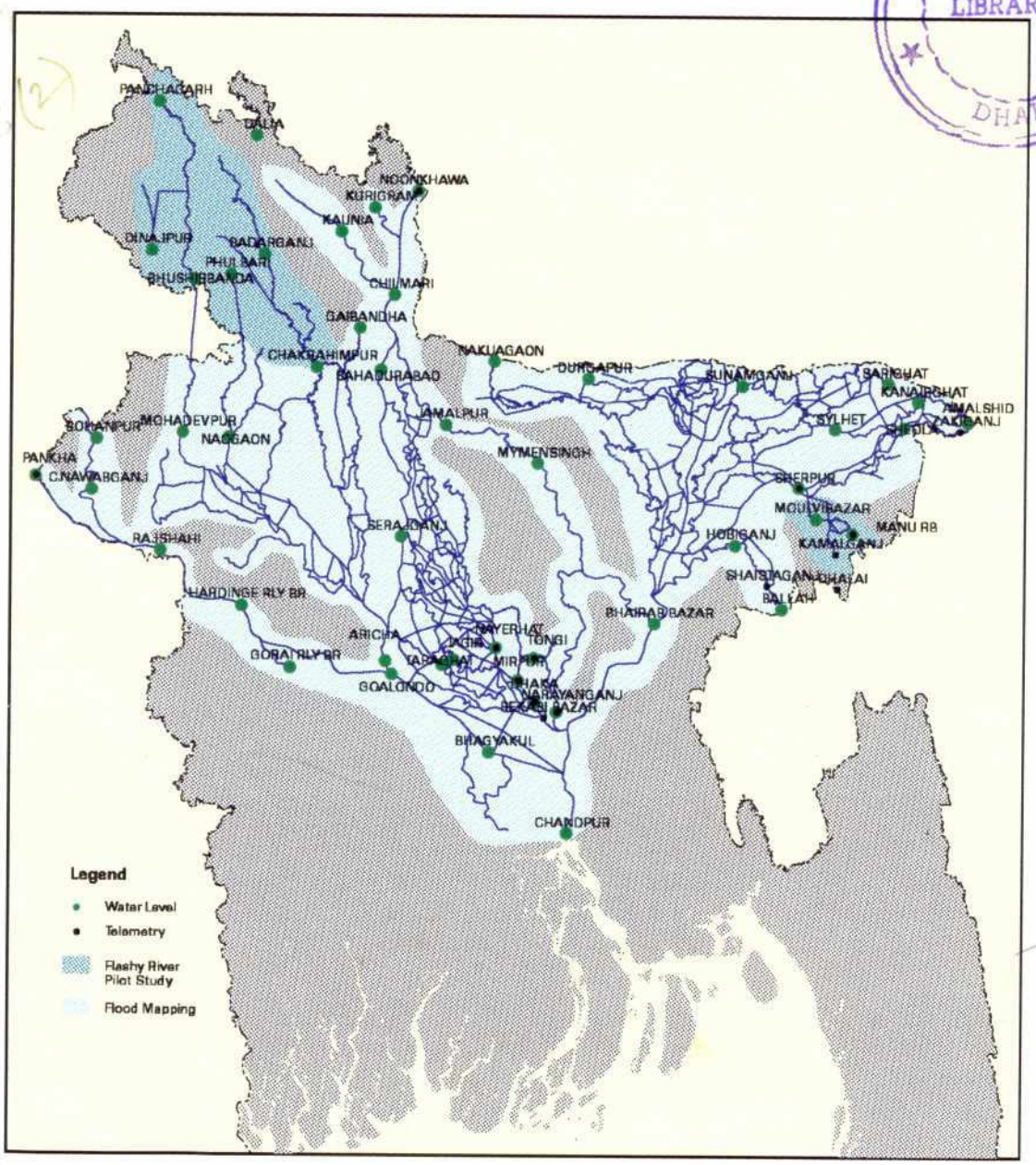
Bangladesh Water Development Board
Ministry of Water Resources

Danida
Ministry of Foreign Affairs

EXPANSION OF FLOOD FORECASTING AND WARNING SERVICES (FAP 10)
QUARTERLY PROGRESS REPORT NO.4

April to June 1996



Danish Hydraulic Institute

In association with:
World Meteorological Organization

July 1996

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PROJECT KEY DATA

Administration	
Country	Bangladesh, Sector: Water Resources
Project Title	Expansion of Flood Forecasting and Warning Services (FAP10)
Danida Ref.No.	104.Bangladesh.167
Government Agreement signed	26/12-1994
Project Implementation Period	1/1-1995 to 31/12-1997 (36 month)
Implementing Agency (host)	Bangladesh Water Development Board
Report no.	4. Quarterly Progress Report
Period Covered	1/4/96 - 30/6/96
Prepared by	Gregers Jørgensen/Md.Alam Miah
Next report due	July 1996
Date, Signature	

Finance		
Danida Contribution	17,097,740 DKK	(Incl. Contingencies)
Government Contribution	387 Lakh Taka	
Item	Total budget (DKK)	Figures pr 1/7-1996
1. Cost of Expatriate	6,978,181	4,295,611
2. Cost of Local Consult.	1,360,680	648,529
3. Travel Cost. Accom.	1,664,680	1,003,062
4. Project Support	1,434,050	484,956
5. Equipment	2,174,420	1,363,764
6. Training	2,067,700	596,620
+ Contingencies	1,567,971	
- Discount	150,000	
TOTAL	17,097,68	8,392,542

LIST OF ABBREVIATIONS AND ACRONYMS

AIT	Asian Institute of Technology
ARC-VIEW	GIS software package
BRTV	Bangladesh Radio and Television
BMD	Bangladesh Meteorological Department
BUET	Bangladesh University of Engineering Technology
BWDB	Bangladesh Water Development Board
Danida	Danish International Development Assistance
DEM	Digital Elevation Model
DHI	Danish Hydraulic Institute
DMB	Disaster Management Bureau
FAP	Flood Action Plan
FAP10	Flood Forecasting and Warning Component of FAP
FAP11	Disaster Management Component of FAP
FAP19	Geographical Information System of FAP
FAP25	Flood Modelling and Management Component of FAP
FF	Flood Forecasting
FFWC	Flood Forecasting and Warning Centre
FFWRS	Flood Forecasting, Warning and Response System
FMM	Flood Management Model
GIS	Geographical Information System
GM	General Model
GM-FF	Dedicated Version of General Model for Flood Forecasting
GM 96	General Model for Flood Forecasting, expanded 1996 version
GOB	Government of Bangladesh
JRC	Joint River Commission
MIKE11	River Modelling System Developed by DHI
NAM	Precipitation Runoff Model
NGO	Non Government Organization
SAARC	South Asian Association for Regional Cooperation
SPARSSO	Space Research and Remote Sensing Organization
SWMC	Surface Water Modelling Centre
UNDP	United Nation Development Program
WAPDA	Water and Power Development Authority
WMO	World Meteorological Organization

SUMMARY

Background

The project "Expansion of Flood Forecasting and Warnings Services" is a component of the Flood Action Plan and is known as FAP 10. The 3 years project was started in January 1995. The project support the Flood Forecasting and Warning Centre and is implemented by BWDB with technical assistance from Danish Hydraulic Institute.

Objectives

The development objective is a contribution towards improved information to aid national preparedness for floods and to mitigate flood impact.

The immediate objectives of the project is to support Flood Forecasting and Warning Centre in order to improve performance with regard to increased mobilization of local resources and efficient utilisation of resources available.

Activities

The project has been divided into 4 modules, out of which the first 3 modules are supported by Danida. Activities during the reporting period are:

Module 1 : Coordination and Monitoring

- Quarterly Progress meeting held 2 July
- installation of 40 new wireless radios started. Installation of the first 11 set completed during April-May 96. GOB will establish 7 new stations by the end of July. In other locations old radios are being replaced with new
- radio-link to be installed between WAPDA building and TV
- data transfer to India ready to be improved after request from GOB to India
- phased upgrading of computer hardware to be continued at FFWC
- upgraded flood forecasting software installed in FFWC
- establishment of a pilot systems for 2 flashy rivers initiated in May 96
- 2 overseas training courses finalised

Module 2 : Expansion of Model Applications

- new expanded model for forecasting of water levels installed at FFWC. Operational forecasting at 16 locations will gradually increase to 30 during the monsoon
- provision for coarse area inundation mapping included in the model to be tested on experimental basis during the 1996 monsoon
- model development of a pilot system for two flashy rivers initiated

Module 3 : Forecast and Warning Dissemination

- a pilot study is ongoing on 4 localities.
- 9 model warning messages have been prepared as part of a module 3 workshop. The warning messages have, however, not yet been finally approved.

Outputs

The FAP 10 project is a three year project and most of the project results will be visible during the 96 and 97 monsoon. However, by the end of the reporting period, just at the unset of the 1996 monsoon, some project output are visible.

Real-time flood forecasts at regional level and provision of coarse area inundation forecast in major part of the Northern Regions at a coarse level developed

- expanded model used operational at FFWC
- experimental mapping of coarse area inundation

Forecast system for 2 flashy rivers established on a pilot basis

- development of a forecasting system for flashy rivers has started. Pilot studies on Manu and Karatoya/Atrai river are ongoing.

Improved data exchange with countries in the Ganges - Brahmaputra - Meghna basins attempted

- exchange of data with India is attempted through an official request from GOB to India

A public awareness programme on the availability and understanding of flood warning and forecast information

- phased model warnings prepared and submitted to GOB for commenting
- first draft version of an action plan for FFWC prepared
- draft Proposal for a National Flood Forecasting and Warning Response System
- a user friendly flood forecasting and warning system with graphical display have been introduced at FFWC
- a PC-link between the FFWC and the prime ministers office established
- a public awareness programme ready to be implemented on experimental basis in 4 villages

Trained staff

- overseas training courses : in Advanced Hydraulic Modelling and Wireless Communication have been conducted
- on the job training and local group training including a number of workshops for FFWC-staff have been conducted

Improved institutional structure within FFWC to provide and maintain the necessary services established

- working environment improved at FF&WC
- improved communication and computer system at FF&WC
- setup of a new workshop and radio room in Green Road
- number of staff in the FFWC increased

Implementation Plan (Strategy)

The project implementation broadly follows the timetable and activity schedule. However, due to the political disturbance during the project period and other unforseen difficulties minor adjustments have been necessary and implemented in the revised work plan as follows :

Module 1

- upgrading of the wireless radio network has started and will continue throughout 1996.
- radio links to Bangladesh Radio/TV is scheduled to be established during July-August 1996.
- the disaster management course at AIT and study tours has been postponed until after the monsoon but is expected to take place within a few months.

Module 2

- flood mapping to be carried out on experimental basis during the 1996 monsoon. Operational flood mapping to be introduced before the 1997 monsoon
- operational forecasting on 2 flashy rivers to be introduced during the 1997 monsoon

Module 3

- implementation of module 3 will continue without input from FAP 11
- introduction of model flood warnings and dissemination arrangements delayed. Some modification of the programme for module 3 foreseen

Financial status

The present disbursement of project funds is in general progressing according to the allocated budget.

Adjustment of individual items within the Equipment budget are foreseen. A proposal will be submitted prior to the Danida review.

Assumptions

The three major assumption related to the implementation of the project mentioned in the project document are still valid and have not been fulfilled.

That the FFWC is relocated to the Hydrological Complex at Green Road before or at the start of the project

- it might not be necessary to relocate the FFWC

That GOB, after termination of the project, is capable to continue the activities of FFWC

- only 1 vacant position at FFWC. Comprehensive training of new staff needed

and staff should not be transferred to other duties

That the interaction between the project and other FAP's, especially FAP 11 and FAP 25 is established

- FAP 11 not started. Good cooperation with other FAP project established

Risks

The identified risk mentioned in the Project Document :

Increased data exchange with countries in the Ganges-Brahmaputra-Meghna basins is not reached during the project period

This risk still exists. However, improvement of data transfer seems possible, after GOB having made an official request to the Indian authorities.

Other minor assumption/risk

- it is foreseen that difficulties could arise with regard to the approval of the new flood warning system
- there is a risk that installation of the new radar at Bangladesh Meteorological Department is delayed

Recommendations

It is recommended to :

- to establish a good communication system to Green Road
- to establish closer relation between the Surface Water Modelling Centre and the FFWC. Staff at the Surface Water Modelling Centre are able to provide backup for the FFWC
- to purchase a PC based satellite receiving equipment to FFWC

1 BACKGROUND

Project history

The project "Expansion of Flood Forecasting and Warnings Services" is a component of the Flood Action Plan and is known as FAP 10. The 3 years project was started in January 1995. The inception phase of the project took place from January to May 1995. The inception period is reported in the Final Inception Report (August 1995).

Project Objectives and Outputs

The development objective is a contribution towards improved information to aid national preparedness for floods and to mitigate flood impact.

The immediate objectives of the project is to support Flood Forecasting and Warning Centre in order to improve performance with regard to increased mobilization of local resources and efficient utilisation of resources available.

In line with the project objectives the anticipated outputs from the current project are:

- real-time flood forecasts at regional level and provision of Real-time area-inundation forecast in major part of the Northern Regions at a coarse level developed
- forecast system for 2 flashy rivers established on a pilot basis
- improved data exchange with countries in the Ganges - Brahmaputra - Meghna basins established, possibly through the framework of regional cooperation.
- a public awareness programme on the availability and understanding of flood warning and forecast information and the benefits to be derived from their use developed in conjunction with and in support of the Disaster Management Bureau
- trained staff
- improved institutional structure within FFWC to provide and maintain the necessary services established

Logical Framework Approach

The project objectives, outputs, activities and inputs are incorporated in a logical framework matrix, see Annex 1. It is the intention to keep this matrix updated during the project.

