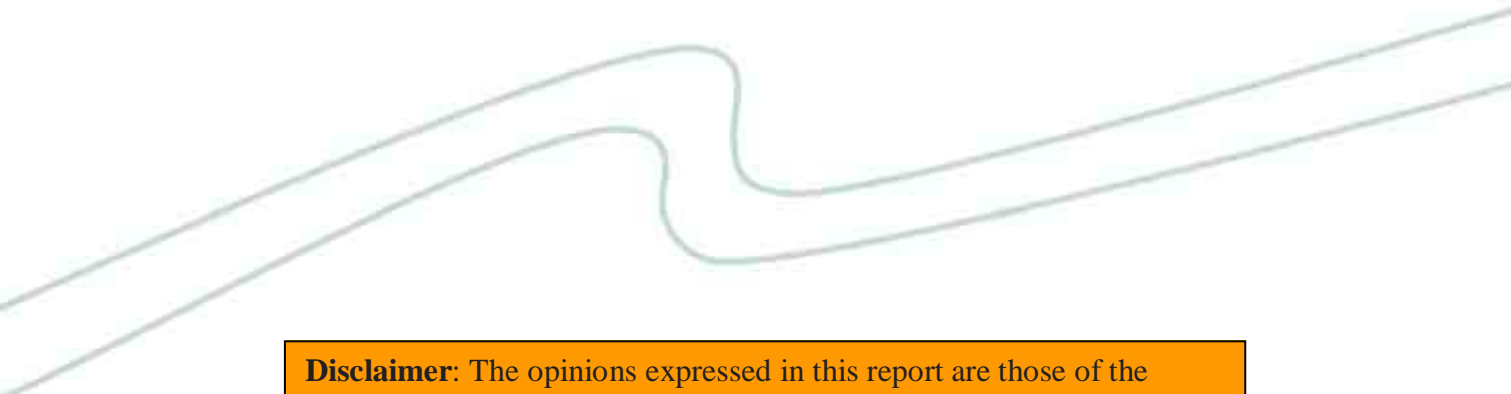


# The Waikato Weather Bomb

## Understanding the impact

March 2004

A report commissioned by the New Zealand Climate Change Office (Ministry for the Environment) in conjunction with Environment Waikato and the Ministry of Civil Defence and Emergency Management



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## Preface

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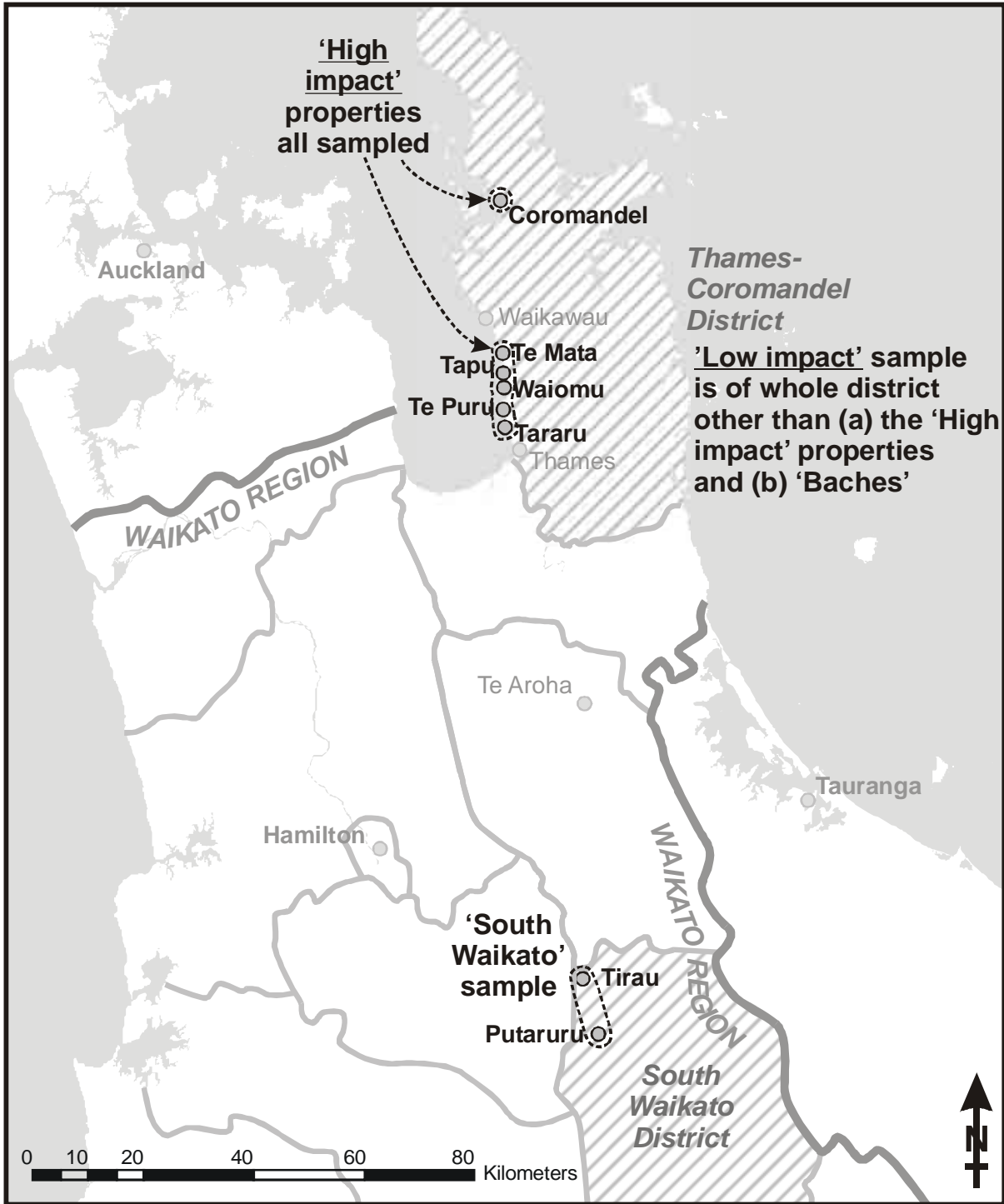
## EXECUTIVE SUMMARY

Extreme weather and climate events are an important natural hazard that cause damage and inflict costs on local communities. To plan appropriate response measures that minimise damage and are cost-effective, it is important to both understand the economic effects of extreme events and to understand the way in which communities understand, perceive and prepare for such risks. Such information becomes increasingly relevant in the context of climate change, which is expected to increase the frequency and severity of heavy rainfall and consequent flooding in New Zealand.

The long-term management of risk is particularly important in the context of climate change, which is expected to change the intensity and frequency of some extreme weather events such as heavy rainfall leading to flooding. This report provides information on the economic costs and community understanding and responses to flood risk for the Coromandel area following the 2002 “weather bomb” that caused major flooding to a number of townships in the area.

The 21 June 2002 Weather Bomb developed from a mid-latitude depression that rapidly deepened as it approached the northern tip of New Zealand. Severe Weather Warnings for the storm were issued by MetService on 19 and 20 June forecasting heavy rain and strong wind for the region. Anticipating the intensity of the storm, MetService issued media releases that deliberately used the term “weather bomb” to attempt to maximise public attention to the potential severity of the weather. Heavy rain and strong winds were widespread over much of the northern parts of New Zealand, with slips and flooding reported in Northland, Coromandel and the Waikato. An intense band of rain occurred at the rear of the main rain area, causing torrential rain to fall after the catchments were already saturated by earlier rainfall. Significant flooding was recorded in Waikawau, Waiomu, Tapu, Te Puru, Tararu, Te Aroha, Tirau and Putaruru, but also occurred in other areas across the region (unrecorded). Return period analysis by Environment Waikato suggests that the storm was a 1-in-100 year event.

For the purposes of this study the Coromandel ‘high-impact’ area is the section of western Coromandel coastline from immediately north of Thames to Coromandel township (inclusive). As well as Coromandel township, this ‘high-impact’ area includes the communities of Waiomu, Tapu, Te Puru and Tararu (See Fig. 1). These are the only areas where ‘high impact’ properties could be analysed because they are the only places for which Civil Defence has records of impact data and maps. The ‘low-impact’ Coromandel takes in the remaining Thames Coromandel District. Many of the district’s residents have experienced flooding at some time in the past. The ‘South Waikato’ sample is of randomly selected homes in Tirau and Putaruru.



**Figure 1** Map of named communities, 'high impact'-Coromandel, 'low impact'-Coromandel and 'South Waikato' areas. Note rivers are shown on enlarged map, Figure 4.

This study:

- a) evaluates the direct and indirect costs of the ‘Weather Bomb’ event,
- b) gives a macroeconomic view of the event in terms of the region-wide economic effects, and
- c) provides an understanding of the impact on the community affected in terms of preparedness and the perception of risk.

Two general surveys were used to collect data from households and businesses within the affected areas. The questionnaires were developed to collect quantitative data for the three main areas of analysis listed above. Particular attention was paid to content and design to enhance the return rate. Both surveys also include full demographic questions compatible with national census data. Questionnaires were hand-delivered to households and businesses that were known to have been directly affected by the flooding. The remaining sample of households and local businesses were mailed questionnaires. The surveys were hand-delivered and posted during September 2003. The total domestic survey return rate was 33.1 %, and the total sample of completed domestic questionnaires was 439. The business survey was conducted on a much smaller scale than the domestic survey and the return rate was 28.5 % (a sample of 69 businesses).

Approximately 35 % of affected properties (about 300 within the ‘high impact’ settlements) had flooded land, 37 % had flooding of the basement and/or outbuildings, and 28 % suffered house flooding above the floors of the living areas. The exact nature of the flooding and losses (other than value) within homes was not centrally recorded and not covered within the scope of the questionnaire.

The depth to which a house is flooded affects the number and types of items that are damaged. Household mean losses are disproportionately low when mean flooding in that house is 5 cm or less deep. Average losses rise roughly proportionately to mean flooding depth for depths from 5 to 50 cm. Household mean losses are disproportionately high when mean flooding in that house is more than 50 cm deep. Vehicle mean losses jump upward on properties where the mean household flooding was above 5 cm deep, and then remain relatively constant.

The largest combined overall losses in the Weather Bomb event were overwhelmingly for flooding in the 10-50 cm depth bracket. If mean household flooding depths > 50 cm had been more common, the losses could have been an order of magnitude greater (other than for vehicle losses, which should have remained at similar levels). Conversely, if mean flooding had rarely exceeded 5 cm depth, losses would have been an order of magnitude less (including vehicle losses).

Analyses of the economic impacts of New Zealand natural hazard events have been relatively sparse compared to analyses undertaken overseas. Impacts have been assessed here under the categories of direct and indirect impacts. Due to difficulties in determining intangible economic impacts these have not been modelled for the Weather Bomb event. The most notable outcome of this analysis is that the economic impacts, although enormous for some individuals, were relatively minor for the Waikato community as a whole, and much less than might have been anticipated, given the severity of the weather event.

Direct costs were limited almost entirely to property damage. The estimated insurance claims made as a result of the event were \$21.5 million, with around \$8 million related to the Thames-Coromandel area. Data from the survey suggests that this was split 0.84/0.16 between households and businesses (\$6.7 and \$1.3 million respectively). Total uninsured losses are estimated at \$2.1 million, based on the survey data. In addition, TCDC estimated that agency response costs were \$3.1 million, with much of that attributed to labour costs. The total direct costs are thus estimated to have been \$13.2 million for the TCDC area. The true loss to the area likely sits somewhere between 0.1 – 0.6 % of the area's asset base (estimated to be around \$1750 million). This relatively crude estimate provides an indication of the relative size of the event.

In terms of indirect losses the business survey results suggest that the net impact of the weather bomb on business sales was positive (around 30 % more revenue from increased business than the value of lost business). Note that this does not represent a true positive net impact to businesses in the Thames-Coromandel area, because many negative impacts, particularly damage to property (a direct loss, quantified above), are missing. The cost borne by insured TCDC households and businesses via insurance excess payments is estimated to total around \$0.45 million. Additional losses as a result of losses of no-claims bonuses, premium increases and, in some cases, cancellation of policies, also occurred but are extremely difficult to quantify. These losses are also only partly related to the Weather Bomb event alone. Adopting a longitudinal framework involving assessment of the incremental impact of successive hazard events is likely to provide a fairer picture of the longer-term cost of repeated events.

A regional version of NZIER's computable general equilibrium (CGE) model was used to estimate flow-on effects to those dependent on parties who were directly affected. These effects were found to be negligible. Industry output, factor demand and household welfare were found to be affected by less than 1 %, probably close to the margin of error.

The flow-on effects of the weather bomb are likely to have been minimal because: (a) the duration of the event was relatively short, (b) the severity of the weather bomb in terms of its direct economic costs were also relatively

mild, and (c) Thames-Coromandel is in effect a small, borderless economy (which means, for instance, that the impact of business closures which arose as a result of the weather bomb is mitigated by the easy accessibility of substitute goods and services from the surrounding Waikato economy).

A key issue resulting from this study is the need to explore in more detail the links between weather warnings and appropriate responses of individuals in high risk areas. Warning the public about flood events is the responsibility of the regional and local councils, based on Warnings from MetService and other information. There is considerable research pointing to the value of simple alert schemes to help individuals, organisations and communities respond to developing crises. The need for improved tools for responding to floods in New Zealand has been identified in recent research on the Waikanae floodplain and suggested by this study. Given the short flood response time in the catchments and the lack of flood warnings systems it is still not clear how a system would work, but it is a problem worth exploring.

The community survey measured a range of attitudes, beliefs and understandings of flood risk, the Weather Bomb event and the community in general. From previous social research we are aware that people's understanding of risk and response to risk are determined not only by scientific information or direct physical consequences, but also by the interaction of psychological, social, cultural, institutional and political processes. Changing people's perceptions of risk alone will not necessarily bring about changes in their behaviour or increased action to address a particular risk. People may not be motivated to prepare if they do not perceive or accept their risk status or perceive hazards as salient. Irrespective of the level of perceived threat, people will be reluctant to act if they perceive the effects of hazards as being difficult or impossible to mitigate through personal action (low outcome expectancy). Measures designed to reduce potential adverse impacts may not be implemented if people do not believe they are competent to carry out the appropriate activities (low self efficacy). People may lack the resources (e.g., time, skill, need for cooperative actions etc.) required to implement reduction measures (low response efficacy), or transfer responsibility for their safety to others (low perceived responsibility). They may not trust information sources, or may not act because of uncertainty regarding the likely timing of a hazard occurrence.

The community consultation over future risk management options, undertaken over the past six months (since August 2003), is continuing to address a range of issues relating to acceptable risk, appropriate mitigation options and the community's willingness to pay. Follow-up research is needed to see how the perceptions documented in this study influence the process. This work is currently underway.

