ECONOVA FLOOD WARNING SYSTEM: GEO-INFORMATION FOR REAL TIME FLOOD RISK MANAGEMENT

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ABSTRACT:

Natural disasters engendered by climate change and global warming have created an unprecedented need for intervention from local governments. Recently, a US senatorial sub-committee on disaster prediction and prevention recently underlined the necessity for developing an effective preventive Pan American warning system to warn the affected population of potential terrorist acts or natural disasters. These warning systems aim to identify areas that are susceptible to be struck by natural disasters. Early warning systems are key tools for local and national governments to avoid losses of human lives and decrease infrastructure impacts caused by destructive elements. Econova Flood Warning System (FWS) integrates the available climatic and water level information with real-time data processing and forecast modeling, and state-of-the-art information broadcasting technology. The system supports different levels at local, provincial and federal governments in helping to identify, manage, minimize and mitigate the risk of flood damage in the affected region. Improvements brought by the Econova FWS is important because it produce a turnkey solution in all facets of flood risk management. (Time series data network, geo-referenced location, flood early warning, flood forecasting and mapping, disaster operation center organization.) Information Technology development possibilities in the field of disaster warning systems are numerous. The combination of wireless transmission systems TCP/IP with communication systems GSM-UMTS allows real time transmission of hydrologic and hydraulic data in a watershed area or multiple watershed areas and provides reliable communication networks. Econova FWS is intended for public security and is used to promote Flood Warning System throughout the world.

1. INTRODUCTION

Watershed management is an issue both at local and international levels. Funding needed for watershed management projects are increasing as they are for risk management projects as well. Natural disasters engendered by climate change and global warming have created an unprecedented need for intervention by local governments. Recently, a US senatorial sub-committee on disaster prediction and prevention underlined the necessity for developing an effective preventive Pan American warning system to reach populations affected by terrorist acts or natural disasters.

International development banks, governments, ministries and state-financed civilian rescue organization are all concerned with risk management and natural disaster warning systems. Some countries have already obtained loans from International development banks to set up national program for flood warning systems.

Warning systems aim to identify areas that are susceptible to natural disasters. Early warning systems are key tools for local and national governments to avoid losses of human lives and decrease infrastructure impacts caused by destructive elements.

In July 1996, the population of Saguenay was impacted by an unprecedented flood generated by heavy rain over a two day period. The weather forecast for the weekend was heavy rainfall and alerts we're send to the public and authorities in the area. The situation became dangerous when the storm kept in place generating massive rainfalls over the lake Kenogami watershed area in the Laurentides Park. (Figure 1).

Within hours thousands of cubic meters of water had accumulated in the lake Kenogami reservoir requiring an immediate increase in the outflow at Portage des Roches and Pikauba Dams. The problems occurred at the structure operation at Portage des Roches limiting water evacuation capacity. Generating a chain of impacts downstream in the Chicoutimi River, the Sand River and numerous streams in the watersheds.

Figure 1. Saguenay Lac St-Jean region

At the same time, water level increase rapidly in the Ha! Ha! lake. The gates at the water dam couldn't be opened, having been previously sealed by the owner. Water level rose dramatically and authorities weren't aware of the upcoming danger. The dam collapsed under heavy pressure from thousands of cubic meters of water that had accumulated. The collapsing dam generated a large pulse of water that pour down the Ha! Ha! river carrying everything in his path. The Ha! Ha! river abandoned it's natural path from the "Chute à Perron" to drop more than 20m in 2 km and taking all materials in it's path throughout the valley; 6,9 millions m^3 of material were taken. During this time the population in the downstream urban areas were asleep and unaware of the pending disaster. Fortunately, an evacuation order was issued just in time and no casualties resulted directly from the flood but billion dollars of infrastructure were destroyed. The Nicolet Commission that was put in place to investigate this disaster concluded that « We cannot predict with certainty when the next flood(s) will take place. In 1997? In 1998? In 2025? The true statistical distribution of the floods remains unknown ».

