New Zealand Lifelines Council

New Zealand Critical Lifelines Infrastructure
National Vulnerability Assessment
Summary Report

2020 Edition

PREPARED BY:

The New Zealand Lifelines Council (NZLC):

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This document is an easy to read summary of the considerable effort and findings contained in the more detailed "New Zealand Critical Lifelines Infrastructure National Vulnerability Assessment, 2020 Edition" available online on several websites.

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New Zealand Lifelines Council

Overview

This report provides a summary of information on the vulnerability of New Zealand's critical lifelines infrastructure to hazards, including those resulting from events such as volcanic activity, earthquake and flooding through to hazards resulting from the increasing interdependence of all infrastructure services.

Lifelines infrastructure refers to the transport, energy, telecommunications and water services that are fundamental to New Zealand's communities and economy. The importance of these assets and the services they provide cannot be overstated, and the impacts of their failure has been evidenced in many recent national and international events.

Through the New Zealand Lifelines Council (NZLC) and 15 Regional Lifelines Groups, New Zealand's lifeline utility organisations work together on projects to understand and identify ways to mitigate impacts of hazards on lifelines infrastructure. This report collates and summarises key findings from regional lifelines studies, national hazard studies, international experience and expert solicitation. It aims to provide insights on New Zealand's critical lifelines infrastructure and its resilience (and conversely its vulnerability) to major hazards. It further identifies knowledge gaps in our understanding and mitigation of New Zealand's critical infrastructure vulnerabilities.

The overall purpose of this assessment is to provide government, industry and communities with a better understanding of:

1. What is nationally significant infrastructure; and
2. Infrastructure vulnerability and resilience to hazards.

This assessment is being progressively updated as knowledge improves, and new information becomes available. First produced in 2017, this 2020 edition strengthens previous reports with:

- New information on nationally significant critical infrastructure gathered through national lifeline utilities.
- New information from a number of major studies relating to significant New Zealand hazards.
- A new section on climate change risk and additional material on fire and pandemic hazards.
- An overview of major resilience investment programmes for each sector.
- A stronger community and critical customer perspective to recommend national investment in regional resilience business cases that recognise infrastructure interdependencies and prioritise across all infrastructure.

Significant research programmes are improving our national understanding of hazard risks and provide new information for this 2020 update.

The Alpine Fault, Wellington Fault, Hikurangi Subduction Zone, Climate Change, Auckland and Taupo Volcanic areas and Mount Taranaki, are all the subject of ongoing major studies.

The Wellington Lifelines Resilience Programme Business Case provides an exemplar of good international practice to prioritise across infrastructure, whether investment in new assets or renewal/repair of existing, to better meet the needs of communities including critical customers.

SH 6 Kawarau Gorge, through Nevis Bluff, a nationally significant lifeline asset in the South Island.

Nationally Significant (Critical) Infrastructure

This report identifies *Nationally Significant* Infrastructure within each lifeline utility sector, broadly based on the criticality rating shown in Figure 1.

Nationally Significant

- Failure of a single asset would cause loss of service to > 100,000 customers or cause loss of utility supply to most of an urban area or loss of supply to another nationally significant customer/site that depends on its service.

Regionally Significant (major)

- Failure of a single asset would cause loss of service to 20,000-100,000 customers or reduced level of service across the region or loss of supply to a regionally significant customer/site.

Regionally Significant (moderate)

- Failure of a single asset would cause loss of service to 5,000-20,000 customers or reduced level of service across part of the region or loss of supply to a locally significant customer/site.

Locally Significant

- Failure of a single asset would cause loss of service to more than 500-5,000 customers or reduced level of service across part of the region or loss of supply to a locally significant customer/site.

Figure 1: Critical Infrastructure Rating

Nationally Significant infrastructure assets are often where there are *single-site* 'pinchpoints' in the supply chain which, if they failed catastrophically, would cause a significant loss of national service. Examples include:

- Marsden Refinery (refines around 70% of New Zealand's fuel) and jetty, the Wiri oil depot (supplying Auckland and surrounds and jet fuel for Auckland Airport) and pipeline between Marsden and Wiri
- The main telecommunications exchanges in Auckland, Wellington, Christchurch, Hamilton and Porirua.
- Ports of Tauranga and Auckland (largest by throughput volume), Wellington and Picton roll-on/roll-off ports (inter-island connection and fuel terminals) and Lyttelton Port (major fuel supplier to the South Island).
- The Taranaki gas fields – source of NZ's natural gas and supplying some major industrial facilities, electricity generators and other critical customers.
- Auckland Airport – the gateway to 75% of international visitors - as well as Wellington, Christchurch and Queenstown airports, the next largest by visitor volume.