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# 1. INTRODUCTION

## 1.1 Overview

This report provides the first major output of a collaborative project to develop methods for the comprehensive economic analysis of the impacts of flood events, and to investigate the social impacts on communities of flooding, and their perceptions surrounding floods. It also feeds into ongoing research on flood warning systems, preparedness, flooding impact mitigation and emergency response planning. The project and ongoing research are a collaboration between the Institute of Geological and Nuclear Sciences (GNS), the New Zealand Institute of Economic Research (NZIER), the Ministry for the Environment (MfE), the Ministry of Civil Defence and Emergency Management (MCDEM), the National Institute of Water and Atmospheric Research (NIWA), Meteorological Service of New Zealand Ltd (MetService), and regional and local government (Environment Waikato, Thames-Coromandel District Council and South Waikato District Council for the Weather Bomb event and this report).

The ‘weather bomb 2002’ was a low-pressure system that led to extensive flooding on the Coromandel Peninsula and the south-west Waikato region, including one loss of life. The New Zealand Climate Change Office, Environment Waikato and Ministry for Civil Defence and Emergency Management commissioned this study to estimate the economic impact of the weather bomb event on the region, and to better understand the way in which communities understand, perceive and prepare for such risks. The aim of this report is to assist local government decision-making, and to inform the development of the Climate Change Office work programme on the economic impacts of severe weather events.

## 1.2 Aims and objectives

The primary aims of this report and their relative emphasis within the report are:

- a) to evaluate the direct and indirect costs of the ‘weather bomb’ event. (40 %),
- b) to give a macroeconomic view of the event in terms of its region-wide economic effects. (40 %), and
- c) to provide an understanding of the impact on the community affected in terms of their preparedness and perception of risk (20 %).

These have been achieved through completion of the following objectives:

- 1) A survey of a representative sample of those affected and unaffected by the weather bomb within the Coromandel Thames and South Waikato Districts, both private households and businesses.
- 2) Compilation and analysis of insurance losses, both corporate and Earthquake Commission, via data from the insurers and data on insured and uninsured losses directly from the victims.
- 3) Numerical macroeconomic modelling utilising regional and national economic data, survey and research results to provide a detailed understanding of the real economic dynamics and impacts surrounding the event.
- 4) Interpretation of the community impact, vulnerability and resilience from a hazard/disaster psychology perspective.

The project includes a non-technical summary, separate to this report, that will be made available to those participating in the study (including flood victims), Regional and District Councillors, Regional and District Council staff and any interested members of the general public.

See Section 7.5 for details of the research that will build on the findings of this initial report.

### **1.3 The 21 June 2002 weather bomb**

The “weather bomb”—a potentially damaging low-pressure system—developed from a mid-latitude depression that formed off the coast of Queensland, Australia. This system rapidly deepened (Fig. 2) as it approached the northern tip of New Zealand, with the central pressure dropping at a rate of 16 hPa in 24 hours. It thus exceeded the internationally-accepted criteria, for our latitude, for a “weather bomb”. Severe Weather Warnings issued (Table 1) by MetService on 19 and 20 June for the region included Heavy Rain Warnings and Strong Wind Warnings. A press release alerting media to these was issued at 12:25 pm on the 19<sup>th</sup> of June. The first sentence read: *“Large parts of the northern third of New Zealand have been targeted by MetService with Severe Weather Warnings or put under a severe weather watch for wind-driven rain during Thursday.”*

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MetService defines heavy rain as: *‘Greater than 1 mm in 10 minutes. Rain falls in sheets, makes a roaring noise on roofs’*

(<http://www.MetService.co.nz/forecasts/terminology.asp#terms>)

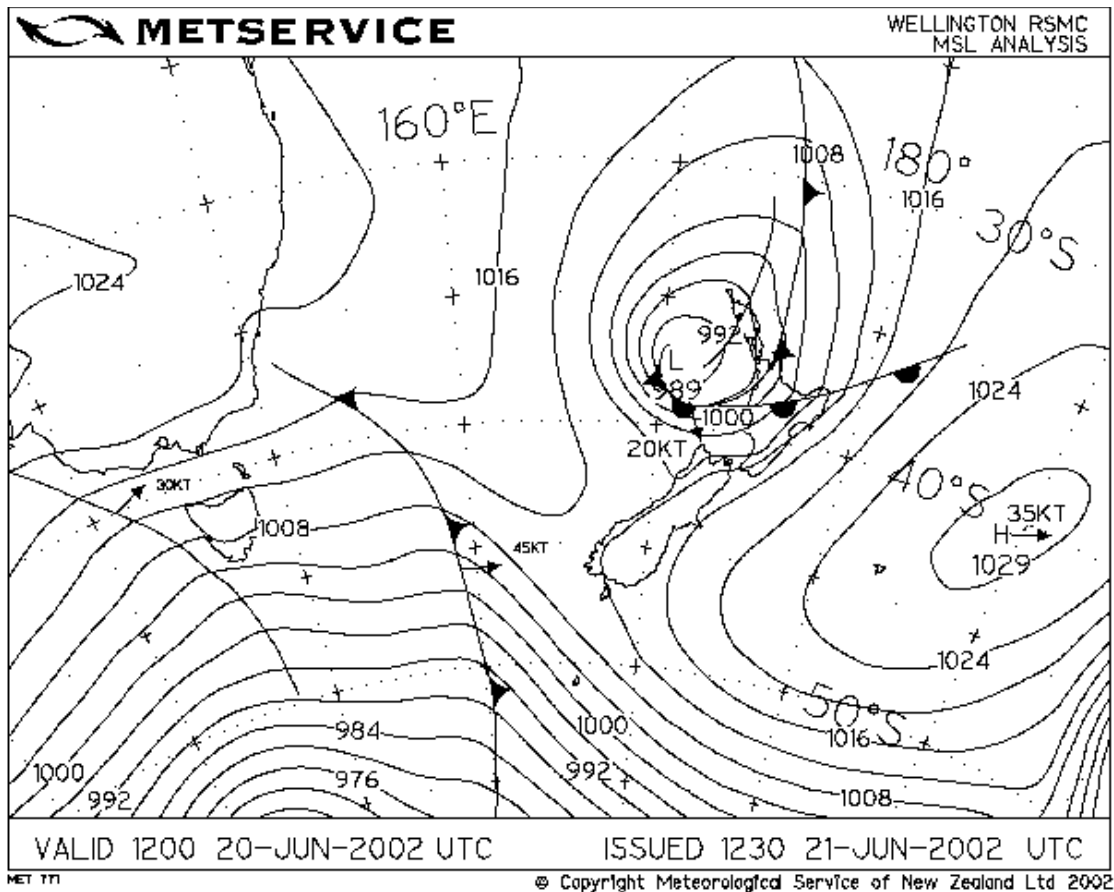
See Appendix 1 for MetService criteria for issuing a ‘Severe Weather Warning’

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**Table 1 Timeline of severe weather and Heavy Rain Warnings issued for the weather bomb storm and the Coromandel Peninsula in particular (summarised from reproductions in Munro, 2002)**

Code	Warning issued	Time	Date
SWW 2002/29.3	WEATHER BOMB ON TRACK TO AFFECT NORTHERN NEW ZEALAND – WIND WARNING NOW EXTENDED SOUTHWARDS	8:31 am	20-Jun-2002
	[MetService is warning residents and travellers in Northland, Auckland Coromandel Peninsula, Waikato and Bay of Plenty to prepare for a spell of damaging winds and heavy rain....]		
	HEAVY RAIN WARNING: NORTHLAND AUCKLAND COROMANDEL PENINSULA WESTERN BAY OF PLENTY. FORECAST: Rain is intensifying. In the 21 hours from 9am Thursday to 6 am Friday, expect 150-200mm rain in the ranges. Intensities are likely to reach 15 to 20 mm per hour in thunderstorms....		
	STRONG WIND WARNING: NORTHLAND AUCKLAND COROMANDEL PENINSULA WAIKATO WAITOMO BAY OF PLENTYTAUPO TAUMARUNUI TARANAKI TAIHAPE WANGANUI MANAWATU. FORECAST: Between 3pm Thursday and 6am Friday, expect east or northeast winds gusting 120km/hr in exposed places, especially over the tops and in the lee of ranges.		
SWW 2002/29.4	RAIN WARNING EXTENDED TO EASTER BAY OF PLENTY AND NORTHERN GISBOURNE, WIND WARNING EXTENDED TO MANAWATU	11:23 am	20-Jun-2002
	[Rain deepening has commenced in the low northwest of the North Island, and it is still on track to bring stormy conditions to many parts of the North Island. ]		
	HEAVY RAIN WARNING [As above]		
	FORECAST [COROMANDEL PENINSULA AND THE KAIMAIS: In the 13 hours from noon Thursday to 1am Friday, expect another 90-120mm of rain...		
	STRONG WIND WARNING [As above] FORECAST: Between 3pm Thursday and 6am Friday, expect east or mortheast winds gusting 120km/hr in exposed places, especially over the tops and in the lee of the ranges.		
SWW 2002/29.5	HEAVY RAIN HEADING SOUTH. WARNING EXTENDED TO WAIRARAPA AND MARLBOROUGH	5:05 pm	20-Jun-2003
	[The low heading for northern North Island continues to deepen and rain has becoming widespread over the North Island. MetService forecasters expect heavy rain in Northland to spread south over Auckland, Bay of Plenty and northern Gisbourne tonight and into Wairarapa and eastern Marlborough for a time on Friday morning. In addition, easterly gales which have already affected the area from Northland to the Coromandel Peninsula, are likely to spread as far south as Manawatu and the central plateau overnight. Auckland and Northland residents are also warned that there could be a sting in the tail of this system with a period of southwesterly gales is likely for a time about the middle of Friday.]		
	HEAVY RAIN WARING [As above] FORECAST: In the 12 hours from 5pm Thursday to 5am Friday, expect another 90-120mm rain in the ranges.		
	STRONG WIND WARNING [As above] FORECAST: Between 5pm		

Code	Warning issued	Time	Date
	Thursday and 6am Friday, expect east or northeast winds gusting 120km/hr in exposed places, especially over the tops and in the lee of the ranges.		
SWW 2002/29.6	STORMY WEATHER HEADING SOUTHWARD BUT EASING IN THE NORTH OVERNIGHT	8:17 pm	20-Jun-2002
	[... Winds and rain are starting to ease in northern parts of the Northland this evening and this improvement should spread southwards over Auckland and the Coromandel Peninsula overnight...]		
	HEAVY RAIN WARNING [As above] FORECAST: In the 9 hours from 8pm Thursday to 5am Friday, expect another 100mm in some high parts of the ranges with intensities 15-20mm/hr, and 40 to 60 mm lower down in the east]		
	STRONG WIND WARNING [As above] FORECAST: Between 8pm Thursday and 3am Friday, expect east to northeast winds gusting 120km/hr in exposed places especially over the tops and in the lee of the ranges.		

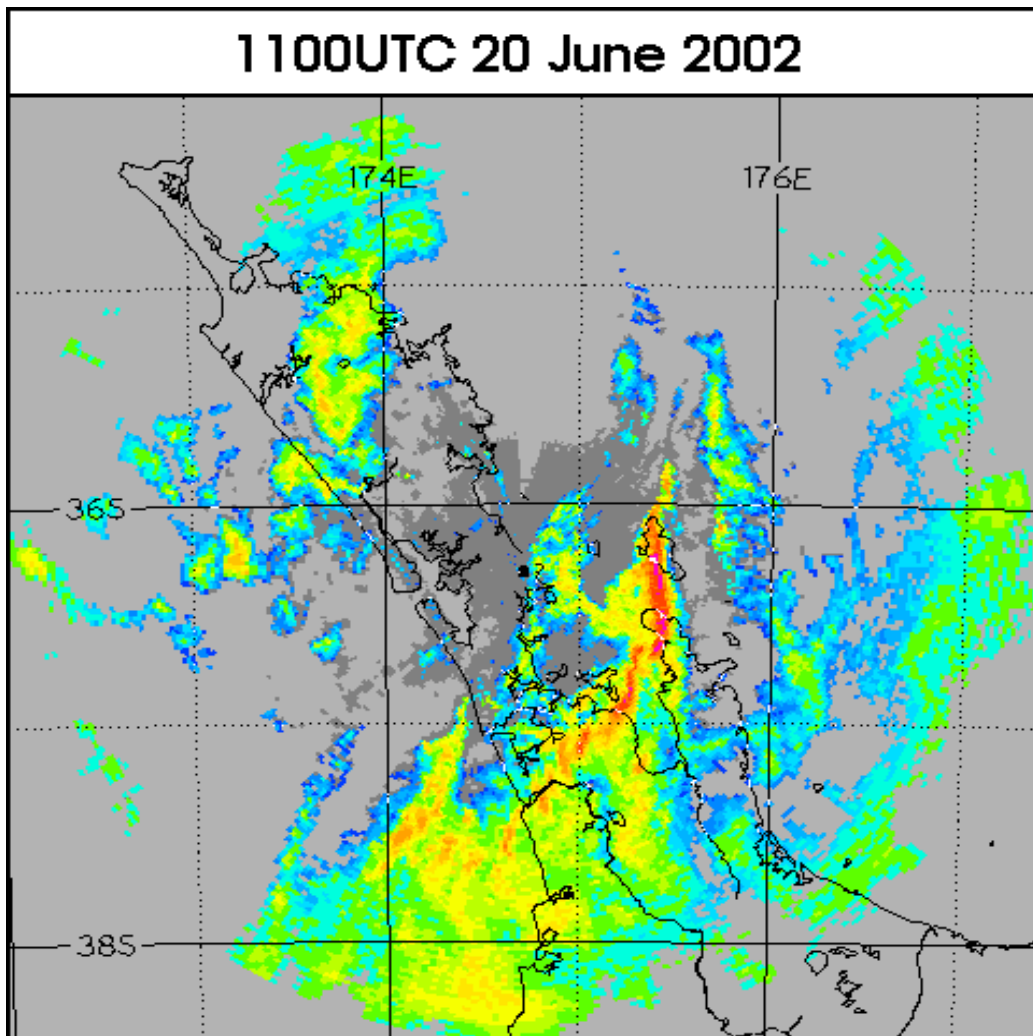


**Figure 2 The mean sea level pressure analysis for 1200 UTC on the 20 June 2002.**

Heavy rainfall from the system was widespread over much of the northern parts of NZ, with slips and flooding reported in Northland, Coromandel and the Waikato. The storm was also accompanied by strong winds—gusts up to 120 km/hour were reported for the Coromandel region. Damage reported included lost roof-tops and toppled trees (especially across the Hauraki plains).

