

## Appendix 3

### Christchurch Earthquake Report

#### ACKNOWLEDGEMENTS

We would like to thank staff from Community and Public Health and Christchurch City Council who assisted in the preparation of this report, providing first hand information and knowledge of Christchurch's drinking-water and the earthquakes which helped the report's authors interpret and understand the available information.

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## Summary

On 22 February 2011 Canterbury experienced an earthquake of magnitude 6.3 on the Richter scale. Infrastructural damage was extensive, particularly in the eastern suburbs, and included both drinking-water and sewerage systems. The subsequently reduced access to safe drinking-water and sewerage systems meant that the city's population was at a heightened risk of waterborne diseases.

The water supplier, Christchurch City Council, had the responsibility for restoring a supply of safe drinking-water as soon as possible, supported by Community and Public Health.

This report summarises the public health response to the February 2011 earthquake, focussing on the need to restore safe drinking-water to the public. It focuses mostly on the actual response to the emergency situation as it unfolded.

The key actions taken by Christchurch City Council and Community and Public Health to prevent a waterborne disease outbreak were:

- using, and having trained with, New Zealand's Coordinated Incident Management System
- having established functional relationships with external agencies that could offer assistance
- understanding the vulnerability of the drinking-water system to factors such as topography, geology and the type of natural disaster
- understanding treatment options and availability
- rapid issuing of a 'boil water notice'
- providing alternative water sources
- chlorinating systems, prioritised on the basis of structural damage, water quality and numbers of people affected
- intensively monitoring water quality
- consistent and blanket coverage public health messaging
- maintaining vigilance and responding to indicators of gastrointestinal disease.

The best measure of the success of the public health response was the lack of a recorded increase in potentially waterborne disease outbreaks in the period following the 22 February 2011 earthquake.

## Introduction

On 22 February 2011 Canterbury experienced an earthquake of magnitude 6.3 on the Richter scale. A combination of factors, including the earthquake's closer proximity to the central business district, its higher peak ground acceleration and shallower depth, meant it caused much greater injury to people and damage to buildings and infrastructure than was caused by the magnitude 7.1 earthquake that occurred in September 2010.

Emergency responses were established at the Regional Emergency Co-ordination Centre, Christchurch City Council and Waimakariri and Selwyn District Councils, and civil defence emergencies were declared in each district. However, it soon became apparent that most of the damage was in Christchurch, so the emergency responses were downgraded in the Waimakariri and Selwyn District Councils. A Government-declared State of National Emergency came into effect on 23 February 2011 and remained in place for nine weeks.

Infrastructural damage was extensive, particularly in the eastern suburbs, and included damage to both drinking-water and sewerage systems. The subsequently reduced access to safe drinking-water and sewerage systems meant that the city's population was at a heightened risk of waterborne diseases.

The authority responsible for providing drinking-water to Christchurch in this situation, Christchurch City Council, and Community and Public Health and Civil Defence, had to respond to a changing and uncertain emergency situation. The Coordinated Incident Management System (CIMS) is New Zealand's framework for managing responses to incidents and hazard events where multiple agencies are involved. All actions during the response phase of this emergency followed the seven CIMS' principles<sup>1</sup> - common terminology, modular organisation, integrated communications, consolidated incident action plans, manageable span of control, designated incident facilities and comprehensive resource management.

Community and Public Health is the Public Health Unit of Canterbury District Health Board, responsible for public health emergency response in Canterbury. Community and Public Health had undergone training and been involved in practice days in the CIMS approach to hazard events before the earthquake on 4 September 2010. The CIMS approach was used in the aftermath of the September earthquake and provided some valuable learning to improve CIMS implementation in the February earthquake.

### Information gathering

Most of the information in this report derived from the situation reports (SitReps) assembled by Community and Public Health's intelligence unit. These reports are intended to support Civil Defence operations. Real time information of this nature may not be completely accurate. This report has not verified the information held in the SitReps or from other source such as media releases. Information was also gathered from a report produced by Community and Public Health (*Public Health*

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<sup>1</sup> [http://en.wikipedia.org/wiki/Coordinated\\_Incident\\_Management\\_System](http://en.wikipedia.org/wiki/Coordinated_Incident_Management_System)

*Response to the February 22 Christchurch Earthquake*), by Rebecca Dell, from the Internet for information on CIMS and the National Civil Defence Emergency Management Plan, and from discussions with staff from Community and Public Health and Christchurch City Council. Information about the compliance status of Christchurch's drinking-water (prior to the earthquake) with the *Drinking-water Standards for New Zealand* was taken from the *Annual Review of Drinking-water Quality in New Zealand 2009-2010*.

