New Zealand Lifelines Council

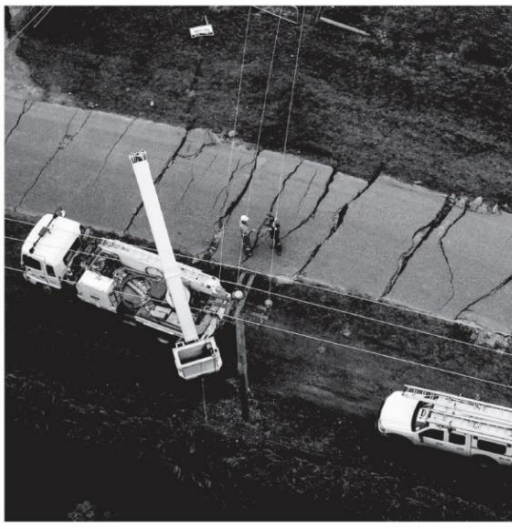
Aotearoa New Zealand's Critical Infrastructure

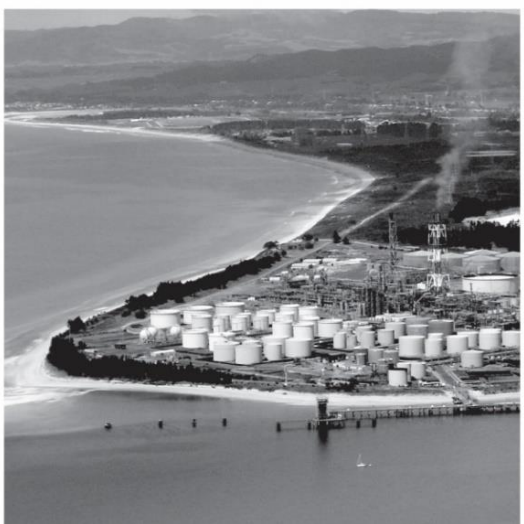
A National Vulnerability Assessment

PART B: MAIN REPORT - INFRASTRUCTURE RESILIENCE IN NEW ZEALAND

2023 Edition








Preface

This report provides a summary of information on the vulnerability of New Zealand's critical lifelines infrastructure to hazards. Volcanic activity, earthquakes and flooding, through to hazards resulting from the increasing interdependence of all infrastructure services, can lead to substantial community impacts. Recent experiences provide ample evidence of this.

This report is intended to:

- provide a unique strategic perspective of all infrastructure services (including energy, transport, telecommunications, and water) as they act in combination to support the wellbeing of New Zealanders,
- stimulate awareness, particularly with regard to interdependencies, and
- drive a change in approach to prioritising resilience investment in infrastructure, to best meet our community needs.

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, Fast Moving Consumer Goods (FMCG) and Financial Payments.
- Development of the definition, 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 section on climate change implications for national infrastructure and mitigation / adaptation pathways.

The report is presented in three Parts:
Part A: Summary
Part B: Infrastructure Resilience in New Zealand
Part C: Infrastructure Sectors and Hazard-Specific Assessments

The use of this report by government, local authorities, utility service providers, researchers, communities and individuals is welcomed and encouraged. This is a national resource and an international exemplar. The New Zealand Lifelines Council is proud to deliver this 2023 Edition.

Roger Fairclough

Chair, New Zealand Lifelines (Utilities) Council

Disclaimer

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.

Acknowledgements

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New Zealand Lifelines Council Members

Project Team

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Other Contributors

Along with NZLC Members, Regional Lifelines Groups, Lifeline Group members, utilities, peak bodies and researchers were invited to contribute to this report.

For this 2023 update, specific mention is made of the input and review feedback gratefully received from the following:

Department of Internal Affairs
Department of Prime Minister and Cabinet
Te Waihanga - Infrastructure Commission
New Zealand Airports Association
Reserve Bank of New Zealand – Te Pūtea Matua
Telecommunications Forum
Toka Tū Ake EQC
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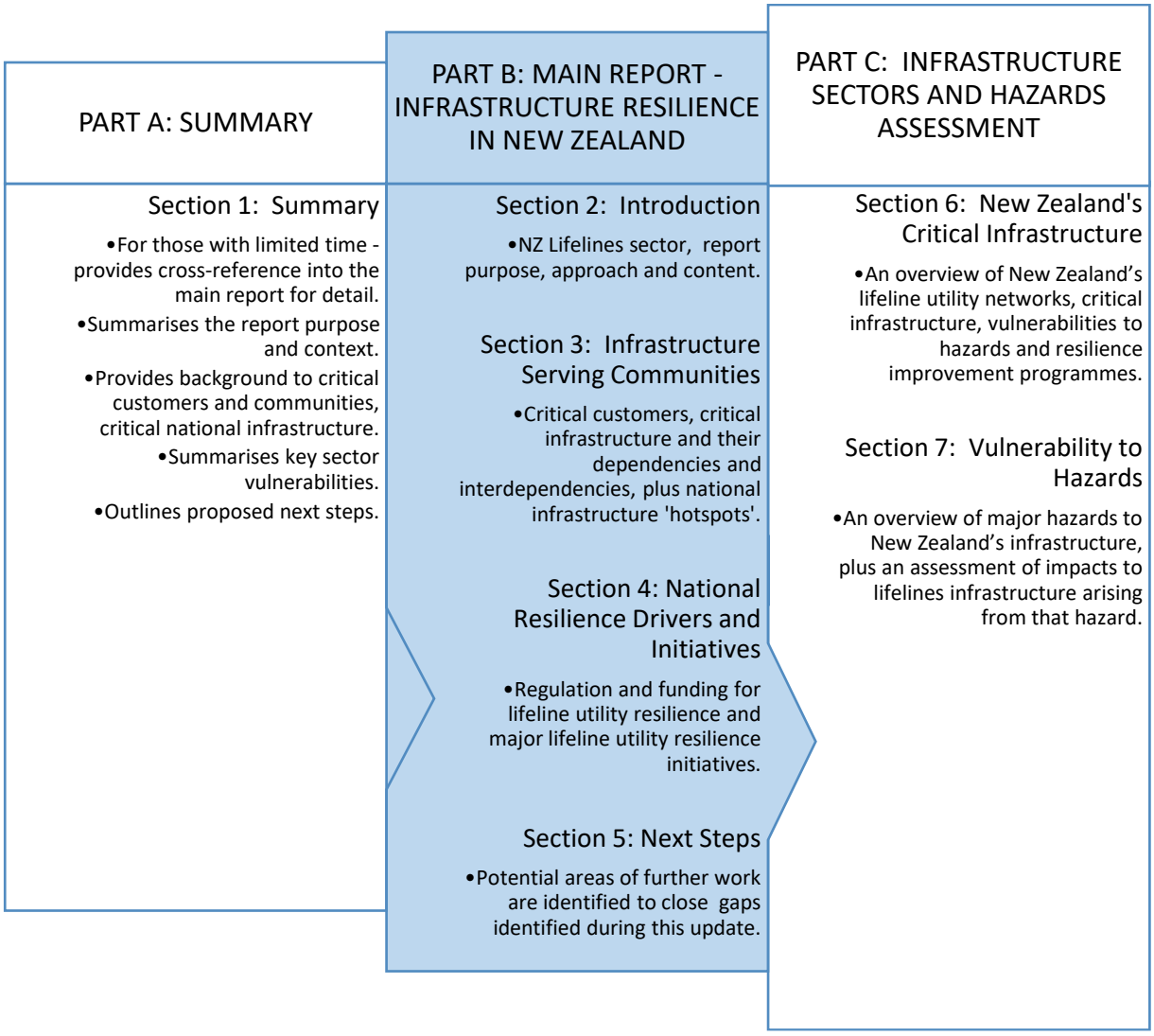
PART B: MAIN REPORT

INFRASTRUCTURE RESILIENCE IN NEW ZEALAND



Contents

2. Introduction

2.1 Background

New Zealand is formed on the collision zone between the Pacific and Australian plates, creating a high earthquake, landslide, volcanic and tsunami risk. New Zealand's position in the Pacific means that it is also exposed to storms and drought, with severe weather events expected to become more extreme with climate change.

A 2018 study of natural hazard loss risk rated New Zealand second in the world. Together with this hazardscape, the long, skinny shape of the country creates infrastructure challenges, with electricity, telecommunications and transport networks running north to south with limited (and sometimes no) redundancy.

The risks that natural hazards pose to our infrastructure networks led to regional *lifelines infrastructure vulnerability studies,* developed from the late 1980s and updated intermittently as resources permitted. These studies aim to understand service impacts of hazard events, such that impacts can be minimised and recovery times reduced. The outputs from this regional work are used by lifeline utilities, communities and others, to support risk mitigation efforts (such as seismic strengthening) together with planning for response and recovery activities.

It is now timely to step up these activities to be more regular, structured and consistent in approach, as well as extending to technical and socio-technical hazards, more community centred information, and structured for improved decision-making through regional resilience programme business cases.

2.2 Purpose

This report provides a national-level vulnerability assessment that addresses regional cross-boundary and national issues. It has been developed by the NZLC with input from organisations across the lifeline utility, government, research and community sectors.

The overall purpose of this assessment is 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. Infrastructure system settings that hinder or enable resilient infrastructure.
4. Customers' and communities' needs, vulnerabilities and ability to contribute to overall resilience improvements.

It is intended to inform a range of activities, including:

- National policy setting, and the development of strategies to mitigate risks.
- Lifeline utility resilience planning (e.g., support prioritisation of resilience projects with consideration of wider infrastructure impacts).
- Regional lifelines projects, to provide an understanding of the cross-boundary issues that need to be considered in regional vulnerability assessments (impacts within the region impacting outside the region and vice versa).
- Community and customer initiatives.
- Future infrastructure and hazard research priorities.

2.3 Audience

This report has been written for:

- Critical Infrastructure Providers (Lifeline Utilities) and their Critical Customers,
- Regional Lifelines Groups,
- Government agencies, research agencies and CDEM Groups involved in emergency management and infrastructure policy,
- Infrastructure funding and regulatory agencies.

Emergency Management and Critical Infrastructure Legislation

CDEM Act 2002

The CDEM Act 2002 placed a requirement for lifeline utilities to *"function to the fullest possible extent"* following an emergency. The CDEM Act 2002 gives effect to the National Civil Defence Emergency Management Plan 2015, which sets out the roles and responsibilities of lifelines (and others) in reducing risks and preparing for, responding to and recovering from emergencies.

Proposed Emergency Management Bill

The Emergency Management Bill replaces the term '**lifelines utilities**' with '**critical infrastructure**'.

If passed in its current form, the Bill will require Critical Infrastructure Providers to support:

1. **Information sharing** requirements, applying before, during and after emergencies.
2. Sector-specific **response and recovery plans.**
3. Stating **Planning Emergency Levels of Service** against hazard scenarios.
4. **Reporting on compliance** with the new Emergency Management Act.

Critical Infrastructure

Many countries have adopted legislation to strengthen the resilience of critical infrastructure. The New Zealand Government is considering whether similar legislation would be appropriate in our context – and committed in the Infrastructure Action Plan to consult on the adequacy of New Zealand's current regulatory approach.

New Zealand Climate-Related Disclosures

Climate reporting requirements include:

- The Carbon Neutral Government Programme focuses on measuring and reducing emissions from core government departments and crown agents.
- The Climate-related Disclosure regime ensures the effects of climate change are routinely considered in business and investment decisions. It covers publicly listed entities, amongst others.

2.4 Scope

The primary scope of assets and services covered in this study has been expanded since the 2020 edition which focussed on 'lifeline utilities' as identified in the Schedule 1 of the CDEM Act 2002. The revised scope adopted for this report:

- brings in Flood Protection, Financial Payments Systems and Solid Waste as critical infrastructure sectors, these being essential and enabling "lifeline utilities".
- aligns the scope of the critical customers' sectors with the definition of social infrastructure in the National Infrastructure Strategy.

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 and DPMC's critical infrastructure work.

Essential and Enabling Infrastructure ('lifeline utilities')	Essential Services ("Critical Customers") *Infrastructure enables service provision but is not the focus.*
▪ Energy ▪ Telecommunications / Broadcasting ▪ Data Storage / ICT ▪ Transport ▪ Water, Wastewater and Stormwater ▪ Flood Protection ▪ Finance (Payment Services) ▪ Solid Waste	▪ Health and Aged Care ▪ Emergency Management ▪ Emergency Services ▪ Financial Services ▪ Fast Moving Consumer Goods ▪ Education ▪ Corrections ▪ Community Facilities ▪ Major Industry

Table 2-1: New Zealand's Infrastructure Sectors.

2.5 Vulnerability Assessment Methodology

This national view of infrastructure vulnerability is drawn from a number of sources, including regionally-based lifelines vulnerability / resilience projects and many significant hazard-based projects such as the *AF8 (Alpine Fault magnitude 8 earthquake) and the Taranaki Maunga volcanic eruption scenarios*.

Figure 2-3 illustrates the general methodology used to assess infrastructure vulnerability in regional lifelines projects, while noting there are variations.

Identifying Critical Infrastructure

The starting point is identifying critical infrastructure in the region and focussing on assets that are likely to have the highest consequences of failure for our communities. There are many approaches to defining asset criticality and this is discussed in Section 3.

Exposure and Vulnerability Assessment

The extent to which quantitative scoring systems are used in regional lifelines projects varies; some earlier studies used detailed asset lists, spreadsheets and multi-criteria analysis to rank asset risks. More recently, several regions have undertaken a higher-level lifelines project approach which provides a more strategic view of the potential infrastructure impacts from natural hazards.

Interdependencies and Restoration times

Understanding lifeline utility interdependencies is an important feature of vulnerability assessments. Firstly, this is considered in the criticality assessment, where an asset becomes more critical if it services

another lifelines asset that requires the service to function. Secondly, when considering service impacts and recovery times, consideration is given to the impact from other lifelines failures, e.g., road access, telecommunication disruptions.

