Economic Risk Assessment of Mount Egmont

The Potential Economic Implications of a Volcanic Eruption in Taranaki

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Abstract

New Zealand is home to a large number of volcanoes, many of which threaten the North Island, with damaging ground hugging hazards or disruptive ash deposits. As little as 2mm of ash will put grazing animals off their feed, completely disrupting the agricultural environment, transport is affected and equipment is vulnerable. The most likely damaging event from an eruption is ash, the potentially unknown area of which is determined by wind direction and strength. The 1995/1996 Ruapehu eruption was geologically considered minor with no more than 10mm of ash deposited, yet the economic consequences and disruption were significant, estimates put the minimum cost of the eruption at $130million made up almost singularly of tourism revenue losses and damage to the hydro-electric turbines.

There has been little work completed in assessing economic impact of a natural disaster in an economy prior to the event. While the expected scale of any disaster is frequently assessed on historical evidence for planning purposes, social or economic studies tend to consider vulnerable sectors during evacuation and recovery as opposed to a monetary figure or the economic impact.

The most recognised volcanic event (and standard example) in recent history was the Mt St Helens eruption in 1980; this eruption killed 57 people and caused damage in excess of US$1billion. Mt Egmont is the visible headstone of Taranaki's volcanic history but is only the youngest location in a series of destructive volcanoes in the area. There have been no known eruptions within the region since 1755, with eight recorded eruptions in the 300 years prior.

It is generally accepted that any future events from Mt Egmont will follow the same path as historic eruptions, explosive ash emissions with gentle lava extrusions. Three eruption scenarios, all skewed towards a more likely smaller eruption, are considered in the overall analysis of the region; future studies may concentrate on rare catastrophic eruptions or the evacuation of New Plymouth. The first scenario is limited largely to the national park with ash fall only within the region, the third scenario pushes ash over much of the North Island and has damaging hazards throughout Taranaki A final consideration is made to investigate how an economy responds to increased volcanic threat without an eruption. If precursors to volcanic activity extend for a long period of time the threat of economic stagnation, reduced investment, emotional stress and permanent relocation from the region will increase. Early warning systems and increased disaster planning has greatly reduced the number of deaths caused by volcanic eruptions, in many ways it has also increased economic vulnerability as danger zones become populated.

Taranaki has a low population density with rich natural resources and an economy largely geared towards dairy farming and the extraction of oil and gas. The five largest sectors in Taranaki create $8,910.18million in total output or 57.83% of regional output; these are oil and gas extraction, dairy manufacturing, dairy farming, meat processing and wholesale trade. Oil and gas exploration adds an additional $331.72million to economic output.

There is a lot of high level energy infrastructure in Taranaki from gas pipelines connecting fields, production stations and delivery systems to the multitude of high voltage power lines connecting two power generation stations with the national grid. All oil and gas production and much of the gas transmission system is based within Taranaki, this industry alone is estimated to contribute more than $1billion a year to the national economy. One factor of Taranaki's gas monopoly is the significant downstream impact any regional disruption in supply could have on the national economy and social well being. Oil and gas is vital to many aspects of New Zealand business not just within Taranaki but day to day business operations, manufacturing processes and power generation capacity.

Iconic industries are those businesses that may have an impact on the local community above that of direct economic loss, that are socially as well as economically significant. These firms are predominantly the largest employers and contributors to the local and national economy, and are the most likely to consider permanent relocation outside the region in the case of a large ongoing event. Research was completed on significant industries to gain a more detailed impression of the largest contributors to the local and national economies and potential disruption. These enterprises include electricity generators and gas production, Fonterra, Ballance, Yarrows and Westgate Port. The National Park, tourism and the airline industry were also considered separately due to their individual importance and likelihood to be affected by an eruption.

The results of the input-output scenario analyses show an immediate value added decline in the regional economy ranging between $519.09million and $2,505.21million due to volcanic eruption. Input-output captures the overall regional impact of an eruption, the immediate reduction in output as a result of evacuation and physical influences. However an eruption of any magnitude will also have a national impact on the economy which should not be forgotten. Iconic industries were considered separately to take into account some of the largest regional contributors to the national economy.

Risk assessment of the iconic industries enabled the assessment of more long term, wide reaching and national effects of an eruption which are not captured in input-output assessments. The gas industry will have the most detrimental economic effect, literally closing the entire gas dependent manufacturing sector throughout the North Island for a number of weeks. Although the Whareroa dairy factory contributes considerable value to national exports with 100% of production being exported milk volumes normally processed could, with the exception of approximately two weeks during the peak season, be absorbed by other factories in the North Island limiting national impact. It is impossible to determine the degree of flow on effects from all of the businesses affected; many interdependencies wouldn't openly be recognised until they occurred.

New Zealand has been lucky in that recent volcanic activity has been minor and sporadic in nature; consequently the public perception of risk has been skewed towards events which in geologic records would not even register. An eruption would overwhelm local civil defence resources almost immediately, the surrounding communities would be flooded with evacuees and the economic ripples would be widely felt. This is particularly the case with Taranaki and the critical high level infrastructure. Mitigating economic risk can only be done by locationally spreading risk, with adequate protection measures (financial or physical) and by increasing public awareness.

Acknowledgements

I would like to take this opportunity to thank my supervisor Anton Meister for his assistance and direction throughout the course of this project and the last five years at Massey University. The assistance of Russell Bell (AON Risk Services), Stuart Birks, Jonathon Proctor and Shane Cronin has been invaluable in understanding the many facets of this research.

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Abbreviations

accom.	Accommodation
AMF	Anhydrous Milk Fat
ANZSIC	Australia New Zealand Standard Industrial Classification
CAE	Centre for Advanced Engineering (Canterbury University)
CDEM	Civil Defence and Emergency Management
CPI	Consumers Price Index
DOC	Department of Conservation
ECLAC	Economic Commission for Latin America and the Caribbean
EMO	Emergency Management Office
FTE	Full Time Equivalent employees
GDP	Gross Domestic Product
GIS	Geographic Information System
GJ	Gigajoule
GRP	Gross Regional Product
Gw	Gigawatt
ha	Hectare
IGNS	Institute of Geological and Nuclear Sciences
ISDR	International Strategy for Disaster Reduction
kg/ms	kilograms of milk solid
kg/su	kilograms per stock unit
KGTP	Kapuni Gas Treatment Plant
km	Kilometre
kV	Kilovolt (measure of electricity)
LCDB2	Land Cover Database 2
LIC	Livestock Improvement Corporation
LPG	Liquefied Petroleum Gas
m	metres
($)m	million
MAF	Ministry of Agriculture and Forestry
MCDEM	Ministry of Civil Defence and Emergency Management
MED	Ministry of Economic Development
mm	millimetres
Mt	Mount (mountain)
Mw	Megawatt
n/a	Not Applicable

NEFD	National Exotic Forestry Description
NGC	National Gas Corporation
NNE	North North East
NNW	North North West
NOAA	National Oceanic and Atmospheric Administration
NP	New Plymouth
NZ	New Zealand
NZDG	New Zealand Dairy Group
NZIER	New Zealand Institute of Economic Research
OECD	Organisation for Economic Co-operation and Development
PJ	Petajoule
PJe	Petajoule equivalent
ppm	Parts per million
PV	Present Value
SBPT	Shell BP Todd
SH	State Highway
SME	Small and Medium Enterprise
SSE	South South East
STOS	Shell Todd Oil Services
su	Stock Unit
TAWN	The Tariki, Ahuroa, Waihapa and Ngaere grouping of gas fields
TCC	Taranaki Combined Cycle (Power Station)
TJ	Terajoule
TRC	Taranaki Regional Council
TSB	Taranaki Savings Bank
TV-SN	Taranaki Volcanic Seismic Network
24-7	Twenty four hours a day, seven days a week
US	United States of America
WINZ	Work and Income New Zealand

1. Introduction

New Zealand is one of the most volcanically active areas on earth with several active volcanoes throughout the heavily populated North Island. Eruptions can have enormous impacts on both the economy and society in terms of physical damage, loss of life and economic disruption. For planning purposes it is important to gain an understanding of where these physical consequences will occur and potentially how important these damages will be to the national and local economy.

This thesis is part of a larger project assessing the risk posed by North Island volcanoes, led by geologist Dr Shane Cronin at Massey University. The volcanic risk project aims to extend and document knowledge of volcanic hazard processes, volcanic risk, risk management strategies and community vulnerability for the Ruapehu and Egmont volcanoes.

The area chosen for analysis is Mt Taranaki/Egmont and Taranaki. The mountain is known by two official names, as the Maori Taranaki or European Egmont. For the purpose of this report Mt Egmont will be used in reference to the mountain whilst Taranaki will refer to the region as a whole. With any disaster, the impact on an individual basis is significant for all businesses and farmers directly affected. What is interesting about Taranaki is that any long term eruption, or even a short term but significant eruption, will be extremely detrimental to New Zealand as a whole given that the economic activity in the entire Central North Island will be disrupted. Many industries originating in Taranaki provide critical facilities well beyond the borders of the region, an interruption to manufacturing and agricultural sectors or to the gas and power supply will be influential over a wide area. This will potentially have a huge adverse impact on national GDP and in particular the trade balance if agricultural exports from Fonterra are damaged. The Fonterra Whareroa dairy factory alone contributes 5% to New Zealand's GDP.

Interruption to the gas supply will impact on all facets of business in the North Island if an alternative immediate gas source can not be found (most likely via import). Interruption will occur even in the event that an eruption does not take place but if alert levels reach a critical level. Many different industries throughout the North Island rely on this gas for day to day production; even the temporary ceasing of gas supply to the Hawkes Bay during the 2004 Manawatu floods had enormous economic consequences. These widespread detrimental effects that are unique to resources within Taranaki will not be offset in GDP by the recovery and replacement costs that traditionally follow a disaster, particularly if the eruption continues for an extended period.

The main objectives of this research are to:

- Develop an analytical framework to support the estimation of economic impacts
- Determine an overall economic impact from a volcanic eruption from Mt Egmont
- Complete a risk assessment of large industries that will experience the greatest impact both regionally and at a national level
- Determine the independent impact of behaviour change as a result of volcanic activity.

The overall aim of this research is to assess the structural vulnerability of Taranaki, to investigate the level of risk to Taranaki's economy of volcanic specific hazards. This is achieved by developing an analytical framework to estimate economic impacts, the direct damage costs of an eruption scenario, business disruption and ongoing economic loss. The thesis also considers the impact of a change in volcanic alert levels which ultimately do not result in an eruption. Economic losses due to eruptive episodes[1] can greatly exceed the losses caused by physical damage. This incorporates the risk assessment of large industries in the region in terms of economic contribution and vulnerability, determining the direct extent of volcanic hazards and the economic consequence for the predominantly agricultural communities. While determination of the financial consequence is one focus of this research also aims to highlight the economic weakness of New Zealand's economic base to volcanic hazards.

Although hazard zones are identified and outlined it is important to note that boundaries are not discrete and specific, volcanic hazards in particular are uncertain and "safe" zones can not be completely assured. Similarly varying degrees of damage exists in each zone. Hazards decrease by increment as topography and distance from the mountain alter; all analysis in this report takes the identified hazard boundaries as absolute and certain. The analysis does not include secondary disasters that could potentially result from an eruption. This includes events such as secondary flooding, tsunami or increased fire risk, threat of starvation or disease to animals and humans. Neither does this analysis assess the potential impact of an event where New Plymouth, the population and business hub of Taranaki, is deemed to be unsafe and requires evacuation. If water supplies become contaminated or the town otherwise becomes uninhabitable, mass evacuation will need to be considered with even greater economic consequences. In addition this analysis only considers the potential gross economic cost to the region as a result of an eruption, the net effects once recovery packages and insurance claims have been received may, particularly in small eruptions, be positive. Gross figures are important as they provide the major impact of damages that result from an eruption (or any event)

The thesis initially discusses the current nature of the Taranaki economy, followed by a contextual overview of the volcanic hazards that will be referred to throughout the analysis and a history of Mt

[1] An eruptive episode refers to all volcanic activity which results in changes to behaviour, whether that is physical eruption or just indicators of activity.

Egmont. A brief literature review is included regarding projects of a similar nature and the civil defence framework that is integral for recovery of the region and consequently the economy. The expected hazards from Mt Egmont and eruption scenarios are discussed as the basis for all analysis. The importance, vulnerability and influence of certain industries in the region are discussed on an individual basis to establish specific impacts on the drivers of the economy, this risk assessment will be representative of the wider, broader and long lasting effects of an eruption which are not incorporated within the input-output analysis. Small and medium enterprises are discussed with regard to volcanic hazards they will face and the potential flow-on effects. Input-output modelling allows the modelling of the entire economy capturing the immediate reductions in output that result from an eruption.

New Zealand is fortunate that modern volcanic eruptions have been relatively minor in geological terms. An eruption of any magnitude has the potential to stall the entire economy to a degree that is immeasurable; all of the flow on effects simply can not be considered. Identifying an economy's economic exposure is critical in protecting against and preparing for disaster recovery.

2. Socio-Economic Profile of Taranaki

Taranaki has a land area of 723,610 hectares located on the west coast of New Zealand and is a region rich in natural resources with a prominent mountain and an extensive 300km coastline. The Mt Egmont and Kaitake Ranges National Park is a large recreational resource. The volcanic plains support highly productive farmland and inland the hill country provides additional natural and farming resources which include large areas of natural bush and the Whanganui National Park (Venture Taranaki, 2005).

Three districts make up the Taranaki Regional Council - New Plymouth, Stratford and South Taranaki. The area is not hugely populated with just two main settlements in New Plymouth and Hawera; provincial centres that support the rural community are located in Stratford, Opunake, Waitara and Inglewood. The smaller rural towns have a moving population towards New Plymouth further diminishing population density in rural areas. In the 2001 Census Taranaki's resident population was 102,858 people in 38,505 households, accounting for only 2.8% of total New Zealand population (Taranaki Regional Council, 2004c; Statistics New Zealand, 2005) and unevenly split between the three districts of New Plymouth (66,603), Stratford (8,883) and South Taranaki (27,537). The median income of residents in the region is slightly below the national average at $17,300 (Statistics NZ, 2005).

Taranaki has a higher rate of dependency (defined as those who are under 15 or over 65) than New Zealand as a whole, 37.9% and 34.8% respectively. Nationally 22.7% of the population was under 15 in 2001, compared to 23.7% in Taranaki; the population over 65 represents 14.2% compared to the national rate of 12.1% (Statistics New Zealand, 2005).

The region's social and economic wellbeing depends heavily on the natural and physical resources and land based business continues to be highly important to the region. The natural gas sector is the only commercial field in New Zealand and a large employer, there are 2,100 dairy farms in the region supplying more than 14% of national milk solids, in addition to sheep and beef farming and forestry (Taranaki Regional Council, 2004). The agricultural sector, in particular dairy farming, is critical to the regional economy with on-farm employment and within secondary processing facilities. Synthetic fuel plants, resin and urea production, power generation, natural gas processing and redistribution networks have all developed within the region to support the only oil and gas producing site in New Zealand (Venture Taranaki, 2005). Industrial manufacturing and heavy engineering industries have also developed a strong base around New Plymouth to support the petrochemical and mining industries. As at February 2003 there were 7,503 businesses in Taranaki, predominantly these were property and business services (30.1% of businesses) in main rural areas and retail trade which represented 13.4% of businesses (Statistics NZ, 2005d).In terms of full time employees the largest industry in the region is manufacturing with 8,040 employees (22.6%) followed by retail trade with 13.7% of employees. Manufacturing is more specifically food and beverage manufacturing (just 39 companies employing 3,960 employees) and then metal manufacturing.

In 1934 the Moturoa Oil Company began production from the Moturoa field in Taranaki that would continue until 1972, New Zealand's first viable natural gas and oil field. However it was not until Kapuni was discovered in 1959 and consequently began production in 1969 that gas became a force in the New Zealand energy market, delivering gas to users throughout the lower North Island. The success of Kapuni spurred further exploration that resulted in the discovery of Maui in 1969 (production began in 1979). These discoveries have driven the energy infrastructure, gas support services, heavy industrial and engineering sectors that are symbolic of Taranaki industry (Shell Todd, 2005). The discovery of Maui spurred a large level of investment which included the development of the $2billion Motonui synthetic fuel plant and the $500million methanol plant at Waitara (Davidson, 2004), although each of these plants is currently closed pending decisions about future gas supply and prices. These plants are extremely important to Taranaki's economy, the two methanol plants of Methanex were assessed by Venture Taranaki to contribute a total economic impact of $1billion, including $375million in valued added and 650 full time equivalent employees to the region (Davidson, 2004).

Although gas production from Maui is in steady decline a recent surge in exploration and production activity means that as of early 2006 a number of fields are beginning to come on line to meet the needs of New Zealand. These fields include Pohokura, Kupe, Tui, Maari and Maui A (Port Taranaki, 2005). The Pohokura development alone is expected to cost close to a billion dollars before production even begins.

The dairy industry has always played an important role in Taranaki's economy. The first co-operative dairy factories opened in Inglewood and Opunake in 1885 and in 1896 the first shipment of butter and cheese left Port Taranaki ultimately destined for London (Davidson, 2004). In 1956 milk tankers began to pick up milk, spurring a dramatic change in the dairy industry throughout the region, 115 small dairy factories slowly amalgamated to form just one – the Kiwi Co-operative Dairy in Whareroa which has since become Fonterra's leading processing facility. The dairy processing industry contributes just under $2.5billion to the regional economy annually (W Hughes, Personal Communication, 2006).

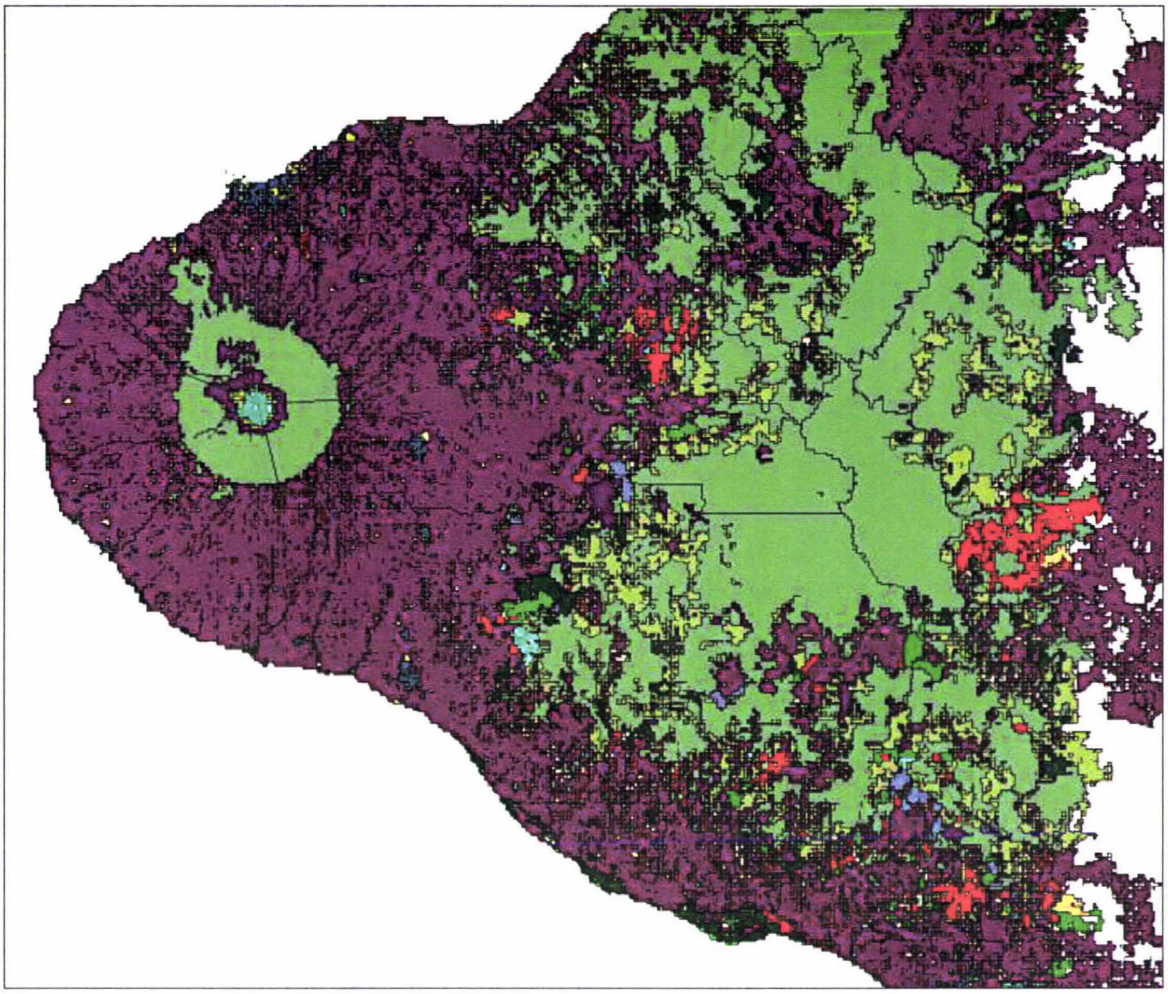
The development of efficient transport systems has spurred significant economic activity although not all effects were positive. The many small towns and rural centres that were supported by freezing works and small dairy factories floundered as these primary sources of employment and income closed down, beginning the trend that continues today of populations in rural centres shifting towards the larger urban areas and employment opportunities.

Freezing works also offered considerable employment opportunities throughout the development of the region, the Borthwicks Waitara freezing works opened in 1902 operating for more than 100 years and employing over 1,000 workers (Davidson, 2004). Borthwicks represented a large part of Waitara's socio-economic development. The closure of this plant in 1995 shortly after Affco took ownership had huge adverse consequences for the town and the predominantly Maori employees. Similar closures in Patea and throughout the region created huge unemployment and stagnation in the regional economy. In 2003 Maori unemployment was still as high as 19.2% (Davidson, 2004). Regional unemployment in 2001 was 7.8%, above the national rate of 7.5% (Statistics New Zealand, 2005).

More recently the region, through development agency Venture Taranaki, has begun to push growth in the tourism industry and to enhance the public image of Taranaki largely through festivals and events that draw visitors to the area. The TSB Bowl and Yarrow Stadium are attracting many big budget concerts, sporting and other events that attract visitors to the region from all around the North Island. The Rhododendron Festival, WOMAD and the Festival of Lights have now been operating for a number of years with growing success. International tourism to the region is also beginning to grow as tourists seek out environmental, natural and adventure destinations distinctly different from their own. The Surf Highway 45, marine park, two national parks with mountaineering and tramping and cultural activities offer attractions to a wide variety of groups. Significant effort has been made by Venture Taranaki and other organisations to market Taranaki as a destination for visitors and economic activities, including film production (Venture Taranaki, 2005b).

Land use as determined from the Land Cover Database 2 (LCDB2) has been obtained for Taranaki Regional Council. This data is best used on much larger scales however this allows a visual representation of land use and the importance of intensive farming such as dairy farms in the region. Purple represents high producing pasture and green indigenous forest. The area has a large ecological value given that Egmont National Park was New Zealand's second national park, large areas of bush reserve as well as the presence of the Whanganui National Park on the eastern boundary of the region. Sheep and beef farming are largely restricted to the inland hill country while dairy dominates the volcanic plains.

Figure 1: Taranaki Land Use as Determined by Land Cover Database

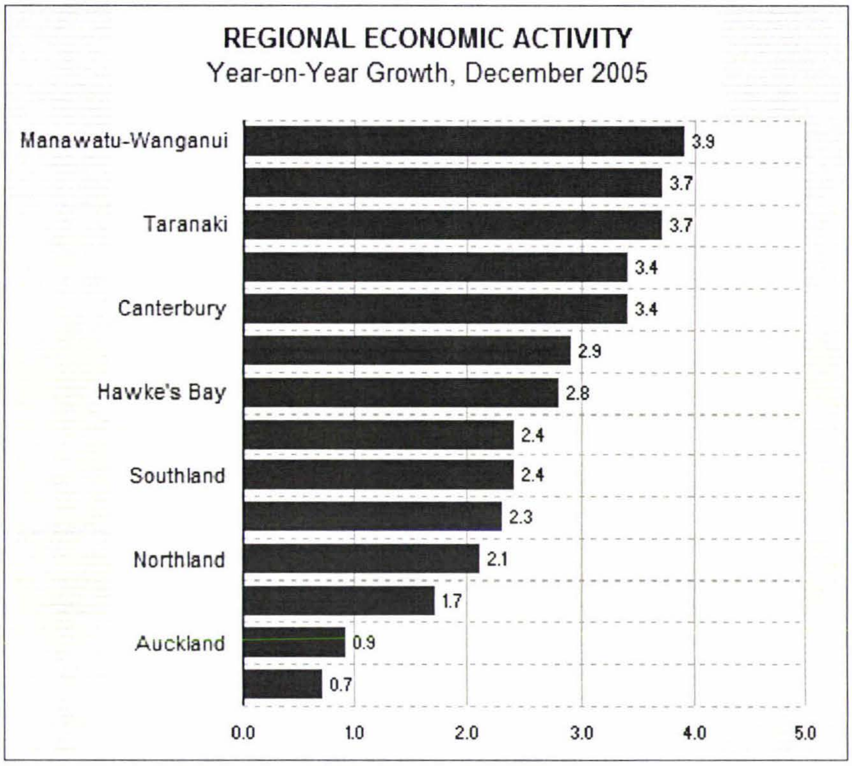


Source: Land Cover Database Two, Terralink International (2005).

Much of Taranaki's production is export oriented with dairy, specialty bakery products, meat, timber, chemicals and metal based products all created specifically for export (Venture Taranaki, 2005). The input-output model for the region provides the most accurate breakdown of sectors by economic contribution as opposed to employment. The five largest industries in Taranaki are thus identified as oil and gas extraction ($3,370.85million in output), dairy manufacturing ($2,471.75million), dairy farming ($1,808.51million), meat processing ($788.68million) and wholesale trade ($470.39million) (Hughes, 2006). In addition the oil and gas exploration activity contributes $331.72million to economic output.

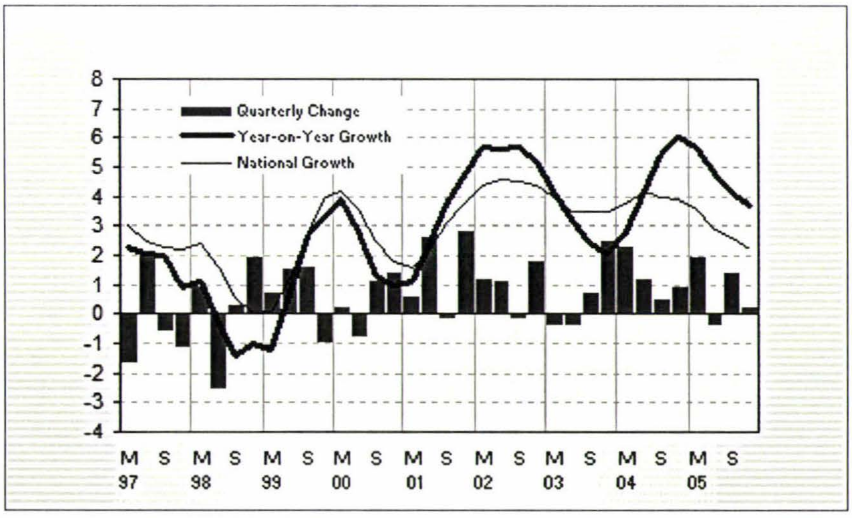
The following figures (produced by National Bank of New Zealand) give an indication of the economy in Taranaki in relation to other regions in New Zealand. Presently Taranaki's year on year growth is second only to the Manawatu- Wanganui region, on par with Gisborne. The economy is in a state of recovery. The region's growth rate has been consistently above the national average since 2001 with the one exception at the end of 2003/2004; this is likely to be a period of 'catch-up' with the national economy. Between 1998 and 1999 the region was experiencing negative year on year growth – a flow on effect from the more than 2% decline in the 1998 June quarter. During this time the region was still recovering from the period of restructuring and freezing works closures which contributed to extremely high unemployment rates. Prior to 2001 growth was in line with, but well below national growth. The percentage growth rates in the region are very cyclical but show an increasing trend to the future.

Figure 2: Comparative Annual Growth between Regions



Source: National Bank of New Zealand, 2006

Figure 3: Annual and Quarterly Growth for Taranaki in Comparison to National Growth

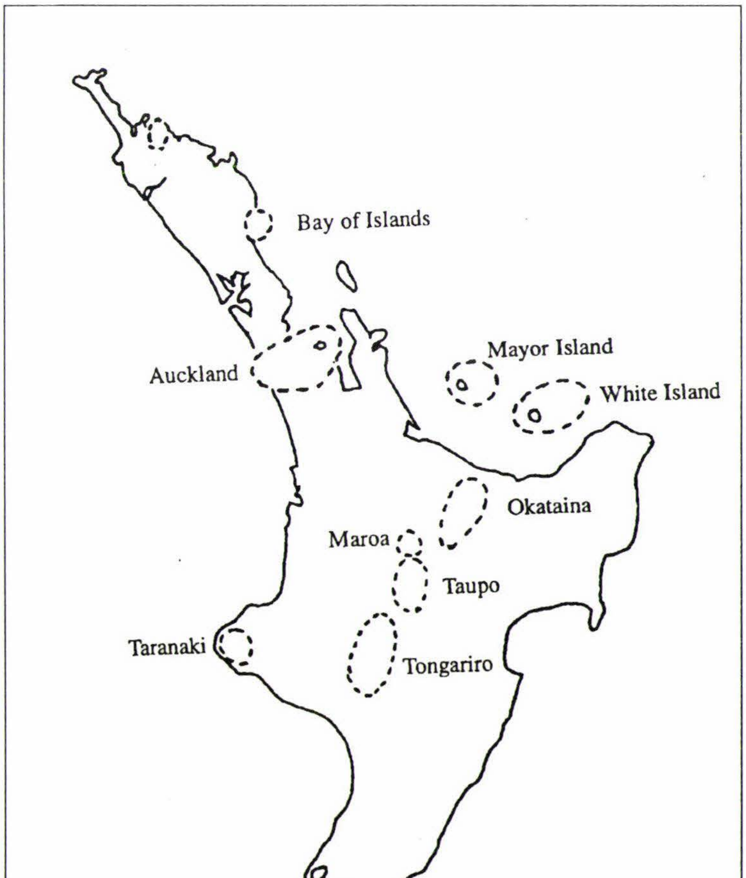


Source: National Bank of New Zealand, 2006

3. Volcanic Hazards

There are ten volcanic centres within New Zealand that have the potential to erupt and cause considerable damage to the surrounding population. However little information is known concerning the possible scenarios, rehabilitation and available assistance if such an event occurred. The 1995/1996 Ruapehu eruption was considered minor with no more than 10 mm of ash deposited, yet the disruption and economic consequences was significant (Johnston et al, 2000). The Ruapehu eruptions highlighted a lack of information on volcanic risks and potential impact on businesses, farmers and agriculture. New Zealand also lacks the formal institutional guidelines, responsibility channels and contingency plans should a major volcanic event take place. A Ministry of Agriculture and Forestry (MAF) commissioned report (1998) sought to rectify some of these shortfalls and provide a template for future planning. From a management perspective the low frequency of events, uncertain nature of eruptions and widespread impact means that the responses required from individual organisations are poorly defined and lacks the communication channels that would be required between normally unconnected groups (MAF, 1998).

Figure 4: Volcanic Hazard Sites of the North Island



Source: Gregory and Neall, 1996

New Zealand contains a wide range of volcanoes including volcanic fields, composite cones and calderas. Irrespective of variety, hazards that result from an eruption can be categorised into near vent destructive hazards (ground hugging hazards) and distal damaging or disruptive hazards (ash deposits). The near vent hazards are typically a lot more damaging but can be restricted to a relatively small area while distal events are less damaging but more widespread and disruptive. Egmont is an andesitic cone volcano, meaning eruptions can be moderate or explosive emitting both lava and ash deposits (Ansell & Taber, 1996).

Ground hugging hazards include lava flows and domes, pyroclastic flows and lateral blasts, landslides, lahars and floods. These hazards have the potential to cause total damage, predominantly destroying anything in their path. Direct damages occur in relatively close proximity to the summit and can be predicted to a degree based on land formation, historic evidence and characteristics of the hazard.

Air borne threats present a completely different hazard. While damage is rarely total, its effects can be considerable even in small quantities. It is the secondary effects of ash, the unpredictable component of its distribution and the chemical breakdown that creates such an unknown threat. Ash can be widespread, unpredictable and affects all aspects of modern life without necessarily causing direct damage. The accumulation of ash (particularly when wet) and its chemical / abrasive properties cause the most damage. To humans, ash generally presents only nuisance irritations such as respiratory problems and eye and skin irritation. In rare cases of considerable exposure to ash or the chemical nature of specific ash falls further complications can develop (Munro & Parkin, 1999).

There are many ways in which a volcano can erupt but the degree of damage generated depends on five main aspects, the distance materials travel and area covered, velocity of material, temperature and duration, length and nature of warning period and the frequency of occurrence (Patterson, 1987, p19).

A brief description of volcanic hazards that could be expected from Mt Egmont is given below:

Lava Flows and Lava Domes:
Lava flows are hot molten rock that flow from a volcano. The distance and speed of the flow is determined by the viscosity (stickiness), volume of material, slope and surrounding geography. Lava forms most of the upper cone of Mt Egmont, The Beehives, Skinner Hill and The Dome (all lava domes). By volume lava would only be a small part of any eruption from Egmont, if present at all (Neall & Alloway, 1993).

Lava poses little threat to people, animals or transportable capital as it rarely travels more than 5km an hour; traditionally it has been restricted to within 7km of the Egmont summit (within the national park boundary). Nothing can be done to halt the lava's flow towards, or destruction of, immovable property.

Pyroclastic Flows and Lateral Blasts:

Pyroclastic flows refer to all forms of hot, rapidly expanding gas and particle emissions resulting from a volcanic eruption. These flows are dry mobile fluids that can reach extremely high temperatures and speeds (up to 1000° C and 200 km/hr). Egmont pyroclastic flows have previously travelled to the northwest, northeast and east up to 15km from source.

Lateral blasts are pyroclastic flows that are ejected sideways, potentially reaching speeds of 300km/hour. These horizontal trajectories have not been recorded at Egmont before, however they are extremely unpredictable and can not be ignored (Neall & Alloway, 1993). It was a lateral blast which caused the catastrophic damage to the northwest of Mt St Helens in the 1980 eruption.

The biggest threat from this type of hazard is the extreme heat and momentum of the blasts which will destroy everything in their path, the only protection being prior evacuation. Of significance is the high temperatures that can melt ice and snow present during winter, causing lahars or floods that can extend considerably further than the immediate hazard.

Landslides, Lahars & Floods:

Landslides (volcanic debris avalanches) are a displacement of earth and are a significant threat on Egmont, with three landslides exceeding 3.5sq/km known to have occurred from the current cone. The landslides have extended to the northeast, southeast and west for as many as 40km. This phenomenon destroys everything with characteristics similar to, but more expansive and destructive than Lahars.

Lahars are fluid mixtures of rock, water and mud originating from the volcano, resembling wet concrete. These erosive surges can travel at high speeds and for long distances, particularly from steep slopes such as Egmont. Further from source, these flows tend to follow existing river and valley channels. Lahars can form even in the absence of eruptive activity when heavy rain consolidates loose debris or after an eruption consolidating unstable ash deposits. The turbidity of lahars and their potential speed is highly erosive to river banks and can destroy vehicles, bridges and other structures within its path, they occur with little warning and travel large distances (Neall & Alloway, 1993).

Flooding due to ice melt or as the end result of a lahar (far from source) is also a common side effect of eruptions. This poses the highest risk at Egmont during winter as there is little snow cover during the summer months.

Gases:

Gases are emitted during an eruption; principally these include carbon and sulphur dioxide, as well as hydrochloric acid, hydrofluoric acid and ammonia. Emissions tend to be localised around the summit so effects can be easily minimised and confined by closure of the National Park, this is unlikely to present any hazard to people (Neall & Alloway, 1993).

Volcanic gas can produce three potential hazards, particularly to agriculture and in a smaller eruption may present one of the greatest threats.

Direct exposure: contact with gas clouds produced in an eruption and can result in respiratory and eye irritation or in extreme cases poisoning and suffocation.

Volcanic fog (vog) and acid rain: result from interactions between the surrounding environment and volcanic gases. The corrosive, acidic nature can result in considerable damage to crops, plantations and machinery, potentially affecting a large downwind area from the mountain.

Volcanic degassing: water soluble chemicals which are emitted and absorbed by ash and water particles. This chemical laden material falls on pasture and forestry, is absorbed into soils and ingested by grazing animals. Pastures with only small amounts of ash deposit, can consequently prove fatal to grazing animals, in particular poisoning sheep and deer (MAF, 1998). This was particularly apparent during the 1995/1996 Ruapehu eruptions which killed more than 2,000 sheep and lambs, as well as numerous wild deer from fluorine poisoning (Johnston et al, 2000).

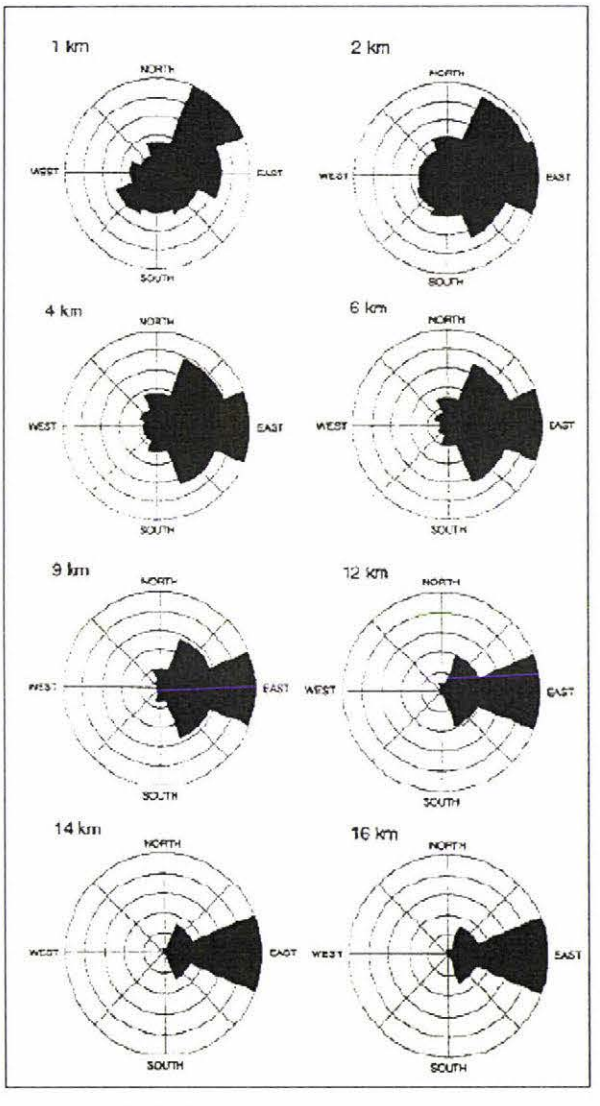
Degassing and volcanic fog can both be very corrosive to metallic equipment and cosmetic surfaces.

Tephra:

The single term defines all aerially projected particles from a volcanic eruption. This can be broken down further to ash (<2mm diameter), lapilli (2-64mm diameter) and blocks (>64mm diameter). The distribution of tephra, unlike ground hazards, can be widespread and in any direction. Once projected into the air distribution is determined by tephra size, wind direction and velocity, remaining problematic far from source. Hazards posed by ash are twofold, the physical presence or nuisance value and the previously mentioned chemical presence (Neall & Alloway, 1993). Ash distribution and effect is difficult to predetermine, even a single ash plume can display wide variation in grain size, distribution, depth, density and chemical composition over both the width and length of the plume (Nairn, 2002).

The most likely disruptive event from an eruption in New Zealand is ash, the potentially affected area of is determined by wind direction and wind strength. At high altitudes the wind is consistently westerly, at lower altitudes winds can swing from any direction but remains predominantly westerly/south westerly. The following diagram is a representation of wind direction at varying heights from Auckland Airport (1966-1979) which can be used to predict wind direction around Mt Egmont.

Figure 5: Frequency of Wind Direction above Auckland Airport 1966 - 1979



Source: MAF, 1998, p9

Building collapse is the most significant, immediate threat from ash fall, usually occurring in cases where there is in excess of 100-300mm; this limits the area likely to be affected to within close proximity (MAF, 1998). Asphyxiation is possible in significant falls however the main problem is the physical and nuisance presence which influences air and land transport, water supplies, agriculture, electricity supply and generation and communication devices. Far from source, fine ash can cause havoc with electrical equipment, machinery and day to day operations due to its highly abrasive nature (Neall & Alloway, 1993).

Ash fall on farm land and within water catchments can be problematic for some period after an eruption. Layers of ash can reduce absorption of rainfall and produce higher surface runoff causing higher flood peaks, exaggerated stream discharge and simultaneously drought characteristics for the soil (MAF, 1998). While ash is unlikely to kill animals directly it creates uninhabitable pastures (lack of feed) and if chemically laden ash is ingested it can be fatal. Reports from recent small eruptions state that ash in excess of 2-5mm will put grazing animals off their feed. Aquatic life, birds and insects are all adversely affected by ash even in very small quantities (MAF, 1998).

4. History of Taranaki Volcanic Hazards

The productive capability of natural resources within Taranaki can be traced to the volcanic episodes that have shaped the peninsula for more than two million years, the modern face of which is Mt Egmont. A shallow sea that existed prior to volcanic activity has formed the oil and gas reserves so critical to New Zealand and Taranaki, whilst the fertile farmland of the ring plain exists as a result of many past cone collapses, debris avalanches and lahars.

Egmont is the visible headstone of the regions volcanic history but is only the youngest in a series of Taranaki volcanoes. Volcanic activity has moved across the region in a NNW to SSE path along a fracture in the earth's crust called the Taranaki volcanic succession (Neall, 2003). North to south (in descending age and degree of erosion) these volcanoes are the Paritutu, Kaitake and Pouakai volcanoes and the youngest, most visible Egmont Volcano, the only one that remains active (presently dormant).

Paritutu – Approximately 1.75 million years old	(Sugarloaf Rocks)
Kaitake – Approximately 0.5 million years old	(Kaitake Ranges)
Pouakai – Approximately 270,000 – 670,000 years old	(Pouakai Ranges)
Egmont – 130,000 years old	(Mt Egmont)

All four volcanoes show evidence of huge cone collapses and debris avalanches which remains a real threat from Mt Egmont during an eruption. Ancestral cones from the site of Mt Egmont were destroyed by enormous collapses, the evidence of which extends as far as the coast line. These collapses formed the distinctive ground formations on the ring plain while successive lahars have also shaped land development.

Due to previous cone collapses the current Egmont Cone (Neo-Egmont) is the fourth known cone formation at this location and is only around 20,000 years old. Other distinctive features of the cone – The Beehives, The Dome and Skinner Hill (all lava domes) were formed around 3,300 years ago during a particularly active period from Fanthams Peak, a parasitic cone on the top of Egmont (Neall, 2003).

Even within the last 500 years Egmont has been relatively active. Hot gas clouds (pyroclastic flows) are known to have decimated forests in the Stony River catchment causing widespread fires. Multiple ash eruptions have occurred, with eight recorded eruptions in the 300 years prior to the last eruptive event in 1755AD (Neall, 2003). The instability of the steep Cone means eleven debris flows have occurred in the past 400 years and lahars occur frequently after heavy rain and snow melt, the most recent in 1998. Geological records indicate that on average, Mt Egmont erupts on a moderate to large scale every 300 years, with many smaller eruptions in between (Neall & Alloway, 1996). This is a greater than 0.3% chance of eruption in any one year.

New research completed in 2005 has revealed that Egmont has erupted more frequently than ever realised. Over the previous 9,000 years the volcano has erupted on average every 90 years on a similar scale to the 1995-1996 Ruapehu eruptions. Every 500 years the volcano has erupted on a scale similar to the 1886 Tarawera eruptions (Massey University, 2005). The volcano may pose a more immediate threat to local communities than previously realised.

The central dome of Mt Egmont faces northwest so any initial eruptions are likely to be directed this way. The bulk of Pouakai and the Kaitake Ranges are expected to shelter the north from ground hugging hazards, largely protecting New Plymouth. The hazard map shown in chapter seven creates the foundation of all analysis used in this project. The map was created by Neall and Alloway (1993) based on historic eruption evidence and is used in conjunction with the Hazards of Egmont Volcano publication (Neall & Alloway, 1993). This map details the expected frequency and possible coverage of all ground hugging hazards. It is expected that the mountain will erupt again, there is no evidence that Egmont has ceased its violent eruptive past, it is merely resting. It may not even have rested its southeast progression.

5. Literature Review

In reviewing literature of the economic impact of natural disasters it has become apparent that theoretical techniques concerning economic assessment are varied and rarely practised. This review focuses on previously completed socio-economic impacts and literature dealing with natural disasters. A discussion of civil defence procedures has been included as planning processes are critical in determining how an area will react, the area affected and how recovery is undertaken and prioritised. Advanced prior planning can be extremely beneficial in accelerating the recovery of an economy.

Risk assessment refers to analysis of consequences and vulnerability to natural disasters, whether economic, social or environmental in nature and using prior hazard assessments. Alternatively economic assessment implies the calculation of business disruption and costs incurred in returning an economy to its original state after a natural disaster. The objective of an economic assessment is to compare the community or area of interest both with and without the event, an economic assessment is also broader in that it incorporates flow-on effects to other sectors of the economy in addition to direct costs (Walton, 2004).

There has been little work completed to assess economic impacts of a potential natural disaster in an economy. Economic assessments typically take place after an event has occurred and the extent of effects is known, if completed at all. While the expected scale and frequency of any disaster is often looked at in hazard assessments for emergency planning purposes (based on historical evidence), social or economic studies prior to an event tend to consider sectors which will be vulnerable during evacuation and recovery and who may require additional help. A monetary figure or economic impact of the event is very rare.

The measurement of impact is based on the concepts of hazard, risk and vulnerability. The basic stages of risk analysis are presented in the table below. As a process, risk assessment typically encompasses a number of activities that include identifying the threat, determining the vulnerability and available resources and an acceptable level of risk. Risk assessment is more expansive than hazard assessment as it includes hazard analysis as a basis for further research.

Figure 6: Stages of Risk Assessment

<table>
<tr><td rowspan="5">Risk Analysis</td><td colspan="2">Identification of Risk Factors</td><td rowspan="7">Risk Assessment</td></tr>
<tr><td>Hazard</td><td>Vulnerability / Capacities</td></tr>
<tr><td>Determined geographical location, intensity and probability</td><td>Determines susceptibilities and capacities</td></tr>
<tr><td colspan="2">Estimates Level of Risk</td></tr>
<tr><td colspan="2">Evaluates Risk</td></tr>
<tr><td rowspan="2"></td><td colspan="2">Socio-economic cost / benefit analysis
Establishment of priorities
Establishment of acceptable levels of risk
Elaboration of scenarios and measures</td></tr>
</table>

Source: ISDR, 2002

Hazards are events with a given probability of occurrence within a certain time period, they usually refer to a specific calculated danger. A hazard is an event or process that is potentially destructive. Vulnerability is a person or region's susceptibility to any disaster based on social factors, it refers not just to physical effects but the way it affects people. This changes depending on proximity to the mountain, population density, public awareness (and knowledge), emergency infrastructure and warning systems in place for any disaster. Vulnerability to volcanic hazards is described as the expression of effects on people, buildings, infrastructure and economic activity. Risk is then defined as hazard x value x vulnerability, this implies that risk is only present when something of human value is at stake. Risk is an objective measurement or subjective determination of the likelihood of adverse outcomes from certain events, representing the magnitude of a potential loss of life, property or productive capacity within the area subject to hazards. Risk assessment requires the identification, description, estimation and evaluation of all risks (Huff, 2001; Kloman, 2005; Martin, 1999; Nelson, 2004). Green and Rose (2005) take one step further and determine value as standard of living x (population density + infrastructure + landuse($/ha)). Often the terms risk analysis and vulnerability analysis are used interchangeably.

Vulnerability and risk assessments complement hazard analyses and although considerable work has been completed in recent years the assessment of social, economic and environmental vulnerability is not well developed when compared with hazard mapping (ISDR, 2002, p69; van der Veen, 2004). Much of the existing work is flawed, incomplete or concentrates only on small scale effects. Development of a single assessment framework has been hampered by the varied range of techniques, definitions and scope of economic projects between organisations. Even within similar hazard groups there are large inconsistencies in methodology, each reflecting the underlying theory adopted in the research, be that welfare economics, macro economics or an accounting framework (van der Veen, 2004). The physical aspect of vulnerability has advanced rapidly using spatial mapping techniques such as GIS to overlay hazard zones with infrastructure networks and locations to reveal potential weakness. Methodological challenges still need to be overcome to allow the incorporation of subjective economic and social variables, each with their own dimensions, into the objective hazard maps (ISDR, 2002). Improvements in technology and the ability to predict events ultimately aim to reduce vulnerability. In reality increasing public confidence in warning systems and disaster preparedness is having the opposite effect as people are willing to move further into high risk areas (Blaikie et al, 1994).