Information gathered by the computer-assisted telephone interview (CATI) surveys<sup>2</sup> of residents of Christchurch during March and April 2011, particularly from the responses to questions relating to drinking-water and access to personal healthcare information, has been used in this report.

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<sup>2</sup> Paine, S. and Bissielo, A. *Final report - The Christchurch Health Survey Following the February 2011 Earthquake*. July 2011. Institute of Environmental Science and Research Limited (ESR), Wellington.

## Pre-earthquake status of the drinking-water system in Christchurch

Within the Christchurch City Council area there were a total of 52 registered drinking-water zones at the beginning of July 2010. These zones supplied 19 communities run by Christchurch City Council, serving 403,000 people, one other communal-run community (Okains Bay), serving 105 people, and 32 self-supplies serving approximately 13,000 people. All of the main Christchurch city zones, except Northwest Christchurch, were sourced from secure aquifers. Based on information published in the *Annual Review of Drinking-water Quality in New Zealand 2009-2010*, of the local authority-run community supplies, 15 complied bacteriologically and 10 complied with the protozoal standard. Four zones serving 1,650 people failed to comply due to *Escherichia coli* transgressions. All the above supplies had public health risk management plans in place and implemented prior to the earthquakes.

Indicative statistics about the physical infrastructure of the drinking-water system published by Christchurch City Council<sup>3</sup>, estimate that the total water pipe length amounted to 1500 km, with 117,000 connections to the system and that it pumped 50 million m<sup>3</sup> water per year from 167 wells.

Christchurch's water infrastructure was damaged by the 4 September 2010 earthquake. Although water services had been restored, many of the repairs were temporary<sup>4</sup>, and the system was operating at reduced capacity<sup>5</sup> when the February 2011 earthquake occurred.

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<sup>3</sup> Christchurch water statistics.

<http://www.ccc.govt.nz/homeliving/watersupply/ourwater/statisticalsummary.aspx>

<sup>4</sup> Media release by Christchurch City Council on 11 February 2011.

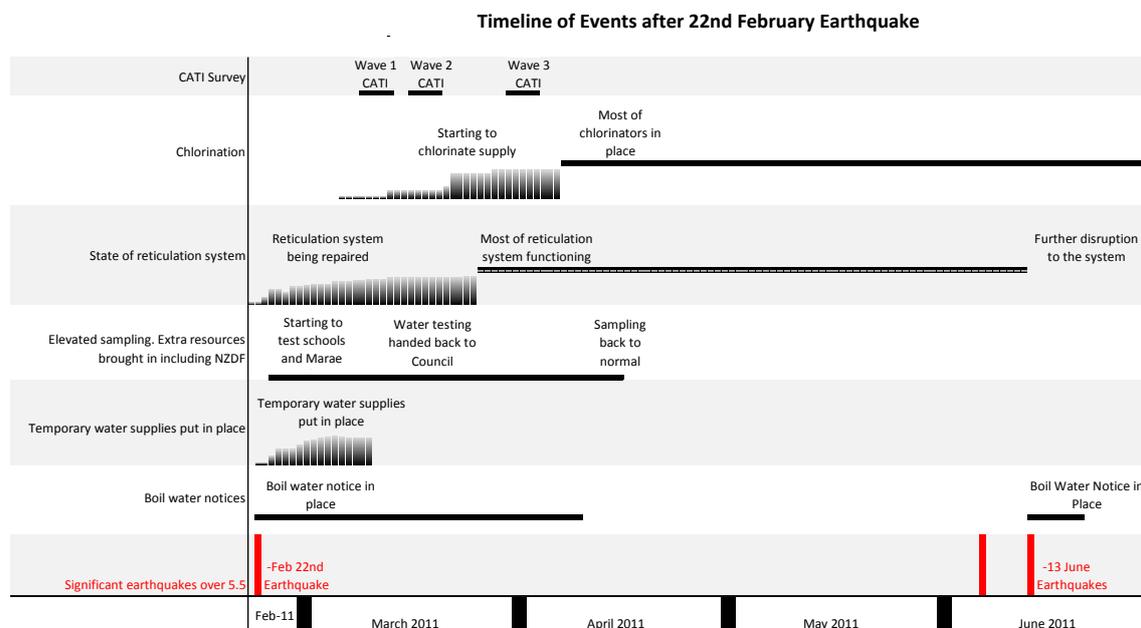
<http://www.ccc.govt.nz/thecouncil/newsmedia/mediareleases/2011/201102112.aspx>

<sup>5</sup> Media release by Christchurch City Council on 10 January 2011.

