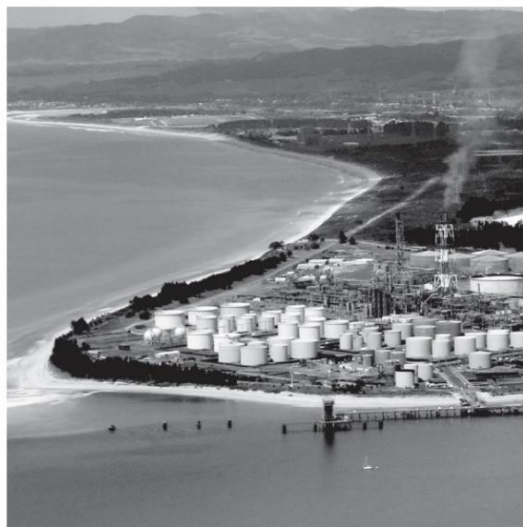
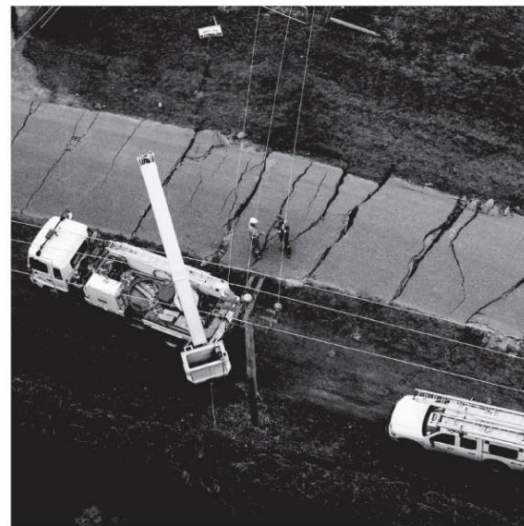
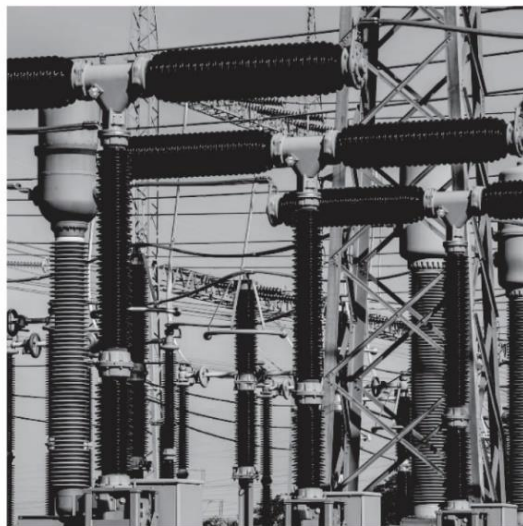




Aotearoa New Zealand's Critical Infrastructure A National Vulnerability Assessment

PART A: SUMMARY

2023 Edition



Prepared By:

This document was funded by the New Zealand Lifelines Council (NZLC) and prepared by the NZLC Delivery Team, with input from a wide range of organisations.

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New Zealand Lifelines Council Members



The NZLC also thanks the many government, local authority, peak bodies, utility service providers, researchers, professionals and experts who have contributed content as well as provided valuable review comments.

This document is an easy-to-read summary of the considerable effort and findings contained in the more detailed “Aotearoa-New Zealand Critical Lifelines Infrastructure National Vulnerability Assessment, 2023 Edition” available online on several websites.

