BRENDAN MORRIS CONSULTING LIMITED

Leadership in hazards and emergency management

The use of sirens for tsunami warning in New Zealand

Supporting information for the *"Standard for the use of sirens in tsunami warnings"*

Prepared for:

Ministry of Civil Defence & Emergency Management
Te Rākau Whakamarumaru

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Brendan Morris Consulting Limited is a hazards and emergency management consultancy. Based in Hamilton, the company offers services throughout New Zealand.

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1 Introduction

1.1 Purpose and scope

The purpose of this report is to provide the evidence base for the Ministry of Civil Defence & Emergency Management (MCDEM) "*Standard for the use of sirens in tsunami warnings*" ("the standard").

This report sits alongside the University of Canterbury Acoustics Research Group report "*An evaluation of the Signals used for Tsunami Warnings in New Zealand*" as one of the two primary documents underpinning the standard.

The scope of this report does not include topics that are specifically addressed by the University of Canterbury Acoustics Research Group report including:

- Danger signal requirements
- Danger signal design
- Unambiguity of danger signals
- Evaluation of the existing tsunami danger signals
- Verbal warning requirements
- Detail on installation requirements
- Review of waning systems.

A summary of the University of Canterbury Acoustics Research Group report is provided within Appendix 1.

1.2 About this report

The target audience for this report is CDEM sector professionals in New Zealand. This report may also be of some benefit to emergency services professionals, siren systems providers/technicians, researchers and others involved in the management of siren systems.

The following sections are included within this report:

- **Section 2 - Background:** provides a brief history of the use of sirens for tsunami warnings, why the standard was developed and how the CDEM sector and stakeholders were engaged during development of the standard.

- **Section 3 - Public alerting and emergency warning systems in New Zealand:** a brief overview of public alerting in New Zealand. The overview is based on the MCDEM Public Alerting Options guideline, updated for technology changes since 2008.

- **Section 4 - Use of sirens for tsunami warning in New Zealand:** an overview of siren locations, numbers, types, signals used and meanings. This section is supported by three appendices that provide maps (Appendix 3), summary details of use of sirens per CDEM group/Territorial Authority (TA) (Appendix 4), and a summary of the types of sirens used (Appendix 5).

- **Section 5 - CDEM sector feedback on the use of sirens for tsunami warnings:** a summary of collective feedback from the CDEM sector on what the standard should address, the implications of a change in signal on TAs and communities, meaning of sirens and community familiarity with this, the role and future of sirens, and current management arrangements.

- **Section 6 - New Zealand Fire Service position on the use of sirens for tsunami warning.**

- **Section 7 - International use of sirens and guidance for the use of sirens in tsunami warnings:** a summary of international use of sirens for tsunami warnings, and an overview and evaluation of international standards and best practice guidance for sirens use.

- **Section 8 - Research findings on the use of sirens:** a summary of national and international research and experience on the advantages and disadvantages of the use of sirens for tsunami warning.

2 Background

2.1 A brief history of the use of sirens for tsunami warning

The use of sirens for emergency management purposes is a long-established practice in New Zealand. For many decades, mechanical sirens have been used for alerting fire parties to emergencies using the rise and fall signal. Although the use of paging was established as the primary means of alerting responders around 2000, the use of sirens remains important. In most areas around New Zealand sirens are used as a back-up to paging, but in some remote areas that have poor communications coverage, they are still used as the primary means of alerting.

The use of mechanical sirens for CDEM purposes has evolved over many decades in some coastal areas, such as Timaru District, Waitaki District and Napier City. The signal most often used in these mechanical sirens is the rise and fall signal, but the 'rise to continuous' signal is used in some areas.

In the early 1980s, electronic siren systems were installed in Whanganui District and Invercargill City as the result of a swarm of offshore earthquakes and a major flood event respectively. Upgrades to existing mechanical systems around New Zealand took place throughout the 1980s and 1990s.

Since the South-east Asian tsunami event of 2004, the use of siren systems for the purpose of issuing tsunami warnings has grown significantly in New Zealand - often at the request of local communities. The use of sirens for tsunami warnings is now widespread across New Zealand. The most commonly used sirens are fixed, signal-only systems.

Some TAs such as Thames Coromandel District, Western Bay of Plenty and Whakatane/Opotiki Districts have modified existing fixed signal-only NZFS sirens to enable them to be used for tsunami warnings, while many other TAs have opted for stand-alone systems.

The majority of new fixed signal-only electronic siren installations have been in Auckland (2007 onwards), Northland (from 2009 onwards) and Christchurch City (2010 onwards). A number of TAs have expanded their use of mechanical siren systems for tsunami warning since 2004, including Thames Coromandel District, Western Bay of Plenty District, Whakatane/Opotiki Districts, Napier City, Hutt City and Timaru District. A number of other smaller TAs have also brought fixed signal-only sirens into use for tsunami warnings since 2004, including Hurunui and Waitaki Districts.

The use of vehicle and helicopter-mounted Public Address (PA) capable systems has grown since 2000, and these systems are primary used along the south and east coasts of the North Island – from Wellington City to the Bay of Plenty.

The use of sirens depends upon a number of factors such as the nature of the tsunami risk, the population at risk, the physical landscape and the philosophy of the CDEM group/Territorial Authority (TA).

2.2 Why the standard was developed

In May 2012, the Director of MCDEM wrote to CDEM groups outlining MCDEM's position on the use of fixed sirens for tsunami warning[1]. The position was outlined in response to requests from local authorities for MCDEM to develop a standard for the use of sirens in tsunami warnings. At this time, the Director of MCDEM informed CDEM groups that on the basis of advice from the Tsunami Warning Group, further guidance related to fixed sirens as a tsunami warning mechanism would not be developed at that time.

The Waikato CDEM group subsequently wrote to the (then Hon Chris Tremain) Minister of Civil Defence in June 2012, acknowledging the above view, but indicated that it is ultimately a community decision as to whether they install sirens or not; that this is in fact happening and where a siren is employed, it should be observant of a national standard. The Waikato CDEM group requested a re-consideration of the Ministry's position for not developing a tsunami standard.

The Minister subsequently requested the Director of MCDEM to investigate the matter further to enable a considered decision on the issue. In late 2012, Tauranga City Council also approached the Director to register a need for national guidelines on tsunami sirens.

As a result MCDEM agreed to take this work on board – however, noting at the time that it had to be prioritised against other more urgent items on its work programme, and therefore it was difficult to attach a definite timeframe to it.

In April 2013 the Waikato CDEM Group again wrote to the (new) Minister of Civil Defence, enquiring about timing for this work, how CDEM groups would be engaged and when a decision could be expected. This resulted in MCDEM re-prioritising its 2013/14 budget to be able to commit to the work.

2.3 How the standard was developed

2.3.1 Overview

The standard was developed between September 2013 and May 2014 by:

- Consultation with TAs and CDEM groups, which sought to understand the use of sirens in detail, and understand the likely implications of the standard for TAs and CDEM groups
- Finding and evaluating overseas standards and guidance in relation to the use of sirens
- Working alongside the New Zealand Fire Service (NZFS) to ensure complementary use of sirens, and clarity on NZFS use of sirens and future direction
- Getting independent advice on the acoustics/audibility aspects of sirens use.

[1] Refer to MCDEM position in previous section.

Development of the standard was overseen by a project team comprising MCDEM, GNS Science, the NZFS, the University of Canterbury Acoustics Research Group and Brendan Morris Consulting Ltd.

2.3.2 Methodology

Information gathering and consultation involved the following:

CDEM sector information gathering and consultation
Semi-structured interviews were held with 60 CDEM staff from all CDEM groups and all TAs within the 12 regions where sirens are used (refer to section 4.2). The interviews were structured around a series of questions designed to understand the current and future use of sirens, and the implications of standard signal different to the signal currently in use in that area. Most interviews involved a phone conversation with a single staff member, but staff interviews in two CDEM groups were conducted face-to-face with staff representatives. The interviews provided an opportunity to update and verify the fundamental information on siren use throughout the country, and expand existing knowledge on the issues faced with the use of sirens.

A summary of key points from each interview was developed following each interview, and returned to each interviewee for comment and correction. Once comments and corrections were received back, these were accepted with no further change. Out of the total of 60 CDEM staff, comments and corrections were received from 56, leaving four interview notes unverified. During the interviews, it was confirmed to participants that the nature of any written material (interview notes) arising from the interview was to be kept confidential to the project team only.

Upon completion of the interviews, the interview notes were compiled by question, and key themes were drawn from the collective feedback. The key themes from the feedback (by question) are provided in section 5.2. The collective feedback provided the fundamental evidence base for development of the standard.

From late October to early December, a series of eight tsunami workshops were held throughout the country, which provided an opportunity for regional CDEM staff and stakeholders to discuss aspects of sirens use and provide feedback to project team members.

Siren providers and technicians
Information from siren providers and service technicians was also sought on the maintenance and operational aspects of sirens. A representative sample of large and small providers and technicians provided technical and operational information to the project team.

NZFS input
The NZFS National Operations Manager was a member of the project team throughout the development of the standard, and provided input on the NZFS view on the use of sirens (refer to section 6). Feedback was also sought from the five region managers on current use and issues related to the use of sirens.

International guidance on the use of sirens in tsunami warnings
Personal contacts (including key national research experts in the USA), the International Tsunami Information Centre email listserver, and LinkedIn and Facebook emergency management discussion groups were utilised, as well as direct internet searching.

Thirty international documents were supplied and considered, from several countries. The majority of forwarded documents are not specifically standards, but rather policies, plans and

other wider documentation, with variable content regarding standardisation, or pointing to standards for specific aspects of the wider consideration and implementation of sirens.

The content and guidance from the thirty documents was then summarised, and a table of key topics developed. The purpose of each document was summarised, and then categorised by the level of usefulness to informing the standard (refer to section 7.2).

Research

The summary of research evidence on the advantages and disadvantages of sirens from the draft Thames Coromandel District sirens policy was updated and expanded (refer to section 8).

Development of the standard is based upon the above information/consultation, and the findings of the University of Canterbury Acoustics Research Group report.

3 Public alerting and emergency warning systems in New Zealand

The introduction to the MCDEM Public Alerting Options guideline provides a useful overview of public alerting and emergency warning systems in New Zealand[2]:

> *"New Zealand is exposed to a wide range of hazards. Since we are able to monitor, analyse, and anticipate many types of hazard events, the Civil Defence Emergency Management (CDEM) and science communities carry a joint responsibility for providing effective public warnings and alerts as part of a comprehensive approach to managing our risks.*
>
> *Warning systems must be capable of delivering timely and relevant messages or alerts to the at-risk public, for all New Zealand hazards for which warnings are possible. For example with flooding, even though there is usually low risk of loss of life, timely warnings can serve to reduce economic damage from stock losses and damage to re-locatable assets. For high consequence, low-frequency events where there is little lead in time, warnings are primarily issued to enable people to move out of harms way or protect themselves. Development of effective warning systems that reduce harm and losses are an integral part of CDEM planning in New Zealand."*

Emergency alerting systems are used for a wide range of hazards, and must take into account the nature of the hazards in order to be effective. The discussion in this section is excerpted and updated from Leonard et al (2008). Different types of hazards operate on different timeframes:

- No lead-in time - such as earthquakes;
- A period of minutes to hours – such as volcanic eruptions or tsunami
- A period of days - such as ex-tropical cyclones
- Possibly weeks – such as drought.

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. Tsunami hazards have the following lead-in times:

- Distant source have a lead-in time of hours, and the duration may last for days; and
- Local source have a lead-in time of minutes, and the duration may last for hours or days.

CDEM groups and CDEM group members around the country use a variety of methods for distributing warnings to the public, and that it is recognised that no single alerting system can reach all at-risk people.

In terms of systems currently in use, clear preferences exist for several methods of alerting the public of an actual or impending emergency. All but two responding agencies in Leonard et al. (2008) 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 also had arrangements in place with local radio stations. Other alerting systems which are widely adopted include the use of Police or Fire Service mobile PA units, Route Alert (door-to-door

[2] Refer to p. 6 of the Guideline.

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

A list of the public alerting options available in New Zealand and overseas are included within Leonard et al. (2008)[3], and are updated as Appendix 2 of this report.

It should be noted that since 2008:

(a) Mobile device / cell broadcasting, and tone alert radio, both of which scored highly, continue to be explored within New Zealand, but are not currently operational.

(b) Mobile devices (now including smartphones), social media, and geotargeting of alerts to the public are areas of active rapidly evolving research (see NRC 2011, 2013a, 2013b).

(c) Smartphone applications (apps) have been developed for public notification both in New Zealand and internationally. There is a gap in the published literature around the reliability, speed and effectiveness of such apps at present, but anecdotally these criteria appear (for the population with smartphones) to all to score quite highly compared to other options reviewed by Leonard et al. (2008).

All warning systems should make provision for giving 'all-clear' messages. The Partnership for Public Warning in the USA (2003)[4] concludes that an effective warning system should:

- Be focused on people at risk
- Be able to be understood by all in the same way
- Be capable of reaching people irrespective of what they are doing
- Be easy to access and use
- Not create added risk
- Be reliable
- Provide appropriate lead time so people can have a chance to protect themselves
- Generate authenticated messages.

[3] In Appendix 2.
[4] Refer to p. 37 PPW Report 2003-01.

4 Use of sirens for tsunami warning in New Zealand

4.1 Locations of sirens used for tsunami warnings

The following table summarises the locations in New Zealand where sirens are used for tsunami warnings. It should be noted that use applies to sirens that are used as a part of the formal CDEM warning arrangements, and does not include private sirens that may be used by individual communities for tsunami warning purposes.

