BELLS AND WHISTLES, BELTS AND BRACES - DESIGNING AN INTEGRATED FLOOD WARNING SYSTEM FOR THE HAWKESBURY NEPEAN VALLEY

Part 2 – Belts and Braces – Designing an Integrated System

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ABSTRACT

The Hawkesbury-Nepean Valley west of Sydney is severely affected by flooding. The nature of flooding, the topography and patterns of development mean that in the most extreme events flood warnings must be disseminated to a population of more than 60,000 spread across a floodplain exceeding 400 square kilometres and along another 50 kilometres of river gorge. Molino Stewart investigated available and emerging technologies which are suitable for emergency warning. It then facilitated a structured process for evaluating the technologies and finding the most appropriate mix for an integrated warning system in the Hawkesbury Nepean. A paper delivered at the 2001 Floodplain Management Authorities Conference described the technologies identified while this paper explains how they were evaluated and how an integrated concept was developed.

1 BACKGROUND

The Nepean Catchment includes the Southern Highlands, the Blue Mountains and Western Sydney and covers 12,000 square kilometres upstream of Windsor. The river runs along the foot of the Blue Mountains between Penrith and Windsor and changes its name to the Hawkesbury River between these two urban centres. At Windsor the river is virtually at sea level but winds through steep sandstone gorges for another 100 kilometres before reaching the ocean at Broken Bay. It picks up another 10,000 square kilometres of catchment along the way.

There is a 400 square kilometre floodplain between Penrith and Windsor which is the home to more than 60,000 people living in urban centres, rural townships and villages, rural residential developments and farms. Further downstream in the gorge area the population is smaller and more scattered with farms, weekenders and mobile homes being the common forms of accommodation. In the urban areas there are also nearly 4,000 commercial and industrial premises as well as schools, hospitals, nursing homes and prisons that may all need evacuation during floods.

In 1997, the NSW State Government formed the Hawkesbury-Nepean Floodplain Management Advisory Committee to undertake investigations and make recommendations to the Government regarding management of the flood risks faced by the Hawkesbury-Nepean Valley communities.

A key recommendation of the Committee's "Achieving a Hawkesbury-Nepean Floodplain Strategy" was:

"That the funding provision for flood warning sirens… be applied to the installation of a cost effective flood warning network comprising a combination of sirens and other appropriate technology." (HNFMAC 1997, 13).

Molino Stewart was engaged to identify and evaluate a range of potential flood warning dissemination technologies that could have an application in the Hawkesbury Nepean. This paper explains how they were evaluated and how an integrated warning system concept was devised.

2 BELLS AND WHISTLES

The results of investigations into available warning technologies are reported in Molino, Begg, Stewart and Opper (2001). A total of ten different types of "technologies" were carried forward from that investigation for further evaluation. They were:

Fixed Public Address – A network of speakers on buildings and/or poles which broadcast an amplified flood warning message throughout the floodplain.

Mobile Public Address – speakers on motor vehicles travelling throughout the floodplain broadcasting an amplified flood warning message.

Sirens – A similar network to a fixed public address system but sirens simply broadcast a warning alarm.

Personal Notification – Emergency Service personnel and others undertaking systematic doorknocking and speaking directly to building occupants

Free to Air TV/radio bulletin – Broadcasting of flood warning messages over existing free to air radio and television networks.

Tone Alert Radio – Individual radios are installed in each building. The radio is powered in a standby mode and activated by a broadcast radio signal. It then receives and amplifies a broadcast warning message.

Dial-out – A computer controlled system which dials all telephones within the area which needs to receive a warning message. When the phone is answered a recorded warning message is delivered.

Community Notification Solutions – This is similar to a dial out system in that a computer controlled system sends a recorded warning message through the telephone network. But rather than ringing telephones and delivering a voice message it sends a data message to a device connected to the recipients phone line. A light on the device then flashes to alert the recipient to a text warning message displayed on the device.

Modulated Electrical Frequency – Using a device similar to that used in the community notification system but triggering it by a frequency ripple sent along power lines in much the same way that off-peak hot water systems are switched on remotely by electricity distribution authorities.

Variable Message Signs – Electronic signs by the roadside displaying flood warning messages

3 BELTS AND BRACES

Having identified the various technologies which were to be evaluated, it was necessary to use a systematic process to compare and evaluate the technologies and develop a concept for an appropriate warning system for the Hawkesbury-Nepean Valley.

3.1 EVALUATING INDIVIDUAL TECHNOLOGIES

3.1.1 Evaluation Method

A methodology called multi-criteria analysis was used to compare the technologies. This allows options with different performance characteristics to be compared objectively while making provision for subjective judgements to be made about the importance of the criteria used to compare options.

