Development of a Real-Time Flood Forecasting and Warning System for the Lower Chao Phraya River, Bangkok, Thailand.

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Abstract

From mid-September to the end of October each year Bangkok residents and businesses fear the rising levels of the Lower Chao Praya River. Unlike previous years however, in 2003 the quality of information available about the behaviour of the Lower Chao Praya River has improved considerably. This follows the implementation of the Hydrodynamic Flow Measurement Project and the application of river system hydraulic modelling and flood forecasting system. Undertaken by the Thailand Royal Irrigation Dept (RID), the Office of the Royal Development Projects Board (RDPB) and the National Research Fund (NRF), the Hydrodynamic Flow Measurement Project represents a significant investment in flood forecasting and management systems. The objective is to provide government engineers with accurate and timely information about likely flood patterns well ahead of any flood event itself. From August onwards residents and businesses in Bangkok, Nontaburi and Pathumthani Provinces begin to take an active and detailed interest in water levels because of the enormous social and economic cost for the whole of Thailand that would result from flooding in the cities. Previously hand calculations based on daily readings of river levels were as flood forecasting tools. It was recognised that the implementation of a more sophisticated telemetry and modelling-based forecasting system would provide Bangkok and the surrounding area with more information about impending floods further ahead of the event itself and enable preventative action to be taken upstream, such as retention of flood water in the less valuable land. The project involved the development of a real time flood forecasting system for the Lower Chao Praya River that flows through the centre of Bangkok and its surrounding area. The active forecast area is from Ayutthaya through Bangkok to the mouth of the Chao Praya River. Implementing a computerised system for the first time required significant hardware and software investments. This included the addition of eight new telemetry sites to the existing network of 25 sites to monitor and record water and rainfall levels. In addition to the software investments, new servers were installed at the offices of the RID and to facilitate remote access to the system, new communications links were established to existing Bangkok Metropolitan Administration (BMA) and Public Works Dept (PWD) telemetry systems along the Chao Praya River.

Main Paper

1. Introduction

From mid-September to the end of October each year Bangkok residents and businesses fear the rising levels of the Lower Chao Praya River.

This paper describes the application of the of river system hydraulic modelling and real time flood forecasting systems to develop a real time flood forecasting and warning system for the Lower Chao Praya River in Thailand.

2. Project definition

The project was undertaken by the Thailand Royal Irrigation Dept (RID), the Office of the Royal Development Projects Board (RDPB) and the National Research Fund (NRF) and represents a significant investment in flood forecasting and management systems for the Lower Chao Praya River.

The objective of the project was to provide government engineers with accurate and timely information about likely flood patterns well ahead of any flood event itself.

3. Project area and existing situation

The Chao Praya is a large river basin, which covers one third of Thailand's land area. The active area of the flood forecasting system was decided as being from Ayutthaya, the historical ancient capital of Thailand, to the mouth of the mouth of the Chao Praya River at the Gulf of Thailand. This is a distance of approximately 100km. The development of the flood forecasting system involved the development of a detailed hydraulic and floodplain model over these lower sections of the river and the determination of inflows from the various upstream catchment areas and reservoir controlled catchments.

With the advent of the monsoon season from August onwards residents and businesses in Bangkok, Nontaburi and Pathumthani Provinces begin to take an active and detailed interest in water levels in the Chao Phraya River. When the Chao Phraya floods there are consequentially enormous social and economic cost for the whole of Thailand due to the vital role that this region has in Thailand.

Previously hand calculations based on daily readings of river levels had been undertaken and used as the basis of forecast water level predictions. It was recognised that the implementation of a more sophisticated telemetry and modelling-based forecasting system would provide Bangkok and the surrounding area with more information about impending floods further ahead of the event itself.

This would possibly enable preventative action to be taken upstream, such as retention of floodwater in the less valuable land.

Figure 1. General project location and area

4. Project methodology

4.1 General

The project involved the development of a real time flood forecasting system for the Lower Chao Praya River that flows through the centre of Bangkok and its surrounding area. The active forecast area is from Ayutthaya through Bangkok to the mouth of the Chao Praya River, a distance of approximately 100km.