Some sectors have nationally significant assets which are *lineal* pinchpoints. For roads, examples include high volume roads such as SH 1 in Auckland and Wellington and other highways (such as the coastal Kaikōura highway and other parts of SH 1 in the South Island) which have economic significance and/or long detour times.

> *New Zealand's geographical nature and low population density makes the development of fully redundant (duplicated) networks challenging. This results in single points of failure in some networks, such as the Marsden-Wiri fuel pipeline and Maui gas line, which need to be carefully managed.*

In the national electricity grid, the transmission lines from Bunnythorpe to Whakamaru (and the substations at each end) transmit a large proportion of electricity to the central/upper North Island. The highest capacity line is the HVDC line transmitting electricity between the North and South Island (its criticality depends on generation demand and supply balance between islands at the time). Key substations for major cities such as Islington (Christchurch), Central Park (Wellington), Otahuhu (Auckland) and Penrose (Auckland) are also critical pinchpoints. Lake Pukaki in the South Island is critical in terms of hydro storage.

While water supply does not have a national supply network, there are nationally significant assets in many cities. For example, the Hunua Dam and Ardmore Treatment Plant in Auckland, Hutt River water supplies in Wellington and the main water treatment plant treating Waikato River water for Hamilton (currently a single source supply for the city). Water supply networks such as Christchurch, that have many smaller sources across the city, are less at risk of water shortages if one or two sources fail.

Interdependencies and Hotspots

Along with key sector pinchpoints such as those described above, there are also high risks associated with infrastructure 'hotspots'. These are where critical assets from a few sectors converge in a common location with a much higher consequence of failure from multiple services. Examples include Auckland's Harbour Bridge, which carries a number of critical utility pipes/cables, and Kawarau Gorge – a key transport and electricity transmission route for Queenstown.

The 'interdependency' aspects of lifelines networks are a major driver for collective projects by lifelines sectors. Electricity is required for the day-to-day operations of most other lifelines; but if the electricity fails then fuel for generators and roads for transporting generators and fuel become more essential. Roads and telecommunications are vital to the everyday functioning of our communities, as well as facilitating access to sites for restoration and communications during readiness, response and recovery. The interdependencies in lifeline networks are numerous and complex.

The interdependent nature of infrastructure networks is a key focus of 'lifelines' projects. For example, widespread electricity and telecommunications failures will have knock-on impacts on all other networks, along with major business and social disruption. Business continuity arrangements to mitigate those dependencies are vital.

Critical Customers

Lifeline utility services are important for the whole community and for functioning of critical community services including emergency services, health services, some government functions, Fast Moving Consumer Goods (FMCG, including food and pharmaceuticals), banking, Corrections facilities, solid waste and some major industry. These service providers maintain business continuity arrangements for backup services based on their own risk assessments and commercial imperatives.

There is currently no national view on the extent to which these critical community sectors have alternative arrangements (such as water storage, access to fuel, backup electricity generation, radio/satellite communication and ability to charge cell phones) for provision of all infrastructure services, the confidence in contractual arrangements and the extent to which supply chains may overlap (for example accessing helicopters and mobile electricity generators).

National Infrastructure Vulnerabilities to Major Hazards

The resilience of New Zealand's infrastructure has been the focus of regional lifelines projects since the first work undertaken in Wellington in the 1980s and the Christchurch lifelines project - '*Risks and Realities*' completed in 1997 which proved remarkably prescient of events in 2010/11 .

Since then many other regional lifelines projects have been undertaken and continue to inform lifeline utility vulnerability assessments and risk mitigation programmes, typically following an approach shown in Figure 2.

Christchurch's 'Risks and Realities Lifelines Project was credited with driving a number of seismic mitigation programmes, the benefits of which were realised many times over in the Canterbury earthquakes in 2010/11.

(Ref: The Value of Lifeline Seismic Risk Mitigation, June 2012).

Together with these lifeline programmes, there are other major hazard studies building our understanding of NZ hazards and impacts, many of these being undertaken under the umbrella of the 'Resilience National Science Challenge' (https://resiliencechallenge.nz), as well as other Science Challenges including Deep South (Climate) and Building Better Homes, Towns and Cities.

