Facing the Risk
Report of the Hawke's Bay
Engineering Lifelines Project

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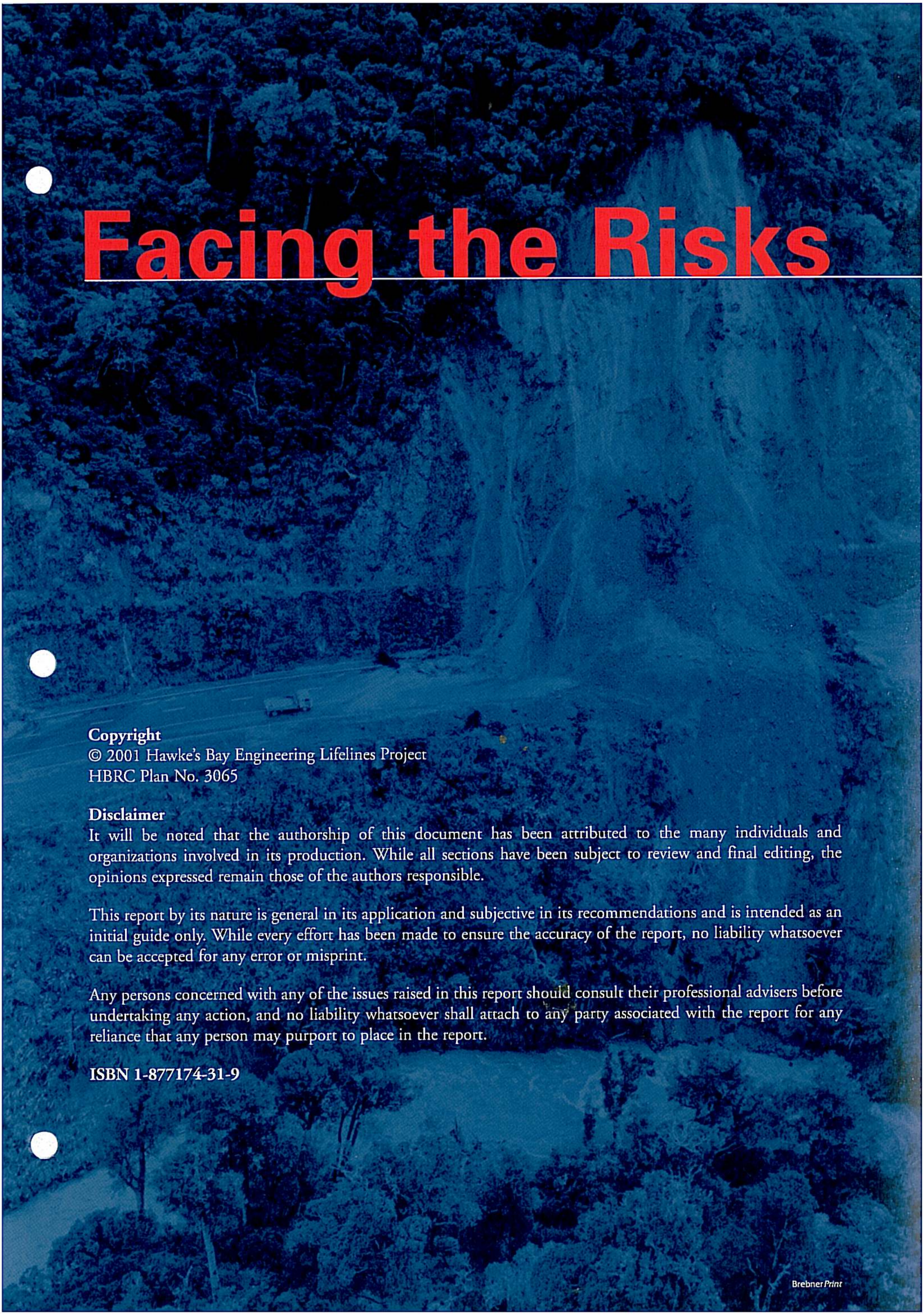
Hawke's Bay Engineering
lifelines



Facing the Risks

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This report by its nature is general in its application and subjective in its recommendations and is intended as an initial guide only. While every effort has been made to ensure the accuracy of the report, no liability whatsoever can be accepted for any error or misprint.

Any persons concerned with any of the issues raised in this report should consult their professional advisers before undertaking any action, and no liability whatsoever shall attach to any party associated with the report for any reliance that any person may purport to place in the report.

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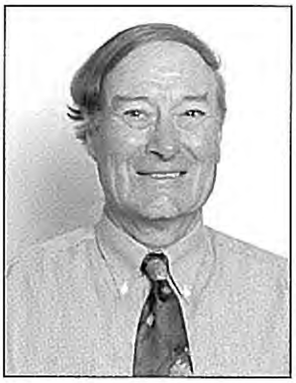


Chairman Ross Bramwell

We all know that the Hawke's Bay community is at risk from severe disruption from a range of natural hazards. Until now this risk had not been quantified and the potential affects of that risk had not been assessed.

The Hawke's Bay Engineering Lifelines Project was initiated to achieve this. There is no one organisation in Hawke's Bay that has a detailed knowledge of all the utility networks that we rely on for our everyday lives and businesses. It was therefore necessary to ensure the active participation of a whole range of organisations to enable the project to be successful. I am pleased that all organisations, without exception, responsible for utilities in Hawke's Bay saw value in the project and committed considerable staff time, and in some cases financial contributions, into providing information on their utilities. This included considering what levels of risk their utilities were at during a range of natural hazard events. The preparation of this comprehensive report has resulted from this work.

I anticipate that those utility operators who have sections of their utility networks at extreme risk will now seek to mitigate that risk as part of their works programmes over the next several years. In the coming years the Hawke's Bay Engineering Lifelines project will continue to encourage these operators to mitigate the risks of damage to their networks. This must occur if the full value of this project is to be realised.

On behalf of the Hawke's Bay community, I would like to thank all those organisations who have contributed staff time and financial contributions to this project, and more importantly thank the staff of those organisations who actively participated in the project. Your efforts and willingness to participate will lead to the Hawke's Bay community being more resilient to the effects of a natural disaster when one occurs.

Ross Bramwell
Chairman
Hawke's Bay Regional Council

Executive Summary

This is a summary of the findings of the Hawke's Bay Engineering Lifelines Project from 1998 to 2001.

Engineering lifelines are infrastructure networks that support life and business in our communities. Lifelines Projects aim to minimise the impact of natural hazards on infrastructure networks and reduce the time that the networks may be out of service.

The Hawke's Bay Engineering Lifelines Project is one of a series of lifelines projects completed or underway in New Zealand.

The project essentially followed the standard AS/NZS 4360:1999 Risk Management to identify the segments of utility networks that are most at risk from natural hazards. Maps were produced electronically, showing where the hazards and the networks overlap.

A Steering Committee and Project Manager administrated the study. Task groups were formed to examine the networks and hazards, and to report on transportation, civil services, energy and communications.

View of Port of Napier and Hawke's Bay - February 2001

Key findings of the project are:

- Hawke's Bay is one of the most earthquake prone regions in New Zealand, with 22 known active faults and folds that are capable of producing very strong earthquakes;
- Large subduction thrust earthquakes on the interface between the Australian and Pacific tectonic plates appear to occur regularly. They are capable of producing high levels of shaking over a large part of the region and could cause ground level drops of up to 600 millimetres;
- The tectonic plate margin close to the East Coast of the North Island is capable of generating earthquakes and submarine landslides that could cause devastating tsunami, despite there being few recorded tsunami in recent times;
- Flooding has caused significant community disruption and economic loss in the past. Most urban areas in Hawke's Bay are protected by flood prevention schemes. However, Wairoa is still susceptible to flooding during events with a frequency of less than a 100-year return period. Napier depends upon pumping to discharge stormwater from a large portion of the city;
- The flood prevention schemes are designed to cope with a 100-year return period. Stopbank breeches are possible during bigger floods that occur less frequently;
- Ash from volcanic eruptions could affect all parts of Hawke's Bay, depending on the wind direction at the time. However Hawke's Bay's engineering lifelines will be much less affected than lifelines near the source of the eruption.

The project's risk assessments have resulted in the following major findings:

- The seismic hazard poses the greatest potential risk to transportation networks, especially structures such as bridges and wharves. Landslips and flooding are potentially the next most serious hazards;
- Civil services are generally underground. At junctions there is a risk they will fracture, especially where they are made of brittle materials and in areas with a high liquefaction potential;
- The installation of automatic seismic shut off valves to reservoirs should be considered to help protect community water supplies during a major earthquake;
- The supply of electric power to Hawke's Bay is limited by the capacity of the single line from Wairakei to Whirinaki. If this supply were to be lost, other sources would not be capable of maintaining full economic production in the region;

- Hawke's Bay needs a well-designed and constructed regional civil defence emergency operating centre. This facility should be built to the highest structural design category for buildings where loss of function would have a severe impact on society. It would need backup supplies of power and water and wastewater discharge capacity to cover an extended period of a civil defence emergency.

Additional key findings of risk assessments carried out on the transportation, civil services, energy and communications networks as part of the project, are summarised below:

Transportation

- Bridges and roads are at risk from the effects of earthquakes, including ground-shaking, liquefaction and fault displacement. These could result in structural damage, the raising or lowering of bridges or roads and chasms opening in roads;
- Many roads and bridges in the region cross low-lying areas, which are difficult to protect from the effects of major flooding or tsunami;
- The availability and maintenance of alternative routes is important to ensure access after a natural disaster;
- In the south of the Hawke's Bay region seismic activity could damage rail lines. In the north the rail network is more at risk from flooding and landslip;
- At the low-lying Hawke's Bay Airport, earthquakes could cause runways to move or crack and a subduction thrust event may lead to an influx of underground seawater. The airport is also at risk from flooding and tsunami inundation;
- Seismic activity could cause major disruption to cargo handling at the Port of Napier. Tsunami also present a major risk to port operations;

Civil Services

- Pipes that are attached to bridges or other structures are at risk from seismic activity;
- Some pumping stations and control equipment are at risk from ground shaking, flooding or tsunami;
- Prolonged power failure will have a serious effect on civil services in the region;

Energy

- Seismic activity poses the greatest potential risk to continued electricity supply;
- Some sites are vulnerable to flooding that could cause electrical equipment to fail;
- Transmission lines can be at risk from earthquakes, landslip, snow, severe wind and ashfall;
- Gas networks are most vulnerable to seismic damage where they are supported above ground by bridges and other structures;
- Remaining cast iron pipes in local gas distribution lines are at risk from fracture during a major earthquake. This could lead to an outbreak of fire;

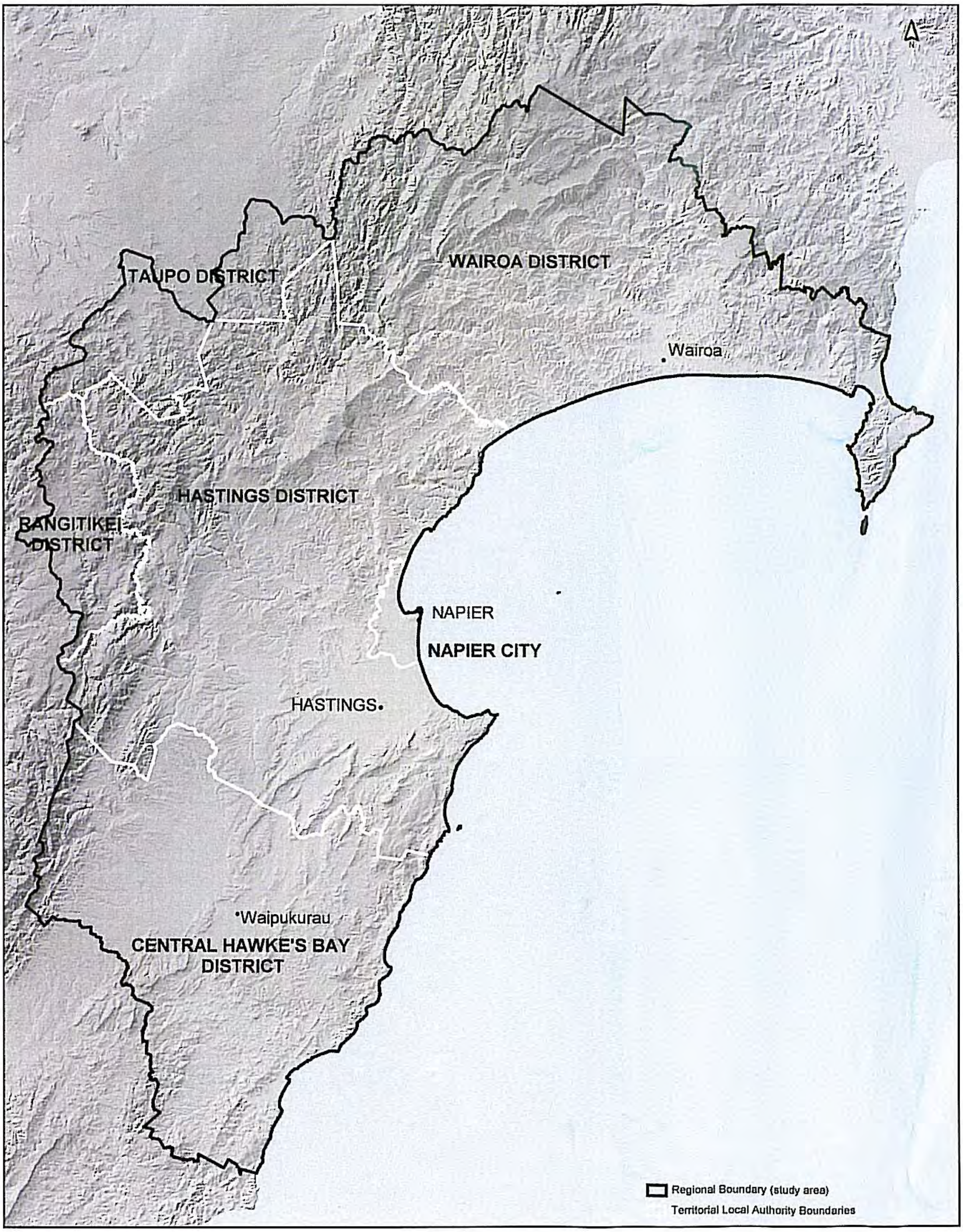
Communications

- Any major emergency is likely to cause overloading of telephone networks;
- People rely on local radio and television stations for information during an emergency and loss of these services could have serious effects;
- Earthquakes pose the biggest threat to broadcasting studios, equipment and transmitter sites. Access to transmitter sites may be difficult after an earthquake or major storm;
- Back-up power supplies to run Emergency Operation Centres during an emergency would be dependent on the availability of diesel deliveries.

Te Waka Microwave tower in a winter snowscape (Photo courtesy Ian Greaves Telecom)

Map 1

Study Area



Introduction

This report summarises the work of the Hawke's Bay Engineering Lifelines Project from 1998 to 2001. The project was established after a seminar in October 1997, which was jointly hosted by the Hawke's Bay Regional Council and the Hawke's Bay branch of the Institute of Professional Engineers of New Zealand.

The overall objectives of the project are to reduce both the damage levels and the time taken to restore services from key utilities, after a major disaster.

This completes Stage 1 of the project in which the emphasis has been on the key utility services, the "engineering lifelines". The aims of Stage 1 have been to define the risk posed to key engineering lifelines from all known and relevant natural hazards and to identify unacceptable risks. Stage 2 will involve emergency management and response planning, using the information gathered in Stage 1. The timing for this project is excellent, given that legislation reviewing New Zealand's approach to civil defence and emergency management is being considered by Parliament. The proposed legislation is intended to improve co-ordination between emergency service providers and utility operators.

The Hawke's Bay Engineering Lifelines Project is one of 14 lifelines projects completed or underway in New Zealand. This project has drawn extensively on the experience of earlier projects for Wellington, Christchurch, Auckland and Wairapara. The national forums held annually for lifelines projects have also contributed significant advice and encouragement.

The methodologies used in this project are based on those developed for the major metropolitan engineering lifelines projects. These have been adapted for the regions of Hawke's Bay and Wairapara, to reflect the extensive areas covered, the networks, and the hazards involved.

Engineering lifelines projects are essentially exercises in risk management. They aim to identify extreme risk elements and encourage appropriate action where practical. Some mitigation measures required will be relatively low cost; others may be prohibitively expensive. Some networks have already taken mitigation measures. The benefit of the project lies in facing the risks and knowingly taking appropriate action.

Another important benefit from the Engineering Lifelines process is improved awareness of natural hazards at a local level. This improved awareness can then be taken into account during the planning, design and installation of alterations and additions to existing networks. Incorporating mitigation measures during the development phase is frequently cheaper and more efficient than modifying existing facilities. Examples of the engineering lifelines project's philosophy are evident in a number of initiatives underway in Christchurch.

Most of this report is based on assessment work that was undertaken during 1999 – 2001. It has been updated as much as possible.

Sponsors

The project would like to gratefully acknowledge the following sponsors who have assisted with the work:

Hawke's Bay Regional Council

Wairoa District Council

Napier City Council

Hastings District Council

Central Hawke's Bay District Council

Hawke's Bay Network

Transit New Zealand

Port of Napier Limited

Transpower New Zealand

Earthquake Commission Research Foundation

Ministry for Civil Defence and Emergency Management

Natural Gas Corporation

Opus International Consultants

Members of the Hawke's Bay Engineering Lifelines Steering Committee.

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Keith Rodel, Institution of Professional Engineers New Zealand and Port of Napier
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Lisa Pearse, Hawke's Bay Regional Council
Ian Greaves, Telecom
Ranad Ducat, Clear
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Introduction

Studies of moderate to large earthquakes and seismicity in Hawke's Bay indicate that the region is one of the most earthquake prone areas of New Zealand. Strong earthquake shaking in excess of Modified Mercalli Intensity VII has been felt in Hawke's Bay on at least 19 occasions in recorded history.

Hawke's Bay has a minimum of 22 known active faults and folds within its onshore and offshore regions that are capable of producing strong earthquake shaking in the future. At least 5 of these are capable of producing levels of earthquake shaking similar to those experienced in 1931 on the Heretaunga Plains.

Large subduction thrust earthquakes on the interface between the Australian and Pacific plates occur frequently and are capable of producing high levels of shaking over a large part of the region.

Hazard Studies

In 1993 the Hawke's Bay Regional Council (HBRC) with the support of territorial local authorities, engaged the Institute of Geological and Nuclear Sciences (IGNS) to carry out a series of studies into the earthquake hazard in Hawke's Bay.

These studies took place over 5 years and included:

- Summarising and giving an overview of existing earthquake hazard information;
- Documenting the location of existing faults and folds and estimating the recurrence intervals of large earthquakes;
- Developing a regional numerical earthquake hazard model by preparing maps showing the level of ground shaking intensity expected at various return periods;
- Determining the nature of subsurface materials within Hawke's Bay and their liquefaction potential, highlighting the main urban areas;
- Determining the susceptibility of subsurface materials to amplified ground shaking, highlighting the main urban areas;
- Estimating the location, size and likely recurrence of large subduction thrust earthquakes in the region.

This has provided a comprehensive and up to date record of the earthquake hazard in the region.

It has also resulted in the preparation of maps of the effects of "scenario" earthquakes resulting from surface fault and subduction zone seismic movements.

Hawke's Bay Tectonic Setting

Hawke's Bay is on the Australian tectonic plate. The Pacific plate starts sliding westward beneath the Australian plate at the Hikurangi Trough about 160 km east of Napier, and becomes progressively deeper below the surface to the west. At this latitude the two plates are converging at an oblique angle at about 50mm/yr.

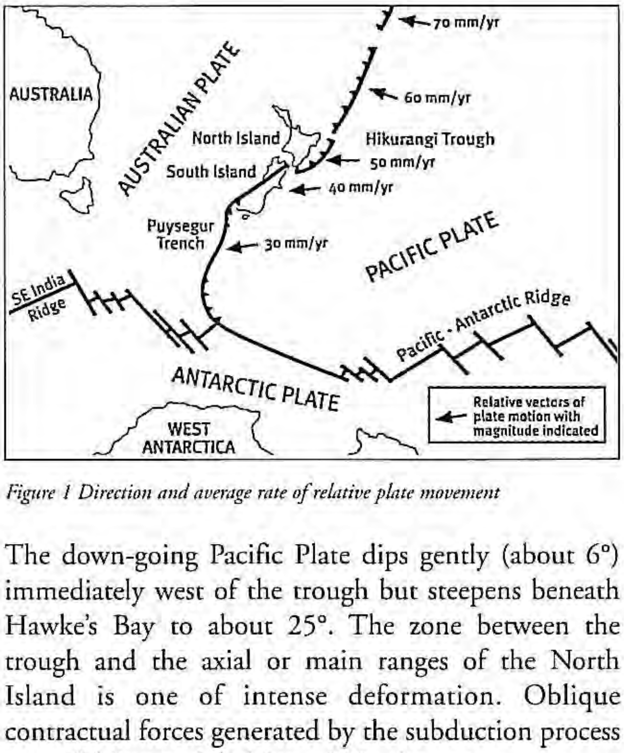


Figure 1 Direction and average rate of relative plate movement

The down-going Pacific Plate dips gently (about 6°) immediately west of the trough but steepens beneath Hawke's Bay to about 25°. The zone between the trough and the axial or main ranges of the North Island is one of intense deformation. Oblique contractual forces generated by the subduction process cause folding and faulting within the zone.

The Heretaunga Plains is a tectonic depression developed between folds within the zone during the last 1.5 million years. Up to 1 km of gravel, sand and silt overlie the limestone and sandstone bedrock.

The gravel-filled basin comprising the Ruataniwha Plains has been formed by a series of west-dipping, north-east-trending reverse faults in the area during the last 1.5 million years. Reverse faulting elevated the hills to the east of the plains resulting in sediment deposits on the relatively low land of the Ruataniwha Plains.

Sea level has risen about 12m since the end of the cold period of the last glaciation (c.18,000 years ago), as a result of climatic warming and polar icecaps melting. Sea level reached its present position c. 6,000 years ago, and has remained more or less stable. The Heretaunga Plains were once more extensive but much of the land was covered by intertidal marine silts during the rise in sea level. Subsequently, there have been continuing deposits of sediment from the mountain ranges to the west together with gravel deposits as a result of regular changes in the course of the Tukituki, Ngaruroro and Tutaekuri rivers. These have built the Plain up above sea level and shifted the coastline eastwards.

The most recent large eruption of Taupo c. 1,800 years ago saw a rapid build-up of large quantities of river deposited Taupo pumice on the Heretaunga Plains. The pumice has been eroded in places by alluvial processes, but up to 10 m of pumice gravel and sand are found in many parts of the Plains. The build-up of aggregates has continued in the rivers, so that 5 – 10 m of alluvial sediment now overlies the pumice in parts of the Heretaunga Plains.

Geologically Hawke's Bay is characterised by a western belt of greywacke axial ranges, bounded to the east by two belts of younger marine sediments that are separated by a low-lying belt of weaker non-marine deposits and shallow marine deposits.

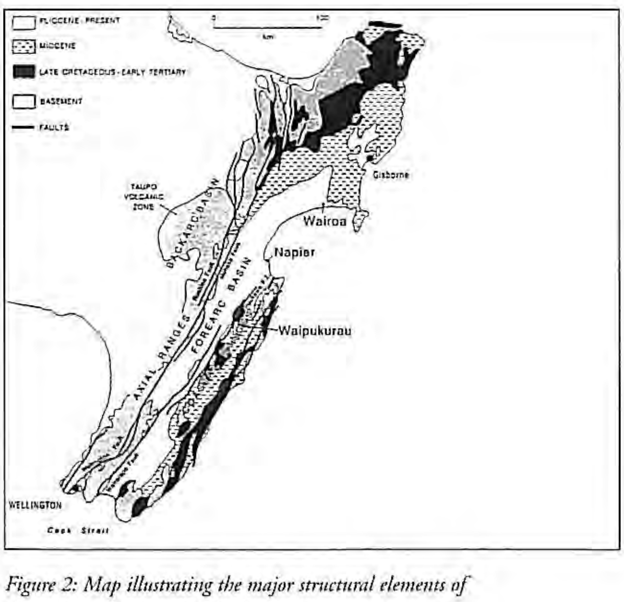


Figure 2: Map illustrating the major structural elements of the geology of eastern North Island.

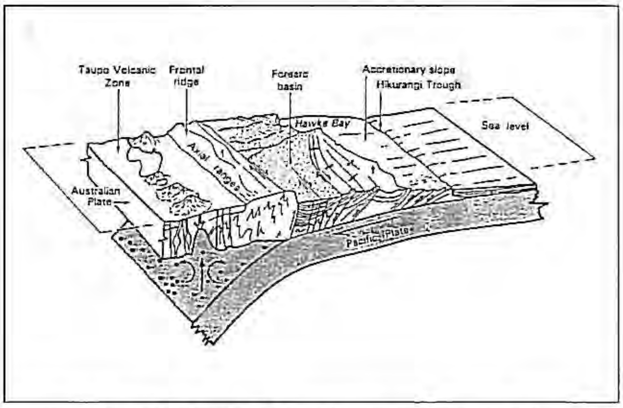


Figure 2a: An idealised model of the subduction zone near Hawke's Bay. The Hikurangi Trough is east of Hawke's Bay.

Earthquake Terminology

Magnitude, Modified Mercalli Intensity and Peak Ground Accelerations are terms frequently used to describe earthquakes and their effects.

The Magnitude (M) is a measure of the energy released by an earthquake at its source and is calculated from seismographic records. For pre-instrumental earthquake observations the Magnitude has been estimated by comparing them with later instrumentally recorded events.

The widely used Modified Mercalli Intensity scale (MM) categorises non-instrumental observations of the felt effects of an earthquake on people, fittings (furniture, crockery, etc) structures and the environment. There are 12 levels on the scale, but only the first 10 (i.e.: up to MM 10) have been reliably observed in New Zealand.

Appendix I to this chapter contains full descriptions of the Modified Mercalli Intensity scales.

Peak Ground Acceleration (PGA) refers to the maximum horizontal acceleration measured during an earthquake at the ground surface and is usually expressed as a percentage of gravity.

The distribution of peak ground accelerations from an earthquake are shown on isoseismal maps, with each isoseismal line enclosing areas experiencing approximately equal intensity of shaking or equal peak ground acceleration.

Earthquakes Affecting Hawke's Bay since 1840

In recent times Hawke's Bay has experienced moderately higher levels of seismicity than most other areas of the country (see figure 3). Since records began 5 large earthquakes (M> 6.9) are known to have occurred, most of which were shallow events.

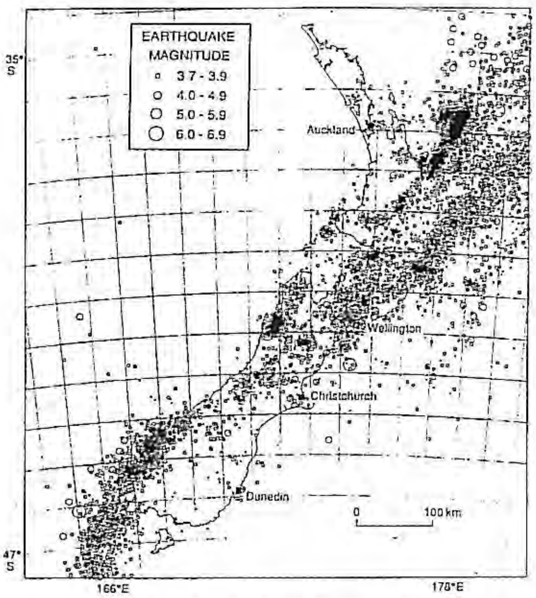


Figure 3: Location of all earthquakes M ≥3.7, and depth ≤ 45 km in the New Zealand area between 1964 and 1992. Note the large number of earthquakes along the Hawke's Bay coast, showing that Hawke's Bay is one of the most seismically active regions of New Zealand.

Hawke's Bay has also experienced felt intensities of up to MM7 from large earthquakes occurring outside the region.

Many moderate magnitude events have occurred within the region. The location of earthquakes of M ≥ 5.0, which are known to have caused intensities ≥ MM5 at Wairoa, Napier, Hastings, Waipawa or Waipukurau, are shown in Figure 4.

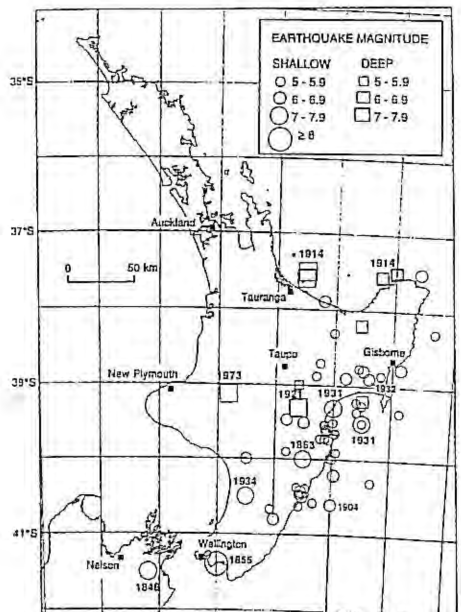


Figure 4: Locations of earthquakes known to have caused intensities ≥ MM5 in Hawke's Bay.

Begg et al 1994 (see Reference 1 to this chapter), contains a description of the large earthquakes that have affected the Hawke's Bay region.

Earthquakes in Hawke's Bay

The Hawke's Bay region is the site of numerous earthquakes because it is close to the boundary of two tectonic plates. These earthquakes result from the sudden release of stresses built up by relative movement between the Pacific and Australian plates over considerable periods of time. The normal subduction process produces these stresses within each of the two plates and along the subduction interface between them. This leads to three types of earthquakes occurring in distinct portions of the earth's crust, as shown in Figures 5a and 5b and discussed below:

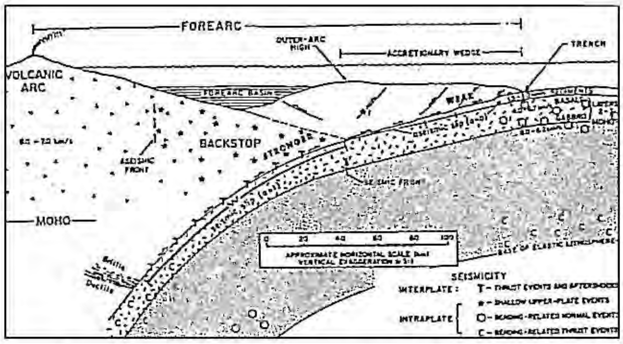


Figure 5a: Idealised schematic cross section of the shallow part of a subduction zone (after Byrne et al. 1988)

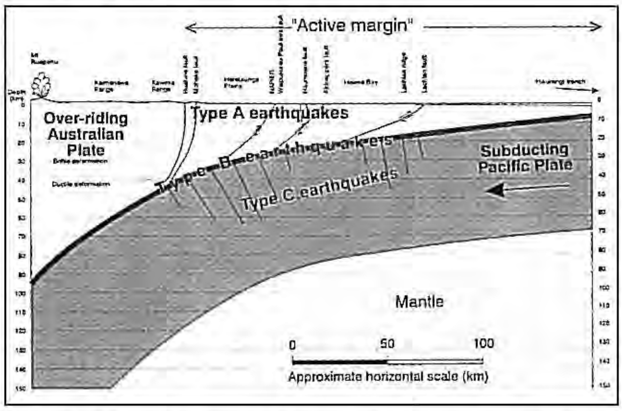


Figure 5b: Schematic cross section illustrating the tectonic setting of the Hawke's Bay region. The section line trends NW-SE and extends from the Hikurangi trench to Mt Ruapehu. Faults, fault zones and earthquake sources are shown.

The three principal types of earthquakes in Hawke's Bay are as follows:

- Type A earthquakes occur within the over-riding Australian Plate from the transfer of stress because of coupling between the two plates at the subduction interface (= "upper plate" earthquakes);
- Type B earthquakes occur at the interface between the subducting Pacific Plate and the over-riding Australian Plate (= "subduction interface");

- Type C earthquakes occur in the upper part of the subducting Pacific Plate as it bends downwards beneath the Australian Plate
(= "deep focus" earthquakes; Figure 5b).

A typical, or "generic", model of a subduction zone can be compiled from world-wide studies, as has been done by Byrne et al. (1988) (Figure 5a). There is almost always a wide "active margin" in which deformation, earthquakes **(Type A)** and possibly volcanism, occur in the overlying plate. The active margin extends from near the "trench", where subduction begins, and continues inland for some distance. Usually, but not always, the magnitude of these **Type A** earthquakes is less than that of large subduction interface **(Type B)** events. However, **Type A** events may be shallower and closer to population centres and present a greater seismic hazard. Earthquakes that occur within the subducted plate **(Type C)** are occasionally quite large magnitude.

As yet there is no method for assessing the seismic hazard of **Type C** earthquakes. However, they are thought to pose a lesser danger to the region than **Type A** earthquakes. This is because they occur at a great depth within the descending Pacific Plate (>25 km beneath Napier, >40 km beneath the northern Ruahine Range) and because that plate may be relatively de-coupled from the Australian Plate, limiting seismic energy. For these reasons **Type C** earthquakes are not considered further in this report.

Active Faults of Hawke's Bay

Fault ruptures associated with earthquakes can occur in the earth's crust. Those that are shallow enough to extend upwards to the ground surface form surface fault traces. Most ruptures that generate a surface trace are associated with large earthquakes, so active fault traces signal likely sites for future large earthquakes.

Major active onshore faults and folds of the Hawke's Bay region are discussed in detail in Reference 1. Their characteristics are updated in Reference 2, by Begg et al.

In order from west to east they are:

Ruahine Fault
The Ruahine Fault is a strike-slip fault separating the stable microcontinental platform area of New Zealand from the zone of deformation known as the East Coast Deformed Belt, that extends to the Hikurangi Trough. The Ruahine and Mohaka faults are two of the major active faults of the Hawke's Bay region and are also major strands of the Wellington fault system.

Waipunga, Big Hill and Thorn Flat, Patoka, Hinerua, Wakarara and Rangiora Faults.
These faults are probably related to the Ruahine and Mohaka faults.

Mohaka Fault
The Mohaka Fault is a major NE tending strike-slip fault which, together with the Ruahine Fault, forms one of the principal structural features of the eastern North Island.

Taniwha, Waikopiro, Oruawhero and Glendown Faults
These faults have been identified in the Ruataniwha and Takapau areas.

Napier – Hawke Bay Fault
The Napier-Hawke Bay Fault tends NW from Bridge Pa, possibly as far south as Tikokino, through Te Awa and offshore.

Napier following 1931 Hawke's Bay Earthquake.

The 1931 Hawke's Bay earthquake (M 7.8) is thought to have been caused by rupture of this fault. The line of zero change in elevation during the 1931 earthquake is currently regarded as the most accurate location of the surface projection of the fault. (see figure 6). This is supported by the presence of a series of springs, which presumably resulted from disruption of an aquifer. The 1931 rupture of the Napier – Hawke Bay Fault was the first for at least 1800 years. The strategraphic record from Ahuriri Lagoon indicates that subsidence has been the dominant direction of tectonic movement during the last 3500 years, in contrast to the uplift experienced in the 1931 event.

Hastings Street Napier following 1931 Hawke's Bay Earthquake.

Waipukurau – Poukawa Shear Zone

A number of strike-slip faults tending NNE NE between Waipukurau and Pakipaki were trenched, mapped and logged as part of the IGNS study and are reported in detail in Reference 2.

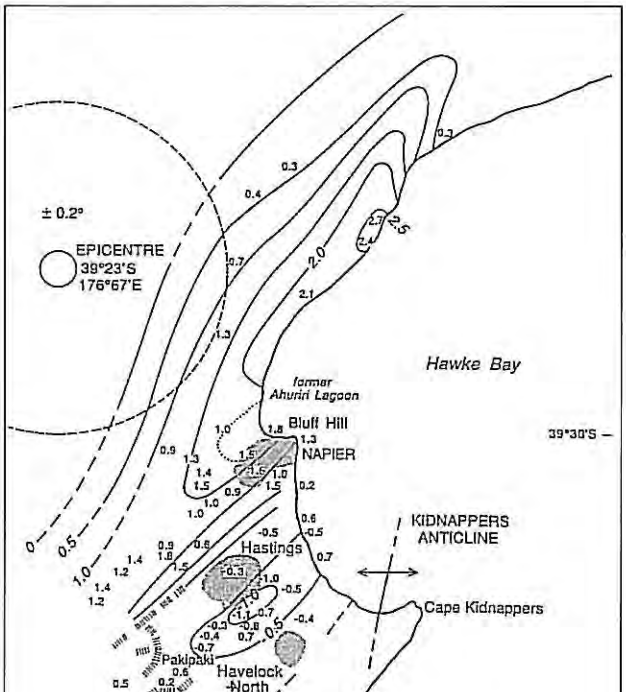


Figure 6a: Subsidence and uplift associated with the 1931 Napier earthquake. Data points and contours are in metres change.

Haumoana Fault Zone

A NNE trending belt of normal faults extends from the coast at Clifton from 70km south beyond Wanstead. A large number of discontinuous fault traces make up a zone that varies in width from several hundred metres to about 8km.

This zone was studied in detail and reported in Reference 2.

Major active offshore structures include:

- Napier – Hawke Bay Fault.
- Kidnappers Anticline/Haumoana Fault zone
- Lachlan Ridge 20km east of Kidnappers Ridge.

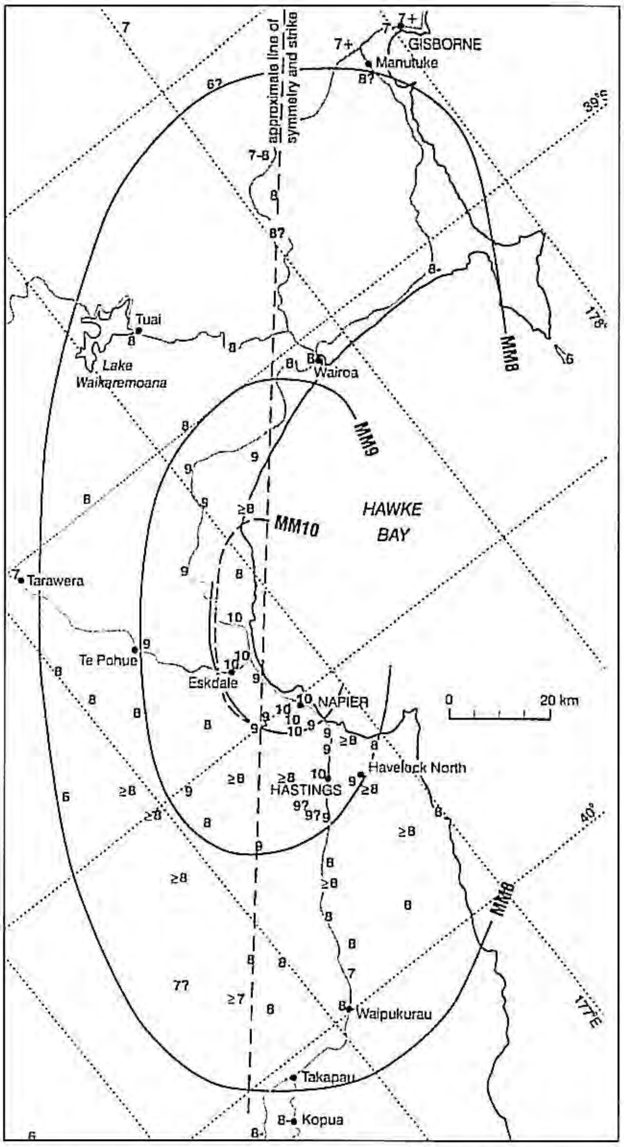


Figure 6b: 1931 Napier earthquake, Ground Shaking (MM) Intensities

Hikurangi Trough

The axis of the Hikurangi Trough lies about 160km to the east of the Hawke's Bay Coast. The trough is not a seismogenic source in its own right but a geomorphological feature that is one indicator of the tectonic environment of the North Island. It represents the surface expression of the subduction plate boundary and is the line along which the Pacific plate starts dipping below the eastern edge of the Australian plate.

Subduction Zone Earthquakes

The second main seismic hazard in the Hawke's Bay region is rupture of the gently dipping subduction interface that exists beneath the region (**Type B** earthquakes).

During a subduction interface rupture, there may not be any primary surface rupture. The history of subduction zone earthquakes can be evaluated by the pattern of coastal emergence or submergence. The pattern is also related to crystal faults. As a result it is very difficult in Hawke's Bay to determine and analyse these earthquakes by geologic evidence.

Historical data from active margins around the world shows that subduction zone earthquakes are among the largest. The hazard associated with subduction faults is difficult to quantify but is an important element of seismic assessment for the Hawke's Bay region.

The subduction zone in the North Island is unusual in two ways. First, a much greater width of the convergent margin is above sea level than is the case in most other subduction zones. This means that large subduction events which are normally offshore, as in Japan for example, may occur much closer to populated areas in New Zealand. Second, the direction of convergence is not perpendicular to the general strike (NE-SW) of the major geologic features and the subducted plate. This is known as oblique convergence and results in the presence of the major, strike-slip faults parallel to the coast in the overlying plate, such as the Wellington, Wairarapa, Ruahine, and Mohaka Faults. Earthquakes on these faults account for a large part of the component of convergence parallel to the coast. However, the component of motion perpendicular to the coast remains largely unaccounted for by these faults. It is usually assumed that this motion is taken up by some combination of slip on the subduction interface (seismic or aseismic), and slip during thrust type earthquakes on shallow faults between the Hikurangi Trough and the axial mountain ranges, such as in the Waipukurau-Poukawa area. It is the relative partitioning of slip between these various tectonic components that determines the potential for large subduction earthquakes in the region.

In order to estimate the location and size of large subduction thrust earthquakes in Hawke's Bay we must first establish the portion of the interface which slips during such events.

Using two methods, IGNS has estimated the average width at about 45km. The length of plate moving based on previous ruptures is 120km, which extends from just north of Cape Turnagain almost to Mahia. If this 120km segment of the plate were to rupture in a single subduction thrust event over a width of 45km, a magnitude 7.7 earthquake could be expected. Such an event is likely to produce an average slip of 3 metres between the plates.

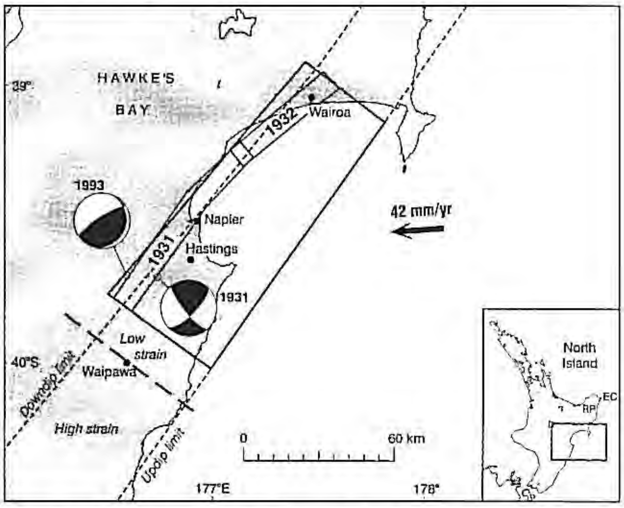


Figure 6c: The inferred updip and downdip limits of the seismogenic zone of the plate interface in Hawke's Bay. The heavy-lined rectangle indicates the portion of the seismogenic zone which might rupture in a single large subduction thrust earthquake, as estimated in this study.

To assess the likely recurrence of such an event, the project used the average relative movement between plates, adjusted for shortening of the overlying plate and factored for seismic slip to total slip. This has resulted in an estimated recurrence of about 550 years for such a subduction thrust event in Hawke's Bay.

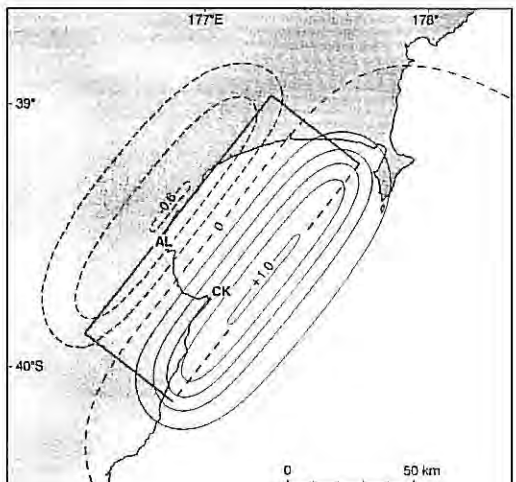


Figure 6d: Elevation changes resulting from elastostatic dislocation modelling of the proposed M_w 7.7 subduction thrust earthquake in Hawke's Bay.
Solid contours denote uplift and dashed contours denote subsidence, and the contour interval is 0.2 m.

Such events would be expected to produce subsidence above the downdip end of the seismogenic zone. Hull (1986) has used peat layers in the Ahuriri Lagoon near Napier to demonstrate that the 1931 co-seismic uplift in this region was a reversal of a subsidence trend. This subsidence could have been produced by large subduction thrust events. The last downdrop of ~ 1m occurred about 500 years ago, and rapid downdrop of 8m occurred during the period ~ 1750-3500 years ago. Elastic dislocation modelling indicates that a maximum of 1m of subsidence will occur above the downdip end of the seismogenic zone as a result of 4m of slip on the fault zone defined above. Thus the downdrop at Ahuriri lagoon some 500 years ago would be broadly consistent with the model for a subduction thrust event. Similarly, if the total 9m of subsidence in the last 3500 years identified by Hull (1986) was to have occurred in similar sized events, a recurrence interval of some 400 years is suggested. Although there are many uncertainties this is also broadly consistent with the recurrence intervals estimated above.

Numerical Assessment of the Earthquake Hazard

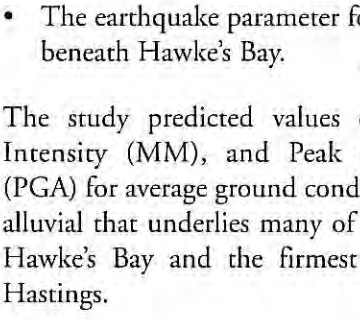
As part of their studies IGNS carried out a regional revision of nationally based earthquake hazard calculations.

These computer calculations used the following source data:

- A catalogue of 1007 shallow earthquakes greater than M4 from 1840-1993;
- 728 deep earthquakes;
- Data from 40 active fault sources;
- The earthquake parameter for the subduction zone beneath Hawke's Bay.

The study predicted values of Modified Mercalli Intensity (MM), and Peak Ground Acceleration (PGA) for average ground conditions, such as the firm alluvial that underlies many of the towns of southern Hawke's Bay and the firmest parts of Napier and Hastings.

A few parts of the region are on very firm sites that are likely to experience less intense shaking than predicted in this study. However many places are on soft ground that will amplify the intensity of shaking. Amplification factors, identified by mapping ground conditions throughout the region in the latter part of the studies, need to be incorporated to produce final estimates of the earthquake hazard.



1907 Westshore and the Iron Pot Napier shows the reclaimed ground upon which much of Napier is built. (Photo courtesy of Don Wilkie collection)

The earthquake hazard results are mainly based on ground motions that have a 10% probability of being exceeded in 15 years, 50 years and 500 years, corresponding to 142, 475 and about 5000-year return period events

The 142-year return period event is likened to the Operating Basis Event - one that can be expected with reasonably high probability. The 475-year event is likened to the Design Level Event (DLE) and corresponds to the New Zealand Loadings Standard (NZS 4203:1992) for many structures. The 5000-year event is likened to the Maximum Design Event (MDE). The MDE has a low probability of occurrence but it is important that critical facilities and structures, such as hospitals, fire stations and key lifeline services, perform well even in this extreme event.

The results of the numerical assessment are presented in Figures 7 to 12.

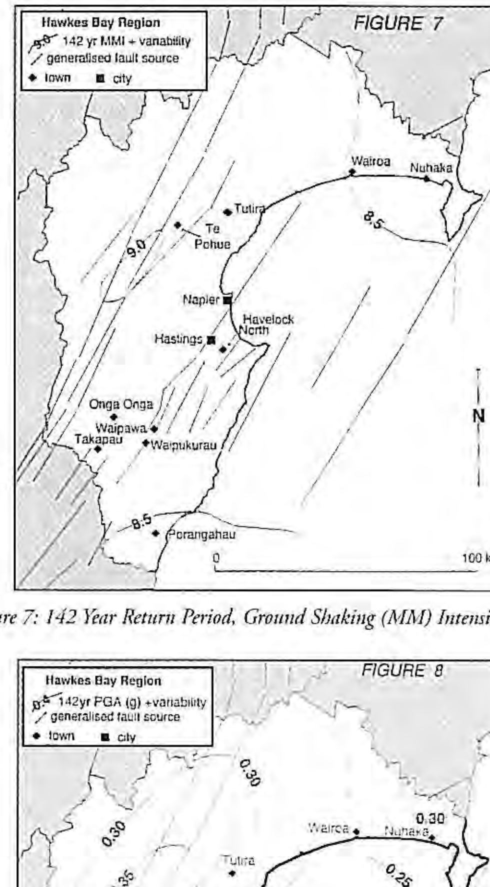


Figure 7: 142 Year Return Period, Ground Shaking (MM) Intensities

Figure 8: 142 Year Return Period, Peak Ground Acceleration (PGA), (g)

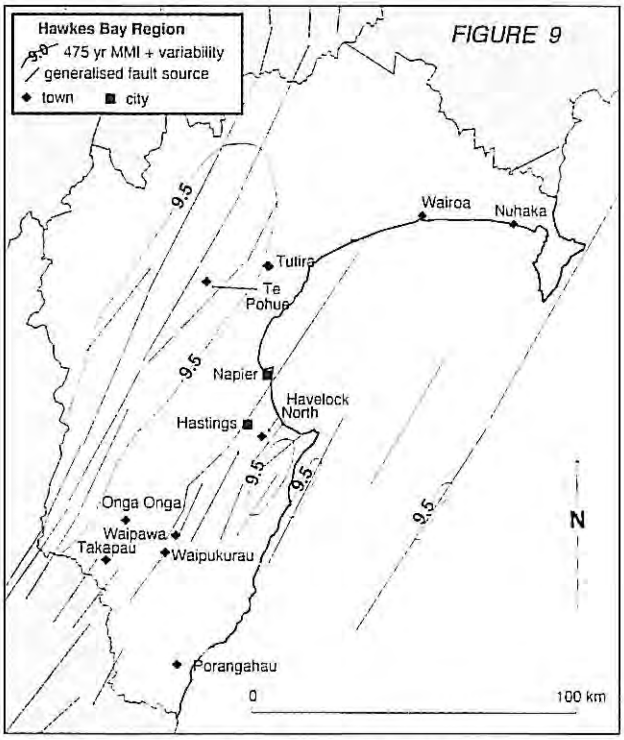


Figure 9: 475 Year Return Period, Ground Shaking (MM) Intensities

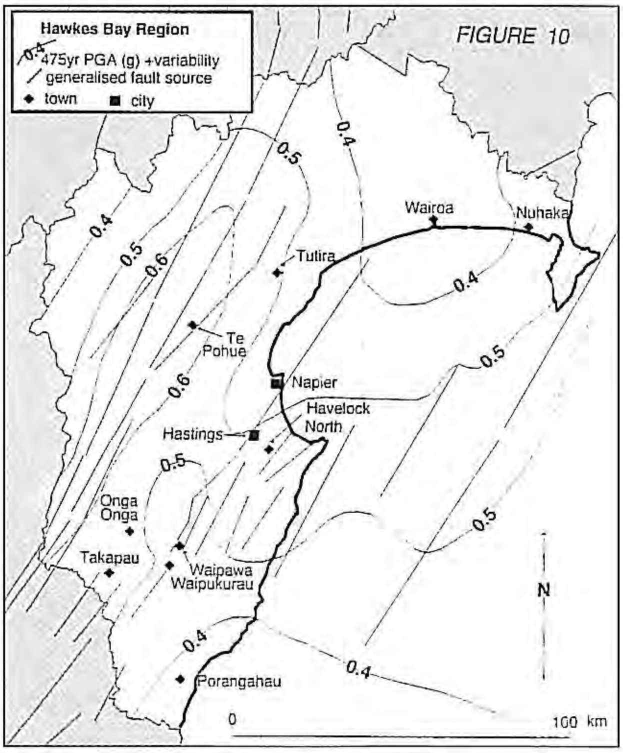


Figure 10: 475 Year Return Period, Peak Ground Acceleration (PGA), (g)

Results of this study indicate that for the Operating Basis Event the Hawke's Bay region may experience MM intensity of about 8.5 – 9.0 and PGA of 0.26 – 0.4g. At MM Intensity 8 – 9 damage to modern structures should be minimal. However there could be serious damage to older, non-reinforced masonry, poorly reinforced structures and well constructed buildings, if permanent ground deformation occurs as a result of liquefaction settlement (see Appendix I for descriptions of damage likely at various MM Intensities). Because of the high probability of occurrence of this level of shaking, all significant structures should be upgraded to maintain life safety and operability at this level of hazard.

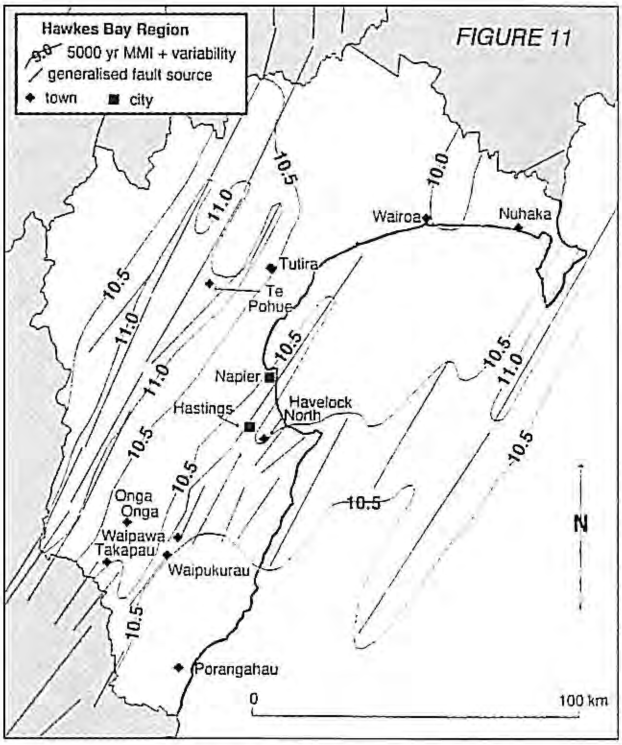


Figure 11: 5000 Year Return Period, Ground Shaking (MM) Intensities

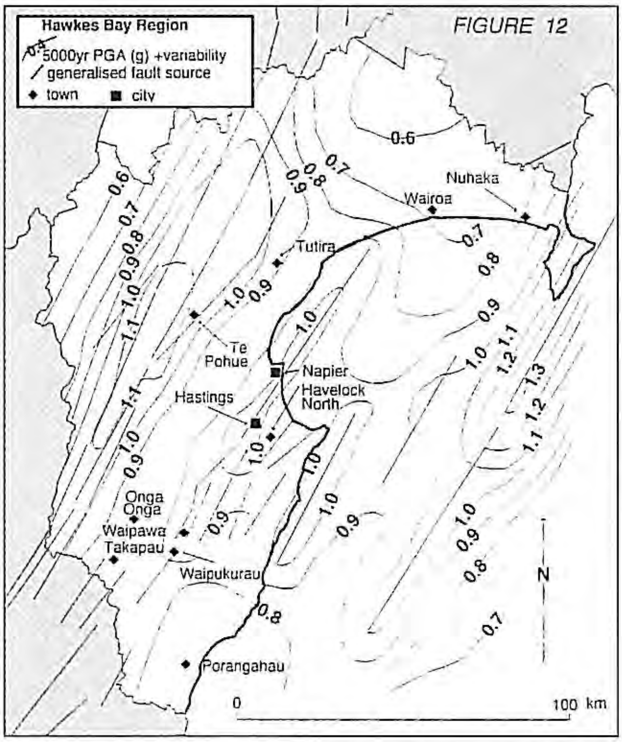


Figure 12: 5000 Year Return Period, Peak Ground Acceleration (PGA), (g)

The variation in strong ground shaking across the region for a 475 year return period is estimated to be MM Intensity 9.1 –9.7, and 0.4 – 0.6g PGA. These estimates represent a revision of ground motion estimates corresponding to code requirements for risk factor R=1 structures. This estimate of hazard has a 10% chance of being exceeded in any 50-year period.

The variation in strong ground shaking across the region in the 5000-year return period is estimated to be MM Intensity 10 - 11, and 0.7 – 1.05g PGA. These hazard estimates represent the likely level of shaking during the maximum earthquake event. This level of shaking has a 10% chance of being exceeded in any 500-year period.

These hazard estimates correspond to a maximum design event and are particularly sensitive to the choice of attenuation (diminishing with distance) expression in the ground motion calculation.

Because the hazard at each return period varies throughout the region, there is a corresponding variation in susceptibility to earthquake damage. This also depends on the style, age, and maintenance of buildings or facilities, and on variations in ground conditions.

Liquefaction Potential in the Hawke's Bay Region

Liquefaction is a process where strong shaking may cause a temporary loss of strength in certain soils (mainly saturated, loose, uniform fine sands and coarse silts). The ground deformations which result from liquefaction and other similar processes can cause significant property damage due to the reduction of bearing strength beneath foundations, and the settlement or lateral movement of soil across buried structures, such as pipelines.

View over Napier in 1880 - Bridge at low tide. Much of Ahuriri and Westshore is built on alluvial deposits.
(Photo courtesy of Don Wilkie collection)

In New Zealand, the most widespread occurrences of liquefaction since European settlement began in 1840, have occurred in coastal regions with extensive deposits of recent, loose, fine-grained alluvial deposits.

The intensity threshold for liquefaction in New Zealand is generally MM7 for sand boils, and MM8 for lateral spreading but both may occur at one intensity lower in highly susceptible materials. The minimum magnitude for liquefaction is M6 but liquefaction is more common at M7, and greater liquefaction induced ground damage is most common at MM 8-10 at distances of 10-100km from the epicentre.

Although liquefaction effects are only seen in loose soils, dense sands and silts may show initial signs of liquefaction. This trend is rapidly halted by the tendency of these soils to increase in volume under added stress.

More effort has recently been made to understand and predict liquefaction potential and ground failures and hazards caused by liquefaction, rather than earthquake induced landsliding. This is because densely populated cities, which are seen as very vulnerable to earthquake damage, are often underlain by potentially liquefiable sediments.

This applies to Hawke's Bay where ground failures due to liquefaction could be serious because essential facilities and structures are at risk in urban centres.

Earthquake induced landsliding is included in the landslide hazard of the Hawke's Bay Engineering Lifelines Project.

Reference 4 contains a detailed summary of liquefaction effects, resulting from nine large earthquakes that have affected the region since 1844.

The above historical data has been combined in maps showing the regional geology and assessments of geotechnical properties of the different surface geological and soils data, to assign liquefaction ratings in different geologic zones.

Liquefaction susceptibility maps have been prepared to show the distribution of deposits that could liquefy during strong ground shaking. These maps provide a general indication of where liquefaction will occur and the extent of it. The results of this mapping indicate that large parts of Napier and Wairoa are underlain by deposits with a high or very high susceptibility to liquefaction. In these areas permanent ground deformation could occur over large areas, with settlements of around 1 metre and lateral spreads of up to 15 metres, during ground shaking that reaches an intensity of MM10.

Hastings, Waipukurau and Waipawa are primarily underlain by deposits with moderate to low liquefaction susceptibility. Permanent ground deformation in these areas would probably be limited with only minor settlements during even the severest earthquake shaking expected in these areas (MM10). However, the stream channels in this area have a very high susceptibility rating and liquefaction in these channels could occur at lower levels of shaking (MM7-8).

Areas of very high or high susceptibility are commonly found in the lower energy, downstream reaches of river channels, near river mouths, in and around coastal lagoons and estuaries, and in enclosed inland sedimentary basins (e.g. the Poukawa basin). These areas are shown on the maps attached to Reference 4.

Liquefaction potential is assessed by comparing the distribution of susceptible deposits, and the opportunity for strong ground shaking during a given event.

Liquefaction potential maps were prepared by overlaying the liquefaction susceptibility maps with ground shaking isoseismal maps for earthquake scenarios.

The three earthquake scenarios were selected because they represent large magnitude events that have a reasonable probability of occurrence (1 in 500 year return periods, the same as building design loadings codes).

The scenarios selected are:

- M7.5 on the Mohaka fault;
- M7.5 on the Poukawa fault and;
- M8.1 on the subduction zone.

The combined map of these three scenarios shows the variation in liquefaction that could occur during the large earthquakes. The map indicates that liquefaction could occur in the high and very high susceptibility areas during almost any large earthquake in the region, although the extent of it will depend on the intensity of the ground shaking. Liquefaction would only be triggered in moderate to low susceptibility areas near earthquake epicentres.

Ground Shaking Amplification Potential

Local geological deposits, or ground conditions, are well known for their ability to influence the type of shaking experienced during an earthquake. By identifying areas with a high shaking risk, it is possible to reduce the community's vulnerability to strong earthquake ground shaking. Sites underlain by soft, flexible, material often experience greater shaking than nearby sites underlain by firmer, stiffer material.

The methodology used in the report (Reference 5) integrates information on geological conditions with geotechnical parameters, such as mean shear wave velocity, and standard penetration test results, to develop amplification response classifications.

In general, the soils in the Heretaunga Plains are classified as average (Class 3) soils with respect to the New Zealand Soil PGA Earthquake Attenuation Equation. Soils in the vicinity of the Ahuriri lagoon and other local deposits in swamps, lagoons and estuaries along the coast (Class 4), are weaker than the alluvium on the Heretaunga Plains.

- At low levels of shaking both the soils of the Heretaunga Plains and the soils of the former Ahuriri lagoon and other lagoons, estuaries and swamps will amplify ground shaking with respect to rock sites. The weaker (Class 4) soils will show greater amplifications.
- During strong shaking the soils of the former Ahuriri lagoon and other local lagoons, estuaries and swamps will begin to liquefy, thus losing shear strength and losing their ability to amplify ground shaking. However, these areas are likely to suffer ground deformation with consequent damage to buried services and structures founded in them.
- The soils of the Heretaunga Plains (Class 3) are unlikely to liquefy west of Hastings, given the ground damage accounts from the 1931 Hawke's Bay Earthquake. These show liquefaction-induced ground damage from sites that lie to the east, south-east and north-east of Hastings.

An area in Flaxmere has shown a site response that doubles the amplification factor of the mean values used to develop the hazard maps. It should be noted that this type of local site response might occur elsewhere, and special studies are required for sensitive facilities, or facilities that would be critical immediately after an earthquake.

These findings indicate that for Hawke's Bay, strong distant earthquakes will have the greatest impact in terms of the hazard of ground shaking amplification at particular sites. The level of shaking required to generate this degree of site response is most likely to be sourced on faults at moderate to large distances from the "site" in question. Scientists are unable to be more specific, as the levels of shaking depend on both magnitude and distance.

Engineering Lifelines Project Earthquake Hazard Assessments

The information summarised above provides a comprehensive study of the earthquake hazard in Hawke's Bay.

To assess the vulnerability of engineering lifelines to earthquakes and the resulting impacts, the above information needs to be rationalised into packages that can be easily evaluated.

When assessing each part of a network the following effects of earthquakes should be considered:

ground shaking
ground rupture
liquefaction potential
slope instability

Slope instability will be considered separately.

Ground rupture is generated by active earthquake faults. Thus the maps of these faults and folds should be considered.

To investigate ground shaking, a subduction zone thrust event of magnitude M7.7 is proposed as a representative scenario event.

Clearing Slips from Napier Hill after 1931 Hawke's Bay Earthquake.

It was chosen because:

- High levels of ground shaking, liquefaction and slope stability problems are likely to result throughout the region;
- Research has shown it has an expected return period of 550 years. The most recent evidence of this type of earthquake, a downdrop of one metre at Ahuriri, occurred about 500 years ago;
- The 550-year return period is close to the Design Level Event return period used as a basis for the New Zealand Standard Loadings Code;
- Although such an earthquake may not result in ground surface rupture, it is likely to have a significant impact on infrastructure due to surface deformation;
- A notable characteristic of subduction zone thrust earthquakes is their expected length of shaking. The few earthquakes of this type that have been recorded indicate strong shaking lasting from 10 to 40 seconds. This duration of shaking is likely to fully test structures, maximise the potential for liquefaction, and have other effects such as lateral spread and landslip at susceptible sites.

Maps were prepared of the scenario subduction thrust earthquakes indicating shaking in terms of MM Intensity and Peak Ground Acceleration. The engineering lifelines networks were overlain by the MM Intensity map to represent surface effects, making assessment easier.

The PGAs given on the map will need to be factored by the ground shaking amplification factors given in Reference 5. These, along with local site effects, could increase or decrease the acceleration levels by up to 30%.

Liquefaction potential maps were prepared for the subduction zone thrust earthquake in Reference 4. This used a magnitude earthquake M8.1 compared to M7.7 for the MM Intensity map. However, most of the susceptible soils still fall within the same MM Intensity.

In conclusion, assessment of the vulnerability of networks during the Hawke's Bay Engineering Lifelines Project involved consideration of the following issues:

- The location of known active earthquake faults and folds;
- The MM Intensity from the scenario subduction thrust M7.7 earthquake ;
- The liquefaction potential for the scenario subduction thrust M8.1 earthquake;
- The MM Intensity and liquefaction potential for the scenario M7.5 earthquakes on the Mohaka and Poukawa faults.

1931 Mass grave at Park Island cemetery, Napier.

These are presented on map 3. It shows the maximum effect of any one of the three events at any location over the region

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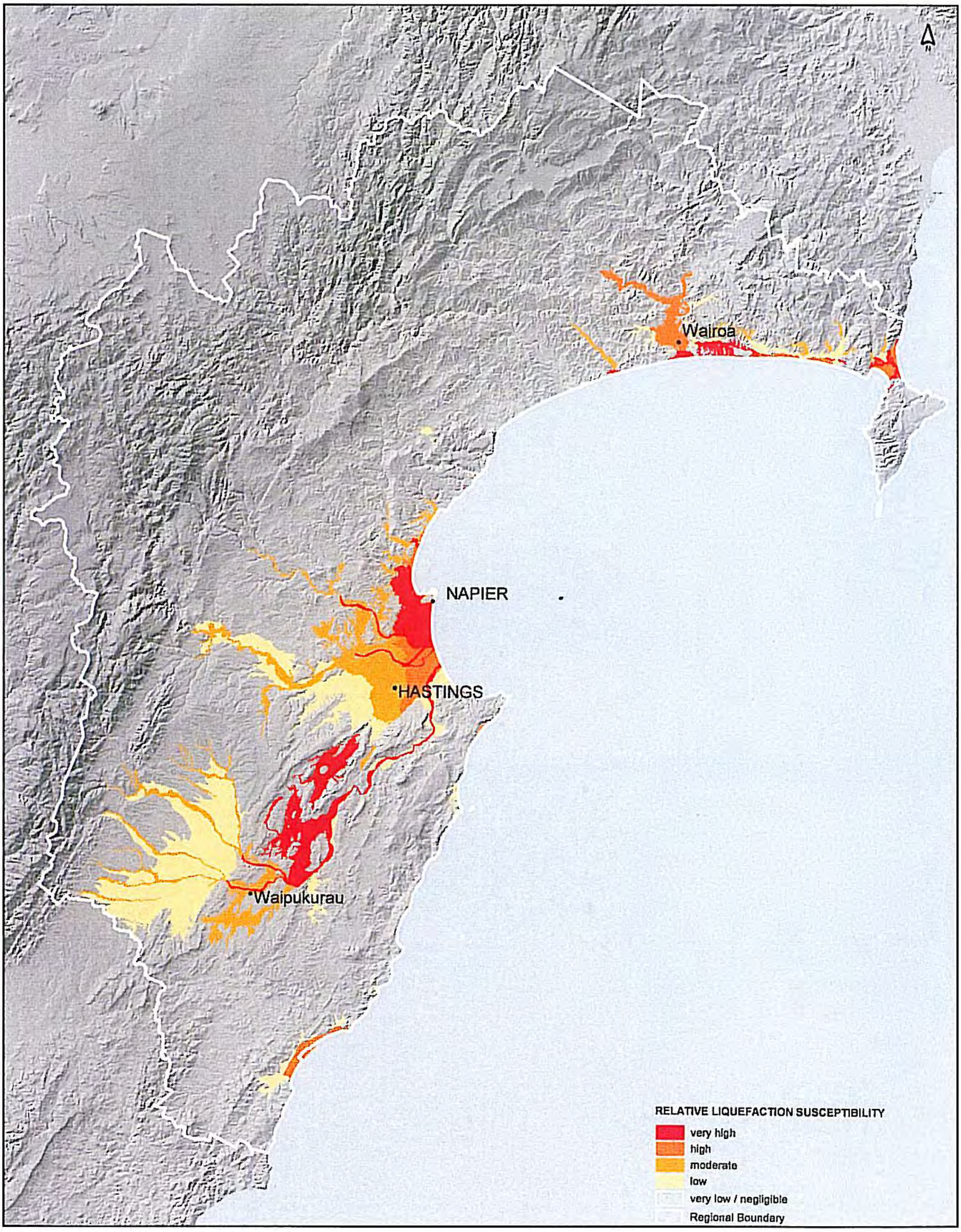
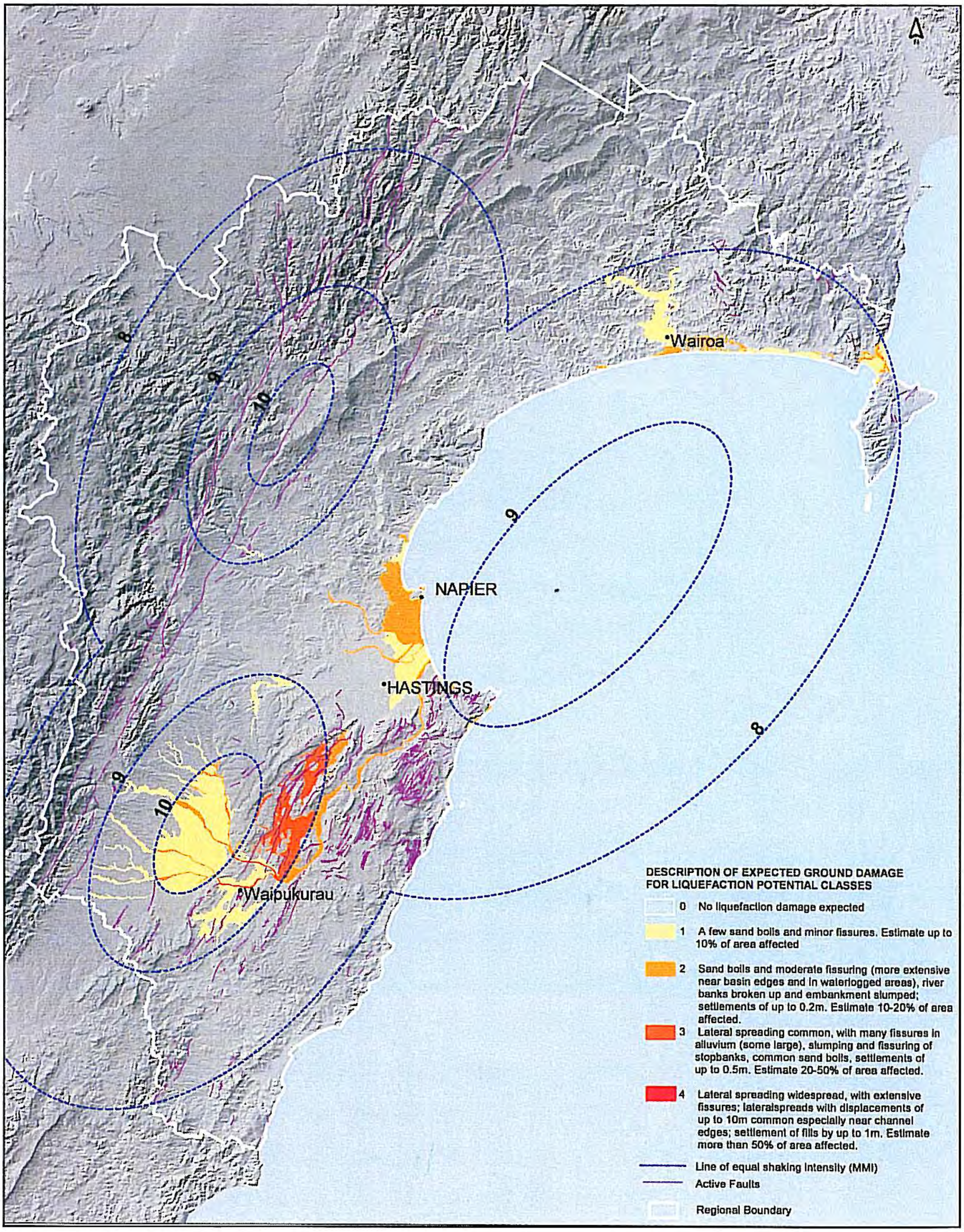
Map 2

Liquefaction Susceptibillity
Hawke's Bay Region



Map 3

Combined Earthquake Hazard Scenarios
- Liquefaction Potential
- Ground Shaking Intensity (MM)
- Active Faults



Appendix 1

Modified Mecalli Intensity Scales Definitions
NZ 1996
(Items marked * in the scale are defined below)

MM1 *People*
Not felt except by a very few people under exceptionally favourable circumstances.

MM2 *People*
Felt by persons at rest, on upper floors or favourably placed.

MM3 *People*
Felt indoors; hanging objects may swing, vibration similar to passing of light trucks, duration may be estimated, may not be recognised as an earthquake.

MM4 *People*
Generally noticed indoors but not outside. Light sleepers may be awakened. Vibration may be likened to the passing of heavy traffic, or to the jolt of a heavy object falling or striking the building.

Fittings
Doors and windows rattle. Glassware and crockery rattle. Liquids in open vessels may be slightly disturbed. Standing motorcars may rock.

Structures
Walls and frame of buildings and partitions and suspended ceilings in commercial buildings may be heard to creak.

MM5 *People*
Generally felt outside, and by almost everyone indoors. Most sleepers awakened. A few people alarmed.

Fittings
Small unstable objects are displaced or upset. Some glassware and crockery may be broken. Hanging pictures knock against the wall. Open doors may swing. Cupboard doors secured by magnetic catches may open. Pendulum clocks stop, start, or change rate (H*).

Structures
Some windows Type I* cracked.
A few earthenware toilet fixtures cracked (H*).

MM6 *People*
Felt by all
People and animals alarmed
Many run outside*
Difficulty in walking steadily

Fittings
Objects fall from shelves.
Pictures fall from walls (H*).
Some furniture moved on smooth floors, some unsecured freestanding fireplaces moved.
Glassware and crockery broken.
Very unstable furniture overturned.
Small church and school bells ring (H*)
Appliances move on bench or table tops.
Filing cabinets or easy-glide drawers may open or shut.

Structures
Slight damage to Buildings Type I*
Some stucco or cement plaster falls
Windows Type I* broken
Damage to a few weak domestic chimneys, some of which may fall

Environment
Trees and bushes shake, or are heard to rustle
Loose material may be dislodged from sloping ground eg: existing slides, scree slopes, shingle slides

MM7 *People*
General alarm
Difficulty experienced in standing
Noticed by motorcar drivers who may stop

Fittings
Large bells ring
Furniture moves on smooth floors and may move on carpeted floors
Substantial damage to fragile* contents of buildings.

Structures
Unreinforced stone and brick walls cracked
Buildings Type I* cracked and minor masonry will fall from some
A few instances of damage to Buildings Type II* Unbraced parapets, unbraced brick gables, and architectural ornaments fall Roofing tiles, especially ridge tiles, may be dislodged Many unreinforced domestic chimneys damaged, often falling from roofline Water tanks Type I* burst A few instances of damage to brick veneers and plaster or cement based linings.

Unrestrained water cylinders (Water Tanks II*) may move and leak.
Some windows Type II* cracked. Suspended ceilings damaged

Environment
Water made turbid by stirred up mud.
Small slides such as falls of sand and gravel banks, and small rock-falls from steep slopes and cuttings.
Settlement of unconsolidated, wet or weak soils.
Some fine cracks appear in sloping ground. A few instances of liquefaction (i.e.: small water and sand ejections).

MM8 *People*
Alarm may approach panic.
Steering of motorcars greatly affected.

Structures
Building Type I*, heavily damaged, some collapse.
Buildings Type II* damaged, some with partial collapse.
Buildings Type III* damaged in some cases.
A few instances of damage to Structures Type IV.
Monuments and pre-1976 elevated tanks and factory stacks twisted or brought down.
Some pre-1965 infill masonry panels damaged.
A few post-1980 brick veneers damaged.
Decayed timber piles of houses damaged.
Houses not secured to foundations may move.
Most unreinforced domestic chimneys damaged, some below roofline, many brought down.

Environment
Cracks appear on steep slopes and in wet ground.
Small to moderate slides in roadside cuttings and unsupported excavations.
Small water and sand ejections and localised lateral spreading adjacent to streams, canals, lakes etc.

MM9 *Structures*
Many Buildings Type I destroyed*.
Buildings II heavily damaged, some collapse*.
Buildings Type III damaged, some with partial collapse*.
Structures Type IV* damaged in some cases, some with flexible frames seriously damaged.
Damage or permanent distortion to some Structures Type V*.
Houses not secured to foundations shifted off.
Brick veneers fall and expose frames.

Environment
Cracking of ground conspicuous.
Landsliding general on steep slopes.
Liquefaction effects intensified and more widespread, with large lateral spreading and flow sliding adjacent to streams, canals, lakes, etc.

MM10 *Structures*
Most Buildings Type I destroyed*.
Many Buildings Type II destroyed*.
Buildings Type III heavily damaged, some collapse*.
Structures Type IV damaged, some with partial collapse*.
Structures Type V moderately damaged, but few partial collapses*.
A few instances of damage to Structures Type VI*.
Some well built* timber buildings moderatelydamaged (excluding damage from falling chimneys).

Environment
Landsliding very widespread in susceptible terrain, with very large rock masses displaced on steep slopes. Landslide dams may be formed.
Liquefaction effects widespread and severe.

MM11 *Structures*
Most Buildings Type II destroyed*.
Many Buildings Type III destroyed*.
Structures Type IV heavily damaged, some collapse*.
Structures Type V damaged, some with partial collapse*.
Structures Type VI suffer minor damage, a few moderately damaged*.

MM12 *Structures*
Most Buildings Type III destroyed*.
Many Structures Type IV destroyed*.
Structures Type V* heavily damaged, some with partial collapse.
Structures Type VI* moderately damaged.

Construction Types:

Buildings Type I (Masonry D in the NZ 1966 MM scale)

Buildings with a low standard of workmanship, poor mortar, or constructed of weak materials like mud brick or rammed earth. Soft storey structures (eg shops) made of masonry, weak reinforced concrete, or composite materials (eg: some walls timber, some brick) not well tied together. Masonry buildings otherwise conforming to Buildings Types I - III, but also having heavy unreinforced masonry towers. (Buildings constructed entirely of timber must be of extremely low quality to be Type I).

Buildings Type II (Masonry C in the NZ 1966 MM scale)
Buildings of ordinary workmanship, with mortar of average quality. No extreme weakness, such as inadequate bonding of the corners, but neither designed nor reinforced to resist lateral forces. Includes buildings that do not have heavy unreinforced masonry towers.

Buildings Type III (Masonry B in the NZ 1966 MM scale)
Reinforced masonry or concrete buildings of good workmanship and with sound mortar, but not formally designed to resist earthquake forces.

Structures Type IV (Masonry A in the NZ 1966 MM scale)
Buildings and bridges designed and built to resist earthquakes to normal use standards, i.e. no special collapse or damage limiting measures taken (mid 1930's to c. 1970 for concrete and to c 1980 for other materials).

Structures Type V
Buildings and bridges, designed and built to normal use standards, i.e. no special damage limiting measures taken, other than code requirements, dating from since c. 1970 for concrete and c. 1980 for other materials.

Structures Type VI
Structures, dating from c 1980, with well defined foundation behaviour, which have been specially designed for minimal damage, e.g. seismically isolated emergency facilities, some structures with dangerous or high contents, or new generation low damage structures.

Windows

Type I – Large display windows, especially shop windows
Type II – Ordinary sash or casement windows

Water Tanks

Type I – External, stand mounted, corrugated iron water tanks
Type II – Domestic hot-water cylinders unrestrained except by supply and delivery pipes
H – (Historical) more likely to be used for historical events.

Other Comments

"Some" or "a few" indicates that the threshold of a particular effect has just been reached at that intensity.
"Many run outside" (MM6) variable depending on mass behaviour, or conditioning by occurrence or absence of previous quakes, i.e.: may occur at MM5 or not till MM7.
"Fragile Contents of Buildings". Fragile contents include weak, brittle, unstable, unrestrained objects in any kind of building.
"Well built timber buildings" have: wall openings that are not too large; robust piles or reinforced concrete strip foundations; superstructure tied to foundations.
E Buildings Type III – V at MM10 and greater intensities are more likely to exhibit the damage levels indicated for low-rise buildings on firm or stiff ground and for high rise buildings on soft ground. By inference lesser damage to low rise buildings on soft ground and high-rise buildings on firm or stiff ground may indicate the same intensity. These effects are due to attenuation of short period vibrations and amplification of longer period vibrations in soft soils.

Chapter 1

Risk Assessment, Methodologies

This chapter briefly describes risk assessment in the engineering lifelines context and the methodologies used in assessing levels of risk in the project. The methodologies follow the Standard AS/NZS 4360: 1999, Risk Management.

A complete description of risk management, as applied to engineering lifelines projects, is provided in Chapter 1 of the Christchurch Engineering Lifelines Group report "Risks and Realities". Some of the key items from that report and AS/NZS 4360: 1999 are summarised in this chapter.

The methodologies used are based on those adopted by the Christchurch and Wairarapa projects. However they have been improved over time and as a result of international review.

In assessing levels of risk during this project some of the methodologies were adapted, to better suit the networks being assessed and the aims of the project.

A rigger is clearing snow from a yagi antenna. This photo illustrates the "flag ice" phenomenon and the impact it can have on both the tower and the antenna's attached to towers.
(Photo courtesy Ian Greaves Telecom)

Risk Assessment

The Australian/New Zealand Standard Risk Management AS/NZS 4360: 1999 uses the following definitions:

Risk

The chance of something happening that will have an impact upon objectives. It is measured in terms of likelihood of consequences.

Risk Analysis

A systematic use of available information to determine how often specified events may occur and the magnitude of their consequences.

Risk Assessment

The overall process of risk analysis and risk evaluation.

Risk Management Process

The systematic application of management policies, procedures and practices to the tasks of establishing the context, identifying, analysing, evaluating, treating, monitoring and communicating risk.

Risk analysis may be carried out using a Quantitative Approach.

Level of "risk" can be calculated as the product of the "probability" of an event or adverse outcome and the "consequences" of the event (damage/ detriment/severity). In symbolic terms we can write the equation $R = P \times C$.

This simple equation does not fully describe the real risk but can be used as a measure for comparing risks or making resource decisions.

Risk analysis may also be carried out using a Qualitative Approach.

The qualitative analysis approach uses words or descriptive scales to describe the magnitude of potential consequences and the likelihood that the consequences will occur.

The qualitative approach is generally used in this project for risk analysis although some assessments have used a semi-quantitative approach i.e. assigning numbered values to descriptions in order to provide a ranking of the relative levels of risk.

In 1998 Ronald T Eguchi, Vice President of EQE International, a US-based consultancy that specialises in earthquake engineering, and a specialist in lifelines engineering, reviewed the methodologies adopted by projects in New Zealand for conformation with the then valid NZS 4360: 1995. In his opinion the Christchurch model represented the best model for New Zealand lifeline projects at that time, although he made a number of recommendations.

The Wairarapa project developed spreadsheets with notes for vulnerability, impact and level of risk assessment using the qualitative approach and incorporating the Eguchi recommendations where appropriate. This methodology and the spreadsheets were adopted as the standard for further New Zealand lifelines projects at the 4th National Lifelines Forum at Christchurch in September 2000. The Hawke's Bay Engineering Lifelines Project is very grateful for the contribution made by the above two projects in particular.

The integration of likelihood and consequences (vulnerability and impact) as described in AS/NZS 4360:1999, provided participants with an unexpected challenge. The qualitative method of AS/NZS 4360: 1999 has a matrix (Table E3) of likelihood and consequences that assigns levels of risk to the various combinations. It is noted that 8 of the 25 combinations of likelihood and consequences (or 32%) are given an E = extreme risk rating.

In a change from the 1995 code that determined the risk as "H = high risk; detailed research and management planning required at senior levels", the 1999 code rates the risk as "E = extreme risk; immediate action required".

Although the new standard applies to all risk analysis, the former "H' code and its requirements are more appropriate for engineering lifelines.

Using the 1999 code matrix is also likely to result in a high proportion of components of networks being assigned an extreme risk rating. This would be of little value to the network operators who are seeking to identify those very few, extreme risk elements that require attention first.

In order to identify these high priority elements, the task groups developed variations to the standard matrix approach. One variation amended the matrix to give a smaller number of combinations assigning the extreme risk rating. Another used a semi quantitative approach, giving numerical values for vulnerability and impact to provide a numerical level of risk. The relative risk of the various elements could then be ranked.

Risk Treatment

Risk treatment involves identifying the range of options for treating risk, assessing those options, preparing risk treatment plans and implementing them.

In the engineering lifelines context the options normally available include:

(a) Minimising the risk by:
  Duplication
  Strengthening
  Demolition

(b) Retaining the risk

Selecting the most appropriate option involves balancing the cost of implementing each option against the benefits derived from it. In general, the cost of managing risks needs to be about equal with the benefits obtained.

Where large reductions in risk can be achieved with relatively low expenditure, these options should be implemented. Further improvements may be uneconomic and it will be a matter of judgement as to whether they can be justified. This is illustrated in Figure 4.3 below, from NZS4360: 1999.

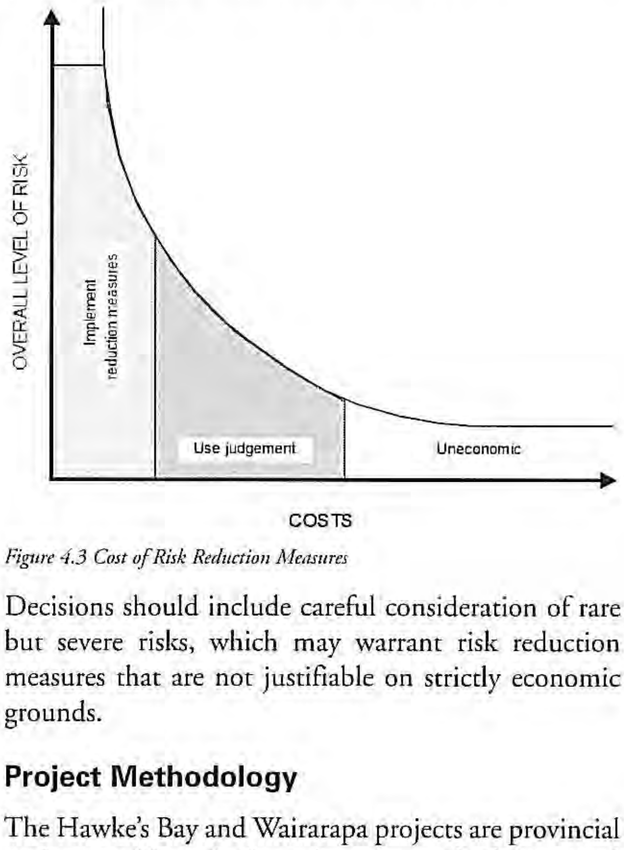


Figure 4.3 Cost of Risk Reduction Measures

Decisions should include careful consideration of rare but severe risks, which may warrant risk reduction measures that are not justifiable on strictly economic grounds.

Project Methodology

The Hawke's Bay and Wairarapa projects are provincial projects and have had to adapt the methodology used in the major metropolitan projects, to reflect the extensive areas covered, the networks, and the hazards involved.

The major issues for provincial projects include:

- The level of detail needed when assessing each utility network given that the project is mostly concerned with regional impacts;
- The different importance rankings that a network segment may have when viewed from a local or a regional perspective;
- The varying impacts of loss or partial loss of a utility both locally or regionally;
- Many of the networks consist of single strands running the full length of the region and are often parts of national networks;
- There are many isolated sites along each network that may be subject to risk from one or more hazard;
- Most project participants are network managers and operators and there are few specialists in risk assessment and risk mitigation;
- There are few local researchers in hazard information gathering. The information has to come from outside the area and needs to be well explained to be useful to project participants;

The organisation structure generally followed that of other projects with the formation of a Steering Committee, Task Groups, and the appointment of a Project Manager. This is shown in Figure 2.

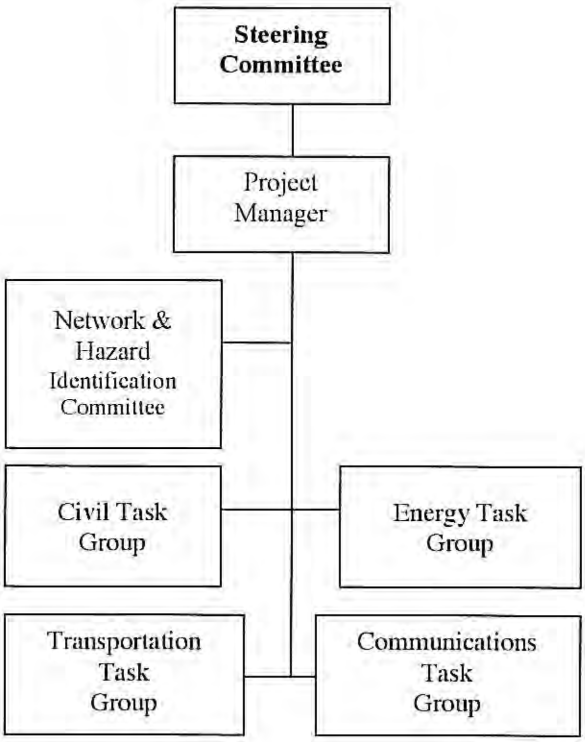


Figure 2 Project Structure

Most of the first year of the project was spent gathering hazard and network information. The Hazard Information Task Group was the only task group operating at that time.