#### 1.4 Coromandel and Southern Waikato flooding

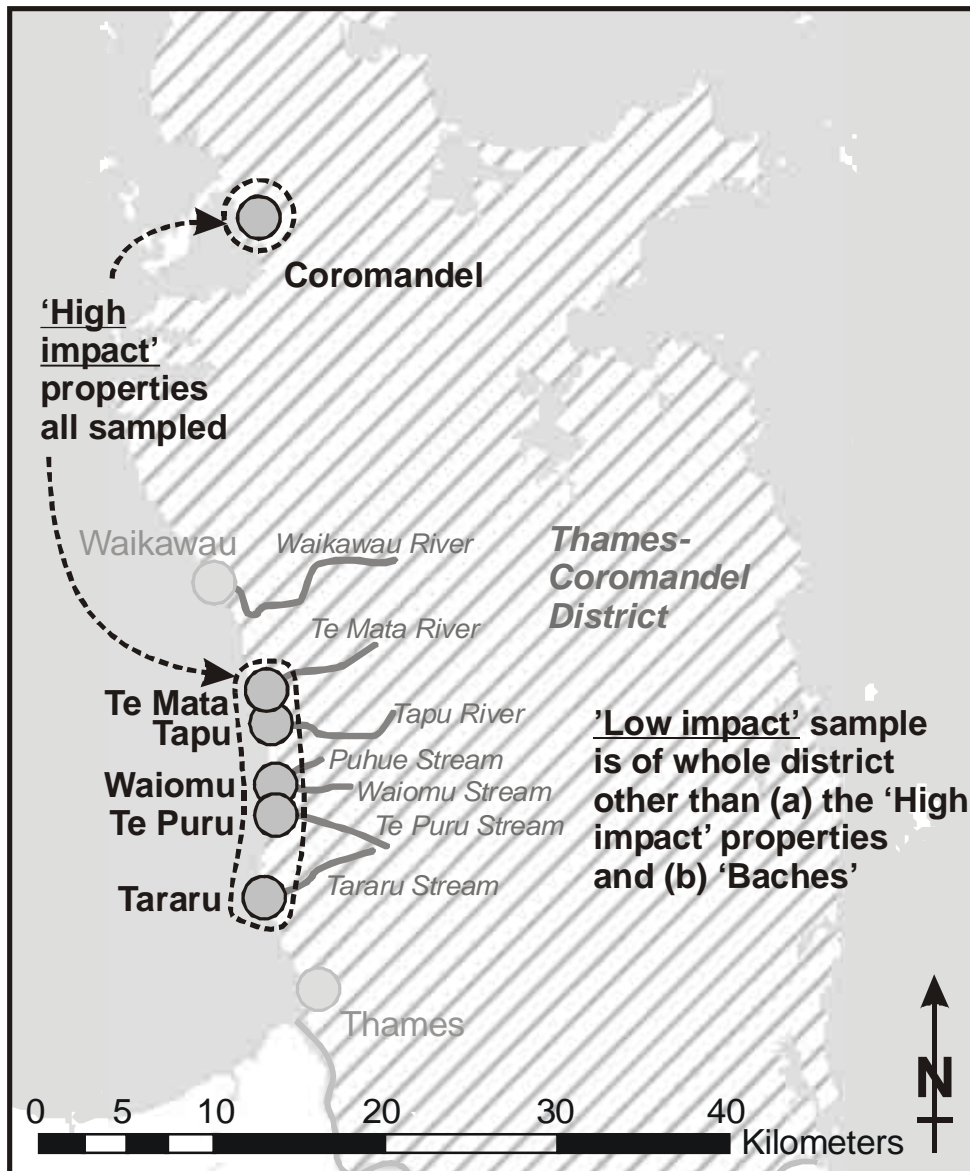
Rainfall totals from this system exceeded 200 mm in 24 hours at seven rain gauge sites, and much of that rain fell in only 1 hour. Radar imagery (Fig. 3) showed that the main band of rain was elongated in shape and moved southward down its length, delivering around 1 hour of intense rainfall to the western side of Coromandel.



**Figure 3** 1100 UTC 20 June 2002 radar image showing the estimated radar reflectivity at the surface. Red colours imply rain rates in excess of 50 mm per hour.

Another smaller band of heavy rain passed over Putaruru, leading to flooding in that area.

A feature of this rainfall was the “sting in the tail” of the event, i.e., an intense band of rain was at the rear of the rain area, so that very heavy rain fell at the end of the rain event, after the catchments were already well saturated by earlier rainfall. This is a recipe for maximising the likely damage.



**Figure 4** Locations described in text within Thames-Coromandel District, including key streams and rivers that burst their banks (enlargement from Figure 1).

Significant flooding occurred in Waikawau, Waiomu, Tapu, Te Puru, Tararu, Te Aroha, Tirau and Putaruru (Figs. 1 and 4, above). Note that 'Waikawau' listed here, on the Coromandel west coast, is different to the place and bay on the Coromandel east coast also of the same name. Five major rivers and streams (Tararu, Te Puru, Tapu, Waiomu and Waikawau Rivers) and many smaller streams burst their banks. Return period analysis by Environment Waikato (based on both rain gauge and flow, Munro 2002) suggest that the storm was a 1-in-100 year event.

The Waikato Region utilises a variety of flood prevention and mitigation measures: these include stopbanks, floodwater pumping stations, floodgates, river and stream channel improvement works, soil conservation fencing, soil conservation planting and retirement, and soil conservation structures<sup>1</sup>. Some of these were damaged during the Weather Bomb event (see Munro 2002).

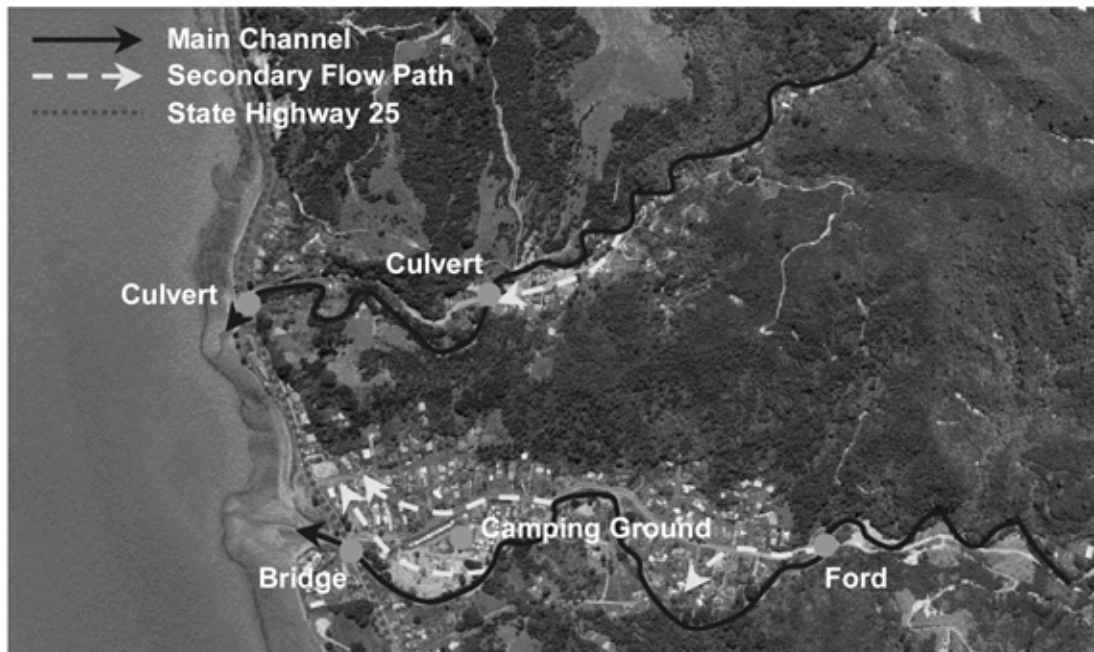
For the purposes of this study, we have defined several areas within the region affected by the weather bomb. The Coromandel 'high-impact' area is the section of the western Coromandel coastline from immediately north of Thames to Coromandel township (inclusive). In this 'high-impact' area, which includes Waiomu, Tapu, Te Puru and Tararu, as well as Te Mata and Coromandel, the townships occupy the valleys and coastal alluvial fans of several streams that had severe flooding. The 'low-impact' Coromandel takes in the remaining Thames Coromandel District. Flooding damage was also recorded by EQC and private insurers in the South Waikato District towns of Putaruru and Tirau in particular. The 'South Waikato' sample herein refers to a random sample from these two towns.

Large steep catchments caused flows to increase very rapidly. Inland of the west coast of the Coromandel peninsula, the flood waters remained largely confined in the valleys and gorges. Where these valley bottoms were populated there was extensive flood damage (e.g., Puhue Stream valley, on the northern fringe of Waiomu). As the rivers reach the coast, they emerge onto coastal alluvial fans. Here the flow rate of the flood waters exceeded the cross-sectional capacity of the existing channels, and flow spread out across the fans, following the easiest path to the Hauraki Gulf. The 'high impact' settlements listed above occupy extensive areas of these coastal fans, as they provide the only flat land along an otherwise steep, rocky coastline. Overtopping of stream channels across the coastal fans was exacerbated by the narrowing of channel width where the rivers flowed under the bridges for State Highway 25. These created a 'pinch point', forcing flood waters over the banks upstream of the bridge and increased the flooding depths across properties beside and down slope of the bridges (note

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<sup>1</sup> Refer: <http://www.ew.govt.nz/ourenvironment/rivercatchment/index.htm#Heading4> for information on the Region wide mitigation measures. Ryan (2003) provides details, including photographs and maps, of the individual existing, and various proposals for additional, flood prevention measures to each of the 'high impact' western Coromandel coast waterways.

the intensity of flooding on the properties north of the bridge in Figs. 5a and 5b). The flood waters contained abundant vegetation and debris and these tended to snag at the bridges, further compounding the problem. There was loss of life where one victim was swept away at the motor camp in Waiomu (Fig. 5b), on one of these coastal fans.



(a)



(b)

**Figure 5** (a) Flooding scenario within the Waiomu community during a 100 year event and (b) Property damage within the Waiomu community during the 'weather bomb' (Ryan 2003).

## 1.5 Survey

Two general surveys were used—these were designed to collect data from (a) households, and (b) businesses, within the affected areas, using identical research procedures across the entire sample. The questionnaires were developed to collect quantitative data specifically on the elements described below. Development of the questionnaires followed the method outlined by Dillman (1978), with particular attention paid to content and design focussed on enhancing the return rate.

The questionnaires are in Appendices 6 and 7.

- a) Households affected by the event were surveyed to determine:
- the losses (value) caused by the event (both direct and indirect) for households and communities alike,
  - disruption caused to infrastructure (e.g., power and roads) and the costs associated with this,
  - levels of preparedness, based on prior understanding of risks, and warnings given by the media and civil defence concerning this event,
  - changed perceptions of the risks among those affected by the weather bomb, and
  - resultant changes in the level and nature of preparedness for future similar events by individuals, businesses and small groups.
- b) Businesses affected by the event were surveyed to determine:
- the losses caused by the event (both direct and indirect) for those businesses and whether they were insured,
  - any offsetting increases to business resulting from the event, and
  - the history of flooding impacts to that business.

Both surveys also include full demographic questions compatible with national census data (see Section 1.5.3).

### 1.5.1 Method of Delivery

Staff from the Institute of Geological and Nuclear Sciences and Thames Coromandel Flood Project coordinators hand-delivered questionnaires to households that were directly affected by the flooding. The questionnaire was personally delivered to a member of the household, so staff members could explain the questionnaire and its purpose, as well as establish a

rapport with the community. If no one was at home, a questionnaire was left at the property.

Other parts of the community, i.e., households that were indirectly affected, either received personally delivered questionnaires or were part a random postal survey. Questionnaires were also available on request, mailed out from council chambers.

A similar approach was taken to survey local businesses. Businesses that were directly affected were delivered questionnaires personally, and those that were indirectly affected were mailed questionnaires. Organizations and local authorities (insurance providers, EW, TCDC etc.) that were directly and indirectly affected were contacted for information they had regarding the event (See Appendices 4, 8 and 9 and refer to Munro, 2002).

Because of this method of delivery, a higher response rate and more comprehensive data set was obtained compared to that commonly obtained using a random postal survey. A postal-only survey would have been particularly hampered in the Coromandel area because of the large number of rural delivery and postal delivery centre addresses.

For the design of the questionnaire, staff from NIWA, GNS, MetService, MfE, NZIER, EW, and TCDC were consulted. This consultation process continued from late May through August 2003. The questionnaire was reviewed by staff of TCDC.

The surveys was hand-delivered and posted during September 2003.

Two weeks after the questionnaire was delivered, a reminder letter and replacement questionnaire were posted to those households that had not returned the questionnaire, again inviting them to participate.

### **1.5.2 Return Rates**

Table 2 presents a breakdown of the survey return rates. The total domestic survey return rate was 33.1 % (439 responses) of those deliveries which did not fail. This contains a sample of 332 responses from households in the Thames-Coromandel District, out of a population of about 26,300 (ie. response from about 1.3 % of the district). The sample of 'high impact' houses with some financial loss was 137 (46 % of an approximate total of 300 flooded from Civil Defence estimates), of these 64 had losses over \$10,000.

Failed deliveries occur when a mailed-out form is returned to the sender by the postal service because it cannot reach the intended address. The overall failure rate was 8.9 %. A failure rate of around 10 % is common for postal surveys and is primarily the result of inaccuracies in the address database.

The database source here was provided directly by the district councils as a random sample from their rating databases.

**Table 2 Survey return rates**

	Total sent	Return to sender	Fail %	Total non-fail	Returned blank	Returned blank (% of non-fail)	Returned complete	Complete (% of non-fail)
<b>South Waikato:</b>	434	51	11.8%	383	4	1.0%	107	27.9%
<b>Coromandel low-impact:</b>								
(a) direct mail	229	57	24.9%	172	-	0.0%	47	27.3%
(b) bach (owner mailed)	269	14	5.2%	255	4	1.6%	72	28.2%
<b>Coromandel high-impact:</b>	522	7	1.3%	515	4	0.8%	206	40.0%
<b>DOMESTIC TOTAL</b>	1454	129	8.9%	1325	12	0.9%	<b>439</b>	<b>33.1%</b>
<b>BUSINESS TOTAL</b>	253	11	4.3%	242	4	1.7%	<b>69</b>	<b>28.5%</b>

There was a relatively high failure rate for the Coromandel low-impact area. This is likely a result of returns from rural sections, which have no means of postal delivery but are directly rated (i.e., rates are paid from that address). This failure rate was already dramatically reduced by a careful effort to remove addresses that are not serviced by rural delivery, and separating out addresses that were clearly owned outside of the district and were thus probably holiday homes or 'baches'. For this latter group the forms were directly mailed to the owner (outside of the district). The failure rate for this group was relatively low (5.2 %), as these addresses were almost exclusively in suburban areas with full mail delivery services.