For each technology a concept was developed for the implementation of that single technology throughout the Hawkesbury Nepean Valley. Each concept accounted for the distribution and density of settlements, topography and infrastructure capacities. For some options there were sub-options to allow comparisons between different configurations of the same technologies but which trade off different performance criteria such as cost and speed of notification.

The SES and Department of Land and Water Conservation identified 28 criteria for evaluating the performance of the options. They also provided a range of weightings for these criteria depending on their opinions as to how important each criterion is in making a decision.

These criteria covered such issues as:

- Whether the system would alert, notify or do both
- Effectiveness
- Cost
- Speed
- Reliance on the infrastructure of other organisations
- Community resistance
- Longevity of the technology

3.1.2 Performing the Evaluation

The evaluation of the performance of each system against the evaluation criteria was undertaken by:

- Identifying information requirements for each system to facilitate the assessment of its performance against each criterion;
- Contacting suppliers of the technology in Australia where possible and overseas in other instances, seeking assistance with information requirements;
- Reaching a consensus with the SES and suppliers on assumptions needed to estimate performance;
- Estimating performance with respect to the agreed assumptions; and
- Cross checking results to ensure consistency.

To ensure that values analysed in the MCA were consistent across all options, a generic option summary sheet was created. The sheet detailed the information required to make an informed decision about each criterion and, if relevant, outlined an appropriate scoring system to ensure consistency.

It was assumed for the purposes of the MCA that any particular option would be applied across the entire floodplain. This determined the system requirements and performance for each option. Consideration was given to more selective application of options to different areas of the floodplain in later stages of the concept development process.

Sensitivity analyses were incorporated into the MCA by estimating optimistic and pessimistic performance scores for each option against each criterion in addition to the best estimate performances. In addition, six individuals from

the State Emergency Service and the Department of Land and Water Conservation each gave a weighting to each criterion which expressed their individual opinion as to the importance of that criterion in choosing between technologies. The group's minimum, mean and average weightings were used in the MCA with pessimistic, best estimate and optimistic scores to test the sensitivity of the option rankings to assumptions about their performance and the importance of criteria.

3.1.3 MCA Results

Multi-criteria analysis can produce outputs in a number of forms. The two forms used in this analysis were **weighted summation** and **concordance**. The weighted summation provided an indicative ranking taking into account the absolute scores and weightings. The concordance analysis was a useful tool for examining the relative performances of particular options by comparing each option in a pair wise comparison with each other option to determine how many options it outperformed. A more detailed explanation of MCA and the different types of analyses can be found in Resource Assessment Commission Working Paper Number 6 (Resource Assessment Commission 1992).

Table 1 summarises the rankings from the different analyses. Consistent patterns emerge from the analyses, and these are discussed further in the following sections.

The term rankings is used in the following when discussing all analyses, although strictly the term is only applicable to the weighted summation analysis. The concordance analyses only give an indicative order of options and it is not valid to compare any two options using these analyses. Rather they are used to validate the weighted summation results or to identify the possibility of biases created by assumptions about scores.

Table 1: Rankings

	WEIGHTED SUMMATION			CONCORDANCE		
RANKING	**MIN**	**MAX**	**MEAN**	**MIN**	**MAX**	**MEAN**
1	Fixed PA	Fixed PA	Fixed PA	Personal notification	Personal notification	Personal notification
2	Personal notification	Personal notification	Personal notification	Free to Air TV/radio bulletin	Free to Air TV/radio bulletin	Free to Air TV/radio bulletin
3	Free to Air TV/radio bulletin	Sirens	Free to Air TV/radio bulletin	Fixed PA	Tone alert radio	Tone alert radio
4	Sirens	Free to Air TV/radio bulletin	Sirens	Mobile PA	Mobile PA	Mobile PA
5	Tone alert radio	Tone alert radio	Tone alert radio	Tone alert radio	Fixed PA	Fixed PA
6	Mobile PA	Mobile PA	Mobile PA	Sirens	Sirens	Sirens
7	Community Notification Solutions	Modulated Electrical Frequency	Modulated Electrical Frequency	Dial-out	Dial-out	Community Notification Solutions
8	Modulated Electrical Frequency	Dial-out	Community Notification Solutions	Community Notification Solutions	Community Notification Solutions	Dial-out
9	Signs	Community Notification Solutions	Signs	Signs	Modulated Electrical Frequency	Signs
10	Dial-out	Signs	Dial-out	Modulated Electrical Frequency	Signs	Modulated Electrical Frequency

A consistent pattern was evident from the weighted summation analyses. Fixed PA systems were consistently the highest ranking options. Personal Notification was consistently the second ranked option. The next two highest ranking options were TV/Radio Broadcasting and Sirens. Examination of the actual scores for these two options showed that they were extremely close.

The concordance analysis indicated that while the same group of four or five options were overall the best performers, there were a number which were better at satisfying a larger number of criteria than Fixed PA (the preferred option from the weighted summation analysis).

