Emergency sanitation challenges and opportunities following a large Wellington Fault earthquake scenario: November 2019 workshop

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Abstract

The greater Wellington region of Aotearoa New Zealand is highly vulnerable to large earthquakes because it is crossed by active faults, both on and offshore. A future earthquake on the Wellington Fault is expected to cause extensive damage to water supply and wastewater networks, which is likely to result in prolonged service outages to households. Widespread landslides may also affect road access and isolate households; such impacts mean that residents may have to manage human waste disposal onsite as well as using stored emergency water supplies. Consequences of wastewater network damage for public and environmental health and habitability of homes remain largely unknown for Wellington City. This Practice Update presents findings from a workshop held in November 2019 that brought together researchers, practitioners, wastewater managers, and emergency managers to explore challenges and opportunities for emergency sanitation in the Wellington region following a Wellington Fault scenario earthquake. Key suggestions include using standard and unambiguous terminology, considering diversity inherent in the groups usually termed the community, and the use of the Sanitation Service Chain framework.

Keywords: *Emergency sanitation, Wellington Fault earthquake, public health, emergency preparedness*

The greater Wellington region of Aotearoa New Zealand is highly vulnerable to large earthquakes as it is cut by active faults, both on and offshore. The likelihood of a magnitude 7.5 earthquake occurring on the Wellington Fault within the next century is approximately 10% (Rhoades et al., 2011). Recent work for the Wellington Lifelines Project modelled infrastructure outages following a M7.5 earthquake on the Wellington Fault (Wellington Lifelines Project, 2019). In the absence of major investments to strengthen wastewater assets, outages of 1 to 2 years duration for the wastewater collection network are expected for Wellington City, and greater than 2 years duration for Petone. For wastewater treatment, outages of 1 to 2 years duration are expected for Wellington City, and greater than 2 years duration for much of the Hutt Valley and Wainuiomata. While attention has been paid to the consequences of earthquake damage to road, electricity, and water supply networks, the consequences of wastewater network damage for public health, environmental health, and the habitability of homes remain largely unknown for Wellington City (Brenin et al., 2019).

Following the two major Canterbury earthquakes in 2010 and 2011, the potential for gastroenteritis outbreaks was considered to be very high due to damage to both the water supply and wastewater reticulation systems (Cubrinovski et al., 2011, 2014) that had provided a pathway for pathogenic microorganisms to enter the water supply (Dell & Williams, 2011; Ministry of Health, 2012). Cubrinovski et al. noted that the wastewater system was hit particularly hard by liquefaction and lateral spreading. A month after the earthquake, 31% of the total wastewater pipe length of 1,766 kilometres had limited service and 8% had no service. In comparison, the drinking-water supply system was more resilient with 5.1% of the total length damaged. However, watermains and submains had to be repeatedly pressurised and depressurised to allow for repairs of leaks, which increased the potential for ingress of pathogens.

There were multiple pathways for exposure to pathogens, including contaminated food and water, hygiene challenges for residents with limited access to power and water and restricted road access, and large-scale catering at welfare centres by volunteers who were not

trained in food safety requirements (Johnston, 2012). Key response actions taken to mitigate these risks are presented in Table 1. Overall, the comprehensive and coordinated response was successful in mitigating the substantial public health risks (Dell & Williams, 2011; Ministry of Health, 2012) as only a small increase in gastrointestinal cases in the weeks following the earthquake was recorded. For the period of 22 February to 21 March 2011, there was a total of 141 enteric (gastrointestinal) disease notifications, compared to the average of 124 for the same time window in 2008 to 2010: an increase of only 14% (Dell & Williams, 2012).