After the main hazard information (on the earthquake hazard) was in a usable form the task groups for Transportation, Civil Services, Energy and Communication were established.

The task groups met every two months, alternating with steering committee meetings. Initially, the network information was recorded on GIS (a computer based geographic information mapping system), corrected and other hazard information added. Once the groups had enough information they were able to start risk assessment exercises.

Further information on other hazards was added as it became available.

Hazard Event Selection

The information on natural hazards used in the risk assessment was derived in a number of ways.

Earthquake Hazard

The earthquake hazard studies resulted in a number of hazard maps of ground shaking (MM) and peak ground accelerations (PGA) for ground motions corresponding to 142, 475 and 5000 year return periods. These maps indicate the expected shaking generated by earthquakes along any one of the 22 known active faults in the subduction zone underlying most of the region.

Bus stranded on crumbled road near Poukawa 1931. Fence line and power poles have buckled along the road due to intense shaking. (Photo Institute of Geological and Nuclear Sciences)

Three scenario events were then selected, representing realistic large magnitude earthquakes that have a fairly high probability of occurring i.e. 10% in 50 years (475 year return period). This is the same basis used for earthquake design loads in the building structures design loadings standard, NZS 4203:1992.

These three events are centred on faults or zones that indicate a high probability of occurrence.

To allow participants to see the total seismic hazard, the plans of the three events were combined in GIS to form a single montage of the three events that showed the highest shaking.

This seismic hazard GIS map also included a similar montage of liquefaction potential, and the location of known active faults.

Next the map was electronically combined with individual network maps. This allowed participants to assess the vulnerability for ground shaking, liquefaction, lateral movement (near faults), and land settlement (associated with subduction zone events).

Meteorological Hazard

The meteorological hazard (windstorm, extreme rainfall, snow and drought) was included in a single report.

SH 5 Snowfall 2000

The report estimates extreme events for 142 and 475-year return periods, based on existing information from recorded climate data about extreme events.

Preparation of this report was hampered by the small number of climate recording stations and the relatively short time they have been operating.

The wind speeds at recording station sites correlate well with the buildings loadings code (NZS 4203: 1992).

The winds vary considerably with topography. The New Zealand Standard NZS 4203:1992 gives factors to help calculate wind speed at exposed sites, compared to speeds on normal, flat land. For Hawke's Bay, the Standard is based on data recorded over time at Hawke's Bay Airport. Actual recorded wind speeds at exposed sites correlate well with wind speeds derived using the airport data and the magnification factors of NZS 4203.

Meteorological effects are very location dependent and are not available on a close grid. For these reasons meteorological hazards were not produced in GIS format. Instead participants used the Meteorological Hazard Report (Chapter 5) and their own local knowledge to make assessments.

Flood Hazard

The flood hazard was considered under two headings: local catchment flooding and extreme storm related events.

The first is important for low-lying communities such as Napier, which relies on stormwater pump stations during most rainstorms.

Onekawa South (now Henry Hill) School Grounds, June 1963.

The second was addressed by the Hawke's Bay Regional Council which reported on flood control schemes, stop bank protection and other measures. Generally, these structures have been designed to the standards of a 100-year return period with some free board. Extensive flood control schemes have been built and upgraded on the Heretaunga and Ruataniwha Plains. This leaves the Wairoa area with no flood control scheme. Also at risk are parts of State Highway 50 near the Waipawa and Tukituki rivers.

The possibility of super floods was also considered. While many parts of the existing flood protection network probably would cope with extreme events, the Regional Council has studied the effects of possible breaches of stop banks at a number of locations.

This information was summarised into typical scenario events and considered during the flooding risk assessment process. Participants also used their own extensive knowledge and experience of recent floods.

Volcanic Impacts

Volcanic impacts for Hawke's Bay were assessed in a single report that included information on the hazard with probabilities and the range of likely impacts.

Participants were given a summary of this information.

Because Hawke's Bay is some distance from any volcanoes, wind blown ash from volcanic eruptions would be the greatest hazard. Even relatively thin deposits of this ash can be hazardous.

Ash plumes from Mt Ruapehu 1995
(Photo courtesy of GNS)

It is very difficult to predict the probability of volcanic hazards which, although rare, can be highly disruptive especially for nearby communities.

Landslides

In Hawke's Bay landslides occur in a variety of shapes and sizes from small rapid surficial slips to slow moving regional slumps.

The main "triggers" for landslides in Hawke's Bay are intense cyclonic rainfall events and earthquake shaking.

Some of the largest landslides in the world can be found in the Waikaremona area and submarine landslides off the East Coast.

Mapping of major landslides in Hawke's Bay has just begun and will be a very useful tool when completed.

While reference was made to the unpublished information obtained, participants used extensive knowledge and experience to classify those areas of the networks that have the potential to be affected by landslides.

State Highway 2 Devils Elbow Cyclone Bola 1988

Tsunami

The low-lying parts of Hawke's Bay, such as the Heretaunga and Wairoa Plains, are the most densely populated and also the most prone to damage from tsunami. This, combined with the fact that Hawke's Bay is very close to an active tectonic plate boundary, makes tsunami a real and significant hazard for the region.

The Lifelines project commissioned a report on the potential for damage from tsunamis in the Hawke's Bay region.

Rather than using a recent historic approach this report used a probabilistic approach that used existing geological and seismic information to generate tsunami wave heights for different probabilities.

This approach resulted in far higher heights for the same probabilities based on historic information only. The Hawke's Bay coastline has been affected by few large tsunami in recorded history.

Activity on the nearby tectonic plate boundary and the potential for submarine landslips to occur off the East Coast increase the probability that tsunami can be generated that would have a severe impact on parts of the shoreline.

Damage in the Ahuriri Channel caused by the 24 May 1960 tsunami, which struck Napier. The old footbridge linking Napier and Westshore was carried away, damaging gas and water mains and cutting a telephone cable. (Photo courtesy Russell Spiller.)

While possible mitigation measures are few the possibility of devastating tsunami affecting parts of the Hawke's Bay coastline must be recognised.

Aquifers and their Potential for Contamination

While not strictly a natural hazard, contamination of the aquifers in Hawke's Bay would have a critical effect on water supplies to much of the population and economic activity in Hawke's Bay.

Various studies have reported on the characteristics of the aquifers on the Heretaunga and Ruataniwha Plains. The summary report lists the risks to the aquifers that could lead to contamination of the aquifers and discusses managing those threats.

Other Hazards

There are other natural hazards which have the potential to affect engineering lifelines, which were not considered by the Steering Committee in detail as they posed limited risk. They included both hail and wildfire.

Records show some areas in Hawke's Bay are more prone to hailstorms than others, particularly the areas between Napier and Waipukurau. The amount of damage caused is dependent on the size of the hailstones, the wind velocity, the number of hailstones per unit area. Traditionally crops, rather than engineering lifelines, have been the most severely affected by hailstones.

Wildfire, a description given to fires that spread with extraordinary speed, was not considered to be significant regional hazard for Hawke's Bay. Our main population centres are not surrounded by flammable vegetation such as gorse and scrub. However, the transportation network and small Hawke's Bay communities are surrounded by forestry who are at risk from wildfire, therefore it was considered as a hazard by the Transportation Group. It should also be mentioned that the Hawke's Bay Regional Council's landcover database may assist those with rural fire management responsibilities in better managing these risks.

Chapter 2

Earthquake Hazards

Introduction

Studies of moderate to large earthquakes and seismicity in Hawke's Bay indicate that the region is one of the most earthquake prone areas of New Zealand. Strong earthquake shaking in excess of Modified Mercalli Intensity VII has been felt in Hawke's Bay on at least 19 occasions in recorded history.

Hawke's Bay has a minimum of 22 known active faults and folds within its onshore and offshore regions that are capable of producing strong earthquake shaking in the future. At least 5 of these are capable of producing levels of earthquake shaking similar to those experienced in 1931 on the Heretaunga Plains.

Large subduction thrust earthquakes on the interface between the Australian and Pacific plates occur frequently and are capable of producing high levels of shaking over a large part of the region.

Hazard Studies

In 1993 the Hawke's Bay Regional Council (HBRC) with the support of territorial local authorities, engaged the Institute of Geological and Nuclear Sciences (IGNS) to carry out a series of studies into the earthquake hazard in Hawke's Bay.

These studies took place over 5 years and included:

- Summarising and giving an overview of existing earthquake hazard information;
- Documenting the location of existing faults and folds and estimating the recurrence intervals of large earthquakes;
- Developing a regional numerical earthquake hazard model by preparing maps showing the level of ground shaking intensity expected at various return periods;
- Determining the nature of subsurface materials within Hawke's Bay and their liquefaction potential, highlighting the main urban areas;
- Determining the susceptibility of subsurface materials to amplified ground shaking, highlighting the main urban areas;
- Estimating the location, size and likely recurrence of large subduction thrust earthquakes in the region.

This has provided a comprehensive and up to date record of the earthquake hazard in the region.

It has also resulted in the preparation of maps of the effects of "scenario" earthquakes resulting from surface fault and subduction zone seismic movements.

Hawke's Bay Tectonic Setting

Hawke's Bay is on the Australian tectonic plate. The Pacific plate starts sliding westward beneath the Australian plate at the Hikurangi Trough about 160 km east of Napier, and becomes progressively deeper below the surface to the west. At this latitude the two plates are converging at an oblique angle at about 50mm/yr.

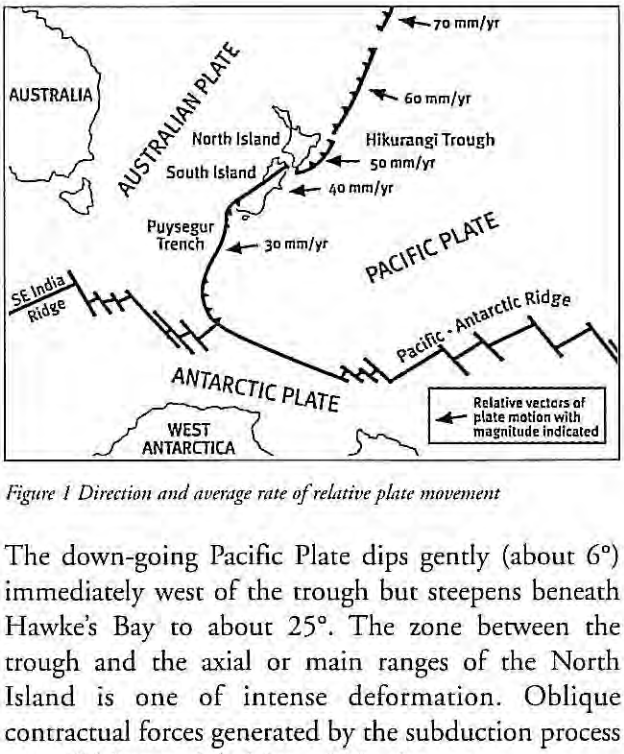


Figure 1 Direction and average rate of relative plate movement

The down-going Pacific Plate dips gently (about 6°) immediately west of the trough but steepens beneath Hawke's Bay to about 25°. The zone between the trough and the axial or main ranges of the North Island is one of intense deformation. Oblique contractual forces generated by the subduction process cause folding and faulting within the zone.

The Heretaunga Plains is a tectonic depression developed between folds within the zone during the last 1.5 million years. Up to 1 km of gravel, sand and silt overlie the limestone and sandstone bedrock.

The gravel-filled basin comprising the Ruataniwha Plains has been formed by a series of west-dipping, north-east-trending reverse faults in the area during the last 1.5 million years. Reverse faulting elevated the hills to the east of the plains resulting in sediment deposits on the relatively low land of the Ruataniwha Plains.

Sea level has risen about 12m since the end of the cold period of the last glaciation (c.18,000 years ago), as a result of climatic warming and polar icecaps melting. Sea level reached its present position c. 6,000 years ago, and has remained more or less stable. The Heretaunga Plains were once more extensive but much of the land was covered by intertidal marine silts during the rise in sea level. Subsequently, there have been continuing deposits of sediment from the mountain ranges to the west together with gravel deposits as a result of regular changes in the course of the Tukituki, Ngaruroro and Tutaekuri rivers. These have built the Plain up above sea level and shifted the coastline eastwards.

The most recent large eruption of Taupo c. 1,800 years ago saw a rapid build-up of large quantities of river deposited Taupo pumice on the Heretaunga Plains. The pumice has been eroded in places by alluvial processes, but up to 10 m of pumice gravel and sand are found in many parts of the Plains. The build-up of aggregates has continued in the rivers, so that 5 – 10 m of alluvial sediment now overlies the pumice in parts of the Heretaunga Plains.

Geologically Hawke's Bay is characterised by a western belt of greywacke axial ranges, bounded to the east by two belts of younger marine sediments that are separated by a low-lying belt of weaker non-marine deposits and shallow marine deposits.

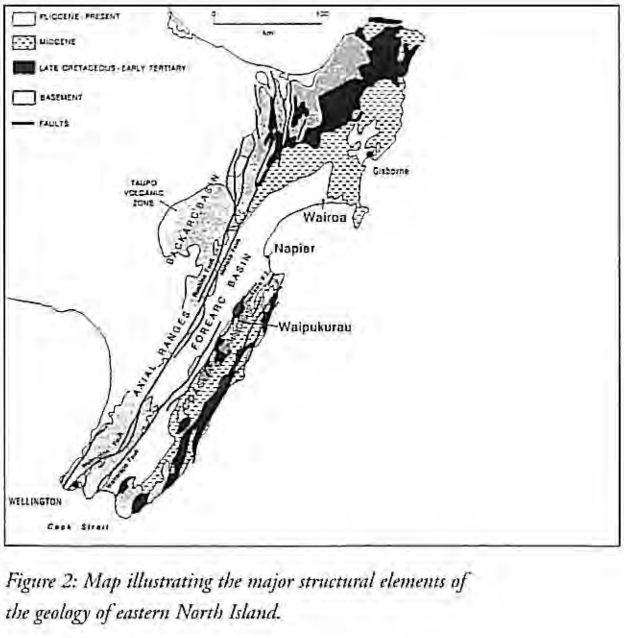


Figure 2: Map illustrating the major structural elements of the geology of eastern North Island.

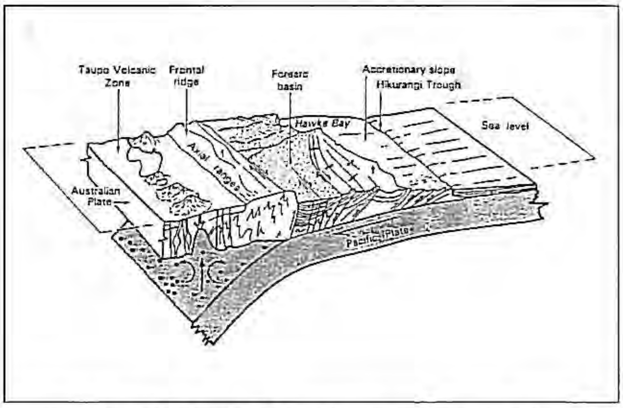


Figure 2a: An idealised model of the subduction zone near Hawke's Bay. The Hikurangi Trough is east of Hawke's Bay.

Earthquake Terminology

Magnitude, Modified Mercalli Intensity and Peak Ground Accelerations are terms frequently used to describe earthquakes and their effects.

The Magnitude (M) is a measure of the energy released by an earthquake at its source and is calculated from seismographic records. For pre-instrumental earthquake observations the Magnitude has been estimated by comparing them with later instrumentally recorded events.

The widely used Modified Mercalli Intensity scale (MM) categorises non-instrumental observations of the felt effects of an earthquake on people, fittings (furniture, crockery, etc) structures and the environment. There are 12 levels on the scale, but only the first 10 (i.e.: up to MM 10) have been reliably observed in New Zealand.

Appendix I to this chapter contains full descriptions of the Modified Mercalli Intensity scales.

Peak Ground Acceleration (PGA) refers to the maximum horizontal acceleration measured during an earthquake at the ground surface and is usually expressed as a percentage of gravity.

The distribution of peak ground accelerations from an earthquake are shown on isoseismal maps, with each isoseismal line enclosing areas experiencing approximately equal intensity of shaking or equal peak ground acceleration.

Earthquakes Affecting Hawke's Bay since 1840

In recent times Hawke's Bay has experienced moderately higher levels of seismicity than most other areas of the country (see figure 3). Since records began 5 large earthquakes (M> 6.9) are known to have occurred, most of which were shallow events.

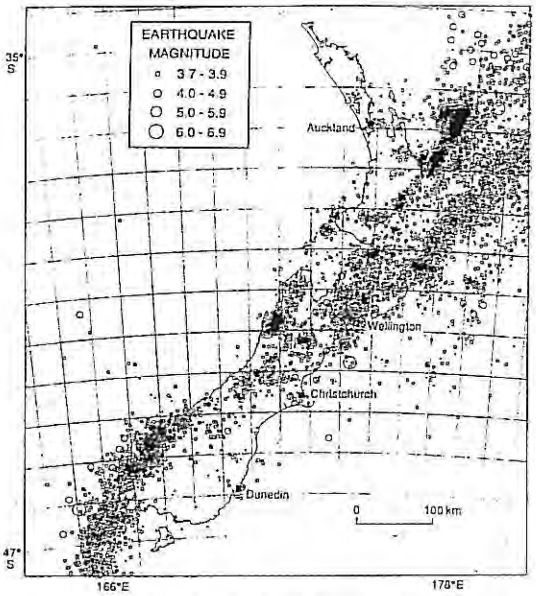


Figure 3: Location of all earthquakes M ≥3.7, and depth ≤ 45 km in the New Zealand area between 1964 and 1992. Note the large number of earthquakes along the Hawke's Bay coast, showing that Hawke's Bay is one of the most seismically active regions of New Zealand.

Hawke's Bay has also experienced felt intensities of up to MM7 from large earthquakes occurring outside the region.

Many moderate magnitude events have occurred within the region. The location of earthquakes of M ≥ 5.0, which are known to have caused intensities ≥ MM5 at Wairoa, Napier, Hastings, Waipawa or Waipukurau, are shown in Figure 4.

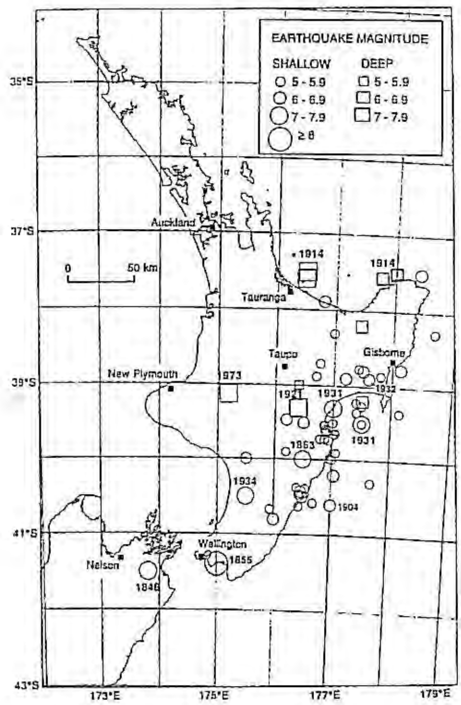


Figure 4: Locations of earthquakes known to have caused intensities ≥ MM5 in Hawke's Bay.

Begg et al 1994 (see Reference 1 to this chapter), contains a description of the large earthquakes that have affected the Hawke's Bay region.

Earthquakes in Hawke's Bay

The Hawke's Bay region is the site of numerous earthquakes because it is close to the boundary of two tectonic plates. These earthquakes result from the sudden release of stresses built up by relative movement between the Pacific and Australian plates over considerable periods of time. The normal subduction process produces these stresses within each of the two plates and along the subduction interface between them. This leads to three types of earthquakes occurring in distinct portions of the earth's crust, as shown in Figures 5a and 5b and discussed below:

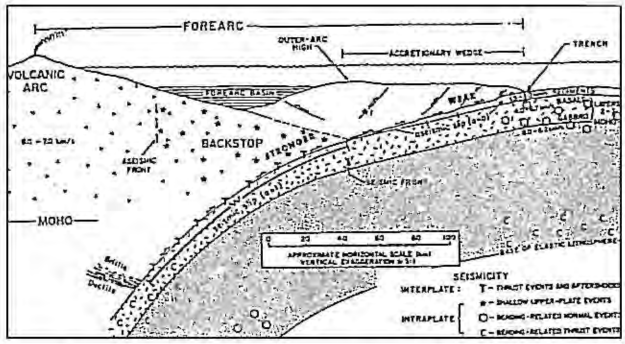


Figure 5a: Idealised schematic cross section of the shallow part of a subduction zone (after Byrne et al. 1988)

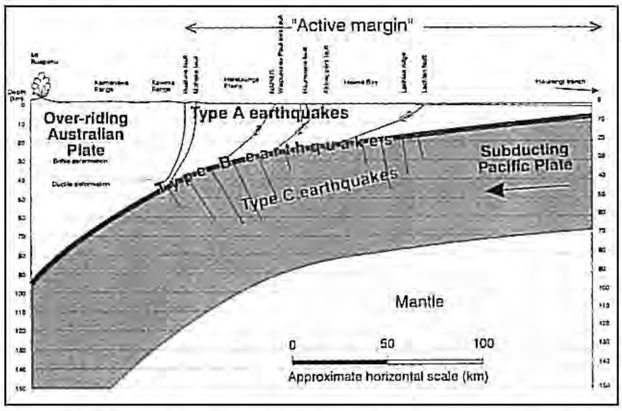


Figure 5b: Schematic cross section illustrating the tectonic setting of the Hawke's Bay region. The section line trends NW-SE and extends from the Hikurangi trench to Mt Ruapehu. Faults, fault zones and earthquake sources are shown.

The three principal types of earthquakes in Hawke's Bay are as follows:

- Type A earthquakes occur within the over-riding Australian Plate from the transfer of stress because of coupling between the two plates at the subduction interface (= "upper plate" earthquakes);
- Type B earthquakes occur at the interface between the subducting Pacific Plate and the over-riding Australian Plate (= "subduction interface");

- Type C earthquakes occur in the upper part of the subducting Pacific Plate as it bends downwards beneath the Australian Plate
(= "deep focus" earthquakes; Figure 5b).

A typical, or "generic", model of a subduction zone can be compiled from world-wide studies, as has been done by Byrne et al. (1988) (Figure 5a). There is almost always a wide "active margin" in which deformation, earthquakes **(Type A)** and possibly volcanism, occur in the overlying plate. The active margin extends from near the "trench", where subduction begins, and continues inland for some distance. Usually, but not always, the magnitude of these **Type A** earthquakes is less than that of large subduction interface **(Type B)** events. However, **Type A** events may be shallower and closer to population centres and present a greater seismic hazard. Earthquakes that occur within the subducted plate **(Type C)** are occasionally quite large magnitude.

As yet there is no method for assessing the seismic hazard of **Type C** earthquakes. However, they are thought to pose a lesser danger to the region than **Type A** earthquakes. This is because they occur at a great depth within the descending Pacific Plate (>25 km beneath Napier, >40 km beneath the northern Ruahine Range) and because that plate may be relatively de-coupled from the Australian Plate, limiting seismic energy. For these reasons **Type C** earthquakes are not considered further in this report.

Active Faults of Hawke's Bay

Fault ruptures associated with earthquakes can occur in the earth's crust. Those that are shallow enough to extend upwards to the ground surface form surface fault traces. Most ruptures that generate a surface trace are associated with large earthquakes, so active fault traces signal likely sites for future large earthquakes.

Major active onshore faults and folds of the Hawke's Bay region are discussed in detail in Reference 1. Their characteristics are updated in Reference 2, by Begg et al.

In order from west to east they are:

Ruahine Fault
The Ruahine Fault is a strike-slip fault separating the stable microcontinental platform area of New Zealand from the zone of deformation known as the East Coast Deformed Belt, that extends to the Hikurangi Trough. The Ruahine and Mohaka faults are two of the major active faults of the Hawke's Bay region and are also major strands of the Wellington fault system.

Waipunga, Big Hill and Thorn Flat, Patoka, Hinerua, Wakarara and Rangiora Faults.
These faults are probably related to the Ruahine and Mohaka faults.

Mohaka Fault
The Mohaka Fault is a major NE tending strike-slip fault which, together with the Ruahine Fault, forms one of the principal structural features of the eastern North Island.

Taniwha, Waikopiro, Oruawhero and Glendown Faults
These faults have been identified in the Ruataniwha and Takapau areas.

Napier – Hawke Bay Fault
The Napier-Hawke Bay Fault tends NW from Bridge Pa, possibly as far south as Tikokino, through Te Awa and offshore.

Napier following 1931 Hawke's Bay Earthquake.

The 1931 Hawke's Bay earthquake (M 7.8) is thought to have been caused by rupture of this fault. The line of zero change in elevation during the 1931 earthquake is currently regarded as the most accurate location of the surface projection of the fault. (see figure 6). This is supported by the presence of a series of springs, which presumably resulted from disruption of an aquifer. The 1931 rupture of the Napier – Hawke Bay Fault was the first for at least 1800 years. The strategraphic record from Ahuriri Lagoon indicates that subsidence has been the dominant direction of tectonic movement during the last 3500 years, in contrast to the uplift experienced in the 1931 event.

Hastings Street Napier following 1931 Hawke's Bay Earthquake.

Waipukurau – Poukawa Shear Zone

A number of strike-slip faults tending NNE NE between Waipukurau and Pakipaki were trenched, mapped and logged as part of the IGNS study and are reported in detail in Reference 2.

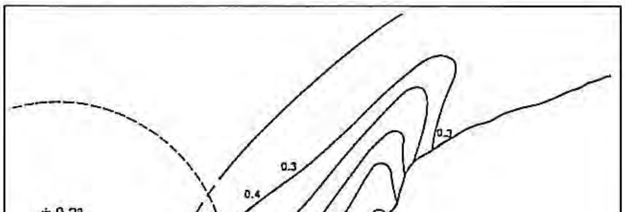


Figure 6a: Subsidence and uplift associated with the 1931 Napier earthquake. Data points and contours are in metres change.

Haumoana Fault Zone

A NNE trending belt of normal faults extends from the coast at Clifton from 70km south beyond Wanstead. A large number of discontinuous fault traces make up a zone that varies in width from several hundred metres to about 8km.

This zone was studied in detail and reported in Reference 2.

Major active offshore structures include:

- Napier – Hawke Bay Fault.
- Kidnappers Anticline/Haumoana Fault zone
- Lachlan Ridge 20km east of Kidnappers Ridge.

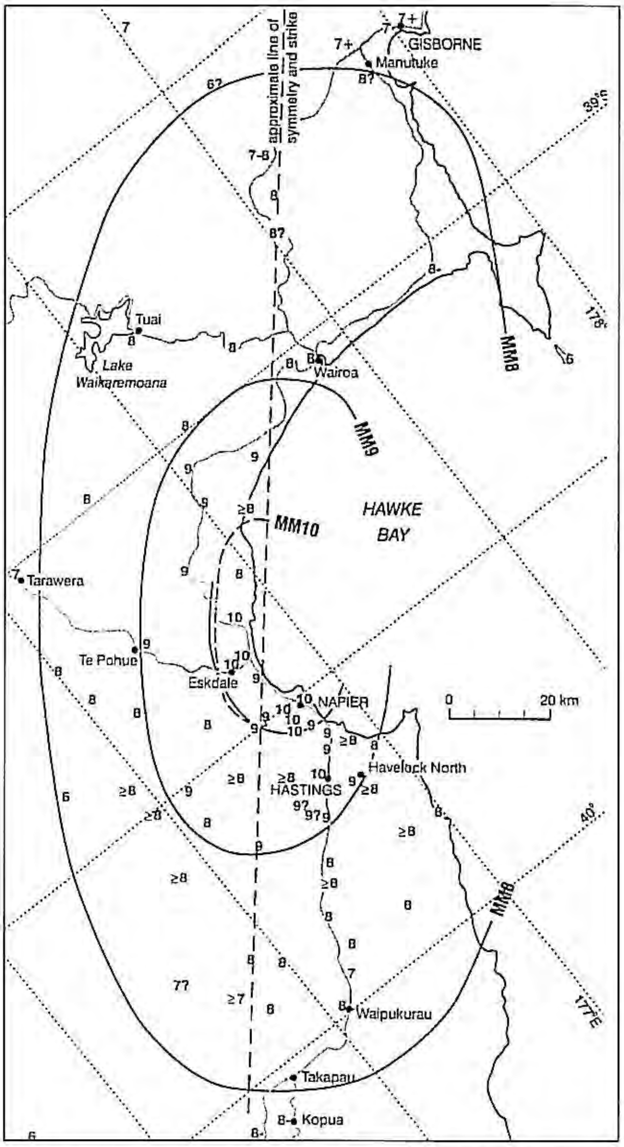


Figure 6b: 1931 Napier earthquake, Ground Shaking (MM) Intensities

Hikurangi Trough

The axis of the Hikurangi Trough lies about 160km to the east of the Hawke's Bay Coast. The trough is not a seismogenic source in its own right but a geomorphological feature that is one indicator of the tectonic environment of the North Island. It represents the surface expression of the subduction plate boundary and is the line along which the Pacific plate starts dipping below the eastern edge of the Australian plate.

Subduction Zone Earthquakes

The second main seismic hazard in the Hawke's Bay region is rupture of the gently dipping subduction interface that exists beneath the region (**Type B** earthquakes).

During a subduction interface rupture, there may not be any primary surface rupture. The history of subduction zone earthquakes can be evaluated by the pattern of coastal emergence or submergence. The pattern is also related to crystal faults. As a result it is very difficult in Hawke's Bay to determine and analyse these earthquakes by geologic evidence.

Historical data from active margins around the world shows that subduction zone earthquakes are among the largest. The hazard associated with subduction faults is difficult to quantify but is an important element of seismic assessment for the Hawke's Bay region.

The subduction zone in the North Island is unusual in two ways. First, a much greater width of the convergent margin is above sea level than is the case in most other subduction zones. This means that large subduction events which are normally offshore, as in Japan for example, may occur much closer to populated areas in New Zealand. Second, the direction of convergence is not perpendicular to the general strike (NE-SW) of the major geologic features and the subducted plate. This is known as oblique convergence and results in the presence of the major, strike-slip faults parallel to the coast in the overlying plate, such as the Wellington, Wairarapa, Ruahine, and Mohaka Faults. Earthquakes on these faults account for a large part of the component of convergence parallel to the coast. However, the component of motion perpendicular to the coast remains largely unaccounted for by these faults. It is usually assumed that this motion is taken up by some combination of slip on the subduction interface (seismic or aseismic), and slip during thrust type earthquakes on shallow faults between the Hikurangi Trough and the axial mountain ranges, such as in the Waipukurau-Poukawa area. It is the relative partitioning of slip between these various tectonic components that determines the potential for large subduction earthquakes in the region.

In order to estimate the location and size of large subduction thrust earthquakes in Hawke's Bay we must first establish the portion of the interface which slips during such events.

Using two methods, IGNS has estimated the average width at about 45km. The length of plate moving based on previous ruptures is 120km, which extends from just north of Cape Turnagain almost to Mahia. If this 120km segment of the plate were to rupture in a single subduction thrust event over a width of 45km, a magnitude 7.7 earthquake could be expected. Such an event is likely to produce an average slip of 3 metres between the plates.

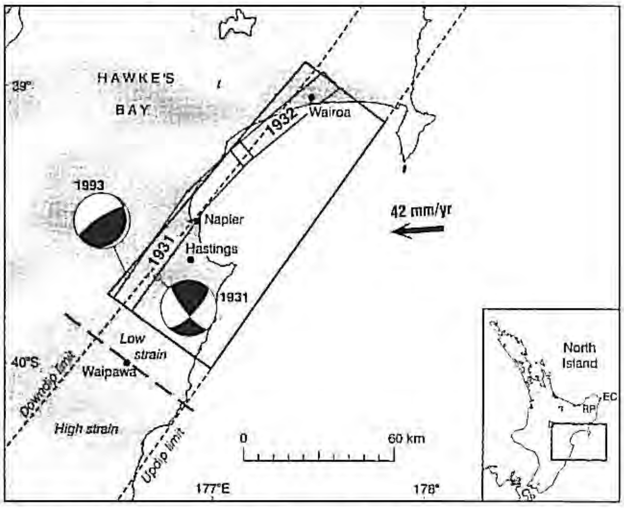


Figure 6c: The inferred updip and downdip limits of the seismogenic zone of the plate interface in Hawke's Bay. The heavy-lined rectangle indicates the portion of the seismogenic zone which might rupture in a single large subduction thrust earthquake, as estimated in this study.

To assess the likely recurrence of such an event, the project used the average relative movement between plates, adjusted for shortening of the overlying plate and factored for seismic slip to total slip. This has resulted in an estimated recurrence of about 550 years for such a subduction thrust event in Hawke's Bay.

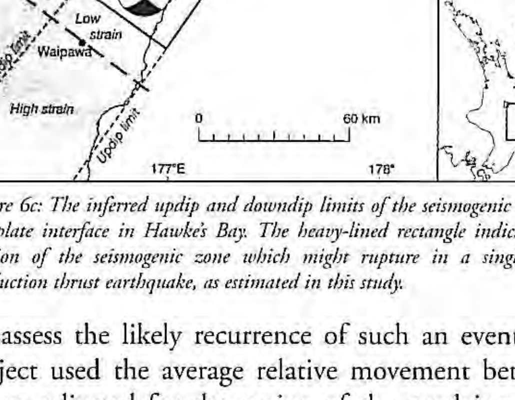


Figure 6d: Elevation changes resulting from elastostatic dislocation modelling of the proposed M_w 7.7 subduction thrust earthquake in Hawke's Bay.
Solid contours denote uplift and dashed contours denote subsidence, and the contour interval is 0.2 m.

Such events would be expected to produce subsidence above the downdip end of the seismogenic zone. Hull (1986) has used peat layers in the Ahuriri Lagoon near Napier to demonstrate that the 1931 co-seismic uplift in this region was a reversal of a subsidence trend. This subsidence could have been produced by large subduction thrust events. The last downdrop of ~ 1m occurred about 500 years ago, and rapid downdrop of 8m occurred during the period ~ 1750-3500 years ago. Elastic dislocation modelling indicates that a maximum of 1m of subsidence will occur above the downdip end of the seismogenic zone as a result of 4m of slip on the fault zone defined above. Thus the downdrop at Ahuriri lagoon some 500 years ago would be broadly consistent with the model for a subduction thrust event. Similarly, if the total 9m of subsidence in the last 3500 years identified by Hull (1986) was to have occurred in similar sized events, a recurrence interval of some 400 years is suggested. Although there are many uncertainties this is also broadly consistent with the recurrence intervals estimated above.

Numerical Assessment of the Earthquake Hazard

As part of their studies IGNS carried out a regional revision of nationally based earthquake hazard calculations.

These computer calculations used the following source data:

- A catalogue of 1007 shallow earthquakes greater than M4 from 1840-1993;
- 728 deep earthquakes;
- Data from 40 active fault sources;
- The earthquake parameter for the subduction zone beneath Hawke's Bay.

The study predicted values of Modified Mercalli Intensity (MM), and Peak Ground Acceleration (PGA) for average ground conditions, such as the firm alluvial that underlies many of the towns of southern Hawke's Bay and the firmest parts of Napier and Hastings.

A few parts of the region are on very firm sites that are likely to experience less intense shaking than predicted in this study. However many places are on soft ground that will amplify the intensity of shaking. Amplification factors, identified by mapping ground conditions throughout the region in the latter part of the studies, need to be incorporated to produce final estimates of the earthquake hazard.

1907 Westshore and the Iron Pot Napier shows the reclaimed ground upon which much of Napier is built. (Photo courtesy of Don Wilkie collection)

The earthquake hazard results are mainly based on ground motions that have a 10% probability of being exceeded in 15 years, 50 years and 500 years, corresponding to 142, 475 and about 5000-year return period events

The 142-year return period event is likened to the Operating Basis Event - one that can be expected with reasonably high probability. The 475-year event is likened to the Design Level Event (DLE) and corresponds to the New Zealand Loadings Standard (NZS 4203:1992) for many structures. The 5000-year event is likened to the Maximum Design Event (MDE). The MDE has a low probability of occurrence but it is important that critical facilities and structures, such as hospitals, fire stations and key lifeline services, perform well even in this extreme event.

The results of the numerical assessment are presented in Figures 7 to 12.

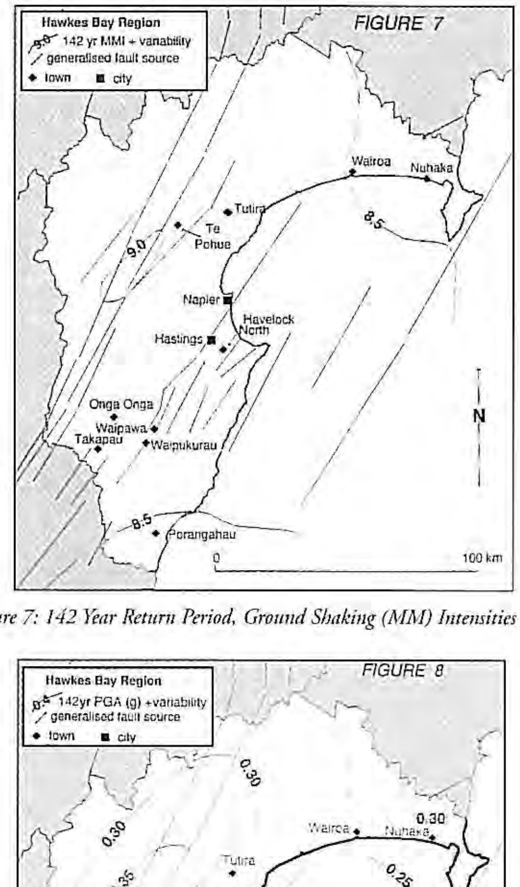


Figure 7: 142 Year Return Period, Ground Shaking (MM) Intensities

Figure 8: 142 Year Return Period, Peak Ground Acceleration (PGA), (g)

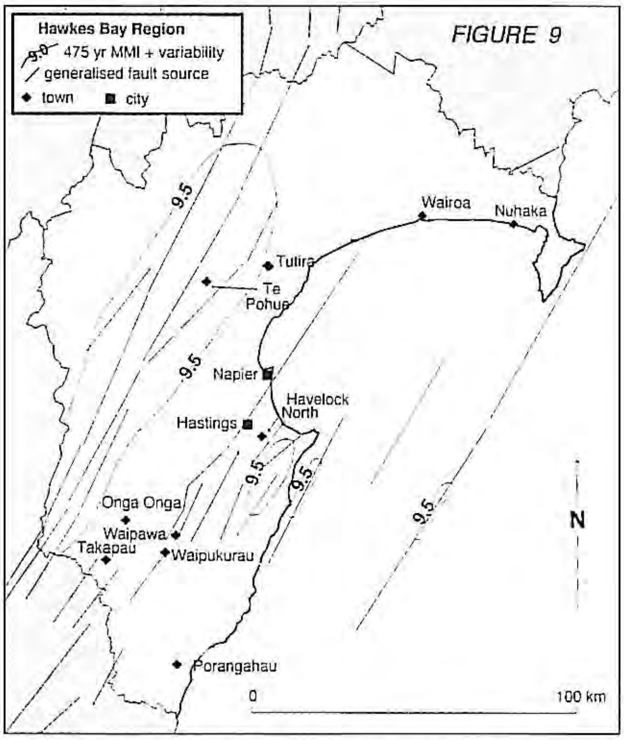


Figure 9: 475 Year Return Period, Ground Shaking (MM) Intensities

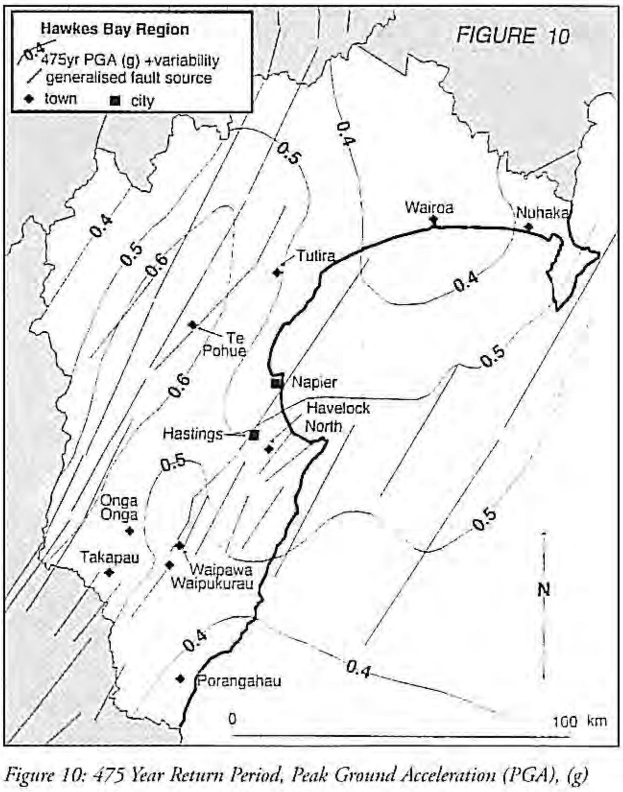


Figure 10: 475 Year Return Period, Peak Ground Acceleration (PGA), (g)

Results of this study indicate that for the Operating Basis Event the Hawke's Bay region may experience MM intensity of about 8.5 – 9.0 and PGA of 0.26 – 0.4g. At MM Intensity 8 – 9 damage to modern structures should be minimal. However there could be serious damage to older, non-reinforced masonry, poorly reinforced structures and well constructed buildings, if permanent ground deformation occurs as a result of liquefaction settlement (see Appendix I for descriptions of damage likely at various MM Intensities). Because of the high probability of occurrence of this level of shaking, all significant structures should be upgraded to maintain life safety and operability at this level of hazard.

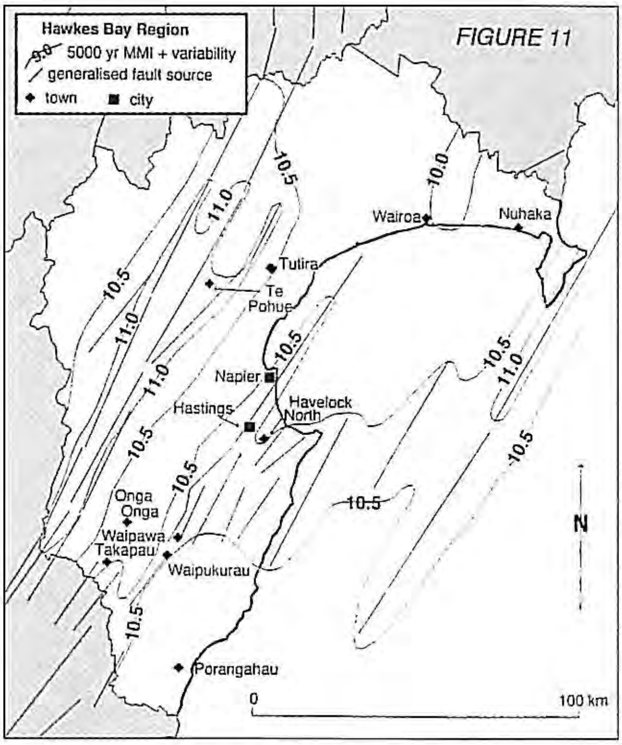


Figure 11: 5000 Year Return Period, Ground Shaking (MM) Intensities

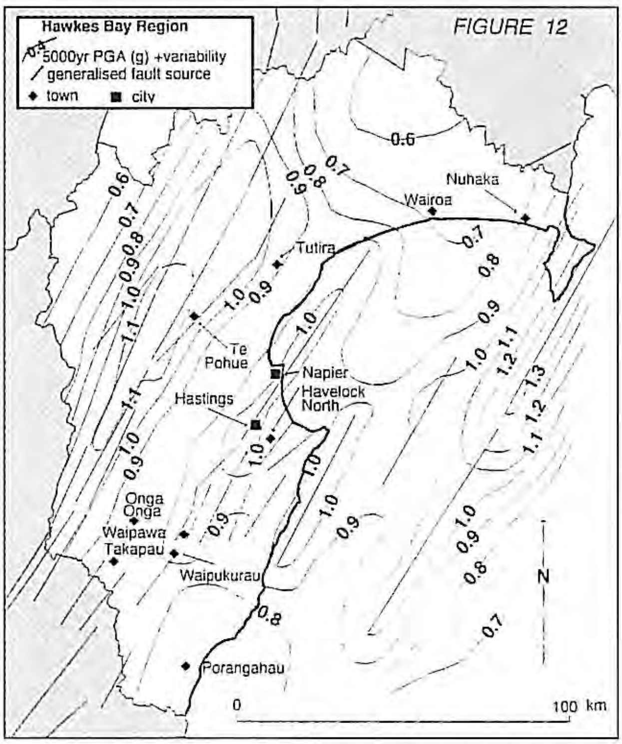


Figure 12: 5000 Year Return Period, Peak Ground Acceleration (PGA), (g)

The variation in strong ground shaking across the region for a 475 year return period is estimated to be MM Intensity 9.1 —9.7, and 0.4 – 0.6g PGA. These estimates represent a revision of ground motion estimates corresponding to code requirements for risk factor R=1 structures. This estimate of hazard has a 10% chance of being exceeded in any 50-year period.

The variation in strong ground shaking across the region in the 5000-year return period is estimated to be MM Intensity 10 - 11, and 0.7 – 1.05g PGA. These hazard estimates represent the likely level of shaking during the maximum earthquake event. This level of shaking has a 10% chance of being exceeded in any 500-year period.

These hazard estimates correspond to a maximum design event and are particularly sensitive to the choice of attenuation (diminishing with distance) expression in the ground motion calculation.

Because the hazard at each return period varies throughout the region, there is a corresponding variation in susceptibility to earthquake damage. This also depends on the style, age, and maintenance of buildings or facilities, and on variations in ground conditions.

Liquefaction Potential in the Hawke's Bay Region

Liquefaction is a process where strong shaking may cause a temporary loss of strength in certain soils (mainly saturated, loose, uniform fine sands and coarse silts). The ground deformations which result from liquefaction and other similar processes can cause significant property damage due to the reduction of bearing strength beneath foundations, and the settlement or lateral movement of soil across buried structures, such as pipelines.

View over Napier in 1880 - Bridge at low tide. Much of Ahuriri and Westshore is built on alluvial deposits.
(Photo courtesy of Don Wilkie collection)

In New Zealand, the most widespread occurrences of liquefaction since European settlement began in 1840, have occurred in coastal regions with extensive deposits of recent, loose, fine-grained alluvial deposits.

The intensity threshold for liquefaction in New Zealand is generally MM7 for sand boils, and MM8 for lateral spreading but both may occur at one intensity lower in highly susceptible materials. The minimum magnitude for liquefaction is M6 but liquefaction is more common at M7, and greater liquefaction induced ground damage is most common at MM 8-10 at distances of 10-100km from the epicentre.

Although liquefaction effects are only seen in loose soils, dense sands and silts may show initial signs of liquefaction. This trend is rapidly halted by the tendency of these soils to increase in volume under added stress.

More effort has recently been made to understand and predict liquefaction potential and ground failures and hazards caused by liquefaction, rather than earthquake induced landsliding. This is because densely populated cities, which are seen as very vulnerable to earthquake damage, are often underlain by potentially liquefiable sediments.

This applies to Hawke's Bay where ground failures due to liquefaction could be serious because essential facilities and structures are at risk in urban centres.

Earthquake induced landsliding is included in the landslide hazard of the Hawke's Bay Engineering Lifelines Project.

Reference 4 contains a detailed summary of liquefaction effects, resulting from nine large earthquakes that have affected the region since 1844.

The above historical data has been combined in maps showing the regional geology and assessments of geotechnical properties of the different surface geological and soils data, to assign liquefaction ratings in different geologic zones.

Liquefaction susceptibility maps have been prepared to show the distribution of deposits that could liquefy during strong ground shaking. These maps provide a general indication of where liquefaction will occur and the extent of it. The results of this mapping indicate that large parts of Napier and Wairoa are underlain by deposits with a high or very high susceptibility to liquefaction. In these areas permanent ground deformation could occur over large areas, with settlements of around 1 metre and lateral spreads of up to 15 metres, during ground shaking that reaches an intensity of MM10.

Hastings, Waipukurau and Waipawa are primarily underlain by deposits with moderate to low liquefaction susceptibility. Permanent ground deformation in these areas would probably be limited with only minor settlements during even the severest earthquake shaking expected in these areas (MM10). However, the stream channels in this area have a very high susceptibility rating and liquefaction in these channels could occur at lower levels of shaking (MM7-8).

Areas of very high or high susceptibility are commonly found in the lower energy, downstream reaches of river channels, near river mouths, in and around coastal lagoons and estuaries, and in enclosed inland sedimentary basins (e.g. the Poukawa basin). These areas are shown on the maps attached to Reference 4.

Liquefaction potential is assessed by comparing the distribution of susceptible deposits, and the opportunity for strong ground shaking during a given event.

Liquefaction potential maps were prepared by overlaying the liquefaction susceptibility maps with ground shaking isoseismal maps for earthquake scenarios.

The three earthquake scenarios were selected because they represent large magnitude events that have a reasonable probability of occurrence (1 in 500 year return periods, the same as building design loadings codes).

The scenarios selected are:

- M7.5 on the Mohaka fault;
- M7.5 on the Poukawa fault and;
- M8.1 on the subduction zone.

The combined map of these three scenarios shows the variation in liquefaction that could occur during the large earthquakes. The map indicates that liquefaction could occur in the high and very high susceptibility areas during almost any large earthquake in the region, although the extent of it will depend on the intensity of the ground shaking. Liquefaction would only be triggered in moderate to low susceptibility areas near earthquake epicentres.

Ground Shaking Amplification Potential

Local geological deposits, or ground conditions, are well known for their ability to influence the type of shaking experienced during an earthquake. By identifying areas with a high shaking risk, it is possible to reduce the community's vulnerability to strong earthquake ground shaking. Sites underlain by soft, flexible, material often experience greater shaking than nearby sites underlain by firmer, stiffer material.

The methodology used in the report (Reference 5) integrates information on geological conditions with geotechnical parameters, such as mean shear wave velocity, and standard penetration test results, to develop amplification response classifications.

In general, the soils in the Heretaunga Plains are classified as average (Class 3) soils with respect to the New Zealand Soil PGA Earthquake Attenuation Equation. Soils in the vicinity of the Ahuriri lagoon and other local deposits in swamps, lagoons and estuaries along the coast (Class 4), are weaker than the alluvium on the Heretaunga Plains.

- At low levels of shaking both the soils of the Heretaunga Plains and the soils of the former Ahuriri lagoon and other lagoons, estuaries and swamps will amplify ground shaking with respect to rock sites. The weaker (Class 4) soils will show greater amplifications.
- During strong shaking the soils of the former Ahuriri lagoon and other local lagoons, estuaries and swamps will begin to liquefy, thus losing shear strength and losing their ability to amplify ground shaking. However, these areas are likely to suffer ground deformation with consequent damage to buried services and structures founded in them.
- The soils of the Heretaunga Plains (Class 3) are unlikely to liquefy west of Hastings, given the ground damage accounts from the 1931 Hawke's Bay Earthquake. These show liquefaction-induced ground damage from sites that lie to the east, south-east and north-east of Hastings.

An area in Flaxmere has shown a site response that doubles the amplification factor of the mean values used to develop the hazard maps. It should be noted that this type of local site response might occur elsewhere, and special studies are required for sensitive facilities, or facilities that would be critical immediately after an earthquake.

These findings indicate that for Hawke's Bay, strong distant earthquakes will have the greatest impact in terms of the hazard of ground shaking amplification at particular sites. The level of shaking required to generate this degree of site response is most likely to be sourced on faults at moderate to large distances from the "site" in question. Scientists are unable to be more specific, as the levels of shaking depend on both magnitude and distance.

Engineering Lifelines Project Earthquake Hazard Assessments

The information summarised above provides a comprehensive study of the earthquake hazard in Hawke's Bay.

To assess the vulnerability of engineering lifelines to earthquakes and the resulting impacts, the above information needs to be rationalised into packages that can be easily evaluated.

When assessing each part of a network the following effects of earthquakes should be considered:

ground shaking
ground rupture
liquefaction potential
slope instability

Slope instability will be considered separately.

Ground rupture is generated by active earthquake faults. Thus the maps of these faults and folds should be considered.

To investigate ground shaking, a subduction zone thrust event of magnitude M7.7 is proposed as a representative scenario event.

Clearing Slips from Napier Hill after 1931 Hawke's Bay Earthquake.

It was chosen because:

- High levels of ground shaking, liquefaction and slope stability problems are likely to result throughout the region;
- Research has shown it has an expected return period of 550 years. The most recent evidence of this type of earthquake, a downdrop of one metre at Ahuriri, occurred about 500 years ago;
- The 550-year return period is close to the Design Level Event return period used as a basis for the New Zealand Standard Loadings Code;
- Although such an earthquake may not result in ground surface rupture, it is likely to have a significant impact on infrastructure due to surface deformation;
- A notable characteristic of subduction zone thrust earthquakes is their expected length of shaking. The few earthquakes of this type that have been recorded indicate strong shaking lasting from 10 to 40 seconds. This duration of shaking is likely to fully test structures, maximise the potential for liquefaction, and have other effects such as lateral spread and landslip at susceptible sites.

Maps were prepared of the scenario subduction thrust earthquakes indicating shaking in terms of MM Intensity and Peak Ground Acceleration. The engineering lifelines networks were overlain by the MM Intensity map to represent surface effects, making assessment easier.

The PGAs given on the map will need to be factored by the ground shaking amplification factors given in Reference 5. These, along with local site effects, could increase or decrease the acceleration levels by up to 30%.

Liquefaction potential maps were prepared for the subduction zone thrust earthquake in Reference 4. This used a magnitude earthquake M8.1 compared to M7.7 for the MM Intensity map. However, most of the susceptible soils still fall within the same MM Intensity.

In conclusion, assessment of the vulnerability of networks during the Hawke's Bay Engineering Lifelines Project involved consideration of the following issues:

- The location of known active earthquake faults and folds;
- The MM Intensity from the scenario subduction thrust M7.7 earthquake ;
- The liquefaction potential for the scenario subduction thrust M8.1 earthquake;
- The MM Intensity and liquefaction potential for the scenario M7.5 earthquakes on the Mohaka and Poukawa faults.

1931 Mass grave at Park Island cemetery, Napier.

These are presented on map 3. It shows the maximum effect of any one of the three events at any location over the region

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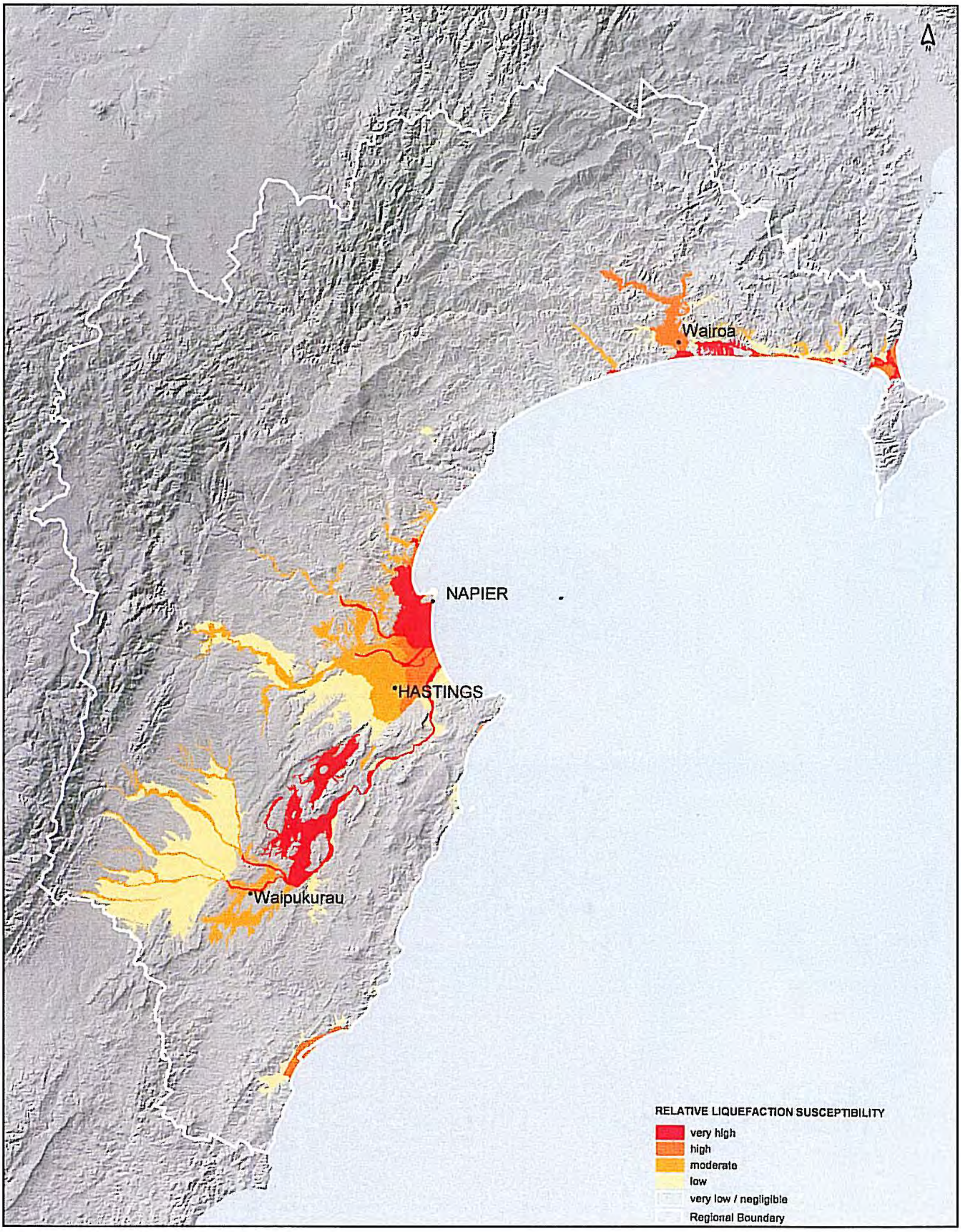
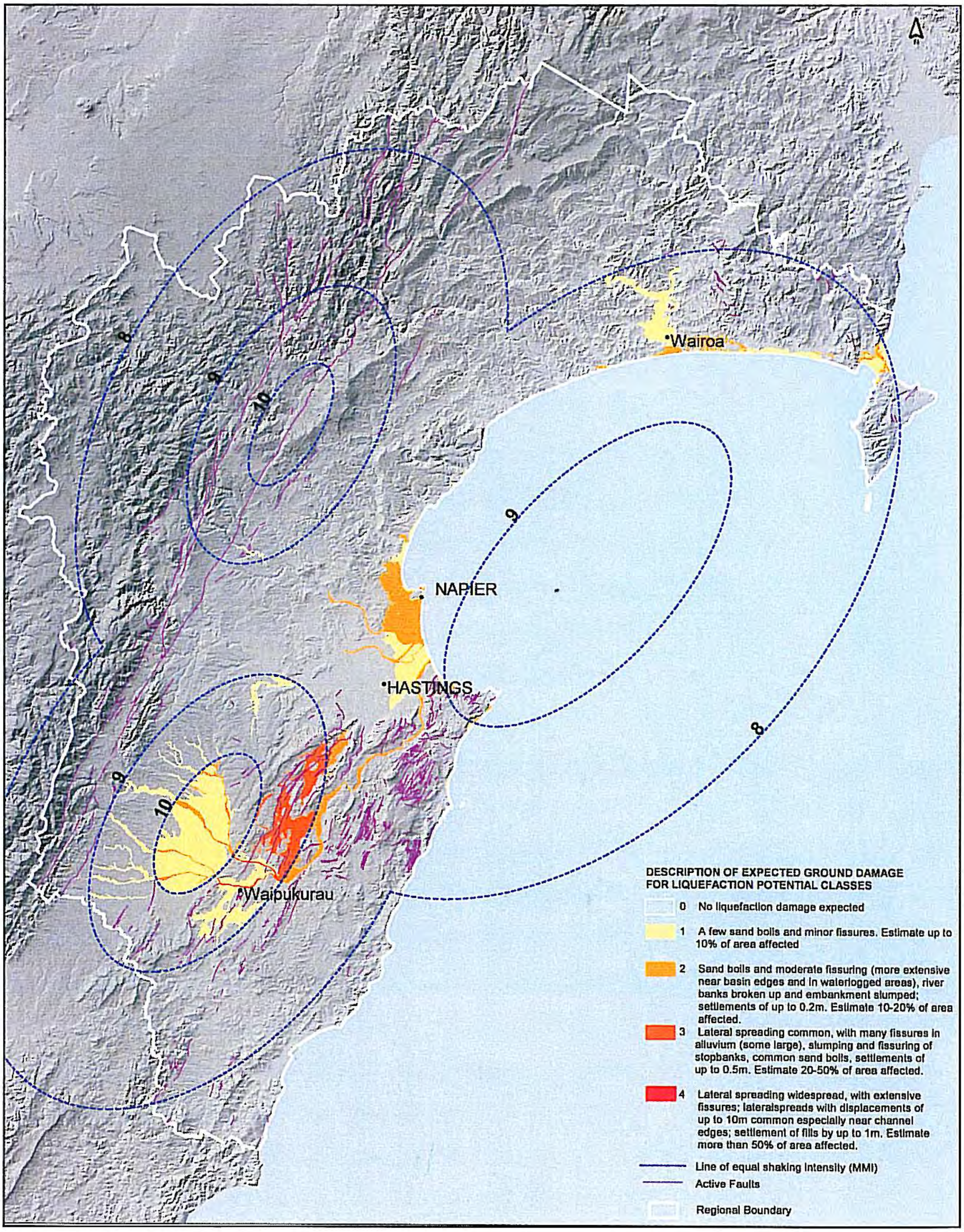
Map 2

Liquefaction Susceptibillity
Hawke's Bay Region



Map 3

Combined Earthquake Hazard Scenarios
- Liquefaction Potential
- Ground Shaking Intensity (MM)
- Active Faults



Appendix 1

Modified Mecalli Intensity Scales Definitions
NZ 1996
(Items marked * in the scale are defined below)

MM1 *People*
Not felt except by a very few people under exceptionally favourable circumstances.

MM2 *People*
Felt by persons at rest, on upper floors or favourably placed.

MM3 *People*
Felt indoors; hanging objects may swing, vibration similar to passing of light trucks, duration may be estimated, may not be recognised as an earthquake.

MM4 *People*
Generally noticed indoors but not outside. Light sleepers may be awakened. Vibration may be likened to the passing of heavy traffic, or to the jolt of a heavy object falling or striking the building.

Fittings
Doors and windows rattle. Glassware and crockery rattle. Liquids in open vessels may be slightly disturbed. Standing motorcars may rock.

Structures
Walls and frame of buildings and partitions and suspended ceilings in commercial buildings may be heard to creak.

MM5 *People*
Generally felt outside, and by almost everyone indoors. Most sleepers awakened. A few people alarmed.

Fittings
Small unstable objects are displaced or upset. Some glassware and crockery may be broken. Hanging pictures knock against the wall. Open doors may swing. Cupboard doors secured by magnetic catches may open. Pendulum clocks stop, start, or change rate (H*).

Structures
Some windows Type I* cracked.
A few earthenware toilet fixtures cracked (H*).

MM6 *People*
Felt by all
People and animals alarmed
Many run outside*
Difficulty in walking steadily

Fittings
Objects fall from shelves.
Pictures fall from walls (H*).
Some furniture moved on smooth floors, some unsecured freestanding fireplaces moved.
Glassware and crockery broken.
Very unstable furniture overturned.
Small church and school bells ring (H*)
Appliances move on bench or table tops.
Filing cabinets or easy-glide drawers may open or shut.

Structures
Slight damage to Buildings Type I*
Some stucco or cement plaster falls
Windows Type I* broken
Damage to a few weak domestic chimneys, some of which may fall

Environment
Trees and bushes shake, or are heard to rustle
Loose material may be dislodged from sloping ground eg: existing slides, scree slopes, shingle slides

MM7 *People*
General alarm
Difficulty experienced in standing
Noticed by motorcar drivers who may stop

Fittings
Large bells ring
Furniture moves on smooth floors and may move on carpeted floors
Substantial damage to fragile* contents of buildings.

Structures
Unreinforced stone and brick walls cracked
Buildings Type I* cracked and minor masonry will fall from some
A few instances of damage to Buildings Type II* Unbraced parapets, unbraced brick gables, and architectural ornaments fall Roofing tiles, especially ridge tiles, may be dislodged Many unreinforced domestic chimneys damaged, often falling from roofline Water tanks Type I* burst A few instances of damage to brick veneers and plaster or cement based linings.

Unrestrained water cylinders (Water Tanks II*) may move and leak.
Some windows Type II* cracked. Suspended ceilings damaged

Environment
Water made turbid by stirred up mud.
Small slides such as falls of sand and gravel banks, and small rock-falls from steep slopes and cuttings.
Settlement of unconsolidated, wet or weak soils.
Some fine cracks appear in sloping ground. A few instances of liquefaction (i.e.: small water and sand ejections).

MM8 *People*
Alarm may approach panic.
Steering of motorcars greatly affected.

Structures
Building Type I*, heavily damaged, some collapse.
Buildings Type II* damaged, some with partial collapse.
Buildings Type III* damaged in some cases.
A few instances of damage to Structures Type IV.
Monuments and pre-1976 elevated tanks and factory stacks twisted or brought down.
Some pre-1965 infill masonry panels damaged.
A few post-1980 brick veneers damaged.
Decayed timber piles of houses damaged.
Houses not secured to foundations may move.
Most unreinforced domestic chimneys damaged, some below roofline, many brought down.

Environment
Cracks appear on steep slopes and in wet ground.
Small to moderate slides in roadside cuttings and unsupported excavations.
Small water and sand ejections and localised lateral spreading adjacent to streams, canals, lakes etc.

MM9 *Structures*
Many Buildings Type I destroyed*.
Buildings II heavily damaged, some collapse*.
Buildings Type III damaged, some with partial collapse*.
Structures Type IV* damaged in some cases, some with flexible frames seriously damaged.
Damage or permanent distortion to some Structures Type V*.
Houses not secured to foundations shifted off.
Brick veneers fall and expose frames.

Environment
Cracking of ground conspicuous.
Landsliding general on steep slopes.
Liquefaction effects intensified and more widespread, with large lateral spreading and flow sliding adjacent to streams, canals, lakes, etc.

MM10 *Structures*
Most Buildings Type I destroyed*.
Many Buildings Type II destroyed*.
Buildings Type III heavily damaged, some collapse*.
Structures Type IV damaged, some with partial collapse*.
Structures Type V moderately damaged, but few partial collapses*.
A few instances of damage to Structures Type VI*.
Some well built* timber buildings moderatelydamaged (excluding damage from falling chimneys).

Environment
Landsliding very widespread in susceptible terrain, with very large rock masses displaced on steep slopes. Landslide dams may be formed.
Liquefaction effects widespread and severe.

MM11 *Structures*
Most Buildings Type II destroyed*.
Many Buildings Type III destroyed*.
Structures Type IV heavily damaged, some collapse*.
Structures Type V damaged, some with partial collapse*.
Structures Type VI suffer minor damage, a few moderately damaged*.

MM12 *Structures*
Most Buildings Type III destroyed*.
Many Structures Type IV destroyed*.
Structures Type V* heavily damaged, some with partial collapse.
Structures Type VI* moderately damaged.

Construction Types:

Buildings Type I (Masonry D in the NZ 1966 MM scale)

Buildings with a low standard of workmanship, poor mortar, or constructed of weak materials like mud brick or rammed earth. Soft storey structures (eg shops) made of masonry, weak reinforced concrete, or composite materials (eg: some walls timber, some brick) not well tied together. Masonry buildings otherwise conforming to Buildings Types I - III, but also having heavy unreinforced masonry towers. (Buildings constructed entirely of timber must be of extremely low quality to be Type I).

Buildings Type II (Masonry C in the NZ 1966 MM scale)
Buildings of ordinary workmanship, with mortar of average quality. No extreme weakness, such as inadequate bonding of the corners, but neither designed nor reinforced to resist lateral forces. Includes buildings that do not have heavy unreinforced masonry towers.

Buildings Type III (Masonry B in the NZ 1966 MM scale)
Reinforced masonry or concrete buildings of good workmanship and with sound mortar, but not formally designed to resist earthquake forces.

Structures Type IV (Masonry A in the NZ 1966 MM scale)
Buildings and bridges designed and built to resist earthquakes to normal use standards, i.e. no special collapse or damage limiting measures taken (mid 1930's to c. 1970 for concrete and to c 1980 for other materials).

Structures Type V
Buildings and bridges, designed and built to normal use standards, i.e. no special damage limiting measures taken, other than code requirements, dating from since c. 1970 for concrete and c. 1980 for other materials.

Structures Type VI
Structures, dating from c 1980, with well defined foundation behaviour, which have been specially designed for minimal damage, e.g. seismically isolated emergency facilities, some structures with dangerous or high contents, or new generation low damage structures.

Windows

Type I – Large display windows, especially shop windows
Type II – Ordinary sash or casement windows

Water Tanks

Type I – External, stand mounted, corrugated iron water tanks
Type II – Domestic hot-water cylinders unrestrained except by supply and delivery pipes
H – (Historical) more likely to be used for historical events.

Other Comments

"Some" or "a few" indicates that the threshold of a particular effect has just been reached at that intensity.
"Many run outside" (MM6) variable depending on mass behaviour, or conditioning by occurrence or absence of previous quakes, i.e.: may occur at MM5 or not till MM7.
"Fragile Contents of Buildings". Fragile contents include weak, brittle, unstable, unrestrained objects in any kind of building.
"Well built timber buildings" have: wall openings that are not too large; robust piles or reinforced concrete strip foundations; superstructure tied to foundations.
E Buildings Type III – V at MM10 and greater intensities are more likely to exhibit the damage levels indicated for low-rise buildings on firm or stiff ground and for high rise buildings on soft ground. By inference lesser damage to low rise buildings on soft ground and high-rise buildings on firm or stiff ground may indicate the same intensity. These effects are due to attenuation of short period vibrations and amplification of longer period vibrations in soft soils.

Chapter 3
Flood Hazard

Floods are defined as the overland flow or ponding of water outside normal river, stream, lake or sea boundaries. Rivers and streams frequently flood, but flooding is only regarded as a hazard when it could damage or adversely affect a development or community.

Flooding is caused by various types of rainfall - short bursts of heavy rainfall affect smaller catchments while prolonged rainfall affects larger catchments.

Hazard Studies

The Hawke's Bay Regional Council has extensively studied the rivers and major catchments in Hawke's Bay. Where flooding has caused significant disruption to communities or economic loss, drainage and river schemes have been put in place to reduce the frequency of flooding and its consequences. The Regional Council now has an extensive library of management plans for the various schemes in Hawke's Bay.

The following list shows the extent of studies done:

- Heretaunga Plains Flood Control Scheme – Part 1 Rivers Plan No. 2770
- Heretaunga Plains Flood Control Scheme – Part 2 Drainage and Pumping Plan No 2784
- Esk River and Whirinaki Drainage Scheme Plan No. 2799
- Paeroa Drainage Scheme – Plan No 2800
- Ohuia Drainage Scheme – Plan No. 2801
- Upper Makara Catchment Control Scheme – Plan No. 2802
- Poukawa Drainage Scheme Plan No. 2798
- Porangahau Flood Control Scheme Plan No.2797
- Kopuawhara Stream Flood Control Scheme Plan No. 2926
- Te Ngarue Stream Flood Control Scheme Plan No. 2837
- Ruataniwha Plains Flood Hazard Study Plan No. 2731
- Wairoa River Catchment Flood Forecasting System Plan No. 2618
- Lower Tukituki River Upgrade Scheme Plan No. 2531

However these schemes are not comprehensive and parts of Hawke's Bay still suffer flooding from time to time. Another factor to consider is that while flood control schemes are generally very effective, they are not a panacea for all flooding problems and can be overwhelmed in extreme weather conditions.

Hawke's Bay Setting

The Wairoa River (3,780 km^2 catchment area) is the major waterway in northern Hawke's Bay. The country in this area is generally broken and the river flats around the town of Wairoa and the coastal plain east of Wairoa are most at risk from flooding. The rivers from the Waikare (335 km^2) to the Esk (281 km^2) and including the Mohaka (2,440 km^2) drain catchments of steep slopes composed of limestone or marl which are being rapidly eroded. The rivers run in gorges until they near the sea, so there are only small areas of low country subject to flooding.

The southern portion of Hawke's Bay is mostly rolling hill country, bounded on the west by mountains and sloping gently to the eastern seaboard. The central Heretaunga Plains area around Napier and Hastings was once an old sea basin which has been filled with sediment out of the three large rivers that drain the Ruahine, Kaimanawa and Kaweka ranges – the Ngaruroro (with a catchment area of 2005 km^2), Tukituki (2500 km^2) and the Tutaekuri (925 km^2). Northern Hawke's Bay is made up of hills intersected by well-defined gorges and a relatively small coastal plain.

The three main rivers in southern and central Hawke's Bay flow from the mountains over the Heretaunga Plains before entering the sea and it is here that extensive flooding has occurred in the past.

Ngaruroro River looking towards Chesterhope March 1965.

The months from May to July are wettest in Hawke's Bay with a dry season from September to January. November and December are the driest months. However the region experiences cyclonic weather patterns from November to April which can result in heavy and prolonged rainfall. The level of rainfall intensity is sometimes phenomenal and greater than that experienced in the wettest parts of the South Island. Prolonged rainfall often accompanies warm weather front conditions. The semicircle of hill country backing the coastal fringe of Hawke's Bay accelerates the condensation of moisture in both warm and cold air masses as they approach from an easterly, south-easterly or southerly direction.

Sometimes there is brief, heavy rainfall in isolated localities associated with afternoon thunderstorm build-ups, due to strong daytime heating, or from thunderstorms that are part of a frontal weather pattern. These situations typically occur between October and April and can result in high intensity rainfall lasting 20 minutes to an hour and causing local surface flooding, occasional washouts and temporary power failures. Rainfall of 91 mm has been recorded in one hour in Hawke's Bay as a result of this type of event.

Previous Floods in Hawke's Bay

Hawke's Bay has had many big floods although its rivers are not large by national standards, with the exception of the Wairoa River.

There are a number of common factors contributing to most floods in Hawke's Bay:

1. Heavy prolonged easterly or south-easterly rains.
2. The highest variation of rainfall in New Zealand, with long hot dry spells followed by heavy rain, resulting in high runoff.
3. Local soils are comparatively shallow and cannot absorb large amounts of rainfall. They are frequently underlain by impermeable sub strata, often mudstone.
4. Short, steep catchments resulting in rapid runoff. This is aggravated by highly erodible soils.
5. A shortage of lake storage with few ponding areas.
6. Three major rivers on the Heretaunga Plains, the Ngaruroro, Tukituki and the Tutaekuri, discharging into the sea within about 5 km of each other.
7. Many major river headwaters are in areas with much higher rainfall averages than the plains. The annual rainfall for the ranges is 3500 mm a year compared to 800 mm for the Napier/Hastings area.

The earliest record of a severe flood in Hawke's Bay dates back to 1867. In 1957 the Soil Conservation and Rivers Control Council made a detailed study, recording 91 floods of varying severity in the 87 years from 1867 to 1953. Table 4 lists some of these together with some of the more severe events since 1953.

The number of times the region has suffered severe flood damage has reduced over the years due to the establishment and maintenance of extensive drainage and river protection schemes in Hawke's Bay.

Hakowhai in the Dartmoor Valley is an example of a community that experienced problems because of severe flooding from the Tutaekuri River and decided to do something about the situation.

There was renewed awareness of the flood vulnerability of the Dartmoor Valley in the mid-1980s, after a relatively flood-free period in the area.

A flood in July 1985 caused considerable damage and boosted interest in flood protection works. In 1988 the land flooded twice, first in March and then September. Both floods were devastating to the local community, which recognised its risk and put forward an application to build a stopbank and fund the works.

The Hakowhai Community went through many stages of a consultative process in order to achieve flood protection. These are summarised below.

1. The Hakowhai Community recognised its flood problem.
2. The problem was quantified. The flood risk was calculated together with an economic analysis. This showed the benefits of flood protection works.
3. Alternative flood protection solutions were quantified.
4. A solution was chosen to a design standard of a 1 in 100-year flood.

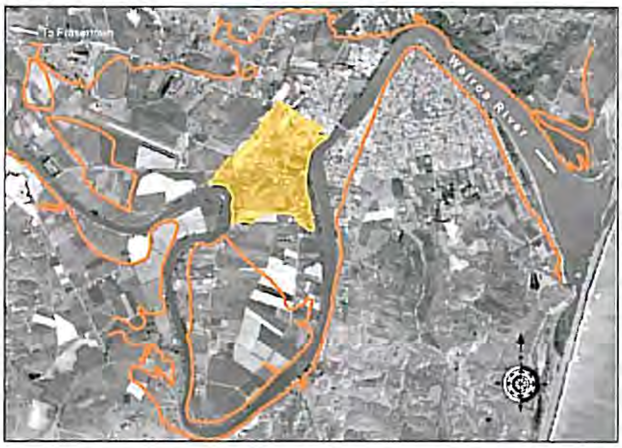
Dartmoor residents - who formed the committee that campaigned for the protection scheme. (Photo courtesy HB Today Duncan Brown)

The community self-funded the scheme primarily through a loan arranged by the then Hawke's Bay Catchment Board, but also received a minor government subsidy to assist with the works. The loan was repaid over 10 years by a special rate and the Hawke's Bay Regional Council maintains the scheme.

The scheme took four summers to complete, but the benefits to the local community have already exceeded expectations, through an increase in land productivity and associated value.

Future Flooding

Rainfall and flood records show that there have been long periods without major floods in Hawke's Bay and other periods where they have been more frequent. Despite the long breaks, the potential for flooding is high and any large flood would have a major effect on the regional community, environment and economic infrastructure.



The above plan shows the flood extent in Wairoa (shaded yellow) which resulted from Cyclone Bola in March 1998, during which the town bridge collapsed. This event had a return period of about 30 years. The outer line (orange) indicates the flood extent for a flood with a return period exceeding a 100 years. The condition of the Wairoa River mouth has a big influence on the flood levels in the Wairoa township.

Some of the areas in Hawke's Bay known to be at risk and capable of impacting on regional lifelines are:

Road

- Areas on the Wairoa coastal plain between Wairoa and Nuhaka.
- Wairoa township and river valley.
- Lake Tutira in the vicinity of Sandy Creek.
- Esk Valley in extreme events.
- Heretaunga Plains in extreme events.
- State Highway 50 in the vicinity of the Waipawa and Tukituki Rivers in an extreme event.
- Takapau in the vicinity of Te Matau Stream.
- Poukawa basin in extreme events

Flooding from Esk River on State Highway 2 March 1987.

Rail

- Areas on the Wairoa coastal plain between Wairoa and Nuhaka.
- Esk Valley in extreme events.
- Heretaunga Plains in extreme events.
- Poukawa Basin in extreme events.

DC 4202 on the loop at Esdale November 1998.
(Photo courtesy John Love)

Super Design Floods

Major flood protection systems have been completed on the Heretaunga and Ruataniwha Plains. These have significantly reduced the risk of small to medium sized floods adversely affecting adjacent land. However a large flood could overwhelm the works and have a devastating effect. Such a flood, which exceeds the design capacity of the flood protection system, or results in the premature failure of river control works, is called a "super design flood".

Ngaruroro River Stopbank with scour damage after Cyclone Bola 1988. (Photo courtesy HBRC)

There is a danger of complacency about flooding in Hawke's Bay because existing flood protection systems give a sense of security and it has been some time since the region had a major flood. Although policy-makers, developers and the public may no longer see flooding as a threat, they need to be aware of the risks, so that Super Design Floods can be managed and the potential effects minimised. At Hakowhai many floods occurred before action was taken.

Ongoing investigation and research will establish flood-prone areas and flood probabilities and this will allow action to be taken before damage occurs.

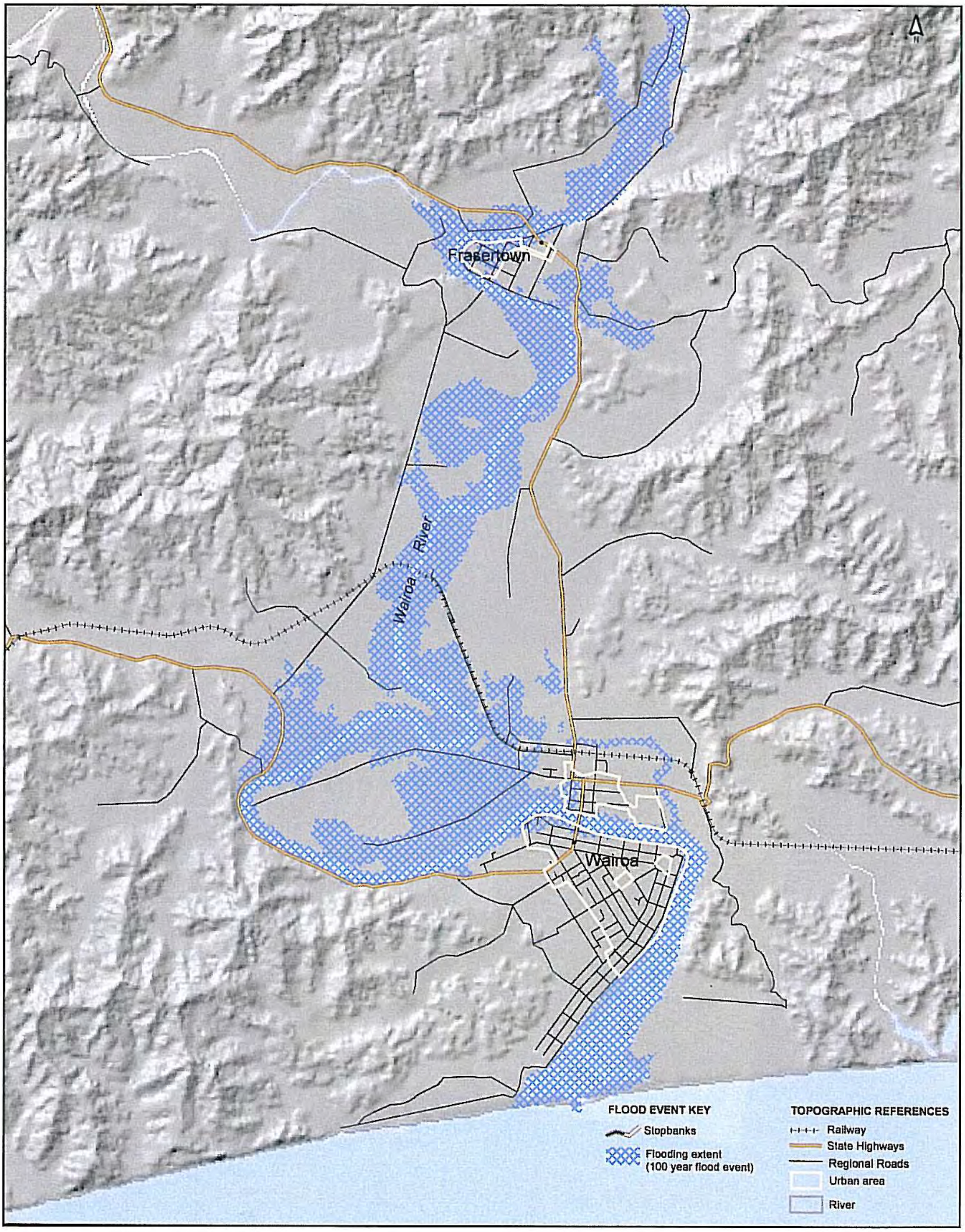
Table 4. Some memorable storms in Hawke's Bay

1867	25 May - 4 June	A large flood in Hawke's Bay, which according to the local Maori, was more sig nificant than anything in the previous forty years. Rainfall in Napier was 380 mm in four days. The Tukituki, Ngaruroro and Tutaekuri all overflowed their banks at several locations, causing extensive flooding.
1893	4 December	Heavy rain flooded the Waipawa River, with the highest levels ever known. The Tutaekuri and Ngaruroro Rivers broke their banks causing widespread damage.
1897	17 April	356 mm of rain fell in Napier over four days. The Ngaruroro River broke its banks between Roy's Hill and Fernhill and menaced Hastings. It also broke its banks south of Roy's Hill and flowed along a very old course. The Tutaekuri River broke its banks and joined with floodwaters from the Ngaruroro River to flood Clive and Napier.
1917	13 June	Flooding estimated to be bigger than that of 1897 and nearly as bad as the 1867 flood, caused widespread damage in Napier. 187 mm fell in 36 hours. At Morere, 522 mm fell in four days, of which 319 mm fell in 24 hours.
1924	11-12 March	Rainfall at Rissington was 510 mm in 10 hours with 230 mm falling in 2.75 hours. At Eskdale, 419 mm was recorded in nine hours.
1936	1 February	A cyclonic storm resulted in extensive flooding throughout Hawke's Bay. In Napier 101mm fell in 24 hours.
1938	23-25 April	Esk Valley Floods. Severe flooding was widespread after three days of heavy rain, with exceptional falls in some areas. In three days, 610 mm fell at Tutira, and a staggering 1,000 mm at Puketitiri (with 390 mm in one day).
1941	4 May	Very heavy rain fell on central and southern Hawke's Bay. At Porangahau 406 mm fell in 24 hours, and the Porangahau River rose 14.3 m above nor mal, causing extensive flooding.
1948	13-14 May	In the Wairoa River catchment 307 mm fell in three days at Onepoto and 260 mm at Tuai in the same period. The Wairoa River rose to a record height and flooded buildings in the Wairoa township.
1953	27-28 January	Exceptionally heavy rainfall over the Wanstead, Elsthorpe and Maraetotara area. In the Mangarouhi Valley 349 mm was registered in 24 hours, with the bulk of the fall occurring over six hours.
1974	15 June	Flooding in Napier from 157 mm of rain in 24 hours.
1980	28 December	Rainfall at Whanawhana was recorded at 157 mm in 48 hours. The Ngaruroro River breached the stopbank at Twyford resulting in serious flooding.
1988	7-10 March	Cyclone Bola, the most significant cyclone event since one in 1975. Cyclone Bola caused considerable damage in the Gisborne and Wairoa districts. The highest total rainfall for the three day period was 635 mm recorded at Pukeorapa.

Map 4

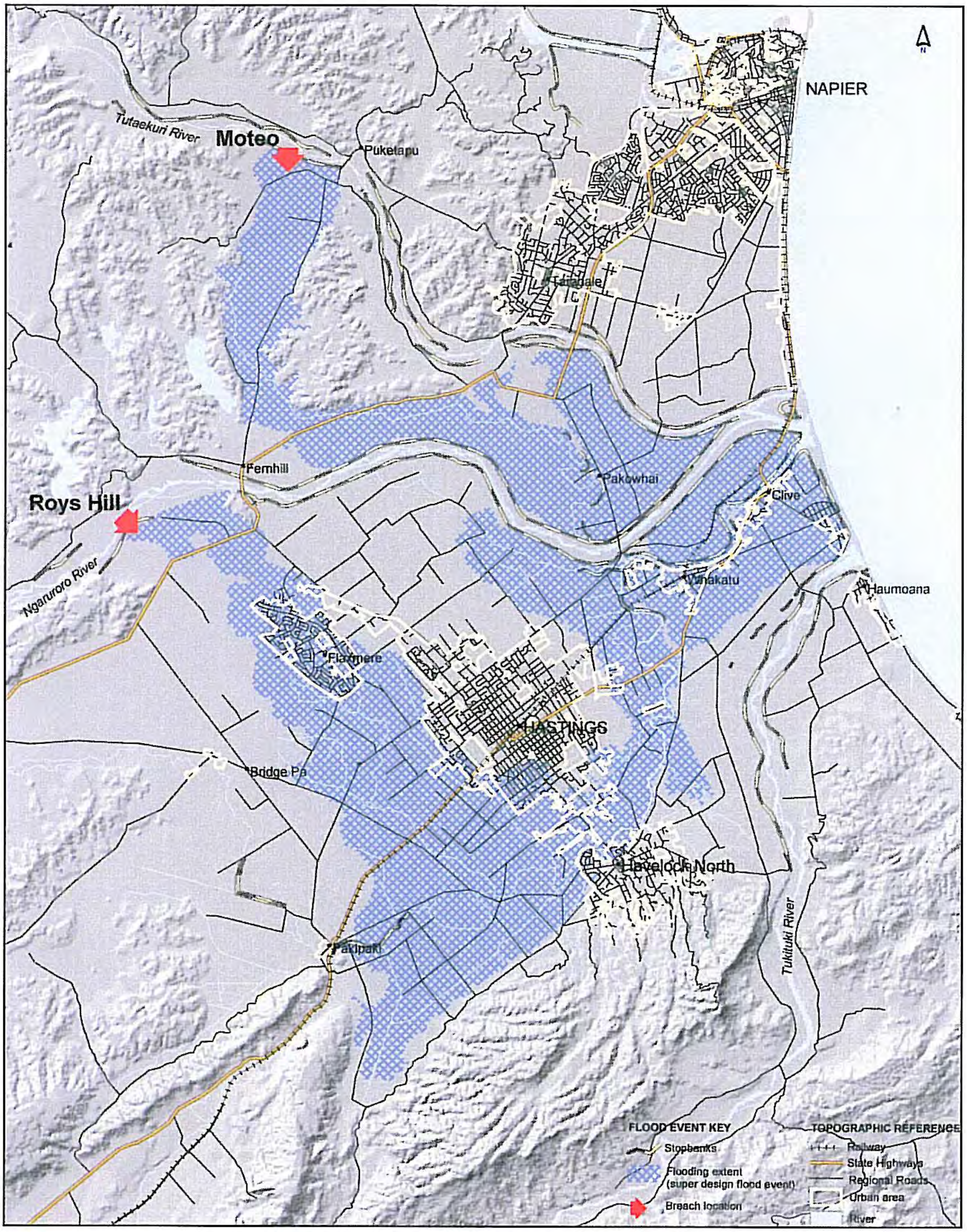
Flood Hazard Scenario's
Wairoa Township

This map shows potential floodable areas resulting from a 1% AEP (100yr) flood.



