Tsunami Evacuation

Director's Guidelines for Civil Defence Emergency Management Groups [DGL 08/25]

Resilient New Zealand
Aotearoa Manahau

Te Kāwanatanga o Aotearoa
New Zealand Government

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Authority

This guideline has been issued by the Director of Civil Defence Emergency Management pursuant to s9(3) of the Civil Defence Emergency Management Act 2002. It helps Civil Defence Emergency Management (CDEM) Groups in the development of the tsunami evacuations zone (the Blue Zone) and related tsunami readiness and response initiatives, including evacuation routes, evacuation maps and information boards. This Director's Guideline supersedes the previous Tsunami Evacuation Zone Director's Guideline [DGL 08/16].

This document is available on the NEMA website www.civildefence.govt.nz.

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Foreword

Aotearoa New Zealand's entire coastline faces potential tsunami threats, from sources across the Pacific Ocean and those closer to home, such as the Kermadec Subduction Zone. Recent tsunami events underscore the critical need for our coastal communities to understand the risk they face and be prepared for future tsunami threats.

With many schools located in high-risk coastal areas across the motu, the vulnerability of our tamariki reinforces the importance of tsunami readiness. It is absolutely critical that we equip our young people with the tools and knowledge to prepare for, and respond to, tsunami, to protect our communities for years to come.

This updated Director's Guideline sets the new nationally consistent approach for public-facing tsunami evacuation zones: the Blue Zone. The purpose of the Blue Zone is to simplify tsunami evacuation; to make it easier for our communities to know what to do when a tsunami arrives at our coast and there is little time to evacuate. This reinforces our Long or Strong, Get Gone message.

This guideline builds upon the foundation laid by the previous version, reflecting the increased understanding of out threat, advances in technology and great social science research. It has been developed through a collaborative effort with experts across the motu. I thank everyone who has contributed to updating this guideline.

It is my expectation that CDEM Groups work quickly to adopt this guideline, so that our communities are better prepared for future tsunami.

John Price

Director, Civil Defence Emergency Management

Contents

Section 1 Introduction and background

This section introduces the guideline, including the timeframe for implementation (Section 1.1) and the new nationally consistent approach for public-facing tsunami evacuation zones (Section 1.2). Background information about evacuation, as part of wider tsunami risk management and some basic information about tsunami is provided in Sections 1.3 and 1.4. Other related tsunami documents are listed in Section 1.5.

Context

All of Aotearoa New Zealand's coastline is at risk from local-, regional-, and distant-source tsunami. Tsunami can also happen in large lakes. Recent tsunami affecting Aotearoa New Zealand[1] and the wider Pacific Ocean[2] highlight the importance for our coastal communities to understand their tsunami risk and to be prepared for future evacuations. Aotearoa New Zealand has a large coastal population, including many schools and aged care facilities. The vulnerability of populations such as young children and elderly underscores the criticality of tsunami readiness.

Purpose of evacuation

The evacuation of a particular area is necessary when a tsunami threatens the safety of people within the area that is at risk.

The process of identifying areas potentially at risk from tsunami, and the actions required to enable the safe evacuation of people from those areas, is essential for evacuation planning. This guideline provides a nationally consistent approach to developing tsunami evacuation zones and routes, maps, and public information.

The benefits of a nationally consistent approach to tsunami evacuation includes enabling:

- a common understanding across Aotearoa New Zealand communities of tsunami evacuation zones and routes, maps, evacuation signage, and tsunami response actions
- improved alignment of tsunami evacuation planning with processes for official tsunami warnings.

Inconsistent approaches to tsunami evacuations across Aotearoa New Zealand have affected public education and tsunami warnings, communication, and the public's responses during evacuations.

1.1 About this guideline

Purpose

The purpose of this guideline is to provide a nationally consistent approach to tsunami evacuation, including the development of tsunami evacuation zones, maps, and public information for Civil Defence Emergency Management (CDEM) Groups and local authorities.

[1] Hikurangi and Kermadec Islands earthquakes and tsunami on 5 March 2021; Kaikōura earthquake and tsunami on 14 November 2016.
[2] Tōhoku earthquake and tsunami in Japan on 11 March 2011.

Scope

This guidance covers the development of tsunami evacuation zones and related tsunami readiness and response initiatives, including evacuation routes, evacuation maps, and information boards. There are also links to tsunami signage, tsunami blue lines, and vertical evacuation.

Out of scope

This guidance does not cover tsunami evacuation planning (managed by CDEM Groups and local authorities) or tsunami advisory and warning processes (see Section 1.5 for links to relevant documents).

Audience

The intended audience of this guideline is CDEM Groups and local authorities, who are responsible for developing and implementing tsunami readiness and response measures in their regions or districts.

Timeframe for guideline implementation

This guideline should be used by CDEM Groups and local authorities for the creation of new tsunami evacuation zones, routes, maps, and signs from the date the guideline is published.

All existing tsunami evacuation zones, routes, maps, and signs should conform to this guideline by 1 July 2031.

Approximately two years following the release of this guideline (2027), the Director Civil Defence Emergency Management will conduct an evaluation to gauge the progress CDEM Groups are making in aligning with the new guidance.

Structure

This guideline has the following main sections:

- *Section 1: Introduction and background* – introduces the guideline, including key terms used.
- *Section 2: Tsunami evacuation zone* – introduces the Blue Zone as the consistent approach for the public-facing tsunami evacuation zone and how to develop the zone.
- *Section 3: Evacuation routes* – explains the background of evacuation routes and how to create them.
- *Section 4: Communication products for tsunami evacuation* – explains how the evacuation zone and routes are communicated with maps, information boards and signs.
- *Section 5: Evacuation information for marine users* – provides information about evacuation for those on water.
- *Section 6: Community engagement and education for tsunami evacuation* – provides key considerations to support CDEM Groups and local authorities in implementing their chosen community engagement approach.
- *Section 7: References* – provides a list of references used in this guideline.
- *Section 8: Appendices* – provides information about other evacuation zones.

Use of icons

Indicates more information is available in another document or website.

Indicates tsunami warning information that is written for the public and can be used on tsunami evacuation maps and information boards.

1.2 Key update from previous guideline

New approach for evacuation zones

This guideline introduces the nationally consistent tsunami evacuation zone approach for Aotearoa New Zealand.

The nationally consistent approach for public-facing tsunami evacuation zones is the use of one zone: the Blue Zone.

This approach simplifies public-facing tsunami evacuation zones, particularly in local-source tsunami, when risk to life is highest and there is not enough time for an official warning.

Further details about this approach are provided in Section 2.

1.3 Tsunami basics

A tsunami is a series of powerful waves with strong currents. They are mostly caused by underwater or coastal earthquakes. Tsunami can inundate coastlines, causing impacts such as property damage, injuries, and loss of life.

Tsunami generation

The primary sources that generate tsunami are:

- large underwater or coastal earthquakes, in which significant uplift or subsidence of the seafloor, lakebed or coast occurs (this is the most common source of tsunami, and the basis of the evacuation zone defined in this guideline)
- underwater landslides
- large landslides from coastal or lakeside slopes
- explosive volcanic eruptions within, or close to, bodies of water
- meteor (bolide) splash-down, or an atmospheric air-burst over the ocean.

Tsunami waves are different from wind-generated surface waves on the ocean. When a tsunami wave is generated, the whole column of water from the sea or lake floor to its surface is affected. In contrast, waves created by wind only involve the surface of the water (Figure 1).

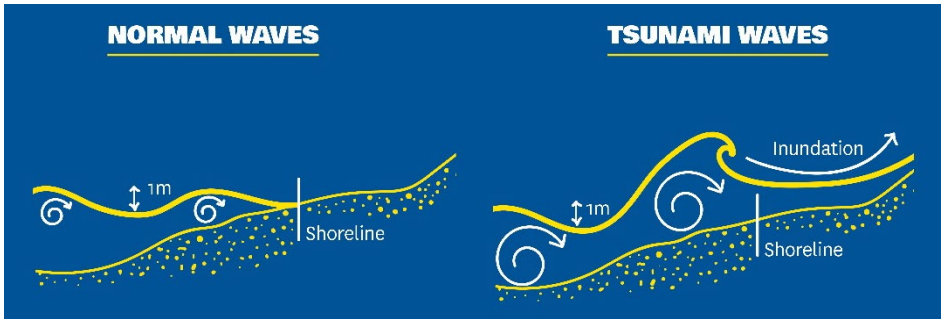

Figure 1 The difference between normal wind-generate coastal waves (left) and tsunami waves (right).

A tsunami is often a series of waves, and the first wave may not be the largest. In the deep ocean, tsunami waves generally have small wave heights, large distances between waves and travel at high speeds. As tsunami waves reach shallow water, their speed decreases rapidly and their height increases.

1.4 Key tsunami terminology

This section provides the definitions for key terminology used in this guideline. The terminology is grouped into the following categories:

- Tsunami evacuation (Section 1.4.1)
- Tsunami warnings (Section 1.4.2)
- Tsunami sources (Section 1.4.3)
- Tsunami science (Section 1.4.4)

1.4.1 Tsunami evacuation terminology

Blue Zone

At minimum, the Blue Zone should encompass the area expected to be inundated by 2500-year tsunami at the 84% confidence level from all sources, i.e., the Blue Zone should cover all maximum credible tsunami scenarios.

See Section 2 for more detail on the Blue Zone.

Safe Zone

A Safe Zone is defined as the entire area beyond the extent of the Blue Zone.

Safe Location

Safe Locations are specific locations that are high enough in elevation, or far enough inland that they are very unlikely to be inundated by tsunami. These locations should be easily accessible via evacuation routes and provide a safe place for people to congregate. These locations may or may not be beyond the extent of the Blue Zone. Examples include vertical evacuation structures or other high elevation locations within the Blue Zone, which have been assessed to ensure they are safe from tsunami inundation, or practical evacuation locations outside of the Blue Zone, such as schools, community centres.

Evacuation routes

Evacuation routes are paths from a location to the nearest Safe Zone or Safe Location. Routes can include paths, tracks, roads, bridges and may cross public and/or private land. They are usually shown on maps and/or signage. The guiding principle is that evacuation routes should be the quickest route to safety. There may be exceptions where the shortest route is not the best route due to potential congestion or safety concerns.

See *Section 3* for more information.

1.4.2 Tsunami warning terminology

Natural warnings

Natural warnings of tsunami include:

- feeling a strong earthquake that makes it hard to stand up, or a weak rolling earthquake that lasts a minute or more
- seeing a sudden rise or fall in water level
- hearing loud and unusual noises from the water.

Official warnings

When tsunami travel more than one hour to reach the coast of Aotearoa New Zealand, it is expected that there is time to issue official warnings.

The National Emergency Management Agency (NEMA) is responsible for issuing tsunami warnings in Aotearoa New Zealand. Tsunami warnings are published on www.civildefence.govt.nz and Twitter/X @NZCivilDefence. Tsunami warnings will also be broadcast on radio and television.

If there is a land threat, Emergency Mobile Alerts (EMA) will be issued by NEMA and CDEM Groups to areas under threat[3]. EMA is the preferred initial method of alerting the public of a tsunami threat to land.

Local areas and communities may have their own methods for additional broadcasting warnings. These might include EMAs, phone calls, or warnings through loud hailers.

Some local areas use sirens for tsunami warnings. NEMA, GNS Science, and New Zealand's Tsunami Reference Group all agree with international best practice that tsunami sirens are not effective as a warning system in regions subject to local-source tsunami.

Informal warnings

A tsunami warning could also come from friends, neighbours, the community or international media. If they are a trusted source and a person feels unsafe, they are encouraged to consider evacuating.