Table 1: Locations of sirens used for tsunami warnings in New Zealand

Region	Council/Area
Northland	Whangarei District, Kaitaia District, Far North District
Auckland	Waitakere City, Rodney District (former Councils)
Waikato	Thames Coromandel District
Bay of Plenty	Western Bay of Plenty District, Whakatane District, Opotiki District
Gisborne	N/A
Hawke's Bay	Napier City, Hastings District, Wairoa District
Manawatu-Wanganui	Whanganui District
Wellington	Wellington City, Hutt City, Masterton District
Chatham Islands	N/A
Canterbury	Hurunui District, Christchurch City, Ashburton District Timaru District
Otago	Waitaki District, Dunedin City
Southland	Invercargill City

There is no known use within the Taranaki, Nelson-Tasman, Marlborough and Westland regions. The locations of all sirens used for tsunami warning is provided in Appendix 3a.

4.2 Overall numbers and distribution of sirens

Appendix 3b shows that there are 376 sirens used currently for tsunami warnings in New Zealand. The high-level breakdown across New Zealand is:

- North-east coast of the North Island: 229 (61%)
- Lower North Island: 68 (18%)
- East and south costs of the South Island: 76 (20%)
- Chatham Islands: 3 (1%).

The distribution of sirens is influenced by tsunami hazards and risks, with most use on the east coast in areas potentially affected by local, regional and distant tsunami. Only around 30 (~8%) of the sirens used in New Zealand are located along the west coast.

4.3 Numbers of sirens by Territorial Authority

A detailed summary of the numbers of sirens by TA is provided in Appendix 3c.

132 sirens (35% of sirens used in New Zealand) are used in Northland. The extensive use in Northland is primarily due to the high risk from regional tsunami events, the presence of numerous small isolated communities, a lack of telecommunications and radio coverage and limited means of alerting communities.

Auckland, Thames Coromandel District, Christchurch City and Timaru District all use more than 20 sirens in their respective areas, while Western Bay of Plenty District, Whakatane/Opotiki Districts, Napier City, Hutt City, Wellington City and Invercargill City use more than 10.

4.4 New sirens confirmed and proposed

Appendix 3d illustrates the known areas where additional siren use is either confirmed or proposed. “Confirmed” sirens are those that have been approved and/or purchased by Councils, and are due for installation in the current financial year. “Proposed” sirens are installations that are either in the early design/proposal phase, or are emerging as a part of thinking on future proposals.

The largest confirmed addition of sirens in the current financial year is 33 in Christchurch City. Other areas where current financial year installations are planned include Thames-Coromandel District, Napier City, Tararua District, and Timaru District.

Areas where additional sirens are proposed include Hauraki District, Wairoa District, Napier City, Masterton District, Waimakariri District and Timaru District.

It should also be noted that a previous proposal to install a siren network in Tauranga City is now on hold, awaiting the development of the standard.

4.5 Types of sirens used

4.5.1 Distribution of fixed signal-only sirens

Appendix 3e shows the distribution of fixed signal-only sirens used for tsunami warnings.

There are two main types of fixed signal-only sirens – electronic and mechanical. The distribution of these two types of sirens across New Zealand is:

- **Electronic:** primarily used in Northland, Auckland, Whanganui District, Hurunui District, Christchurch City and Invercargill City. In addition, there are three electronic sirens in Timaru District, and one in the coastal areas of Waitaki District.
- **Mechanical:** primarily used in Thames Coromandel District, Western Bay of Plenty District, Whakatane and Opotiki Districts, Napier City, Hutt City, Ashburton District. Timaru District, Waitaki District and Dunedin City. In addition, there is one mechanical siren used in Whanganui District, and one used in Invercargill City.

In total, there are 224 electronic fixed signal-only sirens and 115 electronic fixed signal-only sirens.

4.5.2 Distribution of mobile sirens

Appendix 3f shows the distribution of mobile sirens used for tsunami warnings.

There are three main types of mobile sirens – vehicle-mounted, trailer-mounted and helicopter PA. The distribution of these types of sirens across New Zealand is:

- **Vehicle:** primarily used in Wellington City, Hastings District, Whakatane/Opotiki Districts and Gisborne. All vehicle-mounted sirens are PA capable.
- **Trailer:** used in the Chatham Islands, Masterton District, Waitaki District and Dunedin City. The Masterton District unit is electronic (a modified vehicle-mounted siren), while the remainder are mechanical sirens.
- **Helicopter:** used in Wairoa District and Gisborne. In both cases, these units are PA-only systems.

In total, there are 28 vehicle-mounted, seven trailer-mounted and two helicopter mobile sirens used in New Zealand.

4.6 Signals used for tsunami warning

Appendix 3g shows the signals used for tsunami warnings.

The following signals are used:

- **Rise and fall:** this is the most widespread signal used. This signal is used as a primary signal in Napier City, Hutt City, Timaru District, the Chatham Islands, Waitaki District, Dunedin City and Invercargill City. This signal is also used in Whanganui District and Thames Coromandel District as a secondary signal
- **Repeated rapid rise:** used in Northland
- **Alert (dash dash dot dot); Evacuate (dot dot dot dot); All-clear (continuous):** used in Auckland and Hurunui District
- **Rising to continuous:** used in Thames Coromandel District, Western Bay of Plenty, Whakatane/Opotiki District, Ashburton and the Chatham Islands. This signal is also used as a secondary signal in Waitaki District
- **The Sting:** used as the primary signal in Whanganui District
- **The Sting + message:** used in mobile sirens in Wellington City, Masterton District, Hastings District and Whakatane/Opotiki Districts
- **Dot dot dot dot:** used in Christchurch City
- **Public address only:** used in helicopter sirens in Wairoa District and Gisborne.

4.7 Meaning of sirens

Appendix 3h shows the meaning of sirens used for tsunami warnings across New Zealand. The meaning of sirens depends upon whether sirens have PA capability.

The meaning of sirens across New Zealand is as follows:

- **Seek further information:** used by the majority of CDEM groups and TAs including Northland, Western Bay of Plenty District, Whakatane/Opotiki Districts, Napier District, Whanganui District, Hutt City, Ashburton District, Timaru District, Waitaki District, Dunedin City and Invercargill City
- **Seek further information and/or targeted message:** this meaning is associated with PA-capable mobile sirens in Wellington City, Masterton District, Hastings District, Wairoa District, Gisborne, and Whakatane/Opotiki Districts
- **Evacuate:** used in Thames Coromandel District and Christchurch City
- **Multiple meanings:**
    - In Auckland and Hurunui District there are three meanings: Alert, Evacuate and All-clear
    - In the Chatham Islands there are two meanings: Marine threat and Evacuate.

5 CDEM sector feedback on the use of sirens in tsunami warnings

5.1 Overview

During development of the standard, feedback was sought from the CDEM sector on a number of elements of the use of sirens in tsunami warnings (refer to section 2.3.2). In order to guide feedback, a number of questions were asked about the following themes:

- What the CDEM sector thinks the standard should address, and what implications it will have for CDEM groups/TAs and communities
- The meaning of sirens and community familiarity with the current meaning/s
- How the use of sirens relates to thinking about warning systems and public alerting options
- What the role of sirens is in the future
- The reasons why sirens are not used in some CDEM groups and TAs
- The age of siren systems, and opportunities to address some long-term operational issues.

The following collective feedback is summarised from numerous conversations with CDEM sector staff, as outlined within section 2.3.2. The collective feedback is grouped around questions on the themes outlined above. The collective feedback has had a large influence on the content and direction of the standard.

5.2 CDEM sector collective feedback

5.2.1 What should be in the standard?

There was strong, unanimous feedback from all respondents that the use of sirens cannot be effective without public education and awareness. Feedback indicated that the requirements for a well-run programme can be costly and time consuming, and that these factors should not be underestimated when considering the use of sirens for tsunami warnings. There was also strong feedback that public education and awareness must be linked to all other tsunami risk management other activities – especially to community response planning, evacuation planning and testing.

The most important components of public education and awareness with respect to the use of sirens are:

- Pushing the importance of natural warnings as the core message
- Ensuring that education programmes are maintained through time
- Targeting visitors and people who may be unable to hear sirens
- Correcting common misperceptions about sirens
- Pushing individual preparedness and responsibility messages.

There was near unanimous feedback that a consistent signal and meaning is required for the use of sirens in tsunami warnings. In terms of preference for signals (other than those in use within their area), three CDEM groups and three TAs favoured the use of a rise and fall signal, while seven CDEM groups/TAs did not favour this due to a perceived conflict with fire response alerting. Some preference was also expressed for the Sting and for the rise to continuous signals.

More than half of the CDEM groups/TAs viewed setting a minimum frequency for testing as important, and saw benefits in consistency of the timing of testing.

The need for strong linkages to both community response planning and evacuation planning was identified by numerous CDEM groups/TAs, with some CDEM groups such as Northland requiring community response planning to be a pre-cursor to siren installation. In addition, the need to confirm responsibilities and procedures for activating sirens was deemed important – especially with respect to working alongside emergency services during response.

Numerous CDEM groups/TAs recognised the importance of linking the establishment and use of siren systems to tsunami hazards and risks – regardless of whether sirens were used within that CDEM group or not. There was a common perception that at times, siren systems have been installed without recognition of hazards and risks, and that this has led to discrepancies between the risks from tsunami and the type of siren systems installed.

The need to work with existing systems was also seen as important – especially by those TAs that use mechanical sirens. However, it was also recognised that there are significant advantages to be gained by the use of PA-capable sirens.

Other important components mentioned by a number of CDEM groups/TAs included:

- The use of sirens as all hazards alerting mechanisms
- The need for regular, budgeted maintenance programmes
- Recognition of the vulnerabilities of sirens, and a need to manage these
- The duration of sirens – longer is better
- Consideration of environmental factors on the audibility of sirens
- Consideration of emerging technology alongside the use of sirens
- Not to allow the standard to be perceived as promoting the use of sirens
- The standard must be adaptable to fit all communities
- The approach to the standard should consider the investment in sirens to date and the most likely impacts to CDEM groups.

5.2.2 What would a standard that had a signal that was different to your existing signal mean for your CDEM group/TA?

The most significant implications reported are the costs associated with modification of existing sirens, and in particular, the capital costs of purchasing new sirens if the current units are unable to produce the required signal.

The CDEM group that would be most impacted by a change to the signal that would not require complete replacement of sirens is Northland. This is due in part to the number of siren units involved (132), the fact that each siren unit would need to be physically modified, and to the fact that the units cover a large geographical area, which increases travel costs to physically service and modify each unit.

Unsurprisingly, the concerns over capital cost and who pays are expressed primarily by the larger users of mechanical sirens, if the required signal cannot be produced by the current sirens. This is particularly the case for Thames Coromandel District, Napier City, Hutt City and Timaru District, who collectively manage 78 of the 115 mechanical sirens in use. Some concern over the limited ability to change signals was also expressed by Bay of Plenty and Chatham Islands staff.

There was little reported impact of a change for some smaller sirens users, and not surprisingly, from those CDEM groups that do not use sirens.

The need to change public education and awareness programmes was also identified, however most CDEM groups and TAs saw this as a minor implication, with small changes being required to public information messaging and printed material. The potential

implications for TAs such as Napier City and Timaru District were reported as potentially higher, due to the existing emphasis and effort on public education and awareness.

Other implications mentioned included the need to re-train community responders, modification of response plans and the impacts of further public education and awareness on already over-allocated CDEM staff. Several TAs commented that the standard may be an opportunity to engage with communities and increase public awareness of tsunami risks and sirens use, and that the public may perceive this as positive. One TA stated that this may be an opportunity to refresh their public education and awareness programme.

Several TAs stated that it was important that consideration be given to a transition (or grace) period within the standard, and that this should take into account the long-term planning processes of TAs.

5.2.3 What would a standard that had a signal that was different to your existing signal mean for your communities?

Northland CDEM group reported that there would be significant annoyance among communities, and flak directed towards CDEM as the result of a change. This is because there has been a lot of emphasis on public education and community engagement efforts – especially over the past five years. There are 52 community response planning groups, and the level of community familiarity with sirens and the current signal is high.

Several CDEM groups/TAs including Christchurch City, Hurunui District, Chatham Islands and Invercargill City reported that there would be minimal impact to communities, and provided that a reasonable transition period was provided, communities would readily adapt to the changes.

Some TAs indicated that the speed of community transition and level of adaptability was dependent upon the current effort applied to public education and awareness – the more effort, the bigger the potential difficulties in transition. Napier City in particular reported that there would be significant difficulties in working with local communities during the transition to a new signal.

5.2.4 What is the meaning of sirens in your area, and what should the meaning be?

The meaning of fixed signal-only sirens in the large majority of CDEM groups and TAs is “seek further information”. Feedback indicates that the meaning of fixed signal-only sirens cannot be “evacuate”, as this precludes the use of sirens for any hazards other than tsunami.

Feedback from Thames Coromandel District and Christchurch City indicates that the origin of the “evacuate” meaning is pressure from a few vocal individuals within local communities, rather than a thorough assessment of what meaning is most practicable from a management perspective.

Feedback from Auckland, Hurunui District and other TAs indicates that having three signals with different meanings is difficult for communities to understand, and difficult for CDEM staff to manage.

One TA about to install sirens indicated that the meaning would be “evacuate”, while another indicated that a decision was yet to be made on the meaning.

The majority of CDEM groups and TAs recognised the benefits of PA-capability in clarifying the meaning of sirens.

5.2.5 What is the level of community familiarity with the current signals and their meaning/s?

A high level of community familiarity was reported by TAs that place a high emphasis on public education and awareness programmes, including Napier City, Hutt City and Timaru District. A high level of community familiarity was also reported by some TAs that have small coastal communities, such as Ashburton District, Chatham Islands and Hurunui District.

