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IMPROVEMENT OF FLOOD FORECASTING AND WARNING SYSTEM

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PROJECT TERMINAL REPORT

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J E DENT, BSc, MIWEM, FRMetS
WMO CHIEF TECHNICAL ADVISER
DHAKA, SEPTEMBER 1992

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1. PROJECT BACKGROUND

Project BGD/88/013 officially commenced in July 1989 with the arrival of the Chief Technical Adviser (CTA). There had however been some prior short inputs by radar and telecommunications experts in connection with the proposed project activities. The project was initially intended as a forerunner to an extensive programme and the main purpose was therefore to deal with some immediate problems affecting the flood forecasting operations, and develop detailed plans for the future. In the event, the scope of the project was extended, and a certain amount of development of activities, procurement of equipment and training was incorporated. This followed the recommendation of a Tri-partite Review (TPR) meeting in March 1990, which extended the project until June 1991.

However, the Chief Technical Adviser left the project at the end of July 1990, and for various reasons his replacement could not take up duties until January 1991. The absence of a CTA on the project caused a halt to the programme, with the exception of some river forecast model development work under an on-going sub-contract with the Danish Hydraulic Institute (DHI) which continued up to the end of September 1990.

A major project revision based on the recommendation by the TPR, was prepared as Budget code "G". This was not signed until September 1990 and did not come into effect until the arrival of the new CTA. This revision gave the project a one year programme, and it is basically the implementation of this programme which is the subject of this report. However, as Revision G included the initial project objectives, these are covered as far as possible. The first part of the project, up to the departure of the first CTA, is referred to as the first phase, whilst the period after Revision G is referred to as the second phase.

As a result of a second Tri-partite Review, held in August 1991, it was recommended that the project should be extended until May 1992. This was primarily to allow full completion of equipment procurement within the project period and to allow inputs connected with this procurement to be carried out. It was also considered that the extension would cover the early stages of the Pilot Telemetry construction.

The project Terminal Evaluation Mission was carried out in February 1992. This in its turn also recommended an extension of the project by a further six months to the end of November 1992. This was to provide support over the coming monsoon season for new facilities set up under the project, particularly the computer network and operating system on which forecast models would be operating for the first time. It would also allow some work to be carried out on items from the early part of the project which had not been undertaken and for planning for a long term project to be carried out. For both extensions, the overall budget allocation of

Revision G has not been altered. The additional manpower inputs have been met by inter-line budget transfers which were possible due to the delay in the Pilot Telemetry System programme.

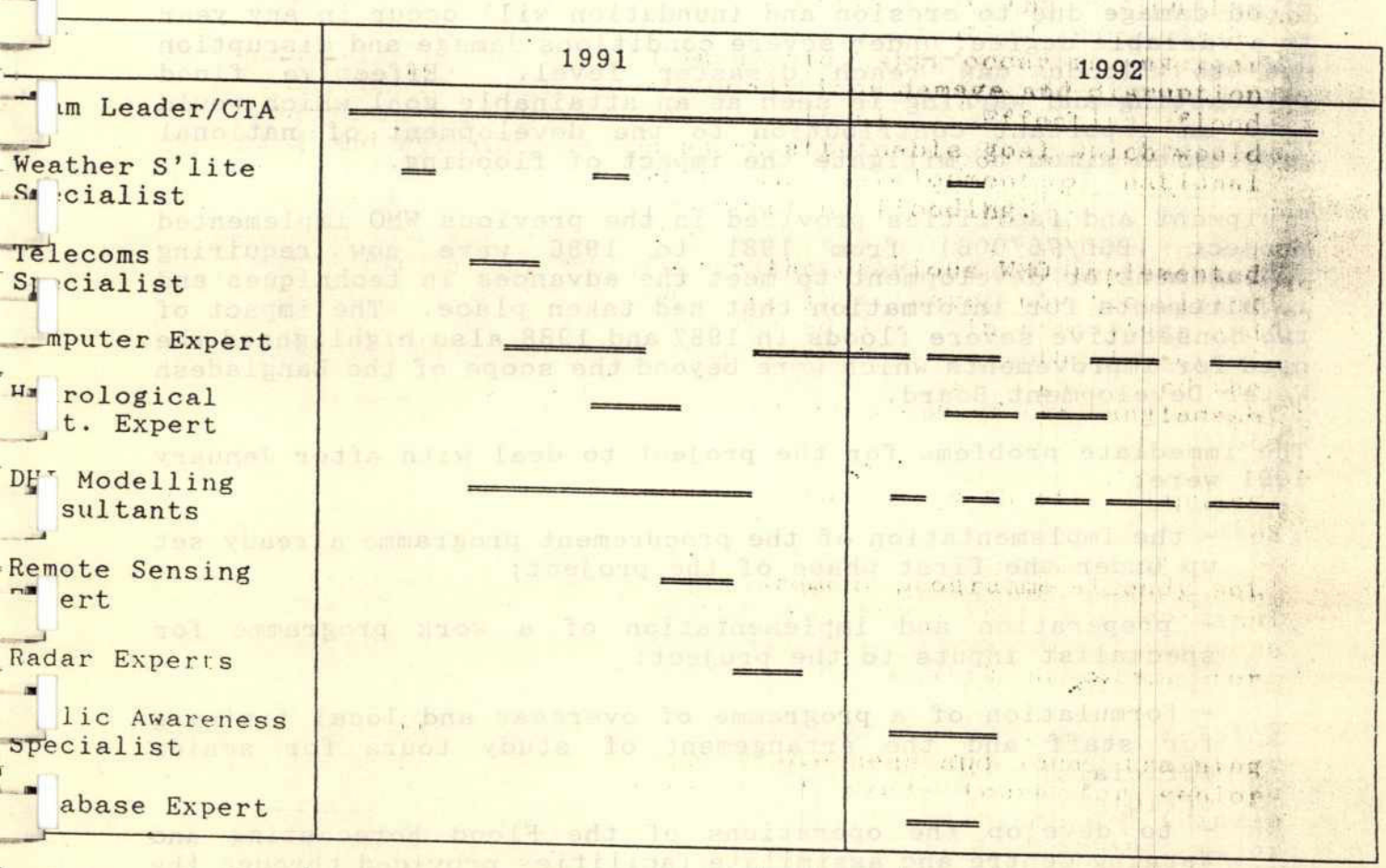

Figure 2.1 Specialist Inputs to the Project After Revision G

2. DEVELOPMENT PROBLEM AND IMMEDIATE PROBLEMS ATTACKED

Annual flooding due to the monsoonal climate of the region has considerable impact on the economic development of Bangladesh. Flood damage due to erosion and inundation will occur in any year to a variable degree: under severe conditions damage and disruption due to floods can reach disaster level. Effective flood forecasting and warning is seen as an attainable goal which would make an important contribution to the development of national programmes aimed to mitigate the impact of flooding.

Equipment and facilities provided in the previous WMO implemented project (BGD/76/006) from 1981 to 1986 were now requiring replacement or development to meet the advances in techniques and requirements for information that had taken place. The impact of two consecutive severe floods in 1987 and 1988 also highlighted the need for improvements which were beyond the scope of the Bangladesh Water Development Board.

The immediate problems for the project to deal with after January 1991 were;

- the implementation of the procurement programme already set up under the first phase of the project;

- preparation and implementation of a work programme for specialist inputs to the project;

- formulation of a programme of overseas and local training for staff and the arrangement of study tours for senior officials;

- to develop the operations of the Flood Forecasting and Warning Centre and assimilate facilities provided through the project.

The implemented programme of specialist staff inputs is illustrated in Figure 2.1. The project team and short term consultants are listed in Appendix 1.

3. OUTPUTS PRODUCED AND PROBLEMS ENCOUNTERED

3.1 Stated Outputs in the Project Documents

The outputs for the project stated in Revision G were arranged under four Immediate Objectives.

1. To strengthen and upgrade the data acquisition and transmission system, so as to increase the availability, accuracy and timeliness of hydrological and other related data.

2. To provide more accurate, reliable and timely forecasts at important sites located along the major and other significant rivers in the country by means of further adaptation and calibration of suitable forecasting models and techniques.

3. To reinforce the infrastructure for, and enhance integration of activities in support of the overall strengthening of the flood forecasting and warning system.

4. To train local staff engaged in flood forecasting and warning activities and related fields.

The project document for Revision G stated that the original objectives of the project were still extant. These objectives were as follows.

1. To continue assistance to FF&WC (Flood Forecasting and Warning Centre) of the Bangladesh Water Development Board (BWDB) in order to complete the calibration of the hydrological radar which was established in 1985, rehabilitation of the existing SSB (single side-band) wireless network and to eliminate existing major bottlenecks in the existing flood forecasting and warning system.

2. To finalise the draft main phase Project Document and to make all preparations for the timely commencement of the main project phase.

3.2 Review of Project Outputs

The work carried out by the project on the outputs related to the above objectives are discussed individually in the following sections. The statement of the outputs is taken directly from their respective project documents.

3.2.1 Outputs of the Immediate Objectives of Original Project Document

Immediate Objective 1

Output 1.1 "The S-band hydrological radar calibrated and fully operational enabling reliable quantitative areal rainfall estimates

in north-eastern, eastern and south-eastern river basins lying within edge of the effective hydrological range of the radar."

This output has not been achieved. The concept of calibration of the radar was completely misunderstood by higher officials of the government and the project did not have the facilities to deal with the problems. In the early stages of the project, two short inputs[1] were carried out by radar specialists to assess the condition of the installation. As a result the transmitter was correctly set up to carry out scanning. It was pointed out then that the operating software for both the radar and the supporting rainfall ground truth monitoring was obsolete (having been produced in 1982) and unlikely to produce good estimates of rainfall intensity from echoes.

Early on in the second phase of the project it was found that the rainfall telemetry software was not working. The suppliers of the original equipment were unable to provide copies of the software. It has therefore not been possible during the life of the project to obtain real time rainfall measurements for operational calibration of the radar echo.

In November-December 1991 a two man mission from the Wuhan Provincial Meteorological Department in China carried out a review of the radar and all its associated facilities. The same type of hydrological radar equipment has been used successfully at Wuhan for monitoring conditions in the middle Yangtze for a number of years. Their recommendations included immediate and long term programmes for the future use of radar monitoring. (See Appendix 2.) They concluded that the actual radar instrument was of high quality and in good condition. The operating control system and that for rainfall monitoring and quantitative estimation on a catchment basis would have to be completely replaced using the most recently available computer hardware and software.

One of the original reasons for installing radar was to estimate rainfall on catchments in India which discharge into north-eastern and eastern parts of Bangladesh. The Chinese mission noted that given the range of the radar, the site at Dhaka was too far away from the areas of interest to give good estimates of rainfall. They were also of the opinion that the rainfall telemetry system was inadequate.

Under project BGD/76/006 the radar centre at the Bangladesh Meteorological Department (BMD) transmitted pictures and processed data to FF&WC by a microwave link. Before the start of this project this link was disrupted by the construction of a high-rise building in the line of sight. Alternative methods were proposed to rectify the situation but no specific funding allocation was

1) One specialist from McGill University and another from the suppliers, EEC Ltd. in July 1989 and December 1989 respectively.

made for future implementation. In view of the funds available and the uncertain capabilities and future of the radar, the least cost option of establishing a telephone land line link was carried out in time for the 1991 monsoon season. The link has functioned, but due to the poor quality of the telephone facilities in Dhaka, breakdowns are frequent, particularly in rainy conditions. The system requires a lot of attention to maintain it and it is not always possible for BWDB to provide this as the source of the fault most usually lies outside their control.

Output 1.2 "The existing wireless data communication network strengthened and fully operational with sufficient stock of spare SSB units."

This output was carried over in a modified form to the outputs of Revision G, and will be described later.

Output 1.3 "Automatic data communication and facsimile system established between BMD and FF&WC and put into operation, for automatic transmission of data received through GTS (Global Telecommunications System), synoptic charts and satellite imagery from BMD and SPARRSO to FF&WC."

Automatic Data Communication. A teleprinter installation existed at FF&WC before the start of this project. Its primary use is for transfer of messages from BMD which are:-

- synoptic inference and weather forecast;
- river level and discharge and river forecast information from a few points in India;
- daily rainfall figures for BMD stations and a few in India.

This has continued throughout this project. The setting up of an automatic data transfer system was partly dependent upon the Storm Warning Centre (SWC) at BMD establishing a computerised system for handling GTS. This was done during 1991, but the message switching system facilities available have not been fully developed. A second dedicated land line, the same as that for the temporary radar link, has been installed to connect SWC with FF&WC. Modem connections are available at either end: the output at FF&WC could be either to line printer or to computer. This system has not been used. GTS data are sent via the teleprinter and have to be decoded by someone at FF&WC. The actual coverage of this data is very sparse and irregular and is of limited practical value.

Facsimile System. Three facsimile machines were ordered during the first phase of the project: installation and operation were carried out in the second phase.

It took some time to decide on the best approach to installation. Although the machines purchased were dual purpose and could be operated in tandem with a manual telephone, the original

requirement of BWDB was to have the machines installed permanently as facsimiles only and with dedicated lines linking SPARRSO, BMD and FF&WC. It was found however that the availability of lines was very limited and that costs of installing dedicated lines would be prohibitive. For the 1991 flood season facsimile machines were installed on existing manual telephone lines at the SWC and in FF&WC. The link was used to send meteorological synoptic charts from SWC to FF&WC on a request only basis.

In 1992 SPARRSO had fixed their facsimile machine to a new "digital" line.(1) A regular operating system was set up for the monsoon period where the synoptic chart for 00 UTZ and the west Pacific geostationary meteorological satellite (GMS) image for 0330 UTZ were sent every day to FF&WC. As Bangladesh is on the margins of the picture of the GMS, the image is computer rectified onto a mercator projection by SPARRSO before transmission. This allows easy comparison with the NOAA satellite imagery received directly by FF&WC.

The operation during the 1992 monsoon was generally successful. It is helpful to have the synoptic chart available to aid understanding of the satellite imagery, although transmission in time for use in preparing the forecast was not usually possible. The synoptic chart is a photocopy of a portion covering the eastern Indian sub-continent and the Bay of Bengal of the chart prepared for the whole of southern Asia. It must be noted however that the detail of the synoptic chart is often generalised, as data may be missing over many areas. In particular there appear to be no readings over the Bay of Bengal and reports from Burma are usually unavailable. To monitor the movement and development of weather systems more closely, more than one chart a day is required. Although SWC prepare synoptic charts every 3 hours, they do not have convenient access to a photocopier to allow chart copies to be sent more frequently than once a day.

Output 1.4 "Existing FF&WC upgraded to the Directorate of Flood Forecasting and Warning (DFFW)."

This was carried over to the second phase of the project and has not been implemented. It requires a policy decision by the Board of BWDB, and is still under periodic consideration.

(1). The telephone system in Dhaka is of two types. A new network is being developed using electronic exchange switching and modern cabling. This is known as the "digital" system. Many parts of the city, including FF&WC and BMD use the older electrical-mechanical exchange system, which can become highly unreliable.

Output 1.5 "Partially upgraded existing computer system with capability of running forecasting version of the hydrodynamic General Surface Water Simulation Model developed at the MPO."

The first phase of the project purchased some IBM compatible personal computers. During this phase inputs were carried out in 1989 and 1990 by the Danish Hydraulic Institute to prepare a version of the MIKE 11 hydrodynamic model which would operate in real time for flood forecasting purposes. A model of the main river system of the Ganges and Brahmaputra in Bangladesh was developed, calibrated and verified. The network of this first version of the forecast model is shown in Figure 3.1. It was first operated in real time for flood forecasting in the second phase of the project during the 1991 monsoon season: this and other developments are discussed in the appropriate later sections.

Output 1.6 "Increased accuracy and lead time of issued forecasts along streams of Ganges, Brahmaputra and lower part of the Meghna; achieved capability for issuing quantitative flash flood forecasts in river basins of Juri, Manu, Gumti and Muhuri."

This output was not achieved during the first phase of the project. The setting up of the general model for flood forecasting was a start in the improvement of the forecast system. The second part of this output was entirely dependent upon the satisfactory performance of the hydrological radar system. As explained under Output 1.1, this was not possible. Even if the radar system had been successfully established, it is hard to see how the objective of producing quantitative flash flood forecasts could have been realised from basins outside Bangladesh. The forecasts of flow or water levels were to be produced by conceptual models of the basins with rainfall as the primary input. The models required a large number of parameters, e.g. catchment wetness, vegetation, land use, percolation, etc., all requiring calibration and regular monitoring. As these data would be impossible to obtain from Indian sources in all but the scantiest detail, the value of the forecasts would be highly questionable.

These restrictions were recognised by the Terminal Evaluation Mission in February 1992. At the mission wind-up meeting it was agreed that during the six month extension of the project from June to November 1992, a pilot study should be carried out on one of the "flashy" rivers in the south east of Bangladesh. This would indicate the feasibility of such programmes in the future. The study was set up on the Halda River basin in the Chittagong Hill Tracts, which lies entirely within Bangladesh.

Output 1.7 "Appropriate support rendered to the Government, if necessary, for extending and exchange of real time hydrological data and forecasts with interested co-riparian countries."

