greater WELLINGTON
REGIONAL COUNCIL

Natural hazards - background report

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Contents

1. Introduction

A natural hazard is defined in the Resource Management Act 1991 (RMA) as "any atmospheric or earth or water-related occurrence (including earthquake, tsunami, erosion, volcanic and geothermal activity, landslip, subsidence, sedimentation, wind, drought, fire or flooding) the action of which adversely affects or may adversely affect human life, property or other aspects of the environment". With the exception of geothermal activity, the Wellington region is subject to all these natural hazards.

This document reports on the following Regional Policy Statement (RPS) objective:

> "*Any adverse effects of natural hazards on the environment of the Wellington Region are reduced to an acceptable level*."

The objective recognises that natural events with the potential to cause adverse effects on the environment (including human life and property) will occur in the region. While complete avoidance of natural hazards within the region is not possible, sustainable management involves avoiding or mitigating adverse effects where possible.

Greater Wellington Regional Council (Greater Wellington) uses a Pressure-State-Response (PSR) model to report on the state of the environment. The principle of this model is that a pressure is exerted on the environment, causing a change in the state of the environment, and prompting a response to mitigate any adverse effects. It is difficult to adequately report on natural hazards within the PSR model. This is, in part, because natural hazards are a combination of human behaviours and natural processes, not simply an environmental value whose quality is affected by humans. There is also a lack of national indicators for natural hazards (particularly risk[1] indicators), and quantitative hazard and risk information.

The RMA definition of natural hazards includes events that "adversely affect or *may* adversely affect human life, property or other aspects of the environment". This definition includes the concept of potential – not only events that have occurred but events that may occur in future. Reporting on the state of natural hazards must, therefore, include not only events that have occurred within the reporting time (in this case the last ten years). It must also describe the likelihood and potential effects of natural hazards in the future, i.e. a measure of our risk at present. This is particularly important in conveying a complete picture of the state of natural hazards. The magnitude-frequency relationship for many natural hazards (such as earthquakes and floods), mean that low-probability, large impact events are often not represented within a ten year time frame. In other words, the events of the last ten years may not be representative of the magnitude of hazards facing our region. In this report they are placed in context by giving an overview of the risk facing the region from natural hazards.

Natural hazard pressures may be analogous with the definition of a natural hazard – created when humans choose to live, work and play in areas where extreme natural events may occur and cause damage, injury and/or loss of life. In this report, the discussion of natural hazard pressures focuses on likely future changes in both human behaviour (such as expanding urban and coastal development) and environmental

[1] Risk, for the purposes of this report, is a combination of the likelihood and potential consequences of a natural hazard event occurring.

factors (such as climate change). Future changes in these two elements may change the likelihood and potential consequences of natural hazard events.

Response describes an organised action to reduce pressure and/or improve the state, in other words to avoid or mitigate the adverse effects of natural hazards. This may include:

- modifying the natural event (e.g. building stopbanks to prevent inundation of an area)
- reducing vulnerability to damage (e.g. avoiding areas where extreme natural events are likely to occur, strengthening buildings, etc), and/or
- minimising the consequences when a natural event occurs and impacts on humans (preparedness, and response and recovery plans).

Responses evaluated in this report include those of Greater Wellington, territorial authorities (TAs) and other organisations. This evaluation includes assessments of Regional Policy Statement policies and methods, district plan provisions in the six district plans[2] in the region, and civil defence emergency management activities. Full Regional Policy Statement policies, methods and anticipated environmental results are given in Appendix 1.

The nature of, and response to, each natural hazard is different. For clarity, the state, pressures and responses are considered separately for each natural hazard within the report. A separate section reports on "general" responses, such as civil defence emergency management awareness campaigns and general district plan provisions.

The specific natural hazards considered within this report are:

- earthquakes
- tsunamis
- flooding
- landslides
- coastal erosion
- severe wind
- wildfire
- drought
- volcanic eruption

[2] Wellington City District Plan, Porirua City District Plan, Kapiti Coast District Plan, Hutt City District Plan, Upper Hutt City District Plan, and the draft combined Wairarapa District Plan.

2. Earthquakes

2.1 State

The Wellington region is located within an area of high seismicity near the boundary of the Pacific and Australian tectonic plates. In terms of potential loss (both economic and social) from earthquakes, the Wellington metropolitan area is the most at-risk population centre in New Zealand.

Earthquake hazards include ground shaking, liquefaction, surface fault rupture, landslides and tsunamis. This section covers ground shaking, liquefaction and surface fault rupture. Landslides and tsunamis are covered separately in Sections 3 and 5 respectively.

2.1.1 The last ten years

The epicentres of earthquakes greater than magnitude 2 recorded in the central New Zealand area between 1 July 1995 and 30 June 2005 are shown in Figure 2.1. There is a general pattern of shallow earthquakes (less than 40 km deep) through Hawke's Bay, Manawatu, Wairarapa, Wellington and Marlborough, and deeper earthquakes from Taranaki to Nelson, linked to the subducting Pacific Plate.

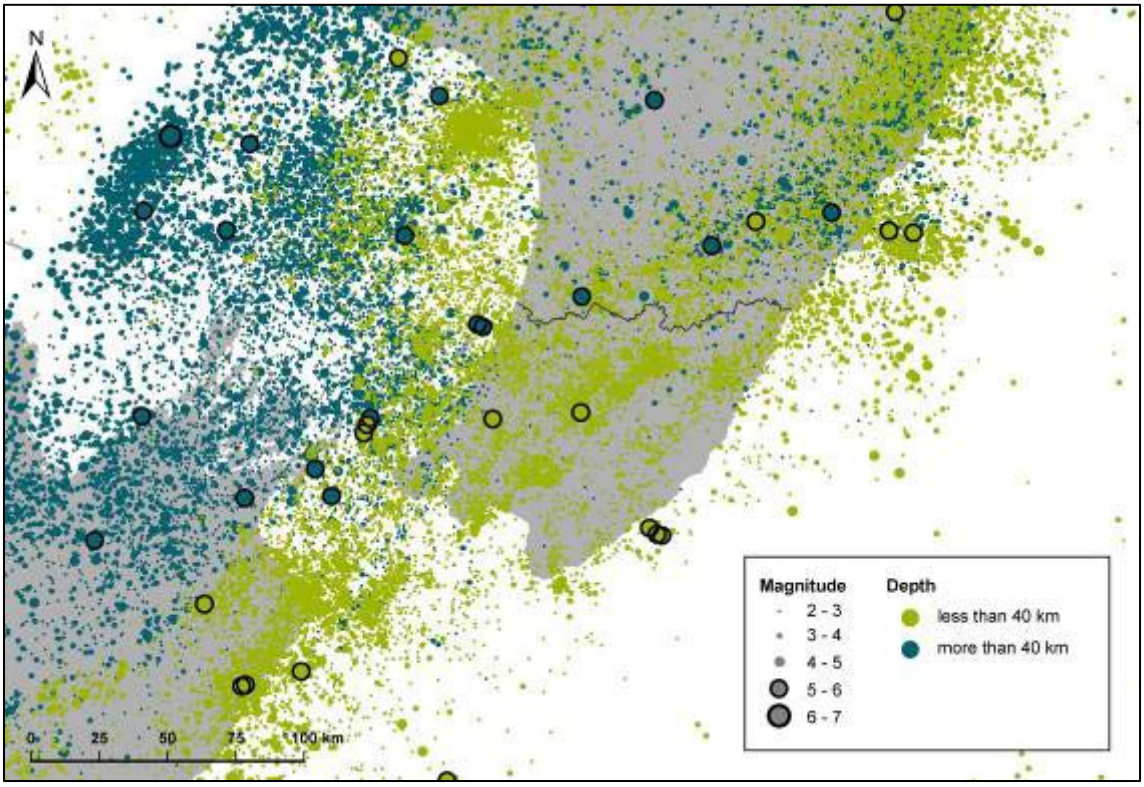

Figure 2.1: Epicentres of earthquakes >M2 between July 1995 and June 2005 (source: GeoNet).

Since 1997, twelve earthquakes have caused significant damage (defined here as prompting more than 30 damage claims to the Earthquake Commission [EQC]) in the region. These twelve earthquakes have together prompted almost 3000 damage claims to EQC, with payouts totalling almost $3 million. Epicentres of these earthquakes are shown in Figure 2.2, and details are given in Table 2.1. The most expensive earthquake was the magnitude 5.5 event near Upper Hutt on 21 January 2005 - EQC claims in the region totalled over $1.3 million.

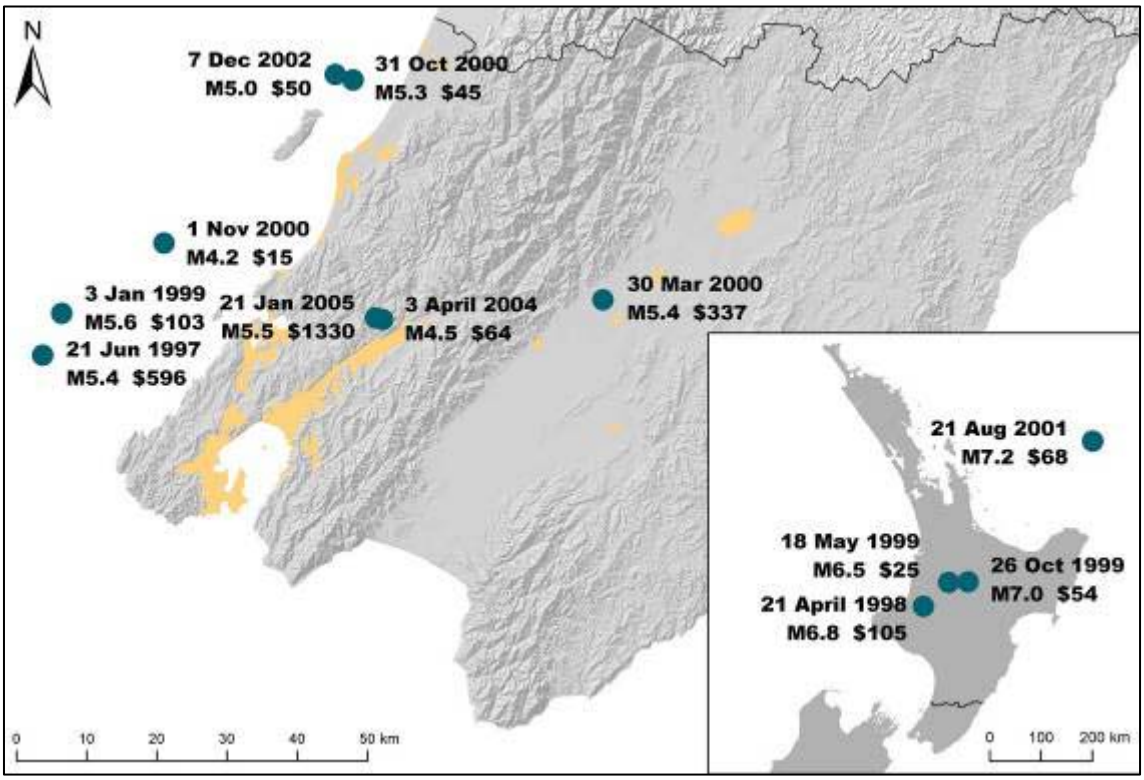

Figure 2.2: Epicentres of earthquakes generating more than 30 EQC claims in the Wellington region between 1997 and 2005, with the date, magnitude and the dollar amount (in 1000s) of EQC claims paid out in the region (source: GeoNet, Earthquake Commission).

Date	Magnitude[1]	Depth (km)	EQC claims[2]	Amount paid out ($)[2]
21 June 1997	5.4	37	712	595,894
21 April 1998	6.8	232	237	105,310
3 January 1999	5.6	58	180	103,348
18 May 1999	6.5	264	42	24,724
26 October 1999	7.0	161	70	53,539
30 March 2000	5.4	31	498	336,777
31 October 2000	5.3	55	56	45,392
1 November 2000	4.2	39	35	15,194
21 August 2001	7.2	33	70	68,133
7 December 2002	5.0	47	39	49,758
3 April 2004	4.5	29	40	63,820
21 January 2005	5.5	32	956	1,330,900
			2935	**2,792,789**

[1] Local magnitude

[2] EQC claims and amounts paid out in the Wellington region (does not include claims from other regions)

Table 2.1: Earthquakes generating more than 30 EQC claims in the Wellington region between 1997 and 2005 (source: GeoNet, Earthquake Commission).

2.1.2 Putting the last ten years into context

Ten years of earthquake data does not give a true indication of the earthquake hazard faced by the Wellington region.

A number of active earthquake sources (faults) in and around the region could produce large, destructive quakes, resulting in hundreds of deaths, thousands of injuries and billions of dollars worth of damage. The basic characteristics of these faults are given in Table 2.2.

Fault	Recurrence interval (yrs)	Time since last event (yrs)	Estimated magnitude[1]
Awatere (South Island)	<1000 - 1300	157	7.5 - 7.8
Wairau (South Island)	1000 - 2300	>800	7.2 - 7.7
Ohariu	1500 - >5000	1060 - 1140	7.6
North Ohariu	1000 - 4000	<4000	7.3 - 7.7
Gibbs	unknown	<10,000	~ 7.0
Shepherds Gully	2500 - 5000	>1000	7.6
Otaki Forks	4000 - 9000	unknown	7.3 - 7.6
Akatarawa	3500 - 9000	<10,000	> 7.0
Wellington	500 - 770	335 - 485	7.6
Wairarapa	1160 - 1880	150	8.0 - 8.3
Carterton	~1000	unknown	7.0
Masterton	~1000	unknown	6.7
Boo Boo (offshore)	500 - 2000?	unknown	7.2 - 7.6
Subduction interface	500 - 5000?	unknown	7.8 - 8.2

[1] Estimated earthquake magnitude able to be generated by that fault.

Table 2.2: Earthquake sources in and near the Wellington region (source: Institute of Geological and Nuclear Sciences).

The fault posing the greatest known hazard to the Wellington region at present is the Wellington Fault, which runs from Wellington's south coast, through Northland and Thorndon, the Hutt Valley and on through the Tararua Range. The Wellington Fault is thought to move, on average, every 500-770 years and last moved between 335 and 485 years ago in an estimated magnitude 7.6 earthquake (Begg and Johnston, 2000).

While the Wairarapa Fault is a large earthquake source (capable of producing magnitude 8.2 earthquakes), the last rupture was 150 years ago in the 1855 Wairarapa earthquake and it is unlikely to rupture again in the near future (i.e. the next few hundred years).

Little is known about past, and potential future, activity on the subduction interface between the Pacific and Australian plates about 25km below Wellington or the recently discovered offshore Boo Boo Fault. These both pose a significant earthquake hazard to the region.

Earthquakes can be described in different ways. "Magnitude" measures the energy released in the earthquake or its "size". This is the number often reported on the news after an earthquake. "Intensity" is the amount of ground shaking and damage at a particular location, and is usually measured with the Modified Mercalli (MM) intensity scale (see Appendix 2). Intensity at a given point depends on the magnitude of the earthquake, how far away and how deep it was, and the local ground conditions – such as whether the ground is sand or rock.

Even distant earthquakes can cause damaging ground shaking in the region, as shown in Figure 2.2 and Table 2.1. Another way of expressing earthquake risk is to give average return periods for different intensities of ground shaking, in a similar manner to those given for different sized flood events. This type of "probabilistic" modelling takes into account the characteristics (location, earthquake size and average recurrence interval) of all potential earthquake sources (faults) in New Zealand, and calculates how often a particular intensity of ground shaking will be felt, on average, at a particular site. The expected ground shaking intensity return periods for a site on bedrock in downtown Wellington are given in Table 2.3 (the Modified Mercalli intensity scale is given in Appendix 2). While the figures are for central Wellington, the values vary little over the whole region.

Ground shaking intensity (MM scale)	Return period (years)
V	2
VI	9
VII	42
VIII	170
IX	450

Table 2.3: Expected ground shaking intensity return periods for a bedrock site in downtown Wellington (source: Institute of Geological and Nuclear Sciences).

The values given in Table 2.3 are for bedrock; ground shaking is often amplified in soft sediments, such as sands and silts. Return periods for equivalent ground shaking intensities on soft sediments will, therefore, be lower. Figure 2.3 shows known areas within the metropolitan Wellington area where ground shaking is likely to be amplified in an earthquake, based on surface geology.

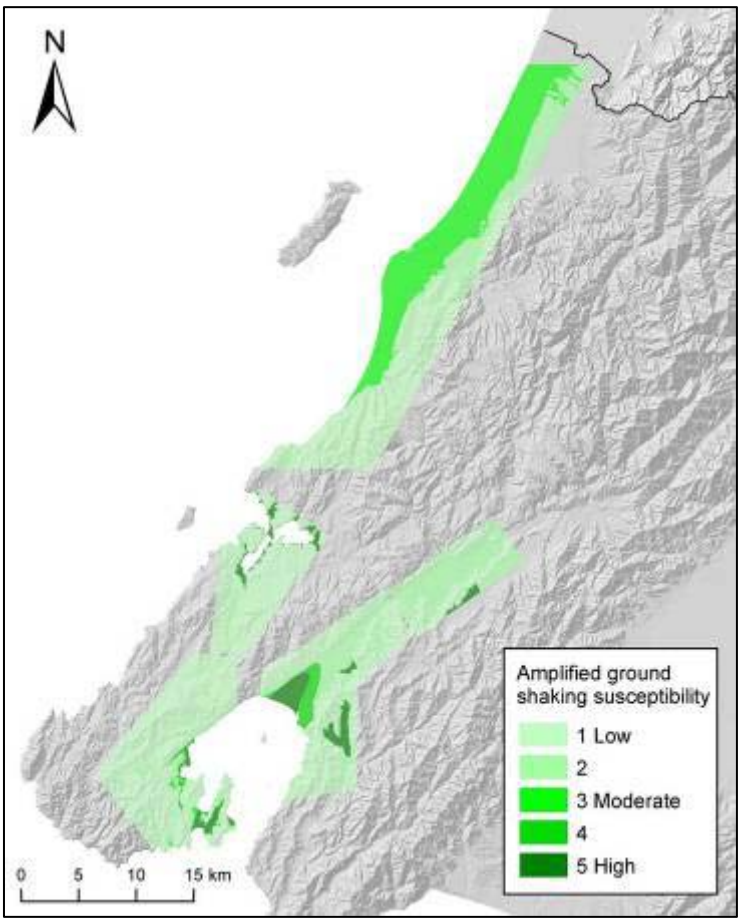

Figure 2.3: Amplified ground shaking hazard map of the metropolitan Wellington area.

Areas of highest likely amplification include reclaimed land around central Wellington, Kilbirnie, Rongotai and Miramar, Petone, Lower Hutt, Wainuiomata, Mangaroa Valley and low lying areas around Porirua Harbour. Areas of likely amplification in the Wairarapa include areas around Masterton, Carterton and Lake Wairarapa.

Areas subject to liquefaction in the metropolitan Wellington area are shown in Figure 2.4. Liquefaction occurs when saturated, loose, fine-grained soil loses strength during earthquake shaking and behaves more like a liquid than a solid. Liquefaction may occur when ground shaking intensities exceed MM VII. Areas at high risk from liquefaction include reclaimed land around central Wellington, Petone, Seaview, Gracefield, and areas around the Porirua CBD and Pauatahanui. Areas at moderate risk include Wainuiomata, Mangaroa Valley and low lying areas of the Kapiti coast. Areas of soft sediments that are susceptible to liquefaction in the Wairarapa include areas around Masterton, Carterton and Lake Wairarapa.

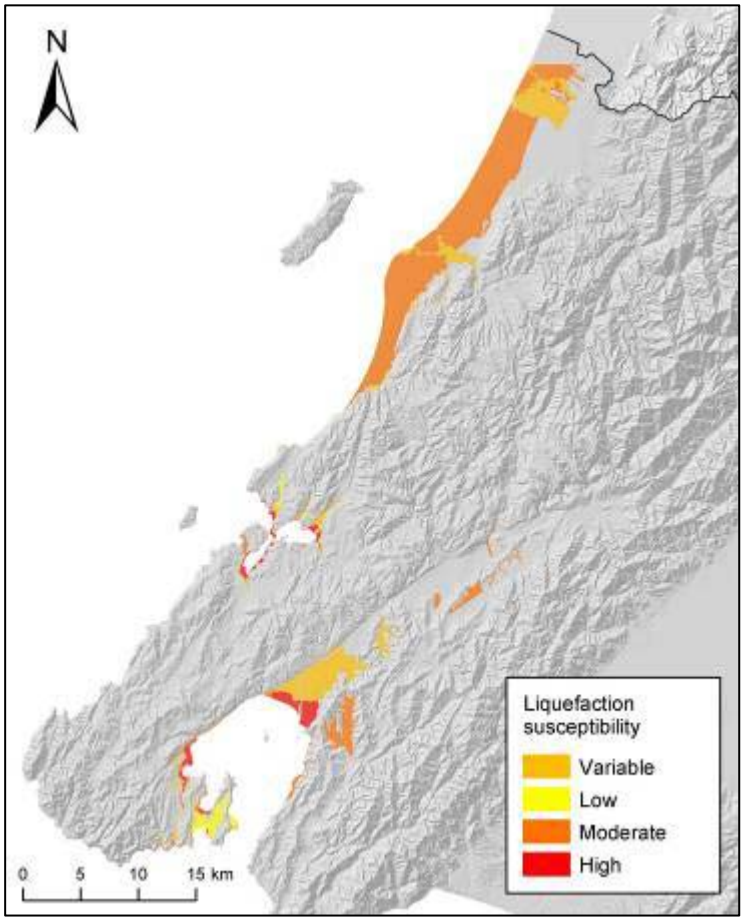

Figure 2.4: Liquefaction susceptibility map of the metropolitan Wellington area.

2.2 Pressure

The potential consequences from earthquake hazards is increasing as more development takes place in the region, and as we become more reliant on built and technological infrastructure. The potential consequences are particularly increased where development takes place on or close to active faults, on areas of soft sediments or near steep/excavated slopes.

2.3 Response

Possible responses to earthquake hazards vary depending on the type of hazard - ground shaking, liquefaction or surface fault rupture.

Ground shaking cannot be avoided or modified but good engineering can reduce building damage. It is important, therefore, that buildings are constructed to an adequate standard to resist earthquake shaking as outlined in the Building Act 2004 and Building Code.

Areas susceptible to liquefaction can be delineated based on underlying soils and geology and can be avoided, or foundation engineering (e.g. soil compaction, drainage) can be used to reduce liquefaction susceptibility.