These results were based on a single technology being applied across the entire floodplain. It is the overall goal of any flood warning system to maximise the performance of the total system against as many of the criteria as possible within the constraints imposed.

Applying this principle could lead to:

- The adoption of different technologies in different locations depending on the particular features of an area; and/or
- The use of multiple technologies in some areas to ensure that the limitations of one technology do not prevent the warning being delivered to most of the population.

This principle was discussed further and applied in later sections of the concept development.

3.1.4 Further Sensitivity Analyses

The results of the MCA were presented to the SES State Planning Co-ordinator and the Division Controller responsible for the majority of the Hawkesbury-Nepean Valley. They asked a number of questions regarding the assumptions about options design and performance and criteria weightings. Those questions were answered by undertaking several sensitivity analyses to see whether changing certain assumptions would alter the relative ranking of options.

As a result, some additional dial out options were developed including larger, faster systems and systems operated by a third party. Some different performance scores were tested for the fixed PA and some different criteria weightings were tested (including zeroing some criteria so they did not contribute to the analysis).

The result was that in the weighted summation the Fixed PA was consistently the first or second highest ranked option. The concordance analyses generally push Fixed PA into fifth place which indicated that there are options which perform better than it on more criteria but the relative difference in performance on those criteria (which is ignored by concordance analysis) is not as great as the difference on the criteria where Fixed PA performs better.

Similarly personal notification was in the top two rankings in most of the analyses and only moves down the weighted summation rankings when selected criteria are zeroed.

Free to air broadcasting was also generally highly ranked in most analyses.

The additional dial out systems considered consistently ranked more highly than the original option. This suggested that workshop participants would consider that the faster speed of alert and notification outweighs the additional costs involved. It also showed that having an outside service provider who is already in the business of operating similar systems would be preferable to having to install, maintain and operate the system independently.

The use of optimistic scores did not alter the ranking of the top four options significantly and Fixed PA remained the highest ranked option.

Pessimistic scores placed personal notification and free to air TV and radio in the top two places followed by the larger dial out systems. However, examination of the weighted summation scores indicated that fixed PA scored only 2-3% lower than the dial out options in this analysis which is not a significant difference.

It should be stressed at this point that the MCA process itself does not select a preferred option but helps give insight into the relative performance of different options. It allows a large amount of diverse information to be sorted so that decision making can focus in on the most critical elements of options performance.

Subsequent sections of this paper explain how the above observations were used by the consultants and the SES in a series of workshops to arrive at a preferred warning system for the Hawkesbury Nepean Valley.

3.2 DESIGNING A WARNING SYSTEM

The MCA made it clear that no single technology or system performs well against all the identified criteria and many of the technologies investigated have not been tested in real emergencies. For these reasons any decision to invest in a technology or implement a particular warning system needs to recognise the uncertainties involved. An appropriate response is likely to be a 'layered' strategy that seeks to implement complementary approaches using a risk management philosophy. Which particular technologies are combined may vary from locality to locality across the floodplain.

The results of the MCA provide guidance in the elimination of some options from further consideration, the adoption of some technologies and the shortlisting of others for further investigation. The following logic was applied:

3.2.1 Eliminated Options

- **Signs** along the roadside ranked very low. They would only be seen by a small number of people and most of these people would either be driving out of the flood zone within about 30 minutes or would get out of their cars within the flood zone where they could be reached by one of the other warning technologies.

- **Modulated Electrical Frequency** ranked low and the available budget would not allow it to be implemented across more than 50% of the floodplain. It would not offer any significant advantages over other systems such as tone alert radios or dial out systems which would also deliver warnings within buildings.

- **Enhanced Dial Out (CNS)** systems rank lower than other dial out systems because they are more expensive, are more reliant on power supply, are an unfamiliar technology and untried technology despite being significantly faster than other dial out systems.

- **Mobile Public Address** consistently ranked lower than Fixed PA and could offer no significant advantages over it as a public warning technology.

- **Sirens** consistently ranked lower than Fixed PA. This would appear to be because they require larger installations, are more reliant upon a power supply and can only deliver an alert message. Although the effectiveness of the notification function of a Fixed PA for people indoors has been questioned by some, it would certainly be a useful adjunct to the alert function and would only cost about 20% more than a siren system. Sirens were therefore not considered further.

3.2.2 Adopted Options

It was clear from the MCA that **Free to Air Radio and Television Broadcasts** rank highly as a warning dissemination technology. They have almost zero cost and quite detailed messages can be delivered and these can be continually updated. The two downsides to this technology are that it cannot be relied upon as an alert technology and it relies upon third parties to accurately communicate the warning messages.