People are advised to check the accuracy of the warning once they have arrived at a safe location, or while traveling but only if it won't slow them down.

Official warnings that have been issued and are accessible should be trusted over informal warnings.

[3] EMAs may also be issued for other tsunami threats. For example, CDEM Groups may issue EMA at their discretion during National Advisory: Tsunami Activity events, where they consider there to be a significant life-safety risk.

1.4.3 Tsunami source terminology

The term ‘tsunami source’ refers to areas in the ocean where a tsunami originates. This guideline uses the terms ‘local’, ‘regional’ and ‘distant’ to refer to tsunami sources based on wave travel time to Aotearoa New Zealand. These terms are described below and in Figure 2.

Local

Local-source tsunami arrive at the coast of Aotearoa New Zealand within one hour. They are generated close to the coast, for example by earthquakes along the Hikurangi Subduction Zone. These tsunami are dangerous because of their short arrival time, meaning it is not always possible to issue an official warning, and there is limited time to evacuate.

Regional

Regional-source tsunami take between one and three hours to reach the coast of Aotearoa New Zealand. Two possible triggers for regional-source tsunami are a large earthquake in the Southwest Pacific or an eruption from an underwater volcano in the Kermadec Trench to the north of Aotearoa New Zealand. Official warnings are expected to be issued for this type of tsunami, though they still have short arrival times and may not produce natural warnings, making them particularly dangerous.

Distant

Distant-source tsunami take at least three hours or more to arrive at the coast of Aotearoa New Zealand. A distant-source tsunami is most likely to be generated by a very large earthquake around the margins of the Pacific Ocean. Aotearoa New Zealand is particularly at risk from earthquakes off the South American coast. Natural warnings are unlikely to be felt from these sources, however, official warnings are expected to be issued for this type of tsunami.

Figure 2 Tsunami source regions. Regions are based on the minimum travel time from source to the point of first arrival at the Aotearoa New Zealand coastline (including the Chatham Islands).

1.4.4 Tsunami science terminology

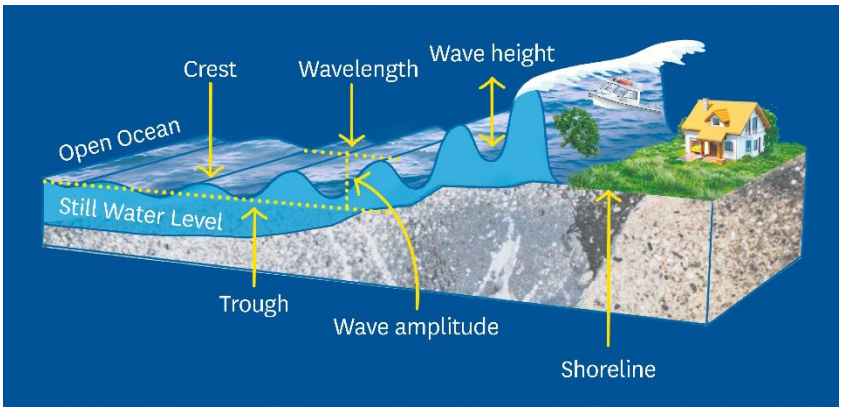

Figure 3 Tsunami-related terminology.

Crest	The highest point of the wave.
Trough	The lowest point of the wave.
Wave height	The height between the trough and crest.
Amplitude	The vertical height of the waves above sea level at the time of the tsunami.
Wavelength	The distance between two waves, measured from crest to crest or from trough to trough.
Wave period	The time between two waves, from crest to crest or from trough to trough (one wavelength). Normal waves have a wave period of 10-15 seconds, while tsunami waves can have wave periods of tens of minutes to hours, meaning the water can keep rising or receding for that length of time.
Run-up height	The maximum elevation a tsunami reaches on land, measured above sea level at the time of inundation.
Inundation area	Area flooded by sea water from a tsunami.
Seiches	Sloshing movement of water in places like harbours, bays or large coves. Seiches are generated in response to other processes such as the generation of large wind waves or tsunami waves.

1.5 Key documents

The key CDEM documents that relate to this guideline are below. Their relationship to this guideline, and each other, is shown in *Figure 4*.

- National Tsunami Advisory and Warning Plan [SP 01/20]
- National Tsunami Signage Technical Standard [TS 01/08]
- Mass Evacuation Planning Director's Guideline [DGL 07/08]
- Public Alerting: Options Assessment [IS 10/09]
- Tsunami Warning Sirens Technical Standard [TS 03/14]
- Consistent Messages for CDEM
- Risk Assessment Guidance for CDEM Group Planning [DGL 23/22]

1.5.1 Vertical evacuation

Tsunami vertical evacuation is another method of evacuation that could be used in some regions.

Tsunami vertical evacuation is the use of buildings or structures which are specifically designed to withstand tsunami impacts as short-term refuge sites within the Blue Zone.

The use of vertical evacuation structures is most appropriate during local-source tsunami evacuations, when available evacuation time could be only a few minutes. It is important that tsunami vertical evacuation is recognised as a supplementary risk management **measure of last resort**,

to meet a clear need, when all other risk management measures have been assessed and implemented.

Guidance

In Aotearoa New Zealand there are two guidance documents for tsunami vertical evacuation:

Assessment and Planning for Tsunami Vertical Evacuation Director's Guideline [DGL 21/18]

- published by the National Emergency Management Agency
- provides CDEM Groups with a step-by-methodology to assess life safety risk, considerations for improving tsunami evacuation and as a last resort, using vertical evacuation.

Tsunami Loads and Effects on Vertical Evacuation Structures Technical Information

- published by the Ministry of Business, Innovation and Employment
- this technical information is intended to inform the design, construction, and operation of vertical evacuation structures.

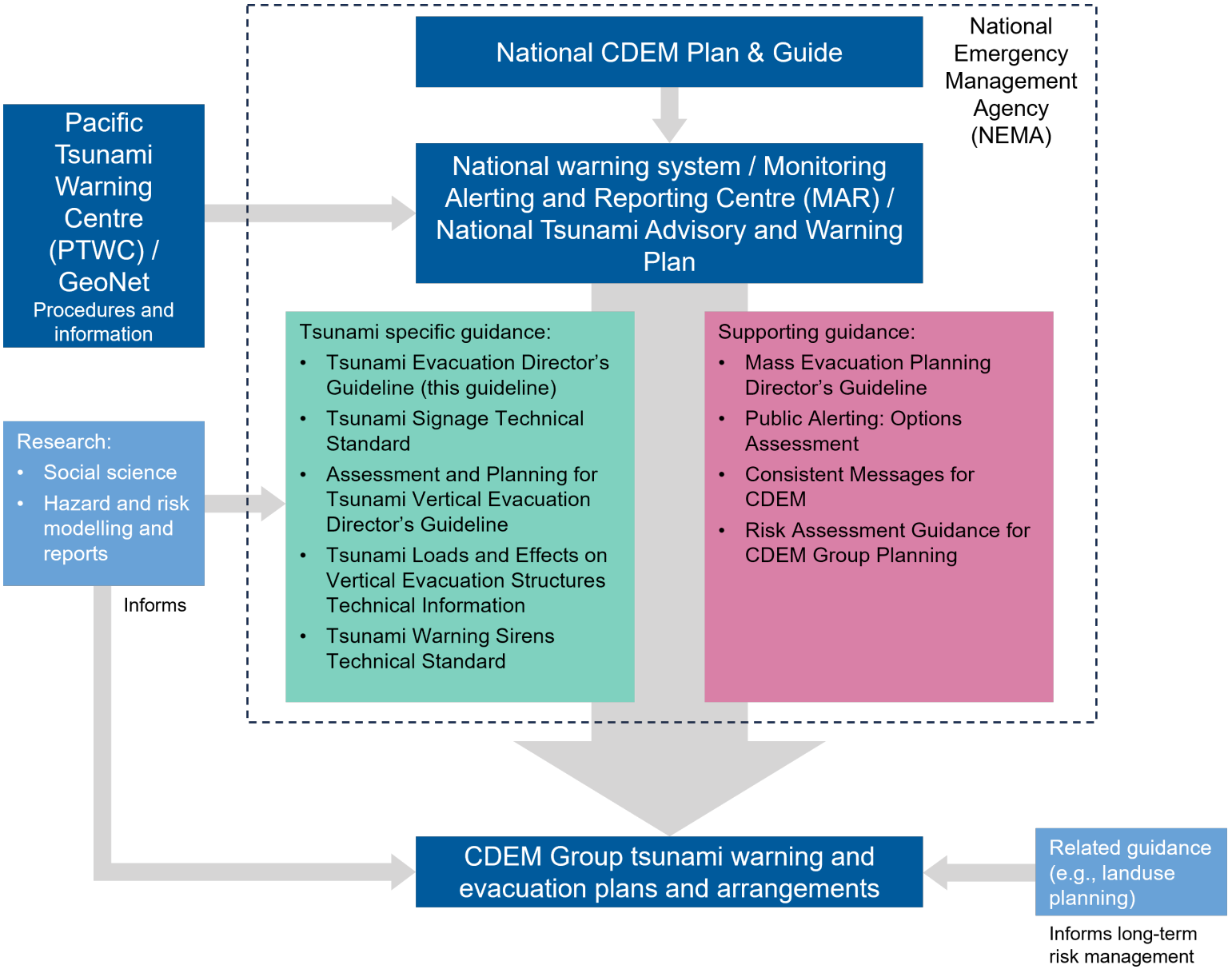

Figure 4 Relationship between this guideline and key tsunami documents in Aotearoa New Zealand.

Section 2 Tsunami evacuation zone

This section introduces the Blue Zone as the nationally consistent approach for public-facing tsunami evacuation zone, and the rationale for this approach (*Section 2.1*). The use of additional zones for evacuation planning is described in *Section 2.2*. This section also outlines how to define the tsunami evacuation zone using modelling (*Section 2.3*).

Purpose of tsunami evacuation zones

Tsunami evacuation zones are intended to be used for both public education before an evacuation, and to support evacuations when a tsunami warning is issued. They can also be used for other risk reduction initiatives, such as land use planning, though this is beyond the scope of this guidance.

Extent of tsunami evacuation zone

A tsunami evacuation zone should encompass the entire coastline of each region, including all areas indicated as at risk by tsunami modelling. When developing the tsunami evacuation zone, priority should be given to populated areas, particularly where there are known evacuation challenges. Regions may also wish to develop a tsunami evacuation zone for any large lakes that are at risk.

2.1 Public-facing tsunami evacuation zone: Blue Zone

This guideline outlines one public-facing tsunami evacuation zone, the Blue Zone, as the approach to consistent tsunami evacuation zones for Aotearoa New Zealand.[4]

Blue Zone description

The Blue Zone must cover all maximum credible tsunami scenarios across all sources (see below for the full definition). People should evacuate this zone when they experience natural tsunami warnings, or when instructed to via official warnings.

The Blue Zone can be defined using modelling Levels 4, 3, or 2 (see *Section 2.3*).

Rationale for the Blue Zone

Showing only one evacuation zone means it is easier to visualise the threat on a map, easier for people to interpret and is less overwhelming for all users. This is supported by research on the social science aspects of tsunami evacuation mapping for Aotearoa New Zealand (Charlton et al. 2023b).

Blue Zone definition

At minimum, the Blue Zone must encompass the area expected to be inundated by 2500-year tsunami at the 84% confidence level from all sources. Such tsunami includes large subduction interface earthquakes, some of which are comparable to the earthquake that caused the 2011 Tōhoku tsunami in Japan. A tsunami of this likelihood is not an absolute 'worst case', as this is not well defined. It is a compromise between the very low probability of even larger tsunami and the issues and risks

[4] "Public-facing" refers to maps, documents, education materials, and signs that the public are aware of and are used in education before tsunami.

involved in a mass-evacuation in the aftermath of strong earthquake shaking.