Surface fault rupture is a relatively localised hazard, affecting land in a narrow band 10s to 100s of metres either side of an active fault. If the likely zone of deformation around an active fault can be delineated then land use activities in this zone can be managed to reduce risk. This may involve avoiding building on or near the active fault, or in some cases designing structures to withstand displacement on the fault. The largest limitation to mitigating fault rupture hazard is obtaining accurate fault location data.

2.3.1 Greater Wellington

(a) Regional Policy Statement methods

There are two methods in the Regional Policy Statement for reducing the adverse effects of earthquakes:

Method 2: The Wellington Regional Council will complete regional scale assessments of the various components of seismic hazard including surface fault rupture, ground shaking, tsunami, liquefaction and ground damage, landslides and locally significant hazards.

Method 8: The Wellington Regional Council will encourage and assist, where possible, territorial authorities to investigate natural hazards within their districts. These investigations should include…seismic hazard…studies at a greater level of detail than provided for in the regional scale studies.

These methods pertain directly to Policies 1 and 5 of the Regional Policy Statement.

(b) Hazard investigations and information provision

Comprehensive regional-scale investigations of earthquake hazards in Wellington City, the Hutt Valley, Porirua, Kapiti and part of the Wairarapa were commissioned by Greater Wellington between 1989 and 1995. These involved studies of active faults, subsurface geology, liquefaction potential, local site effects and microzoning. Active faulting, ground shaking and liquefaction hazard maps were created from the results of these investigations. These components were later combined, along with earthquake triggered landslide and tsunami hazard information, to create combined earthquake hazard maps in 1996. These maps were republished with the new Greater Wellington branding in 2004.

An earthquake risk assessment study and an earthquake and geological hazard mitigation strategy were completed by Greater Wellington in 1995. Earthquake hazard investigations carried out in the last ten years have focussed mainly on further research into active faulting in the region. This has included detailed mapping of the Masterton Fault (Ian R Brown Associates, 2002), and mapping of active faults in Kapiti (Van Dissen and Heron, 2003) and Upper Hutt (Van Dissen et al, 2005), joint projects with Masterton District, Kapiti Coast District and Upper Hutt City councils respectively.

Current earthquake hazard investigations include a joint project with South Wairarapa District Council to better delineate the location of the Martinborough Fault. Greater Wellington have also contributed to an Earthquake Commission-driven project to better define Wellington's active fault characteristics.

In the last five years Greater Wellington has also placed more emphasis on making earthquake hazard information more accessible. Five two-page earthquake fact sheets were produced in 2003. One outlines earthquake hazards in the Wellington region and four give details on earthquake hazards in Wellington City, the Hutt Valley, Porirua and Kapiti.

(c) Utility services

Greater Wellington's Utility Services department, responsible for bulk water supply to the four cities in the region, has commissioned many reports on the water system's vulnerability to earthquakes over the last 15 years. The department is now nearing completion of an extensive programme of securing, strengthening and replacing water supply components, based on a 1993 assessment of the system's seismic security (Kingston Morrison, 1993). Current projects include relocation of the Karori pumping station to a new site away from the Wellington Fault, and realignment of the Te Marua to Karori trunk water main at Haywards Hill onto more stable ground.

The impact of a Wellington Fault movement on the links between the various components of the Te Marua water storage, treatment and pumping facility has also been assessed. Displacement along the fault at Te Marua will have a major impact on reinstatement work on the large number of links that will be severed. Ground shaping in advance may be carried out to minimise this effect. A strain monitoring system was installed across the Wellington Fault at the Te Marua storage lakes by the DSIR in 1980 when the drain from the lower water storage lake was being constructed. An annual report is produced by the Institute of Geological and Nuclear Sciences analysing this data.

(d) Regional plans

The Regional Coastal Plan (2000) acknowledges that poorly designed reclaimed areas may suffer adverse effects during a major earthquake, possibly involving the release of hazardous substances into the coastal marine area. The Plan contains policies to take into account natural hazards, including earthquakes, in the use and development of the coastal marine area and consider the effects of a major earthquake in designing any reclamation to be used for public works such as a major road or any structure in the coastal marine area.

2.3.2 Territorial authorities

All six district plans in the Wellington region identify earthquakes as a natural hazard and have policies and rules regarding earthquake hazards.

Territorial authorities are responsible for mitigating ground shaking and liquefaction effects on buildings in administering building consents under the Building Act 2004. Changes in this Act also require territorial authorities to identify earthquake-prone buildings[3] in their jurisdiction, and to develop policies for dealing with these buildings in order to reduce risk to people over time. Most territorial authorities in the region are currently in the process of developing earthquake-prone building policies.

Surface fault rupture hazard is not dealt with under the Building Act and is therefore included in district plan provisions.

(a) Wellington City Council

The Wellington City District Plan does not have earthquake-specific policies. But it does set out rules for development within a "Hazard (Fault Line) Area" around the Wellington and Ohariu Faults. The construction, alteration of, and addition to, residential buildings within this area are discretionary activities with respect to building height and location, floor area, construction type and the number of household units on the site.

Wellington City Council commissioned work to define the Wellington Fault through Wellington (Perrin and Wood, 2003) to include in the District Plan.

(b) Hutt City Council

Hutt City Council has policies to manage the subdivision and siting of buildings and structures within the "Wellington Fault Special Study Area". All structures and buildings (excluding accessory buildings) within this area are restricted discretionary activities with regard to building location and engineering precautions. There is also a policy to adopt suitable engineering and civil defence measures to safeguard people and property from ground shaking and liquefaction.

(c) Upper Hutt City Council

While there are no earthquake-specific policies in the Upper Hutt City District Plan, constructing any new habitable building or structure within a "fault band" area defined around the Wellington Fault is a discretionary activity. A project to better define active faults within Upper Hutt City has recently been completed (Van Dissen et al, 2005). This information is to be included in the District Plan.

[3] An earthquake-prone building is defined in the Building Act 2004 as a building that, having regard to its condition and to the ground on which it is built, and because of its construction, will have its ultimate capacity exceeded in a moderate earthquake and would be likely to collapse causing injury or death to persons in the building or to persons on any other property or damage to any other property. This definition does not apply to wholly or mainly residential buildings with less than two storeys or less than three household units.

(d) Porirua City Council

The Porirua City District Plan has policies to minimise or manage the effects of:

- ground shaking on pipelines and services
- ground surface rupture from movement on the Ohariu Fault
- liquefaction, and
- earthquake-induced slope failure.

Essential activities (emergency facilities, telecommunications and power facilities, prisons, buildings able to hold more than 500 people at one time) within designated "Seismic Hazard Areas" are restricted discretionary activities.

(e) Kapiti Coast District Council

The Kapiti Coast District Plan contains policies include ensuring appropriate uses, zones and performance standards are developed for areas known to be liable to ground rupture from faults, and promoting viable alternative access to the north after an earthquake. There are rules to restrict building within 20m of active faults.

Active faults within Kapiti Coast District were mapped to update the fault information in the district plan (Van Dissen and Heron, 2003). This information is to be incorporated into the District Plan in 2006.

(f) Wairarapa district councils

The draft combined Wairarapa District Plan does not have any earthquake-specific policies. But any structure for occupation constructed or located within 20m of an active fault is a discretionary activity.

Masterton District Council, in conjunction with Greater Wellington, commissioned mapping of the Masterton Fault (Ian R Brown Associates, 2002) for use in the district plan. South Wairarapa District Council, with Greater Wellington, is undertaking a project to better define the location and activity of the Martinborough Fault.

2.3.3 Other organisations

(a) Ministry of Civil Defence and Emergency Management

The Ministry of Civil Defence and Emergency Management (MCDEM) is responsible for ensuring a co-ordinated approach at both national and community level to planning for reduction, readiness, response, and recovery, and managing central government response and recovery functions for large scale events.

"Tephra" is published annually by MCDEM to improve understanding of New Zealand's major hazards and provide information on how that information is applied in the civil defence emergency management environment in New Zealand. The 1998 issue covered earthquake hazards.

(b) Ministry for the Environment

The Ministry for the Environment (MfE) provides guidance for and promotes best practice for dealing with natural hazards in regional and district plans and policy documents.

MfE recently published "Planning for Development of Land on or Close to Active Faults: A guideline to assist resource management planners in New Zealand" (Kerr et al, 2004). This document provides guidance on land use planning approaches for land that is on or near active faults and includes case studies from Wellington City and Kapiti Coast District.

(c) Wellington Region Civil Defence Emergency Management Group

Greater Wellington and the region's eight city and district councils make up the Wellington Region Civil Defence Emergency Management (CDEM) Group. The CDEM Group advocates risk reduction and readiness for earthquake hazards and is responsible for coordinating response and recovery activities in the event of a major earthquake.

(d) Earthquake Commission

The Earthquake Commission (EQC) insures residential homes, land and personal belongings against earthquake damage (and post-earthquake fire damage) for home owners who hold fire insurance. Homes are insured to $100,000 and contents to $20,000.

EQC encourages earthquake preparedness in New Zealand through television advertisements, brochures, school resource kits and special events. EQC also funds earthquake research. Research relevant to the Wellington region over the last ten years includes:

- the 1855, 1934, 1942 earthquakes in the Wairarapa
- the Wellington, Whitemans Valley, Northern Ohariu and Akatarawa faults
- prehistoric earthquakes
- local site effects of earthquakes.

Details can be found on the EQC website at www.eqc.govt.nz.

EQC organised a major conference in 1995 focused on a Wellington Fault earthquake. The resulting publication "Wellington After the 'Quake: The Challenge of Rebuilding Cities" (EQC, 1995) outlines response and recovery issues. EQC was also the major sponsor of the 1855 Wairarapa Earthquake Symposium, held in September 2005 to commemorate the 150th anniversary of the Wairarapa earthquake.

(e) Institute of Geological and Nuclear Sciences

The Institute of Geological and Nuclear Sciences (GNS) researches earthquake hazards in New Zealand, including Wellington, with funding mainly from the Foundation for Research, Science and Technology, the Marsden Fund and EQC. Current earthquake research is focussed on:

- better defining the Wellington region's earthquake source characteristics
- determining how faults accommodate and release stress
- earthquake triggering
- earthquake clustering over geological timescales
- topographic effects on ground shaking
- the Hikurangi subduction zone interface off the North Island's east coast (currently New Zealand's biggest gap in earthquake hazard knowledge)
- improvements to earthquake resistant design
- post-earthquake functioning of cities.

GNS have published numerous books about earthquake hazards in New Zealand for the general public over the last ten years that contain information on Wellington's earthquake hazard. GNS also produces geological maps with accompanying booklets that discuss, among other things, active faults and earthquake hazards. Those produced for the Wellington Region in the last ten years are 1:50,000 Geology of the Wellington Area (Begg and Mazengarb, 1996), 1:250,000 Geology of the Wellington Area (Lee and Begg, 2000) and 1:250,000 Geology of the Wairarapa Area (Begg and Johnston, 2002). Details can be found on the GNS website at www.gns.cri.nz.

GNS has responsibility, through its EQC-funded GeoNet project, to build and operate an earthquake monitoring system within New Zealand. This aims to improve readiness, response and recovery. The system comprises 46 seismograph stations and more than 250 strong motion recorders throughout New Zealand. A GPS geodetic monitoring system also measures where strain is accumulating or dissipating in the earth's crust. The information collected is used for seismic hazards assessment and earthquake engineering. Near real-time earthquake information is publicly available through the GeoNet website at www.geonet.org.nz.

(f) National Institute of Water and Atmospheric Research

The National Institute of Water and Atmospheric Research (NIWA) currently receives Foundation for Research, Science and Technology funding for ship-based research to delineate offshore faults. This research has revealed many previously unmapped faults within Cook Strait and off the Kapiti/Horowhenua coast. Offshore fault information is combined with onshore fault information to give a more complete picture of the earthquake hazard in the region. Details can be found on the NIWA website at www.niwascience.co.nz.

(g) Engineering lifelines groups

The Wairarapa Engineering Lifelines Association commissioned a probabilistic earthquake ground motion study of the Wairarapa (Berryman et al, 1998) and studies on the Masterton, Carterton and Mokonui faults (Zachariasen et al, 2000; Begg et al, 2001; Townsend et al, 2002; Langridge et al, 2003). These projects were undertaken as part of the Wairarapa Engineering Lifelines Project completed in 2003.

3. Tsunamis

3.1 State

Many of the region's coastal communities and infrastructure are vulnerable to both local and distant tsunamis. There are several offshore faults within and near the region, including the Hikurangi subduction zone to the east, and the Boo Boo, Wairarapa, Wellington and Ohariu faults to the south. There are also some smaller, but still significant, recently discovered faults offshore of Kapiti and Horowhenua.

A submarine landslide in Cook Strait is also a potential tsunami source. Recent bathymetric surveys by NIWA show many landslide scarps in the canyon walls of Cook Strait. Parts of the region's coast, especially in the east, are also exposed to tsunamis generated around the Pacific Ocean, particularly off the coast of South America.

Tsunami wave heights depend on the energy of the triggering event (fault displacement, landslide), distance from source, bathymetry, topography and direction of tsunami waves.

3.1.1 The last ten years

The Wellington region has not experienced any damaging tsunamis in the last ten years. The 2001 Peru and 2004 Asian tsunamis both reached the region but had wave heights of less than 30cm at Queen's Wharf and Riversdale.

3.1.2 Putting the last ten years into context

The Wellington region has experienced both local and distant tsunami over the last 200 years. Paleoseismic and paleotsunami research also indicates that the Cook Strait area has probably experienced large tsunamis before written history.

The 1848 Marlborough earthquake caused unusually high tides in Wellington Harbour, one flooding shops on Lambton Quay. The 1855 earthquake caused a tsunami affecting the entire region. Wave run ups in Palliser Bay were up to 9 metres and wave heights of 2-3 m were recorded on the eastern Wairarapa coast, Wellington Harbour and south coast, the west coast as far as Wanganui, and Marlborough. The tsunami swept across the Rongotai isthmus into Evans Bay and back depositing fish on the then undeveloped sand dunes of Rongotai and Kilbirnie. Differential uplift to the west of the Wairarapa Fault also set up a seiche (sloshing effect) in Wellington Harbour which flooded shops in Lambton Quay.

The 1868 Chilean tsunami reached the Wellington region near low tide. It was reported to reach a little above the normal high tide mark at Castlepoint, and about 1.4m above the low tide mark in Wellington Harbour. No damage was reported in the region from the 1877 or 1960 Chilean tsunamis (although both these tsunamis did cause damage in other areas along New Zealand's east coast, particularly Banks Peninsula).

Estimated return periods for damaging tsunami in the region are 100-150 years for the east coast, 100-250 years for the south coast, and 250-400 years for the west coast. The estimated return period for a damaging tsunami somewhere on the region's coast is around 85 years (GeoEnvironmental Consultants, 2001).

The areas most exposed to tsunamis are:

- Castlepoint and Riversdale on the eastern Wairarapa coast
- Lake Ferry, Te Kopi and Ngawi on the southern Wairarapa coast
- low lying communities in Wellington Harbour and south coast such as Owhiro Bay, Island Bay, Lyall Bay, Evans Bay, Petone, Seaview and Eastbourne.

The Kapiti coast and parts of Porirua are also exposed, but to a lesser degree due to smaller offshore faults and a lower exposure to distant tsunamis from South America.

3.2 Pressure

Increasing demand for coastal property, and the growth in the size and value of dwellings and infrastructure being built near the coast is increasing the potential consequences of tsunamis.

Sea level rise associated with climate change may also increase the consequences of tsunamis as "freeboard" between assets and the sea decreases.

3.3 Response

Tsunami events cannot be modified. The available responses are limited to avoiding tsunami-prone areas, adopting engineering measures to reduce damage, and evacuation planning.

There is a tendency to rely on preparedness and education to mitigate tsunami hazard rather than restricting land use and/or building type in coastal areas. This is probably due to the long return periods for damaging tsunami and the difficulty in defining tsunami hazard zones.

3.3.1 Greater Wellington

(a) Regional Policy Statement methods

There is one method in the Regional Policy Statement for reducing the adverse effects of tsunamis:

Method 5: The Wellington Regional Council will undertake a scoping study on the hazards of … tsunami… and set priorities for more detailed investigations of these hazards if the scoping study shows this to be warranted.

This method pertains directly to Policies 1 and 5 of the Regional Policy Statement.

(b) Hazard investigations and information provision

Greater Wellington commissioned a tsunami hazard investigation for Wellington Harbour and the south coast in 1990 (Gilmour and Stanton, 1990). Internal reports were also produced assessing Wellington Harbour's vulnerability to tsunami (Grindell, 1990) and summarising Wairarapa's tsunami hazard (Saunders, 2000a; Saunders, 2000b).

A regional tsunami hazard scoping project was completed for Greater Wellington in 2001 (GeoEnvironmental Consultants, 2001) followed by an options report for

managing tsunami risk, developed in consultation with territorial authorities (Tonkin and Taylor, 2002). There has been little uptake of these options at a territorial authority level.

Greater Wellington also funded paleotsunami investigations at Okoropunga and Pukerua Bay (GeoEnvironmental Consultants, 2002). A tsunami fact sheet was produced by Greater Wellington in 2003 describing tsunamis, how the region is at risk and what people can do to be prepared.

The Wairarapa Coastal Strategy, a joint project between the three Wairarapa district councils, iwi and Greater Wellington, was released in April 2004. The strategy identifies tsunamis as a high risk for the Wairarapa coast and suggests land use planning as the most sensible mitigation method in as yet undeveloped areas. Research recommendations included mapping the 5 and 10 metre contours and determining awareness of and preparedness for tsunamis. The Hazards Technical Report, written as a background document for the strategy (Barrow, 2002) gives a summary of tsunami hazards in the Wairarapa and mitigation options.

Definition of the 5 and 10 metre contours along the Wairarapa coast using photogrammetry was completed by Tse Group in June 2005 for Greater Wellington (Tse Group Ltd, 2005).

A tsunami hazard fact sheet was produced by Greater Wellington in 2003 and a coastal hazard fact sheet for the Wairarapa, including tsunami hazards, was produced in 2004.

(c) Regional plans

The Regional Coastal Plan (2000) contains a policy to take appropriate account of natural hazards, including tsunami, in the use and development of the coastal marine area.

3.3.2 Territorial authorities

All territorial authorities in the region are vulnerable to tsunamis except land-locked Upper Hutt City.

(a) Wellington City Council

The Wellington City District Plan does not specifically identify tsunamis or coastal hazards as natural hazard issues and has no tsunami-specific policies or rules. A tsunami hazard assessment was commissioned by Wellington City Council as part of their Integrated Risk Assessment Project (Downes et al, 2000). The assessment reviews historical tsunamis and includes inundation maps, tsunami probabilities and loss models.

(b) Hutt City Council

The Hutt City District Plan includes policies to adopt engineering and civil defence measures to safeguard people and property from tsunamis, and to adopt engineering, civil defence and land use control measures to reduce the vulnerability of coastal development.

An early warning system and civil defence plans for emergency response are given as the most appropriate methods for reducing the impact of the tsunami hazard in Hutt City. There are no natural hazard rules in the place to control development in coastal areas. Rules are in place, however, to control development within the Coastal Environment Significant Natural Resource Area between Burdans Gate, Eastbourne and Windy Point on the Palliser Bay coast - the area of Hutt City most vulnerable to tsunamis.

(c) Porirua City Council

The Porirua City District Plan identifies tsunami as a natural hazard issue but there are no specific policies or rules to manage the tsunami hazard.

(d) Kapiti Coast District Council

The Kapiti Coast District Plan does not specifically identify tsunami as a natural hazard issue. It does have a policy, however, to avoid and/or mitigate the potential adverse effects of flooding and erosion from major rivers and the sea when planning for and making decisions on new subdivision, use and development adjacent to the sea.

Coastal erosion is a significant issue along parts of the Kapiti coast and some measures to address this, such as set back zones and recognition of dunes as natural buffers, also help to mitigate the tsunami hazard.

Kapiti Coast District Council commissioned a tsunami hazard and risk assessment in 2002 (Goff, 2002) which gives a summary of past tsunami events and implications for coastal development. The Council is also developing a Coastal Strategy which will consider the management of coastal hazards, including tsunamis.

(e) Wairarapa district councils

The draft combined Wairarapa District Plan has a policy to avoid or mitigate the potential adverse effects of flooding and erosion from rivers and the sea, but has no tsunami-specific rules. Like Kapiti Coast District some plan provisions for coastal erosion may go some way to mitigating the tsunami hazard.

The Wairarapa Coastal Strategy, developed by the three Wairarapa district councils, iwi and Greater Wellington was released in 2004 (details are given in Section 3.3.1 above). Provisions from the Strategy may be incorporated into the draft combined Wairarapa District Plan.

Both Masterton and South Wairarapa district councils have erected tsunami hazard signs along parts of their coasts (e.g. Castlepoint, Riversdale, Palliser Bay). These inform people to move away from low-lying areas if a strong earthquake occurs, and have generally been well received. These were followed up in 2002 by posters distributed to these communities outlining what to do for both local and distantly generated tsunamis.

3.3.3 Other organisations

(a) Ministry of Civil Defence and Emergency Management

The Ministry of Civil Defence and Emergency Management (MCDEM) is responsible for ensuring a co-ordinated approach at both national and community level to planning for reduction, readiness, response, and recovery, and managing central government response and recovery functions for large scale events.

Tsunami warnings (for distant source tsunami) are generated by the Pacific Tsunami Warning Centre in Hawaii[4] and received by the MCDEM. These are then passed on to each regional CDEM Group.

"Tephra" is published annually by MCDEM to improve understanding of New Zealand's major hazards and provide information on how that information is applied in the civil defence emergency management environment in New Zealand. The 1999 issue covered tsunami hazards.

The Institute of Geological and Nuclear Sciences has recently completed a two part report on New Zealand's tsunami risk, commissioned by MCDEM in response to the 2004 Asian tsunami. The first part of the report deals with the science of New Zealand's tsunami hazard (Berryman, 2005) and the second with New Zealand's preparedness (Webb, 2005). The report contains some Wellington region specific information.

(b) Wellington Region Civil Defence Emergency Management Group

Greater Wellington and the region's eight city and district councils make up the Wellington Region Civil Defence Emergency Management (CDEM) Group. The CDEM Group advocates risk reduction and readiness for tsunamis and is responsible for coordinating response and recovery activities in the event of a tsunami.

