, and kharif I crops planted; loss of young crops and seedlings;
monsoon : July-August	the rate of rise of flood levels exceeding the rate of growth of rice; peak main river levels and prolonged flooding partly through backing up from the main rivers and reduced gradients for local rainfall; duration of flood inundation is important, and whether flood water is clear or sediment laden;
post-monsoon :Sept.-Oct.	drainage at too slow a rate to permit timely planting of certain crops;

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In addition to the above flood periods, the general categories under which flooding in the region can be considered are:

- monsoon floods from the River Meghna and Lower Meghna;
- flash floods from those rivers rising in the Tripura Hills to the east of the region;
- localised flooding as a result of heavy and intense rainfall.

The project area is well defined from a flood characteristics point of view, being bounded by the River Titas in the north, the Gumti River in the south, and the Meghna in the west. The areas close to the Meghna are particularly susceptible to deep flooding. During the monsoon season, the Meghna dominates flood extent in the area. In the northern part of the area there is very little west to east gradient, as indicated in Figure B.3.2. From the elevation area characteristics published for MPO planning areas 29 and 31, and water level records, it is apparent that the Meghna is the primary source of prolonged monsoon flooding.

The nature of the drainage system through the project area is such that its evaluation required the application of computational hydraulic modelling techniques. These are discussed in Chapter B.4.

B.3.3 Data Availability

B.3.3.1 General

The locations of water level and discharge measurement stations in or close to the project area are given in Figure B.2.3. Data availability for these, and for the main river stations is summarised in Table B.3.2. A considerable volume of additional hydrometric field data was collected for the project as part of the Surface Water Simulation Modelling Project (SWSMP). No additional hydrometric field data were collected as part of this investigation.

B.3.3.2 Discharge Measurement

There are very few relevant discharge measurement stations in the region. Only the Gumti, Buri Nadi and Hawrah Rivers are gauged. Flows into the Buri Nadi area controlled and the records at Jibanpur are thus of limited value. The station at Bhairab Bazar (273) on the Meghna is a strategic station in the national hydrometric network, but other than assisting in defining boundary flow conditions in the Meghna, gives little insight to conditions within the region itself. The station at Ganga Sagar Railway Bridge (123) is affected by backwater from the Meghna, and has no stable rating. At Brahmanbaria Railway Bridge (3A), flow measurement has now been abandoned.

A short term station was established by the Surface Water Modelling Centre (SWMC) on the Salda River at the Salda railway bridge.and this is also affected by backwater from the Meghna. There are two requirements of discharge measurement data for the present study. One is for the synthesis of inflows to the hydrodynamic model of the project area, and the other for the evaluation of design floods for cross drainage structures close to the Tripura Hills. These aspects are discussed in more detail in section B.3.4.4.

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B.3.3.3 Water Level Data

The locations of water level recording stations in or close to the project area are indicated in Figure B.2.3. The availability of data is summarised in Table B.3.2. It is generally the case that digital records of daily water levels exist only for the post 1983 data. As part of the South East Regional Study (SERS), digital records were extended with maximum 10 day water levels between the months of April and October. These data are of some value in preliminary assessments of the nature of the flood problem in the area, but are of no value in assessing post development conditions. The data are also of importance in defining some of the boundary conditions for the hydrodynamic modelling.

A number of additional water level recording stations were set up by the SWMC in 1986 to permit hydrodynamic model calibration. The records at these stations are too short to permit their use in any frequency analysis.

B.3.3.4 Sediment Data

Sediment deposition from rivers rising in the Tripura Hills is a problem in several areas, as is deposition close to the Meghna. There are, however, very few sediment data available for either the project area or the South East Region. There is no routine sediment or water quality sampling at any location in the region. Some data have been collected by the SWMC, on the Gumti at Comilla and on the Buri Nadi at Jibanpur. Sediment data were also collected as part of the "Hydrological and Morphological Studies of the Gumti-Titas and Atrai Basins" (Ref. 3.1). Sampling points included the River Gumti at Comilla and the River Hawrah at Ganga Sagar. Data are available for one complete wet season, and their use on the present study is discussed in section B.3.5.

TABLE B.3.2

Average Daily Water Level Availability for Gumti Phase II

No.	Station Name		59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
3A	Brahmanbaria Rly bridge	T																									■	■	■	■	■		■	■
110	Comilla		■	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
113	Kangsanagar			■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
114	Jibanpur (Gumpti)																				■	■	■	■	■	■	■	■	■	■	■	■		
115	Daudkandi	T						■	■	■	■	■	■	■	▒	■	■	■	■	■	■	■			■		■	■	■	■	■	■		
123	Ganga Sagar Rly Bridge								■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
230	Bhairab Bazar Rly Bridge	T						▒	■	■	■	■	■	■		■	■	■	■	■		■	■	■	▒	■								
273	Bhairab Bazar	T						■	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
274	Narsingdi	T																			■	■	■	■	■	■	■	■	■	■	■	■	■	
275	Baidyer Bazar	T	▒	■	■							■	■	■	■	■	■	■	■	■	■				■	■	■	■	■	■	■	■	■	
296	Akhaura	T	▒	■	■	■	■					■	■	■		■	■	■	■	■	■					■	■	■	■	■	■	■	■	
297	Gokorna Ghat	T																			■				■	■	■	■	■	■	■	■	■	
298	Nabinagar	T	■	■	■	■	■					■	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	

Legend: ■ - full record ▒ - incomplete record

Mean Daily Discharge Availabilty for Gumti Phase II Area

No.	Station Name		59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91
110	Comilla								■	■	■	■	■	■	▒	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
114	Jibanpur (Gumpti)								■	■	■	■	■	■	▒	■	■	■	■	■	■	■	■	■	■	▒	■	■	■	■	■	■	■		
123	Ganga Sagar Rly Bridge																		■		▒	▒	▒	■	■	■	■	■	■	■	■	■	■	■	
273	Bhairab Bazar	T						▒	■	■	■	■	■	■		■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	■	■	■	■	▒			

B:\Tab3.2.wk1

B.3.4 Analysis of Available Data

B.3.4.1 General

The analysis of flood conditions within the project area has been largely based on computational hydraulic modelling, in view of the complexities of the system. The extent of more traditional forms of analysis in flood hydrology, has therefore been at a fairly general level, and is discussed in the following sections.

Analyses have been made of all primary streamflow and water level data relevant to the project area. The focus has been on water level data, which is most widely available and which for the flood alleviation aspects of the project, is perhaps of most relevance.

B.3.4.2 Analysis of Water Levels

A series of concurrent hydrograph plots have been prepared of water levels at Brahmanbaria (3A), Akhaura(296), Gangasagar (123), and the Meghna at Bhairab Bazar. These are presented in Figure B.3.4 for the 1964 to 1969 period. At Brahmanbaria and Akhaura, there is very little difference in water levels, even in the dry season, and the hydrographs follow very closely that of the Meghna. At Gangasagar, there is no control from the Meghna in the dry season. It is only when Meghna levels exceed about 4 m, that it begins to influence water levels at Gangasagar. It is clear from Figure B.3.4 that any wet season stage discharge rating for the Gangasagar will be very difficult.

An assessment of water level frequencies has been made at a number of relevant stations in the project area. Analysis carried out on the SERS showed that application of Extreme Value Type I distributions provided good fits to the main station data on the Meghna, and this distribution was therefore used throughout. The fitted distributions to the series of annual maximum daily water levels at Chandpur, Satnal and at Baidyer Bazar, are shown in Figures B.3.5 to B.3.7. The EV1 distribution apparently fits the data well and it has been considered appropriate to adopt this. Tabulated values of estimated water levels at these locations are presented in Table B.3.3. It is of particular interest to note the range of variability in levels at different locations. At Chandpur, the 50 year flood level is only 0.61 m above the 2 year flood level, while at Baidyer Bazar, the 50 year flood level is 1.18 m above the 2 year flood level. It should be noted that the above analyses have not been based on a standardised record length.

Frequency analyses has been carried out on all available records of 10 day water levels in and around the project area. For the period April to October, frequency distributions have been fitted to each 10 day period, resulting in a series of independent seasonal water level frequency estimates. The historical 10 day water levels at each of the stations of interest are included in Appendix B.III. A sample of the results from the analysis is presented in Table B.3.4. Full results for each station of relevance to the project area are included in Appendix B.IV. The results for selected stations are presented in graphical form in Figures B.3.8 and B.3.9. It should be noted that the results do not represent homogeneous series, and are in fact envelopes. The analysis provides a preliminary basis for the evaluation of embankment design for both full polder and submersible embankments.

Figure B.3.4

Water Levels between 1964 and 1968

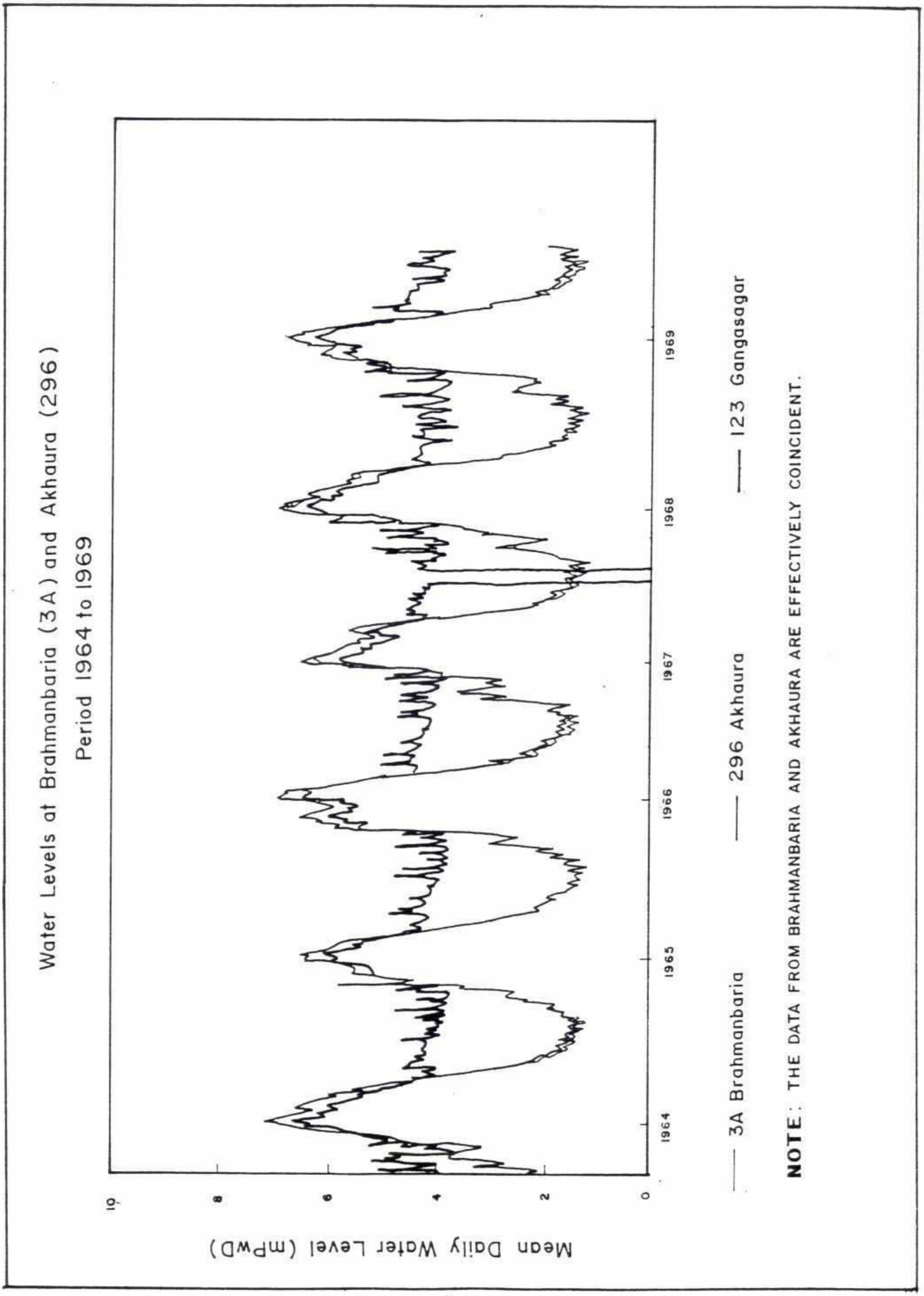

Figure B.3.5

Annual Maximum Water Level Frequencies at Chandpur

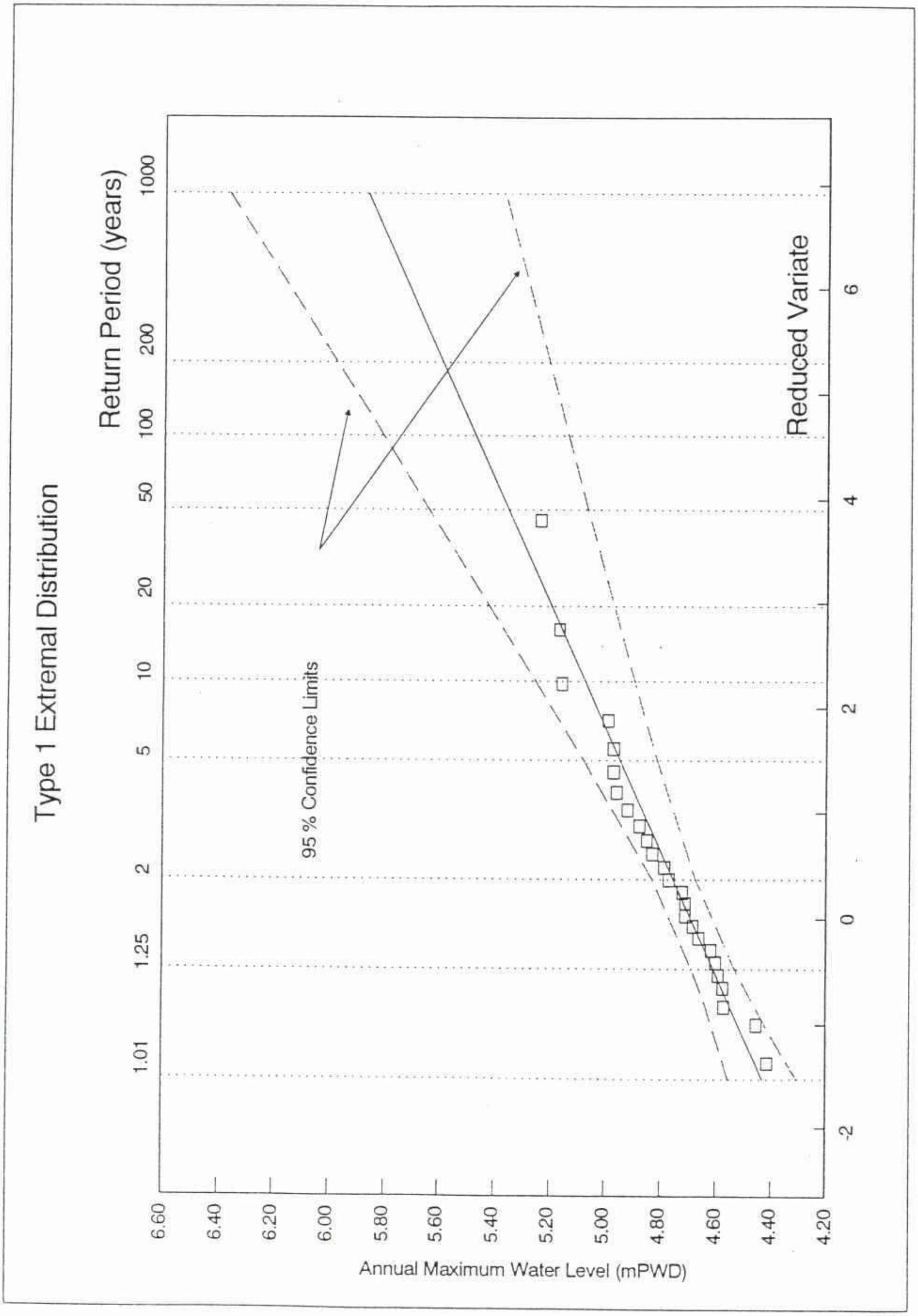

Figure B.3.6

Annual Maximum Water Level Frequencies at Satnal

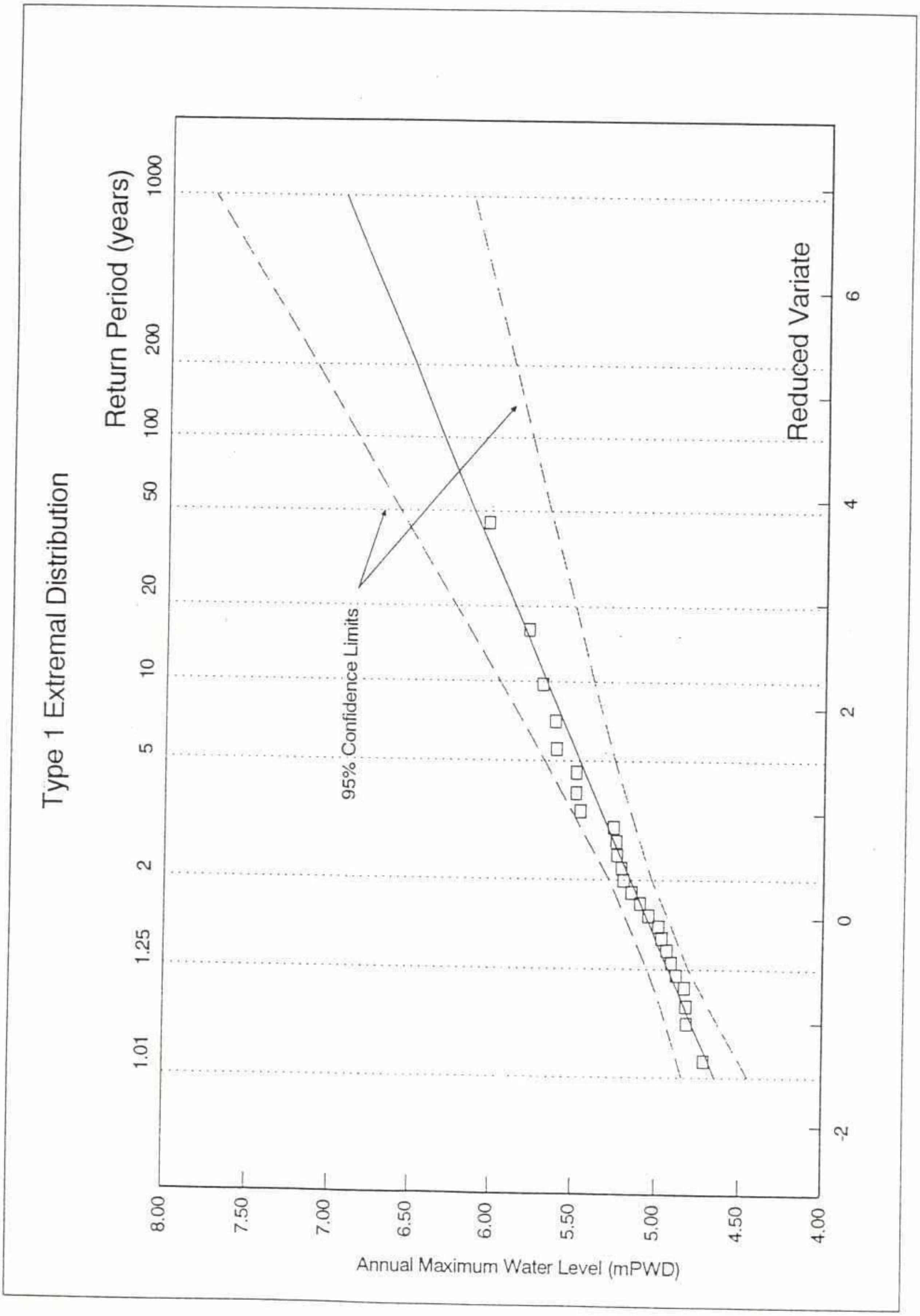

Figure B.3.7

Annual Maximum Water Level Frequencies at Baidyer Bazar

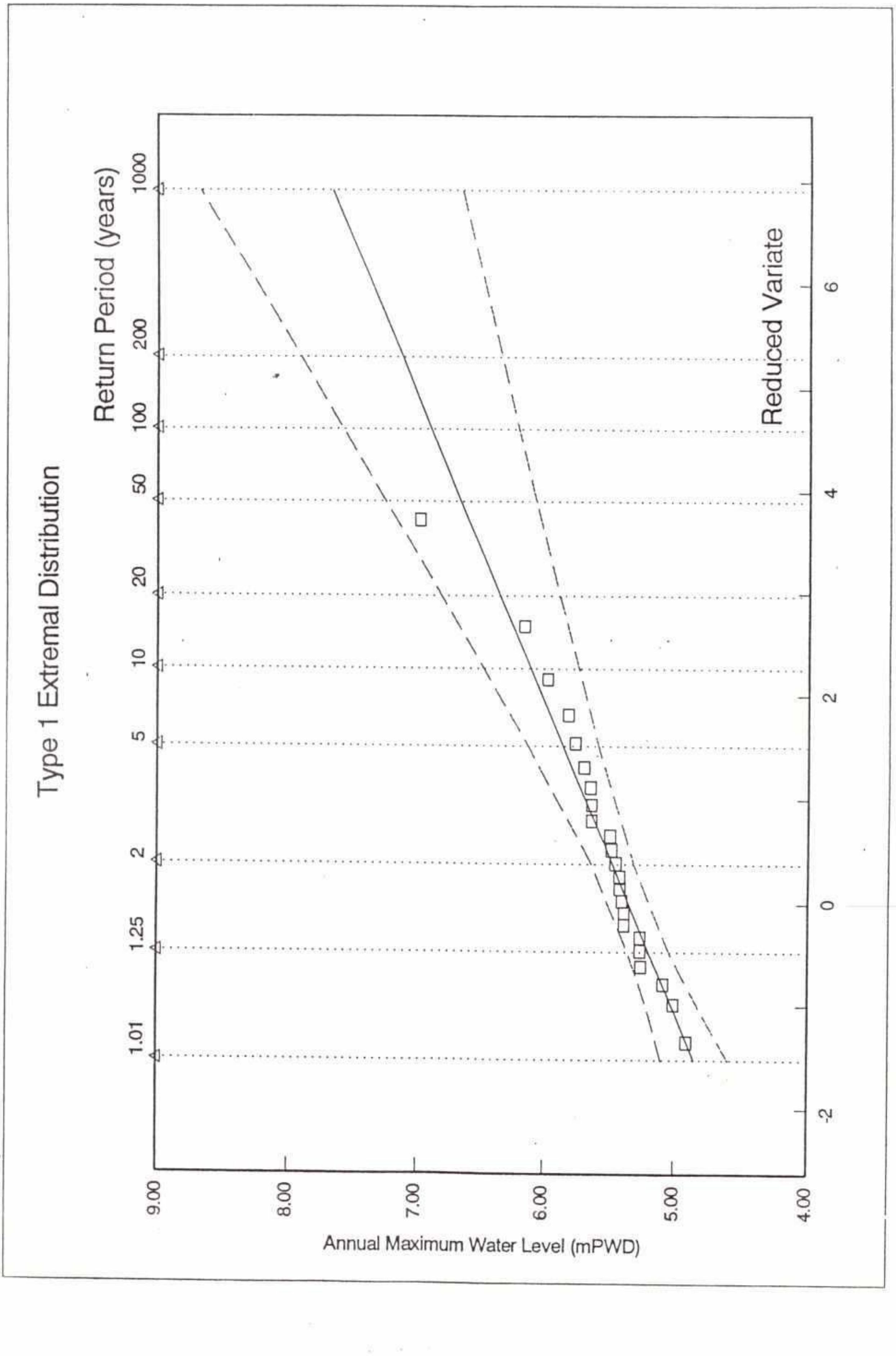

TABLE B.3.3

Annual Maximum Water Levels (mPWD)

Return Period (years)	Chandpur	Satnal	Baidyer Bazar
1.01	4.42	5.64	4.82
1.25	4.61	4.94	5.21
2	4.78	5.18	5.49
5	4.96	5.47	5.83
10	5.1	5.7	6.12
20	5.22	5.88	6.32
50	5.39	6.13	6.67

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TABLE B.3.4

Seasonal Water level Frequencies at Station T-3A

T-3A, Brahmanbaria Railway Bridge; Maximum 10 day levels, Apr. -Oct

Return Period (years)	April			May			June			July			August			September			October			Annual
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
1.11	1.53	1.87	2.09	2.21	2.51	2.55	2.94	3.61	4.27	4.78	5.30	5.65	5.91	5.92	5.73	5.57	5.45	5.43	5.26	4.79	4.16	5.76
1.25	1.62	1.97	2.19	2.37	2.69	2.76	3.13	3.81	4.46	4.99	5.48	5.81	6.04	6.04	5.88	5.73	5.62	5.58	5.39	4.93	4.33	5.95
2	1.82	2.20	2.42	2.75	3.10	3.26	3.59	4.28	4.91	5.49	5.91	6.19	6.36	6.34	6.23	6.10	6.03	5.93	5.69	5.28	4.74	6.39
5	2.09	2.50	2.74	3.27	3.65	3.92	4.21	4.91	5.51	6.16	6.18	6.70	6.80	6.74	6.70	6.60	6.57	6.41	6.10	5.75	5.29	6.99
10	2.27	2.71	2.94	3.60	4.05	4.36	4.63	5.33	5.91	6.60	6.86	7.04	7.08	7.01	7.01	6.94	6.92	6.72	6.37	6.06	5.66	7.39
20	2.44	2.90	3.14	3.93	4.37	4.78	5.02	5.73	6.29	7.03	7.22	7.37	7.36	7.27	7.31	7.26	7.27	7.02	6.63	6.36	6.01	7.77
50	2.66	3.16	3.40	4.35	4.82	5.33	5.53	6.25	6.78	7.58	7.69	7.79	7.72	7.60	7.69	7.67	7.71	7.41	6.97	6.74	6.46	8.26

Figure B.3.8

Annual Maximum Water levels at Jibanpur

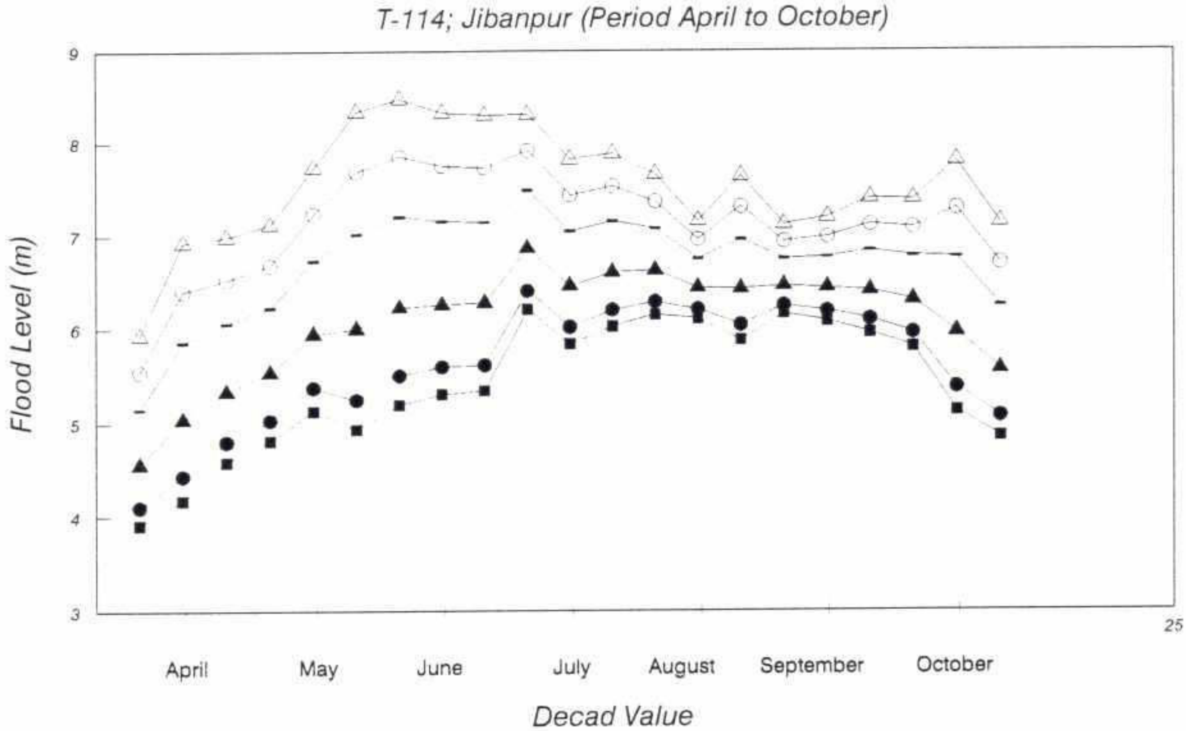
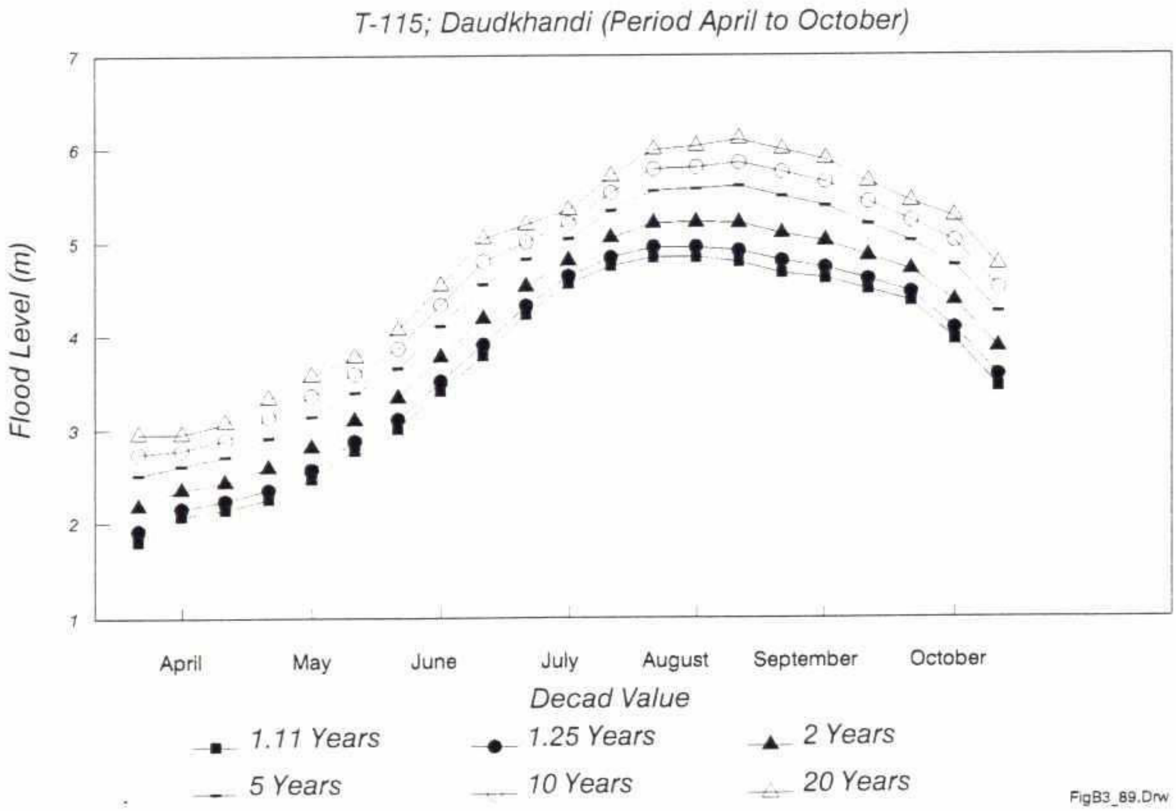


Figure B.3.9

Annual Maximum Water Levels at Daudkandi



In conjunction with local topographic data it also gives an indication of flood risk on different land types. The seasonal presentation of results permits flood levels to be related directly to cropping conditions. It should be noted that there are variable amounts of missing data at of the stations analysed (Appendix B.III), and that derivation of a consistent period of record at each station would have resulted in too short a period for analysis. The record lengths on which the analysis has been based are thus variable. The analysis was, however, for preliminary planning only, and as a precursor to hydrodynamic modelling which has formed the basis of all project evaluation and outline design.

It was also considered important to prepare flood level frequency duration tables, from which an indication of the duration of inundation to certain flood depths could be obtained. The results of the analysis could also be related to elevation area characteristics for different parts of the region in order to give preliminary indications of flood depth area frequency relationships. Flood level frequency duration tables have been prepared for each of the water level stations in the area. The full results of the analysis are presented Appendix B.V. Table B.3.5 presents the typical results output format. A summary of the results for selected flood durations and return periods is presented in Table B.3.6, and serves to give an indication of variability across the Region.

Frequency analyses based on historic water levels are of value in identifying appropriate design events, or preliminary outline design criteria. The statistical analysis of the historic record cannot however, be used as any form of predictor for flood levels that might be expected under future embanked river or polder conditions. The evaluation of such situations requires the use of hydrodynamic modelling techniques. These are discussed in Chapter B.4.

TABLE B.3.5

Flood Level Frequency Duration at Station T-3A

T-3A, Brahmanbaria Railway Bridge; Maximum 10 day levels, Apr. - Oct.

Duration			Return	Period	(Years)		
Days	1.11	1.25	2	5	10	20	50
20	5.88	6.02	6.36	6.82	7.12	7.41	7.79
30	5.80	5.92	6.19	6.56	6.81	7.04	7.35
40	5.68	5.78	6.01	6.32	6.53	6.72	6.98
50	5.58	5.69	5.93	6.27	6.49	6.70	6.98
60	5.49	5.60	5.87	6.22	6.45	6.68	6.97
30	5.28	5.39	5.65	6.01	6.24	6.47	6.76
100	4.92	5.03	5.29	5.64	5.87	6.09	6.37
120	3.98	4.15	4.53	5.05	5.40	5.73	6.15
150	2.54	2.74	3.20	3.82	4.23	4.62	5.13

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B.3.4.3 Analysis of Discharge Data

The analysis of discharge data has effectively been limited to that of the River Gumti at Comilla, for reasons of data availability and quality. For the purposes of this study, the main objective of analysing the Gumti record has been to gain some understanding of the likely flood response of those rivers draining from the Tripura Hills into the project area. In terms of the developable water resources in these rivers, the findings of the National Water Plan have been that all dry season inflows from these rivers are fully utilised at present. There has in fact been a slight increase in dry season flow availability in the Gumti in recent years, but this is related to the phasing of development works upstream, and is unlikely to continue.

The Gumti records at Comilla have been tested for trend and persistence. Both mean annual runoff and annual maximum flood discharges have been evaluated. The results of the statistical tests are presented in Table B.3.7, and the data presented in Figure B.3.10. There is no evidence of persistence or trend in either the mean annual runoffs or annual maximum flood discharges in the Gumti. The situation with regard to mean annual runoff may change with future developments upstream, but it is unlikely that there will be any significant change in the flood response of the catchment.

The Gumti is a flashy type of river, and its' response is likely to be typical of many of the other smaller rivers draining from the Tripura Hills. Figure B.3.11 shows a typical annual hydrograph for the Gumti at Comilla. This is quite different to those of the main rivers, exhibiting direct rainfall response. Frequency analysis has been carried out on the annual maximum series of mean daily flows on the Gumti. The results are summarised in Table B.3.8. The objective of the analysis has been to evaluate characteristics which might be transposed to the other cross boundary rivers on the basis of catchment area. Of interest therefore is the growth factor on the frequency distribution, as well as the specific mean annual flood discharge.

Other records which were thought to be of potential value in assessing flood frequency for cross boundary rivers was at Gangasagar (123). The records were considered to be unreliable, however, and there are many missing values.

Regional flood frequency analysis was carried out as part of the Water Balance Studies (Ref. 2.4). General consistency was found in regional growth curves. The results from the Water Balance Studies are plotted with those for the Gumti in Figure B.3.12. There is excellent agreement, and use of the growth factors on mean annual floods is considered to be an appropriate means of estimating cross boundary flood flows into the region. The difficulty remaining is in evaluating a mean annual flood for any particular catchment area, given that only the Gumti is gauged. The mean annual flood on the Gumti has a specific peak mean daily discharge of 0.26 $m^3/s/km^2$. On the Muhuri at Pashuram, the SERS has found that the mean annual flood has a specific peak mean daily discharge of 0.52 $m^3/s/km^2$. Rainfall over this area is significantly higher than at Comilla, and this combined with a smaller catchment area, results in a higher specific discharge. This analysis has not therefore resulted in any quick assessments for flood peaks from ungauged catchments. The data available are annual maximum mean daily flood discharges, and not instantaneous flood peaks. It is not considered appropriate to use the specific discharge approach for any of the smaller ungauged catchments. It is recommended that for investigations of specific areas, a synthetic unit hydrograph approach be adopted. An appropriate methodology for the hill catchments would be the USSCS method (Ref. 3.2). This could be used with rainfall estimates from Bangladesh, and catchment characteristics estimated from available mapping or imagery. Application of the USSCS method to catchments draining through the Sonaichari area south of Comilla is discussed in the SERS.

TABLE B.3.6

Summary of Flood Level Duration Frequencies

Duration	20 Days			40 Days			60 Days		
Return Period Station	2	5	10	2	5	10	2	5	10
W-110	10.34	11.01	11.45	9.84	10.49	10.91	9.42	9.95	10.29
W-113	7.69	8.25	8.62	7.27	7.80	8.16	6.80	7.38	7.76
W-114	6.81	7.05	7.21	6.45	6.75	6.95	6.27	6.55	6.73
W-123	5.84	6.24	6.50	5.57	5.84	6.02	5.47	5.75	5.94
T-3A	6.36	6.82	7.12	6.01	6.32	6.53	5.87	6.22	6.45
T-115	5.11	5.48	5.73	4.90	5.22	5.44	4.79	5.10	5.30
T-230	6.44	6.86	7.14	6.03	6.40	6.65	5.87	6.30	6.58
T-275	5.20	5.61	5.88	4.96	5.22	5.39	4.81	5.09	5.27
T-296	6.38	6.85	7.16	6.03	6.38	6.62	5.89	6.27	6.51
T-298	6.05	6.44	6.69	5.73	6.01	6.19	5.61	5.91	6.10

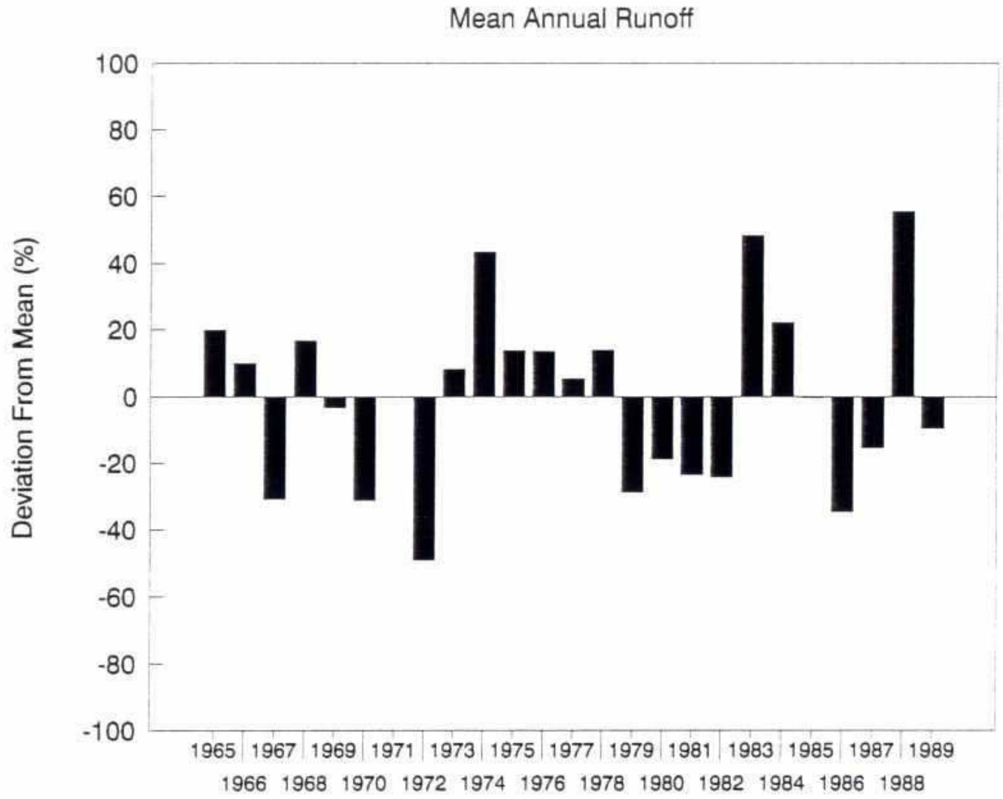
TABLE B.3.7

Statistical Tests on Gumti Flows at Comilla

	Mean Annual Flow		Annual Maximum	
Statistical Test	**Expected**	**Observed**	**Expected**	**Observed**
Randomness				
Median Crosses	11 +/- 6	9	11 +/- 6	11
Turning Points	14 +/- 3	11	14 +/- 3	12
Persistence				
First Order Serial Correlation	-0.04+/-0.41	0.03	-0.04+/-0.41	0.20
Spearman Rank	-0.05+/-0.42	-0.08	-0.05+/-0.42	0.10
Trend				
Rank Order	-0.04+/-0.40	-0.06	-0.04+/-0.40	-0.06
Mann-Whitney U Test	72+/-34	67	72+/-34	70
Wald-Wolfowitz Runs Test	13+/-5	12	13+/-5	12

Figure B.3.10

Annual Runoff of River Gumti at Comilla



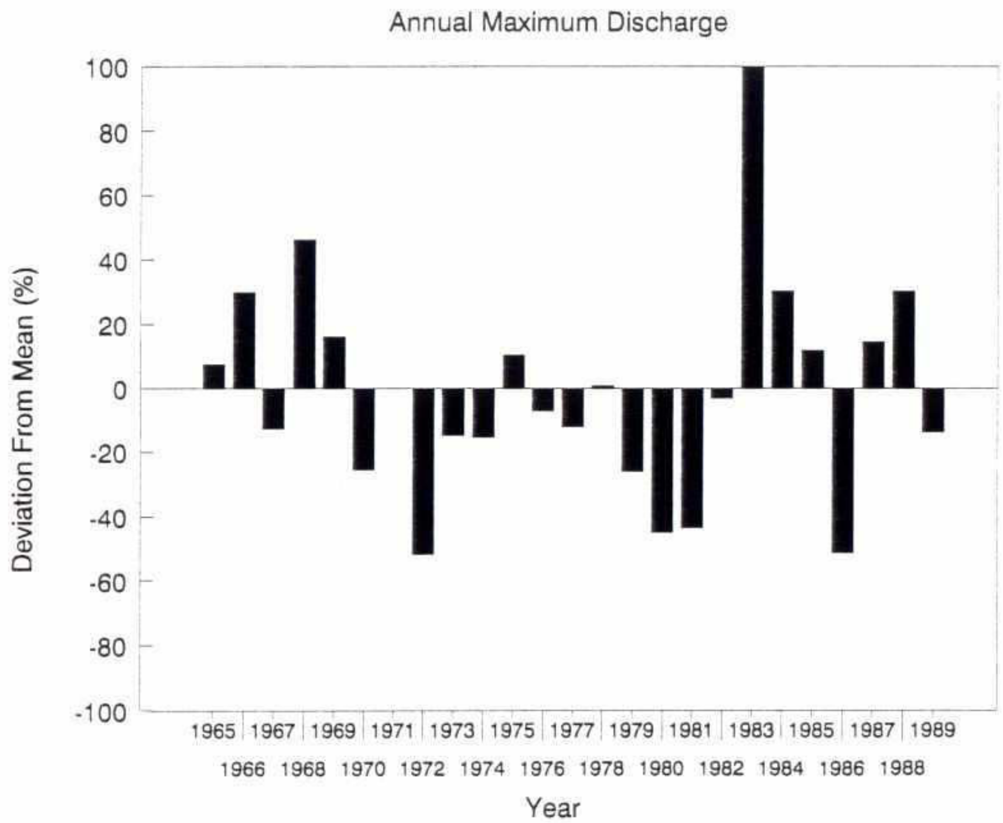
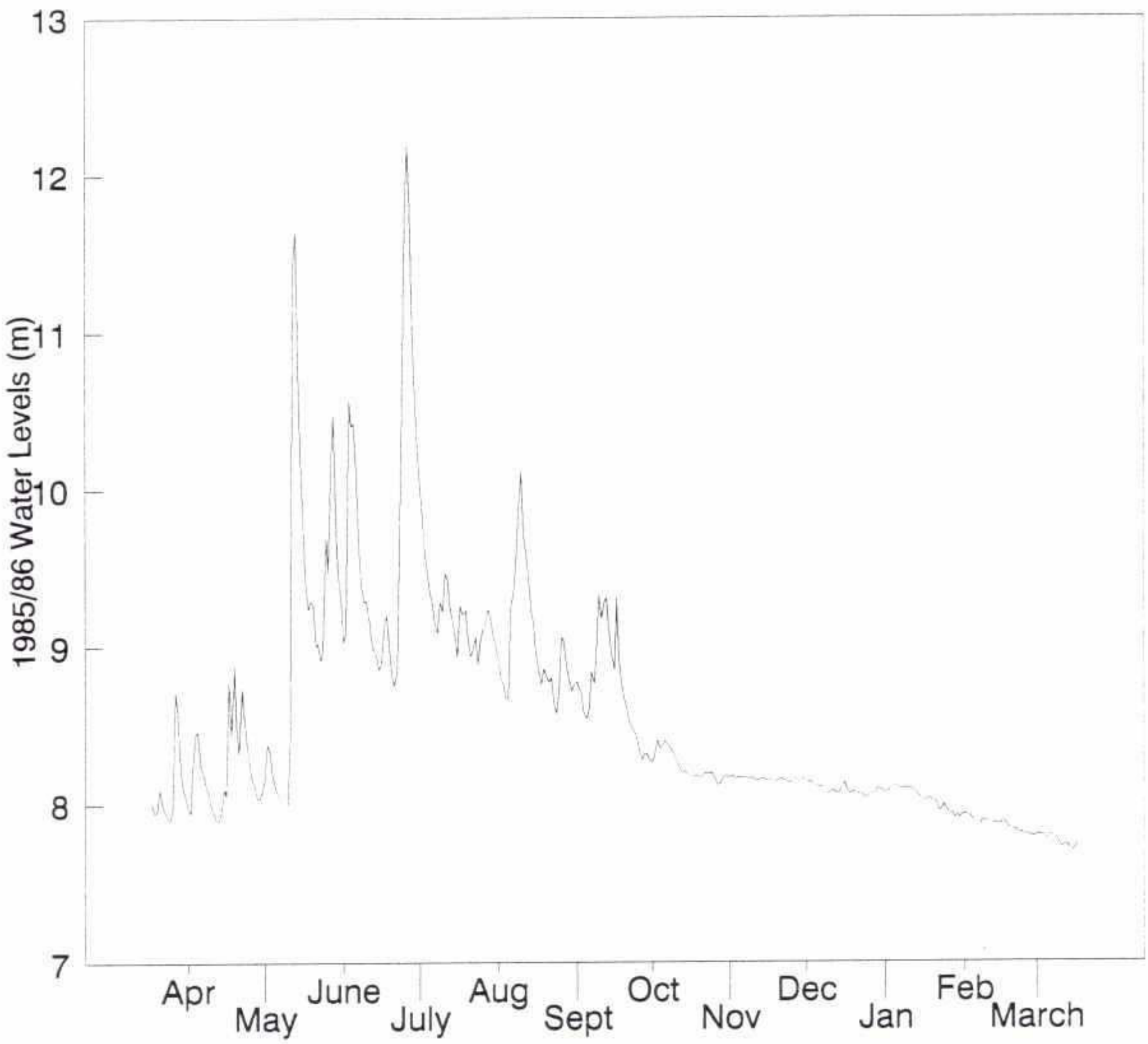


Figure B.3.11

Typical Annual Hydrograph

River Gumti at Comilla



Months in 1985/86 Water Year

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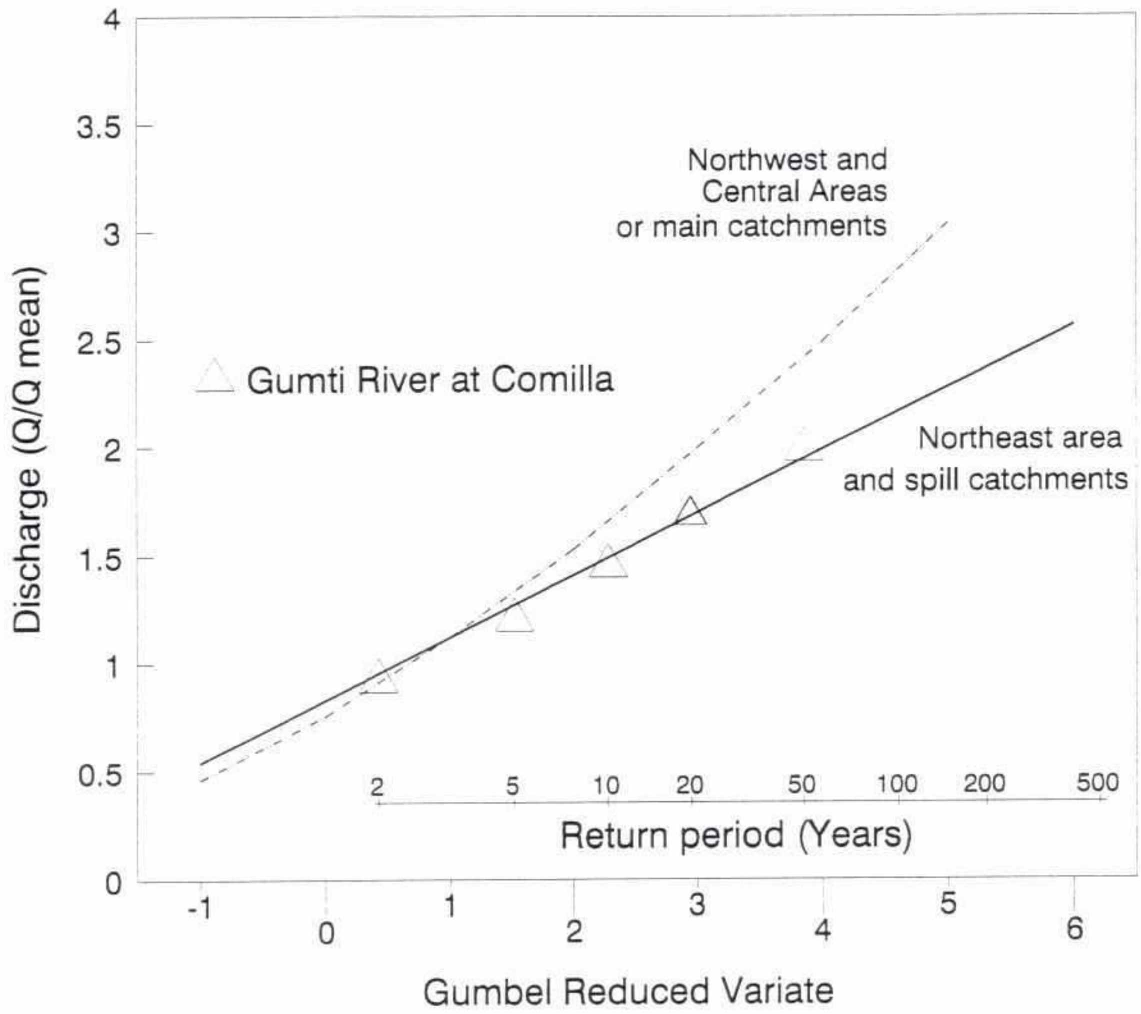
Figure B.3.12
Flood Frequency Analysis

Regional Growth Curves



Source : Water Balance Study

FigB3_12.drw

TABLE B.3.8

Flood Frequencies, Gumti at Comilla

Return Period (years)	Estimated Maxima (m^3/s)	Q/Q_{mean}
2	468	0.94
5	630	1.27
10	738	1.48
20	842	1.69
50	975	1.96

B.3.5 Sediment Discharges

The availability of sediment discharge data for the region is quite limited, as discussed in section B.3.3.4. Work on the Hydrological and Morphological Study of the Gumti, Titas and Atrai Basins (Ref. 3.1) has, however, given some general figures on typical size fractions and annual sediment yields, and these are considered to be appropriate for outline planning purposes in the region. The annual sediment yield from the Gumti was estimated to be 770 tonnes/km^2/year, which compared well with a previous estimate for a catchment in north-east India of 700 tonnes/km^2/year (Ref. 3.3). Studies of reservoir sedimentation in India have indicated sediment yields of the order of 600 to 1400 tonnes/km^2/year for catchments in southern India of less than 150 km^2. Similar measurements for mountain catchments in Northern India indicated annual yields of the order of 1200 to 2000 tonnes/km^2. For smaller catchments draining from the Tripura Hills, sediment yields could be in excess of those estimated for the Gumti. Annual sand extraction from the Kakri River is equivalent to a yield of 490 tonne/km^2.

The composition of Gumti sediment was 700 tonnes/km^2/year of silt, and 70 tonnes/km^2/year of sand. Morphological modelling runs carried out on the Gumti adopted a sand size of 0.2 mm, and a silt size of 0.03 mm.

B.4 Modelling Methodology

The general methodologies adopted for the hydraulic studies in the Gumti Phase II project are described in this Chapter. Details of the application of these methodologies are given in appropriate Chapters of the report.

B.4.1 NAM modelling

NAM is a deterministic model of the lumped, conceptual type. NAM operates on a daily time step, taking in data on rainfall, evaporation and groundwater abstractions, and producing as output river flows at the catchment outfall and values for its internal state parameters. The principal restrictions of NAM are that it does not couple surface inundation from river flow or irrigation into the sub-surface water balance and that it contains only a restricted amount of attenuation for high values of runoff (floods). Technical details concerning NAM can be found elsewhere (Ref. 4.1).

The NAM model used in this study was that developed and calibrated by the SWMC.

The application of NAM was divided into two stages:

Stage 1 : The NAM model, for the entire South East Region, was calibrated for the period April 1986 to March 1988. Calibration was based on simulating variations in groundwater levels since there are no internal discharge gauging points within the region. Verification of the model, against observed groundwater depth, was carried out for the period from April 1989 to March 1991.

Stage 2 : Following calibration and verification, a 25 year simulation for the period from 1965 to 1989 was carried out.

NAM was used to define runoff inputs along river reaches of the hydrodynamic model or to provide boundary condition discharges at locations where gauged discharges were not available. Further details of NAM together with its application to the South East region are given in the Section 2.6.