In 1986 a study of New Zealand's flood risk stated that estimates of flood losses were rare, few and poorly documented. Since then techniques for assessing loss have improved dramatically however New Zealand examples are still rare, instead as a country we focus on the physical impacts (Walton, 2004) of hazard assessment. Economic assessment of natural hazards prior to an event is limited within New Zealand, even post event economic impact assessments for natural disasters has only recently become a recognised output. Events such as the Ruapehu eruptions as recent as 1995 do not have economic effects documented and poor underlying data and inconsistent methods undermine the findings of any reports completed (NZIER, 2004). Even official economic accounts of the February 2004 floods are flawed with large gaps in the data and a high degree of under accounting, standardised techniques are unknown which contributes to inconsistent estimates (P. Moore, Personal Communication, 2006).

More and more emphasis in New Zealand is being placed on assessment of risk, contingency planning and risk reduction by businesses, not just lifeline and network operators. The recently passed Civil Defence and Emergency Management Bill (2002) places more emphasis on lifeline utility providers to prove they can ensure continued service throughout an emergency event (Transfund, 2002). The longer this planning environment continues, the easier it will be to predict damage and impact in an economic sense as data is more freely available. Testing is currently underway at the University of Canterbury to run quantitative assessments of modern infrastructure when faced with varying ash scenarios, specifically the research is looking at the aviation, telecommunications industries, waste water and water supply systems (Barnard, 2005). This kind of information will be vital in future economic assessments, allowing completion with much more detail.

Hazard assessment as an applied field is more developed than risk assessment and usually uses a greater level of technology to monitor natural processes and store data. Vulnerability and risk assessment alternatively uses more conventional methodologies which are less developed in practice (ISDR, 2002). Hazard assessment requires identification of occurrence probabilities within a given time frame, likely intensity of such events and the projected area of impact. This is then used for planning purposes, in development of zoning laws and for identification of risk towards communities (ISDR, 2002; Walton, 2004; Nelson, 2004). Many natural events, such as volcanic eruptions, now have well established techniques and resources to aid assessment (ISDR, 2002).

The development of user friendly interfaces such as GIS has allowed this information to be available to a much wider group of people for increasingly varied requirements and use.

Gross domestic product (GDP) is the common measure used to assess impact of a disaster however on its own this may not give the full picture of damages incurred. As an accounting measure, GDP measures flow values as opposed to stock variables[2]. A natural disaster has the greatest impact on stocks but damage to assets is not registered in GDP only the expenditure required to fix these assets (a positive impact) is. Similarly aid payments and insurance claims are not included in GDP calculations distorting the overall effect (Walton, 2004). Disasters predominantly redistribute incomes so it is not surprising that many smaller events are deemed to be GDP enhancing (Handmer & Hillman, 2004).

Welfare economics centres on the value of consumer surplus, the value is estimated using either flow or stock values which, ultimately, should be the same. Using stock values, direct costs are determined as the value of lost land, capital and machinery. Primary indirect costs relate to business interruption, calculated using flow values. Finally, secondary indirect costs are imputed by multipliers. Welfare economics tends to include non-monetary impacts such as stress and health damage (van der Veen, 2004).

Accounting cost approaches imply that capital and machinery stocks create a businesses flow of income, any business interruption (a direct cost) can be calculated as capital stock damaged. Using this definition, theorists promote flow over stock analysis to be a better proxy of lost value as it is more compatible with macro parameters, gives more consistent distinction between direct and indirect damage and is able to incorporate a time dimension. Accounting definitions imply that stock flows do not reflect the true cost to society (van der Veen, 2004). Indirect costs are thus defined as the impact of inter-relationships between businesses, influenced by factors such as the availability of alternatives and the duration of disruption. Accounting theory has the benefit of being compatible with the system of national accounts and as such has a wider array of data sources.

Macro economic definitions take a different approach in the process of recovery, based on the perspective of the economy as a whole. The effect of diverting money from planned spending to recovery investment and expenditure is considered and included as a secondary effect. Direct costs relate to physical damage, like the welfare definition this is roughly equated with stock loss, indirect costs are interruptions to the flow of goods and services (van der Veen, 2004). These definitions preclude the creation of a 'total damage' figure as summing will incur double counting.

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[2] Stock variables refer to physical assets, inventories, land, buildings and tangible products which produce or are used to produce income..

Natural events are largely redistributive, they spur increased spending and expenses and replacement of potentially outdated equipment to the extent that the overall outcome can be positive, particularly if high insurance payouts, government funding or welfare packages are received. This was the case in the Waikato 'weather bomb' in June 2002. The overall effect was determined to be negligible; business direct effects were determined to be a gain of $60,000 due to increased expenditure associated with the events cleanup and uninsured losses were estimated at only $50,000. Due to the short duration of the event, interdependence with surrounding districts and ultimately a small proportion of infrastructure that was actually damaged, the flow on effects were deemed to be negligible in comparison to the economic base (NZIER, 2004).

If a region has proportionately high imports the ongoing shocks of a disaster will be reduced compared to a region with production skewed towards export and local consumption of resources. When economic conditions (demand) are unfavourable imports can easily be decreased until demand dictates recovery, but if export stock is damaged the flow on effects and shocks within the local economy can be multiplied (NZIER, 2004). In many smaller natural disasters the direct impacts affect very few aspects of the economy with limited physical damage, yet these sectors, particularly lifeline utilities, can cause indirect effects which extend over an entire economy (Cole, 2004).

The Manual of Socio-Economic Effects of Natural Disasters, written by the Economic Commission for Latin America and the Caribbean (ECLAC), is a comprehensive working paper for economic analysis in the face of natural disasters, specifically in poor or developing countries. As with most of the literature the analysis considers an economic environment after the event has taken place when parameters and damage are known as opposed to as a planning tool. This limits comparability with this present study but still acts as a guide to current techniques. A natural disaster can be very selective in the locations and industries affected, making prior damage estimation difficult, an evaluation post event clearly defines the scope of the phenomena. The immediate and future availability of food supplies should be evaluated as a result of damages, although supply will be required for evacuees and residents in 'safe zones', future shortages may be expected as a result of lost production and pasture damage (ECLAC, 1991). Food supply is particularly important in long term events such as droughts or in poorer developing countries and areas of subsistence farming where trade links or alternatives supply sources will be less developed (ISDR, 2002). Effort should be made to identify the entire range of effects on natural resources, physical infrastructure and working capital to provide the total impact and aid recovery direction.

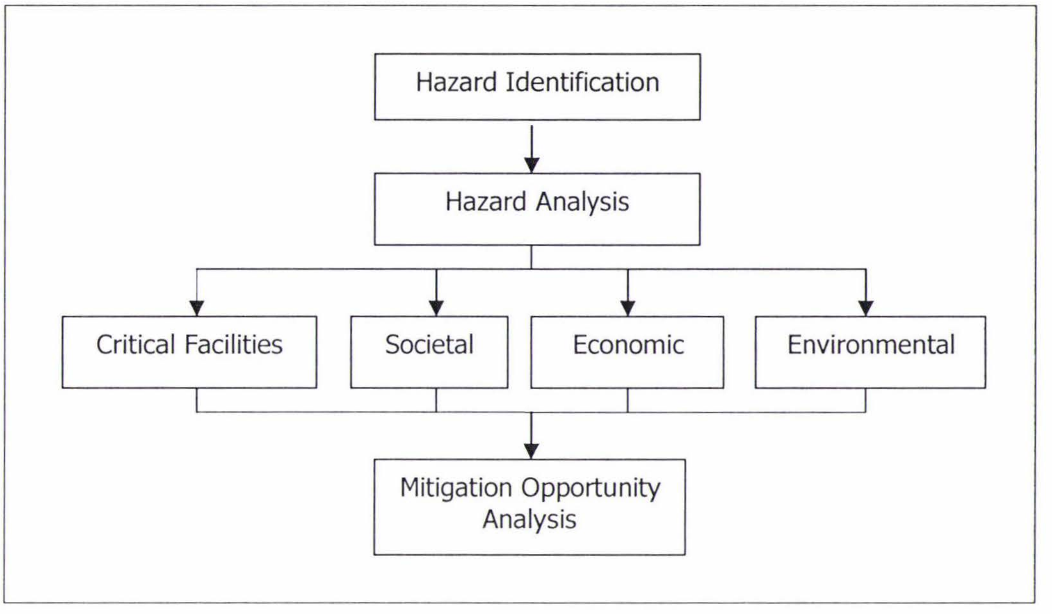
After an event there are several techniques that can be employed to determine direct damages, either by survey, modelling or insurance data. For best results these methods should be used in conjunction with each other to account for the flaws and benefits of each method. Indirect effects can be calculated by either input-output modelling or computable general equilibrium models, the latter providing a more flexible and realistic analysis (Walton, 2004). Intangible assets are by definition difficult to assign a value, how can memories and human life be measured in dollars? For this reason many economic assessments exclude these variables from the final calculation as exclusion allows comparison of different events between countries and assessors without distortion by a subjective measure (Walton, 2004).

A barrier to accurate economic assessment prior to an event is the highly variable impact depending on the season that the phenomenon occurs; this is particularly relevant for volcanic eruptions which are not determined by weather conditions. The economic impact in agriculture is highly dependent on the season, type and growth stage of plants. In describing the damage incurred, analysis should indicate the type of land-use, agriculture and crops involved and the extent of damage in each zone. This information will then be incorporated into the analysis, the degree of damage to permanent crops and an inferred recovery time should be noted (ECLAC, 1991). Permanent crops typically suffer economically greater damage as their recovery time is substantially slower. When describing such damage the responsible phenomena should be noted as this will affect recovery times and potential ongoing effects (ECLAC, 1991). Damaged land should be identified in any reports as land that can be recovered and reverted to original or land that will never be recovered to its original state.

An Enumclaw-Buckley hazard assessment completed by Tracy Trople (unknown) uses GIS to analyse risks and hazards associated with Mt Rainier in Washington. This assessment provides a schematic study of the hazard in comparison to critical facilities, social, economic and environmental factors. While not directly comparable with the work being undertaken in this thesis the paper provides a solid outline of modern hazard assessment. The paper is part of a project to list high risk American volcanoes and plan for future eruptions, much like the current work in New Zealand.

Existing socio-economic studies focus on who is vulnerable and why, incorporating attributes such as economic class, ethnicity, gender, age, disabilities and religion using previous events to identify vulnerability. In rare events such as volcanic eruptions or large earthquakes that have not occurred in living history this is difficult (ISDR, 2002). It is difficult to draw conclusions regarding the level of damage that can be expected based on previous accounts, as Blong (1984, p184) points out 'statements can be found that will support almost any interpretation of the social consequences of an eruption'. Knowing what and where vulnerabilities or susceptibilities are is the basis of disaster planning. Vulnerability assessment in the Trople study takes into account examinations of physical, social, environmental and economic aspects of the surrounding area by following guidelines set out in the National Oceanic and Atmospheric Administration's (NOAA) Vulnerability Assessment Tutorial. The following diagram shows the succession and relationship of activities in a full vulnerability analysis.

Figure 7: Flow Chart of Vulnerability Analysis



Source: Trople, unknown, p3

Trople (unknown) uses a grouped ranking system to identify both the hazardous areas and the populations and sites that are most vulnerable, this is comparable to the hazard maps prepared by Neall and Alloway, (1996), referred to later. Vulnerability is defined as the susceptibility of resources to harmful impacts. Hazard rankings were determined by a relative risk matrix incorporating weighted factors such as frequency, area of impact and magnitude of damages. A one mile buffer around each community was created before determining a risk level within this boundary (Trople, unknown). The analysis focused on locating key facilities and resources (schools, daycares, hospitals, roads, railways, police, fire etc.) and identifying those were at high risk as outlined in figure 8. Similarly population analysis determined areas and households most at risk taking into account income, literacy, dependents, education and presence of a vehicle. Population analysis is more important for mitigation strategies than vulnerability analysis to determine which groups may require more help in evacuation and post event recovery.

The economic cost to businesses is often noted in analysis but rarely considered in detail, or calculated, "The loss of income due to business interruptions and closures after a natural disaster may be one of the most devastating costs to a community" (Trople, unknown, p11). Firms may experience direct losses, unbudgeted expenses and additional staff time, however exact costs are difficult to determine (Johnston et al, 2000b). If a zone produces raw materials or primary inputs this will create secondary impacts for other industries potentially creating work stoppages, the resulting flow-on impact on employment and lost incomes should all be considered in analysis (ECLAC, 1991). To measure vulnerability the Trople economic analysis identifies major economic sectors and economic centres (largest employers, ports, listed companies) and their relative location in each hazard zone. Census data was used to determine where in the study area residents were locationally employed and which field of work they were employed in to assess the impact of access issues. The analysis also identified the area of zoned land affected by each hazard zone, for example land zoned agricultural may be predominantly at moderate risk. The analysis never allocates a figure to vulnerability instead it provides a level of risk associated with each area and potential disruption to important commuter routes.

Figure 8: Conditions of Vulnerability

The Progression of Vulnerability				
Root Causes	Dynamic Pressures	Unsafe Conditions	Disaster	Hazards
Limited Access To: Power Resources Facilities Ideologies: Political Economic System	Lack Of: Local Institutions Training / Skills Free Press Local Markets Ethical Standards Macro Forces: Rapid Population Growth Rapid Urbanization Debt repayment Deforestation Agricultural Productivity	Fragile Physical Environment: Dangerous locations Protection of Physical Infrastructure Fragile Local Economy: Livelihoods at Risk Low Incomes Vulnerable Society: Special Groups Local Institutions Public Actions: Disaster Preparedness Prevalence of Disease	Risk = Hazard x Vulnerability	Earthquake Volcanic Eruption Landslides Etc.

Source: ISDR, 2002

The final environmental analysis of Trople took into consideration possible secondary pollution from a volcanic eruption (oil spills, toxic releases etc.) and lost environmental resources such as critical habitats. While not considered in this research on Taranaki the Trople study also includes mitigation opportunities, including suggestions for zones that remove high risk areas from future development.

An infrastructure risk project completed by the Christchurch Engineering group was similar in form to the Trople study, each network was broken down into components which were assessed for their vulnerability to hazards and importance in the network. Component vulnerability was determined by overlaying network components with hazard maps. The consequences of failure or a networks importance to the area was also assessed to see whether a component could be bypassed or was critical to continuing function. The final factor considered for each component was impact which reflected the communities need for reinstatement of networks within certain timeframes. Mitigation activities were then considered for actions that would reduce either vulnerability, importance or impact of each component (CAE, 1997).

Emergency management planning should assess the social, psychological, community and economic consequences of a disaster based on hazard assessment (Miller, Paton & Johnston, 1999). Unlike hazards vulnerability changes over time in response to changes in activity. 'Over the past 50 years the risk to society from volcanic eruptions has increased sharply due to an increased population, more developed and diversified economies and a more technologically advanced infrastructure' (Johnston et al, 2000, p 720). The intensity of farming in the New Zealand rural sector means that even a minor eruption will have significant impact on all aspects of the farming community. The encroachment of urban settlements into hazardous areas and escalating capital dependence and investment, increases vulnerability every year and while the historical frequency of events is unchanged our exposure has escalated. This was highlighted by the minor eruptions from Ruapehu in the mid nineties. The 1995 eruption of Mt Ruapehu was similar in physical magnitude to the 1945 eruption yet social and economic costs were vastly greater (Johnston et al, 2000).

A survey distributed to communities around Mt Ruapehu in 1997 attempted to analyse levels of community stress and self sufficiency associated with the volcanic eruptions. Two surveys were distributed, one in July following two years of poor ski seasons, volcanic eruptions and continued threat. The second survey two months later came at the conclusion of a successful winter season, although the volcanic threat remained high (Miller, Paton & Johnston, 1999). There was a significant drop in psychological vulnerability between the two periods which can be attributed almost singularly to an easing of economic hardship. While these conclusions are unsubstantiated it implies that communities perceive economic and physical threats differently, with economic threat having the most influence. Risk communication demands that public information first target the threat that is perceived to be the most prominent. Based on these survey results, mitigation strategies framed in terms of physical threat would be deemed less effective in risk reduction than a strategy which incorporates actions to safeguard future economic wellbeing (Miller et al, 1999). The study group was almost entirely dependent on income derived from Ruapehu, which would have distorted results, however the fact remains that economic safety is equally important to social and mental wellbeing as physical protection, if not more so for certain groups of society.

The most recognised volcanic event in recent history was the Mt St Helens eruption in 1980 which killed 57 people and caused in excess of US$1billion in damage. The nature of the eruption (a huge earthquake triggered the cone collapse and caused a lateral blast) immediately devastated a 600km2 area of national park and forestry (Johnston, 1997) before distributing ash over more than three states. This event is the primary source of information regarding impact and effect on modern, developed economies.

Media plays an important role in shaping perception of an event by a community (Blong, 1984). In the modern communication system all major trading partners will be following any perceived threats to trade and know within minutes of an actual eruptive event. Undue emphasis on possible adverse effects and unauthorized 'expert' statements can be extremely damaging to public perception, business and community stress (Blong, 1984; Johnston et al, 2004). Positively, the wide reach and speed of modern communication can be used as an effective tool to educate the public and publicise mitigation techniques which will aid both evacuation and recovery. Adverse or beneficial, the influence of the media requires strict control over dispersal and release of information using a pre-established management plan that meets the needs of both groups (Blong, 1984).

Prior to an eruption seismic indicators and warnings will predict increased activity, a volcanic event can build up over a period of weeks or even years, but is still unpredictable in it's probable course and timing (MCDEM, 2002). If precursors to impending volcanic activity extend for a long period of time, there is an increased threat of economic stagnation, reduced investment, emotional stress and permanent relocation from the region. In events with a long uncertain lead up there exists a fine line between ensuring adequate public warning and safety compared to losing the publics confidence and being seen as crying wolf.

Early warning systems and increased disaster planning has greatly reduced the number of deaths caused by volcanic eruptions. Between 1900 and 1982 there were 52,250 deaths as a result of volcanic eruption, 36,787 or 70% of these were from pyroclastic flows or debris avalanches alone (Blong, 1984, p72). Starvation, which prior to 1900 was the biggest cause of death is now unlikely in the increasingly global aid environment and ease of distribution.

From November 2004 a single integrated regional civil defence model was introduced for the entire Taranaki including operations and planning procedures. This allows a co-ordinated and efficient response to any disaster (CDEM, 2004). The regions volcanic strategy identifies five fundamental concepts for contingency planning by the regional council including:

1- Adoption of scientific alert levels and implementation of responses directly associated with these levels.
2- Integration of Neall and Alloway hazard mapping to response planning.
3- 24hr monitoring of volcano by the Institute of Geological and Nuclear Sciences and the Taranaki Volcanic Seismic Network (TV-SN)
4- Updated risk and impact assessment of the regional infrastructure
5- Pushed public awareness for development of community and contingency planning.

(Taranaki Regional Council, 1998, p1-2)

The Institute of Geological and Nuclear Sciences (IGNS) has prime responsibility to interpret and assess information gathered about New Zealand volcanoes and if required to alter the scientific alert levels (MCDEM, 2002). As these alerts largely dictate the level of response by Civil Defence, councils, government organisations and some private businesses, changes can be highly political. IGNS must maintain political neutrality at all times. The system of volcanic warning in New Zealand (the scientific alert level) is described in the following table; guidelines differ between active and re-awakening cones in relation to observed phenomena.

Table 1: Scientific Alert Levels for New Zealand

Frequently Active Cone Volcanoes White Island, Tongariro – Ngauruhoe, Ruapehu		**Scientific Alert Level**	**Reawakening Volcanoes** Kermadecs, Northland, Auckland, Mayor Island, Rotorua, Okataina, Taupo, Taranaki	
Volcano Status	**Indicative Phenomena**		**Indicative Phenomena**	**Volcano Status**
Usual dormant, or quiescent state	Typical background surface activity; seismicity, deformation and heat flow at low levels.	**0**	Typical background surface activity; seismicity, deformation and heat flow at low levels.	Usual dormant, or quiescent state.
Signs of volcanic unrest.	Departure from typical background surface activity.	**1**	Apparent seismic, geodetic, thermal and other unrest indicators.	Initial signs of possible volcano unrest. No eruption threat.
Minor eruptive activity.	Onset of eruptive activity, accompanied by changes to monitored indicators.	**2**	Increase in number or intensity of unrest indicators (seismic, deformation, heat flow etc.)	Confirmation of volcano unrest. Eruption threat.
Significant local eruption in progress.	Increased vigour of ongoing activity and monitored indicators. Significant effects on volcano, possible effects beyond.	**3**	Minor steam eruptions. High increasing trends of unrest indicators, significant effects on volcano, possible beyond.	Minor eruptions commenced. Real possibility of hazardous eruptions.
Hazardous local eruption in progress.	Significant change to ongoing activity and monitoring indicators. Effects beyond volcano.	**4**	Eruption of new magma. Sustained high levels of unrest indicators, significant effects beyond volcano.	Hazardous local eruption in progress. Large scale eruption now possible.
Large hazardous eruption in progress	Destruction with major damage beyond volcano. Significant risk over wider areas	**5**	Destruction with major damage beyond active volcano. Significant risk over wider areas.	Large hazardous volcanic eruption in progress.

Source: Taranaki Regional Council, 1998

The foundation for regional response is the scientific alert levels in table 1. For each alert level the principle emergency management activities of council are identified, in addition this acts as a guide for organizations in developing and implementing their own contingency plans. As part of the volcanic strategy, lifeline utilities[3] within the region must formulate and maintain plans which outline their responsibilities and functions during an eruption and ability to continue service during an event. Significant to most emergency organizations is the reliance on communication systems located on the mountain slopes. Emergency organisations using this system include local authorities, regional council, police, fire, crown health, MAF, PowerCo and Telecom (Taranaki Regional Council, 2004). Civil Defence, key organisations and the media are all notified immediately upon any changes in the scientific alert level of a mountain (MAF, 1998).

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[3] Lifeline utilities are defined as elements of the built environment, the critical utility and transportation systems required for operation of an economy.

Civil Defence response (table 2) is based around the scientific alert level and is split into two sections to represent the significance of alert level 2 in planning and emergency response. From a management perspective a lot must happen in this stage, little planning can be done for the duration of an eruption (occurring at level 3) until the actual event has begun, when its size, extent and disruption are determined. This similarly makes all emergency planning and economic impact assessments highly generalised.

Table 2: Taranaki Regional Council Emergency Management Activities Based on IGNS Scientific Alert Levels, Including the Extended Steps of Level Two

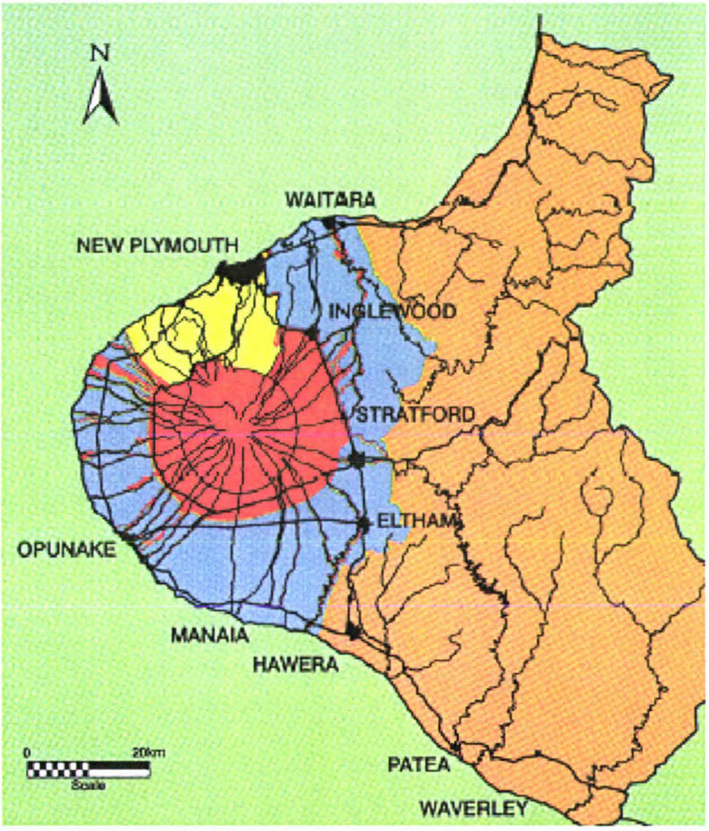
Scientific Alert Level	Principal Emergency Management Activities
0	Routine monitoring and maintenance. Should typical activity change, the Egmont Volcano Advisory Group meets to consider implications.
1	Key organisations advised of change in alert level, and the reasons why. Initial public warning issued (emphasising the change), although there is no significant threat of eruption. Preparation and clarification of plans.
2	This is the most significant level. The possibility of an eruption has been confirmed, the next level will involve material being ejected from the volcano. A state of local emergency is declared by the CDEM Group. See Table 3 for a further breakdown of possible activities within level 2.
3	Monitor the effects of eruptions. Begin post eruption activities. Conduct rescue operations. Withdraw to safe ground.
4	Continue to monitor the effects of the eruptions and conduct post eruption activities.
5	Continue to monitor the effects of the eruptions and conduct post eruption activities.

Level	Step	Emergency Management Activities
2	A	Define the primary hazard zone, if possible based on indicators such as deformation, seismicity etc. This area should receive top priority when the evacuation begins. Restrict access to the Egmont National Park. Begin the evacuation planning giving priority to the sector considered most at risk.
	B	Identify and reserve resources that will be required for the evacuation. Identify and prepare a method of registration for evacuees.
	C	Seek the assistance of the Armed Forces in implementing the evacuation. Encourage/support self evacuation.
	D	Restrict access to the area defined as the primary hazard zone. Promote further self evacuation.
	E	Commence the evacuation, recognise the area most at risk first, then the Red and Blue zones. Deny access to the areas of the evacuation zone that have been successfully evacuated.

Source: Taranaki Regional Council, 1998, p4

As with most natural disasters the emphasis in the Civil Defence plan is for individuals to be responsible for their own welfare. Public education and guidelines encourage appropriate response planning and preparedness by individuals and businesses. Public awareness campaigns already advertise the Civil Defence evacuation zones and push self-reliance before and during an eruption. The red and blue zones, as shown in figure 9, are likely to experience direct ground hugging hazards in a significant eruption; the orange zone will potentially become uninhabitable due to water contamination and disruption of essential services due to ash. The yellow zone is considered to be sheltered from most eruptive activity. Populations in each of these zones were determined from the 2001 census meshblocks, the red zone represents 5,388 people, the blue houses 34,103. Together these two zones together represent 37.2% of the total regional population. The orange zone represents a possible 19,911 people that may be evacuated while New Plymouth has 46,876 residents that shouldn't need to be evacuated. The ability to keep New Plymouth occupied significantly reduces the number of residents that must be moved and housed elsewhere.

Figure 9: Taranaki Volcanic Evacuation Zones



Source: Taranaki Regional Council, 2004, p 7

Enforced evacuations are uncommon and ineffective as more time is spent dealing with dissenters and arrests than in actually achieving the aim of moving residents to safety (Blong, 1984). The duration of evacuation from a volcanic eruption is much less certain than that from any other event, in some cases it may never occur. These factors can deter some residents from evacuating willingly, particularly in New Zealand where there have been no large eruptions in living memory and few resulting in evacuations and may greatly reduce the effectiveness of evacuation strategies. Public notification means residents will be well aware of the eruption threat, once evacuation notices are issued it is up to the residents to self evacuate. In conjunction with other emergency services a decision will be made at this point to determine what to do with those remaining. If needed Police have the power to remove residents from the area (B Raine, Personal

Communication, 2005). In many respects evacuation of a large area can constitute a disaster in its own right; there may be widespread panic, fuel shortages, traffic jams, looting, accidents and economic loss (Blaikie et al, 1994).

The 2004 February floods in the lower North Island caused significant damage to roads, bridges, rail lines, homes and properties as well as cutting lifeline facilities to large numbers of people. At its peak over 2,000 people were evacuated from their homes (MCDEM, 2005). The event caused significant social and economic disruption to Rangitikei and Manawatu communities, yet if Mt Egmont had an eruption more than 5,000 people would be evacuated immediately, potentially 30,000 more people could be removed from their homes and the damage would be over a much wider area (Taranaki Regional Council, 2004).

Similar to a volcanic eruption, the Manawatu flood resulted in evacuation of many people, disruption to services and damage to agricultural pastures, crops and stock. Using examples from this event a more accurate picture of flow on effects may be established. At the height of the emergency some 2,300 people had been evacuated from their homes within the Manawatu-Wanganui, almost two weeks later there were still 750 evacuees (MCDEM, 2004). The cost of housing and accommodating the evacuees in all five affected districts was $259,000 (Horizons, 2004). During and after the event more than 10,000 dairy cows were removed from the region, 15,500 people were without power and the regional state of emergency lasted for 9 days. The repair bill to state highways extended to $4million, to regional roads the cost was $66million. Insurance claims exceeded $112million whilst government estimates indicate the cost of damage would exceed $355million (Horizons, 2004). Claims paid out were broken down into domestic ($46m), commercial damage ($46m), business interruption ($14m) and motor vehicles ($5m), this doesn't take into account any level of under insurance or uninsured properties (Horizons, 2004). Government aid in the Manawatu event exceeded $162million towards roads, infrastructure and property owners (MCDEM, 2005).

Damage experienced by farmers included drowning of stock, interruptions to milking, loss of crops and pasture, damage to bridges and fences, plant, equipment and buildings, loss of grazing, feed and production and delays in re-establishment and access (Horizons, 2004). The total loss to agriculture was between $159 and $180million. Damage to stop banks and erosion protection works exceeded $19.6million; more significant to future vulnerability is the lift in riverbeds that diminishes future flood carrying capacity. It was estimated that 29,000 hectares of hillside were severely eroded reducing productivity on land throughout the Horizons region.

The unpredictable nature of volcanic hazards makes impact planning difficult, especially given variation in damage between seasons and in eruption scenarios. The benefit of assessments prior to the event is to be more prepared on occurrence and to be aware of the full range of effects.

6. Methodology and Design

The first step in the methodology is to obtain and identify the volcanic hazards in Taranaki and create the hazard scenarios which might be expected based on this information. The research will not follow an established model but instead it will follow a process of field research, data collection, identification of affected infrastructure and determination of immediate and intermediate impacts. The extent of the research must be limited as analysis of flow-on and secondary effects to the national economy are potentially huge. Probability of eruption, size and spread will be obtained from the larger project and used to produce a series of dollar values attributable to an eruption.

Ground hugging hazards beyond the regional council boundary will be negligible or extremely rare and are not considered. Ash fall beyond this boundary will be considered in brief, although will not be as significant as ash fall within the direct vicinity. Ash nuisance would be considered for the airline industry as the potentially disastrous damage to airplanes requires the rerouting and increased maintenance of planes that come into contact with ash clouds throughout an eruption.

When the hazards have been assessed and existing economic activity in the region identified the next step is to determine the economic impacts associated with these hazards. A model of the economy could split into three main features, these are iconic industries, small and medium enterprises (SME) and infrastructure. Infrastructure is the foundation of economic activity and community wellbeing although not an active market participant. Small and medium enterprises represent the greatest number of market participants although iconic industries contribute the most to total output. In this study the overall estimated economic impact of volcanic activity or a volcanic eruption from Mt Egmont will be calculated by input-output modelling which allows the incorporation of all contributors to the economy and immediate output loss. Iconic industries will be assessed to give the most expansive perspective of the largest employers and contributors to the local economy but also because these are the enterprises most likely to impact the national economy. Iconic industries, as a representative group for all enterprises, will imply the wider, long term impacts which can not be captured in input-output modelling but are a large part of volcanic eruption impacts. Although reference will be made to infrastructure in this analysis an economic assessment of risk and financial impact with regard to infrastructure is unrealistic without specialised knowledge of networks, recovery options and replacement costs.

In addition it has been suggested that certain industries and businesses will cease production if the volcanic alert level reaches two, this includes the gas fields and by default the treatment plants. It is of interest to investigate the businesses that will change behaviour based on the volcanic alert levels and to calculate the economic outcome of a change in the alert levels even in the event that there is no eruption and therefore no infrastructure damage. Particularly in the case of the gas fields, a long term volcanic alert greater than two will have significant impact on income and secondary production capacity throughout the North Island.

Data will be collected directly from businesses, service providers and a range of secondary sources such as the regional and district councils, Chamber of Commerce, Statistics NZ and public records. The economic analysis will be considered over an extended timeframe as this best encompasses the unpredictability and damage of volcanic activity. From the time activity ceases (which may in itself be for years), the short term is six months. This is a relief period during which all infrastructure damage will be identified and replacement commenced. The medium term (from six months to two years) is considered the rehabilitation stage during which time infrastructure is replaced, business recovers, inventory is replaced, consumer spending recovers and the region returns to business as usual. The long term component considers the somewhat permanent destruction of property associated with ash and debris accumulation. Mainly affecting the farming and agricultural sectors, five years is considered appropriate for land recovery from a small eruption. This long term time-frame for reconstruction is in place to consider the groups reliant on natural resources but is still only an indication. In a significant eruption land use damage and visitor numbers to the national park for example will remain stunted for considerably longer than five years.

A lot of the data, in particular the volcanic hazard maps, probabilities and geological information will be obtained from Vince Neall and Jonathon Proctor from the Department of Soil Science at Massey University. Jonathon Proctor will provide data in GIS (Geographic Information System) format on pipelines and bridges, topographic maps and satellite photos of the area. Land use as determined from the Land Cover Database 2 will be obtained for the Taranaki Regional Council land area from Mike Tuohy in the Soil and Earth Sciences Department at Massey University.

Infrastructure is classified as structures, buildings and service networks that have a replacement cost but no secondary or ongoing costs. This includes items such as buildings, road, rail, power networks, water and sewerage services. The long term impacts will be minimal and depend only on the time lag involved between damage and possible replacement, this lag could be caused by ongoing eruptions or labour and resource shortages. Infrastructure networks will be discussed in terms of vulnerability and extent, the importance of networks in terms of recovery and inter-dependence will also be considered. The sporadic nature of damage from an eruption makes estimating costs of this type extremely difficult.

Iconic businesses are those that will have a significant impact on the wider community if damaged, predominantly the gas and dairy industries. Determining the effect upon these businesses of an eruption will require direct contact where possible and an individual assessment of each. This requires knowledge of contingency plans, vulnerability, flow-on effects and the industries importance within the community. This group also includes businesses that may not be economically significant but are important or symbolic to the region for other reasons.

To complete this step of the research the firms will be identified via common knowledge, visits to the regional and district councils and the Chamber of Commerce and information from Statistics New Zealand. These firms will then be researched and contacted to obtain information on the potential impact, both financial and otherwise, of a volcanic eruption in the region. This includes the flow-on effects to other businesses locally and nationally from reduced production, as well as obtaining information that may be helpful in other aspects of the research. For example Fonterra will know information about dairy farms and milk production in the region.

A lot of information will need to be obtained through interviews, direct communication and by visiting sites; particularly so for the most significant employers and sites in the high risk areas. The impact for these firms must be considered over an extended period. Immediate effects may include total or partial loss of production due to a loss of inputs, a continuing hazardous environment or damage to the production facilities. Short term costs include rebuilding costs and re-sourcing inputs, while long term costs may result if input quality is reduced, purchasers lose confidence in the product or situation, permanent resources are lost or skilled labour is reduced.

The information expected to be obtained from these businesses includes, but is not limited to, current operating capacity, operating revenues, critical production inputs, behaviour changes that can be directly related to alert levels, contingency plans in place for natural disasters, number of employees, potential vulnerability, daily/weekly output and value added percentages. Each firm's before tax trading (operating) profit, when available, will be used to infer the value added to the region by operating.

The third sector is small and medium enterprises, including towns, small businesses, farm entities and groups otherwise unaccounted for. Knowledge of the effect of an eruption on this group is difficult to obtain at a micro level. A Taranaki specific input-output model created by Warren Hughes will be used to model the region as a whole using employment figures and expected impact to calculate the value added. This will create a level of double counting with iconic industries should the two be combined. This approach will more accurately take into account all small business and industries within the region, as well as the iconic industries and allows for the calculation of indicators such as full time equivalent employment, household incomes and total expenditure. Information for this group will come from area, census and economy data from Statistics NZ, MAF and Federated Farmers data as well as information from councils, the chamber of commerce and Tourism Taranaki. Additional detail will be included in the discussion relating to aspects of this group so as not to rely solely on the input-output figure. The large number of stock, in particular dairy cows, within Taranaki means there is little or no capacity to move stock from potentially affected areas. As such, any direct damage to land containing stock must be assumed to involve stock losses.

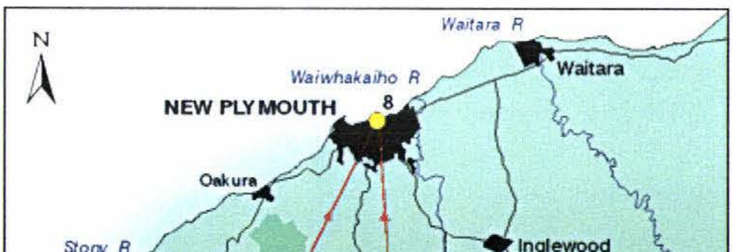
Small business impact is also to be considered in this section with a significant degree of aggregation. Key facilities and resources must be maintained to support continued occupation of the area after an eruption and for planning purposes during an eruption. These facilities include education and medical facilities, emergency services, transport infrastructure, utilities and local government. Damage to this infrastructure will inhibit re-occupation and delay a return to business as usual.

7. Taranaki Volcanic Hazards

Smaller eruptions from Mt Egmont are more likely than larger eruptions, however given the history of the volcano and its unpredictability, a catastrophic debris avalanche must be considered in evacuation preparation. It is generally accepted that any future eruptions will follow the same path as historic eruptions – explosive ash emissions with gentle lava extrusions (Martin, 1999).

The Taranaki Volcanic Seismic Network (TV-SN) is a series of six seismometers[4] that are operational around the clock to monitor the mountain and provide an early warning system in the event the mountain becomes active. Recording equipment is based at Civil Defence House in New Plymouth from where the Institute of Geological and Nuclear Sciences (IGNS) is contracted to analyse and interpret data obtained from the network. The seismometer data is analysed weekly or more immediately given certain conditions. If there are any anomalies in the routine analysis or the region experiences three earthquakes within any 24hr period the information is analysed immediately. Over the five year period between 1999 and 2004 Taranaki averaged 310 earthquakes a year (Bayley, 2004). An annual report is produced for council, updating results and assessing the effectiveness of the network (Taranaki Regional Council, 1998). Should activity commence on the mountain it is IGNS that will determine the scientific alert levels on the mountain, based solely on physical evidence and pre-determined criteria to prevent political influences or weighted decisions.

Figure 10: Map of Taranaki Volcanic Seismic Network



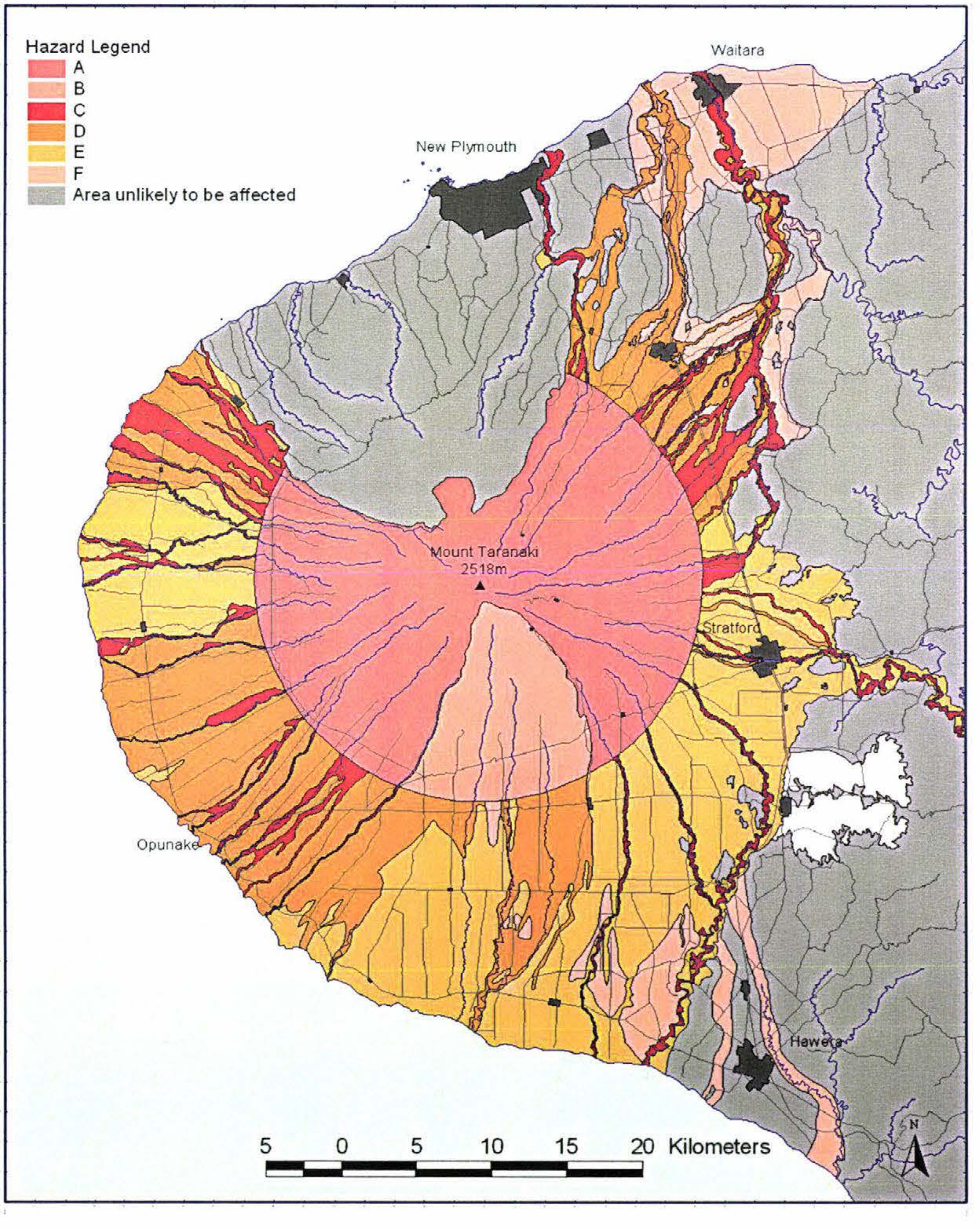
1 Ngariki Road seismometer
2 Mid Kahui repeater site
3 Newall Road seismometer
4 Pukeiti seismometer and repeater
5 North Egmont seismometer
6 Rainy Point seismometer and repeater
7 Dawson Falls seismometer
8 Emergency Management Office recorder equipment

Source: Taranaki Regional Council, 2005

[4] Instruments which measure the force, type and direction of all earth movements.

Detailed, individual hazard maps have been obtained from Neall & Alloway (1993) and are amalgamated to form the Volcanic Hazards of Taranaki as shown below (Neall & Alloway, 1996). These maps assume that any future eruptions will follow historic patterns and occur from the present crater or Fanthams Peak.

Figure 11: Volcanic Ground Hugging Hazard Map of Taranaki



Source: Neall & Alloway, 1996

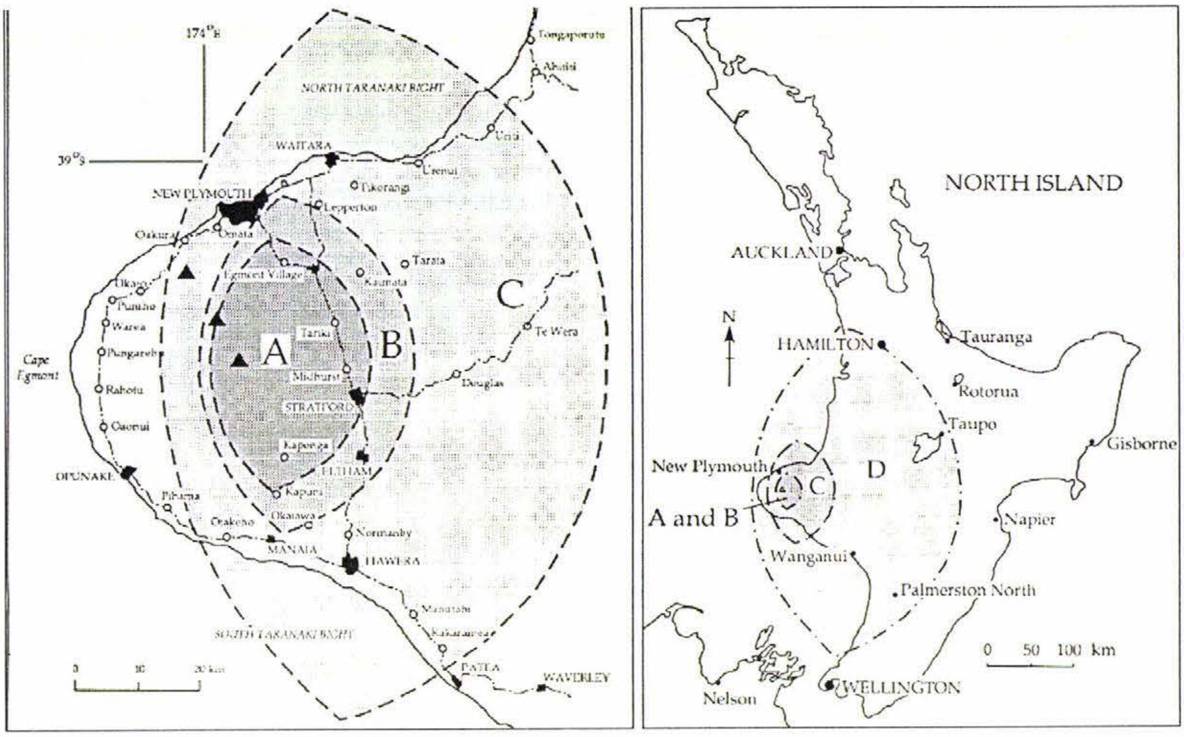
The previous map provides an accumulated hazard map for the volcano in descending order of threat. Zones A and B include hazards that can be restricted to a close proximity; gases, lava bombs, lava flows and small lahars. Zones C, D and E are formed almost entirely from the hazards associated with landslide, lahar and flood, the hazards that will extend further from the mountain predominantly travelling down river channels and valleys. It is likely that Zone E will only be affected in the event of an enormous debris avalanche, a low probability threat from the current Mt Egmont cone, although all previous cones have had enormous collapses that extended to the coast line. Zone F and all areas unshaded are low risk areas unlikely to be affected.

Lahars pose the biggest threat from Egmont due to the extremely high orographic rainfall, steep slopes, regularity of occurrence and extent of reach causing damage from impact (bridge foundations, stop banks etc), silting and erosion, or burying of crops and infrastructure. There are five significantly at risk rivers that pass very close to or through urban developed areas. These rivers include Waiwhakaiho, Stony River, Kaupokonui Stream, Waitara River and Patea River, threatening New Plymouth, Okato, Kaponga and Kapuni, Waitara and Stratford respectively. As the central crater of Egmont is open to the west any initial eruptions will push this way as opposed to the south and east, the presence of the Kaitake Ranges to the North West protects New Plymouth from any direct ground hugging damage. The hazard scenarios used in this project will be based largely on the map in figure 11 and reflect that smaller eruptions from Mt Egmont are more likely than larger eruptions.

The distribution of tephra, particularly ash, unlike ground hazards, can be widespread and in any direction. Once projected into the air distribution is determined by wind direction and speed - neither of which can be easily predicted. Heavy ash falls would be disastrous and have many long term consequences, however even small ash falls will present problems for livestock, electrical equipment, water supplies and communication. Prediction of tephra fall and depth is difficult given the influence of erupted volume and wind direction.

Four ash hazard zones are determined by Neall and Alloway (1993), using data from previous eruptions and wind direction data from Ohakea Air Force Base. Wind direction above 12,000 metres is consistently westerly and lies between the northeast and southeast 91% of the time. The consistency of wind direction to the east falls as altitude decreases to just 55% of the time below 3,000 meters, increasing variability.

Figure 12: Potential Tephra Distribution from Mount Egmont



Source: Neall & Alloway, 1993

These diagrams represent distribution and depths of ash fall which can be expected given prevailing wind directions, although the depth expected in each zone varies depending on the volume of ash emitted. Any irregular wind direction or wind speed will alter the distribution and depths entirely. Low velocity winds will limit the area affected by ash however depths and associated damage will be greater. In high velocity wind conditions the depth of ash fall will be significantly smaller but the area affected will be much larger (Patterson, 1987). The zones are identified in detail below.

Tephra Zone A represents the area of greatest impact for ash fall, the area includes the communities, businesses and farms within approximately 21 kilometres east of the summit including Kaponga, Stratford, Tariki, Inglewood and Egmont Village. Within this area lapilli may be hot enough to ignite fires, pressure loads could induce roof and building collapse, transportation or movement would be impossible and extreme darkness could occur. Ash depths of greater than 0.25m could be expected when comparable with the Inglewood tephra. The Inglewood tephra is the primary historic data on which these ash depths are estimated, and is representative of a moderate to large eruption from Egmont.

Tephra Zone B includes Kapuni, Okaiawa, Eltham and Kaimata, between approximately 21 and 28 kilometres east of the summit, predominantly NNE to SSE. The Inglewood comparable ash depth would be between 0.25 m and 0.1m.

Tephra Zone C includes Hawera, Waitara and New Plymouth incorporating 28-60 kilometres east from the summit with ash depth of between 0.1m and 0.01m.

