Environment Waikato Technical Report 2009/34

Natural Hazard Risk Assessment

Otorohanga District

www.ew.govt.nz
ISSN 1172-4005 (Print)
ISSN 1177-9284 (Online)

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REGIONAL COUNCIL

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14 January 2009

Document #: 3060921

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Table of contents

Executive summary v

1 Introduction 1

1.1 Purpose 1
1.2 Background 1
1.3 Statutory and legal framework 2
1.4 National drivers for hazard management 2
1.5 Key hazard planning considerations 2

2 Profile of Otorohanga District 4

2.1 General description 4
2.2 Physical setting 5
2.2.1 Geology 5
2.2.2 Climate 6

3 Natural hazards in the Otorohanga District 7

3.1 Introduction 7
3.2 Current and previous research 7
3.3 River flood hazards 8
3.4 Coastal hazards 8
3.5 Earthquake hazards 9
3.6 Tsunami hazards 11
3.7 Volcanic hazards 11
3.8 Landslides 13
3.9 Subsidence (karst) 13
3.10 Debris flows 14

4 Risk Assessment 15

4.1 Introduction 15
4.2 Description of scenarios 15
4.3 Risk assessment methodology 16
4.4 Analysis and evaluation 16
4.5 Conclusion 17
4.6 Residual risks 18

5 Summary, discussion and recommendations 19

5.1 Summary of natural hazard risks 19
5.2 Discussion 19
5.3 Recommendations 19

6 References 21

7 Appendix 1: Statutory and legal framework 23

7.1 The Resource Management Act (RMA) 1991 23
7.1.1 Introduction 23
7.1.2 Long-term management strategies 23
7.1.3 Short-term management responses 23
7.2 Resource management policy statements 23
7.2.1 Introduction 23
7.2.2 Regional Policy Statement (RPS) 24
7.2.3 Otorohanga District Plan 24
7.3 Other hazard management statutes 24
7.3.1 Introduction 24
7.3.2 Civil Defence Emergency Management (CDEM) Act 2002 24
7.3.3 Soil Conservation and Rivers Control Act 1941 25

7.3.4 Local Government Act 2002 25
7.3.5 Local Government Official Information and Meetings Act 1987 (LGOIMA) 25
7.3.6 Building Act 1991 25
7.3.7 Reserves Act 1977 26

8 Appendix 2: ODC/EW RMA functions 27

9 Appendix 3: RMA Section 330 28

9.1 Provisions and discussion of Section 330 of the Resource Management Act 1991 28

As soon as practicable after entering any place under this section, every person must identify himself or herself and inform the occupier of the place of the entry and the reasons for it. 28

9.2 Further observations based on case law 28

10 Appendix 4: RPS & natural hazards 30

10.1 Policy One: Consistent Management of Natural Hazards 30

11 Appendix 5: Other work 31

11.1 Hydraulic modeling 31
11.2 LIDAR surveys 31
11.3 River flood risk management 31
11.4 Categorisation of flood risk 31

12 Appendix 6: Key to Table 2 (risk analysis evaluation key) 33

12.1 Measure of likelihood 33
12.2 Measure of consequence of impact 33
12.3 Risk analysis matrix – level of risk 33

13 Appendix 7: Proposed Light Detection and Ranging (LIDAR) Survey Programme 34

13.1 Background 34
13.2 Benefits 34

List of figures

Figure 1: Population distribution in the Otorohanga District 4
Figure 2: Otorohanga District and Wards 4
Figure 3: State highway network in the Otorohanga District 5
Figure 4: Comparison of the average climate across New Zealand 6
Figure 5: Flood hazards in the Otorohanga District 8
Figure 6: Otorohanga District coastal environment 9
Figure 7: Earthquake hazard classification for Otorohanga District 10
Figure 8: Maximum wave height following 2001 Peru tsunami 11
Figure 9: Most probable volcanic fallout across the Waikato Region 12
Figure 10: Landslide hazard assessment for Otorohanga District Council 13
Figure 11: Limestone geological formations in the Otorohanga District 14
Figure 12: Example of a stopbank being overtopped 18

List of tables

Table 1: Natural hazards research relevant to the Otorohanga District 7
Table 2: Risk analysis and evaluation 17

Executive summary

The purpose of this report is to provide an overview of natural hazards in the Otorohanga district as a basis for guiding and prioritising work activities by Otorohanga District Council (ODC) and Environment Waikato (EW) for 2009/10 and beyond. This report also provides a useful insight into the district's natural hazards as part of the scheduled review of the Otorohanga District Plan.

Both agencies have responsibilities for the management of natural hazards in accordance to a complex set of statutory responsibilities, but primarily via the Resource Management Act 1991.

Known natural hazards in the Otorohanga district are identified and explained. Hazard scenarios are defined for each natural hazard and existing risk management controls are outlined. A preliminary (qualitative) risk analysis is then undertaken, and an evaluation of the risk from each natural hazard is made as a basis for prioritising risks.

River flooding hazards pose the greatest risk in terms of potential loss of human life, social disruption, economic cost and infrastructure damage. Coastal flooding has the second highest risk, and land instability has the third highest risk.

1 Introduction

1.1 Purpose

This report provides an overview of the significant natural hazards currently affecting and likely to affect the Otorohanga District, including:

- An initial assessment of a range of existing natural hazard risks that affect the Otorohanga District.
- An initial qualitative risk assessment which identifies the risk to life and property in broad terms
- An identification of gaps and priorities
- A basis for developing effective District Plan provisions regarding natural hazards.

Both Otorohanga District Council (ODC) and Environment Waikato (EW) have ongoing natural hazards commitments in the District. This report presents an initial analysis for the key natural hazards and provides guidance to ODC and EW for the prioritisation of natural hazards work programmes within the Otorohanga District.

The key drivers that for the preparation of this assessment are:

- The review of the Otorohanga District Plan (including the identification of future District growth priorities).
- The review of the Central Government approach to river flood risk management, including the development of a New Zealand Standard.
- The review of the Regional approach to river flood risk management, including the development of a regional strategy.
- EW's commitment to working with District Councils during the district plan review process.

1.2 Background

ODC are currently undertaking a review of the Otorohanga District Plan. In accordance with the Waikato Regional Policy Statement (WRPS), this Plan includes planning provisions that cover the management of land-use to reduce the actual or potential impact of natural hazards.

Since the existing Otorohanga District Plan was prepared, there have been significant changes in the information that is available to describe natural hazards and the management approaches adopted to reduce their impact. It is therefore essential commentary regarding natural hazards information and management approaches are made available to ODC as part of the District Plan review process.

As a first stage in the provision of this information, it is necessary to prioritise the natural hazards that affect the Otorohanga District based on the available information. This report provides this prioritisation by way of a qualitative natural hazards risk assessment.

1.3 Statutory and legal framework

The Local Government agencies primarily charged with managing the natural hazards that affect the Otorohanga District are ODC and EW. This responsibility includes the development of policy and the implementation of strategies and mechanisms to avoid or mitigate the effects of hazards on people, property and the environment. Further details regard these responsibilities are presented in Appendix 2.

The statutory framework guiding EW and ODC is primarily determined by the Resource Management Act 1991. Other relevant statutes include the Local Government Act 2002, the Soil Conservation and Rivers Control Act 1941, the Land Drainage Act 1908, the Building Act 2005, the Public Works Act 1981, the Civil Defence Emergency Management Act 2002, and the Hauraki Gulf Marine Park Act 2000. Further discussion around the relevant provisions of these statutes is provided in Appendix 1.

Several national agencies also have a role in hazard management, including:

- Department of Conservation through the provisions of the New Zealand Coastal Policy Statement.
- Ministry of Civil Defence and Emergency Management through its enabling legislation.

1.4 National drivers for hazard management

There are several key drivers that influence the way natural hazards are managed in New Zealand, including:

- The general shift towards a more comprehensive risk management approach to managing natural hazards (e.g. the Central Government review of flood risk management).
- The Emergency management focus on hazard risk reduction, the treatment of residual risk and an all hazards approach
- Increasing community expectations for natural hazard management to be linked with other community outcomes.
- The impact of predicted future climate change on natural hazards, including the need to adapt existing risk reduction measures (e.g. flood protection schemes).
- Increasing development pressure on land that is affected by natural hazards.
- The damage that continues to be sustained by numerous New Zealand communities due to natural hazards.

1.5 Key hazard planning considerations

In addition to the statutory framework (refer to Section **Error! Reference source not found.**) and national drivers (refer to Section **Error! Reference source not found.**), there are a number of other considerations that are or will affect the management of natural hazards in the Otorohanga District, including:

- Continuing population growth in known natural hazard areas.
- The proximity of existing development to land affected by natural hazards.
- The growing number of Resource Consent applications covering the development of marginal land.

- The incorporation of predicted future climate change into research, planning and operations.

- Increasing property values, particularly in areas that are affected by one or more natural hazards.

- Translating Central Government risk management guidelines into effective policies using the Regional and District planning framework.

- The increasing demand from Central and Regional Government for land use planning controls to be incorporated into a risk reduction strategy.

- The Increasing awareness of the importance of lifelines infrastructure (e.g. roading, electricity and potable water).

- The existing reliance of some communities on physical works that are unlikely to provide the unconditional protection that is often sought.

- The importance of maintaining public awareness and understanding regarding the management of natural hazards.

2 Profile of Otorohanga District

2.1 General description

The Otorohanga District straddles the mid point of the Waipa River valley. It covers an area of approximately 2,000 km^2, incorporates the major townships of Otorohanga and Kawhia, and has population of around 9,000 (as at 2006).