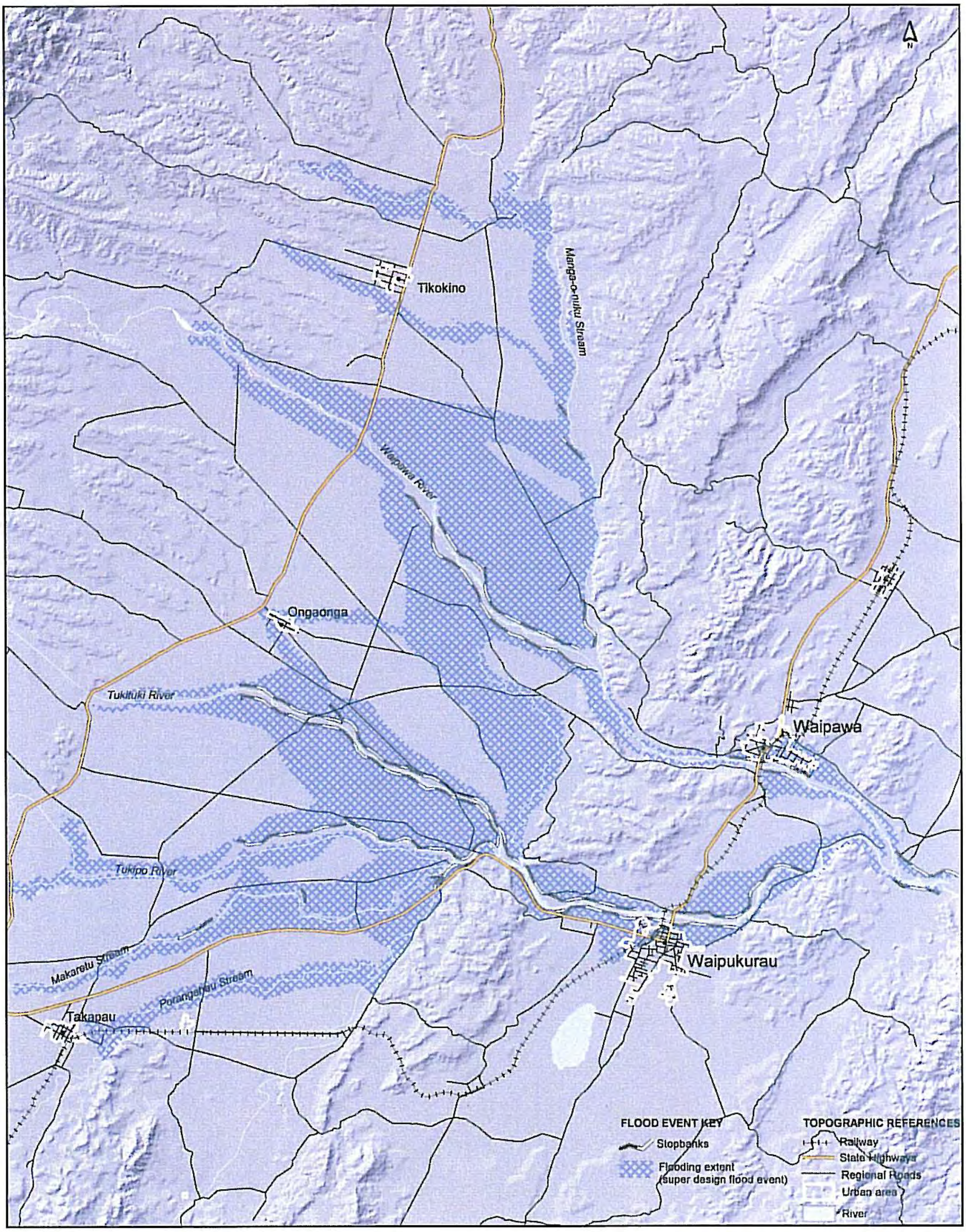
Map 5

This map shows the potential floodable areas following a stopbank breach or overflow at Moteo on the Tutaekuri River and at Roys Hill on the Ngaruroro River. Note; these are two independent events.



Map 6

This map shows the potential floodable areas following a stopbank breach or overflow on the major rivers of the Ruataniwha Plains.



Chapter 4
Aquifers, and their Potential for Contamination

The health and economic welfare of many people in Hawke's Bay, and the economic and social life of the region, depend on supplies of groundwater. This water is taken from groundwater systems, which incorporate linked or related aquifers. Aquifers are deposits of sediments or rock strata, such as gravels or sandstones, from which water can be taken using wells.

Aquifer systems hold water in storage and so function as reservoirs. Water flows through them from areas of recharge to areas of discharge, such as wells, springs, and seeps. They therefore function as pipes or distribution systems. They also act as water treatment systems with overlying materials in recharge areas. Water is modified and organisms die, as they flow through the strata.

The way aquifer systems behave is a product of natural processes. However, man is able to modify the behaviour and value of some systems to an important extent. For example, value can be reduced if the systems are contaminated as a result of particular land uses. Catastrophic events can also significantly reduce the value of systems or disrupt their behaviour. Such events include spills of pollutants, earthquakes, volcanic eruptions, and tsunami. How often these occur or their social impact can be reduced by good management and advance preparations. It is therefore appropriate to consider some Hawke's Bay aquifers, their value and vulnerability, threats to them, risk assessment, and management of their protection.

Importance of some Aquifer Systems

Aquifer systems of importance in Hawke's Bay include :

- Those beneath and adjacent to the Heretaunga Plains, being components of the Heretaunga Plains Groundwater System. (Dravid & Brown 1997);
- Those beneath and adjacent to the Ruataniwha and Takapau Plains, being components of the Ruataniwha Plains Groundwater System (Dravid, Cameron, and Brown 1997);
- Those in the Wairoa Valley and near the coast to the north, being components of the Northern Coastal Groundwater System (Cameron 1999);
- The Poukawa Basin system;
- The Esk system;
- The Papanui Stream Valley system.

The Heretaunga Plains System is of principal importance. The Ruataniwha Plains System is widely regarded as the next most important system.

The Heretaunga Plains Groundwater System.

Dravid and Brown (1997) summarised the importance of the Heretaunga Plains Groundwater System.

The principal population concentration in Hawke's Bay is around the Heretaunga Plains. Most of the water requirements in and adjacent to the Heretaunga Plains are met by water taken from the Heretaunga Plains Groundwater System. Groundwater provided about 85% of the water needs of the local population of 143,000 in the mid 1990s. About 63 million cubic metres of water were extracted per year. About 41% of the water was used for public and rural domestic water supplies. About 41% was used for irrigation and frost protection. About 18% was used for industrial processing.

About 50% of the total New Zealand harvest of fruit, vegetables, and grapes, combined, were produced on the Heretaunga Plains in the mid 1990s, and this level of production was dependent on irrigation using groundwater.

Over all, dependence on groundwater has increased since the mid 1990s.

The Heretaunga Plains Groundwater System is clearly of major importance to the Hawke's Bay region, and is of importance nationally (Dravid & Brown 1997).

The Ruataniwha Plains Groundwater System

Water taken from the Ruataniwha Plains Groundwater System provides about 70% of the water used for irrigation, industry, and public and rural domestic water supply in the area (Dravid, Cameron, & Brown 1997). The maximum weekly extraction of water allowed from the system exceeds 600,000 m^3. Over 2200 ha in the area are irrigated. The rate of extraction has increased 5 to 10 fold during the last 15 years, as a result of more intensive agriculture. Rates of extraction, and reliance on groundwater are expected to increase further.

Features of the Principal Aquifer Systems Risk

Heretaunga Plains System

The most important component of the Heretaunga Plains Groundwater System is the Ngaruroro – Tutaekuri Aquifer System, which underlies most of the 300 km^2 of the Plain. Other aquifer systems included by Dravid and Brown (who have described the Heretaunga Plains System in detail), are:

- The Tukituki system, at shallow depth in the southeast corner of the plain;
- The shallow Moteo Valley system, occupying a former course of the Tutaekuri River;
- The shallow Esk (Bay View – Whirinaki) system;
- The peripheral limestone system beneath the margins of the plain and in the adjacent hills.

The extent of these aquifer systems is shown in Figure 1. (Fig. 5.1 of Dravid & Brown).

Subsequent descriptions will refer to the main system, unless otherwise stated.

The aquifers of the system have a complex spatial distribution. They are dominated by gravels laid down by rivers and shoreline processes in a developing depression. They also include sand and silt. They occur within muds, clays, silts, and poorly sorted sediments which restrict water flow. These sediments are the aquicludes and aquitards of the groundwater system. Volcanic ash, pumice, and peat deposits also occur beneath the Plain.

A general transition in the character of the aquifer system occurs from west to east - from a complex stack of aquifers within river-laid sediments, to a more distinctly layered stack of aquifers inter-leaved with aquitards containing estuarine and marine sediments. Figure 2 (5.3 of Dravid & Brown) illustrates this schematically.

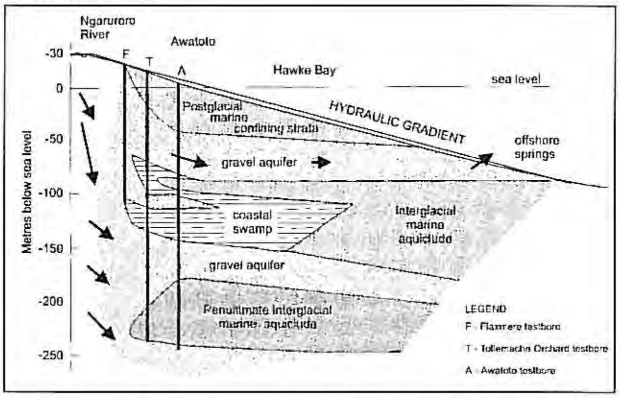


Figure 2: Generalised cross section through Flaxmere, Tollemache Orchard and Awatoto testbores.

The total thickness of the aquifers and their associated aquitards and aquicludes exceeds 250m beneath parts of the Plain. The sediments have accumulated during the last 250,000 years, and many are poorly consolidated.

Water flows in the system are generally from west to east. South-eastward flows predominate to the east of Flaxmere and north-eastward flows predominate in the Taradale – Napier area. Figures 3 and 4 (5.5 and 5.6 of Dravid and Brown) illustrate some winter and summer water pressures measured on the Heretaunga Plain. Water flows from high pressure to low pressure areas. The figures show some of the evidence of water flows through the system from the bed of the Ngaruroro River upstream of Fernhill.

The amount of water entering the system from different sources has been estimated to be:

- 83% (160 million m^3/year) from the leaking bed of the Ngaruroro;
- 13% (25 million m^3/year) from the leaking bed of the Tutaekuri;
- 3% from rainfall on the Plain.

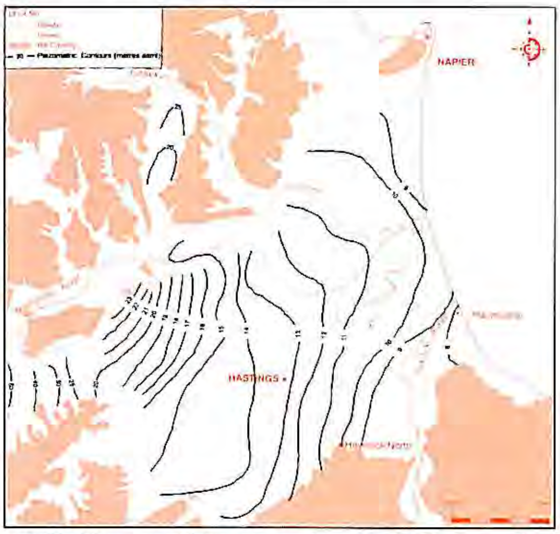


Figure 3: The Heretaunga Plains average winter (1974-77) piezometric map.

Figure 4: The Heretaunga Plains summer 1995 piezometric map.

Excess irrigation is a minor source of recharge.

Discharge from the system occurs through wells (66 million m^3/year), springs and seeps on the lower plains, submarine springs, evaporation and transpiration.

The vertical component of water flow in the system is predominantly downward in the west, and upward in the east. Deep wells in the east are artesian (free-flowing) or sub-artesian, showing they tap into confined aquifers. The western boundary of the area within which sub-artesian wells occur is shown on Figure 1.

Average horizontal water flow speeds tend to reduce with depth in the system, and from west to east. Water flow speeds of 150 m/day occur near where the Ngaruroro River is recharging the system, while speeds of 10 m/day occur in the centre of the area of confined aquifers. Water at shallow depth near the coast at Clive has been estimated to take 7 years to reach there from Fernhill.

The volume of water stored in the main system is about 990 million m^3 in the unconfined aquifers and 60 million m^3 in the confined aquifers. About 15% of this water is replaced each year by water from the Ngaruroro River.

Overall the quality of water in the system is good and very good at depths of less than 80 m. At depths exceeding 100 m the water has more iron and manganese and is harder. Water near the south-eastern and south-western edges of the Plain, and near the hills just to the west of Napier, is also harder and richer in minerals. There is some localised contamination of water, associated with dumps, septic tanks, inappropriate pesticide and fertiliser use, and other causes.

Vulnerability to damage

The groundwater system is vulnerable to damage from pollution, earthquakes, volcanic eruptions, tsunamis and major storms.

Factors affecting vulnerability to pollution include:

- Types of land-use and their distribution;
- Land-use practices and the potential pollutants involved;
- The likelihood of pollution on the surface reaching underlying groundwater;
- The way in which pollution at different locations spreads within the system.

There could be regionally significant contamination of the system from:

- Poor agricultural or industrial practices over a long period;
- Widespread and nearly simultaneous pollutant spills, like those which may occur during and immediately after an earthquake;
- A major spill of a highly toxic and persistent pollutant at a key location.

The system's vulnerability to pollution has been studied for many years (Thorpe, 1977; Thorpe et al. 1982; Dravid & Brown, 1997; Brown, 1998) and research is continuing (e.g. East Coast Environmental & Associates, 2000).

The system is most vulnerable to a major toxic spill over thick stony soils :

- Where the aquifers are unconfined;
- Near to or just downstream of the principal recharge points, or a little upstream of major extractions.

Little can be done by man to control other types of damage to aquifers.

Earthquakes, volcanic eruptions, widespread storms and associated landslides have the ability to significantly reduce recharge of the system from the Ngaruroro and Tutaekuri riverbeds. These events could result in the rapid migration of river channels or the clogging of riverbeds. However the regional impact of reduced recharge would not be catastrophic, given the large amount of stored water.

Ground movements and shaking associated with an earthquake could change levels, ground settlement and water flow patterns in the system. However much of the stored water would remain available and accessible.

Ruataniwha Plains Groundwater System

Aspects of this system have been described by McGuinness (1984), Ludecke (1988), Dravid et al. (1997), and Pattle Delamore Partners (1999) (PDP).

The system underlies a 26,000 ha area in the tectonically active basin lying between the Ruahine Range in the west and the Raukawa Range in the east. The basin is drained by the Waipawa and Tukituki Rivers, and their tributaries.

The basin is filled with gravels sands, silts, and clays, primarily from the mountains to the west. There are also volcanic ash deposits. These deposits are more 150 metres deep in places with the density tending to increase from west to east.

These deposits have been classified into 3 groups : Recent Terrace; Old Terrace, and Ancient Terrace. These deposits will be the focus of subsequent discussion.

The deposits are underlain by older and generally more consolidated mudstones, siltstones, sandstones, conglomerates, and limestones (Ashley and Pebbly Hill Formations).

The system's aquifers are predominantly gravels and sands. They have a complex distribution, and are separated by aquitards and aquicludes (confining beds) made up of fine or poorly sorted sediments such as clays, silts and claybound gravels. The aquifers tend to slope down and deepen to the east. The confining beds become more extensive eastwards.

The horizontal component of water flow in the system tends to parallel the direction of surface flow, which is towards the points of principal discharge of surface water from the basin - the channels of the Waipawa and Tukituki Rivers through the Raukawa Range. (Figure 5) (Figure 6.2 of PDP).

The vertical component of water flow is generally downward beneath the west and central part of the basin, but at depth in the east it is up towards the surface. Artesian and sub-artesian wells, springs, and seeps occur on the lower plains. Figure 6 (6.16 of PDP) schematically illustrates water flow through a west-east vertical section of the system.

Water enters the system from leakage of the Plain's rivers (particularly the Tukituki, Waipawa, Makaroro and Makaretu, estimated at 150 million m^3/year), from downward percolating rainfall on the Plains and their catchment (180 million m^3/year), and from underlying rocks.

Discharge from the system is through spring and seepage flow into the rivers on the lower part of the Plains (estimated at 290 million m^3/year), through wells (30 million m^3/year) and by subflow through the Raukawa Range (6 million m^3/year).

The storage capacity of the system has yet to be estimated.

Water quality in the system is generally good. Near the riverbed recharge zones the water is similar to that in the rivers. Water at shallow depth in the southern (Takapau Plains) area has relatively high nitrogen levels. Water from the deep wells in the southern area, and from some of the other deep wells, has relatively high amounts of calcium, sodium, and bicarbonate.

Vulnerability to damage.

The factors determining vulnerability to damage of the system are similar to those for the Heretaunga Plains system.

No DRASTIC index has been prepared for the Ruataniwha Plains.

Recharge of the Ruataniwha Plains system is more diffuse than that of the Heretaunga Plains System, and discharge is more concentrated. The significance of these differences is not yet understood.

The system is particularly vulnerable to major pollutant spills on stony soils over the parts of the system being recharged by nearby river leakage.

The system is expected to be relatively unaffected by disturbances caused by anything other than pollution.

Risks and their Management

The Hawke's Bay Regional Council (HBRC) has extensively studied the groundwater systems in Hawke's Bay. These studies have led to the development of management strategies to lessen the potential for aquifer pollution in Hawke's Bay. For example, Dravid & Brown (1997) made recommendations concerning:

- Water level, quality, use and land-use monitoring;
- The maintenance and organisation of relevant databases;
- The need for research relevant to water demand, availability, and allocation, and identifying aquifer vulnerability;
- Establishing a groundwater management area, and the rules which should apply in the area;
- Working with the Hastings District Council to ensure appropriate land uses;
- Measures to prevent pollution travelling from wellheads into aquifers.

Potentially high-risk sources of contamination of the groundwater systems beneath the Heretaunga and Ruataniwha Plains have been identified to include:

- Domestic wastewater discharges;
- Industrial and process discharges into or onto land;
- Stormwater discharges;
- Leachate discharges especially from closed landfill(s);
- Septic tank and industrial effluent discharges;

- Storage, use and spillage of hazardous substances, including pesticides;
- Changes in land use from pasture to viticulture;
- Over-use and leaching of fertilisers;
- Backflows into wells;
- The puncturing of seals between aquifers as the result of poor well construction and maintenance.

To assist with managing the threat posed by pollution of the groundwater systems the Council is, or will be :

- Ensuring the groundwater-monitoring network can adequately track changes in the levels and quality of groundwater throughout the aquifer systems;
- Expanding the function of the groundwater quality-monitoring network to include routine monitoring of pesticide concentrations;
- Improving the quality of estimates of the sustainable yields of aquifers;
- Proposing, in the forthcoming Regional Plan, that new consents to take water include a requirement for metering water;
- Proposing, in the forthcoming Regional Plan, a requirement that water-use meters be installed over the next 10 years on existing larger abstractions;
- Seeking to establish water level trigger/warning levels and criteria for well separation distances, minimum depths for new bores and distances of bores from coasts or rivers, for inclusion in new resource consents;
- Working with existing landowners to minimise the risk their activities pose to the aquifers;
- Working with grower and industry groups to minimise the potential risk to the quality of groundwater, from changes in landuse.

Major tasks, yet to be undertaken, are the development of strategic plans explicitly for:

- Minimising the risk of a major spill which will threaten one of the groundwater systems;
- Minimising the impacts of such a spill, should one occur.

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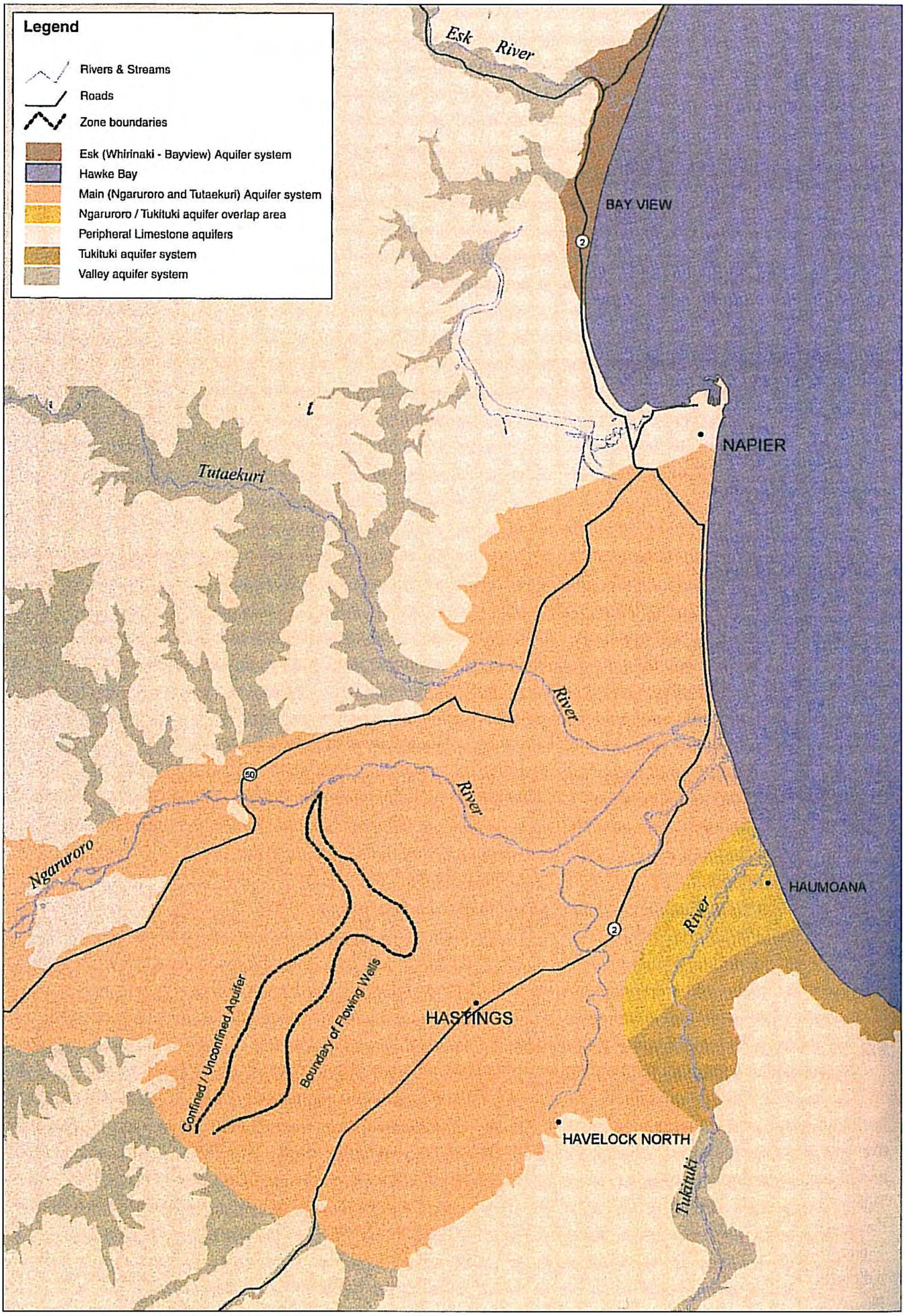


Figure 1: Aerial extent of individual aquifer systems, unconfined - confined aquifer boundary and the inland boundary of flowing artesian wells.

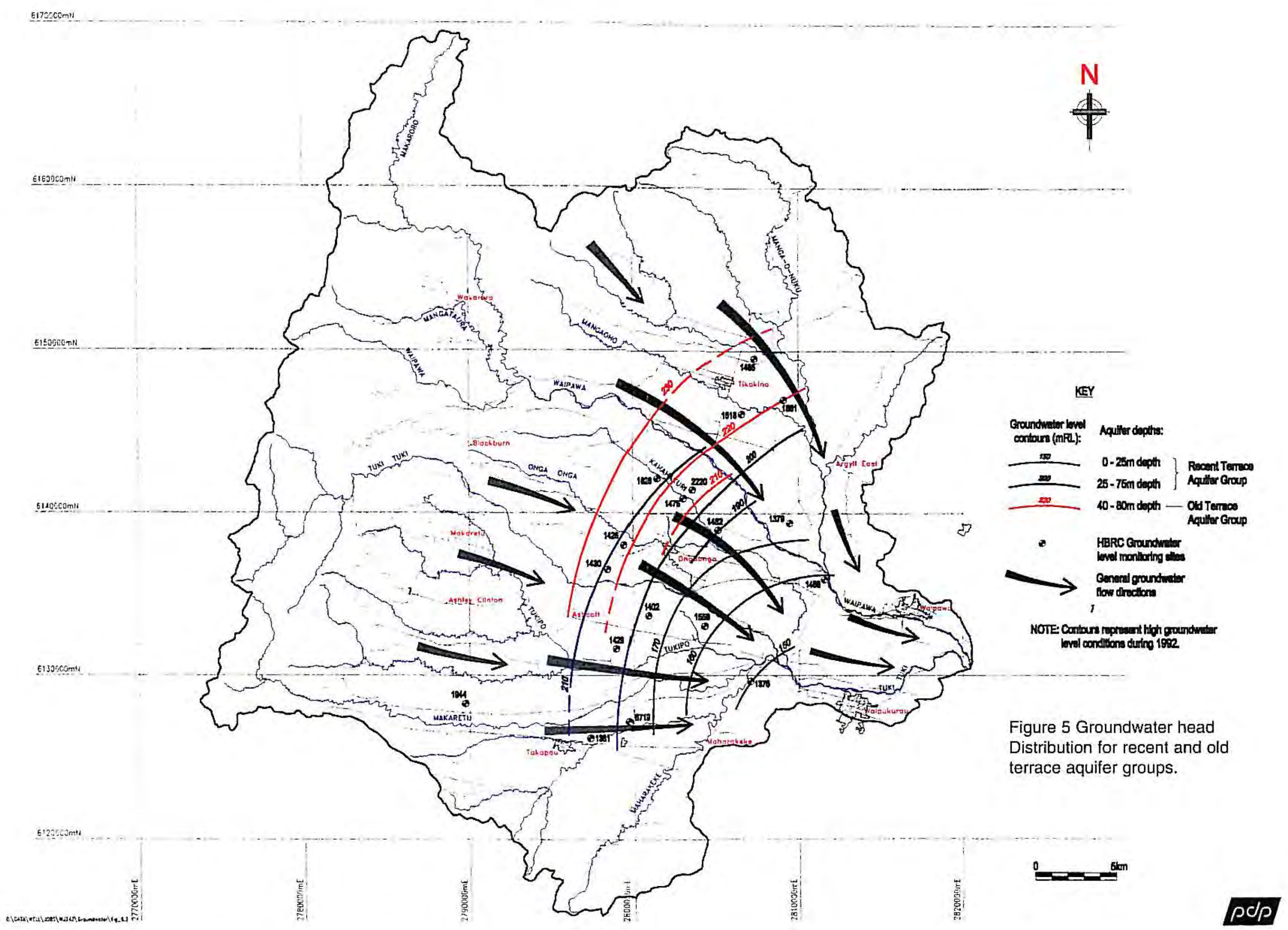


Figure 5 Groundwater head Distribution for recent and old terrace aquifer groups.

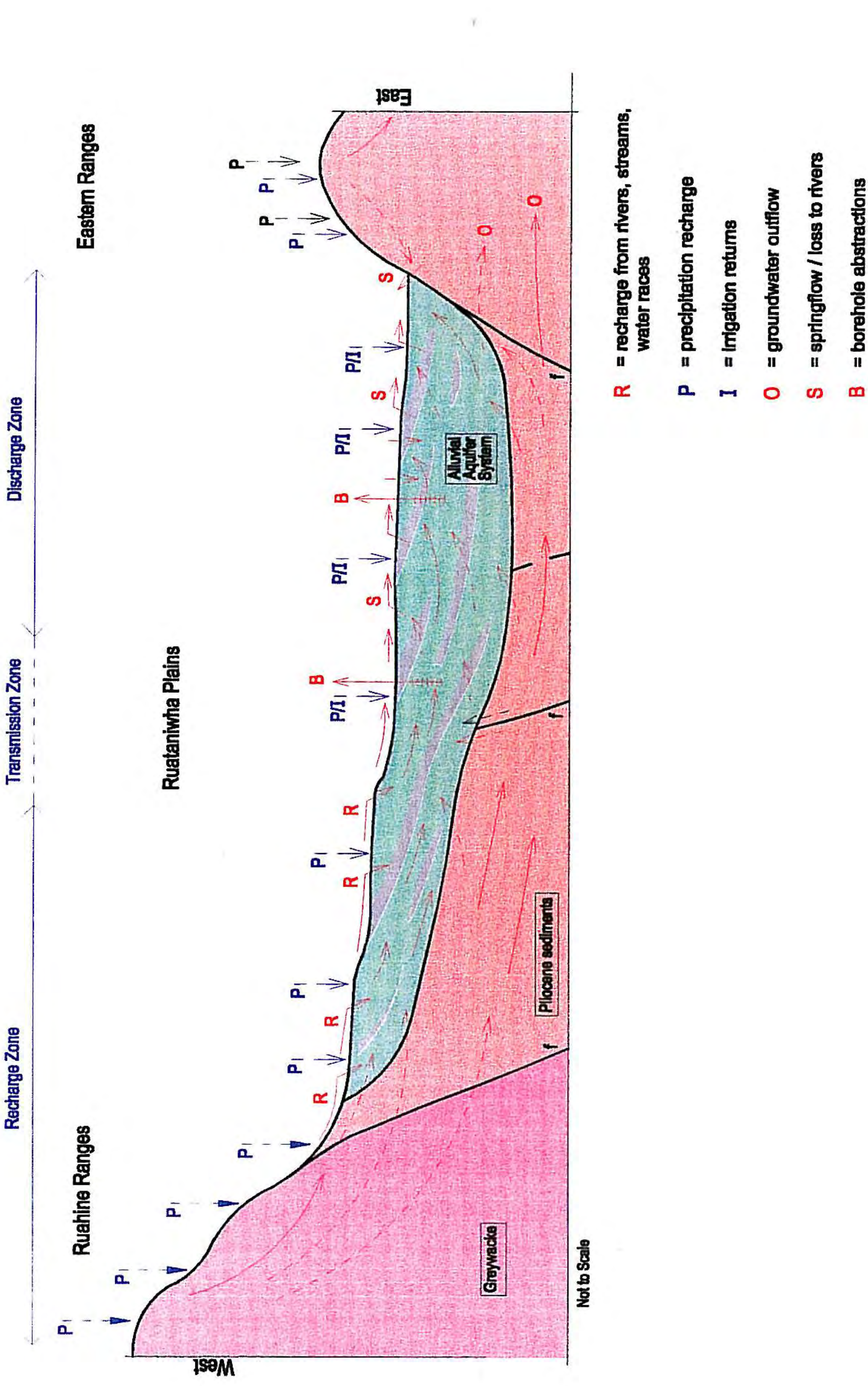


Figure 6 Conceptual Hydrogeological Model: Ruataniwha Plans

Chapter 5

Meteorological Hazard

Introduction

Meteorological hazard information for the Hawke's Bay Engineering Lifelines Project has been summarised in a report prepared by the National Institute of Water and Atmospheric Research (NIWA).

This report examines the following hazards:

- Windstorms
- Extreme rainfall
- Snow
- Drought

The report presents information in two forms:

- A summary of extreme events from recorded climate data;
- An estimate of extreme events for 142 and 475-year return periods based on existing data.

The estimates use the same probabilities as those chosen for extreme earthquake events i.e. 35 and 10 percent probability of occurrence over a 50-year period (142 and 475-year return period events).

While the best possible estimates have been made using the information available, there are a limited number of recording sites with relatively short histories. Very few extreme meteorological events of the scale investigated for this study have been recorded.

Windstorms

The strongest winds in Hawke's Bay typically blow from the west and are associated with the passage of active weather fronts. These high westerly winds commonly occur in the western ranges, along the foot of the lower mountains and in the exposed east-coast hills such as Cape Kidnappers and the Mahia Peninsula. They are relatively infrequent in many lowland areas.

Strong winds from the south and east are usually associated with deep depressions centred east or north of the region. An example of the high winds which can affect the region occurred during the Wahine Storm from 8 -12 April 1968. Gale force mean wind speeds of 63km/hr were recorded at Hawke's Bay Airport and were high enough to cause considerable damage to trees in and around Napier and Hastings. Considerably higher wind speeds were recorded south of the region in Wairarapa and Wellington. Violent storm force winds from the south, with a mean speed of 102km/hr, were reported at the Port of Napier during Cyclone Bola on 8 March 1988.

The NIWA report includes highest wind speed data collected from the few recording stations in the region and to the south. Records have been kept at these sites for up to fifty years and indicate the strongest winds have been from the west.

Tree fall damage from high winds September 2000.

The recorded data shows that wind gusts cause inconvenience on an average of at least 50 days each year in coastal localities. This inconvenience includes dust storms, difficulty for cars towing caravans and crosswinds affecting small aircraft landings at Hawke's Bay Airport. There are far fewer cases of storm force wind gusts (93km/hr, 25m/sec, or more), which occur on average between 1 and 5 days each year. Gusts of this type are strong enough to uproot trees and cause damage to buildings.

Severe Windstorms

Table 1 shows the maximum observed gust speeds and the modelled 3-second gust speeds that are likely to be equalled or exceeded at average intervals of 142 years and 475 years. The modelled speeds are higher than the observed speeds, indicating that neither 142 nor 475-year gusts have been experienced in the region since records began.

The Design Loadings Code NZS 4203:1992 relates design loads to extreme maximum wind gusts. These are defined as gusts which last three seconds or more.

Location	Maximum Observed Gust (km/h)	142 Modelled Speed (km/h)	475 Modelled Speed (km/h)
Mahia Peninsula	146	163	177
Hawke's Bay Airport	130	140	153
Castlepoint	183	198	216

Table 1 Observed maximum wind gust speed (km/hr) for sites compared with modelled 146 and 475-year return period gust speeds.

The modelled 475-year return period speed for Hawke's Bay Airport, of 153km/h, matches the 3 second wind gust used in the design loadings code NZS 4203: 1992 (43 m/second). The increased exposure to westerly winds at some sites justifies their higher base wind speed loadings.

Hawke's Bay Airport July 2001 (Photo courtesy Hawke's Bay Regional Council)

Topographical Effects

Design gust speeds for exposed locations, like mountain ridges, summits and hilltops, will be much higher than the modelled values given for low-lying and more sheltered areas such as Hawke's Bay Airport.

The example data shown in Table 2 suggests that gust speeds over the ranges to the west of Hawke's Bay may be higher than at Hawke's Bay Airport by a factor of 1.5. This would indicate 142-year gust speeds of 210km/h and 475-year speeds of 230km/h.

Therefore, in extreme cases, factors as high as 1.5 should be used.

In practice, the relationship between flat land and hill top gust speeds is highly variable, and measurements at specific sites would be essential to establish more accurate information.

Upwind Slop Gradient	Escarpments	Hills and Ridges
0.08	1.04	1.09
0.10	1.08	1.18
0.20	1.18	1.36
0.03 and greater	1.24	1.54

Table 2 Factors to be applied to flat land gust speeds to obtain gust speeds on hilltops. (taken from NZS 4203:1992).

NZS 4203 provides further explanation of the derivation of factors for specific sites. It should be noted that the code wind loadings vary in proportion to the square of the 3-second gust speed.

To give an example of the effect topography can have, NIWA has estimated the 3-second gust speeds for periods of 475 years and 142 years at 5 representative sites. They are Titiokura, Napier Airport, Crownthorpe, Elsthorpe and Paemutu.

The results are produced in Table 3.

	Titiokura	Hawke's Bay Airport	Crownthorpe	Elsthorpe	Paemutu
475-year 10m gust (m/s)	69	42	46	62	82
142-year 10m gust (m/s)	64	39	43	57	76

Table 3 Estimated 3 second gust speeds

The location of these sites is shown on Figure 1 below, which indicates the topography by contour lines at 300m intervals.

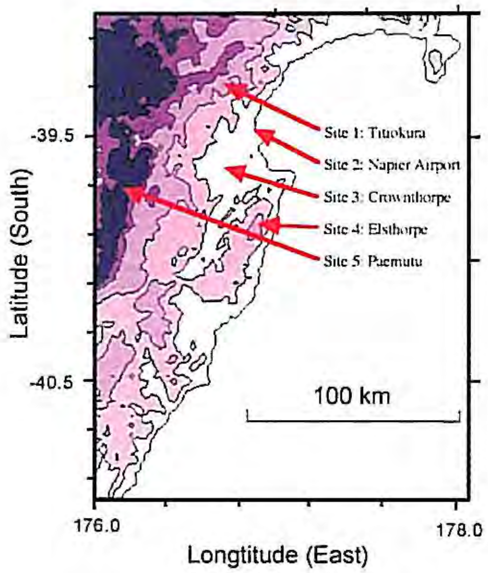


Figure 1: Location map showing positions of points used for determining site winds. The heaviest shading denotes land over 900m. Contour lines are at 300 metre intervals.

Extreme Rainfall

Severe floods have been recorded in Hawke's Bay since 1867. A study in 1957 noted 91 floods of varying severity from 1867 to 1953. There were 15 major floods in the 20th century with 85 percent of these occurring in the first six months of the year.

View back to Napier over Ahuriri estuary after heavy rain August 1990. (Photo courtesy Hawke's Bay Regional Council)

The NIWA report gives data on rainfall at various locations during four of the most destructive floods in the region during the 20th century.

On all four occasions at least 200mm of rainfall was recorded in most affected localities, and this amount sometimes fell in less than 24 hours. In most cases rivers overflowed and floodwaters entered urban areas, or covered large tracts of rural land. These floods caused landslips, damage to bridges, road or rail links and stock losses.

The events noted are:

Flood 1	10 – 13 June 1917
Flood 2	10 – 12 March 1924
Flood 3	23 – 26 April 1938
Flood 4	6 – 9 March 1988 'Cyclone Bola'

Risk Estimates For Extreme Rainfall Events

NIWA analysed storm rainfall over a period of more than 30 years to estimate the likely storm rainfall at certain return periods in different parts of Hawke's Bay.

Return periods of 142 years and 475 years were chosen, the same as those used in the earthquake risk assessments.

Contour maps showing estimated 24-hour rainfall for 142 and 475-year return periods are given on figures 2.5 and 2.6 below.

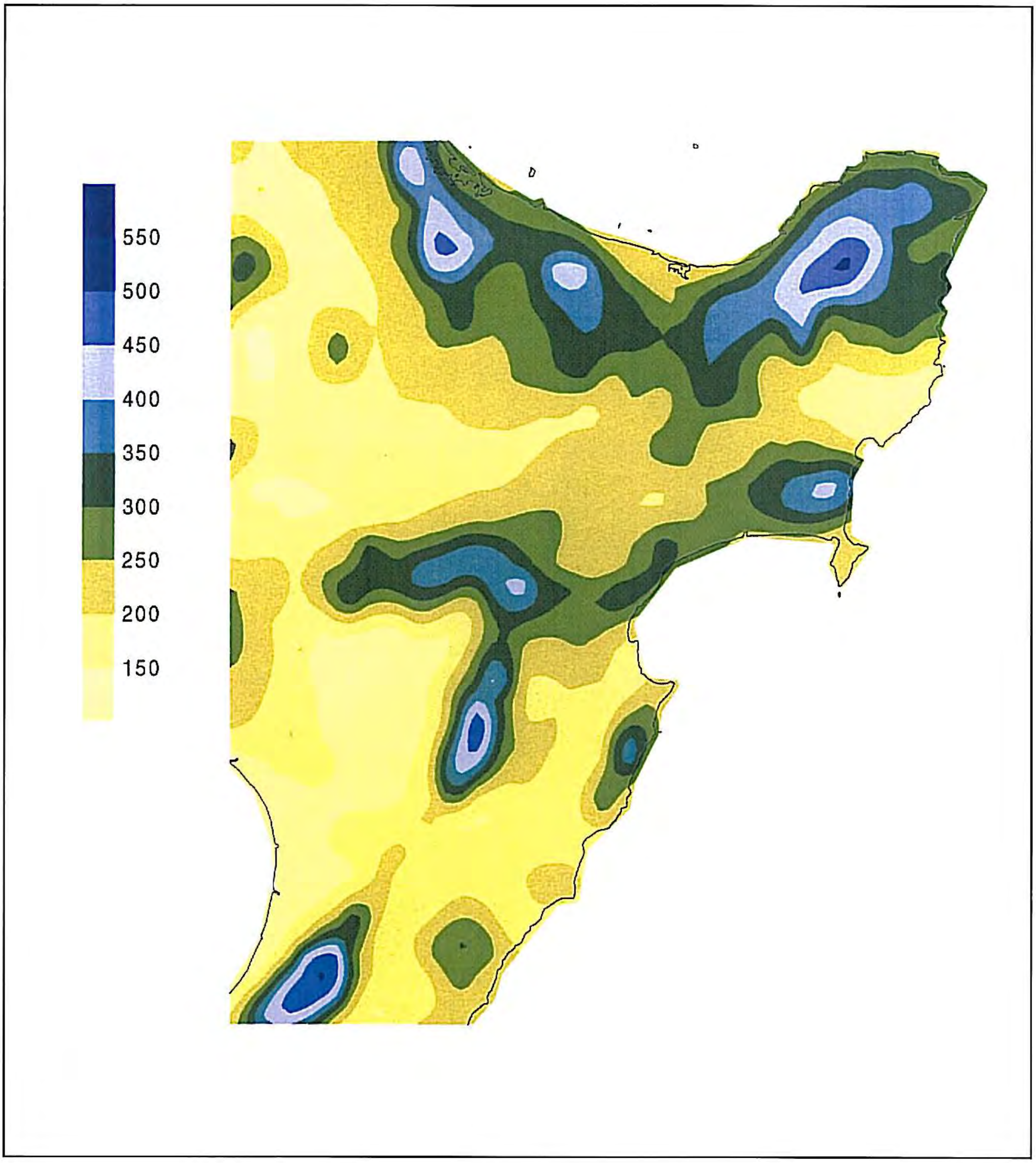


Figure 2.5: Spatial distribution of high intensity 24-hour rainfall (mm), that is expected to be equalled or exceeded at average internals of 142 years. (Based on Tomlinson, 1980)

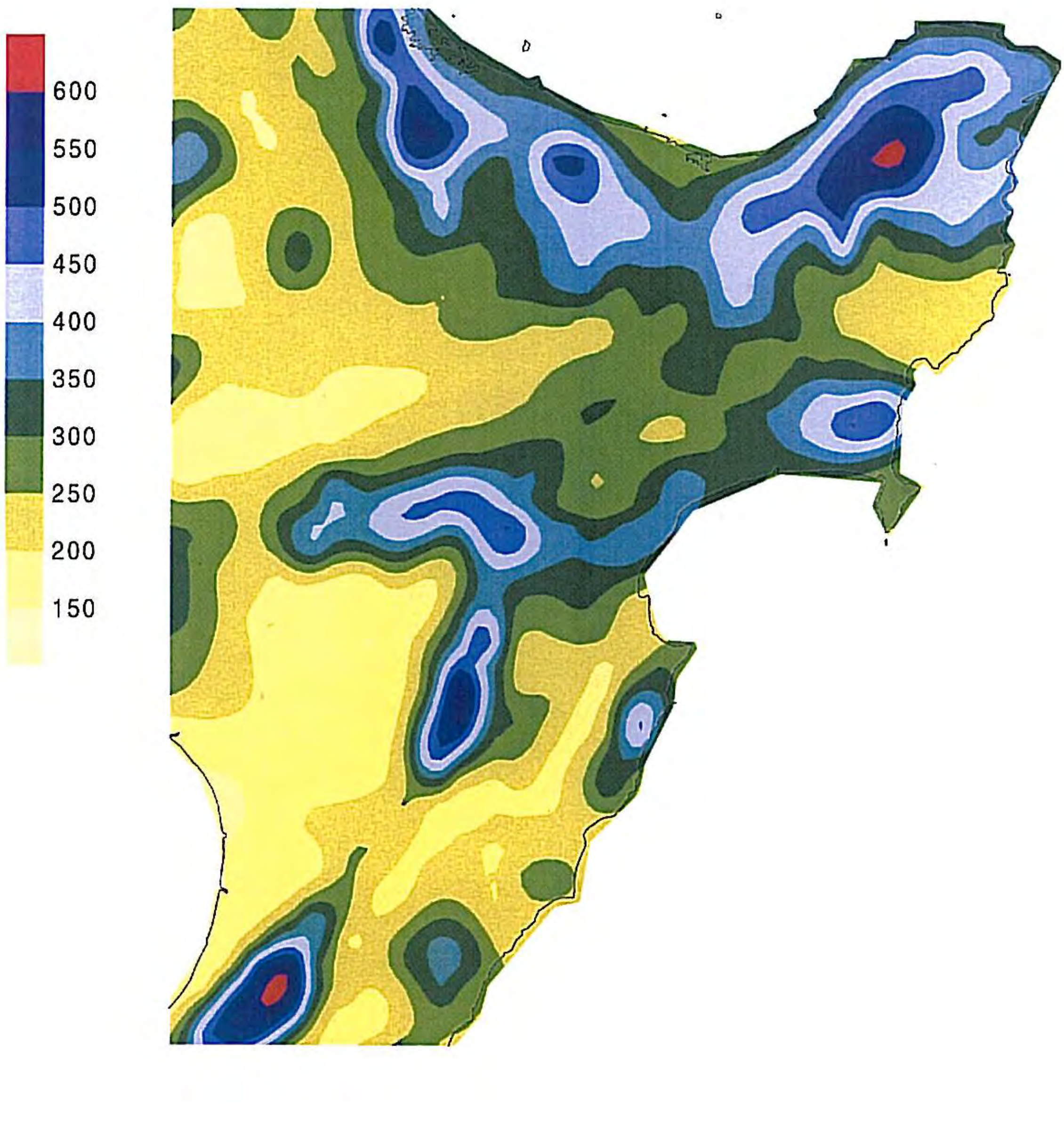


Figure 2.6: Spatial distribution of high intensity 24-hour rainfall (mm), that is expected to be equalled or exceeded at average internals of 475 years. (Based on Tomlinson, 1980)

Storm Duration Ratios

Rainfall for other storm durations can be estimated by relating the relevant depth-duration coefficients, given in Table 3, to the 100-year data used in contouring the above figures. The ratios in Table 3 were compiled from data covering New Zealand (Tomlinson, 1980) and are generally applicable to Hawke's Bay. The base intensity is the 24-hour fall (with a ratio of 1.00 on the table). For example, a 142-year, 12-hour, high intensity storm near Napier could expect to have 77 percent of the 24-hour fall.

Duration (h)	6	12	24	48	72
Ratio (142yr)	0.55	0.77	1.00	1.24	1.38

Table 4 Depth-duration ratios based on the 24-hour storm rainfall, for durations of 6 hours to 72 hours (after Tomlinson, 1980)

Extreme Flooding Events

Extreme rainfall does not necessarily lead to equivalent extreme flooding, possibly because the highest intensities are falling in only one tributary of a river system, differences in the timing of peak rainfall, the ground being dry or other factors.

Because of this the Hawke's Bay Engineering Lifelines Project provides information on extreme rainfall intensities for individual sites over the region. The information used in the Project on extreme flooding is produced by Hawke's Bay Regional Council.

Much of the intensely cultivated and populated areas of the Heretaunga and Ruataniwha Plains are protected by stopbanks. In general, these stopbanks are designed to cope with a 100-year return period flood, with some freeboard.

The freeboard may provide enough capacity to sustain a less frequent but more extreme event. However floods with a return period of 475 years are likely to exceed the stopbank capacity and lead to overtopping and breaching. Just where this breaching would occur is not known.

Ngaruroro River stopbank Cyclone Bola 1988

As a separate exercise the Hawke's Bay Regional Council has studied some "scenario" stopbank breaches during extreme floods, to give an idea of the potential hazard from such events.

Snow

Snowfall is relatively uncommon in the plains area of Hawke's Bay and there are few detailed or systematic records available. Nor are there many records on snowfall in hill country.

Snow and ice conditions at TeWaka Repeater Station taken from a perspective between 2 rock outcrops. At the time of this photo there were 2 towers on the site, the smaller one in the foreground has since been dismantled and removed. (Photo courtesy Ian Greaves Telecom)

Frequency of Snowfalls

NIWA has estimated the number of days when snowfall can be expected, based on height above sea level. Although this simple, straight-line relationship is open to local variations, it provides a guide for locations where there are no records of observations.

The results are presented in Figure 3.1 below

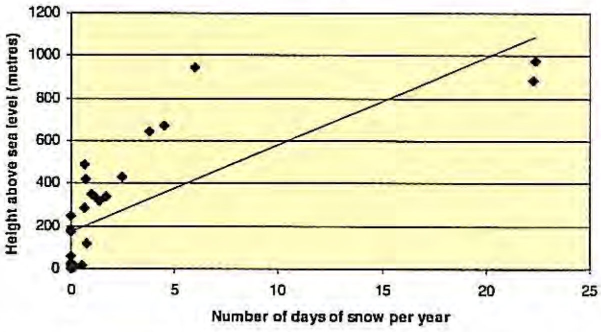


Figure 3.1 Frequency of snowfall in the Hawke's Bay region.

Extreme Snow Depths

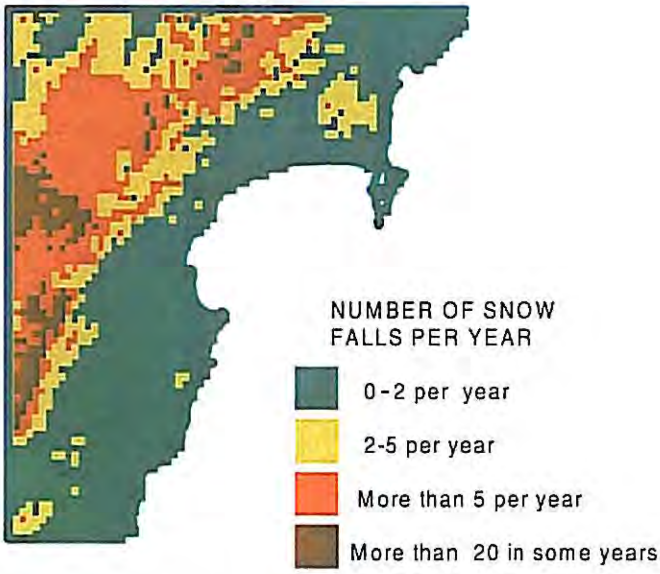


Figure 3.2 Typical annual frequency of snowfalls in the Hawke's Bay region, based on the relationship between snowfall reports and height above mean sea level.

Data on snow depth was available from only one site – Onepoto at Lake Waikaremoana, which is 643 metres above sea level.

The maximum snow depths for extended return periods have been extrapolated for this site and published in the NIWA report. However no comment is made about transferring these estimates to other sites.

Drought

Droughts are hard to quantify and define. They are typically associated with periods when rainfall is much lower than the "normal" amount determined from long term climate records.

The timing, duration and degree of impact that drought has on one area compared to another are all highly variable.

A three-month period of low rainfall will typically have adverse effects on pasture production and water resources. A three-month dry spell will also significantly increase the risk of high dust loads and soil loss from vulnerable areas such as cultivated fields and the risk of forest fires.

The NIWA study has recorded in detail the droughts of 1914-15, 1945-46, 1982-83 and 1997-98.

High winds erode soils on Heretaunga Plains October 1998 (Photo courtesy HBRC)

Probability of Drought

The study has assessed the probability of drought occurrence in Hawke's Bay.

The average recurrence interval (ARI) is expressed in terms of a percentage of normal rain.

Figure 4.4 below suggests that a summer with 30% of average rainfall would be about a 1-in-20 year event while 20% of average rainfall would be recorded only about once in 40-50 years.

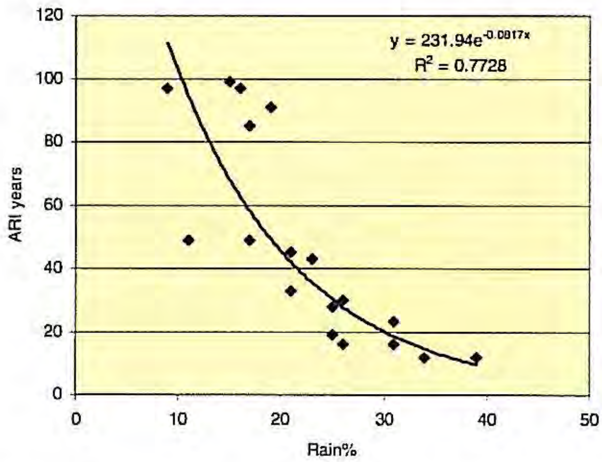


Figure 4.4 Relationship between average recurrence interval (ARI) and percentage of average rainfall for summer droughts (December - February) in Hawke's Bay.

Chapter 6
Volcanic Impacts

Introduction

Hawke's Bay lies many kilometres from any active volcano in New Zealand. Consequently, the region would be spared the multiple and highly damaging near-source effects of a volcanic eruption, except in very large eruptions from the Taupo Volcanic Centre. The main impact will come from volcanic ashfall, and associated hazards.

Hawke's Bay will only be affected by significant eruptions if the wind is blowing from the volcano towards the region. There is a good chance of this happening, given that volcanoes lie to the west and north of Hawke's Bay, the same directions from which the area's prevailing winds blow.

Impact Studies

In 1997 the Hawke's Bay Regional Council (HBRC) asked the Institute of Geological and Nuclear Sciences (IGNS) to study the volcanic hazard and risk and report on the impacts these can have on communities in Hawke's Bay.

That report is summarised in this chapter.

Summary

The impact of volcanic ashfall depends on its thickness. The degree of impact ranges from "nuisance" for 0-1 mm of ash, through "low-medium" for 1-5 mm, to "significant" for 5-50 mm, "very significant" for 50-100 mm and "catastrophic" for more than 100mm. The volcanic ash could come from a variety of volcanic centres. Ashfalls of 0-1 mm can be expected at least once every 10-20 years, falls of 1-5 mm every 100 years, falls of 5-50 mm every 2200 years, falls of 50-100 mm every 3,000 years, and more than 100 mm every 5,000 years.

The smallest eruption of 0.1-1.0 km^3 (108-109 m^3) of volcanic ash from Ruapehu, Tongariro/ Ngauruhoe, Egmont, or the Taupo and Okataina Volcanic Centres would also affect the Hawke's Bay region. There have been 17 eruptions of this size from Ruapehu in the last 1800 years, and at least 4 from Egmont in the last 6,500 years. There have been 24 eruptions of this size from the Taupo Volcanic Centre in the last 22,500 years, with deposits from 9 of those preserved in local swamps over the last 6,500 years. The geological record indicates this style and size of event occurs about every 100 years at Ruapehu and every 1,300 – 1,600 years from the Taupo Volcanic Centre and Egmont Volcano. Eruptions of this size would have a significant impact on the region.

Larger eruptions of 1-10 km^3 (109-1010 m^3) of volcanic ash would have a very significant impact on the region and can be expected from the Okataina and Taupo Volcanic Centres. There have been 8 such eruptions from the Okataina Centre in the last 21,000 years, and 2 from the Taupo Centre in the last 10,000 years. The geological record indicates eruptions of this size occur every 2,500-5,000 years.

Eruptions greater than 10 km^3 (1010 m^3) have occurred in both the Taupo and Okataina Volcanic Centres in the last 22,500 years. Geological records show two events at Taupo and three at Okataina, indicating they occur on average about every 5,000 years.

A community's infrastructure (engineering lifelines) is vulnerable to disruption and damage from ash falls. The degree of impact depends on the thickness of the fall. In Hawke's Bay the most significant impact will come from the original ashfall with secondary effects caused by its remobilization. There is potential for water supplies to be contaminated, storm and waste water systems lost, transport and communication systems interrupted and agricultural and horticultural production lost. There is little risk to human life.

While the effects of volcanic eruption cannot be avoided, pre-planning can reduce the severity of its impact.

Hawke's Bay Setting

Geographically the region lies downwind of several major volcanic centres in New Zealand and has received ashfalls from numerous eruptions. The most recent occasions were in 1995 and 1996 during the Ruapehu eruptions. Although these were relatively small compared to many past eruptions of the central North Island volcanoes, their consequences highlighted how vulnerable communities are, even to small eruptions. With increasing development and population growth, the risk from similar or larger eruptions will continue to grow.

New Zealand has both a high density of active volcanoes and a high frequency of eruptions from individual volcanoes. An active volcano is defined as one that has erupted in the past or one which has had a shorter period of dormancy since the last eruption, than the longest period of dormancy known. Eleven volcanoes have erupted in the New Zealand region in the past 2,000 years, with seven major eruptions since 1830.

Ashfall on vehicles on the East Coast of New Zealand during the 1995 eruption caused problems for transportation lifelines.

Eruption sources, which could have a significant impact on the region, include the Okataina, Tongariro (Ngauruhoe), Ruapehu and Taupo Volcanic Centres and Egmont Volcano (Figure 1). Eruptions from White Island and other volcanoes are not likely to affect the region because their eruptions are relatively small and wind directions are less favourable for ash deposits on Hawke's Bay.

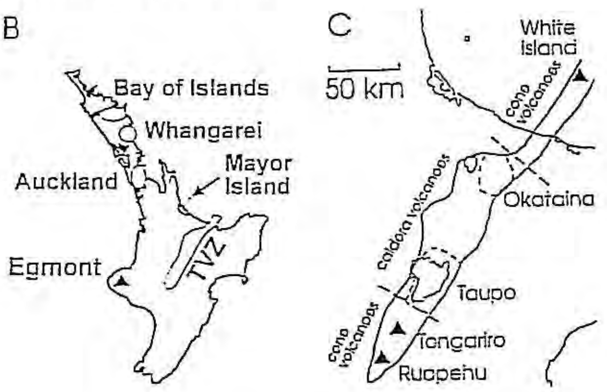


Figure 1: Map showing location of volcanoes and volcanic centres in New Zealand.

Historical Ashfalls

In New Zealand's written recorded history (~160 years), eight volcanoes have erupted, four onshore and four offshore. The largest onshore event occurred on 10 June 1886 when Mt Tarawera erupted more than 1 cubic kilometre of scoria, mud and fine ash over the Bay of Plenty and Gisborne areas. Eruptions of Mt Ruapehu in 1945, 1975, 1995 and 1996 have produced ashfalls in the Hawke's Bay region, as did the 1896 eruption from Te Mari Crater on Tongariro. Activity at White Island in 1977–1993 did not produce any recorded ashfalls in Hawke's Bay. In total 5 eruptions since 1830 have resulted in ashfalls in the Hawke's Bay.

The 1995-1996 Ruapehu eruptions disrupted several key infrastructure sectors including transportation, water supplies, and electricity distribution. Air transport was the most widely affected. Although the ashfall was minor it highlighted how vulnerable the region can be to even a small volcanic eruption. The national and regional response arrangements revealed deficiencies in some sectors, particularly with regard to water quality. However there were no significant problems with stormwater, wastewater, water supply or flood control systems that were some distance from the volcano.

Preserved Ashfalls

Investigations in the Hawke's Bay region have identified 35 volcanic ash layers preserved in swamp and soil horizons. This record of volcanic eruptions dates back over 22,500 years. Although several of New Zealand's volcanoes and volcanic centres have been active for 180,000-500,000 years, only the eruptions of the last 22,500 years are well known.

Eruptive Frequencies

Ashfall in Hawke's Bay can be logically classed into five groups - those depositing less than 1mm, 1-5mm, 5-50mm, 50-100mm and greater than 100mm. When combined with known eruption histories, this provides a basis to predict likely occurrence frequencies. In the last 100 years, ash falls of 0-1mm have occurred 5 times, while in the last 2,000 years there have been 19 eruptions large enough to produce 1-5mm ashfalls. There have been 9 eruptions large enough to produce 5-50mm of ashfall in the last 21,000 years, and 7 eruptions have produced 50-100mm ashfalls. Eruptions that could produce ash falls of over 100mm have occurred 11 times in the last 22,500 years.

Ashfall Models

To illustrate the impact of volcanic eruptions on the Hawke's Bay region the report developed ashfall models for eruptions of various sizes. The eruption histories of the Okataina and Taupo Volcanic Centres, and Ruapehu and Egmont volcanoes provided typical eruption sizes for developing the ashfall models.

The models were produced using the computer program ASHFALL (Hurst 1994), which calculates the likely distribution of wind-borne ash. The information supplied to the programme included the site of the eruption, its volume, column height, wind direction and speed. The output is a contour plot showing the thickness of ashfall downwind of the eruption site.

Wind Direction

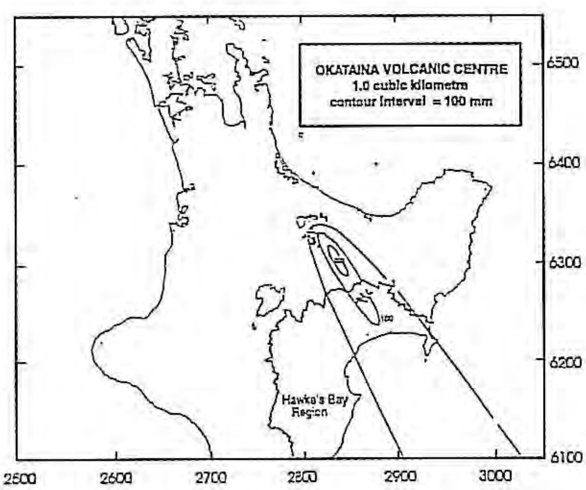
Wind directions in Hawke's Bay vary but blow predominantly from the west and southwest. Wind directions for each model have been chosen to produce near maximum ashfall patterns in the central Hawke's Bay region, i.e. worst-case scenarios.

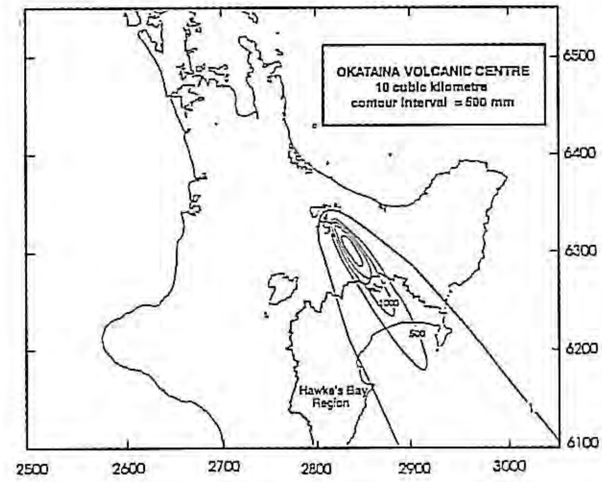
Summary

Nine ashfall models from 4 volcanoes or volcanic centres were produced for the report. Likely ashfall scenarios are shown in Figure 2 and cover eruption sizes ranging from 0.05km³ to 10km³. The expected ashfalls are also summarised in Table 1. Note that the plotted ashfalls represent all of the volcanic ash being erupted as one event. Eruptions are often more complex and consist of several smaller events, with individual ashfalls going different ways as the wind direction changes during the eruption. Larger scale eruptions could last for weeks or months.

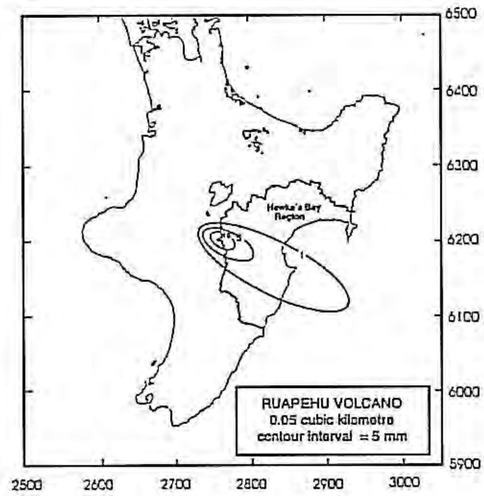
Source	Modelled Size (km³)	Expected Thickness in mm	Frequency of Occurrence
Okataina	1	10-150	700-5000 yrs
Okataina	10	100-150	700-3000 yrs
Ruapehu	0.05	1-5	1-50 yrs
Ruapehu	0.15	1-15	100-500 yrs
Taupo	0.05	1-10	1300-1600 yrs
Taupo	0.5	10-100	1300-1600 yrs
Taupo	5	100-1200	2500-5000 yrs
Taupo	50	100-2000	5000-10000 yrs
Egmont	0.1	0-5	1300-1600 yrs

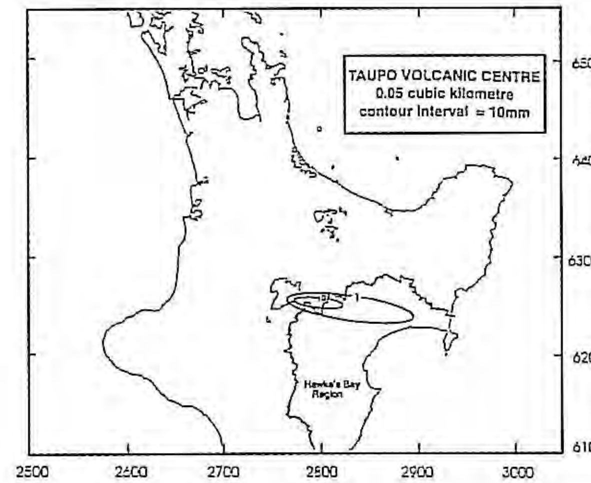
Table 1: Summary of ashfall models, including source, eruption size, expected thickness and frequency of occurrence.

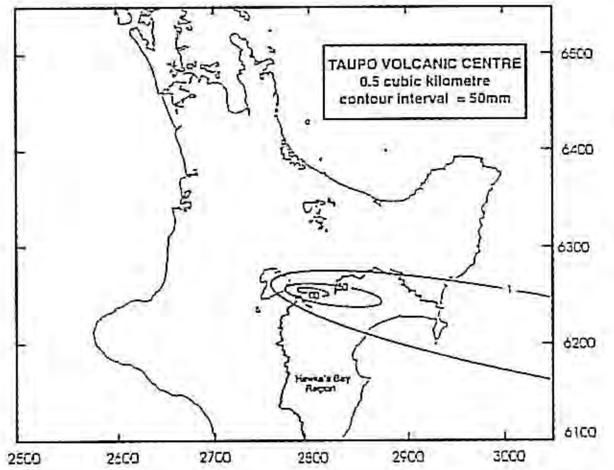


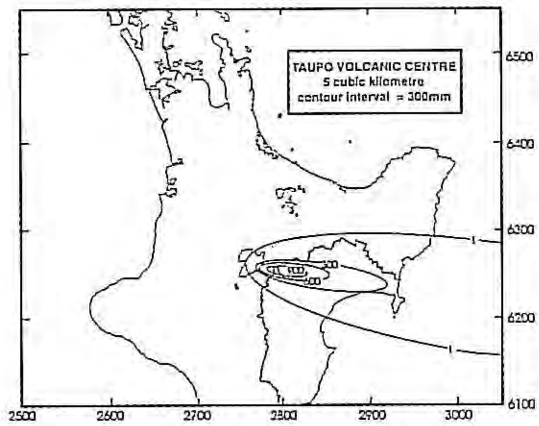


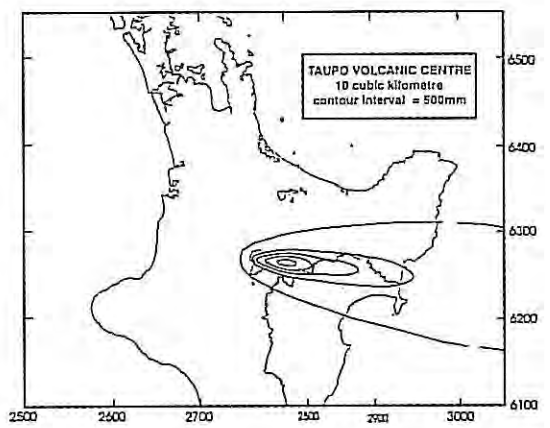
Figures 2 Ashfall Scenarios

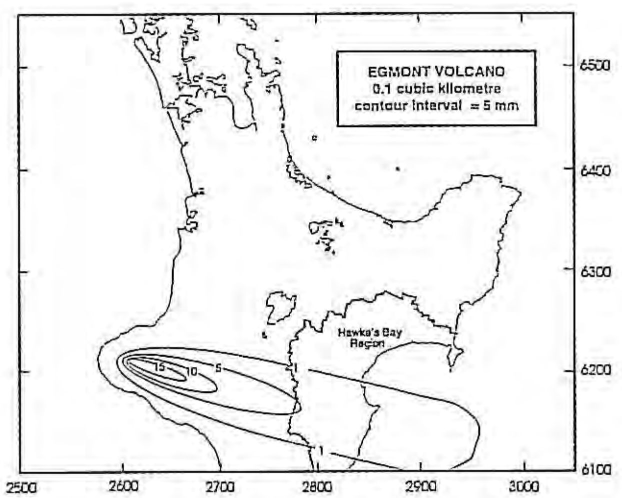












Impacts

Hawke's Bay would experience significant impacts from the original ashfall and secondary effects from the later movement of the ash once it has fallen. Sedimentation associated with larger, less frequent eruptions will be a significant problem that may last for years.

Because Hawke's Bay is many kilometres from any active volcano, it will generally be spared the multiple and highly damaging near-source effects of a volcanic eruption. Only eruptions of more than $10km^3$ from the Taupo Volcanic Centre could directly affect the region. As there have been only 3 such events in the last 22,500 years, these are not considered in any detail.

The impact of ashfall on engineering lifelines is discussed below.

Water Supply and Reticulation

Water supplies in Hawke's Bay are drawn from a variety of sources. The large urban areas of Napier and Hastings rely exclusively on groundwater while many rural properties use only roof-fed sources.

How vulnerable water supplies are to ashfalls depends partly on the type of system. Contamination can take a number of forms resulting from physical and chemical changes in affected supplies. The most common contamination problem results from the suspension of ash in water (turbidity), rather than chemical degradation.

Impact on Water Collection and Distribution

Groundwater supplies have low vulnerability to ashfalls. Stream and lake-fed reticulated water supplies could be contaminated by any significant ashfall-producing eruptions ($0.1km^3$ and larger). Water intake from these sources would probably be restricted or prevented for some time, both during and after a significant eruption. At the same time, there is likely to be increased demand for water for ash and acid rain clean-up operations.

In outlying areas without reticulated water supply, household tank water is collected from roof catchments. In ashfall areas these systems should have their downpipes disconnected from the storage tanks, so that ash is not washed into the tanks. Reconnection should only take place after ash has been removed from roofs and gutters.

Ashfall can also have an indirect impact by causing physical damage to filters at intake structures and/or treatment plants. The plants are also more susceptible to wear as a result of ashfall. Other indirect problems can result from increased water demand for clean up by residents and industry or failure of the electrical supply. The resulting loss of water supplies can lead to a range of other problems such as the loss of services like fire fighting.

The contamination of open water supplies is possible even from relatively small ashfalls. Both turbidity and acidity will usually return to normal within a few hours to days, unless there are prolonged ashfalls. Adverse effects on covered water supplies are minimal. Hazardous changes in water chemistry are rare, except close to a volcano where small volumes of water, such as roof-fed water tanks, stock water troughs and shallow surface water bodies, can be contaminated by ash leaching. Increases in the demand for water, as residents and industry clean ash from their properties, can lead to water shortages. An example of secondary effects would be loss of water pressure to support fire-fighting capability.

Wastewater Reticulation

Ash which falls on roads, roofs, and other impervious areas, will easily be washed into the stormwater system by rain or during cleanup operations. Ash density is usually too high for significant amounts to remain in suspension, at the water velocities which are normal in waste and storm water pipes. Hence ash will readily accumulate to block pipes and channels, leading to surface ponding. Finer ash may remain in suspension and be carried through the pumps. These may fail due to abrasion damage from ash-laden fluids, or to loss of electricity. Failure could result in sewage and stormwater banking up in urban areas. Removing ash from sewage and stormwater systems will be time consuming and costly.

Transportation

Ash Removal From Roads

No communities received more than a few millimetres of ash from the 1995-1996 Ruapehu eruption. However several (notably Rotorua and Wairoa) were forced to or chose to initiate clean-up operations to remove ash from buildings and streets. On the evening after the 12 October 1995 ashfall, the Wairoa cadet unit spent five hours sweeping, scrubbing and washing the town centre to remove ash in preparation for the official opening of the town's parade (The Wairoa Star, 17 October 1995). The Rotorua District Council reported that "after initial ash fall we began the mammoth task of sweeping and removing ash from the central city footpaths etc". The cost of the clean-up operation was estimated at $53,500 and included cleaning the CBD, kerbs and channels in all urban areas and stormwater cesspits in every area.

Disposal of Ash

Ashfalls of more than a few millimetres in urban areas will mean large quantities of volcanic ash must be disposed of. This should be undertaken in a way that minimises public health problems and is cost-effective. Ash left in an uncovered dump can be easily blown around.

Hawke's Bay Airport July 2001 (Photo courtesy Hawke's Bay Regional Council)

Airport Facilities and Air Transportation

Air transportation is vulnerable to eruptions, even if they are small. This was demonstrated during the 1995 and 1996 Ruapehu eruptions, with airports being closed by less than 1 mm thick ash falls, and the restriction of large airspace volumes to avoid actual or suspected ash clouds. This led to some flights being cancelled and others re-routed away from the restricted airspace. The restrictions mean aircraft cannot fly in cloud or at night within these zones. Only seven airports received ashfalls, with Rotorua airport receiving the most (about 1 mm thickness) and requiring a substantial clean-up operation. At least two minor aircraft ash encounters were reported - a Saab Metroliner en route to Nelson form Wellington (20 June 1996) and an Aztec en route to Takaka from Wellington (21 June 1996). However no serious damage was noted.

The Wellington Volcanic Ash Advisory Centre (VAAC) is operated by the Meteorological Service of New Zealand (Metservice) on behalf of the Civil Aviation Authority (CAA). It issued more than 120 volcanic ash advisories in 1995 and more than 90 in 1996 (Metservice 1997).

Electricity Supply and Reticulation

Falls of volcanic ash and mud from Ruapehu on 25 September 1995 caused shorting on high-voltage electric power lines at the base of the volcano. This led to voltage fluctuations and electrical equipment problems throughout the North Island. For example, supply fluctuations tripped the emergency power at Wellington Hospital causing non-essential supplies to be shed. By mistake a water pump in a block containing dialysis machines was included. Thermal power stations to the north were started to ensure security of the system.

Cleaning of 18 electric cable support towers and insulators east of Ruapehu was carried out on 27 September 1995. The ash was dry and easy to remove. Strain towers were most affected because of their insulator configurations (i.e. they were horizontally strung). It was found that subsequent rain, on 26 September 1995, had washed the northern side of towers and insulators. It was concluded that normal rainfall would clean ash from structures, conductors and insulators with the exception of the undersides of strain strings.

On 17 June 1996 electricity supplies were disrupted in parts of Rotorua City after an explosion at a local substation. This was caused by ash and water settling on a transformer, after a resident hosed ash from the roof of a neighbouring building (Daily Post, 19 June 1996)

The loss of electricity supplies has widespread consequences. Many other public utilities like water supply pumps, radio and telecommunication facilities, and airport lighting will be inoperable during the power loss, unless local backup supplies are available.

Telecommunications

A significant eruption will severely disrupt communications. This can be caused by interference due to disturbed atmospheric electrical conditions, overloading of telecommunication systems due to increased demand or direct damage by eruptive phenomena such as lightning strikes. It may also result from indirect impacts such as disruption to electricity supplies or difficulties in transporting technicians, which hampers maintenance or repairs. Ash entering telephone exchanges can cause damage to electrical and mechanical systems and general damage to buildings. Exchanges have battery-generator power backup systems to ensure they can keep operating when electricity supplies are lost. Generators are housed in the exchange building, but rely on external air intakes to air filters. If ash clogs these filters the generator could fail, meaning the capacity of the battery would be exhausted within a few hours.

Table 2: Summary of ashfall impacts

IMPACTS OF ASH FALLS
Less than 1mm ash thickness • Will act as an irritation to lungs and eyes • Airports will close due to the potential damage to aircraft • Possible minor damage to vehicles, houses and equipment caused by fine abrasive ash • Possible contamination of water supplies, particularly roof-fed tank supplies • Dust (or mud) affects road visibility and traction
1-5 mm ash thickness Effects that occur with <1 mm of ash will be amplified, plus: • Possible crop damage • Some livestock may be affected. Most will not be unduly stressed but may suffer from lack of feed, wear on teeth, and possible contamination of stock water supplies • Minor damage to houses will occur if fine ash enters buildings, soiling interiors and blocking air-conditioning filters etc • Electricity may be cut as ash shorting occurs at substations if the ash is wet and therefore conductive. Low voltage systems more vulnerable than high. • Water supplies may be cut or limited due to failure of electricity to pumps • Contamination of water supplies by chemical leachates may occur • High water usage will result from ash clean up operations • Roads may need to be cleared to reduce the dust nuisance and prevent storm water systems becoming blocked • Sewage systems may be blocked by ash, or disrupted by loss of electrical supplies • Damage to electrical equipment and machinery may occur
5-50 mm ash thickness Effects that occur with <5 mm of ash will be amplified, plus: • Ash will affect vegetation, causing burial of pasture and low plants and stock deaths. Foliage may be stripped off some trees but most trees will survive • Major ash removal operations in urban areas • Road transport may be halted due to the build up of ash on roads. Cars still working may soon stop due to clogging of air filters • Rail transport may be forced to stop due to signal failure bought on by short circuiting if ash becomes wet
50-100 mm ash thickness Effects that occur with <100 mm of ash will be amplified, plus: • Most pastures will be killed by over 50 mm of ash • Severe damage to trees, stripping of foliage and breaking of branches • Loss of electrical reticulation due to falling tree branches and shorting of power lines • Most buildings will support the ash load but weaker roof structures may collapse at 100 mm ash thickness, particularly if wet

Conclusions

Because there are no active volcanoes in the Hawke's Bay region the region will not be affected by near-source volcano hazards except in the most extreme circumstances. However, there is a significant volcanic ash hazard from volcanoes to the west and northwest. As recently as 1995 and 1996 the Hawke's Bay region experienced ashfalls.

Any eruption occurring under typical wind conditions may affect the region. The predominant prevailing winds are from the west and south, essentially blowing from the volcanoes to the Hawke's Bay region.

Historical and geological records show that many eruptions have deposited ash in the Hawke's Bay region. Examination of these deposits shows that they can be classed into five groups:

1. Those that form only a trace 0-1 mm (expected once every 10-20 years);
2. Those that form deposits 1-5 mm thick (expected every 100 years);
3. Those that form deposits 5-50 mm thick (expected every 2,200 years);
4. Those that form deposits 50-100 mm thick (expected every 3,000 years);
5. Those that exceed 100 mm in thickness (expected every 5,000 years).

It is noteworthy that deposits from past ashfalls, which are known to have had a significant impact, are often not preserved in the region. This suggests that the region could expect more minor ashfalls than those indicated by the geological record.

In summary, eruptions from the Okataina and Taupo Volcanic Centres are most likely to have very significant impacts on the region. Large eruptions from Ruapehu and Egmont volcanoes may also be significant. Smaller eruptions from these volcanoes could also impact on the region and will probably occur most frequently, although they are more likely to be a nuisance than to cause serious damage. Eruptions from White Island and other volcanic centres are unlikely to impact on the region.

The effects of volcanic ash are pervasive and can be highly disruptive to a modern community's infrastructure. The disposal and clean up of the ash will create major problems. Vital regional assets at risk are water supply systems, storm and waste water systems, buildings, the port, airport and transportation systems.

Volcanic ashfalls can disrupt electricity supply. Weather conditions will influence how falling ash sticks to insulating surfaces, with power loss if the ash is wet (i.e. conductive). Low voltage systems are more vulnerable than higher voltage systems due to smaller weather sheds on insulators. Most power outages are of short duration. The abrasive nature of ash can cause damage to mechanically moving parts, such as cooling fans. Immediate ash removal offers the best chance of preventing widespread power loss.

Volcanic ashfalls can severely damage sewage and stormwater systems. Reducing the amount of ash that gets into the system is the best way of minimising the effect of ashfalls. Sewage treatment plants can be severely affected by ash falling directly on the plant or by receiving ash laden sewage. Bypassing and/or shutting down parts of the plant may be necessary to reduce the likelihood of damage. Pumps will suffer excessive wear from pumping ash laden liquid.

Water supplies are vulnerable to contamination by ashfall. Communities may be unable to use storage lakes and suffer the consequences of extreme demand during the post-eruption ash clean-up. Water management plans are needed to cope with excessive demand and, where possible, should include procedures to fill service reservoirs when an ashfall warning is received. Appropriate public information messages outlining water conservation measures should also be broadcast when an ashfall is advancing. It is important to retain fire-fighting potential.

Ash-affected communities will be forced to undertake expensive and time consuming clean up operations after ashfalls of 1 mm or greater. In each case co-ordinated community wide ash removal plans will need to be developed. These must identify appropriate methods of ash removal, collection and disposal. The public will need to be told how to deal with volcanic ash.

The impact of recent eruptions in New Zealand and overseas highlights the vulnerability of communities receiving only a few millimetres of volcanic ash. In most cases thin ashfalls cause disruption rather than destruction, mostly affecting transportation, electricity, sewage and stormwater systems. Most systems can be fully operational again within a few days. With greater ash thickness, more catastrophic impacts can be expected. Following an ashfall, demand for information from the public can cause overloads on the switchboards of many organisations. This can tie up a large number of staff and prevent them from attending to other essential tasks. The recent Ruapehu eruptions highlighted the value of emergency management plans that identify likely impacts on each community's lifelines and strengthen the links between agencies that will have to respond to such events.

Chapter 7

Landslide Hazard

A landslide is the movement of a mass of rock, debris or earth down a slope. Landslides can occur on land or under water. A combination of steep terrain and weak rock and soils makes Hawke's Bay prone to both deep-seated and shallow landslides. In fact, some of the largest landslides in the world have occurred in Hawke's Bay.

Landslides are a threat to infrastructure, property and assets and life.

Landslide Types and Processes

In Hawke's Bay, landslides come in a variety of shapes speeds and sizes, from small rapid surface slips that are of 1 to 10 cubic metres, to huge slow-moving regional slumps.

Most landslides are caused by a combination of several factors which create the potential for movement, and then an event which triggers the movement.

The important factors in determining the potential for landsliding are soil/rock strength and type, subsurface water levels and slope angles. The common triggering factors are rainfall, burst pipes, melting ice, earthquakes and making slopes steeper, either by natural means such as stream erosion or man made means such as cutting into a slope.

The following factors are important in making Hawke's Bay prone to landslides:

- Active tectonics which disturb the bedrock and create steep terrain;
- Rocks that are geologically young and weak because they haven't had time to become cemented by normal rock forming processes. In engineering terms much of Hawke's Bays so called "rock" is in fact more like soil.

The following are the main triggers for landslides in Hawke's Bay:

- Intense cyclonic rainfall. Although Hawke's Bay is relatively dry compared to other parts of the country, it has a history of intense cyclonic rainfall events such as Cyclone Bola;
- Earthquake shaking. Hawke's Bay is close to a plate boundary and one of the most seismically active areas in New Zealand.

Landslides Triggered by Earthquakes

Napier Hill after 1931 HawkesBay Earthquake.

Landslides are often triggered by strong earthquakes. There are many spectacular examples of this from the 1931 Hawke's Bay and 1932 Wairoa Earthquakes. The damage from these events include:

- Large rock falls off the Bluff Hill cliffs in Napier;
- Numerous rock falls that blocked rivers around the region. One of the biggest blockages was on the Te Hoe River near where it meets the Mohaka River. Rock fell from 300 m high cliffs and formed a debris dam 30 m in height, that created a lake 5 km long and 200 ha in area;
- Landslides pouring from high coastal cliffs into the sea. One cliff failure near the Mohaka River carried away 80 ha of farmland and formed a ridge jutting 700 m into the sea.

Rainfall Induced Landslides

In Hawke's Bay, rainfall of more than 200 mm in a day can cause landslides on some hill country. Rainfall of more than 250 mm per day is likely to cause widespread landslide damage.

Landslides triggered by rainstorms are frequent and widespread. They cause different kinds of damage which affects people, assets, infrastructure and the environment. In 1988, the damage caused by Cyclone Bola in the Hawke's Bay and East Coast regions was estimated at about $150 million. Rainfall of similar magnitude occurred in Hawke's Bay in June 1917, March 1924, and April 1938.

Major landslip Wairoa by Cyclone Bola 1988

Immense Landslides in Hawke's Bay

Some of the largest landslides in the world can be found in Hawke's Bay. An immense landslide formed the barrier which formed Lake Waikaremoana. Studies show that this occurred a minimum of 3280 years ago and was probably triggered by a large, nearby earthquake. An even larger landslide, with an estimated age of 11,000 years, is located on the northern side of Lake Waikaremoana. It covers some 70 km^2 and has a volume of 20 km^3. Other very large earthquake- induced landslides are located at nearby Tiniroto, Te Putere and Lake Tutira.

Much of coastal Central Hawke's Bay has been affected by landslides, some of which cover very large areas. These failures are generally caused by the weathering of mudstone into "smectite" clay which, when wet, becomes very unstable.

Landslide Mapping

Preliminary maps identifying the location and extent of major landslides in Hawke's Bay have been developed by IGNS (Institute of Geological and Nuclear Sciences). These maps were created from a desktop study using information from previous reports and aerial photographs. When fully developed, these maps will be a useful tool for identifying landslide hazards for existing and proposed engineering lifelines.

Lifelines Study

Because the lifelines in Hawke's Bay extend over long distances and cover much of the region, an in-depth study into landslip potential was not feasible.

Instead the study examined the unpublished GNS maps referred to above, and found that the big landslips recorded only intercepted major lifelines at a few locations.

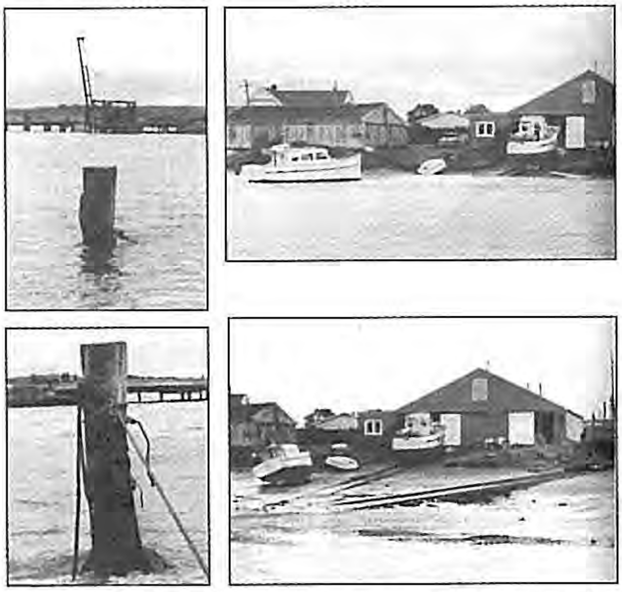
Participants also used their experience and knowledge of certain sites and of shallow landslides, to identify the parts of the networks that have the potential to be affected by landslides.

Landslip Mohaka Hill State Highway 2 July 1997 (photo courtesy Opus)

Chapter 8

Tsunami Hazard

"Tsunami" is a Japanese word meaning "harbour wave". The term is now used world wide to describe long-period waves that are generated by a sudden displacement of water. The displacement is normally caused by a submarine earthquake, but could also be brought about by submarine landslides, large volcanic explosions, and the impact of meteorites in the ocean. Tsunami are characterised by great speed (up to 950 km/hr), long wavelength (up to 200 km between waves), long period (generally 10-60 min between waves), and low observable amplitude or height on the open sea. However on entering shallow water they may "pile" up to heights of 30 metres or more and cause significant damage over a widespread area. Tsunami can result from local events or from sources thousands of kilometres away.



Even though these pictures of the 1960 tsunami were taken many hours after the tides had occurred, they graphically shown the extent of the fall in Napier's Inner Harbour. The interval of time between the taking of the top and bottom shots was only 20 minutes.
(Photo courtesy of Russell Spiller)

The low-lying parts of Hawke's Bay, such as the Heretaunga and Wairoa Plains, are the most densely populated and also the most prone to damage from tsunami. This, combined with the fact that Hawke's Bay is very close to an active tectonic plate boundary, makes tsunami a real and significant hazard for the region.

This chapter summarises work carried out by the Institute of Geological and Nuclear Sciences (IGNS) for the Hawke's Bay Engineering Lifelines Project on the potential damage from tsunami in the Hawke's Bay region.

The study carried out by IGNS involved the following work:

- Assessing the effects of tsunami over a range of return periods (10% probability of occurrence in 15 years, 10% probability of occurrence in 50 years and 1% probability in 50 years);
- Preparing a map showing the areas which could be affected by tsunami with the above return periods.
- Assessing the likely effects of tsunami within Hawke's Bay;
- Analysing current understanding and available data to identify gaps that limit the ability to accurately predict tsunami hazard.

The study used national and international data sets including the active fault database, the historical seismicity database, a landslide database, and the international tsunami database.

The preparation of the tsunami hazard map involved:

- Assessing wave heights for the different return periods;
- Estimating the areas at risk from tsunami inundation. To do this, the study modelled offshore linear waves uniformly impacting the coast. Inland inundation varied according to ground slope (assessed from topographic data) and roughness (which is dependent on ground cover conditions).

Because there is little detailed topographical data for Northern Hawke's Bay (only 20-metre contours were available), the risk map was restricted to the more densely populated areas around Napier and Hastings (where 1-metre contours were available).