B.4.2 Development of the Hydrodynamic Model

B.4.2.1 The Hydrodynamic Model

The simulation of water levels, flow rates and flow velocities in the river system is carried out with the MIKE11-HD hydrodynamic model (hereafter called MIKE11). The model is well tried on rivers in Bangladesh through the efforts of the SWMC. MIKE11 is a deterministic model based on the St. Venant equations of open channel flow and the Abbott-Ionescu finite difference scheme. It represents flow in river channels, through structures and over flood plains. Technical details of MIKE11 can be found in Ref. 4.1. Like all mathematical models, it is based on a variety of assumptions and numerical approximations which determine its scope of application.

The development of models, by the SWMC, is following a programme in which first a pilot model is set up using readily available data from the Master Planning Organisation (MPO) and the Bangladesh Water Development Board (BWDB). The pilot models may be somewhat coarse in many areas pending the collection of further topographic, survey and hydrometric data. Once the full survey information is available the full model is established and finally, following the successful application to a number of flood seasons, the full model achieves the status of the verified model.

B.4.2.2 Collaboration with Surface Water Modelling Centre (SWMC)

The surface water simulation modelling programme in Bangladesh commenced in 1986, and the SWMC now exists as part of the MPO. There is active support from the Bangladesh University of Engineering Technology (BUET), and from the Danish Hydraulics Institute (DHI) who are consultants to the programme.

The South East Regional Model (SERM) was the first hydrodynamic model to be developed in Bangladesh, and is therefore in a more advanced state of calibration and verification than any of the other regional models. Outputs from the model include water levels, discharges and velocities at each node in the network, for each modelled time step. The most recent report by the SWMC on the SERM is their 1990 Verification Report. This report confirms the generally very good calibration of the model within the Gumti Phase II project area.

The SERM was originally developed in two parts because of the computer memory allocation limitations of the DOS operating system on the computers on which the model was being run. The division of the models was at the Daudkandi to Comilla road, which does form a reasonable divide across the region although transfers between the northern and southern systems do exist. The SWMC now operate their models under the UNIX operating system, which overcomes the memory allocation limitations associated with DOS. The SERM model has been transferred to the UNIX system and there is now a single model for the entire South East Region.

The SERM team at the SWMC are currently carrying out a thorough verification exercise on the single model, which has effectively evolved to its present form over a six year period. Full verification of the model is not expected until after the completion of the present project.

The project initially carried out its modelling activities in the SWMC offices, working closely with the SERM team. A connection was established to the SWMC computer network, and UNIX installed on the Gumti Phase II modelling computer. This ensured that full compatibility was maintained and was of mutual benefit to both modelling teams. Once production runs of the model commenced the modelling team moved back to the Gumti II project offices to ensure closer involvement of engineering and other staff in the formulation of model runs and the evaluation of results. For the production runs the latest version of the model, available at the time of the move, was used.

The production runs of the Gumti Phase II model were carried out using the well calibrated northern part of the SERM. The division was at the Daudkandi to Comilla road, which does form a reasonable divide across the region although transfers between the northern and southern systems do exist. The split was carried out to ensure acceptable run times for the 25 year model simulations. Since the Gumti Phase II study area is to the north of the embankment on the right bank of the Gumti river there is little possibility of the developments in this area having a significant impact on conditions to the south of the river.

B.4.3 Application of Hydraulic Models

B.4.3.1 Guidance from FAP 25

Due to the complexity of the Bangladeshi Delta and the interaction of the various flood causing factors, the definition of design events of a given return period in terms of standardised boundary conditions is not practical. In an attempt to overcome these problems, FAP-25 recommended a rationale which involves long term simulations of hydraulic models for the period 1965-89. In detail the rationale required,

- the preparation of boundary conditions required to run models for the period 1965-89.

- running the models for the full 25 year period, at least once for the present (baseline) conditions and once for the ultimately adopted scheme(s).

- combinations of various options to reach the final plan may be studied on the basis of simulations for a reduced number of selected seasons, the selections being based on the analysis of the 25 year baseline run.

- sensitivity analysis of ultimately adopted scheme considering changed boundary conditions in the major rivers due to proposed schemes outside the region.

- statistical analysis of the results, aimed at assigning return periods to historic peak, seasonal or sub-seasonal values of selected design variables.

B.4.3.2 Approach adopted

In keeping with the FAP-25 guidelines, the application of the Gumti Phase II model was divided into five stages,

<u>Stage 1</u> : Calibration and verification. The model was calibrated against observed water level and discharge data at gauging stations. The calibration concentrated on simulating water level variations. Comparison with observed discharges was used to ensure that flow splits between major river channels were correctly simulated. The model was verified over a number of seasons to ensure that reasonable variations in water level and discharge were being produced. This stage of the work was carried out by the SWMC.

<u>Stage 2</u> : Without Project (present / baseline) simulation. The Without project simulation used the 25 years of hydrological data from 1965 to 1989. The objective of the model was to produce data on water level and discharge variations over a period of 25 hydrological years. This information would form the baseline data for investigating the impact of proposed developments in the modelled area. The objective of the Without Project simulation was not to simulate observed water level and discharge variations over the 25 year period from 1965 to 1989.

Stage 3 : Once the Without Project simulation had been completed the results were used to select design years for investigating proposed developments. Design years were selected to give a range of return period events over the whole of the modelled area. The models were run for the design years to investigate the impact of design options or scenarios (set of options). This was done by comparing the results of the design option simulations with the results of the Without Project simulation.

Stage 4 : With Project simulation. Following the design option, or scenario, simulations for a development plan for the modelled area was formulated. A With Project simulation was carried out with this development plan in place. The With Project simulation used the hydrological data for the period from 1965 to 1989. The impact of the proposed development plan was investigated by comparing the results of the With Project simulation with the results of the Without Project simulation.

Stage 5 : Check from the latest FAP 25 runs the difference in boundary levels caused by outside projects. If significant changes were found, carry out sensitivity analysis to investigate the impact, on the proposed development plan, of changed external conditions.

B.4.4 Post-processing of Results from 25-year Hydraulic Model Simulations

B.4.4.1 Introduction

The 25 year MIKE11 simulations generate 25 years of daily water levels and discharges at the model nodes. This is a vast amount of information which in its raw form is of limited use, hence there is a need for post-processing. The output required from this post-processing will depend on the use to which it is to be put. The MIKE11 results are to be used for three forms of analysis; engineering, agriculture and fisheries / environment. This section describes the post-processing of MIKE11 results for each of these disciplines; Figure B.4.1 is a flow diagram illustrating the procedure used.

The engineering analysis requires information at key points within the hydraulic system, whereas for the agricultural and fisheries analysis, information is required for areas. For this purpose the Gumti Phase II project area was divided into 14 analysis areas as shown in Figure B.4.2. These analysis areas were based on the four zones of flooding and agricultural type; they also took into account the proposed interventions. The analysis areas were sub-divided further for the analysis of the hydraulic model results; these sub-areas are also shown in Figure B.4.2. The analysis area sub-divisions were selected by considering surface water gradients and the variation in topographic elevation.

Figure B.4.1

Post-Processing Analysis

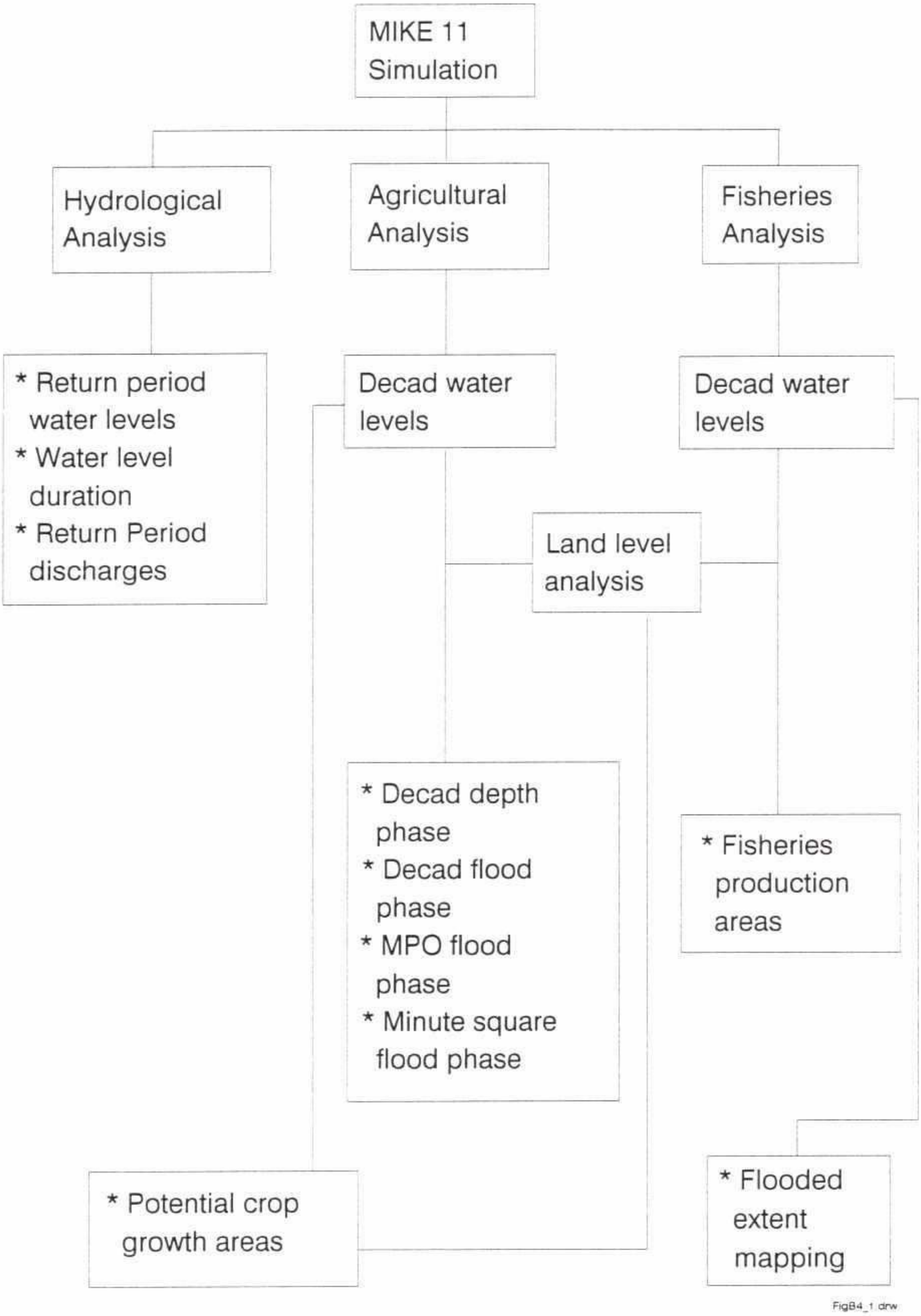
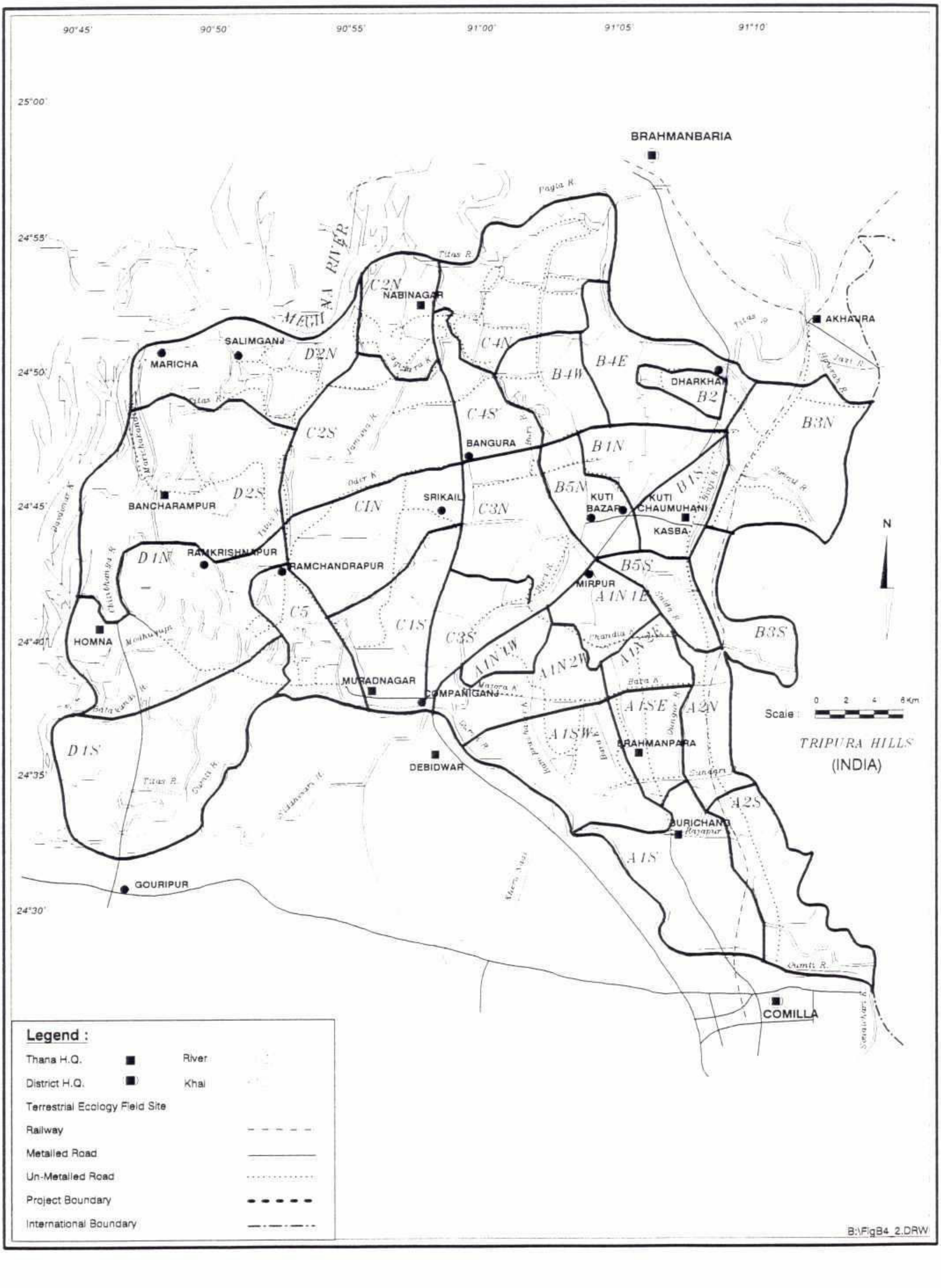


Figure B.4.2
Sub-divided Areas for Post Processing



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B.4.4.2 Engineering

The engineering discipline uses the MIKE11 results for a number of purposes, these include,

- definition of embankment heights
- definition of channel / khal dimensions
- definition of structure details including sill levels and gate sizes

In order to make these decisions water levels and discharges with different return periods at key points within the system are required. The procedure utilised to obtain this information is as follows,

Definition of locations :	The key locations at which information on water levels and / or discharges was required were identified by the engineers.
Output of MIKE11 results :	The standard MIKE11 water level and / or discharge results were output to text files in five year blocks. The output was on a daily basis throughout the full hydrological year. This was done for each required location.
Analysis of MIKE11 results :	The daily values were analysed to obtain decad (10 day) values. The average over the decad was used to represent the decad. Hydrological analysis was carried out on the decad values to give minimum, mean and maximum values for each decad. In addition, return period decad values were calculated for 2, 5, 10, 20, 50 and 100 year return periods. Output from a typical water level analysis is shown in Table B.4.1. A Blom formula was used for the lower return periods, up to 1 in 20 year for a 25 year simulation, and a Gumbel Extreme Value analysis for the higher return period events. Estimates of events with return periods greater than the length of run analysed should be viewed with caution because they result from extrapolation beyond the period of model simulation.

<u>The meaning of return period</u>

The return period for an event (occurrence or exceedance of water level, discharge or any other hydrological parameter) is a convenient label to characterise the frequency of occurrence of that event. Return period is conventionally quoted in years. Since the analysis is in terms of annual occurrence of level exceeding a certain amount, there is no direct meaning of return period of less than two years. For large values (say 5 years or more) the return period becomes the average frequency of occurrence of the event in a very long sequence. This of course begs the question of whether the processes which force the event (climate, river morphology, anthropogenic development) are statistically stationary. There is a danger in the use of the notion of return period for non-specialists, in that it can be misinterpreted as implying some form of regularity of occurrence, that is a five year level occurs every five years ie if it has occurred this year it will not do so next year or if it has not done so for four years it will do so next year. Floods are random.

TABLE B.4.1

Example Output - Water Level Analysis (Decad Basis)

! DATA FILE : GUM-P.RDF BOUNDARY FILE : GUM-P1.BSF !
! Boundary Fil : GUM-P1.RRF CALCULATED : 11-MAR-1993, 10:03!
MIKE-11 file : G65-P-YL.TXT (all files also R70...., R75.... etc).
This analysis file : PLG12015.00S

ANALYSIS OF 10-DAY MEAN WATER LEVELS
(Model output for 24 years - run P)

GN12 (G12) Chainage 15.000

					Return Period (years)					
		Min.	Mean	Max.	2	3	4	5	8	10
Apr	1	2.08	2.82	3.68	2.80	2.85	2.92	2.97	3.19	3.25
	2	2.14	2.93	4.07	2.82	2.97	3.03	3.30	3.46	3.54
	3	2.36	3.18	4.30	3.14	3.34	3.41	3.42	3.71	3.78
May	1	2.78	3.35	4.68	3.24	3.45	3.67	3.71	3.90	3.98
	2	2.92	3.68	4.85	3.65	3.79	4.02	4.12	4.33	4.41
	3	3.03	3.81	4.70	3.69	4.19	4.36	4.38	4.43	4.49
Jun	1	2.99	3.94	4.77	3.92	4.21	4.46	4.54	4.53	4.58
	2	3.13	4.26	4.93	4.35	4.44	4.64	4.67	4.72	4.76
	3	3.39	4.60	5.48	4.66	4.87	5.05	5.12	5.13	5.18
Jul	1	4.04	4.97	5.97	4.95	5.13	5.18	5.22	5.46	5.52
	2	4.39	5.26	6.26	5.24	5.40	5.45	5.51	5.76	5.83
	3	4.94	5.47	6.19	5.37	5.68	5.75	5.77	5.88	5.93
Aug	1	5.13	5.68	6.40	5.71	5.83	5.86	5.91	6.03	6.06
	2	5.14	5.67	6.45	5.70	5.79	5.82	5.86	6.02	6.06
	3	4.85	5.59	6.29	5.62	5.79	5.83	5.88	6.01	6.05
Sep	1	4.74	5.53	7.11	5.39	5.74	5.84	5.87	6.12	6.20
	2	4.78	5.43	7.15	5.45	5.61	5.64	5.71	6.04	6.13
	3	4.56	5.34	6.66	5.23	5.53	5.55	5.71	5.95	6.03
Oct	1	4.19	5.13	6.04	5.07	5.24	5.34	5.44	5.64	5.70
	2	3.81	4.82	5.53	4.84	4.94	5.18	5.30	5.28	5.33
	3	3.52	4.45	5.16	4.47	4.72	4.76	4.82	4.92	4.97
Nov	1	3.20	3.97	4.69	3.96	4.14	4.26	4.35	4.40	4.45
	2	2.98	3.64	4.36	3.70	3.81	3.91	3.93	4.01	4.04
	3	2.79	3.39	4.06	3.39	3.54	3.58	3.60	3.73	3.76
Dec	1	2.60	3.18	3.70	3.18	3.27	3.32	3.42	3.45	3.49
	2	2.42	3.00	3.60	2.97	3.00	3.05	3.23	3.31	3.35
	3	2.29	2.84	3.38	2.80	2.89	2.93	3.02	3.11	3.15
Jan	1	2.17	2.73	2.99	2.75	2.83	2.87	2.89	2.90	2.92
	2	2.17	2.68	2.90	2.73	2.77	2.80	2.81	2.83	2.84
	3	2.11	2.64	2.88	2.72	2.74	2.76	2.77	2.80	2.81
Feb	1	2.10	2.63	2.84	2.68	2.74	2.76	2.79	2.79	2.80
	2	2.09	2.61	2.83	2.66	2.72	2.76	2.77	2.78	2.79
	3	2.16	2.73	5.25	2.67	2.71	2.73	2.75	3.34	3.48
Mar	1	2.15	2.68	3.63	2.67	2.75	2.80	2.83	2.99	3.04
	2	2.19	2.66	3.08	2.69	2.75	2.81	2.81	2.87	2.89
	3	2.16	2.81	3.85	2.75	2.92	2.99	3.02	3.20	3.26

Note: Estimates for return periods of more than 20 years should be viewed with particular caution because they result from extrapolation beyond the period of model simulation.

Return periods up to 20 years from Blom formula; 50 and 100 years by Gumbel Extreme Value Analysis on upper half of points.

Return period is defined in terms of the annual probability of exceedance, P, by

$$T = 1.0 / P$$

Return periods of less than two years should really be expressed as a convenient ratio such as 4 in 5 years for P = 0.8 rather than T = 1.25, or, 9 in 10 years for P = 0.9 rather than T = 1.11.

The return period associated with a given level depends upon several factors,

- the representative nature of the sample used in the estimation (ie are there "too many" wet or dry years?)

- the number of observations (ie record length)

- the statistic analysed (annual peak value, decad mean, peak over threshold etc)

- the statistical model (or probability *distribution*) used for the random process (eg GEV type 1 distribution - the Gumbel plot)

- the "plotting rule" used to assign probability values to the observations as each distribution is associated with a particular plotting rule to minimise bias

- the method of fitting the distribution to the observed probability values.

These factors are considered in setting up the hydrological analysis software.

B.4.4.3 Agriculture

This section presents the form of analysis to determine the probability of crop success or failure in any given area of land due to flood damage. The analysis must be carried out for each crop type taking into account the susceptibility to damage in each phase of its growth. Each sub-division of the analysis areas was analysed separately and this information was combined to give results for the analysis area. The procedure utilised is as follows,

- a water level node in the MIKE11 model is assigned as being representative of the area.

- output of MIKE11 results as described in Section B.4.4.2.

- decad analysis of water levels

- statistical analysis of decad water levels

- calculation of depth and flood phases subject to FPCO and MPO rules

- the land-level database is used to determine the area subject to each phase of flooding

- analysis determines the water level, subject to agricultural rules, which is critical for the success of the crop and this is in turn related to a minimum ground level which can be planted without failure.

- the land-level database is used to determine the area of land over which the crop can be grown without damage.

Decad analysis of the model results

In each decad (with three decads per calendar month), crop failure occurs on the fourth day on which the level exceeds the critical value. Hence each decad should be represented as the maximum of a running four day minimum level, starting by looking three days backwards into the previous decad. The water levels, from the MIKE11 model at each representative node, were analysed in terms of four-day exceedances. The requirements of the agricultural analyses requires the whole year to be analysed.

Thus a representative water level is produced for each decad and these can be analysed using standard statistical techniques as a 25-year sequence for the same decad in each year. The hydrological analysis software described in Section B.4.4.2 was used for this purpose. Thus return periods for water level in each decad can be produced.

Calculation of depth and flood phases

Depth phases

The new draft rules from FPCO define depth phases for flooding analysis. These categories allow the former MPO phases to be reconstituted by addition. For these feasibility studies the following categorisation is used.

Depth Category	MPO Phase	Depth Range (m)		
D1	F0	0.0	to	< 0.2
D2	F0	0.2	to	< 0.3
D3	F1	0.3	to	< 0.5
D4	F1	0.5	to	< 0.7
D5	F1	0.7	to	< 0.9
D6	F2	0.9	to	< 1.8
D7	F3	1.8	to	< 3.6
D8	F4	3.6	and deeper	

Based on the decad water level analysis and land-level analysis, areas flooded to different depth categories were calculated for each decad through the hydrological year. Typical output from this analysis is given in Table B.4.2 which gives the areas flooded to different depth categories for each decad. This information can also be supplied as a percentage of the total area, Table B.4.3. This information can be supplied for the different return periods for which statistical analysis was carried out.

Flood Phases

The widely quoted MPO flood phase figures are not quoted with respect to a time element whereas the model output and flood levels at each node are produced as a time series. The depth categories for the flood phases are also defined differently from those for the depth phase analysis, the depth phases have a higher resolution.

Based on the decad water level analysis and land-level analysis, areas in the different flood phase categories were calculated for each decad through the hydrological year. Typical output from this analysis is given in Table B.4.4 which gives the areas in the different flood phase categories for each decad. This information can also be supplied as a percentage of the total area, Table B.4.5. This information can be supplied for the different return periods for which statistical analysis was carried out.

However, this does not eliminate the time dependent nature of the depth phase information.

Sensitivity analysis carried out during the North-West Regional Study (FAP-2) showed the most suitable method for obtaining the MPO flood phases was to select the 1 in 5 year return period level and take the peak decad flood level. Typical output for this analysis is given in Table B.4.6 which gives the flood phase distribution.

Cropping analysis

Following agronomic principles water depth limitations can be defined for each stage of the growth cycle of a crop. This can be done for each crop of interest as illustrated in Figure B.4.3.

Using the decad water levels together with the cropping water depth limitations, the lowest land level on which the crop can grow in each year can be determined. Having determined the lowest land level, the land area associated with that level can be determined by using the land-level database.

From the information on the lowest land level on which each crop can survive in each year water level statistics can be produced and the levels for various return periods established using the method described in Section B.4.4.2.

TABLE B.4.2

Example Output - Depth Phase analysis by Area

Analysis for Area A1

NCA = 17971.00 (ha)

GCA = 22891.00 (ha)

Water levels based on 1:5 year levels

Area flooded in depth categories - Total Area

		Depth categories (m)							
Month	10 day	0.0-0.2	0.2-0.3	0.3-0.5	0.5-0.7	0.7-0.9	0.9-1.8	1.8-3.6	>3.6
4	1	17964.	2.	5.	0.	0.	0.	0.	0.
4	2	17962.	0.	3.	5.	0.	0.	0.	0.
4	3	17962.	0.	2.	5.	3.	0.	0.	0.
5	1	17953.	3.	5.	1.	3.	5.	0.	0.
5	2	17892.	15.	35.	15.	5.	9.	0.	0.
5	3	17770.	53.	75.	33.	24.	16.	0.	0.
6	1	17662.	77.	113.	54.	34.	31.	0.	0.
6	2	17573.	104.	136.	77.	31.	50.	0.	0.
6	3	14516.	1315.	1319.	467.	170.	175.	10.	0.
7	1	11683.	1553.	2842.	1221.	393.	266.	12.	0.
7	2	8482.	1691.	3560.	2572.	1035.	602.	29.	0.
7	3	6010.	1246.	3139.	3430.	2504.	1570.	72.	0.
8	1	4370.	893.	2437.	3280.	3400.	3482.	110.	0.
8	2	4162.	781.	2601.	3433.	3411.	3489.	94.	0.
8	3	4222.	853.	2642.	3454.	3439.	3265.	96.	0.
9	1	4144.	835.	2666.	3510.	3458.	3259.	99.	0.
9	2	5010.	1214.	3479.	3811.	2647.	1741.	69.	0.
9	3	5386.	1157.	3230.	3630.	2720.	1775.	72.	0.
10	1	8502.	2080.	3752.	2186.	889.	538.	23.	0.
10	2	12423.	1788.	2260.	893.	312.	281.	15.	0.
10	3	16791.	479.	390.	144.	86.	72.	8.	0.
11	1	17798.	49.	60.	33.	16.	15.	0.	0.
11	2	17926.	16.	15.	5.	2.	7.	0.	0.
11	3	17958.	3.	2.	3.	5.	0.	0.	0.
12	1	17962.	0.	3.	6.	0.	0.	0.	0.
12	2	17964.	2.	6.	0.	0.	0.	0.	0.
12	3	17967.	3.	1.	0.	0.	0.	0.	0.
1	1	17968.	3.	0.	0.	0.	0.	0.	0.
1	2	17968.	3.	0.	0.	0.	0.	0.	0.
1	3	17969.	2.	0.	0.	0.	0.	0.	0.
2	1	17969.	2.	0.	0.	0.	0.	0.	0.
2	2	17969.	2.	0.	0.	0.	0.	0.	0.
2	3	17969.	2.	0.	0.	0.	0.	0.	0.
3	1	17967.	3.	1.	0.	0.	0.	0.	0.
3	2	17967.	3.	1.	0.	0.	0.	0.	0.
3	3	17963.	2.	6.	0.	0.	0.	0.	0.

Note : all areas in hectares

TABLE B.4.3

Example Output - Depth Phase Analysis by Percentage Area

Analysis for Area A1

NCA = 17971.00 (ha)

GCA = 22891.00 (ha)

Water levels based on 1:5 year levels

Area flooded in depth categories - Total Area

		Depth categories (m)							
Month	10 day	0.0-0.2	0.2-0.3	0.3-0.5	0.5-0.7	0.7-0.9	0.9-1.8	1.8-3.6	>3.6
4	1	100	0	0	0	0	0	0	0
4	2	100	0	0	0	0	0	0	0
4	3	100	0	0	0	0	0	0	0
5	1	100	0	0	0	0	0	0	0
5	2	100	0	0	0	0	0	0	0
5	3	99	0	0	0	0	0	0	0
6	1	98	0	1	0	0	0	0	0
6	2	98	1	1	0	0	0	0	0
6	3	81	7	7	3	1	1	0	0
7	1	65	9	16	7	2	1	0	0
7	2	47	9	20	14	6	3	0	0
7	3	33	7	17	19	14	9	0	0
8	1	24	5	14	18	19	19	1	0
8	2	23	4	14	19	19	19	1	0
8	3	23	5	15	19	19	18	1	0
9	1	23	5	15	20	19	18	1	0
9	2	28	7	19	21	15	10	0	0
9	3	30	6	18	20	15	10	0	0
10	1	47	12	21	12	5	3	0	0
10	2	69	10	13	5	2	2	0	0
10	3	93	3	2	1	0	0	0	0
11	1	99	0	0	0	0	0	0	0
11	2	100	0	0	0	0	0	0	0
11	3	100	0	0	0	0	0	0	0
12	1	100	0	0	0	0	0	0	0
12	2	100	0	0	0	0	0	0	0
12	3	100	0	0	0	0	0	0	0
1	1	100	0	0	0	0	0	0	0
1	2	100	0	0	0	0	0	0	0
1	3	100	0	0	0	0	0	0	0
2	1	100	0	0	0	0	0	0	0
2	2	100	0	0	0	0	0	0	0
2	3	100	0	0	0	0	0	0	0
3	1	100	0	0	0	0	0	0	0
3	2	100	0	0	0	0	0	0	0
3	3	100	0	0	0	0	0	0	0

Note : all figures in percent

TABLE B.4.4

Example Output - Decad Flood Phase Analysis by Area

Analysis for Area A1

NCA = 17971.00 (ha)

GCA = 22891.00 (ha)

Water levels based on 1:5 year levels

Area flooded in flood categories - Area

Flood categories

Month	10 day	F0	F1	F2	F3	F4
4	1	17967.	5.	0.	0.	0.
4	2	17962.	9.	0.	0.	0.
4	3	17962.	9.	0.	0.	0.
5	1	17957.	9.	5.	0.	0.
5	2	17907.	54.	9.	0.	0.
5	3	17823.	132.	16.	0.	0.
6	1	17739.	201.	31.	0.	0.
6	2	17677.	244.	50.	0.	0.
6	3	15831.	1955.	175.	10.	0.
7	1	13236.	4457.	266.	12.	0.
7	2	10173.	7167.	602.	29.	0.
7	3	7256.	9073.	1570.	72.	0.
8	1	5263.	9117.	3482.	110.	0.
8	2	4943.	9445.	3489.	94.	0.
8	3	5075.	9535.	3265.	96.	0.
9	1	4979.	9634.	3259.	99.	0.
9	2	6224.	9937.	1741.	69.	0.
9	3	6543.	9580.	1775.	72.	0.
10	1	10582.	6828.	538.	23.	0.
10	2	14211.	3464.	281.	15.	0.
10	3	17271.	621.	72.	8.	0.
11	1	17847.	109.	15.	0.	0.
11	2	17942.	22.	7.	0.	0.
11	3	17960.	10.	0.	0.	0.
12	1	17962.	9.	0.	0.	0.
12	2	17965.	6.	0.	0.	0.
12	3	17970.	1.	0.	0.	0.
1	1	17971.	0.	0.	0.	0.
1	2	17971.	0.	0.	0.	0.
1	3	17971.	0.	0.	0.	0.
2	1	17971.	0.	0.	0.	0.
2	2	17971.	0.	0.	0.	0.
2	3	17971.	0.	0.	0.	0.
3	1	17970.	1.	0.	0.	0.
3	2	17970.	1.	0.	0.	0.
3	3	17965.	6.	0.	0.	0.

Note : all areas in hectares

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TABLE B.4.5

Example Output - Decad Flood Phase Analysis by Percentage Area

Analysis for Area A1

NCA = 17971.00 (ha)

GCA = 22891.00 (ha)

Water levels based on 1:5 year levels

Area flooded in flood categories - Area

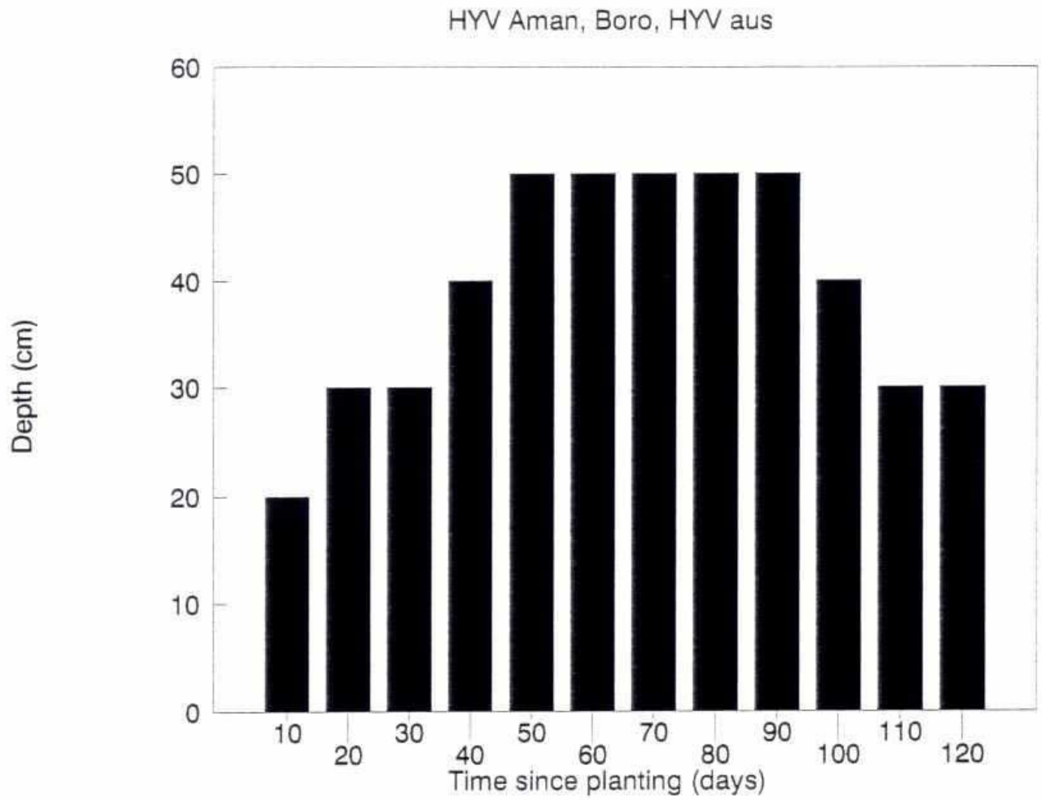
Flood categories

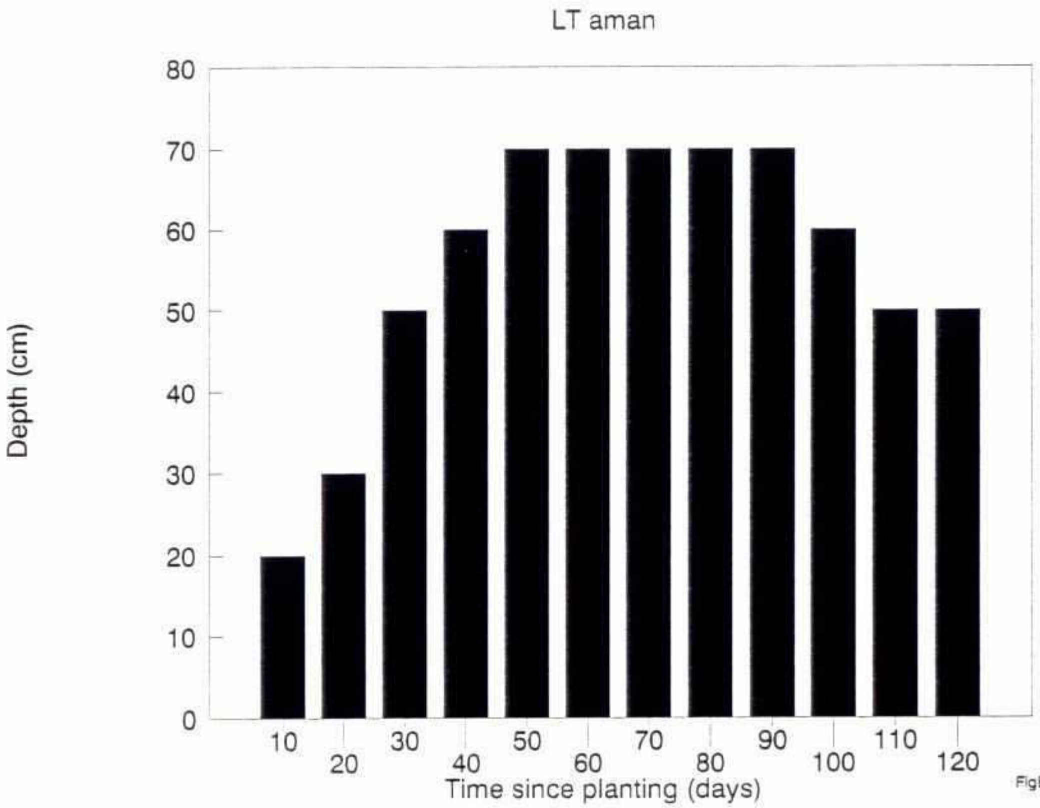
Month	10 day	F0	F1	F2	F3	F4
4	1	100	0	0	0	0
4	2	100	0	0	0	0
4	3	100	0	0	0	0
5	1	100	0	0	0	0
5	2	100	0	0	0	0
5	3	99	1	0	0	0
6	1	99	1	0	0	0
6	2	98	1	0	0	0
6	3	88	11	1	0	0
7	1	74	25	1	0	0
7	2	57	40	3	0	0
7	3	40	50	9	0	0
8	1	29	51	19	1	0
8	2	28	53	19	1	0
8	3	28	53	18	1	0
9	1	28	54	18	1	0
9	2	35	55	10	0	0
9	3	36	53	10	0	0
10	1	59	38	3	0	0
10	2	79	19	2	0	0
10	3	96	3	0	0	0
11	1	99	1	0	0	0
11	2	100	0	0	0	0
11	3	100	0	0	0	0
12	1	100	0	0	0	0
12	2	100	0	0	0	0
12	3	100	0	0	0	0
1	1	100	0	0	0	0
1	2	100	0	0	0	0
1	3	100	0	0	0	0
2	1	100	0	0	0	0
2	2	100	0	0	0	0
2	3	100	0	0	0	0
3	1	100	0	0	0	0
3	2	100	0	0	0	0
3	3	100	0	0	0	0

Note : all figures in percent

(Sheet 1 of 3)

Figure B.4.3
Crop Water Depth Limitations

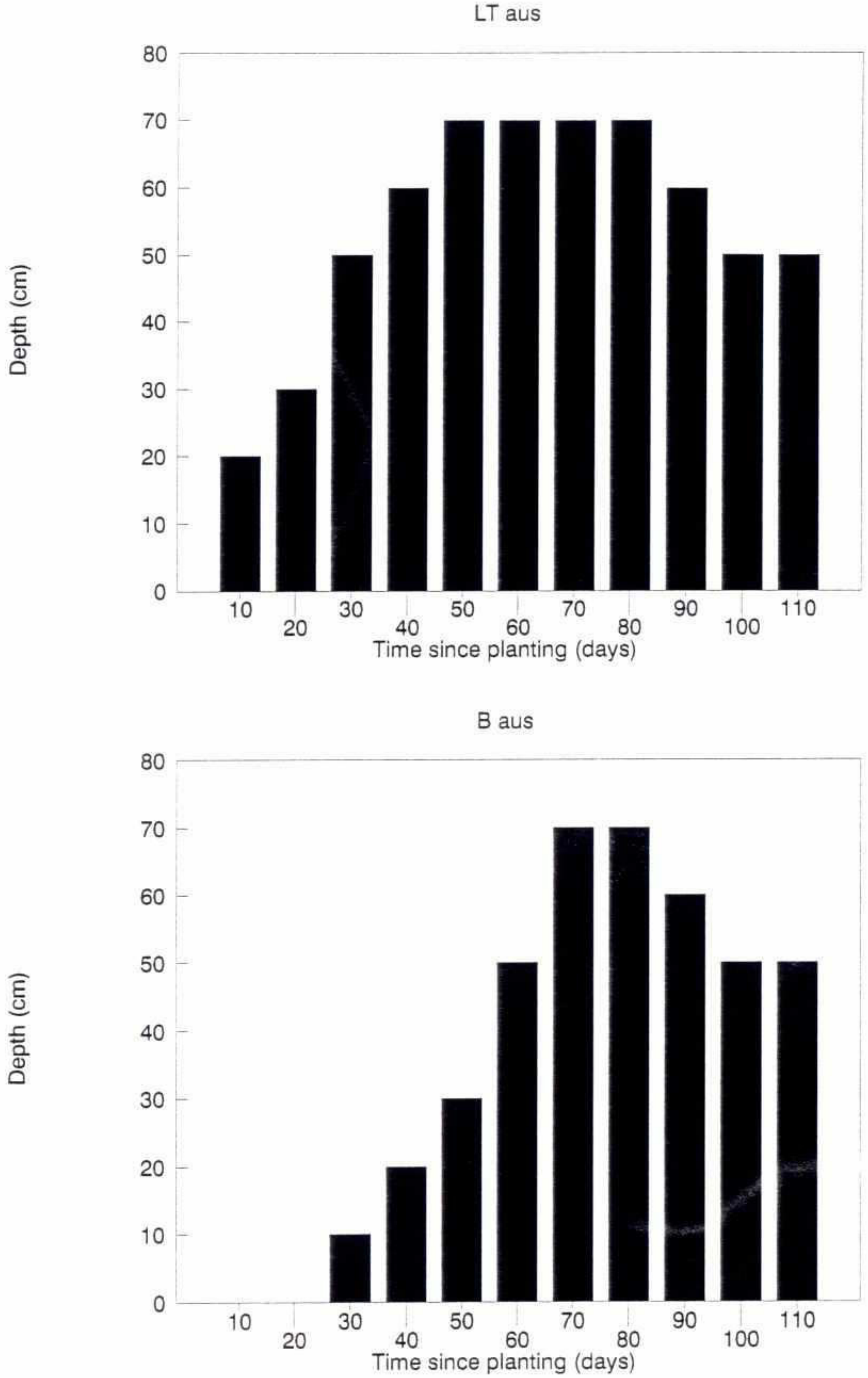




FigB4_3a.drw

(Sheet 2 of 3)

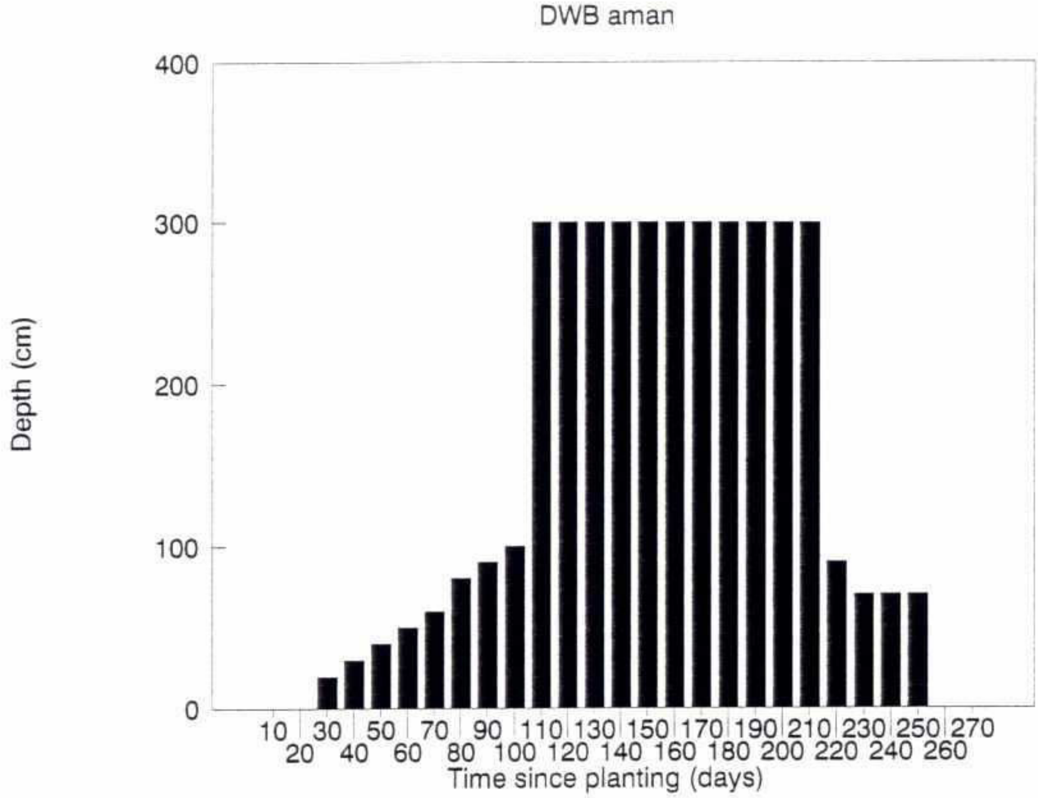
Figure B.4.3
Crop Water Depth Limitations

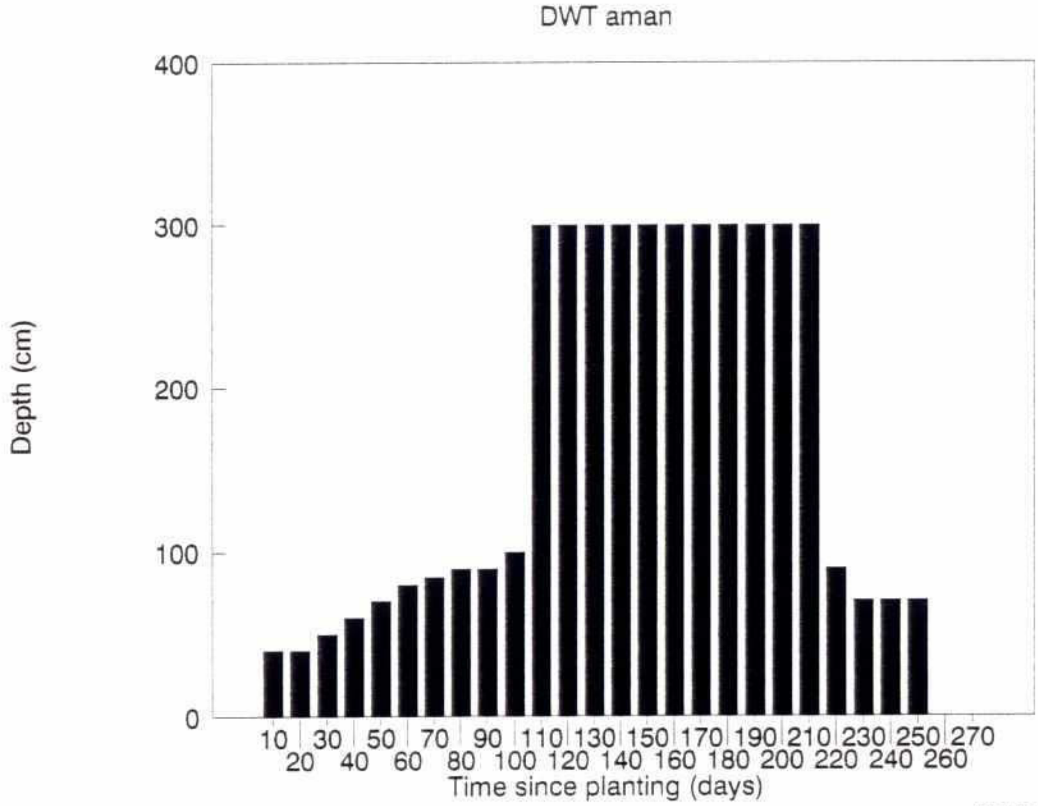


FigB4_3b.drw

(Sheet 3 of 3)

Figure B.4.3
Crop Water Depth Limitations





figb4_3c.drw

TABLE B.4.6

Example Output - MPO Flood Phase

Analysis for Area A1

NCA = 17971.00 (ha)

GCA = 22891.00 (ha)

Water levels based on 1:5 year levels

Total F0 land	28.
Total F1 land	53.
Total F2 land	19.
Total F3 & F4 land	1.

The cultivable land for each crop at any required return period can be derived from the land-level database. An example output for the crops investigated during this feasibility study is given in Table B.4.7. This information can also be supplied as a percentage of the total area, Table B.4.8.

B.4.4.4 Fisheries / Environment

This section presents the form of analysis used to post-process the MIKE11 results for use by the fisheries / environmental discipline. Each sub-division of the analysis areas was analysed separately. The procedure utilised is as follows,

- a water level node in the MIKE11 model is assigned as being representative of the area.
- output of MIKE11 results as described in Section B.4.4.2.
- decad analysis of water levels
- statistical analysis of decad water levels
- calculation of decad flood phases with different return periods
- the land-level database is used to determine the area subject to each phase of flooding

Decad analysis of water levels

For the purposes of the fisheries / environmental analysis the minimum over the decad was used to represent the decad. Hydrological analysis, as described in Section B.4.4.2, was carried out on the decad values to give minimum, mean and maximum values for each decad. In addition, return period decad values were calculated for 2, 5, 10, 20, 50 and 100 year return periods.

Calculation of flood phases

Flood phases for the decad water levels with different return periods were calculated using the procedure outlined in Section B.4.3.2.

For the purposes of the analysis the areas in flood phases F1, F2, F3 and F4 are potentially suitable for fisheries. Results were presented by giving the amount of F0 land and the amount of land greater than F0, see Table B.4.9. This information can also be supplied as a percentage of the total area, Table B.4.10.

Mapping for fisheries analysis

For fisheries analysis the land areas flooded to depths greater than 30 cm were be mapped. This was done for different return period water levels and different decads by considering the representative water level in the model and the variation in topographic level. Figure B.4.4 is an example of a map produced for the fisheries analysis.

TABLE B.4.7

Example Output - Cropping Analysis by Area

Project area Area A1

NCA = 17971.00 (ha)

GCA = 22891.00 (ha)

Maximum land area (ha) on which crop can be safely grown

		Return Period (years)							
	Min.	Mean	Max.	2	3	4	5	8	10
HYV AMAN 1	16472.	7502.	1016.	10154.	4576.	4380.	3846.	2817.	2496.
HYV AMAN 2	13628.	5253.	1129.	5638.	4429.	3977.	3831.	2686.	2435.
HYV AMAN 3	15008.	5682.	1312.	6492.	4618.	4417.	4148.	2891.	2640.
HYV AMAN 4	16633.	6594.	1312.	7160.	5535.	4710.	4395.	3184.	2926.
BORO 1	17970.	17962.	17285.	17963.	17962.	17961.	17960.	17922.	17906.
BORO 2	17969.	17962.	17148.	17962.	17959.	17957.	17950.	17896.	17870.
BORO 3	17968.	17936.	15845.	17952.	17874.	17821.	17770.	17663.	17562.
BORO 4	17961.	17835.	14566.	17812.	17707.	17635.	17473.	17273.	17091.
HYV AUS 1	17901.	16930.	5670.	17090.	14559.	13010.	12491.	10245.	9394.
HYV AUS 2	17862.	14552.	3312.	14470.	12460.	11930.	10699.	6464.	5762.
HYV AUS 3	17214.	10578.	3236.	11483.	8442.	6965.	5793.	5001.	4551.
HYV AUS 4	16555.	7334.	2816.	7075.	5507.	5046.	4685.	4012.	3798.
HYV AUS 5	15187.	7171.	2483.	6930.	5166.	4457.	4375.	3908.	3706.
LT AUS 1	17963.	17825.	14666.	17823.	17627.	17260.	17061.	16917.	16646.
LT AUS 2	17932.	17537.	8208.	17597.	16670.	15832.	15390.	13710.	12879.
LT AUS 3	17910.	16616.	4516.	16603.	15485.	15218.	14153.	9364.	8358.
LT AUS 4	17625.	14026.	4407.	14796.	11673.	10105.	8558.	7369.	6742.
LT AUS 5	17379.	10471.	3736.	10158.	8038.	7259.	6838.	5737.	5357.
LT AMAN 1	17585.	14112.	2337.	14531.	11977.	10490.	7234.	5291.	4649.
LT AMAN 2	17503.	10768.	1122.	12276.	9788.	5960.	4926.	3501.	3069.
LT AMAN 3	16616.	7714.	1016.	10154.	4997.	4470.	4294.	2895.	2562.
LT AMAN 4	14712.	5826.	1690.	6261.	4572.	4340.	4062.	3146.	2944.
LT AMAN 5	17148.	7894.	1690.	8431.	6933.	5262.	4967.	3675.	3333.
LT AMAN 6	17398.	8934.	1690.	10041.	7756.	6011.	5105.	3985.	3592.
B AUS 1	17964.	17903.	17071.	17894.	17834.	17800.	17766.	17718.	17692.
B AUS 2	17962.	17811.	14666.	17811.	17625.	17260.	17061.	16890.	16643.
B AUS 3	17932.	17537.	8208.	17597.	16670.	15832.	15390.	13710.	12879.
B AUS 4	17910.	16607.	4516.	16570.	15438.	15218.	14153.	9348.	8346.
B AUS 5	17962.	17811.	14666.	17811.	17625.	17260.	17061.	16890.	16643.
DWB AMAN 1	17906.	17702.	10377.	17754.	17591.	17426.	17123.	16155.	15650.
DWB AMAN 2	17906.	17671.	10377.	17733.	17557.	17426.	17123.	16106.	15591.
DWB AMAN 3	17900.	17597.	10377.	17655.	17403.	16678.	16093.	15635.	14979.
DWT AMAN 4	17900.	17597.	10377.	17655.	17403.	16678.	16093.	15635.	14979.
DWT AMAN 5	17885.	17402.	9421.	17537.	17209.	15742.	14630.	14217.	13334.
DWT AMAN 6	17841.	17098.	8285.	17287.	15772.	14520.	13890.	12770.	12012.