The SES determined that free to air broadcasts should be an integral part of the flood warning system for the communities of Hawkesbury-Nepean River Valley. To overcome its limitations the following is proposed:

- The local Hawkesbury Radio Station be requested to provide continuous broadcast of flood warning information in event of a flood;

- All community flood preparedness literature and other preparedness communication media advertise the Hawkesbury Radio Station as the preferred source of up to date flood warning information; and

- All other electronic media be requested to only broadcast unedited flood warning messages from the SES.

The SES is also in the process of establishing a **Call Centre** (dial in only) as part of its flood awareness and preparedness strategy. It is anticipated that it would also be available during a flood to provide detailed flood warning notification to those who were already alerted by some other means.

Finally, the SES already has in place a community based **Rural Warden System** in some locations which are frequently flooded. These use a combination of telephoning and doorknocking to reach residents and businesses in high risk locations. This system would be maintained and continue to be used in all floods but may be supplemented with other warning methods.

3.2.3 Options for Further Consideration

In light of the preceding discussion the following technologies remained for further consideration:

- Fixed Public Address;
- Personal Notification;
- Telephone Dial Out System; and
- Tone Alert Radios

Some further discussion was held in relation to what each of these would involve in an integrated warning system.

Fixed Public Address

The Fixed PA evaluated in the MCA involved a network incorporating two base stations, three repeater stations and 27 PA installations to cover almost the whole of the potentially flood affected areas. These included areas of dense and dispersed population. However the system design is such that the more dense the populations, the more cost effective these systems become. Coupled with that however, is that the smaller the total population, the less cost effective the systems become. These were important considerations in designing a concept for an integrated warning system.

Personal Notification

Personal notification in the MCA was confined to SES volunteers door knocking individual houses and commercial and industrial premises. Personal notification can also include personal telephone calls and "telephone trees". These, along with door knocking, are used by the rural wardens where these systems are in place in the Valley. In subsequent discussions personal notification was confined to doorknocking by SES volunteers and did not include doorknocking by rural flood wardens.

Dial Out Systems

With regard to Dial Out Systems the MCA made it clear that the faster the system, the higher it would rank despite the increased costs. It was also clear that a system operated by a third party who was already involved in maintaining and operating dial out systems for other purposes would decrease costs without creating any other distinct disadvantages.

There are therefore many possible scales of dial out system from systems which only cover particular localities to those which cover the entire floodplain. They could be PC based or mainframe based or they could even rely upon manual dial out from a call centre. While any of these systems could theoretically be maintained and operated by a third party as part of a

larger call making business, it was not clear at the time of the evaluations whether there were any such organisations willing to undertake such a task.

Tone Alert Radio

The QuikTrak Tone Alert Radio System used in the MCA exceeds the budget of this project by an order of magnitude and could not be considered for use across the entire floodplain. It may be affordable and appropriate for some small parts of the floodplain but based on the cost estimates provided it would not be affordable to install it in more than about 1,000 of the 20,000 potentially flood affected buildings.

There are other less sophisticated tone alert radio systems available but these have more limited capabilities and are more reliant upon building occupiers for ongoing maintenance and function. Alternatively the QuikTrak system may be able to be installed with fewer features. Such a system might be more realistic for comparison with other warning technologies in the Hawkesbury Nepean. In the discussions in the following sections a reference to a tone alert system is a reference to a lower cost system than the QuikTrak system originally evaluated.