Some TAs are unaware of the level of community familiarity, but usually this is accompanied by a "gut-feeling" that the level of awareness is low. Unsurprisingly, a low level of community awareness is typically associated with a low level of effort in public education and awareness.

5.2.6 Do you have a warning systems strategy?

The majority of CDEM groups and TAs reported that they did not have a formal warning systems strategy. Some exceptions to this include Waitaki District, Thames Coromandel District and Southland CDEM group, where there is either formal or informal policy on the use of sirens, and the use of sirens is considered alongside other alerting mechanisms. The Waikato CDEM group is currently drafting a warning systems strategy. A devolved approach to warning systems – TAs making their own decisions about which public alerting options to use locally as a part of the warning system - was mentioned by Hawke's Bay, Canterbury and Otago CDEM groups.

All CDEM groups and TAs reported having either general or specific response procedures/plans for tsunami events. The need to improve consistency in tsunami response procedures and co-ordination was noted by Bay of Plenty, Wellington and Canterbury CDEM groups.

A number of CDEM groups and TAs such as Gisborne, Nelson-Tasman, Hastings District and Northland linked the use of sirens to a previous formal or informal public alerting options assessment. Feedback indicated that these assessments were helpful in driving CDEM group thinking on the issues, and that links to tsunami threat and consequence assessments were important.

5.2.7 What is the role of sirens in the CDEM group/TA warning system - including tsunami warnings?

All CDEM groups and TAs view the use of sirens for tsunami alerting/warning as "one option among many". The most commonly reported means of alerting alongside the use of sirens were social media, radio, web sites, text alerting, use of telephone trees and door-to-door alerting. Many respondents stated that there was a need to use multiple methods for alerting.

Around half of CDEM groups/TAs viewed the use of sirens as a secondary or supporting alerting option, while a small number viewed them as last a resort option for use.

Feedback indicates that the role of sirens is dependent upon a number of factors. In Northland, the existence of numerous small communities, a lack of other alerting options and a high risk of regional tsunami events make the use of sirens viable, while in most west coast areas, the risk is not viewed as sufficiently high to warrant their use. Feedback indicates that other factors such as population density and access to coastal areas has a large influence on their role.

While there is a general acceptance that sirens should be used as all hazards alerting mechanisms, their use in some areas such as Northland, Whanganui and Christchurch is primarily about tsunami hazards.

When discussing the role of sirens, the most commonly mentioned supporting requirement was public education and awareness. Other important linkages identified were links to tsunami hazards and risks, the type of tsunami event and the alignment with and contribution to community resilience building.

Whanganui District, Hutt City and Invercargill City all noted that the original intent/usage of the siren network was for flood hazards, but that the intent of the sirens has changed towards tsunami hazards over recent years.

5.2.8 What is the future role of sirens within your warning systems?

There is wide variability on the future role of sirens for tsunami warning. A number of CDEM groups and TAs are either continuing to expand their siren networks or are planning to install sirens in the near future, including:

- Thames Coromandel District
- Wairoa District
- Napier City
- Tararua District
- Masterton District
- Waimakariri District
- Christchurch City
- Timaru District
- Hauraki District (possibly)
- Tauranga City (possibly).[5]

Some CDEM groups/TAs such as Northland, Auckland, Whakatane/Opotiki and Hutt City may expand their siren networks in the future depending upon funding availability, but have no immediate plans to do so. The Chatham Islands may look to use fixed sirens in the future, but this is dependent upon funding availability.

Other areas that use sirens but have no plans to expand their networks include Hurunui District, Wairoa District (no fixed sirens) and Gisborne (no fixed sirens). The future in some areas such as Dunedin City and Invercargill City is viewed as limited or unlikely.

There is no intention to start using sirens for tsunami warning in many TAs, including the Selwyn, Waimate and Kaikoura Districts, and also no intention in the Taranaki, Nelson-Tasman, Marlborough and Westland CDEM groups.

5.2.9 Have you done a public alerting options assessment? If so, how did sirens fare?

The following CDEM groups/TAs reported that they had completed an assessment – Northland, Bay of Plenty, Gisborne, and Southland CDEM groups, and Hastings and Kaikoura Districts. Feedback from these CDEM groups/TAs indicated that the exercise was useful for informing both the public alerting options available, and the use of sirens as a part of alerting.

A number of other CDEM groups/TAs reported completing an informal options assessment, including Nelson-Tasman, Hurunui District, Dunedin City, Chatham Islands and Whanganui

[5] Refer to Appendix 3d.

District. The Waikato CDEM group is intending to complete an assessment once the MCDEM guidelines have been updated.

In TAs where long standing siren systems are used, the need to complete an assessment to guide their use is often seen as unnecessary – often due to on-going public expectations and political pressure around continued use. There is also a view in some TAs that if there were a "blank canvas" for warning systems, it would be unlikely that sirens would be viewed as a viable option. There is also a view among some TAs that the assessment tool is stacked heavily against the use of sirens.

5.2.10 Reasons why sirens are not used for tsunami warnings in some CDEM groups

The most common reasons cited for not using sirens are:

- A low level of tsunami hazard threat
- Low risks relative to other regions – normally associated with relatively low, scattered coastal populations
- Sirens are not that effective compared to other mechanisms and have significant limitations – such as power failure, damage sustained in earthquakes and a lack of audibility due to environmental conditions
- The cost of installation and maintenance
- Perceived risks of starting a "domino effect" of demand within local communities.

Feedback indicated that the most important element for TAs in sustaining a position of non-use of sirens was to gain and sustain political support, based on sound reasoning.

5.2.11 Ownership and responsibility for maintenance, funding and operation

The large majority of sirens are owned, maintained, funded and operated by CDEM groups and TAs. Examples of this include Northland, Auckland, Hastings District, Whanganui District, Wellington City, Christchurch City, Timaru District and Invercargill City.

In some TAs such as Thames Coromandel District, Whakatane/Opotiki Districts, Napier City, Waitaki District and Dunedin City, ownership is a mixed model. This means that some sirens within these areas are owned and maintained by the NZFS, but are available for use by CDEM. Maintenance on NZFS sirens is typically carried out by NZFS contractors and funded either by NZFS, or via an agreement with the TA.

There are some other types of arrangements, such as:

- In Hutt City, three private corporate mechanical sirens are available in support of CDEM sirens via an agreement with the owners
- In Ashburton District, sirens are owned by local residents, but are used in support of CDEM via agreement with Ashburton District Council.

5.2.12 When were your sirens installed?

As a general rule mechanical sirens are older systems, while electronic sirens have been installed more recently. While there is little information available on the age of existing mechanical sirens, it is generally understood that some date back to the World War II era, and have been maintained and progressively updated since that time.

Specific information on installations provided by CDEM groups and TAs is shown in Table 2.

Table 2: Installation dates of existing sirens used for tsunami warning

CDEM group/TA	Installation date/comments
Northland	Whangarei District 2009/10; Far North District in 2012/13
Auckland	Former Waitakere City 2007/08; former Rodney District 2008/09 onwards
Thames Coromandel District	Existing NZFS/rural fire sirens used. Existing siren network has been expanded by CDEM since 2004.
Western Bay of Plenty	Use of existing NZFS/rural fire sirens – age unclear.
Whakatane/Opotiki Districts	Existing NZFS/rural fire sirens used. Existing fixed siren network was expanded by CDEM during 2012.
Napier City	The original mechanical sirens were installed during the 1970s, and upgraded in about 2002. The system is being slowly expanded at present.
Hastings	The Stinger units were installed in 2010
Whanganui	The fixed electronic sirens were installed after a swarm of offshore earthquakes in 1983/84.
Masterton District	The trailer-based PA unit was installed in 2012
Hutt City	Mechanical sirens were installed during the 1990s
Wellington City	PA-capable vehicle units were installed around 2000
Christchurch City	The current sirens were installed in 2010/11, and the additional sirens will be installed in the 2013/14 financial year.
Timaru District	The original mechanical sirens were installed around the 1960s, the newer mechanical ones around the 1980s, and the electronic sirens were installed from 2007/08 onwards.
Waitaki District	The mechanical sirens were installed in the 1970s, and the electronic siren in 2011
Invercargill City	Sirens were installed in 1984/85 following the regional flood event.

5.2.13 What are the opportunities to clarify some of the long-standing issues with the use of sirens?

CDEM groups and TAs identified the following issues to be addressed:

- Requirements for testing, including frequency, links to public education and awareness and the use of multiple channels in testing
- Clarifying the meaning of sirens
- Public education and awareness requirements
- Siting of sirens
- When to use sirens
- The benefits of PA-capable systems
- Maintenance requirements.

5.2.14 Are police/fire mobile sirens used for tsunami warnings?

Most CDEM groups/TAs stated that time permitting, emergency services PA systems would likely be used or may be used in support of sirens. Despite this view, the following points were noted:

- Use will often be preceded by an emergency response team meeting between CDEM and emergency services, where response decisions will be made
- The activation of emergency services and use of emergency services PA systems is entirely at the discretion of NZ Police and NZFS
- In many areas, emergency services do not have the personnel to support the use of PA systems, and emergency services staff may have more urgent priorities to attend to.

A small number of TAs stated that emergency services would not be used.

6 New Zealand Fire Service position on the use of sirens for tsunami warnings

The NZFS recognises its position as a formal partner with MCDEM and CDEM groups, and will work accordingly to assist with development of a standard for the use of sirens in tsunami warnings. While recognising this formal partnership, the issues with the use of sirens and their functionality and usefulness MUST be considered.

The NZFS position on the use of sirens for tsunami warnings is covered by the following points:

- Nowhere in the world have sirens been used successfully as the only means of warning
- There are examples in New Zealand of the use of sirens as warning systems that have been less than effective
- They are one part of 8-10 means of alerting that collectively need consideration
- The public must know what a siren means and what action they then need to take
- There has to be clarity between sirens being used for general civil defence events, and sirens being used for warning of tsunamis - we don't need confusion
- NZFS sirens are fixed on the rise and fall arrangement, and given their regularity of use for NZFS response purposes, the rise and fall cycle is not suitable for civil defence or tsunami warnings
- Warnings need to work 24/7 and if we were to lose power then our sirens don't meet that need
- The Mass Evacuation Planning Director's Guideline (DGL 07/08) requires sirens to be different from fire station sirens[6]
- Not all fire stations have sirens
- Not all of NZ's low lying areas have fire stations
- The effectiveness of NZFS sirens is seriously affected by winds
- There are environmental noise issues with the use of sirens, so they may not be a viable long term option for the NZFS.

[6] "*Sirens, if used, should be different to any other sirens in the area (e.g. volunteer fire brigade) and there must be repeated communication and public education about what they mean and about testing in order to avoid confusion*", p. 49.

7 International use of sirens and guidance for the use of sirens in tsunami warnings

7.1 Use of sirens overseas in tsunami warnings

The use of sirens in tsunami warnings is common among countries around the Pacific Rim and increasingly the Indian Ocean.

Japanese towns typically have extensive networks of fixed siren speakers in the streets, which are used daily for official announcements. In the event of a tsunami, these systems can be used to broadcast a warning to the whole town, including spoken messages in addition to a siren signal (Fraser et al, 2012). Sirens were widely used both during and immediately after the 2011 tsunami event.

In the USA, fixed sirens are used extensively in coastal communities of Hawaii, Alaska, Washington and Oregon states, but are also used in California. The State of Washington for example has developed a programme of tsunami understanding and preparedness for over a decade, through a combination of state initiatives and wider national programmes. This programme includes the widespread use of an All Hazard Alert Broadcast system – signal and PA capable sirens in vulnerable coastal communities (Fraser et al, 2012). The State of Hawaii has an extensive network of sirens, due to the multiple risks it faces from subduction zones all around the Pacific Rim. There are 71 sirens on Hawaii (the Big Island) alone.

Fixed sirens are used on a smaller scale in Samoa, Tonga and British Columbia in Canada. Mobile loudspeakers and portable sirens are used in Cairns in Australia. Extensive siren systems are planned or installed in Sri Lanka, Thailand, Indonesia and India, primarily in response to the Indian Ocean tsunami in 2004.

The most common type of sirens used throughout Japan and the USA are signal and PA capable sirens, and the use of sirens in both countries is accompanied by extensive awareness programmes that focus on event recognition and evacuation procedures.

A significant proportion of the siren technical specification literature in the USA is derived from sirens for multiple hazards, or focussed on tornados, chemical releases, or nuclear emergencies. Sirens for non-tsunami hazards have widespread use internationally, especially for flooding, but little standardisation documentation was discovered outside of the USA. For example some communities in the United Kingdom continue to use sirens for flood warning but without apparent standardised guidance (Evelyn Coles, Emergency Planning College, pers comm. 2013). A noted exception is Victoria in Australia, which has some standardisation around sirens for wildfire.

7.2 International sirens guidance, policies and standards

7.2.1 Overview

This section provides an overview and summary of international guidance, policies and standards on the use of sirens as follows:

- Summary of the methodology used in obtaining and assessing the information
- Summary of guidance content and its implications for the standard – including a matrix of guidance and content (Table 3)
- A bibliography of guidance categorised by its usefulness to the review, that outlines:

- Type of document (standard, policy, guideline etc.)
- Brief description of document purpose
- Specifics that the document can provide guidance to the standard on.

