CHARLEVILLE FLOOD MANAGEMENT – MOVING BEYOND PHYSICAL MITIGATION

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Introduction

Charleville is a major regional town located in south west Queensland on the Warrego River, approximately 760 kilometres west of Brisbane. With a population of 3,300 it is the administrative centre of the Murweh Shire.

The Warrego River catchment upstream of Charleville is approximately 16,600 square kilometres, including the tributary Bradley's Gully which joins the Warrego River at Charleville. In April 1990, major flooding in the Warrego resulted Charleville being severely impacted. Over 1,000 homes were inundated and almost 3,000 people evacuated. Charleville was again severely impacted by major flooding in the Warrego River in 1997 and then by flooding in Bradley's Gully in 2010.

In 2009, Murweh Shire Council completed the construction of a levee system to protect the town from flooding in the Warrego River. This levee proved its worth in 2012 when it came close to being overtopped but ultimately protected the town; the flood however still caused significant disruption to the wider community. In 2013, Council completed the construction of a diversion and levee system to protect the town from flooding in Bradley's Gully.

Charleville in Flood, February 2012

With its physical mitigation measures in place, Council's focus turned to improving the knowledge based components of flood management, in particular improving upon their ability to predict the likely magnitude of a flood emergency, determine the appropriate responses, and then communicate these to relevant local agencies and the citizens of the Shire.

This paper describes the collaborative process between CDM Smith and Murweh Shire Council to scope, develop, test, and implement an Emergency Management System (EMS) that encompasses both Charleville and the broader Shire.

The Case for Improved Emergency Advice

The residents of Murweh Shire know all too well the uncertainty and difficulty of decision making that precedes a flood event in the Warrego catchment. Large floods are predicted far ahead of time, and the Bureau of Meteorology is to be commended for its robust and extensive collection of URBS models through which flood predictions are made. However, during particularly wet periods such as occurred in the summer of 2010/2011, staff at the Bureau experience a high and sustained workload in which they may be simultaneously modelling, updating, and communicating their flood predictions for multiple catchments across Queensland.

This necessarily limits the time which can be devoted to any one model and results in the perception that flood height predictions for a given location are being updated less often than could be the case. Residents who may be affected by flooding find the time lag between updates particularly distressing and are often aggrieved when a prediction is revised upwards to show their property will inundated when it hadn't been the case previously - "If only we'd had more time to prepare!", or is revised downwards to a minor event as more information comes to hand and is processed – "Why didn't we know earlier that it was nothing serious?".

Partly in response to this, and partly due the decreasing cost and improved commercialization of the technology, the volume of climate data collected within the Warrego catchment has increased markedly in the past few years. Council worked proactively to have a series of rainfall and river height gauges installed in the Bradley's Gully sub-catchment; real time data from these gauges is delivered to a purpose built "Enviromon" computer system in the Council's office, and rainfall alerts are automatically generated and delivered via SMS. Meanwhile, South West NRM obtained funding to install 30 new weather stations across the south-west, a dozen of which sit within the Warrego catchment. Communicating via the 3G mobile phone network (where available), or via satellite telephony, these gauges provide additional detail on observed rainfall within the catchment, and in the case of the 3G gauges, river levels too.

Finally, and again due to the mainstream commercialisation of the underlying technology, digital elevation data was much more readily available than had been the case half a decade or so earlier. In the case of Charleville and Augathella, detailed LiDAR survey existed, and over the entire Shire Council technical staff had mapped the road network using differential GPS.

But despite the availability of such data, in mid-2013 there didn't exist a coordinated 'system' capable of taking these disparate sources of information to one place and utilizing them to make real-time, or near real-time flood predictions and then determine the attendant emergency response. CDM Smith was commissioned by Murweh Shire Council to create such a system, the development and deployment of which is described below.

Collaboration and Development of the Emergency Management System

Murweh Shire Council was committed to improving their flood resilience, and it was clear to them that that with the physical mitigation works completed, the next step was to look at a knowledge-based system to improve flood resilience, particularly for residents not protected by the levees. Council knew in theory what they wanted, but lacked the in-house expertise to make it happen. CDM Smith had the expertise, but needed access to the accumulated local knowledge to create something truly useful. A collaborative approach was adopted, and as the project progressed it became clear that this would be integral to the success of the endeavour.

Scoping Study and Data Collection and Review

Development began with a US based expert engineer visiting Council offices in Charleville to conduct a two week exercise to review the existing data and determine an achievable scope of works. In addition to multiple flood study and levee design reports held by Council, meteorological, topographic, geophysical, and hydrological data were sought, reviewed, and catalogued in a Data Collection and Review Report. The report was used to conduct a data gap analysis, evaluating the sufficiency of the available data for completing the development of the EMS. No major deficiencies were identified, and the project proceeded to the next phase.

