Intended evacuation behaviour in a local earthquake and tsunami at Napier, New Zealand

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ABSTRACT

We conducted surveys of 136 residents of and visitors to Napier, Hawke's Bay, New Zealand, to understand hazard awareness and intended evacuation behaviour in a hypothetical local earthquake and tsunami. The results provide a unique investigation of evacuation intentions in the context of local tsunami hazard in New Zealand. The data support observations from previous surveys and international literature, and provide new data on intended evacuation destinations, travel mode and opinions of tsunami vertical evacuation buildings.

There were high levels of recall of hazard information among residents in Napier and although the results suggest a low level of information provision to visitors by the tourist industry, there is a high level of tsunami hazard awareness among both groups. There is a reasonably good understanding of potential tsunami arrival times, but an expectation that official tsunami warnings will be given via sirens or TV/radio in the case of local tsunami. Intended behaviour suggests that ground shaking might trigger appropriate earthquake response actions but people may not extend their actions to include appropriate tsunami evacuation response. Location at the time of the earthquake and gender influence respondents' intention to evacuate and their intended travel mode. A moderate proportion of respondents stated that they would evacuate to high ground and some respondents identified their home or prominent locations in the city as intended evacuation destinations, despite those locations being within the tsunami hazard zone. Respondents were receptive to vertical evacuation as an alternative to high ground, but generally consider it a last resort and expressed concern about structural integrity and sufficient height.

KEYWORDS

Local tsunami, evacuation behaviour, Napier, Hikurangi subduction zone, warning, awareness, transient population, vertical evacuation buildings

1.0 INTRODUCTION

This study was undertaken to understand hazard awareness and intended tsunami evacuation behaviour of residents and visitors in the context of local earthquake and tsunami at Napier, Hawke's Bay, New Zealand. Previous research has documented the seismic hazard associated with the Hikurangi subduction margin, 100-150 km offshore of the east coast of the North Island (e.g. Wallace et al., 2009) and paleo-earthquake and tsunami in Hawke's Bay (Cochran et al., 2005, 2006). Numerical modelling has demonstrated that in the worst-case scenario of a whole margin rupture, large areas of urban Napier could experience flow depth exceeding 3 m with maximum inundation extent of 4 km (Fraser et al., 2013). Tsunami wave arrival could occur in as little as 27 minutes after earthquake rupture. The resident population of 57,800 (Statistics New Zealand, 2013a) and large numbers of visitors to the city represent high exposure to the local tsunami hazard. We require improved understanding of tsunami awareness and evacuation intentions to help in designing community engagement programmes and resources, and efficient evacuation strategies in case of local tsunami.

Extensive literature on evacuation behaviour provides a basis for tsunami evacuation planning, but this has been generated largely through the study of U.S. hurricane evacuations and an understanding of tsunami evacuation remains limited (Lindell & Prater, 2010). Behavioural models based on hurricane evacuation data may be applicable to distant tsunami due to the similar availability of official warnings and lead-time of several hours or more. However, the short lead-time of local tsunami requires that we investigate behaviour in a different context, where the challenges of rapidly detecting tsunami and disseminating warnings preclude issuing official warnings ahead of tsunami arrival. In practice, natural and informal warnings are likely to be the predominant source of warnings in such a situation. Much of the evacuation behaviour data has been collected in the United States, which allows us to consider those findings appropriate to New Zealand in the broad cultural context, as the two countries share a similarly individualistic culture, although a complicating factor is the use of mandatory evacuation in some states, whereas in New Zealand evacuation may be advised but is not regulatory.

We conducted 136 face-to-face questionnaire surveys in Napier from Friday 1st March to Sunday 3rd March 2013. The survey focussed on assessing respondents' understanding of tsunami potential, expected wave arrival time and subsequent evacuation intentions, given a scenario of long or strong ground shaking at Napier. Intention data or 'stated preference' data are able to provide insight where a type of event occurs infrequently, precluding observation of actual behaviour. Context to this research is given by an overview of relevant evacuation decision-making and behaviour literature (Section 2). Description of the survey aims and methodology (Section 3) is followed by results and discussion of data analysis (Section 4). Data presented here will inform behavioural assumptions in tsunami evacuation simulations, inform tsunami education, and provide a focus for future social science research into tsunami evacuation in New Zealand.

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2.0 EVACUATION BEHAVIOUR

We use the term evacuation to mean short-term evacuation undertaken prior to impact with the aim of minimising losses due to the event, labelled ‘preventative evacuation’ by Perry et al. (1981). Evacuation is a complex and dynamic process and evacuation behaviour – the choices made and protective actions taken in an emergency or crisis – is influenced by situational, social and cultural contexts, environmental cues and warnings. Personal characteristics are important for recognition and interpretation of warnings, personalisation of risk, and decision-making. Substantial numbers of people choose not to evacuate or are unable to evacuate in disasters. Factors influencing non-evacuation in previous events may include: low personal risk perception due to previous experience, lack of belief in the hazard (Lindell & Perry, 1992); understanding of warnings (Gregg et al., 2006a); situational impediments such as mobility issues or separation from family (Lindell & Perry, 2012); logistical challenges (Lindell, Kang, & Prater, 2011); or lack of knowledge on available protective options (Burton, Kates, & White, 1978). Previously studied personal characteristics include age, gender, income, ethnicity, disability, composition of the household, presence of an adaptive plan, warning factors (source, content, clarity, consistency of message, number of warnings), risk perception, challenges of evacuation, previous experience of similar emergencies, and geographic location – all of which have been shown to have some degree of positive or negative influence on likelihood of evacuation (Dash & Gladwin, 2007 and references therein). Much of the available data on evacuation behaviour comes from US hurricanes (e.g. Lindell, Kang, & Prater, 2011; Lindell & Prater, 2007), undoubtedly owing to the frequency of hurricanes and ease of access to the study areas. Additional data comes from nuclear accidents in the United States (e.g. Urbanik, 1994, 2000).

There is limited discussion in the literature of the extent to which rate of evacuation is affected by receipt of a *mandatory* or *voluntary* evacuation order in the United States. Although these are used for hurricane, tsunami and wildfire, the most-studied is mandatory hurricane evacuation. The use of mandatory evacuations in hurricanes varies by state, with respect to the use of this term, the extent to which such an order is enforced, and by which agency (Wolshon, et al., 2005). Both types of order may be issued in the same event to different geographic areas and groups of people, based on level of hazard and whether they reside in a mobile home or a more substantial construction (Dash & Morrow, 2001). Mandatory evacuations do not necessarily result in complete compliance, and may even result in lower evacuation than for a voluntary evacuation order during the same event (Dash & Morrow, 2001). Mesa-Arango, et al. (2012) suggests that there is a greater correlation between stated preferences and actual behaviour when a mandatory evacuation has been issued, than for voluntary evacuations.

Following the globally significant tsunami of 2004 and 2011 and increased research on tsunami in the intervening years, tsunami evacuation behaviour has been more extensively studied but remains limited (Dash & Gladwin, 2007; Lindell & Prater, 2010). Several studies have described evacuation in the 2011 Great East Japan tsunami including evacuation (or non-evacuation) actions and timing (Yun & Hamada, 2012), use of vertical evacuation buildings (Fraser et al., 2012a) and evacuation rates and use of vehicles (Murakami & Kashiwabara, 2011). Mas et al. (2012) applied observed behaviours in testing an agent-based model of evacuation against observed evacuation rates. Several other international events have resulted in studies of behavioural response to tsunami (Bird, Chagué-Goff, & Gero, 2011; Gregg et al., 2006a; McAdoo et al., 2006; McAdoo, Moore, & Baumwoll, 2009; Okumura, Harada, & Kawata, 2011). In New Zealand, Walton & Lamb (2009) carried out an experimental study of intended post-earthquake travel behaviour and following the 2007 Gisborne earthquake conducted surveys to investigate actual travel behaviour (Lamb & Walton 2011). Several studies of evacuation behaviour have been carried out in the course of on-going research (Currie, et al., 2013; Dorfstaetter, 2012; Stewart et al., 2005) and following distant tsunami events (Rogers 2010; GNS Science unpublished data).

Evacuation decision-making factors, such as personal experience, perception of threats and protective actions, family context, environmental and social cues, have been incorporated previously into decision theory models to determine their relative importance in taking protective actions (Lindell & Perry, 2012; Perry et al., 1981) and to aid in estimating evacuation rates. Agent-based models have also become more commonplace in the study of tsunami evacuation (Goto et al., 2012; Johnstone, 2012; Mas, Adriano, & Koshimura, 2013; Mas et al., 2012). Agent-based models allow simulation of individual components (agents) within a system, each with a particular set of characteristics and rules governing their behaviour, the interactions between multiple agents and interactions between agents and the simulated environment (Crooks & Heppenstall, 2012). In the context of tsunami evacuation, agents represent individuals or family groups, each with a set of characteristics (e.g. physical, experiential) which determine the likely evacuation actions (and efficacy of those actions) they take in the event of a tsunami in their environment (modelled roads, buildings etc.). Therefore, prior knowledge about the influence of personal characteristics and experience on likely behaviours is essential to inform assumptions within the model. This behavioural data is something that has been poorly integrated into the assumptions used in many of these evacuation models (Lindell & Prater, 2007). The following sections provide background to several key behaviours that are explored in this study, to provide context to the results and discussion.

2.1 TSUNAMI WARNINGS AND RESPONSE

Environmental cues or natural phenomena have been observed prior to wave arrival in many previous tsunami. Japanese data from as early as 1896 and 1933 includes accounts of audible cues such as ‘continuous sound like a locomotive’ and ‘thunder-like’ sounds (Shuto, 1997). In Thailand the majority of people surveyed following the Indian Ocean tsunami reported seeing or hearing something unusual in the sea (Gregg et al., 2006a). Visible cues can, but do not always, include drawdown of the water at the coast, exposing the seabed or reefs prior to wave arrival, and other unusual wave activity such as a wall of water, a rapidly rising tide, large eddies, and frothing or ‘boiling’ of the sea surface. These phenomena can provide a natural warning of tsunami in the case of distant, regional and local tsunami as they are due to the mass movement of water occurring at any distance from the source event. In the case of local tsunami generated by an earthquake, ground shaking may also provide a natural warning due to the proximity of the epicentre to the coastline.

Although early earthquake warning systems exist in Japan and are able to provide a tsunami warning within three minutes (Japan Meteorological Agency, 2013), such technology has flaws which were exposed in March 2011, primarily the incorrect automatic estimation of wave heights and mis-communication of subsequent warning messages (Fraser et al, 2012b). Current technologies allow approximation of earthquake magnitude by the global seismic network almost immediately upon detection of ground shaking. However, the time required to refine source magnitude and mechanism in order to issue accurate tsunami warnings is too great to be applied effectively in a local tsunami.

Fixed position, tone-only tsunami siren systems have been installed in several regions of New Zealand[1] and further discussion is underway regarding siren installation (e.g. in Tauranga City) but such systems have flaws, which are particularly important to consider in the context of short tsunami arrival times. Aside from the potential for siren systems to fail due to power outages in a significant local earthquake, and the potential for false alarms[2], a major criticism of the warning provided by sirens (particularly tone-only sirens with no voice message) is that they do not deliver a specific, detailed message to the surrounding area (Leonard, Saunders, & Johnston, 2007). As a result, there is a period of time in which the public may hear the siren but not respond until they are sure of the meaning. In Napier, the council instructs people to listen to local radio for further information; the tsunami siren system in Auckland gives three different tones for 'threat of tsunami', 'immediate evacuation' and 'threat has passed' – the public are expected to interpret these in case of the siren sounding.

In order to make such siren systems effective, they must exist within the framework of an effective early warning system with, among other components, a public education component required to enhance awareness and understanding of the system (Leonard et al., 2008). Even with such a campaign, understanding of the siren may not be enhanced substantially. A tsunami siren system has been present in Hawai'i for several decades but Gregg, et al., (2006b) found that only 13% of the population understand the meaning of the siren, despite high awareness of sirens and siren tests. This level of understanding represents a small increase from 5% in 1960 (Lachman, Tatsuoka, & Bonk, 1961). The complexity of siren systems, requirement for multiple sirens to provide audible coverage to the entire community at risk (indoors and outdoors, in poor weather conditions including high winds and rain which can reduce the audible distance of a siren), and the requirement for redundancy in the system in case of power failure, result in significant installation and maintenance costs ranging from tens of thousands to millions of New Zealand dollars (Leonard et al, 2006; Leonard et al., 2007).

Hastings District Council (Hawke's Bay) and Wellington City have mobile sirens, to be driven in a vehicle around the coastline issuing voice messages in the event of tsunami. Although this method overcomes the issues of tone-only sirens for distant tsunami, these are not suitable for local tsunami as they require time to deploy the sirens and personnel to drive into the tsunami hazard zone to issue the warning. Given the current technological limitations of siren systems for local tsunami, it is important to understand the general population's awareness and interpretation of natural phenomena as warning of tsunami to inform tsunami education, and assumptions of how people in Napier would respond to a natural tsunami warning and try to improve this response mode in future.