Today, people living in Saguenay remember July 16-17 1996 as a nightmare. Government, Industries, municipalities, universities and the general population in Saguenay are sensitive and aware of the necessity for risk management and they have lent their support to Econova's Flood Warning System project. This presentation will address the result of two year development that includes, not only flood warning system, but also emergency management and structure operation system.

2. FLOOD WARNING SYSTEM

Econova's Flood Warning System integrates available climatic and water level information with real-time data processing and forecast modeling, and state-of-the-art information broadcasting technology. The system supports different levels at local, provincial and federal governments in helping to identify, manage, minimize and mitigate the risk of flood damage in the affected region. Improvements brought by Econova Flood Warning System is important because it produce a turnkey solution in all the facets of flood risk management (Time series data network, geo-referenced location, flood early warning, flood forecasting and mapping, disaster operation center organization, etc.)

Information Technology development possibi-lities in the field of disaster warning systems are numerous. The combination of wireless transmission systems TCP/IP with commu-nication systems GSM-UMTS allows real time transmission of hydrometric and hydraulic data in a watershed area or multiples watershed areas and provides reliable communication networks.

The first task was to identify the main actors and what should be the use cases of the system. An actor represents a role played by a person or a thing which interacts with the system. The actors are recruited among the users of the system and also among the people in charge of his configuration and its maintenance. This task would provide all the information necessary to prepare the implementation plan. We consider also that the system had to be developed in two steps. The first step was to apply hydrology and hydraulic modeling tools (MIKE 11) and a real-time flood forecasting system (MIKE FLOODWATCH) in the rural area of the "Petit Saguenay" watershed. This watershed was suggested by Quebec Environmental department as a reference watershed for hydrology modeling. The department had temporal meteorological (rainfall, snow, wind, temperature, etc) and discharge (water level, flow) data useful for model calibration. Also precise cross sections of the Petit Saguenay river were available even though they were concentrated close to the Petit Saguenay community, they still were helpful in the modeling process. (Figure 2)

The other step was to implement the flood warning system prototype in and around an urban area. The area chosen by the stakeholders was the Chicoutimi and Rivière aux Sables watershed who were flooded 10 years ago (Figure 3).

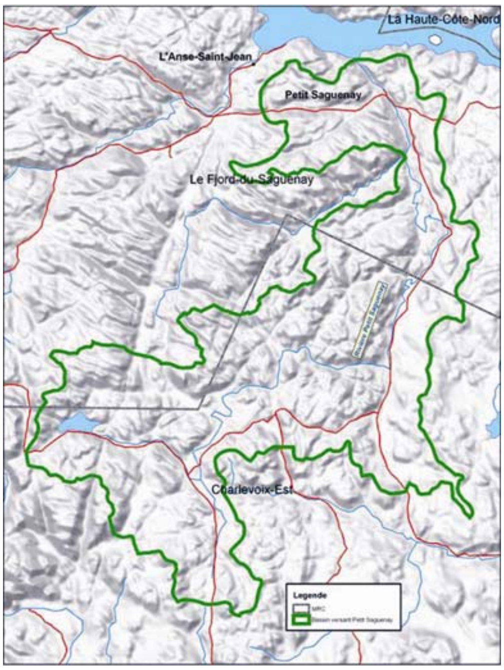

Figure 2. Petit Saguenay river

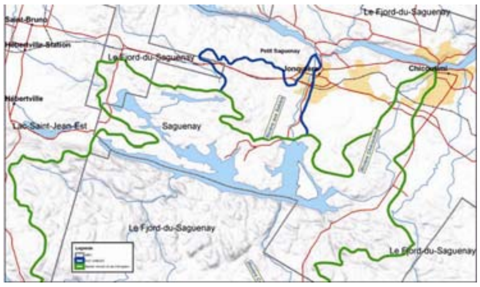

Figure 3. Chicoutimi and Rivière aux sables river

2.1 Needs analysis

With respect to the different authorities and users of the system we selected five actors (city of Saguenay, MRC du Fjord Du Saguenay, Centre d'expertise hydrique du Québec (CEHQ), Quebec Department of Public Security and DHI Water & Environment). These actors have a direct role to play in the system development and implementation. Their input helped us to define the following use cases.

