An evaluation and decision making support tool for public notification systems in New Zealand

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ABSTRACT

The Ministry of Civil Defence and Emergency Management (MCDEM) has undertaken to provide an interactive tool, available for use by Civil Defence Emergency Management (CDEM) groups and their member councils, which will support critical decision–making when choosing which public warning notification systems are available for use during hazard events.

A generic spreadsheet decision-making support tool, based on effectiveness criteria, has been designed to assist emergency managers at a regional and local level to select a combination of warning systems that best suit their hazardscape and communities. This report provides a tool that:

- Can be used across CDEM groups
- Assesses the effectiveness of each alerting mechanism, implemented for the Group, against agreed criteria
- Produces an individual effectiveness score for each of the alerting mechanisms
- Allows these scores to be summed
- Assesses against the target percentage (below)
- Scores the robustness/resilience of each factor
- Compares cost effectiveness.

To do this the report also:

1. Determines a target percentage of the population in at-risk areas that need to be informed by official alerts;

2. Provides a critical review of operational alerting mechanisms available in New Zealand in terms of their advantages and disadvantages across various criteria;

3. Considers other technologies that are currently not available in New Zealand but may be worthy of considering for investment.

This report should be read in conjunction with Kidd et al. (2008) [1], a ‘New Zealand Telecommunications Based Public Alerting Systems Technology Study’. Note that several combined-system mechanisms currently available in New Zealand are also discussed in that report (e.g. combined SMS, email and telephone).

Effectiveness criteria

Criteria for evaluating the effectiveness of warning systems include: whether a system is effective in delivering to residents, transients (tourists) and institutions; the time required to activate the system and to deliver a warning; the effectiveness of a system in varying population densities and terrains; the robustness or resilience of a system; ongoing effectiveness of the system throughout the hazard event; the cost of a system both for set-up and ongoing expenses; and the level of public education required for warnings delivered by each system to be meaningful to the public.

Effective warnings

New Zealand is vulnerable to a diverse range of potentially destructive hazards coupled with a wide range of communities, organisations and individuals requiring hazard warnings. To be effective, warning systems must meet these diversities.

Warning systems effectiveness can be determined from studying systems in use both nationally and internationally, and by using well-established criteria including technical and behavioural indices. No one warning system will meet all effectiveness criteria.

A fully effective public warning system provides (a) a 'heads-up' (making individuals aware that a threat is occurring or imminent) and (b) 'instruction' (e.g. information on the type of hazard, location and potential consequences, and information on what response is required from the public).

All warning systems will require ongoing public involvement (especially response planning, exercises and other education) for maximum effectiveness. For example, those systems with only a heads-up capacity require greater public awareness to ensure the heads-up indicates correctly that a hazard threat exists, where to find information on the threat, and the correct action to take. Systems incorporating both heads-up and instruction capacities will require the least public awareness ahead of an event. Nevertheless, all public engagement that produces a more prepared and resilient community able to respond to hazard threats are worthwhile, and the adoption of an effective warning system will not preclude the need for warning-specific public engagement initiatives.

National arrangements

Alongside the decision support tool it is strongly recommended that a consistent national arrangement of systems underpins local warning systems. Alongside instruction information provided through TV and radio, it is recommended that at least one system capable of providing a heads-up as well as instruction be adopted nationally.

High scoring mechanisms available in New Zealand

Here we assume equally weighted criteria and hazards. Even with effectiveness and hazard weighting changed these scores do not shift dramatically. The following all score well and have reasonable costs for both low and high density populations:

- Website banners (requires some development with ISPs)
- Power line messaging - but needs specific hardware to receive
- Route alert (door-to-door)
- Mobile PA loud-speakers
- Telephone trees
- Via community contact trees/systems
- E-mails
- SMS text messaging

- Websites/Wireless Application Protocol (WAP)
- Pagers
- Natural warnings
- Police/fire mobile PA loud speaker.

Fixed PA loudspeakers score well, but have a high start up cost that is likely to be considered prohibitive for mid and low density areas. Ongoing maintenance should not be overlooked either. These should not be confused with sirens (tone only) which do not score well because they do not give specific instructions on what populations should do on hearing the warning.

Mechanisms not currently available in New Zealand

Mobile-device broadcasting (messaging to all mobile devices on specific cell site(s)) has the potential to meet nationwide requirements but as yet is not used widely overseas for emergency warnings. Nationwide mobile-device broadcasting capability would be reliant on upgrading of Telecom networks (Vodafone networks are technically capable of mobile-device broadcasting). There is no guarantee current and future upgrading of the Telecom network will include mobile-device broadcasting compatibility, however given the reasonably rapid technological changes in telecommunication infrastructure this is not to say that future upgrading will not include this capability. Based on the current situation, it is likely that mobile-device broadcasting capability across all mobile networks is at least five to ten years away under current upgrading plans, unless government support/intervention is provided. The setup of mobile-device broadcasting warning systems across all networks could also prove to be among the more expensive of warning system mechanisms.

Tone alert radio (the ability to turn on a radio remotely) is in widespread use internationally and would be suitable for New Zealand. This system provides both heads-up and instruction information; the main drawback is that each at-risk home, business or institution must have a receiver; start-up expense for this would be considerable and where the costs would fall would require some negotiation. Tone alert radio uses technology that is already familiar to the public (FM radio), can provide nationwide coverage, and large scale tone alert warning systems are available now from overseas. It is strongly recommended that a pilot study and cost benefit analysis of tone alert FM radio be undertaken in New Zealand.

Guidelines

New Zealand has national-scale arrangements currently in place for notifying the public of hazard events; these are the use of radio and television broadcasts. These are set in place by MOUs between the Ministry of Civil Defence and Emergency Management and selected broadcasters. This system provides information on hazards and what actions to take but cannot be considered a fully effective warning system as there is no heads-up capability for people not already ‘tuned in’.

New Zealand currently has no national standards or guidelines for public notification systems to be used at a regional or local level. This is a particular issue for warning the transient population (i.e. visitors to New Zealand and internal holidaymakers) and also for avoiding redundancy or incompatibility of systems currently in place or planned for installation.

Desired 'reach'

Overseas experience has shown that for every two people notified by an official warning system at least a further one person will receive the warning informally (second-hand from an officially warned person). Therefore an effective warning is theoretically one which has the capability to formally reach two-thirds or more of the at-risk population. Special consideration must also be given to populations that have large proportions of people with greater warning requirement needs such as deaf or blind people, intellectually impaired people or those with English as a second language.

The following are **not** expected to be able to reach 70% of the population as a warning system in isolation: aircraft banners, billboards, call-in telephone line, e-mails, marine radio, tourist radio, websites/WAP etc., website banners, GPS receiver messaging, flares and explosives.

KEYWORDS

Public notification system, early warning system, effective warning system, decision support tool, mechanism, New Zealand, alert, Civil Defence Emergency Management (CDEM)

1.0 INTRODUCTION

The Ministry of Civil Defence and Emergency Management (MCDEM) has undertaken to provide an interactive tool, available for use by CDEM groups and their member councils, which will support critical decision–making when choosing which public warning notification systems are available for use during hazard events. The tool allows regionally appropriate public warning notification systems to be determined, based on local hazardscapes and local demographics.

An effective public alerting system needs to be a combination of complementary alerting mechanisms. Noting that, a system of complementary warning mechanisms will never reach 100% of the at-risk population.

1.1 Project tasks

In order to meet the project objectives, several tasks have been undertaken in an all-hazard, all of New Zealand context. This project:

1. Develops a generic "decision-support" (Section 2) tool that:

    - Can be used across CDEM groups
    - Assesses the effectiveness of each alerting mechanism, implemented for the Group, against agreed criteria
    - Produces an individual effectiveness score for each to the alerting mechanisms
    - Allows these scores to be summed
    - Assesses against the target percentage under (2) below
    - Scores the robustness/resilience of each factor
    - Compares cost effectiveness.

    To do this the report also:

2. Determines a target percentage of the population in at-risk areas that need to be informed by official alerts

3. Provides a critical review of operational alerting mechanisms available in New Zealand in terms of their advantages and disadvantages across various criteria (Appendix 1)

4. Considers other technologies that are currently not available in New Zealand but may be worthy of considering for investment (Appendix 1)

1.2 Contributors to this report

This report has been prepared by Graham Leonard, Kim Wright, Warwick Smith and David Johnston of GNS Science, with input from Alisha Kidd (Kestrel) through the Centre for Advanced Engineering (CAE).

2.0 DECISION SUPPORT TOOL

The decision support tool is a Microsoft Excel spreadsheet which can help emergency managers evaluate and compare the cost vs. benefit of different public notification systems. It separately evaluates high and low density population areas, because the cost per capita changes with density for some systems. The 'cost' basis, both start-up and ongoing, is in New Zealand dollars and staff effort spent. Effectiveness (i.e. 'benefit') is derived from a set of scores that can be adjusted through multipliers to meet local priorities.

2.1 How it works

The tool needs to be opened with Microsoft Excel 2002 or later. It consists of eight spreadsheet pages (and additional hidden calculation pages). The pages are:

Input	The user enters their location-specific data here
Basis	Qualitative scoring and quantitative cost data is stored here
Calculation	Calculations based on the Input and Basis page data are shown
Ranking	Notification mechanisms are ranked by calculated score
START LD	Plot of start up (one-off) cost vs. score for low-density populations
START HD	Plot of start up (one-off) cost vs. score for high-density populations
ANNUAL LD	Plot of annual (ongoing) cost vs. score for low-density populations
ANNUAL HD	Plot of annual (ongoing) cost vs. score for high-density populations

2.1.1 'Not considered' systems

The tool allows for systems to be 'not considered' – place a '0' next to the name on the 'input' sheet instead of the default '1'. This may be desirable if, for example, the cost of a system(s) is dwarfing more economical mechanisms on the plots.

2.1.2 Scores

Scores use a qualitative 1 (lowest) to 5 (highest) scale. Total scores for each warning system are calculated as a percentage of a perfect '5' across all.

On the 'input' page the user can set 'multipliers' for those scores that may vary in importance from location to location. The multipliers are factored against scores found on the 'basis' page, with the result visible on the 'calculation' page. Setting the multiplier for a score to 2 will double that score's representation within the total percentage score.

Scores are grouped into:
Hazard type - The tool breaks hazards down into four groups according to short vs. long lead time and localised vs. widespread impact.
Vulnerable groups – how effective each system is for each specific Target population group.
Timeframe to notify – how fast to reach the first person; and to reach the target percentage of people.

Scores are based on the discussion given for each system in Appendices 1 and 2. If the user has a reason to adjust a score please let MCDEM know so adjustments can be considered for future revisions.

2.1.3 Population and density

The tool treats low and high density populations separately. The user enters the population to be reached for each on the ‘input’ page.

A region or district can be selected from the 2006 Statistics New Zealand Census data to get an idea of how many usually resident people fall above and below 200 people/square km (p/km^2). Across all regions the tool treats the average high density area as having on average 2500 p/km^2 and the average low density area about 100 p/km^2.

2.1.4 Reach and telephone coverage

The user can select the proportion of the population they wish each system to be able to reach (default 70%, see Section 3.6). The user is also prompted to enter the proportion of the population with no mobile and/or telephone coverage at home. This is compared to the desired reach to check for any gap in expected coverage.

2.1.5 Budget and cost

The user enters their budget and annual cost for one Full Time Employee (FTE) on the ‘input’ page.

Start up and annual costs are calculated separately. Cost is on the following basis:
Per 1,000 people for direct costs, in dollars
Per 100,000 people for effort, in FTEs

Costs on the ‘basis’ sheet are multiplied by the population and ‘desired reach’ from the ‘input’ sheet. The result is given on the ‘calculation’ sheet.

To improve the result for a given area the user can refine the costing data on the ‘basis’ sheet for both low and/or high density areas. This should be based on real conditions such as the local population density and vendor cost quotes.

2.1.6 Ranking and cost-benefit plots

The ‘ranking’ sheet shows the systems ranked by total percentage score, as derived on the ‘calculation’ sheet.

Four sheets give plots for cost-benefit analysis. The present cost-benefit data are for start up low and high density, and ongoing low and high density.

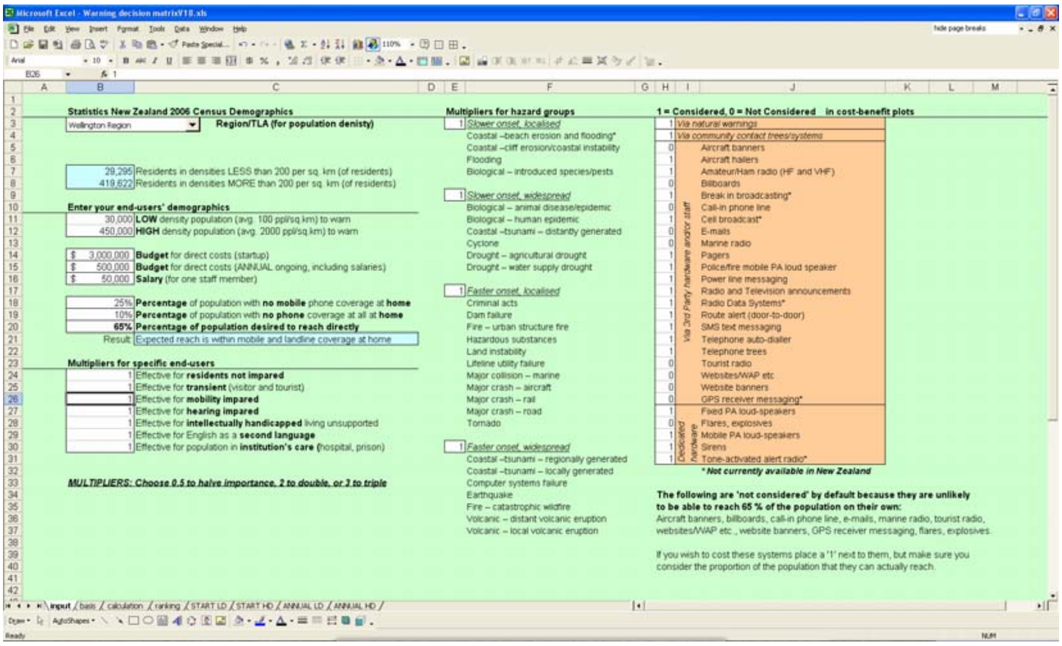
Benefit (score) improves from bottom to top, and cost increases from left to right. The budget, half-of-budget and one-quarter-of-budget are shown as vertical lines. An above-average/below-average score line is drawn at 60%[1].

The best cost-benefit systems plot in the upper left.

