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MAKING FLOOD WARNINGS FLOAT: A PILOT PROJECT ON THE GEORGES RIVER IN SYDNEY

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ABSTRACT

The magnitude of the flood problem on the Georges River became apparent, particularly for large floods greater than the 100-year event, during a floodplain management study on the Georges River undertaken by Bewsher Consulting for Liverpool, Fairfield, Bankstown and Sutherland Councils.

Like some other river systems in New South Wales, there is limited scope to undertake structural works to solve the flood problem. An effective flood warning system and adequate response plans by emergency management personnel and the community are therefore of utmost importance.

Flood warning is potentially a highly effective means of flood loss mitigation. However, recent flooding has demonstrated several problems including poor community understanding of flood warning predictions, poor community response to warnings, and poor client identification by emergency services.

In an attempt to improve the effectiveness of flood warning systems in New South Wales, the State Emergency Service (SES), Bewsher Consulting and the Georges River Floodplain Management Committee have embarked upon a pilot flood warning project in the Georges River catchment. The project involves the creation of an enhanced flood intelligence system for the Georges River, which aims to inform a community education program targeted at improving the local community's understanding of height-time flood predictions and response to warnings.

The planned flood intelligence system will be GIS based, including data on approximately 5,200 households, 600 commercial buildings and numerous evacuation routes, which would be inundated in a PMF flood. It will help the SES identify clients of flood warning services and provide information in advance of flooding to households and businesses. Strategies will also be developed to improve flood warning response including 'how to' guides on the creation of household and business flood plans.

If successful, the pilot program could be applied to other flood prone communities in New South Wales.

1. INTRODUCTION – ARE FLOOD WARNINGS SINKING?

Flood warning is potentially a highly effective means of flood loss mitigation. Experience has shown that warnings have the capacity to enhance public safety and reduce flood damages, by allowing persons adequate time to evacuate and to lift or remove contents (Handmer & Smith, 1995). Recent floods have supported this, but have suggested that flood warning systems are not performing to their full potential. Gissing (2002), in a study of flood warning performance during the Kempsey, NSW, 2001 flood, found problems including poor community understanding of flood warning predictions, poor community response to warnings, and poor client identification by emergency services reduced flood warning effectiveness. Pfister (2002), following the Grafton, NSW, 2001 flood, found that less then ten percent of the at-risk community responded appropriately to evacuation warnings, indicating a poor understanding of the warnings delivered. Anderson-Berry (2002) and Soste and Glass (1996) have reported similar results, stating that many people do not understand flood gauge heights contained in warning messages.

As the lead player, and with a legislated role in flood warning, the SES is keen on developing solutions to the problems identified in the warning performance research. This paper will discuss strategies which the SES is currently pursuing in a pilot project in the Georges River catchment in Sydney.

2. THE ROLE OF THE STATE EMERGENCY SERVICE IN FLOOD WARNINGS

The State Emergency Service is the ‘combat agency’ for flood in NSW, meaning it is the government agency responsible for managing flood emergencies in NSW. This role encompasses numerous functions of which flood warning is an inherent part; these include floodplain risk management, community education for floods, flood planning and flood response. In NSW the SES is responsible for the establishment of warning systems (in partnership with the Bureau of Meteorology and Councils), interpretation of warning predictions, construction of warning messages, communication of warning messages to the public and providing public advice on the appropriate responses to flooding. The Commonwealth Bureau of Meteorology (BOM) is responsible for providing height-time flood predictions to sites listed in the NSW State Flood Plan.

3. CRITICAL COMPONENTS IN THE SES’S FLOOD WARNING ROLE

To enable the SES to effectively perform its flood warning role, two critical components exist: flood intelligence and community education.

Flood intelligence

The term ‘Flood Intelligence’ refers to the process of gathering and analysing flood related information to enable emergency managers to determine the actual or likely effects of flooding on a community (Pfister & Rutledge, 2002). Flood Intelligence has two main uses in the warning context: flood planning and flood response. In flood planning it is used to identify at-risk members of communities (the potential clients of flood warnings) and in response operations to interpret the likely consequences of a forecast flood. By identifying the likely clients of flood warnings for different severities of flooding, the SES can prepare flood warning messages that mention those elements of the community likely to be affected, therefore adding value to the Bureau’s height predictions. In addition, identification of likely clients prior to floods allows the SES to prepare warning messages, conduct public education programs and plan for the dissemination of warnings to the public. The importance of these functions means it is critical that flood intelligence is accurate and complete.