The Coromandel high-impact area was considered the most crucial dataset, for which it was especially important to maximise the return rate (a rate of 40.0 % was achieved). The high return rate and extremely low failure rate here (1.3 %) is the result of these questionnaires being hand-delivered to the household's door.

The number of surveys mailed out took into account forecasted failure and return rates and the total sample of completed domestic questionnaires was 439.

The return rates cited in various studies using identical freepost-return questionnaires vary considerably. Overseas studies have reported return rates as low as around 20 % (e.g. Davies, 1989) and as high as 80 + % (e.g. Perry, 1990). Recent New Zealand studies published by the authors consistently get rates from around 20 % (e.g. Miller et al., 1999) to just over 50 % (e.g. Johnston et al., 2003).

The business survey was a subordinate dataset and conducted on a much smaller scale than the domestic survey. The return rate was 28.5 % (a sample of 69 businesses) with a failure rate of 4.3 %. This failure rate was low because some of the questionnaires were hand delivered and most businesses were located within settlements with regular mail delivery.

With a sample of 439 the margin of error for the domestic sample is 4.8 %, and 12.0 % for the business sample of 69; we can be confident that 95 % of the time the real statistic for the whole population is within the margin of error of the statistic obtained from the survey sample, as long as the sample is representative (see below).

### **1.5.3 Assessment of representativeness**

As a measure of sample bias, demographic characteristics collected from the questionnaire are compared to the 2001 census in Appendix Table A2.1. Census results starting from the age bracket '15 and over' were used as this was the most suitable cut-off available to correlate to the age 18 and over respondents to the survey. A sample bias is common in almost all surveys, however there is usually sufficient variation to ensure that sample bias does not negatively affect the general conclusions drawn from these types of studies. The sampling method also reduced bias as much as possible. The relatively high return rates achieved also reduces sample bias.

The gender balance is within the margin of error for all areas. Age is skewed towards older respondents in all areas (especially those over 60, with a contrast of a particularly low under-30-years-old response). This is a common situation for voluntary response questionnaires. In terms of household composition, people living alone are slightly underrepresented whereas families without children are slightly overrepresented (this is strongest in the Coromandel 'low impact' area).

Europeans are overrepresented compared to all other ethnic groups, however this is not extreme – less than 2.0 % beyond the margin of error, for all areas other than South Waikato. The South Waikato sub-sample has twice the margin of error too large a proportion of Europeans, and a similar margin too few Maori, compared to the 2001 census.

There is a significant skew in educational qualifications, with a substantial (nearly four times the margin of error) lack of respondents with no school qualifications. In contrast, those with University Degrees contribute about

twice the margin of error more respondents than their proportion in the census data.

The skew in most income brackets is slight towards a greater representation of the higher income brackets (most are within the margin of error, but the proportion of respondents with household income > \$50,000 gross p.a. is about one and a half times the margin of error higher than for the 2001 census). There is a skew towards those not in paid employment, compared to those in full-time employment, for the whole sample.

Table A2.2 presents the length that the household has lived in that community and home. The mean length of residence in the community for the whole sample is 19.8 years, with the lowest being the Coromandel 'high impact' sub-sample (mean 17.6 years) and highest 'South Waikato' (mean 25.0 years). The mean length of residence in this home for the whole sample is 13.2 years, with the lowest being the Coromandel 'low impact' sub-sample (mean 10.5 years) and highest Coromandel 'bach' (mean 15.2 years).

#### **1.5.4 Analysis**

Data from the questionnaires has been coded and stored for analysis using the Statistical Package for the Social Sciences (SPSS/PC+) program.

All answers used in the residential economic impact assessment (Appendix 3) are for the household as a whole, whereas all social data presented in Appendix 5 are for the respondent only. Business survey responses are for the business as a whole (Appendix 4).

## 2. Losses vs. flooding type and depth

### 2.1 Type of flooding

Thames-Coromandel Civil Defence supplied colour-coded flood impact maps for the ‘high impact’ settlements. These showed that approximately 35 % of affected properties (about 300 within the ‘high impact’ settlements) suffered flooding of just their land, 37 % had flooded basements and/or outbuildings, and 28 % suffered house flooding above the floors of the living areas.

Documenting specific causes of damage (e.g., saturation of textiles and cladding, sedimentation, shear damage due to flow velocity and water column weight, impact from carried debris, flotation) is beyond the scope of this study. Collection of data on flooding type was considered during the design of the surveys. However the survey was conducted over a year after the event, so it was considered that recollection of details of the range of loss parameters (items damaged vs. how each was damaged) would likely be cloudy to the respondent. A more lengthy questionnaire would have detrimentally affected the return rate, resulting in a smaller sample if these details had been asked. No centralised data on the nature of flooding or damage was systematically captured at the time of the event, beyond impact maps (an example of one such map is given in Figure 5b).

### 2.2 Depth-loss analysis

The depth to which a house is flooded affects the number and types of items that are damaged. For example, flooding as little as 1 centimetre deep would damage flooring, but have little effect on anything that is not within a centimetre of the floor. Conversely flooding greater than 1 metre deep would be expected to damage all tables and bench tops and anything below or on top of these. Flooding above two metres deep would damage virtually everything in that room.

The following analysis and figures are based on data presented in Tables A3.4, A3.6 and A3.8. The mean depth of household flooding was computed for each property from estimated values given in survey responses for living room, bedroom, kitchen, bathroom, basement/cellar, hallway/landing and garage. These were then aggregated into depth brackets: < 5 cm, 5-10 cm, 10-50 cm, 50-100 cm, 100-200 cm and over 200 cm depth. Information, including the total aggregated loss, the number of cases with loss and the mean loss for each loss type (building/structure, contents, both building/structure and contents, removal of silt/debris, vehicles/boats/caravans/trailers, other) in each depth bracket were then computed and are plotted in Figures 6 through 8.

The total combined loss (Fig. 6) is greatest for houses with mean flooding depths of 10-50 cm for all insured loss types, and the majority of uninsured loss types Uninsured building and contents losses, when the respondent treated them separately from one another, were greatest with deeper flooding. This is partly a function of the number of houses flooded within each of the depth brackets (Fig. 7), which across the board is also highest for 1-50 cm depth. However there is also, in the cases of most loss types, a steady increase in mean loss with increasing mean flooding depth, up to 50 cm depth (Fig. 8).

The first point that is important to note from these figures is that, while the number of houses flooded to < 5 cm mean depth is proportionately higher than for the 5-10 cm bracket (for all but vehicle losses), the mean loss value for the < 5 cm bracket is the overall lowest for all costs other than silt and debris cleanup. This suggests that, as long as flooding is less than 5 cm mean depth, the mean value of losses will be disproportionately low. However, silt and debris cleanup costs are higher in more instances (possibly because with such shallow flooding flooring can be cleaned rather than needing to be replaced, thus avoiding a contents loss).

The second important point is that, for non-vehicle losses, the mean loss per house (Fig. 8) is particularly high for all depth brackets over 50 cm. Therefore, losses were a lot lower than if more properties had been flooded to > 50 cm mean depth (there were relatively few properties in this bracket, Fig. 7).

The trends for vehicle loss differ from those for household losses. Vehicle total losses (Fig. 6) are very much in proportion to the number of properties flooded to that average depth (Fig. 7). This is reflected in the relatively constant average vehicle loss (Fig. 8) for all depths > 5 cm. Vehicles on properties flooded to an average depth of < 5 cm had relatively very low average loss values (presumably because these flood waters were not deep enough to easily enter the vehicle's passenger compartment).

In summary:

- Household mean losses are disproportionately low when mean flooding in that house is 5 cm or less deep (cleanup of silt/debris may be possible in many cases, reducing permanent loss of contents).
- Average losses rise relatively proportionately to mean flooding depth for depths from 5 to 50 cm (through the ranges of height of beds, lounge furniture, TVs etc.).
- Household mean losses are disproportionately high when mean flooding in that house is more than 50 cm deep (reaching the heights

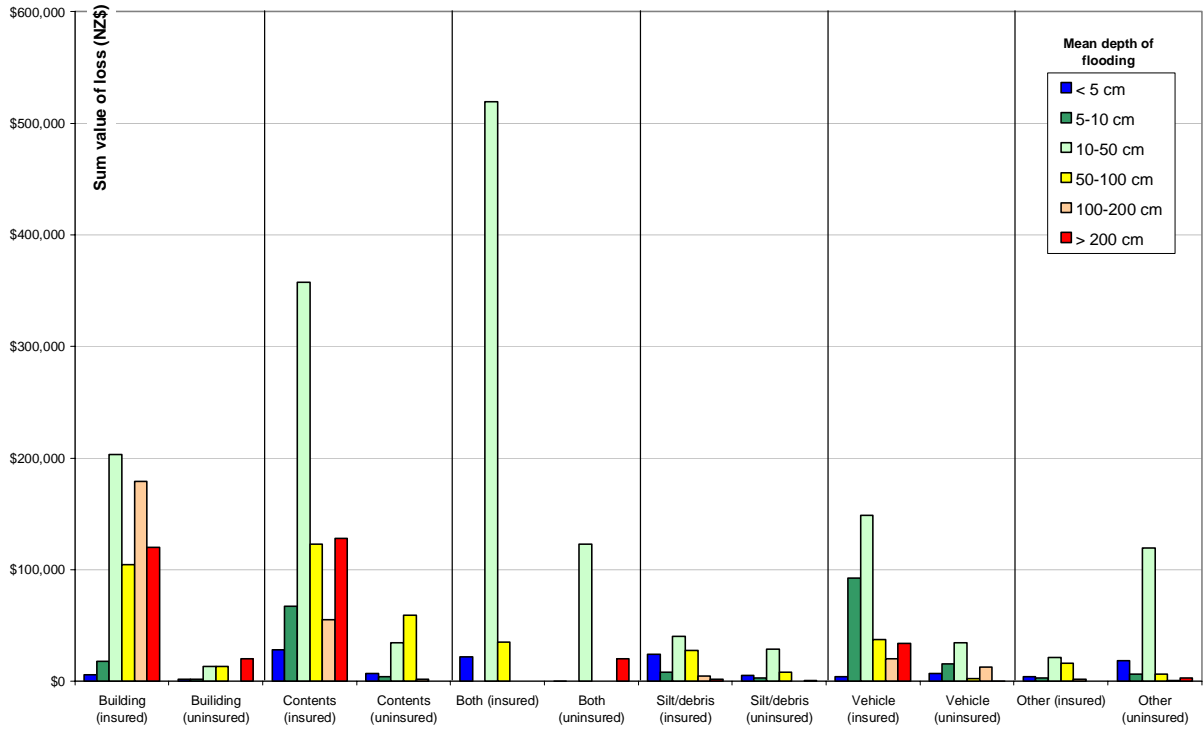
for table and bench tops and anything stored on top of, or above these).

- Vehicle mean losses jump on properties with mean household flooding above 5 cm deep, and then remain relatively constant, even when the vehicle sits on a property with mean flooding over the height of the vehicle roof (the control may be the height of the base of the vehicle floor).

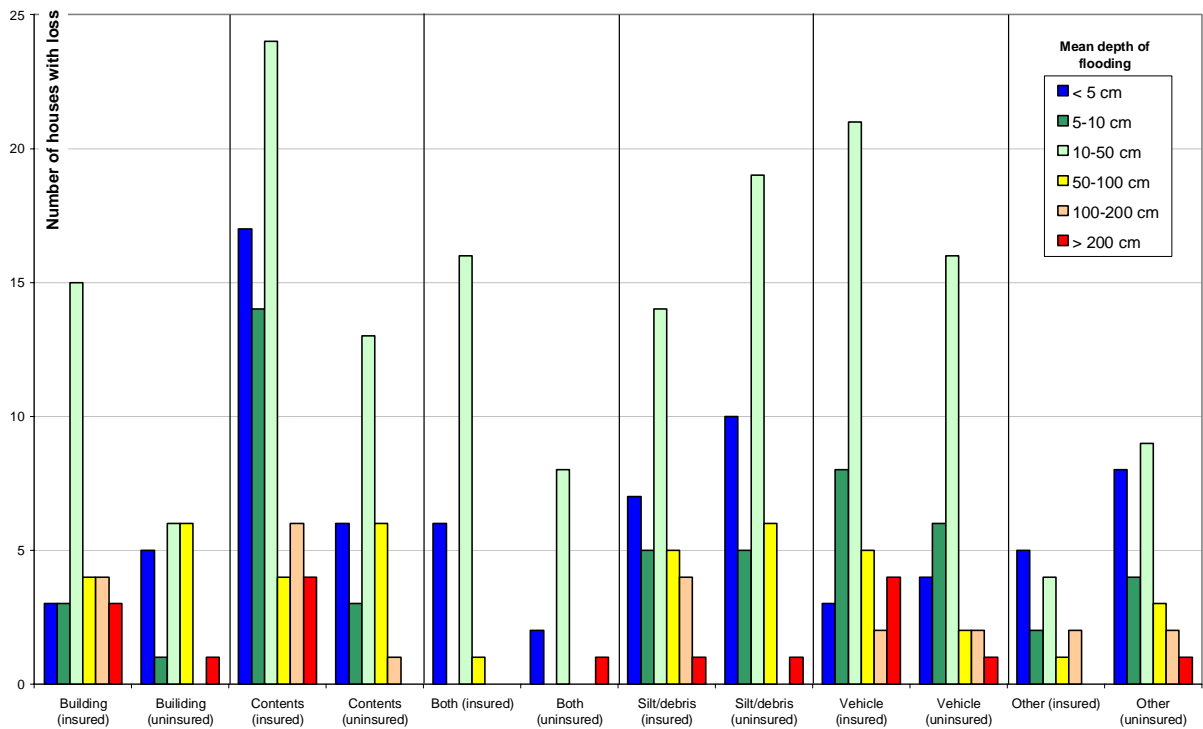
The largest combined overall losses in the Weather Bomb event were overwhelmingly in the 10-50 cm depth bracket, but this is partly because this was the most common mean depth of flooding for a flooded house.

If mean household flooding depths  $> 50$  cm had been more common, the losses could have been an order of magnitude greater (other than for vehicle losses, which should have remained at similar levels). Conversely, if mean flooding had rarely exceeded 5 cm depth, losses would have been an order of magnitude less (including vehicle losses).