Reports

Following reports has been issued up to June 1996:

• Inception Report	: January to May 1995	(August 1995)
• Progress Report No. 1	: June to September 1995	(Oct. 1995)
• Progress Report No. 2	: October to December 1995	(January 1996)
• Progress Report No. 3	: January to March 1996	(April 1996)

In addition some special reports has been issued. A complete list of reports is enclosed as Annex 8.

Review

The yearly Danida review is scheduled to take place from 25 August 1996. The review was originally planned in January 1996. However, due to the unforseen tense political situation in Bangladesh and other reasons the review has been postponed 7 month.

2 ACTIVITIES

The project has been divided into 4 modules, out of which the first 3 modules are supported by Danida. Module 4 - Telemetry Development, is supported by the Japanese Government and is not included in the Danida-project.

Progress for activities of the first 3 modules are presented below and the timing of activities for the next 3 month outlined. The timing of individual activities is given in the revised Work plan, see Annex 2.

2.1 Module 1 : Coordination and Monitoring

Module 1 is divided into six principal tasks:

1. Maintenance and Monitoring
2. Setup and Modernization of Offices
3. Improvement of Communication System
4. Improvement of Computer System
5. Supporting Studies
6. Training

2.1.1 Maintenance and Monitoring

Coordination and Monitoring of activities within the 3 modules has continued throughout the reporting period.

Quarterly Progress Meeting

The Quarterly Progress meeting was held 2 July, where the content of the 3. Quarterly Progress report was discussed. The most important decisions and items discussed were:

- distribution of the model warning messages, prepared under module 3, for final comments before July 9. Comments to be discussed in a meeting arranged by WARPO just after July 9. Emergency Standing Orders for flood should have to be strictly followed in the warning messages
- to give a demonstration of the new flood forecasting and warning system at the FFWC for the Minister of Water Resources, the Secretary and other relevant senior GOB officials
- WARPO to sort out misunderstanding of the role of the Disaster Management Bureau regarding dissemination of flood warning with the relevant authorities

after the demonstration at the FFWC
- GOB adviser, BUET suggested to upgrade the FFWC to a Directorate
- Joint River Commission to approach relevant authorities and initiate a letter to the Indian authorities regarding improvement of data transfer
- timely nomination of candidates for overseas training needed
- filling up the vacant positions in FFWC as soon as possible
- NGOs may be involved in dissemination of Flood Warning Messages

Staffing

In the 3.Quarterly Progress Report it was reported that 2 positions (officers) are vacant at the FFWC. The present situation at the FFWC is that only 1 position out of 12 is vacant. Officers directly involved in the project are shown on the diagram in Annex 9.

2.1.2 Setup and Modernization of Offices

No progress during the reporting period.

2.1.3 Improvement of Communication System

Wireless Radio System

40 new Orion 7000 radio has been procured at Eddystone Radio factory in England. 11 of these radios have been installed in the field during the reporting period. Installation of new radios in the field will continue throughout 1996. During July and August it is planned to install additional 12 radios in the field.

After having finalised installation of these 23 radios by the end of August the telemetric wireless network is expanded with 8 new stations and in 15 other locations old radios are replaced with new radio set. 7 of the new stations are established as permanent BWDB stations. Station number 8, in Bhusirbander, is used to collect data to one of the pilot flashy river forecasting systems.

A more detailed plan for the improvement of the wireless network and installation of the new Orion 7000 radios is provided in Annex 4.

Radio Link between important buildings

During the reporting period it has not been possible to install the radio link between the WAPDA building and the TV-station. However, the final approval from the TV station regarding installation of the radio link was received on July 3 1996 and installation of the communication equipment has started.

A radio link between WAPDA and BMD can be established after having finalised the

radio link between the WAPDA building and the TV-station using the TV station as a relay station. The project has purchased one new fax-machine to BMD to replace an old defect machine until a permanent radio link to BMD has been established.

Communication System at the FFWC

A total number of 4 telephone lines has been established at the FFWC with two fax machines connected. One of these lines is used as a combined line for fax and e-mail. The project has unsuccessfully tried to establish telephone line number 5 since last year.

The updated computer system has been established in a local area network. It is planned also to establish a computer link to the telemetric system (module 4).

Data transfer from India

During April 1996 the Principal Consultant visited Central Water Commission and the Commissioner of Eastern Rivers, Ministry of water resources in New Delhi. The Indian authorities had no objection to improve the data transfer (as agreed in 1972) with modern technology.

It was decided in the progress meeting, July 2 1996, that the Director JRC will approach to the appropriate authorities to hold an Expert Level meeting between Dhaka and Delhi for smooth and uninterrupted data transmission.

2.1.4 Improvement of Computer System

Hardware

At present, the following computer hardware are available for the Flood Forecasting and Warning Services:

- a computer network (Local Area Network) comprising 6 PC's is established by the project in the WAPDA building
- two PC's used for model development in Surface Water Modelling Centre
- one PC in Prime Ministers Office connected to FFWC via modem
- one computer in Green Road used to maintain the wireless radios

It is planned to continue with the phased upgrading of this system as per requirement. Minor adjustment of the total budget for equipment is foreseen.

Software

The new upgraded Flood Forecasting System has been installed at the FFWC replacing the old system. A comprehensive training applying the new system has been given and the new system are being used operational during the monsoon.

2.1.5 Supporting Studies

Supporting hydrological studies to establish pilot systems for 2 flashy rivers were started in May.

A study, testing applicability of satellite images in flood forecasting and flood mapping has been initiated in close cooperation with FAP 19 (Geographical Information Systems). FAP 19 will supply high resolution radar satellite images showing extent of flooding and FAP 10 will supply flood maps produced from the flood forecasting model. The two flood mapping methods will be compared during the 1996-monsoon.

It has been decided to estimate the cost of a high resolution satellite receiving equipment to be used at FFWC, as this equipment is highly needed at the FF&WC. A proposal with expenditures is attached as Annex 10.

2.1.6 Training

Overseas training

Two of the overseas training courses were held during the reporting period.

- Overseas Training Course 1 : Advanced Hydraulic/hydrological modelling. A 4 month training course for 4 FFWC-officers during January to May 1996.
- Overseas Training Course 3 : Wireless Communication/Field Measurement. A 3 weeks training course for 3 engineers during June to July 1996.

The disaster management course and study tours has been postponed until after the Monsoon.

In service training

During the reporting the project has supported:

- a 6 days workshop with training of 33 wireless operators, May 1996.
- a 6 days workshop used to develop warning messages for 8 FFWC-officers

A training program in use of synoptic charge and satellite images will be conducted for the officers of FFWC during the monsoon together with the training in use of the new Flood Forecasting and Warning System.

By the end of each month evaluation of the project implementation will be discussed in workshops at FFWC with the involved officers.

2.2 Module 2 : Expansion of Model Applications

Module 2 is divided into three principal tasks:

1. Development of an expanded model for forecasting of water levels.
2. Development of a system for forecasting of area-inundation.
3. Development of a pilot system for forecasting on two flashy rivers.

2.2.1 Development of an expanded model for forecasting of water levels

The new expanded model (the "Super Model"), developed at the Surface Water Modelling Centre, has been installed at the FFWC. The model is now used on operational basis and it is planned gradually to increase the number of flood forecasting locations on the rivers from 16 to 30 during the 1996 monsoon.

2.2.2 Development of a system for forecasting of area-inundation

The "Super Model" has a provision for area-inundation forecasting. During the 1996 monsoon the area-inundation mapping facilities will be used on experimental and semi-operational basis as part of the daily working routines in FFWC.

In some areas the model, however, still needs to be updated in order to account for river embankments etc. in the digital elevation model. This work is ongoing at SWMC. The area-inundation forecasting will be fully developed and verified after the 1996 monsoon, ready for operational use in the 1997 monsoon, including broadcast in BTV.

2.2.3 Development of a pilot system for forecasting on two flashy rivers

This activity was started in May 1996 and will continue during the 1996 monsoon. Two flashy rivers have been selected and the hydrologist has visited the two selected rivers:

- The Manu River in the North East Region
- The Karatoya/Atrai river in the Northern part of North West Region

The progress of the pilot system is briefly described in Annex 5.

2.3 Module 3 : Forecast and Warning Dissemination

The most important task has been to prepare for the pilot dissemination trials. The National Project Director had attended a seminar early in May, to explain the basic elements of the flood warning scheme to senior officials and Ministry Secretaries. A follow up seminar has been proposed at which the pilot trials will be explained and agreement sought.

Arrangements are being finalised to pass warnings to Bangladesh Radio & TV for broadcast dissemination. These will include graphical displays of the status of flooding

at Thana level prepared from forecasts of river water levels. Messages will also be issued to Districts Deputy Commissioners for onward transmission to TNO's . Only the four Districts in which the field sites are located will receive training on the FFWRS. However, it is felt that wider availability of the improved warnings will increase awareness across many sectors of society and contribute to a more effective response to any flood warning that may be issued and broadcasted on radio and TV.

It is envisaged that warnings will also be disseminated through the Disaster Management Bureau. This has been discussed at a meeting with BMD. BMD have expressed some concern regarding the reliability of BMD's radio system (due to old equipment) and also about difficulties of obtaining telephone lines to enable fax communication. These and other discussions have highlighted concerns about the potentially fragile nature of the country's communications infrastructure, particularly during an emergency. It is possible that the success of the project may be limited by communication facilities, whose improvement lies outside FAP10.

By the end of the reporting period the new dissemination arrangement was not in place, as there has been some reservations from GOB to some of the content of the new warning messages and to the role of the Disaster Management Bureau in dissemination of flood warnings. At the progress meeting, 2 July 1996, it was decided to receive final comments to the warning messages and to sort out the problem of proper involvement of the Ministry of Relief.

Proposed new warning messages

During a 6 days workshop with staff in the FFWC 9 model warning messages were developed to be tested during the 1996 monsoon. These warning messages are enclosed in Annex 7.

It should be noticed, that the project has received the various comments to the model warning messages. Thus, the warning messages and the dissemination arrangements (school materials, marker posts etc.) are not yet officially approved and further discussions are expected to take place.

Pilot studies of dissemination in 4 villages

During the reporting period the final arrangement for the studies in the 4 pilot areas were finalised. This include:

- setup of flood markers in the villages and the corresponding river station
- introduction of school materials in 5th, 8th and 10th grade.
- setup of 4 posters in the villages with information about flood warnings.
- distribution of a booklet with information about flood markers, flood warnings etc.

The local consultants working on module 3, has arranged for a permanent staffing in the 4 pilot villages during the monsoon.

Emergency Standing Orders

The final version of the Emergency Standing Orders was just received by the end of the reporting period. Successful implementation of the FFWRS will require a well defined interface with the ESO procedures. The contents of the FF & WC Action Plan should provide this link. It is likely that some amendments will be required to both the FFWRS and ESO to achieve the aims of the project.

3 OUTPUTS

The FAP10 project is a three year project. Most of the outputs will be visible during the 96 and 97 monsoon. However, by the end of the reporting period, just at the unset of the 1996 monsoon, some output from the project are visible. This section gives a status on the progress to obtain the expected outputs.

Real-time flood forecasts at regional level and provision of coarse area inundation forecast in major part of the Northern Regions at a coarse level developed

The new expanded model (the super model) is now being used operationally in the FFWC to forecast water levels at important river locations. During the 1996 monsoon the number of forecast locations will gradually be increased from 16 to 30.The coarse area inundation forecasting is being tested on experimental and semi-operational basis in FFWC during the 1996 monsoon. Some adjustments in the model still need to be done before the flood maps are correct in all areas. Flood maps will be ready for broadcast in BTV from the beginning of the 1997 monsoon.

After the 1996 monsoon the progress will be evaluated in terms of the indicator for this output: 'Forecast points increased from 16 to 30 including forecasts on secondary rivers and forecasts of inundation introduced on thana levels'.

Forecast system for 2 flashy rivers established on a pilot basis

The Manu river in the North East Region and the Karatoya/Atrai in the North West Region has been selected for pilot studies of flashy river forecasting. Development of a forecasting systems started in May 1996, and experimental forecasting is scheduled for 1997.

Improved data exchange with countries in the Ganges - Brahmaputra - Meghna basins attempted

After having investigated the possibilities to improve the data exchange from India,

it is agreed that JRC will approach the appropriate authorities to hold a high level expert meeting between Bangladesh and India.

The project is ready to support the improvement of the communication (used as verifiable indicator) as soon as there has been a formal agreement between Bangladesh and India. A formal request for improved data exchange has been made by GOB to India authorities.

A public awareness programme on the availability and understanding of flood warning and forecast information

Development of the programme is going on. The UNDP project regarding disaster management (FAP 11) is not likely to start during the project period. The program are therefore being developed with minimum Disaster Management Bureau support. Main outputs from this program will be visible after the 1996 monsoon. Outputs at present are:

- phased model warnings prepared to be commented upon by GOB
- first draft of an action plan for flood forecasting and warning centre
- draft Proposal for a National Flood Forecasting and Warning Response System
- a user friendly flood forecasting and warning system with graphical display
- establishment of a PC-link from the FFWC to prime ministers office
- a public awareness programme ready to be tested on trial in 4 villages

The verifiable indicators : 'phased level warnings introduced', 'forecasts and warnings presented in a user friendly manner', 'improved dissemination system' and 'public awareness developed in 3 pilot areas', will be evaluated after the 96 and 97 monsoon.

