Flood Emergency Decision Support System for Gold Coast City Council

David D. McConnell ¹, Bruce M. Druery ¹ and Khondker Rahman ²

¹ Patterson Britton & Partners, North Sydney, NSW 2060, AUSTRALIA
² Gold Coast City Council, Nerang, QLD 5042, AUSTRALIA

Abstract

Gold Coast City Council has extensive rivers and floodplains. A large number of people have settled in the floodplain with a particular preference for water-front living. Council over the last decade has developed hydrological models and one and two-dimensional flood models for the City’s major catchments and floodplains. Also substantial effort has gone into flood mapping and the collection of GIS-based properties and infrastructure data.

To better monitor the progression of a major flood and its likely impact on people and properties, Council is building a sophisticated Flood Emergency Decision Support System (DSS). The aim of the DSS is to integrate the hydrologic, hydraulic and GIS “flood intelligence” assessed over the last 10 years and extract and present vital flood emergency decision making information during an actual event.

This paper outlines the DSS strategy and show how the DSS extracts and displays all the various components of information to various groups which are required to respond to a flood emergency. Examples are provided of how the DSS interprets the basic hydraulic and hydrologic inputs and GIS data to provide flood intelligence such as:

- Flood Affected Properties – overfloor flooding associated with a predicted flood level.
- Evacuation and Exit Routes – the predicted depth and relative timing along evacuation routes to and from evacuation zones and nearest evacuation centers.
- Affected Road/Bridge crossings – the predicted impact on road crossings and bridges.
- Affected Demographics – display critical information on impacted population profiles. eg population data with age distribution.
- Flood Damage – post flood spatial assessment of the distribution of likely damage.

Introduction

The area covered by Gold Coast City Council includes extensive rivers and floodplains. A large number of people have settled in the floodplain with a particular preference for water-front living within the low relief coastal plain. Consequently, tens of thousands of people and their properties are at threat from severe flooding.

Over the last decade, Council has developed hydrological models and one and two-dimensional flood models for the City’s major catchments and floodplains. Also
substantial effort has gone into flood mapping and the collection of GIS-based properties and infrastructure data.

To better monitor the progression of a major flood and its likely impact on people and properties, Council is building a sophisticated Flood Emergency Decision Support System (DSS). It is anticipated that the DSS will engender a clearer understanding of flood behaviour and its impacts within the non-engineering community, and most importantly provide Council’s Counter Disaster Unit with the tools to plan for and respond to flood events.

The aim of the DSS then, is:

- to integrate the hydrologic, hydraulic and GIS “flood intelligence” assessed over the last 10 years,
- to present design and historic flood results integrated with property, infrastructure and community data and thus assist in the preparation of emergency disaster plans,
- to generate a flood surface for an actual event by interpolating from a library of “pre-cooked” surfaces, or by running a flood model in real time using the predicted hydrograph for the event and converting the results,
- to extract and present vital flood emergency decision making information during an actual event, and
- to assist in incorporating flood impacts responsibly within landuse planning strategies.

**Structure of the DSS**

The following figure shows the DSS as the processing hub of all the information available to Council in an emergency viz:

- GIS database
- Pre-cooked Library of Flood Surfaces
- Real Time Flood Modelling, based on forecast flood hydrographs predicted by BOM
- Land Use Planning Module
In essence the DSS is a Windows application that connects the property, infrastructure and community GIS databases to the predicted flood surface and updates the various flood affected fields within those databases. This information can then be presented to support emergency response or planning decisions as thematic maps and tabular summaries.

A key element in the DSS is simplicity of use for emergency response personnel whilst maintaining flexibility in the variety of views and integration with any number of GIS layers.

In its current form, the DSS makes use of the following datasets:

- Baseline topographic data:
  - an ALS based digital terrain model
  - airphotos
- Baseline GIS data:
  - cadastre,
  - ALERT gauging stations,
  - waterways,
  - evacuation centres,
  - evacuation zones
- Flood data:
  - a library of design flood surfaces
  - an interpolated flood surface calculated by the DSS
  - a time series of flood surfaces calculated by the flood model for the real time hydrograph or for design hydrographs
- Integrated GIS data:
  - property floor levels
The DSS integrates all this information, including the automatic execution of flood models based on hydrographs predicted by BOM, to provide the Flood Intelligence needed to respond to a flood emergency. The static pre-cooked library of flood surfaces is being built in parallel to the real-time system so that it can be used in case the real-time system malfunctions.

The processing capability of the DSS includes the interpolation of a predicted flood surface from the library of design surfaces based on predicted peak flood levels at one or more gauges, Figure 1. The single gauge solution is relatively straightforward, i.e. applying the interpolation ratio between two design surfaces at the gauge to all nodes on the flood surface, however the multiple gauge interpolation requires “zones of influence” to be established for each gauge with a smooth transition being applied across zone boundaries.