Tsunami warnings (for distant source tsunami) are generated by the Pacific Tsunami Warning Centre in Hawaii and are received by the CDEM Group office at Greater Wellington via the Ministry of Civil Defence and Emergency Management. These messages are then disseminated to local emergency management officers in the areas likely to be affected and decisions are made whether to evacuate or not. The CDEM Group tsunami evacuation planning is scheduled to be reviewed by the Group in 2007/08.

A tsunami flyer created by the CDEM Group was delivered to coastal households in Wellington City in 2005.

(c) The Earthquake Commission

The Earthquake Commission (EQC) insures residential homes, land and personal belongings against tsunami damage (and post-tsunami fire damage) for home owners who hold fire insurance. Homes are insured to $100,000 and contents to $20,000. EQC

[4] The Pacific Tsunami Warning Centre in Hawaii was established in 1949 as an international programme to provide Pacific nations, including New Zealand, with tsunami warnings. The PTWC continuously monitors earthquake activity and sea surface levels in the Pacific region using data from participating nations.

have also funded tsunami research. Details can be found on the EQC website at www.eqc.govt.nz.

(d) National Institute of Water and Atmospheric Research

The National Institute of Water and Atmospheric Research (NIWA) currently run three Foundation for Research, Science and Technology funded programmes involving tsunami hazard research. Current projects include:

- numerical modelling to help mitigate the consequences of tsunamis
- ship-based surveys to identify potential tsunami sources such as active offshore faults, submarine volcanoes and landslides
- risk evaluations, warning systems and hazard maps to aid in better planning and increased resilience.

(e) Institute of Geological and Nuclear Sciences

The Institute of Geological and Nuclear Sciences (GNS) works closely with NIWA on tsunami research. Current research includes:

- identifying paleotsunami deposits
- identifying the sources and recording damage from tsunamis that have happened in New Zealand over the last 200 years (to calibrate inundation models)
- collaboration with United States agency NOAA on Pacific-wide tsunamis
- determining probabilistic risk to New Zealand from tsunamis
- modelling of local tsunamis
- studying offshore faults
- modelling long-term economic losses to New Zealand cities from tsunamis
- researching public awareness and the effectiveness of warning systems and public education programmes.

GNS's EQC-funded GeoNet project is also in the process of installing long-period seismic sensors that will be able to detect potential tsunami-generating earthquakes around the New Zealand coast.

4. Flooding

4.1 State

Frequent heavy rainstorms and the steep gradients of many river catchments in the Wellington region, combined with human occupation of floodplains, create a significant flood risk in the region. Flooding is the most commonly experienced natural hazard in the region.

Development on the floodplains of all major rivers means that these rivers must be continually managed to contain the river during flood events. Although flood protection improvements are being made and the level of protection on our rivers is increasing, we must recognise that there will always be a residual risk of flooding.

4.1.1 The last ten years

The region has been affected by several severe floods in the last ten years causing four deaths and tens of millions of dollars of damage - over $11 million worth to Greater Wellington flood protection works alone.

Table 4.1 shows details of major floods to affect large parts of the region within the last ten years.

Catchments (return period in years, where known)	**Flood protection work damage estimates ($000s)**	**Comments**
4 OCTOBER 1997		
Wainuiomata (5-15) Orongorongo (6) Hutt (3-10) Waikanae (3) Otaki (1) Porirua (1)	Hutt 789.5 Otaki 75 Waikanae 10	Northwesterly storm - 650mm over 48 hours recorded in the Tararua Range. Damage/erosion to Hutt River banks, part of Manor Park Golf Course eroded. Surface flooding in Hutt Valley and Wellington. Stormwater drain bursts in Ngauranga Gorge sending water and boulders down SH1 into traffic. One evacuation in the Akatarawa Valley. Two deaths (car aquaplaned into swollen Hutt River).
20/21 and 28 OCTOBER 1998		
20/21 October: Waikanae (28) Akatarawa (17) Waitohu (14) lower Hutt (12) Waipoua Ruamahanga 28 October: Akatarawa (75) lower Hutt (25) Otaki (10)	Total amounts: Hutt 1375.5 Otaki 442.2 Waikanae 156.1 Waitohu 25	20/21 October: Northwesterly storm - 620mm over 48 hours recorded in the Tararua Range, 100mm over 24 hours at Paraparaumu Airport. Civil Defence Emergency declared in Kapiti Coast. 13 homes evacuated in Waikanae, properties flooded. Properties and schools flooded in Otaki. Evacuations in Paekakariki/Paraparaumu due to water/sewerage problems. SH1 and rail inundated on Kapiti Coast. Rimutaka, Akatarawa and Paekakariki Hill Roads closed. Damage/erosion on Hutt River banks, part of Manor Park Golf Course eroded. 68 people evacuated from a school camp in Masterton after Waipoua River stopbank breach, extensive damage to camp ground. Roads closed in the Wairarapa. 28 October: Northwesterly storm on already saturated ground. Civil Defence Emergency again declared in Kapiti Coast. 40 people evacuated from Waikanae. SH1 closed north of Otaki after approaches to Waitohu Bridge washed out. One death (man swept away by the Waikanae River while checking the river bank on his property). Parts of Hutt Valley flooded. Roads, parks, golf courses inundated, properties flooded and homes evacuated. Parts of Wairarapa flooded and roads closed.
2 OCTOBER 2000		
Akatarawa (10) Hutt (6-10) Waitohu (7) Otaki (6) Waikanae (5) Mangaroa (5) Wainuiomata (3) Porirua (1) Ruamahanga	Hutt 245.4 Otaki 186.9 Waikanae 97.3 Waitohu 25	Northwesterly storm - 850mm over 72 hours recorded in the Tararua Range. One house affected in the Hutt Valley. Ruamahanga River flooded large areas, homes isolated and roads closed.

8/9 OCTOBER 2000		
Ruamahanga Waiohine Waingawa Waipoua		Heavy rain in the Tararua Range - ~300mm in 24 hours. Roads and bridges damaged, stock losses.
10 JUNE 2003		
Wainuiomata (12)		Heavy rain in Wellington region, particularly Hutt Valley (123mm in 24 hours) and Wainuiomata (200mm in 24 hours). Roads and properties flooded, Wainuiomata River highest flow since 1977, sheep drowned and collapse of coast road.
3 OCTOBER 2003		
Whakatikei (60) Horokiri (~60?) Mangaroa (11) Waikanae (4-5) Hutt (4) Waiwhetu (4) Wainuiomata (3) Ruamahanga (7)		Heavy rain in the Tararua, Akatarawa and Rimutaka ranges. Most intense rain at Paekakariki where a Civil Defence Emergency was declared. Properties, roads and rail inundated by water, mud and debris from gullies behind the town. Rainfall over 6 hours in the hills behind Paekakariki was estimated to have a greater than 120 year return period.
11-19 FEBRUARY 2004		
Waiwhetu (50) Wainuiomata (30) Mangaroa (14) Porirua (6) Otaki (5) Waikanae (5) Hutt (4)	Hutt 75 Otaki 136 Waikanae 15 Wellington watercourses 210.7 Kapiti watercourses 4.5	Series of intense storms - worst storm on 15/16 February. Extensive flooding, landslides and damage to houses, farms and infrastructure in lower North Island. 41 homes evacuated and 15 commercial properties flooded in Waiwhetu. Local motor camp evacuated. 2 houses evacuated in Wainuiomata. Roads closed in Lower Hutt, Wainuiomata and Eastbourne. 10 families evacuated in Te Marua, Pinehaven and Akatarawa. 35 people stranded on Rimutaka Road. 2 families evacuated in rural Masterton.
18 AUGUST 2004		
Hutt Wainuiomata		Severe southerly storm. Flooding and many landslides in the lower Hutt Valley, Wainuiomata and Eastbourne and the Wairarapa. Postal worker drowned when trying to negotiate a flooded stream north of Bideford.
5/6 JANUARY 2005		
Waikanae (80) Akatarawa (80) Whakatikei (60) Otaki (40) Hutt (25) Mangaroa (12) Mangaone (10) Waiwhetu (5)	Hutt 591.5 Otaki 214.5 Waikanae 255.6 Kapiti watercourses 4.5 Pinehaven Stream 15	Northwesterly storm - 300mm over 12 hours in the Tararua Range. 23 properties inundated in Waikanae, 650 people evacuated from camp ground in Waikanae. SH1 and Main Trunk rail closed at McKay's Crossing. 10 properties affected in Hutt Valley, 3 homes evacuated in Pinehaven, 1 home evacuated in Akatarawa.
30/31 MARCH 2005		
Mataikona Wainuiomata Orongorongo Catchpool		Southeasterly storm - 444mm over 36 hours in Wainuiomata. Damage to farmland - silt covered paddocks, fences destroyed and stock lost. Large amounts of gravel mobilised in debris flows in the Orongorongo Valley - landslide dam created and several tramping huts damaged or destroyed. 15 adults and 5 children evacuated from homes in eastern Wairarapa.

Table 4.1: Major flood events in the Wellington region between 1995 and 2005 (source: MetService, Greater Wellington records).

Table 4.2 gives other, smaller, rainfall events that have caused localised surface flooding over the last ten years.

Date	Effects
7-9 Feb 1996	Flash floods in Wellington region.
19/20 Feb 1996	Heavy rain north Wellington and Wairarapa.
16 March 1996	Flash flooding in Otaki.
1 July 1996	>200mm in Tararua Range, flooding and road closures in Wairarapa.
11/12 July 1996	>100mm in 24 hours in parts of Wellington and Wairarapa.
13/14 September 1996	Heavy rain in Wellington causes local flooding.
7/8 October 1996	30-50mm rain in 10 hours in Wellington, roads closed by flooding.
12 November 1996	Flash floods in Wainuiomata.
5 February 1997	Thunderstorm in Masterton floods properties.
6 March 1997	Heavy rain in Wellington, localised flooding.
17/18 June 1997	90mm in 18 hours in Wellington, roads closed.
10 July 1997	Heavy rain causes localised surface flooding in Wellington.
14 July 1997	Severe hail storm closes Wellington airport because of surface flooding.
4/5 August 1997	Heavy rain causes localised flooding.
1 April 1998	Northwest rain, basements flooded in Paraparaumu and Waikanae.
26 May 1998	Torrential rain in Wellington, flooding of homes and CBD businesses. Miramar worst hit, homes evacuated, school closed, stormwater systems unable to cope. 74.4mm in Hataitai, 44.2mm in Miramar, most falling between 5am and 8am.
14 June 1998	30mm in 3 hours in Wellington, surface flooding, phone lines damaged.
25 June 1998	Heavy rain in Wellington, localised flooding.
26 June 1998	70mm in 1.25 hours at Kelburn, flash flooding, vehicles submerged, power cuts.
2 July 1998	Heavy rain in Wellington, SH1 and SH2 closed by flooding, sewerage problems.
5/6 September 1998	>200mm in 24 hours in Tararua Range.
12 March 1999	Torrential rain in Wainuiomata, flash flooding.
23/24 March 1999	Heavy rain in Wellington, surface flooding.
14/15 May 1999	60mm in 24 hours in Wellington and Kapiti, localised flooding and road closures.
20/21 August 1999	Heavy rain in Tararuas and Hutt Valley, minor flooding, car accidents in Wellington and Kapiti.
21 September 1999	Surface flooding in Lower Hutt.
29 November 1999	Heavy rain in lower North Island, 52 people (mainly children) rescued from Rimutakas after being trapped by the Orongorongo River.
18/19 December 1999	Heavy rain in Horowhenua, eight homes flooded in Otaki.
2 June 2000	Surface flooding in parts of Wellington and Kapiti.
7 September 2000	Heavy rain in Hutt Valley, homes and roads flooded.
22 November 2001	Heavy rain, properties and roads flooded, particularly Hutt Valley (60mm in 3 hours), Johnsonville, Tawa, Newlands.
10 January 2002	50mm in 1 hour at Kelburn, central city businesses flooded.
18 March 2002	Heavy rain, flash flooding in Johnsonville and Newlands
21 March 2002	Heavy rain in Tararuas, two people rescued by helicopter from vehicle stuck in Waingawa River.
23 May 2002	Thunderstorm, surface flooding.
17/18 June 2002	Heavy rain, flash floods, fallen trees, one man rescued from a vehicle trapped in 2m of floodwater in Lower Hutt.
14/15 July 2002	Heavy rain, surface flooding in Wellington.
16 August 2002	Heavy rain, surface flooding affects roads in northern Wellington.
7/8 December 2002	Heavy rain, flash flooding in Wellington.
5/6 April 2003	Heavy rain, flash flooding in Lower Hutt.
28 August 2003	Heavy rain, surface flooding in Wellington.
16 December 2003	Heavy rain, particularly in Lower Hutt.
8 January 2003	Heavy rain, flash floods in Hutt Valley and Kapiti, roads affected.
28 December 2003	Thunderstorms, flash floods and flooded basements in Upper Hutt.
19 February 2004	Heavy rain, SH1 closed at Paekakariki.
16 October 2004	Heavy rain in Tararuas (400mm in 24 hours), rivers rise in Wairarapa.

Table 4.2: Small localised flood events in the Wellington region between 1995 and 2005 (source: MetService).

4.1.2 Putting the last ten years into context

Figure 4.1 shows the 1 in 100 year return period 24 hour rainfall for the region. The areas of greatest flood risk in the region are those catchments and floodplains that drain both west and east of the Tararua Range, where the highest rainfall occurs.

Table 4.3 gives the standards of protection to be achieved upon completion of the Hutt, Waikanae and Otaki floodplain management plans' implementation programmes.

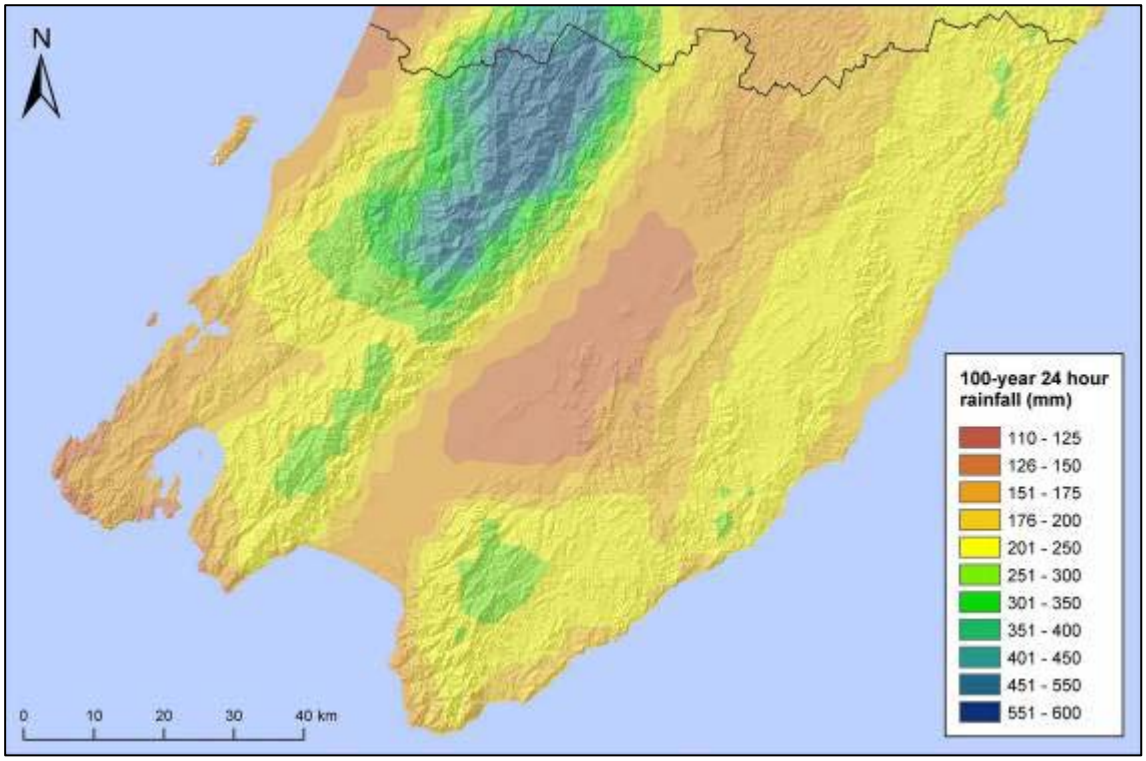

Figure 4.1: 1 in 100 year return period 24 hour rainfall (source: National Institute of Water and Atmospheric Research).

Hutt River Floodplain Management Plan
Lower Valley
Major stopbanks: 1 in 440 year return period flood with additional stopbank capacity (freeboard) and associated bank-edge protection. Manor Park stopbank: 1 in 440 year return period flood. Belmont edge protection: 1 in 100 year return period flood.
Upper Valley
Major stopbanks: 1 in 1000 year return period flood with associated bank-edge protection of 1 in 440 year return period flood. Bridge Road edge protection: 1 in 100 year return period flood. Gemstone Drive stopbank and edge protection: 1 in 100 year return period flood. Totara Park stopbank: 1 in 440 year return period flood.
Waikanae River Floodplain Management Plan
Stopbanks: 1 in 100 year return period flood. House raising to 1 in 100 year return period flood level (where viable, as an alternative to stopbanks).
Otaki River Floodplain Management Plan
Stopbanks: 1 in 100 year return period flood. House raising to 1 in 100 year return period flood level (where viable, as an alternative to stopbanks).

Table 4.3: Levels of protection planned for the Hutt, Waikanae and Otaki rivers.

Other areas away from major rivers can be subject to localised flooding. This is usually the result of intense rainfall and the inability of stormwater systems to cope with the volume of water and debris. This type of flooding is likely to occur in urban areas with a higher proportion of impermeable ground surfaces (i.e. concrete and ashphalt) where the rate of runoff is higher than areas of pasture or bush. Effects include disruption to traffic and infrastructure, localised landsliding and short term evacuations.

4.2 Pressure

Human modification of catchments and floodplains has increased the flood hazard risk since settlement of the region.

Expansion and intensification of urban areas increases the consequences of flooding. As much as 70 per cent of new subdivisions in the Wairarapa are subject to potential flood hazards. There is also pressure in the Hutt Valley to develop land that is prone to flooding.

Land use change may also alter hydrological regimes which affect flood frequency. While there have been few studies into the impact of land use change on flooding in the Wellington region, it is likely that urban development causes quicker runoff during rainfall, resulting in larger and more rapid peak storm flows (Watts, 2005a).

Medium and long term natural climate variations, such as the El Niño Southern Oscillation (ENSO) and the Interdecadal Pacific Oscillation (IPO), have a measurable impact on local weather patterns.

The ENSO results from cyclic warming and cooling of the Pacific Ocean sea surface. It is the dominant driver of natural climate variability influencing New Zealand's rainfall patterns over the two to seven year time scale. The Southern Oscillation Index (SOI) is a measure of the air pressure difference between Tahiti and Darwin and indicates whether the oscillation is in a positive (La Niña) or negative (El Niño) phase. El Niño conditions generally result in more summer rainfall in western areas. La Niña summers tend to produce more easterly/northeasterly flows with increased probability of tropical cyclones from the east.

The IPO is a decadal-scale oscillation in the ocean-atmosphere system that modulates the frequency of El Niño and La Nino phases of ENSO. Evidence suggests we are entering a new negative phase of the IPO. This is likely to result in weaker westerly flows over the next 20 to 30 years, with more La Niña and less El Niño events. Effects for the region include increased probability of ex-tropical cyclones affecting the region from the east (Watts, 2005a).

Human induced climate change is also likely to affect the occurrence and intensity of rainfall in the region. Likely impacts include a general increase in average annual rainfall in Kapiti and central Wellington, and an increased risk of heavy rainfall events across the region (Tait et al, 2002).

4.3 Response

Intense and/or prolonged rainfall cannot be avoided. However, flood events can be modified by decreasing rainfall runoff rate (e.g. by planting trees in upper reaches of catchments) or by containing the flood (e.g. by constructing stopbanks).

Vulnerability to flooding can be reduced by avoiding areas that are particularly prone to flooding, or requiring minimum floor levels on floodplains. Response and recovery plans, once a flood has occurred, are also part of mitigating the flood hazard.

4.3.1 Greater Wellington

(a) Regional Policy Statement methods

There are two methods in the Regional Policy Statement for reducing the adverse effects of floods:

Method 1: The Wellington Regional Council will complete flood hazard assessments on all major floodplains in the Region. The assessments will include an analysis of the potential effect of flooding events.

Method 8: The Wellington Regional Council will encourage and assist, where possible, territorial authorities to investigate natural hazards within their districts. These investigations should include flood hazard assessments for land in floodways managed by territorial authorities (including watercourses managed by agreement with the Wellington Regional Council)… at a greater level of detail than provided for in the regional scale studies.

These methods pertain directly to Policies 1 and 5 of the Regional Policy Statement.

(b) Flood protection

Greater Wellington's Flood Protection (Wellington/Hutt/Kapiti) and Operations (Wairarapa) departments provide flood protection for the major rivers in the region. This includes floodplain management planning and flood protection activities such as stopbank construction, waterway/asset management and gravel extraction.

Floodplain management plans have been prepared for the Hutt, Waikanae and Otaki rivers. These give a 40 year blueprint for managing and implementing programmes to gradually reduce the effects of flooding. The plans outline the level of protection that each community has decided is most appropriate and cost effective, and the measures that will be taken to achieve these standards. The level of protection designed for is defined by flood return period (e.g. 1 in 100 year return period flood).

Floodplain management plans outline both structural and non-structural methods for reducing the effect of floods. Structural methods include stopbanks and rock/vegetation protection. These methods are designed to keep the river in its channel, or river corridor, and away from populated areas and valuable community assets. Non-structural methods deal with the residual risk of flooding (risk left after structural flood protection works are in place) and land use planning controls. These methods involve improving community resilience to flooding and helping people avoid the flood hazard, and encouraging property owners to take responsibility for lessening the effects of floods.

Historical and existing flood protection structures mean that different areas of a river are protected to different levels. Some stopbanks along the Hutt River were built decades ago and may only provide protection against a 1 in 100 year return period flood. The floodplain management plans outline how and when these different areas will be brought up to the chosen level of protection using structural methods, and what other alternative methods will be used.

River schemes are in place for the Waiohine, Waingawa, Waipoua, and upper Ruamahanga rivers and the lower Wairarapa Valley (the Lower Wairarapa Valley Development Scheme incorporating Lake Wairarapa and the lower Ruamahanga River). These schemes include stopbank construction and annual programmes of groyne maintenance, planting, channel alignment and gravel extraction.

