Understanding the impact of a major earthquake on Wellington Lifelines

Mowll, R.L., Brunsdon, D., Wilde, F., Leslie P.D.

Wellington Lifelines Group (Project Manager, previous Project Manager, Chair and Deputy Chair), Wellington, New Zealand.

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ABSTRACT: Understanding seismic hazard and the potential impacts of an earthquake on a population allows better planning of response and recovery. It also allows a better understanding of how to mitigate against the effects of earthquakes.

The Wellington Lifelines Group (WeLG) and the various Wellington lifeline utility organisations over the past five years have synthesised information on the consequences of a major earthquake, drawing upon hazard information (including from the GNS Science-led 'It's Our Fault' studies), learnings from civil defence emergency management exercises and from overseas earthquakes, and specialist studies commissioned by individual utilities. During 2012, WeLG facilitated specific discussions in order to summarise the time taken to restore water, transport, power (electricity) and telecommunications services following a rupture of the Wellington Fault, and therefore the effects on the population.

The outcome of this work was an indication of substantial post-earthquake restoration times, agreed across and within key utility sectors. The time-scales for restoration of lifelines in a major earthquake are in the tens of days for power and water, and some key roads would not be recovered for up to 120 days. Telecommunications systems, particularly cell phone sites, would be recovered earlier, but are critically dependent upon access and fuel supplies for the refuelling of emergency generators.

Given the significance of these likely restoration times for the community, it was decided to publically release the information, with buy-in from all of the lifeline utility organisations involved. The resulting report was released, with appropriate messaging, via the Wellington CDEM Group to the media in mid-November 2012.

This paper provides a summary of the likely restoration times, background to their derivation, and the initial reactions to the release of the information.

1 INTRODUCTION

Recognising that it is not a matter of if, but when, a major earthquake strikes the Wellington Region, the Wellington Lifelines Group (WeLG) worked with the utility (lifelines) providers to summarise the seismic risk to Wellington's lifelines and to the communities they support, and provide a snapshot of existing and planned projects that would mitigate against earthquake effects. The resulting document (WeLG, 2012) will be used as a baseline from which future planning can be carried out. Through the completion of this report, Wellington is in a better position to mitigate against the effects of an earthquake and to plan for a major event.

This paper outlines the sources of information, and process used, in the production of the report, briefly summarises the findings, and outlines reactions following the public release of the report.

2 BACKGROUND WORK, INFORMATION AND EVENTS

The following section outlines the various workstreams and information sources that were used in the compilation of the summary of earthquake risk to Wellington's lifelines. As will be seen, work has been progressing for a number of years, with the summary project providing an opportunity to draw together and synthesise the work to date.

2.1 Phoenix exercises

Between the years 1998 and 2012, the Greater Wellington Civil Defence and Emergency Management office coordinated a series of exercises based on the scenario of a major Wellington earthquake. In addition to the knowledge gained from the post-exercise debrief documentation, these exercises have been influential in a variety of ways. They helped the various Wellington lifeline organisations to think through the likely effects of a large earthquake, and to consider their business continuity and emergency response plans. These outputs have led, directly and indirectly, to a number of the outputs outlined below.

2.2 Work carried out by GNS Science

A study led by GNS Science between 2006 and 2013, titled 'It's our fault', has worked to understand the likelihood and effects of a rupture of the Wellington fault. This study has provided a large quantity of information regarding not just the Wellington fault, but also on the wider seismic risk in the Wellington region (Van Dissen et al, 2010). It has therefore provided the scientific basis for understanding the seismic risk, along with information on how individual infrastructure assets types, for example water mains, would perform in particular areas of Wellington in such an earthquake.