<http://www.ccc.govt.nz/thecouncil/newsmedia/mediareleases/2011/January/101101104.aspx>

## Response

This section outlines the drinking-water quality management actions taken in response to the February 2011 earthquake, up until the time emergency chlorination was being phased out (early December 2011). Figure 1 summarises the chronology of major events and interventions during this period.



**Figure 1**

### Immediate emergency assessment and public health mitigation measures

Less than two hours after the earthquake on 22 February 2011, a state of emergency for Christchurch city was declared. Due to the scale of the event, this was upgraded to a national emergency the next day.

An initial assessment of the city's drinking-water system by the Christchurch City Council showed that the security of the reticulated water system had been compromised, with initial reports indicating that there was zero water pressure across the city, pipes were broken, wells were damaged and reservoirs for the hill suburbs were isolated from the source. In actual fact many western suburbs still had reticulated water, though often at reduced pressure.

The topography and geology of the city influenced its vulnerability to damage from the earthquake. The hill suburbs of Christchurch are on the predominantly fractured volcanic basalt rock of Banks Peninsula. These suburbs are supplied drinking-water via hillside reservoirs. The epicentre of the February 2011 earthquake was under Banks Peninsula, and the violent shaking of the steep and rocky ground damaged the reservoirs and the pipes supplying the reservoirs. Once the reservoirs emptied, they were not able to refill. On the flatter, and especially in the eastern suburbs, major damage to the drinking-water distribution system was caused by severe ground movement and unprecedented amounts of liquefaction. The drinking-water supplies

to the northern and western suburbs were relatively uninterrupted. The priority was therefore to provide alternative supplies of water to the eastern and hill suburbs.

The potential for untreated sewage from the severely damaged wastewater system entering the untreated water supply was a major public health risk, so a 'boil water notice' was issued immediately to mitigate this risk.

### Extent of city's drinking-water supply affected

While initial assessments suggested there was zero water pressure across the city in the immediate aftermath of the earthquake, it became clear that not all Christchurch residents had lost their supplies of water. Information published by the Ministry of Civil Defence and Emergency Management<sup>6</sup> estimated that there was no drinking-water supply to 80% of the city the day after the earthquake, which implies that over 300,000 people did not have access to reticulated water.

The estimates illustrated in Figure 2 indicate that 200,000 people did not have reticulated water in the two or three days that followed the earthquake.

Considerable effort went into restoring water supplies, but the scale of the damage meant that in some instances it took 30 days to restore supplies. Aftershocks and ongoing repairs led to further disruptions to supplies after water had been restored to areas. It was estimated that three weeks after the earthquake 55% of water was being lost due to leakages from the system.

