Buller District Council Lifelines Study

Alpine Fault Earthquake Scenario

Buller District Council

June 2006

IMPORTANT NOTES

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Earthquake Hazard Maps

The hazard maps contained in this report are regional in scope and detail, and should not be considered as a substitute for site-specific investigations and/or geotechnical engineering assessments for any project. Qualified and experienced practitioners should assess the site-specific hazard potential, including the potential for damage, at a more detailed scale.

Buller District Council Lifelines Study

Alpine Fault Earthquake Scenario & Lifelines Vulnerability Assessment

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Cover photograph:

Bridge over Orowaiti River, Westport, carrying Stephen Road traffic and the two water mains supplying Westport.

EXECUTIVE SUMMARY

Introduction

This report was commissioned by the West Coast Engineering Lifeline Group. It has been written specifically for Buller District Council engineers and managers, and Councillors. However, it also contains material that is relevant to other lifeline operators on the West Coast along with those involved in CDEM.

The aim of the report is to raise issues and make recommendations as to what should be done to make the Council and hence the community better able to withstand the effects of a major earthquake disaster and to recover from it more effectively. However, the consultants have not carried out a formal risk analysis. Hence, the report identifies issues that are important, but prioritisation has not been defined in detail. To have done so would have required a more extensive analysis involving quantified risks, which would have needed a far more detailed investigation of earthquake hazards, frequencies and consequences.

The report focuses primarily on lifelines; the network services of water, sewage, transport, power and communications which are essential to the functioning of a community. The report provides:

- Recommendations for improving the resilience of specific lifelines;
- Recommendations on things that need to be addressed, particularly where different lifelines and organisations have mutual interdependencies; and
- Recommendations on broader issues such as leadership, and suggestions for ways forward in this area.

The report uses an Alpine Fault earthquake scenario as a tool for, and as a means of, identifying important issues. The scenario is quite precise about what happens but it is still only a speculation on what might happen. It is NOT intended as a prediction of what would actually happen in an earthquake. An actual earthquake might be worse, or less severe, or significantly different on some way. The scenario is developed and used in this report for two specific purposes. Firstly, it provides a means of producing a checklist of what needs to be done to improve community resilience. Secondly, the scenario is presented to assist those responsible for infrastructure assets to perceive a broader picture that allows them both to imagine how their particular system fits into a much wider setting, and also to see how interdependencies between services might affect their own.

As the Alpine Fault earthquake scenario does not affect the Buller District as much as historic earthquakes, when considering the vulnerability of infrastructure in the district, the impact and consequences of any significant earthquake have also been considered.

The Alpine Fault earthquake was chosen because there is a high probability of it occurring within the next few decades and because it will be the most devastating natural event likely to affect the whole of the West Coast and adjoining regions. Although some of the things we have said do indeed relate specifically to earthquakes, nevertheless the general points we have made, and also many of the detailed recommendations, will apply to any large disaster.

Historic Earthquakes

There have been two major earthquakes in the Buller District since European settlement; the 1929 Buller earthquake and the 1968 Inangahua earthquake. The Buller earthquake was a M7.8 event (measured on the Richter scale, which is a measurement of the energy released) centred about 15km northwest of Murchison. It devastated the Murchison area and caused widespread damage throughout Buller District. The Inangahua earthquake was of magnitude M7.2 centred about 15km north of Inangahua township. It again affected the whole of the Buller District, with the strongest shaking in the Inangahua to Reefton area.

Damage from the Buller earthquake was severe and widespread. Major points about this earthquake are set out below, together with comments on the likely effects of a similar earthquake today:

- The impact of landslides on the roads in 1929 was clearly severe, and could be similar if this earthquake was to occur today. Of particular note is the time needed to clear roads, and the ongoing problems with aftershocks and heavy rain remobilising the disturbed hillsides. The long times to restore some roads might be expected to be greatly reduced with modern earthmoving equipment, but this might be offset by the increased vulnerability of current roads because of different standards and expectations. It is clear that these roads would take at least months to re-establish today.
- Damage to the railways was less than for the roads, probably because for the most part the railways were away from hillsides and landslides. Significant disruption to train operation could be expected for many weeks after a similar event.
- The damage to the Westport wharf in 1929 appears to have resulted from loading by a moored ship; and a similar event today might not cause the same problem. Sections of wharf are now old and failure of retaining walls is possible, as well as distortion of ground along the river front and possible lateral spread damage to the banks around the fishing harbour.
- A similar earthquake to the Buller earthquake must be expected to cause widespread landslides with consequential problems of dammed rivers, debris flows and aggradation.
- Telecommunications technology has changed most dramatically since 1929. However, landlines are still vulnerable.

- Westport's water supply was vulnerable. It took nearly two weeks to repair the 8 inch line, and then only because sufficient pipe was in stock in Westport. There was some damage to the reservoir dams, and shaking stronger than in 1929 might cause failure of one or more of these structures. Today's practice of keeping minimal supplies of stocks and relying on "just in time" delivery might severely affect the Council's ability to respond.

Although the Inangahua earthquake was less damaging overall, nevertheless there was widespread disruption and landslides came very close to destroying some power transmission towers. Lines across the steep topography must remain somewhat vulnerable.

Alpine Fault Earthquake Scenario

Although the direct effects on the district of the Alpine Fault earthquake defined in the scenario are unlikely to be as devastating as suffered during the Buller or the Inangahua earthquake, the impact on BDC would still be serious for the following reasons:

- There will be minimal support from outside the district in the short term as the rest of the West Coast Region, along with much of the rest of the South Island between Nelson and Timaru will also be affected and require support, and
- The damage caused by the earthquake will have a medium to long term impact on the economic viability of the West Coast region as a whole.

It is assumed in the Scenario that the Alpine Fault earthquake will include rupture through the eastern end of the Buller District as far north as the Matakitaki Valley. Shaking will be severe in the Maruia Valley, but decrease in intensity to the north west. West of Reefton, the shaking, although damaging, will be less strong than has been experienced historically in the Buller earthquake and the Inangahua earthquake.

The earthquake will result in:

- Ground rupture destroying buildings, roads and infrastructure on or crossing the fault;
- Shaking damage to buildings, bridges and infrastructure;
- Landslides, particularly east of Reefton and in the mountains, some of which are likely to create dams across rivers. Landslides are expected to cause damage to roads and some buildings and other infrastructure throughout the District; and
- Liquefaction in sandy areas within river valleys, particularly in the Inanguaha area, and the coastal areas, particularly the estuary and river margin areas of Westport and Karamea.

Indirect and longer-term impacts will result from the large volumes of landslide material entering rivers, particularly those with catchments in the Southern Alps close to the fault. The increased sediment load will result in high river water turbidity, river aggradation and channel avulsion with implications for drinking water quality, river control, stop banks, and bridging.

The Alpine Fault earthquake scenario affects the Buller District infrastructure as follows:

1. ***Transportation**:* All roads in the District east of Reefton are effectively closed due to landslides, destruction of the road surface, or damage to bridges. Many roads west of Reefton are also damaged and blocked. The District remains isolated from other centres on the West Coast for the first 48 hours and it is almost a week before transport can reach Westport from Nelson. Fuel shortage becomes a concern. Roads in the Maruia area take many weeks to restore. The Westport airport is not damaged and is in immediate use by aircraft. Railway lines are damaged in many places with severe damage on the Midland Line, and because of the anticipated ongoing debris flow hazard restoration of the rail connection to outside the district is not resumed for over 12 months. Direct road access to Canterbury through the Lewis Pass is not restored until 16 days after the earthquake.
2. ***Drainage**:* Large landslide dams develop in the district as a result of the earthquake. Rainfall in the following weeks breaches some dams and the resulting floods cause some limited damage. Aggradation of rivers and debris flows out of small steep catchments causes ongoing maintenance at bridges, especially in the areas east of Reefton.
3. ***Sewerage**:* Sewers are affected in a limited area of north Westport subject to liquefaction and parts of Reefton, where dilapidated concrete pipes fail completely and sewage flows down some streets for a short while. The trunk main to the Reefton oxidation ponds and discharge fails and is not operable for many weeks.
4. ***Water Supply**:* Liquefaction causes widespread damage to older AC and CI reticulation networks particularly in the northern part of Westport and Carters Beach. Water supply to the affected areas is partially resumed via standpipes and tanker supply after 24hours. However, it is over a month before fully reticulated supplies are resumed, with some delays in obtaining sufficient replacement pipes and fittings. The Reefton water supply suffers some breaks and temporary loss of water from the reservoir.
5. ***Power Supply**:* Power is lost throughout the district. It takes 2 days before a reduced power supply is reinstated from the north.
6. ***Telecommunications**:* There is widespread network failure including the mobile phone network. Damage to fibre optic cables effectively isolates Buller District. Road damage delays reinstatement of the cable until one week after the earthquake.

Individual and community needs change as recovery from the Alpine Fault scenario earthquake proceeds. The two needs of leadership and inwards and outwards information flow remain important throughout the first year after the earthquake. Rescue, medical aid, and evacuation are important initially but are soon replaced by the need for insurance payments, income, and counselling. Of slightly lower priority are the basic needs for lighting, heating, food, shelter, security, water, and sanitation.

Some communities are cut off, separated by loss of transport routes and effectively isolated. A depth of resourcefulness is needed in individual communities to provide leadership, co-ordination of efforts, rescue, and first aid. Isolated communities will need to manage almost on their own for some time without significant outside assistance.

Co-ordination, information, and leadership will be the three highest needs required of, and by, the Council. One area of Council's management identified as likely to need a high level of resources after a major earthquake is building inspection and repair. Building inspections, prioritising and allocating building materials and skilled workers are likely to be a Council responsibility.

Facing a Major Earthquake

The highest priority lifelines to meet individual, community, and Council's needs after a major earthquake are considered to be, in priority order:

- Transportation, including roads, airports, harbours river transport and rail,
- Communication, including telecommunication (landlines and cellular network), one way and two way radios, local radio stations, etc,
- Power supply,
- Water supply,
- Sanitation, and
- Storm water.

The focus of the report is on the effects of a major earthquake on BDC lifelines and physical assets and what BDC needs to address. The scenario is used as a means of identifying what the BDC should address to best prepare itself for an earthquake. In so doing it will also be well prepared to meet other lesser disasters. Sections are included on infrastructure owned and operated by others, such as power supply and telecommunications, in order to identify interdependency issues, but a full vulnerability / lifeline study has not been carried out for these services. Based on the scenario, the priorities and proposed strategies for attending to BDC lifelines after any serious earthquake, such as the Alpine Fault earthquake described in the scenario, are as follows:

1. ***Airport***. Immediately after a major earthquake the airport at Westport is likely to be the main route for getting expertise and urgent supplies into Buller District, and the West Coast region, and for getting the severely injured out for medical assistance. The airport runway is not expected to be damaged to any extent in the quake.

2. ***Roads***. District roads are mostly no-exit roads serving local communities that have a high reliance on the State Highway system to interconnect them. In addition to roading, State Highway bridges sometimes have other network functions in that they can provide structural support for telecommunications, power, water supply and other services. An example is the Buller Bridge at Westport as not only is it the only road link between Westport, its airport and the rest of the South Island, but it also carries the Carters Beach water supply and sewerage, and electricity and communication cables. Because of issues like these, it is essential that BDC and Transit agree beforehand on road reinstatement priority, mitigation work that should be undertaken now, and how BDC and Transit will work together after a major earthquake.

   After a major earthquake the highest priority road access will be to CDEM co-ordination centres and key facilities such as critical communication infrastructure, medical centres, etc. These will be followed by access between higher population centres including a link to Reefton. Road access will also be required to other important utilities such as power and water, and road links will be required between the district and other parts of the South Island.

3. ***Port of Westport***. Although the port may suffer some damage, it is unlikely to be significant in an Alpine Fault earthquake event. The port may be a key transport route for bringing in bulk supplies such as fuel, not only for Buller District, but also for the West Coast Region;

4. ***Water supply***. After a major earthquake water supply systems are likely to have no power to drive pumps, and the closer to the fault trace the greater the damage to water supplies infrastructure. Emergency water supply systems for affected areas will be established according to size of community. The target for re-establishing water supply systems to regional and district centres like Westport is four days, one week for sub-district towns like Reefton, 2 weeks for local centres like Karamea, and up to 3 weeks for local community centres like Seddonville. Return to a normal water supply level of service is anticipated to take between three to six months.

5. ***Sewerage***. As for water supplies it is expected that after a major earthquake, power to drive pumps will be lost and the closer to the fault trace the greater will be the damage to sewerage infrastructure. Where necessary and possible individuals will arrange their own toilet facilities e.g. pit latrines. Priority will be given to providing a normal sewerage service to the Westport CBD. The remainder of the Westport sewerage system and the other systems will be assessed and repaired or components replaced as required. Normal levels of service are expected to be reinstated in 6 to 12 months.

6. ***Storm Water***. It is unlikely that much will be done about storm water systems immediately after a major earthquake as efforts will be focused elsewhere. However, provisions do need to be in place to address flooding in low-lying populated areas. This is particularly important in parts of

Westport and Reefton where failure of both the sewerage and storm water systems may lead to ponding of storm water mixed with sewage, with consequential health issues.

Recommendations

To be more prepared for a large and devastating earthquake BDC should address the recommendations in this report. They are summarised in Section 12 and are presented briefly as follows:

1. ***Communication*** is of paramount importance. It has many aspects and issues. Controllers need to know what is happening, and so in fact do all stakeholders. Instructions, assessments, information, and requests all need to be routed to the right recipient. Moreover, sound leadership is critical, and good communication is essential for its success. And those operating locally need to be aware of the overall extent of the disaster and the wider situation outside their own area. Because good communication is so centrally critical following a disaster, it is strongly recommended that;

    - The communication issues raised in this report should be thoroughly explored where they relate to technical communication between personnel and organisations in the response and recovery periods; and
    - Expert-led training sessions should be held regarding post-disaster communication with the public, with a particular emphasis on those who would be expected to provide community leadership.

2. ***Failures with Compounding Consequences****.* Failure that would lead to a fundamental change in the landscape and/or have significant implications on the long-term viability of affected infrastructure. An example is widespread failures and inadequate or slow re-building of infrastructure and services leading to a large exodus of people from the Buller District effecting the long-term sustainability of infrastructure and the Buller District economy in general.

3. ***Interdependencies****:* Services and lifelines are not independent but are connected in various ways. Some are more obvious than others. It is important to take the interdependencies into account in the response and recovery stages of disaster management, and this requires that they are well understood beforehand. A good working relationship with other lifeline providers is essential to allow common protocols and linkages to be established. We recommend that interdependencies be considered carefully by the groups and individuals concerned, possibly by means of a workshop. Those concerned should include all the main lifeline operators on the West Coast. Aspects to be considered should include:

    - Road access requirements and constraints;

- Dependencies on infrastructure owned by others leading to common causes of failure. For instance, a slip on a road might take out telecommunications, water and other services as well as the road, or a bridge failure might do the same;
- Failure of backup. For example, under normal conditions if sewer pumps or pipes fail surcharging sewage would flow over land and drain via the storm water system. However, in a strong earthquake the storm water system might also have failed;
- Dependence on a common need by different organisations for contractors, plant, personnel, equipment, materials, fuel, transport (surface and air) and so on;
- Storage and accessibility of information;
- Facilities which need several services to be up and running in order to function effectively – a hospital, for instance; and
- Information channels.

4. ***Fuel*** will be in high demand after a major disaster like the Alpine Fault earthquake and supplies will be limited. There is no bulk fuel storage on the West Coast and it may be up to a week before roads are open to bring supplies into the region. It is recommended that:

   - Alternative methods of supplying fuel to the area need to be identified and agreements made for supplying fuel under emergency conditions;
   - Consideration be given to alternative means of extracting fuel from underground tanks that are not dependent on power from the national grid;
   - Protocols be developed for fuel allocation, and
   - Consideration be given to how fuel will be supplied to where it will be needed.

5. ***Critical Infrastructure****:* It is recommended that Council address the following critical infrastructure elements, consider level of risk and seismic resilience then prioritise and implement mitigation measures where appropriate:

   - Key transport routes including:
     - Airports (Westport and Karamea) including access to the airports,
     - Port of Westport, including the port cranes;
     - Access via rivers; and
     - Roads and bridges managed by Transit and BDC including the preparation of hazard maps to identify roads that may become damaged or impassable.
   - Bridges and bottlenecks involving multiple lifelines;

- Key water supply, sewerage and storm water mains including key mains, the Westport raw water storage dam and treatment plant, other water supply reservoirs, pump stations, and important valves. Also restraining of equipment in pump stations, treatment plants etc;
- Locations for standpipes, the number of standpipes required and how these are to be provided; and
- Means of draining areas where sewage and/or storm water are likely to pond and create a public health hazard.

Other lifeline operators such as telecommunication, power companies, railways, etc should also be encouraged to routinely share knowledge about the seismic resilience and vulnerability of their assets with Council.

6. ***Strategy and Response****:* It is recommended that Council prepare detailed strategies and response plans for recovery of Council lifelines after a significant earthquake or other disaster as well as the Council's wider roles in the recovery process. Aspect to be considered should include:

- Availability of staff and outside professionals and contractors;
- Availability of plant and equipment,
- Management and servicing of outside aid and aid organisations;
- Training of people from outside BDC so that they can be mobilised to the district and effectively assist in the recovery effort allowing BDC staff to attend to their own and their family's' requirements;
- Establishing agreements with outside providers to provide support after a major disaster e.g. an agreement with a shipping company or the navy for use of appropriate vessels;
- Flexible contracts, along with building inspection and resource consent procedures for use in emergencies;
- Appropriate emergency levels of service. Some emergency levels of service are proposed in this report;
- Access to, and inspection and assessment of damage to infrastructure to allow damage to be quickly identified and prioritised;
- Prioritising deployment and management of plant, manpower and other resources;
- Spare part requirements;
- Water supply, waste water, power, and other service requirements of emergency centres and essential businesses and industry; and
- Monitoring and management of response and recovery activities.

7. ***Database**:* It is recommended that Council establish a database that includes:

- Holders of satellite phones and VHF facilities;
- Bridges, road structures, major cuttings and embankments to allow progressive upgrading to be undertaken;
- High fire risk/high value areas along with alternative fire fighting options for these areas as the water supply may not be available after an earthquake;
- Discharge requirements of major waste water producers after a major earthquake;
- Boat owners with boats that could be used on rivers and between ports for damage assessment, rescue and ferrying;
- Location and volume of fuel storage facilities; and
- Owners and operators of earth moving resources.

8. ***Asset Upgrading**:* It is recommended that Council continue replacing and upgrading infrastructure assets largely adopting a "business as usual" approach and following normal asset management principles. However, priority should focus on:

- Upgrading weak bridges based on the seismic audit, giving priority to those of highest importance to the community ;
- Assessment of pipe work that is suspected or known to be at risk of failure and replacement or upgrading as required e.g. older reinforced concrete sewers in Reefton and the rising sewer main from Carter's Beach;
- Replacement of sewers and storm water pipes starting from discharge points and working upstream; and
- Building towards greater resilience including:
  - Upgrading with more earthquake resistant materials e.g. replacement of key water mains with PE pipe or similar,
  - Installation of burst control valves on water supply reservoirs, and
  - Considering installing standby generators particularly for water supply and sewerage but also for the airport and port.

PART I – Introduction and Methodology

1 INTRODUCTION

Buller District Council (BDC) is responsible for managing key infrastructure assets including water supply, sewerage, storm water and district road assets. BDC has an essential role to play in reducing, being ready for, responding to and recovering from any disaster in the district. In view of this role, BDC engaged the consultants to identify significant vulnerabilities in BDC's lifeline assets. This will aid in prioritising work to make these assets more resilient in the event of an earthquake and also help with the planning for an appropriate response to a major disaster.

This report aims to raise issues and make recommendations as to what should be done to make the Council and hence the community better able to withstand the effects of a major earthquake disaster and to recover from it more effectively. It focuses primarily on lifelines; the network services of water, sewage, transport, power and communications which are essential to the functioning of a community. However, it also considers some broader issues such as leadership, which have been shown to have a major effect on the ability of a community to recover.

The consultants have used a disaster scenario as a means of sharpening understanding of the issues and requirements and of suggesting recommended actions. The scenario is not in any way meant to predict what would actually happen. Rather, it gives a plausible and feasible picture of a possible major and widespread disaster simply to enable the needs and priorities of the BDC and the community in general to be better understood. A scenario approach is particularly helpful in identifying the main interactions required between the many stakeholders involved. Thus this report necessarily considers its specific recommendations for the BDC in the broad context of community needs and interactions. The consultants have not, however, carried out a formal risk analysis. Hence, the report identifies issues that are important, but prioritisation has not been defined in detail. To have done so would have required a more extensive analysis involving quantified risks, which would have needed a far more detailed investigation of earthquake hazards, frequencies and consequences.

The selected disaster scenario assumes a major Alpine Fault earthquake. The Alpine Fault earthquake is not the most damaging earthquake that can affect Buller district. In fact its effects will be much less than the historical 1929 Buller and 1968 Inangahua earthquakes. However, it is selected because;

- It is the same scenario used for the Grey District and Westland District Lifeline studies. It will have a greater impact on these Districts than any other potential earthquake, and will have the greatest overall impact on the West Coast region as a whole;

- It will certainly occur at some stage, and has a high probability of occurring within the next 50 – 100 years; and
- It will affect not just the West Coast but the whole of the central South Island, including all the main transportation routes, and therefore brings in issues relating to the wider geographical setting of the District.

Any actual earthquake will be different from the scenario earthquake. However, there is no doubt that some day, a major earthquake will occur and the community must be as ready for it as possible.

The Alpine Fault earthquake scenario was presented at a workshop to discuss district lifeline assets held at Punakaiki on the 20th & 21st of September 2005. Those invited to the workshop included:

Buller DC	Grey DC	Communications contractor	Buller Port
WCRC	Fuel companies	Electricity Companies	Greymouth Port
MCDEM	Helicopter pilots	Communication companies	NZ Fire Service
NZ Police	Rockgas	Ontrack/NZ Rail Corp	Transit NZ/Opus
Westland DC	Hokitika airport	Regional & Local Controllers	St Johns Ambulance

A list of those who attended the workshop is presented in Appendix D.

The workshop used the scenario as a basis for identifying and examining lifeline issues, constraints and weaknesses and identifying interdependencies between the lifeline assets. The participants also looked both at priorities for improving lifeline asset infrastructure prior to the occurrence of an Alpine Fault earthquake and also at priorities during the recovery period after the earthquake.

The workshop provided useful information on detailed issues, needs and priorities, and this has been a substantial input into the present report. Some findings, such as the need for leadership, showed that prior preparation would require more than a straightforward concentration on physical assets, and such insights have also been included here.

Part II of this report deals with the earthquake scenario. Its development proceeds in three stages. First, the earthquake itself is discussed. The second step looks at the resulting damage and effects. Finally, in order to ensure that all issues have been captured as far as possible, a bottom-up approach is used in which, as part of the scenario, the situation, reactions and needs of four hypothetical people are considered.

Section 2 describes the setting for an Alpine Fault earthquake and the background to earthquake effects such as shaking, liquefaction, landslides and seiche. This information has been collated from various available sources. No new research has been carried out. Because existing information is very limited in many areas, or is of a very generalised form, the risk to individual components of the lifeline networks is uncertain.

Section 3 outlines the major impacts of two historical earthquakes, which have affected lifelines in the Buller district. They provide useful background information and a "reality" check on the physical destruction described in the Alpine Fault earthquake scenario developed in Section 4. It is based on experience of earthquakes elsewhere in New Zealand and the world.

In Section 5 the stories of four individuals; a Hokitika businessman, a farmer from Kokatahi, a tourist at Franz Josef and a resident of Hokitika, are affected by the Alpine Fault earthquake are presented to examine the impact of the earthquake on individuals. Although the individuals are not from Buller District they highlight the likely effect on individuals in the worst case scenario for Buller District if a major earthquake like the 1929 earthquake were to occur again.

In Section 6 the situation and needs of the four individuals are examined over the first three days, at the end of the first month and at the end of one year. These needs and the lifelines available to meet them are then examined from the perspective of the Council.

Normal and emergency levels of service are defined for BDC's lifeline infrastructure. The levels of service are based on community types, which are defined in Section 6 based on population and role as a service centre.

Sections 7 to 10 examine BDC's key infrastructure assets in detail after a major earthquake suggesting key principles for re-instating roads and defining emergency levels of service in the case of Westport's water supply, sewerage and storm water systems. Strategies for re-instating normal levels of service are presented and improvements identified to allow recovery after the earthquake to proceed more effectively.

Section 11 looks at lifelines in the Buller District operated by others. These include telecommunications and energy (electricity and fuel supply). The assets are described, significant risks identified and improvements suggested.

Finally, Section 12 concludes the report. It both summarises the recommendations of the previous sections and also introduces more general recommendations, which, though not specifically addressing infrastructure assets, are nevertheless important matters for the Council to consider.

PART II – The Alpine Fault Earthquake Scenario

2 EARTHQUAKE OVERVIEW FOR BULLER DISTRICT

2.1 Selection of Earthquake event

The basis for the scenario of this study is an earthquake on the Alpine Fault. The Alpine Fault has been studied in detail (Yetton , 2000; Yetton *et al*, 1998; Wells *et al*, 1998) and the earthquake scenario presented and its likely characteristics are derived directly from these sources.

The Alpine Fault is the largest active fault in New Zealand and extends over 650 km from Milford Sound to Blenheim. Overall movement on the fault has been both vertical, with the east side rising relative to the west side and hence uplifting the Southern Alps, and horizontal with geological rock types matching across the fault but offset by about 470 km. Field evidence suggests that the horizontal offset is episodic and each movement of several metres is accompanied a large earthquake.

The most active part of the fault is the central section, which forms the western boundary of the Southern Alps from Haast to Inchbonnie, well south of Buller District. Further north the fault becomes progressively less active as movement is spread to numerous branch faults within Marlborough.

Yetton *et al*, 1998 used four methods to estimate the timing of past movements of the fault. These were direct trenching across the fault trace and dating organic material within sheared layers, dating landslides and aggradation terraces, using the age of forests re-established after earthquake related destruction, and tree ring chronology which records periods of stress related to earthquake damage to trees living through an earthquake. The methods produce a consistent record and indicate two earthquake events, one at about 1620 from the Paringa River to north of the Matakitaki River, over 300 km in length and passing through Buller District, and one in 1717 with a surface rupture from Milford sound to Haupiri, a distance of at least 375 km, but not quite extending into Buller.

The implied pattern of earthquakes combined with analysis of similar fault behaviour around the world gave Yetton *et al* 1998, a probability estimate of the next earthquake as 65 +/- 15% over the next 50 years increasing to 85 +/- 10% over the next 100 years. This estimate was made in 1998, and current probabilities will be higher. Rhoades & Van Disson (2003) reviewed the probability of a fault rupture, allowing for uncertainties and using four methods. Their estimates were between 22% and 44% (34% average) over the next 50 years starting in 2002, and between 39% and 68% (54% average) over the next 100 years. While Rhoades & Van Disson’s method is mathematically robust, their probabilities are likely to be underestimates, as they do not allow for the physical limits of horizontal displacement and slip rates, or the behaviour of similar faults internationally. What is clear is that both sets of probabilities point to a high probability of an Alpine Fault earthquake within the next few decades.