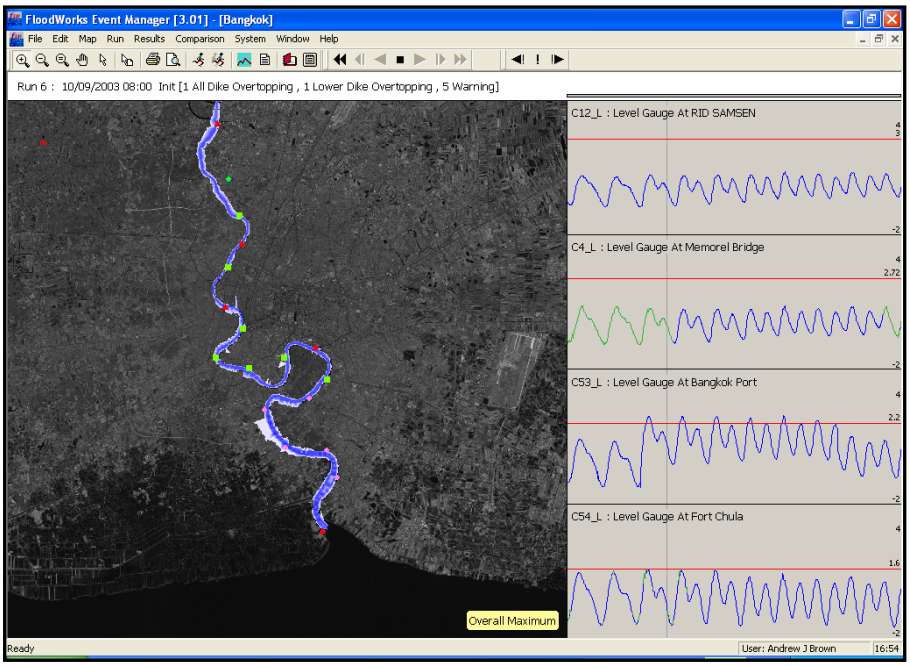

Figure 2. Active forecast area from Ayutthaya to Bangkok, displayed in the flood forecasting software.

The system had to encompass the following major elements:

- Automatic sensing of rainfall and river levels
- Validation of measured data
- Transmission of the measured data to a central master station
- Merging with tide level data
- Merging with planned reservoir releases
- Running detailed hydrodynamic models to predict flows, levels and areas of inundation within the study area

4.2 Telemetry requirements

Implementing a computerised system of this type involved significant hardware and software investments.

This included the following major items:

- Addition of eight new water level and rainfall telemetry sites

- Linking the existing network of 25 water level and rainfall sites to the flood forecasting system.

- Installation of new servers at the offices of the RID in Bangkok

- Remote access to the system, new communications links were established to existing Bangkok Metropolitan Administration (BMA) and Public Works Dept (PWD) telemetry systems along the Chao Praya River.

4.3 Software requirements

Existing ISIS models of the Chao Phraya River already existed and it was decided that the most efficient process of developing the flood forecasting system would be to develop these. The chosen modelling software would therefore have to easily import these models, geo-reference these and then be easily exported to a flood-forecasting system. It was therefore required that the software be full solution one-dimensional hydro-dynamic with GIS capability.

The flood forecasting software had to have an off-line functionality for developing thresholds, importing data streams, updating hydraulic models and defining the outputs of the system. In addition the software had to have an on-line functionality where runs could be scheduled automatically, manually and in response to threshold levels being reached in the system. The software had to be capable of validating the incoming telemetry data to ensure that the data was sensible and the operator had to be able to define the limits of sensibility. Within the forecasting system, the software had to be capable of updating the forecasts using incoming data. In the case of the chosen this was done using a pseudo Kalman algorithm. Finally, the software had to be capable of issuing clear and informative reports and alerting operators and flood managers of any warning or alerts.

The hydraulic models of the Chao Phraya River were built using Wallingford Software's InfoWorks RS and the flood warning aspects of the project were developed using Wallingford Software's FloodWorks software.