Table 1
Key Response Actions Taken to Limit Risk of Gastrointestinal Disease Outbreaks Following the 22 February 2011 Christchurch Earthquake

Action	Reference
Drinking water safety	
City-wide "boil water" notice in place until 8 April 2011	1,2
Chlorination of reticulated drinking water introduced	2
Increased frequency of testing for E.coli and free chlorine residual in drinking water network (from an average of 12 per day pre-earthquake to average of 190 per day over the 6 weeks post-earthquake)	2,4
Provision of tankered water and bottled water to residents	2
Army supplied desalination units	1
Food safety	
Flyers with food and water safety advice distributed via supermarkets	1
Food safety advice provided in several languages	1
Food safety advice for catering for large groups provided to welfare, church, and community groups	1
Food safety advice provided to food businesses	1
General	
Public encouraged to use backyard latrines to keep raw sewage out of reticulation system	3
Provision of emergency sanitation (portable and chemical toilets)	1,3
Consistent, blanket coverage public health messaging on hand washing	2
Advice to public to avoid handling liquefaction silt and waterways, which were likely to have been contaminated with sewage	4
Coordinated approach to disease surveillance	4
Precautionary approach taken for vulnerable populations	2,4
Preventive protocols implemented in welfare centres	4,5

Note. 1: Johnston (2012), 2: Ministry of Health (2012), 3: Wareham and Bourke (2013), 4: Dell and Williams (2011), 5: Chandratilake (2013)

While many lessons have been learned from experiences in Christchurch during the Canterbury Earthquake Sequence (Wareham & Bourke, 2013) and from the 2016 Kaikōura earthquake (Hughes et al., 2017), it is important to note that Christchurch was not isolated. Its interconnected road network remained largely functional and its airport re-opened less than 6 hours after the February 2011 earthquake. Prolonged isolation of parts of the city is likely to be a much greater factor for Wellington households, due to the potential for widespread landslides in hill suburbs affecting road access. This isolation also applies to human waste that may have to be managed onsite because options such as chemical toilets rely completely on road access for delivering chemicals and collecting waste. While some progress has been made on options such as emergency composting toilets (Wellington Region Emergency Management Office [WREMO], 2013), significant knowledge gaps remain concerning how to safely manage waste onsite. In Aotearoa New Zealand, there is also a cultural dimension to the management of waste, including human waste, which is discussed by Ataria et al. (2016) and Pauling and Ataria (2010). Ataria et al. (2016) advocate that the key cultural constructs of tapu and noa, which were central to traditional Māori society but continue to inform thinking and practice in modern Māori society, be integrated into biowaste management, and provide suggestions for facilitating this.

Emergency Sanitation

The World Health Organization (2018) defines sanitation as "access to and use of facilities and services for the safe disposal of human urine and faeces" (p. 1). Emergency sanitation in this context refers to the sanitation technologies, hardware, human behaviours, systems, messaging, and other information for emergency response utilised in the time after a disaster has occurred and prior to the re-establishment of networked wastewater removal systems. The behaviours and practices of people are also important to recognise given the way that human waste evokes disgust and avoidance (Rosenquist, 2005). Emergency sanitation therefore also includes preparation such as community and stakeholder engagement.

WREMO carried out a trial in 2012 to investigate the acceptability and practicality of composting toilet use by households and businesses in Wellington (WREMO, 2013). Eleven households and workplaces participated in the 4-week trial. WREMO concluded that households and workplaces could safely and hygienically use a compost

toilet exclusively for up to a month, and that compost toilets therefore should be promoted as a viable toilet option in an emergency where sewerage systems are disrupted. Further work is currently underway at Massey University optimising conditions in composting toilets for pathogen die-off.

QuakeCoRE[1]-funded research on post-earthquake emergency sanitation options is underway on two fronts: 1) investigating options for safe onsite management of human waste using composting toilets; and 2) initiating conversations on emergency sanitation among researchers, emergency managers, wastewater managers, and other practitioners. The current paper is focused on the second of these objectives and presents and discusses findings from a workshop held in Wellington on 15 November 2019.

Method

On 15 November 2019, a QuakeCoRE-funded workshop was held at Massey University, Wellington, to progress the conversation on emergency sanitation and review current thinking and practice. This half-day workshop brought together 26 people with an interest in emergency sanitation. Participants included emergency management practitioners, local iwi representation, wastewater infrastructure managers, academics, engineers, and representatives from several community advocacy groups. Consistent with the requirements of Massey University, this research was assessed as low risk under Ethics Notification Number: 4000021974.