The 84% confidence level can be expressed in words as 'erring on the side of caution' with respect to unknown or uncertain factors. It is like using the upper bound of a margin of error bar. The following should be considered, which may extend the zone:

- the possibility of larger local-source tsunami that occur at longer return periods than 2500 years
- the extent of inundation found in local high validity palaeotsunami[5] deposits (the New Zealand Palaeotsunami Database is a useful resource for this).

The Blue Zone can be extended inland to avoid crossing through buildings or properties, allowing easier public communication of the zone boundary on the ground. This is especially important to consider for institutions and facilities that are likely to have large numbers of, or highly vulnerable people, such as hospitals, schools and rest-homes.

The Blue Zone boundary must not be reduced in area from what has been modelled, nor have its outer extent moved closer to the coastline. This still applies in situations where there are low inundation depths or low velocities, as tsunami can still be lethal in these situations.

Other public-facing zones

The use of more than one public-facing zone is not recommended.

If additional public-facing zones are to be used, their establishment must be based on the identification of anticipated challenges in evacuating the Blue Zone. Examples of where additional zones may be necessary are for very densely populated coastal areas, or communities that are more likely to experience challenges when evacuating.

Strong consideration must be given to the implications of using additional public-facing zones, including how they may reduce public understanding, and therefore compromise effective evacuation during local-source tsunami, as well as misaligning with the nationally consistent approach.

2.2 Additional zones for evacuation planning

Additional tsunami zones can be developed for planning purposes. These could be used for evacuation planning before (regional- and distant-source) and during (distant-source) tsunami evacuations, or for risk reduction activities (e.g., land use planning).

These zones should not be displayed on public education maps, websites, or information boards prior to a tsunami, to minimise any confusion with the Blue Zone.

Description

The zones that can be used for planning are the Red and Orange Zones, as these have been developed by regions using the former guideline. The

[5] Tsunami occurring prior to the historical record or for which there are no written observations.

Red Zone covers the beach and marine[6] areas. The Orange Zone should be defined by a specific threat level (as defined in the National Tsunami Advisory and Warning Plan [SP 01/20]). The threat level that is selected should at least encompass the area that would be inundated by the largest tsunami with travel time greater than one hour on a 500-year timeframe. See *Appendix A* for full definitions of the Red and Orange Zones.

It should be noted that a small number of regions across Aotearoa New Zealand define their Orange Zone differently. This is because in these regions the largest tsunami threat is from regional- or distant-sources, rather than from local-sources, as it is for the rest of the country.

Intent

Additional evacuation planning zones could be used for two reasons:

1. Preparedness activities, particularly when undertaking tsunami evacuation planning with vulnerable groups (e.g., schools and aged care facilities).
2. During response, when there is sufficient time to undertake a more detailed evacuation (i.e., for a distant-source tsunami) and communicate the zones to the public.

It is important that only the Blue Zone is displayed on public education maps, websites, or information boards to ensure the simple messaging associated with the Blue Zone is effective.

If the Red and Orange Zones are shared with the public during community engagement activities, it is important to:

- emphasise that the Blue Zone is the area to be evacuated following a long or strong earthquake, and it is important that people check if they live, work or play in the Blue Zone
- clarify that the Red and Orange Zones are not included in any online or physical preparedness material
- specify that the Red and Orange Zones will be made available to the public by CDEM Groups solely when there is a tsunami threat that is several hours away, which ensures there is time for CDEM Groups to share the maps and the public to receive them and determine if they are required to evacuate.

2.3 Levels of evacuation zone modelling

Tsunami modelling must be used to create the Blue Zone. This guideline provides four levels of modelling that can be used, rather than prescribing an exact modelling methodology. Level 4, 3, or 2 must be used; Level 1 is only included for completeness.

[6] "Beach and marine" refers to the area that is affected by "strong and unusual currents and dangerous surges at the shore", as per the national messaging for a Beach and Marine Tsunami Activity Emergency Mobile Alert (EMA).

Level 4

Level 4 is the nationally recommended standard for tsunami evacuation zone modelling.

Level 4 is the most comprehensive approach, based on drawing an envelope around all inundations from many well-tested hydrodynamic computer models run from source through to inundation. The number of models must be enough to closely approximate the full range of scenarios that can be expected from all sources. Development to this level of sophistication requires a comprehensive scientific understanding of all possible tsunami sources (distant, regional and local), wave propagation, and inundation behaviour, across a range of magnitudes.

Level 3

Level 3 uses a physics-based computer simulation of the process by which water inundates across land. This allows for complexities that a simpler 'rule' cannot, such as changes in the direction of water flow under the influence of the shape of the land and variations in surface roughness from different land uses. Such modelling is expensive, and the quality of outputs is dependent on the science behind the model and the quality of the elevation or bathymetry data used. The wave impacting the coast may be either based on:

a. an incoming wave of a particular amplitude, or

b. multiple scenarios 'de-aggregated' from an appropriate probabilistic model and modelled from source (this is the preferred Level 3 approach).

Level 2

Level 2 uses a rule-based attenuation calculation of the potential run-up height that depends on the distance inland from the coast (*Figure 5*). Potential run-up height at the coast is taken to be twice the shoreline wave amplitude[7] above high tide, then the following attenuation relationships are applied:

- Over land – 0.5% height attenuation by distance (i.e., water gets 1m shallower every 200m inland)
- Up rivers – 0.25% height attenuation by distance (i.e., water gets 1m shallower every 400m up rivers)
- Over-bank across land from rivers – 2% height attenuation by distance (i.e., water gets 1m shallower every 50m over riverbanks).

This approach provides a more realistic output than a simple 'bathtub' model (Level 1), but still does not account for physical variations in wave behaviour. In the form applied in Aotearoa New Zealand, it is conservative (i.e., erring towards overestimation of inundation extent). This conservatism helps the evacuation zone cover a broad range of potential scenarios. Local knowledge of the topography must also be applied to support the process.

[7] As run-up can be up to double the arriving wave height due to the momentum of the tsunami.

Level 2 is the recommended approach if LiDAR-grade[8] (i.e., better than 1m vertical accuracy) elevation data, and a similar grade of bathymetry data (e.g., from a port-specific navigational chart), are not available. It is only recommended in these circumstances because of the conservative nature of the approach, and because hydrodynamic models (used in Levels 3 and 4) are more error sensitive when using low accuracy data.

Level 2 is generally regarded as an 'interim' approach because of its conservatism, particularly when used in areas of high population density. See Leonard et al. (2008), Fraser and Power (2013), and *Section 2.3.1* for examples of the Level 2 approach. Fraser and Power (2013) also include a validation exercise based on data from the 11 March 2011 Tōhoku earthquake and tsunami.

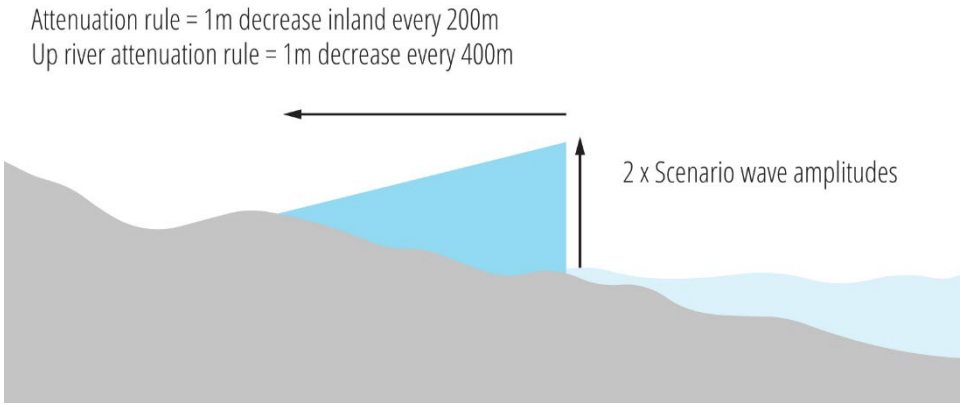

Figure 5 Cross section showing how the evacuation zone boundary can be mapped using a projection of wave amplitude inland, based on attenuation rules.

Level 1

This method is not recommended for use in Aotearoa New Zealand because it does not allow for wave attenuation or the effects of run-up, and overestimates tsunami inundation. It is only included here for completeness.

Level 1 is based on a simple 'bathtub' model where inundation is determined based on maximum wave amplitudes, projected inland from the coast to a cut-off elevation (Figure 6). This approach provides the crudest and simplest method of mapping the evacuation zone.

[8] LiDAR, which stands for Light Detection and Ranging, is a remote sensing method that uses light in the form of a pulsed laser to measure distances to the Earth's surface.

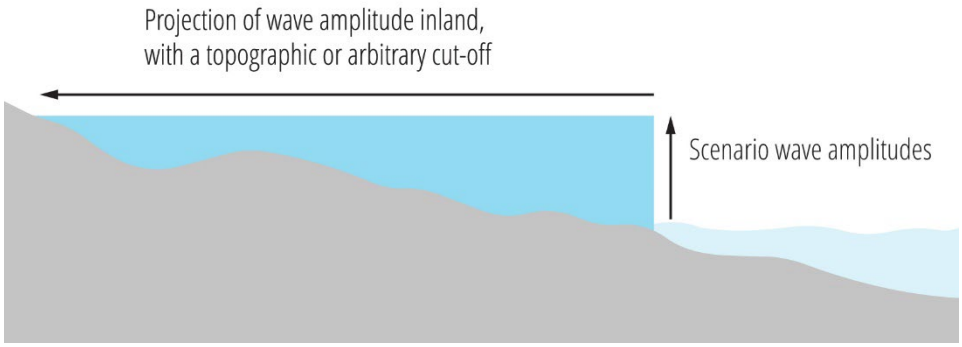

Figure 6 Cross section showing how the evacuation zone boundary can be mapped using a projection of wave amplitude inland using a simple 'bathtub' model.

2.3.1 National Tsunami Hazard Model

The National Tsunami Hazard Model provides estimates of the maximum tsunami height at the coast for all of Aotearoa New Zealand's coastline within specified time periods and confidence levels. The 2021 version of the model is outlined in Power et al. (2022) and the outputs are available on the GNS Science website.

Recommended use of the model for evacuation zones

It is recommended that probabilistic data, such as the 2500-year 84% confidence shoreline wave amplitudes from the National Tsunami Hazard Model, is used for the Level 2 approach.

It is recommended that scenarios for the Level 3b approach are taken from the de-aggregation data provided by the National Tsunami Hazard Model. Random variations between earthquakes and other sources of uncertainty can cause variations in the modelled extent of tsunami inundation. The National Tsunami Hazard Model uses the concept of 'effective magnitude' to encompass these variations into a modelled earthquake of higher magnitude. The use of scenarios from the hazard model avoids the necessity to run a very large number of scenarios to cover the full spectrum of possible tsunami. One consequence of this is that it may sometimes be necessary to run models with an 'effective magnitude' that is larger than the largest 'actual magnitude' a fault is believed to be capable of producing.

2.3.2 Considerations for updating tsunami evacuation zone modelling

There is no national recommendation for when to update tsunami evacuation zone modelling, as it is often location specific. If CDEM Groups or local authorities are concerned that models may be out of date they can seek expert advice to assess whether a revision is needed. The following are some situations where an update of tsunami evacuation zone modelling should be considered:

- major changes to land-use, which could change how a tsunami is likely to travel over land

- significant changes in land topography, local bathymetry or coastal topography, which could change the predicted extent of inundation
- when a new revision of the National Tsunami Hazard Model is released that shows significant changes to the hazard along the coast. This typically reflects changes in the scientific understanding of tsunami and their sources.