Without significant input from FAP 11, it is planned to develop the programme through better coordination of agencies. However a minor reduction of the output is foreseen without FAP 11 support.

Trained staff

Training of the FF&WC staff has continued during the reporting period. Following training has been carried out

- overseas training courses in Advanced Hydraulic Modelling and in Wireless Communication has been conducted
- on the job training and local group training including a number of workshops for FFWC-staff

At present the planned number of staff has been trained in accordance with the work plan for this reporting period.

Improved institutional structure within FFWC to provide and maintain the necessary services established

At present the following contribution towards an improved institutional structure of FF&WC have been achieved:

- working environment improved at FF&WC
- improved communication and computer system at FF&WC
- setup of a new workshop and radio room in Green Road
- number of staff in the FFWC increased

It is possible and probably desirable, that the FFWC will change status to a directorate during the project. This lies however beyond FAP 10's control.

4 IMPLEMENTATION PLAN (STRATEGY)

The project strategy keeping the project separated into 3 modules is still relevant for the project. The interrelation between the modules and the general supports of technical development, studies and training needs closely monitoring and coordination by the Principal Consultant in close cooperation with the National Project Director.

The project implementation broadly follows the timetable and activity schedule. However, due to the political disturbance during the project period and other unforseen difficulties minor adjustments have been necessary and incorporated in a revised work plan as follows :

Module 1

Upgrading of the wireless network of radios has started and is scheduled to take place throughout 1996.

Radio links to Bangladesh Radio/TV is scheduled to be established during July-August 1996.

The disaster management course at AIT and study tours has been postponed until after the monsoon.

Module 2

The new expanded model is used operationally in the FFWC. The mapping of flood inundation will be carried out on experimental basis during the 1996 monsoon. After the monsoon the flood mapping will be verified against satellite imageries at the Surface Water Modelling Centre. Development of a pilot system for flashy river forecasting was initialized in May.

Module 3

There had been no substantive progress with the approval of the UNDP project regarding disaster management (FAP 11) and as its start remain uncertain it has been necessary to progress with implementation of module 3 on a free standing basis.

Some difficulties have occurred to accept the Warning Messages and the dissemination arrangements. Without a test of the Warning Messages and the dissemination system during the 1996 monsoon some modification of the programme will be required. The project is still trying to obtain an initial implementation during the 1996 monsoon season.

5 FINANCIAL STATUS

The project accounting system has been set up as a combined system in Bangladesh and Denmark. All expenditures in Bangladesh are closely monitored by the project management. Monthly reports on expenditures are send to the Account Office in Denmark. The Account office forwards quarterly accounts to Danida. Each quarter a detailed financial status is prepared. Annex 3 gives a detailed financial status up to end of 2. Quarter 1996. The expenditures for 2. Quarter has been estimated as the financial status was not ready at the deadline for this report. Expected expenditures for 3. Quarter 1996 and the remaining project period are also included in the financial status.

The present disbursement of project funds is in general progressing according to the allocated budget. Some adjustments of individual items within the equipment budget are foreseen. A proposals will be developed for these adjustment and discussed in connection with the Danida review mission scheduled for the end of August 1996.

6 PROBLEMS, RISKS AND RECOMMENDATIONS

6.1 Problems

Assumptions

The three major assumption related to the implementation of the project mentioned in the project document are :

That the FFWC is relocated to the Hydrological Complex at Green Road before or at the start of the project

The FFWC is still located in the WAPDA building. A good working environment has been created in the WAPDA building and the pilot telemetric system providing the real time data, has also been established in WAPDA building. If an efficient and reliable communication system between WAPDA and Green Road is established, relocation of FFWC to Green Road is still considered desirable but only of secondary importance.

That GOB, after termination of the project, is capable to continue the activities of FFWC

The FFWC has now 11 officers permanently engaged in the FFWC, which forms a good basis to maintain the services at the FFWC . It is important that this staff is permanently engaged in the FFWC also during the dry season. The best way to ensure this is to upgrade the FFWC to a directorate. Comprehensive training of the new FFWC staff members are also needed. Finally it is decisive that already trained and experienced staff maintains their position in FFWC for a substantial period of time, not to be transferred to other positions.

That interactions between the project and other FAP's, especially FAP 11 and FAP 25 are established

The FAP 11 has not yet started and it is not likely to start before the conclusion of FAP 10. FAP 10 has established good and valuable cooperation relations with FAP 19 and FAP 25 (now SWMC).

Risks

The identified risk mentioned in the Project Document :

Increased data exchange with countries in the Ganges-Brahmaputra-Meghna basins is not reached during the project period

This risk does still exist. However, improvement of data transfer should be possible, after GOB having requested The Government of India.

Other risks

Few other minor assumption/risks should still be considered. These are :

- it is foreseen that difficulties may arise in connection with approval of the new flood warning system
- there is a risk that installation of the new weather radar at Bangladesh Meteorological Department gets further delayed

6.2 Recommendations

After having established a new telemetric system in WAPDA building and with reluctance from GOB to move to Green Road it seems unlikely that the entire FFWC is relocated to Green Road soon. The Consultants therefore recommend that a good communication system is established between WAPDA and Green Road (as outlined in the work plan).

It is recommended to establish closer working relation between the Surface Water Modelling Centre and the FFWC. SWMC staff members are able to provide backup for the FFWC whenever needed. A formal cooperation agreement between SWMC and FFWC should be considered.

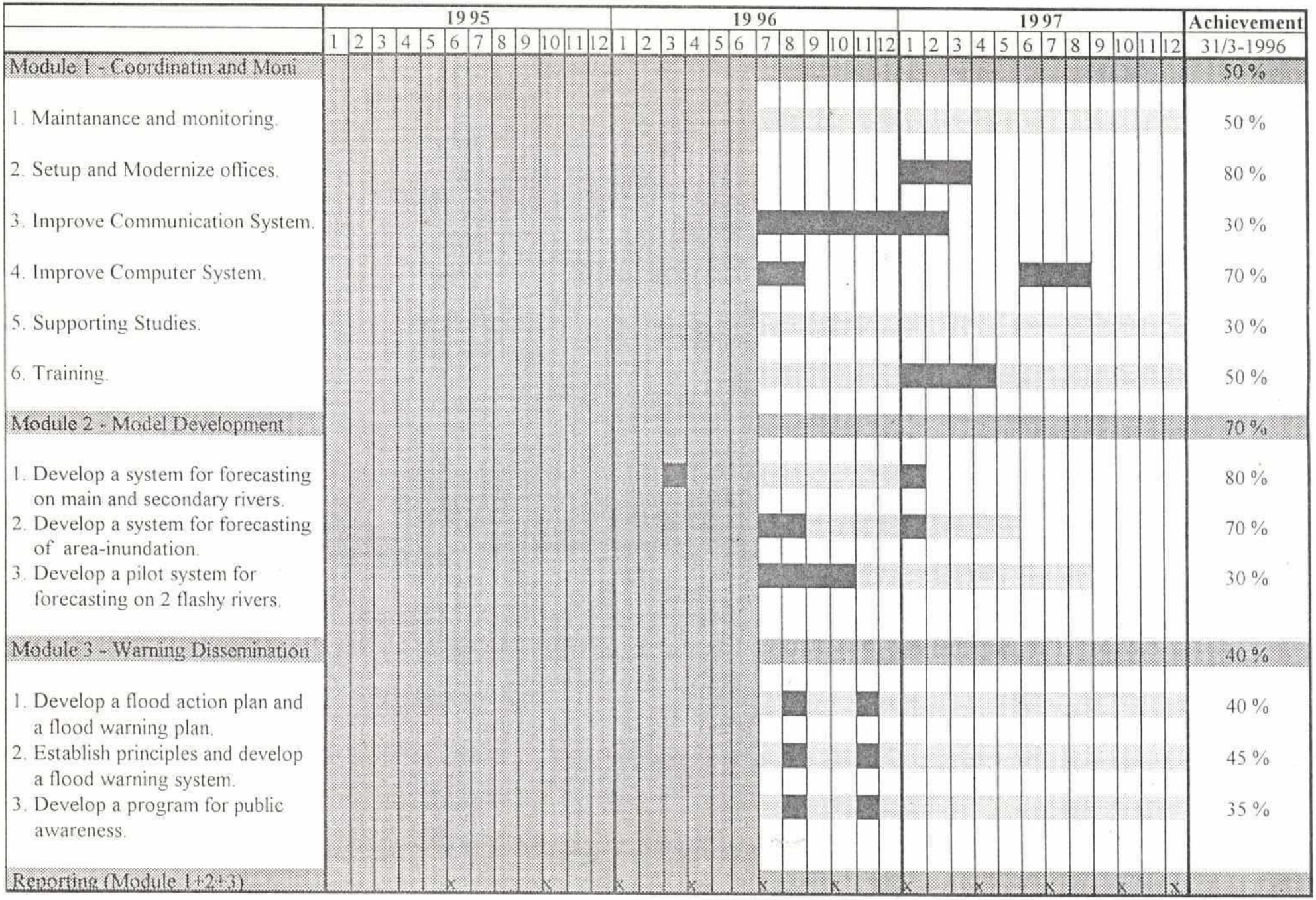
It is recommended to purchase a PC based satellite receiving equipment to be used at FFWC mainly for flood mapping. Such equipment will provide 4-5 satellite imageries pr. day which gives real-time information about flood status (area-inundation). In addition satellite imageries will support rainfall forecasting which is an important issue in real-time flood forecasting. Nowadays satellite imageries are available on most flood forecasting centres and used in combination with mathematical modelling it constitutes a very powerful tool, in particular in relation to control and verification of model forecasts.

ANNEX 1
Logical Framework Matrix

DESCRIPTION	VERIFIABLE INDICATORS	MEANS OF VERIFICATION	ASSUMPTIONS AND RISKS
Development Objective : To provide improved information to aid national preparedness for floods and to mitigate flood impacts.	Reduction of number of life lost on floods and lower property losses on floods through an improved flood warning system.	A. Review of monthly and yearly flood reports. B. Interview of village people regarding disseminated flood warnings.	FAP 11 implemented and results of project sustainable
Immediate Objective : To support Flood Forecasting and Warning Centre in order to improve performance with regard to increased mobilization of local resources and efficient utilisation of resources available.	1. Training provided to professional and technical staff. 2. Expanding number of forecast points on main and secondary rivers. 3. Improvement of lead time and accuracy for real time forecasts. 4. Improvement of facilities for hydrological and meteorological monitoring including data collection. 5. A fully comprehensive flood forecasting and warning centre established within bwdb	1. Capabilities of the staff now and earlier to be compared. 2. Number of forecasting points now and earlier to be compared. 3. Sample of lead time and accuracy statistics now and earlier to be compared. 4. Review of hydrologic and meteorologic information used for flood warning preparation now and earlier. 5. Review of the established facilities at the flood forecasting and warning centre	1. Availability of staff to be trained. 2. Availability of data from improved hydrometric network. 3. Availability of sufficient and reliable data for modelling. 4. Availability of data from external sources. Radar data from BMD and data from India. 5. Interest from Government to establish a comprehensive Flood Operation Centre in a new office with a yearly budget.
Outputs : 1. Real time forecasting at regional level and provision of coarse area inundation forecast for major parts of northern Bangladesh. 2. Forecast System for 2 flashy rivers established on pilot basis. 3. Improved data exchange with countries in the Ganges-Brahmaputra-Meghna. 4. A public awareness programme of the availability and understanding of flood warning and forecast information. 5. Trained staff. 6. Improved institutional structure within FFWC.	1a. Number of forecasting points increased from 16 to 30 including forecasts on secondary rivers.- 1b. Forecasting of inundation introduced on thana level. 2. Forecasting system on 2 flashy rivers has been established. 3. Improved communication with India. 4a. Phased level warnings introduced. 4b. Forecasts and Warnings presented 'userfriendly'. 4c. Improved dissemination system. 4d. Public Awareness developed in 3 pilot areas. 5a. At least 8 staff members at FFWC routine working with the expanded FFWS. 5b. Two teams of technicians capable to maintain the wireless radios. 6. FFWC established as a directorate.	1a, 1b and 2. Review of the flood forecasting bulletin and demonstration at FFWC. 3. Statistics of received data from India now and earlier. 4a. Review of the flood warning system used at FFWC. 4b. Interviews of different end users of the Forecasts and Warnings. 4c. Comparison of the dissemination system now and earlier. 4d. Interview of people in pilot areas. 5a. Simple test, through a demonstration of skills, know how and attitude. 5b. Review of the condition of the wireless radios in the field. 6. Compare the setup of the FFWC now and earlier.	1a. Availability of data from new stations. 1b. Availability of good topographic data. 2. Lack of continuos real time hydrologic data from the upstream catchments. 3. India refuse to improve the data transfer to Bangladesh. 4. Good cooperation with the Disaster Management Bureau. FAP11 project (support to DMB regarding disaster preparedness) is initiated. 5. Trained counterparts may leave the FFWC, due to transfer or better job opportunities. 6. Political support and will to expand the flood forecasting and warning services.