7.2.2 Methodology and response

Personal contacts (including key national research experts in the USA), the International Tsunami Information Centre email listserver, and LinkedIn and Facebook emergency management discussion groups have been utilised, as well as direct internet searching. Responses from a wide range of countries (UK, France, USA, Hawaii, Japan, Australia, Sri Lanka, India) indicate that to a first order the documents supplied indicate the international distribution of documents that exists – i.e. documented standardisation is heavily USA-dominated.

The USA in particular has national, state and county level documentation from standards to policies and plans; materials from the USA provide the majority of the international information found. Some examples from Australia (state) and Japan (national) level come close to 'standards' specific to sirens. Summaries of arrangements for notification have also been supplied for India and Sri Lanka. Despite several responses from the UK no standards for outdoor alerting away from workplace health and safety have yet been discovered. Less direct contacts with continental Europe have similarly turned up no standards.

Within the USA the main national standards are provided by FEMA, Department of Defence, Department of the Army (chemical), US Nuclear Regulatory Commission, and private siren manufacturers. There are also two relevant American National Standards - ANSI/ASA S12.18-1994 (R2009) American National Standard Methods for the Field Measurement of the Sound Output of Audible Public Warning Devices Installed at Fixed Locations Outdoors; and ANSI/ASA S12.14-1992 (R 2012) Outdoor Measurement of Sound Pressure Level. The most comprehensive coverage of wider considerations is by OEM-ODGAMI (2001).

7.2.3 Summary of guidance content and implications

Thirty international documents were supplied and considered, from several countries. FEMA (2006) contains both the most up-to-date and comprehensive coverage of technical specifications of sirens – its content topics should all be considered at least briefly in the New Zealand standard. The other documents reviewed often refer to FEMA (2006) and no significant contradictions to it have been noted so far. Specifications also exist from American Signal Corporation and Federal Signals, but as manufacturers we initially see these as secondary to the FEMA standards.

The majority of forwarded documents (apart from defence and nuclear regulation) are not specifically standards, but rather policies, plans and other wider documentation, with variable content regarding standardisation, or pointing to standards for specific aspects of the wider consideration and implementation of sirens. This highlights the importance of considering siren appropriateness and logistics in a wider policy and planning context.

A range of technical specifications and wider considerations are covered by the documents in either detail or passing comment (see Table 3):

- Hazards covered;
- Other non-siren notifications;
- Mechanical vs. electronic;
- Tone-capable;
- Voice-capable;
- Tone used;
- Different patterns/tones;
- Duration;

- Penetration of structures;
- Attenuation/background noise outdoors;
- Local vs. distant tsunami sources;
- Communication for triggering / control;
- Volume;
- Testing / Exercising;
- Cue to “seek further Information”;
- Limitations assessment;
- Installation of new sirens (cf. existing systems);
- Community engagement / education;
- Governance; and
- Maintenance.

These, along with the sections in FEMA 2006, should all be considered for the New Zealand standard. Confusion as to the meaning of sirens was often mentioned in documents, along with the importance of standardisation, testing and education.

Several places make a point of notifying neighbouring areas that they have activated their sirens. The delivery of an all-clear message is a wider issue relevant to all alerting methods. Discussion of ‘all clear’ is mentioned in some documents, and there is variability in whether ‘all clear’ is chosen to be delivered or not.

Only one document reviewed covers all of the above wider considerations (OEM-ODGAMI, 2001), but the omission of various considerations is not explained within other documents. It can therefore be surmised that all of these considerations should potentially be included within the New Zealand standard. If any considerations are chosen to be omitted we should include a statement explaining why.

There is a lack of reference to evidential research on effective warning systems and the use of sirens in most of the documents reviewed. We should, therefore, also refer to our existing summary of evidence to date (MCDEM IS10/09; Draft Thames-Coromandel District Policy 2013) for additional considerations not covered by the documents reviewed, but which research to date suggests are important. These include the provision of voice messages via digital sirens, the voice and volume used (similar to standards for tone type and volume reviewed), and the nature of those messages.

Table 3: Summary of international standards, policies and guidance content

Country and/or region	Reference	Hazards	Non-siren notifications too	T / V –Tone / Voice	Mechanical vs. electronic	Tone used	Different patterns/tones / meanings	Duration	Penetration of structures	Volume / Attenuation/background	Consideration local vs. distant	Communication to trigger / control	Testing / Exercising	"Seek further Information"	Limitation/alternative assessment	Inclusion of existing sirens to new	Community engagement / Education	Governance	Redundancy / Continuous power	Maintenance
Australia - VIC	FSC 2012	B F H +	X	T			X	X					-	X	-	X	X	X		-
	McArdle 2012 review of pilot project		X	T		X	X	X					X	X	-	X	X	X		X
Canada	Apparently nil		No documents discovered																	
India	TNTRC 2007	T	-									-					-			
	NDMA 2010	T +										X								
Japan 2004/05	Provisions on the siren law to protect the people, in basic guidelines 2005	E T B F		T		X X	X			-										
	Recommended siren patterns						X X													
Sri Lanka	DMC	Multi	X	TV																
UK	HSE	Multi	Workplace health and Safety – limited applicability																	
USA – National	FEMA 1980	Multi		TV					X	X				X						
	FEMA 2006	Multi	X	TV	X				X	X		X	X		X	X				X
	NRC 1980	N +	X	T						X		X	X							
	DA-FEMA 1996 Chemical Stockpiles (Appendix F)	C	X	TV	X			X	-	X		X	X	X	-				X	
	DoD 2008			TV		X		X	X	X		X	X		-				X	X
USA – CA Bay Area	UASI 2012	Multi	X	TV	-		X		-	-			X	-	X	-	X		-	X
USA – CA Redwood Coast	RC-TWG 2011	T	-						-		X				X					
USA – Georgia	GEMA 2010	W	X	T			X		-			-	X		-	X		X		
USA - Michigan	WWS 2011	W		T	-		-					-		-						
USA - Missouri	RH-OWS-WG 2013	W	X	T								-	X				-	-		-
USA - Oregon	OEM-OMD 2009	T	-	T		-		-		-			X							
	OEM-ODGAMI 2001	T	X	T V	X	X	-	-	X	X	X	X	X	-	X	X	X	X	X	X

X covers this
- mentions this, but not in detail

Legend to hazards:
(E)arthquake; (B)ushfire / fire; (F)lood / stormsurge; (H)azardous Material; (T)sunami; (W)eather (primarily tornado); (N)uclear; (C)hemical; + means "and others too"

7.2.4 Bibliography of international guidance

7.2.4.1 Useful guidance

Title	Description
Department of the Army and Federal Emergency Management Agency (DA-FEMA) (1996).	Guidance. National document to assist state, local and Army installation planners with-respect-to chemical stockpiles. **Contains concise guidance for a specific purpose including many technical aspects. Refers regularly to voice capability.**
Department of Defence (DoD) (2008).	Criteria. Provides technical criteria for mass notification systems in compliance with DoD and other requirements. **Wide ranging specifications for relatively specific use. Significant consideration of voice.**
Federal Emergency Management Agency (FEMA) (1980).	Guideline. **Aid public officials in determining the requirements for outdoor warning systems**, including: principles of sound, outdoor warning systems and devices, propagation and detection of sound outdoors, avoiding hazardous noise exposures, and warning system planning, testing and use.
Federal Emergency Management Agency (FEMA) (2006).	Technical Bulletin / Guideline. Improves the usefulness of CPG 1-17 (FEMA, 1980), including a significant evolution and expansion of technology that can be applied to public alert and mass notification, including better ability to target areas, voice warning, and other non-siren technologies. **New Zealand should consider all aspects that this covers**. Note that it contains detail on the planning of many aspects of system roll-out.
Fire Services Commissioner Victoria (FSCV) (2012).	Policy; Guideline. State official document covering the wider implementation of existing brigade and new sirens for multiple hazards. Somewhat useful in terms of technical aspects, very useful in terms of context of siren standardisation. **Highlights the importance of wider planning and policy framework, decision-making process**. Notes that the process takes time, including community engagement. Mentoring is a good idea.
Industries (OEM-ODGAM) 2001. Tsunami Warning Systems and Procedures: Guidance for Local Officials. ODGAMI. 49p.	Guidance. **Comprehensive coverage of wider considerations around tsunami and siren installation**. All topic categories reviewed are present. Some coverage of each technical aspect of siren standardisation (e.g. audibility levels, tone).
Urban Areas Security Initiative (UASI) 2012.	Strategic plan. Importance of a multi-hazard and especially multi-notification plan, not just a sirens standard; lack of consistency in type and use of sirens across state noted as issue. Importance of standardisation for sirens to avoid confusion in different places. One key quote:

"*The world of public warning has recently changed. At the center (sic) of this change is the national-level adoption of the Emergency Alert System (EAS), the institution of standards such as the Common Alerting Protocol (CAP), and tools that include the federal Integrated Alert and Warning System (IPAWS) and the related Commercial Mobile Alert System (CMAS). These standards and tools are designed to become the future backbone of public warning in the United States. They serve to facilitate the standardization (sic) of warning practices throughout the nation. However, as innovative and potentially powerful as these standards and tools may be,* ***they are not a "silver bullet" that will finally "solve" the complex challenge of generating and delivering effective warnings to the public****…"*

7.2.4.2 Somewhat useful guidance

Title	Description
Emergency Managers in the North Central Texas Region (EM-NCTR) 2009.	Guideline covering Dallas Fort Worth area. Mistaken for tornado sirens, but actually multi-hazard. **Variable meaning by community.**
Georgia Emergency Management Homeland Securing (GEMA) 2010.	Guideline. **Variable activation and testing lead to confusion.** Suggests multiple tones. Includes action and seek further information.
Japanese Cabinet Secretariate (2004).	Law. **Primarily covers tone and pattern of sirens for four primary hazards.** Somewhat useful for technical aspects. Principle is short as it is part of a wider civil protection law. See also http://www.kokuminhogo.go.jp/en/about/law.html; http://www.kokuminhogo.go.jp/en/about/means.html
McArdle, D. 2013. Interim report of evaluation of the community alert sirens pilot program 2012-13.	Evaluation of policy. Found effective governance for Community Alert Sirens for wildfire. Review of actual implementation of a policy. **Recommends adopting a standard siren. Exercise/test plan must be implemented. All-hazard approach is essential. Governance and project management are essential. Community education, training and consultation were not yet completed. Adoption of a standard sound, duration of sound, and hardware had many advantages.**
Nuclear Regulatory Commission (NRC) (1980; +Addenda 2002 + Supplements 1-3 1988, 1996, 2011).	Criteria; mandatory policy. National document provides basis for licences and development of radiological emergency plans and improvement of emergency preparedness. Not particularly useful in terms of technical aspects, somewhat useful in terms of context of siren implementation. Points to Figure 1 of FEMA CPG-1-17 to be used as design criteria for siren systems for **populations above density 2000 persons/mi^2**, below

	that 60db(c) required. **Also covers attenuation and background noise.**
Oregon Tsunami Working Group (OTWG) 2013.	Guidance. Differentiates local and distant sources. Decision making around warning for distant sources. Various alerting systems, education and exercises. Use uniform siren signal. **Clearly states sirens have a very limited use for distant source tsunami.**
Redwood Coast Tsunami Work Group (RC-TWG) 2011.	Guidance. High cost compared to potential to use other alerting mechanisms. Confusion potential with fire sirens. Effectiveness at distance and indoors. Highlights issue of linear coastal communities being inefficiently covered by sirens (with radial audibility). Most appropriate in high-density areas with people outdoors – e.g. recreational locations.

7.2.4.3 Guidance of limited use

Title	Description
Disaster Management Centre (DMC).	Presentation from Sri Lankan government Disaster Management Centre. Mentions that more sirens are needed. Discussed a range of alerting options.
Health and Safety Executive (HSE). ONLINE.	- Human Factors Briefing Note No. 9 Alarm Handling. - Safety signs and signals: The Health and Safety (Safety Signs and Signals) Guidance on Regulations - Other documents at http://www.hse.gov.uk/humanfactors/topics/alarm-management.htm. United Kingdom workplace health and safety alarm management. Applies to workplaces. Standards for acoustics used here (ISO) have been applied in the University of Canterbury report. UK HSE documents refer to British Standards instead.
National Disaster Management Authority (NDMA) 2010.	Indian guideline. Details detection and communication of warning messages but simply states sirens will be used in all villages.
Office of Emergency Management Oregon Military Department (OEM-OMD) 2009.	Rule. Limited Usefulness. Short enabling document referring to statutes.
Region H Outdoor Warning Siren Working Group (RH – OWS-WG) 2013.	Short guidelines for Missouri. Under development.

Tamil-Nadu Tsunami Resource Centre (TNTRC) 2007.	Model plan. Mentions that a range of early warning systems including sirens can be used.
Workgroup for Warning Systems (WWS) 2011.	Best practice statement. Varying policies leading to confusion. Standardising testing and use.

7.2.4.4 Measurement standards

The following measurement standard was referred to by multiple documents from the USA: **ANSI/ASA S12.14-1992 (R 2012)** American National Standard Methods for the Field Measurement of the Sound Output of Audible Public Warning Devices Installed at Fixed Locations Outdoors.

Both ISO and ANSI measurement standards are reviewed and applied in the University of Canterbury Acoustics Research Group report "*An evaluation of the Signals used for Tsunami Warnings in New Zealand*". Specifications and acoustic testing procedures were also supplied for specific siren manufacturers.

8 Research findings on the use of sirens

8.1 Types of sirens

The advantages and disadvantages of sirens depend upon the type of sirens in use. Within the MCDEM Public Alerting Options Assessment guideline, five main types of siren are recognised:

1. Aircraft PA loudspeakers or sirens
2. Mobile PA announcements – NZ Police & Fire Service
3. Fixed PA loudspeakers (signal and voice)
4. Mobile PA loudspeakers (signal and voice)
5. Sirens (signal, no voice capability)

Appendix 6 contains the comparative assessment information for each type of siren from the Public Alerting Options Assessment guideline. Note that recent siren tests have also highlighted the importance of considering adverse weather conditions in siren audibility.