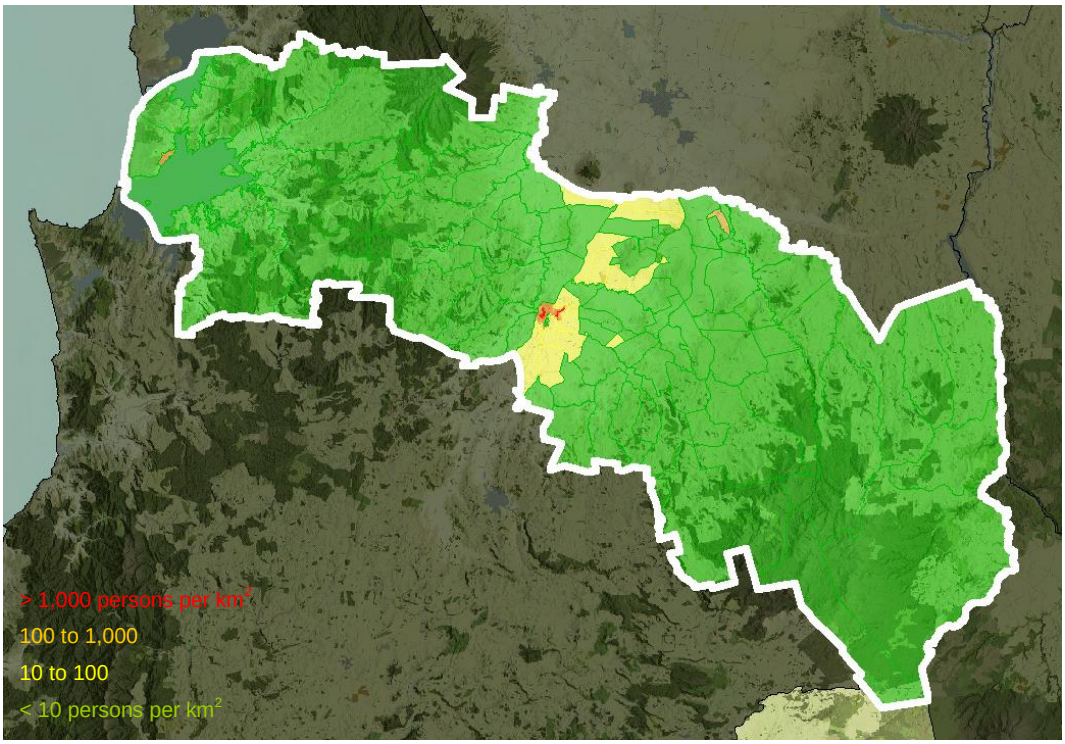

Figure 1: Population distribution in the Otorohanga District

Figure 1 shows that a majority of the Otorohanga District is centred around the Otorohanga urban area and the Waipa River valley.

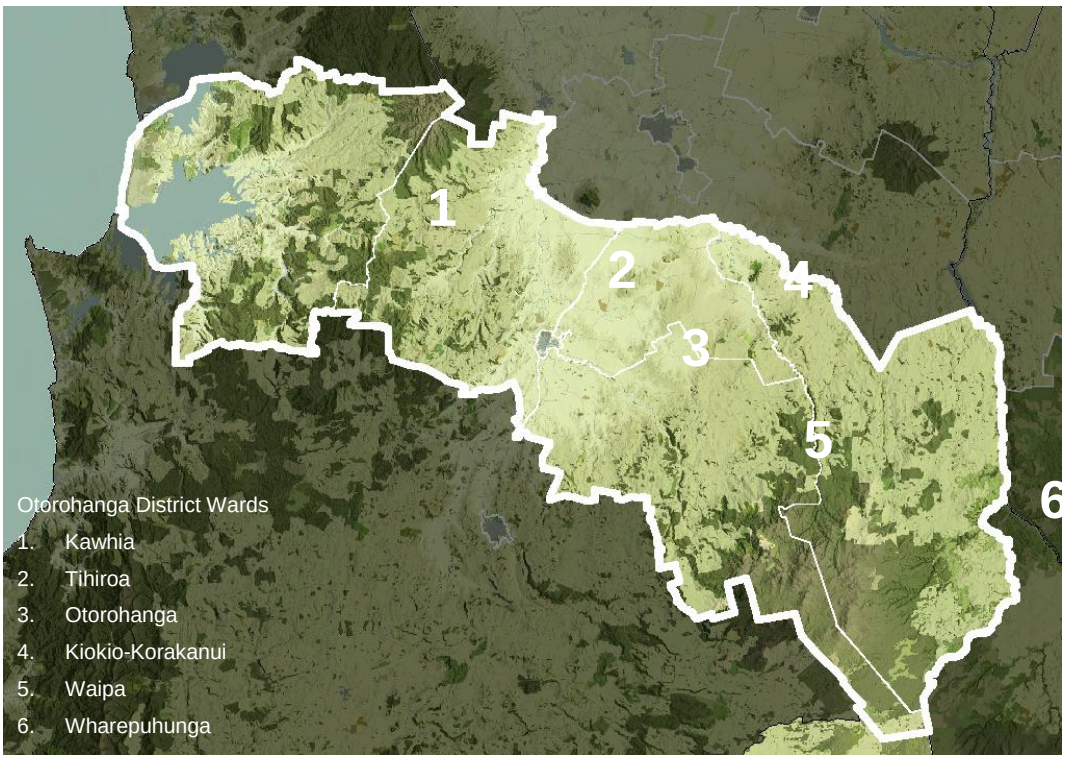

Figure 2: Otorohanga District and Wards

The district is also an important transportation corridor between the major cities (and ports) of Auckland and New Plymouth. Three State Highways run through it (SH31, SH39 and SH3) and provide an alternative north-south route when the Desert Road is impassable (refer to Figure 3).

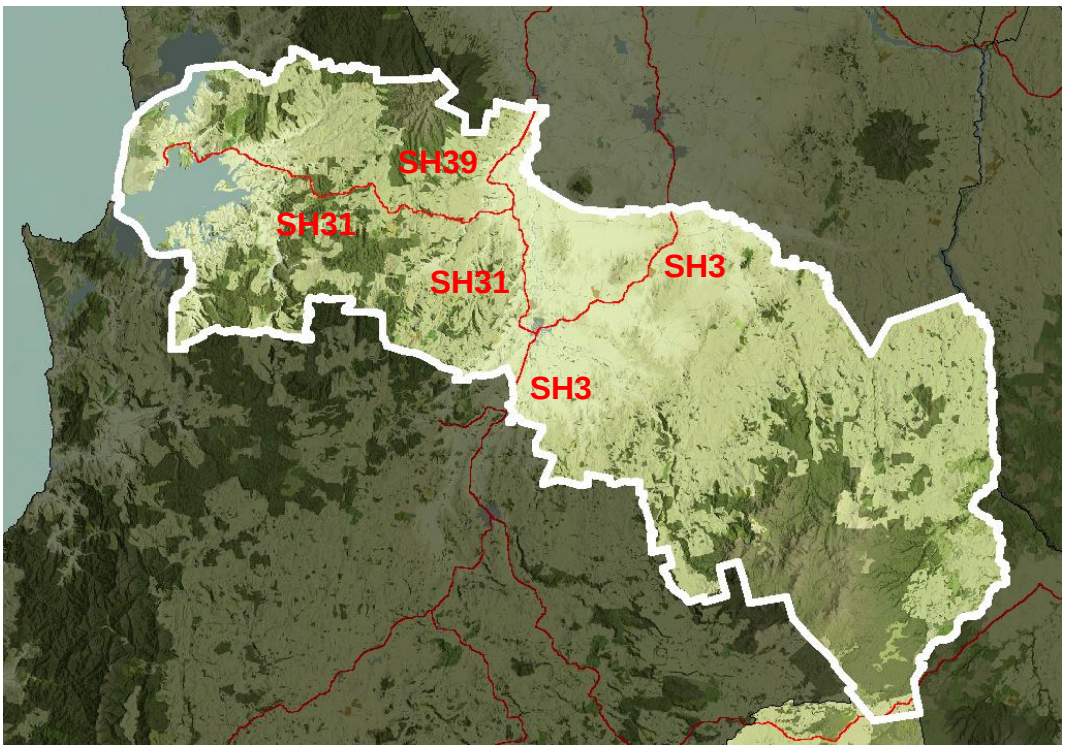

Figure 3: State highway network in the Otorohanga District

2.2 Physical setting

2.2.1 Geology

The Otorohanga District straddles the Waipa River valley and also extends to the west coast of the North Island. Consequently, the geology of the District is varied and ranges from fluvial and marine deposits on the lower lying land to bedrock in the hill country.

With regard to the management of natural hazards, there are several geological features in the Otorohanga District that are very relevant:

- Much of the lower lying geological units include a significant portion of material derived from volcanic fallout (refer to Section 3.7 for further discussion on the volcanic hazard that affects the District).

- Much of the coastal geological units consist of highly mobile marine sediments that result in a dynamic shoreline (refer to Section 0 for further discussion on the coastal hazards that affect the District).

- An interesting geological feature in the Otorohanga District is the presence of karst features. Karst includes a variety of distinctive and often spectacular surface and underground features formed predominantly by the dissolving action of water through limestone bedrock. The presence of karst in the Otorohanga District is particularly relevant to the management of natural hazards, as the creation of underground karst formations often (eventually) results in localised subsidence (refer to Section 3.9 for further discussion on the subsidence hazards that affect the District).

2.2.2 Climate

The Otorohanga District is located in what NIWA refers to as the 'Central North Island Climate Zone'. In general, this zone can be characterised by:

- Less wind due to the sheltering affect of high country to the south and east.
- A significant daily and seasonal variance in temperature due to the inland location of the zone.
- Cool and relatively unsettled weather during winter.

There is however likely to be a localised exception to this where the Otorohanga District approaches the coastline.

The average annual rainfall, temperature and sunshine for the Otorohanga District are presented in the following figures.