DESCRIPTION	VERIFIABLE INDICATORS	MEANS OF VERIFICATION	ASSUMPTIONS
Activities : 1.1 To maintain and monitor activities. 1.2 To Setup and modernize offices. 1.3 To improve communication system. 1.4 To improve computer and database system. 1.5 To implement supporting studies. 1.6 To train staff. 2.1 To develop a system for forecasting of water level on main and secondary rivers. 2.2 To develop a system for forecasting of area-inundation. 2.3 To develop a pilot system for forecasting of two flashy rivers. 3.1 To develop flood action and flood warning plan. 3.2 To establish principles and develop flood warning system. 3.3 To develop programmes for public awareness.	1.1 Project reports. 1.2a Existing FFWC modernized. 1.2b New workshop established. 1.2c New FFWC established in Green road 1.3a 40 new radios installed in the field. 1.3b Fast data link established between important offiecs. 1.4 Computer System upgraded and appropriate database developed. 1.5 Remote sensing used daily as an important tool at FFWC. 2.1 General Model for forecasting of main and secondary rivers. 2.2 GIS system for inundation mapping. 2.3 Model setup of 2 flashy river system. 3.1 Manual for flood action and flood warning. 3.2 Flood warning system incorporated at FFWC and DMB. 3.3 Education material.	1.1 Evaluation of report. 1.2a FFWC working satisfactory. 1.2b Inspection. 1.2c Inspection. 1.3a Less outfall of stations now and earlier compared. 1.3b Faster distribution of flood information now and earlier compared. 1.4 Evaluation report. 1.5 Interview of FFWC staff and reports. 2.1, 2.2, and 2.3 Demonstration of modelling system and review of reports. 3.1 Review of manual. 3.2 Evaluation of flood warning system. 3.3 Review of material and interview with end users.	1.1 Good cooperation with counterpart. 1.2 Availability of sufficient space for relocation of FFWC. 1.3 Approval of new technology for communication by Government. 1.4 Government interested to use new hardware and software developed. 1.5 Availability of data from new radar. 2. Availability of trained staff to maintain modelling system. 3. Availability of statistical data on previous floods.
Inputs: 1. Expatriate consultant services. 2. Local Consultant services. 3. Counterpart input. 4. Administrative supporting staff. 5. Computer hardware and software. 6. Office facilities. 7. Workshop facilities 8. Special data collection. 9. Data transfer links. 10. Remote Sensing. 11. Telemetric network. 12. Other project support. 13. Training program BGD and overseas	A. Approval of project. B. Progress of project.	A. Documents from Government. B. Progress Reports.	A. Availability of Government staff and funds. B. Approval of expatriate and local consultants. C. Approval of equipment procurement. D. New equipment delayed in the customs. E. Overseas training delayed due to slow approval of candidates.

ANNEX 2
Work Plan


1995
1996
1997
Achievement
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
31/3-1996
Module 1 - Coordinatin and Moni
50 %
1. Maintanance and monitoring.
50 %
2. Setup and Modernize offices.
80 %
3. Improve Communication System.
30 %
4. Improve Computer System.
70 %
5. Supporting Studies.
30 %
6. Training.
50 %
Module 2 - Model Development
70 %
1. Develop a system for forecasting on main and secondary rivers.
80 %
2. Develop a system for forecasting of area-inundation.
70 %
3. Develop a pilot system for forecasting on 2 flashy rivers.
30 %
Module 3 - Warning Dissemination
40 %
1. Develop a flood action plan and a flood warning plan.
40 %
2. Establish principles and develop a flood warning system.
45 %
3. Develop a program for public awareness.
35 %
Reporting (Module 1+2+3)

ANNEX 3
Budget and
Financial Status
1/7-1996

ITEM (mm = man month)	Accumulated Exp. 1/7-96	Remaining budget	Acc. exp. % of budget	Est.Expend. Q3-1996	Est. Expend. 1/7-31/12 1996	Est. Expend. 1997	Total Budget DKK	Total Bud. Lakh Taka
Module 1 Principal Consultant	11.5 mm	6.5 mm		1.5 mm	2.5 mm	4.0 mm	18 mm	
Module 1 Computer System Expert	6.8 mm	2.2 mm		0.7 mm	0.7 mm	1.5 mm	9 mm	
Module 1 Short Term Expert	10.1 mm	5.9 mm		2.0 mm	2.5 mm	3.4 mm	16 mm	
Module 2 Expert Services	9.9 mm	4.1 mm		1.3 mm	2.3 mm	1.8 mm	14 mm	
Module 3 Disaster Manag.Spec.	5.2 mm	6.8 mm		1.0 mm	2.0 mm	4.8 mm	12 mm	
Module 3 Forecast Applic.Spec.	2.5 mm	1.5 mm		1.0 mm	1.0 mm	0.5 mm	4 mm	
1. Cost of Expat. Consultants	4,295,611	2,682,570	62	700,000	1,050,000	1,632,570	6,978,181	488.47
2.1 Module 1	17,169	302,991	5	30,000	110,000	192,991	320,160	22.41
2.2 Module 2	474,888	165,432	74	70,000	70,000	95,432	640,320	44.82
2.3 Module 3	156,472	243,728	39	30,000	90,000	153,728	400,200	28.01
2. Cost of Local Consultant	648,529	712,151	48	130,000	270,000	442,151	1,360,680	95.25
3.1 International flight tickets	249,463	178,024	58	50,000	70,000	108,024	427,487	29.92
3.2 Accomendation and per Diem	704,856	483,594	59	140,000	200,000	283,594	1,188,450	83.19
3.3 School Fees	48,743	0	100	0	0	0	48,743	3.41
3. Travel Cost Expat.Consult	1,003,062	661,618	60	190,000	270,000	391,618	1,664,680	116.53
4.1 Admin, support staff	168,330	231,870	42	40,000	80,000	151,870	400,200	28.01
4.2 Office travel (BGD and region)	13,304	186,795	7	30,000	60,000	126,795	200,100	14.01
4.3 Reports: Printing cost etc.	16,427	130,313	11	5,000	10,000	120,313	146,740	10.27
4.4 Communication	16,323	37,037	31	5,000	10,000	27,037	53,360	3.74
4.5 O&M of equip, instal, vehicles	78,326	155,124	34	20,000	40,000	115,124	233,450	16.34
4.6 Office setup	134,947	131,853	51	5,000	10,000	121,853	266,800	18.68
4.7 Special data collection	57,297	76,103	43	20,000	30,000	46,103	133,400	9.34
4. Project Support	484,956	949,093	34	125,000	240,000	709,093	1,434,050	100.38
5.1 Data Transfer Link	57,859	142,241	29	30,000	50,000	92,241	200,100	14.01
5.2 Remote Sensing, Computers	0	333,500	0	0	0	333,500	333,500	23.35
5.3 Audio-visual equipment	0	126,730	0	20,000	30,000	96,730	126,730	8.87
5.4 Vehicles (2 Field and 1 Sedan)	177,290	102,849	63	0	0	102,849	280,140	19.61
5.5 Radio transceivers	794,223	6,177	99	5,000	6,000	177	800,400	56.03
5.6 Radio Spares	61,937	4,762	93	2,000	4,000	762	66,700	4.67
5.7 Office Equipment	220,530	12,920	94	10,000	12,000	920	233,450	16.34
5.8 Software Development Licenses	51,925	81,475	39	5,000	10,000	71,475	133,400	9.34
5. Equipment	1,363,764	811,321	63	72,000	112,000	699,321	2,174,420	152.21
6.1 Local in service training	41,646	125,104	25	30,000	40,000	85,104	166,750	11.67
6.2 Human Resource Development	0	200,100	0	0	200,100	0	200,100	14.01
6.3 Overseas Training	554,974	1,145,876	33	50,000	300,000	845,876	1,700,850	119.06
6. Training	596,620	1,471,080	29	80,000	540,100	930,980	2,067,700	144.74
Total 1.-6.	8,392,542	7,287,833	54	1,297,000	2,482,100	4,805,733	15,679,711	1097.58
7. Contigensies (10% of total)							1,567,971	109.76
GRAND TOTAL - (discount=150000)							17,097,682	1196.84

ANNEX 4

Plan for Installation of the Orion 7000 radios

Plan for Implementation of Orion 7000 Radio For Real Time Data Transfer

1. Introduction

As part of the FAP 10 project 40 Orion 7000 radios has been purchased. These radios will be the backbone of the extended real-time data collection and transmission system used for Flood Forecasting in the Flood Forecasting and Warning Center in Dhaka (FFWC). By the end of June, 11 of these radios have been installed by FAP 10's radio technician in cooperation with BWDB technicians and an additional 20 radios are proposed to be installed during 1996.

Until date the real-time data collection have been based on voice communication. This option is still available for the Orion 7000 radio system. However, as part of the implementation of the Orion 7000 radio a semi-automatic digital data transmission will also be introduced. In brief this involves that the gauge reader brings a data-logger (referred to as data-box) to the gauge and enters the water level and/or the rainfall depth while actually being at the gauge. The data are then stored in the data-box and the time of measuring is registered automatically. Subsequently, the gauge reader brings the data-box to the radio station and connects it to the Orion 7000 radio. All data stored in the data-box are then transmitted automatically to the central radio station in Dhaka. During the early implementation phase the central station has been located at DHI's office in Gulshan. When the new system has been successfully implemented the central station will be relocated to the FFWC. As a temporary solution data will be transmitted from Gulshan to FFWC through the telephone network, via a modem connection between computers in Gulshan and in FFWC. A similar arrangement will be made in regard to BWDB's office in Green Road. During the 1996 monsoon digital data-transmission is used at 11 stations. The remaining 20 Orion 7000 radios will initially use the traditional voice communication for data transfer. The future transmission technique will be agreed between DHI and BWDB based on the experiences with digital data transfer after the 1996 monsoon.

2. Status on Delivery of the Orion 7000 radios

By the end of June 1996, all 40 radios have been transferred to Dhaka. 11 radios are at present in operation at different BWDB stations (see table A4.1) 1 radio serves as central station in Gulshan and 1 is installed in Green Road. The remaining radios are stored at DHI's office in Gulshan and in Green Road and are ready to be installed.

3. Proposed Data Collection and Transmission Plan

It is proposed to establish 31 Real-Time stations based on the Orion 7000 radio system. These 31 stations will be established during 1996. Table A.4.1 provides an overview of the proposed stations including data collection, transmission schedules and a tentative installation time-schedule. The station type refers to the frequency of data collection and transmission. Three different types exists.:

1. *Normal* collection and transmission schedule
2. *NW-Flashy* collection and transmission schedule, and
3. *NE-Flashy* collection and transmission schedule.

The *normal* type makes 5 water level recordings each day and one rainfall recording and transmits data 4 times per day. For the Flashy River Forecasting pilot study carried out for the Karatoya-Atria river in the North-Western region (*NW-Flashy)* and for the Manu river in the North-Eastern region (*NE-Flashy)* a higher collection and transmission frequency as well as measurements 24 hours a day, are required. For the Flashy

river study in the North Western region, hourly data collections have been initiated and for the North Eastern flashy river study, 3 hourly data collections have been implemented. Hourly, data are however also needed for the Manu river study, but these are provided by a telemetry system being established by the Japanese Radio Corporation. Hence, when this telemetry system has been successfully implemented the Orion 7000 radios installed at Manu Railway bridge can be used elsewhere. Thus, the radio installed at Manu railway bridge serves as a temporary backup for the telemetric system. Finally, the real-time station in Chandpur also uses hourly recording 24 hours a day. The reason for that is that Chandpur serves an important purpose as downstream boundary condition in the MIKE11 FF model and that the tidal effects are significant at Chandpur. The data collection and transmission schedule at Chandpur is identical to that of the *NW flashy* rivers. Detailed data collection and transmission schedules for the three station types are enclosed in Annex 4.1. Table A.4.1 and A.4.2 provides an overview of all Orion 7000 radio stations and of the Japanese Telemetry stations, respectively.

Table A.4.1 List of Real Time Stations based on the Orion 7000 radio including data collection and transmission schedule and time-schedule for installation of radios.

Station no	Station Name	Water level	Rainfall	data-box installed (2)	Installation date	Station type
1	Panchagarh	+	+	+	Apr-May 1996	Flashy NW
2	Bhusirbander	+	-	+	Apr-May 1996	Flashy NW
3	Dinajpur	+	+	+	Apr-May 1996	Flashy NW
4	Badarganj	+	+	+	Apr-May 1996	Normal
5	Rohanpur	+	+	+	Apr-May 1996	Normal
6	Taraghat/Jagir	+	-	+	Apr-May 1996	Normal
7	Chakrahinbur	+	+	+	Apr-May 1996	Normal
8	Gaibanda	+	+	+	Apr-May 1996	Normal
9	Moulvi Bazar	+	+	+	Apr-May 1996	Flashy NE
10	Manu Rlw Brd	+	+	+	Apr-May 1996	Flashy NE
11	Chandpur	+	+	+	Apr-May 1996	Tidal (1)
12	Chapai Nawabganj	+	+	-	July 1996	Normal
13	Aricha	+	-	-	July1996	Normal
14	Sylhet	+	+	-	July 1996	Normal
15	Kurigram	+	+	-	July 1996	Normal
16	Sattkira	+	+	-	July 1996	Normal
17	Faridpur	+	+	-	July 1996	Normal
18	Chittagong	+	+	-	July 1996	Normal
19	Phulbari	+	+	-	August 1996	Normal
20	Mohadevpur	+	+	-	August 1996	Normal
21	Sarighat	+	-	-	August 1996	Normal
22	Bogra	-	+	-	August 1996	Normal
23	Nakuagaon	+	+	-	August 1996	Normal
24	Rajshahi	+	+	-	Sep-Dec 1996	Normal
25	Durgapur	+	+	-	Sep-Dec 1996	Normal
26	Bahadurabad	+	-	-	Sep-Dec 1996	Normal
27	Serajganj	+	+	-	Sep-Dec 1996	Normal
28	Hardinge Bridge	+	-	-	Sep-Dec 1996	Normal
29	Bhairab Bazar	+	+	-	Sep-Dec 1996	Normal
30	Sunamganj	+	+	-	Sep-Dec 1996	Normal
31	Kaunia	+	+	-	Sep-Dec 1996	Normal

(1) Data and collection and transmission schedule as for Flashy-NW.
(2) Status by the end of June 1996.