Of course, we have also had many real events that serve as reminders of the exposure and vulnerability of our infrastructure assets to hazards.

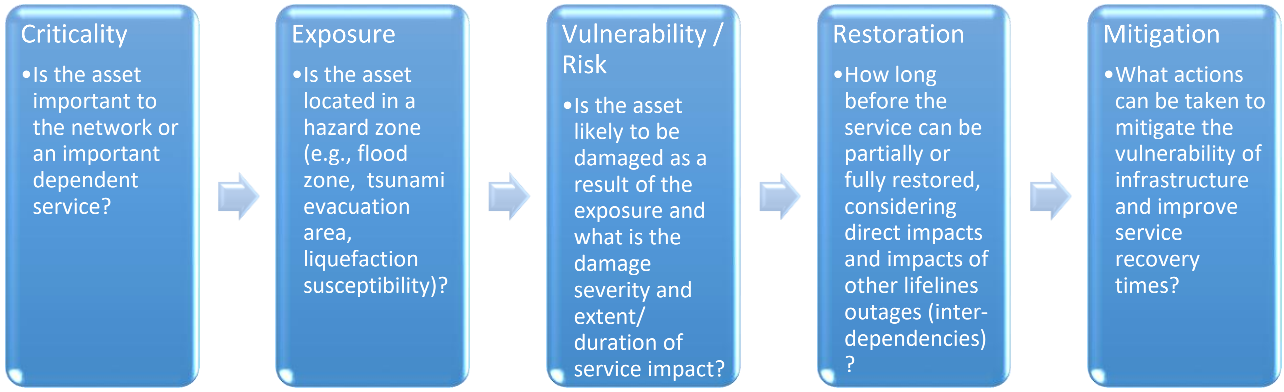

Figure 2: Overview of the Vulnerability Assessment Process

A brief overview of some of the main natural hazards and impacts on lifelines follows.

Alpine Fault

The Alpine Fault runs 400km up the South Island and a major rupture would have devastating consequences. In the scenario modelled for the Alpine Fault Study "*AF8*", with an expected return period of 300 years, tens of thousands of landslides are expected isolating many areas by road (the West Coast and Queenstown are particularly vulnerable) and likely damaging electricity, telecommunications, water/wastewater networks and other lifelines. A response coordination framework (SAFER) has been developed across all six South Island Civil Defence Emergency Management (CDEM) Groups and their partner organisations (including Lifelines) in the first seven days of response.

Rail Lines following Kaikōura Earthquake, 2016

Wellington Fault:

A major earthquake affecting Wellington justifiably continues to receive a lot of attention as it has the potential to isolate the Wellington region by road, rail and sea and cut off water supply, electricity, gas and telecommunications for several weeks to months. Major electricity disruptions would in turn impact telecommunications capability and fuel terminals at the Port are likely to be inoperable immediately following a major quake. Damage to national control centres in wellington may have wider impacts including, for example loss of the rail control centre would cause outages on the Auckland metro network. The precedent setting 2019 Wellington Lifelines Programme Business Case assessed the potential economic consequences of a major quake and developed a coordinated infrastructure mitigation programme. For the first time all infrastructure services in a region were considered at the same time, essentially presenting a users' and community perspective on priorities for resilience improvement.

Hikurangi Subduction Zone

The Hikurangi subduction zone (parallel and offshore the east of the North Island) is potentially the largest source of earthquake and tsunami hazard in New Zealand. A large team of scientists are studying the Hikurangi plate boundary to better understand the potential risks (project 2016-2021). Scenarios developed as part of this project indicate a major earthquake and tsunami could affect the east coast of the lower half of the North Island and top of the South Island.

The Hikurangi Subduction Zone is now recognized as having potentially larger impacts than a Wellington Fault or Alpine Fault rupture. Earthquake shaking could be as severe or worse than the Wellington Fault scenario but extending to a much wider area across the North Island and upper South Island. Tsunami of up to 10m in some areas could cause devastating impacts on the east coast.

Taupo Volcanic Zone

Volcanic hazards are prevalent in the North Island and the Taupo zone poses a hazard to many major electricity generation sites. Impacts of volcanos are not geographically isolated as ash has the potential to ground air traffic and disrupt almost all types of infrastructure services over a large geographical area.

Mount Taranaki

A major eruption of Mount Taranaki could be devastating for the immediate area, which includes all New Zealand's fuel and gas production sites, and have wider reaching impacts across the North Island. A team of researchers, funded by the Government's Endeavour Research Programme, is working on a 5-year programme entitled"*Transitioning Taranaki to a Volcanic Future"*. The focus is looking at how the region might adapt and transform in a period of disruption from a long-term eruption of Mount Taranaki.