8.2 Advantages of sirens

Fixed sirens generally have the following advantages:

- They can be controlled from central trigger point, which has potential for rapid notification
- They can be activated through various channels
- They can be good for special conditions – such as in remote and/or confined communities, areas where there is limited or no cell phone coverage, and where tourists and/or transient populations are located and isolated
- If combined with a clear and on-going public awareness programme, they can provide a single focus to direct people to seek further information
- Voice capable sirens can provide both a "heads-up" that something is occurring and instruction (action information)
- They are used widely in many countries and regions, and are recognised by many communities as existing tsunami warning systems
- Sirens can enhance a warning message, or act as backup (Leonard et al. 2008)[7]
- They can be one of the most effective means of outdoor mass notifications (Anderson 2006)
- Siren and evacuation drills can be effective as a means of improving hazard education (Leonard et al., 2011).

In addition to the above, fixed sirens with a PA capability have the additional advantage of being able to play updated messages as events progress, and may be used following events. Mobile sirens with PA capability have additional advantages such as non-reliance on a fixed power source.

The experience of TAs across New Zealand suggests that sirens can be effective in providing initial warnings, that they can generate interest in tsunami hazards and emergency management, and that mobile PA sirens are effective for use in remote areas.

[7] However, they may not be worth the cost and effort if no system already exists.

8.3 Disadvantages of sirens

There is a substantial amount of guidance, research and practical experience on the disadvantages of the use of sirens for tsunami warnings. The disadvantages of sirens differ depending upon the type of siren used (refer to section 8.1 and Appendix 6).

A brief summary of the disadvantages of sirens is provided below.

8.3.1 MCDEM Public Alerting Options Assessment guideline

The findings of Leonard et al. (2008) with respect to public alerting via sirens underpins the guideline as follows:

> **Good cost-benefit systems available now**
> The following all score well and have reasonable costs for both low and high density populations:
>
> - Radio and TV Broadcasts
> - 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
> - Independently self-maintained networks
> - SMS text messaging
> - Pagers
> - Natural warnings
> - Police/fire mobile PA loud speaker.
>
> Fixed PA loudspeakers score well, but have a high start-up cost, likely to be considered prohibitive for low density areas. On-going maintenance should not be overlooked. Fixed PA loudspeakers should not be confused with sirens (signal-only) which do not score well because they do not give specific instructions on what the population should do on hearing the warning.
>
> **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 explosives, 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).

Expectations that sirens will give a warning may reduce response if the sirens fail. In addition, it is noted that sirens will be ineffective at warning the deaf, holiday makers and other transient populations and will be less effective for new residents (p. 67).

Signal-only sirens are commonly the first suggestion when new public alerting hardware is considered in New Zealand, however, there are substantial limitations to their effectiveness. They are cheaper than voice PA loud-hailers (except self-designed and built) and technically less complex, but understanding the meaning of the siren relies entirely on public awareness. One could assume that a community would eventually seek the meaning of a siren if it continued indefinitely, but the timeframe for seeking that advice is uncertain.

Therefore, sirens are not considered to be ideal for short-lead time hazards where there are only minutes of warning time.

The public is also likely to find differentiating between or interpreting the different and often inconsistent siren signal codes used in different areas problematic. Sirens are likely to be affordable and feasible in urban communities, but most likely not in rural areas with diffuse populations. By not providing action information, and relying on the existing knowledge of the at-risk population, signal-only sirens could potentially result in delays in taking action, or inappropriate response.
Many locations in New Zealand utilise sirens for other non-public alerting purposes (e.g. to summon rural fire service volunteers, or factory sirens to signal shift changes or emergencies). For non-locals this increases the potential for misinterpreting the meaning of sirens intended for tsunami alerting.

UASI (2012) Provide useful analysis in the context of reviewing sirens' role within public alerting for the Bay Area, California:

> *"The technology of siren and alarm systems is such that an audible signal could be provided to most populations at risk, although it can be expensive to implement the technology. These types of warning devices are designed to provide rapid alert to the threatened population. Electronic sirens have public address capabilities as well, although the quality of the message is usually poor. Siren systems are limited in their use by the lack of instructional messages. At best, they alert people to seek further information, unless there has been an intensive program of public education used to instruct people on what to do when the signal sounds. This is possible only in situations when the same response would be desired every time a warning is issued, which is not likely in the Bay Area.*
>
> *Multiple signals, such as a wavering signal versus short blasts, whoops, and wails are rarely differentiated by the public. Consequently, reliance on different signals for diverse hazards is not supported. Other problems that constrain the use of sirens and alarms are false alarms because of technical failures, equipment failures in emergencies, maintenance problems, coverage problems (particularly in adverse weather), difficulties in propagating sounds into buildings, and sometimes public indifference to sirens in large urban areas such as the Bay Area. Nevertheless, siren systems remain a main component of warning systems nationwide and in the Bay Area. Their main benefit is to create a signal that if heard interrupts a normal environment and is noticed by those who hear it."*

8.3.2 Further research

International research shows that sirens are useful when there is time for reliable detection of a hazard, notification and public-action before impact; in that case voice-capable sirens cause a faster response by more people and should be preferred over signal-only-sirens. Multiple signals with different meanings causes confusion. Examples of research supporting this position are:

- The major limitations of sirens were that people did not pay much attention to them and did not understand the meaning of different sounding signals. Now, electronic sirens with voice capabilities provide an alert mechanism as well as a voice message (Sorenson, 2000).

- If only sirens are used to deliver a warning, the public is less likely to understand the message (Lachman, 1961).

- A person is less likely to understand a warning message if sirens alone are used to relay the message (Tierney, 1987).

- Awareness of the siren tests and test frequency is high, but these factors do not equate with increased understanding of the meaning of the siren, which remains disturbingly low (13%) (Gregg and Houghton et al. 2007).

- Traditionally, sirens have only been used as an alerting technology, limited in their utility by the lack of instructional messages. At best they have told people to seek further information unless an intensive program of public education is used to instruct people what to do when the signal sounds. However, some of today's sirens can provide high-power voice messages as well as traditional warning signals, taking them closer to a dual alert/notification classification (Molino et al, 2000).

- Technological advances and warning systems cannot protect coastal populations from a near-source tsunami because the first waves may reach the coast within minutes of the event. Local populations must be able to recognize the signs of an impending tsunami and take appropriate action immediately without official direction (Dengler, 2005).

- The focus for local-earthquake-source tsunami warning should be on widespread education and exercises to evacuate on the huge earthquake itself. People must not wait at all for any official warning, including trying to give warning via sirens, because in the first minutes it won't be any more accurate, it will be slower and the earthquake will already have been huge and unusual. This is also the message from the International Tsunami Information Centre and the USA[8].

Recent findings (Fraser et al. 2012) from the Japan 2011 tsunami event with respect to the use of sirens in New Zealand and Washington State, USA is outlined below:

- *Findings from 2010 siren tests in Ocean Shores and Long Beach in Washington State, USA showed mixed levels of siren audibility in the current system (p. 9).*

- *"It is known that there is public misunderstanding that official warnings and warning hardware (e.g. sirens) will cover local sources – this is an on-going issue for public awareness and preparedness (p. 12)."*

- *"In general there is a high expectation in Japan that official warnings will be provided for local tsunami, in addition to regional or distant tsunami. In Washington and New Zealand there is a much longer response time for the broadcast of official warnings, precluding their use in local events. In addition, the high monetary cost of implementing technology required for a Japanese-style early warning system means that at present, more effective evacuation of the population in local source events can be achieved in Washington and New Zealand if people are educated to evacuate independently of formal warning (i.e. in response to natural warnings)" (p. 56).*

- *"At a time when official hardware-based warning systems are growing in scale and apparent technological advancement, there is increased potential for people to be less likely to respond to natural warnings. While recognising the benefits of tsunami*

[8] http://itic.ioc-unesco.org/index.php?option=com_content&view=category&layout=blog&id=1195&Itemid=2311&lang=en and http://www.emd.wa.gov/preparedness/prep_tsunami_evacuation.shtml are two examples.

warnings for regional and distant tsunami, there should be continued investment into education of the different response issues for local tsunami versus regional and distant tsunami" (p. 56)

- *"Any tsunami warning system in place in Washington or New Zealand that is intended for use in local warnings must have sufficient redundancy to allow full functionality following a local earthquake. The experience of effective warning transmission in Minami-Sanriku via household wireless radio receivers illustrates the effectiveness of a system such as the NOAA Weather Radio system" (57)*

- *"The Japanese approach of utilising siren towers and speakers for post-event announcements of further events or welfare advice (i.e. locations to receive supplies or medical treatment) should be considered for post-event response in the United States and New Zealand where such systems are available. Additional redundancy and resilience is required in the warning broadcasting system if it is required for further warnings and welfare announcements. This must be applied to the broadcasting source point, any telemetry, and the public notification point" (57).*

- *"Siren towers and radio-receiver systems are expensive and can be too slow in a local source event, compared to the natural warning from long or strong earthquakes. These official warning mechanisms should be treated very cautiously and not expected to be a reliable solution for local earthquake and tsunami".*

8.3.3 Experience from Councils across New Zealand[9]

The primary disadvantages of sirens identified by Councils across New Zealand are:[10]

- Cost of installation and maintenance
- Public confusion as to the meaning of sirens
- The need for constant public education and awareness
- A perceived public reliance on sirens
- Insufficient audibility of sirens
- Technical faults and false alarms
- Patchy coverage
- Maintenance issues such as salt, pests and systems that are not maintained.

Other issues mentioned include:

- Managing public expectations on when sirens will be used
- Siren placements not being risk-based
- Lack of testing programmes
- Resource consent issues (not being able to easily install sirens)
- Managing legacy systems
- Failure during earthquakes due to loss of electricity
- Lack of understanding of visitors to the area
- Ineffectiveness for small populations.

The experience from Councils across New Zealand backs up the research evidence about the lack of effectiveness of sirens – particularly fixed, signal-only systems.

[9] Per the feedback provided by TAs during development of the draft Thames Coromandel District Council tsunami sirens policy.
[10] Refer to comments in Appendix 3.

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Appendix 1: Acoustics Research Group report summary (p.2)

A danger signal is used to indicate the possibility or the occurrence of a dangerous situation which requires appropriate measures for the elimination or control of the danger. Therefore, auditory danger signals must be designed to be clearly heard and to elicit the most appropriate action from the target listeners. A list of requirements and recommendations for a tsunami danger signal were compiled from relevant, international standards and from the findings of research studies from around the world. The requirements are summarized below:

- The signal shall be distinct from all other sounds and any other signals.
- The meaning of the danger signal shall be clear.
- The danger signal should include two frequency components in the 500 Hz to 2500 Hz range.
- The danger signal shall have sufficient energy below 1500 Hz to be heard by people with hearing loss.
- Pulsating danger signals should be preferred to signals that are constant in time.
- The repetition shall be between 0.25 s and 2 s.
- Varying fundamental frequencies should be selected for the danger signal.
- The danger signal should include frequency components below 500 Hz for better coverage.
- The danger signal should have a frequency component between 224 Hz and 355 Hz for transmission through windows.
- The danger signal should convey urgency.

Several of the tsunami danger signals currently in use in New Zealand were evaluated. None of the existing signals evaluated met all of the requirements for a danger signal, but the signal used in Northland met most of the requirements. Adding a second tone between 224 Hz and 355 Hz to the Northland signal will make it fully compliant with the requirements for a danger signal. Alternatively, the design of a danger signal that will meet all of the requirements has been proposed. It is recommended that verbal warnings which fully comply with the standard, ISO 9921 be integrated with the non-verbal tsunami danger signals.

An advantage that the electronic sirens have over mechanical sirens is that the tsunami danger signal they produce can be modified to comply with the requirements for a danger signal. Furthermore, the electronic sirens can integrate verbal messages which have been shown to increase the effectiveness of danger signals. Due to the limitations of mechanical sirens and since tsunami danger signals generated by mechanical sirens do not meet the requirements for a danger signal, it is recommended that no additional mechanical sirens be installed for the generation of tsunami danger signals and only electronic sirens be considered in the future.

Regardless of the tsunami danger signal which is chosen, the inclusion of an education program for the people who live and work in the siren coverage area is critical. Educating people about the sound of the signal, its meaning and the appropriate response to be taken must be an integral part of any plan to install tsunami warning sirens in a community.

Appendix 2: Public alerting options available in New Zealand and overseas

The following information is drawn from the MCDEM Public Alerting Options Assessment guideline, and provides a brief overview of warning systems and available in New Zealand and overseas.

The following thirty public alerting mechanisms are available in New Zealand and overseas. Warning systems are divided into four categories:[11]

1. Natural warnings;
2. Independent and self-maintained networks;
3. Mechanisms reliant on third party hardware and/or staff; and
4. Mechanisms that require dedicated hardware (but controlled by the warning agency).