Evacuation triggered by natural warnings has saved many lives in previous events (McAdoo et al., 2009; Yamori, 2013). In some cases, ground shaking has been felt but not interpreted as a warning of the subsequent tsunami, resulting in delayed or non-evacuation (Gregg et

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[1] Including Napier (http://www.napier.govt.nz/index.php?pid=234),
Northland Region (http://www.nrc.govt.nz/civildefence/tsunami/tsunami-sirens/),
Auckland (http://www.aucklandcouncil.govt.nz/en/environmentwaste/naturalhazardsemergencies/civilDefence/Pages/civil_defence_and_emergency_management_home.aspx), and Christchurch (http://www.ccc.govt.nz/homeliving/civildefence/informationondisastershazards/tsunami.aspx)

[2] In Whitianga, Thames-Coromandel District, several false alarms occurred in 2012 due to accidental triggering by a cleaner and a flat battery (www.stuff.co.nz/national/7223142/Whitianga-tsunami-siren-gets-unplugged)

al., 2006a; Murakami & Kashiwabara, 2011; Yun & Hamada, 2012). The importance of immediate evacuation is shown in the data from witnesses to the Tōhoku 2011 tsunami: 75% of people who did not evacuate (n=228) did not survive, whereas 73% of people who evacuated in less than 20 minutes (n=461) survived (Yun & Hamada, 2012). A person's belief that their current location was safe from tsunami, in part due to previous experience of earthquakes without subsequent tsunami, was a factor in producing a sense of safety (Yun & Hamada, 2012). However, it may also be extremely difficult for people to estimate, based on ground shaking alone, whether or not the source earthquake is located offshore and is severe enough to pose a tsunami risk. This is particularly true for long duration, low intensity 'tsunami earthquakes' (Kanamori, 1972) which are capable of causing devastating tsunami with little ground shaking to act as a warning, for example Java in 2006 (Reese et al., 2007). Initiation of evacuation in response to ground shaking in the Canterbury earthquakes was highly dependent on the actions of others rather than demographic factors or risk perception and hazard knowledge – 76% of people responded in the same way as neighbours in September 2010 and 98% did during the major aftershocks (Dorfstaetter, 2012). Individuals' reliance on others' behaviour was also reported in Japan, with 39.4% of people reported to have evacuated due to following other people's direction (Yun & Hamada, 2012).

Significant tsunami inundation has not occurred in New Zealand during recorded history. Consequently, there is little previous experience for coastal populations to draw upon, and previous data suggests a low evacuation response to natural warnings. Only 7.7% of people in a study of travel following an earthquake in Gisborne in 2007 travelled to higher ground to avoid a potential tsunami (Lamb & Walton, 2011). Following the September 2010 Canterbury earthquake only 21% of coastal residents evacuated in case of tsunami (Dorfstaetter, 2012). High levels of media coverage of recent international tsunami events may improve evacuation rates in the future, however, New Zealand presently largely relies on education to raise tsunami hazard awareness and preparedness in case of such an event. Tsunami education particularly emphasises the need for immediate evacuation in the case of long duration (lasting for a minute or more) or strong earthquakes (hard to stand up) (MCDEM, 2010, p. 9, See text box below). The Ministry of Civil Defence and Emergency Management (MCDEM) message is designed to include the potential for subduction zone events, tsunami earthquakes and upper plate ruptures – all of which can be tsunamigenic but are likely to cause a different style and intensity of shaking at a given location:

Special Consideration – Local Source Tsunamis

A tsunami generated in conjunction with a nearby large earthquake or undersea landslide may not provide sufficient time to implement official warning procedures.

Persons in coastal areas who:

- experience strong earthquakes (hard to stand up);
- experience weak earthquakes lasting for a minute or more;
- observe strange sea behaviour such as the sea level suddenly rising and falling, or hear the sea making loud and unusual noises or roaring like a jet engine;

should not wait for an official warning. Instead, let the natural signs be the warning. They must take immediate action to evacuate predetermined evacuation zones, or in the absence of predetermined evacuation zones, go to high ground or go inland.

2.2 THE HOUSEHOLD / FAMILY UNIT

Evacuation behaviour literature has repeatedly cited the importance of the household unit or family because household members attempt to reunite with, or at least account for, all members before evacuating together (Drabek, 1996; Lindell & Perry, 1992; Lindell & Perry, 2012; Perry et al., 1981). This has been shown to be the case for events with lead-times of several hours to days. Although there are fewer data for events with a shorter lead-time of less than one hour, there is anecdotal evidence (Fraser et al., 2012b) and survey data (Yun & Hamada, 2012) from the 2011 Great East Japan tsunami showing that parents travelled to collect children from schools and some families returned home to collect elderly relatives despite imminent tsunami arrival. Those actions resulted in additional deaths as inundation trapped people travelling through unsafe coastal areas following the earthquake and tsunami warnings. In an experimental investigation of post-earthquake intentions in New Zealand, Walton & Lamb (2009) found that around half of the people intending to travel from home or work after an earthquake would travel to reunite with friends or family. It is anticipated that the same actions could occur in New Zealand during a local tsunami, and therefore influence evacuation travel mode, routes and time, ultimately influencing the rate of successful evacuation.

2.3 PRE-EVACUATION ACTIONS AND DEPARTURE TIME

The time at which a person or group begins to evacuate, after receipt of a hazard warning, is closely associated with reception and understanding of an official, informal or natural warning and immediate actions taken. This 'pre-evacuation time' (Purser, 2010) is the first of the two time phases in evacuation and has two main behavioural components: *recognition*, which starts with the cue or warning and ends with the first response to the alarm; and *response*, which starts the first response and ends with person beginning to travel towards an exit or safe location. Response time can include gathering possessions, helping or warning others, investigating the emergency, and is affected by key behavioural factors such as alertness, familiarity with surroundings and warnings, previous experience or training, group interactions, and commitment to on-going activities. Pre-evacuation time is followed by the travel time, which is the subsequent time taken to reach safety. The two are additive to produce the overall evacuation time.

The importance of immediate evacuation was highlighted in Section 2.1.1. Yun & Hamada (2012) reported that the most common pre-evacuation actions taken by people who died in the 2011 Japan tsunami as: helping others (22.4%), finding family or relatives (9.7%) and doing rescue work (13.9%). Intention surveys in Wellington suggest that over 30% of respondents would evacuate immediately in case of an earthquake, and 22% would help others (Currie et al., 2013).

The use of stated intentions to estimate approximate evacuation departure times can provide some insight in the absence of observations of actual evacuation behaviour in real events, but there is the potential to underestimate departure if we rely on this alone. Mas et al. (2012) showed that there was greater correlation between tsunami wave arrival time and actual evacuation departure time ('revealed preference') given in six post-tsunami surveys than there was between 'stated preference' evacuation departure time and a given hypothetical arrival time. To address this issue in modelling, they implement departure time as a Rayleigh distribution with intended departure time as a lower bound and tsunami wave arrival as an upper bound. Kang et al. (2007) showed that the reliability of people's estimates of time required to carry out pre-evacuation actions is determined by the nature of the action, particularly whether it is a usual, repetitive action.

2.4 TRAVEL MODE AND DESTINATION

Travel mode is a key aspect of evacuation planning as it characterises how quickly and at what density people can travel through a transport network. The evacuation behaviour literature suggests that private vehicles are the primary travel mode during evacuation (Lindell et al., 2011; Lindell, 2008; Perry et al., 1981). Lindell (2008) directly relates the proportion of evacuating households in an area who have access to a private vehicle, to the number of vehicles involved in an evacuation (for transients this is based on number of hotel rooms, assuming one vehicle per room). Familiarity with a transport route and expectations of travel time, safety and convenience influences hurricane evacuation route choice, with evacuees taking the routes that are most familiar to them (Lindell et al., 2011). Due to the short lead-time of local tsunami, traffic congestion in the inundation zone can result in loss of life and the potential for congestion can be exacerbated by damage and disruption to evacuation routes during the prior earthquake ground shaking. A study of witness data suggests that 26% of people who died in in the 2011 tsunami were caught in traffic jams (Yun & Hamada, 2012).

The assumption that everyone choosing to evacuate will use a vehicle may be appropriate for long lead-time, long distance evacuations but may not be appropriate in the context of local tsunami where available travel time and distance are shorter. Having said that, a survey of evacuation intentions in the Sendai Plains area of Miyagi, Japan, revealed that 80% of those intending to evacuate inland ahead of a tsunami (n=215) and 38% of those intending to travel to an evacuation building (n=93) would use a car (Suzuki & Imamura, 2005). In 2011, the tsunami warnings prompted 60% of evacuees to use vehicles in this area, with the level of vehicle use influenced by high daily use of vehicles (Murakami & Kashiwabara, 2011). Walton & Lamb (2009) reported that hypothetical travel distance influenced intended travel mode in a survey of post-earthquake evacuation intentions. The frequency with which people reported intentions to drive a vehicle increased with increasing distance, and vice versa for intended pedestrian evacuation. Based on the log-trend of reported frequencies, vehicles were preferred for travelling distances 3.25 km and over. The distance factor may also contribute to the variation in travel mode according to destination reported by Suzuki & Imamura (2005).

New Zealand has a high rate of vehicle ownership, which suggests that there is high daily vehicle use, and therefore there is likely to be a high-use of vehicles during evacuation. This was borne out by Lamb & Walton (2011) who showed that 95% of trips made immediately following the 2007 Gisborne earthquake were made by vehicle. Sixty percent of Papamoa residents reported that their intended evacuation travel mode following a tsunami warning in 2010 had been to drive, while 25% intended to walk and 8% intended to cycle (Rogers, 2010). Recent education and media coverage of the 2011 Japan tsunami may have acted to raise awareness of traffic congestion during tsunami evacuation, therefore reducing the intended levels of vehicle use. A recent survey in Wellington suggested that over 40% of respondents intend to evacuate on foot (Currie et al., 2013). Local topography and urban density are likely factors in the rate of those intending to walk versus drive as they influence distance to high ground, road layout and network capacity, local transportation trends and the presence of additional pedestrian-only tracks and trails. For example, in Hawke's Bay Region 11% of all journey legs travelled are pedestrian, compared to 18% in Gisborne and 25% in Wellington (Statistics New Zealand, 2013b). In Wellington and Kapiti urban area 16%

of journeys are made by public transport with or without walking, and 11% are pedestrian journeys (Statistics New Zealand, 2013c). These are higher than the New Zealand average for urban areas[3] (4% and 6%, respectively), therefore, the expectation is that in a daytime evacuation in Wellington the proportion of the local population having access to a vehicle in the urban area would be lower than in other areas so a greater proportion would opt to evacuate on foot.

Recognition that high ground provides safety from tsunami was reported to be very high (90%) in New Zealand in the 2003 National Coastal Survey (Stewart et al., 2005). We expect that due to the topography of Napier and the recognition that high ground provides safety, Bluff Hill (as the closest high ground to the city centre) will be a primary evacuation destination. However, as already noted in Section 2.1 very few people actually went to high ground following the 2007 Gisborne earthquake, so recognition of the appropriate action is not always acted upon.

2.5 TRANSIENT POPULATIONS

Transient populations (e.g. tourists, temporary workers), have long been neglected in studies of evacuation behaviour and warnings (Quarantelli, 1960; Sorensen, Vogt, & Mileti, 1987). This remains true for vulnerable populations in general, not just transient populations (Drabek, 1994; Phillips & Morrow, 2007) and has been reported internationally (Becken & Hughey, 2013). There are complex dynamics in the evacuation of transient populations. The national guidelines for mass evacuation planning in New Zealand (MCDEM, 2008) outline some of the perceived challenges in evacuation of tourists and reasons why they are classified as a vulnerable population, as: "[tourist] numbers are variable and imprecise"; "tourists do not know the local area" ; and "they are likely not to know how to evacuate or where to access help".

On the other hand, evacuation logistics may be simpler for transient populations than resident families, as they have fewer possessions or property to protect (Lindell & Prater, 2007; Lindell, 2008). This benefit may be more relevant for slow-onset events rather than rapid-onset events where there is less focus on property protection than immediate life preservation. Evacuation intention data from hypothetical tsunami scenarios in Thailand (Charnkol & Tanaboriboon, 2006) and U.S. hurricane data (Drabek, 1996) suggests that transient populations were likely to evacuate faster than permanent residents; Charnkol & Tanaboriboon (2006) suggest that this is due to the reticence of residents to leave their homes.

Direct warning from accommodation staff to guests may expedite the response of visitors (Drabek, 1996), as occurred in Western Samoa (EEFIT, 2009). However, this could apply to confirmation of natural warnings in a local tsunami scenario, but this relies on adequate levels of hazard awareness and prior training of staff and the complex and sometimes conflicted evacuation decision-making of staff (Drabek, 1994). Disparate levels of tsunami preparedness between residents and visitors were observed in Ocean Shores, Washington, U.S. (Johnston et al., 2007), and Long Beach, Washington (Johnston et al., 2009) where levels of preparedness and staff training were found to be low despite moderate to high levels of awareness among residents. There is a concern that a disparity between visitors'

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[3] Includes: Auckland main urban area (MUA), Christchurch MUA, Dunedin MUA, Hamilton Zone, Tauranga MUA and Wellington (+ Kapiti). Data for Gisborne and Napier are not available at this resolution.

and residents' awareness of the tsunami hazard and appropriate response actions could be present in New Zealand coastal areas. Becker et al. (2013) found that "there appears to be little or no outreach when it comes to educating visitors regarding the risks in Hawke's Bay Region" and tourism operators are not well integrated with Civil Defence and Emergency Management (CDEM) activities in the Northland Region of New Zealand (Becken & Hughey, 2013).