The workshop had the following objectives: 1) for key representatives to update the group on their current activities and future plans; 2) to identify challenges, opportunities, and gaps in regard to improving the current preparedness and response strategies; and 3) to identify points of collaboration between sector partners. The workshop focused on preparedness at the household level. Topics beyond the scope of the workshop included emergency sanitation needs of public and large facilities, recovery of the wastewater network, and timeframes beyond the hazard event and recovery of the network. Participants were given a summary of the workshop for feedback, which did not result in any significant changes.

Workshop Design

The workshop was designed to bring together a diverse range of people representing organisations directly involved in emergency management, decision makers in the field, community and interest groups, and researchers. The workshop objectives were drafted and emailed out to the participant list for comment and feedback prior to the workshop to maximise relevance and benefit. Workshop convenors requested short presentations from key participants to allow as much time

1 QuakeCoRE is a Centre of Research Excellence aiming to transform the earthquake resilience of Aotearoa New Zealand. The work described here is funded by Flagship 5: Pathways to Increased Resilience.

Table 2
Summary of Short Presentations for Emergency Sanitation Workshop

Presenter	Title	Description
Joint Centre for Disaster Research, Massey University	"The sanitation service chain: a framework for understanding the sanitation challenge"	This presentation introduced a framework for the assessment and management of different sanitation options with the objective of conveying the complexity of the challenge. This framework seeks to break down the management of waste into stages and within each stage bring an understanding of different cultural, social, environmental, economic, health, and logistical aspects. The framework has been adapted from Zakaria et al. (2015).
Wellington Water	"Seismic resilience of the Wellington wastewater network"	This presentation described expected timeframes for the re-establishment of the wastewater network in different locations and under different scenarios, along with a preliminary "Quake to Flush" strategy (under development at the time of the workshop) with a long-term goal of building resilience in the network for a 30-day reconnection plan.
Wellington Regional Public Health	"Public health, diseases and hygiene"	A public health perspective on emergency sanitation was provided detailing the role of Regional Public Health pre- and post-disaster. The importance of safe and hygienic sanitation was underlined using statistics on the number of cases of enteric diseases in the Wellington region in "normal" and post-disaster times.
WREMO	"Learning what to do when there's nowhere to go"	This presentation described one staff member's personal experiences living in Christchurch in the aftermath of the 22 February 2011 earthquake with no public sanitation or other utilities.
WREMO	"Wastewater solutions for people who don't give a … but need to"	This presentation detailed the current state of general disaster awareness and preparation across the Wellington region, including emergency sanitation. The use of quotes from community members served to highlight differing social and cultural perspectives on emergency sanitation and also to highlight that emergency sanitation preparations are typically regarded as being low priority in the community at large.

as possible for discussion. The workshop was structured in three sections as follows:

Part 1: Five short (10 minute) presentations by key organisations to set the context for post-earthquake emergency sanitation. Presentations are summarised in Table 2.

Part 2: Group Discussion - Engaging communities and marginalised groups in the conversation.

Part 3: Group Discussion - The sanitation options: What are the options and are they suitable and practical? Applicable to whom?

Summary of Discussions on Engaging Communities and Marginalised Groups in the Conversation

The second part of the workshop tackled the issue of how to bring communities and marginalised groups into the conversation on emergency sanitation. The discussion also canvassed participants' views on the adequacy of information currently available, and participants identified key information needs.