1. Natural warnings (identification and response based on natural signs)

2. Independent and self-maintained networks (door-knocking, local community response procedures)

3. Mechanisms reliant on third party hardware and/or staff (siren mechanisms are highlighted)

- Aircraft banners
- ***Aircraft PA loudspeakers or sirens***
- Billboards
- Break-in broadcasting (not currently available in New Zealand)
- Call-in telephone line
- E-mail
- GPS receivers (not currently available in New Zealand)
- Marine Radio
- Mobile-device Broadcasting (not currently available in New Zealand)
- ***Mobile PA announcements – NZ Police & Fire Service***
- Pagers
- Power mains messaging
- Radio and TV broadcasts
- Route alert (door-to-door)
- Smartphone apps [added 2013]
- SMS-PP (Short Message Service - Point to Point)
- Telephone auto-dialling (landline)
- Telephone trees
- Tourist advisory radio
- Websites/WAP [includes social media]
- Website banners

4. Mechanisms that require dedicated hardware - but controlled by the warning agency (siren mechanisms are highlighted)

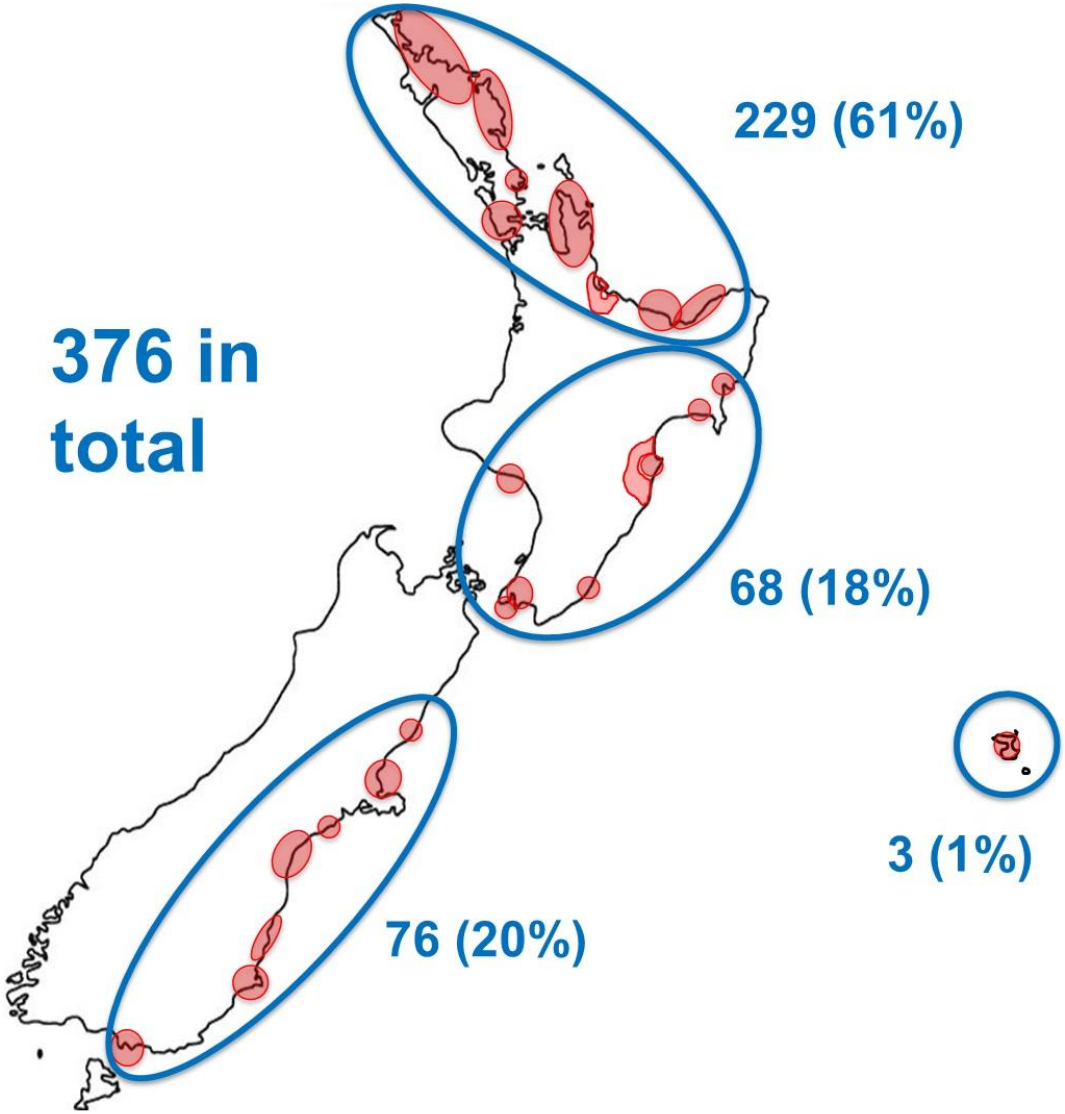
- ***Fixed PA loudspeakers***
- ***Mobile PA loudspeakers***
- Flares, explosives
- Radio data systems
- Radio (UHF, VHF and HF)
- ***Sirens (tone, no voice capability)***
- Tone-activated alert radio (not currently available in New Zealand)

[11] Refer to p. 11.

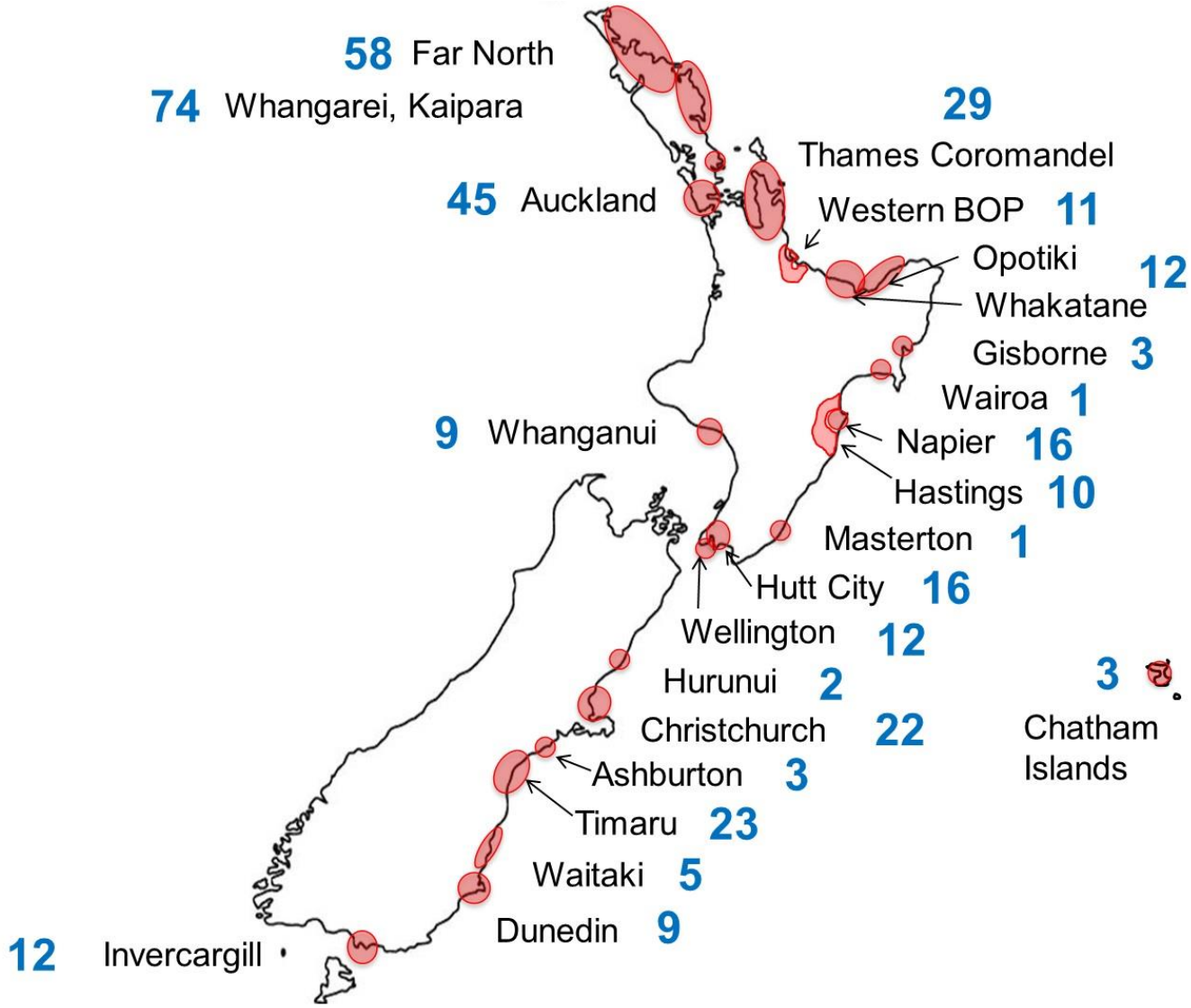
Appendix 3: Distribution and use of sirens for tsunami warning

3a: Locations of sirens used for tsunami warnings

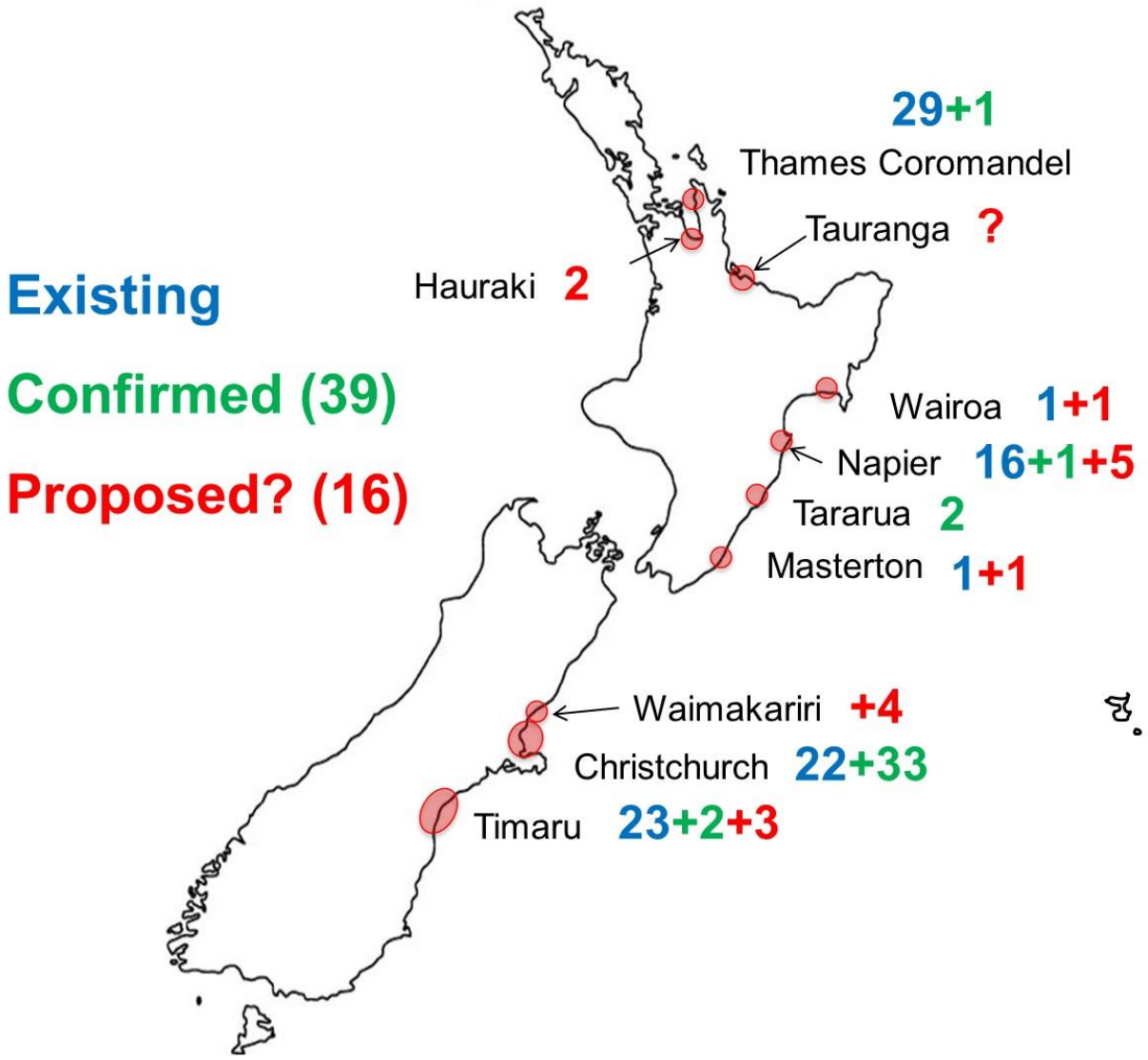
3b: Overall numbers and distribution of sirens