Currently the SES maintains a flood intelligence database which provides height vs. consequence information for approximately 300 river gauges across NSW. The system is text based and has largely been developed from anecdotal information about historical floods. As a result the system can have missing records for flood heights which have not historically occurred or been recorded. Information from Flood Studies and Floodplain Management Studies are used when available to help complete missing entries. One of the most beneficial aspect of these studies is the individual property height data of at-risk properties, which can be interpreted to ascertain the approximate gauge height (within a degree of error) at which each property will be affected by over-ground or over-floor flooding. Due to the obvious limitations of a text-based system, the detail of this information can only be briefly recorded. A further limitation of the current system is that text-based intelligence cannot be easily mapped within a Geographic Information System (GIS). These limitations demonstrate scope for improvements.

Community education

Public education is aimed at improving the awareness of risk and providing information on appropriate actions in response to identified risks. Education is also an important tool in attempting to enhance the community's understanding of flood predictions. At-risk businesses and households make decisions on how to respond to warnings based upon their perception of their flood risk (Anderson-Berry, 2002). An individual or group with an inaccurate view of their flood risk will inevitably make poor judgements when interpreting flood warnings. Hence it is crucial that people understand the level of risk to which they are exposed.

The apparent low level of flood awareness and preparedness in many communities is problematic in this regard. In the NSW floods of 2001 flood awareness and preparedness was largely low resulting in many people being unable to derive personal meaning from height-time flood predictions. Without the understanding of what flood warnings meant, misjudgements were made, resulting in inadequate responses to flood warnings (Gissing, 2002). There is a clear challenge here for the SES to empower communities so that they can understand flood warnings and hence take appropriate actions to reduce flood exposure.

4. SOLVING THE PROBLEMS – ACHIEVING MAXIMUM "BUOYANCY"

The SES continually seeks to improve the performance of flood warning systems. In partnership with Bewsher Consulting and the Georges River Floodplain Management Committee, the SES has embarked upon a pilot project in the Georges River catchment aimed at improving the community's understanding of flood warning predictions and the SES's provision of warning information. In addition the SES has put in place other strategies to improve warnings, which have previously been discussed by Keys (2002).

The project consists of two phases: firstly, the preparation of a GIS flood intelligence database and secondly, a community education program specifically aimed at improving the ability of the community to interpret flood warnings. Incidentally, both phases were key discussion outcomes of the National Flood Warning Workshop held in 2002 (Elliott et al., 2003).

Currently, Phase 1 is well under way and is likely to be completed shortly. Phase 2 will commence later in the year, with the SES currently investigating potential strategies.

5. THE GEORGES RIVER

The Georges River catchment, located in the south of Sydney is approximately 960 square kilometres in size. Flowing through the council areas of Liverpool City, Fairfield City, Bankstown City and Sutherland Shire, the river starts near Appin and flows north to Liverpool before turning eastwards flowing towards Botany Bay. Approximately one-third of the catchment is urbanised and is home to about one million people. The 1988 flood (~5% AEP) was estimated to have inundated over 1,000 residential properties along the Georges River, Prospect Creek and Cabramatta Creek, with an estimated loss of over $28 million (2003 value). The 1873 flood is estimated to have been three metres higher than the height recorded in 1988 at Liverpool Weir. The *Georges River Floodplain Management Study* (Bewsher Consulting, 2003) estimated that the PMF would inundate over 5,200 residential buildings and close to 600 industrial/commercial/public sector buildings, emphasising the alarming scale of the flood risk (Table 1). This risk is further increased by the short-warning time available and the inevitable flooding of some of Sydney's major roads.