2.2 Instructions

(1) Decide which area you want to consider for public notification.

You can make comparisons at any scale from small community to the entire nation in the spreadsheet.



(2) Enter the area's low and/or high density populations.

Use the drop-down menu to get indicative density values from the 2006 census[2].

Note that the indicative values are '<u>usually-resident</u>' so they don't allow for daytime population swelling such as at a beach or central business district, or for holidaymakers. You need to add the population expected in these extra high density places in addition to the 'usually resident' value.

For example:

Usually resident in high density areas	100,000
CBD extra people (max)	50,000
Extra high density visitors/tourists (max)	10,000
Total population in high density areas	**160,000**

[1] Percentage is of a perfect score (all scores are 5). The worst score is 20% (all scores are 1).
[2] Density is calculated by dividing the population for each 'mesh block' by its area in square km. The populations in meshblocks with a 'low' or 'high' value are then summed for each of the drop-down menu spatial areas.

You may wish to calculate both low and high density mechanisms for an entire region, or mechanisms for a specific settlement that you know is either low or high density.

(3) Enter your FTE salary cost for a typical operational person who will be maintaining this system, conducting community engagement, etc..

(4) Enter your total budget.

(5) Enter the percentage of the population with no mobile, and with no landline coverage at home.

(6) Enter the proportion of the population you need the system to reach (we suggest you set this to a minimum of 70%)

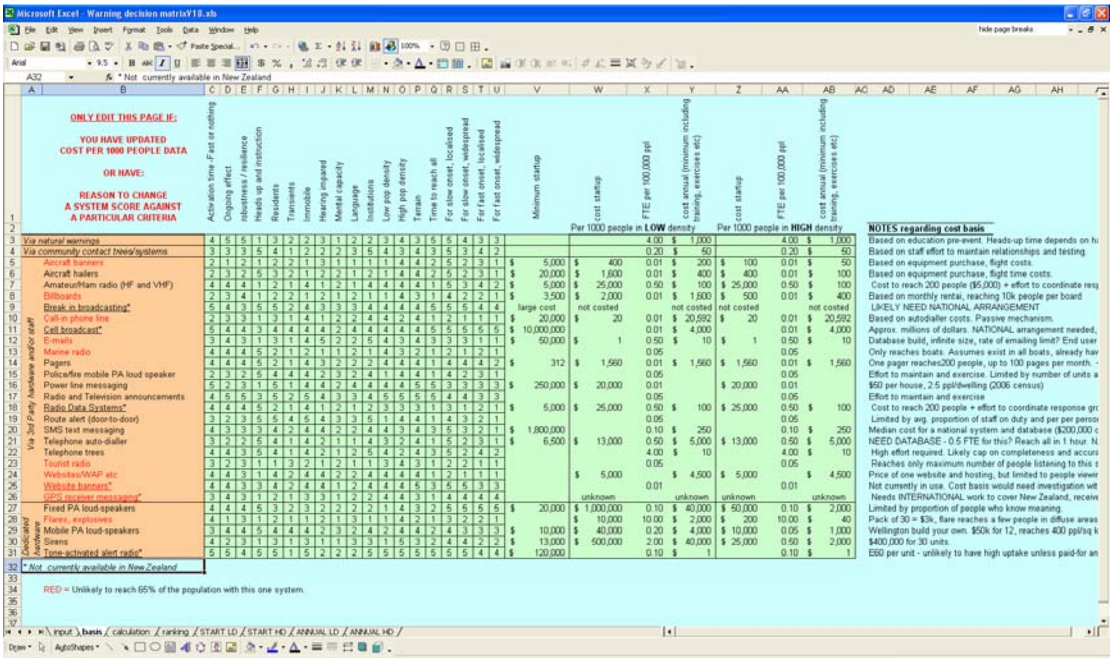
(7) Adjust the multiplier values for any Target population groups and hazard groups that you feel are more or less important in terms of effective notification.

If you have a large tourist group within the area you may choose to give the ability to reach tourists a multiplier higher than other criteria. If you want it to be three times as important set this multiplier to ‘3’.

If you feel tsunami are roughly twice as important as all of the other hazards (due to risk) set at ‘2’ the multiplier for the group of hazards that includes tsunami. If it is half as important set the factor at ‘0.5’.

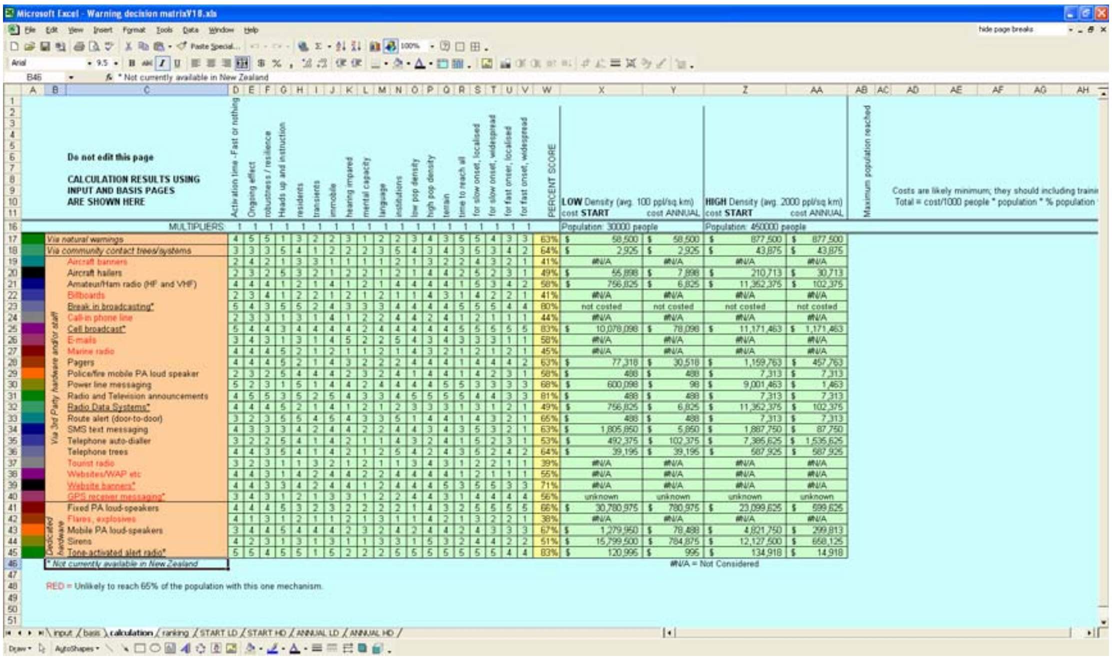
(8) Set any warning systems you do not want to consider to ‘0’.

For example, you will probably not want to consider loudspeaker announcements in low density areas because of the large cost per person – they dwarf the other mechanisms in the cost chart.



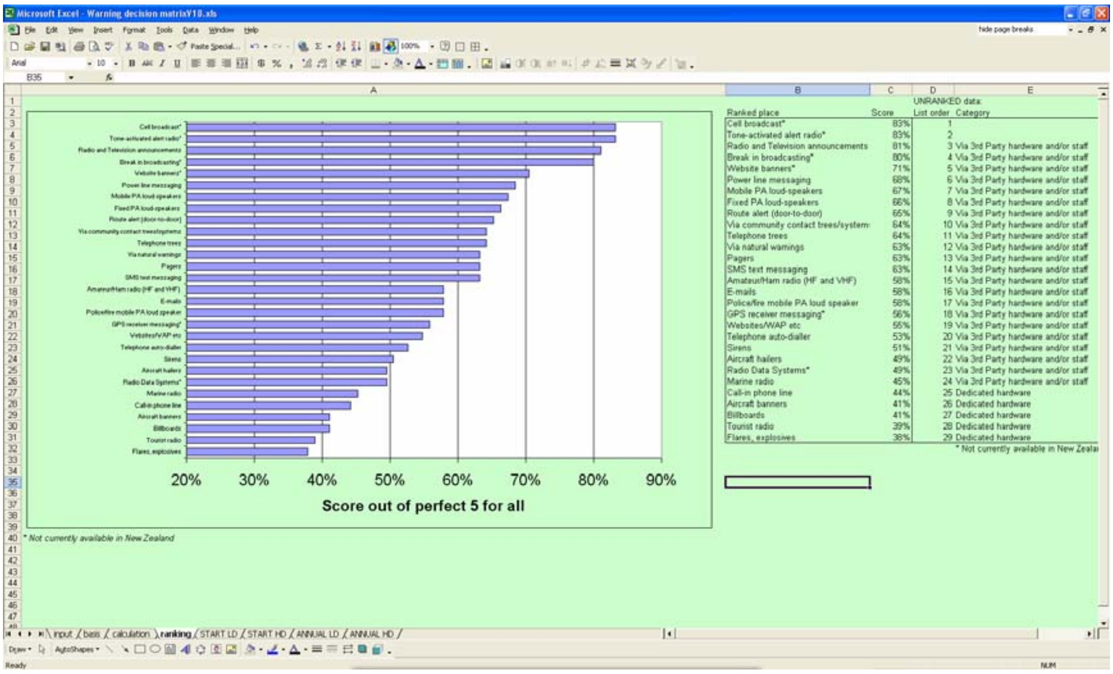
(9) Look at the 'basis' sheet.

The numbers in the matrix of warning system mechanisms vs. criteria are qualitative scores from 1 (lowest) to 5 (highest) based on details in Appendix 1. The dollar values are start-up and ongoing cost and salary effort to reach 1,000 people, listed for both low and high density populations.

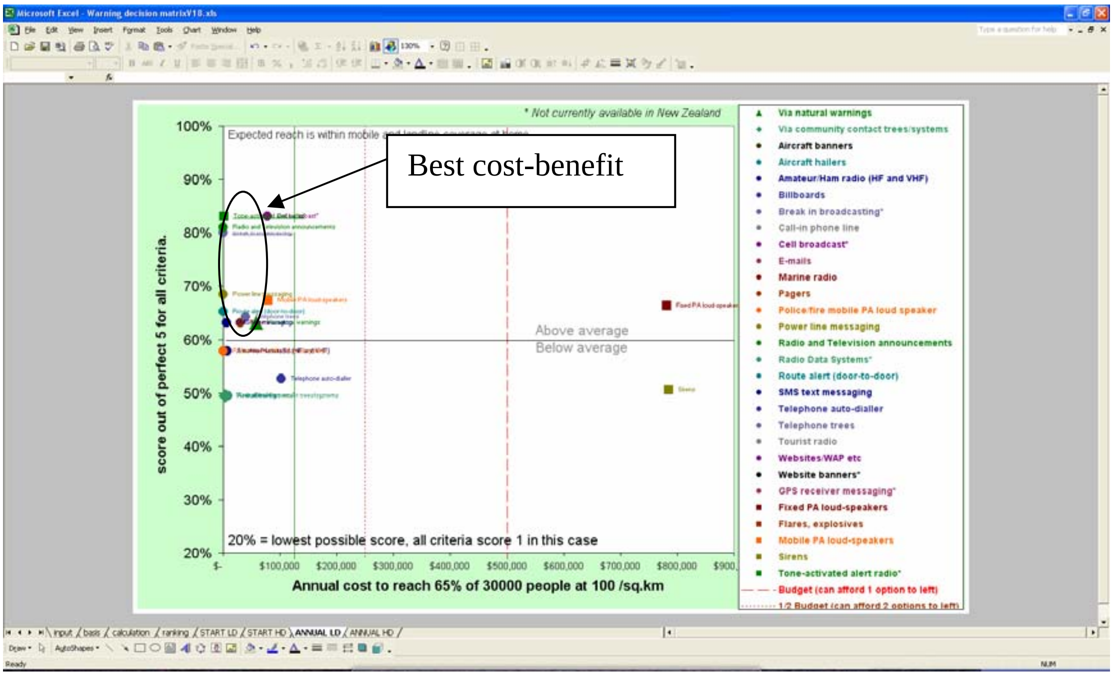


(10) Look at the 'calculation' sheet

- Scores and dollar values have been multiplied against the 'population', 'costs' and 'factors' you entered on the 'input sheet' and are also totalled here.
- The total score for each system is used to rank it on the 'ranking' sheet.



(11) Look at the ranking sheet



(12) Look at the cost plots in detail

You can afford only mechanisms that plot below your budget along the cost axis. You can afford two systems if they both plot at exactly half of your budget, and so on.

Give priority to systems higher up the score axis, as these meet effectiveness criteria the best (including any multipliers you set).

Generally, picking a few or several systems that plot up in the top left of the graph will give you the best cost-benefit.

Remember to consider the results of both the low and high density plots if you entered populations for both of these. Also remember that the start up cost is a one-off hit, whereas the ongoing cost is annual and will be permanently required.

(13) Once you have an idea of the systems to focus on from the charts you can go back to the 'calculation' sheet to see the exact values being plotted for the mechanisms you are interested in.

(14) Consider exploring individual aspects of the initial results further with the tool. You could, for example:

- Turn off some overly-expensive mechanisms – this will rescale the plot, better showing the cost-effective mechanisms.
- Provide revised cost bases for specific population densities within an area.
- Calculate for smaller sub-areas separate from each other, with the correct costing and multipliers for each.

2.2.1 Customising the tool further

Please provide feedback to MCDEM as to any changes you might suggest for the next revision of this tool.
For example:

- Revised cost data per 1,000 people, or revised FTE effort data per 100,000 people (please explain the source for new cost estimates).
- Adjustments to scores in the matrix (please provide an explanation).
- Revised architecture for the tool. For example, one area that could be explored is expanding out the spatially costed mechanisms (loudspeakers, route-alert) to be multiplied by a specific area in square kilometres.

3.0 PUBLIC NOTIFICATION

This section lays out where public notification fits within risk reduction activities.

3.1 Understand the risk

Anderson[2] suggests that an initial stage of hazard identification, risk assessment and vulnerability are important to an effective warning system. This stage identifies the particular hazards a community faces, and then assesses the consequences of hazard impact and vulnerability of 'assets at risk' (people, buildings etc). For example in New Zealand this could include the results of a SMUG analysis. From this assessment the resilience needs (including warning system needs) of the community can be better established.

3.2 Community resilience

Public warning notifications are one part of the wider goal of improving community resilience. Resilience is the ability to cope with an event and return to normal; it may also be necessary to adapt following an event.

As an underlying principle, communities should work in cooperation with their TAs and CDEM Groups to design hazard mitigation that fits with their overall risk management strategy.