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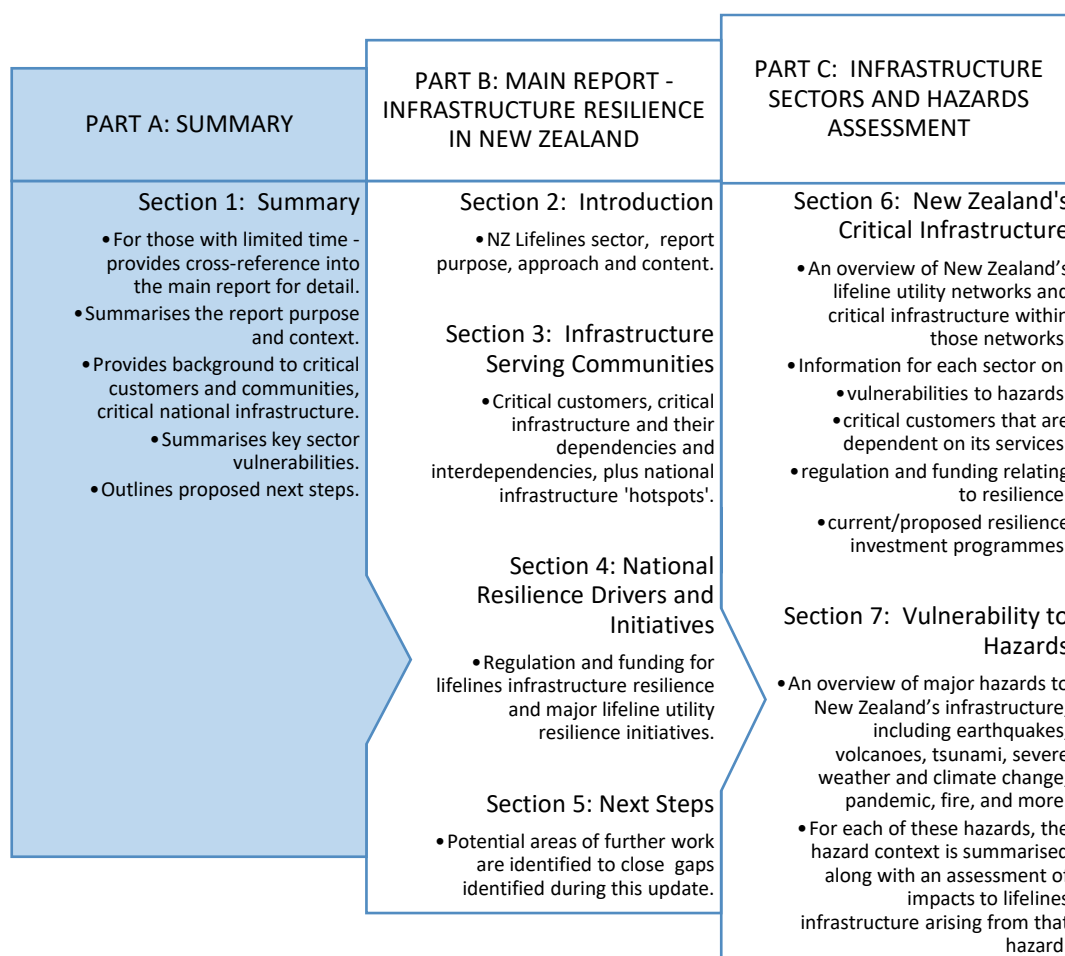
This report is general in its application and subjective in its recommendations. While every effort has been made to ensure the accuracy of the report, no liability whatsoever can be accepted for any error. The findings in this report do not necessarily reflect official policy or position of any agency. Examples presented within this report are for the purpose of demonstration.

It is recommended that users carefully evaluate the accuracy, currency, completeness and relevance of the material for their purposes. This information is not a substitute for independent professional advice and users should obtain any appropriate professional advice relevant to their circumstances.

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Figure 1 provides an overview of the structure of this report.



1. Summary

1.1 About this Report

This report aims to provide government, industry, researchers, and communities with a better understanding of:

1. New Zealand’s critical national infrastructure.
2. The vulnerability of New Zealand’s infrastructure systems to hazards.
3. The infrastructure system settings that hinder or enable resilient infrastructure.
4. Customers’ and communities’ needs, vulnerabilities, and abilities to contribute to overall resilience.

The report provides a unique strategic perspective of all infrastructure services as they act in combination to support the wellbeing of New Zealanders. It is intended to stimulate awareness, particularly about interdependencies, and drive a change in approach to prioritising resilience investment in infrastructure, to best meet our community needs. The New Zealand Lifelines Council (NZLC) updates this report regularly to maintain this work as a current state of play of New Zealand’s infrastructure resilience.