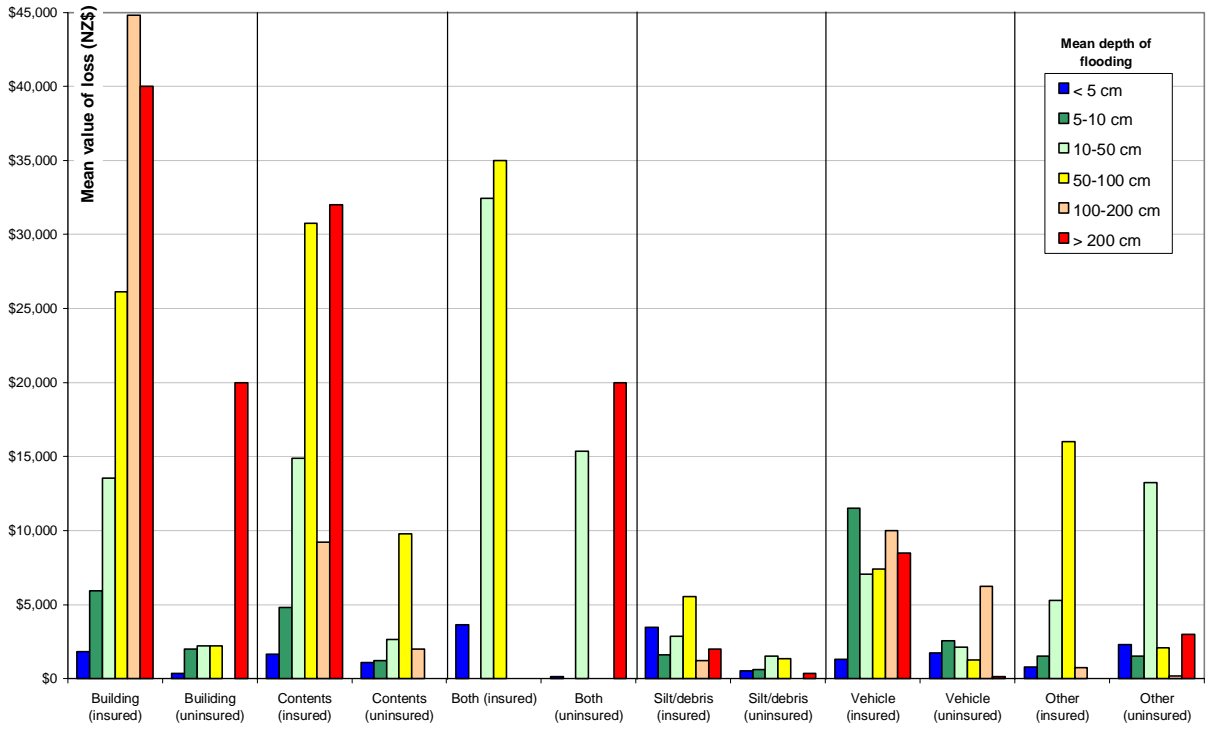
It would be useful to test a range of bracket cutoffs to determine more exact boundary values for key jumps in loss (e.g., vehicle mean loss may actually rise most dramatically at 4 or 6 cm, rather than the 5 cm used here). Such analysis would require an order of magnitude larger sample of loss cases than was collected here. The relatively low number of loss events (all  $n < 25$ ) in each depth/loss-type class means that the margin of error (20 % at  $n=25$ ) is too large for the dataset to be reliably used to determine differences of a few centimetres in the depth bracket boundaries.



**Figure 6** Sum of total aggregated loss (insured and uninsured) by type, compared to mean depth of flooding (cm).



**Figure 7** Number of flooded properties with loss (insured and uninsured) by type, compared to mean depth of flooding (cm).



**Figure 8 Mean value of loss (insured and uninsured) by type, compared to mean depth of flooding (cm).**

### 3. ECONOMIC IMPACT ASSESSMENT

Analyses of the economic impacts of New Zealand natural hazard events has been relatively sparse, especially when compared to the volume of analysis undertaken in countries such as Australia, the United States and Great Britain. However, even where significant research regarding the economic costs of particular events has been undertaken, the poor quality of underlying data and inconsistent methods used across various events have tended to raise doubts about the findings of the studies.

Australia's Bureau of Transport Economics (BTE) found considerable variation in the methods used to estimate the economic costs of past events, and recommended a framework to facilitate future estimation of disaster costs. In general terms, BTE's suggested approach is to analyse losses arising from a hazard event in three broad categories—tangible direct, tangible indirect, and intangible (comprising the direct and indirect intangible costs).

Direct costs, which are typically the easiest to estimate, are those that arise as immediate consequences of the event itself. These costs are almost entirely associated with damage to houses, business premises, stock, etc.

Indirect costs are associated with the flow-on effects of a natural hazard. These range from losses due to business disruption to the additional cost faced by insured households who lose their no-claims bonus as a consequence of making a hazard-related claim. In an input-output modelling context, indirect costs are felt downstream as a result of either direct or other indirect costs.

To illustrate, consider a scenario from the weather bomb event. During the storm many businesses in Thames' Pollen Street sustained flood damage, both to stocks of materials and finished goods and to business property. The cost of this damage represents the direct cost of the weather bomb. In some instances, businesses were forced either to close or to reduce their level of activity, driving two related impacts. Firstly, and perhaps obviously, flood-affected businesses lost sales revenue during the time that they were operating below normal capacity. Secondly, these businesses were unable to serve their customers, many of whom were unaffected by flooding and were attempting to conducting business as usual. Plausibly, the consequence for these dependent businesses and households is that they were forced to travel further afield, hence incurring greater transportation costs than would otherwise have been the case. Both of these two secondary impacts fall within the boundaries of the indirect costs category.

It is worth noting that the sign of the net effect of a hazard event can not always be determined *a priori* with any certainty. In the example described above, demand for additional transportation services and petrol will have a

positive impact on businesses supplying those products. Construction and cleaning services are often in demand following such an event, and this new demand is obviously of benefit to those who supply these services.

The availability of central government funding following a natural hazard event can have a large bearing on the size of the net direct and indirect impact. If, for instance, central government funds are provided to fully cover the replacement of destroyed property, the net impact to the local community may even be positive. Even in this case however, it is clear that the event is not costless; but rather that the cost is being met, if only partially, from outside the local economy.

The third category of BTE's framework is intangible costs. Intangible costs are defined as those for which there is no market, and include ongoing effects on health, household disruption and loss of memorabilia. These costs are almost certainly the hardest to quantify, and for this reason are not considered in this analysis. Injury resulting from the event, which would produce an intangible economic effect, was judged by TCDC and Civil Defence to be particularly low (none was recorded, other than one fatality).

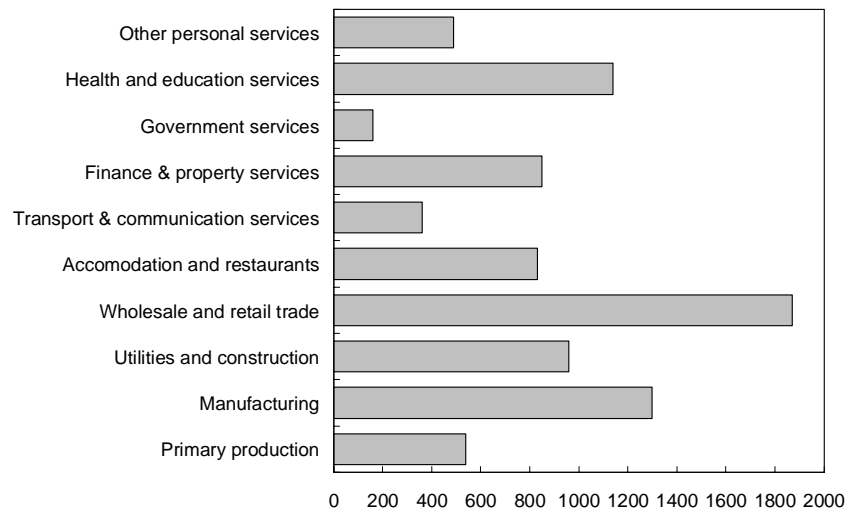
After first providing some context for the weather bomb in terms of the Thames-Coromandel economy, the remainder of this section discusses the direct and indirect costs of the event.

### **3.1 Thames Coromandel Background**

The Thames-Coromandel area economy currently employs around 8,500 full-time equivalents (FTEs) (see Figure 9). The largest sectors in the Thames-Coromandel District Council (TCDC) area in terms of employment are retail and manufacturing (mostly wood and food processing), which collectively employ around 3100 FTEs. The construction, hospitality, business services and health & education sectors are also significant employers.

**Figure 9 Thames-Coromandel employment**

Number of full-time equivalents



Source: NZIER

Over the past six years, Thames-Coromandel employment has grown more quickly than that of both the Waikato region and New Zealand as a whole. Since 1997, TCDC employment has risen 18.0 %, while Waikato and New Zealand employment climbed 12.7 % and 14.4 %, respectively.

In the context of the wider Waikato region, though, the Thames-Coromandel economy is relatively small, with employment in the TCDC area constituting less than 7 % of total Waikato employment. However, the size of the community that is directly serviced by the local economy is larger than the employment data might suggest. Of the 254,000 people living in the Waikato region, 26,300, or 10.4 %, live in the TCDC area. The gap between the employment and population data suggests strong linkages between the TCDC economy and those of surrounding districts, and in particular, that the TCDC area is a net importer of goods and services.

High levels of imports tend to lessen the impact of negative and positive shocks on the local economy. The greater the linkages with surrounding economies, the more likely an exogenous decline in demand in the local economy can be met by a decline in imports. Similarly, the more a local economy relies on external goods and services, the more likely a positive shock to the local economy will be passed on to surrounding districts.

The economic flows characterising the TCDC economy were estimated from national flows using the employment data outlined above and population census data. These TCDC economic flows are summarised in the table below.

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**Table 3 TCDC & NZ: selected economic flows**

\$ million		
Economic flow	TCDC Value	NZ Value (1996)
Industry output	1,031	187,520
Gross operating surplus	210	42,028
Household consumption	398	54,420
Imports to TCDC (including purchases from other NZ regions)	248	26,641
Exports from TCDC (including sales to other NZ regions)	146	27,350

Note: TCDC data is estimated from secondary sources, rather than directly measured, and thus should be regarded as indicative.

Source: NZIER/GNS

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### 3.2 Weather Bomb direct impacts

The analysis that follows is based on data gathered from the two surveys and from information on insurance payouts.

As noted above, direct impacts are limited almost entirely to property damage, and this can be categorised as insured and uninsured damage. This damage can be further broken down into business and household losses.

The Insurance Council of New Zealand (ICNZ) estimate that the value of claims made as a result of the weather bomb across all of New Zealand was around \$21.5 million. Of this value, around \$8 million of claims are estimated to relate to the TCDC area.

Although no direct information about the split of household and business losses was available from the insurance data, these can be estimated using the survey results. According to the survey, the sum of insured losses for household respondents was \$2.9 million, while for business respondents it was \$0.5 million, suggesting a household/business split of 0.84/0.16.<sup>2</sup> Applying this split to the total value of insured losses provided by ICNZ provides a total value of insured (property damage) losses to households in the TCDC area of around \$6.7 million; similarly the total value of insured business losses is around \$1.3 million.

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<sup>2</sup> Note the value of household loss excludes a \$500,000 vehicle loss claim, which has been removed as an outlier from the derivation of the household/business split.

The value of reported uninsured losses from respondents to the household survey was \$0.7 million, while uninsured business losses were reported to have been around \$0.2 million. One approach to scaling this data to represent population losses, is to use the ratio of insured losses according to the survey, to insured losses according to ICNZ. As noted above, ICNZ losses are estimated to be around \$8.0 million, while insured losses from the sample survey (for both businesses and households) were reported to be around \$3.5 million. A simple weighting factor relating population data to sample response can thus be estimated at around 2.3. This in turn provides an estimate of total uninsured losses to the TCDC area from the weather bomb of around \$2.1 million.

In addition to these impacts are the agency response costs—i.e. the costs involved with repair to damaged drains, culverts and roads—that were incurred as a direct consequence of the weather bomb. Environment Waikato estimate that agency response costs for the TCDC area were around \$3.1 million.<sup>3</sup> While some of these costs will relate to replacement of damaged structures, it is assumed that they mainly relate to the labour costs associated with clearing drains and reinstating road access.

Estimates of the direct costs of the weather bomb are summarised in Table 4.

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**Table 4 Direct costs of the weather bomb on the TCDC area**

\$ million	Household	Business	Total
Insured	6.7	1.3	8.0
Uninsured	1.6	0.4	2.1
Total asset damage costs	8.3	1.7	10.1
Agency response costs			3.1
Total direct costs			13.2

Note: Table data may not add due to rounding

Source: NZIER/GNS

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It is difficult to put these losses in context without an idea of the value of the total asset base of the TCDC area. Although no official measures of regional capital stocks exist, an estimate of the value of the asset stock of the TCDC area can be made by equating the value of TCDC's gross operating surplus

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<sup>3</sup> *The Weather Bomb 21 June 2002: Final Technical Report*, Environment Waikato, July 2002, p. 23.

presented in Table 3 above to the return on the area's asset base. Statistics New Zealand capital stock figures suggest that the ratio of gross operating surplus to productive capital stock is typically around 12%.<sup>4</sup> This rate of return implies that TCDC's asset base has a value of around \$1750 million.<sup>5</sup> Thus, the total value of damage caused by the weather bomb represents around 0.6% of TCDC's pre-event asset base.

It is worth noting that this comparison effectively assumes that all losses, both insured and uninsured, are borne by the TCDC economy. The contra position is to assume that it is only the uninsured losses that are borne locally—that is, that insurance acts as an effective means of spreading local losses across New Zealand-wide premium payers. Under this scenario, the damage as assessed above represents around one-tenth of one percent of TCDC's asset base.

The true picture is likely to sit somewhere between these two extremes, and will depend on the extent to which insurance companies price policies to account for local risk. It seems plausible in the case of the TCDC area, which has been prone to a series of floods, that insurance premiums for TCDC property have been adjusted upwards to account for the additional risk inherent in covering that property. TCDC residents thus bear a greater degree of risk than does the average New Zealand policy-holder. The greater the size of this upward adjustment, the greater the extent to which insured losses are borne by the local economy.

Although this assessment is clearly crude, it is hoped that it provides an indication of the relative size of the event.

### **3.3 Indirect impacts**

As noted above, the indirect costs associated with a natural hazard event relate to the flow-on effects of the direct impact of that event. In the case of the weather bomb, these flow-on effects take three main forms:

1. business disruption losses arising from flooding and/or property damage,
2. the potential impact on insurance premiums arising from the event, and
3. the second- and subsequent-round effects of the above and the direct effects. These costs typically affect businesses and households that

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<sup>4</sup> During 1992 – 1999, the period for which the most recent information is available, the ratio of gross operating surplus to productive capital stock—which roughly represents a measure of return to capital—averaged 12.0%.