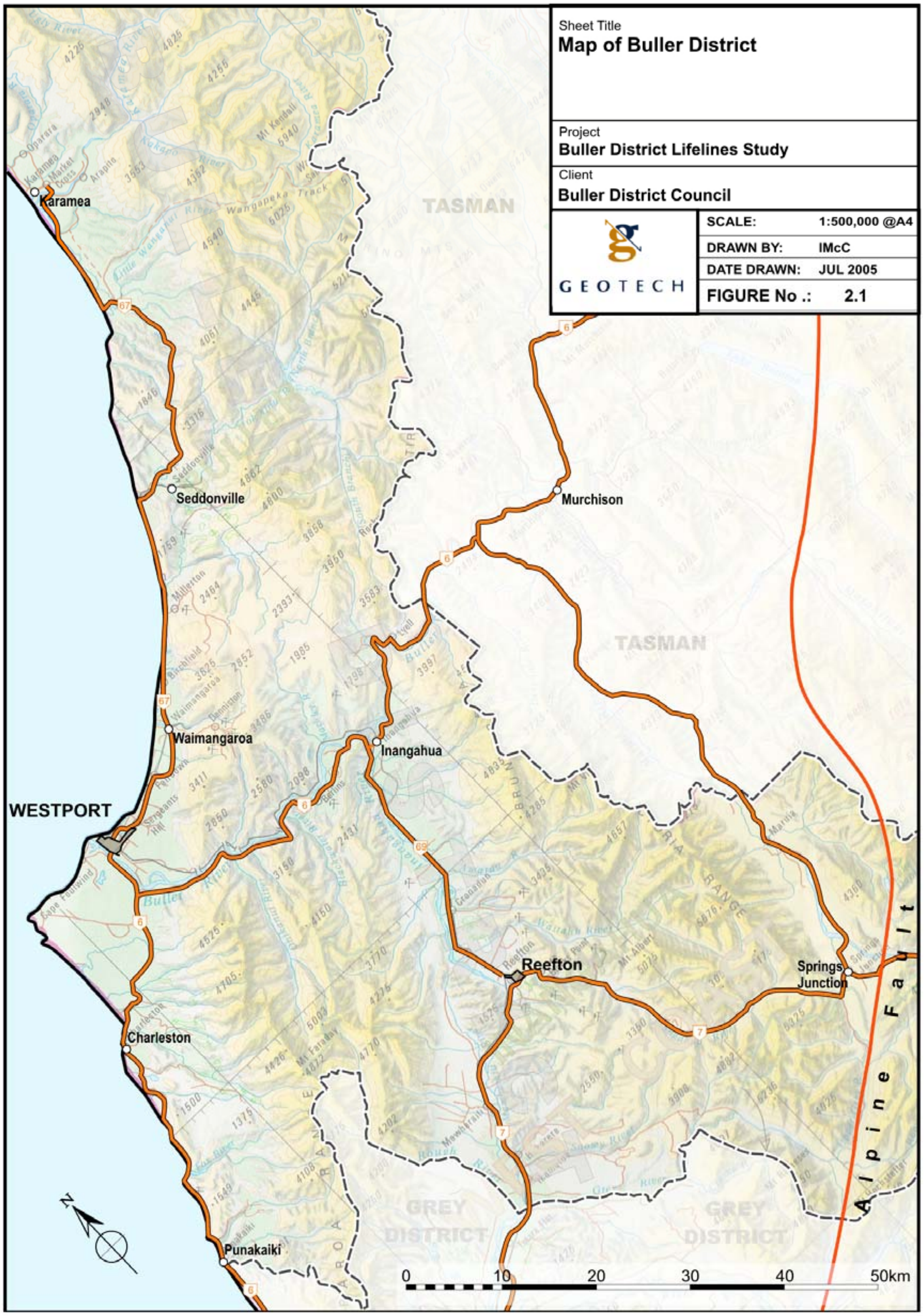
An Alpine Fault earthquake can be expected to rupture over a length of about 300 km. All evidence suggests that the earthquake will be large, with a magnitude of at least M8 (magnitude is a measure of the energy released by the earthquake at its source).

The location of the Alpine Fault in the Buller District is shown in Figure 2.1. The Alpine Fault trace cuts across the eastern extremity of the District between Springs Junction and Maruia Springs. At about 38km from Reefton and 75km from Westport, the earthquake will be a considerable distance from the main centres of population. In terms of direct damage to the district, and certainly the main infrastructure assets of the Buller District, this event is far from being the most damaging earthquake that could affect the District. It has been used however, because:

- It will be by far the most damaging for both Grey and Westland Districts, and is therefore the most damaging for the West Coast region as a whole. It has been used for the Regional Lifelines study, and the effects on the Buller District must be included in that.
- There is a very high probability of the Alpine Fault earthquake occurring within the next 50 – 100 years.
- The Alpine Fault earthquake will affect much of the South Island so that support and resources from other areas will be slow in coming and limited when they arrive. This event therefore highlights some of the interdependency issues that a more damaging but more local earthquake would not.
- Any scenario is a speculation on what might happen, and because of the uncertainties entailed, the details are unreliable. In terms of a Lifelines study, the scenario is presented to assist those responsible for the infrastructure assets to perceive a broader picture that allows them to imagine how their particular system fits into a much wider setting, and how interdependencies between services may affect their own. For this purpose, the exact scenario selected is of lesser importance.

However, because of the lesser impact of the Alpine Fault earthquake on the western and northern areas of the district, this report includes summaries of the 1929 Buller and the 1968 Inangahua earthquakes, along with comments on how these events might have affected the infrastructure had they occurred in 2006.

In the remainder of Section 2 a brief comparison is provided of the two historical earthquakes and the predicted Alpine Fault earthquake. This is followed by an overview of the main effects of a large earthquake. A brief description of the historic earthquakes outlines the major effects with comments on how today's infrastructure may be affected. The Alpine Fault event is outlined with detail of physical effects of the Alpine Fault earthquake scenario along with the impact on individuals. The scenario is a time series of snap shots of the possible situation during and after an Alpine Fault earthquake. By its nature it cannot be precise. Rather it provides a plausible framework within which interdependencies and priorities can start to be considered.


Sheet Title
Map of Buller District
Project
Buller District Lifelines Study
Client
Buller District Council
GEOTECH
SCALE: 1:500,000 @A4
DRAWN BY: IMcC
DATE DRAWN: JUL 2005
FIGURE No .: 2.1
Karamea
Seddonville
Murchison
TASMAN
Waimangaroa
Inangahua
WESTPORT
Reefton
Springs Junction
Charleston
Punakaiki
GREY DISTRICT
Alpine Fault
0 10 20 30 40 50km

2.2 Comparison of Historic and Alpine Fault Earthquakes

The Buller district has experienced two large and damaging earthquakes since European settlement. These provide valuable information on the likely effects of a future large earthquake.

- The 1929 Buller earthquake was of magnitude M7.8, centred about 15 km north west of Murchison, with a zone of very strong shaking extending north into the mountain ranges of north west Nelson. While the worst shaking with this earthquake was outside the district (with the exception of Karamea and Seddonville, which both experienced MM IX shaking being closer to the epicentral area than the rest of the district) or in the uninhabited areas, it affected the whole of the District, and the recorded effects provide a sound basis for the scenario. Although the White Creek fault this earthquake was centred on is most unlikely to rupture again for some thousands of years, somewhat smaller earthquakes (M7 – 7.5) could occur closer to Westport. The smaller earthquakes could easily produce similar effects over much of the district, and greater effects in the epicentral area, as did the 1968 earthquake.

- The 1968 Inangahua earthquake was of magnitude M7.2 centred about 15km north of Inangahua township. It again affected the whole district, with the strongest shaking in the Inangahua to Reefton area.

- The Alpine Fault earthquake is predicted to have a high probability of occurrence within the next 50 – 100 years. It is modelled on events that have occurred within the last 400 years. The earthquake predicted will be larger than both the 1929 and 1968 earthquakes, but the location of the Alpine Fault towards the western extremity of the district means that the impact on the main population centres in the Buller District will be somewhat less than has been experienced historically.

2.3 Earthquake Effects

Direct effects of the Alpine Fault scenario earthquake will include:

- Ground rupture destroying buildings, road and pipelines on or crossing the fault
- Shaking damage to buildings, bridges and infrastructure such as water supplies, sewerage, power and telephone

Secondary effects from earthquake shaking include;

- Liquefaction in sandy areas within river valleys, in low swampy ground near lakes, and the coastal areas of recent deposition, particularly around river mouths, estuaries and lagoons.
- Landslides, particularly in the MM VIII and IX zones and in the mountains, some of which are likely to create dams across rivers. Slips and landslides will cause considerable damage to roads.

- Seiches (water waves generated by seismic oscillations) could be produced on any lakes.

Indirect and longer-term impacts will result from the large volumes of landslide material entering rivers, particularly those with catchments in the Southern Alps. The increased sediment load will result in high river water turbidity, debris flows, river aggradation and channel avulsion with implications for drinking water quality, river control, stop banks, and bridging. These effects will alter the environment in the Springs Junction area, and may affect bed levels in the Buller River down to the river mouth in subsequent years. Aggrading riverbeds will affect bridges in the epicentral area for many years.

2.4 Ground Shaking Hazard

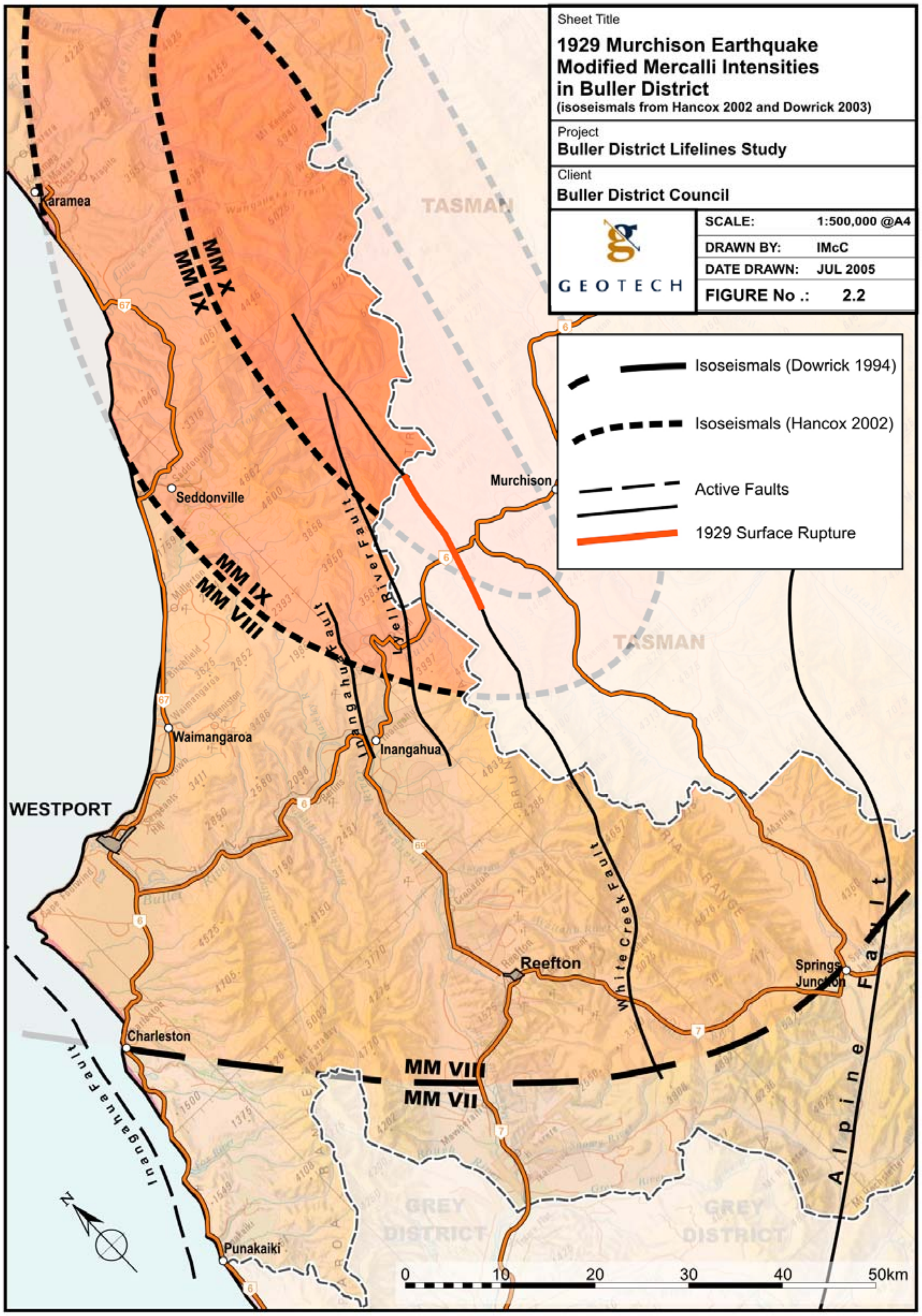
The lifelines are assessed at a general level in this report. However, when an engineer looks at specific structures needing modification they can use the detailed information provided here on the impact of an earthquake.

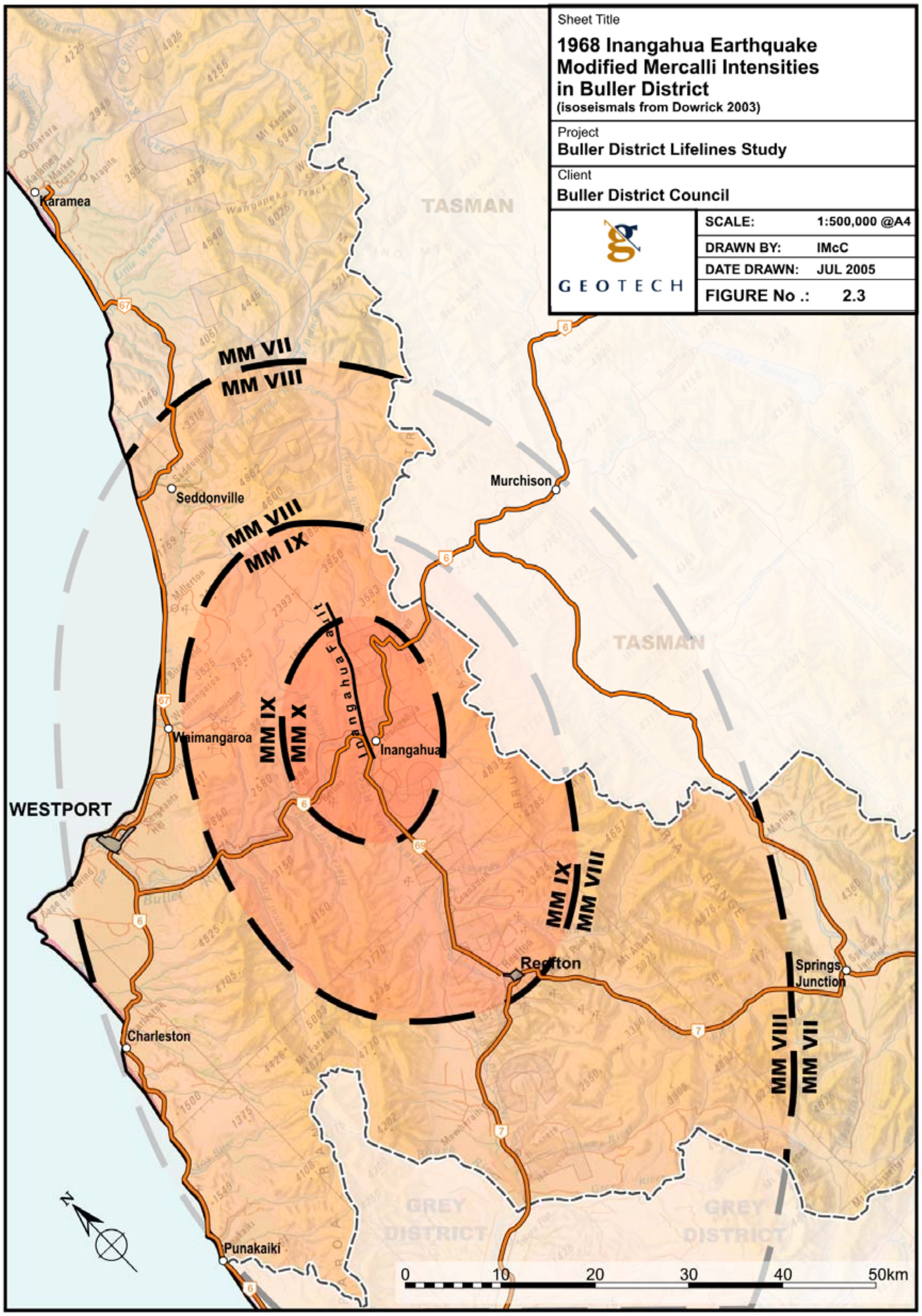
The most widespread and predominant effect of earthquakes is ground shaking experienced as seismic waves generated by the release of energy at the epicentre area propagate through the earth. These waves are modified by the underlying geology, soils and terrain, and generally reduce with distance from the earthquake source. The shaking hazard can be defined in terms of the maximum accelerations caused by the seismic waves, or indirectly in terms of effects. The scale of effects used in New Zealand is the Modified Mercalli (MM) scale of shaking intensity. This is a descriptive scale, which reflects the intensity of shaking according to the resulting damage and felt effects.

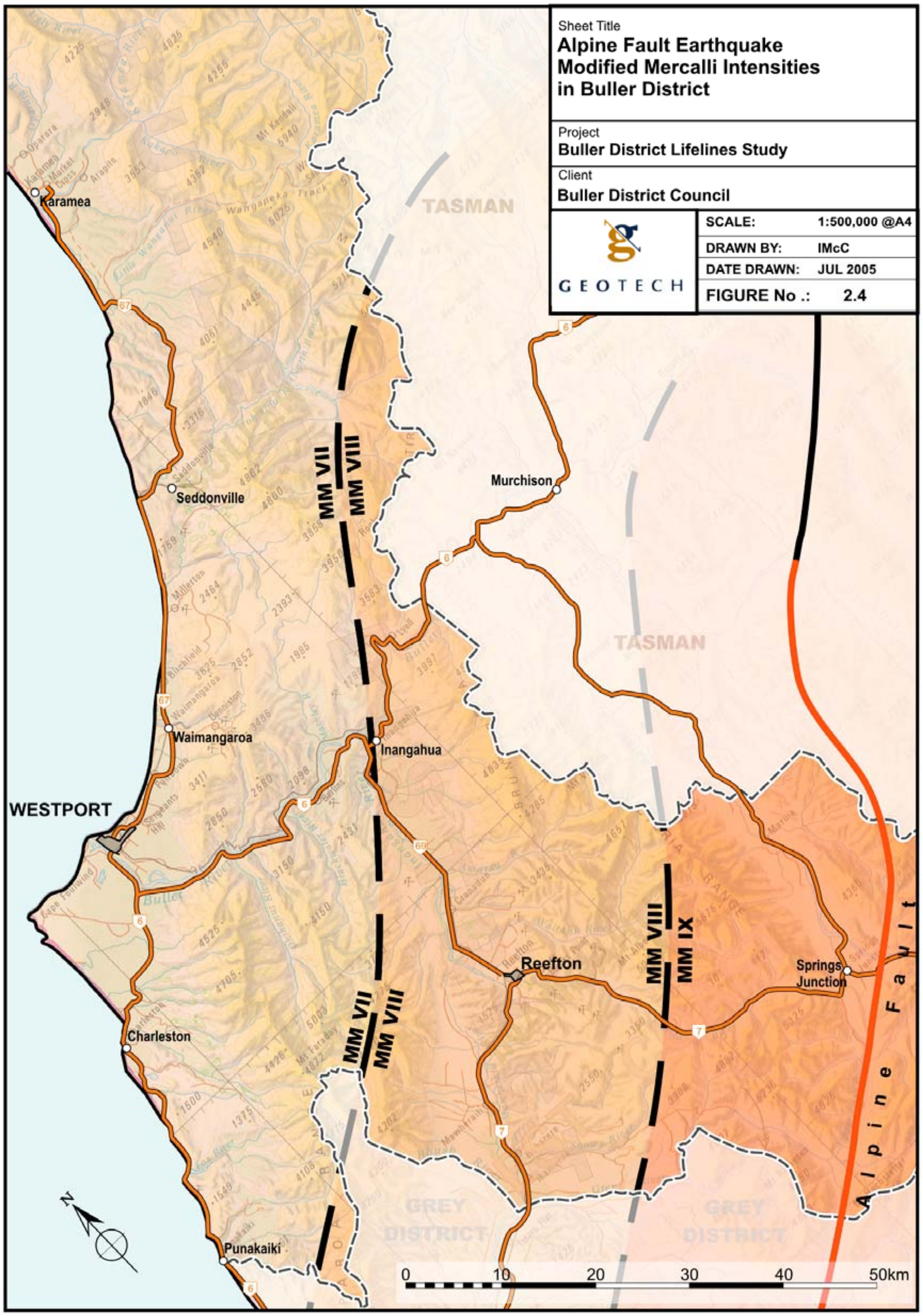
The Modified Mercalli Shaking Zone isoseismals within the Buller district are shown for the 1929 Buller earthquake in Figure 2.2, the 1968 Inangahua earthquake in Figure 2.3, and the Alpine Fault scenario in Figure 2.4. Shaking intensities for the three earthquakes at various localities in the district are compared in Table 2.1.

Table 2.1: Comparison of Historical Shaking Intensities with Alpine Fault Earthquake

Locality	Modified Mercalli Shaking Intensity		
	1929 Buller EQ	1968 Inangahua EQ	Alpine Fault EQ
Karamea	IX	VII	VII
Seddonville	IX	VIII	VII
Westport	VIII	VIII	VII
Punakaiki	VII	VII	VII
Inangahua	VIII	X	VIII
Reefton	VIII	IX	VIII
Ikamatua	VII	VIII	VIII
Springs Junction	VII	VII	X


Sheet Title
1929 Murchison Earthquake Modified Mercalli Intensities in Buller District
(isoseismals from Hancox 2002 and Dowrick 2003)
Project
Buller District Lifelines Study
Client
Buller District Council
GEOTECH
SCALE: 1:500,000 @A4
DRAWN BY: IMcC
DATE DRAWN: JUL 2005
FIGURE No.: 2.2
Isoseismals (Dowrick 1994)
Isoseismals (Hancox 2002)
Active Faults
1929 Surface Rupture
Karamea
Seddonville
Waimangaroa
WESTPORT
Inangahua
Murchison
Reefton
Springs Junction
Charleston
Punakaiki
TASMAN
GREY DISTRICT
MM X
MM IX
MM VIII
MM VII
Lyell River Fault
Inangahua Fault
White Creek Fault
Alpine Fault
0
10
20
30
40
50km


Sheet Title
1968 Inangahua Earthquake
Modified Mercalli Intensities
in Buller District
(isoseismals from Dowrick 2003)
Project
Buller District Lifelines Study
Client
Buller District Council
SCALE: 1:500,000 @A4
DRAWN BY: IMcC
DATE DRAWN: JUL 2005
FIGURE No .: 2.3
GEOTECH
TASMAN
Karamea
MM VII
MM VIII
Seddonville
Murchison
MM VIII
MM IX
Inangahua Fault
MM IX
MM X
Waimangaroa
Inangahua
WESTPORT
MM IX
MM VIII
Reefton
Springs Junction
Charleston
MM VIII
MM VII
GREY DISTRICT
Punakaiki
0 10 20 30 40 50km


Sheet Title
Alpine Fault Earthquake Modified Mercalli Intensities in Buller District
Project
Buller District Lifelines Study
Client
Buller District Council
GEOTECH
SCALE: 1:500,000 @A4
DRAWN BY: IMcC
DATE DRAWN: JUL 2005
FIGURE No.: 2.4
TASMAN
TASMAN
GREY DISTRICT
GREY DISTRICT
Karamea
Seddonville
Murchison
Waimangaroa
Inangahua
WESTPORT
Reefton
Springs Junction
Charleston
Punakaiki
MM VII
MM VIII
MM VII
MM VIII
MM VIII
MM IX
Alpine Fault
0
10
20
30
40
50km

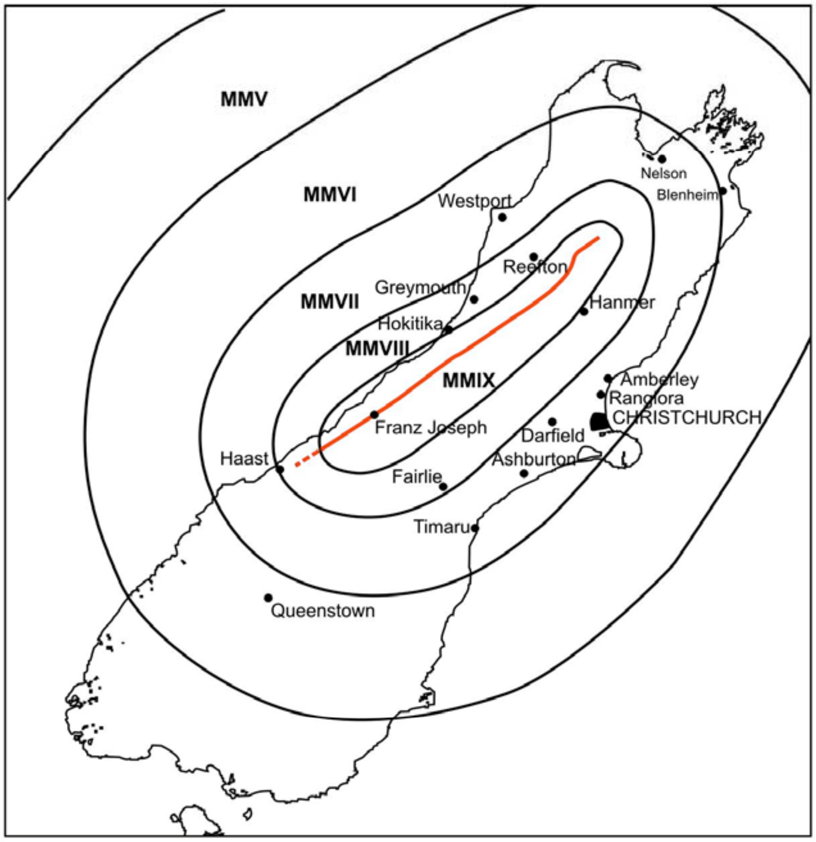


Figure 2.5: Estimated Modified Mercalli intensity isoseismals (lines defining equal shaking intensity) for the Alpine Fault earthquake scenario (adapted from Yetton et al. (1998) 1620 AD earthquake, modified for fault rupture further to the north).