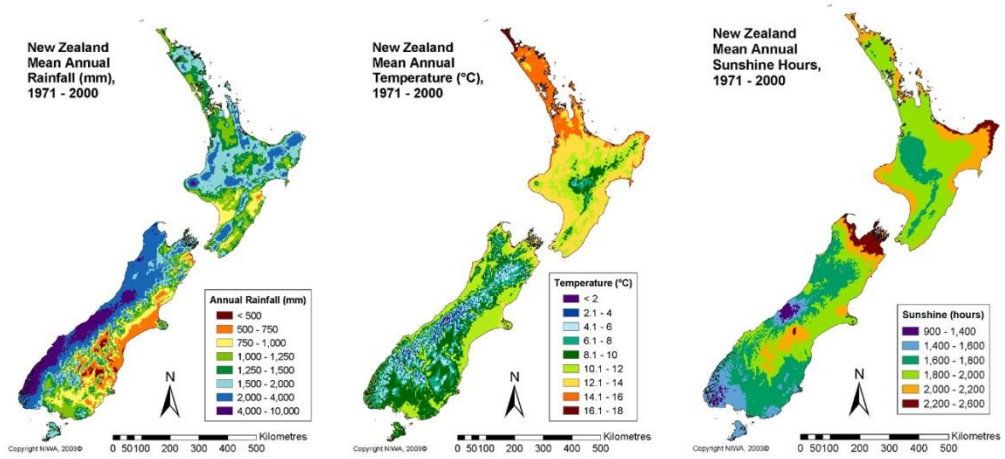

Figure 4: Comparison of the average climate across New Zealand

3 Natural hazards in the Otorohanga District

3.1 Introduction

The Otorohanga district is similar to many areas of New Zealand in that it is subject to a number of natural hazards. Our present understanding of natural hazards within the district stem from a number of sources including:

- Local knowledge and experience, particularly with river flooding, coastal flooding, and severe storm events.
- Detailed investigations of specific hazards.
- River flood engineering, mapping and surveying work
- General hazard studies such as earthquake risks
- The regional hazard risk analysis completed as part of the Civil Defence Emergency Management Group Plan.

Using this information, a comprehensive hazard analysis has been completed during the preparation of the Waikato Civil Defence Emergency Management (CDEM) Group Plan. This analysis, along with knowledge of past occurrences, identified the following natural hazards that were particularly relevant to the Otorohanga District:

- River flooding.
- Shoreline erosion.
- Land slides.
- Rural fire.
- Subsidence (karst).

In addition to the above natural hazards, it is also noted that New Zealand in general is subject to tectonic (earthquake), volcanic and severe storm hazards.

3.2 Current and previous research

Several research projects have been identified to improve the understanding of natural hazards in the Otorohanga District (refer to .

Table 1: Natural hazards research relevant to the Otorohanga District

Research project	Researcher	Year	Hazard
Earthquake Hazard Assessment for the Waikato Region	IGNS	1996	Earthquake
Volcanic Hazard Assessment for the Waikato Region	IGNS	1997	Volcanic
Land Susceptibility Mapping and Risk Assessment for the Waikato Region	UoW	1999	Landslides
Tsunami Project	NIWA	Ongoing	Tsunami
West Coast Hazard Project	EW	2007	Coastal

3.3 River flood hazards

Based on the comprehensive hazard analysis has been completed during the preparation of the Waikato CDEM Group Plan, the most common natural threat to the Otorohanga District is river flooding (refer to Figure 5). Accordingly, this natural hazard is discussed in detail in a separate memo (refer to WRC Document 1196845).

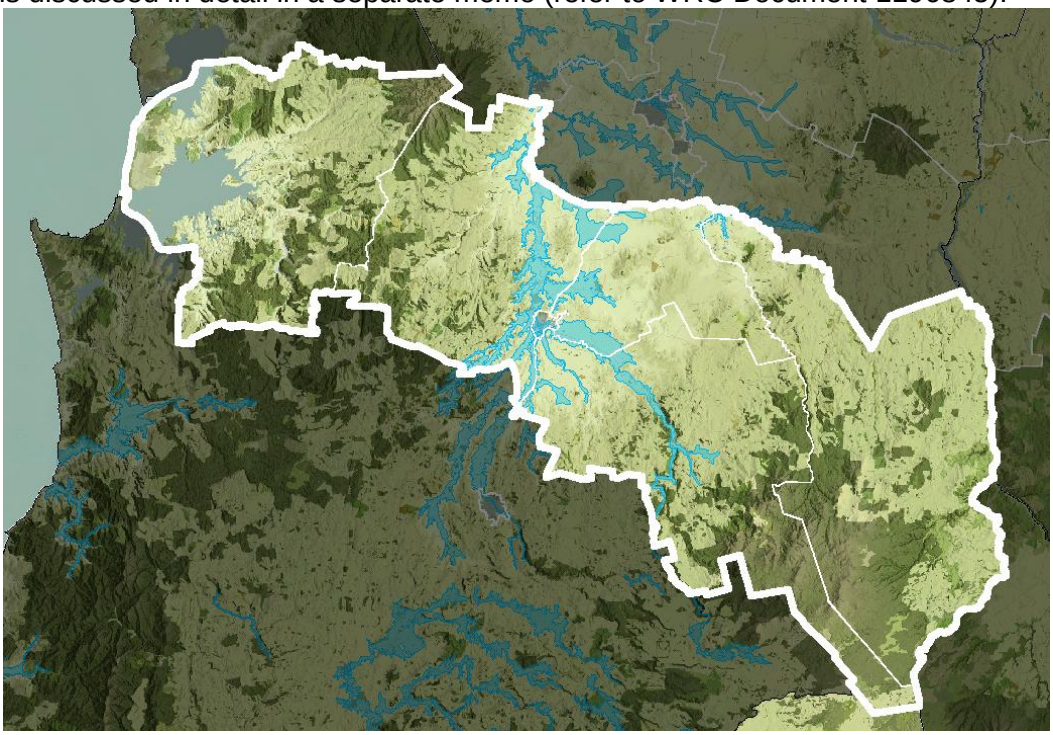

Figure 5: Flood hazards in the Otorohanga District

3.4 Coastal hazards

The coastal environment is one of the most active environments in the Waikato Region and is subject to regular and sometimes instantaneous changes due to erosion and inundation.

To assist with the quantification of the coastal hazard along the west coast of the Waikato Region, Environment Waikato engaged Tonkin and Taylor to undertake an initial study that involves the review of existing information and a site specific comment of the significance of various coastal processes, including:

- Soft shore dynamics.
- Cliff erosion and instability.
- Coastal inundation.
- Mobile wind blown sands.

While this report is currently in draft form, there are several general comments that can be drawn regarding coastal hazards in the Otorohanga District:

Figure 6: Otorohanga District coastal environment

- The coastline around the harbour entrances is likely to be dynamic due to the presence of highly mobile material (e.g. sand, gravel and mud) and coastal features such as sand spits and bars that are sensitive to natural fluctuations in the coastal environment. This dynamic environment also extends into the lower harbours, where there is evidence of shoreline fluctuations.

- Coastal inundation has not been identified as a significant issue with regard to existing development. However, there is the potential for this issue to escalate through the development of low lying land surrounding the harbour.

- Cliff instability has not been identified as a significant issue with regard to existing development. However, as with coastal inundation, there is the potential for this issue to escalate through the future development of land that may be subject to future instability issues.

The report currently being prepared contains greater detail regarding site specific evidence of the above issues. This information will be made available once finalised.

3.5 Earthquake hazards

Earthquakes are natural hazards that occur when the earth's tectonic plates move against each other. They disturb the earth's surface, damaging people and property.

There are some specific areas in the Waikato region that contain active earthquake fault lines which are more likely to experience earthquake activity. To assist with the quantification of earthquake hazards within the Waikato Region, Environment Waikato engaged the Institute of Geological and Nuclear sciences (IGNS) in 1996 to complete an earthquake hazard analysis for the Waikato Region. The resulting hazard classification is presented in Figure 7.

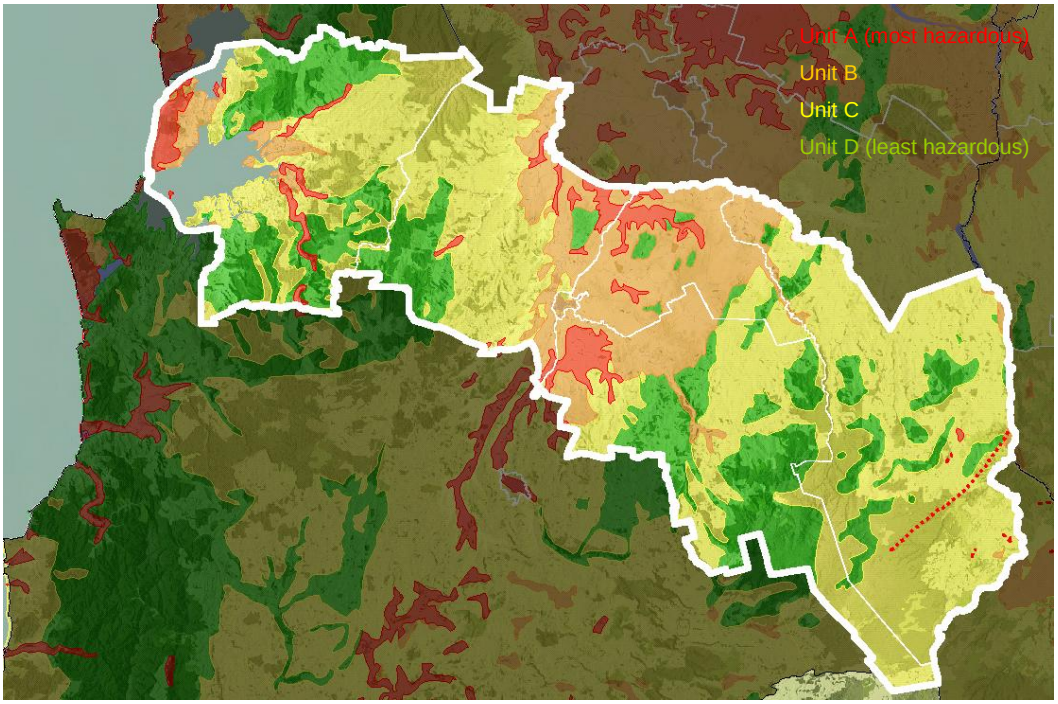

Figure 7: Earthquake hazard classification for Otorohanga District

This hazard classification is based on the response of the underlying geological materials during an earthquake, specifically the relative likelihood that settlement, liquefaction and/or amplification will occur. The units referred to by the hazard classification are further outlined as follows:

- Unit A: Holocene (<10,000 years) fluvial, lake, fan and swamp deposits and near coastal estuarine and beach deposits. Commonly high in volcanic ash content. These deposits comprise unconsolidated, very soft to stiff intermixed peat, clay, silt, ash, sand and gravel. The groundwater table generally very high. May include liquefiable layers. Critical thickness of sediments 2-15 m. MOST HAZARDOUS. Amplification of approximately two MMI units and/or settlement and liquefaction common.