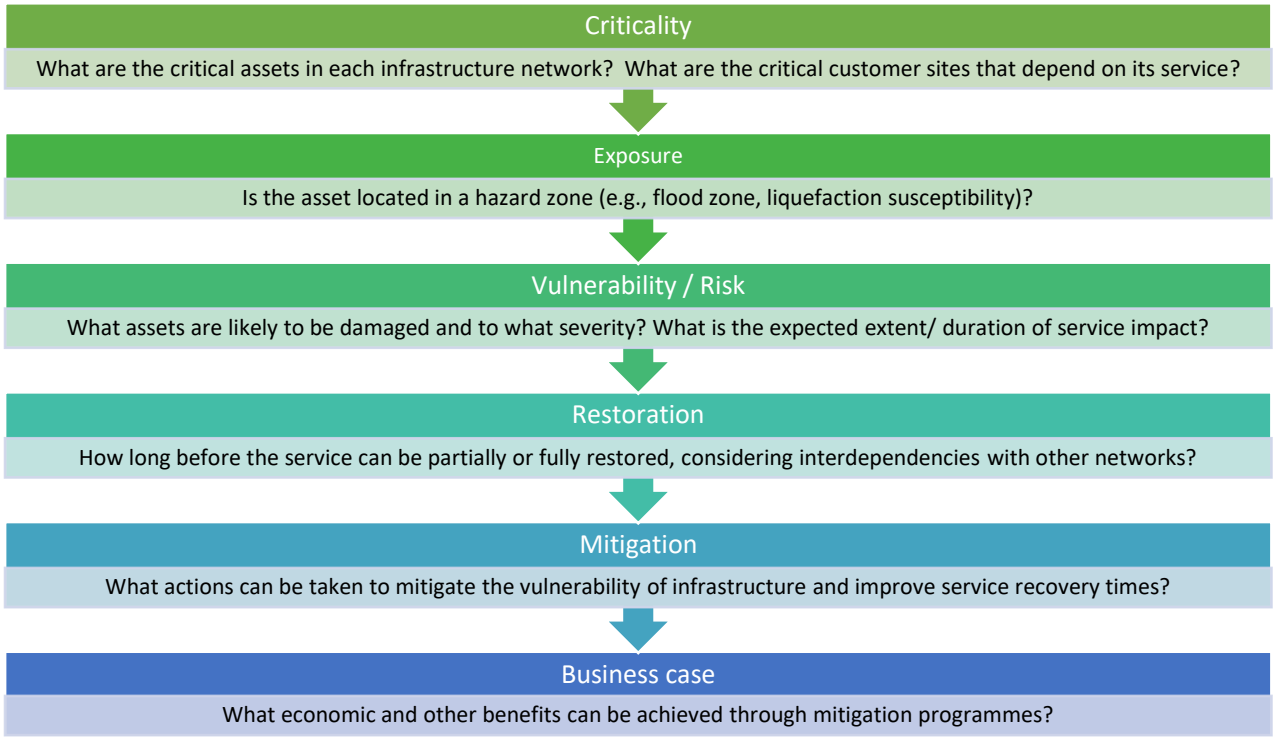


Figure 2-1: Overview of the Vulnerability Assessment Process

Estimated restoration times, which give due consideration to these interdependency issues, are an important input to resilience and emergency planning. One of Wellington Lifelines Group's earlier projects estimated that the water supply to large parts of the urban areas may take three months to restore. This created a strong catalyst for work to reduce those restoration times through network upgrades, modified operational strategies, and installation of emergency water supplies in the most at-risk areas.

Identifying Mitigations and Developing Business Cases

Most regional lifelines group projects identifying mitigations but leave the implementation to the lifeline utilities themselves (having limited mandate or funding to deliver a prioritised, coordinated programme).

A notable enhancement to the development of resilience programmes, is the Wellington Lifelines Group Regional Resilience Project which used seismic damage assessment and economic impact models to identify potential costs and benefits from a coordinated infrastructure resilience capital investment programme *(refer Case Study, Section 5.1).* With improvements in asset and hazard information nationally, this enables similar studies and integrated programmes in other regions.

The tool "Measuring the Economics of Resilient Infrastructure", or MERIT, was used in the Wellington project, to quantify the impacts on communities of lifelines outages, and the benefits to be gained by increased infrastructure resilience. With input from Resilient Organisations, the MERIT tool enables consideration of impacts on businesses over time of prolonged outage and incorporates adaptation strategies, often leading to lesser economic impacts than direct analysis would indicate. The MERIT tool is in a state of continual improvement and development as it is progressively applied by Waka Kotahi New Zealand Transport Agency (Waka Kotahi), ports, local authorities and others.

2.6 New Zealand's 'Lifelines' Sector

Since the 1980s, New Zealand's lifeline utility (critical infrastructure) organisations have been working collectively, through lifelines projects and groups, to understand and identify ways to mitigate impacts of hazards on lifelines infrastructure.

A graphic showing the 'lifelines' sector is graphically illustrated in Figure 2-2.

New Zealand Lifelines Council

The NZLC has the following goals and functions:

Mission: Enhancing the connectivity of lifeline utility organisations across agency and sector boundaries in order to improve infrastructure resilience.

Purpose: Promote arrangements to improve infrastructure resilience to support community wellbeing.

Functions

- Connecting and Supporting Regional Lifelines Groups
- Connecting with National Agencies
- Hosting an annual National Lifeline Utilities Forum
- Updating the national infrastructure vulnerability assessment

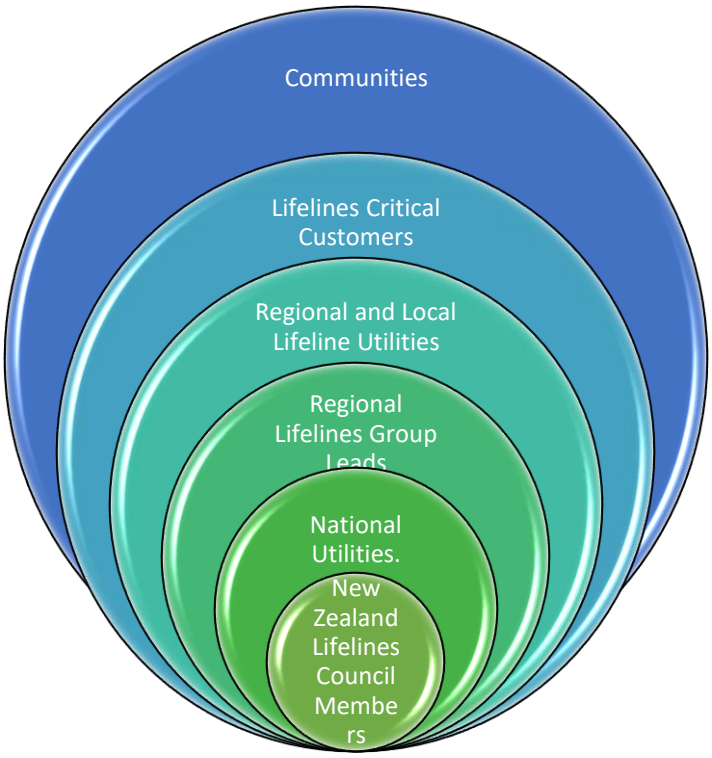


Figure 2-2: New Zealand 'Lifelines' Sector

Regional Lifelines Groups

Lifeline utility representatives collaborate with scientists, emergency managers and other professionals in regionally-based Lifelines Groups. Members of the Groups exchange information and support collective projects to reduce infrastructure outage risks and to promote readiness for emergency responses when outages occur. In these ways, the Lifelines Groups support member utilities in meeting their obligations under section 60 of the CDEM Act 2002.[1]

A Group priority is to identify key regional infrastructure vulnerabilities, often including a list of critical areas where many services may co-exist (e.g., bridges with other services attached). The documents that result typically include mitigation recommendations. When viewed collectively, mitigation recommendations are often seen to have greater benefits than individual asset owners would take into account.

Lifelines Groups are also involved in readiness activities with outputs, including agreed priorities for disaster restoration (including priority routes), petroleum disruption planning and emergency communications arrangements.

Relationships and arrangements established through lifelines groups have proven valuable time and again during responses to major events with multiple lifeline utility outages. Knowing who to contact, having an agreed list of regionally critical 'customers' and having priority access arrangements for fuel, roads etc., are just some of the many benefits that have been recognised.

[1] Source: Guide to the National CDEM Plan 2015, Chapter 7, Clusters.

Lifeline Utilities (Critical Infrastructure Providers)

Infrastructure-owning lifeline utility organisations are identified in each sector (Part C, Section 6). There are a wide range of organisations – government owned, quasi government organisations, privately owned under different models.

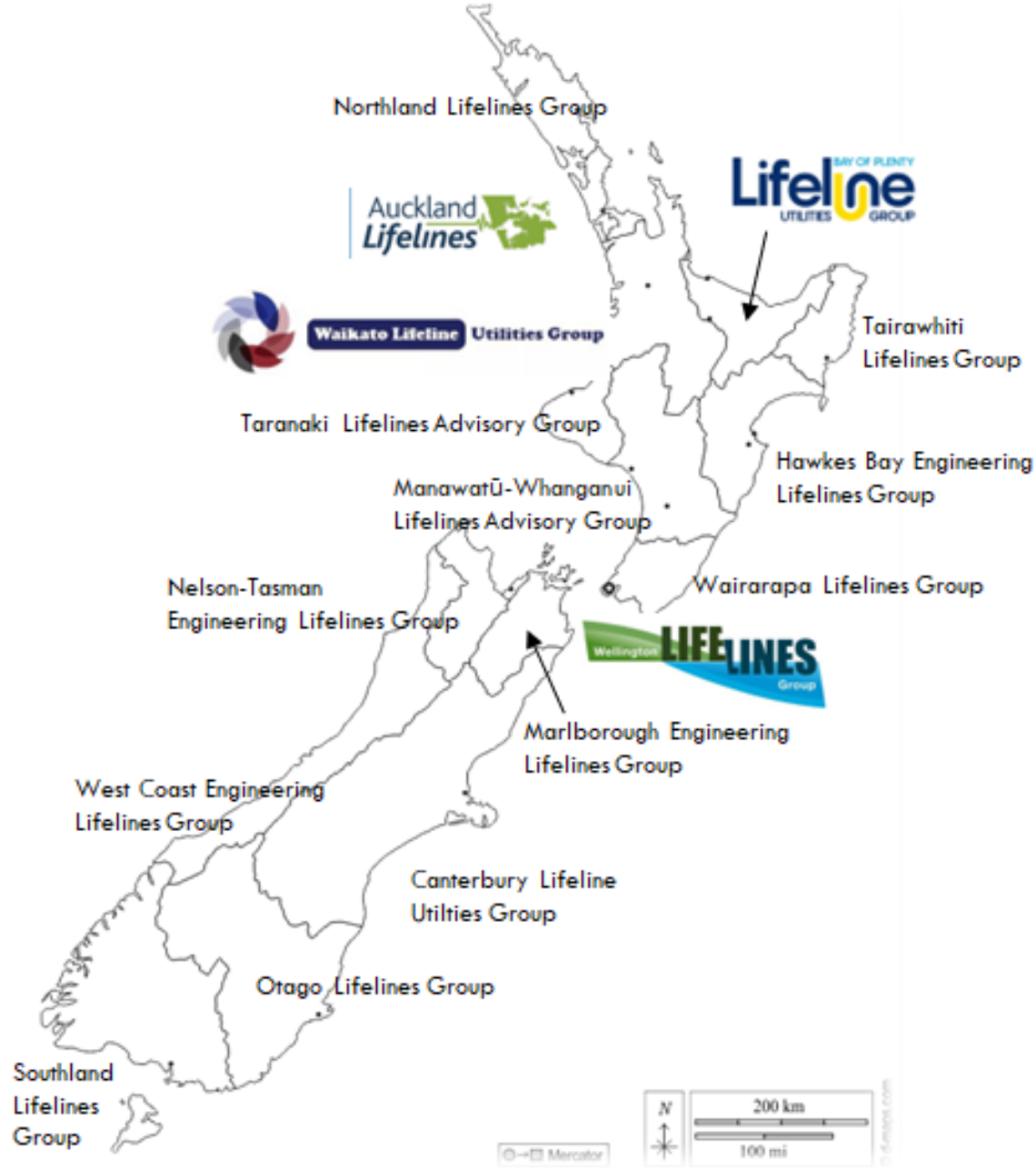


Figure 2-3: New Zealand's Regional Lifelines Groups

3. Infrastructure Serving Communities

3.1 Infrastructure, Customers and Communities

Infrastructure exists to enable customers and communities to function, and in doing so, contributes to community wellbeing. Objectives to improve the resilience of infrastructure are included in disaster and infrastructure strategies at global, national and local levels.

However, it is generally accepted that 100% infrastructure reliability is unaffordable in New Zealand and arguably unwarranted. There is now the technology, capability and willingness to enable a step up in resilience with communities' and individuals' solutions complementing network systems such as roads, transport, water and telecommunications.

Resilient communities feel the impacts of shocks or stresses less deeply and recover faster. Figure 3-1 illustrates this concept.

From a Lifelines perspective, community resilience means having safe housing and local alternatives to lifelines services at customer sites (e.g., rainwater tanks, barbeque gas bottles, battery packs for cell phones) and at community level (e.g., emergency water storage sites).

National legislation and strategies signal the importance of considering resilience from both infrastructure owners' and customers' perspectives. Key examples include:

- The National Disaster Resilience Strategy (NDRS) aims to build resilience by **enabling, empowering and supporting individuals, organisations and communities to act for themselves and others, for the safety and wellbeing of all**.
- A key proposal in the new Bill (in order to replace the Act), is that **critical infrastructure entities undertake *Planning for Emergency Levels of Service (PELoS).*** The intention is for post-event levels of service to be disclosed for major hazard scenarios, providing customers and communities with more information to inform their own emergency planning.

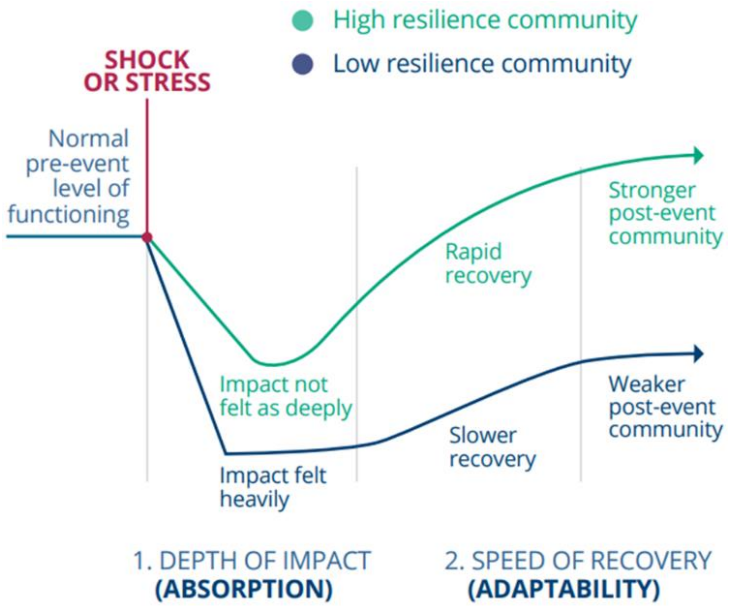


Figure 3-1: Resilient Communities Recover Faster (National Disaster Resilience Strategy, 2019)

Refer to Section 4.1 for further detail on the legislative, regulatory and policy framework for critical infrastructure resilience in New Zealand.

3.2 Defining Critical Infrastructure – Critical to Who?

Critical Customers

The concept of criticality, or importance, of infrastructure is embedded in good infrastructure management practice. All infrastructure networks comprise multiple assets assembled in such a way as to deliver the service required. Critical infrastructure assets are not necessarily the largest or most noticeable, but are those with higher consequences of failure, and which warrant a higher level of management by infrastructure owners. Most critical infrastructure owners in New Zealand apply a form of criticality rating to their assets, typically using an industry-standard 1-5 approach.