The variation in Modified Mercalli shaking intensity for the whole of the South Island in Figure 2.5. The maps in Figures 2.4 and 2.5 are based on the synthetic isoseismals for the 1620 earthquake in Yetton *et al* (1998). Shaking intensities for localities within the district and across the South Island are listed in Table 2.2.

Table 2.2: Shaking Intensities at Selected South Island Centres

Intensity	Localities in Buller District		Localities within South Island	
MM IX +	Springs Junction		Franz Joseph Mt Cook	Arthur's Pass
MM VIII	Reefton Ikamatua Inangahua		Greymouth Hokitika Murchison	Culverden, Hanmer Springfield Haast
MM VII	Westport Ngakawau Karamea	Punakaiki Seddonville	Nelson Kaikoura Christchurch	Ashburton Timaru Wanaka
MM VI			Oamaru Wellington (N.I.)	Dunedin Queenstown

The earthquake is likely to produce very strong shaking in locations close to the Southern Alps. In particular locations such as Arthur's Pass, Mount Cook, Franz Josef and Springs Junction will be seriously affected. Hokitika, Greymouth, Reefton, Murchison, and Hanmer will also be strongly shaken. Predicted intensities are generally less on the east coast, as it is further from the fault, but in virtually all central South Island locations the next Alpine Fault earthquake will be stronger than any other earthquake experienced in the last 150 years or more. The main transport, power, and communication routes out of the District all pass through regions, which will also be badly affected by the earthquake.

The whole of the Buller District will experience strong shaking. It will be most intense in the Springs Junction area with Modified Mercalli Intensity shaking of MM IX or greater. Reefton and the Inangahua Valley will experience MMVIII shaking, but the whole of the coastal area between Punakaiki and Karamea will have lesser shaking of MMVII. This earthquake will produce much stronger shaking in the Springs Junction area than has been experienced there since settlement, but the rest of the district has experienced stronger or much stronger shaking in 1929 and 1968.

The map shows a decrease in shaking across the District toward the northwest as distance increases from the Alpine Fault. If the rupture does not extend as far north as the Matakitaki (as shown on Figure 2.4), but stops at say Springs Junction, then the isoseimals will curve east rather than west, and the northern part of the district will be shaken less.

Appendix B outlines in full the criteria that establish these Modified Mercalli intensity classes but we note here in Table 2.3 the description of MM VIII and IX as defined by the Study Group (1992), modified for the environmental criteria as proposed by Hancox (2002).

Table 2.3: Definition of Modified Mercalli Intensities VIII and IX (Study Group, 1992)

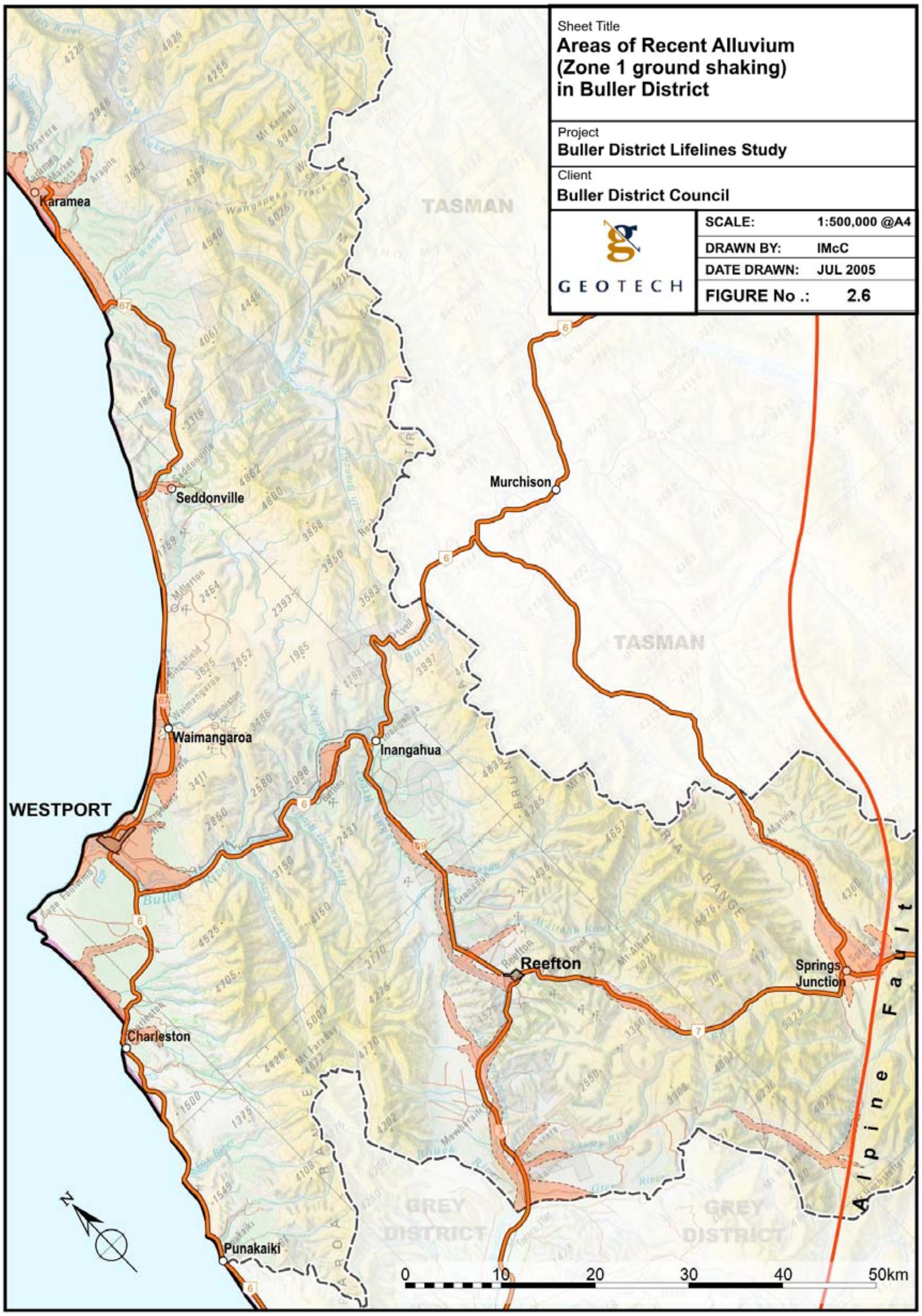
MM VIII	
People	Alarm may approach panic Steering of motorcars greatly affected
Structures	Buildings Type I (i.e. buildings of weak materials such as mud brick, rammed earth, poor mortar) heavily damaged, some collapse. Buildings Type II (i.e. average to good workmanship and materials with some reinforcement but not designed to resist earthquakes) are damaged, some seriously. Buildings Type III (i.e. designed to resist earthquakes with codes operative prior to around 1980) damaged in some cases. Monuments and elevated tanks twisted and brought down. Some masonry infill panels and brick veneers damaged. Weak piles damaged. Houses not attached to foundations may move.
Environment	Cracks appear on steep slopes and wet ground Small to moderate landslides widespread, significant areas of shallow regolith landsliding. A few large landslides from coastal cliffs, and possibly large rock avalanches from steep mountain slopes. Larger landslides in narrow valleys may form small temporary lakes. Roads damaged and blocked by small to moderate failures of cuts and slumping of road fills. Evidence of liquefaction common with small sand boils, localised lateral spreading along river banks and other manifestations of liquefaction.
MM IX	
People	General panic
Structures	Many buildings Type I destroyed. Buildings Type II heavily damaged, some collapsing. Buildings Type III damaged, some seriously Buildings Type IV (i.e. designed and built to codes operative since around 1980) are damaged or suffer distortion in some cases. Brick veneers fall and expose framing.
Environment	Cracking of ground conspicuous Landslides widespread & damaging in susceptible terrain on slopes steeper than 20o Extensive areas of shallow regolith failures and many rock falls and disrupted slides on slopes steeper than 20o, cliffs, and man-made cuts. Many small to large failures and some very large landslides on steep susceptibkle slopes. Very large failures on coastal cliffs and low-angle bedding planes in tertiary rocks. Large rock avalanches on steep mountain slopes. Landslide – dammed lakes in narrow valleys. Damage to road and rail infrastructure widespread with moderate to large failures of road cuts and slumping of fill edges. Liquefaction effects widespread with numerous sand boils on alluvial plains and extensive, potentially damaging lateral spreading along banks. Spreading and settlement of stop banks likely.

The estimates of shaking intensity in Figures 2.2, 2.3, 2.4 and 2.5 are for average ground conditions. For both shaking and acceleration, there will be some additional variation due to local site conditions such as the nature of the underlying rock and soils, their relative thickness and their depths. Areas underlain with deep, recent soils can be expected to have increased shaking intensities, particularly at longer periods, relative to areas underlain with strong rock at shallow depths.

This variation in response has been recognised in New Zealand Loadings Code, with three site subsoil categories in NZS 4203:1992, and five site subsoil classes (A – strong rock, B – rock, C – shallow soil, D – deep or soft soil, E – very soft soil) in the new NZS 1170.5:2004. In theory, it would be possible to zone an area into the different classes if there is sufficient knowledge about the underlying geology. Some indication can be gained from regional geology maps. The greywacke, schist and granite bedrock areas are likely to be class A, the softer tertiary rocks and old well consolidated glacial moraine and outwash gravel are likely to behave as class B or C, and class D and E sites will be confined to the recent alluvial areas. However these broad geological divisions are indicative only and a district wide zoning has not been attempted for Buller, except that areas of recent alluvial soils are shown on Figure 2.6 for the District, and the Westport area at a larger scale in Figure 2.7. The recent alluvial soils are of particular interest as most of the infrastructure and population areas are located on them, and as well as indicating areas of class C – E sites, as these areas are also where liquefaction is possible. Most of the recent alluvial soils will correspond to site subsoil classes C or D, depending on the depth of alluvium, but there may be some limited areas of site subsoil class E (very soft soil sites), particularly around the mouths and the delta areas of the rivers, both into lakes and the sea.

In terms of effects of shaking and ground accelerations a simpler three zone system can be used rather than the five classes in NZS 1170.5, as the uncertainties in earthquake prediction and the lack of information on subsurface conditions makes five classes unrealistic for a regional scale study such as this. The three zones are listed in Table 2.4. Identification of the geology at a particular site can be used to refine the shaking in Figures 2.2 to 2.4, which assume average conditions, site subsoil class C. Zone 2 and 3 areas can have the shaking intensities and ground accelerations reduced from those shown on Figures 2.2 to 2.4, in accordance with Table 2.4, although any reduction of effects close to the epicentral area[1] should be made only with caution.

[1] For this report, the epicentral area is defined as being that area within 5km of the fault rupture.


Sheet Title
Areas of Recent Alluvium (Zone 1 ground shaking) in Buller District
Project
Buller District Lifelines Study
Client
Buller District Council
SCALE: 1:500,000 @A4
DRAWN BY: IMcC
DATE DRAWN: JUL 2005
FIGURE No.: 2.6
GEOTECH
TASMAN
Karamea
Seddonville
Murchison
Waimangaroa
Inangahua
WESTPORT
Reefton
Springs Junction
Charleston
Punakaiki
GREY DISTRICT
Alpine Fault
0 10 20 30 40 50km

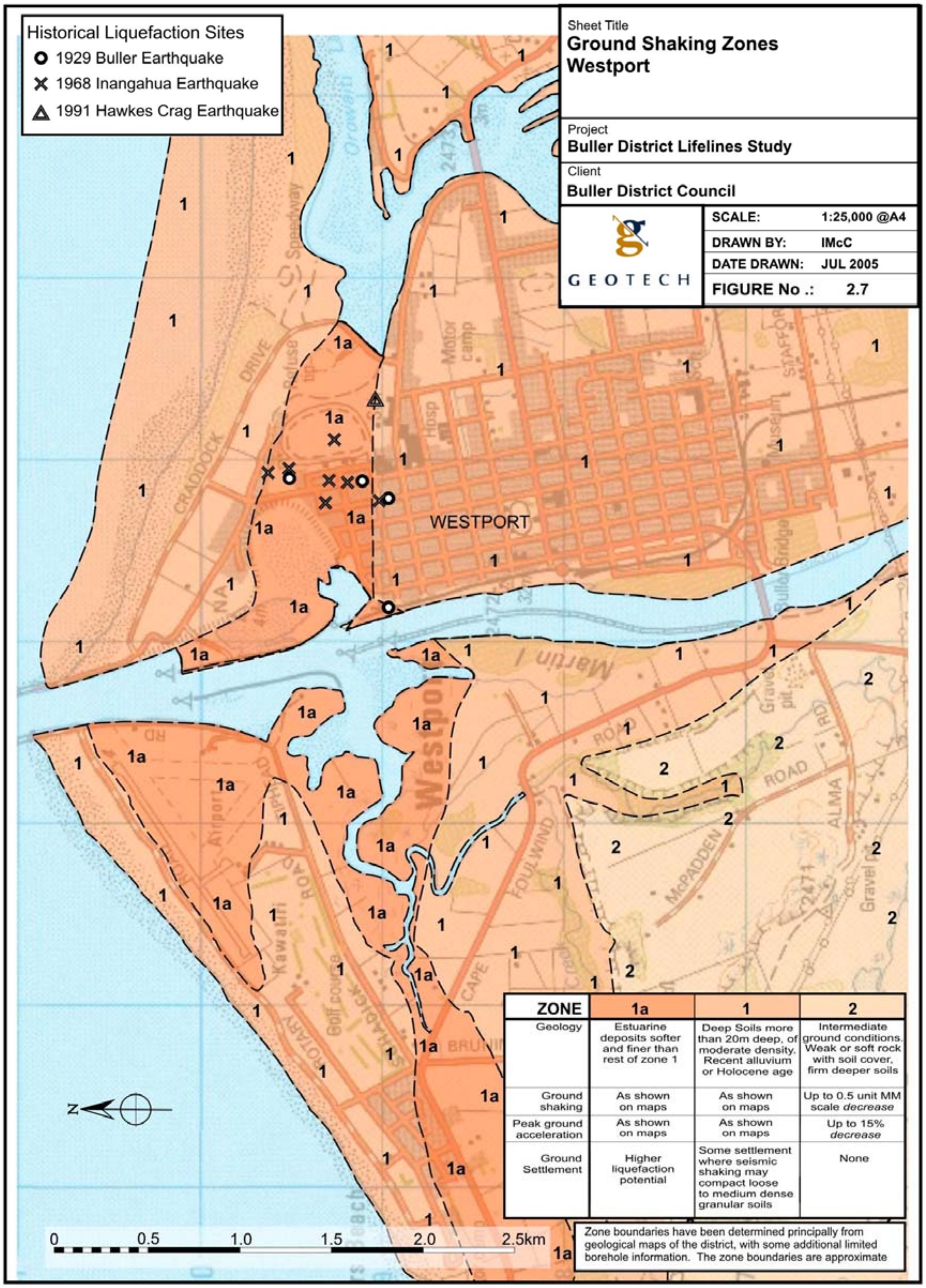

Historical Liquefaction Sites
1929 Buller Earthquake
1968 Inangahua Earthquake
1991 Hawkes Crag Earthquake
Sheet Title
Ground Shaking Zones Westport
Project
Buller District Lifelines Study
Client
Buller District Council
GEOTECH
SCALE: 1:25,000 @A4
DRAWN BY: IMcC
DATE DRAWN: JUL 2005
FIGURE No .: 2.7
WESTPORT
ZONE | 1a | 1 | 2
Geology | Estuarine deposits softer and finer than rest of zone 1 | Deep Soils more than 20m deep, of moderate density. Recent alluvium or Holocene age | Intermediate ground conditions. Weak or soft rock with soil cover, firm deeper soils
Ground shaking | As shown on maps | As shown on maps | Up to 0.5 unit MM scale decrease
Peak ground acceleration | As shown on maps | As shown on maps | Up to 15% decrease
Ground Settlement | Higher liquefaction potential | Some settlement where seismic shaking may compact loose to medium dense granular soils | None
0 0.5 1.0 1.5 2.0 2.5km
Zone boundaries have been determined principally from geological maps of the district, with some additional limited borehole information. The zone boundaries are approximate

Table2.4: Ground Shaking Zones

Zone	1	2	3
Site Subsoil Class NZS 1170.5:2004	C or D, depending on depth of sediment, possible areas of E	B or C	A
Geology	Deep Soils Soils more than 20m deep, of moderate density. Recent alluvium or Holocene age	Intermediate ground Weak or soft rock with soil cover, firm deep soils	Rock Strong hard rock at shallow depth
Geological unit	Holocene sediments	Glacial outwash gravel and till, soft tertiary siltstones	Older sandstone, limestone, greywacke, schist, granite
Ground shaking	As shown on map	Up to 0.5 unit MM scale *decrease*	Up to 0.5 to 1.0 unit MM scale *decrease*
Peak ground acceleration	As shown on map	Up to 15% *decrease*	Up to 30% *decrease*
Ground Settlement	Some settlement where loose to medium dense granular soils may compact	None	None

In the larger scale map of Westport (Figure 2.7), there is an additional zone IA, covering the softest soils of lagoon and estuarine silt. There is likely to be somewhat greater shaking on these soft soils, with possibly a 0.5 unit MM scale increase.

The zones of recent alluvium shown on Figure 2.6 have been derived directly from published geological maps (Bowen, 1964, Nathan, 1976, Nathan et al, 2002). It should be appreciated that limitations in the available data, and the scale of work undertaken in a district wide study such as this, means that the zoning shown in Figures 2.6 and 2.7 has been simplified for application on a broad scale. It is likely that within each zone there will be local areas that would be better included in one of the other zones, and in many places the zone boundaries are approximate. The zones shown are intended to be indicative only, and it is recommended that any critical facility should have a site specific analysis.

Ground shaking intensities can also be affected by both surface and buried topography. Topographic focussing on ridges has been identified in earthquakes, as has increased damage where recent alluvium lies over buried sloping rock hillsides. Attenuation from topography also occurs. It is not yet possible to map these phenomena, and the variation in shaking shown in Figure 2.4 is based solely on the underlying geology, without reference to topography.

Peak ground accelerations (PGA) is the maximum acceleration that occurs at the ground surface during an earthquake, and is normally expressed as a factor of the acceleration due to gravity. PGA is introduced here because it is useful for the detailed review of structural capacity of structures, as used in the Transit screening of bridges (refer to Section 7.2.3) and in liquefaction analysis.

The PGA at any location can be estimated from the attenuation model of Cousins *et al* (1999). Cousins' model is derived from New Zealand data. However, the data set does not include any very large earthquakes, and hence the attenuation for a M8 (Magnitude 8) earthquake such as the Alpine Fault is extrapolated and must be used with caution. The actual accelerations at any site will be subject to many variables, including the site ground conditions. An empirical relationship relating PGA to MM shaking intensity has been used to indicate the variation in PGA that might be expected between different ground conditions ($Log_{10}(PGA) = -0.384 + 0.347(MM\ Intensity)$, where PGA is in cm/sec^2 units, ref Stirling *et al*, 1999 p14). Using an average decrease in shaking intensity of 0.5MM unit between zones, the equation has been used to calculate the corresponding change in PGA for zone 2 and 3 relative to zone 1, as shown in Table 2.4.

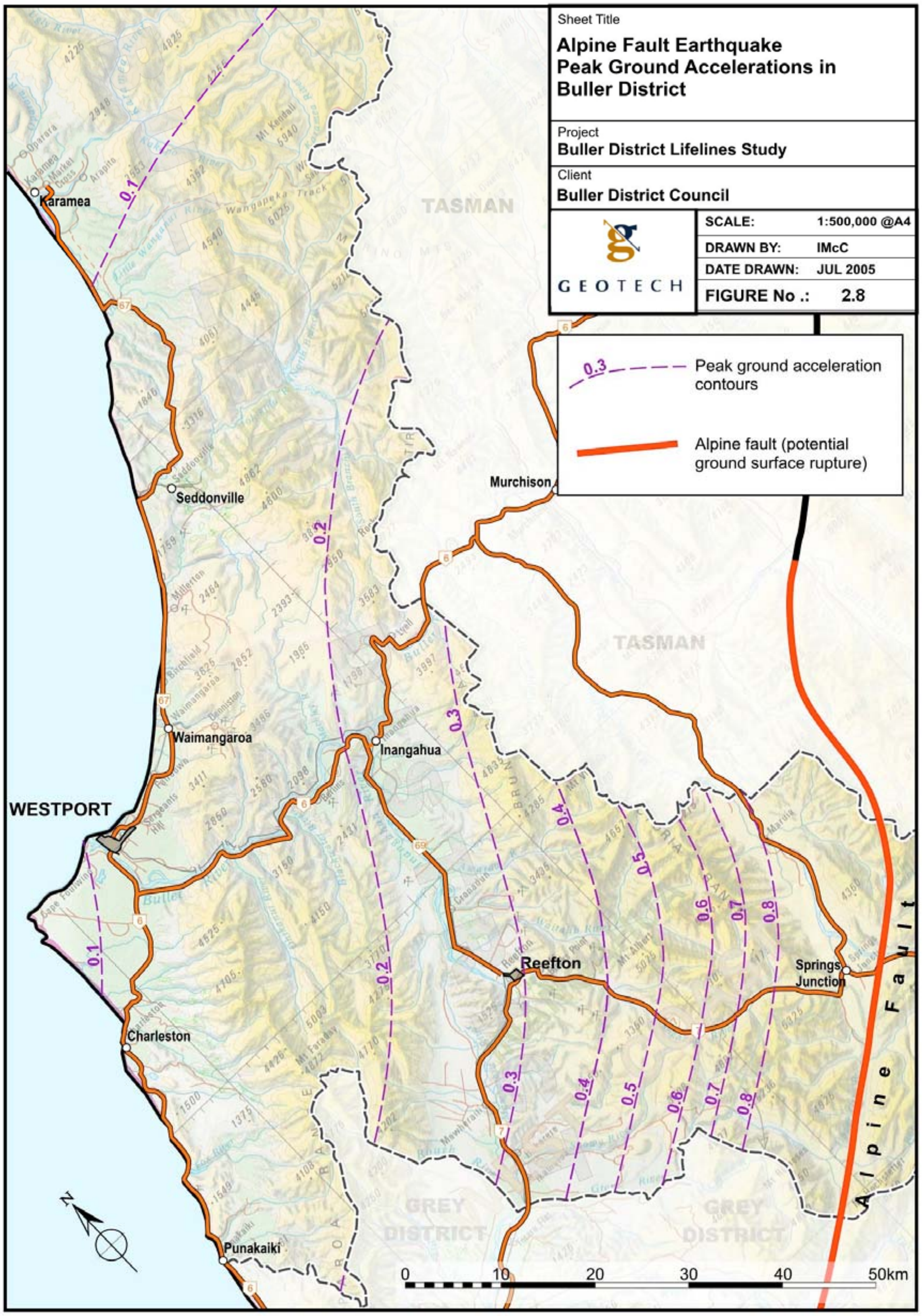
Peak ground accelerations are only loosely related to shaking intensity, and a range of PGA expected for each step in the intensity scale is shown in Table 2.5. The first column comes from Yetton *et al* (1998) and is derived from correlations from overseas data. The third column uses the attenuation model by Cousins *et al* (1999). The fourth column is derived from the equation in Stirling used above.

Table2.5: Correlation Between Peak Ground Acceleration and Shaking Intensity

	Peak ground acceleration (g)			
MM Intensity	Yetton (1998)	Transit (2000)	Cousins (1999)	Stirling (1999)
VII	0.05 – 0.10	0.1 – 0.2	0.05 – 0.2	0.1 – 0.25
VIII	0.1 – 0.2	0.2 – 0.3	0.2 – 0.6	0.25 – 0.55
IX	0.2 – 0.4	0.3 – 0.4	0.6 – 1.0	0.55 – 1.2
X	0.4 – 0.8			1.2 -

Contours of possible peak ground acceleration in an Alpine Fault earthquake are shown on Figure 2.8.

To assist lifeline engineers in their appraisal of the vulnerability of lifeline infrastructure, a damage assessment chart has been prepared (Appendix A). It is divided into sections for structures, in-ground pipework and transport, with comments on expected damage for a range of Modified Mercalli Shaking Intensities, for each of the three ground shaking zones.


Sheet Title
Alpine Fault Earthquake Peak Ground Accelerations in Buller District
Project
Buller District Lifelines Study
Client
Buller District Council
SCALE: 1:500,000 @A4
DRAWN BY: IMcC
DATE DRAWN: JUL 2005
FIGURE No .: 2.8
GEOTECH
Peak ground acceleration contours
Alpine fault (potential ground surface rupture)
Karamea
TASMAN
Murchison
Seddonville
Waimangaroa
Inangahua
WESTPORT
Reefton
Springs Junction
Charleston
Punakaiki
GREY DISTRICT
Alpine Fault
0 10 20 30 40 50km

2.5 Liquefaction Hazard

2.5.1 Extent of Liquefaction potential

Loose granular soils tend to compact on strong shaking, (similar to the effect of shaking a bowl of loose sugar). If the soil is saturated, however, the soil cannot immediately compact as the water in the voids prevents the movement of the particles into a denser state. Instead, the pressure of the pore water increases, and if the shaking is strong and sustained enough, then the pore water pressure can markedly reduce the friction between soil grains and a reduction or even total loss of strength can result. The pore water pressure increase occurs over a number of shaking cycles, and the extent of liquefaction is greater for earthquakes of longer duration. The Alpine Fault earthquake is expected to be a particularly long duration earthquake and hence liquefaction is likely to be severe in susceptible areas.

Liquefaction induced soil deformation can occur as:

- Flow failure, where ground on even very gentle slopes moves laterally,
- Ejection of sand and water onto the ground surface,
- Post liquefaction consolidation, with consequent ground settlement, and
- Large ground oscillations during the earthquake.

Damage from liquefaction is commonly seen as:

- Flotation of buried structures such as manholes and large pipelines,
- Lateral spreading of ground on gentle slopes with resultant ground fissuring, stretching and shear damage to services and structures,
- Settlement of large areas due to consolidation, and
- Foundation failures as the liquefied soil loses its shear strength and its ability to support structures.

Liquefaction can occur in a range of soils from silts to gravely sand. However, it is most likely to occur in saturated, relatively uniform fine sands and coarse silts, which are in a loose state, at depths less than 10 to 15m below ground level, and where the water table is within a few metres of the surface. Typically only geologically recent (Holocene age) sediments are susceptible as consolidation and cementation of older sediments prevents the compaction tendency.