- Unit B: Quaternary (< 2.5 million years) fluvial and marine terrace deposits, lignite, dune sand, pumice alluvium and ignimbrite flows. Unsaturated, slightly weathered, unconsolidated gravel, ash and sand. QUITE HAZARDOUS. Amplification of approximately one MMI unit common.

- Unit C: Tertiary (<75 million years) sandstone, siltstone, mudstone, coal measures, limestone, and conglomerate. Includes volcanic rocks of various ages. Gravels dense to very dense. Rock strength weak to moderately strong. NOT VERY HAZARDOUS, except that fine grained rocks are particularly prone to slumping and land sliding, especially if saturated and/or denuded of vegetation cover.

- Unit D: Basement rocks, (> 75 million years), greywacke (generally indurated, well bedded, sandstones and siltstones, moderately to highly deformed) and minor schist. Weak to very strong. LEAST HAZARDOUS.

It can therefore be concluded from Figure 7 that much of the Waipa River floodplain is located on an underlying geology that is particularly susceptible during an earthquake. It is however also noted that there a very few earthquake sources (i.e. faults) within the Otorohanga District.

3.6 Tsunami hazards

A tsunami is made up of a series of travelling ocean waves of extremely long wavelength. They are triggered by large disturbances such as earthquakes, undersea volcanic eruptions or deep sea landslides.

Tsunamis are a threat to people and property in coastal and low-lying estuarine areas. The waves travel quickly, rapidly flooding and damaging coastal communities, picking up debris as they go. A fast moving wave over 10 metres high can quickly destroy homes and communities. Tsunamis also create seiching in harbours and confined estuaries.

Tsunamis can travel inland along river beds as continuous single standing waves. This puts smaller inland communities at risk and contaminates rivers with saltwater.

To assist with the quantification of the tsunami hazard in the Waikato Region, Environment Waikato engaged NIWA to undertake a study to research evidence of past tsunamis, the most probable sources of future tsunamis and the coastlines that are most likely to be significantly affected. This study has so far concluded that the most significant tsunami hazard in the Waikato Region is limited to the east coast (e.g. Coromandel Peninsula) due to the sheltering affect of New Zealand from the most likely sources of tsunami (as evidenced during the 2001 Peru tsunami that is presented in Figure 8).

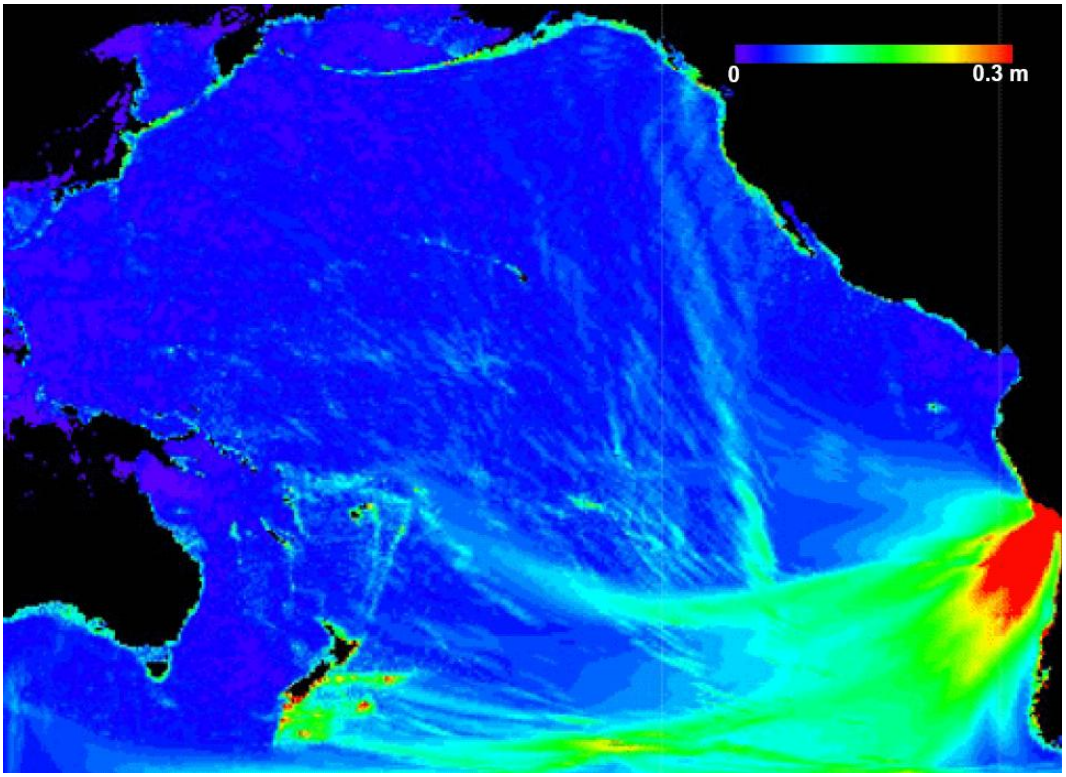

Figure 8: Maximum wave height following 2001 Peru tsunami

3.7 Volcanic hazards

Volcanic activity threatens people and property. The Waikato region has many volcanic centres that vary in activity. The region's most recent major volcanic activity occurred in 1995 and 1996, when Mount Ruapehu erupted, causing ashfalls and volcanic mud flows (lahars).

The central North Island features many landforms that have been created over the last 1.6 million years through volcanic activity ('volcanism'). Volcanic soils are important in supporting farming and forestry.

Volcanism is the biggest source of death from natural disasters in New Zealand over the last 150 years. Over 100 people died when Mount Tarawera erupted in 1886, and 151 people were killed after a mudflow ('lahar') derailed their train at Tangiwai following Mount Ruapehu's eruption in 1953. We need to monitor volcanic zones in our region to prepare for and minimise any effects from future volcanic activity.

To assist with the quantification of the volcanic hazard in the Waikato Region, Environment Waikato engaged IGNS to characterise the most relevant volcanic centres, along with the likely nature and extent of fallout following an eruption.

This study identified the following volcanic centres as having the potential to affect the Waikato Region:

- Taupo (e.g. Lake Taupo, Tongariro, Tarawera and White Island).
- Mayor Island.
- Auckland.
- Egmont.

Maps were also produced for each volcanic field showing the most probably nature and extent of fallout following an eruption.

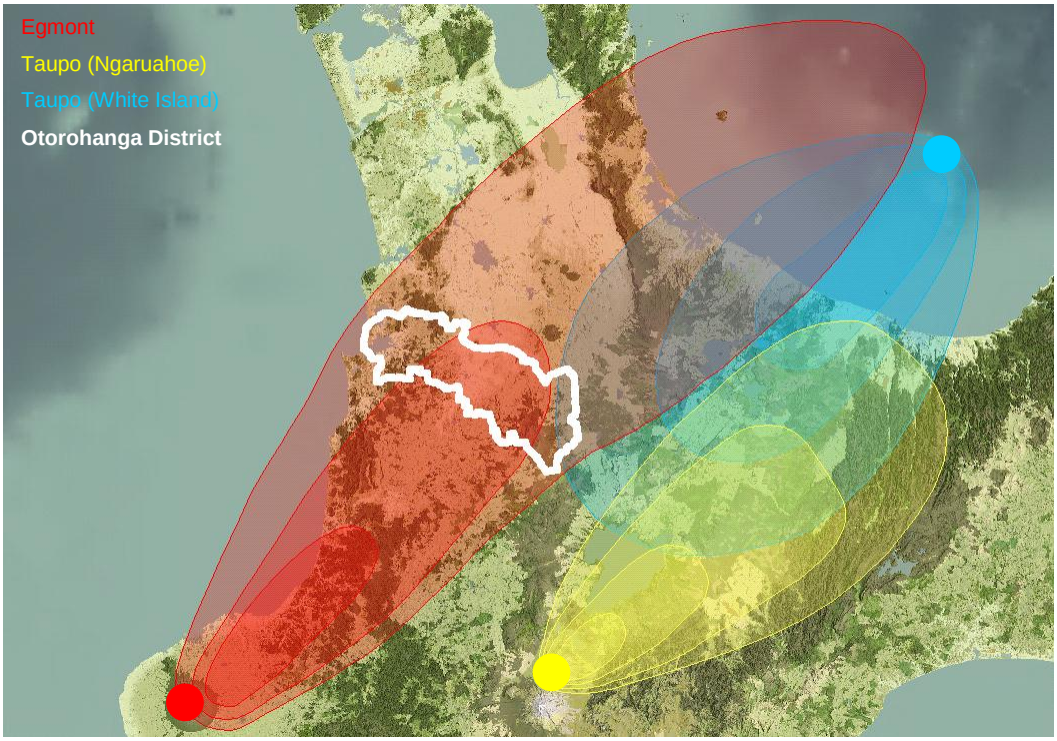

Figure 9: Most probable volcanic fallout across the Waikato Region

Although none of the identified volcanic centres are located within the Otorohanga District, there is the potential for the District to be affected by fallout following an eruption (as is evidenced by the presence of ash in much of the under lying geology). Figure 9 shows that this fallout is most likely to originate from the Egmont volcanic centre, with the thickness of material having a 1 % to 0.1 % of being 0.002 to 0.0001 m.

It is however important to note that Figure 9 is based on prevailing winds and that there is the potential for other volcanic centres to affect the Otorohanga District, depending on the meteorological conditions following the eruption.

3.8 Landslides

Landslides occur when unstable rock and soil on steep slopes are disturbed by earthquakes, heavy rain or activities such as mining or road construction. The diverse nature of the Waikato region's landscapes produces different types of landslides in different areas. Find out more about landslides in the Waikato region.

A landslide is a mass movement of rock, soil and other earth material down a slope. They can be very large (such as a landform at Te Kauri on the West Coast believed to be a large ancient landslide), or small, affecting a limited area.

To assist with the quantification of the landslide hazard in the Waikato Region, Environment Waikato supported the preparation of a post-graduate thesis that, amongst other things, attempted to assess the relative susceptibility of land within the Waikato Region to landslides. The resulting 'landslide susceptibility map' is presented in Figure 10.