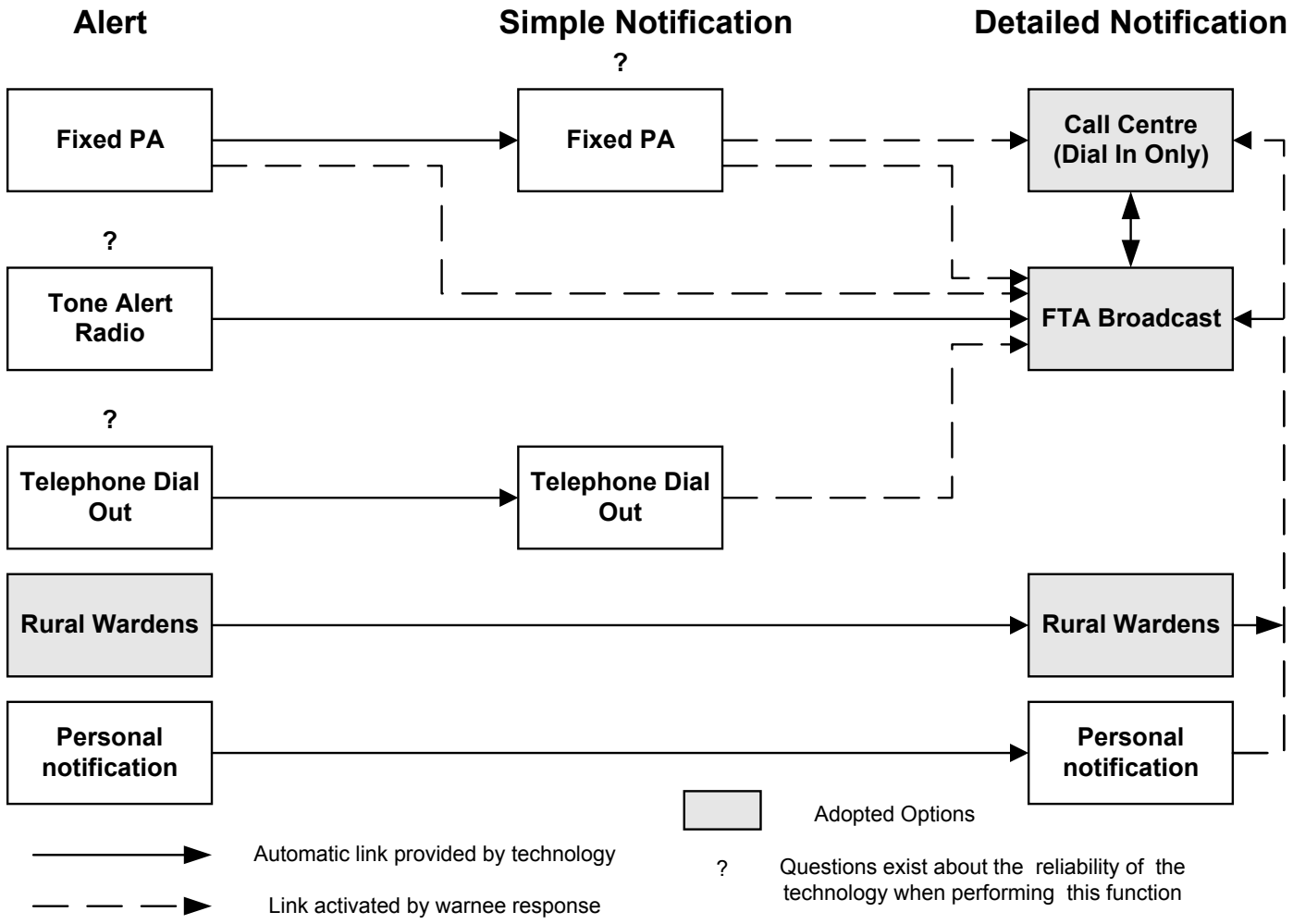
3.3 INTEGRATING TECHNOLOGIES

It must be recognised that designing a flood warning system is not simply selecting the technology or mix of technologies which will be used to disseminate a flood warning. It also involves carefully designing the warning message content which may vary between the dissemination technologies. Furthermore, it must be integrated with a whole awareness and preparedness strategy for the flood affected communities so that when a warning is issued appropriate responses can be made.

It was beyond the scope of this study to explore all of the community preparedness and message content issues but reference was made to these in discussing the relative merits of technologies and the design of an overall warning system.

Figure 1 shows how the various types of warning technologies could be integrated into a total warning system. It highlights those warning technologies which are already in place or will be part of an integrated warning system for the Hawkesbury Nepean. It then shows how other technologies, if adopted, would integrate with the core elements. The diagram shows which technologies would give an alert message, which would give a simple notification message and which would give a more detailed notification message. It also indicates whether the notification automatically follows the alert or whether the warned individual needs to take further steps to receive the notification message(s).

Figure 1: ***POTENTIAL INTERACTION OF FLOOD WARNING SYSTEM COMPONENTS***



3.4 COMMUNICATION BARRIERS

While Fixed PA is the best performing technology overall it has its limitations and there are a number of criteria against which other approaches are better performers. A risk management approach is the most appropriate way to design an integrated warning system.

Put simply, the warning system needs to get a message across to as many people as possible. There are a number of communication barriers which it will need to overcome and there may be some individuals who will not receive the warning message because it is not possible, practical or affordable to commit all the resources necessary to overcome all of the barriers to communicating the warning message to them.

Table 2 sets out a way of considering how each technology overcomes these communication barriers and how they might be integrated in the most effective way. The first row of the table considers the type of warning message which needs to be communicated. There are two types: alert and warning. The alert message simply tells people that there is impending flood danger, the notification provides more detail about the type of danger and the appropriate response. The level of detail in the notification message will be determined by the limitations of the technology and the broader content issues of the overall community preparedness strategy.

The next row is the warning technologies in a preliminary order of preference. This order does not strictly follow that of the MCA but reflects the outcomes of meetings held between the consultants and SES personnel to discuss the MCA results. As explained elsewhere in this paper MCA does not make decisions but is a tool which aids decision making.