Those areas that could contain liquefiable soils are the recent alluvial floodplains of the rivers and late Holocene terraces bordering them, and the coastal strip, as shown on Figure 2.6. These areas also tend to have more development than elsewhere. While the floodplains further south in Westland tend to be gravel dominated with only lenses of sand (except for some lake sediments), the different geology and geography of the Buller area appears to have produced a finer sediment, particularly in the lower reaches of the rivers. While widespread liquefaction is not expected in the inland river floodplains, there is evidence of liquefaction susceptibility in the coastal areas and along the Buller River. Carr (2004) records forty specific localities within Buller district that have liquefied historically. Historic liquefaction locations in the Westport area are shown on Figure 2.7.

The majority of the District is underlain with rock and hill soils or gravel dominated glacially derived alluvium of Pleistocene age or older. The age and predominant gravel grading of this material preclude liquefaction in all but very rare combinations, for example limited areas of loose sand that has not undergone any cementation with age in an area of high water table.

Within the mountain zone, there are the infilled glacial basins along the major rivers. Some of these areas may have finer grained sediments infilling former lakes, which might be expected to liquefy with strong shaking. There is no information available about soil types and soil densities to confirm this. Liquefaction was reported in a lake delta setting at Lake Sumner for the 1929 Arthur's Pass earthquake.

Liquefaction only occurs with saturated soils, and where the water table is within a few metres of the ground surface. There is no information of water table depths for the District as a whole, but again, high water tables are expected in the recent floodplain areas rather than the higher and older glacial gravel deposits.

In the Alpine Fault scenario liquefaction is expected to occur in susceptible soils at distances of up to 250 km from the earthquake epicentral area. As the whole of the Buller District south of Karamea is within 90 km of the Alpine Fault, liquefaction can be expected anywhere within the District where there are susceptible soils. At the very closest distances, some liquefaction is possible in more gravel rich sediments not normally considered liquefiable, because of the intense and long duration shaking expected.

2.5.2 Liquefaction Zones

The Liquefaction zones correspond with the ground shaking zones in Table 2.4. Zone 1 is most susceptible, and as this is the areas of recent alluvium, it is shown in Figure 2.6. The location of any site within this zone does not imply that liquefaction will, or will not occur, but it designates the relative risk. For important structures a site specific investigation is required to determine the actual degree of hazard.

Given the known historical cases of liquefaction that have occurred in the Buller district, there is a high probability of local areas of saturated sand within the Zone 1 areas liquefying with strong seismic shaking. Any liquefied areas are probably going to be limited in extent and area, and would still constitute a very small proportion of the overall District area.

For all the rivers, the surfaces assessed as being Holocene to present age may overlie Holocene or younger deposits, or may be erosion surfaces with a thin veneer of reworked gravel over much older glacial outwash gravel, in which case the possibility and extent of liquefaction is reduced.

It should also be noted that the risk of liquefaction in these deposits is likely to decrease with distance from the coast to the foothills, because gravel is more predominant closer to the river headwaters. The increased river gradients away from the coast tend to carry sand sized particles away, and the higher energy environment will generally produce denser deposits of any sand beds that do form. However, Holocene age deposits within the eastern parts of the District may be more susceptible, in places where lake deposits and low river gradients are present.

There is an area marked as Zone 1A on Figure 2.7 as having a higher liquefaction potential, being the area of estuarine deposits under north Westport. The boundary to this zone is approximate only, and the locations of historical liquefaction indicate that Zone 1A should properly be extended to both the north and south. Testing in Kilkenny Park has verified the presence of loose sand susceptible to liquefaction.

Areas of alluvium older than Holocene age will mainly be dense gravel dominated soils. There may be small areas of Holocene alluvium in places, along watercourses and the like. There is a very small risk of liquefaction of small, isolated areas within this zone.

Remaining areas that are underlain with rock or hill soils would not be expected to contain any liquefiable deposits. No guarantee can be given that liquefaction cannot occur in these areas, because of the very broad nature of the geological mapping at a regional scale, but the risk is considered to be low.

2.6 Landslides

Landslides are a common effect of earthquakes where shaking occurs in steep terrain. A measure of the landslides that may be expected is that produced by the 1929 Buller earthquake. This magnitude M = 7.8 event is thought to have triggered over 50 very large landslides with volumes between 1 and 200 million m^3, and many others of several thousand cubic metres. One estimate is for 410 slides within the Matiri catchment alone (about 100 km^2); another estimate is for 3,000 – 4,000 slides within the central affected area between Matiri and Wangapeka Rivers; a distance of about 50km. The total number of landslides could have been about 10,000. Fourteen of the 17 deaths in the 1929 Buller earthquake were from landslides. The Buller earthquake occurred in a wetter than normal June, and the extent of landslides will be somewhat dependent on the antecedent rainfall and climatic regime.

Most of the landslides expected will be relatively shallow rock falls and surface soil failures. Deeper seated failures of the underlying rock are less common, although the major landslides and the more significant damaging ones in the Buller earthquake were of this type. The least common landslides are likely to be rock avalanches.

A zoning for potential earthquake induced slope instability has not been carried out for this study, because even a simple classification must include a combination of underlying geology and slope.

The impact of landslides can be much wider than the immediate transportation of rock and soil material. Large landslides can easily block valleys and form landslide dams, which impound river inflow and form lakes. While some remain stable, many fail by erosion as water either seeps through them or overtops them. Failure can range from a few hours to years after the landslide. Failure can entail a rapid breach and sudden release of the impounded lake water, thus causing a dam-break flood downstream, which can be much larger than normal floods and cause widespread damage. Landslide dams and dam breaks are generally associated with larger rivers, but landslides into small streams can provide sediment that is subsequently mobilised in debris flows with consequent severe impacts although on a more local basis. The supply of landslide debris to the river can also result in long term changes in riverbed level and gradients affecting stop banks and bridges.

There are a number of empirical methods to assess the extent of landslides for the Alpine Fault earthquake. Yetton *et al*, 1998, has applied three methods and concludes that they all indicate that there will be major impacts from slope failures within 30 km of the region of maximum shaking (this encompasses the whole of Westland region along the fault rupture). His conclusions are summarised in Table 2.6.

Table 2.6: Relative Slope Hazard Triggered by Alpine Fault Earthquake (after Yetton et al, 1998)

Localities within Buller district	Localities within South Island	Distance from axis of maximum shaking (km)	Impact, in terms of relative abundance and impact
Springs Junction		5	Major
Maruia		10	
	Murchison	25	Moderate
Ikamatua	Hokitika	35	
Reefton		40	
Inangahua		45	
	Greymouth	50	
Punakaiki		65	
Seddonville		65	
Westport		75	
Karamea		90	Low
	Nelson	110	
	Christchurch	130	

2.7 Seiches

Strong seismic shaking can induce water in lakes to oscillate (or "slop") at a particular frequency determined by the lake size and depth. These oscillations are referred to as seiches. Seiches were reported at both Lake Brunner and Lake Rotoroa in the 1929 Buller earthquake. At Lake Rotoroa, the lake level initially fell to expose 50m of lakebed, before rising to flood over the shore and carry off the Gowan river bridge which was destroyed. Another example from 1929 was Lake Brunner, where "the centre of the lake sank into a great cavity, and then the waters rose in a terrifying fashion, and a great wave swept towards the edges. [Mr Peat's] boat was thrown clean out of the water and over the [Moana] slip. There was great commotion in the lake for some time afterward." (Press, 20 June 1929). A 4m high wave was reported at Lake Tennyson. Seiches can be expected in all the lakes in the District, but as these are all small or remote from any infrastructure, the effects will be minimal.

2.8 Tsunami

Overall the tsunami risk to Buller District is regarded as low, but the coastal settlements are at some risk (Travers, 2005).

Tsunami are waves produced by displacement of the sea floor, either by sudden earthquake related uplift, or by submarine landslides. Tsunamis can be initiated by an event far away from the coast being considered (as in the 2004 Boxing day tsunami in the Indian Ocean) or by a local event (near field tsunami). The West Coast is not exposed to likely far field tsunami, as New Zealand shields it from the most likely far sources along the North and South American coast and north Asia. Australia has a very low level of seismicity. The impact of a far field tsunami is regarded as being very small to nil, and hence the risk to the West Coast is low to very low (Travers, 2005).

Near field tsunamis are a real possibility for the West Coast. There are reports of tsunami associated with the 1913 Westport earthquake (a 1 – 1.5m high wave near Westport), the 1929 Buller earthquake (unusually high waves at Karamea and Farewell Spit, possibly from a large cliff failure south of Little Wanganui), and the 2003 Te Anau earthquake with a small wave just measurable at Jacksons Bay. There is also evidence of a catastrophic inundation of the Okarito Lagoon in pre European times (Goff et al, 2004). Near field tsunami are of greater hazard to people as there is often very little time between the precipitating event and the arrival of the tsunami.

Damaging tsunamis need a significant area of up thrust or subsidence or both of the seabed, and shallow water approaching the coast to steepen the waves. The seabed movement of the scale needed could be produced by a large M7 or greater magnitude earthquake offshore, or a large M7 – 8 magnitude earthquake onshore. Large submarine landslides, which may be caused by a large earthquake, are also considered able to generate damaging tsunami.

For the Buller coastline, there is a shallower and wider coastal shelf suitable to increase tsunami height, and a possible offshore earthquake source with the Cape Foulwind Fault. The Cape Foulwind Fault lies off shore from Westport extending south past Greymouth and north toward Kahurangi Point. It is thought to have a low recurrence interval of 3,000 – 10,000 years, but could generate large earthquakes (M7.8 – 8.2), and could generate a large tsunami. A tsunami from this source could be very damaging, particularly as the time of arrival would be very short, and there would be little warning after the earthquake. Areas that could be affected are all the low-lying land along the coast and river mouths and estuaries. These include the coastal road to Punakaiki north of Fox River, Carter's Beach, north Westport, the Buller River and Orowaiti Estuary, Granity and Mokinui. The beaches are, of course, subject to significant storm-wave action, generally with storm ridges above the high tide level. A tsunami would have to be of a reasonably large wave height to affect the open beach coastline.

The Alpine Fault only approaches the coast in Fiordland, and deformation sufficient to cause a tsunami is only likely in this area. A tsunami associated with an earthquake on the Alpine Fault is possible, but less likely, and much less likely to generate damaging waves, given the deep water close inshore at Fiordland, and the distance any wave would travel parallel to the coast to reach Buller. The effect might be considerable erosion of the beaches, but the impacts in terms of run-up onto land are likely to be much less than for a wave series approaching the coast directly.

The Alpine Fault earthquake scenario assumed for this study has the fault rupture extending on land only from Paringa northwards. Alpine Fault earthquakes are not generally expected to produce regional submarine uplift or deformation and a coastal tsunami is unlikely, and no tsunami has been included in the scenario. It is still possible that submarine or coastal landslides of sufficient volume could produce local tsunami, but again given the ruggedness of the coastal beaches, the probability of damage from this source is considered low. The most vulnerable locations are probably bridges and roadways across river mouths and estuaries, but these are designed for large floods which are likely to be greater than the effects of a tsunami likely to be generated by the Alpine fault earthquake.

3 HISTORICAL EARTHQUAKES

This section outlines some of the major effects of two large damaging earthquakes since European settlement of the Buller District. It is based on readily available sources, and is not an exhaustive study. The principal sources are Henderson (1937) and newspaper reports in the Christchurch Press from June and July 1929. Some additional details have come from Carr (2004), Hancox et al (2002), MacDonald, 1973) and Rogers (1996).

3.1 1929 Buller earthquake

3.1.1 General

The 1929 Buller earthquake devastated the Murchison area, but also caused widespread damage throughout the Buller District, particularly in the Karamea area. It was a M7.8 event centred about 15km north west of Murchison, occurring at 10:20am on 17 June 1929.

Slight earthquakes were felt about 1:30 and 7:30 on the morning of the disaster, but caused no great alarm. The main shock at 10.17 am … is described as being violently up and down. Unwilling observers had difficulty in keeping their feet, they clung to anything with which they came into contact or found themselves on the ground. Thunderous reverberations from the rocking, heaving earth nearly drowned the creaking and groaning of the houses, the clattering of falling movables, and the crashing of chimneys on and through the roofs. Everyone made for out of doors, many were mentally numb, and some experienced a physical nausea akin to sea-sickness.

Strong shakes, often accompanied by loud detonations, continued throughout the afternoon and following night. The people would not enter their homes, but camped as best they could in sheds and hastily-erected tents; most of them collected at the school grounds, where an open-air kitchen was established. They saw the hills surrounding their fertile flats stripped to the bare rock and the great fissures along the river banks. The bridge across the Matakitaki was impassable, while the river had ceased to flow. Power and telegraph poles were down in all directions; there was no communication with the outside world except through a few wireless receiving sets, no lights, and the generator in the power house was wrenched on its bearings. Settlers struggling in from the neighbouring valleys told of relatives and friends buried and of homes overwhelmed beneath landslides; of miles of vanished roads; of lakes rising behind dams of debris across the Matakitaki, Matiri, Maruia and Buller Rivers. Small wonder that all were terrified and oppressed with the imminence of further disaster."

(Description of the 17 June 1929 earthquake at Murchison, in Henderson, 1937)

I don't know where to start to explain the position as regards Karamea. We are isolated, and it looks as though we will be for some time to come. There is practically nothing left whole in Karamea. Every road in the district is closed, and nearly all bridges are down. The wharf is gone, and the roads are either opened up in all directions or are covered altogether.

There is not a chimney left standing in Karamea, and nearly every tank is gone, and some houses were burnt down. We seem to have been the storm centre. It seems, at first sight, as though we are permanently cut off, as all the hills around us appear to be down. There are great openings you could drive a horse and cart into in the middle of the road. There are water geysers and boiling sulphur in the middle of the paddock, and worse than all, Karamea River is blocked – evidently a big slip in the Gorge. (Unknown author as reported in newspapers, June 1929)

Of the 300 residents of Murchison, 167 left Murchison on the morning of 18 June and reached Nelson that night. By the next day, 289 refugees were in Nelson leaving only 40 – 50 men in the town. There were 17 deaths in this earthquake; 16 of them by landslide, and 4 within the Buller District north of Westport.

3.1.2 Roads

All the roads in the Murchison area were badly affected. Initially the road to Glenhope was cleared sufficiently to allow refugees to leave Murchison on day 2. The bridge across the Buller upstream of Murchison was intact, but parts of the roadway bordering the river closer to Murchison had fallen away and traffic had to take to the neighbouring paddocks. Heavy rain by day 3 caused further slips and hampered work in restoring roads, and some later evacuees travelled south to Reefton.

The road through the Upper Buller Gorge was severely damaged, with "the complete destruction of parts of the road between Lyell and Newton Flat." The Upper Buller Gorge road was not reopened to wheeled traffic until 1 April 1931, but two days after re-opening, heavy rain brought down further slips and the road was closed for a further 4 weeks, more than 22 months after the earthquake.

A service car had just crossed the Iron Bridge over the Buller at the time of the earthquake. The car was trapped between a large slip, which took out most of the road in front, and a rockfall behind. It took over six hours for the car occupants to return about ½ mile to the nearest house, and 4- ½ months before the car was retrieved. The Iron Bridge spans shifted nearly 0.3m on their supports and the holding down bolts pulled out of the piers.

Bridges on the Matakitaki at Murchison and Lyell Creek had trusses displaced and distorted. The Newton River bridge was "much" damaged and later completely destroyed by flood and debris from the "vast" slips upstream. A number of small timber bridges were completely wrecked.

As the main Buller Gorge road was so damaged, an alternative route for transport between Nelson and the West Coast was needed. The road along the lower Matakitaki, upper Maruia and upper Inangahua was hastily improved and a temporary bridge built over the Maruia so that communication was re-established after about 3 weeks. In the Matakitaki, the road between six mile and eight mile was completely destroyed by slips in several places and when public motor transport between Nelson and Westport recommenced on 15 July (4 weeks after the earthquake), there was a 5 km break in the road here with a walking track linking the road ends. The mid Maruia area was still completely without road access on July 4.

In the Inangahua area, a large portion of the road from Cronadun to Three Channel Flat showed "lengthy cracks". At Rotokohu cracks were 0.5m wide and 40m long and the road sank several feet. The approaches to the Rotokohu bridge were damaged. At Oweta a road bridge had "sprung up in the middle and sunk at either end". Two cylinders in the new bridge at the Junction were badly cracked. A slip came down halfway between Landing and Inangahua.

From Westport, the roads to Seddonville, Reefton and Greymouth were reopened within a few days, although repair work in the Lower Buller Gorge took many months to complete. A 1.2m fissure is reported to have opened up at Orowaiti, about 2 miles from town, and another deep fissure down Romily St, as well as in "one of the back streets of Westport". On the road north to Waimangaroa, large fissures appeared on the road ("cracks as wide as 0.2 – 0.3m and extending chains down the road"), and a pier on one bridge was lifted about 1.5m. Extensive fissures are reported on the road to Cape Foulwind, and one bridge was completely demolished and others badly damaged.

Hill roads suffered severely from slips. Two lorries were buried on the Stockton Road, and slips destroyed miles of road in the Denniston area. On July 18 (a month after the earthquake) Millerton and Stockton remained without any road access, as the large slips initiated by the earthquake were continuing to move. Clearing debris from the road only brought down more material and work was abandoned for some time. Access to the towns was by foot track or the inclined tramway to the mine. Two prospectors were killed by a landslide on the track into the upper Mokihinui.

The Karamea Road was so extensively damaged over a twenty mile length that it took over fifteen months to reinstate it for wheeled traffic. Inspection of the Karamea Road at the beginning of July showed that from Mokihinui to Tobins Bridge it could be readily repaired, but from the bridge to the top of the zigzag, repairs would be heavy as numerous slips with bush blocked the road while in other parts the road had bodily dropped 1.5 – 5m. At the top of the zigzag was a slip 120m across, followed by a stretch of road for a short distance, beyond which a slip extended practically to the top of the bluff (a distance of over 1 km). The rest of the road to Corbyvale was destroyed by a series of slips. (Press July 2). Residents from Corbyvale, isolated in the middle of this road were evacuated in mid July after it became apparent that access could not be re-instated readily.

As the coastal route had also been greatly affected by landslides, Karamea remained isolated by land and dependent on coastal ships into the river port. The first relief to Karamea was by a Tiger Moth aeroplane landing on the beach 5 days after the earthquake.

In Karamea, the three bridges (Karamea, Quinlans and Oparara) were all usable after the earthquake, despite subsidence of the abutments to Quinlan's bridge. All bridge approaches dropped 0.3 – 1m, Quinlans bridge had both end spans "let down" about 1 metre at the abutments. The "big bridge" had not shifted, but the Karamea bridge was damaged, with abutment fill slumped 0.6m at either end, and was removed following a large flood in 1931. On demolition, it was found that the piles had been broken, likely to have been earthquake damage. The Little Wanganui River bridge was damaged with distortion and displacement of a truss.

The roads within the Karamea flats were also affected by liquefaction and ground movement: "from here (Karamea) to the bridge used to be perfectly straight, but now it is in and out and up and down all the way. Likewise telegraph poles are leaning this way and that all the way".

As a general comment, Henderson reported "many road fillings across gullies spread at the base, fissured along their length, dropped and pulled away from the more solid ground at one or both ends. In some, one or both ends of the culverts were covered, in others the culverts wrenched apart or crushed. The slumping of bridge approaches caused considerable damage. The abutment walls tended to be forced toward the stream, in some cases allowing the bridge span to drop and in others thrusting the whole structure toward the opposite bank."

Restoration of the roads was continually hampered by aftershocks and rain bringing down further slips. One example, although outside Buller district, illustrates this. About a week after the earthquake it was reported that the new concrete bridge across Doctors Creek is "down, the solid slab that formed the traffic way standing on end". The Doctors Creek bridge appears to have failed on 24 June as a report indicates that a team of linesman made it into Murchison by truck on the 23rd, but on their return to Glenhope the following day found the bridge tipped and impassable. At this time a debris flow also occurred at the Staircase, following a landslide damming a gully, and the resultant flood "was just like the Buller River itself in flood, but with big masses of timber being hurled about in all directions." The following day, "the huge trees which were there the previous night, blocking the road, had been shifted like matchwood right onto the bed of the Buller River, and leaving four times as much newly fallen timber and mud on the road. A temporary track and bridges of felled trees were erected to allow the evacuation of refugees over this area by foot. (Press June 28)

Aftershocks were being experienced at the end of July, with further slips occurring. In mid July it was noted that there were further slips in the Buller Gorge and problems with traversing a temporary road through Walkers Swamp to bypass a destroyed section of road.

Comment: The impact of landslides on the roads in 1929 was clearly severe, and could be similar if this earthquake was to occur today. Of particular note is the time needed to clear roads, and the ongoing problems with aftershocks and heavy rain remobilising the disturbed hillsides. The long times to restore some roads (22 months for the Upper Buller Gorge, 15 months for the Karamea Road) might be expected to be greatly reduced with modern earthmoving equipment, but the much greater road widths and extent and height of cut batters may well increase the vulnerability of the current *roads. In addition, the standard of road acceptable for re-opening is probably far different from 1929. It is clear that these roads would take at least months to re-establish today.*

Also of note is that while many bridges were damaged, many appear to have been usable, at least for light traffic, but that some were subsequently destroyed by floods and debris. Some areas will be less vulnerable. For instance the section of road that had a temporary detour at Whitecliffs was similarly affected in 1968, and the road has now been diverted away from the rockfall area.

3.1.3 Railway

Railway traffic out of Westport was initially impossible because of damage to bridges and spreading of embankments. Damage was not severe, and the lines to Mokihinui and Te Kuha were re-opened within a few days. Worst damage was apparently at Seddonville and Birchfield, where the line was twisted badly. However at the start of July it was reported there were 100 men and two work trains working on Westport section, which was all open except for the last two miles past Seddonville. On July 12 a report stated that trains were operating at a maximum of 16 kilometres per hour, restricted to 4 kph in places, and this was a significant constraint to the coal industry.

The Reefton – Inangahua section was affected with embankment and bridge damage. There was apparently little damage until after Cronadun, from where the line had become "wavy". The north portal of the Reefton tunnel was slightly damaged (further cracks were reported, none serious, on July 2). A train reached Inangahua on June 20 (day 3), and all services were running again from June 24 (day 8).

Comment: Damage to the railways was less than for the roads, probably because for the most part the railways were away from hillsides and landslides. The railway between Westport and Inangahua, construction of which had not been started in 1929, would be expected to be cut by many landslides and rockfalls. Significant disruption to train operation can be expected for many weeks after a similar event due to repair work and speed restrictions.

3.1.4 Port

In Westport, fissures opened parallel with the waterfront for chains back and the wharf warped slightly. The railway lines twisted. The long straight of the breakwater deformed both laterally and vertically from uneven settlement of the embankment over the soft estuarine soils.

Press reports show that assessment of the damage was initially somewhat alarmist. On June 21 it was reported that only about half the wharf was still workable, but the damage at the railway station end was slight. On June 24 it was stated that the wharf was badly strained at the seaward end, and before it could be used again to its full capacity a considerable number of new piles would need to be driven, with some old piles severely damaged or even "completely smashed". A detailed examination on June 24 found the damage comparatively slight given the severity of the shake and the pull of the vessels moored to it. A report on 4 July downgrades the damage even more, and appears that only a section of wharf was strained outwards, damaging some pile sets and steel ties to deadman anchors.

At Karamea, liquefaction and "the slumping of uncompacted alluvium threw the wharf and training wall out of alignment". The port was a crucial link for transport in and out of Karamea for over a year until the road was re-opened, but was subsequently abandoned, as much because of silting up of the river and estuary from transported landslide debris as of economic trends.

Comment: The damage to the Westport wharf appears to have resulted from loading by a moored ship; and a similar event today may not cause the same problem. Sections of wharf are now old and failure of retaining walls is possible, as well as distortion of ground along the river front and possible lateral spread damage to the banks around the fishing harbour. The wharf also illustrates that early damage reports may not be accurate.

3.1.5 Drainage

Landslide dams formed lakes on the Matakitaki, Matiri, Maruia and Buller rivers. Warnings of possible floods from the breaching of these dams caused five ships to leave the port on day 2. Several large landslides blocked both the Mokihinui and Karamea Rivers. Landslides also dammed Glasseye and Tobin Creeks in the Karamea district.

The Matakitaki landslide of about 18 million cubic metres (which also buried two houses and killed four people) formed a lake 3 miles long and up to 25m deep, which took four days to fill. The lake apparently later silted up and became an area of willow trees, before washing out during a flood in the late 1930s, with no significant damage downstream. A slide in the Maruia also formed a 3 mile long lake, but the cone of debris was smaller and within 2 days the river had worked around its toe and cut a channel through terrace gravels and drained the lake. Rockfalls from each side of the valley a little upstream of O'Sullivans Bridge dammed the Buller River for 2 days.

The Mokihinui River was dammed about 1 mile below the forks (about 17km upstream of Seddonville), forming a lake about 20 m deep and extending several miles up the north branch. Two and a half weeks after the earthquake, part of the dam failed and the lake level fell about 8m. At Seddonville the river first rose at 2pm about 1.5m and stayed at that level until about 4:30 when it rose rapidly to peak at about 5pm, allowing little time for the residents to escape (if the flood had occurred at night it was thought that half of the 200 population would have died). Most of the township was flooded by up to 3m, forcing residents to flee or take refuge on their house roofs. Some houses were shifted off their foundations and a hall drifted about 100m before stopping against another building. The damage from the flood was much worse than the earthquake damage (Press July 6). The flood apparently choked in the narrow valley further downstream, with floodwaters passing through the Mokihinui railway tunnel, carrying away ballast and damaging the line. Most of the residents of

Seddonville were evacuated following the flood. (Press July 12). On July 20, attempts were made to lower the remaining landslide dam in the Mokihinui, to prevent any re-occurrence of the flood.

The Karamea River was apparently blocked in several places, the lowest being near the junction of the Roaring Lion, and forming lakes up to 25m deep. Six months after the earthquake, one or more of these dams failed after heavy rain, and the low lying land around Karamea township was flooded. Aggradation in the Karamea raised the riverbed by over 4m at the bridge. There is also a report of flooding at Little Wanganui from a landslide dam failure.

Comment: The 1929 earthquake occurred in an unusually wet winter, and the extent of landslides might be different now, but a similar earthquake must be expected to cause widespread landslides with consequential problems of dammed river, debris flows and aggradation.

3.1.6 Communications

Telegraph wires were broken south of Glenhope from the Nelson end and south of Reefton. Twelve hours (after the earthquake) a messenger from Murchison, who took nine hours to cover 30 miles, reported the first news to Glenhope. Restoration of lines started immediately with the dispatch of a party of linesmen. Connection to Murchison was made by midday on 19 June (day 3), but after 6 hours it was cut again by further slip movement and the falling of trees. Ongoing damage as the results of slips continued to break the line for well over a week after the earthquake.

Westport was isolated telegraphically, and news from that town was by wireless from one of the vessels in the harbour. Tiger Moth aeroplanes were sent on day 2 from Christchurch with wireless operators, landing on the beach. Communication was re-established between Westport and Granity to the north by using the railway telephone, Reefton to the east and Greymouth to the south within a few days. Communication was lost from Westport again on June 22 (day 6) when fresh slips severed the line through the Buller gorge. The mining towns remained cut off on June 24 (day 8).