Hazard Identification and Risk Assessment

Based on discussions with Shire representatives, a consensus was reached on the definition of the risks and hazards to be addressed in the EMS. Elements considered included: critical infrastructure, including roads, bridges, culverts, utilities, police stations, fire stations, and hospitals; communities; and vulnerable persons and properties (considering ingress and egress for emergency traffic). As a result of this task 15 key areas were defined which would become the focus of the flood modelling – at these locations the flood levels that could adversely impact the critical infrastructure were defined, and this information used in the development of the decision support system, described below.

Flood Modelling

A calibrated and verified XPSWMM model of the Warrego River catchment was created, covering approximately 47,000 km2, from the Cunnamulla Weir in the south to the catchment divide in the Carnarvon Range. It includes the major tributaries of the Langlo River, Ward River, Nive River, Angellala Creek, and Bradley's Gully.

A detailed discussion of the model development process is beyond the scope of this paper, however several key features are listed below:

- An integrated hydraulics and hydrology model with over 100 subcatchments, 250 channel cross-sections, and 20 structures.
- Structures and key cross-sections ground-truthed via differential GPS

The model was calibrated against the February 2012 and March 2010 flood events, and validated against the February 1997 flood event. Overall the calibration exercise showed a good level of agreement between modelled and observed data across the catchment, with the majority of peak stage predictions within + 100mm of the observed data. This agreement was similarly borne out in the validation run.

Decision Support System

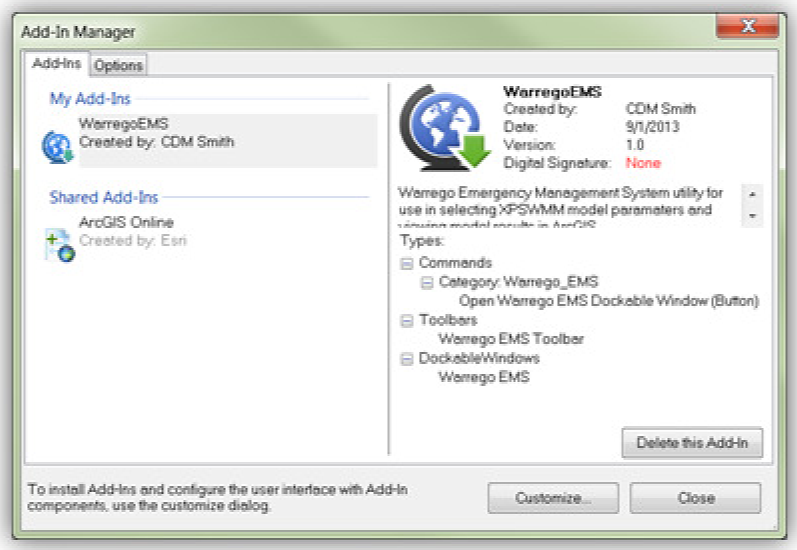
A number of Decision Support System software packages were investigated for use in this project, with the conclusion that the ArcGIS suite of products (ArcMap, ArcCatalog, etc) from ESRI offered the best combination of user-friendliness, widespread use, client acceptance, and customisation ability. An ArcMap geodatabase was created to serve as the graphical front end to the system. In this geodatabase all of the key data collected in the proceeding phases, such as critical infrastructure locations, key elevations, and catchment parameters could easily be navigated and interrogated. To link the actual flood model to the ArcMap environment, a customised Add-In was created, which is described in more detail in the section below.

The Finished Product

At the end of the collaboration and development phase, the finished product consisted of a GIS-based system that contained the following key components:
A calibrated XPSWMM model of the catchment;

A GIS-based decision support system, the "EMS Utility"
An ArcMap Document and Geodatabase; and,
A suite of emergency management documents, including a plain english how-to manual on the operation of the system.

The EMS Utility Tool is installed as an ESRI Add-in to ArcMap. The add-in is a collection of customisations packaged within a single compressed folder. To install, the user simply double-clicks the .AddIn files and the necessary libraries are copied to the appropriate folder on the computer. Delivering the utility this way has the benefit that the installation does not trigger an "Administrator Rights" warning, and the add-ins are small enough to be easily shared and updated.