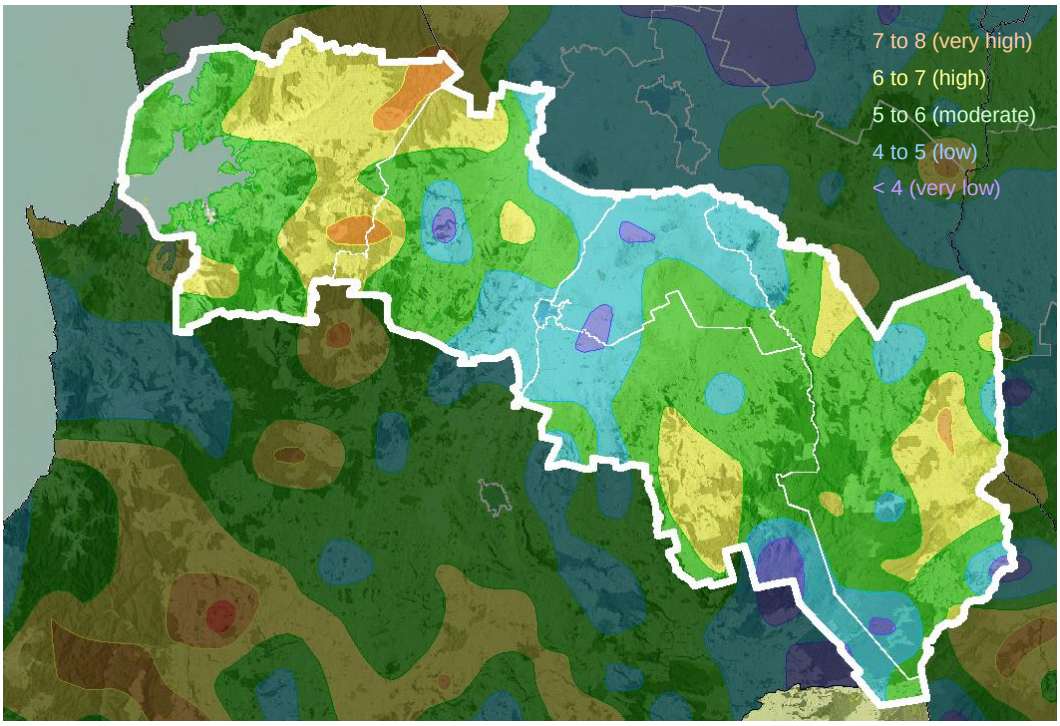

Figure 10: Landslide hazard assessment for Otorohanga District Council

The landslide hazard classification presented in Figure 10 provides a relative assessment of the susceptibility of land to landslides based on geological, meteorological and geographical conditions.

Figure 10 shows that the susceptibility of the Otorohanga District to landslides is variable, ranging from very high in the hill country to very low in the lower lying Waipa River floodplain.

3.9 Subsidence (karst)

As noted in Section **Error! Reference source not found.**, the presence of carbonate geological units such as limestone creates the potential for karst landforms to be created. The most obvious of these landforms are localised subsidence or sink holes, and these are the most relevant when considering natural hazards.

The New Zealand Land Resource Inventory (LRI) provides a nationwide database of various parameters that contribute to the characteristics of land, including the toprock and bedrock that is present. Based on this information, the extent of limestone

toprock/bedrock (and therefore the potential for karst landforms to be created) has been mapped for the Otorohanga District (refer to Figure 11).

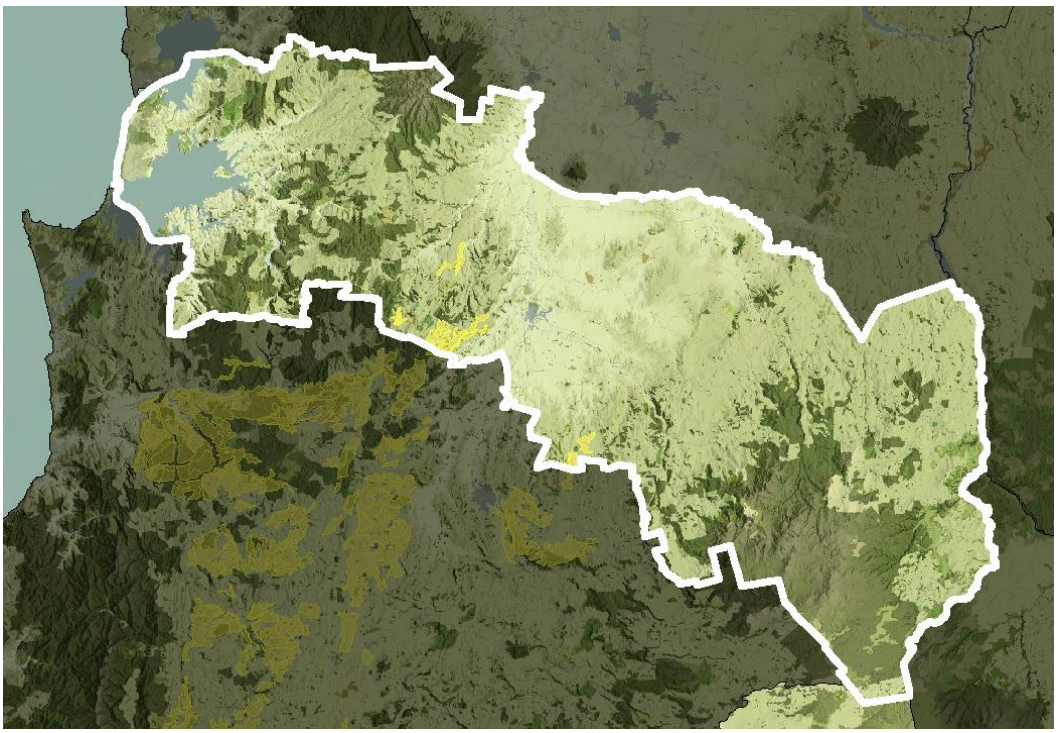

Figure 11: Limestone geological formations in the Otorohanga District

Based on the information presented in Figure 11, the extent of potential karst landforms in the Otorohanga District is generally limited to around the southern boundary of the District, with a vast majority of karst landform potential located in the Waitomo District. It is however noted that there is the potential for karst landforms to emerge in other areas due to the presence of other rocks that exhibit carbonaceous properties.

3.10 Debris flows

Very little is known about the current risk of debris flows across New Zealand, let alone in the Otorohanga district. Rapid development in New Zealand has led to an increasing use of alluvial fans for residential development. There is, as yet, little appreciation of the hazards posed by infrequent but devastating debris-flows on these fans, nor is the risk of debris-flow damage a commonly-used criterion for permitting development. The 1981 Te Aroha and more recently the 2005 Matata debris flow events are good examples.

Debris-flows pose a hazard that is effectively unmanageable; during an intense rainstorm a small creek can generate several-metre-high surges of mixed boulders, sediment and trees that can leave the channel and travel anywhere on an alluvial fan. In a typical catchment, this process might occur only once in a century or two, depending on the occurrence of sufficiently intense rain and the availability of sufficient sediment.

To assist with the quantification of the debris-flow hazard in the Waikato Region, Environment Waikato is supporting a post-graduate thesis that aims to identify land that is particularly susceptible to debris-flows. However, this study is limited to the Coromandel and Kaimai Ranges, where geological, geographic and meteorological conditions are significantly more conducive to the occurrence of debris-flows.

4 Risk Assessment

4.1 Introduction

Having determined the most common and significant natural hazards in the Otorohanga District, it is necessary to analyse and evaluate the level of risk associated with each hazard. This will allow a comparison between different hazards in order to guide prioritisation for the level of work effort. One important precursor to this exercise is determining what the outcome or goal of the hazard mitigation work should be. Suggested goals for both ODC and EW are:

- To work towards the resolution of natural hazard issues in the district.
- To minimise risks from natural hazards to people and infrastructure in the district.
- To determine natural hazard management priorities for the purposes of LTCCP planning.

Work actions should be determined using the combination of agency goals, current work commitments and level of risk associated with the hazard.

4.2 Description of scenarios

The assessment of risk can involve a broad range of approaches, including:

- Checklists.
- Judgements based on experience and records.
- Brainstorming.
- Flow charts and scenario analysis.

One of the most intuitive ways to describe risk is in the form of scenarios, and this approach has been adopted for this risk assessment.

Based on the natural hazard commentary provided in Section 3, a scenario has been developed for each natural hazard that represents the ‘maximum credible event’. These scenarios are outlined as follows:

- River flood involving the 1 % AEP year flood event, resulting in widespread inundation, as indicated by the existing flood hazard information (refer to Figure 5) and similar to that experienced during the March 2004 event.
- Coastal erosion resulting in a retreat of the existing coastline, as discussed in Section 0.
- Land instability following a 1 % AEP rainfall event, resulting in numerous landslides on land that is identified as being highly or very highly susceptible (refer to Figure 10).
- Coastal flooding during a 2 % AEP event, resulting in the inundation of low lying areas around the Kawhia and Aotea Harbours, as discussed in Section 0.
- Volcanic activity involving a 0.1 % AEP event from the Egmont Volcanic Zone, resulting in most of the district being covered in ash to a depth of 2 mm (weather conditions permitting).

4.3 Risk assessment methodology

Risk analysis and evaluation typically involves determining the likelihood of a hazard event occurring and the consequences of the hazard event. A commonly accepted standard for risk management in New Zealand is the AS/NZS 4360: Risk Management Standard. This standard is used as the basis for this report in order to:

- Establish the context (refer to Section **Error! Reference source not found.**).
- Identify risks (refer to Section 3).
- Analyse risks (refer to Section 4.4).
- Evaluate risks (refer to Section 4.4).
- Treat risks.

4.4 Analysis and evaluation

Problematic to any risk analysis is the level of detail and characterisation of the importance rankings. Table 2 shows a two stage approach to analysing and evaluating risks. Stage 1 involves the evaluation of risk based on likelihood and consequences of each scenario. Stage 2 involves a more detailed analysis based on the S.M.U.G model, which allows the evaluation of risk based on four factors:

1. Seriousness: The measure of the potential impact, based on five areas that may be impacted (i.e. human, social, economic, infrastructure and geographic).
2. Manageability: The measure of the ability to manage either the hazard or the potential impacts on the community.
3. Urgency: The measure of how imperative or critical it is to address the risk (e.g. how often is the natural hazard expected to occur and what is the likelihood that the resulting risk being realised).
4. Growth rating: The measure of the potential for the risk to grow (e.g. the hazard may occur more frequently or the community exposure to the hazard may increase).