3.3 Consider other mitigation

Warnings are only one mechanism for risk mitigation. The following mechanisms should be considered and balanced in mitigating risk:

1. Modify the process, e.g.:
    - Catchment restoration (flooding), maintain or restore dunes (tsunami).
2. Modify human activity, e.g.:
    - Land-use planning and building codes.
3. Accept some damage and warn people:
    - Considerable residual risk in many cases,
    - Hard to achieve high effectiveness,
    - Permanently-sustained community preparedness is needed (evacuation mapping, signage, planning and exercising are critical).

With adequate analysis of a low risk doing nothing may also be a valid mechanism.

If the warning process can identify the likely scale, consequences and duration of impact, it may allow more time to evaluate available resources and organise them in ways that enhances response to an emergency. Warnings can be part of an overall strategy to improve community resilience if they are issued to populations capable of acting appropriately on warning information[3]. Paton [4] describes the factors that contribute to community resilience with respect to hazards. Several of these factors: trust in authorities, information exchange, positive outcome expectancy, and self efficacy can be enhanced by effective warning systems delivering timely and accurate information to the public.

3.4 Warning and notification definitions

Early warning system: The hardware, electronics and communications used, together with the planning necessary to generate and notify a hazard warning.

Public notification system: The component of the early warning system that notifies the public; the focus of this report. Note the term 'alert' is not used here[3].

Effective warning system: The wider set of actions necessary to make sure that the message is not only delivered but acted upon in an informed way (Figure 1).

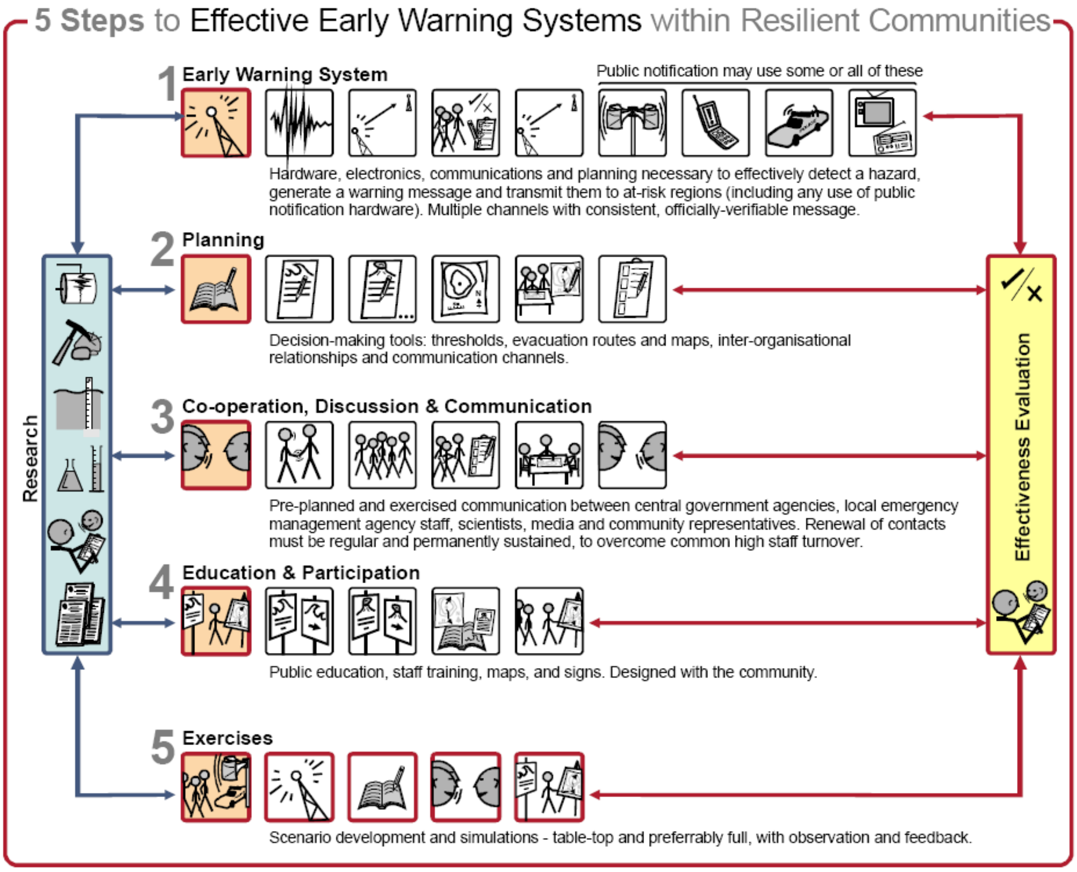


Figure 1 A model of components of an effective hazards warning system. Step 1 (Early Warning) is a Response activity. Steps 2 through 5, and the associated research and effectiveness evaluation, are the Reduction and Readiness activities necessary for effective response to that early warning[4]. [5]

[3] Notification systems are also sometimes referred to as 'alert systems', but the term 'alert' is also often used for warning messages, so this usage is avoided here. Note that 'public notification' is also used in contexts unrelated to warnings, such as the public notification of planning documents.

[4] Currently there is no single international 'best practice' that can effectively remove most people from harm's way consistently for all hazards. However, by drawing together a) evidence from observations of public response to past

3.5 Warnings must be effective

An early warning system only activates a decision-making process. The quality of the decision-making is the true measure of the effectiveness of a warning system; therefore, building the capacity to make effective decisions is a key challenge. There are many historic examples where at-risk populations in full or in part have failed to respond to official warnings, even when a well resourced (and what was considered well planned) warning system was operating [6-10] . Many of these failures have resulted from a lack of understanding of the need for a holistic approach linking various elements into an integrated system [6, 9-11].

To be effective, warnings must reach all persons at risk in time, no matter where they are located or what they are doing. In response, people must successfully take actions that save lives, reduce damage and suffering, and speed recovery [12, 13].

Tierney [14] lists the way these systems can differ as:

- Technologies employed to detect threats
- Reliability of threat detection technologies
- Length of time needed to achieve accuracy in forecasts/predictions
- Reliance on human decisions/input
- Types of warning systems and devices used
- Channels employed to issue warnings
- Familiarity, making routine, and institutionalisation of warning procedures
- Settings in which systems are used
- System goals and objectives.

The first three factors are related to hazard detection and are not the key focus of this report. The remaining factors influence whether different warning systems chosen and adopted throughout the country will vary in effectiveness and have been incorporated into the tool's design.

3.6 Notify at least 2/3 of those at risk

While literature is scarce on this topic, Mileti and Sorenson [15] have undertaken substantial research on the effectiveness of warning systems and have concluded that a warning is effective when it has reached 95% of the at-risk population. This number, however, is not the number needed to be reached by official warning systems. Informal warnings almost always occur and authorities should not only count on this process happening, they should use it to their advantage. The ratio of people informally warned to those receiving official warnings has been found to vary. Mileti and Kuligowski [16] suggest that for every two formal first warnings, there is one informal first warning, i.e. aim for the first official or natural warning to reach 70% of the population, and a further 32% can be expected to hear the warning the first time from one of those officially/naturally warned. This figure may be much higher where informal warnings systems have been developed.

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events internationally, b) empirical studies, and c) common sense best practice, recommendations for developing appropriate and effective response to hazard warnings have been grouped into the components shown in Figure 1 (consistent with UN/ISDR Platform for the Promotion of Early Warning, and discussed and justified in detail by Leonard et. al. (2008).

By enhancing the use of formal and informal social networks as a planned means of disseminating warnings, lower rates of formal penetration of official warnings are needed. Those who receive warnings may want to confirm those warnings, so it is important to ensure there are avenues open for people to verify their first source of information. However it is recognised that some percentage of the at-risk population will always be unreachable for any number of reasons (some people choose to isolate themselves from information/contact, some are isolated by circumstances e.g. homelessness, some have disabilities that make contact more problematic [16].

3.7 The coverage of systems will overlap

Due to overlap in coverage the percentages reached by multiple systems usually cannot be added together to give a total reach of 100% of the population. Unless the proportion of coverage overlap amongst systems is clear and guaranteed, one (or preferably more) notification system should by itself reach 70% of the population, even if multiple notification channels are present.

3.8 Use multiple systems

Despite the fact that one warning system should reach, 70% of the population, it is important to have multiple notification systems. No warning system is foolproof, and all systems have a potential for failure. For example on the 14th June 2005 a Tsunami Warning was issued for Washington, Oregon and California, following a magnitude 7.4 earthquake off shore in northern California. A number of hardware and procedural problems were experienced and as a result some people did not receive warnings [17]. Public response was also inconsistent across the communities that received warnings.

3.9 Population density

In some situations there is difficulty notifying diffuse populations. For example, in rural areas and remote coastal or wilderness areas you may never reach all farmers, let alone trampers and surf-casters, etc. Systems must be appropriate to population density and be available to the majority of people as a priority.

3.10 Who is being warned?

Groups of recipients can be identified each with different needs, expectations and capabilities. When developing warning systems, it is appropriate to consider whose needs have to be served. For example, is the warning intended for emergency management agencies, citizens, community groups (e.g., religious), societal institutions (e.g., welfare agencies, charities, schools), media and/or business? Given this diversity, the emphasis should shift from the delivery of warning messages *per se* to ensuring that each group knows what they mean and that they have a capacity to act upon them. Without developing this Target population capacity to interpret and respond, a myriad of warning content, media of delivery and technology of delivery may have to be developed to meet the needs of each group, which may not be cost effective. The development of a range of target population' capacity to understand and respond to a simpler warning message has additional merit in that it could also be adapted to fit the demands of a range of hazard events and consequences, and future ‘new’ hazards.

3.11 Effective warning messages

The Partnership for Public Warnings concludes that an effective warning system should [18]:

(1) Be focused on people at risk;
(2) Be able to be understood by all in the same way;
(3) Be capable of reaching people irrespective of what they are doing;
(4) Be easy to access and use;
(5) Not create added risk;
(6) Be reliable;
(7) Provide appropriate lead time so people can have a chance to protect themselves; and
(8) Generate authenticated messages.

3.12 Importance of the ‘all-clear” message

It is essential to plan to give an all-clear message and to clearly establish the criteria for issuing this all-clear message. Receivers must know that the all-clear message comes from an official source for it to have credibility.

3.13 Evaluate

As communities and technologies change over time, it is necessary to revise what technology is being used and update plans. Refer to the results of event and exercise evaluations.

3.14 Ineffective warning systems may increase risk

The existence of a public notification system, or even just a report outlining system options and recommendations, may in fact be counterproductive, creating complacency amongst some community members. Individuals may transfer responsibility for managing the risk to the authorities promoting the warning system[19]. This is especially true if it is not specifically designed as part of a wider programme to improve resilience[20]. The management of natural hazard risk relies on balancing three risk management strategies: (1) modifyinbg human behavious (e.g. land-use planning, building codes, community social resilience building), (2) effective early warning systems, and (3) engineering modification of the potentially hazardous natural process.

4.0 REVIEW OF AVAILABLE SYSTEMS

There are a range of systems that can be used for public notification. This section discusses the different types of system and whether or not they are currently available in New Zealand.

4.1 Who owns the system?

Table 1 lists the public notification systems reviewed here and used in the decision support tool. The systems are classed by which type of ownership applies:

Table 1 Public notification systems, grouped by system ownership

Natural warnings	
Independently self maintained networks	
Reliant on third party hardware and/or staff	Aircraft banners
	Aircraft PA loudspeakers or siren
	Amateur/ham radio (HF and VHF)
	Billboards
	Break-in broadcasting *(not currently available in New Zealand)*
	Call-in telephone line
	E-mails
	GPS receivers *(not currently available in New Zealand)*
	Marine radio
	Mobile-device Broadcasting *(not currently available in New Zealand)*
	Mobile PA announcements (NZ Police & NZ Fire Service)
	Pagers
	Power mains messaging
	Radio and TV broadcasts
	Route alert (door-to-door)
	SMS-PP (Short Message Service – Point to Point)
	Telephone auto-dialling (landline)
	Telephone trees
	Tourist Advisory Radio
	Websites/WAP
	Website banners
Require dedicated hardware	Fixed PA loudspeakers
	Flares, explosives
	Mobile PA loudspeakers
	Radio Data Systems *(not currently available in New Zealand)*
	Radio (HF & VHF)
	Sirens (tone, no voice capability)
	Tone-activated alert radio *(not currently available in New Zealand)*

Natural warnings rely on public awareness (maintained through engagement and education) to be effective. No one owns the system.

Independently selfmaintained networks are owned and maintained by formal and informal community groups who are unlikely to be able to be contracted by emergency managers formally. They have the advantage of overcoming language issues and potentially reaching isolated areas. They also have a very low overhead cost because they are self-maintaining. They have the advantage of regular testing and exercising for other purposes: e.g. surf lifesaving, rural fire, church groups, neighbourhood watch.

Third party hardware/staff encompasses the majority of mechanisms. These are owned by someone other than emergency managers but can be formally agreed/contracted as notification systems with emergency managers. They have the advantage of both cost sharing with the owner and, like community networks, regular testing and exercising for other purposes.

Dedicated hardware is owned by emergency managers solely for the purpose of warning notification. It therefore tends to be the most expensive mechanism and also takes the most effort to maintain/check as it is not tested for any other purpose. However, this is commonly an mechanism of interest to agencies because of its high profile as a specific piece of 'warning system' hardware that people can see and touch (e.g. sirens).

4.2 Mechanisms available in New Zealand

All mechanisms listed in Table 1 are considered to be currently available in New Zealand, other than the following:

- Break-in broadcasting
- Mobile-device broadcasting
- Radio Data Systems
- GPS receiver messaging
- Tone-activated alert radio

Only break-in broadcasting is considered to be not feasible in New Zealand.

5.0 WARNINGS AND NOTIFICATION IN NEW ZEALAND

New Zealanders are at risk from a broad range of hazards[21]. Public warnings for each hazard type must necessarily take into account a number of factors that vary across hazards:

- What is the hazard?
- Is warning prior to an event possible (currently not with earthquake hazards)?
- What is the lead-in time from detection to impact? (Seconds, minutes, hours, days, weeks?)
- Can the location and potential magnitude of the impact be determined?
- What is the likely duration of hazard effects?
- What are the potential consequences of the impact?
- Whose responsibility is it to give the official warning (local, regional, national)?
- Who will need to be warned (i.e. who is at risk)?
- Does the time of day or year affect who the at-risk population is?
- Are there vulnerable populations at risk?
- Are there at-risk populations that are difficult to reach or geographically isolated?
- Which warning systems will be used?
- What percentage of the at-risk population will official warning systems reach?
- What information must be given in the warning message?
- What response should recipients make to the warning message?
- How often will the message be repeated?
- How will the all-clear message be delivered?