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TABLE B.4.8

Example Output - Cropping Analysis by Percentage Area

Project area   Area A1

NCA = 17971.00 (ha)

GCA = 22891.00 (ha)

Percentage of NCA on which crop can be safely grown

	Return Period (years)								
	Min .	Mean	Max.	2	3	4	5	8	10
HYV AMAN 1	92.	42.	6.	57.	25.	24.	21.	16.	14.
HYV AMAN 2	76.	29.	6.	31.	25.	22.	21.	15.	14.
HYV AMAN 3	84.	32.	7.	36.	26.	25.	23.	16.	15.
HYV AMAN 4	93.	37.	7.	40.	31.	26.	24.	18.	16.
BORO 1	100.	100.	96.	100.	100.	100.	100.	100.	100.
BORO 2	100.	100.	95.	100.	100.	100.	100.	100.	99.
BORO 3	100.	100.	88.	100.	99.	99.	99.	98.	98.
BORO 4	100.	99.	81.	99.	99.	98.	97.	96.	95.
HYV AUS 1	100.	94.	32.	95.	81.	72.	70.	57.	52.
HYV AUS 2	99.	81.	18.	81.	69.	66.	60.	36.	32.
HYV AUS 3	96.	59.	18.	64.	47.	39.	32.	28.	25.
HYV AUS 4	92.	41.	16.	39.	31.	28.	26.	22.	21.
HYV AUS 5	85.	40.	14.	39.	29.	25.	24.	22.	21.
LT AUS 1	100.	99.	82.	99.	98.	96.	95.	94.	93.
LT AUS 2	100.	98.	46.	98.	93.	88.	86.	76.	72.
LT AUS 3	100.	92.	25.	92.	86.	85.	79.	52.	47.
LT AUS 4	98.	78.	25.	82.	65.	56.	48.	41.	38.
LT AUS 5	97.	58.	21.	57.	45.	40.	38.	32.	30.
LT AMAN 1	98.	79.	13.	81.	67.	58.	40.	29.	26.
LT AMAN 2	97.	60.	6.	68.	54.	33.	27.	19.	17.
LT AMAN 3	92.	43.	6.	57.	28.	25.	24.	16.	14.
LT AMAN 4	82.	32.	9.	35.	25.	24.	23.	18.	16.
LT AMAN 5	95.	44.	9.	47.	39.	29.	28.	20.	19.
LT AMAN 6	97.	50.	9.	56.	43.	33.	28.	22.	20.
B AUS 1	100.	100.	95.	100.	99.	99.	99.	99.	98.
B AUS 2	100.	99.	82.	99.	98.	96.	95.	94.	93.
B AUS 3	100.	98.	46.	98.	93.	88.	86.	76.	72.
B AUS 4	100.	92.	25.	92.	86.	85.	79.	52.	46.
B AUS 5	100.	99.	82.	99.	98.	96.	95.	94.	93.
DWB AMAN 1	100.	99.	58.	99.	98.	97.	95.	90.	87.
DWB AMAN 2	100.	98.	58.	99.	98.	97.	95.	90.	87.
DWB AMAN 3	100.	98.	58.	98.	97.	93.	90.	87.	83.
DWT AMAN 4	100.	98.	58.	98.	97.	93.	90.	87.	83.
DWT AMAN 5	100.	97.	52.	98.	96.	88.	81.	79.	74.
DWT AMAN 6	99.	95.	46.	96.	88.	81.	77.	71.	67.

TABLE B.4.9

Example Output - Fisheries Analysis by Area

Flood Phase analysis

Analysis for A1N1E

NCA = 1539.00 (ha)
GCA = 1866.00 (ha)

Water levels based on 1:5 year levels

Area flooded in flood categories - Area
Flood categories

Month	10 day	F0	>F0
4	1	1539.	0.
4	2	1539.	0.
4	3	1532.	7.
5	1	1525.	14.
5	2	1495.	44.
5	3	1503.	37.
6	1	1464.	75.
6	2	1400.	139.
6	3	1298.	241.
7	1	504.	1035.
7	2	2.	1537.
7	3	47.	1492.
8	1	1.	1538.
8	2	0.	1539.
8	3	0.	1539.
9	1	0.	1539.
9	2	0.	1539.
9	3	2.	1537.
10	1	482.	1057.
10	2	1273.	266.
10	3	1458.	81.
11	1	1518.	21.
11	2	1533.	6.
11	3	1537.	2.
12	1	1539.	0.
12	2	1539.	0.
12	3	1539.	0.
1	1	1539.	0.
1	2	1539.	0.
1	3	1539.	0.
2	1	1539.	0.
2	2	1539.	0.
2	3	1539.	0.
3	1	1539.	0.
3	2	1539.	0.
3	3	1539.	0.

Note : all areas in hectares

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TABLE B.4.10

Example Output - Fisheries Analysis by Percentage Area

Analysis for A1N1E

NCA = 1539.00 (ha)

GCA = 1866.00 (ha)

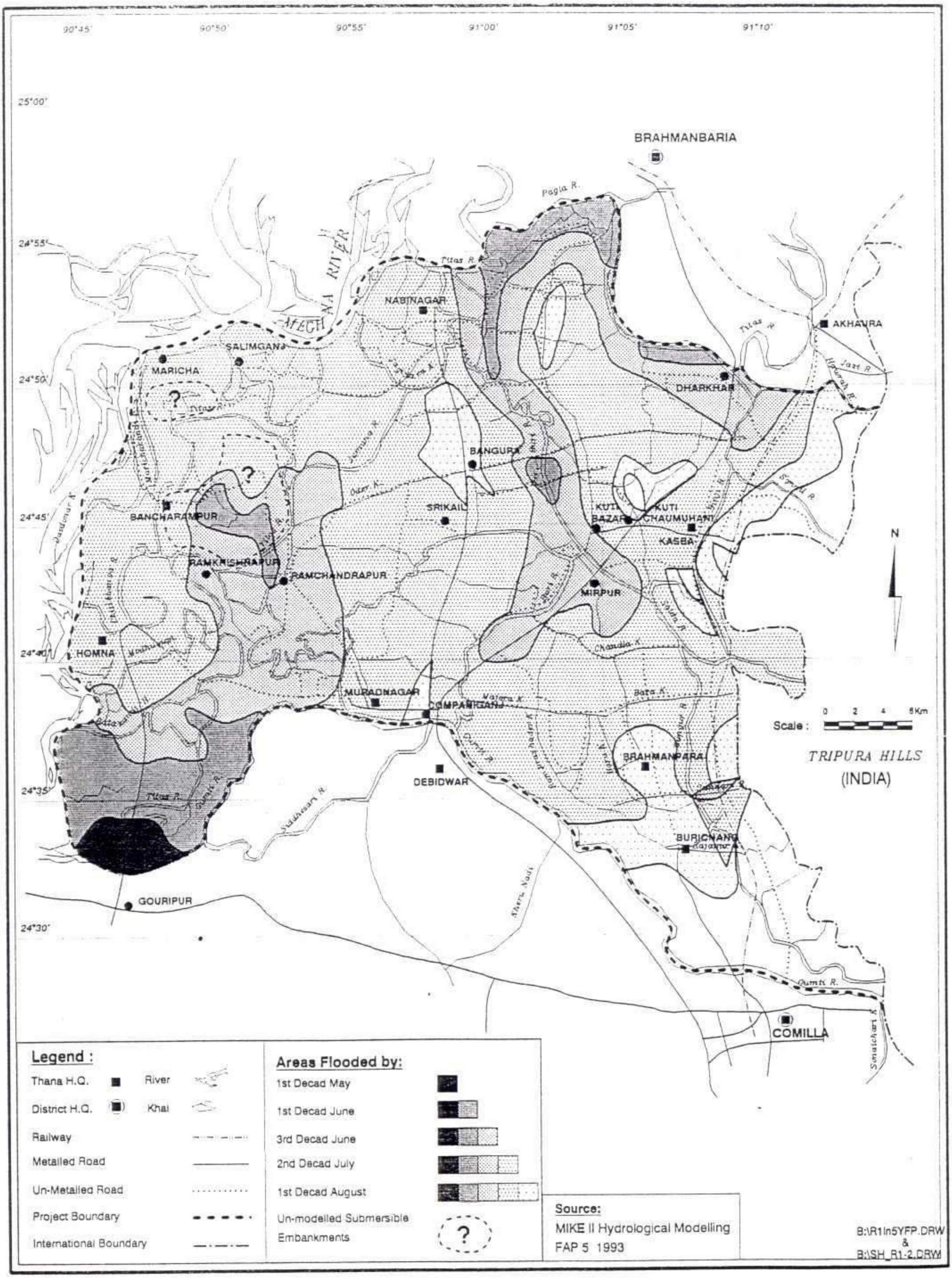
Water levels based on 1:5 year levels

Area flooded in flood categories - Area
Flood categories

Month	10 day	F0	>F0
4	1	100	0
4	2	100	0
4	3	100	0
5	1	99	1
5	2	97	3
5	3	98	2
6	1	95	5
6	2	91	9
6	3	84	16
7	1	33	67
7	2	0	100
7	3	3	97
8	1	0	100
8	2	0	100
8	3	0	100
9	1	0	100
9	2	0	100
9	3	0	100
10	1	31	69
10	2	83	17
10	3	95	5
11	1	99	1
11	2	100	0
11	3	100	0
12	1	100	0
12	2	100	0
12	3	100	0
1	1	100	0
1	2	100	0
1	3	100	0
2	1	100	0
2	2	100	0
2	3	100	0
3	1	100	0
3	2	100	0
3	3	100	0

Note : all figures in percent

Figure B.4.4
Rising 1 in 2 Year Flood Pattern



B.5 Development and Calibration of Gumti Phase II Model

B.5.1 Introduction

This Chapter covers the development and calibration of the Gumti Phase II hydraulic model. The modelled area is bounded to the south by the Gumti River, to the west by the Meghna River, to the north by the Titas (or Pagla) River and to the east by the border with India. The development and calibration of the model was carried out by the SWMC as part of their work on the South East Regional Model (Ref. 5.1); no further development and calibration was undertaken by the Gumti Phase II modelling team.

Hydraulic conditions in the modelled area are dominated by the Meghna River. In the east, most of the rivers coming from India are flashy in nature. Except for the Gumti, these rivers do not generate any significant discharge during the dry period. The rivers in the north west may be treated as tributaries to the Titas. The Gumti is embanked on both sides from the Indian border to downstream of Jibanpur.

The model was originally calibrated for the period from the monsoon 1986 to December 1987; calibration was against both wet and dry season conditions. Subsequently the calibration period was extended to the end of the 1988 monsoon season. The model was verified for the period January 1990 to March 1991.

The calibrated and verified model which was received from the SWMC was used in the 25 year simulation run for a future 'without' project condition; this simulation is reported in Chapter B.6.

B.5.2 Data Sources

The Bangladesh Water Development Board (BWDB) maintains a countrywide data collection network. In order to calibrate the hydrodynamic model a more uniform and denser distribution of collection stations was established by the SWMC.

B.5.2.1 Topographic

Cross section surveys were carried out on behalf of the SWMC during 1986; a large number of these were remeasured during 1987. Important cross-sections were updated further during 1988, 1990 and 1991.

The flood plain levels were obtained from the MPO square kilometre grid. During the river survey spot levels were taken on the flood plain adjacent to the rivers to ensure continuity of datums between the river sections and the flood plain levels.

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B.5.2.2 Hydrometric

BWDB maintains 3 regular discharge measuring stations in the region, two of these are on the Gumti and one at Gangasagar on the Hawrah. Additional discharge stations were established during the monsoon seasons on 1986, 1987, 1988 and 1990 to provide further data for model calibration and verification.

Water level gauging stations were established by the SWMC during 1986, 1987, 1988 and 1990 to augment the BWDB monitoring stations. The water level collection programme was predominantly during the monsoon season. The number of water level monitoring points was reduced by eliminating locations where water level fluctuations were small or the channels were frequently dry.

B.5.3 Model set-up

B.5.3.1 Channel and Floodplain Network

To select the channels for the model several criteria were applied,

- the importance of the channel in terms of drainage
- the possibility that the channel serves as an important route for flood water from outside the area
- the importance of channels which serve as links between two significant areas of water
- the importance of the channels in future developments

The schematisation was based on topographic maps with reference to aerial photographs and satellite images to give more up to date information.

Floodplain geometry is attached to the river cross-sections to accurately represent overland flow and storage available at high flood levels. The boundaries of the flood plain cells are selected on the basis of the flow direction in the flood plain determined from land contours and the orientation of road, rail and flood defence embankments. The resistance to flow on the flood plain is higher than that of the river owing to the irregular surface and vegetation.

The scheme plan of the Gumti Phase II model is shown in Figure B.5.1. While the basic information is one dimensional, the construction of a dense network based on the rivers and khals of the region introduces a quasi two dimensional aspect to the model. This allows the simulation of the one dimensional dry season flow and the more two dimensional monsoon season flow.

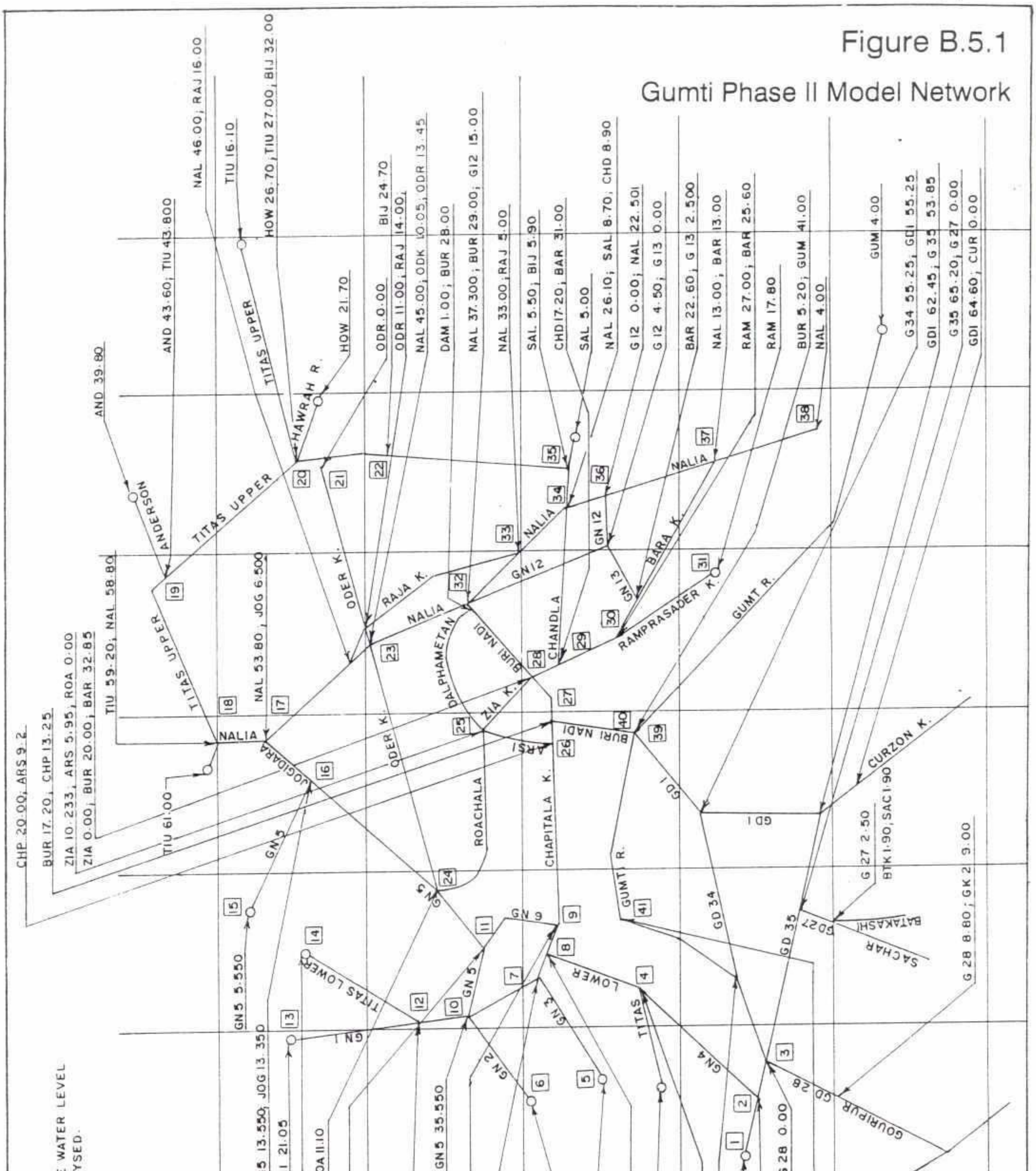

Figure B.5.1

Gumti Phase II Model Network

B.5.3.2 NAM Connection

The hydrodynamic model includes the NAM generated runoff in terms of discharge from the NAM catchments in its computations. The runoff is distributed among a particular reach or reaches of the river system, or throughout the entire river system within the catchment area.

B.5.3.3 Model Boundaries

There are 15 external boundaries in the Gumti Phase II model, the schematic location of the boundaries can be seen on Figure B.5.1.

Water level boundary conditions are used at locations on the Meghna River and rivers close to the Meghna. Discharge boundary conditions are used at the upstream boundaries. The upstream boundaries mainly represent cross border flows from the Tripura Hills in India. Only one of these flows, on the Gumti at Comilla, is gauged. Different methods of representing the flows in the other rivers were investigated during the baseline simulations and is described in Chapter B.6.

B.5.3.4 Structures

There are a number of bridges and culverts in the Gumti Phase II area. During the 1986 data collection period water level gauges were installed upstream and downstream of major bridges over the schematised channels. Observed head losses were negligible and the structures were omitted.

B.5.4 Calibration

The model was originally calibrated for the period from the monsoon 1986 to December 1987; calibration was against both wet and dry season conditions. Subsequently the calibration period was extended to the end of the 1988 monsoon season.

The detailed results of the model calibration are presented in the SWMC South East Regional Model Verification Report (Ref. 5.1). In general the monsoon season calibration of the model is good both in terms of water levels and, at the few locations where data is available, in terms of discharges. Most minor channels dry up during the dry period and numerous temporary cross dams are built in the medium channels to lift water by low lift pumps for irrigation. The calibration for the dry season is difficult to ascertain. The model can become unstable during a sudden shift from a dry to wet condition. This can only be overcome by running the model for short time steps for these short transition periods.

B.5.5 Verification

The model was verified for the period January 1990 to March 1991. The model shows a good comparison with the observations at most of the calibration points. The results of the verification are presented in the SWMC report.

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B.6 Gumti Phase II Model - Without Project Condition

B.6.1 Introduction

The calibrated and verified model which was received from the SWMC was used in the 25 year simulation run for a future 'without' project condition. This simulation was of present conditions in the modelled area; it incorporates all existing developments.

It must be stressed that the objective of the Without Project simulation was not to simulate observed water level and discharge variations over the 25 year period from 1965 to 1989. It was to produce data on water level and discharge variations over a period of 25 hydrological years.

This simulation provides baseline data for investigating and comparing the impacts of developments proposed as part of the Gumti Phase II project.

B.6.2 Meghna Boundary Conditions

A time series for water levels along the Meghna is necessary for the 25-year period of the baseline tests. These may either be produced from reliable long water level records or taken from simulations with the general model produced by FAP 25.

B.6.2.1 Water Level Observations

Missing Data at Daudkandi

The observations at Daudkandi are incomplete with a significant gap in the data in the early 1980's. If this record is to be used in determining the boundary data for the Gumti Phase II analysis, then the missing record must be infilled. Two possible means are the use of the GM results at Daudkandi for the period in question or the use of a correlation between Daudkandi and Nabinagar where the record is complete. Hence the correlation between the two sites has been investigated for both the GM results and the observed record. Figure B.6.1 shows the correlation for average daily levels from the observations, note the scatter about the mean especially in the dry season. Figure B.6.2 shows the same information for the GM simulations and although, the mean relationship is similar, the distribution of the scatter in the results is different. The correlation is sharp in the dry season and deteriorates in the high monsoon. Neither plot shows a linear relationship between the two locations, rather in the dry season the levels are nearly equal, between stages of about 3 m and 4.5 m PWD at Nabinagar an increasing head difference between the sites develops and above 4.5 m PWD at Nabinagar there is a nearly constant head difference of about 1.2 m. This is consistent with the Upper Meghna being under the backwater control of the Padma in the dry season and the head difference arising in the Monsoon when there are substantial flows from the Upper Meghna catchments. The lack of scatter in the dry season in the simulations, shown in Figure B.6.2, is a consequence of the hydraulic model assumptions of fixed geometry, fixed roughness and no atmospheric influence. These are, of course, entirely reasonable given the objectives of the GM. However, it makes the use of the GM results or a fixed correlation based on the GM or data open to significant margin of uncertainty if these are used to infill the missing years in the Daudkandi record.

Figure B.6.1

Correlation of Water Level Observations at Daudkandi and Nabinagar

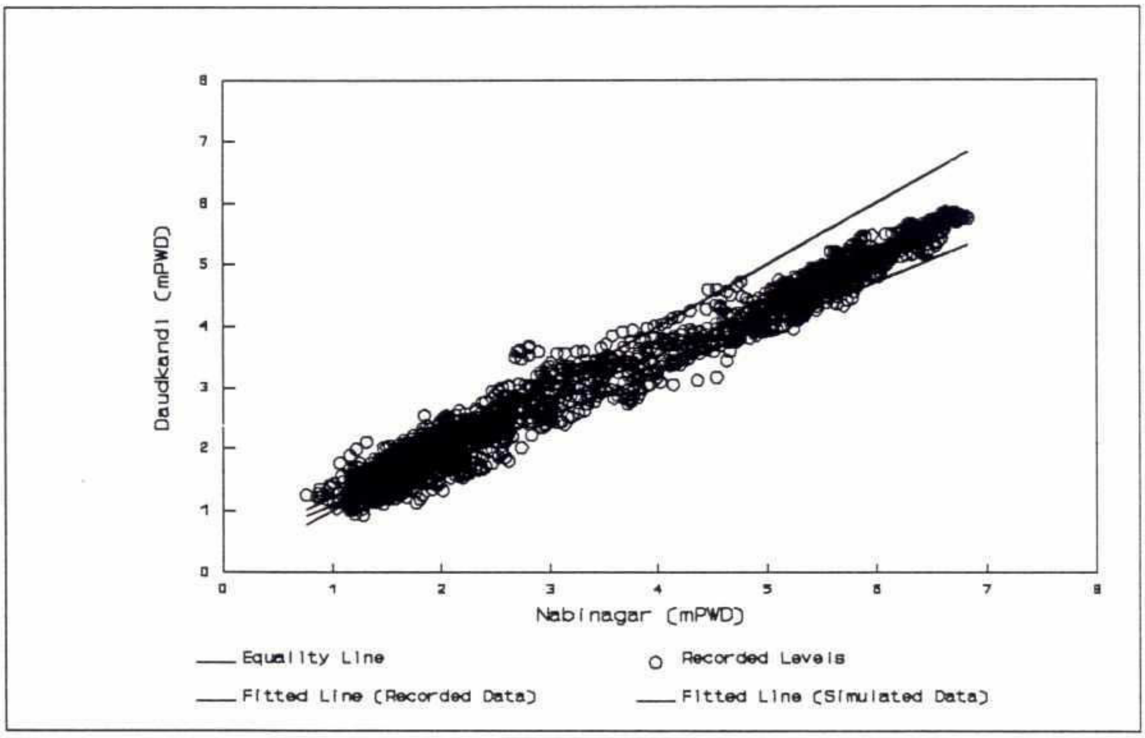
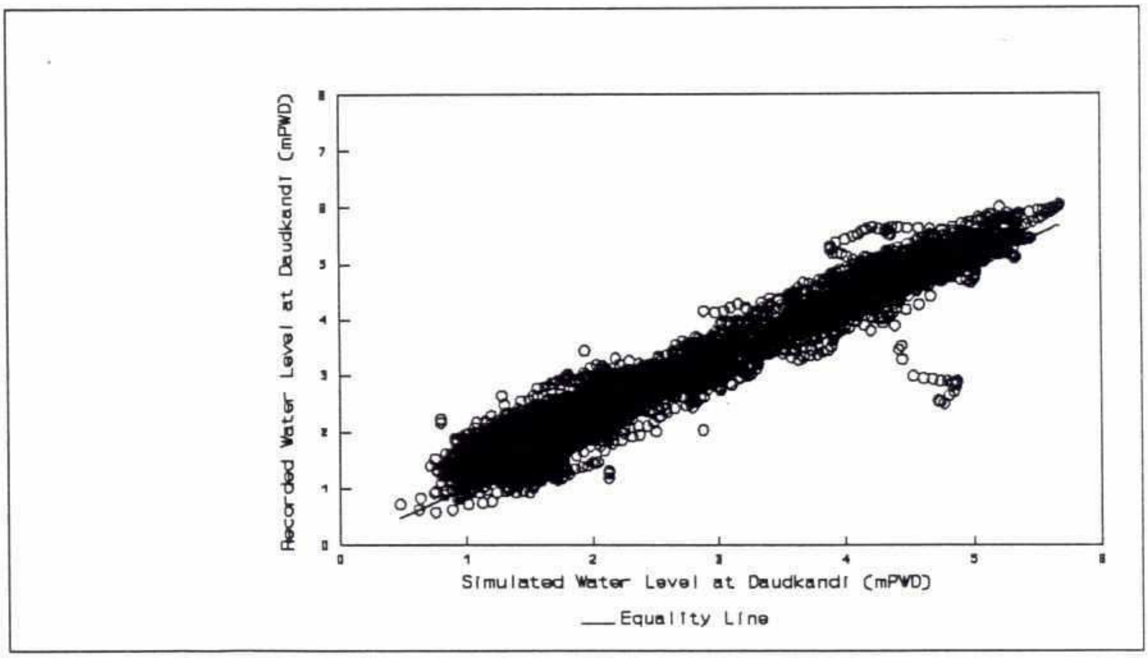


Figure B.6.2

25 Years of Water Level Correlation at Daudkandi for GM and Observations



Interpolation of Meghna levels

In addition to the infilling of missing data at Daudkandi a further problem arises if observed water level data at Daudkandi and Nabinagar is to be used. The Gumti Phase II model requires water level data at six points on the Meghna between Daudkandi and Nabinagar, and at one point on the Meghna upstream of Nabinagar. Since the only observed water levels are at Daudkandi and Nabinagar these would have to be used to generate the water levels at these seven points. Since data only exists at two points this would have to be done by linear interpolation. Since the hydraulic gradient between Daudkandi and Nabinagar is not constant with time this would be subject to some error. In particular the extent of the backwater control from the Padma will vary with time, this will mean that the hydraulic gradient is likely to be flat for some distance upstream of Daudkandi and then it will become steeper as the backwater effect dies out; it will not be possible to take this into account during the linear interpolation.

B.6.2.2 FAP 25 General Model Run 6

FAP 25 have a version of the General Model which is being run for 25 years to provide boundary conditions for the baseline and development scenario runs of the regional models. This model is also being used to investigate the impact of interventions on the major rivers.

Run 6 of the FAP 25 General Model (GM6) shows some systematic bias in the Meghna around the Gumti-II project area. The evidence for this is as follows.

(1) An analysis of decad (10 day average) water levels at Nabinagar shows that whilst the monsoon peak water level is represented reasonable well the rise of the flood occurs too early; this problem is at its worst for the 1 in 20 year flood when the rise is approximately 10 to 15 days early. Figure B.6.3 shows the comparison of the GM6 results with observations at Nabinagar, analysed for average decad water levels.

(2) A correlation between the observed and recorded daily water level at Nabinagar, for 1965, gives the same message. In the dry season, level less than about 3 m PWD, the plot of observed against simulated, Figure B.6.4 for the 1965 water year, shows scatter but without a systematic pattern. On the rising limb of the flood hydrograph the water levels are consistently above observation, around the flood peak the model is well calibrated, on the recession the simulation lies consistently below the observations.

(3) A plot of 25 years of data and simulations for Nabinagar, Figure B.6.5, shows a similar picture, but with obviously more scatter. Note the "hole" in the centre of the plot for stage around 4.5 m PWD, showing that this behaviour occurs consistently in all seasons.

(4) For low return period events GM6 gives close agreement to the observed peak monsoon water level at Daudkandi. As the return period increases GM6 tends to underestimate the peak monsoon water level (see Figure B.6.6).

Figure B.6.3

Frequency Analysis at Nabinagar for GM and Observations

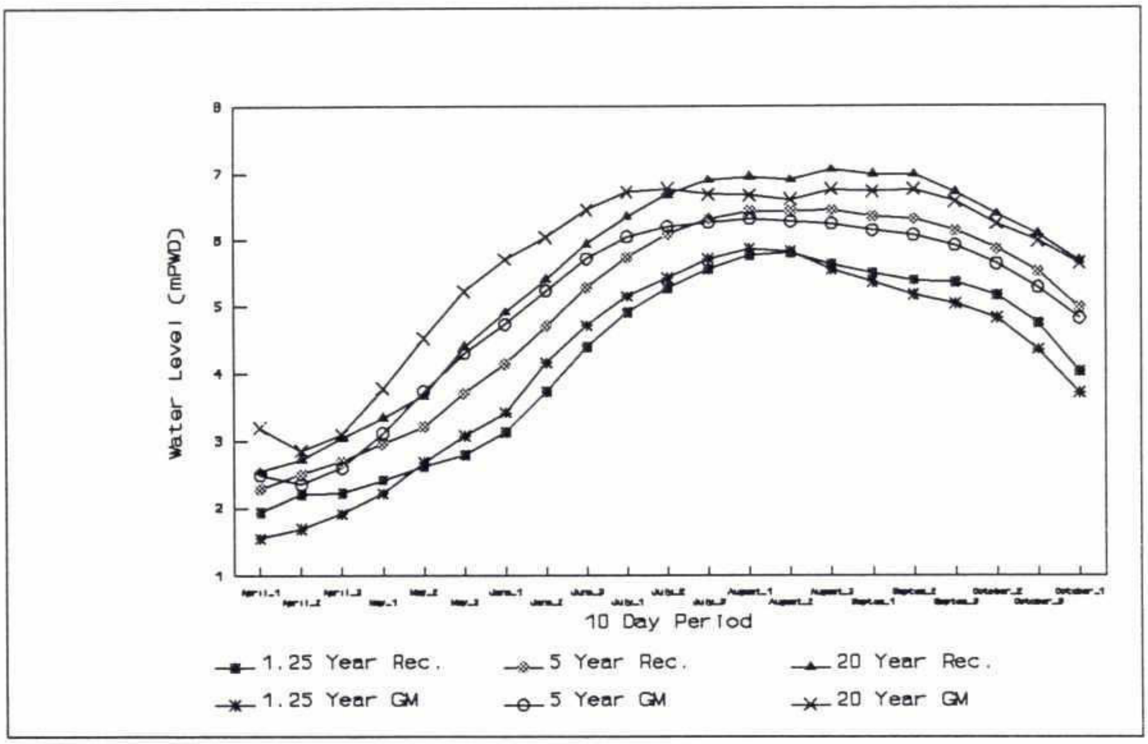


Figure B.6.4

Nabinagar Water Level Correlation for GM and Observations

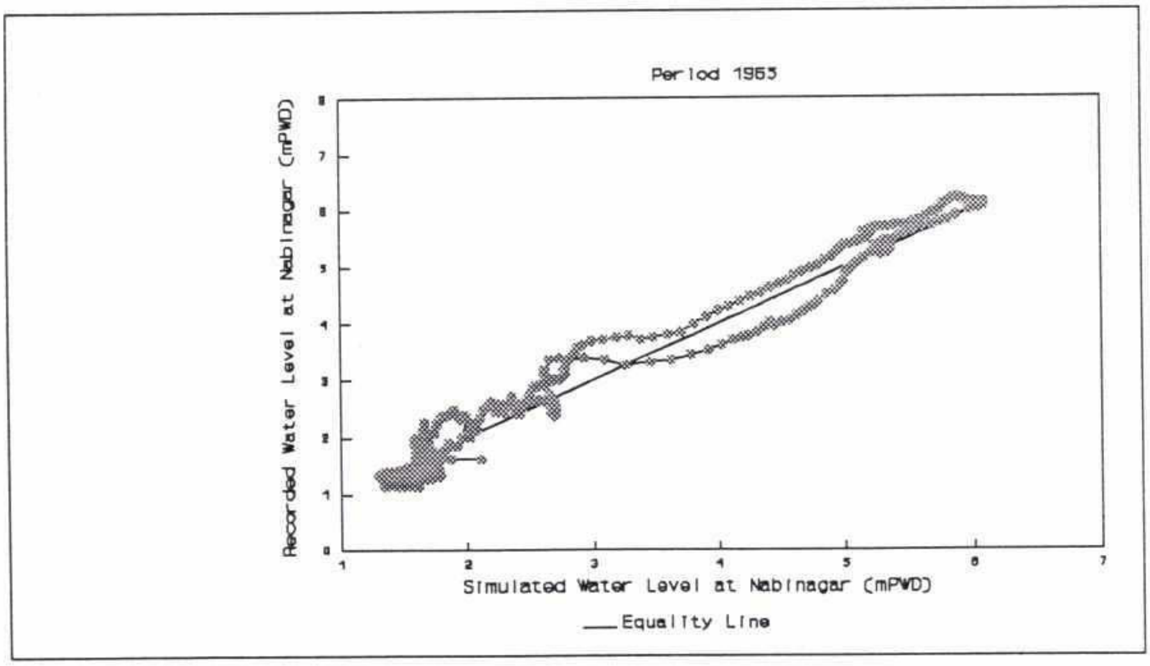


Figure B.6.5

25 Years of Water Level Correlation at Nabinagar GM and Observations

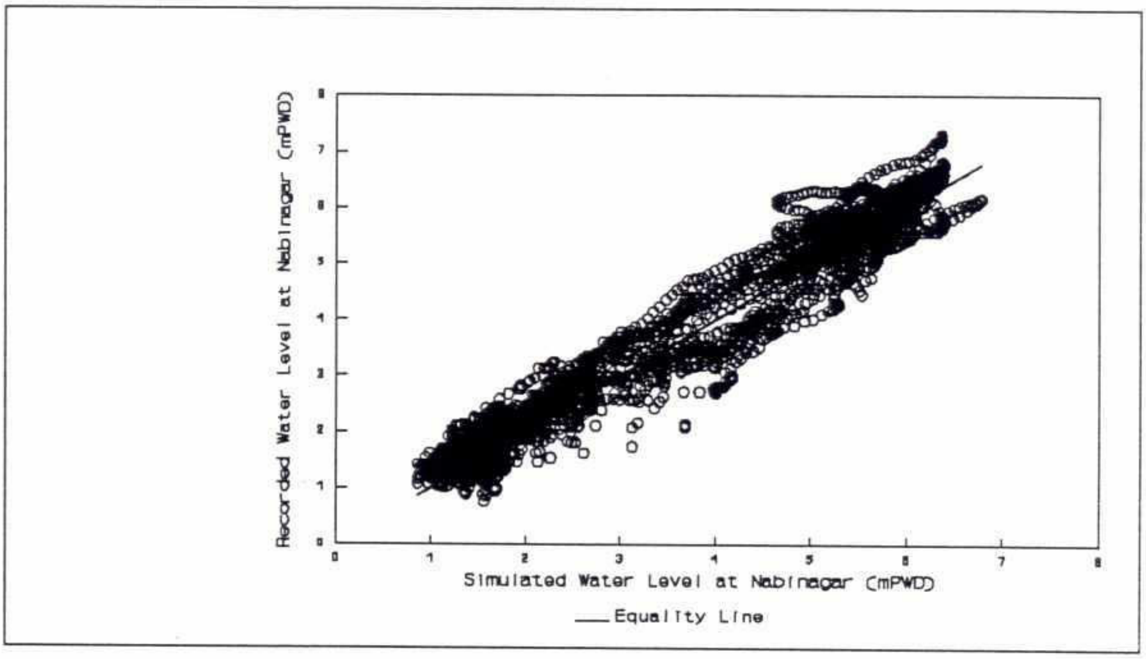
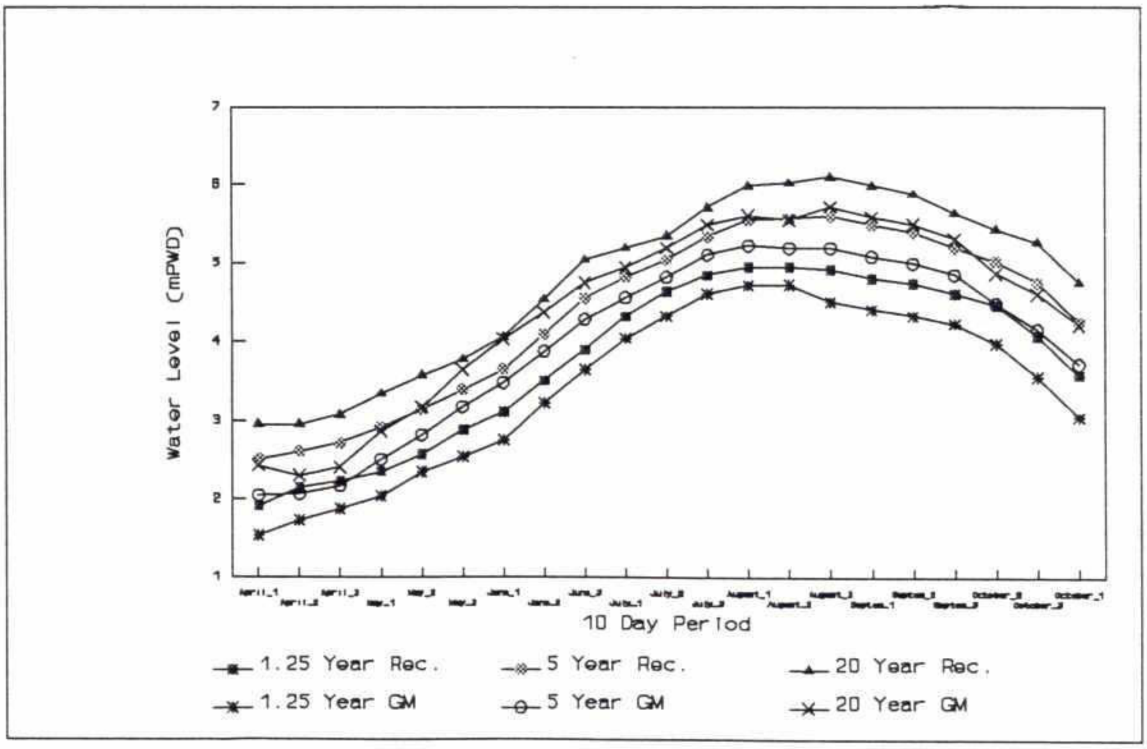


Figure B.6.6

Frequency Analysis at Daudkandi for GM and Observations



An explanation of these phenomena is that, although the GM6 is reasonably calibrated at flood stage, it contains insufficient storage in the upper reaches of the river systems. Thus the floods arrive too soon and recede too early. Figure B.6.3 suggests that the rise was about 10 days too early. The timing difference on the recession is smaller being less than 5 days.

Plots of the GM6 results at Daudkandi show similar behaviour. In the simulation, the timing of the monsoon rise and fall appears to match the observations, Figure B.6.6, and there is no loop evident on the plot of simulated against observed levels, Figure B.6.2. At Daudkandi there does appear to be a systematic difference in level between the observations and predictions. The most likely explanation for this is that the site of GM results associated with Daudkandi is not correct. The absence of the loop on the simulated results at Daudkandi is consistent with the lack of storage in the GM suggested above being located in the Upper Meghna model rather than on the Jamuna or Ganges. At Daudkandi GM6 under estimates the monsoon peak water level for all return periods, as shown in Figure B.6.6.

B.6.2.3 FAP 25 General Model : Revised Run 6

There are uncertainties associated with either choice of representation of the boundary conditions for the Gumti-II project model. These points were discussed in detail with the staff of the SWMC to determine the best way forward for the project.

It was decided to undertake a new run of the FAP 25 General Model, GM6R, to provide the Meghna boundary conditions for the Gumti Phase II model. This model run incorporated an improved definition of the river system in the upper reaches of the Meghna based on the work of the NC and NE regional studies (FAP3 & FAP6). This was expected to improve the estimation of runoff from the NAM hydrological model which contributes about 30% of the total runoff and to improve the representation of the flood plain storage. Thus the performance of the GM at Nabinagar and Daudkandi is expected to improve. There has also been uncertainty about the survey datum of some water level gauges in the tidal reaches of the Lower Meghna, which are of relevance to the Noakhali North feasibility study of FAP5. These have been investigated by SWMC and were incorporated in run GM6R.

Figure B.6.7 shows a comparison of observed decad water levels, for different return periods, at Nabinagar, with those from GM6R. The rising limb of the monsoon hydrograph agrees much better with observed data than for GM6. The monsoon peak water levels are under estimated in GM6R.

Figure B.6.8 shows a comparison of observed decad water levels, for different return periods, at Daudkandi, with those from GM6R. As at Nabinagar the rising limb of the monsoon hydrograph agrees much better with observed data than GM6. The peak monsoon water levels in GM6R are higher than in GM6 but they are still a slight underestimate of the observed peak water levels.

Figure B.6.7

Comparison of Observed and Run GM6R Results for Nabinagar

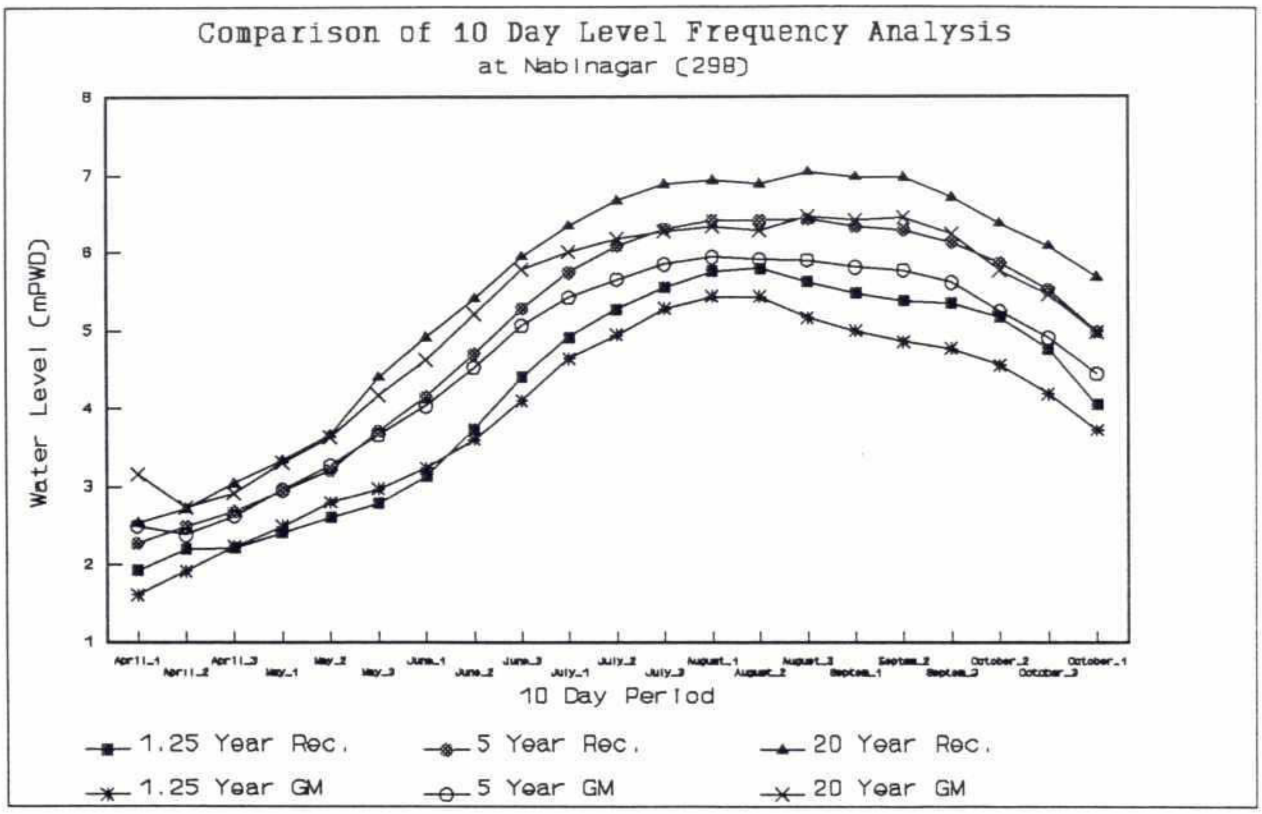
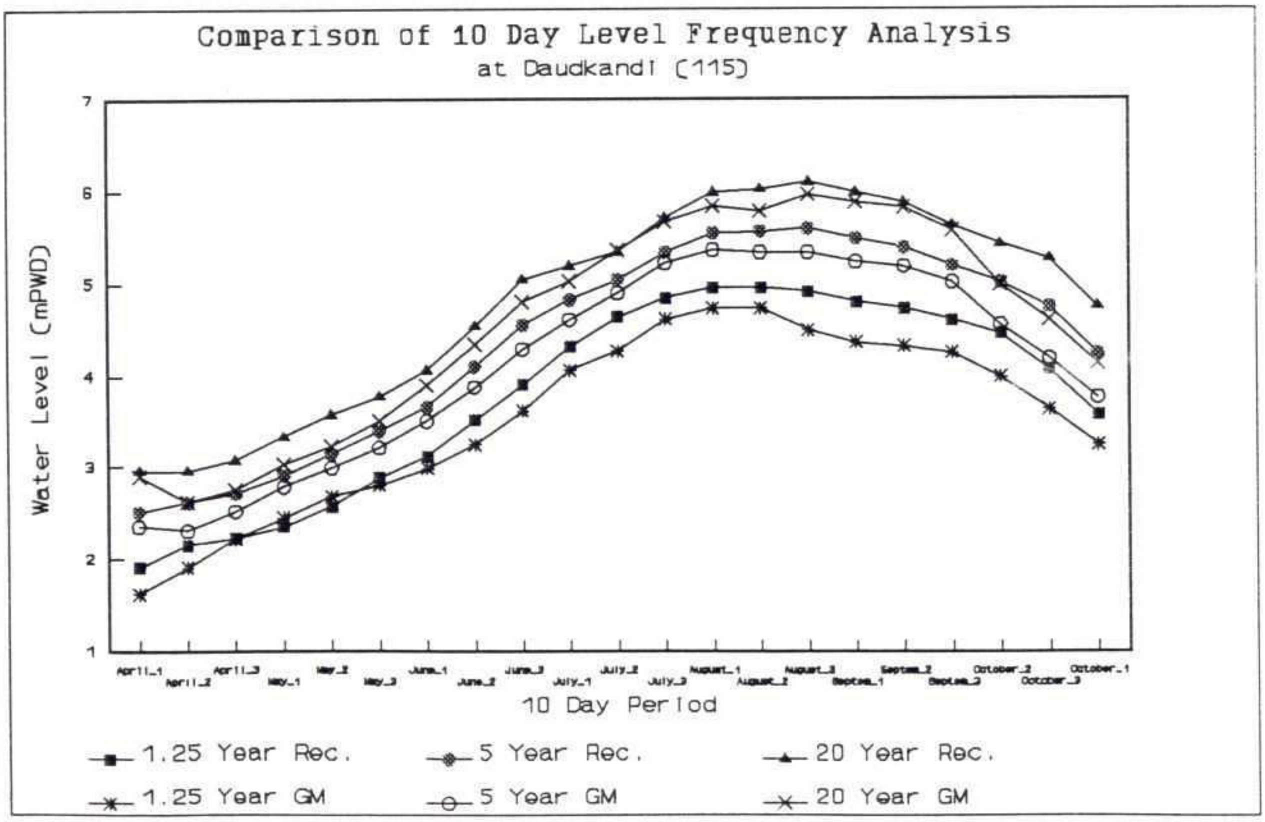


Figure B.6.8

Comparison of Observed and Run GM6R Results for Daudkandi



B.6.2.4 Conclusions

It was decided to use the results of the revised Run 6 of the FAP25 General Model, GM6R, to provide the boundary conditions for the baseline and development scenario simulations of the Gumti Phase II model.

There are several attractions to using the GM to define the boundary conditions around the Meghna, despite the difficulties described above.

(1) It will provide a 25-year time series of level data which are hydraulically consistent.

(2) It will provide a means of investigating the impact of the FAP3 and FAP6 proposals on the project area should these be commissioned as part of an inter-regional FAP study.

(3) It will reflect the behaviour of the major river system under the current geometry rather than under different states of historic development.

(4) The difficulties and associated errors with infilling the water level record at Daudkandi and interpolating between the observations at Daudkandi and Nabinagar will not have to be addressed.

GM6R was selected to provide the boundary conditions instead of GM6 for the following reasons,

- an improved fit to the rising limb of the monsoon water level hydrograph at both Daudkandi and Nabinagar,

- an improved fit to the peak monsoon water level at Daudkandi.

A problem with using the results of GM6R to provide boundary conditions for the Gumti Phase II model is that it gives an underestimate of the peak monsoon water levels at Nabinagar. This may influence the agricultural and fisheries analyses since it will result in an underestimate in the flooded depth and flooded area during the peak of the monsoon. This influence may not be very great since the lands adjacent to the Meghna are deeply flooded and hence an under estimate of the flooded depth may not affect the agricultural productivity or the fisheries potential. Both activities may be equally or more affected by the incorrect timing of the rising of the monsoon flood which is seen in GM6.

B.6.3 Flows from Ungauged Catchments

The 25 year baseline simulation requires an estimate of the inflows from the catchments in the Tripura Hills in India. Flows in the Sonai-Chara, Sundari, Salda, Sonai and Hawrah are required for the model. Flows in these channels are of particular importance during the pre-monsoon period when the levels in the Meghna are relatively low. Two options are available for estimating these flows:

1. NAM - the NAM rainfall-runoff model generates the hydrological response based on the catchment characteristics. Assumptions are necessary in developing NAM for the catchments concerned given the paucity of data available from the Indian side of the border. Some preliminary estimates of inflow using NAM showed a less flashy response than is evident from the short term record at the Salda gauging station. Experiences on the North West Regional Study (FAP2) indicated that large margins of uncertainty are possible when NAM is applied with insufficient calibration data. Theoretically adjustment of the shape of the response of the smaller catchments could be based on physical characteristics of the drainage basins but there is insufficient information readily available to do this.

2. Catchment area weighting - A complete 25 year discharge record exists at Comilla on the Gumti which also drains from the Tripura Hills. Flows from the other catchments can be estimated by catchment area weighting of these flows. Some criticism of this method may be justified in that it assumes that the rainfall, percentage runoff and time of concentration for each of the catchments is effectively the same.

The uncertainties introduced by using catchment area weighting are, in our view, no greater than that introduced by the assumptions necessary in developing NAM hydrological response models for the catchments concerned given the paucity of data available from the Indian side of the border. The catchment area ratios used for the eastern tributaries to the Gumti-II project area are given in Table B.6.1.

TABLE B.6.1

Catchment Area Ratios

Catchment	Area (km^2)	Ratio to Comilla
Gumti	2173	1.0000
Pagli	73	0.0336
Ghungur	60	0.0276
Salda	447	0.2057
Sonai	176	0.0810
Hawrah	496	0.2283

The value estimated for the Salda corresponds well to the range found in the Howard Humphreys (HHP) study reported in 1990 (Ref 3.1); there the overall ratio between Comilla and Salda was 0.27 based on double mass analysis of annual hydrographs. When unreliable flow estimates in the dry season were eliminated, the correlation between the two gauges was found to improve and the ratio of the flows in the two rivers reduced to between 0.15 and 0.20 for flood conditions. This adds confidence to the approach recommended above for the Gumti-II feasibility study.

Two model simulations were carried out to investigate the different treatment of the inflow from the Tripura Hills in India. In one this is estimated using NAM and in the other it is computed on a catchment area basis from the recorded flows for the Gumti at Comilla. These simulations indicated that the catchment area weighting method gave a much more flashy response than the use of NAM; this is what is expected. Because of the dominant backwater effect in the area the choice of method for simulating the inflows from the ungauged catchments in India has little impact on water levels.

B.6.4 Analysis of Results of Without Project Simulation

B.6.4.1 Water Levels

Water levels in the Gumti Phase II area are dominated by levels in the Meghna; when peak levels occur in the Meghna the area is effectively a huge lake. With the exception of the areas in the extreme east and south-east the backwater effect of the Meghna extends throughout the area.

In the pre-monsoon period, before the Meghna rises, the areas in the east and south-east are subject to flooding by flash floods from the catchments in the Tripura Hills.

Hydrological analysis was carried out on the 25 year time series of water levels at 41 key locations within the Gumti Phase II area. The results of the Without Project simulation were analysed on a 10 day basis to give minimum, mean and maximum water levels for each decad. In addition, return period water levels were calculated for 2, 5, 10, 20, 50 and 100 years.

The water levels with different return periods were compared with those calculated from observations; at the few locations where this was possible favourable agreement was found. In making such a comparison it must be recalled that the Without Project simulation assumes the conditions which existed during the calibration and verification period. In reality significantly different drainage patterns may have occurred in the past.

B.6.4.2 Discharge Distribution

The maximum discharges simulated in the Without Project run in the main channels and drainage routes in the Gumti Phase II area are shown in Figure B.6.9. In many of the channels flow occurs in different directions at different times of the year.

In the pre-monsoon period flows from the catchments in India are transferred to the Meghna via the Bijni and Nalia rivers. Only a little of the flow which enters the region in the south-east flows across Zone A and via the river system to the south of the Oder Khal to reach the Meghna between Homna and Daudkandi.

Once the Meghna rises, during June, flows in the Nalia reverse so that water enters the area from the Meghna. This water is transferred as flood plain flow and channel flow in the Oder Khal and the river system to the south to reach the Meghna between Homna and Daudkandi.

North of the Gumti right embankment the hydraulic conditions within the study area are extremely complex. In the pre monsoon water flow is dominantly from south to north whilst at the height of the monsoon it is from north to south and then from east to west; the study area acts as a major flow route from the Meghna upstream of Nabinagar to the Meghna downstream of Homna.

Hydrological analysis was carried out on the 25 year time series of discharges at key locations within the Gumti Phase II area. The results of the Without Project simulation were analysed on a 10 day basis to give minimum, mean and maximum water levels for each decad. In addition, return period water levels were calculated for 2, 5, 10, 20, 50 and 100 years.