Tephra Zone D represents between 60 and 200 kilometres NNE to SSE this area could feasibly extend to Taupo, Wanganui, Palmerston North and Hamilton with ash depth of 0.01m-0.001m. This area is highly dependent on wind conditions at the time but could affect as many as 1,004,154 people through the central and lower North Island (Neall & Alloway, 1993; Statistics NZ, 2005c).

Zones C & D will not pose serious threat to human health or wellbeing but will be economically significant causing at the least cosmetic damage and agricultural losses. The true extent of ash depth and dispersal will be determined by the eruption volume, height of the ash column, wind velocity and wind direction.

8. Iconic Industries

Iconic industries are defined as those businesses or entities that may have an impact on the local community above that of direct economic loss, that are socially as well as economically significant. These firms are predominantly the largest individual employers and contributors to the local and national economy, however some, such as the National Park has been included in this section for their 'Iconic' stature and symbolic importance to the region's identity. Secondary effects of a volcanic eruption on these firms are likely to extend well beyond the boundaries of Taranaki. These larger businesses are most likely to consider permanent relocation outside the region in the case of a large event, either in expanding existing sites or based on a specific decision to avoid ongoing risk.

As such, iconic industries are being studied on an individual basis, a description given of their operations and where obtainable, value attributed to these businesses will be calculated as value added lost, or operating profit. The estimated value added is the value that is added to a product or material at each stage of its manufacture and distribution, this figure is used as it is the value that will no longer be created within the region if production ceases. These individual analyses can not be incorporated into the other sections without double counting so is for informational purposes, to create a detailed perspective of the Taranaki economy and its vulnerability.

8.1. National Park – Department of Conservation

The Egmont forest reserve was created in 1881 when the area with a circle radius of six miles (9.6km) from the summit was set aside, initially to protect the regions water supply, later additions have increased the park to include the Pouakai and Kaitake ranges. In 1900 the Egmont National Park was formed becoming just the second national park in New Zealand. A total land area of 33,534ha of pristine rainforest and natural habitats now exists based on the foresight of initial settlers. The exposed mountain and prevailing westerly produces some of the wettest weather in the North Island, annual rainfall on the plains is between 1000 and 1500mm, however on the mountain it can exceed 7,000mm a year. An abundance of sunshine and mild climate contributes to a perfect agricultural environment throughout the region.

Mt Egmont reaches 2,518m above sea level, a distinctive perfectly shaped bush covered volcano that stands well above its surrounding ring plain. The mountain is one of the most climbed in New Zealand providing an achievable ascent to the summit and easy access. There are 13 entrance points to the park and 208km network of tracks circling the mountain for the approximately

360,000 visitors annually (Valuation Technologies, 1999). Within the national park boundary there are eight huts, two Department of Conservation lodges, the camp-house, two private lodges, two visitor's centres (Dawson Falls and North Egmont). The Manganui ski field also operates in the park, a club run field which operates from June to August. The joint attraction and proximity of the mountain to the sea allows for a diverse range of recreation activities for all types of visitors.

The tramping tracks cater for easy short walks, experienced trampers and many day trip destinations throughout the year. Although the mountain in itself does not contribute to the economy the visitors it attracts to the region produce significant revenue. The Taranaki brand would be incomplete without the iconic mountain, nor would the agricultural environment be as productive without the volcanic soils and microclimate. 'Economic benefits of the national park are ultimately realised directly, or indirectly, in the external market place, as energy, agricultural produce, water supplies, or tourist spending. Protected areas create value for regional business' (Valuation Technologies, 1998).

This national park has been maintained in existence for so long the environmental value is significant, Brown Kiwi and Blue Duck are found in the forests of the national park as well as many other native bird species. There are unique species of insect and moth that have evolved in the park given the unique habitat and distance from other locations, including the giant land snail and Taranaki moth. Insects are particularly vulnerable to volcanic eruptions as the ash damages their protective skins, birds experience a huge drop in food source, potentially dying from starvation. Gases present in an eruption are also hazardous to birds and insects. When vegetation cover is destroyed aquatic life is at risk from increased water temperatures in addition to acidic and otherwise contaminated water (Munro & Parkin, 1999).

A five part survey of the environmental, amenity and resource value of the park was begun in 1997 by Valuation Technologies, the information obtained from these reports provides a valuable key to the underlying value of the national park. The benefits studied as a whole looked at use and non-use values, intangible values and economic resources such as water, weather, soil and tourism (Valuation Technologies, 1999).

Non-users are typically households with older occupants or of lower income, when asked non-users highly valued the mere existence and ecological protection of the park while users valued the development of facilities the most, both highly valued increased pest control (Valuation Technologies, 1998). Contingent valuation was used to determine an annual value of $18 per person associated to the park by non users (approximately 38% of regional households), total consumer surplus of non-use thus became $1,523,038[5] (Valuation Technologies, 1998). In 2005

[5] 1998, based on payments willing to be made for 10 years, using a 10% discount rate

dollars the present value of consumer surplus of non-use is \$5.6million dollars[6]. A present value is the capitalised value of annual payments when assuming people or households will be willing to make this payment every year, the value of all future payments when they are discounted back to current dollars.

The revealed preference of users was completed by undertaking a travel cost survey between October and December 1998. The annual economic use value of recreation was determined at just over \$21million dollars, a present value of \$308million and in current dollar values \$1,136million[7]. 39% of visitors to the park are from within Taranaki (estimated travel cost value of \$26 per visitor), 29% of visitors are from other New Zealand locations (\$62 value) and the remaining 32% are from overseas (\$98 value) (Valuation Technologies, 1999). As population and income increases, demand for environmental quality increases and tourism is developed these values are certain to increase.

The implicit value of the water resource provided by the 300 streams and rivers flowing from the mountain, protected by the national park was also considered within the Valuation Technology study. The Egmont National Park receives almost seven metres of rainfall each year which is dissipated in the heavy forest before emerging as a vital resource for farmers and communities. The survey reveals that farms backing on to the national park with additional bush incur fewer costs in terms of flood damage and erosion than those farms without additional bush (Valuation Technologies, 1999b). The sheer quantity of rainfall received must be absorbed by continued vegetation cover, if an eruption removes some or all of this vegetation farms over the entire ring plain will incur a significant secondary flooding hazard. There is a trade off in location of farms to the national park the risk of flooding is greatest within close proximity, yet as distance increases the water quality falls and potential for surface contamination increases (Valuation Technologies, 1999b). Recent programmes by council and farming groups (particularly Fonterra) aim to maintain water quality and prevent erosion by replanting riparian margins.

Plant recovery after an eruption is systematic – unburied plant recovery, emergence of surviving buried plants, seed germination and then colonisation from external plants, the timeline of this recovery is dependent on ash thickness, disturbance levels and rainfall. The recovery of Mt Tarawera after the 1886 eruption was well documented and this recovery path would most likely be replicated for comparably sized volcanic scenarios throughout New Zealand (MAF, 1998). The entire primary blast zone remained bare for more than ten years, on lower slopes toetoes and tutu shrubs re-established after 20 years, approximately 30 years after the eruption daisies began to colonise the upper slopes and traditional vegetation development had begun on the middle slopes. Only in the 1980's and 1990's, a century later, did advanced vegetation become present on the upper

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[6] ((\$1,523,038 / 319.09) x 1177 = \$5,617,900; using Reserve Bank CPI figures.
[7] 1998, assuming very conservative constant visitor numbers and 7% discount rate. The present value is calculated by ((\$308,000,000 / 319.09) x 1177 = \$1,136,093,000 using Reserve Bank CPI.

slopes of Mt Tarawera (MAF, 1998). This would be indicative of the recovery times for the National Park and the true timeline of recovery to its original state, ecological value and tourism potential.

Irrespective of an eruption's size the damage to native bush, infrastructure and water quality within the National Park will be enormous. Redevelopment of the national park would not be a priority in recovery planning; the cost to rebuild tracks is estimated using the DOC guidelines for establishing new tracks. Costing is calculated based on the need to clear vegetation, landscape and the required standard of the track. New standards require that all tracks have a surface that is not muddy or in other terms tracks must be gravelled and at least a metre wide (B. Dobby, Personal Communication, 2006).

Table 3: Department of Conservation Standardised Costs to Create (Rebuild) New Tracks

Standard / Type of Track	Cost of New Track / metre
Short Walk	\$50 - \$60
Walking Track	\$40 - \$50
Easy Tramping	\$30
Boardwalk	\$100
Bridges	\$1,000 (\$10,000/10m)
Swing Bridge (Heights > 15m)	\$1,000

Source: Brian Dobby, Department of Conservation

There are 208km of actively tracks on the mountain, there is approximately the same in animal control and maintenance tracks which are closed to the public and are of a lower standard. At an average value of \$50 per metre, if all of these tracks require replacement or high level maintenance this is a cost of \$10.4million. The Egmont National Park is well established with many amenities, signs, boardwalks, huts, tracks, bridges and locations that would take years to recover at both enormous cost and number of man hours.

8.2. Dairy Industry

Fonterra's overall goal is a simple one: 'to deliver the highest possible returns to our dairy farm shareholders' and 'to maximise both the value of the milk they deliver to us and the long term value of the co-operative' (Goldberg & Porraz, 2003, p4).

The New Zealand dairy industry has developed from humble beginnings since the early 1800's when cows were first brought into the country. Since then the extent, productivity and technology within the industry have become amongst the best in the world. In the 1930's the New Zealand

Dairy Board was formed to enable the many small farmers to present a united front for customers and to reach a wider range of markets only available with a larger supply. Continuing consolidation of the industry meant that by the end of 2000 just two major manufacturers, Kiwi and New Zealand Dairy Group (NZDG) represented 95% of the industry supply (Goldberg et al, 2003).

An initial attempt in 2000 to merge these companies failed due to government opposition. However in 2001 after obtaining government support 84% of shareholders voted for and approved the merger, Fonterra was born. In 2002 Fonterra employed 20,000 people around the world, sold over a billion kilograms of milk solids to 140 countries with revenue of $6.6billion. Globally they had the fourth largest quantity of sales, were the second largest company by volume and the largest exporter (Goldberg et al, 2003). Fonterra has a wide reach on a global scale with 29 domestic factories, 39 international and total assets exceeding $12billion in value (Fonterra, 2005). Annually Fonterra, the single largest private sector contributor, spends $95million on research and development, focussing on environmental quality, new products and uses for milk and value added for shareholders along all aspects of the milk supply chain (Fonterra, 2005). Total revenue of the collective in the 2004/2005 year was $12,323million with an operating surplus of $244million.

As a collective for more than 11,600 dairy farmers Fonterra manages the manufacturing process from farm gate, through processing, distribution and marketing to the end user (Fonterra, 2005). Growth in New Zealand's domestic milk production has been relatively flat over the last few years with output stabilising. Globally, including all subsidiaries and international operations the business is growing around 2% annually, even though domestic milk production is falling. There is very little excess capacity in New Zealand's 29 production facilities because of the nature of the milk curve, further investment in production can not be justified for the few days of the year during which capacity is over extended. More emphasis and reward is being placed on farmers who can skew their milk distribution to off peak periods (P Moore, Personal Communication, 2006). Annually New Zealand factories process 13billion litres of milk a year (Fonterra, 2005). Within Taranaki alone dairy manufacturing contributes $2,471.75million in output into the economy (W Hughes, Personal Communication, 2006).

There are two Fonterra sites based in Taranaki the research and lactose facility at Kapuni and manufacturing facility at Whareroa. The Whareroa Fonterra factory covers seven hectares of land; the single site has ten manufacturing plants running simultaneously, has its own power generation facility directly receiving Kapuni gas and is the largest dairy factory of its type in the world (Dairyland Visitors Centre, 2005). The site, which employs 950 fulltime staff, produces largely for export using milk from throughout the North Island and is estimated to have a capital value of plant and buildings of approximately $1,045million (P Moore, Personal Communication, 2006). The factory has a scheduled shutdown period through the winter dry off between May and August to allow for routine maintenance. Up to 42 metric tonnes of milk powder is produced per hour from the five driers, there is also cheese, casein and whey products, bulk butter, consumer butter and AMF produced at the site.

Whareroa has the capacity to process 22% of total Fonterra milk solids with a supply zone which includes Hawkes Bay and Manawatu (both by train) and Taranaki, supply is not dictated by regional boundaries but by milk supply and operating capacity. Typically Whareroa processes 9million litres a day, at peak this increases to 14million litres. The supply zone depends on the time of season, factories which are operating and if any problems are being experienced elsewhere. Many factories can accept rail delivery if a neighbouring site loses rail and road access or ceases production. Taranaki itself supports 16.3% of New Zealand's dairy herds, second only to South Auckland (includes Waikato) with 32%, the 492,486 cows represent 12.7% of the national stock (LIC, 2005).

Whareroa is a strategic site for Fonterra, the capacity compared to other factories is such that if anything happened to prevent operation at the peak of the season they would not be able to reallocate all of the milk to other factories, 20-30% of the Whareroa usual milk supply could not be reallocated at peak. The total effect on Fonterra if decommissioned will be minimal while milk can be absorbed by other factories, albeit at increased cost and logistical planning. Already there is huge pressure on schedulers to allocate national milk during the peak without the additional pressure of lost facilities. Still it would be extremely unfortunate if an event such as volcanic eruption occurred in the few weeks of October and November which represents the absolute peak, where more than 14million litres of milk is processed daily and would have to be reallocated. Off peak factories are put into commission as demand dictates, if an adverse event occurs without warning there will be a degree of downtime until further capacity is commissioned.

The energy intensive factory requires its own generating facility and on-supplies power to the national grid during down times, the gas powered cogeneration station is fed gas through a dedicated pipeline from the Kapuni processing station (Todd Energy, 2005). The 69Mw cogeneration facility feeds on average 400Gw of electricity and 900,000tonnes of superheated steam equivalent straight into the factory. There are four turbines operating in the plant to create in-built redundancy in case of failure and maximum possible uptime for the factory – even during peak. During the peak of the milk season very little power is on-supplied to the national grid, however during the winter season factory demand is less and more is supplied in an almost perfect match to the national high demand period. Currently this grid connection allows both supply and demand of power should for any reason the co-generation facility fail, this two-way connection is not guaranteed into the future. There are back up generators on site for emergencies to run critical facilities however these measures are not sufficient to operate the entire factory and neither would the possibility ever be introduced given the level of investment and redundancy it would require (Todd Energy, 2005).

Extensive contingency planning is undertaken by Fonterra for both specific events and specific sites. Scenario planning has been undertaken for volcanic events based on alert levels and expected conditions, including a simulated activity at the Edgecumbe factory. Emphasis sits heavily on pre-emptive action within operations not reactive behaviour, a significant portion of the Fonterra continuity plan is pushing pre-emptive behaviour by managers. Safe controlled shutdown is initiated, ventilation and air conditioning systems are closed and buildings are sealed. A controlled shutdown, even if ultimately un-required is preferred to an emergency shutdown later on or experiencing damage in the process of shutting down.

In the event that the Whareroa factory is required to close the necessary time to complete a safe controlled shutdown is 24 hours although this could be accelerated if required but in a less controlled manner. An immediate emergency shutdown is highly damaging to the equipment and requires extensive operations to reactivate, emergency shutdown is not a primary option. Preliminary shutdown measures would be implemented upon increased warnings by slowly slimming operations to the most compulsory. Fonterra is rapidly adopting just in time processing which means there is a lot less inventory held on sites now than previously, however at any one time there could still be $4-5million worth of processed stock. The characteristics of milk means there are huge environmental consequences if in any event the factory must dump milk, in many respects if milk must be spilled it is best done scattered at farm sites than being sent to the factory and dumped in a single large spill.

A large volcanic eruption may have a huge adverse impact on Fonterra and its suppliers; the purpose of developing contingency plans is to ensure that the risk of customers and the company as a whole are spread. Fonterra, if required, has the capacity to produce many products out of South American or Australian factories, almost 20% of Fonterra's global production are produced outside of Australia and New Zealand. Fonterra production is highly influenced by external events that affect levels of milk produced by farmers, once pasture damage is experienced or farm output decreases there can be impacts right through the supply chain, global instantaneous communications means customers are highly aware of circumstances in New Zealand. When the Takaka factory suffered fire damage in 2005 customers were ringing within 12 hours asking how this would affect their supply.

The factory is located outside the direct damage zone so may be operational relatively quickly after evacuation ends; it will be the delay in return of supporting utilities that is likely to present the largest problem. The water demand required to operate the Whareroa factory is considerable and this is likely to be the factor that induces closure, if water supplies become contaminated the facility will need to closed (P Moore, Personal Communication, 2006). The factory has several sources of water including the Tawhiti Stream and Tangahoe River (Taranaki Regional Council, 2005b) however all are surface sources that may be contaminated by ash. At use around the site are water recycling and processing facilities that aim to reduce external water demand and re-utilise existing water, the water recovery plant has the capacity to process 5.5 million litres of water a day – around 25% of total demand. Monitoring systems are in place on all intakes to monitor water quality, and cease intakes immediately quality declines. Given the factory's high water demand, on site storage facilities will be exhausted within 12 hours of intakes being closed (P Moore, Personal Communication, 2006).

Fonterra has an obligation to pick up milk and process it; as long as farmers are milking the factory must endeavour to collect it. If a pre-emptive evacuation occurs in peak season it is possible that farmers will choose to stay on the farm as long as possible, if this is the case Fonterra will continue to pick up milk as long as it is safe to do so (P, Moore, Personal Communication, 2006). Dairy farmers get paid for the quantity of milk they provide, paid in arrears for the previous year when dividends are confirmed. The 2004/2005 payout to shareholders was $4.59 per kilogram of milk solids (Fonterra, 2005). Anything which reduces milk production reduces income, with long term consequences. After the 2004 February floods farmers were paid for all milk that could not be collected due to road and access issues, however compensation is not made for resulting reductions in output. More than 40,000 cows were dried off and redistributed around the North Island after the floods while pastures were recovered, a similar situation could result after an eruption (P, Moore, Personal Communication, 2006). Pre-evacuation of bulk livestock, while possible, is unlikely due to the number of stock in the region and uncertainty – what happens if the eruption never occurs?

Fonterra Kapuni (formerly Lactose NZ) is one of the world's largest producers of lactose (Venture Taranaki, 2005) employing 120 people and processing by-products from every Fonterra manufacturing site in New Zealand to pharmaceutical grade lactose. Partly processed products from Whareroa and all North Island factories are sent to Kapuni for value added processing. Pharmaceutical lactose is a milk sugar which is an inert carrier for active medications.

The Kapuni site has a capital value of the plant and buildings in excess of $207.8million. In May 2005 a $25million development began operation; the inhalation grade lactose plant was built specifically to cater to the pharmaceutical lactose market. Kapuni is a preferred supplier into the pharmaceutical market which is valued at more than US$100million (Fonterra, 2005b).

Fonterra Kapuni is likely to be affected by ash fall and infiltration into machinery and storage facilities. Production is likely to cease until ash fall stops and the necessary cleanup operations are completed (Martin, 1999). The Kapuni gas processing plant has an onsite cogeneration station that provides steam and energy directly to the neighbouring lactose plant.

8.3. Production and Distribution of Petrochemical and Energy Resources.

Oil and gas production in New Zealand is estimated to contribute more than $1billion a year to the national economy (Venture Taranaki, 2005). The entire industry is based within Taranaki, as is a large percentage of its distribution infrastructure (Martin, 1999). Within the regional input-output model oil and gas extraction is the largest single contributor to total output, generating $3,370.85million to Taranaki. This figure is multiplied considerably in its contribution to the national economy because oil and gas is vital to many aspects of New Zealand business and households throughout the North Island, not just within Taranaki. In day to day business operations, manufacturing processes and power generation capacity. Gas represents the single largest contribution to energy in New Zealand and represents 15.3% of final consumer demand (NGC, 2005e). One third of the gas produced is used directly in the New Plymouth, Stratford and Huntly power stations, before its current closure approximately 45% was used by Methanex, also in Taranaki whilst oil is exported or piped to the Marsden Point refinery. To the March 2005 year annual production from Taranaki gas fields was 155.6petajoules, a decrease from 2004 of almost 9% in line with Maui declines and the closure of Methanex.

All gas users are notified well in advance if Maui is going to have a scheduled shutdown, shutdowns in the other fields can be met by Maui production but the same is not currently true in reverse. Typically Maui will not go offline for more than eight hours throughout which the whole industry is on high alert and usage is altered accordingly. If the outage is known about gas stored in the transmission system is able to accommodate demand, pressure is simply restored when Maui recommences (R Palmer, Personal Communication, 2005). The maximum planned outage from Maui is 5 days during December (over Christmas) and industry participants are notified months in advance to accommodate.

There are more than 3,400km of high pressure transmission pipelines throughout the North Island that transmit natural gas and petrochemical resources from Taranaki, in addition to 2,800km of distribution lines within communities (Gas Industry Company, 2006). The Maui gas transmission pipeline (now also connecting Kupe and Pohokura gas fields) links untreated gas to Huntly Power Station and the wider North Island in connection with the NGC network (NZPA, 2005, 22 September). Treated gas feeds to end domestic users both to the north and south (Patterson, 1987), as crude oil and gas are rarely found in a pure state refining of the product is required before distribution to end users. The Kapuni and Oaonui treatment plants are the largest although production stations are next to most of the producing fields, gas in New Zealand is refined to the standard dictated by the original Kapuni gas (Shell Todd, 2005). These stations are found at Oaonui, Kapuni and next to the Waihapa[8], Rimu[9], Kaimiro and McKee[10] fields (CDEM, 2004b).

[8] Owned by Swift Energy, TAWN fields produce oil and natural gas which is piped to Westgate Port and LPG which is delivered via road tanker.

Production stations maximise the combustion ability of gas by removing excess carbon dioxide and water vapours and removing heavy hydrocarbons.

There are only a few major players in the gas industry which undertake explorative work and operate the Taranaki gas fields, primarily these are Shell, Todd, OMV, Swift, Southern Petroleum and Greymouth Petroleum (Gas Industry Company, 2006). Since exploration began in 1955 over 350 exploration wells have been drilled, the majority of producing fields are onshore even though the oil producing Taranaki basin is largely located offshore (MED, 2005). Exploration activity in the region contributes $331.7million in total output to the region, when fields reach the final feasibility stages towards development this can be elevated even further. Gas is distributed to consumers and retailers by one of four operators – NGC/Vector, Nova Gas, Wanganui Gas and PowerCo (Gas Industry Company, 2006).

The map on the following pages shows the size and location of gas and oil reserves currently under development in Taranaki, further exploration continues all the time. As the price of gas keeps increasing known fields that were not in production due to marginal economics will become more feasible, increasing supply. Further detail on the pipe and gas infrastructure is included in the infrastructure section (chapter ten).

Whilst gas market prices have increased substantially as Maui reserves are depleted, increasing overall energy prices are maintaining the competitiveness of gas in the industry. The reliance of gas producers is now shifting to many small fields both on and offshore to supply New Zealand's gas needs. The large gas development of Pohokura (owned by Shell, Todd and OMV) is due to start concentrated drilling and pipe laying in early 2006, production station development and other construction has already begun (Port Taranaki, 2005). Based from Motonui (north of Waitara) in an area not affected by ground hugging hazards this development is less susceptible to volcanic hazards than its predecessors closer to the mountain, spreading the industry risk. Ash will be the only interruption to operations unless the gas field is deemed unsafe to operate because of increased seismic and volcanic activity, the pipes also feed straight into the Maui pipeline to Auckland and the NGC system if damage is experienced in southern areas.

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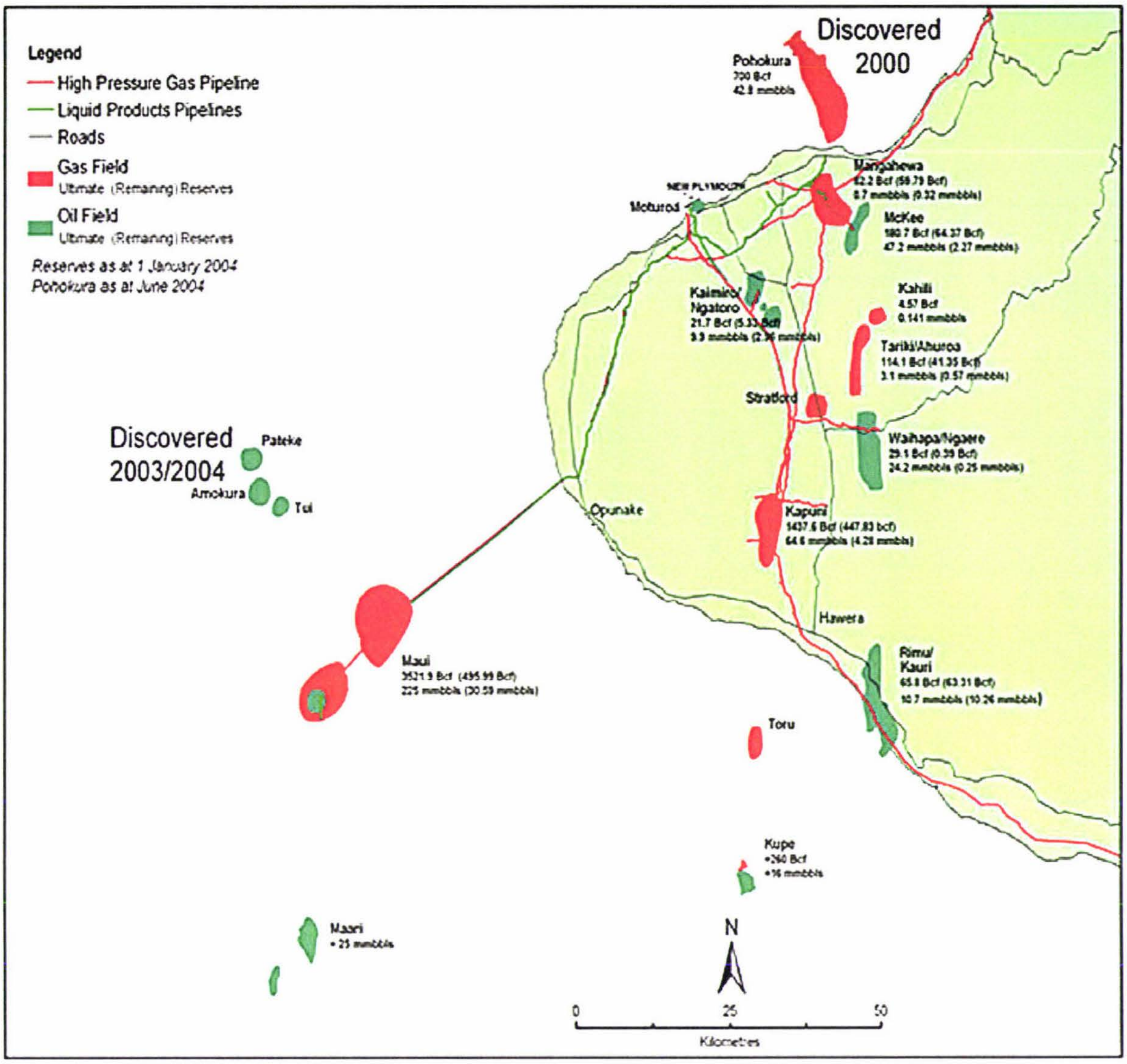
[9] Also owned by Swift, LPG and oil is tanked to Waihapa, natural gas is fed into the NGC pipeline
[10] Oil is piped to the Omata Tank Farm, gas is fed into NGC pipeline

Figure 13: Known Taranaki Gas and Oil Field Reserves



Source: Ministry of Economic Development (MED), 2005

All stages of gas production, treatment and distribution are governed by automatic 'fail safe' shutdown controls that can immediately close the system down to prevent gas leaks and unsafe conditions. Within seconds of any damage or rupture mainline valves (placed approximately every 20-30km) recognise a drop in pressure and automatically shutdown (R Palmer, Personal Communication, 2005). Surface level controls and valves that may be vulnerable to ash or ground hugging hazards are typically for surveillance only and will not prevent emergency distribution or storage of gas in the pipelines, the fail safe shutdown will prevent any gas being released from the pipelines should these points be damaged (Patterson, 1987). The Maui platform is located as such that volcanic hazards will not damage infrastructure or prevent production (Patterson, 1987), however if alert levels and activity reach a level such that gas extraction is no longer safe the entire system and all downstream activities will cease production and distribution. Fail safe modes in gas fields are a lot more sensitive and less tolerant than those governing the transmission system (R Palmer, Personal Communication, 2005). There are no stockpile or storage facilities for natural gas in New Zealand, however the pipe system itself is capable of holding a considerable quantity of gas (R Palmer, Personal Communication, 2005). For five days after the Pohangina Bridge collapsed in 2004 residential and small essential users were supplied from linepack (NGC, 2005f).

There are many risks to continuing gas production, not least of which is closure of the fields if fail safe is activated. Electricity is critical to continued production, while each station has back up generators on site which allow for a degree of operation the generators themselves are vulnerable to ash damage. The Oaonui production station is threatened by the Oaonui Stream (Martin, 1999) whilst the Maui pipeline from Oaonui around the mountain has a number of aerial crossings in steep sided gullies which can not be pushed below the riverbed, these are vulnerable to lahars (Patterson, 1987). Loss of the pipeline would prevent distribution throughout the lower North Island and between processing facilities within the region. Most pipelines carrying methanol, natural gas, LPG and synthetic petrol between storage facilities and processing areas (no unprocessed gas is allowed to enter the main NGC distribution pipelines) must be at least one metre below ground, as such these are unlikely to be affected by surface volcanic hazards. Main level valves, gate or compressor stations, treatment plants, tank farms and all surface equipment could be affected by direct hazards or ash (Martin, 1999).

Shell Todd Oil Services (STOS)

Shell Todd Oil Services is an operational business which manages and operates the petrochemical resources on behalf of its owners Shell Petroleum and Todd Petroleum and other joint venture partnerships; they do not own any physical assets. Operating in Taranaki for 50 years the company is responsible for producing over 85% of the country's natural gas. In conjunction with other products they produce approximately 57% of New Zealand's total energy supply (Shell Todd, 2005). Originally including BP Oil Exploration (Shell BP Todd – SBPT) this partnership began in 1955, New Zealand's first exploration consortium which has led the industry ever since. BP sold its share in the partnership in 1990. Shell and Todd Energy are the most significant companies in the exploration, extraction and production of New Zealand gas, together having a degree of ownership in all major producing fields. Locally Shell-Todd employs over 380 staff in production stations, development sites and the head office (located in New Plymouth). STOS is the developer of Pohokura, operator of McKee, Maui and Kapuni (and the associated production stations) and the Omata tank farm (Shell Todd, 2005). Commercial sensitivity dictates that there is little detailed information available for these companies.

NGC (Vector)

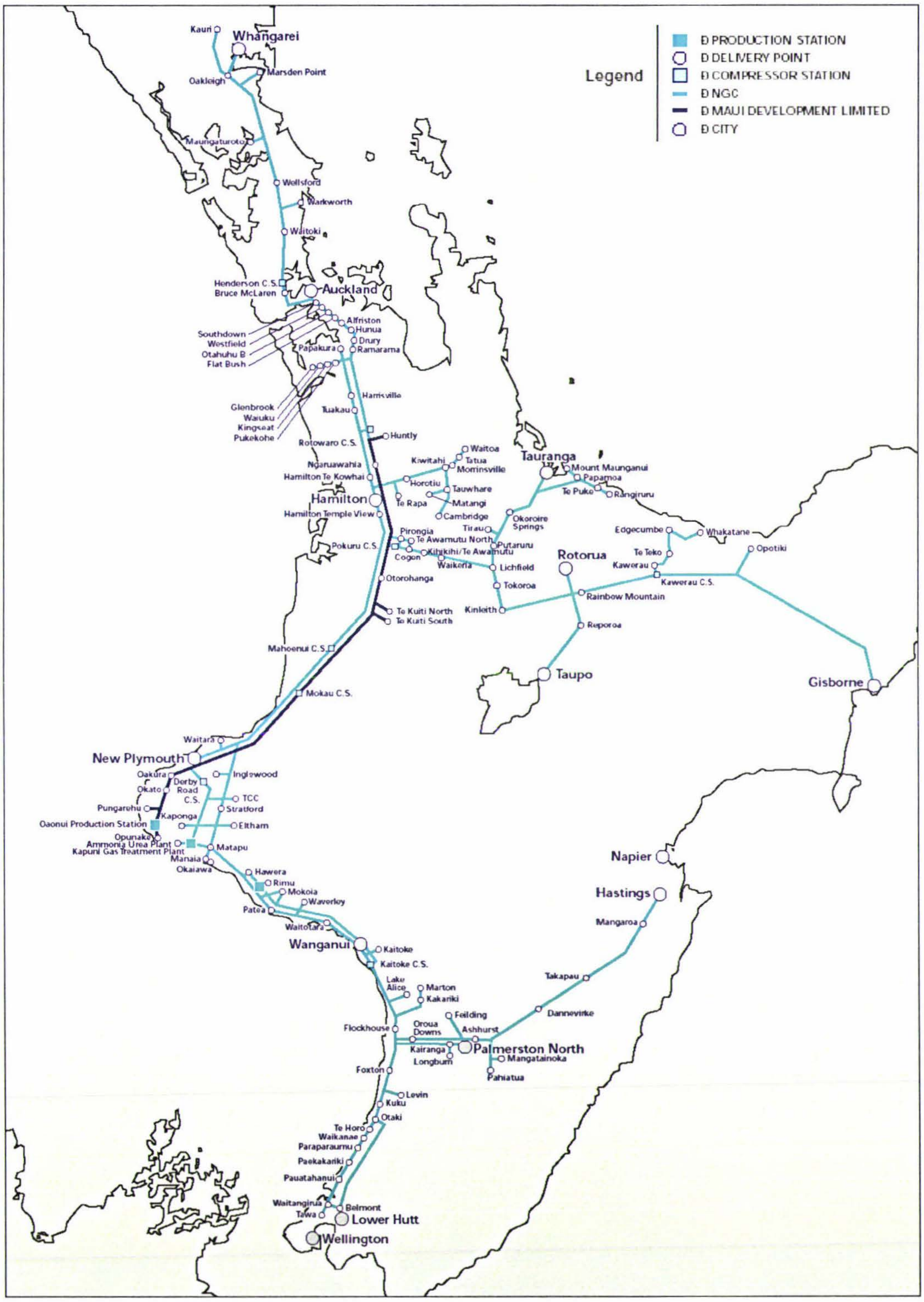
NGC was formed in 1967 as a state-owned enterprise, became a publicly listed company in 1992 and in September 2005 became a wholly owned subsidiary of Vector Energy (NGC, 2005e). Vector, predominantly Auckland based, now operates in electricity, gas and communications services to the public and is able to offer diversified packages to potential customers. NGC consists of the operationally separate Kapuni production station, high pressure (open access) gas transmission and processing infrastructure as well as the retail arm Liquigas and OnGas. Prior to the acquisition of NGC Vector already operated domestic gas networks in the Auckland region supplying close to 76,000 customers, expansion of domestic distribution systems throughout the country is rapid into subdivisions and new commercial developments (Vector, 2005). More than half of Vector's 13petajoule annual supply to Auckland is consumed by just 200 large commercial users (Vector, 2005). NGC supplies natural gas to around 59,000 customers throughout the North Island and employs 399 people, total assets of the company exceed $1,064.42million (NGC, 2005d).

The Kapuni treatment plant has just undergone a $25million expansion development and is valued at $80.2million. Operating 24/7 the factory is capable of operating at 97% utilisation of resources, maintenance schedules are very well defined. In the 2004/2005 year the plant processed 49.8PJ of treated gas, 211,422tonnes of gas liquids (NGC, 2005d). There are three 'processing trains' in operation at the treatment plant, each is only taken out of service for a few days each year for maintenance during the low demand summer period (R Palmer, Personal Communication, 2005). All customers are notified of upcoming maintenance work well in advance. The facility is located within close proximity to the mountain and high risk Kapuni stream, should this waterway be inundated by lahars infrastructure may incur significant or even total destruction resulting in significant cost and time delays to normal business, potentially inducing closure or relocation. The NGC infrastructure is fully insured against the risk of volcanic eruption as is insurance to cover loss of business due to the closure of Maui, Kapuni processing or pipeline damage.

There is also a 25Mw on-site cogeneration facility which NGC has 50% ownership. This generation facility, which feeds into the Ballance Urea plant produced 87Gw of electricity through the 2004/2005 year and 308,311tonnes of high pressure steam (NGC, 2005d).

Although NGC does have gas and LPG retail arms predominantly the business is about transmission of outside parties' gas resources, the highly regulated nature of the gas industry prevents any monopolistic benefit to NGC by operating the transport network. All commercial gas contracts are governed by force-majeure which protects the company from situations outside their control, customers are unable to claim breach of contract if supply is stopped and this protection measure is passed on through to the end users. In any emergency or interruption to supply large users are immediately asked to cease gas use and smaller commercial users and residents are asked to ration use, the aim is for residential customers to never lose gas because at that point it becomes a safety issue (R Palmer, Personal Communication, 2005). As operators of the network it falls on NGC to monitor outages, there is a well defined alert system for any event or drop in pressure and a hierarchy of businesses that are removed from the network. First the power generators are asked to cease then major customers, followed by industrial and finally small commercial depending on the level of gas in the system (R Palmer, Personal Communication, 2005). The request to businesses to cease production is a commercial instruction which is usually sufficient, however if needs must NGC is able to physically go into businesses and shutdown operations.

Figure 14: High Pressure Transmission Pipelines in the Gas Network



Source: Natural Gas Corporation, (NGC, 2005b)

Many of the high pressure gas pipelines are owned by NGC, those that aren't are predominantly operated by NGC, operation includes maintenance work and the management of easements associated with the pipeline. In 2004/2005 NGC moved 94.2PJ of treated gas through 3,479km of transmission pipelines (11.5PJ through its domestic distribution systems). NGC owned transmission pipelines (2,223km) are valued at $438.8million; distribution pipelines (3,083km) are valued at $114.9million (NGC, 2005d). The entire pipeline system is operated and monitored through the control centre located in Bell Block (or if needs must from an external location). As a lifeline agency NGC is required to guarantee service in as much as it is possible to do so, even if this is not economically viable (R Palmer, Personal Communication, 2005).

NGC has a significant share in the LPG industry with a majority holding in Liquigas and wholly owned subsidiary OnGas (retailing LPG produced at NGC Kapuni production facility), in total more than 200,000tonnes of LPG is distributed annually (Vector, 2005). OnGas individually supplies more than 13,000 residential and commercial customers through the introduction of LPG pipelines into high demand areas, since July 2004 OnGas has acquired or developed fourteen LPG reticulation systems in the South Island (Vector, 2005). LPG is the least likely energy source to be disrupted to users outside Taranaki due to its ability to be stored and the domestic distribution infrastructure already in place for imports; existing demand is already supplemented by imports from Australia (10,000tonnes in 2005 financial year). These storage facilities will buffer against any short term interruptions to supply, long term supply interruptions can be met by increased imports (NGC, 2005d).

The gross margins for NGC in the 2004/2005 financial year are representative of the value added by the firm, and is broken down by activity. Natural gas provides value added (gross margin) of $89.1million, LPG (LiquiGas and OnGas) $46.7million, gas transmission $84.7million and gas distribution $26.5million.

LiquiGas

The emphasis of Liquigas has shifted to the operation of assets and LPG wholesale away from the shipping and transportation of LPG. Liquigas exports and distributes LPG from Westgate Port to additional LPG facilities in Christchurch, Dunedin and Wiri (Auckland) for distribution throughout New Zealand (NGC, 2005). Domestic demand for LPG in New Zealand is 160,000tonnes, half of this is industrial and commercial, 25,000tonnes is automotive and the remainder is domestic. The operating profit is suppressed for confidentiality issues.

Liquigas is jointly owned by NGC, Shell, Todd and Rockgas who in turn largely own the LPG that is transported through the network. Liquigas is a LPG transport company which distributes the product owned by its shareholders or other suppliers on contract throughout the country, comparable to NGC's role in natural gas (Peace, 2005). LPG traditionally came from Maui, processed at Oaonui, before being transported to New Plymouth and ultimate distribution. As Maui stocks have diminished and domestic demand increased a shortfall has developed which is being met by imports from Australia (Peace, 2005). Oaonui is the only New Zealand processing facility for LPG; port terminals are capable of odorising the imported stock however this is all.

Storage tanks hold 100tonnes of LPG, 10 are located at Westgate port which allows an entire ship to be loaded immediately, tanks are filled just prior to a ships arrival from the Oaonui pipeline (Liquigas, 2001). As a safety mechanism there is no LPG stored at the port on a long term basis.

Every LPG terminal in the country is operated using a series of automatic and manual shut off valves which protect the LPG and any physical threat. Automatic fire suppression systems operate whenever gas is being loaded or unloaded, seismic switches detect earthquakes and initiate shutdown, fire and gas monitors are placed throughout the storage and loading areas and the entire system is designed with least threat protection criteria (Peace, 2005). Should the Taranaki LPG terminal sustain damage there are no residences within 500m, this is considered a distance safe enough from most events, once a terminal has activated shut-down mode the site is safe from all but direct damages.

The underground pipe-work that is in place for LPG is the same as that used for natural gas, experience dictates that these pipes may bend due to ground disturbance but are unlikely to rupture (evidenced by the Pohangina Bridge 2004, Edgecumbe Earthquake) (Peace, 2005). Storage vessels have similar seismic design features. Risk assessments completed by Liquigas find no undue risk from volcanic ash on gas operation; it also states 'it is reasonable to expect severe erosion and corrosion damage to moving plant such as pumps and air compressors' (Peace, 2005, p18). The Oaonui to Westgate pipeline may be at risk from lahar at aerial crossings.

The Liquigas terminals each have enough generation capacity to power critical function for eight hours should electricity supply be lost, water is not required for operation of the facilities. At peak demand (winter) the storage capacity of terminals could last for four weeks before supplies run out. Given that imports have a travel time of around six days this should not present a problem for demand outside the directly affected area (Peace, 2005). The ability for LPG to be easily shipped between localities and the existing presence of imports means that in the event something happens to Taranaki, flow on effects will be limited. Shortfalls can be met by increased imports, all be that at higher cost (Peace, 2005).

Methanex

Methanex has currently shutdown both of its Methanol manufacturing plants at Waitara and Motonui due to unfavourable economics and uncertain gas supply (MED, 2005b). The increasing price of gas as Maui winds down and the higher dollar has led to the ceasing of all production. The plants remain viable with less than two weeks required to return to full production and all staff remain employed until at least March 2006 should conditions change (MED, 2005b). The ability of the firm to cease production would indicate that, if still operating in the future, production would be suspended for the duration of an eruption. The larger Motonui manufacturing plant (2 million tonne capacity) ceased production at the end of 2004, the Waitara plant (520,000 tonne capacity) ceased production in October 2005, more than 97% of the methanol produced at these two plants was exported (Venture Taranaki, 2005). With the confirmation of numerous new gas fields coming on line late in 2006 a decision may soon be made as to the ongoing future of these facilities. The Waitara Valley Methanex plant is located alongside the Waitara River; this location is at risk of lahars.

Contact Energy and Genesis Power are investigating the feasibility of importing liquefied natural gas for their power stations as a back-up to uncertain future supply from Taranaki, still in feasibility planning a decision is expected by the end of 2006. If liquefied natural gas is considered viable and set up in New Zealand this could spread the risk of the gas industry to interruptions in Taranaki by allowing imports to meet temporary shortages (Steeman, 2005). At the moment planning is pointing towards a regasification terminal at the Westgate Port to fit in with existing pipeline infrastructure, this will make imports vulnerable to the same threats of domestic gas production. Locating the regasification terminal outside Taranaki will allow for a more diversified risk structure.

8.4. Generation and Distribution of Electricity

Energy supply issues are fast becoming a hot topic as population and business expansions increase demand and climate change influences New Zealand's critical hydroelectricity networks with the threat of blackouts around the country (Vector, 2005). Add to this any unexpected interruption to gas energy or gas powered electricity generation and the shortage of alternatives within the industry is apparent. With the increasing vulnerability of the national transmission network a number of large producers are investigating the option of gas powered onsite cogeneration facilities as an alternative to complete reliance on the national grid (Vector, 2005). This shift will place even more pressure on the stability of Taranaki gas and possible import alternatives.

New Plymouth is a net exporter of power containing a small system of hydroelectric power stations owned by TrustPower as well as two thermal electric (gas) stations owned by Contact Energy and the Whareroa and Kapuni co-generation stations. In addition Taranaki gas supplies the Huntly, Southdown and Otahuhu[11] power stations and numerous cogeneration facilities such as Kinleith (Carter Holt), Te Awamutu (Fonterra) and NZ Steel. In 2002 gas powered electricity generation accounted for 25.47% (10,066 Gw Hours) of electricity generated in New Zealand, second only to

[11] Owned by Genesis Energy, Mighty River Power and Contact Energy respectively

hydro electricity (24,062 Gw Hours) (NZ Official Year Book, 2004). In the event that an eruption occurs and gas production is stopped this disruption alone will cause significant problems for business and households throughout the country. Combining the six gas powered generating stations (excluding cogeneration) there is an installed capacity of 2,244Mw (MED, 2005c).

Auckland is well acknowledged as an importer of electricity, in addition the only two generating facilities within the region (Southdown and Otahuhu) are powered by natural gas (Auckland Regional Council, 1999). These two facilities provide 30% of Auckland's power which will need to be sourced from elsewhere, in addition to the reduced output from Stratford and New Plymouth power stations and changes in demand from Taranaki. The nation will have a significant power shortage even in low demand periods.

Within Taranaki electricity generation and transmission creates $160million in total output, electricity supplies contributes a further $236million. In the overall regional economy this is a not a significant contributor in economic terms. After construction the continued operation and maintenance of these facilities does not require a lot of staff or equipment. The value of the generation capacity of Taranaki is better considered in terms of contribution to national power and potential shortages if this capacity is lost.

The hydro electric stations within the region supply only at low voltage to the local networks with the exception of Patea which feeds into the national grid, equivalent power is then fed back into the local networks. These hydro electric schemes supply only a small fraction of the regions electricity requirements and water retention is such that they can not run at full capacity for long periods of time (Patterson, 1987). The scheme may be further unsuitable to supply a degree of emergency power during an eruption due to the potential for ash and debris to enter water intakes. The 1995 Ruapehu Eruption caused considerable damage to the (120Mw) hydro-electric power station in the Tongariro River, ash in the intake structure was estimated to have caused $12million worth of abrasive damage to the station turbines. Some estimates calculated that in seven months the equivalent of 15 years corrosion occurred, requiring new blades to be installed (Johnston, Houghton et al, 2000). The three hydro electric power stations in Taranaki, although on a smaller scale can be expected to receive the same degree of damage from ash distributed by Mt Egmont and will need to be shutdown while rivers are turbid. The Patea dam is additionally recognised as a significant hazard should collapse occur, while this is extremely unlikely lahars will require increased monitoring of the dam (CDEM, 2004b).

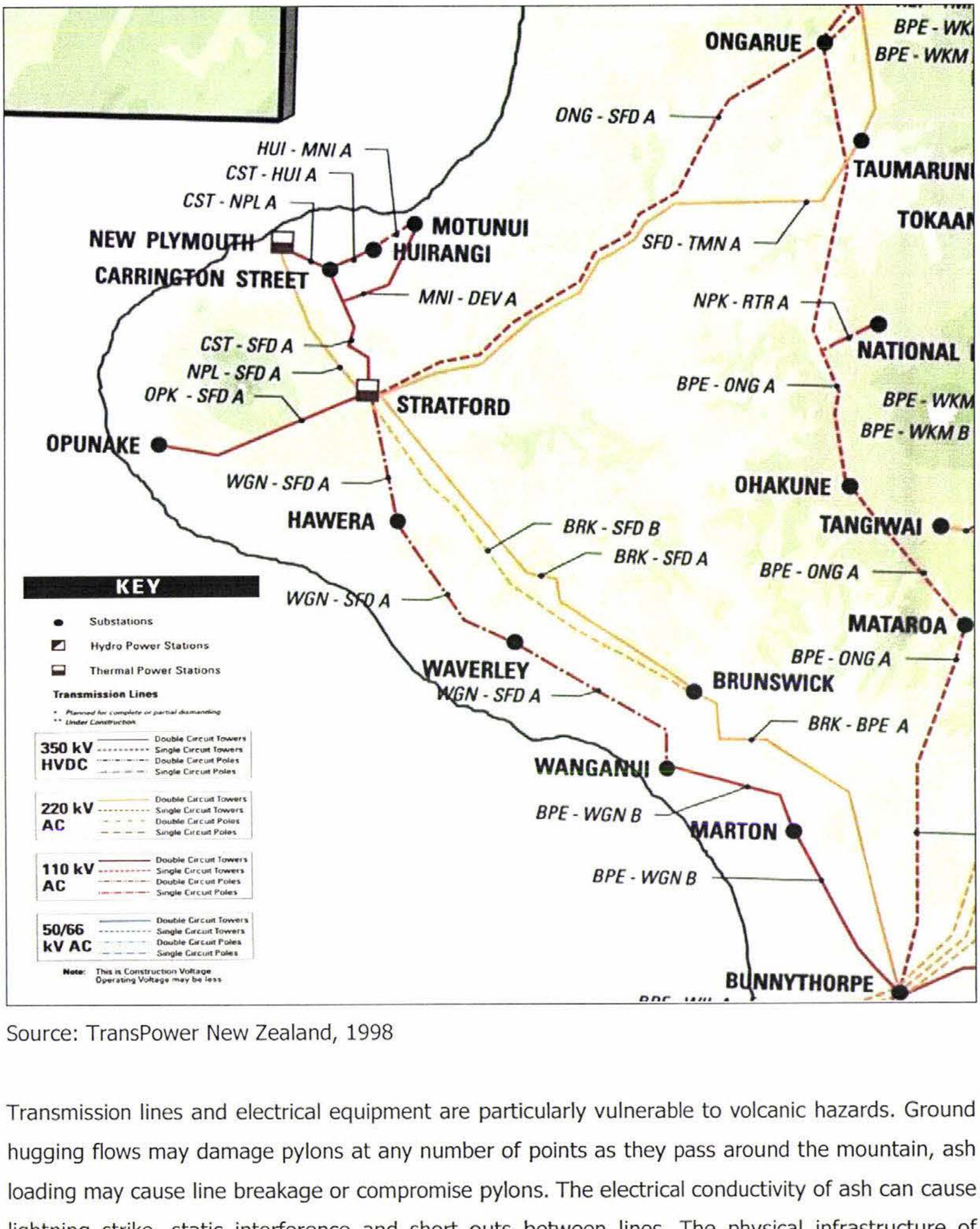
The New Plymouth power station is owned by Contact Energy and located within New Plymouth, the station is currently off line but capable of future generation. The station can produce anywhere between 45Mw and 420Mw depending on turbines operating using either gas or heavy oil (or both) (CDEM, 2004b). Predominantly the station feeds into the national grid through the Stratford substation at 220Mw, the system is capable of feeding the local network through Carrington St Substation at 110kV or Moturoa substation at 33kV to operate in an 'island mode'. This requires a degree of planning prior to an eruption as the station is not capable of a black (cold) start, this means the station requires access to the national grid to initiate start-up (CDEM, 2004b). There is enough heavy oil stored on site (at maximum allowable level) to produce approximately 24 days generating capacity, however there is only 2million litres or five days worth of water stored on site. While there are secondary sources of water available water quality may become an issue (CDEM, 2004b).