In its real time mode, the DSS reads the predicted rainfall runoff hydrograph provided electronically by BoM and converts it to a suitable format for the MIKE-11 flood model. The flood model is then automatically run by the DSS and when finished, the DSS then converts the results onto the flood surface spatial framework. In this case all timesteps at a pre-selected interval are converted to generate a time series of the evolving flood surface.

Once the peak flood surface has been generated, either from the library or through real time modelling, the fields in the various integrated GIS layers can then be updated. This analysis typically includes the transfer of flood levels, the determination of flood depths relative to say a floor level or a road level, the determination of air space under bridges, and with the time series data, the anticipated time when key facilities such as evacuation routes, will become affected.

The results of the analysis are presented to the user in a series of pre-prepared views with thematically mapped data fields, eg showing the predicted depth of flooding over evacuation route low points, Figure 1, the depth of flooding over property floors, Figure 2, the depth and extent of flooding across the landscape, Figure 3, and thematic surfaces of velocity and V*d values to identify areas of high risk. Views can be zoomed and panned and printed out for hard copy reference.
### FIGURE 1 – Depth of flooding over property floor levels for predicted flood interpolated from flood surface library

The map illustrates the depth of flooding over property floor levels, with colors indicating the depth of water. The legend at the top left shows the scale of depth in meters:

- **0.001**
- **0.301**
- **0.601**
- **0.901**
- **1.201**
- **1.501**
- **1.801**

### FIGURE 2 – Depth of flooding over evacuation route low points

The map shows the depth of flooding over the evacuation route, with low points highlighted. The legend at the top left indicates the scale of depth in meters.
The DSS in Emergency Response Planning

The initial preparation of the DSS included a set of draft evacuation zones and routes. These were subsequently refined as part of a flood disaster planning process by Council’s Counter Disaster Unit. The flood visualisation component of the DSS enabled CDU staff to become familiar with the potential behaviour of flooding including rates of rise, evolving flood extents, areas of high flood hazard and lead times prior to roads being cut. Although design floods rarely represent real events, they nonetheless provide a good indication of potential flood coverage, and they often replicate the rising stages of a major flood when the evacuation process is underway.

The preliminary evacuation zones were each scrutinised in detail with respect to:

- coherency for issuing warnings,
- lead time prior to evacuation routes being cut,
- identification of alternate evacuation routes,
- areas where evacuation route upgrades may be required,
- the need for on-site refuge,
- the traffic interplay with other zones along common evacuation routes,
- the flood conditions likely during any rescue operation,
- the distribution and size of facilities requiring managed evacuation, and
- the distribution of the elderly demographic where more assistance may be required.
This data immersion process instilled in the CDU staff, the magnitude of the impacts for a major or severe flooding event and the resources needed to execute such an evacuation. It is expected that further refinements would be applied as the built environment and associated demographic changes as well as after any flood event. However, one of the major benefits of a tool such as the DSS and its associated databases is the capturing of this knowledge for training and passing on to future generations of emergency personnel.

**The DSS in Real Time Flooding**

The two key elements of flood intelligence that are essential for an effective emergency response are knowing the eventual outcome or the area at risk, and having some idea of the rate at which flood waters are rising and likely to rise.

The BoM has a rigorous methodology for determining the peak of a flood, which of course improves with more rain having fallen in the upper catchment. Additionally, GCCC has arranged to obtain the runoff hydrographs generated by the BoM’s rainfall analysis, and whilst the subsequent flood modelling and data processing by the DSS can take up to an hour, the outcomes will still provide many hours of advance notice of flood conditions. In the event of any modelling failure, the “pre-cooked” library of data, which takes only minutes to process can be relied upon. Library design floods with similar rates of rise can be used to predict the short term impacts and assist with prioritising resources.

In real time use, the DSS will assist in graphically identifying the community at risk and the magnitude of the impacts and thus identify the scope for any evacuation. Subsequently as the flood progresses, the DSS can be used to indicate the flood impacts in the near future (say 1 to 2 hours), enabling emergency response priorities and resources to be appropriately assigned.

**Conclusion**

The development of a flood emergency decision support system by Gold Coast City Council brings together a decade of hydrologic and hydraulic modelling into a platform where it can be integrated, as needed, with spatial databases on the community, properties, infrastructure and the environment. The tool has the ability to analyse and then graphically present the impacts of any flood on the community during the event so that an appropriate response can be mounted with as much advance notice as possible.

The DSS was initiated for the real time response capability, however it has proven to be very useful for gaining an appreciation of the magnitude of potential flooding and its impacts, has been invaluable for planning emergency response strategies, and will be a useful asset for training.

It will also provide useful baseline data and analysis capabilities in the area of landuse planning.