As identified by the study, whilst a rupture of the Wellington fault has a return period of 840 years, the last event occurred around 300 years ago. For the WeLG restoration times project, a worst-case scenario of a 'direct hit' epicentre in the Wellington Harbour area, near Ngauranga Gorge was taken. Such an event would cause Modified Mercalli (MM) 10 shaking over much of the Wellington CBD and lower Hutt Valley, MM9 shaking over much of the urban Wellington area and MM8 shaking over an area covering much of the Greater Wellington area. This particular event is estimated to have a return period of 1,500 years. In addition to the shaking, the fault rupture has the potential to cause considerable damage to lifeline utilities crossing, or in proximity to, the fault line. This scenario was chosen as the basis for this project, as it presented a realistic, albeit low-probability event. However, in planning for a worst-case event, the effects of lesser-magnitude events should also be covered by the plans and mitigation actions. 'It's Our Fault' identified that lesser-scale events have higher probabilities, with an MM6 event having an eight-year return period, a MM7 event a 30 year period and a MM8 event a 120 year return period in the Wellington region.

2.3 BERL report

A report commissioned by the Greater Wellington Regional Council Water Group, aided by WeLG, in 2010 (BERL, 2010) estimated the economic impacts of lifeline outages in the case of a Wellington fault rupture. The intent of the project was to create a means of calculating the economic value of constructing one particular item of water infrastructure which would have specific seismic mitigation benefits. This report did not explicitly take lifeline interdependencies into account, but did summarise potential lifeline outage periods, and estimated the economic effects, across both suburbs and the region as a whole, of either individual or multiple lifeline outages. As such, it was a key baseline from which to carry out follow-on estimates of lifeline outages from a major earthquake. It calculated that a rupture of the Wellington fault in a magnitude 7.6 event would cause a one-off $3.1 billion reduction in GDP, with a $1.23 billion impact to the Wellington region in the first year after the event due to lifelines direct damage, and due to businesses closing permanently or relocating out of the region. BERL outlined that, depending on growth, overall ongoing business costs may be far higher across several years.

2.4 Work by individual lifelines

To a greater or lesser extent, the various Wellington lifeline utility organisations have carried out

studies on the effects of an earthquake on their assets over recent years. Such work includes specific studies regarding the roading network, the port, both the bulk water and local water reticulation networks as well as a variety of other related work. Such a variety of information, although held in a variety of different formats also provided information for the summary of restoration times.

2.5 **WeLG Critical Area studies**

In 2010 and 2011, WeLG worked with lifeline utilities on management plans for two 'critical areas', in Thorndon (near the Wellington CBD) and Petone/Seaview (at the southern end of the Hutt Valley). The Thorndon area is typified by a narrow corridor hosting a State Highway and an arterial road. The arterial road hosts bulk and local water supplies, bulk and local gas supplies, mains electricity and fibre optic cables. One key intersection in this area is crossed by the Wellington fault zone. The Petone/Seaview area is typified by a low-lying harbour edge potentially susceptible to liquefaction, and by a key fuel storage depot. Findings from the above two management plans were of use in understanding lifeline network vulnerabilities and response times for the wider region.

3 **PROCESS FOR UNDERSTANDING SEISMIC RISK TO COMMUNITIES**

The World Bank, through SOPAC, (SOPAC, 2005) outlined a best practice approach for improving the resilience of communities in Pacific countries. Summarised, this included the following set of steps, which also match the New Zealand lifelines philosophy:

Step one: Understand the physical hazard. Without an understanding of the physical risk (information provided, in the case of this project, by the GNS Science led 'It's our fault' project), resilience and emergency planning is likely to be vague. A clear understanding of the physical hazard will allow not only broad levels of risk to be identified, but will also, where necessary, provide harder data for economic calculations of potential projects.

Step two: Understand the consequences of a hazard event on the community. Hazard events will not only directly impact communities (for example through shaking events, flood and tsunami), but also indirectly through the failure of the lifeline utilities serving them. Ideally, if the consequences of an event on a community can be articulated in an intuitive manner, this will allow the community to comprehend the nature and scale of the hazard, and will allow follow-on planning to take place.

Step three: Identify mitigation actions (physical infrastructure upgrades). Understanding the hazard and consequences will allow for better identification of what physical mitigation works may be worthwhile. These may include seismic upgrades of roads, power lines or water pipelines.

