Manawatu-Whanganui Lifelines Project

A Vulnerability Assessment of Lifelines Infrastructure in Manawatu Whanganui

Final Report October 2016

MANAWATU-WANGANUI
EMERGENCY MANAGEMENT GROUP
CIVIL DEFENCE

PREFACE

Acknowledgements

This project has been convened and administered by the Manawatu-Whanganui Civil Defence and Emergency Management Group with funding support from the Ministry of Civil Defence and Emergency Management.

The project was managed by the following project team.

Project Chair: Braden Austin, Palmerston North City Council (Manawatu Lifelines Group Chair)
Project Sponsor and Administrator: Ian Lowe, Manawatu Whanganui Emergency Management Group
Project Manager and Plan Writer: Lisa Roberts, Infrastructure Decisions Limited

The contribution of time and effort made by the following organisations and staff is also gratefully acknowledged:

Chorus: Durry Benton
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This project has also drawn on information developed for the 2005 Manawatu-Whanganui Engineering Lifelines Project Report *Risks and Responsibilities* which was developed with contributions from the above agencies and a number of others. A full list of acknowledgements is included in that project report.

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 or misprint.

Most of the hazard information used for this project has been prepared at a regional scale and does not replace any requirement for detailed site-specific geological, geotechnical or other investigation. Readers of the report are advised to consult with Horizons Regional Council as to the suitability of hazard information used in this report for other applications.

Infrastructure information in this report is current at the time of application but ongoing changes will occur. Information in this report may not necessarily indicate the current state of hazard vulnerability or preparedness of the lifeline utilities described other than on the date this report was issued.

The lifelines infrastructure information in this report was provided by lifelines organisations themselves and the Manawatu-Whanganui Emergency Management Group is not responsible for the disclosures made or withheld. The decision as to which information to disclose was the responsibility of each individual utility.

CONTENTS

GLOSSARY

CDEM	Civil Defence Emergency Management.
Criticality	Criticality reflects the level of consequence of asset failure (not the likelihood of failure). The criticality rating system used for this project is described in Section 3.1).
Interdependency	In the lifeline utility sector context, interdependency relates to the dependence by all lifeline utilities on at least some of the other lifeline utilities. For example, electricity operators depend on telecommunications for coordinating response and recovery, telecommunications operators need electricity for plant to operate and fuel refineries depend on water supply for cooling.
Emergency	Means a situation that: ▪ Is the result of a happening, whether natural or otherwise, including without limitation, any explosion, earthquake, eruption, tsunami, land movement, flood, storm, tornado, cyclone, serious fire, leakage or spillage of any dangerous gas or substance, technological failure, infestation, plague, epidemic, failure of or disruption to an emergency service or lifeline utility, or actual or imminent attack or warlike act; and ▪ Causes or may cause loss of life or injury or illness or distress or in any way endangers the safety of the public or property in New Zealand or any part of New Zealand; and ▪ Cannot be dealt with by emergency services, or otherwise requires a significant and coordinated response under the Act. *CDEM Act 2002.*
Hazard	Has the same meaning as in section 4 of the CDEM Act and means something that may cause, or contribute substantially to the cause of, an emergency.
Hotspot	Hotspots are defined as areas where there are: ▪ a number of critical infrastructure assets from different sectors converge in an area. ▪ significant single points of failure for a network or organisation (also called 'pinchpoints').
Lifeline Utility (Lifeline Organisation)	A lifeline utility is an organisation that provides an essential service and is defined in Schedule 1 of the CDEM Act 2002, including water, wastewater, ports, airports, roads, rail, electricity, gas, petroleum, telecommunications, and broadcast media organisations.
Lifelines Groups	Lifelines Groups (sometimes referred to as Lifelines Engineering Groups or Lifeline Utility Groups) operate regionally and: ▪ undertake reduction and readiness planning (the lifelines group itself does not have an operational role in response and recovery) ▪ have members including lifeline utilities, scientists, emergency managers and other professionals.
Pinchpoint	*See hotspot*
Resilience	The state of being able to avoid utility supply outages, or maintain or quickly restore service delivery, when *events* occur.
Risk	The effect of uncertainty in meeting objectives. Usually described as the combination of *likelihood* and *consequence*.
Vulnerability	Potential for loss of service caused by a hazard.

1 EXECUTIVE SUMMARY

Project Overview

Lifeline utility organisations provide important services to the community, including telecommunications, transport, water and energy services. Following a major disaster, restoration of lifelines services is critical to a community's ability to recover from the event.

This report presents the outcomes of an assessment of the potential impacts on Manawatu-Whanganui's infrastructure from major natural hazard events and outlines potential mitigation measures to improve resilience to hazards in the lifelines sector.

The project updates the first regional lifelines vulnerability assessment completed in 2005 *(Risks and Responsibilities)* and uses the latest infrastructure and hazard information available. The approach has been to take a strategic, qualitative assessment of hazard-related lifelines risk focused on the region's most critical assets. The hazard information is available to individual lifelines organisations to undertake more detailed quantitative risk assessment and mitigation option development, as appropriate.

The Region's Critical Lifelines Infrastructure

For this project, lifelines organisations rated the criticality of their assets as nationally, regionally or locally significant, as defined in Section 3.1. Key points in relation to Manawatu-Whanganui's critical lifelines infrastructure include:

- With no significant fuel storage in the region, the fuel supply is almost completely reliant on the road network with fuel trucked in from ports in Wellington and Napier. Only 1-2 days supply is typically held in service stations.
- Most of the region's electricity is supplied from Bunnythorpe in the south, via transmission lines rated as regionally significant (Bunnythorpe is a critical pinchpoint in the North Island transmission network). The transmission lines from Taranaki provide an alternative (albeit reduced) supply for the region if those lines fail, as does the Tararua Wind Farm.
- Gas transmission lines running south from the Taranaki gas fields supply reticulated gas to the region and beyond (Hawke's Bay and Wellington).
- Three north-south fibre cables through the North Island (Chorus) provide diversity for each other. The Palmerston North exchange is regionally significant as it provides switching into a number of local exchanges in the region and the Levin exchange provides an important North Island – South Island link (though there are alternatives).
- Kordia's Wharite site provides telecommunications, broadcasting and radio services to and through the region and on to Taranaki.
- SH 1 and SH 2 (from Woodville north) and SH 57 (from Woodville south) are the nationally significant roads in the region. Manawatu Gorge remains a key vulnerability in the road network, at risk from both seismic and flood hazards.
- Other critical transport infrastructure includes the trunk rail lines, Palmerston North airport and the 'inland port' in Palmerston North which is one of three major food distribution centres in New Zealand.

Further details of critical infrastructure are provided in Section 3.

Lifelines Infrastructure Interdependencies

Many past hazard events have demonstrated the interdependencies that occur in the lifelines sector. In a widespread electricity failure, most fuel stations cannot pump fuel, wastewater pump stations start overflowing within hours and, as the duration of outage lengthens, telecommunications and water supplies are disrupted. This is certainly the case in Manawatu-Whanganui and the interdependency rating carried out for this project confirmed that electricity, roads and fuel are the services that most other lifelines rely on during business-as-usual.

In a major disaster, telecommunications and VHF radio become more important for other lifelines to coordinate and undertake response activities. Broadcasting and the internet is important for disseminating important public information.

These interdependency factors have been considered in the assessment of vulnerability to hazards as a lifelines organisation's assets may not be damaged but the failure of other networks could impact their services.

Lifelines Infrastructure Vulnerability to Hazards

Earthquakes

The Manawatu-Whanganui Region is geologically diverse with numerous potential earthquake sources. The region encompasses some of the most seismically active parts of New Zealand. Earthquakes have the potential to cause damage to infrastructure assets from surface fault rupture, land movement, ground shaking and liquefaction (differential ground settlement and lateral spreading).

Information used for this project to assess which assets were exposed to seismic hazards includes:

- Active faults sourced from the National Seismic model; in Manawatu-Whanganui the main faults include Ohakune, Raetihi, Wellington and the Ruahine Fault.
- Peak Ground Accelerations with annual exceedance probabilities of 1 in 500, 1 in 1000 and 1 in 2500 – generally showing that the risk is highest in the south east gradually reducing moving north.
- Large, pre-existing landslides, identified from a study of geomorphic features using aerial photographs in 2008.
- Regional scale liquefaction maps based on geological information, river gradient and historical liquefaction reports[1] (supplemented by more detailed models for the Palmerston North and Whanganui areas).

As concluded in the original 2005 lifelines project report, the seismic hazard is the most potentially damaging hazard from an infrastructure perspective with almost all lifelines services expected to suffer some level of damage in the 1:2500 year event. Restoration of major transmission lines, State Highways (or less damaged alternate local routes) and bulk water supplies will be a major focus in the first few days but temporary restoration of all services is likely to take days to weeks and full recovery of networks months to years.

Tsunami

Damage from tsunami is caused by the impact of the flowing water, debris impacts and inundation of salt water. The extent of damage therefore is highly variable and will depend on the scale of the debris.

There are a number of critical assets in tsunami risk areas – including electricity substations in Whanganui, wastewater treatment plants in Foxton and Koitiata and trunk telecommunications fibre cables crossing coastal bridges. The State Highway network only passes through tsunami risk zone across the Whanganui River, but a number of coastal local roads are at risk.

Volcano

There are three primary volcanic centres that could affect the region; Tongariro National Park volcanoes (Ruapehu, Ngauruhoe and Te Maari), Taupo Volcanic Centre and Taranaki volcano. Volcanic ash hazard maps were prepared for this study for each volcano for three approximate scenarios representing a 500, 1000 and 1,500 return period event.

Close source volcanic risks including lahars and eruptive material are not expected to pose a major risk to the region's critical lifelines assets. However volcanic ashfall will potentially impact on lifelines services in the projected ashfall areas to the north and west of the region, as follows:

- Ongoing electricity outages caused by flashovers, for the duration of the eruption, particularly in some wet conditions. Loading damage can occur with > 100mm ash (not expected to be at that level in the modelled scenarios).
- Disruption to both electricity and telecommunications control systems due to ash ingress into heating, ventilation and air-conditioning.
- Unsafe road driving conditions due to reduced visibility and traction with ash clearance and disposal required.

[1] Update of Hazard Information for 2015, Lifelines Risk & Responsibilities Report, GNS Science Consultancy Report 2016/40, May 2016.

- Increased turbidity in raw water sources causing operational problems at water treatment plants, accompanied by an expected high water demand during the cleanup phase.
- Potential ash entry causing clogging of sewer networks and damage to treatment plant and pump station assets.

Severe Weather

In a major storm event, the road network will be affected by flooding, scouring, washouts, slips and debris from high winds and the potential for isolation of communities and disruption to major routes was well evidenced in the 2004 floods.

Secondary affects due to transport impacts are the loss of access to infrastructure for repairs and restoration, particularly in the scenario of a regionally widespread severe storm.

The local electricity network is likely to be affected in multiple locations due to flooding, high winds and debris causing damage to lines, poles and pillar.

Telecommunications and broadcasting in the region are unlikely to be directly affected (unless fibre cables crossing river bridges are swept away). However the loss of power and damage to overhead telecommunication lines if there are high winds are likely to cause some service disruption.

Mitigating Lifelines Infrastructure Vulnerabilities

Since the original lifelines project was completed in 2005, a number of significant projects have been completed which reduce the vulnerability of infrastructure services in the region. For example, upgrades to Saddle Road (the main alternative to the Manawatu Gorge Road) are ongoing. These are detailed in Section 7, along with a list of further mitigation projects that are being considered in the future and which should become part of each organisation's asset management planning processes. It is intended that this project provide updated information for lifelines to review their risks and risk mitigation programmes.

Lifelines organisations also have ongoing programmes to mitigate the potential impact of hazards on their own networks, such as seismic screening programmes and regular critical asset inspections.

During the workshops held for this project, a number of areas of potential further work have been identified for the Manawatu-Whanganui Lifelines Group (or the CDEM Group), including more planning around emergency routes and fuel supply. Further projects are listed in Section 7.

2 INTRODUCTION

2.1 Scope and Purpose

Lifelines projects aim to assess the potential impacts of hazards on lifelines infrastructure and identify mitigation strategies to reduce that risk. Over the last 25 years, lifelines projects have been carried out in many regions in New Zealand. This project covers the jurisdiction of the Manawatu-Whanganui Civil Defence Emergency Management (CDEM) Group.

In Manawatu-Whanganui, the first lifelines project was undertaken in the early 2000s and completed in 2005 and was a significant undertaking culminating in the *Risks and Responsibilities* report. This report presents the findings of a project to update that work using the latest infrastructure and hazard information available.

The collaboration that occurs between lifelines organisations during the project enhances the understanding of each other's networks and operations and improves coordination across the sector in both preparedness and response to major hazards. In the words of the mission of the New Zealand Lifelines Council, this over-arching purpose of this lifelines project is to:

> *"Enhance the connectivity of lifeline utility organizations in order to improve critical infrastructure resilience."*

2.2 Lifeline Infrastructure

Lifelines organisations provide important infrastructure services to the community. The CDEM Act 2002 defines lifeline utilities as providers of water, wastewater, telecommunications, gas, electricity, fuel, road, rail. Other lifelines specified in the Act include TVNZ, Radio NZ and, in the Manawatu-Whanganui region, Palmerston North and Whanganui Airport.

2.3 Project Benefits

Through participation in this project, lifelines infrastructure providers achieve the following benefits - they:

- have the latest regional hazard information available (in GIS files where available);
- have maps of critical lifelines and community sites in the region (to enable them to take into account supply to these sites when prioritising their response and recovery);
- understand the likely impact of natural hazards on their assets and services; as well as on other utilities that they rely on (interdependency impacts);
- gain knowledge of potential mitigation measures to reduce vulnerability to hazards that can feed into long term asset management plans; and
- have the opportunity to facilitate communication with other lifelines organisations and critical community service providers about hazard mitigation and to establish 'pre-event' relationships.

The project also provides information to CDEM and other agencies involved in disaster response, as to the potential infrastructure impacts and recovery times in major disaster scenarios to assist in planning for these events.

The project outputs therefore support an improved, coordinated response to major hazards by and between CDEM agencies and lifeline utilities.

Finally, participation in the project helps lifeline utilities in meeting the requirements of the CDEM Act 2002, which include that each lifeline utility organisation must:

- ensure that it is able to function to the fullest possible extent, even though this may be at a reduced level, during and after an emergency;
- make available to the Director in writing, on request, its plan for functioning during and after an emergency;
- participate in the development of the national CDEM strategy and CDEM plans.

The Director's Guidelines for Lifeline Utilities and CDEM Groups (DGL 16/14) published June 2014 expand on these legislative requirements.

2.4 Project Methodology

Figure 2-1 illustrates the broad approach taken to assessing the vulnerability of Manawatu-Whanganui's lifelines infrastructure to natural hazards.

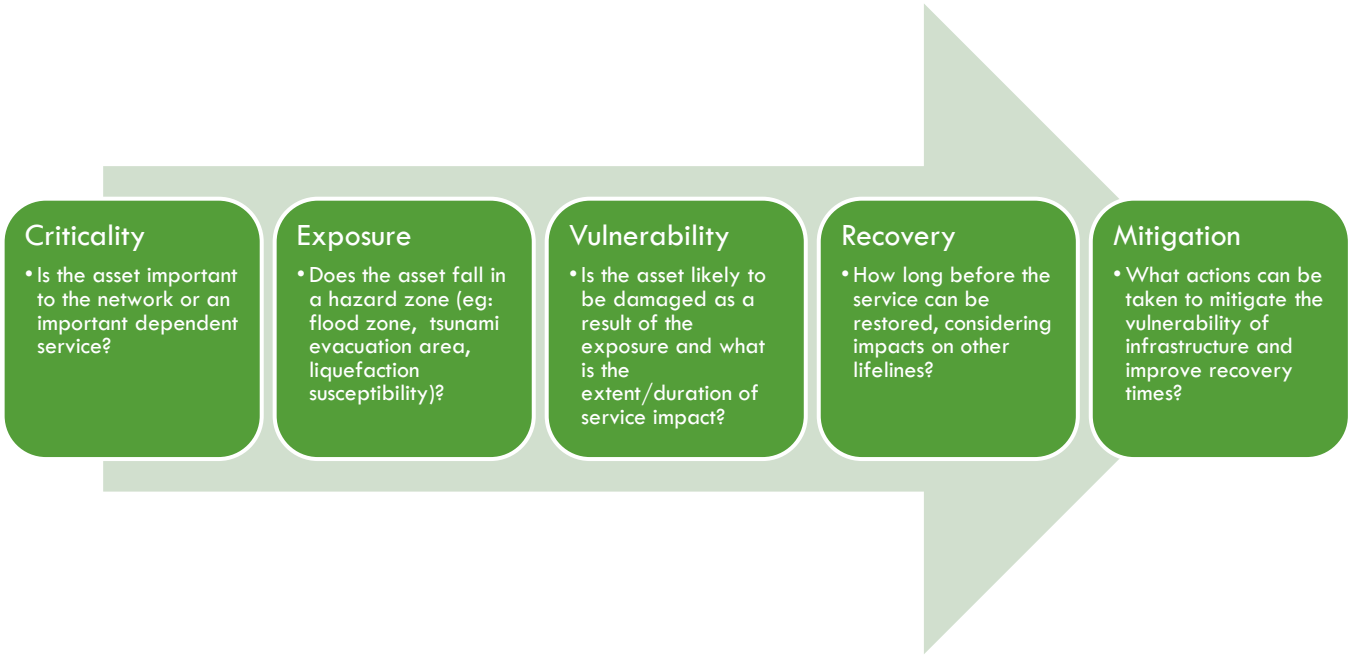


Figure 2-1: Overview of the Vulnerability Assessment Process

The methodology followed is summarised below:

1. Identification and mapping of critical lifelines infrastructure

   Each lifeline was asked to provide information on its critical infrastructure using the methodology described in Section 3.1, rating assets as nationally, regionally and locally significant.
   As a minimum, the data provided included spatial (locational information), asset type and a criticality rating. At the first project workshop, the criticality assessment process was discussed so that a reasonably consistent approach was taken across the lifelines sector.

2. Collection of regional hazard information

   The most accurate and recent hazard information was sourced as regional GIS layers, including tsunami evacuation zones, earthquake hazards such as liquefaction risk areas and active faults and modelled and historical flood inundation areas. Some further hazards analysis was commissioned to support the project, including volcanic ash scenario modelling and review of liquefaction risk areas[2].

3. Development of a GIS Viewer

   Horizons Regional Council GIS staff collated the infrastructure and hazard information into a set of regional GIS layers which were made available to lifeline utilities in a password-protected GIS viewer.

4. Assessment of infrastructure interdependencies

   An assessment was made of the dependency that each lifelines type had on other lifelines in order for its service to function, using a rating system described in Section 4.1. This information also informed the

[2] Update of Hazard Information for 2015, Lifelines Risk & Responsibilities Report, GNS Science Consultancy Report 2016/40, May 2016.

vulnerability assessment described in the next step, in that each lifelines recovery times were assessed considering service outage impacts of other lifelines they depended on.

5. Assessment of infrastructure exposure and vulnerability

   The GIS viewer enabled lifelines to identify where critical infrastructure assets fell within hazard areas. An assessment of the likely extent of damage arising from the hazard was made by lifelines representatives using a rating system described in Section 5 (ranging from minimal impact to total asset failure requiring full reconstruction). The lifelines further considered the extent of service area outage and recovery times arising from the asset failures.

6. Identification of Regional 'Hotspots' and 'Pinchpoints'

   The GIS viewer was used to overlay critical assets from all infrastructure sectors to identify where a number of them were co-located and in a hazard risk area, creating areas of particularly high vulnerability. Knowledge of lifelines representatives was also valuable for this assessment.

7. Identification of Potential Mitigation Options.

   Each lifelines organisation was asked to identify significant mitigation projects completed since the original lifelines project was undertaken, as well as further mitigation actions identified to further improve infrastructure resilience to hazards.

It is noted that the original lifelines project carried out in the 2000s included an individual analysis of asset components using a spreadsheet and a multi-criteria analysis risk scoring approach. This provided a useful multi-hazard ranking of the region's highest risk assets but was very time-intensive. The higher level approach taken for this project provides a more strategic view of the potential infrastructure impacts from natural hazards. It is envisaged that, when the next project review is undertaken, asset and hazard data may be of a suitable quality to support more detailed modelling using vulnerability assessment and economic impact tools.

3 MANAWATU-WHANGANUI'S LIFELINES INFRASTRUCTURE

This section provides an overview of the lifeline utilities in the Manawatu-Whanganui region, how they operate and critical assets in the network.

3.1 Critical Lifelines Infrastructure Assets

Each lifelines organisation in the region has categorised its assets as Criticality 1, 2 or 3 (***nationally, regionally*** or ***locally*** significant).