Obviously, the needs were the same for the local authorities but at different geographic scale, population and means! Six internal use cases were clearly defined in the process. Those use cases are:

2.1.1 Database update: Several graphic and non-graphic databases are necessary to implement the system. Geographical data, hydrological data, meteorological data set into time series with different time step were identified as essential to the information system. Their update is critical in order to have real time modeling and flood forecasting. The main actors providing those data are numerous and mainly government owned.

2.1.2 Operation and maintenance: Once the system is in operation, it will need different people to ensure the system is functional. These people will have to ensure the system is updated, provides quality data and answers the needs of the project. If problems occurred, they will have to resolve the problem and update the system. The main actors identified are the hydrologist, DHI Water & Environment and the web administrator.

2.1.3 Modeling and simulation: Two models are necessary to implement Chicoutimi flood forecasting system. The hydrodynamic model and the hydrologic model (Rainfall Runoff). The hydrodynamic and hydrologic models are generated using MIKE 11 software. MIKE 11, developed by DHI Water & Environment, is a software package for simulating flows and water quality in estuaries, rivers, irrigation channels and other water bodies. The hydrodynamic (HD) module is the nucleus of the modeling system and forms the basis for flood forecasting. Use cases for this main actor of the system are: Flood forecasting, reservoir operation and simulation of flood control measures. The main actors for this use case are the MIKE 11 software and the hydrologist.

2.1.4 Broadcast information: Real time flood maps will be published on Web server such as Map Server, GeoWeb Publisher and JMap. These web servers will show and download data for analysis and consultation by the people in charge and user of the system. The main actors associated with this use cases are the web server and the hydrologist.

2.1.5 Real-Time flood forecasting: MIKE FLOODWATCH software will enable the information system to perform forecast modeling. MIKE FLOODWATCH is a forecast modeling shell that integrates data management, forecast models and dissemination technologies. Real time data such as meteorological forecast and point based telemetry data will be imported into the Chicoutimi flood warning system as input to the hydrologic and hydraulic forecasting models. The system will import real-time data from remote data acquisition stations, initiate forecast modeling and disseminate selected results to the people in charge, emergency staff, authorities and the public. The main actors are the MIKE FLOODWATCH software and the hydrologist.

- Alarm notification: MIKE FLOODWATCH software includes an alarm framework that facilitates the definition of multiple aggregated alarms; each of which is based on data thresholds, failed simulations or other states in the system. When an alarm is raised, the system can automatically initiate responses;
including notification of staff, dissemination of warnings, polling of telemetry sources and execution of forecast model scenarios.

2.2 Implementation plan

The implementation plan includes various aspects of the system implementation. It is based on a logical framework that presents descriptive levels of the projects (deliverables, goal, outputs, and inputs), objectively verifiable indicators (informers), means to check verify critical conditions, hypothesis and risk factors to the project. The implementation plan includes all tasks and deliverables. Fifteen tasks where presented to the management board for approval. The implantation plan was adopted on February 16th, 2007. Since then, we've been carrying the plan on all aspects. The logical framework provided us ways to verify our task achievements and at what level of satisfaction.

3. TEST & TRIAL THE PETIT SAGUENAY RIVER WATERSHED SYSTEM

This task series was a first start for Econova's floodwatch warning system. It included hydrologic and hydrodynamic modeling of the watershed and gathered real time and temporal data necessary to implement the hydrology models produce with MIKE 11 and after in real time using MIKE FLOODWATCH. This task series was conducted on a short period including training session with trainers from DHI Water & Environment. Mainly this task was aimed to do some test and experimentation of the system in the Petit-Saguenay river watershed. The requested task was that we establish the first Rainfall Runoff model of the watershed and is hydrodynamic model to produce the whole model (hydrologic and hydrodynamic) of the watershed. As soon as the project started it was clear that a lack of raw data for characterizing the watershed and calibrating the model would give a real challenge for the project. Fortunately, we received good training and technical supports from DHI Water & Environment and we were able to implement the system prototype in the Petit Saguenay watershed. Here are the different steps that we're followed in order to establish this first real-time flood warning system in the Saguenay-Lac St-Jean area.