Step four: Prepare pre-plans for response. In almost all environments, it will be virtually impossible to eliminate all natural hazard risk, even with upgraded infrastructure. While the gap in delivery exists, plans may be created to cover this gap. Such plans may include actions by the lifeline utility organisations (emergency response plans) or actions by the communities (storage of food and water, or movement away from a hazard).

Step five: Engage from an early stage with the local Civil Defence agency for planning and public messaging purposes. WeLG is an organisation that is resourced to facilitate projects, but not to carry out larger-scale communications functions. WeLG worked alongside the local Wellington Region Emergency Management Office (WREMO) in order to allow WREMO to carry out public messaging actions on the report, and to take on follow-on actions regarding some of the community consequences highlighted in the summary document.

This process is closely matched by the process taken in the implementation of this WeLG project.

4 **INFORMATION GATHERED**

4.1 **Information gathered by sector**

Information for the restoration times report was gathered largely sector by sector, namely the water (bulk supply and reticulation), transport (road, rail, port and airport), energy (gas and electricity

supply) and telecommunications sectors. This method allowed for coordination within sectors, which was particularly necessary where there was direct flow from one asset to another.

In the water sector, the delineation between bulk supply and reticulation is the bulk reservoirs that are located around Wellington. The bulk water supply asset owner (Greater Wellington Regional Council Water Group) was able to calculate broad timespans for the restoration of supply to those reservoirs. This was agreed to be the 'survival' restoration time for water, as restoration to this point would allow public collection of water from standpipes located near the reservoirs. 'Operational' restoration was considered to be the recovery of the reticulated water system to property boundaries, albeit with expected service outages whilst repairs continued. The electricity transmission and distribution restoration times was a similarly 'linear' process, with one organisation (Transpower) managing the transmission network and another (Wellington Electricity Lines Limited) managing the distribution network. Articulating transport recovery times is outlined in Section 4.3 below. Restoration times for the telecommunications sector were the hardest to articulate, due to the variety of telecommunications methods (fibre optic cable for 'backhaul', mobile telephone networks, microwave dish transmission and VHF radio networks). Due to the complexity and inter-connectedness of the sector, it would have proved impossible for a study of the size and nature of this one to fully understand the vulnerabilities of the telecommunications sector in the Wellington region, thus it was only possible to make broad statements and approximations regarding telecommunications restoration times.

Cross-sector interdependencies were captured, to a lesser degree, but were taken into account in the water sector's dependence on transport and electricity. It was not possible, due to the complexity of estimating other cross-sector dependencies, and due to the effects of taking assumptions on top of assumptions, to be more specific about other interdependencies between sectors.

4.2 **Setting common assumptions and levels of service**

In order to compare equally across different sectors, common assumptions were set for all sectors. These included items such as 'The majority of the expected damage will be caused by the initial fault rupture and earthquake. Significant aftershocks would potentially cause further damage and therefore potentially lengthen restoration times.' Levels of service were also established, relevant to each sector, for 'emergency', 'survival', 'operational' and 'full (normal)'. These levels of service allowed the story of restoration to be told through the spectrum of initial earthquake response to longer-term recovery of the various networks. Although relatively simplistic, the common assumptions and levels of service provided a common basis for analysis from which the remainder of the restoration information could be assembled.

The levels of service presented in this paper are for the 'operational' level of service. The following is a description of each of these levels:

- Water: Treated water reticulated to consumers, in quantity allowing businesses to resume, but subject to frequent disruptions for local network repairs.
- Power: Power reconnected with regular outages for repair work. Businesses will be able to resume operations on this basis.
- Gas: Gas reconnected with regular outages for repair work. Businesses will be able to resume operations on this basis.
- Telecommunications: Voice and data services, and landlines, would be available in most locations at reliability levels adequate for most normal business purposes.
- Land access: The availability of the roading network has been assumed to be that shown in the 'availability' and 'outage' state mappings compiled by the road controlling authorities.