But the consequences of failure are borne by customers and communities. It follows that the consequence of asset failure depends on who is being supplied, such that an asset with high criticality is the electricity cable supplying a hospital (ignoring contingency options for now) or a single pipe supplying the water supply for a large town.

Rating Customer and Infrastructure Criticality – a Basic Approach

Therefore, a key step in defining critical infrastructure is to first define the critical customers that depend on infrastructure services. We describe these customer dependencies in two sections:

- Section 3.3 describes Essential Service customers such as emergency services and hospitals, and how each sector is reliant on lifelines infrastructure services.
- Section 3.4 describes how lifeline utilities are customers of each other, giving rise to dependencies and interdependencies in infrastructure systems.

The NZLC has encouraged a common approach to defining critical assets for regional lifelines projects, to provide a consistent language within the infrastructure lifelines sector and an ability to compare and prioritise infrastructure importance nationally (refer Figure 3-4).

This methodology has been used in all regional lifelines projects in the past decade (sometimes in a modified form). The criticality rating depends on both the numbers of customers impacted and the criticality of those customers (e.g., other lifelines, hospitals, etc.) to reflect the overall consequence of the asset failing. The broad categorisation of 'national', 'regional' and 'local' is applied to both customers and infrastructure assets.

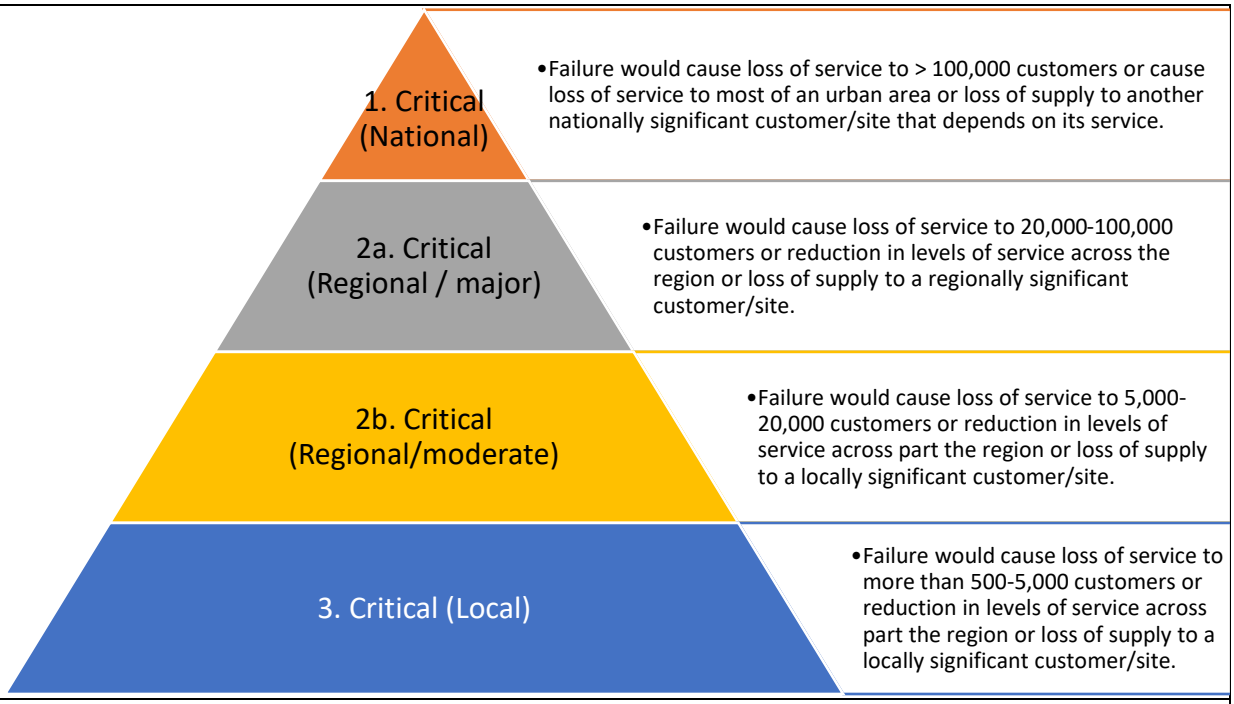
Rating Customer and Infrastructure Criticality – a Multi-Criteria Approach

The NZLC worked with the New Zealand Treasury in 2020 on potential enhancements to this basic framework, to incorporate broader consequences such as environmental and other criteria which may provide more degrees of relative asset criticality across sectors and align with the Government's Living Standards Framework.

The criticality (consequence) table developed is shown in Figure 3-3. This criticality framework has been successfully applied to large assets and various infrastructure sectors. With some modification, it has now been applied to assessing customer criticality in a local resilience project – refer New Plymouth District Council (NPDC) case study (after diagrams on following two pages).

The intention is to continue work with this national multi-consequence criteria framework to provide a more robust approach to defining Critical National Infrastructure (refer Section 0) and better enabling identification of critical customers.

Figure 3-2: Infrastructure Criticality – A Basic Rating System



Notes:

- The definitions are intended to represent the service impact of an asset or service failing – both in terms of the numbers of customers affected and the importance of the services to those customers (e.g., hospitals).
- The framework does not incorporate the concept of 'duration' of outage as the duration will depend on the cause of the outage. Similarly, it does not explicitly cover gradual onset events such as climate change. This framework is scenario-neutral.
- The framework does not attempt to rank sectors (e.g., whether an electricity asset supplying 100,000 customers is more important than a gas asset supplying the same number of customers).
- The application of the 'numbers' should allow for some judgement, considering factors such as the length of time to restore an alternative supply (or detour route) and the social implications, e.g., isolated communities.
- This framework is applied in this national assessment, but regions and organisations have modified the thresholds for 'regionally' and 'locally' significant – reflecting the regional context.
- A basic rule is applied to reflect redundancy in the networks – if work-arounds are in place to largely maintain service the asset criticality rating level is dropped by 1.
- Previous versions of this framework had a 3-tier rating, with the middle two tiers combined.

Figure 3-3: Treasury Criticality (Consequence) Ratings, pilot 2020

Consequences		Insignificant	Minor	Moderate	Major	Extreme
	Scope	1	2	3	4	5
Human (life)	Human health and wellbeing, physical and mental. Includes impacts of illness, injury, income, skills, knowledge and the things that enable people to engage in society.	Mild impacts and inconvenience	Local/moderate illness or injury with no deaths, or serious hardship for <1000 people	Regional/serious illness or injury, 1 death likely, or serious hardship for >1000 people	National/serious illness or injury, up to 10 deaths, serious hardship for >10,000 people	more than 10 deaths, or serious hardship for >100,000 people
Social (&cultural)	Social and cultural structures and norms in NZ, law and order, cultural identity, communities, and community, social, and cultural facilities	Local public issue and sense of frustration or disadvantage	Regional public issue, loss of community facilities or impacts to social or cultural practices, sense of injustice within communities.	National sense of injustice, damage to many communities, social or cultural values challenged, public protests	Damage to social or cultural structures or values for up to 1 year, serious protests/disruptions, or loss of high value heritage	Long-term or permanent loss of social structures or key cultural values/identity. Civil disobedience and extended disruptions.
Governance (political)	Trust in government or management, maintaining credibility and a mandate to lead and/or continue to supply services. Includes international reputation.	Local issue (single region), stakeholder frustration	Issue for <1 month, with embarrassment for Govt or asset manager and some loss of confidence	Issue for <3 months, with loss of confidence in responsible ministers/officials/executives	Issue for >3 months, with loss of confidence and trust in Govt or organisation (asset manager)	long-term loss of trust in Govt or organistion (reputation), impaired ability to govern
Environment (natural env.)	All aspects of the natural environment to support NZ and the planet (biodiversity) and human wellbeing. Includes land, water, plants, animals, and other natural resources.	Minor, very localised impact <1ha, no residual effects	local area impact, recoverable, effects last <3 months	Local/regional impact, recoverable, effects last < 1 year	Regional impact, effects last > 1 year, some long-term residual impacts	Regional impact > 1 year, or long-term or permanent loss of ecosystem, species, or a natural resource
Economic (#people)	The economic impact to NZ (GDP). This is broadly indicated by the number of people impacted directly and indirectly, and may include customers, customers of impacted businesses, suppliers, and others.	Proxy= Total people impact, direct and indirect. # people <500	# people > 500	# people > 5000	# people > 50,000	# people > 500,000
Physical (asset value)	The value of the physical (or intangible) asset being assessed. An estimate of the replacement value of the asset (an indicator of impact to the asset owner).	Proxy= Total replacement value of asset. asset < $10m	asset > $10m	asset > $100m	asset > $1B	asset > $10B

Case Study: New Plymouth District Council – Rating Critical Customers

The NPDC is responsible for managing the council-owned and operated water supplies for New Plymouth city, Inglewood, Oakura, and Okato. In total, they provide an average of approximately 36 ML of water per day to around 29,500 households and businesses.

NPDC identified the following requirement as part of a package of resilience work for Council's potable water systems.

We require a simple and effective Criticality Framework that can consistently assess the overall criticality of any customer (government, infrastructure, health care, industrial concern, commercial business or residential).

The framework assesses multiple criticality (consequence) factors, illustrated to the right. For each factor, consideration is given to both:

- Direct loss of function (e.g., employment, production, community services), and
- Indirect loss of integrity (e.g., security, reputation, trust, confidence, fire protection, health & safety, data corruption, water contamination)

The criticality factors are weighted to reflect the relative importance of each factor and consequence level. The Human (health/life) factor is assigned **twice** the significance as any of the other factors which have equal weighting. Each level of consequence (1-5) is assigned **triple** the significance of the previous level. These factors can be adjusted to identify sensitivities.

	Insignificant	Minor	Moderate	Major	Extreme
Consequences	1	2	3	4	5
Human (life)	Inconvenience	Local/moderate illness or injury, OR income lost for <1000 people	Regional/serious illness or injury, OR >5 days income lost for >1000 people, no deaths	National/serious illness or injury, up to 50 deaths	More than 50 deaths
Social (&cultural)	Public debate and some cultural frustration	Social/cultural values challenged, minor protests	Sense of injustice or cultural threat, non-violent protests	Serious protests, damage to social or cultural values for <1 year	Civil disobedience, long-term loss of social structures, key cultural values, or high value heritage
Governance (political)	Local issue (single region), stakeholder frustration	Issue for <1 month. embarrassment for Govt or asset manager	Issue for <3 months, loss of confidence in responsible ministers/officials	Issue for >3 months, loss of confidence in Govt or asset manager	Long-term loss of trust in govt (reputation), impaired ability to govern
Environment (natural env.)	Minor, very localised (<1ha), effects last < 1 month	Local area, fully recoverable, effects last < 1 year	Local/regional impact, effects last < 1 year	Regional impact, effects last > 1 year	Regional+ impact > 1 year, or long-term loss of ecosystem, species, or a natural resource
Economic (#people)	Proxy= total people impacted directly and indirectly as customers of impacted businesses, # people <500	# people > 500	# people > 5000	# people > 50,000	# people > 500,000
Physical (asset value)	Proxy= Total value of asset (indicator of impact to asset owner), asset < $10m	Asset > $10m	Asset > $100m	Asset > $1Bm	Asset > $10B

When assessing Customer Criticality, the underlying assumption is this is based on a "Business-As-Usual (BAU)" state, with an upgrade to the Consequence rating should this be deemed higher in a "During or post event" state. Examples of the results from this approach are presented in the table below.

The critical customer rating process will inform risk and emergency management aspects, such as priority reinstatement of services and prioritising future resilient network upgrades. It also provided useful context for engagement with the 'top ten' critical customers. The discussions found that generally low levels of awareness and preparedness of customers for potential loss in potable water supplies were concerning, but discussions did reveal opportunities for customers to positively contribute to system resilience.

Customers	Human	Social	Governance	Environment	Economic	Physical	Final Score
	29%	14%	14%	14%	14%	14%	
Taranaki Base Hospital	5	4	4	1	3	4	**4.1**
Airport	2	3	4	2	3	3	**2.9**
Food Processor	2	3	3	4	3	3	**3.0**
NPDC WW Treatment Plant	3	3	3	3	4	3	**3.2**
Todd Energy Junction Road	2	3	3	2	4	2	**2.8**

3.3 Critical 'Essential Services' Customers

Generally, the more critical customers of lifeline utility services are entities that provide an essential service to communities and depend on them to function before, during and after emergencies. These include both critical lifelines infrastructure and the critical customer sectors that were shown in Table 2-1..

To define these sectors is challenging. For example, Figure 3-6 shows the supply chain for the FMCG sector. This sector is dominated by the two major retailers (Foodstuffs and Woolworths) but they require the whole supply chain to function, from primary production through to retail.

Critical customers maintain business continuity arrangements for backup services based on their own risk assessments and commercial requirements, but still warrant priority restoration of service and access. Examples of this include priority access to fuel under the National Fuel Plan, and access through cordons and restricted routes to maintain critical sites. Infrastructure providers should also consider the resilience of the supply to critical customer sites (in some cases these are direct commercial arrangements between the lifeline utility and the critical customer).

There is currently no national view on the extent to which critical community sectors have alternative arrangements (such as radio/satellite, water stocks or on-site backup generation), however a brief overview of critical customer sectors and dependence on lifelines services is provided in Table 3-1. As part of regional lifelines studies, each region identifies what they assess to be critically important sites for their community. This information then informs each lifelines criticality analysis in that an asset that services a critical site (such as a hospital) that depends on them, also becomes critical.