The Taranaki Combined Cycle (TCC) power station is located in Stratford, also owned by Contact Energy. This station was commissioned in 1998 with average capacity of 354Mw, at 57.5% fuel efficiency this natural gas powered station is one of the most efficient generators in New Zealand. The TCC plant has full black start capability requiring no external energy supply to initiate generation activity; the facility feeds the national grid through the neighbouring Stratford substation.

The most vulnerable and critical point of the electricity network is the Stratford substation this is the central point of the Taranaki electrical system, all electricity into and out of this region passes through this point (Patterson, 1987). Given the proximity and location of Stratford on the eastern side of the mountain this area will receive considerable quantities of ash. Extensive clean up operations are required in substations to prevent ash build-up, conductivity and corrosive nuisance. In most circumstances this will require rolling stoppages to facilitate cleaning of equipment. This process alone will be time consuming and expensive.

The high voltage electricity transmission network is owned and operated by TransPower NZ Ltd transmitting electricity between generating facilities, a select number of heavy industrial users and substations (110kV transformed to 33kV). The local sub-transmission and distribution company for Taranaki is PowerCo; the network consists of 21 zone substations (transforming 33kV to 11kV or 6.6kV) and numerous distribution transformers (11/6.6kV to 400v) which deliver to households and businesses.

Figure 15: Taranaki TransPower Transmission Network



Source: TransPower New Zealand, 1998

Transmission lines and electrical equipment are particularly vulnerable to volcanic hazards. Ground hugging flows may damage pylons at any number of points as they pass around the mountain, ash loading may cause line breakage or compromise pylons. The electrical conductivity of ash can cause lightning strike, static interference and short outs between lines. The physical infrastructure of substations and generation facilities are vulnerable to the same threats (Patterson, 1987). At lower voltages, aerial lines are at risk of being damaged and isolating any number of households.

8.5. Yarrows (Manaia)

The Yarrows baking company has operated from the same six acre site in the centre of Manaia since 1923 remaining owned and operated by the Yarrows family, one of the few large family bakeries left in New Zealand. The present director Mr Noel Yarrow and his two sons continue the tradition with the head office remaining firmly based in Manaia. Across all sites throughout New Zealand, Australia, Singapore and the United States the business employs over 380 people plus an additional 30 technical and sales staff.

The original bakery, built in 1928 has undergone numerous renovations and extensions. The most recent series of extensions through the nineties extended floor space, constructed freezing space and modernised dispatch areas. Considerable levels of new manufacturing equipment were imported and installed at this time. Yarrows has undergone a long period of continued growth, Russell Guckert (Yarrows, Personal Communication) puts a conservative estimate of this growth at 10% per annum for the last 10 years. This growth, which is expected to continue, is largely driven by the ongoing expansion of major customer Subway.

The company is increasingly supplying frozen baked and unbaked goods to bakeries and restaurants around New Zealand and significantly to Subway Restaurants in New Zealand, Australia and Middle Asia (Korea, Taiwan and Japan). Each week around 450tonnes of frozen goods are despatched from the factory to their final destination by a Hawera owned trucking company.

The factory operates 24 hours a day 7 days a week producing frozen products and fresh daily delivery for Foodstuffs; this extends delivery to supermarkets throughout both the North and South Island. The bulk of flour supplies are sourced from Champion Flour Mills transported by road from Mt Maunganui, Tauranga, Auckland and Wellington – a weekly demand of more than 350tonnes. None of these flour products are grown or sourced from Taranaki given the unsuitable agricultural environment for grain and cereal crops. The factory operates with stable demand all year round with the exception of a peak just prior to Christmas. Every day five twenty foot containers are loaded for export, each containing 1,200 cartons of frozen dough products. In total the factory produces, 6,500 cartons of frozen dough products and 15,000 units of fresh bread products daily.

The Manaia factory and office employs 220 people, injecting close to $150,000 into the local economy in wages every week. More than 50% of the work force lives directly in Manaia, the remainder travel from within the wider Taranaki.

There are seven automated production lines operating in the factory which can produce between 58,000 and 69,000 units of bakery goods in an hour depending on product, from croissants, pies and tarts to bread roll, loaves and frozen dough. The cost to replace the factory and equipment to the existing level would exceed $30million. The facility including contents and stock is insured for $36million. On site at any one time the level of inventory totals $1.25million, comprising $0.75million in product awaiting delivery and $0.5million in materials.

Products made at the Manaia factory are largely intended for export, on average 65% of total production is exported through Tauranga and Auckland, the remaining 35% is consumed domestically. When considering dough products created specifically for Subway the rate of export increases to 90%. No production is exported through Westgate due to inconsistency of shipping timetables, products are loaded into containers on site before being trucked North. Vulnerable transport movement within Taranaki is only along the coast between Manaia and Hawera.

If at any time conditions are deemed too dangerous, or evacuation is ordered then a structured shutdown would take place, this is a relatively minor process requiring less than five hours to complete. The process requires the clearing of all stock from freezers and clearing of bread already in the production line. Continued operation of the factory after an eruption is dependent on the availability of transport routes for staff access, sourcing ingredients and moving production to port. The maintenance of the equipment and removal of ash is also important given the strict hygiene requirements for food production.

A collaborative relationship with Tip Top bakers regarding the fresh bread products would allow a degree of continued production to take place while the factory is closed. Similarly the Yarrow's factory in Perth could pick up some of the production shortfall that would result from factory closure.

Being a privately owned company and for commercial sensitivity reasons the operating profit could not be obtained for this company, however as a goal Yarrows aims to maintain a gross profit percentage of between 40 and 45%. It is estimated that the manufacturing of bakery and confectionary products within the region as a whole injects $170million into the economy in total output (Hughes, 2006).

8.6. Ballance Urea Plant (Kapuni)

The Ballance Urea plant is a urea fertiliser manufacturing plant which is situated on a 32.4ha site in Kapuni, alongside the NGC processing facility. Ballance receives approximately 7PJ of gas a year from NGC and the KGTP (NGC, 2005e). Other Ballance infrastructure within Taranaki includes four service centres located throughout the region. The Ballance Group operates four manufacturing facilities in Whangarei, Mt Maunganui, Invercargill and Kapuni. Financial information is unobtainable for Ballance because of commercial sensitivity, although the group reports separately each facility is bundled together in financial reports to protect competitive advantage. The Urea plant enables

Ballance to produce urea domestically, the sole competitive advantage over Ravensdown who must import all fertilisers. The urea plant in Taranaki is the only such factory in New Zealand and represents approximately a quarter of the manufacturing sites owned by Ballance. Annually there is 145,000tonnes of ammonia produced at the factory in turn producing 263,000tonnes of granular urea. All urea produced is used in New Zealand yet still does not meet existing demand of 600,000tonnes, the balance is made up by imports. Financial figures stated are estimates based on 25% of the overall Ballance position. The operating surplus representing value added is estimated as approximately (120,871,000 x 0.25) $30million. The modelled economy estimates total output from fertiliser manufacturing as $194.66million.

Approximately 750tonnes of urea is produced daily from the factory and while it can be used straight away it is preferable to have a stand down of 2-3 days in storage before sale to allow the heat produced in manufacture to dissipate and to ensure that ambient temperatures have been reached. Inventory on site at any one time is approximately 450tonnes of liquid urea and up to 12,000tonnes of bulk granular urea. The plant runs 24-7 with no scheduled annual shutdowns; there is a major plant shutdown every 24-36 months for statutory inspections and maintenance.

Ballance has secure gas contracts which extend until the end of 2007, there is no expectation of problems in renewing these or sourcing new contracts if required. A major expansion program was completed in 1996/1997 which increased output by around 35%; there is little additional potential for further growth in output from the existing factory. Currently a project is underway to increase efficiency in the production process, driven predominantly by the increasing gas prices.

The biggest influencing factor in shutdown for the factory would be contamination of the water supply, followed by loss of gas supply; the two critical factors in production. The factory is built to all seismic requirements, however if there are a lot of earthquakes associated with the eruption then the factory may need to shutdown in case of damage to structures and potential chemical spills from ground movement. Water is obtained entirely from surface sources and treated on site. The process is sensitive to the quality of water so any contamination from ash is likely to inhibit production, particularly regarding chemical contamination. Generating facilities on site (in conjunction with the KGTP cogeneration facility) are capable of producing approximately 45% of required electricity however this is not enough to run the manufacturing process.

The minimum time required to shutdown the factory in a controlled and safe manner is 36hours, there is an emergency shutdown capacity however this will effectively write off the factory and is a last resort. Urea is manufactured in liquid form, if the system is not cleared prior to shutdown the liquid solidifies, the catalysts would be compromised and extensive recovery work is required. The replacement cost for a plant of this size would be $500million, however if redevelopment of the site was to take place it would be on a considerably larger scale than the existing facility.

The ammonia and granulated urea in addition to use as a fertiliser is used in the manufacture of adhesive, pharmaceuticals, cosmetics and cleaners. The predominant alternative use is as an adhesive used in particle board and plywood, most of which is exported.

8.7. Westgate Port

The New Plymouth port is the only deep water port on the West Coast serving the offshore oil rigs and facilities as well as shipping that ranges from refrigerated vessels to oil tankers and container ships (Westgate, 2004). Expansion activity and future planning is currently underway at the port to maintain growth and facilities, the current deepening project has allowed planning for the development of expansive coal and container terminals, a potential LNG import terminal and infrastructure for the additional oil fields being developed (Port Taranaki, 2005).

The port facilities and equipment (excluding land value) are valued at just under $71million. There is little in the way of inventory to the port although containers and goods awaiting transport are not included in this value. The port employs 110 full time staff on site. Trading profit for Westgate in 2005 was $1.54million although profits have experienced 50% annual decline since 2003[12]. Profitability is highly influenced by oil and gas activity.

In the 2003/2004 financial year total trade tonnages from the New Plymouth Port were 3.48 million freight tonnes, in 2004/2005 they were 3.45 million tonnes, a reduction from previous years (Westgate, 2004, 2005). Traditional trade from Westgate is gas, oil and methanol products as a result of Maui, as Maui production declines and petrochemical trade decreases the port profitability has been falling. The production declines from Maui will not be offset until at least 2006/2007 when the new gas fields (specifically Pohokura) begin production. A diversified cargo base is primary in the strategic direction of the port, especially towards development of container volumes, expansion of port facilities has allowed increased storage and growth in this area. Dairy cargo from Fonterra represents a considerable proportion of container volume. Coal transport (increasing 282% from 2003/2004), cement, fertiliser and logs are other significant goods moved through the port as diversification has continued. Pohokura gas is expected to begin distribution at the end of 2006 while Kupe should begin production some time in 2007 (Westgate, 2004, 2005).

The port is within New Plymouth and not based within a river mouth, as such it faces no threat from lahars or other ground hugging hazards. Like all businesses in New Plymouth ash damage and corrosion should be expected resulting in increased maintenance, clean up costs and increased monitoring for critical equipment such as cranes.

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[12]Trading Profit in 2003 $6,267,208; 2004 $3,085,280; 2005 $1,547,435.

The most significant impact for Westgate will be the loss of business, even though operations will not be greatly inhibited. The gas field operations, maintenance, transport and secondary production will all cease if gas production stops. Fonterra production will be reduced if not completely moved to external sites in the short run, in the long run output will be slow to recover until local farms re-stabilise milk production; transport routes may prevent transfer between facilities. Damage to businesses and farms in the local area will all reduce volumes traded from the port, whether grain, meat, dairy, oil, fertilisers, or engineering and manufactured goods.

8.8. Airline Industry

The threat of volcanic activity to aircraft came to foremost attention in 1982 when two passenger jets experienced engine failure and powerless descents after flying through ash plumes they did not know were there and had not been warned about. Both aircrafts managed to restart their engines at low altitudes and land safely though not without experiencing considerable damage (IGNS, 2006; Coch, 1995). These encounters prompted the development of international protocol for warning about volcanic eruptions. Ash clouds have more impact on airlines more than any other industry. The threat to human safety requires significant reorganisation of flights, man hours and planning in terms of ash movement, exclusion zones, flight restrictions and airport closures.

Modern radars cannot detect ash or ash clouds while the ash can potentially stall engines, is highly abrasive and can significantly damage vital plane equipment. Ash is effectively volcanic glass, when in contact with superheated jet engines the silicates and glass melts adhering to engine surfaces blocking airflow and stalling the engine. A 1990 eruption from Mt Redoubt in Alaska was modest in size and effect but spread an ash cloud more than 240km to the northeast, a brand new Boeing 747 was unwittingly caught in the ash plume stalling all four engines. While the plane was able to restart its engines at a lower altitude and land safely the repair bill to engines, electronics and exterior surfaces exceeded $80million (Coch, 1995).

Only a few millimetres of ash are required to close an airport, airspace and ground planes. All aircraft are diverted around ash plumes that may be present in the area, the extent of the diversion will be dictated by eruption height and wind direction. Without the luxury of radar detection no fly zones and diversions are crudely estimated using computer programmes of ash volume and wind characteristics. Flight planning, diversion and efficient notification are the only way to eliminate the hazard of ash plumes to the airline industry. Appropriate civil aviation guidelines[13], planning and commonsense behaviour by people involved should ensure that little or no damage is experienced

[13] Established in New Zealand as a direct result of Ruapehu eruptions in 1995 / 1996

by aircraft. Given the appropriate notice planes can be removed to safe airports or sheltered in hangars and flight paths can be temporarily altered to account for ash clouds (Blong, 1984).

A 2002 eruption in Ecuador (and previous 1999 eruption) closed the Quito airport on three occasions for between a week and ten days for ash removal (Barnard, 2005). Prior to ash falls vulnerable equipment on each grounded plane was covered, including windshields, landing gear and engines. In addition to these measures all aircraft were towed from their storage positions to prevent ash being sucked into engines upon ignition and cleaning by high pressure hose was undertaken to clear ash. Significant maintenance checks before flight proved this technique to be undamaging to both the physical and cosmetic features. Corrosion in this instance did not occur as ash was cleared within 48 hours and was never wet while sitting on planes. Individual circumstances will dictate damage and concentrated checks will be required on every plane before flight (Barnard, 2005).

The most significant delay in reinstating flights and normal operations is cleanup associated with buildings and runways. In Ecuador this was completed manually using brooms, one sweeper was owned by the airport however it was deemed to be ineffective in removing ash. 500 men working 15 hours a day took 7 days to clear the taxing area and runway – 52,500 hours to clean 285,000 square metres (Barnard, 2005). In Ecuador where labour is plentiful and inexpensive this is a valid option to recovery, in developed countries specialised or more advanced machinery may prove more effective in this respect. New Zealand's advanced monitoring systems will allow a degree of luxury in planning and the ability to remove vulnerable equipment such as planes from the area prior to eruption.

After the Mt St Helens eruption it took 150 people, 40 assorted heavy vehicles and five days to clean 10mm of ash from runways of the 420ha Yakima airport to a standard where flights could resume. 20,000tonnes of ash was removed from the 40ha of runway, adjacent areas were watered 24hrs a day until ash had been washed away or absorbed, preventing redistribution (Blong, 1984). The clean up itself cost US$75,000 however the seven day closure resulted in the cancellation of 182 commercial flights and $25,000 in fuel commission. Neighbouring Grant County airport took 15 days to reopen after 30-40mm of ash at a cost US$200,000 plus cancelled flights and lost revenue (Blong, 1984).

New Plymouth has a commercial airport and there are smaller airports at Hawera, Stratford and Inglewood. The New Plymouth airport has one sealed and two grass runways, the sealed runway is 1,310m in length. The most significant impact from an Egmont eruption is not the local airport but to the international and domestic travel routes that run through the central North Island. Egmont, given its location, has the potential to close airports from Wellington to Auckland depending on wind conditions. The threat from an eruption at Egmont is much greater than a similar eruption from Ruapehu as it will disrupt flights that go through the centre of the North Island and require more westward rerouting. Ash from Ruapehu reached as far as Christchurch which indicates that variable wind conditions have the potential to shutdown the entire country. It is likely that all airports in the region will be shut throughout an eruption episode and for as long as is required to remove ash from runways to prevent ash disturbance by plane movements. If wind direction is favourable it may be possible for New Plymouth, the largest airport within Taranaki, to remain available for evacuation or delivery of supplies and emergency personnel.

During the 1995/1996 Ruapehu eruption more than 210 volcanic ash advisories were issued by the aviation authority, informing of restricted air space. This requires re-routing, flight cancellations, inability to fly at night or during heavy cloud, extended flight times, fuel costs and workloads (Johnston, Houghton et al, 2000). The direct cost of cancelled flights alone was $2.4million during the Ruapehu eruption period. If clean up costs, increased maintenance, flight disruptions and secondary costs were included this figure would be considerably more (IGNS, 2005). An estimate by the Civil Aviation Authority places the overall cost to the industry as $10million from what was a relatively minor eruption (P Lechner, Personal Communication, 2006). When Ruapehu erupted flights were diverted around the western side of the mountain, the same could happen to the west of Egmont in direct flights between unaffected airports, the question therefore is how much further and at what additional cost are airlines willing to divert before cancelling flights.

Table 4 below provides the activity statistics for the New Plymouth airport in terms of movements in and out, there are no international flights operating from Taranaki. The number of passenger movements has increased dramatically over the previous four years primarily because of increased capacity on flights; the long term growth constraint has been and remains the number of flights and seats offered by airlines. Whilst the number of commercial flights has remained relatively static in number the size of the planes is increasing. Commercial flights include Air New Zealand, Air Nelson, Origin and ambulance flights at the airport while total flights incorporates private and training flights as well. While appearing to increase flight movements actually follow a stable cyclical cycle, not moving far from 30,000 since 1980 (M Perry, Personal Communication). Total flight movements is highly dependent on the number of students at the flight school

Table 4: Activity Statistics from New Plymouth Airport

Calendar Year	Number of Passenger Movements	Number of Aircraft Movements	Number of Commercial Aircraft Movements
2005	229,000	33,020	10,200
2004	224,500	31,500	10,500
2003	200,650	30,412	10,300
2002	170,750	27,638	9,300

Source: Morris Perry, New Plymouth Airport

The first two months of 2006 has seen a 12% increase in passengers due to the high level of activity in the gas industry at present and continued increase in capacity, growth of passenger numbers is expected to stabilise by the end of 2006 (M Perry, Personal Communication).

8.9. Tourism

In 2004 there were 250,392 visitors in commercial accommodation in Taranaki, a 14.6% increase on the previous year and the largest increase of any region in New Zealand, tourism in Taranaki is an actively targeted growth industry (Moran, 2005). There were 502,412 guest nights in the region (occupancy of 32.8%) with New Plymouth remaining the predominant destination and growth area. 61,347 international guest nights were recorded in 2004, a significant reduction on 2003. This decline in international visitors is largely dependent on the conclusion of filming for the Last Samurai which elevated visitor numbers throughout 2003.

In comparison with other parts of New Zealand the tourism industry in Taranaki is underdeveloped, significant effort is underway to promote and develop this sector. Large organised sporting, cultural and recreation events play a large role in this development and advertising of the region as a destination.

Tourism would be slow to recover, whilst some visitors will come for the volcanic attraction this will be minor in comparison to normal circumstances. Largely tourists will be frightened away from the direct hazard zone and a much wider area generally not affected, this trend will extend for considerably longer than the eruption. Public perception of the 'danger zone' is often widely inaccurate and can cause significant economic loss for tourist operators well outside the region affected.

Damage to land caused by an eruption will damage the scenic landscape that is so distinctive within Taranaki. The film industry is being actively marketed by Venture Taranaki to attract directors and movies to the region. Big budget films can inject significant revenue into the local economy through set construction, accommodation and employment of film personnel. The recently completed Last Samurai was calculated to have injected $50million of direct spending into the region, creating 616 FTE jobs over the 12 month period (Venture Taranaki, 2005b). This industry may become more consistent in the future although at present the films are actively sought on a one by one basis and there is no consistency in revenues.

9. Eruption Scenarios

Three eruption scenarios will be considered in the overall analysis of the region, these scenarios are discussed here. While they are skewed towards more likely smaller eruption future studies may concentrate on rare catastrophic eruptions or an event causing the evacuation of New Plymouth. This research briefly considers where there are ongoing indicators to an eruption which induce behaviour changes but ultimately does not result in an eruption.

In areas of Taranaki that are not directly mentioned as being affected by ash it is still expected that they will receive a degree of ash. These areas are likely to receive ash fall due to irregular wind direction or swirling winds however the depth and impacts will be considerably less. Small ash fall causes disruption as opposed to destruction which can greatly impact upon service and utility providers (Johnston, 1997). These areas will require increased monitoring of stock and water supplies, disconnection of rain water collection systems and potentially some increased feeding out to stock. Long term pasture and plant damage will be nil and the effects will diminish after a period of rain.

When ash is less than 50mm there are unlikely to be long term damages, impacts or losses to farmland exceeding 2-5 years. Ash will be absorbed, ploughed in under normal operations or easily degraded to the point where it does not affect crops or pastures on the next rotation. Ash may in fact be beneficial to some farms by reducing fertiliser requirements or increasing output. The Martin impact report (1999) mentions ash as a significant threat to all critical facilities between Inglewood and Eltham. It will contaminate water supplies, interfere with waste water and reticulation systems, disrupt power generation and distribution infrastructure as well as gas, roads, communications and rail facilities throughout the region (particularly Stratford).

Lahars pose a risk to the entire region, particularly southeast, west and north along river channels. Agriculture is vulnerable to lahars as are the Kapuni treatment plant and Waitara Methanex plant, both are situated in susceptible valleys. Other reasonably vulnerable features include hydro power schemes, communications infrastructure and transport routes. Again, Stratford is the most at risk (Martin, 1999).

Zone references made in the following paragraphs relate to the hazard map and ash distribution map from chapter seven, figures 11 and 12.

Scenario 1: National Park

The first scenario considers a minor eruption, limiting ground hugging hazards to within the national park boundary and any lahars extending further than this will not breach existing flood control barriers. Bridges will be vulnerable and require increased monitoring but should remain open and undamaged. Ash fall will be limited to zones A, B and C. Ash depths are represented by the minimum values of the Inglewood tephra[14] depths – zone A up to 100mm, zone B up to 50mm and zone C up to 10mm. Zone D has less than a millimetre of ash deposits. Throughout the duration of the eruption alert levels are unlikely to reach level four.

Significant damage to the national park will be considered, complete access restrictions are in place whenever alert levels move above level 2 due to instability of the mountain and further threats. Restoration of facilities in the national park will be required even if there is no need to completely rebuild. The main attraction to the park is for recreation, the exclusion of tracks, facilities and huts prevents this use.

Evacuations will occur when the alert level reaches the final stages of two or on reaching level three, this scenario allows for only a brief eruption before conditions stabilise and evacuation orders end. Total evacuation time will be two weeks, reoccupation will be immediate.

It is assumed gas supplies will cease for large and industrial users for one week. While voluntary restrictions will be put in place for domestic and commercial users the linepack stored in pipes will be sufficient to meet the smaller users demand. There will be no damage to pipe infrastructure and any measuring instrumentation that is damaged will not prevent gas movement once conditions permit. Within Taranaki no circumference roads will be damaged, smaller, low demand roads will be damaged if in close proximity of the mountain.

Scenario 2: Ground Hazard Zones A and B

The second scenario considers a minor to moderate eruption that extends ground hugging hazards into zone A and B. This creates a degree of destruction in populated areas and farms next to the national park. Lahars will extend with force into zone C affecting developed areas and breaching some flood control barriers. Ash fall will extend right into zone D to light levels, creating disturbance for economic activity outside Taranaki.

Evacuation, including time to regain a level of vital services and ongoing eruption threat will be for four weeks. Some road bridges will be damaged; any infrastructure using these bridges as

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[14] The Inglewood Tephra is a representative moderate to large eruption incorporating behaviour of previous eruptions. Zone A - >0.25m, Zone B – 0.25-0.10m, Zone C – 0.10-0.01m, Zone D – 0.01-0.001m.

crossings will be severed or interrupted although the degree of damage is highly selective[15]. These damaged bridges will present problems for reoccupation, some individual households may be delayed in regaining access. Rail will be damaged on a short term basis potentially requiring bailey bridges or speed restrictions. The local roads will receive damage associated mainly with ash and the inner ring of roads will receive damage to bridges and some erosion damage from flooding, redundancy in the transport network will allow most households to return. Within the national park there will be significant damage to roads due to coverage, erosion or subsidence.

Ash depths for scenario two are still smaller than the representative Inglewood tephra used in the ash hazard maps. Zone A will have a maximum depth of 150mm, zone B up to 100mm deep and zone C to a maximum 50mm. In this scenario minimal levels will extend beyond Taranaki into zone D to a maximum depth of 5mm. Damage to farmland and crops will be minimal and sporadic outside Taranaki but will begin to influence flight paths and airports throughout the Central North Island.

Scenario 3: Extended Damage

This scenario considers a moderate to large eruption in line with the Inglewood tephra distribution. Ash depths in zone A will approach 250mm in depth, zone B 150mm, C 100mm and up to 10mm into zone D. This level of ash will begin to have damaging consequences for farmers around Wanganui and the Rangitikei and will be severely disruptive to aircraft travel.

Ground hugging hazards will extend into zone D with significant consequence for Inglewood, the south west coastal communities, the industrial sites around Kapuni and farm infrastructure. Potentially both the Kapuni and Maui gas production stations could be damaged. Stock losses would be likely.

This scenario imposes an evacuation period of twelve weeks. This allows for a longer eruption and instability period but also for some degree of recovery to begin. Individual households will remain in temporary accommodation for a significant period longer than twelve weeks.

Rail links between New Plymouth and Hawera will be severed until temporary replacement of bridges is possible and tracks cleared (ten weeks), the peninsular will be isolated by road due to bridge damage occurring on the outer circumventing road (SH45). Repairs required will be extensive. Fonterra will cease production for at least eight weeks due to increased risk, water contamination or ash contamination, stock loss and transportation issues.

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15 In the future to increase accuracy of estimates bridge vulnerability assessments currently being completed could be used.

Scenario 4: Behaviour Change

The final scenario will consider the behaviour of firms at a national and regional level directly associated with alert levels, not volcanic eruption. As part of the civil defence planning guidelines emergency services are required to plan according to these levels and businesses have been encouraged to do the same. Whilst the alert levels are politically neutral and determined by the Institute of Geological and Nuclear Sciences, there is no question that a change in the alert levels will have significant political and economic consequences – specifically changing from level 1 to level 2 where an eruption is not yet guaranteed. That is the purpose of this scenario, to investigate no infrastructure damage but disruption, changes in behaviour and changes in expectations.

When volcanic indicators suggest the possibility of an eruption, business and private activity will begin to alter. One of the biggest detrimental influences on investment and economic growth is risk and uncertainty. Alert levels are characterised by movement, they will slide up and down the activity scale many times before ultimately erupting or subsiding. Each movement will increase uncertainty. The longer uncertainty exists, more and more projects will be delayed until a more stable environment exists. Community stress increases, investment and building projects are delayed and the economy begins to stagnate. This final scenario considers the potential impact of this uncertainty, largely focussing on gas supply and business opinion.

10. Infrastructure

Infrastructure is classified as structures, buildings and service networks that have a replacement cost but will not incur ongoing or secondary costs due to disruption. All mechanical, electrical and electronic equipment is susceptible to the corrosive, abrasive and conductive nature of ash. Infrastructure that is reliant on water resources in the region is particularly vulnerable from volcanic eruption, due to increased turbidity or lahar damage. This includes all water and waste water intakes, distribution and filtering systems as well as hydro electricity networks and irrigation systems. Stratford infrastructure is particularly vulnerable given its location to the East and proximity to the mountain and rivers; this threatens the rail and road links, Stratford power station and the entire regions electricity distribution network.

Emergencies, even small localised events, place increased demand on utilities as people reassure safety, co-ordinate recovery and begin clean up operations. This can place sometimes overwhelming pressure on vulnerable equipment and infrastructure. Timely and appropriate recovery of infrastructure is commonly hindered by a lack of skilled employees during peak demand; infrastructure often requires highly specialised personnel to maintain and repair (Brunsden et al, 2004). When the infrequency of natural events increases the capacity for correct response by emergency and recovery organisations is diminished and effectiveness decreased. There is huge uncertainty in estimating factors such as length of closure, damage and response due to the varied impacts of the event and secondary factors such as weather conditions (Dalziell & Nicholson, 2001).

Concentrated public notification procedures must be in place to ensure residents deal with ash in an appropriate manner that does not compound problems for utility providers. Clean up operations to re-establish normal utility function and infrastructure can be lengthy and expensive. In 1992, Mt Spur in Alaska deposited 3mm of ash on the neighbouring city of Anchorage (population ~ 300,000), it took 3-4 days to clear the central business district and more than six weeks to clear the entire city of ash at a cost of over (1992) US$780,000 (Johnston, 1997). In Yakima, America (population ~ 50,000) the 10mm of ash accumulated during the Mt St Helens eruption took three months of around the clock operations to clear, at a cost of more than (1980) US$2million (Johnston, 1997). These estimates exclude the cost of residents' time needed in clean up operations.

An estimate for clean up costs of ash removal was estimated by the Institute of Geological and Nuclear Sciences based on population numbers and the cost of clean up from 42 communities associated with the Mt St Helens, Mt Spur and Mt Ruapehu eruptions (Johnston, Nairn et al, 2000b, p23). Using this figure (1998 dollars) the cost of cleaning up ash is assumed to be $19/person/mm.

This figure is likely to underestimate the true cost in Taranaki given the low population density but provides a realistic figure for this purpose. Further clean up costs would be associated with soiled interiors, cosmetic external damage or roof loading and damage to mechanical or electrical services (Johnston et al, 1997).

Building damage from ash fall is unpredictable depending on roof span and strength, compaction, density and humidity of ash and the pitch of the roof. Blong (1984) suggests a critical ash depth of 100mm before systematic damage is incurred by buildings. Guttering is the most susceptible part of all buildings and buildings with a wide roof span (typically industrial buildings or sheds) are the most at risk structures. When ash exceeds 300mm more than half of all buildings will incur roof collapse (Johnston et al, 1997).

Where possible all attempts should be made for road and transport clean up activities to include residents in an overall removal programme. This will prevent unnecessary redistribution of ash to previously cleaned areas, will allow for more ash to be removed to designated dump zones and importantly, will prevent residents' simply hosing or sweeping ash into vulnerable waste water systems (Nairn, 2002).

Experience gained from Mt St Helens (1980) determined that the most effective method of ash removal in urban areas is to:

1- Storm water drains cleared by hand and covered with sand bags or similar
2- Residents and business owners are required to clear ash from roofs and properties which is then piled on roads
3- Areas are arranged into 'blocks' which then organise themselves and are able to phone the council for street clearing once completed
4- Fines are able to be imposed on those not cleaning their properties or seen to be dumping ash into drains. Preventing wind contamination over clean areas is important as wind-blown ash severely hampers the speed and effectiveness of cleanup.

(Blong, 1984)

The Auckland Lifelines project identified emergency generation units, air conditioning facilities and points of direct air access as being the most susceptible points for ash penetration and damage to domestic, commercial or industrial structures. Additional filters will need to be installed or entire systems shutdown prior to sustained ash fall. If insufficient cooling equipment is available systems will need to be ceased periodically until temperatures return to safe operational levels (Auckland Regional Council, 1999). This is particularly the case in telecommunication systems where computers overheat without cooling facilities. Buildings with long roofing spans are at considerable risk from collapse when ash depth begin to exceed 100mm. Buildings are likely to experience damage either from overloading or, as ash depths decrease, more superficial damages such as soiling of interiors, service disruption and abrasion of roofing and external materials. The characteristics of both the ash and the buildings will determine vulnerability, as will the degree of pre-emptive action such as clearing roofs (Johnston, Nairn et al, 2000b).

10.1. Communication

Businesses involved in landline telephone communications in Taranaki include Telecom and Telstra Clear, Telecom and Vodafone operate the cellular or mobile network. The main other enterprise operating in the region is Broadcast Communications Limited who operate radio communications. Damage to communication systems (telecommunications, cellular phones, VHF/UHF, radio) can be due to direct or indirect damage or as a result of overloading after the event. Direct damage includes the destruction of underground fibre optic cabling, removal of cellular or repeater sites, interference of radio waves or electromagnetic disturbance due to ash. Indirect damage may result from the loss of electricity, overheating when air conditioning systems are shutdown or lack of access to equipment by technicians. Telecom has the ability to prevent calls from entering an area or from being initiated to prevent overloading, in almost any event this will be an immediate action by Telecom and will be in place until demand stabilises.

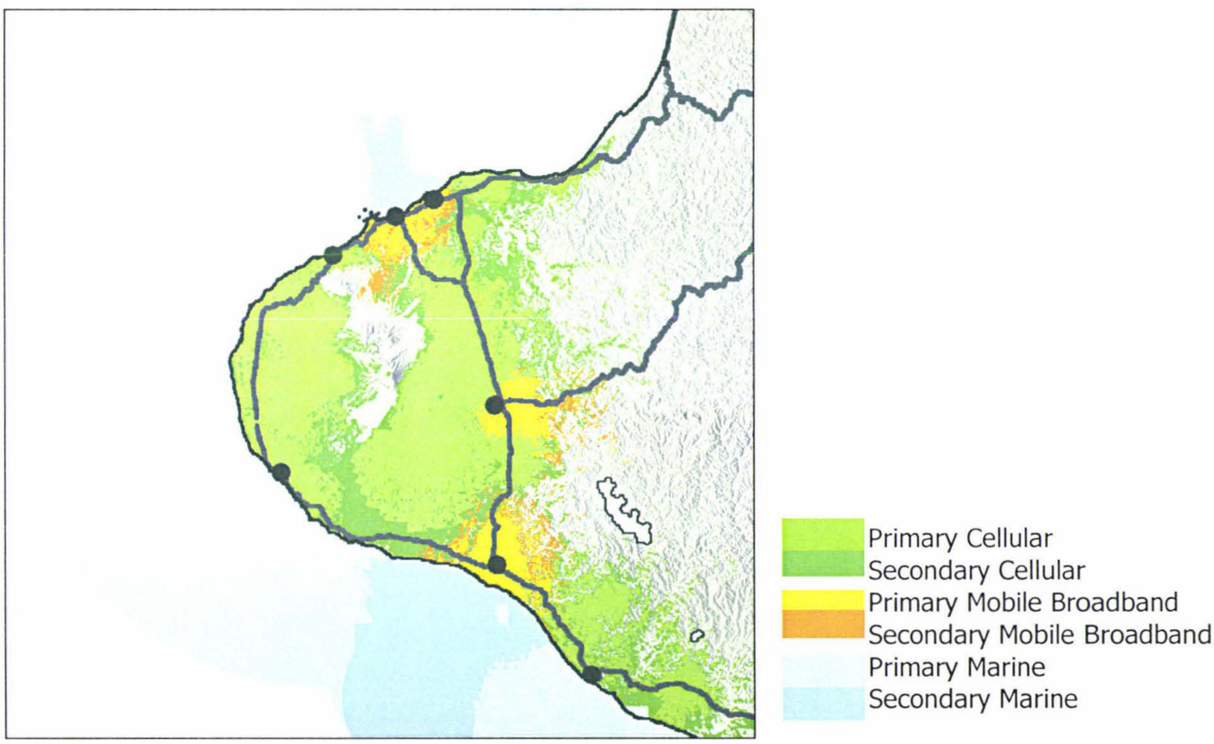
Landline telephone communication networks are fully automated with built-in redundancies, automatic rerouting, network rings and overlays (Auckland Regional Council, 1999). This allows the network to be tolerant to individual failures but not multiple failures. Major exchanges all have back up generation facilities which can continue operation for anywhere up to a few weeks. Phone systems are heavily reliant on air conditioning systems to cool electronic equipment and prevent overload. Air conditioning systems are highly vulnerable to ash in an eruption.

Taranaki's geography is such that a lot of communications infrastructure is located on the mountain, including emergency services. The civil defence system is the only one not dependent on structures located on the mountain (predominantly Jacksons Lookout). Removal of communications by an eruption will present considerable difficulties in co-ordinating rescue and recovery (B Raine, Personal Communication, 2005). Emergency services, commercial radio telephone (RT) and cellular networks all have sites based on the slopes of Mt Egmont (CDEM, 2004b). Local calls are directed through exchanges in Hawera and New Plymouth using fibre optic cables. The buried cables predominantly follow the State Highway route and are placed underneath riverbeds. Toll calls are carried via fibre optic cabling routed through New Plymouth (Martin, 1999). Buried cables are largely protected from ground hugging hazards but junction points will be damaged if directly hit.

Increasingly cellular communication is becoming the primary means of communication for individuals and households. The network is a system of cellular sites which offer overlapping coverage zones to users. Users are switched between sites by a parent switching centre and cellular sites are typically linked to each other via fibre optic cable or digital microwave links (Auckland Regional Council, 1999). Mobile networks can be highly vulnerable to increased demand; in the event a cell site is damaged the surrounding sites will extend coverage to compensate by sacrificing capacity and increased black spots. Even in the event all sites remain operative, excessive demand can overload the system and decrease efficiency. Overseas experience has shown that cellular networks are seriously overloaded within 15-30 minutes of an emergency (Auckland Regional Council, 1999).

There are 20 operational Telecom cell sites within Taranaki, each site costs between $300,000 and $500,000 to design and build, averaging $450,000. Three of these sites are located directly on the slopes of the mountain at Jacksons Lookout, Kahui Trig and Carrington Road (N King, Personal Communication, 2006). Figure 16 provides the level of cell coverage for Taranaki in normal circumstances, loss of any cell sites will diminish both the spread and capacity of coverage.

Figure 16: Telecom Cellular Coverage in Taranaki as at 31 December 2005



Source: Telecom New Zealand, 2006

The cellular network infrastructure as a whole is likely to be less affected than land line infrastructure as neighbouring cell sites can temporarily pick up the gap to continue providing a degree of service (Auckland Regional Council, 1999). If fibre optic cables are damaged at a number of points (most likely at river crossings or surface points) then entire sectors can be excluded from service until repairs can be made.

A joint venture initiative fast tracked the installation of technology which has allowed the majority of Taranaki residents' access to broadband internet. Predominantly this involved the updating of equipment in telephone exchanges and the development of wireless networking in remote rural areas (CDEM, 2004b). Consequently there is a high level of infrastructure investment within the region but also less reliance on cable connections.

10.2. Land Transport

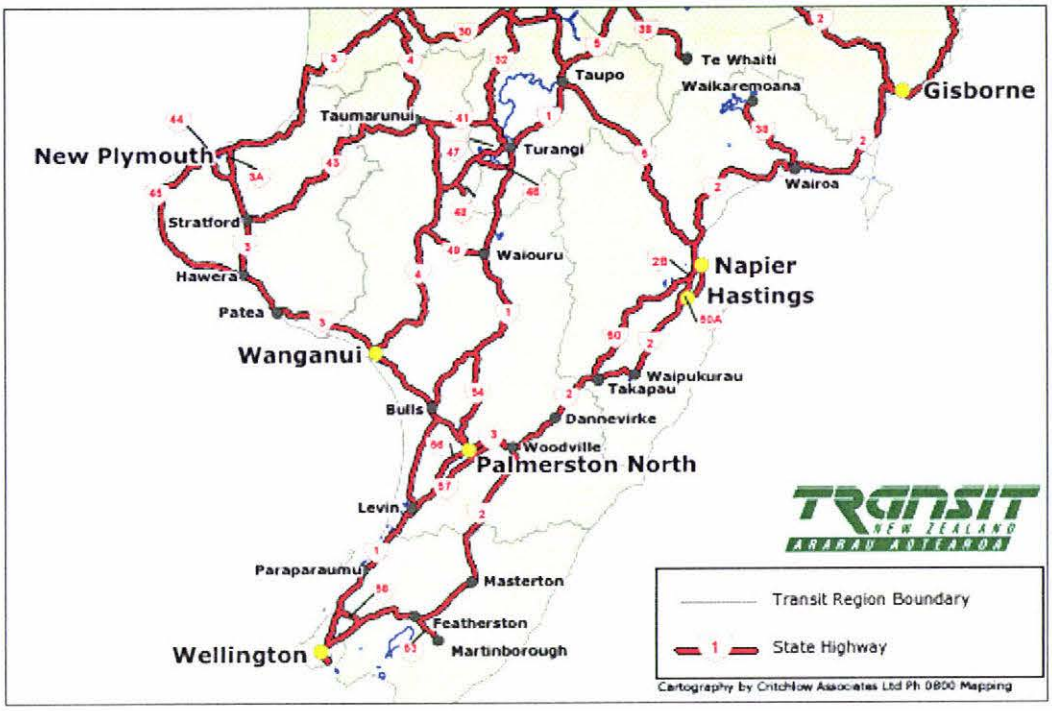
Road and transport networks are lifelines for communities and essential for the continuation of economic activity. Widespread disruption to these systems hinders emergency response, clean up operations and the reoccupation of affected areas (Transfund, 2002). Mitigation strategies and contingency plans can help reduce recovery times and the potential effect however the emphasis most often lies with population safety as opposed to economic recovery. Transportation networks typically have little or no redundancy built into the systems (i.e. alternative routes) however eliminating all risk is extremely costly, particularly given the low probability of certain events. Increasingly this vulnerability is being considered as more firms and communities revert to just in time inventory stocks. Food supply and business operations are vulnerable to even temporary road closures which can cause critical shortages.

Ash fall can disrupt road and rail travel by burial of the networks, visibility and traction loss, mechanical failure, engine abrasion and failure of electrical control systems (Patterson, 1987). Airlines are affected by the widespread 'invisible' nature of ash to planes in the air and on the ground. Rail is the least susceptible to volcanic hazards, airlines are the most at risk yet roads are the most critical to recovery.

Roads

The nature of transport systems in Taranaki, with few routes out of the region, means that if evacuations are delayed or if people choose not to leave until the last minute the road capacity will not be able to cope. The majority of people will be required to leave on one of only three two lane roads, delaying evacuations could be highly dangerous (B Raine, Personal Communication, 2005). The following figure clearly shows the lack of significant routes into and out of the region and the potential for isolation.

Figure 17: State Highways for the Lower North Island



Source: Transit New Zealand, 2005

The primary roads which circumvent Mt Egmont are SH3 inland (through Stratford) and SH45 (Surf Highway) around the coast. Although located some distance from the summit these roads are high risk due to the number of river crossings and their strategic importance. The regional roads predominantly extend in a radial pattern from the mountain without crossing streams and gullies, connected by the state highway and an inner set of roads which also circumnavigate the mountain. Local roads are built to a lower standard to withstand lower levels of demand; typically these roads are then more susceptible to damage from any given event (Auckland Regional Council, 1999). The pattern of roads in the region can be seen in figure 18 below.

Taranaki hosts 3,853 kilometres of roads, 3,131km (81%) of which are sealed. Only 10% of Taranaki roads are state highways, placing a high level of burden on the regional and district councils in terms of maintenance and recovery costs. The regions roads are predominantly rural local roads (86%) as opposed to urban. The numerous streams throughout Taranaki require many bridges to the extent that they occur approximately every six kilometres. State highways have 158 bridges; local roads have 668, of which 437 are single lane (Taranaki Regional Council, 2005c). The roading network is summarised in table 5.

Figure 18: Distribution of the Road Network in Taranaki

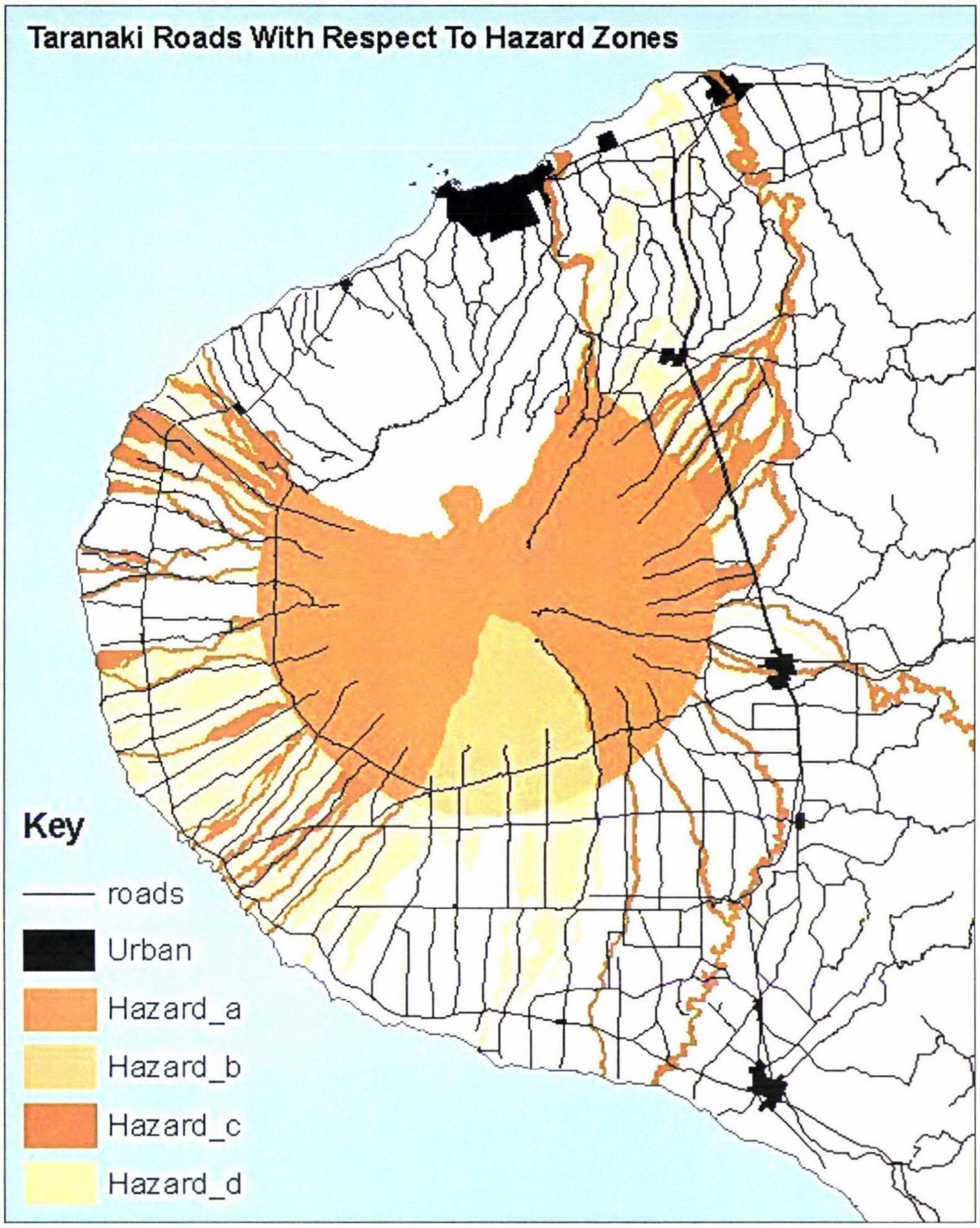


Table 5: Regional Road Network

Road Type	Stratford	South Taranaki	New Plymouth	Total
Rural (km)	541.4	1475.7	954.1	2971.2
Urban (km)	54.5	136.3	304.3	495.1
Total Local Roads	595.9	1612.0	1258.4	3466.3
	State Highways			386.5
	Total Roads			3852.8

Source: CDEM, 2004b, p87

Despite the lack of state highways Taranaki boasts the fifth highest level of combined vehicle kilometres and net tonne kilometres. This is attributed to the high road demand of industries in the region such as dairy, gas (particularly LPG which is trucked) and forestry (Taranaki Regional Council, 2005c). Into New Plymouth from the south (SH3) are just under 9,000 vehicle movements a day; to the east and west (SH3 and SH45 respectively) there are just over 5,000 vehicles a day (K Moore, Personal Communication, 2006). Stratford has through traffic of 9,000 vehicle movements a day (K Wheelen, Personal Communication, 2006); this confirms a daily movement along the length of SH3 around 9,000 vehicles a day. The centre of Stratford has traffic flow of 15,000 vehicles, a combination of town movements and traffic bypassing through SH43.