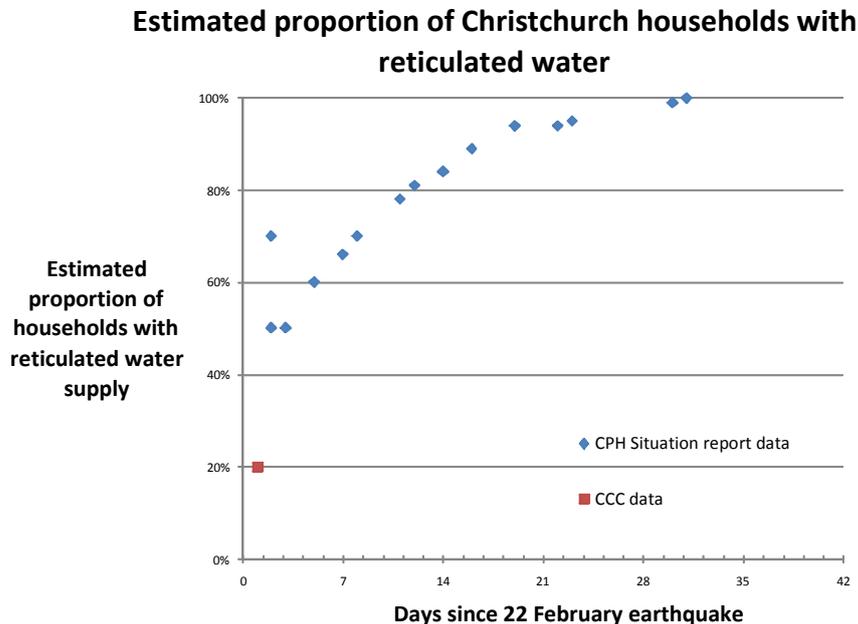


Figure 2

<sup>6</sup> Media release by Christchurch City Council on Wednesday 23 February 2011.  
<http://www.ccc.govt.nz/thecouncil/newsmedia/mediareleases/2011/201102235.aspx>

## The public health risk from sewage contamination

Following each of the major earthquakes in Christchurch there was a high likelihood of waterborne disease outbreaks because of the dual threats of fractured drinking-water supplies and ruptured wastewater systems, with the latter providing a potential source of disease-causing organisms (pathogens). The damaged water supply network created a pathway by which pathogens in the wastewater could reach the city's residents. Wastewater soaking into the ground also threatened the city's drinking-water sources (the aquifers) with contamination, thereby providing another pathway by which contamination could reach the public.

### Water quality

An extensive drinking-water sampling programme was carried out with Community and Public Health assisting Christchurch City Council. Community and Public Health, with additional staff from other public health units and New Zealand Defence Force personnel sampled for *E.coli* and free available chlorine in the distribution system. Christchurch City Council focussed on the bores and reservoirs and Community and Public Health on the distribution system. The personnel from outside Christchurch brought in additional water quality testing equipment.

In the month leading up to the February 2011 earthquake an average of 12 water samples were taken per day by Christchurch City Council. Over the 6 week post-earthquake period when the boil water notice was in force, an average of over 190 water samples were taken per day, reaching a maximum of 300 samples per day in mid March 2011 in response to the spike in positive *E. coli* results, and again immediately after the June 2011 earthquake. Summary water quality results for the period July 2010 to June 2011 are shown in Table 1.

**Table 1: Summary results 2010-2011 for *E.coli* testing for Christchurch**

Supply	Pop	Zone / Plant Code	July 2010 to June 2011		
			No. samples	<i>E. coli</i> (+)ve	% (+)ve
Brooklands-Kainga	2300	BRO012BR	637	1	0.2%
		TP00964	100	0	-
Central Christchurch	236,000	CHR001CE	8930	121	1.4%
		TP00179	1294	3	0.2%
Diamond Harbour	690	LYT001DI	213	0	-
Governors Bay	900	LYT001GO	318	8	0.3%
Lyttelton	2130	LYT001LY	479	10	2.1%
Northwest Christchurch	83,000	NOR012CH	1123	15	1.3%
		TP00181	1130	11	1.0%
Parklands	17,000	CHR001PA	517	0	-
		TP00182	193	0	-
Riccarton	11,500	CHR001RI	364	0	-
		TP00185	130	0	-
Rocky Point	4500	CHR001RP	273	0	-
		TP00184	88	0	-
West Christchurch	42,000	CHR001WE	1336	5	0.4%
		TP00183	233	1	0.4%

Colour-coding links to Figure 3

Although the proportion of positive samples throughout the July 2010 to June 2011 year did not exceed 2.1%, samples taken in the three weeks during the immediate aftermath of the earthquake showed a number of transgressions, the red bars shown in Figure 4. These transgressions appear in Table 1 as positive *E. coli* results, and were not evenly distributed across the city. This information was used to prioritise responses such as which areas might benefit from flushing and chlorination, and when to lift the ‘boil water notice’.