The approach is summarised in Figure 3-2 and further explained below.

In general, the criticality approach takes into account the number and type of customers affected, both directly and indirectly, if an asset fails.

The criticality rating reflects the consequences of failure, not the likelihood of failure under various hazard scenarios, i.e., just because it is in a flood prone area does not make an asset 'critical'.

If alternative arrangements can be put in place before serious financial and/or social problems emerge (e.g. within 4 – 8 hours) then the criticality can be reduced down one level. These alternatives might be either made available:

- by the utility themselves, through network reconfiguration, or
- by critical customers with alternative supplies on-site such as generators or water tanks that enable substantial functioning for longer than 2-3 days.

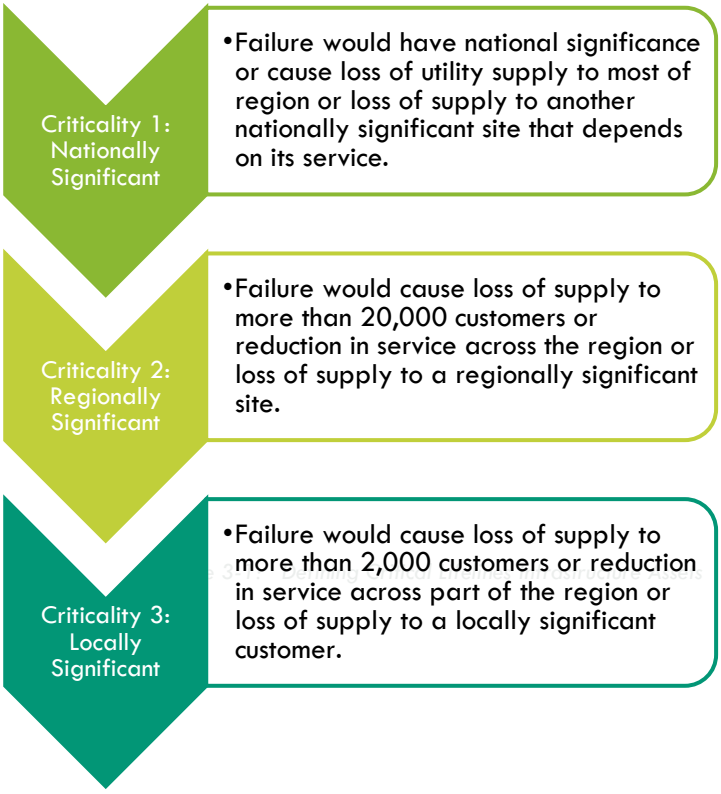


Figure 3-2: Critical Infrastructure Rating Approach

Note the term 'customer' refers to 'connections', 'households', or vehicles depending on the relevant sector.

3.2 Electricity

3.2.1 Sector Overview

New Zealand's national electricity grid is illustrated in Figure 3-3. Electricity networks are broadly comprised of:

- generation sources (grey nodes);
- Transpower's national transmission grid;
- electricity lines distributors which connect to the Transpower grid and distribute to consumers;
- electricity retailers - which buy wholesale electricity and sell to consumers (not part of the scope of the project as they do not operate network assets); and
- Consumers (demand nodes shown in blue).

3.2.2 Electricity Generation

The region's main power generation is the Tararua Wind Farm with around 160MW capacity. However, it requires supply from the National Grid to operate (ie in a major grid failure to the region it does not provide near source generation).

3.2.3 Electricity Transmission

Most of the region's electricity feeds into the region via major transmission lines from Bunnythorpe substation in the south.

Bunnythorpe is a nationally significant asset and a major switching point into the North Island grid from the South Island generation sites. If the site is inoperable there would be a significant load reduction to the central and north North Island. Therefore, Bunnythorpe is considered a 'pinchpoint' in the electricity network and is further discussed in Section 6.1.

From Bunnythorpe, the 220kV transmission lines through to Taranaki are considered to be regionally significant and 110kV lines are locally significant, while noting there is some redundancy and backfeed options around all these lines. The Transpower substations and Grid Exit Points (GXPs) along the 220kV circuits are also rated as regionally significant.

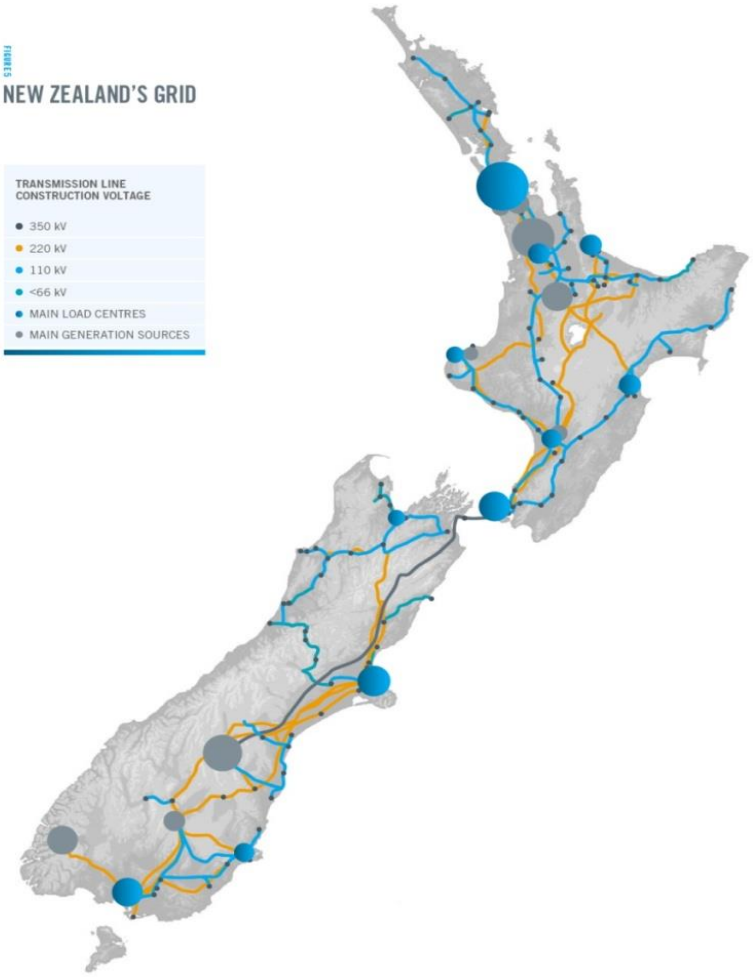


Figure 3-3 New Zealand's National Electricity Grid

3.2.4 Electricity Distribution

Four distribution companies operate in the region, providing assets and services as briefly described below:

Powerco

Powerco distributes electricity around most of the region including the main centres of Palmerston North and Whanganui. Powerco takes supply from the National Grid at Grid Exit Points at Bunnythorpe, Linton, Marton, Whanganui, Brunswick and Mataroa. Powerco distributes around the region via 33kV and 22kV network sub-transmission networks.

Powerco's electricity network comprises mainly overhead lines in rural areas and smaller urban centres with underground networks in the central city areas of Whanganui, Palmerston North and Feilding (the distinction becoming important when considering the vulnerability of underground versus overhead assets to various hazards).

Powerco has identified a number of substations as locally significant, with each supplying between 1,000 – 10,000 connections. The largest serve Palmerston North (Pascal Street, Main Street, Keith Street), Feilding (Feilding) and Whanganui (Peat Street).

Electra

Electra takes supply from the National Grid at Mangahao and distributes electricity to around 40,000 customers (connections) in Kapiti Coast and Horowhenua. It has rated its 33kV sub-transmission line and associated substations as locally significant.

The Lines Company

The Lines Company operates in a large part of the western region of the central North Island. Its coverage in the Manawatu-Whanganui region is the Ruapehu District area, with its largest zone substations in Ohakune and Taumarunui rating as locally significant.

Scanpower

Scanpower distributes electricity to around 7,000 customers (connections) in Dannevirke, Woodville and surrounding areas. It has two zone substations in Dannevirke and Woodville, however none of its assets meet the criticality rating criteria used for this project.

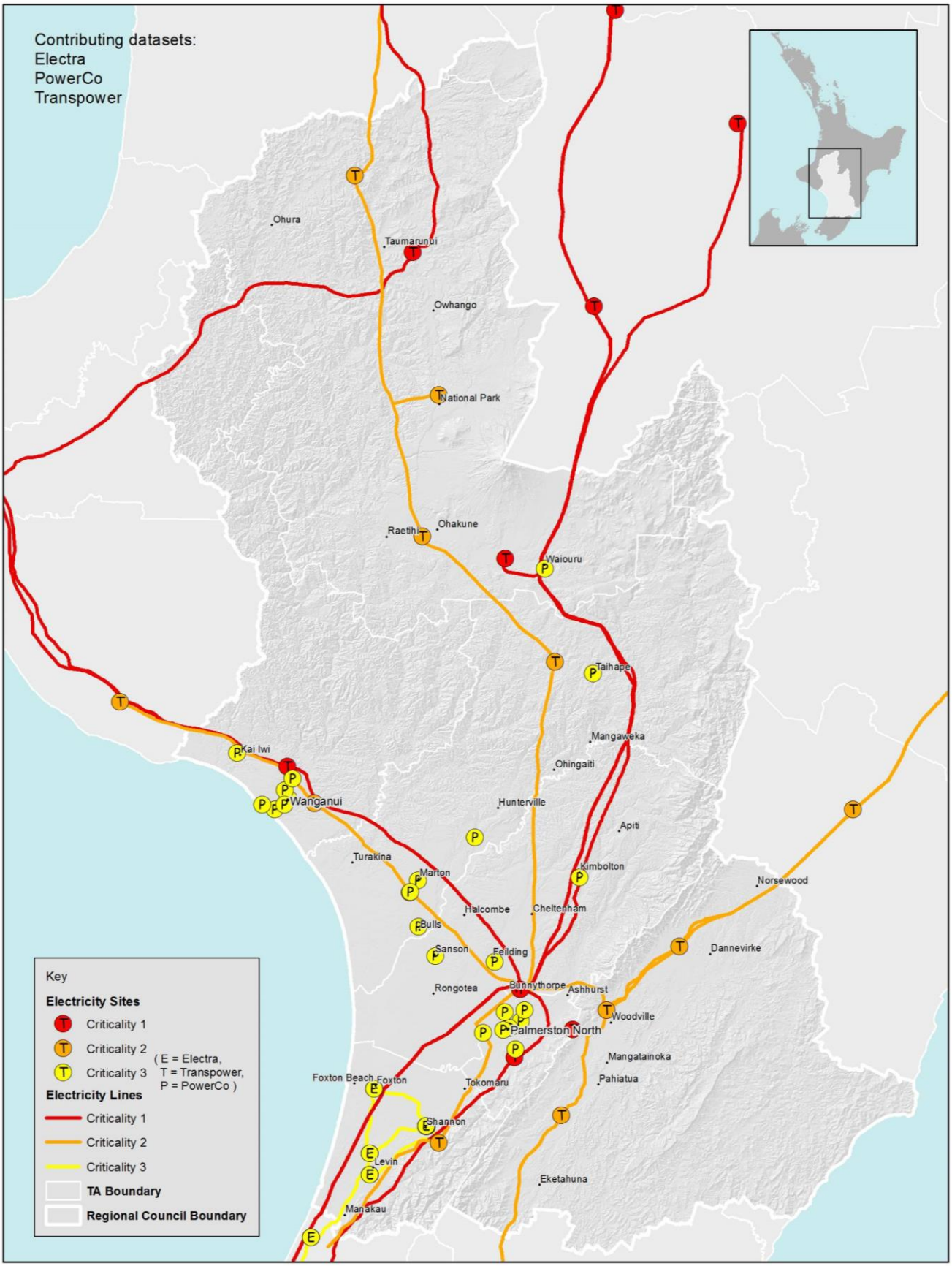


Figure 3-4: Manawatu-Whanganui Critical Electricity Assets

3.3 Fuel

3.3.1 National Supply Chain

Around 80% of New Zealand's fuel is refined at the Marsden Refinery, south of Whangarei, and distributed by ship to ports around the country (and by pipeline to Auckland) as illustrated in Figure 3-5. The remainder is refined overseas and shipped directly to ports from overseas sources.

Therefore Marsden Refinery, though it is not located in the region, is a critical fuel site for Manawatu-Whanganui and all of New Zealand.

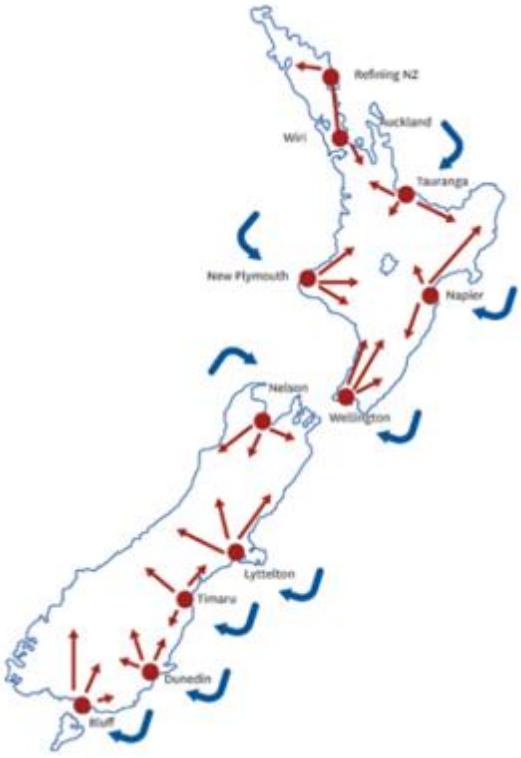


Figure 3-5: New Zealand's Fuel Supply Chain

3.3.2 Regional Fuel Storage and Distribution

There are no significant storage facilities for diesel, petrol or aviation fuels within the Manawatu-Whanganui region. Fuel is trucked into the region via terminals in Wellington and Napier to fuel stations and depots. Road access is therefore vital to the supply of fuel in the region.

There is no centralised database of fuel station information, however anecdotally it is believed that:

- Fuel stations typically hold 1-2 days' supply of fuel.
- Few fuel stations have backup generators on site however some others do have connectivity for generators.
- Whanganui DC holds some generators that can be made available to fuel stations.

3.4 Gas

Natural gas is an important source of energy in the New Zealand – while household consumers only use a small amount of the gas produced (<5%), it is critical to the electricity generation and petrochemical industries.

Natural gas in New Zealand is sourced from the gas fields in the Taranaki.

The region's gas supply is piped via the First Gas transmission lines shown in Figure 3-6 and distributed by Powerco Gas to networks in Palmerston North, Levin and Foxton and by Gasnet to networks in Whanganui, Marton, Bulls, Flockhouse, Waitotara.

There are no significant industrial users of natural gas in the Manawatu-Whanganui region, the major customers are considered to be the larger CBD areas.

The First Gas transmission network from Taranaki to the southern end of the region is rated as nationally significant as it supplies Palmerston North as well as customers further south (notably Wellington).

The First Gas transmission line running inland to the east is rated as regionally significant (Criticality 2).

Powerco has identified four regionally significant sites – pressure regulating sites servicing Palmerston North – and four locally significant sites – pressure regulating sites servicing Levin and the pipe to Manawatu Prison.

Gasnet identified 3 main sites servicing Whanganui as regionally significant and a number of locally significant sites (refer Figure 3-6).

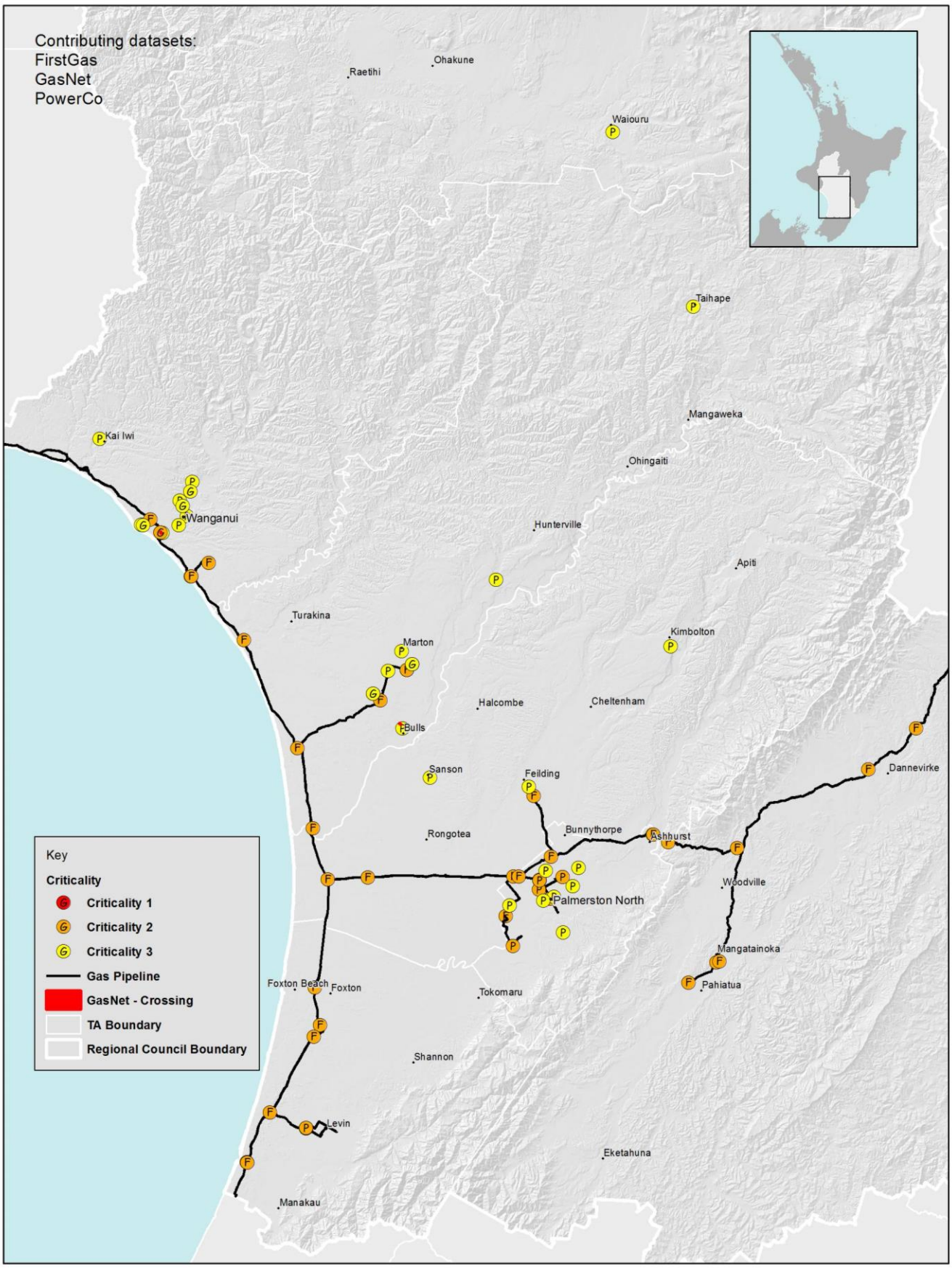


Figure 3-6: Natural Gas Transmission and Distribution Network

3.5 Telecommunications and Broadcasting

Information provided by Kordia, Spark and Chorus.

The telecommunications sector is one of the most complex of the lifelines sectors – technology changes rapidly and there is a high level of inter-connectedness between the various providers which share parts of the network and exchange (voice and data) messages between networks.

3.5.1 Mobile (Cellular) Networks

Cell sites typically provide overlapping coverage such that a cellsite failure may only cause partial loss of service to the normal supply area. A number of cell sites rated as regionally or locally significant, as illustrated in Figure 3-8.

3.5.2 Fixed Line Networks

The Chorus trunk fibre network in the North Island includes three main north-south cables – broadly described the 'eastern', 'central' and 'western' cables. These are considered as nationally significant assets, though they do provide redundancy for each other if one fails.

Spark has identified two nationally significant sites in the region including the Levin Exchange which is a connection point between the North and South Island. Palmerston North Exchange provides switching services to a number of sites in the region. These sites have standby generators and fuel storage for several days.

3.5.3 Broadcasting

Kordia's most critical sites in the region are Wharite and the inner city, fibre node site at the Palmerston North railway station.

Wharite provides multi directional, Digital Microwave Radio linking of Telecommunications, Television and Radio services to and through Palmerston North (North and South) and on to the Whanganui and Taranaki regions. Wharite is also the broadcast site of these services to the Palmerston North Area and hosts equipment owned by other telecommunications and media companies.
The Palmerston North Railway station site is the Kordia point of interconnect to customers in the region, is a major fibre node, and links (via DMR) to the Microwave network at Wharite. Three other sites have local significance and are shown in Figure 3-8.