3.0 SURVEY METHOD

3.1 AIMS

The survey was carried out to collect Napier residents' and visitors' intended, or 'stated preference', evacuation behaviour in the context of local tsunami. This data was collected in lieu of behavioural observations collected during or after a real event, which is the preferred method of data collection (Lindell & Prater, 2010). 'Stated preference' surveys have been used to inform evacuation assumptions in several recent studies of evacuation behaviour (Solís, Thomas & Letson, 2010; Mas et al., 2012). Whitehead (2005) demonstrated that intention data have some degree of predictive validity for hurricane evacuation behaviour and Kang et al. (2007) demonstrated, for some aspects of behaviour, correlation between expectations and actions actually taken when an event occurred. There appears to be a greater correlation between intended and actual evacuation behaviour where there has been prior experience of an event, for behaviour of a repetitive nature, or for behaviours that are based on a dichotomous choice, i.e. to evacuate or not to evacuate (Kang et al., 2007). Further research is required to strengthen the validity of this approach, but research to date shows good agreement at the aggregate data level (proportions citing intended behaviours) (Kang et al., 2007), which is the main focus for this study.

Within our overall aim of enhancing knowledge of tsunami evacuation behaviour in New Zealand, we explore awareness of the local tsunami hazard and recognition of natural warnings of tsunami. We establish the range of actions that people intend to take prior to evacuating, in order to inform modelled pre-evacuation behaviour and calibrate estimates of pre-evacuation time for simulation. We investigate intended congregation behaviour of family units to assess the extent to which this might be observed during a local tsunami in Napier. This can inform education regarding the dangers of travelling through tsunami hazard zones and facilitate inclusion of such actions in evacuation simulations and planning initiatives.

We identify preferred travel modes and destinations, hypothesising that these would vary according to the location in Napier at which people experience a local earthquake, due to distance to high ground, proximity of family, and availability of resources. Increased understanding of intended evacuation destinations can inform community engagement and planning for evacuation routes and emergency response. We include visitors in our survey to investigate comparative levels of tsunami hazard awareness and differences in intended response actions between residents and visitors. This represents the first study of visitors' tsunami evacuation intentions in New Zealand, and aside from informing evacuation simulations, will help to develop a knowledge base for more extensive research on this issue. This study does not extend to evacuation behaviour of tourist industry staff, nor does it investigate interactions between industry staff and guests.

3.2 SURVEY STRUCTURE

The survey used a combination of closed-response and open-ended questions to capture hazard awareness and behavioural intention data. Survey questions were piloted by a group of GNS Science summer students (Currie et al., 2013) in the Greater Wellington region and tested with a number of GNS Science staff prior to implementation. The written survey is presented in Appendix 1. Appendix 2 shows a copy of the information sheet that was offered to respondents following completion of the survey providing further information on the issues raised during the survey.

The survey captured details of the respondent's status as a *resident* of Napier, a visitor from the Hawke's Bay Region (hereafter, *regional visitor*), from elsewhere in New Zealand (*national visitor*) or from overseas (*international visitor*) and their recollection of receiving hazards information in Napier. The key part of the survey was an investigation of respondents' tsunami hazard awareness, types of tsunami warning and estimates of arrival times given an official warning or a natural warning, and intended evacuation behaviour in a local tsunami. To achieve this, two scenarios were presented – each framed by the experience of long or strong ground shaking, defined as 'ground shaking lasting longer than a minute or during which it was hard to stand up'. The first scenario required that the respondent consider they were undertaking the same activity at the same location as when the survey was conducted (hereafter, 'survey location'); the second scenario was for the respondent being at home (if *resident* or *regional visitor*) or at their temporary accommodation in Napier (if *national* or *international visitor*). In each case, respondents were asked to describe their actions during and after ground shaking. If they failed to mention evacuation, they were prompted as to whether they would evacuate, and this prompt was noted on the survey. If they stated that they would not evacuate, the reasons for this were solicited. If evacuation was stated (either prompted or unprompted), we asked how long after the earthquake they would evacuate and what, if anything, they would do before evacuating. We also asked where they would evacuate to and by what travel mode.

The survey concluded with an investigation of opinions about using tsunami vertical evacuation buildings. These were open-ended in order to solicit un-prompted responses and act as pilot questions for later surveys which may focus more closely on this issue. We first asked respondents to provide all of the types of places they could think they could evacuate to if a tsunami was imminent, to see if the concept of evacuation into buildings occurred to them independently. We then asked how respondents would feel about evacuating into a building in a tsunami, and what might particularly encourage or discourage them from taking this course of action.

3.3 SAMPLING METHOD

Surveys were conducted by convenience sampling at several locations in Napier from Friday 1st to Sunday 3rd March 2013 inclusive. Convenience sampling was applied in order to solicit qualitative responses and data specific to peoples' actions at the survey locations, which were selected on the basis of having high levels of day-time foot-traffic. These high-traffic locations are the locations with high population concentrations during a usual day-time in Napier and are likely to have a high population exposure during a tsunami occurring in the daytime. As the focus of the survey was to understand people's intended actions when in the city at the time of an event, the study benefited from face-to-face interviewing at the location of interest, rather than providing scenarios in written form using a postal survey. As a non-probability sample, it is not possible to know the relationship between our sample and the entire population (Bryman, 2012), therefore this method precludes extrapolation of data to the entire population and it is not valid to estimate a margin of error. Despite these limitations, the sample remains useful to gain preliminary understanding of intended evacuation behaviour, and as a basis to develop a series of subsequent probability-sample surveys in Napier and elsewhere in New Zealand.

There is a certain amount of self-selection in our sample (the sample only includes those who frequented the survey locations on the survey days) and systematic exclusion of some sections of the population who do not frequent the survey locations, for example, due to health or socio-economic reasons. In order to minimise further bias in the convenience sample we recruited respondents in an unbiased manner by approaching every individual or small group who passed on the street while we were not actively interviewing a respondent. We did not record the rate of participation. To ensure our sample was as representative as possible of the people who frequent the city at different times, we surveyed in several different locations and throughout the day on one week-day and two weekend days, one of which was a busy market day.

The total number of surveys carried out was 136, comprising 97 *residents* of Napier Territorial Authority and 39 *visitors* (10 *regional*, 14 *national*, 15 *international*). One survey was incomplete (only questions 1 to 6 were answered), therefore was used in analysis of hazard awareness, but excluded from analysis of evacuation intentions. The majority of surveys (78%) were conducted in the city centre main shopping area on Emerson Street and the surrounding streets. Further surveys were conducted at Marewa shopping centre (9%), Ahuriri marina (6%) and Westshore Beach (7%) to investigate intended behavioural responses at different locations (see Figure 1).

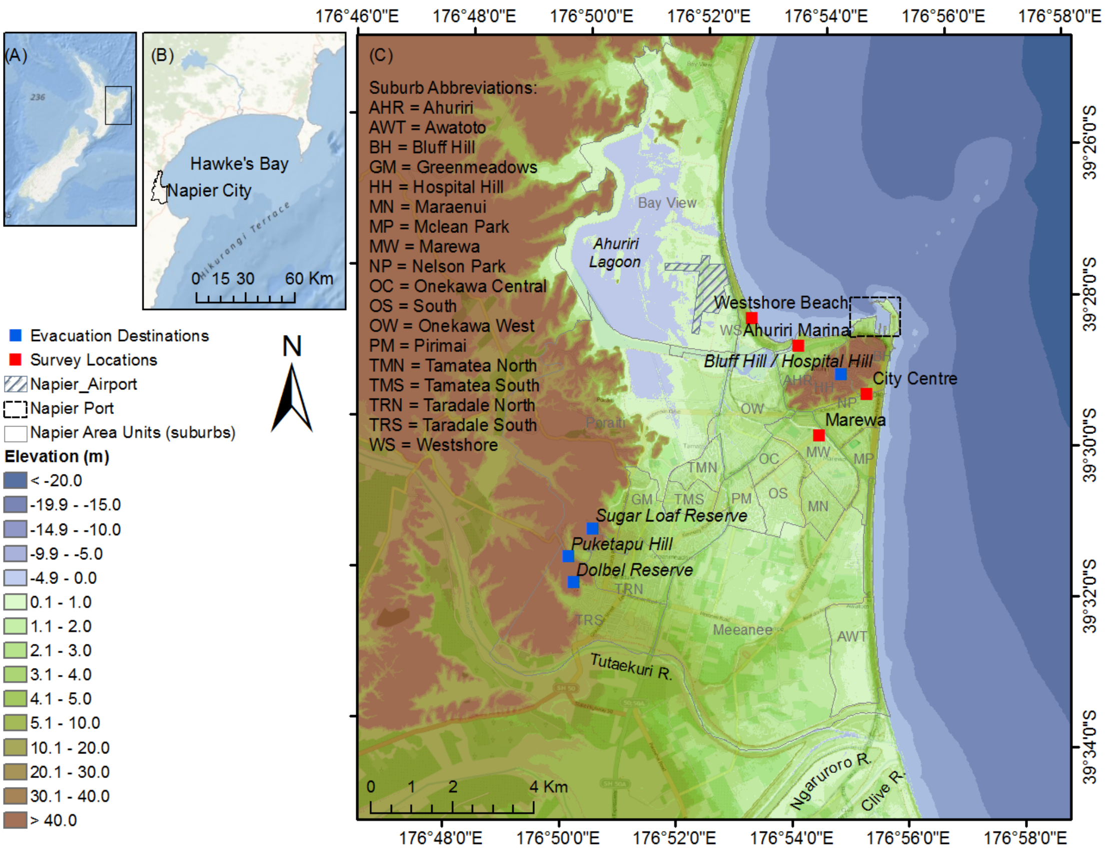

Figure 1 **A)** Location of Hawke's Bay on a national scale; **B)** Location of Napier Territorial Authority in the context of Hawke's/ Bay; **C)** Napier Territorial Authority boundary overlain on a Digital Elevation Model (DEM) to illustrate local topography; **D)** Map of survey locations and evacuation destinations overlain on the DEM and road network. Basemap sources: GEBCO, NOAA, National Geographic, DeLorme, and Esri; OpenStreetMap and contributors, Creative Commons-Share Alike License (CC-BY-SA).

3.4 STUDY AREA AND DEMOGRAPHICS

Napier Territorial Authority (hereafter, Napier) is a generally low-elevation coastal area of 106 km^2, comprising residential suburbs, commercial and industrial areas and agricultural land including orchards and vineyards. Bluff Hill provides an area of high ground immediately north of the city centre to maximum elevation over 100 m. Napier Port is the fourth largest in New Zealand, handling cargo including forestry products and container shipments, with storage of timber and containers on site (Port of Napier Limited, 2012). The estimated population of Napier in 2013 is 57,800 based on medium growth projections from the most recent census in 2006 (Statistics New Zealand, 2013a). During peak tourist season (January to March), an average of 2,342 *visitors* stay in Napier accommodation every night (2006-2011 data; Statistics New Zealand, 2012). Numerous accommodation facilities (59), schools (34, plus one tertiary education campus), early childhood centres (64) and care homes or retirement villages (17) form concentrations of people who may be less able to evacuate effectively in a local earthquake and tsunami due to mobility issues or deficiency in local knowledge.

At the eastern shore of the city there is a steep gravel beach and berm stretching along the coastline south from Bluff Hill, where it is approximately 7 m above Mean Sea Level (MSL) to the confluence of the Tutaekuri, Ngaruroro and Clive Rivers, where it is 4 m above MSL. Northwest of Bluff Hill the suburbs of Ahuriri and Westshore are separated by a tidal inlet and small marina. Westshore is situated on a peninsula elevated 4-6 m above MSL. Bay View is the most northern suburb of Napier, extending north around the bay. Much of the land around the present Ahuriri Lagoon was previously below sea level until uplift during the 1931 Hawke's Bay earthquake and due to artificial drainage in the years since (Hull, 1986).

The 1931 Hawke's Bay earthquake destroyed many of the buildings in Napier and triggered a rebuild in 1930s Art Deco style. The current building stock retains a large number of one- and two-storey 1930s structures, which are an important factor in the city's tourism activities. Ninety-five percent of the building stock in Napier is one or two storeys in height (Figure 2). Ninety-two percent of structures are of light timber construction, 3% are reinforced concrete shear wall and 3% are concrete masonry (Cousins, 2009; King & Bell, 2009; King et al., 2008). The remainder are Brick Masonry, Light Industrial, Reinforced Concrete Moment Resisting Frame, Steel Braced Frame, Steel Moment Resisting Frame, or Tilt-up Panel construction. The small number of tall buildings in Napier has implications for tsunami evacuation. The suburban building stock primarily comprises single-storey family homes or small commercial premises and the only concentration of taller buildings occurs in the primary retail, tourist and civic area of Nelson Park.

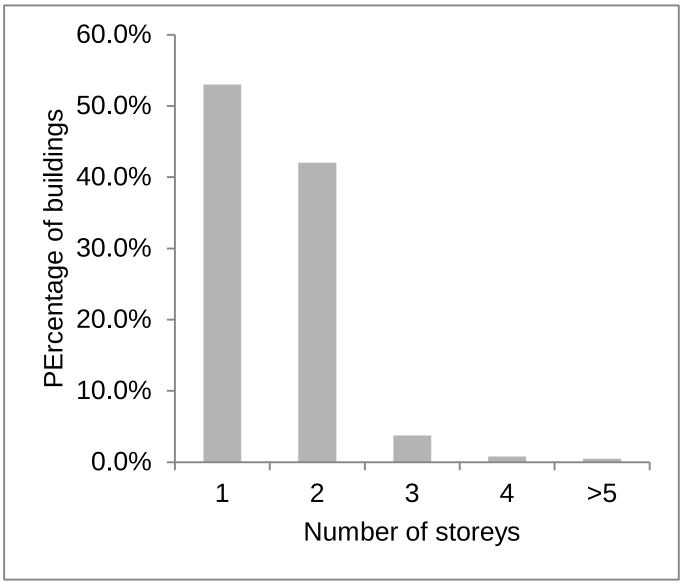

Figure 2 Heights of buildings in Napier, assuming that one storey is approximately 3 m in height. Data source: Napier City Council.