Installation of the Add-in is a One Click Process

After installing the EMS Utility Tool, and upon opening ArcMap, the user is presented with a customised dockable toolbar window which contains everything the user requires to:
build a storm;
export rainfall hyetographs;
import and process flood hydrographs; and, most importantly,
interpret the results in the context of key critical locations throughout the catchment.

The EMS Utility Tool makes use of ArcMap's extensive support of the Python programming language, and contains a series of bespoke scripts created specifically for this application. The scripts carry out the various actions requested by the user from the graphical interface. This tool is the heart of the entire system, and the power lies in its ability to enable a user to progress seamlessly through the entire order of operations – from creating rainfall inputs to delivering emergency response advice – without requiring specialist knowledge of the inner workings of the underlying technical software.

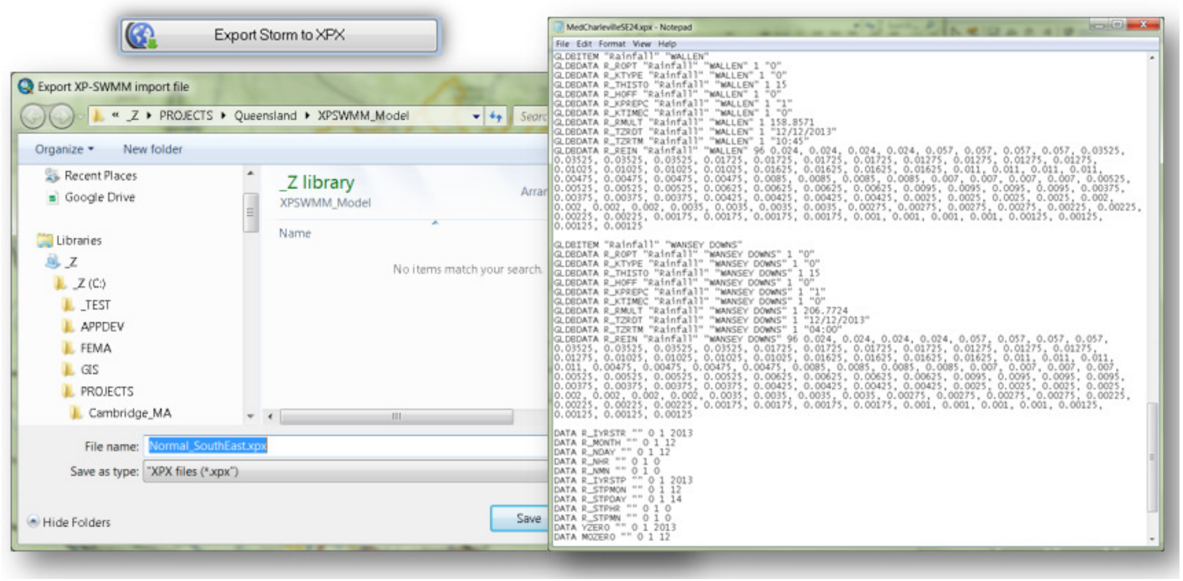
The first step in making a flood prediction is to interrogate the available rainfall records and predictions– either from the Bureau website, via Enviromon, or through the South West NRM data streams – and use these to “build” a storm.

As example is described below where a user identifies a rainfall area on the weather radar, and perhaps in combination with the expected rainfall forecast, decides to build a storm that might represent the expected future rainfall. The aim being to provide a first-pass early warning of the flood conditions that might be expected; later on the user may equally as well update this storm to better reflect the recorded precipitation and rerun the model. To build the expected storm, the user sets following parameters in the EMS Utility:

- Select Antecedent Conditions: The calibration effort showed the catchment to be quite sensitive to soil moisture levels, hence there are three base conditions (Wet, Medium, Dry) from which to select.
- Select Storm Centre: A choice of ten locations throughout the catchment
- Set Maximum Storm Volume at Centre: The expected maximum rainfall, in millimetres. Totals away from the centre are reduced via an areal reduction factor.
- Select Design Storm Duration
- Set Storm Direction and Speed