5.1 The New Zealand hazardscape

New Zealand, because of its location on the boundaries of two tectonic plates, and in the “roaring 40’s” latitudes, combined with a long coastline relative to size of landmass, is subject to a wide range of geophysical, meteorological, and coastal hazards [21].

The variety of hazards for which warnings can potentially be generated makes the delivery of effective warnings a complex process. The most frequently occurring natural hazard in New Zealand is flooding. Those at risk of flooding are often familiar with established warning methods (e.g. rural telephone trees, radio or television broadcasts of heavy rain warnings). Lead-in times and natural confirmation signs (e.g. intense or prolonged rainfall, rising river levels) mean that New Zealand’s losses from flood events are these days almost exclusively economic; lives are lost to flooding in New Zealand very infrequently [21]. However, for less frequent, potentially high consequence hazards (e.g. tsunamis or volcanic eruptions) warnings are not so frequently activated or tested, yet are a vital for public safety. Additionally, the time and location of some hazards cannot be predicted; in particular many parts of New Zealand are in areas of high earthquake hazard. Currently there is no reliable method for predicting earthquake location and timing (and to assist with warning the public). Consequently, public awareness of how warnings will be delivered, under what circumstances, and by whom, is lower for low frequency events than for more frequent hazards such as floods and wind storms.

Warning systems must be capable of delivering timely and relevant messages to the at-risk public, for all New Zealand hazards for which warnings are possible. For example with respect to flooding, even though there is low risk of loss of life, timely warnings can serve to reduce economic damage from stock losses and damage to relocatable assets. For high-consequence, low-frequency events where there is little lead-in time, warnings are primarily delivered to protect lives, and reduce injuries. Warning systems that effectively reduces losses (social, economic, infrastructural and environmental) to the community are an integral part of Civil Defence Emergency Management Planning in New Zealand.

5.1.1 Hazard types and timeframes

In New Zealand different types of hazards operate on different timeframes, from no lead-in time (e.g. earthquakes) to the threat being apparent for a period of days (e.g. ex-tropical cyclones) or possibly weeks (e.g. drought). Table 2 shows the range of lead in times varying hazards; due to operational and technical constraints, the focus of effective warnings to the public must realistically be on those hazards with hours or longer lead-in time.

Table 2 Lead in times for varying hazards (adapted from Leonard et al [3])

Hazard (alphabetically ranked)	Lead Time	Duration of event	Visibility to majority of the public
Bio-security emergency	Days	Days to years	Limited
Civil unrest	Variable	Hours to days	Limited
Criminal acts	Variable	Minutes to hours	Limited
Drought	Variable	Days	Visible
Earthquake	Seconds	Seconds	Limited
Erosion/instability	Variable	Hours to years	Visible
Fire – rural	Variable	Hours to days	Visible
Fire – urban	Minutes	Hours to days	Visible
Flooding (large scale)	Hours	Days	Visible
Hazardous substances	Minutes	Minutes to days	Limited
Mud volcanoes	Variable	Days	Visible
Public health emergency	Days	Days to months	Visible
Severe weather, snow and Hail	Variable	Minutes to days	Visible
Storm surge	Variable	Hours to days	Limited
Transportation – air	Minutes	Minutes	Limited
Transportation – marine	Minutes	Seconds	Limited
Transportation – rail	Minutes	Seconds	Limited
Transportation – road	Minutes	Seconds	Visible
Tsunami – distant	Hours	Days	Visible
Tsunami – local	Minutes	Hours to days	Visible
Utility failure	Variable	Hours to days	Variable
Volcanic	Variable	Hours to days	Visible
Wind storm	Hours	Hours to days	Visible

5.2 New Zealand society – considerations for warnings

The New Zealand population (~4,270,000) is primarily urban (84%). Over half of New Zealanders live in the Northern half of the North Island [22]. The distribution and demographics of the urban and rural populations mean that warning systems must deliver to diverse communities, sometimes over very large distances. Urban populations (Auckland in particular) have greater percentages of residents who are immigrants or overseas students [23]; these people may not necessarily have English as a first language and warning systems must be able to target them also. Comprehensive public education prior to hazard events, about the New Zealand hazardscape and the warning systems that will provide notification of an event, is essential. Also, Impairment of sight or hearing may affect people's capacity to receive warning messages. Physical barriers to receiving a 'Heads-up' and instructions must be considered when designing an effective warning system.

New Zealand is also a popular tourist destination, and at any given time thousands of holiday-makers both domestic and from overseas are travelling throughout the country[23]. This transient population is vulnerable in several ways, including having a lack of familiarity with local hazards, lack of familiarity with local procedures and warning systems, and lack of local support and communication systems (friends, family, community and employment networks). As with immigrants (short and long-term), public education around hazards and warnings also needs to be targeted to transient populations to raise hazard awareness, ensure warning messages are received and understood, and appropriate action is taken.

5.3 Current national and regional/local warning systems

Warnings for some hazards (e.g. volcanic eruption, tsunami) are generated and distributed by MCDEM via the national warning system, which alerts the emergency management community, government departments, and lifeline utilities to the hazard. While warnings can also be issued via radio and television (as per the MOUs in place with selected broadcasters) and via the MCDEM website, the message contained in these broadcasts will be general in nature and lacking specific local information or instructions. For more localised events, CDEM Groups and territorial authority emergency management offices share responsibility for disseminating warnings to the public, and for maintaining local warning systems. The National Plan does not include local actions and procedures required to disseminate local warnings to the public—that is the responsibility of each CDEM Group or Group members [24]. CDEM Groups and members also receive information regarding impending hazards through other sources; for example, the source for meteorological warnings is Metservice, emergency services may pass on warnings of threats such as hazardous substance releases, lifeline utilities may pass on warnings of infrastructure failure likely to result in an emergency situation.

Currently CDEM Groups and CDEM Group members around the country use a variety of methods for distributing warnings to the public. Methods currently used are outlined in Section 3.3.1. It is recognised that no single warning system can reach all at-risk people; in the absence of national guidelines and standards, or inter and intra CDEM Group coordination, different combinations of technologies and methods have been adopted across different districts and regions. A lack of commonality is not surprising given that the hazardscape differs throughout the country, budgets for CDEM planning also vary from authority to authority, and systems have largely developed independently. For NZ holiday-makers, overseas tourists/students, and other transient populations, the lack of consistency raises issues around the effectiveness of the warning methods employed, particularly for those systems that require substantial ongoing public education.

5.3.1 Early warning systems in use in NZ

This section outlines the physical process used by agencies to communicate a warning message to the population. This process is only one step of a comprehensive public notification system as outlined in Section 2.1.

A survey of warning systems currently in use (or that agencies have expressed interest in using) in New Zealand was distributed throughout CDEM Groups for group members (councils, rural fire etc) to complete. A summary of survey responses is shown in Appendix 1. Forty-four responses out of a possible 85 (52%) were received and analysed. Most responses came from city or district councils/unitary authorities (73%); some of these also have rural fire functions. The remaining 27% of responses were from regional councils or CDEM Groups. Proportionally, the South Island (SI) is better represented than the North Island (NI); 58% of South island councils responded (18 out of a possible 31). Of the North Island councils, 26 responses were received from a possible 54 (48%). A lower response rate from agencies in the North island regions can possibly be attributed to the timing of the survey which coincided with Exercise Ruaumoko. This was a national CDEM exercise with an eruption scenario from the Auckland Volcanic Field and involved many NI agencies, and some SI agencies.

In terms of systems currently in use, clear preferences exist for several methods of alerting the public of an actual or impending emergency (Figure 2). All but two responding agencies indicated they would use the radio to distribute messages. This is consistent with national procedures and reflects the MOU which was been signed in July 2006 between MCDEM and national networks Radio NZ, the Radio Broadcasters' Association, Television New Zealand and Canwest TV Works. Several responding agencies indicated they had arrangements in place with local radio stations also.

Other warning systems which are widely adopted include the use of Police or Fire Service mobile PA units, Route Alert (door-to-door alerting), Sirens, Telephone trees and Websites. Many agencies noted that some systems were used for localised hazards, such as billboards for floods, or sirens for tsunami.

To gauge interest from agencies in new technologies, the survey questionnaire listed three alerting methods that are not currently available in NZ,.. These are: Tone-activated alert radio (such as the US NOAA weather warning system), GPS receiver messaging, and mobile-device broadcasting (individual cell phone towers transmitting direct onto cellphone display screens, in a spatially specific area). Including technologies currently not available in NZ was also intended to act as a prompt for agencies to mention any technologies not listed in the survey that they would like assessed and included in the decision-making support tool. Several agencies listed they were interested in further information on mobile-device broadcasting technology, while one agency was interested in technology that could automatically interrupt regular television viewing to broadcast emergency messages.

All agencies currently use a minimum of three different methods for alerting the public (and key staff/responders/stakeholders) during emergency events, and one agency used up to twelve different methods, depending on hazard type and location.

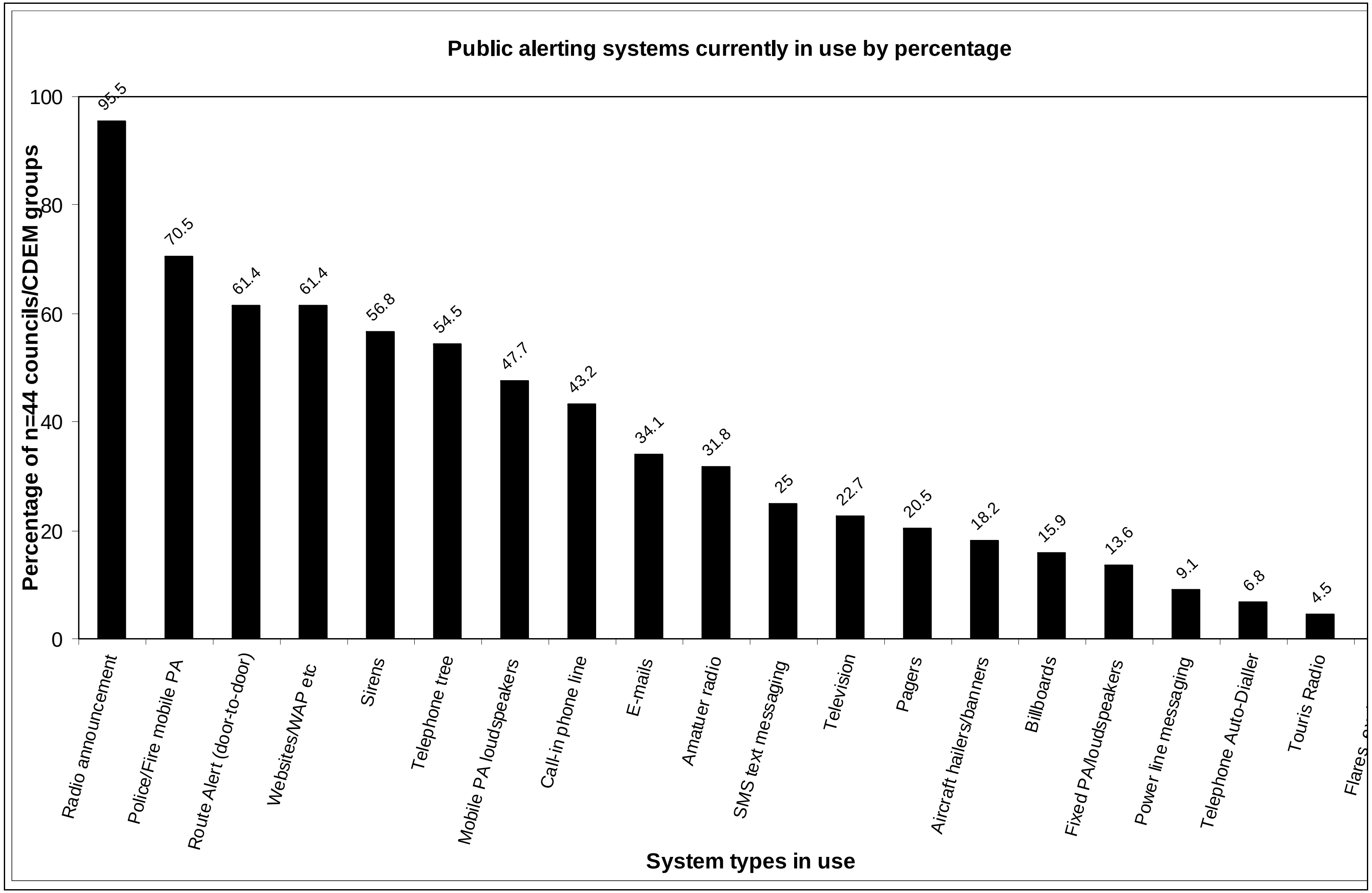

Figure 2 Prevalence of warning systems in use by NZ local authorities and CDEM groups (data from 44 out of 85 possible respondents).

6.0 FINDINGS AND RECOMMENDATIONS

6.1 Consistency

While it is important that capacity exists to notify at a national scale for nationally significant threats, the current public notification system recognises that most warnings will be required at a regional or local scale. The Ministry of Civil Defence and Emergency Management receives information on threats from hazard monitoring agencies (e.g. GeoNet) and distributes this information to Civil Defence Emergency Management (CDEM) Groups who are responsible for notifying the public of any impending threat or potential emergency. This devolved responsibility is practical as CDEM Groups best know their own communities; however it has resulted in the development of non-standardised notification systems throughout the country. Each local authority or CDEM Group has chosen their systems or notification methods in relative isolation from what other local authorities or Groups are choosing.

New Zealand currently has no national standards or guidelines for public notification systems to be used at a regional or local level. This is a particular issue for warning the transient population (visitors to NZ and internal holidaymakers) and also for avoiding redundancy or incompatibility of systems currently in place or planned for installation.

6.2 Reach

The following are not expected to be able to reach 70 % of the population as a warning system in isolation: Aircraft banners, billboards, call-in telephone lines, e-mails, marine radio, tourist radio, websites/WAP etc., website banners, GPS receiver messaging, flares and explosives.

Radio and TV Broadcasts may not reach 70 % of the population depending on local reception and time of day.

If emergency managers wish to cost these systems, they must be aware of the proportion of the population that they can actually reach.

6.3 Telecommunications mechanisms

For telecommunications mechanisms this report should be read in conjunction with Kidd et al. (2008), a 'New Zealand Telecommunications Based Public Alerting Systems Technology Study'. Kidd et al., (2008) provide a detailed feasibility analysis that is complementary to this report.

Note that several combined-system mechanisms are currently available in New Zealand and are also discussed in the report by Kidd et al. (2008) (e.g. combined SMS, email and telephone).