The sites are unmanned and are monitored from the Transmission Control Centre (TCC), located in Avalon, which is a 24/7 operation. Kordia provides a managed environment (watertight, ventilated, and powered) with associated towers (antenna aperture) for others to locate their transmission equipment such as Police, Ambulance,

Cellular network assets:

- The **Cell Site** provides the local coverage and a mobile phone will connect to the cell site with the strongest signal, usually, but not always the nearest cell site.
- **Transmission** links connect the cell site to the Aggregation Node and the Aggregation Node to the Exchange. The transmission links are fibre, copper or microwave radio (increasingly, transmission links are moving to fibre connections).
- The **Aggregation Node** is a Base Station Controller (BSC) for a 2G (GSM) phone or a Radio Network Controller (RNC) for a 3G phone. Transmission links then connect the aggregation point to the exchange.
- The exchange (**Mobile Telephony Exchange, or Strong Node**) is the brains of the operation; it makes the connection between the caller and the called. If the transmission links are broken, the call cannot be completed (it is not possible for a cell site to work in local mode).
  Exchanges/strong nodes are connected by fibre transmission links. If these links are broken, the network functionality will be severely impacted and they are therefore heavily protected with redundant links and automatic failovers.

Fixed Line Networks:

Roadside Cabinets provide the first aggregation point for Digital Subscriber Line (DSL) broadband connections and connection point for landline phone services. Roadside cabinets have the ability to connect to standby generators.

Telephone exchange buildings (**Fixed Line Exchanges**) operate direct copper pair connections to customer premises. If an exchange becomes isolated from the nationwide network of exchanges, it will in some cases continue to operate in local mode, meaning that local phones will be able to call local phones from the same network. 111 service may be rerouted to a local number, such as the local police station or answered by a technician at the exchange building.

Links between exchanges are used for carrying long distance traffic such as tolls, fixed to mobile, international, 0800, 111 services etc. These links may be fibre cables, copper cables or microwave radio links.

Increasingly, other operators are installing fixed line exchange equipment as local loop unbundling[3] becomes the norm.

[3] Enabling multiple telco operators to use connections from the telephone exchange to the customer's premises.

Transpower, Vodafone and Spark cellular).

3.5.4 Radio

TeamTalk is the major provider of analogue and digital mobile radio in the country and provides services to a number of lifeline utilities and emergency services in the region including Ambulance Services and the Ministry of CDEM. TeamTalk's most critical site is at North Range Road.

North Range Road site is also the radio site for PNCC telemetry repeater radio, PNCC Civil defence radio, and PNCC depot/trucks RT's. There is a standby generator for the site.

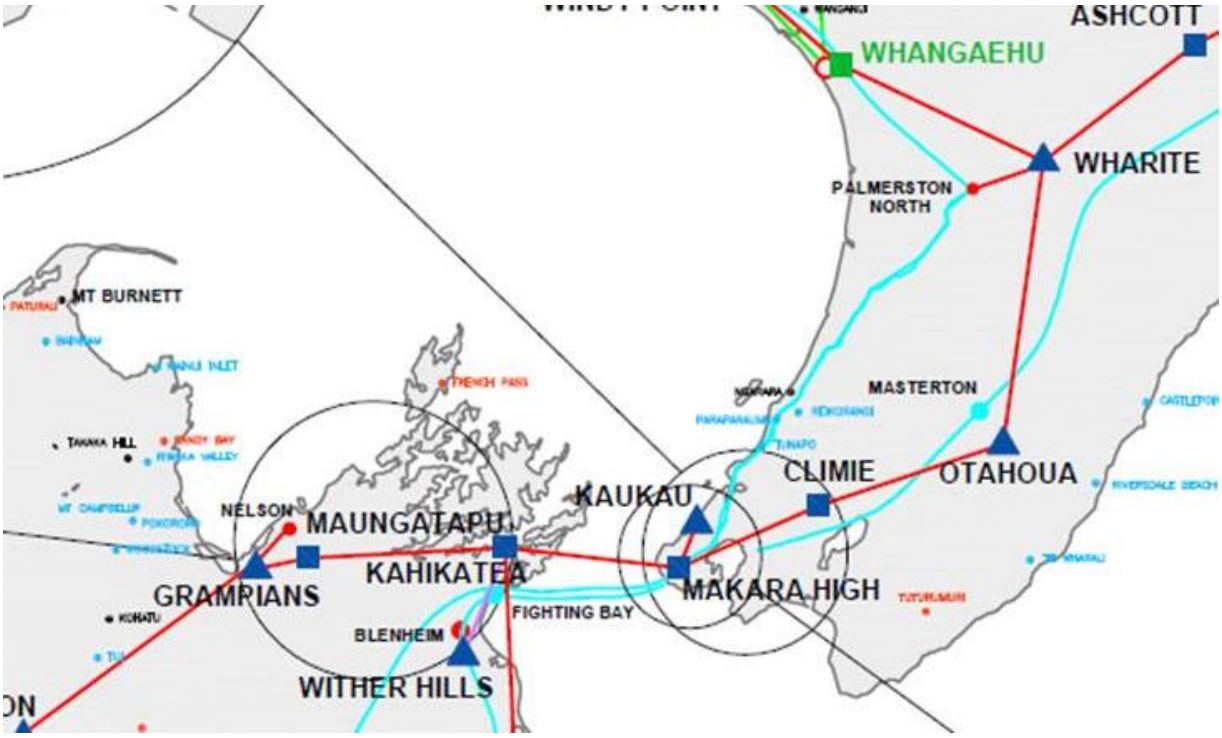


Figure 3-7: Kordia services.

Red line: Microwave Linking
Light Blue: Fibre
Blue triangles/ squares: High sites (triangle is broadcast and linking, square is linking only).
Red dots: Inner-city interconnect sites

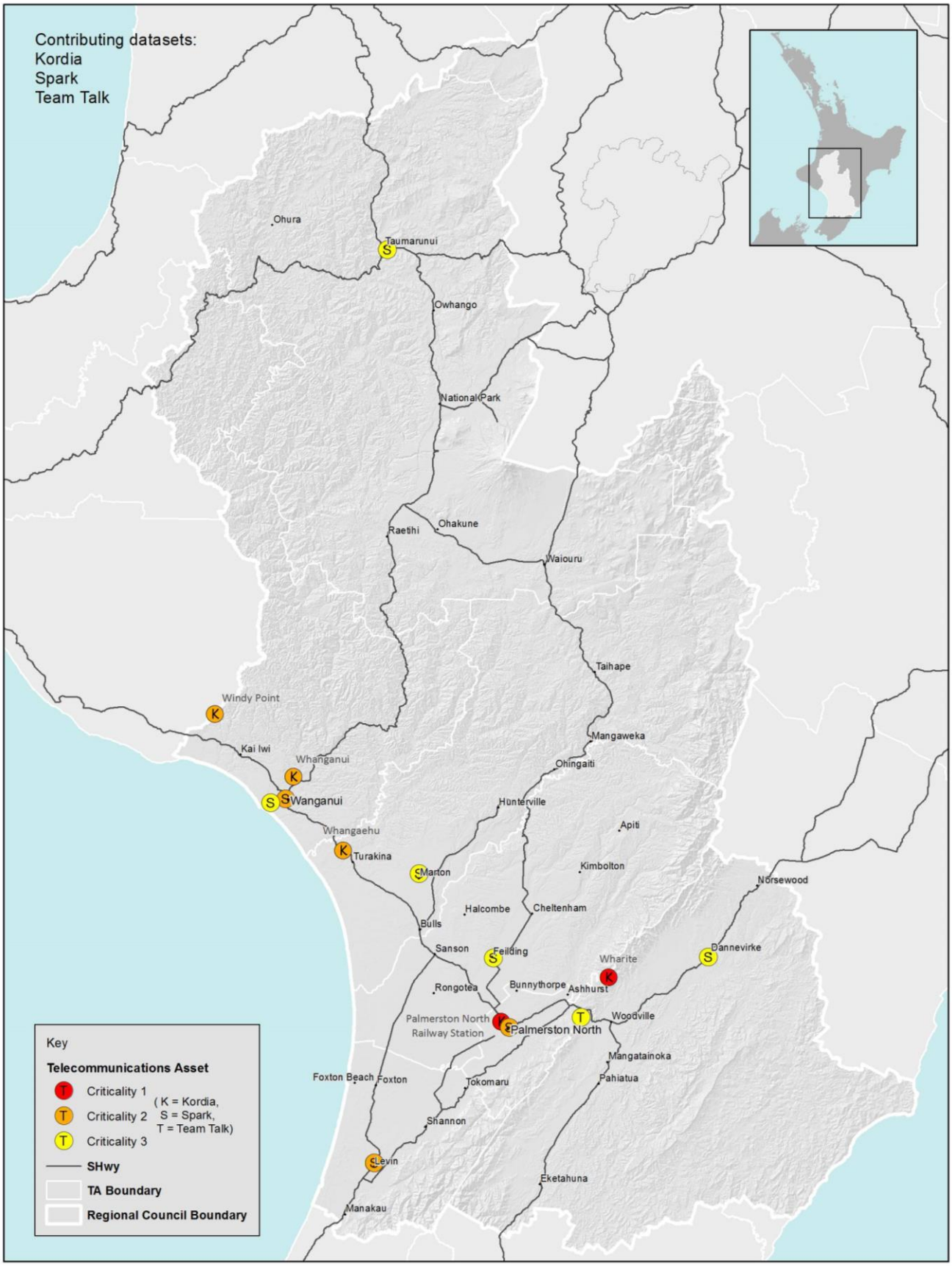


Figure 3-8: Critical Telecommunications and Broadcasting Assets.

3.6 Transport

3.6.1 Roads

Figure 3-9 illustrates the region's critical road network.

State Highway criticality ratings are based on the national One Network Road Classification system whereby:

- National Roads are rated nationally significant (SH 1, SH 2 north of Woodville and SH 57).
- Regional and Arterial Roads are rated regionally significant (SH 3 and SH 2 south of Woodville)
- Other Highways are rated locally significant.

Each of the local authorities have also determined critical roads for their area considering factors such as whether it provides access to critical community and infrastructure sites or are an important State Highway alternative. Using this methodology, a number of roads were rated as locally significant, as illustrated in Figure 3-9. As an example, Ruapehu District Council identified the following local roads:

- Ongarue Back Road – Ongarue Waimiha Road – Poro o Tarao (alternative route north from SH 4 Taumarunui to SH 30)
- Taringamotu Road (an alternative route east or south from SH 4 Taumarunui to SH 41
- A number of State Highway options from Raetihi to Ohakune.

3.6.2 Rail

The North Island's north-south line runs through the region and with a hub terminal at Palmerston North. From here, rail runs north-east to Napier (rating as regionally significant) and north to Hawera, linking in to the Fonterra factory and Port Taranaki (rated as locally significant due to the scale of freight carried).

3.6.3 Airports

Palmerston North International Airport
The region's main airport is rated as regionally significant. It has capacity for up to B767 sized aircraft, and services as an alternative airport for Wellington Airport.

Ohakea Airport
Ohakea is rated as nationally significant as it is an important facility for the RNZAF. Ohakea provides an alternative to larger aircraft of up to B747 aircraft, though passenger and refuelling facilities are limited.

Whanganui Airport
The Whanganui Airport, rated as locally significant, is certified to PCN12 status allowing aircraft up to 70 passengers.

Dannevirke Aerodrome
Dannevirke is a 'non-certificated' aerodrome suitable for light aircraft and transport aircraft suited to grass operations (such as Hercules).

Taonui Aerodrome
Feilding is a 'non-certificated' aerodrome.

3.6.4 Port

The main coastal port in the region is Whanganui; however this is not currently considered a significant asset. More important to the community is the 'inland port' in Palmerston North which is a freight hub servicing Taranaki, North to Tauranga and Auckland, Hawkes Bay and linking into Wellington. Palmerston North is one of the three main food distribution hubs in New Zealand (the others being Christchurch and Auckland).

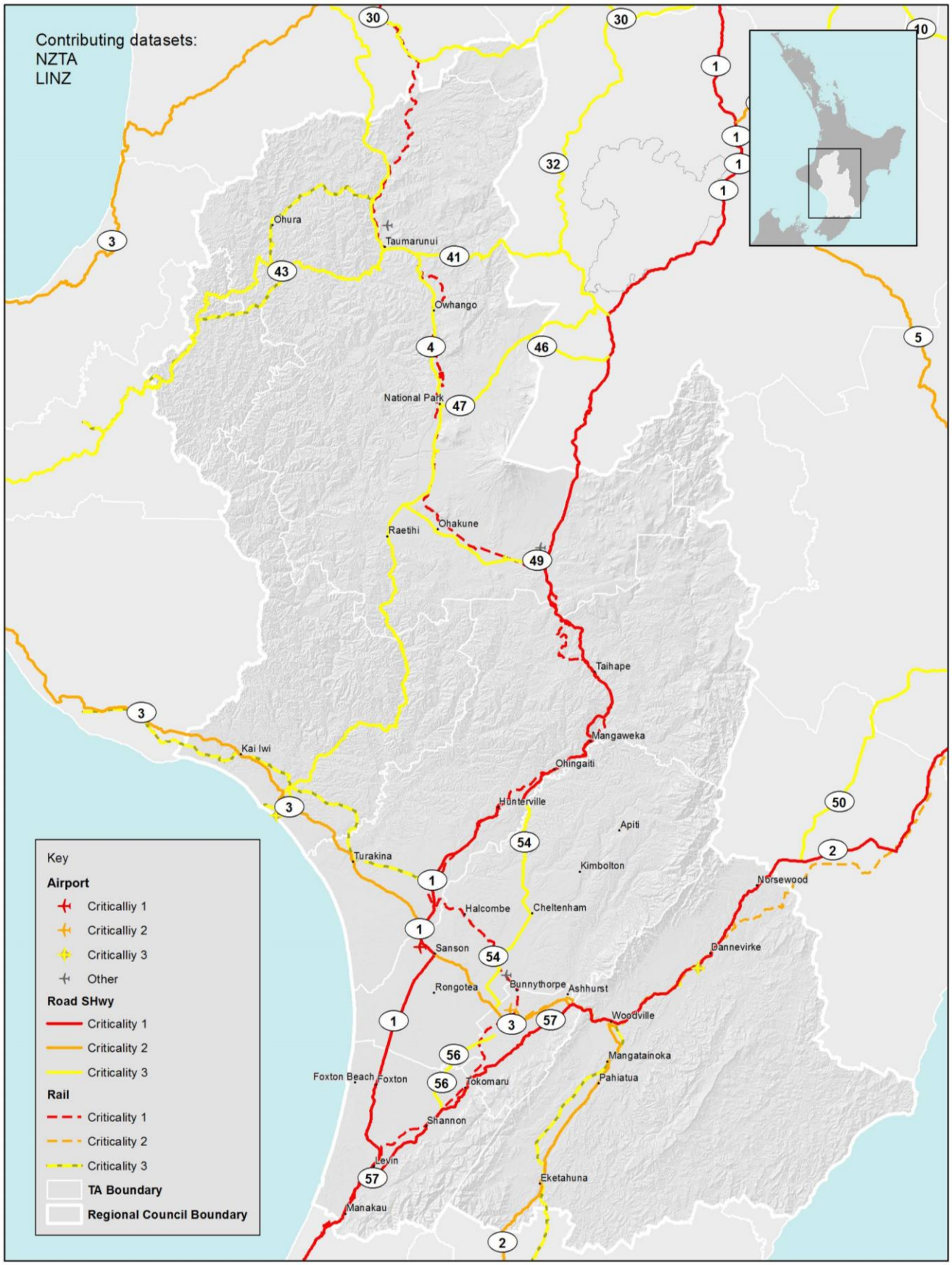


Figure 3-9: Critical Transport Infrastructure in Manawatu-Whanganui

3.7 Water and Wastewater

3.7.1 Water Supply

Table 3-1 and Figure 3-10 illustrate the scale and location of the region's water supplies. Some points of note include:

- Palmerston North manages the only 'regionally significant' water supply assets (supplying more than 20,000 customers). These include assets associated with the main Turitea source (dams, trunk mains, water treatment plants, Ngahere Reservoirs), the main bore stations, trunk mains >400mm and the pipe supplying the hospital. Some bores are critical to supplement during peak demand periods for the City main pressure zone. Other bores are essential as they are the water source for separate pressure zones. In the event of a failure of the Turitea supply, the bore supplies can provide around half of Palmerston North's demand at reduced pressure.
- 6 further schemes supply more than 2,000 customers (Whanganui, Levin, Feilding, Dannevirke, Taumarunui and Marton). Many schemes only have one source, meaning that the failure of the main source/mains/treatment plant and reservoirs of all the other schemes would result in a loss of supply to the whole town (once treated water stocks run out).
- A large proportion of the region's water supply is gravity fed, with power mainly required for treatment and boosting to some higher areas.
- Typically around 1-2 days of treated water storage provides backup in temporary disruption to sources and treatment.

3.7.2 Wastewater

Table 3-2 and Figure 3-10 illustrate the scale and location of the region's public wastewater schemes. Some points of note include:

- Palmerston North's wastewater network comprises the main City and three small satellite towns. Wastewater from these towns is now pumped to the City Treatment Plant at Totara Road, which is fitted with backup generation for critical functions. Backup generators are also on site at two of the major pump stations (Maxwells line and Massey)
- Outside Palmerston North, wastewater pump stations and treatment plants typically do not have backup generators on site, though some do have facility to connect to mobile generators (as shown in Table 3-2).

3.8 Flood Management

Horizons Regional Council (HRC) is responsible for flood management, with District Councils only looking after their own stormwater systems in developed areas.

HRC manage a number of flood protection assets that are critical from a social and economic perspective. These include[4]:

- Lower Manawatu Scheme, protecting pastoral, horticultural and urban land between the Manawatu Gorge and sea from flooding of the Manawatu River and Tributaries. The City Reach project raised the level of protection provided to Palmerston North City.
- Ashhurst Scheme, protecting urban land on the town side of the Ashhurst Stream.
- Rangitikei Scheme provides erosion control from Rewa to the sea and stop banking is intermittent over a number of locations.
- Lower Whanganui River Scheme, protecting land in the Balgownie area and Anzac Parade.
- Upper Whanganui River Scheme, protecting the township of Taumarunui.
- Porewa Scheme, protecting the townships of Rata and Hunterville
- Tutaenui Scheme, protecting the townships of Bulls and Marton and surrounding rural land.

[4] Horizons Regional Council Flood Protection Scheme Standards, May 2012.