We compared the demographics of the resident portion of our sample (71%; Table 1) with that of the estimated 2013 population in Napier. We present the demographics of *visitors* (29%) but available visitor statistics do not allow comparison to assess sample bias. Our sample represents age distribution of the population of Napier very well (Table 2), slightly over-represents females (Table 3) and slightly under represents Maori but otherwise represents ethnicity relatively well (Table 4). Highest level of education (Table 5) significantly under-represents people with no qualification or a trade qualification and over-represents those with school, undergraduate or postgraduate qualifications. Neither Territorial Authority nor regional census data is available for comparison of household income (Table 6) and length of time living in Napier (Table 7).

Table 1 Residential status of respondents. *Residents* are classed as those living in Napier Territorial Authority. *Visitors* are separated into those from Hawke's Bay, those from the rest of New Zealand and those from overseas. Percent values may not sum to 100% due to rounding.

Residential status	Total (n=136)
Resident: Napier Territorial Authority	71%
Regional visitor	7%
National visitor	10%
International visitor	11%

Table 2 Distribution of age group in the survey sample and the Subnational Population Estimates: At 30 June 2012 (SNPE; http://www.stats.govt.nz/browse_for_stats/population/estimates_and_projections/). *Age group shows 16-39, while the SPE original data showed 15-39. SNPE data for ages <15 are omitted from the total. Percent values may not sum to 100% due to rounding.

Broad Age Group	Survey *residents* (n=97)	Survey *visitors* (n=39)	Survey total (n=136)	Napier subnational population estimates (n=46,100)
16-39*	35%	28%	33%	36%
40-64	44%	46%	45%	41%
65 and over	19%	18%	18%	22%
Not provided	2%	8%	4%	n/a

Table 3 Distribution of gender within the survey sample and the 2006 census data for Napier City, excluding people under the age of 15. Source: http://www.stats.govt.nz/Census/about-2006-census/regional-summary-tables.aspx. Percent values may not sum to 100% due to rounding.

Gender	Resident (n=97)	Visitor (n=39)	Total (n=136)	Napier 2006 census (n=43,650)
Male	42%	59%	47%	42%
Female	58%	39%	52%	58%
Not Provided	0%	3%	1%	0%

Table 4 Distribution of ethnicity within the survey sample and the 2006 census data for Napier City. *For the census, people stating multiple ethnic groups are included in as many groups as they list, so one person listing their ethnic group as European and Maori is counted once in each of the separate groups. All ages are included in the census totals as the data does not allow exclusion of people under the age of 16. Source: http://www.stats.govt.nz/Census/about-2006-census/regional-summary-tables.aspx. Percent values may not sum to 100% due to rounding.

Ethnicity	Resident (n=97)	Visitor (n=39)	Total (n=136)	Napier 2006 census (n=53,970)
European / NZ European / Pakeha	71%	85%	75%	72%
Maori	11%	5%	10%	18%
New Zealander	7%	3%	6%	14%
Asian	2%	5%	3%	3%
European and Maori	3%	0%	2%	n/a *
Pacific Islands	1%	0%	1%	3%
Latin American	1%	0%	1%	0%
Other	1%	0%	1%	0%
Not Provided	2%	3%	2%	n/a

Table 5 Distribution of highest level of education within the survey sample. *Trade qualification includes Level 1, 2, 3, 4, Certificates gained post-school; Undergraduate includes Level 5 and 6 Diplomas, Bachelor degree and Level 7 qualifications. Source: http://www.stats.govt.nz/Census/about-2006-census/regional-summary-tables.aspx. Percent values may not sum to 100% due to rounding.

Highest Level of Education	Resident (n=97)	Visitor (n=39)	Total (n=136)	Napier 2006 census (n=43,647)*
None	0%	3%	1%	27%
School	39%	36%	38%	30%
Trade Qualification	10%	5%	9%	15%
Undergraduate	34%	36%	35%	16%
Postgraduate	9%	13%	10%	2%
Other	2%	0%	2%	0%
Not Provided	5%	8%	6%	10%

Table 6 Distribution of household income within the survey sample. Household income statistics are not available at the Territorial Authority or regional level for the 2006 census or more recently. Percent values may not sum to 100% due to rounding.

Household Income (banded)	Resident (n=97)	Visitor (n=39)	Total (n=136)
Benefit	2%	0%	2%
Under $20,000	10%	13%	11%
$20,001-$30,000	7%	8%	7%
$30,001-$50,000	12%	3%	10%
$50,001-$70,000	21%	13%	18%
$70,001-$100,000	9%	10%	10%
Over $100,001	13%	28%	18%
Not Provided	25%	26%	25%

Table 7 Length of time *residents* have lived in Napier. Percent values may not sum to 100% due to rounding.

Length of residence in Napier	Total (n=97)
Less than 1 year	10%
1 to 5 years	21%
6 to 10 years	10%
11 to 20 years	20%
21 to 30 years	16%
31 to 40 years	8%
Greater than 40 years	16%

3.5 DATA ANALYSIS

We apply a thematic analysis approach to analyse survey responses at a semantic level (Braun & Clarke, 2006), in that we focus on coding and reporting the explicit meaning of responses to develop knowledge of evacuation intentions, without interpreting social or psychological influences on those responses. Data were coded manually and analysed using IBM® SPSS Statistics® version 20. Our coding is theoretically driven, shaped by previous findings in the evacuation behaviour literature, which formed expectations of intended behaviour and informed the development of research and survey questions. Due to the relatively short responses to each open-ended question we assigned codes using the full response rather than an excerpt of the response. We coded responses to each open-ended question into common themes before reviewing, refining and editing the themes. In many cases, a response was coded into several themes. Initially, some themes comprised a single response but after reviewing the themes, these were grouped under ‘Other’. Noteworthy responses grouped under ‘Other’ are reported in our results.

We conducted frequency analysis to determine the most commonly reported intentions and cross-tabulation to assess the correlation of evacuation intentions with demographic variables. Statistical analysis and correlation with demographics have been conducted where the sample size was sufficient. Analysis of survey responses primarily focussed on the respondents’ gender and status as *resident* or *visitor*. Due to low numbers of respondents of non-European ethnicity, the influence of ethnicity has not been analysed. Several demographic variables have been grouped to facilitate analysis of those demographics. These are: Household income (grouped to: under $30,000, $30,001-$70,000, $70,001-$100,000, >$100,001); Education (School and trade qualification, undergraduate and postgraduate); Length of residence (<5 years, 6 to 20 years, 21 to 40 years, >40 years).

4.0 RESULTS AND DISCUSSION

4.1 HAZARDS INFORMATION IN NAPIER

4.1.1 Receipt of hazards information in Napier

Public education is a key component of raising awareness of natural hazards, encouraging household preparation and increasing community resilience. Various channels of information are used, from information in telephone books and newspapers, community meetings, online and social media campaigns, and the MCDEM Shakeout national earthquake exercise. We asked a series of questions designed to investigate the level to which *residents* of Napier and *visitors* to Napier recall previously receiving information about natural hazards in Napier. We also enquired as to the source and format of that information in order to provide feedback to authorities about which types of information are most commonly received and recalled.

The majority (71%) of the total number of *residents* in our sample (n=97) recalled previously receiving information about natural hazards. This represents good progress since the 2003 National Coastal Survey, in which only 30% reported having seen tsunami information (Stewart et al., 2005). There was no gender influence on receipt of information. Amongst *visitors*, the proportion of respondents who recalled receiving information was lower (60% for *regional visitors*, 50% for *national visitors* and 47% for *international visitors*). The difference in receipt of information between *residents* and *visitors* (combined) is statistically significant (p=0.04 at 95% confidence interval) using the Fisher Exact test with Freeman-Halton extension, and confirms that *visitors* are likely to receive less local hazard information than *residents*. The *visitor* sub-samples are too small to analyse according to visitors' origin.

There did not appear to be a strong correlation between *residents*' receipt of information and *residents*' age or highest level of education. There was some correlation between length of residency and information receipt, and household income and information receipt. Fifty-three percent of people resident for five or fewer years recall receiving hazards information; 80% for 6-10 years, 21-30 years and >40 years, 68% for 11-20 years; and 100% for 31-40 years. Sixty percent and 55% of *residents* in household income categories $50,001-$70,000 and $70,001-$100,000 reported having received information, but for all other categories (three lower, one higher) this proportion is 75% to 86%. Further analysis of receipt of information among *residents* revealed no statistical relationship between receipt of information and age (Fisher Exact Test at 5% significance and 95% confidence interval: p=0.078), gender (p=0.553), length of residence in Napier (p=0.084), highest level of education (p=0.420), household income (p=0.873) or ethnic group (p=0.304).

4.1.2 Source of hazard information

The most-quoted source of hazards information among *residents* who recalled receiving information (n=69) was 'Civil Defence' (32%), 'Council' (19%) and 'Radio, TV or media' (15%). Other sources quoted were: 'newspapers' (n=3), 'work' (2), 'school' (2), 'siren tests or previous warnings' (2), 'New Zealand Earthquake Commission (EQC)' (2), 'New Zealand ShakeOut'[4] (1), and 'information at the museum or aquarium' (2). Few *visitors* who recalled receiving information (n=20) were able to elaborate on the source of any previous information they had received, however, two *regional visitors* recalled the source as 'Civil Defence', one *international and one national visitor* quoted 'guidebooks' and one *international visitor* received information on their 'cruise ship'.

Further clarity on the source of information was provided when we asked the question '*how was the information provided*'. There appears to have been some confusion in these questions between the use of 'source' (intended to mean 'who provided the information'), and 'how' (intended to mean 'the format of information received'), which will be revised in further surveys. Of those *residents* who recalled receiving information (n=69), the most common format was 'TV/Radio' (45%), 'newspaper' (32%), 'brochures or leaflets' (17%), through 'work or school' (16%) and 'mail-drop' (10%). Other formats reported by *residents* include: 'informal or conversational' (n=6), 'telephone book' (5), 'siren test or previous warnings' (4), 'tourist industry' including heritage signs and publicity of the 1931 earthquake through Art Deco Week[5] (4), 'council website' (2), 'signs' (2), 'community meetings' (1), and 'previous experience' (1). Among *visitors* who recalled receiving information (n=20), the most common formats were 'TV/Radio' (25%), 'informal/conversational' (25%), 'brochures or leaflets' (15%), 'signs' (15%) and 'books or guidebooks' (15%). This small sample suggests further differences in receipt of information based on a visitor's home location. The most commonly-cited format for *international visitors* (n=7) was 'guidebooks' (43%), for *national visitors (n=7)* it was 'signs', 'TV or radio' and 'informal or conversational' (each 29%) and regional visitors (n=6) it was 'TV or radio' (50%).

In summary, the majority of *residents* recalled receiving hazards information, and most reported receiving this via 'TV/Radio' or 'newspaper' media. A wide range of other information formats were recalled but by far fewer respondents. A moderate proportion of *visitors* recalled receiving information and there was only one report of receiving information from tourist industry staff. This data is encouraging in that there is a high rate of *residents* receiving hazard information. This also provides a basis for more detailed investigation of the extent to which local hazards information is delivered to *visitors* and the formats being used, in order to improve communication of hazards information to this group in the future.

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[4] New Zealand ShakeOut was the first nationwide earthquake drill to take place in any country. The first NZ ShakeOut took place on 26 September 2012, organised by MCDEM and preceded by a national public information campaign to encourage individuals, organisations and communities to participate (http://www.shakeout.govt.nz/)

[5] Art Deco Week takes place in Napier annually in February to celebrate the Art Deco architecture of Napier – a result of rebuilding after the 1931 earthquake (http://www.artdeconapier.com/)

4.2 TSUNAMI HAZARD AWARENESS AND UNDERSTANDING

Despite increasing tsunami education and media coverage of tsunami since 2004 we have concerns that although people are aware of the tsunami hazard in New Zealand, there is confusion around the different warnings for local, regional and distant tsunami as defined by travel time. This is particularly true of the role and function of tsunami warning sirens. Therefore, we use the survey to investigate hazard awareness and understanding of tsunami warnings.

4.2.1 Hazard awareness

Respondents recognised that several natural hazards, from a list that was read to them, could affect Napier (Table 8). 'Earthquake' (98%) and 'tsunami' (93%) are the hazards most cited by *residents* (n=97), ranking higher than any of the other hazards. 'Storm', 'river flood' and 'landslide' were each cited by between 74% and 76% of *residents*, with 'wildfire' cited by 30%. The same relative trend between hazards was observed in *visitors*' responses, although the rate of recognition was lower in each case, including: 87% for 'earthquake' and 82% for 'tsunami'.

Table 8 Percentage of respondents who believed each hazard has the potential to cause damage or casualties at Napier.

Status	Earthquake	Tsunami	Land-slide	Storm	Flood	Wild-fire	Don't know
Resident (n=97)	98%	93%	75%	74%	76%	30%	0%
Visitor (n=39)	87%	82%	51%	51%	41%	23%	3%
Total (n=136)	**95%**	**90%**	**68%**	**68%**	**66%**	**28%**	**1%**

There was a strong correlation between recognition of both earthquake and tsunami as local hazards: *residents* (92%), *regional visitors* (90%) and *national visitors* (93%) believed both earthquake and tsunami could affect Napier (Table 9). There were more varied responses from *international visitors,* 42% of whom believed both hazards could affect Napier, reflecting a lower level of local hazards knowledge, as expected.