In addition 1 radio is installed in Green Road and one will be installed in the WAPDA building (FFWC - Central station). The remaining 7 radios will be kept in reserve at BWDB in Green Road.

During April-May 1996, 11 radios were installed by FAP-10's radio technician. Most of the remaining stations are to be installed by BWDB technicians.

3.1 Actions to be taken by BWDB

In order to accomplish the implementation of the Orion 7000 radio system the following actions must be taken by BWDB:

- water level measurements must be initiated at station 22 (Bogra) as soon as possible.
- a new rainfall gauge should be installed in Bhusirbander to be used for the flashy river study on the Karatoya-Atria river. The *NW-Flashy* collection and transmission schedule should be employed.

For station 1-11 digital data transmission is adopted, but initially the remaining stations (12-31) will use normal voice communication. Remaining stations may adopt digital data transfer at a later stage. This will be agreed with BWDB.

3.2 Telemetry System

A Japanese Telemetry system are being established at 14 locations on selected rivers of Bangladesh. These stations provide hourly measurements of water level and/or rainfall which complements the FAP10 real time stations. Data are automatically transferred to a central computer in FFWC. Table A.4.2 lists the stations included in the telemetry system.

Table A.4.2 Stations Included in Japanese Telemetry System

Station no.	Station name	Water level	Rainfall
T1	**Zakiganj**	+	+
T2	**Sherpur**	+	-
T3	**Dhalai**	+	-
T4	**Manu Rlw Bridge**	+	+
T5	**Shaistaganj**	+	-
T6	**Kamalganj**	-	+
T7	**Jatrapur**	+	+
T8	**Pankha**	+	+
T9	**Tongi**	+	-
T10	**Nayarhat**	+	-
T11	**Mirpur**	+	-
T12	**Mill-Barak**	+	-
T13	**Narayanganj**	+	+
T14	**Rekabi Bazar**	+	-

Annex 4.1 Data Collection and Transmission Schedules

Data Collection And Transmission Schedule (Normal)

Data Collection and Transmission Schedule			
Time	*Water level (cm)*	*Rainfall depth (mm)*	*Radio Transmission*
1			
2			
3			
4			
5			
6	6.00		
7			6.30 - 7.30
8			
9	9.00	9.00	
10			9.30 - 10.30
11			
12	12.00		
13			12.30 - 13.30
14			
15	15.00		
16			15.30 - 16.30
17			
18	18.00		
19			
20			
21			
22			
23			
24			

Data Box Usage

1) Bring the box to the gauge.
2) Press <1> to activate the box
3) Press <1> to enter water level (cm), or
   Press <2> to enter rainfall depth (mm)
4) Enter the water level or the rainfall

Entering Dummy Data

If you enter data which are not a real measurement, for instance, if you are demonstrating the box for other persons, you must enter the data value 8888. When receiving the value 8888 at the radio central in Dhaka this value will be filtered out.

Data Transmission

The data box must be connected to the radio whenever possible. As a minimum the box must be connected to the radio for 30 min. whenever data are transmitted. Data must be collected and transmitted in accordance with the agreed "Data Collection and Transmission schedule"

Usage of Data

The data are registrered in Dhaka and used to forecast the water level in the most important rivers of Bangladesh. In near future these forecasts will be broadcasted in Bangladesh television and radio and through other medias. Without timely and correct water level and rainfall measurements this cannot be done

This data collection and transmission schedule has been agreed between:

Gauge Reader: _____ and FAP10 or BWDB representative: _____

Data Collection And Transmission Schedule (Flashy NW)

Data Collection and Transmission Schedule			
Time	*Water level (cm)*	*Rainfall depth (mm)*	*Radio Transmission*
1	1.00		
2	2.00		
3	3.00	3.00	
4	4.00		
5	5.00		
6	6.00	6.00	
7			6.30 - 7.30
8	8.00		
9	9.00	9.00	
10			9.30 - 10.30
11	11.00		
12	12.00	12.00	
13			12.30 - 13.30
14	14.00		
15	15.00	15.00	
16			15.30 - 16.30
17	17.00		
18	18.00	18.00	
19			18.30 - 19.30
20	20.00		
21	21.00	21.00	
22	22.00		
23	23.00		
24	24.00	24.00	

Data Box Usage

1) Bring the box to the gauge.
2) Press <1> to activate the box
3) Press <1> to enter water level (cm), or
   Press <2> to enter rainfall depth (mm)
4) Enter the water level or the rainfall

Entering Dummy Data

If you enter data which are not a real measurement, for instance, if you are demonstrating the box for other persons, you must enter the data value 8888. When receiving the value 8888 at the radio central in Dhaka this value will be filtered out.

Data Transmission

The data box must be connected to the radio whenever possible. As a minimum the box must be connected to the radio for 30 min. whenever data are transmitted. Data must be collected and transmitted in accordance with the agreed "Data Collection and Transmission schedule"

Usage of Data

The data are registrered in Dhaka and used to forecast the water level in the most important rivers of Bangladesh. In near future these forecasts will be broadcasted in Bangladesh television and radio and through other medias. Without timely and correct water level and rainfall measurements this cannot be done

This data collection and transmission schedule has been agreed between:

Gauge Reader: _____ and FAP10 or BWDB representative: _____

Data Collection And Transmission Schedule (Flashy NE)

Data Collection and Transmission Schedule			
Time	*Water level (cm)*	*Rainfall depth (mm)*	*Radio Transmission*
1			
2			
3	3.00		
4			
5			
6	6.00		
7			6.30 - 7.30
8			
9	9.00	9.00	
10			9.30 - 10.30
11			
12	12.00		
13			12.30 - 13.30
14			
15	15.00		
16			15.30 - 16.30
17			
18	18.00		
19			18.30 - 19.30
20			
21	21.00		
22			
23			
24	24.00		

Data Box Usage

1) Bring the box to the gauge.
2) Press <1> to activate the box
3) Press <1> to enter water level (cm), or
   Press <2> to enter rainfall depth (mm)
4) Enter the water level or the rainfall

Entering Dummy Data

If you enter data which are not a real measurement, for instance, if you are demonstrating the box for other persons, you must enter the data value 8888. When receiving the value 8888 at the radio central in Dhaka this value will be filtered out.

Data Transmission

The data box must be connected to the radio whenever possible. As a minimum the box must be connected to the radio for 30 min. whenever data are transmitted. Data must be collected and transmitted in accordance with the agreed "Data Collection and Transmission schedule"

Usage of Data

The data are registrered in Dhaka and used to forecast the water level in the most important rivers of Bangladesh. In near future these forecasts will be broadcasted in Bangladesh television and radio and through other medias. Without timely and correct water level and rainfall measurements this cannot be done

This data collection and transmission schedule has been agreed between:

Gauge Reader: _____ and FAP10 or BWDB representative: _____

ANNEX 5

Pilot System for Forecasting of 2 flashy rivers

FLOOD FORECASTING IN FLASHY RIVER CATCHMENTS

1. INTRODUCTION

Many of the rivers in the North-Eastern and North-Western regions of Bangladesh shows a flashy behaviour. Flashy river catchments are typically mountainous with steep slopes which rapidly leads excess rainfall to the rivers, often with a time of concentration of less than 24 hours. Hence, when heavy showers occur in the catchment a very fast response is seen in the rivers. For some rivers the water level may rise with more than 1 meter per hour which may bring the water level from a "normal" water level to danger level in as little as 6-12 hours. In flash-flood prone areas extensive flooding may occur almost without warning causing losses of human lives and animals as well as damaging of crops and house holds.

Along the north-eastern and north-western borders of Bangladesh such flashy rivers enters Bangladesh from India. Often the major part of the catchment area is lying within India which, at present, limits data availability and thus makes traditional rainfall-runoff based flood-forecasting impossible. In order to provide flash-flood warnings other methodologies must be used.

2. OBJECTIVES

As part of FAP-10 a pilot study on forecasting of Flashy-rivers is carried out. The objective of this pilot study is to test if flood-forecasting on Flashy rivers is possible and subsequently give recommendations for suitable forecasting methodologies.

3. STATUS AND EXPERIENCES SO FAR

The flashy river pilot studies was initiated in the middle of May 1996 and will continue during the 1996 monsoon. Based on the experiences from the 1996 monsoon FAP-10 will give recommendations for flashy-river flood forecasting methodologies suitable for Bangladesh conditions.

3.1 Selected Pilot Study Catchments

Two catchments have been selected for the flashy river pilot study. The Karatoya-Atria river system in the North West region and the Manu river in the North East region of Bangladesh. In the Karatoya-Atria river system flash-flood events typically occur in the period May-July while events in Manu river generally takes place a bit earlier, in April-June.

3.1.1 Karatoya-Atria River System

In the north-western region the Karatoya-Atria river system, including Dhepa and Punarbhaba, were chosen. The Karatoya river enters Bangladesh about 20 km north of Panchagarh, where a Bangladesh Water Development Board (BWBD) gauging station is located providing real-time rainfall and water level data. Some 30 km upstream of Bhusirbander the Karatoya-Atria river is connected to the Dhepa river, which in Dinajpur is connected with the Punarbhaba river.

The total catchment area is about 3,500 km2 of which about 30% is located within India. Within the catchment rainfall and water level data is available at BWDB stations in Panchagarh, Phulbari, Bhusirbander and Dinajpur. Hence, in this catchment it is expected that traditional rainfall-runoff flood-forecasting using MIKE11-FF, will be possible.

It is intended to forecast water levels at the two real-time stations in Bhusirbander on Atria and in Dinajpur

on Punarbhaba. At Dinajpur the water level practically only depends on the rainfall in the Punarbhaba/Dhepa catchments and thus forecasting is possible only based on Bangladesh rainfall data. In Bhusirbander the water level dynamics also depends on the rainfall data in India. However, most of the catchment is located within Bangladesh and rainfall analysis indicates that the rainfall station in Panchagarh represents the rainfall in India reasonably good, thus it is expected that the available data will enable a MIKE11 FF approach.

A MIKE11 FF model setup for the Karatoya-Atrai river system has been established and preliminarily calibrated. The performance of the model will be tested and fine tuned on data collected during the 1996 monsoon.

3.1.2 The Manu River System

The Manu River enters Bangladesh in the North-East about 40 km South-East of Moulvi Bazar. More than 80% of the Manu river catchment is located in the mountainous Tripura region of India. The data availability in the catchment is limited to the rainfall and water level stations at Manu railway bridge and in Moulvi Bazar. No Indian real-time rainfall data is presently available. Due to the large surface topographic changes along the Indian border there is very little correlation between the rainfall measured at Manu railway bridge and the rainfall in the Indian part of the river catchment. Interviews with local people at Manu Railway Bridge, 10 km west of the Indian Border, show that flash-flood events are totally controlled by the rainfall in India. Often it is not even raining in Bangladesh prior to, or during flash flood events. Hence, without rainfall data from India rainfall-runoff flood forecasting is impossible. Although the water level in Moulvi Bazar, which is the largest settlement along the Manu river, could be forecasted using MIKE11 FF, based on the water level at the Manu Railway Bridge real-time station, this will only provide a warning in the order of a couple of hours, which is not of much use. Hence, alternative methodologies must be employed for Manu river.

One possibility would be to issue flash flood-warnings only based on the "shape" of the hydrograph in the early stage of a flash flood event. This would require that frequent data (hourly) is recorded as close to the Indian border as possible (eg. Manu railway bridge) 24 hours a day. It is expected that a flash-flood warning can be issued 6-12 hours prior to the event. Such simple approaches is being used in other parts of the world, eg. in India and in England. Such an approach would probably be very uncertain since it, only to a very limited extend, takes into account the state of the river when the event occurs. For instance, a flood event that follows just a couple of days after another event, may have a completely different impact because all available water storage on flood-plains, lakes etc. was filled up by the first event.

As outlined above such a methodology is based on simple "pattern recognition" where a certain water level increase rate at one or more points will release a flash flood warning. A much more complex, and increasingly used pattern recognition methodology is the so called neural networks which, in principle simulates the behaviour of the human brain. Before a neural network can be used it needs to be trained, implying that it must be fed with as much relevant historic information as possible. If a neural network has been sufficiently trained (ie. fed with sufficient water level data from flash flood events) it may be able to identify patterns that can be used to predict how the water level will develop some hours ahead. Such a methodology is being tested on the Manu river. The neural network is being trained on water level data measured at Moulvi Bazar and at Manu railway bridge. It will be tested whether a neural network will be able to predict water levels at Manu railway bridge and at Moulvi Bazar based on real-time water level data. The biggest problem in this regard is probably whether sufficient data is available to ensure a proper training of the network. If the neural network approach turns out successfully it is expected that a water level forecast 6-12 hours ahead can be issued.

3.2 Preliminary Conclusions

Flash flood forecasting is being tested on two pilot areas in Bangladesh and will continue during the 1996 monsoon. On the basis of the experiences obtained during the monsoon a number of recommendations and

conclusions will be made.

Forecasting on flashy rivers is a difficult task where the key-problem is, not surprisingly, related to the (limited) time available for forecasting. In the best case it may be possible to issue reliable flash flood warnings/forecasts 8-24 hours ahead of the event, depending on the characteristics and data availability in the river catchment. Hence, if such a warning should be of any benefit to the inhabitants a very efficient flood warning and dissemination system is required.