4.3 **Transport access information**

In parallel to the WeLG 'restoration times' project a WeLG/WREMO project was run to understand how freight would be moved into and around the Wellington metropolitan area following an earthquake. Preliminary findings from that project were inserted into the 'restoration times' project. Understanding freight movement following an earthquake was made possible through a mapping process carried out by the six road controlling authorities (the New Zealand Transport Agency

[NZTA] for the State Highways, and the roading departments of five local councils) and seismic response plans for the State Highways compiled by NZTA. Furthermore, a series of workshops with the key transport access asset owners were undertaken: NZTA, local council road departments, the owner/operator of the port, the Harbourmaster, the military (tasked with post-event logistical operations) and the owner/operator of Wellington International Airport were all involved. The resulting information allowed for not only the transport asset owners to understand their network vulnerabilities on a strategic level, but also allowed the other lifeline asset owners in the other sectors (energy, water, telecommunications) the opportunity to assess how they would be able to access around the region in recovering their assets. Additionally, the road seismic vulnerability mapping acted as a 'surrogate' broad-brush vulnerability mapping for other sectors, for example the gas sector, who were able to understand the likely road-slip or liquefaction hazards that would also affect buried gas assets.

4.4 **Compiling the information together**

WeLG provided the structure of the overall report, into which the various lifeline utilities provided both text and diagrams explaining the restoration methods and timescales. WeLG then formed the information together and provided an introduction and conclusion. By this method, drafts of the overall document were created, edited, and gaps in information identified, which were subsequently filled by an additional round of information gathering and editing. Broadly, around three such loops were necessary to finalise the document. Additionally, the Greater Wellington Regional Council provided formal editing of the document, to ensure that it was a polished final product.

5 **RELEASING THE INFORMATION**

At the outset, it was recognised that the summarised report would be of interest not just to WeLG member organisations, but to the Wellington community. Knowledge of the likely restoration times of utilities following an earthquake after a 'worst case' scenario event would give the affected communities opportunities to understand and prepare for such an event, and releasing the report was considered to be in the public interest. It was recognised however that for public release, the document should provide a balance not just of the hazard, but information on 'what is being done' to reduce earthquake risk in Wellington.

Due to the long restoration periods for some of the utilities identified in the report, and the mix of utility ownership from government (State Highways), local council (roads, water, wastewater, stormwater) through to private (telecommunications and energy), it was considered that the information in the report would generate political interest. Careful communication was therefore undertaken between the Chair of WeLG (also the Chair of the Regional Council) and the Chief Executives of key utilities, and with the Mayors and Chief Executives of the affected local councils. This created political buy-in and additional support to the process of releasing the report.

WeLG is a facilitating organisation, without public messaging capability, although its member organisations do hold such capability. It was decided to 'soft release' the report by presenting it to the high level Civil Defence and Emergency Management (CDEM) Joint Committee, which comprises the Mayors and Chief Executives of the local Councils in the Wellington Region and is a forum open to the public and media. This provided an opportunity not only to highlight infrastructure resilience issues at the highest levels within the councils, but also allowed for collaboration on public messaging with the councils.

Public messaging regarding the report was a function coordinated by the GWRC. This is because the Regional Council provides some administrative support to WeLG, and was best placed, and best resourced, to carry out this coordination. Alongside agreeing a common media release message from WeLG's members, each member organisation provided a short paragraph outlining perspectives of each utility on the restoration times. In addition to this, each WeLG member was invited to provide parallel media releases, in case they wished to highlight particular areas of work or resilience issues regarding their organisation and infrastructure. One organisation provided such a parallel release, while many of the others had responses or 'frequently asked questions' on standby in case of media

approaches.

Whilst the public messaging approach outlined above required considerable coordination and input, it was recognised that it was in the interest of the various utilities to provide a 'common standpoint' with each other, demonstrating that Wellington's utility providers were both aware of the region's seismic vulnerabilities, and were working together to improve resilience. Such a combined approach allowed WeLG and the utility providers confidence that the release of the report had buy-in and common acceptance across the utility sectors.