2.4 How to use tsunami evacuation zones

This section provides information for triggering evacuations based on tsunami warnings.

Warning types

Evacuations are triggered by two main types of warning:

1. **Natural** – in which case people should evacuate the Blue Zone. These are tsunami where there is not enough time to issue an official warning and the public need to rely on natural warnings and their knowledge of the actions to take (i.e., Long or Strong, Get Gone).
2. **Official**[9] – in which case national and/or local warnings will state the zone(s) to be evacuated.

During a tsunami evacuation, a combination of natural and official warnings may be received.

Official evacuations of the public are authorised by NEMA and CDEM Groups. The decision to evacuate communities is based on a National Advisory or Warning issued by NEMA, in conjunction with local threat assessments, plans and standard operating procedures (SOPs). When issuing official warnings, CDEM Groups could make use of additional tsunami evacuation zones they have developed (see *Section 2.2*).

The process and responsibilities for issuing tsunami warnings are described in the Tsunami Advisory and Warning Plan [SP01/20].

Public alerting of areas to evacuate

Warning agencies need to tell the public which areas need to be evacuated following an official warning. In the first instance this should be through Emergency Mobile Alerts (EMA). Information about evacuation, including maps, should be distributed via multiple channels like social media, traditional media, websites, and links included in EMAs.

It should be noted that there may be insufficient time or internet access and capacity for the public to check evacuation zones on official websites.

[9] Official notifications or warnings are issued by designated alerting authorities.

Section 3 Evacuation routes

This section defines tsunami evacuation routes, provides guidance on how to create them and important considerations for planning. It also explains how to identify and use Safe Zones and Safe Locations.

Evacuation routes are used to facilitate effective evacuation, and to encourage public readiness through tsunami hīkoi[10] (see *Section 6.1.4*) and other readiness initiatives.

Creating and sharing information on evacuation routes and Safe Zones can:

- aid in faster evacuation and better decision making by those evacuating to safety
- allow people to practice and time their routes to safety, reinforcing their awareness of how much time they require to successfully evacuate (see *Section 6.1.4*)
- contribute to a person's belief in their ability to successfully evacuate in the event of a tsunami evacuation. There is evidence which suggests that self-efficacy (belief in one's ability to complete a task) plays an important role in individual-level response (Benight et al. 2009).

Evacuation routes definition

Evacuation routes are paths from a location to the nearest Safe Zone or Safe Location. Routes can include paths, tracks, roads, bridges and may cross public and/or private land. They are usually shown on maps and/or signage. The guiding principle is that evacuation routes should be the quickest route to safety. There may be exceptions where the shortest route is not the best route due to potential congestion or safety concerns.

Types of evacuation routes

Official evacuation routes are optional and may not be developed by all CDEM Groups across Aotearoa New Zealand. However, it is good practice to have evacuation routes to communicate how people should evacuate before a tsunami. CDEM Groups should consider their capacity to maintain and update routes before developing official evacuation routes and communicating them to the public.

Alternatively, or alongside official evacuation routes, CDEM Groups should support and inform the development of community or 'informal' evacuation routes (for example, routes that are created by community groups or whānau). See *Section 6.1.2* for more details.

Safe Zones and Safe Locations

Safe Locations and Safe Zones (defined in *Section 1.4.1*) are not used consistently across Aotearoa New Zealand. It is recommended that CDEM Groups investigate any liability concerns before adopting these terms.

Alternatively, CDEM Groups that do not wish to adopt Safe Locations and Safe Zones can replace these terms with "assembly point" and "area outside the evacuation zone", respectively.

[10] hīkoi means walk in te reo Māori.

Additional guidance

These documents on evacuation routes and considerations are relevant to designing tsunami evacuation routes:

- NZ Transport Agency Waka Kotahi framework for evacuation routes
- NZ Transport Agency Waka Kotahi pedestrian wayfinding sign guidance: how to use and design
- Mass Evacuation Planning Director's Guideline [DGL 07/08]
- United States' Oregon Office of Emergency Management tsunami evacuation wayfinding guidance

The content of these documents and other research is summarised in the following sections.

3.1 Creating tsunami evacuation routes

The following is the recommended approach to create new, or update, existing evacuation routes.

1. **Determine the tsunami evacuation zone:** define the extent of the Blue Zone (see *Section 2*).
2. **Identify Safe Zone (if using):** label the area beyond the extent of the Blue Zone so that it can be identified as a general destination for evacuation routes.
3. **Identify Safe Locations (if using):** locate all areas that are sufficiently elevated, inland or otherwise safe from tsunami inundation that could be considered. These locations must also be safe for people to congregate during a tsunami. See the Safe Location definition in *Section 1.4.1*.
4. **Engage with stakeholders:** involve local communities and first responders in the planning process to ensure the routes, Safe Zones and Safe Locations are practical and accessible.
5. **Route selection:** choose the most direct and safest routes from areas to Safe Zones and Safe Locations. Consider factors like topography, distance, accessibility, as well as the guidelines outlined in *Section 3.2.2*. Multiple routes may lead to the same Safe Location. Routes can be selected by staff overlaying information on maps and choosing appropriate routes. More detailed means such as evacuation modelling or participatory mapping (see pages 20-21) can also be used.
6. **Assess infrastructure:** speak to infrastructure experts to check that paths, tracks, roads and bridges can handle the expected volume of evacuees. Consider whether there may be a need for temporary traffic management, particularly at pinch points, and contra-flow[11] access for emergency vehicles.

[11] Traffic moving in the opposite direction of normal.

7. **Ground truth:** practice using the evacuation routes to ensure there are no other barriers or issues that have not already been identified.
8. **Revise and adjust evacuation routes if necessary.**
9. **Socialisation and communication:** add routes, Safe Zones and Safe Locations to maps and install signage (see Section 4.1 and Section 4.4). Test and exercise the evacuation routes to ensure the community are familiar with the routes (see Section 6.1.4).
10. **Review and update as required:** for example, when urban intensification occurs, access to private land changes, or new tsunami modelling is undertaken.

Useful information to create evacuation routes

The following information is useful when creating evacuation routes:

- up-to-date tsunami hazard or evacuation zones (plus Safe Zones and Safe Locations)
- up-to-date data on people or groups to be evacuated (e.g., number of people, vulnerability profile of the community). Ideally dynamic population data (e.g., variability of the population throughout the day, week, year)
- maps and spatial data of transport datasets including paths, roads, and other transport routes
- location of existing evacuation routes and signs
- environmental data such as terrain, locations of water bodies, steep or unsafe slopes, heavy vegetation, and anything else that may impact people's ability to evacuate
- validation of route options, using feedback on routes from residents and the community or through tsunami hīkoi (drills)
- human behaviour data, such as information about how people evacuate to compare against how people should evacuate (e.g., by foot). See Section 3.2.1.

Modelling evacuation routes

Tsunami evacuation modelling can be used to create and refine evacuation routes. Modelling tsunami evacuations is complex due to the different factors that influence evacuation outcomes, including the number of people evacuating, interactions between people, terrain and infrastructure, potential damage from earthquakes, and meteorological conditions.

There are three main evacuation modelling approaches:

Agent-based evacuation modelling is the recommended approach for modelling tsunami evacuations. However, it is resource and time intensive and therefore may not be a practical option for all areas. Agent-based evacuation modelling dynamically simulates the evacuation of individuals (agents) to Safe Zones and Safe Locations by using available transportation or pedestrian networks and considering the effects of obstacles such as bottlenecks and pinch points. The dynamic approach

also considers the realistic evacuation routes used by evacuees to travel to Safe Zones and Locations.

Least-cost distance modelling is a well-established method for tsunami evacuation modelling. It applies travel speeds to determine the likely route from the evacuation zone to Safe Zones and Safe Locations using available paths, tracks and roads. The simplified approach calculates the evacuation time based on the shortest horizontal route to reach the Safe Zone. Least-cost distance modelling does not usually take congestion effects into consideration, which can be a limitation, especially when modelling in urban areas.

Network modelling is commonly used for traffic modelling. The tool uses network capacity, evacuee density and congestion potential to model evacuation.

Participatory approach to creating evacuation routes

Another approach that can be used to create evacuation routes is through participatory mapping. This approach can be used in conjunction with evacuation modelling. See Section 6.1.2.

Participatory or community mapping is a collaborative process where community members share their experiences, knowledge, and ideas to create maps. This approach empowers communities by fostering connections among members and providing a platform for individuals to contribute their unique perspectives.

Different types of participatory or community mapping techniques that could be used include:

Participatory GIS (Geographic Information Systems) combines community input with spatial data from GIS technology to create detailed maps.

Sketch mapping involves community members drawing simple maps based on their perceptions of the area, typically used in early-stage or low-technology participatory projects.

Transect mapping is a specific type of mapping where participants walk a line (transect) through an area and record observations and thoughts.

3.2 Factors that influence evacuation routes

There are many factors that affect which evacuation routes people take. Additionally, there are many different considerations that influence how evacuation routes are created. This section provides some background information on human behaviour (Section 3.2.1) and considerations when creating evacuation routes (Section 3.2.2).

3.2.1 Human behaviour and evacuation decision making

There are several aspects of human behaviour that can affect evacuation decision-making. These are detailed below and should be considered when creating evacuation routes.

How people behave in evacuations

Evacuation decision-making is based on complex interactions between comprehension of warning information, risk perception and an individual's personal attributes.

Personal attributes such as gender, age and living situation, knowledge of hazards and warnings, preparedness actions, and prior disaster and evacuation experiences have been shown to influence a person's likelihood of evacuation in different ways. For example, people who have experienced a tsunami, hold knowledge about tsunami hazard and/or have physically prepared for a tsunami tend to have an increased risk perception. These people are more inclined to evacuate immediately. In contrast, people who have received tsunami warnings that have not resulted in substantial impacts or do not have existing awareness of tsunami hazard can have a lower risk perception that results in a delay in evacuating, or not evacuating at all.

There are several Aotearoa New Zealand studies, with recent examples including Blake et al. (2018), Dhellemmes et al. (2021), and Vinnell et al. (2022) that examine how different factors may have influenced likelihood of evacuation in previous tsunami evacuations, or how they may influence intentions for future tsunami evacuations. These may be useful as an evidence base to inform evacuation planning at the regional and local levels.

There is also the consideration of individual versus crowd behaviour. Some individuals try to make logical decisions but also have a self-preservation mindset, where they prioritise their own safety. Individuals may also take actions to protect their families, friends, pets, and physical assets at the expense of their own safety. People within a large crowd tend to undergo herd mentality where they often follow the actions of others even if they are not the correct actions.

The evacuation behaviour of different groups of people can also influence the overall success of evacuation. For example, potential differences between tourists and residents. Tourists tend to have a lower risk perception, making them less likely to evacuate than residents.

Methods of evacuation

The method of evacuation that individuals choose influences evacuation outcomes. In Aotearoa New Zealand, the recommended approach for tsunami evacuation is to evacuate on foot if able. However, results from a public survey showed that around 70% (averaged across three evacuation scenarios) of surveyed New Zealanders intended to evacuate by vehicle (Dhellemmes et al. 2021). If most evacuees choose to evacuate by vehicle this may cause congestion and overall delay of evacuation, which can be exacerbated by people abandoning cars.

The chosen evacuation method could depend on the perceived time available to evacuate, time of day and weather conditions. For example,

people are more likely to evacuate by vehicle if it is raining or during the night.