B.6.4.3 Flood Phases

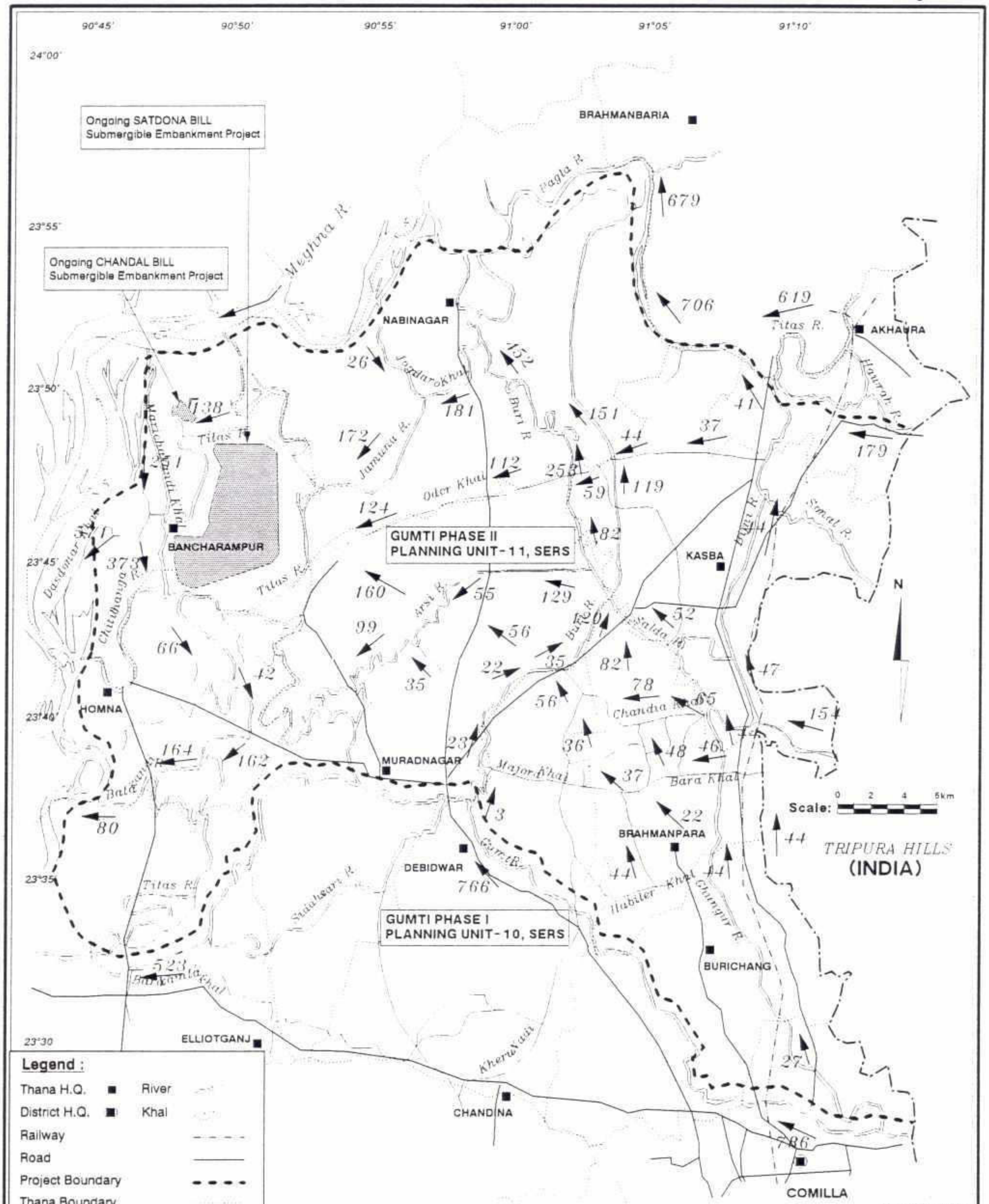
Table B.6.2 presents the model predicted flood phases, for the Without Project simulation, for the post-processing analysis areas in the Gumti Phase II area. These are the results for the decad with the deepest flooding. The percentages of inundation to 0.9 m are also graphically represented in Figure B.6.10, for the Without Project situation.

These clearly indicate that the worst flooded areas lie adjacent to the Meghna. The depth of flooding generally decreases in an easterly and south easterly direction. The shallowest depths of flooding occur in the east of the area where the topographic elevation tends to rise towards the Tripura Hills. The low lying areas in the east of the region suffer deep flooding because of flows from the Tripura Hills and drainage congestion as a result of the backwater effect from the Meghna.

These flood phase figures form a baseline against which proposed developments and scenarios may be assessed.

Figure B.6.9

Maximum Discharges (without Project)



Gumti Phase II - Without Project Inundation (F0 and F1)

Figure B.6.10

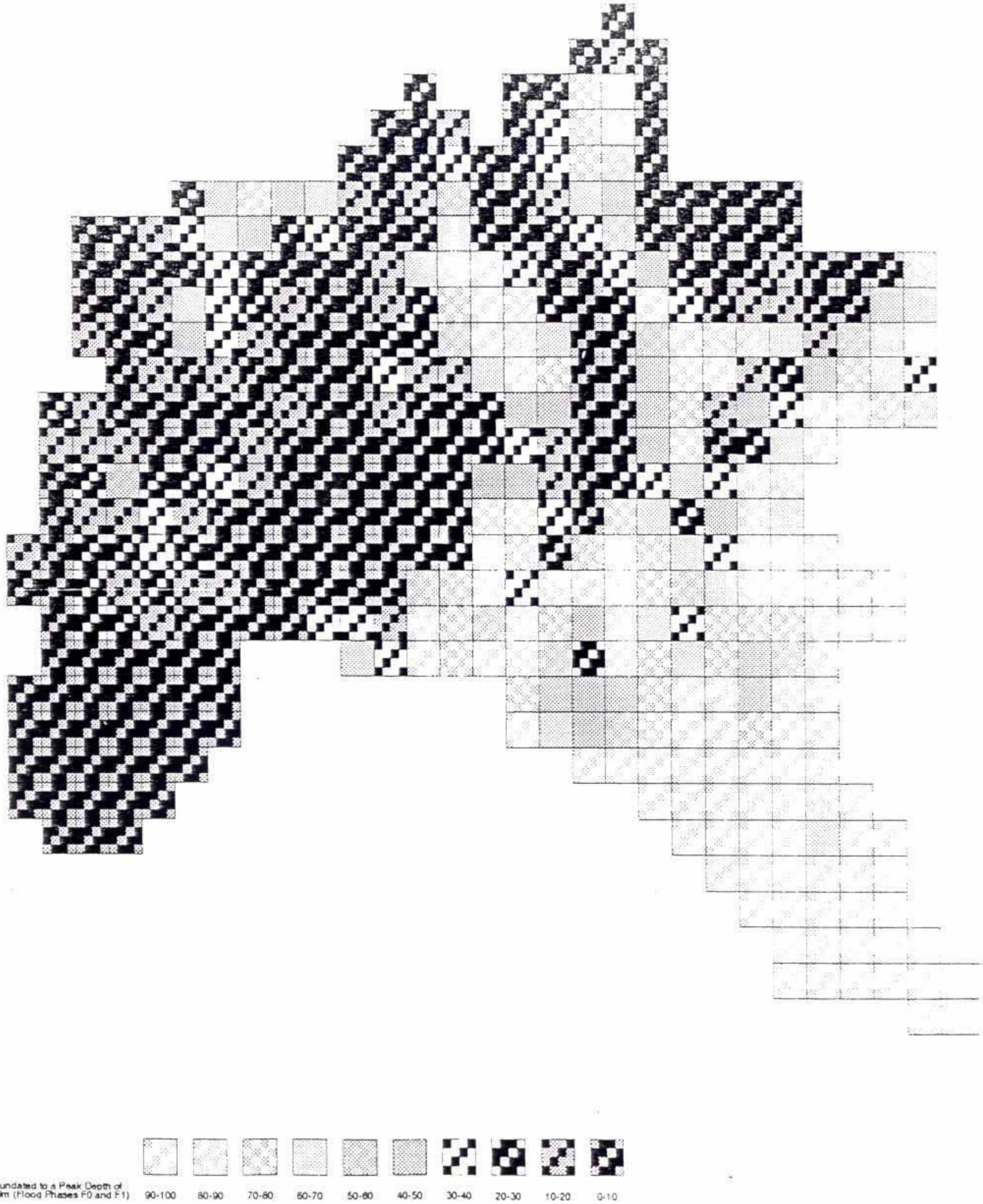


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TABLE B.6.2

Without Project simulation flood phases for Gumti Phase II area

AREA	MPO Flood Phase (%)			
	F0	F1	F2	F3+F4
A1	28	53	19	0
A2	71	24	5	0
B1	20	31	44	5
B2	0	2	44	54
B3	35	22	24	19
B4	4	13	46	37
B5	20	35	31	14
C1	2	11	67	20
C2	7	17	61	15
C3	10	32	42	16
C4	3	28	27	42
C5	3	9	48	40
D1	2	7	31	60
D2	4	13	42	41

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B.7 Gumti Phase II Model Design Option Simulations

B.7.1 Introduction

For the purposes of assessing the relative merits of different options prior to the With Project model run, which includes the selected options, model runs over periods shorter than 25 years were carried out.

The impact of the initial design options were investigated over the period from 1985 to 1989. This period was selected since it includes the best hydrological records and the channel topology will be closest to the present conditions. The 1985 to 1989 period includes a range of events with different return periods. 1987 was a extreme flood year because of the high internal rainfall whilst 1988 was a extreme year because of high levels in the external rivers. The high water levels in the external rivers were a result of simultaneous flood peaks in the Jamuna, Padma and Meghna; this resulted in a peak level in the Meghna higher than any other during the period from 1965 to 1989.

The final design option was investigated by carrying out a 25 year model simulation and comparing the results with the Without Project conditions.

B.7.2 Initial Design Options

The initial design options were conceived by taking account of the diverse situations which occur in the Gumti Phase II Project Area. For the purposes of selecting design options it is convenient to split the project area into four zones of flooding and agricultural type, these zones are shown in Figure B.7.1. It should be noted, however, that the zonal boundaries need not form a barrier to the boundaries of any scheme therein.

The proposed developments, determined mainly from public participation meetings, are presented below zone by zone and summarised in Table B.7.1. Figure B.7.2 is a diagram showing the initial design options.

B.7.2.1 Zone A

Design option simulation A1

This design option includes embankments on the left bank of the Ghungur and the right bank of the Buri Nadi; these embankments polder area A1. Drainage regulators are included in each embankment. The drainage regulators prevent water entering the area from the external rivers.

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Figure B.7.1

Location of Zone Boundaries

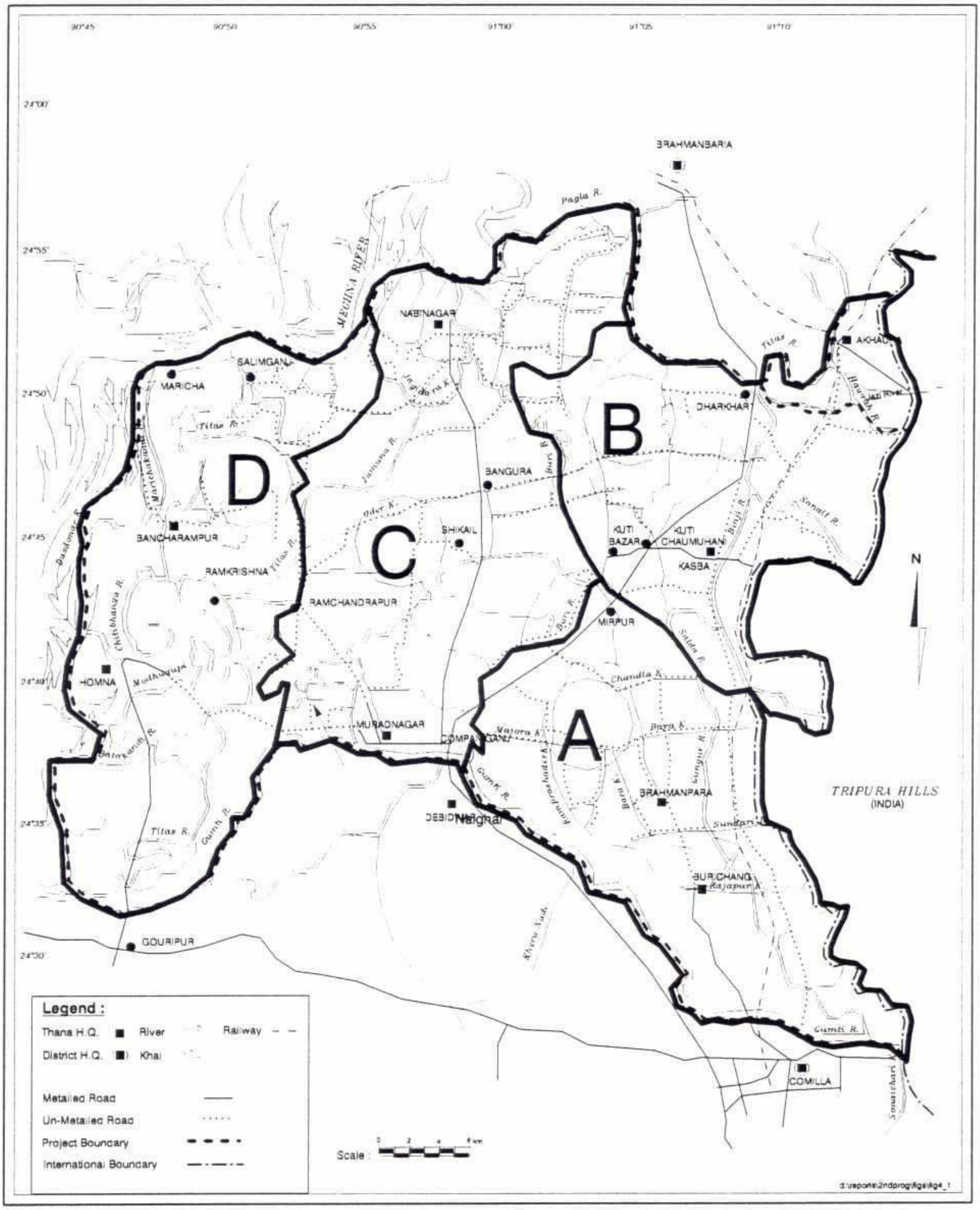

TABLE B.7.1

Summary of Gumti Phase II initial design options

	A1	A2	A3	A4	B1	C1	C2	C3	D1
Embankment on Ghungur left bank upstream of Buri Nadi confluence	X	X	X	X	X	X	X	X	X
Embankment of Buri Nadi right bank upstream of Ghungur confluence	X	X	X	X	X	X	X	X	X
Excavation in Ghungur upstream of Buri Nadi confluence		X	X		X	X	X	X	X
Excavation in Ghungur downstream of Buri Nadi confluence			X	X	X	X	X	X	X
Flow through Ghungur left embankment				X					
Embankment surrounding area B1 (Unit 2)					X	X	X	X	X
Embankment surrounding area B2 (Unit 5)					X	X	X	X	X
Embankment surrounding area C1 (south of Oder khal)						X	X	X	X
Embankment surrounding area C2 (north of Oder khal)						X	X	X	X
Excavation in Oder Khal							X	X	X
Pumped drainage from area C2 (north of Oder khal)								X	
Extension of Gumti right embankment to Meghna confluence									X

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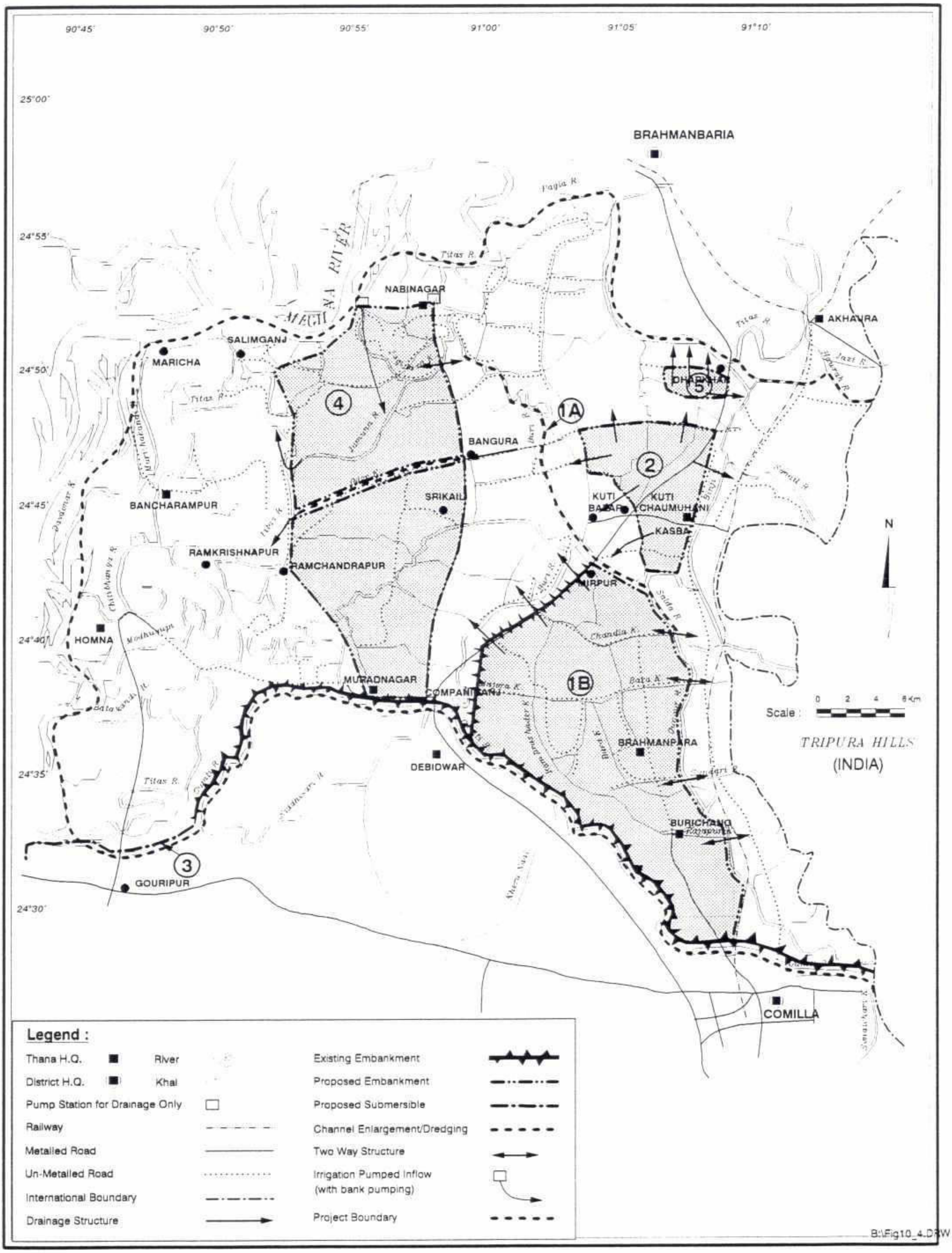
Figure B.7.2
Initial Design Options



These developments result in a reduction in flood levels in area A1 in the pre-monsoon and early monsoon seasons; this is as a result of preventing spillage into the area from the Ghungur. Peak water levels are reduced by a smaller amount since high water levels in the Buri Nadi, which occur as a result of high water levels in the Meghna, prevent drainage from the area.

Drainage only occurs through the regulators in the Ghungur left embankment during years of extreme water levels in the Meghna.

The elimination of spillage on the left bank of the Ghungur results in an increase in water level of approximately 0.8 m in the river and more flooding on the right bank. The elimination of spills on the left bank of the Ghungur results in more water flowing along the Ghungur and then up the Buri Nadi; this longer flow path results in the increase in water levels in the Ghungur upstream of the Buri Nadi confluence.

The construction of the Ghungur left embankment results in a reduction in flood depths in area A1 but an increase in flood depths on the right bank of the Ghungur; these should be mitigated against.

Design option simulation A2

Option A2 is the same as A1 but includes excavation in the Ghungur River upstream of the Buri Nadi confluence; a uniform bed profile was assumed. The existing bed level profile is not uniform, high points in the bed occur both upstream and downstream of the Buri Nadi confluence. The upstream bed level peak is probably due to the backwater effect of the Buri Nadi. The downstream bed level peak is likely to result from the backwater effect of the Meghna; this could also be the explanation for the upstream bed level peak. These high points in the bed cause a flow constriction and result in an increase in water level. If this rise in water level could be reduced the rise in flood level on the Ghungur right bank, as a result of the construction of the Ghungur left embankment may be mitigated.

Excavation of the river bed results in a decrease in water levels, but, the water level is still much higher than in the absence of the Ghungur left embankment.

Excavation of the bed of the Ghungur upstream of the Buri Nadi confluence does not affect the water levels inside the poldered area A1.

Design option simulation A3

Design option simulation A3 incorporated excavation of the bed level high points both upstream and downstream of the Buri Nadi confluence as well as the features included in design option simulation A1; a uniform bed profile was assumed.

Excavation of the river bed results in a decrease in water levels to a level only a little higher to that in the absence of the Ghungur left embankment.

Excavation of the bed of the Ghungur downstream of the Buri Nadi confluence results in a reduction in pre-monsoon water levels in the Buri Nadi. This in turn improves the drainage from area A1 and results in a decrease in flooding depth inside the poldered area.

From design option simulation A3 it was concluded that excavation of the high point on the bed of the Nalia is essential since it improves drainage from area A1 and also in the areas adjacent to the dredged part of the Nalia.

Design option simulation A4

The increase in water level on the right bank of the Ghungur is a direct result of the elimination of the spills on the left bank by the construction of the Ghungur left embankment. An alternative to mitigating this effect by excavating the bed high point upstream of the Buri Nadi confluence is to allow some spillage through the Ghungur left embankment.

Design option simulation A4 includes embankments on the left bank of the Ghungur and the right bank of the Buri Nadi; these embankments polder area A1. The drainage regulators in the Ghungur left embankment allow flow to enter the poldered area from the Ghungur; approximately one third of the current spillage from the Ghungur is allowed to enter the area. In this simulation excavation of the bed high point downstream of the Buri Nadi confluence has been assumed.

Controlled spillage through the Ghungur left embankment results in a moderate decrease in water levels, but, the water level is still higher than in the absence of the Ghungur left embankment.

The water levels inside the poldered area A1 increase as a result of the controlled spillage thus many of the benefits of constructing the Ghungur left embankment are lost and its negative impact is not mitigated.

As a result of design option simulations A1 to A4 it was concluded that the following were the best developments for Zone A.

- an embankment on the left bank of the Ghungur which only allows drainage from area A1.
- an embankment on the right bank of the Buri Nadi which only allows drainage from area A1.
- excavation of the bed high point upstream of the Buri Nadi confluence
- excavation of the bed high point downstream of the Buri Nadi confluence

These developments result in a significant reduction in the flooding depth in area A1. This is in part offset by a flooding depth on the right bank of the Ghungur which is a little higher than presently occurs during the monsoon season but which is reduced during the pre-monsoon season.

B.7.2.2 Zone B

Design option simulation B1

This design option simulation includes the recommended developments for Zone A together with the following,

- Village roads will be upgraded to form a flood embankment surrounding Unit 2. (See Figure B.7.2). Structures for rainfall-runoff drainage will be provided in the embankment.

- The ring road which encircles part of Unit 5 will be improved for full flood control with gated structures at the locations of existing bridges to facilitate rainfall-runoff drainage.

These developments result in a reduction in flood levels in the poldered areas. The reduction in flood level is greatest in the pre- and early monsoon seasons; flash flooding from India and inundation as the Meghna levels rise is eliminated. Peak water levels are reduced by a smaller amount since high water levels in the Meghna, prevent drainage from the poldered areas.

Drainage from the poldered areas is improved by the excavation of the high point on the bed of the Nalia downstream of the Buri Nadi confluence since this results in a reduction in water levels in the Nalia.

The construction of the embankments to create the poldered areas does not result in any rises in external water levels; there are no negative effects to be mitigated.

As a result of design option simulation B1 it was concluded that the following developments were recommended for Zone B,

- Village roads will be upgraded to form a flood embankment surrounding Unit 2. Structures for rainfall-runoff drainage will be provided in the embankment.

- The ring road which encircles part of Unit 5 will be improved for full flood control with gated structures at the locations of existing bridges to facilitate rainfall-runoff drainage.

These developments result in a significant reduction in the flooding depth in poldered areas.

The construction of the embankments to create the poldered areas does not result in any rises in external water levels.

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B.7.2.3 Zone C

Design option simulation C1

This design option simulation includes the recommended developments for Zones A and B together with the following,

- The part of this zone to the West of the Nabinagar - Muradnagar road and the North of the Oder Khal will be poldered. The polder will extend as far as the Meghna in the north. Structures will be provided on the Jamuna Khal at the western boundary of the polder and on the Jamuna Khal at the eastern boundary of the polder for controlling drainage.

- The part of this zone to the West of the Nabinagar - Muradnagar road and the South of the Oder Khal will be poldered. The polder will extend as far as the River Gumti in the south. Drainage structures will be provided on the Arsi, Zia and Chapitala Khals under the Companiganj - Nabinagar road at the eastern boundary of the polder. Structures are also provided at the outfalls of the Roachala, Arsi and the khal to the south of the Roachala, for controlled drainage.

These developments result in a reduction in flood levels in the poldered areas. The reduction in flood level is greatest in the pre- and early monsoon seasons; inundation as the Meghna levels rise is eliminated. Peak water levels are reduced by a smaller amount since high water levels in the Meghna, prevent drainage from the poldered areas.

Drainage never occurs through the regulators on the eastern side of the poldered areas.

Design option simulation C2

The construction of the two polders in Zone C result in embankments on both the north and south bank of the Oder Khal. This could result in increases in flow velocity in this channel, erosion and subsequent deposition in the channel downstream of the embanked reach.

Excavation of the Oder Khal was simulated in design option C2; a uniform profile from the channel it leaves to the channel it joins was assumed.

Design option simulation C2 showed that velocities in the Oder Khal were similar with the embankments on either bank in place and under present conditions. Excavation of the bed of the Oder Khal did not affect water levels either upstream or downstream since these are controlled by levels in the Meghna.

Design option simulation C3

The northern poldered area of Zone C will be provided with irrigation water by a pumping station on its northern boundary adjacent to the Meghna. These irrigation pumps can be reversed during the monsoon season to aid the drainage of the poldered area; pumped drainage was investigated in design option simulation C3.

The model simulation showed that if the full capacity of the irrigation pumps was used during the monsoon season the flooding depth in the northern poldered area could be greatly reduced. Table B.7.2 shows the flood phase distribution for this area with and without pumped drainage.

TABLE B.7.2

Flood Phases for Northern Polder of Zone C with and Without Pumped Drainage

	F0	F1	F2	F3+F4
Without pumped drainage	7 %	17 %	61 %	15 %
With pumped drainage	73 %	21 %	6 %	0 %

As a result of design option simulations C1 to C3 the following developments were recommended for Zone C.

- The part of this zone to the West of the Nabinagar - Muradnagar road and the North of the Oder Khal will be poldered. The polder will extend as far as the Meghna in the north. Structures will be provided on the Jamuna Khal at the western boundary of the polder and on the Jamuna Khal at the eastern boundary of the polder for controlling drainage.

- The part of this zone to the West of the Nabinagar - Muradnagar road and the South of the Oder Khal will be poldered. The polder will extend as far as the Gumti in the south. Drainage structures will be provided on the Arsi, Zia and Chapitala Khals under the Companiganj - Nabinagar road at the eastern boundary of the polder. Structures are also provided at the outfalls of the Roachala, Arsi and the khal to the south of the Roachala, for controlled drainage.

- the use of the irrigation pumps for pumped drainage could greatly reduce the flooding depth in the northern poldered area of Zone C.

These developments result in a reduction in flood levels in the poldered areas.

In the initial design option simulations construction of the embankments to create the poldered areas did not appear to result in any very major rises in external water levels.

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B.7.2.4 Zone D

Design option simulation D1

This design option includes the recommended developments for Zones A, B, and C, with the exception of pumping from the northern poldered area of Zone C together with an extension of the Gumti right embankment as far as Gouripur.

Two polders formed by submersible embankments are proposed in Zone D. Each of these polders will have a drainage control structure. The impact of these polders on external water levels will be negligible; they were not included in the model design option simulations.

It should be noted that the SWMC had used model bed levels that were lower than those evident in the survey information in some of the khals in the west of the project area. This fact was drawn to the attention of SWMC who checked the model with the survey sections and discovered no difference to the water level results. This concurs with our findings and is to be expected, as the dry season flows go to the Meghna via the Nalia River and the monsoon flows in the area are completely Meghna dominated. However, because of this, is was not considered worthwhile to include the proposed Zone D khal excavations in the With Projects runs.

The model simulation showed that the extension of the Gumti right embankment results in a reduction in flood depth in the area adjacent to the river in the pre- and early monsoon seasons. However, as the embankments are designed to be submerged during the monsoon season, they will have no effect on peak flood levels.

B.7.3 Final Design Option Simulation

B.7.3.1 Description

Based on the initial design option simulations the following developments were considered for a full 25 year run:

- an embankment on the left bank of the Ghungur which only allows drainage from area A1.
- an embankment on the right bank of the Buri Nadi which only allows drainage from area A1.
- excavation of the bed high point upstream of the Buri Nadi confluence
- excavation of the bed high point downstream of the Buri Nadi confluence
- Village roads will be upgraded to form a flood embankment surrounding Unit 2. Structures for rainfall-runoff drainage will be provided in the embankment.
- The ring road which encircles part of Unit 5 will be improved for full flood control with gated structures at the locations of existing bridges to facilitate rainfall-runoff drainage.
- The part of this zone to the West of the Nabinagar - Muradnagar road and the North of the Oder Khal will be poldered. The polder will extend as far as the Meghna in the north. Structures will be provided on the Jamuna Khal at the western boundary of the polder and on the Jamuna Khal at the eastern boundary of the polder for controlling drainage.

- The part of this zone to the West of the Nabinagar - Muradnagar road and the South of the Oder Khal will be poldered. The polder will extend as far as the Gumti in the south. Drainage structures will be provided on the Arsi, Zia and Chapitala Khals under the Companiganj - Nabinagar road at the eastern boundary of the polder. Structures are also provided at the outfalls of the Roachala, Arsi and the khal to the south of the Roachala, for controlled drainage.

- an extension of the Gumti right embankment to Gouripur.

A scheme which included these features formed the basis for the 25 year design option simulation. This simulation did not included pumped drainage from the poldered area in the northern part of Zone C. The final design option simulation was run for the full 25 year period between 1965 and 1989 and complete post-processing analysis was carried out on the model results.

B.7.3.2 Results

The proposed developments result in a reduction in flooding depth in all the poldered areas. The changes in the polders in Zone B and the southern polder in Zone C are significant. The improvements in the polder in Zone A and the northern polder in Zone C are much smaller. The improvements in the northern polder of Zone C could be greatly enhanced by pumped drainage.

Conditions in the un-poldered areas of Zones A, B and C are made worse by the proposed developments. Conditions in the southern part of Zone D are improved slightly by the extension of the Gumti right embankment; those in the northern part of Zone D are unchanged.

It was observed in the Without Project simulation that flow from the south east of the area passes through the drainage channels in the southern part of Zone C to the Meghna throughout the wet season. Once the external rivers rise in May and June, flow passes through this area from the Meghna in the vicinity of Nabinagar to the Meghna a short distance upstream of Daudkandi.

The polder in the southern part of Zone C blocks this flow path and results in the negative impacts in the un-poldered parts of Zones A, B and C, and the small improvements in the poldered part of Zone A.

The improvements in flooding conditions in the southern part of Zone C are at the expense of a worsening situation in the areas upstream since the embankment blocks flow from these areas. This, together with the fact that the southern part of Zone C is very important for fish production, led to the conclusion that the polder in the southern part of Zone C should not be included as one of the recommended developments for the Gumti Phase II area.

Based on the results of the final design option simulation it was concluded that all the developments included in this simulation should be included in the With Project simulation with the exception of the polder in the southern part of Zone C. It was decided that the With Project simulation should not include pumped drainage from the polder in the northern part of Zone C; initial design option C3 indicated the benefits that could be gained from pumped drainage in this area.

B.8 Gumti Phase II Model - With Project Condition

B.8.1 Description

B.8.1.1 General

Following the design option simulations, a development plan for the Gumti Phase II area was formulated. A "With Project" simulation was carried out with this development plan in place.

The With Project simulation used the hydrological data for the period from 1965 to 1989. The impact of the proposed development plan was investigated by comparing the results of the With Project simulation with the results of the Without Project simulation.

The With Project simulation looked at the impact of proposed developments within the modelled area.

B.8.1.2 Proposed Developments

The key components of the formulated development plan which were simulated under the With Project conditions are.

Zone A

- Embankment along the left bank of the Ghungur (Nalia) and Salda Rivers. This will extend from the railway in the South West to the main Sylhet to Comilla road.

- Water control structures on the main spillage channels where they cross the alignment of the embankment. These structures consist of gates which allow controlled flow into the Ghungur River. This was not simulated in the model.

- Closure of some of the openings on the main Sylhet to Comilla road and the introduction of regulating structures on the more important drainage paths.

- Channel excavation of the Ghungur (Nalia) river as far as the confluence with the Buri Nadi.

Zone B

- Village roads will be upgraded to form a flood embankment surrounding Unit 2. Structures for rainfall-runoff drainage will be provided in the embankment. These structures may be used to allow some water to enter the poldered area for irrigation purposes; this was not simulated in the model.

- The ring road which encircles part of Unit 5 will be improved for full flood control with gated structures at the locations of existing bridges to facilitate rainfall-runoff drainage. These structures may be used to allow some water to enter the poldered area for irrigation purposes; this was not simulated in the model.

- channel excavation of the Ghungur (Nalia) River downstream of the confluence with the Buri Nadi.

Zone C

- The part of this zone to the West of the Nabinagar - Muradnagar road and the North of the Oder Khal will be poldered. The polder will extend nearly as far as the Meghna in the north.

- Structures will be provided on the Jamuna River at the western boundary of the polder and at the eastern boundary of the polder for controlling drainage. These structures may be used to allow some water to enter the poldered area for irrigation purposes; this was not simulated in the model.

- The poldered area will be provided with irrigation water by a pumping station on its northern boundary adjacent to the Meghna. These irrigation pumps can be reversed during the monsoon season to aid the drainage of the poldered area; pumped drainage was investigated in a model simulation.

- Excavation (approximately 1.4 m deep) of the Oder Khal along the length over which it is embanked on the northern side.

Zone D

- A submersible embankment is proposed along the north bank of the Gumti from Gouripur as far as the present embankment. In the model this embankment was simulated as a full embankment under the With Project conditions.

Two polders, formed by submersible embankments are proposed in Zone D. Each of these polders will have a drainage control structure. The impact of these polders on external water levels will be negligible; they were not included in the model.

Figure B.8.1 presents the modelled developments for the Gumti Phase II area pictorially.

B.8.2 Results of the With Project Simulation

B.8.2.1 Water Levels

Hydrological analysis was carried out on the 25 year time series of water levels, under With Project conditions, at key locations within the Gumti Phase II area. The results were analysed on a 10 day basis to give minimum, mean and maximum water levels for each decad. In addition, return period water levels were calculated for 2, 5, 10, 20, 50 and 100 years.

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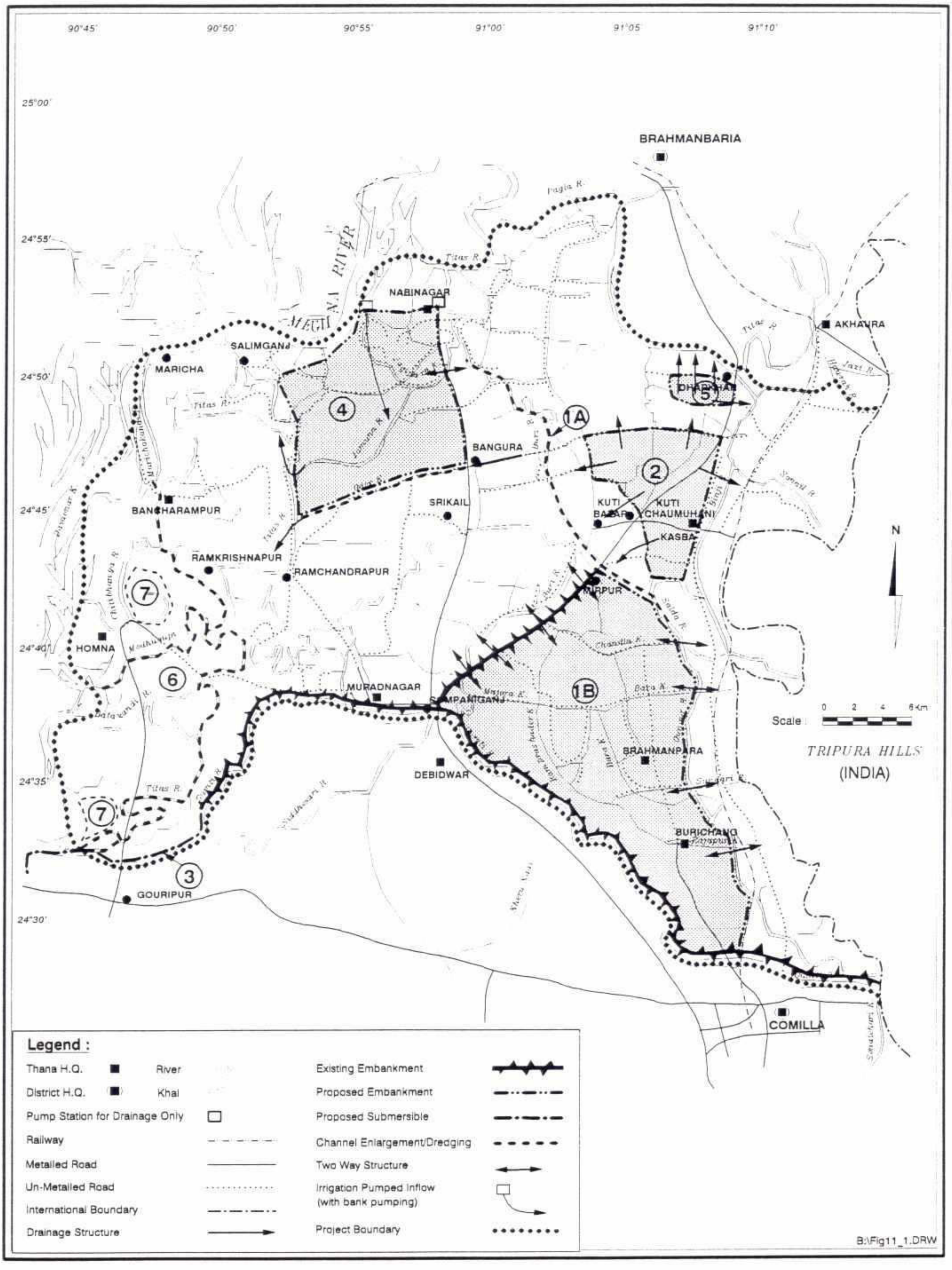
Figure B.8.1
Layout of Developments



The water levels with different return periods were compared with those calculated from the Without Project simulation to ascertain the impact of the proposed developments.
Despite the excavation of the channel upstream of the Buri Nadi confluence the elimination of spills along the left bank of the Nalia has resulted in a rise in peak water level in the Nalia. The water levels to the west of the Nalia remain very much the same as the Without Project situation.

B.8.2.2 Discharges

The maximum discharges simulated under With Project conditions, in the main channels of the Gumti Phase II area, are shown in Figure B.8.2. These discharges mainly occurred during the 1988 peak floods, however, it should be noted that the peak discharges shown did not necessarily occur at the same instant of time.

The flow patterns are changed very little by the proposed developments. The elimination of spills on the left bank of the Nalia result in more water flowing along the Nalia and then up the Buri Nadi; this longer flow path results in the increase in peak water levels in the Nalia upstream of the Buri Nadi confluence. This also directs westward flowing water north, towards the Oder khal, instead of taking its normal path through Zone A.

The reversal in flow direction, between the pre-monsoon and monsoon seasons, in the Nalia downstream of the Buri Nadi confluence still occurs under With Project conditions. As the embankment is closed north of the Oder khal the discharge which used to flow down the Jogidara has been directed into the enlarged Oder khal and its floodplain.

Hydrological analysis was carried out on the 25 year time series of discharges, under With Project conditions, at key locations within the Gumti Phase II area. The results were analysed on a 10 day basis to give minimum, mean and maximum water levels for each decad. In addition, return period water levels were calculated for 2, 5, 10, 20, 50 and 100 years. These results were compared with those from the Without Project simulation.

The excavation in the Nalia will increase the velocity of flow during the pre-monsoon. However, as the Meghna controls the monsoon water levels, the velocities will revert to without project levels during peak floods. Velocities in the remainder of the area will remain largely unaffected.

B.8.2.3 Flood Phases

The flood phases for the Gumti Phase II area, under With Project conditions, are presented in Table B.8.1. In brackets in this table are the corresponding figures for Without Project conditions. These are the results for the decad with deepest flooding. The results presented in Table B.8.1 for area C2 are for the model simulation with pumped drainage.
In areas A1, B1 and B2 which have been poldered, there is a significant reduction in the depth of flooding. The impact has been greatest in area B1 where the area flooded to depths of F2 or greater has been reduced from 49 % to 7 %.

In area A2 the percentage of the area flooded to depths of F2 or greater has been increased from 5 % to 18 %. This is as a result of the elimination of spills on the left bank of the Nalia into area A1.

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Figure B.8.2

Maximum Discharges (with Project)

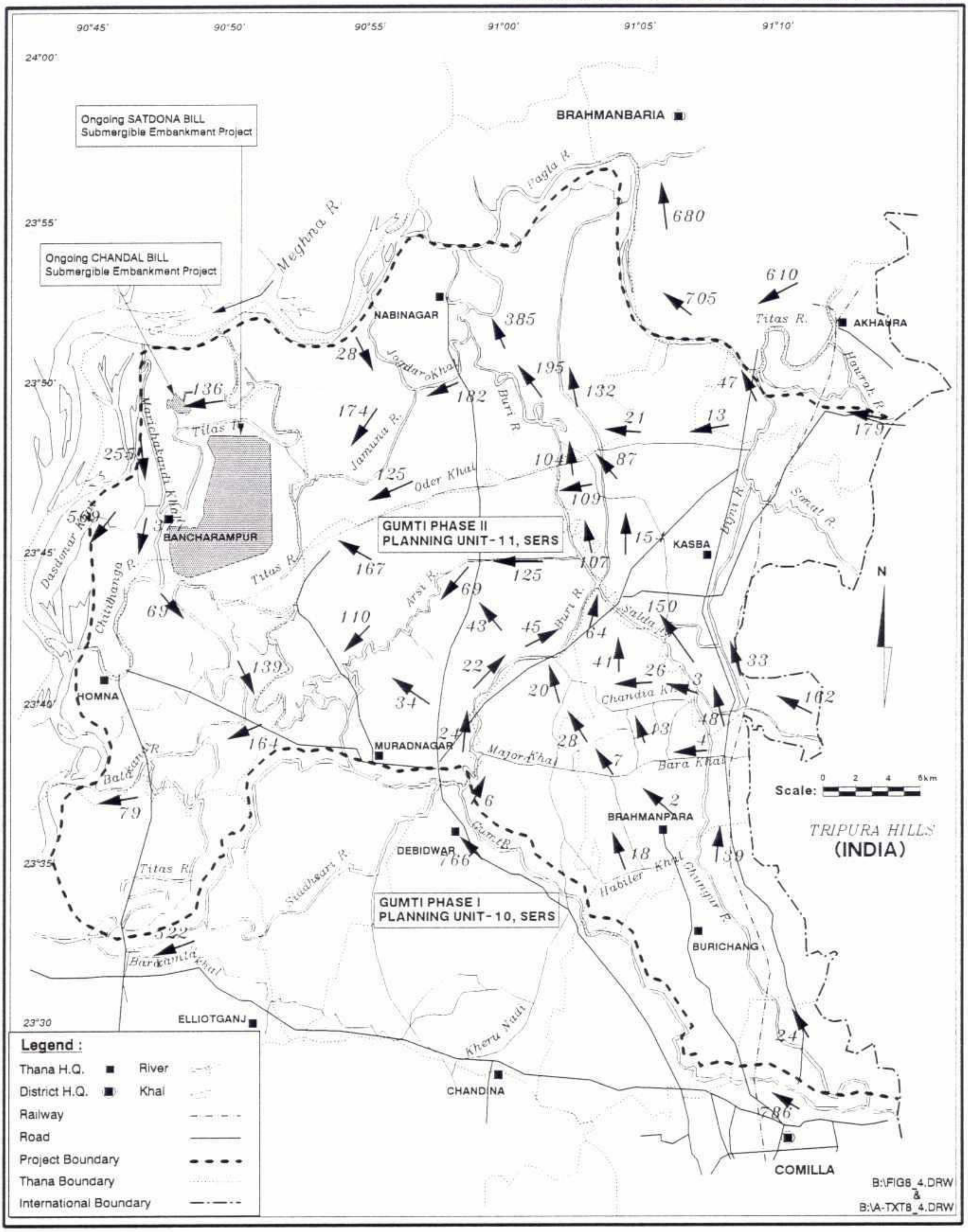

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TABLE B.8.1

Recommended Development Flood Phases
for Gumti Phase II Area

AREA	MPO Flood Phase %			
	F0	F1	F2	F3+F4
A1	46 (28)	47 (53)	6 (19)	0 (0)
A2	60 (71)	22 (24)	18 (5)	0 (0)
B1	59 (20)	34 (31)	7 (44)	0 (5)
B2	3 (0)	29 (2)	48 (44)	20 (54)
B3	33 (35)	22 (22)	26 (24)	19 (19)
B4	4 (4)	14 (13)	46 (46)	36 (37)
B5	19 (20)	35 (35)	31 (31)	15 (14)
C1	2 (2)	12 (11)	68 (67)	18 (20)
C2 (pumped)	73 (7)	21 (17)	6 (61)	0 (15)
C3	12 (10)	36 (32)	39 (42)	13 (16)
C4	5 (3)	29 (28)	25 (27)	41 (42)
C5	3 (3)	9 (9)	51 (48)	37 (40)
D1	2 (2)	7 (7)	31 (31)	60 (60)
D2	4 (4)	13 (13)	42 (42)	41 (41)

Note: Bracketed values are without project

In the other analysis areas the situation is little changed from the Without Project conditions. Flood control options elsewhere in Bangladesh are unlikely to affect the impact of the recommended developments.
In area C2, which has been poldered, there is only a small reduction in the amount of deeply flooded land in the absence of pumped drainage. Table B.8.1 shows that the percentage of land flooded to a depth of F2 or greater in this area could be reduced to 6 % by pumping at the fitted capacity of the irrigation pumps in the north of the area.

In area D1 the situation has improved slightly in the pre-monsoon period as a result of the extension of the Gumti right embankment. However, this is not shown by Table B.8.1 as the values relate to peak flood depth, when the submersible embankment will have been overtopped.

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In the other analysis areas the situation is little changed from the Without Project conditions. In general, conditions are slightly improved even in these areas as a result of the proposed developments. This is mainly a result of excavation in the Nalia downstream of the Buri Nadi confluence and in the Oder Khal in Zone C.

During the initial model runs, the removal of the southern Zone C embankment was shown to have a marked effect on the water levels in the projects in Zones A and B. An additional model run was therefore carried out without the Zone C embankment, in order to check if its removal would affect water levels in Zones A and B. As was expected, the result on the overall water levels was negligible. The percentages of inundation to 0.9 m for this run are graphically represented in Figure B.8.3, for the With Project situation. In this case, pumping has not been included.

B.8.3 Sensitivity Analysis

The final stage of the hydrodynamic modelling methodology outlined in Chapter B.4 is to carry out sensitivity analysis to investigate the impact, on the proposed development plan, of changed external conditions. For the Gumti Phase II area these changed external conditions are changes in the water level in the Meghna as a result of various flood control options elsewhere in Bangladesh.

The Flood Modelling and Management project, FAP-25, have carried out General Model simulations to investigate the impact of the following,

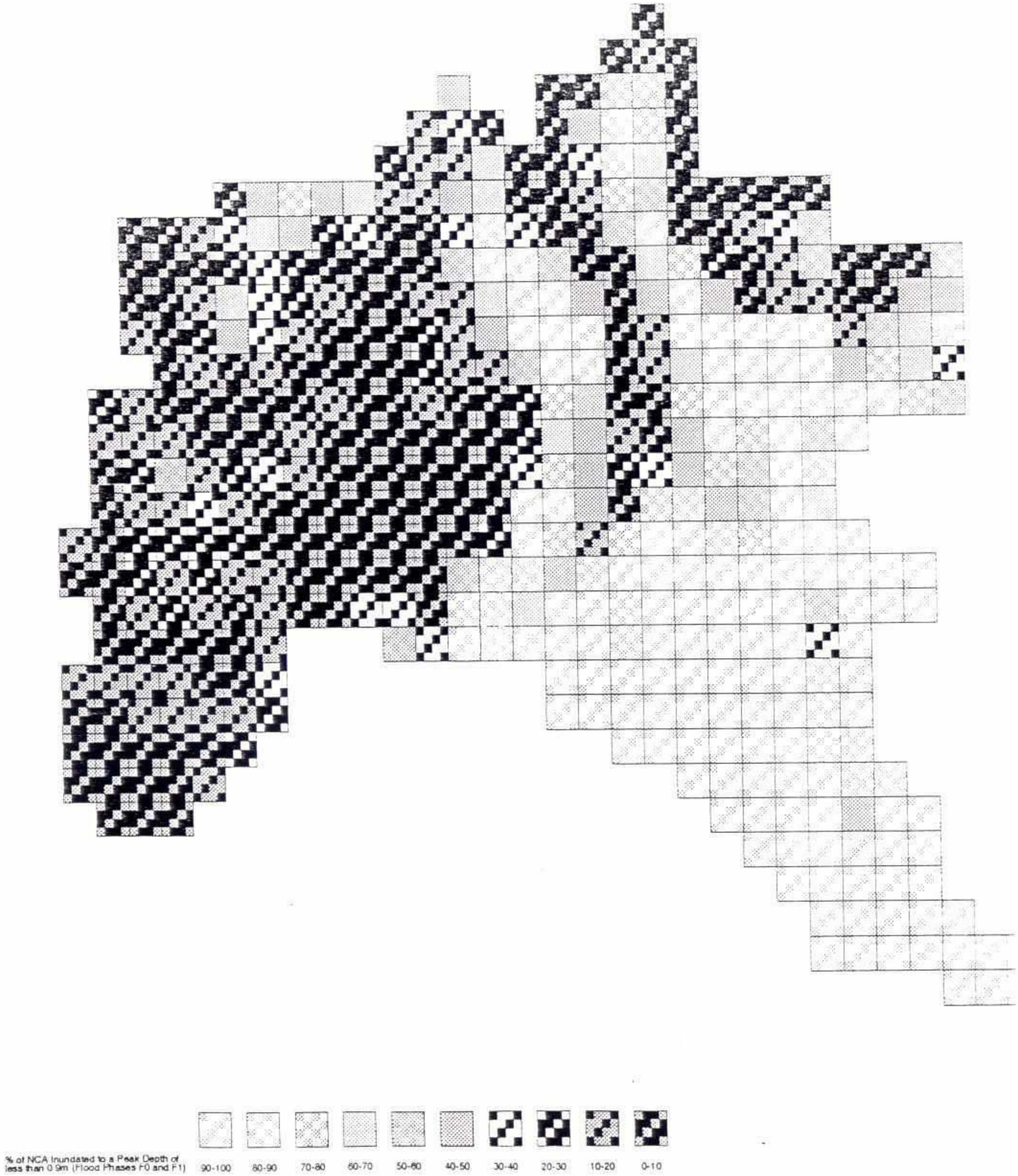
- sealed Brahmaputra Right embankment
- Jamuna Left embankment
- Ganges Left embankment
- Ganges Right embankment
- Padma Left embankment
- Padma Right embankment
- Old Brahmaputra embankments
- Dhaleswari Left embankment
- Dhaleswari Right embankment
- Upper Meghna Left embankment
- Upper Meghna right embankment
- Lower Meghna Left embankment
- Lower Meghna Right embankment

None of the simulated developments produces changes in mean daily water level in the reach of the Meghna adjacent to the Gumti Phase II area of more than +/- 10 cm. In general the developments result in a slight decrease in water level in the Meghna.

Changes in water level of this order in the Meghna are unlikely to affect the conclusions drawn from the modelling work. Since the changes elsewhere in Bangladesh result in a slight reduction in Meghna level the improvements could be slightly greater than those indicated. Therefore, no additional model simulations were carried out to investigate the impact of changes in Meghna level.

Figure B.8.3

Gumti Phase II - With Project Inundation (F0 and F1)



B.9 Modelling of the 1990 Feasibility Study Developments

B.9.1 Introduction

A number of flood control studies have been carried out previously in the Gumti Phase II area. The most recent of these, the Gumti Phase II Sub-Project Feasibility Study, which was carried out by Bureau of Consulting Engineers Ltd (Bangladesh) in association with Sir William Halcrow and Partners Ltd (UK) (Ref. 2.5), produced three options for development. These were,

- Flood control
- Flood control, Drainage and irrigation - Alternative A
- Flood control, Drainage and irrigation - Alternative B

Because of the shortage of irrigation water in the area it was concluded that an FCDI scheme was the best technical option. Both the FCDI options were studied in detail. It was concluded that FCDI Alternative B had several problems that did not occur, or were greatly mitigated, in Alternative A. In view of these problems it was decided to concentrate on the FCDI option Alternative A.

The flood control option and the FCDI Alternative A option were simulated in the hydrodynamic model and the results compared with those from the Gumti Phase II recommended developments.

B.9.2 Flood Control Option

B.9.2.1 Description of Developments

Flood control works will consist of a main perimeter embankment, embankments on either side of the Nalia, the Nalia and Bijni left embankments, and a total of twelve drainage regulators. The embankment elevations are designed on the basis of the 1 in 20 year peak flood levels.

From a drainage point of view the area is divided into three main polders by these embankments. The flows into the area across the Indian border are routed to the relevant drainage regulators by enlarged drainage channels; these enlarged channels route the water from Zone A through Zone C to Zone D, or in the case of the Salda, through the Buri Nadi (Nalia) to Nabinagar. The embankments on both sides of the Nalia disrupt the normal drainage pattern in this area. To compensate for this two side drains are included in this alternative.

The alignments of the embankments and the location of the regulators are shown on Figure B.9.1.