Table 9 Percentage of *residents* and *visitors* regarding earthquake and / or tsunami as hazards in Napier.

Status	Earthquake	Tsunami	
		Yes	No
Residents (n=97)	Yes	92%	6%
	No	1%	1%
Regional Visitors (n=10)	Yes	90%	10%
	No	0%	0%
National Visitors (n=14)	Yes	93%	0%
	No	7%	0%
International Visitors (n=15)	Yes	47%	27%
	No	13%	13%

While the recognition of both earthquake and tsunami as hazards at Napier is high, it is important to explore the understanding of the relationship between these hazards. There was a high level of recognition that tsunami is possible after experiencing ground shaking in Napier (Table 10). Eighty-eight percent of *residents*, 95% of *regional* and *national visitors* (combined) and 57% of *international visitors* said that a tsunami would be possible after ground shaking. *Residents*' responses displayed some difference between males and females, with 95% of females but only 78% of males believing that a tsunami is possible after ground shaking. The reason for this disparity has not been explored as it requires a larger sample to allow cross-tabulation across all demographics. These results suggest that people are aware of the potential for tsunami following a local earthquake. However, results of open-ended questions discussed in the following section show that this does not necessarily translate into understanding that the earthquake is a warning of tsunami.

Table 10 Respondents' opinions on whether a tsunami might be possible after long or strong ground shaking at Napier.

Status	Gender	Yes	No	Don't Know
Resident	Male (n=41)	78%	20%	2%
	Female (n=56)	95%	4%	2%
	Total (n=97)	88%	10%	2%
Visitor	Male (n=22)	82%	5%	14%
	Female (n=14)	79%	14%	7%
	Total (n=36)	81%	8%	11%
Total (n=133)		**86%**	**10%**	**5%**

4.2.2 Understanding of tsunami warnings

Respondents were asked to provide responses to the open-ended question *'What would warn you of a potential tsunami in Napier?'* and were prompted to provide as many responses as possible. Contrary to the well-recognised link between earthquake and tsunami in the previous section, the percentage of respondents considering 'earthquake' (17%) as warning of tsunami is low in comparison to the percentage of respondents citing 'sirens' (67%) and/or 'TV or radio' (65%) as a potential tsunami warning (Table 11). This is also true of 'tidal changes or seeing waves' (13%) and there was no mention of unusual sounds from the sea. Fourteen percent of respondents cited 'public reaction' or 'hearing by word of mouth from family or friends', while 13% would expect a warning via 'social media' or 'cell-phone' alerts. A greater proportion of *visitors* cited natural warnings than *residents* ('earthquake': 23% and 14% respectively; 'tidal changes or seeing waves': 15% and 11%) with little variation due to *visitors*' home location. Other responses included hearing from 'school', being 'contacted by work' and 'seeing ships moving out of port into deep water'.

These results reaffirm our concern that many people expect to rely on tsunami sirens as a warning rather than reacting to natural warnings and that there is a disconnect between people's high level of hazard knowledge and their warning expectations. Our findings replicate those of an earlier survey of New Zealand coastal communities following the Chile 2010 tsunami (GNS Science unpublished data), which indicated that:

- Although 60-70% of respondents believed that in a local tsunami, ground shaking or sea level drawdown or unusual waves would occur, 57% believed that a siren warning is likely to be given for a local tsunami.

- A siren warning for local tsunami was rated more likely than for regional or distant events, indicating confusion between technological warning capabilities for different types of tsunami.
- Sirens were the most-requested improvement to current warning and evacuation procedures, which supports anecdotal evidence from emergency managers that sirens are seen as the most important solution by their communities.

During recent surveys in Wellington most respondents reported an expectation that sirens would provide a tsunami warning but also reported confusion over the signal and efficacy of such a system (Currie et al., 2013).

Table 11 Percentage of respondents citing potential information sources of tsunami warning. Respondents were requested to name as many formats as possible.

Information Format	Residents (n=97)	Visitor (n=39)	Total (n=136)
Siren	67%	67%	67%
TV/Radio/News	73%	46%	65%
Earthquake	14%	23%	17%
Public reaction / word of mouth / family/friends	12%	18%	14%
Alert (incl. Text/social media/online)	14%	8%	13%
Tidal change / see waves	11%	15%	13%
Civil Defence / council	11%	3%	9%
Other	7%	10%	8%
Emergency Services	3%	8%	4%
Animal response	3%	0%	2%
Don't know	1%	5%	2%
No response	1%	5%	2%
Other person in authority	0%	5%	1%

4.2.3 Perceived tsunami arrival times

To investigate the perception of potential tsunami arrival times with respect to receipt of an *official warning* and occurrence of a *natural warning*, we asked respondents which time frames they thought might apply in each situation. Responses in both cases were skewed towards arrival times of less than one hour (Table 12). Encouragingly, among *residents* who believe a tsunami could be possible after ground shaking (n=85), the most common anticipated time frames for the case of a *natural warning* were 'less than 10 minutes' (24%), '10-30 minutes' (28%) and '30-60 minutes' (20%). Only 6% of *residents* believed that following a local earthquake, a tsunami could take between '1-3 hours' to arrive, and no *residents* thought it would take 'longer than 3 hours'. These data support 2010 survey results, which found that 57% of people in Napier believe that a tsunami could arrive within 30 minutes if ground shaking was felt at the beach (GNS Science unpublished data). Previously, the 2003 National Coastal Survey revealed that 45% of respondents believed a tsunami could follow ground shaking within 30 minutes (Stewart et al., 2005) so this finding is relatively consistent over the last ten years. Simulations of local tsunami at Napier show that tsunami arrival can occur in as little as 27 minutes after rupture (Fraser et al., 2013), so *residents*' estimates of arrival time after a natural warning were reasonably accurate. There is a more diverse range of anticipated timeframes from *visitors* (n=30), with 7% anticipating arrival after '3-10 hours', but the most-anticipated timeframe is 'less than 10 minutes' (38%), which would likely encourage immediate evacuation.

In the case of receiving an *official warning* (Table 13), the most common anticipated timeframes were '10-30 minutes' (19% of all respondents) and '30-60 minutes' (20%). Ten percent of respondents cited arrival time of '3-10 hours' and 10% cited 'greater than 10 hours'. The distribution of responses was similar between *residents* and *regional visitors*. A greater proportion of *national visitors* tended to underestimate arrival time after an official warning (36% – 'less than 10 minutes'; 29% – '10-30 minutes'; 36% – '30-60 minutes'). To some extent this was also true of *international visitors* (21% – '10-30 minutes'; 29% – '30-60 minutes'). These results show some recognition that there would be a longer interval between an official warning and subsequent tsunami than there would be between a natural warning and tsunami but there is there is an underestimation of the likely time available between an official warning and tsunami arrival. It is encouraging that responses err on the shorter end of the scale as it is possible, particularly in the case of regional tsunami, that an official warning could precede a tsunami by timeframes on the order of minutes rather than hours.

A substantial portion of respondents replied 'don't know' or could not specify a time period (23% for official warning and 18% for natural warning). Additional comments from respondents reveal that this was due to an appreciation that arrival time depends on earthquake location. However, this also reveals that those respondents did not relate the type of warning to the general earthquake location and therefore make an inference of arrival time on that basis.

Table 12 Percentage of respondents who anticipate tsunami arrival in each timeframe following a natural warning. Respondents were requested to select all categories that they believed to be applicable – percentage reflects the 'Yes' responses in each timeframe as a percentage of the status group. Only respondents who answered 'Yes' to the previous question (Do you believe that a tsunami may be possible after long or strong ground shaking?) were asked to provide estimates of arrival time.

Status	<10 min	10-30 min	30 min-1hr	1-3 hrs	3-10 hrs	>10 hrs	Don't Know
Resident (n=85)	24%	28%	20%	6%	0%	0%	18%
Regional visitor (n=10)	30%	30%	0%	10%	0%	0%	20%
National visitor (n=12)	58%	17%	33%	8%	0%	0%	8%
International visitor (n=8)	25%	0%	0%	25%	25%	0%	25%
Total (n=115)	**27%**	**25%**	**18%**	**8%**	**2%**	**0%**	**18%**

Table 13 Percentage of respondents who anticipate tsunami arrival in each timeframe following an official warning. Respondents were requested to select all categories that they believed to be applicable – percentage reflects the 'Yes' responses in each timeframe as a percentage of the status group.

Status	<10 min	10-30 min	30 min-1hr	1-3 hrs	3-10 hrs	>10 hrs	Don't Know
Resident (n=97)	11%	20%	18%	14%	10%	9%	23%
Regional visitor (n=10)	10%	0%	10%	10%	10%	0%	40%
National visitor (n=14)	36%	29%	36%	21%	21%	14%	14%
International visitor (n=14)	7%	21%	29%	7%	0%	14%	21%
Total (n=135)	**13%**	**19%**	**20%**	**14%**	**10%**	**10%**	**23%**

4.3 EVACUATION INTENTIONS IN A LOCAL TSUNAMI

In order to investigate evacuation intentions in a local tsunami scenario, respondents were asked a series of questions relating to their intended actions during and after a local earthquake. To assess the influence of location on intended actions, this set of questions was asked first in the context of them being at the survey location, and then for a situation in which they were at home.

4.3.1 Intention to evacuate or not evacuate

The first question, *'What would you do after an earthquake that lasted for more than a minute or during which it was hard to stand up?'* was designed to investigate whether or not tsunami was one of the respondents' immediate concerns during an earthquake and what they might do in relation to that concern. This question solicited open-ended responses, and if respondents made no mention of evacuation (or non-evacuation) after being prompted for as many action intentions as they could think of, a prompt (*'Would you evacuate?')* was given. For the case of evacuation from the survey location, 64% of *residents* and 57% of *visitors* required prompting before mentioning evacuation. When given the situation of evacuation from home, the majority again required prompting (66% of *residents*, 55% of *visitors*). This demonstrates that when provided a scenario of ground shaking, the majority of respondents do not consider the tsunami risk but focus solely on response to the earthquake, suggesting that there might be a low rate of evacuation to high ground.

After prompting, the majority of respondents (*residents*: 85%; *regional visitors:* 100%; *national visitors: 92%*; and *international visitors*: 67%) reported their intention to evacuate from the survey location (Table 14). The proportion of female *residents* intending to evacuate the survey location was higher (89%) than that of male *residents* (78%) and among *visitors* there is less difference (female: 87% versus male: 83%). A smaller proportion intends to evacuate the home (*residents*: 57%; *regional visitors*: 20%; *national visitors*: 69%; *international visitors*: 67%). The low proportion for *regional visitors* reflects the fact that most of these respondents' homes are further inland than Napier therefore perceived to be safe from tsunami. Male *residents* are more likely to evacuate the home (63%) than female *residents* (52%) but among *visitors*, females are more likely to evacuate the home or accommodation (60%) than males (52%). The influence of location on intention to evacuate demonstrates the existence of a spatial dimension (both topographic elevation and distance to coast) in rate of evacuation in addition to the temporal influence of whether people are awake or asleep, or facing the prospect of night-time evacuation when a natural warning occurs.

Table 14 Percentages of respondents who would evacuate from the survey location or from home, split by residential status and gender. These values represent intentions after prompting in the survey to consider tsunami evacuation.

		Evacuate from survey location			Evacuate from home	
Status	**Gender**	**No**	**Yes**	**Don't Know**	**No**	**Yes**
Residents	M (n=41)	22%	78%	0%	37%	63%
	F (n=56)	11%	89%	0%	48%	52%
	Total (n=97)	15%	85%	0%	43%	57%
Visitors	M (n=23)	13%	83%	4%	48%	52%
	F (n=15)	13%	87%	0%	40%	60%
	Total (n=38)	13%	84%	3%	45%	55%
All respondents	M (n=64)	19%	80%	2%	41%	59%
	F (n=71)	11%	89%	0%	46%	54%
	Total (n=135)	**15%**	**84%**	**1%**	**44%**	**56%**

Given the similar proportions of *residents* and *visitors* intending to evacuate, we look at the impact of further demographics on the total sample. As age increases there is a lower intention to evacuate the survey location. In each of four age categories covering the range 16-34, over 91% of respondents would evacuate the survey location. In each of five categories between age 40 and 64, the percentage intending to evacuate is between 80% and 93%. For the age group 65 and over, the percentage intending to evacuate is lower, at 68%. The percentage of respondents who intend to evacuate the home or temporary accommodation is more variable: 62%-88% for ages 16-34, 36%-77% for ages 40-64 and 48% for age 65 and over.

There is little variation in intention to evacuate with respect to household income category except for lower intention to evacuate in one middle-income category. In all categories 90%-93% report an intention to evacuate, except for those with a household income of $30,001-$50,000, in which case 69% would evacuate. Similar consistency occurs between most household income categories for evacuation from the home with 50%-60% reporting an intention to evacuate in most categories. The exceptions are $30,001-$50,000, again showing much lower evacuation intention (38%), and $70,001-$100,000 with higher evacuation intention (85%).

Evacuation from the survey location is similarly high at all levels of education (Table 15), with postgraduates showing higher proportion of evacuation (93%), and undergraduates the lowest (77%). Respondents educated to post-graduate level are least likely to evacuate the home (21%), while 75% of those educated to trade qualification level would evacuate the home. The greatest difference between proportions intending to evacuate based on survey location is for postgraduates, while those with a trade qualification retain the most consistent intentions based on location.