Another key problem when forecasting in flashy river catchments is that forecasting require detailed real-time data. In some flashy river catchment a flood occurs maybe 12-24 hours after the start of the rainfall event. In such cases frequent real-time data is needed 24 hours a day. In general hourly water level and rainfall data must be provided. Hence, data collection for flash flood forecasting will require many human resources to read gauges and transmit data. Moreover, the collected data is of limited use unless forecasts are made frequently and 24 hours a day, implying that the Flood Forecasting & Warning Center must be manned 24 hours a day.

The overall conclusions made so far is that traditional rainfall-runoff flood forecasting can be made in a flashy river catchment if sufficient real-time data is available. For such catchments it may be possible to issue warnings 12-24 hours ahead of the event. However, for many of the flashy river catchments in Bangladesh sufficient data is, at present, not available due to the fact that most flash flood events is created by rainfall events in India. Under such circumstances it is very difficult to provide a reasonable warning time. Only a few hours can be expected, and thus a warning may be of limited use for most people in the flash flood prone areas.

ANNEX 6
Proposed Flood Warning Dissemination Trials

Proposed Flood Warning Dissemination Trials

Introduction

FAP10 is a 3 year project (1995 - 1997) in which Module 3 is a programme of public awareness of the availability and understanding of flood warning and forecast information and of the benefits to be derived from their use.

The World Meteorological Organisation which is undertaking Module 3 has recently produced proposals for a National Flood Forecasting and Response System for Bangladesh (FFWRS), comprising:

- A draft for a Bangladesh Flood Warning Manual, which establishes the basic philosophy and principles for flood warning, to develop increased awareness and participation by other agencies and by community leaders.
- Education and publicity material to raise flood awareness at community level.
- A structured classification of flood warning and information products which separates information and forecasts from warning messages and supplies key information to decision makers in a concise form.
- A suite of phased warning messages that introduce early notification to other agencies and additional phases of warning messages as the severity and impact of flooding increases.
- Warning messages origanating from credible and authoritative sources [nationally from FF&WC of BWDB, locally from DC (prompted by FF&WC)].
- Warning messages designed to communicate effectively to members of the community at risk by using simple messages; these would also be broadcast in appropriate local dialects.
- Warning messages providing information on the impact of flooding.
- Increased use of Bangladesh Radio and TV to broadcast flood warning messages
- Plans for Flood Marker Posts in villages and at BWDB river water level stations showing, by means of coloured bands, the likely level of flooding . The warning messages will advise which colour and band of severity is being warned.
- Compatibility and ultimately integration with Emergency Standing Orders for Disaster

The FAP10 programme incorporates a period of testing of the flood warning arrangements during the 1996 monsoon season, followed by a period of field work to assess their effectiveness and revision during the winter 1996/7. Further testing in 1997 will be followed by minor revisions and the development of a Long Term Plan for nationwide implementation.

An associated programme of social science work is evaluating the impact of forecast and warning information and identifying the sociological features of community response. Four locations have been selected for field work by local social science consultants; these are at Jamalpur, Manikganj, Nawaganj and Maulabibazar.

The field work has still to be analysed fully, but some initial conclusions can de drawn:

- Indigenous knowledge in rural populations on flooding and how to respond to flood threats is much lower than expected.
- Villagers get very little information on flood threats from the official flood warning system. Messages do not disseminate down to local officials so cannot be distributed in communities.
- Local people demand support from central authorities but lack knowledge of what could be provided. Many are completely unaware that BWBD operates a Flood Forecasting & Warning Centre, which issues flood warnings.

Trial Implementation of Dissemination Plan

It is proposed that only pilot areas should receiving the full suite of phased warning messages on a trial basis during 1996 monsoon. However, it is also intended to produce general "demonstration" warning messages for dissemination whenever FF&WC forecasts predict flooding as a result of rivers exceeding Danger Level. These would be broadcast on radio and TV and issued to the press during the 1996 monsoon. Existing recipients of Bulletins, Summaries etc from FF&WC would also receive these messages as well as more detailed information on the flood situation. The warning messages will be simpler and clearer than those issued by FF&WC in the past and should enable all communities to increase their awareness of a flood threat. They will also increase general awareness in the community of the existence of a National Flood Warning Service.

However, it is not expected that the response to general warnings will be as full as that which would be achieved where awareness has been increased in the community by a programme of eduction and public information.

It is, therefore, proposed that this programme should be introduced into selected villages in the pilot areas as part of this year's 1996 trial. It would comprise:

- Four pilot areas at the same location as the social science field work
- Introduction of educational material into Grades 5, 8 & 10.
- Construction of BWBD Flood Marker Posts in villages
- Publicity programmes including posters and information booklets
- Short (3-5 minute slot) TV and radio programmes broadcast nationwide to provide general information and publicity about flood warning.
- Training for key local authority staff on what to do on receipt of a warning
- Warnings broadcast on TV and radio.
- Dissemination of warnings to local communities by direct communication from Dhaka, using Disaster Management Bureau radio to pass warnings to DC who would be responsible for onward transmission to TNO. (DC has access to police radio would normally be expected to use this to communicate with Thanas.)
- Preparation of Action Plan (tick-list) for use by TNO in response to a received warning or when river reaches a trigger level.

ANNEX 7
Model Flood Warning Message

Model Flood Warning Messages

1 Flash Flood Watch

2 Flash Flood Warning

3 Monsoon Flood Watch

4 General Flood Warning (Medium Monsoon Flood)

5 Severe Flood Warning (Severe Monsoon Flood)

6 Rainfall Flood Watch

7 General Flood Warning (Medium Rainfall Flood)

8 Severe Flood Warning (Severe Rainfall Flood)

9 Widespread and Very Severe Flood Warning
(Catastrophic Monsoon or Rainfall Flood)

[Model Flash Flood Watch]

FLASH FLOOD WATCH
NOT FOR BROADCAST OR PUBLIC RELEASE

This Flood Watch is issued by Flood Forecasting and Warning Centre telephone xxxxxx

DISASTER MANAGEMENT BUREAU should IMMEDIATELY transmit this message to ALL DISTRICTS in the vulnerable Region.

All NATIONAL AGENCIES and LOCAL ADMINISTRATION in the vulnerable areas should prepare for the possibility of flooding and IMMEDIATELY INITIATE the ALERT stage of their ESO ACTION PLAN.

BANGLADESH RADIO and TV should standby to receive and broadcast all Flood Warnings that may be issued at any time in next 3 days.

This Flood Watch should NOT be passed to the public

A Flash Flood Watch for *<regionname>* was issued at *<time>* on *<day>* *<date>* to initiate ALERT stage of Emergency Standing Orders

The BWDB Flood Forecasting and Warning Centre reports River(s) *rivername* are flowing close to Danger Level.

Bangladesh Meteorological Department forecasts that intense and torrential rainfall is expected over these areas and in the neighbouring hills of India for the next few days.

As a result conditions in which flash flooding might occur are likely to develop over *regionname* of Bangladesh. The Districts of *districtname* are most likely to experience the flash flooding, which would cause damage to property.

This is an **alert of possible flash flooding** for agencies and NGOs. BWDB and Local Administration at all levels should

follow the ALERT stage of their ESO Action Plans and advise NGOs to prepare to respond when Flood Warning is issued.

FF&WC will issue updates at 12.00 noon and 6.00PM until further notice

[Message ends]

17 June 1996

[Model for Flash Flood]

FLOOD WARNING FOR IMMEDIATE BROADCAST

This Flood Warning is issued by Flood Forecasting and Warning Centre telephone xxxxxx

DISASTER MANAGEMENT BUREAU should IMMEDIATELY transmit this message to ALL DISTRICTS in the vulnerable Region.

BANGLADESH RADIO and TV should broadcast this Flood Warning IMMEDIATELY and hourly on National & Local Radio and arrange for <*radiostations*> Radio Stations to broadcast throughout the night.

This Warning should not be broadcast after <*lasttime*>

A Warning of Flash Flooding for <*regionname*> Region was issued at <*time*> and <*day*> <*date*>.

The BWDB Flood Forecasting & Warning Centre reports that River(s) <*rivername*> are flowing very close to Danger Level.

Meteorological Department forecasts more intense and heavy rainfall in next few days over upstream catchment areas.

BWDB advises that river levels will increase further and a flash flood is highly likely anytime in <*districtname*>.

Flash flooding causes water to flow at dangerous and high speed. The Disaster Management Bureau advises people to be prepared for a sudden onrush of water and to take particular care of children and the elderly.

Severe damage to property and crops and disruption to communications are likely.

BWDB and Local Administration Officers at all levels should follow their ESO Action Plans and together with NGOs should prepare to respond to flooding.

You should listen to radio for further information. This

information will be updated at *lasttime* through *radiostations* local radio.

A Warning of Flash Flooding has been issued for *regionname*>
Region

[Message ends] 17 June 1996

[Model Monsoon Flood Watch]

MONSOON FLOOD WATCH
NOT FOR BROADCAST OR PUBLIC RELEASE

This Flood Watch is issued by Flood Forecasting and Warning Centre telephone xxxxxx

DISASTER MANAGEMENT BUREAU should IMMEDIATELY transmit this message to DISTRICTS

All NATIONAL AGENCIES and LOCAL ADMINISTRATION in the vulnerable areas should prepare for the possibility of flooding and IMMEDIATELY INITIATE the ALERT stage of their ESO ACTION PLAN.

BANGLADESH RADIO and TV should standby to receive and broadcast all Flood Warnings that may be issued at any time in next 3 days.

This Flood Watch should NOT be passed to the public

A Monsoon Flood Watch for <*regionname*> was issued at <*time*> on <*day*> <*date*>to initiate ALERT stage of Emergency Standing Orders

The BWDB Flood Forecasting and Warning Centre reports that major rivers in the region are rising steadily and approaching close to Danger Level.

BWDB observers report heavy rainfall over last few days and Meteorological Department forecasts further heavy downpour in the next few days.

As a result the River(s) *rivername* are expected to exceed Danger Level within next 3 days and monsoon flood conditions are liable to develop over *regionname* of Bangladesh. The Districts of *districtname* are most likely to experience flooding.

Low lying areas risk inundation within a few days and evacuation from Char and Haor areas may become necessary.

This is an **alert of possible flooding** for agencies and NGOs. BWDB and Local Administration at all levels should follow the ALERT stage of their ESO Action Plans and advise NGOs to prepare to respond when Flood Warning is issued.

FF&WC will issue updates at 12.00 noon and 6.00PM until further notice

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[Message ends] 17 June 1996

[Model Message for Medium Monsoon]

FLOOD WARNING FOR IMMEDIATE BROADCAST

This Flood Warning is issued by Flood Forecasting and Warning Centre telephone xxxxxx

DISASTER MANAGEMENT BUREAU should IMMEDIATELY transmit this message to DISTRICTS.

BANGLADESH RADIO and TV should broadcast this Flood Warning IMMEDIATELY and hourly on National & Local Radio.

This Warning should not be broadcast after *lasttime*

A Warning of General Flooding for <*districtname*> District was issued at <*time*> and <*day*> <*date*>.

The BWDB Flood Forecasting & Warning Centre reports that the River(s) <*rivername*> are rising and flowing close to or above Danger Level.

BWDB observers report moderate monsoon rainfall in last 24 hours in *rainfallregion* and Meteorological Department forecasts more rainfall in next few days.

River levels will continue to rise and areas of all Thanas in particular < *thananames*> will experience general flooding. This will affect low lying villages and may cause some property damage and disruption to local communications.

Flood water will inundate low-lying areas of many Districts during the next 24 hours. It will rise into the BLUE zone in those villages with a Flood Marker Post. Damages to crops and fisheries are expected.

The Disaster Management Bureau advises people to keep grain and livestock in a safe place. People in low lying areas are advised to harvest standing crops. People in low lying areas should prepare for evacuation.

BWDB and Local Administration Officers at all levels should follow their ESO Action Plans and together with NGOs should prepare to respond to flooding.

You should listen to radio for further information. This information will be updated at *lasttime* through radio and television.

A Warning of General Flooding has been issued for <*districtname*>

[Message ends] 17 June 1996

[Model Message for Severe Monsoon]

FLOOD WARNING FOR IMMEDIATE BROADCAST

This Flood Warning is issued by Flood Forecasting and Warning Centre, telephone xxxxxx

DISASTER MANAGEMENT BUREAU should IMMEDIATELY transmit this message to DISTRICTS.

BANGLADESH RADIO and TV should broadcast this Flood Warning IMMEDIATELY and hourly on National & Local Radio and arrange for *<radiostations>* **Radio Stations to broadcast throughout the night.**

This Warning should not be broadcast after *<lasttime>*

A Warning of Severe Flooding for Districts of *<districtname>* was issued at *<time>* on *<day>* *<date>*

The BWDB Flood Forecasting & Warning Centre reports continuing heavy monsoon rainfall in *<regionname>* of the country and that River(s) *<rivername>* are flowing well above Danger Level.

Meteorological Department forecast further rainfall over many parts of the upper regions.

FF&WC forecasts predict that river levels will increase further over next few days. Flood water will rise above the BLUE zone on Flood Marker Posts and will inundate large areas of all these Districts during the next 48 hours.

Flooding will occur in many rural areas and may affect some towns. Damages to property are expected. Roads, railways, embankments and bridges are likely to be washed and damaged.

The Disaster Management Bureau says people should move livestock, food grain and valuables to a safe place. DMB also warns of a risk of a serious risk of epidemics and advises people to only drink purified water and to procure packaged oral saline if required. People in the worst areas should prepare for evacuation within next 24 hours.

District flood control rooms will remain open day and night and together with local disaster preparedness committee members will issue further local advice.

You should remain alert and listen to radio bulletins for further information. This bulletin will be updated at *lasttime* through *radiostations* of local radio.