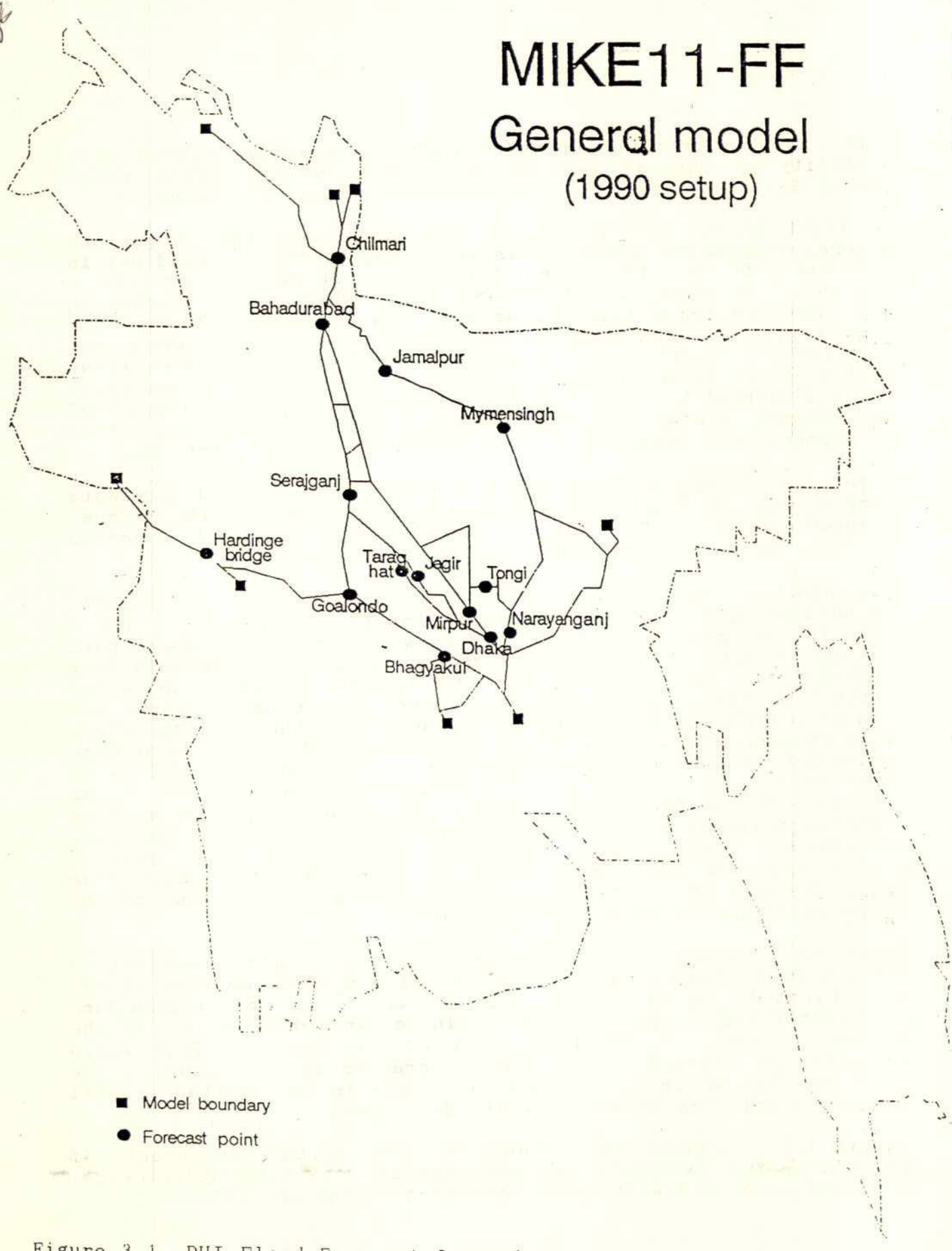

Figure 3.1 DHI Flood Forecast General Model, Initial Set-up.

Bangladesh would be a user, rather than a supplier of information to co-riparian countries. As the project has not been specifically requested at any time to provide information for these countries, it must be assumed that the necessity has not arisen. Information exchange takes place at ministerial level and through the Joint Rivers Commission. Information supplied as routine to these bodies may well have been used.

Output 1.8 "Reconnaissance Survey for nationwide telemetry network conducted, specification of equipment prepared and radio propagation tests carried out."

The reconnaissance survey was carried out by the Telemetry Specialist between December 1989 and March 1990 and a report produced. This proposed a full survey for the Pilot Telemetry Scheme which was initiated during the second phase of the project. This is discussed in more detail in the relevant section below.

Immediate Objective 2

Output 2.1 "Full Project Document and TOR for consultants for the follow-up main phase finalised in accordance with the existing PFF, comments of the PAC, GoB and prospective donors."

This was deferred from the first phase, due to the revision of the project structure. Revision of the TAPP took place after the Tripartite Review of August 1991. Following the recommendations of the Evaluation Mission in February 1992, work commenced to assist BWDB to prepare TAPP and Terms of Reference on behalf of the Government for a long-term assistance project, component 10 of the Flood Action Plan.

Output 2.2 "GoB inputs identified and selected, draft work plan and preliminary equipment list prepared."

The GoB inputs and the preliminary equipment list was prepared early in the first phase of the project. The detailed work plan was finalised at the start of phase 2.

3.2.2 Outputs of the Immediate Objectives of Project Revision G

Immediate Objective 1.

Output 1.1 "Pilot Telemetry Scheme Established"

This output was not under the control of the project and has not been achieved. The work is being implemented directly by the Government of Bangladesh through funds available under a Debt Relief Grant from the Government of Japan.

The Preliminary Report (see Output 1.8 above) prepared a work plan for detailed survey, outline design, drawing up of equipment

specifications and tender documents, and a programme for manufacture, construction and commissioning. This covered a period of 20 months and was originally planned to commence in December 1990. It would thus have still not been possible to complete the Pilot Telemetry Scheme inside the initial given time frame of the project of one year.

A design team provided through the Japanese International Co-operation Agency (JICA) was fielded in June 1991. Survey, design and the preparation of draft tender documents was completed by the end of August. The tender documents were scheduled to be finalised by the Government of Bangladesh and made available to bidders from 1 December 1991. They were eventually published in March and the date for final receipt of bids set at 31 May 1992. This was subsequently extended to 17 June. Evaluation of the bids was still incomplete at the time of preparing this report. It now unlikely that the system will be installed until after 1993.

The project was involved from time to time in liaison meetings between the JICA team and BWDB and in some early reviews of the draft tender documents. Under the UNDP project funding a sum of US$359,000 was assigned to training in connection with the pilot telemetry work. It was not possible to utilise this allocation as intended. Some funds were utilised in providing training related to more general telemetry applications and some for additional staff time resulting from the two project extensions.

Output 1.2 "Semi real time wireless communication network, including laboratory/workshop facilities strengthened by additional 32 sets of HF/SSB transceivers and mobile workshop facilities."

The 32 transceivers were purchased, though their delivery in late August 1991 was too late to be of any great value in that year's monsoon. Various wireless and other electrical spares were delivered before the transceivers and this enabled some emergency repair of sets which were fielded to begin the expansion of the wireless monitoring network. The 32 sets were fully utilised as field or back-up instruments for the 1992 monsoon. The expansion of the wireless network in respect of rainfall and water level stations is referred to under the next output.

Preliminary specifications for the mobile workshop were made during the first phase of the project. Detailed specifications were arranged between WMO headquarters in Geneva and the suppliers. The mobile workshop was finally ordered in August 1991, but not delivered until May 1992. The mobile workshop will allow repairs and fabrication of field installations to be carried out on site, using a wide range of mechanical and electrical equipment.

Output 1.3 "Hydrometric network along the significant rivers improved for hydrological forecasting purposes in accordance with the recommendations of DHI's Phase 1 final report."

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The production of this output went considerably further than the recommendations of DHI as the needs of the project developed. The output was largely achieved through the inputs of the Hydrological Instruments Specialist.

The DHI recommendations primarily concerned the upgrading of stations around Dhaka and the north east of the country. This was commenced in the interim period between the two phases of the project and was largely complete early on in the 1991 monsoon season.

The first input of the Hydrological Instruments Specialist took place in July and August of 1991. The main purpose was to ascertain the requirements for new instruments, spares and the improvement of workshop facilities. The performance of the operation and maintenance of equipment was evaluated in order to standardise on certain equipment types as far as possible, and to provide adequate spares for the next five years of operation. Detailed specifications were drawn up and orders placed.

If the project had not been extended to May 31 1992, the equipment ordered would not have arrived in time. The specialist's second input took place from February to April 1992 and much of this time was spent in supervising the installation of solid state data loggers for rainfall and river level at three sites. These loggers are to run experimentally alongside chart recorders at two sites and instead of a chart recorder at one site, Chilmari. In addition to the use of checking the accuracy of observers, their performance will be evaluated in order to ascertain their suitability for replacing chart recorders in the future. The loggers have their own software to download information through a standard PC. A programme has also been developed to download the information direct into the FF&WC (TIDEDA) data base. The loggers can be easily modified for use with telemetry equipment at site.

The development of wireless facilities, the requirements for modelling and the provision of hydrometric equipment has resulted in a significant expansion of the daily flood season monitoring network. At the start of the 1991 monsoon period this network comprised 35 water level and 34 rainfall stations: at the end of the 1992 monsoon the number of stations had increased to 47 water level and 46 rainfall, all with HF/SSB transceivers. The expanded networks are shown in Figures 3.2 and 3.3.

Output 1.4 "Satellite Receiver at Directorate of FF&W installed for direct read-out of satellite imageries for use in flood forecasting and local staff trained in the interpretation of satellite products."

The equipment was delivered and installed at the end of the first phase of the project, in June 1990. Due to damage during delivery, it did not function satisfactorily and repair was delayed until the

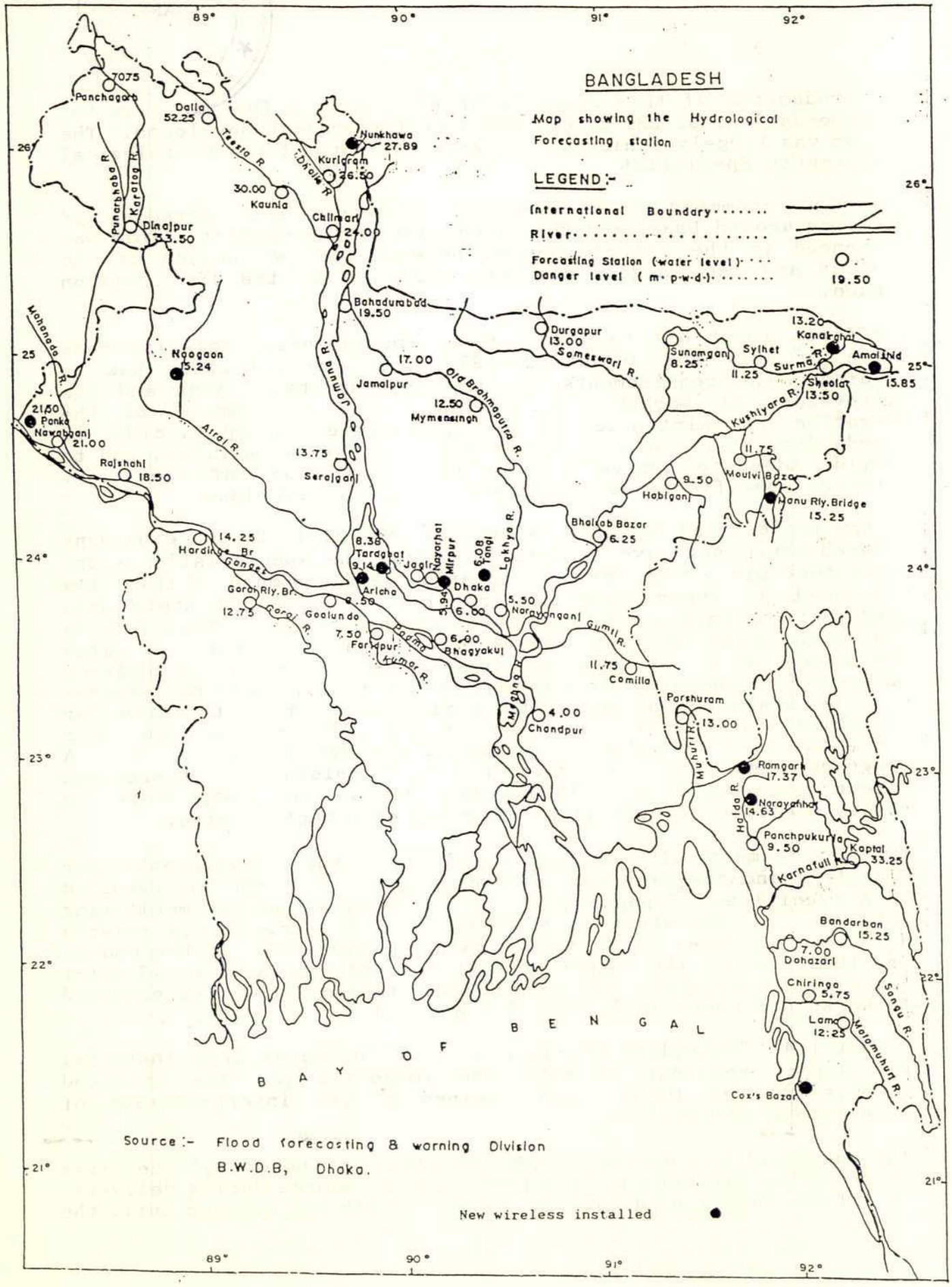

Figure 3.2 Expansion of the Water Level Monitoring Network During the Project

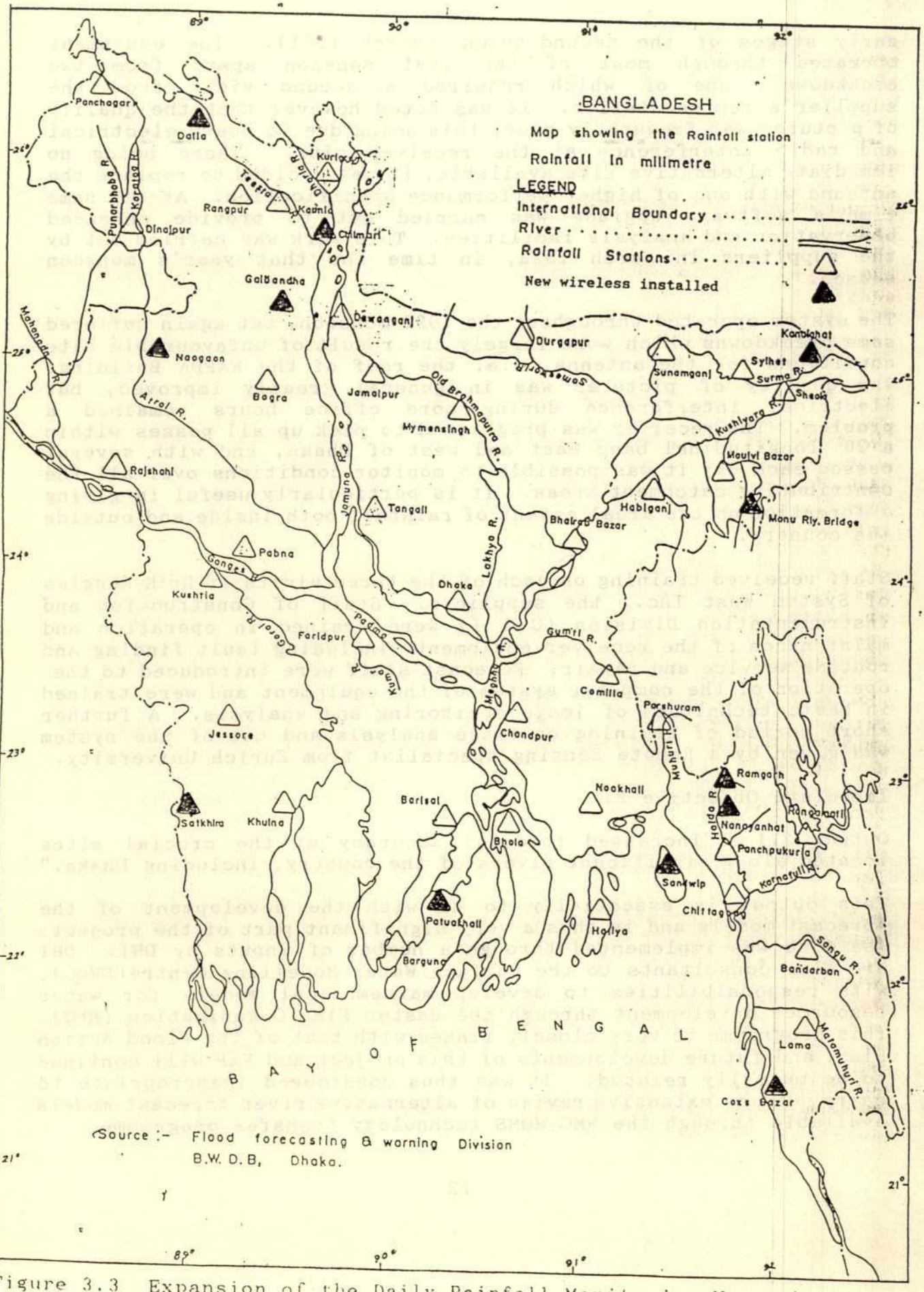

Figure 3.3 Expansion of the Daily Rainfall Monitoring Network During the Project

early stages of the second phase (March 1991). The equipment operated through most of the 1991 monsoon apart from two breakdowns, one of which required a second visit from the supplier's representative. It was noted however that the quality of pictures was frequently poor, this being due to heavy electrical and radio interference at the receiver site. There being no immediate alternative site available, it was decided to replace the antenna with one of higher performance specification. At the same time a software upgrade was carried out to provide enhanced observation and analysis facilities. This work was carried out by the suppliers in March 1992, in time for that year's monsoon season.

The system operated throughout the 1992 monsoon, but again suffered some breakdowns which were largely the result of unfavourable site conditions for the antenna, i.e. the roof of the WAPDA Building. The quality of pictures was in general greatly improved, but electrical interference during core office hours remained a problem. The receiver was programmed to pick up all passes within a 20^0 longitudinal band east and west of Dhaka, and with several passes each day it was possible to monitor conditions over all the contributing catchment areas. It is particularly useful in giving information on the areal extent of rainfall both inside and outside the country.

Staff received training on each of the three visits of Dr K Ruggles of System West Inc., the suppliers. Staff of Construction and Instrumentation Division (C & I) were trained in operation and maintenance of the receiver equipment, including fault finding and routine service and repair. Forecast staff were introduced to the operation of the computer system of the equipment and were trained in basic techniques of image monitoring and analysis. A further short period of training on image analysis and use of the system was given by a Remote Sensing specialist from Zurich University.

Immediate Objective 2.

Output 2.1 "Increased forecast accuracy at the crucial sites located along significant rivers of the country, including Dhaka."

This output is essentially to do with the development of the forecast models and is thus a very significant part of the project. The work was implemented through a number of inputs by DHI. DHI are also consultants to the Surface Water Modelling Centre(SWMC), with responsibilities to develop mathematical models for water resources development through the Master Plan Organisation (MPO). This programme is very closely linked with that of the Flood Action Plan, and future developments of this project and FAP will continue to be mutually related. It was thus considered inappropriate to carry out any extensive review of alternative river forecast models available through the WMO HOMS technology transfer programme.

Prior to the start of the 1991 monsoon season the model was recalibrated and set up using the latest information available from the SWMC general model. After a period of testing it was possible to commence running the model in real time to produce forecasts. The results proved satisfactory and were quickly incorporated into the bulletins issued by the FF&WC. At the same time the model was enlarged to include stations in the Meghna basin and upstream extensions into India on the Brahmaputra and Ganges established for use when this data was available. The real time flood forecasting model for the main river system is now termed MIKE11-FF (Figure 3.4), with the version containing the Indian extensions known as MIKE11-FFX (Figure 3.5). Towards the end of the 1991 monsoon season a regional model for the North Central area, as defined by FAP3 was set up (Figure 3.6). Preliminary tests of this as a real time model were successful.

A detailed analysis of the forecast results from MIKE11-FF and FFX over the 1991 monsoon season was carried out and reported by DHI. It was generally concluded that the 24 hour forecasts were of good accuracy for the whole of the network. At 48 hours the forecasts were reasonably good, apart from in the Meghna basin, which may still be considered in some ways experimental. The 72 hour forecasts were frequently inaccurate. It was found, as expected, that if data for upstream stations in India were available for inclusion, the forecast results from MIKE11-FFX showed an improvement in accuracy at all time steps.