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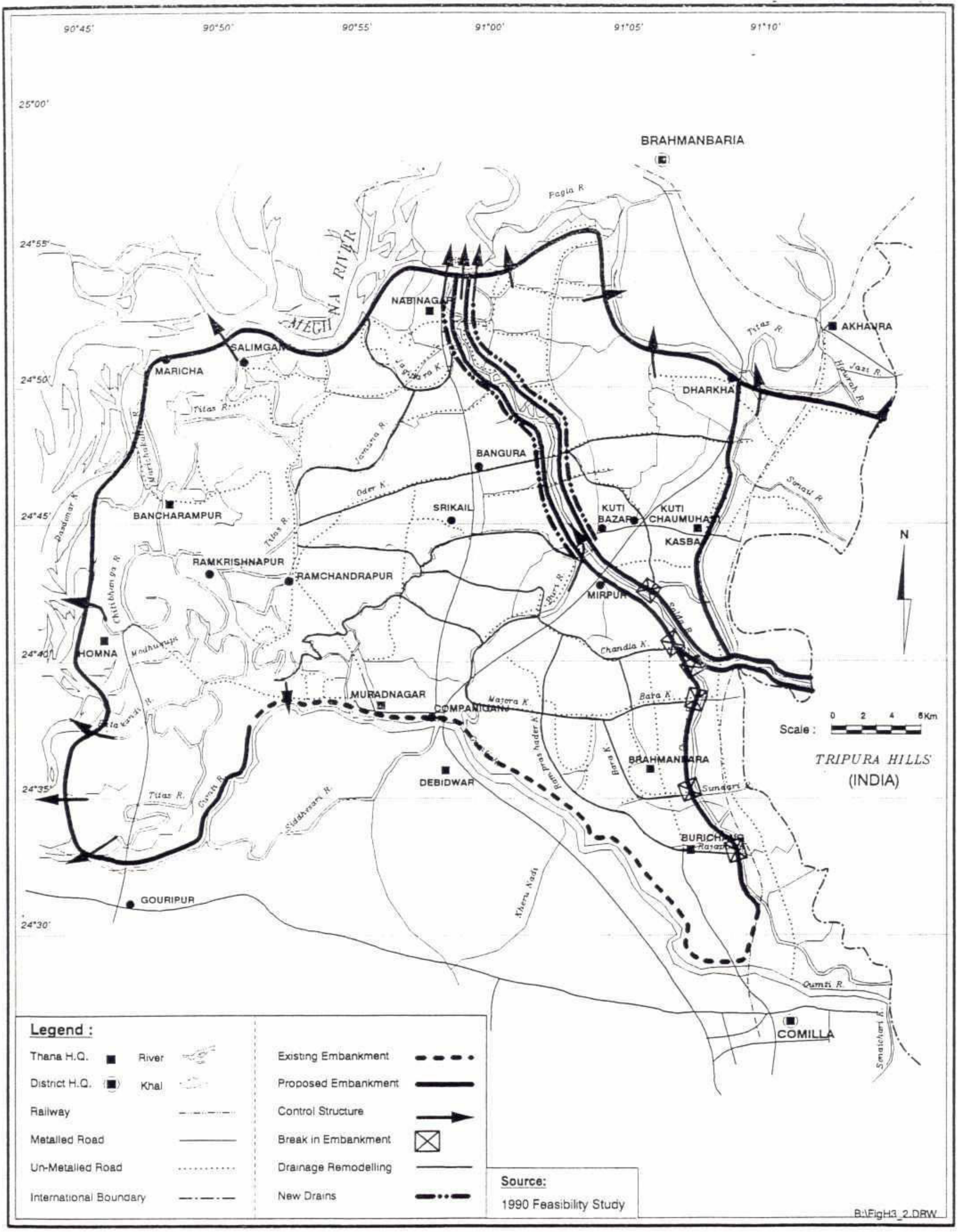
Figure B.9.1
Map of 1990 FCD Option



B.9.2.2 Results of Model Simulation

Flood Phases

The flood phases for the Gumti Phase II area, with the FCD option, are presented in Table B.9.1. In brackets in this table are the corresponding figures for Without Project conditions. These are the results for the decad with deepest flooding.

Flood conditions are improved in all of the post-processing areas of the Gumti Phase II study area; in many of the areas the changes are small.

The greatest improvements are in the north Buri Nadi block which is on the right bank of the Nalia and extends as far as the Bijni.

TABLE B.9.1
Flood Control Option Flood Phases
for Gumti Phase II Area

AREA	MPO Flood Phase (%) With Project (Without Project)			
	F0	F1	F2	F3+F4
A1	46 (28)	48 (53)	6 (19)	0 (0)
A2	76 (71)	20 (24)	4 (5)	0 (0)
B1	59 (20)	35 (31)	6 (44)	0 (5)
B2	6 (0)	45 (2)	32 (44)	17 (54)
B3	39 (35)	22 (22)	22 (24)	17 (19)
B4	13 (4)	41 (13)	28 (46)	18 (37)
B5	33 (20)	35 (35)	22 (31)	10 (14)
C1	2 (2)	13 (11)	71 (67)	14 (20)
C2	10 (7)	29 (17)	51 (61)	10 (15)
C3	24 (10)	39 (32)	30 (42)	7 (16)
C4	17 (3)	31 (28)	17 (27)	35 (42)
C5	4 (3)	10 (9)	55 (48)	31 (40)
D1	2 (2)	10 (7)	40 (31)	48 (60)
D2	7 (4)	19 (13)	39 (42)	35 (41)

B.9.3 Flood Control, Drainage and Irrigation Option - Alternative A

B.9.3.1 Description of Developments

Flood control works will consist of a main perimeter embankment, embankments on either side of the Nalia, the Nalia and Bijni left embankments, and a total of nine drainage regulators and flushing sluices. The embankment elevations are designed on the basis of the 1 in 20 year peak flood levels.

From a drainage point of view the area is divided into three main polders by these embankments. The south and west area is further divided by an embankment on the right bank of the Buri Nadi. Regulators are included in the embankment of the left bank of the Nalia, upstream of the Buri Nadi confluence, to control flow into area A1.

The flows into the area across the Indian border together with those from the south and west polder are routed from east to west via enlarged drainage channel, or in the case of the Salda, through the Buri Nadi (Nalia) to Nabinagar. Eventual drainage to the Meghna will be via a pumping stations at Homna, Nabinagar and Mohanpur.

The embankments on both sides of the Nalia disrupt the normal drainage pattern in this area. To compensate for this two side drains are included in this alternative. At the end of these side channels pumping stations are provided to transfer the drainage water to the Meghna.

The alignments of the embankments and the location of the regulators and pump stations are shown on Figure B.9.2. The pump station capacities were taken to be the same as those modelled in the 1990 report. They were 12.5 cumecs at Nabinagar East, 25 cumecs at Nabinagar West, 50 cumecs at Homna and 4.5 cumecs at Mohanpur.

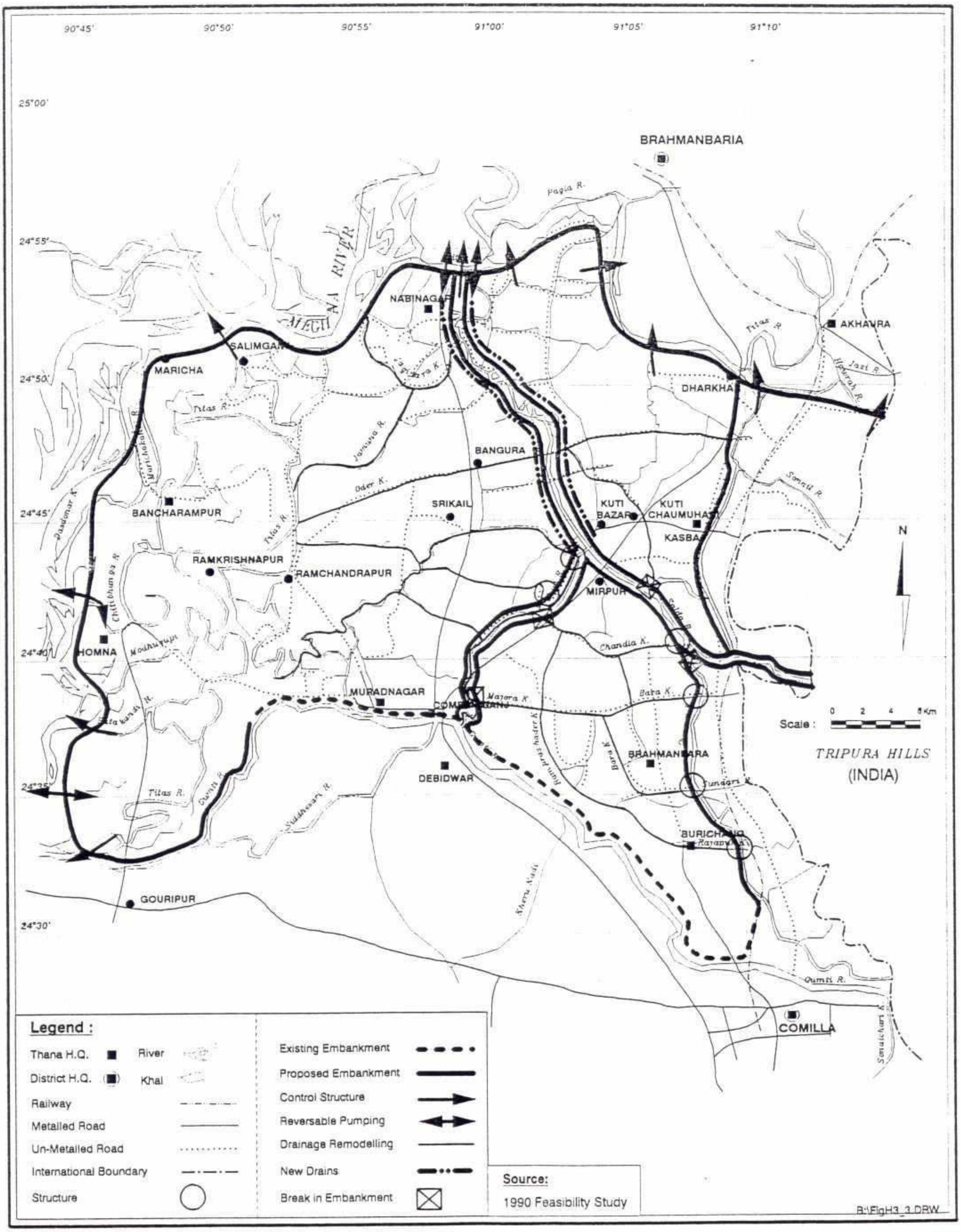
B.9.3.2 Results of Model Simulation

Pumping rates

The model results indicate that the pumping stations in the west of the area, at Mohanpur and Homna, will pump drainage water into the Meghna at their full capacity for many months of the year. Even with this large amount of pumping the pump stations are unable to prevent flooding to significant depths in the areas which drain towards the pumping stations.

The two pumping stations at the confluence of the two Nalia side drainage channels are able to maintain acceptable flood levels in most years by pumping within their capacity.

Figure B.9.2
Map of 1990 FCDI Option



Flood Phases

The flood phases for the Gumti Phase II area, with the FCDI option, are presented in Table B.9.2. In brackets in this table are the corresponding figures for Without Project conditions. These are the results for the decad with deepest flooding.

In all of the Gumti Phase II post-processing areas the results from the FCDI option give less deeply flooded land than both existing conditions and also the FCD option. In the eastern part of the area the improvements over the FCD option area small whilst in the northern and western parts, which are mainly affected by the pumping, the improvements are more pronounced. In the western part of the area significantly more than 50 % of the land area remains flooded to depths of F2 or more despite the pump stations operating for many months of the year.

TABLE B.9.2
FCDI Alternative A Option Flood Phases
for Gumti Phase II area

AREA	MPO Flood Phase (%) With Project (Without Project)			
	F0	F1	F2	F3+F4
A1	64 (28)	33 (53)	3 (19)	0 (0)
A2	83 (71)	15 (24)	2 (5)	0 (0)
B1	81 (20)	18 (31)	1 (44)	0 (5)
B2	6 (0)	45 (2)	32 (44)	17 (54)
B3	40 (35)	21 (22)	21 (24)	18 (19)
B4	27 (4)	42 (13)	18 (46)	13 (37)
B5	50 (20)	26 (35)	18 (31)	6 (14)
C1	7 (2)	22 (11)	69 (67)	2 (20)
C2	18 (7)	41 (17)	35 (61)	6 (15)
C3	42 (10)	32 (32)	21 (42)	5 (16)
C4	34 (3)	20 (28)	16 (27)	30 (42)
C5	7 (3)	12 (9)	67 (48)	14 (40)
D1	5 (2)	16 (7)	44 (31)	35 (60)
D2	12 (4)	26 (13)	34 (42)	28 (41)

B.10 Conclusions and Recommendations

B.10.1 Conclusions

Hydrodynamic modelling of the Gumti Phase II area has brought the complex hydraulic regime into an analytical framework. It has proved to be an invaluable tool with which to assess and understand present flooding problems and to assess the impacts of measures to alleviate these problems.

The results of Run 6 of the General Model, and also the results of the revised Run 6 of the General Model, underestimate the peak water levels at both Nabinagar and Daudkandi. The results of the revised Run 6 of the FAP 25 General Model were used to provide the boundary conditions for the baseline and development scenario simulations of the Gumti Phase II model. This run gave the best agreement to the shape of the observed monsoon hydrographs at Daudkandi and Nabinagar. It provides a 25-year time series of level data which are hydraulically consistent.

Catchment area weighting methods were used to estimate the flows from the ungauged catchments in India. This method gave discharge hydrographs with the expected flashy response. The NAM estimated discharges gave much smoother discharge hydrographs.

Water levels in the Gumti Phase II area are dominated by levels in the Meghna; when peak levels occur in the Meghna the area is effectively a huge lake. With the exception of the areas in the extreme east and south east the backwater effect of the Meghna extends throughout the area.

In the pre-monsoon period, before the Meghna rises, the areas in the east and south east are subject to flooding by flash floods from the catchments in the Tripura Hills.

In the pre-monsoon period flows from the catchments in India are transferred to the Meghna via the Bijni and Nalia rivers. Some of the flow which enters the region in the south east flows via the river system to the south of the Oder Khal to reach the Meghna between Homna and Daudkandi.

Once the Meghna rises, during June, flows in the Nalia reverse so that water enters the area from the Meghna. This water is transferred as flood plain flow and channel flow in the Oder Khal and the river system to the south to reach the Meghna between Homna and Daudkandi.

The deepest flooded parts of the Gumti Phase II area lie adjacent to the Meghna. The depth of flooding generally decreases in an easterly and south easterly direction. The shallowest depths of flooding occur in the east of the area where the topographic elevation tends to rise towards the Tripura Hills. The low lying areas in the east of the region suffer deep flooding because of flows from the Tripura Hills and drainage congestion as a result of the backwater effect from the Meghna.

The initially proposed polder in the southern part of Zone C blocks an important flow path for water during the monsoon season; this results in the deepening of flood depths in the un-poldered parts of Zones A, B and C, and only small improvements in the poldered part of Zone A.

The recommended developments, which do not include this southern polder, have little impact on the existing flow paths.

In the poldered areas there is a significant reduction in the depth of flooding. Flood depths are increased on the right bank of the Ghungur as a result of the elimination of spills on the left bank.

In the poldered area of Zone C there is only a small reduction in the amount of deeply flooded land in the absence of pumped drainage. Model simulations indicate that the percentage of land flooded to a depth of F2 or greater in this area could be reduced to 6 % by pumping at the fitted capacity of the irrigation pumps in the north of the area.

In area D1 the situation has improved slightly as a result of the extension of the Gumti right embankment.

Flood control options elsewhere in Bangladesh are unlikely to affect the impact of the recommended developments.

Flood conditions are improved throughout the Gumti Phase II study area by the 1990 report FCD developments; in many of the areas the changes are small. The greatest improvements are in the north Buri Nadi block which is on the right bank of the Nalia and extends as far as the Bijni.

Throughout the Gumti Phase II area the results from the FCDI option give less deeply flooded land than both existing conditions and also the FCD option. In the eastern part of the area the improvements over the FCD option are small whilst in the northern and western parts, which are mainly affected by the pumping, the improvements are more pronounced. In the western part of the area significantly more than 50 % of the land area remains flooded to depths of F2 or more despite the pump stations operating for many months of the year.

B.10.2 Recommendations

Further detailed hydrodynamic modelling should be carried out at the detailed design stage; the boundary conditions for these models should be provided by the most appropriate hydrodynamic model which is available at the time.

At the detailed design stage the hydrodynamic model should be updated using the latest hydrometric and topographic information. To obtain the maximum benefits the model should be linked to digital elevation model.

The General model should be improved to give better agreement with observed peak water levels at Nabinagar and Daudkandi.

Monitoring networks should be established to better quantify the cross-border flows from India, thereby ensuring a better model for flash floods.

Linking the model output results to other post-processing programs has enabled the models to be used in a much wider context than that of simply predicting water levels and discharges within the modelled river reaches and drainage channels. Further work should be undertaken on these applications.

More detailed analysis should be carried out, at the design stage, to quantify, as far as possible, the morphological changes which may be induced by projects in the Gumti Phase II area. Also, at the design stage, detailed sub models should be used to better determine the affects to the east of Gunghur River and also downstream of Gouripur.

APPENDIX B.I

Ten Day Rainfall Data

R-076, Narsingdi; Daily Rainfall (mm).

10-DAY RAINFALLS

	APR			MAY			JUN			JUL			AUG			SEP			OCT			NOV			DEC			JAN			FEB			MAR		
Year	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
62/63	45	12	85	117	24	166	79	133	135	44	204	229	38	191	43	81	90	39	115	0	164	0	0	0	0	0	0	0	2	0	0	0	0	2	52	0
63/64	0	67	30	125	98	74	256	310	7	140	204	93	35	117	37	6	84	47	82	5	111	16	0	0	0	0	0	0	0	0	0	0	12	0	26	0
64/65	88	183	62	153	148	22	129	263	128	175	299	438	53	123	-999	252	32	269	146	218	68	0	6	47	0	0	0	0	0	0	18	0	0	0	0	39
65/66	14	7	5	53	84	17	243	281	118	269	75	244	167	294	244	142	321	118	6	30	30	59	0	0	0	0	6	12	0	0	0	0	0	0	0	6
66/67	34	109	117	83	32	58	93	185	316	151	100	54	85	147	348	84	378	33	174	189	22	0	0	62	0	25	0	27	0	0	0	0	0	19	41	20
67/68	0	162	40	120	36	38	150	347	36	198	243	44	260	50	81	138	98	327	69	48	0	0	0	0	0	0	0	0	5	0	0	7	0	0	24	33
68/69	74	119	17	10	140	115	71	397	120	243	121	44	139	118	137	99	137	30	22	0	5	12	21	0	0	0	0	0	3	0	0	0	0	0	51	151
69/70	0	226	189	13	0	49	294	308	152	193	395	30	72	437	45	46	192	215	54	78	0	0	53	0	0	0	0	0	5	10	0	4	0	12	0	25
70/71	11	124	0	49	155	63	95	103	82	37	348	216	182	90	304	87	194	38	343	0	133	0	18	0	0	0	0	0	3	9	0	5	5	0	0	0
71/72	19	40	44	263	105	64	240	76	441	26	161	326	29	770	112	23	0	129	30	40	5	60	8	0	0	0	0	0	0	0	19	10	0	0	7	16
72/73	112	61	142	73	98	231	81	297	211	18	251	69	202	76	210	162	80	12	57	0	0	0	0	0	0	0	0	0	15	0	0	32	61	57	0	0
73/74	0	14	147	344	320	211	106	283	279	46	60	424	228	84	134	61	248	69	91	52	18	47	26	0	166	0	0	0	3	0	0	0	0	0	0	109
74/75	219	46	47	168	135	43	91	28	181	334	329	384	21	-999	248	47	108	133	46	8	18	0	0	3	0	0	0	0	0	0	8	4	0	5	0	0
75/76	4	52	32	0	104	138	68	29	11	20	338	132	56	4	57	107	139	43	43	113	0	19	29	0	0	0	0	0	0	0	41	0	0	27	0	25
76/77	5	21	76	113	89	56	415	223	84	238	65	46	263	190	173	9	30	38	5	40	8	0	0	11	0	0	0	0	0	0	5	0	11	2	8	8
77/78	143	165	77	140	169	103	102	214	188	19	72	276	23	191	89	24	0	8	279	7	18	24	0	5	0	0	36	0	0	0	11	5	0	0	2	9
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79/80	7	46	14	75	38	22	70	180	109	305	268	62	29	280	37	124	188	64	58	0	2	0	0	37	22	0	0	8	0	0	5	5	0	22	0	0
80/81	0	139	32	205	307	164	125	203	24	142	115	47	43	42	63	24	31	158	257	275	46	0	0	0	0	1	0	2	1	0	32	6	0	6	28	24
81/82	16	505	4	32	123	101	47	0	64	198	114	359	31	88	310	173	154	5	0	8	0	0	0	0	0	11	0	0	0	0	2	0	0	26	91	8
82/83	3	44	115	144	131	52	84	239	246	30	5	29	247	23	89	48	106	18	0	0	30	0	30	0	0	0	0	5	0	6	2	0	26	25	101	25
83/84	3	60	129	291	133	81	14	262	78	222	18	59	454	25	226	165	45	22	94	215	0	0	0	0	0	0	41	0	0	5	0	0	0	0	7	12
84/85	39	0	67	409	500	155	236	248	269	111	296	367	177	232	209	394	343	5	67	56	11	0	0	0	0	0	0	13	0	0	0	0	0	0	18	58
85/86	37	21	47	42	94	220	189	190	126	150	25	279	114	53	336	157	68	49	73	80	0	0	0	0	0	3	0	0	23	0	0	0	0	2	0	0
86/87	185	80	113	117	201	43	20	71	166	109	9	379	82	140	175	106	39	419	470	119	0	196	0	0	0	0	0	0	2	0	18	0	0	41	0	18
87/88	22	28	176	71	23	41	238	218	118	73	64	327	109	148	379	65	25	140	29	0	44	0	27	0	0	22	0	0	0	0	0	22	24	39	85	0
88/89	0	41	60	25	60	564	47	414	232	443	143	34	54	95	150	48	139	8	38	126	0	0	0	114	9	0	0	0	0	0	0	57	0	0	0	12
89/90	0	18	65	68	49	158	100	233	99	37	289	107	82	81	34	81	60	124	47	89	132	0	0	0	0	0	10	0	0	0	0	13	20	29	41	155
90/91	218	281	87	101	177	142	89	326	95	81	173	254	101	114	39	226	119	104	292	19	0	15	0	0	0	4	3	12	0	0	0	7	10	29	42	156
91/92	0	103	16	435	262	161	131	76	76	49	24	87	52	59	78	174	82	62	100	142	25	18	0	0	0	0	44	8	0	0	2	0	1	14	44	6
Mean	43	97	71	134	135	129	139	214	151	138	163	190	115	147	155	106	118	94	106	66	30	16	7	9	7	2	5	3	2	1	6	6	6	12	23	31
Max	219	505	189	435	500	564	415	414	441	443	395	438	454	770	379	394	378	419	470	275	164	196	53	114	166	25	44	27	23	10	41	57	61	57	101	156
Min	0	0	0	0	0	17	14	0	7	18	5	29	21	4	34	6	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

R-101, Bhairab Bazar; Daily Rainfall (mm)

10-DAY RAINFALLS

	APR			MAY			JUN			JUL			AUG			SEP			OCT			NOV			DEC			JAN			FEB			MAR		
Year	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
62/63	37	56	104	103	28	158	132	256	97	10	202	44	81	204	145	226	50	16	72	0	56	0	0	0	0	0	0	0	0	0	0	0	0	9	51	0
63/64	11	23	7	44	48	93	419	275	59	104	181	97	88	45	14	75	81	17	107	19	81	5	0	0	0	0	0	0	0	0	0	0	17	0	9	20
64/65	56	138	31	197	90	17	36	276	16	165	135	300	46	60	65	172	105	258	405	301	76	0	3	14	0	76	0	0	0	0	11	0	0	6	0	87
65/66	64	6	0	77	71	28	120	363	136	374	90	110	102	145	161	41	102	129	18	0	85	15	0	0	0	0	0	15	0	0	0	0	0	0	0	12
66/67	0	28	42	162	32	11	91	241	68	165	127	60	16	83	302	21	153	82	149	174	0	0	0	88	0	21	0	46	0	0	0	0	0	0	63	19
67/68	0	210	41	138	37	108	126	373	15	275	112	64	126	72	84	50	23	215	17	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	24	12
68/69	68	115	1	0	155	110	101	245	73	183	113	128	280	97	150	63	81	168	28	0	0	0	38	0	0	0	0	0	0	0	0	0	0	0	16	102
69/70	0	107	79	18	0	20	254	231	38	121	110	28	41	416	31	8	67	37	13	58	0	0	27	0	0	0	0	0	2	34	0	1	0	12	1	114
70/71	4	159	0	46	75	17	123	133	123	45	152	118	88	128	78	15	129	78	124	0	90	0	14	0	0	0	0	0	0	2	0	23	-999	-999	-999	-999
71/72	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0	0	0	0	0	0	1	0	0	2	79
72/73	121	65	123	132	31	135	74	221	70	6	121	153	138	29	42	52	22	9	42	0	0	0	0	0	0	0	0	6	4	0	0	14	99	0	3	1
73/74	0	40	253	172	268	253	52	250	232	68	110	432	98	79	140	6	301	61	7	3	12	11	12	0	53	0	0	0	0	0	0	0	0	0	0	96
74/75	175	29	50	154	159	85	90	86	135	309	33	167	19	34	250	16	87	179	28	46	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	1
75/76	3	28	11	12	49	4	141	43	27	12	280	118	54	42	143	176	151	66	65	55	4	3	20	0	0	0	0	0	0	6	0	0	0	26	0	4
76/77	0	0	71	161	62	3	293	263	118	237	137	29	95	183	200	9	20	34	30	0	0	0	0	0	0	0	0	0	0	0	0	0	23	0	0	0
77/78	105	186	3	89	61	35	207	50	188	32	135	73	10	147	67	72	28	71	318	0	43	33	0	4	0	0	27	0	0	0	0	0	0	0	0	55
78/79	0	78	55	149	258	394	285	100	178	34	169	117	27	21	140	165	36	64	46	32	0	0	27	0	0	0	0	0	0	3	21	0	0	4	58	22
79/80	9	26	1	65	0	16	20	208	126	503	183	10	22	287	31	119	263	54	66	0	0	0	0	39	33	3	0	2	0	0	0	19	0	16	10	3
80/81	0	16	21	256	200	197	24	160	7	74	60	162	41	48	149	47	70	96	98	76	138	0	0	0	0	0	0	0	0	11	27	6	0	0	25	19
81/82	127	247	15	40	187	285	88	56	49	183	152	303	129	70	108	90	152	0	32	9	0	0	0	0	0	0	0	0	0	0	0	36	0	28	37	1
82/83	0	0	16	84	119	44	92	125	95	166	71	104	261	56	34	55	61	25	0	0	5	5	15	0	0	0	0	3	0	3	0	0	41	0	30	39
83/84	9	36	220	185	70	51	65	123	131	180	9	6	561	15	340	154	36	34	35	77	10	0	0	0	0	0	9	0	0	0	0	0	0	0	0	12
84/85	0	0	15	164	369	119	116	169	92	67	141	299	72	134	71	203	267	0	41	13	10	0	0	0	0	0	0	0	0	0	12	0	0	0	2	27
85/86	12	29	134	39	96	77	353	126	45	37	10	63	175	78	67	70	63	127	0	16	0	0	0	0	0	0	9	0	3	0	0	5	0	0	11	0
86/87	189	99	60	125	153	42	17	96	42	55	28	152	70	63	62	145	62	213	111	67	0	155	0	0	0	4	0	0	0	0	0	0	0	32	15	10
87/88	23	0	148	81	21	32	261	79	35	37	82	186	124	87	274	69	36	380	89	69	70	0	17	0	0	17	0	0	0	0	0	11	44	52	58	0
88/89	0	48	142	156	84	542	110	167	159	292	115	37	74	206	53	125	185	8	88	186	0	0	0	15	13	0	0	0	0	0	0	18	0	0	0	0
89/90	0	0	131	6	109	216	237	111	0	82	119	207	33	62	48	43	135	65	105	109	6	0	0	0	0	0	2	0	0	0	0	8	20	5	9	180
90/91	61	56	72	17	134	187	117	43	50	271	9	74	140	19	110	74	178	91	219	0	0	32	0	0	0	7	0	13	1	0	11	0	0	21	9	32
91/92	49	11	114	225	199	394	179	106	8	46	80	41	130	20	200	149	171	150	84	141	79	14	0	0	0	0	12	0	0	0	1	1	1	0	0	0
Mean	39	63	68	107	109	127	146	171	83	142	113	127	108	101	123	87	107	94	84	50	26	9	6	5	3	4	2	3	0	2	3	5	8	7	15	33
Max	189	247	253	256	369	542	419	373	232	503	280	432	561	416	340	226	301	380	405	301	138	155	38	88	53	76	27	46	4	34	27	36	99	52	63	180
Min	0	0	0	0	0	3	17	43	0	6	9	6	10	15	14	6	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

R-103, Brahmanbaria; Daily Rainfall (mm)

10-DAY RAINFALLS

Year	APR 1	APR 2	APR 3	MAY 1	MAY 2	MAY 3	JUN 1	JUN 2	JUN 3	JUL 1	JUL 2	JUL 3	AUG 1	AUG 2	AUG 3	SEP 1	SEP 2	SEP 3	OCT 1	OCT 2	OCT 3	NOV 1	NOV 2	NOV 3	DEC 1	DEC 2	DEC 3	JAN 1	JAN 2	JAN 3	FEB 1	FEB 2	FEB 3	MAR 1	MAR 2	MAR 3
62/63	28	13	94	94	46	221	86	119	87	23	221	69	38	181	48	18	0	48	61	10	48	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
63/64	-999	-999	-999	-999	-999	-999	-999	-999	-999	111	89	243	96	18	29	142	27	33	143	33	116	11	0	0	0	0	0	0	0	0	0	0	8	0	11	16
64/65	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
65/66	15	7	4	43	57	31	146	424	70	149	78	80	121	183	129	67	100	49	44	0	80	10	0	0	0	4	0	13	0	0	0	0	0	0	0	54
66/67	0	39	62	178	51	54	56	251	63	145	148	81	24	88	149	64	120	15	90	357	0	0	0	77	0	23	0	55	0	0	0	0	0	0	62	41
67/68	0	151	48	100	38	71	77	166	17	224	128	48	118	66	107	69	43	338	78	27	0	0	0	0	0	0	0	0	0	0	0	8	1	0	3	32
68/69	54	136	0	0	143	91	97	303	115	307	172	196	102	44	187	3	133	68	18	0	0	5	17	0	0	0	0	0	0	0	0	0	0	0	9	118
69/70	0	89	165	18	0	27	198	183	116	67	69	105	22	367	50	44	104	39	34	52	0	0	28	0	0	0	0	0	3	27	0	1	0	8	0	68
70/71	20	107	1	13	120	9	80	166	119	46	165	101	66	100	57	48	112	3	162	0	62	1	23	0	0	0	0	0	0	3	0	15	0	0	0	0
71/72	-999	-999	-999	-999	-999	81	177	128	76	5	116	243	46	179	34	133	46	149	93	71	28	61	1	0	0	0	0	0	0	0	13	0	0	0	10	85
72/73	23	60	23	8	71	202	79	239	122	5	108	237	85	32	43	144	0	17	25	4	0	0	0	0	0	0	0	9	4	0	0	12	0	40	0	0
73/74	0	23	228	407	243	274	103	187	169	37	48	238	50	98	131	46	147	73	29	8	19	57	64	0	117	0	0	0	0	0	0	0	0	0	0	51
74/75	207	33	48	274	207	79	121	93	149	158	169	134	0	139	324	24	37	59	61	0	32	0	0	5	0	0	0	0	0	0	20	9	0	3	0	0
75/76	0	61	18	108	169	104	108	108	13	18	598	117	108	23	97	38	136	42	74	45	0	58	20	0	0	0	0	0	0	0	20	0	0	17	0	18
76/77	0	5	145	142	109	32	347	205	71	265	86	67	61	165	108	14	13	38	19	14	5	0	0	5	0	0	0	0	0	0	9	0	10	0	0	0
77/78	329	154	60	145	103	31	169	50	114	25	187	56	14	152	53	58	10	28	358	0	66	29	0	0	0	0	-999	0	0	0	0	2	0	0	6	36
78/79	1	125	70	119	328	500	156	134	198	14	177	119	47	60	104	103	25	11	26	11	0	4	0	0	0	0	0	0	0	14	1	0	0	2	89	0
79/80	25	3	9	108	0	11	23	60	163	480	135	20	81	201	19	87	211	84	32	29	1	0	3	0	38	13	0	0	0	0	13	20	0	55	0	4
80/81	10	28	69	329	283	150	55	140	18	122	169	212	83	46	107	38	128	37	144	231	94	0	0	0	0	0	0	10	0	24	22	13	0	4	46	4
81/82	84	321	83	8	236	134	15	23	46	295	47	201	74	55	142	24	50	0	15	1	0	0	0	0	1	13	0	0	0	0	2	40	0	17	37	3
82/83	37	22	66	72	135	56	61	182	62	136	64	49	269	3	19	42	67	34	0	0	1	1	23	0	0	0	0	10	0	2	0	0	28	22	103	55
83/84	13	33	99	92	104	61	43	227	80	265	5	9	372	15	318	222	33	53	33	57	22	0	0	0	0	0	28	0	1	0	0	0	0	0	0	14
84/85	32	2	56	266	377	80	132	194	72	53	180	268	142	174	118	310	182	0	93	6	18	0	0	0	0	3	0	0	0	0	19	0	4	0	0	47
85/86	26	64	141	40	59	137	225	161	13	126	9	86	70	1	42	15	85	185	17	25	0	0	0	0	0	0	31	0	3	0	0	0	0	0	20	0
86/87	128	107	249	121	205	42	9	123	73	118	8	271	61	84	135	60	84	267	310	23	0	163	0	0	0	0	0	0	0	0	1	0	0	6	38	0
87/88	18	56	113	112	5	39	241	46	17	47	117	216	85	48	226	38	30	127	64	75	15	0	8	0	0	18	0	0	0	0	0	20	41	24	94	0
88/89	0	31	107	102	75	542	112	144	483	408	123	28	30	76	38	151	201	113	103	161	0	0	0	61	8	0	0	0	0	0	0	51	0	0	15	0
89/90	23	0	109	9	103	132	145	199	14	83	86	123	95	65	71	88	85	97	62	85	5	0	0	0	0	0	3	0	0	0	0	9	27	17	2	227
90/91	70	64	82	19	153	214	108	39	46	278	9	76	123	16	97	62	149	76	218	0	0	37	0	0	0	7	0	18	2	0	10	0	0	23	9	34
91/92	55	12	130	257	227	450	165	98	7	47	82	42	114	17	175	125	143	126	84	141	79	17	0	0	0	0	13	0	0	0	1	1	1	0	0	0
Mean	44	65	84	118	135	138	119	157	93	140	124	129	90	93	109	78	86	76	86	51	24	16	6	5	6	3	3	4	0	2	4	7	4	8	19	31
Max	329	321	249	407	377	542	347	424	483	480	598	271	372	367	324	310	211	338	358	357	116	163	64	77	117	23	31	55	4	27	22	51	41	55	103	227
Min	0	0	0	0	0	9	9	23	7	5	5	9	0	1	19	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

R-105, Chandpur Bagan; Daily Rainfall (mm)

10-DAY RAINFALLS

	APR			MAY			JUN			JUL			AUG			SEP			OCT			NOV			DEC			JAN			FEB			MAR		
Year	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
62/63	59	64	132	99	46	163	142	316	101	33	228	16	106	214	59	152	43	21	68	0	99	0	0	0	0	0	0	0	0	0	0	0	0	2	40	16
63/64	13	131	36	138	137	165	227	218	158	77	42	177	91	76	73	87	73	63	215	16	203	0	0	0	0	0	0	2	0	0	15	0	58	3	53	111
64/65	140	187	35	265	137	24	80	332	54	174	166	224	63	52	55	121	84	36	128	159	38	0	32	59	0	0	0	0	0	0	48	0	0	15	0	32
65/66	35	16	12	128	46	28	198	181	65	131	142	68	93	88	99	21	67	84	53	0	49	84	0	0	0	6	1	21	0	0	0	0	0	29	1	12
66/67	9	80	67	174	38	217	63	336	190	214	102	101	69	192	309	50	72	20	55	83	14	0	0	36	1	11	0	32	0	0	30	0	0	35	66	91
67/68	0	290	54	80	47	131	126	193	57	35	132	60	85	102	41	80	48	232	89	3	1	0	0	0	0	0	0	0	0	0	0	21	1	0	29	32
68/69	38	140	0	51	138	150	151	230	59	211	153	67	117	65	184	75	170	80	44	0	33	75	30	0	0	0	0	0	1	14	0	0	0	0	28	40
69/70	0	302	66	21	8	103	216	352	147	47	48	43	23	450	113	75	67	51	33	51	0	0	31	0	0	0	0	0	0	38	0	1	2	3	0	64
70/71	13	46	0	22	185	114	178	162	109	181	135	218	90	109	70	43	85	114	274	0	87	11	18	0	0	0	0	0	0	8	0	77	1	0	0	30
71/72	157	137	13	472	69	161	152	138	97	24	147	143	80	132	63	91	53	119	54	35	29	41	0	25	0	0	0	0	0	0	76	1	0	0	24	58
72/73	66	43	19	33	91	74	106	253	86	23	83	291	197	62	38	57	14	13	72	0	0	0	0	0	0	0	0	7	5	0	0	7	88	16	1	0
73/74	0	29	183	476	198	216	178	143	171	165	71	125	104	30	145	60	34	108	27	15	40	70	87	0	107	0	0	0	4	0	2	0	0	0	1	30
74/75	216	66	97	239	61	48	148	146	105	256	40	133	36	68	320	67	85	117	10	29	68	0	0	15	0	0	0	0	0	0	4	8	0	1	0	0
75/76	0	99	69	57	117	171	144	88	6	20	283	156	103	39	147	73	95	36	43	51	0	27	18	0	0	0	0	0	0	0	15	0	0	8	0	19
76/77	50	28	110	158	231	21	751	249	212	149	156	102	31	168	115	110	19	60	18	15	8	0	4	22	0	0	0	0	9	3	8	0	37	0	19	0
77/78	299	118	198	38	197	213	231	72	246	13	46	55	33	133	61	43	66	26	199	54	43	67	0	2	0	0	16	0	0	0	0	0	0	0	7	45
78/79	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
79/80	87	22	27	44	8	30	69	255	116	257	92	88	94	253	132	159	209	111	47	11	0	0	0	16	47	1	0	0	0	0	19	4	0	19	32	3
80/81	9	53	86	292	227	221	220	215	142	52	66	196	50	58	53	102	66	134	72	146	128	0	0	0	0	2	0	19	0	6	30	11	0	19	7	91
81/82	140	156	9	75	121	318	42	129	53	329	63	118	92	11	235	72	104	33	0	0	0	0	0	0	3	9	0	0	0	0	2	24	0	16	8	2
82/83	43	49	142	23	261	84	105	163	235	197	111	129	360	51	71	56	199	35	3	0	19	1	11	0	0	0	0	2	0	4	0	0	11	15	124	71
83/84	10	76	175	315	144	62	56	288	92	197	60	19	358	52	227	95	69	40	69	136	17	2	0	0	0	0	51	0	1	1	0	0	0	0	0	18
84/85	0	2	56	220	254	107	26	294	62	101	68	162	59	66	123	206	304	5	32	43	19	0	0	0	0	3	0	3	0	0	57	0	2	4	0	70
85/86	20	121	154	82	87	188	311	165	52	50	39	44	62	119	52	45	74	139	0	44	9	1	0	0	0	0	6	0	5	0	0	0	0	1	18	0
86/87	108	168	185	146	83	12	13	106	85	71	34	150	54	129	90	105	69	193	387	5	0	187	0	0	0	0	0	2	1	0	1	0	1	3	41	5
87/88	11	40	214	74	16	116	201	56	6	79	12	255	109	93	193	73	64	131	48	26	54	2	15	0	2	15	0	0	1	0	0	5	26	6	46	0
88/89	0	53	92	75	92	436	37	33	465	368	143	48	44	296	39	139	45	34	138	99	0	0	0	54	0	0	0	0	0	0	0	37	0	0	4	4
89/90	0	2	55	27	89	94	75	148	34	42	105	203	63	116	102	59	35	186	67	92	38	0	0	0	0	0	4	0	0	0	0	17	13	9	2	136
90/91	68	104	95	6	156	138	182	55	58	170	11	72	97	23	42	99	153	152	199	0	0	74	1	0	0	5	0	22	0	0	26	0	0	0	3	11

R-131, Sarail; Daily Rainfall (mm)

10-DAY RAINFALLS

	APR			MAY			JUN			JUL			AUG			SEP			OCT			NOV			DEC			JAN			FEB			MAR		
Year	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
62/63	11	32	96	101	23	201	189	199	103	35	294	68	97	247	99	156	38	13	100	0	74	0	0	0	0	0	0	0	0	0	0	0	0	0	56	29
63/64	-999	-999	-999	33	16	90	264	248	67	71	103	77	61	39	21	214	94	53	130	26	32	64	0	0	0	0	0	0	0	0	0	0	18	0	28	16
64/65	70	188	58	207	68	10	112	257	27	165	130	241	96	55	40	74	74	109	304	212	58	0	4	36	0	0	0	0	0	0	24	0	0	4	0	85
65/66	90	44	9	139	81	27	245	432	122	434	132	87	125	122	202	24	121	112	10	0	102	31	0	0	0	0	0	0	18	0	0	0	0	0	0	22
66/67	7	46	26	132	25	13	0	205	70	176	122	142	41	126	143	18	169	17	93	217	0	0	0	0	0	29	0	37	0	0	0	0	0	6	56	20
67/68	0	179	153	208	33	86	80	192	7	375	132	103	149	55	86	61	92	219	32	22	0	0	0	0	0	0	0	0	23	0	0	1	0	0	23	12
68/69	42	108	3	13	137	124	153	248	80	140	104	97	244	86	171	84	142	85	40	0	4	3	60	0	0	0	0	0	1	0	0	0	0	0	43	62
69/70	0	105	120	6	0	29	165	286	109	95	88	101	48	437	35	53	53	43	22	61	0	0	27	0	0	0	0	0	13	15	0	0	0	0	1	83
70/71	12	86	0	24	126	38	151	179	141	71	185	103	55	272	62	36	154	24	133	0	60	2	22	0	0	0	0	0	5	6	0	25	9	0	0	-999
71/72	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
72/73	-999	56	25	8	19	173	117	236	403	8	67	140	145	55	112	85	0	3	28	0	0	11	0	0	0	0	0	0	5	0	0	6	62	5	9	0
73/74	1	13	248	203	211	301	103	326	198	65	55	301	203	102	66	28	172	80	19	30	47	63	41	0	125	0	0	0	1	0	0	0	0	0	0	17
74/75	189	36	22	174	193	51	128	27	149	230	118	155	23	123	175	20	156	90	29	34	32	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
75/76	0	76	22	6	99	250	171	13	0	8	345	150	122	93	345	33	98	90	17	34	32	0	23	0	0	0	0	0	0	0	10	0	0	9	0	14
76/77	0	22	83	121	114	0	414	246	122	207	0	74	56	163	151	22	36	120	84	8	3	0	0	6	0	0	0	0	7	0	5	0	33	0	0	0
77/78	246	102	55	76	62	49	206	81	125	8	96	28	12	118	64	43	75	22	194	19	85	40	0	2	0	0	20	0	0	0	1	0	0	0	5	67
78/79	0	104	67	88	290	432	224	147	188	40	106	172	24	53	106	113	23	53	69	62	1	0	0	0	0	0	0	0	0	2	13	0	0	5	41	10
79/80	25	29	15	67	3	28	15	183	195	445	86	32	46	283	21	192	159	70	48	16	1	0	0	0	29	1	1	0	0	0	1	4	0	13	6	3
80/81	3	37	30	248	230	179	51	137	28	80	121	235	57	33	145	114	75	37	65	89	119	0	0	0	0	1	0	5	1	1	20	8	0	0	36	18
81/82	84	307	24	45	309	187	15	71	46	311	63	182	112	95	124	88	25	0	29	10	0	0	0	0	1	15	0	0	0	0	0	18	0	20	37	0
82/83	0	13	62	82	189	80	93	130	54	94	44	110	236	35	47	113	37	77	1	0	5	0	14	0	0	0	0	0	0	1	0	0	12	56	66	49
83/84	6	39	202	165	57	64	41	250	77	215	39	12	294	56	282	128	38	6	36	71	8	0	0	0	0	0	20	0	0	0	0	0	0	0	0	14
84/85	28	0	21	203	349	103	116	274	58	76	187	286	77	108	54	191	187	0	47	20	101	0	0	0	0	0	0	1	0	0	27	0	7	0	0	83
85/86	7	61	67	56	71	123	448	107	11	53	35	57	46	48	62	51	64	106	45	38	0	8	0	0	0	0	15	0	1	0	0	1	0	0	11	0
86/87	107	100	118	141	102	12	8	67	64	33	49	141	46	50	102	124	111	202	217	43	0	155	0	0	0	6	0	0	0	0	0	0	0	6	27	11
87/88	25	4	134	104	8	62	282	77	40	62	90	269	105	59	201	57	30	193	35	15	57	0	22	0	0	13	0	0	0	0	0	11	78	17	52	0
88/89	0	29	81	150	70	531	56	172	327	277	117	17	39	199	43	61	126	63	85	195	0	0	0	97	6	0	0	0	0	0	0	40	0	0	6	1
89/90	8	5	66	8	135	97	183	146	8	108	89	138	95	77	41	114	76	145	127	80	3	0	0	0	0	1	11	0	0	0	0	18	24	10	5	235
90/91	65	60	77	17	140	195	125	45	53	267	9	72	138	18	108	67	160	82	220	0	0	42	0	0	0	7	0	11	1	0	12	0	0	21	8	32
91/92	52	11	122	235	207	412	190	113	8	45	79	41	127	19	196	134	153	134	84	143	80	18	0	0	0	0	12	0	0	0	1	1	1	0	0	0
Mean	40	68	72	106	116	136	150	176	99	145	106	125	101	111	114	86	94	77	81	50	31	15	7	5	6	2	3	2	3	1	4	5	8	6	18	31
Max	246	307	248	248	349	531	448	432	403	445	345	301	294	437	345	214	187	219	304	217	119	155	60	97	125	29	20	37	23	15	27	40	78	56	66	235
Min	0	0	0	6	0	0	0	13	0	8	0	12	12	18	21	18	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

R-132, Nasirnagar; Daily Rainfall (mm)

10-DAY RAINFALLS

	APR			MAY			JUN			JUL			AUG			SEP			OCT			NOV			DEC			JAN			FEB			MAR		
Year	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
62/63	0	86	73	100	36	211	84	272	101	39	304	52	44	149	146	119	79	40	43	0	89	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0
63/64	30	52	30	58	47	90	204	229	193	64	154	113	43	120	260	125	88	198	134	67	87	22	0	0	0	0	0	0	0	0	0	0	25	0	76	14
64/65	165	193	65	318	206	2	19	377	32	126	166	351	85	234	184	175	157	154	321	340	116	0	1	94	0	0	0	0	0	0	0	0	5	0	0	17
65/66	41	34	23	6	37	148	118	285	56	351	279	158	210	43	58	74	95	127	0	1	79	45	0	0	0	0	2	0	0	0	0	0	0	1	3	0
66/67	24	35	29	160	95	133	135	352	217	192	166	144	41	135	298	107	110	24	177	101	0	0	0	46	0	15	0	50	0	0	0	0	0	21	80	50
67/68	0	154	82	115	37	0	70	162	89	172	90	48	94	138	75	13	100	180	32	32	0	0	0	0	0	10	0	3	1	0	0	3	4	0	18	43
68/69	63	81	0	19	107	129	47	309	56	132	136	147	138	254	340	99	75	136	47	0	7	0	27	0	0	0	0	0	4	3	0	0	0	0	6	64
69/70	0	385	110	34	11	5	262	318	194	24	46	89	107	555	88	67	45	10	150	70	2	0	6	0	0	0	0	12	3	42	0	1	2	16	0	22
70/71	5	164	4	27	146	90	169	130	73	132	117	136	68	309	67	20	58	18	178	0	37	22	17	0	0	0	0	0	0	6	0	73	0	0	0	15
71/72	54	106	31	305	113	83	147	66	60	25	120	151	58	276	92	81	31	66	214	52	33	66	0	0	0	0	0	0	0	-999	-999	0	0	0	5	35
72/73	-999	56	25	8	19	173	117	236	403	8	67	140	145	55	112	85	0	3	28	0	0	11	0	0	0	0	0	0	5	0	0	6	62	5	9	0
73/74	0	34	74	235	259	224	219	120	110	96	55	217	25	68	151	51	150	61	60	7	42	46	41	0	114	0	0	0	3	0	0	0	0	0	0	37
74/75	273	53	27	174	145	88	118	52	65	344	95	192	14	77	166	24	65	32	53	58	55	0	1	24	0	0	0	0	0	0	6	15	0	13	0	14
75/76	0	72	46	6	63	137	3	2	0	3	245	265	45	86	93	18	171	90	67	43	0	6	39	0	0	0	0	0	0	0	13	0	0	33	0	0
76/77	25	36	106	142	217	1	212	213	196	186	222	132	62	169	136	23	13	66	39	4	8	0	0	27	0	0	0	0	18	19	15	0	46	0	4	3
77/78	311	150	103	58	155	158	321	89	164	88	62	30	27	205	117	150	57	74	403	13	104	73	0	53	0	0	23	0	0	0	3	0	0	1	3	36
78/79	0	103	61	74	348	427	319	74	153	39	83	136	55	-999	-999	-999	-999	-999	-999	-999	1	0	0	0	0	0	0	0	0	2	12	0	0	9	13	72
79/80	8	9	55	65	6	15	33	252	173	362	121	65	94	286	52	335	159	61	46	0	0	0	0	9	46	0	3	0	0	0	31	0	0	38	25	1
80/81	0	50	65	363	213	225	187	113	121	55	88	119	117	41	85	84	37	57	69	28	57	0	0	0	0	0	0	11	3	6	18	1	0	11	33	25
81/82	110	312	4	31	74	107	80	8	121	119	170	161	52	77	111	65	69	28	0	0	6	0	0	0	11	59	0	0	0	0	5	0	0	105	19	10
82/83	34	55	76	144	160	43	64	149	191	158	224	85	191	41	46	268	115	56	0	0	3	5	10	0	0	0	0	5	0	1	0	0	31	28	144	25
83/84	3	55	141	320	57	60	54	181	121	267	116	1	279	85	358	206	136	59	83	76	20	0	0	0	0	0	29	1	1	3	0	0	0	0	0	29
84/85	1	5	46	259	307	66	80	233	98	151	151	337	78	64	90	332	337	3	43	41	6	0	0	0	0	0	0	27	0	0	118	25	25	0	12	56
85/86	33	123	58	71	48	130	421	170	41	30	59	72	101	12	123	73	82	164	37	6	0	0	0	0	0	0	5	0	5	0	0	0	0	0	45	0
86/87	135	131	198	158	76	17	9	102	25	100	10	195	53	192	123	83	81	273	352	20	0	241	0	0	0	1	0	0	3	0	1	0	0	0	32	0
87/88	22	8	183	130	29	194	337	79	48	130	45	343	173	45	381	117	0	260	95	18	51	0	33	0	0	19	0	3	0	0	0	20	52	17	112	0
88/89	0	51	64	123	157	845	6	160	404	372	89	32	83	381	71	69	153	24	205	140	3	0	0	109	5	0	0	0	0	0	2	5	0	0	5	0
89/90	3	4	47	3	130	142	182	141	51	84	75	185	125	142	131	70	109	149	52	102	5	0	0	0	0	0	6	0	0	1	0	18	20	13	0	177
90/91	11	75	58	18	141	272	147	37	75	235	9	69	276	34	46	22	93	159	197	42	0	69	0	0	0	8	0	13	1	0	38	1	6	10	6	10
Mean	48	92	65	121	119	145	143	169	125	141	123	144	99	152	143	105	95	92	112	45	28	21	6	13	6	4	2	4	2	3	9	6	10	12	22	26
Max	311	385	198	363	348	845	421	377	404	372	304	351	279	555	381	335	337	273	403	340	116	241	41	109	114	59	29	50	18	42	118	73	62	105	144	177
Min	0	4	0	3	6	0	3	2	0	3	9	1	14	12	46	13	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

R-351, Bancharampur; Daily Rainfall (mm)