<sup>5</sup> That is, \$210 million divided by 12% = \$1750 million

are dependent in some way on businesses that were themselves directly affected by the event.

Information regarding business disruption gathered via the business survey described above was mixed. Revenue losses were reported by 39 respondents, and totalled \$202,725. However, 15 respondents reported that their business increased as a result of the weather bomb, with a total increase in sales of \$261,850. Thus the survey results suggest that, of those surveyed, the net impact of the weather bomb on business sales was nearly \$60,000 (positive).

Although this result may seem counter-intuitive at first glance, it would be misleading to suggest that this represents the true net impact to TCDC businesses of the weather bomb. Many of the negative impacts of the event on businesses, particularly damage to property, are missing from this comparison, which instead relates solely to the impact on TCDC business turnover. *Increases* in turnover following a hazard event will almost certainly occur during the clean-up and reconstruction phase in specific firms, particularly those in the building, roading and general construction sectors.

A natural hazard event will have a negative impact even on those that are insured against its damage. Insurance policy-holders will almost certainly be required to pay an excess in the event of a claim, and some—those that haven't been in similar circumstances before—will lose their no-claims bonus.

These impacts relate to a single event, and their significance in terms of the local economy will depend on the proportion of affected households and businesses. IAG insurers, which covered around 56 % of all weather bomb claims under their State Insurance and NZI brands, estimate that there were 4443 weather bomb related claims throughout all of New Zealand. Around 1650 of these were made from the TCDC area, which by simple extrapolation suggests that a total of around 3000 weather bomb claims were made against all insurers by TCDC residents.<sup>6</sup>

IAG have also indicated that the average excess payable on their claims was \$150. Thus, the cost borne by insured TCDC households and businesses via excess payments totals around \$450,000.

It is more difficult to gauge the extent to which TCDC residents lost any no-claims bonus as a result of making weather bomb-related claims. In part, this will depend on the degree to which TCDC residents have made prior claims—clearly for those that have, a no-claims bonus is not applicable.

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<sup>6</sup> That is, 1650 (the number of IAG claims) divided by 55% (IAG's share of weather bomb claims) equals 2945.

The discussion of earlier claims raises the issue of the impact on insurance premiums of repeated claims resulting from similar causes. As noted above, households and businesses that are prone to flood damage will almost certainly face higher premiums as a consequence of repeated claims. At the extreme, insurers will simply refuse to continue to cover riskier properties, with the obvious consequence that the owners of those properties will bear all the inherent risk and consequent costs. Environment Waikato suggested in the follow-up to the weather bomb that, although insurance companies met most, if not all, weather bomb claims, they “may opt to cancel or refuse to renew policies for properties located within high flood risk zones (unless the risks are reduced)”.<sup>7</sup>

The impact of repeated events, particularly in terms of the costs and availability of insurance cover, can not be attributed to the weather bomb alone. However, the issue raises the point that simply looking at the impact of the weather bomb in isolation may lessen the apparent impact that flood and storm damage has on the local community over time. In short, the overall impact of successive events in the TCDC area is greater than the sum of the individual impacts of those events due to the reasons suggested above. Although it may require a degree of forward thinking, adopting a longitudinal framework involving assessment of the incremental impact of successive hazard events (as well as the individual costs of each event) is likely to provide a fairer picture of the longer-term cost of repeated events.

The final series of impacts, which have not yet been touched on, are the flow-on effects arising from any of the above direct and indirect impacts. For instance, TCDC households that face higher insurance premiums are forced to adjust their (collective) budget to accommodate this increase. This effectively means doing without some other less essential products. If these products were purchased locally, then a local provider is faced with lower sales, which in turn can have implications for his purchases, demand for labour, etc. Similarly, flooding prevented some businesses from opening in the days following the weather bomb, which in turn may have disrupted households or other business’s purchasing patterns and costs.

We have used a regional version of NZIER’s computable general equilibrium (CGE) model to estimate this final category of the weather bomb’s indirect costs. For the purposes of this analysis, a 9-sector, 9-commodity model and social accounting matrix was used.<sup>8</sup>

Perhaps unsurprisingly, these impacts were found to be negligible. Industry output, factor demand and household welfare (effectively a measure of the cost of an average household consumption bundle relative to household

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<sup>7</sup> *The Weather Bomb 21 June 2002: Final Technical Report*, Environment Waikato, July 2002

<sup>8</sup> General notes regarding the model are attached in the appendices. More detail is available upon request from the authors.

income) were found to be affected by less than 1 %, which in the instance of a regional New Zealand CGE model is probably close to the margin of error.

There are three main reasons why the flow-on impacts of the weather bomb are likely to have been minimal:

1. The duration of the event was relatively short. Although some businesses were still returning to normal weeks after the event, many had returned to 'business as usual' within a few days. Although electricity outages were widespread in the area, in most cases service was resumed within a day.<sup>9</sup> As a result, the impact of the weather bomb in terms of disruption to day-to-day economic flows was relatively mild.
2. The severity of the weather bomb in terms of its direct economic costs was also relatively mild. As noted above, the weather bomb is estimated to have affected just one-tenth of one percent of the total value of TCDC's asset base. The impact on households' insurance premiums was of a similar size relative to the size of total TCDC household consumption.<sup>10</sup>
3. TCDC is in effect a small, borderless economy. The consequence of this is that any disruptions to local supply that did occur (i.e., where a business was forced to close for an extended period as a result of the weather bomb) that could not be met via alternative local suppliers, could be met relatively easily from suppliers in the non-affected surrounding districts.

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<sup>9</sup> WEL Energy reported that the longest outage time was 14.5 hours.

<sup>10</sup> That is, the payment of no-claims bonuses by TCDC residents was around \$450,000, while total TCDC household is around \$400 million (see Table 3).

### 3.4 TCDC Summary

The table below presents a summary of the value of the total economic impact of the weather bomb on the TCDC economy.

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**Table 5 Total costs of the weather bomb on the TCDC area**

\$ million

Direct costs

Insured losses	8.0
Uninsured losses	2.1
Response agency costs	3.1
Total direct costs	13.2

Indirect costs

Business disruption losses	0.0
Insurance excess payments	0.5
Total indirect costs	0.5

Total costs	13.7
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Source: NZIER/GNS

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### 3.5 South Waikato losses

Losses resulting from the weather bomb in the wider South Waikato area were relatively insignificant compared to those in the TCDC area and compared to the size of the South Waikato area and economy. Household survey respondents reported around \$400,000 of insured losses and around \$50,000 of uninsured losses (compared to TCDC survey responses of \$2.9 million and \$0.7 million, respectively). Unfortunately, the insurance data collected did not provide the basis on which to derive a value for population losses for the South Waikato area. However, from the magnitude of the survey responses, it seems reasonable to assume that both direct and indirect losses are relatively insignificant in relation to the South Waikato economy.

## 4. HEAVY RAIN WARNINGS

MetService is responsible for releasing weather warnings in New Zealand. Severe Weather Warnings for the storm were issued on 19 June for heavy rain and strong wind for the region. Anticipating the intensity of the storm, MetService issued media releases and in those deliberately used the term “weather bomb” to attempt to draw public attention to the potential severity of the weather. There was moderate to high reported awareness of the MetService Heavy Rain Warnings that had been issued prior to the Weather Bomb event. This ranged from 81 % in the low impact Coromandel area to 46 % in South Waikato (Table 6).

MetService issues Heavy Rain and other Warnings according to specific criteria (see Appendix 1); territorial authorities decide on the basis of this and other information if flood and other warnings are necessary within their jurisdiction. Along the western Coromandel the catchments are small and have short response times, and no flood warning system exists. To explore the public’s perception of warnings and see if people make any link between the Heavy Rain Warning and the subsequent flooding, two questions were asked (Tables 7 and 8). Only a minority reported receiving a specific warning of the forthcoming flood itself (the highest being 32 % in the high impact area) (Table 7). Of those who received a warning, a range of sources were reported, with MetService and the media (TV and radio) being the most common in all areas (Table 8). The largest percentage of warned respondents in the South Waikato and Coromandel low impact areas received their warning more than six hours prior to the flooding. The highest percentage of bach owners were warned of possible flooding one to six hours ahead, but in the Coromandel high impact area people had less than 10 minutes warning before being flooded (Table 7).

The questions asked in this survey do not fully address what is a complex issue and further work is need to explore the links (real or perceived) between weather and flood warnings, the public’s understanding of them and how best to improve the effectiveness of both. The need for improved tools for responding to floods in New Zealand has also been identified in recent research on the Waikanae floodplain (Johnston et al. 2002).

Some residents suggested that they did not fully realise the potential impacts of the forecast heavy rain. One resident stated (Appendix 11) “We took no special action as we were not warned the 'weather bomb' would be any threat - we just thought we would have heavy rain. No way did we realise how much & what impact it would have”. One TCDC staff member suggested that they get a lot of Severe Weather Warnings and didn’t necessarily expect this to be different to any of the others (i.e. expect it to cause flooding). This raises the possibility of ‘warning saturation’ due to regular warnings reducing the impact of, and response to, individual warnings. The effects of ‘warning saturation’ require further research.

There is considerable research pointing to the value of simple alert schemes to help individuals, organisations and communities responding to developing crises (Mileti, 1999, Sorensen, 2000, Hander, 2002). A number of alert schemes have been developed in New Zealand for a range of hazards, notably drought, rural fire and volcanic hazards. Other overseas schemes have also been developed for tornado, hurricanes and recently terrorism in the USA. Recent flood events in New Zealand and the USA have lead a number of groups to raise the idea of developing alert level scheme to provide a tool for managing local flood events. In the USA Congress has ordered the National Oceanic and Atmospheric Administration (NOAA), through the United States Weather Research Program to develop an index to assist in this effort (Natural Hazards Observer 2002). On October 2002, the Inland Flood Forecasting and Warning System Act of 2002 (Public Law 107-253) was signed into law to provide for research, training, and outreach activities relating to improving inland flood forecasting and awareness. Under the legislation NOAA is required to develop, test, and deploy a new flood warning index to give the public and emergency management officials more detailed, understandable, and accurate information about the risks and dangers posed by expected floods.

Despite the above suggestions it is still not clear, given the short flood response time in the catchments and the lack of flood warnings systems how a system would work but it is an issue worth exploring. Environment Waikato does operate an automated flood warning system for the region in other, larger catchment, watercourses<sup>11</sup>. Even if the capacity to disseminate a flood warning alert existed, possibly following an alert scheme, the MetService may not have been able to forecast the full magnitude of this event compared to other Heavy Rain Warning events.

**Table 6 Respondents aware of the Heavy Rain Warning issued by MetService before the flood**

%	All n=412	South Waikato n=101	Coromandel Low n=43	Coromandel Bach n=72	Coromandel High n=195
Respondents aware of Heavy Rain Warning	<b>62.1</b>	<b>45.5</b>	<b>81.4</b>	<b>68.2</b>	<b>64.6</b>

<sup>11</sup> Refer: <http://www.ew.govt.nz/ourenvironment/hazards/naturalhazards/river1/index.htm#Heading6>

**Table 7** proximate period before the flood waters entered respondents property that they received the first warning

%	All n=439	South Waikato n=107	Coromandel Low n=47	Coromandel Bach n=72	Coromandel High n=174
I did not receive any warning	45.6	50.5	34.0	27.8	52.9
Less than 10 minutes	4.8	1.9	0	0	9.2
10-30 minutes	3.4	0	2.1	0	6.8
30 minutes to one hour	2.7	1.9	0	1.4	4.4
One to six hours	6.6	7.5	4.3	2.8	7.8
More than six hours	5.7	9.3	14.9	1.4	3.4
No response	31.2	29.0	55.3	66.7	15.5

**Table 8** Respondent received the warning(s) from:

%	All n=439	South Waikato n=107	Coromandel Low n=47	Coromandel Bach n=72	Coromandel High n=206
I did not receive any warning	45.8	52.3	31.9	30.6	51.9
District Council (includes local Civil Defence)	6.6	0.9	10.6	0	11.2
Regional Council (includes regional Civil Defence)	1.4	0.9	2.1	0	1.9
MetService	8.4	5.6	10.6	8.3	9.7
Police	1.1	0.9	2.1	0	1.5
Fire Service	3.0	0.9	2.1	1.4	4.9
Radio	13.7	12.1	29.8	18.1	8.3
Television	14.6	19.6	31.9	13.9	8.7
Can't remember	2.5	4.7	0	2.8	1.9

## 5. WEATHER FORECASTING

The survey asked the community a series of general questions about weather forecasts. Weather forecasts provide information primarily about daily weather patterns and short-term weather predications. Forecasts can be viewed as a means to educate and/or warn people about potential or imminent flood risk. The findings presented in Tables 9 through 13 show that there is a high level of interest in weather forecasts, with over 90 % of the respondents in all areas either listening to the weather at least daily or more often (Table 9). A range of reasons that residents take an interest in the weather were given, with ‘planning activities’ or ‘it interests [the respondent]’ being the most commonly cited (Table 10). Most of these people recognise that they may need to change their activities due to the weather (Table 11).

Table 13 shows that a high proportion of the respondents (over 85 % in all areas) believe weather forecasts most of the time or some of the time. This information, when related back to Table 11, shows that belief in weather forecasts can influence behaviour. However, since around 39 to 50 % stated that forecasting was only ‘sometimes’ a determinant of their behaviour, further work is required to examine the conditions under which it does or does not influence behaviour. Television (90 to 95 %) and radio (60 to 76 %) are the most effective means to distribute such information (Table 12).