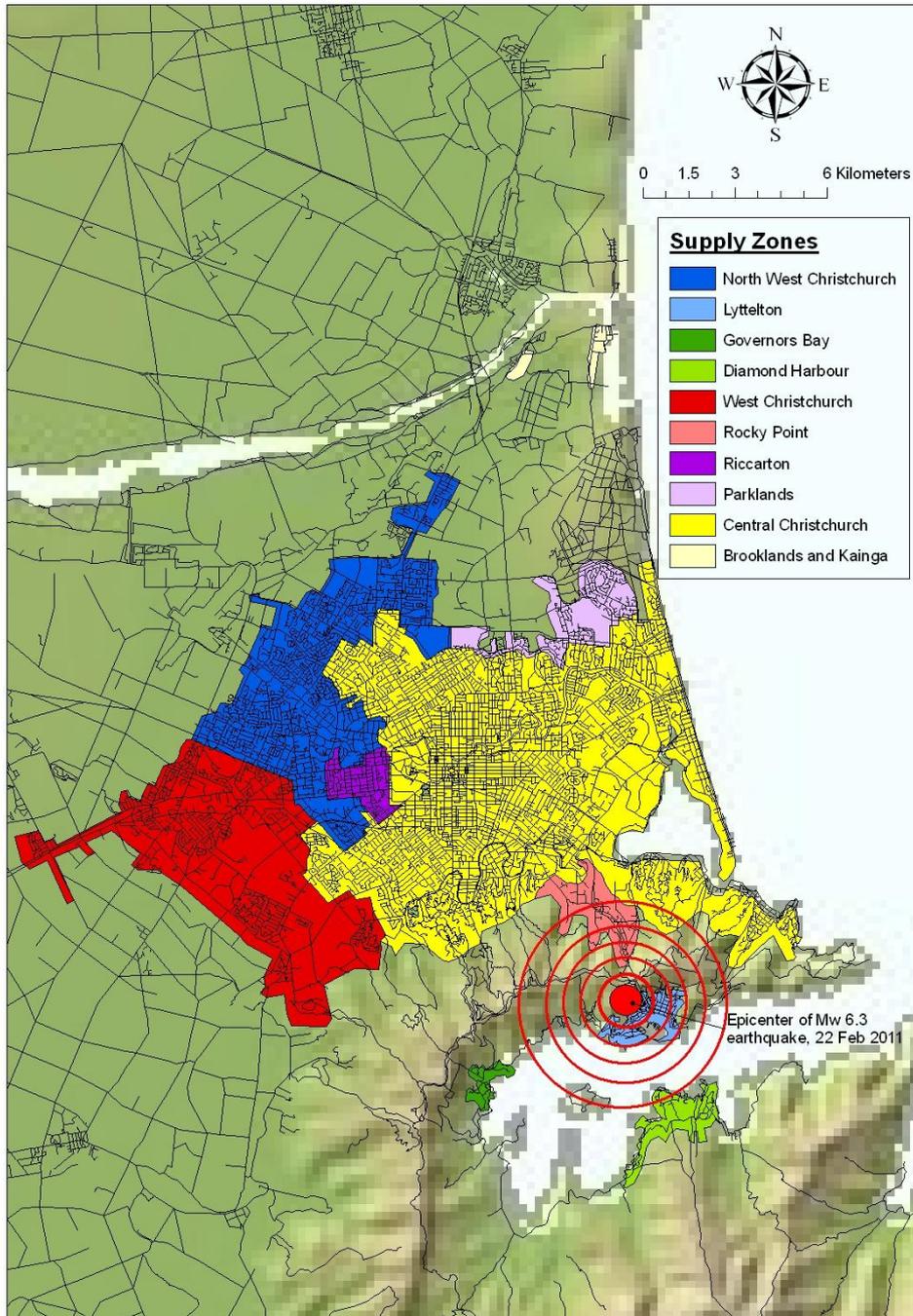


Figure 3

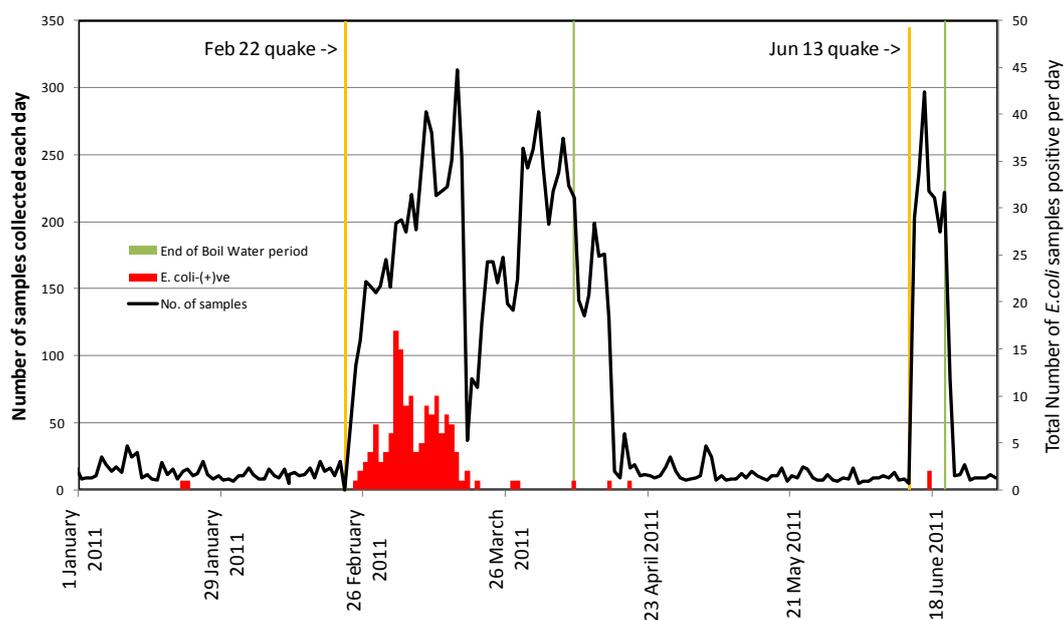


Figure 4

### Disease surveillance

Several enteric pathogens can be transmitted by contaminated drinking-water. Of these, notified incidences of *Campylobacter*, *Cryptosporidium*, *Giardia*, *Salmonella*, *Shigella*, *Yersinia* and pathogenic *E. coli* are captured by the national disease notification system, EpiSurv. In addition, acute gastroenteritis of non-specific cause is also a notifiable disease captured by EpiSurv.

In the aftermath of the earthquakes, the disease surveillance system in Christchurch was fully operational. The intelligence team at Community and Public Health gathered information about cases of gastroenteritis from after-hours surgeries, general practitioners and the emergency department, updates of illness from welfare centres, disease notifications for Community and Public Health, EpiSurv extracts, Canterbury Health Laboratories' specimen numbers and the community pharmaceutical warehouse and distribution centre<sup>7</sup>.

There were no reports of disease outbreaks captured by the disease surveillance system in the weeks following the major earthquakes of September 2010, February 2011 and June 2011.

### Impacts of aftershocks

Major earthquakes are followed by a sequence of aftershocks. In Christchurch these aftershocks caused further disruption and damage to the water supply. In the case of the 13 June 2011 aftershock, the boil water notice was reissued and remained in place

<sup>7</sup> Dell, R. and Williams, D. *Public Health Response to the February 22 Christchurch Earthquake*. 2011, Canterbury District Health Board.

for one week. Many of the aftershocks caused more damage to the wastewater and drinking-water distribution systems, delaying these services coming back on line and requiring more testing of drinking-water to ensure it was safe.