Tsunami Height/Frequency Relationship

Previous Work

Van Dissen et. al. (1994) used tsunami heights from past events together with numerical modelling to assess the likely variations in tsunami heights around the coast.

Fraser (1998) compiled a New Zealand historical tsunami catalogue and analysed tsunami height/frequency relationships for various locations including Napier. Based on the limited historical data for Napier, a tsunami height of 1 metre at the coast has a return period of 56 years, 2.5 metres, ~97 years, 5 metres, ~240 years, and 10 metres, ~1500 years. The maximum tsunami height of 10% probability in 15 years is 3.5 metres.

Probabilistic Approach

To obtain a "probabilistic" tsunami hazard assessment, IGNS used data from the UK Tsunami initiative (TPR-UK), where specialists estimated tsunami height/frequency relationships for many regions, including New Zealand. To estimate the relationship for long return periods (up to 1000 years, which is much longer than the New Zealand record), they used the world wide tsunami catalogue, and adjusted a generic relationship from New Zealand historical data. Using this the maximum tsunami height expected in Hawke's Bay would be:

- 8 metres with 10% probability of exceedence in 15 years;
- 11 metres with 10% probability of exceedence in 50 years;
- 20 metres with 1% probability of exceedence in 50 years.

These figures disagree with existing records which show that in the 160 years of Hawke's Bay written history, there has been no widespread tsunami inundation matching the estimated 8-metre high tsunami with 10% probability of exceedence in 15 years. According to IGNS, this is probably because the earlier studies did not consider the possibility of tsunami triggered by very large landslides. Estimates for this kind of event are included in the TPR-UK study. Given that Hawke's Bay is very close to a tectonic plate margin (the Hikurangi trench), which is capable of generating tsunami-causing earthquakes and submarine landslides, IGNS thought it appropriate to be conservative when estimating the tsunami height/frequency relationship. Both tsunami earthquakes and submarine landslides are discussed in following sections.

Tsunami Inundation Modelling

A digital elevation model (DEM) was used to estimate the possible extent of inundation from the 8, 11 and 20 metre "scenario" tsunami events discussed in the previous section. Problems with using imported digital data meant that it was only possible to prepare a model for the Heretaunga Plains around Napier and Hastings. The map derived from this model is shown in Figure 1.

The map shows the expected maximum extent of inundation by tsunami reaching 8, 11 and 20 metres. It would be wrong to infer that all of the areas shown to be at risk would be damaged in the one tsunami – they merely have the same probability of being inundated and damaged within the specified time periods.

Because of the complex nature of tsunami inundation modelling and the lack of data, several simplifying assumptions had to be made. As a result, IGNS describe the model as "simplistic" and just a starting point on which more refined models can be built. There is no uncertainty about potential tsunami heights; the uncertainties relate to the probability of occurrence and likely areas of inundation.

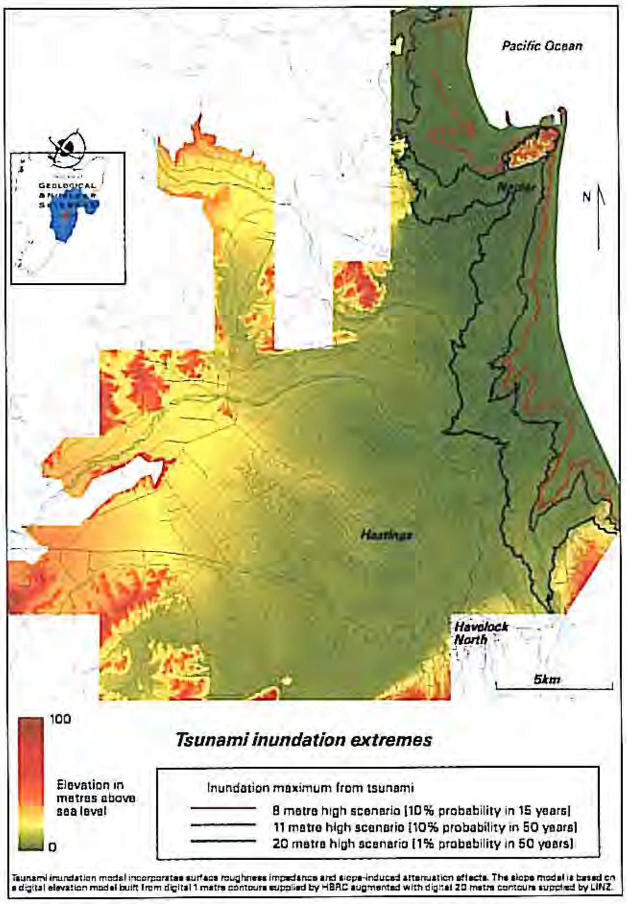


Figure 1 : Tsunami – potential inundation extremes

Potential for Very Large Submarine Landslides

Recent sea-bed "swath" mapping has identified an extremely large submarine avalanche just off the coast from Ruatoria (Lewis et.al. 1999), which involved 3,600 cubic kilometres of blocks of debris flowing into the 3.5 km deep Hikurangi Trough. The debris and scarp of the avalanche cover an area about the same size as the Coromandel. This kind of landslide would generate a gigantic wave with severe consequences. Geologists estimate that these extremely large landslides occur about every 100,000 years, making them a rare event in terms of the human time scale. Smaller, more frequent failures that may produce tsunami many metres high present the greater risk. Potential sites for such failures have been identified in the Hawkes Bay/East Coast region. However, further work is required to gain a better understanding of how often such failures might occur.

Potential for Tsunami Earthquakes

In March 1947 and May 1947, two large tsunami earthquakes occurred north of Hawke's Bay. They were unusual because the tsunami were larger than would normally be expected given the magnitude of the earthquakes. The March 1947 tsunami was more than 10 metres high at its point of greatest impact, and the May event about 5-6 metres high. Further studies have identified these earthquakes as classic "tsunami earthquakes"- they had long rupture times and most of the energy was radiated at a long wavelength which is not well represented by the local earthquake magnitude. Both earthquakes involved rupture of the interface between the Pacific and Australian tectonic plates. The potential for similar tsunami earthquakes to occur in Hawke's Bay is not known.

Possible Effects of a Large Tsunami

Extent of Inundation

Figure 1 shows the possible extent of inundation of tsunami with wave heights of 8, 11 or 20 metres. These heights correspond with frequencies of 10% in 15 years, 10% in 50 years and 1% in 50 years respectively. The wave heights can be expected to occur somewhere along the East Coast. Figure 1 indicates the likely area if such a wave was centred on the marked foreshore.

Most of the damage from tsunami can be expected at the coastline or as a result of surges up waterways and estuaries. Inundation further inland would cause little or no damage, because the waves would have dissipated all their energy.

While the study was only able to calculate these tsunami for the length of shoreline shown the information can be applied to all the coastline of the Hawke's Bay region.

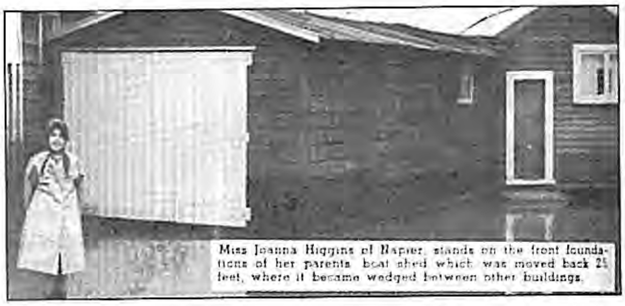
The study used the 11-metre event to consider the risk to engineering lifelines from the tsunami hazard, due to the lower and uncertain probability of a 20-metre event.

The cliffs around Cape Kidnappers and along the coast between Whirinaki and Wairoa show signs of large-scale collapse in the past, probably as a result of earthquake shaking. These failures are likely to have generated "edge wave" type tsunami, which have short wave length and tend to run parallel to the shoreline. These tsunami are a threat to coastal areas from Clifton to Clive, and small communities between Whirinaki and Wairoa. Even relatively minor "edge waves" would considerably worsen the existing and significant coastal erosion problems at places like Te Awanga and Bay View. At the moment, with very little information on the magnitude and frequency of these coastal landslides, it is not possible to estimate the likely magnitude/frequency of tsunami generated by cliff collapse.

Specific Damage

Tsunami interact with the coast to produce a variety of hazards which are specific to a particular location. Because of this, further extensive study would be needed to fully assess the extent of likely damage. However, in general terms, large tsunami (i.e. above 5 metres in height) could be expected to cause the following types of damage:

- Flooding of houses and lower levels of multi-storey buildings;
- Significant damage to buildings from the force of the wave surge and the impact of floating debris;
- Death by drowning and injuries from the direct impact of debris;
- Localised contamination of coastal effluent treatment plants located at vulnerable sites;
- Drains filled and roads covered with deposits of scoured material;
- Large trees and power poles scoured out and carried substantial distances. Scour could also seriously damage underground services;
- Road seal lifted and rolled;
- "Bore" waves extending a long way inland up rivers and drains and causing considerable damage to bridges;
- Significant further damage from debris-laden backflow following the initial surge;
- Landslides, retreating sea-cliffs and coastal erosion in beach areas;
- The potential for significant loss of life and almost complete destruction of the infrastructure over large areas from a very big tsunami i.e. greater than 20 metres.



A boat shed was pushed back many metres and wedged between other buildings after the 24 May 1960 tsunami struck Napier's Inner Harbour. (Photo courtesy of Russel Spiller)

Mitigation Measures

It is very difficult to mitigate against the effects of large tsunami (i.e. above 8 metres in height).

The only practical mitigation measure, given the low probability of large tsunami and the fact that any effects would be most devastating at coastal locations, could be some form of early warning system.

Although the communications media could be used to alert the public of a tsunami originating at a far off site this could only take the form of an extremely urgent warning.

A warning of this type would need to stress the importance of moving to higher ground i.e. well above sea level or well inland from the coast. The community must also be strenuously discouraged from staying to view the tsunami at the coastline and told that this could put their lives at risk.

Another consideration would be weighing up the protection offered by remaining within buildings with the risk of traffic chaos heading away from the coast.

As more is found out about the origins of earthquakes and other events leading to tsunami, appropriate advance warning systems should be investigated and upgraded.

Further Work

The catastrophic implications of the three different damage scenarios i.e 8, 11 and 20-metre tsunami are wholly dependent on the accuracy of the data used in this study (i.e. the adopted probability distribution of tsunami heights) and the way it has been applied to Hawke's Bay. As discussed above, there are still many unknowns that make it difficult to confidently predict the frequency and size of future tsunami.

IGNS state that the following work is needed to improve understanding of the tsunami hazard and its potential threat to Hawkes Bay:

- High resolution sea floor mapping of the shore near Hawke's Bay. NIWA is currently carrying out a long-term New Zealand-wide research programme with this aim;
- Gathering information on the magnitude and frequency of submarine slumps. This would be a major exercise;
- Investigations into the potential for earthquakes involving rupture of the subduction interface between the Pacific and Australian tectonic plates. These are currently being carried out by IGNS researchers;
- Further investigations into traces of tsunami in the geological record.

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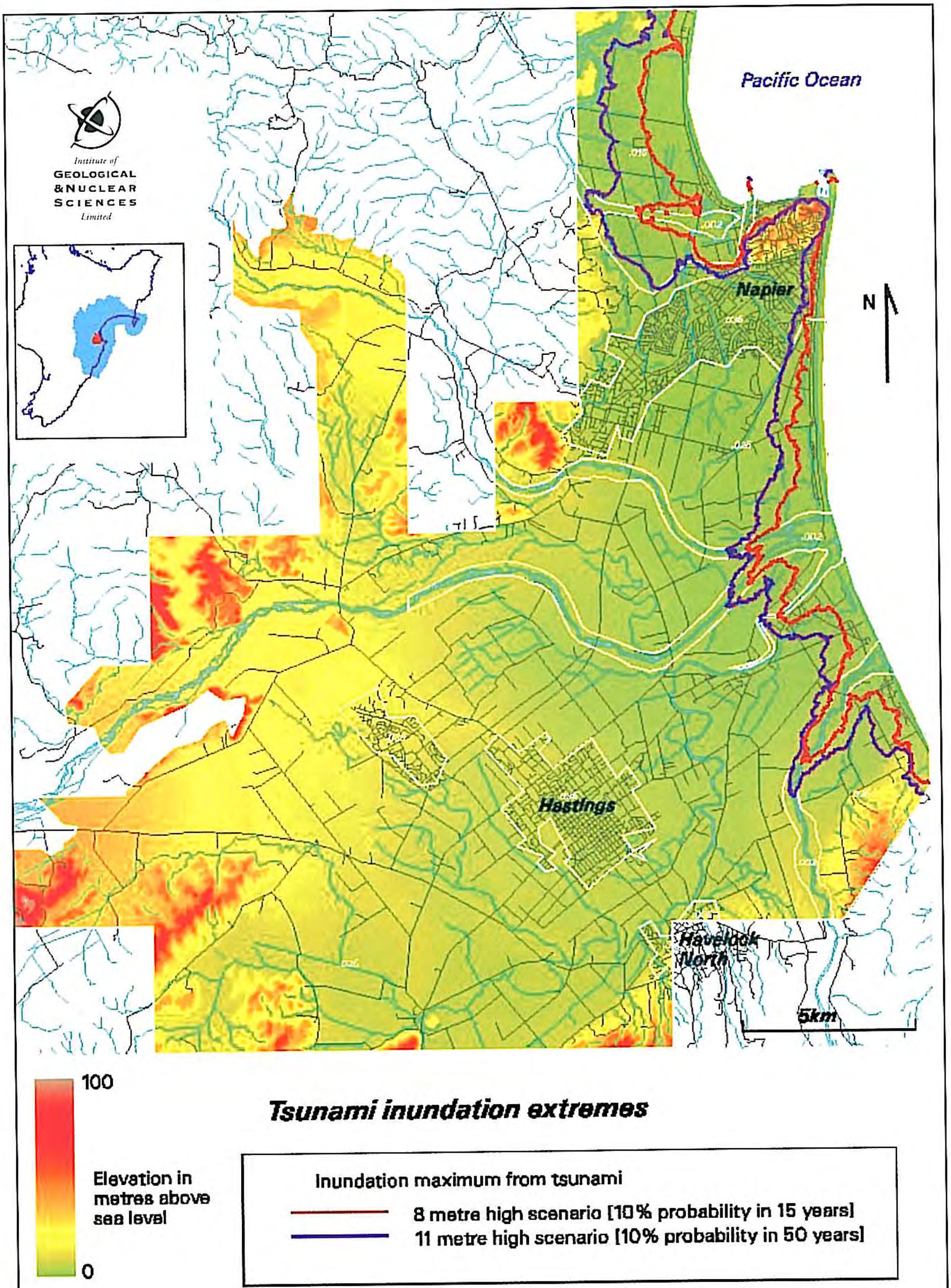


Tsunami inundation model incorporates surface roughness impedance and slope-induced attenuation effects. The slope model is based on a digital elevation model built from digital 1 metre contours supplied by HBRC augmented with digital 20 metre contours supplied by LINZ.

Figure 2 : Tsunami – potential inundation extremes used for Risk Assessment

Chapter 9.1
Transit New Zealand

State Highways

The roading network in the Hawke's Bay region totals 4,583 km, of which 511 km (11%) are state highways, under the control of Transit New Zealand (Transit).

State Highway 2

The 266 km of State Highway 2 in Hawke's Bay is the strategic north-south route through the region.

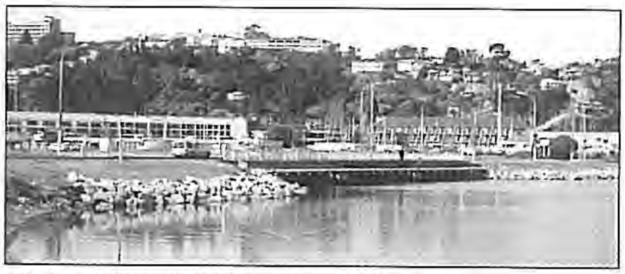
Between Napier and Hastings this strategic route is moving onto the Hawke's Bay Expressway (currently parts of State Highways 50 and 50A), as sections are constructed. Once the Expressway project is completed there will be some rationalisation of the state highway network and its numbering, on the Heretaunga Plains.

Traffic volumes on State Highway 2 range from 1,200 to 1,800 vehicles per day (vpd) north of the State Highway 5 junction, with further increases close to urban areas. South of Hastings, traffic volumes range from 3,600 to 6,000, once again increasing near towns. Around and between the cities of Napier and Hastings cities, traffic volumes increase to 12,000 vpd.

North of Napier, State Highway 2 is the only route suitable for significant volumes of heavy vehicles. A viable alternative route (Tiniroto Road) runs from Wairoa north to the region's boundary. However, for the remainder of the length, there are only some relatively tortuous and unsealed local roads, which do not offer a suitable alternative.

State Highway 2 south of Napier has a parallel state highway (State Highway 50) for all but the last 8 kilometres.

State Highway 2 north of Napier will become even more strategically important in the future with a predicted reduction in the use of the railway between Napier and Gisborne, and an expected increase in forestry traffic.



Westshore Bridge on State Highway 2 crosses Ahuriri Estuary. (Photo courtesy of Hawke's Bay Regional Council)

State Highway 5

State Highway 5 is the only major route connecting the east coast regions to the central and northern North Island regions. The only reasonable alternative routes for traffic involve major detours. One alternative route is the Napier to Taihape Road although part of this route is unsealed (approximately 25 Km), narrow and relatively tortuous.

Traffic volumes on State Highway 5 range from 2,500 vpd at the region's boundary, to 3,500 vpd at its junction with State Highway 2.

State Highway 38

State Highway 38 is the section of road between Wairoa and Rotorua which runs from the Te Urewera National Park Headquarters at Aniwaniwa, back to Wairoa. The road from Aniwaniwa to Murupara is controlled by the relevant District Councils and carries fewer than 140 vpd.

Traffic volumes on the Hawke's Bay section of State Highway 38 range from 130 vpd in the National Park to 500 vpd at Frasertown, and up to 1,700 vpd near Wairoa.

The state highway services the local farming industry as well as the Urewera National Park, three power stations in the Tuai area and a logging industry closer to Wairoa.

State Highway 50

State Highway 50 runs parallel to State Highway 2 between Napier and Takapau, and is strategically important because of the forestry industry based on the Gwavas Forest.

Traffic volumes vary from 3,000 to 16,000 vpd between Napier and Hastings, but for the majority of the highway's length range between 900 to 1,600 vpd.

State Highway 50A

State Highway 50A covers the portion of the Hawke's Bay Expressway which is not part of State Highway 50. It runs from Links Road, south of Napier, to Pakipaki, south of Hastings (effective 1 July 2001).

It is strategically important for inter-city and inter-regional traffic, but is well supported by alternative routes.

State Highway Segmentation

For the Engineering Lifelines Project the state highway network has been subdivided into sections based on the availability of alternative bypass routes for traffic, when a section of state highway is closed.

As a result the project divides the 511km of state highway into 32 separate sections, of lengths ranging from 2.4 km to 54.1 km.

Within those sections, there may well be a number of points that are vulnerable to specific hazards. However, if any one of those points fails the highway as a strategic lifeline throughout the length of that section, effectively closes.

Highway Importance

Each segment of the state highway network was assigned an importance ranking of 1 to 5. A 5 is allocated to sections of the highway that are extremely important to the region's transport network while a 1 indicates a segment is relatively unimportant.

The rankings are based on the regional and inter-regional strategic importance of the state highway in that section, together with the availability and condition of alternative routes.

State Highway 2 north of Napier for example, is given the highest rating (5) because of its strategic importance and the lack of a suitable alternative route. In contrast State Highway 38 around Lake Waikaremoana has been given a relatively low ranking (2) indicating its importance is well below that of any other portion of the region's state highway network. This is because it only services a relatively low volume tourist industry.

Hazard Ranking

The at-risk locations and facilities within each state highway section were identified and assessed for each of the defined hazards according to the following criteria:

- Their relative vulnerability, and
- The effect the hazardous event would have on that highway section during impact and until normal services were restored.

These aspects were 'scored' and totals assigned to the highway sections for each of the hazards being considered. The hazards were also ranked to develop the total scores. See attached Worksheet.

This has resulted in a ranking schedule which identifies the sections, and locations or facilities on them, which pose the greatest risk to the state highway network, and thus the region's recovery after a natural disaster. It gives Transit a good basis for setting priorities for asset management and improvements. See Top 50 ranked hazards attached.

Results of Risk Assessment

Hazard Ranking

The hazard ranking process has identified seismic activity as the event likely to cause the greatest disruption to the state highway network and to regional recovery. This is followed by flooding then landslip. The impact of wind, volcanic activity and wild fire on the roading network would be significantly lower, more short-term and less disruptive to the region than the other hazards.

Seismic activity has four main components:

- ***Ground shaking*** which can shake decks off bridges and cause structural damage to them;
- ***Liquefaction*** which may cause bridges, other structures and the road itself to 'sink';
- ***Fault displacement*** which will sever a highway, raise or lower the level of the road and/or offset sections of road. Chasms may well be formed in the road along the fault;
- ***Ground settlement*** where ground levels over an area change as a result of a subduction thrust earthquake. This could also form chasms in the road.

A road controlling authority can only mitigate against the first two of the above features. Bridges can be designed, and existing bridges can be retrofitted, to reduce the likelihood of damage from seismic activity.

Transit has carried out a national review of all bridges to assess their earthquake resistance and has identified those most at-risk. Those findings have been included in this analysis. Transit is now developing a programme for the modification of the most at-risk bridges, which will become part of a national priority programme as funds become available.

State Highway 5 Runanga flood 1985. (Photo courtesy of Opus)

State Highway 5 Runanga landslip 1985. (Photo courtesy of Opus)

It is more difficult for a road controlling authority to plan for the effects of ***Flooding.*** Although bridges are normally designed and constructed at a height which will allow a major flood to pass without damage, roads are frequently constructed across flood-prone areas. Raising road levels to keep them flood-free is often unacceptable to the wider community because the higher road embankment causes water to back up or redirects it, causing more significant damage elsewhere.

Normal maintenance of highway drainage systems, maintaining waterways below bridges, and protecting bridge approaches in waterways will help mitigate minor flooding events. However these measures will not address the problems likely to occur during a major flood or a tsunami.

Landslip is also difficult for a road controlling authority to mitigate although planting trees on unstable hillsides can significantly reduce the likelihood of surface landslip. Transit has set aside and planted some areas of unstable roadside reserve and other unstable land next to State Highways.

In a number of areas landowners have planted trees adjacent to the highway either to prevent surface landslip or for other reasons which nevertheless deliver the benefits of having a more secure hill face. However Transit cannot expect landowners to modify their management and farming activities to provide additional security to the highway network.

There are no practical means of planning for the impact of larger and deeper land movements.

Wind damage can be mitigated by Transit in conjunction with adjacent landowners. Transit ensures the removal of trees within the road reserve which are likely to fall in a storm and also removes self-sown trees near roads when they are still young.

In addition Transit asks landowners to remove any trees which they think are at risk of falling onto the highway in a storm. It cannot, however, require this work to be carried out and relies on the co-operation of the landowner.

Transit will continue with the above initiatives to mitigate the effects that wind damage could have on the roading network.

Transit can reduce the effects of ***Volcanic Ash*** by ensuring it has the means to properly clear ash from highway surfaces. It is important that the ash is not dealt with in a way that will create another infrastructural problem such as being washed into an urban stormwater system.

Transit requires its highway maintenance contractors to be equipped to deal with emergency situations. They will normally have graders, brooms, loaders, trucks, water carriers and the like, which are needed to remove ash.

There is no reasonable way to mitigate against ***Wild fire.*** A community expects roads and adjacent land to be landscaped and planted. It is not practical to create and maintain a road verge that is free of combustible material.

VULNERABILITY		SCORE
5	= Almost Certain	5.0
4		4.0
3	= Likely	3.0
2		1.0
1	= Very Unlikely	0.1

IMPACT OF DAMAGE		SCORE
5	= Catastrophic	25
4	= Major	16
3	= Moderate	9
2	= Minor	4
1	= None	1

IMPACT TIME		SCORE
IA	(Immediately after)	2
PF	(Period following)	5
RN	(Return to normal)	4

SEISMIC WORKSHEET

VULNERABILITY & IMPACT OF DAMAGE

COMPONENT/ SEGMENT				Regional Ranking	Ref	GROUND SHAKING					LIQUEFACTION					FAULT DISPLACEMENT					GROUND SETTLEMENT					SEISMIC HAZARD SCORE
						Vulner-ability	Impact Time			Hazard Score	Vulner-ability	Impact Time			Hazard Score	Vulner-ability	Impact Time			Hazard Score	Vulner-ability	Impact Time			Hazard Score	
SH	From	To	Length				IA	PF	RN			IA	PF	RN			IA	PF	RN			IA	PF	RN		
2	Region Boundary	Bridge Street, Wairoa	49.7	5	2 / 1	5	4	4	4	880	5	4	4	4	880	1	4	4	4	176	1	4	4	4	176	2112
2	Bridge Street Wairoa	Awamate Road	7.3	5	2 / 2	3	4	4	4	528	5	4	4	4	880	1	4	4	4	176	1	4	4	4	176	1760
2	Awamate Road	Mohaka North Road	21.2	5	2 / 3	5	4	4	4	880	5	4	4	4	880	1	4	4	4	176	1	4	4	4	176	2112
2	Mohaka North Road	Mohaka South Road	4.6	5	2 / 4	3	4	4	3	444	1	4	4	3	148	1	4	4	3	148	1	4	4	3	148	888
2	Mohaka South Road	Matahorua Road	30.5	5	2 / 5	3	4	4	4	528	1	4	4	4	176	1	4	4	4	176	3	4	4	4	528	1408
2	Matahorua Road	Waikoau Road	11.6	5	2 / 6	5	4	4	3	740	1	4	4	3	148	1	4	4	3	148	5	4	4	3	740	1776
2	Waikoau Road	Kaiwaka Road	12.1	5	2 / 7	3	4	4	4	528	1	4	4	4	176	1	4	4	4	176	5	4	4	4	880	1760
2	Kaiwaka Road	Tongoio Road	8.5	5	2 / 8	3	4	4	3	444	1	4	4	3	148	1	4	4	3	148	5	4	4	3	740	1480
2	Tongoio Road	SH 5 Junction, Esk	8.7	5	2 / 9	5	4	4	4	880	5	4	4	4	880	1	4	4	4	176	5	4	4	4	880	2816
2	SH 5 Junction, Esk	Hill Road	2.7	5	2 / 10	3	4	4	3	444	3	4	4	3	444	1	4	4	3	148	5	4	4	3	740	1776
2	Hill Road	Pandora/Hyderabad Intersection	8.6	5	2 / 11	5	4	4	4	880	5	4	4	4	880	1	4	4	4	176	5	4	4	4	880	2816
2	Pandora/Hyderabad Intersection	Marine Parade	3.4	3	2 / 12	3	3	3	3	297	5	3	3	3	495	1	3	3	3	99	5	3	3	3	495	1386
2	Marine Parade	Farndon Road, Clive	8	3	2 / 13	5	4	3	3	565	5	4	3	3	565	1	4	3	3	113	3	4	3	3	339	1582
2	Farndon Road, Clive	Paki Paki	17.9	3	2 / 14	5	3	3	3	495	3	3	3	3	297	1	3	3	3	99	3	3	3	3	297	1188
2	Paki Paki	Ruataniwha Street, Waipawa	35.5	4	2 / 15	3	4	3	3	339	5	4	3	3	565	5	4	3	3	565	3	4	3	3	339	1808
2	Ruataniwha Street, Waipawa	Ashcott Road	12.7	4	2 / 16	3	4	3	3	339	3	4	3	3	339	1	4	3	3	113	1	4	3	3	113	904
2	Ashcott Road	SH 50 Junction, Takapau	15.6	4	2 / 17	5	4	3	3	565	3	4	3	3	339	3	4	3	3	339	1	4	3	3	113	1356
2	SH 50 Junction, Takapau	Olawhao Road - Region Boundary	7.8	5	2 / 18	5	4	3	3	565	1	4	3	3	113	1	4	3	3	113	1	4	3	3	113	904
5	Region Boundary	Glengarry Road	54.1	5	5 / 1	5	4	4	4	880	1	4	4	4	176	5	4	4	4	880	1	4	4	4	176	2112
5	Glengarry Road	Waipunga Road	9.9	5	5 / 2	3	4	4	4	528	1	4	4	4	176	1	4	4	4	176	5	4	4	4	880	1760
5	Waipunga Road	Hill Road	3	5	5 / 3	3	4	4	3	444	1	4	4	3	148	1	4	4	3	148	5	4	4	3	740	1480
5	Hill Road	SH 2 Junction, Esk	2.4	4	5 / 4	3	4	3	3	339	1	4	3	3	113	1	4	3	3	113	5	4	3	3	565	1130
38	Aniwaniwa	Onepoto	10.5	2	38 / 1	3	3	3	2	237	1	3	3	2	79	1	3	3	2	79	1	3	3	2	79	474
38	Onepoto	Frasertown	46	3	38 / 2	5	3	3	3	495	3	3	3	3	297	1	3	3	3	99	1	3	3	3	99	990
38	Frasertown	Wairoa	7.5	5	38 / 3	3	4	3	3	339	3	4	3	3	339	1	4	3	3	113	1	4	3	3	113	904
50	Port	Meeanee Road	9.6	3	50 / 1	5	3	3	3	495	5	3	3	3	495	1	3	3	3	99	5	3	3	3	495	1584
50	Meeanee Road	Omahu Road	13.3	4	50 / 2	5	3	3	3	495	5	3	3	3	495	1	3	3	3	99	5	3	3	3	495	1584
50	Omahu Road	Maraekakaho, Kereru Road	14.6	4	50 / 3	3	3	3	3	297	1	3	3	3	99	1	3	3	3	99	3	3	3	3	297	792
50	Maraekakaho, Kereru Road	Tikikino Road	30.5	4	50 / 4	5	4	3	3	565	3	4	3	3	339	1	4	3	3	113	3	4	3	3	339	1356
50	Tikikino Road	Ashcott Road	17.8	4	50 / 5	5	4	3	3	565	3	4	3	3	339	1	4	3	3	113	1	4	3	3	113	1130
50	Ashcott Road	SH 2 Junction, Takapau	8.4	4	50 / 6	5	4	3	3	565	3	4	3	3	339	1	4	3	3	113	1	4	3	3	113	1130
50A	Junction SH 50	Pakipaki	17.6	3	50A / 1	3	3	3	3	297	3	3	3	3	297	1	3	3	3	99	3	3	3	3	297	990

Transit New Zealand Seismic Risk Assessment Worksheet.

TRANSIT NEW ZEALAND : STATE HIGHWAYS - TOP 50 RANKED HAZARDS

SH	From	To	Hazard	Reason
2	Tongoio Road	SH 5 Junction, Esk	seismic	Pakaruatahi Br, Esk River Br, Esk O/Br, Esk River liquefaction
2	Hill Road	Pandora/Hyderabad Intersection	seismic	Westshore Br, Bay View to Ngaruroro River liquefaction
2	Region Boundary	Bridge Street, Wairoa	seismic	Rakaipake Br, Tahaenui Br, Whakaki Lagoon liquefaction
2	Awamate Road	Mohaka North Road	seismic	Ohinepake Br, Waihua Br, Waihua River liquefaction
5	Region Boundary	Glengarry Road	seismic	Mohaka Br, Mohaka faults (3)
2	Matahorua Road	Waikoau Road	seismic	Matahorua Br
2	SH 5 Junction, Esk	Hill Road	seismic	SH 5 Junction to South end Bay View liquefaction
2	Bridge Street Wairoa	Awamate Road	seismic	Wairoa town to Turiroa liquefaction
2	Waikoau Road	Kaiwaka Road	seismic	
5	Glengarry Road	Waipunga Road	seismic	
2	Region Boundary	Bridge Street, Wairoa	Flood	Tunanui, Omana, Tahaenui, Whakaki, Iwitea flooding: Nuhaka - Whakaki - Wairoa tsunami
2	Bridge Street Wairoa	Awamate Road	Flood	Wairoa, Turiroa flooding : Wairoa River tsunami
2	Tongoio Road	SH 5 Junction, Esk	Flood	Esk River flooding : Tongoio Beach and Esk River tsunami
2	Awamate Road	Mohaka North Road	Flood	Thorpes, Cricklewood - Waihua flooding : Waihua River valley tsunami
2	Kaiwaka Road	Tongoio Road	seismic	
5	Waipunga Road	Hill Road	seismic	
2	Paki Paki	Ruataniwha Street, Waipawa	seismic	Te Mahanga to Waipawa liquefaction, Poukawa faults (3)
2	Mohaka South Road	Matahorua Road	seismic	
2	SH 5 Junction, Esk	Hill Road	Flood	Esk River valley tsunami
2	Hill Road	Pandora/Hyderabad Intersection	Flood	Westshore Beach tsunami
5	Waipunga Road	Hill Road	Flood	Esk River flooding
50	Meeanee Road	Omahu Road	seismic	Tutaekuri Br, Fernhill Br, Port to Waiohiki liquefaction
2	Matahorua Road	Waikoau Road	Flood	Sandy's Creek flooding
2	Waikoau Road	Kaiwaka Road	Flood	Tutira, Arapaoanui flooding
2	Kaiwaka Road	Tongoio Road	Flood	Tongoio Valley flooding
2	Ashcott Road	SH 50 Junction, Takapau	seismic	Waipawa to Takapau liquefaction, Takapau fault (1)
50	Maraekakaho, Kereru Road	Tikikino Road	seismic	Manga-o-nuku 1 Br, Mangamate Br, Mangamouku Br, Manga-o-nuku Stream liquefaction
2	Mohaka South Road	Matahorua Road	Flood	
50	Port	Meeanee Road	seismic	Port to Waiohiki liquefaction
2	Marine Parade	Farndon Road, Clive	seismic	Waitangi-Ngaruroro Br, Bay View to Ngaruroro River liquefaction
5	Region Boundary	Glengarry Road	Flood	Waipunga flooding
2	SH 50 Junction, Takapau	Otawhao Road - Region Boundary	seismic	
5	Hill Road	SH 2 Junction, Esk	seismic	
38	Frasertown	Wairoa	seismic	Frasertown to Wairoa liquefaction
50	Tikikino Road	Ashcott Road	seismic	Tuki Tuki River and other rivers liquefaction
50	Ashcott Road	SH 2 Junction, Takapau	seismic	various river valleys liquefaction
38	Frasertown	Wairoa	Flood	Waiau & Wairoa Rivers flooding and Wairoa River tsunami
2	Mohaka North Road	Mohaka South Road	seismic	
2	Pandora/Hyderabad Intersectio	Marine Parade	seismic	Bay View to Ngaruroro River liquefaction
50	Meeanee Road	Omahu Road	Flood	Tutaekuri & Ngaruroro Rivers flooding and tsunami
50	Omahu Road	Maraekakaho, Kereru Road	Flood	Ngaruroro River flooding and tsunami
2	Region Boundary	Bridge Street, Wairoa	landslip	Reg Bdy to Nuhaka, Whakaki Bluffs, Prydes Cutting, Ngaio, Te Uhi Hill
2	Bridge Street Wairoa	Awamate Road	landslip	Turiroa Cutting
2	Awamate Road	Mohaka North Road	landslip	Waihua Hill, Mohaka Ascent
2	Mohaka South Road	Matahorua Road	landslip	All - Adjacent to Mohaka River, Waikare Gorge
2	Matahorua Road	Waikoau Road	landslip	All - Matahorua Gorge
2	Waikoau Road	Kaiwaka Road	landslip	All - Waikoau Hill, Devils Elbow ascent
2	Tongoio Road	SH 5 Junction, Esk	landslip	Tongoio Cuttings and Whirinaki Bluff
5	Region Boundary	Glengarry Road	landslip	All
5	Glengarry Road	Waipunga Road	landslip	All
5	Waipunga Road	Hill Road	landslip	Bluffs west of Waipunga Road

General

The roading network under the control of the Wairoa District Council (WDC) comprises 868km of roads of which approximately 24% (211km) are sealed and 76% (657km) unsealed. There are 104 bridges and numerous culverts within this network.

Tree fall damage on Awamate Road, Wairoa 26 September 2000

There are also 30kms of Special Purpose Road under the Council's control, that service the area between Lake Waikaremoana and the Huiarau Summit to the north.

Location

The WDC roading network runs between the boundaries of the Hastings District Council, Gisborne District Council, Rotorua District Council, Taupo District Council and the coast.

The Roading Network

The district is broken down into four wards; Waikaremoana/Ruakituri, Mahia/Tuhara, Mohaka /Waiau and Wairoa/Frasertown. The latter covers the urban and adjacent rural areas.

The Wairoa district is served by two state highways under the control of Transit New Zealand - SH2 and SH38. SH2 runs between Napier and Gisborne, passing through the town of Wairoa. SH38 runs between Wairoa and Lake Waikaremoana in the Te Urewera National Park. At the Park headquarters SH38 continues towards Rotorua as Special Purpose Road 38. This road is maintained by the Wairoa District Council.

A number of roads lead off the state highways and in some places these link the two state highways together. This does not apply to the Special Purpose Road as any side roads leading off it service only the lake area and are controlled by the Department of Conservation.

The Lifelines Project has considered both significant roads (state highways, rural arterial and distributor routes) as well as selected local roads (those serving significant settlements or providing alternative access to the adjacent local authorities or state highways).

Alternative Access/Support

The district has a number of alternative means of access which could be used if a hazard caused a breakdown of part of the roading network. These are:

- Alternative Routes: In some areas alternative routes could used to circumnavigate the affected area;
- Rail: The rail line runs between Gisborne and Napier and, in places, is parallel with SH2;
- Airstrips: There is an airport at the end of Kaimoana Road, north-west of Wairoa township. It has a sealed runway, is 910m in length and can accommodate a wingspan of up to 30 metres. In dry conditions the grass strip along one side of the runway can accommodate light aircraft. Helicopters also use this airport and it has a helicopter-landing pad at the Memorial Park end on the northern side of the Wairoa River. The airport and the helicopter pad are controlled by the Wairoa District Council. In addition there are a number of airstrips on agricultural land within the Wairoa district, which are used during top-dressing. Smaller flat areas around the district could also be used for helicopter landings during an emergency.

Roading Network Vulnerability

The WDC roading network hierarchy has been summarised above. For the Engineering Lifelines Project the sections of state highways within the district have been excluded from the WDC road network, because they are under the control of Transit New Zealand. To assess the overall network vulnerability, route vulnerability and possible mitigation options for Wairoa, its roading network was subdivided into separate sections. These were chosen to verify the availability of alternative routes to bypass vulnerable sections, or duplicate important sections, of the network.

This process led to the selection of six routes, including the state highways, being identified within the Wairoa District. Within the overall district two routes were chosen to service most significant settlements. The selected roads or road sections are shown on Map 9.

Bridge Vulnerability

Bridges are key elements within the roading network. Earthquake and flood damage to bridges will vary greatly - those built to modern codes and construction standards are likely to perform well, while pre-1960s bridges may well be damaged. A significant number of the district's older bridges are relatively robust, with short spans and low pier height. The damage to them is likely to include impact (concrete deck to concrete abutment), batter slope failure, approach settlement, concrete cracking/spalling, rotation and foundation failure.

The main threat to bridges in the district comes from the potential for span collapse. Given this vulnerability, the importance of superstructure linkage cannot be overstated. In this study evaluating how bridges perform during seismic activity has been limited to a 'local knowledge and experience' assessment. More in depth screening of the bridges is required to identify specific bridge deficiencies.

Road Section Importance

Each of the chosen sections of the WDC roading network was assigned a local importance ranking. These were based on a combination of the district or inter-district strategic importance of the route, whether the route was regionally important (being an alternative to the state highway) together with the availability and condition of alternative routes within the district. While there is some correlation between route importance and current traffic volumes there is not a direct relationship, as this study is focussed on network robustness not route service.

Road Section Ranking

The key risk elements within each road section were identified and assessed for each of the defined hazards in the following terms:

- Their relative vulnerability, and
- The impact each hazard would have on the section of road during the event, immediately after and throughout the period of recovery.

These aspects were 'scored' with totals determined for each road section and defined hazard.

After including hazard rank and route importance the selected sections of road were given an overall hazard score which was used to rank or prioritise them. This has provided a subjective (being based on local knowledge and experience) but logical and systematic method of identifying the sections of road which could pose the greatest risk to the WDC road network, and hence to the district's recovery, following a natural disaster. It gives WDC asset managers a basis for determining priorities and improvement requirements.

The results of the road section ranking are given below. The sections of road with the highest risk are:

Seismic

Tiniroto Road

Nuhaka/Opoutama Road

Willowflat Road

Ruapapa Road

Flooding

Nuhaka/Opautama Road

Ruapapa Road

Patanamu Road

Kaiwaitau Road

Wind

Putornanu Road

Willowflat Road

Ramarama drain floods State Highway 2 at Whakaki March 1991. (Photo courtesy of Hawke's Bay Regional Council)

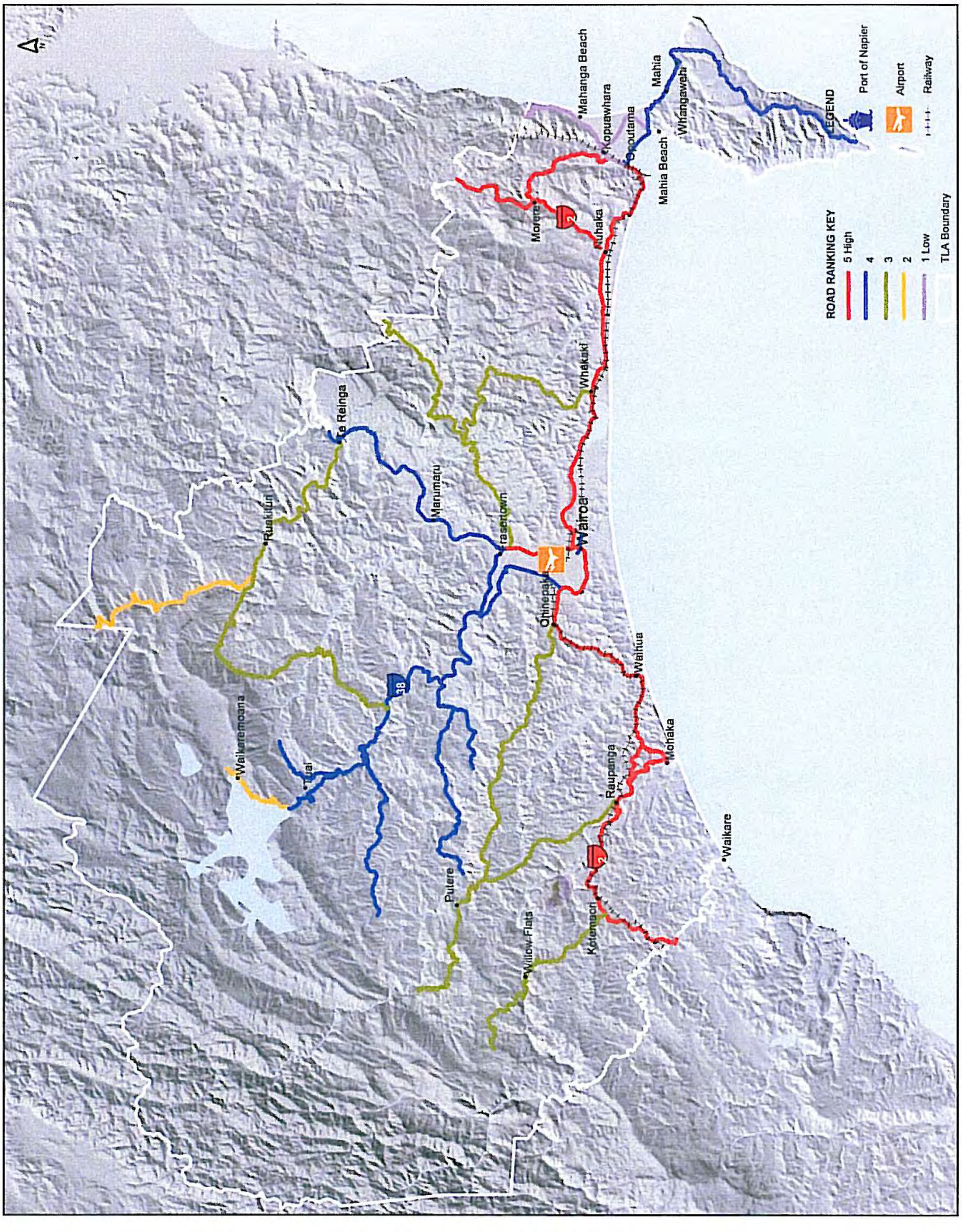
The main roading network issues identified from the ranking process are:

- SH2 is the main lifeline through the district both north to Gisborne and south to Napier;
- SH38 provides the main alternative route through the north of the district and to Rotorua;
- Awamate Road offers an alternative route between SH2 and SH38, giving access to the small townships of Frasertown and Tuai and providing a bypass of the SH2 bridge over the Wairoa River;

- Tiniroto Road is the main alternative route through the north-east of the district to Gisborne;
- Tunanui Road is the only alternative route to the Mahia area and being basically a single lane road, is unsuitable for heavy traffic;
- Awamate Road and SH38 are vitally important for servicing and recovering the water supply pump station and pipelines to Wairoa and Frasertown;
- Ruapapa Road is important for maintaining access to the river metal supplies that will be required following any emergency event;
- A high level of good, alternative access routes need to be maintained throughout the district;
- Both roads and bridges in the district are vulnerable to seismic activity;
- The lower reaches of the Wairoa River are very susceptible to flooding.

In addition to identifying asset management priorities, the ranking process showed that seismic hazard is likely to cause the greatest disruption to the network and therefore the recovery of the district. Flooding poses the next greatest risk, followed by landslip. The next hazards, ranked in decreasing order, are wind, volcanic ash and wild fire. The impact of these last 3 and the disruption they cause is likely to be significantly lower and more short-term than that of the other hazards.

Map 9


Mahanga Beach
Kopuawhara
Opoutama
Mahia
Mahia Beach
Whangawehi
Morere
Nuhaka
Whakaki
Te Reinga
Marumaru
Frasertown
Wairoa
Ruakituri
Ohinepaka
Waihua
Mohaka
Raupunga
Waikare
Kotemaori
Willow Flats
Putere
Tuai
Waikaremoana
38
ROAD RANKING KEY
5 High
4
3
2
1 Low
TLA Boundary
LEGEND
Port of Napier
Airport
Railway

Chapter 9.3
Napier City Council

NETWORK DESCRIPTION

Location

Prior to the 1931 earthquake, Napier City consisted of a town constructed on a relatively narrow shingle spit running from Ellison Street to Domain Road and including the hill area (Scinde Island). At that time the Tutaekuri River ran along the western side of Georges Drive and exited to the sea via the Iron Pot. Much of the developed area between the inner city and Georges Drive had been reclaimed from tidal marshlands.

During the 1931 earthquake the land in and around Napier rose between 1 and 2 metres. Large areas of seabed and marshland were lifted above the high tide level and became suitable for land development.

Today, Napier City covers an area of 10,270 hectares and has a population of approximately 50,000. The city area is bounded by coastline to the east, the Tutaekuri River to the south, the Poraiti hills to the west and the Esk River to the north.

The Roading Network

There are 338 kilometres of roads in Napier, of which 99.7% are sealed.

Much of the network - 285 kilometres – can be described as urban. This includes the inner city, the townships of Meeanee and Bay View and the Awatoto industrial area. The balance of the network - 53 kilometres - is rural.

Three state highways (SH2, SH5 and SH50), with a total length of around 37 kilometres, pass through the City. The carriageways and traffic services of these roads are managed by Transit NZ.

The state highway system is an integral part of the Napier City and regional transportation network. The city is ringed by 10 major bridges. Seven of these are on the state highway system, 2 are jointly managed by the Napier and Hastings councils and one is managed by the Hastings District Council.

Within the city's roading network are the Port of Napier and Hawke's Bay Airport, making Napier the focus of the region's major long distance heavy transport system

Lifelines Network Description

Most of the roads evaluated for the Engineering Lifelines Project are on the Heretaunga Plains where the land was uplifted from the seabed and marshlands during the 1931 earthquake. In general they lie between 0m and 3m above mean high water level and are therefore at high risk from liquefaction, flooding and tsunami.

For this project, 29.4 kilometres have been identified as "critical" during a major hazard event. These have been further subdivided into 8 strategic routes including collector, principal and arterial routes with traffic volumes between 2,000 and 21,000 vehicles per day.

The attached Map10 shows these routes and they are described below.

Route 1

This route runs along Puketitiri Rd from the city boundary and includes Wharerangi Rd, Westminster Ave and Tamatea Dr to the roundabout on Hyderabad Rd. The route has been divided into a hill section and a plains section and ranked accordingly.

Route 2

This route runs along Puketapu Rd from the city boundary and Meeanee Rd to the Expressway intersection. The route has been divided into a hill section and a plains section and ranked accordingly.

Route 3

This route runs along Church Rd and links routes 1 and 2.

Route 4

This route runs along Gloucester St from the city boundary and Lee Rd and Kennedy Rd to the CBD. This is the main arterial between Taradale and the inner city and connects most of the main suburbs.

Route 5

This route runs along Meeanee Rd from the intersection with the Expressway, Meeanee Awatoto Rd and Waitangi Rd. to SH 2.

State Highway 2 Waitangi Bridge July 1992

Route 6

This route runs along Sandy Rd from Meeanee Rd to the city boundary at the Tutaekuri River.

Route 7

This route runs along Breakwater Rd and Marine Parade to the city Boundary at the Tutaekuri River.

Route 8

This route runs the length of Hill Rd from SH2 to SH 5.

Risk Assessment

Seismic Damage

Although there are no known major fault lines passing through Napier City, the area is ringed by a number of major regional fault lines which present a seismic risk to the city and its transportation network.

There is medium probability that a future major earthquake would result in land subsidence of up to 0.6m. Therefore, in addition to the risk of structural damage to bridges and culverts and liquefaction of soils on the Plains area from a major earthquake, there is also an increased risk of flooding and tsunami. Wind, fire and volcanic ash deposits pose lesser risks.

It should be noted again that most of the major bridges in and around Napier City are under the control of Transit NZ or the joint control of the Napier and Hastings Councils. These structures are analysed in the Transit NZ and Hastings District Council reports and assessments.

In the rest of the network there are a number of major box and pipe culverts, most of which are on raft foundations. These may sustain structural damage and could slump and tilt in a major event because the soils they are in will be subject to liquefaction. If there is general and/or uneven subsidence parts of the network may end up below mean high water level, leading to ongoing drainage problems.

Westshore Embankment Road following 1931 Hawke's Bay Earthquake.

Flooding and Tempest

A breach or overtopping of the left-hand stop bank on the Tutaekuri River is expected to result in major flooding of much of the Napier City roading network in the Plains area. This is likely to close most of the network in the short-term although no major structural damage is expected.

Tsunami

Napier City has a significant length of coastline that is highly vulnerable to a tsunami. Tsunami wave action would damage buildings and structures along the coastline, resulting in debris and inundation for a significant distance inland. An event like this would have the same effects as flooding of roads in the area of inundation.

Volcanic Ash

There is low risk of a significant volcanic ash fall and any such fall is likely to be of nuisance value only.

Wildfire and Wind

This risk of wild fire and high wind is low.

Risk Assessment Results

The risk assessment shows that seismic activity poses the greatest threat to the roading network, with the identified routes ranked from highest to lowest in terms of the impact they would suffer:

Routes 4, 1, 2, 8, 7, 5, 4 and 6.

The risk of flooding was assessed as high on Routes 4 and 7.

The hazard ranking and risk analysis was undertaken using the system adopted by the transportation group. This provided a logical step-by-step process.

Hazard Mitigation

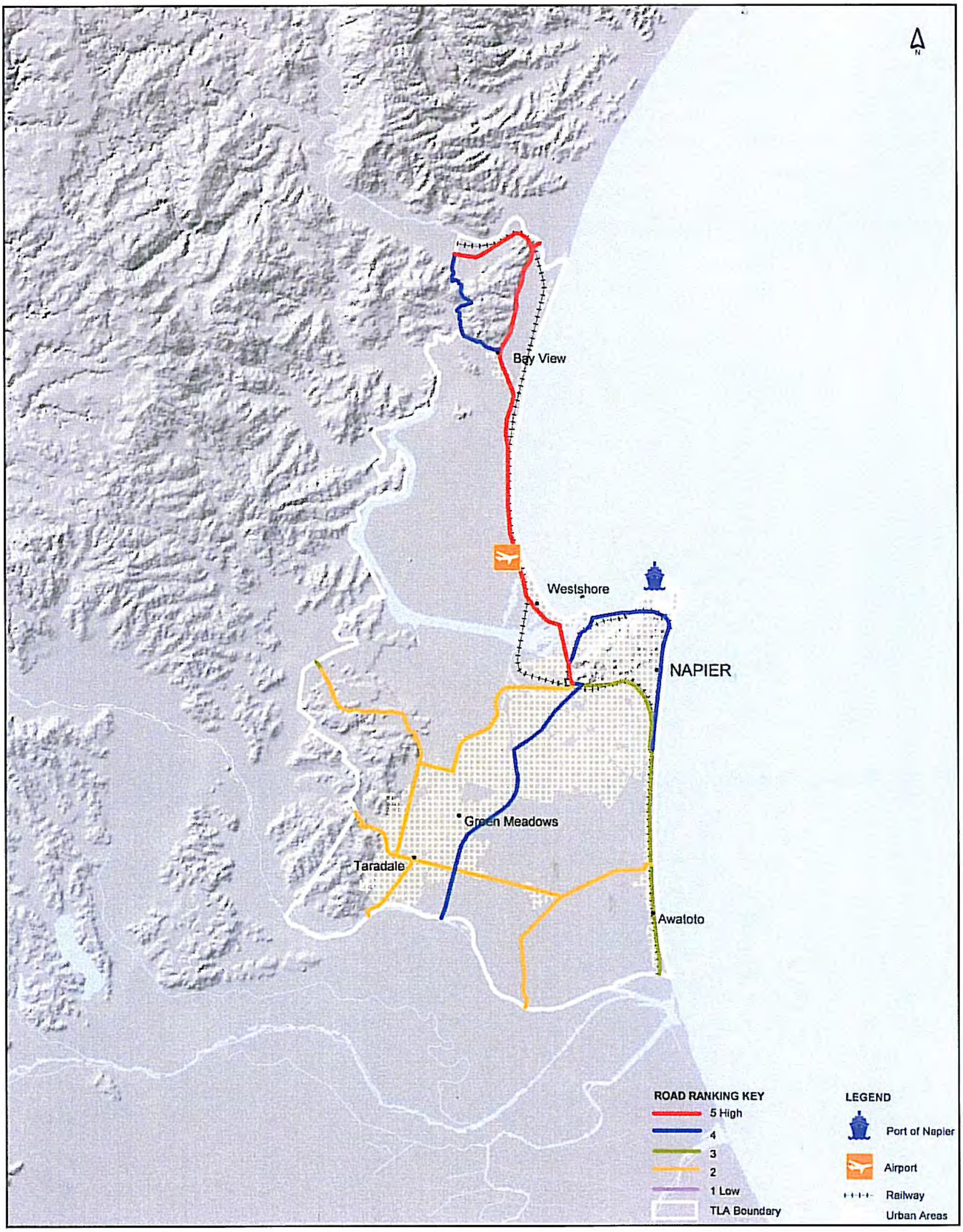
As most of the routes are on the Plains area mitigation requirements are minimal.

All structures on the defined routes are designed to current codes and no further hazard mitigation measures are planned.

On the hill sections of the various routes a programme is underway to improve benching and road widths. This will increase the ability of the routes to cushion the effect of landslips. This applies to Route 1 Puketitiri Rd, Route 2 Puketapu Rd and Route 8 Hill Rd. Hill Rd is regarded as an important alternative to parts of SH2 and SH5.

Map 10

Transportation
Roading Network Napier City Rankings



Chapter 9.4

Hastings District Council

General

Hastings District is centred on Hawke Bay and covers just over 500,000 hectares. It is predominantly rural but also includes a significant urban base in the City of Hastings, together with Havelock North and Flaxmere. The total urban population is about 50,000. There are rural townships at Clive, Haumoana, Te Awanga, Waimarama, Pakipaki, Bridge Pa, Omahu/Fernhill, Puketapu and Patoka. There are also a number of rural settlements including Puketitiri, Whirinaki, Tangoio/Tangoio Beach, Waipatiki, Arapaoanui, Tutira and Putorino. The population of the Heretaunga Plains, excluding the main urban centers but including Clive, Haumoana and Te Awanga, is around 10,000 with approximately 10,000 more people spread across the rural area.

Geographic Setting

Hastings is bounded by Wairoa District to the north, Taupo District in the northwest, Rangitikei to the west and Central Hawke's Bay District to the south. It surrounds the city of Napier. SH2 runs north/south through the district and SH5 runs northwest/southeast, to the Esk Junction with SH2. SH50 runs across the Plains out to the west via Maraekakaho and then southwards to Central Hawke's Bay. The new Hawke's Bay Expressway has been designated State Highway 50A at Links Road intersection to SH2 at Pakipaki via York, Maraekakaho and Pakipaki roads.

The state highways provide the only road access in and out of the district to the north and the northwest. The Taihape Road is a regional arterial route and provides the only link to the west. There are a number of parallel routes to the south, where the terrain is generally easier. It would probably be from this direction that assistance would first come after a major lifelines event.

The Roading Network

The Hastings District roading network consists of 1600km of roads and extends from the coastline of Hawke Bay and Waimarama to the central ranges in the west and north. A total of 1100km of the roads are sealed, covering the urban areas, the Heretaunga Plains and extensive peripheral roading. The 500km of unsealed roads are predominantly in the Waimarama sector (east), the hinterland of the Kaweka Ward (west/northwest) and the Tutira Ward (northwest/north). This latter ward lies almost entirely in steep hill terrain (refer Map 11 attached). There are also some unsealed roads in the south of the district.

Five major rivers run through the district; the Mohaka, Esk, Tutaekuri, Ngaruroro and Tukituki. The latter three are on the Plains and near to urban areas. In the Plains area, bridges are long and vital to maintaining access.

The district has a total of 249 bridges and major culverts. Of these, 38 have been identified as part of the strategic Lifelines roading network. of which 16 are on the Plains.

Hastings City is built on a mixture of ground conditions, including extensive underlying swamp, together with lenses of river shingle, silts, good soils and running sands occurring randomly across the urban area. Only three specific roads have been singled out for in-depth study - the Hastings-Havelock Road and Pakowhai and Omahu Roads.

Vulnerability

Hawke's Bay is laced with earthquake fault lines, making seismic activity the dominant risk to the strategic lifelines network particularly for bridging. Landslip, followed by flooding, present the next, but lesser risks. Wind, volcanic ash and wild fire pose a relatively minor risk to the network.

Access Alternatives

In a major event, access to the north, northwest and west will be dependent on the two state highways and the Taihape Road, as there are no alternative routes in these directions. Toward the south there are a number of parallel routes, which should be able to provide quick access in and out of the district. There is also a private aerodrome at Bridge Pa owned and operated by Hawke's Bay East Coast Aero Club. The Palmerston North – Gisborne rail line provides a further link for the region.

Risk Analysis

Out of the roads and 38 bridges in the strategic lifelines network, risk analysis has identified 10 roads and 10 bridges as critical links in the Hastings District Council roading network. These are listed below:

Critical Roading Links – Hastings District

Note: all links are seismic risks

1. Rissington Bridge
2. Red Bridge
3. Swamp Road
4. Havelock Bridge
5. Glengarry Road
6. Valley Road # 3 Bridge
7. Redclyfffe Bridge
8. Taihape Road
9. Waipunga Bridge
10. Kaiwaka-Waikoau Roads
11. Seafield (Nth)
12. Whanakino Bridge
13. Te Onepu-Raukawa-Valley Roads
14. Kuripapaongo Bridge
15. Dartmoor Road
16. Middle Road (Hv.Nth-CHB boundary)
17. Waimarama Road (East)
18. Kahuranaki Rd- (Red Br to Rochfort Rd)
19. Brookfields Bridge
20. Dartmoor Bridge

Seismic Damage

Seismic damage will be extensive in a major event, affecting the rural hill areas of the district fairly evenly. The Heretaunga Plains are not likely to be severely affected.

Fault displacement is the primary threat to most of the roads listed, with liquefaction being identified as a risk for Swamp Road, Seafield Road (N), Dartmoor Road and parts of Puketapu Road.

Rissington Bridge, across the Mangaone River, is most at risk from seismic activity, followed by Red Bridge across the Tukituki River. The Havelock Bridge across the Karamu Stream is also high on the list because of its strategic location and the services it carries.

Flood

Major flooding is likely to have the following impacts:

i) The Tutaekuri River will break out and flow south through Swamp Road (Puketapu to Omahu);

ii) The Ngaruroro River will come through the Mere Road area and head south east through Flaxmere, along the southeast edge of Hastings City toward the south side of Havelock North;

iii) The area around Pakowhai will be inundated to over 1m;

iv) The lower reaches of the Karamu Stream and Muddy Creek will inundate land and roads south of Mangateretere through Whakatu and Clive, with up to 1.5m of water in the Mill Road area and 1m over Napier Road.

Red Bridge has also been identified as being at risk in the event of a major flood.

Tsunami

Only two coastal roads of the critical network will be affected by a 'scenario' Tsunami (10% probability in 50 years). These are Mill Rd and Tukituki Rd, together with Black Bridge and its approaches.

Volcanic Ash

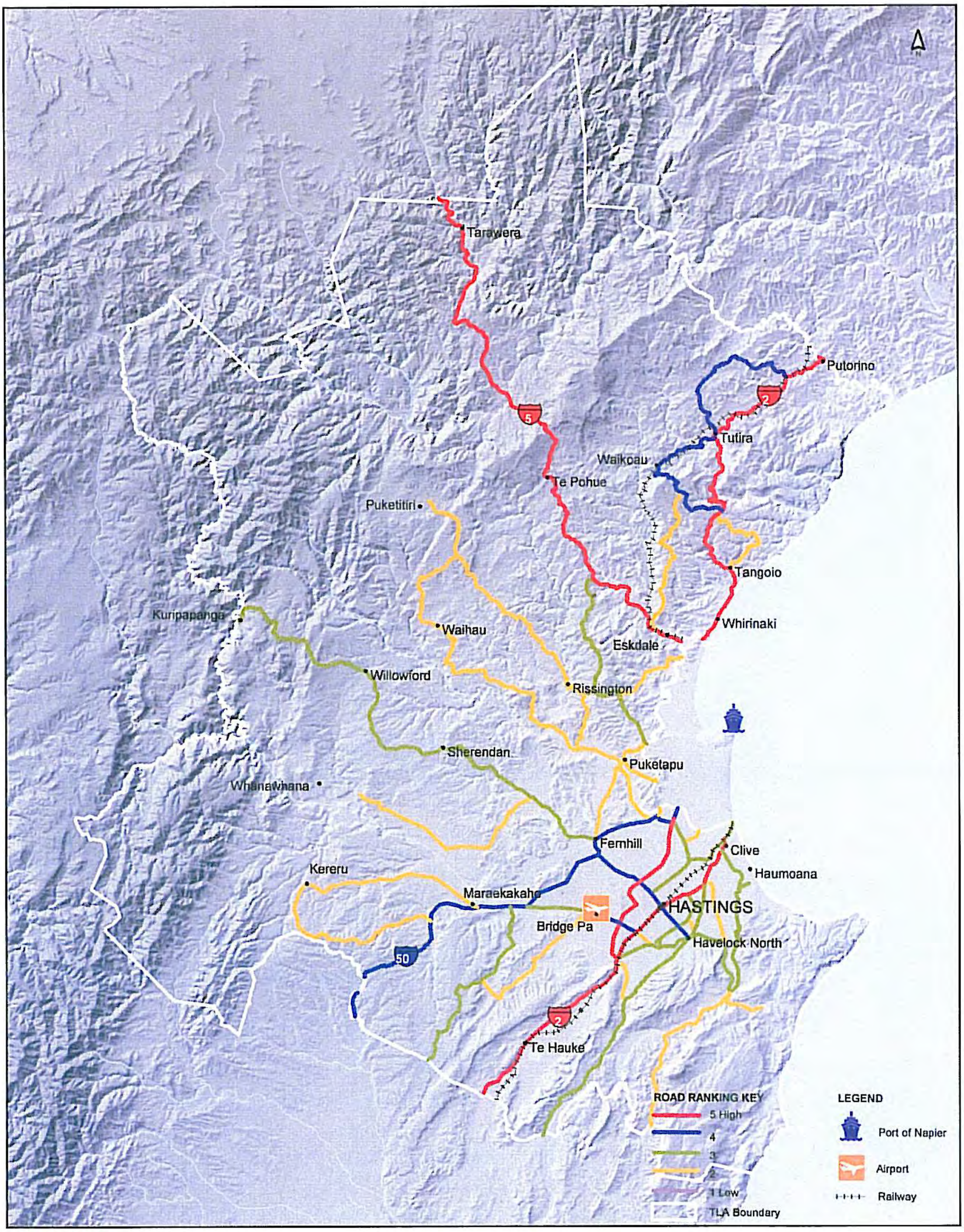
Ash falls will only be significant toward the western ends of the Taihape and Puketitiri roads, and are unlikely to close these roads.

Wild fire

Only Taihape Road and Kereru Road south are at risk from wild fire.

Map 11

Transportation
Roading Network Hastings District Rankings



Chapter 9.5

Central Hawke's Bay District Council

General

The roading network under the control of Central Hawke's Bay District Council (CHBDC) comprises 1293km of roads of which approximately 65% (846km) are sealed and 35% (447km) unsealed. Within this network are 171 bridges and numerous culverts.

Location

The Central Hawke's Bay District roading network is located between the Hastings District boundary to the north and the Tararua District boundary to the south. To the west, the network borders the Ruahine Ranges and to the east, the coast and Pacific Ocean.

The Roading Network

The district is broken down into three wards; the Ruahine Ward on the western side, the Aramoana Ward on the eastern side and the small Ruataniwha Ward, which includes the built up areas surrounding the towns of Waipawa and Waipukurau.

The area is served by two state highways under the control of Transit New Zealand - SH2 and SH50. These run northeast/southwest through the centre of the district. A rural arterial route, comprising the Porangahau and Wimbledon Roads, runs south from Waipukurau towards Porangahau and then southwest, parallel with the coast, to the district boundary.

A number of distributor roads, with local roads leading off them, link SH2 and SH50. The location of these distributor roads is fixed by topography or the major Tukituki and Waipawa river systems, or their tributaries. To the west of SH50, distributor roads lead towards the Ruahine Ranges and small farming settlements in the area. East of SH2, several distributor roads link directly, or through local roads, with the significant settlements of Takapau and Porangahau, and to the popular beach destinations of Kairakau, and Pourerere, the marine reserve at Aramoana, Blackhead and Te Paerahi (near Porangahau).

Alternative Access

In a major event, access could be provided by alternative routes parallel to the state highway to the northeast and southwest. There is also a private airfield owned and operated by the Central Hawke's Bay Aero Club at Waipukurau. The Palmerston North to Gisborne rail line provides another link through the district and, in extreme circumstances, topdressing airstrips and sea access (beach landing) are available.

Vulnerability Ranking

For the Engineering Lifelines project the sections of state highway within the district are addressed by Transit New Zealand. Assessment of the remaining roading network has focused on the significant routes (rural arterial and distributor) as well as selected local roads (those serving significant settlements, providing alternative access to adjacent local authorities or alternative routes to State Highways).

Road Network Vulnerability Assessment

To assess the overall network and route vulnerability following a hazard event the road network was subdivided into 36 sections. These were chosen to verify the availability of alternative routes to bypass vulnerable sections, or duplicate important sections, of the network.

This selection process resulted in four routes (including the state highways) crossing the northern and southern district boundaries, reflecting the importance of the main traffic movements and access to the district for recovery from an event. Within the district, two routes were chosen to service most significant settlements. The selected roads or road sections are shown on the attached Map 12.

Bridge Vulnerability Assessment

Bridges are key elements within the roading network. Earthquake and flood damage to bridges will vary greatly, with those built to modern codes and construction standards likely to perform well and pre-1960s bridges expected to sustain damage. A significant number of the older bridges are relatively robust with short spans and low pier height. Damage to them is likely to include impact (concrete deck to concrete abutment), batter slope failure, approach settlement, concrete cracking/spalling, rotation and foundation failure.

Span collapse is the main threat to bridges and the importance of superstructure linkage cannot be overstated. In this study local knowledge and experience has been used to evaluate the likely seismic performance of the bridges. More in depth screening is required to identify specific bridge deficiencies.

Road Section Importance

Each chosen sections of the CHBDC road network was given a local roading importance ranking. These were based on a combination of their district or inter-district strategic importance, whether the route was regionally important (being an alternative to the state highway) and the availability and condition of alternative routes.

Road Section Ranking

The key risk elements within each road section were identified and assessed for each of the defined hazards in the following terms:

- Their relative vulnerability, and
- The impact each hazard would have on the section of road during the event, immediately after and throughout the period of recovery.

These aspects were 'scored' with totals determined for each road section and defined hazard.

After including hazard rank and route importance the selected sections of road were given an overall hazard score which was used to rank or prioritise them.

Vulnerability Ranking Results

The results of the vulnerability ranking confirm that the CHBDC roading network is robust and has good availability of alternative routes. The process highlighted the following network issues:

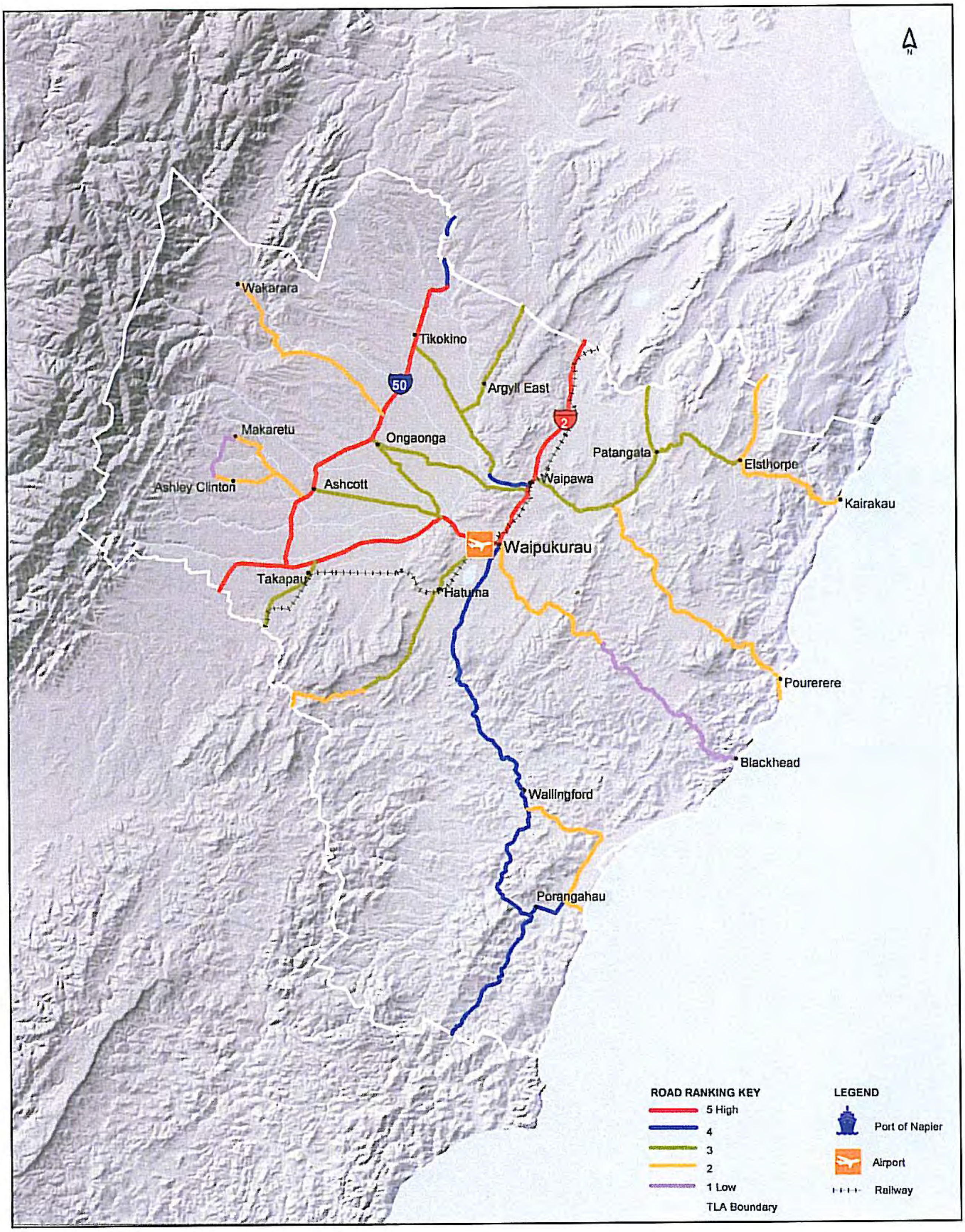
- SH2 provides the main lifeline through the district and connects the towns of Waipawa and Waipukurau;
- SH50 is the main alternative route through the north of the district and, in conjunction with local roads, provides an alternative route between Waipawa and Waipukurau;
- Onga Onga Road and Onga-Waipukurau Road form another alternative route between Waipawa and Waipukurau, giving the network a by-pass around the older SH2 bridges just north of Waipukurau;
- The Takapau-Ormondville Road provides an alternative route through the south of the district, close to SH2;
- Porangahau Road and Wimbledon Road form an alternative route through the south of the district, further away from SH2;
- The Salesyard, Old Station and Willis Bridges are susceptible to ground shaking;
- The Wallingford, Mangamaire, Old Station and Willis Bridges are susceptible to liquefaction;
- Tikokino Road is important for servicing and assisting with the recovery of Waipawa township and the Waipawa and Otane water supply pump station and pipeline;
- The Porangahau Bridge is susceptible to tsunami and large floods;
- A relatively high level of alternative routes needs to be maintained through the north of the district, due to the number of earthquake fault traces in the area;
- Both roads and bridges in the network are susceptible to seismic activity.

The ranking process also identified that seismic hazard is likely to cause the greatest disruption to the network and recovery of the district. The next ranked hazards, in decreasing order, are flooding and landslip. Wind, volcanic ash and wild fire are expected to have a significantly lower and more short-term impacts than the other hazards.

Further investigations are required to ensure upgrading or mitigation works are appropriately targeted. Mitigation measures, such as those suggested in the Transportation Group report, will be considered and implemented if appropriate.

Map 12

Transportation
Roading Network Central Hawke's Bay District Rankings



Chapter 9.6

Tranz Rail Limited

Description of Network

Tranz Rail Ltd operates the railway lines through Hawke's Bay. They comprise the Palmerston North – Gisborne Line (PNGL), and the Ahuriri Branch Line, which links the Port of Napier with the PNGL at Pandora, Napier. These lines are part of a larger network running from Wellington to Auckland through the central North Island.

In general the rail link from Palmerston North follows the same valley systems as the state highway, from Waipukurau to Napier. The topography is mostly easy, but with heavy grades at Opapa, and long bridges across major rivers. From Bay View, the topography is more difficult, and the line follows an inland route, rejoining the state highway at Tutira. From there, it generally follows the highway to Nuhaka. The route is characterised by numerous tunnels, some large steel and concrete viaducts, and many timber piered bridges across narrow waterways. From Nuhaka the route mainly follows the coast to Gisborne.

The Ahuriri Branch Line follows the western side of Bluff Hill to the Port. Tranz Rail has fuel and repair facilities at Pandora.

North of Eskdale and south of Hastings train control is via radio-based track warrants from the Wellington Train Control. Tranz Rail operates its own radio network. From Hastings to Eskdale signals and points are remote controlled from Wellington, via Telecom circuits. When power fails, many installations have back up supplies, or can be manually operated. Tranz Rail has operating procedures which allow it to work around failed equipment. However, these are dependent on communications systems.

Results of Risk Assessment Study

The study has highlighted that seismic activity presents the greatest overall risk for Tranz Rail in the Hawke's Bay region. The major problems are likely to result from settlement and displacement in the southern part of the region, affecting rail formation. This is due to the nature of underlying strata, rather than the rail formation itself. It is therefore difficult to take measures to deal with this problem.

Westshore rail bridge. (Photo courtesy John Keenan)

Tranz Rail has procedures which will ensure that trains do not pass over any affected lines before a safety inspection has been carried out. After a major seismic event, it is expected that trains will be running at reduced speed within a reasonable time frame.

Although key structures on the rail network are less vulnerable than rail lines, any damage to them could disrupt the rail services for longer. The up-to-date data gathered for this study will be applied to structures in due course, to reassess their vulnerability.

Generally, seismic hazard presents less of a risk north of Napier than to the south. To the north, flooding and landslip are more of a threat. Again, Tranz Rail has procedures to ensure that trains do not pass over any affected lines before a safety inspection has been completed. It is expected that trains will run at reduced speeds within a reasonable time frame after flooding of landslip.

Train Gisborne bound. (Photo courtesy John Love)

Chapter 9.7

Hawke's Bay Airport

Locality

The Hawke's Bay Airport is built on land uplifted by the 1931 earthquake and is situated at Westshore in Napier, alongside State Highway 2 and the Napier-Gisborne rail-link. The land is low-lying with the sea water table at about 500 mm below ground level, depending on the tides. The site is continuously pumped to protect the facilities from tidal flow.

Hawke's Bay Airport July 2001.
(Photo courtesy of Hawke's Bay Regional Council)

Services

Airside

There are two main runways - '16/34', fully sealed 1310m x 45m and '07/25', sealed 600m x 30m and grass 619m X 60m. There is also a parallel grass strip, '16/34' 766m x 60m, for light aircraft. Grass '10/28' is closed. There are two sealed and a number of grass taxiways, and a sealed and concrete apron in front of the terminal.

The main runway has runway edge lighting, approach lighting and Precision Approach Path Indicator (PAPI) lights. Lighting towers next to the terminal light the apron. A VHF mnidirectional Radio Ray (VOR) station is situated 0.7 nautical miles north of the main taxiway on land owned by Landcorp.

The Airways Corporation provides air traffic control services with a new 20m tower about to be built. VHF radio is used to communicate with aircraft and ground vehicles.

Airport Rescue Fire staff are on duty whenever there are scheduled arrivals or departures of aircraft that seat 30 or more passengers.

There are a number of private hangars at the airport used for aircraft storage and as maintenance facilities.

Mobil, Shell and BP provide aircraft refuelling facilities

The airport has large open drains along the main runway and excess water is pumped into the estuary by four pumps. Normally one pump operates from 12 to 24 hours per day with the others coming in progressively as required.

Landside

Terminal and car parking facilities are provided for scheduled airline services.

BP has a Jet A1 fuel depot beside the main access road.

The Napier Aero Club has its clubhouse on airport land.

Rental car companies have vehicle cleaning and storage facilities.

Power, water and telephone services are provided to the terminal and a number of other facilities.

Sewerage is pumped to the Napier sewage system from two pumps, situated at the terminal and beside SH2.

Stormwater and ground water are pumped off site by 4 pumps. The water table is normally only 500 mm below the low-lying ground level. Because the gravel foundation materials are porous, the water table rises during high tides and in periods of sustained rainfall.

Results of Risk Assessment

Risk assessment has identified a long power cut as posing the greatest risk to the continued operation of the airport, particularly if the runways are flooded.

Risk assessments for electricity power supply have been made by the Energy Task Group and are reported in Chapter 11. For the airport, there is a need to provide connections for mobile power generators.

Seismic Hazard

Ground Shaking

The performance of the various buildings on site will depend on their age, construction and the date of their most recent structural upgrade.

A new control tower is presently under construction and will conform to current codes.

It is possible that ground shaking would result in uneven or cracked runways. However there is no practical way of preventing this.

After a report of any earthquake, it is normal practice to issue a notice to aircraft that landing lights are suspect until checked. A similar notice could be issued in regard to damage to the runway following an extreme earthquake.

Liquefaction

Although the area around the airport is designated as having very high susceptibility to liquefaction, the airport site itself is generally underlain by gravels from a very shallow depth.

As a result, liquefaction is not expected to be a problem, except at a few isolated locations where there are silt and sand deposits.

Fault Displacement

Fault displacement is not expected to occur.

Ground Settlement

A subduction thrust earthquake could result in general settlement accompanied by a greater influx of underground seawater. This would have seriously affect the operation of the airport.

There are no practical measures to mitigate against this risk.

Flooding

Extreme flooding could affect the operation of the airport.

Stormwater systems need to be maintained to ensure continual pumping is possible to minimise the extent of flooding.

Tsunami

Large tsunami would significantly affect the operation of the airport. There are no practical mitigation measures against this hazard.

Landslip

Landslip is unlikely to pose a threat to the airport.

Wind

Because the local meteorological station is located at the airport, all structures are designed and built to the relevant loading code.

Volcanic Ash

Volcanic ash has an immediate effect on aircraft movement. Any volcanic ash in the area is expected to affect aircraft flights and, as a result, the airport itself.

In the past flights have been diverted to avoid areas where it is suspected the air is laden with ash.

An ashfall on runways and taxiways would close the airport until the surfaces had been adequately cleaned.

Wild Fire

Wild fire is not expected to occur at or near the airport.

Chapter 9.8

Port of Napier

Locality and Layout of Berths

The Port of Napier (Port) is situated north of Bluff Hill within Hawke Bay. It is a breakwater port with the breakwater lying south of Pania Reef. The cargo stacking areas and the area adjacent to the main berths are on reclaimed land.

The layout of the berths is shown on the attached plan. All the main berths may be classified as open pile structures. The date each berth was constructed is shown on the plan. The working draughts of the berths varies from 9.2m to 11.5m.

Port of Napier July 2001

Layout of Services

Water

The Port receives its drinking water from the Napier City Council (NCC) ring main that traverses the base of Bluff Hill. There are two feeds of 150mm diameter and one of 65mm diameter. All three connections are protected with backflow preventors. There are ring main feeds behind both Kirkpatrick and Higgins Wharves. Although there is no separate fire reticulation system, there are a large number of fire hydrants on the drinking water pipe network.

Wastewater Reticulation

Seventeen independent pump stations, situated on two different systems, pump the Port's wastewater to the NCC sewerage network. One system discharges into a NCC manhole at the bottom of Coote Road and the other into a manhole at the bottom of Hornsey Road. The Port of Napier maintains the network.

High Tension (HT) Voltage Reticulation

Hawke's Bay Networks' high tension 11 kV reticulation is ring-fed throughout the Port. Two main below-ground feeders enter the Port, one from the eastern end and one from the western end of Bluff Hill. HB Network maintains this reticulation.

Low Tension (LT) Voltage Reticulation

There are 11 transformer substations strategically placed on the HT reticulation. The 400v LT reticulation is inter connected and has limited capability of providing a ring main type system. The average power demand of the Port is approximately 2000kVA.

The Port of Napier maintains the LT reticulation.

Communications

Telephones

The Port of Napier has a local area network (LAN) made up of an integrated fibre and copper cable reticulation. The communication cable reticulation is owned and maintained by the Port of Napier. At present Telecom have a 200 pair gas-filled cable connected. This cable feeds directly into the PONL PABX, which is situated in the Port Administration Building. This system will be mirrored in the Port Operations Building. A second 15 pair independent Telecom incoming cable is located at a junction box at the container cleaning amenity. This cable is not connected but is able to be used as an alternative feed if there is an outage on the main cable.

Mobile Phones

The Port utilises a large number of mobile phones, which are connected to the Telecom Cellular Network.

VHF and UHF Radios

Cargo operations activities use UHF radios while marine operations are handled on the VHF frequency.

Wharf Importance

No. 1 Wharf is regarded as the most important, mainly because it is the newest wharf to be designed to modern design codes. The land-based wharves, including No. 1, are considered to be more useful from a cargo handling point of view than the No. 3 and No. 4 finger wharves. "A" Wharf is a sheet piled structure and is used as the Port's tug berth. The Port's container terminal is situated behind No. 5 (north) and No. 5 (south) Wharves. Breakbulk cargo is mainly handled from No. 1, No. 2 (north) and No. 2 (south).

No 5 Kirkpatrick Warf Port of Napier July 2001.
(Photo courtesy HBRC)

Hazard Ranking

The Port's 8 main wharves were assessed for each of the defined hazards in terms of their vulnerability, the impact on a wharf during the hazardous event and the effect on normal cargo handling operations while the wharf was repaired.

These aspects were scored with totals given for each wharf for each of the defined natural hazards. The hazards themselves were also ranked to develop the total scores.

This procedure is similar to the assessment for roading networks. It enables a ranking schedule to be developed which identifies those wharves likely to pose the greatest risk to the Port, and thus the region's recovery, following a natural disaster.

Results of Risk Assessment

The hazard ranking process has shown that seismic activity is the natural hazard most likely to cause major disruption to cargo handling at the Port. This is followed by flooding, wind, landslip volcanic ash and wild fire in descending order of their potential for causing major disruption to operations.

Given the Port's vulnerability to major seismic activity an investigation of wharf structures and reclamations was carried out.

No 3 Geddis Wharf under construction 1939.

There are four main components of seismic activity:

Ground Shaking

The rock armouring to the reclamation faces can be expected to yield and deform under seismic load. However, because they are relatively flexible, they can survive seismic events with only minor damage. Some of the rock armour may drop off in minor earthquakes and this could get progressively worse for large earthquakes. Although this would result in some shallowing of the berths, it would not close them or render them useless. Grab dredging would be required to clear the berths.

The principal concern is whether piles passing through the reclamation batter faces could survive any slumping or deformation. Given past experiences, the piles could be expected to remain serviceable after minor or medium events. However, in a major event, the embankment deformation for the land-backed wharves could render the piles incapable of carrying their design loads.

Wharves supported on raking piles can experience failure from low level events in the pile/subsoil skin friction and pile/deck reinforcing bond, yield in the pile reinforcing steel and shear failure in the deck beams for transverse events. For longitudinal events most wharves should suffer little damage. The exception is Wharf No. 3, which has longitudinal raking piles. This wharf deck structure will suffer damage in the region of these piles.

For wharves which are tied back to concrete deadman anchors, the anchors and back wall will yield for medium transverse events and fail for major events.

All wharf structures should be fully serviceable following a minor earthquake and most following a medium event. Although a major earthquake is likely to severely damage the horizontal force resisting elements, most wharves will still be serviceable with loading and draft restrictions.

Liquefaction

The seismic stability analysis carried out for the design of the No. 1 wharf indicates that there is little potential for massive failure as a result of liquefaction. The site geology of the harbour can be simplified into four units - recent fill, marine silts, interbedded sand and sandstone and basement siltstone. Of these, only the marine silt and sand layers are susceptible to liquefaction. Any silt layers that have not been removed by dredging or displacement by reclamation fill are generally thin and sporadic. There is a possibility that some of the sand layers within the interbedded sands and sandstone are prone to liquefaction. However, any liquefaction that does occur will be localised because of the fragmented nature of the sand layers.

Fault Displacement

This hazard is not expected to occur on this site.

Ground Settlement

This hazard is not expected to occur on this site.

The investigation has identified some design shortcomings in the older wharves. However retrofitting or strengthening them would be expensive and is not economically viable. While it is recognised that not all risks can be practically eliminated, mitigation measures should be incorporated where possible.

Flooding

In assessing this hazard, flooding was defined as normal floods due to heavy rainfall, tsunami and severe storm. Flood conditions should not unduly affect cargo operations and an isolated storm would only disrupt operations while it was in progress. However a tsunami would completely disrupt the cargo handling operation. The extent of structural damage to the wharves would depend on the number of large vessels berthed at the time. Large vessels are likely to break their moorings and collide with adjacent vessels and berths, causing structural damage. Otherwise the wharves should remain structurally sound apart from loss of armouring below the wharves due to the action of incoming and outgoing waves. All buildings would be extensively damaged.

1890's Repairing monoliths on Breakwater after storms

Landslip

Rock fall from Bluff Hill could be expected but, with three entrances located away from the base of the bluff, this is not expected to significantly disrupt access to the Port.

Wind

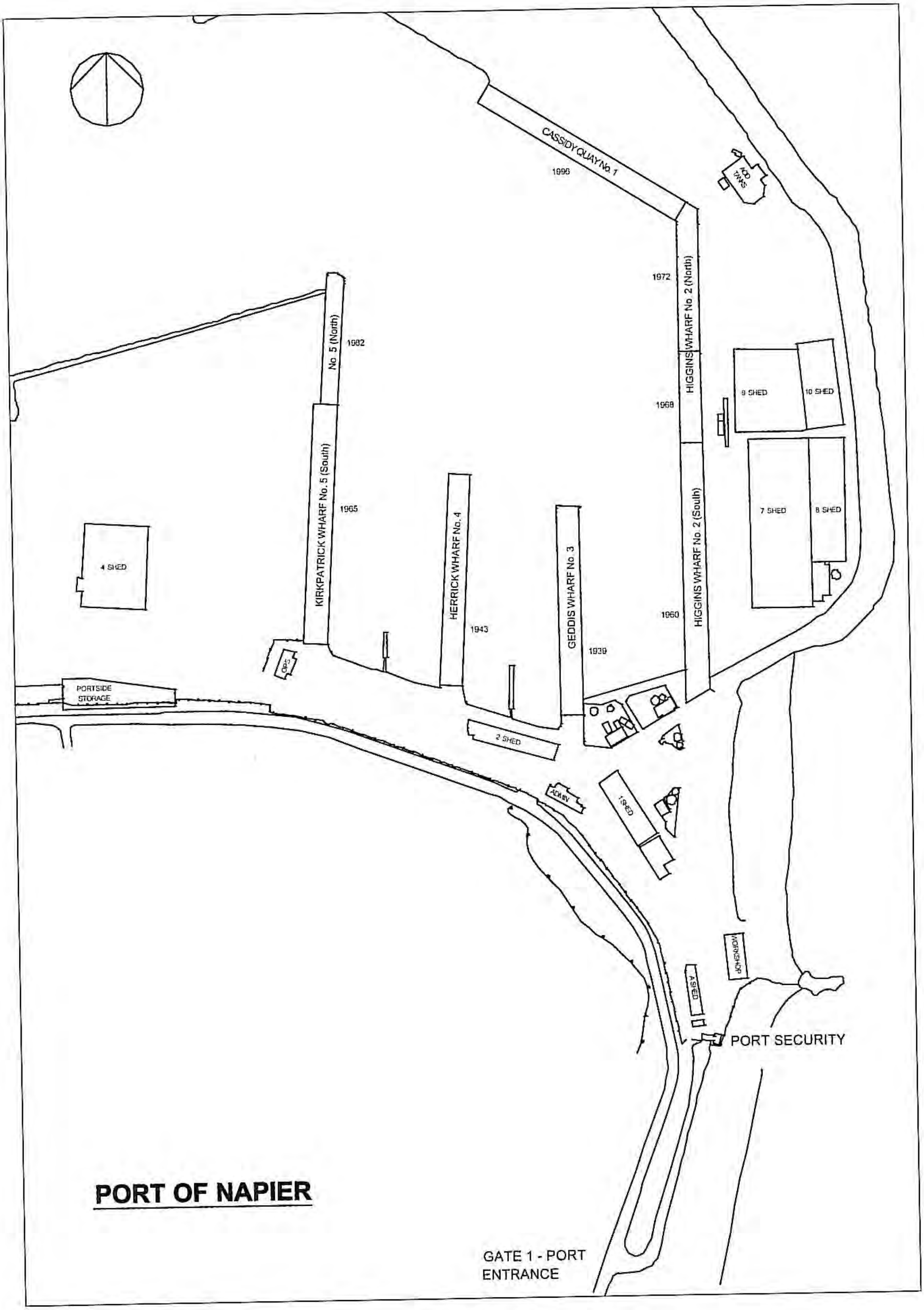
Severe wind will only affect wharf operations and cargo handling, not the wharf structures themselves.