If the multipliers for fast onset widespread hazards and reaching transients (visitors and tourists) are increased the score for text messaging relative to mobile-device broadcasting drops. The former cannot derive a location/number for transients as quickly, or notify large numbers of people as quickly.

6.4 Good cost-benefit systems available now

The following comments assume equally weighted criteria and hazards. Even with multipliers changed for hazards and criteria these scores do not shift dramatically.

The following all score well and have reasonable costs for both low and high density populations:

- Radio and TV Broadcasts
- Website banners (requires some development with ISPs)*
- Power line messaging
  - But needs specific hardware to receive – this makes uptake lower (if people buy themselves) or cost much higher
- Route alert (door-to-door)
- Mobile PA loud-speakers
- Telephone trees (does this link to next line?)
- Via independently, self-maintained systems
- E-mails*
- SMS text messaging
- Websites/WAP etc.*
- Pagers
- Natural warnings
- Police/fire mobile PA loud speaker.

*Limited reach, see Section 6.2.

Fixed PA loudspeakers score well, but have a high start up cost, likely to be considered prohibitive for low density areas. Ongoing maintenance should not be overlooked. Fixed PA loudspeakers should not be confused with sirens (tone only) which do not score well because they do not give specific instructions on what the population should do on hearing the warning.

6.5 Other good cost-benefit mechanisms available

These mechanisms score the highest, but are not currently available in New Zealand. They would potentially be cost effective only if implemented nationally.

- Mobile-device broadcasting
  - Would need to be implemented nationally
- Tone-activated alert radio
  - But needs specific hardware to receive – this makes uptake lower (if people buy themselves) or cost much higher.

Break-in broadcasting also scores very high, but is not considered advantageous at this time as arrangements for emergency broadcasts are already in place.

6.5.1 Consider nationally implemented systems

There is potential for a nationally consistent nationwide system supporting local arrangements. Some mechanisms, such as media agreements and cell-broadcasting, are most-easily implemented nationwide.

6.5.2 Radio and TV broadcasts

National arrangements for radio and TV broadcasts are now in place and have one of the cheapest local costs and highest local effects. However, unless people are actively listening/watching at the time of a warning, this method will not reach them. To reach people in short lead-time hazard events TV and radio broadcasts must be supported by other systems, particularly those that give a positive heads-up and would work at night.

6.5.3 Mobile-device broadcasting

For warnings, mobile-device broadcasting scores highly. However, at a regional and local scale it is prohibitively expensive and a national arrangement will probably be a much more cost-effective path for implementation. The source of payment for cost per-message would need careful consideration. Overseas implementations have used a small monthly cost applied to all mobile users to recoup start up and maintenance costs.

6.6 Low scores with high cost

For multi-hazard, broadly applied systems, little emphasis should be placed on the following low-scoring systems:

Sirens, flares and explosive, tourist radio, billboards, aircraft banners, call-in telephone lines, marine radio, and Radio Data Systems do not score well.

However, some may be useful for specific circumstances (for example billboards for long-term hazards).

6.7 Future improvements

Consider which criteria are ‘deal-breakers’ and so may need to be treated with more importance than as just one of a range of weighted scores (even with multipliers). These may differ regionally.

Consider dealing with public alert systems on a spatial basis (e.g. per square kilometre).

6.8 Revision

It is suggested that the scores, costs and overall methodology of the tool presented here be reviewed within 2 years to allow for updates from the real experience and data of local emergency managers.

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APPENDICES

APPENDIX 1 A CRITICAL ASSESSMENT OF WARNING MECHANISMS

In general: a 0.01 FTE per 100,000 people overhead has been used as a minimum for any system. It is assumed that four times the equipment is needed for diffuse areas relative to dense areas, if density is relevant to that system. This is because people are still assumed to be clustered in rural areas so targeting would be possible. Otherwise, in the case that even coverage of entire rural areas including forest and farm was needed, the amount of equipment needed could be up to twenty times that for urban areas.

A1.1 Natural warnings (Education & Engagement)

Natural warnings are where a hazard effect or precursor (e.g. an earthquake for a tsunami) is actually experienced by the public. Natural warning is not a technological system comparable with the other mechanisms described in this document but is analysed in order to assess its potential in the absence of any system and its value against other systems.

Limitations	Awareness of meaning, exposure of natural warnings to the public, timeframe for response given natural warning, planning, informing and motivating suitable response.
Time-frame	Seconds to hours
Heads-up and Instruction	Heads-up only
Effectiveness residents	Yes but ongoing public education required
Effectiveness transients	Not suitable unless familiar similar hazards in home region/country
Effectiveness institutions	Yes but ongoing public education required
Vulnerable & immobile	Limited by perception of precursors and comprehension
Robustness/resilience	Hazard must exhibit typical precursor activity for this method to be robust
Ongoing effectiveness	Likely to increase in effectiveness as more hazard symptoms manifest, however response time will therefore be reduced
Terrain suitability	All terrain
Population density	More effective in high density areas but also effective for isolated population centres if located nearby
Cost basis	Development of community resilience (capacity, intention and action) through education and other interventions. 4 FTE staff per 100,000 people.
Suitable Terrains	All
Not suitable	None
Hazards	Possible for all hazards, but suits those with distinct signs giving adequate lead-time for response
Target population(s)	Residents and organisations, more difficult for visitors/tourists

A1.2 Mechanisms that are independently self-maintained networks

Volunteer and community networks have the potential to reach many people without any effort on the part of emergency management to maintain those networks. However, there is no obligation for those networks to act as a warning mechanism so reliability of this pathway will always vary to some degree. This has an important potential to reach English as a second language populations, cultural groups, rural groups etc..

Limitations	Hardware (e.g. telephone, internet) relied upon; duty person required at all hours; volunteer only - no legal obligation
Time-frame	Minutes to hours
Heads-up and Instruction	Yes – provides both
Effectiveness residents	Yes
Effectiveness transients	Depends on the group
Effectiveness institution	Yes
Vulnerable and immobile	Yes
Robustness/resilience	Reliant on trained volunteer pool, could be issues of conflicting priorities if own household at risk
Ongoing Effectiveness	High
Terrain suitability	All terrain
Population density	More effective in high density areas due to resultant informal warnings but also effective for isolated or diffused population centres
Cost basis	Start up:$0, but effort and planning, ongoing: plans, exercises
Hazards	Possible for all hazards, but may not suit very short time frames
Target population	Residents and organisations and any visitors/tourists members are in contact with

Further comments

Volunteer and community organisations often operate self-maintaining networks that could be used to warn the public within their immediate reach. These organisations may include:

- Surf Lifesaving
- Neighbourhood Support
- Rural Fire
- Royal New Zealand Volunteer Coastguard
- St Johns
- Red Cross
- Salvation Army
- Community Link response call trees and route alerts in remote areas

A1.3 Mechanisms reliant of third party hardware and/or staff

A1.3.1 Aircraft banners

Aircraft banners are used to communicate a written message to the general public in specific targeted areas.

Limitations	Available helicopters. CAA Regulations (flight path and equipment certification); Agreements with operations, craft and pilot availability, limited coverage – prioritise. Banners with appropriate message need to be already available. Weather conditions may hamper visibility. **Will never reach 70% of the population as the primary warning**.
Time-frame	Minutes to hours
Heads-up and Instruction	Instruction only unless in an area where aircraft are seldom used.
Effectiveness residents	Effective for residents who are outdoors, but more effective if both sound and visual alert is included
Effectiveness transients	Effective if transient population are outdoors but more effective if both sound and visual alert is included
Effectiveness institutions	Low effectiveness (not visible)
Vulnerable & immobile	Low effectiveness (not visible)
Robustness/resilience	Aircraft are maintained to robust standard, runways, and weather-flight restrictions.
Ongoing effectiveness	Would only remain effective while reaching un-warned members of the population (as the aircraft relocates to new areas), and up to the point when adequate time for public response expires
Terrain suitability	All
Population density	All – better for remote areas with some population clustering. Less effective per minute over rural diffuse populations.
Cost basis	Equipment and flight costs for one craft
Cost (for each craft)	Start-up: $20k+, ongoing: in event helicopter $1,000/hr, effort, planning and exercises. Banner costs $3,000 each
Dense	Two helicopter units for 100,000 people, ten hours use per year (five per helicopter).
Diffuse	Eight helicopter units for 100,000 people, forty hours use per year.
Hazards	All hazards with a lead-in time of more than tens of minutes
Target population(s)	All within visual range (blind people will not receive warning)

A1.3.2 Aircraft PA loudspeaker or siren

Aircraft loudspeakers or sirens are used to alert the public in specific areas. In the case of a siren only, the intent is to alert people to conduct some other action in order to establish the warning content (e.g. listening to their local radio station), or to take certain action in accordance with pre-established instructions. With loudspeakers the instruction can be given directly.

Limitations	Available helicopters. CAA Regulations (flight path and equipment certification; Tauranga states that the latter is not required if carried on cargo hook), Agreements with operations, craft and pilot availability, limited coverage – prioritise
Time-frame	Minutes to hours
Heads-up and Instruction	Yes – provides both
Effectiveness residents	Effective for residents who are outdoors, but more effective if both sound and visual alert is included
Effectiveness transients	Effective if transient population are outdoors but more effective if both sound and visual alert is included
Effectiveness institutions	Low effectiveness (not visible and sound dulled)
Vulnerable & immobile	Low effectiveness (not visible and sound dulled)
Robustness/resilience	Aircraft are maintained to robust standard, runways, weather-flight restrictions.
Ongoing effectiveness	Would only remain effective while reaching un-warned members of the population (as the aircraft relocates to new areas), and up to the point when adequate time for public response expires
Terrain suitability	All
Population density	All – better for remote areas with some population clustering. Less effective per minute over rural diffuse populations.
Cost basis	Equipment and flight costs for one craft
Cost (for each craft)	Start-up:$20k+, ongoing: in event helicopter $1,000/hr, effort , planning and exercises.
Dense	Two helicopter units for 100,000 people, ten hours use per year (five per helicopter).
Diffuse	Eight helicopter units for 100,000 people, forty hours use per year.
Hazards	All hazards with a lead in time of more than tens of minutes
Target population(s)	All within audible range (deaf people will not receive warning)

A1.3.3 Billboards

Billboards are used to communicate written warning messages in specific target areas. They normally have limited space for text and can be electronic or printed/written.

Limitations	Time to erect, exposure only to those who view message, agreements required for electronic billboards. Mobile billboards may not be suitable in high wind events. Only suitable for events with long lead in times. **Will never or only slowly reach 70% of the population as the primary warning**.
Time-frame	Hours to days
Heads-up and Instruction	Instruction only
Effectiveness residents	Yes
Effectiveness transients	Yes
Effectiveness institutions	No – these rely on mobile target population viewing alert
Vulnerable & immobile	Less effective
Robustness/resilience	Fixed billboards resilient, mobile resilient depending on conditions
Ongoing effectiveness	Effectiveness decreases with time unless new viewers constantly exposed
Terrain suitability	Good visibility and limited routes increases effectiveness. Less suitable on convoluted roading networks
Population density	For longer time-frame hazards this can reach people in both high and very low population density areas.
Cost basis	Single billboard
Cost	Start-up: $5k+ (printing), ongoing: rental of site from $3.5k/month, installation from $500 planning. Mobile (trailer) billboards available for $300/day + printing costs.
Dense	One board reaches 10,000 people/day
Hazards	All hazards that have long lead in times
Target population(s)	All that pass billboard and can see it (not the blind)

A1.3.4 Break-in broadcasting (not currently available in New Zealand)

A typical example of break-in broadcasting is the Emergency Alert System (EAS) in the USA that requires broadcasters, cable television systems, wireless cable systems, satellite digital audio radio service (SDARS) providers and, direct broadcast satellite (DBS) service providers to provide the communications capability to the President to address the American public within 10 minutes of a warning being issued. The Federal Communications Commission (FCC), in conjunction with the Federal Emergency Management Agency (FEMA) and the National Oceanic and Atmospheric Administration (NOAA) implement the EAS at the federal level. The President has sole responsibility for determining when the EAS will be activated at the federal level, and has delegated this authority to the director of FEMA. FEMA is therefore responsible for implementation of the national-level activation of EAS, tests and exercises. The EAS has never been used at federal level for a real event. The system can however also be used by state and local authorities to deliver important emergency information targeted to a specific area. Each state and several territories have their own EAS plan.

Limitations	Technology not currently available in New Zealand, legislation may be required. Likely to be used only for life-threatening situations only. Warning agencies need to have broadcasting and trained staff capability.
Time-frame	Minutes
Heads-up and Instruction	Yes - provides both
Effectiveness residents	Yes
Effectiveness transients	Yes
Effectiveness institutions	Yes
Vulnerable & immobile	Yes (requires subtitles for deaf viewers)
Robustness/resilience	Unknown
Ongoing effectiveness	Can be continuously updated – highly effective.
Terrain suitability	All
Population density	All
Cost basis	Unknown but likely to be expensive
Hazards	All hazards

Further comments

The arrangements for the broadcast of emergency announcements maintained by the Ministry of Civil Defence & Emergency Management (MCDEM) with Radio and TV, as well as those maintained at local level with local broadcasters (see page 52) do not constitute this technology.

A1.3.5 Call-in telephone line

The 'Call-in telephone line' mechanism involves the establishment and maintenance of a call centre capability to provide information to callers about an event. It is not a 'primary' warning mechanism as it requires the public to be prompted to call in by some other mechanism. A call-in telephone line may be useful for the confirmation of warnings.