We can conclude from this, that there is a higher intention to evacuate from the survey location than from the home or accommodation and that a slightly greater proportion of females than males intend to evacuate the survey location. Household income, education and ethnicity influence the disparity in intention to evacuate the survey location and the home to different extents, but full exploration of this dynamic requires a larger sample of data.

Table 15 Influence of level of education on intention to evacuate from the survey location and from the home. Percentage values refer to the number of respondents quoting each theme.

Level of Education	Evacuate from survey location			Evacuate from home	
	No	**Yes**	**Don't Know**	**No**	**Yes**
School (n=52)	12%	88%	0%	37%	63%
Trade (n=12)	17%	83%	0%	25%	75%
U/graduate (n=47)	23%	77%	0%	45%	55%
P/graduate (n=14)	7%	93%	0%	79%	21%
Not Provided (n=7)	0%	86%	14%	43%	57%
None (n=1)	0%	100%	0%	100%	0%
Other (n=2)	0%	100%	0%	50%	50%
Total (n=135)	**15%**	**84%**	**1%**	**44%**	**56%**

The three most-commonly reported intentions of respondents who would evacuate from the survey location were to ‘move out of and away from buildings’ (39%), evacuate to ‘high ground’ (28%) and to ‘drop, cover, hold’ (15%) (Table 16). A greater percentage of *visitors* reported intentions to ‘help others’ (16%, versus 5% of *residents*), otherwise the most common responses were replicated in similar proportions for both *residents* and *visitors*. Due to the small sub-samples of *visitors* reporting across a large number of intended actions, with few responses in each category, we do not present the disaggregated responses of the visitor sub-samples. The same actions are predominant among those respondents who intend to evacuate from home or accommodation (n=76, Table 16), although there is a greater influence of gender on some of these actions: ‘move out of or away from the building’ (32% of males, 45% of females), ‘drop, cover and hold or equivalent’ (18%, 37%), ‘shelter in a doorway’ (18%, 16%) and / or evacuate to ‘high ground’ (18%, 13%). Eleven percent of people would ‘seek further information’ and 15% would ‘contact friends or family’. No *visitors* discussed intentions to seek guidance from accommodation staff. Intention to ‘evacuate inland’ was reported less frequently than evacuation to high ground – only 3% would evacuate inland from home and only 10% from the survey location.

The high response rate for moving away from buildings at the survey location is likely due to the fact that the majority of surveys were conducted in the main shopping streets of Napier, where shops are primarily two-storey with awnings, thus prompting respondents to consider the danger of building damage and falling debris. In referring to building collapse and falling debris, several respondents quoted either direct experience or media coverage of damage due to the 2010-2011 Christchurch earthquake sequence. These data suggest that response to ground shaking is focussed primarily on earthquake hazard rather than tsunami hazard and is highly dependent on evacuee location at the time of ground shaking. This is particularly important for the percentage of respondents intending to evacuate to high ground. Less than one-third of people who are in the city, for example, shopping or working, are likely to evacuate to high ground upon experiencing ground shaking. This percentage drops to less than one-fifth for those who are at home in that situation. The predominant destination would be to areas of high ground, rather than inland.

Table 16 Percentage of respondents citing intended evacuation actions at the survey location and the home. Action themes are sorted (descending order) by percentage citing the action at the survey location.

Intended action	At survey location			At home		
	Resident (n=82)	**Visitor (n=32)**	**Total (n=114)**	**Resident (n=55)**	**Visitor (n=21)**	**Total (n=76)**
Out of or away from buildings to open space	37%	44%	39%	33%	52%	38%
Evacuate to high ground	29%	25%	28%	16%	14%	16%
Drop, cover, hold (or variation)	15%	16%	15%	29%	24%	28%
Evacuate inland	9%	13%	10%	4%	0%	3%
Evacuate (unspecified destination)	7%	9%	8%	7%	0%	5%
Help others	5%	16%	8%	0%	5%	1%
Get emergency supplies / kit	7%	3%	6%	5%	0%	4%
Wait until safe or shaking has stopped	5%	3%	4%	2%	14%	5%
Other	6%	0%	4%	4%	10%	5%
Shelter in doorway	2%	3%	3%	20%	10%	17%
Check on / contact loved ones	4%	0%	3%	15%	0%	11%
Panic	2%	3%	3%	n/a	n/a	n/a
Go home	2%	0%	2%	n/a	n/a	n/a
Seek information	0%	3%	1%	11%	5%	9%
Wait for sirens / warning	1%	0%	1%	2%	0%	1%
Into building	0%	3%	1%	n/a	n/a	n/a
No response	n/a	n/a	n/a	2%	0%	1%
Go to school / community Centre	n/a	n/a	n/a	2%	0%	1%
Stay put	n/a	n/a	n/a	2%	0%	1%
Check property / clear up	n/a	n/a	n/a	0%	5%	1%
Go to upper floor of building	n/a	n/a	n/a	0%	0%	0%

Of those people not evacuating the home (n=59), the most common intended actions are to ‘drop, cover, hold’ (41%) or ‘shelter in a doorway’ (24%) and ‘seek further information’ or ‘contact friends or family’ (14%). The most common reasons given for not evacuating from home are because it is located ‘too far inland’ to be in danger of inundation (12%) or located ‘on high ground’ (20%). Additional common responses were that it was ‘more dangerous to evacuate’ than stay put (14%), already being in an ‘earthquake safe building’ or ‘feeling safe at home’ (14%), and being ‘unconcerned about tsunami’ (14%). Other themes created from responses include ‘don’t know what to do’ or ‘don’t know if I need to evacuate’, ‘wait for advice’ and feeling that it is ‘impossible to evacuate’. Mapping respondents’ intentions reveals that although some correctly consider themselves safe at home, others are in fact located within the tsunami hazard zone according to numerical simulation of the maximum credible inundation scenario (Fraser et al., 2013) (Figure 3A).

Twenty respondents stated they would not evacuate the survey location in case of ground shaking. This is too small a sample to analyse effectively; however, it is worth noting the common themes into which the responses have been grouped (Table 17). These reflect issues which should be investigated further as they have the potential to contribution to a low evacuation rate if not addressed through education.

Table 17 Reasons given for non-evacuation of the survey location. *Four of these responses were given at Clive Square and one at Marewa shops, both of which are located within the tsunami hazard zone.

Respondents’ reasons for non-evacuation of survey location	Count
Safe at the survey location *	5
Dangerous to evacuate	4
Don't know where to go	2
Evacuation is impossible	2
No transport	2
Need to help others	2
No response	2
Never had tsunami here	1

Previous research has highlighted active responses in disasters including information-seeking, helping others (Rodriguez, Quarantelli & Dynes, 2006) and the desire to bring the family together before evacuating in the case of warned events (see Section 2.2). In responding to the initial question, few respondents referenced information-seeking or efforts to bring families together immediately following ground shaking. When ground shaking is experienced at home, only 11% of respondents reported that they would ‘seek further information’ and 13% of respondents intend to ‘check on or contact loved ones’, although inherently emotional responses such as these may be the most sensitive to being misrepresented in stated intention surveys compared to actual behaviour. For evacuation from the survey location these actions were reported by 1% and 3% respectively. With respect to household preparedness, only 5% of respondents reported intentions to ‘get an emergency kit or emergency supplies’ if they experienced ground shaking at home. These findings are somewhat surprising, but these expected behaviours were referenced more commonly in subsequent questions and are discussed in the next section.

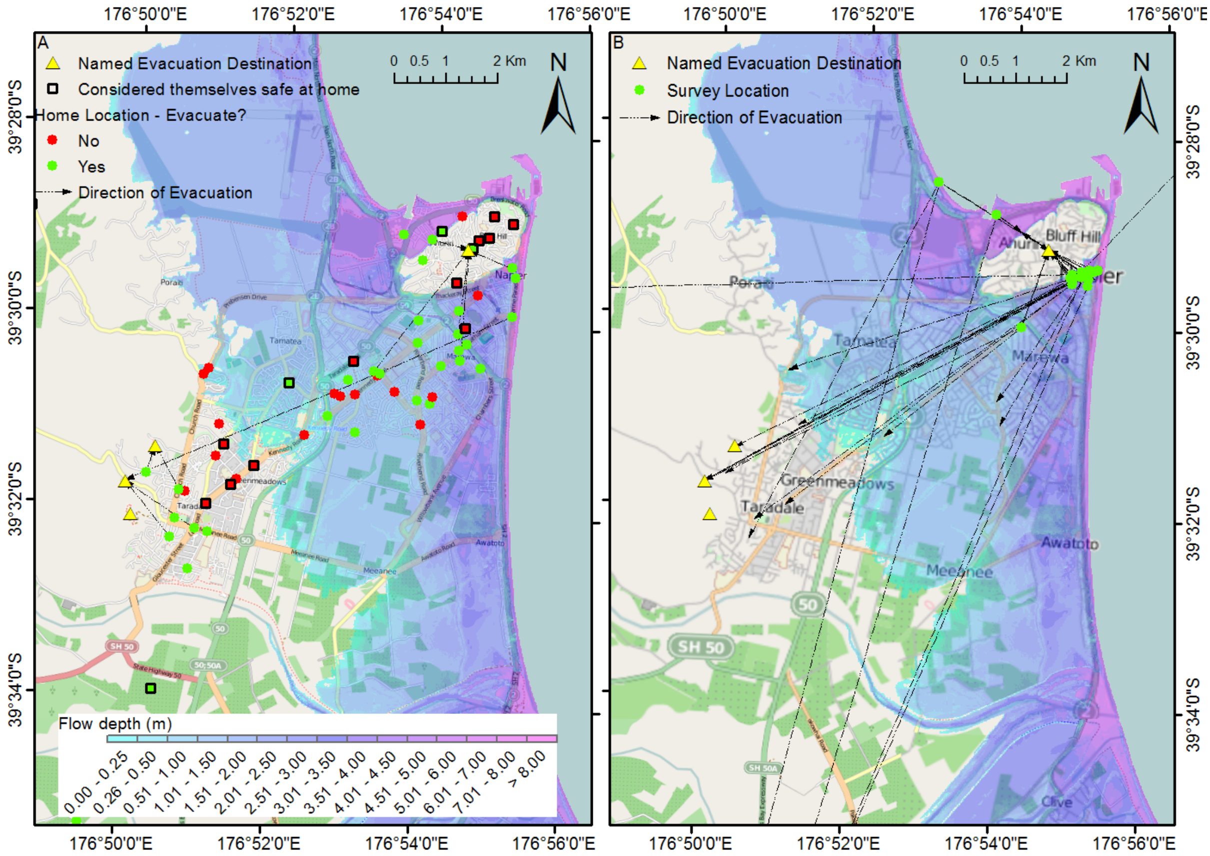

Figure 3 **A)** *Residents*' approximate home location and their intention to evacuate or remain at home following ground shaking. Green circles show intention to evacuate, with evacuation arrows indicating direction to their stated destination (if named during the survey). Red circles mark intention to not evacuate and a square indicates that the reason was because they believed themselves to be safe at that location. **B)** Survey locations with evacuation direction to respondents' stated destination (if named during the survey) or their home if that was their intended destination. Evacuation arrows which end off the map indicate evacuation to Hastings or Wairoa. Tsunami flow depth and inundation extent generated by Fraser et al. (2013) for an M_W 9.0 rupture of the Hikurangi margin is including on the map to indicate the worst-case tsunami hazard zone. Basemap source: OpenStreetMap and contributors, Creative Commons-Share Alike License (CC-BY-SA).

4.3.2 Pre-evacuation actions and estimated departure time

It is important to gain information on likely pre-evacuation actions that respondents might take and the delays caused by these actions, given that there is little time available to evacuate. We anticipated that intended actions will be similar to those described in previous literature (Section 2.3). Respondents who indicated their intention to evacuate (from survey location n=114; from home or accommodation n=76) were asked when they would intend to evacuate. For both scenarios the most common response for both *residents* and *visitors* was 'as soon as possible' (48% of respondents at survey location and 55% at home) followed by 'immediately' (19% from the survey location, 9% from home or accommodation). When a specific time was provided regarding evacuation of the survey location (by 5% of respondents) the stated times were '20 seconds' (n=1), '5 to 10 minutes' (n=2) and '10 to 15 minutes' (n=3). A specific time was provided by 12% of respondents regarding evacuation of the home, comprising '5 to 10 minutes' (n=4), '20 minutes' (n=2) and '30 minutes' (n=2).

The actions that respondents intend to take before departing include: 'help others' (at survey location: 22%; at home: 4%) or 'check on, travel to or gather loved ones' (29%; 23%); 'get emergency kit' (1%; 19%); 'get / secure property' (4%, 19%); and 'nothing' – i.e. evacuate immediately without stopping to do anything (34%, 19%). There is little difference between the proportions of *visitors* and *residents* taking each action. Within these results the influence of location is apparent. When in public a greater proportion of people intend to help others, while at home this is cited less often, perhaps because there are likely to be fewer people in immediate proximity when at home. The proportion of respondents intending to check on, travel to or gather loved ones is also lower for the home situation, perhaps due to respondents considering that loved ones will all be together when at home. The other actions apparently influenced by location is the use of emergency kits and collecting or securing property, which were more frequently reported as actions taken at home where emergency kits and property are more readily accessible to people. It is encouraging that people recognise the need to take emergency kits, but the proportion of people citing kits or supplies is low to moderate.