Mount Taranaki has a relatively recent active eruption history. Of national interest is the potential consequences of long-term disruptions to the national production of gas and oil. Major industries, including for food supply, are also in the vicinity.

Auckland Volcanic Field

There is no 'good' location for an Auckland volcanic eruption from an infrastructure perspective. The two most catastrophic scenarios for Auckland are somewhere near the narrow part of the isthmus through Otahuhu/Sylvia Park, a major transmission path for most lifeline utilities, or the CBD with the Harbour Bridge, major telecommunication exchanges, Ports of Auckland, Britomart and critical water reservoirs. A major research programme, *DEVORA,* has developed models for eight volcanic eruption scenarios which are being used to facilitate response planning such as evacuations.

Tsunami

A national tsunami exercise in 2016 'Exercise Tangaroa' brought attention to the fact that New Zealand's main fuel refinery and most major fuel terminals are on the east coast. To date, there have been limited solutions found for offloading and transporting fuel if ports suffer significant damage. The *National Fuel Plan 2020* identifies a number of potential areas such as these requiring further planning work. A particular national vulnerability is that most ports could be subject to impacts from a South American sourced tsunami for example.

Severe Weather

Severe weather events are a frequent part of New Zealand life. Northern areas are particularly vulnerable to ex-tropical cyclones bearing heavy rain and high winds. Large catchments and rivers in the South Island create major flooding hazards.

In 2019, flooding in the Rangitata River brought down one major transmission line and threatened others. While transmission towers within riverbeds are designed to withstand flood flows, the river breached its normal path and washed away a tower, the lines collapsed bringing down other towers.

Rangitata River

Climate Change

A large body of work has been focussing on the potential impacts of climate change in terms of rising sea levels, more ex-tropical cyclones, more intense rain and windstorms, as well as areas generally becoming drier, wetter and/or windier. There are significant potential infrastructure impacts. For example, the *Deep South Science Challenge* programme has found that 1,400km of road is currently exposed to sea level inundation in a 1:100 year coastal storm, and that this will increase to 2,300km with 0.6m of sea level rise (expected between 2070 and 2130 *(Ref: MfE Climate Change for Local Government, 2017).*

There has been significant investment in the last decade to understand potential climate change risks for infrastructure networks. Sea level rise implications for coastal infrastructure have been quantified in recent studies.

The implications of more frequent heavy rain and high-wind storms are still being worked through, along with appropriate responses. A National Climate Change Risk Assessment is due in 2020.

Human Pandemic

A human pandemic does not have the same physically damaging impacts as the hazards covered so far, but it does have the potential to impact lifeline services due to disruption to staff operational activities and supply chains. The COVID-19 pandemic response has seen lifeline utilities' business continuity arrangements holding up well to maintain service continuity.

Fire

One of the consequential risks associated with a major earthquake is the outbreak and spread of fire in urban areas exacerbated by disruptions to water supplies impeding firefighting efforts. Wildfires are also starting to gain global attention, and, from a lifeline utility perspective, can disrupt, damage or destroy any physical infrastructure in its path. Climate change with more extreme temperatures is also exacerbating this hazard. Research into this hazard is part of Wellington's 'It's Our Fault' programme.

And many more

Aside from these specific hazard scenarios there are many other natural and technological hazards such as coastal erosion, space weather events, cyber-attack and asset failures due to causes such as ageing assets, third party damage and operator error.

For those involved in hazards planning and mitigation, the compounding and cascading nature of hazards needs to be carefully considered.

Key Resilience Issues by Sector

Electricity

- **Changing generation sources:** Although the physical resilience of the national generation transmission and distribution system is largely unchanged since 2017, the electrical performance from new intermittent energy sources such as solar and wind creates new electrically complex electricity flow issues. While the new energy resources provide more geographical and fuel source diversity and resilience, they are also more reliant on intermittent weather patterns and require additional systems and hardware to enable them to provide as resilient and stable a generation source as traditional synchronous generators such as hydro or geothermal.

Source: windenergy.org.nz

- **Small distribution networks:** Common to many sectors, the larger capacity 'upstream' assets (for electricity, the generation stations and higher voltage transmission/distribution assets) are generally designed to higher standards due to the greater impact a failure would have. Smaller distribution companies may have less resources to manage and renew their networks with the state of some local networks of potential concern for local communities, including critical customers.