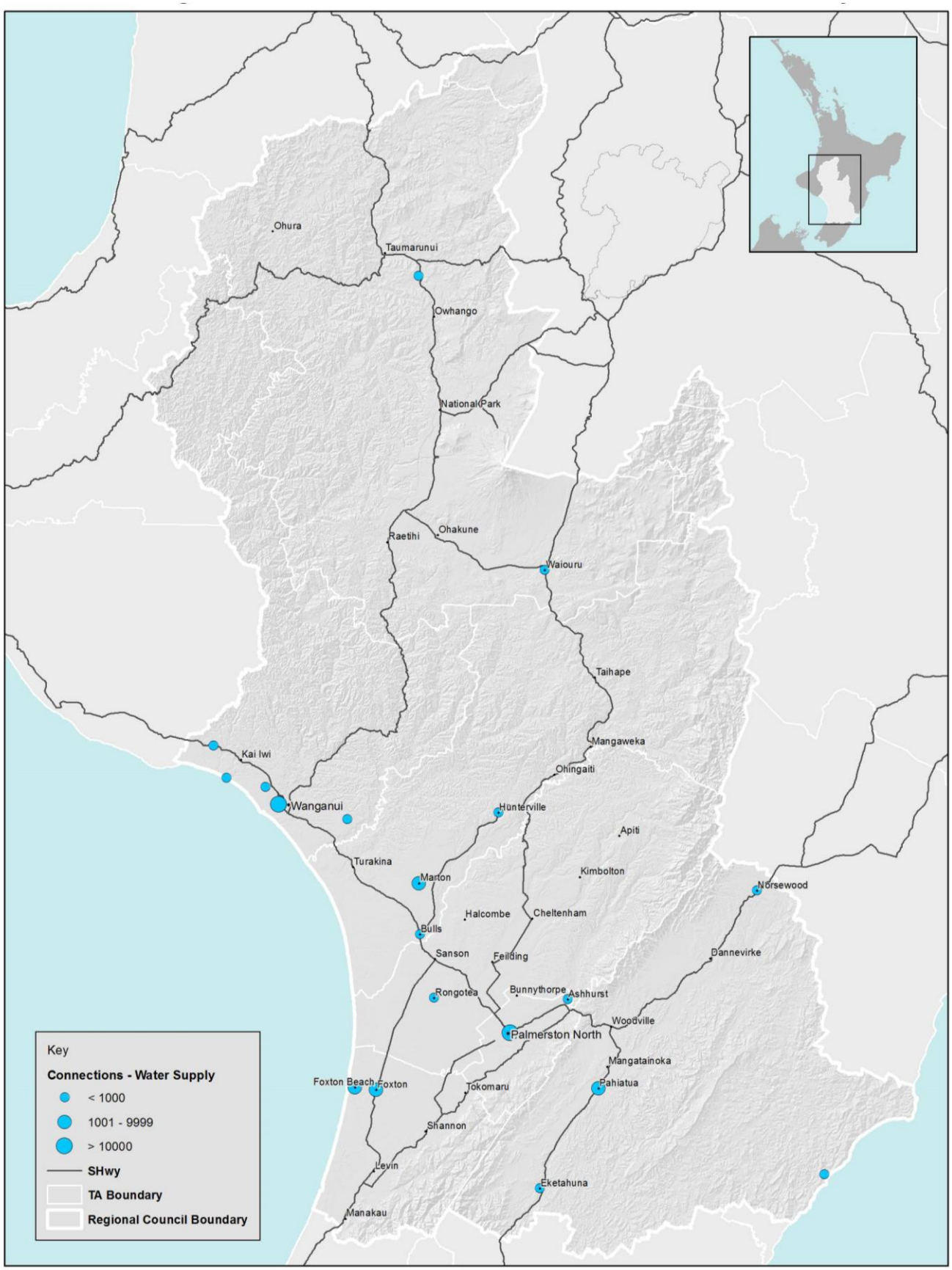


Figure 3-10: Public Water Supplies in Manawatu-Whanganui

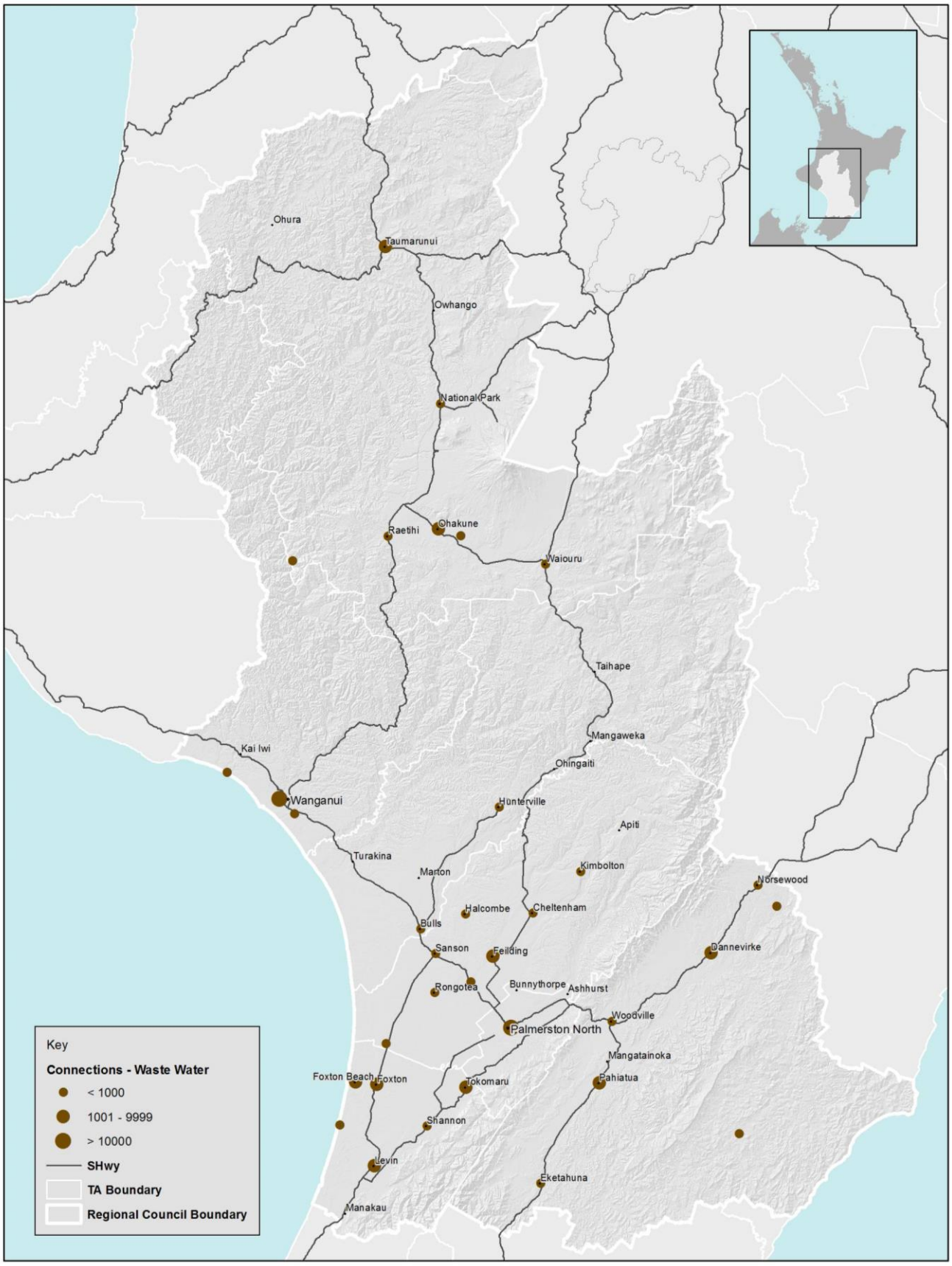


Figure 3-11: Public Wastewater Schemes in Manawatu-Wanganui

Table 3-1: Public Water Supplies in Manawatu-Whanganui

Scheme	TLA	Connectns (approx.)	Brief description	Electricity backup
Palmerston North City	PNCC	29,000	Sourced from Turitea Stream (2/3), remainder from bores.	WTP & 3 main bores
Whanganui	WDC	17000	4 artesian bores, 1 Treatment Plant, 3 Storage Reservoirs. Mostly gravity, with 3 Booster Stations and 1 Water Tower. All supply and reticulation is chlorinated.	Mobile
Levin	HDC	6500	Ohau River source	
Feilding	MDC	5,400	Oroua River to Almadale WTP and Bore supplies to Awa St WTP	Yes
Dannevirke	TDC	2570	Tamaki River – reservoirs – gravity fed.	No
Taumarunui	Rua DC	2400	Whanganui River – Matapuna tmt plant. Some areas rely on booster pumps.	Mobile
Marton	Rang DC	2,300	Tutaenui Stream and Bore to Marton WTP, full treatment.	Yes
Ohakune	Rua DC	1500	Serpentine Stream – reservoir.	Mobile
Foxton Beach	HDC	1200	Bore Supply	
Pahiatua	TDC	1200	Bore – pump to reservoir – gravity fed.	No
Foxton	HDC	1100	Bore supply	
Ashhurst	PNCC	1050	Single bore supply, 2 reservoirs	No
Bulls	Rang DC	900	Bore supply, filtration, chlorination, UV disinfection.	No
Woodville	TDC	799	Mangapap Stream – tmt plan – reservoirs – gravity retic. Dam for supply when river turbid or low flow.	No
Raetihi	Rua DC	570	Makotuku River – tmt plant – gravity fed retic.	Mobile
Shannon	HDC	550	Mangaore Stream source	
Himatangi Beach	MDC	400	Bore supply, ammonia removal, chlorination.	No
National Park	Rua DC	320	Mangahuia Stream – reservoir.	Mobile
Eketahuna	TDC	300	Makakihi River – pump to reservoir – gravity fed.	No
Hunterville Urban	Rang DC	250	Rangitikei River, filtration chlorination, UV disinfection.	No
Sanson	MDC	150	Pumped bore supply with chlorination.	No
Ohura	Rua DC	150	Mangapere Stream – tmt plant. Emergency supply from drain in heavy rain	Mobile
Owhango	Rua DC	150	Deep Creek – tmt plant.	Mobile
Rongotea	MDC	150	Bore supply, chlorination.	No
Tokomaru	HDC	140	Tokomaru River source	
Rātana	Rang DC	120	New water supply under construction.	No
Mangaweka	Rang DC	100	Rangitikei River, filtration chlorination, UV disinfection.	No
Piriaka	Rua DC	<100	3 springs – storage reservoir. Private supply	No
Waiouru	Rua DC	<100	Purchased from Army, distribute to local community	Mobile
Akitio	TDC	<100	Low pressure supply	No
Norsewood	TDC	<100	Low pressure supply	No
Mowhanau	WDC	<100	Kai-iwi bore, Cl Treatment.	Mobile
Fordell	WDC	120	Own bore supply, Cl Treatment.	Mobile
Westmere	WDC	340	From Westmere Urban Supply Reservoirs	Mobile

Scheme	TLA	Connectns (approx.)	Brief description	Electricity backup
Maxwell	WDC	<100	Own bore supply	Mobile

Table 3-2: Public Wastewater Schemes in Manawatu-Whanganui

Scheme	TLA	Connectns (approx.)	Brief description	Electricity backup
Palmerston North / Ashhurst	PNCC	29,000	4 networks. Totara Rd tmt plant is major plant	At tmt plant plus 2 lge PS. Others wired.
Whanganui	WDC	16,000	Treatment plant to ocean outfalls	Mobile
Levin	HDC	6400	Tmt – land disposal	
Feilding	MDC	5,600	Full treatment. Discharge to land and Oroua River.	Partial treatment only
Dannevirke	TDC	2700	4 pond system, microfiltration, tephra filter	
Taumarunui	Rua DC	2300		Mobile
Marton	Rang DC	2200	Full Treatment. Discharge to Tutaenui Stream	
Ohakune	Rua DC	1523		Mobile
Pahiatua	TDC	1300	3 pond system plus new treatment plant	
Tokomaru	HDC	1200	Tmt – land disposal	
Foxton	HDC	1100	Tmt – Manawatu River	
Foxton Beach	HDC	1100	Tmt – land disposal	
Bulls	Rang DC	900	Secondary tmt. Discharge to Rangitīkei River.	No
Woodville	TDC	780	2 pond system, 2 maturation ponds, new tmt plant	
Waitarere Beach	HDC	700	Tmt – land disposal	
Shannon	HDC	600	Tmt – Mangaore Stream	
Raetihi	Rua DC	572		Mobile
National Park	Rua DC	319		Mobile
Himatangi Beach	MDC	300	Primary and secondary tmt. Discharge to land.	No
Rongotea	MDC	300	Secondary tmt. Discharge to land/Campbells Drain.	No
Rangataua	Rua DC	250		Mobile
Eketahuna	TDC	250	2 pond system	
Sanson	MDC	240	Secondary tmt. Discharge to land/Piakatutu Strm.	No
Hunterville	Rang DC	200	Secondary tmt. Discharge to land/Porewa Strm.	No
Ratana	Rang DC	180	Secondary / tertiary tmt, discharge to unnamed tributary of Waipu Stream.	No
Halcombe	MDC	130	Secondary tmt. Discharge to land/Rangitawa Strm.	No
Awahuri	MDC	<100	Secondary tmt. Discharge to Bennetts Drain.	No
Cheltenham	MDC	<100	Secondary tmt. Discharge Oroua River tributary.	No
Kimbolton	MDC	100	Secondary and tertiary tmt. Discharge Oroua River tributary.	No
Norsewood, Ormondville, Pongaroa	RDC	<100 <100 <100	Septic tank discharge treatment.	
Mowhanau	WDC	<100	Public septic tanks and Spray Irrigation.	No
Marybank	WDC	<100	Oxidation pond	No
Pipiriki	Rua DC	<100		Mobile
Waiouru	Rua DC	<100		Mobile

4 LIFELINES INFRASTRUCTURE INTERDEPENDENCIES

4.1 Lifelines Sector Interdependence

All lifelines services rely to some extent on some or all of the other lifelines services in order to operate and vice versa. Therefore, a hazard impacting on one lifelines network is likely to have a knock on effect on others. To mitigate the risk that arises from this dependence, many lifelines have backup services should the service they rely on fail.

Figure 4-1 and Figure 4-2 summarise interdependencies between lifelines sectors during business-as-usual and major disaster events where disruption is expected to roads and electricity networks. The ratings presented in this section are illustrative only – obviously the extent of dependence in a response and recovery situation will depend on the specific scenario. The total dependency scores clearly illustrate the importance of electricity, roads, fuel and telecommunications to the other sectors, with air transport and broadcasting becoming more important in a major disaster event.

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	Roads	Rail	Sea Transport	Air Transport	Water Supply	Wastewater	Stormwater	Electricity	Gas	Fuel Supply	Broadcasting	VHF Radio	Telecomms	**Total Dependency**
Electricity	1	2	3	3	3	3	2		2	2	3	3	3	30
Roads		3	3	3	2	2	2	2	2	3	2	2	2	28
Fuel	2	3	3	3	2	2	2	2	2		2	2	2	27
Tele-comms	2	2	2	2	2	2	2	2	2	2	2	3		25
Water Supply	1	1	1	2		3	1	1	1	1	1	1	2	16
VHF Radio	2	2	2	2	1	1	1	1	1	1	1		1	16
Stormwater	2	1	1	2	1	1		1	1	1	1	1	1	14
Wastewater	1	1	1	2	1		1	1	1	1	1	1	1	13
Rail	1		1	1	1	1	1	1	1	1	1	1	1	12
Sea Transport	1	1		1	1	1	1	1	1	1	1	1	1	12
Air Transport	1	1	1		1	1	1	1	1	1	1	1	1	12
Gas	1	1	1	1	1	1	1	1		1	1	1	1	12
Broadcasting	1	1	1	1	1	1	1	1	1	1		1	1	12

Figure 4-1: Interdependency Matrix – Business As Usual

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	Roads	Rail	Sea Transport	Air Transport	Water Supply	Wastewater	Stormwater	Electricity	Gas	Fuel Supply	Broadcasting	VHF Radio	Telecomms	**Total Dependency**
Fuel	3	3	3	3	3	3	3	3	3		3	3	3	36
Roads		3	3	3	3	3	3	3	3	3	2	2	3	34
Tele-comms	3	2	2	2	3	3	3	3	3	2	2	3		31
Electricity	1	2	3	3	3	3	2		2	2	3	3	3	30
VHF Radio	2	2	3	3	2	2	2	2	2	2	2		2	26
Broadcasting	2	2	2	2	2	2	2	2	2	2		2	2	24
Air Transport	2	1	1		2	2	2	2	2	2	2	2	2	22
Water Supply	1	1	1	2		3	1	1	1	1	1	1	2	16
Stormwater	2	1	1	2	1	1		1	1	1	1	1	1	14
Wastewater	1	1	1	2	1		1	1	1	1	1	1	1	13
Rail	1		1	1	1	1	1	1	1	1	1	1	1	12
Sea Transport	1	1		1	1	1	1	1	1	1	1	1	1	12
Gas	1	1	1	1	1	1	1	1		1	1	1	1	12

Figure 4-2: Interdependency Matrix – During / Post Disaster Event

4.1.1 Dependence on Electricity

During normal operations, electricity is required to operate most the other lifeline utilities to some degree and, because of this dependence, most utilities have backup generation at their most critical sites. However, a widespread regional power outage would, after varying periods of time, still impact on telecommunications, water supply, wastewater, gas, fuel supply and traffic management services.

The figure below illustrates the extent to which other lifeline utilities depend on electricity.

3: Required for Service to Function, 2: Important but can partially function and/or has full backup, 1: Minimal requirement for service to function.

Roads	Rail	Sea Transport	Air Transport	Water Supply	Wastewater	Stormwater	Electricity	Gas	Fuel Supply	Broadcasting	VHF Radio	Telecomms
Dependence during business as usual												
1	2	3	3	3	3	2		2	2	3	3	3
Dependence during major response / recovery												
1	2	3	3	3	3	2		2	2	3	3	3

4.1.2 Dependence on Telecommunications

A major telecommunications failure will impact the business sector and wider community and impede the efficiency of utility businesses, however most utilities could continue core services at near full capacity without telecommunications in the short term. Some utilities would need to revert to manual operation and monitoring of facilities and response to service requests could be impaired.

The situation changes in an emergency because telecommunications become critical for coordinating response. There is a high reliance on the cellular network for voice communications and this network may become overloaded during or shortly after an event. However, the copper, fibre and wireless infrastructure (including cellular) provides diversity and is very resilient. Most of the region's utilities use a combination of the above technologies to monitor their own infrastructure and some have their own dedicated network of links and radio.

3: Required for Service to Function, 2: Important but can partially function and/or has full backup, 1: Minimal requirement for service to function.

Roads	Rail	Sea Transport	Air Transport	Water Supply	Wastewater	Stormwater	Electricity	Gas	Fuel Supply	Broadcasting	VHF Radio	Telecomms
Dependence during business as usual												
2	2	2	2	2	2	2	2	2	2	2	3	
Dependence during major response / recovery												
3	2	2	2	3	3	3	3	3	2	2	3	

4.1.3 Dependence on Broadcasting

All utilities rate broadcasting as '1' (minimal requirement for service to function) during business as usual. This increases to a '2' during a response situation as a means of communicating public information such as road disruptions, public water supply warnings and advising of fuel shortages.

4.1.4 Dependence on Roads

The road network is important for all utilities to operate, particularly for sea/air/rail networks which are connected by road and for fuel as there is no major fuel storage in the region (refer Section 3.3.2). Road failures during business-as-usual may affect response to service requests and asset failures would be affected. Also, staff need to be able to access facilities and diesel and plant needs to be transported to construction sites and this would become critical in longer-term road failures.

In a major disaster, road access to other critical sites to enable restoration makes the road network much more critical.

3: Required for Service to Function, 2: Important but can partially function and/or has full backup, 1: Minimal requirement for service to function.

	Roads	Rail	Sea Transport	Air Transport	Water Supply	Wastewater	Stormwater	Electricity	Gas	Fuel Supply	Broadcasting	VHF Radio	Telecomms
Business as usual		3	3	3	2	2	2	2	2	3	2	2	2
Major response / recovery		3	3	3	3	3	3	3	3	3	2	2	3

4.1.5 Dependence on Sea and Air Transport

Air services also become important to other lifelines in a major disaster, to assess damage, bring in equipment and spares and access sites when there is significant road disruption. Dependence on air transport is shown below. Generally utilities are not reliant on sea transport, though there may be specific circumstances whereby resources are required to be shipped in.

3: Required for Service to Function, 2: Important but can partially function and/or has full backup, 1: Minimal requirement for service to function.

	Roads	Rail	Sea Transport	Air Transport	Water Supply	Wastewater	Stormwater	Electricity	Gas	Fuel Supply	Broadcasting	VHF Radio	Telecomms
Business as usual	1	1	1		1	1	1	1	1	1	1	1	1
Major response / recovery	2	1	1		2	2	2	2	2	2	2	2	2

4.1.6 Dependence on Water Supply and Wastewater

While water supply and wastewater services are critical for the community (and for firefighting), the lifeline utilities only require these for building services (and alternative arrangements can be made such as re-location other locations, or using bottled water supplies and temporary wastewater facilities). The exceptions are air transport, which does require water supply at the airport for commercial flights, and telecommunications, which requires water for equipment cooling. Dependence on water supply is shown below.

3: Required for Service to Function, 2: Important but can partially function and/or has full backup, 1: Minimal requirement for service to function.

	Roads	Rail	Sea Transport	Air Transport	Water Supply	Wastewater	Stormwater	Electricity	Gas	Fuel Supply	Broadcasting	VHF Radio	Telecomms
Business as usual	1	1	1	2		3	1	1	1	1	1	1	2
Major response / recovery	1	1	1	2		3	1	1	1	1	1	1	2

4.1.7 Dependence on Fuel

All utilities have some dependence on fuel for vehicles for service personnel. If electricity is affected, diesel supply to critical sites to operate backup generators becomes more important. Even those sites with on-site diesel storage typically only hold a few days' supply. Refueling of generators deployed to other critical facilities is likely to become a significant logistical issue.

3: Required for Service to Function, 2: Important but can partially function and/or has full backup, 1: Minimal requirement for service to function.

	Roads	Rail	Sea Transport	Air Transport	Water Supply	Wastewater	Stormwater	Electricity	Gas	Fuel Supply	Broadcasting	VHF Radio	Telecomms
Business as usual	2	3	3	3	2	2	2	2	2		2	2	2
Major response / recovery	3	3	3	3	3	3	3	3	3		3	3	3

4.1.8 Dependence on Gas

No other lifelines networks are reliant on gas for network operation.

4.2 Critical Community Facility Dependence on Lifelines

Lifeline utility services are important for the functioning of critical community facilities such as hospitals, CDEM operations centres and emergency services headquarters. To mitigate this dependence, most facilities have backup arrangements.

The Group ECC in Victoria Ave, Palmerston North and the alternate EOC in Pascal Street both have generator backup, regional CDEM radio channels (Teamtalk) and HRC radio network (HRC repeaters).