First produced in 2017 and updated in 2020, this 2023 edition strengthens previous reports with:

- Expanded scope of ‘critical infrastructure’ sectors to include sections on Flood Protection, Solid Waste and Financial Payments.
- Development of the definition and criteria, and identification of Critical National Infrastructure.
- Increased focus on the needs of customers and communities and their ability to contribute to overall resilience improvements.
- Expanded content on climate change implications for national infrastructure and mitigation / adaptation pathways.

The focus of this report is on the resilience and vulnerabilities of traditional ‘lifeline utilities’, broadened in scope in this edition, and now referred to as critical (*‘essential and enabling’*) infrastructure - refer Table 1-1. Enabling infrastructure provides services that other infrastructure needs to function (interdependencies). Other essential services such as hospitals and financial services, that depend on lifelines infrastructure to function, are recognised as ‘critical customers’.

Essential and Enabling (Lifelines) Infrastructure	Essential Services (Critical Customers).
<ul style="list-style-type: none"> ▪ Energy ▪ Telecommunications / Broadcasting ▪ Transport ▪ Water, Wastewater and Stormwater ▪ Flood Protection ▪ Finance (Payment Services) ▪ Solid Waste ▪ Data Storage / ICT 	<ul style="list-style-type: none"> ▪ Health and Aged Care ▪ Education ▪ Corrections ▪ Emergency Management and Emergency Services ▪ Financial Services ▪ Fast Moving Consumer Goods ▪ Community Facilities ▪ Major Industry

Table 1-1: ‘Lifelines’ Infrastructure and Critical Customers

It is important to note that this categorisation is intended to advance thinking around ‘critical infrastructure’ but is not intended to pre-determine the outcomes of NEMA’s and DPMC’s Critical Infrastructure work.

1.2 Context

In February 2023, New Zealand declared a National State of Emergency to support the response to Cyclone Gabrielle and the Auckland flood event the week prior. In the wake of the devastation wrought by widespread landslips and silt-laden flood waters, many communities largely proved resilient and tolerant of the infrastructure outages. A few days and weeks later, community tolerance started slipping and hard questions were being asked about whether the performance of the infrastructure networks was ‘acceptable’.

Of course, no-one with any knowledge of interdependent infrastructure systems was surprised at the cascading outages that resulted from electricity failures: telecommunications disruption, difficulties accessing cash to pay for essentials like food and fuel, innumerable wastewater system overflows and more. Furthermore, many of the damaged critical infrastructure assets were known to be vulnerable – critical roads through slip-prone land, water supplies that relied on single sources and water mains, old bridges not strong enough to withstand powerful debris-filled floodwaters, and electricity substations in flood-prone locations. And yet resilience projects that would have mitigated many of these failures had been identified, but not prioritised or funded.

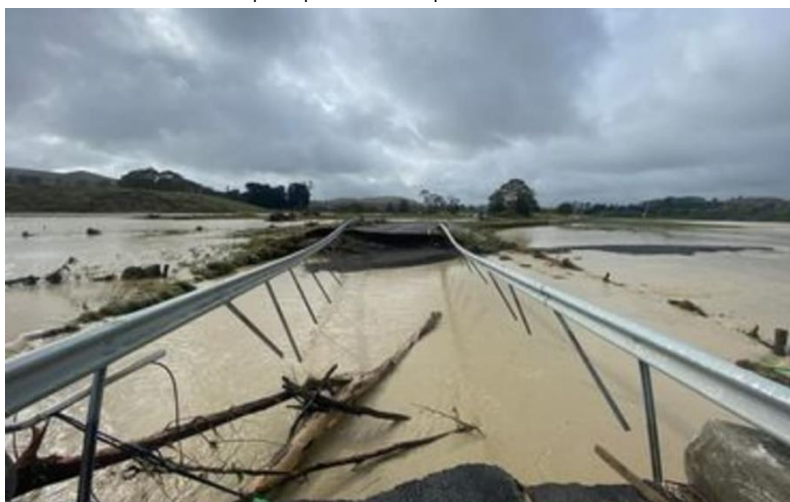
Prior to these events, the Government’s attention on the resilience of critical national infrastructure was already heightened. The Emergency Management Bill proposes to re-define and expand the scope of ‘lifeline utilities’ to ‘critical infrastructure’ and increase requirements in several areas, such as a proposal to require statements of emergency levels of service for planning purposes. Te Waihangā - Infrastructure Commission released a new 30-year Infrastructure Strategy in 2022, with many actions targeted at improving infrastructure resilience. National climate change work has included assessing climate change impacts on infrastructure sectors and supporting the development of adaptation strategies. Furthermore, the New Zealand Government is progressing regulatory reform to enhance the resilience of New Zealand’s critical infrastructure system to all hazards and threats.