6 REPORT RESULTS

Restoration times in Wellington, following a rupture of the Wellington fault were represented in a variety of ways in the WeLG report to the CDEM Joint Committee titled "Lifeline Utilities Restoration Times for Metropolitan Wellington Following a Wellington Fault Earthquake" (WeLG, 2012). After providing the common assumptions for the production of the restoration times and outlining the levels of service (emergency, survival, operational, full), the restoration times were presented. As an example, the *operational* restoration times are presented in Table 1.

Table 1 - Operational restoration times of gas, power and water utilities

	Gas restoration time (days)	**Power restoration time (days)**	**Water restoration time (days)**
Upper Hutt and Stokes Valley	80	50	30
Hutt Western Hills	80	60	40
Hutt Central	80	60	25
Wainuiomata	80	50	35
Hutt City Harbourside	80	70	40
Mana, Plimmerton and Pukerua Bay	60	40	75
Porirua Central	60	40	75
Pauatahanui – Haywards	60	40	35
Northern Wellington suburbs	60	60	45
Western Wellington suburbs	60	60	55
Wellington CBD	80	95	55
Central Wellington suburbs	80	60	55
Roseneath, airport and Southern Bays	80	60	70
Eastern Wellington suburbs	80	60	70

Additionally, the water restoration times were represented by times to restore bulk water to reservoirs and to restore reticulation on 'recovery contour maps'. An example, showing the Wellington City area is presented in Figure 1. A similar mapping was provided in the report for expected road 'outages'.