10-DAY RAINFALLS

Year	APR 1	APR 2	APR 3	MAY 1	MAY 2	MAY 3	JUN 1	JUN 2	JUN 3	JUL 1	JUL 2	JUL 3	AUG 1	AUG 2	AUG 3	SEP 1	SEP 2	SEP 3	OCT 1	OCT 2	OCT 3	NOV 1	NOV 2	NOV 3	DEC 1	DEC 2	DEC 3	JAN 1	JAN 2	JAN 3	FEB 1	FEB 2	FEB 3	MAR 1	MAR 2	MAR 3
62/63	40	17	108	106	18	152	121	70	74	149	266	71	53	224	142	65	34	64	-999	-999	-999	-999	-999	-999	0	0	0	0	0	0	0	0	0	0	37	0
63/64	52	41	113	60	103	52	331	182	198	163	184	42	118	31	28	51	70	42	156	0	133	-999	-999	-999	0	0	0	0	0	5	0	0	48	0	38	0
64/65	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
65/66	13	51	27	9	40	74	235	113	60	132	117	183	206	116	162	212	147	4	0	25	46	85	0	0	0	6	0	0	0	0	0	0	0	0	0	13
66/67	0	65	81	11	7	0	95	76	248	235	47	48	35	218	217	68	576	27	165	76	0	0	0	33	0	0	0	20	0	0	0	0	0	30	37	77
67/68	0	84	15	172	16	36	49	182	12	174	200	21	340	42	122	119	25	215	61	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	20
68/69	6	63	0	2	130	63	19	230	98	332	72	46	20	46	75	16	45	4	28	0	14	0	53	0	0	0	0	0	0	0	0	0	0	0	7	53
69/70	0	251	130	22	0	12	108	168	61	136	314	39	80	201	29	84	55	62	21	26	0	0	36	0	0	0	0	0	18	9	0	2	0	1	0	15
70/71	33	70	0	7	104	3	127	48	54	28	151	92	75	103	130	61	164	58	308	0	48	0	135	0	0	0	0	0	0	0	0	22	0	0	10	46
71/72	107	55	69	198	63	57	41	60	41	22	70	292	52	159	43	44	18	17	0	0	11	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0
72/73	0	39	27	14	0	16	0	89	205	-999	84	93	113	36	27	29	7	33	17	0	0	0	6	0	0	0	0	0	0	0	0	12	16	26	8	0
73/74	0	5	23	229	194	101	92	93	116	62	19	413	189	77	128	9	112	45	18	23	29	20	2	0	118	0	0	0	0	0	0	0	0	0	0	46
74/75	46	0	6	46	58	52	262	175	109	116	210	278	184	274	144	43	132	77	65	0	0	0	0	107	0	0	0	0	0	0	0	0	0	8	0	0
75/76	0	43	0	10	83	66	123	214	6	7	592	9	27	21	35	150	64	38	40	140	0	14	23	0	0	0	0	0	0	0	0	0	0	41	0	69
76/77	0	0	30	66	100	18	-999	174	133	198	60	67	175	198	-999	3	20	20	3	8	12	0	0	0	0	0	0	0	0	0	0	0	56	0	0	0
77/78	97	95	75	37	145	109	132	48	89	0	95	108	23	57	34	61	20	17	31	19	41	0	0	40	0	0	11	0	0	0	3	5	0	0	2	12
78/79	36	76	90	224	68	424	272	118	67	3	102	76	28	23	92	42	20	70	17	9	34	0	0	0	0	0	0	0	0	0	5	0	0	11	3	7
79/80	0	13	65	0	0	0	46	150	102	202	29	18	19	7	16	130	64	83	76	0	0	0	0	62	13	0	0	0	0	0	17	6	0	7	7	3
80/81	0	33	33	121	157	84	73	29	0	16	105	73	54	61	73	42	33	54	34	66	53	0	0	0	0	0	0	5	0	4	19	13	-999	0	21	25
81/82	32	407	6	0	31	69	15	10	43	47	73	74	58	55	54	104	41	2	27	22	0	0	0	0	0	12	0	0	0	0	0	27	0	11	35	0
82/83	15	15	35	25	28	17	10	87	28	46	33	47	110	116	62	49	51	32	0	0	11	11	17	0	0	0	0	9	0	3	0	0	8	18	29	3
83/84	8	99	131	166	142	1	10	110	97	90	7	15	425	19	109	65	23	26	34	46	20	0	0	0	0	0	7	0	5	0	0	0	0	0	0	0
84/85	38	0	45	263	400	111	116	105	43	20	198	143	54	207	66	141	215	0	54	34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	17
85/86	21	10	0	27	67	140	59	65	67	84	30	39	71	42	21	10	28	58	0	16	0	0	9	0	0	0	7	0	7	0	0	0	0	0	18	0
86/87	21	73	12	47	19	18	23	27	31	26	13	363	29	27	77	139	88	331	74	28	0	85	0	0	0	0	0	0	0	0	7	0	0	4	0	0
87/88	0	29	137	106	58	59	234	25	31	63	66	391	173	0	134	66	40	104	28	15	27	0	25	0	0	11	0	0	0	0	0	0	25	8	40	0
88/89	13	64	69	142	264	663	14	204	108	181	43	28	40	67	111	30	47	0	17	80	0	0	0	75	0	0	0	0	0	0	0	0	75	0	0	0
89/90	0	5	18	18	13	42	40	94	40	18	141	52	37	36	15	43	32	66	30	57	85	0	0	0	0	0	10	0	0	0	0	12	18	50	71	266
90/91	0	0	0	0	12	18	50	71	266	235	303	94	89	156	125	48	176	51	43	92	135	52	59	20	133	70	61	133	9	0	16	0	0	0	5	4
91/92	22	0	0	22	0	0	27	86	12	0	52	8	337	203	125	91	53	53	39	19	69	30	34	45	115	54	41	100	140	24	0	0	0	0	0	51
Mean	21	59	46	74	80	85	97	107	84	99	127	111	111	97	85	69	83	57	49	30	27	11	15	14	13	5	5	9	6	2	3	3	9	7	14	25
Max	107	407	137	263	400	663	331	230	266	332	592	413	425	274	217	212	576	331	308	140	135	85	135	107	133	70	61	133	140	24	19	27	75	50	71	266
Min	0	0	0	0	0	0	0	10	0	0	7	8	19	0	15	3	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

R-356, Comilla; Daily Rainfall (mm)

10-DAY RAINFALLS

Year	APR 1	APR 2	APR 3	MAY 1	MAY 2	MAY 3	JUN 1	JUN 2	JUN 3	JUL 1	JUL 2	JUL 3	AUG 1	AUG 2	AUG 3	SEP 1	SEP 2	SEP 3
62/63	31	6	95	73	11	136	171	123	100	25	269	254	63	100	87	36	25	15
63/64	-999	-999	-999	-999	-999	-999	302	145	47	151	215	95	215	124	32	7	97	51
64/65	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
65/66	14	2	0	32	55	6	111	219	259	211	19	364	207	284	185	132	49	56
66/67	0	34	40	53	28	29	152	238	96	120	38	69	51	66	173	56	383	15
67/68	0	116	147	101	19	87	83	344	3	143	192	20	252	15	52	113	122	131
68/69	66	120	30	0	294	119	65	407	78	253	139	67	84	123	118	42	74	50
69/70	0	151	88	17	0	75	275	135	303	316	183	21	105	323	116	116	24	107
70/71	41	56	0	1	112	0	78	28	77	96	247	218	86	63	66	46	33	15
71/72	135	58	7	229	26	23	200	54	134	0	159	166	98	75	152	120	79	124
72/73	-999	-999	-999	42	1	175	40	171	110	14	148	115	177	67	150	18	-999	-999
73/74	0	2	92	252	147	183	60	190	235	43	42	201	21	79	31	20	42	80
74/75	177	77	21	154	25	124	193	142	133	240	257	401	29	109	139	149	248	46
75/76	0	23	53	0	95	144	274	27	29	36	442	79	63	33	172	198	107	32
76/77	0	53	59	81	156	57	282	179	105	298	137	115	317	205	93	19	12	0
77/78	137	165	77	114	194	78	139	66	138	32	252	191	18	98	27	51	117	15
78/79	8	99	26	110	99	333	209	42	227	9	286	120	35	40	185	170	5	79
79/80	53	5	2	97	0	0	138	161	88	226	199	30	48	220	88	60	59	138
80/81	1	15	40	188	187	130	43	71	23	116	158	160	142	121	213	89	104	175
81/82	74	489	9	18	274	207	240	166	85	443	310	267	192	99	263	151	88	33
82/83	97	171	151	109	226	52	83	448	81	139	107	180	370	32	116	88	113	39
83/84	24	89	182	215	86	84	48	164	78	225	11	197	384	88	189	108	178	197
84/85	18	0	81	191	479	122	117	337	194	135	173	135	167	154	155	93	164	0
85/86	5	51	103	87	67	162	102	157	82	105	29	80	173	56	84	94	53	89
86/87	101	43	75	99	154	22	23	59	119	104	33	262	70	128	112	62	155	199
87/88	0	84	122	117	0	29	156	134	64	95	117	229	86	77	282	100	20	237
88/89	0	92	112	104	97	259	47	161	144	401	95	121	57	68	222	199	36	7
89/90	22	19	89	0	84	150	79	263	14	118	55	207	17	27	35	149	66	75
90/91	96	25	132	11	272	103	301	80	87	365	60	132	162	88	71	20	68	103
91/92	152	41	97	268	265	127	153	267	39	28	96	109	201	21	136	163	72	195
Mean	46	77	71	99	123	108	143	172	109	155	154	159	134	103	129	92	93	82
Max	177	489	182	268	479	333	302	448	303	443	442	401	384	323	282	199	383	237
Min	0	0	0	0	0	0	23	27	3	0	11	20	17	15	27	7	5	0

Year	OCT 1	OCT 2	OCT 3	NOV 1	NOV 2	NOV 3	DEC 1	DEC 2	DEC 3	JAN 1	JAN 2	JAN 3	FEB 1	FEB 2	FEB 3	MAR 1	MAR 2	MAR 3
62/63	63	2	116	0	0	0	0	0	0	0	1	0	0	5	0	0	14	0
63/64	243	21	294	24	0	0	-999	-999	-999	0	0	2	1	0	33	1	12	6
64/65	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
65/66	0	25	33	136	0	0	0	11	0	14	0	0	0	0	0	0	0	16
66/67	96	190	0	0	0	25	0	89	0	25	1	0	0	0	0	43	61	19
67/68	86	119	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	20
68/69	41	0	27	4	10	0	0	0	0	0	0	0	3	0	0	2	18	36
69/70	6	21	0	0	25	0	0	0	0	0	0	22	0	8	3	5	1	34
70/71	219	0	76	5	68	0	0	0	0	0	0	5	0	12	0	0	0	34
71/72	90	23	-999	59	0	0	0	0	0	0	0	1	43	4	0	0	0	9
72/73	-999	-999	-999	-999	-999	-999	0	0	0	0	5	0	0	-999	-999	-999	0	0
73/74	24	84	39	70	130	0	73	0	0	0	2	0	0	0	0	0	0	103
74/75	81	18	57	0	0	37	0	0	0	0	0	0	0	12	0	3	0	1
75/76	-999	15	1	77	27	0	0	0	0	0	0	0	11	0	0	19	3	33
76/77	61	27	9	1	1	13	0	0	0	0	0	0	0	0	69	0	36	0
77/78	96	3	38	23	0	2	0	0	7	0	0	0	11	1	0	0	1	17
78/79	69	2	0	0	0	0	0	0	0	0	0	5	15	0	0	0	11	20
79/80	156	0	0	0	23	46	68	0	0	0	0	0	33	10	-999	36	0	1
80/81	119	78	88	0	0	0	0	0	0	22	0	5	44	11	0	13	22	52
81/82	18	8	0	13	29	0	0	0	0	0	0	0	12	24	0	27	22	0
82/83	10	0	9	8	48	0	0	0	0	18	0	1	-999	0	38	24	60	51
83/84	43	122	10	5	0	3	0	0	14	0	0	0	0	0	0	0	0	0
84/85	121	33	66	0	0	0	0	3	0	3	0	0	4	4	0	0	27	52
85/86	0	25	0	0	0	0	0	0	0	0	5	0	0	0	0	0	3	1
86/87	165	113	0	104	0	0	0	0	0	0	0	0	0	0	0	0	47	0
87/88	83	33	0	0	70	0	0	11	0	0	0	0	0	4	12	31	42	0
88/89	43	117	0	0	10	40	6	0	0	0	0	0	0	19	0	0	0	0
89/90	165	63	3	0	0	0	0	0	5	0	0	0	0	8	13	44	9	224
90/91	360	0	0	83	25	0	0	51	0	20	0	0	60	0	0	3	12	115
91/92	57	162	73	3	0	0	0	0	115	0	0	0	55	12	6	1	0	0
Mean	93	47	35	22	17	6	5	6	5	3	0	1	10	5	6	9	15	29
Max	360	190	294	136	130	46	73	89	115	25	5	22	60	24	69	44	61	224
Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

R-357, Daudkandi; Daily Rainfall (mm)

10-DAY RAINFALLS

	APR			MAY			JUN			JUL			AUG			SEP			OCT			NOV			DEC			JAN			FEB			MAR		
Year	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
62/63	39	76	104	53	42	85	191	34	40	16	46	209	7	90	77	26	24	44	102	0	99	0	0	0	0	0	0	0	0	0	0	0	0	1	13	0
63/64	4	5	6	139	147	153	299	337	20	60	112	55	45	39	18	11	154	34	153	1	197	60	0	0	0	0	0	0	0	1	6	0	116	0	0	114
64/65	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
65/66	62	30	30	27	82	39	250	178	368	285	34	197	51	44	213	56	152	145	0	7	130	21	0	0	0	3	0	3	0	0	0	0	0	0	0	25
66/67	0	34	46	93	40	21	161	179	182	342	53	137	134	120	138	52	221	48	225	188	13	0	0	63	0	50	0	64	4	0	0	0	0	90	62	112
67/68	0	203	55	90	37	32	37	306	25	236	105	44	361	37	116	95	225	176	143	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	39
68/69	80	67	28	26	312	178	69	245	47	466	237	192	221	65	166	14	80	10	106	42	24	0	76	0	0	0	0	0	0	0	33	0	0	0	89	119
69/70	0	105	135	120	0	78	358	372	160	246	107	75	117	560	138	68	37	105	63	76	0	0	124	0	0	0	0	0	0	20	0	34	0	0	8	-999
70/71	37	137	0	75	78	4	265	147	122	155	195	225	95	109	174	273	115	103	432	0	209	23	76	0	0	0	0	0	0	35	0	21	0	0	0	34
71/72	102	169	227	351	66	56	181	116	261	134	169	431	286	349	145	73	61	75	77	49	29	-999	-999	-999	-999	-999	-999	-999	-999	-999	0	0	0	0	0	86
72/73	38	16	52	33	-999	66	38	0	53	325	293	-999	8	98	92	95	5	60	59	0	0	0	0	0	0	0	0	-999	-999	0	0	19	14	113	0	0
73/74	0	43	42	146	153	137	85	202	151	0	277	297	86	37	75	0	193	66	39	33	24	73	72	0	107	0	0	0	0	0	0	0	0	0	0	213
74/75	47	0	19	48	70	79	263	74	83	113	304	245	43	241	95	99	164	61	78	0	136	0	0	10	0	0	0	0	0	0	0	11	0	0	0	0
75/76	10	38	33	0	94	98	196	138	30	43	400	13	46	19	15	132	123	53	131	48	0	17	8	0	0	0	0	0	0	0	4	0	0	3	0	66
76/77	0	11	111	71	137	43	257	257	152	183	216	98	118	258	49	6	159	138	12	29	39	0	0	76	0	0	0	0	0	0	0	0	-999	0	0	18
77/78	301	245	108	184	257	297	185	309	332	110	183	286	77	54	24	53	14	74	191	51	89	0	0	31	0	0	36	0	0	0	29	33	0	0	28	61
78/79	55	166	81	232	110	395	214	163	127	37	150	171	142	47	220	371	47	100	85	4	19	0	0	0	0	0	0	0	0	18	53	0	0	0	0	0
79/80	0	0	38	81	69	168	153	282	338	301	147	0	53	310	159	258	110	121	127	8	10	0	50	169	80	0	0	0	0	0	76	52	0	86	0	0
80/81	0	80	102	287	406	56	113	307	89	188	180	206	132	153	302	201	119	185	66	0	0	0	0	0	0	0	0	10	8	18	100	0	0	33	91	186
81/82	170	577	48	23	269	157	320	8	302	213	378	485	297	358	226	381	198	23	0	23	0	0	0	0	3	97	0	0	0	0	8	22	0	67	50	0
82/83	76	241	276	217	91	53	36	483	175	206	104	244	539	43	86	61	109	97	36	0	0	74	0	0	0	0	0	18	0	0	0	0	114	0	333	0
83/84	89	224	533	523	198	25	122	208	41	235	89	99	430	122	114	219	109	36	185	119	0	0	0	0	0	0	25	0	25	0	0	0	0	0	0	0
84/85	32	0	103	310	363	160	208	313	442	150	424	277	226	208	155	231	259	0	51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	429
85/86	3	0	135	157	175	193	79	189	114	209	119	61	91	41	124	46	25	117	0	69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86/87	137	150	135	66	173	13	23	23	213	94	92	170	46	66	62	36	63	257	175	28	0	218	0	0	0	0	0	0	0	0	0	0	0	41	3	3
87/88	0	213	239	0	0	3	43	107	102	-999	-999	334	94	17	349	130	56	231	13	6	50	0	25	0	0	21	0	0	0	0	0	19	16	36	77	0
88/89	0	134	138	109	25	68	1	68	47	273	45	56	107	50	-999	-999	-999	36	49	115	0	0	0	115	0	0	0	0	0	0	0	3	0	0	0	0
89/90	7	0	72	0	128	91	78	143	37	161	94	107	15	64	19	99	76	112	100	144	2	0	0	0	0	0	7	0	0	0	0	7	35	13	5	224
90/91	29	40	203	26	130	52	197	32	104	293	72	51	133	22	0	69	122	32	257	0	0	53	0	0	0	8	0	58	0	0	57	0	0	75	38	17
91/92	112	60	64	202	157	153	149	201	50	119	25	49	193	28	150	258	35	295	57	105	56	0	0	0	0	0	150	0	0	9	40	16	0	0	30	0
Mean	49	106	109	127	136	102	158	187	145	185	166	172	145	126	125	122	109	98	104	40	39	19	15	17	7	6	8	6	1	4	14	8	11	19	30	62
Max	301	577	533	523	406	395	358	483	442	466	424	485	539	560	349	381	259	295	432	188	209	218	124	169	107	97	150	64	25	35	100	52	116	113	333	429
Min	0	0	0	0	0	3	1	0	20	0	25	0	7	17	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

262

R-362, Kasba; Daily Rainfall (mm)

10-DAY RAINFALLS

	APR			MAY			JUN			JUL			AUG			SEP			OCT			NOV			DEC			JAN			FEB			MAR		
Year	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
62/63	12	4	220	90	30	217	115	160	144	13	250	128	84	130	135	34	24	24	62	2	95	0	0	0	0	0	0	0	1	0	0	0	0	0	79	0
63/64	83	79	34	75	56	30	181	210	16	138	144	105	69	41	3	8	35	43	110	22	284	6	0	0	0	0	0	0	0	1	0	0	47	0	12	4
64/65	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
65/66	15	4	3	41	108	125	228	349	235	278	95	284	242	255	324	98	23	93	4	0	58	36	0	0	0	2	0	5	0	0	0	0	0	0	0	0
66/67	0	12	91	67	31	104	66	228	54	288	105	36	67	102	174	95	377	20	129	208	0	0	0	54	0	52	0	24	0	0	0	0	0	18	16	56
67/68	0	141	75	164	45	75	100	220	4	183	82	19	125	71	64	87	75	176	87	69	0	0	0	0	0	0	0	0	0	0	0	0	3	0	11	1
68/69	12	127	1	0	202	78	36	351	152	232	119	89	34	52	129	3	47	47	84	0	31	33	3	0	0	0	0	0	0	0	1	0	0	0	55	84
69/70	0	83	90	8	0	9	226	152	141	165	116	28	38	226	52	53	80	28	112	18	0	0	109	0	0	0	0	0	0	20	0	4	0	6	7	57
70/71	8	114	0	18	141	50	59	57	140	66	203	171	28	105	32	23	31	12	270	0	83	4	99	0	0	0	0	0	0	2	0	27	0	0	0	-999
71/72	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0	0	0	0	0	0	0	0	0	17
72/73	72	41	55	48	14	88	96	207	77	15	150	126	116	94	10	31	2	15	3	10	0	0	0	3	0	0	0	0	0	0	0	11	54	76	2	0
73/74	0	1	218	329	107	110	185	190	145	30	68	153	19	39	4	5	31	117	4	7	42	19	115	0	97	0	0	0	0	0	0	0	0	0	0	123
74/75	126	63	11	174	72	50	121	28	21	117	252	360	12	190	106	47	68	48	57	16	36	0	0	11	0	0	0	0	0	0	0	18	0	0	0	0
75/76	0	53	28	36	49	117	191	7	5	6	427	18	77	38	128	60	136	23	28	17	0	16	47	0	0	0	0	0	0	0	15	0	0	18	7	21
76/77	3	47	110	64	100	22	374	174	154	204	60	13	195	189	150	31	45	7	23	28	3	3	0	5	0	0	0	0	0	1	0	0	16	2	4	0
77/78	320	122	75	103	174	121	218	83	128	30	237	88	15	79	46	46	46	14	248	0	28	37	0	1	0	0	6	0	0	0	1	0	0	0	0	86
78/79	0	144	35	258	123	307	325	141	188	5	260	44	9	13	221	232	8	61	29	7	3	0	0	0	0	0	0	0	0	1	3	0	0	1	19	29
79/80	28	6	1	104	0	0	39	104	157	300	193	38	10	316	10	13	93	83	35	0	0	0	0	34	62	0	1	0	0	0	36	5	13	10	0	3
80/81	0	57	37	241	219	150	57	168	28	19	82	74	56	13	36	12	81	122	28	130	109	0	0	0	0	1	0	9	0	2	19	3	0	0	5	9
81/82	127	304	0	2	173	139	69	30	78	166	70	148	55	25	145	37	79	6	22	1	0	0	0	0	0	8	0	0	0	0	0	22	0	24	112	2
82/83	7	67	27	60	113	25	18	153	97	64	54	107	447	21	32	46	89	76	0	0	4	10	12	0	0	0	1	25	0	1	0	0	32	15	53	43
83/84	3	137	177	278	43	73	65	131	93	421	0	45	279	4	170	187	19	21	32	101	46	3	0	0	0	0	6	0	1	1	0	0	0	0	0	0
84/85	31	0	39	141	319	66	86	278	75	30	192	190	89	166	49	74	216	0	94	12	33	0	0	0	0	2	0	1	0	0	23	1	7	0	7	81
85/86	12	25	62	52	95	159	177	157	78	61	22	44	41	23	66	64	98	80	30	14	0	0	0	0	0	0	11	0	3	0	0	0	0	2	1	2
86/87	80	47	100	122	100	54	13	32	61	44	25	338	89	65	128	31	67	171	147	59	0	193	0	0	0	0	0	1	2	0	0	0	0	2	26	0
87/88	31	6	196	103	1	34	133	44	12	123	183	213	73	40	246	41	38	213	39	25	0	0	8	0	0	2	0	0	0	0	0	1	2	41	112	1
88/89	0	134	138	24	42	89	0	41	129	264	15	4	13	57	96	214	231	26	95	186	0	0	0	17	0	0	0	0	0	0	0	27	0	0	0	0
89/90	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
90/91	132	0	170	132	70	195	250	45	0	325	12	110	177	33	147	51	123	194	216	0	0	12	10	0	0	7	0	20	0	0	75	0	0	80	25	75
91/92	178	38	95	326	304	303	256	340	14	115	78	139	177	0	197	275	114	276	95	223	160	0	0	0	0	0	100	0	0	0	15	10	17	0	0	0
Mean	47	69	77	113	101	103	136	151	90	137	129	115	98	88	107	70	84	74	77	43	38	14	15	5	6	3	4	3	0	1	7	5	7	11	20	26
Max	320	304	220	329	319	307	374	351	235	421	427	360	447	316	324	275	377	276	270	223	284	193	115	54	97	52	100	25	3	20	75	27	54	80	112	123
Min	0	0	0	0	0	0	0	7	0	5	0	4	9	0	3	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

R-365, Munshiganj; Daily Rainfall (mm)

10-DAY RAINFALLS

Year	APR 1	APR 2	APR 3	MAY 1	MAY 2	MAY 3	JUN 1	JUN 2	JUN 3	JUL 1	JUL 2	JUL 3	AUG 1	AUG 2	AUG 3	SEP 1	SEP 2	SEP 3	OCT 1	OCT 2	OCT 3	NOV 1	NOV 2	NOV 3	DEC 1	DEC 2	DEC 3	JAN 1	JAN 2	JAN 3	FEB 1	FEB 2	FEB 3	MAR 1	MAR 2	MAR 3
62/63	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
63/64	0	68	62	124	118	72	170	-999	19	64	119	87	90	108	25	29	59	49	67	27	221	16	0	0	0	0	0	1	0	0	2	0	99	0	0	39
64/65	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
65/66	7	31	1	-999	69	112	117	64	243	307	11	125	102	123	204	-999	67	126	1	10	47	33	0	0	0	5	0	7	0	0	0	0	0	0	0	6
66/67	0	28	12	-999	0	16	81	164	169	158	68	67	-999	97	140	92	534	19	120	125	23	0	1	12	0	30	0	32	1	0	0	0	0	20	60	2
67/68	0	-999	30	90	44	54	31	126	16	199	102	38	245	53	134	57	104	141	27	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	44	14
68/69	53	18	14	5	111	-999	41	370	139	342	111	112	82	132	41	23	53	5	59	11	0	57	55	0	0	0	0	0	0	0	0	0	0	0	21	55
69/70	0	79	69	30	0	29	127	159	119	91	164	36	-999	291	60	24	63	183	88	51	0	0	26	0	0	0	0	0	6	10	0	7	0	12	7	100
70/71	105	86	0	29	51	0	192	103	58	42	123	232	137	84	72	133	168	5	286	0	127	0	74	0	0	0	0	0	0	28	0	19	0	0	0	0
71/72	55	74	25	-999	-999	53	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0	45	13	0	-999	38	0	0	0	0	0	0	0	0	6	0	-999	0	0	0
72/73	-999	-999	-999	15	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0	46	0	0	0	0	0	0	0	0	0	0	0	0	0	-999	-999	0	0
73/74	0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0	-999	0	-999	-999	0	0	0	0	0	0	0	0	0	0	0
74/75	0	-999	-999	-999	-999	-999	-999	-999	-999	10	-999	-999	-999	-999	-999	-999	-999	0	0	0	0	0	0	0	0	0	0	0	0	0	-999	0	0	0	0	-999
75/76	0	36	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0	-999	93	55	264	118	23	0	34	0	0	0	0	0	0	10	0	0	0	0	0	0
76/77	0	0	-999	42	52	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-999	-999	0	8
77/78	-999	-999	-999	-999	197	-999	44	94	-999	49	-999	-999	6	13	8	0	48	0	-999	13	6	1	0	1	0	0	2	0	0	0	8	11	0	0	0	10
78/79	11	37	3	-999	53	-999	-999	95	196	0	47	-999	29	1	-999	3	2	150	13	1	-999	1	0	0	0	0	0	0	0	1	1	0	0	1	0	2
79/80	8	0	14	0	0	2	-999	330	-999	2	-999	-999	46	-999	-999	-999	-999	-999	0	0	0	0	0	2	1	0	0	0	0	0	1	1	1	0	0	0
80/81	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
81/82	55	260	19	15	113	145	118	36	49	158	32	90	80	80	107	92	163	8	65	16	0	4	0	0	3	21	0	0	0	0	0	0	0	0	34	8
82/83	0	109	165	-999	100	18	16	213	-999	24	37	207	-999	49	36	35	-999	38	0	0	24	-999	29	0	0	0	0	7	0	0	0	3	21	11	-999	0
83/84	37	111	-999	-999	193	40	0	-999	-999	23	19	53	292	14	-999	-999	101	0	-999	46	-999	26	15	5	0	0	12	0	1	3	0	0	0	0	14	48
84/85	31	3	0	132	180	48	319	126	-999	30	165	-999	23	35	109	-999	233	1	34	31	8	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
85/86	0	4	55	39	112	137	116	89	33	63	34	102	39	42	80	75	91	67	0	40	0	0	0	0	0	0	0	0	3	0	0	0	0	0	4	0
86/87	49	15	122	29	93	37	24	21	227	13	-999	493	46	15	82	27	115	189	118	0	0	216	0	0	0	0	0	0	0	0	0	2	0	8	5	0
87/88	0	102	-999	72	15	28	-999	32	71	-999	-999	-999	114	-999	-999	11	0	27	9	0	0	0	0	0	0	0	0	0	0	0	0	0	34	-999	-999	0
88/89	0	119	74	11	62	191	180	184	53	-999	29	-999	20	52	-999	-999	57	31	23	208	0	0	0	59	0	0	0	0	0	0	0	2	0	0	0	0
89/90	0	0	57	0	163	93	85	171	8	94	23	124	0	0	14	210	80	39	-999	-999	3	0	0	0	0	0	5	0	0	0	0	2	7	13	0	203
Mean	18	59	43	42	86	63	104	140	100	93	72	136	84	70	74	54	102	51	59	31	22	17	9	3	0	2	1	2	0	2	1	2	7	3	8	21
Max	105	260	165	132	197	191	319	370	243	342	165	493	292	291	204	210	534	189	286	208	221	216	74	59	3	30	12	32	6	28	8	19	99	20	60	203
Min	0	0	0	0	0	0	0	21	8	0	11	36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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R-366, Muradnagar; Daily Rainfall (mm)

10-DAY RAINFALLS

	APR			MAY			JUN			JUL			AUG			SEP			OCT			NOV			DEC			JAN			FEB			MAR		
Year	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
62/63	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
63/64	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
64/65	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
65/66	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
66/67	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
67/68	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
68/69	15	18	0	0	55	23	8	83	22	41	27	38	50	23	-999	36	42	4	5	0	0	25	5	0	0	0	0	0	0	0	0	0	0	0	24	76
69/70	0	0	32	46	0	37	197	104	103	174	188	83	72	243	102	96	72	48	24	53	9	0	41	0	0	0	0	0	8	6	0	2	0	3	0	27
70/71	4	123	15	0	137	42	77	77	202	64	193	214	62	100	70	41	66	4	232	0	78	1	56	0	0	0	0	0	0	3	0	6	0	0	0	0
71/72	16	163	28	226	52	26	120	62	184	16	78	316	79	210	85	133	77	160	109	55	5	107	0	0	0	0	0	0	0	0	11	0	0	0	0	4
72/73	59	4	52	13	0	32	14	238	148	9	79	155	131	117	107	80	15	34	27	0	0	0	0	0	0	0	-999	0	0	-999	0	19	25	130	13	0
73/74	0	0	117	215	175	83	22	284	182	30	131	337	29	168	28	18	92	82	5	32	18	65	66	0	112	0	0	0	0	0	0	0	0	0	0	91
74/75	75	29	27	80	94	101	126	135	97	187	253	318	-999	-999	-999	-999	44	52	60	0	44	0	0	10	0	0	0	0	0	0	1	6	0	0	0	0
75/76	0	53	33	3	153	139	148	40	18	79	301	45	0	0	125	110	69	3	122	62	1	75	2	0	0	0	0	0	0	0	0	0	0	0	0	53
76/77	0	18	43	36	134	11	209	226	88	230	40	25	20	32	-999	-999	-999	-999	-999	12	4	0	0	0	0	0	0	0	0	4	0	0	51	0	0	0
77/78	122	226	78	63	186	131	153	82	145	15	170	77	25	46	83	104	61	33	104	0	18	16	0	3	0	0	0	0	0	0	8	0	3	0	6	16
78/79	6	132	65	324	224	494	221	65	256	5	191	109	33	25	77	102	0	22	8	20	0	0	0	0	0	0	0	0	0	13	8	0	0	33	31	31
79/80	17	3	0	155	0	0	79	127	220	136	241	51	41	280	62	75	92	51	61	0	0	0	5	93	51	0	0	0	0	0	38	10	0	28	0	9
80/81	3	25	36	176	113	83	71	215	0	109	97	68	89	165	107	92	50	101	27	170	38	0	0	0	0	0	0	23	0	5	43	3	0	5	0	25
81/82	51	506	0	0	178	84	56	20	43	156	234	284	121	20	57	71	69	13	28	0	0	0	0	0	18	0	0	0	0	0	0	38	0	43	41	0
82/83	116	89	107	64	226	25	25	259	63	165	63	145	346	13	66	198	97	64	48	13	0	0	20	0	0	0	0	15	0	13	0	0	30	33	118	99
83/84	173	0	198	196	163	140	0	81	64	351	18	152	577	0	183	429	94	18	15	165	18	0	0	0	0	0	15	0	0	8	3	0	0	0	0	0
84/85	0	0	267	267	508	51	450	254	168	74	418	436	329	130	556	279	445	0	46	18	1	0	0	0	0	0	0	0	0	5	0	0	8	0	31	158
85/86	8	58	64	51	71	175	143	89	97	150	5	91	51	15	0	38	10	64	0	9	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
86/87	83	8	48	41	191	61	13	119	114	46	28	326	38	102	135	42	113	211	50	5	0	241	0	0	0	0	0	0	0	0	0	0	0	0	33	0
87/88	0	64	226	0	38	36	213	25	81	112	132	252	147	23	292	132	124	132	42	57	0	0	18	0	0	0	0	0	0	0	0	18	13	48	84	0
88/89	0	82	66	0	102	290	58	127	175	99	89	41	61	61	107	-999	-999	33	31	28	25	0	0	36	25	0	0	0	0	0	0	10	0	0	0	10
89/90	5	36	84	0	145	140	56	23	87	141	76	74	58	59	48	115	50	94	98	150	0	0	0	0	0	0	8	0	0	0	0	9	24	11	6	179
90/91	113	100	39	60	145	78	205	95	95	231	98	105	133	65	190	242	50	48	200	0	0	75	0	0	0	8	0	9	0	0	0	0	7	24	62	16
91/92	54	0	59	227	150	176	129	135	35	65	25	76	225	35	250	205	19	213	72	192	60	52	0	0	0	0	54	0	0	10	30	15	15	0	0	0
Mean	38	72	70	93	135	102	116	124	112	112	132	159	118	84	130	126	79	64	61	43	13	27	9	6	9	0	3	2	0	3	6	6	7	15	19	33
Max	173	506	267	324	508	494	450	284	256	351	418	436	577	280	556	429	445	213	232	192	78	241	66	93	112	8	54	23	8	13	43	38	51	130	118	179
Min	0	0	0	0	0	0	0	20	0	5	5	25	0	0	0	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

R-367, Nabinagar; Daily Rainfall (mm).

10-DAY RAINFALLS

	APR			MAY			JUN			JUL			AUG			SEP			OCT			NOV			DEC			JAN			FEB			MAR		
Year	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
62/63	42	10	75	97	23	244	92	174	79	136	177	55	35	140	57	144	86	62	49	0	62	0	0	0	0	0	0	0	-999	-999	-999	-999	-999	-999	-999	-999
63/64	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
64/65	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
65/66	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
66/67	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
67/68	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
68/69	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
69/70	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
70/71	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
71/72	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
72/73	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
73/74	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
74/75	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
75/76	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
76/77	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
77/78	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
78/79	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
79/80	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
80/81	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
81/82	92	281	0	29	166	117	77	12	13	165	134	100	46	22	103	21	71	12	41	5	0	0	0	0	0	22	0	0	0	0	0	12	0	23	43	1
82/83	31	18	53	110	123	45	15	213	123	109	17	83	259	5	48	44	47	24	0	0	0	0	15	0	0	0	0	27	0	13	0	0	20	17	76	13
83/84	10	94	148	213	97	53	6	131	120	158	25	17	366	57	184	141	38	6	67	123	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0
84/85	19	0	66	195	299	125	183	153	63	68	228	199	104	130	68	350	94	0	152	38	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	58
85/86	21	35	22	29	59	142	318	199	73	77	22	61	38	4	85	22	59	113	56	36	0	0	0	0	0	0	4	0	1	0	0	0	0	0	5	0
86/87	140	34	117	109	156	70	6	63	44	21	14	210	78	45	116	160	123	223	137	57	0	137	0	0	0	0	0	0	0	0	0	0	0	10	26	1
87/88	24	10	146	57	5	84	153	66	38	35	34	254	85	1	177	27	27	66	18	0	6	0	0	0	0	5	0	0	0	0	0	13	24	25	57	0
88/89	0	22	58	79	53	389	8	179	306	313	47	28	98	30	28	114	108	10	59	157	0	0	0	101	6	0	0	0	0	0	0	40	0	0	1	0
89/90	5	0	38	0	122	170	163	158	26	104	97	75	37	61	46	83	86	67	46	91	0	0	0	0	0	0	4	0	0	0	0	1	58	5	4	97
90/91	131	28	0	6	147	115	154	69	109	205	81	86	76	0	90	130	133	121	245	0	0	23	0	0	0	0	0	53	0	0	7	0	0	1	13	50
91/92	9	13	92	216	195	260	85	48	3	18	20	42	53	3	58	-999	-999	-999	7	9	3	60	0	0	0	0	4	0	0	0	3	0	1	0	0	0
Mean	44	45	68	95	121	151	105	122	83	117	75	101	106	42	88	112	79	64	73	43	6	18	1	8	1	2	2	7	0	1	1	6	9	7	21	20
Max	140	281	148	216	299	389	318	213	306	313	228	254	366	140	184	350	133	223	245	157	62	137	15	101	6	22	15	53	1	13	7	40	58	25	76	97
Min	0	0	0	0	5	45	6	12	3	18	14	17	35	0	28	21	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

R-371, Raipur (Comilla); Daily Rainfall (mm)

10-DAY RAINFALLS

	APR			MAY			JUN			JUL			AUG			SEP			OCT			NOV			DEC			JAN			FEB			MAR		
Year	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
62/63	7	44	133	48	24	90	116	26	49	11	154	107	12	155	45	163	20	63	51	0	109	0	0	0	0	0	0	0	1	0	0	0	0	0	12	3
63/64	0	0	-999	224	56	108	281	212	19	73	115	69	68	119	39	58	100	23	168	0	248	18	0	0	0	0	0	0	0	0	0	0	46	0	0	7
64/65	30	0	0	56	42	52	133	170	212	120	177	268	30	232	43	181	0	85	164	168	62	0	42	39	0	0	0	-999	-999	-999	-999	-999	-999	-999	-999	-999
65/66	0	1	17	21	14	11	61	163	144	212	5	344	110	185	183	82	108	69	0	0	79	41	0	0	0	0	0	8	0	0	0	0	0	0	1	13
66/67	0	113	17	56	17	60	38	144	10	114	46	70	62	107	250	83	228	37	94	132	12	0	0	9	0	53	0	28	0	0	0	0	0	51	17	71
67/68	81	66	43	37	239	146	37	336	121	179	90	25	236	64	121	163	99	240	67	57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33	0
68/69	0	118	105	11	0	66	148	169	96	286	175	110	81	104	117	4	67	17	33	20	4	1	17	0	0	0	0	0	0	0	0	0	0	0	79	23
69/70	71	99	0	20	68	0	202	46	147	164	196	78	107	234	41	13	62	81	28	32	0	0	32	0	0	0	0	0	0	13	0	0	0	6	9	48
70/71	88	104	47	250	42	46	114	58	124	90	166	155	81	-999	117	85	55	86	310	0	111	0	48	0	0	0	0	0	0	5	0	13	0	0	0	0
71/72	62	13	37	21	0	80	4	248	164	21	165	370	129	249	134	150	57	202	56	21	32	44	1	0	0	0	0	0	0	0	21	0	0	0	0	28
72/73	0	37	124	159	179	199	73	266	198	15	104	32	132	90	110	65	0	94	23	0	0	0	0	10	0	0	0	0	0	0	0	11	25	94	0	0
73/74	60	10	17	102	83	71	147	67	83	13	140	295	63	76	59	71	124	130	33	38	30	55	72	0	112	0	0	0	0	0	0	0	0	0	0	129
74/75	5	23	37	4	97	89	187	21	26	180	197	230	49	311	140	78	111	66	46	29	41	0	0	19	0	0	0	0	0	0	0	8	0	0	0	0
75/76	0	18	86	53	163	47	219	240	102	25	503	71	43	17	181	109	117	28	74	67	5	15	34	0	0	0	0	0	0	0	14	0	0	33	0	65
76/77	119	105	77	43	206	146	71	71	159	286	105	59	66	188	55	7	59	59	19	-999	-999	0	0	42	0	0	0	0	0	1	0	0	85	0	0	5
77/78	16	91	36	167	51	440	187	37	264	11	300	230	20	72	68	84	41	70	55	56	24	17	0	11	0	0	14	0	0	0	8	5	0	0	11	26
78/79	-999	-999	-999	-999	-999	-999	-999	-999	-999	4	177	75	38	14	140	137	33	34	21	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
79/80	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
80/81	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
81/82	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
82/83	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
83/84	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
84/85	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
85/86	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
86/87	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
87/88	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
88/89	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
89/90	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
90/91	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
91/92	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
Mean	34	53	52	79	80	103	126	142	120	106	166	152	78	139	108	90	75	81	73	40	47	11	14	8	7	3	1	2	0	1	3	2	10	11	10	26
Max	119	118	133	250	239	440	281	336	264	286	503	370	236	311	250	181	228	240	310	168	248	55	72	42	112	53	14	28	1	13	21	13	85	94	79	129
Min	0	0	0	4	0	0	4	21	10	4	5	25	12	14	39	4	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

R-373, Ramchandrapur;Daily Rainfall Data (mm)

10-DAY RAINFALLS

	APR			MAY			JUN			JUL			AUG			SEP			OCT			NOV			DEC			JAN			FEB			MAR		
Year	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
62/63	41	26	109	102	11	119	217	113	76	29	120	65	25	157	67	139	0	21	35	0	72	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0
63/64	16	85	47	108	72	58	270	141	43	128	168	179	107	48	42	55	70	55	133	18	216	13	0	0	0	0	0	0	0	4	2	0	37	0	13	0
64/65	27	4	0	27	56	14	170	339	174	78	183	209	43	91	69	105	44	92	248	239	0	0	81	5	0	0	0	-999	-999	-999	-999	-999	-999	-999	-999	-999
65/66	0	38	48	18	8	34	104	237	235	207	10	255	136	213	227	84	152	37	20	27	75	67	0	0	0	2	0	8	0	0	0	0	0	0	10	0
66/67	0	69	19	108	9	38	24	241	6	258	39	100	29	42	190	71	206	0	199	211	0	0	0	67	0	83	0	60	0	0	0	0	0	41	56	117
67/68	0	142	112	13	0	19	146	220	97	160	145	27	226	39	117	80	127	221	47	24	0	0	0	0	0	0	0	0	0	0	4	0	0	0	15	28
68/69	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
69/70	45	52	0	0	64	25	155	27	161	71	189	51	52	318	147	122	36	70	76	52	0	0	37	0	0	0	0	0	13	4	0	0	0	0	0	19
70/71	77	125	60	83	104	32	155	71	114	56	175	122	90	103	113	46	81	45	192	0	117	23	36	0	0	0	0	0	0	0	0	20	0	0	0	0
71/72	0	0	0	0	0	0	0	0	0	72	113	305	127	262	143	64	85	164	76	0	76	51	0	0	0	0	0	0	0	0	4	0	0	0	0	0
72/73	0	0	178	277	293	218	33	206	146	15	253	42	125	35	102	76	0	13	22	0	0	0	0	0	0	0	0	0	0	0	0	25	58	70	6	3
73/74	69	13	33	104	168	117	132	222	139	15	126	310	38	32	29	10	195	79	36	33	51	60	38	0	141	10	0	0	0	0	0	0	0	0	0	60
74/75	0	74	57	12	137	112	96	20	14	182	301	137	24	278	218	95	91	53	28	6	46	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0
75/76	-999	-999	-999	-999	-999	-999	-999	-999	-999	20	495	23	84	31	69	163	117	124	20	76	0	8	51	0	0	0	0	0	0	0	6	0	0	62	0	62
76/77	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
77/78	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
78/79	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
79/80	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
80/81	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
81/82	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
82/83	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
83/84	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
84/85	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
85/86	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
86/87	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
87/88	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
88/89	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
89/90	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
90/91	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
91/92	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
Mean	23	52	55	71	77	65	125	153	100	99	178	140	85	127	118	85	93	75	87	53	50	17	19	6	11	7	0	6	1	1	2	4	8	14	10	24
Max	77	142	178	277	293	218	270	339	235	258	495	310	226	318	227	163	206	221	248	239	216	67	81	67	141	83	0	60	13	4	13	25	58	70	56	117
Min	0	0	0	0	0	0	0	0	0	15	10	23	24	31	29	10	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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APPENDIX B.II

Annual Maximum Seasonal Rainfall Estimates

Annual Maximum Pre-Monsoon Rainfall
R-076, Narsingdi; Daily Rainfall (mm).

Duration Days	Return Period (years) 2	5	10	20	50
1	113	151	175	199	230
2	168	215	245	275	313
3	204	267	308	348	399
4	232	305	354	401	461
5	252	329	380	429	492
7	302	407	476	543	629
10	355	479	561	640	743

Annual Maximum Mid-Monsoon Rainfall
R-076, Narsingdi; Daily Rainfall (mm).

Duration Days	Return Period (years) 2	5	10	20	50
1	122	165	193	219	254
2	178	235	273	310	357
3	206	276	323	367	425
4	236	317	370	421	488
5	255	347	408	466	542
7	290	391	459	523	607
10	342	449	520	588	676

Annual Maximum Post-Monsoon Rainfall
R-076, Narsingdi; Daily Rainfall (mm).

Duration Days	Return Period (years) 2	5	10	20	50
1	90	126	151	174	204
2	123	176	211	244	288
3	143	207	250	291	344
4	160	231	279	324	383
5	169	244	293	341	403
7	186	270	326	380	449
10	221	311	370	426	500

Annual Maximum Rainfall
R-076, Narsingdi; Daily Rainfall (mm).

Duration Days	Return Period (years) 2	5	10	20	50
1	147	184	208	231	261
2	212	256	286	314	350
3	258	316	354	391	438
4	296	361	405	446	500
5	317	392	442	490	552
7	364	463	528	590	671
10	424	531	601	669	756

Annual Maximum Pre-Monsoon Rainfall
R-101, Bhairab Bazar; Daily Rainfall (mm)

Duration Days	Return Period (years)				
	2	5	10	20	50
1	107	141	163	184	211
2	147	192	222	250	287
3	179	246	290	333	388
4	204	279	328	375	436
5	224	305	358	410	477
7	265	358	420	479	556
10	312	412	479	542	625

Annual Maximum Mid-Monsoon Rainfall
R-101, Bhairab Bazar; Daily Rainfall (mm)

Duration Days	Return Period (years)				
	2	5	10	20	50
1	110	156	186	216	253
2	147	218	264	309	366
3	174	248	298	345	406
4	195	276	329	381	447
5	213	297	353	406	476
7	239	328	387	444	517
10	280	369	428	484	558

Annual Maximum Post-Monsoon Rainfall
R-101, Bhairab Bazar; Daily Rainfall (mm)

Duration Days	Return Period (years)				
	2	5	10	20	50
1	88	133	163	191	229
2	118	178	218	256	306
3	135	199	241	281	334
4	147	213	257	299	354
5	155	224	270	314	371
7	168	241	290	336	397
10	196	282	339	394	465

Annual Maximum Rainfall
R-101, Bhairab Bazar; Daily Rainfall (mm)

Duration Days	Return Period (years)				
	2	5	10	20	50
1	138	185	215	245	283
2	186	257	305	350	409
3	224	304	356	407	472
4	250	333	388	441	509
5	273	358	414	468	537
7	313	406	467	526	603
10	360	462	530	595	680

Annual Maximum Pre-Monsoon Rainfall
R-103, Brahmanbaria; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	117	157	184	209	242
2	156	209	245	279	323
3	193	268	318	365	427
4	216	302	358	413	483
5	235	328	390	450	527
7	271	382	455	525	616
10	313	428	503	576	670

Annual Maximum Mid-Monsoon Rainfall
R-103, Brahmanbaria; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	117	161	190	218	254
2	149	208	247	285	333
3	177	254	305	355	418
4	194	285	344	401	476
5	213	311	376	439	520
7	242	342	408	472	554
10	274	368	430	490	567

Annual Maximum Post-Monsoon Rainfall
R-103, Brahmanbaria; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	77	120	148	176	211
2	102	156	193	227	272
3	119	184	226	267	320
4	129	196	241	284	339
5	141	216	266	314	377
7	158	244	301	355	425
10	179	269	329	387	461

Annual Maximum Rainfall
R-103, Brahmanbaria; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	156	193	218	243	274
2	202	251	283	314	354
3	247	321	370	417	478
4	275	359	415	469	538
5	298	392	454	513	590
7	334	439	509	576	663
10	371	474	543	609	694

Annual Maximum Pre-Monsoon Rainfall
R-105, Chandpur Bagan; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	111	155	184	212	249
2	153	212	250	288	336
3	187	263	314	363	426
4	213	300	357	411	482
5	235	329	391	451	528
7	276	379	447	512	597
10	322	436	511	584	677

Annual Maximum Mid-Monsoon Rainfall
R-105, Chandpur Bagan; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	94	135	162	189	223
2	134	198	240	280	332
3	161	235	284	331	391
4	177	253	303	351	413
5	189	272	326	379	446
7	209	290	344	395	462
10	239	323	378	430	499

Annual Maximum Post-Monsoon Rainfall
R-105, Chandpur Bagan; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	72	111	138	163	195
2	97	144	175	205	244
3	114	169	205	240	285
4	123	177	213	248	293
5	133	191	229	265	313
7	149	210	251	290	340
10	171	238	283	325	380

Annual Maximum Rainfall
R-105, Chandpur Bagan; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	138	184	215	244	283
2	189	255	298	340	394
3	234	310	361	410	473
4	258	340	395	447	515
5	281	372	431	489	563
7	315	410	472	532	610
10	359	464	534	601	687

Annual Maximum Pre-Monsoon Rainfall
R-131, Sarail; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	118	157	182	207	239
2	155	205	238	269	310
3	190	260	307	352	410
4	220	303	359	412	480
5	236	324	383	439	511
7	273	372	437	500	582
10	330	437	508	576	664

Annual Maximum Mid-Monsoon Rainfall
R-131, Sarail; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	106	161	197	232	277
2	143	209	252	293	347
3	168	245	296	345	408
4	184	264	317	368	433
5	199	281	336	389	457
7	228	318	378	435	509
10	258	348	408	466	540

Annual Maximum Post-Monsoon Rainfall
R-131, Sarail; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	78	103	120	136	157
2	102	139	163	186	216
3	115	153	178	202	233
4	125	168	197	225	261
5	135	179	207	235	270
7	148	193	222	251	287
10	175	228	263	297	341

Annual Maximum Rainfall
R-131, Sarail; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	145	192	223	253	292
2	194	246	281	314	357
3	234	302	347	390	446
4	264	339	389	437	499
5	283	360	411	460	524
7	320	405	462	516	586
10	362	462	527	590	672

Annual Maximum Pre-Monsoon Rainfall
R-132, Nasirnagar; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	114	154	180	206	238
2	156	207	240	272	314
3	194	254	293	331	380
4	222	285	327	367	418
5	240	307	351	394	449
7	285	369	424	478	547
10	336	448	523	594	687

Annual Maximum Mid-Monsoon Rainfall
R-132, Nasirnagar; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	104	140	164	187	217
2	149	206	244	280	327
3	182	251	296	340	396
4	202	283	336	388	455
5	220	306	363	418	489
7	249	339	400	457	532
10	276	371	433	494	571

Annual Maximum Post-Monsoon Rainfall
R-132, Nasirnagar; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	76	109	131	152	180
2	101	148	178	208	247
3	122	184	225	265	316
4	137	207	254	298	356
5	149	221	268	314	373
7	172	259	317	372	444
10	198	303	373	439	526

Annual Maximum Rainfall
R-132, Nasirnagar; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	134	169	193	216	245
2	192	240	272	303	342
3	235	292	329	365	411
4	266	328	369	408	460
5	287	351	394	434	487
7	333	412	463	513	578
10	387	490	559	624	709

Annual Maximum Pre-Monsoon Rainfall
R-351, Bancharampur; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	90	132	159	185	219
2	121	172	206	239	281
3	146	205	244	281	329
4	169	245	295	343	405
5	186	272	330	384	455
7	221	324	393	459	544
10	258	385	469	550	655

Annual Maximum Mid-Monsoon Rainfall
R-351, Bancharampur; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	96	147	181	214	256
2	129	204	254	302	363
3	149	250	317	381	463
4	169	275	345	413	500
5	183	294	368	438	529
7	205	323	401	476	573
10	239	362	443	521	622

Annual Maximum Post-Monsoon Rainfall
R-351, Bancharampur; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	58	101	130	158	193
2	76	130	166	200	244
3	85	150	194	236	290
4	93	166	214	260	320
5	99	175	225	273	336
7	110	200	260	317	392
10	130	233	301	366	451

Annual Maximum Rainfall
R-351, Bancharampur; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	127	171	200	228	264
2	177	238	279	318	369
3	213	297	352	405	474
4	244	334	394	451	525
5	265	361	425	486	566
7	307	414	485	554	642
10	353	472	551	626	723

Annual Maximum Pre-Monsoon Rainfall
R-356, Comilla; Daily Rainfall (mm)

Duration Days	Return Period (years)				
	2	5	10	20	50
1	105	145	172	197	230
2	140	190	222	254	294
3	167	222	259	295	340
4	194	258	301	342	395
5	211	278	323	366	421
7	243	327	382	435	504
10	285	378	440	500	577

Annual Maximum Mid-Monsoon Rainfall
R-356, Comilla; Daily Rainfall (mm)

Duration Days	Return Period (years)				
	2	5	10	20	50
1	97	129	150	170	197
2	144	191	222	252	290
3	172	228	266	301	348
4	195	261	304	345	399
5	220	285	328	369	423
7	256	329	377	423	482
10	297	370	419	465	526

Annual Maximum Post-Monsoon Rainfall
R-356, Comilla; Daily Rainfall (mm)

Duration Days	Return Period (years)				
	2	5	10	20	50
1	75	111	134	156	185
2	106	161	198	234	279
3	119	180	221	260	311
4	133	198	240	282	335
5	142	209	254	296	351
7	156	223	268	311	366
10	175	250	299	347	408

Annual Maximum Rainfall
R-356, Comilla; Daily Rainfall (mm)

Duration Days	Return Period (years)				
	2	5	10	20	50
1	127	165	190	214	246
2	182	232	264	296	337
3	213	271	309	346	393
4	241	305	347	387	439
5	263	326	367	406	457
7	302	373	419	464	523
10	340	422	475	527	594

Annual Maximum Pre-Monsoon Rainfall
R-357, Daudkandi; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	90	111	124	138	155
2	137	168	189	208	234
3	166	215	248	279	319
4	194	256	297	337	388
5	217	290	339	386	447
7	266	366	432	496	578
10	325	447	527	605	705

Annual Maximum Mid-Monsoon Rainfall
R-357, Daudkandi; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	93	136	164	191	226
2	145	199	235	269	314
3	180	249	295	339	396
4	209	294	350	404	474
5	237	331	393	452	529
7	279	384	453	520	606
10	330	450	529	606	704

Annual Maximum Post-Monsoon Rainfall
R-357, Daudkandi; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	76	106	126	145	169
2	110	143	165	185	212
3	130	171	198	224	258
4	146	193	224	253	292
5	161	215	251	285	330
7	179	243	286	327	379
10	211	294	350	403	472

Annual Maximum Rainfall
R-357, Daudkandi; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	119	151	173	193	220
2	183	221	246	270	301
3	224	279	316	351	396
4	257	327	374	418	476
5	290	368	421	471	536
7	342	436	499	559	636
10	408	518	590	660	750

Annual Maximum Pre-Monsoon Rainfall
R-362, Kasba; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	90	113	129	143	162
2	131	177	207	237	274
3	155	210	246	280	325
4	181	244	287	327	380
5	197	266	311	355	411
7	232	320	377	433	504
10	274	363	421	478	550

Annual Maximum Mid-Monsoon Rainfall
R-362, Kasba; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	94	139	170	198	236
2	133	190	228	265	312
3	161	228	272	315	370
4	182	260	312	362	427
5	200	282	336	387	454
7	230	317	374	429	500
10	263	353	412	469	542

Annual Maximum Post-Monsoon Rainfall
R-362, Kasba; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	72	115	143	170	205
2	105	162	199	235	282
3	123	191	237	280	336
4	131	203	250	295	354
5	141	216	266	313	375
7	154	232	283	332	396
10	168	249	302	353	419

Annual Maximum Rainfall
R-362, Kasba; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	118	163	192	220	257
2	172	232	272	310	360
3	203	274	322	367	425
4	229	309	363	414	479
5	250	333	387	439	506
7	293	380	437	493	564
10	328	419	479	537	612

Annual Maximum Pre-Monsoon Rainfall
R-365, Munshiganj; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	96	132	156	179	209
2	131	196	238	280	333
3	147	215	261	304	360
4	161	230	276	320	377
5	174	251	301	350	413
7	191	267	317	366	428
10	212	302	362	419	493

Annual Maximum Mid-Monsoon Rainfall
R-365, Munshiganj; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	96	143	174	205	244
2	136	206	252	296	353
3	147	234	291	346	418
4	156	251	315	375	454
5	156	258	326	391	475
7	171	276	346	413	499
10	181	304	385	464	565

Annual Maximum Post-Monsoon Rainfall
R-365, Munshiganj; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	79	123	151	179	215
2	101	172	219	265	323
3	116	196	249	300	366
4	122	208	266	320	391
5	127	216	275	332	405
7	136	234	298	361	441
10	154	263	335	404	493

Annual Maximum Rainfall
R-365, Munshiganj; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	135	173	198	222	253
2	197	263	306	348	402
3	211	292	345	397	463
4	225	312	369	424	496
5	221	323	390	455	539
7	231	339	410	479	568
10	253	375	455	533	633

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Annual Maximum Pre-Monsoon Rainfall
R-366, Muradnagar; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	101	137	161	184	214
2	134	191	228	264	311
3	155	224	270	313	370
4	183	264	318	370	436
5	199	289	348	404	478
7	224	341	418	492	588
10	270	390	470	546	645

Annual Maximum Mid-Monsoon Rainfall
R-366, Muradnagar; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	95	150	186	221	266
2	134	213	266	317	383
3	167	274	344	411	499
4	190	299	371	440	529
5	208	317	390	459	549
7	231	346	422	494	588
10	264	383	462	538	636

Annual Maximum Post-Monsoon Rainfall
R-366, Muradnagar; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	61	95	118	139	168
2	86	138	173	206	249
3	101	164	206	247	299
4	110	179	225	270	327
5	120	195	245	293	354
7	138	230	292	351	427
10	159	257	323	385	466

Annual Maximum Rainfall
R-366, Muradnagar; Daily Rainfall (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	126	170	199	227	264
2	170	239	285	329	385
3	206	304	369	431	512
4	233	331	397	459	540
5	253	355	422	487	570
7	283	405	486	564	665
10	329	449	528	604	702

Annual Maximum Pre-Monsoon Rainfall
R-367, Nabinagar; Daily Rainfall (mm).