The telephone system in Westport was badly affected by the collapse of part of the Post Office and its subsequent demolition. It was restored with the equipment being installed in a makeshift Post Office. Telephone services to the mining towns and Seddonville were working from about 26 June (day10).

By June 26, telegraph traffic was normal into Westport but Karamea was still isolated. The transport of an expert radio telegrapher and the necessary radio equipment to Karamea by air was delayed by poor weather until 1 July (day 15).

Comment: In this area, technology has changed most dramatically. However, landlines are still vulnerable, whether buried or on poles.

3.1.7 Water

The water supply was cut in Westport. It appears that the main supply pipe was badly damaged over a considerable length in the Orowaiti River area. There was damage (cracked and "crumbling") to the reservoir dams, and within the town, inference that ground fissuring ruptured pipes, although the gas mains suffered little damage

On June 21 (day 5) it was reported "close to the railway station in Westport two men are pumping water for dear life. It is the town's only supply at present, for that in the river and creeks is too muddy to use. There is a constant stream of residents with containers. They have to keep the railway locomotives supplied as well. Fortunately the electric light has not failed and water may be obtained in the manner indicated, but sanitation is causing everybody a good deal of concern." (Press, 21 June) A day later a brewery and the railway department were arranging for water to be pumped from wells into the mains by steam power. Westport's water supply was partially restored by this means on 23 June (day7) to an area from the riverfront to Queen Street and from Brougham Street to Packington Street.

Elsewhere people were drawing water from whatever source was available. Dr Telford, Medical Officer of Health, allowed only water from wells with a depth of 8m of more to be used. He placed a ban on a spring from which hundreds of people were drawing water, contaminating it with kerosene to make it non-potable, as it posed a potential health risk.

Meanwhile the Borough was working to reinstate the water mains. By the 29 June (day 13) the smaller 8 inch main was in operation, although there was a shortage of 8 inch pipes, with just enough to complete repairs. "Had there been a more lengthy break the position would have been serious." The borough engineer reported "the 14 inch main would be unavailable until new pipes over a considerable distance were procured, as the pipes had been drawn apart, crunched by the earthquake and made quite unfit for further service." New pipes were to be ordered from the Wanganui Spiral Pipe Company for the earliest delivery. (Press 27 June). The services of the railway department's pumps were requisitioned to keep the mains full, and a steam fire engine was brought in from one of the outlying districts in case of any emergency.

A heavy aftershock on July 8 (day22) nearly brought down the bridge at Orawaiti carrying the water main to Westport. The work of straightening up and strengthening the bridge had just been completed, with the bridge being held up by the fastenings on to the railway bridge, which ran beside it.

Comment: Details are sketchy, but the vulnerability of Westport's water supply is clear. The details of the damage to the supply main are not known, but it may have been damage at pipe joints from ground distortion and possible liquefaction. It was clearly not an insignificant length of pipeline affected as it took nearly two weeks to repair the 8 inch line. Since 1929, much of the pipeline length has been buried, but this may not change the vulnerability much. Restoration of full supply had to wait until replacement pipe was made and delivered, and the 8 inch line was restored earlier only because *sufficient pipe was in stock in Westport. A well allowed a temporary supply, but there were areas without a water supply for a long time, with people resorting to potentially unsafe sources. There was some damage to the reservoir dams, and shaking stronger than in 1929 might cause failure of one or more of these structures. There was no mention of Reefton water supply in the reports sighted – it apparently survived MM VIII shaking relatively well.*

3.1.8 Sewer

Ground fissuring ruptured pipes so that the sewer failed. In Derby St from Cobden to Gladstone Street, a distance of some 300m, the 9 inch main sewer was badly broken and some 30 house connections had to be renewed. In Romily St between Cobden and Bright Streets some 100m of the main and about 12 connections had to be renewed. (Letter from the Borough Engineer to the Mayor of Westport, August 1929).

3.2 1968 Inangahua earthquake

This was a M7.2 event with an epicentre about 15km north of Inangahua township. It occurred at 5:24 am on 23 May 1968. There were three deaths (two by landslide) and widespread damage from Karamea to Hokitika. Communications were affected, such that initial reports suggested that Greymouth was worst affected, and it was 3 hours after the earthquake that the first radio communication from Inangahua was achieved. Aerial reconnaissance by helicopter began later in the morning. By 9;30pm, 196 people had been evacuated from Inangahua area by helicopter to Rotokohu and thence by bus to Reefton. A state of emergency was declared in Reefton and Westport, and maintained in place until 30 May. The following information has been taken mainly from Adams et al, 1986.

3.2.1 Roads

There was widespread damage to roads, from landslides, slumping and fissuring. Spreading of embankments, particularly at bridge approaches, caused longitudinal cracking. Differential movement and slumping caused transverse cracking at terrace faces. Subsidence of bridge abutment fills was particularly large in the Inangahua – Rotokohu area, but extended as far south as Reefton and west to Westport. Subsidence of a high fill at the Camp overbridge near Runanga resulted in the death of a driver who drove into the abutment shortly after the earthquake. Approaches to the Orowaiti Bridge and the Waimangaroa overbridge were lowered by 0.2 – 0.3m.

Access between Reefton and Inangahua was initially gained along the Brown Creek Road two days after the earthquake, initially to heavy and four wheel drive vehicles only. The main road was reopened on 14 June, three weeks after the earthquake, due to damage to the Landing road-rail bridge and a large slip. The Lower Buller Gorge Road was damaged by landslides and rockfalls at Whitecliffs, 5 km west of Inangahua. It was reopened on 14 June, 3 weeks after the quake, with a low level road built over a flood channel to by-pass the rock falls. The Upper Buller road was extensively damaged with several sections completely carried away by landslides. It was reopened on 2 August, 10 weeks after the earthquake, after temporary reconstruction.

Structural damage to bridges was substantial within about 7km of Inangahua, but minor to none beyond this distance. Damage and cracking to piers was typical. Generally the bridges could be used after comparatively minor repairs and once the abutment slumping had been remedied. The Landing Bridge suffered a failure of a concrete abutment and tilting of one pier and was unable to be used for about 3 weeks until temporary repairs had been effected.

Comment: Similar damage can be expected. The Landing Bridge has been replaced with a new structure. Depending on the extent of slips, SH 69 could be reopened within 1 – 2 days. Subsidence to new bridge abutments should not be quite the same obstacle as bridges built in the last 30 years will all have settlement slabs. The Whitecliffs section of SH6 has been rebuilt since 1968 away from the bluffs, and reopening of the lower Buller Gorge could be expected to occur with a few days. Similar damage and time for reinstatement can be expected through the Upper Buller gorge.

3.2.2 Railway

Movement of the surface fault traces damaged the line with buckling due to compression and lateral displacement. Much more significant was lateral spreading of embankments with pronounced distortion to the track in both vertical and horizontal alignment. One train was derailed about 2km south of Rotokohu through embankment spreading. A number of slips blocked the line in the Buller Gorge, including one 1,900 m^3 rock fall, and collapse of a river bank below the line needing 2,300 m^3 of fill to rebuild the line. The railway was reopened, with severe speed restrictions, about 3 weeks after the earthquake.

Comment: Similar damage can be expected.

3.2.3 Drainage

The major effect was a rock fall avalanche, which blocked the Buller River 3km upstream of Lyell. Material was carried down the whole 600m height of the southern valley side and 50m up the northern side. The slide dammed the river flow, forming a lake about 8 km long. It overtopped the dam within a short time (the references are unclear about the duration taken) and the dam eroded out without causing any significant flood.

Comment: Similar events can be expected in any large earthquake in the area.

3.2.4 Telecommunications

Local calls were apparently able to be made within Inangahua township shortly after the earthquake, but all lines away from the township were cut by fallen trees, slips and the spreading of road and rail embankments displacing poles.

3.2.5 Electricity

Damage was not significant other than at Inangahua substation, where equipment was disconnected and bypassed allowing the restoration of supply after only 3 hours. However, landslides threatened several transmission towers, and a partial rerouting of the line was carried out in the Upper Buller Gorge to bypass the unstable areas.

Comment: Landslides from this earthquake came very close to destroying some transmission towers. Re-routing the lines will have mitigated the 1968 problem, but the lines across the steep topography must remain somewhat vulnerable.

3.2.6 Water and Sewer

There is little information reported:

"Cemented glazed sewer pipes suffered severe damage in the Inangahua earthquake. Unfortunately no rubber-ringed pipes were found, and comparison could not be made. In Westport some underground pipes were broken." (p36 Adams et al, 1968). "All the services (to Westport) were cut with the exception of the gas which continued to flow as usual through pipes that had been damaged in the 1929 earthquake." (p46 MacDonald, 1973).

Reconnection of a broken water main in Derby Street near Kilkenny Park required the addition of 1.2m of pipe, indicating that lateral extension of the ground had occurred here (Carr, 2004).

Comment: There appears to have been less damage in Westport in 1968 than in 1929, although shaking intensities were similar (MM VIII). The direction and duration of strong shaking may have had some influence, but further research may reveal more damage in 1968 than reported in the references used.

4 ALPINE FAULT EARTHQUAKE SCENARIO –PHYSICAL EFFECTS

4.1 Introduction

This section outlines a possible Alpine Fault earthquake scenario for Buller District with particular regard to the potential impact of an earthquake on the lifelines systems.

The scenario below is realistic with respect to the potential level of earthquake shaking and the associated secondary effects (liquefaction, landslides etc) that could occur. It is not intended to be predictive with respect to the precise lifeline impacts or the exact locations of any impact. We have only a limited knowledge of the various networks and components and their capacity and/or resistance to withstand the impact of a significant earthquake. In effect this is a preview of the types of issue that may follow as an end result of a detailed study of the susceptibility of each lifeline. The impacts listed are intended to help focus thinking on the way that lifelines systems can be affected by a strong earthquake and suggest some of the interdependency issues between lifelines.

The scenario also includes possible damage that may occur to the main lifeline links between Buller District, the surrounding Districts and the remainder of the South Island. This is because impacts outside the District will have a direct and significant effect on the ability and speed with which Buller District can respond to the earthquake and the consequential damage.

The scenario has been set for a particular time of day and year. In terms of the lifelines, this is not so significant, except that rainfall patterns both before and after the earthquake will impact on the number and nature of landslides both immediately and following the event, and the likelihood of damaging floods. If the scenario is used as a basis of emergency planning, the timing becomes more significant. For instance, visitor numbers in the summer are much higher than in winter, and initial response may be significantly more complicated with large numbers of people trapped in outlying areas of the District. An earthquake during the day would result in many travellers being caught on the road network, whereas a night event would have most people at home or in accommodation. While these may appear small details, such variabilities could have a significant effect on the focus and availability of resources during the early part of recovery, which could in turn affect the re-establishment of lifeline services.

4.2 Time zero - 10:15am on a weekday morning in late winter

For several days there have been a series of minor tremors registered by seismographs but too small to be felt in the vicinity of Mt Cook and the central Southern Alps. At 10.15am there is a very large earthquake (M_s 8) on the Alpine Fault with an epicentre near the Whitcombe Pass, approximately 10km east of the Alpine Fault trace.

The fault ruptures over a length from Paringa in the south to north of the Matakitaki Valley in the north. The fault movement on the section through the Buller District decreases from 6m horizontally and 0.5 m vertically at the south boundary near Haupiri to 4m horizontally and 0.3m vertically at the northern District boundary in the Glenroy River. The bracketed duration of strong shaking (defined as acceleration exceeding 0.05g) lasts for approximately one minute in the epicentral area (within the MMIX isoseismal) but about 30 seconds in the coastal part of the District. For the Alpine Fault with its extremely long rupture length, the epicentral area is not confined to where the earthquake rupture originates, but to the area close to the rupture. For this scenario, it can be regarded as the area within about 10km of the fault rupture. The duration of strong shaking decreases for the coastal areas of Buller because of the attenuation affects with distance.

4.3 Time zero plus 1 minute

Within **time zero plus 1 minute** of the first shaking there is damage to lifelines in the epicentral and near epicentral areas as follows:

(a) Transport

Damage is extensive in the epicentral area and all roads within the district are blocked. The fault rupture severs SH7 4.5km east of Springs Junction, and causes severe damage to a 1km section of Palmers Road north of Palmers Flat. There are widespread landslides that block the SH7 highway east of the fault in the upper Maruia, particularly between the Maruia Hotel and Lewis Pass. Most bridges in the Maruia valley are damaged to some degree. Both Woolley Creek and Mairs bridge over the Maruia suffer significant structural damage. The Blue Grey bridge on Palmers Road is destroyed.

There are rockfalls and landslides blocking SH7 between Springs Junction and Craigs Clearing, particularly in the upper Inangahua, and slips between Blacks Point and Reefton, one of which has blocked both lanes.

SH7 and SH69 and the district roads tributary to them are affected by batter failures, settlement of abutment fill, fissuring from liquefaction and some bridge damage between the Grey River at Ikamatua and Inangahua Junction. The Grey River bridge is damaged and slumping occurs at both abutments. The Little Grey bridge and the bridge over the Inangahua at Reefton are damaged, but remain serviceable for light vehicles.

There are rockfalls and batter failures on SH6 through the lower Buller Gorge, and along the coast between Charleston and Punakaiki. Similar damage occurs on SH67 to Mokihinui and on the district roads to Stockton, Denniston and Karamea, with large failures on the Karamea Bluff.

Liquefaction causes some damage to streets within the north part of Westport, and at places on the roads between Cape Foulwind and north of Karamea

The Westport aerodrome is essentially undamaged, as is the airfield at Karamea.

The Westport aerodrome is essentially undamaged, as is the airfield at Karamea.

The harbour facilities at Westport suffer only minor damage and remain functional. Collapse of retaining walls behind the old wharfs restricts access along the rear of these structures in places.

The Railway is damaged by embankment distortion and some bridge damage between the Grey River and Inangahua and rockfalls through the Buller gorge. An empty coal train is derailed by a rockfall opposite Stitts Bluff in the middle of the Buller Gorge.

(b) Drainage

There are large landslide dams in the upper Maruia, Glenroy and Matakitaki Rivers, all tributaries of the Buller, and in the Upper Buller Gorge. The rivers are completely blocked at all these locations.

Liquefaction has damaged some lengths of the embankments around the fishing basin at the north end of Westport, and extensive lengths of stop bank at Karamea are damaged with longitudinal cracking and slumping caused by lateral spread of the foundation material.

(c) Sewerage

At Reefton, there are many breaks in the sewers. There is significant failure of the older reinforced concrete pipes that have deteriorated over the years and failure of some laterals. Surcharging occurs with some ponding and the remainder discharging to local waterways. One of the mains that fails is a trunk main to the oxidation ponds. In Westport, liquefaction causes breaks in the sewers at the north end of the town. Failure of a dilapidated retention system under the old wharfs blocks the sewer outlet opposite the end of Packington St.

(d) Water supply

The Reefton water supply intake is affected and the pumps stop. There is considerable damage within the reticulation (65% CI and AC pipe) and breaks in several places allow water to escape at large flows. The reservoir is not damaged.

The Westport water supply headworks are largely unaffected, but there are some breaks in the older AC and CI pipe (55%) in the reticulation, particularly at the north end where liquefaction occurs. There is similar damage at Carters Beach (75% AC pipe). The Mokihinui water supply is also damaged by failures within the AC reticulation.

(e) Power Supply

Power supply is lost throughout the whole District. All links into the District lose supply. There is widespread line damage in the Maruia valley.

(f) Telecommunications

Fixed line phones within most of Westport and as far north as Seddonville remain operable (for local calls) but the larger network fails, as does the mobile phone network. The fault rupture cuts the fibre optic cable over Arthur's Pass in four places, and the fibre optic cable to Nelson is also cut in three places due to bridge abutment settlements and road dropout.

4.4 Time zero plus 1 hour

(a) Transport

The situation in the epicentral zone in the Maruia Valley is one of widespread devastation with all roads effectively blocked and most bridges damaged. Traffic movement is occurring in the Reefton – Inangahua area, but is greatly disrupted by road damage and slumping at many bridge abutments. Roads in the Westport area are open with minor disruption where liquefaction or fill settlement has damaged the road. The roads to Denniston, Stockton and Karamea are all blocked by rockfalls.

All road links outside the district are closed. SH6 is extensively damaged outside the district in the Murchison area, and the upper Buller gorge. It is closed by rockfalls in the lower Buller gorge, and on the coast south of Punakaiki. SH7 is blocked by landslide and bridge damage between Springs Junction and Hanmer Springs, and is also closed by damage in the Grey Valley.

All traffic on the railway has been suspended.

(b) Drainage

There is no immediate issue, with priorities elsewhere. The landslide dams are filling, but the impounded water will not approach dam height for some time.

(c) Sewerage

Sewage is ponding in Church Street, Reefton. There are no immediate issues in other areas.

(d) Water supply

The Reefton supply is slowly draining through breaks in the reticulation. A fire has broken out in Reefton, but there is enough pressure in the main to allow water to be sprayed, and there is little risk of the fire spreading.

(e) Power Supply

Power remains off throughout the District. Back up generators at the hospital and Council are working. The Upper Waitaki Hydro stations are all off line following the earthquake, and there is damage throughout the network on the east Coast.

(f) Telecommunications

All the telephone links out of the region and between districts, the mobile network, paging, and Eftpos services are all down.

4.5 Time zero plus 3 hours

(a) Transport

In the Maruia area, there is no traffic movement other than a few of the locals from Hunters Rd and the motels off SH7 moving off their properties to Springs Junction. A bus is trapped between the fault rupture and the Maruia hotel. Two of the passengers are walking to Springs Junction. Elsewhere there is little traffic other than people attempting to return to their homes. The Buller bridge has been officially re-opened for traffic.

(b) Drainage

There is no immediate issue with priorities elsewhere.

(c) Sewerage

There are no immediate issues. The sewers that have broken at the north end of Westport still allow sewage to flow and where pipe joints have failed sewage is draining out of the sewer into the surrounding sandy soils. The blocked sewer outlet off Pakington St caused sewage to bank up within the sewer until there was sufficient pressure for the sewage to force its way out the outlet.

(d) Water supply

All valves on the pipes into the damaged areas of Westport have been closed, leaving about 15% of the town without water. The Carters Beach reticulation has been isolated and the whole township is without water. In Reefton, the valves at the reservoir have been shut to prevent loss of the remaining water (about half full). The whole town is without water. The intakes to the small schemes to the coastal communities are all functioning, but there are some breaks to pipes in the older reticulation, resulting in a loss of pressure in some areas.

(e) Power Supply

No change

(f) Telecommunications

Local networks at Westport and Reefton are functioning, with some small areas inoperative. All other services are not operating.

4.6 Time zero plus 9 hours

(a) Transport

It is now dark. The roads to Charleston and Seddonville have been checked by a Westroads employee, and are negotiable, although many damaged areas restrict speed. The roads between SH7 and Karamea, Stockton and Denniston remain closed, as does the Buller Gorge. Four wheel drive vehicles have traversed the road between Reefton and Inangahua, but with difficulty. Slips still block SH7 4km west and 1km east of Reefton.

(b) Drainage

There is no immediate issue, with priorities elsewhere.

(c) Sewerage

Sewage is ponding in Church Street, Reefton. There are no immediate issues in other areas.

(d) Water supply

A standpipe has been installed at the end of the main to Carters beach, and a water tanker is supplying water to those areas without supply in Westport. In Reefton, a standpipe has been installed at the east end of Broadway, and residents are able to obtain drinking water.

(e) Power Supply

The whole District is without power except for those facilities with back up generators.

(f) Telecommunications

All cell phone towers are inoperable because of loss of link to national network, but are now without power due to battery depletion.

4.7 Time zero plus 24 hours

(a) Transport

A works crew is clearing SH6 through the Buller Gorge, and is expected to allow four wheel drive access to Inangahua and Reefton by the end of the day. Access to Ikamatua and Greymouth is expected to be open for essential four-wheel drive vehicles within a few hours. SH7 is also expected to be cleared as far as Crushington by the end of the day.

The coastal route to Westport is still closed south of Charleston. It is clear that the Alpine SH links of SH6, 7 and 73 will all be closed for some days (if not weeks). The West Coast is still effectively isolated.

(b) Drainage

There is no immediate issue, with priorities elsewhere. The landslide dam in the Matakitaki overtopped, without any problems downstream.

(c) Sewerage

Workmen in Reefton are attempting to drain the ponded sewage in a low-lying area in Church Street. No change in other areas.

(d) Water supply

Repairs are in hand in Westport and Carters Beach. In Reefton, the pipes between the pump station and the reservoir are being checked to allow the reservoir to be refilled as soon as power is restored. The small water schemes at Waimangaroa and Ngakawau are affected by turbidity from slips and disturbance in the catchments. The normal foot access into the gravity operated headworks is more difficult but possible.

(e) Power Supply

The Transpower system is still down and no power is reaching the district. Repairs to distribution lines within the district are happening, but are constrained in part by road damage restricting access.

(f) Telecommunications

A team of cable specialists has arrived from Wellington to start repairing breaks in the fibre optic cables.

4.8 Time zero plus 48 hours

(a) Transport

Clearing of roads continues. The coastal road to Greymouth has been reopened to light vehicles, but traffic is confined to single lanes in many places. SH7 to Greymouth and SH6 through the Lower Buller Gorge are both open. The road to Karamea is expected to be re-opened within two days, and mining plant has cleared the roads to Stockton and Denniston. Roads out of the West Coast remain closed. No work has started on the railways as the extent of damage and options for reinstatement of the whole network are still being assessed. The airport and port at Westport are functioning with little disruption.

Fuel supplies are of concern, and are available to essential vehicles and plant only.

(b) Drainage

The landslide dam in the upper Maruia has overtopped, but only limited scour of the dam occurred and no significant flood resulted downstream.

(c) Sewerage

The failure of the sewer in at the north end of Westport and at the Pakington St outlet continue to go unnoticed as there is no surcharging and because Council are busy attending to more obvious needs. The ponded sewage in Reefton has been drained away and workmen have sanitised the area by sprinkling hydrated lime. In other areas no change.

(d) Water supply

Repairs are continuing in Westport and Carters Beach. In Reefton, the pumps are feeding into a greatly reduced system centred on the Broadway as far west as Kelly St. Repairs are in hand to reconnect supply to the hospital. The water from the intake well is turbid.

(e) Power Supply

Transpower has reinstated supply from the north. The coastal area (Charlestown to Seddonville) , Inangahua and Reefton are now all on reduced power. The Maruia valley remains without power.

(f) Telecommunications

The microwave towers on Mt Rochfort and Reefton have had the alignments corrected, a fault on the fibre optic cable in the Grey Valley is repaired and telephone communication is re-established between Westport, Greymouth and Hokitika. Springs Junction and Karamea are without telephone links. Mobile phones and Eftpos are still down as the fibre optic link to the national network is still cut.

4.9 Time zero plus 1 week

(a) Transport

Strong aftershocks on day 3 delayed road repair work by bringing down more landslides and damaging temporary repairs to some bridge abutments.

The first transport from Nelson reached Westport and Reefton on day 6 after the earthquake. Supplies of food and fuel were among the first deliveries. SH7 over the Lewis Pass remains closed, but a repair team is at work erecting a temporary bridge in the Waiau Valley west of Hanmer. SH7 between Reefton and Springs Junction has been cleared for essential four-wheel drive vehicles, and limited access is also possible to Maruia. Most of the residents of the Maruia Valley have been evacuated to Westport. No reinstatement has been attempted on the district roads in the Maruia area and many of the back roads in the Ikamatua - Inangahua area remain obstructed. All roads north of Westport are negotiable, although great care is needed in places and the roads are reduced to single lane in many places. Some plant and manpower has been sent to assist recovery work in Grey and Westland Districts.

(b) Drainage

No change.

(c) Sewerage

The Westport sewerage scheme is functioning adequately. The Reefton sewerage scheme is out of operation as workmen have established that a significant length of the trunk main to the ponds collapsed in the earthquake. All residents are being advised on setting up pit latrines in their back yards.

(d) Water supply

Reefton water supply is reinstated to 40% of the town area. Turbidity continues to be a problem as the quake disrupted the soils around the gallery releasing fine material. However, with pumping the turbidity is quickly reducing in severity. Sixty percent of Carters Beach is now supplied, and there are only a few isolated pockets in Westport without supply.

(e) Telecommunications

The fibre optic link to Nelson through Springs Junction has just been repaired by day seven. This allowed landline communication to outside the West Coast for the first time since the earthquake. Mobile phones and Eftpos are expected to be operable again in Westport, Greymouth and Hokitika within 24 hours.

4.10 Time zero plus 2 weeks

(a) Transport

Rain during the second week triggered a number of slips within earthquake weakened ground, particularly on the Karamea Road and east of Reefton. Access to the Maruia Valley is restricted to essential services only.

(b) Drainage

Intermittent heavy rain during the second week caused all the rivers in the District to rise. The landslide dam on the Glenroy River breached on day 12. The resulting flood wave caused flooding in Matakitaki outside the district, but was largely dissipated by the time it reached Inangahua on the Buller River. River levels did not rise enough to cause problems with the damaged stop banks in Karamea.

(c) Sewerage

Heavy rain during the second week brought the failure of the Pakington St outlet to the attention of Council. Surcharging occurred in low lying areas of Pakington St because of the added strom water flow and blocked outlet. A gang of workmen was quickly taken off other work to un-block the outlet and pumps were brought in to dispose the ponding storm water contaminated with sewage.

The rain has exacerbated the effects of the sewer damage in Reefton, with ponding occurring again in the Church Street area.

(d) Water supply

Repairs to the water supply systems are continuing. Some repairs in Carters Beach and Westport cannot be made because the fittings necessary have all been used, and replacements are not immediately available from outside the district due to demand from throughout the South Island. Reefton water is now reinstated to 70% of the town.

(f) Telecommunications

Slips cut the fibre optic link to Nelson for 3 days before access and another repair kit brought into the area allowed repair.

4.11 Time zero plus 1 month

(a) Transport

The roading network within the District is largely functional again, although there are many areas with metalled surface, one way sections and weight and speed limitations on bridges.

SH6 between Inangahua and Murchison was reopened three weeks after the earthquake. The Lewis pass route was reopened 16 days after the earthquake to essential traffic only. The problems of landslide damage are now added to by aggradation in the Maruia River resulting in flooding and debris across the road in several places downstream of the Maruia Hotel. The Arthur's Pass route remains closed between Turawhati, Inchbonnie and Arthur's Pass, with no immediate plans of repairing this length due to other priorities for resources. SH6 through South Westland is being repaired, but it will be several months before the whole route through to Wanaka will be reopened.

The railway network remains completely closed. No repair work has been attempted and it is uncertain as to whether the railway will be repaired, because of the extent of damage on the Midland Line between Moana and Springfield. Damage is also widespread west of Moana, but repair of these lines is only likely to happen if the Midland link is restored. The local line between Hokitika and Ngakawau could be used for transport within the region and between the ports, but CDEM has decided to concentrate resources on the road system, because of the greater versatility of the road network.