The first column lists the main potential communication barriers. The subsequent rows in the table indicate whether each technology is able to deliver the alert and/or notification message when a particular communication barrier exists. A ‘Y’ means that it can, an ‘N’ means that it can’t and a question mark means that it cannot be determined with the information available at this stage or that it depends on the circumstances at the time.

Although most of these appeared as criteria in the MCA the purpose of this table is different. The MCA ranked the technologies based on their ability to perform against these and other criteria. This analysis seeks to find the best combination of technologies to overcome the communication barriers. The preference is to have an integrated system which can overcome all communication barriers within the available budget. The table should therefore be read in conjunction with Figure 1 which shows how each of these technologies might be integrated.

Table 2: Managing Communication Barriers

MESSAGE TYPE	ALERT							NOTIFY						
WARNING TECHNOLOGY	FREE TO AIR TV AND RADIO	CALL CENTRE (DIAL IN)	RURAL WARDENS	FIXED PA	PERSONAL NOTIFICATION	DIAL OUT	TONE ALERT RADIO	FREE TO AIR TV AND RADIO	CALL CENTRE (DIAL IN)	RURAL WARDENS	FIXED PA	PERSONAL NOTIFICATION	DIAL OUT	TONE ALERT RADIO
COMMUNICATION BARRIER														
INDOORS	N	N	Y	Y	Y	Y	Y	Y	Y	Y	?	Y	Y	Y
ASLEEP	N	N	Y	Y	Y	Y	Y	N	N	Y	N	Y	Y	Y
OUTSIDE FLOOD ZONE	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N
NO POWER	N	N	Y	Y	Y	?	?	N	?	Y	Y	Y	Y	?
NO TELEPHONE	N	N	?	Y	Y	N	Y	Y	N	?	Y	Y	N	Y
NO ROAD ACCESS	N	N	?	Y	N	Y	Y	Y	Y	?	Y	N	Y	Y
NO RADIO RECEPTION	N	N	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	N
LANGUAGE OTHER THAN ENGLISH	N	N	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N
HEARING IMPAIRED	N	N	?	N	?	N	N	Y	Y	N	N	N	N	N

3.5 SECTOR ANALYSIS

The evaluations of all of the technologies in the MCA assumed that a single technology would be used to warn the entire population. However, this may not be the most financially optimal solution.

It has already been explained that the warning system would need to have a suite of technologies to maximise its effectiveness in reaching all those needing to be warned. However, for it to be cost effective that suite may need to vary from locality to locality.

Furthermore the time available for disseminating warning messages and the consequences of warnings not being heard or understood varies from locality to locality. It may be preferable in critical locations to have more options available for delivering warning messages than in areas where the consequences of not receiving a warning are less critical.

The SES has divided the floodplain up into sectors in its Hawkesbury/Nepean Flood Emergency State Plan (SES, 2000). It has then given each of these sectors a flood classification as follows based on the characteristics of the probable maximum flood:

- **Category FL:** These are inhabited areas of high ground within a floodplain linked to the flood-free valley sides by a road along a low ridge. The road can be cut by floodwater, closing the only evacuation route and creating an island. If floodwater continues to rise after it is isolated, the island will eventually be completely covered.

- **Category FH:** These are also flood islands but the flood island is higher than the limit of flooding (i.e. above the PMF). The island is surrounded by floodwater but there is no direct risk to life or property on the island from inundation.

- **Category O:** These are inhabited areas on flood prone ridges jutting into the floodplain or on the valley side. Escape from rising floodwater will be possible by walking overland to higher ground, but not by driving.

- **Category R:** These are inhabited areas on flood prone ridges jutting into the floodplain or on the valley side with access road/s rising steadily uphill and away from the rising floodwaters. Evacuation can take place by vehicle or on foot along the road as floodwater advances.

The flood categories of sectors and the population sizes and densities were analysed in conjunction with the information in Figure 1 and Table 2.

3.6 PREFERRED WARNING SYSTEMS

Based on the analyses the SES selected preferred combinations of technologies for each sector as set out in Table 3. It was decided that in some sectors different combinations of technologies would be appropriate in different parts of the sectors and these are set out in the table. The letters in the table mean the following:

- **E** - Existing – this already exists and will be continued as part of the new flood warning system;
- **C** – Committed – does not yet exist but the SES is committed to implementing this as part of the new flood warning system;
- **P** – Proposed – does not yet exist but it is a proposed technology for the flood warning system subject to satisfactory piloting;
- **?** – Not certain at this stage – it warrants further investigation but there are currently too many unknowns about the cost and/or reliability of the technology for a commitment to this application at this stage; and
- **X** - Definitely not to be utilised.

3.6.1 Free to Air and Call Centre

The SES is committed to free to air broadcasting because it is a low cost means of disseminating a detailed notification message to many people in the valley. It is committed to the call centre as part of the preparedness strategy and therefore the additional cost of operating it during a flood would be small and it would provide an additional means of providing detailed notification to a large number of people.