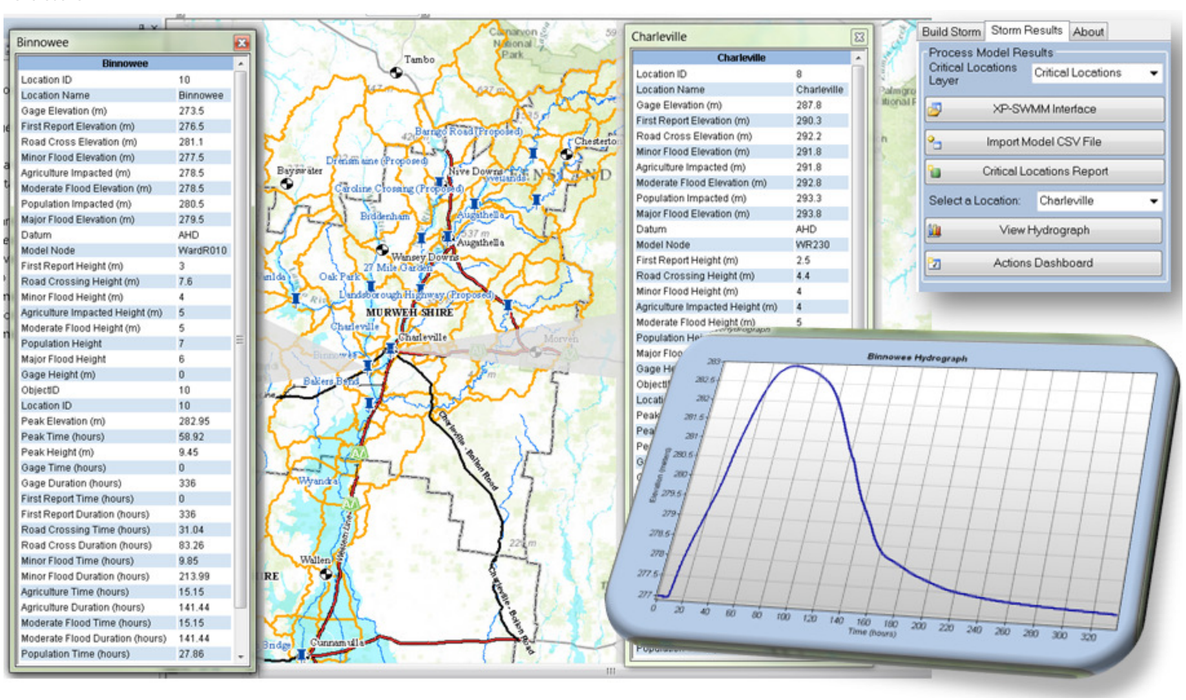
Note that if actual precipitation were being used instead, this step would be replaced by the user directly entering recorded rainfall values. A proposed enhancement is to automate this process such that recorded precipitation is obtained directly from the live data stream from South West NRM.

Once the conditions have been set, the “Process Storm Data” radio button is selected, transforming the parameters into an .xpx formatted precipitation file that can be read by the XPWSMM model, and automatically launching the XPSWMM user interface. Inside XPSWMM the user need only load the appropriate model for the selected antecedent condition, and then read the previously created .xpx rainfall file. Once the data are loaded the user solves the model, a process that typically takes several minutes, and then returns back to the GIS tool to import and interpret the results. Results are stored in a format proprietary to XPSWMM, and therefore need to be converted to a usable format. This is achieved by XPSWMM’s Results Files Utility, which is called up from inside the GIS environment by clicking upon the “XPSWMM Interface” button located on the EMS utility toolbar. This utility processes the model results data (.syf format) and converts it to a comma separated value (.csv) file, enabling access to the data in a friendly format.



Storm Characteristics are Exported to an XPSWMM Format

The results, in .csv format, are imported into the ArcMap geodatabase, enabling the generation of flood height hydrographs, time-to-closure, and time of closure calculations for the critical locations within the catchment. The user has the choice of generating a critical locations report table, containing all key data regarding flood heights and times, or may choose to navigate the map interface directly and click on points of interest. In this case, an HTML popup window appears containing the relevant information for that location.



Graphical Interface for Viewing Results

With knowledge of the likely scale and timing of a flood event, the user may then move to the "Emergency Management System Forms Dashboard". There are upwards of a dozen different forms that are required to be sent to multiple regulatory and emergency agencies in the event of a flood, with examples including obtaining permission from Department of Transport and Main Roads to install the flood gates that close the Landsborough Highway, a request for hospital evacuation, and numerous operational checklists. Past experience has shown that locating and completing the appropriate form can be a frustrating and time consuming task. Here, the complete suite of forms is stored in GIS environment, enabling the user to easily locate and track which forms have been filled out.

Conclusions

Flooding will continue to be a threat both to Charleville and to many other towns around Australia. Through this project CDM Smith has shown that by working collaboratively with a motivated Council it is possible to create a customised product that decentralises the prediction and decision making process and improves the resilience and self-sufficiency of the local community.

The Emergency Management System allows Murweh Shire Council to be proactive in their handling of flood emergencies. It builds upon the existing method of flood prediction, and improves it by incorporating new data sources, and tailoring the outputs to suit the requirements of Council.