The 2 stage approach to risk evaluation is necessary to allow the prioritisation of risks that receive the same evaluation during Stage 1 (e.g. ‘high’).

Table 2: Risk analysis and evaluation

Hazard scenario	Likelihood	Consequence	Risk level	Seriousness: Human costs	Seriousness: Social impact	Seriousness: Economic cost	Seriousness: Infrastructure costs	Seriousness: Geographic impact	Average	Manageability rating	Urgency rating	Growth rating	Total	Priority
River flood	A	3	Extreme	3	3	4	4	3	3.4	2 MH	5	5 HH	15.4	1
Coastal erosion	B	4	Extreme	2	3	4	3	2	2.8	4 HM	3	4 HM	13.8	2
Land instability	B	2	High	3	2	2	3	2	2.4	4 HM	4	2 LM	12.4	3
Coastal inundation	B	2	High	2	2	3	3	3	2.6	3 MM	2	4 HM	11.6	4
Volcanic	C	3	High	3	2	2	3	2	2.4	5 HL	3	1 LL	11.4	5

Note: An outline of the terms used in Table 2 are presented in Appendix 6

The following comments have been derived from Table 2:

- River flooding, coastal erosion, land instability, coastal inundation and volcanic hazards have been identified as being most relevant to the Otorohanga District based on the discussion in Section 3.

- These natural hazards are all identified as creating a significant risk to the Otorohanga District, with river flooding and coastal erosion being identified as being particularly significant.

- Further analysis of these natural hazards using the S.M.U.G model confirms that river flooding and coastal erosion is most significant, followed by land instability, coastal inundation and volcanic hazards.

- The priority assigned to river flooding is driven by the serious of the hazard, along with the potential for the risk associated with the hazard to escalate due to both increased development and future climate change.

- Coastal erosion and inundation are both assigned a lower priority than river flooding. It is however important to note that this priority is based on the current environment, and that there is a significant potential for the risk associated with both hazards to escalate due to inappropriate development and medium to long term changes in the natural environment (e.g. sea level rise and the natural dynamics of the coastal environment).

- Volcanic hazards have been assigned to lowest priority of the five hazards that are most relevant to the Otorohanga District. It is however noted that this hazard has received the highest 'manageability' rating, indicating the lack of measures available to prevent the hazard from occurring.

4.5 Conclusion

As a result of this qualitative risk assessment, it is concluded that river flooding, coastal erosion and land instability are the highest priority natural hazards in the Otorohanga District. The reasoning for this conclusion is presented in Table 2, along with the accompanying discussion.

Note: As part of the preparation of the Waikato CDEM Group Plan, ODC staff were involved in the risk evaluation process to determine (collectively with their Waikato Valley Emergency Operating Area (EOA) partners) to establish the priorities for the district and EOA. As a result, it was determined that river flooding, land instability, earthquake and ash fall were the top four ranked natural hazards (in terms of relative level of impact) for the Waikato Valley EOA. With regard to the Otorohanga District, river flooding, shoreline erosion and land instability were the top three ranked natural hazards. The assessment outlined in this report has resulted in a similar order of priorities.

4.6 Residual risks

Residual risk is the term used to define those risks that cannot be defined in more detail after elimination or inclusion of all conceivable quantified risks have been addressed. Residual risk can also be described in terms of “the bigger than event”. For example, if planning and operational measures are only implemented against the 1 % AEP event scenario, then anything larger (e.g. 0.2 % or 0.1 % AEP events) would be considered a residual risk.

With regard to the Otorohanga District, the most obvious application of residual risk is with regard to flood risk. Specifically, there is a residual risk that the flood defences that protect the Otorohanga District from inundation will either overtop or structurally fail.

Figure 12: Example of a stopbank being overtopped

5 Summary, discussion and recommendations

5.1 Summary of natural hazard risks

River flooding has been identified as the most significant natural hazard in the Otorohanga District. Accordingly, EW has prepared a separate report covering the management of river flood hazards in the Otorohanga District (refer to document 1196845). Land instability and coastal erosion, coastal inundation and volcanism have also been identified as being significant in Otorohanga District.

Further discussion regarding the basis for this prioritisation of natural hazard risks in the Otorohanga District can be found in Sections 3 and **Error! Reference source not found.**.

5.2 Discussion

The following discussion is relevant to natural hazards in the Otorohanga District:

- The proposed prioritisation of natural hazards in the Otorohanga District is based on a variety of considerations. It is however important to note that the relative significance of a natural hazard is generally dependant on the nature of development on susceptible land. It is therefore important that a range of natural hazards continue to be considered when planning for future growth, including those hazards that are currently assessed as being less significant.

- The characteristics of most natural hazards are dependent on the natural environment. Therefore, a natural hazard that is currently relatively insignificant may become significant following changes in the environment (e.g. climate change that is currently predicted due to global warming or a change in the coastal environment accelerating in coastal erosion).

- This assessment is at a District Scale and is intended to assist with the identification of issues that may need to be considered. This may include a trigger for a more site specific assessment to confirm/discount any natural hazard.

5.3 Recommendations

As a result of this qualitative risk assessment, the following recommendations are proposed for the Otorohanga District with regard to the management of natural hazards:

- It is recommended that river flood risk be considered the highest priority natural hazard affecting the Otorohanga District. This is because of the existing level of risk, along with the potential for the risk to escalate due to increased development and future climate change.

  It is also recommended that the approach to the management of river flood risks is developed to be consistent with the current Regional and National approaches (e.g. Draft Regional River Flood Risk Management Strategy and National Standard for Flood Risk Management).

- It is recommended that coastal erosion and inundation be considered a high priority in the Otorohanga District. This is because there is the significant potential for the risk associated with these natural hazards to escalate due to increased development, future climate change and the impact of the naturally dynamic coastal environment.

- It is recommended that the Otorohanga District Plan be adopted as a key tool to reduce the actual of potential impact of natural hazards, particularly those identified as having a priority in the Otorohanga District (e.g. river flooding, coastal erosion and coastal inundation).

- The significance of various natural hazards in the Otorohanga District is partially dependant on the appropriate development of susceptible land. It is therefore recommended that the full range of natural hazards continue to be considered when planning for future growth, even those that have been identified as relatively insignificant by this assessment.

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7 Appendix 1: Statutory and legal framework

7.1 The Resource Management Act (RMA) 1991

7.1.1 Introduction

The RMA sets in place a planning framework with respect to hazard management. The Act defines the role of central government agencies, such as the Department of Conservation, and regional and district councils such as EW and ODC respectively. The mechanisms to achieve this include a hierarchy of linked interrelated policy statements supported by non-statutory documents such as action plans developed to address individual (river flooding) or a suite of related hazards (coastal erosion and flooding).

The RMA assigns to regional councils responsibility for the integrated management of natural and physical resources within their region. Regional councils are required to control the use of land, the taking and use of water, and the planting of plants in water bodies for soil conservation, the quality of water, the quantity of water, and the avoidance or mitigation of natural hazards. Regional and district functions are specified by the Act and are outlined in *Appendix 2*.

7.1.2 Long-term management strategies

The RMA provides for the long-term management of hazards through various policy mechanisms, some of which are discussed above. These include, in the case of coastal hazards, the New Zealand Coastal Policy Statement and regional coastal plans, and for other hazards regional policy statements, and district plans. Policy implementation is given effect through various methods and can include non-statutory mechanisms such as education programmes, advocacy and community consultation and engagement; or statutory mechanisms such as the application of rules and standards in respect of defined zones. Monitoring strategies provide feedback on the effectiveness of the various methods employed to mitigate or avoid the adverse effects of hazards.

7.1.3 Short-term management responses

Section 330 of the RMA builds on powers presently available to Council pursuant to the Public Works Act 1981 (s.234) and the Local Government Act 1974 (s.708A(3)). The section permits activities in an emergency situation that might otherwise contravene the Act. The section empowers employees and agents of councils to enter upon land and take action in an emergency situation. Section 331 of the Act requires that the appropriate consent authority must be advised when emergency works have been undertaken. Resource consents must be sought where adverse effects of the activity continue. The provisions and a discussion of section 330 is outlined in *Appendix 3*.

7.2 Resource management policy statements

7.2.1 Introduction

The RMA requires that a hierarchy of policy documents is prepared by central, regional and local government bodies with respect to resource management issues generally including the management of natural hazards. The documents are interrelated (to achieve integrated management) and the Act requires that subordinate regional and district documents are not inconsistent with each other or any national policy statement.

7.2.2 Regional Policy Statement (RPS)

EW's RPS incorporates policy on natural hazards. The statement indicates the dual role of the region and district in managing hazards, but that the district council is likely to take a lead role in managing responses to localised hazard events.

The RPS identifies implementation methods for the management of natural hazards relating to both the region and the district. Those relating to district councils, in summary, refer to:

- The development of objectives, policies, rules and methods in district plans to control the use of land;
- The delivery of environmental education programmes;
- The implementation of hazard mitigation plans;
- To provide information on natural hazards through land information memoranda;
- To work in partnership with the regional council.
- Similarly, those implementation methods relating to the regional council include:
- The development of specific objectives, policies, rules and/or other methods in regional plans for the avoidance or mitigation of coastal hazards;
- To take a lead role in the collection, analysis, storage and communication of coastal hazard information to territorial authorities;
- The development, in conjunction with territorial authorities and the wider community, hazard mitigation plans for managing the risks associated with coastal hazards**;**
- To support the development and implementation of environmental education programmes related to coastal hazards.

The text on the "Management of Natural Hazards" contained in the Regional Policy Statement is attached as *Appendix 4*.

7.2.3 Otorohanga District Plan

The Otorohanga District Plan includes a section on "Natural Hazards". This section identifies the relevant issues, objectives, policies, methods, principle reasons, environmental results and monitoring.

7.3 Other hazard management statutes

7.3.1 Introduction

This section will examine in greater detail the legal obligations for EW and the ODC and the organisations' staff and elected members in terms of other relevant legislation including the Civil Defence Emergency Management Act 2003, Building Act 1991, Soil Conservation and Rivers Control Act 1941 and the Local Government Official Information and Meetings Act 1987.