3.6.2 Rural Wardens

The Rural Wardens system which already exists in the lower reaches and the low-lying areas of Richmond and Windsor sectors is already working well for frequent floods. This would be maintained and the preference is to develop a similar system for low lying, but less frequently flooded rural areas around Yarramundi and possibly Wilberforce and North Richmond. There is already a personal notification strategy developed by the SES for the rural areas of South and Eastern Creek and this would be maintained in preference to a warden system.

Table 3: Preferred Warning Systems

SES SECTORS	FLOOD CATEGORY	APPROXIMATE POPULATION	TECHNOLOGY						
			FREE TO AIR TV AND RADIO	CALL CENTRE (DIAL IN)	RURAL WARDENS	FIXED PA	PERSONAL NOTIFICATION	DIAL OUT	TONE ALERT RADIO
RICHMOND, WINDSOR, MCGRATHS HILL, EMU PLAINS, PITT TOWN	FL/R/L	URBAN 27,800	C	C	X	P	P	?	?
		RURAL 1,000	C	C	E	X	X	?	?
CASTLEREAGH/CRANEBROOK, LONDONDERRY, YARRAMUNDI	O	URBAN 1,200	C	C	X	P	P	X	X
		RURAL 1,600	C	C	P	X	X	?	?
PENRITH, WALLACIA	R/FH	URBAN 6,500	C	C	X	P	P	X	X
WILBERFORCE, NORTH RICHMOND,	R	URBAN 1,500	C	C	X	X	P	X	X
		RURAL 180	C	C	P	X	X	?	?
OAKVILLE/CATTAI, LOWER REACHES, SOUTH CREEK A & B, EASTERN CREEK A, B &C	R/L	URBAN 8,500	C	C	X	X	P	X	X
		RURAL 2,900	C	C	E	X	E	?	?

3.6.3 Fixed Public Address

Richmond, Windsor, McGraths Hill, Emu Plains and Pitt Town are the most critical sectors in terms of flood warning because most of these are flood islands which would become completely inundated in some floods. For this reason the SES considers that a Fixed PA system would be required as a minimum in the urban parts of these sectors. This would be a cost effective solution here because the population numbers are large and at an urban density. The PAs may be able to be heard in surrounding rural areas but it was considered that the lower population density would reduce the cost effectiveness of extend the PAs into these areas. If more detailed investigation indicated that the PA system could be extended at only marginal incremental cost then this would be considered.

It was also considered that Fixed PA would be worthwhile in the urban areas of the category O Sectors. The population sizes are not great and so the cost effectiveness of this option is reduced but it will give these people maximum alert to evacuate and maximise the chances of evacuation by road. The same logic was applied in deciding that the Wallacia sector should have a Fixed PA.

The need to warn the Penrith sectors is less urgent but the population size, and its contiguity with the Emu Plains and Castlereagh/Cranebrook Sectors should make it a cost effective addition to the Fixed PA Network.

The remaining sectors have less critical evacuation needs and therefore it was considered that any remaining budget should be spent on supplementing warning systems in the more critical sectors.

Based on the information available, the net present cost of a Fixed PA system across all of the sectors proposed is likely to be less than $1.5 million and possibly as low as $1 million.

3.6.4 Personal Notification

There remained concerns that the notification function of a fixed PA system will not be able to be relied upon and there is a desire to supplement the PA in the most critical sectors (FL and O). Personal notification is the preferred supplementary alert and notification strategy in these sectors. However, the large number of people who need to be contacted and the short warning times available mean that large numbers of teams are required to complete the doorknocking.

In the other sectors this is less critical. Personal notification is the preferred alternative alert and notification strategy in urban areas where it is not intended to install a PA system.

It is not intended to use personal notification in most rural areas because of issues with distances and flooding of local access roads. It already is used in

the South Creek sectors where this is less of a problem and it is intended to continue to do so.

3.6.5 Dial Out and Tone Alert Radio

In the most critical sectors there is a preference to supplement the Fixed PA and the personal notification with another dual alert/notification technology. The greatest potential limitation of the PA is that the notification message may not be able to be comprehended by people who are indoors and for personal notification the time to disseminate the message is the issue. Either a dial out system or a tone alert radio could potentially overcome these problems, as they are effectively “indoor” warning technologies. However, both have their own limitations.

It is uncertain whether a dial out system would be able to function if the warning dissemination caused people to make other phone calls and the telephone network capacity is insufficient to manage all of the calls. Also if there is a power supply failure then cordless and some other telephones will not function. A dial out system is also sequential in its function and would not deliver a message as instantaneously as either a fixed PA or a tone alert radio.