- **Climate Change:** There is evidence that more frequent high-wind storm events are impacting distribution system reliability, but to date there has been limited analysis at a national level of the longer-term impacts and necessary responses. Managing 'dry-year' risks are going to be an increasing focus for the electricity sector.

Gas

- **Criticality of key transmission lines**: Gas transmission lines are designed to withstand seismic movement; their main vulnerabilities are coastal erosion, land slips, and third-party damage (e.g. accidental damage by diggers). The 2019 *Government Fuel Inquiry* made several recommendations relating to establishing higher levels of control and enforcement when working near fuel and gas lines, and it is important that these be implemented.
- **Reducing national production:** The government decision in 2018 to stop issuing new permits for offshore gas exploration will likely result in a reduction in national gas production over time, potentially leaving the country more reliant on imported and alternate fuels, and reducing gas availability for heat and electricity production.

Fuel

- **Tight supply chain and dependence on road network:** Fuel distribution within NZ is heavily dependent on the road network. With limited storage around the regions (storage tanks may run to quite low levels immediately before refuelling) a key risk is isolation of a region by road and sea. The capacity to fly in fuel to an isolated area is very small.
- **Jet fuel storage at Auckland Airport:** This was raised as a key issue in the *2019 Government Fuel Inquiry*, because there are no logistical options if supply through the Marsden-Wiri pipeline fails (though the COVID-19 pandemic has delayed the urgency of this issue).
- **Most regional fuel storage tanks are on the east coast** and are potentially exposed and vulnerable to tsunami. Damage to multiple ports would have devastating impacts on the fuel sector.

Roads are another example of the inter-connectedness of the infrastructure networks and the compounding impacts of a road failure. For example, roads carry fuel distribution trucks, connect ports and airports and, in a disaster, carry response crews and equipment.

Land Transport

- **Weather and climate change impacts** are front-of-mind in the land transport sector – there is evidence of increasing emergency response costs over the last decade from higher frequency high impact storms, and national studies into sea level rise impacts for coastal roads and rail. These studies are indicating significant mitigations are likely to be needed in the medium-long term and adaptation strategies need to be developed soon to avoid locking in inflexible or short-term response options.
- **Slope instability and landslides** are an ongoing issue, with many examples in recent years of major slips causing closures of state highways and rail, and adding significant travel times for weeks to months. The resilience of local road alternate routes (used when state highways are closed) is often inadequate, and upgrades are needed to make them viable alternate routes.
- **Developing evidence-based mitigation programmes**: Many road resilience improvement projects occur reactively when major damage occurs, such as in storms. The Wellington Resilience Programme is a good example of how the lifeline utility sector collectively agreed mitigation investment priorities and many in the sector are keen to expand these programmes across the country.

Air and Sea Transport

- **Volcanic ashfall can cause prolonged air traffic disruptions** and there is ongoing work to improve ashfall modelling following an eruption to try and minimise airspace closures (while remaining safe).
- **Vulnerability to earthquakes:** Most NZ ports are located to some extent on reclaimed land that varies both in age and construction quality.

- **Ports** are vulnerable to tsunami, particularly on the east coast, and sea level rise is a key issue for this sector.
- **Climate change** is an emerging vulnerability for airports; the Deep South Science Challenge found 13 of the 28 international or domestic airports are potentially exposed to extreme coastal flooding, groundwater rise and sea-level rise up to 1 m.

Three-Waters

- **Highly variable levels of resilience and preparedness between water authorities:** Many authorities struggle with funding and resource to maintain current levels of service, let alone investing in major resilience improvements. Major industry changes are underway to address and balance sector capacity and capability issues.
- **Climate change and increasing drought conditions:** A number of urban water supplies ran out of water in the summer of 2019/2020, with the cost of providing higher levels of drought protection being considered unaffordable for many local authorities.
- **Climate change and increasing high intensity rainfall:** Stormwater networks designed to historic rainfall standards (typically to carry 1:10 to 1:20 year runoff in primary networks) are expected to flood more frequently and intensively over time.
- **Dependence on electricity with limited backup capacity**: For example, only around 10% of NZ's wastewater sites (pump stations, treatment plants) have on-site standby generation.
- **Pipe networks vulnerable to land movement**: Modern pipe materials and installation methods are designed to be seismically resilient, however older, less resilient pipe materials still form a significant part of New Zealand's pipe networks.