Regarding pre-evacuation actions at the survey location, 29% of respondents reporting ‘as soon as possible’ also responded that their departure would be delayed by ‘checking on loved ones’ or ‘travelling to or gathering loved ones’, 25% would delay by ‘helping others’, and 45% would evacuate as soon as possible with no delaying action reported. Therefore, around half of those reporting ‘as soon as possible’ are likely to experience a delay but this is difficult to quantify without further data on how long it might take to complete such actions. Further research should link pre-evacuation actions with respondents’ household composition (i.e. whether there are children to care for) and collect data on time required for each action. The high number of respondents citing short intended evacuation start time is encouraging for tsunami education, however, the fact that these are intentions means they should be treated with caution as they may not correlate well with actual behaviour (Kang et al., 2007; Mas et al., 2012).

4.3.3 Evacuation destination

The topography of Napier provides few options for evacuating to high ground and the general expectation is that people evacuating the city centre will go to the nearest area of high ground, which is Bluff Hill. It is important to understand whether this is in fact the case, and where people located further from Bluff Hill would intend to go. This will help emergency managers to prepare primary evacuation routes and anticipate where concentrations of evacuees might relocate to in a local tsunami event, which has implications for route congestion and emergency response planning.

When asked to provide an evacuation destination if evacuating from the survey location, the most common intended destinations were ‘Bluff Hill’ (Figure 1 and Figure 3B – *residents*: 33%; *regional visitors*: 10%; *national visitors*: 33%; *international visitors*: 10%) and ‘unspecified high ground’ (*residents*: 15%; *regional visitors*: 20%; *national visitors*: 33%; *international visitors*: 0%) (Table 18). It is notable that a very low number of *international visitors* reported ‘high ground’ as their intended destination and that 50% gave no response or reported ‘don’t know’. This specific question about destinations solicited a higher percentage of responses citing high ground than the more general question about actions following an earthquake (28%, Section 4.3.1). Fifteen percent of *residents* would evacuate to ‘home’, and 22% of *visitors* (origins combined) would evacuate ‘further inland’. Several of those intending to evacuate to their home would still be in the tsunami hazard zone there, while others would be sufficiently inland towards the Taradale Hills to be safe (Figure 3B). Ten percent of respondents would intend to evacuate to ‘Clive Square’ (Figure 1). This was a focus for evacuation during the 1931 earthquake, but is not currently an official Hawke’s Bay Civil Defence and Emergency Management assembly point (Marcus Hayes-Jones, personal communication, 4 April 2013) and is located within the published tsunami hazard zone (Hawke’s Bay CDEM Group, 2011).

When considering evacuation from the home, 19% of *residents* cited ‘unspecified high ground’, and others named their high ground destinations as: ‘Bluff Hill’ (11%), ‘Sugar Loaf Reserve’ (6%), and ‘Puketapu Hill’ (6%) (Figure 3A). In the *visitor* sub-samples, 33% of *national visitors* cited ‘Bluff Hill’, but otherwise ‘high ground’ was not well-cited as a destination, whereas ‘beach’, ‘open areas’ and ‘away from buildings’ were all cited in each sub-sample, although the small sub-sample precludes drawing further conclusions at this level of detail. In terms of the two major status groups 11% of *residents* but no *visitors* would travel ‘further inland’. Twenty-five percent of *residents* and 48% of *visitors* reported their intention to ‘move away from buildings’ or go to an ‘open area’ such as a park, a field or to the end of the driveway, which again suggests a primary aim of being outside in case of further aftershocks rather than any intention to evacuate in case of potential tsunami inundation.

Table 18 Respondents’ reported destinations if intending to evacuate from the survey location.

Reported destinations from the survey location	Resident (n=82)	Regional visitor (n=10)	National visitor (n=12)	International visitor (n=10)
Unspecified or other high ground	15%	20%	33%	0%
Bluff Hill	33%	10%	33%	10%
Sugarloaf Reserve	1%	0%	0%	0%
Taradale Hills	5%	0%	0%	0%
Unspecified or other place inland	10%	20%	25%	20%
Civil Defence centre / school	4%	0%	0%	0%
Open areas - e.g. park	5%	0%	8%	10%
Home	15%	20%	8%	0%
Away from buildings	1%	0%	8%	0%
Clive Square	11%	20%	0%	0%
Don't Know	2%	0%	0%	20%
Other	5%	30%	0%	10%
No response	1%	0%	0%	30%

4.3.4 Travel mode during evacuation

The preference to evacuate in vehicles for long-distance and long-lead time evacuations has been discussed, as have variable rates of vehicle use in recent tsunami warnings (Section 2.4). To investigate the intended travel mode at Napier, we asked the open-ended question ‘*How would you travel to your intended destination?*’. It is hypothesised that the majority of respondents will prefer to use their vehicles, on the basis of previous response to earthquake and tsunami in New Zealand (Lamb & Walton 2011) and the belief that vehicles are the most commonly used form of evacuation transport in developed countries due to daily reliance on vehicles (Murakami & Kashiwabara, 2011).

The most-cited intended travel modes (Table 19) for *residents* evacuating the home (n=55) were evacuation in a ‘vehicle’ (53%) and ‘walk or run’ (49%) whereas a greater proportion of *residents* evacuating the survey location intend to ‘go on foot’ (61%) than use a ‘vehicle’ (40%). A greater proportion of female *residents* intend to walk or run than do male *residents* when evacuating the home or survey location. Among *visitors*, 62% intend to ‘walk or run’ when evacuating the home and 24% intend to use a ‘vehicle’ and there is little variation between *visitor* sub-samples. The majority of *regional visitors* (60%) and *international visitors* (70%) would evacuate the survey location in a 'vehicle' but the majority of *national visitors* (67%) would 'walk or run'. Only two respondents offered cycling as a potential means of evacuation.

There is a certain degree of recognition that using a vehicle may not be possible in a post-earthquake situation – 13% of respondents expressed such concern, although many did so in the context of their preference to drive, including responses such as 'Drive - if road weren't damaged', 'Car if possible' and 'Car. If roads bad, run'. Analysis of household income categories and level of education reveals no consistent influence on intended travel mode.

Table 19 Proportion of *residents* and *visitors* with vehicle or pedestrian intended travel modes. Respondents were able to answer with more than one travel mode, therefore percentages may sum to greater than 100%.

Status and Gender		**Evacuate from survey location**			**Evacuate from home**		
		n	**Vehicle**	**Foot**	**n**	**Vehicle**	**Foot**
Residents	Male	32	50%	50%	26	73%	31%
	Female	50	34%	68%	29	34%	66%
	Total	82	40%	61%	55	53%	49%
Visitors	Male	19	47%	53%	12	17%	58%
	Female	13	69%	23%	9	33%	67%
	Total	32	56%	41%	21	24%	62%

4.4 VERTICAL EVACUATION BUILDINGS

The final set of questions in the survey explored respondents' views and concerns about the use of tsunami vertical evacuation buildings in Napier. Previous experience in Japan highlights the value of a vertical evacuation strategy (Fraser et al., 2012a), but also the components required for a strategy to be successful. A scoping study has previously looked at the potential for using existing buildings for vertical evacuation in New Zealand (Leonard et al., 2011) and with increased international research and development of design guidelines for such facilities (FEMA 2008, 2009; and forthcoming update by the ASCE 7 Subcommittee on Tsunami Loads and Effects[6]) it is important to understand public opinion of such strategies to guide further community engagement on the topic.

Respondents were first asked to name all of the possible types of places they could think that might provide safety in a tsunami, with no prompting about vertical evacuation. The overwhelming majority of respondents (80%) referred in their response to 'high ground or uphill' (Table 20). Thirty-eight percent referred to moving 'inland or away from coast', while 15% cited buildings as a safe destination, indicating a relatively low level of consideration of vertical evacuation. Nine percent cited 'Civil Defence centre or school' as a safe location, and other interesting but uncommon responses included 'away from waterways' or rivers (2%), 'tall trees' (2%) and one respondent specifically indicated that they would 'not evacuate into a building'. The trend in responses is generally consistent between genders and *resident* or *visitor* status. The only group with more respondents citing evacuation to buildings rather

[6] http://nthmp.tsunami.gov/2012tsuhazworkshop/abstracts/Chock_abs.pdf

than evacuation inland was *national visitors*, 29% of whom cited buildings versus 14% who cited going further inland. There is no apparent correlation in this limited sample between the respondent's home city and their recognition of buildings as a safe location, which might suggest familiarity with tall buildings at home and work, but this issue should be explored further in later surveys.

Table 20 Percentage of respondents citing different possible safe locations in a tsunami.

Safe Evacuation Location	Respondent Status - Resident / Visitor				
	Resident (n= 97)	Regional visitor (n= 10)	National visitor (n= 14)	International visitor (n= 15)	Total (n=136)
High ground / uphill	83%	80%	93%	53%	80%
Inland / away from coast	39%	70%	14%	33%	38%
Upper storeys / roof of building	13%	10%	29%	13%	15%
CD centre / school	9%	20%	7%	0%	9%
Away from buildings	1%	10%	7%	13%	4%
Open areas - e.g. park	2%	10%	0%	13%	4%
Tall tree	1%	0%	7%	7%	2%
Home	3%	0%	0%	0%	2%
Away from waterways	2%	0%	7%	0%	2%
Not up building	0%	10%	0%	0%	1%
Don't Know	0%	0%	0%	7%	1%
Other	4%	0%	0%	20%	5%
No response	2%	0%	7%	0%	2%

Of those respondents citing evacuation to the 'upper storeys or roof of building' (n=20), there were repeated references to building height and strength, demonstrating understanding of the requisites of a building to be safe in a tsunami. References to height were made by 19 of these respondents, including three references to evacuation above three storeys and others referring to the roof, top of the building or use of a tall building. Four respondents referred to the building being strong, and one cited the need for an open ground floor. Five respondents said they would use a building as a last resort if they could not reach a hill or go inland.

Next, respondents were given some context to the subsequent questions, by stating "*In Japan, many people survived the tsunami by evacuating to the third storey or above in reinforced concrete buildings. This is an approach that we could consider for New Zealand, and we are interested in your thoughts on this.*" They were then asked "*How would you feel about evacuating to the upper floors of a reinforced concrete building*". The themes that arose in respondents' views on evacuation buildings have been grouped into *encouraging* themes and *discouraging* themes. Of the respondents who gave factors that would encourage their use of buildings (n=35), 40% would be encouraged if they knew the building was reinforced or if the building was described officially as safe or reinforced (including signs on the building). Twenty-nine percent were encouraged if it was the safest option in the available time for evacuation and 14% if there was easy access. These opinions are in line with the factors considered in official designation of vertical evacuation facilities in Japan (Cabinet Office Government of Japan, 2005) and identified as important features of vertical evacuation buildings from their performance in the 2011 Japan tsunami (Fraser et al., 2012a). Discouraging factors were grouped into themes including: having doubts or being unsure about safety due to the height or strength of available buildings (43% of respondents); potential to be trapped with no or slow access to safe floors (20%); potential for panic or overcrowding (19%); and visible building damage or falling debris (14%). Twenty-six percent of people provided factors that would encourage them to seek safety in a building during a tsunami, 55% gave discouraging factors and 21% provided neither. There is little difference in the responses of males and females, except that a high proportion of females provided encouraging or discouraging factors, rather than a non-committal response. The potential for fire, further earthquakes, being afraid of heights or worried about hygiene were also given as discouraging factors. Concern about the availability of supplies in the building was raised by a single respondent. Within these responses, several respondents reiterated their preference to go to high ground rather than into buildings.

These data demonstrate that many people would consider the visible structural integrity of the building and the time available to get to the often-preferred option of high ground or inland as determining factors in their decision to evacuate into a building. It is apparent that a key component of tsunami evacuation is provision of clear information about which buildings would be safe for tsunami evacuation use in a post-earthquake situation. The risk of fire and provision of food or emergency supplies within a building are considered by few respondents, but these components should also be addressed in any education or evacuation planning that includes a vertical evacuation component.

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5.0 CONCLUSIONS

A survey of 136 *residents* and national and international *visitors* in Napier was carried out to investigate hazard awareness and intended evacuation behaviour in a local earthquake and tsunami. This study provides a unique investigation of evacuation intentions in the context of local tsunami hazard in New Zealand. The data supports several observations of previous surveys, demonstrating high levels of tsunami hazard awareness but confusion around warning expectations, and evacuation behaviours cited by respondents are in line with findings in international evacuation behaviour literature. The survey provides new local data on intended evacuation destinations, travel modes, and opinions on tsunami vertical evacuation buildings, while demonstrating the existence of demographic influence on decision-making.

There was a high level of receipt of hazards information among *residents* in Napier, primarily via TV, radio and newspaper media. Each group of *visitors* demonstrated a moderate receipt of information, and responses suggest a low level of information provision by the tourist industry. Awareness of earthquake and tsunami hazard in Napier is high, the majority of respondents recognise that tsunami could follow a local earthquake and there is good perception that wave arrival would occur within one hour after local ground shaking. There is a good level of understanding that earthquake location influences tsunami wave arrival time. Some respondents appreciate that following an official warning, wave arrival is likely to be later than following local ground shaking. However, many respondents believe there will be less than one hour after an official warning until wave arrival, and while this is possible in a regional tsunami, it is an underestimation of the time available for evacuation following an official warning of a distant tsunami.