The modelling activities for 1992 followed a similar programme. Revisions to the general model were incorporated and recalibration carried out before setting up for the forecast season. A major task however was to establish the models to operate under UNIX on the newly installed local area network. Model forecasts from MIKE11-FF were produced daily from 1 June. The finalised version of the North-central Regional model was not available until later in the season and the real-time forecast model was run experimentally from late July. The work and the results of the DHI inputs to the project have been fully covered in a series of reports, as listed in Appendix 3.

In 1992 the new database system for FF&WC was established. The DHI models were fully integrated into the system through establishing UNIX versions of the models before the start of the monsoon season. The running of the forecast models is now the operational focus of the daily routine of FF&WC and the data management system allows exchange of data to and from the model and the database during operation.

Immediate Objective 3.

Output 3.1 "New multi-user micro-computer based Local Area Network (LAN) installed, tested and operational."

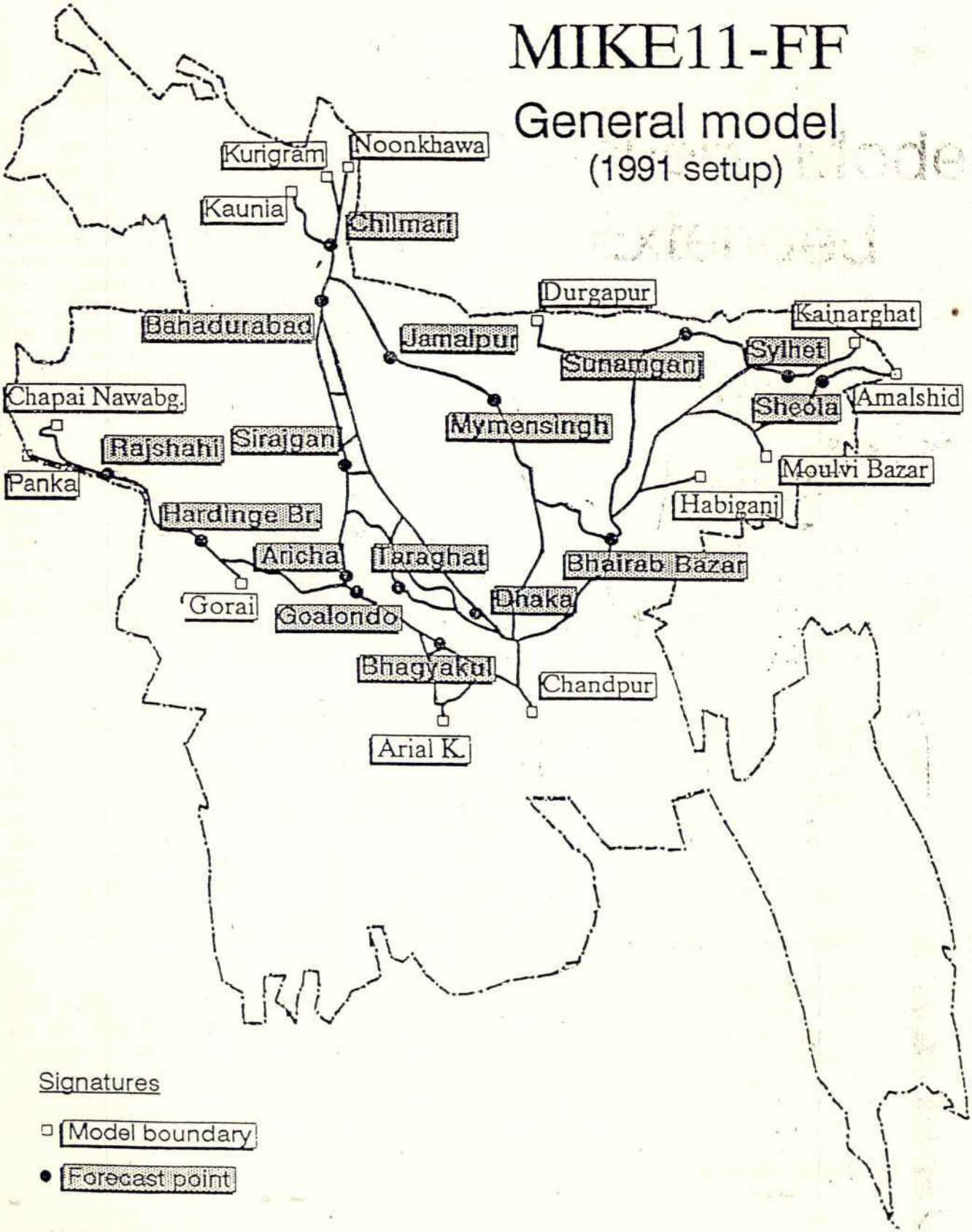

Figure 3.4 DHI Flood Forecast General Model, Final Set-up.

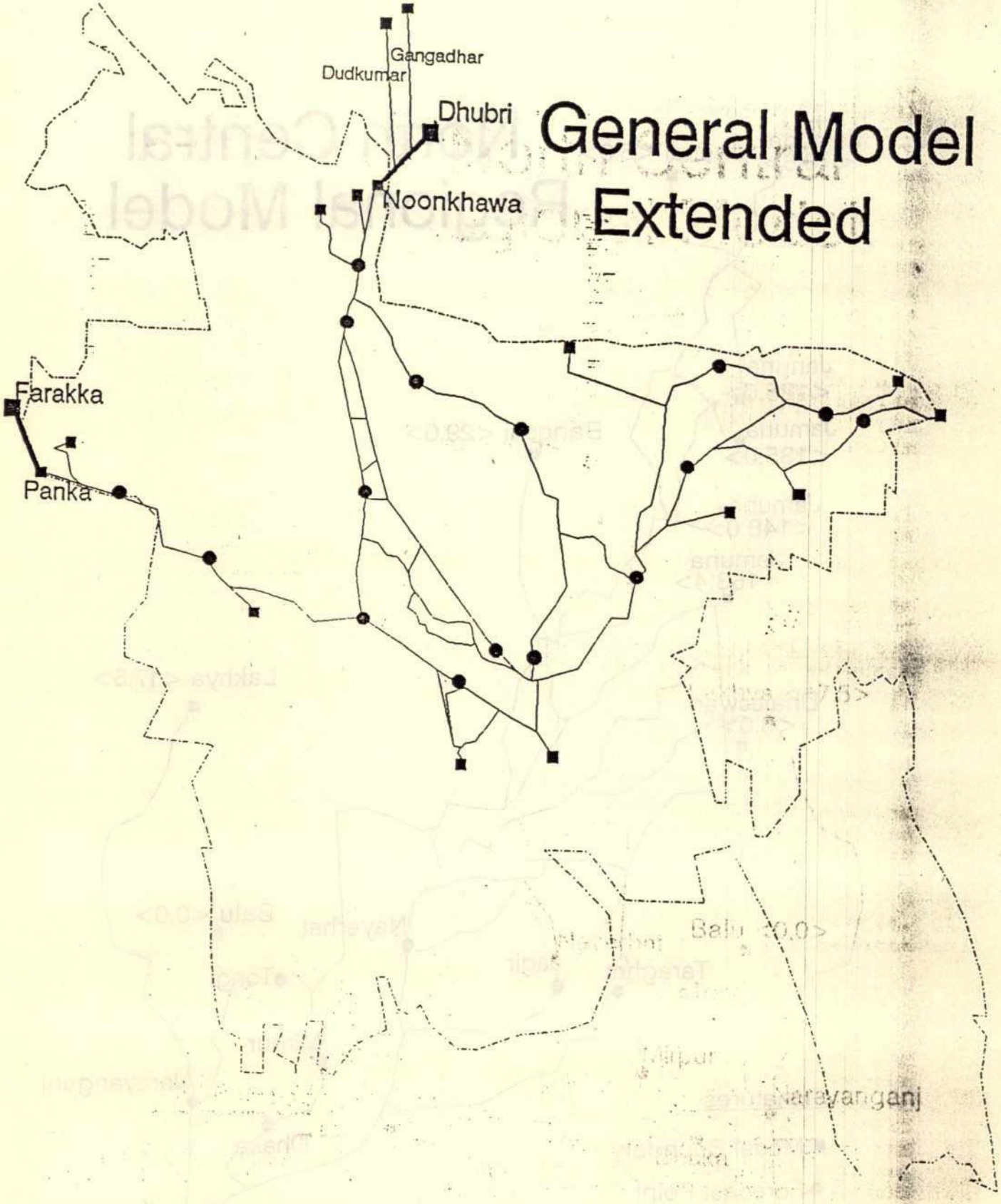

Figure 3.5 DHI Flood Forecast Model Extended for Indian Stations.

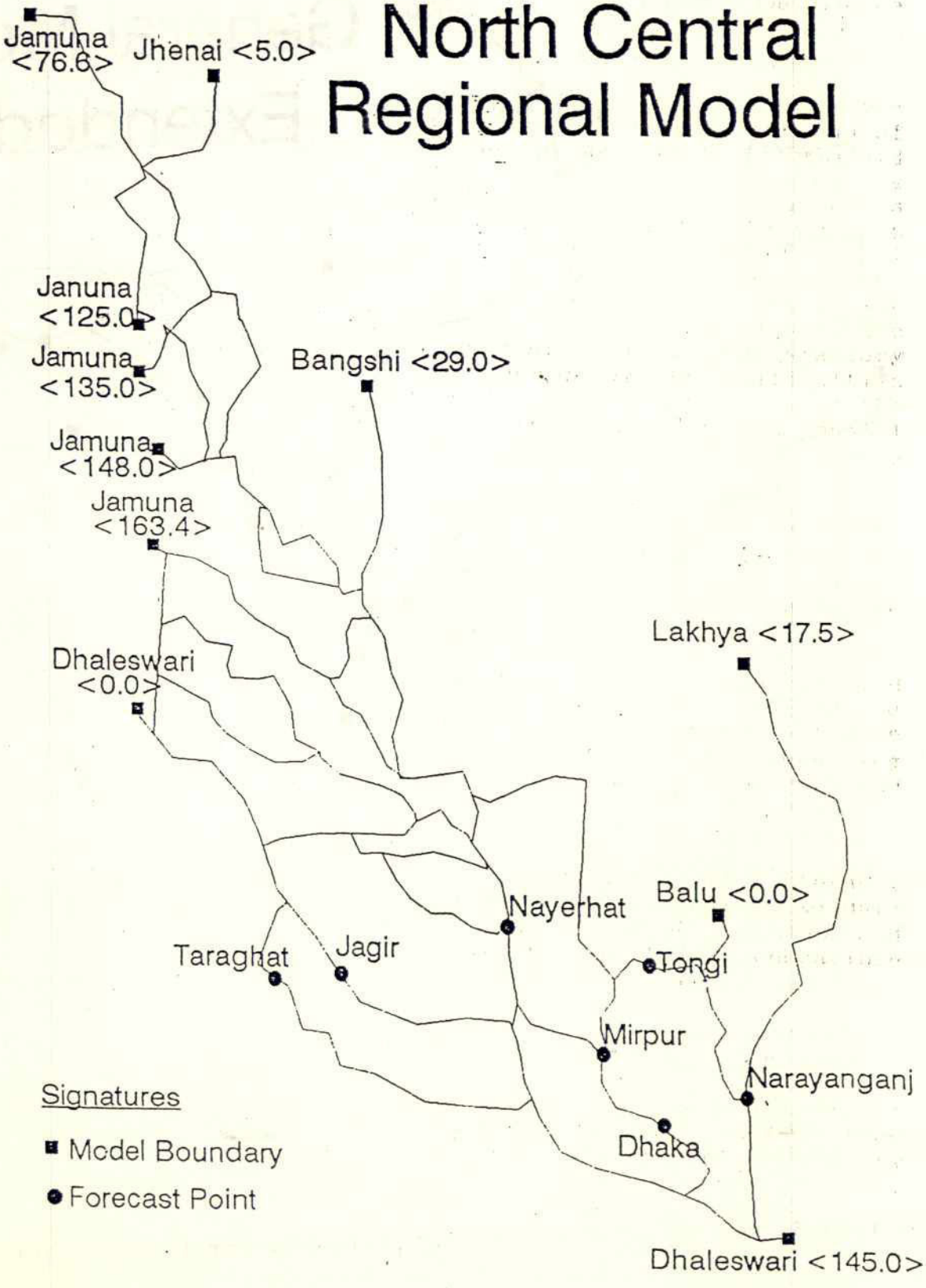

Figure 3.6 Network for Preliminary North-central Regional Model.

The hardware and software components of the new computer system had been ordered during the first phase of the project and delivered during the hiatus when no CTA was present. Although the principal aim was to replace the existing computer network which had become obsolete, there was no clear information of the rationale and plans for the new system.

The hardware/software expert had two main inputs into the programme. The first concentrated on the physical setting up of the new equipment and the replacement as far as possible of the old system hardware. At this stage the design of the new system was carried out and all additional hardware and software requirements identified. His second input concentrated on the setting up testing and commissioning of the network and ensuring that all facilities of the old system could be carried out on the new one. Installation of hardware and software was a contractual obligation of the suppliers, and their staff worked in close liaison with the project specialist. This in general was a satisfactory arrangement, though a number of unforeseen delays and difficulties did occur. During this second input DHI and the suppliers of the new database system also had inputs to ensure the successful integration of all activities to the network. A diagram of the network is given in Figure 3.7

The procurement of modems gives the capability of the network to be linked to other external computer facilities. Setting up and operation of the modem connection was successfully carried out, but this has not been permanently established due to lack of adequate telephone or other data communications facilities.

The procurement contract for the hardware and software carried warranty and support arrangements for one year. This expired during the currency of the project, so a hardware and software maintenance support contract was entered into for the remaining project duration. The continuation of this support after the end of the project is essential and BWDB must ensure the allocation of sufficient funds, Taka 219,000 per annum, for this.

Output 3.2 "Existing software for data reception, storage, control, retrieval and processing of real and non-real time data installed at present on TRS computers at the FF&WC upgraded and subsequently implemented on LAN consisting of IBM/PC compatible computers."

The software on the TRS system had been largely purpose written for the tasks required by FF&WC in the early 1980's under Project BGD/76/007. Since then, amongst all the other rapid advances in computers, there has been the development of commercial hydrological database systems. It was decided that the best long term option would be to establish such a database system on the new network, rather than upgrade the TRS software and transfer that,

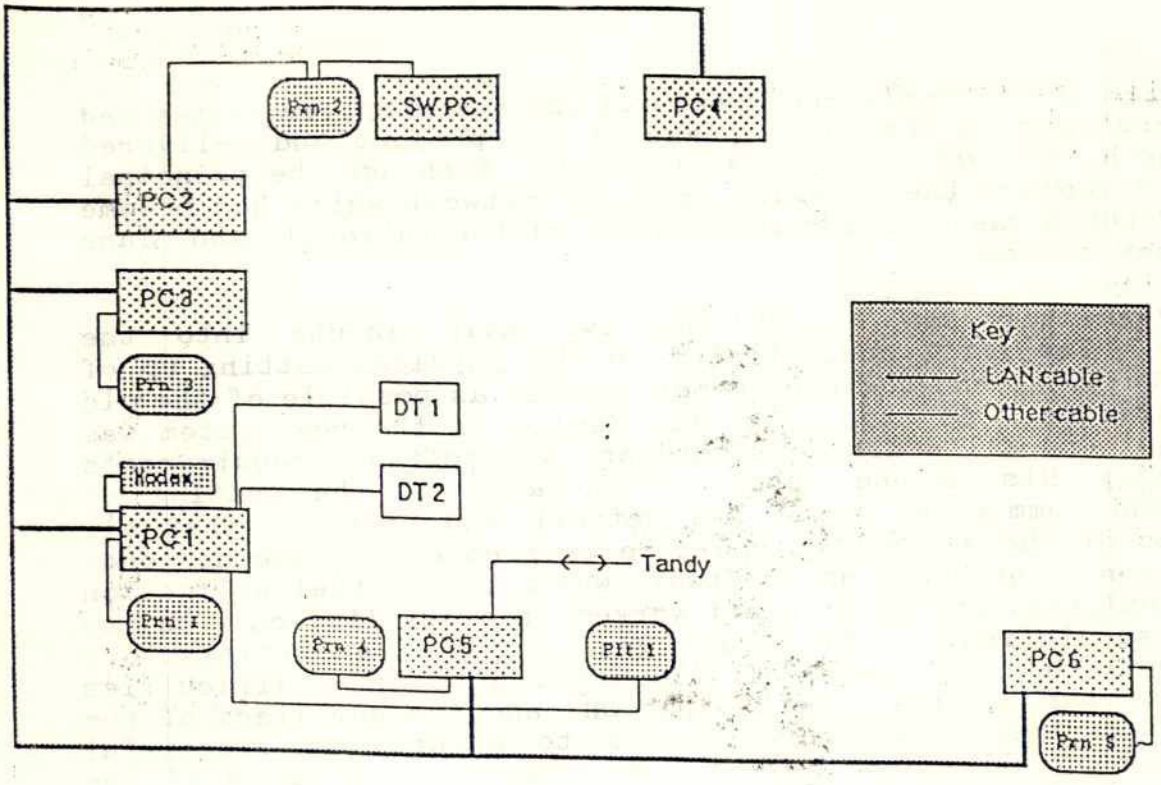

Figure 3.7 Schematic layout of computer system

The specification of the computers shown in Figure 3.7 are as follows:

Figure reference	Computer identifier	Processor	Speed	Memory	Disc
PC 1 (server)	ffwc01	386 DX + 387	33 MHz	8 Mb	650 Mb
PC 2	ffwc02	486 DX	33 MHz	9 Mb	650 Mb
PC 3	ffwc03	386 DX + 387	20 MHz	4 Mb	200 Mb
PC 4	ffwc04	386 DX + 387	25 MHz	5 Mb	200 Mb
PC 5	ffwc05	386 SX + 387	16 MHz	5 Mb	200 Mb
PC 6	ffwc06	386 SX + 387	16 MHz	4 Mb	200 Mb

with the proviso that the new system could perform all the functions already established at FF&WC. A number of database systems are available under HOMS, and from these the TIDEDA[1] system was chosen. The main reason for this choice was that this was the only system which was available in a UNIX version. As it was understood that the long term programme of DHI/SWMC was to convert all MIKE11 models to UNIX operation versions, a UNIX database would be necessary. The successful use of TIDEDA in a number of countries for national hydrometric databases and knowing that FF&WC staff were familiar with the XENIX operating system for the TRS installation also guided the choice. Tideda also uses FORTRAN programs and routines, which is again useful as FF&WC staff have most experience of this language.

The TIDEDA system was carefully tested and evaluated before the decision was made to purchase it. The system was installed in February 1992 under the direct supervision of an officer of the Hydrology Centre, Christchurch, New Zealand. Prior to the installation of the database a programme had been carried out to change the file format of the TRS database so that a direct machine to machine transfer of the database could take place. Several new programmes have now been prepared by FF&WC staff to carry out operations with the database.