These efforts are leading to a broader definition of “Critical Infrastructure” and increased recognition of the needs of communities and critical customers. Communities, including critical customers, can be better prepared to contribute to resilience. As New Zealand’s population and the effects of climate change increase, so too do the consequences of infrastructure failure.

While this groundswell of interest in infrastructure resilience is extremely welcome, not everything will be able to be addressed immediately; a robust, prioritised, structured works plan including maintenance, renewals and new investment across all infrastructure sectors is required. A coordinated approach across the infrastructure system will enable resilience improvement to be prioritised recognising extensive interdependencies. One means of doing this is to complete regional resilience programme business cases in a consistent way and to integrate these with a national perspective on priorities.

The 2018 Hawkes Bay Lifelines Vulnerability Study highlighted risks relating to flooding at Redclyffe substation and vulnerability to failures of critical bridges. A prioritised regional infrastructure resilience programme may have seen more urgency given to these, mitigating these critical asset risks that caused cascading issues for other sectors.

Photo: rnz.co.nz



1.3 Critical Customers and Communities

Infrastructure services are important for communities to function, and a key purpose of this report is to communicate to community stakeholders that (despite the best management efforts) infrastructure services can fail at any time. End-user resilience is imperative, and community members must act to ensure their homes are resilient to natural hazards and that they follow standard Civil Defence Emergency Management (CDEM) emergency kit advice such as storing water, cash, and food, to ‘get through until services can be restored or backup options provided.

Essential services that rely on infrastructure services to function are termed ‘critical customers’ and their key facilities are ‘critical customer sites’ - examples being emergency services communications hubs, hospitals and correctional facilities. The definition and identification of these sites is important for infrastructure providers, helping prioritise service restoration and assessment of the resilience of supply to these sites. Some regional lifelines groups maintain lists and maps of critical customers which have proven to be valuable in response and recovery prioritisation. However, this does not absolve critical customers of their responsibility to establish business continuity arrangements and enhance the resilience of their sites to withstand infrastructure outages.

An overview of communities, ‘critical customer’ sectors and their dependence on lifelines services is provided in Section 3 of this report.

1.4 Critical National Infrastructure

Critical national infrastructure assets are often ‘pinch points’ in the supply chain which, if they failed, would cause a significant loss of service with major consequences.

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 many networks, such as the Marsden-Wiri fuel pipeline, Maui gas line, single water supply sources to large urban populations (e.g., Hamilton, Invercargill), electricity transmission lines to areas such as Northland and Hawkes Bay and many others.



Figure 1-1: Hamilton water intake, single source for Hamilton City

Section 4 of this report identifies *Critical National Infrastructure* within each lifelines infrastructure sector (the ‘Essential and Enabling Infrastructure’ sectors shown in Table 1-1). It presents information for each sector on its vulnerabilities to hazards, critical customers that are dependent on its services, regulation and funding relating to resilience and current/proposed resilience investment programmes.

Along with key sector ‘pinch points’ such as those described above, there are also high risks associated with infrastructure ‘hotspots’. These are where critical assets from a few sectors converge with a high consequence of failure associated with cumulative loss of services at that site and beyond.

Section 3 of this report presents an overview of national infrastructure hotspots and analyses the complex interdependencies between critical infrastructure networks. Examples of national hotspots identified in regional lifelines studies is shown in Figure 1-2.