Vehicles are susceptible to ash deposits, anything from clogging air filters to the abrasive, corrosive nature of ash on windscreens, paint work, metal and moving parts. Accumulation of ash on road surfaces can cause traction problems when wet or visibility difficulties when dry (Martin, 1999; Nairn, 2002) and must be removed from roads either by wind, rain or manual cleaning before they can be reopened to traffic or restrictions eased, irrespective of the depth of ash present (Nairn, 2002).

Thick ash falls (>100mm) will bury sealed road and concrete surfaces usually without affecting surface condition, these surfaces can then be reinstated following excavation. Mechanical removal is the best initial solution. Provided no other obstruction is present, limited access can be maintained prior to removal over these surfaces when the ash is dry (Nairn, 2002). In heavy ash deposits the greatest threat to road infrastructure comes from secondary impacts - increased surface runoff, flash flooding and lahars resulting from reduced vegetation and absorption of rainfall. Drainage systems and culverts are easily blocked by the concrete like nature of wet ash while bridge structures and the road base can become compromised due to erosion (Auckland Regional Council, 1999).

Distal ash deposits present more of a nuisance and increased cost to road systems than actual damage. Modern eruptions at Mt St Helens, Rabaul and Pinatubo have all used the same general technique to clear roads. The bulk is scraped and removed from the area with heavy machinery, the remainder is then dampened and swept or water jetted off the roads (Nairn, 2002). Experience has taught that ash must be removed from road sides or artificially stabilised to prevent redistribution of ash by wind or rain. Ongoing cleaning is likely to be required until ash that is present in areas adjacent to the road has stabilised. After the Ruapehu eruption roads were closed due to visibility problems on three separate occasions, when considering sweeping and manning road blocks the cost of each closure was in the range of $4,000-$5,000 (R Devine, Personal Communication, 2006).

Unsealed roads are the most difficult and costly to clear as scraping will remove the existing road surface requiring complete replacement of gravel. Replacement of gravel presented the largest proportion of cost in reinstating roads after the Mt St Helens eruption (Nairn, 2002). Even after scraping ash will remain on gravel road surfaces presenting visibility and traction problems for an undefined period of time after the eruption.

A risk and impact assessment of natural hazards was completed for the Desert Road that considered remedial work and user costs of closure (Dalziell & Nicholson, 2001). The economic cost of road closures depends primarily on the availability of alternative routes. In circumstances such as volcanic eruption where neighbouring routes are similarly affected, the potential cost to society increases as alternatives can not be sought (Dalziell & Nicholson, 2001). The Desert Road (SH1) is a high demand north-south route in the North Island, when the alternative route through National Park is open the economic cost of closure[16] is $8,000 per hour closed. New Plymouth roads, while not as busy, have few alternatives particularly during a widespread event such as volcanic eruptions. If the Desert Road and National Park are simultaneously closed the total economic cost of closure jumps to $23,000[17] per hour. Irrespective of the length of road closed this figure, in the absence of specific study, represents a comparative cost when 'routes' are unavailable, feasibly the larger figure created by no alternatives could be used in Taranaki by assuming exclusion of an entire region as a trade off to reduced traffic use.

Access after a disaster is one of the most important factors to allow assessment of damage and the beginning of reoccupation. Table 6 below indicates the length of road at risk in an eruption for four of the ground hugging hazard zones. Future studies could incorporate the more detailed assessment of bridge vulnerability that is being completed by Massey University. Many bridges are the structural support for other infrastructure at river crossings. This infrastructure includes, but is not limited to, telephone cables, fibre-optic cables, gas, water and wastewater pipes. These roads represent only the proportion that are at risk, not total road area within each region as shown earlier.

[16] Incorporating increased travel times and elasticity of travel demand, changes in expected accidents and lost business
[17] 1997 figures

Table 6: Road and Bridge Infrastructure at Risk by District Council and Hazard Zone

Region	Hazard Zone	Length of Roads at Risk (Km)	Total Number of Crossings / Bridges	Bridges at Risk	Bridges at Risk With Additional Infrastructure
South Taranaki	A	154.1	27	24	11
	B	58.1	13	12	4
	C	106.2	38	35	21
	D	16.9	33	32	20
Stratford	A	173.1	10	6	3
	B	50.5	6	5	1
	C	925.2	20	14	6
	D	1120.2	2	2	2
New Plymouth	A	48.5	21	13	2
	B	n/a	n/a	n/a	n/a
	C	335	36	29	23
	D	531.8	33	30	19
Total	A	375.7	58	43	16
	B	108.6	19	17	5
	C	1366.4	94	78	50
	D	1668.9	68	64	41

Source: Infrastructure at Risk (Procter, 2004)

Bailey bridges are the quickest way to regain access when bridges are damaged for both road and rail services, throughout New Zealand there are many of these temporary 'kitset' bridges stored for emergency events. Depending on availability, a standard bridge of approximately 30 metres can be erected and in use within 48 hours (Transit New Zealand, 2006). A hire charge exists of $85 per tonne (approximately one metre) per month plus transport and construction costs.

Rail

Rail is the least affected method of transport but will still require speed restrictions and increased monitoring of equipment, bridges and electronic signals. The vulnerability of bridges to lahar is the same as that for road bridges. Alternative tracking and communication systems may be required to prevent accidental collisions or malfunctions should signals short circuit.

If the main trunk rail line in Taranaki was severed in any one place (most likely due to lahars) then critical cargo can be redirected around the central North Island to approach from either side. However if the off shoot tracks to Kapuni, Waitara or New Plymouth were damaged train traffic would cease until replacement occurred. The train lines in Taranaki are freight only so whilst no private movements would be disrupted, commercial activity, particularly from the industrial centre of Kapuni and the Fonterra factory would be severely affected.

Toll NZ is the only national operator of rail in New Zealand, primary customers on the Taranaki route are Fonterra, Ballance, Ravensdown and NGC (LPG transport). Fonterra alone receives four trains and more than 3.2million litres of milk from Pahiatua and the East Coast everyday (Dairyland Visitors Centre, 2005).

The tracks have recently been acquired by the New Zealand Government who after negotiations with Toll NZ to purchase the tracks and undertake well overdue, expansive maintenance programmes. Any maintenance in Taranaki (and wider NZ) is likely to assess vulnerability and strength of existing bridges and if necessary upgrade.

Table 7: At Risk Rail Infrastructure by District Council and Hazard Zone (excluding bridges)

Region	Hazard Zone	Length of Rail at Risk (Km)
South Taranaki	A	n/a
	B	n/a
	C	293
	D	72.2
Stratford	A	n/a
	B	n/a
	C	48
	D	21.7
New Plymouth	A	n/a
	B	n/a
	C	311
	D	347
Total	A	n/a
	B	n/a
	C	652
	D	440.9

Source: Infrastructure at Risk (Procter, 2004)

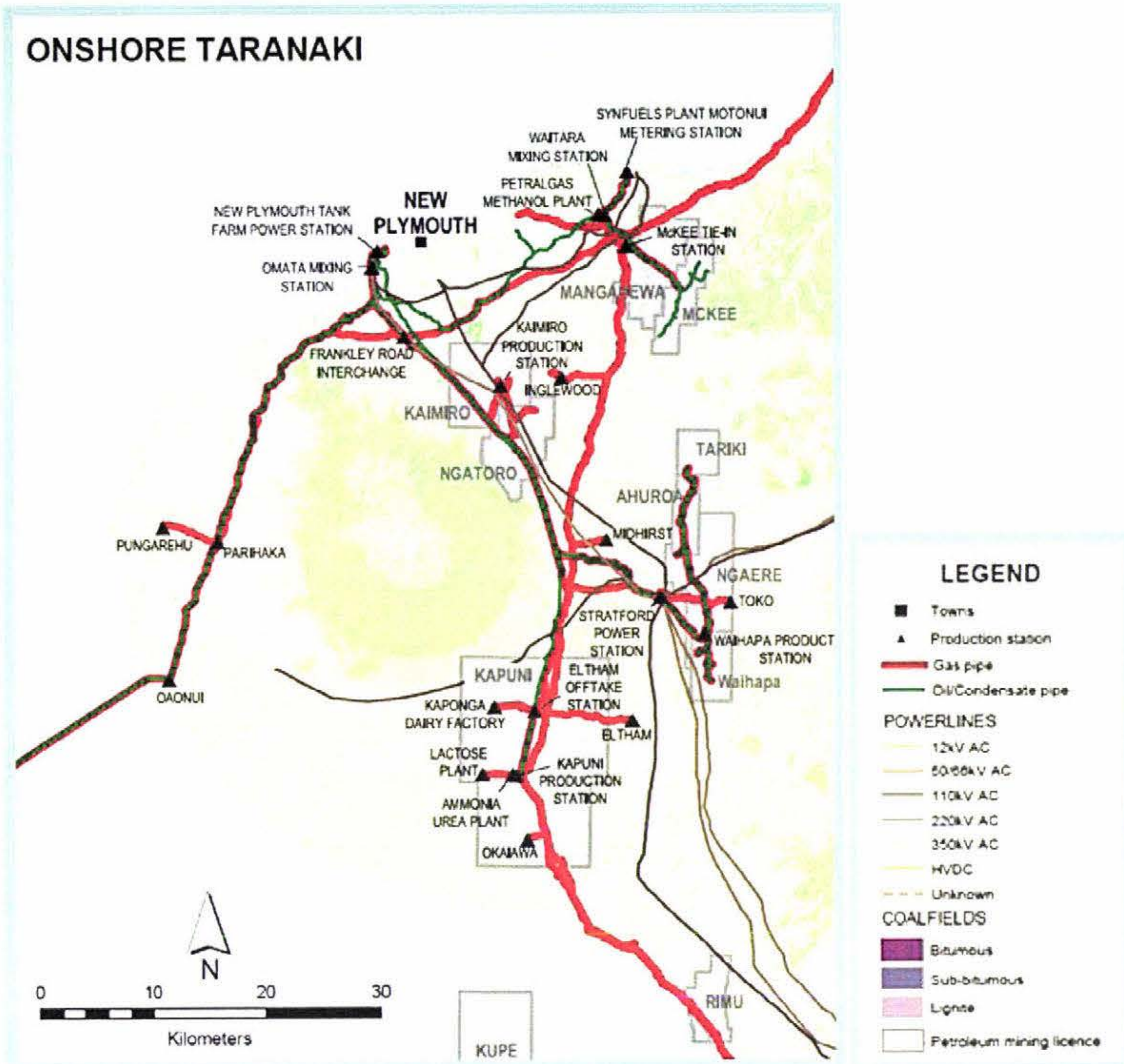
Marine

The location of Westgate port within the boundary of New Plymouth and protection of the Pouakai Ranges means the port facilities will be undamaged by ground hugging hazards but may experience ash disturbance and abrasion to facilities. Abrasion may have long term unseen consequences which can not be accounted for such as an increased propensity to rust. Secondary volcanic hazards such as a tsunami would have an effect on operations and facilities (Patterson, 1987). A description of the port activities is included in the iconic industries chapter. The port is a deep water port not a river port so lahars will not present any undue problems.

10.3. Energy

There is a lot of high level energy infrastructure in Taranaki due to the numerous gas pipelines and the multitude of high voltage power lines. The following figure provides an overview of the gas and electricity systems.

Figure 19: Taranaki Energy Transmission Infrastructure



Source: Crown Minerals, 2006

Electricity

There are two power stations located in Taranaki and a number of cogeneration systems, this makes the local electricity network more complex than simple transmission and distribution lines. The electricity network is made up of a system of substations, transmission and distribution lines, protection and isolation equipment. Low voltage distribution lines deliver to households while the high voltage transmission lines in the TransPower network transmit power between substations and power stations on the national grid. The Stratford substation is the most critical point in Taranaki's electricity network, damage to it or the distribution lines from it can seriously isolate the entire region.

The high voltage electricity network in Taranaki is made up of eight TransPower substations located in New Plymouth, Carrington St (NP), Huirangi, Motunui, Opunake, Stratford, Hawera and Waverly.

There are numerous low voltage zone substations and distribution transformers through the region as well, predominantly in urban areas.

New Plymouth hosts an operative power generating station (although the station is currently out of commission) which in normal circumstances is distributed for use through Stratford. In an emergency situation the New Plymouth power station may operate in an island mode to exclusively feed the local network without requiring co-ordination with the national grid through Stratford. This supports New Plymouth remaining occupied through any event although the turbines must be operative before external power is lost (transmission lines through Stratford); external power is required to initiate generation as a black start is not possible.

In small eruptions supply outages in the electricity network are most likely due to insulator flashover when ash exceeds 10mm in depth (Auckland Regional Council, 1999). Wet ash is conductive and can potentially disrupt entire networks due to insulator flash-over, voltage fluctuations, shortage/outages, or line breakage due to weight loading. The level of impact can be influenced by weather conditions, particle size, adherence, type of insulator and voltage. Light rainfall or no wind after or during an eruption is the most damaging to the network, heavy rain and wind will simply wash ash off equipment and can actually be beneficial to cleaning requirements.

Prompt cleaning of substations is recognised as the most effective protective measure against flashovers. If light rain occurs during or immediately after ash fall the chance of outages and flashovers increases significantly (Johnston, 1997). Low voltage networks are more vulnerable than high voltage as they are more expansive and have less protection measures in place. Controlled outages are required to clean all ash from equipment following an eruption by air brushing or hosing. Experience from the Mt St Helens eruption determined problems in low voltage areas and substations when wet ash exceeded 5mm. Significantly, Mt St Helens revealed that conductivity increased as particle size decreased. Areas further from the mountain experienced more flashover and outage problems than those within close proximity to the mountain (Johnston, 1997). Evacuation of inner Taranaki means short term electricity outages in close proximity to the mountain are not an issue, the areas remaining occupied are more vulnerable and at higher risk of damage.

After the 1995 Ruapehu eruptions electricity lines did not need any special cleaning as wind and rain cleared the lines before any problems were experienced. Substations did require special cleaning to clear ash from critical equipment however this did not incur additional cost as it was completed under normal maintenance schedules (B Hewitt, Personal Communication, 2006).

Gas

NGC is the operator of all high pressure gas transmission pipelines in the North Island, these pipelines link all production stations, major users and the wider North Island as shown in figure 13 and figure 14 (chapter 8.3). The following table identifies the NGC pipelines which are exposed in each recognised hazard zones and the associated levels of risk. Predominantly pipelines are below ground and relatively safe, some degree of ground deformation can be absorbed by the pipeline design.

Table 8: At Risk NGC Operated Gas Pipelines by Hazard Zone

Hazard Zone	Total Number of Pipeline Crossings	Pipelines at Risk (exposed / aerial crossing)
A	29	25
B	n/a	n/a
C	7	7
D	4	4
Total	40	36

Source: Infrastructure at Risk (Procter, 2004)

Gas pipelines are required to be laid at least one metre below ground making them less vulnerable to volcanic hazards. The infrastructure of the network located above ground will be vulnerable to direct and ash damages however this equipment will not affect the integrity of the gas pipeline. Above ground locations include main level valves, gate stations and compressor stations.

The Kapuni to Petrochem Valley extension of the high pressure gas pipelines contains many aerial pipeline crossings which support numerous pipes in each span, five of these crossings are at risk from lahars. A factor of Taranaki's gas monopoly is the significant downstream impact any disruption in supply could have on the national economy and social well being. There are presently no alternatives in either supply or fuel. The breakage of a single gas pipeline to the Hawkes Bay in February 2004 caused absolute disruption and the closure of factories completely unaffected by the initiating event (Cronin & Neall, 2004).

The domestic gas distribution network in Taranaki is operated by PowerCo, providing gas availability to the entire region. The network consists of 730km of distribution mains and approximately 20,700 gas customers (CDEM, 2004b).

10.4. Water Supply

Water supplies are the most at risk lifeline service with eight town water supplies and one rural water supply dependent on Mt Egmont catchments and as much as 95% of Taranaki water is obtained from surface water sources (CDEM, 2004b). New Plymouth surface water supply will be contaminated even though this area is not likely to be evacuated during an eruption, considerable planning and protection measures have been undertaken by the New Plymouth City Council to maintain potable water in New Plymouth during an eruption. If required water could be transported into the region by boat, or as a last resort the residents shipped out (B Raine, Personal Communication, 2005). Ground water from the region is typically of poor quality with low flow rates and as such will not be suitable as an alternative in the event of surface water contamination (Martin, 1999). Domestic water tanks are easily contaminated, regardless of distance from the mountain, if down-pipes are not disconnected from tanks prior to any ash fall. Water systems can experience excessive demand as residents attempt to clean up ash. Overwhelming demand will be felt by communities that receive even the smallest quantity of ash (Johnston, 1997).

Careful monitoring will be required of water supplies and water usage immediately following ash fall or reoccupation both within the region and surrounding communities. Water supplies and treatment facilities will already be vulnerable as a result of increased turbidity and contamination without increased demands on use. After the 1995 Ruapehu eruption Rotorua, 140km away from the mountain, almost ran out of water. Immediately following the first ash fall a resident hosed ash into a transformer which supplied electricity to the water treatment plant and pumps. Further efforts by residents to clean up the ash almost drained the supply and required a complete hosing ban until the situation could be resolved (Johnston et al, 2000).

The New Plymouth water treatment facility at Junction Road supplies to New Plymouth, Bell Block, Waitara, Tikorangi and Urenui with a maximum daily capacity of 44,000 cubic metres. Stratford water supply has a daily water capacity of 8,000 cubic metres. The South Taranaki water supply network is widespread with 14 different schemes supplying both residential and commercial users with a combined water capacity of 30,000 cubic metres (CDEM, 2004b).

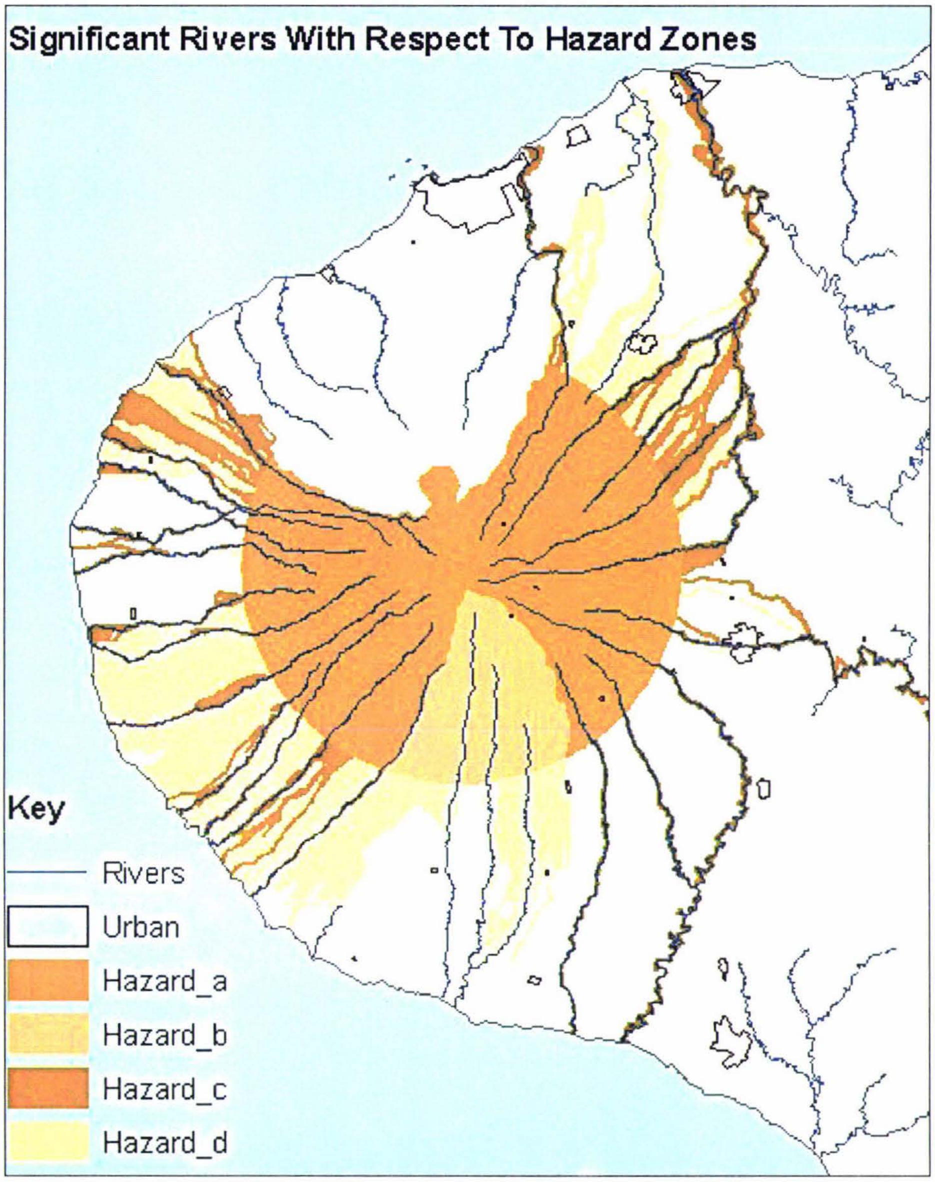
More than 300 rivers and streams radiate from the mountain supplying water to much of the region for drinking, irrigation systems, utilities and industrial factories (Martin, 1999). Rivers originating in the hill country are typically larger with many tributaries. These rivers will still be inundated with ash deposits even though they are not directly affected by lahars or debris flows, almost all rivers originating on the mountain will funnel lahars during and after an eruption. Ash or volcanic debris falling into water catchments increases turbidity and acidity (many of the chemicals emitted during an eruption are water soluble) contaminating water supplies.

The four main municipal water catchments are:

- Lake Mangamahoe and Waiwhakaiho River (New Plymouth and Waitara),
- Kapuni Stream (Hawera),
- Patea River and Konini Stream (Stratford)
- Ngatoro Stream (Inglewood)

(Martin, 1999).

Figure 20: Significant Rivers within Taranaki



There are many domestic water and rural water supply schemes in place around the mountain for smaller settlements. Closer to the mountain, pipe-work, uptake valves and pumping facilities may all be damaged by blockage, ground movement or debris. While pipelines are largely underground from extraction point through to water treatment plants the predominant risk is present where these pipelines cross streams. The following table 9 gives an indication of the aerial crossings that are at risk.

Table 9: At Risk Water Pipeline Infrastructure By District Council and Hazard Zone

Region	Hazard Zone	Total Number of Pipeline Crossings	Pipelines at Risk (exposed / aerial crossing)
South Taranaki	A	4	3
	B	9	5
	C	18	9
	D	102	33
Stratford	A	8	1
	B	n/a	n/a
	C	7	7
	D	1	1
New Plymouth	A	n/a	n/a
	B	n/a	n/a
	C	13	6
	D	39	5
Total	A	12	4
	B	9	5
	C	38	22
	D	142	39

Source: Infrastructure at Risk (Procter, 2004)

Aside from hydro electricity which returns water to the rivers, the use of extracted surface water from urban catchment schemes is distributed between the petrochemical and dairy industries 39%, domestic water supply 33% and irrigation 27% (Taranaki Regional Council, 2005b). Streams with their headwaters on the slopes of Mt Egmont have a number of water resource consents issued to commercial entities who independently draw their own water. Business operations for these firms will be significantly interrupted until water supplies are deemed to be safe for use, intakes cleared and any damaged equipment is replaced. These businesses include Fonterra's New Plymouth Cool-store, Taranaki By-Products, NGC Kapuni Gas Treatment, Ballance Agri-Nutrients, Fonterra Kapuni, Vickers Quarries, Winstone Aggregates, Egmont Tanneries, Stratford Power Station, Taranaki Abattoirs, Riverlands and Methanex (Motunui and Waitara) (Taranaki Regional Council, 2005b). In addition companies with independent extractions of water from the Wanganui hill country include Swift Energy (drilling and exploration), Shell Todd Oil Services, Fonterra Whareroa and Richmonds although the contamination in these rivers is likely to be lower (Taranaki Regional Council, 2005b).

Irrigation (of pasture, golf courses etc) is the next largest user of water, although these sites are scattered throughout the region. The economic impact of irrigation loss will not be considered given that normal rainfall in the area could maintain a degree of growth and the overwhelming impact of ash damage to pastures will present a greater threat. Adequate warning will allow irrigation activity to cease and the closure of intakes to prevent damage to internal mechanisms and pumps.

10.5. Waste Water / Sewerage

The predominantly rural population means that there are only two waste water treatment plants in Taranaki, in New Plymouth and Waitara (CDEM, 2004b); treatment plants are more vulnerable to physical damage than oxidation ponds. If ash remains suspended in water in the pipe system until the sewerage treatment plants increased wear and blockage may occur to screens, milliscreens, mechanical grit and sludge removal systems (Martin, 1999). The remainder of the region depends on oxidation ponds and soakage mechanisms which are less equipment intensive (CDEM, 2004b). Oxidation systems are still vulnerable but the recovery cost will be relatively less. The greatest threat to these systems is ash density increasing the solid waste in the system and compromising biological filters.

Much like water supply systems ash contamination in waste water systems is a significant problem, mostly occurring once clean up begins. Ash washed into drains accumulates easily and dries hard to create pipe blockages. When ash enters pipe systems in large quantities suspended particles drop throughout the system restricting flow and causing blockages, localised flooding and large clean up operations are then required to flush the pipe network to remove ash and clear systems (Martin, 1999). Vacuum trucks are sufficient to clean these systems if care is taken to reduce intake and they are not left to solidify for long periods. Prevention is the best solution.

It is hoped that the integrity of all sewerage systems is maintained in which case the level of ash entering the system will be minimised. If there are illegal connections, breaks in pipes or other malfunctions ash can enter systems and wreak havoc. The chemical nature of ash can destroy biological filters in sewerage systems rendering them useless and halting the oxidation process. In a worst case scenario raw sewerage will need to be pumped directly into local streams and rivers as the process is compromised.

11. Small and Medium Enterprises

Small and medium enterprises (SME) represent the largest number of businesses by far in Taranaki, including all businesses, communities and the agricultural sector. The agricultural sector in particular can expect long term consequences due to land damage and stock losses while small businesses and communities will be influenced by evacuation and delays in return to business as usual.

Agricultural output is still an important consideration in the New Zealand economy, in 2004 agriculture alone contributed $6,095million to GDP, the entire industry through to processing contributes approximately 20% of annual GDP (MAF, 2005b).

Expected losses to SME's may be experienced due to stock loss, halted milk production or pick-up interruption, pasture loss, damage to plant, equipment and buildings, loss of land and access issues. These impacts expected in volcanic activity are all similar to that of serious flooding such as that experienced in the lower North Island in 2004. In the five months to June 2004 year the Manawatu February floods were estimated to have caused total gross output or production losses of $223.26million, $117million of this was direct loss associated to the flooding and the remainder indirect flow on effects. The following year to June 2005 ongoing total gross output loss of $99.42million was calculated, including a direct production loss of $50.80million (Vision Manawatu, 2004). It is believed agricultural production will return to pre-flood levels in 2006, an ongoing effect of two years. In addition to the regional effects, it was estimated that the national impact was $23.85million due to linkages outside the region. In this case the overall regional impact was limited due to the success of the recovery assistance and injections into the economy (Vision Manawatu, 2004).

11.1. Communities

Three districts make up the Taranaki Regional Council - New Plymouth, Stratford and South Taranaki. The area is not hugely populated with just two main settlements in New Plymouth and Hawera; provincial centres that support the rural community are located in Stratford, Opunake, Waitara and Inglewood. Hawera and New Plymouth are the largest towns, supporting the most tertiary services and the only two hospitals of the region. Stratford, Waitara, Manaia, Opunake, Inglewood and Eltham are satellite towns which support the wider rural population. There are smaller medical centres in Stratford, Patea, Opunake, Waitara and Mokau. There is only one professional fire station in the region located in New Plymouth, the remaining sixteen fire districts and two auxiliary units are supported by volunteer fire brigades (CDEM, 2004b). Throughout Taranaki there are nine community police stations (with two central commands), nine Ambulance services and three medical emergency response teams. These community services are vital to evacuations, reoccupation of the region and the beginning of economic recovery. Without such social supports there is no basis to drive recovery.

Taranaki is predominantly rural in nature with a low population density; the smaller rural towns have a moving population towards New Plymouth further diminishing population density in rural areas. In the 2001 Census Taranaki's resident population was 102,858 people in 38,505 households, accounting for only 2.8% of total New Zealand population (Taranaki Regional Council, 2004c; Statistics New Zealand, 2005). The population within the region is unevenly split between the three districts of New Plymouth (66,603), Stratford (8,883) and South Taranaki (27,537). The median income of residents in the region is slightly below the national average at $17,300 (Statistics NZ, 2005).

Taranaki has a higher rate of dependency (defined as those who are under 15 or over 65) than New Zealand as a whole, 37.9% and 34.8% respectively. Nationally 22.7% of the population was under 15 in 2001, compared to 23.7% in Taranaki; the population over 65 represents 14.2% compared to the national rate of 12.1% (Statistics New Zealand, 2005). The average household in Taranaki is 2.5 people, slightly lower than the national average.

Evacuation comes with a social cost - stress, trauma and personal loss is experienced by all of those whose life is interrupted. Volcanic eruptions are often ongoing, sporadic events that may have long calm periods in between eruptive episodes. Evacuation, reoccupation and recovery planning is therefore difficult in advance and particularly stressful for residents (Patterson, 1987). Demand for all healthcare services can be expected to increase dramatically. Long term evacuation and suspension of business as usual creates problems such as how to deal with animals, mortgages, schools for children and resettlement. There are so many uncertainties when evacuation is at such a large scale, these factors will discourage evacuation by residents who believe they will be disadvantaged or face undue pressure.

New Plymouth faces the threat of being stranded by lahars during an eruption by destruction and damage of transportation networks. If during an eruption the area is deemed to be unsafe or if water supplies are contaminated the only means of evacuation may be by sea. Similarly restocking of supplies, should the area remain occupied, is most likely to be by sea. Evacuation of New Plymouth is not considered but would present enormous logistical and financial problems.

In an evacuation of this potential size, evacuees would be accommodated wherever they can be taken, in motels, private houses, hostels and temporary shelters. In these circumstances costs will vary considerably between groups and regions depending on capacity and availability. Work and Income New Zealand (WINZ) has an established reimbursement framework for these costs for the evacuees (M Harrison, Personal Communication, 2005). These figures are not incorporated in the final analysis as they represent a transfer payment as opposed to a true cost. It is acknowledged that these figures will grossly underestimate the cost of evacuation as it excludes travel cost, lost incomes and any direct costs in excess of the maximum reimbursement (predominantly while in motels) they are representative of the expense of evacuation.

Table 10: WINZ Payment Rates for Accommodating Evacuated Persons

In Billeted Accommodation		
Evacuee	*Maximum Weekly*	*Maximum Daily*
Single Adult	127.00	18.14
Couple	208.00	29.71
Child	63.50	9.07
In Paid Accommodation		
Evacuee	*Maximum Weekly*	*Maximum Daily*
Single Adult	665.00	95.00
Couple	665.00	95.00
Couple / Single Parent +Child	840.00	120.00

Source: Mark Harrison, Horizons Regional Council, 2005

Assuming all residents within the red and blue zones will be evacuated in line with Civil Defence policy, this is 39,491 residents that will need to be housed and accommodated outside the region. In estimating the cost of housing evacuees it is assumed that 25% will stay in paid accommodation and 75% will be housed in billeted accommodation, either with friends and family or as part of emergency housing. To correspond with WINZ reimbursement rates the percentage of these evacuees classed as children is 24% (adopted from the dependency rate within the region, 23.7% of Taranaki's population is under the age of 15) and each chid has one parent. The cost to house evacuees is thus $15million, calculated as below:

Children in paid accom.	((39,491 x 0.24) x 0.25) x 840 = 1,990,347
Adults in paid accom.	(((39,491 x 0.76) – 9,478) x 0.65[18] x 0.25) x 665 = 2,219,080
Children billeted	((39,491 x 0.24) x 0.75) x 63.50 = 451,382
Adults billeted	((39,491 x 0.76) x 0.75) x 127 = 2,858,754
Weekly Evacuation Transfer Payment	$7,519,563
Daily Evacuation Transfer Payment	$1,074,223

[18] This 65% accounts for couples in the calculation, 30% of the adult population are assumed single. Each child was assumed to have a single parent to account for multiple children

Using these figures the estimated transfer cost of evacuating the red and blue mandatory Civil Defence zones is in excess of $1million a day. When also considering the lost incomes and personal costs to residents the effect of an evacuation order is enormous, decisions are heavily weighted by consequences should the wrong decision be made. Specific prearranged evacuation plans based on the independent and neutral alert levels from IGNS are important to ensure that a decision is supported, justified and not skewed because of public pressure.

11.2. Small Business

Businesses may be disrupted in any number of ways during volcanic activity either through enforced closures from infrastructure loss, or evacuation, contaminated merchandise, reduced business activity, building damage, absent employees or distribution problems (Johnston, Nairn et al, 2000b). One of the key factors in economic stability or economic growth is confidence; confidence in security and in the outlook of a region (Johnston, Nairn et al, 2004). Business confidence will be greatly affected by indication of future volcanic activity. On going risk may also lead to escalating costs, increased insurance premiums or even the cancellation of policies.

The following table provides a breakdown of industries in the region in terms of number of employees and number of enterprises. New Plymouth, with the exception of agriculture, is the most significant location in each industry in line with populations and settlement. Property and business services incorporate the most individual enterprises although retail trade is the largest regional employer (Statistics NZ, 2005c). Together wholesale trade and retail trade generate $900million in total output, combined property and business services contributes $1,000million to output (Hughes, 2006).

Table 11: 2004 Taranaki Enterprises and Employees by ANZSIC Code and District

ANZSIC Industry	New Plymouth		Stratford		South Taranaki	
	Enterprises	Employees	Enterprises	Employees	Enterprises	Employees
Total Industry	5149	26680	715	2150	1894	9740
Agriculture, Forestry & Fishing	187	270	74	45	210	170
Mining	25	510	3	3	4	270
Manufacturing	385	3740	50	180	116	4090
Electricity, Gas & Water Supply	9	340	2	15	9	20
Construction	588	1810	64	140	144	490
Wholesale Trade	259	1430	26	110	59	320
Retail Trade	683	4100	91	470	232	1100
Accommodation, Cafes & Restaurants	174	1690	27	100	66	270
Transport and Storage	172	1030	19	140	48	240
Communication Services	82	350	7	9	8	12
Finance & Insurance	134	430	10	45	52	100
Property & Business Services	1625	2950	239	140	674	700
Government Admin & Defence	22	580	6	140	7	220
Education	118	2120	26	260	67	650
Health & Community Services	295	3740	24	230	70	680
Cultural & Recreation Services	153	630	25	50	60	180
Personal & Other Services	238	960	22	65	68	210

Source: Statistics New Zealand, 2005c

Each industry can also be measured in terms of the (modelled) total output contributed to the Taranaki regional economy. Manufacturing is the largest individual sector contributing 31.5% of total regional output, with fewer larger enterprises. This breakdown of output by industry emphasises the importance of natural resources within the region, although representing only 3.3% of employees the Agriculture and Mining sectors contribute 39.16% of output. It should be noted that the agricultural sector in particular is skewed towards more owner/operated business structures and fewer employees than other sectors.

Table 12: Taranaki Total Output, Employment and Enterprises by ANZSIC Code

ANZSIC Industry	Enterprises	Employees	Total Output ($m)
Agriculture, Forestry & Fishing	466	500	2272.00
Mining	30	780	3761.78
Manufacturing	537	8020	4849.53
Electricity, Gas & Water Supply	16	370	491.62
Construction	786	2420	605.74
Wholesale Trade	331	1860	470.39
Retail Trade	977	5690	428.13
Accommodation, Cafes & Restaurants	265	2080	123.54
Transport and Storage	234	1380	331.46
Communication Services	95	370	114.72
Finance & Insurance	176	590	130.71
Property & Business Services	2515	3790	1001.45
Government Admin & Defence	24	930	216.34
Education	202	3040	155.54
Health & Community Services	374	4640	287.23
Cultural & Recreation Services	237	870	105.35
Personal & Other Services	317	1220	62.04
Total	7582	38540	15407.58

Source: Statistics New Zealand, 2005c; Hughes, 2006.

Iconic industries have been discussed in detail earlier; an additional significant industry is the regions meat processing capability. Taranaki supports several large meat processing facilities, including Riverlands in Eltham, Richmonds in Hawera and Tegal in Bell Block. All factories will be affected by a loss of stock supply from within Taranaki however if they still have operating capability some shortfalls could be met by animals from outside the region. The Hawera and Bell Block factories are unlikely to experience any direct or ongoing damage; this can not be said for the Eltham factory which is situated within both the direct hazard zone D and ash zone B. The meat processing industry in Taranaki is calculated as contributing 1,783 FTE jobs and $788.68million in output while poultry processing contributes 282 FTE jobs and $120.99million in output, both significant sectors in the regional economy.

The Riverlands processing facility employs around 540 people, an additional smaller Riverlands plant is located in Bulls, Rangitikei and may be able to temporarily increase production to cover closure in Eltham. The company as a whole (part of ANZCO) processes over 200,000 beef animals a year – more than 50,000tonnes of meat and several thousand tonnes of hides (Port Taranaki, 2005). Most of the meat is exported through Port Taranaki, reliant on road access between Eltham and New Plymouth.

The increasing trend towards just in time inventory ordering and the efficiency of delivery systems increases the vulnerability of all businesses in both receiving goods and making deliveries should something go wrong. The just in time formula for inventory ordering is made up of the lead time between placing and receiving orders and the average demand (Tim Ryan, Personal Communication, 2006).

Just in time Re-Order Point = (Lead) x Demand / 365

This formula, in conjunction with information obtained from Bev Raine, estimates that critical stock levels for businesses (and community shortage) in New Plymouth will begin after just 3 days. This is a much aggregated estimate as normal demand conditions are unlikely; some firms will experience huge increases in demand while others will experience complete loss of demand. Within New Plymouth there are only 3-5 days food supplies on the shelves given normal demand (B Raine, Personal Communication, 2005).

Many after effects of an eruption will be positive – almost all 'trades' will receive a boost in economic activity as mechanics, builders, electricians and the like will be required to repair and replace damages. Emergency services personnel and utility workers will be expected to work overtime and some manufacturers are likely to face increased demand. With that said, tertiary or luxury goods suppliers are likely to see huge reductions in demand and some businesses will be required to shut due to overwhelming damage. Evacuations will close businesses and slow demand until reoccupation is complete.

11.3. Agriculture

The intensity of farming in the New Zealand rural sector means that even a minor eruption will have a significant impact on all aspects of the farming community. This was highlighted by the minor eruptions from Ruapehu in the mid nineties which identified the lack of information on volcanic risks and potential rural impact. New Zealand lacks institutional guidelines and contingency plans for agriculture should a major event take place. A MAF commissioned report sought to rectify some of these shortfalls and provide a template for future planning, however long term impacts and recovery rates in an agricultural environment are still largely unknown. Especially given the variation in economic impact depending on time of year, stage of production and farming type.

Table 13 provides an overview of livestock in the region in terms of animal numbers and farms (where the stock listed is the mainland use). The main other economic land uses include forestry and horticulture. Total land in Taranaki is approximately 725,600ha of which 414,400ha is employed in pastoral farming and 18,651ha is planted in commercial forestry. Indigenous forests occupy the next largest land area of 229,800ha. Taranaki undertakes very little commercial cropping or even summer fodder crops, the climatic environment is highly conducive to pasture growth, pasture oriented farming and minimal supplementary feeding (MAF, 2004).

Table 13: Characteristics of the Taranaki Agricultural Sector – Farms by Type and Stock Numbers

Taranaki	New Plymouth		Stratford		South Taranaki	
As At 30 June 2002	Farms	Stock	Farms	Stock	Farms	Stock
Dairy Cows	840	182546	440	96372	1400	373213
Beef	670	43164	300	36425	680	55030
Sheep	320	185700	210	238736	320	329118
Deer	-	4068	-	2090	-	4604
Pigs	80	4877	30	-	55	-
Goats	-	3608	-	2377	-	474
Horses	-	1015	-	402	-	1002
Poultry	-	3906971	-	-	-	-

Source: Statistics New Zealand, 2005b; MAF, 2005d

Consistent rainfall in Taranaki means that unlike many modern farms around New Zealand (particularly dairy); the region has only limited land under irrigation (2,941ha or less than 1%). This irrigation is predominantly located in South Taranaki, 1,867ha for use in dairy farms, the remainder is split between New Plymouth, 959ha and Stratford, 129ha (MAF, 2005b). Irrigation is a large investment for farms and is vulnerable as ash damages and blocks the system either in falls or through the water intake.

Taranaki horticulture is insubstantial compared to total New Zealand supply, still the mixed horticulture and cropping sectors contribute an estimated $106million to output (MAF, 2005; Hughes, 2006). Other regions are likely to experience more economically significant damage to horticultural products than Taranaki itself from ash fall, the Ruapehu eruption in 1995 destroyed the annual cauliflower crop in Gisborne, while other crops, even those considerably closer to the mountain were unharmed (IGNS, 2005). This kind of random distal damage cannot be incorporated into pre-emptive assessments of economic risk even though they are a possibility. This is just one of the many difficulties in estimating impacts of events that have not yet occurred, particularly towards agriculture where timing plays such a critical factor towards economic cost. Horticulture is, by both national and regional standards, insignificant with only 433ha employed in this way (predominantly around New Plymouth). Land that is used in horticultural pursuits is focussed towards long term crops such as kiwifruit (47ha), avocadoes (52ha), olives (12ha) and asparagus (125ha) (MAF, 2004, 2005; Statistics NZ, 2005b).

Forestry in Taranaki is predominantly in the hill country but is not overly important, with only 18,651ha throughout the region and contributing $34million in forestry to the local economy (NEFD, 2005; Hughes, 2006). Stratford has the most established plantation with 6,560ha with an average age of 14years. New Plymouth has an average age of 11.98 over 2,965ha and South Taranaki has 9,126ha averaging 10.92 years (NEFD, 2005). The supporting services and logging contributes an additional $13million to the local economy (Hughes, 2006). Impacts considered do not include secondary fires and any trees knocked over in an eruption that are deemed unrecoverable, unlike the Mt St Helens forests which were largely recovered. New Zealand forestry plantations are characterised by steep hills which make access difficult, recovery dangerous and usually uneconomic. New Zealand conditions promote 'sapstain' when trees are left on the ground for more than a week, sapstain results when organisms and warm temperatures stain and destroy the value of the wood. Very little of the 1,500 hectares completely flattened during the 2004 Manawatu floods were recovered.

Dairying dominates land-use in Taranaki with 2,006 herds, 492,486 milk producing cows and more than 174,594 effective hectares employed in dairy farming in the 2004/05 year (LIC, 2005). Taranaki accounts for 12.7% of the country's dairy cows, although the herds are marginally smaller than the national average there are proportionately more of them than in other regions. The stocking rate in Taranaki is higher with 2.86 cows per hectare compared to 2.78 nationally with South Taranaki being the most dairy intensive district in New Zealand. The dairy farming sector is one of the largest sectors in Taranaki, the input-output model estimates total output equal to $1,809million. In the 2004/05 year the dairy company payout was $4.58 per kg/ms, when adjusted for inflation this is an increase from the low of 2002/03 but still well below the highs of 2000/01 (LIC,2005). All farms are currently experiencing huge growth in land value, whether sustainable or not the average price per hectare of dairy land in Taranaki was $18,666 in 2004, the fifth consecutive year on year increase in value. Lower payouts have seen some farms exit the dairy industry to pursue subdivision or alternative farming options; three quarters of those exiting the market retain ownership of the farm. If payouts continue to decline more farms can be expected to exit especially while land prices continue to rise (MAF, 2004).

One of the most vulnerable times for dairying is throughout the milking season (approximately August to June depending on farm) as this is the main income earning period for farms and disruption can stunt an entire year's income. Calving typically starts at the end of July and peaks mid August (LIC, 2005).

As part of MAF monitoring, annual financial assessments are made for farms with similar land and production characteristics, representing typical return for land farmed in any one year using current prices and seasonal statistics (MAF, 2004, 2005). These models are used to give an indicative base year return for farmers in Taranaki and also the average capital value of infrastructure on farms. Availability of data has resulted in some discrepancy in years compared but these are matched as closely as possible.

The predominant agricultural land use within Taranaki, dairy farming, is included with lower North Island farm estimates[19], all of who supply to the Fonterra factories of Pahiatua and Whareroa. Average farm size in 2004/05 was 90 effective hectares and 240 cows. This closely corresponds to the actual LIC figures where average herd size equates to 245.5 cows and farm size 87ha. Given these assumptions each average dairy farm in Taranaki is as follows in table 14. Dairy farm sizes throughout the lower North Island continue to trend upwards with fewer larger herds (MAF, 2004).

Table 14: 2004/05 Financial Value of an Average Taranaki Dairy Farm

Average Dairy Farm Financial Value in Taranaki 2004/05		
Item		
Total Milk Solids (kg)		72,000
Milk Solids Revenue ($)	$/kg/MS @ 3.86/kg	277,920
Gross Farm Revenue ($)		300,708
Net Trading Profit ($)		72,804
Assets		
Farm and Buildings ($)		2,200,000
Plant and Machinery ($)		71,500
Stock Value ($)		236,050
Dairy Company Shares ($)		418,215
Total Capital Value ($)		2,925,765

Source: MAF, 2004

Calculated in this manner the value added to the region from dairy farming is $603.22million (assuming the 2,006 herds and value added as inferred by gross revenue, 300,708 x 2,006 = $603,220,248). Total tangible capital infrastructure for the region associated with dairy farms is $5,030.15million (2,507,550 x 2,006 = $5,030,145,300), this figure excludes dairy company shares because shares may be transferred or suspended but will never be lost to the economy as physical assets may be.

[19] Includes Manawatu, Horowhenua, Wairarapa and Southern Hawkes Bay

Taranaki sheep and beef are classified as central North Island hill country[20]. Sheep and beef farming in Taranaki tend to be on the less productive hill country to the east of the mountain. The MAF modelled average farm for the Central North Island hill country is 550ha which supports 5,499 mixed stock units. Sheep and beef farms are a lot more complex than dairy receiving revenue from a variety of stock types and many different markets, revenue can vary depending on the precise stocking ratios and strategies of individual farmers. The MAF 'average' farm is being considered absolute for the purposes of this estimate.

Table 15: 2004/05 Financial Value of an Average Taranaki Sheep and Beef Farm

Average Sheep and Beef Farm Financial Value in Taranaki 2004/05	
Item	
Gross from Sheep ($)	170,527
Gross from Cattle ($)	90,688
Wool ($)	44,693
Total Gross Farm Revenue ($)	305,908
Net Trading Profit ($)	104,563
Assets	
Farm and Buildings ($)	2,200,000
Plant and Machinery ($)	59,343
Stock Value ($)	531,552
Total Capital Value ($)	2,790,895

Source: MAF, 2004

Mean land prices for sheep and beef farms are considerably lower than that of dairy however farm size is much larger. Capital equipment is also less intensive for this sector and the stocking rate considerably higher.

A realistic number of farms involved in sheep and beef has not been found from within Statistics NZ or MAF documents, using the 2002 agricultural production census level of stock (888,173 from table 13) the number of farms has been obtained by applying the average stocking rate from the MAF model. This determines a number of farms as 162 (888,173/5,499) and a probable 89,100ha employed in sheep and beef farming (162 x 550) (MAF, 2004; Statistics NZ, 2005b). The total value added for sheep and beef farming, calculated using gross revenue as a proxy, equates to $49.56million (305,908 x 162 = $49,557,096). Input-output estimates determined the total output from sheep and beef as $176.94million. Total capital infrastructure associated with farms involved in sheep and beef is $452.12million (2,790,895 x 162 = $452,124,990).

[20] This area also includes Ruapehu, Taupo, Wanganui and Rangitikei districts

Heavy ash falls would have many long term consequences, however even small ash falls will present problems for livestock. Ash contamination of pasture and water supplies will require increased feeding out and monitoring, ingestion of large quantities of ash even in light falls when stock must close-crop pasture can be fatal. Fluorine leaching and absorption appear to be the most significant chemical threat of ash to livestock, followed by sulphur (MAF, 1998). Fluorine poisoning becomes fatal when it exceeds 250ppm. In the 1970 Hekla, eruption in Iceland over 7,500 ewes and lambs were killed due to poisoning of pastures (Gregory & Neall, 1996). The range of damage to the agricultural sector could include stock and pasture loss, milk loss, land damage, damaged farm infrastructure, buildings and equipment and damage to infrastructure preventing reoccupation and access (Vision Manawatu, 2004).