This output also included activities to develop direct data links with BMD, to include the weather satellite system within the network and to establish an interface with the Pilot Telemetry System. The data link with the Storm Warning Centre (SWC) of BMD has been made by a telephone land line as part of the short term measure to replace the former microwave link. It has however not been operated, largely due to the unreliability of the telephone system. The link is primarily for receiving hydrological and meteorological data through the regional WMO Global Telecommunications System (GTS). The computer facilities for this at SWC have been upgraded, but some software developments are still required to carry out data selection and abstraction. Until these are completed and the extent of data exchange required finalised, there is little to be gained by proceeding with the link as the raw information is already being sent via teleprinter.

The connection of the weather satellite system to the network was not practical during a time when the core system for the model and database operations were being established. The operation of the system is entirely satisfactory as a stand-alone PC at the present staffing levels of FF&WC. The design for the link has however been prepared by the software/hardware specialist in collaboration with Systems West.

1). The TIDEDA database system was developed by the Hydrology Centre of the Department of Scientific and Industrial Research, New Zealand. It is available as a commercial package for which DSIR provides user support.

As the Pilot Telemetry System has not been established, there has been no possibility of carrying out any work on interfacing with the LAN. In the invitations to tender for the telemetry system, it was clearly stated that proper interfacing arrangements would be required to allow direct access of data by the model and database.

Output 3.3 "Proposal for strengthened organisational framework for and enhanced coordination within BWDB of flood forecasting and warning activities developed."

This output presupposed a move to create a Directorate of Flood Forecasting as in Output 1.4 of the first phase of the project. As this would be a high level policy decision, this has to be very much left to the Board for action. However, it is clear that the organisational structure of the flood forecasting unit requires development. Along with this, a physical reorganisation of office location would be very beneficial, and this was highlighted by the Evaluation Mission. A proposal was prepared by CTA and submitted to National Project Director and this is reproduced as Appendix 4.

Output 3.4 "Support to the design of a nationwide integrated data acquisition, transmission and dissemination system, including the infrastructure required and programme for its establishment provided."

The output mentions "support" whereas the activities include design, study and preparation of an implementation programme. As a number of different government departments with varying tasks and responsibilities act during critical flood situations, possibilities of action from within the project were limited. The problems of dissemination and public awareness was closely looked at by one consultant. A summary of the recommendations is given in Appendix 5. Some time after the start of this project the government, with UNDP support has placed the co-ordinating role for disaster preparedness with the Ministry of Relief and Rehabilitation. The planning of communications systems will be carried out by them. It has thus been recommended that the activities of FF&WC proceed only to a certain point on the chain of dissemination. A number of recommendations on the improvement of the content of forecast materials have been made and close liaison has been established with disaster preparedness activities through UNDP and component 11 of the Flood Action Plan.

Immediate Objective 4.

Output 4.1 "Overseas training of national staff in the fields of hydrological modelling and telemetry and telecommunication completed."

Plans for training of staff in modelling studies were already in hand at the start of the second phase of the project. These were finalised and a full training programme developed by CTA in liaison

with the National Project Director. The following overseas training programmes took place.

1) Four professional staff of Assistant Engineer and Assistant Director level spent 3 months at the Danish Hydraulic Institute to receive training in hydrological and hydraulic modelling. This was followed up by individual practical projects in Bangladesh under supervision by DHI.

2) Three staff from the Construction and Instrumentation Division spent 6 weeks on attachment training with the Water Resources Survey of New Zealand. This covered field and workshop maintenance of a range of hydrometric and telemetry equipment, and introduction to the operation of a modern, electronic telemetry based monitoring network.

3) One data processing officer and one field officer from Surface Water Hydrology-2 spent 4 weeks training in Germany at the headquarters of Seba Hydrometrie. This company is on of the main suppliers of field instruments to BWDB and training was on telemetry, maintenance and operational aspects.

Two study tours were also arranged for senior BWDB and Ministerial staff. These were:_

1) To UK and Europe. In England, a programme was organised through the Institute of Hydrology which included visits to the Severn-Trent unit of the National Rivers Authority, the Meteorological Office and Middlesex Polytechnic. The main focus was familiarisation with flood monitoring and forecast systems along with flood impact assessment and preparedness planning. Visits to DHI headquarters in Denmark and WMO in Geneva were also included.

2) To USA. This was primarily co-ordinated by the National Weather Service, Office of Hydrology. It included visits to national and river basin forecast centres and the US Geological Survey headquarters. Sierra Misco and Systems West, who are equipment suppliers to FF&WC also arranged visits to their factories.

Output 4.2 "On the job training on modelling, data processing and telemetry provided."

All short term consultants carried out on the job training as part of their programme. This comprised practical and theoretical training as appropriate. The main training activities were:-

- maintenance of the land line data link between BMD and FF&WC along with radar display equipment;

- repair and maintenance of transceivers;

- operation and maintenance of the weather satellite receiver system;

- interpretation and analysis of weather satellite imagery;

- workshop and field maintenance of hydrometric equipment, including training in operation of data logger installations;

- analysis of model results and performance;

- use of meteorological information in forecast preparation;

- computer programming and software development;

- operation and management of the UNIX system;

- operation of the TIDEDA database system and data transfers for model operations;

- forecast output preparation and reporting.

4. OBJECTIVES ACHIEVED

The development objective as stated in Revision G is "to strengthen and improve the existing flood forecasting and warning system in Bangladesh so as to increase the forecasts' accuracy and timeliness in order to reduce loss of life, property damage and social and economic disruption caused by floods. It will therefore directly contribute to the implementation of the country's development plans and programmes related to flood preparedness, flood control and water management." This overall objective and all the immediate objectives of the project have been achieved to a greater or lesser degree, with the exception of those relating to the radar. The constituent outputs have been discussed in detail in the preceding section: the combination of these in achieving their objectives are reviewed below.

Immediate Objective 1 of First Phase.

This objective was not achieved. In attempting to restore the radar to meet its intended function it was found that the requirements would be far beyond the scope of the project in terms of manpower and financial allocation. It appeared also that the role and the facilities of the radar had been improperly understood to the extent that even if the radar was functioning properly, it could not have produced the required detail of information. In the second phase of the project, a thorough review of the situation was carried out which allowed the problems to be fully understood. A range of recommendations were forthcoming, which although not possible to be acted upon immediately, have provided the basis for future plans for the development and use of radar in flood forecasting.

Immediate Objective 2 of First Phase.

The extension of the project to a second phase somewhat altered the nature of this objective. The "main project phase" in the original context meant the long term project which would be component 10 of the Flood Action Plan. The extension of the project into a second phase of one year meant that some of the long term plans could be taken up and these appeared in the Revision G programme. This objective was carried forward to the project extension and was carried out as it is still the intention of the government to continue the development of flood forecasting activities as part of the Flood Action Plan.

Immediate Objective 1 of Second Phase.

This was certainly achieved through the expansion of the transceiver (wireless) network and improvements to the hydrometric network. The establishment of the weather satellite system and the restoration of the radar data link, albeit as a qualitative

indicator of rainfall conditions, allowed a more comprehensive assessment of conditions to be made.

Immediate Objective 2 of Second Phase

This was achieved through the development of the real time flood forecasting model, MIKE11-FF. The model network contains 16 forecast points on the main rivers, i.e. Ganges, Brahmaputra, the Meghna system and around Dhaka. Forecasts were produced daily throughout the monsoon seasons of 1991 and 1992 and were for 24, 48 and 72 hours ahead. The results for the Ganges and Brahmaputra systems, including Dhaka for 1991 were very satisfactory. For the 24 hour forecasts, almost 70% were within an average deviation of 5cm or less and 90% were within 10cm. At 48 hours and 72 hours ahead the forecasts were within 10cm for 68% and 48% of occasions respectively.

The daily process of forecasting takes about 3 hours. The wireless operators take about one hour to interrogate all observers and record the rainfall data for the previous 24 hours and the water level, which is taken at 3 hourly intervals during daylight hours. This data is then entered manually to the model and the database. If available, water level and rainfall data from India are taken into consideration when setting up the model run, along with forecast indications of rainfall conditions. The model outputs are carefully examined by the forecaster in charge before they are published. A flow chart of the forecast operations is shown in Figure 4.1.

The daily output of the FF&WC consists of a bulletin giving statistical details of rainfall and river level from all the observation stations and a situation report for the country, the latter including the forecasts for the key stations produced by the model. Examples are given in Appendix 6. This information is printed at FF&WC and distributed by messenger within Dhaka to a wide range of government departments, press and media. For regional offices distribution is by post, but in periods of critical conditions, the information is broadcast through the FF&WC transceiver network.

Immediate Objective 3 of Second Phase

The project has improved the internal co-ordination of the flood forecasting operations and the training has strengthened the capacities of staff. However, the organisational changes envisaged in the project document have not taken place and it must be noted that the project could have little or no influence in these being implemented.

The existence of the project has greatly helped co-ordination with other projects and activities which are aimed at improving preparedness and protection against flooding. There has been

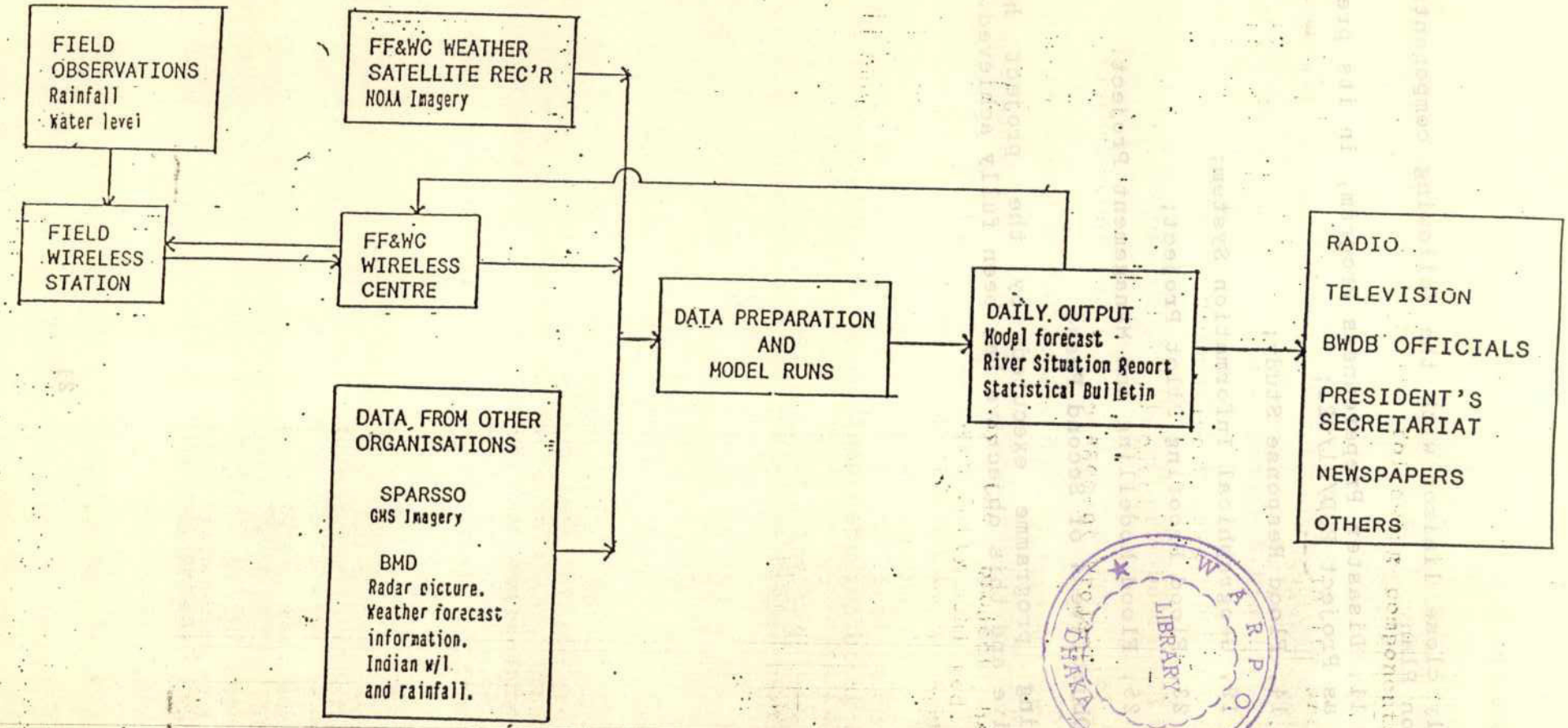

Figure 4.1 Flow Chart of Daily Forecast Operations at FF&WC.

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particularly close liaison with the following components of the Flood Action Plan.

- FAP 11, Disaster Preparedness Program, in its preliminary stage as Project BGD/91/021;
- FAP 14, Flood Response Study;
- FAP 19, Geographical Information System;
- FAP 23, Flood Proofing Pilot Project;
- FAP 25, Flood Modelling and Management Project.

Immediate Objective 4 of Second Phase

The training programme executed by the project has been comprehensive and this objective has been fully achieved.

5. FINDINGS AND LESSONS LEARNT

5. 1 Introduction

The findings are given from the total experience of the project and do not relate solely to the elements of the project document. An attempt has been made to include all influencing factors, internal and external to the project. It must be concluded that the overall aim of strengthening the project has been achieved. There were however a number of areas where the actual implementation diverged from what was foreseen when the project documents were drawn up.

5.2 Project Formulation

Some assumptions made at the time of project formulation, either initially or for the preparation of Revision G, did not prove valid as the project developed. The assumed requirements for the radar system rehabilitation and the linkages with the Pilot Telemetry System were the major items which varied from what was proposed and what was achieved. Details of the work carried out with the radar are described under the appropriate output in Chapter 3. A more detailed appraisal before or even during the first phase of the project would have resulted in appropriate decision being taken on the future of the radar. Even though the problems with the system were eventually identified by the project, the requirements for rectifying these were far beyond the scope available, particularly in the short time frames accorded to the project originally and at the outset of the second phase. The problems with the radar go back much further than the time of project formulation and arise from basic misconceptions, misunderstandings and lack of sustainability of the system.

The assumption that the Pilot Telemetry System would be at least started, if not completed within the time frame of the project was perfectly valid at the time of project formulation. The various delays in implementation could not have been foreseen, but even with a prompt start to system design and placement of a contractor, it is difficult to see how the project allocation for training and other related outputs could have been fully implemented during the original one year programme of Revision G.

Other points of project formulation which could not be fully met by the project were in areas where liaison with other project developments were assumed. These were certainly essential to establish a working framework for the project, but were perhaps too specific. In particular the objectives to change the status of FF&WC, the taking of a leading role in the establishment of a national database and the coordination with components of the Flood Action Plan assumed a greater level of influence than the project actually could exert.

Lessons to be Learned. Considerable care needs to be taken in drawing up a project plan where so many interactions outside the immediate counterpart agency are required. Planning for a development project must aim at improving existing systems, but it cannot entirely ignore the existing constraints.

5.3 Staffing and Procurement

In this project these two have been very closely linked, especially as concerns the establishment of the new computer system and the upgrading of instrumentation. At the start of the second phase, one of the immediate tasks was the preparation of the staffing plan. The one year programme proposed is illustrated in Figure 5.1, and may be compared with the actual programme implemented as in Figure 2.1. Some of the specialists had been selected and cleared by the government previously, but others had not yet been identified. Because of the delay in commencing the second phase of the project, some of the specialists had other commitments which influenced the timing of their availability. A further complication to timing of specialist inputs is brought about by the influence of the monsoon on project activities. For instance, installation of field equipment and construction is best carried out during the dry season, whereas operational testing must be done during the monsoon to ensure proper functioning under severe operational conditions.

For the selection of specialists, the project has to rely to some extent on the support of headquarters to provide information from their register of consultants and their knowledge of availability and past performance. There were some delays in identifying specialists for remote sensing, the radar evaluation and public awareness. In addition, there was some criticism from the government that they were not presented with alternatives to the nominations in order that they could judge suitability. Although all the proposed staffing inputs were completed, this was only possible within the time frame of the extended project i.e to 31 May 1992. The special problems relating to the inputs of the Software /Hardware Specialist and the Hydrological Instruments Specialist will be discussed in more detail below. Other specialist inputs were affected as follows:-

- the input of the Remote Sensing Specialist was shorter than would have been ideal, largely due to his other commitments;

- the radar evaluation took place outside the monsoon season, so operation could not be tested under the full range of conditions;

In general it was found that the procurement process took much longer than anticipated. A number of steps are involved:-

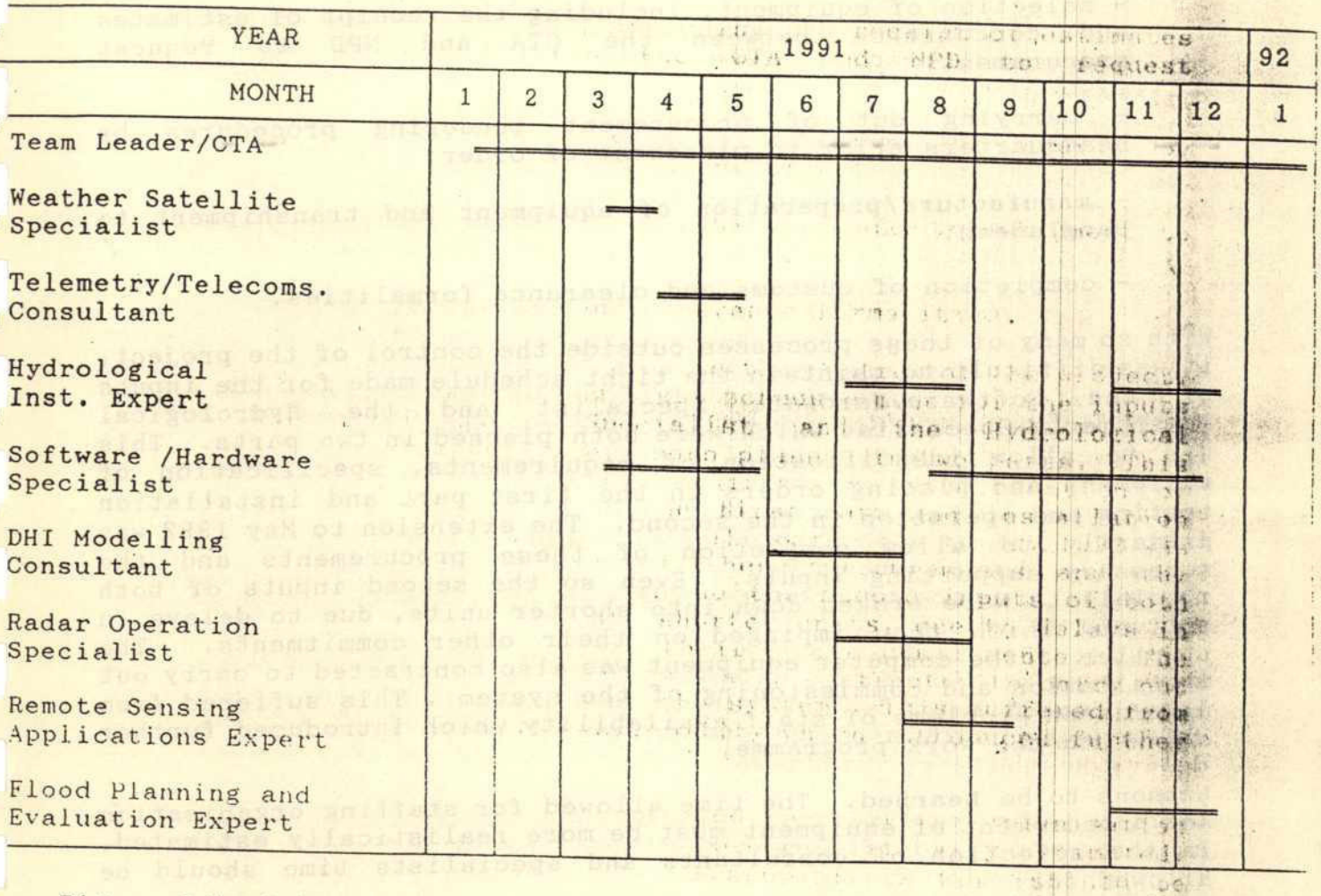

Figure 5.1 Originally Proposed Staffing Programme at Start of Revision G

- selection of equipment, including the receipt of estimates and concurrence between the CTA and NPD to request procurement;

- carrying out of procurement tendering procedures by headquarters prior to placement of order;

- manufacture/preparation of equipment and transhipment to Bangladesh;

- completion of customs and clearance formalities.