A Warning of Severe Flooding has been issued for *districtname* Districts.

[Message ends]

17 June 1996

[Model Rainfall Flood Watch]

FLOOD WATCH
NOT FOR BROADCAST OR PUBLIC RELEASE

This Flood Watch is issued by Flood Forecasting and Warning Cell, telephone xxxxxx

DISASTER MANAGEMENT BUREAU should IMMEDIATELY transmit this message to DISTRICTS

All NATIONAL AGENCIES and LOCAL ADMINISTRATION in the vulnerable areas should prepare for the possibility of flooding and IMMEDIATELY INITIATE the ALERT stage of their ESO ACTION PLAN.

BANGLADESH RADIO and TV should standby to receive and broadcast all Flood Warnings that may be issued at any time in next 3 days.

This Flood Watch should NOT be passed to the public

A Flood Watch for <*regionname*> was issued at <*time*> on <*day*> <*date*> to initiate ALERT stage of Emergency Standing Orders

The BWDB Flood Forecasting and Warning Centre has received reports of heavy rainfall in *regionname* and that drainage is being restricted by rising rivers in that region.

Bangladesh Meteorological Department forecasts further heavy rainfall in the next few days.

As a result flood conditions are likely to develop over *regionname* of Bangladesh. The Districts of *districtname* are most likely to experience flooding.

Low lying areas risk inundation within a few days and damage to standing crops and pond fisheries may occur.

This is an **alert of possible flooding** for agencies and NGOs. BWDB and Local Administration at all levels should follow the ALERT stage of their ESO Action Plans and advise NGOs to

prepare to respond when Flood Warning is issued.

FF&WC will issue updates at 12.00 noon and 6.00PM until further notice

[Message ends] 17 June 1996

[Model Message for Medium Rainfall]

FLOOD WARNING FOR IMMEDIATE BROADCAST

This Flood Warning is issued by Flood Forecasting and Warning Centre telephone xxxxxx

DISASTER MANAGEMENT BUREAU should IMMEDIATELY transmit this message to DISTRICTS.

BANGLADESH RADIO and TV should broadcast this Flood Warning IMMEDIATELY and hourly on National & Local Radio.

This Warning should not be broadcast after *lasttime*

A Warning of General Flooding for *<districtname>* **District was issued at** *<time>* **and** *<day>* *<date>*.

The BWDB Flood Forecasting & Warning Centre reports heavy rainfall in last 24 hours and that high river levels are preventing runoff.

Meteorological Department forecasts more heavy rainfall in next few days.

BWDB forecasts that river levels will continue to rise and advise that inundation of low lying areas of all Thanas may occur. This will particularly affect low lying villages and may cause some property damage and disruption to local communications.

Flood water will inundate low-lying areas of many Districts during the next 24 hours. It will rise into the BLUE zone in those village with a Flood Marker Post. Damages to crops and fisheries are expected.

The Disaster Management Bureau advises people to keep grain and livestock in a safe place. People in low lying areas are advised to harvest standing crops.

BWDB and Local Administration Officers at all levels should follow their ESO Action Plans and together with NGOs should prepare to respond to flooding.

You should listen to radio for further information. This information will be updated at *lasttime* through radio and

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television.

A Warning of General Flooding has been issued for <*districtname*> Districts

[Message ends] 17 June 1996

[Model for Severe Rainfall]

FLOOD WARNING FOR IMMEDIATE BROADCAST

This Flood Warning is issued by Flood Forecasting and Warning Centre Telephone xxxxxx

DISASTER MANAGEMENT BUREAU should IMMEDIATELY transmit this message to DISTRICTS.

BANGLADESH RADIO and TV should broadcast this Flood Warning IMMEDIATELY and hourly on National & Local Radio and arrange for *radiostations* Radio Stations to broadcast throughout the night.

This Warning should not be broadcast after *lasttime*

A Warning of Severe Flooding for Districts of <*districtname*> was issued at <*time*> on <*day*> <*date*>

The BWDB Flood Forecasting & Warning Centre reports continuing and exceptional heavy rainfall in *regionname* of the country and that high levels in most rivers are seriously preventing runoff from country areas.

Meteorological Department forecasts further heavy rainfall over many parts of the region.

FF&WC forecasts predict that river levels will increase further over next few days. Flood water will rise above the BLUE zone on Flood Marker Posts and will inundate large areas of all these Districts during the next 48 hours.

Flooding will occur in many rural areas and may affect some towns. Water levels are expected to remain high for the next few days.

Damages to property are expected. Roads, embankments and bridges are likely to be washed and damaged. Communications by road and rail will become difficult.

The Disaster Management Bureau says people should move livestock, food grain and valuables to a safe place. DMB also warns of a risk of a serious risk of epidemics and advises people to only drink purified water and to procure packaged oral saline if required. People in the worst areas should prepare for evacuation within next 24 hours.

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District flood control rooms will remain open day and night and together with local disaster preparedness committee members will issue further local advice.

You should remain alert and listen to radio bulletins for further information. This bulletin will be updated at *lasttime* through *radiostations* local radio.

A Warning of Severe Flooding has been issued for *districtname* Districts.

[Message ends] 17 June 1996

[Model Message for Catastrophic Flooding]

FLOOD WARNING FOR IMMEDIATE BROADCAST

This Flood Warning is issued by Flood Forecasting and Warning Centre xxxxx

DISASTER MANAGEMENT BUREAU should IMMEDIATELY transmit this message to DISTRICTS.

BANGLADESH RADIO and TV should broadcast this Flood Warning IMMEDIATELY and hourly on National & Local Radio and arrange for ALL Radio Stations to broadcast throughout the night.

This Warning should not be broadcast after *<lasttime>*

A Warning of Widespread and Very Severe Flooding for Districts of *districtname* was issued at *time* on *day* *date*

The BWDB Flood Forecasting & Warning Centre reports continuing and exceptional heavy rainfall in *regionname* of the country and abnormally high river levels.

FF&WC forecasts predict that river levels will increase further over next few days and will be close to recorded highest levels. Flood water will rise into the RED zone on Flood Marker Posts and will inundate large areas of all these Districts during the next 48 hours.

Flooding in rural areas will worsen and will spread into many areas of the towns and cities. Water levels are expected to remain high for many days.

Serious damages to property will occur and all communications will be seriously disrupted. Further damages to roads, railways, embankments, bridges and other structures will occur. Watch and take care of embankments.

The Disaster Management Bureau says people should move to high ground and protect their valuable properties and where possible should prepare rafts. People should move livestock, food grain and valuables to a safe place.

DMB also warns of a serious risk of epidemics and advises people to only drink purified water and to procure packaged oral saline if required. In flooded urban areas turn off electricity, gas and water when houses will be unoccupied.

District flood control rooms will remain open day and night and together with local disaster preparedness committee members will issue further local advice.

You should remain alert and listen to radio bulletins for further information. This bulletin will be updated at *lasttime* . All radio stations will broadcast throughout the night.

A Warning of Widespread and Very Severe Flooding has been issued for *districtname* **Districts.**

[Message ends] 17 June 1996

ANNEX 8
FAP 10, Publications

List of Publications

/1/ TAPP

/2/ Danida. Expansion of flood forecasting and warning services (FAP10). Technical Proposal, December 1994. Danish Hydraulic Institute.

/3/ Flood Plan Coordination Organisation. Expansion of flood forecasting and warning services (FAP10). Inception Report, August 1995. Danish Hydraulic Institute.

/4/ Bangladesh Water Development Board. Expansion of flood forecasting and warning services (FAP10). Quarterly Progress Report No.1, October 1995. Danish Hydraulic Institute.

/5/ Bangladesh Water Development Board. Expansion of flood forecasting and warning services (FAP10). Quarterly Progress Report No.2, January 1996. Danish Hydraulic Institute.

/6/ Bangladesh Water Development Board. Expansion of flood forecasting and warning services (FAP10). Quarterly Progress Report No.3, April 1996. Danish Hydraulic Institute.

/7/ World Meteorological Organization. Progress Report of first mission in Flood Action Plan 10 Module 3, June 1995. WMO-consultant Dr. Peter Walsh.

/8/ World Meteorological Organization. Progress Report of second mission in Flood Action Plan 10 Module 3, November 1995. WMO-consultant Dr. Peter Walsh.

/9/ World Meteorological Organization. Progress Report of third mission in Flood Action Plan 10 Module 3, April 1996. WMO-consultant Dr. Peter Walsh.

/10/ World Meteorological Organization. Progress Report of forth mission in Flood Action Plan 10 Module 3, June 1996. WMO-consultant Dr. Peter Walsh.

/11/ Bangladesh Water Development Board. FAP 10: Expansion of flood forecasting and warning services. Training report on advanced hydraulic modelling, May 1996.

/12/ Mohammed Alam Miah. Report on visit in Denmark and England from 10-04-96 to 24-02-96 regarding observation of flood forecasting and warning system, April 1996.

/13/ Project Management and training consultants. Preliminary Technical Assessment (of wireless equipment), August 1995. Danish Hydraulic Institute.

/14/ Expansion of flood forecasting and warning services (FAP 10), Module 3. Phase 1 Preparation and review, September 1995. Prof. Ahmed Kamal, Local Consultant.

/15/ Expansion of flood forecasting and warning services (FAP 10), Module 3. Phase 2 Preparation and review, June 1996. Prof. Ahmed Kamal, Local Consultant, Module 3.

/16/ Expansion of flood forecasting and warning services (FAP 10), Module 3. Phase 2 Report on finalizing instruments for field evaluation of flood warnings in 1996-1997 and preliminary findings from four pilot evaluation study areas, June 1996.

ANNEX 9

Staffing : Officers directly involved in the project

Government Staff Directly Involved in the project

Note:

1) Officers should be involved fully in FFWC activities
2) Equipment Maintenance Persons should be placed in the C&I division group

ANNEX 10

Proposal to purchase a high resolution satellite equipment

PROPOSAL FOR PURCHASE OF SATELLITE IMAGERY RECEIVING EQUIPMENT.

0. Background

Flood mapping and rainfall forecasting are two important issues in relation to flood forecasting and inundation-area mapping, which are the key elements of FAP 10. In the beginning of the project, in particular rainfall forecasting was given high emphasiz. Therefore, remote sensing and application of wheather radars to forecast rainfall to be applied in the flood forecast modelling, were foreseen, and taken into account in the project budget (budget item 5.2). Originally, this budget was dedicated for repair of the old weather radar at Bangladesh Meteorological Department (BMD) and to establish data transfer of radar imageries to WAPDA. However, through the first two years it has been realized that reliable spatial data regarding area-inundation are more important for the executation of the FAP 10 project for model development and verification, as well as for WAPDA to support their daily working routines, in relation to issuing of flood forecasts. Moreover, flood mapping (area-inundation) based on model results have been given even higher emphasiz in the project than foreseen in the Inception phase. This is mainly due to BWDB's desire to broadcast not only forecasts at the established forecast locations, but also to present area-inundation maps in Bangladesh Television, as part of the daily flood forecasting broadcast, which is scheduled to start during the 1996 monsoon. Sattelite imageries provides very valuable data for verification and maintenance of a flood forecasting system. In addition the satellite equipment is suitable for meteorological monitoring (cloud cover) of precipitation areas. Due to the problems with regard to real-time data transfer from India, such facility will be very useful in order to improve the rainfall forecasts for the flood forecasting model.

It was already recommended to purchase satellite receiving equipment in the previous progress report (no. 3).

During our work the last few months the need for such equipment has been confirmed, in particular after a 1 month visit by DHI's flood mapping expert. In this regard it should also be mentioned that comprehensive experience with application of satellite receiving equipment in flood forecasting is already available on many flood forecasting centres worldwide. These experiences confirms the benefits of such a system.

We are therefore proposing to purchase a PC based satellite equipment to be covered under the FAP 10 budget (item 5.2). This equipment will substitute the originally planned investments in the weather radar at BMD. This weather radar was installed in 1982 and is considered outdated by BMD. A new radar is likely to be installed at BMD within a few years. Hence, investments in the old radar seems not cost-effective.

The reasoning behind this proposal is briefly described in the following sections. In addition, on FAP 10 request, a quotation on such equipment has been provided from an American supplier (GTI Electronic). This quoation is enclosed as Annex 10.1.

1. Area-Inundation Forecasting Methodology

Area-Inundation Forecasting is based on a coupling between the MIKE11 Flood Forecasting modelling system and a digital elevation model (DEM), representing the surface topographical conditions in Bangladesh. Flood mapping is basically a simpel comparison of water levels calculated in rivers on floodplains in MIKE11, with surface topographic elevation stored in the DEM, and a subsequent calculation of the flood depth at a certain location. However, in particular in a country like Bangladesh flood mapping is indeed a very complex tast. Bangladesh is a very flat country and practically all rivers are embanked. Hence, reliable area-inundation mapping requires:

1) that water levels in rivers are calculated with high precision (few centimeters), and

2) that the DEM is sufficiently precise and includes embankments, compartmentizations etc.

The MIKE11 FF model has already demonstrated the ability to simulate water levels with a sufficiently high precision, less than 5 cm on 24 hour forecasts. A precise DEM has been developed at SWMC and is presently being updated. Hence, the basis of reliable area-inundation forecasting is available. However, the hydraulic regime in Bangladesh is a very dynamic system, where rivers change due to erosion, sedimentation and excavation, and where embankments are broken down, reconstructed, enhanced etc. Hence, flood forecasting, and in particular area-inundation mapping must constantly be updated in order to reflect the actual conditions in the rivers and flood plains of Bangladesh. This implies that the MIKE11 FF model must be regularly verified against field data, and whenever serious deficiencies between model results and field data, the reason must be identified and taken into account in the MIKE11 FF model and in the DEM.