There is little historic data on the effects of tephra and ash on land which is intensively farmed, although the 1980 Mt Saint Helens eruption is the primary case study used, there have been few large recent eruptions to compare impact. The impact on agriculture, not accounting for continued volcanic activity, can be influenced by ash type, consistency and depth, chemical components, time lag until rainfall, wind direction and speed, nutritional demands and age of livestock at the time and pasture length (MAF, 1998, p iii). Horticulture, cropping and forestry are influenced by the time of year and life cycle of the plant; even minimal levels of ash at the wrong time can significantly reduce output (Patterson, 1987). Acidic ash, acid rain or water contamination can all contribute to poor fruit yield, blossom drop and reduced size and quality of food crops, in most cases damage will be random over all areas where ash has fallen lightly and severity will depend on the time lag until rainfall. The impact on plants and agriculture is predominantly determined by ash thickness (MAF, 1998). Appendix one provides a standardised table of potential effects for varying ash thickness. When ash fall is not too deep it can be incorporated into soil by plough or harrow to enable rapid decomposition and cultivation back to previous use. Alternatively at greater depths ash can be formed into ridges with crops or trees planted between the rows in the base soil. Small concentrations can actually be beneficial on heavy and clay soils as it aids absorption and drainage when mixed in.

After the devastating February 2004 flooding in the lower North Island issues were raised regarding the need for more comprehensive farm insurance to be available. The physical and financial impacts from an eruption will be the same or similar as that from flooding with the exception of time lags and recovery expectations, under insured property is likely to be a reality. Whilst natural disaster insurance is available from crops and seasonal harvests it is rarely obtained and is typically limited to just $20,000; infrastructure such as buildings and machinery are usually the only aspects insured (Sutton, 2004). While flooding, and most other natural disasters have a distinct timeframe and duration a volcanic eruption may continue for any length of time, influencing the degree of insurance cover and the definition of an 'event'.

If indicators suggest a significant eruption is impending farmers are still faced with hard decisions. To evacuate a farm, let alone an entire region of livestock is a mammoth and time consuming exercise. The confidence that an event is actually going to occur, will occur imminently and will extend to the farm in question is a highly subjective call by each individual without specific volcanic knowledge (Johnston, Nairn et al, 2004). Even if the decision is made to evacuate stock the problem remains where to remove stock to; most farms in New Zealand run to peak carrying capacity and would find it difficult to absorb large numbers of additional stock. Freezing works are equally unlikely to have the capacity to accept wholesale de-stocking of farms. Both of these scenarios are tightly constrained by the degree of transportation for such large scale stock movement.

12. Input – Output Analysis

Input-output analysis is being used to consider an overall effect on the economy from volcanic activity. Such analysis allows the incorporation of both iconic and smaller businesses and agriculture in a single analysis and to determine flow on effects from direct damage. The previous discussions of iconic businesses in chapter eight provide detailed information regarding the most significant industries in the local economy, specific details about these sites and their activities and how they influence the wider economy. The input-output analysis incorporates direct damages and flow on effects from these larger businesses on the economy in conjunction with smaller enterprises to provide a total business disruption effect to Taranaki. Total economic impact from an eruption is thus defined as the business disruption effect (input-output) measured using value added.

The input-output (general equilibrium) model represents for a given year the level of inputs required from each sector to produce a given output, quantifying the total labour and capital inputs required for a specific level of production. An inter-industry study provides an economic statement of the industrial structure of the economy for a given year. The key variables looked at when considering growth, or decline in an economy due to a given event are total output, net household income, fulltime equivalent employment and the level of value added in the system (Vision Manawatu, 2004). Value added, the net benefit of activity in a region, is the most important variable considered in this event as it allows the comparison with value added figures previously discussed for iconic infrastructures.

The term 'value added' has been referred to throughout this report. The concept as a whole is also known as gross domestic or regional product (GDP/GRP) and represents the value of output produced within a geographical region. In accounting terms value added is represented as operating profit, the improvements by a firm after direct costs of transforming the good have been removed (Venture Taranaki, 2004). Total sales represent an accurate measure of economic value in an economy but can be distorted by large one off imports of goods whereas value added best represents the true gain to the economy.

The all encompassing nature of a general equilibrium model accounts for the multiplier and indirect effects of an increase or decrease in demand. This is due to one of the foundation principles that employment (demand) by any one sector must be met by another sector which in return requires its own alteration to demand and employment levels. Both forward (output used in other sectors) and backward (required inputs) linkages are present and create multiplier effects.

The 114 sector input-output model used in this report was developed by Warren Hughes at Waikato University with data originating from Statistics New Zealand for the 1995/1996 time period, updated to 2005 prices to reflect productivity gains, inflation and GDP growth. Each of the 114 sectors incorporates transactions that occur within other sectors in forward and backward linkages in order to produce the level of output in each period. Taranaki's base economy for the year ending March 2005 is modelled to 43,860 full time equivalent employees and total output of $15,407.58million. Gross regional product is $6,480.9million including exports from the region which outweigh imports by more than $3billion. Net household income is $1,523.4million.

The scenario analysis used in this report creates an overall impact on each industry sector in three ways, the effect of evacuation, volcanic specific damage and recovery benefits. Together these three aspects will produce either a positive or negative effect on the economy. The input-output assessment used looks only at a single period of damage. While this would be adequate in smaller events which do not impact on future periods this fails to account for long term damages. Currently in theoretical development is the concept of an event matrix. When incorporated into the matrix framework of input-output this can spread effects and recovery over an extended timeframe.

Each scenario is modelled within the input-output framework, a direct output loss is determined and then incorporated into the model which determines indirect and total effects of any event. The direct output loss (or gain) is calculated in this study by combining three aspects – evacuation, eruption specific, and recovery. Evacuation effects consider only the loss in output associated with the withdrawal of labour, the temporary cease in output activities because the workforce has been shifted. Eruption specific effects take into consideration the physical influences which reduce output. This is the loss in output that relates directly to eruption specific hazards, resource loss, safety considerations or direct physical damage. The final recovery factor is a subjective percentage which takes into account those industries that traditionally benefit during recovery activities and rehabilitation stages, primarily the trade or service providers.

When these three factors are combined (recovery is subtracted from the overall loss) a total scenario impact, and direct output loss is calculated.

Evacuation must be incorporated into the volcanic eruption effects on the regional economy as businesses are forced to close when evacuation commences. By determining the proportion of people evacuated from each territorial authority and assuming even distribution of these workers amongst industries the proportionate industry effect can be identified. The evacuation zones, as identified in Figure 9, are split into red, blue, orange and yellow with population in each of these zones identified by Civil Defence using the 2001 census data, shown in table 16. In this analysis only the red and blue zones are considered to be evacuated in line with the higher probability of smaller eruptions. Evacuations from the red and blue zones are deemed to be mandatory and will be enforced in an eruption of any size, Civil Defence planning, by requirement, must take into account the possibility of rare catastrophic volcanic events in evacuation planning and enforcements.

Table 16: Evacuation Rates from each Territorial Authority within Taranaki (2001 Census population)

District	Population in Each Evacuation Zone				Total District Population	Enforced Rate of Evacuation from Red and Blue Zones (%)	Adjusted Evacuation Rate (%)
	Red	Blue	Orange	Yellow			
New Plymouth	3621	14532	2352	46876	67381	26.94	50
Stratford	1398	7233	915		9546	90.41	100
South Taranaki	369	12338	16644		29351	43.29	50
Total	5388	34103	19911	46876	**106278**	37.16	

Source: Taranaki Regional Council, 2004, p 7

The difference between the Civil Defence enforced evacuation rate and the adjusted evacuation rate (both shown in the above table) which will be used in this analysis is justified for a number of reasons. The orange zone is assumed to incur some evacuation but not as a mass group, particularly as eruption size increases. As this area is on the eastern side of the mountain they are at risk from contaminated water supplies, possible service failure and inundation by ash – systematic evacuations of this area will take place as and when required dictated by conditions and potential threat. The red and blue zones are guaranteed to be evacuated irrespective of eruption size however compulsory evacuation from these two zones does not prohibit voluntary evacuation by residents from any other point in the region. Higher evacuation estimates includes those people who choose to make voluntary evacuations from places like New Plymouth or Hawera. Evacuated numbers will never fall below the residents of the red and blue zones but are almost guaranteed to increase as the eruption dictates, this requires an elevated adjusted evacuation rate to be used in calculations.

Two weeks of evacuation, as assumed in scenario one equates to 4% of the years production (2/52=0.04), the five weeks of scenario two's evacuation equates to 10% of annual production and the twelve weeks assumed in scenario three to 23%. Industry output will decrease relative to the number of employees from each territorial authority, length of evacuation and the evacuation rate. The evacuation rate calculated for each industry in each scenario allows a direct impact for all industries in the input-output table as a result of emergency evacuation. This accounts for the fact that almost all businesses will cease during evacuation due to insufficient staffing and safety issues.

The workings are best described by looking at the table of workings, an extract of which is shown below. The 114 sectors are grouped by ANZSIC codes at the two digit level with employment rates and number of enterprises known for each ANZSIC class and territorial authority. Variation within each ANZSIC class is unlikely and will be insignificant to the final outcome. To obtain a higher degree of accuracy the employees evacuated figure, breaks down employees and enterprises by territorial authority to obtain the regional impact. Incorporating industry employment and evacuation rates for each territorial authority (district) the evacuation impact by industry for the region as a whole was calculated using the following process.

For example in ANZSIC class A02 the total enterprises and employees are the sum of South Taranaki, New Plymouth and Stratford enterprises and employees.

Table 17: Extract of Underlying Enterprise and Employment Data by Territorial Authority

	New Plymouth District		Stratford District		South Taranaki District		Sum	
	Enterprises	Employees	Enterprises	Employees	Enterprises	Employees	Enterprises	Employees
A02	104	220	44	40	110	130	258	390
A03	65	35	28	6	97	40	190	81

The employees evacuated are then calculated with the adjusted evacuation rate:

Employees Evacuated = 220 x 0.50 + 40 x 1.00 + 130 x 0.50 = 215

Industry evacuated is the evacuated population divided by total employees in the region:

Industry Evacuated = 215 / 390 = 0.5513

Table 18: Extract from Scenario Calculations (Full table in appendix)

Taranaki's 114 Sector Model			Estimated (Sum of Districts)			
ANZSIC	Sector	Total Output	Enterprises	Employees	Employees Evacuated	Industry Evacuated
A02	Services to Agriculture	74.8230	258	390	215	0.5513
A03	Forestry	33.9975	190	81	43.5	0.5370
	Services to Forestry	7.5987				
	Logging	5.4178				

The evacuation rate for each scenario was then calculated by including the length of evacuation, in scenario one this is two weeks.

Scenario One Evacuation Effect = 0.5513 x 0.04 = 0.0212

The evacuation rate for all sectors within each two digit ANZSIC class are the same, this can be seen in ANZSIC A03 where all forestry operation have the same output loss due to evacuation based on the single calculation.

Table 19: Extract from Scenario Calculations (Full table in appendix)

Taranaki's 114 Sector Model			Scenario One			
ANZSIC	Sector	Total Output	Evacuation	Eruption Specific	Recovery	Total Impact
A02	Services to Agriculture	74.8230	0.0212		0.100	-0.0788
A03	Forestry	33.9975	0.0207			0.0207
	Services to Forestry	7.5987	0.0207			0.0207
	Logging	5.4178	0.0207		0.050	-0.0293

Eruption specific influences are determined using the knowledge gained from the research and discussed in the previous chapters. Many of these figures are subjective but based on known and documented effects where available. An explanation of the main assumptions used in the eruption effects is included in the notes to the table in appendix three. The eruption specific column represents where direct effects from volcanic eruption are likely to immediately and directly affect an industry.

Recovery effects are where an industry is likely to benefit from recovery spending. The total impact is the direct loss for each sector as a result of volcanic eruption, calculated by adding the evacuation effect and the eruption effect and subtracting the recovery benefit. A negative figure represents an overall gain to the sector.

The overall impact on each industry sector for each of the four scenarios is shown in the table below; full working is shown in the appendix. The figures shown in the table represent the percentage point loss (or gain) in each industry sector as a result of an eruption, representing the percentage of output lost (direct effect) to the region when taking into account the three aspects of evacuation, eruption and recovery.

Table 20: Percentage Point Impact for each Scenario and Industry in the Taranaki 114 Sector Model

Sector	Scenario One	Scenario Two	Scenario Three	Scenario Four
Other Horticulture	-0.2221	-0.4553	-0.7327	0
Apple and Pears	-0.2221	-0.4553	-0.7327	0
Kiwifruit	-0.2221	-0.4553	-0.7327	0
Other Fruit	-0.2221	-0.4553	-0.7327	0
Mixed Cropping	-0.1221	-0.2553	-0.5327	0
Sheep and Beef	-0.0721	-0.1553	-0.4327	0
Dairy	-0.1721	-0.3553	-0.7327	0
Other Farming	-0.0721	-0.1553	-0.4327	0
Services to Agriculture	0.0788	0.2470	0.3728	0.1
Forestry	-0.0207	-0.2516	-0.5239	0
Services to Forestry	-0.0207	-0.0516	-0.1239	0
Logging	0.0293	0.0484	0.0761	0
Fishing	-0.0192	-0.0481	-0.1154	0
Coal Mining	0.0000	0.0000	0.0000	0
Services to Mining	-0.0192	-0.0481	-0.1154	0
Other Mining and Quarrying	-0.0208	-0.0520	-0.1247	0
Oil and Gas Extraction	-0.0692	-0.1481	-0.3654	-0.3
Oil and Gas Exploration	-0.0192	0.0000	-0.2154	-0.2
Meat Processing	-0.0194	-0.0985	-0.2164	0
Poultry Processing	-0.0194	-0.1485	-0.3164	0
Bacon Ham and Small Goods	-0.0194	-0.0485	-0.1164	0
Dairy Manufacturing	-0.0194	-0.0985	-0.2164	0
Fruit & Veg, Oil & Cereal Processing	-0.0194	-0.0485	-0.1164	0
Bakery & Confectionary	-0.0194	-0.0485	-0.1164	0
Seafood Processing	-0.0194	-0.0485	-0.1164	0
Other Food Manufacturing	-0.0194	-0.0485	-0.1164	0
Soft Drink, Cordial, Water	-0.0194	-0.0485	-0.1164	0
Beer, Wine & Tobacco	-0.0194	-0.0485	-0.1164	0
Textile Manufacturing	-0.0201	-0.0503	-0.1207	0
Clothing Manufacturing	-0.0201	-0.0503	-0.1207	0
Footwear	-0.0201	-0.0503	-0.1207	0
Other Leather Products	-0.0201	-0.0503	-0.1207	0
Sawmilling and Timber Dressing	-0.0195	-0.0487	-0.1169	0
Other Wood Products	-0.0195	-0.0487	-0.1169	0
Paper and Paper Products	-0.0195	-0.0487	-0.1169	0
Printing and Services	-0.0220	-0.0549	-0.1319	0
Publishing and Recorded Media	-0.0220	-0.0549	-0.1319	0
Petroleum Refining	-0.0194	-0.0486	-0.1166	0
Petroleum & Coal Products	-0.0194	-0.0486	-0.1166	0
Fertilisers	-0.0194	-0.0486	-0.1166	0
Other Industrial Chemicals	-0.0194	-0.0486	-0.1166	0
Medicinal, Detergents and Cosmetics	0.0306	0.0264	-0.0166	0
Other Chemical Products	-0.0194	-0.0486	-0.1166	0
Rubber Manufacturing	-0.0194	-0.0486	-0.1166	0

Plastic Products	-0.0194	-0.0486	-0.1166	0
Glass and Ceramics	-0.0204	-0.0511	-0.1226	0
Other non-metallic mineral products	-0.0204	-0.0511	-0.1226	0
Basic Metal Manufacturing	-0.0199	-0.0497	-0.1194	0
Structural, sheet and fab-metal Production	-0.0199	0.0003	0.0306	0
Motor Vehicles	-0.0195	-0.0486	-0.1167	0
Ship Building	-0.0195	-0.0486	-0.1167	0
Other Transport Equipment	0.0305	0.1014	0.1833	0
Photographic and Scientific Equipment	-0.0195	-0.0486	-0.1167	0
Electrical and Appliance Manufacturing	0.0005	0.0514	0.0833	0
Agricultural Equipment	0.0805	0.2014	0.2833	0
Other Industrial Machinery	0.0005	0.0514	0.0833	0
Prefabricated Buildings	-0.0225	-0.0564	-0.1353	0
Furniture	-0.0225	-0.0564	-0.1353	0
Other Manufacturing	-0.0225	-0.0564	-0.1353	0
Electricity Generation	-0.6201	-0.7502	-0.9204	0
Electricity Transmission	0.0299	0.0498	-0.1204	0
Electricity Supply	-0.0201	-0.0502	-0.1204	0
Gas Supply	-0.5901	-0.7502	-1.1204	0
Water Supply	0.0308	0.0519	-0.0154	0
Residential Building	-0.0212	-0.0530	-0.1272	-0.4
Non-residential Building	-0.0212	-0.0530	-0.1272	-0.4
Non-building Construction	-0.0212	-0.0530	-0.1272	-0.4
Ancillary Construction Services	-0.0198	-0.0495	-0.1188	0
Wholesale Trade	-0.0204	-0.0509	-0.1222	-0.1
Retail Trade	0.0292	0.0979	0.2751	-0.1
Accommodation	-0.0202	-0.0506	-0.1215	0
Restaurants, Cafes, Bars & Clubs	-0.0202	-0.0506	-0.1215	0
Road Freight	-0.1218	-0.2545	-0.6308	0
Road Passenger	-0.1218	-0.2545	-0.6308	0
Water & Rail Services	-0.0265	-0.2162	-0.4589	0
Air Services, Transport & Storage	-0.1194	-0.2484	-0.5161	0
Communication Services	-0.0697	-0.1493	-0.3182	0
Finance and Superannuation	-0.0211	-0.0526	-0.1263	0
Insurance	-0.0192	-0.0481	-0.1154	0.1
Services to Finance & Insurance	-0.0199	-0.0498	-0.1196	0
Property Services	-0.0200	-0.0499	-0.1198	0
Owner Occupied Housing	-0.0200	-0.0499	-0.1198	0
Vehicle and Equipment Hiring	-0.0200	-0.0499	-0.1198	0
Scientific Research	0.0300	0.0501	0.0301	0
Technical Services	-0.0200	-0.0499	-0.1199	0
Computer Services	-0.0200	-0.0499	-0.1199	0
Legal Services	-0.0200	-0.0499	-0.1199	0
Accounting Services	-0.0200	-0.0499	-0.1199	0
Advertising and Marketing Services	-0.0200	-0.0499	-0.1199	0
Business, Administration, & Management Services	-0.0200	-0.0499	-0.1199	0
Employment and Security Services	-0.0200	-0.0499	-0.1199	0

Pest and Cleaning Services	-0.0200	-0.0499	-0.1199	0
Other Business Services	-0.0200	-0.0499	-0.1199	0
Central Government	-0.0221	-0.0553	-0.1328	0.1
Defence	-0.0221	-0.0553	-0.1328	0
Fire and Police	-0.0221	-0.0553	-0.1328	0.1
Local Government	-0.0221	-0.0553	-0.1328	0.2
Pre-School Education	-0.0209	-0.0522	-0.1253	0
Primary and Secondary Education	-0.0209	-0.0522	-0.1253	0
Post School Education	-0.0209	-0.0522	-0.1253	0
Other Education	-0.0209	-0.0522	-0.1253	0
Hospitals	-0.0197	-0.0492	-0.1180	0
Medical and Dental	0.0303	0.0508	0.0320	0
Veterinary Services	0.0803	0.1508	0.1820	0
Child Care	-0.0208	-0.0520	-0.1247	0
Aged Accommodation	-0.0208	-0.0520	-0.1247	0
Other Community Services	-0.0208	-0.0520	-0.1247	0
Movies, Radio and TV	-0.0192	-0.0481	-0.1154	0
Libraries, Museums and Arts	-0.0201	-0.0503	-0.1207	0
Horses and Dog Racing	-0.0208	-0.0520	-0.1248	0
Gaming	-0.0208	-0.0520	-0.1248	0
Other Sport and Recreation	-0.0208	-0.0520	-0.1248	0
Personal and Community Services	-0.0204	-0.0511	-0.1226	0
Other Services	-0.0202	-0.0506	-0.1215	0

13. Scenario Analysis

None of the repair, replacement or recovery costs include the problem of ultimate disposal of ash. Knowledge of areas that can be used for this purpose (the land will need to be retired or used as a recreational reserve for a long period afterwards) should be thought about prior to the event.

Infrastructural costs are not quantified due to a lack of information. Where possible the level of damage that could be expected in each scenario and the most vulnerable factors are included. The interdependency between infrastructure networks, and the wider domestic and business communities, has been identified because of the significance of these relationships in effective and timely recovery strategies.

The 1995/1996 Ruapehu eruption was geologically considered minor with no more than 10mm of ash deposited, yet the economic consequences and disruption were significant, estimates put the minimum cost of the eruption at $130million made up almost singularly of tourism revenue losses and damage to the hydro-electric turbines (Johnston et al, 2000). Small businesses and the agricultural sector were not included at all.

13.1. Eruption Scenario One

The first scenario limits ground hugging hazards to within the national park boundary and any lahars that extend further than this will not breach existing flood control barriers. Bridges will be vulnerable and require increased monitoring but should remain secure and open. Ash fall is limited to zones A, B and C, the depths considered represent the minimum values of the Inglewood tephra depths. The maximum depths in each zone are 100mm in zone A, 50mm in zone B and zone C up to 10mm. Zone D has less than a millimetre of ash deposits which will not be damaging. Throughout the duration of the eruption, alert levels are unlikely to reach level 4. Evacuations will occur when the alert level reaches the final stages of 2 or at level 3. This scenario allows for only a brief eruption before conditions stabilise and evacuation orders end. Total evacuation time will be two weeks with immediate reoccupation.

Complete access restrictions to the National Park start as soon as alert levels reach two and will remain in place until all activity ends, due to instability of the mountain and further threats. The 360,000 visitors to the park annually will be disrupted and the visitor spending this brings to the region lost. As the main recreational attraction is suspended, upper tracks will be damaged and are likely to remain closed for a long period due to delays in recovery. Facility and hut damage will be varied depending on exact distribution of ground hazards. The attraction for visitors to an active volcano will counteract some of these losses however the national park is unlikely to be the focus of immediate recovery efforts.

Under this scenario there will be no need to evacuate residents within the orange zone, all residents within the red and blue zones will be evacuated in line with Civil Defence policy. This is almost 40,000 residents that will need to be housed and accommodated outside the region

The cost of clean up can be one of the most significant costs after an eruption given the expanse of area covered to varying degrees and the ongoing impacts if ash is left in developed locations. Exterior clean up costs for the region under scenario one would be $205million; this is using the IGNS estimate of clean up costs based on population and depth of ash[21]. Zone A encompasses 13,257 people, zone B 17,916 people and Zone C is assumed to be the remainder of Taranaki or 71,854 people. Zone D is not affected by ash under this scenario.

Zone A	13,257 x 100 x 70[22] = 92,799,000
Zone B	17,916 x 50 x 70 = 62,706,000
Zone C	71,854 x 10 x 70 = 50,297,800
	$205,802,800

Buildings will not collapse due to ash loading under this scenario as the critical depth at which ash threatens buildings is 100mm. This depth would only be reached within the boundaries of the national park and even then collapse would be unlikely.

The estimated effect from each eruption scenario is predominantly accounted for in the input-output analysis, in depth discussions on which the assumptions are based are included in the previous chapters. This is the most inclusive way to account for disruptions to an economy and the flow on effects that can be expected. Appendices three and four provide detailed workings and the industry results for each scenario.

Input-output calculated regional losses as a result of an eruption based on scenario one are[23]:

Direct Output ($m)	-878.48	
Gross Output ($m)	-1192.10	
Net Household Income ($m)	-98.78	
Employment (FTE)	-2802.59	6.39% of the base economy
Value Added or GRP ($m)	-519.09	8.00% of the base economy

[21] Clean up costs are estimated using IGNS compiled cost estimates. This equates 'residents in each zone' x 'ash depth in mm' x '$/person/mm to clean up'. This process is discussed further in chapter ten.

[22] $19/person/mm in 2005 dollars is $70 = (19/319.09) x 1177 using the Reserve Bank CPI index

[23] Input-output model of W Hughes, scenario working shown in appendix four

Gross regional product is reduced by 8% to $5,961.81million; these effects are likely only for one year as they largely result from disruption as opposed to physical damage. The greatest contributing factor to value added loss is dairy farming and gas extraction, gas being the larger of the two. Natural resources and the primary sector are the most affected by smaller eruptions. Value added lost from dairy farming is $118.21milion, from gas the value lost id $186.77million. Almost all other sectors have only marginal reductions in value added as there are few on-going influences after evacuation ends, the next largest contributor to value added lost is gas supply ($21.79million reduction) and then road freight movements ($12.71million). The ongoing employment effects represent a loss in base employment of over 6%, dropping net household income by 98.78million. Employment losses are dominated by the dairy farming sector which loses an estimated 934 jobs, a third of all job losses. Total output lost is 7.74% of regional output valued at $1,192.10million.

Ongoing costs in the second year will be minimal, possibly positive if ash scatter acts as a fertiliser inducing growth, or if machinery and recovery spending spurs growth and productivity improvements. Provided there are no ongoing volcanic indicators all recovery should be made within the same year. Direct damages and ash fall are assumed to damage 5% of infrastructure on dairy farms, concentrated within farms bordering the national park. This is a damage estimate for infrastructure valued at $251.51million.

The cellular sites located on the mountain are highly at risk from ash or direct damage, under this scenario the minimal nature of ground hugging hazards will not directly damage any of the cells on the mountain. Ash will damage equipment on sites due to increased interference and potential weight bearing. A maintenance value will be associated to mobile communications of $450,000 for all sites. Throughout the eruption these sites will not be able to transmit or receive calls, decreasing capacity of the network.

Within Taranaki no circumference roads will be damaged under this scenario keeping access around the peninsular open, smaller low demand roads will be damaged within close proximity of the mountain. The road network under scenario one is assumed to sustain 10% damage to roads and bridges at risk in zone A (ground hugging hazards) and no damage to roads in other areas. All roads in the region will require sweeping or clearing by some means, however this is included within the 'cost of clean up'. A degree of damage is consequently incurred to 40km of roads and 4 bridges. Under this scenario bridge damage is not complete removal but destabilising the structural integrity requiring temporary weight restrictions or closure until maintenance or repairs can be made, bailey bridges would not be required. By assuming that ground hugging hazards (away from the upper slopes) remain within existing flood control measures we can imply that any road damage is most likely from erosion of banks and substructures as opposed to coverage or removal.

Table 21: Damage Sustained to Roads and Bridges under Scenario One

Hazard Zone	Length of Roads at Risk (Km)	Total Number of Crossings / Bridges	Bridges at Risk	Bridges at Risk With Additional Infrastructure	Damage Sustained (km, bridges)
A	375.7	58	43	16	40, 4
B	108.6	19	17	5	-
C	1,366.4	94	78	50	-
D	1,668.9	68	64	41	-

Rail is not affected under this scenario as there are no tracks within the primary damage zone of ground hugging hazards and ash will not be to the extent that stops rail transport. Ash will require speed restrictions, increased monitoring as ash may short circuit signals, all of which increase normal operational costs. It is unlikely that commercial activity will continue from within Taranaki while evacuations are in place although trains may operate in supplying New Plymouth with essential goods. Pipelines are also assumed to be unaffected as lahars will predominantly remain within existing flood control barriers and as such will not damage pipelines placed over streams.

Gas supplies are assumed to cease for large and industrial users for one week. While voluntary restrictions will be put in place for domestic and commercial users the piped gas supply will be sufficient to meet the smaller users demand. There will be no damage to pipe infrastructure, any measuring instrumentation that is damaged will not prevent gas movement once conditions permit. Using figures included in the input-output analysis this is a direct cost to regional output of $233.37million. Not included with the regional input-output model is the national value of gas use which is wide spread, estimates put a national value of $1.25billion on the national gas supply.

Flights into the region will be cancelled although national flights may be diverted to the east or west around the ash plume allowing continued operation. The Ruapehu eruptions resulted in the creation of an operational standard such that Civil Aviation protocol is firmly in place for such an event.

13.2. Eruption Scenario Two

The second scenario extends ground hugging hazards to zone A and B. This creates a level of destruction in populated areas and farms next to the national park. Lahars will extend with more force into zone C affecting developed areas. Ash fall will extend right into zone D to light levels, creating disturbance for activity outside Taranaki. Ash depths for scenario two are still smaller than the representative Inglewood tephra used in the ash hazard maps. Zone A will have a maximum depth of 150mm, zone B to 100mm and zone C to a maximum 50mm. Minimal levels will extend beyond Taranaki into zone D to a maximum depth of 5mm. This will begin to influence flight paths and airports throughout the Central North Island, damage to farmland and crops will be minimal and sporadic outside Taranaki. Evacuation, including time to regain a level of vital services and incorporating any ongoing eruption threat will be for four weeks. Like the previous scenario there will be no need to evacuate residents within the orange zone, all residents within the red and blue zones will be evacuated in line with Civil Defence policy

The national park in scenario two is assumed to lose visitors for two years, although the evacuation period is only four weeks, prior closure, instability and damaged facilities will close the mountain for this extended period surrounding an eruption. Existence value of the park will be diminished and use value lost. Water resources from the park will have stabilised within a month of the eruption ceasing however contamination (and further lahars) may occur after heavy rainfall.

The cost of clean up from an eruption is significant, exterior clean up costs for the region under scenario two would be $718million, this is using the IGNS estimate of clean up based on population and depth of ash. Zone A encompasses 13,257 people, zone B 17,916 people and Zone C is assumed to be the remainder of Taranaki or 71,854 people. Zone D is more expansive and in this scenario includes Manawatu-Wanganui and Waikato regional council land areas with a total population of 577,818.

Zone A	13,257 x 150 x 70 = 139,198,500
Zone B	17,916 x 100 x 70 = 125,412,000
Zone C	71,854 x 50 x 70 = 251,489,000
Zone D	577,818 x 5 x 70 = 202,236,300
	$718,335,800

Zone A is at risk from building collapse because ash is expected to reach a maximum of 150mm, collapse becomes a problem when ash exceeds 100mm, after 300mm approximately 50% of buildings will collapse. Roofs with steeper pitches are less vulnerable than flat or wide span roofing. The predominantly residential and rural nature of the population in zone A, and the large expanse of the National Park before occupied areas means there are fewer buildings at risk than in an industrial or highly populated area, only buildings within the national park or poorly constructed farm buildings are likely to collapse under this scenario. Commercial buildings around Stratford with expansive flat roofs (i.e. Mainland factory) may need to have their roofs cleared to prevent weakening; being on the edge of zone A this area will receive less ash than within the national park. Guttering in Stratford may sustain damage on some houses.

The overall effect from evacuation is more significant with over four weeks during which normal economic activity is stopped. Small businesses will not be able to sustain business-as-usual costs over this timeframe without significant losses; jobs within the small and medium business sector will be vulnerable unless assistance of some sort is provided and immediate. Waged or self employed people will find this period of decreased activity extremely damaging with respect to mortgage or debt payments and in continued standard of living. Short term expenses may be overwhelming for these individuals until assistance packages are actioned. The input-output model does not take into account assistance packages, this is reflected in the full time equivalent employment levels which will fall by almost 15%, more than 6,400 jobs will be lost in the short to medium term. Total value added lost as the result of an eruption of this magnitude is over 17% of the base, a reduction in excess of $1.1billion. Ongoing eruption effects will continue for at least two years depending on exact timing of eruptions in the growth cycle and the availability and timing of resources for repairs and recovery work.

The input-output analysis (workings and results in appendices) is the basis of the financial estimate of an eruption, the final results and regional losses of an eruption based on scenario two are:

Direct Output Loss ($m)	-1,947.32	
Gross Output ($m)	-2,725.87	
Net Household Income ($m)	-223.05	
Employment (FTE)	-6,420.03	14.64% of the base economy
Value Added or GRP ($m)	-1,113.89	17.19% of the base economy

As in the last scenario the greatest contributors to value added lost are dairy farming and oil and gas extraction, together accounting for 60% of value added lost. The next greatest loss is in electricity generation where $42.14million of value added is destroyed. In addition the meat processing sector will begin to sustain considerable losses with total output losses of $86.32million. Employment effects under scenario two are beginning to reflect lower disposable incomes as a result of the increased cost of recovery to individual households with significant FTE losses in the restaurants and bars and non-essential services. The expansion of areas receiving ash and greater depths on the eastern hill country has fed through to higher job losses in the sheep and beef sector.

Telecommunications infrastructure located on the mountain is likely to be damaged to a level requiring substantial maintenance or complete replacement. Cell sites outside the national park boundary will face increased interference and ash damage. Replacement of all three sites on the mountain equates to a replacement cost of $1.35million plus maintenance costs on eight other sites estimated at (assuming damage equivalent to 10% of cost) $360,000. Overseas examples indicate that unprecedented demand for communication systems will collapse within 15-30minutes of the event if not suspended immediately.

Some road bridges will be damaged; this will present problems for reoccupation with individual households delayed in regaining access. Any infrastructure using these bridges as river crossings will be severed or interrupted although the degree of damage is highly selective. The wider local roads will sustain damage mainly associated with ash. The inner ring of roads will sustain damage from direct hazards to bridges however redundancy in the network will allow most households to return immediately. This scenario imposes an estimate of 25% damage in zone A and 5% damage within zone B to roads and bridges as a direct result of ground hugging hazards, ash accumulation will contribute to the damage sustained by road structures throughout the region. Sweeping is likely to be required on roads outside the boundaries of Taranaki, although this cost is included within clean up estimates.

Table 22: Damage Sustained to Roads and Bridges under Scenario Two

Hazard Zone	Length of Roads at Risk (Km)	Total Number of Crossings / Bridges	Bridges at Risk	Bridges at Risk With Additional Infrastructure	Damage Sustained (km, bridges)
A	375.7	58	43	16	94, 11
B	108.6	19	17	5	6, 1
C	1,366.4	94	78	50	-
D	1,668.9	68	64	41	-

Rail is still largely unaffected by ground hugging hazards although bridges in zone C will be vulnerable to destabilisation from erosion and require increased monitoring and clearance before normal operations commence. Rail will be interrupted on a short term basis requiring speed restrictions and potentially bailey bridges but closure or bridge loss is unlikely.

Gas pipelines will be damaged under this scenario if a sizeable lahar passes through vulnerable valley channels. Namely this is a possibility along the western coast between Oaonui and New Plymouth. The structural integrity of the pipelines may prevent complete breakage of any pipes affected however fail safe will be activated as soon as there is any question of pipeline integrity. It is assumed that zone A will sustain damage 20% damage and zone C 5% damage (1 point).

Table 23: Gas Transmission Pipelines at Risk in Scenario Two

Hazard Zone	Total Number of Pipeline Crossings	Pipelines at Risk (exposed / aerial crossing)	Damage Sustained
A	29	25	5
B	n/a	n/a	-
C	7	7	1
D	4	4	

Domestic flights will face a lot more interruption, cancellations and airport closure as the ash cloud extends further over the North Island. International flights will still be able to land in both Auckland and Wellington.

All electricity generation in the region will cease immediately upon gas supply being cut. Insulator flashover is a possibility whenever ash exceeds 10mm in depth. Flashover is unlikely to cause permanent damage but will result in temporary outages and surges to all households affected. Low voltage networks are more vulnerable than high voltage to this damage. No residents outside

Taranaki will be affected under this scenario; the most affected will be residents in New Plymouth and the orange zone that are not evacuated.

The money flows of the agricultural sector are incorporated in the input-output modelling however this does not take into consideration any infrastructure damages that may be sustained on farms. In scenario two it is assumed that ash depths will not be great enough to damage infrastructure on the hill country sheep and beef farms however direct hazards and ash will damage the dairy farms on the volcanic plains. Dairy farms are capital intensive and are assumed to sustain 10% damage to infrastructure, a value of $503million for the industry.

13.3. Eruption Scenario Three

This scenario considers a moderate to large eruption in line with the Inglewood tephra distribution. Ash depths in zone A will be to a maximum of 250mm in depth, zone B 150mm, C 100mm and up to a 10mm into zone D. Ground hugging hazards will extend into zone D with significant consequences for farm infrastructure, Inglewood, the south west coastal communities and the industrial sites around Kapuni. Potentially both the Kapuni and Maui gas production stations could be damaged. Stock losses would be likely on affected farms. This level of ash will begin to have damaging consequences for farmers around Wanganui and the Rangitikei and will be highly disruptive to aircraft travel. Fonterra will cease production for at least eight weeks due to increased risk, water contamination or ash contamination.

This scenario imposes an evacuation period of twelve weeks. This allows for a longer eruption and instability period but also for some degree of recovery to begin. Individual households will remain in temporary accommodation for a significant period longer than twelve weeks. A larger eruption of this type will require some residents within the orange zone to be evacuated due to a lack of services and increased threat, all residents within the red and blue zones will be evacuated in line with Civil Defence policy. This is assumed to add 2,500 evacuees to those that will need to be housed outside the region. In an evacuation of this size and duration some residents will be able to return to their homes immediately upon the eruption ceasing, others will have their homes completely destroyed and may not return for many months, it is hoped that these estimates of evacuation will be balanced by such differences.

Cleaning up ash from an eruption of this size will be a lengthy and time consuming task as the area covered is extensive and quantity of ash will require careful planning. Ash clean up costs for the region under scenario two would be $1,427million, using the IGNS estimate of clean up costs. Zone A encompasses 13,257 people, zone B 17,916 people and zone C 71,854 people. Zone D includes Manawatu-Wanganui, Waikato and in addition scenario three includes Hawkes Bay with a total population of 720,768.

Zone A	13,257 x 250 x 70 = 231,997,500
Zone B	17,916 x 150 x 70 = 188,118,000
Zone C	71,854 x 100 x 70 = 502,978,000
Zone D	720,768 x 10 x 70 = 504,537,600
	$1,427,631,100

The national park will be destroyed by an eruption of this size with almost complete damage to vegetation and infrastructure in the boundaries of the park. The existence value of the park will be greatly diminished as damage is sustained to the natural environment; use value will be lost for at least five years as recovery to the park is of lower priority than other resources in the region. Secondary hazards that may result from decreased vegetation make a detrimental impact to surrounding farms and communities during clean up and in the long term recovery of the region.

The extended time frame of this scenario increases the chance of closure at Whareroa through the peak of the milk cycle. Accordingly this scenario considers one week during which 30% of the 14million litres of milk destined for Whareroa daily can not be absorbed by other factories. At current milk prices this is a raw value of milk worth $11,613,253[24] which must be dumped by farmers. This level of milk to be dumped will also influence the wider national economy and level of exports.

Regional losses calculated using input-output modelling as a result of an eruption based on scenario three are:

Direct Output Loss ($m)	-4,341.47	
Gross Output ($m)	-6,051.78	
Net Household Income ($m)	-497.09	
Employment (FTE)	-14,072.01	32.08% of the base economy
Value Added or GRP ($m)	-2,505.21	38.66% of the base economy

The value added lost from scenario three equates to a reduction in regional value added to just over 60% of the pre-eruption levels. Like the previous scenarios the gas extraction and dairy farming sectors contribute the greatest amount to value added losses representing 60.72% of the total. Further significant sectors included dairy processing, electricity generation, wholesale trade and road freight.

Total gross output is reduced by 30% compared to existing levels, while household income is reduced by 32.63 and full time equivalent employment falls by more than 14,000 jobs. These costs represent the regional impact for a single period immediately following an eruption, the financial cost of an eruption this size will continue for several years. Agriculture is likely to sustain losses for

[24] Based on LIC industry and regional statistics. 1kg/ms = 11.62litres, 1kg/ms = $4.59

at least five years while land and breeding stock recover, long term horticultural crops that are favoured in Taranaki will need to be completely re-established. Stratford businesses and households will have experienced considerable building damage and will require rebuilding and redevelopment of economic activity. Business and household spending patterns are unlikely to stabilise until three years on while recovery activity transfers funds from traditional uses.

All telecommunications infrastructure on the slopes of the mountain will be destroyed, sites within close proximity will also incur damage to the extent that replacement is required. In total five cell sites will require replacement at a cost of $2.25million. Further from the mountain the bulk of the damage will be caused by ash damage to the mechanics of each site, significant maintenance will be required to all cell towers within Taranaki, maintenance valued at approximately 10% of cost at each of the remaining sites is assumed. A total maintenance cost of $675,000 (15 sites x $450,000 x 0.10). Imposed restrictions on the system will remain in place for quite some time to protect the network from continuing peaks in demand and to protect already vulnerable infrastructure from overloading and crashing the network.

Roads will sustain a considerable level of damage largely due to erosion from lahar, surface flooding as a result of ash depths and on upper slopes by coverage or complete loss. Zone A will experience 40% structural damage to roads and bridges, zone B will sustain 15% damage and zone C 5% damage over and above ash coverage.

Table 24: Damage Sustained to Roads and Bridges under Scenario Three

Hazard Zone	Length of Roads at Risk (Km)	Total Number of Crossings / Bridges	Bridges at Risk	Bridges at Risk With Additional Infrastructure	Damage Sustained (km, bridges)
A	375.7	58	43	16	150, 7
B	108.6	19	17	5	16, 3
C	1366.4	94	78	50	68, 4
D	1668.9	68	64	41	-

Rail links between New Plymouth and Hawera will be severed until temporary replacement of bridges is possible and tracks cleared (ten weeks), the peninsular will be isolated by road due to bridge damage occurring on the outer circumventing road (SH45). Repairs required to transport links will be extensive. Although commercial activity is unlikely through this period the loss of rail creates another obstruction to land based emergency operations. It is assumed that rail experiences 20% damage within zone C and 5% damage to zone D, some of this will be along the Kapuni offshoot.

Table 25: Length of Rail at Risk within Scenario Three

Hazard Zone	Length of Rail at Risk (km)	Rail Damaged (km)
A	n/a	-
B	n/a	-
C	652	130.4
D	440.9	22.0

Gas pipelines will be damaged under this scenario as multiple lahars are likely to pass through vulnerable channels, some surface points outside direct gullies may also be damaged, again this will occur predominantly along the western coast between Oaonui and New Plymouth but also along the inland line. The structural integrity of the pipelines may prevent complete breakage of some pipes affected, others will be completely destroyed. Fail safe will be activated as soon as there is any question of pipeline integrity, this measure will protect all sections of gas pipeline that remain intact however there is likely to be a considerable amount of gas lost through pipe breakage at numerous points. It is assumed that zone A will sustain damage 30% damage to vulnerable points and zone C 15% damage, zone D although at risk will be undamaged.

Table 26: Gas Transmission Pipelines at Risk in Scenario Three

Hazard Zone	Total Number of Pipeline Crossings	Pipelines at Risk (exposed / aerial crossing)	Damage Sustained to Pipelines
A	29	25	8
B	n/a	n/a	-
C	7	7	1
D	4	4	

The agricultural environment will be sustain long term damages from an eruption of this size, some farms within close proximity to the mountain may never recover to their original state or productivity levels. Under scenario three the level of damage to infrastructure on dairy farms is 20%, a value of $1,006.03million. Infrastructure includes all land improvements including fencing, irrigation, dairy sheds, farm tracks and stock. This figure represents the cost of returning land to a usable standard. Sheep and beef farms on the eastern hill country are also expected to sustain a degree of damage to infrastructure under this scenario. Damage is assumed to be 10% of total capital value or $45.21million.

13.4. Behaviour Change (Increase in Volcanic Indicators)

The final scenario considers behaviour of firms at both the national and regional level directly associated with alert levels, not volcanic activity. As part of the Civil Defence planning guidelines utilities and emergency services are required to plan according to these levels and businesses have been encouraged to do the same. Whilst the alert levels are politically neutral and determined by the Institute of Geological and Nuclear Sciences there is no question that a change in the alert will have significant economic consequences – specifically changing from level 1 to level 2 where an eruption is not yet guaranteed but behaviour changes are required. That is what this scenario will look into, no infrastructure damage but disruption, changes in behaviour and changes in expectations. For the purpose of the analysis an arbitrary time frame of one year has been imposed during which activity begins, fluctuates repeatedly and ultimately subsides without eruption.

When volcanic indicators suggest the possibility of an eruption business and private activity will begin to alter, one of the biggest detrimental influences on investment and economic growth is risk or uncertainty. Alert levels are characteristic in that they will slide up and down the activity scale many times before ultimately erupting or subsiding. Each shift will increase uncertainty. As this uncertainty persists more projects will be delayed until a stable environment exists, community stress will increase, investment and building projects delayed and the economy will begin to stagnate.

The build up to a volcanic eruption can be long, short, violent or sporadic and highly confusing to untrained observers. Anxiety in residents will be high as large quantities of information is released warning of imminent or possible eruption, pre-emptive evacuations may be made and some residents will choose to make voluntary evacuations or to leave the area completely (Johnston, Nairn et al, 2000b). While there is no damage to the region during this stage disruptions may still occur if roads within close proximity of the volcano are be closed (in the case of Taranaki the National Park will be closed) and air restrictions may be initiated around the summit (Johnston, Nairn et al, 2000b).

Closure of the national park is one of the first actions that will result from increased volcanic activity as a public safety measure. Use value of $79million 56 from the mountain will be lost. As there is not a physical threat to tourists during this period visitors to the region will continue, some will be put of by the increased threat however this is likely to be counteracted by visitors who come specifically because of the seismic activity.

Calculated regional losses as a result of behaviour change,[25] using the input-output model are:

Direct Output Loss ($m)	-1,267.92	
Gross Output ($m)	-1,620.90	
Net Household Income ($m)	-104.50	
Employment (FTE)	-2,545.49	5.80% of the base economy
Value Added or GRP ($m)	-926.09	14.29% of the base economy

The main contributors to these figures is from oil and gas extraction and oil and gas exploration as these activities may need to cease due to instability issues of the gas fields. Sectors such as

[25] Input-output model of W Hughes, scenario working shown in appendix four

services to agriculture, local government and insurance all experience gains as residents do all that they can to prepare for a possible eruption. Stagnation and uncertainty affects long term spending in the retail and buildings sectors. Some jobs will be created as there is increased monitoring and preparedness for a possible event however these are far outweighed by the loss of spending and economic activity created by uncertainty.

The largest contributor to the loss of $926,09million as a result of scenario four is the oil and gas extraction sector which represents 80% of the overall decline.

Whilst only incorporating changes in behaviour and the influence of consumer and business confidence scenario four provides an indication of how volcanic activity will affect economic activity immediately upon signs of an eruption. A long lead up to volcanic activity will have the same effect in years leading up to an eruption and a similar effect for as long as volcanic indicators remain.

13.5. Iconic Industries

The wider effects of an eruption can not be quantified in a single period regional economic model. To take into account these long term and far reaching consequences the iconic industries are extremely important. The iconic industries will have the greatest external impacts, by definition, however they are also representative of the kind of flow-on effects that can be expected from all levels of enterprise. Taranaki is independent, particularly in a small country such as New Zealand. Even small businesses will have relationships throughout the country in suppliers, purchasers, and customers throughout the country.

All of these relationships could not be identified, or quantified yet the study of iconic businesses allows an inference of what could be expected.

The National Park is one of the most accessible, it has 13 entrance points and 208km network of tracks encircling the mountain for the approximately 360,000 visitors annually. Within the national park boundary there are eight huts, two Department of Conservation lodges, the camp-house, two private lodges, two visitor's centres (Dawson Falls and North Egmont) and the club operated Manganui ski field. The Taranaki brand would not be complete without the iconic mountain, nor would the agricultural environment be as productive without the volcanic soils and microclimate, economic benefits of the national park are ultimately realised either directly or indirectly. As population and income increases, demand for environmental quality and ecological tourism is likely to increase. The Egmont National Park is a well established park with many amenities, signs, boardwalks, huts, tracks, bridges and locations that would take years to recover at both enormous cost and number of man hours. Replacement or high level maintenance of tracks within the park would incur a replacement cost of $10.4million; recovery would not be a priority for government spending. A significant eruption could easily destroy the unique eco-system and native forestry that has been protected for more than a century. Damage on this scale could take centuries to regenerate. More important the Egmont National Park receives almost seven metres of rainfall each year which is dissipated in the heavy forest before emerging as a vital resource for farmers and communities. The sheer quantity of rainfall received must be absorbed by continued vegetation cover, if an eruption removes some or all of this vegetation farms over the entire ring plain will be highly susceptible to flooding on an extreme scale. This secondary impact is not considered in the financial analysis of this study and must be considered as a real threat to rehabilitation strategies and economic recovery.

Fonterra is a global co-operative with 29 domestic factories, 39 international and total assets exceeding $12billion in value. There is very little excess capacity in New Zealand's 29 production facilities because of the nature of the milk curve, further investment in production can not be justified for the few days of the year during which capacity is over extended, annually New Zealand factories process 13billion litres of milk a year. The seven hectare site at Whareroa covers seven hectares of land, has ten manufacturing plants running simultaneously, employs over 950 full time staff, has its own power generation facility and is the largest dairy factory of its type in the world. The factory at peak processes 14million litres of milk a day and is capable of processing 20% of Fonterra milk supply annually. Fonterra production is highly influenced by external events that affect levels of milk produced by farmers, once pasture damage is experienced or farm output decreases there can be impacts right through the supply chain, global instantaneous communications means customers are highly aware of circumstances in New Zealand. The factory is located outside the direct damage zone so may be capable of operation relatively quickly after evacuation ends; it will be the delay in return of supporting utilities (electricity, gas and water) that is likely to present the largest problem. Whareroa is a strategic site for Fonterra, the capacity compared to other factories is such that if something happened at the peak of the season they would not be able to reallocate all of the milk to other factories, 20-30% of the Whareroa usual milk supply could not be reallocated. The total effect on Fonterra and national export accounts will be minimal while milk can be absorbed by other factories; it is if an eruption occurs through the peak season that interruption to Whareroa operations would have a significant national affect.