7.3.2 Civil Defence Emergency Management (CDEM) Act 2002

This Act establishes a framework for CDEM aimed at building resilient New Zealand communities. It's purpose is to improve and promote the sustainable management of hazards in a way that contributes to the social, economic, cultural, and environmental well-being and safety of the public and also to the protection of property. It also

provides for the planning and preparation for an emergency and for response and recovery in the event of an emergency.

Under the Act, ODC is a member of the Waikato CDEM Group (a consortia of local authorities working with emergency services and lifeline utilities to reduce risk across the region). It is also one of the councils that make up the Waikato Valley Emergency Operating Area (EOA).

7.3.3 Soil Conservation and Rivers Control Act 1941

The provisions of the Soil Conservation & Rivers Control Act 1941 apply only to regional councils and determine their role for river and catchment management and include the following responsibilities:

- To minimise and prevent damage by floods and erosion;
- To construct, reconstruct, alter, repair, and maintain all such works it considers necessary;
- To exercise a general supervision over local authorities of any powers they exercise as to river and drainage matters;
- To give directions for the guidance of local authorities with regard to the above matters.

EW also has responsibility for land drainage in terms of the provisions of the Land Drainage Act 1908, primarily within the specified drainage areas scheduled in 1989.

7.3.4 Local Government Act 2002

Section 551 of the Local Government Act outlines the river clearance powers available to territorial local authorities. At present, responsibilities for these functions are generally shared.

7.3.5 Local Government Official Information and Meetings Act 1987 (LGOIMA)

Section 44A of LGOIMA deals with Land Information Memoranda (LIM). Any person may apply to council for a LIM in respect of any property in the district. Among the matters that must be included in a LIM is information relating to natural hazards that is known to council.

Unless there is proof to the contrary hazard information contained in a LIM shall be sufficient evidence of the correctness, as at the date of issue, of any hazard information. There is no opportunity or grounds that allow council to withhold hazard information.

These latter provisions of the Act have implications generally for council when receiving information such as reports that apply to a property or group of properties and more specifically when that information relates to hazards.

7.3.6 Building Act 1991

7.3.6.1 Project Information Memoranda (PIM)

A similar mechanism as land information memoranda is contained at Part V of the Building Act. Sections 30 and 31 of the Act makes provision for persons wishing to proceed with building works to first obtain a Project Information Memorandum (PIM) in respect of the works and the land upon which the works are to be established. As with the provisions of LGOIMA every PIM shall include information on “special features” of the land likely to be relevant to the proposed building work identifying, amongst other things, potential hazard information that falls within council’s current knowledge-base.

This requirement places a great deal of responsibility on council to get it right. One of the challenges will be to ascertain the "special features" of the land that do fall within council's knowledge. The section intends a considered response by council that will involve some research and investigation.

7.3.6.2 Building Consents

Council must refuse to issue a building consent in respect of any application for building works on land that is subject to, amongst other things, flooding or erosion or the building work itself is likely to worsen the effects of or cause erosion or flooding. If council is satisfied that adequate provision has been made to protect the hazard prone land a building consent will be issued.

Where council considers that the building works will not increase losses arising from an extreme natural event then a building consent may issue in terms of s74 of the Building Act, 2004 provided a notice to such effect is registered against the Certificate of Title of the land upon which the building works stand. The section absolves Council, its officers and elected representatives of any liability if the building works are subsequently damaged by an extreme event.

7.3.7 Reserves Act 1977

The Reserves Act guides district councils such as the ODC in how they manage reserve lands that fall within their jurisdiction. It provides for the acquisition, control, management, maintenance, preservation (including the protection of the natural environment), development, and use, and to make provision for public access to the coastline and the countryside.

As the administering body for coastal reserve land ODC must prepare a management plan for this land. Such plans must provide for and ensure the use, enjoyment, maintenance, protection, preservation, and, where resources permit, the development of the reserve.

Plans must be submitted to the Minister of Conservation for approval within 5 years after the date of appointment of the administering body, although this time may be extended. In preparing a management plan public notice must be given, and all submissions received must be considered.

Local authorities must also keep management plans under continuous review so that they are adapted to changing circumstances or in accordance with increased knowledge.

8 Appendix 2: ODC/EW RMA functions

The functions, powers and duties of local authorities with respect to hazards as defined by the Resource Management Act 1991 are outlined below.

Section 30(1)(d)(v):

Functions of regional councils under this Act:

Every regional council shall have the following functions for the purpose of giving effect to this Act in its region:

> *…(d) In respect of any coastal marine area in the region, the control (in conjunction with the Minister of Conservation) of—*
>
> *…(v) Any actual or potential effects of the use, development, or protection of land, including the avoidance or mitigation of natural hazards …*

And section 31(b):

Functions of territorial authorities under this Act—

Every territorial authority shall have the following functions for the purpose of giving effect to this Act in its district:

> *…(b) The control of any actual or potential effects of the use, development, or protection of land, including for the purpose of the avoidance or mitigation of natural hazards…*

Section 62(ha) requires that a regional council in its regional policy statement defines:

For the region or any part of the region, which local authority shall have responsibility within its own area for developing objectives, policies, and rules relating to the control of the use of land for—

The avoidance or mitigation of natural hazards … and may state particular responsibilities for particular hazards … or group of hazards …; but if no responsibilities for a hazard … are identified in the policy statement, the regional council shall retain primary responsibility for the hazard …

9 Appendix 3: RMA Section 330

9.1 Provisions and discussion of Section 330 of the Resource Management Act 1991

Section 330 provides (emphasis added):

Emergency works and power to take preventive or remedial action—

Where—

> *Any public work for which any person has financial responsibility; or*
> *Any natural and physical resource or area for which a local authority or consent authority has jurisdiction under this Act; or*
> *Is, in the opinion of the person or the authority…, affected by or likely to be affected by—*
>
> > *An adverse effect on the environment which requires immediate preventive measures; or*
> > *An adverse effect on the environment which requires immediate remedial measures; or*
> > *Any sudden event causing or likely to cause loss of life, injury, or serious damage to property—*

the provisions of sections 9, 12, 13, 14, and 15 shall not apply to any activity undertaken by or on behalf of that person, authority, … or mitigate any actual or likely adverse effect of, the emergency.

Where a local authority or consent authority—

> *Has financial responsibility for any public work; or*
> *Has jurisdiction under this Act in respect of any natural and physical resource or area—which is, in the reasonable opinion of that local authority or consent authority, likely to be affected by any of the conditions described in paragraphs (d) to (f) of subsection (1), the local authority or consent authority by its employees or agents may, without prior notice, enter any place (including a dwellinghouse when accompanied by a constable) and may take such action, or direct the occupier to take such action, as is immediately necessary and sufficient to remove the cause of, or mitigate any actual or likely adverse effect of, the emergency.*

As soon as practicable after entering any place under this section, every person must identify himself or herself and inform the occupier of the place of the entry and the reasons for it.

9.2 Further observations based on case law

1. Sudden events or emergencies — subs (1)(c)

a. "Sudden emergency" test

In *Gisborne DC v Falkner*, the Planning Tribunal examined the pre-RMA Amendment Act 1993 "sudden emergency" test. It determined that damage by storms, although causing a state of danger, did not fulfil the test as they were not unexpected. The statute emphasises suddenness, and an emergency should be limited to a state of danger that is unexpected. Earlier case law determined that sudden emergencies are events that are otherwise unforeseeable. It is suggested that despite the removal of "emergency" and replacing it with "event", these cases

still assist in determining what is a "sudden event". *Falkner* also applied subs (1) to determine who was responsible for the works on the facts of that case. The applicability of Mean High Water Springs (MHWS) as the demarcation between regional and district jurisdictions prevails.

The Court had found that where the council had failed to act for several years to address the issue of sewage disposal, for example, it could not then rely on the emergency powers of ss.330 or 330A. The statute requires that there be both immediacy and urgency.

b. Foreseeability

In *Auckland CC v Minister for the Environment*, the Environment Court held that the fact that a situation or occurrence, as contemplated by s.330(1), may have been foreseen as a possibility, does not operate to prevent an "emergency" from arising if the relevant elements or qualifying aspects are satisfied.

2. Immunity from prosecution in relation to emergency works

Section 18(2) of the RMA provides that: "no person may be prosecuted for acting in accordance with section 330". In *Southland RC v Invercargill CC* (1996), the District Court found that persons charged with statutory functions in respect of works which cause environmental harm are to be permitted to exercise emergency powers without fear of prosecution. Accordingly, if a prosecution is commenced, the onus is on the informant to prove that s 330 powers were not properly exercised.

This approach was not accepted in *Canterbury RC v Doug Hood Ltd* (1998), where his Honour followed the judgement of the High Court in *Bay of Plenty RC v Bay Milk Products Ltd* (1996); — the onus is on the defendants to establish that the defence of immunity is available. Two salient issues arise that are implicit but perhaps not immediately apparent in terms of the preceding discussion on s.330. The issues are:

1. Regional versus district Responsibilities

It is axiomatic that each of the authorities can only exercise authority within its own area of jurisdiction. The demarcation between regional and district jurisdictions is defined by Mean High Water Mark Springs (MHWS). A corollary of this, as it applies to an emergency situation and especially as it applies to coastal hazards, is that for a council to be able to clearly exercise its authority the MHWS needs to be defined in advance of any extreme event. Prudence would dictate that this is a sensible course of action for a council where coastal hazards are an issue to undertake in certain anticipation of the next severe storm.

2. Exercise of Section 330 Authority in Relation to Council Policy

S.330 makes it clear that any person acting in accordance with that section is immune from subsequent prosecution. It is unclear however, what the position is if a person in exercising authority in terms of s.330 on behalf of council acted contrary to council's formally adopted policy. Does, for example, a liability claim fall on the body corporate or the individual? The Act offers no assistance in this regard but the matter is important and has therefore been referred to council's solicitor for advice. It would seem however that in the absence of council policy if a person in exercising s.330 authority met the tests of forming their opinion reasonably and responsibly then this would constitute a defence against prosecution or liability claim.

10 Appendix 4: RPS & natural hazards

10.1 Policy One: Consistent Management of Natural Hazards

Ensure that natural hazards are managed in a consistent manner throughout the Waikato Region and roles and responsibilities of agencies are defined.