Table 4.4 outlines major structural works, including stopbank construction, river realignment and bank edge protection, undertaken by Greater Wellington on the Hutt, Waikanae, Otaki, Waiohine and Ruamahanga rivers, as well as the Lower Wairarapa Valley Development Scheme, over the last ten years.

Hutt River	
Alicetown stopbank	Design completed 2005 (construction due for completion 2007)
Norfolk Street stopbank	Completed 2004 (some additional work ongoing)
Strand Park stopbank	Design completed (construction due for completion 2010)
Opahu pumping station	Design completed (construction due for completion 2006)
Ava Bridge stopbank	Design completed (construction due for completion 2006)
Whirinaki Crescent	Design completed (construction due for completion 2007)
Otaki River	
Chrystalls stopbank	Completed 2000
Chrystalls extended stopbank	Construction due for completion 2008
Rangiuru floodgates	Completed 2002
South Waitohu stopbank	Construction due for completion 2008
Mangapouri Stream Culverts	Three culverts completed 2003
Waikanae River	
Kauri-Puriri stopbank	Completed 1997
Kauri-Puriri Greenway road raising	Completed 1997
Kauri-Puriri removal of Riverside Lodge	Completed 1997
Kauri-Puriri Chillingworth stopbank	Completed 1997
Otaihanga road raising Stage 1	Completed 2000
Otaihanga road raising Stage 3	Completed 2004
Otaihanga house raising Toroa Rd	Completed 2000
Otaihanga house raising Makora Rd	6 of 15 houses proposed in Long Term Council Community Plan
Jim Cooke Park channel realignment	Currently underway
Lower Wairarapa Valley Development Scheme	
Tauherenikau stopbank upgrade	Completed 1995 and 2001
Papatahi stopbank	Completed 2003
Shifting Scaddens & Herricks stopbanks	Completed 2005
Sheltons & Guscotts repair	Completed 2005
Waiohine River	
Greytown stopbank construction	Completed 1998
Tui Glen & Fullers Bend upgrade	Completed 2004
Channel and protection works	Completed 2001
Wongs channel works	Completed 2001
Upper Ruamahunga River	
Te Whiti stopbank upgrade	Completed 2004
Rathkeale stopbank upgrade	Completed 2002

Table 4.4: Major flood protection works carried out by Greater Wellington since 1995.

(c) Flood warning

Greater Wellington provides flood warnings to the region's urban and rural communities. Data is collected from a network of 48 automatic rainfall stations (42 Greater Wellington, 5 MetService and 1 NIWA) and 44 automatic river level monitoring stations (34 Greater Wellington, 9 NIWA, 1 joint Greater Wellington/NIWA). Most sites, located at strategic positions across the region, are telemetered and transmit real-time information via radio or cell phone to Greater Wellington.

After receiving a heavy rain warning from weather forecasters, Greater Wellington staff monitor the information transmitted from monitoring stations. Information collected every 15 minutes is compared to pre-set alarm levels. If rainfall and river levels reach the alarm point the system automatically warns staff.

Where possible, territorial authorities and landowners are given advance warning of the situation. Incoming data is updated at least every hour and flood predictions are adjusted accordingly.

(d) Hazard investigations and information provision

Flood hazard investigations have been undertaken as part of the Hutt, Waikanae and Otaki floodplain management plans and the upper Ruamahanga and Waipoua river schemes. Flood hazard investigations have also been completed for the Mangaroa and Wainuiomata rivers and Mangaone and Waitohu streams, and an investigation is currently underway for Waiwhetu Stream.

Reports on the meteorology and hydrology of major flood events are also produced by Greater Wellington. Over the last ten years these have included:

- February 1996 flood (Lew, 1996a)
- October 1997 flood (Harkness, 1997)
- May 1998 storm (Harkness, 1998a)
- 14 June 1998 storm (Harkness, 1998b)
- 26 June 1998 storm (Harkness 1998c)
- July 1998 storm (Harkness, 1998d)
- October 1998 floods (Harkness, 1998e)
- October 2003 Paekakariki storm (Watts and Gordon, 2003)
- 15/16 February 2004 flood (Watts and Gordon, 2004)
- 17 February 2004 Miramar storm (Watts, 2004b)
- January 2005 flood (Watts, 2005b).

A general flood hazard fact sheet was produced by Greater Wellington in 2003 explaining why floods happen and what can be done about them. Area-specific flood hazard fact sheets have since been prepared for the Wairarapa (2003), Hutt Valley (2004) and Kapiti (2004).

Greater Wellington also produces a newsletters informing communities of flood protection works being undertaken in their area. Recent newsletter series include the Belmont flood protection improvements (2003-04), Ava to Ewen river realignment

(ongoing since early 1990s) and Jim Cooke Park river realignment (2005). Community consultation and events are undertaken when required.

(e) Utility services

There has been recent recognition that Greater Wellington water supply facilities may be at greater risk from floods than previously considered. Return periods have recently been established to use in the assessment of different types of facilities.

The Point Howard pumping station is currently being relocated to a new site to reduce the flood risk.

(f) Regional plans

The Regional Freshwater Plan (1999) addresses Greater Wellington's function to avoid or mitigate flooding. Objectives are given to reduce the adverse effects of flooding in the region to an acceptable level, to allow flood mitigation works, to ensure there is enough flood hazard information for the hazard to be mitigated and to encourage community awareness of flood hazard. There are several policies and rules relating to flood and erosion mitigation in river and lake beds and on floodplains.

The Regional Soil Plan (2000) recognises vegetation clearance and soil disturbance as activities that may increase sediment runoff and increase flood hazard. The Plan contains objectives and rules to regulate soil and vegetation disturbance to reduce adverse effects on flood mitigation assets.

The Regional Coastal Plan (2000), recognises the importance of the Hutt River hydraulic line in reducing flood risk in the Hutt Valley and contains policy to protect this line from inappropriate use and development. It also recognises dredging of the Hutt River mouth as an appropriate activity to maximise efficient flow of the river. There is also policy that gives regard to the benefits of dams and diversions in the lower reaches of rivers in the coastal marine area for flood mitigation. The Plan outlines trigger flood levels for mouth cutting on 17 rivers and streams in the region.

(g) Care groups

Flood protection works are supported by community care groups. The Friends of the Waikanae River and Friends of the Otaki River care groups were established in 1998 and 1999 respectively. These two groups work with Greater Wellington to implement the Waikanae and Otaki floodplain management plans by monitoring day-to-day flood protection activities and considering ways to enhance the environment.

4.3.2 Territorial authorities

Flooding is recognised as a significant hazard by all territorial authorities in the Wellington region.

(a) Wellington City Council

The Wellington City District Plan recognises flooding as a natural hazard issue that requires measures to reduce risk. Flood hazard areas are identified within the Plan at

Tawa and Takapu and rules are in place to control earthworks and the construction, alteration of and addition to residential buildings within these areas.

(b) Hutt City Council

Hutt City District Plan policies with respect to flooding include:

- limiting the scale and density of development in areas where the risk of flooding is “medium” to “high”
- discouraging the subdivision of land subject to flooding
- adopting engineering, civil defence and land use control measures to reduce the vulnerability of people and their property to flood hazards
- ensuring recreational activities do not have adverse effects on flood protection measures and river works, and have less than minor effects on the flow of flood water
- ensuring gravel extraction is only carried out for flood control purposes
- limiting the number of buildings and structures in the river recreation activity area that are not associated with flood protection measures and river works
- ensuring that buildings and structures within the river recreation activity area are sited to avoid increasing flood risk.

All works necessary for the management of any river or stream by Greater Wellington or Hutt City Council are permitted activities. Any buildings or structures within the river recreation activity area (a narrow band of land around the Hutt River, Waiwhetu Stream and small parts of the Wainuiomata River) are discretionary activities.

(c) Upper Hutt City Council

The Upper Hutt City District Plan identifies inappropriate development and activities located within floodplains and obstruction of flood flow paths as natural hazard issues. It also recognises the need for ongoing river management activities and flood protection works along the Hutt River.

Flood mitigation works undertaken by a local authority are permitted activities. Earthworks and the erection of buildings and structures within the 1 in 100 year flood extent of the Hutt River are discretionary activities.

Upper Hutt City Council is currently looking to update the District Plan flood hazard provisions as part of implementing the Hutt River Floodplain Management Plan.

(d) Porirua City Council

The Porirua City District Plan recognises flood hazard as a particularly significant issue and has a policy to ensure flood hazard is considered in subdivision, use, development and protection of land.

There are no flood-specific rules in the Plan but earthworks over a specified volume or depth (depending on zone) is a discretionary activity.

(e) Kapiti Coast District Council

The Kapiti Coast District Plan outlines issues surrounding development within river corridors, ponding areas, overflow paths, flood storage areas and flood erosion areas, and consequent flood damage susceptibility, and adverse effects on existing development and flood mitigation structures.

The Plan has policies regarding:

- earthworks and their effect on flood hazard
- providing flood and erosion free building sites within new lots
- avoiding or mitigating adverse flooding effects when making decisions on new subdivisions or development in river corridors
- ensuring appropriate uses, zones and performance standards for areas known to be liable to flooding.

Earthworks in ponding areas or overflow paths involving >20m^3 volume or altering ground level by more than one metre is a discretionary activity. New and relocated buildings must be above the estimated 1 in 50 year flood level and owners are supplied with the 1 in 100 year flood level.

(f) Wairarapa district councils

The draft combined Wairarapa District Plan has one flood specific policy to avoid or mitigate the adverse effects of flooding and erosion from rivers and the sea, and to identify areas of the Rural (Special) Zone to manage rural areas affected by particular land use issues including flood hazard management.

Activities including subdivision, planting, earthworks, construction and storage/production of hazardous substances are discretionary within delineated flood hazard areas.

4.3.3 Other organisations

(a) Ministry of Civil Defence and Emergency Management

The Ministry of Civil Defence and Emergency Management (MCDEM) is responsible for ensuring a co-ordinated approach at both national and community level to planning for reduction, readiness, response, and recovery, and managing central government response and recovery functions for large scale events.

“Tephra” is published annually by MCDEM to improve understanding of New Zealand’s major hazards and provide information on how that information is applied in the civil defence emergency management environment in New Zealand. The 2001 and 2003 issues covered flood hazards.

(b) Ministry for the Environment

The Ministry for the Environment (MfE) provides guidance for and promotes best practice for dealing with hazards in regional and district plans and policy documents.

MfE funded a report on Floodplain Management Planning Guidelines completed in 2001 (Berghan and Westlake, 2001) and is currently leading a two-year work programme to improve how New Zealand manages its flood risk and river control. This is expected to be completed by late 2006.

(c) Earthquake Commission

The Earthquake Commission (EQC) insures residential land (but not houses or contents) against storm or flood damage for those home owners who hold fire insurance. EQC will contribute to the cost of removing flood debris from under and around homes, and will cover damage to retaining walls, bridges or culverts within 60m of a house.

(d) Wellington Region Civil Defence Emergency Management Group

Greater Wellington and the region's eight city and district councils make up the Wellington Region Civil Defence Emergency Management (CDEM) Group. The CDEM Group advocates risk reduction and readiness for flood hazards and is responsible for coordinating response and recovery activities in a major flood event.

Members of the Wellington Region CDEM Group receive Severe Weather Warnings and Watches from the MetService.

(e) National Institute of Water and Atmospheric Research

The National Institute of Water and Atmospheric Research (NIWA) receives Foundation for Research, Science and Technology funding for several programmes involving flood hazard research. Research areas include forecasting the occurrence and predicting the effects of floods, mesoscale data collection and weather prediction, and modelling weather systems.

(f) MetService

MetService gathers, analyses and disseminates weather information. MetService issues a Severe Weather Warning when >50mm of rain is expected in a widespread area within the next 6 hours or >100mm of rain is expected in a widespread area within the next 24 hours. A Severe Weather Watch is generated if >50mm of rain in 6 hours or >100mm of rain in 24 hours is expected to occur 24 to 72 hours into the future. These messages are disseminated to CDEM groups.

5. Landslides

5.1 State

The region's geology, tectonic setting and climate make it particularly prone to landslides. Landslides in the region are generally triggered by earthquakes or, more commonly, by intense or prolonged rainfall.

While most landslides may ultimately be triggered by earthquakes or rainfall, the underlying cause is often human-induced: development and modification of slopes in

the region, particularly in steeper areas, can create or exacerbate slope instability. Natural causes of landslides include zones of weakness in rock material and river erosion/undercutting.

5.1.1 The last ten years

Most landslides in the region over the last ten years have been triggered by intense or prolonged rainfall. There have been no reported deaths or injuries from landslides.

Significant landslide events within the region (involving widespread slipping, property damage and/or evacuations) between 1997 and 2005 are given in Table 5.1. A list of all known landslide events in the region between 1996 and 2005, including smaller localised events, is given in Table 5.2.

Date	Effects	EQC claims	EQC paid
14 October 1997	Landslide in Upland Road, Kelburn after heavy rain. Houses damaged and three houses evacuated. Caused by excavation of slope.	95 (incl flood damage)	$256,000 (incl flood damage)
26 June 1998	Landslides in central Wellington after heavy rain. Properties damaged and people evacuated from Thorndon and Oriental Bay.	106	$392,000
2 July 1998	Numerous landslides around Wellington after heavy rain. SH1 and SH2 and Wellington hill suburbs affected.	127	$193,000
20/21 October 1998	Widespread landslides after heavy rain block, or partially block, many roads including Akatarawa, Paekakariki Hill, Rimutaka Hill, Tuapaka Hill and Otaki Gorge roads. SH1 and the main trunk rail line also affected at Kapiti.	<30	unknown
8 March 1999	Several large landslides (>10,000m^3) at Whatarangi Cliffs, Palliser Bay. Road and baches damaged. Trigger unknown but thought to be human-caused.	<30	unknown
21 July 2001	Numerous landslides after prolonged rain. Car damaged by a soil flow in Northland. Rockfall in Lower Hutt and SH2 partially blocked by landslides at Kaitoke Hill and south side of Rimutaka Hill.	<30	unknown
22 November 2001	Numerous landslides after heavy rain. One lane of SH2 closed at Melling after a rockfall. Landslides block roads at Kelson, Makara Road, Takarau Gorge Road, SH58, Grays Road and Paekakariki.	89	$461,000
10 January 2002	Landslides after heavy rain. Soil flow on The Terrace, three houses evacuated.	36 (incl flood damage)	$152,000 (incl flood damage)
9 September 2003	Landslides after heavy rain. House evacuated at Worser Bay, Seatoun after a large (~400m^3) soil slump, SH2 partially blocked on Rimutaka Hill.	<30	unknown
3 October 2003	Widespread landslides after intense rain. Debris flow at Paekakariki inundated a motel, houses, SH1 and the main trunk rail, and 20 homes evacuated. SH2 blocked by numerous landslides between Ngauranga and Petone. Numerous other landslides in the western Hutt hills, between Plimmerton and Pukerua Bay, Paekakariki Hill Road, Transmission Gully, SH58, Bulls Run Road (Upper Hutt), Blue Mountain Road and Rimutaka Road.	119 (incl 13 Oct)	$762,000 (incl 13 Oct)
13 October 2003	Widespread landslides after heavy rain. Roads closed in Wellington and the Wairarapa.		
11/12 February 2004	Widespread landslides after heavy rain. Roads closed in Wellington, Kapiti. Akatarawa and Rimutaka Roads blocked.	37 (11-17 Feb)	$225,000 (11-17 Feb)

14/15 February 2004	Widespread landslides after heavy rain. Roads blocked, or partially blocked, at SH58, Karori, Johnsonville, Gracefield Road, coastal Miramar, Karaka Bay, Korokoro, SH2 Normandale, eastern Hutt Road, Rimutaka Road, Akatarawa Road, Eastbourne cut off. Homes evacuated, garage undermined and car destroyed in Eastbourne, garage threatened on scarp in Korokoro, house at risk on scarp in Stokes Valley. Large soil slide (40,000m^3) at Te Marua blocked the Hutt River forcing it to flow through Te Marua golf course, causing significant damage.		
17 February 2004	House destroyed by landslide after heavy rain.		
18 August 2004	Widespread landslides after heavy rain. Landslides in Lower Hutt, Wainuiomata, Eastbourne, Breaker Bay. Homes threatened and damaged in Porirua and Days Bay. Homes evacuated in Wadestown. Johnsonville and Paraparaumu rail lines closed. Rimutaka Road closed.	270	$2,882,000
5/6 January 2005	Widespread landslides after heavy rain in Kapiti and Hutt Valley.	44	$231,000
30/31 March 2005	Widespread landslides in eastern Wairarapa hill country after heavy rain. Several debris flows in the Orongorongo Valley, one of which dammed the river forming a small lake behind.	unknown	unknown

Table 5.1: Major landslide events reported in the Wellington region between 1997 and 2005 (source: MetService, GeoNet, Earthquake Commission).

Date	**Effects**
11/12 July 1996	Heavy rain causes slips in southern Wairarapa, cutting off Ngawi.
7/8 October 1996	Roads closed by slips in Wellington after heavy rain.
17/18 June 1997	Roads closed and slips caused by heavy rain in Wellington.
30 July 1997	Soil slide in Ngauranga Gorge, trigger unknown, caused by excavation of slope, drains blocked and only two lanes open for northbound traffic on SH1.
14 October 1997	Landslide in Upland Road, Kelburn after heavy rain. Houses damaged and three houses evacuated. Caused by excavation of slope.
26 June 1998	Landslides in central Wellington after heavy rain. Properties damaged and people evacuated from Thorndon and Oriental Bay.
2 July 1998	Numerous landslides around Wellington after heavy rain. SH1 and SH2 and Wellington hill suburbs affected.
12/13 October 1998	Heavy rain. Large slip in Kelson allows sewerage leak into Hutt River, roads closed, traffic disrupted. Human causes compounded by groundwater flow
20/21 October 1998	Widespread landslides after heavy rain block, or partially block many roads including Akatarawa, Paekakariki Hill, Rimutaka Hill, Tuapaka Hill and Otaki Gorge roads. SH1 and the main trunk rail line also affected at Kapiti.
8 March 1999	Several large landslides (>10,000m^3) at Whatarangi Cliffs, Palliser Bay. Road and baches damaged. Trigger unknown but thought to be human-caused.
17 June 1999	Large slip on Paekakariki Hill blocks SH1 and main trunk rail line after wet weather.
28/29 November 1999	Heavy rain causes landslides and fallen trees in Wellington closing several roads.
1 October 2000	Several landslides at Kaitawa Road swingbridge, Otaki Gorge Road after prolonged rain, traffic on SH1 disrupted.
29 December 2000	Large rockslide (80,000 - 100,000 m^3) at the head of the Butcher's Creek in the Tararua Ranges after prolonged rain.
9-16 February 2001	Rockfall on eastern side of Rimutaka Hill Road after intense rainfall, one lane blocked.
February 2001	Large rock slide (1.5M m^3) at Arete Forks in the Tararua Ranges, trigger unknown, causing aggradation of the Waingawa River.
21 July 2001	Numerous landslides after prolonged rain. Car damaged by a soil flow in Northland. Rockfall in Lower Hutt and SH2 partially blocked by landslides at Kaitoke Hill and south side of Rimutaka Hill.
1 November 2001	Rockfall at Wadestown Hill, unknown trigger, one lane of road partially blocked.
22 November 2001	Numerous landslides after heavy rain. One lane of SH2 closed at Melling after a rockfall. Landslides block roads at Kelson, Makara Road, Takarau Gorge Road, SH58, Grays Road and Paekakariki.
6 December 2001	Landslide blocks road between Johnsonville and Makara, trigger unknown.
28 December 2001	Landslide on Ngawi Road, closing road, trigger unknown.
10 January 2002	Landslides after heavy rain. Soil flow on The Terrace, three houses evacuated.

16 January 2002	Landslide in the Takarau Gorge, trigger unknown, road closed, rockslide in Wadestown trigger unknown, one lane blocked.
June 2002	Landslide in Wadestown, unknown trigger, landslide on Blue Mountain Road, Upper Hutt.
11 June 2002	Landslide on Akatarawa Road after intense rain, road closed for six days.
early July 2002	Landslides on Akatarawa Road, Upper Hutt and west side of Rimutaka Hill Road partially blocking SH2.
19 July 2002	Landslide at Ngauranga Gorge.
15 July 2002	Landslide on SH2, Lower Hutt.
25 July 2002	Landslide on Marewa Road and Rimutaka Road.
31 July 2002	Landslide at Johnson Hill, Southern Wairarapa.
9 August 2002	Landslide on Paekakariki Hill Road.
15/16 August 2002	Landslides on Wadestown Road, Middleton Road (Johnsonville) and the main trunk railway between Plimmerton and Pukerua Bay.
11 November 2002	Landslide in Wadestown.
8 December 2002	Landslide in Northland after intense rain, closing the Northland Kindergarten for one day.
early February 2003	Landslide at South Ohau Hut, Tararua Ranges, trigger unknown, hut demolished.
10 June 2003	Landslide in Newlands after intense rainfall, backyard of two houses filled with debris.
1 July 2003	Rock slide/fall in Ngauranga Gorge after intense rainfall, blocking two lanes of SH1, one lane of SH2 also blocked between Ngauranga and Petone.
12 August 2003	Landslide on Miromiro Road, Lower Hutt, trigger unknown, road partially blocked.
28 August 2003	Heavy rain, landslides affect roads.
9 September 2003	Landslides after heavy rain. House evacuated at Worser Bay, Seatoun after a large (~400m^3) soil slump, SH2 partially blocked on Rimutaka Hill.
25 September 2003	SH2 between Ngauranga and Petone partially blocked for four hours after rock fall.
28 September 2003	SH2 eastern side traffic delayed due to small landslide after intense rain, traffic also delayed after landslide at Mt Bruce.
3 October 2003	Widespread landslides after intense rain. Debris flow at Paekakariki inundated a motel, houses, SH1 and the main trunk rail, and 20 homes evacuated. SH2 blocked by numerous landslides between Ngauranga and Petone. Numerous other landslides in the western Hutt hills, between Plimmerton and Pukerua Bay, Paekakariki Hill Road, Transmission Gully, SH58, Bulls Run Road (Upper Hutt), Blue Mountain Road and Rimutaka Road.
13 October 2003	Widespread landslides after heavy rain. Roads closed in Wellington and the Wairarapa.
26/27 November 2003	Eastern side of Rimutaka Hill Road partially blocked after heavy rain.
26/27 December 2003	SH58 partially blocked by small landslide after intense rain.
19 January 2004	Paekakariki Hill Road blocked by landslide after intense rain.
1 February 2004	Subsidence in Kelburn after intense rain damages walkway and threatens houses. Debris on road at York Bay, Mahina Bay.
11/12 February 2004	Widespread landslides after heavy rain. Roads closed in Wellington, Kapiti. Akatarawa and Rimutaka Roads blocked.
15 February 2004	Widespread landslides after heavy rain. Roads blocked, or partially blocked, at SH58, Karori, Johnsonville, Gracefield Road, coastal Miramar, Karaka Bay, Korokoro, SH2 Normandale, eastern Hutt Road, Rimutaka Road, Akatarawa Road, Eastbourne cut off. Homes evacuated, garage undermined and car destroyed in Eastbourne, garage threatened on scarp in Korokoro, house at risk on scarp in Stokes Valley. Large soil slide (40,000m^3) at Te Marua blocked the Hutt River forcing it to flow through Te Marua golf course, causing significant damage.
17 February 2004	House destroyed by landslide after heavy rain.
19 February 2004	Heavy rain, slips on Rimutaka Hill Road traps 20 vehicles.
22 February 2004	Prolonged rain, Rimutaka Hill Road closed due to several slips.
6 March 2004	Karapoti Road closed after prolonged rainfall.
mid-March 2004	Rock slide in Khandallah undermines house.
18-21 June 2004	Small slips in Ngaio Gorge after heavy rain partially blocks road, river bank erosion at Whakatiki Park, Upper Hutt, SH2 partially blocked near Rimutaka summit.
18 August 2004	Widespread landslides after heavy rain. Landslides in Lower Hutt, Wainuiomata, Eastbourne, Breaker Bay. Homes threatened and damaged in Porirua and Days Bay. Homes evacuated in Wadestown. Johnsonville and Paraparaumu rail lines closed. Rimutaka Road closed.
29 August 2004	SH2 between Wellington and Petone closed by several slips after heavy rain.
14 September 2004	Landslide after intense rain in Wadestown. Wadestown Road closed and buses cancelled. SH2 at Maungaraki reduced to single lane after landslide.
29 September 2004	Both lanes of Paekakariki Hill Road blocked by landslide.
early October 2004	Minor slips on roadcuts after intense rain, traffic delays on SH1 at Pukerua Bay after landslide, several minor slips on road cuts in Hutt Valley.
5/6 January 2005	Widespread landslides after heavy rain in Kapiti and Hutt Valley.
30/31 March 2005	Widespread landslides in Eastern Wairarapa hill country after heavy rain. Several debris flows in the Orongorongo Valley, one of which dammed the river forming a small lake behind.