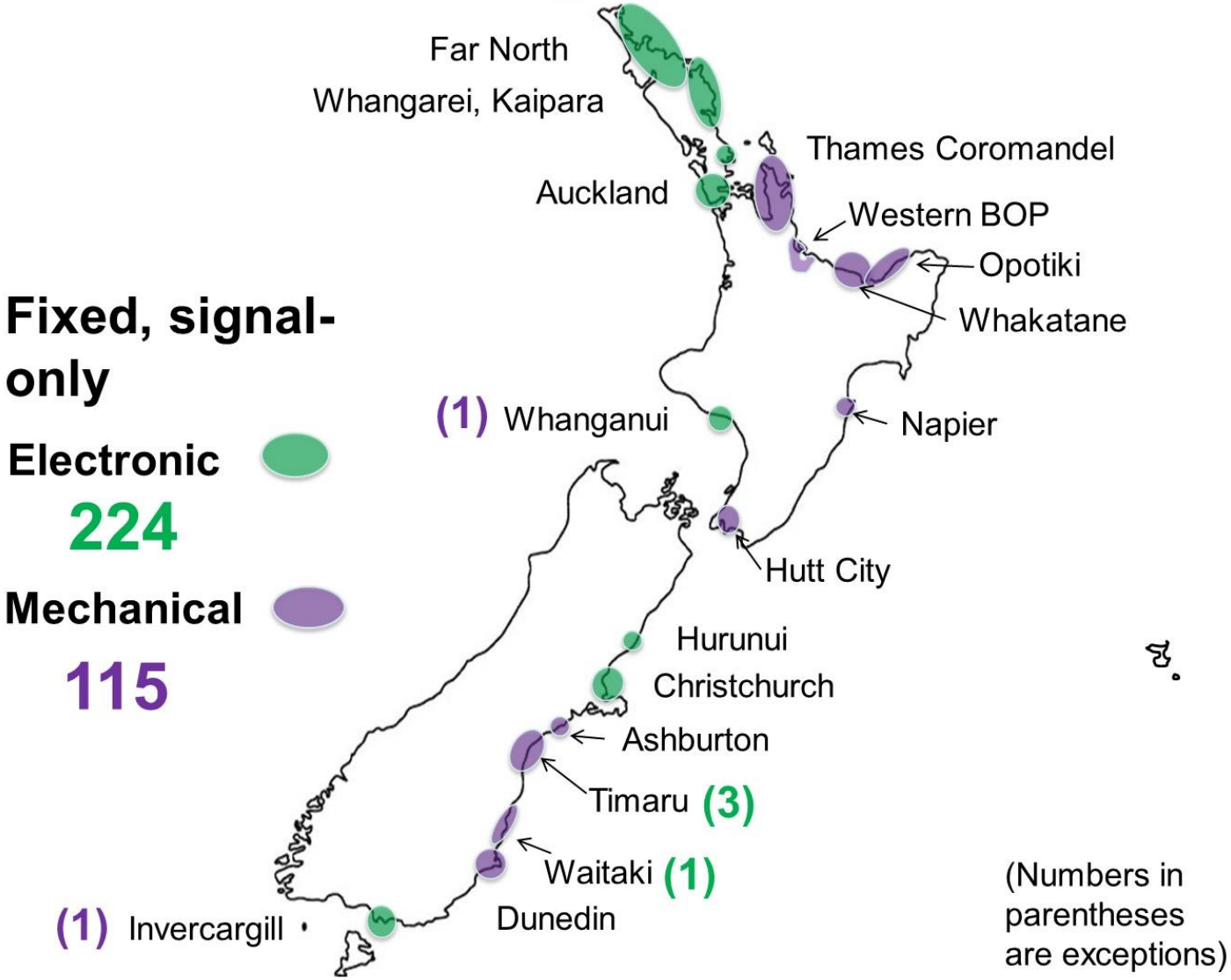
3c: Numbers of sirens by Territorial Authority



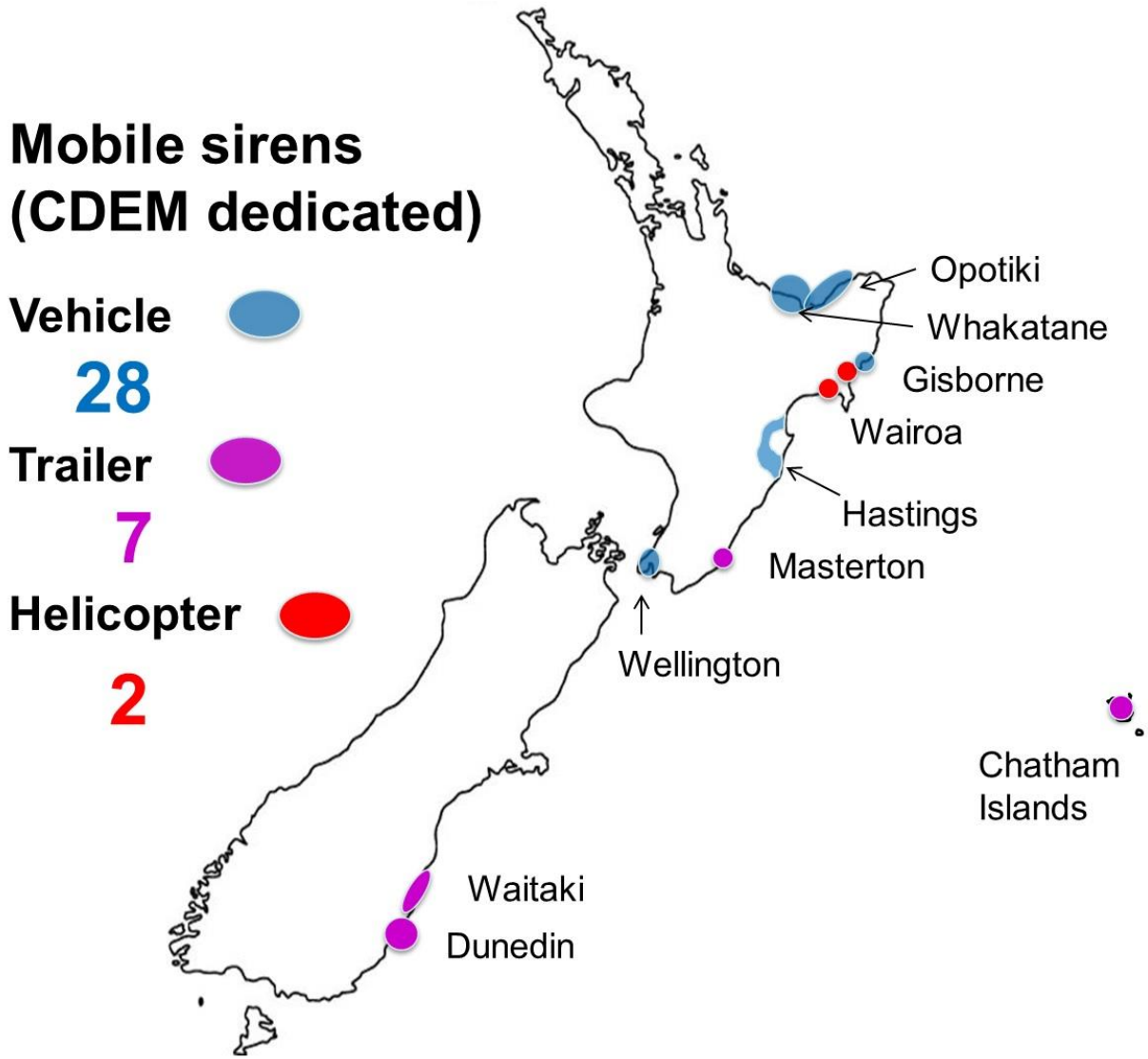
3d: New sirens confirmed and proposed



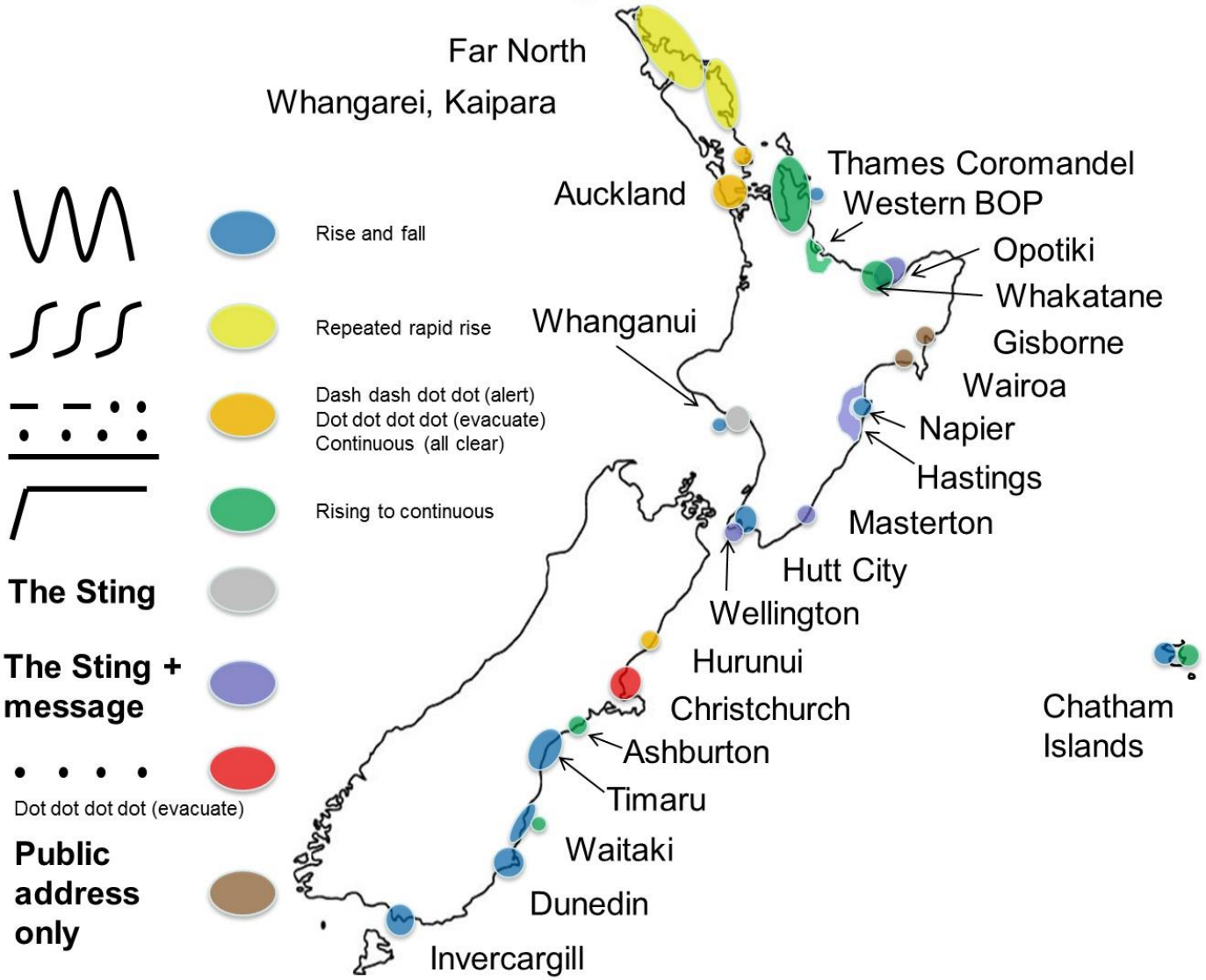
3e: Distribution of fixed signal-only sirens



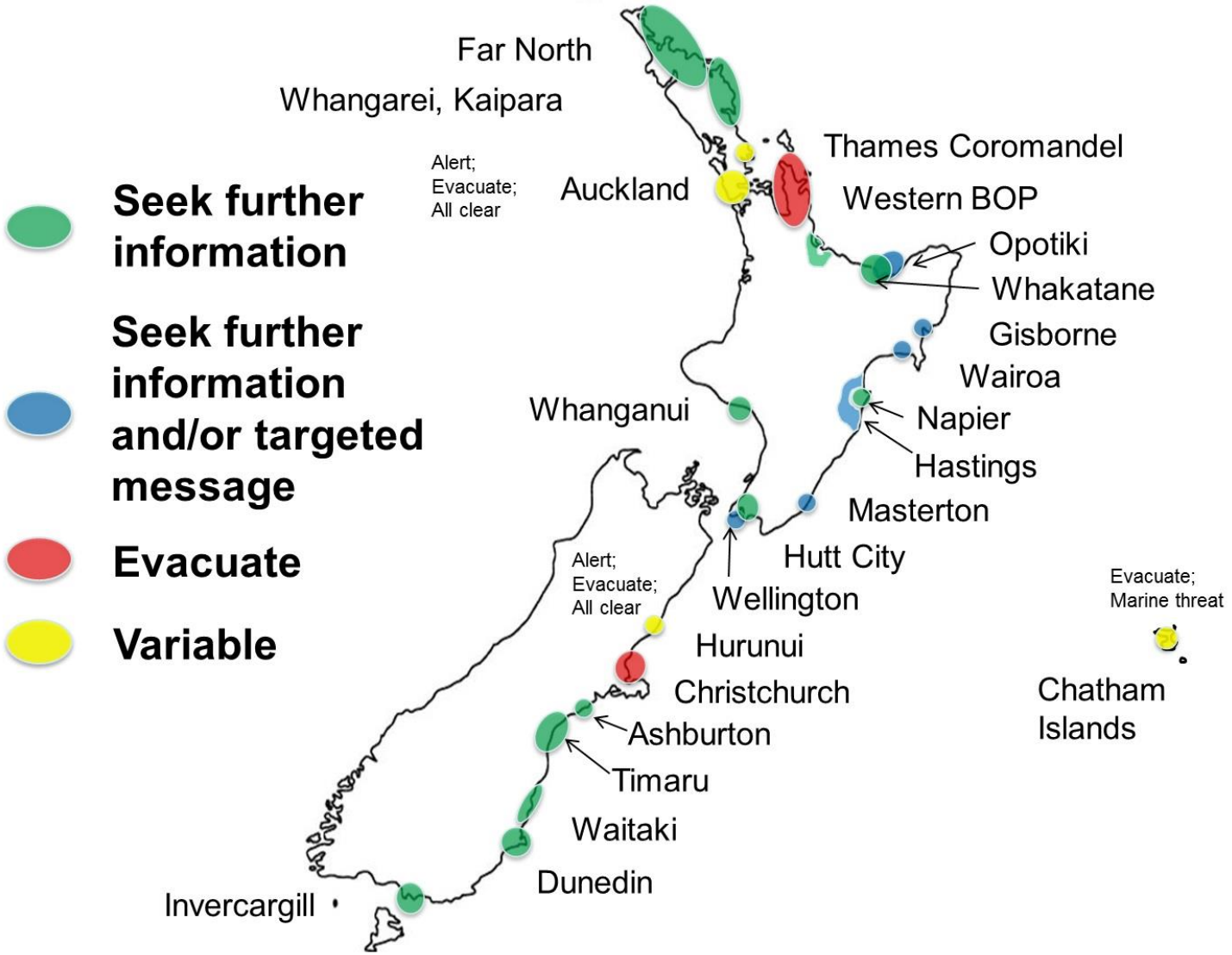
3f: Distribution of mobile sirens



3g: Signals used for tsunami warning



3h: Meaning of sirens



Appendix 4: Summary of types of sirens used for tsunami warning in New Zealand

4a: Current types of sirens

The following table provides a summary of the various types of sirens currently used for tsunami warning in New Zealand.