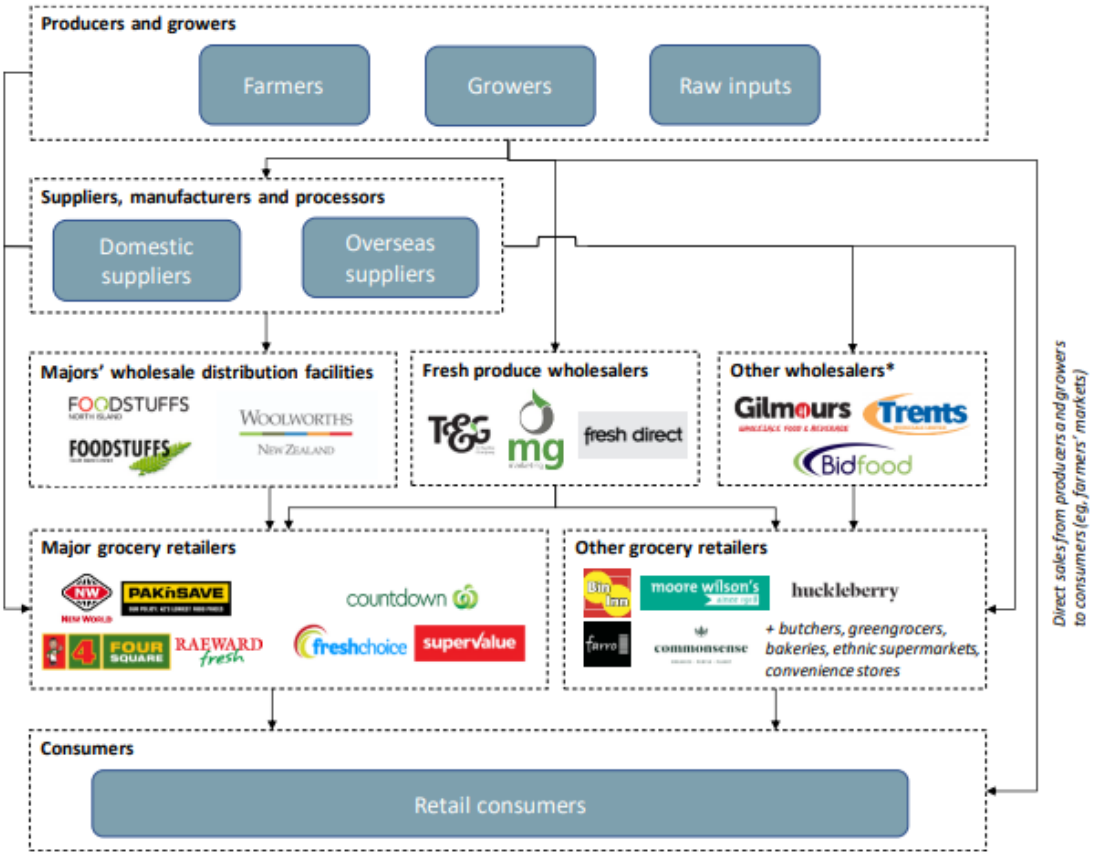


Figure 3-4: Overview of New Zealand's Fast Moving Consumer Goods sector

Sector	Reliance on lifeline utilities
Emergency Services (Police, Fire and Ambulance)	▪ reliant on all lifelines to operate, including telecommunications, fuel, water (potable and wastewater), electricity, and transport (road) access. ▪ most critical sites are the hubs where 111 calls are taken and despatched. ▪ headquarters and main depots are self-reliant with backup generators, water supply and multiple communication systems. ▪ ability to operate from vehicles and alternate depot sites. ▪ in an emergency, road access and telecommunications are critical, particularly the 111 system for communities to access emergency help.
Health Services including hospitals, primary care (general practice and pharmacies), maternity centres, private surgical centres, psychiatric hospitals, aged residential care facilities, and disability support services and hospices	▪ hospitals are of highest importance to maintain function, approximately 220 hospitals (public and private) with the major ones being Whangarei, North Shore, Waitakere, Auckland City, Middlemore, Waikato, Palmerston North, Wellington, Christchurch, Dunedin, Southland and Starship Hospital (Auckland) which provides critical paediatric services nationally. ▪ reliant on all lifeline utility services and hospitals have backup generation and stored water (typically enough for a few days). ▪ common issues include that on-site water storage may not be potable if it isn't properly managed, fuel for generators is typically only enough for 2-3 days. ▪ medically dependent customers may have partial or complete reliance on electricity to run medical equipment for dialysis, respirators, etc. ▪ hospitals also depend on suppliers that are themselves dependent on lifelines services (e.g., food and linen suppliers reliant on gas supply).
Corrections	▪ responsible for the safety of large numbers of individuals who are unable to protect themselves in emergency situations, or who may pose a risk to communities if facilities fail. ▪ 18 adult corrections facilities and four youth correctional facilities. ▪ sites require water, wastewater, electricity and comms services to ensure safety and security of staff, prisoners, and the community. ▪ roading/transport services needed to deliver goods, prisoner transfer, providing health services to facilities, and maintain security measures. ▪ business continuity plans in place for loss of supply, including limited (days) self-sufficiency for electricity and water, but depend on roads and telecommunications to implement their business continuity plans i.e., re-supply for fuel, water, food and medical.
Government (other)	▪ required to have and maintain business continuity arrangements to deliver their critical functions in a disruption, e.g., emergency generators, working from home, failover to alternate sites. Does not fully negate reliance, e.g., require access to continued fuel supply for generators, staff need electricity and comms to work from home. ▪ many agencies have plans to scale their operations to ensure their core services are provided, e.g., only activating staff who perform 'critical' functions (i.e., ensuring welfare payments are made on time) or re-deploying staff to critical roles.
Fast Moving Consumer Goods	Refer case study following.
Major Industry (e.g., freezing works, dairy processing, main construction depots).	▪ many major industry providers are reliant on lifelines services to operate, and typically have backup electricity and water to maintain important functions. ▪ in the primary food sectors, prolonged loss of electricity and water supply can have severe economic consequences and animal welfare issues. Environmental consequences may also be significant if unprocessed products cannot be disposed of safely.

Table 3-1: Critical Customers of Infrastructure Services

Fast-Moving Consumer Goods – Sector Spotlight

Overview

More than $22 billion was spent at supermarkets and grocery stores in the year to September 2021. Grocery and supermarket items capture a significant portion of the FMCG industry with two main retailers:

1. Woolworths NZ's retail banners are Countdown, FreshChoice and SuperValue. Woolworths NZ operates and supplies over 180 Countdown stores throughout New Zealand. In 2022, Woolworths NZ estimates that 3 million customers are served at its retail stores weekly.
2. Foodstuffs' main retail banners include PAK'nSAVE, New World and Four Square. Smaller franchisee stores also operate in the South Island. Foodstuffs has more than 400 retail stores nationwide under the New World, PAK'nSAVE and Four Square retail banners. Foodstuffs is comprised of two main entities: Foodstuffs North Island Limited and Foodstuffs South Island Limited – these are regional cooperatives owned by their retail members.

There are also a range of independent retailers offering grocery and FMCG products, typically operating in urban areas and providing a narrower range of products and services than the major grocery retailers. A sector overview is presented in **Error! Reference source not found.**.

Critical National Infrastructure

National distribution centres are a critical part of the FMCG supply chain, where (simplistically) goods are collected from suppliers and distributed to retailers. Distribution centres of national significance include:

1. **Woolworths** regional distribution centre (Auckland), which supplies 40% of all FMCG products.
2. **Foodstuffs** National distribution centre (Auckland).

Reliance on other Critical Infrastructure

The FMCG sector has a number of key dependencies on other 'lifelines', including:

- High reliance on transportation sector; dependence on fuel supply and distribution, roading and port networks.
- High reliance on electricity and gas network for day-to-day operations of stores and distribution centres. Most stores and distribution centres have generators, although these have limited supply.
- Reliance on telecommunications for communicating between stores and across the supply chain.
- Reliance on water network for day-to-day operations of stores and distribution centres.

Pandemic

The COVID-19 pandemic had a major impact on the FMCG sector, highlighting sector strengths and weaknesses. As an essential service, supermarket retailers were able to operate during the government mandated level 4 lockdown periods (though others such as groceries and butchers were not).

The pandemic saw wide-ranging impacts, including: supply chain disruption; panic buying by consumers; staff disruption; short-term effects on prices, choice and availability of groceries; and collaboration between supermarkets to stabilise supply and protect consumers.

During the pandemic, the shortage of goods and demand patterns had a serious impact on the operation of the supply chain, creating disruption to the sector and to communities. Traditional supply chain disruption preparation and mitigation strategies were simply inadequate to cope with the mass disruption. New strategies and solutions were required to minimise the impacts of disruption.

3.4 Critical 'Lifelines' Customers (Interdependencies)

Lifeline utilities are themselves often critical customers of each other. Figure 37 and Figure 38 summarise interdependencies between lifelines sectors during business-as-usual and major disaster events where disruption is expected to roads and electricity networks.

The 'Total Dependency' scores are indicative only – obviously, the extent of dependence in a response and recovery situation will depend on the specific scenario and there is some variation by region. The total interdependency scores illustrate the importance of electricity, roads, fuel and telecommunications to the other sectors, with air transport, very high frequency (VHF) and broadcasting becoming more important in a major disaster event.

Figure 3-7 confirms that electricity is the lifeline utility service that most others depend on to function during normal operating periods. This is closely followed by roads, telecommunications and fuel.

Figure 3-8 shows how the dependencies change following a significant emergency (a damaging event with major power outages) where the following lifelines become more important:

- Fuel: to supply backup generators and to fuel vehicles involved in response and restoration.
- Broadcasting: to communicate important public messaging.
- Solid waste: to dispose of disaster debris (assumption of a damaging event).
- Telecommunications and radio: to facilitate response coordination.
- Financial payments: to enable payment for food, fuel, flights and waste disposal.
- Air transport: to deliver emergency backup supplies of utilities such as fuel and food, and support evacuations.

Key

3: Required for Service to Function,

2: Important but can partially function and/or has full backup,

1: Minimal requirement for service to function.

The degree to which the utilities listed to the right are dependent on the utilities listed below	Electricity	Roads	Telecomms	Fuel	Water Supply	VHF Radio	Financial&Cash Payments	Stormwater/Flood Protection	Wastewater	Rail	Sea Transport	Solid Waste	Gas	Air Transport	Broadcasting	Total Dependency
Electricity		2	3	2	3	3	2	2	3	2	3	2	2	3	3	35
Roads	2		2	3	2	2	3	2	2	3	3	3	2	3	2	34
Telecomms	2	2		2	2	3	3	2	2	2	2	2	2	2	3	31
Fuel	2	2	2		2	2	1	2	2	3	3	2	2	3	2	30
VHF Radio	1	2	1	1	1		2	1	1	2	2	1	1	2	1	19
Water Supply	1	1	2	1		1	1	1	3	1	1	1	1	2	1	18
Financial&Cash Payments	1	1	1	3	1	1		1	1	1	1	2	1	2	1	18
Stormwater / Flood Prot.	1	2	1	1	1	1	1		1	1	1	1	1	2	1	16
Wastewater	1	1	1	1	1	1	1	1		1	1	1	1	2	1	15
Rail	1	1	1	1	1	1	1	1	1		2	1	1	1	1	15
Sea Transport	1	1	1	1	1	1	1	1	1	2		1	1	1	1	15
Solid Waste	1	2	1	1	1	1	1	1	1	1	1		1	1	1	15
Gas	2	1	1	1	1	1	1	1	1	1	1	1		1	1	15
Air Transport	1	1	1	1	1	1	2	1	1	1	1	1	1		1	15
Broadcasting	1	1	1	1	1	1	1	1	1	1	1	1	1	1		14

Figure 3-5: Interdependency Matrix – Business As Usual.

The degree to which the utilities listed to the right are dependent on the utilities listed below	Fuel	Roads	Telecomms	Electricity	VHF Radio	Broadcasting	Air Transport	Solid Waste	Financial&Cash Payments	Water Supply	Stormwater/Flood Protection	Wastewater	Sea Transport	Gas	Rail	Total Dependency
Fuel		3	3	3	3	3	3	3	3	3	3	3	3	3	3	42
Roads	3		3	3	2	2	3	3	3	3	3	3	3	3	3	40
Telecomms	2	3		3	3	2	2	2	3	3	3	3	2	3	2	36
Electricity	2	2	3		3	3	3	2	2	3	2	3	3	2	2	35
VHF Radio	2	2	2	2		2	3	1	2	2	2	2	3	2	2	29
Broadcasting	2	2	2	2	2		2	1	2	2	2	2	2	2	2	27
Air Transport	2	2	2	2	2	2		1	2	2	2	2	1	2	1	25
Solid Waste	1	3	2	2	1	1	1		1	2	2	2	1	2	2	23
Financial&Cash Payments	3	1	1	1	1	1	3	3		1	1	1	1	1	1	20
Water Supply	1	1	2	1	1	1	2	1	1		1	3	1	1	1	18
Stormwater / Flood Prot.	1	2	1	1	1	1	2	1	1	1		1	1	1	1	16
Wastewater	1	1	1	1	1	1	2	1	1	1	1		1	1	1	15
Sea Transport	1	1	1	2	1	1	1	1	1	1	1	1		1	1	15
Gas	1	1	1	1	1	1	1	1	1	1	1	1	1		1	14
Rail	1	1	1	1	1	1	1	1	1	1	1	1	1	1		14

Figure 3-6: Interdependency Matrix – During / Post Disaster Event

Sector / Service	Dependence on that service by other lifeline utilities
Electricity	▪ During normal operations, electricity is required to operate most of the other lifeline utilities to some degree and, because of this dependence, typically utilities have backup power (batteries, generators) at their most critical sites. ▪ A widespread regional electricity outage would, after varying periods of time, still impact on telecommunications, water supply, wastewater, gas, fuel supply and traffic management services.
Telecommunications	▪ A major telecommunications failure will impact the business sector and wider community and impede the efficiency of utility businesses. ▪ Almost all businesses rely on telecommunications to operate and to receive payments. However, most utilities could continue core services without telecommunications in the short term. Impacts on control systems would mean that some utilities would need to revert to manual operation and monitoring of facilities and response to service requests could be impaired. As technology enables more complex operations arrangements, the service impacts of reverting to manual operation may be significant. ▪ The situation changes in an emergency because telecommunications become critical for coordinating response and recovery efforts. The cellular network may become overloaded during or shortly after an event. However, the copper, fibre, and wireless infrastructure (including cellular) and satellite services provides diversity. Most utilities use a combination of the above technologies and some have their own dedicated network of links and radio.
Broadcasting	▪ Broadcasting is not generally considered a critical supply to other utilities during business as usual. However, in a response situation, particularly where other telecommunications are impacted, broadcasting is a means of communicating public information such as to issue warnings, road disruptions, public water supply warnings and advising of fuel shortages. Some broadcasters are designated lifeline utilities, so have an obligation to relay this information.
Roads	▪ The road network is important for all utilities to operate, particularly for sea/air/rail networks which are connected by road and used for fuel distribution. FMCG, Financial payments and Cash System Networks need roads for food and cash movements. ▪ Road failures during business-as-usual may affect response to service requests and asset failures. In an emergency, staff need to be able to access facilities and diesel, and plant needs to be transported to sites.
Air Transport	▪ Air services also become important to other lifelines in a major disaster; to assess damage, bring in responders, equipment and spares and access sites when there is significant road disruption. It may be the only source for critical supplies in the early days of an event where roads are heavily disrupted and can be critical for evacuations.
Sea Transport	▪ The fuel sector is reliant on shipping for distribution of fuel, though most other sectors do not have a major dependency on sea transport during BAU operations. ▪ In a major disaster, some regions may be heavily dependent on sea transport for provision of emergency supplies (for example, Wellington and West Coast of the South Island) or evacuation of people.