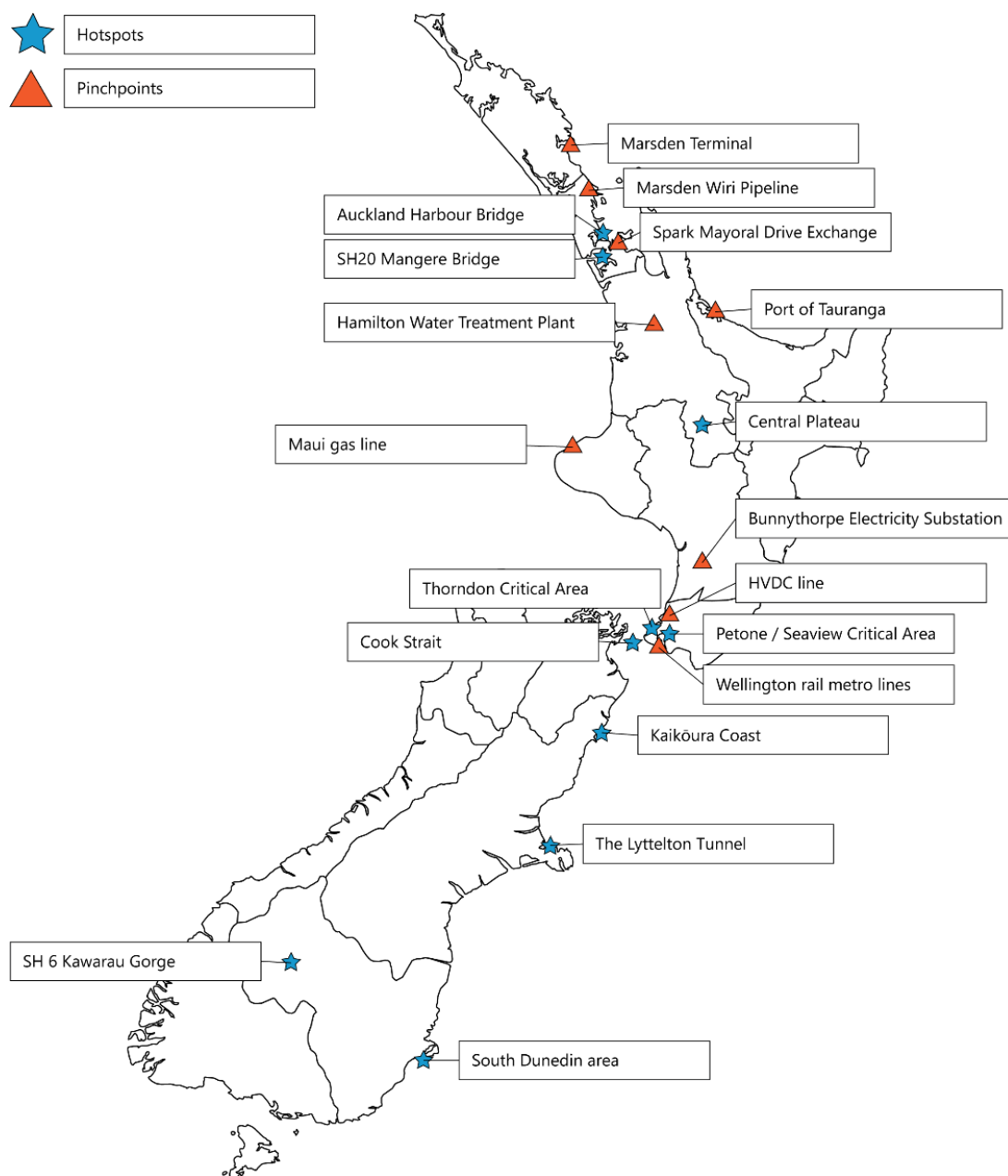


Figure 1-2: Examples of National Hotspots and Pinch Points

1.5 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 (a requirement which is also contained in the Emergency Management Bill). However, there are no nationally consistent standards for resilience that would better define ‘fullest possible extent’. The proposed Emergency Management Bill includes a requirement for critical infrastructure providers to state their *planning emergency levels of service* i.e., to state the levels of service they intend to be able to provide after the hazard impacts.

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. A summary of the key regulatory and funding agencies for lifeline utilities, that have a role in contributing to infrastructure resilience, is outlined in Section 4 of this report.