Duration Days	Return Period (years) 2	5	10	20	50
1	104	138	161	183	211
2	139	170	190	210	235
3	159	195	219	242	272
4	177	218	246	272	306
5	194	246	280	313	356
7	224	281	320	356	404
10	268	335	380	423	478

Annual Maximum Mid-Monsoon Rainfall
R-367, Nabinagar; Daily Rainfall (mm).

Duration Days	Return Period (years) 2	5	10	20	50
1	83	124	151	177	210
2	112	173	214	253	304
3	131	202	249	294	353
4	150	219	265	308	365
5	164	239	289	336	398
7	184	263	315	365	430
10	214	297	351	404	472

Annual Maximum Post-Monsoon Rainfall
R-367, Nabinagar; Daily Rainfall (mm).

Duration Days	Return Period (years) 2	5	10	20	50
1	59	103	132	160	197
2	78	132	167	201	245
3	86	143	180	216	263
4	94	151	188	224	270
5	105	166	206	245	295
7	124	210	266	320	390
10	149	237	296	351	424

Annual Maximum Rainfall
R-367, Nabinagar; Daily Rainfall (mm).

Duration Days	Return Period (years) 2	5	10	20	50
1	124	165	192	218	251
2	163	211	243	273	313
3	186	241	278	313	358
4	203	256	292	326	370
5	223	277	314	348	393
7	260	309	341	372	411
10	305	349	379	407	444

Annual Maximum Pre-Monsoon Rainfall
R-371, Raipur (Comilla); Daily Rainfall (mm)

Duration Days	Return Period (years)				
	2	5	10	20	50
1	99	140	166	192	225
2	129	171	199	226	261
3	151	200	232	263	303
4	169	223	259	293	337
5	182	244	285	325	376
7	215	286	333	378	436
10	261	347	404	459	529

Annual Maximum Mid-Monsoon Rainfall
R-371, Raipur (Comilla); Daily Rainfall (mm)

Duration Days	Return Period (years)				
	2	5	10	20	50
1	98	141	169	196	231
2	140	192	227	261	304
3	169	231	272	311	362
4	186	257	304	349	408
5	203	281	333	383	448
7	240	325	381	435	505
10	272	358	415	470	541

Annual Maximum Post-Monsoon Rainfall
R-371, Raipur (Comilla); Daily Rainfall (mm)

Duration Days	Return Period (years)				
	2	5	10	20	50
1	65	106	133	158	192
2	89	136	167	196	235
3	105	160	197	233	279
4	114	172	210	246	294
5	123	184	223	261	311
7	141	200	239	276	324
10	157	220	262	302	354

Annual Maximum Rainfall
R-371, Raipur (Comilla); Daily Rainfall (mm)

Duration Days	Return Period (years)				
	2	5	10	20	50
1	131	176	205	234	271
2	170	218	250	281	321
3	196	254	293	330	377
4	215	283	328	371	427
5	235	309	358	405	466
7	276	353	404	453	516
10	320	404	460	513	582

Annual Maximum Pre-Monsoon Rainfall
R-373, Ramchandrapur;Daily Rainfall Data (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	107	147	173	199	232
2	143	198	235	270	315
3	170	230	269	307	356
4	201	277	327	375	437
5	226	306	359	409	475
7	255	338	394	446	515
10	279	370	431	489	564

Annual Maximum Mid-Monsoon Rainfall
R-373, Ramchandrapur;Daily Rainfall Data (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	100	141	168	194	228
2	145	187	214	241	275
3	176	216	243	269	302
4	199	248	280	311	352
5	214	277	319	359	410
7	242	315	364	410	470
10	276	350	399	446	507

Annual Maximum Post-Monsoon Rainfall
R-373, Ramchandrapur;Daily Rainfall Data (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	81	116	140	163	192
2	111	151	177	202	235
3	124	167	195	222	257
4	134	180	211	240	278
5	142	190	221	252	291
7	166	243	295	344	408
10	185	269	325	379	448

Annual Maximum Rainfall
R-373, Ramchandrapur;Daily Rainfall Data (mm)

Duration Days	Return Period (years) 2	5	10	20	50
1	132	172	199	224	258
2	180	221	248	274	308
3	212	250	275	299	330
4	243	300	337	373	419
5	269	333	376	416	469
7	307	384	435	484	547
10	339	416	468	517	580

APPENDIX B.III

Ten Day Maximum Water Level Data

T-3A , Brahmanbaria Railway Bridge ; Maximum 10 day levels, Apr. - Oct.

YEAR	April			May			June			July			August			September			October			Annual
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
1964	2.180	3.200	3.185	3.580	3.690	3.780	3.335	4.630	5.180	5.575	6.185	6.735	7.160	7.085	6.675	6.505	6.570	6.290	6.005	5.760	5.305	7.160
1965	1.600	1.890	1.875	2.300	2.605	2.710	3.400	4.570	4.615	5.135	5.500	5.485	5.790	6.325	6.460	6.445	5.975	5.865	5.610	4.935	4.265	6.460
1966	1.815	1.815	2.055	2.245	2.955	2.530	3.155	5.545	5.805	6.140	6.490	6.460	6.080	6.095	6.905	6.935	6.840	6.645	5.960	5.255	5.075	6.935
1967	1.765	2.710	2.970	3.320	3.305	3.050	3.110	3.750	4.295	5.000	5.895	6.250	6.185	5.865	5.760	5.530	5.255	5.485	5.545	5.365	4.905	6.250
1968	1.920	2.680	2.660	2.135	2.760	3.215	3.520	4.405	5.180	5.820	6.545	6.750	6.680	6.555	6.250	6.250	5.990	5.615	5.500	5.425	4.830	6.750
1969	1.760	2.150	2.445	2.390	2.110	2.675	3.505	4.205	5.055	5.310	5.935	6.070	6.005	6.265	6.575	6.630	6.425	6.045	5.480	4.900	4.205	6.630
1970	2.180	2.545	2.530	2.680	3.185	3.565	3.725	4.235	5.320	5.645	5.665	6.690	6.960	7.080	6.850	6.290	5.880	5.915	6.185	6.170	5.640	7.080
1971	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1972	1.950	2.225	2.250	2.430	2.880	3.275	3.385	3.880	5.510	5.700	5.575	5.710	6.050	6.050	5.770	5.410	5.410	5.105	4.725	4.200	3.690	6.050
1973	1.680	2.050	2.590	4.455	4.580	4.360	4.170	4.945	6.005	6.445	6.370	5.790	6.295	6.425	6.415	6.150	6.000	6.125	6.030	5.545	5.045	6.445
1974	2.455	2.440	2.605	3.445	3.520	3.585	3.825	4.070	5.255	6.600	6.690	7.560	7.710	7.590	7.070	6.735	6.780	6.660	6.265	5.990	5.240	7.710
1975	1.525	2.150	2.375	2.345	2.745	3.345	4.055	4.040	3.810	4.100	5.090	6.200	6.485	6.370	5.990	5.945	5.915	5.895	5.610	5.210	5.030	6.485
1976	1.555	2.110	2.375	2.880	3.415	3.305	4.160	5.395	5.575	6.875	6.980	6.810	6.310	6.170	6.215	6.185	5.880	5.425	5.150	4.435	3.370	6.980
1977	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1978	1.560	2.040	2.190	2.530	3.510	4.710	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	4.710
1979	1.680	1.680	1.830	2.130	2.420	2.700	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	5.680	5.380	5.030	5.680
1980	1.400	1.810	2.270	3.610	3.860	3.810	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	5.580	5.200	4.860	5.580
1981	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1982	2.018	2.346	2.748	2.886	3.980	2.014	2.860	3.708	5.002	5.416	5.800	5.792	6.236	6.292	5.876	5.516	5.492	5.576	5.362	4.616	3.782	6.292
1983	2.300	2.365	2.990	3.500	3.410	3.590	3.550	3.900	4.510	5.420	5.660	5.690	6.420	6.380	6.460	6.540	6.640	6.700	6.470	5.920	5.500	6.700
1984	1.720	1.960	2.050	2.740	4.410	4.430	4.980	5.280	5.600	5.550	6.480	6.930	6.930	6.560	5.980	5.920	6.840	6.930	6.520	5.810	4.850	6.930
1985	2.260	2.570	2.840	3.020	2.910	3.550	4.320	5.060	5.270	5.520	5.860	6.340	6.460	6.160	5.890	5.890	5.750	5.630	5.470	5.060	4.590	6.460
1986	1.700	2.160	2.720	2.930	2.910	2.700	2.480	2.780	3.560	4.120	4.570	5.240	5.570	5.540	5.140	5.240	5.230	5.460	5.460	5.570	5.490	5.570
1987	1.650	2.210	2.520	2.550	2.430	2.480	3.240	3.660	4.170	5.430	5.620	6.160	6.680	6.750	6.640	6.410	6.260	6.510	6.570	6.200	5.240	6.750
1988	1.890	2.190	2.280	2.590	3.270	5.020	5.510	5.340	5.870	7.020	7.350	6.950	6.530	6.510	7.370	7.590	7.590	6.800	6.060	5.590	5.140	7.590
1989	2.460	2.520	2.720	2.850	2.780	3.320	3.900	4.600	4.840	5.500	5.990	6.090	6.360	6.270	6.020	5.810	5.810	5.780	5.610	5.580	5.500	6.360

W-110, Comilla ; Maximum 10 day levels, Apr. - Oct.

YEAR	April			May			June			July			August			September			October			Annual
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
1960	7.390	7.405	7.375	7.300	7.405	9.690	9.320	12.115	11.010	10.615	12.185	11.580	9.475	9.740	10.175	10.380	10.570	10.450	10.560	11.515	9.655	12.185
1961	7.535	7.770	7.810	7.715	7.850	7.655	10.225	12.270	11.160	9.330	11.065	10.510	10.885	10.850	8.960	8.895	9.030	8.835	8.275	8.090	8.015	12.270
1962	7.430	7.255	8.890	8.610	7.625	8.570	9.715	11.500	10.500	10.270	10.090	9.900	8.495	9.610	10.315	9.220	9.035	8.175	8.205	7.710	9.435	11.500
1963	7.265	8.040	8.425	8.230	8.115	9.945	10.620	11.410	12.025	10.120	12.505	11.910	10.670	10.115	9.130	9.100	9.145	9.185	10.955	10.845	12.720	12.720
1964	8.070	9.215	8.850	9.180	9.925	9.935	8.430	11.475	9.980	12.070	12.860	11.380	11.435	10.415	10.310	10.525	9.970	10.105	11.095	10.625	10.990	12.860
1965	7.440	7.445	7.965	9.455	7.815	7.380	10.245	11.310	10.880	11.935	12.715	10.800	11.150	11.795	10.855	10.670	9.820	10.285	9.645	8.495	9.545	12.715
1966	7.905	7.710	7.765	7.765	8.885	7.925	7.955	11.120	10.810	11.470	9.735	8.990	9.175	9.965	12.250	10.825	11.915	11.815	10.385	10.720	9.550	12.250
1967	7.320	8.745	8.685	9.100	8.310	7.895	7.985	9.725	9.145	11.380	11.515	9.100	10.150	9.580	9.425	9.420	9.365	9.690	10.270	11.440	9.110	11.515
1968	8.400	9.650	8.125	7.515	8.700	9.300	9.770	12.055	12.650	11.970	12.960	10.660	9.550	8.975	10.230	9.480	9.740	8.965	8.635	8.190	8.435	12.960
1969	7.325	8.310	8.675	8.100	7.465	7.695	10.965	10.660	11.790	10.615	10.575	9.960	9.090	11.985	12.485	10.150	9.235	9.430	8.560	8.580	8.300	12.485
1970	7.330	7.800	7.525	7.175	8.200	8.225	8.940	9.520	9.580	8.820	10.565	10.995	10.310	9.875	9.120	8.955	8.920	9.155	9.865	8.565	8.700	10.995
1971	8.600	-99.000	-99.000	9.000	9.385	8.270	9.745	10.485	9.730	9.530	9.115	10.850	9.725	10.005	10.245	10.285	9.310	9.135	8.895	8.645	8.190	-99.000
1972	7.685	7.300	8.210	7.765	7.185	7.865	7.450	10.115	9.530	7.995	10.480	9.975	9.560	9.625	10.505	8.675	8.240	8.215	8.210	8.225	7.550	10.505
1973	7.090	7.045	8.800	11.740	12.235	10.105	10.550	10.610	10.270	9.840	9.735	11.080	11.035	9.620	8.930	8.690	8.715	8.920	9.290	8.685	8.540	12.235
1974	9.495	8.000	7.560	10.200	9.655	8.980	11.600	9.520	11.455	11.560	11.345	11.755	11.535	9.830	10.560	11.645	10.800	10.410	10.710	9.390	9.490	11.755
1975	7.350	8.545	7.745	7.465	8.490	9.430	11.135	10.045	8.740	7.970	11.830	12.200	11.495	9.990	10.150	10.455	10.630	9.920	9.255	10.210	8.905	12.200
1976	7.390	8.365	7.725	8.410	9.715	8.960	11.445	12.095	11.510	12.440	12.205	10.365	10.160	10.610	11.115	10.090	10.220	8.865	9.115	8.660	8.775	12.440
1977	9.090	9.575	8.930	9.380	10.265	9.980	11.305	9.975	11.485	11.090	10.305	9.635	9.535	10.575	9.525	9.405	9.555	8.910	10.190	9.160	8.560	11.485
1978	7.693	8.019	7.718	8.169	9.059	10.848	11.253	11.226	12.207	10.775	10.360	10.196	9.918	9.296	9.607	10.458	9.805	10.052	9.693	8.940	8.540	12.207
1979	7.711	7.687	7.742	8.275	7.790	7.745	7.910	8.790	8.315	10.336	10.080	9.432	9.000	10.050	11.640	9.600	10.964	9.954	9.660	9.080	8.415	11.640
1980	7.730	7.740	7.800	10.200	9.900	9.700	10.140	9.175	8.830	8.410	9.535	10.115	9.310	9.365	10.075	9.405	10.710	10.225	9.725	9.020	9.150	10.710
1981	8.570	10.090	9.800	8.445	10.000	9.575	10.410	8.740	9.500	11.690	10.405	10.045	9.625	9.365	10.395	9.620	9.120	8.630	8.705	8.295	8.210	11.690
1982	8.100	8.012	8.318	8.226	9.045	8.092	8.056	10.031	10.205	9.478	8.782	8.751	12.498	10.182	8.940	9.653	10.260	9.311	8.886	8.381	8.224	12.498
1983	7.978	9.068	9.956	11.426	10.424	10.096	9.490	10.471	9.598	12.050	9.980	9.026	13.218	12.488	11.068	10.116	9.374	9.270	9.712	9.970	9.662	13.218
1984	7.707	7.690	7.844	9.114	12.298	9.860	8.830	12.194	10.982	10.162	11.256	10.682	10.150	9.966	9.778	10.470	11.184	10.482	9.572	8.882	9.022	12.298
1985	8.716	8.576	8.198	8.872	8.384	11.638	10.212	10.576	9.600	12.192	11.784	9.470	9.228	9.250	10.112	9.054	8.878	9.324	9.304	8.404	8.376	12.192
1986	7.882	8.608	8.388	8.788	8.560	8.480	8.290	7.904	8.710	9.898	8.464	10.692	9.116	9.018	8.720	9.464	9.120	10.228	10.682	10.028	8.578	10.692
1987	7.758	7.868	9.252	8.910	8.154	7.796	9.622	8.912	8.700	8.228	9.298	11.394	12.158	9.082	12.382	10.294	9.120	10.956	9.830	9.222	9.180	12.382
1988	7.824	8.440	8.474	9.388	9.756	11.276	10.674	9.016	9.926	12.778	11.724	10.590	9.772	11.554	11.328	11.448	10.906	10.718	10.320	10.234	10.068	12.778
1989	8.082	7.936	8.630	8.526	8.508	8.510	8.872	10.656	8.916	10.478	9.730	11.092	10.442	9.302	8.556	9.658	9.888	9.234	10.068	11.532	9.668	11.532

W-113, Kangsanagar ; Maximum 10 day levels, Apr. - Oct.

YEAR	April 1	April 2	April 3	May 1	May 2	May 3	June 1	June 2	June 3	July 1	July 2	July 3	August 1	August 2	August 3	September 1	September 2	September 3	October 1	October 2	October 3	Annual
1960	4.120	4.130	4.070	4.000	4.055	6.890	6.735	8.885	8.215	7.665	9.045	8.425	6.860	7.015	7.310	7.725	7.865	7.735	7.855	8.505	6.760	9.045
1961	3.945	4.080	4.385	4.180	4.390	4.045	7.255	9.020	8.155	6.660	8.265	7.840	8.015	8.060	6.295	6.200	6.235	6.070	5.540	5.350	5.135	9.020
1962	3.650	3.430	5.450	5.440	4.000	5.350	6.605	8.405	7.675	7.610	7.285	7.245	5.830	6.660	7.435	6.835	6.680	6.025	5.715	5.020	5.485	8.405
1963	3.375	4.445	5.115	4.985	4.810	6.975	7.300	8.390	8.785	7.085	8.990	8.475	7.695	7.200	6.445	6.425	6.385	6.445	7.910	7.895	9.245	9.245
1964	4.890	5.945	5.930	6.125	6.015	6.750	5.015	8.255	6.990	8.640	8.535	7.935	8.075	7.375	7.130	7.300	6.735	6.935	7.770	7.500	7.720	8.640
1965	3.705	3.640	4.360	6.365	4.354	3.520	7.100	8.200	8.060	8.625	8.930	7.740	8.060	8.685	7.650	7.665	6.895	7.000	6.695	5.545	6.600	8.930
1966	3.625	3.445	4.175	4.265	5.790	4.450	4.630	7.970	7.880	8.320	6.795	6.375	6.355	7.070	8.960	7.770	8.320	8.365	7.315	7.545	6.460	8.960
1967	3.475	5.150	5.560	6.050	5.365	4.525	3.960	6.825	6.095	8.105	8.290	6.185	7.085	6.925	6.430	6.280	6.475	6.555	7.195	8.410	6.095	8.410
1968	5.335	6.145	5.285	3.810	5.500	6.335	6.810	8.950	9.490	8.655	9.360	7.390	6.705	6.310	7.210	6.530	6.610	5.950	5.555	5.310	5.145	9.490
1969	3.470	4.585	5.240	4.460	3.710	3.900	7.655	7.695	8.660	7.620	7.620	7.160	6.270	8.785	9.050	7.125	6.490	6.505	5.640	5.585	5.075	9.050
1970	3.575	4.215	4.030	3.350	4.760	4.805	5.750	6.365	6.740	5.830	7.795	7.965	7.490	7.235	6.740	6.435	6.095	6.210	7.125	6.150	5.890	7.965
1971	5.575	7.075	4.695	6.655	6.640	5.155	6.875	7.455	7.010	6.835	6.350	7.910	7.100	7.230	7.445	7.490	6.935	6.640	6.290	6.125	5.535	7.910
1972	4.345	3.860	5.000	4.695	3.565	5.315	4.080	7.180	6.765	5.425	7.590	7.310	6.850	6.735	7.660	6.035	5.505	5.120	5.085	5.230	4.145	7.660
1973	3.280	3.125	5.655	8.700	9.205	7.420	7.880	7.895	7.590	7.270	7.085	8.075	8.200	6.995	6.415	6.200	6.080	6.960	6.600	5.990	5.455	9.205
1974	6.795	4.955	4.155	7.430	6.675	6.870	8.840	6.825	8.675	8.765	8.505	8.880	8.710	7.595	7.730	8.610	7.785	7.480	7.670	6.515	6.400	8.880
1975	3.595	5.235	4.500	4.115	5.370	6.735	8.355	7.530	5.875	4.795	8.855	9.145	8.460	7.250	7.215	7.685	7.895	7.240	6.465	7.435	6.035	9.145
1976	3.990	5.320	4.480	5.455	6.890	6.310	8.400	9.245	8.510	9.410	8.990	7.590	7.405	7.755	8.370	7.315	7.340	5.985	6.340	5.720	5.755	9.410
1977	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1978	4.625	5.275	5.205	5.480	6.660	8.355	8.560	8.535	8.670	8.155	7.390	7.415	7.025	6.475	6.535	7.635	7.035	7.390	6.355	6.070	5.685	8.670
1979	4.340	4.310	4.480	5.160	4.400	4.400	4.630	5.730	5.380	7.620	7.300	6.800	6.290	7.570	8.850	6.970	8.320	7.210	6.980	6.350	5.520	8.850
1980	4.410	4.410	4.590	7.090	7.750	6.810	7.490	6.290	5.930	5.310	6.550	7.420	6.970	6.800	7.770	6.870	8.140	7.450	7.270	6.590	6.710	8.140
1981	5.507	7.776	7.605	5.471	7.593	7.123	7.794	6.422	5.837	9.942	7.483	7.452	7.117	7.239	7.666	6.843	6.758	6.200	6.080	5.482	5.300	9.942
1982	4.690	4.960	5.398	5.398	6.206	5.266	6.886	7.428	7.802	6.402	6.006	6.072	9.293	7.504	7.183	7.307	7.448	7.350	6.579	5.790	7.270	9.293
1983	7.026	7.632	9.335	9.375	9.333	9.375	8.321	9.299	9.271	9.350	9.227	8.707	9.556	8.612	8.022	7.600	7.078	7.420	7.292	7.582	7.502	9.556
1984	4.724	4.690	4.986	6.864	9.356	7.532	6.432	9.064	8.392	7.678	9.166	7.564	7.454	7.152	7.136	7.462	8.148	7.614	6.976	6.434	6.692	9.356
1985	5.646	6.198	5.628	6.284	5.872	9.150	8.278	8.574	7.634	9.484	9.388	8.474	8.176	8.204	9.136	7.544	7.350	7.440	6.398	5.834	5.806	9.484
1986	4.932	5.698	5.848	6.136	5.928	5.968	5.196	4.920	5.038	7.614	5.720	8.304	6.702	6.528	6.052	6.854	6.520	7.740	8.200	7.692	5.882	8.304
1987	4.490	4.796	6.512	5.878	5.454	4.742	6.844	6.228	6.246	5.550	6.856	8.534	9.348	7.158	9.476	7.830	6.876	8.556	7.568	7.010	6.636	9.476
1988	4.706	5.732	5.796	6.532	7.246	8.928	8.722	6.668	7.640	10.038	9.142	7.860	7.170	8.518	8.494	8.576	8.120	7.866	7.654	7.896	7.840	10.038
1989	5.060	4.810	5.348	5.740	5.540	5.706	6.540	8.318	6.888	8.242	7.256	8.532	8.130	6.906	5.958	6.490	7.596	6.466	7.146	8.966	7.188	8.966

W-114, Jibanpur (Gumti) ; Maximum 10 day levels, Apr. - Oct.

YEAR	April 1	April 2	April 3	May 1	May 2	May 3	June 1	June 2	June 3	July 1	July 2	July 3	August 1	August 2	August 3	September 1	September 2	September 3	October 1	October 2	October 3	Annual
1977	5.550	6.523	5.621	6.108	6.523	6.437	7.303	6.126	7.455	7.175	6.578	6.340	6.166	6.779	6.443	6.288	6.312	5.767	6.578	5.764	5.060	7.455
1978	4.084	4.795	4.724	4.865	5.694	6.949	7.620	7.266	7.467	6.840	6.303	6.462	6.340	5.870	6.328	6.523	6.157	6.431	5.907	5.288	5.072	7.620
1981	6.160	6.950	6.890	5.150	6.880	6.720	7.070	5.620	5.320	7.520	6.730	7.170	6.380	6.300	6.800	6.370	6.270	5.910	5.570	5.050	4.860	7.520
1982	4.862	4.456	4.926	4.718	5.928	4.732	4.418	6.382	6.982	6.261	5.665	5.695	7.185	6.619	5.919	6.403	6.662	6.399	5.875	5.193	4.833	7.185
1983	4.405	5.906	6.967	7.515	6.859	6.587	6.287	6.903	6.513	7.327	6.495	5.839	7.161	6.975	6.765	6.627	6.505	6.505	6.639	6.651	6.515	7.515
1984	4.324	4.298	4.614	6.276	7.768	6.656	6.004	7.370	6.822	6.878	7.108	6.644	6.678	6.494	6.350	6.492	6.932	6.712	6.232	5.908	6.066	7.768
1985	4.880	5.592	5.142	5.814	5.300	7.456	7.310	7.510	7.030	7.792	7.744	6.636	6.464	6.358	6.960	6.182	5.992	6.294	6.066	5.308	5.270	7.792
1986	4.304	4.822	5.202	5.476	5.274	5.320	4.626	4.314	4.208	6.926	5.390	7.456	6.220	5.920	5.670	6.288	6.130	7.072	7.406	6.806	5.530	7.456
1987	3.882	4.222	5.944	5.362	4.914	4.070	6.196	5.584	5.688	5.270	6.286	7.380	7.608	6.724	7.674	6.960	6.440	7.454	6.930	6.472	5.810	7.674
1988	4.110	5.076	5.210	5.698	6.496	7.728	7.520	6.094	6.832	7.452	7.110	6.706	6.324	6.770	7.064	7.246	7.056	6.678	6.690	7.068	7.030	7.728
1989	4.678	4.458	4.936	5.348	5.422	5.464	6.182	7.534	6.506	7.412	6.884	7.536	7.302	6.648	5.878	6.302	7.046	6.200	6.464	7.794	6.636	7.794

T-115, Duadkandi ; Maximum 10 day levels, Apr. - Oct.

YEAR	April 1	April 2	April 3	May 1	May 2	May 3	June 1	June 2	June 3	July 1	July 2	July 3	August 1	August 2	August 3	September 1	September 2	September 3	October 1	October 2	October 3	Annual
1957	1.800	2.190	2.100	2.410	3.050	3.080	3.110	3.160	4.000	4.150	4.260	4.560	4.870	5.020	4.970	4.510	4.310	4.310	3.670	3.570	3.140	5.020
1958	2.070	1.890	2.040	2.680	2.770	3.080	3.340	3.110	3.470	3.900	3.980	4.000	-99.000	-99.000	-99.000	5.480	5.120	4.780	-99.000	-99.000	-99.000	5.480
1959	1.950	2.130	2.500	2.590	2.710	3.020	3.280	3.660	4.790	4.620	4.550	4.550	4.620	5.000	5.080	4.670	4.420	4.270	4.400	4.190	3.890	5.080
1960	1.710	1.980	1.950	1.950	2.320	2.900	3.020	3.350	3.450	3.830	4.390	5.070	5.050	4.970	4.820	4.970	5.120	5.230	5.000	4.580	3.990	5.230
1961	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1962	2.440	2.260	2.410	2.530	2.560	3.140	3.540	3.780	4.110	4.880	4.910	4.800	4.750	5.060	5.670	5.760	5.520	5.300	4.850	4.270	3.660	5.760
1963	1.890	1.920	2.320	2.260	2.230	2.590	3.540	4.110	4.420	4.540	4.880	5.090	5.150	5.180	5.210	5.380	5.290	4.850	4.570	4.150	3.690	5.380
1964	2.010	2.670	2.680	2.830	3.260	3.200	3.260	3.900	4.270	4.660	4.880	5.360	5.880	5.930	5.470	5.350	5.180	5.170	5.170	4.750	4.420	5.930
1965	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1966	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1967	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1968	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1969	2.010	2.320	2.410	2.410	2.470	3.130	3.350	3.870	4.150	4.330	4.880	5.210	5.240	5.090	5.430	5.460	5.270	5.000	4.750	4.110	3.410	5.460
1970	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1971	2.190	2.130	2.230	2.440	2.740	3.690	3.630	4.130	4.340	4.610	4.920	5.210	5.350	5.500	5.620	5.650	5.500	5.130	4.970	4.830	4.520	5.650
1972	2.100	2.590	2.530	2.640	3.080	3.140	3.230	3.960	5.070	4.620	4.680	4.680	5.070	4.980	4.480	4.720	4.740	4.430	3.860	3.370	3.310	5.070
1973	2.150	2.650	2.640	2.850	3.150	3.400	3.380	4.450	4.950	5.090	4.820	4.750	5.030	5.460	5.360	4.910	4.850	5.060	4.880	4.750	4.080	5.460
1974	2.390	2.320	2.590	3.000	2.970	3.320	3.400	3.630	4.400	4.970	5.270	5.650	6.050	6.000	5.820	5.430	5.300	5.170	4.970	4.390	3.840	6.050
1975	2.880	2.530	2.510	3.020	3.600	3.320	3.580	3.870	4.110	4.180	4.420	4.740	4.690	4.770	4.920	4.950	4.540	4.050	3.930	3.960	3.140	-99.000
1976	-99.000	2.073	2.377	2.499	3.246	3.414	3.322	3.795	4.054	4.115	4.176	4.404	4.496	4.816	4.816	4.267	4.496	4.420	4.313	3.551	3.261	-99.000
1977	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1978	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1979	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1980	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1981	2.340	2.640	2.820	2.920	3.040	2.960	3.190	3.250	3.750	4.140	4.190	4.210	4.630	4.640	4.420	4.720	4.830	4.890	4.630	4.290	3.960	-99.000
1982	2.450	2.820	2.650	2.720	3.200	3.630	3.860	3.970	4.270	4.280	4.880	5.000	5.190	4.670	4.530	4.490	4.700	4.980	4.440	4.210	3.640	-99.000
1983	2.750	2.250	2.500	2.500	2.950	3.300	3.200	3.550	4.400	4.750	4.900	4.800	5.300	5.200	5.250	5.300	5.500	5.530	5.370	4.890	4.320	5.530
1984	2.440	2.840	2.620	2.970	3.520	3.600	4.010	4.370	4.750	4.870	5.200	5.250	5.520	5.200	4.670	4.720	5.350	5.460	5.200	4.590	-99.000	-99.000
1985	2.820	2.370	2.140	2.370	2.050	2.770	3.870	3.830	4.210	4.310	4.560	4.650	4.950	4.540	4.660	4.710	4.670	4.380	4.650	4.950	4.430	4.950
1986	2.460	2.570	3.080	2.880	2.960	3.280	3.030	3.710	4.230	4.510	4.750	5.110	5.400	5.400	5.230	5.080	5.170	5.320	4.980	4.950	4.720	5.400
1987	2.000	2.320	2.550	2.340	2.650	2.520	2.830	2.820	3.250	4.670	4.730	5.310	5.610	6.060	6.020	5.510	5.570	5.460	5.230	4.770	3.870	6.060
1988	2.270	2.350	2.460	3.360	3.350	3.430	4.020	4.080	4.210	5.100	5.550	5.490	5.470	5.420	6.270	6.340	6.120	5.380	4.400	4.240	3.820	6.340
1989	2.710	2.640	2.720	2.600	2.250	-99.000	3.060	3.710	4.240	4.480	4.860	5.080	5.000	4.780	4.740	4.660	4.760	4.740	4.560	4.540	3.980	-99.000

W-123, Ganga Sagart Railway Bridge ; Maximum 10 day levels, Apr. - Oct.

YEAR	April			May			June			July			August			September			October			Annual
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
1965	4.375	3.935	4.805	4.100	4.345	3.800	4.775	5.900	4.775	5.015	5.170	5.260	5.415	5.930	6.020	6.020	5.595	5.505	5.230	4.740	4.680	6.020
1966	4.115	4.135	4.345	4.775	4.620	4.270	4.590	5.320	5.415	5.720	6.025	5.990	5.595	5.750	6.370	6.415	6.445	6.110	5.595	5.210	4.630	6.445
1967	4.040	4.600	4.570	4.665	4.160	4.540	4.540	4.935	4.360	5.575	5.500	5.775	5.775	5.425	5.255	5.090	4.935	5.305	5.290	5.135	4.390	5.775
1968	4.875	5.115	4.110	4.015	4.930	5.055	4.885	5.420	5.895	5.670	6.140	6.375	6.310	6.230	5.925	5.850	5.570	5.150	5.080	5.030	4.355	6.375
1969	3.900	4.870	5.030	3.985	3.720	4.465	5.220	5.225	5.225	5.205	5.500	5.680	5.595	5.960	6.165	6.225	6.030	5.686	5.090	5.090	4.130	6.225
1970	3.990	4.840	3.840	3.765	4.625	4.480	4.650	4.275	4.890	5.255	5.500	6.235	6.475	6.615	6.395	5.865	5.440	5.485	5.775	5.715	5.235	6.615
1971	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1972	4.510	4.390	4.290	4.110	3.565	4.720	3.870	4.955	5.105	5.265	5.145	5.265	5.615	5.585	5.360	4.960	5.040	4.705	4.415	3.975	3.735	5.615
1973	4.205	3.430	4.360	5.775	4.695	4.510	4.435	4.785	5.545	5.990	5.865	5.275	5.850	5.975	5.975	5.625	5.560	5.700	5.610	5.210	4.495	5.990
1974	4.860	4.130	3.795	4.970	4.890	3.945	4.680	4.600	5.105	5.975	5.975	6.935	7.160	7.055	6.570	6.215	6.325	6.185	5.895	5.595	4.770	7.160
1975	4.375	4.380	3.845	3.655	4.830	4.905	4.730	4.695	4.145	3.690	4.790	5.730	6.040	5.860	5.610	5.545	5.455	5.410	5.225	4.900	4.585	6.040
1976	4.480	4.800	3.810	4.740	4.955	4.085	4.770	5.225	5.295	5.880	6.465	6.355	5.720	5.670	5.730	5.675	5.380	4.970	4.785	4.250	4.085	6.465
1977	4.890	4.235	4.570	4.625	4.780	4.540	5.085	5.100	5.575	5.525	5.600	5.625	5.610	5.745	5.920	5.980	5.745	5.235	5.320	4.750	4.870	5.980
1978	4.890	5.195	4.385	5.150	5.210	5.295	5.115	5.025	5.175	5.205	5.305	5.390	5.410	5.435	5.435	5.240	5.090	5.060	4.985	4.725	4.205	5.435
1979	4.570	5.050	5.030	5.135	4.265	3.960	4.860	4.905	5.105	5.440	5.440	5.700	5.880	5.685	5.640	5.515	5.775	5.670	5.250	5.045	4.630	5.880
1980	4.650	4.695	4.690	5.335	5.350	5.120	5.240	5.210	5.135	5.225	5.275	5.545	5.485	5.820	5.915	5.915	5.615	5.380	5.225	4.875	4.920	5.915
1981	4.975	4.815	4.330	3.810	5.150	5.455	4.805	4.000	5.030	5.610	5.080	5.395	5.900	5.900	5.625	5.655	5.775	5.685	5.820	4.465	4.070	5.900
1982	5.246	3.840	3.900	3.832	4.870	3.680	3.762	4.700	4.980	5.063	5.245	5.458	5.944	5.960	5.516	5.256	5.100	5.180	4.954	-99.000	-99.000	-99.000
1983	4.800	4.464	5.512	5.785	5.450	5.180	4.587	5.770	5.456	5.862	5.436	5.280	6.075	6.040	6.100	6.150	6.280	6.290	6.176	5.718	5.236	6.290
1984	-99.000	-99.000	-99.000	5.858	5.978	4.704	4.800	5.800	5.646	5.160	6.000	6.430	6.416	6.050	5.610	5.618	6.280	6.390	6.034	5.370	5.544	-99.000
1985	4.524	4.916	4.644	4.830	4.540	5.280	5.340	5.260	5.300	5.512	5.282	5.710	5.862	5.766	5.250	5.230	5.144	5.138	5.184	4.576	4.474	5.862
1986	4.640	4.808	4.368	5.252	4.526	4.260	3.758	3.982	4.186	5.270	4.200	5.576	5.170	5.230	5.342	5.204	5.416	6.410	5.860	5.434	5.040	6.410
1987	-99.000	3.822	5.000	4.524	3.810	3.600	4.452	4.268	4.026	5.030	5.216	5.560	6.360	6.420	6.344	6.042	5.832	5.950	5.970	5.712	5.248	-99.000
1988	5.100	4.212	3.978	5.342	5.098	5.850	5.300	5.140	5.670	6.450	6.900	6.784	6.100	6.100	6.906	7.026	6.960	6.508	5.566	5.508	5.104	7.026
1989	-99.000	-99.000	-99.000	4.336	4.042	5.126	5.698	5.764	4.500	5.038	5.532	5.756	5.926	5.800	5.632	5.364	5.416	5.520	5.216	5.380	5.190	-99.000

W-157, Ballah ; Maximum 10 day levels, Apr. - Oct.

YEAR	April			May			June			July			August			September			October			Annual
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
1960	-99.000	-99.000	-99.000	18.860	19.030	21.360	21.910	23.590	21.580	22.320	23.240	22.230	20.800	21.850	21.550	21.760	22.740	22.120	21.470	22.950	20.170	23.590
1961	19.340	19.570	21.970	20.010	19.530	20.490	23.100	24.290	20.770	19.920	21.910	21.970	20.860	20.540	20.620	19.850	20.160	20.230	20.310	19.870	19.660	24.290
1962	19.340	19.350	20.040	20.070	19.280	20.190	22.170	24.020	22.250	20.500	22.380	20.740	19.920	23.490	22.510	20.860	21.030	21.270	20.120	19.500	22.310	24.020
1963	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1964	20.860	21.380	20.070	21.380	20.350	22.270	20.790	22.420	20.200	23.600	22.330	24.940	21.920	20.850	20.470	20.640	20.410	20.520	20.870	21.700	21.090	24.940
1965	19.440	19.450	19.400	20.280	19.550	19.250	20.490	23.730	20.720	22.230	22.720	21.380	22.060	23.700	22.370	20.910	21.420	21.200	20.690	19.690	20.140	23.730
1966	19.260	21.000	21.270	20.970	21.520	21.030	20.050	24.730	21.710	23.620	20.890	20.680	20.650	21.500	23.410	20.800	24.680	20.750	23.130	22.350	20.070	24.730
1967	19.430	21.750	20.740	21.110	19.950	20.270	20.260	23.180	20.650	24.880	21.530	20.310	21.590	22.090	20.860	20.910	20.190	22.600	21.050	21.930	20.000	24.880
1968	21.060	21.440	20.700	19.470	20.360	21.290	21.600	22.680	23.280	22.910	23.830	21.500	20.260	20.260	21.400	21.750	20.680	20.740	20.550	20.520	20.080	23.830
1969	19.420	20.490	20.560	19.680	19.440	19.780	21.960	21.410	21.850	21.490	21.110	20.190	19.900	24.490	21.090	21.000	21.100	20.220	21.070	21.460	19.760	24.490
1970	19.430	19.450	19.360	19.310	21.050	19.850	20.510	20.230	20.250	21.360	21.320	22.990	20.930	22.390	19.930	19.700	19.640	20.270	21.100	19.720	20.160	22.990
1971	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1972	19.280	19.580	20.640	19.690	19.220	20.300	19.450	20.270	20.270	19.240	20.060	19.280	19.660	20.300	19.950	19.500	19.720	19.720	19.700	19.700	19.690	20.640
1973	19.830	19.830	19.850	23.080	22.560	23.540	21.860	21.960	21.580	21.450	21.450	21.120	21.320	21.040	20.310	21.350	20.650	-99.000	-99.000	-99.000	-99.000	23.540
1974	20.120	20.110	20.230	21.480	21.560	20.320	21.950	21.210	22.630	21.880	23.660	21.690	20.910	21.070	21.090	22.250	21.870	21.220	20.790	19.850	19.840	23.660
1975	19.660	20.860	19.930	19.750	20.170	21.330	22.520	20.220	19.990	19.500	22.260	22.420	21.550	20.510	21.530	20.990	22.260	21.120	20.140	19.930	19.900	22.520
1976	19.470	20.310	20.110	20.120	21.200	19.570	24.840	24.590	23.310	23.070	22.160	20.810	21.030	21.380	21.310	21.750	21.380	20.270	20.740	20.370	20.410	24.840
1977	21.310	21.420	23.100	22.710	22.330	21.720	22.570	21.190	22.710	20.960	20.810	20.810	20.670	21.510	21.060	21.100	20.740	20.320	22.290	20.420	20.560	23.100
1978	19.960	19.950	19.960	21.160	22.150	24.790	24.180	22.520	23.070	22.470	22.800	22.410	20.550	21.250	21.190	21.390	20.640	21.420	21.230	21.040	20.130	24.790
1979	19.910	19.820	19.880	20.460	19.910	19.860	20.090	20.100	20.910	22.170	21.800	20.520	20.710	21.710	20.630	20.470	24.220	21.070	20.320	20.200	19.910	24.220
1980	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1981	21.100	21.320	20.800	20.010	21.920	23.130	21.200	21.620	20.770	23.250	20.950	20.810	20.290	20.280	22.210	20.900	21.100	20.510	20.540	20.170	20.060	23.250
1982	19.760	20.184	20.949	20.632	20.946	19.891	20.750	21.930	21.363	21.019	21.287	20.988	24.268	21.494	20.367	21.308	21.693	20.336	20.470	19.980	19.940	24.268
1983	20.330	20.510	21.208	23.716	22.180	21.204	20.286	24.748	21.266	22.486	20.522	20.306	26.104	25.276	24.220	22.918	20.950	21.108	21.240	21.596	20.750	26.104
1984	19.820	19.816	20.104	21.180	-99.000	-99.000	20.218	25.308	23.648	21.056	21.540	21.534	20.840	21.224	21.068	23.034	22.658	21.322	20.826	20.766	21.958	-99.000
1985	20.420	21.154	20.808	21.200	20.970	24.090	21.880	22.504	21.920	21.890	21.244	22.004	21.036	21.476	21.076	21.586	21.252	21.400	21.392	21.300	20.630	24.090
1986	20.844	20.880	20.752	21.580	21.112	20.620	19.980	20.202	20.716	20.822	20.170	21.244	20.496	21.660	21.288	21.564	21.168	22.010	23.092	21.512	20.382	23.092
1987	19.718	19.910	21.170	20.710	20.398	20.070	21.500	21.084	20.468	20.536	20.182	23.834	23.442	20.740	23.092	20.636	20.586	23.234	20.680	20.762	20.782	23.834
1988	19.820	20.268	20.336	20.814	20.980	24.344	21.212	20.578	23.362	23.570	21.996	20.766	20.840	24.850	21.252	21.662	22.366	21.094	21.830	21.962	20.974	24.850
1989	20.068	19.960	21.092	20.788	20.344	21.174	22.180	21.966	20.444	21.474	21.250	22.978	21.648	20.850	21.094	21.094	20.984	21.136	21.520	21.690	20.750	22.978

W-158, Chunarghat ; Maximum 10 day levels, Apr. - Oct.

YEAR	April			May			June			July			August			September			October			Annual
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
1960	12.210	12.500	12.240	12.180	12.330	14.230	14.520	15.690	13.240	14.840	15.720	16.010	13.980	14.730	13.860	14.220	16.230	15.120	15.080	15.860	13.420	16.230
1961	12.710	12.740	12.740	13.610	12.920	13.090	14.140	16.650	14.460	13.510	15.190	15.310	13.660	14.030	13.570	13.350	13.650	13.830	13.300	13.310	13.170	16.650
1962	13.010	12.750	13.870	13.550	12.680	13.620	16.290	16.660	15.880	14.570	16.390	14.700	14.140	16.550	16.520	14.520	14.480	14.490	13.350	13.130	12.970	16.660
1963	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1964	13.910	13.870	13.500	14.430	13.910	14.050	13.980	16.640	13.650	16.670	16.290	16.750	16.700	14.710	14.560	14.390	14.280	14.550	14.750	15.670	14.820	16.750
1965	12.800	12.660	13.100	14.000	13.040	12.600	15.020	14.540	14.670	15.720	14.220	15.210	15.510	16.640	16.080	14.570	14.750	15.150	14.080	13.190	13.470	16.640
1966	12.720	14.380	14.780	13.830	15.820	15.720	13.930	17.370	17.740	16.670	14.870	14.720	14.690	16.300	16.610	14.630	16.700	14.410	16.430	16.150	13.650	17.740
1967	12.950	16.210	14.570	15.020	13.560	13.770	14.140	16.640	13.960	16.820	15.270	14.050	15.690	16.400	14.900	13.990	14.090	16.460	16.060	16.940	13.420	16.940
1968	14.350	15.630	14.000	13.070	13.930	15.360	15.440	15.600	16.850	16.360	17.360	15.530	14.540	16.160	16.470	15.010	16.350	14.660	14.200	14.020	13.710	17.360
1969	13.030	14.450	14.540	13.170	12.930	13.190	13.190	15.540	16.270	14.460	14.190	13.550	13.260	17.110	15.590	14.690	13.980	14.010	14.500	15.720	13.190	17.110
1970	12.780	12.860	12.670	12.710	14.480	13.620	14.770	14.310	14.110	16.100	15.270	16.830	14.310	16.200	13.910	13.800	14.000	14.110	14.970	13.560	13.560	16.830
1971	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1972	13.060	12.900	14.870	13.120	12.850	14.310	12.900	16.020	13.910	13.290	14.580	15.070	14.880	14.160	14.750	13.670	13.420	13.380	13.190	12.980	12.810	16.020
1973	12.600	12.680	14.840	17.840	16.330	16.740	16.490	15.500	15.290	14.870	15.190	14.140	14.710	14.090	14.820	14.360	13.510	13.790	14.840	13.700	13.550	17.840
1974	14.430	13.960	13.650	15.640	14.690	13.650	16.620	15.050	16.880	16.330	17.100	15.770	14.700	14.350	15.040	16.520	15.330	15.510	14.730	14.040	14.190	17.100
1975	12.780	14.490	13.360	12.890	13.930	15.570	16.880	14.520	13.830	13.010	15.570	16.600	14.760	14.010	14.760	14.530	16.180	14.200	13.830	14.480	13.360	16.880
1976	12.910	13.740	13.690	14.100	14.900	13.910	16.940	16.660	16.440	16.360	16.290	14.550	15.260	15.710	15.020	15.880	14.880	13.580	14.210	13.690	13.650	16.940
1977	15.780	15.340	16.390	15.680	16.240	15.770	16.430	15.150	17.110	14.790	14.820	14.300	13.840	15.640	14.580	15.000	14.690	13.700	16.540	13.970	13.980	17.110
1978	13.280	13.500	13.430	14.370	15.040	17.020	16.140	16.650	17.110	14.940	15.890	17.130	15.530	15.280	15.430	15.170	14.350	14.830	14.760	14.640	13.710	17.130
1979	13.910	13.820	13.830	14.450	13.820	13.830	13.910	14.550	14.430	16.780	16.100	14.470	14.830	16.040	17.650	15.430	17.880	15.600	15.190	14.940	14.390	17.880
1980	13.550	13.970	13.960	17.110	16.950	15.860	15.970	14.610	15.200	14.490	13.820	16.020	14.000	14.410	14.040	15.220	16.080	15.280	14.800	14.380	15.030	17.110
1981	14.440	15.150	14.440	13.430	17.540	17.570	16.260	15.300	14.350	17.330	14.750	14.550	15.410	14.010	15.130	13.780	15.030	13.690	14.170	13.370	13.310	17.570
1982	13.730	13.646	14.301	13.704	15.362	13.527	13.598	15.567	15.135	15.692	15.277	14.796	17.882	14.316	14.015	15.380	15.308	14.572	14.003	13.475	13.327	17.882
1983	13.350	13.758	15.660	17.144	15.642	14.818	14.594	17.236	15.038	17.878	14.268	13.946	18.140	15.564	15.976	14.138	14.042	14.160	16.002	14.984	14.388	18.140
1984	12.910	12.838	12.954	15.130	17.648	15.796	14.392	18.032	15.856	14.296	15.350	15.186	14.476	15.012	13.686	16.774	16.984	14.820	13.922	13.960	16.076	18.032
1985	13.378	14.980	14.118	14.976	14.610	18.012	15.812	16.294	16.276	15.354	14.216	15.156	14.056	16.654	14.320	14.788	14.586	14.724	14.512	14.706	13.730	18.012
1986	13.410	14.124	14.318	15.704	14.370	13.700	13.120	13.500	13.646	14.380	13.376	14.728	13.938	15.432	14.744	15.590	14.706	16.050	17.010	15.402	13.764	17.010
1987	13.010	13.486	15.080	13.934	14.128	13.664	15.548	14.778	14.010	14.176	13.474	17.618	16.804	14.570	16.458	14.092	14.182	17.012	14.236	14.546	14.494	17.618
1988	12.960	13.494	13.438	14.290	14.556	17.784	15.020	14.468	17.714	17.882	15.660	14.342	14.600	18.170	14.874	15.782	15.750	14.932	15.580	14.802	14.366	18.170
1989	13.432	13.370	14.444	14.442	14.544	14.974	16.712	15.894	13.878	15.106	14.868	17.170	15.858	14.690	14.614	15.096	15.006	15.256	15.600	15.636	14.094	17.170

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T-273, Bhairab Bazar ; Maximum 10 day levels, Apr. - Oct.

YEAR	April 1	April 2	April 3	May 1	May 2	May 3	June 1	June 2	June 3	July 1	July 2	July 3	August 1	August 2	August 3	September 1	September 2	September 3	October 1	October 2	October 3	Annual
1964	2.165	2.985	2.775	3.125	3.655	3.655	3.505	5.000	5.365	5.775	6.325	6.750	7.130	7.085	6.690	6.535	6.520	6.310	6.005	5.775	5.350	7.130
1965	1.830	2.150	2.105	2.500	2.775	2.955	3.535	4.345	4.860	5.240	5.640	5.610	5.960	6.415	6.490	6.460	6.035	5.930	5.625	4.970	4.055	6.490
1966	2.180	2.010	2.180	2.285	2.375	2.635	3.690	5.730	5.850	6.185	6.460	6.400	6.065	6.155	6.825	6.905	6.795	6.520	5.975	5.225	4.650	6.905
1967	1.830	2.165	2.360	2.440	2.775	3.110	3.185	3.780	4.860	5.060	6.095	6.250	6.140	5.880	5.730	5.530	5.290	5.545	5.545	5.380	4.785	6.250
1968	1.940	2.590	2.290	2.290	2.880	3.150	3.620	4.280	5.420	5.940	6.580	6.770	6.730	6.600	6.330	6.300	6.000	5.620	5.560	5.500	4.860	6.770
1969	1.980	2.440	2.440	2.420	2.260	2.990	3.340	4.430	5.230	5.500	6.020	6.110	6.070	6.260	6.690	6.710	6.490	6.100	5.530	4.890	4.050	6.710
1970	2.530	2.440	2.420	3.020	3.380	3.690	4.060	4.470	5.610	5.720	6.150	6.760	7.050	7.100	6.860	6.320	5.930	5.950	6.230	6.170	5.540	7.100
1971	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1972	2.290	2.530	2.650	2.680	3.220	3.380	3.480	3.900	5.770	5.820	5.620	5.880	6.090	6.080	5.750	5.500	5.520	5.080	4.700	4.220	3.640	6.090
1973	2.040	2.560	2.550	3.340	3.730	3.960	-99.000	-99.000	6.110	6.450	6.340	5.820	6.390	6.480	6.450	6.140	6.110	6.220	6.050	5.550	4.970	-99.000
1974	2.390	2.350	2.740	3.350	3.460	3.630	3.980	4.270	5.430	6.540	6.690	7.480	7.650	7.530	7.060	6.660	6.720	6.630	6.260	5.930	5.150	7.650
1975	2.040	2.440	2.770	2.680	2.960	3.230	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1976	1.900	2.580	2.340	2.560	3.020	2.940	3.710	5.610	5.760	6.910	7.020	6.840	6.310	6.170	6.310	6.280	5.910	5.450	5.170	4.400	3.660	7.020
1977	2.930	2.930	2.940	3.570	3.890	4.190	5.230	5.560	5.960	5.990	6.080	6.120	6.240	6.310	6.540	6.570	6.190	5.670	5.330	5.180	4.660	6.570
1978	1.940	1.920	2.270	2.560	3.050	4.020	4.370	5.050	5.640	5.740	5.720	5.920	5.980	5.990	5.920	5.560	5.500	5.480	5.210	4.740	4.130	5.990
1979	2.080	1.980	2.160	2.200	2.800	2.920	2.600	3.180	3.820	5.190	5.550	6.300	6.330	6.150	5.720	5.870	6.240	6.120	5.570	5.460	5.070	6.330
1980	1.860	2.350	2.790	3.200	3.560	3.810	3.992	4.996	5.160	5.190	5.334	5.916	6.030	6.304	6.410	6.364	6.058	5.782	5.610	5.120	4.660	6.410
1981	2.450	2.800	2.800	2.720	2.870	3.280	3.845	3.915	3.980	5.485	5.695	6.135	6.460	6.350	6.150	6.180	6.255	6.115	5.530	4.805	3.855	6.460
1982	2.280	2.310	2.750	2.850	2.920	2.912	2.970	4.000	5.282	5.664	5.896	5.971	6.431	6.407	5.964	5.612	5.661	5.724	5.411	4.628	3.682	6.431
1983	2.440	2.500	3.000	3.170	3.465	3.655	3.675	4.005	4.705	5.745	5.805	5.905	6.505	6.470	6.580	6.645	6.745	6.790	6.550	6.020	5.535	6.790
1984	2.390	2.710	2.610	2.740	3.690	4.940	5.040	5.330	5.620	5.690	6.510	6.890	6.880	6.520	5.960	5.960	6.830	6.880	6.470	5.710	4.690	6.890
1985	2.520	2.600	2.770	3.130	2.660	3.050	4.430	5.090	5.280	5.500	5.820	6.310	6.380	6.120	5.810	5.770	5.650	5.530	5.380	4.960	4.550	6.380
1986	2.110	2.340	2.940	2.740	2.720	2.900	2.630	2.900	3.710	4.340	4.770	5.420	5.670	5.620	5.290	5.360	5.410	5.510	5.550	5.610	5.480	5.670
1987	2.020	2.650	2.640	2.580	2.650	2.640	3.130	3.750	4.580	5.630	5.730	6.360	6.850	6.910	6.830	6.530	6.320	6.550	6.540	6.140	5.130	6.910
1988	2.210	2.670	2.440	2.600	3.410	5.230	5.600	5.330	6.000	7.120	7.280	6.970	6.530	6.550	7.440	7.660	7.660	6.930	6.030	5.580	5.160	7.660
1989	2.250	2.220	2.530	3.050	2.830	3.520	3.970	4.900	5.030	5.720	6.090	6.290	6.410	6.340	6.090	5.890	5.850	5.840	5.690	5.640	5.550	6.410
1990	2.210	2.420	3.140	3.000	3.090	3.800	4.870	5.280	5.420	5.570	5.640	5.950	6.000	6.040	5.930	5.730	5.310	5.540	5.980	6.020	5.630	6.040

T-275 , Baidyer Bazar ; Maximum 10 day levels, Apr. - Oct.