Several of the presentations from the first part of the workshop highlighted the limited degree to which people have planned or even considered toileting needs as part of their emergency kit. This was the basis for a discussion

Table 3
Summary of Discussion on Engaging Communities and Marginalised Groups

Prompt question	Responses
What key information needs to be part of a pre-disaster conversation?	- Projected wastewater service outage durations when toilets cannot be flushed. - Consequences of flushing toilets when the wastewater network is damaged; waste will be discharged into some residences, onto residential land, and overland in streets or to waterways. - Serious nature of diseases transmitted by the faecal-oral pathway. - Options for emergency sanitation (may be location dependent). - Probability that some homes may be uninhabitable following the scenario earthquake or disasters with similar wastewater consequences.
What are the main challenges for the pre-disaster conversation?	- Agencies engaging with community groups need better information on options and context to help with conversations and planning. - How do we even define communities? Who are they and what challenges might they face in their particular situation? For example: students or those in apartments, people living with a disability, migrants and refugees, and those for whom English is a second language. There is a diversity of community groups with differing needs and abilities to access and maintain sanitation facilities. - To reach different communities, start with approaching key people/influencers. - Consider pre-planning messaging and assistance for those who will most need help.
What socially and culturally awkward norms do we need to consider when coming up with solutions?	- Environmental, social, and cultural standards may be temporarily compromised following an event. - There is social awkwardness and squeamishness around bodily functions, with reference to Rosenquist (2005). However, for emergency preparedness communications, use of euphemisms such as "human waste" may not be helpful. Participants agreed on the need for consistent terminology and suggested that the terms "wee" and "poo" be adopted as they are direct and unambiguous, if informal.
What will those who have lesser capacity do?	- Groups representing the disabled find it difficult to prioritise emergency preparedness in general, as their finite resources are occupied with day-to-day issues such as transport and access. - The disabled are more likely to favour emergency sanitation solutions based on their regular toilet arrangements (e.g., bag inside toilet) due to ease of use. - It is incumbent on all community members to support those with reduced capacity.
What are some of the tikanga Māori perspectives and plans for sanitation in disasters?	- Marae around the Wellington region are well set up to cope in a disaster, although many urban marae may lack the appropriate space for the separation of sanitation facilities from other areas (due to overall space limitations). - Marae are likely to source portable toilets where appropriate and able to do so, with long drops also identified as an option. The larger marae have pre-identified places where long drop toilets may be located. Pre-digging of long drops has been put forward as an appropriate action. - All plans should align with the Treaty of Waitangi principles and articles.
Who is best to lead work on engaging communities and marginalised groups in the conversation about emergency sanitation?	- WREMO are the appropriate lead as they have the regulatory authority under the Local Government Act. - Other stakeholders must be engaged, and collaboration is essential. - WREMO should be a public voice but in partnership and with input from other key partners such as Regional Public Health and Wellington Water. - All advice should be evidence based.

where several questions were posed to the group as prompts. The questions posed are summarised in Table 3 along with a summary of points raised in the discussion.

Summary of Discussion on Emergency Sanitation Options

The third part of the workshop was based on a discussion of the Sanitation Service Chain (SSC) framework as a basis for understanding and evaluating different sanitation options and how they might apply in different contexts (Zakaria et al., 2015). The SSC framework is based on the concept that emergency sanitation should be perceived beyond the provision of latrines/toilets to include storage/containment of the waste, emptying and transport, treatment, and final disposal or re-use (Figure 1). The main discussion points for each option are presented in Table 4.

While there was insufficient time during the workshop to work systematically through the entire matrix for each emergency sanitation option (shown in Figure 1), there was general agreement from participants that the SSC framework was an appropriate basis on which to proceed and that the options identified were appropriate for more detailed consideration. The SSC framework highlights the complexity of the challenges and knowledge gaps in the management of human waste and also provides a mechanism to support decisions on the provision of emergency sanitation. Participants also noted that there is merit in providing end users with options for their emergency sanitation.

Next steps include the following: 1) planning for a follow-up workshop for detailed consideration of the viability of the proposed emergency sanitation options using the SSC framework, 2) clarifying roles and responsibilities for all parties during a response and identifying resource requirements, and 3) developing key messages and opportunities to increase household preparedness.