Volcanic Ash

Cargo handling operations will cease during an ashfall. The Port would rely on external contractors to remove the ash and dispose of it.

Wild Fire

This is not expected to occur within the Port.



CASSIDY QUAY No. 1
1996
1972
HIGGINS WHARF No 2 (North)
No 5 (North)
1982
9 SHED
10 SHED
1968
KIRKPATRICK WHARF No. 5 (South)
1965
HERRICK WHARF No. 4
GEDDIS WHARF No. 3
HIGGINS WHARF No. 2 (South)
7 SHED
8 SHED
4 SHED
1960
1943
1939
OPS
PORTSIDE STORAGE
2 SHED
ADMIN
1 SHED
WORKSHOP
A SHED
PORT SECURITY
PORT OF NAPIER
GATE 1 - PORT ENTRANCE

Chapter 9.9

Transportation Group Risk Assessments and Mitigation Measures

Results of Risk Assessments

Risk assessments have identified seismic activity as posing the greatest threat, particularly to structures in the transportation networks.

Bridges built to modern standards are expected to perform well, but those built before the 1960s are likely to sustain damage. The nature of that damage will vary but could include impact damage, batter slope failure, approach settlement, rotation and foundation failure. In-depth investigations can determine if span collapse is possible.

If bridges remain standing following an earthquake it should be possible to temporarily repair them and keep that section of the network open, even on a restricted basis.

Alternative Access

Where a hazard causes part of the roading network to break down, there are number of alternative means of access:

- Road: In many areas alternative routes could be used to circumnavigate affected areas;
- Rail: The rail line generally runs parallel to SH2;
- Air: There are aerodromes at Napier, Hastings, Wairoa and Waipukurau, and several airstrips used for topdressing on agricultural land within the region. Smaller flat areas within the region could also be used for helicopter access in an emergency;
- Sea: The importance of the Port as an alternative access for goods and equipment can not be overstated.

Support Services

The Hawke's Bay region is serviced by relatively large civil/roading contractors, as well as other earthworks and farming contractors, who could be expected to help with recovery operations after a natural disaster. Some of the contractors plant and machinery is likely to be in the district when a natural hazard strikes.

Mitigation Measures

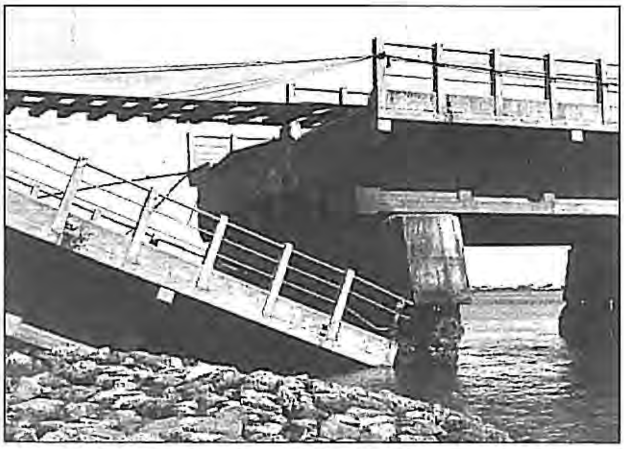
The road section ranking process has identified elements and features of the network that are vulnerable. It shows that the greatest disruption to the networks, and recovery of the region, is likely to be caused by seismic activity.

Seismic activity

Seismic activity has four main components:

- ground shaking
- liquefaction
- fault displacement
- ground settlement

Of the above four only the first two can be practically mitigated against.



1931 Hawke's Bay Earthquake. Lateral spread of the embankment has allowed the landspan to drop off the first pier support collapsing it to the ground. The rail track has remained suspended free of the fallen bridge. (Photo Institute of Geological and Nuclear Sciences)

Mitigation measures may include:

- Strengthening connections between superstructures and substructures on bridges;
- Strengthening lateral and longitudinal restraints on structures and bridges;
- Increasing column, pier or pile strength and ductility on bridges;
- Strengthening abutment or approach fill retention and providing approach slabs to bridges;
- Providing structure, bridge foundation or geotechnical improvements to enhance structural performance and/or limit liquefaction effects;
- Ensuring that vulnerable services on lifeline routes are upgraded;
- Ensuring traffic signs and signals are secured as part of a strategic lifelines approach to network planning;
- Undertaking earthquake response planning for materials, equipment, plant and machinery in co-ordination with the contracting industry.

While specific measures have been suggested above, further investigations are needed to identify and prioritise upgrading work needed for roads and bridges.

Flood Hazard

The flood hazard has three main components:

- Severe storm
- Significant flood
- Tsunami

Mitigation measures may include:

- Continuing the Hawke's Bay Regional Council programme of monitoring, strengthening and upgrading stopbanks;
- Maintaining road drainage systems and bridge and culvert waterways;
- Reducing surface flooding, although caution is needed with this measure as it often leads to more significant flood problems somewhere else, due to flow diversions or water backup;
- Providing scour protection for bridges and structures, as localised, high velocity flow effects are most likely to damage the road network.

Once again further investigations are needed to identify and prioritise road bridge and structures deficiencies to ensure any upgrading programme is appropriately targeted.

Key Lifeline services, ie water, telephone, electricity and sewerage, straddle Wairoa River after Cyclone Bola 1988.

Landslip Hazard

Landslip hazard has two main components:

- Landslide
- Severe storm

Mitigation measures for surface landslip may include:

- Planting vegetation
- Ground reinforcement
- Groundwater drainage

Geotechnical investigations are required to identify and prioritise landslip problems before any of the above mitigation measures can be investigated.

Wind Hazard

Wind hazard has three main components:

- Severe storm
- Local wind effects
- Wind storm

Mitigation measures may include:

- Ensuring vulnerable (overhead) services on lifeline routes are maintaned and upgraded as necessary;
- Ensuring plantings and 'self sown' trees within the road reserve are not too close to traffic areas;
- Ensuring planting areas are appropriately managed, with controls on tree species, tree spacing, pruning, felling and replanting.

Volcanic Ash Hazard

Volcanic ash hazard can lead to:

- Traffic disruption

Maintenance contractors would need to limit the effects of ashfall with more frequent road and drainage maintenance. Mitigation measures suggested for the wind hazard are also appropriate.

Wild Fire Hazard

Wild fire hazard mitigation measures that can be reasonably undertaken include mowing roadside verges and leaving clear space between plantings and the road reserve.

Recommendation

Transportation network authorities must investigate their civil engineering structures more intensively to determine their resistance to earthquake loadings in particular. Where practical, mitigation measures should be incorporated to minimise the risks noted. Where these measures are appropriate, they can normally be undertaken as part of an upgrade or redevelopment programme.

Chapter 9
Transportation

Introduction

The Transportation Group was made up of representatives from the major transportation networks in Hawke's Bay. This covered roading networks including Transit New Zealand (State Highways), Wairoa District, Napier City, Hastings District and Central Hawke's Bay District Councils (local roads), Tranz Rail (railways), Port of Napier and the Hawke's Bay Regional Airport. The Road Transport Association also gave valuable input and support.

In general the group followed risk assessment methodology developed for the Wairarapa project. However a number of variations were introduced to make the process more efficient and more meaningful.

The Wairarapa methodology closely follows the qualitative analysis method of ASNZS 4360: 1999 Risk Assessment.

Variations like those introduced by the Transportation Group are permitted within AS/NZS 4360:1999: Section 4.3.4 (a) notes that Tables E1 to E3 "need to be tailored to meet the needs of an individual organisation or the particular subject of the risk assessment".

Roading and railway representatives on the Transportation Group found that identifying each particular feature or structure of their whole network would result in many pages of assessments of individual components.

Instead they subdivided their networks into sections. However, even within those sections, there may well be a number of locations that are vulnerable to different hazards. Because the network will effectively be closed if one of those locations fails, the assessments are recorded against the section of network On the electronic spreadsheet the assessors recorded the exact location and the particular risk assessment for each given hazard.

It proved necessary to adapt Table E3 of AS/NZS 4360:1999. The table has 25 combinations of "likelihood" and "consequences". Of these 8 (32%) have a risk rating of E for Extreme, indicating that immediate action is required.

Risk assessment in an engineering lifelines project is a broad sieve that identifies the parts of networks at greatest risk, and therefore most worthy of consideration for mitigation measures. Such a high percentage of E risk ratings is inconsistent with the aims of the project.

The Transportation Group chose to use a semi quantitative method as it meant the elements could be given a 'score' and ranked in order from highest to lowest risk.

This allowed assessors to rate the networks' vulnerability to the various hazards and assess impacts as per the qualitative method. The risk ranking allowed the weighting to use factors derived for generic outcomes.

For a roading network these factors include a weighting allowance for the long-term effects that earthquake damage can have on structures, compared to the effects of a windstorm. Although damage from a windstorm could well lead to a road being closed, it would generally be cleared sufficiently to allow single lane traffic through within 24 hours. By comparison, the loss of a bridge due to earthquake damage would be much more serious and could mean a section of the road is affected for many months.

A number of other weightings were included, for importance, vulnerability, impact of damage, impact time and hazard.

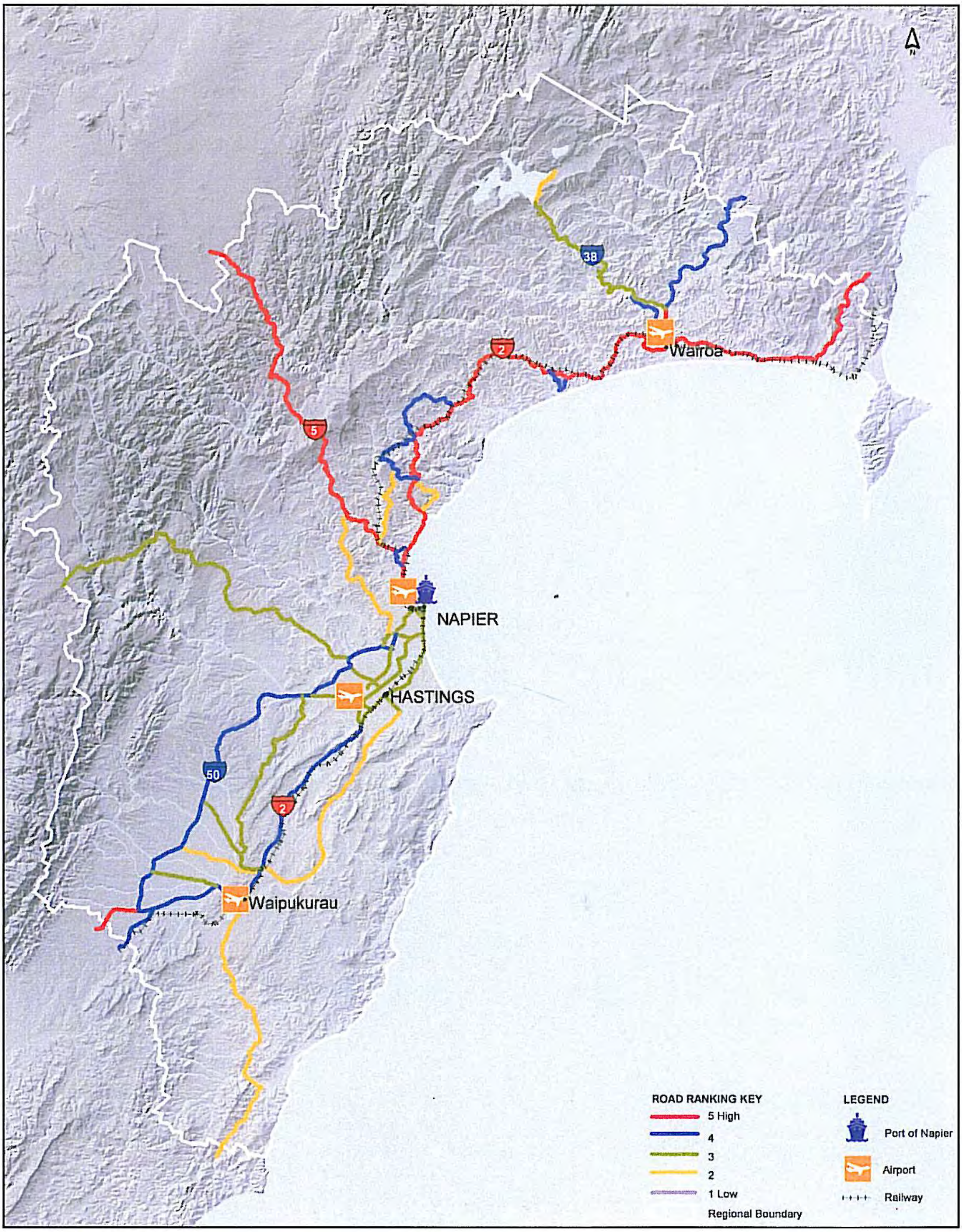
While the numerical values of the weightings used could be debated, any change would only slightly amend the overall rankings. Ultimately, it is the order of risk assessment that is of interest, not the numerical values.

Using this method, the group was able to identify, in order, the elements for which risk mitigation measures should be evaluated.

Flood damaged bridge at Makaretu, September 1988

Map 7

Transportation
Roading Network Regional Rankings



Map 8

Transportation
Territorial Local Authority Road Ranking

Chapter 10

Civil Services Group

Introduction

The Civil Services Group concentrated mainly on water supply and water discharge services. Drinking water and wastewater networks include those operated by Wairoa District Council, Napier City Council, Hastings District Council and Central Hawke's Bay District Council. The same councils are also responsible for stormwater discharge in urban areas, while the Hawke's Bay Regional Council is responsible for operating and maintaining the major flood control and drainage networks.

Because each network is virtually autonomous, they were individually assessed, with minimal comparisons made between them to ensure consistency.

The qualitative assessment method was followed, with little variation.

Wairoa District Council

The Wairoa District Council provides water supply schemes to the communities in Wairoa township, Frasertown, Tuai and the beach settlement at Mahanga. The rural areas immediately surrounding Wairoa are also serviced from the town supply.

Water reatment plant at Frasertown, Wairoa (Photo courtesy WDC)

The systems include a spring, river and bore sources, pumping stations, treatment plant, reservoirs, reticulation pipework, gravity-fed main, service connections, fire hydrants, valves, water meters, electrical and pumping equipment.

The supply for Wairoa and Frasertown comes from an intake on the Waiau River, approximately 2 km from the water treatment plant on SH38. There is a 300mm pipeline between the two communities, made from a mixture of fibrolite and steel. One section of the pipeline is fixed to the structure of the Frasertown Bridge. This portion has gibault joints, which can pull apart during an earthquake, making it very susceptible to failure.

Each pump station is able to connect a generator in the event of an emergency and there is a permanent generator at the water treatment plant.

Wairoa Township Supply

Water is supplied to Wairoa via a treatment plant at Frasertown and a 375mm low pressure main, approximately 11km long. This gravity-fed main was installed in 1966.

To supplement the town supply, there are water storage reservoirs at the same low-level elevation as the town on the northern boundary and high-level storage reservoirs on the hills to the south of the town. Water pressure at the low level is boosted to maintain a supply to the high level storage on Tawhara Hill. When the booster pumps are not operating, reticulation pressure is maintained via the gravitational head provided by the Tawhara Hill reservoirs.

The reservoirs on the Tawhara Hill have a total capacity of 2480 cubic metres (m^3), are built of concrete and are 68 years old. The reservoirs at the northern boundary have a total capacity of 2940 m^3, are also concrete and are 62 years old.

In recent years the high level reservoirs have had rehabilitation work to repair a number of leaks.

Wairoa's water reticulation system services a mix of residential, commercial and light industrial properties. There is also a hospital with limited storage capacity in case of an emergency when water cannot be provided.

A separate 300mm water main and pump system originates at the northern boundary reservoirs to supply water to the AFFCO freezing works, which has its own low level storage tanks.

The town reticulation system has a total length of 68.8 km and ranges in size from 25 mm to 300 mm. It is made of various materials, including uPVC, fibrolite, everite, steel, concrete lined steel and galvanised steel and was constructed between 1940 and 2000.

There are 328 hydrants, 343 isolating valves, 1421 services and 63 water meters. The system has been designed so that, in most areas, small sections can be isolated by closing off just four valves.

A telemetry monitoring system is used with the base monitoring station sited at the water treatment plant at Frasertown.

Frasertown Water Supply

Frasertown's water is sourced from the same river intake on the Waiau River and, after treatment, is reticulated to the township, which is a small residential community.

The supply is gravity-fed from four inter-connected reservoirs that are, in turn, fed by a pump at the water treatment plan via a 150mm water main. These reservoirs are at a relatively low level, resulting in a low water pressure of between 70-200 kpa within the reticulation system. The reservoirs have a total holding capacity of $90m^3$.

The reticulation system was installed in 1963 with minor additions since then. It has a total length of 8.924 km and ranges in size between 25 mm and 150 mm. Pipe materials include uPVC, fibrolite, galvanised steel and alkathene. There are approximately 100 service connections, 100 water meters, 29 fire hydrants and 25 valves.

Tuai Water Supply

The water reticulation system for the rural settlement of Tuai is not treated to conform to drinking standards. It is obtained from a spring at Waimako Pa Road approximately 1 km north of the village on SH38. The water is primarily used for toilet flushing, watering gardens and as a fire fighting supply. Drinking water is gathered in roof tanks.

The spring is interconnected with the reticulation system and also supplies three interconnected reservoirs that act as a buffer during fire fighting or for other similar events. The reservoirs are built of concrete and have a total holding capacity of $135m^3$. No pumps are needed for this reticulation system which has recorded pressures of 350 – 700 kpa.

The original reticulation was installed in 1950 and there have been several additions and replacements between then and 2000. There is a total of 4.520 km of reticulation with sizes ranging between 50 and 150 mm. The materials for these pipelines is a range of uPVC galvanised steel and fibrolite. There are approximately 100 service connections, 14 fire hydrants and 27 valves.

A telemetry monitoring system is used with the base monitoring station sited at the water treatment plant at Frasertown.

Mahanga Water Supply

The water reticulation system serves the settlement of Mahanga, which is a beachside residential community with a population that reaches over 300 at its summer holiday peak.

The supply comes from an underground aquifer and does not conform to drinking standards. The water pressure is very low with recorded pressures of about 100 kpa.

The supply is gravity-fed from a $45m^3$ storage tank which is, in turn, fed from a bore pump and aquifer. The reticulation system is 880m long and is made up of 40 mm and 100mm mains made of either uPVC or fibrolite. There are 55 service connections, 8 valves and 6 fire hydrants.

Wastewater Schemes

The Wairoa District Council provides wastewater schemes in the both Wairoa and Tuai.

Wairoa Township Wastewater Scheme

Records show that the reticulation for the Wairoa wastewater system started in or before 1948, and services a mix of residential, commercial and light industrial properties. The system was upgraded in 1980 with the construction of a new trunk main, pump station and wastewater treatment plant.

Wairoa wastewater plant aeration lagoon and control building. (Photo courtesy WDC)

The system collects wastewater from the properties and carries it, via five pump stations, to a treatment plant at Pilot Hill south of the town and adjacent to the Wairoa River mouth. The reticulation varies in size from 100mm diameter up to and including 375mm diameter and is made of a range of materials including uPVC, concrete, concrete lined steel and asbestos cement.

There are 486 manholes within the system, 35.1 km of sewer mains and 31 lampholes. A total of 1720 properties are connected to the Wairoa system.

The system is made up of four areas, each serviced by a pump station. From these stations the sewage is fed into a gravity main which takes it to the final pump station just before the wastewater treatment plant. From here the sewage is pumped to the plant, first entering a pre-aeration lagoon and then an oxidation pond. It is discharged at night into the Wairoa River on an outgoing tide, using a telemetry control system. This ensures it reaches the sea as efficiently as possible.

Fitzroy Street pump station which is the final pump station in the Wairoa system. At this point, the sewage is pumped into the wastewater plant. (Photo courtesy WDC)

During emergencies the wastewater system can be bypassed at each pump station other than Rutherford Street. The wastewater plant can also be by-passed. Each site has a generator that can be connected to operate the sites in sequence if necessary.

This system also relies on the telemetry monitoring system based at Frasertown.

Tuai Village Wastewater Scheme

The wastewater scheme for Tuai, which is thought to date from around 1940, serves a small rural residential community. The system was designed to separately reticulate grey water and wastewater, meaning much of it is made up of two parallel pipes to carry the separate streams. The wastewater then entered a septic tank while the grey water was discharged direct into the adjacent river. Since 1984 the combined flows have entered a triple bed sand filtration system.

The system includes 4483m of reticulation ranging in size from 80 mm to 200 mm and made from earthenware and uPVC. There are 60 manholes and 1 small pump station with a submersible pump.

The wastewater and grey water from 65 properties enters the gravity-fed main and flows to the pump station. From here it is pumped to a delay chamber and then to a small holding tank where it is dosed to the sand filter bed. The flows to the bed are controlled by probes within the holding tank. The wastewater is filtered through each sand bed in sequence during discharge into the Kahurangaroa Stream, about 50m downstream from the station.

The system is monitored by telemetry from the base station at Frasertown.

Stormwater Systems

The council provides some formal stormwater drainage within Wairoa township and Tuai while other settlements rely mainly on open roadside drains and water tables. There are piped drains to carry the stormwater between open drains.

Wairoa Township Stormwater Scheme

Wairoa's stormwater drainage system is a combination of piped drains, formed open channels, roadside drains and natural water courses.

The system has 36315 m of earthenware and concrete pipes, ranging in size from 100 mm to 2440 mm, and includes 211 manholes and 912 sumps. There are 3417m of mainly concrete culverts, ranging in size from 100 mm to 3000 mm, and 26134m of open channels. The system was constructed between 1948 and 2000.

The system relies on gravity flows, rather than pump stations. All stormwater outlets terminate at the Wairoa River so the flow is controlled by the height of the river and river bar conditions.

A number of low-lying areas within Wairoa are prone to surface flooding and require monitoring during heavy rain.

Tuai Village Stormwater Scheme

Tuai's stormwater system is a combination of piped drains and roadside sumps. Most of the village is built on sloping sections and stormwater gravitates through the system and discharges into Lake Whakamarino. There are no stormwater pump stations.

Other Rural Settlement Stormwater Schemes

The settlements of Mahia and Mahanga are served by a combination of open stormwater drains, watertables and a limited number of piped drains. These beach side settlements are flat and prone to flooding during high seas.

Other rural settlements are served by roadside drains, watertables and natural water courses.

Mitigation Measures

Water Supply

The Wairoa District Council has identified several areas that require further investigation to help prevent disruption to water supply during an emergency.

This includes ensuring that water mains attached to bridges are strong enough to withstand movement of the bridge, and do not rupture. In addition a programme to replace old water mains is needed. In particular there is a need to replace trunk mains which, due to their age and surrounding ground conditions, could break as a result of ground shaking.

Reservoirs which have the potential to collapse during major ground shaking also need to be replaced.

Boundary Reservoirs and pump station at Wairoa (Photo courtesy WDC)

Pump stations have the capability to plug in a generator in the event of an emergency and the water treatment plant has a permanent generator that can be quickly actioned.

The following components are at risk during a hazard event, in descending order:

- Tawhara water storage tanks – from seismic activity;
- Water supply pumping main, Frasertown to Wairoa – from seismic activity;
- Intake to water treatment plant – from seismic activity;
- Intake to water treatment plant – from flooding.

Sewer

All sewer reticulation within Wairoa and Tuai has been inspected by video and any problems recorded. While repairs and replacements required are being addressed within present budgets, the process may need to be accelerated.

Pump stations will require regular monitoring to ensure all pumps and fittings are secure to minimise damage from ground shaking. Pump stations have also been fitted with the capability to plug in a generator during emergencies.

Stormwater

The stormwater system relies on a gravity-fed drainage network. The main concerns are overloading during heavy rain and pipes breaking as a result of ground shaking. Future investigations will need to address potential blocks as a result of pipes being out of line or too small to cope with the flow.

Several flood prone areas have been identified and these are the first to be attended to during heavy rain.

Napier City Council

Napier is situated on an alluvial flood plain on the east coast of New Zealand. The topography is characterised by a limestone hill to the northeast, the plains, on which more than 80% of the population live, and the Taradale hills to the west. Bay View, a separate settlement from the main urban area, is to the north.

Public Water Supply System

Water is drawn from the Heretaunga Plains aquifer and recharged from the Ngaruroro and to a lesser extent the Tutaekuri rivers. The water is non-corrosive and well buffered to resist change to pH. This has considerably reduced the internal corrosion problems normally experienced with cast iron pipes.

Work commenced on a reticulated supply in the 19th century with water sourced from bores in the central business district.

The 1931 Hawke's Bay Earthquake (magnitude 7.8 and with an epicentre approximately 25 km north of Napier), caused widespread damage and considerable elevation of land. The greatest uplift was 2.7 metres just north of Tangoio. In the Napier Hill area the uplift was 1.8 metres, while the unconsolidated gravels near the present mouth of the Tutaekuri River subsided by about 0.8 metres.

Areas such as Tamatea, Pirimai and the Hawke's Bay Airport were transformed from lagoons and swamps to dry land. Soil properties vary depending on whether or not an area was submerged prior to the earthquake and these influences the performance of certain pipe materials. Before the earthquake, the Tutaekuri River was diverted to reclaim Napier South with up to 1.2 metres of river silt deposited to reclaim land east of Georges Drive. Metal pipes and fittings installed more recently in the river silt, are less prone to corrosion than similar pipes installed in the old seabed to the west of Georges Drive.

After the earthquake came a period of reconstruction, interrupted by World War II and the Korean War. The latter caused a boom in development, while the former affected the supply of materials, leading to the use of poor quality cast iron pipe. Problems from this have become evident in recent years.

In 1968, Taradale Borough was amalgamated with Napier City and the reticulation of Taradale began. This included a trunk main along Taradale Road, connecting the area to the main system. At this time asbestos cement was the preferred construction material and 50% of the reticulation system is made up of asbestos cement pipes.

Amalgamation with Taradale created the opportunity to utilize the high quality groundwater source in Taradale. The first public water supply well in Taradale was built in the early 1980s, and six more wells have since been completed. Lower water quality wells closer to Napier City have progressively been decommissioned, culminating with the decommissioning of the McLean Park bores in 1998. To improve security of supply, the Coverdale and Pirimai wells remain in the aquifer fringe zone, between the areas of poorer and higher quality water.

Bay View was amalgamated with Napier in 1989. A separate bulk water supply from the newly constructed Tannery Road bore to Bay View was installed by Hawke's Bay County Council in 1988, to replace the Esk River bore. This remained the sole supply to Bay View until 1998, when a second main was built from Westshore. Bay View's reticulation system was constructed during the 1960's.

A pumping main from Taradale to Hyderabad Road, with a diameter of 450mm, was completed in 1995 providing for the bulk transfer of water from Taradale to the rest of Napier. Napier's water supply system now consists of two distinct supply areas - the Napier Water Supply Area (NWSA) and the Bay View Water Supply Area (BVWSA).

The Enfield and Thompson reservoir systems supply water to the NWSA and the Bay View system supplies water to the BVWSA.

There are ten source pump stations to pump water from the aquifer and six booster pump stations to transfer water between pressure zones. A total of 10 tanks on 7 sites provide the storage required for fire fighting, emergency supply and to balance peak demand. A total of 409 kilometres of main, ranging in diameter from 50mm to 450mm, is used to distribute water to 96% of Napier's population, via 22,000 service connections and 1,000 water meters. The Awatoto industrial area, Jervoistown, Meeanee and Poraiti are the only areas that are not reticulated.

Sewerage

The urban part of Napier, where 93% of the population live, has a reticulated sewerage system while the rural areas of Bay View, Jervoistown and Meeanee rely on septic tanks.

Although parts of the sewerage system date from the mid 1870s, most of it has been built since the 1931 earthquake. The present outfall discharge at Awatoto was commissioned in 1973 and a milliscreen facility built in 1991.

Napier's flat topography means the sewerage system must be pumped, often through two or three pumping stations, before discharging through the marine outfall at Awatoto.

The majority of the pipe reticulation is constructed of rubber ring jointed reinforced concrete pipe. However, pipes laid during post quake reconstruction in Napier South and on Napier Hill are made of spigoted earthenware filled with lime cement mortar. These pipes and joints are now deteriorating and being progressively replaced with uPVC pipes, the preferred material over the last 15 years.

There are 21 drywell and 12 wetwell pumping stations.

Most have at least one duty and one standby pump with no emergency overflows. With a few exceptions, the pumping stations are in good condition.

From the pumping stations, sewage is disposed though pumping mains of various ages, material, sizes and condition. The two larger pumping mains – Latham and Greenmeadows - are reinforced concrete pipelines, with limited capacity and structural strength. At 3 locations, pumping mains are exposed in drain crossings.

The sewerage system has no emergency back-up capability and is vulnerable to both pump station loss, particularly from power cuts, or pipeline damage. In addition, the collapse of some sewerage system pipes would result in major reconstruction difficulties and traffic problems because of their location (e.g. the gravity trunk mains in Taradale Road).

Stormwater

Because Napier City is relatively flat, with little elevation above sea level, pumping is needed in a large part of the area to achieve satisfactory drainage. The land is protected from the sea by a naturally formed shingle spit, and from the waters of both the Ahuriri Estuary and the Tutaekuri River by man-made stopbanks.

Most surface water is discharged to the Ahuriri Estuary, apart from some areas of land that drain south to the Tutaekuri River, and north to the Esk River.

With the exception of Napier Hill, the CBD and Napier South, all catchments have a combination of piped reticulation and open drains and most are served by a pumping station. In the CBD and Napier South all the reticulation is piped. Both areas are also served by pumping stations.

There is no overflow capability or standby generator capacity at any of the pumping stations, making them almost wholly dependent on electrical power supply.

There are several low-lying areas within the city that will "pond" during heavy rainfall and are also susceptible to flooding during pump station failure or stopbank breach.

Network Statistics

Stormwater

- 9 stormwater pumping stations
- 208km of pipe reticulation ranging in size from 100mm to 1800mm
- 58km of open drain

Sewerage

- 38 sewage pumping stations
- 298km of pipe reticulation ranging in size from 100mm to 1050mm
- 1 Milliscreen Plant

Water Supply

- 9 Wells
- 7 Booster Pump Stations
- 8 Reservoir Sites
- 409km of water main ranging in size from 50mm to 450mm
- 22,000 service connections

Emergency Management Plan

The Napier City Council Works has an Emergency Management Plan for the city's 3 water utilities and essential elements of its road network. This plan covers emergencies up to a declared Civil Emergency.

Among other things it provides details of emergency equipment such as generators, capabilities and auxiliary power supply connections at pumping stations.

Results of Hazard Risk Analysis

Risk analysis methodology for the infrastructural pipeline services was based on AS/NZS 3460:1995 Risk Management.

This gives a degree of risk based on likelihood and the impact, ranging from low to high risk.

The facilities or infrastructure in the high-risk category are tabulated below. Generally the risk assessment shows that tsunami and liquefaction hazards present the greatest threat to Napier.

Napier in ruins after 1931 Hawke's Bay earthquake

Earthquake and Liquefaction

Earthquake induced damage has always been a consideration when designing infrastructure. However it is important to regularly revisit both the design principles in the Engineering Code and how they are put into practice. For the Lifelines project some aspects of pumping station construction and a range of mitigation measures were reviewed.

Earthquake induced liquefaction is a significant threat in the main urban part of Napier, particularly for sewage and stormwater pumping stations.

While appropriate mitigation measures can be taken with new installations, the best way of protecting existing facilities will be under consideration for some time yet.

Napier City today

Vulnerability - Water

Ground Shaking

The Tamatea trunk main has been constructed using continuous welded steel in areas that are prone to liquefaction. However portions of other trunk mains, such as the Taradale trunk main, are made of asbestos cement pipe and have a higher risk of failure.

Most of the reticulation on Napier Hill consists of cast iron pipe that performed well during the 1931 earthquake. Large areas of the plains are prone to liquefaction and pipe breaks are likely to occur there. About 50% of the water reticulation system is made up of asbestos cement pipe.

Ground Movement

The 300mm cast iron main from the Priestley Steps to Thompson Reservoir is the only significant main likely to be at risk due to ground movement. It is one of two trunk mains to the Thompson Reservoir.

Flooding

The water supply system is not directly at risk from the effects of flooding.

Wind

Extreme wind conditions affect the radio communications network and have a minor impact on pump station control. The effect of strong winds on power supply is of most concern.

Tsunami

The McLean Park, and Westshore booster pump stations and the 300mm main across the Pandora Road Bridge may be at risk from a tsunami. In all cases alternative supplies exist.

Ash

Ashfall may impact on pump motors and the power supply. The pump motors at the Tannery Road pump station are air-cooled and should not be operated during ash outfalls. The pumps at the Westshore booster station are water-cooled and can provide an alternative supply to Bay View.

All other pumps in the water supply system are water-cooled and can be operated as long as the power supply is maintained.

Artesian Wells

The artesian wells are regarded as robust and at little risk of failure due to natural events. Because they are spread out a number of wells would survive most disasters. An interruption to power supply will limit the production capacity of wells to the flow that can be provided under artesian pressure.

Trunk Mains

The Tamatea trunk main is the most critical main in the bulk supply system and also the least likely to fail. However, the supply to Enfield Reservoir and Thompson Reservoir relies on trunk mains made in part from asbestos cement and cast iron. There are multiple routes to each reservoir and this issue will be addressed as part of a future main replacements programme.

Reservoirs

All reservoirs meet seismic design standards and the only issue to be addressed is that of maintaining emergency storage following a catastrophic failure of the reticulation. One solution would be installing emergency automatic shutoff valves. These valves close when a sudden increase in the rate of discharge is detected, thereby storing water in the reservoir instead of spilling it through multiple leaks.

However automatic shutoff valves are not suitable for Napier because the city's reservoirs act as header tanks and the source pumps are connected to the reservoirs as well as the reticulation. Should the source pumps fail during high demand conditions (most likely because of power failure) the outflow from the reservoirs can instantly increase by 700 litres per second. Should automatic shutoff valves close during such an event, most of the water supply will be interrupted.

Other methods of preventing a total loss of emergency storage will be investigated, such as raising the level of the outlet pipes in some tanks and installing emergency connections to artesian bores.

Reticulation

Reticulation areas which have service connectioins and brittle pipes installed in ground that is prone to liquefaction are the most vulnerable parts of the system. This risk will have to be addressed over time as part of the ongoing mains and service connection replacement programme.

Stormwater Pumping Stations

- Sale Street
- Dalton Street
- Kenny Ave
- Purimu
- County Drain

Sewer Pumping Stations

- Westshore - 4
- Ahuriri - 3
- Pandora - 1
- Napier Coast - 3
- Milliscreen - 1

Vulnerability - Stormwater and Sewer

Ground Shaking

Apart from earthenware pipe used in Napier South, Napier Hill and parts of Ahuriri during post quake reconstruction, reticulation in recent decades has used rubber ring jointed pipes, which should fare better during ground shaking and liquefaction.

The earthenware pipework is now showing evidence of deterioration and is gradually being replaced with modern materials as part of the asset renewal program.

View back to Napier over Ahuriri estuary after heavy rain August 1990. (Photo HBRC)

Flooding

Both the sewer and stormwater systems and particularly the pumping stations are vulnerable to flooding. This risk is an important design consideration with both new installations and in upgrading works.

Infrastructure Subject to Tsunami

Some pumping stations are at risk from tsunami. The degree of risk varies depends on the physical impact and the extent to which various elements are exposed to the onslaught. Most installations cannot be relocated and the risk must be addressed through design and/or operational measures.

Wind

Extreme wind conditions can interrupt power supplies, affect the radio communications network and have minor impacts on pump station control.

Ash

Volcanic ashfalls can have a significant impact on pump motors and power supply. Napier City Council has a Volcanic Ash Response Plan based on work undertaken after the 1996 Central Plateau eruptions.

Hastings District Council

Water Network

The Hastings District Council operates 10 public water supply schemes, providing water to houses, schools, industrial and commercial properties throughout the district.

Water for 7 of the schemes comes from the Heretaunga Plains aquifer while the remaining 3 use surface water or tap into bores.

History

During the 1931 Hawke's Bay Earthquake the Hastings water reticulation system sustained very little damage, apart from subsidence to bridges and filling. The pipe to the Hastings Reservoirs, attached to the bridge over the Karamu Stream, was lost when the bridge collapsed. This pipe is no longer fixed to the bridge but passes underneath the Karamu Stream.

			Pipe over 50mm in dia	
Location	Joints	Reticulation Length (km)	Ductile %	Non Ductile %
Hastings Havelock and Flaxmere	17219	318.3	53	46
Haumoana and Te Awanga	658	10	19.6	77.8
Clive	123	2.8	22.4	77.6
Whakatu	81	2.2	78.7	21.3
Waipatu	10	0.1		
Omahu	37	0.6	0	100
Waimarama	272	10.1	55.5	44.5
Waipatiki	35	1.7	100	0
Whirinaki	167	6.5	100	0
Paki Paki	13	1.1	100	

Table 1 Hastings Reticulation Systems

Network

Statistical data about the water reticulation network is tabulated above in Table 1.

The Hastings District Council has been progressively replacing all pre-1910 and 1950-60 non-ductile iron water mains and cast water mains. All these pipes are targeted for replacement by 2005.

Ductile materials include concrete lined steel, ductile iron, galvanised steel, MDPE, mPVC and steel uPVC.

Brittle or non-ductile materials include asbestos cement, cast iron and concrete.

Reservoirs

All reservoirs in the Hastings District have been built since the 1931 earthquake. The Havelock North Reservoirs were constructed in 1959 and are the oldest while the Hastings Reservoirs, built in 1995, are the most recent.

Pump Stations

All the networks rely on pumps to supply water to the respective reservoirs or mains systems. There are 19 water supply pump stations within the Hastings District - 9 in Hastings, Havelock North and Flaxmere, 2 at Clive and 1 at each of Haumoana/Te Awanga, Omahu, Pakipaki, Waimarama, Waipataki, Whirinaki, Waipatu and Whakatu. The Waimarama supply comes mainly from a spring but a pumped supply is also available.

All the stations are monitored by telemetry and, in the event of a power failure, there is a back up base unit at one of the stations in Hastings, which has a permanently fixed power generator on site.

On-site power generators are available at 4 of the stations in the event of a power shutdown, 2 in Hastings, 1 in Havelock North and 1 in Haumoana. The pump station at Pakipaki has been fitted with a plug to enable the instant connection of a mobile generator.

Sewer Network

The Hastings District Council's sewerage reticulation network services Hastings, Havelock North, Flaxmere and the townships of Clive and Whakatu. The sewage is collected from houses, schools, industrial and commercial properties and carried via three separate trunk mains to the Hastings wastewater treatment facility in Richmond Road, East Clive.

The sewerage reticulation network, which is constructed of concrete and glazed earthenware, suffered little damage during the 1931 Napier earthquake.

Statistical data about the sewerage reticulation is tabulated below:

Location	Reticulation Length km	No of Connections
Hastings, Havelock Nth, Flaxmere	292.6	19020
Clive (excluding trunk main)	7.7	347
Whakatu	4.9	128

Network

An ongoing reticulation network maintenance programme has resulted in most existing pipes being replaced at an average rate of 4.1 km per year.

Pump Stations

There are 32 sewer pump stations, all monitored by telemetry, within the reticulation network - 2 at Clive, 1 at Whakatu and the remainder in Hastings, Havelock North and Flaxmere.

A station in Havelock North and one at Clive have on-site generators and another 12 are fitted with generator plugs to enable the instant connection of mobile generators.

Stormwater

The Hastings District Council operates a stormwater and pump station reticulation network, all monitored by telemetry, servicing Hastings, Flaxmere, Havelock North, Haumoana, Te Awanga, Clive, Whakatu and Waimarama.

This network suffered very little if any damage during the 1931 Napier earthquake.

Statistical details on the reticulation systems are tabulated below:

Location	Reticulation Length	No of Manholes
Hastings, Havelock Nth, Flaxmere	173.1	2862
Clive Whakatu Haumoana, Te Awanga, Waimarama	5.1	122

Network

Most of the network is made from reinforced concrete pipes in sizes ranging from 225 mm to 2250 mm.

Pump Stations

There are 12 stormwater pumps stations within the various networks - 1 at Waimarama, 3 in Clive, 1 at Omahu and the remainder in Hastings.

Te Awanga Motor Camp Flooded September 2000

Results of Risk Assessment

The hazard ranking process has identified seismic activity as the hazard likely to cause the greatest disruption to underground services.

The sections of individual networks at greatest risks are those where pipes, particularly water mains, cross bridges and/or pass into the ground from pump stations or water reservoirs. Mains failure presents the next most serious threat as this would restrict the ability to continuously supply water or sewerage disposal.

Retrofitting of flexible joint systems to pipes at bridges, pump stations, and water storage reservoirs is being considered. Priority would be given to trunk water and sewer mains and the larger pumping stations.

To minimise the impact of mains failure from seismic activity, additional valves may be retrofitted to the various networks when existing non-ductile pipes are replaced as part of the District Council's pipe replacement programme.

Long-term power failure is also a risk to the network, and would particularly affect the large number of sewer pump stations the Council maintains. To minimise this risk three portable generators capable of running the stations have been purchased and portable generator plugs are being progressively installed at pump stations.

Conclusions

The Lifelines project has highlighted a number of areas that need further investigation with regard to protecting Council services during and after a major natural disaster.

Water Supply

For water supplies there is a need to find ways to protect control equipment from shaking during earthquakes. The Council also needs to look at the issue of water storage after an earthquake. This may mean installing valves to protect reservoirs from emptying if an earthquake were to rupture a distribution main leading from a reservoir.

Stormwater.

The stormwater system relies mainly on a gravity fed drainage network. It is at risk from overloading of the system during a storm and/or the disruption of pipe work by seismic movement. Future investigations should focus on ways to prevent the inlets to drainage pipes being blocked and the effect broken pipes would have on properties in the district. Risk analysis has also highlighted the need for the residential open drain network to be regularly checked to ensure it is not being obstructed by property owners.

Sewer

The sewer network relies on a number of pumping stations, which need to be checked to ensure all equipment is protected against movement during an earthquake. A more detailed analysis of the systems vulnerability to seismic activity will be done as part of the asset management programme. Future upgrades or new reticulation systems will need to be take into account the potential for natural disasters.

Communications

A number of sites have been fitted with telemetry to monitor and control reticulation systems. The vulnerability of this system is one area where a specialist risk analysis should be carried out. At present the Council is reviewing and checking the telemetry system, a process that will result in a better understanding of it.

Central Hawke's Bay District Council

Water Supply Schemes

The Central Hawke's Bay District Council has water supply schemes servicing communities in Hautope, Kairakau, Otane, Te Paerahi Beach and Porangahau township, Takapau, Waipawa, Waipukurau and the Pourerere Camping Ground. Each system includes wells or bores, pumping stations and associated mechanical and electrical equipment, rising mains, reservoirs, treatment plants, reticulation pipework, service connections (up to the property boundary), valves, hydrants and water meters.

Hautope Water Supply Scheme

The Hautope water supply scheme was installed in 1973 to pump water to on-site holding tanks.

Kairakau Water Supply Scheme

The Kairkau water supply scheme was installed in the mid 1950s and upgraded in the 1970s. In 1993 the scheme was expanded to include a new subdivision.

Otane Water Supply Scheme

The Otane water supply receives treated water from the Waipawa system via a 100mm diameter AC pipeline, connected through a meter and running along the road reserve of State Highway 2. The water supply scheme has been regularly upgraded since it was first commissioned in the 1940s, using the town's old gas mains as a reticulation network.

Porangahau Water Supply Scheme

The Porangahau water supply scheme covers the settlements of Te Paerahi Beach and Porangahau township. It takes groundwater from a shallow bore off Beach Road behind the Te Paerahi Golf Club. This bore, which is approximately 7m deep, was first developed in 1979 when a 100mm AC rising main was laid from the pump shed into Porangahau township and then into the storage tanks on Old Hill Road.

Pourere Water Supply Scheme

This scheme supplies water to the Pourere Beach Camping Ground. The source is a spring located high in the hills above Gibraltar Road behind the beach on Pourere Station.

Takapau Water Supply Scheme

The town of Takapau draws its water from a bore 40m deep and 150mm in diameter located at the northern end of Meta Street. Water is delivered to two 24,000 litre tanks adjacent to the well head and sterilised by chlorine gas injection.

Waipawa Water Supply Scheme

The Waipawa water supply has two distinct sources. The primary one is a 375mm diameter shallow bore about 3m deep, on the Tikokino Road approximately 3.km from Waipawa.

There is a second source adjacent to the pump station at the end of Johnson Street in Waipawa.

Waipawa's water supply scheme is monitored by a telemetry system, which is based in the office of the company which has a contract to manage the facility.

Waipukurau Water Supply Scheme

Waipukurau's water comes from a group of 3 450mm diameter bores under Pukeora Hill alongside the Tukituki River and approximately 4km west of Waipukurau.

The Waipukurau water supply scheme is also monitored by a telemetry system, based in the office of its management contractor.

Location	Connections	Reticulation Length (km)	% Ductile	% Non-ductile
Hautope	14	11.2	21	69
Kairakau	41	2.5	100	-
Otane	217	16.8	20	80
Porangahau	238	13.7	63	27
Pourerere	-	2.5	100	-
Takapau	930	37.8	30	70
Waipawa	930	37.8	30	70
Waipukurau	2066	47.8	26	74

Central Hawke's Bay District Council Wastewater Schemes

The Council provides wastewater schemes in the townships of Otane, Te Paerahi Beach, Porangahau, Takapau, Waipawa and Waipkurau.

Otane Wastewater Scheme

The reticulation for the wastewater system in Otane was installed in 1990. The sewage is gravity-fed to an oxidation pond at the end of Lawrence Street.

Te Paerahi Beach Wastewater Scheme

The reticulation for this scheme was installed in 1990 and covers all of the Te Paerahi Beach residential area. The sewage is collected at the main pump station on Te Paerahi Road then pumped to an oxidation pond in the sand dunes behind the golf course.

Porangahau Township Wastewater Scheme

The reticulation in Porangahau was installed in 1990. The system gravity feeds to a pump station and the sewage is then pumped to an oxidation pond at the end of Jones Street.

Takapau Wastewater Scheme

The reticulation in Takapau was installed in 1982. The sewage gravity feeds to a chamber before being pumped to an oxidation pond adjacent to the Makaretu River on Burnside Road.

Waipawa Wastewater Scheme

The Waipawa wastewater scheme has been in operation for 80 to 100 years. It collects wastewater from the residential, commercial, and industrial areas of Waipawa and delivers it, via a gravity-fed system, to the pump station at the oxidation pond.

Waipukurau Wastewater Scheme

The Waipukurau wastewater system was installed about 80 years ago and has had numerous upgrades to ensure it meets present and projected demands.

The system collects wastewater from the residential, commercial, and industrial areas of Waipukurau and carries it to a treatment facility on Mt Herbert Road, using a combination of gravity, four lift pump stations and one main pump station.

Location	Connections	Reticulation Length (km)
Otane	218	6.8
Porangahua	109	2.6
Te Paerahi	149	2.2
Takapau	234	6.3
Waipawa	965	20.3
Waipukurau	2359	39.4

Central Hawke's Bay District Council Stormwater Systems

The Council provides formal stormwater drainage systems in Waipawa and Waipukurau. Other townships in the district rely on open roadside drains and water tables with some piped sections between open drains.

Waipawa Stormwater Scheme

Waipawa's stormwater drainage system is a combination of piped drains, formed open channels and developed natural watercourses. The Waipawa River is isolated from the township by stopbanks and all pipes passing underneath the stopbanks are protected against backflow by non-return valves at the pipe outlet. The Hawke's Bay Regional Council owns and is responsible for maintenance of the stopbanks, the pipes beneath them and the non-return valves.

Waipukurau Stormwater Scheme

Waipukurau's stormwater drainage system is also a combination of piped drains, formed open channels and developed natural watercourses. The Tukituki River is isolated from the township by stopbanks and all pipes passing underneath the stopbanks are protected against backflow by non-return valves at the pipe outlet. Once again, maintenance is the responsibility of the Hawke's Bay Regional Council.

Risk Assessment

The natural hazard risk assessment analysis has identified a number of areas at risk.

Seismic Risk (Ground Shaking, Liquefaction and Fault Displacement)

The risk analysis chart shows that the hazard presenting the greatest risk to the Central Hawke's Bay District Council's network is seismic activity. Non-ductile pipes such as asbestos cement pipes give the greatest cause for concern. Careful planning and design of future works can mitigate this hazard in some areas.

Wind

This hazard only affects above-ground services such as pump buildings and aerials. Sound construction of buildings can mitigate against the effects of wind. Most at risk from wind are the Telemetry network aerials. Good design and construction of the antennas will mitigate any problems.

Tsunami

The coastal towns of Kairakau and Te Paerahi Beach are at risk from tsunami. The topography of the surrounding land may amplify the effects of such an event and the resulting damage.

Volcanic Ash

Ashfall does not present a major hazard to underground services. Its main effect would be disruption to electric motors and above ground electrical systems. This can be easily mitigated by adding filters to the pump station air intakes and cleaning exposed electrical supply points if such an event were to happen.

Conclusions

The Lifelines project has highlighted a number of areas that need further investigation to ensure maximum protection of the Council's services during and after a major natural disaster. They are briefly summarised below:

Water Supply

- Control equipment needs protection from shaking during earthquakes;
- The installation of shut off valves in reservoirs should be considered to ensure water storage after an emergency.

Stormwater

- A major storm could cause overloading of the system;
- There is a need to protect pipes from blockages after seismic activity;
- Investigations into the effect that broken pipes will have on properties is needed;
- The residential open drain network must be checked regularly for obstruction.

Sewer

- Pumping stations must be checked to ensure equipment is protected from movement during an earthquake;
- A more detailed analysis of the sewerage system will be carried out and future upgrades or new installations will take into account the potential for natural disasters.

Communications

- A specialist risk analysis of the telemetry system is needed.

Hawke's Bay Regional Council

Network Description

The Hawke's Bay region covers a land area of 14,160 square kilometres on the east coast of the New Zealand's North Island. The region stretches from north of Mahia Peninsula to just south of Porangahau and is flanked in the east by the coast and in the west by the Ruahine, Kaweka, Huiarau and Ahimaniwa Ranges.

The region includes 24 catchments consisting of 8 major rivers - Wairoa, Mohaka, Esk, Tutaekuri, Ngaruroro, Tukituki, Waipawa, and Porangahau - and many smaller rivers. Settlement and intensive land use has tended to concentrate around the lower reaches and floodplains of these rivers, resulting in the need for extensive drainage and flood protection. Over the years various schemes have been developed to manage the flood plains and allow for continued low risk development.

The Hawke's Bay Regional Council plays an active role in managing the region's rivers with over 180 km of stopbanks and associated channel edge protection and berm planting. Four major flood control schemes cover 350 km of rivers, which is less than a quarter of the total 1600km of significant rivers and streams in the region. The major schemes are:

- Heretaunga Plains Flood Control Scheme;
- Upper Tukituki Flood Control Scheme;
- Porangahau Flood Control Scheme;
- Esk River Scheme.

Hertaunga Plains in flood before stop banks and flood prevention schemes June 1935 (Photo courtesy HBRC)

Heretaunga Plains Flood Protection Scheme

This network consists of engineered, composite earth and gravel stopbanks in the Heretaunga Plains area. Edge protection works (mainly tree planting) which provide velocity and erosion control of the active channel and berms, are included in the assessed network.

All stopbanks in this area have been designed for a 1% annual exceedance probability flood. (100 year return period event).

Stopbanks have a 4.0 metre top width and batter slopes of between 1 - 2 and 1 - 2.5. Heights vary, but generally lie between 3.5m and 5.5m. Foundations include low permeability cut-offs and gravel toe filters where appropriate.

Scheme assets include 111 km of stopbank; 75 km of cleared river channel defined by edge protection, 645 hectares of berm planting and 32 drainage structures.

Other Schemes

These other networks make up all the significant flood protection systems outside the Heretaunga Plains and include the Esk, Te Ngarue, Porangahau and Upper Tukituki Flood Control Schemes and the Mokau, Paeroa, Ohuyia, Whakiki, Kouwhare and Whirinaki schemes.

Pump Stations

There are 15 pump stations, all within the Heretaunga Plains, with pumping capacities from 0.2 cumecs to 3.6 cumecs.

All stations rely on mains power supply. The Regional Council has 5 tractor-driven mobile pumps for emergencies. Four of these have a nominal capacity of 0.5 cumecs and the fifth 0.18 cumecs.

Flood Detention Dams

The Council operates 12 flood detention dams on the Heretaunga Plains or surrounding areas for flood control purposes. These are all earth dams with low-level discharge pipes and high level spillways.

Risk Assessment Methodology

Flooding presents the most serious threat to the flood protection and drainage systems. All the other hazards are unlikely to cause any significant damage providing they do not occur at the same time as major flooding. The one exception is liquefaction, which could pose a risk to the systems.

A qualitative risk analysis matrix based on AS/NZS 4360:1999 Risk Management was used to determine components of the Council's drainage and flood protection infrastructure at greatest risk. The matrix was altered to give 16% of extreme risk and 32% of moderate risk compared to 32% extreme and 16% moderate in the standard.

Higher Risk Components

The following areas of flood plain were shown to be at higher risk mainly because of the consequences of damage, rather than actual damage to the infrastructure

- Tukituki West;
- Fernhill, Twyford, Raupare;
- Omahu, Moteo;
- Ngatarawa, Roys Hill;
- Taradale, Brookfields;
- Karamu;
- Ahuriri Outfall Channel;
- Upper Tukituki Right Bank;
- Waipawa Left Bank.

Conclusions and Mitigation Options

The Council is examining a super design flood strategy, which will identify the best mitigation measures for any breach of the flood defence system. Options range from secondary flood banks to planning restrictions. Public consultation and education will be an essential part of any proposals.

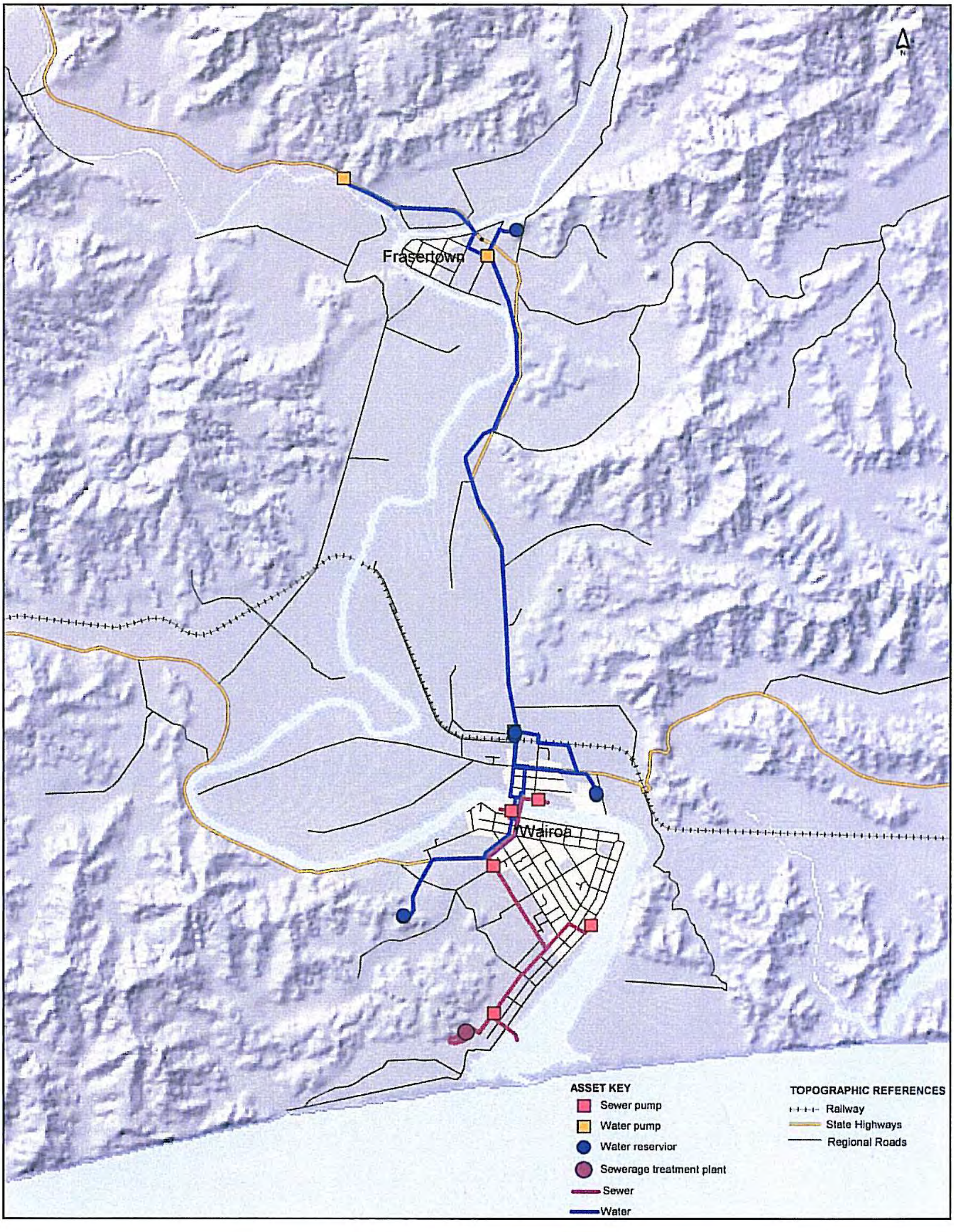
Repair of flood defence systems is ongoing as most significant floods result in some damage within the fairway between the stopbank system. A super design event leading to a breach and escape of floodwater would have far reaching effects not only on the flood defences but on surrounding land.

Damage to the outfall channel stopbanks, especially from liquefaction, would require immediate action to prevent seawater flooding the airport and surrounding low-lying land.

Other non-flood related hazards are unlikely to pose a significant risk unless they coincide with a major flood, either during or before repairs can be carried out. It is anticipated that temporary repair work will be carried out to provide adequate protection until long term permanent rebuilding can be completed.

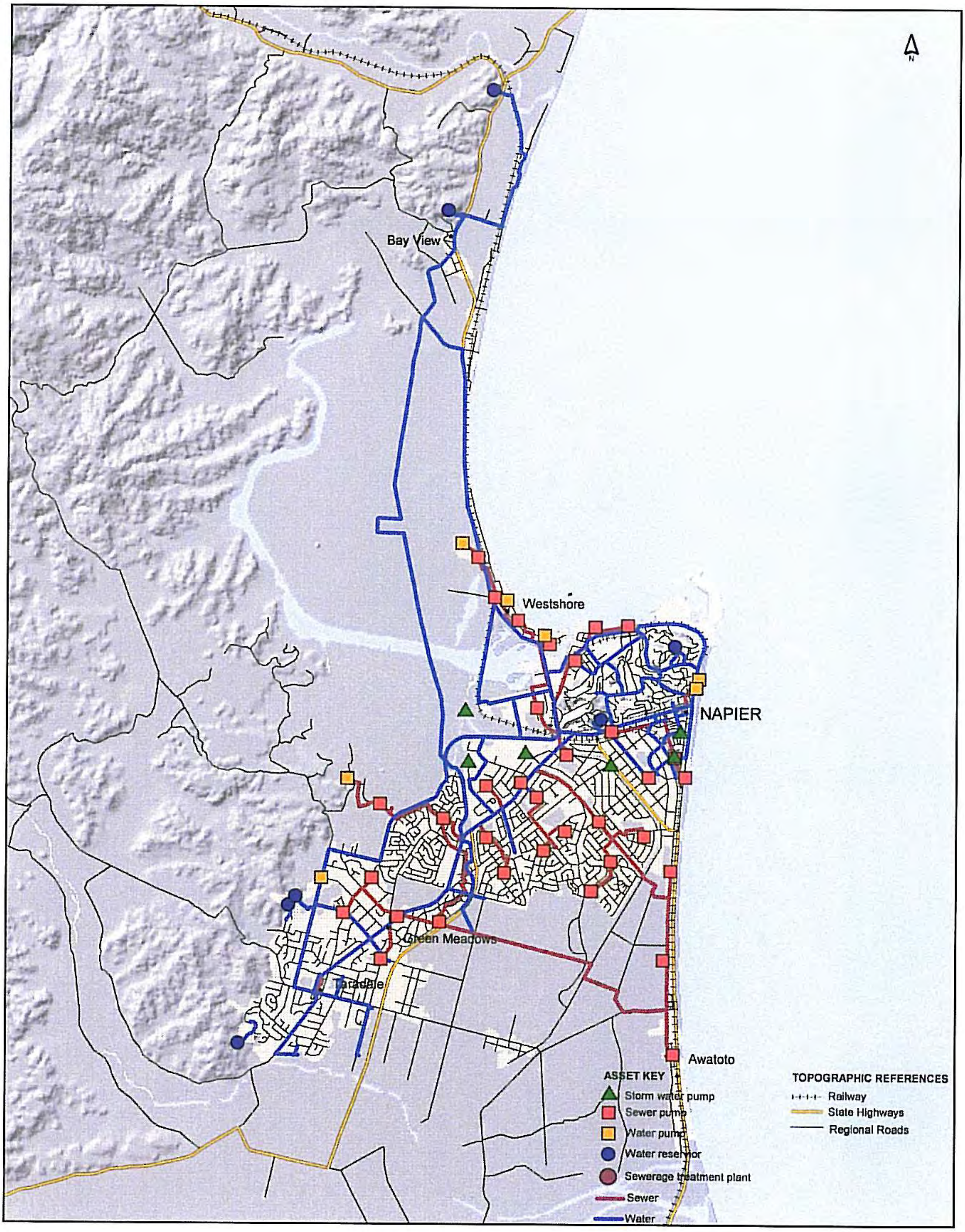
Map 13

Civil Services
Wairoa Township



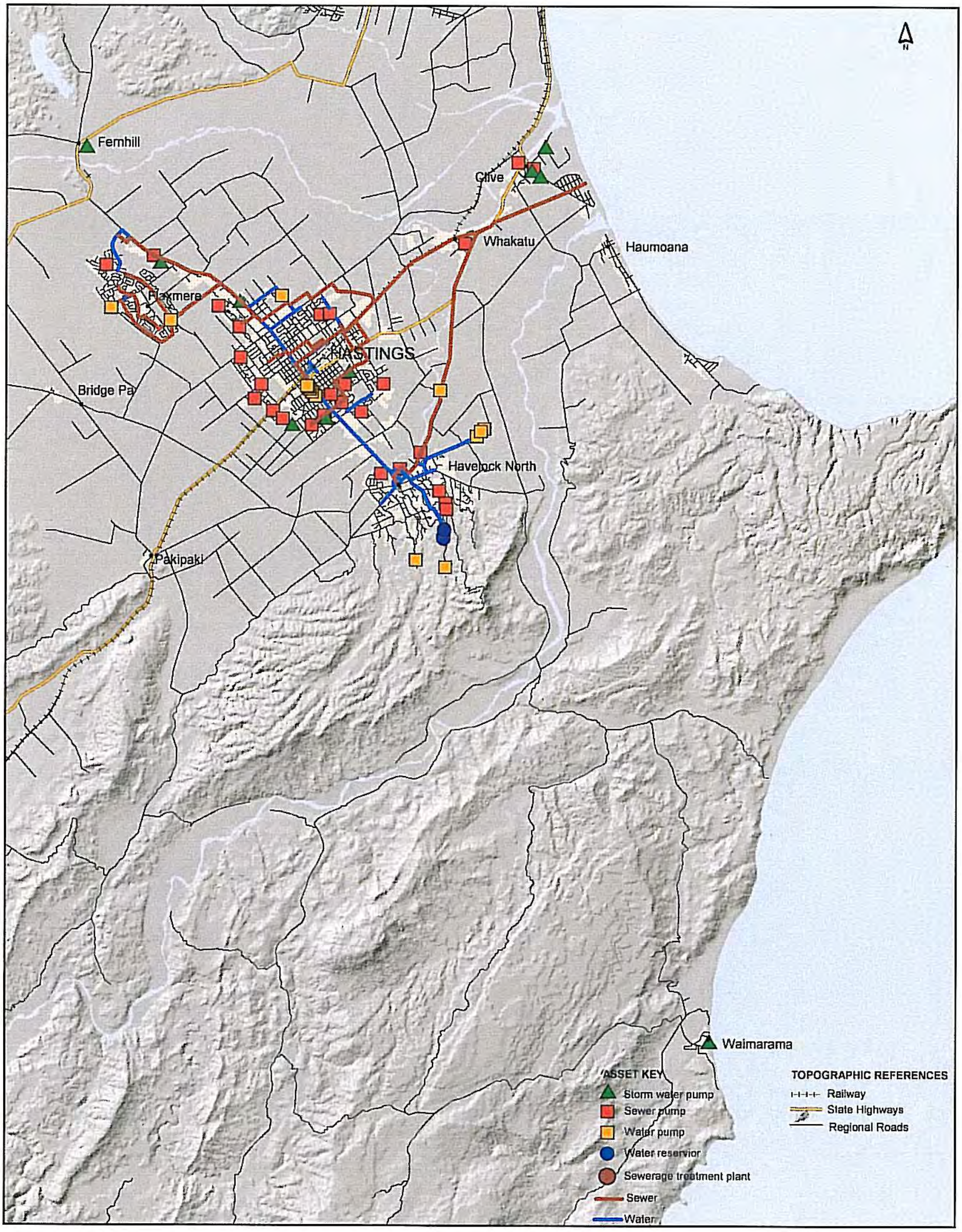
Map 14

Civil Services
Napier City



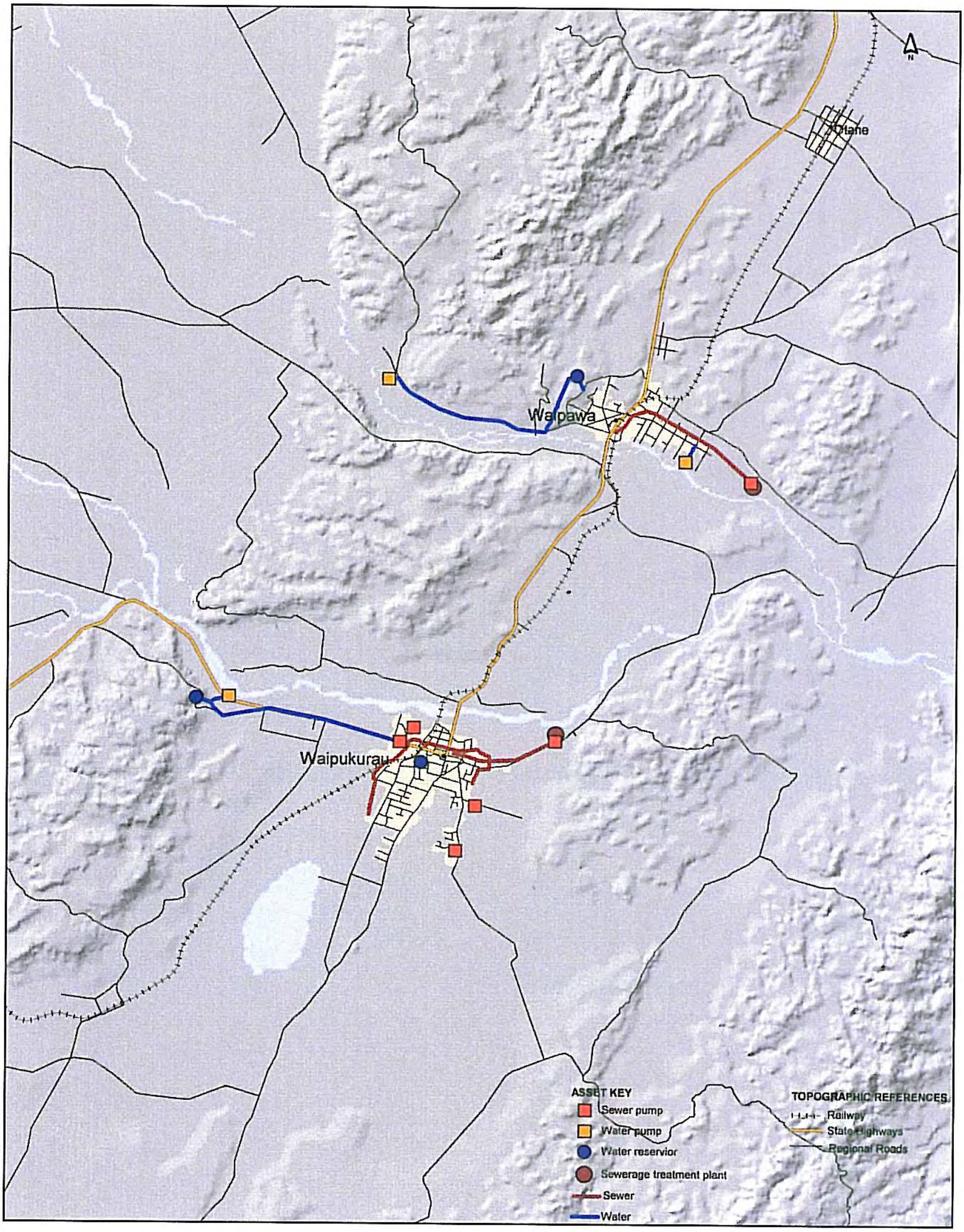
Map 15

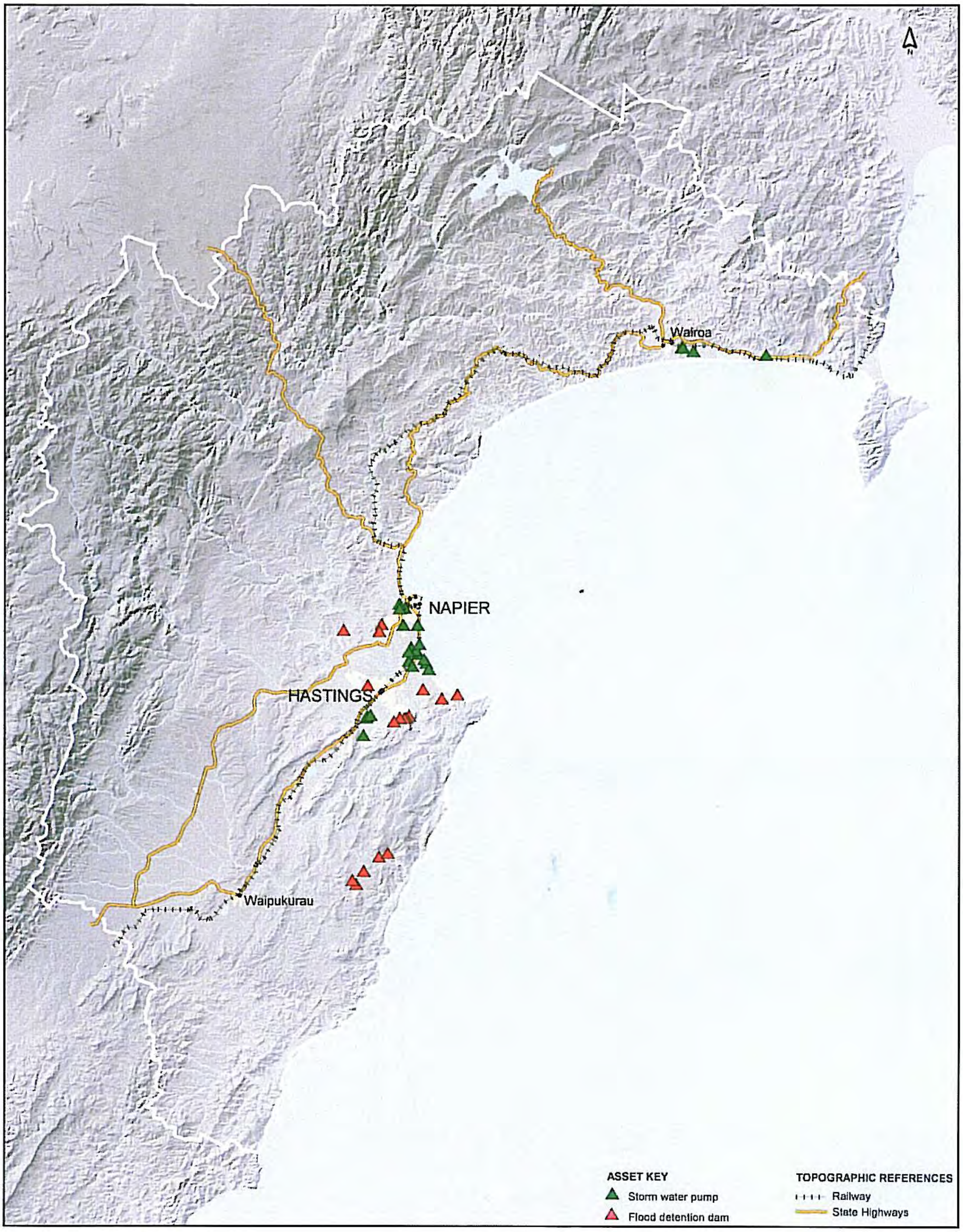
Civil Services
Hastings District



Map 16

Civil Services
Waipawa and Waipukurau Townships




Wairoa
NAPIER
HASTINGS
Waipukurau
ASSET KEY
Storm water pump
Flood detention dam
TOPOGRAPHIC REFERENCES
Railway
State Highways

Chapter 10

Civil Services Group

Introduction

The Civil Services Group concentrated mainly on water supply and water discharge services. Drinking water and wastewater networks include those operated by Wairoa District Council, Napier City Council, Hastings District Council and Central Hawke's Bay District Council. The same councils are also responsible for stormwater discharge in urban areas, while the Hawke's Bay Regional Council is responsible for operating and maintaining the major flood control and drainage networks.

Because each network is virtually autonomous, they were individually assessed, with minimal comparisons made between them to ensure consistency.

The qualitative assessment method was followed, with little variation.

Wairoa District Council

The Wairoa District Council provides water supply schemes to the communities in Wairoa township, Frasertown, Tuai and the beach settlement at Mahanga. The rural areas immediately surrounding Wairoa are also serviced from the town supply.

Water reatment plant at Frasertown, Wairoa (Photo courtesy WDC)

The systems include a spring, river and bore sources, pumping stations, treatment plant, reservoirs, reticulation pipework, gravity-fed main, service connections, fire hydrants, valves, water meters, electrical and pumping equipment.

The supply for Wairoa and Frasertown comes from an intake on the Waiau River, approximately 2 km from the water treatment plant on SH38. There is a 300mm pipeline between the two communities, made from a mixture of fibrolite and steel. One section of the pipeline is fixed to the structure of the Frasertown Bridge. This portion has gibault joints, which can pull apart during an earthquake, making it very susceptible to failure.

Each pump station is able to connect a generator in the event of an emergency and there is a permanent generator at the water treatment plant.

Wairoa Township Supply

Water is supplied to Wairoa via a treatment plant at Frasertown and a 375mm low pressure main, approximately 11km long. This gravity-fed main was installed in 1966.

To supplement the town supply, there are water storage reservoirs at the same low-level elevation as the town on the northern boundary and high-level storage reservoirs on the hills to the south of the town. Water pressure at the low level is boosted to maintain a supply to the high level storage on Tawhara Hill. When the booster pumps are not operating, reticulation pressure is maintained via the gravitational head provided by the Tawhara Hill reservoirs.

The reservoirs on the Tawhara Hill have a total capacity of 2480 cubic metres (m^3), are built of concrete and are 68 years old. The reservoirs at the northern boundary have a total capacity of 2940 m^3, are also concrete and are 62 years old.

In recent years the high level reservoirs have had rehabilitation work to repair a number of leaks.

Wairoa's water reticulation system services a mix of residential, commercial and light industrial properties. There is also a hospital with limited storage capacity in case of an emergency when water cannot be provided.

A separate 300mm water main and pump system originates at the northern boundary reservoirs to supply water to the AFFCO freezing works, which has its own low level storage tanks.

The town reticulation system has a total length of 68.8 km and ranges in size from 25 mm to 300 mm. It is made of various materials, including uPVC, fibrolite, everite, steel, concrete lined steel and galvanised steel and was constructed between 1940 and 2000.

There are 328 hydrants, 343 isolating valves, 1421 services and 63 water meters. The system has been designed so that, in most areas, small sections can be isolated by closing off just four valves.

A telemetry monitoring system is used with the base monitoring station sited at the water treatment plant at Frasertown.

Frasertown Water Supply

Frasertown's water is sourced from the same river intake on the Waiau River and, after treatment, is reticulated to the township, which is a small residential community.

The supply is gravity-fed from four inter-connected reservoirs that are, in turn, fed by a pump at the water treatment plan via a 150mm water main. These reservoirs are at a relatively low level, resulting in a low water pressure of between 70-200 kpa within the reticulation system. The reservoirs have a total holding capacity of $90m^3$.

The reticulation system was installed in 1963 with minor additions since then. It has a total length of 8.924 km and ranges in size between 25 mm and 150 mm. Pipe materials include uPVC, fibrolite, galvanised steel and alkathene. There are approximately 100 service connections, 100 water meters, 29 fire hydrants and 25 valves.

Tuai Water Supply

The water reticulation system for the rural settlement of Tuai is not treated to conform to drinking standards. It is obtained from a spring at Waimako Pa Road approximately 1 km north of the village on SH38. The water is primarily used for toilet flushing, watering gardens and as a fire fighting supply. Drinking water is gathered in roof tanks.

The spring is interconnected with the reticulation system and also supplies three interconnected reservoirs that act as a buffer during fire fighting or for other similar events. The reservoirs are built of concrete and have a total holding capacity of $135m^3$. No pumps are needed for this reticulation system which has recorded pressures of 350 – 700 kpa.

The original reticulation was installed in 1950 and there have been several additions and replacements between then and 2000. There is a total of 4.520 km of reticulation with sizes ranging between 50 and 150 mm. The materials for these pipelines is a range of uPVC galvanised steel and fibrolite. There are approximately 100 service connections, 14 fire hydrants and 27 valves.

A telemetry monitoring system is used with the base monitoring station sited at the water treatment plant at Frasertown.

Mahanga Water Supply

The water reticulation system serves the settlement of Mahanga, which is a beachside residential community with a population that reaches over 300 at its summer holiday peak.

The supply comes from an underground aquifer and does not conform to drinking standards. The water pressure is very low with recorded pressures of about 100 kpa.

The supply is gravity-fed from a $45m^3$ storage tank which is, in turn, fed from a bore pump and aquifer. The reticulation system is 880m long and is made up of 40 mm and 100mm mains made of either uPVC or fibrolite. There are 55 service connections, 8 valves and 6 fire hydrants.

Wastewater Schemes

The Wairoa District Council provides wastewater schemes in the both Wairoa and Tuai.

Wairoa Township Wastewater Scheme

Records show that the reticulation for the Wairoa wastewater system started in or before 1948, and services a mix of residential, commercial and light industrial properties. The system was upgraded in 1980 with the construction of a new trunk main, pump station and wastewater treatment plant.

Wairoa wastewater plant aeration lagoon and control building. (Photo courtesy WDC)

The system collects wastewater from the properties and carries it, via five pump stations, to a treatment plant at Pilot Hill south of the town and adjacent to the Wairoa River mouth. The reticulation varies in size from 100mm diameter up to and including 375mm diameter and is made of a range of materials including uPVC, concrete, concrete lined steel and asbestos cement.

There are 486 manholes within the system, 35.1 km of sewer mains and 31 lampholes. A total of 1720 properties are connected to the Wairoa system.

The system is made up of four areas, each serviced by a pump station. From these stations the sewage is fed into a gravity main which takes it to the final pump station just before the wastewater treatment plant. From here the sewage is pumped to the plant, first entering a pre-aeration lagoon and then an oxidation pond. It is discharged at night into the Wairoa River on an outgoing tide, using a telemetry control system. This ensures it reaches the sea as efficiently as possible.

Fitzory Street pump station which is the final pump station in the Wairoa system. At this point, the sewage is pumped into the wastewater plant. (Photo courtesy WDC)

During emergencies the wastewater system can be bypassed at each pump station other than Rutherford Street. The wastewater plant can also be by-passed. Each site has a generator that can be connected to operate the sites in sequence if necessary.

This system also relies on the telemetry monitoring system based at Frasertown.

Tuai Village Wastewater Scheme

The wastewater scheme for Tuai, which is thought to date from around 1940, serves a small rural residential community. The system was designed to separately reticulate grey water and wastewater, meaning much of it is made up of two parallel pipes to carry the separate streams. The wastewater then entered a septic tank while the grey water was discharged direct into the adjacent river. Since 1984 the combined flows have entered a triple bed sand filtration system.

The system includes 4483m of reticulation ranging in size from 80 mm to 200 mm and made from earthenware and uPVC. There are 60 manholes and 1 small pump station with a submersible pump.

The wastewater and grey water from 65 properties enters the gravity-fed main and flows to the pump station. From here it is pumped to a delay chamber and then to a small holding tank where it is dosed to the sand filter bed. The flows to the bed are controlled by probes within the holding tank. The wastewater is filtered through each sand bed in sequence during discharge into the Kahurangaroa Stream, about 50m downstream from the station.

The system is monitored by telemetry from the base station at Frasertown.

Stormwater Systems

The council provides some formal stormwater drainage within Wairoa township and Tuai while other settlements rely mainly on open roadside drains and water tables. There are piped drains to carry the stormwater between open drains.

Wairoa Township Stormwater Scheme

Wairoa's stormwater drainage system is a combination of piped drains, formed open channels, roadside drains and natural water courses.

The system has 36315 m of earthenware and concrete pipes, ranging in size from 100 mm to 2440 mm, and includes 211 manholes and 912 sumps. There are 3417m of mainly concrete culverts, ranging in size from 100 mm to 3000 mm, and 26134m of open channels. The system was constructed between 1948 and 2000.

The system relies on gravity flows, rather than pump stations. All stormwater outlets terminate at the Wairoa River so the flow is controlled by the height of the river and river bar conditions.

A number of low-lying areas within Wairoa are prone to surface flooding and require monitoring during heavy rain.

Tuai Village Stormwater Scheme

Tuai's stormwater system is a combination of piped drains and roadside sumps. Most of the village is built on sloping sections and stormwater gravitates through the system and discharges into Lake Whakamarino. There are no stormwater pump stations.

Other Rural Settlement Stormwater Schemes

The settlements of Mahia and Mahanga are served by a combination of open stormwater drains, watertables and a limited number of piped drains. These beach side settlements are flat and prone to flooding during high seas.

Other rural settlements are served by roadside drains, watertables and natural water courses.

Mitigation Measures

Water Supply

The Wairoa District Council has identified several areas that require further investigation to help prevent disruption to water supply during an emergency.

This includes ensuring that water mains attached to bridges are strong enough to withstand movement of the bridge, and do not rupture. In addition a programme to replace old water mains is needed. In particular there is a need to replace trunk mains which, due to their age and surrounding ground conditions, could break as a result of ground shaking.

Reservoirs which have the potential to collapse during major ground shaking also need to be replaced.

Boundary Reservoirs and pump station at Wairoa (Photo courtesy WDC)

Pump stations have the capability to plug in a generator in the event of an emergency and the water treatment plant has a permanent generator that can be quickly actioned.

The following components are at risk during a hazard event, in descending order:

- Tawhara water storage tanks – from seismic activity;
- Water supply pumping main, Frasertown to Wairoa – from seismic activity;
- Intake to water treatment plant – from seismic activity;
- Intake to water treatment plant – from flooding.

Sewer

All sewer reticulation within Wairoa and Tuai has been inspected by video and any problems recorded. While repairs and replacements required are being addressed within present budgets, the process may need to be accelerated.

Pump stations will require regular monitoring to ensure all pumps and fittings are secure to minimise damage from ground shaking. Pump stations have also been fitted with the capability to plug in a generator during emergencies.

Stormwater

The stormwater system relies on a gravity-fed drainage network. The main concerns are overloading during heavy rain and pipes breaking as a result of ground shaking. Future investigations will need to address potential blocks as a result of pipes being out of line or too small to cope with the flow.

Several flood prone areas have been identified and these are the first to be attended to during heavy rain.

Napier City Council

Napier is situated on an alluvial flood plain on the east coast of New Zealand. The topography is characterised by a limestone hill to the northeast, the plains, on which more than 80% of the population live, and the Taradale hills to the west. Bay View, a separate settlement from the main urban area, is to the north.

Public Water Supply System

Water is drawn from the Heretaunga Plains aquifer and recharged from the Ngaruroro and to a lesser extent the Tutaekuri rivers. The water is non-corrosive and well buffered to resist change to pH. This has considerably reduced the internal corrosion problems normally experienced with cast iron pipes.

Work commenced on a reticulated supply in the 19th century with water sourced from bores in the central business district.

The 1931 Hawke's Bay Earthquake (magnitude 7.8 and with an epicentre approximately 25 km north of Napier), caused widespread damage and considerable elevation of land. The greatest uplift was 2.7 metres just north of Tangoio. In the Napier Hill area the uplift was 1.8 metres, while the unconsolidated gravels near the present mouth of the Tutaekuri River subsided by about 0.8 metres.

Areas such as Tamatea, Pirimai and the Hawke's Bay Airport were transformed from lagoons and swamps to dry land. Soil properties vary depending on whether or not an area was submerged prior to the earthquake and these influences the performance of certain pipe materials. Before the earthquake, the Tutaekuri River was diverted to reclaim Napier South with up to 1.2 metres of river silt deposited to reclaim land east of Georges Drive. Metal pipes and fittings installed more recently in the river silt, are less prone to corrosion than similar pipes installed in the old seabed to the west of Georges Drive.

After the earthquake came a period of reconstruction, interrupted by World War II and the Korean War. The latter caused a boom in development, while the former affected the supply of materials, leading to the use of poor quality cast iron pipe. Problems from this have become evident in recent years.

In 1968, Taradale Borough was amalgamated with Napier City and the reticulation of Taradale began. This included a trunk main along Taradale Road, connecting the area to the main system. At this time asbestos cement was the preferred construction material and 50% of the reticulation system is made up of asbestos cement pipes.

Amalgamation with Taradale created the opportunity to utilize the high quality groundwater source in Taradale. The first public water supply well in Taradale was built in the early 1980s, and six more wells have since been completed. Lower water quality wells closer to Napier City have progressively been decommissioned, culminating with the decommissioning of the McLean Park bores in 1998. To improve security of supply, the Coverdale and Pirimai wells remain in the aquifer fringe zone, between the areas of poorer and higher quality water.

Bay View was amalgamated with Napier in 1989. A separate bulk water supply from the newly constructed Tannery Road bore to Bay View was installed by Hawke's Bay County Council in 1988, to replace the Esk River bore. This remained the sole supply to Bay View until 1998, when a second main was built from Westshore. Bay View's reticulation system was constructed during the 1960's.

A pumping main from Taradale to Hyderabad Road, with a diameter of 450mm, was completed in 1995 providing for the bulk transfer of water from Taradale to the rest of Napier. Napier's water supply system now consists of two distinct supply areas - the Napier Water Supply Area (NWSA) and the Bay View Water Supply Area (BVWSA).

The Enfield and Thompson reservoir systems supply water to the NWSA and the Bay View system supplies water to the BVWSA.

There are ten source pump stations to pump water from the aquifer and six booster pump stations to transfer water between pressure zones. A total of 10 tanks on 7 sites provide the storage required for fire fighting, emergency supply and to balance peak demand. A total of 409 kilometres of main, ranging in diameter from 50mm to 450mm, is used to distribute water to 96% of Napier's population, via 22,000 service connections and 1,000 water meters. The Awatoto industrial area, Jervoistown, Meeanee and Poraiti are the only areas that are not reticulated.

Sewerage

The urban part of Napier, where 93% of the population live, has a reticulated sewerage system while the rural areas of Bay View, Jervoistown and Meeanee rely on septic tanks.

Although parts of the sewerage system date from the mid 1870s, most of it has been built since the 1931 earthquake. The present outfall discharge at Awatoto was commissioned in 1973 and a milliscreen facility built in 1991.

Napier's flat topography means the sewerage system must be pumped, often through two or three pumping stations, before discharging through the marine outfall at Awatoto.

The majority of the pipe reticulation is constructed of rubber ring jointed reinforced concrete pipe. However, pipes laid during post quake reconstruction in Napier South and on Napier Hill are made of spigoted earthenware filled with lime cement mortar. These pipes and joints are now deteriorating and being progressively replaced with uPVC pipes, the preferred material over the last 15 years.