**Table 9 How often respondent listens to or reads a weather forecast**

%	All n=434	South Waikato n=107	Coromandel Low n=46	Coromandel Bach n=70	Coromandel High n=204
Hourly, or several times throughout the day	<b>21.0</b>	<b>19.6</b>	<b>34.8</b>	<b>17.1</b>	<b>19.6</b>
Daily	<b>73.3</b>	<b>70.1</b>	<b>63.0</b>	<b>78.6</b>	<b>75.5</b>
Weekly	<b>1.8</b>	<b>1.9</b>	<b>2.2</b>	<b>1.4</b>	<b>2.0</b>
Rarely	<b>3.7</b>	<b>8.4</b>	<b>0</b>	<b>1.4</b>	<b>2.9</b>
Never	<b>0.2</b>	<b>0</b>	<b>0</b>	<b>1.4</b>	<b>0</b>

**Table 10 The main reason the respondent would listen to or read a weather forecast**

%	All n=423	South Waikato n=102	Coromandel Low n=46	Coromandel Bach n=68	Coromandel High n=200
To choose clothes for the day	1.9	2.0	2.2	1.5	2.0
To decide whether to take rain gear with them or not	6.9	7.8	4.3	7.4	6.5
To plan activities (sports, boating, tramping, gardening, shopping, etc.)	34.8	33.3	41.3	44.1	31.5
Because it interests them	37.1	37.3	23.9	36.8	39.5
For work purposes (e.g. to plan farm activities)	10.4	13.7	19.6	5.9	8.0
Other	9.0	5.9	8.7	4.4	12.5

**Table 11 Whether the respondent would change plans for a weather-dependent activity (tramping, sport, gardening, etc.) two days ahead because the forecast is for bad weather**

%	All n=423	South Waikato n= 104	Coromandel Low n=46	Coromandel Bach n=70	Coromandel High n=197
Yes, most often	41.8	45.2	39.1	52.9	36.5
Yes, but only sometimes	46.1	41.3	45.7	42.9	50.8
No, never	12.1	13.5	15.2	4.3	12.7

**Table 12 The respondent normally gets their weather forecast from:**

%	All n=423	South Waikato n=102	Coromandel Low n=46	Coromandel Bach n=68	Coromandel High n=200
Radio	67.9	59.8	76.6	73.6	67.5
TV	92.5	95.3	93.6	93.1	90.3
Newspaper	37.1	29.0	40.4	62.5	32.5
0900 phone	3.9	3.7	6.4	6.9	2.4
Website	10.0	10.3	10.6	9.7	9.7
Neighbours, friend, relative, or family member	7.3	6.5	6.4	8.3	7.3
Look out the window	40.5	35.5	42.6	34.7	45.1
Other	4.8	4.7	6.4	4.2	6.9

**Table 13 How often the respondent thinks weather forecasts are right**

%	All n=423	South Waikato n=102	Coromandel Low n=46	Coromandel Bach n=68	Coromandel High n=200
All of the time	0	0	0	0	0
Most of the time	46.2	46.7	47.8	50.7	44.6
Some of the time	46.4	42.1	39.1	46.5	49.5
Not very often	7.2	11.2	13.0	2.8	5.4
Never	0.2	0	0	0	0

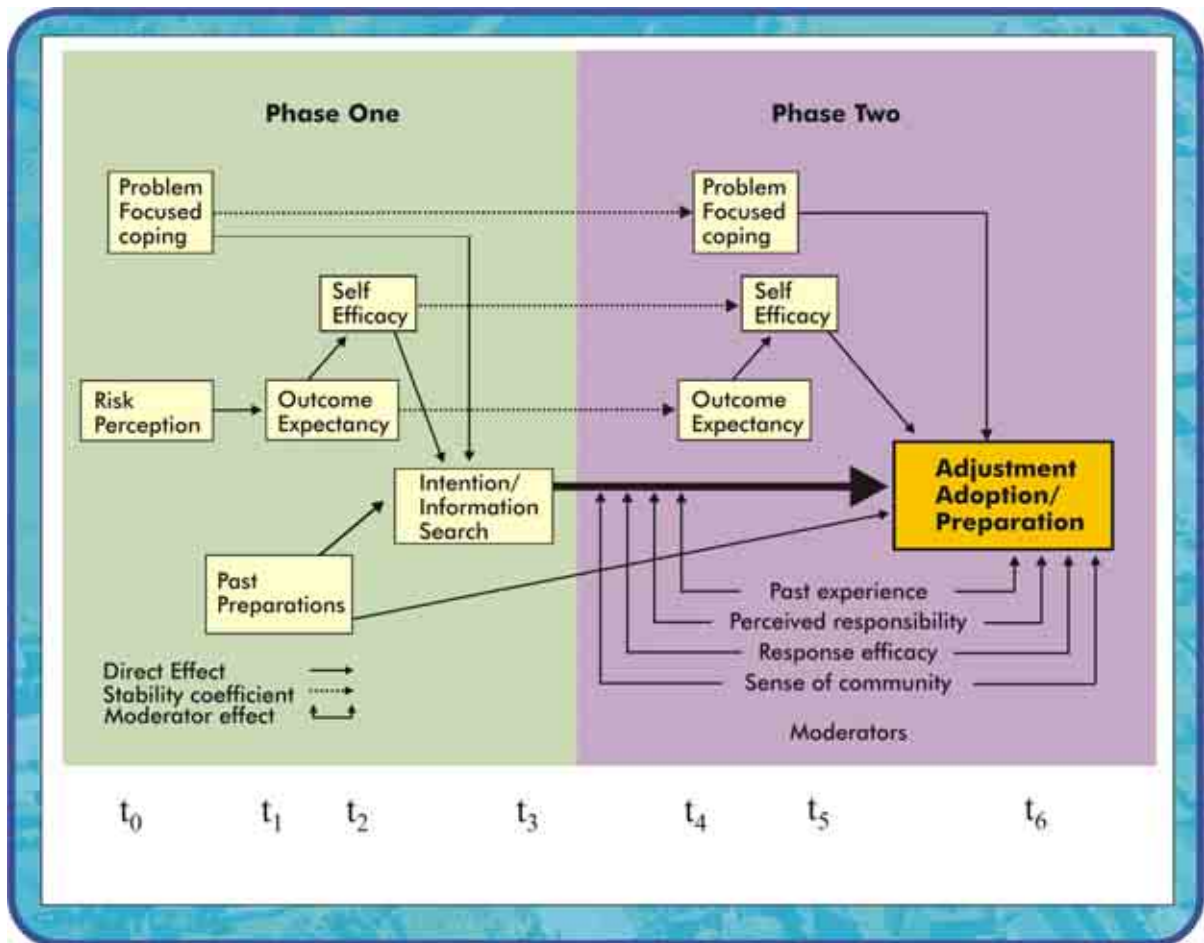
## 6. RELATING HAZARD KNOWLEDGE & RISK PERCEPTION TO IMPACTS AND READINESS

The data is presented in Appendix 5 and summarized and discussed in the subsections below.

An important aspect of hazard preparedness is people's perceptions in terms of their 'outcome expectancy' and 'self-efficacy'. Outcome expectancy describes the level to which people believe that their personal actions will be capable of mitigating risk, and self-efficacy whether they believe that they are competent to carry out risk reduction measures and to act effectively deal with the consequences of hazardous events. Self-efficacy particularly seems to affect the diversity of action plans that people will develop, as well as their effort and perseverance in carrying out risk reduction activities. Plan development is an important factor, as hazards occur only rarely and household reduction and readiness activities need to be sustained over prolonged periods of time. These factors, and their relationship to risk reduction behavior, are described as a model in Figure 10. This model (Paton 2003; Paton et al. 2001; Paton et al. 2003) was derived from an empirical examination of earthquake and flood readiness in New Zealand and provides a framework for analysing hazard reduction and readiness activities and for planning future hazard awareness initiatives.

The model (Fig. 10) illustrates the relationship between people's perception of risk and their behaviour to reduce the hazard. People make assumptions about whether successful outcomes are possible before they form an intention to adopt readiness measures. The model also illustrates the factors that risk reduction strategies must address to promote and sustain readiness. For example, irrespective of the level of perceived risk, people are unlikely to formulate intentions to act if they think the hazard risk is insurmountable (low outcome expectancy) or believe they do not have the competence to act (low self-efficacy).

Even when intentions are formed, they may not be acted on. Whether intentions are converted to actions depends upon people's **interpretation of their past experiences**, their **response efficacy** (appraisal of whether they have the time, resources, skills and social networks required for adoption), their **sense of community** (feelings of attachment for people and places), and whether they **accept personal responsibility** for the safety of themselves and others (Ballantyne et al. 2000, Bishop et al. 2000, Duval & Mulilis 1999, Lindell & Whitney 2000, Paton et al. 2000).



**Figure 10** The proposed risk perception-preparation model ( $t_1$  to  $t_6$  represent progressive points in time from  $t_0$ ).

Three inter-related issues are examined in this section—one concerns the degree of preparedness of residents for flooding, the second concerns the role of their prior knowledge and experience, and the third concerns the role of warnings in affecting behaviour. The suddenness of occurrence of weather bomb phenomena highlight the need for preparedness—even with very good warnings, unprepared households will be particularly vulnerable to losses and adverse outcomes. Consequently, we first examine levels of preparedness. Questions were asked about the levels of respondent's preparedness prior to this event and about activities they have undertaken since the weather bomb occurred.

## 6.1 Degree of preparedness of residents for flooding

Firstly, what was the level of preparedness for flooding prior to this event? Overall, the levels of preparedness were low. Only 5 % of the respondents had raised the floor, 44 % had kept ditches and drains clean, 11 % had protected septic tanks, and 22 % avoided keeping valuables at ground floor levels. One possible reason for this low level of preparedness is people's lack of prior experience of floods. Overall, only some 22 % of respondents

had prior experience of floods, particularly repeat experiences. Some activities, such as structurally altering the home by raising floor levels, could also be discounted on the ground of cost. Some 55 % of respondents cited cost as a significant constraint on carrying out hazard preparation activities.

The next question concerns changes in the level of preparedness that can be attributed to having experienced the weather bomb. Overall, some 74 % of respondents cited the weather bomb event as the worst incidence of flooding they had experienced. Direct experience of losses or awareness of potential losses (e.g., from first-hand accounts of neighbours, media reporting etc.) could be expected to have triggered better preparedness. However, the experience appears to have had little significant influence on preparedness. When respondents were asked about levels of preparedness instigated by the weather bomb experience, some 20 % reported taking out insurance, 3 % raising floor levels, 37 % ensuring ditches were kept clean, 9 % protecting septic tanks, and 27 % avoiding keeping valuables on the ground floor.

This is a significant finding. If direct and indirect experience of a threatening event does little to encourage preparedness, what chances are there that more traditional public education programs will be successful in facilitating better preparedness? The next stage in the process is to identify reasons for this outcome. This will be analysed within the context of the empirically tested process model introduced above (Paton et al. 2003). The use of a theoretically rigorous and empirically tested model facilitates the identification of areas where risk reduction strategies can be implemented and applied to public hazard education.

Preparedness intentions form the starting point for this analysis. Intentions are important precursors to actual preparedness—within the model (Paton et al. 2003) there is an important distinction between the intention to seek information and intentions to act. These are discrete elements—the intentions to seek information represents an end point and does not lead to actual preparedness. Risk reduction will thus be indicated by the proportion of respondents who indicate an intention to prepare. Restricting discussion to only those who responded in the affirmative, overall, only 4 % signaled an intention to prepare, whereas 29 % signaled an intention to seek information. This finding suggests a need to work back through the process to define levels of variables that predict intention to prepare. This subsequent analysis is conducted within the above model (Paton et al. 2003).

According to the model, the preparedness process is triggered by high levels of two variables—‘perceived threat’ and ‘critical awareness’. While the content of perceived threat is self evident, critical awareness requires some explanation. Research into the effective precursors of community action has highlighted the importance of the level of perceived salience—how critical

or important an issue is for people. Specifically, unless people see an problem as salient, it is unlikely to motivate action. One measure of the level of perceived salience is the amount of time that people spend talking and thinking about an issue.

In the present sample, the mean levels of critical awareness was 5.44 (range 2–10, median, 6), indicating that awareness is present at moderate levels. The strong direct and indirect influence that this variable has on intention to prepare makes it particularly important. The level of critical awareness present in this sample indicates a need for future risk communication strategies to increase the degree to which people see flooding issues as salient or important within their everyday lives.

## **6.2 Role of respondents' prior knowledge and experience**

The second precursor variable is the extent to which respondents attribute a level of threat to a specific hazard, such as flooding. In this sample, the mean level of perceived threat was 5.25 (range 2–10, median, 6), indicating only a moderate to low level of perceived threat. The low level of perceived threat by respondents in this sample indicates a need for future risk communication strategies to increase the degree to which people see flooding as a threat to significant aspects of their lives.

The data on critical awareness and perceived threat indicate only moderate levels of motivation to carry out risk reduction or preparedness measures. People's levels of critical awareness and perceived threat also may be reduced by other factors. Despite the severity of the weather bomb, large losses were not widespread and those experiencing loss reported generally positive experiences with their insurers. Overall, of those who made damage claims on their insurers (137 respondents), some 91 % reported a positive outcome. This may have the effect of reducing the impact of the losses, and therefore the salience of flooding, for this group. A follow-up survey would be required to investigate this aspect in more detail. Another factor influencing levels of this variable is the incidence of involvement in community groups (within which discussion occurs and ideas are obtained), which is at low to moderate levels. Overall, 44 % of respondents report no involvement in community groups, although this ranges from 18 % in the Coromandel 'high impact' area, 55 % in the Coromandel 'low impact' area, 69 % in South Waikato, and 72 % among Coromandel bach owners. Attempts to increase the salience of flooding may not represent a cost-effective use of resources. However, attempts to increase participation in community groups may help in this regard.

Attempts to influence preparedness through changing people's perceptions of the threat may prove more fruitful. For example, a substantial proportion of respondents across the areas surveyed reported not having seen a flood

hazard map. While a substantial majority in the Coromandel ‘high impact’ area had seen this information, 82 % of respondents in South Waikato, 72 % in the Coromandel ‘low impact’ area, and 83 % of the Coromandel batch owners group had not seen it. These data suggest that the effective dissemination of this information could enhance levels of threat perception.

Note, however, that critical awareness is more important in instigating preparedness, so the level of change in preparedness that could be expected from merely increasing people’s perception of the threat remains low. More detailed, systematic analysis of the content of the discussions and cognitions regarding flooding could furnish the information required to analyse the salience of hazard issues. This would require that systematic, structured interviews were conducted with respondents to articulate the beliefs and cognitions that predict their intentions.

The second important group of factors are those that are responsible for converting motivation into intentions. Key factors here are outcome expectancy and self efficacy. The conversion of motivation into intentions requires that people believe that the effects of hazards are amenable to mitigation through their personal action (outcome expectancy). However, even if that belief is present, people may not act if they do not think they are competent to carry out the appropriate actions (low self efficacy). For example, media coverage and documentaries about flooding often focus on their catastrophic nature and destructive potential. If such perceptions are internalised, a person, even if motivated to do something about a problem, may not progress any further.

In the present sample, the mean level of outcome expectancy was 13 (range 4–20, median, 12), indicating its presence at a moderate level. This level indicates that future risk communication strategies need to increase the degree to which people see that the consequences of flooding can be reduced through their personal actions. Risk communication strategies should thus focus on specific effects of a given hazard and on concrete reduction or preparatory measures that can be taken to mitigate them.