Limitations	Useful for people to confirm warning message. **Will never reach 70% of the population as the primary warning**. Lines available, congestion, access to telephone, awareness of system, awareness of hazard and need to call
Time-frame	Minutes to days
Heads-up and Instruction	Instruction only
Effectiveness residents	Yes
Effectiveness transients	Yes
Effectiveness institutions	Yes
Vulnerable & immobile	Yes for immobile – less effective for the deaf population, those with English as a second language or the intellectually impaired
Robustness/resilience	Congestion problems could arise
Ongoing effectiveness	Can update the message as required
Terrain suitability	All
Population density	All
Cost basis	100 lines, plus hardware
Cost (all areas)	Start-up: $20k+ Ongoing: $20k+/yr and testing awareness effort awareness effort
Dense/Diffuse	3,000 people reached in 30 minutes.
Hazards	Hazards with hours or more (days) of lead-time, and with a primary system to have notified the existence of a risk
Target population(s)	All with access to a telephone (can operate for disabled if special telephony catered for)

A1.3.6 E-mail

Email has become a normal method of day-to-day communication and is widely used to pass information

Limitations	**Will never reach 70% of the population as the primary warning** - exposure only to those with and connected to and checking email, relies on internet and related hardware systems, maintenance of email list, timeframe to emailing region.
Time-frame	Minutes to hours
Heads-up and Instruction	Instruction only (unless recipient has live email updating and is online when message sent)
Effectiveness residents	Yes
Effectiveness transients	Not effective, need email details of receiver and receiver must be online
Effectiveness institutions	Yes – effective in institutions with 24/7 duty admin staff
Vulnerable & immobile	Yes (less effective for those with English as second language)
Robustness/resilience	As robust as email service provider – could suffer congestion problems
Ongoing effectiveness	Messages can be updated but if congestion occurs messages could take longer to transmit as events unfold
Terrain suitability	All – but some rural areas have restricted access to broadband
Population density	All (areas with higher population density generally have faster speed broadband)
Cost basis	Free national emails, internet hardware in place
Cost (all areas)	Start-up: $50,000 (1 FTE for a year), list development; ongoing: 0.5 FTE for 100,000 people list maintenance, awareness
Hazards	All hazards for those connected to internet, delays in email delivery may exclude hazards with minutes of warning time
Target population(s)	All with and attached to email

Further comments

Several Wellington councils have joined the Readynet system which provides a web-based database service to list groups and institutions and sends emails and SMS texts containing emergency early warnings (although the SMS function is more commonly used than the email mechanism). This method will become more effective as the proportion of the population with portable internet access (3G mobile telephones, Blackberries, iPhones etc) increases.

A1.3.7 GPS receivers (not currently available in New Zealand)

Warning to GPS receiver units is possible via a new set of GPS geostationary satellites. GPS inherently can locate the receiver and thus control the area of warning. These messages can be received on existing GPS units (e.g. in-car and hand-held) with only a software upgrade. However, at this time coverage is not available in New Zealand.

Limitations	Not feasible in NZ at present [1] Target population hardware and required to be on and waiting for message. **Will not currently reach 70% of the population as the primary warning**.
Time-frame	Seconds to hours?
Heads-up and Instruction	Instruction only
Effectiveness residents	Yes (dependant on being in proximity to GPS unit)
Effectiveness transients	No (unless rental cars have GPS)
Effectiveness institutions	Yes but depends on location of and monitoring of unit
Vulnerable & immobile	Yes (dependant on being in proximity to GPS unit)
Robustness/resilience	Need good satellite signal , not affected by power cuts, telecommunications problems
Ongoing effectiveness	Message can be updated
Terrain suitability	Need clear signal from several satellites, not suitable in some terrains (particularly hill shadow or forested areas)
Population density	All
Cost basis	Existing hardware, but costs of implementation uncertain
Cost (all areas)	Start-up: unknown, ongoing: unknown
Hazards	All hazards
Target population(s)	All with GPS receiver turned on

A1.3.8 Marine Radio

Limitations	Limited audience, agreements with maritime operations required. **Will never reach 70% of the population as the primary warning**.
Time-frame	Minutes to hours
Heads-up and Instruction	Yes – provides both
Effectiveness residents	No – only those in coastal areas with at-home VHF (and HF in Taupo) radios and those in boats
Effectiveness transients	No
Effectiveness institutions	No
Vulnerable & immobile	Not suitable for the deaf population
Robustness/resilience	Robust, well maintained.
Ongoing effectiveness	Can only target those within range, however message can potentially be changed as necessary
Terrain suitability	Coverage over all of coastal NZ, Lake Taupo (HF) and offshore including the Chatham Islands
Population density	All densities
Cost basis	Service provided by Maritime Operations, target population would have VHF radio as standard equipment already Ongoing, cost of training and exercises
Hazards	All maritime hazards
Target population(s)	Boaters – coastal people with VHF receivers

A1.3.9 Mobile-device broadcasting (not currently available in New Zealand)

Whereas SMS-PP (Short Message Service - Point to Point- page 55) is a one-to-one and one-to-a-few service, Mobile-device broadcasting is a one-to-many geographically focused messaging service (point to multi-point/area). Network cell sites are activated to send a broadcast message to all devices within its coverage area at that point in time. Mobile-device broadcasting has no limitations on capacity (number of messages sent), can be geo-located and can in theory deliver to target population very rapidly with pre-programming of messages. Most modern digital mobile telephone systems such as GSM, UMTS and CDMA are capable of this functionality. Mobile telephone users can switch the receiving of Mobile-device broadcasting messages on or off. A Mobile-device broadcasting message is also an unconfirmed push service, meaning that the originator of the message does not know who has received the message.

Limitations	Technology implementation cost and timeframes (Vodafone and Telecom), new Telecom telephones needed that can receive broadcasts, users need to activate functionality on handset, telecommunication network being in place and functioning.
Time-frame	Seconds to minutes.
Heads-up and Instruction	Yes – potentially provides both
Effectiveness residents	Yes
Effectiveness transients	Yes if they have functionality activated on their handset and the channel being used in their country is the same as in New Zealand.
Effectiveness institutions	Yes
Vulnerable & immobile	Yes - except the blind – which can use text to speech conversion software.
Robustness/resilience	Untried in NZ – implemented in a small number of countries internationally and further trials currently underway overseas
Ongoing effectiveness	Message can be updated as long as telecommunications infrastructure is in place and functioning, not prone to congestion as SMS text messaging
Terrain suitability	Cell phone coverage in NZ is limited or non-existent in some areas due to terrain. Mobile coverage is at least 97% of the country
Population density	Greater density areas generally have better coverage
Cost basis	New technology and development estimates only (no running/use costs)
Cost (whole country)	Start-up: Up to millions of dollars across both networks (confidential). All: programming, maintenance cost, planning and agreement, testing and exercising, Target population awareness development and keeping awareness maintained

Hazards	All hazards
Dense/Diffuse	All
Target population(s)	All with mobile telephone and within coverage areas

Further comments

Another type of Mobile-device broadcasting is used in GSM networks to identify cell sites on the screen of mobile telephones. Theoretically this capability can be used for warnings targeted to specific cell sites. This type of Mobile-device broadcasting is not considered in the assessment due to:

- character limitations (11-36 depending on the age of the device)
- this type of Mobile-device broadcasting does not trigger alert tones
- not all mobile telephones possessing this functionality

A1.3.10 Mobile PA announcements – NZ Police & NZ Fire Service

Both the NZ Police and NZ Fire Service are closely aligned with local-level CDEM response but specific arrangements for the availability of their staff and hardware to be used as part of local warning systems at short or immediate notice will have to be agreed, which may prove to be practically unachievable. However, there is a common expectation that NZ Police and NZ Fire Service will have some role in most, if not all, public alerts at the local level.

Limitations	Available staff and equipment, deployment times, planning, agreements
Time-frame	Realistically 30 minutes or more, theoretically a few minutes
Heads-up and Instruction	Yes – provides both
Effectiveness residents	Yes, but less effective for those indoors
Effectiveness transients	Yes, but less effective for those indoors
Effectiveness institutions	Not suitable (most in institutional care will be indoors)
Vulnerable & immobile	Yes – but less effective for those indoors
Robustness/resilience	Resilient with regular maintenance
Ongoing effectiveness	Effective throughout event as message can be updated, would need to re-visit areas if message changes
Terrain suitability	All terrain
Population density	More effective in high density areas but also effective for isolated population centres if located nearby
Cost	Start-up: $0, effort and planning, ongoing: planning and exercises
Hazards	All hazards, but response will take minutes
Target population(s)	All

A1.3.11 Pagers

‘Paging’ is based on telecommunications technology and is a common means for ‘heads- up’ notifications to agency staff. They are used to alert the ‘paged’ staff to take some kind of action in accordance with established procedures.

Limitations	Exposure only to those with pagers, time to initiate/send and transmit pages, list of pager numbers needed, relies on third-party hardware, system coverage
Time-frame	Minutes
Heads-up and Instruction	Yes – but Instruction message size possibly limited
Effectiveness residents	Only as effective as the number of pagers in community
Effectiveness transients	Not suitable
Effectiveness institutions	Suitable – institutions often have 24/7 duty staff
Vulnerable & immobile	Yes – could target specific individuals for pager allocation
Robustness/resilience	Robust system but relies upon third party hardware
Ongoing effectiveness	New messages or alerts can be transmitted as required
Terrain suitability	All
Population density	All
Cost basis	$312 per pager, per person, per year.
Hazards	All hazards
Target population(s)	Those with pagers in range

A1.3.12 Power mains messaging

Power mains messaging is based on the application of 'ripple control' by power companies (at the request of a warning agency) via existing power infrastructure to activate tone or code alert on devices plugged into power outlets. The technology has been trialled in New Zealand but is not currently applied.

Limitations	Hardware to transmit and receive messages available but not implemented in New Zealand. Agreement with carrier, relies on third-party power network. Exposed only to those with a receiver and near that receiver
Time-frame	Seconds to hours
Heads-up and Instruction	Heads-up only (but could be included in unit design)
Effectiveness residents	Yes
Effectiveness transients	No
Effectiveness institutions	Yes
Vulnerable & immobile	Yes
Robustness/resilience	New technology for NZ (warnings) but already used to control electricity peak demand
Ongoing effectiveness	Once household/institution alerted other information source is required, therefore less effective as event progresses
Terrain suitability	All
Population density	All
Cost basis	Further research would be needed to look at the feasibility and cost structure for New Zealand
Cost (all areas)	Start up: software and agreement costs, ~$50 per unit in households (2.5 people per house). Who pays?, ongoing: unknown. Minimum 5,000 units for pilot.
Hazards	All hazards
Target population(s)	All near receiver on mains electricity

Further comments

A New-Zealand-based system, 'Meerkat' has recently entered the New Zealand market-place.

From the product documentation:

(1) Meerkat relies on existing infrastructure and does not need full new broadcast or control hardware, just an agreement, protocol and some interface (software?) with the electricity provider. Therefore, this mechanism has many useful attributes.

And the following potential limitations:

(a) It can reach only to locations with power lines or power outlets, (b) It relies on the power being on (for the in-home units at least), (c) It requires the user to purchase a receiving unit (unless free supply and installation is subsidised and planned), (d) This system is non-message-carrying (the same problem as tone-only sirens - people know there's a warning, but not what it is). Multiple message triggering (different ripple signals triggering pre-recorded messages - not simply different alarm tones), such as what appears to be covered by the optional sounder on the 'sentinel outdoor alarm' Meerkat mechanism, would significantly enhance its potential effectiveness. However, it appears the in-home unit as advertised only gives off a single alarm-tone-based sound.

'Meerkat' ripple control activated units are being considered for use in the Northland region, although decisions are ongoing regarding where the $50 cost per unit should lie. A test of 24 units provided good results, but due to economy of scale production costs this system will not be available in New Zealand unless an order of 5,000 units or more can be funded.

A1.3.13 Radio and TV broadcasts

Radio broadcasts are commonly applied to convey warning information to the public. The broadcasts are made upon the request of warning agencies to radio stations on the basis of prior arrangements. Television broadcasts are applied on the same basis although to a lesser extent. In this case the television station will normally announce the warning by broadcasting a scrolling banner over the existing programme.

Limitations	Possibly changes to warning message, time-lag, only reaches those listening or watching
Time-frame	Realistically with current technology in place 30 minutes or more, theoretically seconds to a few minutes with dedicated automated tested broadcast 'break-in' technology.
Heads-up and Instruction	Primarily Instruction (unless already listening/viewing)
Effectiveness residents	Yes
Effectiveness transients	Yes, if they have access to these media
Effectiveness institutions	Yes
Vulnerable & immobile	Yes
Robustness/resilience	Generally robust/resilient with redundancy built-in and quick repair times for faults
Ongoing effectiveness	Highly effective throughout as new messages (and images on TV) can be broadcast as event progresses
Terrain suitability	All, although reception varies in some areas
Population density	All
Cost basis	'Public good' role for stations (no cost to CDEM Group). Some minor effort cost.
Cost (all areas)	Start up: $0, effort and planning, ongoing: planning, exercises
Hazards	All, but takes a minimum of minutes
Target population(s)	All 'tuned in'

The Ministry of Civil Defence & Emergency Management (MCDEM) maintains MOUs with Radio NZ, the Radio Broadcast Association, TVNZ and TV3 for the broadcast of emergency announcements[5]. Several CDEM Groups/Territorial Authorities maintain arrangements with local radio stations for similar broadcasts. The contents of any emergency broadcast are shown below and come from the "Request for the broadcast of an emergency announcement" [26]

Emergency Announcement

This is an official announcement for ……(insert affected area) issued by….(insert name of authority) concerning…..(insert type of emergency).

(Details to be presented in a ready-to-read form, including:

1. Nature of the threat (what has happened)
2. When it happened.

[5] These arrangements are described in Section 22 of The Guide to the National CDEM Plan.

3 Where it happened and what areas are under threat.
4. What has been done to date.
5. What is proposed to be done.
6. Public safety instructions/messages/directions).

This Emergency Announcement was issued by ….(name authority). Stay tuned to this station for further information.”

A1.3.14 Route alert (door-to-door)

Route alert involves the physical door-to-door delivery of a warning by persons. Normally route alert would in the first instance be undertaken by staff from NZ Police and NZ Fire Service. Door-to-door notification is also commonly applied via volunteer networks (e.g. CDEM volunteers and neighbourhood watch groups).

Limitations	Staff available and number of locations those staff can visit per minute
Time-frame	Minutes to days
Heads-up and Instruction	Yes – provides both
Effectiveness residents	Yes
Effectiveness transients	Yes
Effectiveness institutions	Yes
Vulnerable & immobile	Yes
Robustness/resilience	Relies on adequate number of staff/volunteers
Ongoing effectiveness	Time consuming, less effective where hazard conditions change and updated messages must be transmitted
Terrain suitability	All
Population density	Not suitable for areas of diffuse populations
Cost basis	Using available response staff
Cost urban	Start up: $0, planning effort, ongoing: planning and exercises
Cost rural communities	As above
Cost (rural diffuse)	**Likely not feasible** except for hazards with days of lead time
Hazards	All hazards with hours or more of lead time
Target population(s)	All within reach of staff/volunteers

Further comments

Would in the first instance comprise staff from Police and Fire, and possibly CD volunteers. Door-to-door notification is commonly used in New Zealand via volunteer networks (e.g. CD Volunteers neighbourhood watch groups) and in Australia via Police and State Emergency Service (SES) volunteers.

A1.3.15 SMS-PP (Short Message Service - Point to Point)

SMS-PP has become a common means of communication of short text messages via cell phones to the public. Through SMS-PP a message is sent from one point to one or many specifically targeted cell phone numbers. Similar to e-mail, the message is sent on a one-by-one basis to all the targeted numbers.