2. Benefits of Area-Inundation Forecasting and Modelling

Area-inundation forecasting enhances flood forecasting from a principally 1-dimensional problem to a 2-dimensional problem, providing a more direct inundation picture and a much easier dissemination process. Traditional 1-dimensional flood forecasting predicts water levels in a number of locations in rivers, but the inundation status outside the rivers is not considered. Hence, the organization which issues flood forecasts and warnings must somehow compile this point information into 2D information leading to issuing of a flood warning to certain districts or regions within Bangladesh. Area-inundation forecasting will automatically make this compilation in a much more direct manner enabling faster issuing of flood warnings on a more reliable scientific basis. Furthermore the forecasts (water depths) are presented in a readily understandable manner through a Geographic Information System (GIS), providing flood maps which are principally ready to be broadcasted in Bangladesh Television.

In addition to application within flood forecasting, area-inundation modelling also serves an important purpose within flood protection. Area-inundation can be used to give a direct impact assessment of flood protection measures, such as an increased river embankment levels or utilization of artificial or natural flood water storages.

Our experiences through the first phase of FAP 10 have shown that we are able to do area-inundation forecasting, but that we will be able to increase the forecasting precision and thus the reliability of the forecasts if detailed satellite imageries are available for model verification and maintenance.

At present the project does not get any real-time rainfall nor water level data from India. For some of the rivers which enters Bangladesh from India the rainfall in India is the controlling factor. Real-time satellite imageries will provide information about cloud cover in these Indian catchments. In combination with real-time rainfall data collected within Bangladesh, and other meteorological data obtained from BMD, cloud cover information will enable a more reliable estimate of those model boundary conditions (rainfall and river water levels) which are controlled by rainfall in India.

3. Description of the Proposed Satellite Imagery Receiving Equipment

On FAP10 request an informal quotation has been submitted by the American firm GTI Electronic, which is specialized within satellite and radar services.

The equipment includes all needed hard- and software for data receiving, conversion and processing. Real time satellite imageries in a mesh of 1.2 km, will be transmitted 4-5 times pr. day. This imageries can be used to monitor and update area-inudation forecasts, as part of the daily working routines in WAPDA. The system is very user friendly and easy to use and maintain. According to the supplier new users can operate the equipment in a matter of a few hours. Training in the use of the equipment will however be conducted as part of the 4 month training course in Denmark scheduled for 1997. Originally training in application of weather radar and remote sensing data were included in this training course.

A more detailed technical description is enclosed as Annex 10.1.

4. Economy

As mentioned it is proposed to purchase the equipment under the FAP 10 budget item 5.2 (Remote sensing and computers). 333.500 DKK are allocated for this budget item, and so far no money have been spend. FAP 10 has not yet requested a precise financial offer from GTI, but based on fax and telephone conversations the price level has been estimated by the supplier to around DKK 300.000 including delivery etc. Hence, there should be sufficient room for this supply within budget item 5.2. The equipment can be supplied within 3-6 months after ordering.

ANNEX 10.1 TECHNICAL SPECIFICATIONS

GTI ELECTRONICS INTERNATIONAL

TIROS HRPT Multi-Tasking Ingest & Processing System

The TIROS HRPT system, is another pioneering advance from GTI Electronics and is the first desktop system to contain all demodulation and bit-sync cards in one unit under a multi-tasking, multi-threaded environment. It offers the power and sophistication of larger systems in a low cost, PC-based interactive graphics environment.

COMPACT

The TIROS HRPT system is simple to install. The antenna is a 1.2 meter, vacuum formed aluminum dish which mounts to a very rugged chain driven, worm drive rotor unit supported by a superbly designed all aluminum pedestal. All conversion is accomplished at the feed with a single cable running to the computer and monitor only occupying a space 18 inches wide by 25 inches high operating in a 3-button mouse-driven graphics environment.

COST-EFFECTIVE

The TIROS HRPT system is a low cost, PC-based earth station providing full ingest, display and processing capabilities of the primary downlink from multiple satellites.

COMPATIBILITY

The TIROS HRPT system will support HRPT data from the NOAA-10, 11, 12 & 14 satellites with compatibility with future NOAA satellites K, L, M, O, P, & Q with header information to automatically determine which satellite you are ingesting.

CALIBRATED DATA

The TIROS HRPT system data is calibrated to provide precise temperature readings of all infrared channels to 1 degree centigrade, and to support analytical research along with forecasting and present forecasting needs.

GTI ELECTRONICS INTERNATIONAL

VERY HIGH RESOLUTION

The TIROS HRPT system provides 1.1 Km digital image data as generated by the Satellite sensors. There is no conversion from analog to digital. The digital data prevents distortion, henceforth the result is *PERFECT IMAGERY!*

AFFORDABLE

The TIROS HRPT system is an affordable system. It can be used for aviation weather information for pilots and small airports, early storm warnings and cloud cover information for agriculture, key data for oceanographic, environmental and meteorological programs for education and business activities.

EASY TO USE

The TIROS HRPT system is very easy to use and user friendly. The standard "click-and-point" concept lends itself to a very quick learning curve. With no previous experience, operators can be up and running in less that one hour, analyzing key data and viewing with resolutions down to 1.2 Km with no panoramic distortion along the entire pass.

HIGH RELIABILITY

The TIROS HRPT system uses the highest quality components found in industry today. The advanced design gives the end user the confidence of long term, continuous operation with very high reliability. Each system is individually tested and run under real-time conditions of ingesting and processing for a period of 48 Hrs prior to shipment. Each printed circuit board is 100% individually tested, not sampled from a production line to give you the highest quality, trouble free operation attainable.

UPGRADES

Software upgrades to the TIROS HRPT system will be shipped to the end user for a period of one year from the date of purchase free of charge.

GTI ELECTRONICS INTERNATIONAL

WARRANTY

Each TIROS HRPT system is an all inclusive system warranted for a period of one year from the date of delivery against defects including the HRPT Receiver/Demodulator card, HRPT Frame Formatter card, Super VGA Video Card, Computer, Monitor, Keyboard and Integrated Feed Downconverter. Should any item become defective during this period, GTI Electronics will repair or replace the product involved. This limited warranty does not extend to any product which has been damaged as a result of accident, misuse, abuse, or as a result of unauthorized service.

GTI ELECTRONICS INTERNATIONAL

TIROS HRPT Desktop System

FEATURES:

- Fully Multi-Tasking
- Single Computer Operation
- Intel Pentium 90 Processor
- OS/2 Warp Operating System
- User Friendly Menus
- Automatic Unattended Operation
- Ingesting of All Channels
- Very High Reliability
- Background Image Capture
- Very High Resolution 1280 X 1024 X 256
- SCSI Very High Speed Controller
- Separate C & D Drives
- 17" NEC Monitor Standard
- PCI Very High Speed Video Card
- Internal Receiver/Demodulator Card
- Internal Frame Formatter Card
- 16 Meg 70ns Internal Ram
- Keyboard/Mouse Driven
- Full 8 Bit Color (16,777,216 colors)
- Individual Channel Selection
- Real-time Display of Line and Error Count
- Automatic detection of sync and phase lock
- Interactive scheduling for automatic acquisition
- Automatic track of available disk storage space
- Ingesting of All data from All channels on every pass

GTI ELECTRONICS INTERNATIONAL

TIROS HRPT Software Highlights

A partial listing of the scientific post processing capability for the interpretation of the TIROS HRPT data is listed below but not limited to .....

- Ingesting of ALL channels, 1 thru 5 on every pass.
- Proper aspect ratio correction for any area at any resolution.
- Multiple selection of user programmed palettes.
- User defined palettes for specific interpretation.
- Recall of pre-selected co-registered areas at specific resolutions.
- Histogram graphics for highlighting and contrasting defined areas.
- Information block for pixel value, temperature and albedo.
- Absolute XY crosshair for precise pixel position readout.
- Scheduling for totally unattended operation.
- Automatic obsolete file delete.
- User defined roaming window for precise area display.
- Zooming from 5 to 400% at the true aspect ratio.
- Geopolitical boundary overlay for coastline and map composition on/off.
- Gridding display for latitude and longitude readout.
- True temperature readout of IR channels to 1 pixel and 1 degree C.
- Mouse driven cursor for bearing and distance measurement in Km.
- Roaming cursor with instant crosshair Lat/Lon readout.
- Precise contrasting of image for in depth analysis of specific land areas.
- Images saved as GIF, TIFF, BMP, JPEG, PCX, PPM & Targa
- Graphic engine software including HSV, Color Balance, Gamma, Flip etc.

GTI ELECTRONICS INTERNATIONAL

TIROS HRPT Hardware Specifications

Antenna System

Antenna Type	Parabolic Solid Aluminum
Antenna Diameter	4 Foot Vacuum Formed
Gain	26 dB
Beamwidth	9 Degrees
F/D	.375
Wind (operational)	135 km/hr (85 mph)
Mounting	Heavy Duty Pedestal, Heavy Duty Rotor

Integrated Feed/Downconverter

RF Input Frequency	1650 - 1750 MHz
RF Input Bandwidth	Bandpass & Combline filters for 20 MHz width
Downconverter Gain	Up to 80 dB, 70 dB supplied
IF output frequency	70 MHz
Power Requirements	+12 VDC @ 700 ma surge, 350 ma operating
Polarization	Right Hand Circular
Frequency Stability	+/- 1.8 Khz typical, oven controlled
IF Output connector	Type BNC Female, type "N" on request
Finish	White Powder coat, waterproof
Environmental	-50 to +60 Centigrade

PSK Demodulator

IF Input Frequency	70 MHz for maximum signal recovery
Bit Rate	665,400 Kb/sec
Loop Bandwidth	3% of center frequency
Capture Range	Automatic Phase Lock, +/- 1 MHz
Input Level	-10 to -60 dBm at 50 Ohms input
Input Impedance	50 Ohms
Bit error Rate	>1 X 10 -7 or greater
Demodulator Type	BPSK, Digital Phase Lock
Output	0 Degree Clock and Data
Size	Plug-in Computer Card, 8.3"

Bit/Frame Synchronizer

Input	Clock and data from Demodulator card
Bit Rate	665,400 Kb/sec
Clock Recovery	Digital
Size	Plug-in Computer Card, 8.3"

GTI ELECTRONICS INTERNATIONAL

Micro-Track Microprocessor Tracking Unit

The Micro-Track controller unit, is a self-contained, microprocessor based tracking and control unit, specifically designed for the antenna tracking of LEO, (low earth orbiting) satellites namely the TIROS HRPT types. The unit is housed in a very compact, streamlined cabinet measuring 11 1/2" Wide X 13" Deep X 4" High It utilizes a tilt front panel with an LCD readout for the display of all tracking parameters including manual position override of the antenna system. It has provisions on the rear panel for interfacing to any standard IBM 386/33 or higher system when used as a separate tracking unit. When used with the Pentium 90 machines under a multi-tasking environment, it becomes a totally integrated, automatic tracking and ingesting system. Provisions are provided on the rear panel for the input of a GPS system for receiving precise date, time, latitude and longitude plus a separate RS-232 connector for integrating to a standard IBM computer for program control. Power for the unit is either 120 VAC or 240 VAC with twin fuse receptacles for both the main power and the low voltage rotor motors.

The controller uses an LCD readout for the display of the Date, Time, whether or not passes are loaded in the controllers memory and at what time the next AOS, (acquisition of satellite) is programmed and the maximum elevation it will reach. Once the Micro-track program is executed, the computer graphic screen will poll the controller and report back to the computer displaying the dish position, latitude & longitude of your location, whether the autoload is active, and what passes are available in the controllers' memory. The antenna may be positioned manually over its entire control range at any time. When returned to the automatic mode, the system will resume automatic control and will immediately begin to track in the event of an on-going pass.

The program uses only one screen for rapid and easy click and point operation. There are no sub-menus so the end user always knows the status of the system at a glance. When in the automatic mode it will predict the acquisition times for the satellites that are selected continuously at the time so designated by the end user every 24 Hrs and download those passes into the controllers' memory. Once this has been done, the controller will operate independently of the computer and track the satellites totally unattended.

GTI ELECTRONICS INTERNATIONAL

HRPT Multi Tasking Ingest & Display System

The following list constitutes a TIROS HRPT Multi-Tasking, Fully Automatic, Desktop ingesting and display system including all components necessary to Track, Ingest, Display and scientifically post process imagery from the TIROS HRPT type satellites under a True multi-tasking, multi-threaded environment.

SYSTEM COMPONENTS:

- Pentium Based Processor, 90 MHz, 64 bit data path
- IBM OS/2 Warp Ver 3.0 operating system
- 16 Meg 70 ns ram expandable to 128 Mbyte
- SCSI 32 bit Adaptec controller, 10 Mbyte transfer rate
- IDE Controller, 32 bit for drive C
- Super VGA PCI Video Card, 1280 X 1024 X 256 resolution
- 1.44 Meg Floppy drive A
- 640 Mbyte drive C
- 2 Gbyte Drive D, HPFS
- 101 Key enhanced keyboard
- Serial Mouse
- Phase Demodulator Receiver Card
- Frame Formatter Card
- Sony or NEC 17" Video monitor, .28 dot pitch
- DC Block, (bias t) w/cable
- Integrated feed/Downconverter
- 100 Feet coaxial cable w/connectors
- Micro-Track Orbital Tracking Unit w/controller cable (100 Feet)
- 4 Foot, vacuum formed, aluminum dish w/mounts
- Heavy duty, chain driven, worm drive rotors w/pedestal
- Garmin GPS unit with interface cables