Other local EOCs are generally equipped with backup generators and regional CDEM radio channels.

There are considered to be sufficient Civil Defence Centres (formerly referred to as Welfare Centres) to be able to select venues which still have operational lifelines services.

Major police stations have emergency generators and alternate communication channels and major hospitals generally have backup generators for critical functions as well as on-site water storage (specifics were not available for this project).

5 HAZARD VULNERABILITY ASSESSMENT

Section 5 provides an overview of the major natural hazards in the region – earthquake, tsunami, volcano and severe weather. For each hazard, the source of hazard information used in this project is described and the impact of the hazard on infrastructure assets and services is assessed, where provided by the lifelines organisation (inputs were not received from Whanganui District Council or any of the telco providers apart from Chorus).

5.1 Earthquake

5.1.1 Hazard Overview

The Manawatu-Whanganui Region is geologically diverse with numerous potential earthquake sources. The region encompasses some of the most seismically active parts of New Zealand. Small earthquakes have occurred regularly throughout c.150 years of recorded history.

5.1.2 Hazard Exposure

Information used for this project to assess which assets were exposed to seismic hazards is as follows:

Faults
Active faults are sourced from the National Seismic model. In the region, the main ones include Ohakune and Raetihi (200-500 year return period activity), Wellington (1000 years) and the Ruahine Fault (1000-5000 years expected return period). There are a number of other known active faults in the region, as shown in Figure 5-1.

Peak Ground Acceleration
PGA hazard estimates are determined for the Manawatu-Whanganui region using GNS Science's National Seismic Hazard Model (NSHM; Stirling et al., 2012). The horizontal PGA estimates were incorporated with the New Zealand inferred site sub-soil class information to produce maps and datasets that show, at a regional scale, the estimated PGAs across the region with annual exceedence probabilities of 1 in 500, 1 in 1000 and 1 in 2500 (shown in Figure 5-3).

The return period (in years) for different levels of Modified Mercalli (MM) shaking intensity for the eighth largest urban areas in the Horizons Region is provided as a link to enable some comparison with previous work (Table 5-1).

A correlation between MM shaking intensity values and PGA values is provided in Table 5-2.

Landslide
Large, pre-existing landslides (or remnants of these) were identified from a study of geomorphic features using aerial photographs in 2008. The landslide hazard is shown in Figure 5-4. Assets in these areas are at risk of substantial land movement associated with a landslide.

Liquefaction
Areas considered at higher risk of liquefaction are characterised by saturated unconsolidated fine grained sediments. These include areas of reclaimed land (most susceptible), landslide deposits, dune sand, beach deposits and alluvial/colluvial / swamp deposits, particularly where there are high groundwater levels. Liquefaction of very high risk soils can occur at MM7, and high risk soils from MM8.

Assets in these areas can be subject to lateral spreading and subsidence. Areas that are underlain by gravels (such as the main river channels and their adjacent flood plains) are not expected to liquefy.

Regional scale liquefaction maps for this project have been developed based on:

- Eliminated geological units >10,000 years old, gravel or clay
- Remaining units assessed based on river gradient, historical liquefaction reports.

Mapped layers from liquefaction studies for Palmerston North and Whanganu cities were also available.

Table 5-1: Modified Mercali Shaking Intensity Return Periods (in years) for the main urban areas

Town	MM7	MM8	MM9	MM10
Palmerston North	26	113	625	4237
Wanganui	40	278	3448	58824
Dannevirke	25	107	521	5000
Fielding	28	134	905	9804
Levin	25	103	502	3650
Taihape	36	201	1639	23256
Ohakune	47	208	684	3155
Taramaranui	101	750	7194	125000

Table 5-2: Correlation between MM Shaking Intensity and Peak Ground Acceleration (Hancos et al 2002)

MM Intensity	PGA (Peak Ground Acceleration, g)
5	0.03-0.04
6	0.05-0.08
7	0.10-0.15
8	0.18-0.25
9	0.3-0.5
10	>0.5

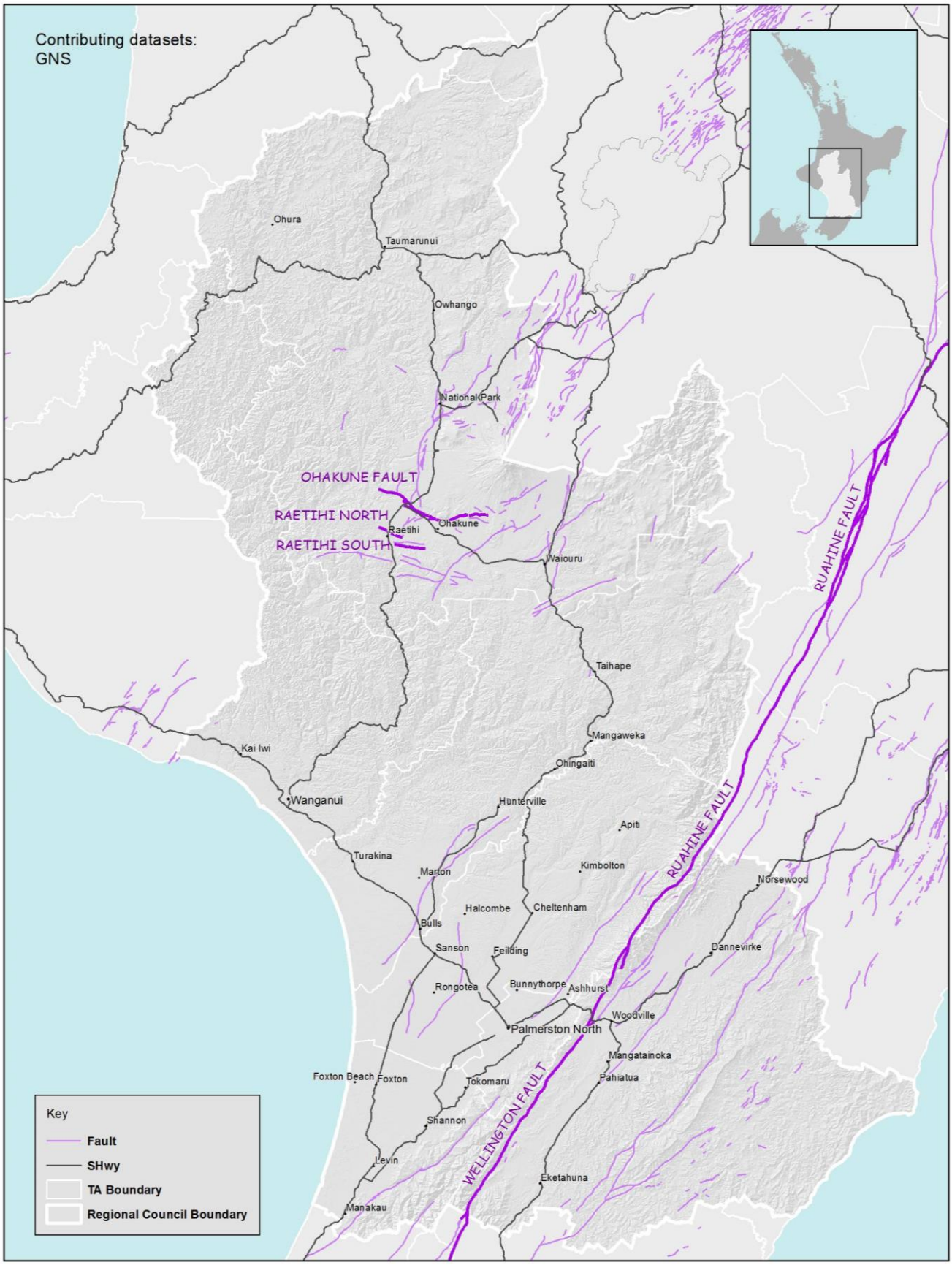
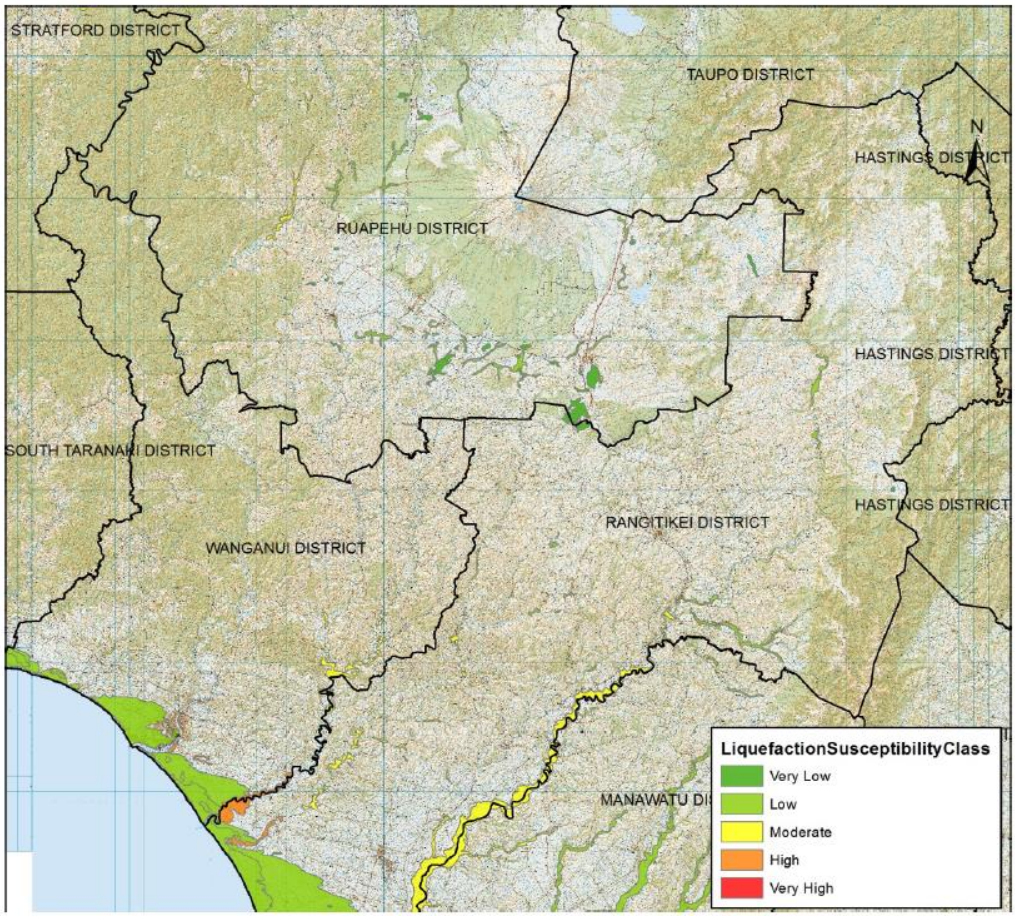
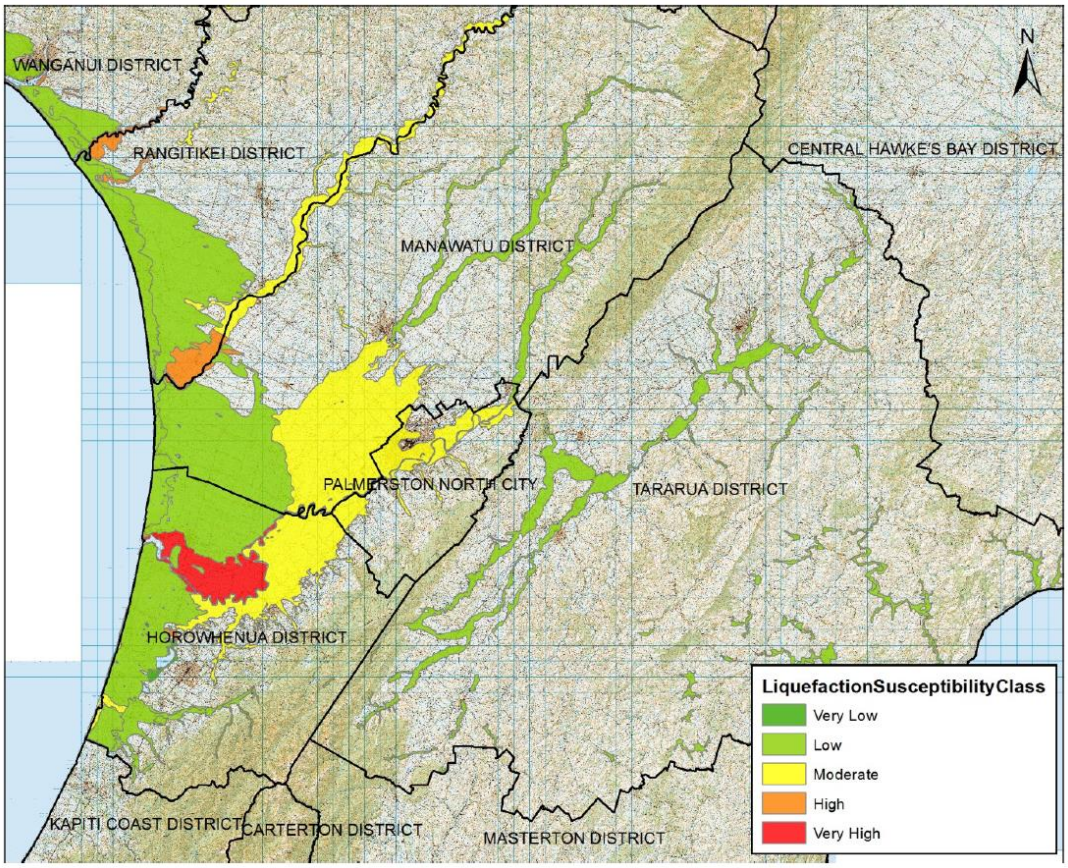


Figure 5-1: Active Fault Lines.



Rangitikei and Whanganui District



Horowhenua District, Tararui District, Manawatu District and Palmerston North City

Figure 5-2: Liquefaction Hazard

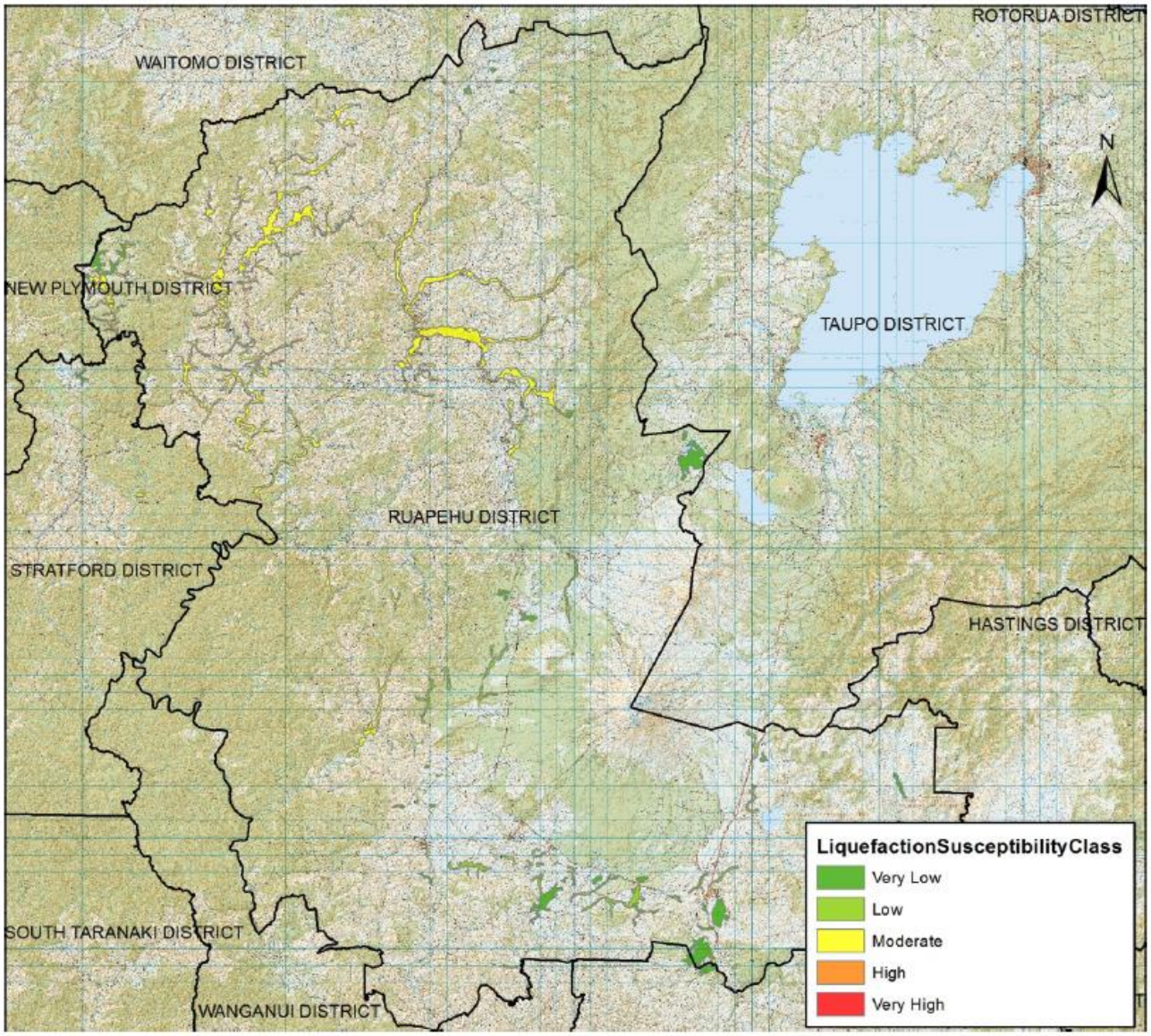


Figure 5-2 cont'd. Ruapehu District

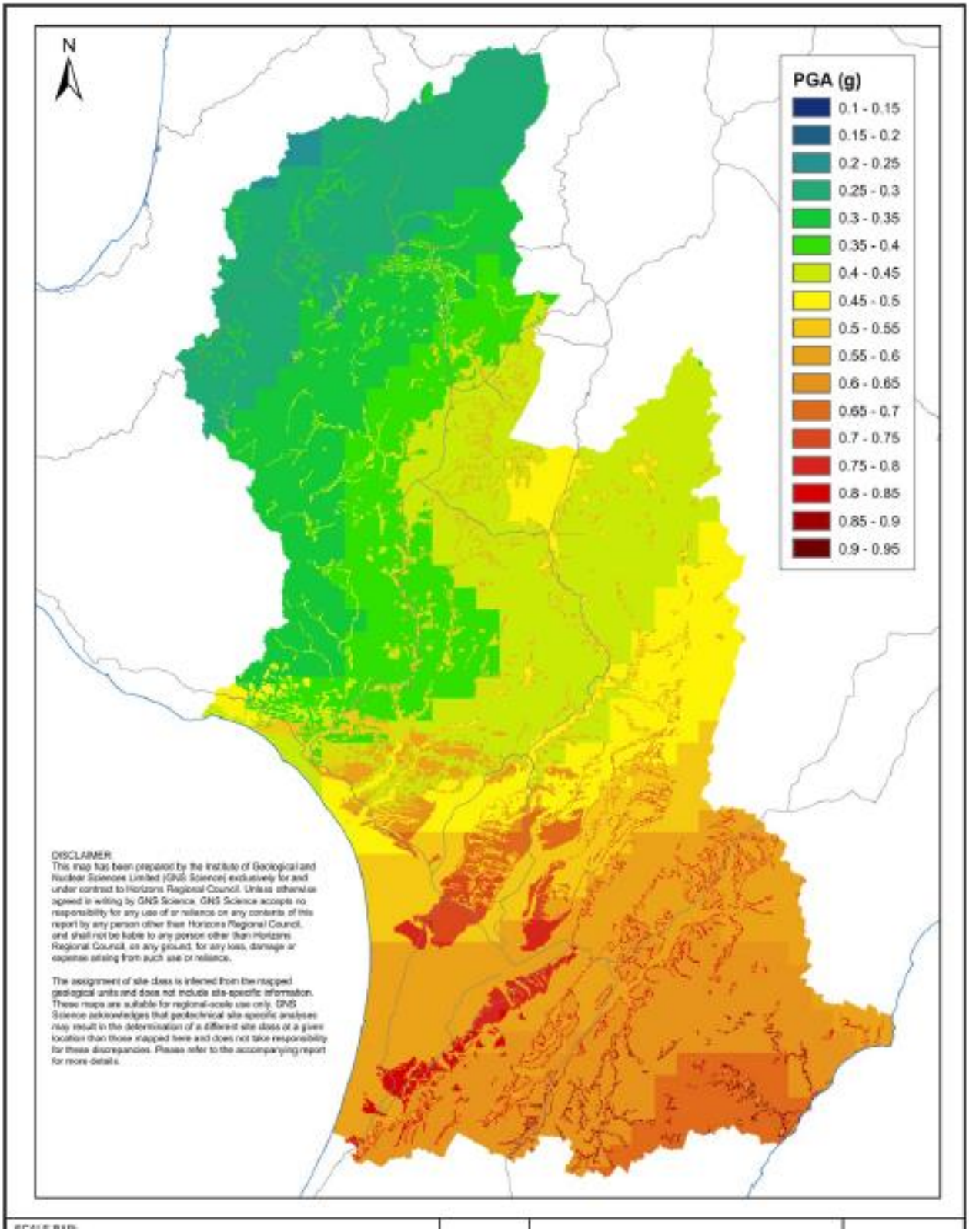


Figure 5-3: Peak Ground Acceleration with an annual exceedance probability of 1 in 2500 incorporating NZS 1170.5 site sub-soil class.