Limitations	Congestion, time for large population groups, more time to be spatially-specific and unable to make spatially-specific currently for Telecom customers, third-party hardware reliance. Exposure only to those with mobile telephones and those that know how to and can read SMS e.g. not as effective for the elderly and the blind.
Time-frame	2-3 hours nationally, more to break out regions or cells, if no congestion (includes coordination time)
Heads-up and Instruction	Yes – provides both
Effectiveness residents	Yes
Effectiveness transients	Not suitable
Effectiveness institutions	Yes
Vulnerable & immobile	Yes
Robustness/resilience	Currently SMS services can be slowed considerably during unplanned high traffic periods, congestion would be exacerbated as those who receive messages forward them to others and call others for confirmation. Relies on telecommunication infrastructure being in place and functioning.
Ongoing effectiveness	If congestion issues do not arise and infrastructure failure does not occur updated messages could be provided as event progresses
Terrain suitability	Some parts of NZ have no or limited mobile coverage due to terrain. Overall mobile coverage is at least 97% of the country.
Population density	All
Cost basis	Depends on agreement with carriers. “Readynet” minor start-up costs and then ~40c per subscriber charged to council on monthly basis. Some staff time required for data maintenance and considerable for assisting subscribers with readiness/planning part of the Readynet programme. OPTN costs (see below) estimated at $4-7,000 per month per council.
Cost (whole country)	Planning and agreements, ongoing: planning and testing
Hazards	All hazards with hours of lead time
End –users	All with mobile telephones switched on

Further comments

Currently geo-location of message recipients is not possible on the Telecom network and it would take several hours to locate and send messages to telephones in specific areas using the Vodafone network. A key issue for sending warnings is ensuring you are targeting those in the affected area. Problems associated with SMS text warning messages being received by those not in at-risk areas include: potential congestion as the warnings are forwarded; inappropriate response from those not at risk, including evacuation of safe areas (and potential traffic congestion); resources needing to be diverted to send corrective messages to those not at risk; etc.

Warnings to individuals: Nine North Island councils in New Zealand have signed up with OPTN, a SMS messaging service designed for commercial advertising which has an adapted service for CDEM messages; these are provided on a subscriber basis. Warnings are entered via a website or from a mobile telephone and distributed to all on the local database (wherever they may be). Some congestion problems have been documented during initial usage of the system, for example during the 2007 Ruapehu Lahar SMS warning messages through the OPTN system were received several hours after the event, however recent small scale tests by councils reported no delays. There is no recent data on large scale tests of the system for public notification but minimum message rate according to contracts with carriers (barring congestion overload) is 600 messages per minute sent. The infrastructure that supports this system needs to be made more resilient,both the telecommunication carriers and OPTN networks, before it can be considered a robust form of notification for Civil Defence purposes.

There has been only partial delivery to users, taking hours, during overseas trials of SMS messaging to thousands (French Polynesia; D. Coetzee pers comm., 2005) and millions of people (Hong Kong) [27]. However the technology is being used increasingly overseas for commercial applications and investigated for public notification. One product currently in use overseas includes Whispir, which allows message senders to use a web interface to automatically generate SMS, email and voice messages. This system is not currently in use as an emergency alerting tool but there are proposals for testing Whispir in this capacity in Australia.

Warnings to groups: SMS messaging appears to work well when the number of people on contact lists is limited, and the system encourages users to seek further information elsewhere. The Readynet system (a partnership between the provider and Local Government Online in use widely in Wellington provides SMS (and email) warnings to institutions (schools, hospitals, child care, aged care, as well as police, fire, district health boards etc). All staff from institutions on the database are contacted; these staff should activate emergency plans. After receiving the initial SMS warning, receivers of warnings log on to emergency management websites to receive detailed and periodically updated messages. Subscribers to the Readynet system must develop an emergency plan which must be in place, including an evacuation plan, identification of special needs persons, emergency supplies etc. Institutions using this system appear to have a high degree of resilience. A recent warning sent via Readynet showed that 400 individuals (out of 500 on database) logged onto the Hutt Valley EMO website within 30 seconds of the warning message being sent. This mechanism is only really suitable for early warnings as systems are likely to become congested once initial warnings are out.

SMS with geo-location [1] would be the preferred mechanism (not currently implemented) reducing the time to spatially locate telephones.

A1.3.16 Telephone auto-dialling (landline)

Telephone auto-dialling is based on the communication of a recorded voice message by a warning agency via telephone to a targeted numbers list. Similar to SMS-PP, the message is sent on a one-by-one basis to all the targeted numbers. Telephone auto-dialling is technically possible but not currently applied much in New Zealand. The main reasons are access to public number data and complex, potentially expensive agreements have to be established with the telecommunications carriers.

Limitations	System failure, lines available, system capacity (overload, especially in specific small areas with acute hazards), time per call, number list availability and maintenance, coverage. Need for a public number database – establishing and maintaining this would involve considerable resources.
Time-frame	Hours to days, first calls in minutes.
Heads-up and Instruction	Yes – provides both
Effectiveness residents	Yes if indoors
Effectiveness transients	No
Effectiveness institutions	Yes
Vulnerable & immobile	Yes
Robustness/resilience	Tests of systems overseas have experienced overloading and delays
Ongoing effectiveness	Message can be updated
Terrain suitability	All
Population density	More efficient at lower population densities
Cost basis	Equipment, software and 100 lines
Cost (all areas)	Start up: $6.5k (four lines), List development could be $200,000 for a small region. Ongoing: list maintenance $200,000 per year based on SMS list; $52/month/line, 8 lines, 1 line = 150 people (60 households). Additional ongoing effort is also required; 0.5 FTE to maintain list of 100,000 people. Development, agreements, list maintenance, planning
Areas suitable	All
Not suitable	Will miss people not near a ‘land-line’ or not on the list
Hazards	Only those with long lead-time
Target population(s)	All near a telephone that is listed

A1.3.17 Telephone trees

Telephone trees are mostly used in rural areas where a warning agency relies on the existing (and normally well established) population to pass a warning from one to the other, using their normal telephones. Telephone trees require careful planning and regular checking by the warning agency for points for currency of numbers and understanding by residents of their responsibilities.

Limitations	Major time cost in maintenance of list, relies on third-party hardware, time, needs redundant check calls across branches to allow for failures in tree
Time-frame	Minutes to hours
Heads-up and Instruction	Yes – provides both
Effectiveness residents	Yes if indoors
Effectiveness transients	No
Effectiveness institutions	Yes
Vulnerable & immobile	Yes but depends on capacity of recipients to pass on accurate messages
Robustness/resilience	Constant updating of telephone list required
Ongoing effectiveness	Message can be updated
Cost basis	Labour to develop and maintain list only
Cost (all areas)	Start up: List and relationship development at 4 FTE per 100,000 people. Ongoing: List maintenance at same rate list development
Areas suitable	All with telephone coverage
Hazards	All hazards
Target population(s)	All telephone coverage (disabled only if specialised telephony allowed for)

A1.3.18 Tourist Advisory Radio

Tourist radio is common in areas with high tourist traffic. Often these areas' attractions are associated with natural hazards, making tourist radio a useful instrument to educate and warn particularly tourists of those hazards.

Limitations	**Will only reach a small percentage of the population.** Radio station coverage, agreement, exposure only to those listening to this station
Time-frame	Seconds to minutes
Heads-up and Instruction	Instruction only
Effectiveness residents	Yes if tuned in (low percentage audience among residents likely)
Effectiveness transients	Dependent on access to radio and awareness of service
Effectiveness institutions	No - not target audience
Vulnerable & immobile	No – unless tuned in
Robustness/resilience	Usually on low power frequencies; may not have live staff (i.e. pre-recorded loops)
Ongoing effectiveness	Not effective, expected listeners would seek further information elsewhere
Terrain suitability	Limited range and for FM lose signal through topographic interference
Population density	All
Cost basis	Agreement with station, start up: planning, ongoing and exercises
Hazards	All hazards
Target population(s)	All listening to this station (has the advantage of targeting tourists)

A1.3.19 Websites/WAP

The internet is widely accessible at home, work and via some cell phones through Wireless Application Protocol (WAP) making it a commonly applied mechanism for the communication of information. A dedicated website is required.

Limitations	**Will never reach 70% of the population as the primary warning**. Target population hardware and required to be connected and waiting for message (Target population alerting software may work, but would need to be installed).
Time-frame	Seconds to hours
Heads-up and Instruction	Primarily Instruction, Heads-up technically possible
Effectiveness residents	Yes if logged on
Effectiveness transients	Only if aware of website and logged on (education campaign required)
Effectiveness institutions	Yes – especially those with 24/7 staff monitoring other live data
Vulnerable & immobile	Only if logged on
Robustness/resilience	Websites can become overloaded, reliant on server resilience, website robustness (no bugs) and home hardware resilience
Ongoing effectiveness	Can be updated but requires viewers to keep checking webpage
Terrain suitability	All
Population density	All
Cost basis	Existing hardware, some programming
Cost (all areas)	Start-up: $5k minimum. Ongoing: $0.10 per person awareness, traffic and maintenance
Areas suitable	All with connection to internet
Not suitable	Any with no connection to internet
Hazards	All hazards
Target population(s)	All connected to internet, with some alerting software installed

A1.3.20 Website banners

Internet Service providers have the capability to push banners across web browsers connected to the internet via their service. This is currently used for ISP-related communications. It has not been explored for warnings but is theoretically feasible.

Limitations	**Will never reach 70% of the population as the primary warning**. Target population hardware and required to be connected and waiting for message (Target population alerting software may work, but would need to be installed).
Time-frame	Seconds to hours
Heads-up and Instruction	Primarily Instruction, Heads-up technically possible
Effectiveness residents	Yes if logged on
Effectiveness transients	Only if aware of website and logged on (education campaign required)
Effectiveness institutions	Yes – especially those with 24/7 staff monitoring other live data
Vulnerable & immobile	Only if logged on
Robustness/resilience	Websites can become overloaded, reliant on server resilience, website robustness (no bugs) and home hardware resilience
Ongoing effectiveness	Increases with time
Terrain suitability	All
Population density	All
Cost basis	Existing hardware, some programming
Cost (all areas)	Start up: <$10k, awareness, ongoing: $
Areas suitable	All with connection to internet
Not suitable	Any with no connection to internet
Hazards	All hazards
Target population(s)	All connected to internet, with some alerting software installed

A1.4 Mechanisms that require dedicated hardware (but controlled by the warning agency)

A1.4.1 Fixed PA loudspeakers

Fixed PA loudspeakers are installed in target areas to communicate voice messages directly from the warning agency to the public. They are normally installed in high traffic public areas and in high density residential areas.

Limitations	Cost, coverage, complex system, resource consent required.
Time-frame	Seconds
Heads-up and Instruction	Yes – provides both
Effectiveness residents	Yes but effectiveness reduced for those indoors
Effectiveness transients	Yes but effectiveness reduced for those indoors
Effectiveness institutions	Less suitable; institutional staff and populations are generally indoors
Vulnerable & immobile	Not suitable for the deaf population, less effective for those with English as a second language
Robustness/resilience	Depends on initial spend, location (e.g. subject to sea spray corrosion or snow) and ongoing maintenance
Ongoing effectiveness	Can only target those within range, however message can potentially be changed as necessary
Terrain suitability	Best suited where terrain is flat or amplifies sound. Topographic features may create sound barriers
Population density	More effective in high density areas but can be used in rural population hubs or specific at-risk localities. Not suitable for diffuse populations
Cost basis	Whakapapa village systems ($6k, limited range), and larger USA-supplied systems (US$45k, larger range) Urban: Start-up: $100k-1M+, ongoing: $, maintenance and planning, exercises. Rural communities: Start-up: $500k-5M+, ongoing: $, maintenance and planning, exercises
Hazards	All hazards
Target population(s)	All within audible range (not the deaf)

Further Comments

Loud-speaker announcements are probably the most effective form of warning message transmission to groups. They do, however, have a substantial cost and ongoing testing and exercising cost and work-load associated. They are not likely to be feasible for rural diffuse-population areas. Examples of use: Whakapapa ski area and village, New Zealand (lahar). Coastal Pacific northwest, USA (tsunami).

A1.4.2 Mobile PA loud-speakers

Limitations	Vehicles and people available to transport, cost, complex system reliance. Exposure only to those that can be reached during lead time.
Time-frame	Minutes to hours
Heads-up and Instruction	Yes – provides both
Effectiveness residents	Yes, but less effective for those indoors
Effectiveness transients	Yes, but less effective for those indoors
Effectiveness institutions	Not as suitable (most in institutional care will be indoors)
Vulnerable & immobile	Yes – but less effective for those indoors
Robustness/resilience	Resilient with regular maintenance
Ongoing effectiveness	Effective throughout event as message can be updated, would need to re-visit areas if message changes
Terrain suitability	All terrain as long as vehicle suitable
Population density	More effective in high density areas but also effective for isolated population centres if located nearby
Cost basis	Aerial units (helicopter-mounted PA $23,000 each), vehicle mounted: Wellington City has designed and built own system of 12 units to be mounted on vehicles for $50,000 total; ongoing maintenance and exercises
Hazards	All hazards for areas that can be reached
Target population(s)	All within audible range (not the deaf)

A1.4.3 Flares, explosives

Limitations	Safety and potential to cause panic, public understanding of meaning, coverage - **will never reach 70% of the population as the primary warning**.
Time-frame	Seconds to hours
Heads-up and Instruction	Heads-up only
Effectiveness residents	Yes but less effective for those indoors
Effectiveness transients	Yes but less effective for those indoors
Effectiveness institutions	Not suitable
Vulnerable & immobile	Not suitable: could be misconstrued
Robustness/resilience	Resilient and robust
Ongoing effectiveness	Effectiveness likely to decrease if used over a period of time with no other information provided
Terrain suitability	Hilly terrain could impede visual or audible impact of flares and explosives
Population density	Better suited for high density areas
Cost basis	Consumables alone; would take unknown hardware to remotely trigger within seconds.
Cost urban	Start-up: $270 for a complete set of flares (expiry date 3 yrs), ongoing purchase costs, exercises, testing, awareness
Hazards	All hazards
Target population(s)	All within audible/visible range depending on type (not the deaf for explosives). Not visitors/tourists.