There are unanswered questions about the scalability of such a system because investigations to date have focussed on a large, automated, computer based system for use throughout the floodplain. A smaller system may be able to be cost effectively provided for these sectors alone or it may be affordable and more cost effective to include some of the lower lying rural areas of other sectors as part of such a system.

Alternatively low lying rural areas may be better served by a manual system. If it takes an individual 5 minutes to make a phone call and deliver a detailed notification message to the person at the other end, a team of 25 call centre operators could deliver a warning to 600 households (1,800) people in two hours. A larger team could do it more quickly and it is possible that each call could only take two or three minutes.

There are many organisations which operate call centres all year round for multiple purposes. If one or more of these were to be used to disseminate the warning manually by telephone then there would be far lower hardware costs to the SES than an equivalent computer based system. Operator training could incorporate annually ringing properties in the targeted areas of the floodplain to ensure telephone numbers remain up to date. This would also reinforce the preparedness message with the people at risk.

A tone alert radio by comparison would connect all recipients instantaneously directly to free to air broadcast. The downsides of this technology is that unless a very expensive system is installed it may be possible for the building occupiers to effectively disable (either deliberately or accidentally) the system by removing the device, changing its pre-tuned frequency or not maintaining its battery backup power supply. It is also a technology that people are not familiar with.

There was consensus in the meetings that farmers and caravan park operators in the lowest parts of the floodplain would be more likely to maintain these devices because they are already flood aware and are keen to get early warning of flooding to protect their assets from inundation. In less frequently inundated areas radio maintenance may be more problematic.

It is therefore likely to be a choice between tone alert radios and a dial out system as a supplementary system to PA in the FL category sectors. More information about their costs and reliability would be needed before that choice could be made.

If one of these technologies were chosen then it would be worthwhile extending its use into other rural areas if there remains funding to do so. The order of priority in extending the use of one of these technologies would be O then R then L category sectors.

4 CONCLUSIONS

At the time of writing, management within the State Emergency Service were considering the outcomes of the study and were yet to determine the next steps. It is considered prudent to trial the higher capital cost technologies in a small area first before committing to installing them and relying upon them across large areas of the floodplain.

The SES recognises that there is a need to consult with the community and the local Council in the areas for such trials to ensure that they understand and support the need for the pilot program. Consultation will also provide an opportunity to gauge community attitudes towards the suite of warning technologies being actively considered.

At the time of writing the analysis was still being undertaken with some sensitivity analysis being done to see how sensitive the ranking of options is to assumptions about option performance and criteria weightings.

The study demonstrated that:

- Multi Criteria analysis is a useful tool in comparing diverse options against a wide range of criteria;
- Traditional lower technology options such as door knocking and public media broadcasts are extremely valuable;
- Tone alert radios and telephone dial out systems may be useful warning technologies in particular circumstances;
- No single technology can be relied upon to alert and notify all 60,000 people in the floodplain;

- A layered approach with more than one technology will maximise the reach of the warning and provide backup communication in the event of contingencies; and

- Analysis of the population distribution, the nature of flooding, warning times and evacuation routes are important considerations in optimising an integrated warning system.

5 REFERENCES

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Steven Molino

Steven Molino is a Principal of Molino Stewart who has considerable experience in a wide range of water cycle projects and has spent a considerable part of the last decade investigating flood damages, mitigation and preparedness. He was the project manager for the Warragamba Flood Mitigation Dam EIS and the Warragamba Auxiliary Spillway EIS and has advised the Hawkesbury-Nepean Inter Departmental Committee and the Hawkesbury Nepean Flood Management Advisory Committee. He recently prepared a flood preparedness strategy for the Woronora River in southern Sydney which is now being implemented.

He has also used multi-criteria analysis and other techniques to evaluate options and facilitate conceptual development of sewerage schemes, water supply schemes, waste management strategies and ecotourism developments.

Graham Begg

Graham Begg was a senior consultant with Molino Stewart and has had a long involvement in the water industry. He has developed methodologies for estimating agricultural flood damages and has investigated flooding induced by mine subsidence. Before joining Molino Stewart, Graham was the General Manager of a company whose services included installation and maintenance of remotely operated metering, information technology and communication systems utilising new technologies.

Graham is now a strategic and business planner with the Sydney Catchment Authority. He is helping it identify its risk management, including flood risk, responsibilities and is preparing a report on these for the regulator.

Steve Opper

Steve Opper has 27 years experience in emergency management, and for the last 15 years he has been as a full time officer of the NSW SES. He has been involved in the management of floods at the local field level, and in both regional and state operation centres. He holds the Disaster Services Administration Certificate from Emergency Management Australia (EMA) and has completed a number of specific emergency management training courses offered by that organisation (EMA). Steve also holds a Graduate Certificate in Applied Management from the Australian Institute of Police Management and has been awarded the National Medal for emergency service to the community. He is the project manager for the Hawkesbury-Nepean project within the SES.