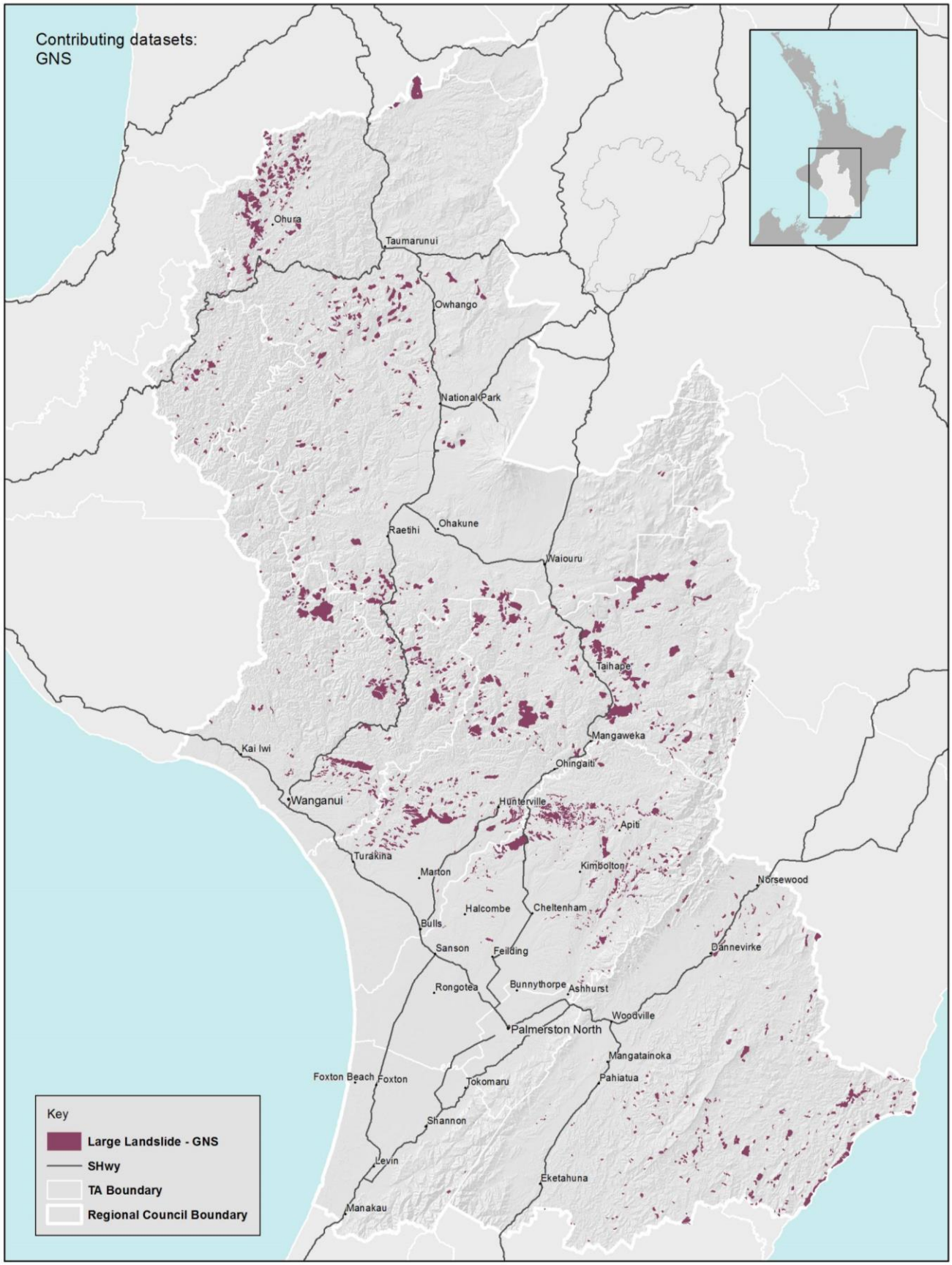


Figure 5-4: Large pre-existing landslides (mapped from geomorphic features)

5.1.3 Infrastructure Vulnerability Assessment

The expected effects from earthquakes that create a potential hazard to infrastructure includes:

- Surface fault rupture – in a large shallow crustal earthquake where the fault reaches the ground surface. The rupture can range in length from a few metres to hundreds of kilometers and with ground displacements of several meters possible. Shearing of assets can result where ground displacements occur.
- Land movements – in a moderate to large earthquake the ground in nearby areas maybe uplifted, dropped or tilted – again ground displacement can be several meters. In the Edgecumbe earthquake a large part of the ground in the Rangitaiki Plain dropped by up to 2m.
- Strong shaking is the most obvious earthquake hazard and can cause damage to structures – the extent of damage can be mitigated through modern seismic design.
- The combination of ground shaking and earth movement can produce secondary effects including rockfall / landsliding, tsunami, ground settlement and liquefaction.
- Liquefaction was shown in the Canterbury earthquakes to be particularly devastating to underground, brittle assets due to the associated differential ground subsidence and lateral spreading. Liquefaction of very high risk soils can occur at MM7, high risk soils from MM8 and moderate soils from MM9.

Table 5-3 provides a summary of the assessment of potential impacts of liquefaction on assets by lifeline utilities in the region. The largest area of liquefaction risk lies in the area between Palmerston North, Levin and Bulls. Disruption to almost all lifelines networks can occur in those areas.

Table 5-3: Potential asset damage and service disruption in liquefaction risk areas

Sector	Critical assets exposure to hazard	Vulnerability[5]	Potential Service Disruption
Wastewater – MDC / Rang DC	Koitiata, Bulls, Kimbolton, Feilding and Awahuri have critical assets in liquefaction zones.	3-4	Damage to or destruction of plants, pumps and pipelines could lead to environmental damage and/or public health risk.
Wastewater - HDC	Foxton / Foxton Beach WWTP in high susceptibility area.	3-4	As above
Wastewater – PNCC	PNCC WWTP, pump stations and trunk network in moderate susceptibility area.	3-4	Partial/total loss of service to city due to damage to major pipeworks & structures.
Water Supply – MDC	Mangaweka, Stanway-Halcombe, Sanson, Bulls, Feilding and Himatangi Beach have critical assets in liquefaction zones.	3-4	Damage to or destruction of intakes, pumps, pipelines, reservoirs and/or plants could lead to loss of supply.
Water Supply – PNCC	Damage to PNCC pipe network and structures in liquefaction prone soil, southern part of town.	3-4	Disrupted water supply to affected areas.
Stormwater - PNCC	Stormwater network, structures, stopbanks	2-4	Damaged assets increase flooding risk.
Electricity – Distribution	Foxton Beach 33kV lines to substation. Castlecliff Sub, Whanganui Beach Rd Sub, Whanganui Taupo Quay Sub, Whanganui Hatricks Wharf Sub. Whanganui Peat St Sub Whanganui Kairanga Sub, PN Pascal St Sub, PN Feilding Sub Whanganui CBD/eastern urban Whanganui western urban	3-4	Partial/total loss of supply Very low susceptibility Partial/total loss of supply High susceptibility Total/partial loss of supply Moderate susceptibility Total/partial loss of supply Low susceptibility Total/partial loss of supply High susceptibility Very low susceptibility

[5] 1: Unlikely to cause damage. 2: Possible damage, short term disruption. 3: Possible damage, longer term repairs (weeks/months). 4: Complete failure, full reconstruction required.

Sector	Critical assets exposure to hazard	Vulnerability[5]	Potential Service Disruption
	PN CBD PN urban Feilding region (3-4)		Total/partial loss of supply Moderate susceptibility Low susceptibility
Electricity Transmission	Liquefaction in the Horowhenua district and Foxton, could significantly undermine transmission tower foundations on the Bunnythorpe-Paraparumu-Haywards circuits resulting in a number of tower collapses. Paraparaumu sub would be supplied from south only. A number of transmission circuits could be affected by liquefaction in the Palmerston North area, but this has been identified in the model as lower liquefaction risk.	3	Redundancy with a supply from the Bunnythorpe-Linton-Wilton 220kV circuits that hug the ranges to the east. No immediate threat to supply to region, but would have national implications if circuits out for an extended duration. Temporary towers could be erected in 2-4 weeks, rebuilding failed towers would take months.
Flood protection	Tangimoana rock work	1-2	Weeks for permanent repair
Gas Transmission	Buried pipeline Pipeline on bridge crossings	1 2	Likely to be able to repair damage before major service impacts occur.
Telecomms - Chorus	Trunk fibre cables in manhole / duct systems in cities and towns.	1-2	Likely to be able to repair damage before major service impacts occur.
Transport – State Highways	SH 3 Whangaehu River Bridge Turakina Oroua River Bridge Awahuri SH3/1 Bulls Bridge SH1 Whirokino Trestle / Manawatu River Foxton Ohau to Manakau Sth Levin SH56 Manawatu River Bridge and stopbanks	3 3 3-4 4 1-2 3	Transportation disruption to National and Inter-regional routes affecting other utility and emergency service response, logistics distribution.
Flood Protection	Lower Manawatu Scheme	3-4	SH1/SH3 flooding Months for permanent repair
Transport - MDC	Part or all of Turakina Beach Rd, Parewanui Rd, Kakariki Rd, Pohangina Rd, Pohangina Valley East Rd, Kawakawa Rd, Awahuri-Feilding Rd, Rongotea Rd, McDonell Rd, Tangimoana Rd, Rangiotu Rd and Himatangi Beach Rd are in liquefaction zones. Bridges along other lifeline routes could also be affected.	2 (pavements) 3-4 (bridges)	In some cases could cause roads to be impassable.
Water Supply – Whanganui DC	Water Supply Network along parts of Taupo Quay and Anzac Parade (SH4)	1-2	Short to medium term disruption (repairs estimated at 1-3 months)
Wastewater – Whanganui DC	Wastewater Network (including 2 Area Pumping Stations + Beach Road Pumping Station) along parts of Taupo Quay, Beach Road and Anzac Parade (SH4)	2-4	Medium to longer Term disruption (repairs estimated at 3-6 months)
Stormwater – Whanganui DC	Stormwater Network along parts of Taupo Quay and Anzac Parade (SH4)	1-2	Medium to longer Term disruption (repairs estimated at 3-6 months)
Roading – Whanganui DC	Roading Network along parts of Taupo Quay and Anzac Parade (SH4)	1-2	Medium to longer Term disruption (repairs estimated at 3-6 months)

Table 5-4: Ground Shaking / Fault Rupture / Landslide Risk

Sector	Critical assets exposure to hazard	Vulnerability[6]	Potential Service Disruption
Water Supply – MDC/Rang DC	All assets in the District are at risk from earthquakes. The critical assets most at risk of high PGA are in the Taihape, Mangaweka, Hunterville, Marton, Rātana, Stanway-Halcombe, Sanson, Feilding, Rongotea and Himatangi Beach schemes. Taihape intake and part of raw water main, Mangaweka intake, parts of Hunterville RWS trunk main in vulnerable locations for landslip	1-4	Damage to or destruction of plants, pumps, pipelines and reservoirs could lead to loss of supply. Supply of raw water could be disrupted. Water supply would continue using treated water storage, and tankering if necessary.
Wastewater – MDC/Rang DC	All assets in the District are at risk from earthquakes. The critical assets most at risk of high PGA are in the Taihape, Mangaweka, Hunterville, Rātana, Halcombe, Sanson, Rongotea and Himatangi Beach schemes. Hunterville WWTP road access in vulnerable locations for landslip.	1-4 1-2	Damage to or destruction of plants, pumps and pipelines could cause environmental impacts, compliance issues, and/or public health risks. Access to WWTP could become difficult or impossible. Possibility of landslide continuing downslope and damaging plant.
Water Supply PNCC	Bore stations, Turitea Dams and treatment plant, Ngahere Reservoirs, trunkmains from Dam to City, Turitea access road	1-4	Loss of water supply and pressure in affected areas.
Wastewater PNCC	Totara Rd WWTP, pump stations and trunk mains	1-4	Inability to convey& treat wastewater as a result of asset damage.
Stormwater - PNCC	Stormwater network, structures, stopbanks	1-3	Damaged assets increase flooding risk.
Electricity - Distribution	Whanganui CBD Whanganui Urban PN CBD PN urban Feilding CBD	2-3	Partial loss of supply / Low susceptibility
Electricity - Transpower	Towers and substations built to seismic standard (1:2000 return). Little damage expected from ground shaking.	2	Several weeks if towers suffer damage due to ground acceleration. No immediate threat to supply.
Telecomms - Chorus	Fibre cables pass fault lines in several areas. Multiple cables provide redundancy for each other.	2	Service impacts should be minimal unless all north-south cables impacted.
Transport – State Highways	SH3 Manawatu Gorge rock-fall (3) (72 bridges) SH1 Utuku (2), Mangaweka (3)	3 3	Inter-regional link to Hawkes Bay severed, but alternative route available. 72 bridges in gorge at risk of damage or overloading National Strategic Link – limited alternative routes

[6] 1: Unlikely to cause damage. 2: Possible damage, short term disruption. 3: Possible damage, longer term repairs (weeks/months). 4: Complete failure, full reconstruction required.

Sector	Critical assets exposure to hazard	Vulnerability[6]	Potential Service Disruption
Transport – MDC/Rang DC	All assets in the District are at risk from earthquakes. The critical assets most at risk of high PGA are Taihape-Napier Rd, Toe Toe Rd, Ongo Rd, Mangahoe Rd, Kauangaroa Rd, Rātana Rd, Kakariki Rd, Kawakawa Rd, Stewart Rd, Awahuri-Feilding Rd, Rongotea Rd, Tangimoana Rd, Rangiotu Rd and Himatangi Beach Rd. Sections of Taihape-Napier Rd, Te Moehau Rd, Spooners Hill Rd, Toe Toe Rd, Ongo Rd, Mangahoe Rd, Kauangaroa Rd vulnerable to landslides	2 (pavements) 3-4 (bridges/ structures) 2-4	Potentially slips blocking or damaging roads. Could affect evacuations and cut off certain communities. Road closures, with duration depending on extent of damage, which could be severe.
Water Supply – Whanganui DC	Trunk Mains feeding major storage to Urban area.	2-4	Medium to long term disruption (repairs estimated at 4-12 months for bores and Trunk Mains and 2-6 months for standard network pipelines).
Wastewater – Whanganui DC	Main interceptors along the riverbanks and the rest of the network especially older earthenware pipes.	2-4	Medium to long term disruption (repairs estimated at 4-12 months for interceptors and 2-6 months for standard network pipelines).
Stormwater – Whanganui DC	All the network is vulnerable – especially older earthenware pipes.	2-3	Medium to long term disruption (repairs estimated at 4-12 months for larger pipelines and 2-6 months for standard network pipelines).
Roading – Whanganui DC	Both Urban and Rural roads affected and Bridges	2-4	Medium to long term disruption (repairs estimated at 4-15 months for Bridges and 2-6 months for roads).

5.2 Tsunami

5.2.1 Hazard Overview

Tsunami are typically generated as a result of displacement of ocean water due to landslides, earthquakes, volcanic eruptions and bolide impacts.

The region is vulnerable to tsunami hazards on both the east and west coasts. The primary sources of tsunami risks include:

- Distant: South America, particularly southern Peru, and to a much lesser extent Cascadia (North America) and the Aleutian Islands;
- Regional: Solomon Islands, and to a much lesser extent the southern New Hebrides; and
- Local: the Hikurangi Margin, located off the east coast of the Region and local faults including undersea faults located off the west coast.

Reference Manawatu-Wanganui CDEM Group Plan 2016-21.

5.2.2 Hazard Exposure

The hazard layers used for this project are tsunami evacuation maps prepared in accordance with the MCDEM Director's Guidelines for Tsunami Evacuation Mapping *DGL 08-16* using a 'level 2' rule-based methodology. This essentially models the height of the wave with GIS-calculated attenuation rules for open coast, harbours and rivers. Three layers are used:

- The Yellow zone is the area expected to be inundated by a 2500-year tsunami and is intended to be used for local source events generating a 7-9m wave height.
- The Orange zone is intended to be used for distant or regional source tsunami and broadly equates to a 1:500 year tsunami with a travel time >1 hour generating a 3-5m wave height.
- The red zone is intended as the marine and beach exclusion zone, land levels up to 2m above high tide.

5.2.3 Infrastructure Vulnerability Assessment

Table 5-5 summarises the critical lifelines assets exposure to the hazard layers described above and the likely extent of service disruption arising from that exposure.

Damage from tsunami is caused by the impact of the flowing water, debris impacts and inundation of salt water. The extent of damage therefore is highly variable and will depend on the scale of the debris. The damage assessment tables from the Wellington and Auckland Lifelines Group report[7] were used to assist the assessment.

There are a number of critical assets in tsunami risk areas – including electricity substations in Whanganui, wastewater treatment plants in Foxton and Koitiata and trunk telecommunications fibre cables crossing coastal bridges. The State Highway network only passes through tsunami risk zone across the Whanganui River, but a number of local roads are at risk.

Table 5-5: Potential impacts of tsunami hazard on infrastructure assets and services

Sector	Critical assets exposure to hazard	Vulnerability[8]	Potential Service Disruption
Wastewater - HDC	Foxton Beach wastewater plant.	3-4	Raw sewage discharge.
Wastewater – MDC / Rang DC	Koitiata WWTP and WWPS.	4	Discharge of partially treated or untreated wastewater to environment and potentially through Koitiata.

[7] An Analysis of Tsunami Impacts to Lifelines, GNS Science Report 2016/22.

[8] 1: Unlikely to cause damage. 2: Possible damage, short term disruption. 3: Possible damage, longer term repairs (weeks/months). 4: Complete failure, full reconstruction required.

Water Supply – MDC / Rang DC	Himatangi Beach WTP.	2	Depending on run-up height and distance, plant building could be affected, potentially causing loss of supply.
Telecommunications - Chorus	Eastern, Western, Central NI Fibres – particularly at bridge / river crossings.		Cross regional and national links if all three fail. Exchange and cell site isolations.
State Highways	NZTA – SH3 Whanganui River Cobham Bridge	1-2	Minor risk of transport disruption
Electricity	Foxton Beach network	3-4	
Electricity - Powerco	Castlecliff Substation, Whanganui Beach Rd Substation, Whanganui Taupo Quay Substation, Whanganui Hatricks Wharf Substation, Whanganui Peat St Sub, Whanganui	3-4	Water entering zone substation Partial loss of supply
Transport - MDC	Damage to roads at Koitiata, Scotts Ferry, Tangimoana and/or Himatangi Beach	2	Could affect evacuation.
Water Supply – Whanganui DC	Trunk Mains feeding major storage to Urban area.	2-4	Medium to long term disruption (repairs estimated at 4-12 months for bores and Trunk Mains and 2-6 months for standard network pipelines).
Wastewater – Whanganui DC	Main interceptors along the riverbanks and the rest of the network especially older earthenware pipes.	2-4	Medium to long term disruption (repairs estimated at 4-12 months for interceptors and 2-6 months for standard network pipelines).
Stormwater – Whanganui DC	All the network is vulnerable – especially older earthenware pipes.	2-3	Medium to long term disruption (repairs estimated at 4-12 months for larger pipelines and 2-6 months for standard network pipelines).
Roading – Whanganui DC	Both Urban and Rural roads affected and Bridges	2-4	Medium to long term disruption (repairs estimated at 4-15 months for Bridges and 2-6 months for roads).
Water Supply – Whanganui DC	Inundation of some above ground connection facilities for heavy commercial and industrial sites.	1	Very short term disruption (repairs estimated at 1-2 weeks).
Wastewater – Whanganui DC	Tregenna Street Pump Station, Beach Road Pump Station and inundation of some of the pipe network close to the beach and up the river to the Cobham Bridge.	2-4	Medium to longer term disruption (repairs estimated at 4-6 months for the Pumping Stations). Short to medium term disruption (repairs estimated at 1-3 months for the Pipe Network).
Stormwater – Whanganui DC	Inundation of some of the pipe network close to the beach front and up the river to the Cobham Bridge.	1-2	Short to medium term disruption (repairs estimated at 1-3 months for the Pipe Network).
Roading – Whanganui DC	Inundation over roads close to the beach front and up the river to the Cobham Bridge.	1-2	Short to medium term disruption (repairs estimated at 1-3 months for the Roading Network).