A1.4.4 Radio Data Systems (not currently available in New Zealand)

Limitations	Agreements, hardware for transmission, exposure to only those with compatible receiving radios, potentially cost
Time-frame	Seconds to hours (untested technology for this purpose in New Zealand)
Heads-up and Instruction	Instruction only
Effectiveness residents	Yes
Effectiveness transients	Not suitable
Effectiveness institutions	Yes
Vulnerable & immobile	Yes
Robustness/resilience	Untested in New Zealand
Ongoing effectiveness	Theoretically remains highly effective as has capacity to transmit updated messages as event progresses
Terrain suitability	All
Population density	All
Cost basis	Further research would be needed to look at the feasibility and cost structure for New Zealand
Cost (all areas)	Se HF Radio
Hazards	All hazards
Target population(s)	All near receiver who can hear/view it

Radio Data Systems are one part of an internationally used tone alert radio system, see section A1.4.5 for more detail.

A1.4.5 Radio (UHF, VHF and HF)

Radio communications forms part of the communications arrangements of all local emergency management offices or Emergency Operations Centres (EOCs). Warnings via these mechanisms are based on radio-to-radio communication and they are therefore not commonly used as public alerting mechanisms.

Limitations	Exposure only to amateur radio users, radio licences required from Ministry of Economic Development, training and equipment required for operation.
Time-frame	Seconds to minutes
Heads-up and Instruction	Instruction only
Effectiveness residents	Yes – but very limited numbers (only those with licences, equipment and interest in ham radio)
Effectiveness transients	Not suitable
Effectiveness institutions	Yes – but must have equipment and licensed operator on site
Vulnerable & immobile	Yes – could connect person to person with support
Robustness/resilience	HF very robust technology, broadcasting equipment may be affected by some hazards, VHF often reliant on internet and power supply
Ongoing effectiveness	Able to update message continuously - highly effective
Terrain suitability	All
Population density	All (especially remote, diffuse populations)
Cost	Start-up: equipment ~$5k, licence from ~$100 yr HF to ~$16,000 UHF, planning, ongoing: Target population-development exercises
Dense/Diffuse	One unit reaches 200 people, 0.5 FTE to maintain arrangement with 100,000 people. $100 per year to maintain with 1,000 people.
Hazards	All hazards
Target population(s)	All within audible range and receiving radio (not the deaf)

Further comments

In 1932 AREC (Amateur Radio Emergency Communications) was established as part of NZART (New Zealand Amateur Radio Technicians) [25]. AREC members use VHF primarily with handheld HF units supplementing the system where required. Their role is to provide amateur radio communications during emergencies and assist authorities (e.g. police, search and rescue, emergency managers etc as required). Although this is a voluntary duty, there are standards of professionalism expected from AREC members and they work closely to align their activities with those with statutory duties. There is an expectation within AREC that they will provide a service if called upon by authorities. While there is no direct contact with the general public among amateur radio networks, some emergency management offices use VHF as a direct link to schools etc.

A1.4.6 Sirens (tone, no voice capability)

Sirens are used for tone alert only. Upon hearing the tone alert, the public is expected to take some form of pre-determined action e.g. listening to the radio or evacuating.

Limitations	Cost, coverage, complexity and maintenance/testing, understanding meaning, differentiating hazards, need for resource consent
Time-frame	Realistically minutes, theoretically a few seconds (but significantly longer for appropriate response in reality, as extra information is sought)
Heads-up and Instruction	Heads-up only
Effectiveness residents	Yes but less effective for those indoors
Effectiveness transients	No – lack of understanding will render broadcast meaningless
Effectiveness institutions	Less suitable (most in institutional care will be indoors)
Vulnerable & immobile	Not suitable where vulnerability is linked to learning difficulties (comprehension) or for the deaf
Robustness/resilience	Have been used by rural fire for many years, could be less resilient in exposed coastal locations (sea spray)
Ongoing effectiveness	Continued broadcast by this means could reduce effectiveness due to normalisation and lack of information on threat
Terrain suitability	Most; except where topography creates sound barriers (need to be positioned for maximum range)
Population density	All, but more cost-effective with increasing density
Cost basis	Recent siren development in Waitakere start-up: $475,000 for 30 sirens including installation and project management, ongoing maintenance = battery replacement every 5 years (~$400 per replacement), cost of public education and exercising
Hazards	Possible for all hazards, but very difficult to make effective
Target population(s)	Residents and organisations (NOT visitors/tourists)

Further comments

Sirens are commonly the first suggestion when new hardware is considered in New Zealand, however there are substantial limitations to their effectiveness[2]. These are cheaper than voice PA loud-hailers (except self-designed and built as at Wellington City), and technically a little less complex, but understanding the meaning of the siren relies entirely on public awareness; this is a major problem. One could assume that a community would eventually seek the meaning of a siren if it continued indefinitely, but the timeframe is uncertain – maybe at least 30 minutes? Therefore, this should not be considered for short time-frame hazards with minutes of warning time. It is difficult to differentiate warning message codes with a siren, especially with the slow tone-variable ‘air-raid’-style siren most commonly used in New Zealand. Sirens are likely to be affordable and feasible in urban and rural communities, but most likely not in rural areas with diffuse populations. This means that they are inappropriate as the primary source of warning for rural hazards such as bushfire or biological disease outbreak.

Sirens can enhance a warning message, or act as backup, but may not be worth the cost and effort if no system already exists. Expectation that sirens will give a warning may reduce response if the sirens fail.

Hutt City council have sirens that will sound indefinitely which are supposed to trigger the public to seek information from the radio. Waitakere City Council has installed tone-only Meerkat sirens in coastal locations throughout their district. The system relies on the public understanding three different signals (different combinations of dot or dash tones) which convey either a heads-up (dash – dash - dot – dot sounded for 15 minutes) an evacuation signal (dot – dot – dot sounded in bursts for 15 minutes) or an all clear signal (continuous tone for five minutes). Major public awareness and exercising are required for such a complex set of messages. The system is dependent on receivers of heads-up messages understanding the three different tones and knowing the appropriate action to take (turn on radio, evacuate or return home). Sirens will be ineffective at warning the deaf, holiday makers and other transient populations and will be less effective for new residents.

A1.4.7 Tone-activated alert radio (not currently available in New Zealand)

Two systems are considered:

1. Tone alert radio is used widely throughout the USA for weather information and warnings. It is based on the broadcast of weather information by the US National Oceanic and Atmospheric Administration (NOAA) to dedicated receivers ('weather radios') in homes, workplaces etc. For warnings the system "wakes up" receivers that are not switched on and sends a distinctive alarm tone to all receivers followed by information about the warning. This means all receivers whether switched on at the time of the warning or not will receive the alert tone and warning information.

2. FM RDS is a commercial warning system that relies on agreements with national broadcasters on FM frequencies to 'piggy back' on their transmission capacity. In case of an emergency situation a warning signal is transmitted by the agency responsible for warnings via RDS over an Early Warning (EW) FM Transmitter. An EW FM Receiver in the radio station switches over to the EW-FM frequency automatically and the normal programme is interrupted by alert tones. A running text with warning information is displayed on the LCD display of the EW Receiver in the radio station enabling them to broadcast the warning to the public via their normal audio channel. This system is in use in several countries including Germany, Switzerland, Sri Lanka, Singapore and Indonesia.

Limitations	Cost, exposure to only people with receivers or near PA receivers who can hear it, complex system, testing requirements
Time-frame	Seconds
Heads-up and Instruction	Yes - provides both
Effectiveness residents	Yes if indoors
Effectiveness transients	No unless accommodation has receiver unit
Effectiveness institutions	Yes
Vulnerable & immobile	Yes
Robustness/resilience	Yes
Ongoing effectiveness	Yes – broadcast message can be updated live
Terrain suitability	All
Population density	All
Cost	Start up: $ broadcasting equipment and frequencies (National Oceanic and Atmospheric Administration Weather Radio type system); or encoder/decoder equipment and software (FM RDS "piggy back" break-in system ongoing: exercises, awareness, planning. Plus approx US$20-$100 for a range of radios that receive service (subsidised for target population?)
Areas suitable	All areas with reception

Not suitable	Areas out of reception
Hazards	All hazards
Target population(s)	All within audible range (usually have flashing lights and can have text displays for hearing impaired e.g. FM RDS system

Tone alert radio is used widely throughout the USA for weather information and warnings. The US NOAA system broadcasts weather information 24/7 to those tuned in. For warnings the system “wakes up” receivers in homes/offices etc that are not switched on, and sends a distinctive alarm tone to all units followed by information about the warning. This means all receivers whether switched on at the time of warning or not will broadcast the alert tone and warning instruction. FM RDS is a warning system commercially available from the German company ‘2wcom’ in use in: Sweden (for residents near power plants); Indonesia (tsunami); Singapore (all hazards); Germany (all hazards); Switzerland (all hazards); Sri Lanka (all hazards) ; USA (institutions such as universities); and Montserrat (volcanoes). The system relies on agreements with national broadcasters on FM frequencies to piggy back on their transmission technology. The 2wcom Multi-Hazard Public Early Warning System [28] sends its information "piggy-back" via a normal FM radio audio channel. RDS will be transmitted on 57 kHz in parallel to the normal audio information on an FM channel. RDS is sending data only and does not disturb the normal audio FM transmission channel of a radio station - RDS is inaudible. In case of an emergency, the warning signal will be transmitted via RDS over the Early Warning (EW) FM transmitter. The EW receiver switches over to the EW alert FM frequency automatically, the normal programme will be interrupted by alert tones, a running text with information about the situation will be received on the LCD display of the EW receiver. Now the FM station is able to transmit special instructions to the public "what to do, how to behave etc." via their normal audio channel. The 2wcom system is in widespread use internationally for a variety of hazards and should be seriously considered for a pilot study to determine suitability for New Zealand.

APPENDIX 2 SENSITIVITY OF SCORES TO MULTIPLIERS

In most cases the adjustment of a single multiplier to '3' will not change the ranking of a warning system by more than one or two places, if any (Figure 3). However, the cumulative effect of changing more than one multiplier may be more significant.

Example:

If the multipliers are set to '3' for (a) effectiveness for transients (visitors and tourists), (b) fast onset localised hazards and (c) fast onset widespread hazards, the result for SMS text messaging vs. fixed PA loudspeakers is:

- 'SMS text messaging' moves from 14th place to 16th place, with a score or 63% dropping to 56 %
- compared to fixed PA loudspeakers moving from 7th to 5th place, with a score of 67% increasing to 70%.

This is primarily because SMS text messages require a list of telephone numbers to be derived and kept up to date – more difficult for transients; and there are a maximum number of SMS messages that can be sent in a given time period.

In contrast fixed PA loudspeakers are fast and will reach all people within earshot who speak the broadcast language, including transients. However, note that fixed PA loudspeakers may be found to be prohibitively expensive for diffuse-population areas (see the cost-benefit charts).

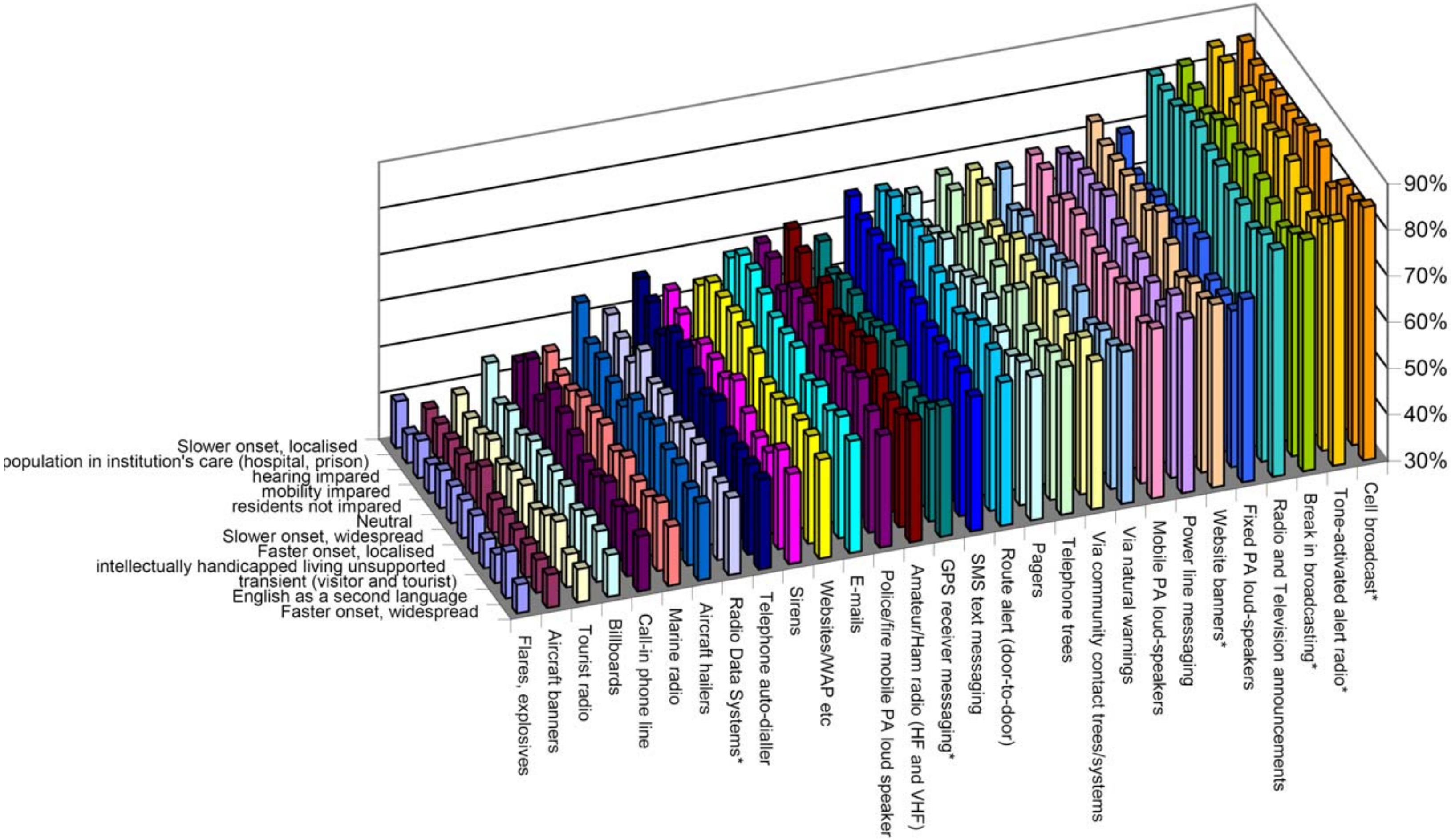

Figure 3 The variability in score for each warning system when multipliers are adjusted. The score (bar height) for a given system/multiplier combination is a result of that multiplier being set to ‘3’ while all of the other multipliers were left at ‘1’.

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