4.4 Hydraulic and flood plain modelling methodology

The hydraulic and flood plain modelling methodology involved four key tasks, which are further described as follows.

- Geo-referencing of existing models. - Existing ISIS models of much of the project area had already been built for flood control planning and design purposes. These were imported into the InfoWorks RS software and each modelling node (river cross-section, floodplain section, flood embankment spill) was accurately geo-referenced against digital maps of the river channel system, urban areas and road infrastructure to enable the model results to be used in the mapping process.

- Then the hydrodynamic model was linked to a detail ground model of the lower Chao Phraya basin topography. This ground model was constructed as a Triangular Irregular Network (TIN) of ground elevations from a series of digitised contour, spot height data sources and of course the surveyed channel, embankment and floodplain cross-sections. Integrating the hydrodynamic model with the ground model within InfoWorks RS allows the automatic generation of flood inundation maps.

- Next the model was improved to ensure stability over the full range of flows, essential for operational use and details of the floodplain drainage structures added to ensure that the return of floodwaters would be realistically represented.

- Finally alternative flood control strategies were developed within the model. These included employing sandbags to raise dykes, altering reservoir releases and manually introducing dyke breaches to release floodwaters.

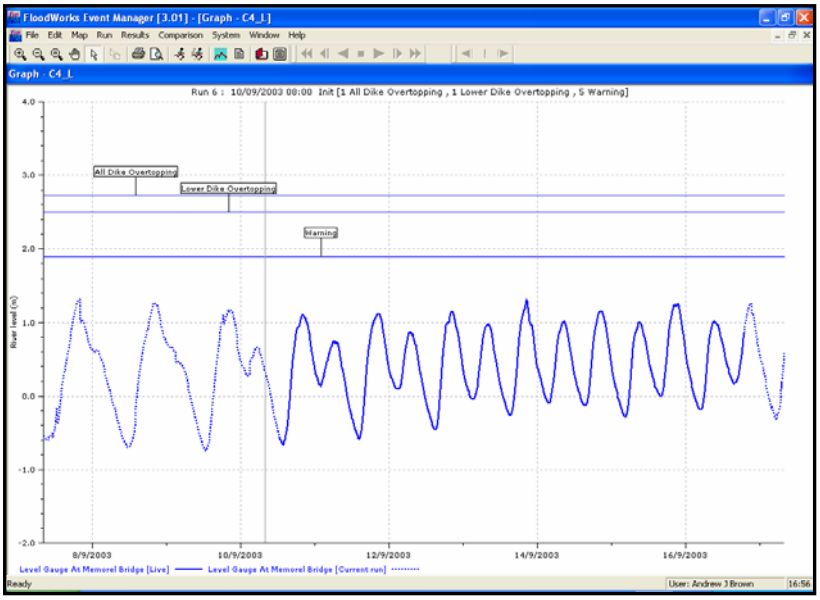

Figure 3. An example of the various flood different warning water levels shown at a single location along the river system. On the left of the vertical line is the 'hindcast' water level and on the right are the forecast water levels. At the top of the figure are the threshold water levels for warnings and alerts.

4.5 System configuration

In order to develop the hydraulic river and flood plain models into a fully operational flood forecasting system, the following major tasks need to be completed.

- Linking of the hydraulic model to the various telemetry and data stream sites. This was completed offline using the FloodWorks Configuration Manager Software (FWCMS).

- Establish the key forecast locations / nodes within the FWCMS.

- Establish and define the forecast criteria and critical warning levels on which future flood warning would be based. This was also undertaken using the FWCMS for all critical points along the river system.

- Linkage of the model and real time forecasting system to all available GIS and mapping data. This included incorporating layers of SHP files, CAD files and scaled satellite images within the operation system. These tasks were undertaken using the FWCMS.

- Arrange the associated SCADA software and the FloodWorks real time system to exchange real time data as it arrived in the RID flood control room. This was arranged by configuring the SCADA software to output copies of the telemetry data

to a shared network location, in a pre-defined format, as soon as the data was received in the flood control room.

- Selection of key locations within the system, which were both telemetry sites and forecast nodes and use error prediction / correction tools, which are available within the FloodWorks software, to correct any errors or differences that developed between the observed and predicted forecast values during the flood prediction process.