Table 5.2: Reported landslides in the Wellington region between 1996 and 2005 (source: MetService, GeoNet).

5.1.2 Putting the last ten years into context

Ten years of rainfall-triggered landslide data is a fairly good reflection of the rainfall-triggered landslide hazard, being medium-high frequency/low-medium impact events. A rainfall-triggered landslide event occurs in the region on average 7 times per year, with major rainfall-triggered landslide events occurring about twice per year. This type of event generally involves widespread and numerous small (<10,000 m^3) soil/colluvium slides and flows.

Earthquake-triggered landslides, however, are not represented in the last ten years of data - these are generally low frequency/high impact events. Strong earthquake shaking of Modified Mercalli intensity[5] XIII and above is likely to generate large (>100,000 m^3) bedrock landslides throughout the region (Hancox et al, 1997). This intensity shaking is expected in the region every 170 years on average (Warwick Smith, pers comm).

For example, the 1855 Wairarapa earthquake triggered landslides over 20,000 km^2 in the southern North Island. These included a 5 million m^3 landslide in the southern Rimutaka Ranges and a 11 million m^3 landslide at Kopuranga that blocked the Ruamahanga River. A lake formed upstream of the landslide dam and later overtopped it.

Figure 5.1 shows the earthquake-triggered landslide susceptibility for metropolitan Wellington developed by Greater Wellington in 1995. The degrees of susceptibility are mainly based on slope angle and do not indicate slopes that *will* fail during an earthquake, but rather those that are more likely to. Although based on earthquake-triggered landslide susceptibility the map also indicates areas susceptible to rainfall-triggered landslides.

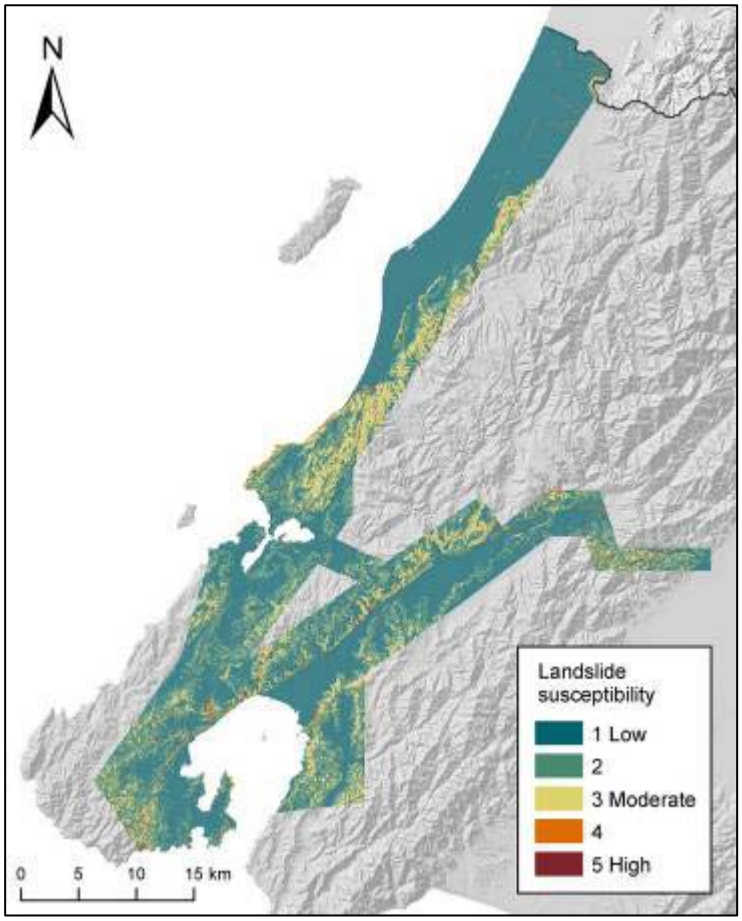

Figure 5.1: Earthquake-triggered landslide susceptibility map of the metropolitan Wellington area.

The areas most susceptible to landslides are steep, unsupported cuts along the Hutt motorway, Ngauranga Gorge, and Haywards and Rimutaka Hill roads. Similar cuts in metropolitan hill suburbs are also sensitive, as are areas of steep coastal slopes, fault scarps, steep river terraces and quarry slopes.

Much of the eastern and coastal Wairarapa hill country is prone to slumps and shallow soil slips. A study of landslide and rainfall records for the Wairarapa indicates that widespread landsliding occurs when daily rainfall exceeds 120mm. These events are expected in the eastern Wairarapa hill country every four to 12 years, with smaller landslide events every one to three years (Glade, 1998).

Debris flows, such as the Paekakariki event in October 2003, have historically been uncommon in the region.

5.2 Pressure

One of the most common underlying causes of landslides is human modification and destabilisation of slopes. For example, more than two thirds of the 74 landslides reported in the region during the February 2004 storms happened on slopes already weakened by earthworks.

Continued development and modification of land, particularly on steep slopes, will increase landslide susceptibility. Future development in steep areas must be carefully managed.

In terms of landslide triggering events it is unlikely that there will be variations in the frequency and magnitude of strong ground shaking over the long term. However, natural climate variations (such as the El Niño Southern Oscillation (ENSO), the Interdecadal Pacific Oscillation (IPO)) have a measurable impact on local rainfall patterns in the region and hence rainfall-triggered landslide occurrence.

Human induced climate change is also likely to affect the occurrence and intensity of rainfall in the region (Tait et al, 2002). These rainfall variations are in turn likely to affect the occurrence of landslides in the region. If intense rainstorms do become more common then rainfall-triggered landslides will too.

The ENSO, the IPO and global climate change, and what these mean for rainfall patterns, are discussed in more detail in Section 4.2.

5.3 Response

There are many ways landslide risk can be mitigated. In many cases, good engineering can prevent or modify landslides. Steep areas susceptible to landslides can be avoided.

While readiness, response and recovery are still important components of landslide mitigation, we can be far more proactive in reducing landslide likelihood and impact in the first place compared to other natural hazards (such as earthquake ground shaking and tsunamis).

5.3.1 Greater Wellington

(a) Regional Policy Statement methods

There are two methods in the Regional Policy Statement for reducing the adverse effects of landslides:

Method 2 *The Wellington Regional Council will complete regional scale assessments of the various components of seismic hazard including … landslides … .*

Method 3 *The Wellington Regional Council will continue to identify and investigate the risks from slope instability with areas of greatest development or development potential within the Region.*

These methods pertain directly to Policies 1 and 5 of the Regional Policy Statement.

(b) Hazard investigations and information provision

A series of investigations were undertaken in the early 1990s into earthquake-triggered landslides in the Wellington region. This information was then compiled into a series of 1:50,000 earthquake-triggered slope failure maps in 1995 for Wellington, Porirua (including SH58), Kapiti, the Hutt Valley and SH2 from Upper Hutt to Featherston. The information on these maps was later combined with ground shaking, liquefaction and active fault maps to create the combined earthquake hazard maps in 1996.

Landslides and erosion were considered in a report commissioned by Greater Wellington into the potential impacts of climate change in the region (Tait et al, 2002). A landslide hazard fact sheet was produced by Greater Wellington in 2003.

(c) Utility services

Two risk assessments have been completed for Greater Wellington's Utility Services for potential earthquake-triggered landslide damage to water mains at Haywards Hill and the Orongorongo and Big Huia water mains (Brabhaharan and Fleming, 1999a; Brabhaharan and Fleming, 1999b). Work is currently underway to realign the water main at Haywards Hill to reduce the risk from earthquake-triggered landslides.

(d) Regional plans

The Regional Soil Plan (2000) addresses the sustainable management of soil, vegetation disturbance activities and soil disturbance activities on erosion prone land - all factors which influence erosion and landslide susceptibility. The plan contains policies to promote land management practices that recognise the susceptibility of some landforms to erosion, to avoid, remedy or mitigate the adverse effects of soil disturbance and to regulate soil disturbance. Rules in the plan control roading and tracking, disturbing more than 1000 cubic metres of soil and clearing more than one hectare of vegetation.

(e) Soil conservation

Greater Wellington works with landowners to control soil erosion, particularly in the eastern Wairarapa, by helping to develop individual farm management plans. Greater

Wellington also monitors erosion, offers advice on soil management and stock rotation and subsidises the revegetation of eroded land.

5.3.2 Territorial authorities

Landslide hazards are generally dealt with at the territorial authority level through Building Act controls and s106 of the Resource Management Act.

No territorial authority in the region has specific rules to manage land use in landslide prone areas. However, all have rules to control earthworks in particular areas to ensure (among other things) that the potential adverse effects of landslides and erosion are not increased.

(a) Wellington City Council

The Wellington City District Plan contains policies and rules to manage earthworks. The Wellington City earthworks bylaw also requires earthworks to be designed, supervised and certified by an engineer. The bylaw also provides for the reduction of risks and adverse effects from earthworks including subsidence and slips.

(b) Hutt City Council

The Hutt City District Plan outlines policies to manage subdivision to ensure building platforms that will not be adversely affected by slope instability (including debris deposition), and to manage earthworks and vegetation clearance, including imposing conditions on vegetation clearance, topsoil removal, excavation and earthworks.

The Plan has rules to control the amount of vegetation removal in specified areas.

Hutt City Council commissioned a study of issues affecting land stability in Hutt City in 2004. The resulting report (Ian R Brown Associates Ltd, 2005) assesses whether Building Act controls and the Building Code are adequate to mitigate landslide hazards and whether more stringent controls should be imposed in some areas.

(c) Upper Hutt City Council

The Upper Hutt City District Plan contains policies to ensure that earthworks are designed and engineered in a manner compatible with the mitigation of natural hazards, and to avoid, remedy or mitigate soil erosion from earthworks or vegetation removal. The Plan has rules for managing earthworks and vegetation clearance.

(d) Porirua City Council

The Porirua City District Plan contains a policy to minimise the effects of slope failures, earthquake-triggered slope instability and landslides, and has rules to manage earthworks.

(e) Kapiti Coast District Council

The Kapiti Coast District Plan outlines slope failure as a natural hazard issue but has no landslide-specific policies. The Plan has rules for controlling earthworks on land steeper than 28 degrees.

Kapiti Coast District Council commissioned a report on the October 2003 Paekakariki debris flow which gave recommendations for future management (Ollivier, 2003).

(f) Wairarapa district councils

The draft combined Wairarapa District Plan identifies hill country erosion as a natural hazard issue. There are no landslide-specific policies or rules but there are provisions for controlling earthworks in specified areas.

5.3.3 Other organisations

(a) Ministry of Civil Defence and Emergency Management

The Ministry of Civil Defence and Emergency Management (MCDEM) is responsible for ensuring a co-ordinated approach at both national and community level to planning for reduction, readiness, response, and recovery, and managing central government response and recovery functions for large scale events.

"Tephra" is published annually by MCDEM to improve understanding of New Zealand's major hazards and provide information on how that information is applied in the civil defence emergency management environment in New Zealand. The 2002 issue covered landslide hazards.

(b) Wellington Region Civil Defence Emergency Management Group

Greater Wellington and the region's eight city and district councils make up the Wellington Region Civil Defence Emergency Management (CDEM) Group. The CDEM Group advocates risk reduction and readiness for landslides and is responsible for coordinating response and recovery activities in an event with widespread landsliding.

(c) Earthquake Commission

The Earthquake Commission (EQC) insures residential homes, land and personal belongings against landslide damage for home owners who hold fire insurance. Homes are insured to $100,000 and contents to $20,000.

EQC encourages landslide mitigation in New Zealand through brochures, school resource kits and special events.

(d) Institute of Geological and Nuclear Sciences

The Institute of Geological and Nuclear Sciences (GNS) runs a Foundation for Research, Science and Technology funded Geological Hazards and Society programme focussing on (among other things) factors that trigger landslides, rock mass characterisation and resilient construction practice. Planning guidelines for managing landslide hazards are also currently being developed as part of this programme.

GNS maintains a landslide catalogue for New Zealand and produces reports on major landslide events, including the 2003 Paekakariki debris flow (Hancox, 2003) as part of the EQC-funded GeoNet programme.

6. Coastal erosion

6.1 State

Coastal erosion is part of a natural cycle of sediment movement, and only becomes a hazard when buildings, roads and other assets are built too close to erosion-prone sites.

Much of our coast is hard bedrock, but softer sediments, such as the dunes at Castlepoint, Riversdale and the Kapiti coast, soft mudstone on the Palliser Bay coast and small areas within Wellington and Porirua Harbours, are prone to erosion.

6.1.1 The last ten years

Coastal erosion damage over the last ten years has been relatively minor on a regional scale. The most damage has occurred on the Palliser Bay coast where ongoing erosion has caused houses to topple into the sea and has rendered many uninhabitable. Erosion is also an ongoing problem for the road to Cape Palliser along this stretch of coast.

In 2005 a teenager was badly hurt when he walked out of the door of a house at Whatarangi in Palliser Bay that erosion had left hanging over a 20m drop.

6.1.2 Putting the last ten years into context

While the Palliser Bay coast has suffered the most coastal erosion damage over the last ten years parts of the Kapiti coast and the eastern Wairarapa coast require careful management to reduce coastal erosion risk over the long term.

6.2 Pressure

The desire for coastal property and the increasing value of coastal assets is increasing the potential impact of coastal erosion.

Both natural and human-induced future climate variations are likely to cause more erosion in already susceptible areas. The IPO is a decadal-scale oscillation in the ocean-atmosphere system that modulates the frequency of El Niño and La Nino phases of ENSO. Evidence suggests we are entering a new negative phase of the IPO which may result in more stormy weather and increasing frequency of coastal erosion events over the next 20 to 30 years (Watts, 2005a).

Global climate change will not only result in sea level rise, but may also cause changes in other coastal erosion drivers such as wave climate, storminess and other factors affecting coastal sediment supply (e.g. sediment input from rivers) (Tait et al, 2002).

6.3 Response

There is a range of available responses to coastal erosion. The mechanism for causing coastal erosion - meteorological and oceanographic processes - cannot be controlled but the erosion itself can be prevented or lessened.

Hard engineering options, such as building sea walls can be used to prevent or lessen erosion in specific locations. However, this may in fact exacerbate erosion further along the coast. Hard engineering is, therefore, becoming a less desirable option for coastal erosion management as the problem is often not solved but only shifted.

Other alternatives include dune renourishment and planting, and avoiding development in areas prone to coastal erosion. Doing nothing to prevent or avoid erosion is also a commonly taken option, but this requires evacuations and repairs when coastal erosion occurs.

6.3.1 Greater Wellington

(a) Regional Policy Statement methods

There is one method in the Regional Policy Statement for reducing the adverse effects of coastal erosion:

Method 4 *The Wellington Regional Council will identify those areas in the Region which are susceptible to coastal erosion and inundation. The work will concentrate on the areas of greatest development or development potential.*

This method relates to Policies 1 and 5 of the Regional Policy Statement.

(b) Hazard investigations and information provision

Greater Wellington produced a report on coastal erosion at Queen Elizabeth II Park in 1989 (Hastie, 1989) and then a general report on the characteristics of the coastal marine area for the region (Rosier and Hastie, 1992).

Since then specific studies have been carried out for Greater Wellington with South Wairarapa District Council on coastal erosion in Palliser Bay. A series of reports (Steel, 1993a; Steel, 1993b; Steel, 1994) examined coastal processes in Palliser Bay and possible erosion mitigation options between Te Kopi and Whatarangi cliffs.

A summary report into coastal hazards in the Wairarapa was produced by Greater Wellington in 2000 (Saunders, 2000c). The Wairarapa Coastal Strategy Hazards Technical Report (Barrow, 2002) also gives an overview of coastal erosion issues in the Wairarapa.

A fact sheet covering coastal hazards in the Wairarapa, including coastal erosion, was produced by Greater Wellington in 2004.

A review of coastal erosion issues and management in the region is currently being undertaken by Greater Wellington.

(c) Regional plans

The Regional Coastal Plan (2000) promotes beach nourishment as a mitigation method for coastal erosion and contains a policy and a rule to allow the deposition of material on the foreshore or seabed under certain conditions.

(d) Care groups

Greater Wellington has supported thirteen care groups through its "Take Care" project in restoring and rehabilitating degraded areas in the coastal environment. Care groups at Otaki, Paraparaumu, Days Bay, Island Bay, Castlepoint and Riversdale Beach have fenced off and replanted dunes with native sand binding grasses, like spinifex and pingao, to help curb dune erosion. Some of these groups are also supported by territorial authorities (Forsyth, 2005).

6.3.2 Territorial authorities

All territorial authorities in the region are to some degree vulnerable to coastal erosion except land-locked Upper Hutt City. Kapiti Coast, Masterton and South Wairarapa districts have the most significant coastal erosion issues.

(a) Wellington City Council

The Wellington City District Plan does not have any coastal erosion-specific policies or rules.

Wellington City Council produced guidelines on enhancement and restoration of the Wellington Coast from Owhiro Bay to Oriental Bay in 1997 (Bedard, 1997). This report records existing erosion problems and gives recommendations for coastal management.

(b) Hutt City Council

The Hutt City District Plan recognises coastal hazards as a natural hazard issue and contains a policy to adopt engineering, civil defence and land use control measures to reduce the vulnerability of coastal development.

The most erosion prone areas of the Hutt City coast are within the Significant Natural Resource Area within which land use and development requires consent. Seawall protection is provided in Muritai, for residential properties in Days Bay and for Eastern Bays Marine Drive.

(c) Porirua City Council

The Porirua City District Plan does not have any coastal erosion-specific policies or rules.

Porirua City Council commissioned a report into coastal erosion at Ngatitoa Domain in 1993 (Gibb, 1993) and more recently an assessment of management options for erosion at specific sites in Porirua (Beca Carter Hollings and Ferner Ltd and Coastal Consultants (NZ) Ltd, 2003).

(d) Kapiti Coast District Council

Kapiti Coast District Council is currently developing a coastal strategy to take a comprehensive and integrated approach to coastal management, including coastal erosion. A Coastal Erosion Hazard Management Study feeds into the development of the strategy and includes several reports:

- wave, tide, storm surge and sea level rise processes on the Kapiti coast (Lumsden, 2000a)
- beach profiling at Paraparaumu and Raumati (Lumsden, 2000b)
- strategies for managing coastal erosion hazards on the Kapiti coast (Lumsden, 2003) and a subsequent peer review (Shand, 2005).

A prior report outlining management strategies for Paraparaumu was also produced in 1997 (Lumsden, 1997).

A key output of the Coastal Erosion Hazard Management Study will be the resetting of the building set back line in the Kapiti Coast District Plan. No coastal protection works are being implemented while the Coastal Strategy is being completed, but beach renourishment and restoration programmes continue.

The Kapiti Coast District Plan recognises coastal erosion as a significant issue for the district and contains policies to:

- discourage development in areas which may be prone to coastal erosion
- control the location of residential buildings in areas subject to coastal erosion
- discourage coastal protection works and encourage managed retreat and coastal renourishment
- ensure appropriate uses, zones and performance standards are developed for areas liable to coastal erosion
- avoid and/or mitigate the potential adverse effects of erosion when making decisions on new subdivision, use and development adjacent to the sea.

The Plan outlines coastal building line restrictions and requires relocatable buildings in specified zones.

(e) Wairarapa district councils

The draft combined Wairarapa District Plan delineates a Coastal Environment Management Area and a Foreshore Protection Area. The Plan has policies to not exacerbate coastal erosion risk within the Coastal Environment Management Area and to adopt a cautious approach to subdivision in the coastal environment where natural hazard risk is high. Rules are in place to control development within the Coastal Environment Management Area.

The Wairarapa Coastal Strategy, released in 2004, is a non-statutory document produced by Masterton, Carterton and South Wairarapa district councils and Greater Wellington. The Strategy provides a long-term vision for the Wairarapa coast and identifies coastal erosion as a major issue. The strategy covers issues, goals, policies and recommendations for coastal erosion management. Provisions from the Strategy may be built into the combined Wairarapa District Plan.