The Bureau issues height-time flood predictions for up to four gauges: Liverpool Weir, Milperra, Kelso Creek (East Hills) and Picnic Point. These locations are shown in Figure 1. The flood warning network consists of 18 telemetric rain gauges and 10 telemetric river gauges. Typically six hours' warning time will be available for flooding at Liverpool, though this can be less during severe floods. Flood predictions are based upon numerical weather models, which indicate probable rainfall intensity, as well as tidal variation, which exerts an influence at Milperra and downstream.

TABLE 1: NUMBER OF GEORGES RIVER PROPERTIES AND BUILDINGS SUBJECT TO FLOODING

Source: Bewsher Consulting, 2003

	100 year flood	**PMF**
Residential properties	1,363	5,697
Residential buildings	721	5,204
Industrial/commercial/public sector properties	261	617
Industrial/commercial/public sector buildings	216	591

6. PHASE 1 – DEVELOPMENT OF GIS FLOOD INTELLIGENCE DATABASE

Method

The software for the model was written using MapBasic™. The SES user operates the software using MapInfo™.

The means by which the predicted flood level at the flood gauge(s) is translated to particular elements at risk is via average recurrence intervals (ARIs). Flood frequency relationships were derived for each of the four gauges, using the hydraulic model MIKE 11. Similarly, as part of the *Georges River Floodplain Management Study*, the 20 year, 100 year and PMF heights at each property were estimated. In order to cater for more frequent floods, the level of the 5 year flood was estimated as part of this project. The Study also collected ground and floor level data for properties that could potentially be affected by floods up to the PMF. If the predicted ARI at the flood gauge(s) is greater than (i.e., rarer than) the ARI of the element at risk (say, the floor level of a house), then that element will be included in the output, either by being coloured in on a map, or listed in a printable table.

The thousands of properties included in the database have been allocated to one of six flood gauge regions, which are shown in Figure 1. Four of these regions are centred on one of the four flood gauges. The Milperra-Liverpool flood region is situated in an area downstream of Cabramatta Creek that may be influenced by tributary inflows. For this region, the flood frequency is estimated by averaging the ARIs for Liverpool Weir and Milperra gauges, when both of these are available. The area 'protected' by Kelso Creek levee is also treated as a separate flood gauge region, because properties behind the levee will be inundated only when the levee is overtopped at 5.8 m AHD, corresponding to a frequency of about 150 years. Floods more frequent than this will produce unrealistic outputs, because the influence of the levee has not (yet) been incorporated into the model.

The Bureau only issues forecasts for the lowermost gauges if they expect moderate or major flooding at Milperra. It is also possible that predictions may be compromised if one or more gauges malfunction in the early stages of a flood. To cater for every possible combination of predictions, the program allows for 15 scenarios. For example, if no flood prediction is issued for the Kelso Creek (East Hills) gauge, properties within the East Hills region are automatically allocated to the Milperra gauge for the estimation of flood recurrence interval.

Input

The only required input is at least one flood prediction for the Georges River. Figure 2 presents the dialogue box that the SES will use on their PC.

Outputs

Figure 2 shows that the model produces two outputs. The first is a *map* (viewed in MapInfo™) highlighting elements flooded for a particular flood prediction; the second is a *list* of those elements flooded for a particular flood prediction. An 'element' at risk is a land use selected by the SES user. Typical elements are houses, shops, factories, 'special risks' such as nursing homes, low-points in roads and other critical infrastructure. Capacity has been developed to select floor levels or ground levels for buildings at risk.

These outputs can be used by the SES for several purposes: identifying persons potentially at risk as a consequence of a predicted flood height, who require warning and/or evacuation; traffic management; the assessment of pre-deployment needs due to isolations; informing community education programs; and conducting flood simulation exercises and training.

Limitations

Like all models, the quality of the output is contingent upon the quality of the base data. Surveyed ground and floor level data were used where available, but most ground levels were derived from a digital terrain model, and most (91%) floor levels were estimated by adding 0.5 m to the ground level. In most cases, the ground level is taken from the centre of a property, which may give a false impression for steeply sloping lots. It is envisaged that the MapInfo™ property data tables shall be updated as better information comes to hand.

Similarly, the flood study did not estimate flood levels more frequent than the 5 year flood, so the model cannot provide outputs for these (generally low consequence) events.