Telecommunications

- **Dependence on electricity with limited backup capacity**: Critical sites have on-site generators and fuel storage but most others rely on battery backups that last only a few hours or days unless generators can be sourced.
- **Commercial drivers do not incentivise capital investment in resilience**: The 2019 government review of telecommunication network resilience found the sector focussed on preparedness and response arrangements with little investment in risk mitigation.
- **Increased isolation risk for some communities:** Traditional local switching exchanges are progressively being shut down and services are digitally distributed to larger, centralised nodes. Small communities or rural areas that could previously have made local calls (even if the fibre link connecting it to the national network failed) now have a higher risk of telecommunications isolation following a failure.

Regulation and Funding for Resilience

Lifeline utilities operate under a variety of business and regulatory models. The CDEM Act 2002 is the only over-arching legislation for all lifeline utility sectors; this has a requirement for lifeline utilities to *"function to the fullest possible extent"* following an emergency. However, there are no nationally consistent standards for resilience (e.g., to better define 'fullest possible extent') - these are defined by each lifeline utility, and in some cases the sector regulator.

There are different funding constraints and regulatory regimes both between and within the public and private sectors and many organisations require a commercial return on resilience investment projects. These factors influence the level of investment in resilience improvements.

Private sector lifelines (e.g., telecommunications, fuel, ports, airports and electricity) are regulated by authorities such as the Commerce Commission, Civil Aviation Authority and the Electricity Authority. The Ministry of Business, Innovation and Employment provides policy direction and maintains an overview of resilience in the energy and communication sectors – most recently completing a study in the resilience of the telecommunications network. The Ministry of Transport has a similar role for transport and a soon-to-be-established Water Services Regulator will take on that role for the three waters.

Building Resilience into Infrastructure Networks

New Zealand's infrastructure networks are designed for (varying levels of) resilience. Technical resilience is inherent in many networks through redundancy (multiple paths of supply) and robustness (design codes for strength). However, there are geographical and other constraints in providing alternative supply routes and100% security of supply is neither feasible nor affordable.

Billions of dollars are continuing to be invested in projects that will increase the resilience of nationally significant infrastructure. These include major projects such as Wellington's Transmission Gully and a second major water supply pipeline from Auckland's Ardmore Treatment Plant to the City. The Christchurch and other recovery programmes have a vital role in 'building back better' with more resilient networks, such as creating 'loop' redundancy in the Christchurch electricity supply. Incremental improvements in all sectors occur as renewal programmes replace older assets with newer modern materials and design.


Wellington's Transmission Gully

For growing urban areas, growth can enable resilient infrastructure investment– many major national projects provide for growth but also provide additional redundancy in the networks. Conversely if infrastructure upgrades do not keep pace with growth it contributes to a reduction in infrastructure redundant capacity and resilience.

There is currently no national picture or monitoring of planned investment in infrastructure resilience or understanding of societal risk tolerance. There was an intention to collate a high-level programme of planned national infrastructure resilience investment for this report. However, with some exceptions, most national lifeline utility organisation either did not have specific resilience categories in their investment programmes or noted that major resilience projects (without other drivers such as growth) fail to pass benefit-cost thresholds under current funding models. Research around emerging hazards such as climate change is a key focus, but it is expected to be some years before this translates into physical asset programmes.

The Wellington Lifelines Programme Business Case is the first regional lifelines project to quantify the economic impacts of infrastructure failure in a disaster (major Wellington Fault) and develop a costed, coordinated risk mitigation programme. The Business Case puts forward a $3.9B programme of work with an estimated $6B of benefits.

Conclusion and Recommendations

This report provides a summary of information on the vulnerability of New Zealand's critical lifelines infrastructure to hazards, gathered from expert and researched sources. There are identified knowledge gaps and the intention is to progressively update this report as further information becomes available.

It is recommended that:

1. The New Zealand Lifelines Council (NZLC) continues it efforts with others to act as a conduit for improved community outcomes from infrastructure services.
2. Lifeline Utilities use the information in this report to review and update their own risk mitigation and preparedness programmes.
3. The NZLC specifically engage with new stakeholders such as the Infrastructure Commission, the Climate Commission and the Water Services Regulator.
4. The NZLC work with the research sector to identify which knowledge gaps are being addressed in current research programmes and where there are opportunities to progress remaining gaps.
5. Regions in New Zealand undertake programmes similar to the Wellington Lifelines Resilience Programme Business Case.