Fonterra Kapuni (formerly Lactose NZ) is one of the world's largest producers of lactose employing 120 people and processing by-products from most manufacturing sites in New Zealand to pharmaceutical grade lactose. Production will cease initially due to evacuation given its location within the red zone and will continue until the necessary cleanup operations are completed. Operating revenue from Kapuni will directly affect national exports as there are no other pharmaceutical processing facilities in the North Island that could temporarily absorb the production demand.

The Taranaki oil and gas industry is estimated to contribute more than $1billion a year to the national economy; there are no substitutes and no alternative supplies. Any unplanned interruption could have serious consequences to North Island business, in day to day operations, manufacturing processes and power generation capacity. A third of the gas produced is fed directly into the New Plymouth, Stratford and Huntly power stations. Typically Maui will not go offline for more than eight hours in a scheduled shutdown, throughout which the whole industry is on high alert and usage is altered accordingly. The Pohokura development at Motonui includes new pipelines and a production station which is successfully spreading industry risk by moving facilities away from the mountain and direct hazard influences. Fail safe modes in gas fields are a lot more sensitive and less tolerant than those governing the transmission system. If alert levels and activity reach a level such that gas extraction is no longer safe the entire system and all downstream activities will cease production and distribution. There are no storage facilities for natural gas in New Zealand in which to stockpile for emergencies although the pipe system itself is capable of holding a considerable level of gas, there is a well defined alert system for any event or drop in pressure and a hierarchy of businesses that are removed from the network. If liquefied natural gas is considered viable and set up in New Zealand this could spread the risk of the gas industry to interruptions in Taranaki by allowing imports to meet temporary shortages. At the moment planning is pointing towards a regasification terminal at the Westgate Port to fit in with existing pipeline infrastructure, this will make imports vulnerable to the same threats of domestic gas production.

In total more than 200,000tonnes of domestic LPG is distributed annually, LPG is the least likely energy source to be disrupted to users outside Taranaki due to its ability to be stored and the domestic distribution infrastructure already in place for imports; existing demand is supplemented by imports from Australia. Storage facilities will buffer against any short term interruptions to supply, long term supply interruptions can be met by increased imports

New Plymouth is a net exporter of power being home to a system of hydroelectric stations as well as two thermal electric (gas) stations, KGTP and Whareroa co-generation facilities. In addition Taranaki gas supplies the Huntly, Southdown and Otahuhu power stations and numerous cogeneration facilities such as Kinleith (Carter Holt), Te Awamutu (Fonterra) and NZ Steel. In 2002 gas powered electricity generation accounted for 25.47% of electricity generated in New Zealand, second only to hydro. In the event that an eruption occurs and gas production is stopped this disruption alone will cause significant problems for business and households throughout the country.

The New Plymouth power station is currently off line but still capable of full generation or in an island mode to support remaining residents if required. The Taranaki Combined Cycle (TCC) power station is located in Stratford; this natural gas powered station is one of the most efficient generators in New Zealand but is locationally vulnerable. The most vulnerable and critical point of the electricity network is the Stratford substation; this is the central point of the Taranaki electrical system, all electricity into and out of this region passes through this point. Given the proximity and location of Stratford on the eastern side of the mountain this area will receive considerable quantities of ash. Transmission lines and electrical equipment are particularly vulnerable to volcanic hazards, ground hugging flows may damage pylons at any number of points as they pass around the mountain, ash loading may cause line breakage or compromise pylons. The electrical conductivity of ash can cause lightning strike, static interference, insulator flashover and short outs between lines. The physical infrastructure of substations and generation facilities are vulnerable to the same threats.

The Yarrows baking company has operated from the same 6 acre site in the centre of Manaia since 1923 remaining owned and operated by the Yarrows family. The original bakery, built in 1928 has undergone numerous renovations and extensions, the most recent series of extensions in the nineties, factory replacement to existing levels would exceed $30million. Each week around 450tonnes of frozen goods are despatched from the factory to their final destination by a Hawera owned trucking company. The Manaia factory and office employs 220 people, injecting close to $150,000 into the local economy every week. Products made at the Manaia factory are largely intended for export, on average 65% of total production is exported out of Tauranga and Auckland, the remaining 35% is consumed domestically.

The Ballance Urea plant is situated in Kapuni, alongside the NGC processing facility from which it receives approximately 7PJ of gas a year. The ammonia produced at the factory creates 263,000tonnes of granular urea. The plant runs non-stop with just one scheduled shutdown every 24-36 months for statutory inspections and maintenance. The biggest influencing factor in shutdown for the factory would be contamination of the water supply, followed by loss of gas supply; these are the two critical factors in production. The minimum time required to shutdown the factory in a controlled and safe manner is a day and half, there is an emergency shutdown capacity however this will effectively write off the factory and is a last resort. The replacement cost for a plant of this size would be $500million.

Ash clouds have more impact on airlines more than any other industry. The threat to human safety requires significant reorganisation of flights, man hours and planning in terms of ash movement, exclusion zones, flight restrictions and airport closures. Only a few millimetres of ash are required to close an airport, airspace and ground planes. Ash is made up of silicates and glass which can melt in contact with superheated airplane engines, all planes must avoid all ash. Restricted air space requires re-routing, flight cancellations, inability to fly at night or during heavy cloud, extended flight times, fuel costs and workloads. The most significant delay in reinstating flights and normal operations of affected airports is cleanup associated with buildings and runways. Egmont, given its location, has the potential to close airports from Wellington to Auckland depending on wind conditions. When Ruapehu erupted flights were diverted around the western side of the mountain, the same could happen to the west of Egmont in direct flights between unaffected airports, the question therefore is how much further and at what additional cost are airlines willing to divert before cancelling flights.

Tourism in Taranaki is an underdeveloped growth industry, significant effort is underway to promote and develop this sector. Large organised sporting, cultural and recreation events form the basis of efforts to develop and advertise the region as a destination. Tourism would be slow to recover from an eruption, whilst some visitors will come for the volcanic attraction this will be minor in comparison to normal circumstances. Largely tourists will be frightened away from the direct hazard zone and a much wider area generally not affected. Public perception of the 'danger zone' is often widely inaccurate and can cause significant economic loss for tourist operators well outside the region affected.

14. Conclusions

Volcanic activity is unpredictable; it is difficult to estimate an eruption's sequence of events and to assess the conclusion of eruptive activity which will allow recovery activity to commence. It is almost impossible to estimate the extent and level of damage given the sporadic and widespread nature of impacts. Neither is it possible to identify all of the downstream impacts that may be expected after an event as a result of damage. Human behaviour which dictates business confidence, sense of security and overall recovery is unpredictable and highly dependent on how individual events are perceived. Irrespectively these estimates will provide some indication of the influence of an eruption to Taranaki and the wider economy.

Calculating the economic impact on the region is just one way of measuring the potential risk of an eruption. No estimation can be complete but any evaluations raise awareness, identify gaps in planning, vulnerabilities and prepare residents and planners for what could be expected.

Spring would be the worst time to sustain an eruption within Taranaki as this would be most detrimental to the dairy industry for both farmers and in overall processing capacity in the North Island. Spring is also the most vulnerable time for the cropping, horticultural and agricultural sectors.

Taranaki has a low population density, rich natural resources and an economy largely geared towards primary products, or primary based production. The five largest sectors in Taranaki create $8,910.18million in total output or 57.83% of regional output; these are oil and gas extraction, dairy manufacturing, dairy farming, meat processing and wholesale trade.

Total economic impact of a scenario one eruption is total value added lost of $519.09million, 8.00% of regional domestic product. A scenario two eruption will have total impact of $1,113.89million or 17.19% value added lost and scenario three a loss of $2,505.21million (38.66%). Scenario four does not incur infrastructure or physical damage and allocates a cost towards uncertainty and business behaviour in the economy as a result of volcanic activity; the value added cost of such changes in behaviour is $926.09million, representing a loss of 14.29% of gross regional product. The following table provides an overview of each of the scenarios considered in this analysis including both the direct (damage) and indirect (multipliers) costs to output, income, value added and the employment effect. This table also provides a summary of the evacuation and clean up costs that can be expected in each event.

Table 27: Comparative Input-Output Results from Each Scenario

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Output ($m) Base $15,407.58 million				
Direct Output	-878.48	-1,947.32	-4,341.47	-1,267.92
Indirect Output	-313.62	-778.55	-1,710.31	-352.98
Total Output	-1,192.10	-2,725.87	-6,051.78	-1,620.9
Value Added ($m) Base $6,480.9 million				
Direct Value Added	-378.31	-787.07	-1,790.41	-762.53
Indirect Value Added	-140.78	-326.81	-714.8	-163.55
Total Value Added	-519.09	-1,113.89	-2,505.21	-926.09
Income ($m) Base $1,523.4 million				
Direct Income	-59.10	-127.63	-286.87	-57.96
Indirect Income	-39.68	-95.41	-210.21	-46.54
Total Income	-98.78	-223.05	-497.09	-104.5
Employment (FTE) Base 43,860 Full Time Equivalents				
Direct Employment	-1,585.00	-3,396.33	-7,375.79	-1,148.58
Indirect Employment	-1,217.59	-3,023.7	-6,696.22	-1,396.91
Total Employment	-2,802.59	-6,420.03	-14,072.01	-2,545.49
Clean Up Costs ($m)	205.80	718.34	1,427.63	-

Infrastructure replacement costs are highly subjective depending on the damage experienced at the time. Electricity infrastructure will be the most affected and disruptive service given its vulnerability to conductive ash, many households may be without power for an extended time. Isolation of the Stratford power station may result in shortages or rolling blackouts outside the region, particularly if an eruption occurs mid-winter when national demand is high. If the Stratford substation or power stations are damaged by direct hazards there will be long term power outages within the region as power can not be redistributed through the region without passing through Stratford. If the power station is damaged through a high demand period, or the substation prevents New Plymouth and Stratford generating capacity to be placed on the national grid then there may be rolling shortages throughout the country, not just within the North Island

Roading is vulnerable to ash however the importance of transport networks in recovery and access after an eruption will emphasise and compound any damage. The multitude of bridges in the region means that recovery of smaller or less vital bridges may be delayed indefinitely until both funds and capability is obtained, any number of communities may be affected by such resource shortages.

Gas transmission pipelines are only vulnerable at aerial river crossings however as soon as access is a possible temporary pipe can be installed immediately reinstating supply. Long term influences related to gas resources are likely to be from fails safe modes activated on gas fields. As long as seismic activity continues there is a threat of gas fields requiring short or long term closure. Some fields may be required to discontinue production for a period of time whilst processing infrastructure is replaced. Severe gas shortages will exist throughout the industry if either of the largest production stations, Kapuni or Oaonui, is declared unusable. Business disruptions can be expected throughout the North Island for a long period after an eruption, particularly as eruption size increases. The gas industry alone is estimated to contribute more than $1billion a year to the national economy, a significant factor of Taranaki's gas monopoly is the downstream impact any regional disruption in supply could have on the national economy and social well being.

In an economic sense Fonterra's national influence has the potential to cut export revenue, and destroy farm returns throughout New Zealand if farmers are forced to dump milk or absorb the losses of capacity shortages as a result of a closure at Whareroa. Whilst other factories are able to absorb Whareroa production, possible through all but a few weeks of the year, the national export balance and total output figures may be largely unaffected, even though Taranaki impacts are enormous.

Regional impact analysis, as explained and developed in the text, captures the impact in terms of lost output, tourism and tangible losses, but it does not take into account the full effects of an eruption. Financial assessments do not consider the long term consequences from events such as the National Park sustaining long term or permanent destruction or the loss of unique ecosystems. Community disruption will result in increased stress, personal disadvantages and interruptions to lifestyle or even the permanent relocation of community members away from the region.

Public perception of risk in New Zealand is skewed towards small events which in geologic records would not even register. An eruption in Taranaki would overwhelm local civil defence resources almost immediately, the surrounding communities would be flooded with evacuees and the economic ripples would be widely felt. This is particularly the case with Taranaki and the critical high level infrastructure. Mitigating economic risk can only be done by locationally spreading risk, with adequate protection measures (financial or physical) and by increasing public awareness.

The economic impact of a small to moderate eruption on the regional Taranaki economy is a loss of value added of between eight and forty percent. An extended period of elevated alert levels (level two or greater) could in itself stunt the economy by fifteen percent each year.

15. Future Research

This research only looks at recovery from the cease of volcanic activity. In reality an eruption may continue for months during which time alert levels fluctuate, evacuations continue, recovery efforts be put off and business uncertainty remains. Additional research may investigate the daily cost of an ongoing eruption, of re-housing evacuees, civil defence and emergency personnel on the ground, losses due to business closure etc. The effect of uncertainty should be investigated further.

Further study may create a more detailed input output analysis at the regional level and integrated national assessment. Similarly a survey of smaller businesses in the region will be beneficial to determine attitudes and behaviour of these individuals when facing increased risk and evacuation. Particularly within the New Plymouth urban area which has been assumed to remain in operation through the surrounding evacuations, are businesses likely to close for the duration, make voluntary evacuations or remain.

This report in no way considers secondary impacts that result from an eruption. These may include increased flooding risk from reduced vegetation, increased surface run off or even events such as tsunami or fire. These events may be considered in terms of additional cost to a community. Insurance data has not been considered in this assessment; a net loss may be implied by incorporating the level and type of insurance cover in the region and expected Government assistance packages.

An issue that has emerged throughout this research report is the level of dependence of the electricity network on natural gas, sourced from Taranaki. Additional work may complete analysis of disruption to the gas supply on the national electricity balance. All gas supplied co-generation projects will be required to source from the national grid if gas is suspended. The six power stations that run entirely on gas will remove supply from the national grid, as will any other suppliers that rely on gas. Taranaki hydro stations, if disrupted by volcanic activity will also increase the demand put on the National grid by New Plymouth users.

The communication of information collected in this and future research regarding Ruapehu would benefit from visual representation in line with the hazard maps created. This would require a high level of knowledge in geographic information systems. The layering of socio-economic indicators provides a valuable, but underdeveloped tool in determining groups vulnerable in recovery. Future research will also have access to the output created by the volcanic risks project as a whole. This information will allow more detailed technical information, potential scenarios and impacts to be included in further analysis.

Glossary

Distribution – typically low voltage/pressure on a more detailed scale to individual customers.

Transmission – high voltage/pressure and large volumes moved over wide areas before being routed to distribution networks.

Joule – A primary measure of energy (specifically gas) in the metric system.

A gigajoule is equivalent to one billion joules; the average household consumes approximately 55GJ of gas per annum.

A terajoule is equivalent to one thousand gigajoules.

A petajoule is equivalent to one million gigajoules. 1 Petajoule = 1,000,000 Gigajoules

Petajoule Equivalent (PJe) can be used to compare different energy sources

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Appendices

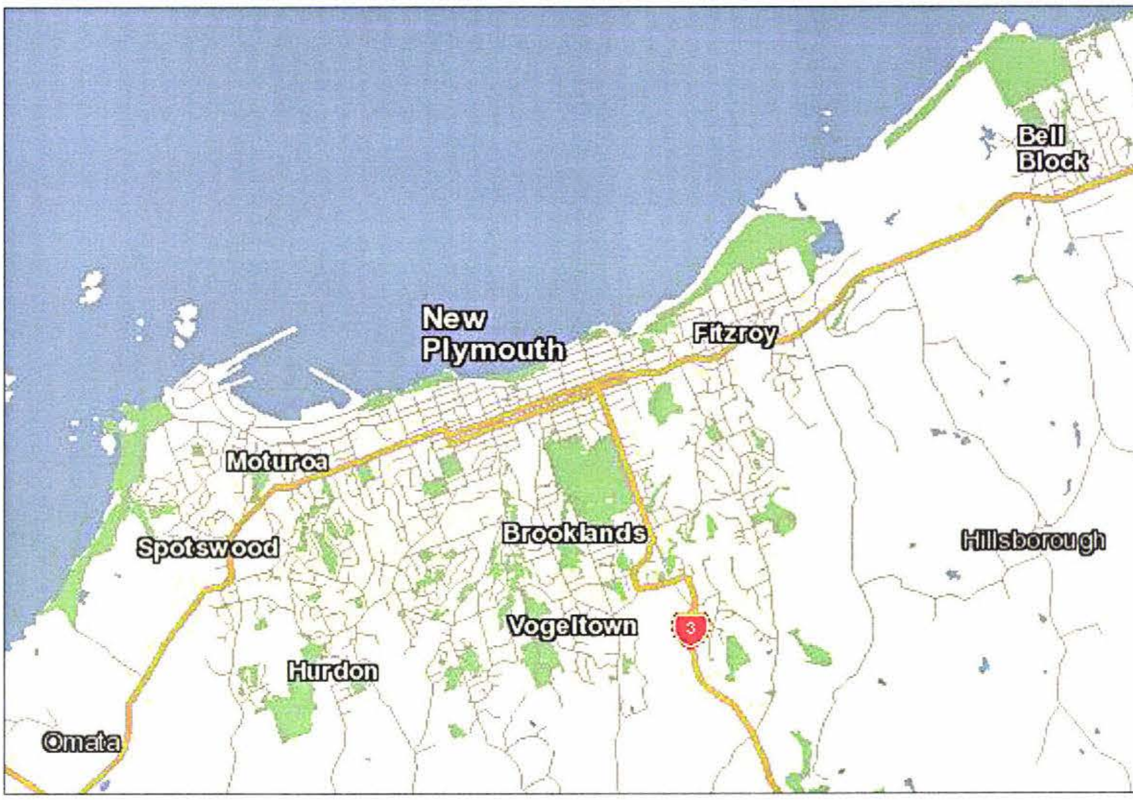
Appendix One: Expected Impact of Ash Fall with Varying Depth

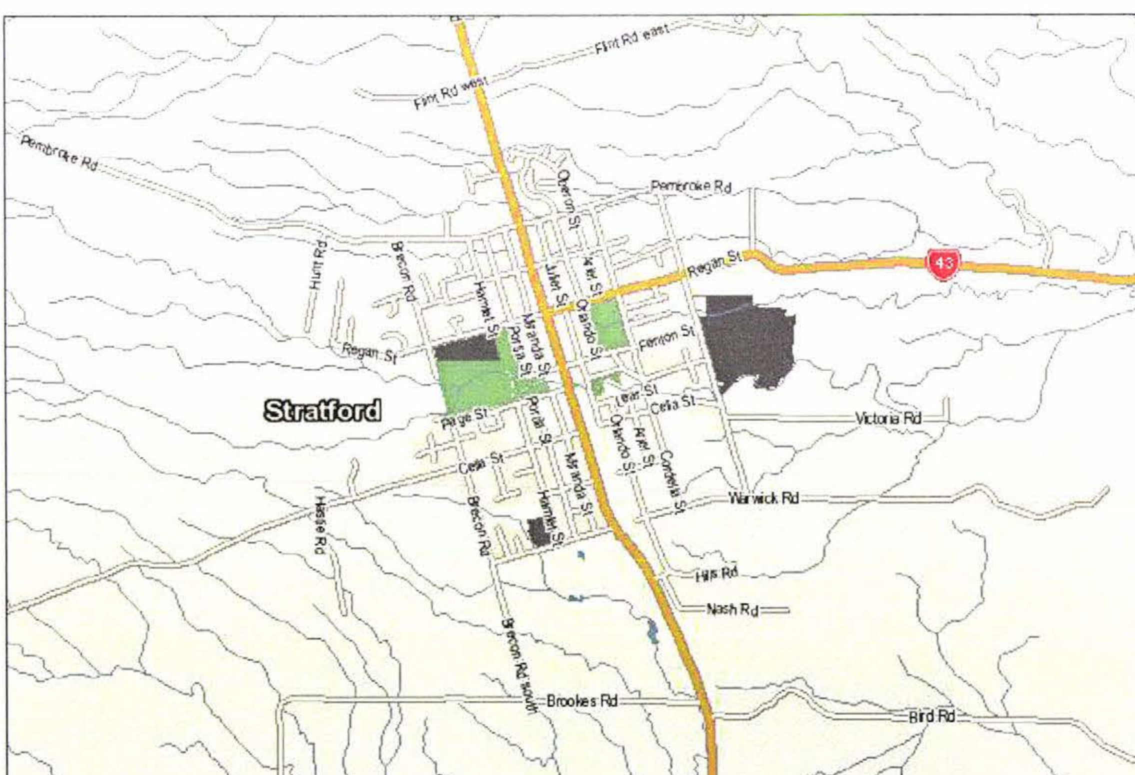
Expected Impacts of Ash Falls with Varying Depths	
Less than 1mm of ash	Acts as an irritant to lungs and eyes Airport closures due to potential risk Possible water contamination, particularly rainwater systems Visibility and traction problems on roads, road markings obscured
1-5 mm ash thickness	Possible crop damage, vegetation canopies recover in weeks. Minimal long term damage to agriculture Some livestock affected, increased stress Minor cosmetic damage to cars, households and commercial buildings Electrical pumps may fail Water contamination may apply due to chemical absorption Excessive demand for water in cleanup operations Some roads may need sweeping Sewerage and storm water systems may experience blockages Electrical equipment may fail or short circuit Aircraft movements will be affected, airspace restricted
5-100mm ash thickness	Burial of pasture and ground hugging plants, trees will survive with canopies recovered within a year. Annual crops destroyed Pastures killed when ash exceeds 50mm, tephra will remain intact on ground after a year. Soil is still viable Major ash removal programmes required in urban areas Weaker roof structures may fail at the upper limit, particularly when wet Roads may close, air filters will clog in vehicles. 2WD vehicles may struggle Rail transport will be interrupted due to unreliability of signals Electrical supply disrupted as conductivity causes short outs
100-300mm ash thickness	Increased impacts associated with effects of previous depths Buildings, in particular flat roofed commercial buildings will risk collapse if not cleared immediately Severe damage to trees, re-colonisation required for future plant growth. 4-5 years required for soil recovery Loss of electricity due to line breakage, trees falling and short circuiting
Greater than 300mm	Heavy kill of vegetation, soil is sterilised due to lack of oxygen and water Complete burial of soil horizon (water and oxygen absorption), hundreds of years before soil reaches a new equilibrium Livestock and animals killed or severely injured Complete contamination of river, lakes and aquatic life Breakage of power [poles, pylons and lines Roads impassable
Ash clouds create powerful electrical fields that can interfere with radio communications, electrical installations and cellular phone systems.	

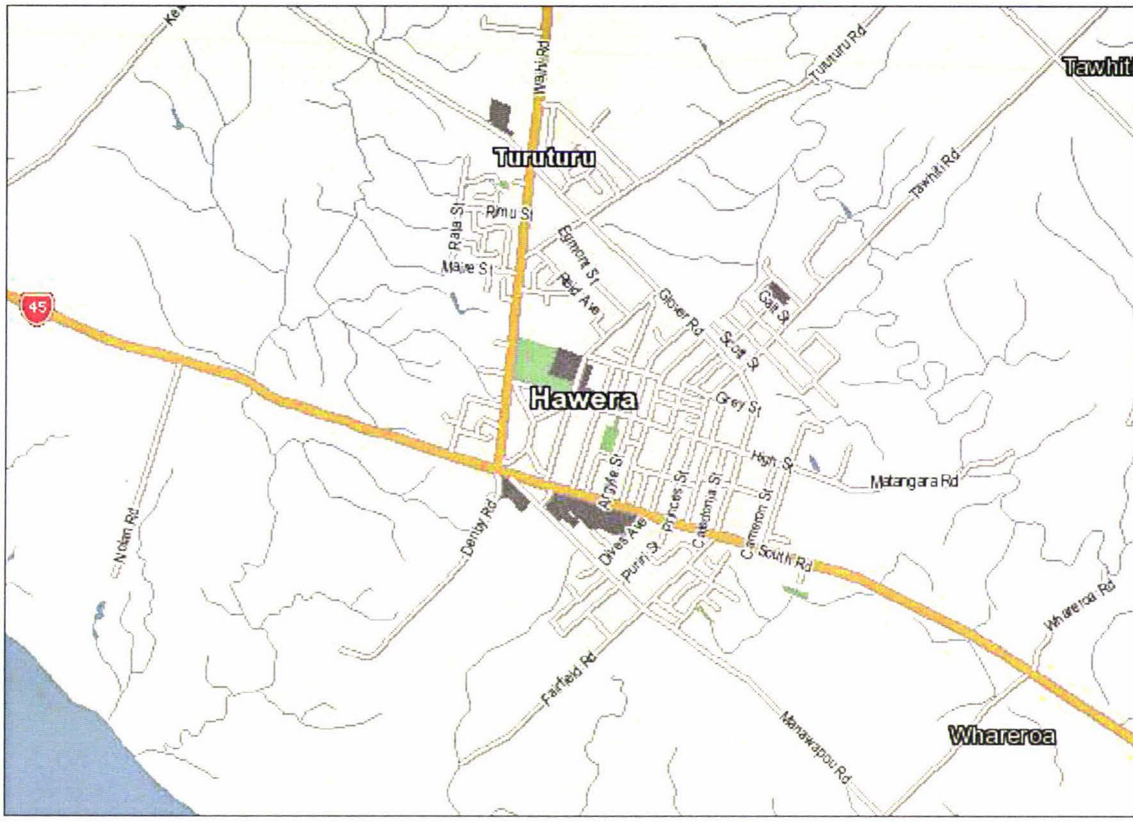
Adapted from Institute of Geological and Nuclear Sciences (2005) and Munro & Parkin (1999)

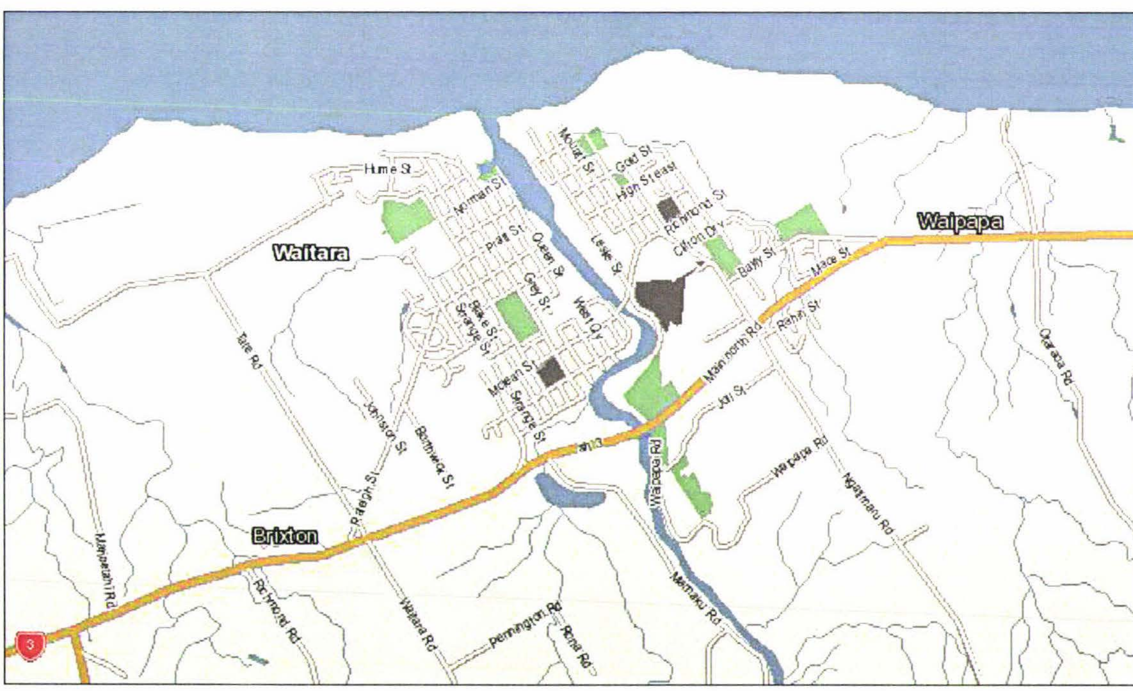
Appendix Two: Significant Towns in the Taranaki Region

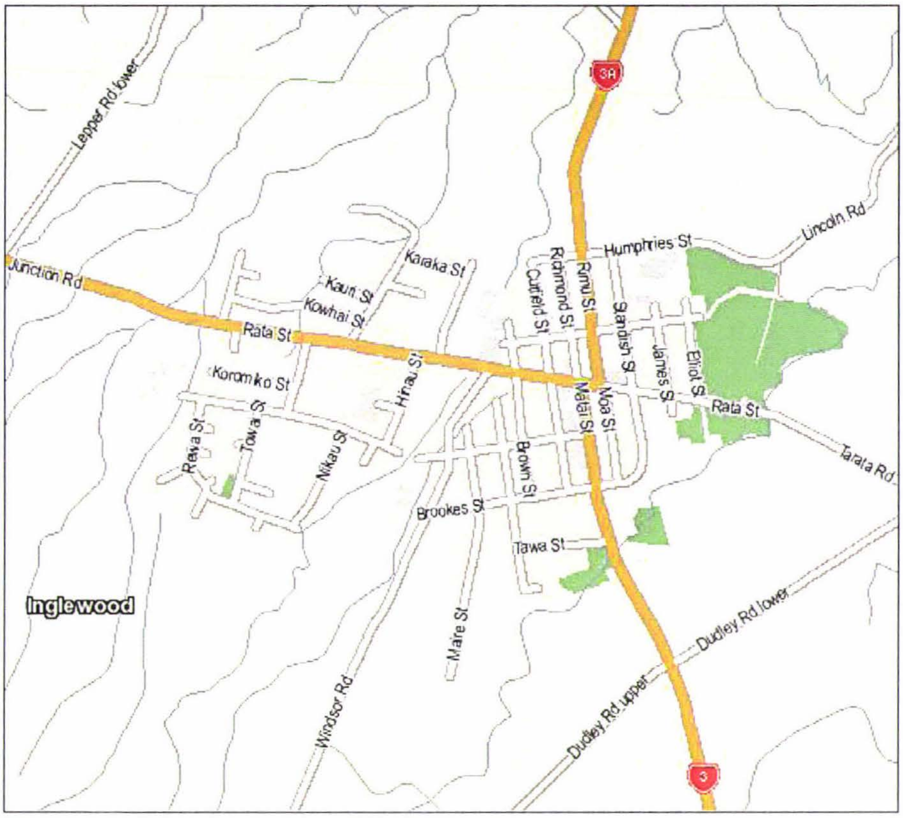
Maps sourced from zoomin.co.nz, created by Projectx Technology

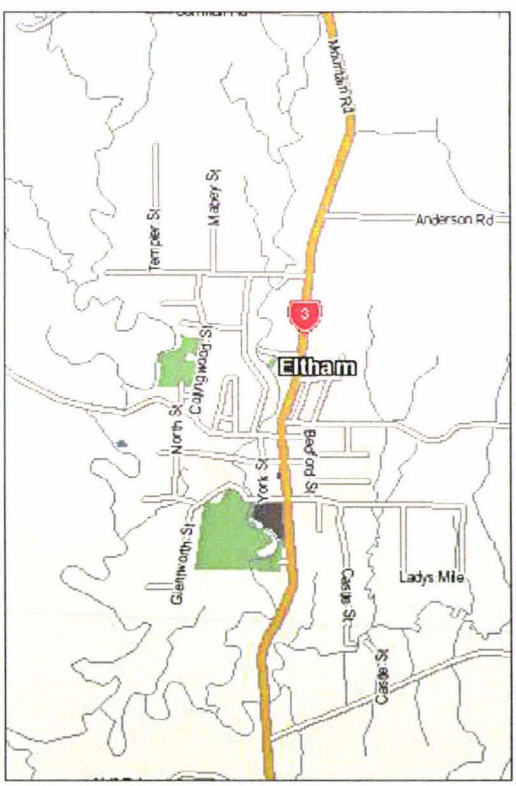


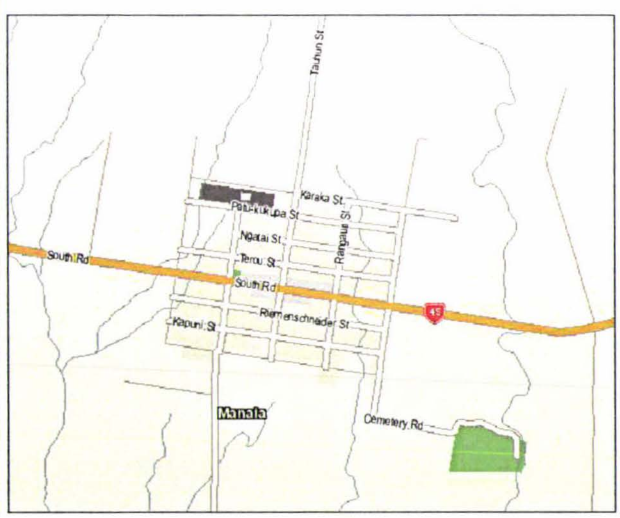



Tawhiti
Turuturu
Hawera
Whareroa
Waihi Rd
Turuturu Rd
Tawhiti Rd
Rimu St
Rata St
Maire St
Egmont St
Reid Ave
Glover Rd
Scott St
Gail St
Grey St
High St
Matangara Rd
Argyle St
Princes St
Caledonia St
Cameron St
South Rd
Dixon Ave
Puriri St
Denby Rd
Nolan Rd
Fairfield Rd
Manawapou Rd
Whareroa Rd
45


Waitara
Waipapa
Brixton
Hume St
Norman St
Pratt St
Queen St
Grey St
West Qy
Mouat St
Gold St
High St east
Richmond St
Clifton Dr
Leslie St
Bayly St
Mace St
Rehiri St
Main north Rd
Joll St
McLean St
Tate Rd
Johnston St
Raleigh St
Waipapa Rd
Ngatimaru Rd
Manukau Rd
Waitara Rd
Pennington Rd
Richmond Rd
Mamaku Rd
3


Inglewood
Junction Rd
Rata St
Humphries St
Lincoln Rd
Tarata Rd
Dudley Rd lower
Dudley Rd upper
Windsor Rd
Mataí St
Brookes St
Tawa St
Brown St
Karaka St
Koromiko St
Nikau St
Rewa St


Eltham
Mountain Rd
Anderson Rd
Collingwood St
North St
York St
Bedford St
Glenworth St
Ladys Mile
Castle St


Manaia
South Rd
Karaka St
Kapuni St
Cemetery Rd

Appendix Three: Input – Output Scenario Workings Using the 114 Sectors of the Taranaki Economy

The table is included over the page.

Notes to the table:

- Evacuation is the most influential factor for small businesses and community impact. Evacuation is 2 weeks for scenario one, 5 weeks for scenario two and 12 weeks for scenario three for all residents within the red and blue zones (more explanation provided in 10.4).
- The regional fruit sectors are assumed to be affected at the most vulnerable time resulting in high losses due to blossom drop, acid burn, reduced plant health and the lack of insects required in fertilisation (Spring / Summer eruption)
- Contamination of water supply incorporates the fact that 80% of the regions water supply is surface water. Each scenario will result in contaminated (unusable) water for 5%, 10% and 25% of the year respectively.
- In scenario one milking is interrupted by animal stress and unappetising pastures. In scenario two milking is more significantly interrupted and some cows are dried up early. Scenario three significantly disrupts the milking season due to pasture and stock loss and the inability for milking to occur.
- Agriculture is the most influenced sector due to either increased feed out costs, pasture or stock loss and increased operating costs.
- Gas is stopped in line with unsafe operating conditions, the is largely in line with evacuation periods but accounts for line pack and the ability to control lines from outside the region – reducing the requirement to shutdown solely depending on evacuation.
- Any interruptions to gas supply will cut all industrial and commercial users.
- Gas exploration behaviour is only influenced in scenario three due to perceived stability of the region into the future. On-site work can be suspended until conditions permit in the other scenarios but will not be cancelled.
- Dairy manufacturing is only influenced marginally in scenarios two and three to account for the fact that milk can be absorbed by factories outside the region.
- Meat processing facilities are influenced largely by loss of stock within the supply zone – particularly poultry which is more susceptible. The Bell Block poultry site is largely protected from volcanic hazards. Vulnerability of the Eltham meat processing site is reflected in the direct impact.

Taranaki's 114 Sector Model

ANZSIC	Sector	Total Output	Estimated (Sum of Districts) Enterprises	Employees	Employees Evacuated	Industry Evacuated	Scenario One Evacuation	Eruption Specific	Recovery	Total Impact	Scenario Two Evacuation	Eruption Specific	Recovery	Total Impact	Scenario Three Evacuation	Eruption Specific	Recovery	Total Impact
A01	Other Horticulture	40.8412	4177	3190	1835	0.5752	0.0221	0.200		0.2221	0.0553	0.400		0.4553	0.1327	0.600		0.7327
	Apple & Pears	0.3202					0.0221	0.200		0.2221	0.0553	0.400		0.4553	0.1327	0.600		0.7327
	Kiwifruit	0.3969					0.0221	0.200		0.2221	0.0553	0.400		0.4553	0.1327	0.600		0.7327
	Other Fruit	1.1147					0.0221	0.200		0.2221	0.0553	0.400		0.4553	0.1327	0.600		0.7327
	Mixed Cropping	56.7922					0.0221	0.100		0.1221	0.0553	0.200		0.2553	0.1327	0.400		0.5327
	Sheep & Beef	176.9354					0.0221	0.050		0.0721	0.0553	0.100		0.1553	0.1327	0.300		0.4327
	Dairy	1808.5122					0.0221	0.150		0.1721	0.0553	0.300		0.3553	0.1327	0.600		0.7327
	Other Farming	50.2927					0.0221	0.050		0.0721	0.0553	0.100		0.1553	0.1327	0.300		0.4327
A02	Services to Agriculture	74.8230	258	390	215	0.5513	0.0212		0.100	-0.0788	0.0530		0.300	-0.2470	0.1272		0.500	-0.3728
A03	Forestry	33.9975	190	81	43.5	0.5370	0.0207			0.0207	0.0516	0.200		0.2516	0.1239	0.400		0.5239
	Services to Forestry	7.5987					0.0207			0.0207	0.0516			0.0516	0.1239			0.1239
	Logging	5.4178					0.0207		0.050	-0.0293	0.0516		0.100	-0.0484	0.1239		0.200	-0.0761
A04	Fishing	14.9605	23	12	6	0.5000	0.0192			0.0192	0.0481			0.0481	0.1154			0.1154
B11	Coal Mining	0.0000	0	0	0		0.0000			0.0000	0.0000			0.0000	0.0000			0.0000
B15	Services to Mining	14.6049	16	210	105	0.5000	0.0192			0.0192	0.0481			0.0481	0.1154			0.1154
B13+B14	Other Mining & Quarrying	44.6036	8	37	20	0.5405	0.0208			0.0208	0.0520			0.0520	0.1247			0.1247
B12	Oil & Gas Extraction	3370.8459	8	530	265	0.5000	0.0192	0.050		0.0692	0.0481	0.100		0.1481	0.1154	0.250		0.3654
	Oil & Gas Exploration	331.7206					0.0192			0.0192	0.0000			0.0000	0.1154	0.100		0.2154
C21	Meat Processing	788.6813	42	3955	1995	0.5044	0.0194			0.0194	0.0485	0.050		0.0985	0.1164	0.100		0.2164
	Poultry Processing	120.9892					0.0194			0.0194	0.0485	0.100		0.1485	0.1164	0.200		0.3164
	Bacon Ham & Small Goods	3.8225					0.0194			0.0194	0.0485			0.0485	0.1164			0.1164
	Dairy Manufacturing	2471.7493					0.0194			0.0194	0.0485	0.050		0.0985	0.1164	0.100		0.2164
	Fruit & Veg, Oil & Cereal Processing	38.3563					0.0194			0.0194	0.0485			0.0485	0.1164			0.1164
	Bakery & Confectionary	170.0239					0.0194			0.0194	0.0485			0.0485	0.1164			0.1164
	Seafood Processing	14.5403					0.0194			0.0194	0.0485			0.0485	0.1164			0.1164
	Other Food Manufacturing	24.0620					0.0194			0.0194	0.0485			0.0485	0.1164			0.1164
	Soft Drink, Cordial, Water	0.0000					0.0194			0.0194	0.0485			0.0485	0.1164			0.1164
	Beer, Wine & Tobacco	5.9029					0.0194			0.0194	0.0485			0.0485	0.1164			0.1164
C22	Textile Manufacturing	6.0996	22	65	34	0.5231	0.0201			0.0201	0.0503			0.0503	0.1207			0.1207
	Clothing Manufacturing	9.6674					0.0201			0.0201	0.0503			0.0503	0.1207			0.1207
	Footwear	0.1044					0.0201			0.0201	0.0503			0.0503	0.1207			0.1207
	Other Leather Products	0.5326					0.0201			0.0201	0.0503			0.0503	0.1207			0.1207
C23	Sawmilling & Timber Dressing	104.0852	66	669	339	0.5067	0.0195			0.0195	0.0487			0.0487	0.1169			0.1169
	Other Wood Products	43.2292					0.0195			0.0195	0.0487			0.0487	0.1169			0.1169
	Paper & Paper Products	0.0000					0.0195			0.0195	0.0487			0.0487	0.1169			0.1169
C24	Printing & Services	24.8683	30	315	180	0.5714	0.0220			0.0220	0.0549			0.0549	0.1319			0.1319
	Publishing & Recorded Media	41.0535					0.0220			0.0220	0.0549			0.0549	0.1319			0.1319
C25	Petroleum Refining	0.0000	36	556	281	0.5054	0.0194			0.0194	0.0486			0.0486	0.1166			0.1166
	Petroleum & Coal Products	0.0000					0.0194			0.0194	0.0486			0.0486	0.1166			0.1166
	Fertilisers	194.6648					0.0194			0.0194	0.0486			0.0486	0.1166			0.1166
	Other Industrial Chemicals	120.7484					0.0194			0.0194	0.0486			0.0486	0.1166			0.1166
	Medicinal, Detergents & Cosmetics	0.0000					0.0194		0.050	-0.0306	0.0486		0.075	-0.0264	0.1166		0.100	0.0166
	Other Chemical Products	28.3905					0.0194			0.0194	0.0486			0.0486	0.1166			0.1166
	Rubber Manufacturing	10.2367					0.0194			0.0194	0.0486			0.0486	0.1166			0.1166
	Plastic Products	11.4835					0.0194			0.0194	0.0486			0.0486	0.1166			0.1166
C26	Glass & Ceramics	3.8617	27	96	51	0.5313	0.0204			0.0204	0.0511			0.0511	0.1226			0.1226
	Other non-metalic mineral products	36.7854					0.0204			0.0204	0.0511			0.0511	0.1226			0.1226
C27	Basic Metal Manufacturing	107.7362	119	1160	600	0.5172	0.0199			0.0199	0.0497			0.0497	0.1194			0.1194
	Structural, sheet & fab-metal prod	199.7068					0.0199			0.0199	0.0497		0.050	-0.0003	0.1194		0.150	-0.0306
C28	Motor Vehicles	16.9363	151	1052	532	0.5057	0.0195			0.0195	0.0486			0.0486	0.1167			0.1167
	Ship Building	22.0959					0.0195			0.0195	0.0486			0.0486	0.1167			0.1167
	Other Transport Equipment	11.3307					0.0195		0.050	-0.0305	0.0486		0.150	-0.1014	0.1167		0.300	-0.1833
	Photographic & Scientific Equip	27.0881					0.0195			0.0195	0.0486			0.0486	0.1167			0.1167
	Electrical & Appliance Manuf	62.5368					0.0195		0.020	-0.0005	0.0486		0.100	-0.0514	0.1167		0.200	-0.0833
	Agricultural Equipment	14.9010					0.0195		0.100	-0.0805	0.0486		0.250	-0.2014	0.1167		0.400	-0.2833
	Other Industrial Machinery	85.5619					0.0195		0.020	-0.0005	0.0486		0.100	-0.0514	0.1167		0.200	-0.0833
C29	Prefabricated Buildings	1.1802	58	145	85	0.5862	0.0225			0.0225	0.0564			0.0564	0.1353			0.1353
	Furniture	23.4772					0.0225			0.0225	0.0564			0.0564	0.1353			0.1353
	Other Manufacturing	3.0422					0.0225			0.0225	0.0564			0.0564	0.1353			0.1353
D36	Electricity Generation	112.3690	14	343	179	0.5219	0.0201	0.600		0.6201	0.0502	0.700		0.7502	0.1204	0.800		0.9204
	Electricity Transmission	46.1496					0.0201		0.050	-0.0299	0.0502	0.100	0.200	-0.0498	0.1204	0.400	0.400	0.1204
	Electricity Supply	236.3692					0.0201			0.0201	0.0502			0.0502	0.1204			0.1204
	Gas Supply	84.2088					0.0201	0.570		0.5901	0.0502	0.700		0.7502	0.1204	1.000		1.1204
D37	Water Supply	12.5210	6	18	9	0.5000	0.0192	0.050	0.100	-0.0308	0.0481	0.100	0.200	-0.0519	0.1154	0.200	0.300	0.0154
E41	Residential Building	118.2565	298	925	510	0.5514	0.0212			0.0212	0.0530			0.0530	0.1272			0.1272
	Non-residential Building	128.6841					0.0212			0.0212	0.0530			0.0530	0.1272			0.1272
	Non-building Construction	115.9882					0.0212			0.0212	0.0530			0.0530	0.1272			0.1272
E42	Ancillary Construction Services	242.8138	498	1515	780	0.5149	0.0198			0.0198	0.0495			0.0495	0.1188			0.1188

F4	Wholesale Trade	470.3899	344	1860	985	0.5296	0.0204			0.0204	0.0509			0.0509	0.1222			0.1222
G5	Retail Trade	428.1275	1006	5670	3070	0.5414	0.0208		0.050	-0.0292	0.0521		0.150	-0.0979	0.1249		0.400	-0.2751
H57	Accommodation	48.5667	267	2080	1095	0.5264	0.0202			0.0202	0.0506			0.0506	0.1215			0.1215
	Restaurants, Cafes, Bars & Clubs	74.9724					0.0202			0.0202	0.0506			0.0506	0.1215			0.1215
I61	Road Freight	158.8147	184	900	510	0.5667	0.0218	0.100		0.1218	0.0545	0.200		0.2545	0.1308	0.500		0.6308
	Road Passenger	15.0122					0.0218	0.100		0.1218	0.0545	0.200		0.2545	0.1308	0.500		0.6308
I62+I63	Water & Rail Services	77.4458	3	53	36.5	0.6887	0.0265			0.0265	0.0662	0.150		0.2162	0.1589	0.300		0.4589
I64+I65+I66+I67	Air Services, Transport & Storage	80.1898	49	463	233	0.5032	0.0194	0.100		0.1194	0.0484	0.200		0.2484	0.1161	0.400		0.5161
J7	Communication Services	114.7244	97	364	186.5	0.5124	0.0197	0.050		0.0697	0.0493	0.100		0.1493	0.1182	0.200		0.3182
K73	Finance & Superannuation	101.4431	114	475	260	0.5474	0.0211			0.0211	0.0526			0.0526	0.1263			0.1263
K74	Insurance	8.6909	13	39	19.5	0.5000	0.0192			0.0192	0.0481			0.0481	0.1154			0.1154
K75	Services to Finance & Insurance	20.5711	69	82	42.5	0.5183	0.0199			0.0199	0.0498			0.0498	0.1196			0.1196
L77	Property Services	168.6582	1836	468	243	0.5192	0.0200			0.0200	0.0499			0.0499	0.1198			0.1198
	Owner Occupied Housing	336.8607					0.0200			0.0200	0.0499			0.0499	0.1198			0.1198
	Vehicle & Equipment Hiring	55.9139					0.0200			0.0200	0.0499			0.0499	0.1198			0.1198
L78	Scientific Research	0.0000	702	3340	1735	0.5195	0.0200		0.050	-0.0300	0.0499		0.100	-0.0501	0.1199		0.150	-0.0301
	Technical Services	133.4603					0.0200			0.0200	0.0499			0.0499	0.1199			0.1199
	Computer Services	37.6361					0.0200			0.0200	0.0499			0.0499	0.1199			0.1199
	Legal Services	35.1967					0.0200			0.0200	0.0499			0.0499	0.1199			0.1199
	Accounting Services	48.7224					0.0200			0.0200	0.0499			0.0499	0.1199			0.1199
	Advertising & Marketing Services	14.9299					0.0200			0.0200	0.0499			0.0499	0.1199			0.1199
	Bus, Admin, & Mgmt Services	68.9611					0.0200			0.0200	0.0499			0.0499	0.1199			0.1199
	Employment & Security Services	36.0523					0.0200			0.0200	0.0499			0.0499	0.1199			0.1199
	Pest & Cleaning Services	24.4311					0.0200			0.0200	0.0499			0.0499	0.1199			0.1199
	Other Business Services	40.6270					0.0200			0.0200	0.0499			0.0499	0.1199			0.1199
M8	Central Government	43.9664	34	930	535	0.5753	0.0221			0.0221	0.0553			0.0553	0.1328			0.1328
	Defence	0.0000					0.0221			0.0221	0.0553			0.0553	0.1328			0.1328
	Fire & Police	25.3302					0.0221			0.0221	0.0553			0.0553	0.1328			0.1328
	Local Government	147.0428					0.0221			0.0221	0.0553			0.0553	0.1328			0.1328
N84	Pre-School Education	9.7040	211	3040	1650	0.5428	0.0209			0.0209	0.0522			0.0522	0.1253			0.1253
	Primary & Secondary Education	93.2749					0.0209			0.0209	0.0522			0.0522	0.1253			0.1253
	Post School Education	32.0175					0.0209			0.0209	0.0522			0.0522	0.1253			0.1253
	Other Education	20.5519					0.0209			0.0209	0.0522			0.0522	0.1253			0.1253
O86	Hospitals	112.0942	303	2650	1355	0.5113	0.0197			0.0197	0.0492			0.0492	0.1180			0.1180
	Medical & Dental	104.2552					0.0197		0.050	-0.0303	0.0492		0.100	-0.0508	0.1180		0.150	-0.0320
	Veterinary Services	11.0221					0.0197		0.100	-0.0803	0.0492		0.200	-0.1508	0.1180		0.300	-0.1820
O87	Child Care	3.9287	86	1980	1070	0.5404	0.0208			0.0208	0.0520			0.0520	0.1247			0.1247
	Aged Accommodation	21.7046					0.0208			0.0208	0.0520			0.0520	0.1247			0.1247
	Other Community Services	34.2281					0.0208			0.0208	0.0520			0.0520	0.1247			0.1247
P91	Movies, Radio & TV	30.3276	17	113	56.5	0.5000	0.0192			0.0192	0.0481			0.0481	0.1154			0.1154
P92	Libraries, Museums, & Arts	15.8522	36	262	137	0.5229	0.0201			0.0201	0.0503			0.0503	0.1207			0.1207
P93	Horses & Dog Racing	9.0729	185	490	265	0.5408	0.0208			0.0208	0.0520			0.0520	0.1248			0.1248
	Gaming	6.0336					0.0208			0.0208	0.0520			0.0520	0.1248			0.1248
	Other Sport & Recreation	44.0630					0.0208			0.0208	0.0520			0.0520	0.1248			0.1248
Q95	Personal & Community Services	54.8258	189	480	255	0.5313	0.0204			0.0204	0.0511			0.0511	0.1226			0.1226
Q96	Other Services	7.2127	139	755	397.5	0.5265	0.0202			0.0202	0.0506			0.0506	0.1215			0.1215
	Total Regional Output	**15407.5771**																