7. PHASE 2 – COMMUNITY EDUCATION

Previously, community education programs have been conducted throughout the Georges River catchment. These programs have focused upon developing a broad awareness of the flood risk within the catchment and have involved the creation and distribution of FloodSafe guides. These guides have included broad information of the flood risk and actions people can take.

Following this the SES wishes to deepen the program to communicate to at-risk property owners, prior to flooding, the severity of flooding which may affect them. The theory is that if people have knowledge of the severity of flooding at which they will be affected, they will be better able to understand flood warnings and relate them to their own personal circumstances. The SES is currently investigating ways to achieve this objective. The data for the project will be sourced from the GIS database created in Phase 1.

Additional FloodSafe guides will be produced to support the program. These will be produced for specific risk areas, rather than on a whole of catchment basis. These guides will link at risk areas to relevant flood warning gauges by notifying residents of critical flood gauge heights in their respective areas.

As part of this initiative the SES will produce template household and business flood plans. These templates will enable individuals to create their own flood plans, which detail simple actions to be taken on receipt of flood warnings. It is intended that this process will empower individuals to improve their preparedness for floods and therefore respond appropriately to flood warnings. Templates aim to guide individuals through the planning process, ensuring that appropriate issues are addressed, and attempt to overcome the problems of poor development and implementation identified by Gissing (2003).

8. FUTURE DIRECTIONS – BROADENING THE SCOPE

The GIS interface for the Flood Intelligence database is transferable to other areas of the State, where appropriate property height and flood height information is available. The MapBasic™ interface is also flexible allowing modifications if necessary.

Combined with the SES's other GIS flood intelligence initiatives being performed as part of the NSW Government Hawkesbury Nepean Strategy (Crowe et al., 2003), the SES will continue to further develop GIS as part of its flood intelligence system. In the future it will become a key component of the total flood warning system by providing smart, computerised, complete and map based flood intelligence. The enhanced flood intelligence system will improve the identification of properties at risk, which will better enable the SES to communicate the likely consequences of predicted flood heights to the public. With customisation and user training the system could be effectively utilised by local unit volunteers in their roles of interpreting warning predictions, planning and responding to floods.

The variety of community education initiatives that will be trialed within the project will be evaluated. Based upon the outcomes of the evaluation, lessons learnt will be incorporated into the SES's state wide community education strategy.