3.1 Description of the Petit Saguenay setup

This setup was implemented in order to operate MIKE FLOODWATCH. It consists in creating and acquiring a number of files and folders – as well a numerous definitions in the MIKE FLOODWATCH database.

3.2 Folders

The folder structure is like this (relative to c:\floodwatch\projects\PetitSaguenay):

Import\	the scripts and data relevant to importing real-time data
Models\	the MIKE 11 model setups
Telemetry\	location of the files FLOOD WATCH uses for storing the real-time data
Themes\	location of ArcMAP shape files
Utilities\	Helper programs
Web\	output folder for web publication output

3.3 Import

The data import reads data from external sources (ftp-sites) and stores the data in the real-time sensors defined in MIKE FLOODWATCH.The import is a 3-steps function made up of a number of batch-files, scripts and utility programs.

3.3.1 Models: This folder contains – in separate folders – the MIKE 11 model setups defined in the database (currently only one).

3.3.2 Telemetry: The Telemetry folder holds the files used by MIKE FLOODWATCH to store the real-time data and other time series data used by the sensors in MIKE FLOODWATCH. A special time series is the "fw – PortAlfred.dfs0" which holds the long term astronomical tidal signal or Port Alfred. This can be calculated and updated on a yearly basis. The other time series are used for storing of the real-time data received during the data import.

3.3.3 Themes: Geographical features used by MIKE FLOODWATCH have been imported as data setting in the database. This folder holds the original shape files used for the import, as well as extra shapes files used by the MIKE FLOODWATCH ArcMap display

3.3.4 Utilities: Two sub-folders exist in this folder: WET and convert Data.

In the WGET sub-folder resides the WGET utility which is used for getting FTP data.

In the Convert Data folder are two VBScripts and two bat-files developed for converting historical data for model calibration into MIKE 11 input format.

3.3.5 Web: This folder is the output of the web publication and could be the location of a web folder for a web server.

4. CHICOUTIMI FLOODWATCH SYSTEM : THE PILOT PROJECT

This task series is the main achievement of Econova's floodwatch warning system project. It includes specific hydrologic and hydrodynamic modeling for urban areas including structure operations such as dams (5) for water supply and hydroelectricity production. The Chicoutimi floodwatch system is now operational for floodwatch control and monitoring at the Public security department of Saguenay. It as the same set up than the Petit Saguenay test project but with significant precision differences in hydrology modelling and real-time data for flood forecasting (waterlevel, discharges, rainfall).

5. CONCLUSIONS

Implementation of a flood warning system requires several key considerations prior to proceeding «winning conditions», You must have temporal and real-time data available for model input but also for model calibration. The hydrologic and hydrodynamic models are critical in the system implementation. Hydrologic and hydrodynamic models require field survey and data verification in order to calibrate the model and perform real time modeling. The capture process of observed and forecast data is one of the most challenging aspects in a flood early warning system development. Access to ftp sites through wireless transmission systems TCP/IP is possible. The main difficulty in acquiring the data, is not accessibility, but the way it is formatted and compiled. Meta data and Data description are not necessarily available and most of the data that we download from the FTP sites had to be analyzed and processed. The data came in different formats with different time steps and even in different GMT times.

The Chicoutimi floodwatch system is now running in the Saguenay Lac St-Jean area. The system requires constant maintenance and it is not an automatic system. Forecast and observed data need constant verification and follow-up therefore requesting a minimum permanent staff to follow up real-time model results.

The final system implementation is planned over a two year basis. It will require investment for operation and maintenance. In order to enhance the precision and reliability in the hydrologic and hydrodynamic modeling and extend the system to other watersheds it will require new hydrometric station, rainfall station and communication capacity.

This project has opened new perspectives in the Saguenay-Lac St-jean area in flood watch system development. It has increased local government's know-how in flood control and monitoring and enhanced their capacity in emergency response and risk management. A pool of expertise in flood early warning, flood mapping, and disaster operation center organization is now a reality in the Saguenay Lac-St-Jean region.

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