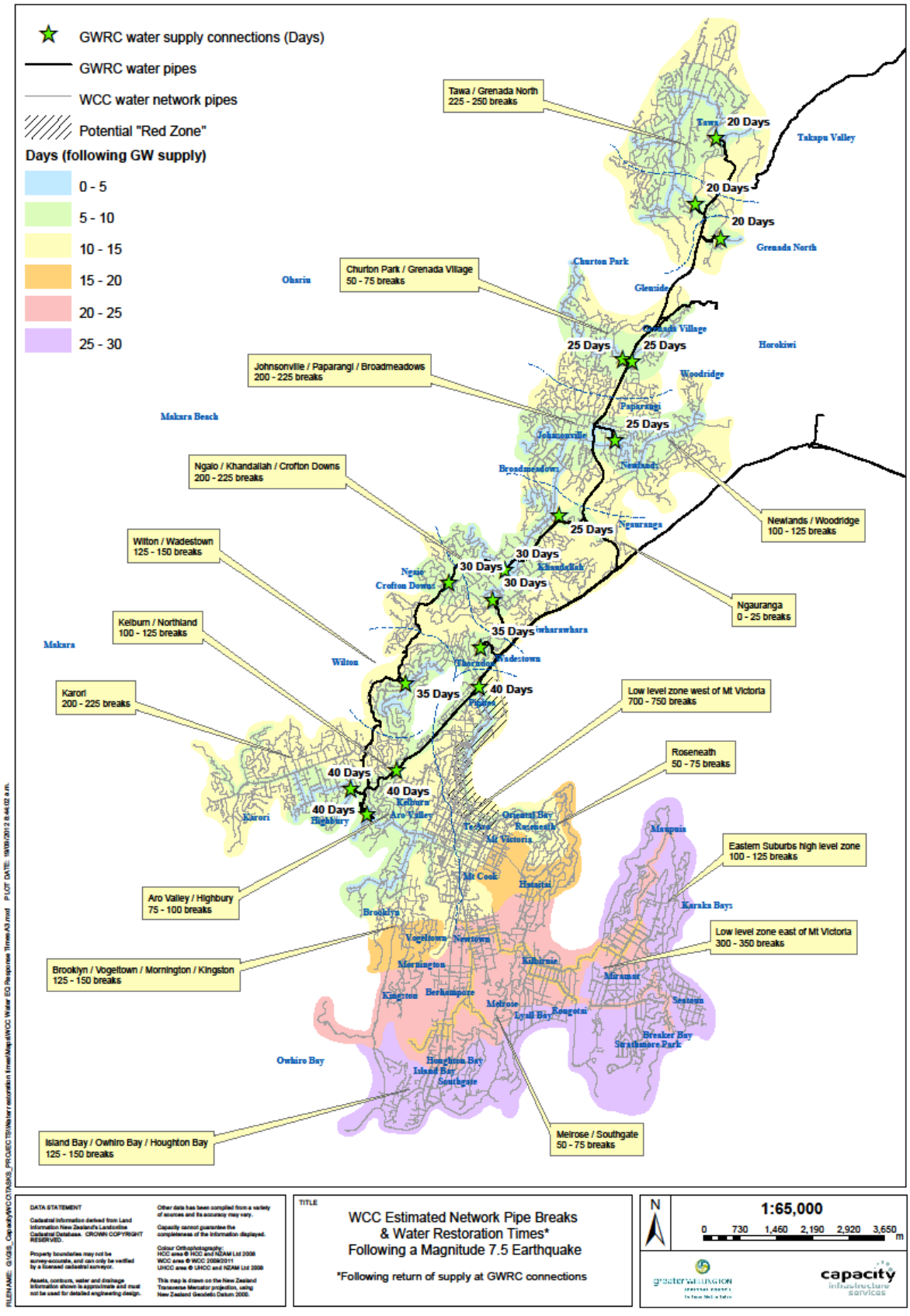

Figure 1 - water restoration times for the Wellington City area

7 HOW THE REPORT WAS RECEIVED

The report was released to the CDEM Joint Committee, and due to the mechanisms of that committee, therefore also made publically available, on 12 November 2012. The media viewed the report that day, and presented the report widely on 13 November 2012. The document was reported in most major New Zealand newspapers, on National Radio and in television reports. A report on the day is typified by the article in The Press titled "Quake would cut Wellington off for months" (The Press, 2012) in which the key elements of the restoration times were reported. It is noted however that the mitigation actions, or 'what is being done' part of the report received considerably less coverage.

In addition to the reporting on the day following the release of the report, the Dominion Post's editorial of 15 November 2012 focussed on the WeLG report. It included the following comment: *"... There is nothing that can be done to prevent earthquakes, and science has yet to find a way to predict them – if that is possible at all. The best that can be done in a nation like New Zealand, which is criss-crossed with faults and prone to sudden, violent events like that which left Christchurch in ruins, is to be prepared."* This editorial comment broadly typified the way in which the report was received – accepting that vulnerabilities exist, that the report outlined a worst-case scenario, and that the various utility providers were working to provide greater resilience.

8 CONCLUSIONS

Through the production of the WeLG 'restoration times' report, Wellington will be better able to mitigate against the effects of an earthquake and to plan for a major event. Understanding seismic risk is just part of the process towards being able to mitigate against it. Conducting this study has allowed for an understanding, both by the utility providers themselves, and by the Wellington community, of the seismic risk facing the region.

It should be noted that a number of benefits were identified through the process of production of this report. These can be summarised broadly as follows:

- Production of an overview of seismic implications to Wellington's utilities, and therefore its community, in a major earthquake
- Identification of a variety of small- and large-scale follow-on projects, both for WeLG itself and for the various utility operators
- An opportunity for WeLG to work to its purpose, including valuable cross-understanding of across-sector response and recovery activities.
- Release, in a controlled manner, of major earthquake restoration times information to the public

Thus, whilst the main goal was of summarising and telling the Wellington community of its earthquake risk, it can be seen that a number of 'spin-off' benefits of the project were realised.

It is anticipated that the above process may be repeated periodically, to provide updates on Wellington's earthquake vulnerabilities, and in many aspects, of its increasing resilience.

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