6.3.3 Other organisations

(a) Ministry for the Environment

The Ministry for the Environment (MfE) provides guidance for and promotes best practice for dealing with natural hazards in regional and district plans and policy documents.

The Climate Change Office of MfE has produced reports on the potential effects of climate change on coastal erosion in New Zealand.

(b) Department of Conservation

The Department of Conservation (DoC) is responsible for the New Zealand Coastal Policy Statement. This document "promotes the sustainable management of the natural and physical resources of the foreshore, seabed, coastal water and airspace from the high tide mark to the 12 nautical mile limit" (DoC website, 2005). The Policy Statement is the only mandatory national policy statement under the Resource Management Act and outlines policies for avoiding or mitigating the effects of natural hazards in the coastal environment.

The New Zealand Coastal Policy Statement was released in 1994 and a review of its ability to address coastal issues was released in 2004. This review included a report assessing the Policy Statement's effectiveness in promoting sustainable coastal hazard management (Jacobson, 2004). The report "recommends more specific policies that recognise and address the particular challenges of coastal hazard management, and draws attention to the many barriers to sustainable coastal hazard responses" (DoC website, 2005).

(c) Wellington Region Civil Defence Emergency Management Group

Greater Wellington and the region's eight city and district councils make up the Wellington Region Civil Defence Emergency Management (CDEM) Group. The CDEM Group advocates risk reduction and readiness for coastal erosion and is responsible for coordinating response and recovery activities in a large scale coastal erosion event.

(d) National Institute of Water and Atmospheric Research

The National Institute of Water and Atmospheric Research receives Foundation for Research, Science and Technology funding for their "Physical Hazards Affecting Coastal Margins and the Continental Shelf" research programme. This programme involves projects on coastal erosion and sediment systems, hazards planning and awareness, and building resilient communities.

7. Severe wind

7.1 State

Climate and topography make the Wellington region especially windy. Westerly winds, turned south by the Tararua Range, are funnelled through the gap of Cook Strait to produce strong north or northwesterly winds in the western Wellington region. The Tararua Range also creates turbulent downwind waves in such conditions, delivering very high northwesterly winds to the Wairarapa.

Southerlies flow parallel to the main Wellington ranges and although they don't gust as strongly as northerlies average southerly wind speeds are higher.

7.1.1 The last ten years

Strong wind events over the last ten years are given in Table 7.1.

Date	Effects
17/18 March 1996	NW gales in Wellington, properties damaged.
27 May 1996	S gales, 5m swell in Cook Strait, average wind speed 110 kph, gusting to 130 kph.
1/2 June 1996	S gales and hail in Wellington, 9m swell in Cook Strait, fishing boat with two people on board lost.
11-13 June 1996	S gales in Cook Strait, Rimutaka Road closed by snow, hail in Wellington.
13/14 September 1996	N gales in Wellington.
7/8 October 1996	N gales in Wellington, damage to property.
12-14 October 1996	NW gales, roofs lifted off houses in the Wairarapa.
18-20 November 1996	NW gales in Wellington, gusts to 132 kph at Kelburn, 150 kph at Beacon Hill and 156 kph at Castlepoint. Roofs lifted off houses, boats blown from moorings, power/phone lines brought down, an elderly woman blown over and knocked unconscious with broken bones, furniture truck blown over and a carport destroyed.
26/27 November 1996	NW gales in Wellington, boat capsized off South coast, water spout in Wellington Harbour.
6 March 1997	S gales in Cook Strait, fishing boat washed ashore in Island Bay, Lynx ferry crossings cancelled.
19 April 1997	S gales in Wellington, three boats rescued by coastguard from Evans Bay.
2/3 June 1997	SE/S gales in Cook Strait, disrupted ferry services.
10 July 1997	N gales in Wellington.
4 August 1997	S gales, 6m swells in Cook Strait, ferries cancelled.
13/14 August 1997	NW gales in Wellington, house being moved blown over, hail in many places.
7/8 November 1997	NW gales fan a number of scrub fires in Wellington, trailer of truck blown over on Rimutakas.
11/12 November 1997	NW gales flip a car near summit of Rimutakas, flights delayed at Wellington airport, roof and window damage.
30 November 1997	NW gales, car accidents on the Rimutakas, flights disrupted at Wellington airport.
15/16 January 1998	NW gales in Wellington and the Wairarapa, roofs damaged in Featherston and one house blown off its piles, sailor rescued off Cape Palliser, Lynx ferries cancelled.
18/19 January 1998	NW gales over lower North Island, 122 kph gusting to 163 kph at Castlepoint.
23/24 February 1998	NW gales, boats blown off moorings, trees fallen.
28/29 March 1998	N gales, roofs lifted (incl Badminton Hall), flights disrupted, Lynx ferry cancelled, maximum gusts of 165 kph at Mt Kaukau, 139 kph at Beacon Hill and 144 kph at Castlepoint.
1 April 1998	NW gales, roofs lifted in Wellington, two vehicles blown over on the Rimutaka Hill Road, trees felled, windows blown in.
3 April 1998	NW gales in Wellington and the Wairarapa, truck blown over on Rimutaka Hill Road.
14 May 1998	S gales in Wellington.
27 May 1998	S gales, ferries cancelled due to 8m swells in Cook Strait.
31 May 1998	W gales over lower North Island, building "blown to bits" at Mount Bruce, planes unable to land at Wellington airport due to crosswinds, whirlwind at Waikanae moves onshore from the sea, destroying a conservatory.
2 June 1998	NW gales, warning for motorists on the Rimutakas.
22/23 July 1998	N gales, windows blown in in Wellington.

6 August 1998	NW gales over central New Zealand, gusts to 148 kph at Castlepoint.
16 September 1998	NW gales in Wellington, roof damage.
2/3 October 1998	NW gales in Wellington and the Wairarapa, warnings for motorists on the Rimutakas.
13 October 1998	NW gales.
18/19 October 1998	NW gales, windows blown in, boats broken from moorings, aircraft landings difficult, house damage in Hutt western hills, Rimutaka Road closed. Gusts of 120 kph at Wellington Airport, 166 kph at Beacon Hill, 183 kph at Castlepoint, 207 kph at Hau Nui wind farm, south of Martinborough.
27 October 1998	N gales in Wellington, roofs lifted and windows blown in.
1 February 1999	S gales, debris washed onto Eastbourne Road, vehicle blown over on Wanui Hill Road, 5m swells in Cook Strait, Lynx ferries cancelled.
27 February 1999	NW gales in Wellington, roofs lifted, trees blown over, boats blown off moorings, flights disrupted.
23 March 1999	NW gales cause damage in Wellington.
16/17 April 1999	NW gales, trees damaged, flights disrupted. Thunderstorms cause power cuts in Upper Hutt.
5/6 May 1999	S gales, container ship in Wellington breaks moorings, ferries cancelled, thunder and hail in Wellington, Metroliner struck by lightning on its approach to Wellington airport.
26 May 1999	NW gales.
26 July 1999	S gales, 5m swell in Cook Strait, ferries cancelled, snow on Rimutaka Road and Mt Bruce (SH2), and northeastern Wairarapa where there were power cuts.
21 September 1999	S gales, ferries cancelled, windows blown in, snow on Rimutaka Road.
28/29 November 1999	S gales, ferries cancelled, waves and debris thrown over Eastbourne roads, roofs lifted and windows blown in on south coast.
13/14 December 1999	S/SW gales, ferries cancelled.
13/14 March 2000	S gales, property damage, power cuts, ferries disrupted.
22 March 2000	S gales, disruption.
25 April 2000	S gales, 4.5m swells in Cook Strait, Lynx cancelled.
8 May 2000	NW then S gales, 5m swells in Cook Strait, Lynx cancelled.
2 June 2000	NW gales in Wellington, gusts to 120 kph at Kelburn, lightning affects power supply and marble to golf ball size hail reported in Wellington and the Wairarapa.
4 June 2000	S gales, ferries disrupted.
13 June 2000	S gales, boat blown ashore in Wellington, trolley bus wires downed.
18 June 2000	NW gales in the Wairarapa, roofs lifted, windows blown in, fences, trees and power lines brought down.
27 July 2000	NW gales over central New Zealand, roofs lifted in Wellington and the Wairarapa, Rimutaka Road closed, truck blown off road.
10 August 2000	NW gales, damage in Wellington.
2 October 2000	NW gales, damage in Wellington and the Wairarapa.
9 October 2000	Mini-tornado in Kapiti, property and trees damaged.
12/13 October 2000	S/SW gales in Wellington and the Wairarapa, gusts in Cook Strait of 161 kph, ferries cancelled, debris washed onto Eastbourne road, two overseas cruise liners had to shelter in Wellington harbour overnight.
19 November 2000	S gales, Wellington roads around south coast and Eastbourne flooded by sea.
29 November 2000	S gales, flights disrupted.
16 January 2001	NW gales in Wellington and the Wairarapa, gusts to 140 kph, roofs lifted, power lines downed, rail barriers blown away, boats broke their moorings, coast road at Seatoun blocked by debris, driving dangerous on Rimutaka and Wainuiomata Hill Roads.
27 March 2001	NW gales in Wellington, flights disrupted.
13 April 2001	S gales, heavy swell, ferries cancelled.
27/28 May 2001	S gales, ferries cancelled.
22 July 2001	S gales, ferries cancelled.
15 August 2001	S gales, gusting to 140 kph, power lines and trees downed, roofs lifted, ferries cancelled, flights disrupted.
10/11 October 2001	S gales, 8m waves in Cook Strait, ferries cancelled, flights disrupted, powerlines and trees downed and roofs damaged.
4 November 2001	S gales, fast ferries cancelled.
14/15 November 2001	S gales, fast ferries cancelled.
22 November 2001	S gales, fast ferries cancelled.
9 December 2001	S gales, fast ferries cancelled.
19 December 2001	S gales, fast ferries cancelled.
6 February 2002	S gales, 8m swell in Cook Strait, ferries cancelled, roads and properties flooded along south coast, three waterspouts spotted off the Otaki coast.
13/14 February 2002	S gales, fast ferries cancelled.
21 March 2002	NW gales in Wellington and the Wairarapa, warnings for vehicles on Rimutaka Road,

	glass blown from building in Wellington falls 21 stories onto car below.
30 March 2002	NW gales in Wellington and the Wairarapa, roads closed, roofing iron blown around.
2-4 April 2002	S gales, power lines blown down on Hutt Road, ferries cancelled/disrupted for three days.
29 April 2002	S gales, 7m swells in Cook Strait, ferries cancelled.
24 May 2002	S gales, fast ferry cancelled.
9 June 2002	NW gales, roofs damaged in Wellington.
11-15 June 2002	NW gales in Wellington and the Wairarapa, 135 kph at Castlepoint.
14/15 July 2002	S gales, ferries cancelled, ship holed in Wellington harbour while trying to dock.
4 August 2002	NW gales, scaffolding blown down in Wellington.
9 August 2002	S gales, ferries cancelled.
12 August 2002	NW gales, trees blown over and roofs lifted in coastal Wairarapa.
26 August 2002	S gales, ferries disrupted, hail and sleet in Wellington, snow on Rimutakas.
8-10 September 2002	NW gales, gusts over 130 kph in Castlepoint.
22 September 2002	NW gales in Wellington and the Wairarapa.
27 September 2002	NW gales in the Wairarapa.
3 October 2002	NW gales in the Wairarapa.
6 October 2002	S gales, ferries disrupted.
21 October 2002	W gales in the Wairarapa.
26 October 2002	W/NW gales in the Wairarapa
1 November 2002	NW gales in Wellington and the Wairarapa, roofs lifted, gusts to 130 kph at Kelburn.
2 November 2002	S gales.
5 November 2002	NW gales.
9 November 2002	NW gales in Wellington and the Wairarapa, gusts to 111 kph at Kelburn, 140 kph at Castlepoint.
10 November 2002	W/NW gales in Wellington and the Wairarapa, windows blown out, roofs damaged and powerlines downed.
19 November 2002	S gales in Wellington and the Wairarapa, some damage, ferries cancelled.
11-14 December 2002	NW gales in Wellington and the Wairarapa, driving dangerous on Rimutaka Road, gusts to 137 kph at Castlepoint, roofs lifted (one from a church in Wellington) and a shed blown away in Petone.
23 December 2002	NW gales in the Wairarapa, gusts up to 140 kph at Castlepoint.
19/20 January 2003	NW gales in Wellington and the Wairarapa, gusts to 146 kph at Castlepoint.
31 January 2003	NW gales in Wellington and the Wairarapa.
18/19 February 2003	NW gales in Wellington, gusts up to 110 kph at Kelburn, trees blown down damaging cars.
17/18 April 2003	S gales, ferries disrupted, driving dangerous on Rimutaka Road, sea spray on coastal roads.
24 April 2003	NW gales, gusts to 130 kph at Castlepoint.
30/31 May 2003	W gales, truck blown off Rimutaka Road.
9/10 June 2003	S gales, trees down and roofs lifted, winds at Beacon Hill 145 kph, Castlepoint 131 kph, flights disrupted, boats broke moorings in Wellington and Porirua Harbours.
30 June 2003	NW gales, trees felled, marble-sized hail in Upper Hutt damages property.
5 July 2003	S gales and heavy snow damage power lines causing power cuts in the Wairarapa.
15/16 July 2003	NW gales in Wellington and the Wairarapa.
14 September 2003	NW gales in Wellington and the Wairarapa.
18 September 2003	NW gales, SH2 closed near Mt Bruce after five trucks were blown over, trees felled, roofs lifted, power lines downed, windows blown in, fences toppled, flights diverted, damage to plots at Karori cemetery, gusts to 111 kph at Kelburn and 176 kph at Castlepoint.
25 September 2003	W gales in the Wairarapa.
2 November 2003	W/NW gales in Wellington and the Wairarapa.
7 Nomember 2003	NW gales in Wellington and the Wairarapa.
12 November 2003	NW gales gust to 144 kph at Castlepoint.
5/6 December 2003	NW gales in Wellington.
20 December 2003	NW gales in Wellington and the Wairarapa, newly constructed wall in Paraparaumu blown onto neighbouring restaurant.
24 December 2003	NW gales in Wellington.
26 December 2003	NW gales, Rimutaka Road closed to high vehicles and motorcycles.
9 January 2004	N gales, gusts to 150 kph, roofs damaged.
11/12 February 2004	NW gales, power cuts in Hutt Valley.
15 February 2004	S/SW gales, roofs lifted, trees felled, ferries cancelled, gusts to 167 kph at Beacon Hill, 178 kph at Mt Kaukau, Wellington airport closed.
19 February 2004	NW gale, gusts to 167 kph at Mt Kaukau.
21 February 2004	W/NW gales in Wellington and the Wairarapa, roofs lifted, trees felled (many in wet

	ground due to recent rain), gusts to 163 kph at Castlepoint and 181 kph at Mt Kaukau.
27 March 2004	NW gales, gusts to 135 kph at Castlepoint.
5 May 2004	NW gales, gusts to 120 kph at Kelburn and 135 kph at Castlepoint.
7 May 2004	NW gales, gusts to 131 kph at Castlepoint.
4 June 2004	NW gales, gusts to 155 kph at Beacon Hill, property damage, roofs lifted, trees felled, windows and doors blown in, glass doors destroyed, power pole forced into a car, two elderly women blown over, car blown off road near Mt Bruce in the Wairarapa, driving dangerous on Rimutaka Hill.
15/16 June 2004	NW gales in Wellington.
21 June 2004	W gales in the Wairarapa, gusts to 133 kph at Castlepoint.
30 June/1 July 2004	SSW gales, roofs lifted, trees felled, gusts to 131 kph at Castlepoint and 141 kph at Mt Kaukau.
18 August 2004	S gales severe in Wellington and coastal Wairarapa, gusts to 183 kph on Mt Kaukau (and Baring Head before the instrument broke), roofs lifted, trees and fences blown over, fallen power lines, fire service called out to hundreds of incidents, airport closed due to roof being blown off, ferries cancelled due to 14.5m swell in Cook Strait.
18 September 2004	NW gales in the Wairarapa, gusts to 130 kph at Castlepoint.
19 September 2004	Tornado reported in the Wairarapa.
22 September 2004	W/SW gales in the Wairarapa, gusts to 152 kph at Castlepoint.
27 September 2004	NW gales in the Wairarapa, gusts to 131 kph at Castlepoint.
30 September 2004	NW gales in Wellington, gusts to 133 kph at Kelburn.
13 October 2004	NW gales in the Wairarapa, gusts to 126 kph at Castlepoint.
17 October 2004	Thunderstorms and hail in the Wairarapa, tornado seen but it didn't touch the ground.
15 November 2004	W/NW gales in Wellington, roofs lifted, gusts to 124 kph on Mt Kaukau.
29 November 2004	W gales in the Wairarapa, trees felled, roofs lifted, power lines downed, gusts to 141 kph at Castlepoint.
5/6 December 2004	S/SW gales in Wellington and the Wairarapa, airport closed, ferries disrupted by 10-13m swells, roofs lifted, gusts to 140 kph on Mt Kaukau.
9/10 December 2004	W/SW gales in the Wairarapa, trees/powerlines downed, roofs lifted, sheds blown over.

Table 7.1: Strong wind events in the Wellington region 1996-2004 (source: MetService).

7.1.2 Putting the last ten years into context

Strong winds occur frequently in the region, so the last ten years are a good representation of the wind hazard. Damaging winds blow on average about once a month, disrupting transport (particularly ferry crossings), felling trees, power and telecommunication lines, and even lifting roofs.

Figure 7.1 shows the general variation in severe wind hazard across the region. The values are for wind at 10m above the ground and do not take into account local topographic effects (features like hills, gorges and vegetation can create very localised wind effects).

The windiest areas are generally the eastern Wairarapa coast – particularly Castlepoint and the area around Tora – followed by the southern Wairarapa and Wellington coasts. Localised strong wind effects are known to occur in areas such as Featherston, Mt Bruce and parts of the Rimutaka Road.

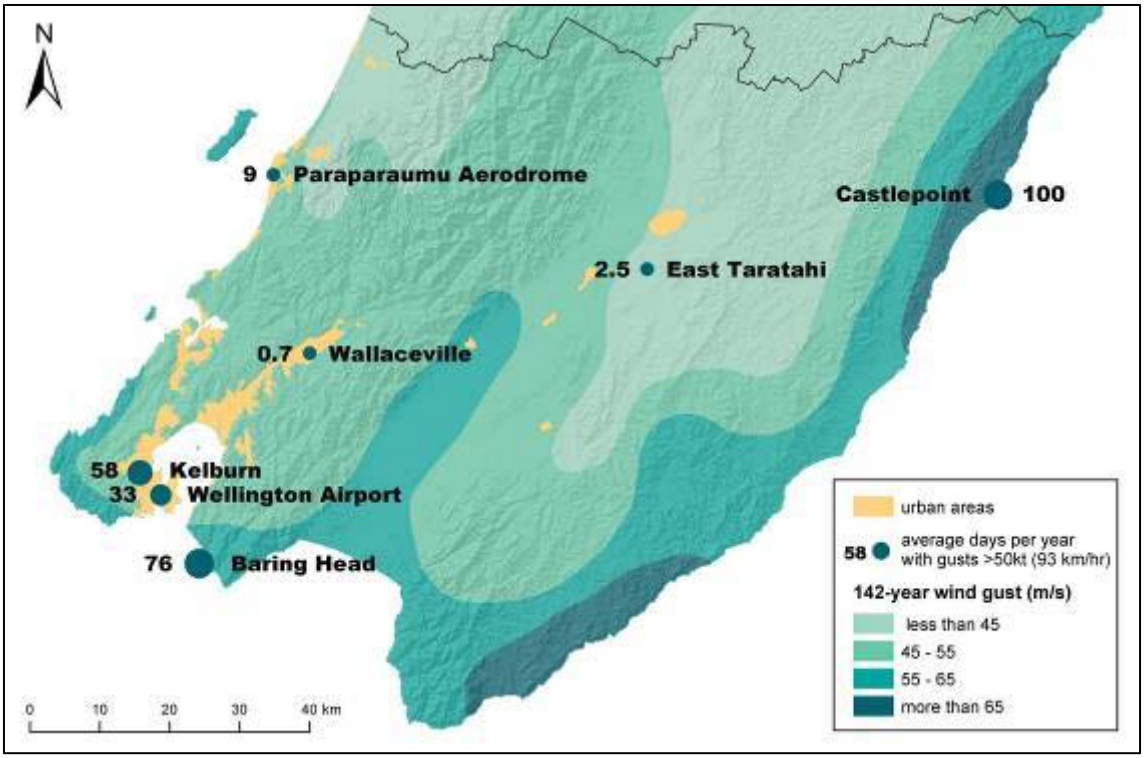

Figure 7.1: 1 in 142 year wind gust for the Wellington region (source: National Institute of Water and Atmospheric Research).

7.2 Pressure

Climate change may increase the frequency of westerly component winds across the region, but the increase in severe wind occurrence is unknown.

7.3 Response

Severe wind events cannot be modified although localised wind effects, such as wind tunnelling along high-rise streets like Lambton Quay, can be mitigated to a degree by good design. The effects of severe wind can be mitigated by appropriate construction standards for buildings and infrastructure. Readiness is also a key component of mitigating severe wind, particularly as these events can generally be predicted.

7.3.1 Greater Wellington

(a) Regional Policy Statement methods

There is one method in the Regional Policy Statement for reducing the adverse effects of severe wind:

Method 5 *The Wellington Regional Council will undertake a scoping study on the hazards of … severe wind …and set priorities for more detailed investigations of these hazards if the scoping study shows this to be warranted.*

This method relates to Policies 1 and 5 of the Regional Policy Statement.

(b) Hazard investigations and information provision

The severe wind hazard, and the possible impact of climate change on it, is included in a 2002 NIWA report produced for Greater Wellington on meteorological hazards (Tait et al, 2002).

A meteorological hazard fact sheet including some wind hazard information was produced by Greater Wellington in 2003.

7.3.2 Territorial authorities

The severe wind hazard is generally dealt with by territorial authorities through the Building Act and building consent process. However, both the Wellington City and Hutt City district plans identify local wind effects caused by buildings as an issue. Both plans contain policies and rules to ensure that buildings are designed to avoid, remedy or mitigate these effects.

7.3.3 Other organisations

(a) Ministry of Civil Defence and Emergency Management

The Ministry of Civil Defence and Emergency Management (MCDEM) is responsible for ensuring a co-ordinated approach at both national and community level to planning for reduction, readiness, response, and recovery, and managing central government response and recovery functions for large scale events.