*E. coli* transgressions directly associated with the aftershocks were not found, and there was no upsurge in waterborne diseases at these times either, an indication of the effectiveness of the risk management actions taken.

#### Vulnerable populations

Although the lack of safe drinking-water following February's earthquake put the entire population at greater risk of disease, certain population groups were at particular risk of disease from unsafe drinking-water, for example, people requiring kidney dialysis, children, hospitalised patients, the elderly, immuno-compromised people and those in aged care facilities.

Those people receiving dialysis treatment require safe water so they do not get infections. These people were evacuated from the city. Special consideration was given to these patients once they returned to Christchurch, as the introduction of chlorination to a reticulated water system can be an issue for dialysis.

People in hospitals and aged care facilities were also highly vulnerable. A precautionary response was taken for these high-risk populations. For example, the Princess Margaret Hospital supply was chlorinated within the first week of the earthquake.

#### **Alternative and temporary water supplies**

Where damage to the distribution system prevents supply of drinking-water to properties, alternative water supplies are required. Commercially bottled water provides a rapid solution, if it is accessible and available in the volumes required.

Given the damage to the drinking-water supply in the eastern and hill suburbs, these areas were a priority for providing alternative supply. In addition, vulnerable population groups situated in places such as hospitals, aged care facilities, and welfare centres needed water brought to them.