- Define the hindcast and forecast period. It was decided to use a hindcast period of three days and a forecast period of seven days.

- Define how often and on what basis the flood forecasting system would operate. For normal operational periods, it was decided that forecast runs would initiated automatically on a 24-hour basis at 08.00 on a daily basis.

- Configuration of the operational flood forecasting server and remote access from four additional networked computers. This involved the establishment of the operational FloodWorks server on a powerful PC located in the main RID flood control centre. System operator level access was then established from another four seats on the network. Two of these seats were located on a LAN in the RID Flood Control Centre and another two were located at the BMA and RDPB offices in Bangkok. Access to the server and networks was provided by way of a dedicated leased line.

5. Conclusions

The major conclusions that can be drawn from this project and this paper can be summarised as follows:

- The application of the InfoWorks RS and FloodWorks have alleviated concerns about the risk of flooding by improving the accuracy of flood forecasting in the Lower Chao Praya River very considerably.

- This methodology provided a cost effective and quick solution to providing accurate real time flood and flow forecasting services for the lower Chao Praya River.

- Bangkok now benefits from 7-day predictions of water levels and flows in the lower Chao Praya River compared with or two days previously.

- Dissemination of flood warning can now be automatically produced and diseminated.

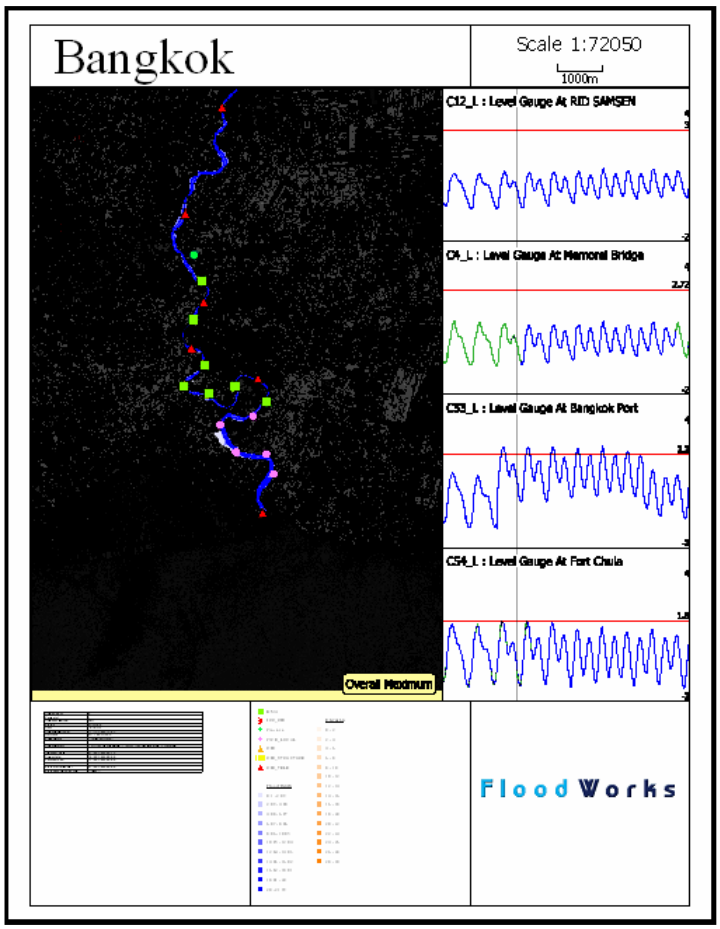

Figure 5. An example of flood warning report, ready for dissemination.

- In summary, this project has provided significant improvements in the areas of flood forecasting / warning and general river management, which directly benefits the residents and businesses of Bangkok.

6. References

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2. FloodWorks. Technical Documentation. Version 3.0. Wallingford Software Ltd. (2003)

3. Flood Estimation Handbook (1999). Centre for Ecology and Hydrology, Wallingford, Oxfordshire (formerly the Institute of Hydrology). December 1999. ISBN 0 948540 94 X.