Appendix Four: Input–Output Scenario Results Using the 114 Sectors of the Taranaki Economy

SCENARIO 1 IMPACTS: OUTPUT, INCOME & EMPLOYMENT								
	Estimated Output Effects ($m)		Estimated Income Effects ($m)		Estimated Employment Effects (u)		Estimated Value Added Effects ($m)	
SECTOR	Direct	Total	Direct	Total	Direct	Total	Direct	Total
Other Hort	-9.07	-12.67	-1.54	-2.15	-81.28	-113.53	-4.87	-6.8
Apple&Pear	-0.07	-0.08	-0.02	-0.02	-0.87	-1.02	-0.04	-0.04
Kiwifruit	-0.09	-0.11	0	0	0	0	0	0
OtherFruit	-0.25	-0.33	-0.01	-0.01	-0.67	-0.9	-0.02	-0.03
MixedCrop	-6.94	-9.76	-0.26	-0.37	-10.75	-15.12	-1.15	-1.62
SheepBeef	-12.76	-19.09	-0.87	-1.3	-46.52	-69.59	-4.01	-6
Dairy	-311.29	-350.22	-27.08	-30.47	-830.16	-933.98	-105.07	-118.21
Other Farm	-3.63	-6.47	-0.23	-0.4	-28.8	-51.34	-1.13	-2.01
AgSv&Hunt	5.9	-0.5	1.16	-0.1	39.82	-3.36	2.7	-0.23
Forestry	-0.7	-1.28	-0.02	-0.04	-0.82	-1.51	-0.22	-0.41
ServtoFor	-0.16	-0.29	-0.05	-0.09	-1.37	-2.46	-0.09	-0.16
Logging	0.16	0.08	0.05	0.02	1.48	0.74	0.1	0.05
Fishing	-0.29	-0.36	-0.02	-0.03	-0.58	-0.73	-0.12	-0.15
CoalMine	0	0	0	0	0	0	0	0
ServMining	-0.28	-1.2	-0.04	-0.18	-0.71	-3.04	-0.12	-0.53
OthMinQuar	-0.93	-4.12	-0.03	-0.13	-0.73	-3.24	-0.18	-0.78
Oil&G Extr	-233.37	-275.97	-4.39	-5.19	-31.15	-36.84	-157.94	-186.77
Oil&G Expl	-6.38	-6.38	-0.78	-0.78	-2.69	-2.69	-2.22	-2.22
Meat Proc	-15.3	-18.41	-1.32	-1.59	-34.59	-41.62	-2.97	-3.57
Poultry	-2.35	-4.44	-0.22	-0.42	-5.48	-10.35	-0.8	-1.52
Bacon Ham	-0.07	-0.25	0	0	0	0	0	0
Dairy	-47.95	-50.76	-1.51	-1.6	-31.04	-32.86	-5.33	-5.64
Fr&VegProc	-0.74	-0.83	-0.06	-0.07	-1.77	-2	-0.16	-0.18
BakeryConf	-3.3	-4.15	-0.22	-0.28	-5.45	-6.86	-0.42	-0.53
SeafoodPro	-0.28	-0.35	-0.02	-0.03	-0.54	-0.67	-0.05	-0.06
OtherFood	-0.47	-2.2	-0.04	-0.18	-1.02	-4.75	-0.09	-0.43
Soft Drink	0	0	0	0	0	0	0	0
BeerWineTo	-0.11	-0.24	-0.01	-0.02	-0.17	-0.36	-0.03	-0.07
Textiles	-0.12	-0.21	-0.02	-0.03	-0.59	-1.05	-0.03	-0.06
Clothing	-0.19	-0.59	-0.02	-0.06	-0.81	-2.52	-0.03	-0.09
Footwear	0	0	0	0	0	0	0	0
Oth Leathe	-0.01	-0.03	0	0	0	0	0	0
Sawmilletc	-2.03	-3.55	-0.3	-0.52	-7.68	-13.45	-0.56	-0.98
OthWoodPro	-0.84	-1.71	-0.13	-0.26	-4.66	-9.49	-0.25	-0.5
Paper&Pro	0	0	0	0	0	0	0	0
Print&Serv	-0.55	-1.44	-0.1	-0.26	-3.07	-8.05	-0.24	-0.63
Pub,Record	-0.9	-2.08	-0.15	-0.35	-4.38	-10.14	-0.44	-1.01
PetrolRef	0	0	0	0	0	0	0	0
PetCoalPro	0	0	0	0	0	0	0	0
Fertilise	-3.78	-15.93	-0.19	-0.81	-3.53	-14.9	-0.63	-2.67
OthIndChem	-2.35	-2.98	-0.21	-0.27	-4.32	-5.47	-0.62	-0.78
Medic,Cosm	0	0	0	0	0	0	0	0
OthChemPro	-0.55	-0.75	-0.06	-0.08	-1.16	-1.58	-0.14	-0.19
Rubber	-0.2	-0.34	-0.03	-0.06	-0.68	-1.15	-0.07	-0.11
Plastics	-0.22	-0.57	-0.03	-0.09	-0.77	-1.99	-0.07	-0.19
Glass&Prod	-0.08	-0.12	-0.02	-0.02	-0.37	-0.56	-0.03	-0.04
OthNon-met	-0.75	-2.59	-0.1	-0.33	-1.59	-5.5	-0.26	-0.9
BasicMetal	-2.14	-2.46	-0.25	-0.29	-5.18	-5.95	-0.58	-0.67
Struct&Fab	-3.97	-7.49	-0.76	-1.43	-19.08	-36.01	-1.32	-2.49
Vehicles	-0.33	-0.82	-0.03	-0.07	-0.78	-1.95	-0.06	-0.15
Ship&Boat	-0.43	-0.46	-0.1	-0.1	-2.72	-2.94	-0.17	-0.18
Oth.transp	0.35	0.33	0.08	0.07	1.27	1.19	0.13	0.12
Photo&Sci	-0.53	-0.6	-0.12	-0.13	-2.15	-2.43	-0.2	-0.23
ElectEquip	0.03	-0.67	0	-0.1	0.11	-2.53	0.01	-0.19

Agric Mach	1.2	0.69	0.22	0.13	6.2	3.55	0.45	0.26
OthIndMach	0.05	-2.15	0.01	-0.44	0.29	-12.54	0.02	-0.82
PrefabBldg	-0.03	-0.07	0	0	0	0	0	0
Furniture	-0.53	-0.93	-0.11	-0.19	-3.54	-6.21	-0.17	-0.3
Other Man	-0.07	-0.16	-0.02	-0.04	-0.51	-1.18	-0.03	-0.06
ElectGen	-69.68	-73.28	-1.94	-2.05	-35.35	-37.17	-31.56	-33.2
ElectTrans	1.38	-8.15	0.02	-0.14	0.42	-2.47	0.76	-4.47
ElectSuppl	-4.74	-12.7	-0.25	-0.67	-4.59	-12.3	-1.27	-3.4
GasSupply	-49.69	-59.96	-2.62	-3.17	-35.4	-42.73	-18.06	-21.79
WaterSupp	0.39	-0.08	0	0	0.06	-0.01	0.01	0
Resid Bldg	-2.51	-3.08	-0.35	-0.42	-13.44	-16.46	-0.46	-0.56
Non-resBld	-2.73	-4.26	-0.31	-0.48	-5.56	-8.67	-0.44	-0.69
Non-Bldg	-2.46	-5.58	-0.4	-0.92	-7.21	-16.37	-0.81	-1.83
AncService	-4.81	-12.29	-1.19	-3.04	-43.14	-110.24	-1.83	-4.69
Wholesale	-9.58	-23.87	-1.5	-3.73	-40.53	-100.98	-3.89	-9.7
Retail	12.49	-5.11	3.51	-1.44	148.35	-60.69	6.18	-2.53
Accommodn	-0.98	-1.91	-0.19	-0.37	-13.12	-25.57	-0.43	-0.85
Bars,Rest	-1.52	-3.16	-0.27	-0.56	-20.58	-42.81	-0.5	-1.04
RoadFrate	-19.34	-29.67	-3.23	-4.96	-87.07	-133.59	-8.28	-12.71
Road Pax	-1.83	-2.53	-0.47	-0.65	-19.63	-27.17	-0.87	-1.2
Water&Rail	-2.05	-3.58	-0.34	-0.59	-5.88	-10.26	-1.09	-1.91
Air,Serv	-9.57	-12.99	-1.14	-1.55	-28.64	-38.87	-3.26	-4.42
Communicat	-8	-11.29	-1.14	-1.61	-28.1	-39.64	-3.88	-5.48
Finance	-2.14	-10.11	-0.41	-1.94	-8.35	-39.48	-1.22	-5.79
Insurance	-0.17	-0.72	-0.03	-0.11	-0.61	-2.58	-0.07	-0.3
ServFinIns	-0.41	-1.08	-0.09	-0.25	-2.03	-5.34	-0.22	-0.59
Property	-3.37	-8.65	-0.32	-0.82	-12.75	-32.74	-1.95	-5.01
Owner-Occ	-6.73	-21.43	0	0	0	0	-4.45	-14.18
EquipHire	-1.12	-2.89	-0.14	-0.36	-3.77	-9.71	-0.58	-1.49
Sci Resrch	0	0	0	0	0	0	0	0
Tech Serv	-2.67	-18.89	-0.89	-6.28	-19.17	-135.58	-1.5	-10.58
ComputerSv	-0.75	-1.92	-0.22	-0.56	-3.79	-9.72	-0.4	-1.03
Legal	-0.7	-1.83	-0.27	-0.69	-5.97	-15.56	-0.48	-1.24
Accounting	-0.97	-3.22	-0.4	-1.33	-9.12	-30.3	-0.67	-2.24
AdvertMktg	-0.3	-0.69	-0.07	-0.16	-1.15	-2.63	-0.11	-0.25
Bus. Admin	-1.38	-3.18	-0.32	-0.74	-12.15	-28	-0.67	-1.55
Emp&SecSvc	-0.72	-1.49	-0.27	-0.55	-6.37	-13.15	-0.44	-0.9
Pest,Clean	-0.49	-0.89	-0.23	-0.42	-6.58	-11.92	-0.35	-0.63
OtherBusSv	-0.81	-2.22	-0.15	-0.4	-7.24	-19.86	-0.31	-0.85
CentralGov	-0.97	-1.33	-0.26	-0.36	-8.07	-11.1	-0.44	-0.6
Defence	0	0	0	0	0	0	0	0
FirePolice	-0.56	-0.57	-0.28	-0.29	-7.32	-7.44	-0.45	-0.46
Local Govt	-3.25	-3.6	-0.49	-0.55	-10.23	-11.35	-1.07	-1.18
PreSch. Ed	-0.2	-0.39	-0.09	-0.18	-3.9	-7.58	-0.14	-0.27
Prim&SecEd	-1.95	-2.52	-0.95	-1.23	-33.8	-43.72	-1.54	-1.99
PostSchEd	-0.67	-0.7	-0.3	-0.31	-6.8	-7.15	-0.47	-0.49
Other Ed	-0.43	-0.93	-0.15	-0.33	-7.09	-15.35	-0.23	-0.49
Hospitals	-2.2	-2.5	-0.99	-1.12	-21.14	-24.04	-1.53	-1.74
MedicDent	3.16	2.62	0.92	0.77	33.37	27.7	1.89	1.57
Veterinary	0.89	-0.5	0.31	-0.17	9.69	-5.4	0.55	-0.3
ChildCare	-0.08	-0.16	-0.03	-0.07	-2.85	-5.83	-0.05	-0.11
Aged Accom	-0.45	-1.39	-0.16	-0.49	-8.83	-27.32	-0.27	-0.84
OthComCare	-0.71	-1.28	-0.24	-0.44	-9.54	-17.17	-0.39	-0.7
MovieRadTV	-0.58	-1.09	-0.12	-0.22	-2.2	-4.13	-0.22	-0.42
Lib,Museum	-0.32	-0.5	-0.09	-0.15	-4.38	-6.88	-0.16	-0.25
Racing	-0.19	-1.1	-0.03	-0.16	-1.24	-7.17	-0.07	-0.4
Gaming	-0.13	-0.18	-0.01	-0.02	-0.39	-0.53	-0.08	-0.1
OthSporRec	-0.92	-1.86	-0.13	-0.27	-6.12	-12.37	-0.34	-0.68
Pers&Comm	-1.12	-2.91	-0.4	-1.04	-18.96	-49.33	-0.6	-1.56
WasteSewer	-0.15	-0.38	-0.02	-0.06	-1.16	-2.92	-0.07	-0.18
TOTAL	-878.48	-1192.1	-59.1	-98.78	-1585	-2802.59	-378.31	-519.09

SCENARIO 2 IMPACTS: OUTPUT, INCOME & EMPLOYMENT								
	Estimated Output Effects ($m)		Estimated Income Effects ($m)		Estimated Employment Effects (u)		Estimated Value Added Effects ($m)	
SECTOR	Direct	Total	Direct	Total	Direct	Total	Direct	Total
Other Hort	-18.6	-27.66	-3.16	-4.7	-166.68	-247.91	-9.99	-14.85
Apple&Pear	-0.15	-0.18	-0.04	-0.05	-1.87	-2.24	-0.08	-0.09
Kiwifruit	-0.18	-0.25	0	0	0	0	0	0
OtherFruit	-0.51	-0.73	-0.02	-0.02	-1.37	-1.96	-0.05	-0.07
MixedCrop	-14.5	-23.57	-0.54	-0.88	-22.47	-36.52	-2.4	-3.91
SheepBeef	-27.48	-51.3	-1.87	-3.48	-100.18	-187.01	-8.64	-16.13
Dairy	-642.58	-830.39	-55.91	-72.25	-1713.65	-2214.5	-216.89	-280.28
Other Farm	-7.81	-16.71	-0.49	-1.04	-61.96	-132.53	-2.43	-5.2
AgSv&Hunt	18.48	0.85	3.63	0.17	124.73	5.73	8.46	0.39
Forestry	-8.56	-9.98	-0.25	-0.3	-10.07	-11.74	-2.72	-3.17
ServtoFor	-0.39	-0.84	-0.12	-0.26	-3.34	-7.16	-0.22	-0.48
Logging	0.25	-0.1	0.07	-0.03	2.31	-0.97	0.15	-0.06
Fishing	-0.72	-0.9	-0.05	-0.07	-1.44	-1.81	-0.29	-0.37
CoalMine	0	0	0	0	0	0	0	0
ServMining	-0.7	-2.42	-0.11	-0.37	-1.77	-6.14	-0.31	-1.08
OthMinQuar	-2.32	-8.79	-0.07	-0.27	-1.82	-6.9	-0.44	-1.67
Oil&G Extr	-499.14	-567.01	-9.39	-10.67	-66.63	-75.69	-337.81	-383.75
Oil&G Expl	0	0	0	0	0	0	0	0
Meat Proc	-77.69	-86.32	-6.71	-7.46	-175.64	-195.15	-15.08	-16.75
Poultry	-17.97	-23.08	-1.68	-2.16	-41.88	-53.8	-6.14	-7.89
Bacon Ham	-0.19	-0.61	0	0	0	0	0	0
Dairy	-243.47	-252.33	-7.67	-7.94	-157.6	-163.33	-27.05	-28.04
Fr&VegProc	-1.86	-2.08	-0.15	-0.17	-4.46	-4.99	-0.4	-0.45
BakeryConf	-8.25	-10.27	-0.55	-0.68	-13.63	-16.97	-1.05	-1.31
SeafoodPro	-0.71	-0.87	-0.06	-0.07	-1.37	-1.68	-0.13	-0.15
OtherFood	-1.17	-5.64	-0.09	-0.45	-2.53	-12.18	-0.23	-1.1
Soft Drink	0	0	0	0	0	0	0	0
BeerWineTo	-0.29	-0.58	-0.02	-0.04	-0.44	-0.88	-0.08	-0.16
Textiles	-0.31	-0.52	-0.04	-0.07	-1.52	-2.55	-0.08	-0.14
Clothing	-0.49	-1.37	-0.05	-0.14	-2.08	-5.83	-0.08	-0.21
Footwear	-0.01	-0.02	0	0	0	0	0	0
Oth Leathe	-0.03	-0.07	0	0	0	0	0	0
Sawmilletc	-5.07	-8.45	-0.74	-1.23	-19.19	-31.99	-1.39	-2.33
OthWoodPro	-2.11	-4.15	-0.32	-0.64	-11.71	-23.05	-0.62	-1.21
Paper&Pro	0	0	0	0	0	0	0	0
Print&Serv	-1.37	-3.4	-0.24	-0.6	-7.66	-18.99	-0.6	-1.5
Pub,Record	-2.26	-4.84	-0.38	-0.82	-11.01	-23.6	-1.1	-2.35
PetrolRef	0	0	0	0	0	0	0	0
PetCoalPro	0	0	0	0	0	0	0	0
Fertilise	-9.46	-38.61	-0.48	-1.95	-8.84	-36.1	-1.58	-6.47
OthIndChem	-5.87	-7.3	-0.53	-0.66	-10.79	-13.43	-1.54	-1.91
Medic,Cosm	0	0	0	0	0	0	0	0
OthChemPro	-1.38	-1.84	-0.15	-0.21	-2.92	-3.89	-0.34	-0.46
Rubber	-0.5	-0.81	-0.08	-0.14	-1.71	-2.77	-0.17	-0.27
Plastics	-0.56	-1.64	-0.09	-0.25	-1.95	-5.73	-0.18	-0.53
Glass&Prod	-0.2	-0.28	-0.04	-0.06	-0.93	-1.32	-0.07	-0.1
OthNon-met	-1.88	-5.8	-0.24	-0.75	-3.99	-12.3	-0.66	-2.02
BasicMetal	-5.36	-5.83	-0.63	-0.68	-12.99	-14.12	-1.46	-1.59
Struct&Fab	0.05	-6.45	0.01	-1.23	0.24	-31.02	0.02	-2.15
Vehicles	-0.82	-1.89	-0.07	-0.17	-1.94	-4.47	-0.15	-0.35
Ship&Boat	-1.07	-1.14	-0.24	-0.26	-6.78	-7.23	-0.42	-0.45
Oth.transp	1.15	1.11	0.25	0.24	4.16	4.02	0.43	0.41
Photo&Sci	-1.32	-1.47	-0.3	-0.33	-5.36	-5.96	-0.5	-0.56
ElectEquip	3.21	1.85	0.47	0.27	12.06	6.95	0.92	0.53
Agric Mach	3	1.84	0.55	0.34	15.5	9.51	1.13	0.69
OthIndMach	4.4	0.46	0.9	0.09	25.71	2.66	1.69	0.17

PrefabBldg	-0.07	-0.16	0	0	0	0	0	0
Furniture	-1.32	-2.21	-0.27	-0.46	-8.83	-14.78	-0.43	-0.72
Other Man	-0.17	-0.37	-0.04	-0.09	-1.23	-2.69	-0.07	-0.14
ElectGen	-84.3	-93.02	-2.35	-2.6	-42.76	-47.18	-38.19	-42.14
ElectTrans	2.3	-11.96	0.04	-0.2	0.7	-3.63	1.26	-6.55
ElectSuppl	-11.86	-31.02	-0.63	-1.64	-11.49	-30.05	-3.17	-8.3
GasSupply	-63.17	-77.19	-3.34	-4.08	-45.01	-55	-22.95	-28.05
WaterSupp	0.65	-0.81	0	0	0.1	-0.13	0.02	-0.03
Resid Bldg	-6.27	-7.53	-0.87	-1.04	-33.56	-40.3	-1.14	-1.37
Non-resBld	-6.82	-10.05	-0.77	-1.14	-13.89	-20.46	-1.1	-1.63
Non-Bldg	-6.15	-12.52	-1.01	-2.05	-18.03	-36.7	-2.02	-4.11
AncService	-12.02	-28.17	-2.97	-6.97	-107.82	-252.7	-4.58	-10.74
Wholesale	-23.95	-56.25	-3.74	-8.78	-101.32	-237.98	-9.74	-22.87
Retail	41.93	1.77	11.8	0.5	498.02	20.98	20.74	0.87
Accommodn	-2.46	-4.52	-0.47	-0.86	-32.92	-60.56	-1.09	-2.01
Bars,Rest	-3.8	-7.51	-0.67	-1.32	-51.45	-101.68	-1.25	-2.47
RoadFrate	-40.42	-66.83	-6.76	-11.17	-181.97	-300.88	-17.31	-28.62
Road Pax	-3.82	-5.4	-0.98	-1.39	-40.97	-57.86	-1.82	-2.56
Water&Rail	-16.75	-22.21	-2.78	-3.69	-48.01	-63.66	-8.94	-11.85
Air,Serv	-19.92	-27.51	-2.38	-3.28	-59.62	-82.34	-6.78	-9.36
Communicat	-17.12	-24.44	-2.45	-3.5	-60.14	-85.84	-8.31	-11.86
Finance	-5.34	-21.94	-1.02	-4.21	-20.85	-85.65	-3.05	-12.55
Insurance	-0.42	-1.63	-0.07	-0.25	-1.5	-5.81	-0.17	-0.68
ServFinIns	-1.03	-2.48	-0.23	-0.56	-5.11	-12.29	-0.56	-1.36
Property	-8.42	-20.24	-0.8	-1.92	-31.85	-76.56	-4.88	-11.72
Owner-Occ	-16.82	-50.01	0	0	0	0	-11.13	-33.09
EquipHire	-2.79	-6.92	-0.35	-0.86	-9.38	-23.25	-1.44	-3.56
Sci Resrch	0	0	0	0	0	0	0	0
Tech Serv	-6.67	-31.44	-2.22	-10.45	-47.88	-225.66	-3.74	-17.61
ComputerSv	-1.88	-4.27	-0.55	-1.24	-9.49	-21.53	-1.01	-2.28
Legal	-1.76	-4.38	-0.67	-1.66	-15	-37.33	-1.2	-2.98
Accounting	-2.43	-7.68	-1	-3.17	-22.84	-72.21	-1.69	-5.35
AdvertMktg	-0.75	-1.58	-0.17	-0.37	-2.86	-6.03	-0.27	-0.57
Bus. Admin	-3.44	-7.29	-0.8	-1.69	-30.28	-64.2	-1.68	-3.55
Emp&SecSvc	-1.8	-3.51	-0.67	-1.3	-15.93	-31.09	-1.09	-2.13
Pest,Clean	-1.22	-2.19	-0.58	-1.04	-16.38	-29.37	-0.87	-1.56
OtherBusSv	-2.03	-4.96	-0.36	-0.89	-18.14	-44.3	-0.77	-1.89
CentralGov	-2.43	-3.27	-0.65	-0.88	-20.23	-27.25	-1.09	-1.47
Defence	0	0	0	0	0	0	0	0
FirePolice	-1.4	-1.42	-0.71	-0.72	-18.29	-18.57	-1.12	-1.14
Local Govt	-8.13	-8.97	-1.24	-1.36	-25.6	-28.24	-2.66	-2.94
PreSch. Ed	-0.51	-0.94	-0.23	-0.43	-9.93	-18.26	-0.36	-0.65
Prim&SecEd	-4.87	-6.1	-2.37	-2.97	-84.43	-105.72	-3.85	-4.82
PostSchEd	-1.67	-1.75	-0.74	-0.77	-16.95	-17.75	-1.16	-1.22
Other Ed	-1.07	-2.11	-0.37	-0.74	-17.65	-34.88	-0.57	-1.12
Hospitals	-5.51	-6.18	-2.48	-2.78	-52.94	-59.38	-3.84	-4.3
MedicDent	5.3	3.99	1.55	1.17	55.97	42.16	3.18	2.39
Veterinary	1.66	-1.66	0.57	-0.57	18.07	-18.06	1.02	-1.02
ChildCare	-0.2	-0.41	-0.08	-0.17	-7.13	-14.45	-0.13	-0.26
Aged Accom	-1.13	-3.28	-0.4	-1.16	-22.18	-64.28	-0.69	-1.99
OthComCare	-1.78	-3.07	-0.61	-1.06	-23.92	-41.3	-0.97	-1.68
MovieRadTV	-1.46	-2.58	-0.3	-0.53	-5.54	-9.8	-0.56	-0.99
Lib,Museum	-0.8	-1.23	-0.23	-0.36	-10.95	-16.8	-0.4	-0.61
Racing	-0.47	-2.91	-0.07	-0.42	-3.06	-18.94	-0.17	-1.07
Gaming	-0.31	-0.42	-0.03	-0.04	-0.92	-1.24	-0.18	-0.24
OthSporRec	-2.29	-4.42	-0.33	-0.64	-15.23	-29.42	-0.84	-1.63
Pers&Comm	-2.8	-7.3	-1	-2.6	-47.39	-123.57	-1.5	-3.9
WasteSewer	-0.37	-1.03	-0.06	-0.17	-2.87	-8.03	-0.17	-0.48
TOTAL	-1947.32	-2725.87	-127.63	-223.05	-3396.33	-6420.03	-787.07	-1113.89

SCENARIO 3 IMPACTS: OUTPUT, INCOME & EMPLOYMENT								
	Estimated Output Effects ($m)		Estimated Income Effects ($m)		Estimated Employment Effects (u)		Estimated Value Added Effects ($m)	
SECTOR	Direct	Total	Direct	Total	Direct	Total	Direct	Total
Other Hort	-29.93	-49.14	-5.09	-8.35	-268.22	-440.41	-16.07	-26.39
Apple&Pear	-0.23	-0.29	-0.06	-0.08	-2.87	-3.67	-0.12	-0.15
Kiwifruit	-0.29	-0.45	0	0	0	0	0	0
OtherFruit	-0.82	-1.3	-0.03	-0.04	-2.21	-3.49	-0.08	-0.12
MixedCrop	-30.26	-50.1	-1.13	-1.88	-46.89	-77.63	-5.01	-8.3
SheepBeef	-76.57	-129.14	-5.2	-8.77	-279.13	-470.78	-24.07	-40.6
Dairy	-1325.18	-1737.72	-115.3	-151.2	-3534.03	-4634.22	-447.28	-586.52
Other Farm	-21.76	-41.03	-1.35	-2.55	-172.63	-325.48	-6.77	-12.76
AgSv&Hunt	27.89	-10.32	5.47	-2.02	188.24	-69.63	12.77	-4.72
Forestry	-17.81	-21.07	-0.53	-0.63	-20.95	-24.78	-5.66	-6.7
ServtoFor	-0.94	-1.91	-0.29	-0.59	-8.04	-16.3	-0.54	-1.09
Logging	0.41	-0.37	0.12	-0.11	3.78	-3.4	0.24	-0.22
Fishing	-1.73	-2.15	-0.13	-0.16	-3.47	-4.32	-0.71	-0.88
CoalMine	0	0	0	0	0	0	0	0
ServMining	-1.69	-6.8	-0.26	-1.03	-4.28	-17.24	-0.75	-3.03
OthMinQuar	-5.56	-22.61	-0.17	-0.71	-4.36	-17.74	-1.05	-4.29
Oil&G Extr	-1231.66	-1380.94	-23.17	-25.98	-164.42	-184.35	-833.58	-934.61
Oil&G Expl	-71.45	-71.45	-8.76	-8.76	-30.15	-30.15	-24.87	-24.87
Meat Proc	-170.68	-189.57	-14.75	-16.38	-385.86	-428.57	-33.13	-36.79
Poultry	-38.28	-49.07	-3.59	-4.6	-89.22	-114.38	-13.09	-16.78
Bacon Ham	-0.44	-1.36	0	0	0	0	0	0
Dairy	-534.9	-554.61	-16.84	-17.46	-346.25	-359	-59.44	-61.63
Fr&VegProc	-4.46	-4.96	-0.37	-0.41	-10.7	-11.89	-0.97	-1.07
BakeryConf	-19.79	-24.34	-1.31	-1.61	-32.71	-40.22	-2.53	-3.11
SeafoodPro	-1.69	-2.04	-0.13	-0.16	-3.25	-3.92	-0.3	-0.36
OtherFood	-2.8	-12.36	-0.23	-1	-6.05	-26.72	-0.55	-2.42
Soft Drink	0	0	0	0	0	0	0	0
BeerWineTo	-0.69	-1.34	-0.05	-0.1	-1.05	-2.04	-0.19	-0.38
Textiles	-0.74	-1.2	-0.1	-0.17	-3.64	-5.91	-0.2	-0.32
Clothing	-1.17	-3.08	-0.12	-0.3	-4.96	-13.06	-0.18	-0.47
Footwear	-0.01	-0.03	0	0	0	0	0	0
Oth Leathe	-0.06	-0.15	0	0	0	0	0	0
Sawmilletc	-12.17	-20.1	-1.77	-2.92	-46.07	-76.08	-3.35	-5.53
OthWoodPro	-5.06	-9.92	-0.78	-1.52	-28.09	-55.05	-1.48	-2.89
Paper&Pro	0	0	0	0	0	0	0	0
Print&Serv	-3.28	-7.85	-0.58	-1.4	-18.33	-43.89	-1.45	-3.46
Pub,Record	-5.41	-11.07	-0.92	-1.88	-26.36	-53.92	-2.63	-5.37
PetrolRef	0	0	0	0	0	0	0	0
PetCoalPro	0	0	0	0	0	0	0	0
Fertilise	-22.7	-85.46	-1.15	-4.32	-21.22	-79.9	-3.8	-14.32
OthIndChem	-14.08	-17.29	-1.28	-1.57	-25.89	-31.79	-3.69	-4.53
Medic,Cosm	0	0	0	0	0	0	0	0
OthChemPro	-3.31	-4.32	-0.37	-0.48	-7	-9.13	-0.83	-1.08
Rubber	-1.19	-1.85	-0.2	-0.31	-4.07	-6.34	-0.4	-0.62
Plastics	-1.34	-3.7	-0.21	-0.57	-4.67	-12.87	-0.44	-1.2
Glass&Prod	-0.47	-0.67	-0.09	-0.13	-2.19	-3.11	-0.17	-0.25
OthNon-met	-4.51	-14.42	-0.58	-1.86	-9.56	-30.58	-1.57	-5.03
BasicMetal	-12.86	-13.8	-1.51	-1.62	-31.15	-33.44	-3.5	-3.76
Struct&Fab	6.12	-7.78	1.17	-1.49	29.42	-37.39	2.04	-2.59
Vehicles	-1.98	-4.32	-0.18	-0.39	-4.68	-10.19	-0.37	-0.8
Ship&Boat	-2.58	-2.73	-0.58	-0.61	-16.35	-17.33	-1.02	-1.08
Oth.transp	2.08	2	0.45	0.43	7.53	7.22	0.77	0.74
Photo&Sci	-3.16	-3.5	-0.71	-0.79	-12.83	-14.2	-1.2	-1.33
ElectEquip	5.21	2.26	0.76	0.33	19.58	8.49	1.49	0.65
Agric Mach	4.22	1.76	0.77	0.32	21.81	9.09	1.59	0.66
OthIndMach	7.13	-0.88	1.45	-0.18	41.67	-5.14	2.74	-0.34

PrefabBldg	-0.16	-0.37	0	0	0	0	0	0
Furniture	-3.18	-5.16	-0.66	-1.07	-21.27	-34.51	-1.04	-1.68
Other Man	-0.41	-0.86	-0.1	-0.2	-2.96	-6.19	-0.16	-0.33
ElectGen	-103.43	-122.92	-2.89	-3.43	-52.47	-62.35	-46.85	-55.68
ElectTrans	-5.56	-28.91	-0.09	-0.48	-1.69	-8.77	-3.05	-15.84
ElectSuppl	-28.47	-72.02	-1.5	-3.8	-27.58	-69.77	-7.62	-19.28
GasSupply	-94.35	-116.23	-4.98	-6.14	-67.23	-82.82	-34.28	-42.24
WaterSupp	-0.19	-3.5	0	-0.02	-0.03	-0.56	-0.01	-0.12
Resid Bldg	-15.05	-18.06	-2.08	-2.49	-80.56	-96.69	-2.74	-3.29
Non-resBld	-16.37	-24.63	-1.85	-2.79	-33.33	-50.14	-2.65	-3.99
Non-Bldg	-14.76	-31.95	-2.42	-5.24	-43.27	-93.67	-4.84	-10.48
AncService	-28.85	-69.39	-7.14	-17.16	-258.78	-622.41	-11	-26.46
Wholesale	-57.49	-129.54	-8.98	-20.22	-243.21	-548.02	-23.37	-52.66
Retail	117.76	28.34	33.13	7.97	1398.67	336.57	58.24	14.02
Accommodn	-5.9	-10.56	-1.13	-2.02	-78.96	-141.3	-2.61	-4.68
Bars,Rest	-9.11	-17.38	-1.6	-3.06	-123.33	-235.35	-2.99	-5.71
RoadFrate	-100.18	-162.52	-16.75	-27.17	-451.02	-731.67	-42.9	-69.59
Road Pax	-9.47	-13.06	-2.43	-3.36	-101.56	-140.12	-4.5	-6.21
Water&Rail	-35.54	-47.58	-5.9	-7.9	-101.88	-136.4	-18.96	-25.38
Air,Serv	-41.39	-59.77	-4.94	-7.13	-123.88	-178.88	-14.09	-20.34
Communicat	-36.51	-52.81	-5.22	-7.56	-128.25	-185.51	-17.72	-25.63
Finance	-12.81	-47.45	-2.46	-9.09	-50.01	-185.21	-7.33	-27.14
Insurance	-1	-3.85	-0.16	-0.6	-3.57	-13.73	-0.42	-1.6
ServFinIns	-2.46	-5.66	-0.56	-1.29	-12.2	-28.07	-1.35	-3.1
Property	-20.21	-45.86	-1.92	-4.35	-76.45	-173.5	-11.7	-26.56
Owner-Occ	-40.36	-114.33	0	0	0	0	-26.7	-75.65
EquipHire	-6.7	-16.05	-0.84	-2	-22.53	-53.97	-3.45	-8.27
Sci Resrch	0	0	0	0	0	0	0	0
Tech Serv	-16	-61.71	-5.32	-20.52	-114.85	-442.96	-8.96	-34.57
ComputerSv	-4.51	-10.48	-1.31	-3.06	-22.77	-52.91	-2.42	-5.61
Legal	-4.22	-10.02	-1.6	-3.81	-35.97	-85.39	-2.87	-6.82
Accounting	-5.84	-17.35	-2.41	-7.16	-54.9	-163.12	-4.06	-12.08
AdvertMktg	-1.79	-3.56	-0.42	-0.83	-6.83	-13.59	-0.65	-1.29
Bus. Admin	-8.27	-17.15	-1.92	-3.97	-72.79	-150.95	-4.03	-8.35
Emp&SecSvc	-4.32	-8.18	-1.6	-3.03	-38.22	-72.39	-2.62	-4.96
Pest,Clean	-2.93	-5.08	-1.4	-2.42	-39.34	-68.19	-2.09	-3.62
OtherBusSv	-4.87	-12.06	-0.87	-2.17	-43.51	-107.77	-1.86	-4.6
CentralGov	-5.84	-7.7	-1.57	-2.07	-48.62	-64.11	-2.63	-3.47
Defence	0	0	0	0	0	0	0	0
FirePolice	-3.36	-3.41	-1.7	-1.73	-43.91	-44.52	-2.7	-2.74
Local Govt	-19.52	-21.51	-2.97	-3.27	-61.46	-67.74	-6.4	-7.05
PreSch. Ed	-1.22	-2.17	-0.56	-0.99	-23.76	-42.33	-0.85	-1.52
Prim&SecEd	-11.68	-14.36	-5.68	-6.99	-202.48	-248.91	-9.22	-11.34
PostSchEd	-4.01	-4.19	-1.78	-1.85	-40.7	-42.51	-2.79	-2.91
Other Ed	-2.57	-4.85	-0.9	-1.7	-42.39	-79.92	-1.36	-2.56
Hospitals	-13.23	-14.72	-5.95	-6.62	-127.11	-141.46	-9.21	-10.25
MedicDent	3.34	-0.03	0.98	-0.01	35.27	-0.36	2	-0.02
Veterinary	2.01	-5.13	0.69	-1.77	21.88	-55.87	1.23	-3.15
ChildCare	-0.49	-1.01	-0.21	-0.43	-17.46	-36.07	-0.32	-0.66
Aged Accom	-2.71	-7.53	-0.96	-2.66	-53.19	-147.7	-1.64	-4.57
OthComCare	-4.27	-7.18	-1.47	-2.47	-57.39	-96.56	-2.34	-3.93
MovieRadTV	-3.5	-5.95	-0.71	-1.21	-13.27	-22.54	-1.34	-2.28
Lib,Museum	-1.91	-2.89	-0.56	-0.84	-26.15	-39.55	-0.95	-1.44
Racing	-1.13	-6.43	-0.16	-0.92	-7.35	-41.8	-0.41	-2.35
Gaming	-0.75	-0.99	-0.07	-0.09	-2.24	-2.94	-0.44	-0.57
OthSporRec	-5.5	-10.25	-0.8	-1.49	-36.57	-68.19	-2.02	-3.77
Pers&Comm	-6.72	-16.82	-2.39	-5.99	-113.75	-284.69	-3.59	-8.99
WasteSewer	-0.88	-2.46	-0.15	-0.41	-6.83	-19.07	-0.41	-1.15
TOTAL	-4341.47	-6051.78	-286.87	-497.09	-7375.79	-14072.01	-1790.41	-2505.21

SCENARIO 4 IMPACTS: OUTPUT, INCOME & EMPLOYMENT								
	Estimated Output Effects ($m)		Estimated Income Effects ($m)		Estimated Employment Effects (u)		Estimated Value Added Effects ($m)	
SECTOR	Direct	Total	Direct	Total	Direct	Total	Direct	Total
Other Hort	0	-0.69	0	-0.12	0	-6.23	0	-0.37
Apple&Pear	0	0	0	0	0	-0.05	0	0
Kiwifruit	0	0	0	0	0	0	0	0
OtherFruit	0	-0.02	0	0	0	-0.05	0	0
MixedCrop	0	-0.5	0	-0.02	0	-0.77	0	-0.08
SheepBeef	0	-1.79	0	-0.12	0	-6.52	0	-0.56
Dairy	0	-2.25	0	-0.2	0	-5.99	0	-0.76
Other Farm	0	-0.3	0	-0.02	0	-2.38	0	-0.09
AgSv&Hunt	7.48	7.22	1.47	1.42	50.48	48.74	3.42	3.31
Forestry	0	-1.32	0	-0.04	0	-1.56	0	-0.42
ServtoFor	0	-0.08	0	-0.02	0	-0.64	0	-0.04
Logging	0	-0.09	0	-0.03	0	-0.87	0	-0.06
Fishing	0	-0.05	0	0	0	-0.1	0	-0.02
CoalMine	0	0	0	0	0	0	0	0
ServMining	0	-4.16	0	-0.63	0	-10.54	0	-1.85
OthMinQuar	0	-11.68	0	-0.37	0	-9.17	0	-2.21
Oil&G Extr	-1011.25	-1095.07	-19.02	-20.6	-135	-146.19	-684.4	-741.13
Oil&G Expl	-66.34	-66.34	-8.13	-8.13	-28	-28	-23.1	-23.1
Meat Proc	0	-4.04	0	-0.35	0	-9.14	0	-0.78
Poultry	0	-0.96	0	-0.09	0	-2.25	0	-0.33
Bacon Ham	0	-0.18	0	0	0	0	0	0
Dairy	0	-2.85	0	-0.09	0	-1.84	0	-0.32
Fr&VegProc	0	-0.08	0	-0.01	0	-0.19	0	-0.02
BakeryConf	0	-0.73	0	-0.05	0	-1.2	0	-0.09
SeafoodPro	0	-0.09	0	-0.01	0	-0.17	0	-0.02
OtherFood	0	-0.34	0	-0.03	0	-0.74	0	-0.07
Soft Drink	0	0	0	0	0	0	0	0
BeerWineTo	0	-0.12	0	-0.01	0	-0.18	0	-0.03
Textiles	0	-0.14	0	-0.02	0	-0.68	0	-0.04
Clothing	0	-0.55	0	-0.05	0	-2.35	0	-0.09
Footwear	0	0	0	0	0	0	0	0
Oth Leathe	0	-0.03	0	0	0	0	0	0
Sawmilletc	0	-10.89	0	-1.58	0	-41.22	0	-3
OthWoodPro	0	-7.81	0	-1.2	0	-43.37	0	-2.28
Paper&Pro	0	0	0	0	0	0	0	0
Print&Serv	0	-1.34	0	-0.24	0	-7.51	0	-0.59
Pub,Record	0	-1.73	0	-0.29	0	-8.45	0	-0.84
PetrolRef	0	0	0	0	0	0	0	0
PetCoalPro	0	0	0	0	0	0	0	0
Fertilise	0	-0.13	0	-0.01	0	-0.12	0	-0.02
OthIndChem	0	-0.71	0	-0.06	0	-1.31	0	-0.19
Medic,Cosm	0	0	0	0	0	0	0	0
OthChemPro	0	-0.23	0	-0.03	0	-0.49	0	-0.06
Rubber	0	-0.15	0	-0.03	0	-0.52	0	-0.05
Plastics	0	-0.35	0	-0.05	0	-1.23	0	-0.11
Glass&Prod	0	-0.11	0	-0.02	0	-0.5	0	-0.04
OthNon-met	0	-10.86	0	-1.4	0	-23.03	0	-3.79
BasicMetal	0	-0.34	0	-0.04	0	-0.84	0	-0.09
Struct&Fab	0	-6.67	0	-1.28	0	-32.08	0	-2.22
Vehicles	0	-0.59	0	-0.05	0	-1.4	0	-0.11
Ship&Boat	0	-0.06	0	-0.01	0	-0.38	0	-0.02
Oth.transp	0	-0.01	0	0	0	-0.05	0	-0.01
Photo&Sci	0	-0.13	0	-0.03	0	-0.54	0	-0.05
ElectEquip	0	-0.89	0	-0.13	0	-3.33	0	-0.25
Agric Mach	0	-0.12	0	-0.02	0	-0.63	0	-0.05
OthIndMach	0	-2.92	0	-0.6	0	-17.08	0	-1.12

PrefabBldg	0	-0.4	0	0	0	0	0	0
Furniture	0	-0.52	0	-0.11	0	-3.51	0	-0.17
Other Man	0	-0.14	0	-0.03	0	-1	0	-0.05
ElectGen	0	-2.53	0	-0.07	0	-1.28	0	-1.14
ElectTrans	0	-1.22	0	-0.02	0	-0.37	0	-0.67
ElectSuppl	0	-6.55	0	-0.35	0	-6.35	0	-1.75
GasSupply	0	-1.88	0	-0.1	0	-1.34	0	-0.68
WaterSupp	0	-0.3	0	0	0	-0.05	0	-0.01
Resid Bldg	-47.3	-50.17	-6.53	-6.93	-253.19	-268.57	-8.63	-9.15
Non-resBld	-51.47	-57.83	-5.82	-6.55	-104.79	-117.75	-8.34	-9.37
Non-Bldg	-46.4	-57.6	-7.61	-9.45	-136.01	-168.85	-15.21	-18.89
AncService	0	-39.5	0	-9.77	0	-354.31	0	-15.06
Wholesale	-47.04	-64	-7.34	-9.99	-199	-270.74	-19.12	-26.02
Retail	-42.81	-57.97	-12.04	-16.31	-508.47	-688.48	-21.17	-28.67
Accommodn	0	-1.32	0	-0.25	0	-17.7	0	-0.59
Bars,Rest	0	-1.64	0	-0.29	0	-22.25	0	-0.54
RoadFrate	0	-10.61	0	-1.77	0	-47.78	0	-4.54
Road Pax	0	-0.84	0	-0.22	0	-9	0	-0.4
Water&Rail	0	-1.31	0	-0.22	0	-3.75	0	-0.7
Air,Serv	0	-7.23	0	-0.86	0	-21.64	0	-2.46
Communicat	0	-2.92	0	-0.42	0	-10.26	0	-1.42
Finance	0	-3.67	0	-0.7	0	-14.33	0	-2.1
Insurance	0.87	-0.11	0.14	-0.02	3.1	-0.4	0.36	-0.05
ServFinIns	0	-0.99	0	-0.23	0	-4.92	0	-0.54
Property	0	-5.66	0	-0.54	0	-21.42	0	-3.28
Owner-Occ	0	-15.55	0	0	0	0	0	-10.29
EquipHire	0	-0.98	0	-0.12	0	-3.28	0	-0.5
Sci Resrch	0	0	0	0	0	0	0	0
Tech Serv	0	-10.25	0	-3.41	0	-73.6	0	-5.74
ComputerSv	0	-3.05	0	-0.89	0	-15.37	0	-1.63
Legal	0	-1.12	0	-0.43	0	-9.58	0	-0.76
Accounting	0	-1.63	0	-0.67	0	-15.32	0	-1.13
AdvertMktg	0	-0.55	0	-0.13	0	-2.11	0	-0.2
Bus. Admin	0	-2.83	0	-0.66	0	-24.95	0	-1.38
Emp&SecSvc	0	-1.25	0	-0.46	0	-11.09	0	-0.76
Pest,Clean	0	-0.33	0	-0.16	0	-4.45	0	-0.24
OtherBusSv	0	-3.57	0	-0.64	0	-31.93	0	-1.36
CentralGov	4.4	4.03	1.18	1.08	36.63	33.59	1.98	1.82
Defence	0	0	0	0	0	0	0	0
FirePolice	2.53	2.51	1.28	1.27	33.06	32.82	2.03	2.02
Local Govt	29.41	30.38	4.48	4.62	92.6	95.64	9.64	9.96
PreSch. Ed	0	-0.2	0	-0.09	0	-3.84	0	-0.14
Prim&SecEd	0	-0.46	0	-0.22	0	-8.01	0	-0.36
PostSchEd	0	-0.03	0	-0.02	0	-0.35	0	-0.02
Other Ed	0	-0.36	0	-0.13	0	-5.94	0	-0.19
Hospitals	0	-0.29	0	-0.13	0	-2.78	0	-0.2
MedicDent	0	-0.63	0	-0.18	0	-6.62	0	-0.38
Veterinary	0	-0.21	0	-0.07	0	-2.25	0	-0.13
ChildCare	0	-0.09	0	-0.04	0	-3.18	0	-0.06
Aged Accom	0	-0.9	0	-0.32	0	-17.65	0	-0.55
OthComCare	0	-0.59	0	-0.2	0	-7.93	0	-0.32
MovieRadTV	0	-0.61	0	-0.12	0	-2.33	0	-0.24
Lib,Museum	0	0.07	0	0.02	0	1.01	0	0.04
Racing	0	-0.05	0	-0.01	0	-0.34	0	-0.02
Gaming	0	-0.05	0	0	0	-0.15	0	-0.03
OthSporRec	0	-0.91	0	-0.13	0	-6.08	0	-0.34
Pers&Comm	0	-1.24	0	-0.44	0	-20.95	0	-0.66
WasteSewer	0	0.09	0	0.01	0	0.68	0	0.04
TOTAL	-1267.92	-1620.9	-57.96	-104.41	-1148.58	-2545.49	-762.53	-926.09