FIGURE 1: DISTRIBUTION OF FLOOD GAUGES, AND FLOOD GAUGE REGIONS FOR THE GEORGES RIVER REGION

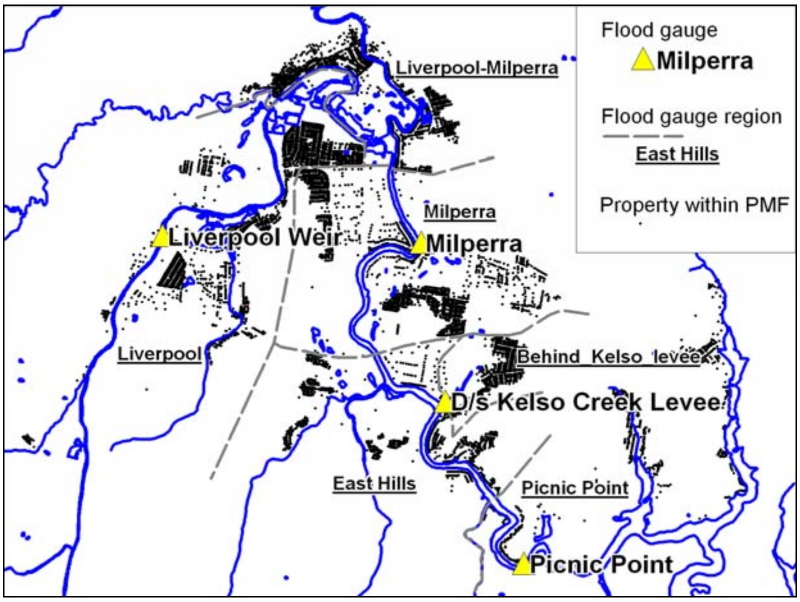
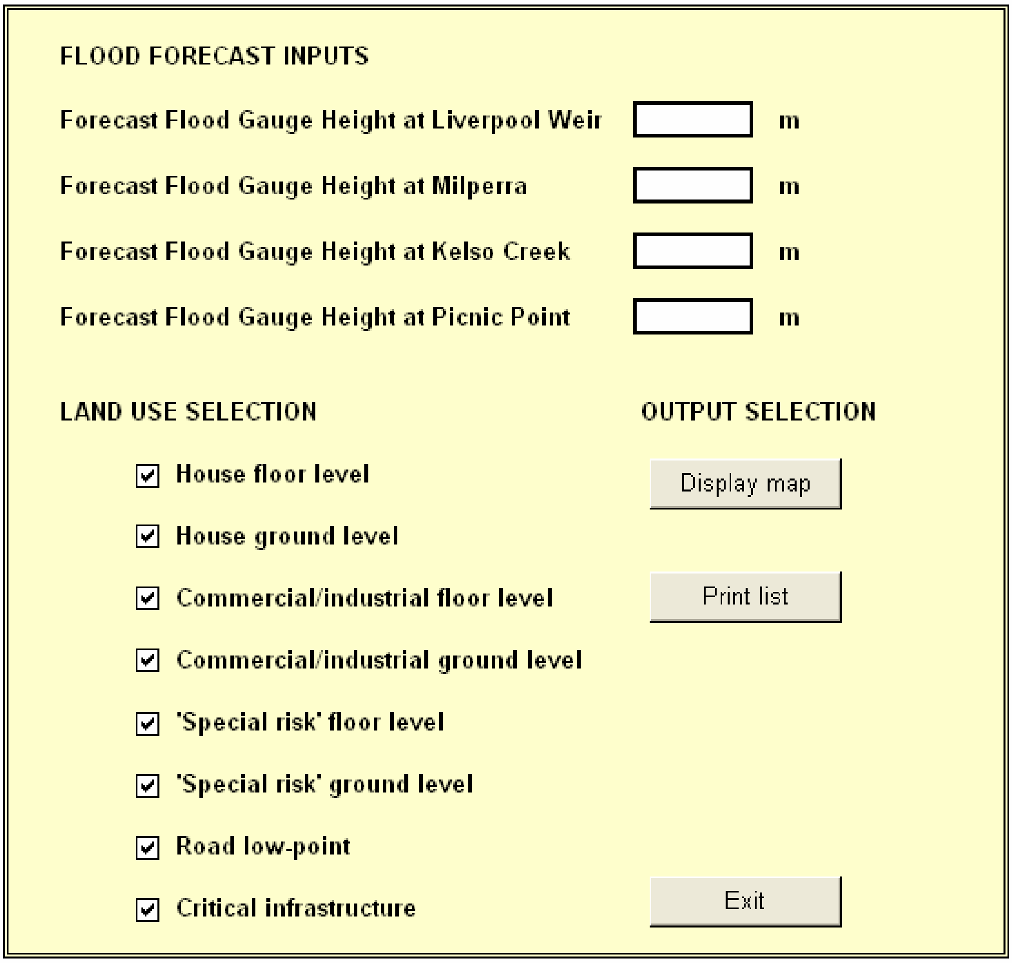


FIGURE 2 - DIALOGUE BOX



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Presenters Profiles

Andrew Gissing

Andrew Gissing formally with the Risk Frontiers Natural Hazards Research Centre joined the SES in 2002 as a Planning and Research Officer. Andrew has a Masters (Hons) degree in Science, specialising in flood management. His main flood related interests are in the preparation of flood emergency plans, community education, coastal flooding, business continuity planning and flood warning systems.

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Drew Bewsher

Drew Bewsher has been a director of Bewsher Consulting Pty Ltd since the company was established in 1986. In the seven years prior to that, he was a senior water resources engineer with Sinclair Knight and Partners. Drew also spent three years working as the investigations engineer with the Murray Darling Basin Commission.

Drew has been responsible for the preparation of nearly 20 floodplain management studies and plans across the State. In addition, his firm has completed many dozens of flood studies for rural and urban communities.

Drew has authored a number of technical papers on issues relating to floodplain management. His particular interests include floodplain planning, development controls for floodplains, flood awareness and effective community participation in floodplain management studies.

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