Consistent with previous research findings, we report the high expectation that official tsunami warnings will be given via sirens or TV/radio in the case of local tsunami. There was relatively low recognition that ground shaking would provide a natural warning despite education messages to this effect from Hawke's Bay CDEM and MCDEM, and *visitors* reported greater recognition of natural warnings than *residents*. Given that respondents recognise the potential for a short arrival time of tsunami after ground shaking, it appears that this expectation is due to a misunderstanding of the warning process and current technological capabilities governing the time to warning dissemination. This expectation may be a function of the fact that the majority of past events have been from distant sources, therefore tsunami is associated with official warnings. Further communication of siren functions and importance of the natural warning is required to address these prevalent expectations.

The intended behavioural responses to an earthquake suggest that in an earthquake ground shaking might trigger appropriate earthquake response actions but people may not extend their actions to include appropriate tsunami evacuation response, as most respondents did not consider tsunami until prompted. Respondents expressed a greater intention to evacuate when they were at the survey location than they did for an event occurring when they were at home, with similar proportions of *residents* and *visitors* stating an intention to evacuate. There were variations between genders, with females more likely to evacuate the survey location and males more likely to evacuate the home. Intention to evacuate the survey location reduces with increasing age. Further research is required to confirm and explain these trends. Many people reported that if they were at home at the time of the earthquake, they would evacuate the building (i.e. to open space) but did not indicate intention to evacuate further (i.e. to high ground). Others would be reluctant to evacuate the home as they feel that it is safer to remain in place rather than try to evacuate, or that they are not at risk of tsunami, which is true in some cases but not all. There was a high proportion of responses recognising the need for evacuation as soon as possible and the range of pre-evacuation actions are consistent with those previously cited in hurricane evacuation literature. The data did not permit detailed analysis of evacuation departure times.

Evacuation to high ground is recognised as an appropriate evacuation action, but only a moderate proportion of respondents stated that they would evacuate to high ground. The reported evacuation destinations suggest that in an event, there would be concentrations of evacuees on Bluff Hill and in the Taradale Hills. Some respondents identified their home as an intended evacuation destination, despite that location being within the tsunami hazard zone. Reported intentions to use Clive Square as an evacuation point are of concern, as Clive Square is situated within the tsunami hazard zone and congregation at that location could result in many deaths. Tsunami hazards maps available for Napier should be used to ensure that people are aware of whether or not their intended destination is in the hazard zone when planning for evacuation. Travel mode intentions suggest an approximately equal proportion of people evacuating on foot and in a vehicle, which is relatively in line with travel mode observations from Japan. Travel mode appears to be location-dependent with a greater proportion of *residents* using vehicles if they are at home rather than at the survey location whereas the opposite is true for *visitors*. Gender also appears to influence travel mode, with a greater proportion of female *residents* than male *residents* reporting intention to evacuate on foot. Some respondents recognise that evacuation by vehicle may not be possible in a post-earthquake situation. Cycling was rarely reported as an intended travel mode, and several respondents reported a reliance on others for transport.

'Buildings' ranked below 'high ground' and 'travelling inland' as possible safe locations in a tsunami. Most respondents were concerned about structural integrity and sufficient height of buildings but many also cited the available time to evacuate to their first choice destination as factors in deciding to use vertical evacuation. Vertical evacuation is recognised as a potentially life-saving option if is not possible to reach high ground. Responses indicate the importance of ensuring that the public has prior knowledge about the safety or designation of buildings, or can see signage to this effect on the building. There is a common concern that few suitable buildings exist in Napier.

This survey has a number of limitations that should be addressed in future research, although it provides a useful base for subsequent surveys, informs evacuation modelling, community engagement on evacuation planning and vertical evacuation, and hazard education of resident and transient populations. The survey did not attempt to investigate evacuation behaviour within educational or care-giving facilities or the role of tourist industry staff in evacuations, which are important groups to study in terms of group evacuation. Household composition and its influence on evacuation behaviour should be studied more closely in subsequent surveys, and pre-evacuation actions should be linked more closely with the estimated time required for each action. In order to investigate the provision of information to *visitors* in Napier, a more focussed survey of accommodation providers and tourism operators should be carried out. We should also explore peoples' intended actions when they have reached a safe place, specifically with respect to returning to inundation zone before an 'all clear' message.

The fact remains that data presented here are stated intentions given for a hypothetical tsunami scenario and behaviours are likely to show some differences in an actual event.

Although other researchers have previously shown good agreement between some aspects of expected and actual behaviour for hurricane evacuation, the comparison of such data for tsunami is limited to evacuation departure time and travel mode. Of particular concern is the validity of such data where there has been little or no experience of a similar event in recent memory, which is the case for local tsunami in New Zealand. In order to collect a larger, more geographically diverse sample of evacuation intentions this survey should be refined and administered as a postal survey using probability sampling in multiple study areas for *residents* and *visitors*. We should also develop a corresponding survey to assess the same behaviours in an actual event, in case of a local tsunami in New Zealand. Consistent collection of data across the two surveys will allow for a comparison of intended and observed behaviours for further improvement of evacuation planning and testing of the validity of stated intention data.

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APPENDICES

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APPENDIX 1: QUESTIONNAIRE SURVEY

This survey was implemented face-to-face in the streets of Napier. The questions were delivered verbally and responses recorded by the interviewer. An exclamation ([!]) after a question indicates that the interviewers will prompt the respondent to offer any other responses until those responses are exhausted. Respondents were offered an information sheet following completion of the survey (see Appendix 2). A question code was included on the survey for coding purposes (e.g. *[resvis]*).

Clipboard Questionnaire: Awareness of hazards and intended response actions

Q1 *[resvis]* Are you resident in Napier City or visiting? ☐$_1$ Resident ☐$_2$ Visitor

Q2 **If resident,**

a. *[reslen]* How long have you lived in Napier? ____________________

b. *[resloc]* What is your home address (or nearest intersection)?

____

c. *[resact]* What are you doing here today? ☐$_1$ Commute/Work ☐$_2$ Visiting friends/family ☐$_3$ Leisure activities ☐$_4$ Other ______________________________

d. *[resinf]* Do you recall previously seeing or hearing information about natural hazards in Napier?

☐$_1$ Yes ☐$_2$ No ☐$_3$ Don't know

e. *[resinfsrc]* **If yes,** who was the source of this information?

____

f. *[resinftyp]* **If yes,** how was the information provided? (tick all that apply) ☐$_1$ TV/Radio broadcast ☐$_2$ Brochure/Leaflet ☐$_3$ Mail-drop ☐$_4$ In phonebook ☐$_5$ Council website ☐$_6$ Community meeting ☐$_7$ Informal/Conversational ☐$_8$ Other____

Q3 **If visiting,**

a. *[visorg]* Where are you visiting from? (**city & country**)

____

b. *[visact]* What is the purpose of your visit? ☐$_1$ Business ☐$_2$ Holiday ☐$_3$ Visiting friends/family ☐$_4$ Other ____

c. *[visreg]* How regularly do you visit Napier? ☐$_1$ First time ☐$_2$ Weekly ☐$_3$ Monthly ☐$_4$ Annually/less

d. *[acctype]* What type of accommodation are you staying in? ☐$_1$ Hotel ☐$_2$ Motel ☐$_3$ Backpackers ☐$_4$ Holiday Park ☐$_5$ Home of friends/family ☐$_6$ Holiday Home/Bach ☐$_7$ Other ___________

e. *[hazinfo]* Have you seen or heard any information about natural hazards in Napier? ☐$_1$ Yes ☐$_2$ No ☐$_3$ Don't know

f. *[hazinfo]* **If yes,** who was the source of this information?

____

g. *[hazinftyp]* **If yes,** how was the information provided? (tick all that apply) ☐$_1$ TV/Radio broadcast ☐$_2$ Brochure/Leaflet ☐$_3$ Mail-drop ☐$_4$ In phonebook ☐$_5$ Council website ☐$_6$ Community meeting ☐$_7$ Informal/Conversational ☐$_8$ Other________________

Q4 *[haznpr]* Which of the following hazards do you think could cause damage or casualties **in Napier City**?

☐$_1$ Wildfire/Bushfire ☐$_2$ Earthquake ☐$_3$ Storm/Cyclone ☐$_4$ Tsunami ☐$_5$ Flood ☐$_6$ Landslide
☐$_7$ Don't know ☐$_8$ Other (please give details): ______________________________

Q5 *[tsuwrn]* What would warn you of a tsunami potentially affecting Napier? [!]

____

Q6 If you were to hear an official tsunami warning (via siren, police, tv, radio),

a. *[offarr]* How long do you think there would be until the first tsunami waves might arrive at Napier? (**tick all that apply**)
☐$_1$ < 10 min ☐$_2$ 10 - 30 min ☐$_3$ 30 min - 1 hr ☐$_4$ 1 - 3 hr ☐$_5$ 3 - 10 hr ☐$_6$ > 10 hr
☐$_7$ Don't know

Q7 If you were to experience ground shaking that lasted for more than a minute or during which it was hard to stand up,

a. *[nattsu]* Do you think that a tsunami may be possible? ☐$_1$ Yes ☐$_2$ No ☐$_3$ Don't know

b. *[natarr]* **If Yes,** How long do you think there would be until the first tsunami waves might arrive at Napier? (**tick all that apply**)

☐$_1$ < 10 min ☐$_2$ 10 - 30 min ☐$_3$ 30 min - 1 hr ☐$_4$ 1 - 3 hr ☐$_5$ 3 - 10 hr ☐$_6$ > 10 hr
☐$_7$ Don't know

State: '**Two** different **scenarios** will now be presented':

First, please consider, for **what you are doing right now:**

Q8 *[evcnatactN]* What would you do after an earthquake that lasted for more than a minute or during which it was hard to stand up? [!] then prompt: "**Would you evacuate?**"
[Note if prompt required: ☐]

____

a. *[evcnonN]* **If No**, what are your reasons for not evacuating?

____

b. *[evcdprtN]* **If Yes,** How long after the earthquake do you think you would begin evacuation?

____

c. *[evcdlyN]* What would you do, if anything, before evacuating?

____

d. *[evcdestN]* Where would you evacuate to? [**landmark / intersection / suburb / city**]

____

e. *[evctrvlN]* How would you travel to your intended destination?

____

Now please consider, **if you were at home (or at your accommodation):**

Q8 *[evcactH]* What would you do after an earthquake that lasted for more than a minute or during which it was hard to stand up? [!] then prompt: "**Would you evacuate?**"
[Note if prompt required: ☐]

____

a. *[evcnonH]* **If No**, what are your reasons for not evacuating?

____

b. *[evcdprtH]* **If Yes,** How long after the earthquake do you think you would begin evacuation?

____

c. *[evcdlyH]* What would you do, if anything, before evacuating?

____

d. *[evcdestH]* Where would you evacuate to? [**landmark / intersection / suburb / city**]

____

e. *[evctrvlH]* How would you travel to your intended destination?

____

Q10 *[evclocs]* Can you list all of the types of places you think you could evacuate to if a tsunami was imminent?

____

<u>For context:</u> In Japan, many people survived the tsunami by evacuating to the third storey or above in reinforced concrete buildings. This is an approach that we could consider for New Zealand, and we are interested in your thoughts on this.

Q11 *[evcbld]* How would you feel about evacuating to the upper floors of a reinforced concrete building, and why?

____

____

____

Q12 *[evcbld]* Is there anything that would encourage/discourage you from evacuating into a building during a tsunami?

____

<u>Demographics:</u> (**These are confidential responses, used only to check our survey sample**):

Q13 *[demyr]* In what year were you born? 19_______ ☐1 Declined to answer

Q14 *[demedu]* What is the highest level of education you have completed? ☐1 School ☐2 Trade Qualification ☐3 Undergraduate (e.g. Bachelors) ☐4 Postgraduate (e.g. Masters, PhD) ☐5 Declined to answer

Q15 *[deminc]* What is your household income category? ☐1 Under $20,000 ☐2 $20,001-$30,000 ☐3 $30,001-$50,000 ☐4 $50,001-$70,000 ☐5 $70,001-$100,000 ☐6 Over $100,001 ☐7 Declined to answer

Q16 *[demethn]* What is your ethnic group? ☐1 European ☐2 Maori ☐3 Pacific Island ☐4 Middle East ☐5 Latin America ☐5 Africa ☐6 Other ______________________________ ☐7 Declined to answer

Q17 *[demgen]* Gender**:** ☐1 Male ☐2 Female

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APPENDIX 2: QUESTIONNAIRE INFORMATION SHEET

This information below was offered to respondents following completion of the survey:

Thank you for taking time to complete this survey

GNS Science and Hawke's Bay Civil Defence and Emergency Management Group are interested in what people know about tsunami and warnings, to help improve education. This survey is being conducted by a student from Massey University in collaboration with GNS Science and Hawke's Bay Civil Defence and Emergency Management Group.

Further information regarding tsunami hazard, warnings and evacuation in Napier can be found on the Hawke's Bay Emergency Management Group web pages:

http://www.hbemergency.govt.nz/

Natural warning signs of tsunami are: Strong earthquake shaking; Weak, rolling earthquake shaking of unusually long duration (i.e. a minute or more); Out of ordinary sea behaviour (e.g. unusual and sudden sea level fall or rise); The sea making loud and unusual noises, especially roaring like a jet engine.

When experiencing any of the above go immediately to high ground or as far inland as possible. Do not wait for an official warning. Let the natural signs be your warning – the first wave may arrive within minutes. Once away from the water, listen to a radio station for information from local civil defence about further action you should take. Wait for official all clear before returning.

If you have any questions please contact Stuart Fraser or Graham Leonard at GNS Science: s.fraser@gns.cri.nz or g.leonard@gns.cri.nz or 04 570 1444

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