MATHEMATICAL MODELLING FOR REAL-TIME FLOOD FORECASTING AND FLOOD CONTROL IN CENTRAL AMERICA

PLAN OF ACTIVITIES FOR 1995

PANAMA

February, 1995

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1. INTRODUCTION

Within the present project Mathematical modelling for real time flood forecasting and flood control in Central America, modelling technology is being transferred to the six participating countries, including Panama. In 1993 and 1994 the main project activities have been an Inception Phase from January to July 1993 followed by a Data Collection and Training Phase from July 1993 to December 1994. The main activities have been data collection in the case study areas, regional workshops, two oversees training courses and transfer and installation of hard- and software to the participating Institutions. In January 1995 the project is entering into its Application and Consolidation Phase with a duration of two years.

The objective of the present document is to describe project activities during the Application and Consolidation Phase with special emphasis on project status, targets for 1995, identification of activities required to achieve these targets and a scheduling of the necessary inputs.

The document has been prepared by DHI in cooperation with Dali Espinosa (IHRE), Mathias Carrera D. (UTP), Sidney Salvatory S.Solis (CIHH) and Pablo E. Martinez (CIHH).

2. PROJECT STATUS

Below is given a short status of the project as per January 1995.

2.1 Institutional Framework

In the recently finalized Data Collection and Training Phase three institutions have been the main participants:

Instituto de Recursos Hidráulico y Electrificación (IHRE)

IHRE is the national institute responsible for power production and distribution and for the monitoring and management of surface water resources. With the exception of the Panama Canal Zone IHRE operates the meteorological and hydrometric network of the country.

The hydrometeorological activities of IHRE are undertaken by the Department of Hydrometeorology, which is divided into two sections for Meteorology/Climatology and Hydrology. In addition a more field oriented Hydrometry unit exist. The Hydrology section

comprises units of Data Processing and Statistics, Data Base Management, Hydrological Studies and one for Water Resources. The staff on the Hydrology Unit totals some 15 members in addition to the 12 working in the field unit .
Besides the above mentioned activities the Hydrology section undertakes a number of hydrological studies related to the operation of existing hydro power schemes and assessment of new potential sites and the section has already applied the modelling system as a standard tool for these investigations.

One person from the Hydrology Department participated in the overseas training in Denmark.

Universidad Technológica de Panama (UTP)

At UTP the Faculdad de Ingeniera Civil (FIC) has a professional staff of approximately __ persons out of which three professors undertakes education and research in the field of hydrology and hydraulics. The faculty is offering base courses in Fluid Mechanics, Hydrology and Hydraulics and advanced courses in Engineering Hydrology and Engineering Hydraulics. The latter includes introduction to mathematical modelling (the HEC modelling system).

To strengthen the national capacity in sustaining the project and in dissemination of the project technology FIC is expected to expand its activities in the fields of mathematical modelling in the near future.

FIC has had a close collaboration with IHRE introducing the modelling technology in the Hydraulic section. This interaction should make it possible in the future to be able to provide students and research personals with real-time data .

Centro de Investigaciones Hidráulicas y Hidrotécnicas (CIHH)

CIHH was established in 1982 in order to enhance research activities and to provide external services in hydrology and hydraulics. CIHH, still linked to UTP, has presently a staff of 15 of which 11 are engineers. They have some experience in developing and applying mathematical models, including the HBV model.

In the **application and consolidation** phase it is expected that the following organizations will be involved in the project in the role of end-users of the calibrated models, defining applications or as coordinator of dissemination of model results.

The Ministry of Agriculture.

The Ministry is interested in applying the Rio La Villa model for irrigation investigations, and it is understood that they are willing to assist in a survey programme.

2.2 Counterpart staff

In total four counterparts have attended the 6 months overseas training course in Denmark:

* Ing. Mathias Carrera Delgado (UTP), who is assistant professor at the Civil Engineering Faculty.

* Ing. Dali Espinosa (IHRE), who is Head of the Hydrology Section under Department of Hydrometeorological.