(b) Drainage

It has already become apparent that aggradation of the rivers draining the alpine areas is occurring. In the most affected epicentral area in the Upper Grey and upper Maruia catchments, virtually all the local catchments are choked with landslide debris. During heavy rain, debris flows and the streams carry material onto the outwash fans and the lower stream channels have become unstable and are changing course with virtually every fresh. Palmers Road, badly damaged by the earthquake, is being covered by debris at most of the stream crossings.

(c) Sewerage

The blocked Pakington Street sewer outlet has been cleared in Westport. Council is trying to organise a CCTV inspection of the sewer in the north end of town to assess the sewer pipes.

The Reefton sewerage scheme is still not operating. However, the Australian Government has supplied new 900mm pipes as part of a relief package and the pipes have been brought in by barge to the Port of Westport. The Council is organising emergency labour to install the pipes.

(d) Water supply

Repairs to the water supply systems are continuing, with water reinstated to 90% of Reefton and all of Westport and Carters Beach.

(f) Telecommunications

Telecommunications are back to normal for 95% of the district.

4.12 Time zero plus 1 year

(a) Transport

The roading network is essentially back to pre-earthquake condition, but with many speed and weight restrictions in place within the MM VIII and IX zones. The Council bridge across the Maruia remains closed as does Woolley Creek bridge, awaiting resources for repair. Palmers Road also remains closed with no immediate plans for reinstatement. SH7 between the Calf paddock and Maruia Hotel is frequently cut by flooding and debris from the aggraded Maruia River. Plans are being formulated for a combination of stop banks and relocation to secure this length of road.

The railway was re-opened ten months after the earthquake, with Government funding for its reconstruction, to re-establish a means for the bulk export of coal. Prior to this, coal has been transported by road to the ports for export by barge.

(b) Drainage

Problems with aggradation are ongoing in the upper Grey and upper Maruia areas. This has caused little direct impact to infrastructure, other than Palmers Road, which remains closed, and to SH7 east of Springs Junction.

The stop banks at Karamea and in the Westport area damaged by liquefaction have been repaired, before any major floods and no consequential damage has resulted.

(c) Sewerage

Council have had the pipe network assessed using CCTV in areas Westport most prone to surcharging. Some repairs have been made to improve the situation and a contract was set up to replace lengths of sewer where major failure had occurred. The remainder of the Westport sewer is being progressively assessed using CCTV.

The Reefton sewerage scheme became partially operational after approximately 6 weeks. Much of the remaining reinforced concrete pipes were damaged by the quake. The Council had the whole reticulation assessed using CCTV and is arranging contracts to replace the badly damaged sections of pipeline.

(d) Water supply

The water supplies have returned to normal operation

5 ALPINE FAULT EARTHQUAKE SCENARIO –EFFECT ON INDIVIDUALS

In order to ensure the fullest understanding of the community's needs and the interactions between them, we next consider four hypothetical individuals and the details of what might be happening to them as time passes following the earthquake. The four individuals are a Hokitika businessman, a Kokatahi farme, a tourist in Franz Josef and a Hokitika resident. They have been chosen to be in the Westland District rather than Buller for no other reason than that Westland suffers the most damage in the earthquake scenario and so represents the worst case. The impact on the individuals could equally apply to people in Buller District were a large earthquake like the Buller or Inangahua earthquakes to occur in the Buller District today.

Although the four individuals are made up the events presented in the stories are quite plausible. Through identifying the needs, priorities for re-instating lifelines can be established and appropriate emergency levels of service defined along with time periods for return to normal service. Finally the stories look at wider needs than those directly linked to lifeline assets and so touch on leadership, counselling, insurance, income etc. These are important needs so must be addressed by Council in its overall planning and prioritisation. Some of these needs may also require the support of lifelines to be effective.

5.1 Hokitika Businessman

John lives in Hokitika. He is a businessman, owning an adventure tourism business with his head office in Hokitika and branches in Westport and Franz Josef. He has about 40 staff ranging from experienced guides to receptionists. Each branch has a building centred round a reception/booking area. It also contains a café and souvenir shop.

At the time of the earthquake, John was at the Hokitika premises upstairs sorting out some accounts. The receptionist had called in to say she was sick and couldn't come into work. The café manager, Jan, was working in the café and a driver, Bill, had come in to set up the four-wheel drive vehicles for the afternoon trips. Jan, Bill and John all live in Hokitika. Jan is married but does not yet have children. John has two children at the local primary school while Bill's children have grown up and moved away from the West Coast. It was mid morning. There were no customers in the shop at the time although there were two adventure tours booked for that afternoon and two of John's small buses would be arriving around lunchtime with clients.

5.1.1 First three days

When the earthquake hit, John's first thoughts were for his family. John had dived under the desk when the earthquake began. The office and computer equipment were now strewn all over the place. Some of the ceiling tiles and light fittings had come down. It was rather a struggle to open the door to get out. Downstairs the cafeteria was a mess, with broken crockery and glassware scattered around. The souvenir shop had its contents strewn over the floor and anything breakable was broken. Although the plate glass shop front window had shattered, structurally the building seemed to be mostly undamaged.

Jan was on the floor in some pain. She looked a mess as she was covered in blood from cuts caused by the flying glass and being knocked to the floor by a glass cabinet, which had hit her. Bill came in from outside. Bill took one look at Jan, rushed back outside, and brought back a first aid kit from one of the vehicles. Bill had up-to-date first aid training and immediately attended to Jan's cuts. John hurried over to help Bill with Jan. He went to fetch water but there was no water in the cold tap. However the hot water cylinder had been secured for an earthquake and John was able to get water from the hot water tap.

John left Bill to attend to Jan and considered what to do. He wanted to find out about his family. His children were at school and his wife at home. John tried to contact his wife with his cell phone but couldn't get through. He tried on the landline but there was no dial tone. He tried to send a text message to his wife but got a "message not sent" response. John looked up again now feeling overwhelmed at the devastation in front of him and wondering what his other premises on the West Coast were looking like. Were his other staff alright, was his wife all right and were his children all right ……

Bill had cleaned up Jan as best he could and she was looking much better. They agreed that Bill would take Jan home in one of the four-wheel drive vehicles and then go to his own home.

John could not drive all the way to the school because the road was blocked but got within easy walking distance. He got out of the vehicle and joined other worried parents heading in the direction of the school. John found the school was in a state of relative chaos although the children were being organised and were safe. The children displayed a range of responses to the earthquake. A few children were excited as if this experience was an adventure. Others were traumatised. Some of these children were sitting "shell shocked" while others were hysterical and their hysteria was affecting other children. John found his own children. They were very pleased to see him and needed a big long hug before discussing anything with their father. John reassured them before telling the person in charge that he was taking them home. John had briefly considered leaving the children at the school but the children would not let their father leave without them.

John drove them home. The drive was difficult as there was debris on the road and at some locations the road was dangerous and uneven. Some power and telephone poles had fallen or were leaning at acute angles. The house was in a considerable mess, especially the kitchen, and his wife had been hurt by the television. Fortunately it was a minor injury and no bones were broken, but she was shivering and suffering from shock. John helped his wife to the couch where she lay down and the children gathered around to be comforted. After-shocks continued, some quite large. The power and telephone were out, and there was no water supply. However, the house structure was relatively undamaged. Using some of their emergency supplies, John boiled some water on a camp stove for a cup of tea and some Milo for the children. He then set about clearing the kitchen as a matter of urgency so that they could try to put together some sort of meal. First, though, he checked on his elderly neighbour, and talked briefly to others who were outside. Someone had a battery radio, and was able to catch an AM broadcast with the news. Clearly the earthquake was very large and reports of damage were coming in, but no one knew much in the way of detail, and there was no reported news from much of the West Coast. They did find out the earthquake had measured 8 on the Richter scale and the epicentre was near Whitcombe Pass.

John began again to think about the business. His immediate concern was where the two buses were. He began to worry about the welfare of his other staff and also about the state of his other business premises in Westport and Franz Josef, which he was unable to contact.

Heavy rain started. When John left the business earlier he had not thought to collect important documents and records. He decided to go back to get them.

The rain was coming in. He went upstairs to the office. Water had come through the ceiling at one end and had soaked some of the paperwork. He was glad he had backed up his vital booking and financial records. He collected these along with cash takings, cheque books and some important documents, turned off the electricity and the gas then left as there was little more he could do. He was worried about security but decided to leave any action till the next day. He ran into others in the street, and found there had been a number of injuries in the town and some building collapses. They also said that several Civil Defence posts had been established in schools and people without shelter were going to these. Although a Control and Information Centre had been established the overall picture of what was going on and the extent of affected areas was still not clear.

During the next two days, a clearer picture emerged. John was able to contact all his Hokitika staff and get some of them to come in to clear up the mess as much as possible. Three of his guides were able to take the four-wheel drive vehicles and help the rescue efforts attempting to reach families in outlying areas. Although a number of bridges were impassable there were sections where rivers could be forded. Co-ordination of their efforts was initially difficult until the telecom network, which the vehicle radios rely on, was functioning again. The vehicles ferried injured people to an emergency medical aid centre that had been set up in Hokitika. Then once a ford had been established across the

Arahura River the vehicles were also used to take people requiring hospital treatment to Greymouth. The staff managed to salvage some food from the cafeteria, but there was not much there as there was very little stock held on site. Finally, on the third day he was able to contact the manager of the Westport Branch and found that the damage there was much less than at Hokitika. In fact, the Westport Branch was fully functional, though naturally it was not operating as no tourists were coming in.

The two buses that were due in Hokitika at midday on the day of the earthquake had been delayed and in the end had not left Westport. The clients were still in Westport and John's staff were helping them look for some way to get out of the West Coast.

His worries about his Hokitika premises were lessened as the shop front had been boarded up.

John began to turn over ideas of reorienting his business and using its capability in some other direction. He was still intensely worried about his Franz Josef business as there had as yet been no contact. He continued to try to get information on Franz Josef with increasing urgency. By now the picture of the areas affected by the quake were becoming clearer, and he was beginning to think about the future of his business and how long it might be before it could be up and running again. He was particularly worried about the effect of the quake on the tourist industry as it was the mainstay of his income. Mostly, though, his focus was on immediate survival, and providing basic needs for his family like food and warmth. A series of frequent large aftershocks had traumatised his wife and made her desperate to get out of the area.

5.1.2 One month after

One month after the quake, the essential services of water and sewage were operational, and road access over the Alps was re-established for the flow of goods and people. Telephones were working, and the EFTPOS/ATM services vital to John's business were operational. The township of Franz Josef had been virtually abandoned so his business there had closed. The road through to Haast and Wanaka would not be open for some time, so few tourists came through Hokitika. However, a few had begun to travel through Westport, so that part of his business was operating, though still at less than a quarter of the number of people normally expected.

John had gone to the Council to ask about using his business premises and perhaps having them inspected. However, he found the Council staff were very busy. Priorities for inspections had been established and all building inspectors were out looking at the highest priority structures. Council appeared also to be taking on the role of co-ordinating the supply and distribution of tradesmen and building materials to ensure the highest priority structures were repaired first. John left his details with a Council staff member and was told to check back in a week when hopefully Council would be clearer about when they could inspect John's business premises.

John had sat down with his staff and brainstormed what they should do. There was a small but increasing number of visitors coming to look at the devastation caused by the earthquake. John decided to try a new venture of disaster tourism. They began taking more intrepid visitors to see some of the places most devastated by the earthquake as access was now possible for his four wheel drive vehicles.

However, the business still experienced serious cash flow problems and John was forced to dismiss some of his staff. He reduced his staff in Westport by half and Hokitika by two thirds, although half the guides were not originally from the area and decided to leave as soon as they could get out anyway. Those wanting to take significant household effects with them had to put their name on a waiting list. There was a high demand on land transport, the roads to the West Coast were still in a rough state and were closed from time to time because of fresh landslides and/or flooding and debris at aggrading rivers. Two of his staff decided it was time for them to leave home and travel elsewhere as the future outlook in Hokitika seemed bleak. The receptionists and office staff were permanent residents of the area, but were worried about their future and sought support from the temporary disaster relief agency office the Government had established in Greymouth and Hokitika.

The local chamber of commerce was co-ordinating efforts to support local businesses and to encourage them to stay in the area. John managed to obtain a bank loan to tide him over, but the state of his finances was an ongoing worry. While the cost of repairing the physical damage was not high, there was just no cash, and the loss of income, both immediately and a long time into the future was of particular concern. Insurance assessors had visited the premises but had been unable to give answers to his questions although it did appear his premises would be covered under EQC. Though some of his staff were capable handymen, it was not clear if they would be paid if they carried out necessary repairs themselves. There was a shortage of building supplies anyway. In particular there was very little window glass available.

His wife had left the area with their children and was living with her sister in Dunedin.

5.1.3 One year after

A year later, we find that John has relocated his business and his family to Kaikoura.

John has avoided bankruptcy, although it was a close thing. He has shut down his Hokitika and Franz Josef operations, but keeps the Westport Branch going on a break-even basis. The basic problem is that tourist numbers on the West Coast are too few – still only a very small fraction of those coming before the earthquake. He thinks it will take another 2-3 years to get trading back to anything like it was pre earthquake.

5.2 Kokatahi Farmer

Pete lives and works on his diary farm with his wife and their three teenage children. The house is a seventy-year-old weather board structure.

5.2.1 First three days

The earthquake occurred mid morning, just as the family was having morning coffee together. The children were at home for the day as the secondary school teachers were having a teachers-only day. The movements were violent, and everyone and everything were thrown around. The free-standing wood burning stove in the kitchen broke loose. It caught Pete's wife Jane breaking one and burning both her legs. All the contents of the kitchen shelves and cupboards fell out onto the floor and the fridge toppled over. The living room chimney broke off and came through the roof leaving a major hole. Fortunately no one was in the living room at the time. The house itself slewed off its piles at one end, punching holes in the floor and breaking the connection from the water tank, which, in turn, fell off its stand. The house still stood though, despite the damage, and so did the barn and milking shed, though they also leaned out of plumb. There were major slips on the hills behind the farm.

The immediate issue was to attend to Jane and deal with the stove. Pete and his son levered the stove away so that they could pull Jane free and carry her to a bed. Although she was in great pain, they could not attend to her until sparks from the stove and broken flue had been doused with what little water they could find in the wreckage. The fire continued to burn in the stove, but Pete decided that it was safely contained, although it was rapidly filling the house with smoke. It was clear that Jane's injuries were serious, but as the telephone and power lines were dead, it was not possible to call for help. Pete and his daughter dressed her wounds as best they could, and after much difficulty found some painkillers.

There was now time to look at each other and their situation. The house was a shambles with damage throughout, holes in both floor and roof, distorted and twisted. All the floors were strewn with debris, rain was leaking into the living room and smoke from the fires pervaded the air. The devastation seemed so great that they all found it hard to think of what to do or where to start. Pete and the boys walked around the house and immediate farm buildings trying to comprehend the damage. Jane's moans reminded them that action was needed and Pete sent his older son off in the pickup to try to get help and find out what was going on.

Their son got back an hour later. Although he had been able to negotiate several sections of the road that were badly deformed, he had been unable to pass the bridge over the Kokatahi River as it was damaged. He had reached some of the neighbours, and found some were in a worse position. They also worried about the river, as the flow seemed to have reduced significantly. He had also brought back the next door neighbour's wife, who was a trained St Johns ambulance volunteer, to look at Jane.

Pete's next job was to go and check on the animals and farm buildings. The milking season was just starting. About 25% of the cows had calved and these cows were heading towards the cowshed for their afternoon milking. There was no power to drive the milking machines and shed was in disarray anyway. Pete and his younger son arranged for the cows to be put back with their calves. At least that way the cows would continue to produce milk so that when the milking machines could operate again they could continue milk production.

There had been occasional showers and it was getting dark by the time Pete and his son got back from their farm work. The whole family was hungry, so it was decided to check what food was available. The freezer was full and would stay frozen for a day or two, and there was a good stock of flour and vegetables. Cooking was a problem, but they knew they could make a fire outside, and use the barbecue.

They tidied up the master bedroom, moved Jane in and all slept together. They had a sleepless night, with severe aftershocks and damp cold bedding. They really needed to get out of the house. The next morning they decided to take up their neighbours offer to move in with them. Their house had suffered less damage and was still relatively sound.

Jane had to be taken to hospital somehow. Going by road to Hokitika seemed unlikely, so the eldest son was sent off to try to get through on his trail bike, to call for a helicopter and medical aid. There was no battery radio and the family was desperate to hear from the outside world, and to know the extent of the earthquake. And of course the two younger children could not go to school.

Their son reached Hokitika, found the CD controller's location, delivered the message and found out that the quake was very widespread. He was assured that help would be sent as soon as possible, but that helicopter transport was stretched to the limit as many aircraft had been damaged and because the quake had caused a massive demand for helicopters. He was able to get some more pain killers for Jane, though. Unfortunately, he could not get any petrol to take him all the way back. He rode as far as he could, then set off on foot, arriving late in the afternoon. He was able to bring a picture of the extent of the earthquake, though it was confused and with many gaps. The state of the roads over the Alps, for instance, was unknown.

During the second day after the quake, two neighbours ventured up the Kokatahi River to see why it had stopped flowing. However, they found the going impossible due to rockslides and fallen trees and turned back before they were able to reach the point where the river was blocked.

Towards the end of the third day a reaction was setting in. No help had arrived yet. Everyone was tired, hungry, cold, and increasingly grubby. Conditions were cramped in their neighbours house and frustration showed. They were able to get water from a nearby stream, and dug a latrine outside.

Information trickled in, and they counted themselves lucky. Finally, at the end of that day a helicopter arrived and Jane could be evacuated to Hokitika.

What to do? Pete decided to try to send the two youngest children to Christchurch to stay with his brother. Pete and his eldest son continued to live with their neighbour while they worked on the farm and got their own home to a state where they could live in it again.

5.2.2 One month

After contacting the dairy factory, Pete was advised that milk processing had stopped indefinitely due both to damage at the plant and to transportation difficulties. He decided to keep the calves with the cows and allow the cows to dry off naturally. Power and telephone connections had now been restored. Pete and his son had been able to do some house repairs including jacking the house back to level and weatherproofing the roof but they would still need to have the house checked by Council before the house was considered safe. Four wheel drive access was now possible to Hokitika, and he was finally able to buy much-needed groceries and some limited hardware supplies. Jane had been taken to Christchurch and was able to walk with crutches. Physiotherapy was helping, but it would be a while before she would be back to normal. Back at the farm, the cooking was, well, basic.

Physical things were now almost fixed up. About five days after the earthquake the Kokatahi River level rose significantly with some minor flooding and then over the next day or so went down again. The locals assumed the river had been dammed by a major slip and the river had over topped the slip and washed it out. They all hoped that the river level would not rise again.

The house was habitable but required a complete repair and repainting of damaged interior walls. The farm buildings were useable. About 10% of the farm was affected by flooding and debris carried down from landslides on the neighbouring hills. Neighbours had helped each other. Pete now faced two major problems. The first was to do with immediate finance. He had a bank loan, but it was reaching its limit and he needed cash to pay for repairs. The other was his day to day living costs, quite apart from the costs of his wife and children in Christchurch. And there was no income from milking, and neither would there be any till at least the next season when milking could start again. There would be some income from the calves and they were doing well. Of more concern was their longer-term future. Would the dairy factory be up and running next season? Would the factory be able to rollover this year’s supply contracts for next year? He needed sound advice, and a clear picture of what the dairy factory’s plans were and what the Government would be providing in the way of the help they had promised. Some cash, he knew, would be coming from the EQC, and assessors had already been round; but how much and when was not clear. Some community meetings held in Kokatahi by Federated Farmers had led to useful discussion, and the presence of the Mayor of Westland was helpful. The mayor’s regular broadcasts on local radio led to a feeling that something was being done and the long-term future was looking better.

There was still plenty to do, but it was hard.

5.2.3 One year

At the end of a year, Jane was back and so were the two younger children. They were living in two small portable buildings donated by an international organisation. One building was used for kitchen and ablutions and the other for bedrooms. Their home had been demolished and with a pay out from their insurance company builders had started building a new home. Construction was very slow because of the huge demand for tradesmen and materials as the West Coast slowly rebuilt.

The dairy factory had an agreement with Pete to take all the milk he could produce that season. The eldest son had left, though, and gone to Australia. Half the businesses in Hokitika had reopened – the important half, as far as Pete was concerned, as the rest were mainly aimed at tourists. But the town did not look good – it looked half-dead, and many people had left. Clearly there was no longer much money around. It was not much fun for the children. They could hardly wait to leave and go on to university as they had planned to do. Jane found it very hard. To add to her troubles she kept having very real and vivid flashbacks to the earthquake. These episodes did not seem to diminish. She went to the doctor and was told it was Post Traumatic Stress Disorder (PTSD). He went on to say that fortunately it was fixable, but that she would need a competent counsellor. One was available, so she signed up for a course of therapy.

5.3 Franz Josef Tourist

5.3.1 First three days

Rudi, a young German tourist, had been walking on some of the Franz Josef tracks the previous day, thoroughly enjoying himself, and was setting out on another track when heavy rain set in. He decided to return to the crowded backpackers' and was swapping stories and information with some of the others when the earthquake hit; it was sudden, it seemed interminable and it was devastating. Everyone was thrown around. Some were hurt by flying furniture, cooking pots, and glass. Two were quite badly scalded, another two probably had broken limbs and one seemed to have a back injury. Rudi himself had minor cuts from broken glass, and a few bruises. Though the blood from his cuts was spectacular, he was not badly hurt and went to the help of some of the others, particularly three pinned down beneath a fallen mezzanine floor. Fortunately the wood stove did not cause a fire, although the stovepipe wrenched a hole in the roof. Most windows were broken, and the rain blew in. It was difficult to move around in the mess. In any case, all the doors had jammed and the building was badly twisted out of shape.

Rudi and a couple of others put their parkas on and went out to find out what was happening. The scene was appalling. The roads were impassable to vehicles. All buildings were damaged, and some had collapsed. They tried to remember where the Park Headquarters was, and went there. A Conservation Officer appeared and told them there had been a major earthquake, but he had no idea of its extent. The group was told to go to the school, and get injured people there if possible. So they went back to their backpackers' and relayed the message. A violent aftershock meant that some left the building in any case with whatever gear they could collect.

Rudi decided to go to the school. He had no food left. Normally he relied on buying whatever food he needed on a day-by-day basis. The school was crowded, with many injured people. His own cuts were minor in comparison. A Council employee seemed to be in charge. There was some food, but very little, so an expedition was sent to the wrecked supermarket to try to salvage what could be found. Others had the same idea. There was a major problem as to how to get the food to the school – sacks pushed on bikes seemed to be the best solution. And still it rained.

Rudi was cold, wet, hungry and thirsty. There was rainwater to drink, but bushes had to suffice for toileting. There was little sleep that night. By the morning he was hungry again, and cold. Rudi was looking forward to hopefully better weather and thinking that his first priority would be to get out of there in whatever way he could. He and his friends desperately wanted information as to what was happening. Rudi realised that his family back in Germany would be anxious, and he desperately wanted to let them know he was safe. Telephones were out of action. He began to pester anyone he could find in authority about this, but with little success. He was heartened, though, by the presence of a sort of control centre where people seemed to know what they were doing. Announcements were coming out as to what to do and where to go. Everyone desperately hoped for a break in the weather so that much-needed medical aid could be flown in by helicopter. And still Rudi's underlying priority was to get out of the area as soon as possible.

By the third day, Rudi was cold, grubby, hungry and very nervous of the aftershocks that still came. An additional worry was a rumour that the river might flood through the town and potentially reach as far as the school and the airport.

5.3.2 One month after

By the end of the month everyone had been evacuated, and the Franz Josef township has been declared a restricted area; off limits to all but authorised personal. Because of continuing after shocks, the serious destruction of buildings and infrastructure and concerns about the rising bed level of the Waiho River that could potentially cause the river to flow through the town, the town is uninhabited except for a security person. No repair work has been carried out and the future of the township is being debated.

Rudi is home in Germany. The earthquake remains a vivid experience to him and he still recounts his adventures frequently. However, the trauma and the chaos that followed the earthquake have coloured his view of New Zealand and he shakes his head when travel to New Zealand is mentioned.

5.3.3 One year after

Rudi is working now and saving for his next trip – this time to South East Asia. He has heard that it is very difficult to go to areas on the West Coast of the South Island south of Hokitika because of on going problems with road access.

5.4 Hokitika Resident

Margaret is 63 and lives in a 30-year old brick veneer house with her husband, Dick. He is retired and a few years older than Margaret.

5.4.1 First three days

When the earthquake hit, Margaret was just about to get the car out and go shopping. Dick was sitting reading the paper. The shaking seemed to go on for ages. In the kitchen, cupboard doors flew open and plates, glasses, jars and bottles flew around. All Margaret could do was hold on to the kitchen sink as best she could, crying and screaming with fright. The fridge shifted halfway across the room. Fortunately Margaret was unhurt apart from a few minor bruises. In the next room Dick was fixated on finding his glasses in the debris on the floor and seemed to be in a state of shock. It was difficult for Margaret to get him outside.

Outside, neighbours gathered in the street. All the houses seemed to be standing, but she could see big diagonal cracks in the brickwork of her own, and the carport had collapsed on to the car. Beyond saying "It's a big one," no one seemed to know what was going on. Margaret ventured back in the house and set about trying to clean up the mess. She was feeling tired and would dearly have loved a cup of tea, but this was impossible. She fairly drove Dick to help, but he was ineffective, needing to be told what to do. By now it was the middle of the day so she made sandwiches with the last remaining bread. There was nothing to drink, so she put out saucepans to catch rainwater. A knock on the door brought a neighbour. The police had asked him to check on all the people on the street and tell them a little news – that the earthquake was very widespread on the Coast and that the roads over the Alps were cut but that they were expecting aid to come over by helicopter shortly. There was food and shelter available at the school. There was no food left in the shops. Margaret felt very relieved. She was very tired indeed but knew she had to do something. There was no edible food in the house and it was cold. She needed to go to the toilet and went behind a bush in the garden as best she could in the rain.

After another big after shock Margaret was frightened the roof would come down so she and Dick got out of the house and began to walk to the school a kilometre away. At least they could get something to eat and a cup of tea. They decided to settle into the school hall for a few days where there was some food and plenty of people to keep them company.

That first night was terrible. It was cold, damp, dark and although there were lots of people around, it was still lonely. The three large aftershocks were also very frightening. Nobody slept much that night. Several of the people tried to console others, but most were pretty scared.