Time taken to evacuate

The total time taken to evacuate can be divided into two parts: reaction time and evacuation time.

Reaction time is the time it takes for an individual to receive a warning (natural and/or official), and undertake pre-evacuation actions[12], before they start to evacuate. Research has found that on average, reaction time is 10-14 minutes after an earthquake has occurred (Kitamura et al. 2020). However, this timeframe can vary considerably depending on the event, the individual's location, their level of awareness about what to do, and other social factors. For example, people who have prior knowledge of tsunami hazard will likely evacuate faster, while those with larger families might take longer to start evacuating.

Evacuation time is the time taken for an individual to reach safety. This time will vary considerably based on many factors including distance to safety, evacuation method used, personal mobility, and any delays experienced while traveling. Aotearoa New Zealand research indicates that walking speeds vary from about 3.6km/hr for a slower pedestrian (e.g., children, elderly, vision impaired or mobility impaired), to 5.4km/hr for a typical purposeful walking speed. This equates to being able to walk 1km in 15 minutes and 10 minutes, respectively. Busy areas or steep slopes will decrease general walking speeds and increase evacuation time.

Choice of evacuation route

There has been limited research in Aotearoa New Zealand on which specific evacuation routes people choose during emergencies. There are a range of factors that influence which evacuation routes people take such as current location, travel times, travel costs, the individual's knowledge about the area, weather conditions, congestion, the age and ability of individuals, the behaviour of others and the ability to make logical decisions under pressure. Most commonly, people choose routes based on proximity or familiarity.

3.2.2 Factors affecting evacuation routes

There are several factors that can affect tsunami evacuation routes and influence evacuation. Table 1 outlines some of these and provides some additional considerations and possible solutions.

[12] Pre-evacuation actions are the activities undertaken before evacuating. Examples include seeking further information, contacting or locating family members or neighbours, assisting others with evacuation or retrieving essential belongings.

Table 1 Factors which could influence effective tsunami evacuation

Factors influencing evacuation	Considerations and possible solutions
Number of routes: isolated coastal or rural communities may only have a single route option, whereas large urban centres may have multiple route options.	Communicate which locations are likely to experience significant vehicle congestion, particularly in communities that have a single route, to encourage evacuation on foot. Where possible, identify multiple evacuation routes, including those on roads, paths and across private land (after obtaining permission).
Route conditions: the conditions of the route can slow or prevent evacuation. The effectiveness of the route could vary depending on the time of the day, such as nighttime or during bad weather, or damage caused by other hazards.	Consider possible damage on nearby routes that may affect the viability of the route. Ideally use multi-hazard risk assessment to determine the likelihood of other hazards (earthquake, fire, landslide, ground instability) occurring at the same time. Identify alternative routes that are less likely to be damaged by other hazards.
Route capacity: capacity of the route and Safe Locations. Overcrowding, queuing, and capacity (primarily related to vehicular evacuation) may be an issue.	Simulations, modelling and conversations with local emergency managers and community leaders can help understand and solve capacity issues. It is noted that simulations and modelling are typically not a cost-effective solution. If possible, widen or add more routes. If this is not possible, communicate these challenges to the community.
Route location: communities in low lying areas may be too far from the Safe Zone to consider evacuating to there.	Counterintuitive evacuation (towards the sea) to a Safe Location within the Blue Zone could be considered. Consider what resources are required at Safe Locations if the locations could be isolated for a period of time.

	It is also worth considering evacuation routes that might put people in danger for a short part of the route (e.g., evacuation around the coast or crossing over an evacuation zone to reach a more practical Safe Zone).
Bridges and roads: earthquakes can damage roads and bridges, making evacuation impossible (noting this might not be known at the time of evacuation). This also applies to foot bridges.	Consider strengthening bridges. Add alternative routes if bridges and roads are likely to be damaged.
Evacuation may occur outside of zone: people outside of the evacuation zone may still evacuate to further away locations, where they feel safer.	Account for a larger than expected number of people evacuating.
Evacuation time: consider the time required to evacuate along the route, accounting for possible delays and differences in people's mobility.	Consider including the anticipated evacuation times on maps and signs. It is easier for people to understand walking time than distance. Conduct tsunami hīkoi to regularly test evacuation times.
Route access: consider use of routes that people already use (e.g., beach accesses). This can include routes over private land.	Secure and regularly confirm access with landowners if route relies on access through private land.

Section 4 Communication products for tsunami evacuation

This section provides information about using maps (Section 4.1), information boards (Section 4.2) and signage (Section 4.4) to communicate the Blue Zone and evacuation routes. CDEM Groups and local authorities should use these products to communicate tsunami evacuation information to their communities. In addition, Section 6 provides considerations for community engagement and public education that may be useful when implementing these products.

The aim of the communication products is to make evacuation information (routes, zones or locations) easy to remember, so people can recall the details when they need to evacuate. Signage provides a visual reminder in day-to-day life that tsunami risk is present and educates people on what they should do in the event of a tsunami.

This section also includes templated text and guidance for general tsunami evacuation messaging to include on maps and information boards (Section 4.3).

The information provided in this section is based on research and review undertaken by GNS Science's Hazard and Risk Social Sciences team, see Charlton et al. (2023a and 2023b).

4.1 Tsunami evacuation maps

Evacuation maps are critical for communicating tsunami risk and response information to the public. They also provide a common platform for integrated evacuation planning. This section details map content, design, and usability.

This guideline refers to both static and interactive maps.

Static maps

Static maps are fixed and cannot be changed by users. They provide a snapshot in time of the Blue Zone, Safe Zones/Safe Locations and evacuation routes. These maps are used on websites, printed on signs or information boards or available for download as PDF documents.

Interactive maps

Interactive maps are digital maps that allow users to interact with the map content. They are usually embedded in websites or applications (e.g., ArcGIS Online). Users can often click on elements to get more information or see changes based on their input.

4.1.1 Map content and design

Tsunami evacuation maps should be kept as simple as possible. Too much detail can be distracting and counterproductive whereas not enough can leave the user with unanswered questions. The level of detail required to be effective may be dependent on local preferences, culture, experiences, and expertise of map users.

The user should be able to identify key evacuation information immediately (i.e., the most important information should stand out and be easy to interpret).

At a minimum, all tsunami evacuation maps (both static and interactive) should include the elements listed in this section.

Evacuation zone

The Blue Zone should be included on all tsunami evacuation maps. The blue colour details are specified below:

Fill:

- Colour: HEX: #23B6E6 / RGB: 35, 182, 230
- Transparency[13]: 40-60%

Outline:

- Colour: HEX: #005A9C / RGB: 0, 90, 156
- Transparency: 0%
- Line width/weight: 2pt

A transparency range is provided to ensure the Blue Zone is visible on a range of different basemaps.

The Blue Zone should be extended at least 500 metres offshore but can be extended further to accommodate specific aspects of the local marine environment. This is to ensure the Blue Zone is visible on maps along the entire coastline.

Evacuation routes (if relevant)

If tsunami evacuation routes are used in a region, they should be shown on maps as either specific routes or general routes.

Specific routes should show the exact path people need to take to evacuate, whereas general routes only show the general direction people should evacuate out of the Blue Zone.

Both type of routes should be shown with arrows. No one colour is effective for every map, however a white arrow with a thin black outline is typically a good option (Figure 7). The most important consideration is how the routes contrast with the basemap and the Blue Zone.

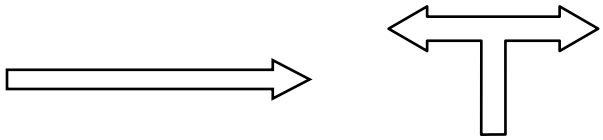

Figure 7 Examples of evacuation route arrows.

There is no evidence to guide how many routes should be shown on maps. A balance should be found between the number of evacuation routes shown and

[13] There are different meanings for the word transparency. This guideline defines 0% transparency as full colour and 100% transparency as no colour ('see-through').

the overall readability of the map. Interactive maps can alleviate this by varying the number of routes shown based on the map scale being used.

Safe Zones and Safe Locations (if relevant)

If used, Safe Zones and Safe Locations (defined in Section 1.4.1) should be shown on maps.

50 metre water depth for marine users (if relevant)

If CDEM Groups and local authorities choose to show the 50-metre water depth for marine evacuation, it should be shown as a dashed line, as follows:

- Colour: HEX: #89478F / RGB: 137, 71, 143
- Transparency: 0%
- Line: dashed

Note, this is the standard and internationally recognised way of depicting safety zones at sea on maritime maps.

Basemap

The basemap that is selected should be easy to read. For static maps, depending on the scale and audience preferences, aerial imagery or street maps are good for people to easily orientate themselves. A combination of aerial imagery overlaid with streets and paths is also effective.

For the ocean basemap, aerial imagery may not provide complete ocean cover, and therefore a solid colour may be the preferred choice to ensure adequate coverage of the area.

For interactive maps, allowing users to select which basemap is displayed is best practice.

Basic cartographic elements

The following cartographic elements should be included on both static and interactive maps:

- North arrow
- Scale
- Legend (with plain language descriptions for all map elements)
- Descriptive title
- Roads (and major road names), paths, walkways, and tracks
- Rivers and other key water bodies
- Authors of the map
- Publication year
- Basemap information.

Key local landmarks can be added to maps to help people orientate themselves and make the information easier to understand. These landmarks could be features or structures that are unique and easily recognisable to the community, such as a building, urban areas or parks. Ensure these elements stand out, but do not detract from the evacuation zone and routes.

Additional features on interactive maps such as a zoom tool or 'locate my device' (e.g., device location or address search), can help to improve the accessibility of the information.

It is important to ensure these elements stand out, but do not detract from the evacuation zones and routes.

Where possible, use the CDEM colours (blue[14], yellow[15]) for the general colour scheme.

Map scale

There is no specific recommendation for the scale of static maps and what area they should cover, as the most effective scale will vary for different areas.

The area displayed on the map should be large enough that the community can recognise it and locate themselves, but not so wide that roads and other key locations are not visible. The scale chosen should ensure the map is still readable while clearly displaying the Blue Zone and evacuation routes.

An effective approach would be to use a similar scale to other maps used in the region, as the areas shown will already be familiar to the communities.

Warning information

The most important message that the eye is drawn to first on every map should be:

If an earthquake is Long or Strong, Get Gone.

All other messages are a secondary priority and must not distract from this message.

See Section 4.3 for additional warning information to include on maps.

Additional information links

Provide links to where users can find further information. On static maps, this could be a short, easy-to-remember website address or a QR code. On downloadable PDF maps, ensure hyperlinks to more information are available. Interactive maps could link to another website or include a sidebar where more information can be provided.

Metadata

When users select elements on interactive maps, information (metadata) should be provided to give additional information about that element.

Limitations

Provide simple information about the limitations and the intended use of the map. Being transparent about all limitations helps users understand how the map was created and what it can be used for.

4.1.2 Map functionality and usability

This section provides information about how to make maps easy to understand and use. These aspects should be considered when creating tsunami evacuation maps.

[14] Civil Defence blue: HEX: #005A9C / RGB: 0, 90, 156
[15] Civil Defence yellow: HEX: #FFF200 / RGB: 255, 242, 0

The key to creating an effective map is to include only the elements that are most useful to the audience, without overwhelming them with too many options or making the map too complicated. For static maps, the map needs to be simple and intuitive. Interactive maps have elements that allow the user to learn more about the layers in the map. However, sometimes the design elements are restricted by the web mapping service used.