* Ing. Sidney Salvatory S. Solis (UTP), who is Research Assistant at CIHH.

* Ing. Pablo E. Martinez (UTP), who is Research Assistant at CIHH

In addition to these additional staff members have been introduces to the modelling system. At IHRE five staff members from the Hydrological Section, listed below, have been introduced to MIKE 11 by Dali Espinosa and Mathias Carrera both participants at the first training course in Denmark:

- Abril Méndez, Lic, Assistant Hydrologist,

- Aurelio Grajales, Assistante Hydrologist.

- Iván Jaramillo, Civil Engineer

- Rigel Moscote de Marine, Lic, Water Recources Analyst

- Jonny Cuevas, Civil Engineer.

Data entry and analyses, model checking and modification and calibration simulations (Mainly HBV) have been the main tasks.

Training of additional staff members in operating the modelling system has been discussed with IHRE and UTP and at present it is anticipated that through the coming one to two years five additional staff members (in addition to the five from IHRE) will be frequent users of the modelling system.

At UTP/FIC Ing. Civil David Cedeño and Ing.Civil Riomar Espinosa is expected to be involved in the project and at UTP/CIHH Ing. Civiles Ricardo Gonzales, Lucas Calvo and Elsa Flores will be introduced to and trained in operating the system.

2.3 Hardware and software installation

In total four hardware installations have been made, each consisting of a 486 based personal computer, a 17" colour monitor, a laser printer and an UPS. Two systems have been installed at UTP/CIHH, one at UTP/FIC and one at IHRE.

Computers installed after the first training courses were all supplied with a 450 Mb harddisk. It has been found that institutions carrying out intensive modelling activities are having disk capacity problems and it has been decided to upgrade these computers with an additional 500 Mb harddisk.

The MIKE 11 version 3.11 for MS-Windows has been installed on all computers. The HIS module at present under transfer to Windows but still operated under DOS has been installed in addition. During the visit in May the HIS module for Windows will bee installed. WordPerfect 6.0, Quadro Pro 4.0, Lahey F77 Fortran compiler and ArcSolo tape backup system have been supplied and installed.

Backup procedures of system software and data files has been discussed and established. No virus problems has been detected on the computers installed in June 1994, but anti-virus software has been supplied and installed on all computers.

At IHRE two additional MIKE 11 installations have been made after a request. These additional software installations have been made on computers provided by IHRE and are presently made available for the user for the duration of the ongoing project.

A request for one additional software installation at IHRE have been made during the visit of the Consultant in February. This installations will be forwarded by mail in March and installed by the counterpart staff.

Based upon experiences from participating institutions installing unauthorised software on the supplied computers, is must be strongly recommended NOT to initiate any kind of software updating on the provided computers without consulting DHI in advance.

2.4 The Rio Chiriqui case study.

The Rio Chiriqui catchment is situated in the western part of Panama and flows towards south into the Pacific Ocean. The river system drains approximately 2,000 Km2 with the highest elevation at 3,474 m.a.s.l. The annual precipitation varies between 8,000 mm in the northern part, 4,000 mm in the central and southern and 2,800 mm in the northwestern areas.

The Chiriqui basin is of great importance to the country as one of the main rivers with hydropower installations. Three plants are active and IHRE plans to construct additional four (the ESTI scheme).

In the Rio Caldera flooding is a frequent problem. There is no dam operation in the upper part of Rio Caldera where flooding often occurs, but one hydropower station is located downstream of the City of Boquete. IHRE is expected to prepare a land use plan in the future.

The selection of the Rio Chiriqui basin as case study area was based upon the possibilities to undertake the following applications:

- To prepare a mapping of flood hazards below the hydropower outlet in the Rio Esti and investigate the possibilities for flood control, including an outline design of measures to control more frequent type of flooding.

- To develop and implement a real-time forecast and management system for the operation of the hydropower installations in order to optimize production.