The next day things were both cheerful and grim at the school. Some people told stories while others set out to make the place more habitable. Latrines were dug outside, but they were primitive and open to the rain. There was food but no washing facilities except for hand basins by the latrines. It was cold, and everything was damp. Regular reports came in as to what was happening, though, and several times the Mayor came in and spent time talking to people. It was clear that Hokitika had got off lightly compared with some places. Standpipes were now in service for water, and it seemed that power would be restored to Hokitika in another day or so – though individuals might not get power for a few days more because of damage to street poles. There was a limited supply of tarpaulins and building material to try to patch buildings up temporarily, and many able-bodied people were directed to help. More people were trickling in from outlying areas.

Margaret's worry was the security of her house. She had heard that there was some looting going on and abandoned unsecured homes were a prime target. She and Dick went home with a young person Margaret had met at the school. They gathered up their most valuable small possessions and the young person helped them carry them back to the school.

Margaret longed for decent food. There was no bread, and they had to eat potatoes, pasta and rice, some of it flown in from Australia. Tents were set up in the school grounds. Surprisingly, the old Post Office had survived the earthquake well, and was being used as a food distribution centre. No shops or service stations were operating though.

Margaret felt tired and helpless, and resentful of Dick who lay around all day. She felt grubby and unclean, as there were no opportunities even for a sponge bath, and she had run out of clean clothes. It would have been of great comfort to be able to talk to her sister in Ashburton or her daughter in Auckland, but there was no phone connection out of the area. Still, the Mayor cheered them up with her optimism. She talked with the Methodist minister and at his suggestion she started organising some of the women to help with the cooking and cleaning. At least she was doing something now, and felt better for it.

5.4.2 One month after

They were back in their house, despite the damage. At least it was weatherproof and warm, and water and power were on. In the last week they were able to use the toilet, and the television gave them a link to the outside world. But Hokitika seemed a strange place. The crowds of tourists had disappeared. The car had been repaired and she could use it for shopping – what shopping was possible, for many things were in short supply as the only way by land was through the Lewis Pass of from Nelson, and on both routes, traffic was still restricted. She could buy bread, and unpasteurised milk brought in from a nearby farm. Tinned food was available but all other perishable food was in short supply as it had to come over from Christchurch. Dick was at last showing some energy after help from the doctor, and was pottering around carrying out a few repairs. They discussed whether to move out of the area. Hokitika had been their life, though, and that was where their friends were, so they decided to stay. In fact, it was really surprising the strong community spirit had developed. This was helped by regular meetings at the school hall. Many people had turned their hand to construction because of the extent of damage to buildings and facilities. The insurance assessors had been, and they had been very helpful, giving an assurance of rapid pay out.

One way that Margaret was able to help was with evacuees from South Westland. The whole area had been hit hard, and still people were coming into Hokitika in a state of shock after losing everything and having some terrible experiences. Prefabricated buildings were being brought in, but what the evacuees seemed to need most was hope, and care, and this is what Margaret and her friends tried to give. Many had now gone on to other parts of New Zealand, but a significant number wanted to stay. Fortunately the Government was helping with emergency payments. The Mayor led a programme to establish a “buddy system” where people severely affected by the quake received care and support from volunteer relief agencies that had come into the area as well as members of the Hokitika community.

5.4.3 One year After

Things were getting back to normal for Margaret and Dick. They were busier than they had been for years, organising repairs to their home and helping a charity organisation and a craft co-operative. Everyone seemed spurred on by the Mayor’s slogan, “Westland can Win!” There was a new optimism around.

PART III – Interdependencies & Lifelines

6 INTERDEPENDENCIES – POST EARTHQUAKE

6.1 Individual Needs

The needs of a Hokitika businessman, a Kokatahi dairy farmer, an international tourist at Franz Josef and a Hokitika resident were discussed above in Section 5.

Analysis of the needs of these individuals resulted in thirteen generic needs. These are presented in Table 6.1. The needs may be met by the individuals themselves or by the community. Individuals' means of meeting needs are characterised by independence, and self-sufficiency. For example for sanitary needs individuals can use a shovel and construct a latrine in most locations on the West Coast except perhaps for CBDs. Communities on the other hand often use networks including system and infrastructure networks to meet the needs of individuals more efficiently and effectively. Individual solutions may well be necessary early in the response, but expectations would be that these solutions would be temporary, until such time as the community networks are restored. For instance, for a few days, water supply from rainwater would be acceptable to most individuals, but after that an expectation would be for community supplied water from a standpipe within a convenient distance, and not too long after that a full restoration of piped supply.

Table 6.1: Generic Needs

Need	Means of Meeting Needs	
	By Individual	**Via Community Networks**[1]
Leadership	Leaders	Leaders, protocol, communication
Information in/out	Word of mouth, loudhailer, letters, notices, 1-way radio, 2-way radio	Radio, Telephone, TV, armed forces, notice boards
Rescue/ Medical Aid	Rescues by individuals/groups of people/First Aid	Skilled people, plant/equipment, transport[2], armed forces, shelter, medical station, medical supplies, communication
Security	Security in small groups	CD controller, police, armed forces
Evacuation[3]	Walking, off road vehicles, boats	Transport[2], communications, protocols, triage, welfare centres
Relocation[3]	Walking, off road vehicles	Transport[2], communications, protocols, welfare centres
Psychological support / Counselling	Family & friend support	Support agencies
Insurance & Income	Self-employment, multi-skilled individuals	Employers, Insurance companies, Earthquake Commission
Water	Shallow well, springs, rain water tanks, streams etc	Community water supply, transport[2] to access water supply facilities
Sanitation	Shovel	Facilities at community centres, community centre sanitation protocols, morgues
Shelter	Tents, tarps, mobile homes (vehicles) materials from damaged buildings, undamaged homes, new homes	Community centres, transport[2] to bring in tents, tarps, new homes
Food	Farm & wild animals, local fruit & vegetables	Supply point, transport[2], distribution points
Lighting & Heat (Cooking + Warmth)	Candles, gas cylinders, torch, gensets, wood, coal	Functioning generation plants, functioning grid & distribution system, gensets, functioning fuel distribution systems

1. The "community networks" are defined as infrastructure and systems that may function at a local, regional, national or international level.

2 Transportation includes transport networks and vehicles (boats, cars, aeroplanes, helicopters, trucks etc).

3 Evacuation is defined as an immediate emergency response required because of injury or unliveable conditions e.g. no food, clean water, shelter, security etc. Includes the evacuation of people and where necessary, value items. Relocation is a planned response where the move is required because of employment or education needs and the move happens after a period of considering options.

Based on the hypothetical effects (refer Section 5) of the earthquake on the four individuals, the importance of each of these thirteen needs is explored. The importance of each need is assessed by assigning two grades: one for level of need and one for reliance on community networks. The two numbers are summed for each category of need. The grades used for level of need and reliance on networks are presented in Table 6.2.

Table 6.2: Need & Reliance Grades

Grade	Level of Need	Reliance on Community Networks
0	No need	No reliance
1	Normal every day need	Small reliance
2	High need	Large reliance
3	Very high need	Total reliance

Needs of individuals and their reliance on community networks vary after the earthquake. The importance of all needs is considered for the four individuals for three time intervals after the earthquake; the first three days, the end of the first month and the end of the first year. Two objectives of this assessment are firstly to identify individual needs that will be met predominantly by community networks and secondly to establish priorities. The full assessment is presented in Appendix C and the summary results presented in radar graphs in Figure 6.1. The “importance scores” for each need for the four individuals have been added together and the results presented in Table 6.3. The same results are presented graphically in Figure 6.2. Note that the numerical scores are purely relative and have no meaning by themselves.

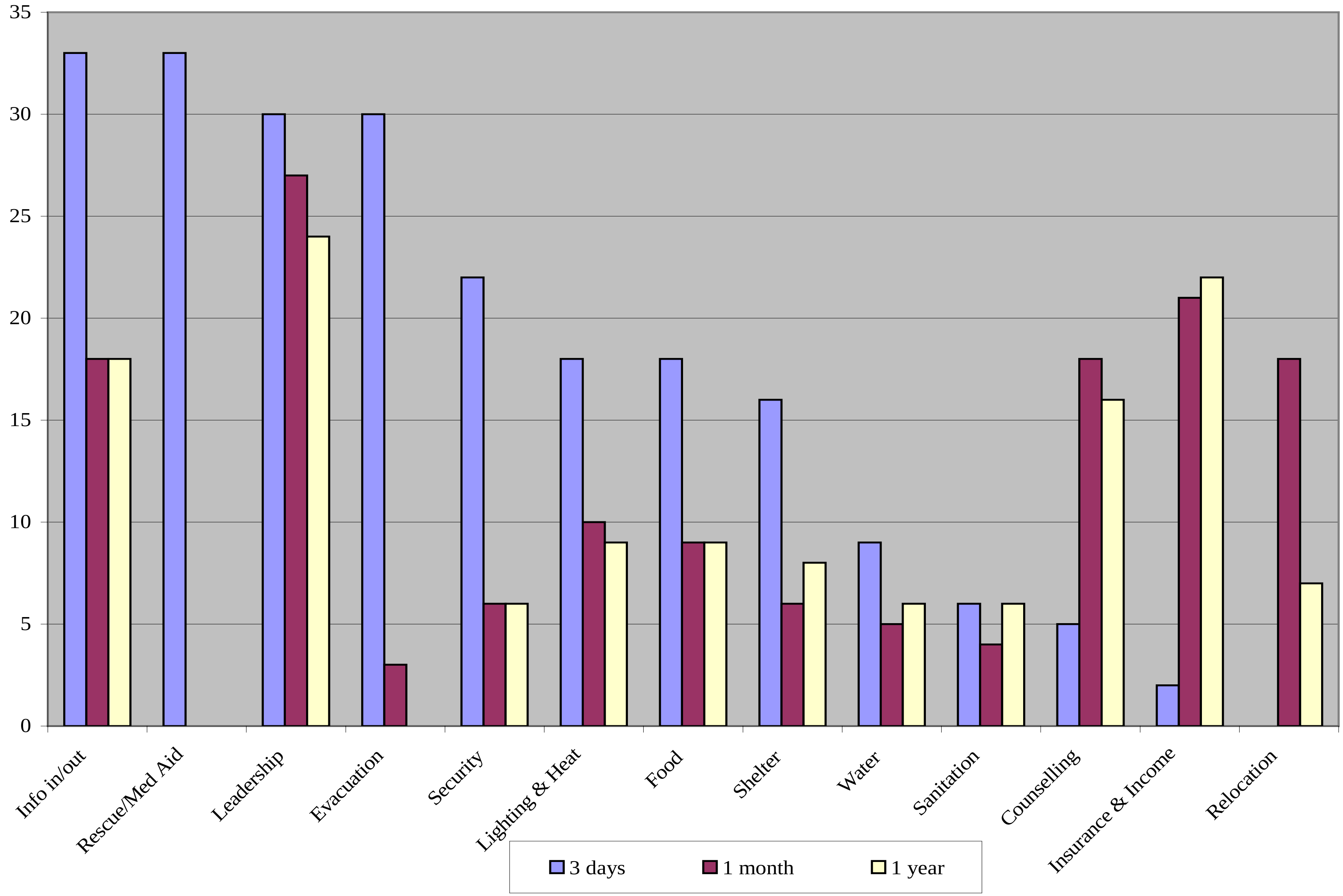
It can be seen in the table and figures that the importance of each need changes depending on the time following the earthquake. The results are discussed in detail in the following sections.

Figure 6.1: Individual Needs – 3 day, 1 month & 1 year

Table 6.3: Priority of Needs

Priority	3 days	Sum	1 month	Sum	1 year	Sum
1	Information in/out	33	Leadership	27	Leadership	24
2	Rescue/Medical Aid	33	Insurance & Income	21	Insurance & Income	22
3	Leadership	30	Information in/out	18	Information in/out	18
4	Evacuation	30	Relocation	18	Counselling	16
5	Security	22	Counselling	18	Lighting & Heat (Cooking + Warmth)	9
6	Lighting & Heat (Cooking + Warmth)	18	Lighting & Heat (Cooking + Warmth)	10	Food	9
7	Food	18	Food	9	Shelter	8
8	Shelter	16	Security	6	Relocation	7
9	Water	9	Shelter	6	Security	6
10	Sanitation	6	Water	5	Water	6
11	Counselling	5	Sanitation	4	Sanitation	6
12	Insurance & Income	2	Evacuation	3	Rescue/Medical Aid	0
13	Relocation	0	Rescue/Medical Aid	0	Evacuation	0

Figure 6.2: Bar Graph of Priority Needs for the Four Individuals



6.1.1 Three Days

From the assessment presented in Figure 6.1, Table 6.1 and Figure 6.2, it can be seen that for the four individuals considered, the dominant needs in the first three days are leadership, information in and out, rescue and medical aid, and evacuation. These are important for the following reasons:

- *Leadership*: Because of the widespread impact of the quake it is almost certain that normal lines of communication will be down or only provide a marginal service. Individuals will be almost totally reliant on leadership to provide responses to address, for example, the wellbeing of isolated and vulnerable people, direct an effective response effort, and to maintain security. Leadership will be required from a local community level through to national and international level. The leadership will be dealing with emergency needs created by the quake as well as co-ordinating a potentially massive assistance response from outside the area and outside New Zealand. Leadership will also be required to keep up morale and provide hope. It is noted that the Kokitahi farmer is the only one of the four individuals who has a lower need for leadership. This is expected because farmers, due to the nature of their work, operate fairly independently;
- *Information:* Information is going to be important particularly for isolated people (the Kokitahi farmer and the Franz Josef tourist) and for those who run networks on the Coast (the businessman along with all infrastructure operators). Everyone will want to know if they have any family or friends that are hurt, how badly they are hurt, and where they are. Network operators will also want to know about the condition of their assets; what is damaged, the extent of damage and the impact of damage on the operation of the network. People in areas badly affected by the quake will want to get information regarding who is hurt and who is not, where help is needed immediately, what is needed etc. Information is likely to be just as critical for residents in the main urban centres such as Hokitika, Greymouth and Westport. However, they are likely to be less reliant on formal information networks (telephone, battery radio, etc) as they will be able to use word of mouth to pass on information from the CD control centre and from those who have a battery radio or a functioning telephone.
- *Rescue and Medical Aid:* It is almost certain there will be injuries and deaths from the earthquake. Some people may be trapped under rubble or under plant. For those living or working near the fault trace, the need for professional rescuers and medical aid will be higher and they are likely to be totally reliant on outside support. Examples are the Hokitika businessman with staff and clients at Franz Josef, the Kokitahi farmer and the Franz Josef tourist. The further from the fault trace the lower the likelihood of injuries, and so the less the need for rescue and medical aid;
- *Evacuation:* As for rescue and medical aid, the group of people with the highest need for evacuation is likely to be those nearest to the fault rupture e.g. Franz Josef and Fox. As well as buildings becoming uninhabitable and people needing to be evacuated because of injuries, it is likely that people will want to leave because of trauma and the ongoing after shocks. Another group of people likely to require evacuation is tourists anywhere on the Coast. For example, for

the late winter (August) period chosen for the scenario, there is likely to be in the order of 1,600[2] tourists on the Coast; there could be as many as 5,600 in the peak of the tourist season (January).

Communication and transport lifeline networks will be critical to allow the needs for leadership, information in and out, rescue, medical aid and evacuation to be met. It is likely that a variety of communication and transportation networks will be required to meet these needs.

Security, lighting and heating, food and shelter are likely to be the next most important needs to be met for the four individuals:

- *Security:* Damage to buildings is likely to make some buildings vulnerable to looting. Security will be required to ensure that finite and limited food supplies are managed equitably until food supplies arrive from outside the earthquake-effected areas. Some people may also take advantage of the situation and loot valuables from damaged and vacant buildings. Security will be important for business operators but will also be important for people who have been forced to abandon their homes because they are uninhabitable;
- *Lighting and Heating:* Lighting and heating is likely to be important and difficult. People living in temporary shelter such as light timber structures (garages), tents etc may have no heating. Equipment for lighting, cooking and heating such as candles, gas camping equipment, gas heaters and barbecue units may not be accessible in badly damaged buildings or may have been damaged in the earthquake. Even where people can stay in their homes, damage such as broken windows and doors that no longer close may make heating difficult. Heating will be particularly important if the earthquake occurs during a cold and/or wet period;
- *Food:* Some households will have access to a reasonable food supply. Food is unlikely to be an issue for those who live away from main centres and buy in a stock of food, say weekly, as part of their normal lifestyle e.g. farming communities, and those who are prepared and have established a food stock for an event such as an earthquake. For others however they may have only limited food either because the earthquake made their food inaccessible or because they only keep a limited amount of food with them anyway, e.g. tourists. These people will rely heavily on others to provide them with food; and
- *Shelter:* The earthquake is likely to make many homes uninhabitable particularly in areas close to the earthquake fault. Those with homes that remain habitable or those with access to alternative shelter e.g. tents, a caravan or a light timber structure such as a garage, may be able to make their own shelter arrangements. Those with homes that are uninhabitable will depend on others to provide shelter.

[2] Statistics New Zealand website.

Again transport networks are important to allow food to be brought in and evacuation of those who do not have shelter. The power supply network along with other energy sources such as gas will be required to provide lighting and heating.

Water and sanitation are less likely to be critical. Water is relatively abundant on the West Coast and it is likely that water can be obtained, although it may need boiling before it can be consumed. The exception may be urban areas where there are less natural water sources and any there are are more likely to be contaminated. Toilets are unlikely to function. However, except in business districts, people can make alternative arrangements such as digging a hole at a private location or going behind some bushes.

Counselling, insurance and income, and relocation are unlikely to be important in the first three days.

6.1.2 End of First Month

By the end of the first month the priority ranking of needs has changed. The Franz Josef tourist has gone home and no longer has any needs to be met by the West Coast community. *Leadership* and *information* have remained important while *insurance and income* along with *relocation* and *counselling* have become important:

- *Leadership:* Leadership remains important to provide direction and support as the recovery phase gets fully underway;
- *Information in/out:* Information required in the first three days focused on what has happened and the status of friends and family. After one month, information about how recovery is to be achieved and where to go to get guidance, counselling and support as well as banking needs (ATMs) have now become more important;
- *Insurance and income:* People will have been able to assess their situation. They will be making insurance claims and may be worried about income, as it is almost certain that the earthquake has affected their place of work. People will be considering their income options. There may be no market for businesses that depend on tourism. There may be a huge demand for freight transport (e.g. building materials) once sufficient roads are open to allow freight to be transported. In the short to medium term there is also likely to be huge demand for tradesmen and labourers;
- *Relocation:* Where some or all services such as power, telecommunications, water, sewerage, banking, schools etc are likely to be unavailable for months, people may chose to relocate to another area or at least relocate their family until conditions improve; and
- *Counselling:* People are likely to need counselling to deal with stress due to loss of family members or friends, or just due to the level of devastation as well as on how to re-establish and get on with life. Those that are to provide the counselling services will require normal basic services

(accommodation, power, telecommunications, water, sewerage, food supply) to be able to carry out their tasks effectively;

All the above needs (*Leadership*, *information*, *insurance and income*, *relocation* and *counselling*) will require communication and transport networks. As the region moves out of the response phase and into the recovery phase, more and more of the other service networks such as water and sewerage will be required. Transport networks will be particularly important for:

- Moving people and goods in (food, spare parts, building materials etc) and out (people moving out of the area with their household goods) of the region; and
- Accessing other networks (water, sewerage, power, telecommunication etc).

The next most important needs by the end of one month are *lighting and heating*, *food*, *security*, *shelter*, *water* and *sanitation*:

- *Lighting and Heating:* There is likely to be a normal need for lighting and heating and for most, there will be an increased reliance on outside sources of energy such as the national grid, gas, diesel etc. In some instances generators may be used to provide more reliable power until the electricity networks are fully functioning again;
- *Food:* Although some people may have access to some foods e.g. the farming communities and some home gardeners, these are unlikely to provide a complete diet; flour, bread, eggs, meat, potatoes are unlikely to all be available locally. The demand for food is likely to increase rapidly as private supplies are used up. There will be an increasing reliance on supply networks to bring food into the West Coast communities;
- *Security:* Security is likely to have improved. Damaged and vacant buildings will probably have been made secure or valuable items removed. With some form of normality returning to many communities, security will be less of a problem;
- *Shelter*: In areas close to the earthquake fault where damage is serious but communities have largely remained (Reefton, Moana, Ross etc) it is likely that many people may still be in community shelters although some will have repaired their homes sufficiently adequately to return. Further from the fault there will be less damage and less repairs required for shelter;
- *Water and Sanitation*: As people try to return to a normal life there will be an increasing need to have normal water supply and sanitation facilities to allow people to cook, obtain drinking water, wash and toilet. However it is likely that standpipe supplies and long-drop toilets will be the norm in many areas for some time. A higher level of service is likely to be required for:
  - The business districts so that viable businesses e.g. retail outlets can return to business as quickly as possible;
  - Mass accommodation for people whose homes are uninhabitable but who want to remain in the area; and
  - Offices required for recovery services such as EQC, insurance companies, social services etc.

The *rescue* and *emergency medical aid* phase is well over and the only *evacuation* remaining is the evacuation of valuables from areas that are uninhabitable for the time being e.g. Franz Josef. This may include retrieving valuable items from abandoned shops, money (automatic teller machines), etc.

To encourage people to remain in the district, services need to be re-established as quickly as possible. At the very least, an emergency level of service is required that is acceptable both in terms of the level of service and the length of time until a normal level of service can be re-established. Where relocation is the preferred option, communication networks will be required for planning and affordable transport networks will be required.

6.1.3 End of First Year

For our three remaining individuals, need priorities have not changed significantly since the end of the first month. *Leadership*, *information*, *insurance and income* and *counselling* remain important while relocation is the only need that has dropped in importance.

- *Leadership*: Recovery is underway. Leadership is required to sustain a fast recovery and recovery is likely to take a number of years;
- *Information in/out:* By now people will expect a normal level of information service. Communication traffic is likely to be greater than normal, both because of families being split with part being relocated, and also because those on the Coast will be actively seeking information on how they can re-establish viable work/business;
- *Insurance and income:* Many people will still be in the process of re-establishing themselves and their work/business. They will require insurance payments to replace what is damaged and an income stream to keep them going until their work/business is profitable again; and
- *Counselling:* Many people will be severely affected by the earthquake event and require counselling. Ongoing advice will also be required for those who remain to re-establish their work/business or set up a new business.

The remaining needs of *lighting and heating*, *food*, *security*, *shelter*, *water* and *sanitation* as well as services such as schools, banks, shops etc are all required to re-establish a normal life. Families can only relocate back to any area affected by the earthquake when these are in place.

6.1.4 Summary

For our four individuals *leadership* and *information* remained the highest priority needs throughout the first year. *Rescue*, *medical aid* and *evacuation* were important in the first three days, and possibly longer than this. However, by the end of the first month they had been replaced by *insurance and income*, *counselling,* and *relocation*. *Insurance and income* and *counselling* still remain important at the end of the first year.

Communities will be cut off, separated by loss of transport routes and effectively isolated. There is a need for a depth of resourcefulness in individual communities to provide leadership, co-ordination of efforts, rescue and first aid. These isolated communities will need to manage almost on their own for some time (probably much longer than just three days) without any significant outside assistance.

The importance of basic needs such as *lighting and heating*, *food, shelter, security*, *water* and *sanitation* although varying a little, remained relatively consistent throughout the first year. This constant and medium importance of these needs, rather than a significant increase in importance as occurs with *leadership* and *information,* is attributed to the availability of alternatives and the ability of the West Coast community to adapt to using them. Water can be obtained from alternative sources and a simple long drop can be dug in the back for toilet needs. Food is, however, always at the top of this group of needs because of the limited number of alternative complete food sources, and results in a high reliance on transport networks to bring food in.

Based on the needs assessment presented in this section the order of priority for getting infrastructure functioning again is as follows:

- Transport, including roads, airports, harbours, river transport and rail;
- Communication including telecommunication (land lines and cellular network), one way and two way radios, local radio station, etc;
- Power supply,
- Water supply,
- Sanitation, and
- Storm water.

6.2 Council Responsibilities and Priorities

The analysis of the previous section establishes sets of needs together with their relative importance. This is helpful in establishing priorities. However, the analysis considers each need in isolation. It does not take into account the interdependencies between them.

The interdependencies can be dealt with in general terms by developing a dependency diagram connecting the needs of individuals (as in the previous section) with the lifelines available to meet these needs. The number of links to the nodes of the diagram give some idea as to the relative importance of the nodes.

A dependency diagram for the response and recovery periods of the Alpine Fault earthquake is shown in Figure 6.3. The convention used is that the need/lifeline at the head of the arrow is dependent on the need/lifeline at its tail.

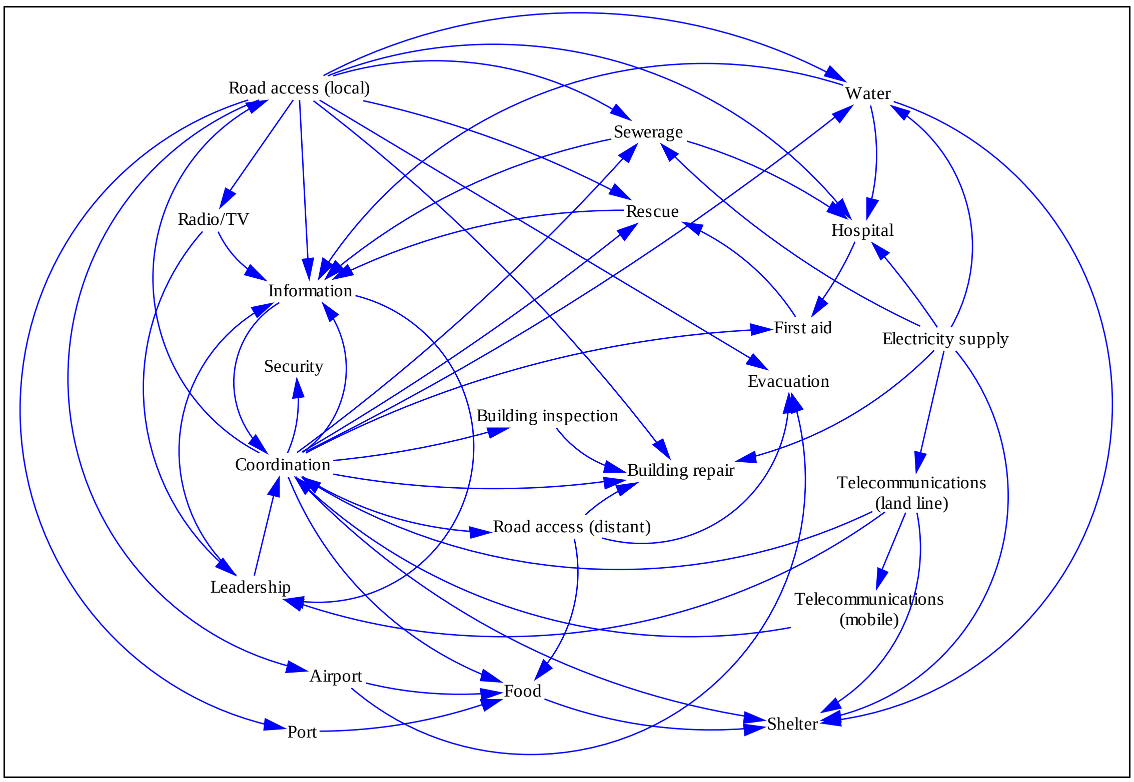


Figure 6.3: Dependency Assessment

Generally, the more links to any node in the diagram, the greater its importance. The two most highly linked nodes in the diagram are *Co-ordination* (pre-eminently) and *Information*. But this does not give the whole picture, for *Leadership* actually contributes to all activity, and these contributing links are not shown in the diagram. The next most important need, beyond these three, is *Local road access*. What is missing are the mechanisms by which the necessary information flow for *Co-ordination* is gathered and sent out and also the relative importance as some links will be more important than others.