There are 21 drywell and 12 wetwell pumping stations.

Most have at least one duty and one standby pump with no emergency overflows. With a few exceptions, the pumping stations are in good condition.

From the pumping stations, sewage is disposed though pumping mains of various ages, material, sizes and condition. The two larger pumping mains – Latham and Greenmeadows - are reinforced concrete pipelines, with limited capacity and structural strength. At 3 locations, pumping mains are exposed in drain crossings.

The sewerage system has no emergency back-up capability and is vulnerable to both pump station loss, particularly from power cuts, or pipeline damage. In addition, the collapse of some sewerage system pipes would result in major reconstruction difficulties and traffic problems because of their location (e.g. the gravity trunk mains in Taradale Road).

Stormwater

Because Napier City is relatively flat, with little elevation above sea level, pumping is needed in a large part of the area to achieve satisfactory drainage. The land is protected from the sea by a naturally formed shingle spit, and from the waters of both the Ahuriri Estuary and the Tutaekuri River by man-made stopbanks.

Most surface water is discharged to the Ahuriri Estuary, apart from some areas of land that drain south to the Tutaekuri River, and north to the Esk River.

With the exception of Napier Hill, the CBD and Napier South, all catchments have a combination of piped reticulation and open drains and most are served by a pumping station. In the CBD and Napier South all the reticulation is piped. Both areas are also served by pumping stations.

There is no overflow capability or standby generator capacity at any of the pumping stations, making them almost wholly dependent on electrical power supply.

There are several low-lying areas within the city that will "pond" during heavy rainfall and are also susceptible to flooding during pump station failure or stopbank breach.

Network Statistics

Stormwater

- 9 stormwater pumping stations
- 208km of pipe reticulation ranging in size from 100mm to 1800mm
- 58km of open drain

Sewerage

- 38 sewage pumping stations
- 298km of pipe reticulation ranging in size from 100mm to 1050mm
- 1 Milliscreen Plant

Water Supply

- 9 Wells
- 7 Booster Pump Stations
- 8 Reservoir Sites
- 409km of water main ranging in size from 50mm to 450mm
- 22,000 service connections

Emergency Management Plan

The Napier City Council Works has an Emergency Management Plan for the city's 3 water utilities and essential elements of its road network. This plan covers emergencies up to a declared Civil Emergency.

Among other things it provides details of emergency equipment such as generators, capabilities and auxiliary power supply connections at pumping stations.

Results of Hazard Risk Analysis

Risk analysis methodology for the infrastructural pipeline services was based on AS/NZS 3460:1995 Risk Management.

This gives a degree of risk based on likelihood and the impact, ranging from low to high risk.

The facilities or infrastructure in the high-risk category are tabulated below. Generally the risk assessment shows that tsunami and liquefaction hazards present the greatest threat to Napier.

Napier in ruins after 1931 Hawke's Bay earthquake

Earthquake and Liquefaction

Earthquake induced damage has always been a consideration when designing infrastructure. However it is important to regularly revisit both the design principles in the Engineering Code and how they are put into practice. For the Lifelines project some aspects of pumping station construction and a range of mitigation measures were reviewed.

Earthquake induced liquefaction is a significant threat in the main urban part of Napier, particularly for sewage and stormwater pumping stations.

While appropriate mitigation measures can be taken with new installations, the best way of protecting existing facilities will be under consideration for some time yet.

Napier City today

Vulnerability - Water

Ground Shaking

The Tamatea trunk main has been constructed using continuous welded steel in areas that are prone to liquefaction. However portions of other trunk mains, such as the Taradale trunk main, are made of asbestos cement pipe and have a higher risk of failure.

Most of the reticulation on Napier Hill consists of cast iron pipe that performed well during the 1931 earthquake. Large areas of the plains are prone to liquefaction and pipe breaks are likely to occur there. About 50% of the water reticulation system is made up of asbestos cement pipe.

Ground Movement

The 300mm cast iron main from the Priestley Steps to Thompson Reservoir is the only significant main likely to be at risk due to ground movement. It is one of two trunk mains to the Thompson Reservoir.

Flooding

The water supply system is not directly at risk from the effects of flooding.

Wind

Extreme wind conditions affect the radio communications network and have a minor impact on pump station control. The effect of strong winds on power supply is of most concern.

Tsunami

The McLean Park, and Westshore booster pump stations and the 300mm main across the Pandora Road Bridge may be at risk from a tsunami. In all cases alternative supplies exist.

Ash

Ashfall may impact on pump motors and the power supply. The pump motors at the Tannery Road pump station are air-cooled and should not be operated during ash outfalls. The pumps at the Westshore booster station are water-cooled and can provide an alternative supply to Bay View.

All other pumps in the water supply system are water-cooled and can be operated as long as the power supply is maintained.

Artesian Wells

The artesian wells are regarded as robust and at little risk of failure due to natural events. Because they are spread out a number of wells would survive most disasters. An interruption to power supply will limit the production capacity of wells to the flow that can be provided under artesian pressure.

Trunk Mains

The Tamatea trunk main is the most critical main in the bulk supply system and also the least likely to fail. However, the supply to Enfield Reservoir and Thompson Reservoir relies on trunk mains made in part from asbestos cement and cast iron. There are multiple routes to each reservoir and this issue will be addressed as part of a future main replacements programme.

Reservoirs

All reservoirs meet seismic design standards and the only issue to be addressed is that of maintaining emergency storage following a catastrophic failure of the reticulation. One solution would be installing emergency automatic shutoff valves. These valves close when a sudden increase in the rate of discharge is detected, thereby storing water in the reservoir instead of spilling it through multiple leaks.

However automatic shutoff valves are not suitable for Napier because the city's reservoirs act as header tanks and the source pumps are connected to the reservoirs as well as the reticulation. Should the source pumps fail during high demand conditions (most likely because of power failure) the outflow from the reservoirs can instantly increase by 700 litres per second. Should automatic shutoff valves close during such an event, most of the water supply will be interrupted.

Other methods of preventing a total loss of emergency storage will be investigated, such as raising the level of the outlet pipes in some tanks and installing emergency connections to artesian bores.

Reticulation

Reticulation areas which have service connectioins and brittle pipes installed in ground that is prone to liquefaction are the most vulnerable parts of the system. This risk will have to be addressed over time as part of the ongoing mains and service connection replacement programme.

Stormwater Pumping Stations

- Sale Street
- Dalton Street
- Kenny Ave
- Purimu
- County Drain

Sewer Pumping Stations

- Westshore - 4
- Ahuriri - 3
- Pandora - 1
- Napier Coast - 3
- Milliscreen - 1

Vulnerability - Stormwater and Sewer

Ground Shaking

Apart from earthenware pipe used in Napier South, Napier Hill and parts of Ahuriri during post quake reconstruction, reticulation in recent decades has used rubber ring jointed pipes, which should fare better during ground shaking and liquefaction.

The earthenware pipework is now showing evidence of deterioration and is gradually being replaced with modern materials as part of the asset renewal program.

View back to Napier over Ahuriri estuary after heavy rain August 1990. (Photo HBRC)

Flooding

Both the sewer and stormwater systems and particularly the pumping stations are vulnerable to flooding. This risk is an important design consideration with both new installations and in upgrading works.

Infrastructure Subject to Tsunami

Some pumping stations are at risk from tsunami. The degree of risk varies depends on the physical impact and the extent to which various elements are exposed to the onslaught. Most installations cannot be relocated and the risk must be addressed through design and/or operational measures.

Wind

Extreme wind conditions can interrupt power supplies, affect the radio communications network and have minor impacts on pump station control.

Ash

Volcanic ashfalls can have a significant impact on pump motors and power supply. Napier City Council has a Volcanic Ash Response Plan based on work undertaken after the 1996 Central Plateau eruptions.

Hastings District Council

Water Network

The Hastings District Council operates 10 public water supply schemes, providing water to houses, schools, industrial and commercial properties throughout the district.

Water for 7 of the schemes comes from the Heretaunga Plains aquifer while the remaining 3 use surface water or tap into bores.

History

During the 1931 Hawke's Bay Earthquake the Hastings water reticulation system sustained very little damage, apart from subsidence to bridges and filling. The pipe to the Hastings Reservoirs, attached to the bridge over the Karamu Stream, was lost when the bridge collapsed. This pipe is no longer fixed to the bridge but passes underneath the Karamu Stream.

			Pipe over 50mm in dia	
Location	Joints	Reticulation Length (km)	Ductile %	Non Ductile %
Hastings Havelock and Flaxmere	17219	318.3	53	46
Haumoana and Te Awanga	658	10	19.6	77.8
Clive	123	2.8	22.4	77.6
Whakatu	81	2.2	78.7	21.3
Waipatu	10	0.1		
Omahu	37	0.6	0	100
Waimarama	272	10.1	55.5	44.5
Waipatiki	35	1.7	100	0
Whirinaki	167	6.5	100	0
Paki Paki	13	1.1	100	

Table 1 Hastings Reticulation Systems

Network

Statistical data about the water reticulation network is tabulated above in Table 1.

The Hastings District Council has been progressively replacing all pre-1910 and 1950-60 non-ductile iron water mains and cast water mains. All these pipes are targeted for replacement by 2005.

Ductile materials include concrete lined steel, ductile iron, galvanised steel, MDPE, mPVC and steel uPVC.

Brittle or non-ductile materials include asbestos cement, cast iron and concrete.

Reservoirs

All reservoirs in the Hastings District have been built since the 1931 earthquake. The Havelock North Reservoirs were constructed in 1959 and are the oldest while the Hastings Reservoirs, built in 1995, are the most recent.

Pump Stations

All the networks rely on pumps to supply water to the respective reservoirs or mains systems. There are 19 water supply pump stations within the Hastings District - 9 in Hastings, Havelock North and Flaxmere, 2 at Clive and 1 at each of Haumoana/Te Awanga, Omahu, Pakipaki, Waimarama, Waipataki, Whirinaki, Waipatu and Whakatu. The Waimarama supply comes mainly from a spring but a pumped supply is also available.

All the stations are monitored by telemetry and, in the event of a power failure, there is a back up base unit at one of the stations in Hastings, which has a permanently fixed power generator on site.

On-site power generators are available at 4 of the stations in the event of a power shutdown, 2 in Hastings, 1 in Havelock North and 1 in Haumoana. The pump station at Pakipaki has been fitted with a plug to enable the instant connection of a mobile generator.

Sewer Network

The Hastings District Council's sewerage reticulation network services Hastings, Havelock North, Flaxmere and the townships of Clive and Whakatu. The sewage is collected from houses, schools, industrial and commercial properties and carried via three separate trunk mains to the Hastings wastewater treatment facility in Richmond Road, East Clive.

The sewerage reticulation network, which is constructed of concrete and glazed earthenware, suffered little damage during the 1931 Napier earthquake.

Statistical data about the sewerage reticulation is tabulated below:

Location	Reticulation Length km	No of Connections
Hastings, Havelock Nth, Flaxmere	292.6	19020
Clive (excluding trunk main)	7.7	347
Whakatu	4.9	128

Network

An ongoing reticulation network maintenance programme has resulted in most existing pipes being replaced at an average rate of 4.1 km per year.

Pump Stations

There are 32 sewer pump stations, all monitored by telemetry, within the reticulation network - 2 at Clive, 1 at Whakatu and the remainder in Hastings, Havelock North and Flaxmere.

A station in Havelock North and one at Clive have on-site generators and another 12 are fitted with generator plugs to enable the instant connection of mobile generators.

Stormwater

The Hastings District Council operates a stormwater and pump station reticulation network, all monitored by telemetry, servicing Hastings, Flaxmere, Havelock North, Haumoana, Te Awanga, Clive, Whakatu and Waimarama.

This network suffered very little if any damage during the 1931 Napier earthquake.

Statistical details on the reticulation systems are tabulated below:

Location	Reticulation Length	No of Manholes
Hastings, Havelock Nth, Flaxmere	173.1	2862
Clive Whakatu Haumoana, Te Awanga, Waimarama	5.1	122

Network

Most of the network is made from reinforced concrete pipes in sizes ranging from 225 mm to 2250 mm.

Pump Stations

There are 12 stormwater pumps stations within the various networks - 1 at Waimarama, 3 in Clive, 1 at Omahu and the remainder in Hastings.

Te Awanga Motor Camp Flooded September 2000

Results of Risk Assessment

The hazard ranking process has identified seismic activity as the hazard likely to cause the greatest disruption to underground services.

The sections of individual networks at greatest risks are those where pipes, particularly water mains, cross bridges and/or pass into the ground from pump stations or water reservoirs. Mains failure presents the next most serious threat as this would restrict the ability to continuously supply water or sewerage disposal.

Retrofitting of flexible joint systems to pipes at bridges, pump stations, and water storage reservoirs is being considered. Priority would be given to trunk water and sewer mains and the larger pumping stations.

To minimise the impact of mains failure from seismic activity, additional valves may be retrofitted to the various networks when existing non-ductile pipes are replaced as part of the District Council's pipe replacement programme.

Long-term power failure is also a risk to the network, and would particularly affect the large number of sewer pump stations the Council maintains. To minimise this risk three portable generators capable of running the stations have been purchased and portable generator plugs are being progressively installed at pump stations.

Conclusions

The Lifelines project has highlighted a number of areas that need further investigation with regard to protecting Council services during and after a major natural disaster.

Water Supply

For water supplies there is a need to find ways to protect control equipment from shaking during earthquakes. The Council also needs to look at the issue of water storage after an earthquake. This may mean installing valves to protect reservoirs from emptying if an earthquake were to rupture a distribution main leading from a reservoir.

Stormwater.

The stormwater system relies mainly on a gravity fed drainage network. It is at risk from overloading of the system during a storm and/or the disruption of pipe work by seismic movement. Future investigations should focus on ways to prevent the inlets to drainage pipes being blocked and the effect broken pipes would have on properties in the district. Risk analysis has also highlighted the need for the residential open drain network to be regularly checked to ensure it is not being obstructed by property owners.

Sewer

The sewer network relies on a number of pumping stations, which need to be checked to ensure all equipment is protected against movement during an earthquake. A more detailed analysis of the systems vulnerability to seismic activity will be done as part of the asset management programme. Future upgrades or new reticulation systems will need to be take into account the potential for natural disasters.

Communications

A number of sites have been fitted with telemetry to monitor and control reticulation systems. The vulnerability of this system is one area where a specialist risk analysis should be carried out. At present the Council is reviewing and checking the telemetry system, a process that will result in a better understanding of it.

Central Hawke's Bay District Council

Water Supply Schemes

The Central Hawke's Bay District Council has water supply schemes servicing communities in Hautope, Kairakau, Otane, Te Paerahi Beach and Porangahau township, Takapau, Waipawa, Waipukurau and the Pourerere Camping Ground. Each system includes wells or bores, pumping stations and associated mechanical and electrical equipment, rising mains, reservoirs, treatment plants, reticulation pipework, service connections (up to the property boundary), valves, hydrants and water meters.

Hautope Water Supply Scheme

The Hautope water supply scheme was installed in 1973 to pump water to on-site holding tanks.

Kairakau Water Supply Scheme

The Kairkau water supply scheme was installed in the mid 1950s and upgraded in the 1970s. In 1993 the scheme was expanded to include a new subdivision.

Otane Water Supply Scheme

The Otane water supply receives treated water from the Waipawa system via a 100mm diameter AC pipeline, connected through a meter and running along the road reserve of State Highway 2. The water supply scheme has been regularly upgraded since it was first commissioned in the 1940s, using the town's old gas mains as a reticulation network.

Porangahau Water Supply Scheme

The Porangahau water supply scheme covers the settlements of Te Paerahi Beach and Porangahau township. It takes groundwater from a shallow bore off Beach Road behind the Te Paerahi Golf Club. This bore, which is approximately 7m deep, was first developed in 1979 when a 100mm AC rising main was laid from the pump shed into Porangahau township and then into the storage tanks on Old Hill Road.

Pourere Water Supply Scheme

This scheme supplies water to the Pourere Beach Camping Ground. The source is a spring located high in the hills above Gibraltar Road behind the beach on Pourere Station.

Takapau Water Supply Scheme

The town of Takapau draws its water from a bore 40m deep and 150mm in diameter located at the northern end of Meta Street. Water is delivered to two 24,000 litre tanks adjacent to the well head and sterilised by chlorine gas injection.

Waipawa Water Supply Scheme

The Waipawa water supply has two distinct sources. The primary one is a 375mm diameter shallow bore about 3m deep, on the Tikokino Road approximately 3.km from Waipawa.

There is a second source adjacent to the pump station at the end of Johnson Street in Waipawa.

Waipawa's water supply scheme is monitored by a telemetry system, which is based in the office of the company which has a contract to manage the facility.

Waipukurau Water Supply Scheme

Waipukurau's water comes from a group of 3 450mm diameter bores under Pukeora Hill alongside the Tukituki River and approximately 4km west of Waipukurau.

The Waipukurau water supply scheme is also monitored by a telemetry system, based in the office of its management contractor.

Location	Connections	Reticulation Length (km)	% Ductile	% Non-ductile
Hautope	14	11.2	21	69
Kairakau	41	2.5	100	-
Otane	217	16.8	20	80
Porangahau	238	13.7	63	27
Pourerere	-	2.5	100	-
Takapau	930	37.8	30	70
Waipawa	930	37.8	30	70
Waipukurau	2066	47.8	26	74

Central Hawke's Bay District Council Wastewater Schemes

The Council provides wastewater schemes in the townships of Otane, Te Paerahi Beach, Porangahau, Takapau, Waipawa and Waipkurau.

Otane Wastewater Scheme

The reticulation for the wastewater system in Otane was installed in 1990. The sewage is gravity-fed to an oxidation pond at the end of Lawrence Street.

Te Paerahi Beach Wastewater Scheme

The reticulation for this scheme was installed in 1990 and covers all of the Te Paerahi Beach residential area. The sewage is collected at the main pump station on Te Paerahi Road then pumped to an oxidation pond in the sand dunes behind the golf course.

Porangahau Township Wastewater Scheme

The reticulation in Porangahau was installed in 1990. The system gravity feeds to a pump station and the sewage is then pumped to an oxidation pond at the end of Jones Street.

Takapau Wastewater Scheme

The reticulation in Takapau was installed in 1982. The sewage gravity feeds to a chamber before being pumped to an oxidation pond adjacent to the Makaretu River on Burnside Road.

Waipawa Wastewater Scheme

The Waipawa wastewater scheme has been in operation for 80 to 100 years. It collects wastewater from the residential, commercial, and industrial areas of Waipawa and delivers it, via a gravity-fed system, to the pump station at the oxidation pond.

Waipukurau Wastewater Scheme

The Waipukurau wastewater system was installed about 80 years ago and has had numerous upgrades to ensure it meets present and projected demands.

The system collects wastewater from the residential, commercial, and industrial areas of Waipukurau and carries it to a treatment facility on Mt Herbert Road, using a combination of gravity, four lift pump stations and one main pump station.

Location	Connections	Reticulation Length (km)
Otane	218	6.8
Porangahua	109	2.6
Te Paerahi	149	2.2
Takapau	234	6.3
Waipawa	965	20.3
Waipukurau	2359	39.4

Central Hawke's Bay District Council Stormwater Systems

The Council provides formal stormwater drainage systems in Waipawa and Waipukurau. Other townships in the district rely on open roadside drains and water tables with some piped sections between open drains.

Waipawa Stormwater Scheme

Waipawa's stormwater drainage system is a combination of piped drains, formed open channels and developed natural watercourses. The Waipawa River is isolated from the township by stopbanks and all pipes passing underneath the stopbanks are protected against backflow by non-return valves at the pipe outlet. The Hawke's Bay Regional Council owns and is responsible for maintenance of the stopbanks, the pipes beneath them and the non-return valves.

Waipukurau Stormwater Scheme

Waipukurau's stormwater drainage system is also a combination of piped drains, formed open channels and developed natural watercourses. The Tukituki River is isolated from the township by stopbanks and all pipes passing underneath the stopbanks are protected against backflow by non-return valves at the pipe outlet. Once again, maintenance is the responsibility of the Hawke's Bay Regional Council.

Risk Assessment

The natural hazard risk assessment analysis has identified a number of areas at risk.

Seismic Risk (Ground Shaking, Liquefaction and Fault Displacement)

The risk analysis chart shows that the hazard presenting the greatest risk to the Central Hawke's Bay District Council's network is seismic activity. Non-ductile pipes such as asbestos cement pipes give the greatest cause for concern. Careful planning and design of future works can mitigate this hazard in some areas.

Wind

This hazard only affects above-ground services such as pump buildings and aerials. Sound construction of buildings can mitigate against the effects of wind. Most at risk from wind are the Telemetry network aerials. Good design and construction of the antennas will mitigate any problems.

Tsunami

The coastal towns of Kairakau and Te Paerahi Beach are at risk from tsunami. The topography of the surrounding land may amplify the effects of such an event and the resulting damage.

Volcanic Ash

Ashfall does not present a major hazard to underground services. Its main effect would be disruption to electric motors and above ground electrical systems. This can be easily mitigated by adding filters to the pump station air intakes and cleaning exposed electrical supply points if such an event were to happen.

Conclusions

The Lifelines project has highlighted a number of areas that need further investigation to ensure maximum protection of the Council's services during and after a major natural disaster. They are briefly summarised below:

Water Supply

- Control equipment needs protection from shaking during earthquakes;
- The installation of shut off valves in reservoirs should be considered to ensure water storage after an emergency.

Stormwater

- A major storm could cause overloading of the system;
- There is a need to protect pipes from blockages after seismic activity;
- Investigations into the effect that broken pipes will have on properties is needed;
- The residential open drain network must be checked regularly for obstruction.

Sewer

- Pumping stations must be checked to ensure equipment is protected from movement during an earthquake;
- A more detailed analysis of the sewerage system will be carried out and future upgrades or new installations will take into account the potential for natural disasters.

Communications

- A specialist risk analysis of the telemetry system is needed.

Hawke's Bay Regional Council

Network Description

The Hawke's Bay region covers a land area of 14,160 square kilometres on the east coast of the New Zealand's North Island. The region stretches from north of Mahia Peninsula to just south of Porangahau and is flanked in the east by the coast and in the west by the Ruahine, Kaweka, Huiarau and Ahimaniwa Ranges.

The region includes 24 catchments consisting of 8 major rivers - Wairoa, Mohaka, Esk, Tutaekuri, Ngaruroro, Tukituki, Waipawa, and Porangahau - and many smaller rivers. Settlement and intensive land use has tended to concentrate around the lower reaches and floodplains of these rivers, resulting in the need for extensive drainage and flood protection. Over the years various schemes have been developed to manage the flood plains and allow for continued low risk development.

The Hawke's Bay Regional Council plays an active role in managing the region's rivers with over 180 km of stopbanks and associated channel edge protection and berm planting. Four major flood control schemes cover 350 km of rivers, which is less than a quarter of the total 1600km of significant rivers and streams in the region. The major schemes are:

- Heretaunga Plains Flood Control Scheme;
- Upper Tukituki Flood Control Scheme;
- Porangahau Flood Control Scheme;
- Esk River Scheme.

Hertaunga Plains in flood before stop banks and flood prevention schemes June 1935 (Photo courtesy HBRC)

Heretaunga Plains Flood Protection Scheme

This network consists of engineered, composite earth and gravel stopbanks in the Heretaunga Plains area. Edge protection works (mainly tree planting) which provide velocity and erosion control of the active channel and berms, are included in the assessed network.

All stopbanks in this area have been designed for a 1% annual exceedance probability flood. (100 year return period event).

Stopbanks have a 4.0 metre top width and batter slopes of between 1 - 2 and 1 - 2.5. Heights vary, but generally lie between 3.5m and 5.5m. Foundations include low permeability cut-offs and gravel toe filters where appropriate.

Scheme assets include 111 km of stopbank; 75 km of cleared river channel defined by edge protection, 645 hectares of berm planting and 32 drainage structures.

Other Schemes

These other networks make up all the significant flood protection systems outside the Heretaunga Plains and include the Esk, Te Ngarue, Porangahau and Upper Tukituki Flood Control Schemes and the Mokau, Paeroa, Ohuyia, Whakiki, Kouwhare and Whirinaki schemes.

Pump Stations

There are 15 pump stations, all within the Heretaunga Plains, with pumping capacities from 0.2 cumecs to 3.6 cumecs.

All stations rely on mains power supply. The Regional Council has 5 tractor-driven mobile pumps for emergencies. Four of these have a nominal capacity of 0.5 cumecs and the fifth 0.18 cumecs.

Flood Detention Dams

The Council operates 12 flood detention dams on the Heretaunga Plains or surrounding areas for flood control purposes. These are all earth dams with low-level discharge pipes and high level spillways.

Risk Assessment Methodology

Flooding presents the most serious threat to the flood protection and drainage systems. All the other hazards are unlikely to cause any significant damage providing they do not occur at the same time as major flooding. The one exception is liquefaction, which could pose a risk to the systems.

A qualitative risk analysis matrix based on AS/NZS 4360:1999 Risk Management was used to determine components of the Council's drainage and flood protection infrastructure at greatest risk. The matrix was altered to give 16% of extreme risk and 32% of moderate risk compared to 32% extreme and 16% moderate in the standard.

Higher Risk Components

The following areas of flood plain were shown to be at higher risk mainly because of the consequences of damage, rather than actual damage to the infrastructure

- Tukituki West;
- Fernhill, Twyford, Raupare;
- Omahu, Moteo;
- Ngatarawa, Roys Hill;
- Taradale, Brookfields;
- Karamu;
- Ahuriri Outfall Channel;
- Upper Tukituki Right Bank;
- Waipawa Left Bank.

Conclusions and Mitigation Options

The Council is examining a super design flood strategy, which will identify the best mitigation measures for any breach of the flood defence system. Options range from secondary flood banks to planning restrictions. Public consultation and education will be an essential part of any proposals.

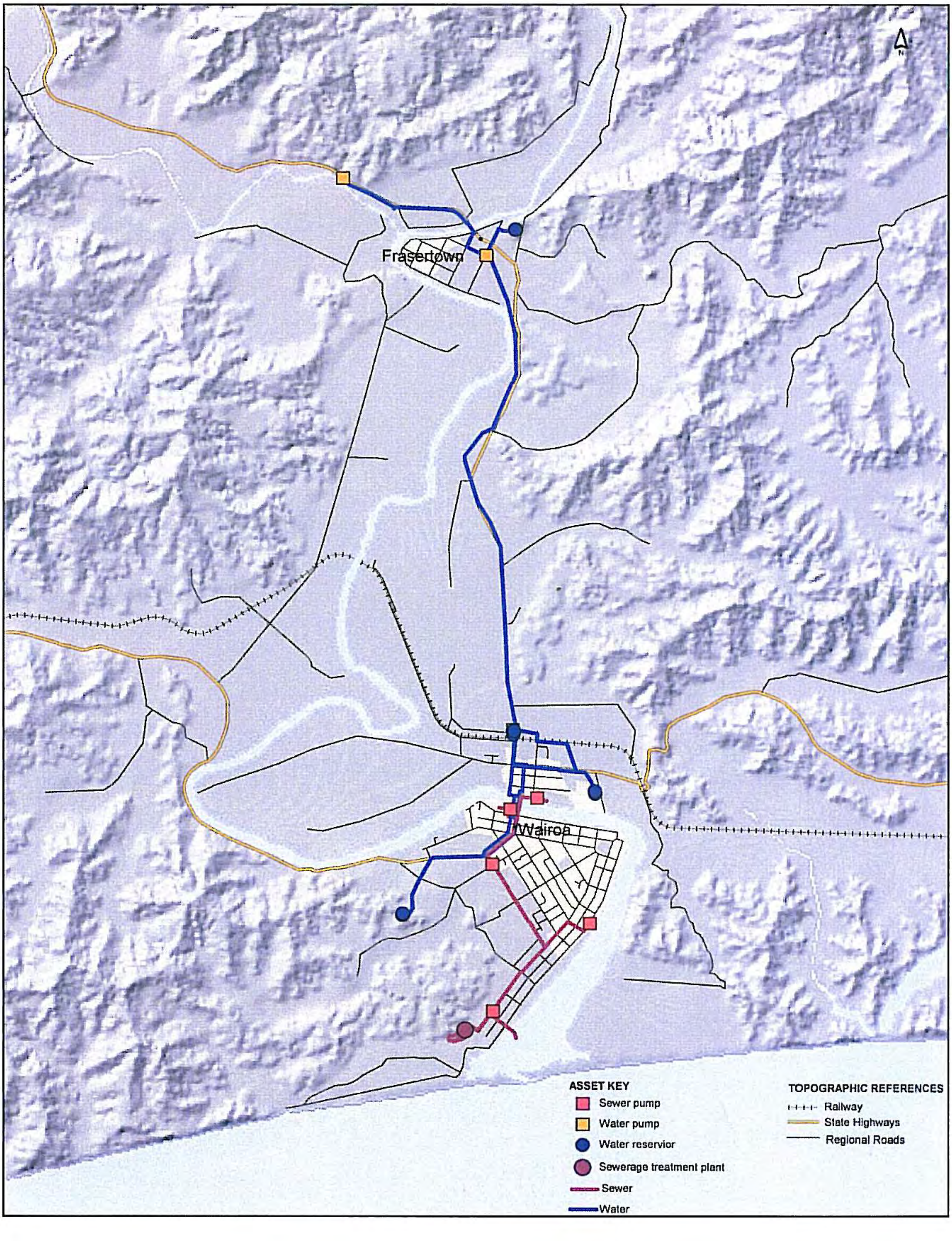
Repair of flood defence systems is ongoing as most significant floods result in some damage within the fairway between the stopbank system. A super design event leading to a breach and escape of floodwater would have far reaching effects not only on the flood defences but on surrounding land.

Damage to the outfall channel stopbanks, especially from liquefaction, would require immediate action to prevent seawater flooding the airport and surrounding low-lying land.

Other non-flood related hazards are unlikely to pose a significant risk unless they coincide with a major flood, either during or before repairs can be carried out. It is anticipated that temporary repair work will be carried out to provide adequate protection until long term permanent rebuilding can be completed.

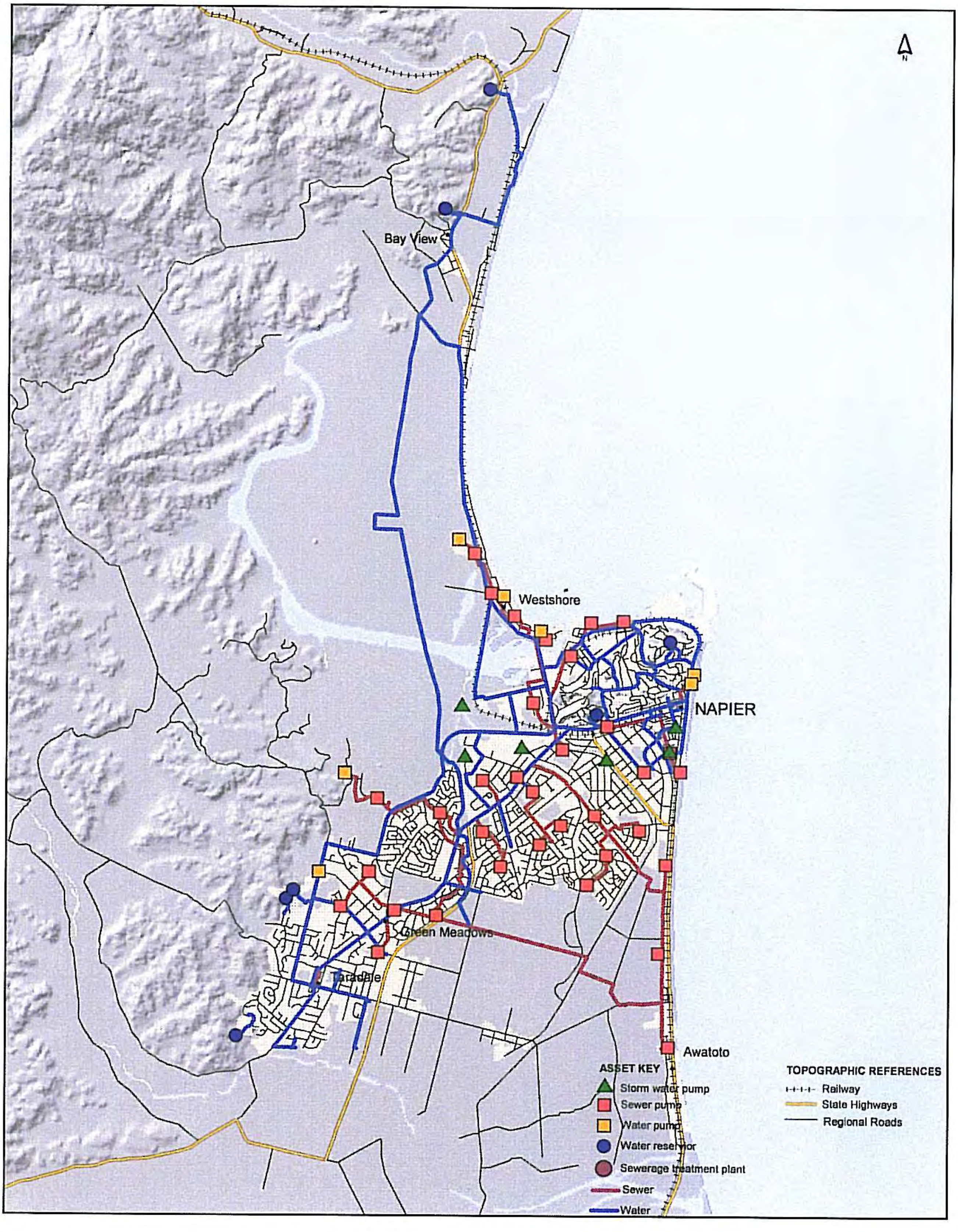
Map 13

Civil Services
Wairoa Township



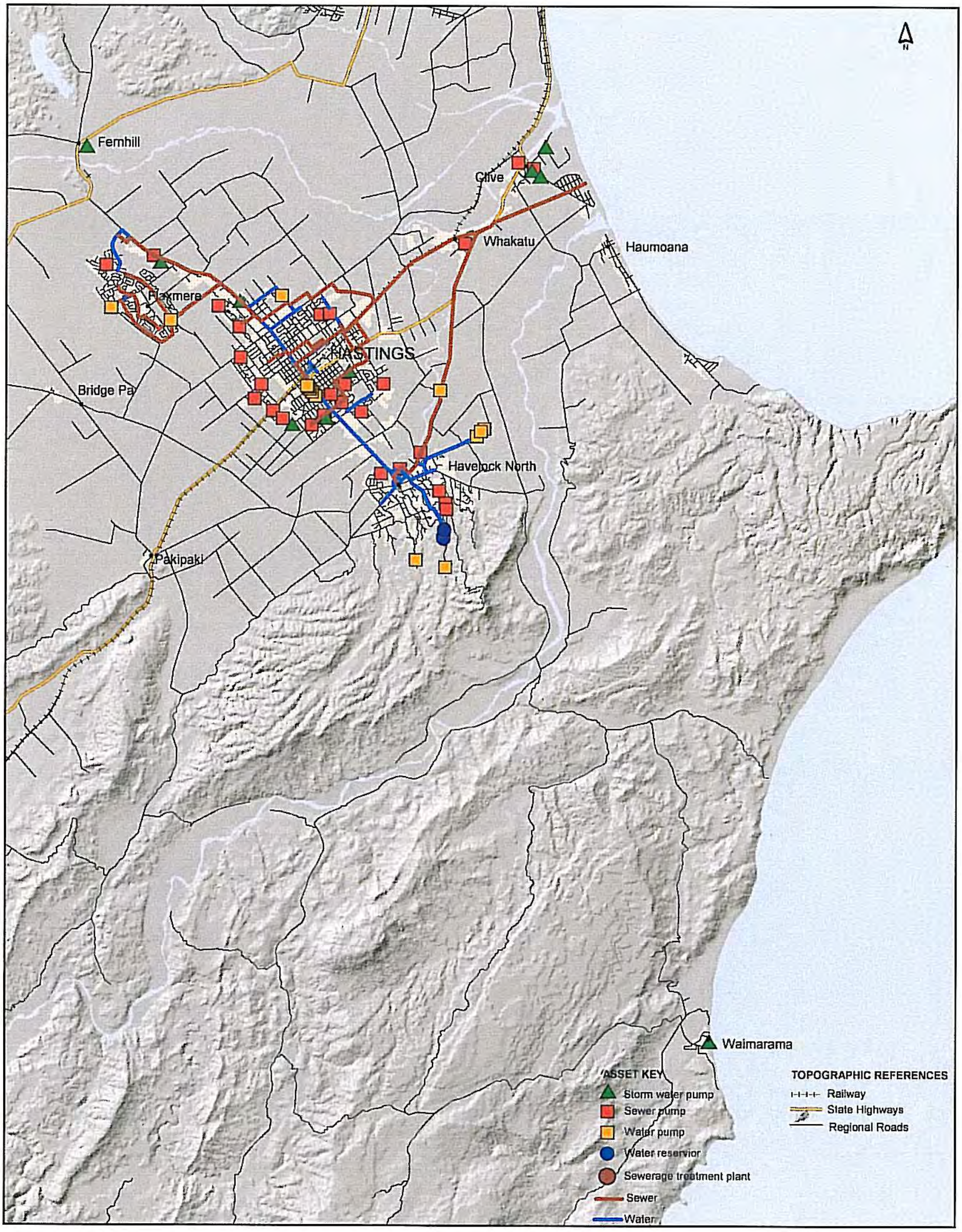
Map 14

Civil Services
Napier City



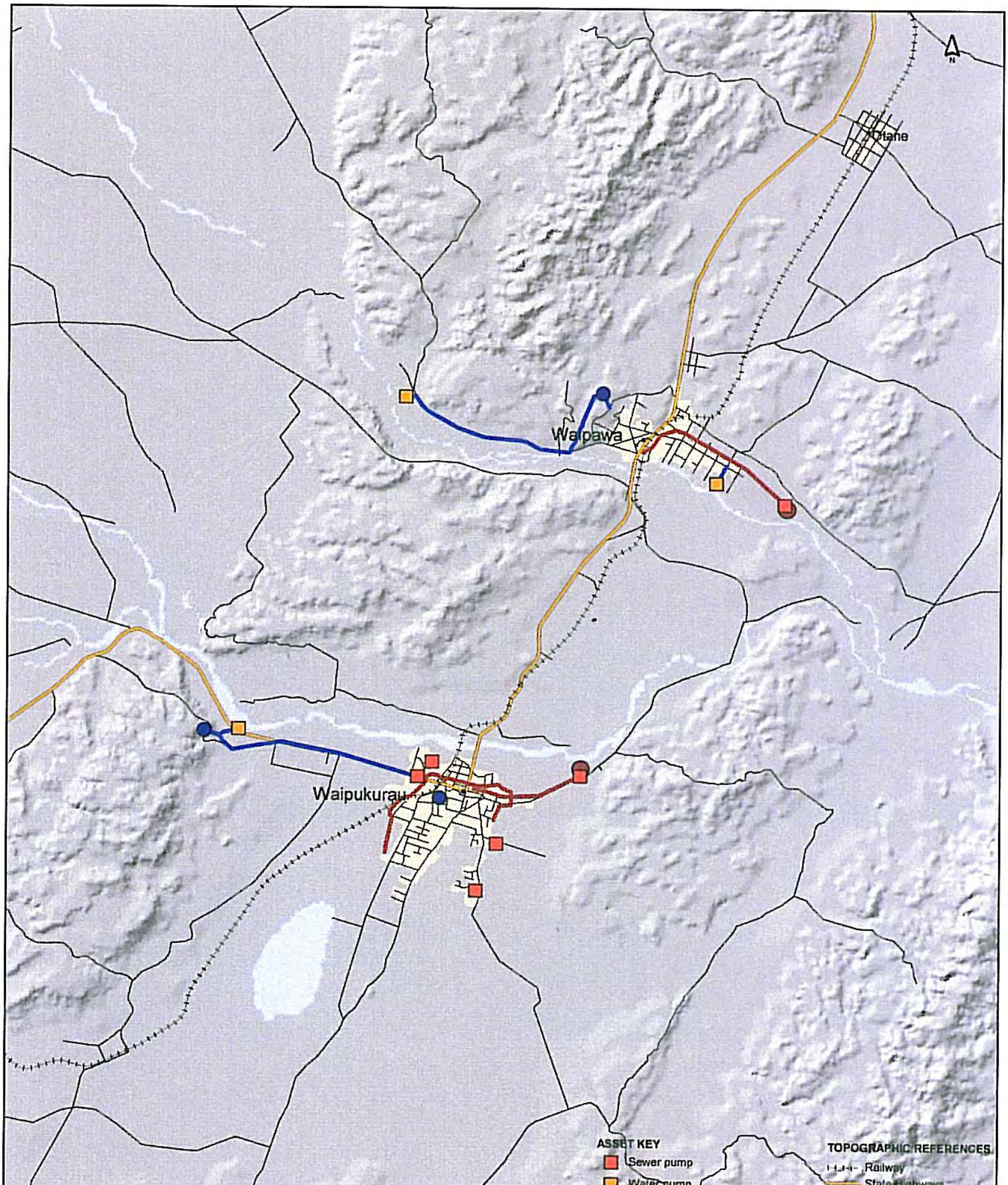
Map 15

Civil Services
Hastings District

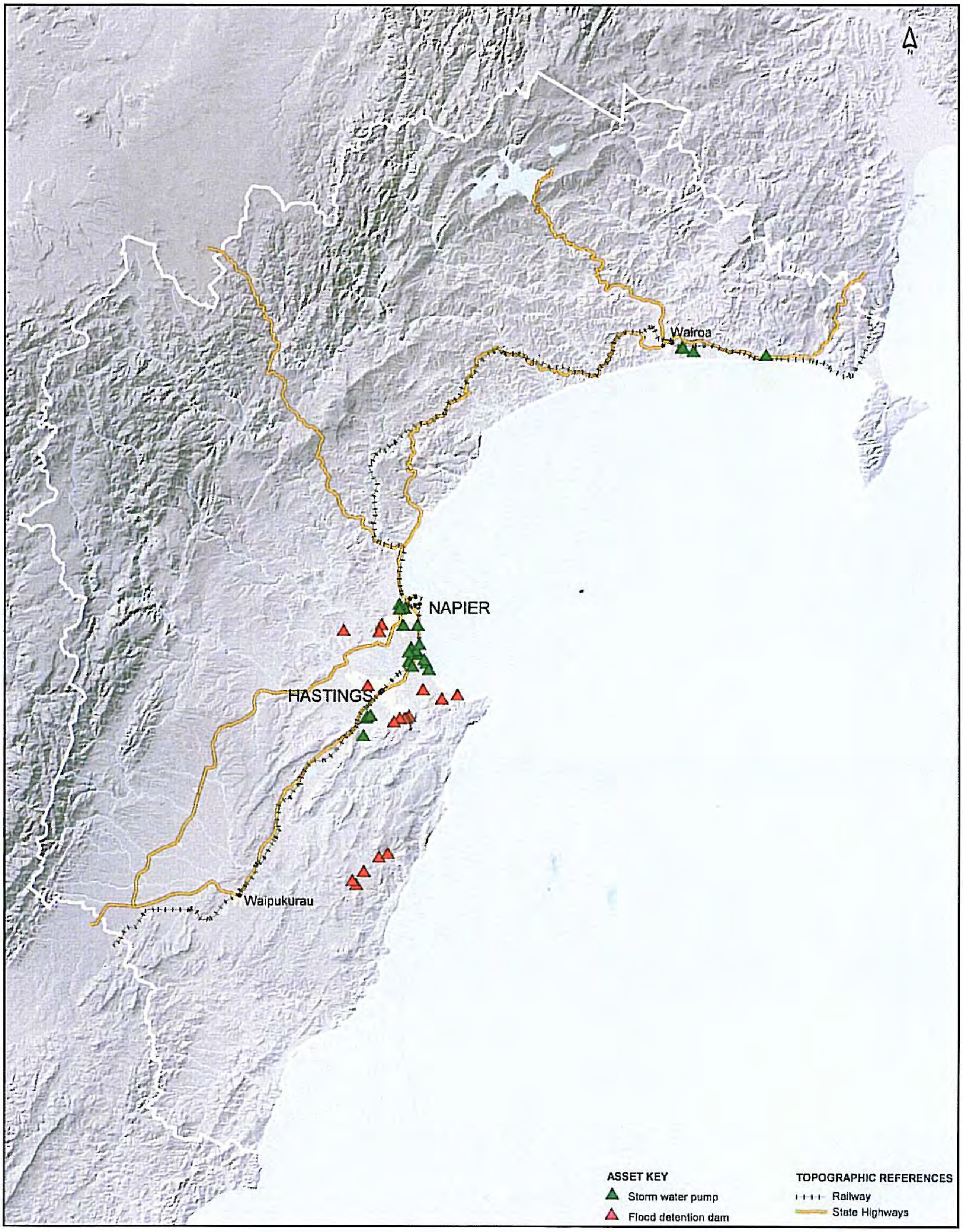


Map 16

Civil Services
Waipawa and Waipukurau Townships



Map 17


Wairoa
NAPIER
HASTINGS
Waipukurau
ASSET KEY
Storm water pump
Flood detention dam
TOPOGRAPHIC REFERENCES
Railway
State Highways

Chapter 11
Energy Group

Introduction

The Energy Group was made up of representatives from electrical, gas and oil industries with networks within the Hawke's Bay region. These electrical networks included Eastland Energy in the Wairoa district, Hawke's Bay Network in Napier and Hastings, and Centralines in Central Hawke's Bay. Contact Energy had an oil-fired electrical generating plant at Whirinaki but this was not included in the Lifelines study, as it is has been decommissioned. Gas networks included Natural Gas Corporation of New Zealand, United Networks and Nova Gas.

The oil industry has two supply terminals in Napier operated by Caltex NZ Limited and New Zealand Oil Services Ltd at Ahuriri.

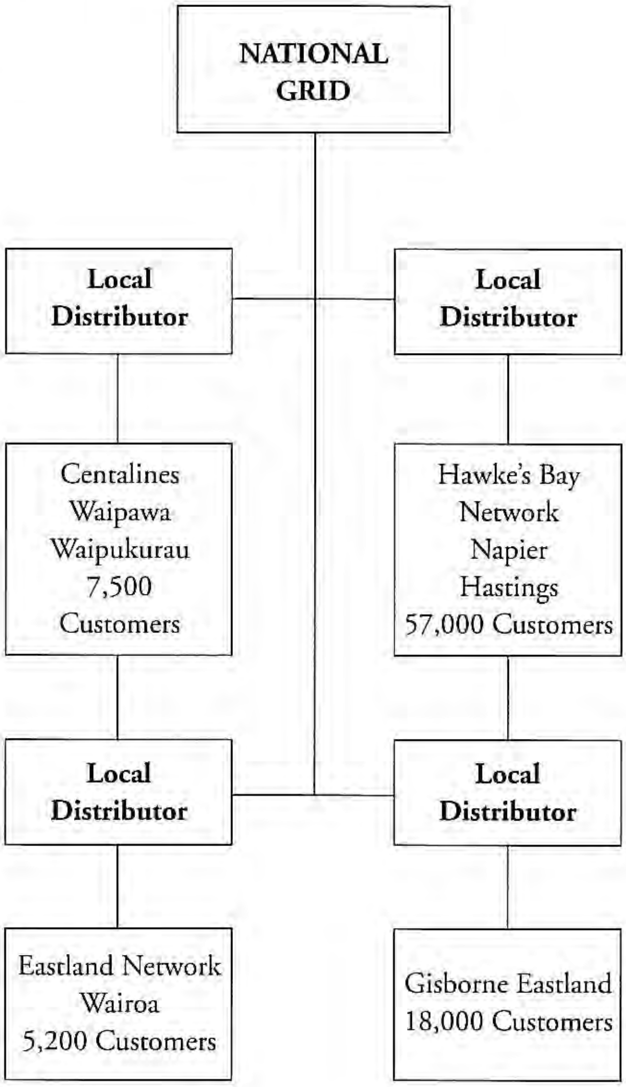
A particular feature of the Energy Group networks in Hawke's Bay is their participation in national supply networks. There could well be natural disasters occurring outside the region that have significant effects within it. While the risk of such events is outside the scope of this project, the responses within the region would be similar to those resulting from a total loss of service from the main feeder to the region.

Similarly, the East Coast north of Hawke's Bay would be very much affected by loss of electricity service within Hawke's Bay. The Poverty Bay/East Coast area is supplied by a single branch from Tuai and is totally dependent upon maintenance of that supply.

The Energy Group experienced similar difficulties to the Transportation Group in assessing a large and complex network and trying to produce a short list of items for consideration for mitigation measures.

Again the first use of Table E3 of AS/NZS 4360:1999 produced a large number of elements with an E risk rating. By adjusting the matrix so that there were less E generating combinations and electronically re-running the risk assessment, a meaningful short-list of elements of highest risk was produced.

Electrical Power



Introduction

The electrical power distribution is made up of a regional supply from the National Grid (owned and operated by Transpower (NZ) Limited) with three local distribution systems covering Napier-Hastings (Hawke's Bay Network) Wairoa (Eastland Energy in part) and Waipawa-Waipukarau (Centralines).

There are power generating stations at Waikaremoana-Tuai, Piripaua and Kaitawa (Genesis Power), and Wairoa (Eastland Network).

The Energy Group notes with concern that the Whirinaki generation plant has been sold for removal. Although Contact Energy has applied for resource consents for a 100 MW combined cycle power station on this site, there are not yet any firm development plans. This has a major effect on the energy lifelines in the Hawke's Bay region.

The majority of electrical power is bought from producers outside the Hawke's Bay region and supplied to consumers via the regional and local networks.

Regional network

The supply networks at regional and local distribution level form an interrelated chain, making them mutually dependent on the overall availability of electric power to deliver supplies to users. This report treats the regional and local distribution systems separately to avoid confusion and to highlight the importance of the regional supply to Hawke's Bay. The New Zealand transmission network is made up of the following components:

Wairakei Transpower lines at Whirinaki stretching towards the western ranges. (Photo courtesy HBRC)

Regional Major Lines:

- 2 x 220kV transmission lines from Wairakei Power station which connect the National Grid to the 110kV Hawke's Bay-East Coast Network at Redclyffe;
- 2 x 110kV transmission circuits connecting to the National Grid at Bunnythorpe (Palmerston North) and running via Redclyffe up to Waikaremoana (Tuai) to form the basis of the 110kV Hawke's Bay-East Coast Network;
- 1 x 110kV transmission circuit connecting Fernhill with Waikaremoana to supplement the 110kV Hawke's Bay-East Coast Network.

Regional feeder lines are detailed below:

- 2 x 110kV circuits from Tuai to Gisborne (Eastland Network);
- 2 x 110kV circuits to Wairoa (Wairoa-Eastland Network);
- 2 x 220kV circuits from Redcliffe to Whakatu (Hawke's Bay Network);
- 1 x 110kV circuit from Gisborne to Tokomaru Bay (Eastland Energy);

Normally the 110kV system is disconnected between Fernhill and Waipawa to give operational stability and control between the 110kV and 220kV sections of the National Grid.

Power is supplied to the local distribution networks at the following locations or Grid Exit Points (GXPs):

Regional Offtake Arrangements	Within the study area the National Grid Offtake of power is generally:
MW Offtake	Local Distributor
18	Waipawa (OngaOnga) to Centralines
39	Fernhill to Hawke's Bay Network
54	Redclyffe to Hawke's Bay Network
74	Whakatu to Hawke's Bay Network
75	Whirinaki to PanPac Limited
8	Wairoa to Eastland Network (Wairoa)
46	Gisbourne to Eastland Network - not in study area*

** Not in study area but totally reliant on power supply from the Hawke's Bay study area.*

Redclyffe is by far the most important GXP from an operational point of view as it is the interconnection node between the 220kV and the 110kV networks and is crucial to the supply of power to the study region from the North, West and South.

Whakatu (74MW), PanPac (75MW) and Redclyffe (54MW) are the most important GXPs in the region for energy supply, comprising 66% of the total supply in the East Coast region.

Electrical system vulnerability - Regional System

Transpower New Zealand

System seismic design

All equipment and buildings at Transpower substations and transmissions lines are designed to strict seismic design codes. The only problems which could occur would result from ground distortion and land slips in some transmission line locations.

The vulnerability assessment has identified the following issues:

Tuai PowerStation

The age of equipment at Tuai varies with some dating back to the initial installation in 1929 but most having been replaced or upgraded in the intervening years. In the switchyard area there is a high risk of landslip and the local transmission lines cross some very rugged and difficult country.

The Tuai-Fernhill and Tuai-Redclyffe transmission lines have a medium landslip risk assessment for most of their length. These two lines are also at risk from seismic activity in the northern section between the Tuai and Mohaka river crossing. They provide the only link with Waikaremoana generation and the Northern end of the East Coast region.

220kV Wairakei Lines (Whirinaki and Redclyffe)

Although most transmission lines are not at risk from seismic activity or landslip because of the high standard of tower and line capability design, the two Wairakei lines in the Te Pohue to Rangitaiki area are an exception. This area is seismically active, subject to major landslips and extreme weather conditions, including wind, rain, snow, and ice, and rises to a height of 900 meters. Recent operational incidents for these and the Tuai lines provide evidence of this risk.

Electrical system windstorm vulnerability

The design criteria for transmission lines makes them generally able to withstand all expected windstorms. However a windstorm associated with a severe weather condition would greatly increase the risk.

Electrical system flooding vulnerability

The substations at Whirinaki, Redclyffe, Whakatu, Wairoa, and Waipawa are all on low-lying land adjacent to a major river system, making them vulnerable to flooding.

In each case failure of a flood protection system could pose a major risk and prevent normal working access to these sites.

Whirinaki and Wairoa face the highest because of their low-lying position and drainage arrangements.

The flooding risk for transmission lines in the region is generally low. The greatest risk is in Esk Valley, on the Redclyffe-Tuai line at the river crossing adjacent to SH5, and adjacent to the Wairoa substation on the pole section of the Tuai-Wairoa lines.

Electrical system volcanic vulnerability

Volcanic ash deposits on electrical transmission equipment present a medium risk in the study area. The ashfall is most likely to drift eastwards from volcanic emissions in the Taupo-Rotorua region.

The Waipawa, Fernhill, Tuai, and Wairoa substations and all the transmission lines associated with these locations are most at risk.

However, the ashfall pattern could be highly variable, meaning all National Grid lines and switching stations in the region are at some risk.

Electrical system landslip vulnerability

Most of the grid network substations have been designed and sited to minimise the effects of landslip or ground displacement.

However Tuai Power Station and its associated switching station are an exception, The power station site was chosen for its hydroelectric potential but is on the Waikaremoana fault barrier, putting it at risk from landslip or ground movement.

Because of the very broken and rugged terrain in the region, transmission lines are located on ridge tops and in prominent locations, which are at risk from landslip. For this reason all the lines in steep hill country are at medium risk. The Wairakei lines are at high risk in the Titiokura to Rangitaiki Plains area as the potential for landslip due to seismic activity, weather, or erosion is a constant possibility.

Electrical system operational importance

Grid Layout

The Transpower grid layout has developed over time, starting with the initial supply into Hawke's Bay from the south in the 1920s, via the Bunnythorpe-Woodville-Redclyffe lines. In the late 1920s and 1930s the Tuai-Redclyffe and Tuai-Fernhill lines were installed to cater for the development of the Waikaremoana generation project and to feed supply back to Hawke's Bay.

Redclyffe Substations for Transpower and Hawke's Bay Network showing proximity to the Tutaekuri River.

Until the early 1970's when the Pan Pac mill was built, the East Coast relied on the Bunnythorpe-Tuai (via Redclyffe) interconnection and Waikaremoana generation for power supply.

In the early 1970's 220kV was introduced from Wairakei to support major developments in Hawke's Bay including the arrival of Pan Pac and the installation of the Whirinaki Power Station.

With the introduction of the major 220kV link, Hawke's Bay's previous problems with power supply were overcome, if not forgotten. The level of power transfer from the 220kV supply to the 110kV network at Redclyffe is 200MVA, which is well able to cope with normal demands.

The introduction of 220kV to Redclyffe saw power generation and voltage support from Waikaremoana becoming less important and a greater regional reliance on the main North Island grid via Wairakei. For operational reasons the previous supply via Bunnythorpe and Woodville is not connected. This improves power flow and avoids equipment overloading.

Today the power loading in the East Coast region is such that if there is a total loss of 220kV, the original 110kV lines and Waikaremoana services, if available, cannot supply all the region's requirements without severe loading restrictions.

In summary:

The 220kV lines into the area from Wairakei are a major lifeline for Hawke's Bay. The other lines into the area from the south can only provide sufficient supply if Waikaremoana is operating at full capability and severe loading restrictions are imposed.

The decommissioning of the Whirinaki Power Station makes the region more vulnerable to power supply interruptions.

Normal supply arrangements are directed at the 220kV lines and any loss or disruption of these lines, even momentarily, will affect the whole Hawke's Bay/East Coast region until system stability is restored.

Redclyffe Substation is the most vital switching node in the region because it interconnects the 220kV /110kV Waikaremoana generation, the East Coast and the southern Hawke's Bay supply.

If the 220kV supply were interrupted, there would have to be reverse power flow of the interconnection banks for Whakatu and Pan Pac to maintain supply. They will therefore be included in the restrictions outlined above.

In conclusion, any loss of the 220kV circuits and/or Redclyffe Substation will have a major impact on Hawke's Bay and the East Coast.

During September 2000 such an event caused the loss of power to the region for up to four hours. This resulted from severe storm conditions in the Mohaka and Waipunga Valleys and snow and ice damage to the Wairakei circuits. The Redclyffe-Tuai and Fernhill-Tuai lines were also damaged, leaving Hawke's Bay without any power. Fortunately the incident started at 11pm, repeated again at 4am and supply was restored about 8am. Had the incident occurred during a peak load period or continued into a working day the consequences would have been far-reaching and more serious.

The storm that led to this incident concentrated into a narrow region from the upper Mohaka-Tarawera area across to the Gisborne-Mahia area. It inflicted some damage on distribution lines operated by Hawke's Bay Network and also damaged most lines in the Wairoa (Eastland Network) area.

The return period of such an event is probably 60 years. However, given that such storms in the area have never before affected transmission lines, the return period of localised high intensity storms, including ice and snow buildup on lines, may be at variance with this.

The incident clearly identified the importance of the 220kV lifeline.

Conclusions

The HB Engineering Lifelines Project has identified the following risks:

- Substations at risk from flooding and seismic events;
- Transmission lines at risk from seismic events and extreme weather events.

All assets have been built to current New Zealand design standards and modified where necessary to bring them up to new standards.

No further upgrading of Transpower assets, for the mitigation of risks identified in this project, is planned.

Power Lines feeding power to TeWaka have had their spans shortened by including extra poles. This was necessary to prevent the combination of ice and wind causing the spans to collapse under the strain.
(Photo courtesy Ian Greaves Telecom)

Local Distribution Networks

Hawke's Bay Network

The network owned and operated by Hawke's Bay Network Limited covers the area between Putorino in the north, Te Aute in the south and the Kaiweka Ranges to the west. There are 57,000 customers using 850GWh per year.

Power is supplied into the network by Transpower at Redclyffe (adjacent to Napier), Whakatu (adjacent to Hawke's Bay industrial loads between Napier and Hastings), and Fernhill (adjacent to Hastings).

Subtransmission System

Connections are all at 33,000 volts and comprise a substantial 33,000-volt subtransmission system that allows supply to be transferred to 23 zone substations from the three Transpower GXPs.

Hawke's Bay Network can overcome equipment failure by transferring load to most of its zone substations using alternative connections via its subtransmission system. However multiple failures or widespread damage will have more serious outcomes. Industrial and urban load areas have more secure back-up from alternative supply routes.

Local Distribution System

From the three GXPs power is transferred to 23 zone substations before being distributed, via 127-11,000 volt feeders, to 4,000 local pole-top and ground-mounted transformers. These provide the 400-volt and 230 volt power connection to domestic and commercial end use customers.

Some larger high-use industrial customers are directly connected to the 11,000-volt system to improve reliability and reduce losses. In some instances duplicate supplies are provided.

The 11kV system can be reconfigured to isolate most network faults and facilitate repairs.

At the low voltage level (400/230 volts) alternative supply arrangements are available in some urban and high-load areas. If the failure zone is not too widespread, alternative connections can be made to adjacent transformers.

Local Generation

The only local generation interconnected to Hawke's Bay Network's subtransmission system is at Ravensdown's Awatoto Fertiliser Plant. Ravensdown operate a 6MVA turbo alternator as part of their sulphuric acid plant. This unit runs on waste heat and feeds any excess generation into Hawke's Bay Network's 33kV network. This plant is not able to start itself and requires a grid connection for all but specially arranged and isolated operations.

The plant is unsuitable for emergency supply purposes.

Electrical system vulnerability HB Network

The Lifelines study covers the 33,000V and 11,000-volt network and the zone substation that provides local distribution nodes.

Seismic vulnerability

33,000 Subtransmission Network

Most of the 33kV network is vulnerable to seismic disturbance in the short term because of its widespread exposure, numerous support structures and importance to supply continuity. Line tripping and subsequent re-livening after the event can be expected in most cases.

The 33kV/11kV cable sets between Faraday Street and Bluff Hill are particularly vulnerable to in-ground damage from seismic fracture or displacement.

Damage to support structures such as pole footings, tower bases and support distortion is not likely to be insurmountable, providing it is localised and does not affect alternative lines at the same time.

In some places the 33kV network is on common support structures. Of particular vulnerability are the Onekawa Switching Station, Faraday/Bluff Hill at Faraday Street and Windsor/ Arataki/Tomoana/Hastings City at Rangitane to Ruahapia Road. However each of these, except Faraday Street, has an alternate supply route.

The Napier CBD is particularly vulnerable. All supply is routed through the Faraday 33kV switchyard and confined within this vital area, which sits on reclaimed liquefaction land adjacent to the area most damaged by the 1931 earthquake.

Zone substations

Zone substations are most vulnerable to seismic damage in the area of their outdoor switchyard, particularly where these are older, at a higher level on supports, with extensive buswork and overhead line connections.

Most of the transformer and indoor switchgear installations in zone substations are designed to withstand seismic activity. The control equipment, although various, is well located and supported but could malfunction during a disturbance.

Locations likely to suffer the greatest impact from a lifelines emergency are Flaxmere, Mahora, Rangitane, Tamatea, Irongate and Tannery Road.

11kV supply network

Some brief loss of supply can be expected on most of approximately 120 feeders due to lines clashing during an event.

There would be ongoing faults on some feeders, as a result of network damage. The most vulnerable are those in the following areas, as they are likely to experience displacement or ground shifting:

- Downtown Napier CBD
- Downtown Hastings CBD
- Havelock Hills (upper sections)
- Westshore
- Flaxmere

Throughout the network area there are numerous faultlines. The 11kV lines are vulnerable where they traverse these faultlines. However any problems would be short term.

1931 Hawke's Bay Earthquake.

Windstorm vulnerability

33kV network: Southern area

There is vulnerability to windstorms on the exposed sections of the Fernhill supply lines to Flaxmere, Camberley, Irongate and Havelock as all of these cross the path of the prevailing northwesterly winds.

The Sherenden line is also vulnerable but less important.

33kV network: Northern area

The North Tie and the Onekawa/Marewa lines are particularly vulnerable to line clashing as a result of flying debris and tree contact. The North Tie (Marewa and Bluff Hill/CBD) is the longest and most heavily loaded 33kV line, making it the most vulnerable asset.

The Patoka line is also vulnerable but less important.

Zone substations

Esk, Patoka, Sherenden and Tutira would be at risk in a major windstorm as they all have pole mounted switchgear and are in and serve exposed rural locations.

11kV network

Most vulnerable are the long rural feeders at exposed locations and with long spans, light conductors and trees in close proximity. This includes:

- Valley Feeder
- Roys Hill
- Twyford
- All Patoka feeders
- All Sherenden feeders
- All Tutira feeders

Flood vulnerability

33kv network

This network is vulnerable to flooding and possible damage to support structures at the following sites:

- Onekawa A&B lines – across the Napier Flats and river crossing area
- Rangitane/Arataki – four lines adjacent to Ruahapia Road
- Windsor/City – Karamu Creek
- North Tie river crossings (x2)
- Napier Flat Zone substations

The flooding risk is assessed as follows:

Awatoto	Very low-lying, a high water table with poor drainage and prolonged surface water flood pumping.
Esk	Within a river valley and known to have flooded many times. Subject to river flooding.
Rangitane	Low-lying with poor, but recently improved drainage. Subject to flood pumping.
Tamatea	Low-lying and near the estuary level on a flood plain. Subject to flood pumping.
Powdrells Road/ Tannery Road	Low-lying and adjacent to a riverbank. Subject to river flooding.
Tutira	Adjacent to lake level. Known to have seriously flooded before.
Springfield	A breach of the Tutaekuri River would be a major risk as the flowpath will erode Springfield and redclyffe itself.

11kV network

The major network vulnerability is in the low-lying areas above. Ground mounted transformers and 11kV switches are of major concern.

Awatoto	Foreshore industrial area
Bluff Hill	Napier section and CBD area.
Farady Street	Napier CBD and Napier South.
Marewa	Westshore, adjacent to estuary, and Ford Road.
Clive/ Haumoana	Possible flooding East Clive/ Te Awanga

Tsunami vulnerability assessment

All low-lying and coastal installations face a significant risk from tsunami. However the extent of damage is uncertain and will depend on the magnitude of the tsunami and where the seawall is breached.

Grid Exit Point vulnerability:

One GXP – Whakatu - is particularly vulnerable to tsunami because it is close to the Karamu Stream and in a low-lying area.

33kV network

The low-lying/coastal sections of the Onekawa lines, adjacent to Napier estuary, and the North Tie line, north of Tutaekauri, are vulnerable to tsunami.

Zone substations

The Esk and Awatoto substations are at high risk from tsunami because they are coastal, low-lying and experience natural flooding.

Faraday Street is at minor risk from tsunami.

It is possible that Springfield, Tamatea and Tannery Road could be affected by a tsunami. However, given that the floodwaters will rise and fall rapidly, any impacts are likely to be short-term.

11kV network

Most of the 11kV feeders from the above zone substations have similar levels of risk.

Awatoto, Bluff Hill (Harbour and Marine Parade) and the coastal areas adjacent to the Esk substation show extreme vulnerability.

Te Awanga and Haumoana are also a tsunami risk because each is a coastal feeder with some ground-mounted items.

Volcanic vulnerability

The inland rural network is the only section specifically at risk from the volcanic hazard.

The Patoka, Sherenden and Maraekakaho network areas and zone substations are vulnerable because of their location. Ashfall patterns and the coverage area will depend on weather conditions.

The Valley 11kV feeder is also expected to be vulnerable to some extent from ashfall.

Landslip vulnerability

Patoka and Tutira zone substations are vulnerable to landslips affecting the 33kV lines and 11kV feeders in these localities.

Within the Network

Esk Valley feeder, Bay View, Tangoio, Tutira and Poukawa are vulnerable to landslip.

Wairoa Section of Eastland Network

The Wairoa portion of the Eastland Network is made up of a 50kV, 33kV and an 11kV network and two Transpower GXPs. Power is delivered to customers throughout the Wairoa region, from Morere in the North to Lake Waikaremoana in the west and Putorino in the south, where it joins the Hawke's Bay Network. Demand is concentrated around the town of Wairoa.

The Grid Exit Points are:

Wairoa	Supply is available from Tuai Power Station via two 110,000-volt transmission lines to the Wairoa GXP.
Tuai	11kV supply is distributed to Tuai and Lake Waikaremoana in a localised network.

50kV and 33kV network

A 50kV network connects the Waihi Generation Station with Wairoa and with a 33kV line to Mahia in the Blacks Beach area.

11kV network

The 11kV network that distributes in each area from Tuai, Wairoa and Mahia, is made up of a conventional distribution system with local transformers to take supply to customers.

Waihi generation

The Wairoa network includes a connection to a stand-alone generation station with capability for 5MW output. It is self-starting and has the ability to operate independently of the National Grid. Waihi generation can provide about half the supply needed in the area, as long as water storage is available.

This puts Wairoa is in a favoured position and means this plant will be a valuable lifeline in a major incident.

Tuai generation

The Wairoa network is connected to the National Grid at Tuai, which is the source of more generation power than Wairoa can distribute. If the grid connection between Tuai and Redclyffe/Fernhill was lost, Wairoa and Gisborne/East Coast can rely on an uninterrupted supply from Tuai. This area can run as an isolated island for a considerable period of time

Vulnerability Assessment

With one GXP at Wairoa supplying most consumers, this site has a high risk to any major activity.

Geographical features have determined the network configuration, which would be susceptible to line clashes and resulting outages. Restoring supplies would be prioritised according to damage sustained and accessibility.

Most underground cables are located in Wairoa township, meaning ground damage in this area could impact on supply.

Wind

50kV network

This feeder between the Waihi Power Station and Kiwi substation follows a largely sheltered route and is not vulnerable to wind damage.

33kV network

This feeder is constructed on the main coastal ridge between Wairoa and Nuhaka and is exposed to southerly winds, making it extremely vulnerable. It has suffered major damage in southerly storms in the past. Extensive repairs, reconfigurations, pole stabilisation work and additional support structures have been carried out since the last major outage in September 2000.

11kV Network

The rural network can be split into two areas depending on wind direction, to assess its vulnerability.

Northerly winds affect the high country areas of Putere, Mangone and Ruakituri while southerly winds dominate the coastal areas between Mohaka and the end of the Mahia Peninsular.

The network is more likely to be damaged by tree contact as a result of high winds, rather than component failure.

Flood

Kiwi substation and A Park switching station are vulnerable because they are low-lying and close to the Awatere Stream and the Wairoa River.

The ground mounted 11kV switches and transformers in Wairoa itself, associated with the underground cabling, are also vulnerable if flooding breaches the banks of the Wairoa River.

Tsunami

Again, due to their location, Kiwi substation and A Park switching station are vulnerable to tsunami.

A large portion of the network is reticulated around the populated coastal areas of Mohaka, Wairoa, Nuhaka, Opoutama, Mahanga and Mahia Beach, making it vulnerable to tsunami.

These are all low-lying areas. The resulting damage would be a directly related to the size of the tsunami.

Volcanic

The wind speed and direction at the time of volcanic activity affects the level of vulnerability.

Putere, Mangone, Tuai and the upper Ruakituri Valley are most likely to be affected due to their proximity to volcanic areas.

Landslide

The outdoor station (ODS) associated with the Tuai Power Station is extremely vulnerable to landslides.

A landslide which damaged this equipment would completely isolate the Wairoa and Gisborne areas from a source of electrical supply.

All feeders in the rural area transverse high hill country and are therefore vulnerable to landslide.

Centralines Ltd

Centralines (formerly CHB Power) operates a network throughout the Central Hawke's Bay District Council area.

The network is supplied from one GXP -Transpower's Waipawa Substation near Onga Onga.

Power is distributed directly from the Onga Onga site at 11,000 volts throughout the western portion of the district.

Four 33,000-volt transmission lines supply power to Waipawa, Waipukurau, Porangahau and Takapau, where zone substations reduce the voltage to 11,000 volts for further local distribution.

Most of Centralines customers are in and around Waipawa and Waipukurau.

The Waipawa (Transpower) GXP is on the two 110,000 volt transmission lines running from Bunnythorpe via Woodville to Fernhill. Grid power can be supplied on either of the two parallel lines from the north (Fernhill) or the south (Bunnythorpe). In this respect Centralines' supply is more secure and less at risk from overloading or voltage stability problems as long as the north-south connection has not been established, which could happen during an emergency, as part of operational needs to support the region from the south.

The major problem for Centralines is that only one GXP is involved and there is no alternate supply. Centralines is normally connected to the Grid from the south or the north but not both together.

Centralines Assessment

Seismic

Because the Waipawa GXP at OngaOnga is Centralines single point of supply, it is at high risk from seismic activity.

Line clashes on both 33kV and 11kV circuits are highly likely, depending on the size of earthquake. Outlying areas would inevitably lose supply, and restoration would be governed by the amount of damage sustained. 11kV tie-lines provide flexibility for redirecting supply to outlying areas.

Underground cables are susceptible to land fissures and shear fractures.

Zone substations at Waipukurau, Waipawa and Takapau have been fitted with earthquake protection devices to reduce the risk of transformer rollover.

Wind

A number of areas on Centralines 11 kV network are at risk during high wind events. This includes risk of damage from the wind itself and from trees. The areas are:

- Mangaorapa
- Whangaehu
- Herbertville
- Flemington
- Wanstead
- Wakarara
- Ashley Clinton

Flood

The Waipukurau zone substation is considered to be a high-risk flood site, given its proximity to the Tukituki River. The Porangahau substation near the Porangahau River is a medium risk site while both Waipawa and Takapau are at low risk from flooding.

The 33kV and 11kV circuits have river crossings on the Tukituki and Waipawa rivers that are at some risk during major flood events.

Tsunami

Tsunami poses little risk to the Waipukurau, Waipawa and Takapau zone substations. However Porangahau, with it proximity to the Porangahau River, has a low-level risk.

11kV lines supplying coastal areas are high-risk assets during this type of event.

Volcanic

The Waipawa GXP, Waipukurau, and Takapau zone substations are all at risk from volcanic activity, depending on weather conditions at the time and ashfall patterns.

Ashfall could also impact on the 33kV and 11kV feeders within the western and central areas of Centralines network.

Landslip

No zone substations are vulnerable to landslips.

The Porangahau 33 kV and a small number of sites on the 11kV feeders are under threat from potential landslips.

Natural Gas Supply

Natural Gas Corporation of New Zealand

The Natural Gas Corporation (NGC) has approximately 80 km of high pressure transmission line (the 700 line) in the Hawke's Bay Region. This pipeline was designed and constructed to USAS B31.8, I.P or to DZ5223 (Draft) or NZS 5223, NZ Standard Code of Practice for High Pressure Gas and Petroleum Liquids Pipeline, Part 1, High Pressure Gas Pipelines and Pipeline Authorisations.

NGC has carried out a pipeline risk assessment for its Kapuni-South pipeline system in accordance with AS/NZS 2885 : 1997 Pipelines – Gas and Liquid Petroleum. Approximately 80km of this pipeline is in the Hawke's Bay Region. All perceived risks to the pipeline have been identified and evaluated. The risk level associated with these events has been determined as acceptable and meeting the requirements of AS/NZS 2885.

SAA HB105-1998 Guide to Pipeline Risk Assessment in accordance with AS 2885.1 – Section 3 Process of Pipeline Risk Assessment was used to ensure a consistent and informed approach to risk assessments. The Pipeline Risk Assessment report and the Pipeline Integrity Report will be used by a certifying body to issue a "certificate of fitness" for the pipeline to operate under the Health and Safety in Employment (Pipelines) Regulations 1999.

The Hawke's Bay Engineering Lifelines Project vulnerability assessment was extracted from this larger document. During this process some key issues were identified:

- NGC operates a trransmission system that begins in the Taranaki region and extends over the North Island. The pipeline in Hawke's Bay is at the end of a system, meaning gas supplies to the region may be disrupted by events outside of the area.
- The pipeline in Hawke's Bay does not directly feed any large sites, such as dairy factories or power stations, but supplies distribution companies from sales gates in Takapau, Mangaroa and Hastings. This makes it difficult for NGC to accurately evaluate the social and economic effects of losing gas supply downstream of these points. Natural gas may be used for heating in hospitals, schools and old folks homes or embedded generation, cogen or other industrial processes and interruption of supply to such facilities may adversely affect the

community. Because NGC cannot access information on this scenario, there is a degree of uncertainty in the assessment of possible consequences.

- The vulnerability assessment only deals with the natural hazards of seismic activity, wind, flooding, volcanic activity and landslip. NGC's pipeline risk assessment shows that the event most likely to affect gas supplies are excavations by third parties which damage the pipeline. Prevention and mitigation measures are in place to reduce the risk of this.
- Segments 6, 7 and 8 are not within the Hawke's Bay region but the Dannevirke offtake point at the beginning of segment 6 forms a recognisable basis to work from.
- Although earthquakes have the potential to cause a total rupture of the pipeline, the risk of this occurring is low. This was demonstrated during activity on the Edgecumbe fault, where there was significant land movement around the pipe. This event caused structural damage to roads and buildings but none to the pipeline. Furthermore, in the San Francisco earthquake of 1992, although there was wide spread damage and ground movement, no electric arc welded pipes failed.

United Networks Ltd, Natural Gas Network

Hastings / Napier Network Description

United Networks (UNL) owns and operates two networks in the region, one in Hastings/Napier and the other in Takapau. Several energy retailers use the network to deliver natural gas to their customers through their own gas measurement systems (GMS). UNL's responsibility ends at the service isolation valve, which is installed before the GMS on the service riser pipe.

The Gate Station (GS) in Karamu Road, Hastings, is the transfer point between the natural gas transmission network and United Network's gas network.

The gas is fed into a steel intermediate pressure (IP) pipeline at 10 bar pressure (approx. 150psi) which extends about 36km, from Hastings to Whirinaki. This pipeline also supplies natural gas to the cities and towns of Hastings, Havelock North, Clive, Napier, Taradale, and Bay View and the industrial areas of Whakatu, Awatoto and Whirinaki. There are a number of GMS's along the pipeline supplying gas to industrial and commercial customers.

District pressure-reducing stations (DPRS) are situated along the pipeline, reducing the pressure to supply gas into the medium pressure (MP) network. The MP network consists of polyethylene pipe (PE) which has a maximum operating pressure of 4.2 bar (60psi). This network mainly supplies commercial and domestic customers and stretches from boundary to boundary of each of the urban areas. There is also a low pressure (LP) network in the Napier/ Hastings area. Typically the LP network is made of cast iron, asbestos and unprotected steel pipes.

The IP steel network is protected from corrosion by an impressed current cathodic protection system.

Takapau Network Description

The network in Takapau is made up of a 4km long steel intermediate pressure pipeline with a maximum operating pressure of 10 bar. The pipeline supplies natural gas to Richmonds' plant.

Both the Hastings/Napier and the Takapau networks comply with NZS 5258 Gas Distribution.

Vulnerability Assessment

The assessment was carried out by looking at the IP pipeline from the Hastings gate to the end of the line at Whirinaki. Along the route each component was identified (such as DPRS or line valve) and analysed in terms of the various hazard scenarios for:

- seismic activity
- wind
- flooding
- tsunami
- volcanic activity
- landslip

The medium and low pressure networks were then examined separately.

Seismic Activity

The IP and MP pipelines that make up the United Networks gas network have been constructed over the last 20 years. The MP pipelines are built to best practise and NZ and international standards, using steel or polyethylene pipes, or both. New Zealand and overseas experience has shown that these types of network have an exceptional ability to remain intact during seismic activity and generally survive undamaged. Conversely, LP pipelines do not fare as well and it is therefore likely that there will be some damage to this network.

Where the pipelines are attached to another structure, rather than buried in the ground, the structure may inflict damage to the pipeline. The IP pipeline is attached to 5 road bridges and 1 pipe bridge. In a large event we would expect some degree of damage to the pipeline at these locations, although the extent will depend on a number of factors. Some allowance for this has already been factored into the design at these sites, particularly in regard to the way the pipeline approaches the bridge and the supports that attach the pipeline to the bridge structure.

The design of some DPRS sites means they may also experience movement of the station structure. Sites located in areas with a high probability of liquefaction may face similar problems. Damage may also occur at some of the larger GMS sites.

The line valve pits on each side of the bridge crossings are in soils susceptible to liquefaction and may also cause problems. Again this will depend on the exact location and magnitude of the event. The remaining cast iron pipes in the network could fracture during a major earthquake, which could lead to an outbreak of fire. United has a replacement programme for all cast iron lines in the network.

Wind

Most of the gas network is underground and protected from wind-related problems. However wind could impact on above ground structures such as DPRS and GMS sites. Damage at these sites could result from flying debris, falling poles, trees or branches. This type of damage would be localised and is unlikely to have a major impact on the integrity of the network.

Floods

A major flood could have severe impact on the IP network, especially near points where the pipeline crosses the various rivers in the region.

Several of the DPRS and GMS sites are in areas that may be flooded. The DPRS sites can operate even when fully submerged in water. Customer GMS sites are generally unable to function under water so some problems are expected at these locations. Generally these will be small GMS sites on domestic dwellings.

Volcanic

Given that the gas network is buried, ashfall is unlikely to cause major problems. The only forseeable difficulty is the potential for regulator vents at the GMS sites to be blocked with volcanic ash.

Landslip

With most of the gas network under urban areas on the plains of Hawke's Bay, landslip is unlikely to be a problem. Napier Hill and some sections of Havelock North may be susceptible to localised network damage from landslip but the overall impact of this would be minimal.

Tsunami

Tsunami could affect sections of the gas pipeline that are near to the coast and rivers, from Whakatu to Whirinaki. Depending on its magnitude and location, a tsunami could have a major impact on the network.

Nova Gas Hastings Network

Nova Gas has approximately 9km of pipe installed in Hastings, which was commissioned in 1999. All the underground pipe is made from PE100 SDR11 plastic while all the above ground pipe is constructed in steel. The pipeline's operating pressure is 720kPa and it supplies industrial customers. Each customer has a GMS, which includes emergency isolation valves and slam shut protection against excessive pressures in their outlet's pipework.

Only major seismic activity, flooding and excavation by third parties is likely to affect the pipeline, given that it is underground.

However the GMS's are above ground and the system's sites and pipeline would be affected as follows:

Seismic Activity

The PE pipeline will generally be unharmed except for the possibility of damage at tees and tapping tees. GMS sites may experience some movement with resulting damage, especially at larger sites. Falling building debris, trees and other objects could also cause damage.

Wind

Falling trees, poles, and flying debris may cause localised damage to GMS sites.

Flood

GMS sites will not function fully under water. Raging water could damage pipelines and GMS sites.

Volcanic

Volcanic ash could block regulator vents and affect the operation of the GMS sites.

Oil Supply

Caltex New Zealand Limited.

Locality and description

Caltex NZ Ltd is situated southeast of Bluff Hill in Ahuriri, Hawke's Bay. Caltex Napier is a bulk storage terminal with the capacity to hold 22 million litres of refined petroleum products.

The location of the terminal can be seen on the attached Map 21.

Caltex hosts Mobil at its Napier terminal and operates 24 hours a day, 7 days a week.

Layout of services

Water

Caltex receives its water supply from the Napier City Council ring main that feeds the Ahuriri area. There is one 80mm diameter feed off Tuatu St, which is protected with a backflow preventor. Fire protection is fitted to one of the tanks in the Electricorp compound and fed by the ring main off Tangiora St. All fire reticulation is via the drinking water pipe network.

Power

All operations are supplied through cabling which is maintained by the HB Network.

Communications

Telephones

Caltex uses a Centrex system that is owned and operated by Telecom. The system is based in the main administration building on Tuatu St.

Mobile Phones

All employees have mobile phones or access to phones in vehicles. These are connected to the Telecom Cellular Network.

UHF Radios

All tanker and inter-company communications during discharges are by way of UHF radios. Caltex and NZOSL have their own separate channel for this purpose.

Wastewater Reticulation

All wastewater is discharged into the NCC manhole at the end of Tuatu St. This network is maintained by the NCC.

Rail

Caltex relies on rail services to supply its Palmerston North depot in times of product shortages in Wellington. The rail network is maintained by TranzRail.

Pipeline

All supplies of refined product to the Napier terminal are via a 250mm pipeline, which runs from the terminal to the Port of Napier. The pipeline is underground, and is maintained jointly by Caltex and NZOSL.

Quarterly pressure tests are carried out on this pipeline to confirm its integrity.

Stormwater

Much of the tank farm is at a level about 1 metre lower than local ground level.

As a result all stormwater, after passing through a triple interception tank, needs to be pumped to an off-site discharge point.

Results of Risk Assessment

In-depth risk assessments are regularly carried out on the single pipeline to Caltex and Oil Services NZ Limited's terminal facilities.

The line is pump tested every 3 months under a requirement of the dangerous goods regulations.

It is constructed in ductile steel.

The major risk for the pipeline is at the junction between wharf structure and land. However, since the systems operate on a 3-weekly supply, there should usually be time to install a temporary connection for the next shipment.

At the Caltex terminal, two tanks were built in 1996 and one in 1959. The latter tank had its foundations upgraded in 1989. The other tank, in the former Electricorp compound, was built in 1977. All the tanks are built to current or recent design standards.

Terminal emergency operations planning has confirmed that, in the event of a power failure, tanks could be gravity-filled from other, well-supplied facilities.

Seismic Hazard

Ground Shaking

This does not pose a significant risk to tanks and structures.

Liquefaction

Given that the site is on reclaimed land, liquefaction could occur, depending on the reclamation materials and methods used at different locations.

Fault Displacement

This hazard is not expected to occur in this site.

Ground Settlement

General ground settlement could affect the stormwater systems and heights from which pumping is needed.

Any further development of the site would need to take into account the problems associated with the lower bank farm area.

Flooding

Extreme flooding could affect operations at the terminal.

Some means of ensuring a power supply to the stormwater pumps would reduce this risk.

Tsunami

Tsunami pose a high risk, given that the network is close to the coastline. However there are no practical mitigation measures that can be taken.

Wind, Landslip, Volcanic Ash and Wild Fire

None of these are likely to put the operation of the terminal at risk.

Energy Group Risk Assessments

The Energy Group has identified the following higher risk elements in the energy networks:

- The single 220 kV line from Wairakei to Whirinaki;
- No alternative additional generating power supply in emergency conditions;
- Seismic activity poses the greatest potential risk to continued electricity supply;
- Some sites are vulnerable to flooding that could cause electrical equipment to fail;
- Gas networks are most vulnerable to seismic damage where they are supported above ground by bridges and other structures;
- Cast iron pipes, where they remain in local distribution lines, are at risk from fracture during a major earthquake. This could lead to an outbreak of fire.

Mitigation Measures

All networks have ongoing maintenance and risk mitigation programmes of varying standards. These may need to be reviewed and upgraded in light of this study.

Recommendation

All network owners should review their maintenance and asset management programmes to mitigate the identified risks.

While it is not possible to eliminate all risks, mitigation measures should be incorporated where practical. This could occur as part of a maintenance, upgrade or redevelopment programme.