Following the training course in Denmark a HBV and a HD model covering the entire Chiriqui basin was established and initial calibrated. Details regarding model setup and calibration can be found in the training report prepared by the counterparts. After the return to Panama the refinement and calibration of the model was continued, mainly at IHRE and the status as per January 1995 can be summarised as below:

Data:
One complete data base containing all hydrometeorological data within the Chiriqui basin has been created. All data have been revised.

Rating curves from Esti and Los Valles has been corrected, corresponding discharge time series updated.

Hourly data from 6 catchment covering a 6 months wet period have been processed.

Cross-sections have been checked and new sections have been surveyed to complete the HD setup.

Training material has been prepared and training of four additional staff members initiated.

Two catchments have been finally calibrated based on daily data and the final calibration based on hourly data initiated.

2.5 The Rio Chiriqui Viejo case study.

The Chiriqui Viejo basin is located in the western part of Panama, near the border of Costa Rica. The river system drains 1,376 km2. The northern part is mountainous with the highest elevation of 3,474 m.a.s.l. while the southern part consists of a floodplain area near the coast.

Mean annual precipitation is 3,300 mm with a maximum up to 4,800 mm in the central area and a minimum of 2,200 mm in the northwestern part.

Flash floods occurs often in the mountain areas damaging bridges, roads and farming areas. Inundations of the flood plains have caused severe damages to the banana plantations, drainage system and communication facilities.

The Rio Chiriqui Viejo basin was selected as a case study area with the purpose to undertake the following application:

- Preparation of flood hazard maps and investigate possibilities for flood control, including preliminary design and evaluation of measures to control different types of flooding.

Following the second training course in Denmark a HBV/HD model covering the basin was established and initially calibrated.

Details regarding model setup data availability and quality and calibration efforts can be found in the report prepared by the counterparts, and can be summarised as following:

The catchment is extremely fast responding in the mountainous catchments where only one precipitation station with continuous records exists. As a result the HBV simulations are based on daily mean values, making it difficult to match peak runoff.

Applying measured runoff as upstream inflow boundaries the HD model is able to simulate the measured conditions in the most downstream calibration point, but the flood plains are still not represented in the schematisation.

3. PROJECT TARGETS

The general immediate objectives of the present project has been defined as follows:

- to enhance the capability of the countries to plan, design and operate flood mitigation measures.
- to contribute to the improvement of flood preparedness programs by improving flood forecasts methods and increase lead times.

Through discussions with the institutions and counter parts involved in the project in Panama these objectives have been further detailed in more specific long and short term targets reflecting the needs and possibilities. The short term targets to be accomplished within 1995 are listed below:

3.1 Specific targets for 1995

IHRE:

- Update MIKE 11 time series data bases.
- Install four telemetric stations in the Caldera catchment.
- Upgrade 6 meteorological stations from manual to automatic reading (from Pluviometricas to Pluviograficas) and install 3 automatic stations at new locations.
- Run and calibrate the HBV model using hourly precipitation and runoff data where available.
- Modify HD setup to reflect actual situation at power stations.
- Run and calibrate HD model with new setup using daily and hourly data, respectively.
- Convert setup to FF mode to assess improvements in the operation and production using forecasts of reservoir inflow in management procedures.
- Prepare flood hazard maps of area downstream the proposed hydropower outlet in the Rio Esti.
- Investigate the possibilities and effects of flood control in the Rio Esti.
- Continue training of new staff members from IHRE.

UTP/CIHH:

- Obtain flood plain information in flood prone areas of Rio Chiriqui-Viejo.
- If possible establish a temporary water level gauge in the above mentioned areas.
- When these additional data are available carry out final calibration of the Chiriqui-Viejo model.
- Apply the calibrated model to prepare flood hazards maps and to investigate possibilities for flood control.
- Outline design of measures to control frequent types of floods.
- Initiate setup of Rio La Villa model.

UTP:

- General introduction of the modelling software and training of additional professionals.
- Apply MIKE 11 as a general tool in research and theses work.
- Introduce the modelling system in university courses.
- Preparation of course material and computer exercises.

All:

- Participate in a one month Regional Training Course.