Keep functionality and layout as simple as possible

Research has shown that adding more functionality to interactive maps does not necessarily benefit users. One study found that a simpler interactive map resulted in more correct decisions, reduced the perceived difficulty of understanding the content, and increased user confidence in the map's information.

Provide a personalised experience

Enable users to find information that is specific to their area (e.g., address search to locate property in relation to the evacuation zone) or data that is useful to them.

- consider a choice between overlapping layers or side-by-side visualisations
- consider a 'build your own map' feature, if the web service allows
- guide users to develop their own evacuation routes, if they prefer.

Make maps usable for as many people as possible

Information should be made accessible and usable for as many people as possible. When designing websites and digital maps, consider all types of disabilities and impairments, including cognitive, visual, auditory, and motor. Websites and maps should address the four principles of accessibility: perceivable, operable, understandable, and robust.[16]

Adhere to web accessibility standards and guidelines

To assist with accessibility, the New Zealand Government Web Accessibility Standard has been developed to set out the requirements to make web-based content accessible. Since July 2019, all public service and non-public service agencies must have met this standard.

The standard also links to the international Web Content Accessibility Guidelines (WCAG) 2.1. This guideline provides the practical requirements needed to make website information accessible.

It might be difficult to make all tsunami evacuation information fully accessible, but consideration should be given to using alternate text, colour and contrast, and alternate formats.

Provide text alternative for maps

Where possible, text should be used to describe maps and other visual elements. For maps that are available online (both static and interactive), a description of the map should be added as 'alt text', along with a full text description for screen readers. This ensures that as many people as

[16] Perceivable: information must be presentable to users in ways they can perceive. Operable: user interface components and navigation must be operable. Understandable: information must be understandable. Robust: content must be interpreted reliably by a wide variety of users, including assistive technologies.

possible can understand the information presented by tsunami evacuation maps.

The New Zealand Government Web Accessibility Standard states that "where data points or shapes within a map can be represented by common identifiers such as postal addresses or the names of specific places or regions, the map must be accompanied by a text alternative that serves the equivalent purpose."

Ensuring the colours are colour vision deficiency friendly

It is important to consider how colour is used for tsunami evacuation maps. This guideline specifies the colour of the Blue Zone (see Section 4.1.1). Any other colours should be used in a way that ensures people with colour blindness, colour vision deficiencies, partial sight or low vision, can access all the information. The use of online checkers or simulators can assist with checking colours against different vision deficiencies.

Producing maps in alternate formats

Consider producing maps or spatial data in alternate formats such as tactile maps. Any text on the map could be reproduced in large print, easy read[17], and braille.

Adding multilingual translation

Consider how maps and information could be translated into different languages that are relevant to the community.

4.2 Tsunami information boards

Tsunami information boards assist the community with understanding the risks and appropriate response actions they need to take to enable an effective response to a tsunami. Physical boards should be located in Blue Zones, particularly in areas of high foot traffic.

Section 4.2.1 below covers what should be included on information boards and Section 4.2.2 has some design and audience considerations. Two example information board templates are provided in Section 4.2.3.

4.2.1 Information board content and design

All tsunami information boards should include the elements described below.

Warning information

The most important message that the eye is drawn to first on every information board is:

If an earthquake is Long or Strong, Get Gone.

All other messages are a secondary priority and must not distract from this message.

[17] Easy Read is a way of communicating information using straightforward language, clear sentence structure, and supporting pictures.

See Section 4.3 for additional warning information to include on information boards.

Evacuation map

Visual attention should be directed towards a large, easy-to-read map that shows the elements listed in Section 4.1.1, as well as a 'You are here' symbol.

Logos, contact details and further information

The information board should include the Civil Defence logo and the logo of the agency maintaining the board (e.g., local or unitary authority, regional council or CDEM Group). The board should also include options where people can find further information. This could be a short, easy-to-remember website address or a QR code.

Additional information about tsunami

Information boards can facilitate knowledge-sharing about tsunami hazard and risk by including information about tsunami, how to prepare and respond, and where to learn more. They also have more space than single maps, however, they should not be overcrowded to ensure priority messages remain clear and effective.

Information about the tsunami risk and how it was assessed may facilitate understanding, motivate preparedness, and create trust in the information. While this information is optional and lower priority than life-safety evacuation messaging, including some supporting information could be beneficial for audience engagement.

4.2.2 Information board considerations

Tsunami information boards should be designed to capture attention and maximise understanding. Eye-catching features, such as bold colours and large font size, should be used to capture the attention of passers-by. Visual attributes such as orientation can be used to guide attention to the key messages. Icons can help to group types of information and make the content more accessible to a broader, non-English speaking audience.

Consistent design

The design of information boards should be regionally consistent but flexible enough to prioritise and incorporate locally relevant, culturally inclusive information for communities where possible.

Adopting a consistent design appearance across the region will enhance familiarity with, and recognition of, tsunami information. It may also reduce the cognitive load of processing new information, therefore increasing the likelihood of sustained attention and engagement.

Board layout

Priority information should be positioned in the top-left or top-centre of the information board (Figure 8). This ensures that readers see the most important information first.

Location and placement of information boards

Information boards should be located within the Blue Zone, in coastal areas and areas where the public congregate (e.g., shopping centres, parks, beaches, and toilet blocks). Tsunami information boards positioned in popular coastal areas that are exposed to tsunami are more likely to reach both residents and visitors. However, to reach more residents,

additional tsunami information boards installed in other areas of public concentration, such as community centres, local businesses, and parks, will have greater impact. Local knowledge is helpful to identify the locations that will be most effective.

In addition to where boards should be located, the NZ Transport Authority Waka Kotahi provides specific guidance on how high above the ground signs should be placed. Their guidance recommends that the top of information boards should typically be no more than 1.5 metres above the ground. This ensures they are at a height where they are easily readable by most people.

Empower the reader

Tsunami information boards should promote messaging that supports self-efficacy and positive action outcomes – that is, belief that people are personally capable of taking protective action that could save their life. For example, if an individual believes that the act of getting to high ground after a large earthquake is possible and will result in survival, they may be more likely to evacuate to high ground. Clear messaging about when and how to evacuate to safety can reinforce beliefs that personal actions can make a difference. Tsunami information boards should also encourage taking initiative if an individual feels unsafe, instead of waiting for an official warning.

Clearly communicating the nature and cause of the known tsunami risks may facilitate understanding and intention to act. For example, understanding that nearby earthquakes can generate tsunami that rapidly inundate low coastal areas may help explain why it is important to treat earthquakes as a natural warning sign for tsunami evacuation.

Audience

Audiences for information boards will include residents and visiting tourists (domestic and international). Different audiences will have differing levels of knowledge of the area and its hazardscape, so the information presented on the board needs to be simple and clear to understand. Symbols can be a more effective form of communication than text, as they can be universally recognised.

Local nuances

While design should appear consistent through similar structure, layout, colour themes and graphic style, content should be developed with the following factors in mind:

- the community's demographics (e.g., culture, language, or age)
- previous experience with tsunami and geohazards
- nuances in local physical geography that are known to affect tsunami inundation behaviour
- evacuation context (e.g., consider discussion of evacuating 'inland' in flat areas with little topography or 'vertically' where there are vertical tsunami evacuation structures; refer to recognisable or distinctive local areas of high ground, such as a maunga)
- transport options (e.g., paths or tracks).

Engagement with local communities in the design can make sure the most appropriate, locally-relevant information is included on the boards. Locally-relevant information developed through community-led response planning may increase the effectiveness of a tsunami evacuation. See Section 6 for considerations when undertaking community engagement.

4.2.3 Information board templates

Figure 8 below shows two information board templates. These templates show where different information should be placed on the boards to ensure key information is easy to read.

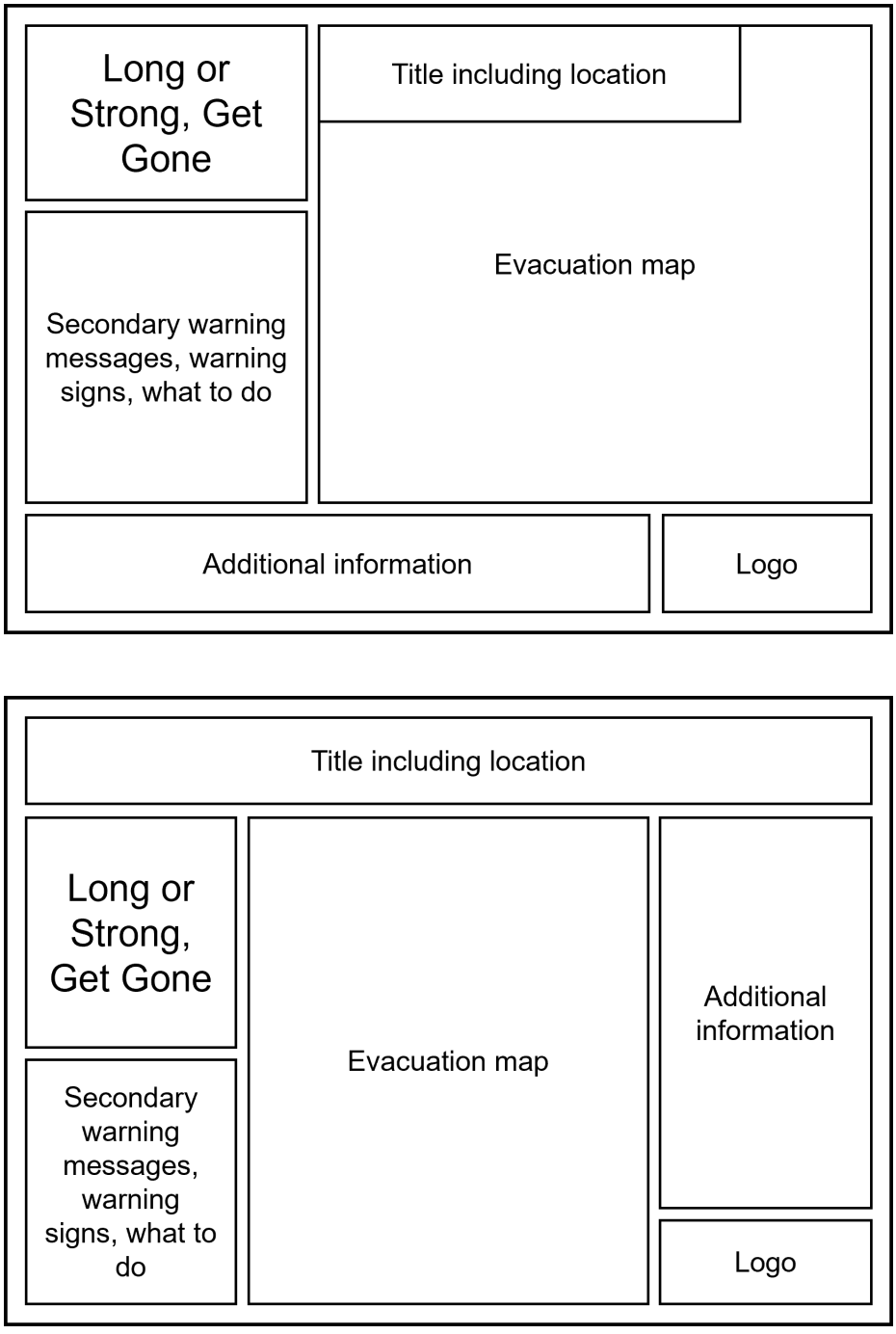

Figure 8 Tsunami information board templates.

4.3 Essential warning and evacuation messages

Principles behind evacuation messages

When natural warnings occur, people are expected to evacuate the Blue Zone. When an official warning is issued by NEMA or CDEM Groups, people are expected to follow the specific instructions stated in the warning message. Evacuation should be on foot (or bicycle) wherever possible.