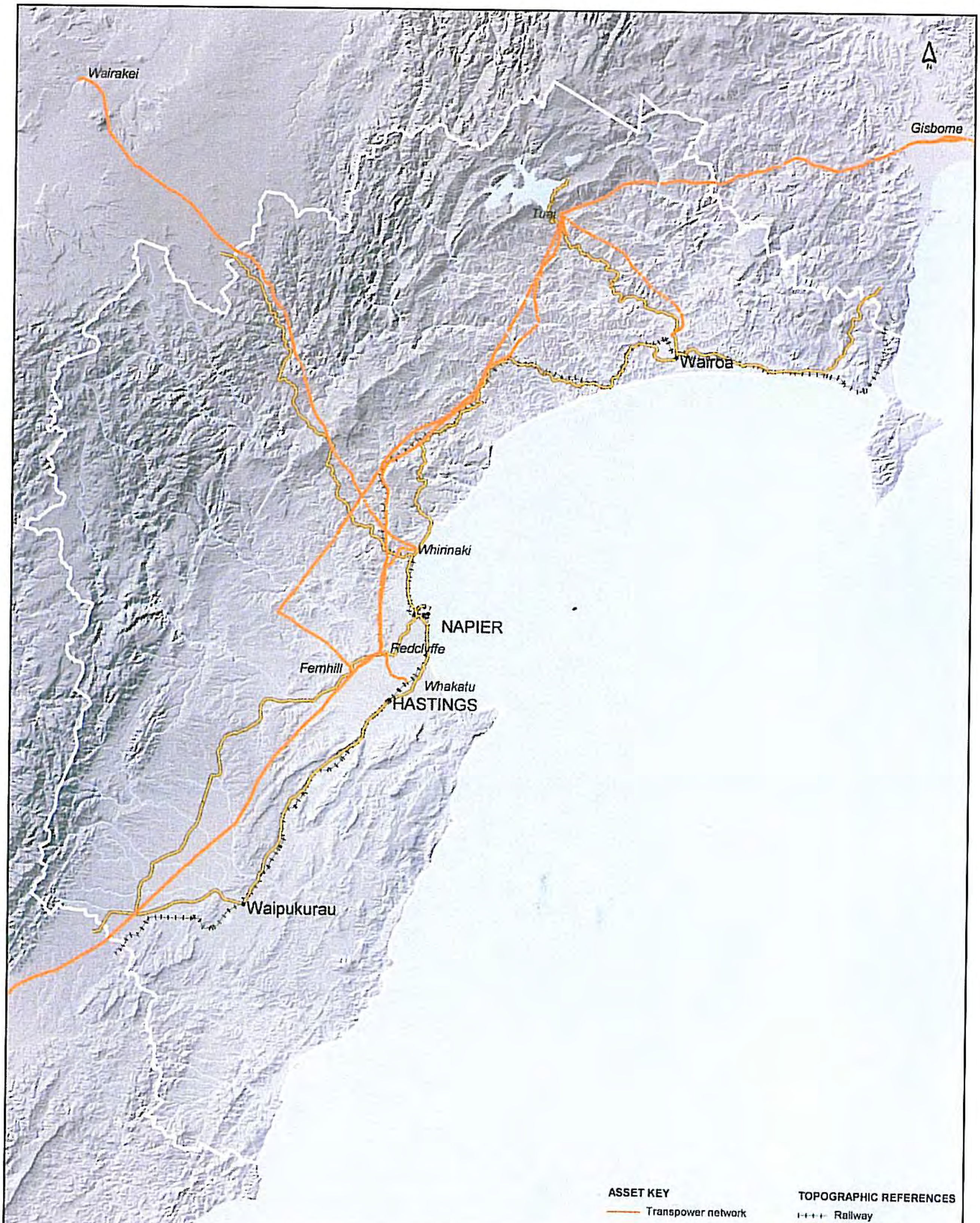
Hawke's Bay Network 33 KV Lines Risk Assessment

COMPONENT/ SEGMENT	SEISMIC			WIND				FLOOD				TSUNAMI				VOLCANIC				LANDSLIP			
	IA	PF	RN	DE	IA	PF	RN	DE	IA	PF	RN	DE	IA	PF	RN	DE	IA	PF	RN	DE	IA	PF	RN
REDCLYFFE	H	H	H	E	H	H	H	E	H	H	M	H	M	M	M	M	H	M	M	H	M	M	M
WHAKATU	H	H	M	H	M	M	M	E	H	H	M	E	H	M	M	M	H	M	M	L	L	L	L
FERNHILL	H	H	H	E	H	H	H	H	H	H	H	L	L	L	L	M	H	M	M	L	L	L	L
33KV SUB TRANS																							
ONEKAWA A/B	E	E	H	H	H	M	M	E	E	H	H	H	H	H	H	M	M	M	M	L	L	L	L
ONEKAWA C/D	E	E	H	E	E	H	H	M	M	M	M	H	H	H	H	M	M	M	M	L	L	L	L
GILLIGANS	M	M	M	M	M	M	M	H	H	H	H	H	H	M	M	M	M	M	M	L	L	L	L
SPRING A/B	L	L	L	M	M	M	M	H	H	H	H	H	H	M	M	M	M	M	M	L	L	L	L
PATOKA	H	H	H	H	H	H	H	M	M	M	M	L	L	L	L	E	H	H	H	H	H	H	H
RANG/ARA	H	H	M	E	H	M	M	H	H	H	H	M	M	M	M	M	L	L	L	L	L	L	L
MAH/TOM	H	H	M	H	H	H	M	H	H	H	M	M	M	L	L	M	L	L	L	L	L	L	L
WIN/CITY	H	H	M	H	H	M	M	H	H	H	H	M	M	L	L	M	L	L	L	L	L	L	L
ARA/WIN	H	H	M	H	M	M	M	H	H	H	H	M	M	L	L	M	L	L	L	L	L	L	L
NORTH TIE	E	E	H	E	H	H	H	E	H	H	H	H	H	H	H	M	L	L	L	L	L	L	L
FLAX/CAM	H	H	M	H	H	H	H	H	H	H	M	L	L	L	L	M	L	L	L	L	L	L	L
HVN/HAST/IRONGATE	E	H	M	H	H	H	H	H	H	H	M	M	M	L	L	M	L	L	L	L	L	L	L
FERNHILL	H	H	M	H	H	H	H	H	H	H	H	L	L	L	L	M	L	L	L	L	L	L	L
MKK/SHER	H	H	M	E	H	H	H	H	H	H	H	L	L	L	L	M	M	M	M	L	L	L	L
BLUFF/FDY CABLES	E	E	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	M	M	M	M
ONE/MAREWA TIE	E	H	M	E	E	H	H	H	H	H	M	H	H	M	L	L	L	L	L	L	L	L	L
ONE/NAPIER LINES	E	H	M	E	E	H	H	E	H	M	M	H	H	M	L	M	L	L	L	L	L	L	L
ARA/HVN CABLE TIE	E	E	H	L	L	L	L	M	M	L	L	L	L	L	L	L	L	L	L	L	L	L	L
CAM/MAHORA TIE	H	H	H	L	L	L	L	M	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
HAST/FERN TIE CAB/LINE	H	H	M	M	L	L	L	M	M	M	L	L	L	L	L	L	L	L	L	L	L	L	L

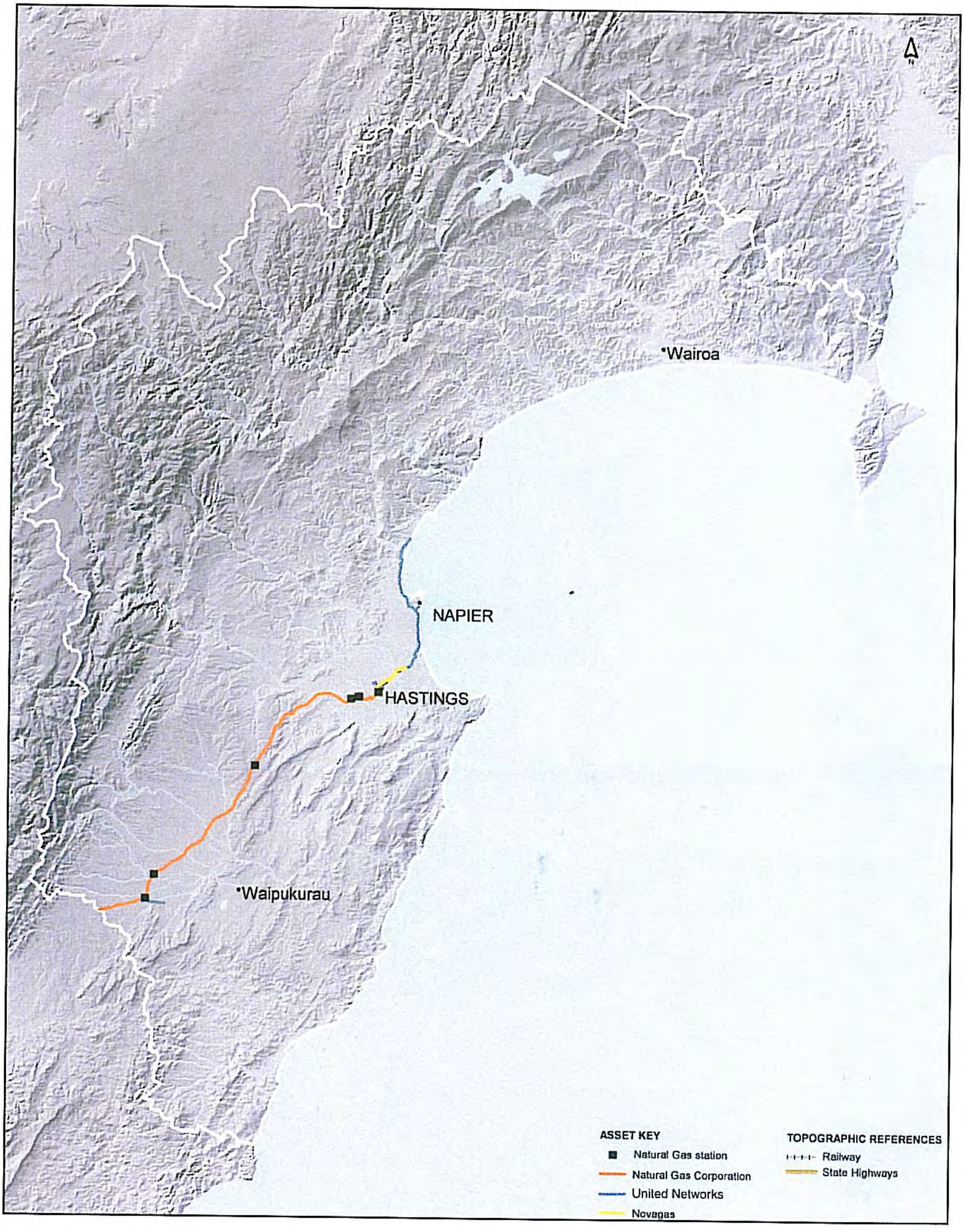
Hawke's Bay Network Sample Risk Assessment Spreadsheet.

Map 18

Energy
Transpower Network

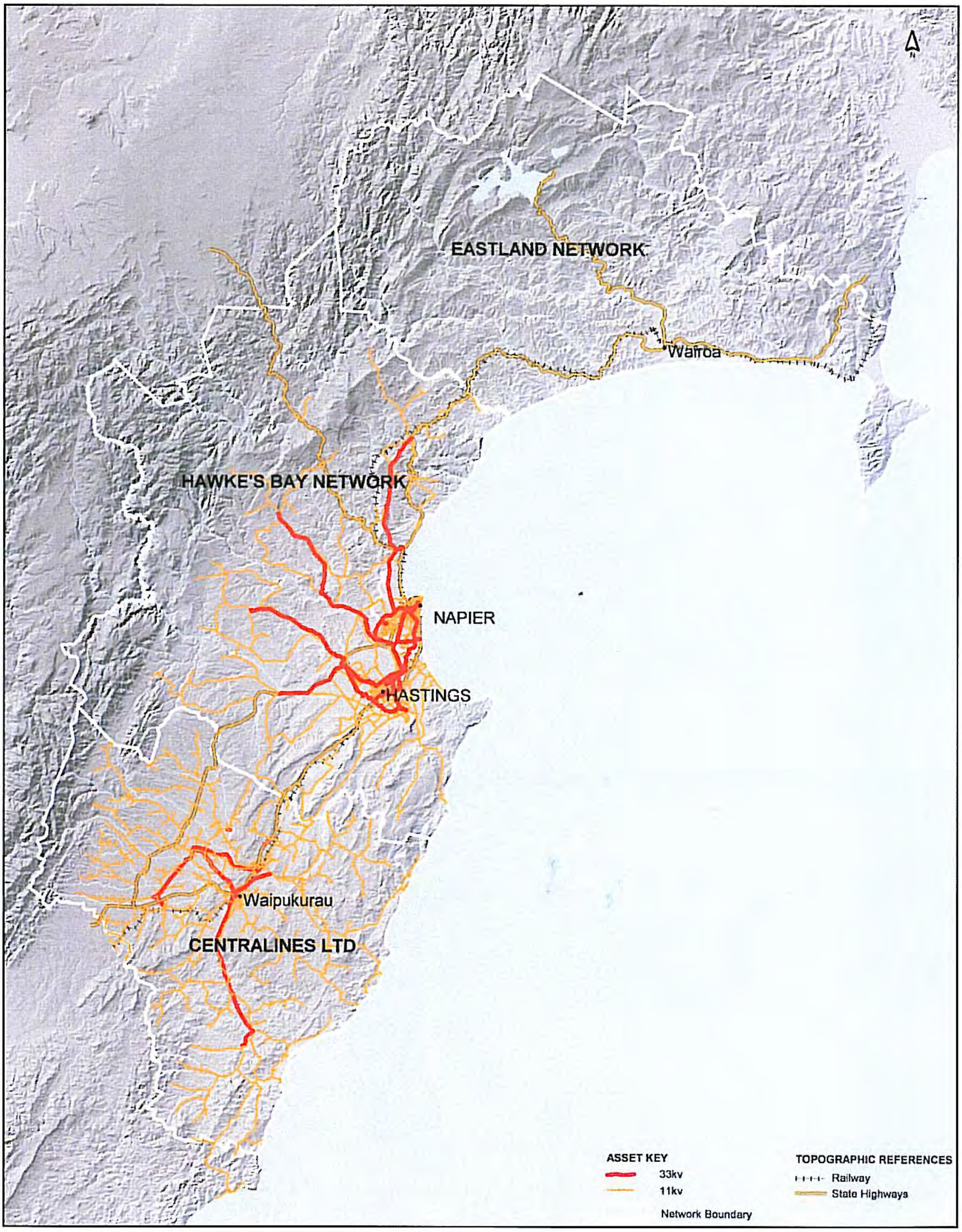


Map 20


Wairoa
NAPIER
HASTINGS
Waipukurau
ASSET KEY
Natural Gas station
Natural Gas Corporation
United Networks
Novagas
TOPOGRAPHIC REFERENCES
Railway
State Highways

Map 19

Energy
Local Powerline Network



Map 21

Oil Suppliers
Lines from Port of Napier

Chapter 11
Energy Group

Introduction

The Energy Group was made up of representatives from electrical, gas and oil industries with networks within the Hawke's Bay region. These electrical networks included Eastland Energy in the Wairoa district, Hawke's Bay Network in Napier and Hastings, and Centralines in Central Hawke's Bay. Contact Energy had an oil-fired electrical generating plant at Whirinaki but this was not included in the Lifelines study, as it is has been decommissioned. Gas networks included Natural Gas Corporation of New Zealand, United Networks and Nova Gas.

The oil industry has two supply terminals in Napier operated by Caltex NZ Limited and New Zealand Oil Services Ltd at Ahuriri.

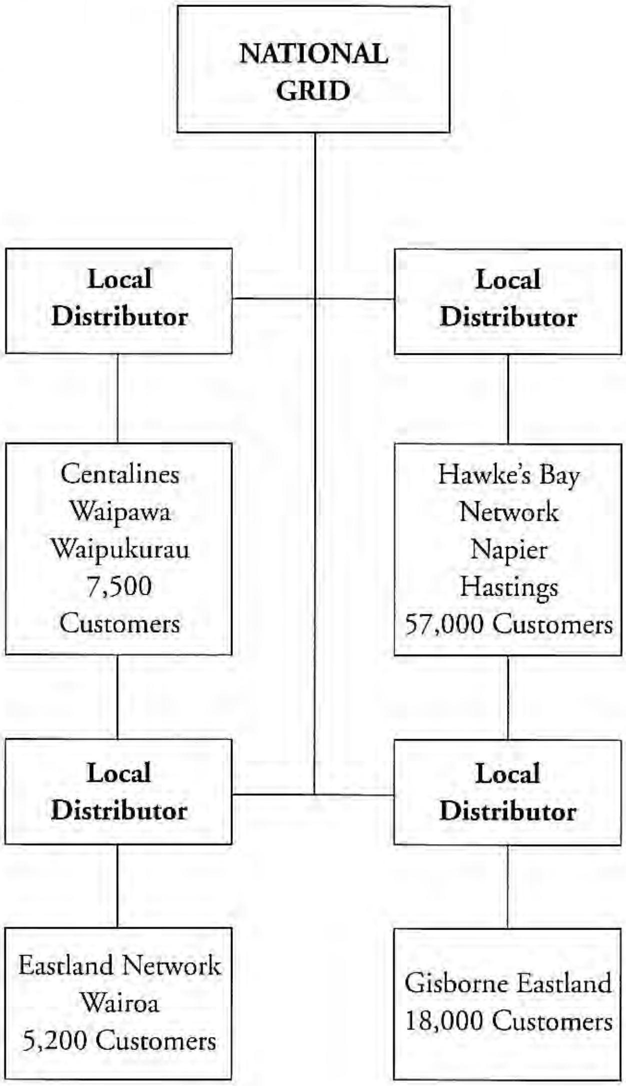
A particular feature of the Energy Group networks in Hawke's Bay is their participation in national supply networks. There could well be natural disasters occurring outside the region that have significant effects within it. While the risk of such events is outside the scope of this project, the responses within the region would be similar to those resulting from a total loss of service from the main feeder to the region.

Similarly, the East Coast north of Hawke's Bay would be very much affected by loss of electricity service within Hawke's Bay. The Poverty Bay/East Coast area is supplied by a single branch from Tuai and is totally dependent upon maintenance of that supply.

The Energy Group experienced similar difficulties to the Transportation Group in assessing a large and complex network and trying to produce a short list of items for consideration for mitigation measures.

Again the first use of Table E3 of AS/NZS 4360:1999 produced a large number of elements with an E risk rating. By adjusting the matrix so that there were less E generating combinations and electronically re-running the risk assessment, a meaningful short-list of elements of highest risk was produced.

Electrical Power



Introduction

The electrical power distribution is made up of a regional supply from the National Grid (owned and operated by Transpower (NZ) Limited) with three local distribution systems covering Napier-Hastings (Hawke's Bay Network) Wairoa (Eastland Energy in part) and Waipawa-Waipukarau (Centralines).

There are power generating stations at Waikaremoana-Tuai, Piripaua and Kaitawa (Genesis Power), and Wairoa (Eastland Network).

The Energy Group notes with concern that the Whirinaki generation plant has been sold for removal. Although Contact Energy has applied for resource consents for a 100 MW combined cycle power station on this site, there are not yet any firm development plans. This has a major effect on the energy lifelines in the Hawke's Bay region.

The majority of electrical power is bought from producers outside the Hawke's Bay region and supplied to consumers via the regional and local networks.

Regional network

The supply networks at regional and local distribution level form an interrelated chain, making them mutually dependent on the overall availability of electric power to deliver supplies to users. This report treats the regional and local distribution systems separately to avoid confusion and to highlight the importance of the regional supply to Hawke's Bay. The New Zealand transmission network is made up of the following components:

Wairakei Transpower lines at Whirinaki stretching towards the western ranges. (Photo courtesy HBRC)

Regional Major Lines:

- 2 x 220kV transmission lines from Wairakei Power station which connect the National Grid to the 110kV Hawke's Bay-East Coast Network at Redclyffe;
- 2 x 110kV transmission circuits connecting to the National Grid at Bunnythorpe (Palmerston North) and running via Redclyffe up to Waikaremoana (Tuai) to form the basis of the 110kV Hawke's Bay-East Coast Network;
- 1 x 110kV transmission circuit connecting Fernhill with Waikaremoana to supplement the 110kV Hawke's Bay-East Coast Network.

Regional feeder lines are detailed below:

- 2 x 110kV circuits from Tuai to Gisborne (Eastland Network);
- 2 x 110kV circuits to Wairoa (Wairoa-Eastland Network);
- 2 x 220kV circuits from Redcliffe to Whakatu (Hawke's Bay Network);
- 1 x 110kV circuit from Gisborne to Tokomaru Bay (Eastland Energy);

Normally the 110kV system is disconnected between Fernhill and Waipawa to give operational stability and control between the 110kV and 220kV sections of the National Grid.

Power is supplied to the local distribution networks at the following locations or Grid Exit Points (GXPs):

Regional Offtake Arrangements	Within the study area the National Grid Offtake of power is generally:
MW Offtake	Local Distributor
18	Waipawa (OngaOnga) to Centralines
39	Fernhill to Hawke's Bay Network
54	Redclyffe to Hawke's Bay Network
74	Whakatu to Hawke's Bay Network
75	Whirinaki to PanPac Limited
8	Wairoa to Eastland Network (Wairoa)
46	Gisbourne to Eastland Network - not in study area*

** Not in study area but totally reliant on power supply from the Hawke's Bay study area.*

Redclyffe is by far the most important GXP from an operational point of view as it is the interconnection node between the 220kV and the 110kV networks and is crucial to the supply of power to the study region from the North, West and South.

Whakatu (74MW), PanPac (75MW) and Redclyffe (54MW) are the most important GXPs in the region for energy supply, comprising 66% of the total supply in the East Coast region.

Electrical system vulnerability - Regional System

Transpower New Zealand

System seismic design

All equipment and buildings at Transpower substations and transmissions lines are designed to strict seismic design codes. The only problems which could occur would result from ground distortion and land slips in some transmission line locations.

The vulnerability assessment has identified the following issues:

Tuai PowerStation

The age of equipment at Tuai varies with some dating back to the initial installation in 1929 but most having been replaced or upgraded in the intervening years. In the switchyard area there is a high risk of landslip and the local transmission lines cross some very rugged and difficult country.

The Tuai-Fernhill and Tuai-Redclyffe transmission lines have a medium landslip risk assessment for most of their length. These two lines are also at risk from seismic activity in the northern section between the Tuai and Mohaka river crossing. They provide the only link with Waikaremoana generation and the Northern end of the East Coast region.

220kV Wairakei Lines (Whirinaki and Redclyffe)

Although most transmission lines are not at risk from seismic activity or landslip because of the high standard of tower and line capability design, the two Wairakei lines in the Te Pohue to Rangitaiki area are an exception. This area is seismically active, subject to major landslips and extreme weather conditions, including wind, rain, snow, and ice, and rises to a height of 900 meters. Recent operational incidents for these and the Tuai lines provide evidence of this risk.

Electrical system windstorm vulnerability

The design criteria for transmission lines makes them generally able to withstand all expected windstorms. However a windstorm associated with a severe weather condition would greatly increase the risk.

Electrical system flooding vulnerability

The substations at Whirinaki, Redclyffe, Whakatu, Wairoa, and Waipawa are all on low-lying land adjacent to a major river system, making them vulnerable to flooding.

In each case failure of a flood protection system could pose a major risk and prevent normal working access to these sites.

Whirinaki and Wairoa face the highest because of their low-lying position and drainage arrangements.

The flooding risk for transmission lines in the region is generally low. The greatest risk is in Esk Valley, on the Redclyffe-Tuai line at the river crossing adjacent to SH5, and adjacent to the Wairoa substation on the pole section of the Tuai-Wairoa lines.

Electrical system volcanic vulnerability

Volcanic ash deposits on electrical transmission equipment present a medium risk in the study area. The ashfall is most likely to drift eastwards from volcanic emissions in the Taupo-Rotorua region.

The Waipawa, Fernhill, Tuai, and Wairoa substations and all the transmission lines associated with these locations are most at risk.

However, the ashfall pattern could be highly variable, meaning all National Grid lines and switching stations in the region are at some risk.

Electrical system landslip vulnerability

Most of the grid network substations have been designed and sited to minimise the effects of landslip or ground displacement.

However Tuai Power Station and its associated switching station are an exception, The power station site was chosen for its hydroelectric potential but is on the Waikaremoana fault barrier, putting it at risk from landslip or ground movement.

Because of the very broken and rugged terrain in the region, transmission lines are located on ridge tops and in prominent locations, which are at risk from landslip. For this reason all the lines in steep hill country are at medium risk. The Wairakei lines are at high risk in the Titiokura to Rangitaiki Plains area as the potential for landslip due to seismic activity, weather, or erosion is a constant possibility.

Electrical system operational importance

Grid Layout

The Transpower grid layout has developed over time, starting with the initial supply into Hawke's Bay from the south in the 1920s, via the Bunnythorpe-Woodville-Redclyffe lines. In the late 1920s and 1930s the Tuai-Redclyffe and Tuai-Fernhill lines were installed to cater for the development of the Waikaremoana generation project and to feed supply back to Hawke's Bay.

Redclyffe Substations for Transpower and Hawke's Bay Network showing proximity to the Tutaekuri River.

Until the early 1970's when the Pan Pac mill was built, the East Coast relied on the Bunnythorpe-Tuai (via Redclyffe) interconnection and Waikaremoana generation for power supply.

In the early 1970's 220kV was introduced from Wairakei to support major developments in Hawke's Bay including the arrival of Pan Pac and the installation of the Whirinaki Power Station.

With the introduction of the major 220kV link, Hawke's Bay's previous problems with power supply were overcome, if not forgotten. The level of power transfer from the 220kV supply to the 110kV network at Redclyffe is 200MVA, which is well able to cope with normal demands.

The introduction of 220kV to Redclyffe saw power generation and voltage support from Waikaremoana becoming less important and a greater regional reliance on the main North Island grid via Wairakei. For operational reasons the previous supply via Bunnythorpe and Woodville is not connected. This improves power flow and avoids equipment overloading.

Today the power loading in the East Coast region is such that if there is a total loss of 220kV, the original 110kV lines and Waikaremoana services, if available, cannot supply all the region's requirements without severe loading restrictions.

In summary:

The 220kV lines into the area from Wairakei are a major lifeline for Hawke's Bay. The other lines into the area from the south can only provide sufficient supply if Waikaremoana is operating at full capability and severe loading restrictions are imposed.

The decommissioning of the Whirinaki Power Station makes the region more vulnerable to power supply interruptions.

Normal supply arrangements are directed at the 220kV lines and any loss or disruption of these lines, even momentarily, will affect the whole Hawke's Bay/East Coast region until system stability is restored.

Redclyffe Substation is the most vital switching node in the region because it interconnects the 220kV /110kV Waikaremoana generation, the East Coast and the southern Hawke's Bay supply.

If the 220kV supply were interrupted, there would have to be reverse power flow of the interconnection banks for Whakatu and Pan Pac to maintain supply. They will therefore be included in the restrictions outlined above.

In conclusion, any loss of the 220kV circuits and/or Redclyffe Substation will have a major impact on Hawke's Bay and the East Coast.

During September 2000 such an event caused the loss of power to the region for up to four hours. This resulted from severe storm conditions in the Mohaka and Waipunga Valleys and snow and ice damage to the Wairakei circuits. The Redclyffe-Tuai and Fernhill-Tuai lines were also damaged, leaving Hawke's Bay without any power. Fortunately the incident started at 11pm, repeated again at 4am and supply was restored about 8am. Had the incident occurred during a peak load period or continued into a working day the consequences would have been far-reaching and more serious.

The storm that led to this incident concentrated into a narrow region from the upper Mohaka-Tarawera area across to the Gisborne-Mahia area. It inflicted some damage on distribution lines operated by Hawke's Bay Network and also damaged most lines in the Wairoa (Eastland Network) area.

The return period of such an event is probably 60 years. However, given that such storms in the area have never before affected transmission lines, the return period of localised high intensity storms, including ice and snow buildup on lines, may be at variance with this.

The incident clearly identified the importance of the 220kV lifeline.

Conclusions

The HB Engineering Lifelines Project has identified the following risks:

- Substations at risk from flooding and seismic events;
- Transmission lines at risk from seismic events and extreme weather events.

All assets have been built to current New Zealand design standards and modified where necessary to bring them up to new standards.

No further upgrading of Transpower assets, for the mitigation of risks identified in this project, is planned.

Power Lines feeding power to TeWaka have had their spans shortened by including extra poles. This was necessary to prevent the combination of ice and wind causing the spans to collapse under the strain.
(Photo courtesy Ian Greaves Telecom)

Local Distribution Networks

Hawke's Bay Network

The network owned and operated by Hawke's Bay Network Limited covers the area between Putorino in the north, Te Aute in the south and the Kaiweka Ranges to the west. There are 57,000 customers using 850GWh per year.

Power is supplied into the network by Transpower at Redclyffe (adjacent to Napier), Whakatu (adjacent to Hawke's Bay industrial loads between Napier and Hastings), and Fernhill (adjacent to Hastings).

Subtransmission System

Connections are all at 33,000 volts and comprise a substantial 33,000-volt subtransmission system that allows supply to be transferred to 23 zone substations from the three Transpower GXPs.

Hawke's Bay Network can overcome equipment failure by transferring load to most of its zone substations using alternative connections via its subtransmission system. However multiple failures or widespread damage will have more serious outcomes. Industrial and urban load areas have more secure back-up from alternative supply routes.

Local Distribution System

From the three GXPs power is transferred to 23 zone substations before being distributed, via 127-11,000 volt feeders, to 4,000 local pole-top and ground-mounted transformers. These provide the 400-volt and 230 volt power connection to domestic and commercial end use customers.

Some larger high-use industrial customers are directly connected to the 11,000-volt system to improve reliability and reduce losses. In some instances duplicate supplies are provided.

The 11kV system can be reconfigured to isolate most network faults and facilitate repairs.

At the low voltage level (400/230 volts) alternative supply arrangements are available in some urban and high-load areas. If the failure zone is not too widespread, alternative connections can be made to adjacent transformers.

Local Generation

The only local generation interconnected to Hawke's Bay Network's subtransmission system is at Ravensdown's Awatoto Fertiliser Plant. Ravensdown operate a 6MVA turbo alternator as part of their sulphuric acid plant. This unit runs on waste heat and feeds any excess generation into Hawke's Bay Network's 33kV network. This plant is not able to start itself and requires a grid connection for all but specially arranged and isolated operations.

The plant is unsuitable for emergency supply purposes.

Electrical system vulnerability HB Network

The Lifelines study covers the 33,000V and 11,000-volt network and the zone substation that provides local distribution nodes.

Seismic vulnerability

33,000 Subtransmission Network

Most of the 33kV network is vulnerable to seismic disturbance in the short term because of its widespread exposure, numerous support structures and importance to supply continuity. Line tripping and subsequent re-livening after the event can be expected in most cases.

The 33kV/11kV cable sets between Faraday Street and Bluff Hill are particularly vulnerable to in-ground damage from seismic fracture or displacement.

Damage to support structures such as pole footings, tower bases and support distortion is not likely to be insurmountable, providing it is localised and does not affect alternative lines at the same time.

In some places the 33kV network is on common support structures. Of particular vulnerability are the Onekawa Switching Station, Faraday/Bluff Hill at Faraday Street and Windsor/ Arataki/Tomoana/Hastings City at Rangitane to Ruahapia Road. However each of these, except Faraday Street, has an alternate supply route.

The Napier CBD is particularly vulnerable. All supply is routed through the Faraday 33kV switchyard and confined within this vital area, which sits on reclaimed liquefaction land adjacent to the area most damaged by the 1931 earthquake.

Zone substations

Zone substations are most vulnerable to seismic damage in the area of their outdoor switchyard, particularly where these are older, at a higher level on supports, with extensive buswork and overhead line connections.

Most of the transformer and indoor switchgear installations in zone substations are designed to withstand seismic activity. The control equipment, although various, is well located and supported but could malfunction during a disturbance.

Locations likely to suffer the greatest impact from a lifelines emergency are Flaxmere, Mahora, Rangitane, Tamatea, Irongate and Tannery Road.

11kV supply network

Some brief loss of supply can be expected on most of approximately 120 feeders due to lines clashing during an event.

There would be ongoing faults on some feeders, as a result of network damage. The most vulnerable are those in the following areas, as they are likely to experience displacement or ground shifting:

- Downtown Napier CBD
- Downtown Hastings CBD
- Havelock Hills (upper sections)
- Westshore
- Flaxmere

Throughout the network area there are numerous faultlines. The 11kV lines are vulnerable where they traverse these faultlines. However any problems would be short term.

1931 Hawke's Bay Earthquake.

Windstorm vulnerability

33kV network: Southern area

There is vulnerability to windstorms on the exposed sections of the Fernhill supply lines to Flaxmere, Camberley, Irongate and Havelock as all of these cross the path of the prevailing northwesterly winds.

The Sherenden line is also vulnerable but less important.

33kV network: Northern area

The North Tie and the Onekawa/Marewa lines are particularly vulnerable to line clashing as a result of flying debris and tree contact. The North Tie (Marewa and Bluff Hill/CBD) is the longest and most heavily loaded 33kV line, making it the most vulnerable asset.

The Patoka line is also vulnerable but less important.

Zone substations

Esk, Patoka, Sherenden and Tutira would be at risk in a major windstorm as they all have pole mounted switchgear and are in and serve exposed rural locations.

11kV network

Most vulnerable are the long rural feeders at exposed locations and with long spans, light conductors and trees in close proximity. This includes:

- Valley Feeder
- Roys Hill
- Twyford
- All Patoka feeders
- All Sherenden feeders
- All Tutira feeders

Flood vulnerability

33kv network

This network is vulnerable to flooding and possible damage to support structures at the following sites:

- Onekawa A&B lines – across the Napier Flats and river crossing area
- Rangitane/Arataki – four lines adjacent to Ruahapia Road
- Windsor/City – Karamu Creek
- North Tie river crossings (x2)
- Napier Flat Zone substations

The flooding risk is assessed as follows:

Awatoto	Very low-lying, a high water table with poor drainage and prolonged surface water flood pumping.
Esk	Within a river valley and known to have flooded many times. Subject to river flooding.
Rangitane	Low-lying with poor, but recently improved drainage. Subject to flood pumping.
Tamatea	Low-lying and near the estuary level on a flood plain. Subject to flood pumping.
Powdrells Road/ Tannery Road	Low-lying and adjacent to a riverbank. Subject to river flooding.
Tutira	Adjacent to lake level. Known to have seriously flooded before.
Springfield	A breach of the Tutaekuri River would be a major risk as the flowpath will erode Springfield and redclyffe itself.

11kV network

The major network vulnerability is in the low-lying areas above. Ground mounted transformers and 11kV switches are of major concern.

Awatoto	Foreshore industrial area
Bluff Hill	Napier section and CBD area.
Farady Street	Napier CBD and Napier South.
Marewa	Westshore, adjacent to estuary, and Ford Road.
Clive/ Haumoana	Possible flooding East Clive/ Te Awanga

Tsunami vulnerability assessment

All low-lying and coastal installations face a significant risk from tsunami. However the extent of damage is uncertain and will depend on the magnitude of the tsunami and where the seawall is breached.

Grid Exit Point vulnerability:

One GXP – Whakatu - is particularly vulnerable to tsunami because it is close to the Karamu Stream and in a low-lying area.

33kV network

The low-lying/coastal sections of the Onekawa lines, adjacent to Napier estuary, and the North Tie line, north of Tutaekauri, are vulnerable to tsunami.

Zone substations

The Esk and Awatoto substations are at high risk from tsunami because they are coastal, low-lying and experience natural flooding.

Faraday Street is at minor risk from tsunami.

It is possible that Springfield, Tamatea and Tannery Road could be affected by a tsunami. However, given that the floodwaters will rise and fall rapidly, any impacts are likely to be short-term.

11kV network

Most of the 11kV feeders from the above zone substations have similar levels of risk.

Awatoto, Bluff Hill (Harbour and Marine Parade) and the coastal areas adjacent to the Esk substation show extreme vulnerability.

Te Awanga and Haumoana are also a tsunami risk because each is a coastal feeder with some ground-mounted items.

Volcanic vulnerability

The inland rural network is the only section specifically at risk from the volcanic hazard.

The Patoka, Sherenden and Maraekakaho network areas and zone substations are vulnerable because of their location. Ashfall patterns and the coverage area will depend on weather conditions.

The Valley 11kV feeder is also expected to be vulnerable to some extent from ashfall.

Landslip vulnerability

Patoka and Tutira zone substations are vulnerable to landslips affecting the 33kV lines and 11kV feeders in these localities.

Within the Network

Esk Valley feeder, Bay View, Tangoio, Tutira and Poukawa are vulnerable to landslip.

Wairoa Section of Eastland Network

The Wairoa portion of the Eastland Network is made up of a 50kV, 33kV and an 11kV network and two Transpower GXPs. Power is delivered to customers throughout the Wairoa region, from Morere in the North to Lake Waikaremoana in the west and Putorino in the south, where it joins the Hawke's Bay Network. Demand is concentrated around the town of Wairoa.

The Grid Exit Points are:

Wairoa	Supply is available from Tuai Power Station via two 110,000-volt transmission lines to the Wairoa GXP.
Tuai	11kV supply is distributed to Tuai and Lake Waikaremoana in a localised network.

50kV and 33kV network

A 50kV network connects the Waihi Generation Station with Wairoa and with a 33kV line to Mahia in the Blacks Beach area.

11kV network

The 11kV network that distributes in each area from Tuai, Wairoa and Mahia, is made up of a conventional distribution system with local transformers to take supply to customers.

Waihi generation

The Wairoa network includes a connection to a stand-alone generation station with capability for 5MW output. It is self-starting and has the ability to operate independently of the National Grid. Waihi generation can provide about half the supply needed in the area, as long as water storage is available.

This puts Wairoa is in a favoured position and means this plant will be a valuable lifeline in a major incident.

Tuai generation

The Wairoa network is connected to the National Grid at Tuai, which is the source of more generation power than Wairoa can distribute. If the grid connection between Tuai and Redclyffe/Fernhill was lost, Wairoa and Gisborne/East Coast can rely on an uninterrupted supply from Tuai. This area can run as an isolated island for a considerable period of time

Vulnerability Assessment

With one GXP at Wairoa supplying most consumers, this site has a high risk to any major activity.

Geographical features have determined the network configuration, which would be susceptible to line clashes and resulting outages. Restoring supplies would be prioritised according to damage sustained and accessibility.

Most underground cables are located in Wairoa township, meaning ground damage in this area could impact on supply.

Wind

50kV network

This feeder between the Waihi Power Station and Kiwi substation follows a largely sheltered route and is not vulnerable to wind damage.

33kV network

This feeder is constructed on the main coastal ridge between Wairoa and Nuhaka and is exposed to southerly winds, making it extremely vulnerable. It has suffered major damage in southerly storms in the past. Extensive repairs, reconfigurations, pole stabilisation work and additional support structures have been carried out since the last major outage in September 2000.

11kV Network

The rural network can be split into two areas depending on wind direction, to assess its vulnerability.

Northerly winds affect the high country areas of Putere, Mangone and Ruakituri while southerly winds dominate the coastal areas between Mohaka and the end of the Mahia Peninsular.

The network is more likely to be damaged by tree contact as a result of high winds, rather than component failure.

Flood

Kiwi substation and A Park switching station are vulnerable because they are low-lying and close to the Awatere Stream and the Wairoa River.

The ground mounted 11kV switches and transformers in Wairoa itself, associated with the underground cabling, are also vulnerable if flooding breaches the banks of the Wairoa River.

Tsunami

Again, due to their location, Kiwi substation and A Park switching station are vulnerable to tsunami.

A large portion of the network is reticulated around the populated coastal areas of Mohaka, Wairoa, Nuhaka, Opoutama, Mahanga and Mahia Beach, making it vulnerable to tsunami.

These are all low-lying areas. The resulting damage would be a directly related to the size of the tsunami.

Volcanic

The wind speed and direction at the time of volcanic activity affects the level of vulnerability.

Putere, Mangone, Tuai and the upper Ruakituri Valley are most likely to be affected due to their proximity to volcanic areas.

Landslide

The outdoor station (ODS) associated with the Tuai Power Station is extremely vulnerable to landslides.

A landslide which damaged this equipment would completely isolate the Wairoa and Gisborne areas from a source of electrical supply.

All feeders in the rural area transverse high hill country and are therefore vulnerable to landslide.

Centralines Ltd

Centralines (formerly CHB Power) operates a network throughout the Central Hawke's Bay District Council area.

The network is supplied from one GXP -Transpower's Waipawa Substation near Onga Onga.

Power is distributed directly from the Onga Onga site at 11,000 volts throughout the western portion of the district.

Four 33,000-volt transmission lines supply power to Waipawa, Waipukurau, Porangahau and Takapau, where zone substations reduce the voltage to 11,000 volts for further local distribution.

Most of Centralines customers are in and around Waipawa and Waipukurau.

The Waipawa (Transpower) GXP is on the two 110,000 volt transmission lines running from Bunnythorpe via Woodville to Fernhill. Grid power can be supplied on either of the two parallel lines from the north (Fernhill) or the south (Bunnythorpe). In this respect Centralines' supply is more secure and less at risk from overloading or voltage stability problems as long as the north-south connection has not been established, which could happen during an emergency, as part of operational needs to support the region from the south.

The major problem for Centralines is that only one GXP is involved and there is no alternate supply. Centralines is normally connected to the Grid from the south or the north but not both together.

Centralines Assessment

Seismic

Because the Waipawa GXP at OngaOnga is Centralines single point of supply, it is at high risk from seismic activity.

Line clashes on both 33kV and 11kV circuits are highly likely, depending on the size of earthquake. Outlying areas would inevitably lose supply, and restoration would be governed by the amount of damage sustained. 11kV tie-lines provide flexibility for redirecting supply to outlying areas.

Underground cables are susceptible to land fissures and shear fractures.

Zone substations at Waipukurau, Waipawa and Takapau have been fitted with earthquake protection devices to reduce the risk of transformer rollover.

Wind

A number of areas on Centralines 11 kV network are at risk during high wind events. This includes risk of damage from the wind itself and from trees. The areas are:

- Mangaorapa
- Whangaehu
- Herbertville
- Flemington
- Wanstead
- Wakarara
- Ashley Clinton

Flood

The Waipukurau zone substation is considered to be a high-risk flood site, given its proximity to the Tukituki River. The Porangahau substation near the Porangahau River is a medium risk site while both Waipawa and Takapau are at low risk from flooding.

The 33kV and 11kV circuits have river crossings on the Tukituki and Waipawa rivers that are at some risk during major flood events.

Tsunami

Tsunami poses little risk to the Waipukurau, Waipawa and Takapau zone substations. However Porangahau, with it proximity to the Porangahau River, has a low-level risk.

11kV lines supplying coastal areas are high-risk assets during this type of event.

Volcanic

The Waipawa GXP, Waipukurau, and Takapau zone substations are all at risk from volcanic activity, depending on weather conditions at the time and ashfall patterns.

Ashfall could also impact on the 33kV and 11kV feeders within the western and central areas of Centralines network.

Landslip

No zone substations are vulnerable to landslips.

The Porangahau 33 kV and a small number of sites on the 11kV feeders are under threat from potential landslips.

Natural Gas Supply

Natural Gas Corporation of New Zealand

The Natural Gas Corporation (NGC) has approximately 80 km of high pressure transmission line (the 700 line) in the Hawke's Bay Region. This pipeline was designed and constructed to USAS B31.8, I.P or to DZ5223 (Draft) or NZS 5223, NZ Standard Code of Practice for High Pressure Gas and Petroleum Liquids Pipeline, Part 1, High Pressure Gas Pipelines and Pipeline Authorisations.

NGC has carried out a pipeline risk assessment for its Kapuni-South pipeline system in accordance with AS/NZS 2885 : 1997 Pipelines – Gas and Liquid Petroleum. Approximately 80km of this pipeline is in the Hawke's Bay Region. All perceived risks to the pipeline have been identified and evaluated. The risk level associated with these events has been determined as acceptable and meeting the requirements of AS/NZS 2885.

SAA HB105-1998 Guide to Pipeline Risk Assessment in accordance with AS 2885.1 – Section 3 Process of Pipeline Risk Assessment was used to ensure a consistent and informed approach to risk assessments. The Pipeline Risk Assessment report and the Pipeline Integrity Report will be used by a certifying body to issue a "certificate of fitness" for the pipeline to operate under the Health and Safety in Employment (Pipelines) Regulations 1999.

The Hawke's Bay Engineering Lifelines Project vulnerability assessment was extracted from this larger document. During this process some key issues were identified:

- NGC operates a trransmission system that begins in the Taranaki region and extends over the North Island. The pipeline in Hawke's Bay is at the end of a system, meaning gas supplies to the region may be disrupted by events outside of the area.
- The pipeline in Hawke's Bay does not directly feed any large sites, such as dairy factories or power stations, but supplies distribution companies from sales gates in Takapau, Mangaroa and Hastings. This makes it difficult for NGC to accurately evaluate the social and economic effects of losing gas supply downstream of these points. Natural gas may be used for heating in hospitals, schools and old folks homes or embedded generation, cogen or other industrial processes and interruption of supply to such facilities may adversely affect the

community. Because NGC cannot access information on this scenario, there is a degree of uncertainty in the assessment of possible consequences.

- The vulnerability assessment only deals with the natural hazards of seismic activity, wind, flooding, volcanic activity and landslip. NGC's pipeline risk assessment shows that the event most likely to affect gas supplies are excavations by third parties which damage the pipeline. Prevention and mitigation measures are in place to reduce the risk of this.
- Segments 6, 7 and 8 are not within the Hawke's Bay region but the Dannevirke offtake point at the beginning of segment 6 forms a recognisable basis to work from.
- Although earthquakes have the potential to cause a total rupture of the pipeline, the risk of this occurring is low. This was demonstrated during activity on the Edgecumbe fault, where there was significant land movement around the pipe. This event caused structural damage to roads and buildings but none to the pipeline. Furthermore, in the San Francisco earthquake of 1992, although there was wide spread damage and ground movement, no electric arc welded pipes failed.

United Networks Ltd, Natural Gas Network

Hastings / Napier Network Description

United Networks (UNL) owns and operates two networks in the region, one in Hastings/Napier and the other in Takapau. Several energy retailers use the network to deliver natural gas to their customers through their own gas measurement systems (GMS). UNL's responsibility ends at the service isolation valve, which is installed before the GMS on the service riser pipe.

The Gate Station (GS) in Karamu Road, Hastings, is the transfer point between the natural gas transmission network and United Network's gas network.

The gas is fed into a steel intermediate pressure (IP) pipeline at 10 bar pressure (approx. 150psi) which extends about 36km, from Hastings to Whirinaki. This pipeline also supplies natural gas to the cities and towns of Hastings, Havelock North, Clive, Napier, Taradale, and Bay View and the industrial areas of Whakatu, Awatoto and Whirinaki. There are a number of GMS's along the pipeline supplying gas to industrial and commercial customers.

District pressure-reducing stations (DPRS) are situated along the pipeline, reducing the pressure to supply gas into the medium pressure (MP) network. The MP network consists of polyethylene pipe (PE) which has a maximum operating pressure of 4.2 bar (60psi). This network mainly supplies commercial and domestic customers and stretches from boundary to boundary of each of the urban areas. There is also a low pressure (LP) network in the Napier/ Hastings area. Typically the LP network is made of cast iron, asbestos and unprotected steel pipes.

The IP steel network is protected from corrosion by an impressed current cathodic protection system.

Takapau Network Description

The network in Takapau is made up of a 4km long steel intermediate pressure pipeline with a maximum operating pressure of 10 bar. The pipeline supplies natural gas to Richmonds' plant.

Both the Hastings/Napier and the Takapau networks comply with NZS 5258 Gas Distribution.

Vulnerability Assessment

The assessment was carried out by looking at the IP pipeline from the Hastings gate to the end of the line at Whirinaki. Along the route each component was identified (such as DPRS or line valve) and analysed in terms of the various hazard scenarios for:

- seismic activity
- wind
- flooding
- tsunami
- volcanic activity
- landslip

The medium and low pressure networks were then examined separately.

Seismic Activity

The IP and MP pipelines that make up the United Networks gas network have been constructed over the last 20 years. The MP pipelines are built to best practise and NZ and international standards, using steel or polyethylene pipes, or both. New Zealand and overseas experience has shown that these types of network have an exceptional ability to remain intact during seismic activity and generally survive undamaged. Conversely, LP pipelines do not fare as well and it is therefore likely that there will be some damage to this network.

Where the pipelines are attached to another structure, rather than buried in the ground, the structure may inflict damage to the pipeline. The IP pipeline is attached to 5 road bridges and 1 pipe bridge. In a large event we would expect some degree of damage to the pipeline at these locations, although the extent will depend on a number of factors. Some allowance for this has already been factored into the design at these sites, particularly in regard to the way the pipeline approaches the bridge and the supports that attach the pipeline to the bridge structure.

The design of some DPRS sites means they may also experience movement of the station structure. Sites located in areas with a high probability of liquefaction may face similar problems. Damage may also occur at some of the larger GMS sites.

The line valve pits on each side of the bridge crossings are in soils susceptible to liquefaction and may also cause problems. Again this will depend on the exact location and magnitude of the event. The remaining cast iron pipes in the network could fracture during a major earthquake, which could lead to an outbreak of fire. United has a replacement programme for all cast iron lines in the network.

Wind

Most of the gas network is underground and protected from wind-related problems. However wind could impact on above ground structures such as DPRS and GMS sites. Damage at these sites could result from flying debris, falling poles, trees or branches. This type of damage would be localised and is unlikely to have a major impact on the integrity of the network.

Floods

A major flood could have severe impact on the IP network, especially near points where the pipeline crosses the various rivers in the region.

Several of the DPRS and GMS sites are in areas that may be flooded. The DPRS sites can operate even when fully submerged in water. Customer GMS sites are generally unable to function under water so some problems are expected at these locations. Generally these will be small GMS sites on domestic dwellings.

Volcanic

Given that the gas network is buried, ashfall is unlikely to cause major problems. The only forseeable difficulty is the potential for regulator vents at the GMS sites to be blocked with volcanic ash.

Landslip

With most of the gas network under urban areas on the plains of Hawke's Bay, landslip is unlikely to be a problem. Napier Hill and some sections of Havelock North may be susceptible to localised network damage from landslip but the overall impact of this would be minimal.

Tsunami

Tsunami could affect sections of the gas pipeline that are near to the coast and rivers, from Whakatu to Whirinaki. Depending on its magnitude and location, a tsunami could have a major impact on the network.

Nova Gas Hastings Network

Nova Gas has approximately 9km of pipe installed in Hastings, which was commissioned in 1999. All the underground pipe is made from PE100 SDR11 plastic while all the above ground pipe is constructed in steel. The pipeline's operating pressure is 720kPa and it supplies industrial customers. Each customer has a GMS, which includes emergency isolation valves and slam shut protection against excessive pressures in their outlet's pipework.

Only major seismic activity, flooding and excavation by third parties is likely to affect the pipeline, given that it is underground.

However the GMS's are above ground and the system's sites and pipeline would be affected as follows:

Seismic Activity

The PE pipeline will generally be unharmed except for the possibility of damage at tees and tapping tees. GMS sites may experience some movement with resulting damage, especially at larger sites. Falling building debris, trees and other objects could also cause damage.

Wind

Falling trees, poles, and flying debris may cause localised damage to GMS sites.

Flood

GMS sites will not function fully under water. Raging water could damage pipelines and GMS sites.

Volcanic

Volcanic ash could block regulator vents and affect the operation of the GMS sites.

Oil Supply

Caltex New Zealand Limited.

Locality and description

Caltex NZ Ltd is situated southeast of Bluff Hill in Ahuriri, Hawke's Bay. Caltex Napier is a bulk storage terminal with the capacity to hold 22 million litres of refined petroleum products.

The location of the terminal can be seen on the attached Map 21.

Caltex hosts Mobil at its Napier terminal and operates 24 hours a day, 7 days a week.

Layout of services

Water

Caltex receives its water supply from the Napier City Council ring main that feeds the Ahuriri area. There is one 80mm diameter feed off Tuatu St, which is protected with a backflow preventor. Fire protection is fitted to one of the tanks in the Electricorp compound and fed by the ring main off Tangiora St. All fire reticulation is via the drinking water pipe network.

Power

All operations are supplied through cabling which is maintained by the HB Network.

Communications

Telephones

Caltex uses a Centrex system that is owned and operated by Telecom. The system is based in the main administration building on Tuatu St.

Mobile Phones

All employees have mobile phones or access to phones in vehicles. These are connected to the Telecom Cellular Network.

UHF Radios

All tanker and inter-company communications during discharges are by way of UHF radios. Caltex and NZOSL have their own separate channel for this purpose.

Wastewater Reticulation

All wastewater is discharged into the NCC manhole at the end of Tuatu St. This network is maintained by the NCC.

Rail

Caltex relies on rail services to supply its Palmerston North depot in times of product shortages in Wellington. The rail network is maintained by TranzRail.

Pipeline

All supplies of refined product to the Napier terminal are via a 250mm pipeline, which runs from the terminal to the Port of Napier. The pipeline is underground, and is maintained jointly by Caltex and NZOSL.

Quarterly pressure tests are carried out on this pipeline to confirm its integrity.

Stormwater

Much of the tank farm is at a level about 1 metre lower than local ground level.

As a result all stormwater, after passing through a triple interception tank, needs to be pumped to an off-site discharge point.

Results of Risk Assessment

In-depth risk assessments are regularly carried out on the single pipeline to Caltex and Oil Services NZ Limited's terminal facilities.

The line is pump tested every 3 months under a requirement of the dangerous goods regulations.

It is constructed in ductile steel.

The major risk for the pipeline is at the junction between wharf structure and land. However, since the systems operate on a 3-weekly supply, there should usually be time to install a temporary connection for the next shipment.

At the Caltex terminal, two tanks were built in 1996 and one in 1959. The latter tank had its foundations upgraded in 1989. The other tank, in the former Electricorp compound, was built in 1977. All the tanks are built to current or recent design standards.

Terminal emergency operations planning has confirmed that, in the event of a power failure, tanks could be gravity-filled from other, well-supplied facilities.

Seismic Hazard

Ground Shaking

This does not pose a significant risk to tanks and structures.

Liquefaction

Given that the site is on reclaimed land, liquefaction could occur, depending on the reclamation materials and methods used at different locations.

Fault Displacement

This hazard is not expected to occur in this site.

Ground Settlement

General ground settlement could affect the stormwater systems and heights from which pumping is needed.

Any further development of the site would need to take into account the problems associated with the lower bank farm area.

Flooding

Extreme flooding could affect operations at the terminal.

Some means of ensuring a power supply to the stormwater pumps would reduce this risk.

Tsunami

Tsunami pose a high risk, given that the network is close to the coastline. However there are no practical mitigation measures that can be taken.

Wind, Landslip, Volcanic Ash and Wild Fire

None of these are likely to put the operation of the terminal at risk.

Energy Group Risk Assessments

The Energy Group has identified the following higher risk elements in the energy networks:

- The single 220 kV line from Wairakei to Whirinaki;
- No alternative additional generating power supply in emergency conditions;
- Seismic activity poses the greatest potential risk to continued electricity supply;
- Some sites are vulnerable to flooding that could cause electrical equipment to fail;
- Gas networks are most vulnerable to seismic damage where they are supported above ground by bridges and other structures;
- Cast iron pipes, where they remain in local distribution lines, are at risk from fracture during a major earthquake. This could lead to an outbreak of fire.

Mitigation Measures

All networks have ongoing maintenance and risk mitigation programmes of varying standards. These may need to be reviewed and upgraded in light of this study.

Recommendation

All network owners should review their maintenance and asset management programmes to mitigate the identified risks.

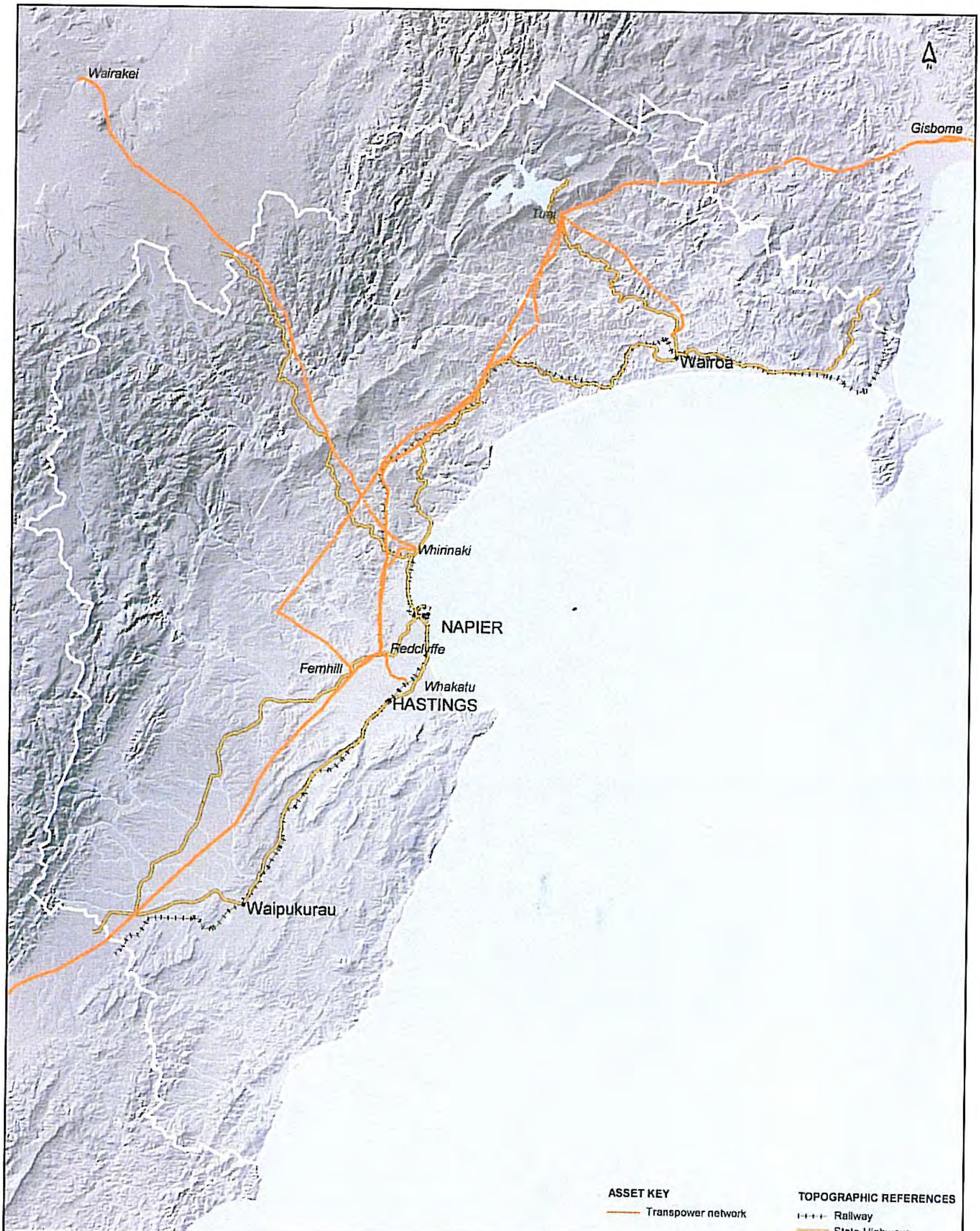
While it is not possible to eliminate all risks, mitigation measures should be incorporated where practical. This could occur as part of a maintenance, upgrade or redevelopment programme.

COMPONENT/ SEGMENT	SEISMIC			WIND				FLOOD				TSUNAMI				VOLCANIC				LANDSLIP			
	IA	PF	RN	DE	IA	PF	RN	DE	IA	PF	RN	DE	IA	PF	RN	DE	IA	PF	RN	DE	IA	PF	RN
REDCLYFFE	H	H	H	E	H	H	H	E	H	H	M	H	M	M	M	M	H	M	M	H	M	M	M
WHAKATU	H	H	M	H	M	M	M	E	H	H	M	E	H	M	M	M	H	M	M	L	L	L	L
FERNHILL	H	H	H	E	H	H	H	H	H	H	H	L	L	L	L	M	H	M	M	L	L	L	L
33KV SUB TRANS																							
ONEKAWA A/B	E	E	H	H	H	M	M	E	E	H	H	H	H	H	H	M	M	M	M	L	L	L	L
ONEKAWA C/D	E	E	H	E	E	H	H	M	M	M	M	H	H	H	H	M	M	M	M	L	L	L	L
GILLIGANS	M	M	M	M	M	M	M	H	H	H	H	H	H	M	M	M	M	M	M	L	L	L	L
SPRING A/B	L	L	L	M	M	M	M	H	H	H	H	H	H	M	M	M	M	M	M	L	L	L	L
PATOKA	H	H	H	H	H	H	H	M	M	M	M	L	L	L	L	E	H	H	H	H	H	H	H
RANG/ARA	H	H	M	E	H	M	M	H	H	H	H	M	M	M	M	M	L	L	L	L	L	L	L
MAH/TOM	H	H	M	H	H	H	M	H	H	H	M	M	M	L	L	M	L	L	L	L	L	L	L
WIN/CITY	H	H	M	H	H	M	M	H	H	H	H	M	M	L	L	M	L	L	L	L	L	L	L
ARA/WIN	H	H	M	H	M	M	M	H	H	H	H	M	M	L	L	M	L	L	L	L	L	L	L
NORTH TIE	E	E	H	E	H	H	H	E	H	H	H	H	H	H	H	M	L	L	L	L	L	L	L
FLAX/CAM	H	H	M	H	H	H	H	H	H	H	M	L	L	L	L	M	L	L	L	L	L	L	L
HVN/HAST/IRONGATE	E	H	M	H	H	H	H	H	H	H	M	M	M	L	L	M	L	L	L	L	L	L	L
FERNHILL	H	H	M	H	H	H	H	H	H	H	H	L	L	L	L	M	L	L	L	L	L	L	L
MKK/SHER	H	H	M	E	H	H	H	H	H	H	H	L	L	L	L	M	M	M	M	L	L	L	L
BLUFF/FDY CABLES	E	E	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	M	M	M	M
ONE/MAREWA TIE	E	H	M	E	E	H	H	H	H	H	M	H	H	M	L	L	L	L	L	L	L	L	L
ONE/NAPIER LINES	E	H	M	E	E	H	H	E	H	M	M	H	H	M	L	M	L	L	L	L	L	L	L
ARA/HVN CABLE TIE	E	E	H	L	L	L	L	M	M	L	L	L	L	L	L	L	L	L	L	L	L	L	L
CAM/MAHORA TIE	H	H	H	L	L	L	L	M	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
HAST/FERN TIE CAB/LINE	H	H	M	M	L	L	L	M	M	M	L	L	L	L	L	L	L	L	L	L	L	L	L

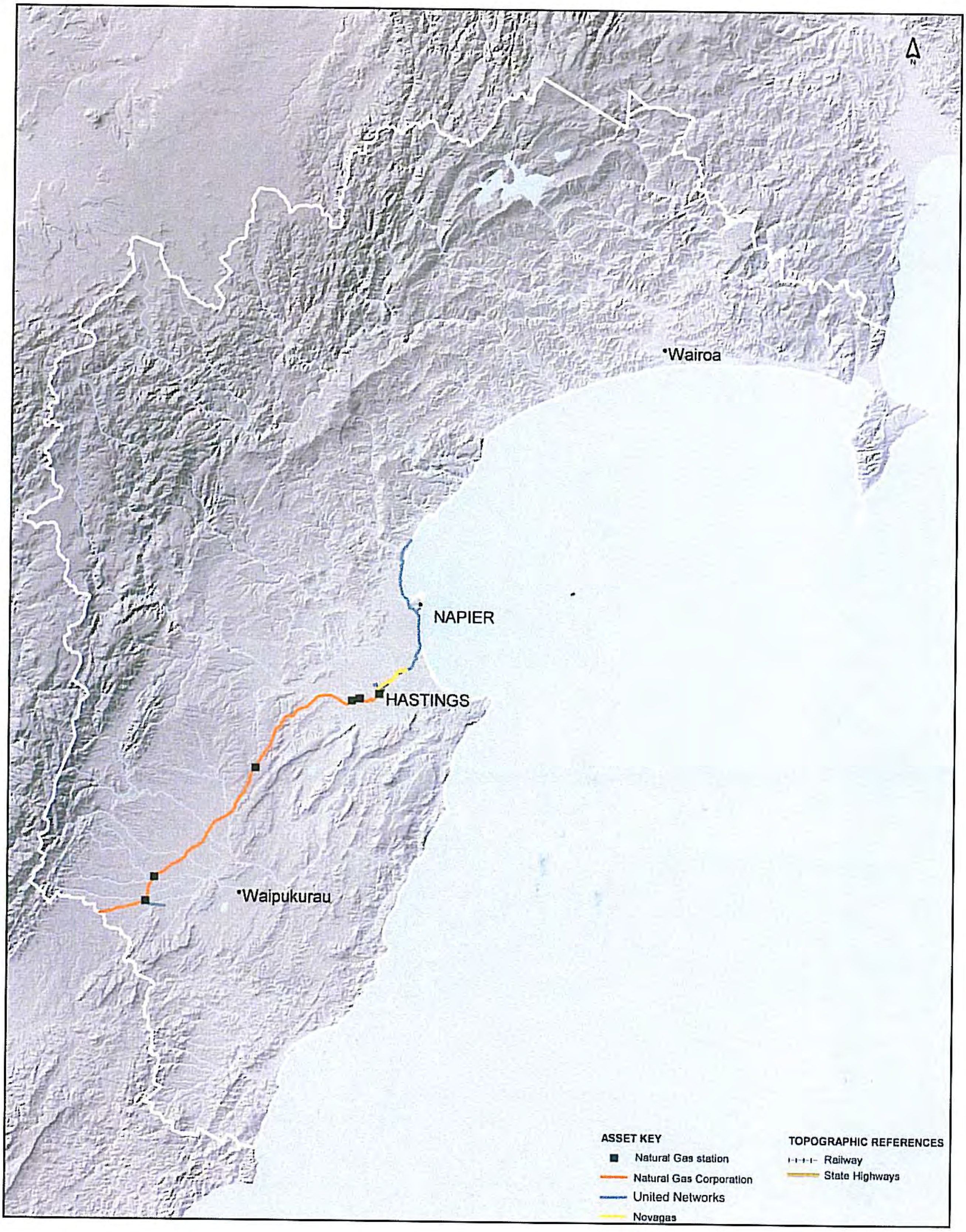
Hawke's Bay Network Sample Risk Assessment Spreadsheet.

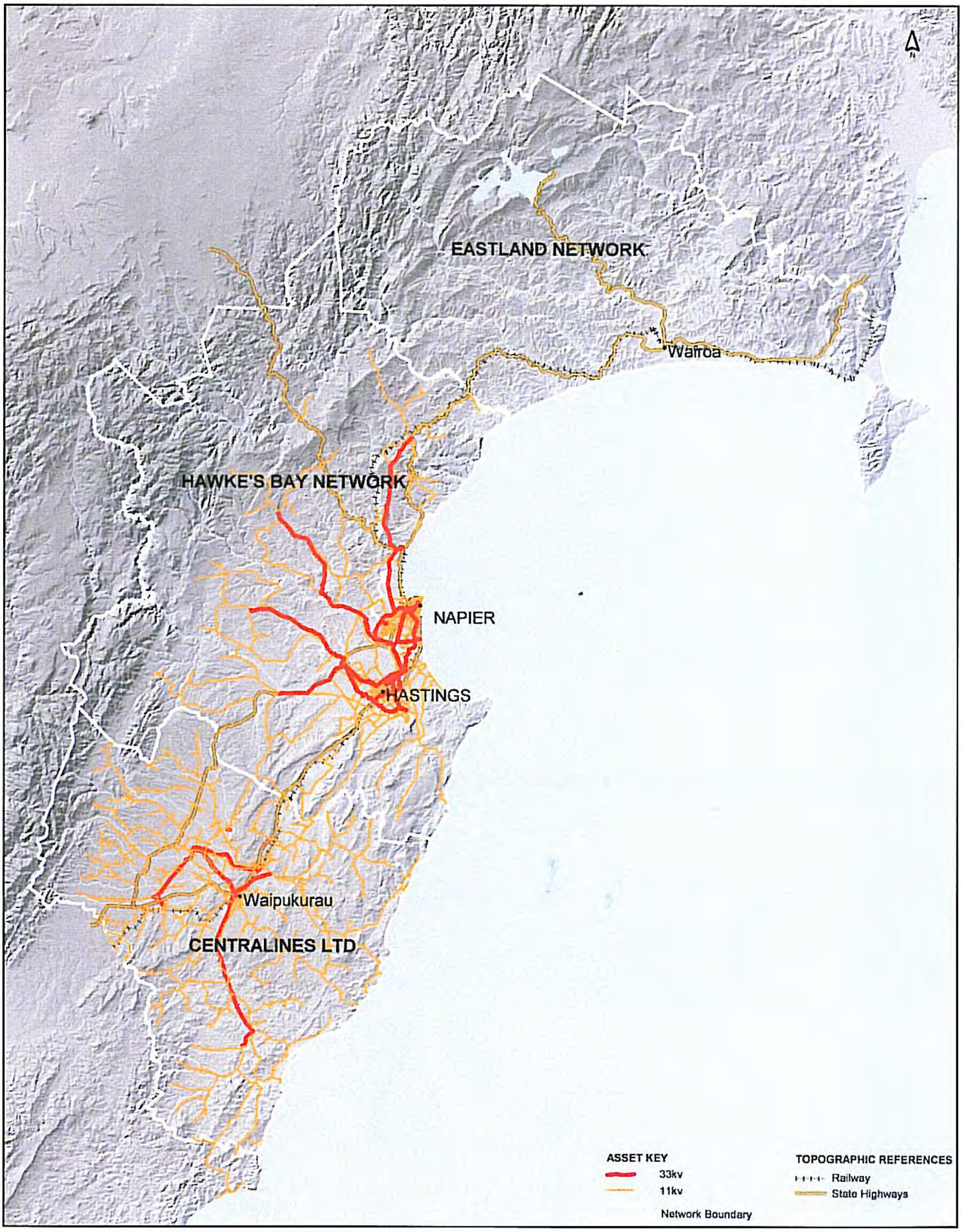
Map 18

Energy
Transpower Network



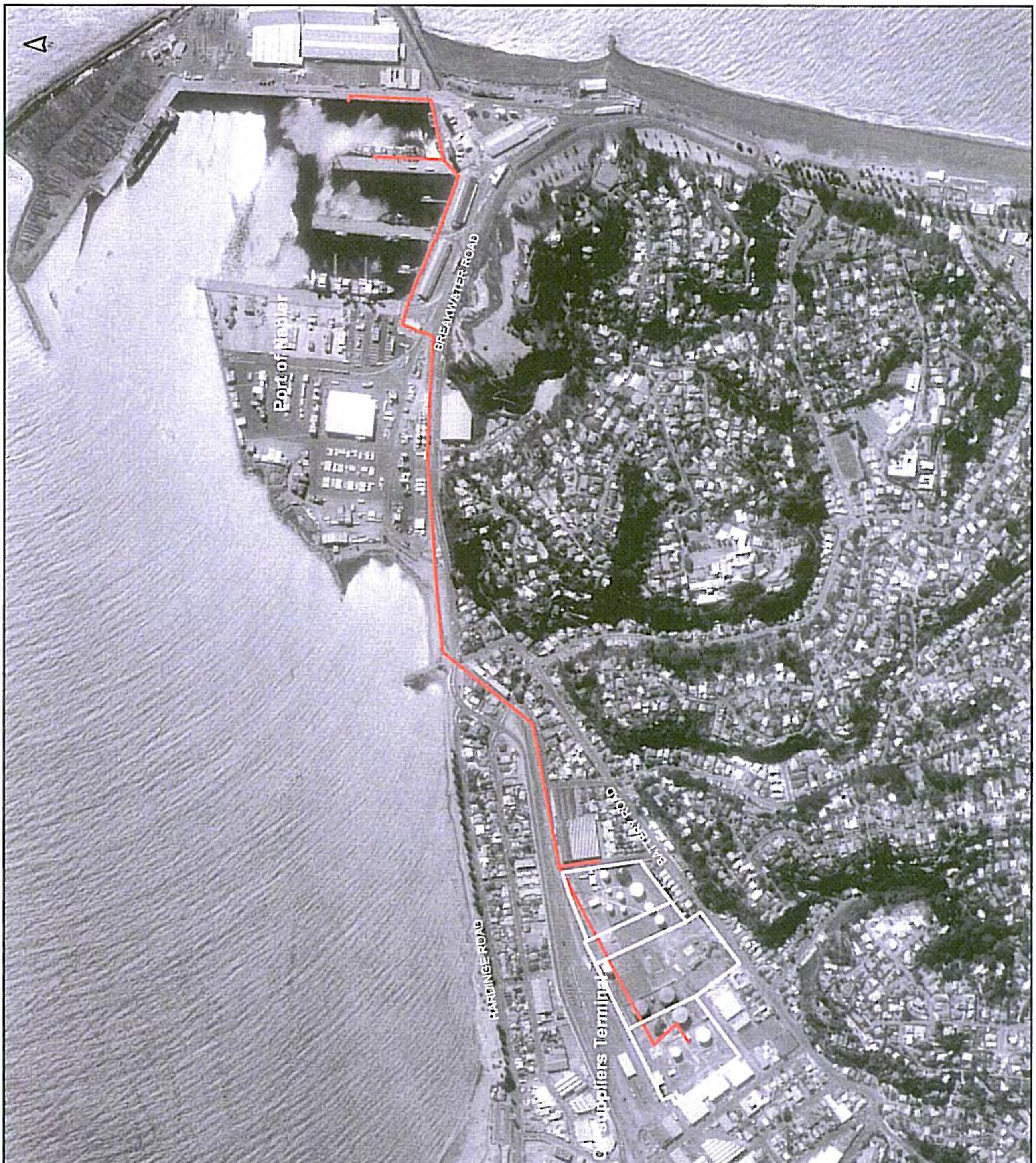
Map 20


Wairoa
NAPIER
HASTINGS
Waipukurau
ASSET KEY
Natural Gas station
Natural Gas Corporation
United Networks
Novagas
TOPOGRAPHIC REFERENCES
Railway
State Highways


EASTLAND NETWORK
Wairoa
HAWKE'S BAY NETWORK
NAPIER
HASTINGS
Waipukurau
CENTRALINES LTD
ASSET KEY
33kv
11kv
Network Boundary
TOPOGRAPHIC REFERENCES
Railway
State Highways

Map 21

Oil Suppliers
Lines from Port of Napier



Chapter 12
Communications

Introduction

The Communications Group was made up of representatives from the telephone companies, broadcast radio, radio network operators, local government and emergency services that use radio networks.

The organisations represented were:

Telecom

Clear Communications

Vodafone

The Radio Network

Rangitoto Radio

Napier City Council

Hawke's Bay Regional Council

Hastings District Council

Bay Forests Rural Fire District

New Zealand Fire Service

Group membership was wide to ensure that emergency management people became familiar with the risk assessment phase of this project. This will be useful in Stage 2 of the project, when emergency plans are developed.

Many of the group's risk assessments were made on the basis of judgement and experience. It may well be important therefore, to carry out an in-depth and professional assessment for those elements identified as having greatest risk.

Telecommunication Companies

Telecom New Zealand Limited

Risk assessments for natural hazards were carried out for the Telecom network on the following basis:

Network Elements:

- switching sites
- radio sites
- strategic cell sites
- telepaging transmitter sites
- important fibre cable sections

Takapau Microwave Tower against a beautiful Hawke's Bay sky. (Photo courtesy Ian Greaves Telecom)

It is important to remember that the Telecom network is complex and there are daily changes to its configuration, to achieve the overall goal of total network availability and reliability.

Results

Switching Sites (Telephone Exchanges)

A total of 18 sites were identified where public switched telephone network (PSTN) equipment is installed. In many instances this switching equipment is co-located with fibre terminal or other transmission equipment. All the sites have modern generation-stored programme control exchange equipment, which has been installed to seismic specifications within the last 15 years. Seismic restraints are also being used to protect ancillary equipment housed at exchanges, such as office furniture, ladders and test equipment.

Volcanic ash could affect the operation of the PSTN by getting into the cooling mechanism. The exchange equipment relies on air conditioning to keep temperatures at acceptable levels. If volcanic ashfall blocked the filters, impeding airflow through the heat exchangers, temperatures could rise to the point where the equipment permanently equipment failed. To prevent this, equipment may have to be shut down so it can cool off before damage occurs. This would result in some service outages.

During a spell of recent volcanic activity, extra filters were kept on-hand to replace any affected by ashfall. Fresh air intake fans were disabled to stop ash getting into equipment rooms and the air-conditioning was set to re-circulation.

The PSTN invariably becomes overloaded with traffic after a significant event - studies overseas indicate a 20-fold increase in telephone traffic volumes. A Network Control Centre in Hamilton is responsible for managing traffic congestion and minimising the impact of local overloads, through a variety of switched network control commands. These procedures are designed to prevent a gridlock.

Important Fibre Cable Sections:

One of the more important fibre cables, which is shared with another carrier, is vulnerable to natural hazards because it is attached to the Mohaka Bridge on SH5 between Napier and Taupo. Although Telecom is not responsible for maintaining this cable, risk has been mitigated through the use of "ring technology". With this technique, the cable is configured as a ring, with various network elements connected around it. If there is a break in the cable at a particular point, traffic can be routed around the affected portion of the ring. This is also known as a self-healing network and is used in many other parts of the fibre network.

In the area immediately around Napier, liquefaction could affect the ring. Displacement at bridge abutments, including Redclyffe, Chesterhope and Awatoto, as well as liquefaction, could impact on the reliability of the fibre network. However a microwave radio system terminating at Napier Exchange could provide some alternative network capability.

The Hawke's Bay area is equipped with fibre restoration kits for quick temporary repairs to any fibre break. A routine visual inspection of the important sections of fibre cable routes that are known to be vulnerable, is likely to be implemented. This will include checking bridge abutments and attachments and areas of unstable ground.

Radio Sites (Including Cell and Telepager)

Most radio sites have been purpose built for the equipment they house and have had extensive seismic bracing work carried out in the last 10 – 15 years. Wind loading on the towers tends to be conservative. (usually greater than 200kph). Ice formation is the only natural event that has caused damage at these sites in the past. Some sites are more prone to this hazard than others, probably because of a combination of altitude and latitude. A typical scenario is for lumps of ice to break off the upper regions of the structure and damage other parts on its way down. As a mitigation measure, ice shields have been attached above vulnerable antenna at affected sites. The other problem results from wind, sleet and snow combining to form "flag ice" where large horizontal, flags of ice form on parts of the antennas, creating torsion (twisting) forces which can either bend or break the section to which they are attached. To prevent this problem, Telecom installs antenna types that are less susceptible to damage from flag ice.

Photo taken on the North side of Takapau Microwave Radio Station after an earthquake event which occurred during the mid 1980's. There is evidence of backfill settlement around the foundations of the building and tower footings. (Photo courtesy Ian Greaves Telecom)

Radiated radio frequency power levels are relatively low so the effects of ash falling directly on antennas are minimal. Other site plant considerations regarding

A rigger is clearing ice away from a corner reflector antenna on the Te Waka Microwave tower. The lower antenna has already been cleared of ice and should now be performing normally. The fromation of "Flag Ice" on this structure is not uncommon. (Photo courtesy Ian Greaves Telecom)

volcanic ash are similar to those for switch sites, although access is usually more difficult. Remote management of these sites is achieved using PLC technology. This means equipment like fresh air fans can be remotely turned off and room temperatures monitored from a centralised control centre.

As with the PSTN, the cellular network is likely to be overloaded after an event such as an earthquake. Organisations incorporating cellphones into their emergency response plans need to understand the limitations of the cellular network.

Interdependencies

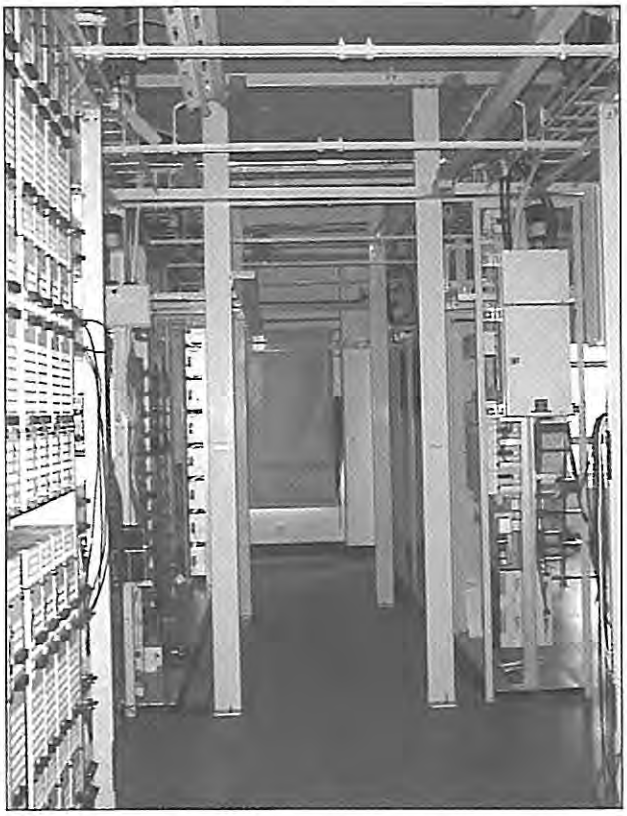
The Hawke's Bay Engineering Lifelines Project has shown that disaster recovery in the region will be heavily dependent on the communications network being operational. This includes the PSTN, cellular network, paging, data, and other dispatch systems such as Fleetlink and VHF landmobile. There is likely to be considerable pressure to have the telecommunication network functioning before other utilities can begin restoration activities.

Impact on Neighbouring Regions

Natural hazard events in Hawke's Bay may well impact on other regions, especially northern Hawke's Bay (Wairoa) and Poverty Bay. The network north of Hawke's Bay is very dependent on some key sites within Hawke's Bay to maintain service. From Te Waka (on SH5) north, the network consists of a spur, fed from Hawke's Bay. There is no ring configuration or any connection to the Bay of Plenty for an alternate route from this spur.

Conclusion

Telecom continually assesses the vulnerability of its network as a part of normal business practise and has a Business Continuance Group set up for this purpose. Some customer-owned networks and equipment are not be able to continue operating even after something as straightforward as a power outage. This needs to be taken into account when developing plans to cope with a natural or man-made event that has disrupted normal services. This is a public awareness and education issue to which Telecom is responding, where possible, by offering advice and options to mitigate risk.



Steel Columns have been installed in the aisles between equipment as part of the additional seismic bracing. (Photo courtesy Ian Greaves Telecom)

CLEAR Communications

CLEAR Communications operates cable and radio local access systems within Hawke's Bay. CLEAR has a major network node in Napier to manage circuits and calls from its own network and those from other, interconnecting networks. Connection to the rest of CLEAR's New Zealand network is through fibre optic cables from Auckland through Taupo to Napier and south through Hawke's Bay and Wairarapa to Wellington. From Pakipaki to southern Hawke's Bay it shares the same sheath with Telecom. Telecom is responsible for the maintenance of that section of cable. On the Napier-Taupo Road, CLEAR has another node where its network interfaces with Broadcasting Communications Limited's (BCL) microwave systems connecting to the East Coast. CLEAR manages and monitors services from a duplicated Network Management Centre in Auckland, manned 24 hours a day, 7 days a week.

Risk Assessment.

A second fibre optic cable on the west coast of the North Island duplicates the CLEAR national network. In the event of a cable break, affected circuits are automatically switched to the other route.

CLEAR circuits from Napier can be routed north or south, with automatic switching if the cable breaks. The CLEAR equipment node at Napier is not duplicated so any damage there will isolate CLEAR lines in Hawke's Bay from the rest of New Zealand.

CLEAR circuits to the East Coast are on an unduplicated microwave spur to Gisborne, with bandwidth leased from BCL.

Repairs to fibre cables take 6 to 12 hours, provided there is unrestricted access to the damaged cable. A large contracting company with national resources carries out repairs.

The assessment of risk and impact of damage takes the following issues into account:

- Fibre but not equipment diversity;
- Whether a few or many cable breaks are expected for each hazard;
- Whether there is likely to be easy access for repair crews.

Cables are buried in the rail or road reserves, and are waterproof. This minimises the risk of damage from most hazards. The most likely risk of damage is by shearing due to:

- Movement of fault lines;
- Ground movement at bridge abutments, or scouring by floods;
- Bridge failures due to floods and earthquakes.

Cables are looped in joint chambers, to provide slack to mitigate against shearing.

Equipment between Napier and Taupo is housed in a modern, single-storey and robust concrete block structure, located on a valley floor away from hillsides. The equipment is seismically braced. There is more than 12 hours of battery reserve power available, with an auto-start emergency diesel generator on site. Problems may arise if access difficulties delay the delivery of fuel.

The Napier equipment is housed in a seismically sound building and the equipment is seismically braced. About 8 hours of battery reserve power is available, with a socket to plug in a portable emergency generator, held by a Napier-based contractor.

Mitigation Measures.

While it is not practical to eliminate all risks, CLEAR will continue with the following mitigation measures.

- Regular civil engineering inspections and reports for all network nodes, covering accommodation and seismic bracing of plant and equipment;
- Regular load testing and reports for standby generators;
- Regular inspections and reports for batteries and fuel stocks;
- Regular checks and reports on local stocks of spares, including fibre repair kits and air filters;
- Continuing provision of permanent diesel generators at larger and more remote nodes, as part of CLEAR's business plan.

Vodafone New Zealand Limited

Network Structure

The Vodafone network comprises approximately 600 cell sites, linked in geographical clusters to 17 base station controllers (BSCs) which, in turn, feed into the nearest geographical switches in Auckland, Wellington and Christchurch.

The significant facilities close to Hawke's Bay are two BSCs, in Hastings and Palmerston North, and a switch in Wellington.

Connections between cell sites, BSCs and switches are made via Vodafone microwave links, Clear microwave links or landline spans, Telecom microwave links or landline span, and BCL microwave links. All these methods are used in Hawke's Bay.

Connection to and from landlines, Telecom 025 and international lines is achieved via other telecommunication operators.

All of Vodafone's major cell sites have route and carrier diversity, along with diesel generation systems. Cell sites are designed for extreme conditions and have battery backup that can maintain services for between 2 and 12 hours, and connections for external generators. Vodafone holds a number of generators designated for regional use for this purpose.

The nature of cellular technology means overlapping coverage between cells is common. The loss of a cell site will impact on coverage and could temporarily reduce the capacity to carry calls. However some sites and services outside the Hawke's Bay area, will be able to provide service into the region during an emergency.

Network Management

Vodafone's main engineering department is based in Auckland, supported by small operational bases in Wellington and Christchurch. The Network Management Centre, which can remotely view and control all sites throughout New Zealand, is in Auckland.

Vodafone employs a number of contractors to service its sites in regions throughout New Zealand.

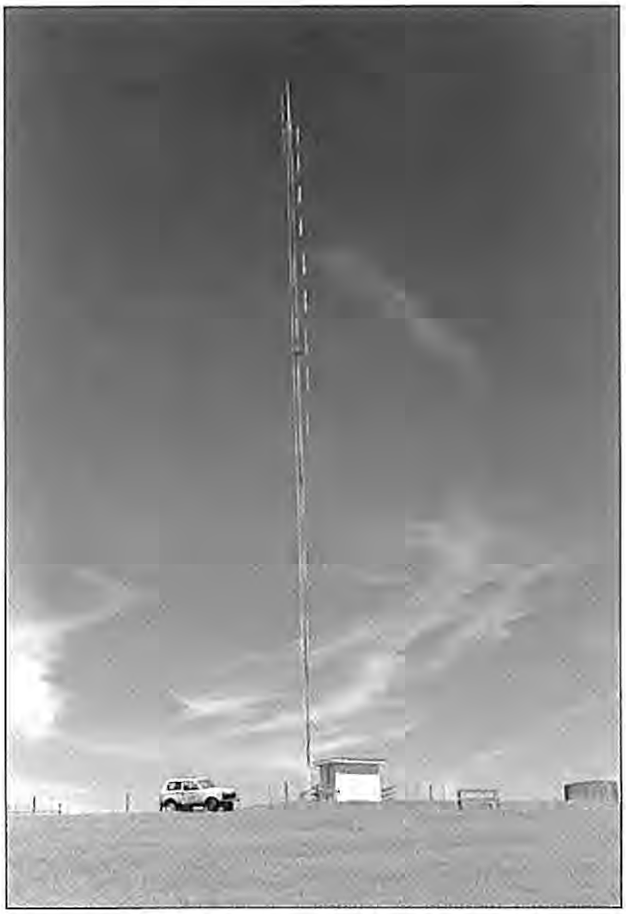
Conclusion

Cell sites are designed to carry traffic on a busy day with a margin for growth. In normal circumstances this provides a full service to customers. However, overseas experience shows that during an emergency, the network could become seriously overloaded, at local levels, within 15 to 30 minutes. Additional capacity can be added to sites, but this would take some time.

Broadcast Radio Napier/Hastings/Wairoa

Purpose

This assessment was to determine the vulnerability of the various studio and transmitter broadcast sites in Hawke's Bay to damage from natural events. The study also examined the effect this damage could have on the operation of the site after the event.



Rangitoto Radio hut and mast at Tourere Hill December 1988 (Photo courtesy Garth Cassidy)

Background

Various radio and television broadcasters deliver programmes in the Hawke's Bay area.

Some of these originate in studios within Hawke's Bay and some from outside the area.

The facilities used to transmit this programming to the Hawke's Bay audience are located within the region, generally close to the most populated areas.

Studio Sites

The Radio Network Limited

The Radio Network Limited broadcasts both network radio programmes (compiled outside Hawke's Bay) and local programmes (compiled in Napier).

These programmes are transmitted on both MF-AM and VHF-FM, from three different transmitter sites in Hawke's Bay

Studios

Location: Corner Dickens and Dalton Streets, Napier

Owner: The Radio Network Limited

Importance: Extremely important

Services Involved: All Radio Network services except Radio Sport

Standby Power: Through an automatic diesel generator

Radio Works Limited

Radioworks broadcasts network radio programmes originating outside Hawke's Bay, and local programmes originating in Hastings.

These programmes are transmitted on VHF-FM from the Mount Erin transmitter site.

Studios

Location: Top Floor, BNZ Building, Hastings

Owner: Radioworks Ltd

Importance: Extremely Important

Services Involved: All Radioworks services

Standby Power: Through an automatic diesel generator

Radio Kidnappers

Radio Kidnappers is an Access Radio station based in Hastings. All Radio Kidnappers programming originates from its studios in Queen Street, Hastings and Dickens Street, Napier.

Radio Kidnappers transmits this on MF-AM from the Radio Network's transmitter site at Pakowhai.

Studios

Location: Queen Street, Hastings and Dickens Street, Napier

Owner: Radio Kidnappers Community Trust

Importance: Extremely Important

Services Involved: All Radio Kidnappers services

Standby Power: Not available

Radio Kahungunu

Radio Kahungunu is the local Iwi broadcaster based in the Maori Studies Faculty at the EIT in Taradale.

Radio Kahungunu broadcasts network radio programmes compiled outside Hawke's Bay, and local programmes originating in Taradale. The programmes are transmitted on MF-AM from Radio New Zealand's transmitter site at Opapa and on VHF-FM from the Threave transmitter site.

Studios

Location: Maori Studies Faculty, EIT, Taradale

Owner: Radio Kahungunu

Importance: Extremely Important

Services Involved: All Radio Kahungunu services

Standby Power: Not available

Channel Fifty-One Limited

Channel Fifty-One Limited broadcasts television programming compiled in its studios in Napier, on UHF Channel 51 from the Threave transmitter site.

Studios

Location: Top Floor, Hawke's Bay Motor Company Building, Dickens Street, Napier

Owner: Channel Fifty-One Limited, Napier

Importance: Extremely Important

Services Involved: All Channel Fifty-One services

Standby Power: Not available

Results of Risk Assessment of Studios in the Napier/Hastings area

Any hazard that affects broadcasting studios will impact on the network or networks involved. Although the major networks have contingency plans allowing them to operate from remote sites, the loss of local broadcasting during and immediately after a natural hazard can have an extreme impact on the public and emergency management.

Earthquakes present the greatest risk to studios. While most are located in relatively modern buildings, or reinforced concrete buildings that survived the 1931 Hawke's Bay earthquake, they are still vulnerable to non-structural damage.

Although measures are taken to ensure that fittings and equipment are fixed in place, this will not cover all equipment and fittings that could be damaged during a major earthquake.

The effect of extreme wind on aerials poses the next greatest risk to broadcasting networks. Although this equipment is normally well designed and constructed, it can be damaged or lost during natural disasters, and this would have an immediate effect on the networks.

Studios and Transmitters of Broadcasters outside Hawke's Bay

Several broadcasters transmit programmes into Hawke's Bay from studios based outside the region.

Radio New Zealand Ltd

Radio New Zealand transmits National Radio on 630khz and the parliamentary network on 900 khz from Opapa and Concert FM on 91.10 mhz, from Mt Erin, out of studios in Wellington.

Radio Rhema

Radio Rhema transmits a programme of the same name on 549 khs from Mahia and Southern Star on 909 khz from Opapa, out of studios in Auckland.

Television New Zealand Ltd

TVNZ transmits TV1 on VHF Channel 6 and TV2 on VHF Channel 8, both from Mt Erin, out of studios in Auckland.

Canwest Limited

Canwest transmits TV3 on VHF Channel 10 from Mt Erin and TV4 on VHF Channel 11 from Threave, out of studios in Auckland.