4. PROJECT ACTIVITIES

4.1 The Rio Chiriqui case study

4.1.1 Updating of the MIKE 11 data bases.

As it is the intension to keep the MIKE 11 data bases "up to date" , recorded field data from the Chiriqui catchment must continuously entered. To maximize data security it is recommended to establish a "field data directory" where all observed data are stored in MIKE 11 format. This includes also data from meteorological stations planned to be established or upgraded in the Chiriqui catchment.

4.1.2 Final calibration

As the response time in the most upstream catchments is less than 24 hours, it is important to base the final calibration of both the HBV and the HD model on a combination of daily and hourly data.

HBV-model:
The calibration of the HBV model with respect to simulating yearly water balance and dry season runoff daily should be based on daily precipitation and a simulation period of say five years, while calibration of the parameters important simulating peak events must be submitted using hourly data.

Simulating these peaks it is important that the model is "hot", ie running the model eventual using daily data until the flashy period begins and then hotstart using the hourly data.

HD-model:
Finalizing the training in Denmark the HD setup did not represent the actual situation with respect to turbinated discharges. The schematisation must be updated including spillways, tunnels, minor reservoirs and turbines before the model will be able to represent the actual situation and can be calibrated.

After these modifications the HD model should be calibrated using the runoff from the calibrated HBV model.

4.1.3 Model application

Two possible applications have been discussed:
When the Caldera telemetric systems are operational the Caldera sub-model must be calibrated using the hourly data available. Following this the model will be converted into FF mode,

experimental forecast simulations carried out and finally used on an operational basis.

Based on the calibrated full model of the Chiriqui basin the proposed schemes from the ESTI project can simulated with respect to flooding problems in the Esti, evaluation of proposed measures to control flooding, operational policies, etc.

4.2 The Rio Chiriqui Viejo case study.

To refine the calibration of the Rio Chiriqui-Viejo model carried out in Denmark, additional topographical and hydrometeorological information is needed.

Flood plain descriptions must be included in the flood prone areas to simulate the correct inundation and one (temporary) gauging stations should established between the Paso Canoas station and the sea. These data are essential for the calibration of the downstream area.

Apply the calibrated model. Define precipitation scenarios to be simulated and prepare inundations maps based on the results from these simulations.

In corporation with potential end-users define possible flood protection measures and evaluate the consequences of these.

4.3 Training

4.3.1 Local training

Training of additional counterparts at IHRE was initiated by the counterparts from the first course in Denmark and is expected to continue.

UTP:
UTP is expected to launch an internal training program with the purpose of training university teachers and research staff. After this internal training UTP is expected to be in a position to offer courses for people from other organisations, potential end-users, students, etc.

4.3.2 Regional training course.

A one months training course will be held in the region, probably in November. Three to five persons nominated among the new "additional staff members", see chapter 2.1, will here have a chance to get a deeper knowledge about the modelling system, data requirements, model schematisation and set-up, calibration techniques and application simulations. The counterparts

having received training in Denmark will be requested to provide their support to this course as instructors together with persons from DHI/SMHI. DHI will forward requests in this respect in May.

Participants in the above course will be selected by a committee comprising the counterparts having served as instructors on the national training courses, the national Representative and a representative from DHI.

4.3.3 Support to UTP

As a support to the integration of the modelling technology at UTP the Consultant will assist in preparing lecture notes and computer exercises. A one week regional seminar will be arranged in July/August with participants from the consultant and the involved universities. The purpose will be exchange of ideas and experiences in teaching the subjects.

4.4 Model setup and applications in new areas.

4.4.1 The Rio La Villa basin model.

The La Villa basin is considered as a potential new model area. The Ministry of Agriculture is interested in La Villa as a source for irrigation and could be willing to provide support to a survey.

Within the basin studies may be undertaken with the following purposes:

- To prepare flood hazards maps and investigate possibilities of flood control.
- To develop the basis for design of an irrigation scheme and of requires flood control measures.

CIHH is expected to initiate this project.

5.1 Activity schedule and staff input (Panama)