With so many of these processes outside the control of the project, it was difficult to maintain the tight schedule made for the inputs of the Software/Hardware Specialist and the Hydrological Instruments Specialist which were both planned in two parts. This was to allow identification of requirements, specification of equipment and placing orders in the first part and installation testing and operation in the second. The extension to May 1992 was primarily to allow completion of these procurements and the necessary supporting inputs. Even so the second inputs of both specialists were broken down into shorter units, due to delays in delivery which then impinged on their other commitments. The supplier of the computer equipment was also contracted to carry out installation and commissioning of the system.. This suffered from unforeseen problems of staff availability which introduced further delays to the work programme.

Lessons to be Learned. The time allowed for staffing organisation and procurement of equipment must be more realistically estimated. In the selection of consultants and specialists time should be allowed for:

- drawing up a short list of specialists and contacting them to ascertain availability;

- submission of candidates to government for approval, which may not be automatic;

In the case of procurement, there is a risk of duplication of effort by the field project and headquarters, and close liaison must be made to avoid this. Quite often the field office has to approach suppliers for cost estimates before deciding on the best option to request for procurement. Headquarters then has to repeat the procedure to fulfil procurement regulations. Until orders are confirmed, along with delivery times, which can take several months to Bangladesh, the firm planning of follow-up inputs cannot be made.

5.4 Project Management and Co-ordination

The project had to be managed at a number of different levels, which were at times not always directly compatible. The management requirements from WMO and UNDP were straightforward, and little difficulty occurred, apart from occasional communication problems. It must also be noted that the maintenance of accurate project expenditure records was difficult with the majority of purchases being made through headquarters. In the overall objective of the project the co-ordination between the main counterpart agency, BWDB and the local UNDP organisation there was little divergence. The main problem areas were brought about by some of the internal organisation of BWDB and in co-ordination with BMD which comes under a entirely separate government department.

The efficient running of flood forecasting activities is certainly hampered by staff being dispersed in four separate locations. Many technical matters and most policy matters have to be referred to the Director, Surface Water Hydrology-2 and/or the Chief Engineer, Hydrology. With these two officers in separate buildings some kilometers apart and the FF&WC being in a third location, special efforts have to be made to arrange meetings. Telephone communication between offices are frequently disrupted so this is not an effective alternative. The FF&WC relies on the services of the Construction and Instrumentation Division of SWH-2 for routine maintenance of field and base equipment. C&I staff are located at the Hydrology Complex and with their transport very restricted, it is difficult to maintain the necessary physical contact. The fact that administrative matters for C&I division have to be referred to yet another location only adds to the complications. The C&I division lacks adequate transport facilities to be mobile both within Dhaka and with the various field centres. The consequence of this is that service and repair of instruments is slow or neglected.

The presence of this project has acted as a powerful catalyst to reduce these problems, partly through the CTA having to maintain the momentum of the project activities and partly through being able to provide transport and funds for rapid action when required. It is hard to see how these matters will be dealt with after the end of the project with the lack of funds and the necessity to follow more extensive bureaucratic channels. The situation would be considerably helped by relocating the FF&WC to the Hydrology Complex at Green Road.

The liaison with the Meteorological Department is not as good as it should be. A link at some point between a meteorological service and a water undertaking is a common feature to most flood warning services throughout the world. The flood forecasting operation must be given adequate and relevant information to give as much lead time to warnings as possible. The liaison between FF&WC and BMD is a victim of the highly compartmentalised and bureaucratic

attitude prevalent within the government service of Bangladesh as a whole. This results in much inflexibility over provision of information. Thus only the most generalised forecast information is made available as routine. The presence of the project has helped to develop liaison a little: the direct involvement has been to provide some equipment, repair and maintenance facilities and a consultancy input to review the radar situation.

The internal management of FF&WC is generally good and has assimilated the many new facilities developed under the project with varying degrees of completeness. The presence of a project with a limited time-frame and definite goals has no doubt helped in providing a focus for the work, other than the routine obligation of providing a forecast in a particular format each day. How much this is sustainable remains in question however. The availability of competent staff within the unit is just adequate, but as a number of facilities have to be maintained, breakdowns and an emergency situation could place the organisation under some pressure. Particular problems are anticipated with the maintenance of the computer system through which the model forecasts are prepared and database maintained. The smooth operation of the UNIX network system requires good hardware and software maintenance. This is available through local service contracts, but these are expensive at Taka 219,000 (approximately US$ 5,650) per annum, and could be difficult for the government department to assign the additional funds. The problem of funds for future servicing also applies to the weather satellite receiver system and to the radar and the maintenance of field equipment. The combination of this with the logistic problems mentioned previously is likely to make sustainability difficult.

Lessons to be Learned. The object of any technical assistance project is to provide support to develop systems and facilities in the recipient country which would otherwise be difficult under existing circumstances. The improvements and developments brought about should however be sustainable beyond the life of the project. What appears feasible at the planning and formulation stages may not be borne out as the implementation of the project takes place. Where inter-departmental lines of communication are required for the project programme, the extent of their capacities and flexibility should be carefully considered.

5.5 Project Technical Performance

The project has improved some of the existing facilities and capabilities of FF&WC and has introduced a number of new ones. The coverage of observations and forecasts has increased during the project and the general model is producing consistent and accurate results. The use of ancillary information, such as from weather satellites has become an integral part of the forecast routine and has helped build up the overall understanding of the situation. The training and study tours have proved beneficial in improving

staff skills and developing concepts of the role of flood forecasting and warning. Where the project has failed to meet objectives, the causes have mostly been outside the immediate control of the project. In the case of the radar this was due to problems in the past and insufficient knowledge at project formulation. In other cases the timing and inter-dependence of other activities did not allow the objectives to be fully achieved.

It has to be noted that in some areas, the technical advancement achieved has been less than the potential. This has resulted partly from the inevitable inertia encountered when an established unit is introduced to new ideas and requirements. The FF&WC fulfills an almost statutory function in having to produce a certain amount of information at a certain time for specific recipients, and completing this becomes an end in itself. Unless there is pressure from the outside, then there appears little need to alter what is established and apparently sufficient. The model outputs and the database have considerable potential for graphical presentation, which could go some way to countering the frequent criticism that forecast outputs are hard to understand. The reluctance of BWDB to make changes to the format of the forecast outputs and to widen and diversify information distribution is probably made in anticipation of a negative response from higher authority, rather than unwillingness on the part of those directly involved.

One major technical drawback for the project is the extremely limited availability of data from India. It is clearly absurd that the flood problem in Bangladesh cannot be treated in the context of the entire basin. The exchange of information on rivers between Bangladesh, India and Nepal is a highly political issue and beyond the ability of the project to rectify.

Arrangements are in place to receive data on discharge, water level and rainfall from a number of locations in India, upstream of Bangladesh. These are given in Appendix 7. Whether or not data is transmitted is governed by two provisos.

1. The actual or forecast water level has to be at or above the warning stage at river stations. In general, the warning level is 1.0m below danger level[1].

2. The daily rainfall has to exceed 50mm.

(1). BWDB defines danger level as "...a level above which it is likely that the flood may cause damages to crops and homesteads. In a river having no embankment, danger level is about annual average flood level. In an embanked river, danger level is fixed slightly below the design flood level of the embankment. Danger level is defined for a particular measuring station for the area to its immediate vicinity." Due to the shared colonial background of India and Bangladesh, it is assumed that the same criteria are relevant in India.

The pathway of messages within India is protracted. Field stations report to local centres which then pass on the information to Calcutta, from whence they are relayed to the Storm Warning Centre, BMD, for onward transmission to FF&WC. Messages in this chain are sent by a number of means; telephone, teleprinter, wireless and telegram. Only two stations on relatively minor rivers discharging into eastern Bangladesh have recently been set up to have direct wireless contact. The complexity of this transmitting system inevitably suffers breakdowns and delays, and messages are sometimes received too late to be of use in preparing the forecast. The overall lack of consistency and regularity of data from India makes it difficult to maintain up-to-date knowledge of the general catchment conditions. Two most significant particular shortcomings are:

1. Due to political restrictions, no level or discharge data are available for the whole of the Ganges, apart from Farakka, which is only a few kilometers upstream of the Indo-Bangladesh border.

2. No rainfall data is given for the Shilong Hills and the Barak River catchment in Assam, areas of very high rainfall from which frequent flash floods affect the Sylhet basin.

During the 1991 monsoon which included some periods of persistent high river levels, it was possible to run the extended version of the FF model using data from the Brahmaputra (from Dhubri and sometimes Goalpara) and the Ganges (Farakka). The accuracy of the predictions at all time steps showed a marked improvement over those obtained with the normal model, as would be expected.

Lessons to be Learned. The established systems and practices of an organisation need to be carefully considered before extensive operational changes are undertaken. The incorporation of additional work has to be planned against an understanding of the capabilities of personnel and the organisation. Assumptions cannot be made regarding expansion of staff numbers which are controlled by establishment regulations. This project, along with many others in the same field, has encountered difficulty with the government and BWDB policy and attitude to use and exchange of data, which appear restrictive to the agency view as to what is required. Care needs to be taken to avoid these differences becoming points of conflict, and project plans need to recognise the realities of the situation.

6. RECOMMENDATIONS

6.1 General

Although the project has been able to advance the capability for flood forecasting and warning in Bangladesh, considerable developments have to take place before the system reaches a level appropriate to the importance which it should have in a country where floods play such a critical role. Efforts towards a comprehensive future programme for flood mitigation in Bangladesh are at the moment largely concentrated under the Flood Action Plan, and development of flood forecasting is a component of that programme, i.e. FAP 10. All of the following recommendations have therefore been included in a draft proposal for a project under the Flood Action Plan. However, the existence of such a project is not a prerequisite for the implementation of these recommendations.

6.2 Recommendation 1

Continued developments are required to the flood forecasting capabilities in the country. There are technical developments, requiring new instruments and more detailed analysis techniques, but these technical developments must be matched by a vigourous approach to improve public awareness, preparedness and the means of disseminating information on the broadest base possible. To integrate this development <u>further external project support is required.</u>

6.3 Recommendation 2

Flood forecasting and warning is only one part of the overall requirement for a national programme of flood mitigation, which comprises both structural and non-structural approaches. The development of the various facets of a flood policy need to be carefully co-ordinated for planning and implementation. As the Flood Action Plan is aimed at performing this integration through the Flood Plan Co-ordination Organisation, it is strongly advisable that <u>any future project should be part of the Flood Action Plan.</u>

6.4 Recommendation 3

Considerable operational and logistic difficulties were experienced by the project due to the dispersed physical organisation of flood forecasting within BWDB. This also had internal administrative difficulties for FF&WC. It was also noted that the present location was far from ideal for telecommunications, which are essential for receiving weather satellite, radar and telemetry information. Therefore, <u>it is necessary for the Flood Forecasting and Warning Centre to be relocated to more suitable premises, preferably on the same site as other hydrology functions.</u>

6.5 Recommendation 4

The new facilities introduced and developed under this project have increased the work-load of FF&WC. Although staff have received training and have assimilated considerable knowledge and ability, the full potential has not been realised. This is largely due to the limited number of staff available and the time at their disposal in having to maintain deadlines for production of forecasts. To sustain the present level of operations without external project support, further qualified staff are required. As any future project would further increase the work load and would introduce more activities with the necessary training, **the staff establishment of FF&WC must be considerably expanded.**

6.6 Recommendation 5

In addition to technical assistance and training, this project has been responsible for the introduction of a range of additional equipment to improve the capabilities of FF&WC. These principally were; vehicles, computer hardware and software, hydrological equipment and a weather satellite monitoring system. These facilities are meant to be sustainable and their continued operation should not be dependent upon the support of any future project. However, they will require maintenance, service and repair from time to time, which in some cases, particularly for specialist equipment, will require purchases or services from outside Bangladesh. The government of Bangladesh, through BWDB should make appropriate budget and administrative support to FF&WC to sustain the present level of facilities.

6.7 Recommendation 6

Although still largely a hydrological forecasting operation, the project has introduced, through training and new equipment, a much stronger meteorological component into the activities. However, it is neither feasible nor desirable that FF&WC should develop its own comprehensive meteorological observation and forecasting system. Irrespective of the role of any future project, this information must come from the specialised sources, largely the Bangladesh Meteorological Department. However, with the increased sophistication of modelling now practiced by FF&WC the meteorological inputs need to be upgraded. Liaison and physical lines of communication between BMD and FF&WC must be improved and bureaucratic formalities between the two concerned government departments kept to a minimum.

6.8 Recommendation 7

It is repeatedly pointed out that Bangladesh is situated at the mouth of three major rivers and that 90% of the catchment area of these rivers lies outside the national boundary. The problem of flooding requires to be treated in the context of a river basin.

However, the availability of hydrological and meteorological data from other countries occupying the catchments is limited in the extreme and insufficient for a proper river forecast operation. Until better, more consistent and comprehensive data is made available, there will be limitations to the development of flood forecasting. Representations must continue to be made at the appropriate political level to lessen the obstacles to making adequate data available for flood forecasting and warning purposes.

6.9 Recommendation 8

During the course of the project there have been a number of criticisms that forecast and warning outputs are difficult to understand. It is anticipated that the improvements in this field will be undertaken by a continuation to this project in conjunction with other disaster preparedness initiatives under FAP. However the situation was addressed during this project and a report produced, which included a number of proposals for improved forecast outputs. Some of these could be adopted by BWDB without outside involvement. BWDB should take positive steps to implement proposed improvements to forecast outputs which have already been suggested and to increase dialogue with users.

APPENDIX 1

International Personnel Engaged on Project

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INTERNATIONAL PERSONNEL ENGAGED ON PROJECT.

Name & Nationility	Post	Field	From	To
J Drako (Czech)	11-01	Team Leader/Hydrological Forecaster	7/89	7/90
J E Dent (UK)		Team Leader/Hydrological Forecaster	1/91	11/92
Y Tsuboi (Japan)	11-02	Telemetry	12/89	3/90
D N Caro(Ph'pine)	11-02	Telemetry/Telecommunications	6/89	9/89
			5/91	
J K Xiang (China)	11-03	Radar Operations	11/91	12/91
H X Jin (China)	"	"	"	"
G Jorgensen (Denmark)	11-04	Hydrodynamic Modelling (DHI)	7/89	9/89
			7/90	9/90
			4/91	7/91
			1/92	2/92
			5/92	
J Host-Madsen(Denmark)	11-04	"	6/91	8/91
			7/92	
			9/92	10/92
C S Green (UK)	11-05	Computer Software/Hardware Specialist	5/91	7/91
			11/91	3/92
			5/92	6/92
			9/92	10/92
R C Curry (N Z'land)	11-06	Hydrological Instrumentation	7/91	8/91
			2/92	5/92
A Singh (Canada)	11-07	Radar Engineer	6/80	7/89
K Ruggles (USA)	11-07	Weather Satellite System	3/91	
			7/91	
			3/92	
P Schimid(Sw'land)	11-07	Remote Sensing	8/91	9/91
A Kachic (USA)	11-07	Public Awareness/Forecasting	2/92	3/92
T Hill (N Z'land)	11-07	Hydrological database	2/92	3/92

APPENDIX 2

Recommendations of the Chinese Radar Experts

RECOMMENDATIONS OF THE CHINESE RADAR EXPERTS.

7. SUMMARY.

Based upon the description in detail in the above 6 sections of this report, we would like to concentrate and summarise the main problems having been revealed and the possible solutions having been recommended as follows:

7.1 Scanning Instability of System.

this is mainly caused by loose connections in interface boxes and lines seriously resulting in frequent failure of regular operation on the radar system(See section 2). this situation will become worse and worse as time elapses. Therefore, before the coming of next flood season in 1992. dealing with this problem as quickly as possible is an urgent task.

solution: The repairs might be done in three ways:

(1) by BMD engineers themselves;
(2) to call in EEC from USA;
(3) to call WCWS from China. In this case, the interface box has to be sent immediately to Wuhan for rewelding all the line connections within the box and retesting it. Two engineers would then be required to visit Dhaka to reinstall it, as well as to check and improve other instability problems so that the radar system could bi in operation regularly and normally.

7.2 Obsolete Version of WMS/ HYDRA software in Dhaka.

The software version in Dhaka was developed before 1984 in which there are many defects as described in section 3.

Solutions: Assuming that the computer PDP 11/44 will continue be used, then the best way is simply to obtain the better version of WMS/ HYDRA developed in 1986. We consider there might not be any better version available for the PDP 11/44 than that existing in Wunan radar system. This software could be copied from Wuhan for use in dhaka. but the permission must firstly be obtained from EEC.

7.3 improvement of HYDRA Products.

As we have described in detail in section 4, the means of obtaining the HYDRA products to high precision using integrated radar and raingauge system is a very difficult and complicated problem. We are sure however it is impossible to improve HYDRA products, given that the Alert System or an alternative is operational.

solutions: according to the conditions mentioned in Section 4. to organise and develop research works in Bangladesh, using domestic and international co-operation over a period of 5 years.