Prime TV

Prime TV transmits on UHF Channel 61 from Mt Erin into Hawke's Bay out of studios located in Auckland.

Sky TV

Sky TV transmits pay-to-view television programmes on UHF Channels 29, 33, 45, 53 and 57 from Mt Erin out of studios in Auckland.

Sky TV also transmits pay-to-view programming direct to Hawke's Bay homes via its satellite, from studios in Auckland.

Transmitter Sites

There are 6 transmitter sites broadcasting radio and television programming to Hawke's Bay.

Four of these transmit MF-AM and the other three transmit VHF-FM radio and FHV/UHF television.

Two of the VHF sites also house VHF/UHF radio communications and linking equipment used by broadcasters to relay programming from remote locations back to the studio. This equipment also carries programming from the studio to the main transmitter site for broadcast.

Opapa

Location:	SH 2, Te Hauke	
Owner:	Radio New Zealand Ltd,	
Importance:	Extremely Important	
Services Involved:	National Radio:	630 khz
	Radio Kahungunu	765 khz
	Parliamentary N/W	909 khz
	Southern Star N/W	909 khz
Standby Power:	Through an automatic diesel generator	

PakiPaki

Location:	Te Aute Road, Paki Paki	
Owner:	Hylton Read Havelock North	
Importance:	Important	
Services Involved:	Jammin' Oldies	1530 khz
Standby Power:	Not available	

Pakowhai

Location:	Corner Gilligan & Allen Roads, Pakowhai	
Owner:	The Radio Network Ltd	
Importance:	Extremely Important	
Services Involved:	Radio Sport	1125 khz
	Newstalk ZB	1278 khz
	Kidnappers	1431 khz
Standby Power:	Through an automatic diesel generator	

Mahia

Location:	Pongaroa Station Mahia Peninsula Mahia	
Owner:	Radio Rhema Auckland	
Importance:	Important	
Services Included:	Radio Rhema	549 khz
Standby Power:	Not available	

Mt Erin

Location:	Mt Erin Station, Havelock North	
	NZMS V22 392 557	
Owner:	Television New Zealand Ltd	
	Auckland	
Site Manager:	Broadcast Communications Ltd	
	Wellington	
Importance:	Extremely Important	
Services Involved:	Concert FM	91.10 mhz
	Solid Gold	91.90 mhz
	Hot 93	92.70 mhz
	The Rock	95.10 mhz
	ZM	95.90 mhz
	Radio Pacific	97.50 mhz
	The Edge	98.30 mhz
	Radio Car linking/COMMS services, various VHF/UHF frequencies.	
	TV1	VHF CH6
	TV2	VHF CH8
	TV3	VHFCH10
Sky TV	UHF CH 29	
	UHF CH 33	
	UHF CH 45	
	UHF CH 53	
	UHF CH 57	
	Prime TV	UFHCH61
Standby Power:	Through an automatic diesel generator	

Threave

Location	J D Scoular's Property, Poukawa	
Owner:	Hylton Read	
	Havelock North	
Importance:	Extremely Important	
Services Involved:	Classic Hits	89.50 mhz
	Easy I	90.30 mhz
	Radio Kahungunu	94.30 mhz
	Radio Rhema	99.10 mhz
	Hauraki	99.90 mhz
	Radio Kahungunu linking	
	To Opapa	UHF
	TV4 VHF CH11	
	Channel Fifty One	UHFCH51

Standby Power: Yes 2 systems in use:

Classic Hits has its own automatic LPG powered generator.

Other services share an automatic diesel generator.

Results of Risk Assessments of Transmitter Sites in the Napier/Hastings Area

Transmitter sites are vital for the continued operation of broadcast networks.

The earthquake hazard presents the greatest risk to transmitter sites. Tower structures are generally well designed and built to resist seismic loadings. The greater risk is to control apparatus where it is not restrained.

At sites where risk assessments are regularly reviewed, apparatus is restrained. However this is not the case for some less critical sites.

The greatest threat is loss of access roads as a result of a major storm or earthquake.

Towers and control buildings are generally constructed for high wind loadings and are regularly tested in this respect.

In extreme circumstances helicopters could be used to maintain operations or fill diesel generators.

Most transmitter sites are on very exposed peaks. Wildfire would only pose a serious risk if transmitters were located within forests.

Radio Broadcast Central/Southern Hawke's Bay

Purpose

This assessment was to determine the vulnerability of the various studio and transmitter broadcast sites in Hawke's Bay to damage from natural events. The study also examined the effect this damage could have on the operation of the site after the event.

Studio Sites

Central FM Ltd

Central FM Ltd broadcasts radio programming to central and southern Hawke's Bay. All programming is compiled at their studios in Waipukurau.

Central FM transmits on VHF-FM from three different sites.

Studios

Location:	Ruataniwha Street, Waipukurau
Owner:	The Radio Network Ltd
Importance:	Extremely Important
Services Involved:	All Central FM services
Standby Power:	Available from a petrol-powered generator which must be manually connected and started

Transmitter Sites

Central FM transmits from transmitters at 3 separate sites in the Central/Southern Hawke's Bay region.

All of these sites transmit VHF/FM Radio.

The Central FM transmission set-up is unusual. Instead of the radio programme being fed direct from the studio to each transmitter site, it is sent to the first transmitter site; and relayed to the next two sites in turn.

This allows Central FM to have a broadcast signal over a very large geographical area.

The disadvantage of the system is that failure at one site will cause failure in sites further downstream. Consequently failure of a site early in the transmission chain can result in broadcast coverage being lost to very large geographical areas.

Site One: Two Peaks

Location:	Peacock Road, Waipukurau	
Owner:	Central FM Ltd Waipukurau	
Importance:	Extremely Important	
Services Involved	Central FM	93.50 mhz
Standby Power:	Available from a petrol-powered generator which must be manually connected and started	

Site Two: Tourere Hill

Location:	Tourere Road	
Owner:	Rangitoto Radio Waipukurau	
Importance:	Extremely Important	
Services Involved:	Central FM	96.60 mhz
Standby Power:	Through an automatic diesel generator	

Rigger working on Rangitoto Radio mast Tourere Hill December 1988. (Photo courtesy Garth Cassidy)

Site Three: Dannevirke

Location:	Reservoir Knob, off Adelaide Road	
Owner:	Central FM Ltd Waipukurau	
Importance:	Extremely Important	
Services Involved:	Central FM	99.40 mhz
Standby Power:	Not available	

Rangitoto Radio Incorporated

Description

Rangitoto Radio is a Radio User Association with three fixed repeater sites in Central and Southern Hawke's Bay.

Its mobile radio coverage does not extend beyond Hawke's Bay. It is used by local contractors, carriers, farmers, veterinarians, and other people requiring two-way radio service.

The sites are also used by Telecom and other network providers for a range of communications including broadcasting, microwave linking, data, trunking, and switching for power companies.

Mains power is the normal power supply, with each site having limited back-up in the form of a battery or diesel powered generator.

The organisation is run on a commercial basis, so risk assessments are carried out regularly, and mitigation measures put into effect.

Rangitoto Radio's localised network could be of assistance to the Police and Civil Defence in an emergency. A mobile command, four-wheel drive vehicle, installed with Rangitoto channels, is available.

Rangitoto radio site, Transpower Hut and Discs Tourere Hill (Photo courtesy Garth Cassidy)

Results of Risk Assessments of Studio and Transmission Sites in Central/Southern Hawke's Bay

The importance of broadcast facilities, especially straight after a disaster, cannot be overstated.

The results of risk assessments for Central/Southern Hawke's Bay are the same as those for the Napier/Hastings area. These are summarised below:

- Structural or non-structural damage from earthquakes presents the greatest risk to studios and transmission sites. At transmission sites, control apparatus that is not restrained is most at risk from seismic activity;
- Loss of access roads is the next greatest risk, following a major storm or earthquake event;
- Aerials, towers and control buildings are generally well designed for high wind loadings particularly at the exposed sites;
- In extreme circumstances helicopter access by helicopter could be needed to maintain operations;
- Wildfire does not pose a serious risk.

Local Government Essential Services

Risk assessments for the communications networks for local government services were carried out on the following basis:

Network Elements: Central Hawke's Bay District, Hastings District, Napier City, Wairoa District and Hawke's Bay Regional Councils.

Emergency Operations Centres (EOC's)

Alternate EOC's

Radio Network:

Council Operations Repeater Networks

Council Telemetry Networks

Local government organisations use a wide range of systems to meet their communications needs.

Results

Local Government Emergency Operations Centres (EOC's)

Each local government is able to provide an emergency operations centre (EOC) for continuing essential services during emergencies. There are generally two locations: at a dedicated works and services depot and in the civic buildings. The centre at the civic building will also usually provide facilities for civil defence emergency management should an event develop into a declared emergency.

Buildings accommodating EOC's and their lifeline services have some level of risk from seismic impact.

All other natural hazards pose a moderate level of risk, with flooding and tsunami inundation ranked the highest, depending on the individual site.

Seismic Activity

Local government buildings in Hawke's Bay vary in age. The initial construction and subsequent alterations or extensions meet the building codes current at the time the work was undertaken. In some buildings that accommodate an EOC, new work or renovations meet the highest structural design category for buildings where loss of function would have a severe impact on society.

Some of the buildings have been checked against the building loadings code to assess their suitability for use as an EOC.

Mitigation Actions

The contents of buildings pose a considerable risk to occupants during seismic events and, as a result, some councils have adopted hazard reduction strategies. These include securing tall furniture, mobile and desktop equipment and the contents of shelves, keeping passageways clear and replacing heavy plaster ceiling tiles.

All EOC's have interdependencies with other engineering lifeline networks.

Energy

Electricity is used in most EOC's to power the facilities and operational equipment. When power fails, this can usually be supplemented by dedicated generators on each site. However this back-up is dependent on the availability of diesel deliveries during prolonged power disruptions.

Telecommunications

Each organisation relies heavily on telecommunications equipment for telephone, fax, data transfer and email and Internet connections for both internal and external communications.

Radiotelephone is the alternative means of communication for all councils, despite its limitations.

Water and Sewage Reticulation

Only a small number of the EOC buildings can store enough drinking water for the numbers of staff who may be working there during a prolonged emergency. This makes them reliant on the availability of drinking water delivery tankers and storage facilities, if the water reticulation network is disrupted.

None of the buildings identified as EOC's have facilities for retaining or storing wastewater or sewage.

Roading and Transportation:

Disruption of these networks will affect the ability of staff to commute to and from the EOC and to co-ordinate the delivery of goods and services to affected areas.

Alternate Emergency Operations Centres

The designated works or services depots and civic buildings are critical sites and it is expected that one of the two buildings will be usable as an EOC in an emergency.

Where councils have split the EOC responsible for continuing essential services from the EOC handling civil defence emergency management, the 2 are likely to co-locate on the same site.

Seismic Activity

This hazard poses the highest risk even at alternate EOC sites.

Local Government Communications Networks

A diverse range of communication systems is used in the day-to-day operation of local government in Hawke's Bay. These include telephone, cellular telephone, fax, e-mail and radio.

To meet the needs of these organisations a number of independent radiotelephone networks are also used. They are structured as follows:

Radio Networks

Council Operations Repeater Voice Networks

The radio networks detailed below are primarily used for the transmission of voice messages.

The Central Hawke's Bay District Council operates its own repeater network, using radio frequencies and repeaters in its district that are dedicated for use in a civil defence emergency.

The Hawke's Bay Regional Council leases an operational and administrative radio network from Fleetlink. This provides access to a number of linked repeater sites throughout the region.

The Napier City Council leases a dedicated radio frequency and repeater network from Telecom Mobile. This is located within the Napier District.

The Wairoa District Council has access to a radio network operated by Quality Roading and Services.

Regional Civil Defence Voice Repeater Network

The radio networks detailed below are primarily used for the transmission of voice messages.

Most councils in Hawke's Bay are responsible for civil defence emergency management and rural fire activities within their districts and are generally able to call on additional communications resources (refer to the civil defence emergency management section in this chapter).

The Hawke's Bay Regional Council leases a dedicated repeater frequency, which links to radio equipment located at each council within the region. This network provides a valuable communications link for local government when telecommunications systems fail or are overloaded. Some councils can also assess radio equipment and frequencies linking to Gisborne and other centres throughout New Zealand.

Telemetry Data Networks

All councils also use radio networks to transmit data from remote sites to centralised monitoring control centres such as pumping stations or weather monitoring stations.

Conclusion

Local government organisations regularly review their need for radio frequencies and networks. Whether the equipment is owned and operated by the organisation or managed by a contractor, all of it also needs to be continually monitored for reliance and resilience.

Civil Defence Emergency Management

Assessment of vulnerability to natural hazards was carried out for the various elements that make up the communications networks of local government civil defence emergency management (CDEM) in Hawke's Bay, on the following basis:

Network Elements:

Central Hawke's Bay District,Hastings District, Napier City, Wairoa District and Hawke's Bay Regional Council.

Emergency Operations Centres (EOC's)

Alternate EOC's

Radio Network: CDEM repeater networks

CDEM Simplex networks

Rural Fire radio networks

Local government organisations use a range of options to meet their CDEM communications needs.

Results

Local Government Emergency Operations Centres (EOC's)

Each local government is able to provide an emergency operations centre (EOC) for civil defence emergency management. Generally these are located in, or adjacent to, the council's civic buildings. Each council has also identified alternative sites for their CDEM EOC.

Central Hawke's Bay District Council

The CDEM EOC is in the civic building on Ruataniwha Street, Waipawa.

The alternate EOC (AEOC) is in the St. Mary's Church Hall, St. Mary's Road, Waipukurau.

Hastings District Council

The CDEM EOC is in the extensively renovated and strengthened Emergency Management Building at 311 Lyndon Road East, Hastings.

The AEOC is the Hastings District Council Engineering Division building, 100 Warren Street South, Hastings.

Hawke's Bay Regional Council

The CDEM EOC is the council's offices at 102 Vautier Street, Napier.

The AEOC is in the Hawke's Bay Regional Council Works Offices, Guppy Road, Taradale, Napier.

Napier City Council

The CDEM EOC is in the civic building at 231 Hastings Street, Napier.

The AEOC is in the council's depot, Austin Street, Napier, or co-located with other emergency services at Napier Fire Station.

Wairoa District Council

The CDEM EOC is in the council offices, Queen Street, Wairoa.

The AEOC is at the Wairoa Hospital, Kitchener Street, Wairoa.

The buildings accommodating CDEM EOC's and AEOC's and their lifeline services, are all at some risk from seismic impact.

Radio equipment at the Regional Emergency Operations Centre-Hawke's Bay Regional Council.

All other natural hazards pose a moderate level of risk, with flooding and tsunami inundation generally having the highest ranking.

Seismic Activity

The findings are the same as for local government EOC's.

Mitigation Actions

Mitigation measures are the same as for local government EOC's and include the need to secure the contents of buildings, keep passageways clear and replace heavy plaster ceiling tiles.

Energy

Energy issues are the same as for local government EOC's with back-up generators reliant on the availability of diesel deliveries.

Telecommunications

Once again the issues are the same as for local government EOC's.

All councils use radiotelephone as their secondary means of communication.

Water and Sewage Reticulation

Only a small number of the buildings identified have drinking water stored on site and, with the exception of the Napier City Council CDEM EOC, none have enough for the number of staff who would be working at the EOC during a prolonged emergency. Napier City Council has 15,000 litres of water in the top floor of its library building. This means the EOCs would have to rely on the availability of drinking water delivery tankers and storage facilities if the reticulation network was disrupted for a long time.

None of the buildings identified as CDEM EOC's can retain or store wastewater or sewage.

Roading and Transportation

As with local government EOC's, disruption to these networks will affect staff getting to and from the EOC and the delivery of goods and services to affected areas.

CDEM Communications Networks

A number of independent radio networks are used by local government organisations, in addition to the day-to-day communication systems. The civil defence emergency management radio networks are structured as follows:

RADIO NETWORKS

Repeater Voice Networks

The radio networks detailed below are primarily used for the transmission of voice messages.

Central Hawke's Bay District Council operates the following:

- 2 VHF repeaters provide 2 duplex CDEM radiotelephone networks;
- 1 repeater site accommodates several repeaters, which are solar powered;
- The equipment operates in the emergency services public safety band;
- 28 civil defence centres and the council's vehicle fleet access the local networks;
- 1 regionally operated VHF CDEM radiotelephone network is accessible;
- 1 nationally operated HF SSB CDEM radio network is available.

The local networks are moderately vulnerable to severe seismic shaking and storm damage or loss of solar power generation capability at the repeater sites.

Hastings District Council leases 1 and operates another 6 CDEM radiotelephone networks.

- 2 VHF repeaters provide 2 duplex CDEM/rural fire radiotelephone networks.
- 4 additional frequencies provide 4 simplex CDEM/rural fire radiotelephone networks.
- 1 repeater is at a major communications transmitter site leased from Telecom.
- 1 portable repeater is owned and operated by the emergency management office.
- the equipment operates in the civil defence communications FM band.
- 42 civil defence centres, 3 vehicles and hand-held radios access the local networks.
- 1 regionally operated VHF CDEM radiotelephone network is accessible.
- 1 nationally operated HF SSB CDEM radio network is accessible.
- 1 duplex VHF fleet link network which is leased by the council for administration and operational purposes is accessible by the CDEM/rural fire personnel.
- 1 linked duplex NZ Fire Service operated VHF radio network is accessible.
- 1 ground to air simplex air transportation industry radio system is accessible.

The local networks are moderately vulnerable to loss of service at repeater sites or damage to the 28 metre tall main antenna at the EOC. In some terrain, particularly in remote rural areas, simplex communication is vulnerable to intermittent or complete breakdown.

Hawke's Bay Regional Council leases 1 CDEM radiotelephone network.

- 1 VHF repeater provides 1 duplex CDEM radiotelephone network;
- 1 repeater is at a major communications transmitter site leased from Telecom;
- The equipment operates in the civil defence communications FM band;
- 5 local councils, 2 emergency services and the regional health authority have access and equipment dedicated for operation on this VHF CDEM radiotelephone network;
- 1 nationally operated HF SSB CDEM radio network is accessible;
- 1 duplex VHF fleet link network that is leased by the Council for administration and operational purposes is accessible by the CDEM personnel.

The regional CDEM radiotelephone network is moderately vulnerable to overloading.

Napier City Council operates 5 CDEM radiotelephone networks.

- 2 VHF repeaters provide 2 duplex CDEM radiotelephone networks;
- 3 additional frequencies provide 3 simplex CDEM radiotelephone networks;
- 1 repeater is located on a commercial building, supported by battery back-up;
- 1 repeater is located in a shared repeater site, supported by battery backup;
- The equipment operates in the civil defence communications FM band;
- 10 civil defence centres, 1 vehicle and handheld radios access the local networks;
- 1 regionally operated VHF CDEM radiotelephone network is accessible;
- 1 nationally operated HF SSB CDEM radio network is accessible;
- 1 duplex VHF Telecom Mobile radio network, which is leased by the Council for administration and operational purposes, is accessible to the CDEM EOC.

The local networks are moderately vulnerable to severe seismic shaking and storm damage at the repeater sites or to the building housing the EOC.

Wairoa District Council does not maintain a local CDEM radiotelephone network.

- 1 regionally operated VHF CDEM radiotelephone network is accessible.

Telemetry Data Networks

Some of the networks and equipment identified above are capable of transferring data from remote sites to centralised monitoring control centres.

Telemetry room at the Hawke's Bay Regional Council October 2001.

Conclusion

Local government civil defence emergency management organisations need to regularly review their requirements for radio frequencies and networks and ensure all equipment is monitored for reliance and resilience.

Emergency Services

Communications networks for Hawke's Bay's emergency, medical and health services were assessed for their risk to natural hazards on the following basis:

Network Elements:

NZ Fire Service, St John Ambulance, NZ Police and Hawkes Bay District Health Board.

Emergency Operations Centres (EOC's)

Alternate EOC's

Radio Network: repeater networks

Simplex networks

Results

Emergency Operations Centres (EOC's)

Each agency is able to provide an emergency operations centre.

New Zealand Fire Service

The Fire Service regional EOC is at Napier Fire Station, 18-20 Taradale Road, Napier.

St John Ambulance Central Region (Hawkes Bay)

The St John Ambulance regional EOC is in Cook Street, Palmerston North

Hawke's Bay District Health Board

The District Health Board regional EOC is in the Education Centre, HB Hospital, Omahu Road.

Buildings accommodating EOC's and their lifeline services have some level of risk from seismic impact.

All other natural hazards pose a moderate level of risk, which is greatest from flooding and tsunami inundation, depending upon each individual site.

Seismic Activity

The findings are the same as for local government and CDEM EOC's.

Mitigation actions

Mitigation measures are the same as for local government and CDEM EOC's.

Energy

Electricity is used to power the facilities and equipment at most EOC's with back-up in times of failure from dedicated generators on each site. This places a secondary reliance on the availability of diesel deliveries during prolonged power disruptions.

The Napier Fire Station also uses reticulated gas for domestic activities.

Telecommunications

Each organisation relies heavily on telecommunications equipment for telephone, fax, data transfer, email and Internet connections.

The Napier Fire Station is a fall-back site for a 111 system and has a restoration category of 5.

Each agency identifies radiotelephone as their secondary means of communication, and regional CDEM radiotelephone network equipment is installed at the Napier Fire Station and Hawke's Bay Hospital.

Water and Sewage Reticulation

None of the buildings identified above have enough dedicated drinking water storage for the number of staff who would be at an EOC during a prolonged emergency. This makes them reliant on the availability of tankers to deliver drinking water, and facilities to store it.

Once again, none of the buildings identified as EOC's have facilities to retain or store wastewater or sewage.

Roading and Transportation

Each agency is heavily dependent on the roading network to deliver goods and services to affected areas. Disruption to these networks will affect those deliveries and the ability of staff ability to commute to and from the EOC.

Alternate Emergency Operations Centres (AEOC's)

Each agency has an alternate site for its EOC.

New Zealand Fire Service

The AEOC is at the Hastings Fire Station mobile command unit.

St John Ambulance Central Region (Hawke's Bay)

The AEOC is Napier Fire Station, 18-20 Taradale Road, Napier.

Hawke's Bay District Health Board

The AEOC will be at the best alternate facility available at the regional hospital in Hastings.

Seismic Activity

This hazard presents the highest level of impact risk even at alternate EOC sites. A similar range of issues remains in relation to other hazards and the interdependencies with other engineering lifelines as discussed earlier in the chapter.

Communications Networks

The emergency agencies in Hawke's Bay use a number of independent radiotelephone networks.

Radio Networks

Agency Repeater Voice Networks

The radio networks detailed below are primarily used to transmit voice messages:

New Zealand Fire Service shares 2 VHF radiotelephone networks and maintains access to others

- 1 shared fire/police duplex VHF linked repeater network operated by the police;
- 1 simplex fire VHF radiotelephone network operated by the fire service;
- 1 x multi services/agencies radio telephone network operated by several providers;
- 1 x rural fire radiotelephone network operated by Bay Forests;
- 1 x duplex VHF CDEM regional radio- telephone network operated by Hawke's Bay Regional Council and providing links to local government and other agencies;

St John Ambulance Central Region (Hawke's Bay) operates 2 radiotelephone networks and accesses one other:

- 1 duplex VHF linked repeater network operated by Telecom in the ES Band;
- 1 simplex VHF radiotelephone network operated by Telecom in the ES Band;
- 1 x duplex VHF CDEM regional radio telephone network operated by Hawke's Bay Regional Council and providing links to local government and other agencies.

Hawke's Bay District Health Board makes use of 1 radiotelephone network

- 1 x duplex VHF CDEM regional radio telephone network operated by Hawke's Bay Regional Council and providing links to local government and other agencies.

Telemetry Data Networks

Some of the networks and equipment identified above are capable of sending data from remote sites to centralised monitoring control centres.

Conclusion

These agencies need to regularly review and test their business continuity plans and the co-ordinated use of the back-up radio during a large emergency.

Bay Forests Rural Fire District Network

There are 4 forest industry-owned VHF repeaters at Te Heroutureia, Waikato, Kurpipapango and Poutaki. Only forest company staff, contractors and service people and the staff of the Department of Conservation can use them.

These repeaters were sited to service the forest industry, while also providing reasonable coverage of the wider Hawke's Bay region. However, the Telecom owned repeaters at Tarapanui, Te Waka and Kahuranaki service many more users and are a much higher priority than the forest industry repeaters.

Power Source

The repeaters are operated by battery with solar power support.

Access

The Mohaka and Esk sites can be reached by four-wheel drive vehicle but access is not reliable. The Esk site, for example, requires track maintenance on private land.

Local helicopters provide an alternative but even this form of site access can be delayed for over a week, if weather conditions are unfavourable.

Regional Significance

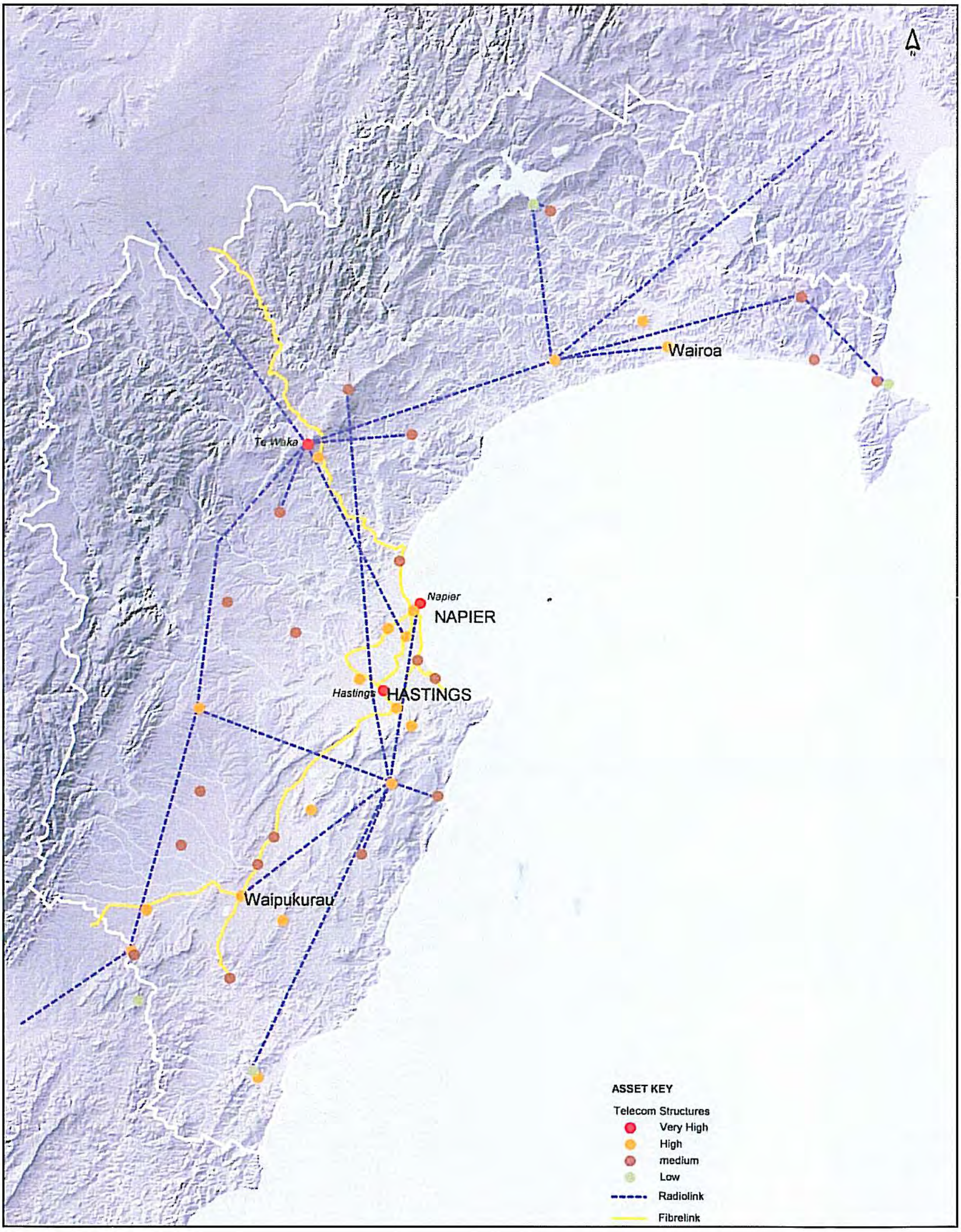
The regional significance of these repeaters is low. The key advantage of the network is that it provides the best radiotelephone coverage for the backblocks of Hawke's Bay. The network can be used to complement other networks such as the Hastings civil defence network and the Napier Fire Service, in an emergency.

Vulnerability

Clouds of volcanic ash pose the greatest hazard to the network.

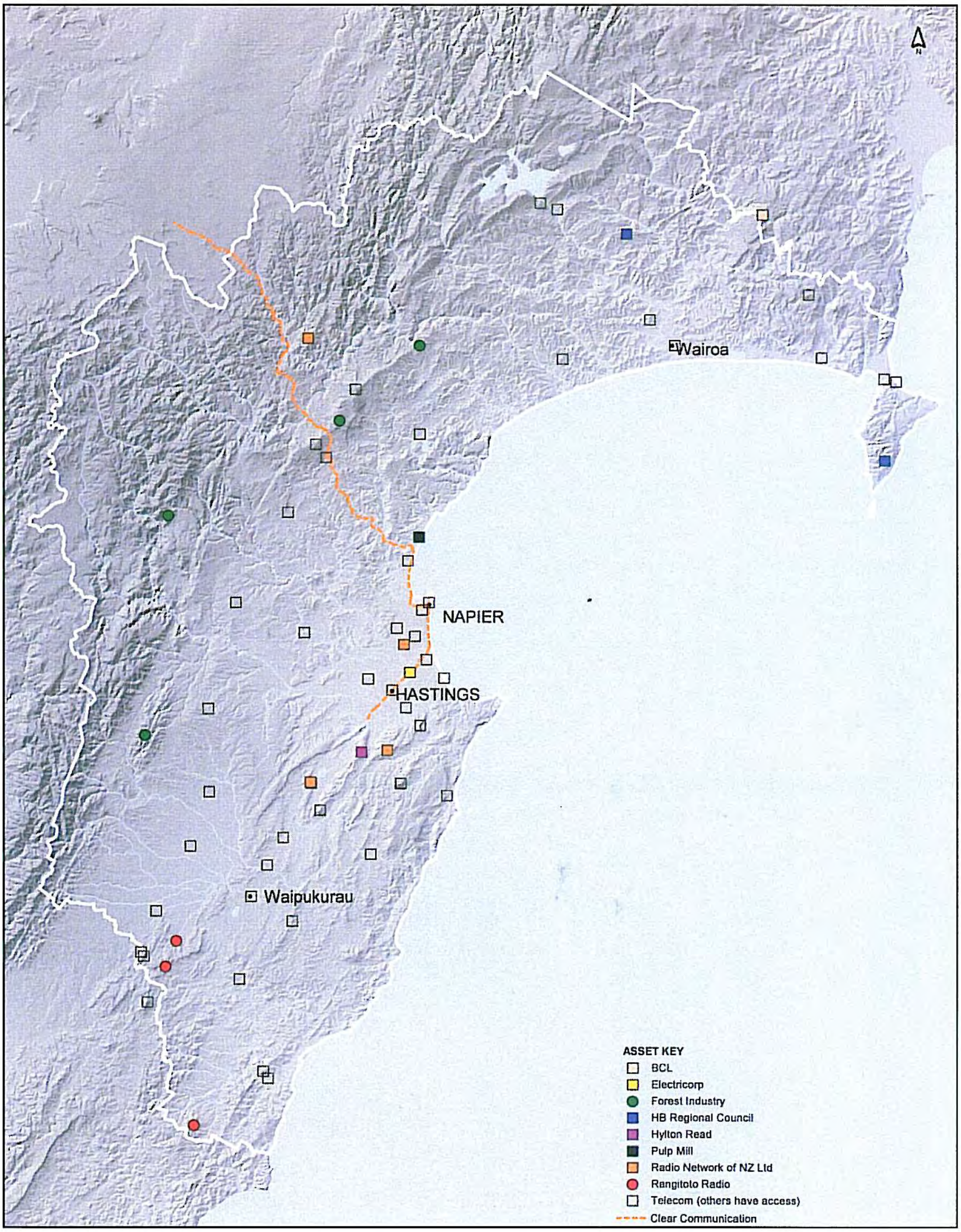
Map 22

Communication
Telecom Network



Map 23

Communication
User Network



Chapter 12
Communications

Introduction

The Communications Group was made up of representatives from the telephone companies, broadcast radio, radio network operators, local government and emergency services that use radio networks.

The organisations represented were:

Telecom

Clear Communications

Vodafone

The Radio Network

Rangitoto Radio

Napier City Council

Hawke's Bay Regional Council

Hastings District Council

Bay Forests Rural Fire District

New Zealand Fire Service

Group membership was wide to ensure that emergency management people became familiar with the risk assessment phase of this project. This will be useful in Stage 2 of the project, when emergency plans are developed.

Many of the group's risk assessments were made on the basis of judgement and experience. It may well be important therefore, to carry out an in-depth and professional assessment for those elements identified as having greatest risk.

Telecommunication Companies

Telecom New Zealand Limited

Risk assessments for natural hazards were carried out for the Telecom network on the following basis:

Network Elements:

- switching sites
- radio sites
- strategic cell sites
- telepaging transmitter sites
- important fibre cable sections

Takapau Microwave Tower against a beautiful Hawke's Bay sky. (Photo courtesy Ian Greaves Telecom)

It is important to remember that the Telecom network is complex and there are daily changes to its configuration, to achieve the overall goal of total network availability and reliability.

Results

Switching Sites (Telephone Exchanges)

A total of 18 sites were identified where public switched telephone network (PSTN) equipment is installed. In many instances this switching equipment is co-located with fibre terminal or other transmission equipment. All the sites have modern generation-stored programme control exchange equipment, which has been installed to seismic specifications within the last 15 years. Seismic restraints are also being used to protect ancillary equipment housed at exchanges, such as office furniture, ladders and test equipment.

Volcanic ash could affect the operation of the PSTN by getting into the cooling mechanism. The exchange equipment relies on air conditioning to keep temperatures at acceptable levels. If volcanic ashfall blocked the filters, impeding airflow through the heat exchangers, temperatures could rise to the point where the equipment permanently equipment failed. To prevent this, equipment may have to be shut down so it can cool off before damage occurs. This would result in some service outages.

During a spell of recent volcanic activity, extra filters were kept on-hand to replace any affected by ashfall. Fresh air intake fans were disabled to stop ash getting into equipment rooms and the air-conditioning was set to re-circulation.

The PSTN invariably becomes overloaded with traffic after a significant event - studies overseas indicate a 20-fold increase in telephone traffic volumes. A Network Control Centre in Hamilton is responsible for managing traffic congestion and minimising the impact of local overloads, through a variety of switched network control commands. These procedures are designed to prevent a gridlock.

Important Fibre Cable Sections:

One of the more important fibre cables, which is shared with another carrier, is vulnerable to natural hazards because it is attached to the Mohaka Bridge on SH5 between Napier and Taupo. Although Telecom is not responsible for maintaining this cable, risk has been mitigated through the use of "ring technology". With this technique, the cable is configured as a ring, with various network elements connected around it. If there is a break in the cable at a particular point, traffic can be routed around the affected portion of the ring. This is also known as a self-healing network and is used in many other parts of the fibre network.

In the area immediately around Napier, liquefaction could affect the ring. Displacement at bridge abutments, including Redclyffe, Chesterhope and Awatoto, as well as liquefaction, could impact on the reliability of the fibre network. However a microwave radio system terminating at Napier Exchange could provide some alternative network capability.

The Hawke's Bay area is equipped with fibre restoration kits for quick temporary repairs to any fibre break. A routine visual inspection of the important sections of fibre cable routes that are known to be vulnerable, is likely to be implemented. This will include checking bridge abutments and attachments and areas of unstable ground.

Radio Sites (Including Cell and Telepager)

Most radio sites have been purpose built for the equipment they house and have had extensive seismic bracing work carried out in the last 10 – 15 years. Wind loading on the towers tends to be conservative. (usually greater than 200kph). Ice formation is the only natural event that has caused damage at these sites in the past. Some sites are more prone to this hazard than others, probably because of a combination of altitude and latitude. A typical scenario is for lumps of ice to break off the upper regions of the structure and damage other parts on its way down. As a mitigation measure, ice shields have been attached above vulnerable antenna at affected sites. The other problem results from wind, sleet and snow combining to form "flag ice" where large horizontal, flags of ice form on parts of the antennas, creating torsion (twisting) forces which can either bend or break the section to which they are attached. To prevent this problem, Telecom installs antenna types that are less susceptible to damage from flag ice.

Photo taken on the North side of Takapau Microwave Radio Station after an earthquake event which occurred during the mid 1980's. There is evidence of backfill settlement around the foundations of the building and tower footings. (Photo courtesy Ian Greaves Telecom)

Radiated radio frequency power levels are relatively low so the effects of ash falling directly on antennas are minimal. Other site plant considerations regarding

A rigger is clearing ice away from a corner reflector antenna on the Te Waka Microwave tower. The lower antenna has already been cleared of ice and should now be performing normally. The fromation of "Flag Ice" on this structure is not uncommon.
(Photo courtesy Ian Greaves Telecom)

volcanic ash are similar to those for switch sites, although access is usually more difficult. Remote management of these sites is achieved using PLC technology. This means equipment like fresh air fans can be remotely turned off and room temperatures monitored from a centralised control centre.

As with the PSTN, the cellular network is likely to be overloaded after an event such as an earthquake. Organisations incorporating cellphones into their emergency response plans need to understand the limitations of the cellular network.

Interdependencies

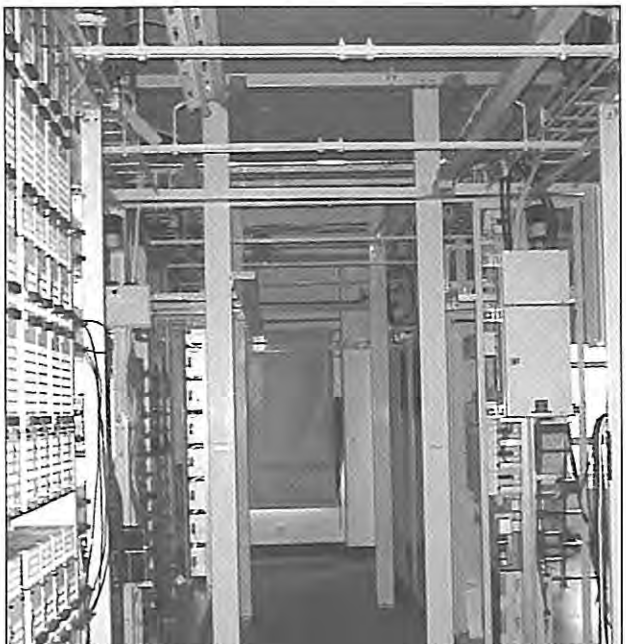
The Hawke's Bay Engineering Lifelines Project has shown that disaster recovery in the region will be heavily dependent on the communications network being operational. This includes the PSTN, cellular network, paging, data, and other dispatch systems such as Fleetlink and VHF landmobile. There is likely to be considerable pressure to have the telecommunication network functioning before other utilities can begin restoration activities.

Impact on Neighbouring Regions

Natural hazard events in Hawke's Bay may well impact on other regions, especially northern Hawke's Bay (Wairoa) and Poverty Bay. The network north of Hawke's Bay is very dependent on some key sites within Hawke's Bay to maintain service. From Te Waka (on SH5) north, the network consists of a spur, fed from Hawke's Bay. There is no ring configuration or any connection to the Bay of Plenty for an alternate route from this spur.

Conclusion

Telecom continually assesses the vulnerability of its network as a part of normal business practise and has a Business Continuance Group set up for this purpose. Some customer-owned networks and equipment are not be able to continue operating even after something as straightforward as a power outage. This needs to be taken into account when developing plans to cope with a natural or man-made event that has disrupted normal services. This is a public awareness and education issue to which Telecom is responding, where possible, by offering advice and options to mitigate risk.



Steel Columns have been installed in the aisles between equipment as part of the additional seismic bracing. (Photo courtesy Ian Greaves Telecom)

CLEAR Communications

CLEAR Communications operates cable and radio local access systems within Hawke's Bay. CLEAR has a major network node in Napier to manage circuits and calls from its own network and those from other, interconnecting networks. Connection to the rest of CLEAR's New Zealand network is through fibre optic cables from Auckland through Taupo to Napier and south through Hawke's Bay and Wairarapa to Wellington. From Pakipaki to southern Hawke's Bay it shares the same sheath with Telecom. Telecom is responsible for the maintenance of that section of cable. On the Napier-Taupo Road, CLEAR has another node where its network interfaces with Broadcasting Communications Limited's (BCL) microwave systems connecting to the East Coast. CLEAR manages and monitors services from a duplicated Network Management Centre in Auckland, manned 24 hours a day, 7 days a week.

Risk Assessment.

A second fibre optic cable on the west coast of the North Island duplicates the CLEAR national network. In the event of a cable break, affected circuits are automatically switched to the other route.

CLEAR circuits from Napier can be routed north or south, with automatic switching if the cable breaks. The CLEAR equipment node at Napier is not duplicated so any damage there will isolate CLEAR lines in Hawke's Bay from the rest of New Zealand.

CLEAR circuits to the East Coast are on an unduplicated microwave spur to Gisborne, with bandwidth leased from BCL.

Repairs to fibre cables take 6 to 12 hours, provided there is unrestricted access to the damaged cable. A large contracting company with national resources carries out repairs.

The assessment of risk and impact of damage takes the following issues into account:

- Fibre but not equipment diversity;
- Whether a few or many cable breaks are expected for each hazard;
- Whether there is likely to be easy access for repair crews.

Cables are buried in the rail or road reserves, and are waterproof. This minimises the risk of damage from most hazards. The most likely risk of damage is by shearing due to:

- Movement of fault lines;
- Ground movement at bridge abutments, or scouring by floods;
- Bridge failures due to floods and earthquakes.

Cables are looped in joint chambers, to provide slack to mitigate against shearing.

Equipment between Napier and Taupo is housed in a modern, single-storey and robust concrete block structure, located on a valley floor away from hillsides. The equipment is seismically braced. There is more than 12 hours of battery reserve power available, with an auto-start emergency diesel generator on site. Problems may arise if access difficulties delay the delivery of fuel.

The Napier equipment is housed in a seismically sound building and the equipment is seismically braced. About 8 hours of battery reserve power is available, with a socket to plug in a portable emergency generator, held by a Napier-based contractor.

Mitigation Measures.

While it is not practical to eliminate all risks, CLEAR will continue with the following mitigation measures.

- Regular civil engineering inspections and reports for all network nodes, covering accommodation and seismic bracing of plant and equipment;
- Regular load testing and reports for standby generators;
- Regular inspections and reports for batteries and fuel stocks;
- Regular checks and reports on local stocks of spares, including fibre repair kits and air filters;
- Continuing provision of permanent diesel generators at larger and more remote nodes, as part of CLEAR's business plan.

Vodafone New Zealand Limited

Network Structure

The Vodafone network comprises approximately 600 cell sites, linked in geographical clusters to 17 base station controllers (BSCs) which, in turn, feed into the nearest geographical switches in Auckland, Wellington and Christchurch.

The significant facilities close to Hawke's Bay are two BSCs, in Hastings and Palmerston North, and a switch in Wellington.

Connections between cell sites, BSCs and switches are made via Vodafone microwave links, Clear microwave links or landline spans, Telecom microwave links or landline span, and BCL microwave links. All these methods are used in Hawke's Bay.

Connection to and from landlines, Telecom 025 and international lines is achieved via other telecommunication operators.

All of Vodafone's major cell sites have route and carrier diversity, along with diesel generation systems. Cell sites are designed for extreme conditions and have battery backup that can maintain services for between 2 and 12 hours, and connections for external generators. Vodafone holds a number of generators designated for regional use for this purpose.

The nature of cellular technology means overlapping coverage between cells is common. The loss of a cell site will impact on coverage and could temporarily reduce the capacity to carry calls. However some sites and services outside the Hawke's Bay area, will be able to provide service into the region during an emergency.

Network Management

Vodafone's main engineering department is based in Auckland, supported by small operational bases in Wellington and Christchurch. The Network Management Centre, which can remotely view and control all sites throughout New Zealand, is in Auckland.

Vodafone employs a number of contractors to service its sites in regions throughout New Zealand.

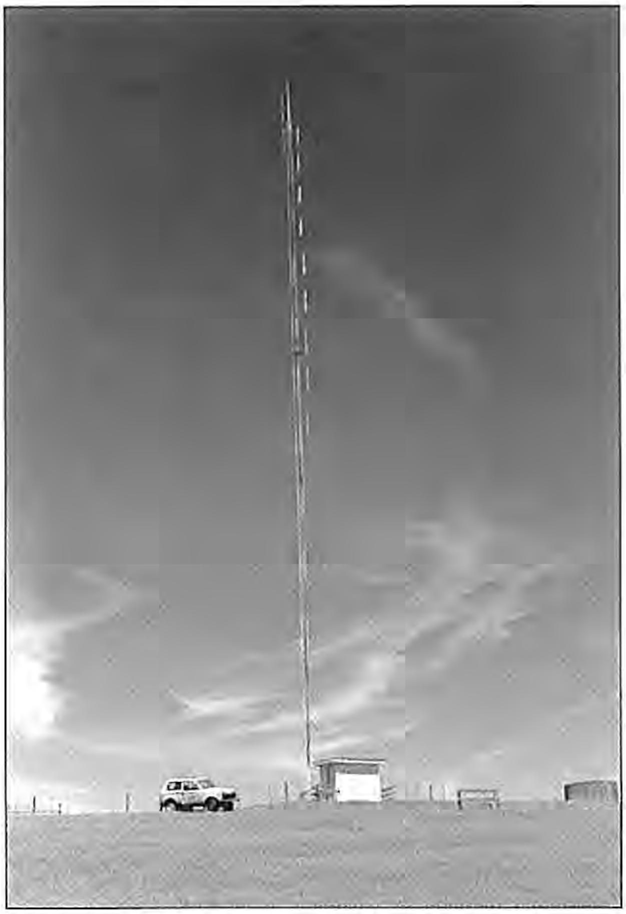
Conclusion

Cell sites are designed to carry traffic on a busy day with a margin for growth. In normal circumstances this provides a full service to customers. However, overseas experience shows that during an emergency, the network could become seriously overloaded, at local levels, within 15 to 30 minutes. Additional capacity can be added to sites, but this would take some time.

Broadcast Radio Napier/Hastings/Wairoa

Purpose

This assessment was to determine the vulnerability of the various studio and transmitter broadcast sites in Hawke's Bay to damage from natural events. The study also examined the effect this damage could have on the operation of the site after the event.



Rangitoto Radio hut and mast at Tourere Hill December 1988 (Photo courtesy Garth Cassidy)

Background

Various radio and television broadcasters deliver programmes in the Hawke's Bay area.

Some of these originate in studios within Hawke's Bay and some from outside the area.

The facilities used to transmit this programming to the Hawke's Bay audience are located within the region, generally close to the most populated areas.

Studio Sites

The Radio Network Limited

The Radio Network Limited broadcasts both network radio programmes (compiled outside Hawke's Bay) and local programmes (compiled in Napier).

These programmes are transmitted on both MF-AM and VHF-FM, from three different transmitter sites in Hawke's Bay

Studios

Location: Corner Dickens and Dalton Streets, Napier

Owner: The Radio Network Limited

Importance: Extremely important

Services Involved: All Radio Network services except Radio Sport

Standby Power: Through an automatic diesel generator

Radio Works Limited

Radioworks broadcasts network radio programmes originating outside Hawke's Bay, and local programmes originating in Hastings.

These programmes are transmitted on VHF-FM from the Mount Erin transmitter site.

Studios

Location: Top Floor, BNZ Building, Hastings

Owner: Radioworks Ltd

Importance: Extremely Important

Services Involved: All Radioworks services

Standby Power: Through an automatic diesel generator

Radio Kidnappers

Radio Kidnappers is an Access Radio station based in Hastings. All Radio Kidnappers programming originates from its studios in Queen Street, Hastings and Dickens Street, Napier.

Radio Kidnappers transmits this on MF-AM from the Radio Network's transmitter site at Pakowhai.

Studios

Location: Queen Street, Hastings and Dickens Street, Napier

Owner: Radio Kidnappers Community Trust

Importance: Extremely Important

Services Involved: All Radio Kidnappers services

Standby Power: Not available

Radio Kahungunu

Radio Kahungunu is the local Iwi broadcaster based in the Maori Studies Faculty at the EIT in Taradale.

Radio Kahungunu broadcasts network radio programmes compiled outside Hawke's Bay, and local programmes originating in Taradale. The programmes are transmitted on MF-AM from Radio New Zealand's transmitter site at Opapa and on VHF-FM from the Threave transmitter site.

Studios

Location: Maori Studies Faculty, EIT, Taradale

Owner: Radio Kahungunu

Importance: Extremely Important

Services Involved: All Radio Kahungunu services

Standby Power: Not available

Channel Fifty-One Limited

Channel Fifty-One Limited broadcasts television programming compiled in its studios in Napier, on UHF Channel 51 from the Threave transmitter site.

Studios

Location: Top Floor, Hawke's Bay Motor Company Building, Dickens Street, Napier

Owner: Channel Fifty-One Limited, Napier

Importance: Extremely Important

Services Involved: All Channel Fifty-One services

Standby Power: Not available

Results of Risk Assessment of Studios in the Napier/Hastings area

Any hazard that affects broadcasting studios will impact on the network or networks involved. Although the major networks have contingency plans allowing them to operate from remote sites, the loss of local broadcasting during and immediately after a natural hazard can have an extreme impact on the public and emergency management.

Earthquakes present the greatest risk to studios. While most are located in relatively modern buildings, or reinforced concrete buildings that survived the 1931 Hawke's Bay earthquake, they are still vulnerable to non-structural damage.

Although measures are taken to ensure that fittings and equipment are fixed in place, this will not cover all equipment and fittings that could be damaged during a major earthquake.

The effect of extreme wind on aerials poses the next greatest risk to broadcasting networks. Although this equipment is normally well designed and constructed, it can be damaged or lost during natural disasters, and this would have an immediate effect on the networks.

Studios and Transmitters of Broadcasters outside Hawke's Bay

Several broadcasters transmit programmes into Hawke's Bay from studios based outside the region.

Radio New Zealand Ltd

Radio New Zealand transmits National Radio on 630khz and the parliamentary network on 900 khz from Opapa and Concert FM on 91.10 mhz, from Mt Erin, out of studios in Wellington.

Radio Rhema

Radio Rhema transmits a programme of the same name on 549 khs from Mahia and Southern Star on 909 khz from Opapa, out of studios in Auckland.

Television New Zealand Ltd

TVNZ transmits TV1 on VHF Channel 6 and TV2 on VHF Channel 8, both from Mt Erin, out of studios in Auckland.

Canwest Limited

Canwest transmits TV3 on VHF Channel 10 from Mt Erin and TV4 on VHF Channel 11 from Threave, out of studios in Auckland.

Prime TV

Prime TV transmits on UHF Channel 61 from Mt Erin into Hawke's Bay out of studios located in Auckland.

Sky TV

Sky TV transmits pay-to-view television programmes on UHF Channels 29, 33, 45, 53 and 57 from Mt Erin out of studios in Auckland.

Sky TV also transmits pay-to-view programming direct to Hawke's Bay homes via its satellite, from studios in Auckland.

Transmitter Sites

There are 6 transmitter sites broadcasting radio and television programming to Hawke's Bay.

Four of these transmit MF-AM and the other three transmit VHF-FM radio and FHV/UHF television.

Two of the VHF sites also house VHF/UHF radio communications and linking equipment used by broadcasters to relay programming from remote locations back to the studio. This equipment also carries programming from the studio to the main transmitter site for broadcast.

Opapa

Location:	SH 2, Te Hauke	
Owner:	Radio New Zealand Ltd,	
Importance:	Extremely Important	
Services Involved:	National Radio:	630 khz
	Radio Kahungunu	765 khz
	Parliamentary N/W	909 khz
	Southern Star N/W	909 khz
Standby Power:	Through an automatic diesel generator	

PakiPaki

Location:	Te Aute Road, Paki Paki	
Owner:	Hylton Read Havelock North	
Importance:	Important	
Services Involved:	Jammin' Oldies	1530 khz
Standby Power:	Not available	

Pakowhai

Location:	Corner Gilligan & Allen Roads, Pakowhai	
Owner:	The Radio Network Ltd	
Importance:	Extremely Important	
Services Involved:	Radio Sport	1125 khz
	Newstalk ZB	1278 khz
	Kidnappers	1431 khz
Standby Power:	Through an automatic diesel generator	

Mahia

Location:	Pongaroa Station Mahia Peninsula Mahia	
Owner:	Radio Rhema Auckland	
Importance:	Important	
Services Included:	Radio Rhema	549 khz
Standby Power:	Not available	

Mt Erin

Location:	Mt Erin Station, Havelock North	
	NZMS V22 392 557	
Owner:	Television New Zealand Ltd	
	Auckland	
Site Manager:	Broadcast Communications Ltd	
	Wellington	
Importance:	Extremely Important	
Services Involved:	Concert FM	91.10 mhz
	Solid Gold	91.90 mhz
	Hot 93	92.70 mhz
	The Rock	95.10 mhz
	ZM	95.90 mhz
	Radio Pacific	97.50 mhz
	The Edge	98.30 mhz
	Radio Car linking/COMMS services, various VHF/UHF frequencies.	
	TV1	VHF CH6
	TV2	VHF CH8
	TV3	VHFCH10
Sky TV	UHF CH 29	
	UHF CH 33	
	UHF CH 45	
	UHF CH 53	
	UHF CH 57	
	Prime TV	UFHCH61
Standby Power:	Through an automatic diesel generator	

Threave

Location	J D Scoular's Property, Poukawa	
Owner:	Hylton Read	
	Havelock North	
Importance:	Extremely Important	
Services Involved:	Classic Hits	89.50 mhz
	Easy I	90.30 mhz
	Radio Kahungunu	94.30 mhz
	Radio Rhema	99.10 mhz
	Hauraki	99.90 mhz
	Radio Kahungunu linking	
	To Opapa	UHF
	TV4 VHF CH11	
	Channel Fifty One	UHFCH51

Standby Power: Yes 2 systems in use:

Classic Hits has its own automatic LPG powered generator.

Other services share an automatic diesel generator.

Results of Risk Assessments of Transmitter Sites in the Napier/Hastings Area

Transmitter sites are vital for the continued operation of broadcast networks.

The earthquake hazard presents the greatest risk to transmitter sites. Tower structures are generally well designed and built to resist seismic loadings. The greater risk is to control apparatus where it is not restrained.

At sites where risk assessments are regularly reviewed, apparatus is restrained. However this is not the case for some less critical sites.

The greatest threat is loss of access roads as a result of a major storm or earthquake.

Towers and control buildings are generally constructed for high wind loadings and are regularly tested in this respect.

In extreme circumstances helicopters could be used to maintain operations or fill diesel generators.

Most transmitter sites are on very exposed peaks. Wildfire would only pose a serious risk if transmitters were located within forests.

Radio Broadcast Central/Southern Hawke's Bay

Purpose

This assessment was to determine the vulnerability of the various studio and transmitter broadcast sites in Hawke's Bay to damage from natural events. The study also examined the effect this damage could have on the operation of the site after the event.

Studio Sites

Central FM Ltd

Central FM Ltd broadcasts radio programming to central and southern Hawke's Bay. All programming is compiled at their studios in Waipukurau.

Central FM transmits on VHF-FM from three different sites.

Studios

Location:	Ruataniwha Street, Waipukurau
Owner:	The Radio Network Ltd
Importance:	Extremely Important
Services Involved:	All Central FM services
Standby Power:	Available from a petrol-powered generator which must be manually connected and started

Transmitter Sites

Central FM transmits from transmitters at 3 separate sites in the Central/Southern Hawke's Bay region.

All of these sites transmit VHF/FM Radio.

The Central FM transmission set-up is unusual. Instead of the radio programme being fed direct from the studio to each transmitter site, it is sent to the first transmitter site; and relayed to the next two sites in turn.

This allows Central FM to have a broadcast signal over a very large geographical area.

The disadvantage of the system is that failure at one site will cause failure in sites further downstream. Consequently failure of a site early in the transmission chain can result in broadcast coverage being lost to very large geographical areas.

Site One: Two Peaks

Location:	Peacock Road, Waipukurau	
Owner:	Central FM Ltd Waipukurau	
Importance:	Extremely Important	
Services Involved	Central FM	93.50 mhz
Standby Power:	Available from a petrol-powered generator which must be manually connected and started	

Site Two: Tourere Hill

Location:	Tourere Road	
Owner:	Rangitoto Radio Waipukurau	
Importance:	Extremely Important	
Services Involved:	Central FM	96.60 mhz
Standby Power:	Through an automatic diesel generator	

Rigger working on Rangitoto Radio mast Tourere Hill December 1988. (Photo courtesy Garth Cassidy)

Site Three: Dannevirke

Location:	Reservoir Knob, off Adelaide Road	
Owner:	Central FM Ltd Waipukurau	
Importance:	Extremely Important	
Services Involved:	Central FM	99.40 mhz
Standby Power:	Not available	

Rangitoto Radio Incorporated

Description

Rangitoto Radio is a Radio User Association with three fixed repeater sites in Central and Southern Hawke's Bay.

Its mobile radio coverage does not extend beyond Hawke's Bay. It is used by local contractors, carriers, farmers, veterinarians, and other people requiring two-way radio service.

The sites are also used by Telecom and other network providers for a range of communications including broadcasting, microwave linking, data, trunking, and switching for power companies.

Mains power is the normal power supply, with each site having limited back-up in the form of a battery or diesel powered generator.

The organisation is run on a commercial basis, so risk assessments are carried out regularly, and mitigation measures put into effect.

Rangitoto Radio's localised network could be of assistance to the Police and Civil Defence in an emergency. A mobile command, four-wheel drive vehicle, installed with Rangitoto channels, is available.

Rangitoto radio site, Transpower Hut and Discs Tourere Hill (Photo courtesy Garth Cassidy)

Results of Risk Assessments of Studio and Transmission Sites in Central/Southern Hawke's Bay

The importance of broadcast facilities, especially straight after a disaster, cannot be overstated.

The results of risk assessments for Central/Southern Hawke's Bay are the same as those for the Napier/Hastings area. These are summarised below:

- Structural or non-structural damage from earthquakes presents the greatest risk to studios and transmission sites. At transmission sites, control apparatus that is not restrained is most at risk from seismic activity;
- Loss of access roads is the next greatest risk, following a major storm or earthquake event;
- Aerials, towers and control buildings are generally well designed for high wind loadings particularly at the exposed sites;
- In extreme circumstances helicopter access by helicopter could be needed to maintain operations;
- Wildfire does not pose a serious risk.

Local Government Essential Services

Risk assessments for the communications networks for local government services were carried out on the following basis:

Network Elements: Central Hawke's Bay District, Hastings District, Napier City, Wairoa District and Hawke's Bay Regional Councils.

Emergency Operations Centres (EOC's)

Alternate EOC's

Radio Network:

Council Operations Repeater Networks

Council Telemetry Networks

Local government organisations use a wide range of systems to meet their communications needs.

Results

Local Government Emergency Operations Centres (EOC's)

Each local government is able to provide an emergency operations centre (EOC) for continuing essential services during emergencies. There are generally two locations: at a dedicated works and services depot and in the civic buildings. The centre at the civic building will also usually provide facilities for civil defence emergency management should an event develop into a declared emergency.

Buildings accommodating EOC's and their lifeline services have some level of risk from seismic impact.

All other natural hazards pose a moderate level of risk, with flooding and tsunami inundation ranked the highest, depending on the individual site.

Seismic Activity

Local government buildings in Hawke's Bay vary in age. The initial construction and subsequent alterations or extensions meet the building codes current at the time the work was undertaken. In some buildings that accommodate an EOC, new work or renovations meet the highest structural design category for buildings where loss of function would have a severe impact on society.

Some of the buildings have been checked against the building loadings code to assess their suitability for use as an EOC.

Mitigation Actions

The contents of buildings pose a considerable risk to occupants during seismic events and, as a result, some councils have adopted hazard reduction strategies. These include securing tall furniture, mobile and desktop equipment and the contents of shelves, keeping passageways clear and replacing heavy plaster ceiling tiles.

All EOC's have interdependencies with other engineering lifeline networks.

Energy

Electricity is used in most EOC's to power the facilities and operational equipment. When power fails, this can usually be supplemented by dedicated generators on each site. However this back-up is dependent on the availability of diesel deliveries during prolonged power disruptions.

Telecommunications

Each organisation relies heavily on telecommunications equipment for telephone, fax, data transfer and email and Internet connections for both internal and external communications.

Radiotelephone is the alternative means of communication for all councils, despite its limitations.

Water and Sewage Reticulation

Only a small number of the EOC buildings can store enough drinking water for the numbers of staff who may be working there during a prolonged emergency. This makes them reliant on the availability of drinking water delivery tankers and storage facilities, if the water reticulation network is disrupted.

None of the buildings identified as EOC's have facilities for retaining or storing wastewater or sewage.

Roading and Transportation:

Disruption of these networks will affect the ability of staff to commute to and from the EOC and to co-ordinate the delivery of goods and services to affected areas.

Alternate Emergency Operations Centres

The designated works or services depots and civic buildings are critical sites and it is expected that one of the two buildings will be usable as an EOC in an emergency.

Where councils have split the EOC responsible for continuing essential services from the EOC handling civil defence emergency management, the 2 are likely to co-locate on the same site.

Seismic Activity

This hazard poses the highest risk even at alternate EOC sites.

Local Government Communications Networks

A diverse range of communication systems is used in the day-to-day operation of local government in Hawke's Bay. These include telephone, cellular telephone, fax, e-mail and radio.

To meet the needs of these organisations a number of independent radiotelephone networks are also used. They are structured as follows:

Radio Networks

Council Operations Repeater Voice Networks

The radio networks detailed below are primarily used for the transmission of voice messages.

The Central Hawke's Bay District Council operates its own repeater network, using radio frequencies and repeaters in its district that are dedicated for use in a civil defence emergency.

The Hawke's Bay Regional Council leases an operational and administrative radio network from Fleetlink. This provides access to a number of linked repeater sites throughout the region.

The Napier City Council leases a dedicated radio frequency and repeater network from Telecom Mobile. This is located within the Napier District.

The Wairoa District Council has access to a radio network operated by Quality Roading and Services.

Regional Civil Defence Voice Repeater Network

The radio networks detailed below are primarily used for the transmission of voice messages.

Most councils in Hawke's Bay are responsible for civil defence emergency management and rural fire activities within their districts and are generally able to call on additional communications resources (refer to the civil defence emergency management section in this chapter).

The Hawke's Bay Regional Council leases a dedicated repeater frequency, which links to radio equipment located at each council within the region. This network provides a valuable communications link for local government when telecommunications systems fail or are overloaded. Some councils can also assess radio equipment and frequencies linking to Gisborne and other centres throughout New Zealand.

Telemetry Data Networks

All councils also use radio networks to transmit data from remote sites to centralised monitoring control centres such as pumping stations or weather monitoring stations.

Conclusion

Local government organisations regularly review their need for radio frequencies and networks. Whether the equipment is owned and operated by the organisation or managed by a contractor, all of it also needs to be continually monitored for reliance and resilience.

Civil Defence Emergency Management

Assessment of vulnerability to natural hazards was carried out for the various elements that make up the communications networks of local government civil defence emergency management (CDEM) in Hawke's Bay, on the following basis:

Network Elements:

Central Hawke's Bay District,Hastings District, Napier City, Wairoa District and Hawke's Bay Regional Council.

Emergency Operations Centres (EOC's)

Alternate EOC's

Radio Network: CDEM repeater networks

CDEM Simplex networks

Rural Fire radio networks

Local government organisations use a range of options to meet their CDEM communications needs.

Results

Local Government Emergency Operations Centres (EOC's)

Each local government is able to provide an emergency operations centre (EOC) for civil defence emergency management. Generally these are located in, or adjacent to, the council's civic buildings. Each council has also identified alternative sites for their CDEM EOC.

Central Hawke's Bay District Council

The CDEM EOC is in the civic building on Ruataniwha Street, Waipawa.

The alternate EOC (AEOC) is in the St. Mary's Church Hall, St. Mary's Road, Waipukurau.

Hastings District Council

The CDEM EOC is in the extensively renovated and strengthened Emergency Management Building at 311 Lyndon Road East, Hastings.

The AEOC is the Hastings District Council Engineering Division building, 100 Warren Street South, Hastings.

Hawke's Bay Regional Council

The CDEM EOC is the council's offices at 102 Vautier Street, Napier.

The AEOC is in the Hawke's Bay Regional Council Works Offices, Guppy Road, Taradale, Napier.

Napier City Council

The CDEM EOC is in the civic building at 231 Hastings Street, Napier.

The AEOC is in the council's depot, Austin Street, Napier, or co-located with other emergency services at Napier Fire Station.

Wairoa District Council

The CDEM EOC is in the council offices, Queen Street, Wairoa.

The AEOC is at the Wairoa Hospital, Kitchener Street, Wairoa.

The buildings accommodating CDEM EOC's and AEOC's and their lifeline services, are all at some risk from seismic impact.

Radio equipment at the Regional Emergency Operations Centre-Hawke's Bay Regional Council.

All other natural hazards pose a moderate level of risk, with flooding and tsunami inundation generally having the highest ranking.

Seismic Activity

The findings are the same as for local government EOC's.

Mitigation Actions

Mitigation measures are the same as for local government EOC's and include the need to secure the contents of buildings, keep passageways clear and replace heavy plaster ceiling tiles.

Energy

Energy issues are the same as for local government EOC's with back-up generators reliant on the availability of diesel deliveries.

Telecommunications

Once again the issues are the same as for local government EOC's.

All councils use radiotelephone as their secondary means of communication.

Water and Sewage Reticulation

Only a small number of the buildings identified have drinking water stored on site and, with the exception of the Napier City Council CDEM EOC, none have enough for the number of staff who would be working at the EOC during a prolonged emergency. Napier City Council has 15,000 litres of water in the top floor of its library building. This means the EOCs would have to rely on the availability of drinking water delivery tankers and storage facilities if the reticulation network was disrupted for a long time.

None of the buildings identified as CDEM EOC's can retain or store wastewater or sewage.

Roading and Transportation

As with local government EOC's, disruption to these networks will affect staff getting to and from the EOC and the delivery of goods and services to affected areas.

CDEM Communications Networks

A number of independent radio networks are used by local government organisations, in addition to the day-to-day communication systems. The civil defence emergency management radio networks are structured as follows:

RADIO NETWORKS

Repeater Voice Networks

The radio networks detailed below are primarily used for the transmission of voice messages.

Central Hawke's Bay District Council operates the following:

- 2 VHF repeaters provide 2 duplex CDEM radiotelephone networks;
- 1 repeater site accommodates several repeaters, which are solar powered;
- The equipment operates in the emergency services public safety band;
- 28 civil defence centres and the council's vehicle fleet access the local networks;
- 1 regionally operated VHF CDEM radiotelephone network is accessible;
- 1 nationally operated HF SSB CDEM radio network is available.

The local networks are moderately vulnerable to severe seismic shaking and storm damage or loss of solar power generation capability at the repeater sites.

Hastings District Council leases 1 and operates another 6 CDEM radiotelephone networks.

- 2 VHF repeaters provide 2 duplex CDEM/rural fire radiotelephone networks.
- 4 additional frequencies provide 4 simplex CDEM/rural fire radiotelephone networks.
- 1 repeater is at a major communications transmitter site leased from Telecom.
- 1 portable repeater is owned and operated by the emergency management office.
- the equipment operates in the civil defence communications FM band.
- 42 civil defence centres, 3 vehicles and hand-held radios access the local networks.
- 1 regionally operated VHF CDEM radiotelephone network is accessible.
- 1 nationally operated HF SSB CDEM radio network is accessible.
- 1 duplex VHF fleet link network which is leased by the council for administration and operational purposes is accessible by the CDEM/rural fire personnel.
- 1 linked duplex NZ Fire Service operated VHF radio network is accessible.
- 1 ground to air simplex air transportation industry radio system is accessible.

The local networks are moderately vulnerable to loss of service at repeater sites or damage to the 28 metre tall main antenna at the EOC. In some terrain, particularly in remote rural areas, simplex communication is vulnerable to intermittent or complete breakdown.

Hawke's Bay Regional Council leases 1 CDEM radiotelephone network.

- 1 VHF repeater provides 1 duplex CDEM radiotelephone network;
- 1 repeater is at a major communications transmitter site leased from Telecom;
- The equipment operates in the civil defence communications FM band;
- 5 local councils, 2 emergency services and the regional health authority have access and equipment dedicated for operation on this VHF CDEM radiotelephone network;
- 1 nationally operated HF SSB CDEM radio network is accessible;
- 1 duplex VHF fleet link network that is leased by the Council for administration and operational purposes is accessible by the CDEM personnel.

The regional CDEM radiotelephone network is moderately vulnerable to overloading.

Napier City Council operates 5 CDEM radiotelephone networks.

- 2 VHF repeaters provide 2 duplex CDEM radiotelephone networks;
- 3 additional frequencies provide 3 simplex CDEM radiotelephone networks;
- 1 repeater is located on a commercial building, supported by battery back-up;
- 1 repeater is located in a shared repeater site, supported by battery backup;
- The equipment operates in the civil defence communications FM band;
- 10 civil defence centres, 1 vehicle and handheld radios access the local networks;
- 1 regionally operated VHF CDEM radiotelephone network is accessible;
- 1 nationally operated HF SSB CDEM radio network is accessible;
- 1 duplex VHF Telecom Mobile radio network, which is leased by the Council for administration and operational purposes, is accessible to the CDEM EOC.

The local networks are moderately vulnerable to severe seismic shaking and storm damage at the repeater sites or to the building housing the EOC.

Wairoa District Council does not maintain a local CDEM radiotelephone network.

- 1 regionally operated VHF CDEM radiotelephone network is accessible.

Telemetry Data Networks

Some of the networks and equipment identified above are capable of transferring data from remote sites to centralised monitoring control centres.

Telemetry room at the Hawke's Bay Regional Council October 2001.

Conclusion

Local government civil defence emergency management organisations need to regularly review their requirements for radio frequencies and networks and ensure all equipment is monitored for reliance and resilience.

Emergency Services

Communications networks for Hawke's Bay's emergency, medical and health services were assessed for their risk to natural hazards on the following basis:

Network Elements:

NZ Fire Service, St John Ambulance, NZ Police and Hawkes Bay District Health Board.

Emergency Operations Centres (EOC's)

Alternate EOC's

Radio Network: repeater networks

Simplex networks

Results

Emergency Operations Centres (EOC's)

Each agency is able to provide an emergency operations centre.

New Zealand Fire Service

The Fire Service regional EOC is at Napier Fire Station, 18-20 Taradale Road, Napier.

St John Ambulance Central Region (Hawkes Bay)

The St John Ambulance regional EOC is in Cook Street, Palmerston North

Hawke's Bay District Health Board

The District Health Board regional EOC is in the Education Centre, HB Hospital, Omahu Road.

Buildings accommodating EOC's and their lifeline services have some level of risk from seismic impact.

All other natural hazards pose a moderate level of risk, which is greatest from flooding and tsunami inundation, depending upon each individual site.

Seismic Activity

The findings are the same as for local government and CDEM EOC's.

Mitigation actions

Mitigation measures are the same as for local government and CDEM EOC's.

Energy

Electricity is used to power the facilities and equipment at most EOC's with back-up in times of failure from dedicated generators on each site. This places a secondary reliance on the availability of diesel deliveries during prolonged power disruptions.

The Napier Fire Station also uses reticulated gas for domestic activities.

Telecommunications

Each organisation relies heavily on telecommunications equipment for telephone, fax, data transfer, email and Internet connections.

The Napier Fire Station is a fall-back site for a 111 system and has a restoration category of 5.

Each agency identifies radiotelephone as their secondary means of communication, and regional CDEM radiotelephone network equipment is installed at the Napier Fire Station and Hawke's Bay Hospital.

Water and Sewage Reticulation

None of the buildings identified above have enough dedicated drinking water storage for the number of staff who would be at an EOC during a prolonged emergency. This makes them reliant on the availability of tankers to deliver drinking water, and facilities to store it.

Once again, none of the buildings identified as EOC's have facilities to retain or store wastewater or sewage.

Roading and Transportation

Each agency is heavily dependent on the roading network to deliver goods and services to affected areas. Disruption to these networks will affect those deliveries and the ability of staff ability to commute to and from the EOC.

Alternate Emergency Operations Centres (AEOC's)

Each agency has an alternate site for its EOC.

New Zealand Fire Service

The AEOC is at the Hastings Fire Station mobile command unit.

St John Ambulance Central Region (Hawke's Bay)

The AEOC is Napier Fire Station, 18-20 Taradale Road, Napier.

Hawke's Bay District Health Board

The AEOC will be at the best alternate facility available at the regional hospital in Hastings.

Seismic Activity

This hazard presents the highest level of impact risk even at alternate EOC sites. A similar range of issues remains in relation to other hazards and the interdependencies with other engineering lifelines as discussed earlier in the chapter.

Communications Networks

The emergency agencies in Hawke's Bay use a number of independent radiotelephone networks.

Radio Networks

Agency Repeater Voice Networks

The radio networks detailed below are primarily used to transmit voice messages:

New Zealand Fire Service shares 2 VHF radiotelephone networks and maintains access to others

- 1 shared fire/police duplex VHF linked repeater network operated by the police;
- 1 simplex fire VHF radiotelephone network operated by the fire service;
- 1 x multi services/agencies radio telephone network operated by several providers;
- 1 x rural fire radiotelephone network operated by Bay Forests;
- 1 x duplex VHF CDEM regional radio- telephone network operated by Hawke's Bay Regional Council and providing links to local government and other agencies;

St John Ambulance Central Region (Hawke's Bay) operates 2 radiotelephone networks and accesses one other:

- 1 duplex VHF linked repeater network operated by Telecom in the ES Band;
- 1 simplex VHF radiotelephone network operated by Telecom in the ES Band;
- 1 x duplex VHF CDEM regional radio telephone network operated by Hawke's Bay Regional Council and providing links to local government and other agencies.

Hawke's Bay District Health Board makes use of 1 radiotelephone network

- 1 x duplex VHF CDEM regional radio telephone network operated by Hawke's Bay Regional Council and providing links to local government and other agencies.

Telemetry Data Networks

Some of the networks and equipment identified above are capable of sending data from remote sites to centralised monitoring control centres.

Conclusion

These agencies need to regularly review and test their business continuity plans and the co-ordinated use of the back-up radio during a large emergency.

Bay Forests Rural Fire District Network

There are 4 forest industry-owned VHF repeaters at Te Heroutureia, Waikato, Kurpipapango and Poutaki. Only forest company staff, contractors and service people and the staff of the Department of Conservation can use them.

These repeaters were sited to service the forest industry, while also providing reasonable coverage of the wider Hawke's Bay region. However, the Telecom owned repeaters at Tarapanui, Te Waka and Kahuranaki service many more users and are a much higher priority than the forest industry repeaters.

Power Source

The repeaters are operated by battery with solar power support.

Access

The Mohaka and Esk sites can be reached by four-wheel drive vehicle but access is not reliable. The Esk site, for example, requires track maintenance on private land.

Local helicopters provide an alternative but even this form of site access can be delayed for over a week, if weather conditions are unfavourable.

Regional Significance

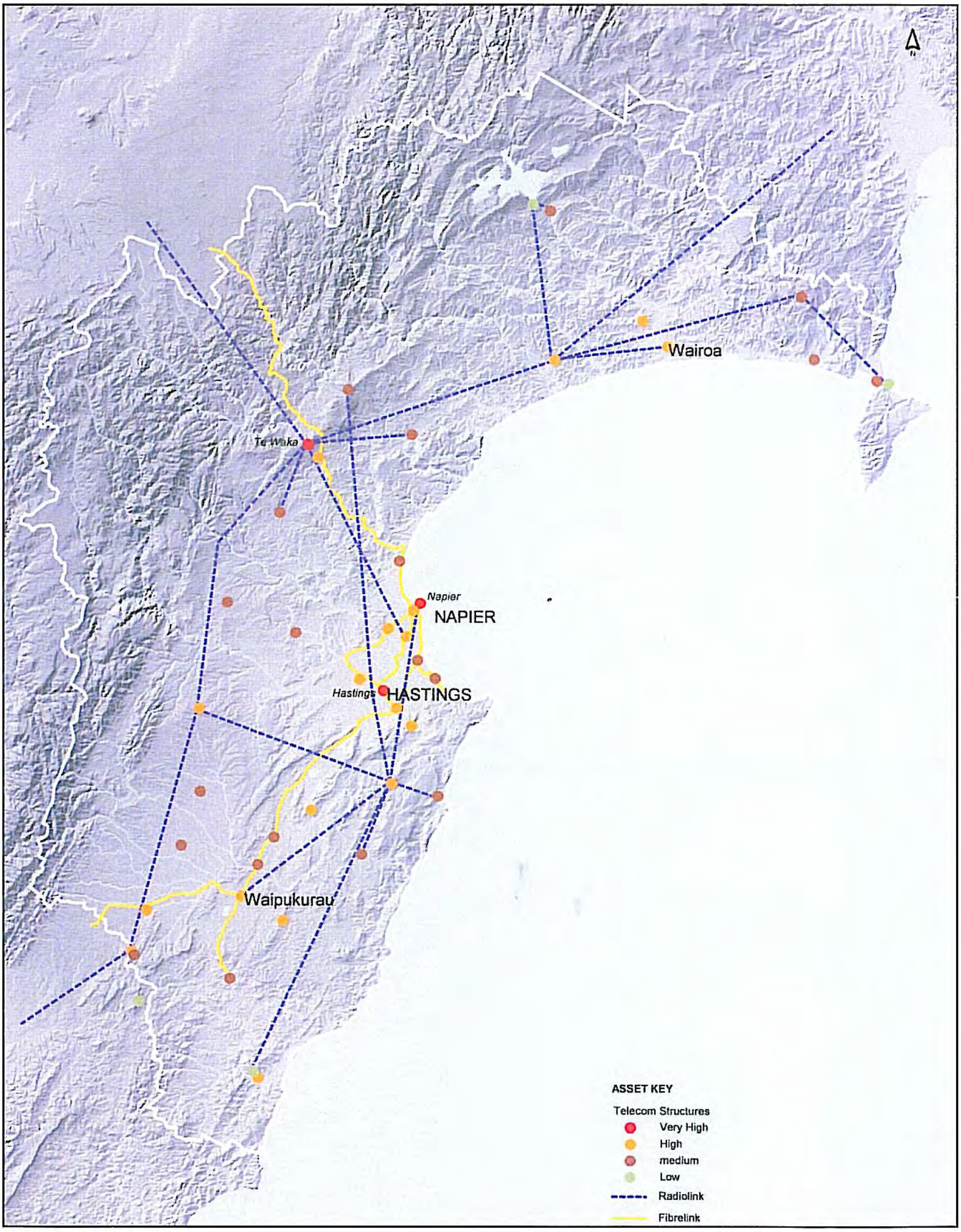
The regional significance of these repeaters is low. The key advantage of the network is that it provides the best radiotelephone coverage for the backblocks of Hawke's Bay. The network can be used to complement other networks such as the Hastings civil defence network and the Napier Fire Service, in an emergency.

Vulnerability

Clouds of volcanic ash pose the greatest hazard to the network.

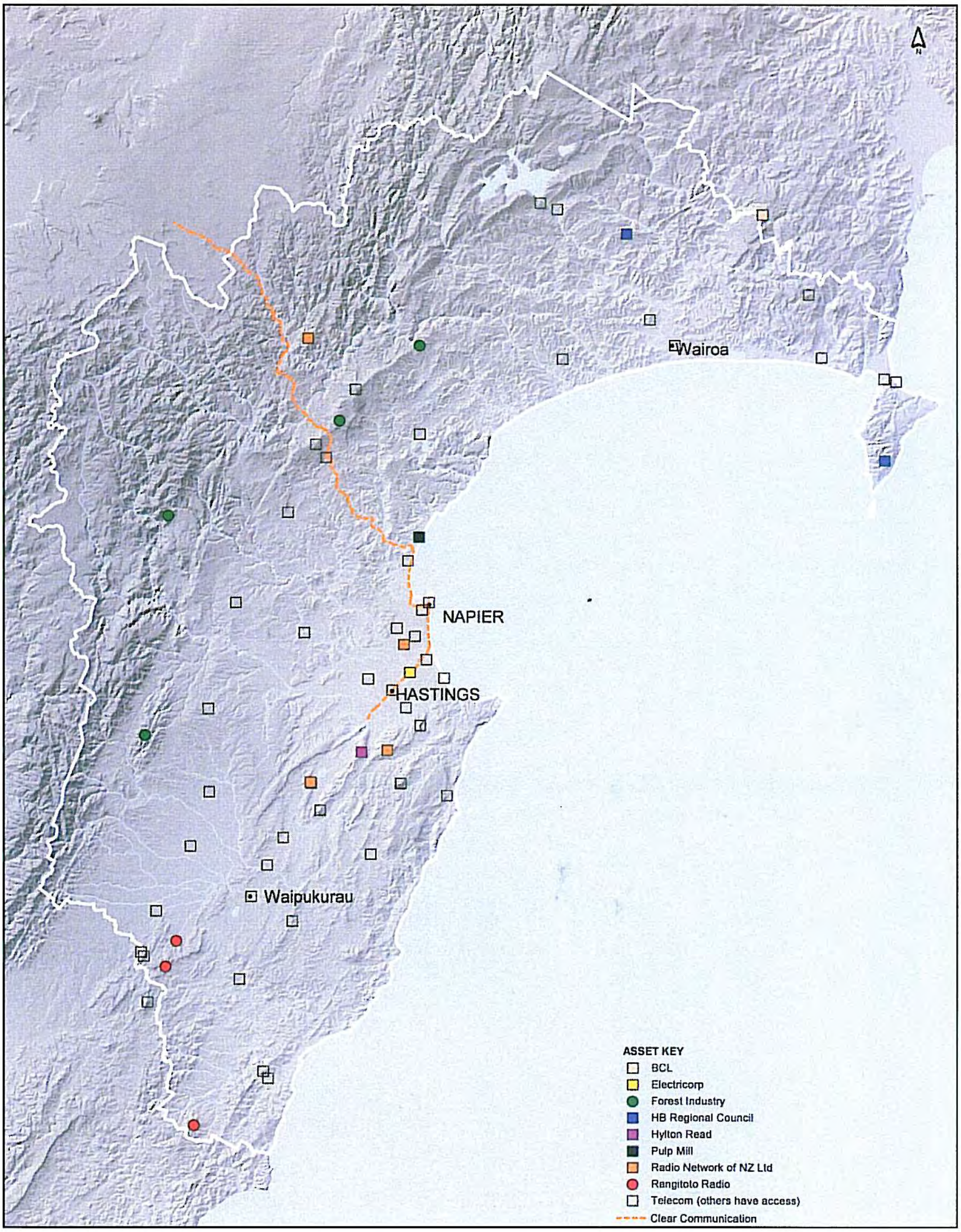
Map 22

Communication
Telecom Network



Map 23

Communication
User Network



Chapter 13
Interdependencies

Interdependencies

This project, like all engineering lifelines projects, has identified the ways in which the various utility networks are dependent on each other. This can be illustrated by a simple example such as a piped network passing over a transport network bridge structure. The piped network relies on the bridge structure remaining stable during hazard events such as earthquakes or floods. Too much movement of the bridge will disrupt the piped network.

For this project, each utility network operator was responsible for assessing the risk to its own network. Where one network used property belonging to another, such as the pipe over the bridge example, those in charge of the pipe network were responsible for checking the likely performance of the bridge during a hazard.

This policy was introduced to ensure utility operators became aware of the risks to all parts of their network.

Any mitigation measures deemed necessary are to be carried out by the network that has identified the need for them. In the case of the pipe over the bridge this could mean removing the risk by relocating the pipe under the river or estuary or minimising the risk by installing flexible joints and fasteners or laying a duplicate pipe on another structure.

Because interdependencies vary between networks and will also vary immediately after an extreme emergency, the project conducted a study on interdependencies at a project workshop held in Hastings in November 2000.

Participants in the exercise joined one of the four project task groups and rated the interdependency of their utility network on other networks during normal operation and during the recovery period after a major natural disaster.

The task groups then shared their findings to improve awareness of the ways in which utility networks rely on each other.

The results of these assessments are summarised on Tables 1 and 2.

Conclusions

The results of the assessment are consistent with those expected for a provincial region that depends on national distribution networks for its power.

For Hawke's Bay, the participants decided that maintaining road transport is essential if other networks are also to be maintained, both in times of normal operation and during recovery from a natural disaster.

Standby and mains electricity were considered the next most essential networks during times of normal operation. The importance given to standby electricity supplies is surprising but may be due to a vigorous discussion that took place just before this part of the workshop on power outages in Hawke's Bay in September 2000. Standby electricity is also very important during recovery from a natural disaster.

The importance of telephone, VHF Radio and broadcast radio services increased dramatically in the recovery period after a major hazard. This is consistent with recorded overloads of telephone and cellular phone systems following events such as the ChiChi Earthquake in Taiwan. During the September 2000 Hawke's Bay power outage, the answer desk of local electricity retailer Hawke's Bay Network, was overloaded despite additional staff being on duty and the telephone network being fully operational.

These conclusions are simlar to those of other engineering lifelines projects.

Westshore Bridge on State Highway 2 is a critical lifeline for many utilities. The expressway northern extension when constructed, will mitigate the roading transportation dependence on this structure.

ASSESSMENTS

INTERDEPENDENCE OF ENGINEERING LIFELINES FOR OPERATION

These utilities are Dependent on These → (↓)	Roading	Railways	Sea Transport	Air Transport	Water Supply	Sanitary Drainage	Storm Drainage	Mains Electricity	Standby Electricity	Gas	Fuel Supply	~~Fuel Supply~~ Telephone Systems	VHF Radio	Broadcasting
Roading		1	1	1	1	2	2	1	1	5	2	2	1	
Railways	5		2	1	3	1	1	5	5	1	5	2	2	1
Sea Transport	5	4		1	3	3	1	5	5	2	5	4	5	1
Air Transport	5	1	1		3	3	5	5	5	1	5	5	5	1
Water Supply	5	1	1	1		5	1	5	4	1	4	5	2	3
Sanitary Drainage	5	1	1	1	5		4	5	4	1	4	5	2	3
Storm Drainage	5	1	1	1	1	1		5	4	1	4	5	2	1
Mains Electricity	5	1	1	2	1	1	3		5	1	5	5	5	2
Standby Electricity														
Gas	3	1	1	2	1	1	2	1	1		5	2	3	1
Fuel Supply	5	2	5	1	2	1	3	5	5	1		3	3	1
~~Fuel Supply~~ Telephone Systems.	5	1	1	1	1	1	3	4	4	1	4		1	1
VHF Radio	2	1	1	1	1	1	1	4	4	1	4	3		1
Broadcasting	2	1	1	1	1	1	1	4	4	1	4	4	1	
Total Assessment of Dependency by other utilities	52	16	17	14	23	20	27	50	51	13	44	45	33	17

Interdependence assessment against each lifeline item on a scale from 1-5 (low-high requirement for operation)

ASSESSMENTS

INTERDEPENDENCE OF ENGINEERING LIFELINES FOR RECOVERY FOLLOWING A DISASTER

These are Dependent ↓ on These →	Roading	Railways	Sea Transport	Air Transport	Water Supply	Sanitary Drainage	Storm Drainage	Mains Electricity	Standby Electricity	Gas	Fuel Supply	~~Fuel Supply~~ Telephone Systems	VHF Radio	Broadcasting
Roading		1	1	1	1	1	3	1	1	1	5	3	3	3
Railways	5		1	1	1	1	1	3	3	3	5	3	3	1
Sea Transport	5	5		1	3	3	1	5	5	2	5	5	5	1
Air Transport	5	1	1		3	3	1	5	5	1	5	5	5	2
Water Supply	5	1	4	4		5	1	5	4	1	4	5	3	4
Sanitary Drainage	5	1	4	4	5		4	5	4	1	4	5	3	4
Storm Drainage	5	1	1	1	1	1		5	4	1	4	5	3	2
Mains Electricity	5	1	1	3	1	1	3		5	1	5	5	5	3
Standby Electricity														
Gas	5	1	1	3	1	1	1	1	1		5	5	5	1
Fuel Supply	5	2	5	2	2	1	1	5	5	1		5	4	2
~~Fuel Supply~~ Telephone Systems.	5	1	1	4	2	1	3	4	5	1	5		4	4
VHF Radio	4	1	1	3	2	1	1	4	5	1	5	4		4
Broadcasting	4	1	1	3	4	4	4	4	5	1	5	4	4	
Total Assessment of Dependency by other utilities	58	17	22	30	26	23	24	47	52	13	57	54	47	31

Interdependence assessment against each lifeline item on a scale from 1-5 (low-high requirement for operation)

Map Data Acknowledgements

1. Regional and Territorial Authority boundaries obtained from Statistics Department.

2. Digital Elevation Models obtained from GeographX New Zealand Ltd. The data are derived from elevation source data originating from Land Information New Zealand Ltd (LINZ).

3. The Liquefaction Susceptibility and Combined Earthquake Hazard Scenario maps were prepared by the Institute of Geological & Nuclear Sciences Limited exclusively for and under contract to Hawke's Bay Regional Council. The information will be used at the users own risk. The Institute of Geological & Nuclear Sciences Limited, while providing the information in good faith, accepts no responsibility for any loss, damage, injury, or loss in value of any person, property, service or otherwise resulting from earthquake hazards or knowledge of earthquake hazards in the Hawke's Bay Region.

   The presence of a hazard zone on these maps does not guarantee the existence of such a hazard, nor does the lack of a hazard on the map preclude the existence of a hazard. Site-specific investigations should be conducted to determine actual soil properties and liquefaction susceptibility.

4. Topographic References obtained from from Land Information New Zealand Ltd (LINZ)