Approximately 70 temporary supplies were set up to serve people who did not have access to reticulated water. Half of the temporary supplies became available within three days of the earthquake, and most were deployed within one week. Initially these supplies were located at schools. The temporary supplies consisted of tankers, fixed tanks and pump stations, as well as desalination plants. Information about the location and timing of water delivery was disseminated through the media and on the Christchurch City Council website. Water for the tanks was brought in from areas outside Christchurch where the water supplies had not been compromised by the February 2011 earthquake. Registered<sup>8</sup> and non-registered water tankers from the region were used, the emergency situation over-riding the need for registered tankers.

Welfare centres used bottled water, even when reticulated water was available due to the difficulty of treating or boiling water in these environments. Bottled water was

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<sup>8</sup> Defined in the Health Act 1956.

also distributed from a number of locations in the city in the days after the earthquake before tankers could be brought in.

### **Re-establishing safe self-supplies**

Alongside the community supplies in the Christchurch City Council area there were 32 self-supplies. These supplied drinking-water to schools, marae, hospitals and holiday parks that are not served by the council-owned distribution system.

The damage to buildings, including those of Community and Public Health and Christchurch City Council, meant that paper records were inaccessible. Fortunately, contact information for these supplies was accessible to Community and Public Health from their own electronic records and the *Register of Community Drinking-water Supplies in New Zealand*<sup>9</sup>. Community and Public Health was able to contact all of the self-suppliers to advise them of the need to assume their drinking-water supply was contaminated and to treat or boil the water until it was tested and assured to be safe.

### **Public health messaging**

In emergency situations, when the local authority is unable to provide services such as reticulated water and wastewater, the responsibility for maintaining public health shifts from central agencies to the individual. Despite this, individuals are still dependent on a central agency to provide advice, such as a 'boil water notice'. Consequently, it is critical that these important messages reach the people and that the possibility of confusion is minimised.

Everyone needs to receive the messages. However, in an emergency the usual ways of mass communication may have been disrupted, for example, through power and telecommunication outages. Multiple avenues of communication are necessary. Following the February 2011 earthquake, public health information was communicated by local and national television and radio, central and local government websites public notices displayed at gathering points such as temporary water supply points and mailbox drops.

A series of CATI (telephone) surveys<sup>10</sup> indicated the public obtained personal health care information most frequently from newspapers (68.6%), television (66.6%), radio (66.0%), family, friends and neighbours (51.5%) and websites (38.4%).

The initial public health messages relating to drinking-water included being told to use water sparingly, to boil or treat all tap and tanker water and where to find tankered water. Later messages also included the information that some of the city water supply was being disinfected.

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<sup>9</sup> Water Information New Zealand (WINZ) is a national database developed by ESR for the Ministry of Health. It provides an up-to-date source of national water supply information required for drinking-water quality management

<sup>10</sup> Refer Footnote 2.

### Boil water notice

The ‘boil water notice’ was perhaps the most important public health message and was critical to ensure microbes that may have been present in contaminated water were killed.

The boil water message that appeared on the Canterbury District Health Board website on 23 February stated that all water was to be boiled, even if it came from a water tanker, and that boiled water should be used for drinking, brushing teeth or washing/preparing food. It further stated that if boiling the water in a pot, it should be boiled for one minute and it should be boiled twice if a kettle was used. This notice was later modified as described in the “Effectiveness of messaging” section.

The ‘boil water notice’ applied to the whole of Christchurch was widely and repeatedly communicated, including being attached to water tankers, and incorporated advice to boil or treat all tap or tanker water before drinking, brushing teeth and food preparation.

When the ‘boil water notice’ was lifted on 8 April by the National Controller in consultation with the Medical Officer of Health, it was lifted across the whole of the city, rather than lifting the notice in one area of the city at a time to avoid confusion of which areas were and were not under a ‘boil water notice’.

### Effectiveness of messaging

A clear message is important for ensuring that residents take the actions needed to protect against disease. Within a few days of the 22 February earthquake, anecdotal evidence highlighted issues of inconsistent messaging.

On 25 February the wording of the ‘boil water notice’ was changed from stating that all water had to be boiled, including water from tankers, to saying that all water had to be boiled unless it was bottled. This suggested problems with some residents misunderstanding when boiling water was not necessary. The SitRep issued by Community and Public Health on 26 February reported that anecdotal evidence indicated some problems with the consistency of messages displayed on tankers and at other temporary supplies.