7.4 Development and update.

With the progress in modern technology, in order to greatly improve the capability of the Flood Forecasting and Warning Centre in Bangladesh, it is very necessary to develop and update the system existing in Dhaka at present. In section 5, based of our experiences in China we have proposed 4 ideas how to do it based on the original format of equipment available.

APPENDIX 3

List of Reports Produced by the Project

LIST OF REPORTS PRODUCED BY THE PROJECT

Initial System Checking of Hydrological Radar, A Singh, McGill Radar Observatory, Canada, July 1989.

Status Report to WMO, Geneva, J Drako, August, 1989.

Summary of Evaluation of Software Methodology for Weather Radar. Prof. G L Austin, McGill Radar Observatory, Canada, November, 1989.

Application of SWSMP Models for Real Time Flood Forecasting, DHI, October, 1989.

Visit Report: Evaluation of WSR 81 S-Band Radar and Hydra Software. K Kless, December 1989.

Application of SWSMP Models for Real Time Forecasting, during June 1990. DHI June 1990.

Application of SWSMP Models for Real Time Forecasting July-September, 1990. DHI October 1990.

Report of Consultation Mission for Telecommunication for Flood Forecasting and Warning Project. Y Tsuboi March, 1990

A Pre-Feasibility Study on the Restoration & Upgrading of the Data Communication Link between FF&WC and BMD. D N Caro, July, 1990.

Project BGD/88/013 Report on Assignment. Dr. J Drako, CTA, July, 1990.

Project BGD/88/013 Status Report. J E Dent, CTA, February, 1991.

Project BGD/88/013 Proposed Training Programme. J E Dent, CTA, March, 1991.

Project BGD/88/013 Position Paper. J E Dent, CTA, March, 1991.

Weather Satellite Receiver: Installation and Training Summary. K Ruggles, System West Inc., March, 1991.

Note on Work Plan for DHI Modelling Activities. J Refsgaard, DHI, April, 1991.

Survey for Pilot Telemetry System in Bangladesh, Inception Report. JICA, June, 1991.

Application of SWSMP Models for Real Time Flod Forecasting, May - June, 1991. DHI, July, 1991.

Hardware & Software Consultant: Mission Report 1. Dr. C S Green. July, 1991.

Project BGD/88/013. Progress Report for Tripa[illegible]te Review Meeting. J E Dent, CTA, July, 1991.

Hydrological Instruments Specialist: Mission Report 1. R C Curry, August, 1991.

BWDB/FF&WC: Use of Satellite Imagery for Precipitation Estimation: Mission Report. P. Schmid, September, 1991.

Detailed Design Study Report on Flood Forecasting and Warning Pilot Telemetry System. JICA, September, 1991.

BGD/88/013 Report for Flood Action Plan Progress Review. J E Dent, CTA, October, 1991.

Application of SWSMP Model for Real Time Flood Forecasting. DHI, October, 1991.

Hardware & Software Consultant Mission 2. Inception Report. Dr. C S Green, November, 1991.

Radar Experts - Mission Report. Jin Hong-Xian, Xiang Jing-Kui, December, 1991.

Report on Training Assignment - Hydrological Dataloggers, Telemetry and System Maintenance Training. Water Resources Survey, DSIR, New Zealand. February, 1992.

Database Access Library, Version 1.00. Dr. C S Green, February, 1992.

Computer Software and Hardware Document Library. Dr. C S Green, February, 1992.

Hardware/Software Consultant, Mission Report 2. Dr. C S Green, March 1992.

Public Awareness for Flood Preparedness. A S Kachic, March, 1992.

Mission Report for Second Mission of Operational Hydrology and Hydrometrical Instrumentation Specialist. R C Curry, May, 1992.

Hardware/Software Consultant, Mission Report 3. Dr. C S Green, June 1992.

Use of Indian Synoptic Station Reports. J E Dent, CTA, July 1992.

Proposal For Strentthened Organisational Framework For Flood Forecasting And Warning Centre. J E Dent, CTA, August, 1992.

APPENDIX 4

Proposal for Strengthened Organisational Framework for Flood Forecasting and Warning Centre

PROPOSAL FOR STRENGTHENED ORGANISATIONAL FRAMEWORK FOR FLOOD FORECASTING AND WARNING CENTRE.

1. Introduction.

This proposal is written to fulfil some of the activity requirements listed under Output 3.3 of the Project Document (Revision G). Specifically, Output 3.3 is stated as:

> "Proposal for strengthened organisational framework for and enhanced co-ordination within BWDB of flood forecasting and warning activities developed".

The related activities are:

3.3.1 Definition of responsibilities and functions of the Directorate of FF&W within the organisational structure of BWDB.

3.3.2 Preparation of proposals for the strengthening of the infrastructure (regional offices and/or sub-centres) of FF&WS.

3.3.3 Assessment of staffing needs to adequately support present and future flood forecasting and warning activities.

Activity 3.3.4, being concerned with liaison with existing or future FAP projects has not been covered by this proposal.

2. Responsibilities and Functions of Flood Forecasting and Warning Centre.

The matter of whether or not flood forecasting and warning activities should come under a separate directorate in BWDB will not be pursued in this proposal. There seems to be some doubt as to the correct definition of Directorate status as although, for example, the heads of Surface Water Hydrology 1 and 2 are given the title Director, the units do not constitute separate directorates. The creation of a directorate would be a matter of policy for the Board and is likely to be hard to justify and implement on financial and establishment grounds.

The principal function of FF&WC is to provide information on floods to the Board and to many other units within BWDB at a national and regional level. The fact that FF&WC is also expected to provide information to the national government and act indirectly as a public service need not conflict with responsibilities within BWDB. These responsibilities range from the collection of information in the field to dissemination of forecasts and other information to users. The successful meeting of these responsibilities does however depend on the activities of organisations outside the control of FF&WC, and this entails some weaknesses.

FF&WC takes its rainfall and water level information from the general hydrometric network of BWDB. The responsibilities for the maintenance and operation of this network lies with the Construction and Instrumentation (C&I) Division which is under the control of the Director Surface water Hydrology-2 . A unit of C&I division exists specifically for the work required for flood forecasting operations. This mainly concerns maintenance of field installations and instruments and the repair of transceivers. There are however practical problems with this arrangement in that the C&I staff are based at Green Road and transport and communications can be a problem if work is required at FF&WC. These logistic problems and the future requirements for maintenance staff are discussed in later sections.

A high level of support is essential for the operation of the wireless network, which is the key to the effective performance of FF&WC. The wireless operators are directly responsible to FF&WC and now that the network has reached 60, and likely to expand, adequate facili-ties for repair and provision of spares is essential.

A clear distinction must be maintained between the responsibility for issuing the forecast and the responsibilities for implementing any action that might be required. The production of the forecast and other information is a technical responsibility of FF&WC and the levels of staff required to perform this function efficiently is discussed in a later section. FF&WC does however rely on some external sources for information, in particular the Bangladesh Meteorological Department (BMD). As the BMD serves both national and regional weather service functions, it would not be appropriate for FF&WC to develop these. However, the provision of information through BMD must have a high level of reliability. Some flexibility is also required and close liaison at operational level must be maintained, for which bureaucratic involvement should be minimised.

The distribution of forecast outputs do face logistic constraints on occasions. There is potential here for use of facsimile, but this would require better reliability of the telecommunications system before it could replace present messenger or postal distribution. The FF&WC could increase the effectiveness of the information produced by developing contacts with users. Use outside the established official circles should be encouraged, and potential exists here for revenue earning. Thus FF&WC will develop a responsibility for awareness and public education and information.

3. Strengthening of Infrastructure.

The main area where the infrastructure of FF&WC requires strengthening is in logistic support. It is clear over the time of

this project that FF&WC activities have receive considerable support from project funding and vehicle availability. It is important that this is sustainable. Vehicles will stay with FF&WC after the close of the project, but adequate provision must be made for maintenance, provision of fuel, etc. The computer hardware and software facilities established by the project will require continued maintenance and service software Adequate funds should be provided to meet this, either as needs arise or through a service contract. The present annual maintenance contract with the suppliers is Tk 2,66,600/-

The most severe constraint on improved functioning of FF&WC at the moment is caused by the central activities having to be carried out in at least 3 localities. Moving around Dhaka can be very time consuming and much staff time is wasted when meetings have to be attended or equipment repaired. It is understood that the reason for keeping the FF&WC at the WAPDA Building is in order to be close at hand for Board Members during time of emergency. It has to be pointed out that emergencies of sufficient magnitude to require the Board's active involvement occur perhaps every 4 or 5 years, and that for only a few days in the whole of the monsoon season. At all other times, the closeness of FF&WC to the Board is irrelevant. A move to the Hydrology Compound at Green Road is essential.

Administrative and management functions between the officer-in-charge if FF&WC and Director, SWH-2 would be facilitated. Liaison over field programmes and maintenance of FF&WC equipment by C&I division staff would be much better implemented. At present much time is lost when C&I work is required at FF&WC in that staff have to come from Green Road, transport may not be available and workshop facilities are not on-hand. Even with the additional flexibility during the project given by additional vehicles and funds for purchase of spares and consumable items, this co-ordination has not been easy to maintain. The need to have rapid communication with the Board could be met by installing a facsimile for the Board and retaining a wireless room at WAPDA Building which could be manned at times of emergency.

Apart from the wireless operators, there are no regionally based staff, which is certainly a weakness. Although the BWDB hydrometric network is used and there exists a well defined structure under Surface Water Hydrology of Measurement Divisions, Sub Divisions and Hydrological Sections, there are constraints in manpower and facilities which could sometimes hinder the rapid response required by FF&WC. The most important function of regional or Sub-centre staff would be to check and maintain instruments, report faults promptly and have close liaison through the centre to C&I division. It is most important that lines of communication are clearly established. If equipment cannot be repaired in the field, arrangements should be made for its transport to Dhaka. and request made for sending of a replacement

instrument. Once repaired the return operation should be promptly carried out. It would appear un-necessary to appoint separate staff member and thus increase the establishment of FF&WC. However an officer at a suitable grade of authority should be designated to take responsibility for FF&WC functions.

4. Staffing for Present and Future Needs.

The present levels are more or less adequate, but it should be noted that during the time of this project, no serious emergency has been encountered. The presence of project staff and the availability of project funds have also assisted in providing responses to problems as the arose. With the advances in techniques applied to the operations of FF&WC, some officers have developed considerably high levels of skills in comparison with others. There is a danger that these particularly competent officers could be overburdened with duties. The main tasks in preparing the daily forecast are:

- reception of field information by wireless operators;
- entry of data;
- set-up and running of models;
- finalisation of forecast;
- production of bulletin and situation reports.

As staff are required to work over a fourteen hour period during the main part of the monsoon season, rostering is required, with the result that some staff will not be present for the main morning forecast duties. Thus two teams are required to meet the requirements to prepare the forecast. This should comprise:

- 2 wireless operators
- 1 data recording/entry staff;
- 2 engineers to carry out model operations;
- 1 statistical preparation staff;
- 1 duty forecaster in charge of operation.

As there are other full time tasks of data base management, preparation of information for other reports, analysis, administration, operation management, etc., the duplication of the above team, with the addition of an officer in overall charge and supporting clerical and technical staff is required The staff requirement at present is given below and a suggested structure shown in Figure 1.

1. Officer in charge of section. Supervision of functions, management, maintenance of forecast quality.

2. Senior officers (3). Two to be senior (duty) forecaster, one to be database/computer system manager.

3. Forecast Officers (4). To constitute two 2-man teams for model operations for forecast production.

4. Forecast Assistants(3). To prepare data and perform data entry tasks. During the period of forecasting, two will be on duty and one off for evening observation duties.

5. Wireless Operators (5). Two teams of two, with one on reserve in case of emergency or absence.

6. Draughtsman (1).

7. Clerks for printing, distribution of forecast bulletin (2).

8. Office clerical/administration assistants (4).

9. Caretaker/cleaner (2).

10. Driver (1).

The total staff proposed is 25, which is close to the current strength of FF&WC of 24. The staffing support requirement from C&I Division is adequate with the present group of 6 staff.

The main developments envisaged over the next few years are the introduction of telemetry, the expansion of the use of radar and the introduction of regional and/or local forecast models. Although all these will be integrated with the existing model and database system with a high degree of automation, additional staff will be required for maintenance support, management and evaluation of information. The principal requirements will be for staff in electronics maintenance, computer system operations, hydraulic modelling and hydrological forecasting/analysis. The planned level of development under FAP 10 by the end of 1995 will include:

- a hydrological radar network of 3 radar installations, up to 15 telemetering raingauges and base station hardware and software;

- hydrometric telemetry network of at least 20 stations, along with a base station system;

- up to 20 more wireless stations for local observation;

- two or three regional flood forecasting models and a depth/area flooding model of critical areas.

These facilities will require:

- A permanent team of electronics technicians under the control of an electronics engineer;

- One computer hardware and one software engineer to work under the system manager;

- 3 or 4 junior engineers working on model development and operation. At some stage it will be necessary to re-organise the modelling personnel as a unit under a Chief Modeler;

- At least 2 hydrologists to strengthen support to duty forecasters and to develop the data base applications;

- One hydrologist responsible for research and to improve forecast outputs, reporting, dissemination and public awareness. This officer would also be a suitable focus for liaison functions with other FAP studies.

The possible future structure is illustrated in Figure 2.

5. Summary of Recommendations.

The recommendations listed below are in approximate priority order with regard to importance and timing.

1. The Flood Forecasting and Warning Division should be re-located to the Hydrology Complex at Green Road, to be in close physical contact with the other hydrological functions of BWDB.

2. Following conclusion of this project, BWDB must ensure that the operational budget for FF&WC is adequate to sustain facilities. In particular this relate to operation and maintenance of vehicles and continued service support for the computer system.

3. Liaison with BMD must be developed at an operational level, day to day information requirements being available on a request basis, with minimal bureaucratic procedure.

4. The present professional and operational staff strength should be established at 16.

5. One officer at each Hydrology Sub-division should be designated as the co-ordinator for flood forecasting activities, particularly instrument maintenance.

6. If future proposed developments in radar and telemetry take place, a maintenance team under an electronics engineer must be set up within FF&WC.

7. For planned operational developments over the next 3 years, a further 8 professional staff should be added to the existing FF&WC establishment.