All sectors have funding constraints, rules and competing priorities that make sourcing funding for infrastructure resilience projects – especially those that address low-probability high-impact hazards - an ongoing challenge. Yet following each natural disaster, findings show that investment prior to the event could have mitigated many impacts (at much lower cost than waiting until after the damage is done).

1.6 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 100% security of supply is neither feasible nor affordable.

Billions of dollars have been, and are continuing to be, invested in projects that will increase the resilience of critical national infrastructure – including major projects such as Wellington’s Transmission Gully as well as more incremental improvements which occur as renewal programmes replace older assets with modern equivalents. However, there remains an enormous number of identified vulnerability issues and resilience improvement projects that (without other drivers such as growth) often fail to pass benefit-cost thresholds under current funding models.

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

The NZLC considers that every region should conduct a regional infrastructure vulnerability assessment and develop programme business cases for any identified significant regional or national risks.



Figure 3: The Wellington Lifelines (Utilities) Group produced the ‘first regional ‘Business Case’

Currently, there is no national assessment or monitoring of planned investment in infrastructure resilience or understanding of societal risk tolerance. The NZLC has attempted to compile this information for all editions of this report, but it is generally not available from infrastructure providers. Information sharing requirements in the Emergency Management Bill may assist in progressing this work.

1.7 New Zealand’s Infrastructure Vulnerabilities

The resilience of New Zealand’s infrastructure has been the focus of regional lifelines projects since the first work undertaken in Wellington in the late 1980s. This was followed by the Christchurch lifelines project ‘Risks and Realities’ (1993-1996) - which was credited with driving a number of seismic mitigation

programmes, the benefits of which were realised many times over with the Canterbury earthquakes in 2010/11.

Section 6 of this report provides an overview of each of the *essential and enabling* lifelines infrastructure sectors, defines critical national infrastructure and identifies sector vulnerabilities to major hazards. Key sector vulnerability issues are briefly summarised below:

Electricity: Climate change, ‘Dry Winters’ and Trees

As New Zealand transitions to fully renewable electricity generation, there are strategic resilience challenges to be addressed. New energy sources, such as solar and wind, create electrically complex electricity flow issues with increased reliance on intermittent weather patterns. Increasing drought conditions through climate change will exacerbate security of supply issues relating to dry winters and low water flows. A solution to provide a stable ‘baseload electricity generation source’ to replace non-renewable sources, such as Huntly power station, is still to be determined - even as electricity demand continues to grow and an expected mass uptake of Electric Vehicles (EVs) looms.

At the electricity distribution network level, the clash between overhead lines and trees continues to be a major challenge, often causing the majority of outages in high wind storms. It is hoped new regulations aimed at reducing the distance between the two will go some way to reduce this risk.

Fuel and Air: Limited Fuel Storage and Dependence on Electricity and Road networks

Fuel distribution in NZ is heavily dependent on the road network, with road damage hindering deliveries following Cyclone Gabrielle and fuel stations unable to operate without power, telecommunications, and electronic payment systems. With limited fuel 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. Limited jet fuel storage at Auckland Airport, which buffers against disruptions in the fuel supply chain, is a key vulnerability issue highlighted during the Marsden-Wiri oil pipeline failure in 2017.

MBIE has progressed work to review the implications of the 2022 Marsden Refinery closure on emergency fuel storage volumes in New Zealand. This is leading to a package of fuel resilience policies that is likely to see mandated minimum fuel storage requirements.

Gas: Transitioning to Carbon Zero

The New Zealand Government’s Climate Action Plan requires transformation of the sector as it transitions out of fossil fuels as a major energy source. Biofuels and hydrogen are being trialled to mix in with existing products, and international developments into other alternatives are being closely monitored. However, maintaining a critical pipe network that may not have a long-term future raises some important resilience issues such as decisions around replacing potentially obsolete assets.



Figure 1-4: North Island Road Damage

Roads and Rail: Land Stability

The last two years have seen record levels of rain in many parts of the country, and the sodden upper-half of the North Island has been besieged with landslips - particularly during Cyclone Gabrielle. The government is proposing much needed investment through Cyclone Gabrielle Recovery Programmes, but this is a huge national issue which won’t be solved quickly.