Warning information that is presented on maps needs to be supported by community engagement and public education initiatives, to ensure the information is well understood. In addition, communities should exercise their evacuation plans on a regular basis. More information about community engagement and public education activities is detailed in Section 6.

Recommended text to include on maps and boards is shown in grey boxes below. Additional information can be found in the tsunami section of the Consistent Messages for CDEM document.

Priority message – natural warnings

The most important message that the eye is drawn to first on every map and information board is:

If an earthquake is Long or Strong, Get Gone.

All other messages are a secondary priority and must not distract from this:

Further information could be included alongside this key message to provide additional context and clarify what actions people need to take:

Leave the Blue Zone immediately if you experience any of the following:

- **Feel** a strong earthquake that makes it hard to stand up, or a weak rolling earthquake that lasts a minute or more.
- **See** a sudden rise or fall in water level.
- **Hear** loud and unusual noises from the water.

Drop, Cover and Hold if there is earthquake shaking. As soon as the shaking stops, move immediately to the nearest high ground or as far inland as you can out of the Blue Zone. Tsunami waves may arrive within minutes. Even if you can't get out of the Blue Zone, go as far inland or as high as you can. Every metre makes a difference. Do not return until an official all-clear message is given by Civil Defence Emergency Management.

Official warnings

Official warnings come from the National Emergency Management Agency (NEMA) and local CDEM Groups via Emergency Mobile Alert (EMA), New Zealand TV/radio broadcasts or the emergency services (i.e., police, fire or ambulance). You may receive warnings from one or several sources.

Evacuate from the zone *(or zones, add if relevant)* stated in the warning message. Do not return until an official all-clear message is given by Civil Defence Emergency Management.

Local response arrangements should be explained through customisation of the information, for example, outlining that public alerts may be through siren[18], telephone, loud hailer or other arrangements.

Tsunami evacuation

Guidance on how to evacuate and what to expect after evacuation should be included on maps and information boards. Information about how to evacuate may include:

> Evacuate via the routes shown on this map.
>
> Follow the directions on tsunami evacuation route signs where present.
>
> Walk, run or cycle, if you can. This reduces the chances of getting stuck due to damaged roads or traffic congestion. If you have to drive, keep going once you are well outside the Blue Zone to allow room for others behind you.
>
> Safe Locations are places that are high enough in elevation or far enough inland that they are very unlikely to be reached by tsunami.
>
> The Safe Zone is the entire area beyond the extent of the Blue Zone.
>
> Stay **OUT** of the evacuation zone(s) and **DO NOT** return until an official all-clear message is given by Civil Defence Emergency Management.
>
> If you are outside of the Blue Zone you do not need to evacuate. Stay where you are to help reduce congestion for people who have to evacuate.

4.4 Tsunami signage

Signage is an integral part of tsunami risk management. Signage depicting the evacuation zone, Safe Zones or Safe Locations and routes raises public awareness of tsunami risk and provides information to increase the efficiency and effectiveness of an evacuation.

Below is a summary of types of tsunami signage contained within the National Tsunami Signage Technical Standard [TS 01/08]. Refer to the technical standard for the full details of these signs.

- **Evacuation zone signs** are designed to be placed within the Blue Zone, especially at the coast to clearly indicate that a place is within the Blue Zone.
- **Evacuation route signs** are designed to mark the route from within the Blue Zone to the Safe Zone or Safe Location.
- **Evacuation Safe Zone signs** should be inside Safe Zones to show people that the zone is safe from tsunami.

[18] The National Emergency Management Agency (NEMA), GNS Science and New Zealand's Tsunami Reference Group, all agree with international best practice that tsunami sirens are not effective as a warning system in regions subject to local-source tsunami.

- **Tsunami information boards** are intended to show evacuation maps and supporting information. See Section 4.2 for more details.

Placement of evacuation route signage

The following principles should be followed when placing evacuation route signs:

- Signs should be placed along the entire evacuation route.
- Signs should be placed such that when people reach a sign, they should be able to clearly see the next sign along the evacuation route. The distance between signs will vary based on the route and topography. Ground-truthing may be required to determine the best placement.
- Signs should be placed at key pedestrian or road intersections directing people which way to go. This reduces the decision making that evacuees need to make at the time.
- Signs should be visible from beaches where practical.
- Signs should be placed so they do not block the evacuation route.

4.5 Tsunami blue lines

Tsunami blue lines (blue lines painted on roads) are a community engagement tool to educate the public on where they need to evacuate beyond during a tsunami.

Guidance for tsunami blue lines will be progressed through the NZ Transport Agency Waka Kotahi regulatory process for incorporation in the Land Transport Rule (Traffic Control Devices) 2004.

Further guidance will be made available once tsunami blue lines have been included in this Rule.

Section 5 Evacuation information for marine users

In addition to land evacuations, CDEM Groups should provide tsunami evacuation advice for those on the water.

Tsunami can be dangerous to vessels and people on the water even if there is no land inundation. They can produce strong currents and unpredictable surges. Impacts can include:

- grounding of vessels if the water level suddenly drops
- capsizing from incoming surges, complex coastal waves or surges hitting grounded boats
- collision with other boats, docks or debris.

CDEM Groups and harbourmasters should work together in the readiness phase to plan their respective response actions and the advice they will provide to vessel operators and people on water during evacuations from tsunami generated by different regional- and distant-sources. During a tsunami evacuation, the CDEM Group should communicate with the harbourmaster to provide relevant information on the threat.

Minimum water depth for on water evacuation

The general evacuation advice for people on the water is to travel to deeper water. Experts on tsunami behaviour for Aotearoa New Zealand's coast estimate that 50 metres is an appropriate water depth for vessels to evacuate beyond, to minimise the impacts of tsunami on vessels. This is based on research that finds dangerous ocean current speeds caused by tsunami generally reduce at a water depth of 50 metres (Lynett et al. 2014). It is advised that people do not stop at a depth of 50 metres but continue to head to deeper water, which is safer from tsunami currents and waves. This 50-metre depth can be shown on tsunami evacuation maps with a dashed line as shown in Section 4.1.1.

This advice is indicative only, as the minimum water depth for evacuation in a specific area is highly dependent on how on the local marine environment affects tsunami behaviour.

Assessing tsunami risk in marine areas

Tsunami behaviour is highly influenced by the local environment (water depth, shape of coastline, influence of ports and marinas), which can lead to unusual effects not seen in the open ocean, e.g., amplification of waves or seiches. To understand how local marine environments may influence tsunami behaviour, site-specific assessments can be undertaken. A site-specific assessment requires a high-resolution model (10-metre spatial resolution) for the area of interest (e.g., a harbour) to determine water current speeds and how they may change during a tsunami.

Without these assessments, the local harbourmaster will need to make judgement calls during a tsunami evacuation, based on their expertise and local knowledge. It should be recognised that they are likely to be the most informed official to provide advice about the possible effects of tsunami within local harbours, estuaries and bays.

5.1 Warnings and guidance for people on the water during tsunami

The following sections outline the recommended advice for CDEM Groups to provide the public for local-, regional- and distant-source tsunami.

The overall key messages for people on the water to remember during a tsunami are:

- **Do not return to local ports, marinas or boats/liveaboards as they may be damaged and there may be ongoing strong and unusual currents. Wait until an official all-clear message is given by Civil Defence Emergency Management.**
- The first wave may not be the largest.
- It is not unusual for strong and unusual currents and unpredictable surges to continue for hours or even days after the first wave.
- Official warnings come from the National Emergency Management Agency and local CDEM Groups via Emergency Mobile Alert (EMA), New Zealand TV/radio broadcasts or the emergency services (i.e., police, fire or ambulance). You may also receive tsunami advice on your VHF radio or notification from the local harbourmaster a different way, although there may not be enough time to issue an official warning, particularly during a local tsunami.

Tsunami related navigational warnings issued by harbourmasters

In addition to the official tsunami warnings issued by NEMA and CDEM Groups, harbourmasters may issue local navigational warnings for tsunami.

The following is from the Annual New Zealand Notices to Mariners No 11, as outlined in the New Zealand Nautical Almanac 2024 – 2025 which explains harbourmasters' responsibilities during tsunami.

Harbourmasters may take full control of shipping operations in their area and masters (person in charge of the vessel) are required to give their unreserved cooperation.

There are two types of local navigational warnings that could be issued during a tsunami evacuation to vessels located inshore (within the 12 nautical mile limit):

1. **Verbal warnings:** vessels will be advised verbally by the harbourmaster or port company.
2. **Sounds signal:** the signal to be given to warn vessels in harbour to take action is a series of five prolonged blasts. In some ports this signal could be made by sirens (on instruction from the CDEM Group).

The local harbourmaster will, in accordance with any planned response arrangements, issue Urgent Marine Information Broadcasts on Channel 16[19] as required.

[19] Channel 16 is a very high frequency (VHF) radio channel used for marine emergencies.

The harbourmaster may need to order vessels to sea to avoid serious damage being caused to ships and harbour structures by strong wave action in their harbours.

In addition, advice will be given to vessels at sea (beyond the 12 nautical mile limit) by the existing coastal navigational warning system.

5.1.1 Local-source tsunami

In a local-source tsunami, people may only have a few minutes to act. Official warnings are unlikely to occur and people on water will have to rely on natural warnings of a tsunami. These natural warnings can include:

- loud and unusual noises from the sea
- sudden rise or fall in the sea level
- earthquake shaking being felt through boat hulls
- rapid and extreme shifts in currents and simultaneous changes in wind-wave heights.

It is important that people on vessels have a plan for actions that can be taken in a very short amount of time, for example a quick way to release commercial fishing gear, to prevent their boat being dragged down by currents. Vessels should ideally have one week (or a minimum of three days) of non-perishable food, fuel and water stored on board.

Warning information for people on vessels

At less than 50 metres depth, people on the water are advised to:

- Stop commercial fishing operations immediately.
- Free the vessel from any bottom attachment (cut lines if necessary).
- If you can beach or dock your boat and evacuate outside of the Blue Zone on foot within a few minutes of a natural warning, then this is the best option.

If the above actions are not possible, then head for the deepest water possible, a minimum water depth of 50 metres, doing the following:

- Travel perpendicular to the shore where possible.
- Travel directly into waves; keeping in mind that tsunami can interact with wind waves, headlands and islands, and produce unusual effects.
- Where possible, avoid narrow channels where tsunami waves may be amplified.
- Maintain as much separation as possible from other vessels.

At greater than 50 metres depth, people on the water are advised to:

- Continue to head to deeper water, which is safer from tsunami currents and waves.

Information for people on land or tied up at a dock

In addition to other advice about tsunami evacuation in Section 4.3, the following can be provided to people with vessels tied up at a dock.

> People that are on land or have a vessel tied up at a dock are advised to evacuate out of the Blue Zone. There is not enough time to save boats and successfully evacuate.

5.1.2 Regional- and distant-source tsunami

In a regional- or distant-source tsunami, people will generally have enough time to take action.

People on water should be advised to check with their local CDEM Group and local harbourmaster on required actions.

Section 6 Community engagement and education for tsunami evacuation

This section provides key considerations for community engagement and education related to tsunami evacuation. It includes guidance on engaging communities around tsunami evacuation maps and routes, as well as community-based preparedness initiatives such as tsunami blue lines and tsunami hīkoi.[20]

CDEM Groups and local authorities are best placed to determine the most effective community engagement approach for their region or district. The guidance in this section is intended to support CDEM Groups and local authorities in implementing their chosen community engagement approach for tsunami evacuation initiatives.