Sector / Service	Dependence on that service by other lifeline utilities
Water Supply	▪ Water supply and wastewater services are critical for the community, both for public health and firefighting purposes, as well as some dependence on these services by other lifelines. For example: ▪ Fuel terminals require a high-capacity water supply (or alternative firefighting capability). ▪ Building services require water and wastewater for health reasons, though alternative arrangements can be made - such as re-location or using bottled water supplies and temporary wastewater facilities. ▪ Water required for air-conditioning and plant cooling operations in some sectors. ▪ Air transport requires water supply at the airport (for passenger services for commercial flights), and telecommunications requires water for equipment cooling. ▪ Natural gas electricity generators require high quality water for cooling and compression.
Wastewater	▪ Wastewater pump stations and treatment plants rely on electricity and there is limited availability of backup generation apart from the most critical sites. ▪ Limited dependence on wastewater by other utilities, apart from airport operations.
Fuel	▪ All lifelines require fuel for plant and vehicles for service personnel. If electricity is affected, diesel supply to critical sites to operate back-up generators becomes more important. Even those sites with on-site diesel storage typically only hold a few days' supply. Refuelling of generators deployed to other critical facilities is likely to become a significant logistical issue.
Gas	▪ Lifelines networks are not generally reliant on gas for network operation, with the exception of gas-powered electricity generators.
Solid Waste	▪ Roads have a higher BAU dependence on solid waste than other lifelines, due to the larger amount of construction activity and waste. In a damaging event, waste disposal become critical for clearing debris of roads and properties.
Stormwater / Flood Protection	▪ Drainage is most important for roads and at airports. There are also many individual assets reliant on stormwater and flood protection systems, however these represent a small % of the overall networks and have only been assigned a '1' dependency rating.
Financial Payments	▪ Financial payments systems are widely used across all sectors, most frequently for fuel, food and materials payments. In a response, there are likely to be a much larger number of transactions in some sectors, such as solid waste and air transport. Cash provides an alternative if electronic payments are down.

Table 3-2: Lifelines Interdependencies

3.5 Defining Critical National Infrastructure

Under the proposed Emergency Management Bill, there is an intention to replace the CDEM Act Schedule 1 definition of Lifelines Utilities with a principles-based approach to defining critical infrastructure.

Critical Infrastructure Definition:

Essential and enabling assets, systems, services and supply chains.

Principles

- Essential for the economy, national security, public safety and the continuous provision of basic public and other infrastructure services; and/or
- Disruption would severely prejudice the functioning or stability of the nation or national security.

Criteria

- Of significant economic, public, social and strategic importance; and/or
- Service disruption could affect the nation's ability to function, deliver basic public services, or maintain law and order; and/or
- Infrastructure failure could have a significant effect on the environment, the health or safety of the public or the functioning of other critical infrastructure.

In developing the 2023 version of this report, NZLC has worked with its members and partner agencies to develop a more detailed criticality rating system that follows the above principles.

The framework provides criteria specific to each infrastructure service, such as the number of impacted customers and overall demand (MW capacity for electricity). This is still a work-in-progress, and where information wasn't available to support specific demand criteria, a list of assets within each broad category were provided. The results of this work are presented in *Attachment 3: Infrastructure Criticality Framework*.

A summary of critical national infrastructure derived from the above framework is included in Table 3-3.

There is an intention to continue working on a national multi-consequence criteria framework to provide a more robust approach to defining Critical National Infrastructure.

Sector	Critical Infrastructure Entities	Critical Assets	Critical Infrastructure Thresholds
Energy - Electricity	System Operator (Transpower) Major Generators National Grid Owner (Transpower)	Core Grid Infrastructure, inc. communications, data centres and control. Generation Infrastructure, inc. civil and structural Multi-regional distribution of infrastructure	Dependent community populations in excess of 200k Infrastructure serves >200MW of demand Has a "Black Start" or stability role Economic Losses of failure >$200M
Energy - Fuel	Fuel Importers ('big 3') National Distributors (e.g., Allied)	Bulk Fuel Wharves / Terminals (Marsden, Wiri, Tauranga, Centreport, Lyttelton). Major fuel pipelines (Marsden-Wiri, Wellington, Christchurch port to city).	Specific thresholds may be developed, e.g.: ▪ Fuel import > (x) l/day ▪ Tank storage volumes > (x) m3
Energy - Gas	Major Gas Producers Gas Transmission Owner	Major Production Facilities North-South Transmission Line (Auckland to Wellington)	Specific thresholds may be developed, e.g.: ▪ Supplies > 500,000 customers ▪ > (x) tjoule demand
Water - Water Supply	Water / Local authorities	Major sources, treatment plants, trunk mains with limited redundancy.	Supplies > 100,000 customers
Water - Wastewater	Water / Local authorities	City treatment plants, limited redundancy.	Supplies > 1M customers
Water - Flood Protection	Local authorities	Stopbanks protecting major urban populations.	Specific thresholds may be developed, e.g.: ▪ Protects > (x) Dwellings ▪ Protects > (x) $land
Transport - Roads	Waka Kotahi	State Highways (national) State Highways (regional) long detour times	ONRC = National ONF M1, long detour
Transport - Air	Major Airport Owners Airways New Zealand	International Airports – runway, terminal. Navigation Aids International Airports National Control Centres	Auckland, Wellington, Christchurch, Queenstown, Ohakea Christchurch, Auckland.
Transport - Rail	KiwiRail Auckland Transport GWRC	National trunk lines (inc. inter-island) Rail to major national ports (Tauranga, Auckland, Hamilton, Wellington, Picton). Wellington and Auckland metro lines and hub train stations. National Control Centre	Specific thresholds may be developed, e.g.: ▪ > (x) volume of freight ▪ > (x) Passengers
Transport - Sea	National Port Owners: Port of Tauranga, Auckland Council, Channel Infrastructure	Wharves / cranes: Tauranga, Auckland, Marsden, Wellington, Picton.	Specific thresholds may be developed, e.g.: ▪ > (x) volume of freight

Sector	Critical Infrastructure Entities	Critical Assets	Critical Infrastructure Thresholds
	(Marsden), GWRC / CentrePort, MDC / Port of Marlborough.		
Telecommunications	Southern Cross Cable, Hawaiiki Chorus, Spark, Vodafone, 2degrees	International cables / landing points / cable stations. Core trunk fibre network Major exchanges / POIs	Specific thresholds may be developed, e.g.: ▪ Supplies > 200,000 customers
Solid Waste	Large city councils and waste management operators	Large city landfills with long drive to alternate disposal.	Specific thresholds may be developed, e.g.: ▪ > (x) m3 waste disposed / day
Food Production / Distribution	Progressives, Foodstuffs, Fonterra	Distribution Centres (Auckland, Palmerston North, Christchurch). Largest Fonterra sites	Specific thresholds may be developed.
Financial Payments	Reserve Bank Cash in Transit industry (major firms) Major Banks Independent ATM providers Financial Market Infrastructure Providers (legal term)	RBNZ Monetary Policy Committee (emergency function) Cash storage, processing and distribution facilities Payments systems – wholesale and retail	Specific thresholds may be developed.
ICT – Data Storage	Data Centre Owners	Major data centres.	Specific thresholds may be developed.

Table 3-3: Critical National Infrastructure Entities and Assets

(Work-in-Progress)

3.6 National Critical Infrastructure Hotspots

Infrastructure interdependencies, as described in the previous section, increases the overall risk and consequence of a potential failure of a single infrastructure type.

Co-location of critical infrastructure assets also increases the consequences of a damaging event at a single site, both in terms of the direct impact of many critical assets simultaneously failing (e.g., a major landslide) and in the potential hazards that some assets pose to others (major water main failure could wash away other assets in the area). These areas have been termed 'hotspots' - where a number of critical infrastructure assets from different sectors are concentrated in a single area.

Examples of national infrastructure hotspots identified in regional vulnerability studies are shown in Figure 3-9, with the Kawarau Gorge shown below.

Nevis Bluff, SH 6 Kawarau Gorge

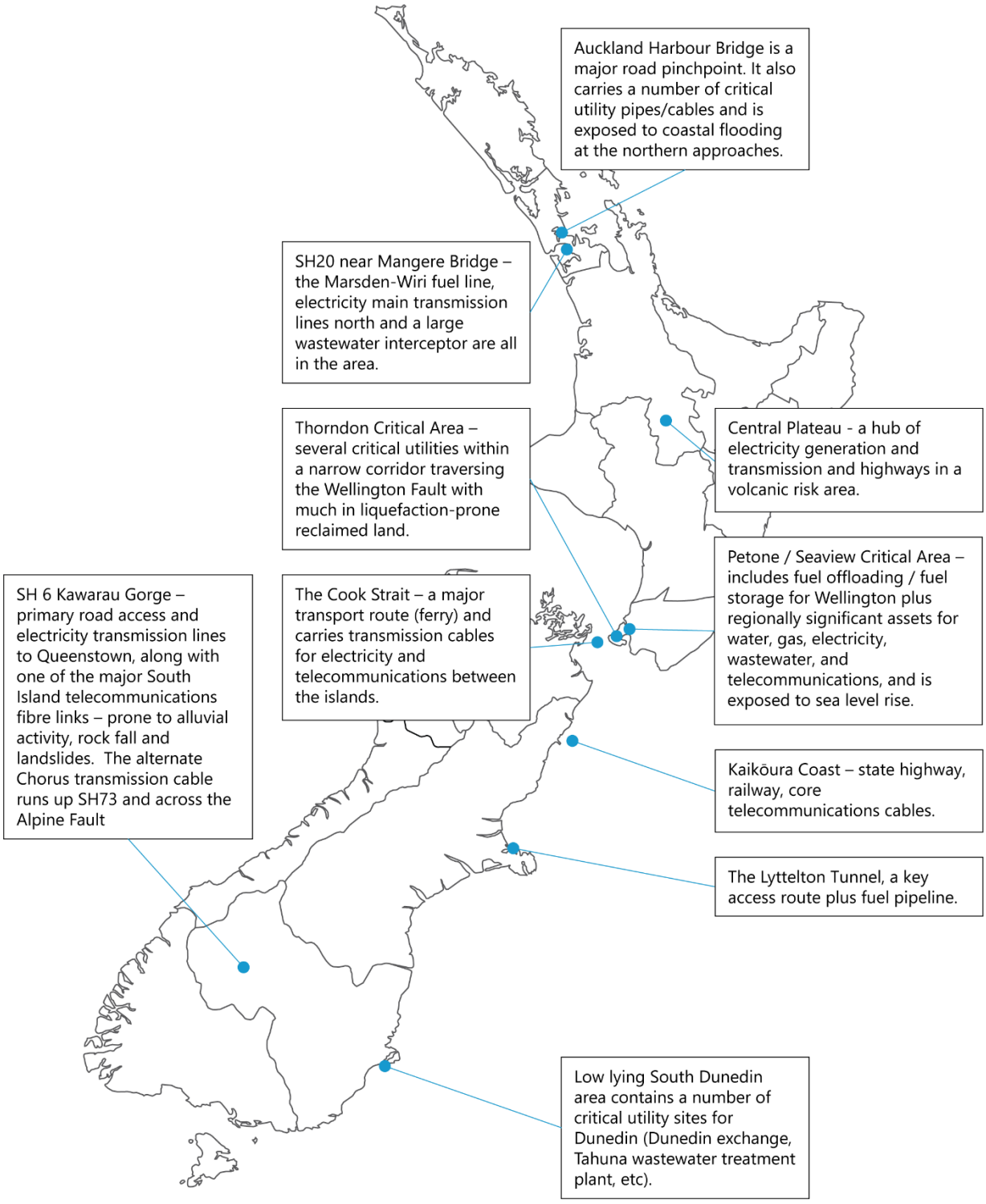


Figure 3-7: Examples of National Infrastructure Hotspots

4. National Infrastructure Resilience Drivers and Initiatives

This section presents a summary of the policy and regulatory settings for lifeline utilities that contribute to infrastructure resilience. It includes information on proposed initiatives to improve resilience by individual lifeline utilities, regional lifeline utility groups, and national research programmes.

4.1 Policy and Regulatory Framework

Lifeline utility services operate under a range of regulatory frameworks and market models; these are discussed for each sector in Section 5. The main cross-sector regulation is summarised below.

Legislation

CDEM Act 2002

The CDEM Act 2002 has a requirement for lifeline utilities to *"function to the fullest possible extent"* following an emergency. The CDEM Act 2002 gives effect to the National Civil Defence Emergency Management Plan 2015, which sets out the roles and responsibilities of lifelines (and others) in reducing risks and preparing for, responding to and recovering from emergencies.

However, while the CDEM Act 2002 and National CDEM Plan 2015 may be used by utilities to support investment decisions, there has been no substantive compliance monitoring of this legislation.

Emergency Management Bill

The Emergency Management Bill, going through a Select Committee process at the time of preparing this 2023 Edition, contains a number of new requirements for Lifeline Utilities, including being re-named as 'Critical Infrastructure Providers'. These were summarised in the discussion box in Section 2.2, with further information available on NEMA's website.

The Emergency Management Law Reform Programme will ensure the Act, Plan Order/Guide, and NDRS Roadmap are aligned in content and outcomes, as well as ensuring the projects are coordinated and aligned with other NEMA projects and workstreams.

Other Regulation

There are many other legislative and regulatory requirements that apply across multiple sectors, including:

- The Building Act 2004, which sets standards for building quality and resilience, with higher standards for important sites.
- The Health and Safety at Work Act (Major Hazard Facilities) 2015 which requires operators to identify and eliminate / minimise risks and hazards and major hazard facilities such as fuel and gas terminals.
- The Resource Management Act (RMA) 1991 recognises the management of significant risks from natural hazards as a matter of national importance. Consenting requirements under the RMA also consider risk mitigation in the location and design of infrastructure sites.

Critical Infrastructure Regulation Review

The government is currently reviewing the regulatory approach to delivering resilient critical infrastructure in New Zealand. The first Discussion Document issued in June 2023 sets out the case for a revised regulatory approach, noting the currently fragmented state of the system.
Critical Infrastructure Phase 1 Consultation - Department of the Prime Minister and Cabinet - Citizen Space (dpmc.govt.nz)

National Policy and Strategies

National Disaster Resilience Strategy (NDRS)

This national strategy (2019), made under the CDEM Act 2002, has an overall aim to build resilience of the nation to disasters.

The NDRS has the following objective specifically relating to infrastructure:

Address the capacity and adequacy of critical infrastructure systems, and upgrade them as practicable, according to risks identified.

New Zealand Lifelines has been pursuing this objective since its inception.

New Zealand Infrastructure Strategy

The current 30-year New Zealand Infrastructure Strategy puts communities front and centre with its vision:

Our infrastructure lays a foundation for the people, places and businesses of Aotearoa New Zealand to thrive.

The diagrammatic representation of this concept is shown in Figure 3-2, with particular note that "off-grid" solutions, as well as "non-infrastructure" solutions such as 'zero waste' are included.