Another key resilience issue is that the state of local road alternate routes (used when state highways are closed) is often inadequate, and upgrades are needed to make them viable alternate routes.

Three-Waters: Asset Resilience and Climate Change

Major sector reforms are underway, aimed at tackling years of under-investment in three waters networks. This has resulted in networks that are highly vulnerable to seismic events (older pipe networks), power failure (only 10% of NZ’s wastewater sites have on-site standby generation) and intense rainfall (many stream-sourced supplies cannot treat highly turbid water). As with the electricity sector, climate change and increasing drought conditions are concerning, with an increasing number of water supply systems using enforced restrictions to manage summer peak demands.

Telecommunications: Rapidly Evolving Technology and Power Dependence

The sector’s dependency on electricity supply – not just for the core networks but customer technology in the home and business – was another well-known vulnerability further highlighted following Cyclone Gabrielle. Critical telco 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. Another issue is the increased isolation risk for some communities as technology changes and traditional local switching exchanges are progressively being shut down (these previously enabled local calling even if the main cable links failed).

Flood Protection: Climate Change, Floods and Earthquakes

Flood protection assets such as stopbanks protect communities as well as other infrastructure. Climate change and more intense and frequent rainfall is reducing the level of protection provided by systems, most of which were built decades ago. Communities are re-thinking ‘acceptable’ levels of risk and questioning whether protection against 1:100 or even 1:500 year return periods is sufficient for the most critical stopbanks. Stopbanks are also vulnerable to earthquakes, with 60km of stopbanks within 100m of a known active fault.



Figure 1-5 Wairoa during Cyclone Gabrielle

1.8 National Hazard Programmes

There are many programmes of work investigating hazards with national scale impacts, including the Alpine and Wellington faults, Mount Taranaki, the Hikurangi Subduction Zone and the Auckland Volcanic Field. These programmes involve emergency management, critical infrastructure providers, the broad research sector and others.

Through this work, and as a result of strong partnerships between infrastructure providers and the science and research sector, the quality of outputs to support infrastructure vulnerability assessments continues to improve. An example is shown in Figure 1-6; this map showing probabilistic risk of ashfall in the North Island can be used to identify most at risk critical asset locations and consider mitigations to enable operation during ashfall.

Section 7 of this report provides an overview of major hazards to New Zealand’s infrastructure. For each hazard, the hazard context is summarised along with an assessment of impacts to lifelines infrastructure arising from that hazard. Case studies are provided for each major national hazards programme. While

there is a focus on the most damaging hazards, such as earthquakes and severe weather, it is recognised that the hazardscape is much broader than natural hazards.