In addition to low preparedness intentions being linked to low outcome expectancy, an additional constraint is the self efficacy of respondents. In this sample, the mean level of self efficacy was 10.2 (range 4–20, median, 12), which are low to moderate levels. These levels indicate a need for future risk reduction strategies or community development strategies to enhance self efficacy. Manipulation of levels of self efficacy is more difficult. It involves engaging people in activities in which they are responsible for defining and managing problems within their community. Pursuing this approach requires links between emergency management and community development agencies. It should be noted that a potential constraint on pursuing this option is people’s attitudes to cooperating with others. The data suggest that respondents were split in regard to their

willingness to engage in cooperative risk reduction strategies. That is, while some 39 % were favourable towards working with other community members, the same proportion (39 %) were opposed to adopting this approach.

An additional concern for future risk communication are the factors that affect whether people perceive themselves as legitimate targets for risk communication efforts. One key aspect is unrealistic optimism bias—this is a tendency for people to perceive themselves as less vulnerable and/or more skilful than average. This bias can be discerned when comparing perceptions of personal preparedness with levels of preparedness the respondents attribute to other community members. Overall, the mean level of personal preparedness was recorded at 2.02, whereas that attributed to other members of the community was recorded at 2.32.

This bias has significant implications for public hazard education. While people may appreciate need for mitigation, they attribute the need to other members of the community. Because they assume that messages are directed to others, this reduces both their perceived need for personal preparedness and their attentiveness to information presented as part of a risk communication or public education program. If all members of the community are doing this (as indicated by the fact that all respondents are rating their own preparedness as being better than that of others) everybody assumes that risk communication information is intended for others, reducing collective levels of preparedness.

This is not an easy issue to deal with, as it is a relatively enduring aspect of human psychological defences for dealing with significant threats. Furthermore, the recommendations for increased consultative and participative actions to increase people's motivation can, as a consequence of group polarization, increase the prevalence of unrealistic optimism bias. Thus, it is important to bear these processes in mind when estimating the effectiveness of risk reduction strategies, particularly in regard to the continuing presence of residual risk.

### **6.3 Role of warnings in affecting behaviour**

The data suggest that little benefit will accrue from increasing the perceived accuracy of forecasts. Overall, some 93 % of respondents believed in the accuracy of forecasts. A key problem is the fact that most people listen to forecasts only once a day. This limits the likelihood of people hearing a warning that is issued at any other time. Additional research into other media habits would be required to build a comprehensive picture of community access to warnings at other times of day. The general habit of listening to one forecast a day may account for data reporting that, overall, only 46 % of respondents received a warning (this ranged from a low of

29 % to a high of 56 %). Examination of the timing and media used to provide warnings needs further investigation.

The data also suggest a need to examine different ways of presenting information on this hazard. Even actual experience of the hazard appears to have had limited success in motivating people to reduce risk. However, the absence of pre-event data on these variables makes it difficult to assess whether people's perception of risk has changed as a consequence. Notwithstanding, current level of precursor or motivational variables have not been raised enough induce people to carry out household actions to reduce risk. Thus, an event occurring next year would likely have similar effects. It is possible that these data reflect relatively the low levels of loss and damage and the satisfaction of those whose experienced losses with their insurance provider. This could also lead to a normalisation bias—people think they can deal effectively with a future event on the basis of this experience. If this is the case, they are unlikely to adopt any actions to reduce the risk. Overall, these data suggest that motivation to adopt risk reduction measures is low. In the short term, this suggests more stress is needed on affecting people's behaviour during the time between the warning and the hazard occurrence (i.e., things that people could do within hours—for example, remove valuables from the ground floor, or protect septic tanks).

Overall, intention to prepare is present at very low levels, and levels of outcome expectancy and self efficacy—the variables mediating the conversion of motivation to intentions—are also low. Thus, estimates of residual social risk suggest that the response to future events would be similar to that observed in this event.

## 7. CONCLUSIONS

Assuming that climate change will, in all likelihood, affect the frequency and severity of some natural hazards, we need to address the challenge of accommodating this change in our long-term planning and in risk management for communities. Sea-level rise is a potential effect of climate change that will affect coastal areas, but other factors such as changes in storminess and windiness could alter the likelihood of inundation and erosion inland. These need to be understood in the context of response to natural climate cycles, such as El Niño, to ensure planning for communities is consistent with the ever-changing risk profile. The human response to the effects of climate change can conveniently be grouped into three main categories—protect, adapt or retreat. However, the implementation of any of these planning responses is fraught with environmental and socio-economic difficulties, particularly in already-settled areas. The impacts of the 2002 “Weather Bomb” event highlights the complex nature of the physical, economic and social issues that need to be managed.

### 7.1 Flooding and losses

Approximately 35 % of affected properties (about 300 within the ‘high impact’ settlements) had flooded land, 37 % had flooding of the basement and/or outbuildings, and 28 % suffered house flooding above the floors of the living areas. The exact nature of the flooding and losses (other than value) within homes was not centrally recorded and not covered within the scope of the questionnaire.

The depth to which a house is flooded affects the number and types of items that are damaged. Household mean losses are disproportionately low when mean flooding in that house is 5 cm or less deep (cleanup of silt/debris may be possible in many cases, reducing permanent loss of contents). Average losses rise roughly proportionately to mean flooding depth for depths from 5 to 50 cm (through the ranges of height of beds, lounge furniture, TVs etc.). Household mean losses are disproportionately high when mean flooding in that house is more than 50 cm deep (reaching the heights for table and bench tops and anything stored on top of or above them).

Vehicle mean losses jump upward on properties where the mean household flooding was above 5 cm deep, and then remain relatively constant, even if the vehicle sits on a property with mean flooding over the height of the vehicle roof (the control is probably the height of the base of the vehicle floor).

The largest combined overall losses in the Weather Bomb event were overwhelmingly for flooding in the 10-50 cm depth bracket, but this is partly because this was the most common mean depth of flooding for a flooded house. If mean household flooding depths > 50 cm had been more

common, the losses could have been an order of magnitude greater (other than for vehicle losses, which should have remained at similar levels). Conversely, if mean flooding had rarely exceeded 5 cm depth, losses would have been an order of magnitude less (including vehicle losses).

## 7.2 Economic impacts

To put the economy of the affected area into context, over the past 6 years the Thames-Coromandel economy has been relatively small, contributing less than 7 % of the total Waikato employment; in contrast 10.4 % of the Waikato population lives in Thames-Coromandel. Putaruru and Tirau contribute an even smaller proportion of the Waikato employment and population than the Thames-Coromandel area. Analyses of the economic impacts of New Zealand natural hazard events have been relatively rare compared to those undertaken overseas. Based on overseas recommendations designed to lessen variations amongst individual impact studies, impacts have been assessed under the categories of (1) direct and (2) indirect impacts. Due to difficulties in determining intangible economic impacts, these have not been modelled for the Weather Bomb event. Injury resulting from the event, which would produce an intangible economic effect, was judged by TCDC and Civil Defence to be particularly low (no injuries were recorded, other than one fatality).

Direct costs were limited almost entirely to property damage. The estimated insurance claims made as a result of the event were \$21.5 million, with around \$8 million related to the Thames-Coromandel area. Data from the survey suggests that this was split 0.84/0.16 between households and businesses (\$6.7 and \$1.3 million respectively). Total uninsured losses are estimated at \$2.1 million, based on the survey data. In addition, TCDC estimated agency response costs at \$3.1 million, with the much of that the cost of labour. The total direct costs are thus estimated to have been \$13.2 million for the TCDC area. This is around 0.6 % of the area's asset base, which is estimated to be around \$1750 million. If we assume that only the uninsured losses are borne by the area's asset base, then the loss to the area is only around 0.1 % of its asset base. The true loss to the area likely is somewhere between these 0.1 – 0.6 % loss extremes. This estimate is clearly crude, but hopefully provides an indication of the relative severity of the event.

To better illustrate the spatial and loss-type breakdown of insurance claims Appendices 3 and 4 present a summary of the Earthquake Commission (EQC) and AMI insurance claims related to the Weather Bomb event. The EQC claims totalled about \$1.5 million, with about \$886,000 in the Thames-Coromandel district. In comparison the EQC claims in the South Waikato district were about \$73,000. The AMI claims totalled \$662,000 at Thames township office, and \$161,000 at Coromandel township office. These were attributed to “house”, “contents” and “vehicle” losses, in decreasing order of value.

Indirect “flow-on effect” costs take on three main forms: (1) losses due to business disruption, (2) potential impacts on insurance premiums, and (3) second- and subsequent-round effects, typically on those dependent in some way on businesses that were directly affected. The business survey results suggest that the net impact of the weather bomb on business sales was positive (around 30 % more revenue from increased business than the value of lost business). Note that this does not represent a true positive net impact to businesses in the Thames-Coromandel area because many negative impacts, particularly damage to property (a direct loss, quantified above), are missing. The cost borne by insured TCDC households and businesses via insurance excess payments is estimated to total around \$0.45 million.

Excess payments are not the only insurance-related indirect loss. Losses as a result of the loss of a no-claims bonus, premium increases and, in some cases, cancellation of policies also occurred but are extremely difficult to quantify. These losses are also only partly related to the Weather Bomb event alone. Adopting a longitudinal framework involving assessment of the incremental impact of successive hazard events is likely to provide a fairer picture of the longer-term cost of repeated events.

A regional version of NZIER’s computable general equilibrium (CGE) model was used to estimate flow-on effects to those dependent on directly affected parties. A 9-sector, 9-commodity model and social accounting matrix was used. These effects were found to be negligible, which is perhaps not particularly surprising, given the relatively low direct losses. Industry output, factor demand and household welfare were found to be affected by less than 1 %, probably close to the margin of error.

The flow-on effects of the weather bomb are likely to have been minimal because: (a) the duration of the event was relatively short, (b) the severity of the weather bomb in terms of its direct economic costs were also relatively mild and (c) Thames-Coromandel is in effect a small, borderless economy.

The table below presents a summary of the value of the total economic impact of the weather bomb on the TCDC economy.

**Table 14 Total costs of the weather bomb on the TCDC area**

\$ million	
Direct costs	
Insured losses	8.0
Uninsured losses	2.1
Response agency costs	3.1
Total direct costs	13.2
Indirect costs	
Business disruption losses	0.0
Insurance excess payments	0.5
Total indirect costs	0.5
Total costs	13.7

Source: NZIER/GNS

In summary, while hardship was extreme for the individuals who lost their entire house, for the vast majority of damaged households the insurance cover was apparently very high and so uninsured loss was very low. Locally borne (i.e., uninsured) losses at community, and even suburb or street level appear to have been quite low. The data and economic modelling, summarised above, points toward a low community-level economic impact, even in the ‘high-impact’ areas.

### 7.3 Warnings

Anticipating the intensity of the storm, MetService issued media releases and in those deliberately used the term “weather bomb” to maximise public attention to the potential severity of the event. There was a moderate to high reported awareness of MetService warnings that had been issued prior to the Weather Bomb event. This ranged from 81 % in the low impact Coromandel area to 46 % in South Waikato.

MetService issues Heavy Rain and other Warnings according to specific criteria (see Appendix 1); territorial authorities decide on the basis of this and other information if flood and other warnings are necessary within their jurisdiction. Because the local catchments are small and have short response times, no river monitoring systems existed along the western Coromandel

(there are, in contrast, monitoring systems on many rivers in larger catchments in the wider Waikato region). Two questions were asked to explore the public's perceptions of warnings, and to see if people made any link between the extreme weather/Heavy Rain Warnings and the subsequent flooding. However, the questions asked in this survey do not fully address this complex issue and further work is needed to explore the links (real or perceived) between weather and flood warnings, the public's understanding of them, and how best to improve the effectiveness of both. The need for improved tools for responding to floods in New Zealand has also been identified in recent research. The data from this study provides a sound baseline for research currently underway. This research incorporates new information from the ongoing community consultation process that has been underway since the time that the survey data presented here was conducted (see further work below).

#### **7.4 Preparedness and perception of risk**

The community survey measured a range of attitudes, beliefs and understandings of flood risk, the Weather Bomb event and the community in general. From previous social research we are aware that people's understanding of risk and their response to risk are determined not only by scientific information or direct physical consequences, but also by the interaction of psychological, social, cultural, institutional and political processes. Changing people's perceptions of risk alone will not necessarily bring about changes in their behaviour or increased action to address a particular risk. People may not be motivated to prepare if they do not perceive or accept their risk status or perceive the hazards as salient. Irrespective of the level of perceived threat, people's actions will be limited if they perceive hazard effects as being difficult or impossible to mitigate through personal action (low outcome expectancy). Even if people believe that personal actions may reduce adverse impacts, people may not implement these actions if they do not think they are competent to carry them out (low self efficacy). Acknowledgement of a threat may not guide actions if people lack resources (e.g., time, skill, need for cooperative actions etc) required to implement reduction actions (low response efficacy), transfer responsibility for their safety to others (low perceived responsibility), lack of trust in information sources, or because of uncertainty regarding the likely timing of hazard occurrence (Paton 2003). The community consultation over future risk management options, undertaken over the past six months, is continuing to address a range of issues relating to acceptable risk, appropriate mitigation options and the community's willingness to pay. Follow-up research is needed to see how the perceptions documented in the study influence this process.

A key issue resulting from this study is the need to explore in more detail the links between weather warnings and appropriate responses of individuals in high risk areas. There is considerable research pointing to the value of simple alert schemes to help individuals, organisations and communities respond to developing crises (Mileti 1999, Sorensen 2000,

Hander 2002). The need for improved tools for responding to floods in New Zealand has been identified in recent research on the Waikanae floodplain (Johnston et al. 2002) and suggested by this study. Despite the above suggestions, it is still not clear, given the short flood response time in the catchments and the lack of flood warnings systems how a system would work, but it is an issue worth exploring. Environment Waikato does operate an automated flood warning system for the region in many watercourses with larger catchments.<sup>12</sup>

Decision making to mitigate the effects of climate-change impacts for vulnerable localities needs to be a sequential process, taking into account scientific uncertainty, public perceptions, and risk exposure. It is essential that the climate-change planning process start now, given the longevity of housing developments and infrastructure in increasingly at-risk communities.

## **7.5 Further research**

The data for this report was collected over a very limited time period (August/September 2003). Since this study was undertaken, both the local and regional councils have been consulting extensively with the affected communities to identify and discuss a range of risk management options. Ongoing research will explore how the understanding and attitudes documented in this report have shaped the outcomes of this process. Further work is also ongoing in the Waikato and other regions to explore issues related to weather warnings and links to flood response. The nature and effects of possible ‘warning saturation’ also requires further research. Another ongoing area of work is the development of better flood depth-to-damage ratios. This is needed to build better loss modelling capabilities for future scenarios.

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<sup>12</sup> Refer: <http://www.ew.govt.nz/ourenvironment/hazards/naturalhazards/river1/index.htm#Heading6>

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