The Government's response to the strategy supported two recommendations relating to infrastructure resilience supported in full (refer Figure 3-3). Later in this section, content on critical infrastructure definition aims to contribute to Recommendations 25a-25c. The Government's subsequent action plan (May 2023) further reinforces these recommendations.

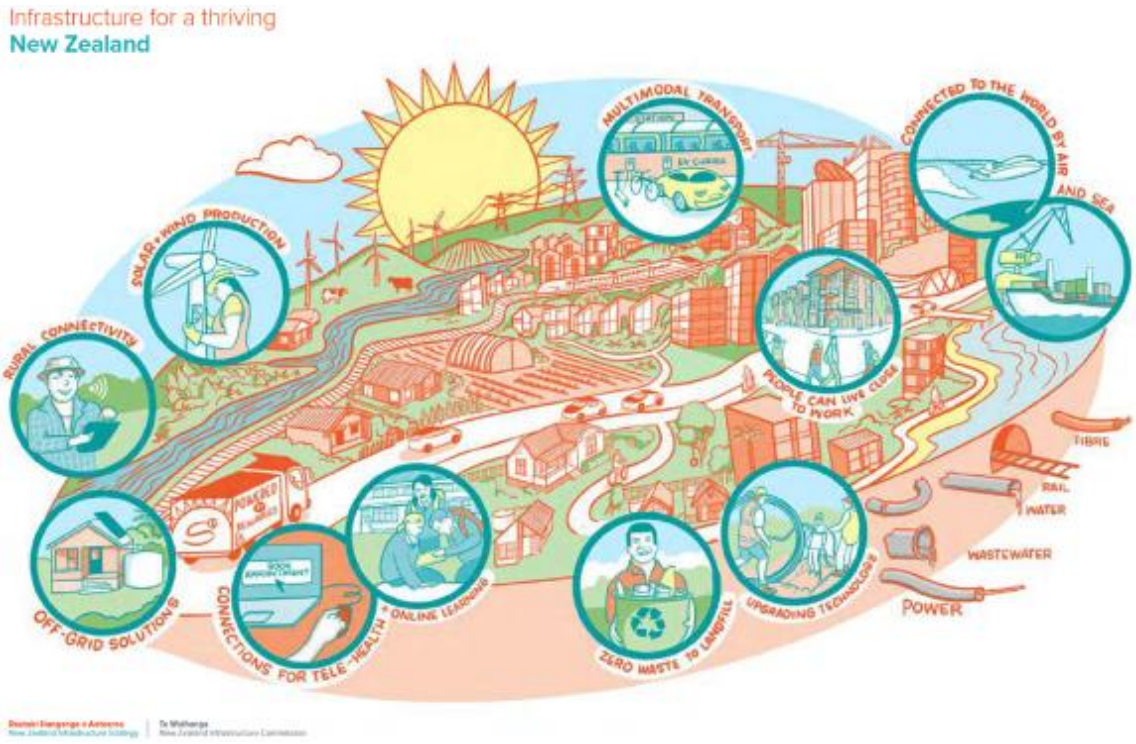


Figure 4-1: Infrastructure and Communities (New Zealand Infrastructure Strategy)

Recommendation 25	Increase the resilience of critical infrastructure
Recommendation description	To increase the resilience of critical infrastructure the government should: a Develop a principles-based definition of critical infrastructure. b Apply the definition of critical infrastructure consistently across the policy and legislative framework for resilience. c Develop the criteria to set infrastructure criticality levels and then identify New Zealand's critical infrastructure. d Clarify and strengthen requirements to identify minimum service levels for critical infrastructure in the event of an emergency. e adequately resource lead resilience agencies to carry out the functions required to support the delivery of critical infrastructure, on a consistent and long-term basis.

Recommendation 26	Improve infrastructure risk management by making better information available
Recommendation description	To make better information available to support risk management steps should be taken to: a Require regular disclosures of information about critical infrastructure preparedness and minimum levels of service in an emergency. b Resource the maintenance, upkeep and availability of research, information, datasets, and tools to support decision-making that enables resilience outcomes.

Figure 4-2: Government Responses to Infrastructure Strategy – Recommendations 25 and 26 'Supported in Full'

4.2 Policy Setting, Regulating and Funding Agencies

The following agencies have a key role in New Zealand's critical infrastructure resilience (Refer Table 6-1). Regulation and funding bodies specific to each sector are discussed in Section 4

Agency	Role (in relation to funding, regulation or policy relating to infrastructure resilience)
Civil Aviation Authority	Aviation safety and security regulator.
Commerce Commission	Enforce competition, fair trading and consumer credit contracts laws. Have regulatory responsibilities in the electricity lines, gas pipelines, telecommunications, dairy and airport sectors.
Climate Change Commission	Established in 2019 to provide independent, evidence-based advice to Government to help Aotearoa-New Zealand transition to a low-emissions and climate-resilient economy. One of their tasks is to undertake regular national climate-change risk assessments.
DPMC	The DPMC (Department of Prime Minister and Cabinet) Critical Infrastructure reforms unit is currently reviewing the settings for critical infrastructure in New Zealand.
Electricity Authority	Promote and regulate reliability in the electricity industry (except where regulated by the Commerce Commission), including security of supply and resilience. Provides support to the Security and Reliability Council and acts on their advice.
Toka Tū Ake EQC	A Crown entity that invests in natural hazard research and education, develops, supports and submits on policies relating to natural hazard risks, and provides natural hazard insurance to residential property owners.
Te Waihanga - Infrastructure Commission	Te Waihanga was established in 2019 to advise the Government on infrastructure delivery and planning at a strategic level to improve New Zealand's long-term economic performance and social wellbeing.
MBIE	Policy setting across telecommunications, electricity, gas, and building sectors.
Ministry for the Environment	The Climate Change Response Act empowers the Minister for Climate Change and the Climate Change Commission to request information from lifelines utilities about their climate change adaptation plans.
Ministry of Transport	Policy setting for the transport sector.
NEMA	National Emergency Management Agency - National emergency management through the 4R's of reduction, readiness, recovery and response.
Waka Kotahi	Standards and funding across State Highway network, part funding for local roads; regulation of rail.
Treasury	Government funding and oversight of the Infrastructure Commission.

Table 4-1: Agencies with Infrastructure Resilience Regulation or Funding Roles

4.3 Lifeline Utilities Resilience Programmes

Physical Network Resilience

New Zealand's infrastructure networks have all been designed to be resilient to varying degrees. Technical resilience is inherent in many networks through redundancy (multiple paths of supply) and robustness (design codes for strength). However, geographical constraints and the size of our population often makes redundancy impractical and unaffordable.

Most lifeline utilities have asset/activity management plans in place, with medium to long term investment programmes to renew and improve the networks.

In some parts of New Zealand, growth is both contributing to and reducing resilience. Growth has been a major driver for several investment programmes which will also add to network redundancy and resilience. However, growth also reduces the spare capacity of existing infrastructure.

Organisational Resilience

New Zealand's infrastructure resilience does not just apply to the physical lifeline networks – the infrastructure-owning organisations and the organisations on their supply chain need to be resilient. This brings many other aspects into consideration, such as financial resilience, leadership, the ability to adapt and customer awareness.

The organisational resilience of infrastructure service providers is increasingly recognised as a key ingredient to overall resilience improvement. The guidance, tools and products of Resilient Organisations (www.resorgs.org.nz) are strongly founded on advice and experience with infrastructure providers.

Resilience Investment

Some lifelines services are competitive (electricity generation, gas supply, liquid fuel supply and telecommunications), some are monopolies (electricity and gas transmission and distribution and Airways Corporation), and some are run as public services funded through taxes, levies or rates (roads and water supply).

These different business models give rise to different approaches to resilience. Investment decisions in some sectors are made on a purely commercial basis ("will the investment provide financial gain?"), in others, there are constraints imposed by the price-quality regulator. These models do not necessarily provide the best overall community outcomes.

All sectors operate with some level of financial constraint, and resilience projects compete with many others for funding.

4.4 National Infrastructure Programmes

While recognising major infrastructure investment is ongoing, **there is no national picture of required and planned investment specifically focussed on improving infrastructure resilience**.

The NZLC has attempted to compile information on significant resilience programmes and projects to provide this national picture in this report. However, most organisations 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.

There are also no nationally consistent standards for resilience applied to New Zealand's critical infrastructure, and little clarity on what acceptable levels of service are following different event scenarios.

4.5 Regional Lifelines Group Projects

The first Lifelines Project was initiated in Wellington in the late 1980s. This was followed by the commencement of projects in Christchurch (1993) and Auckland (1995) with similar projects following in several cities and regions over the following decade. Each Project typically culminated in the establishment of a Lifelines Group to progress and monitor recommendations arising from the Lifelines Projects.

Lifelines Groups support individual utilities through work programmes focussing on Risk Reduction, and Readiness / Preparedness for Response and Recovery. Specifically, Lifelines Groups:

- Undertake vulnerability studies to summarise and communicate information on individual utilities' vulnerability to hazards and interdependencies, together with identification of risk mitigation options[2].
- Identify collective risks and vulnerabilities (e.g., regional 'hotspots'), including establishing arrangements to manage issues arising.
- Promote best-practice approaches to preparation for response and recovery, including through Lifeline Utility co-ordination.
- Help build relationships amongst utilities and between utilities and CDEM Groups – good relationships are most valuable in emergencies.
- Improve CDEM-critical customers' understandings of utility failure likelihood and consequence.

Regional lifelines projects typically produce a summary of impacts and recovery times following scenario hazards, but the progression of mitigation work is left to the individual lifeline utility. A recent exception is the Wellington Lifelines Group Programme Business Case which compiled a coordinated and prioritised programme of infrastructure works to mitigate the region's vulnerability to earthquake and other hazards (a case study is presented in Part B, Section 7.2).

4.6 National Research Programmes

The research sector is a major contributor to our understanding of hazards, impacts of hazards on infrastructure and potential risk mitigation strategies. Many of these are collaborative initiatives with government and stakeholder agencies, such as major hazard-specific programmes described in previous sections. A significant amount of research is being undertaken through the National Science Challenges and QuakeCoRE.

Case studies summarising the outcomes of major research programmes are included in the relevant 'hazard' section in Section 7.

The National Science Challenges (mainly "Resilience to Nature's Challenges", "Better Homes, Towns and Cities", and "Deep South" (Climate Change)) includes substantial multi-organisation research programmes aimed at infrastructure resilience.

Other major research programmes are summarised in Attachment 4.

[2] A standard terms of reference for Vulnerability Studies is in NZLC's DropBox. The studies should be refreshed every 5 or 6 years and preferably be aligned with CDEM Group Plans.

Project	Typical Scope
Lifelines Vulnerability and Risk Assessment	Documented outputs include: • Descriptions of critical lifeline infrastructure and hazards in the region • GIS viewers showing lifeline layouts and positions of main community service sites • Regional lifelines interdependency analysis • Assessment of the vulnerability/risk of infrastructure to the hazards and interdependencies including estimates of recovery times • Mitigation options and suggested ongoing work programme for the Lifelines Group *Examples – Manawatu-Whanganui, Taranaki Lifelines Vulnerability Project Reports.*
As above – plus Regional Infrastructure Resilience Business Case	• Quantitative hazard / asset risk modelling to identify asset damage and service loss. • Identification of mitigation projects. • Economic modelling to show loss impacts with and without mitigation proposals (quantification of benefits of mitigation programmes). *Example reports - Wellington Business Case*
Regional Critical Sites Lists	• A schedule of 'nationally' and 'regionally' critically sites from the lifelines and other critical community sectors (health, emergency services, emergency management). • Typically held in spreadsheet or GIS form with information about site importance, electricity / fuel backup arrangements.
Hotpots and Pinchpoints Analysis	Often as a follow-on to vulnerability assessment projects, this involves: • Identification of hotspots through visual assessment of mapped critical infrastructure or GIS analysis. • Risk assessment of identified hotspots and pinch points to identify highest risk areas. Can include: • Development of response plans or identification of mitigation measures. *Example reports – WeLG Thorndon Critical Area, Auckland Hotspots.*
Organisational Resilience Benchmarking	• Two tools have been used by lifelines groups for this purpose – the NEMA Lifelines Capability Assessment Tool (Auckland, Northland) and ResOrgs online tool (BoP). • Process has identified improvements both at a lifelines / CDEM sector level and for individual lifelines.
Shared resource Dependencies	• This project involved identifying each utility's service providers and where there may be conflicting priorities in an emergency. *Example report: WeLG Emergency Resource availability.*

Table 4-2: Recommended Lifelines Group Foundational Projects

5. Next Steps

This section identifies gaps in our understanding of critical lifelines and community infrastructure and their vulnerability to hazards. Areas of further work are recommended to close these gaps – many of these are well beyond the resources of Lifelines alone but are considered nationally important to guide infrastructure investment to meet community needs and expectations.

5.1 Key Issues and Opportunities

The following knowledge gaps and opportunities have been developed through engagement with NZLC members and stakeholders in the development of this report.

- **No mechanism for prioritising investment across infrastructure networks** and decisions between investment in new assets or renewal/repair of existing assets.
- **Limited understanding of the cumulative impacts and implications of climate change on infrastructure** in the near to long term, particularly coastal and river flooding, intense rainfall, landslides, wind, rising groundwater and the emergence of compound hazards (combinations of these hazards coinciding or being sequential).
- **Lack of a national level understanding of acceptable risk/service levels** for critical national infrastructure (e.g., defined resilience standards).
- **Limited information available on nationally significant customers' dependence on lifelines** and availability of backup arrangements (e.g., alternate telecommunications, backup generators). This is also a gap at regional and local levels.
- **Low level of customer and community awareness of potential duration of infrastructure outages** in a major disaster.
- **Understanding the vulnerability of key supply chains for lifeline utilities,** such as bitumen supply for roads, availability of aggregate, Bailey Bridge stocks, availability of critical components and access to critical skills.
- **Knowledge of the vulnerability of networks to malicious cyber-attack,** though this is not recommended as an area of NZLC work as it is covered in the DPMC security function.
- **Opportunity for further work on translating research into practical guidance** such as damage matrices and volcanic ash posters.
- **Areas of limited hazard vulnerability assessment information** in this report – rural fires, disruptive technologies, cyber-attack, space weather, satellite GNSS system failures, malicious acts.
- **Limited information on vulnerabilities in the 'new' critical infrastructure sectors -** solid waste, Financial/Cash Payments, data centres and flood protection systems.

5.2 Areas of Further Work

This report represents a strategic overview of critical national infrastructure and its vulnerability to hazards, drawing largely on existing documented information and advice from lifelines organisation. There are many areas of further work to address the knowledge gaps above.

1. **Further develop the critical infrastructure thresholds and criteria,** including testing these against the multi-criteria critical model developed by Treasury.
2. **Develop a national model of critical infrastructure,** to support vulnerability assessment and modelling economic impacts of critical national infrastructure failures (and cost/benefit of mitigation programmes).