YEAR	April 1	April 2	April 3	May 1	May 2	May 3	June 1	June 2	June 3	July 1	July 2	July 3	August 1	August 2	August 3	September 1	September 2	September 3	October 1	October 2	October 3	Annual
1959	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	4.750	4.820	4.750	5.270	5.390	5.030	4.720	4.480	4.720	4.300	4.180	5.390
1960	1.800	1.800	2.010	2.070	2.530	3.030	3.050	3.320	3.660	4.100	4.540	5.300	5.260	5.170	4.940	5.040	5.270	5.460	5.150	4.570	3.960	5.460
1961	2.130	1.950	2.040	3.290	2.500	2.740	3.380	3.630	3.750	3.840	3.870	4.180	4.180	4.540	4.910	4.910	4.720	4.390	4.320	4.290	3.950	4.910
1962	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1963	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1964	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1965	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1966	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1967	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1968	1.730	2.250	1.960	2.020	2.600	2.690	3.180	3.670	4.400	4.860	5.130	5.620	5.650	5.370	5.050	5.010	4.730	4.340	4.640	4.610	3.790	5.650
1969	1.870	2.180	2.060	2.120	2.000	2.760	2.970	3.750	4.150	4.390	4.910	5.180	5.180	5.150	5.490	5.490	5.270	4.910	4.540	4.050	3.140	5.490
1970	2.320	2.130	2.190	2.770	3.050	3.410	3.470	3.630	4.480	4.540	4.910	5.550	5.820	5.780	5.730	5.180	4.850	4.880	5.120	4.910	4.450	5.820
1971	1.980	2.230	2.230	2.500	2.500	2.620	3.020	3.990	4.240	4.510	4.910	5.060	5.270	5.490	5.640	5.640	5.360	5.150	4.910	4.630	4.360	5.640
1972	1.860	2.190	2.260	2.380	2.900	2.930	3.170	3.610	4.430	4.470	4.370	4.740	5.010	4.920	4.860	4.680	4.590	4.250	3.830	3.310	2.940	5.010
1973	1.800	2.260	2.230	2.830	2.850	3.140	3.150	4.040	4.940	5.150	4.940	4.720	5.150	5.430	5.270	4.940	4.910	4.910	4.850	4.690	4.180	5.430
1974	1.860	2.550	3.120	2.970	2.960	3.410	3.350	3.540	4.390	5.000	5.150	5.700	6.160	6.130	5.760	5.460	5.360	5.180	4.970	4.660	4.020	6.160
1975	1.860	2.230	2.530	2.500	2.680	2.930	3.080	3.450	3.690	3.840	4.420	4.940	5.270	5.240	4.940	4.850	4.820	4.630	4.540	4.300	3.810	5.270
1976	1.870	2.330	2.270	2.180	2.410	2.650	3.350	4.050	4.390	5.180	5.260	4.980	4.800	4.860	4.890	4.980	4.860	4.470	3.950	3.540	2.990	5.260
1977	2.451	2.573	2.481	2.969	3.274	3.368	3.947	4.252	4.572	4.694	4.923	5.045	5.075	5.136	5.380	5.410	5.014	4.587	4.176	4.176	3.414	5.410
1978	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1979	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1980	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1981	1.524	1.615	1.433	2.225	2.438	2.652	3.505	3.170	3.353	4.572	4.603	4.999	5.304	5.426	5.426	4.999	4.938	4.633	4.420	4.115	2.835	5.426
1982	2.190	2.100	2.190	2.500	2.320	2.440	2.650	3.490	4.090	4.440	4.740	4.940	5.090	4.940	4.700	4.610	4.740	4.710	4.340	3.720	3.100	5.090
1983	2.030	2.080	2.480	2.280	2.780	3.030	2.980	3.230	3.380	4.680	5.880	5.980	5.000	4.950	4.900	5.000	5.500	5.600	5.000	4.450	3.950	5.980
1984	1.990	2.540	2.390	2.570	3.390	3.940	4.490	4.300	4.700	4.650	5.400	-99.000	5.770	5.100	4.800	5.100	5.430	5.650	5.200	4.150	3.700	-99.000
1985	2.010	2.060	2.130	2.850	2.500	3.000	3.350	3.800	4.400	4.550	5.050	5.250	5.700	5.300	5.200	4.900	5.000	4.700	4.550	4.650	4.150	5.700
1986	2.330	2.430	3.030	2.880	2.830	3.430	2.780	3.660	4.060	4.610	4.800	5.100	5.390	5.190	4.890	5.040	4.940	5.040	4.910	4.960	4.730	5.390
1987	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1988	2.440	2.840	2.540	2.940	3.690	4.410	4.640	4.490	4.820	5.740	6.500	6.300	5.850	5.750	6.830	6.980	6.870	6.050	5.220	4.830	4.380	6.980
1989	2.610	2.530	2.760	3.180	3.080	3.630	3.780	4.630	4.730	4.930	5.250	5.500	5.350	5.120	5.060	5.080	5.150	5.110	5.060	4.970	4.720	5.500

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T-296 , Akhaura ; Maximum 10 day levels, Apr. - Oct.

YEAR	April 1	April 2	April 3	May 1	May 2	May 3	June 1	June 2	June 3	July 1	July 2	July 3	August 1	August 2	August 3	September 1	September 2	September 3	October 1	October 2	October 3	Annual
1959	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	5.335	5.270	5.880	6.110	5.850	5.490	5.340	5.200	5.155	5.005	6.110
1960	1.235	1.450	1.580	1.555	1.800	3.165	3.165	4.165	4.250	4.570	5.685	6.225	6.180	5.980	5.735	5.800	6.415	6.490	6.410	5.875	5.180	6.490
1961	2.250	2.080	2.095	2.430	2.605	3.125	4.025	5.025	5.005	4.795	4.870	5.085	5.130	5.290	5.540	5.525	5.465	5.280	5.160	5.145	5.025	5.540
1962	1.930	1.930	2.295	2.585	2.585	3.260	3.805	4.130	4.665	5.975	6.965	6.090	5.600	5.835	6.610	6.730	6.610	6.270	5.890	5.320	4.585	6.965
1963	1.685	1.860	2.080	2.265	2.235	2.830	4.085	4.785	5.680	5.725	6.080	6.320	6.320	6.255	6.305	6.445	6.365	6.075	5.570	5.360	4.810	6.445
1964	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1965	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1966	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1967	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1968	2.040	2.880	2.830	2.270	2.990	3.380	3.600	4.510	5.285	5.930	6.640	6.875	6.750	6.675	6.350	6.335	6.075	5.710	5.590	5.515	4.980	6.875
1969	1.820	2.290	2.600	2.460	2.150	2.690	3.610	4.275	5.130	5.395	5.990	6.155	6.075	6.365	6.660	6.720	6.515	6.165	5.600	5.040	4.310	6.720
1970	2.190	2.620	2.560	2.670	3.200	3.550	3.810	4.295	5.425	6.005	6.080	6.810	7.070	7.180	6.975	6.430	6.015	6.065	6.325	6.325	5.775	7.180
1971	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1972	2.130	2.740	2.270	2.500	3.140	3.380	3.520	3.990	5.680	5.865	5.745	5.830	6.155	6.165	5.905	5.510	5.515	5.220	4.855	4.345	3.805	6.165
1973	1.750	2.090	2.900	4.710	4.790	4.470	4.265	4.875	6.020	6.475	6.430	5.820	6.310	6.490	6.415	6.155	6.050	6.185	6.065	5.670	5.135	6.490
1974	2.550	2.550	2.680	3.570	3.660	3.630	3.945	4.295	5.180	6.690	6.645	7.560	7.770	7.605	7.130	6.780	6.810	6.735	6.265	6.188	5.275	7.770
1975	1.570	2.270	2.470	2.470	2.900	3.350	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	3.350
1976	1.768	2.286	2.576	3.079	3.566	3.490	4.334	5.441	5.672	6.919	7.071	6.892	6.535	6.401	6.462	6.462	6.099	5.508	-99.000	4.542	3.780	-99.000
1977	3.292	3.597	3.277	3.536	3.886	4.222	5.233	5.526	5.938	5.989	6.075	6.127	6.127	6.264	6.471	6.538	6.288	5.767	5.395	5.212	4.862	6.538
1978	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1979	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1980	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1981	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1982	2.150	2.170	2.630	2.770	3.450	3.120	2.882	3.796	5.140	5.658	5.970	6.028	6.506	6.520	6.096	5.600	5.620	5.800	5.570	4.940	4.030	6.520
1983	2.330	2.225	3.105	3.765	3.575	3.545	3.565	4.145	4.570	5.430	5.700	5.635	6.560	6.520	6.630	6.675	6.785	6.840	6.685	6.040	5.680	6.840
1984	1.980	2.215	2.350	3.100	4.520	4.630	5.050	5.330	5.630	5.580	6.500	6.950	6.940	6.570	5.900	5.960	6.830	6.950	6.570	5.850	4.930	6.950
1985	2.180	2.560	2.800	3.000	2.950	3.580	4.300	5.050	5.220	5.490	5.820	6.300	6.400	6.230	5.860	5.830	5.710	5.600	5.440	5.100	4.680	6.400
1986	2.060	2.390	2.990	3.100	3.040	2.880	2.680	2.850	3.560	4.240	4.670	5.350	5.670	5.670	5.280	5.370	5.380	5.580	5.620	5.670	5.600	5.670
1987	1.720	2.320	2.700	2.720	2.570	2.580	3.430	3.760	4.300	5.550	5.770	6.340	6.880	6.980	6.880	6.610	6.420	6.590	6.610	6.320	5.360	6.980
1988	1.930	2.290	2.360	2.580	3.350	5.060	5.660	5.450	6.020	7.180	7.400	7.060	6.620	6.630	7.480	7.600	7.600	7.060	6.210	5.730	5.250	7.600
1989	1.860	1.920	2.440	2.880	2.860	3.440	4.040	4.690	4.960	5.610	6.140	6.270	6.490	6.500	6.180	6.000	5.980	5.980	5.760	5.760	5.660	6.500

T-297 , Gokorna Ghat ; Maximum 10 day levels, Apr. - Oct.

YEAR	April 1	April 2	April 3	May 1	May 2	May 3	June 1	June 2	June 3	July 1	July 2	July 3	August 1	August 2	August 3	September 1	September 2	September 3	October 1	October 2	October 3	Annual
1977	2.896	2.896	2.865	3.460	3.764	4.023	4.974	5.316	5.724	5.761	5.855	5.913	5.944	6.038	6.297	6.340	6.008	5.535	5.090	4.938	4.465	6.340
1978	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1979	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1980	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1981	2.408	2.926	2.911	2.682	3.002	3.231	3.731	3.783	3.859	5.337	5.499	5.925	6.309	6.218	6.011	6.035	6.096	6.023	5.441	4.709	3.841	6.309
1982	2.225	2.290	2.940	2.780	2.880	2.920	2.854	3.868	5.020	5.468	5.680	5.744	6.240	6.244	5.854	5.486	5.514	5.590	5.340	4.560	3.640	6.244
1983	2.410	2.500	2.900	3.190	3.410	3.550	3.550	3.920	4.540	5.500	5.630	5.660	6.370	6.350	6.420	6.480	6.610	6.640	6.440	5.930	5.440	6.640
1984	2.230	2.620	2.530	2.720	3.730	4.670	4.890	5.160	5.470	5.450	6.300	6.680	6.680	6.350	5.770	5.760	6.570	6.660	6.300	5.530	4.580	6.680
1985	2.310	2.510	2.740	2.970	2.660	3.030	4.240	4.830	5.020	5.320	5.610	6.030	6.150	5.920	5.600	5.590	5.450	5.350	5.200	4.810	4.470	6.150
1986	2.090	2.300	2.940	2.710	2.710	2.910	2.510	2.930	3.580	4.240	4.600	5.240	5.540	5.490	5.130	5.210	5.250	5.390	5.380	5.410	5.310	5.540
1987	2.000	2.520	2.620	2.560	2.590	2.610	3.120	3.640	4.390	5.450	5.590	6.170	6.680	6.770	6.700	6.430	6.210	6.370	6.370	6.010	5.020	6.770
1988	2.200	2.600	2.390	2.530	3.500	4.960	5.380	5.160	5.740	6.850	7.070	6.780	6.340	6.340	7.240	7.410	7.420	6.750	5.840	5.370	5.000	7.420
1989	2.220	2.140	2.480	3.020	2.890	3.430	3.880	4.680	4.880	5.480	5.930	6.060	6.260	6.220	5.940	5.730	5.700	5.700	5.540	5.470	5.400	6.260

T-298, Nabinagar ; Maximum 10 day levels, Apr. - Oct.

YEAR	April 1	April 2	April 3	May 1	May 2	May 3	June 1	June 2	June 3	July 1	July 2	July 3	August 1	August 2	August 3	September 1	September 2	September 3	October 1	October 2	October 3	Annual
1959	1.760	2.040	2.370	2.530	2.710	3.170	3.750	4.810	5.850	5.880	5.790	5.540	5.240	5.940	6.060	5.790	5.450	5.300	5.210	5.060	4.930	6.060
1960	1.670	2.070	2.070	1.950	2.250	2.950	3.410	3.960	4.230	4.660	5.570	6.090	6.030	5.820	5.610	5.910	6.280	6.310	6.060	5.510	4.810	6.310
1961	2.370	2.150	2.120	2.460	2.730	3.280	3.830	4.530	4.560	4.440	4.680	4.770	4.830	5.050	5.290	5.260	5.140	4.900	-99.000	-99.000	-99.000	5.290
1962	2.350	1.980	2.160	2.470	2.530	3.170	3.570	4.050	4.630	5.700	5.760	5.670	5.300	5.580	6.370	6.460	6.310	5.970	5.550	4.880	4.020	6.460
1963	1.680	1.950	2.070	2.160	2.290	2.830	3.720	4.690	5.360	5.460	5.910	6.070	6.070	5.970	5.990	6.130	5.970	5.640	5.090	4.750	4.240	6.130
1964	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1965	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1966	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1967	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
1968	1.830	2.410	2.070	2.070	2.680	2.990	3.475	4.305	4.985	5.390	6.380	6.620	6.490	6.325	6.010	5.965	5.695	5.320	5.170	5.120	4.540	6.620
1969	1.980	2.320	2.350	2.320	2.260	2.930	3.215	4.205	4.945	5.180	5.770	5.915	5.860	5.990	6.415	6.430	6.170	5.775	5.270	4.720	3.930	6.430
1970	2.500	2.350	2.350	2.990	3.200	3.540	3.885	4.220	5.255	5.350	5.820	6.490	6.765	6.825	6.600	6.020	5.685	5.730	5.970	5.880	5.270	6.825
1971	2.100	2.420	2.320	2.800	2.960	3.000	3.305	4.130	4.630	5.045	5.485	5.670	5.830	6.140	6.340	6.320	6.250	5.975	5.650	5.430	5.150	6.340
1972	2.150	2.380	2.410	2.350	3.030	3.280	3.336	3.750	5.450	5.555	5.310	5.570	5.845	5.840	5.450	5.230	5.260	4.830	4.480	3.990	3.440	5.845
1973	2.000	2.440	2.460	3.290	3.660	3.840	4.035	4.970	5.820	6.170	6.035	5.530	6.050	6.185	6.140	5.775	5.775	5.915	5.760	5.270	4.750	6.185
1974	2.330	2.270	2.560	3.200	3.310	3.520	3.795	4.040	5.075	6.200	6.325	7.115	7.315	7.180	6.780	6.370	6.400	6.310	5.970	5.640	4.880	7.315
1975	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	5.350	5.010	4.740	5.350
1976	1.810	2.420	2.270	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	5.140	4.210	3.610	5.140
1977	2.743	2.774	2.713	3.322	3.627	3.871	4.938	5.243	5.669	5.669	5.791	5.867	5.883	6.005	6.188	6.248	5.944	5.426	5.029	4.877	4.389	6.248
1978	1.920	1.859	2.225	2.530	2.987	3.841	4.191	4.770	5.349	5.410	5.410	5.608	5.685	5.700	5.685	5.974	5.380	5.410	5.029	4.557	3.932	5.974
1979	2.027	1.920	2.118	2.118	2.667	2.637	2.286	2.804	3.658	4.923	5.227	5.959	6.020	5.944	5.502	5.624	5.928	5.898	5.288	5.197	4.831	6.020
1980	1.783	2.347	2.682	3.079	3.383	3.597	3.719	4.724	4.907	4.938	5.075	5.730	5.807	6.111	6.233	6.188	5.867	5.563	5.380	4.968	4.435	6.233
1981	2.393	2.789	2.758	2.667	2.911	3.216	3.764	3.734	3.780	5.258	5.395	5.837	6.157	6.066	5.852	5.883	5.928	5.822	5.273	4.511	3.658	6.157
1982	2.270	2.270	2.630	2.750	2.790	2.840	2.930	3.780	4.960	5.350	5.550	5.640	6.110	6.100	5.705	5.350	5.410	5.480	5.160	4.420	3.480	6.110
1983	2.350	2.480	2.900	3.000	3.260	3.510	3.510	3.680	4.450	5.430	5.485	5.570	6.200	6.180	6.250	6.290	6.450	6.490	6.300	5.710	5.270	6.490
1984	2.320	2.580	2.450	2.650	3.470	4.590	4.810	5.040	5.370	5.360	6.210	6.610	6.620	6.280	5.650	5.690	6.500	6.600	6.220	5.430	4.410	6.620
1985	2.300	2.450	2.620	3.050	2.590	2.870	4.220	4.770	4.970	5.160	5.560	6.010	6.100	5.870	5.460	5.490	5.430	5.300	5.170	4.770	4.420	6.100
1986	2.120	2.280	2.880	2.650	2.650	2.830	2.550	2.950	3.600	4.170	4.530	5.150	5.430	5.380	5.040	5.130	5.170	5.290	5.270	5.310	5.180	5.430
1987	2.050	2.570	2.670	2.520	2.610	2.580	3.100	3.590	4.350	5.380	5.540	6.120	6.540	6.680	6.610	6.290	6.140	6.290	6.290	5.940	4.950	6.680
1988	2.130	2.580	2.340	2.450	3.480	4.900	5.340	5.040	5.710	6.770	7.000	6.700	6.300	6.280	7.160	7.340	7.320	6.630	5.720	5.280	4.880	7.340
1989	2.180	2.100	2.420	2.960	2.840	3.350	3.800	4.580	4.780	5.380	5.780	5.910	6.080	6.000	5.780	5.570	5.570	5.580	5.420	5.330	5.220	6.080

APPENDIX B.IV

Results of Water Level Frequency Analysis

Annual Maximum Water Levels
T-3A , Brahmanbaria Railway Bridge ; Maximum 10 day levels, Apr. - Oct.

Return Period (YEARS)	April			May			June			July			August			September			October			Annual
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
1.11	1.53	1.87	2.09	2.21	2.51	2.55	2.94	3.61	4.27	4.78	5.30	5.65	5.91	5.92	5.73	5.57	5.45	5.43	5.26	4.79	4.16	5.76
1.25	1.62	1.97	2.19	2.37	2.69	2.76	3.13	3.81	4.46	4.99	5.48	5.81	6.04	6.04	5.88	5.73	5.62	5.58	5.39	4.93	4.33	5.95
2	1.82	2.20	2.42	2.75	3.10	3.26	3.59	4.28	4.91	5.49	5.91	6.19	6.36	6.34	6.23	6.10	6.03	5.93	5.69	5.28	4.74	6.39
5	2.09	2.50	2.74	3.27	3.65	3.92	4.21	4.91	5.51	6.16	6.48	6.70	6.80	6.74	6.70	6.60	6.57	6.41	6.10	5.75	5.29	6.99
10	2.27	2.71	2.94	3.60	4.02	4.36	4.63	5.33	5.91	6.60	6.86	7.04	7.08	7.01	7.01	6.94	6.92	6.72	6.37	6.06	5.66	7.39
20	2.44	2.90	3.14	3.93	4.37	4.78	5.02	5.73	6.29	7.03	7.22	7.37	7.36	7.27	7.31	7.26	7.27	7.02	6.63	6.36	6.01	7.77
50	2.66	3.16	3.40	4.35	4.82	5.33	5.53	6.25	6.78	7.58	7.69	7.79	7.72	7.60	7.69	7.67	7.71	7.41	6.97	6.74	6.46	8.26

Annual Maximum Water Levels
W-110, Comilla ; Maximum 10 day levels, Apr. - Oct.

Return Period (YEARS)	April			May			June			July			August			September			October			Annual
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
1.11	7.23	7.37	7.59	7.54	7.56	7.78	8.38	9.16	8.95	9.00	9.40	9.43	9.01	9.08	9.05	9.03	8.83	8.70	8.70	8.10	7.96	11.26
1.25	7.39	7.58	7.78	7.85	7.92	8.10	8.72	9.49	9.28	9.38	9.74	9.69	9.33	9.33	9.35	9.24	9.07	8.94	8.93	8.41	8.23	11.45
2	7.77	8.08	8.21	8.57	8.76	8.86	9.51	10.26	10.06	10.29	10.57	10.29	10.08	9.92	10.05	9.74	9.64	9.49	9.47	9.14	8.89	11.92
5	8.27	8.75	8.79	9.54	9.89	9.88	10.57	11.31	11.11	11.51	11.67	11.09	11.08	10.71	11.00	10.42	10.41	10.23	10.20	10.12	9.77	12.54
10	8.61	9.19	9.17	10.18	10.64	10.55	11.28	12.00	11.81	12.32	12.41	11.63	11.75	11.24	11.63	10.87	10.91	10.72	10.68	10.77	10.35	12.95
20	8.93	9.62	9.54	10.79	11.35	11.20	11.95	12.66	12.48	13.09	13.11	12.14	12.39	11.74	12.23	11.30	11.40	11.20	11.15	11.40	10.91	13.35
50	9.35	10.17	10.02	11.59	12.28	12.03	12.83	13.52	13.34	14.09	14.02	12.80	13.21	12.39	13.01	11.85	12.03	11.81	11.75	12.20	11.63	13.86

Annual Maximum Water Levels
W-113, Kangsanagar ; Maximum 10 day levels, Apr. - Oct.

Return Period (YEARS)	April			May			June			July			August			September			October			Annual
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
1.11	3.45	3.70	4.04	4.18	4.17	4.40	5.30	6.41	6.13	6.13	6.72	6.90	6.47	6.62	6.44	6.41	6.26	6.09	5.90	5.38	5.09	8.30
1.25	3.72	4.03	4.35	4.56	4.62	4.85	5.70	6.73	6.46	6.52	7.03	7.12	6.74	6.81	6.71	6.60	6.47	6.31	6.13	5.69	5.38	8.46
2	4.36	4.81	5.09	5.48	5.68	5.90	6.63	7.49	7.25	7.45	7.74	7.62	7.37	7.25	7.35	7.05	6.97	6.83	6.67	6.42	6.07	8.85
5	5.21	5.85	6.07	6.71	7.11	7.31	7.88	8.50	8.31	8.69	8.71	8.31	8.22	7.85	8.21	7.65	7.64	7.53	7.39	7.41	6.99	9.37
10	5.77	6.54	6.72	7.52	8.06	8.25	8.71	9.18	9.01	9.52	9.34	8.76	8.78	8.25	8.78	8.04	8.08	8.00	7.87	8.06	7.61	9.71
20	6.31	7.21	7.35	8.30	8.96	9.14	9.50	9.82	9.68	10.31	9.96	9.19	9.32	8.63	9.33	8.42	8.51	8.44	8.33	8.68	8.19	10.04
50	7.01	8.07	8.16	9.31	10.14	10.31	10.53	10.66	10.55	11.34	10.75	9.76	10.02	9.12	10.04	8.91	9.06	9.02	8.92	9.49	8.95	10.47

Annual Maximum Water Levels
W-114, Jibanpur (Gumti) ; Maximum 10 day levels, Apr. - Oct.

Return Period (YEARS)	April			May			June			July			August			September			October			Annual
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
1.11	3.91	4.17	4.58	4.81	5.13	4.93	5.20	5.31	5.35	6.21	5.84	6.03	6.15	6.11	5.88	6.16	6.08	5.96	5.81	5.13	4.85	7.39
1.25	4.10	4.43	4.80	5.03	5.38	5.25	5.51	5.60	5.62	6.41	6.02	6.20	6.29	6.21	6.04	6.25	6.19	6.10	5.96	5.38	5.07	7.44
2	4.55	5.04	5.34	5.54	5.95	6.00	6.23	6.26	6.28	6.87	6.46	6.61	6.63	6.44	6.43	6.46	6.44	6.41	6.31	5.97	5.57	7.56
5	5.15	5.86	6.06	6.23	6.73	7.02	7.21	7.16	7.15	7.49	7.05	7.16	7.08	6.75	6.96	6.75	6.77	6.84	6.78	6.77	6.25	7.73
10	5.55	6.40	6.53	6.68	7.24	7.69	7.85	7.75	7.73	7.91	7.44	7.53	7.37	6.96	7.31	6.94	6.99	7.12	7.09	7.29	6.70	7.84
20	5.93	6.93	6.99	7.12	7.73	8.33	8.47	8.32	8.29	8.30	7.82	7.88	7.66	7.16	7.64	7.12	7.20	7.40	7.39	7.80	7.14	7.94
50	6.43	7.60	7.58	7.68	8.37	9.17	9.27	9.05	9.01	8.82	8.30	8.33	8.03	7.41	8.07	7.35	7.48	7.75	7.77	8.45	7.69	8.08

Annual Maximum Water Levels
T-115, Duadkandi ; Maximum 10 day levels, Apr. - Oct.

Return Period (YEARS)	April			May			June			July			August			September			October			Annual
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
1.11	1.90	2.06	2.18	2.30	2.41	2.84	3.04	3.30	3.72	4.11	4.31	4.46	4.70	4.69	4.59	4.54	4.57	4.45	4.17	3.85	3.36	5.08
1.25	1.99	2.14	2.26	2.39	2.53	2.92	3.13	3.41	3.85	4.21	4.42	4.58	4.82	4.81	4.74	4.68	4.69	4.57	4.30	3.98	3.49	5.19
2	2.21	2.32	2.43	2.59	2.81	3.13	3.34	3.68	4.14	4.45	4.66	4.84	5.08	5.10	5.07	5.01	4.98	4.86	4.60	4.28	3.79	5.45
5	2.50	2.57	2.66	2.86	3.18	3.40	3.63	4.03	4.53	4.76	4.99	5.21	5.44	5.48	5.53	5.45	5.38	5.24	5.00	4.69	4.19	5.81
10	2.70	2.73	2.81	3.05	3.43	3.58	3.81	4.26	4.80	4.97	5.21	5.45	5.68	5.73	5.83	5.74	5.64	5.49	5.27	4.96	4.45	6.04
20	2.89	2.89	2.96	3.22	3.66	3.75	3.99	4.49	5.05	5.17	5.42	5.68	5.91	5.97	6.11	6.02	5.89	5.74	5.52	5.21	4.71	6.27
50	3.13	3.09	3.15	3.44	3.97	3.98	4.23	4.78	5.37	5.43	5.69	5.98	6.20	6.28	6.49	6.38	6.22	6.05	5.85	5.55	5.04	6.56

Annual Maximum Water Levels
W-123, Ganga Sagar Railway Bridge ; Maximum 10 day levels, Apr. - Oct.

Return Period (YEARS)	April			May			June			July			August			September			October			Annual
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
1.11	4.16	3.96	3.90	3.93	4.05	3.96	4.22	4.42	4.50	4.83	4.91	5.27	5.43	5.49	5.38	5.21	5.12	5.06	4.92	4.54	4.17	5.69
1.25	4.26	4.10	4.03	4.12	4.21	4.12	4.35	4.57	4.65	4.98	5.07	5.40	5.55	5.60	5.50	5.34	5.26	5.20	5.04	4.67	4.30	5.81
2	4.51	4.41	4.34	4.57	4.59	4.52	4.67	4.92	4.98	5.32	5.43	5.72	5.83	5.85	5.79	5.66	5.59	5.53	5.33	4.98	4.60	6.10
5	4.84	4.83	4.76	5.17	5.10	5.05	5.09	5.40	5.43	5.77	5.92	6.14	6.21	6.20	6.17	6.08	6.04	5.97	5.71	5.40	5.01	6.49
10	5.06	5.10	5.03	5.57	5.43	5.40	5.38	5.71	5.73	6.08	6.25	6.42	6.46	6.42	6.43	6.37	6.33	6.26	5.96	5.68	5.29	6.74
20	5.28	5.37	5.29	5.95	5.76	5.74	5.65	6.01	6.01	6.37	6.56	6.69	6.70	6.64	6.68	6.64	6.62	6.54	6.21	5.95	5.55	6.99
50	5.55	5.72	5.63	6.45	6.17	6.18	6.00	6.40	6.38	6.74	6.96	7.04	7.02	6.93	7.00	6.99	6.98	6.91	6.52	6.29	5.89	7.30

Annual Maximum Water Levels
W-157, Ballah ; Maximum 10 day levels, Apr. - Oct.

Return Period (YEARS)	April			May			June			July			August			September			October			Annual
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
1.11	19.28	19.58	19.70	19.50	19.54	19.50	20.04	20.52	20.30	20.35	20.57	20.16	19.74	20.23	20.24	20.27	20.02	20.17	20.13	19.75	19.67	22.75
1.25	19.45	19.78	19.92	19.82	19.84	19.94	20.40	20.98	20.62	20.73	20.85	20.50	20.13	20.62	20.53	20.50	20.36	20.39	20.36	20.02	19.85	23.04
2	19.86	20.26	20.45	20.56	20.52	20.96	21.25	22.04	21.36	21.62	21.52	21.30	21.04	21.54	21.20	21.04	21.15	20.92	20.91	20.65	20.28	23.72
5	20.41	20.90	21.15	21.56	21.44	22.35	22.39	23.47	22.36	22.81	22.41	22.37	22.27	22.78	22.11	21.77	22.21	21.62	21.64	21.49	20.86	24.65
10	20.77	21.32	21.62	22.22	22.05	23.26	23.15	24.42	23.02	23.61	23.00	23.09	23.08	23.60	22.70	22.25	22.91	22.08	22.13	22.05	21.24	25.26
20	21.12	21.73	22.07	22.86	22.64	24.14	23.87	25.33	23.65	24.36	23.56	23.77	23.86	24.38	23.28	22.71	23.58	22.53	22.59	22.59	21.60	25.84
50	21.57	22.26	22.65	23.68	23.40	25.28	24.81	26.51	24.48	25.35	24.30	24.66	24.86	25.40	24.02	23.31	24.45	23.11	23.19	23.28	22.07	26.60

Annual Maximum Water Levels
W-158, Chunarghat ; Maximum 10 day levels, Apr. - Oct.

Return Period (YEARS)	April			May			June			July			August			September			October			Annual
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
1.11	12.52	12.76	13.02	12.89	13.02	13.17	13.72	14.50	13.74	13.99	14.09	14.08	13.69	14.17	13.95	13.88	13.77	13.74	13.69	13.33	13.08	16.60
1.25	12.73	13.03	13.27	13.28	13.42	13.60	14.07	14.80	14.12	14.36	14.37	14.39	14.02	14.48	14.23	14.11	14.09	13.99	13.97	13.62	13.27	16.76
2	13.21	13.67	13.88	14.18	14.36	14.60	14.89	15.52	15.02	15.23	15.03	15.11	14.81	15.21	14.90	14.66	14.83	14.57	14.62	14.30	13.73	17.14
5	13.87	14.53	14.69	15.40	15.63	15.95	16.00	16.48	16.23	16.41	15.91	16.08	15.87	16.19	15.80	15.40	15.83	15.34	15.49	15.22	14.34	17.65
10	14.30	15.10	15.23	16.21	16.48	16.84	16.73	17.11	17.03	17.19	16.50	16.73	16.57	16.84	16.40	15.89	16.49	15.86	16.07	15.82	14.75	17.99
20	14.72	15.65	15.74	16.99	17.28	17.70	17.44	17.72	17.80	17.93	17.06	17.34	17.24	17.46	16.97	16.36	17.12	16.35	16.63	16.40	15.14	18.31
50	15.26	16.36	16.41	17.99	18.33	18.80	18.34	18.51	18.79	18.90	17.78	18.14	18.11	18.26	17.72	16.96	17.94	16.99	17.35	17.16	15.65	18.73

Annual Maximum Water Levels
T-273, Bhairab Bazar ; Maximum 10 day levels, Apr. - Oct.

Return Period (YEARS)	April			May			June			July			August			September			October			Annual
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
1.11	1.90	2.15	2.29	2.40	2.61	2.76	3.00	3.69	4.50	5.10	5.44	5.76	5.92	5.94	5.76	5.61	5.50	5.44	5.24	4.75	4.03	6.09
1.25	1.97	2.22	2.36	2.50	2.73	2.94	3.22	3.91	4.68	5.27	5.59	5.89	6.05	6.05	5.90	5.76	5.66	5.58	5.36	4.90	4.21	6.23
2	2.14	2.40	2.55	2.74	3.01	3.36	3.73	4.42	5.11	5.65	5.95	6.21	6.34	6.33	6.23	6.11	6.03	5.91	5.66	5.26	4.63	6.55
5	2.37	2.64	2.79	3.06	3.39	3.93	4.41	5.10	5.69	6.17	6.43	6.63	6.73	6.69	6.67	6.59	6.53	6.36	6.07	5.74	5.20	6.98
10	2.53	2.80	2.95	3.28	3.64	4.31	4.86	5.56	6.07	6.51	6.74	6.91	6.99	6.94	6.97	6.90	6.86	6.65	6.34	6.05	5.58	7.26
20	2.67	2.95	3.11	3.48	3.88	4.67	5.29	5.99	6.44	6.84	7.05	7.18	7.24	7.17	7.25	7.20	7.17	6.94	6.60	6.36	5.94	7.54
50	2.86	3.15	3.31	3.75	4.20	5.13	5.85	6.56	6.92	7.27	7.44	7.53	7.56	7.47	7.61	7.59	7.58	7.30	6.93	6.75	6.41	7.89

Annual Maximum Water Levels
T-275 , Baidyer Bazar ; Maximum 10 day levels, Apr. - Oct.

Return Period (YEARS)	April			May			June			July			August			September			October			Annual
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
1.11	1.73	1.93	1.90	2.18	2.32	2.57	2.80	3.34	3.72	4.15	4.37	4.67	4.80	4.86	4.71	4.62	4.56	4.39	4.24	3.87	3.21	5.05
1.25	1.80	2.01	2.01	2.29	2.43	2.70	2.94	3.45	3.85	4.27	4.52	4.80	4.92	4.96	4.84	4.76	4.70	4.52	4.35	4.00	3.37	5.18
2	1.99	2.20	2.25	2.54	2.70	3.03	3.28	3.72	4.16	4.56	4.88	5.12	5.21	5.19	5.16	5.08	5.02	4.83	4.62	4.30	3.75	5.47
5	2.23	2.45	2.59	2.88	3.05	3.47	3.73	4.08	4.56	4.96	5.36	5.54	5.61	5.50	5.59	5.51	5.45	5.25	4.98	4.70	4.26	5.87
10	2.40	2.62	2.81	3.10	3.29	3.75	4.03	4.32	4.83	5.22	5.68	5.82	5.87	5.71	5.87	5.80	5.73	5.53	5.22	4.97	4.60	6.14
20	2.55	2.78	3.02	3.31	3.51	4.03	4.32	4.54	5.09	5.47	5.98	6.09	6.12	5.91	6.14	6.07	6.00	5.80	5.45	5.23	4.92	6.39
50	2.76	2.98	3.30	3.59	3.81	4.39	4.70	4.84	5.43	5.79	6.38	6.44	6.44	6.16	6.50	6.43	6.36	6.15	5.74	5.56	5.34	6.72

Annual Maximum Water Levels
T-296 , Akhaura ; Maximum 10 day levels, Apr. - Oct.

Return Period (YEARS)	April			May			June			July			August			September			October			Annual
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
1.11	1.57	1.84	2.13	2.13	2.33	2.80	3.13	3.77	4.45	4.95	5.38	5.55	5.68	5.82	5.74	5.63	5.57	5.44	5.26	4.88	4.30	5.50
1.25	1.68	1.96	2.24	2.32	2.53	2.97	3.34	3.96	4.63	5.16	5.56	5.73	5.85	5.96	5.89	5.78	5.73	5.60	5.41	5.04	4.46	5.75
2	1.95	2.25	2.49	2.75	3.01	3.39	3.83	4.41	5.06	5.63	6.00	6.14	6.25	6.30	6.24	6.14	6.10	5.97	5.75	5.39	4.84	6.33
5	2.32	2.63	2.83	3.33	3.66	3.95	4.48	5.01	5.63	6.28	6.59	6.69	6.79	6.75	6.72	6.63	6.60	6.46	6.22	5.87	5.36	7.13
10	2.56	2.89	3.05	3.72	4.09	4.32	4.92	5.41	6.01	6.70	6.98	7.06	7.14	7.05	7.03	6.95	6.93	6.79	6.53	6.19	5.70	7.65
20	2.79	3.13	3.27	4.08	4.50	4.68	5.33	5.80	6.38	7.11	7.36	7.41	7.48	7.34	7.34	7.26	7.24	7.10	6.82	6.49	6.02	8.15
50	3.08	3.45	3.55	4.56	5.03	5.14	5.87	6.29	6.85	7.64	7.84	7.86	7.93	7.71	7.73	7.66	7.65	7.51	7.21	6.89	6.45	8.80

Annual Maximum Water Levels
T-297 , Gokorna Ghat ; Maximum 10 day levels, Apr. - Oct.

Return Period (YEARS)	April			May			June			July			August			September			October			Annual
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
1.11	2.03	2.25	2.50	2.54	2.62	2.67	2.86	3.44	4.01	4.80	5.09	5.52	5.88	5.83	5.44	5.34	5.36	5.39	5.14	4.72	4.02	5.90
1.25	2.10	2.32	2.56	2.62	2.75	2.89	3.13	3.67	4.22	4.97	5.26	5.65	5.98	5.92	5.61	5.52	5.54	5.54	5.28	4.86	4.20	6.03
2	2.26	2.49	2.70	2.81	3.04	3.40	3.76	4.20	4.70	5.38	5.67	5.95	6.20	6.14	6.00	5.94	5.97	5.91	5.61	5.19	4.61	6.35
5	2.48	2.71	2.88	3.07	3.44	4.10	4.60	4.91	5.35	5.94	6.23	6.35	6.49	6.43	6.52	6.51	6.56	6.40	6.06	5.63	5.17	6.79
10	2.62	2.86	3.01	3.25	3.70	4.56	5.16	5.38	5.78	6.30	6.59	6.62	6.69	6.63	6.87	6.88	6.94	6.73	6.36	5.93	5.54	7.07
20	2.76	3.00	3.12	3.41	3.95	5.00	5.70	5.83	6.20	6.66	6.95	6.87	6.87	6.82	7.21	7.24	7.31	7.04	6.64	6.21	5.89	7.35
50	2.93	3.18	3.28	3.63	4.27	5.57	6.39	6.42	6.73	7.11	7.40	7.20	7.12	7.06	7.64	7.71	7.79	7.45	7.01	6.57	6.35	7.70

Annual Maximum Water Levels
T-298, Nabinagar ; Maximum 10 day levels, Apr. - Oct.

Return Period (YEARS)	April			May			June			July			August			September			October			Annual
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
1.11	1.82	2.04	2.15	2.23	2.46	2.70	2.95	3.56	4.19	4.77	5.08	5.35	5.45	5.58	5.45	5.41	5.34	5.21	4.97	4.52	3.88	5.63
1.25	1.90	2.11	2.22	2.34	2.57	2.86	3.14	3.73	4.37	4.92	5.23	5.49	5.60	5.70	5.59	5.55	5.48	5.34	5.10	4.66	4.04	5.78
2	2.08	2.27	2.38	2.59	2.85	3.23	3.59	4.15	4.79	5.28	5.57	5.83	5.94	5.99	5.92	5.87	5.81	5.67	5.40	4.99	4.42	6.13
5	2.31	2.50	2.60	2.93	3.22	3.73	4.19	4.71	5.35	5.76	6.03	6.28	6.39	6.37	6.37	6.30	6.26	6.11	5.79	5.42	4.93	6.60
10	2.47	2.64	2.75	3.16	3.46	4.06	4.59	5.08	5.73	6.08	6.33	6.58	6.70	6.62	6.66	6.59	6.56	6.39	6.06	5.71	5.26	6.90
20	2.62	2.78	2.89	3.37	3.69	4.38	4.97	5.44	6.09	6.39	6.63	6.86	6.99	6.86	6.95	6.86	6.84	6.67	6.31	5.99	5.58	7.20
50	2.82	2.96	3.08	3.65	4.00	4.79	5.47	5.90	6.55	6.79	7.00	7.23	7.36	7.18	7.31	7.22	7.21	7.03	6.64	6.35	6.00	7.59

APPENDIX B.V

Flood Level Duration Frequency Analysis

Flood Level Duration / Frequency
T-3A , Brahmanbaria Railway Bridge ; Maximum 10 day levels, Apr. - Oct.

Duration Days	Return Period (years) 1.11	1.25	2	5	10	20	50
20	5.88	6.02	6.36	6.82	7.12	7.41	7.79
30	5.80	5.92	6.19	6.56	6.81	7.04	7.35
40	5.68	5.78	6.01	6.32	6.53	6.72	6.98
50	5.58	5.69	5.93	6.27	6.49	6.70	6.98
60	5.49	5.60	5.87	6.22	6.45	6.68	6.97
80	5.28	5.39	5.65	6.01	6.24	6.47	6.76
100	4.92	5.03	5.29	5.64	5.87	6.09	6.37
120	3.98	4.15	4.53	5.05	5.40	5.73	6.15
150	2.54	2.74	3.20	3.82	4.23	4.62	5.13

Flood Level Duration / Frequency
W-110, Comilla ; Maximum 10 day levels, Apr. - Oct.

Duration Days	Return Period (years) 1.11	1.25	2	5	10	20	50
20	9.72	9.92	10.39	11.02	11.44	11.84	12.35
30	9.38	9.59	10.09	10.77	11.21	11.64	12.20
40	9.22	9.41	9.87	10.48	10.88	11.27	11.77
50	9.12	9.27	9.64	10.12	10.45	10.76	11.16
60	8.88	9.04	9.44	9.97	10.32	10.65	11.09
80	8.70	8.85	9.21	9.69	10.00	10.31	10.70
100	8.60	8.73	9.06	9.51	9.80	10.08	10.44
120	8.26	8.41	8.76	9.24	9.55	9.85	10.24
150	7.74	7.89	8.24	8.72	9.04	9.34	9.73

Flood Level Duration / Frequency
W-113, Kangsanagar ; Maximum 10 day levels, Apr. - Oct.

Duration Days	Return Period (years) 1.11	1.25	2	5	10	20	50
20	7.10	7.28	7.69	8.25	8.62	8.97	9.43
30	6.84	7.03	7.48	8.08	8.48	8.86	9.35
40	6.71	6.87	7.27	7.80	8.16	8.50	8.93
50	6.48	6.65	7.03	7.54	7.88	8.21	8.63
60	6.19	6.37	6.80	7.38	7.76	8.13	8.60
80	5.93	6.12	6.55	7.13	7.51	7.88	8.36
100	5.78	5.97	6.40	6.99	7.38	7.75	8.24
120	5.33	5.53	6.01	6.66	7.08	7.49	8.02
150	4.31	4.57	5.18	6.01	6.55	7.08	7.75

Flood Level Duration / Frequency
W-114, Jibanpur (Gumti) ; Maximum 10 day levels, Apr. - Oct.

Duration Days	Return Period (years) 1.11	1.25	2	5	10	20	50
20	6.56	6.63	6.81	7.05	7.21	7.36	7.56
30	6.20	6.30	6.54	6.86	7.06	7.27	7.53
40	6.14	6.23	6.45	6.75	6.95	7.14	7.39
50	5.97	6.07	6.32	6.65	6.86	7.07	7.35
60	5.98	6.07	6.27	6.55	6.73	6.91	7.14
80	5.76	5.85	6.05	6.33	6.51	6.69	6.91
100	5.51	5.61	5.83	6.13	6.33	6.53	6.78
120	4.98	5.15	5.54	6.07	6.42	6.76	7.19
150	4.45	4.65	5.12	5.75	6.17	6.57	7.09

Flood Level Duration / Frequency
T-115, Duadkandi ; Maximum 10 day levels, Apr. - Oct.

Duration Days	Return Period (years) 1.11	1.25	2	5	10	20	50
20	4.71	4.83	5.11	5.48	5.73	5.97	6.28
30	4.63	4.73	4.98	5.30	5.52	5.72	5.99
40	4.55	4.66	4.90	5.22	5.44	5.65	5.91
50	4.50	4.60	4.84	5.15	5.37	5.57	5.83
60	4.46	4.56	4.79	5.10	5.30	5.50	5.76
80	4.31	4.39	4.58	4.84	5.01	5.17	5.39
100	3.98	4.07	4.28	4.55	4.74	4.91	5.14
120	3.49	3.59	3.84	4.18	4.40	4.61	4.89
150	2.79	2.88	3.08	3.34	3.52	3.69	3.91

Flood Level Duration / Frequency
W-123, Ganga Sagart Railway Bridge ; Maximum 10 day levels, Apr. - Oct.

Duration Days	Return Period (years) 1.11	1.25	2	5	10	20	50
20	5.42	5.55	5.84	6.24	6.50	6.75	7.08
30	5.34	5.45	5.71	6.05	6.27	6.49	6.77
40	5.28	5.37	5.57	5.84	6.02	6.19	6.41
50	5.23	5.32	5.52	5.79	5.96	6.13	6.36
60	5.17	5.26	5.47	5.75	5.94	6.12	6.35
80	4.96	5.05	5.26	5.54	5.72	5.90	6.13
100	4.70	4.79	5.01	5.30	5.50	5.68	5.92
120	4.24	4.36	4.67	5.07	5.34	5.60	5.94
150	3.79	3.93	4.23	4.65	4.93	5.19	5.53

Flood Level Duration / Frequency
W-157, Ballah ; Maximum 10 day levels, Apr. - Oct.

Duration Days	Return Period (years) 1.11	1.25	2	5	10	20	50
20	20.71	20.97	21.59	22.42	22.97	23.49	24.17
30	20.50	20.72	21.25	21.96	22.43	22.89	23.47
40	20.39	20.56	20.95	21.49	21.84	22.18	22.62
50	20.15	20.32	20.71	21.25	21.60	21.94	22.38
60	20.11	20.27	20.65	21.16	21.50	21.82	22.23
80	19.99	20.12	20.41	20.81	21.07	21.32	21.64
100	19.88	20.00	20.28	20.66	20.91	21.15	21.46
120	19.78	19.89	20.17	20.54	20.79	21.03	21.33
150	19.52	19.65	19.94	20.34	20.61	20.86	21.19

Flood Level Duration / Frequency
W-158, Chunarghat ; Maximum 10 day levels, Apr. - Oct.

Duration Days	Return Period (years) 1.11	1.25	2	5	10	20	50
20	14.86	15.04	15.48	16.07	16.45	16.83	17.31
30	14.26	14.47	14.97	15.63	16.08	16.50	17.05
40	14.05	14.23	14.63	15.18	15.54	15.88	16.33
50	13.99	14.13	14.46	14.91	15.20	15.49	15.85
60	13.92	14.05	14.36	14.78	15.05	15.32	15.66
80	13.72	13.85	14.14	14.53	14.79	15.04	15.36
100	13.55	13.68	13.99	14.40	14.67	14.94	15.28
120	13.34	13.46	13.74	14.13	14.38	14.62	14.94
150	13.09	13.21	13.49	13.87	14.12	14.36	14.68

Flood Level Duration / Frequency
T-273, Bhairab Bazar ; Maximum 10 day levels, Apr. - Oct.

Duration Days	Return Period (years) 1.11	1.25	2	5	10	20	50
20	5.91	6.04	6.35	6.77	7.05	7.32	7.67
30	5.79	5.90	6.17	6.54	6.78	7.01	7.30
40	5.71	5.80	6.02	6.31	6.51	6.70	6.94
50	5.63	5.73	5.95	6.26	6.46	6.65	6.90
60	5.53	5.63	5.87	6.20	6.41	6.62	6.89
80	5.35	5.45	5.68	5.99	6.20	6.40	6.65
100	4.98	5.09	5.33	5.66	5.88	6.09	6.36
120	4.12	4.28	4.64	5.14	5.46	5.77	6.18
150	2.73	2.91	3.33	3.90	4.28	4.64	5.11

Flood Level Duration / Frequency
T-275 , Baidyer Bazar ; Maximum 10 day levels, Apr. - Oct.

Duration Days	Return Period (years) 1.11	1.25	2	5	10	20	50
20	4.77	4.90	5.20	5.61	5.88	6.14	6.48
30	4.72	4.81	5.05	5.36	5.57	5.77	6.03
40	4.68	4.76	4.96	5.22	5.39	5.56	5.77
50	4.62	4.70	4.90	5.16	5.34	5.51	5.72
60	4.52	4.61	4.81	5.09	5.27	5.44	5.67
80	4.31	4.41	4.64	4.94	5.15	5.35	5.60
100	3.97	4.06	4.29	4.59	4.80	4.99	5.24
120	3.44	3.56	3.84	4.22	4.47	4.70	5.01
150	2.53	2.65	2.95	3.35	3.62	3.87	4.20

Flood Level Duration / Frequency
T-296 , Akhaura ; Maximum 10 day levels, Apr. - Oct.

Duration Days	Return Period (years) 1.11	1.25	2	5	10	20	50
20	5.88	6.02	6.38	6.85	7.16	7.46	7.85
30	5.75	5.89	6.20	6.63	6.91	7.18	7.53
40	5.65	5.76	6.03	6.38	6.62	6.84	7.14
50	5.57	5.69	5.96	6.32	6.56	6.79	7.09
60	5.50	5.62	5.89	6.27	6.51	6.75	7.06
80	5.35	5.46	5.73	6.08	6.31	6.53	6.82
100	4.99	5.11	5.38	5.74	5.98	6.22	6.52
120	4.17	4.32	4.66	5.13	5.44	5.74	6.12
150	2.73	2.91	3.36	3.95	4.35	4.73	5.21

Flood Level Duration / Frequency
T-297 , Gokorna Ghat ; Maximum 10 day levels, Apr. - Oct.

Duration Days	Return Period (years) 1.11	1.25	2	5	10	20	50
20	5.64	5.78	6.12	6.57	6.87	7.16	7.53
30	5.58	5.70	5.98	6.37	6.62	6.86	7.18
40	5.52	5.62	5.86	6.17	6.38	6.58	6.84
50	5.44	5.55	5.80	6.13	6.35	6.56	6.84
60	5.38	5.49	5.75	6.11	6.35	6.57	6.86
80	5.26	5.35	5.58	5.89	6.09	6.29	6.54
100	4.82	4.92	5.17	5.50	5.71	5.92	6.19
120	3.88	4.04	4.43	4.94	5.28	5.60	6.02
150	2.58	2.80	3.34	4.07	4.55	5.01	5.60

Flood Level Duration / Frequency
T-298, Nabinagar ; Maximum 10 day levels, Apr. - Oct.

Duration Days	Return Period (years)						
	1.11	1.25	2	5	10	20	50
20	5.64	5.76	6.05	6.44	6.69	6.94	7.26
30	5.52	5.63	5.88	6.23	6.46	6.68	6.96
40	5.43	5.52	5.73	6.01	6.19	6.37	6.60
50	5.36	5.46	5.67	5.96	6.15	6.34	6.58
60	5.30	5.39	5.61	5.91	6.10	6.29	6.53
80	5.12	5.21	5.42	5.70	5.89	6.06	6.29
100	4.74	4.83	5.05	5.35	5.54	5.73	5.97
120	3.95	4.09	4.42	4.86	5.15	5.43	5.79
150	2.66	2.83	3.21	3.74	4.08	4.41	4.84

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Ref 2.3	South East Regional Study Draft Final Report, 1992 - by Mott MacDonald and Associating Companies
Ref 2.4	MPO Water Balance Study
Ref 2.5	Bureau of Consulting Engineers in Association with Sir William Halcrow and Partners Gumti Phase II sub-project Feasibility Study Final Report, March 1990
Ref 3.1	Hydrological and Morphological Modelling of the Gumti-Titas and Atrai River Basins Final Report, April 1990 - by Howard Humphreys and Partners
Ref 3.2	"Use of Storm and Watershed Characteristics in Synthetic Hydrograph Analysis and Application - by U.S. Soil Conservation Service
Ref 3.3	Sediment in India - by Howard Humphreys and Partners
Ref 4.1	MIKE 11 Scientific Documentation - by Danish Hydraulics Institute
Ref 5.1	South East Regional Model Verification Report, November 1991 - by Surface Water Modelling Centre