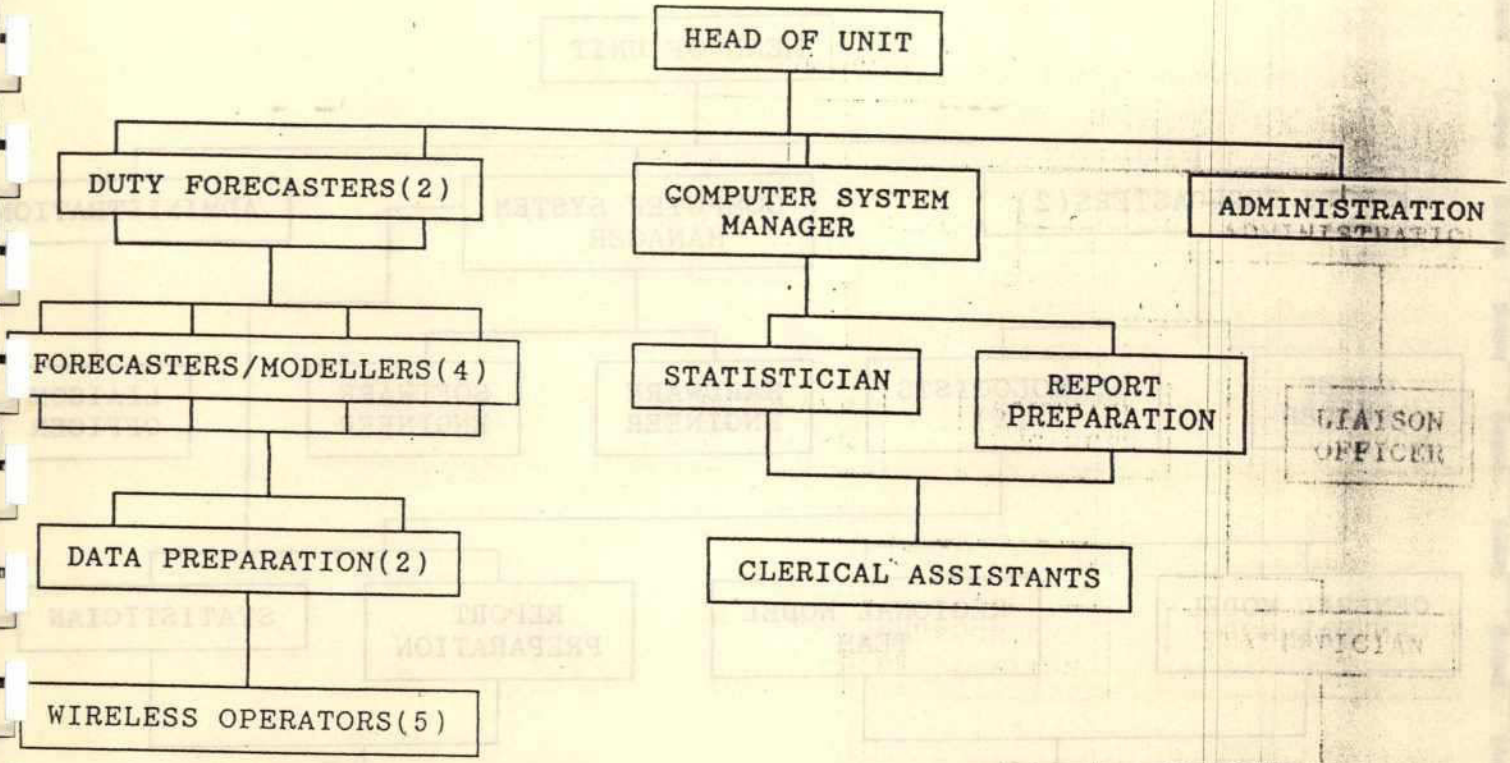

FIGURE 1. PROPOSED PRESENT ORGANISATION/STAFFING STRUCTURE FOR FLOOD FORECASTING AND WARNING DIVISION

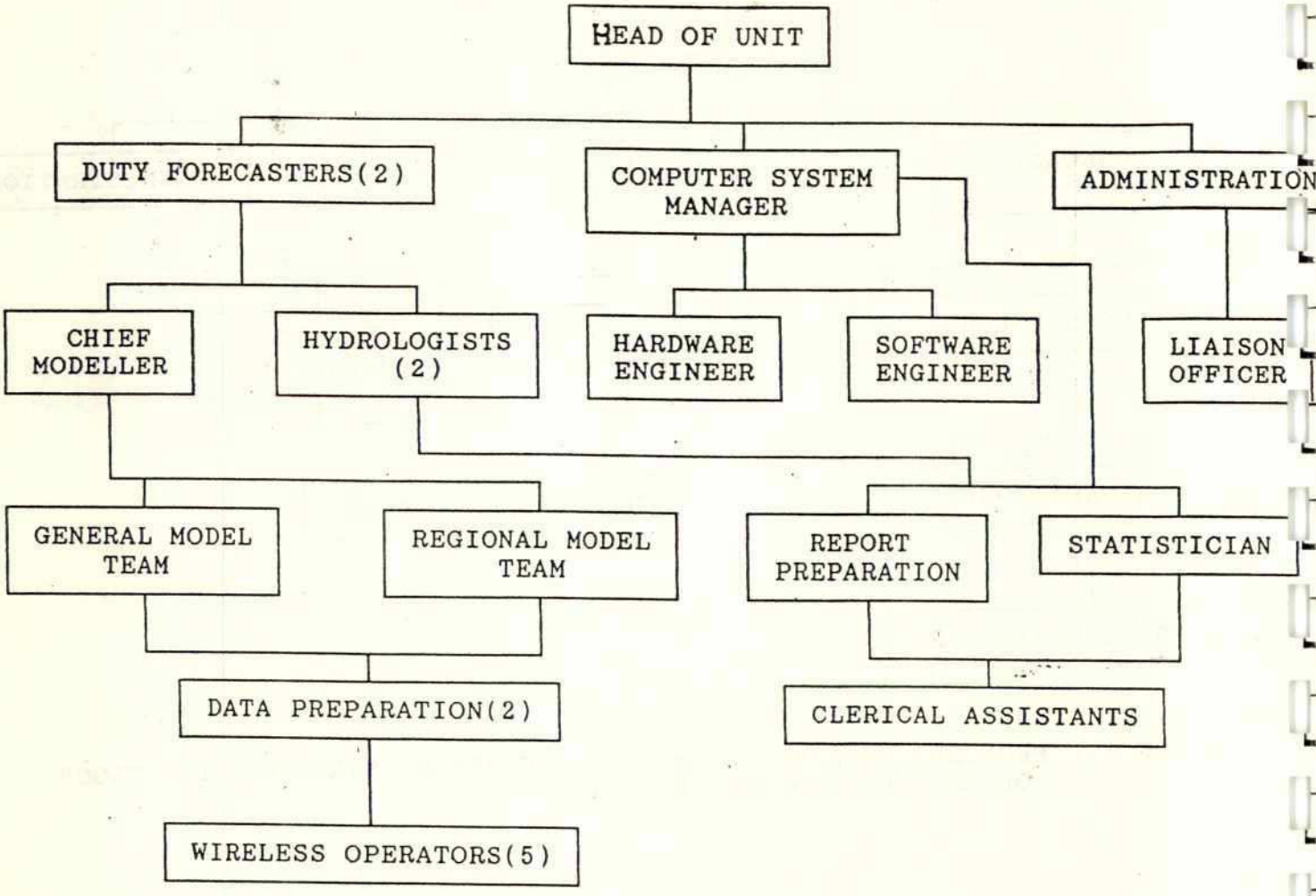

FIGURE 2. PROPOSED FUTURE ORGANISATION/STAFFING STRUCTURE FOR FLOOD FORECASTING AND WARNING DIVISION

APPENDIX 5

Recommendations for Improvement of Public Awareness for Flood Preparedness

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PROJECT BGD/88/013
IMPROVEMENT OF FLOOD FORECASTING AND WARNING
PUBLIC AWARENESS FOR FLOOD PREPAREDNESS

1.0 Abstract:

The purpose of this report is to review the use of flood warnings issued by the Flood Forecast & Warning Center (FF & WC) and recommend ways that the presentation and dissemination may be improved.

As a result of the extensive flood of 1988 and the devastating cyclone of 1991, a number of components of the Bangladesh Flood Action Plan that are concerned with non structural approaches reviewed the Government's and Public's response to floods. Two common findings of these studies are:

1. There is a perceived shortfall in information reaching the public, and in particular, rural communities.

2. A need for more flood and river information at the basic district administrative level.

After reviewing the types of flooding Bangladesh is subjected to, its institutional structure, the existing dissemination process and paths, the operations of the FF & WC and interviewing government officials, businesses, non government organizations and the public at large, the findings confirmed the original studies and provided additional insight into the flood warning dilemma.

The river forecast model and the technical operations of the FF & WC are providing accurate and timely warnings and forecasts, despite restricted data availability from outside the country.

The present organizational structure, as outlined in the "Emergency Standing Orders For Flood" (ESO), dated 1984, is designed to be more reactive than proactive, especially at the upper echelons of government.

The major obstacle to completing a well rounded and efficient warning operations in Bangladesh is the ill defined dissemination process at the national level.

However, the existing organizational arrangements, as described in the EOC appears cable of achieving its flood warning mission.

A number of recommendations have been developed that include proposals for assigning to the Ministry of Relief & Rehabilitation the same responsibilities for flood that they have for cyclones, easier broadcast of warnings, revision and titling of the present Flood and Daily Bulletin, Flood/Flash Flood Watch and Warning program, training for the need-to-know ministries and government down to the village level and for the public - Flood Safety rules and films and video tapes

2.0 Conclusions and Recommendations:

2.1 Forecast Operations and Process:

The river forecast model and the technical forecast operations of the Flood Forecast & Warning Center (FF & WC) are providing accurate and timely flood forecasts and warnings, in spite of restricted data availability from outside the country. The warning lead times could be extended with additional and more timely data.

More intensive employment of RADAR would be useful in monitoring local situations as they develop.

The FF & WC provides flood forecasts and warnings for 16 locations although it receives river data from about 50 sites.

Parts of Bangladesh are subject to flash flooding. Heavy rains in the Eastern Hill Basins as well as a number of Northern Districts cause rivers and streams to rise rapidly to damaging levels. The FF & WC has no effective program for this type of flooding.

a. The World Meteorological Organization (WMO) should investigate the feasibility of a international data exchange test project similar to the one promoted by UN Region IV between Canada and the United States. All countries in the Brahmaputra and Ganges drainage would be participants.

b. The FF & WC should test the feasibility of a meteorologist working with the river forecast center to provide rainfall forecasts and RADAR interpretations for flood and flash flood forecasts and warnings.

c. The number of flood forecast and warning points should be increased to provide expanded service coverage.

d. The FF & WC should consider the development of a Flood/Flash Flood Watch and Warning program. The program would include the preparation of a Flood Guidance for 6, 12 and 18 hour periods for use by the FF &WC and Bangladesh Meteorological Department (BMD) for issuing Flood Watches and Warnings.

2.2 Dissemination:

The present organizational structure, as outlined in the "Emergency Standing Orders For Flood" (ESO) is designed to be more reactive than proactive - especially at the upper echelons of government. Reactive is preparing for and responding to the flood after it begins i.e. rescue, shelters, food distribution, etc.

The major obstacle to completing a well rounded and efficient warning operation in Bangladesh is the ill defined dissemination process at the national level. There appears to be no single Ministry assigned the responsibility to supervise and monitor the distribution of the flood forecasts and warnings through the system after they have been issued by FF & WC.

The existing organizational arrangement, as designated and described in the ESO, appears to be capable of achieving its flood warning and dissemination mission.

The publication "Emergency Standing Orders For Flood" was published in 1984 and requires updating. All Ministries, Divisions, Districts, Upazilas, Unions and other need-to-know groups and persons should all have the latest version of the ESO.

a. The Ministry of Relief and Rehabilitation should be assigned the responsibility and authority to immediately transmit the FLOOD WARNING BULLETIN down the line. This Ministry has these responsibilities assigned to them for cyclones events.

b. Radio and TV should be given the standing authority to broadcast Flood Warning Bulletins immediately.

c. The existing organizational structure should be strengthened and motivated by additional training and instructions. Each tier of government should know and understand its assignment and be given the authority to accomplish its mission.

d. The ESO should be updated and reissued.

2.3 Flood Bulletin:

The present flood bulletin does not provide 1) information most users indicated they needed; 2) specific identification or title on the issuance; 3) distinction between flood warning and daily river forecasts and 4) is not concise for radio dissemination or for public radio or TV transmission.

The label "DANGER LEVEL", as defined in the present daily bulletin, is the river level above which it is likely that the flood may cause damages to crop and homesteads. Flooding at this level does not normally constitute a life threatening situation. At the same time, the cyclone warning program uses labels such as Danger Signal No. V, Danger Signal No. VI, Great Danger Signal No. VIII, etc. The use of the word "danger" could cause confusion and misunderstanding.

a. The FF & WC should provide specific water level forecasts out to 48 or 72 hours. Included would be the forecast time of the location reaching Flood Level (Danger Level), the crest forecast and time (when possible) and the time the river is expected to go below the Flood Level (Danger Level).

b. The present flood warning bulletin needs to be assigned two different headers or titles to identify the products and to reflect the urgency of the information. The titles recommended are FLOOD WARNING BULLETIN and FLOOD AND RIVER FORECAST STATEMENT. The FLOOD WARNING BULLETIN would be used when rivers are forecasted to reach or exceed Flood Levels (Danger Level) and be continued to be used until the river has crested. After the rivers have crested, the FLOOD AND RIVER FORECAST STATEMENT header would be used.

c. Revise the bulletin format to make it compact and the information concise. This will allow for easier transmission and receipt by radio and for uncomplicated broadcast by public radio and TV. The key lines in the proposed format would be ideal for TV trailers.

d. To make it quicker and simpler to copy radio transmissions, all users would be provided with preformatted blank forms which correspond to the FLOOD WARNING BULLETIN and the FLOOD AND RIVER FORECAST STATEMENT.

e. It is recommended the labels FLOOD LEVEL or FLOOD STAGE replace the label DANGER LEVEL.

2.4 Daily Bulletin:

The daily bulletin is the primary means the FF & WC uses to distribute the river and rainfall observations. Since it provides no warnings or forecasts, it should not have bulletin in its title.

River stations above Flood Levels (Danger Level) are underlined by the computer and then manually underlined with red pencil. This is a time consuming operation and could be done by computer only.

The Summary should be made more generally available. It provides information and background at locations other than the official forecast points. It can be used to assess the river trend, provide information for planning at the District and lower levels for flood and evacuation planning and encourage feedback.

a. The daily bulletin should be assigned a title without the term bulletin. A recommended title is RIVER AND RAINFALL SUMMARY.

b.To speed up preparation of the summary, the red line emphasis could be replaced with a combination of computer underline and <u>BOLD</u> format.

c. To provide broader dissemination the Summary, could be published in the newspapers during the flood season next to or near the weather forecasts and information.

2.5 Training:

Many recipients of the present Flood and Daily bulletins, from the Ministry level down, do not understand, know about or know how to use or obtain the flood forecasts and warning information.

At the start of the flood season, the press announces the opening of the FF & WC by a small news item. This news item of a few lines is generally overlooked or missed.

a. A printed training package should be prepared and distributed to the news and broadcast media and all need-to-know Ministries, groups and persons.

b. Before the next flood season, FF & WC should arrange to present a seminar to the Senior Officials and staff of the control room of the Ministry of Relief and Rehabilitation, Ministry of Home Affairs (Police), Non Government Organizations (NGO) and any other interested Ministry to provide training on the use of the flood bulletins and its dissemination.

c. Before the beginning of the flood season, the warning and communications infrastructure should be exercised on a national basis. Prepackaged flood warnings and river forecasts should be disseminated through the planned process and tracked through the system.

d. For public education, it is suggested the Ministry of Information and Broadcast obtain the volunteer efforts of a famous film actor/actress to narrate and appear in a short film and video presentation on flood preparedness and response. Printed Flood Safety Rules could be distributed to individuals and used to supplement the film and video presentation.

e. To provide a more noticeable announcement, newspaper and appropriate periodical advertisements should be used to notify the public and the need-to-know. During the monsoon season, the FF & WC's telephone numbers should be carried in the newspapers in the weather section.

APPENDIX 6

Example FF&WC Outputs of Daily Bulletin and River Situation Report

FLOOD FORECASTING AND WARNING DIVISION
SURFACE WATER HYDROLOGY-2
FLOOD INFORMATION CENTRE, BWDB
WAPDA BUILDING, 8TH FLOOR
DHAKA

IME OF ISSUE OF THE BULLETIN:
0:15 Hrs. ON 15 Aug 1992

PHONE: 233118 (08.00 TO 21.00 Hrs
231680 ON ALL DAYS)

6 A.M. WATERLEVEL IN METER (PWD DATUM)

L NO	RIVER	STATION	RECORDED HIGHEST LEVEL	DANGER LEVEL	DATE 13- 8 1992	DATE 14- 8 1992	DATE 15- 8 1992	DATE 15- 8 1991
	BRAHMAPUTRA BASIN: RANGPUR, BOGRA, PABNA, MYMENSINGH, JAMALPUR, TANGAIL, DHAKA							
1	Dharla	Kurigram	27.50	26.50	24.52	24.30	24.22	25.28
2	Teesta	Dalia	52.97	52.25	51.44	51.34	51.38	51.57
3	Teesta	Kaunia	30.52	30.00	28.91	28.87	28.80	29.17
4	Brahmaputra	Noonkhawa	28.10	27.89	24.43	24.37	24.28	25.58
5	Brahmaputra	Chilmari	25.06	24.00	22.26	22.20	22.12	23.25
6	Brahmaputra	Bahadurabad	20.62	19.50	18.05	17.99	17.94	19.09
7	Brahmaputra	Serajganj	15.12	13.75	12.34	12.30	12.29	13.65
8	Brahmaputra	Aricha	10.58	9.14	7.66	7.68	7.75	9.00
9	Old Brahmaputra	Jamalpur	18.00	17.00	14.56	14.42	14.33	16.22
10	Old Brahmaputra	Mymensingh	14.02	12.50	10.17	9.98	9.80	11.57
1	Buriganga	Dhaka	7.58	6.00	3.75	3.81	3.90	5.01
2	Lakhya	Narayanganj	6.71	5.50	4.28	4.04	4.22	4.99
3	Turag	Mirpur	8.35	5.94	4.24	4.24	*	5.31
4	Turag	Tongi	7.84	6.08	4.25	4.24	*	5.16
5	Kaliganga	Taraghat	10.39	8.38	6.34	6.29	*	8.15
	GANGES BASIN: DINAJPUR, RAJSHAHI, PABNA, KUSHTIA, JESSORE, KHULNA, DHAKA, FARIDPUR, BARISAL							
1	Karatoa	Panchgarh	72.65	70.75	68.00	67.96	68.00	68.37
2	Punarbhaba	Dinajpur	34.40	33.50	29.81	29.71	29.60	29.89
3	Mahananda	Chapai Nawabganj	22.25	21.00	18.60	18.62	18.68	19.50
4	Jamuna	Naogaon	15.63	15.24	13.52	13.44	13.34	13.75
5	Ganges	Pankha	22.97	21.50	18.71	18.75	18.81	19.86
6	Ganges	Rajshahi	20.00	18.50	16.35	16.38	16.42	16.96
7	Ganges	Hardinge Bridge	15.04	14.25	12.50	12.52	12.56	13.35
8	Ganges	Goalundo	9.83	8.50	7.10	7.13	7.19	8.40
9	Ganges	Bhagyakul C	7.58	6.00	5.02	4.97	5.05	6.09
10	Gorai	Gorai Rly Bridge	13.65	12.75	10.61	10.67	10.70	11.80
11	Kumar	Faridpur	8.76	7.50	4.11	4.10	4.06	4.25

9 A.M. RAINFALL IN MILLIMETER (FOR LAST 24 HOURS)

SL NO	STATION	MONTHLY MAXIMUM	MONTHLY NORMAL	DATE 13- 8 1992	DATE 14- 8 1992	DATE 15- 8 1992	CUMULATIVE Aug 1992	CUMULATIVE Aug 1991
1	Kurigram	722.5	291	0.0	0.0	0.0	220.0	157.9
2	Dalia	1247.5	570	8.0	0.0	0.0	264.5	222.0
3	Kaunia	729.9	345	0.0	0.0	3.5	245.8	67.5
4	Rangpur	710.1	318	18.0	0.0	0.0	143.3	234.0
5	Chilmari	834.4	299	0.0	0.0	21.5	263.5	79.2
6	Dewanganj	618.7	337	0.0	6.8	0.0	98.5	162.5
7	Gaibandha	272.8	288	0.0	0.0	0.0	79.6	80.6
8	Bogra	733.8	297	0.0	2.0	0.0	100.9	232.3
9	Jamalpur	702.2	361	0.0	0.0	0.0	114.9	40.1
10	Mymensingh	800.1	362	0.0	0.0	0.6	168.9	33.4
11	Dhaka	704.8	337	0.0	3.0	0.0	119.7	135.0
12	Tangail	512.5	253	0.0	0.0	0.0	193.0	23.0
1	Panchagarh	1604.2	572	0.4	0.0	11.5	315.2	431.7
2	Dinajpur	892.7	336	0.0	0.0	0.0	122.3	241.0
3	Pabna	639.0	264	0.0	0.0	1.0	60.8	132.0
4	Naogaon	858.9	289	0.0	4.0	4.4	101.0	31.6
5	Kushtia	774.8	268	0.0	0.0	0.0	73.4	76.5
6	Rajshahi	537.8	251	0.0	0.0	4.4	80.6	52.4
7	Jessore	751.1	314	4.1	0.0	0.0	88.7	312.6
8	Khulna	666.2	347	39.0	2.0	14.0	150.0	138.0
9	Satkhira	548.8	332	14.0	0.0	8.0	181.3	183.2
10	Faridpur	650.0	289	0.0	0.0	1.0	114.0	66.5
11	Barisal	994.2	398	38.3	0.0	*	179.9	138.3
12	Patuakhali	1049.8	551	78.4	0.0	6.0	227.5	241.1