3. **Develop a national view of resilience investment programmes** and use a national model of critical infrastructure (above) to support prioritisation of resilience funding across sectors.
4. **Support regional lifelines groups to undertake the foundational projects** described in Section 2.6, particularly regional vulnerability assessments.
5. **Extend the "Resilience Programme Business Case" approach to all regions in New Zealand**, to confirm regional vulnerabilities, consider infrastructure interdependencies, raise awareness of service outage durations, take a community wellbeing perspective and assess the relative merits of various infrastructure investment options.
6. **Review and map knowledge gaps identified in this report** against existing research programmes to identify which are and are not being addressed.
7. **Include more of an overview of national information** on the resilience of wastewater, stormwater, flood protection, solid waste and Financial/Cash payments sectors in the next update of this report.
8. **Further information and analysis of the impact of new technologies,** as both resilience opportunities and challenges, in the next update of this report.

5.3 Recommendations

To progress the issues, opportunities and further work identified above, it is recommended that:

1. This national critical infrastructure vulnerability assessment report gets periodically updated to maintain it as a current position on NZ'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, to recognise infrastructure interdependencies and prioritise investment across all infrastructure.
4. Lifeline Utilities, the government, businesses and communities use the information in this report to review and update their own risk mitigation and preparedness programmes.
5. The New Zealand Lifelines Council:
    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 continue 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.

Attachment 1: List of Acronyms

AEP	Annual Exceedance Probability
AF8	Alpine Fault 8
AMP	Asset Management Plan
ARI	Annual Recurrence Interval
ARP	Average Return Period
ATM	Automatic Teller Machine
AVF	Auckland Volcanic Field
AUFLS	Automated Under Frequency Load Shedding
CAA	Civil Aviation Authority
CBD	Central Business District
CDEM	Civil Defence Emergency Management
DART	Deep-ocean Assessment and Reporting of Tsunami
DEVORA	Determining Volcanic Risk in Auckland
DIA	Department of Internal Affairs
DMR	Digital Microwave Radio
DPMC	Department of Prime Minister and Cabinet
DSCC	Deep South (Climate Change)
DSP	Digital Subscriber Line/Loop
ESAS	Exchange Settlement Account System
FENZ	Fire and Emergency New Zealand
FM	Frequency Modulation
FMCG	Fast Moving Consumer Goods
FMI	Financial Markets Infrastructure
GBNA	Ground-Based Navigation Aids
GCSB	Government Communications Security Bureau
GDP	Gross Domestic Product
GEO	Geo-stationary satellites
GIC	Gas Industry Company
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GXPs	Grid Exit Points
HDPE	High Density Poly-Ethylene
HVCS	High Value Clearing System
HVDC	High-Voltage Direct Current
ICT	Information and Communications Technology
IDMF	Investment Decision-Making Framework
IEA	International Energy Agency
LEO	Low Earth Orbit
LGNZ	Local Government New Zealand
LiDAR	Light Detection and Ranging
LINZ	Land Information New Zealand
LMN	Land Mobile Networks
LMRS	Land Mobile Radio System
LNG	Liquified Natural Gas
LPG	Liquid Petroleum Gas
MBIE	Ministry of Business, Innovation & Employment
MERIT	Measuring the Economics of Resilient Infrastructure tool
MfE	Ministry for the Environment
MVNO	Mobile Virtual Network Operators
NCCRA	National Climate Change Risk Assessment
NCMC	National Crisis Management Centre
NCSC	National Cyber Security Centre
NDRS	National Disaster Resilience Strategy
NEMA	National Emergency Management Agency
NOC	Network Operations Centre
NPDC	New Plymouth District Council
NSHM	National Seismic Hazard Model
NZLC	New Zealand Lifelines Council
NZTA	Waka Kotahi - The New Zealand Transport Agency
ONF	One Network Framework
ONT	Optical Network Termination
PCE	Parliamentary Commissioner for the Environment
PELoS	Planning Emergency Levels of Service
RBI	Rural Broadband Initiative
RCG	Rural Connectivity Group
RLTP	Regional Land Transport Plan
RMA	Resource Management Act
RNIP	Rail Network Investment Programme
RNZAF	Royal New Zealand Air Force
SAFER	South Island/Te Waipounamu Alpine Fault Earthquake Response
SBAS	Satellite-Based Augmentation System
SBI	Settlement Before Interchange
SCE	Sector Coordinating Entity
SES	Satellite Earth Station
SOE	State Owned Enterprise
SWIFT	Society for Worldwide Interbank Financial Telecommunication
TCF	Telecommunications Forum
TEF	Telecommunications Emergency Forum
TGA	Tasman Global Access
EQC	EQC Toka Tū Ake Earthquake Commission
TSO	Telecommunications Service Obligations
TVZ	Taupō Volcanic Zone
UAV	Unmanned Aerial Vehicle
UFB	Ultra-fast broadband
UHF	Ultra-High Frequency
USAR	Urban Search and Rescue
VEI	Volcanic Explosivity Index
VHF	Very High Frequency
WISP	Wireless Internet Service Provider

Attachment 2: Glossary

Term	Definition
Asset	The physical hardware (e.g., pipes, wires), software and systems to own, operate and manage Lifelines Utilities (energy, transport, telecommunications, water). In the broadest sense this includes utility business owners, operators and contractors.
Asset Management Plan	A document that specifies the activities, resources and timescales required for an individual asset, or a group of assets, to achieve the utility's asset management objectives. 3F[3] *Note:* May extend to information on funding plans.
Consequence	The impact of a supply outage on direct customers, usually extending to include the downstream impacts of the outage on society as a whole.
Critical Assets (Sites / Facilities / Routes)	Assets that have a high consequence of failure with potentially significant consequences to societal wellbeing. *Note:* Both Infrastructure and community sites/facilities will generally feature in regional lifelines group critical sites/facilities lists. 4F[4] A broad criticality rating of *Nationally Significant, Regionally Significant and Locally Significant* has been used.
Critical Customer	An organisation that provides services deemed critical to the functioning of communities and that rely on lifelines services to function. For this report, these include emergency services, health, banking, Fast Moving Consumer Goods and Corrections services, as well as the lifeline utilities themselves.
Emergency	A situation that ▪ is the result of any happening, whether natural or otherwise, including natural hazard, technological failure, failure of or disruption to an emergency service or a lifeline utility; and ▪ causes or may cause loss of life, injury, illness or distress, or endangers the safety of the public or property; and ▪ cannot be dealt with by emergency services, or otherwise requires a significant and co-ordinated response under the Civil Defence Emergency Management Act 2002. *Paraphrased from the Civil Defence Emergency Management Act 2002*
Event	An occurrence that results in, or may contribute substantially to, a utility supply outage (i.e., an inability to continue service delivery). *Notes:* This informal term is often used by lifeline utilities to refer to the onset of a hazard or an emergency. Events can be 'external', i.e., something that happens to the utility, or 'internal', i.e., a breakdown within the utility.
Exposure	The extent to which an asset is potentially exposed to a hazard.

[3] Based on the definition in the ISO Asset Management Standard.

[4] A list in *The Guide to the National CDEM Plan* identifies these and other sectors and areas that should be prioritised in *response* and *recovery*.

Term	Definition
Four R's	Categories that form a framework for emergency planning and post-event actions. New Zealand's CDEM framework breaks down into four such categories: *Reduction, Readiness, Response and Recovery*. • *Reduction* means identifying and analysing risks to life and property from hazards, taking steps to eliminate risks if practicable, and, if not, reducing the magnitude of their impact and/or the likelihood of occurrence • *Readiness* means developing systems and capabilities before an *event* happens to deal with *risks* remaining after *reduction* possibilities have been put in place, including self-help and response programmes for the general public and specific programmes for *lifeline utilities,* emergency services and other agencies. The term *preparation* is sometimes used. • *Response* means actions taken immediately before, during, or directly after an *event* to save life and property and to help communities begin to recover. • *Recovery* means efforts and processes to bring about the immediate, medium-term, and long-term holistic regeneration and enhancement of a community after an *event.* *Paraphrased from the National CDEM Plan*
Global Navigation Satellite Systems (GNSS)	GNSS provides the positioning, navigation and the timing (PNT) of data exchange between/to users worldwide and is now used extensively in many of New Zealand's critical infrastructure sectors (e.g., transport and information and communications technology (ICT) networks).
Hazard	Something that may cause, or contribute substantially to the cause of, a utility performance failure. *Adapted from the CDEM Act 2002.*
Hotspot	Place where especially significant assets of different infrastructure utilities or sectors are co-located. *Notes: It is envisaged that the 'location' will be 'tight' – the underlying principle is 'if a hazard strikes here, several asset-types will be affected'. Bridges often offer good examples. There doesn't need to be a 'supply' relationship between the assets for a hotspot to exist. Simple co-location is the test.*
Interdependence	Relationship between infrastructure types characterised by one's need for supply from another in order for their service to function.
Lifeline Utility	Lifeline utilities own and operate the assets and systems that provide foundational services enabling commercial and household functioning. *Notes:* Lifeline utilities are defined formally in the CDEM Act to include those operating in the following sectors: electricity, gas, petroleum, telecommunications, broadcast media organisations, ports, airports, roads, rail, water, and wastewater. The term 'critical infrastructure' is sometimes used.
Lifelines Groups	Regional collaborations, typically bringing together representatives of utilities, the science community, emergency managers, emergency services and other relevant professionals, with the objectives of improving the resilience of the region's lifeline utilities. Lifelines Groups focus on the first two of CDEM's *Four R's*: *Reduction* and *Readiness*.
Likelihood	The probability that an event will occur. *Note:* Depending on the context, 'likelihood' can be applied either to natural hazard return periods (e.g., 1:100 year flood) irrespective of whether a supply outage results, and to *events* (essentially, outage-causing occurrences whatever the cause).

Term	Definition
Locally Significant	An asset or facility that, if it failed, would cause a loss of service of local impact (broadly, loss of service to more than 2,000-5,000 customers, or partial loss of service across the country). *Note:* The threshold for 'locally significant' used in regional lifelines projects has varied.
Mitigation	The asset-related or operations related steps of a utility to reduce or eliminate supply outages.
Critical National Infrastructure	An asset or facility that, if it failed, would cause a loss of service of national impact (refer Section 3 and Attachment 3 for further categorisation).
Pinch point	Utility asset or site where a satisfactory alternative is not available, and which is therefore essential to service delivery. *Note: A pinch point* is equivalent to a 'single point of failure' (a term sometimes used in telecommunications) or 'bottleneck' (a term often used in road transport).
Resilience	The state of being able to avoid utility supply outages, or maintain or quickly restore service delivery, when *events* occur. *Note: It is sometimes helpful to distinguish:* • 'technical' or 'asset-related' resilience: i.e., the ability of physical system(s) to perform to an acceptable/desired level (and beyond the design event to prevent catastrophic failure) when subject to a hazard event. • 'organisational' resilience: i.e., the capacity of an organisation to make decisions and take actions to plan, manage and respond to a hazard event in order to achieve the desired resilient outcomes. Adaptation by the utility following an outage-threatening event can be an important aspect of resilience. *Similarly, the broad 'service delivery' resilience focus adopted in this glossary draws attention to three components adopted by the New Zealand Lifelines Council):* • Robust assets (bringing in the engineering perspective) • Effective coordination pre-event and during response and recovery (participation in Lifelines Groups and sector coordination entities assist here) • Realistic end-user expectations (utilities have roles in fostering an appreciation that occasional outages will occur) *The National Infrastructure Unit's (NIU's) description of resilience (one of its six 'guiding principles') is 'national infrastructure networks are able to deal with significant disruption and changing circumstances'. The extension to 'changing circumstances' broadens the interest to include pressures other than outage events.*
Regionally Significant	An asset or facility that, if it failed, would cause a loss of service of regional impact (broadly, loss of service to more than 20,000 customers, or partial loss of service across the region). *Note:* The threshold for 'regionally significant' used in regional lifelines projects has varied.
Risk	The effect of uncertainty in meeting objectives. Usually described as the combination of *likelihood* and *consequence*.

Term	Definition
Risk Management	A systematic process to identify, analyse, evaluate, treat, monitor, and review *risks* that cannot be reduced. *Notes: Risk management has an 'event-specific' emphasis, i.e., typically addressing identified risks – likely to be those where the likelihood and consequence are greatest. In common with business continuity planning, risk management may be undertaken both by utilities and by organisations that depend on infrastructure services.*
Vulnerability	The utility state of being susceptible to loss of utility service delivery/outages when *events* occur and being unable to recover quickly. *Notes: The serviceability loss could arise from a failure of the utility's assets or systems, or from any external event. Vulnerability and resilience can be regarded as opposite ends of a continuum.*
Vulnerability Study	A review of and report on utility *vulnerability*, generally undertaken at regional level by Lifeline Groups. *Notes: Vulnerability studies generally include description of interdependencies and may also identify hotspots and pinch points.*

Attachment 3: Infrastructure Criticality Framework

Work in Progress

Sector	Criticality	Critical Infrastructure Entities	Critical Functions	Critical Assets	Critical Infrastructure Thresholds
Energy - Electricity	National	System Operator (Transpower) Major Generators National Grid Owner (Transpower)	Operating a balanced national grid Facilitating an energy market Generating power, voltage and frequency control Transmitting electricity from generators to Grid eXit Points (GXP's)	Core Grid Infrastructure, inc. communications, data centres and control. Generation Infrastructure, inc. civil and structural Multi-regional distribution of infrastructure	Dependent community populations in excess of 200k Infrastructure serves >200MW of demand Has a "Black Start" or stability role Economic Losses of failure >$200M
Energy - Electricity	Regional	Grid Connected Generation National Grid Owner Lines Companies	Generating power Transmit and distribute electricity via GXPs and zone substations Managing demand	Generation infrastructure 50kV+, non-core-grid and sub-transmission electricity infrastructure Distribution communication and control Automatic demand management systems	Dependent community populations >50k Infrastructure serves >50MW of demand Economic Losses of failure >$50M
Energy - Electricity	Local	Lines Companies Embedded and Co-Generation Cos	Distribute electricity Managing demand Generating power	All other critical electrical assets (33kV and below) Generation Infrastructure Demand management systems	Dependent community populations >10k Infrastructure serves <>0MW of demand Economic Losses of failure >$10M
Energy - Fuel	National	Fuel Importers ('big 3') National Distributors (e.g., Allied)	Importing Fuel Pipelines supplying national airports	Bulk Fuel Wharves / Terminals (Marsden, Wiri, Tauranga, Centreport, Lyttelton). Major fuel pipelines (Marsden-Wiri, Wellington, Christchurch port to city).	Fuel import > l/day? Tank storage volumes > m3?
Energy - Fuel	Regional	Other Major Fuel Retailers and Distributors	Tank storage at national ports.	Bulk Fuel Storage Tanks at other ports/wharves (New Plymouth, Dunedin, Bluff, …)	Tank storage volumes > m3? CDEM-Priority 1 Fuel Stations
Energy - Fuel	Local	All Retailers and Distributors	Regional Priority Fuel Stations	All assets – retail outlets, storage	
Energy - Gas	National	Major Gas Producers Gas Transmission Owner	Generating gas Transmitting gas to cities	Major Production Facilities North-South Transmission Line (to Auckland, Wellington)	Supplies > 500,000 customers, or > … demand (for electricity, this is 200MW) *this takes into account large, nationally significant customers.*
Energy - Gas	Regional	Gas Transmission Owner	Gas transmission to reticulated towns and large essential industry. Major gas storage facilities (South Island)	Other transmission lines Bulk gas storage (?)	Supplies > 100,000 customers, or > … demand *this takes into account large 'regionally significant' customers.*