"Tephra" is published annually by MCDEM to improve understanding of New Zealand's major hazards and provide information on how that information is applied in the civil defence emergency management environment in New Zealand. The 1997 and 2003 issues covered meteorological hazards, including severe winds.

(b) Wellington Region Civil Defence Emergency Management Group

Greater Wellington and the region's eight city and district councils make up the Wellington Region Civil Defence Emergency Management (CDEM) Group. The CDEM Group advocate risk reduction and readiness for storm events and are responsible for coordinating response and recovery activities in the event of a severe wind storm.

Members of the Wellington Region CDEM Group receive Severe Weather Warnings and Watches from the MetService.

(c) MetService

MetService gathers, analyses and disseminates weather information. MetService issues a Severe Weather Warning when widespread gales with a minimum wind speed of 90 km/hr, or frequent gusts exceeding 110 km/hr are expected. A Severe Weather Watch is generated if widespread gales with a minimum wind speed of 90 km/hr, or frequent gusts exceeding 110 km/hr are expected to occur 24 to 72 hours into the future. These messages are disseminated to regional and local civil defence emergency management.

(d) National Institute of Water and Atmospheric Research

The National Institute of Water and Atmospheric Research receive Foundation for Research, Science and Technology funding for several programmes involving severe wind hazard research. Research areas include developing mesoscale data assimilation and weather prediction capability and improving New Zealand's ability to mitigate and adapt to the effects of severe weather.

8. Wildfire

8.1 State

A wildfire is an unplanned blaze that starts in an open space, such as a gorse covered hillside or forest. A wildfire hazard is created when wildfire threatens lives, properties or areas with values that human hold important (i.e. areas of natural or cultural significance). Wildfires can be started naturally, such as by lightning strike, but are more commonly started by humans.

Wildfire spread depends on available fuel and oxygen, weather conditions and slope angle. Wildfires are most common between November and March when conditions are generally drier and temperatures higher.

8.1.1 The last ten years

There were 1,544 separate wildfire incidents in the region between July 1995 and June 2005 with a total of around 1460 hectares of land burnt. Figures 8.1 and 8.2 show the number of wildfires and areas burnt per year, and per rural fire authority.

There were particularly large numbers of wildfires during 1997-98, 2000-01 and 2002-03. This can generally be attributed to the hot and dry weather conditions during those summers.

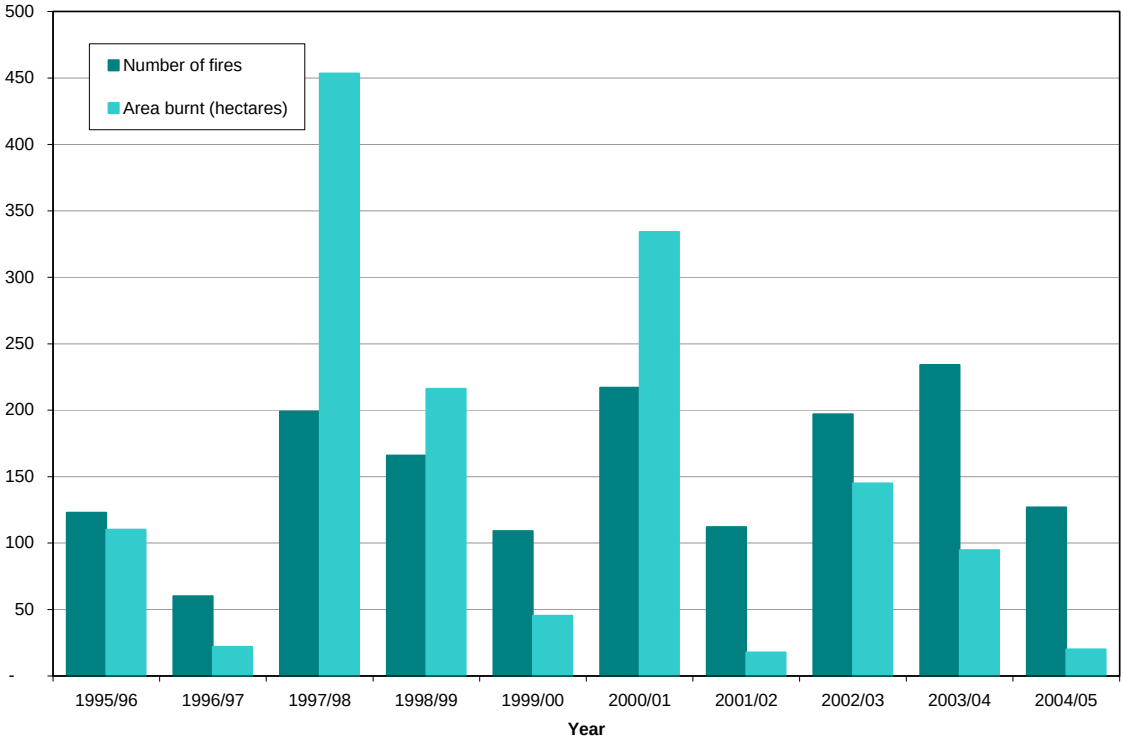

Figure 8.1: Number of wildfires and area burnt per year 1995/96 to 2004/05 (source: National Rural Fire Authority).

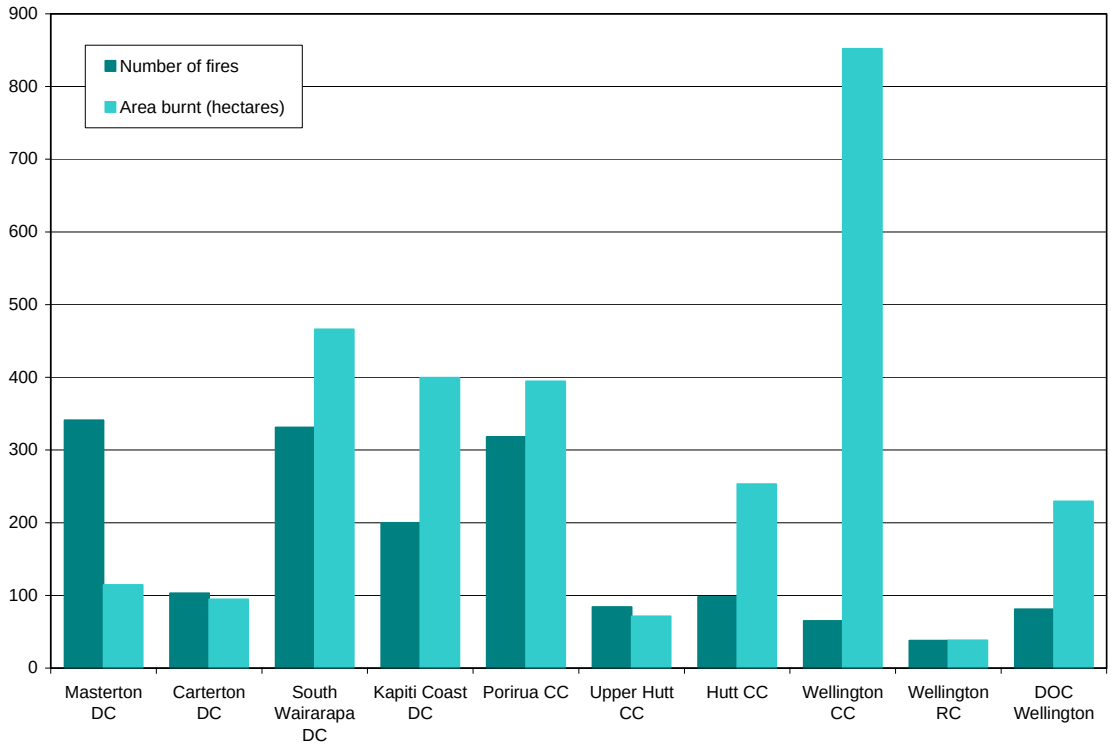

Figure 8.2: Number of wildfires and area burnt in each rural fire authority area between 1995 and 2005 (source: National Rural Fire Authority).

8.1.2 Putting the last ten years into context

Wildfires are relatively common events - the last ten years are fairly representative of the wildfire hazard. Around 20 per cent of land (165,500 hectares) in the region is at high to extreme risk from wildfire. This land is characterised by gorse and scrub vegetation, steep slopes, low rainfall and proximity to people.

The most at-risk areas are the southern and western edges of Wellington, the eastern Hutt hills and areas around Wainuiomata and Eastbourne. In the Wairarapa the eastern foothills of the Rimutaka and Tararua Ranges, the Cape Palliser coast and parts of the coastal eastern hills are most at risk.

On a national basis there is a general downward trend in the number of wildfires and area burnt. This is attributed to more public education, more volunteers and better equipment, a focus on developing better processes, and better cooperation between the National Rural Fire Authority and the New Zealand Fire Service.

8.2 Pressure

There is an increasing trend of people living on the rural/urban fringe, and on lifestyle properties. This increases the wildfire risk in two ways: by increasing the likelihood of fire ignition, and by increasing the potential consequences of wildfire.

Climate change may also impact on the likelihood of wildfire with a drier climate predicted for the Wairarapa.

8.3 Response

There are many available responses to the wildfire hazard. Wildfire control includes prevention, detection, control, restriction, suppression and extinction of fires.

8.3.1 Greater Wellington

(a) Regional Policy Statement methods

There is one method in the Regional Policy Statement for reducing the adverse effects of wildfire:

Method 5 *The Wellington Regional Council will undertake a scoping study on the hazards of … wildfire …and set priorities for more detailed investigations of these hazards if the scoping study shows this to be warranted.*

This method relates to Policies 1 and 5 of the Regional Policy Statement.

(b) Hazard investigations and information provision

Four reports have been prepared for Greater Wellington during the last ten years. These include a review of recent urban interface fires in the region (Forme Consulting Group, 1997a) and three interface fire hazard susceptibility studies for Wellington, the Hutt Valley (including Eastbourne and Wainuiomata) and Porirua (Forme Consulting Group, 1997b, 1997c, 1997d).

Wildfire hazard maps were created for the region in 1998 based on vegetation type, slope, rainfall and ignition sources (Forme Consulting Group, 1998).

A wildfire hazard fact sheet was produced by Greater Wellington in 2003 outlining the hazard facing the region and what can be done to minimise the wildfire risk.

8.3.2 Territorial authorities

No territorial authorities in the region identify wildfire as a natural hazard issue in District Plans. However, all territorial authorities in the region, along with the Department of Conservation, are rural fire authorities and are responsible for fire control within their jurisdictions.

Rural fire authorities are responsible for training and exercising a rural fire force, running education campaigns and maintaining fire breaks. Each rural fire authority must produce a written fire plan, reviewed yearly, that outlines fire control responsibilities and how these will be implemented. Rural fire authorities are also responsible for declaring fire seasons (open, restricted or prohibited) and for issuing fire permits.

All rural fire authorities in the region serve on the Wellington Rural Fire Committee along with the Fire Service, Federated Farmers, the New Zealand Forest Owners Association and Greater Wellington. The Wellington Rural Fire Committee produced a comprehensive report in 1996 on managing the wildfire hazard in the region (Wellington Rural Fire Committee, 1996).

8.3.3 Other organisations

(a) Department of Conservation

The Department of Conservation (DoC) is a rural fire authority and is responsible for preventing and controlling fires on public conservation land (national parks, conservation parks, and scenic, scientific and recreation reserves) and unoccupied crown land.

DoC occasionally produces reports on specific fires such as the two 1994 rural/urban interface fires in Karori (Fogarty, 1996).

(b) Wellington Region Civil Defence Emergency Management Group

Greater Wellington and the region’s eight city and district councils make up the Wellington Region Civil Defence Emergency Management (CDEM) Group. The CDEM Group advocates risk reduction and readiness for wildfires and contributes to response and recovery activities in the event of a major wildfire event.

(c) National Rural Fire Authority

The National Rural Fire Authority (NRFA) coordinates rural fire authorities at a national level. Its key responsibilities include encouraging and promoting effective fire control measures through national standards and fostering coordination between fire authorities. The NFRA also administers the Rural Fire Fighting Fund, the national fire

training programme, the collection of national rural fire statistics and research and interpretation of fire weather conditions.

The NFRA has a network of 150 remote automatic weather stations, the data from which is used with a Fire Weather Index System to calculate vegetation moisture and expected fire behaviour. This information is disseminated to rural fire managers and posted on the internet. The NRFA receives fire climate forecasts from NIWA and has commissioned them to produce a series of reports into climate and severe fire seasons. The NRFA also produces public education brochures.

(d) Ensis

Ensis, a joint venture between Scion (formerly the New Zealand Forest Research Institute) and the Australian Commonwealth Scientific and Industrial Research Organisation, runs a Forest and Rural Fire Research programme. This programme aims to predict where wildfires are most likely to start, to identify what fuels them, and to determine how rural fire managers can best fight them. Current projects within the programme are:

- fire behaviour modelling
- grassland curing
- fire climate
- tussock fire ecology
- New Zealand fire danger rating system, and
- technology transfer.

Ensis also produces Fire Research Bulletins, Fire Technology Transfer Notes and regular Fire Research Update newsletters.

9. Drought

9.1 State

There are numerous definitions of drought, but it generally describes an extended period of low rainfall causing hydrological imbalances. Drought becomes a hazard when people choose to live, and gain their livelihoods, in drought-prone areas and consequently suffer the adverse effects of low rainfall. These include water shortages or restrictions, crop failure, damage to horticulture, lack of feed and increase wildfire potential.

9.1.1 The last ten years

The last decade saw three serious droughts in the region. El Niño conditions in the 1997/98 summer, with predominant westerlies, mainly affected the Wairarapa. Only 30 to 50 per cent of normal summer rain fell on the eastern hills. The drought was thought to be the worst for almost 100 years in the eastern and central Wairarapa. Water restrictions were put in place and farmers were forced to sell stock.

The summer/autumn drought of 2000/01, associated with La Niña conditions, primarily affected the Wellington, Hutt and Kapiti areas and, to a lesser degree, southeast Wairarapa. The summer was the driest in Wellington City in almost 100 years, and the driest in Kapiti and the Hutt Valley for 70 and 60 years respectively. In Kapiti, water supplies were restricted and swimming pools were closed. Farmers sold stock and a total fire ban was enforced over the entire Wellington region.

The entire region experienced below average rainfall during the El Niño summer and autumn of 2002-03. Kapiti was the worst affected along with the Tararua Range and the Wairarapa valley. Rainfall between January and March 2003 was only 20-40 per cent of average in Kapiti and Porirua. Irrigation and water supply takes were restricted and Greater Wellington issued water shortage directions in some areas prohibiting water takes other than for domestic or stock use.

9.1.2 Putting the last ten years into context

Some degree of water shortage is likely to occur in Kapiti and Wairarapa during a normal summer. However, water shortage is only likely in the Wellington metropolitan area during a significant drought.

Research by Greater Wellington indicates a relationship between the Southern Oscillation Index and seasonal low rainfalls. For example, if El Niño conditions are present in spring then summer rainfall is likely to be below average in the Wairarapa.

Timely and accurate climate information is essential for those potentially affected by droughts in order to plan ahead. Soil moisture, rainfall, long range weather forecasts and seasonal climate outlooks can help farmers and water users plan. The efficient use of water for water supply, horticulture and agriculture is particularly important during droughts (although this should be promoted at all times).

9.2 Pressure

Medium and long term natural climate variations, such as the El Niño Southern Oscillation (ENSO) and the Interdecadal Pacific Oscillation (IPO) have a measurable impact on local weather patterns. The causes and impacts of these cycles are described in Section 4.2.

La Niña conditions, with predominant easterly/northeasterly flows, cause lower than average rainfall in Kapiti, the western and southern Tararua Range and the Rimutaka Range. This leads to low flows in the Otaki, Waikanae, Hutt, Wainuiomata and Orongorongo rivers. El Niño conditions, which enhance westerly flows, increase the probability of low summer rainfall in the Wairarapa (Watts, 2005a).

Evidence suggests we are entering a new phase of the IPO which is likely to result in weaker westerly flows over the next 20 to 30 years with more La Niña events. Effects for the Wellington region include increased probability of low flows in Kapiti, Hutt and central Wellington catchments, and decreased probability of drought in the Wairarapa during summer (Watts, 2005a).

The occurrence of drought is likely to be impacted by climate change, with the Wairarapa experiencing increased drought risk over the longer term (more than 50

years). This would be the result of higher temperatures, reduced mean rainfall, a change in rainfall distribution and more westerly winds (Tait et al, 2002).

9.3 Response

The available responses to drought are limited as the event itself cannot be modified. The effects of drought, however, can be mitigated to some extent by the effective management of water and other resources (such as stock feed).

9.3.1 Greater Wellington

(a) Regional Policy Statement methods

There is one method in the Regional Policy Statement for reducing the adverse effects of drought:

Method 5 *The Wellington Regional Council will undertake a scoping study on the hazards of … drought …and set priorities for more detailed investigations of these hazards if the scoping study shows this to be warranted.*

This method relates to Policies 1 and 5 of the Regional Policy Statement.

(b) Regional plans

The Regional Freshwater Plan (1999) identifies the conflict between availability of water and the desire for people to take water from aquifers and waterways as a water management issue.

Minimum flow abstraction restrictions and aquifer allocation limits are outlined in the Plan to maintain surface water flows and groundwater quantity. Water users are advised to have contingency plans in place for drought and consequent low flow restrictions.

The Plan policies also encourage land uses that do not have adverse effects of river flows or groundwater levels and encourage water conservation. Drought management plans providing contingencies for water supply management during drought are taken into account when considering public supply water take consent applications.

(c) Hazard investigations and information provision

Greater Wellington monitors the effects of natural climate variations and has undertaken research into predicting their impacts. Drought predictive models have been developed using the Southern Oscillation Index as an indicator of drought potential in the region (Lew, 1996b; Lew, 1996c; Lew, 1997; Harkness, 1999; Harkness, 2000).

These models require ongoing testing but at present provide the best method for advance drought warning. Drought warnings can alleviate some adverse effects of low rainfall by enabling water users and supply managers to plan for drought in advance.

NIWA completed a study for Greater Wellington in 2002 (Tait et al, 2002) which describes the potential impact of climate change on meteorological hazards, including drought, in the region.

(d) Utility services

A report was produced by Greater Wellington in 1996 outlining hydrological information and recommendations for water management (Lew, 1996d). This contributed to the development of a strategy for managing the metropolitan bulk water supply during droughts.

(e) Monitoring

Data is collected from a network of 48 automatic rainfall stations (42 Greater Wellington, 5 MetService and 1 NIWA) and 44 automatic river level monitoring stations (34 Greater Wellington, 9 NIWA, 1 joint Greater Wellington/NIWA). This data is monitored in order to provide drought warnings if necessary.

9.3.2 Territorial authorities

Drought is not identified as a natural hazard in any district plan in the Wellington region.

However, water bylaws are used by all territorial authorities within the Wellington region during summer to promote water conservation and to spread water demand. Restrictions generally only apply to garden watering and include rules for the number of sprinklers allowed and time periods during which they can be used.

Kapiti Coast District Council produced a water demand management document “Water Matters” in 2002 which outlines the Council’s approach to sustainably managing water resources in the district.

9.3.3 Other organisations

(a) Ministry for the Environment

The New Zealand Climate Change Office, a business unit within the Ministry for the Environment, is responsible for leading the development, coordination and implementation of whole-of-government climate change policy.

The Climate Change Office has commissioned reports on the impact of climate change New Zealand agriculture (Kenny, 2001) and more recently the impact on drought risk (Mullan et al, 2005).

(b) Ministry of Agriculture and Forestry

The Ministry of Agriculture and Forestry (MAF) informs, advises, regulates and delivers services relating to agriculture, forestry, rural affairs, biosecurity and food safety.

MAF distributes a booklet outlining drought recovery strategies prepared by Wrightson Ltd that provides basic information to help farmers evaluate options and make decisions before, during and after droughts. MAF also produces reports on the impact of droughts on New Zealand farm businesses.

MAF helps drought affected communities with livestock disposal, recovery coordination, labour assistance and deployment of Defence Force personnel to assist in water supply or supplementary feeding.

(c) Wellington Region Civil Defence Emergency Management Group

Greater Wellington and the region's eight city and district councils make up the Wellington Region Civil Defence Emergency Management (CDEM) Group. The CDEM Group advocate risk reduction and readiness for drought and contribute to response and recovery activities in the event of a severe drought.

(d) National Institute of Water and Atmospheric Research

The National Institute of Water and Atmospheric Research (NIWA) receives Foundation for Research, Science and Technology funding for a research programme to forecast the occurrence and effects of droughts in order to increase community resilience and minimise losses. Components of this programme include research on precipitation formation and distribution, and the development of relationships with other hazard management organisations.

NIWA produces monthly climate updates describing recent climate, river flow and soil moisture levels and giving outlooks for the following three months.

10. Volcanic eruption

10.1 State

There are no active volcanoes within the Wellington region. However, an eruption of Mt Taranaki, Mt Ruapehu or Mt Ngauruhoe could result in ash fall over the region causing damage and disruption.

10.1.1 The last ten years

The Wellington region has not been directly affected by ash fall in the last ten years. Ash from the 1995 and 1996 Mt Ruapehu eruptions was deposited over East Cape, Hawke's Bay and the Bay of Plenty by southerly and westerly winds. Given the lateral extent of these ash falls it can be assumed that the Wellington region would have been impacted by a ~1mm ash fall had winds been northerly at the time of the eruption. Although Wellington airport was not closed, flights between Wellington and other North Island towns were severely disrupted during these eruptions.

10.1.2 Putting the last ten years into context

Volcanic eruptions producing ash fall over the Wellington region are low frequency events and are not well represented in a ten year time frame.

Ash fall from distant sources has occurred within the region in the past. Ash layers preserved in the geological record in the Wairarapa indicate a 30mm thick ash deposit probably originating from an eruption around Taupo about 22,500 years ago. It is very

likely that there have been many smaller ash falls since then that have not been preserved in the geological record.

Calculating return periods for ash fall in the region is difficult due to variations in source location, eruption size and wind direction. Return intervals for the Wairarapa are estimated at 1300-1600 years for a 1-5mm ash fall from Mt Taranaki, and greater than 2000 years for a 0-2mm ash fall from Mt Ruapehu or Mt Ngauruhoe (Paterson, 2001). These estimates are based on the prevailing wind direction in the Wairarapa being northwesterly rather than northerly. Ash fall from a large prolonged eruption of Taupo or Okataina, near Rotorua, is likely to have a very long return period of thousands or tens of thousands of years.