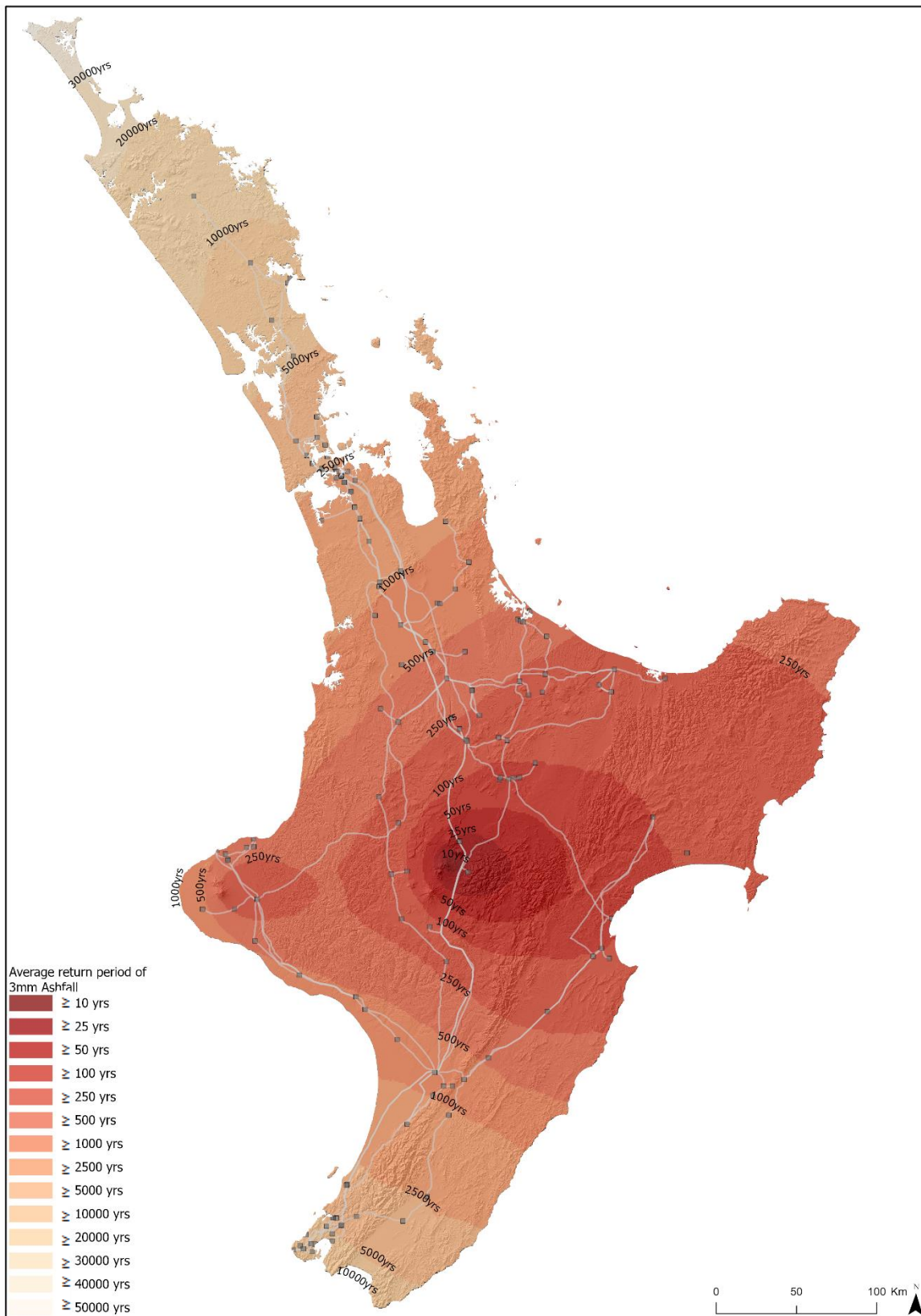


Figure 1-6: The average return period (ARP) for 3mm of ashfall from New Zealand volcanoes (the estimated average time between 3mm ashfall deposition events). Figure from Wilson et al. (2023). Transpower's high-voltage transmission lines and sites are shown for context. Full referencing in Section 7.3.

1.9 Next Steps

This report provides a summary of information on the resilience of New Zealand's critical lifelines infrastructure, gathered from existing lifelines project reports, research, inputs from NZLC members and expert solicitation.

To progress the issues, opportunities and future work identified in this assessment, it is recommended that:

1. This national critical infrastructure vulnerability assessment report gets regularly updated to maintain it as a current position on New Zealand's infrastructure resilience.
2. A national critical infrastructure vulnerability model be developed to support cross-sector prioritisation and investment for resilience.
3. A national investment be made in regional resilience business cases, to take a community and critical customer perspective, in order to recognise infrastructure interdependencies and prioritise mitigations across all infrastructure.
4. Critical infrastructure providers, the government, businesses and communities use the information in this report to review and update their own risk mitigation and preparedness programmes.
5. The NZLC:
 - a) Continue to support engagement of the lifelines sector in critical infrastructure reforms and changes to emergency management legislation.
 - b) Engage with the broader lifelines sector to review the structure, form and funding of the NZLC and regional lifelines groups to support the critical infrastructure and emergency management reforms.
 - c) Continue work with each sector and other key agencies to develop the critical infrastructure thresholds.
 - d) Continue 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.
 - e) Continue to promote positive community wellbeing and natural environment outcomes in the endeavours of the New Zealand Lifelines collective.
 - f) Engage with its members and stakeholder agencies to identify its role in progressing any other *Further Work* above.