Sector	Criticality	Critical Infrastructure Entities	Critical Functions	Critical Assets	Critical Infrastructure Thresholds
Energy - Gas	Local	Gas Distribution Owner	Distribute reticulated gas. Distribute and store bottled gas.	Gas distribution lines feeding critical customers Bottled gas storage centres.	Supplies > 20,000 customers, or > … demand *this takes into account large 'locally significant' customers.*
Water - Water Supply	National	Water / Local authorities	Supply, store and distribute potable water	Major sources, treatment plants, trunk mains with limited redundancy.	Supplies > 100,000 customers
Water - Water Supply	Regional	Water / Local authorities	Supply, store and distribute potable water	Major sources, treatment plants, trunk mains	Supplies > 20,000 customers or critical (national) customer
Water - Water Supply	Local	Water / Local authorities	Supply, store and distribute potable water	Source / treatment / storage / trunk main assets with limited redundancy.	Supplies > 2,000 customers or critical (regional) customer
Water - Wastewater	National	Water / Local authorities	Collect, treat and safely discharge wastewater	City treatment plants, limited redundancy.	Supplies > 1M customers
Water - Wastewater	Regional	Water / Local authorities	Collect, treat and safely discharge wastewater	City treatment plants with limited treatment / disposal options, pump stations, bulk mains.	Supplies > 100,000 customers
Water - Wastewater	Local	Water / Local authorities	Collect, treat and safely discharge wastewater	Large town treatment plants with limited treatment/ disposal options, pump stations, bulk mains.	Supplies > 10,000 customers
Water - Flood Protection	National	Local authorities		Stopbanks protecting major urban populations.	? Protects > ? Dwellings Protects > ? $land
Water - Flood Protection	Regional	Regional / Local Councils		Stopbanks protecting urban populations and significant economic activity.	? Protects > ? Dwellings Protects > ? $land
Water - Flood Protection	Local	Regional / Local Councils		Stopbanks protecting small urban areas or large mixed-use areas or high value cultural areas	? Protects > ? Dwellings Protects > ? $land
Transport - Roads	National	NZTA-Waka Kotahi	Roads connecting city populations and critical national infrastructure sites.	State Highways (national) State Highways (regional) long detour times	ONRC = National ONF M1, long detour
Transport - Roads	Regional	NZTA-Waka Kotahi, local authorities	Roads connecting major populations and critical regional infrastructure sites	State Highways (regional) Local roads servicing critical national customers.	ONRC = Regional ONF M1 ONF M2, long detour
Transport - Roads	Local	NZTA-Waka Kotahi, local authorities		Local roads servicing critical regional customers.	ONRC = Arterial
Transport - Air	National	Major Airport Owners Airways New Zealand	International air connections. Navigation control and safety.	International Airports – runway, terminal. Navigation Aids International Airports National Control Centres	Auckland, Wellington, Christchurch, Queenstown, Ohakea Christchurch, Auckland.
Transport - Air	Regional	Airport Owners Airways New Zealand	Inter-city and major tourist destination connections. Navigation control and safety.	Regional and Strategic Airports – runway, terminal Navigation Aids Regional Airports	Dunedin, West Coast, all other regional airports?

Sector	Criticality	Critical Infrastructure Entities	Critical Functions	Critical Assets	Critical Infrastructure Thresholds
Transport - Air	Local	Airport Owners		Airports	All airports with sealed runway?
Transport - Rail	National	KiwiRail Auckland Transport GWRC	Rail freight to national ports. Rail commutes to major cities.	National trunk lines (inc. inter-island) Rail to major national ports (Tauranga, Auckland, Hamilton, Wellington, Picton). Wellington, Auckland metro lines and Hub train stations National Control Centre	> ? freight > ? Passengers
Transport - Rail	Regional	KiwiRail Auckland Transport GWRC		Rail to regional ports. Train stations on metro lines	> ? freight > ? Passengers
Transport - Rail	Local				> ? freight > ? Passengers
Transport - Sea	National	National Port Owners (Port of Tauranga, Auckland Council, Channel Infrastructure (Marsden), GWRC / CentrePort, MDC / Port of Marlborough.	Transporting freight internationally. Transporting rail freight inter-island.	Wharves / cranes: Tauranga, Auckland, Marsden, Wellington, Picton.	> ? Freight
Transport - Sea	Regional			Wharves / cranes: Lyttleton, Northport, Invercargill, Timaru, Nelson	> ? Freight
Transport - Sea	Local			Wharves / cranes: other ports / wharves with local economic or emergency management significance (e.g., evacuation point).	> ? Freight
Telecommunications	National	Southern Cross Cable, Hawaiiki, ? Chorus, Spark, Vodafone, 2degrees	111 Services. Emergency Service channels.	International cables / landing points / cable stations. Core trunk fibre network Major exchanges / POIs	? Supplies > 200,000 customers
Telecommunications	Regional	Chorus, Spark, Vodafone, 2degrees, Tua Tahi Fibre		Core trunk fibre network Major exchanges / POIs	? Supplies > 50,000 customers or critical (national) customer
Telecommunications	Local				
Solid Waste	National	Large city councils and waste management operators	Waste disposal, recycling, re-use.	Large city landfills with long drive to alternate disposal.	> ..m3 waste disposed / day
Solid Waste	Regional	Large district councils and waste management operators	Waste disposal, recycling, re-use.	Other large regional landfills with long drive to alternate disposal.	> ..m3 waste disposed / day
Solid Waste	Local	Councils and waste management operators.	Waste disposal, recycling, re-use.	Operating landfills and major transfer stations.	> ..m3 waste disposed / day

Sector	Criticality	Critical Infrastructure Entities	Critical Functions	Critical Assets	Critical Infrastructure Thresholds
Food Production / Distribution	National	Progressives, Foodstuffs, Fonterra	Food Production Food Storage	Distribution Centres (Auckland, Palmerston North, Christchurch). Largest Fonterra sites?	
Food Production / Distribution	Regional	Progressives, Foodstuffs, Fonterra	Food Production Food Storage		
Food Production / Distribution	Local	Progressives, Foodstuffs, Fonterra			
Financial Payments	National	Reserve Bank Major Banks	Enabling electronic financial payments.		
Financial Payments	Regional	Second tier banks			
Financial Payments	Local				
ICT?	National	Data Centre Owners?			
ICT?	Regional				
ICT?	Local				

Attachment 4: Major Research Programmes

Programme/ Host Provider	Future Work
AF8	▪ Next phase being scoped for further funding.
Deep South Science Challenge	▪ Next phase being scoped for further funding.
DEVORA	▪ Major project supported by Toka Tū Ake EQC and Auckland funding, with co-funding from a number of additional organisations: ▪ Governance around unrest and eruption (PhD shared with RNC2); ▪ Crustal structure for clarity around magma ascent (PhD); ▪ Novel monitoring opportunities for earlier magma detection and reduced uncertainty (working group); ▪ Unrest and eruption decision support for emergency management (PhD); ▪ Eruption gas dispersion and impacts (MSc/PhD); ▪ Calculation of risk and loss from Auckland eruption scenarios, and initiation of probabilistic approach (PhD).
ECLIPSE	ECLIPSE is working with CDEM, Lifelines and local Iwi to co-produce: ▪ A decision support and planning framework for unrest and eruptions. ▪ Unrest and eruption scenarios for the area from Taupo to Tarawera. ▪ Impacts (including to infrastructure) from both unrest (earthquakes, tremor, ground deformation, geothermal changes, landslides) and the wide range of eruption hazards in the central Taupo Volcanic Zone caldera complex area. ▪ A wide range of physical science related to the magma systems and interaction with fault-lines and earthquakes to reduce uncertainty in the next unrest episode.
GNS Science	▪ Member of the MBIE-led governance group overseeing the update to the National Seismic Hazard Model (NSHM). ▪ Major projects supported through MBIE's Strategic Science Investment Fund: ▪ A multi-year project is on-going to develop an end-to-end framework demonstrating various aspects of hazards and risk management including impact, recovery, risk communication and risk governance. The research supports scientifically advanced models for regional cascading hazard and impacts on physical/social/economic environment from a Hikurangi subduction event. ▪ Current research on infrastructure networks: A computational platform in the form of a decision support system (DSS) is being developed to analyse infrastructure networks including their interdependencies to determine service disruptions and recovery time after a hazard event for regional scale networks. The DSS can link with RiskScape damage models and generates outputs required for socio-economic modelling. DSS provides user-friendly platform to run several 'what-if' scenarios required for decision making. ▪ Research is underway to apply probabilistic methods to assess and generate heatmaps of potential impacts in regional networks. The research is supported by GIS platform and associated tools.

Programme/ Host Provider	Future Work
East Coast Life at the Boundary (East Coast LAB)	▪ East Coast Life at the Boundary (East Coast LAB) is a collaborative programme that brings stakeholders together across the East Coast to foster well connected research to increase understanding of the plate boundary and associated natural hazards, e.g., earthquakes & tsunami. Outcomes include: ▪ Publication of the Hikurangi Response Planning Toolbox (from the Hikurangi Response Planning project), to help inform and advance response planning for a large Hikurangi Subduction Zone earthquake and tsunami. ▪ Building on the Hikurangi Response Planning project, research is proposed with Toka Tū Ake EQC and GNS improving tsunami loss modelling capability in programs like RiskScape by building a set of scenarios. ▪ Proposed recovery research through Massey University to ensure councils make adequate provisions for the costs of a potential disaster in terms of the recovery process, and development of a framework to improve the economic resilience and recovery of businesses after large disasters.
NIWA	▪ RiskScape: continual development of a multi-hazard risk modelling software application. Current development focuses on deterministic and probabilistic modelling functions, compatible with all infrastructure network components. ▪ Hazard Vulnerability and Impacts: post-event investigations of flood (fluvial and coastal) and tsunami hazard impacts for building and infrastructure component vulnerability function development. National and local level assessments of hazard exposure and impacts from flood and tsunami hazards under current and future climate scenarios. ▪ Adaptation to coastal change: guidance on adaptive design of infrastructure, serious games for decision-making under climate uncertainty, updated sea-level rise trends and projections (with the NZ SeaRise Programme, Victoria University of Wellington): https://www.searise.nz/ ▪ Flood hazards: national flood hazard and risk models and implications of climate change (Mā te haumaru ō te wai: Increasing flood resilience across Aotearoa MBIE Endeavour programme and ongoing strategic science funding) ▪ High Intensity Rainfall Design System (HIRDS v4): ongoing development of the tool for estimating future rainfall intensities for different rainfall durations (1 to 120 hours) for different average recurrence intervals: https://niwa.co.nz/information-services/hirds/help ▪ Versatile adaptation of coastal roads (Resilience Science Challenge with University of Auckland Civil and Environmental Engineering) – development of more adaptive and versatile response options for coastal roads arising from ongoing sea-level rise and wave/storm surge overtopping. ▪ Coastal flooding (storm-tide and wave overtopping) forecast tools for low-lying coastal areas, connected to operational weather, wave and storm surge forecasting system EcoConnect. First pilot is being trialled in Christchurch.
Resilience Science Challenge – Built Environment	▪ Recently completed and upcoming projects summarised in a wiki page that is regularly updated - link.

Programme/ Host Provider	Future Work
Toka Tū Ake EQC	▪ Upgrading RiskScape (with GNS and NIWA) - (further details below) ▪ Member of the MBIE-led governance group overseeing the update to the National Seismic Hazard Model (NSHM). ▪ Supporting DEVORA, It's Our Fault and QuakeCentre programmes including infrastructure, buildings, land performance and hazards work. ▪ Supporting several local councils to identify and map liquefaction hazards and recently transferred its automated groundwater monitoring network of around 250 with high-tech sensors to the Christchurch City Council. ▪ Supported a 2-3 year project led by MBIE on updating the National Seismic Hazard Model, working with GNS Science, Universities, and other govt agencies. Design loading standards are now being assessed by MBIE following this update. ▪ Supporting NZSEE in Phase 1 of developing a think piece for building design for the 21st century. ▪ Continued support for, and development of, the Natural Hazards Portal (www.naturalhazardsportal.govt.nz) - a public, self-service Natural Hazards Portal that houses comprehensive data and information on New Zealand's natural hazard risks and aims to enable more risk-informed decision-making.
Transitioning Taranaki to a Volcanic Future | He Mounga Puia	▪ TTVF | HMP is a five-year MBIE funded research programme that aims to enhance volcanic resilience in Aotearoa by co-creating risk management support tools that utilise new dynamic thinking and mātauranga Māori, all within the case study context of Taranaki Mounga.

Attachment 5: References

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It's Our Fault (https://www.gns.cri.nz/Home/IOF/It-s-Our-Fault).

MBIE Energy Information (www.mbie.govt.nz)

MERIT (Measuring the Economics of Resilient Infrastructure) (https://merit.org.nz)

Resilience To Nature's Challenges National Science Challenge (https://resiliencechallenge.nz)

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Additional Volcano Resources

Volcanic ashfall preparedness poster series:

Domestic poster series: https://www.gns.cri.nz/our-science/natural-hazards-and-risks/volcanoes/ash/
International poster series: https://volcanoes.usgs.gov/volcanic_ash/resources.html
Posters are available for the following sectors:

- Airport Operators
- Facilities Managers & Buildings
- Operators of Generators & HVAC Systems
- Power Plant Operators
- Power Transmission & Distribution System Operations
- Urban Cleanup Operations
- Water Supply Managers
- Wastewater Collection & Treatment Managers
- Road Network Operations
- Telecommunications Operators (domestic poster in development (2023), funded by the Auckland Lifelines Group)

General information on volcanic ash impacts:

https://volcanoes.usgs.gov/volcanic_ash/
A website/online encyclopaedia on volcanic ash impacts and mitigation that is maintained with the US Geological Survey, who host the site.

Resources on volcanic impacts on health:

https://www.ivhhn.org/ash-pamphlets
Information for the public in the form of pamphlets on the topics of: health hazards of volcanic ash, preparing for volcanic ashfall including clean-up, protection from breathing volcanic ash, and health hazards of volcanic gases, aerosols and acid rain.

Resources on health & safety in volcanic environments:

Auckland Lifelines Group report (2005): https://www.alg.org.nz/document-library/volcanic-ash-impacts/
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Endnotes

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