Although it is unlikely, it is important that the impacts of ash fall over the region are considered and prepared for. Even a small amount of ash can have adverse effects: the impacts of a 1mm ash fall include irritation of lungs and eyes, airport closure, damage to vehicles, houses and mechanical equipment from fine abrasive ash, and possible contamination of water supplies.

10.2 Pressure

Long term changes in volcanic activity in the North Island are not anticipated. Further development in the Wellington region increases the potential impact of ash fall on the region.

10.3 Response

There are limited responses to volcanic ashfall. The event cannot be modified; mitigation measures are largely confined to response and recovery. The mitigation of volcanic ash fall in the Wellington region has been given a low priority due to the low risk it poses.

10.3.1 Greater Wellington

There are no methods given in the Regional Policy Statement to reduce the adverse effects of volcanic hazards.

A small desktop study of the volcanic hazard in the Wairarapa was undertaken in 2001 (Paterson, 2001). Return periods for ash fall were estimated based on a similar study commissioned by Hawke’s Bay Regional Council.

10.3.2 Territorial authorities

Volcanic ash fall is not identified as a natural hazard issue in any district plan in the region.

10.3.3 Other organisations

(a) Ministry of Civil Defence and Emergency Management

The Ministry of Civil Defence and Emergency Management (MCDEM) is responsible for ensuring a co-ordinated approach at both national and community level to planning

for reduction, readiness, response, and recovery, and managing central government response and recovery functions for large scale events.

Volcano warnings generated by GeoNet are received by the Ministry of Civil Defence and Emergency Management. These are then passed on to each regional CDEM Group.

"Tephra" is published annually by MCDEM to improve understanding of New Zealand's major hazards and provide information on how that information is applied in the civil defence emergency management environment in New Zealand. The 1995 and 2004 issues covered volcanic hazards.

(b) Ministry of Agriculture and Forestry

The Ministry of Agriculture and Forestry has produced a report investigating the impact of a volcanic eruption on agriculture and forestry in New Zealand (Neild et al, 1998) that provides information on the impacts of ash fall on pastoral agriculture, arable cropping, horticulture and production forestry.

(c) Wellington Region Civil Defence Emergency Management Group

Greater Wellington and the region's eight city and district councils make up the Wellington Region Civil Defence Emergency Management (CDEM) Group. The CDEM Group advocates risk reduction and readiness for volcanic eruptions and is responsible for coordinating response and recovery activities in the event of ash fall in the region.

Volcano warnings are generated by GeoNet and are received by the CDEM Group office at Greater Wellington via the Ministry of Civil Defence and Emergency Management. These messages are then disseminated to local emergency management officers in the areas likely to be affected.

(d) Earthquake Commission

The Earthquake Commission (EQC) insures residential homes, land and personal belongings against volcanic activity damage for home owners who hold fire insurance. Homes are insured to $100,000 and contents to $20,000.

EQC encourages preparedness for volcanic hazards in New Zealand through advertising, brochures, school resource kits and special events.

(e) Institute of Geological and Nuclear Sciences

The Institute of Geological and Nuclear Sciences (GNS) undertakes a wide range of research into volcanic hazards in New Zealand and its EQC-funded GeoNet project monitors volcanic activity at key sites around the North Island.

Volcanic surveillance is undertaken using seismic networks, GPS surveys, remote sensing, geochemical analysis and digital photography. Emergency Management agencies are notified if volcanic alert levels change. GNS have also developed volcanic ash fall models that can predict ash movement during an eruption so that responses can be implemented in affected areas.

11. General responses

11.1 Greater Wellington

11.1.1 Regional Policy Statement methods

There are ten non hazard-specific methods in the Regional Policy Statement for reducing the adverse effects of natural hazards. These are given in full in Appendix 1 and cover:

- Method 6: Reviewing climate change and effects on natural hazards
- Method 7: Making natural hazard information available
- Method 8: Assisting territorial authorities with local hazard assessments
- Method 9: Requiring assessment of natural hazards in Greater Wellington consent applications
- Method 10: Identifying risks to existing development
- Method 11: Implementing risk reduction measures
- Method 12: Preparing a five year communication strategy
- Method 13: Minimising risks to Greater Wellington assets, preparing contingency plans and having adequate insurance cover
- Method 14: Implementing natural hazard policies through Regional Plans
- Method 15: Advocating the use of District Plans for supply of information and consideration of natural hazards in land use planning.

11.1.2 Regional plans

The Regional Coastal Plan contains objectives to:

- reduce any adverse effects from natural hazards to an acceptable level
- not increase the risk from natural hazards from structures and/or activities in the coastal marine area beyond an acceptable level
- take account of natural hazards in the use and development of the coastal marine area
- not allow the use or development of structures in the coastal marine area where there will be significant adverse effects on the risk from natural hazards.

(The Regional Soil and Freshwater plans contain provisions to mitigate landslide /erosion and flooding/erosion hazards respectively.)

11.1.3 Hazard investigations and information provision

Most of Greater Wellington's hazard investigations are hazard-specific. However, we provide a lot of general hazard information. A general hazard fact sheet was produced in 2003 and we respond to day-to-day requests from the public for hazard information.

The hazards web pages on the Greater Wellington website contain information on natural and human-made hazards in the region along with the latest hazard news and the Hazards Online database.

The Hazards Online database was developed in 2003 and records over 500 natural hazard resources (reports, articles, maps, etc) relevant to the Wellington region. The

database includes resources from a number of agencies including Greater Wellington, territorial authorities, crown research institutes, universities and consultants, and is continually updated with new resources.

11.2 Territorial authorities

While all territorial authorities in the region contain some hazard-specific rules to implement natural hazard policies, they also use other regulatory and non-regulatory methods to reduce the adverse effects of natural hazards. These include:

- Building Act controls (including the use of s72 to allow building on hazard prone land)
- Resource Management Act controls (including the use of s106 to manage subdivision)
- recording information in a hazard register
- including hazard information in district plans
- providing information through Land Information Memorandums and Project Information Memorandums
- public education and preparedness campaigns, particularly as part of civil defence emergency management functions.

Some district plans contain general policies to mitigate the adverse effects of natural hazards - these are outlined below.

11.2.1 Wellington City Council

The Wellington City District Plan contains general natural hazard policies to:

- identify the hazards that pose a significant threat to Wellington and ensure that areas of significant potential hazard are not occupied or developed for vulnerable uses or activities

- ensure that the adverse effects of hazards on critical facilities and lifelines are avoided, remedied or mitigated

- ensure that the adverse effects of hazard on the natural environment arising from a hazard event are avoided, remedied or mitigated, and

- to require hazardous facilities to be located away from Hazard Areas.

Wellington City Council commissioned an integrated risk assessment for the city. The assessment includes a series of reports produced in between 2000 and 2003 incorporating liquefaction, tsunami, fault rupture, landslide hazards and estimating damage and loss figures for earthquake and fire related events.

11.2.2 Hutt City Council

All natural hazard policies in the Hutt City District Plan are hazard-specific and are outlined in previous sections.

11.2.3 Upper Hutt City Council

The Upper Hutt City District Plan contains general natural hazard policies to:

- provide for rural lifestyle subdivision which maintains the rural character and amenity values and avoids, remedies or mitigates the effects of natural hazards
- ensure that earthworks are designed and engineered in a manner compatible with … the mitigation of natural hazards
- identify and mitigate the potential adverse effects of natural hazards that are a potentially significant threat within Upper Hutt, and
- design and locate activities and buildings in areas of known susceptibility to natural hazards to avoid, remedy, or mitigate, where practicable, adverse effects of natural hazards on people, property and the environment.

11.2.4 Porirua City Council

Porirua City District Plan's natural hazard policies relate specifically to earthquake and flooding hazards and are outlined in the relevant sections of this report.

11.2.5 Kapiti Coast District Council

The Kapiti Coast District Plan contains general natural hazard policies to:

- ensure that land subject to natural hazards is subdivided so that all lots are capable of being used in such a manner that natural hazards can be avoided or mitigated and that suitable building sites can be identified for each lot created
- permit subdivision and development where the effects of natural hazards can be avoided, remedied or mitigated
- ensure services are designed to resist natural hazard events, and
- promote community awareness of natural hazards to encourage avoidance of adverse effects of hazards.

11.2.6 Wairarapa district councils

The draft combined Wairarapa District Plan contains general natural hazard policies to:

- control the location and design of land use and subdivision in identified natural hazard areas to avoid or mitigate adverse effects
- manage the type and location and design of new activities and development to avoid or mitigate the adverse effects of natural hazards
- ensure that where development occurs within natural hazard areas property owners and/or occupiers are informed of the risk

- raise awareness and educate people about the risks of natural hazards and prepared them for the occurrence of natural hazard events through the provision of information and advice

- ensure that activities and structures do not increase the risks to life, property and the environment from the effects of natural hazards

- manage activities within natural hazard prone areas to ensure they do not alter or exacerbate the intensity or scale of a natural hazard

- control the location and presence of hazardous substances in areas subject to natural hazards to ensure that there is no increase in the effects of the natural hazard risk to the community from hazardous substances, and

- adopt a cautious approach to new subdivision and development where the risks from natural hazards are likely to be high.

11.3 Ministry of Civil Defence and Emergency Management

The Ministry of Civil Defence and Emergency Management is responsible for ensuring a co-ordinated approach at both national and community level to planning for reduction, readiness, response, and recovery, and managing central government response and recovery functions for large scale events.

11.4 Ministry for the Environment

The Ministry for the Environment provides guidance for and promotes best practice for dealing with hazards in regional and district plans and policy documents.

Best practice yet to be developed for hazard management (coastal, water and land) for regional and district planning process.

11.5 Wellington Region Civil Defence Emergency Management Group

Greater Wellington and the region's eight city and district councils make up the Wellington Region Civil Defence Emergency Management (CDEM) Group. Released in May 2005, the CDEM Group Plan provides the context and direction for the region's civil defence emergency management. The Plan sets out a five-year work programme addressing areas such as public information and media management, communications systems, public education and debris disposal.

In an emergency, city and district councils are guided by their own standard operating procedures. Should a major disaster strike, the CDEM Group's job is to assess damage and needs, co-ordinate a response, and manage information through its Emergency Operations Centre.

11.6 Engineering lifelines groups

The Wellington Lifelines Group (WeLG) and the Wairarapa Engineering Lifelines Association (WELA) are voluntary associations of utility owners including power and telecommunications companies, water and sewerage providers, and transport infrastructure owners.

These two lifelines groups carry out hazard analyses and mitigation work to reduce vulnerability to natural hazards and to boost resilience during and after a disaster. WELA published the results of a major study of natural hazards, and the risk to lifelines in the Wairarapa, in 2003.

12. Information barriers

There is little information or statistics on hazard events and damages that have occurred over the last ten years. Reporting formats vary widely between different organisations, so even when information is available it may not be comparable with other, similar, information.

Good information was obtained from both the National Rural Fire Authority and the Earthquake Commission. In both cases data was able to be supplied for each wildfire, earthquake or landslide event and could be broken down by territorial authority (and therefore calculated for the region as a whole).

In comparison the Insurance Council was able to give damage amounts for specific events, e.g. “lower North Island floods” but these were not broken down by region or territorial authority so could not be used in this report.

There is a large amount of information on the likelihood and extent of natural hazards in the region. However, there is little information on the potential impacts of these natural hazards.

The assessment of risk is highly dependent on being able to access data, particularly consent information, from territorial authorities. This information was difficult to access for state of the environment reporting. This was mainly due to each territorial authority using a different system for recording consent information and these systems being mainly paper-based.

As a result of poor documentation highlighted during state of the environment reporting Greater Wellington now plans to collate both technical and impact information where possible when hazard events occur. It is hoped that this will assist in future state of the environment reporting and in future risk reduction and readiness activities.

13. Achieving our objective

There are fifteen methods given in the Regional Policy Statement for achieving the objective of reducing the adverse effects of natural hazards to an acceptable level. These methods are given in full in Appendix 1. Table 13.1 assesses the implementation of each of these methods.

Method	Implementation
Flood hazard assessments for major floodplains	Floodplain management plans are in place for the Hutt, Waikanae and Otaki Rivers and flood hazard assessments have been completed for some smaller rivers and streams.
Regional scale seismic hazard assessments	Seismic hazard assessments have been carried out for the developed areas of the Wellington region.
Identification of risks from slope instability	Earthquake induced landslide hazard investigations have been carried out for the developed areas of the western Wellington region along with SH 58 and SH 2 (Rimutaka Hill). This information can also be applied to rainfall triggered landslides.
Identification of coastal erosion and inundation susceptibility	There has been no single coastal erosion hazard investigation for the whole region. However, there have been numerous local coastal erosion investigations carried out at various scales (by both Greater Wellington and a number of territorial authorities).
Scoping studies for wildfire, severe wind, tsunami and drought	Wildfire analyses have been undertaken and wildfire hazard maps created. A regional analysis of severe wind hazard was included in a meteorological hazard report. A regional tsunami hazard scoping study has been carried out followed by a management options report. Drought predictive models, based on the Southern Oscillation Index, have been developed for the region.
Periodical review of climate change and effects on natural hazards	Developments in climate change predictions are monitored and a study into the effects of climate change on meteorological hazards in the Wellington region has been completed.
Information provision	Combined earthquake hazard maps have been produced for a general public audience. A series of hazard fact sheets have been produced. A database of hazard resources relevant to the Wellington region has been created (Hazards Online) and made available on the Greater Wellington website, along with the hazards web pages. Specific hazard information is also made available on request. Public education campaigns are also run through the Wellington Region Civil Defence Emergency Management Group.
Assist territorial authorities with local hazard investigations	Greater Wellington have assisted territorial authorities with detailed fault mapping projects, coastal erosion investigations, and local stream flooding hazard assessments.
Require assessment of natural hazards in GW consent applications	Natural hazards are assessed when processing Greater Wellington resource consent applications.
Identification of risks to existing development	Hazard investigations carried out have generally included an analysis of risks to existing development. Both flood hazard assessments and earthquake risk analysis in particular have measured risk to existing development.
Implementation of risk reduction measures	Flood risk reduction measures have been carried out including constructing stopbanks, channel maintenance and house raising. The Civil Defence Emergency Management Group have produced a Group Plan outlining operational and strategic arrangements for risk reduction.
Preparation of a five year communication strategy	A communication and marketing strategy has been developed. This function is now incorporated into the new Civil Defence Emergency Management Group arrangements.
Minimising of risks to GW assets, preparation of contingency plans and adequate insurance cover.	Essential and high priority services have been identified and plans put in place to ensure continuity. Gaps in insurance cover have been identified and are currently being addressed. Greater Wellington utility services (bulk water supply) have carried out numerous risk assessments and has undertaken a programme of strengthening and/or relocating bulk water supply infrastructure to reduce risk.
Implementation of natural hazard policies through Regional Plans	The Freshwater Plan became operative in 1999 and the Coastal and Soil Plans became operative in 2000.
Advocating the use of District Plans for supply of information for decision making, and consideration of natural hazards in land use planning.	All District Plans within the region contain provisions to address natural hazard issues. Effective natural hazard planning provisions in District Plans are advocated through the sharing of hazard information, recommendation of risk reduction measures and the submissions process.

Table 13.1: Implementation of Regional Policy Statement natural hazard methods.

While we are able to measure the achievement of our methods (and we have achieved most of them), it remains difficult to assess whether these methods have been successful in reducing the adverse effects of natural hazards in the region to an acceptable level. This is because an "acceptable level" of adverse effects from different hazards of different frequencies and magnitudes is often not defined. And without measurable and monitorable risk indicators it is difficult to tell whether the adverse effects are reducing or not.

14. Recommendations

The focus of hazard investigations over the last ten years has been hazard identification and analysis. While there is still a need for ongoing hazard analysis there must be a shift towards risk analysis where potential consequences are taken into account for different events (in nature and magnitude).

If we are to measure the success of our objective we must be able to measure our risk and monitor this over time. This involves developing risk indicators (e.g. the number of people or value of properties exposed to a particular magnitude hazard).

In the years ahead, Greater Wellington will also continue to work closely with city and district councils on local hazard investigations, and continue to advocate for appropriate land use through district plans.

A July 2005 survey showed that 80 per cent of residents in the Wellington region consider themselves very or quite well informed about hazards – up from 69 per cent the previous year. However, only 69 per cent have emergency water stored, 65 per cent have emergency food supplies, and just 26 per cent have a household emergency plan. Greater Wellington and the new CDEM Group need to continue their hazard awareness and preparedness education.

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Appendix 1 Regional Policy Statement natural hazard objective, policies, methods and anticipated environmental results

Objective

1. Any adverse effects of natural hazards on the environment of the Wellington Region are reduced to an acceptable level.

The Wellington Regional Policy Statement outlines five policies and fifteen methods for reducing the adverse effects of natural hazards in the Wellington Region to an acceptable level.

Policies

1. To ensure that there is sufficient information available on natural hazards to guide decision making.

2. To consider all of the following matters when planning for, and making decisions on, new subdivision, use and development in areas which are known to be susceptible to natural hazards:

   (a) the probability of occurrence and magnitude of the natural hazards, and the location of the effects including any possible changes which might arise from climate change.

   (b) the potential consequences of a natural hazard event occurring, both on-site and off-site. Potential loss of life, injury , social and economic disruption, civil defence implications, costs to the community, and any other adverse effects on the environment should be considered.

   (c) the measures proposed to mitigate the effects of natural hazard events, the degree of mitigation they will provide and any effects on the environment from adoption such measures.

   (d) alternative measures that might be incorporated into the subdivision, use and development to mitigate the effects of natural hazard events, the degree of mitigation they will provide and any effects on the environment from adoption such measure. Both structural and non-structural measures should be considered.

   (e) the benefits and costs of alternative mitigation measures

   (f) the availability of alternative sites for the activity or use

   (g) any statutory obligations to protect people and communities from natural hazards.

3. To recognise the risks to existing development from natural hazards and promote risk reduction measures to reduce this risk to an acceptable level.

4. To ensure that human activities which modify the environment only change the probability and magnitude of natural hazard events where these changes have been explicitly recognised and accepted.

5. To encourage people and communities to prepare for the occurrence of natural hazard events by providing them with relevant information and advice.

Methods

1. The Wellington Regional Council will complete flood hazard assessments on all major floodplains in the Region. The assessments will include an analysis of the potential effect of flooding events.

2. The Wellington Regional Council will complete regional scale assessments of the various components of seismic hazard including surface fault rupture, ground shaking, tsunami, liquefaction and ground damage, landslides and locally significant hazards.

3. The Wellington Regional Council will continue to identify and investigate the risks from slope instability within areas of greatest development or development potential within the Region.

4. The Wellington Regional Council will identify those areas in the Region which are susceptible to coastal erosion and inundation. The work will concentrate on the areas of greatest development or development potential.

5. The Wellington Regional Council will undertake a scoping study on the hazards of wildfire, severe wind, tsunami and drought and set priorities for more detailed investigations of these hazards if the scoping study shows this to be warranted.

6. The Wellington Regional Council will periodically review the current knowledge on climate change and possible effects on natural hazards.

7. The Wellington Regional Council will make information it has on natural hazards available to the people and communities of the Wellington Region.

8. The Wellington Regional Council will encourage and assist, where possible, territorial authorities to investigate natural hazards within their districts. These investigations should include flood hazard assessments for land in floodways managed by territorial authorities (including water courses managed by agreement with the Wellington Regional Council) and seismic hazard and landslip studies at a greater level of detail than provided for in the regional scale studies.

9. The Wellington Regional Council will, in situations where it is the consent granting authority, require applicants for resource consents to include, in their assessment of effects, the risks posed by natural hazards. The level of assessment should be appropriate to the potential consequences of the hazard and the location of the activity in relation to known natural hazards.

10. The Wellington Regional Council will use its information on natural hazards to identify the risks to existing development and ways in which these can be reduced.

11. The Wellington Regional Council will implement measures directly within its power to ensure risk levels are acceptable. The will involve the Council exercising its functions, powers, and duties under the legislation which governs its operations. The cost effectiveness of any measures much be acceptable to the Council.

12. The Wellington Regional Council will, in consultation with major regional civil defence responding organisations, territorial authorities and other interested parties, prepare a five year strategy to inform people and communities in the Region about the ways in which they can prepare for the occurrence of natural hazard events.

    In developing the strategy consideration will be given to:

    (a) The various means available to inform the public including advertising programmes, brochures, presentations to schools and interest groups, signs and the provision of reports;

    (b) The actions that people can and should take to prepare themselves for the occurrence of natural hazard events.

    (c) Funding implications

    (d) Identification of the appropriate agencies to implement the strategy.

13. The Wellington Regional Council will ensure that the risks from natural hazards to it own assets and operations are minimised. Where significant risks still exist, the Council will prepare contingency plans to ensure that essential operations can continue to function following a major natural hazard event. The Council will also ensure that, as far as practicable, it is covered by insurance against damaged from natural hazard events.

14. The Wellington Regional Council will implement natural hazards policies, as appropriate, through regional plans.

15. District plans would be an appropriate means of implementing Natural Hazards Policies 1 and 2.

Anticipated environmental results

1. The adverse environmental effects arising from natural hazards are minimised as far as possible.

2. Risks to existing subdivision, use and development are identified, and mitigation measures implemented where appropriate.

3. New development in hazard prone areas occurs only after explicit consideration of the natural hazard aspects of the proposals.

4. People and communities in the Region are better prepared to cope with the occurrence of natural hazard events.

Appendix 2 Modified Mercalli intensity scale

From Aitken (1999), simplified from Dowrick (1996).

I	Not felt in general.
II	Felt by people at rest or on upper floors of buildings.
III	Felt indoors, hanging objects may swing slightly.
IV	Felt indoors by many, dishes rattle, walls may creak.
V	Felt outside, sleepers wakened, some crockery broken, hanging pictures move.
VI	Felt by everyone, furniture moves, plaster cracks, some minor chimney damage.
VII	General alarm, difficult to stand up, damage to weak masonry buildings, small slides and rock falls, unrestrained water cylinders may move and leak, windows crack.
VIII	General alarm approaching panic, unreinforced chimneys fall, stone and brick walls damaged, possibly collapse, moderate landslides, ground cracks, liquefaction.
IX	Panic, serious damage to masonry buildings, some destroyed, many partially collapse, ground cracks, some houses shirt of their foundations.
X	General panic, wooden buildings seriously damaged, landslides widespread, rivers slop over banks, severe liquefaction.
XI	General panic, broad ground cracks, soils slumps, great damage to underground pipes, few buildings remain standing.
XII	General panic, total destruction, objects thrown up in the air.