5.3 Volcanoes

5.3.1 Hazard Overview

The Manawatu-Whanganui region flanks and includes a portion of the Taupo Volcanic Zone (home to many active volcanoes) and lies downwind of another volcanic complex, Taranaki. This relative positioning confirms there is an exposure to volcanic hazards. Aspects of volcanic hazards and the relationship to lifelines have been covered by Hodgson and Houghton (1995), Horizons (2005) and Morris (2014).

There are three primary volcanic centres that could affect the region; Tongariro National Park volcanoes (Ruapehu, Ngauruhoe and Te Maari), Taupo Volcanic Centre and Taranaki volcano.

5.3.2 Hazard Exposure

Volcanic ash hazard maps were prepared for this study for each volcano for three approximate scenarios representing a 500, 1000 and 1,500 return period event. Events from the last 27,000 years have been analysed to determine the likely volume of eruption for each of these return periods and two broad scenarios have been presented by GNS:

- The first is a series of concentric circles assuming the **average wind speed** regardless of direction and illustrates the maximum ashfall thicknesses for a given **volume of material erupted** at that wind speed.
- The second are scenarios where, for the volume of material erupted, the wind speed and direction is specified. The output from this modelling is a series of elongate ellipses. These were developed for the original 2005 project.

Table 5-6: Taranaki Volcanic Ash Layers

Map Type	Volume (range if applicable)	Volume used	Return period
Modelled ashfall	0.1-0.25 km^3	0.1 km^3	500
Modelled ashfall			
Modelled ashfall	1 km^3	1 km3	2500
Scenario	0.1 km^3	0.1 km^3	500
Scenario	0.5 km^3	0.5 km^3	1000
Scenario	1 km^3	1 km^3	2500

Table 5-7: Ruapehu-Tangario Volcanic Ash Layers

Map Type	Volume (range if applicable)	Volume used	Return period
Modelled ashfall	0.1-0.25 km^3	0.1 km^3	500
Modelled ashfall			
Modelled ashfall	1 km^3	1 km3	2500
Scenario	0.1 km^3	0.1 km^3	500
Scenario	0.5 km^3	0.5 km^3	1000
Scenario	1 km^3	1 km^3	2500

Table 5-8: Taupo Volcanic Centre Volcanic Ash Layers

Map Type	Volume (range if applicable)	Volume used	Return period
Modelled ashfall	0.1-0.2 km^3	0.1 km^3	500
Modelled ashfall			
Modelled ashfall	0.2-0.5 km^3		2500

Some of the modelled maps are shown on the following pages. The full set are available in the GNS report[9].

[9] Update of Hazard Information for 2015, Lifelines Risk & Responsibilities Report, GNS Science Consultancy Report 2016/40, May 2016.

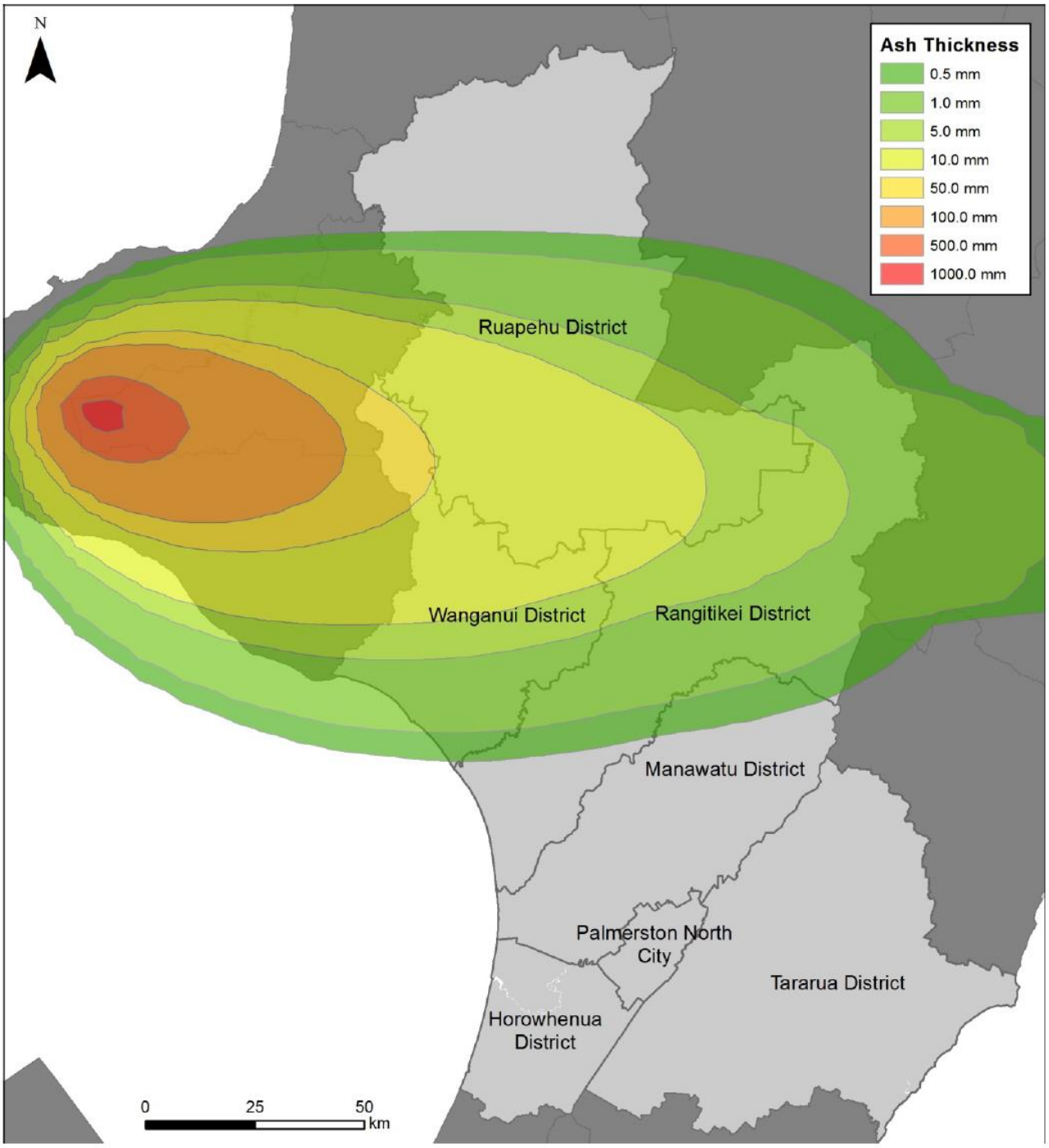


Figure 12 Ashfall depths for the maximum credible event for Mt Taranaki where approximately 1 km^2 of material is erupted. In the Horizons Region maximum ashfall depths are expected to be 50 mm. Most of the northern half of the Horizons Region will be affected by ashfall ranging from 0.1 to 50 mm in thickness.

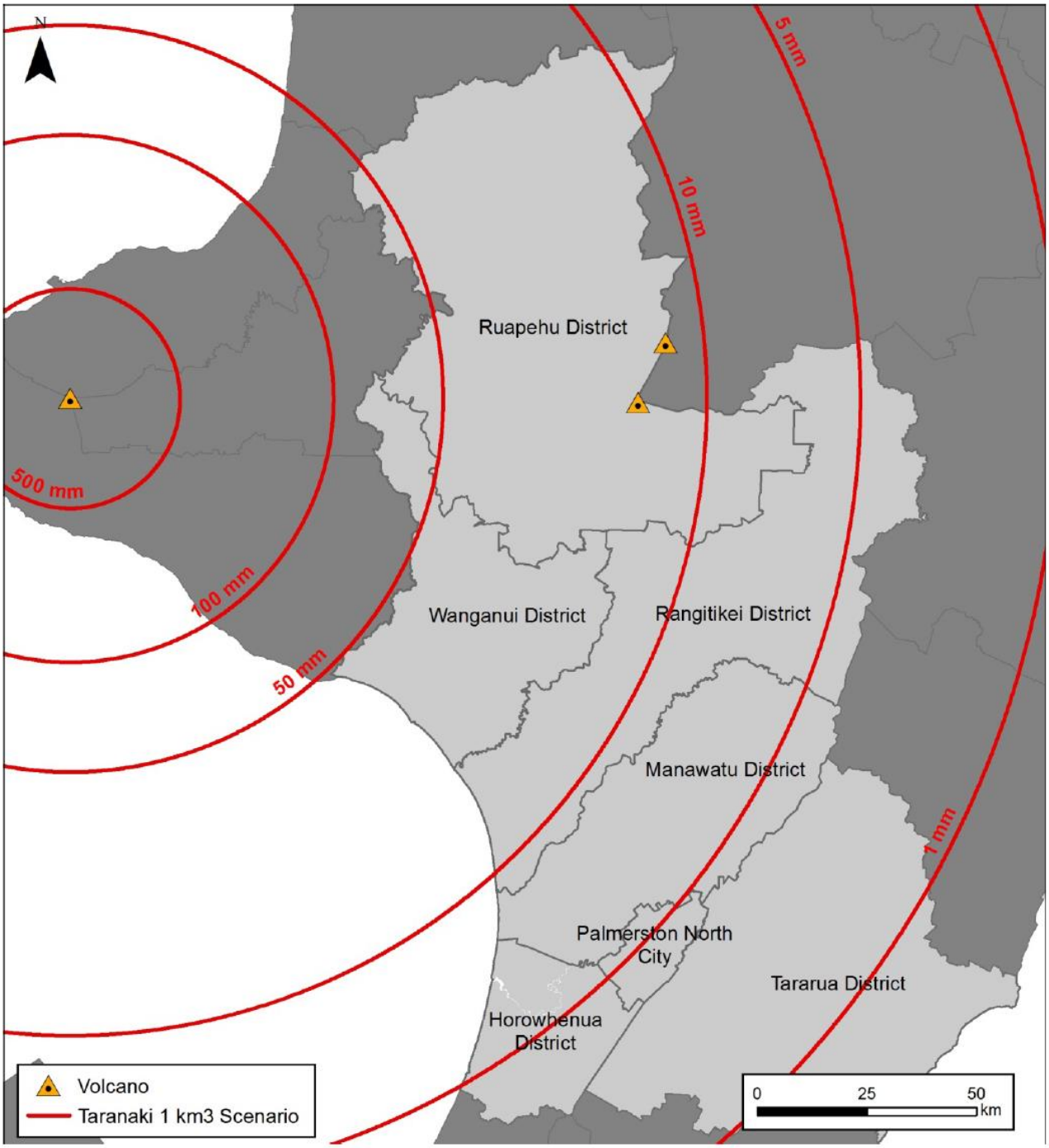


Figure 17 Ashfall contours for an eruption volume of 1.0 km^3 from Mt Taranaki. For Mt Taranaki this is equivalent to the 2500 year return period event and is also the likely maximum credible event (MCE) for this volcano. Under westerly wind conditions the impacts from the 2500 year return period eruption from Mt Taranaki will impact all of the Horizons Region to some degree with ashfall thicknesses potentially varying from 0.5 to 100 mm.

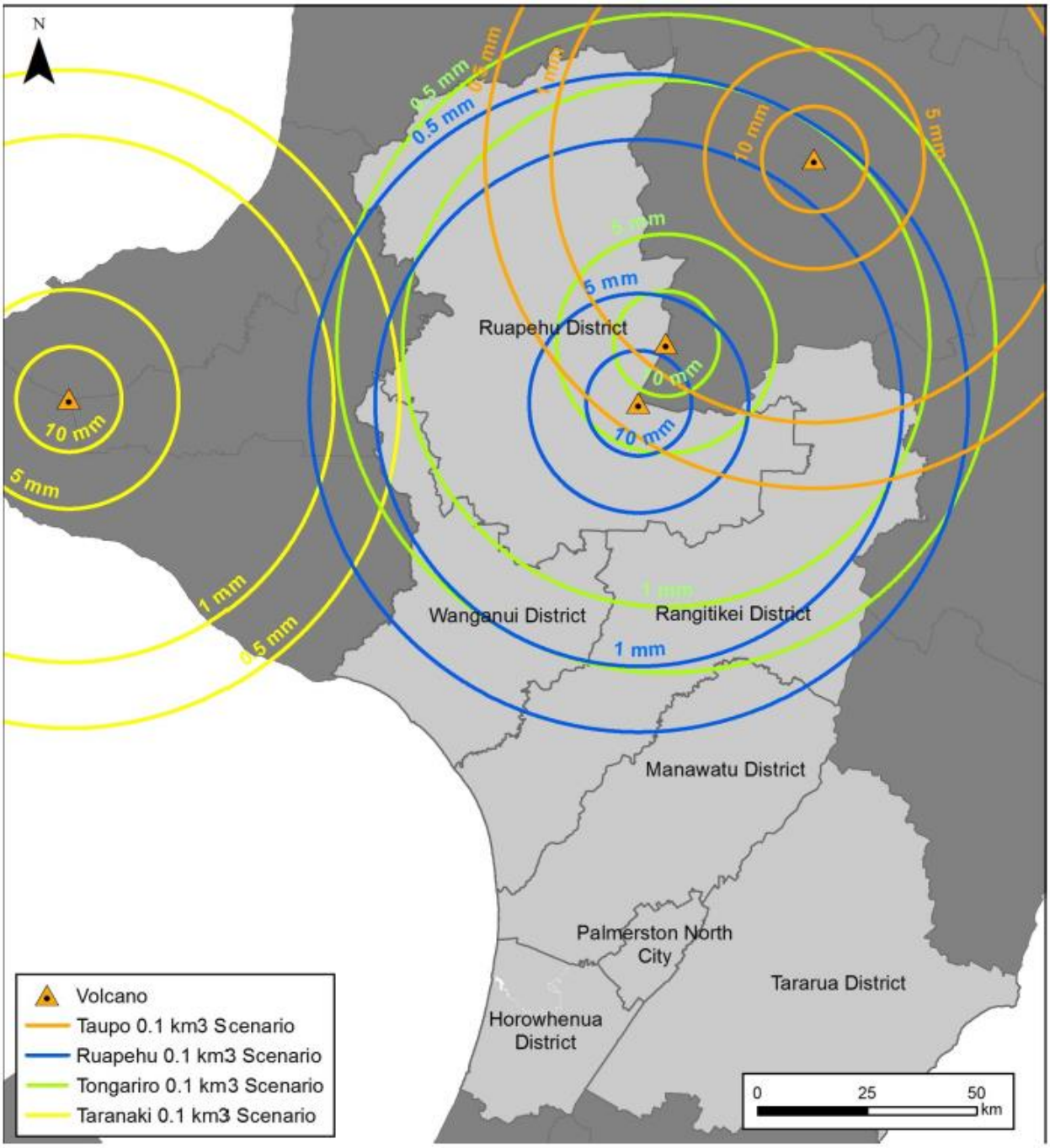


Figure 16 Ashfall contours for eruption volumes of 0.1 km^3 for Tongariro, Ruapehu, Taupo and Taranaki volcanoes. For Tongariro and Ruapehu volcanoes this is equivalent to the 2500 year return period event and is also the likely maximum credible event (MCE) for these volcanoes. For Mt Taranaki and Taupo this event is equivalent to the 500 year return period event and only has a very minor impact on the Horizons Region under favourable weather conditions. Under most conditions the major impacts from Ruapehu and Tongariro are at the 2500 year return period and are limited to Ruapehu District with some thin ashfall occurring in Wanganui and Rangitikei Districts when weather conditions are conducive.

Figure 5-5: 1:2,500 return period volcanic ash fall events

5.3.3 Infrastructure Vulnerability Assessment

Close source volcanic risks including lahars and eruptive material are not expected to pose a major risk to the region's critical lifelines assets. However volcanic ashfall will potentially impact on lifelines services in the projected ashfall areas to the north and west of the region (depending on the volcanic source), as follows:

- Ongoing electricity outages caused by flashovers, for the duration of the eruption, particularly in some wet conditions. Loading damage can occur with > 100mm ash (unlikely to be to that level in this region).
- Disruption to both electricity and telecommunications control systems due to ash ingress into heating, ventilation and air-conditioning.
- Unsafe road driving conditions due to reduced visibility and traction with ash clearance and disposal required.
- Increased turbidity in raw water sources causing operational problems at water treatment plants, accompanied by an expected high water demand during the cleanup phase.
- Potential ash entry causing clogging of sewer networks and damage to treatment plant and pump station assets.

Lifeline utilities have identified the following specific areas and assets at risk:

Table 5-9: Volcanic Ash Impacts on Critical Assets

Organisation / Sector	Critical assets exposure to hazard	Vulnerability[10]	Potential Service Disruption
Electricity - Powerco	33kV and 11kV networks will be impacted. Whanganui City Whanganui rural region Manawatu city/towns Manawatu rural regions Waiouru Taihape	2-3	Total/partial loss of supply
Electricity - Transpower	Volume of ash does not present an immediate risk to TP assets. Expect significant cleaning to do in the short term during controlled outage conditions.	2	NA
Emergency Services	Hospital HVAC Radio comms		Disruption to health services, possibly long term. Radio communication services.
Gas Transmission	Effect use of gas compressors at Kaitoke	2	Effecting supply south of Kaitoke (Whanganui)
Telecomms - Chorus	HVAC	2	Potential impact on air conditioning systems.
Flood Protection	Loss of capacity in storage dams with Tutaenui catchments	1-2	Temporary impacts on Road and Rail
Transport – MDC / Rang DC	Ruapehu 0.1 km^3 scenario could affect Taihape-Napier Rd, Te Moehau Rd, Spooners Hill Rd, Toe Toe Rd, Ongo Rd, Mangahoe Rd, Kauangaroa Rd and Ruahine Rd; Tongariro 0.1 km^3 scenario could affect some of these; Taranaki 1.0 km^3 scenario could affect entirety of both Districts.	2-4	Decreased visibility and covering of road markings. Loss of traction. Increased loading on bridges especially if ash is wet. Potential lahars causing further damage, especially to bridges. Damage to vehicles, including road maintenance vehicles. Health & Safety risks to road maintenance staff requiring PPE including appropriate face masks.

[10] 1: Unlikely to cause damage. 2: Possible damage, short term disruption. 3: Possible damage, longer term repairs (weeks/months). 4: Complete failure, full reconstruction required.

Organisation / Sector	Critical assets exposure to hazard	Vulnerability[10]	Potential Service Disruption
Transport/ Ruapehu	Ash affected roads	2	Disruption to access and use with potential disruption to vehicles air intake systems
Transport – State Highways	SH1 – Waiouru to Bulls SH4 – Rataehi to Whanganui SH3 – Patea to Whanganui (1)	1-2 1-2 1	Disruption due to removal of ash from road surface. Blockage of underground services. Dust nuisance
Wastewater – MDC / Rang DC	Ruapehu 0.1 km^3 scenario could affect Taihape, Mangaweka and Hunterville networks; Tongariro 0.1 km^3 scenario could affect some of these; Taranaki 1.0 km^3 scenario could affect entirety of both Districts.	2-3	Potential damage to pumps, pipelines, plant equipment and vehicles could affect level of service.
Wastewater/Ruapehu	Reticulation and treatment	2	SW infiltration could affect some older sewers.
Water Supply – MDC / Rang DC	Ruapehu 0.1 km^3 scenario could affect Taihape, Mangaweka and Hunterville supplies; Tongariro 0.1 km^3 scenario could affect some of these; Taranaki 1.0 km^3 scenario could affect entirety of both Districts (2-3).		Increased turbidity, acidity and toxicity of raw water could affect water quality. Potential damage to intakes, pipelines, pumps, plant equipment and vehicles could lead to loss of supply.
Water Supply/Ruapehu	Insecure surface water sources in Ruapehu – would shut down – acidity levels – ration reservoirs.	3	Contaminated source water and reinfection post event
Water Supply PNCC	May impact Turitea water supply.		
Water Supply – Whanganui DC	All supplies are from secure sources.	1	Secure sources – potentially no service disruption.
Wastewater – Whanganui DC	Ash entry into pipe network potentially from private inlets and entry into the new Wastewater Treatment Clarifiers.	1-2	May affect the WWTP operation, requiring shut down and cleaning – this would result in direct pumping to the ocean outfall.
Stormwater – Whanganui DC	Ash entry into pipe network from open sumps and Natural Waterways inlets.	1	May cause some surface flooding and a reduction in the level of services till pipe networks are cleaned out.
Roading – Whanganui DC	Ash affected roads.	1	Disruption to access and use with potential disruption to vehicles air intake systems.

5.4 Severe Weather

5.4.1 Hazard Overview

From CDEM Plan 2016
River flooding as a result of sustained or high intensity rainfall is the most frequent and widespread hazard throughout the Region. Given this the Regional Council manages and maintains extensive river control systems throughout the Region.