Implementation Methods:

1. The Waikato Regional Council (EW) will:

    i. develop specific objectives, policies, rules and/or other methods in regional plans for the avoidance or mitigation of natural hazards in the coastal marine area and in the beds of rivers and lakes
    ii. take a lead role in the collection, analysis, storage and communication of natural hazard information to territorial authorities
    iii. prioritise risks from natural hazards across the Region for further investigation, in consultation with territorial authorities and the Region's community
    iv. develop, in conjunction with territorial authorities and the wider community, hazard specific mitigation plans for managing the risks associated with natural hazards
    v. implement those aspects of mitigation plans that are relevant to EW's functions
    vi. co-ordinate responses to regionally significant natural hazard events with those of territorial authorities, network utility operators, government departments and other relevant agencies
    vii. support the development and implementation of environmental education programmes related to specific natural hazards

2. Territorial authorities will:

    i. develop specific objectives, policies, rules and/or other methods in district plans that control the use of land (except for in the beds of lakes and rivers and the coastal marine area) for the avoidance or mitigation of natural hazards
    ii. deliver environmental education programmes on local natural hazards to their communities
    iii. implement relevant hazard specific mitigation plans through building consents and other regulatory and non-regulatory methods
    iv. provide information on the presence of natural hazards at specific sites through land information memoranda and project information memoranda where such information is known by the territorial authority
    v. work in partnership with the Waikato Regional Council (EW) and their communities to ensure efficient and effective response and recovery to natural hazard events including planning for emergencies

3. Local authorities will advocate that other agencies such as network utility operators and neighbouring regional councils work with territorial authorities and the Waikato Regional Council (EW) for the management of natural hazards through the development of partnership agreements and memoranda of understanding.

Local authorities will advocate that all the roles and responsibilities identified above are implemented through strategic plans, annual plans, district and regional plans, civil defence plans and partnership agreements within three years of this Regional Policy Statement becoming operative.

11 Appendix 5: Other work

11.1 Hydraulic modeling

EW has developed a comprehensive/dedicated hydraulic modeling programme in response a rapid increase in resource consent applications and river management issues. Hydraulic modeling is carried out on a priority basis and includes both one dimensional (Mike 11) and two dimensional (Mike 21) outputs. It is seen as being one of the most crucial elements of our flood risk management approach

EW's modeling programme aims to achieve the following:

- Outputs are based on best practice and methodology and includes all available information such as hydro-met data, climate change allowances, sea level rise, and land information
- Models provide a robust and sound basis for assessing/determining likely extents of flooding from a given-sized event (or across a range of scenarios)
- Flood hazard risk maps are produced that as accurately as possible depict the flood extent, velocity, and depth of floodwaters
- District Plans use the assessed flood hazards/levels and employ a sound planning framework as a basis for reducing risks.

11.2 LIDAR surveys

The proposed LIDAR survey (including benefits, costs, and coverage area) of the Hauraki district is outlined in Section 13 (Appendix 7).

11.3 River flood risk management

Following the significant flood events of 2004 (re: Manawatu and Bay of Plenty), the Government commissioned a full review on how the country was dealing with and managing flood risks. Consequently, a number of projects developed and lead by the Ministry for the Environment and Local Government New Zealand were commissioned to address the issue at both the national and regional level. To this end, EW is developing a Regional Flood Risk Management Strategy as a basis for guiding policy and decision making for the region.

11.4 Categorisation of flood risk

To assess flood risks, it is necessary to consider the nature and degree of the potential impacts of flooding, which are dependent on the magnitude of specific hazard parameters within the overall flood hazard. During flooding, the primary hazard parameters in terms of potential impacts are:

- Flood depth: The potential impacts directly related to this parameter include:
  - Drowning (flood waters rising higher than waist level)
  - Damage (flood waters damaging property and contents as they rise)
  - Isolation (deep flood waters preventing escape by flood victims or access by emergency services)
- Flood flow velocity: The potential impacts directly related to this parameter include:
  - Drowning (flood waters flowing too fast for people to maintain balance or washing away occupied vehicles)
  - Damage (the force of fast flowing flood waters damaging structures)

- Isolation (the force of fast flowing waters and/or debris transport preventing escape by flood victims or access by emergency services

The severity of flooding is largely governed on the magnitude of these two primary hazard parameters. For example, the higher the combined depth and velocity, greater are the risks to people and property.

12 Appendix 6: Key to Table 2 (risk analysis evaluation key)

12.1 Measure of likelihood

Level	Descriptor	Description
A	Almost certain	Expected to occur in most circumstances
B	Likely	Will probably occur in most circumstances
C	Possible	Might occur at some time
D	Unlikely	Could occur at some time
E	Rare	May only occur in exceptional circumstances

12.2 Measure of consequence of impact

Level	Descriptor	Detail description
1	Insignificant	No injuries, little or no damage, low financial loss
2	Minor	First aid treatment, minor building damage, medium financial loss
3	Moderate	Medical treatment required, moderate building and infrastructure damage, high financial loss
4	Major	Extensive injuries, high level of building and infrastructure damage, major financial loss
5	Catastrophic	Deaths, most buildings extensively damaged and major infrastructure failure, huge financial loss

12.3 Risk analysis matrix – level of risk

	Consequences				
Likelihood	1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophic
A Almost certain	High	High	Extreme	Extreme	Extreme
B Likely	Moderate	High	High	Extreme	Extreme
C Possible	Low	Moderate	High	Extreme	Extreme
D Unlikely	Low	Low	Moderate	High	Extreme
E Rare	Low	Low	Moderate	High	High

13 Appendix 7: Proposed Light Detection and Ranging (LIDAR) Survey Programme

13.1 Background

LIDAR stands for *Light Detection And Ranging* and is an example of an active remote sensing technique particularly suited to developing terrain elevation data. Geographic data can be acquired by various methods, including a variety of techniques which fall under the category of remote sensing. Remote sensing is often used as a means of collecting large amounts of data in a relatively short time frame. It is an extremely valuable source of information for many applications, including land use and land cover mapping, agricultural and environmental resource management, mineral exploration, weather forecasting, global change research, and terrain elevation.

A typical LIDAR system consists of a plane equipped with a rapidly pulsing laser unit, an accurate clock, Global Positioning System (GPS), inertial measuring unit, and associated computer/electronics equipment. A surveyed ground location within the sampling area and differential post processing allows for accurate geo-referencing of the LIDAR data.

The LIDAR instrument transmits pulses of laser light to a target; some of the light is absorbed and some is reflected back, measured, and analyzed. Differences between the properties of the light which were transmitted and those which were received are analyzed to produce the desired data. Ranges are calculated based on the difference between the time the signal left the transmitter and the time it returned to the transmitter.

Accurate geo-referencing is developed by comparing onboard GPS data with GPS of known on-the-ground control locations, differentially correcting the plane's location. The onboard inertial system allows correction for acceleration, pitch, and roll of the plane as it flies along.

13.2 Benefits

Generally, LIDAR data is used in the following applications:

- spot heights
- Digital Elevation Model (DEM), Digital Terrain Model (DTM), Digital Surface Model (DSM)
- contours
- feature extraction
- building footprints and heights
- vegetation measurements
- breakline definition
- road centre-line location and road surface modelling

LIDAR also produces value-added products such as:

- hydrologically enforced terrain models
- data fusion
- view shed analysis
- virtual reality / augmented reality
- 3D fly-through

The applications possible from LIDAR information include flood modelling, corridor

mapping, wireless network planning, transportation, power line mapping, hazard clearance, natural resource assessment, demographic profiling and urban planning.

There are a number of projects currently underway or planned under both council's LTCCP that will benefit from a LIDAR survey. These benefits are outlined below.

LTCCP project/outcome area	Benefits
Otorohanga District Plan Review	• Better identification of planning zones or areas for the management of land use within the district (e.g. avoiding or managing high hazard areas). • Updating the corporate data base with a snap shot of highly accurate spatial (contour) information reflecting the state and condition of the environment, especially urban, infrastructure, floodplain, upper catchment and coastal information. • Determination of building footprints and heights.
Asset management	• Better definition of urban areas for asset management planning and modelling
Ngatea stopbank stability	• Accurate determination of stopbank heights and surrounding ground levels in terms of mean sea level. • Provision of high quality benchmark information to allow trend analyses if repeated surveys are carried out (say once every 5 years).
Hauraki natural hazard and risk assessment project	• Flood plain areas more clearly and accurately defined and will provide highly accurate input data into any agreed modelling work. • Provision of high quality benchmark information to monitor tectonic (seismic) processes within the district. Also allows trend analyses to be undertaken if repeated surveys are carried out (say once every 5 years).
Roading network	• Accurate determination of road heights and surrounding ground levels in terms of mean sea level. Also allows trend analyses to be undertaken if repeated surveys are carried out (say once every 5 years). • Road centre-line location and road surface modelling can also be determined.
Stormwater network	• Accurate determination of ground levels in terms of mean sea level to assist in overland flow modelling of storm water networks and surrounding ground levels. • Removes the need for GPS
Drainage areas	• Accurate determination of drainage/canal network gradients via ground contour information in terms of mean sea level.
Peat settlement monitoring	• High quality benchmark information which will allow trend analyses to be established if repeated surveys are carried out (day once every 5 years).

River channel assessment and scheme reviews (Piako and Waihou Rivers)	• Accurate determination of ground levels in terms of mean sea level to assist in monitoring channel movement and overland flow modelling of river systems.
River modelling	• Highly accurate digital terrain model and contour information necessary for hydraulic modelling, geotechnical assessments, catchment/erosion studies, flood hazard mapping information, and for assessment of performance of existing and proposed works.
Debris flow analysis (Coromandel/Kaimai Ranges)	• Highly accurate digital terrain model and contour information necessary for mapping susceptible catchments and modelling alluvial fan processes.
Other benefits	• Standardisation of datums (expressed where possible in terms of mean sea level) • All data geo-referenced from inception, which directly interfaces to GIS applications.

It is anticipated that the need for LIDAR survey data will increase as technical people/organisations become more conversant with the capabilities and advantages of LIDAR for landform, vegetation definition and bathymetry analysis purposes.

A LIDAR survey programme for the Hauraki district is currently being proposed for the 2007/08 financial year.