Area	Fixed signal-only		Mobile			
	Electronic	Mechanical	Electronic			Mechanical
			Vehicle	Trailer	Helicopter	Trailer
Northland	132					
Auckland	45					
Thames Coromandel		29				
Western BOP		11				
Whakatane/Opotiki		8	4			
Gisborne			2		1	
Wairoa					1	
Napier		16				
Hastings			10			
Whanganui	8	1				
Masterton				1		
Wellington City			12			
Hutt City		16				
Hurunui	2					
Chatham Islands						3
Christchurch	22					
Ashburton		3				
Timaru	3	20				
Waitaki	1	3				1
Dunedin		7				2
Invercargill	11	1				
Totals	**224**	**115**	**28**	**1**	**2**	**6**

4b: Future types of sirens confirmed and proposed

The following table provides a summary of the various types of sirens either confirmed or proposed sirens for future tsunami warning in New Zealand.

Area	Fixed signal-only		Mobile			
	Electronic	Mechanical	Electronic			Mechanical
			Vehicle	Trailer	Helicopter	
Thames Coromandel		1				
Hauraki	2					
Wairoa					1	
Napier		*6				
Tararua	2					
Masterton				1		
Waimakariri	4					
Christchurch	33					
Timaru	**5					
Totals	**46**	**7**	**0**	**1**	**1**	**0**

Appendix 5: Regional summary of siren use for tsunami warnings

Region	Council	Coverage	System type	# sirens	Signal	Meaning	Event type
Northland	**Whangarei and Kaipara Districts** **Far North District**	Mangawhai (south) to Bland Bay (north) Opua (east) to Ahipara (west)	Fixed, signal-only electronic, mounted to power poles, ripple control activation via lines company	**74 total** **58 total**	Repeated rapid rise	Seek further information	Both regional and distant (but no guarantee for local)
Auckland	**Rodney District (former)** **Waitakere City (former)**	Omaha to Waiwera Bethells Beach to Hobsonville	Fixed, signal only electronic	**12 total** **33 total**	Alert (dash dash dot dot); Evacuate (dot dot dot dot); All clear (continuous)	Alert = evacuate beaches, get further information; prepare to evacuate	Distant events only. No credible threat from local or regional events
Waikato	**Thames Coromandel District**	Puriri (West Coast) – Whangamata (East Coast)	Fixed, signal-only mechanical, mounted to power poles	**29 total** (one additional to be installed)	Constant (five sirens are rise and fall signal only)	Evacuate	Primarily distant, but may be used in regional event if enough time
Bay of Plenty	**Tauranga City**	No tsunami sirens installed – delays to project					
	Western Bay of Plenty District	Waihi Beach – Pukehina Beach	Fixed, signal-only mechanical	**11 total**	Rises to constant signal	Seek further information	Depends upon threat and information available particularly for local and regional events

Region	Council	Coverage	System type	# sirens	Signal	Meaning	Event type
	Whakatane and Opotiki Districts	Matata – Waihau Bay	Fixed, signal-only mechanical and mobile (signal and voice) stinger sirens	**12 total**: 8 fixed, 4 mobile stinger units	Fixed rises to continuous signal, stinger units play sting plus recorded message	Seek further information; listen to radio	All hazards, but only use for tsunami, all events if we can
Taranaki	**All**	No tsunami sirens used in the region					
Gisborne	**Unitary**	Gisborne and District-wide	Vehicle-mounted PA system, Helicopter PA system	**3 total**: 2 vehicle, 1 helicopter	Public address only	Messaging per the event	Distant
Hawke's Bay	**Napier City**	Eskdale to Taradale	Fixed, signal-only mechanical, mounted mainly at fire stations and businesses	**16 total**; 3-4 others planned	Rise and fall	Emergency imminent, listen to radio	Distant, but also local/regional if possible
	Hastings District	Whirinaki; Clive to Clifton	Stingers – electronic mobile siren units	**10 total**	The Sting, followed by recorded voice messages and voice if required	Listen to radio and/or follow voice instructions	Distant only. Not enough time to deploy in local tsunami event
	Wairoa District	District-wide	Helicopter-mounted PA system	**1 total**	PA-only	Messaging tailored to the event	Distant, regional if possible

Region	Council	Coverage	System type	# sirens	Signal	Meaning	Event type
Manawatu-Wanganui	**Wanganui District**	Mowhanau and Wanganui River sites	Fixed, signal only electronic pole mounted, 2 speakers in opposite directions	**9 total**: (8 are electronic, 1 mechanical)	Electronic ones play the Sting; mechanical is rise and fall	Turn radio on, seek further information	Use for all events, most likely event is local
	Tararua District	Council is planning to add two sirens to the east coast communities of Akitio and Herbertville (2 fixed, signal only electronic sirens have been purchased). Installation of sirens is pending planning with local communities and standard.					
Wellington	**Hutt City**	Hutt Valley to Coastline	Signal only, mechanical, fixed, on power poles or buildings	**16 total**, (3 are private that can also be used	Rise and fall	Turn radio or TV on, seek further information	Distant only, used for floods as well
	Wellington City	Central city, coastal areas	Mobile PA electronic vehicle mounted	**12 total**	The Sting, followed by a message	PA advice, instructions depending upon event	Distant only
	Masterton District	Riversdale	Mobile PA electronic - trailer mounted	**1 total**	The Sting, followed by a message	PA advice, instructions depending upon event	Distant, regional if possible
Canterbury	**Christchurch City**	Waimairi Beach to Sumner	Fixed, signal-only electronic, mainly pole mounted	**22 total**: 33 more being installed this year	Dot dot dot dot	Evacuate coastal (tsunami) inundation zone	Distant and regional events only

Region	Council	Coverage	System type	# sirens	Signal	Meaning	Event type
	Hurunui District	Amberley Beach and Leithfield Beach	Fixed, signal-only, electronic mounted to power poles	**2 total**	Alert (dash dash dot dot); Evacuate (dot dot dot dot); All clear (continuous)	Alert = seek further information (listen to radio)	Distant, but community expects it for local and regional as well
	Timaru District	Coastal Rangitata Huts to Pareora, particularly Timaru (CBD and Port areas), Washdyke industrial and inland riverside communities. Other sites investigated based on current and future demographics and risk.	20 sites older mechanical sirens. 3 sites electronic, voice capable and forward compatible for future SCADA upgrade.	**23 total**; 2 more to be installed by Christmas, proposal for 3 more.	All same Rise and fall.	Turn on your radio/get further information	River flooding, storm surge, distant tsunami (no appreciable local risk).
	Ashburton District	Rakaia, Ashburton and Rangitata river mouths	Fixed, signal-only mechanical units	**3 total**	Rising to continuous	Seek further information	Distant primarily, but other events if time
Chatham Islands	**N/A**	Waitangi, Owenga, and Kaingaroa.	Mechanical, trailer-based sirens,	**3 total**	Continuous and rise and fall	Continuous is evacuate, rise and fall is marine threat	Distant, but all events if possible

Region	Council	Coverage	System type	# sirens	Signal	Meaning	Event type
Otago	**Dunedin City**	Waikouaiti to Brighton, including the harbour	Fixed signal-only mechanical mounted at fire stations, 2 trailer.	**9 total**: 2 mobile, plus 7 fixed at 6 fire stations	Fixed and trailer are rise and fall;	Turn on radio/ seek further information	Distant. Regional risk may not allow sufficient lead time to sound sirens. Local – minimal risk assessed
	Waitaki District	Oamaru, Kakanui, Hampden, Shag Point	Fixed-signal only, one mobile, mix of electronic (1 – Shag Point) and mechanical (4)	**5 total** in coastal zone	Rise and fall (Oamaru, Shag Point) Continuous (Kakanui, Hampden)	Seek further information	Probably regional, unlikely for local or distant events
Southland	**Invercargill City**	Some urban areas of Invercargill City	Fixed, electronic pole/building mounted sirens (11), mechanical (1)	**12 total**: (15 present, but three inoperable)	Rise and fall	Seek further information	Distant, but also local/regional if possible, but no guarantees

Appendix 6: Sirens comparative assessment information

The following tables are drawn from the MCDEM Public Alerting Options Assessment guideline (pp. 15, 23, 35, 36 and 40).

6a: Aircraft PA loudspeakers or sirens

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.

Criteria	Explanation
Limitations	Available aircraft, CAA Regulations (flight path and equipment certification, agreements with operators. Limited coverage – prioritising of at risk areas.
Time-frame	Minutes to hours
Heads-up and instruction	PA both, siren heads-up only
Effective residents	Effective for residents who are outdoors
Effectiveness transients	Effective if transient population are outdoors
Effectiveness institutions	Low effectiveness (sound dulled)
Vulnerable & immobile	Low effectiveness (sound dulled)
Robustness/resilience	Aircraft and agreements with operators are maintained to a robust standard. Airport operability, weather conditions
Ongoing effectiveness	Will only remain effective while reaching un-warned 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 for rural diffuse populations
Cost basis	Retainer, equipment purchase and flight time costs
Cost (for each aircraft)	Start-up:$20k+, ongoing (helicopter $1k/hr, effort, planning and exercises)
Dense	Two aircraft units for 100,000 people, ten hours use per year (five per aircraft)
Diffuse	Eight aircraft units for 100,000 people, forty hours use per year (five per aircraft)
Hazards	All hazards with a lead in time of more than tens of minutes
Target population	All within audible range

6b: 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.

Criteria	Explanation
Limitations	Availability of staff, equipment and vehicles. Deployment time, planning, agreements
Time-frame	Realistically 30 minutes or more, theoretically a few minutes
Heads-up and instruction	Yes – provides both
Effective residents	Yes, but less effective for those indoors
Effectiveness transients	Yes, but less effective for those indoors
Effectiveness institutions	Not suitable (most will be indoors)
Vulnerable & immobile	Yes – but less effective for those indoors
Robustness/resilience	Robust (regular maintenance assumed)
Ongoing effectiveness	Effective throughout event as message can be updated, would need to re-visit target areas if message changes
Terrain suitability	All terrain suitable for vehicles
Population density	More effective in high density areas but also effective for isolated population centres if start area is located nearby.
Cost basis	Effort to arrange and exercise only. Depends on local arrangement with NZ Police/NZFS
Cost	Effort- setting retainer arrangement, planning, ongoing (testing, awareness, exercises)
Hazards	All hazards, but response will take minutes
Target population	All

6c: 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.

Criteria	Explanation
Limitations	Cost, coverage, complex system, resource consent required
Time-frame	Seconds
Heads-up and instruction	Yes – provides both
Effective residents	Yes but effectiveness reduced for those indoors
Effectiveness transients	Yes but effectiveness reduced for those indoors
Effectiveness institutions	Less suitable- 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. exposure to the elements) and ongoing maintenance
Ongoing effectiveness	Can only target those within range, however message can 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	Hardware
Cost	Village: Start-up $6k (limited range) to 50k (larger range) Urban: Start-up: $100k-1M+, planning, ongoing (maintenance, exercises) Rural communities: Start-up: $500k-5M+, planning, ongoing (maintenance and exercises)
Hazards	All hazards
Target population	All within audible range

Loudspeaker announcements are one of the more effective forms of transmission of warning messages to specific target areas, e.g. ski fields and sea fronts. They do, however, have a substantial start-up and ongoing testing, exercising and maintenance costs associated.

6d: Mobile PA loudspeakers

In this instance specifically dedicated mobile PA loudspeakers attached to land vehicles are used by warning agencies to communicate warnings to the public.

Criteria	Explanation
Limitations	Availability of vehicles and drivers, complex systems. Effective only for those that can be reached during lead in time
Time-frame	Minutes to hours
Heads-up and instruction	Yes – provides both
Effective residents	Yes, but less effective for those indoors
Effectiveness transients	Yes, but less effective for those indoors
Effectiveness institutions	Less suitable (most will be indoors)
Vulnerable & immobile	Yes – but less effective for those indoors
Robustness/resilience	Robust with regular maintenance, arrangements in place
Ongoing effectiveness	Effective throughout event as message can be updated, would have to re-visit target 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 start point
Cost basis	Build your own. $50k for 12, reaches 400 people/sq km in dense areas, 1/4 of that in diffuse areas. 10% annual maintenance
Cost	$10k per unit start-up, $1 per person ongoing and effort (maintenance and exercises)
Hazards	All hazards for areas that can be reached
Target population	All within audible range

6e: 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.

Criteria	Explanation
Limitations	Coverage, complexity, 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
Effective 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 robust 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; where topography creates sound barriers (need to be positioned for maximum range)
Population density	All but more cost-effective with increasing density
Cost basis	Network design, hardware, implementation
Cost	$475k for 30 sirens including installation and project management, ongoing maintenance (battery replacement every 5 years (~$400 per replacement), public education, exercising)
Hazards	All hazards
Target population	Local residents and organisations within audible reach (not visitors/tourists)