Conclusion

As explained in the introduction, although many useful reports were produced following the Canterbury

Figure 1
The Sanitation Service Chain Framework as Presented for Discussion

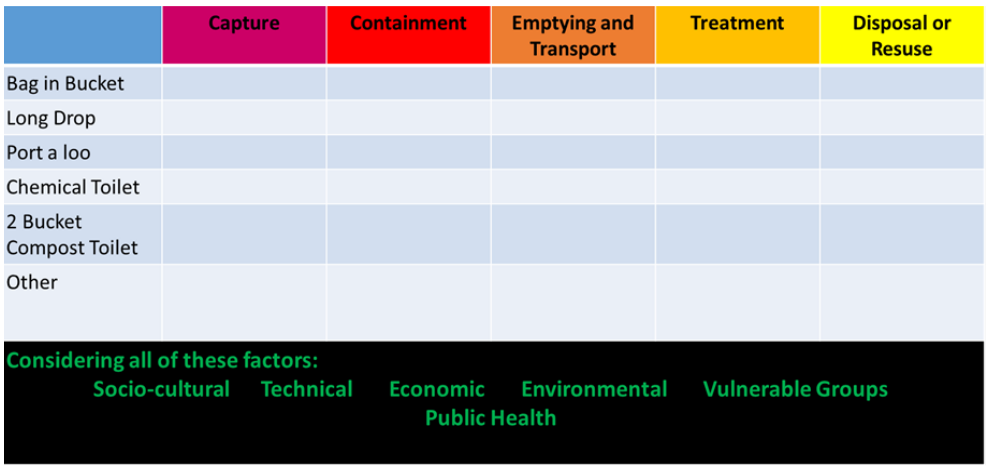

Table 4
Summary of Discussion on Emergency Sanitation Options

Emergency sanitation option	Points raised
Bag in Bucket	For the Bag in Bucket option, there are likely to be substantial public health risks at the "emptying and transport" stage if domestic waste collection trucks are used to collect bags, because trucks are not sealed and waste will probably leak from bags and trucks and contaminate roadways.
Long Drops	Long drops are a simple and effective option for many households, but location and soil type should be considered. In sites such as the Hutt Valley, proximity of groundwater bores to long drop toilets may be an issue. Many other locations in the hill suburbs may be on bedrock with insufficient soil depth to excavate a long drop. A further problem may be waste seeping downslope in these hill suburbs into lower elevation properties.
Portable Toilets	Portable toilets were not discussed further in this workshop because it was considered that their use would be impractical in post-earthquake Wellington where road access is likely to be very limited, particularly in hill suburbs.
Chemical Toilets	Chemicals used in chemical toilets can present problems for waste treatment plants if there is not sufficient dilution. Road access is required to deliver chemicals and collect waste.
Two-Bucket Composting Toilet	Preliminary research suggests that composting, with the use of carbon additives, can reduce pathogen levels in human waste in approximately 10 weeks, so that it can be handled using similar precautions as for potting mix. The emptying and transportation of waste from the two-bucket composting system requires more assessment from a public health and logistics perspective. A further problem may be that water supplies are likely to be very limited following a large earthquake on the Wellington Fault, so it will be difficult to clean the bucket following emptying.

earthquake sequence, specifics of the Wellington context mean that these lessons are not entirely applicable. For example, recently revised timeframes of 1-2 years for the re-establishment of networked wastewater collection and treatment in Wellington following a major Wellington Fault earthquake provide additional urgency to consideration of emergency sanitation options and arrangements for the region. This workshop, held in November 2019, was an attempt to initiate a conversation between emergency management practitioners, local iwi representatives, wastewater managers, academics, engineers, and representatives from several community advocacy groups. Participants commented on the value of assembling a diverse range of people to discuss this important and often-overlooked topic in emergency preparedness. Key findings from the workshop were: a recognition that standard and unambiguous terminology is required when communicating about this sensitive subject, an acknowledgement that the community is made up of diverse groups with diverse needs and that different strategies may be required to engage with these groups, and that the Sanitation Service Chain framework is an appropriate basis on which to progress emergency sanitation arrangements. Finally, we note that the provision of emergency sanitation is just one component of an effective, comprehensive, and co-ordinated public health response to manage the risk of gastrointestinal disease outbreaks following a major earthquake. Planning therefore needs to proceed on multiple fronts.

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