6.1 Community engagement in tsunami evacuation initiatives

Community engagement is a critical element for effective implementation of tsunami preparedness measures, as it helps to empower the community to manage its risk.

Any engagement undertaken with the community should be strongly linked to national and regional tsunami education programmes within the CDEM Group's work programme.

Several techniques have been used in Aotearoa New Zealand for community engagement across tsunami preparedness. These include:

- Identifying high-risk communities and prioritising focused engagement across the region with them. "High-risk" can be defined both in terms of exposure (i.e., identification based on existing hazard mapping) and vulnerability (e.g., aged care facilities, early childhood centres and schools).
- Identifying active community groups whose existing activities can support and strengthen the implementation of the initiative, and vice versa. For example, iwi and hapū, Ratepayers' Associations, and Surf Life Saving clubs.
- Timing the engagement with other public education and preparedness activities to increase community interest, such as the national earthquake drill – ShakeOut, which is coupled with a tsunami hīkoi.

6.1.1 Tsunami evacuation maps

Communication and engagement planning

The public release of new or updated tsunami evacuation maps may affect individual and community-level response planning, land use planning and decision making. New or updated zones are also likely to generate public and media attention. Therefore, a release should be accompanied by a

[20] hīkoi means walk in te reo Māori.

comprehensive communication and engagement plan that is linked with the region's wider tsunami response system, and national tsunami warning system.

An engagement plan for tsunami evacuation maps could include aspects of user testing, co-design (for example, community-informed evacuation routes – if needed) and community consultation depending on capacity, resources, and pre-existing engagement plans.

Release of maps

Table 2 below provides some suggestions of how engagement could be carried out in relation to releasing new tsunami evacuation zone maps. This is based on work carried out by Charlton et. al (2023a) and grounded in the code of ethics, values and principles of the International Association for Public Participation (IAP2) public participation framework.

Table 2 Suggested engagement activities when releasing new tsunami evacaution zone maps.

Before release of any new or updated maps	
Engagement approaches – emphasis on communication and hazard awareness	**User-testing examples – emphasis on feedback and improvement**

• Identify how much engagement is possible and required with resources available.
• Define key stakeholders and users of the new zones or maps.
• Identify the level of engagement and involvement that different groups or individuals will have in the final map.
• Suggested methods:
  ○ Public and community focus groups in high interest or threat areas.
  ○ Specific iwi-focused discussions.
  ○ Community map development sessions.
	• Structured testing with feedback from community, volunteer and local emergency response groups.
	• Scenario exercises with more technical users and emergency management staff.
	• Empirical testing using surveys or eye-gaze tracking to understand how users interact with the maps and test comprehension.
	• Public survey asking for feedback on what tsunami information they would like to see.

At release	
• Community roadshow sharing the new zones and the hazard information that goes behind them. Could include scientist or specialist support. • Online videos explaining the new maps and why they are different.	• Ad-hoc and informal feedback. • Feedback surveys after the roadshow sessions.

• Narrative around the new modelling and tsunami science.	
After initial release and ongoing use	
• Small public and community focus groups in key areas of change. • Exercise evacuation plans, zones and routes.	• Incorporate any in-scope feedback into the next iteration of map(s). • Review evacuation map, signage and information board placement if needed. • Evaluate map or zone effectiveness after any tsunami evacuation. • Survey for awareness and public response to maps and signs. This can be simple community-based self-evaluation or a more structured regular check-in.

6.1.2 Tsunami evacuation routes

Community engagement is important in the development of tsunami evacuation routes. If CDEM Groups or local authorities choose to create official evacuation routes, it is beneficial to co-create evacuation routes with communities. Community members have critical local knowledge that will help to ensure any routes developed are viable, safe, and effective for use during a tsunami evacuation. Co-creation is also an effective method to increase community awareness of the evacuation routes, however, this process is time and resource-intensive, so may not always be a realistic option. If co-creation is not possible, engagement with the community will be helpful to validate the routes before they are implemented.

Engagement with iwi and hapū is also valuable to incorporate mātauranga (Māori knowledge) about the local landscape into the creation of evacuation routes.

Following the development of tsunami evacuation routes, regular drilling of evacuation routes is essential (see Section 6.1.4).

If community groups or whānau choose to develop their own evacuation routes, CDEM Groups and/or local authorities should support and inform the process, resource- and time-allowing.

6.1.3 Tsunami information boards

As outlined in Section 4.2.2, local community groups could be engaged to provide advice on practical, high traffic locations to install tsunami information boards, as well as areas to avoid.

Engagement with community members to provide input into information boards design is encouraged, though may not be feasible for all CDEM Groups, depending on resources, timelines. Some elements of information

boards can be tailored (see Section 4.2) to better align with the community's identity and values.

Recent implementation of tsunami information boards in Aotearoa New Zealand involved community engagement during the design process to include elements of importance to the community. An example is the translation of information into different languages (such as Te Reo Māori and English translations) and culturally significant design elements. These additions should be applied to the signage in a way that does not detract from the key nationally consistent elements of the signage, such as those outlined in Section 4.2 for information boards. Te Puni Kōkiri have developed best practice guidance for Māori-English bilingual signage that could be useful when developing bilingual tsunami information boards: Māori-English Bilingual Signage – A guide for best practice.

6.1.4 Evacuation drills

International research following several large-scale tsunami has shown that practicing tsunami evacuation improves community readiness and helps to save lives (Chen et al. 2022). In the 2011 Tōhoku earthquake and tsunami, the rate of evacuation was significantly higher amongst the population who participated in tsunami evacuation drills before the event than those who did not participate (Nakaya et al. 2018).

Evacuation drills involve coordinated mass testing of evacuation routes and Safe Zones or Safe Locations. They provide the opportunity to evaluate routes, through feedback mechanisms such as surveys. Questionnaires on accessibility, timing, location of route markers can be provided to community groups and individuals to inform any necessary changes to the routes or future public education material. Evacuation drills can provide community cohesion benefits alongside the public education advantages, such as more able participants planning to assist those who may require support to evacuate.

ShakeOut and tsunami hīkoi

Aotearoa New Zealand's annual earthquake drill, ShakeOut, is coupled with a tsunami evacuation drill commonly known as tsunami hīkoi. ShakeOut is coordinated by NEMA and co-sponsored by the Natural Hazards Commission Toka Tū Ake. CDEM Groups have a critical role in ShakeOut, as they provide promotion and coordination of the event at the regional level, to ensure there is effective community interest and participation across Aotearoa New Zealand.

Regionally and community-led evacuation drills

It is recommended that CDEM Groups and communities also run their own evacuation drills at different times of the year. Drills should be run annually at minimum, and coincide with other emergency preparedness activities or wider community events. Aim to run drills during summer months, when peak visitor numbers are typically highest, to ensure evacuation routes are suitable for the increased number of people.

6.2 Public education for tsunami evacuation initiatives

Recommended topics for public education

Public education is a critical component of the implementation of any tsunami evacuation initiative, as it ensures that the public understand the intent of what is being implemented.

Education initiatives for tsunami can often be incorporated with other community safety or development activities.

The following topics should be considered in public education for tsunami evacuation:

- **National tsunami preparedness messaging:** 'Long or Strong, Get Gone' key messaging.
- **Tsunami warnings:** different types of warnings for different tsunami, why the public should take immediate action following natural warnings, how official warnings will be delivered.
- **Locally-specific information:** tsunami sources and arrival times, evacuation zones, routes, and Safe Zones or Safe Locations (if used).
- **Tsunami signage:** tsunami evacuation zone, evacuation route, Safe Location and any others used in the area.

Methods for public education

Public education and communication methods should be tailored to meet the needs of different communities. For example, some parts of the community will respond better to digital material, while others may prefer physical copies of information. It is important to consider what has been used previously and how the community will respond to a change in approach. A mixed-method approach for sharing information is recommended for the greatest coverage, which could include:

- meetings with education providers, businesses and other community organisations
- public meetings and workshops
- printed materials (billboards, pamphlets, newspaper materials)
- website and social media materials including videos
- local radio broadcasts
- displays at community events
- "ask a scientist" sessions
- community drills and exercises to test tsunami response and evacuation route usage.

6.2.1 NEMA Get Ready website

Get Ready is a website to provide information about hazards in Aotearoa New Zealand and advice about how to get prepared for an emergency. It promotes both general advice about emergency preparedness and specific advice for before, during and after a tsunami. Get Ready summary messages for tsunami.

The Civil Defence website also provides Consistent Messages for CDEM Groups to use before, during and after a tsunami in greater detail.

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Section 8 Appendices

Appendix A Defining other tsunami evacuation zones

This appendix provides information about the development of other tsunami evacuation zones. These zones are Red and Orange as these have been developed by regions using the former guideline. These could be used for evacuation planning before (regional- and distant-source) and during (distant-source) tsunami evacuations, or risk reduction activities (e.g., land use planning).

The use of more than one public-facing zone outside of a tsunami evacuation is not recommended.

Refer to Section 2.2 for more information about when other these zones could be used.

Red Zone definition

The Red Zone is intended as a beach and marine evacuation zone (including harbours, rivers and estuaries) for tsunami that are above the minimum warning threshold (currently 30cm amplitude) up to 1m amplitude.

Defining the Red Zone depends on the elevation data available, which is normally either high resolution such as LiDAR data, or low resolution such as the Toitū Te Whenua Land Information New Zealand (LINZ) topographic data. Calculation of the Red Zone from hydrodynamic models is very difficult because of the large variety of potential sources of tsunami in the 0.3-1m range, which may behave in a variety of ways upon reaching land.

In high resolution areas (e.g., LiDAR) it is recommended to use the 2m above mean high-water springs (MHWS) contour level, extended to make sure it covers the beach and rocky foreshore in any instances that the 2m elevation does not.

In low resolution areas (e.g., LINZ topographic data) the beach and foreshore is generally expected to be approximately 2m above the high tide contour level. The beach and rocky foreshore area should simply be designated as the Red Zone, with advice from local experts (including CDEM authorities) on where the zone might extend further inland to cover wider areas that are considered to lie less than 2m above high tide level. In addition:

- The 1:50,000 scale beach, rocks, sand, mud, lagoon, swamp, mangroves, and/or estuary polygons can be used to define the Red Zone.
- Tidal parts of rivers and estuaries should also be the Red Zone, along with the above same polygon classes where they border rivers and estuaries.
- Local knowledge may be used to buffer areas alongside rivers where these are estimated to be less than 2m above high tide level.
- In the absence of local information, a buffer of the tidal part of rivers can be used that extends 100m perpendicular to the river at

the coast, tapers to 50m wide at 400m inland, and to no buffer at 800m inland.

In all cases the Red Zone should be visible along the entire coast at the map's scale, so it should be enlarged to create a decent visible red line along any coast where it is otherwise too thin to be clearly visible.

Orange Zone definition

The Orange Zone can be used for official warnings of distant- or regional-source tsunami. The Orange Zone should be defined by a specific threat level (as defined in the National Tsunami Advisory and Warning Plan [SP 01/20]). The threat level that is selected should at least encompass the area that would be inundated by the largest tsunami with travel time greater than one hour on a 500-year time frame.

It is very important that CDEM Groups understand which threat level their Orange Zone is defined by, so they know when to evacuate this zone. With this in mind, it is best to minimise the number of threat levels used to define the Orange Zone.

The Orange Zone can be extended inland to avoid crossing through buildings or properties and allow clarity of the boundary location on the ground. This is especially important to consider for sites that have large numbers of, or highly vulnerable, people associated with them. The zone should never be reduced in area, nor have its outer extent moved closer to the coastline, in order to achieve this purpose.

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