The level of flood protection across the region is highly variable, ranging from 1-in-5 year design standards in isolated rural areas to 1-in-500 year design standards for Palmerston North.

Significant flood events occurred in 2004 and 2015 that impacted wide parts of the region. There are several major river systems within the Region including:

Whanganui River: the largest river system, it drains a significant proportion of the land area within the Ruapehu and Whanganui districts. The headwaters are located on the northern slopes of Mount Tongariro, and the river system flows south to enter the Tasman Sea at Whanganui. The primary area of risk is Whanganui, with some risk also present at Taumarunui.

Manawatu River: the second largest river system in the Region, and covers much of the land area within the Tararua and Manawatu Districts, and Palmerston North city. The upper catchment drains the eastern side of the Ruahine and Tararua Ranges, extending almost to the east coast, while the lower catchment encompasses a large area between the Ruahine and Tararua Ranges and the Tasman Sea. The primary flood risk areas within the lower river system are Palmerston North, Feilding, Foxton and Foxton Beach, while Pahiatua is the primary risk area in the upper catchment.

Rangitikei River: the third largest catchment in the Region, and it covers much of the land area within the Rangitikei District. The river is sourced from headwaters in the Kaimanawa and Ruahine Ranges, and flows into the Tasman Sea near Tangimoana. The primary flood risk areas are Marton, Bulls, Scotts Ferry and Tangimoana.

Whangaehu River: sourced from the eastern side of Mount Ruapehu, and flows in a south-west direction towards the Tasman Sea south of Whanganui. Flood risks are largely confined to the main channel. Whangaehu village, located on the flood plain near the coast, has been inundated several times in recent years.

5.4.2 Hazard Exposure

Flooding information used for the vulnerability assessment included:

- 1:200 year river flood models across the region.
- Hydrological stormwater models for Palmerston North and Whanganui.

5.4.3 Infrastructure Vulnerability Assessment

The road network will be affected by flooding, scouring, washouts, slips and debris from high winds and the potential for isolation of communities and disruption to major routes was well evidenced in the 2004 floods.

Secondary affects due to transport impacts are the loss of access to infrastructure for repairs and restoration, particularly in the scenario of a regionally widespread severe storm. This would particularly impact power supply, water supply, wastewater treatment and telecommunications.

The local electricity network is likely to be affected in multiple locations due to flooding, high winds and debris causing damage to lines, poles and pillars. While many lifelines that are reliant on electricity have back up power supplied by batteries and generators, getting access to these sites for refuelling in longer term outages may be problematic.

Telecommunications and broadcasting are unlikely to be directly affected (unless fibre cables crossing river bridges are swept away). However the loss of power and damage to overhead lines from high winds is likely to cause some service disruption.

Specific areas and assets likely to be impacted are summarised in Table 5-10.

Table 5-10: Severe Weather Impacts on Lifelines Infrastructure

Organisation / Sector	Critical assets exposure to hazard	Vulnerability[11]	Potential Service Disruption
Telecomms - Chorus	Eastern, Western, Central NI Fibres – particularly at bridge / river crossings.		Cross regional and national links if all three fail. Exchange and cell site isolations.
Electricity - Transpower	Major slips as a result of continued heavy rainfall pose the biggest threat to transmission towers. The Whanganui-Bunnythorpe and Brunswick-Bunnythorpe circuits are located in high risk slip zones. Also parts of the Bunnythorpe-Whakamaru and Bunnythorpe-Wairakei circuits (located in the Rangitikei area) in high risk zones. Significant scouring would be a very rare failure mode even in a flood event. An analysis of structures and flood risk was completed 10 years ago. The report can be made available.	3	Temporary tower within 2-3 weeks. Rebuilding several months. A slip could reduce security to Whanganui and Brunswick subs as well as Taranaki region as whole. No immediate threat to supply to region, but would have national implications if circuits out for an extended duration.
Electricity - Powerco	Whanganui CBD	2-3	Partial loss of supply
	Whanganui CBD	2	Total/partial loss of supply
	Palmerston North urban	2-3	Partial loss of supply
	Feilding urban	2	Partial loss of supply
State Highways	<u>Bridges</u> SH3 Whanganui (Cobham Bridge) Whangaehu Bridge Bulls Bridge Tutaenui Stream Bridge (nth Bulls) Turakina River Bridge SH1 – Manawatu/Whirokino Trestle Ohau River Bridge Manakau River Bridge. SH2 - Mangatainaka Bridge. Manawatu River Bridge <u>Highways</u> SH1 – Ohau – Manakau SH2 – Pahiatua Sth (Makakahi River) SH3 – Awahuri to Palmerstion North Manawatu Gorge to Woodville SH4 - Whang, Anzac Parade SH56 – Opiki (Manawatu River bridge and Taonui Basin)	 1 1 3-4 1 1 3 2 2 1 1 1 1 2 1 1 2	Transportation disruption to National and Inter-regional routes affecting other utility and emergency service response, logistics distribution.
Flood Protection	Bulls Bridge River Work	1-2	SH1/SH3 Weeks for permanent repair
Transport – PNCC	Inundation of Saddle Road by the Pohangina River on the river flats between the Village and the road bridge.		
Transport – MDC	Calico Line, Tutaenui Rd, Turakina Beach Rd, Parewanui Rd, Rongotea Rd, Kawakawa Rd, Awahuri-Feilding Rd, Rangiotu Rd, Pohangina Rd, Pohangina Valley East Rd within 200-year flood		Closure of roads, potentially isolating Koitiata and/or Scotts Ferry. Flood mapping needs to be reviewed, as more communities could be expected to be cut off in a 1 in

[11] 1: Unlikely to cause damage. 2: Possible damage, short term disruption. 3: Possible damage, longer term repairs (weeks/months). 4: Complete failure, full reconstruction required.

Organisation / Sector	Critical assets exposure to hazard	Vulnerability[11]	Potential Service Disruption
	zone. Pavements and drainage Structures	 2 4	200 event.
Wastewater – MDC / Rang DC	Marton, Feilding, Awahuri WWTPs within 200-year flood zone. Koitiata WWTP and WWPS near 200-year flood zone *Flood mapping needs to be reviewed. Bulls WWTP and Hunterville WWTP are at recognised risk of damage/ destruction by flood (refer to Bulls WWTP consenting process with Horizons).*	2-4 1-4	Damage to or destruction of plants, pumps and pipelines could lead to environmental damage and/or public health risk.
Wastewater - TDC	Pahiatua ww plant.	2	Raw sewage discharge.
Wastewater - PNCC	PNCC WW Plant, unable to discharge due to high river level. High inflow into wastewater system causing sewer outflows.	2	Raw sewage discharge.
Water / Wastewater - RDC	Ohakune WWTP Raetihi WWTP Inundated but continued to work.	2 2	Raw sewage discharge.
Water Supply - HDC	Pahiatua water intake	2	Water supply disruption.
Water Supply – MDC / Rang DC	Marton WTP, Trickers Hill reservoir (Bulls), Awa St WTP (Feilding) within 200-year flood zone.	2-4	Damage to or destruction of plants, pumps, pipelines and reservoirs could lead to loss of supply at Marton. Access to Trickers Hill reservoir (Bulls) could be cut off. Pipe bridge feeding Trickers Hill reservoir from WTP (Bulls) most likely destroyed, causing loss of supply from this reservoir. Loss of Awa St WTP would mean Feilding supply fed from Almadale WTP only. *Flood mapping needs to be reviewed, as it's expected the Barrows Rd intake (Feilding) would be damaged or destroyed.*
Water Supply - HDC	Pahiatua water intake		Water supply disruption.
Water Supply - PNCC	Access to Turitea treatment plant and dams	2	Chemical supply disruption.
Water Supply – Whanganui DC	Power supply restricted or lost to bores and pumping stations.	1-2	Temporary loss of pumping ability until mobile generators are engaged.
Wastewater – Whanganui DC	Power supply restricted or lost to pumping stations.	2-3	Temporary loss of treatment plant operation and pumping ability until mobile generators are engaged.
Stormwater – Whanganui DC;	Blocked intakes from natural waterways and blocked outlets from Urban network along river and streams.	1-2	Potentially some surface flooding in localised areas until debris is cleared.
Roading – Whanganui DC	Some roads and bridges in the Rural areas, and some Urban roads cut-off.	2-4	Potential damage to roads and bridges across the district which could impact on road users for short to long term (estimated 1-18 mths).

6 INFRASTRUCTURE HOTSPOTS

Hotspots are defined as areas where there are:

- a number of critical infrastructure assets from different sectors converge in a single area.
- significant single points of failure for a network or organisation (also called 'pinchpoints').

The infrastructure hotspots identified in the region are summarised below.

6.1 Bunnythorpe

Bunnythorpe substation has a significant concentration of electricity transmission assets, critical to the region and to the North Island. It is part of the main transmission route from South Island generation sources and a point of convergence from a number of transmission circuits from Haywards substation.

The substation is built to high seismic standards and is expected to be operational following a seismic event. However Transpower have developed a contingency plan for an event causing significant damage to the site to provide temporary transmission capacity around the substation within a matter of days.

6.2 Wharite

Kordia's Wharite site provides telecommunications, broadcasting and radio services to and through the region and on to Taranaki. As well as housing Kordia's assets, a number of other lifelines lease space and have critical assets here. The site is self-sufficient for electricity and fuel for many days and is built to high seismic standards. However the site is in close proximity to the Ruahine Fault and a risk of damage from a seismic event does remain.

6.3 Manawatu Gorge and the East-West Road Connectors

The three main routes that connect Palmerston North and Woodville (including the Manawatu Gorge) do provide diversity in east-west routes, but there is a risk that an earthquake or significant storm event could close all routes (this was close to happening in the 2004 flood event). Upgrades to Saddle Road, the main alternate route to the Manawatu Gorge, are ongoing but it remains a point of vulnerability in the region's road network.

6.4 Fitzherbert Bridge

The Fitzherbert Bridge was identified in the 2005 project report as being a critical regional hotspot, and it remains so in 2016. It is a key transportation route and carries a number of critical lifelines including a Chorus trunk fibre cable, Powerco sub-transmission cable, water mains, trunk wastewater rising main and gas pipeline. A pedestrian / cycle bridge is being planned close by and the intention is for lifelines to include assets that provide diversity for those on the main Fitzherbert Bridge. This project is due for completion within 3 years.

6.5 Woodville-Dannevirke

A number of lifelines services pass through this area providing supply to the east including Transpower transmission lines, SH 2, the rail line and the gas transmission line. At various points these intersect with each other and with the Mohaka and Pahiatua Faults.

6.6 Manawatu River Bridge and Whirokino Trestle

This large bridge also carries critical gas and telecommunications cables. The bridge is known to be nearing end of life and was not built to modern seismic or loading standards. construction of a bridge replacement is due to start construction in 2017.

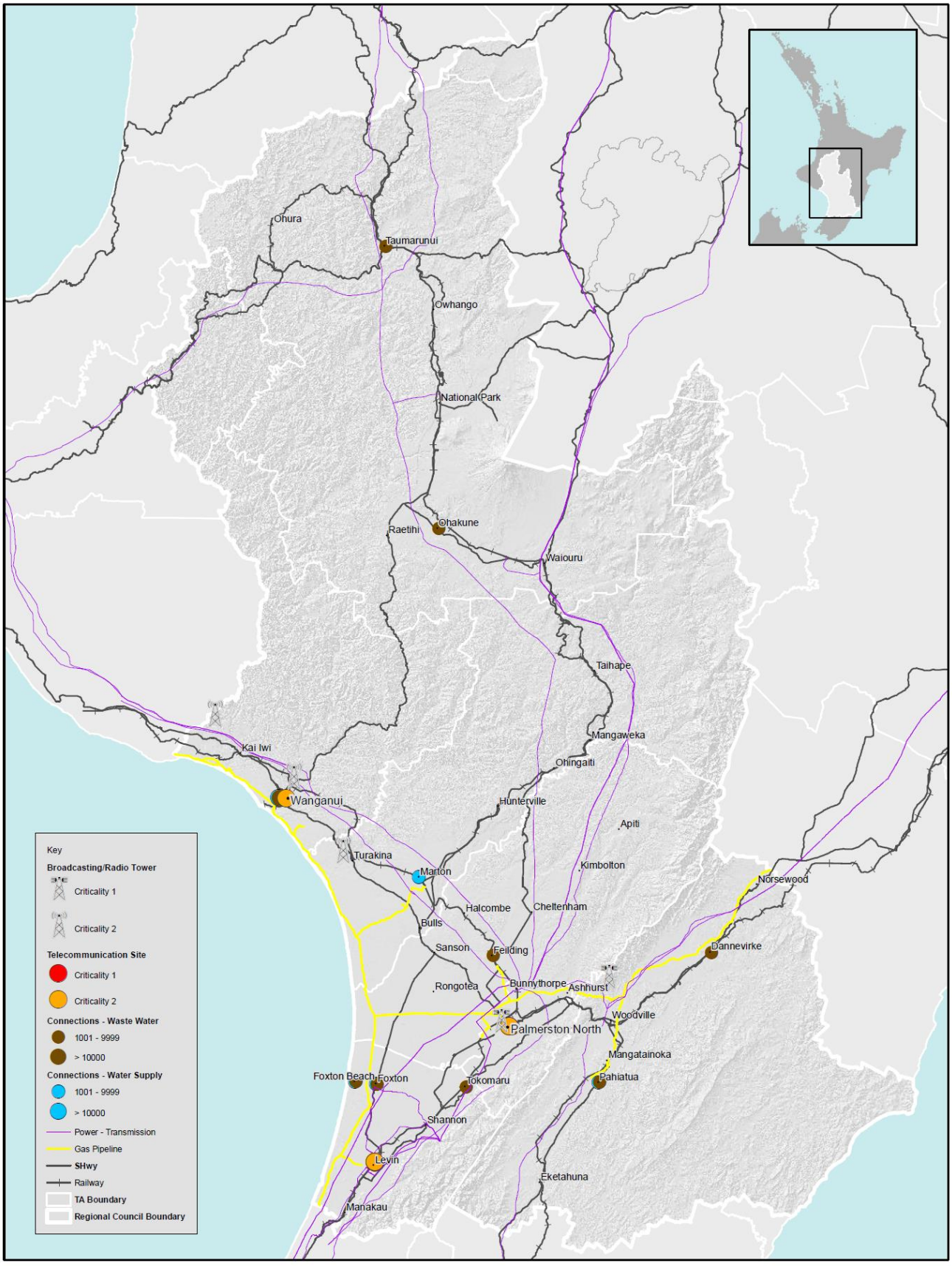


Figure 6-1: Nationally and Regionally Significant Infrastructure

7 IMPROVING THE REGION'S INFRASTRUCTURE RESILIENCE

The original project report identified a number of potential mitigation actions that lifeline utilities identified to improve the region's infrastructure resilience. This section summarises those that have been completed and identifies further actions that can be taken.

7.1 Lifeline Utility Mitigation Programmes

Lifelines organisations all have a range of programmes to maintain the resilience of their networks such as inspection and maintenance programmes and ongoing minor capital upgrade programmes.

On top of these programmes, there have been some significant capital projects completed in the last eight years, such as seismic mitigation works (bridge upgrades and strengthening) reduction to hazard exposure (upgrading of substations from indoor to outdoor) and building of network alternatives (such as the third north island Chorus cable). These major projects are detailed in Table 7-1.

It is noted that future mitigation actions identified do not represent a commitment to undertaken these projects. While some are committed projects in business plans, others have been identified as desirable but are yet to go through a business case and funding review.

7.2 Further Work Identified

It is intended that the information developed for this project be used by lifeline utilities to review their risk exposure and risk mitigation programmes, with consideration of the potential impacts of service failures on other lifelines (interdependencies) and communities.

The information in this report should also be used to inform local authority and CDEM risk reduction planning.

During the workshops held for this project, a number of areas of potential further work have been identified for the Manawatu-Whanganui Group (or CDEM Group):

1. Establish a response and recovery plan for volcanic ash removal and disposal (including protocols with Regional Council for management and consents).
2. Development of a regional fuel contingency plan.
3. Further development of mitigation projects – only around half the participants contributed to the table on the following page.

Table 7-1: Completed and Proposed Lifeline Utility Mitigation Actions

Organisation	Mitigation actions completed since 2005	Further mitigation actions identified
Chorus	▪ Installation of third fibre optic cable through North Island ▪ Stabilisation works around flood damaged areas.	
Electra	▪ Creation of 'ring' network ▪ Second line to Foxton Beach ▪ Reinforcement of supplies to some remote areas.	
HRC Flood Protection	▪ City Reach Upgrade ▪ Lower Manawatu Rural Upgrade ▪ Whanganui River upgrade around industrial area.	
Manawatu and Rangitikei DC	▪ Programme of renewals to improve condition of Water Supply, Wastewater and Roading infrastructure. ▪ Improved risk management practices embedded in asset management planning. ▪ Identification of lifeline routes. ▪ Training and experience for staff involved in emergency management. ▪ Sealing of Taihape-Napier Rd (Rangitīkei District). ▪ Upgrades to Water Treatment Plants to move towards compliance with Drinking Water Standards for bacteria and protozoa. ▪ Construction of new Taihape Wastewater Pump Station to reduce overflows (Rangitīkei District).	▪ Seismic assessments on key assets at Water Treatment Plants, followed by upgrading or renewals. ▪ Ongoing renewals programme for water supply and wastewater reticulation and treatment assets. This includes key assets such as reservoirs and raw water intakes. ▪ Investigations into additional backup electricity generation at Water Treatment Plants and Wastewater Treatment Plants. ▪ Raising level of service along HPMV (High Productivity Motor Vehicle) routes, particularly bridges. ▪ Roading programme of work to focus on lifeline routes, especially Longburn to Feilding route prioritised in Joint Transport Study. ▪ Continuing focus on risk management through asset management planning, including prioritisation of work programmes based on criticality and risk exposure. ▪ Appropriate materials to be used in high-risk areas e.g. PE pipe for water supply and wastewater in Taihape slip zone (Rangitīkei District). ▪ Continuation of upgrades to Water Treatment Plants to achieve compliance with Drinking Water Standards for bacteria and protozoa. ▪ Mangaweka Bridge renewal (boundary bridge between Manawatū and Rangitīkei Districts). ▪ Condition assessments on key assets.
NZTA	▪ Flood protection of Bulls Bridge ▪ Resilience work continues in the Manawatu Gorge – ongoing programme each year ▪ Whakaruatapu bridge SH2 Dannevirke, currently being replaced	▪ Manawatu hill bridge replacement. SH2 Norsewood (low funding priority) ▪ Whirikino Trestle and Manawatu River Bridge being replaced from April 2017 ▪ Seismic strengthening of Bulls Bridge,

Organisation	Mitigation actions completed since 2005	Further mitigation actions identified
	▪ Complete upgrade of Manawatu Gorge bypass route – Saddle Road ▪ Whanganui River Bridge seismic strengthening	(assessments to be completed), ▪ Monitor and maintain river protection works within 250m of each structure.
PNCC	▪ Replacement of Ashhurst Reservoir with installation of EQ shutoff valve and new reservoir in Aokautere. ▪ Additional bore source. ▪ Seismic strengthening and flood protection work for Massey pumpstation.	▪ Duplication of water supply pipeline from Turitea Dam and wastewater pipeline to WWTP. ▪ Seismic strengthening of Ngahere Reservoirs and Totara Road WWTP. ▪ Assessment of major WW pumpstations. ▪ Pedestrian cycle bridge will carry cables providing diversity for Fitzherbert Bridge (within 3 years). It will also carry an emergency water pipe crossing if its location is not too far away from Fitzherbert bridge.
Powerco - electricity	▪ Major upgrading of Taupo Quay Substation (Whanganui) for security enhancements; ▪ Flooding mitigation work in our Beach Road Substation (Whanganui).	▪ Additional underground sub-transmission cables into Palmerston North City are being installed for capacity increase and security enhancements and will be completed over the next 1 to 2 years.
Powerco Gas	▪ Renewal programme – old cast iron pipes replaced with PE ▪ Programme to increase pressure monitoring at pressure regulation stations	▪ New reinforcement pipeline to eastern Palmerston North to meet growing demand in the area ▪ Pressure regulator station (DRS) protection programme
Ruapehu District Council	▪ Renewal programme, eg: replacing aging concrete reservoirs, bridges.	
Tararua District Council	▪ Saddle Road upgrade (complete April 2017) ▪ Impounded water supplies (stored water for supply during source disruptions).	
TeamTalk	Network 'loop' redundancy programmes.	
Whanganui District Council	▪ Completing study on operations criticality assessment to inform forward works programme and future location options when services are replaced. ▪ Power supply replaced to Kai-iwi Bores. ▪ Two Mobile Generation Plants being established to power Water and Wastewater Facilities.	