Community and Public Health acted quickly to improve the effectiveness of the messaging by appointing a person dedicated to public health communications (SitRep 27 February). This person assisted with updating and circulating the key messages to government websites and the media, as well as distributing information at temporary supplies, and through the Civil Defence briefings.

Findings about the behaviour of residents in response to the messaging became available from the first wave of the CATI (telephone) surveys<sup>11</sup> on 21 March. The report showed that 21% of respondents were using either unboiled or untreated water for food preparation, and some (2 of 23 with bottle-fed infants) were using unboiled or untreated water for the preparation of baby formula. The SitRep of 21 March recorded that public health advice had been updated to reinforce the message that boiled or treated water was needed for these purposes. The results from the second

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<sup>11</sup> Refer Footnote 2.

wave of CATI surveys became available a few days before the ‘boil water notice’ was lifted, the percentage of respondents who were using unboiled or untreated water for food preparation increased to 36%.

### **Chlorination**

Once mains repairs had been undertaken, water could be reticulated again. However, the security of the distribution network remained uncertain. Chlorination of the system was necessary to maintain the safety of the untreated water supplied until there was sufficient evidence to demonstrate that the system was secure from contaminant entry.

In view of the level of pipe and reservoir damage, chlorinating the drinking-water supply began in the Central Christchurch zone on 1 March 2011<sup>12</sup>. This zone included the badly damaged eastern suburbs and hill suburbs with reservoirs. The Lyttelton and Diamond Harbour zones were also chlorinated, because of the risk of contamination if the reservoirs were damaged or receiving contaminated water. Over the next three weeks, approximately 22 chlorinators were installed, and by the sixth week post-earthquake, 26 chlorinators had been installed. Chlorinators were installed on the basis of structural damage, water quality, and numbers of people affected, and were not installed on all supplies.

Once the level of free available chlorine reached an acceptable level within the distribution system and the non-chlorinated areas were free of *E. coli* transgressions, the ‘boil water notice’ was lifted.

### **The responses of the water supplier and public health unit**

The responses of the water supplier (Christchurch City Council) and Community and Public Health in the months following the 22 February earthquake, in terms of drinking-water supply are summarised in Table 2.

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<sup>12</sup> Refer Footnote 9.

**Table 2**

	<b>Christchurch City Council</b>	<b>Community and Public Health</b>
Assessment of situation	Determining extent of physical damage	Identifying risks to public health
	Determining priorities for responding to damage	Disease surveillance from a variety of sources
	Providing SitRep reports for Christchurch City Council staff and Civil Defence Emergency Coordination Centre	Providing SitReps for Community and Public Health staff, Civil Defence Emergency Coordination Centre and Ministry of Health
Restoring water supply	Temporary repairs to the level of street laterals	
	Providing temporary supply, including organising water tankers	Ensuring signage on tankers and also using tanker delivery points to distribute a wider range of public health messages
	Implementing water conservation measures and restrictions	
Ensuring safe drinking-water	Monitoring water quality at bores and reservoirs, then resuming all water quality monitoring after the first month	Monitoring water quality in distribution system for the first month, both <i>E. coli</i> and free available chlorine
		Providing mapping of <i>E. coli</i> transgressions to Christchurch City Council
	Installing chlorination units	Informing self-suppliers of quality issues and public health risk
	Notifying public of boil water notice	Issuing boil water notice, and notifying when it can be lifted
Public information	Providing information on availability of drinking-water supply	Providing correct and clear public health messages
	Distributing public health messages	Distributing public health messages

## Conclusion

Following each of the major earthquakes in Christchurch there was a high likelihood of waterborne disease outbreaks because of the dual threats of fractured reticulation for the untreated drinking-water supply and ruptured wastewater systems.

Although some *E. coli* transgressions occurred following the earthquakes, the actions of Christchurch City Council and Community and Public Health controlled the additional risks sustained through earthquake damage and minimised the health risk posed by drinking-water. The best measure that we have of the success of the public health response is the lack of a recorded increase in potentially waterborne disease outbreaks in the periods following the earthquakes. Christchurch City Council, Civil Defence and Emergency Management and the public health services should be commended for their responses, both initial and on-going, that were made to the extreme risks that the earthquakes presented to the drinking-water supply infrastructure.