CONVERSION FACTOR: 1 FT =0.3048 M; 1 M = 3.2808 FT
1 INCH = 25.4 MM; 1 MM = .03937 INCH

* NOT AVAILABLE
C COMPUTED HIGHEST LEVEL FOR 1954 FLOOD

6 A.M. WATERLEVEL IN METER (PWD DATUM)

SL NO	RIVER	STATION	RECORDED HIGHEST LEVEL	DANGER LEVEL	DATE 13- 8 1992	DATE 14- 8 1992	DATE 15- 8 1992	DATE 15- 8 1991
	MEGHNA BASIN: SYLHET, MYMENSINGH, COMILLA, DHAKA							
1	Surma	Kanairghat	15.26	13.20	12.28	11.90	11.52	12.56
2	Surma	Sylhet	11.95	11.25	9.84	9.63	9.43	10.02
3	Surma	Sunamganj	9.46	8.25	7.33	7.26	7.19	7.59
4	Kushiyara	Amalashid	18.28	15.85	14.92	14.42	13.91	15.30
5	Kushiyara	Sheola	14.33	13.50	12.77	12.47	12.14	12.97
6	Manu	Manu Rly Bridge	19.39	15.25	14.90	14.41	14.94	13.91
7	Manu	Moulvi Bazar	13.14	11.75	9.09	8.85	8.70	8.53
8	Khowai	Habiganj	11.00	9.50	7.43	7.17	7.41	6.90
9	Someswari	Durgapur	15.15	13.00	11.05	10.96	10.96	11.22
10	Upper Meghna	Bhairab Bazar	7.66	6.25	5.15	5.12	5.13	5.85
11	Gumti	Comilla	13.32	11.75	8.19	7.89	8.16	10.05
12	Meghna	Chandpur H.W.L.	5.35	-	3.89	4.09	*	4.51
13	Meghna	Chandpur L.W.L.	4.86	4.00	2.94	3.09	*	3.78
	SOUTH EASTERN HILL BASIN: NOAKHALI, CHITTAGONG, BANDARBAN, CHITTAGONG HILL TRACTS							
1	Muhuri	Parshuram	14.48	13.00	10.29	10.26	10.21	10.74
2	Karnafully	Kaptai	34.32	33.25	25.25	25.63	25.68	29.86
3	Halda	Narayan Hat	18.25	14.63	12.46	12.45	12.25	12.63
4	Halda	Panchpukuria	10.52	9.50	4.96	5.46	5.22	5.39
5	Sangu	Bandarban	20.38	15.25	6.95	6.88	6.60	7.50
6	Sangu	Dohazari	9.05	7.00	*	*	*	3.45
7	Matamuhuri	Lama	15.45	12.25	6.88	6.89	6.72	7.75
8	Matamuhuri	Chiringa	6.83	5.75	3.27	3.32	3.16	3.48
9	Feni	Ramgarh	21.41	17.37	12.21	12.12	12.09	13.22

9 A.M. RAINFALL IN MILLIMETER (FOR LAST 24 HOURS)

SL NO	STATION	MONTHLY MAXIMUM	MONTHLY NORMAL	DATE 13- 8 1992	DATE 14- 8 1992	DATE 15- 8 1992	CUMULATIVE Aug 1992	CUMULATIVE Aug 1991
1	Kanair ghat	1227.0	763	0.0	0.0	32.0	422.0	561.0
2	Sylhet	1152.2	637	0.0	26.0	16.0	222.5	298.0
3	Sunamganj	2514.7	1089	0.0	33.0	19.0	723.0	618.0
4	Sheola	850.6	561	0.0	4.0	102.0	431.0	520.0
5	Moulvi Bazar	666.9	393	0.0	2.0	3.0	205.0	33.0
6	Manu Rly Brid	520.6	406	0.0	0.0	21.0	195.0	135.0
7	Habiganj	955.5	398	0.0	4.0	10.0	145.7	89.1
8	Durgapur	1093.7	617	0.0	0.0	14.5	194.9	346.1
9	Bhairab Bazar	526.3	337	0.0	0.0	3.8	105.1	30.5
10	Comilla	692.2	566	0.0	0.0	0.0	72.0	218.5
11	Chandpur	588.6	334	28.0	0.0	0.0	115.0	202.0
1	Parshuram	671.1	410	0.0	0.0	0.0	84.9	161.8
2	Noakhali	994.4	616	5.8	2.5	3.0	272.6	262.0
3	Narayan Hat	928.1	584	31.0	0.1	0.0	168.6	-
4	Panchpukuria	860.3	478	22.5	0.0	0.0	266.7	360.1
5	Bandarban	911.1	464	0.0	4.8	0.0	7[illegible]	531.2
6	Rangamati	1377.9	507	0.8	1.3	0.0	10[illegible]	324.0
7	Lama	1048.7	571	7.0	55.0	0.0	17[illegible]	637.0
8	Chittagong	1086.9	548	0.7	0.0	0.0	184.7	257.0
9	Ramgarh	1075.7	467	0.0	1.5	0.0	147.4	239.4
10	Sandwip	1820.4	736	*	*	*	-	149.9
11	Cox's Bazar	1286.4	719	22.0	1.0	3.0	159.0	514.0

* NOT AVAILABLE

REMARKS : RIVER ABOVE DANGER LEVEL UNDERLINED
HIGHEST WATERLEVEL EXCEEDED DURING CURRENT SEASON UNDERLINED

DANGER LEVEL: Danger level of a river is a level above which it is likely that the flood may cause damages to crops and homesteads. [In a river having no embankment, danger level is about annual average flood level. In an embanked river, danger level is fixed slightly below the design flood level of the embankment. Danger level is defined for a particular measuring station for the area to its immediate vicinity.]

NO. FFW/F-4/FIC/107(75) DATED: 15 Aug 1992

COPY FORWARDED FOR FAVOUR OF INFORMATION TO:

COMPARED BY:

DUTY OFFICER,
FLOOD INFORMATION CENTRE,
BWDB, DHAKA.

FLOOD FORECASTING AND WARNING DIVISION
SURFACE WATER HYDROLOGY - 2
FLOOD INFORMATION CENTRE
BWDB, DHAKA.

RIVER SITUATION AS ON 15th August 1992

RAINFALL :

Very light to moderate rainfall at one or two places over the Brahmaputra basin & at most places over the Ganges basin, very light to moderately heavy fall at most places over the Meghna Basin except at Sheola where it was very heavy and very light fall at one or two places over the South Eastern Hill basin has been recorded during the last 24 hours. Significant rainfall was experienced 102.0 mm at Sheola, 32.0 mm at Kanairghat, 21.5 mm at Chilmari and 21.0 mm at Manu Rly Bridge during the same period.

GENERAL RIVER CONDITION :

The Brahmaputra observed further fall at the upstream while the Ganges showed rise at all points. Other rivers in the Brahmaputra and the Ganges basin showed rise and fall. The rivers in the Meghna basin also observed rise and fall while those in the South Eastern Hill basin marked fall at all points. The details of the basin reports are as follows :

BRAHMAPUTRA BASIN :

The Brahmaputra recorded further fall by 9 cm at Noonkhawa, 8 cm at Chilmari, 5 cm at Bahadurabad and slight fall at Serajganj but it recorded further rise by 7 cm at Aricha. The Teesta recorded rise by 4 cm at Dalia while it receded by 7 cm at Kaunia. The Dharla recorded further fall by 8 cm at Kurigram. The Old Brahmaputra also recorded further fall by 9 cm at Jamalpur and 18 cm at Mymensingh. The Buriganga at Dhaka registered rise by 9 cm and the Lakhya at Narayanganj by 18 cm. All the rivers in this basin are flowing below danger level.

GANGES BASIN :

The Ganges registered further rise by 6 cm at Pankha, 4 cm each at Rajshahi & Hardinge Bridge, 6 cm at Goalundo and 8 cm at Bhagyakul. The Karatoa at Panchagarh recorded rise by 4 cm while the Punarbhaba at Dinajpur receded by 11 cm. The Mahananda at Chapai-Nawabganj registered further rise by 6 cm but the Jamuna at Naogaon further receded by 10 cm. The Gorai at Gorai Rly Bridge recorded further rise by 3 cm while the Kumar at Faridpur marked fall by 4 cm. All the rivers in this basin are flowing below danger level.

MEGHNA BASIN :

The Surma recorded further fall by 38 cm at Kanairghat, 20 cm at Sylhet and 7 cm at Sunamganj. The Kushiyara also registered further fall by 51 cm at Amalshid and 33 cm at Sheola. The Manu recorded rise by 53 cm at Manu Rly Bridge while it receded by 15 cm at Moulvi Bazar. The Khowai at Habiganj registered rise by 24 cm and the Someswari at Durgapur remained steady. The Meghna at Bhairab Bazar recorded slight rise and the Gumti at Comilla by 27 cm. All the rivers in this basin are flowing below danger level.

SOUTH EASTERN HILL BASIN :

The rivers in this basin recorded fall at all points. The Muhuri at Parshuram recorded further fall by 5 cm, the Halda by 20 cm at Narayan Hat & 24 cm at Panchpukuria, the Sangu at Bandarban by 28 cm, the Matamuhuri by 17 cm at Lama & 16 cm at Chiringa. All the rivers in this basin are flowing well below danger level.

P.T.O

FORECAST FOR THE NEXT 24 HOURS. (for 16th August at 0600 hours)

The Brahmaputra at :

a) Chilmari is likely to fall by 10 cm and may flow 1.98 metre below danger level.
b) Bahadurabad is likely to fall by 10 cm and may flow 1.66 metre below danger level.
c) Serajganj is likely to fall by 5 cm and may flow 1.51 metre below danger level.
d) Aricha is likely to rise by 5 cm and may flow 1.35 meter below danger level.

The Old Brahmaputra at :

a) Jamalpur is likely to fall by 10 cm and may flow 2.77 metre below danger level.
b) Mymensingh is likely to fall by 13 cm and may flow 2.83 metre below danger level.

The Ganges at :

a) Rajshahi is likely to rise by 4 cm and may flow 2.04 metre below danger level.
b) Hardinge Bridge is likely to rise by 5 cm and may flow 1.64 metre below danger level.
c) Goalondo is likely to rise by 6 cm and may flow 1.25 metre below danger level.
d) Bhagyakul is likely to rise by 5 cm and may flow 90 cm below danger level.

FORECAST FOR THE NEXT 48 HOURS. (for 17th August at 0600 hours)

The Brahmaputra at :

a) Chilmari is likely to further fall by 8 cm and may flow 2.06 metre below danger level.
b) Bahadurabad is likely to further fall by 8 cm and may flow 1.74 metre below danger level.
c) Serajganj is likely to further fall by 8 cm and may flow 1.59 metre below danger level.
d) Aricha is likely to further rise by 1 cm and may flow 1.33 meter below danger level.

The Old Brahmaputra at :

a) Jamalpur is likely to further fall by 11 cm and may flow 2.88 metre below danger level.
b) Mymensingh is likely to further fall by 10 cm and may flow 2.93 metre below danger level.

The Ganges at :

a) Rajshahi is likely to further rise by 5 cm and may flow 1.99 metre below danger level.
b) Hardinge Bridge is likely to further rise by 5 cm and may flow 1.59 metre below danger level.
c) Goalondo is likely to further rise by 2 cm and may flow 1.23 metre below danger level.
d) Bhagyakul is likely to further rise by 2 cm and may flow 88 cm below danger level.

15.08.92

(Sudhir Goswami)
Assistant Engineer,
Flood Forecasting & Warning Division,
BWDB, Dhaka.

APPENDIX 7

Arrangements for Receiving Hydrometric Data from India

ARRANGEMENTS OR THE TRANSMISSION OF WATER LEVEL, DISCHARGE AND RAINFALL DATA OF BANGLADESH DURING THE MONSOON SEASON OF 1991.

A. CENTRES AND PARTICULARS OF DATA TO BE COMMUNICATED:

Sl. No.	Name of Centre/ Stations	Particulars of data to be communicated	Remarks
I.	PATNA CENTRE.		
	Ganga at Farakka	Actual and forecast levels and daily discharge.	To be communicated when either the actual or the forecast level is at or above the warning stage.
II.	GUWAHATI CENTRE.		
	i) Brahmaputra at Pandu	Daily discharge	-do-
	ii) Brahmaputra at Goalpara	Actual and forecast levels	-do-
	iii) Brahmaputra at Dhubri	Actual and forecast levels	-do- (In addition the daily rainfall data of Goalpara Dhubri and Tura are to be included in the messages if rainfall exceeds 50mm.)
	iv) Barak at Silchar	Actual and forecast levels	-do-
III.	JALPAIGURI CENTRE.		
	i) Teesta at Domohani	Actual and forecast levels and discharge	To be communicated when either the actual or the forecast level is at or above the warning stage. In addition the daily rainfall data of Coochbehar, Jalpaiguri and Siliguri are to be included in the message if rainfall exceeds 50mm.
IV.	TRIPURA STATE.		
	i) Khowai at Khowai Town	Actual levels	To be communicated when the level is at or above the warning stage. In addition the daily rainfall data of Agartala
	ii) Juri at Dharamnagar	-do-	
	iii) Gumti at Sonanmura	Actual levels	

iv) *Gumti at Amarpura -do-

v) *Manu at Kailashar -do-

is to included in the message if rainfall exceeds 50mm.

*: Till such time direct point-to point exchange of data begins between India and Bangladesh. (Reference - Item V below).

V. DIRECT POINT-TO-POINT EXCHANGE OF DATA.

i) Gumti at Amarpura Actual levels

ii) Manu at Kailashar -do-

To be communicated when the level is at or above the warning stage.

B. FREQUENCY OF TRANSMISSION.

I. Levels of 2100 hrs., 2400 hrs., of the previous day and of 0300 hrs., and 0600 hrs., of the days of report to be transmitted at 0800 hrs.

II. Levels of 0900 hrs., 1200 hrs., 1500 hrs., and 1800 hrs., of the day of report to be transmitted at 2000 hrs. This transmission will also contain discharge data and weather forecast received from IMD and rainfall data (when it exceeds 50mm).

C. MODE OF TRANSMISSION.

I. Executive Engineer, Middle Ganga Division No. V, Patna will pass on the message to Meteorological Office, Patna for onward transmission to 'Weather Dum Dum' through IMD teleprinter channel.

II. Executive Engineer, Lower Brahmaputra Division, Jalpaiguri, will send the message through wireless at 0700 hrs., and 1930 hrs., to Guwahati Control Room.

III. Executive Engineer, Middle Brahmaputra Division, Guwahati will pass on the message relating to his own centre as well as the one received from Jalpaiguri Centre to Regional Meteorological Office, Guwahati for onward transmission to 'Weather Dum Dum'.

IV. In respect of rivers in Tripura except for those covered under direct point-to-point exchange the messages will be sent by the local authorities concerned to 'Weather Dum Dum' by Flood Priority Telegrams.

IMD Officer 'Weather Dum Dum' would convey all the messages to 'Flood Warning Centre' C/O 'Storm Warning Centre' - Dhaka (Bangladesh).

V. In respect of rivers in Tripura mentioned in Sl. No. V after the arrangements for direct point-to-point exchange of data become operational between India and Bangladesh, the data will be sent directly by Executive Engineer, Barak Division, Guwahati.

APPENDIX 8

List of Major Capital Purchases by the Project

MAJOR CAPITAL PURCHASES BY THE PROJECT.

: Computer Hardware and Spares for Tandy TRS-80 System.

: 32 HF/SSB Wireless Transceivers, Batteries and Spares.

: Project Vehicles and Spares.

: Mobile Workshop Van and Maintenance Equipment.

: Computers, Printers, UPs, etc. for PC based Local Area Network and Software.

: Raingauges, Water Level Recorders, Solid State Loggers and Spares.

: Office Equipment, Photocopier, Facsimile, Typewriter, Vacuum Cleaner, etc.

: Weather Satellite Receiver installation and Spares.

: Air-conditioners and Spares.

APPENDIX 9

Summary of the Findings of the Evaluation Mission

I. EXECUTIVE SUMMARY

1. Objectives:

The development objectives of the project may be seen to have been met in general terms.

Of the six immediate objectives, the four in the revised project document BGD/88/013/G/01/16 of Sept 1990 have been substantially met. On the other hand, the two in the original document BGD/88/013/B/01/16 of April 1989, which should not be seen as superceded, have not been fully met. The immediate objectives not met are those associated with the missing outputs given below.

2. Activities:

Most of the activities specified in the revised project document should by May 1992 be complete. The activities in the original document which are incomplete are those associated with the missing outputs given below.

3. Outputs:

Most of the outputs specified in the revised document have been achieved. The important outputs in the original document which have not been achieved are as follows:-

- o A fully-calibrated radar (but the radar as-is serves a valuable function, even more to BMD than the FFWC).
- o Forecasting services in the flashy Eastern rivers.
- o FFWC upgraded to a Directorate.
- o Finalised project document for the main phase of the project (awaiting the outcome of this present review mission).

4. Extensions and delays:

The series of extensions and delays since 1989 has three primary causes as follows:-

- o Delays in procurement, both by WMO and by suppliers.
- o Personality conflicts between Government and WMO staff, culminating in the replacement of the CTA in 1990.
- o Change in circumstances, arising from Japanese support to a Pilot Telemetry Project.

As the project nears completion, the first of these problems seems to persist. The second

has been fully rectified.

5. Sustainability:

Many of the elements of the FFWC and its associated C & I Division are impressive, which implies that the outputs of this project and its predecessor are mostly sustainable. These outputs are sustainable within recurrent Government expenditure, and this is particularly the case in respect of the following elements:-

- o The wireless network.
- o The routine operation of the forecasting model.

On the other hand, there are outputs which are almost certainly **unsustainable** if the project finishes in May 1992:-

- o Operation and maintenance of the FFWC computer network and associated software including the LAN.
- o Maintenance and development of the forecasting models.

Independent of the main phase project discussed below, a project extension from May 1992 will be necessary in order to meet the outstanding objectives. Furthermore, this extension should include a pilot study for flashy Eastern rivers. The extension should wholly comprise technical assistance amounting to a total of 10 man-months over a 6-month period.

6. Longterm perspective:

The extended project document of September 1990, together with the above proposed extension from May 1992, should not be seen as the **main phase** of the project as identified in the original document, although it contains some elements thereof. The main phase is still to come.

It is the perception of those associated with the FAP that donors need to take a longterm perspective on support. This is nowhere more true than in the activities of FFWC/FAP-10 where there is such dependence on high technology.

7. The main phase project:

The following represents a brief outline for the main phase project, which UNDP advise **must** be a new project and cannot be an extension to the existing one.

A proposal has been tabled by Government at the last tripartite review, for an extension until December 1993, having the following summarised activities:-

- o Integration of Pilot Telemetry Project.
- o Development of regional modelling (but should also include models in flashy Eastern rivers).
- o Coordination and integration with FAP.

We do not believe that these proposals are sufficiently far-reaching, either in terms of timescale or of scope. We would suggest a new project until December 1995, albeit at a less intense level in terms of equipment procurement and technical assistance than in the initial phase. To the above activity list should be added the following:-

- o Strengthening of dissemination and response functions.
- o Further strengthening of FFWC operational activities (including broader training of local staff).
- o Linkage with radar developments (see below).

8. Radar:

The issue of radar should be removed from the main phase project, for the following reasons:-

- o BMD is the primary beneficiary of the Dhaka radar, not FFWC.
- o The development and rehabilitation needed is capital-intensive and therefore not attractive to UNDP.

The existing radar is making important contributions both to storm warning and to flood forecasting. A project for the rehabilitation and possible further development of radar should be investigated, but perhaps would be of interest to other donors.

9. Dissemination and response:

The whole area of what happens to forecasts and/or warnings when they leave FFWC is presently being examined by a WMO Expert. That notwithstanding, this vital area has been relatively neglected both by Government and by previous project proposals. This situation should be rectified in the main phase project, and should be its most important objective. This activity will need careful integration with the activities of the UNDP-supported FAP-11 component on Flood Preparedness.

10. Telemetry:

We are uneasy about the move towards telemetry at the present time, vis-a-vis the Pilot Telemetry proposal. Even at the pilot level, the operation & maintenance implications on recurrent Government expenditure may not have been fully considered.

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