A working radio station for example is a very important requirement for *Leadership*, as also is the leader's requirement for information.

In system terms, any management activity requires the three elements of *decision*, *implementation* and *monitoring*. For example, it may be decided to repair a bridge as the next priority. It is important that when the work is carried out, the controllers monitor the situation to get feedback on the progress of the work, particularly its completion. The diagram (Figure 6.3) does not show how decision, implementation and monitoring are to be achieved. This needs to be considered by the Councils and other lifeline providers beforehand.

After the Alpine Fault earthquake there will be a high need for *building inspection* and *building repair*. Many buildings and structures, including lifeline structures, will be damaged and need to be assessed to determine whether they are safe to use again. Some structures will need to be assessed by structural engineers, and for others and at different times, building inspectors will be involved. Buildings will need to be repaired or replaced which will require building materials and skilled workers. Building inspections, prioritising and allocating building materials and skilled workers may be a Council responsibility, at least initially.

Management and resource needs of the Council are not discussed in any more detail. However this preliminary assessment has highlighted a few areas where input from Council is likely to be required.

Based on the simple dependency assessment presented in Figure 6.3 and only considering the dependence of others on a particular lifeline i.e. the number of arrow tails leaving a lifeline, the priority for re-establishing lifelines from the Councils' perspective is as follows:

- Transportation – primarily local roads but also national roads, airports and ports,
- Electricity supply,
- Telecommunications,
- Water supply, and
- Sewerage

6.3 Community Importance

The level of importance of townships and villages (centres) as community centres after the Alpine Fault earthquake can be established based on:

- The number of people living in the centre, and
- How much the centre functions as a service centre for people living around that centre.

West Coast townships have been allocated an importance category as shown in Table 6.4, where 4 represents highest importance.

Table 6.4: Township Importance Categories

Type	Category	BDC	GDC	WDC
Regional/ District Centres	4	Westport	Greymouth[1]	Hokitika
Sub-District Centres	3	Reefton	Runanga Dobson	Ross
Local area centres	2	Karamea Inangahua Hector – Granity[2] Waimangaroa Ngahawai	Moana, Ahaura Blackball Gladstone Camerons Taylorville	Kumara Kaniere Harihari Whataroa Franz Josef Fox Glacier Haast
Local Community centres	1	Punakaiki Little Wanganui Mokihinui Seddonville Denniston Millerton Charleston Ikamatua	Rapahoe Barrytown Nelson Creek Kopara – Haupiri Ngahere Stillwater Gladstone Iveagh Bay Rotomanu	Otira Arahura Rimu Kokatahi Kowhitirangi Ruatapu Okarito Jacob’s River Okuru Hannahs Clearing Neil’s Beach Jacksons Bay

1. Includes all communities between Cobden and Paroa
2. Includes urban area of Granity – Ngakawau - Hector

Based on the categories defined in Table 6.4, emergency levels of service have been established for each lifeline and these are used to identify vulnerabilities and to determine improvements.

7 TRANSPORTATION

7.1 Overview

7.1.1 Buller District Transport systems

The Buller district is served by the following transport systems:

- State Highway network, of which the major routes are:
  - SH6 from Murchison via the Buller Gorges to Westport,
  - SH6 from Westport to Greymouth via the coast,
  - SH7 which links Reefton and Springs Junction with Greymouth to the south and Christchurch over the Lewis Pass,
  - SH65 from Springs Junction to Murchison,
  - SH 69 from Reefton to Inangahua, and
  - SH 67 from Westport to Mokihinui.
- District roads, which are mostly no-exit roads to serve local communities, with no or little interconnectedness except through the State Highway system including the road from the end of SH 67 to Karamea;
- Railway, with lines from Ngakawau through Westport and Reefton to link at Stillwater with the Midland line and through the Otira Tunnel to Canterbury;
- Regular airline flights into Westport airport, and a small airfield at Karamea; and
- River mouth harbour at Westport, servicing fishing boats and bulk export ships and barges.

7.1.2 Role of Transport on the West Coast

The West Coast is heavily reliant on transport for survival.

- Most food and essential supplies are processed out of the region and are brought in on an almost daily basis by road.
- There is minimal fuel storage in the area.
- A large component of the economy is export of bulk products reliant on transport, including cement and coal from Westport by road and rail.
- Transport is central to tourism.

While transport disruption of a few days has little effect on bulk exports, it can have a significant effect on daily supplies and tourism. Thus, while the centralisation of food and basic commodity production and storage to Christchurch may have made some economic savings, it has also made the West Coast much more vulnerable to transport system disruption. Supermarkets for instance usually only have a few days' supply of high turnover goods and rely heavy on refrigeration for food preservation. Some time ago the only bulk fuel tank farm on the West Coast at Karoro was decommissioned resulting in the only fuel storage being that held in service station underground tanks, with limited overall supply.

In the event of a major Alpine Fault seismic event the West Coast may have to be heavily reliant on the stores of food, equipment, spares and other items held in the area for survival and recovery until transport links are restored and such stock becomes available. It is important to keep in mind that other areas are also likely to be significantly affected and there may be a shortage of food and supplies over much of the South Island, as well as means of transport.

For the above reasons, it is important that mitigating potential disruption to the transport system be given careful consideration.

7.1.3 Transport Situation Following an Alpine Fault Earthquake

As explained in the previous sections, the following situation is likely to occur after an earthquake on the Alpine Fault:

- The West Coast road network is extensively damaged over the length of the region from Haast to Springs Junction, close to the fault line. In particular, South Westland can be expected to be cut into a series of isolated areas by landslides and by destruction of major bridges, and the three mountain pass routes will suffer extensive landslide and bridge damage. In addition, catchments in the vicinity of the Alpine Fault are expected to experience significant aggradation and debris flow events in streams and rivers, which will threaten many bridge sites for some years. Damage will be severe enough to make road reinstatement take weeks or months in and close to the mountains, with high long-term maintenance requirements at bridge sites and to clear slips from destabilised slopes;
- Road damage away from the fault line will be progressively less with increase in distance, and the coastal area of Buller will be little affected;
- The airports at Hokitika and Westport should remain operable;
- The Westport harbour is expected to remain fully functional; and
- The Midland railway will suffer great damage between Moana and south of Arthur's Pass. The lines west of Moana will be damaged to a lesser degree, but such that all train services would be stopped. However, ONTRACK have assured us that in general it is quicker to reinstate railways than roads. It would depend on the situation, but it is possible that a rail link across Arthur's Pass

could be restored relatively quickly and this might have significant implications in the restoration period.

7.1.4 Key Principles for Reinstatement of Transport

The key principles for re-establishing transport links after an Alpine Fault earthquake such as that described in Section 4 are as follows. To begin with, the initial priorities for providing transport will be for:

- Access to critical emergency management co-ordination centres;
- Search and rescue and evacuation of injured people;
- Assessing the impact of the earthquake on the District e.g. damage to infrastructure such as bridges and roads, potential hazards such as landslide dams, etc
- Access to repair critical communication infrastructure;
- Access to civil defence community centres and between communities, starting with communities of highest population;
- Access to power infrastructure;
- Access to sites that will require drainage because they have potential to pond sewage/storm water;
- Access to water supply assets to set up emergency water supplies;
- Access to outside the district to establish transport routes for supplies;
- Immediate post earthquake needs of co-ordination, rescue and evacuation and, for transport of initial supplies into the district with the airports being of highest priority.

The order here is arbitrary and not in any order of priority. Helicopters may play a key role in transport reinstatement, in identifying damage with the aid of video cameras and GPS locations.

The road network is the prime transportation system in terms of people and general freight movement as well as access to all parts of the region. Air transport is significant, and will play a crucial role during the emergency phase of the earthquake response. Boat access up rivers may be important during the response period. The Westport port will be important for importing supplies. Depending on the nature of the damage, the rail link to Canterbury might assume significant importance.

7.1.5 Possible Regional and District Transport Strategies

The following strategies are suggested.

The road link into the West Coast that is least likely to suffer extensive damage in an Alpine Fault earthquake is SH6 from Nelson. Plots of peak ground acceleration and spectral accelerations prepared by IGNS (Stirling et al, 2000) show that this route has the lower predicted accelerations from all earthquake sources, not just the Alpine Fault. While the route is exposed to significant risk from earthquakes other than the Alpine Fault, as experienced in 1929 and 1968, east of Murchison the topography is less hazardous than the alpine pass routes, and west of Murchison there is some redundancy with alternative routes. In the event of an Alpine Fault earthquake, this route is likely to be the one that can be re-established in the shortest time. It is therefore suggested that this route be screened for specific vulnerabilities and given priority for works that might reduce its risk to damage, such as seismic strengthening of bridges.

The higher, steeper and more rugged nature of the Arthur's Pass route, the known history of large rock avalanches and the greater predicted rupture on the closest section of fault suggest that SH73 is likely to be more significantly damaged than SH7 over the Lewis Pass. Again it would seem sensible to place a greater priority on seismically upgrading the Lewis Pass route in preference to SH 73. SH6 is likely to be so damaged that access from South Westland over Haast Pass to Otago will cease for many months.

As the Westport airport is likely to be a major transport link after an Alpine Fault earthquake, facilities and equipment here should be secured as much as practicable, and the route between the airport and Westport should be checked for vulnerabilities.

The port of Westport is likely to play a more prominent role following an earthquake than it does now, both in the recovery period and in the longer term, as an alternative transportation nodes for bulk exports that currently go by rail. While this possibility may not justify expenditure in upgrading facilities now, it should be borne in mind if planning changes and in keeping and maintaining facilities.

The possibility that the rail link to Canterbury could be repaired fairly rapidly should be explored with ONTRACK.

7.2 Roads

7.2.1 Characteristics of the Road System

The Buller District is characterised by low traffic volumes, frequently mountainous or hilly terrain with high rainfall, and the many rivers and streams that cross the main routes. As explained above, there are five links to the rest of the South Island, namely

- Two routes north to Murchison; SH 6 from Inangahua and SH 65 from Springs Junction,
- SH 7 over the Lewis Pass, and
- Two routes south through Grey District; the coastal route via SH 6 and the inland route via SH 7.

Within the District there are very few interconnected roads providing alternative routes. There is only a single road to Karamea (route 67) although there is some redundancy in the state highway network in the south of the district.

Table 7.1: Buller District Road Statistics

Description	**Transit (SH)**	**Buller District**
Roads		
Total length	350	580
Urban sealed		302
Rural sealed	350	?
Rural gravel		278 (48%)
Bridges		
Number	91	138
Length (km)		2.9
Longer than 10m		84 (61%)
Single lane		115 (83%)
Timber no.		19

There is also a significant length of roads in the district not maintained by the District Councils such as forestry and mining access roads, which may be significant as alternative 4WD routes.

Relative traffic volumes on the state highways in the district are indicated below.

Table 7.2: Annual Average Daily Traffic Volumes (Transit for 2004)

SH	Location	AADT	SH	Location	AADT
6	Murchison	1960	69	Landing bridge	840
6	Upper Buller Gorge	890	65	Maruia Valley	880
6	Lower Buller gorge	940	7	Lewis Pass	1170
6	Punakaiki	970	7	Rahu Saddle	450
			7	South of Reefton	1340

7.2.2 System Vulnerabilities

It is virtually certain that in an Alpine Fault earthquake the roading system will be significantly, and in some areas severely, affected. Immediate damage will result from earthquake shaking directly and also from secondary effects such as liquefaction and landslides. Damage is likely to include:

- Fault rupture offsetting the road vertically and horizontally,
- Structural damage to at least some bridging, and in some cases resulting in bridge closure,
- Slumping of abutment fill which may close bridges temporarily,
- Slips that either deposit material onto roadways, or results in the carriageway falling away, and
- Liquefaction induced slumping and fissuring in local areas.

Damage subsequent to the earthquake will result from aggradation and flooding in rivers, debris flows covering roads with debris and water and destroying bridges and culverts, and damage to culverts resulting in washouts.

7.2.3 State Highways

The West Coast State Highway system is shown in Figure 7.1. The State Highway system provides all the external links beyond the Buller District, and the principal network within the District. Although it is not the BDC's responsibility, its performance will impact greatly on the district's resilience to an earthquake event. Transit NZ has carried out a seismic screening of all the bridges on the state highway system. The report on region 12 – West Coast – was prepared in 1999. This study identified the following bridges in the region (Table 7.3) at risk of serious damage or collapse, requiring closure. Other bridges are at risk of damage, but have not been included in Table 7.3, and the table does not include the vast majority of bridges where little or no damage is expected.

Figure 7.1: West Coast State Highway Sytem

Table 7.3: SH Bridges with Significant Seismic Risk – Transit Study

State Highway	Bridge	PGA EQ (1)	PGA cause (2)	Damage (3)	Likelihood (4)	Comments
6	***Upper Buller***					
	Iron Bridge (Buller R)	0.25	0.35 0.5 0.5	5 5 5	C D D	linkage - Pier damage, possible collapse Poor truss bracing -Possible collapse abutment rock slide - Possible collapse
	Inangahua R	0.2	0.5	3	D	
6	Lower Buller					
	Fern Arch	0.15	0.5	5	C	Collapse from Rock failure
69	***Inangahua – Reefton*** (no bridges classified at risk)					
65	***Murchison – Springs Junction***					
	Maruia	0.8+	0.5	3	C	
7	***Reefton – Greymouth***					
	Inangahua	0.3	0.5	3	C	
	Little Grey	0.3	0.4	5	C	Poor linkage – span collapse
	Big Grey	0.35	0.5	3	C	
	Nelson Ck	0.35	0.5	3	C	
	Kiwi O/B	0.35	0.5	3	C	
67	***Westport – Seddonville***					
	Big Ditch	0.15 0.15	0.6 0.4	3 3	D C	Settlement + and pier failure Liquefaction
	Waimangaroa ob	0.15	0.4	3	C	Settlement, liquefaction slumping of fills
	Waimangaroa R	0.15	0.5	3	C	pile cap failure - damage, settlement
	Mohikinui	0.15	0.5	3	D	Shear failure, settlement
6	***Westport – Greymouth***					
	Mountain Ck	0.1	0.5	5	C	Probable collapse from pier failure
	Nile	0.1	0.4	3	C	
	Canoe Ck	0.2	0.4	3	C	liquefaction abutment + pier movement
	Camp o/b	0.3	0.5	3	D	
	Coal Ck O/B	0.3	0.5	3	C	

(1) Probable peak ground acceleration (PGA) at the bridge location from the Alpine Fault earthquake. Other earthquake sources, or different rupture lengths on the Alpine Fault will produce different PGA

(2) Minimum PGA to cause significant damage to bridge

(3) Extent of damage to bridge

1 – insignificant; superficial damage, no disruption to traffic

3 – moderate; significant damage in a number of locations requiring closure

5 – Catastrophic; damage requiring replacement of more than one span

(4) likelihood of risk event

A – very likely B – likely C – moderate D – unlikely E – very unlikely

It should be recognised that these bridges have been identified from a preliminary screening study, and detailed analysis may reduce (or increase) the relative risk. For instance, the Iron Bridge over the

Buller River has been subject to MM IX shaking in 1929 and MM X in 1968, and survived with relatively minor damage, whereas the screening suggests that significant damage might have been expected.

Comparison of the PGA expected with the Alpine Fault and the PGA needed to initiate the serious damage indicated in the damage column shows that only one (Maruia River SH 65) of the State Highway bridges in Buller district will be subjected to seismic forces in excess of the damaging level. For other earthquakes this could be quite different, as was demonstrated with the 1968 Inangahua earthquake.

It should also be borne in mind that the **importance of a bridge**, and hence its acceptable risk level, will be **influenced by the volume of traffic using it, access to vital facilities or communities, the presence of other services on the bridge etc**.

A full and detailed assessment of the State Highway system has not been carried out, but preliminary review and common sense suggest the following is probable. Immediate links outside the regional boundary are included as these also impact directly on the regional resilience.

1	***Link***	***SH6 Murchison to Nelson/Marlborough***
	Importance	Very High: Only link to Nelson, probably least damaged of four SH links outside
	EQ Shaking	MM VIII
	Time to reopen	A few days
	Damage	Landslides, settlement at bridge abutments
2	***Link***	***SH 65 Murchison to Springs Junction***
	Importance	Low to region, provided Upper Buller Gorge is less damaged, one of two links from West Coast to Springs Junction. Fibre Optic cable route
	EQ Shaking	MM VIII – MM IX or greater
	Time to reopen	1 – 2 weeks
	Damage	Landslides, bridge damage
3	***Link***	***SH 6 Murchison – Inangahua (Upper Buller Gorge)***
	Importance	Very High: Direct route to Nelson, alternative route through Springs Junction likely to be much more damaged. Land access to Transpower lines
	EQ Shaking	MM VIII
	Time to reopen	A few days. In 1968 Inangahua EQ, MM IX – X, 10 weeks to reopen
	Damage	Landslides, some bridge damage

4	***Link***	***SH6 Inangahua – Westport (Lower Buller Gorge)***
	Importance	Very High: Direct route from Westport north, one of only two roads from Westport, telephone route
	EQ Shaking	MM VII
	Time to reopen	A few days; maybe only a few hours
	Damage	Rockfall, landslide, minor bridge damage
5	***Link***	***SH 67 Westport – Mokihinui***
	Importance	High: Only road to north Buller
	EQ Shaking	MM VII
	Time to reopen	A few hours
	Damage	Minor slips, minor bridge damage
6	***Link***	***BDC Karamea - Mokihinui Road***
	Importance	High: Only road to Karamea
	EQ Shaking	MM VII
	Time to reopen	A few days
	Damage	Rockfalls and landslips over Karamea bluff, minor bridge damage
7	***Link***	***SH 6 Westport – Greymouth – coast road***
	Importance	High: second of two roads from Westport
	EQ Shaking	MM VII increasing to MM VIII south of Barrytown
	Time to reopen	A few days
	Damage	Rockfall, landslide, some bridge damage
8	***Link***	***SH 69 Inangahua to Reefton***
	Importance	High
	EQ Shaking	MM VIII
	Time to reopen	A few hours to a day or two (two days after 1968 EQ with MM IX - X shaking),
	Damage	Some liquefaction, minor bridge damage
9	***Link***	***SH 7 Springs Junction – Hanmer (Lewis Pass)***
	Importance	Very high: main link West Coast to Christchurch over Lewis Pass
	EQ Shaking	MM IX – X
	Time to reopen	2 to 4 weeks
	Damage	Fault rupture east of Springs junction, extensive landslides west of Lewis Pass and in Waiau Valley, bridge damage and possible bridge collapse.
10	***Link***	***SH 7 Springs Junction to Reefton (Rahu Saddle)***
	Importance	High; Part of main West Coast – Canterbury link over Lewis Pass. Fibre optic cable route
	EQ Shaking	MM IX – MM VIII
	Time to reopen	A few days – a week
	Damage	Landslides, rockfalls and bridge damage

11	***Link***	***SH 7 Reefton to Greymouth***
	Importance	Very High. Main route from Greymouth to both Nelson and Lewis Pass. Main access to Grey Valley communities. Fibre optic cable route in part
	EQ Shaking	MM VIII
	Time to reopen	One – three days
	Damage	Small slips, rockfall, some bridge damage

In general, the times to reopen roads suggested above are for basic four-wheel drive and truck access, with one-lane sections as necessary. For instance, it is probable that even basic access between Greymouth and Westport will take some days to restore. The time to restore full service levels comparable to pre-earthquake may take much longer – from weeks to months, and in some instances perhaps even years.

The damage outlined above is direct damage from the earthquake. Ongoing effects will result from the combination of steep to very steep and high terrain, with many slips and de-stabilised slopes, and high rainfall. Many slip areas originally caused by earthquake shaking are bound to move again when subject to heavy rain. Sediment input into the rivers will cause aggradation and debris flows will discharge from many small catchments. It should be noted that SH7 to the Lewis Pass is highly vulnerable to aggradation in the Maruia River between Springs Junction and Maruia Hotel. There is also an unpredictable hazard from flooding and debris as a consequence of earthquake dam breaks.

7.2.4 Buller District Roads

The BDC roading network runs through a considerable variation of terrain from flat river valleys to more hilly areas with embankments and cuttings. Where the roads are in relatively flat areas, the main hazards are liquefaction or being within an active earthquake fault zone, and there is little that can be done practically to improve robustness against these hazards. Embankments and cuttings are a vulnerability that can be reduced in some cases by bank stabilisation and maintenance.

A significant issue is the relatively extensive bridging on the BDC roading network. At present the BDC has a comprehensive database of its bridges, which are inspected every three years, but does not have a seismic vulnerability study. There will be at least some bridges vulnerable to earthquake damage due to insufficient structural robustness at the shaking intensities expected through much of the district. It is therefore recommended that bridges on critical routes be structurally audited for robustness against seismic attack and flood damage potential.

It is assumed that rural areas in general will be expected to be more self reliant, as well as less populated, and therefore where appropriate would be less of a priority for re-establishing access. Roads will be reinstated in the first instance to a four-wheel drive level of service for access within the district.

While key roads managed by Buller District can be identified prior to the earthquake, the order of priority for reinstating access along them will be influenced by the actual damage sustained. The priority is also closely linked to the State Highway network, and Transit and Buller District must work closely together in co-ordinating the road recovery. While this may be forced on both parties through the emergency management that will be imposed after the earthquake, liaison between the parties prior to any emergency could greatly enhance the speed and ease of recovery.

The district roads, which are likely to have priority in reinstatement, are listed below. Comments on their vulnerability are also given. These comments are based on superficial observations of the topography and related features. There is no detailed inventory of the routes and additional surveys of the roads are recommended to better identify vulnerabilities and any mitigation measures that might be taken prior to an earthquake. A model for such a study is outlined in Speed & Brabhaharan, 2006. This model uses six factors to prioritise road links; average annual daily traffic, percentage heavy vehicles, detour routes, no-exit roads, average property values, and land use, and considers a range of impacts for each of the earthquake consequential hazards. Other than the area immediately around Westport, most of the district roads are short, no exit, branches off the state highways. Reinstatement can really only follow the re-opening of the state highways.

Priority roads are:

- Roads within the Westport urban area providing access to key facilities such as the hospital, medical centers, CD posts, electrical substation, and the port. There is redundancy in access roads, and a basic level of service is expected to be obtainable quickly. The north end of the town may suffer some liquefaction damage, but this is unlikely to prevent four wheel drive access;
- Local roads in Reefton and the townships of Waimangaroa, Granity, Ngakawau and Hector, again to access key facilities;
- The roads to Carters Beach and the airport; SH 67A and Schadick Road. Some liquefaction damage is possible;
- Stephen Road and Waterworks Road to give access to the Westport water supply pipeline, treatment plant, storage and intakes. Some liquefaction and slips are possible;
- Mokihinui to Seddonville Road; slips or rockfall are possible near Chasm stream; and
- Karamea Highway – slips and rockfall are likely over Karamea Bluff, and liquefaction is possible in places between Little Wanganui and Karamea. The Mikonui and Karamea bridges are key components of this route as they are not easily bypassed.

For the Alpine Fault earthquake, none of the above roads are likely to be blocked, with the possible exception of the Karamea Bluff for up to a day or so, and reinstatement to a close to normal level of service should be rapidly achievable. District roads in the Springs Junction area will be significantly damaged however. The West Bank Road and more especially Palmer Road will be significantly damaged with slips and bridge damage. Given the small population these roads serve, and there will be a low priority immediately to repair these roads. Earthquake damage along Palmer Road, which follows the fault line, is such that it may be impracticable to reinstate this road for some considerable time after the earthquake.

The roads through Millerton to Stockton and to Denniston are important to the coal mining industry. For an Alpine Fault earthquake, the current transport arrangements for the coal will be greatly disrupted, and it is likely that mining will cease for a period of several days to several weeks. Re-opening these roads is therefore unlikely to be priority, other than allowing mine officials to assess any damage to the mines themselves. These roads are likely to suffer some rockfall and slips with an Alpine Fault earthquake that may take a day or two to clear.

For an earthquake centred close to Westport, the damage can be expected to be much greater, as instanced in 1929 and 1968. Reference should be made to the summary of those events earlier in the report (refer Section 3) for an indication of the damage and reinstatement times that could be involved.

7.2.5 Upgrades and Improvements

Given that the actual extent of damage cannot be predicted completely accurately in advance, it is still possible to identify some key routes for priority for reinstatement following a major catastrophic event using the key principles outlined in Section 7.1.4. These routes include:

- Local roads to access key facilities, infrastructure and the airport in Westport and airfield in Karamea;
- The airport at Westport, as this facility is of regional importance in gathering information for damage assessment, rescue and evacuation, and for delivery of emergency supplies;
- Access to Medical Centres and Community Emergency Centres firstly within each community then from outlying areas;
- Links between population areas with centres of highest population (potential areas of greatest need) and those close together being given priority. For instance Westport and Carters Beach, Granity, Ngakawau, and Hector;
- Access to critical lifeline installations such as major sub stations (electricity), telephone exchanges (communications), water pumping stations and reservoirs (potable water supply); and
- The road between Westport and Karamea, as this is the only access into Karamea other than the small airfield.

It is assumed that rural areas in general will be expected to be more self reliant, as well as less populated, and therefore where appropriate would be less of a priority for re-establishing access.

While key roads in the region can be identified prior to the earthquake, the order of priority for reinstating access along them will be subject to the actual damage sustained. The priority is also closely linked to the State Highway network, and Transit and District Councils must work closely together in co-ordinating the road recovery. While this may be forced on both parties through the emergency management that will be imposed after the earthquake, liaison between the parties prior to any emergency could greatly enhance the speed and ease of recovery. An example of this is the Buller Bridge at Westport. Although Transit seismic assessment of the bridges suggests that it would survive an earthquake with little damage, their ranking (which do not include bridge approaches) represents a ranking of importance within the Transit system. This ranking may be quite different to the importance the Buller District may have for the bridge as not only is it the only road link between Westport, its airport and the rest of the South Island, but it also carries the Carters Beach water supply and sewerage, and electricity and communication cables. Damage to this bridge could have severe repercussions on the ability of the district to respond quickly after the earthquake, and some additional mitigation work on the bridge may be warranted from the district perspective. In other words the acceptable level of risk may be quite different to the two parties, and this would be best openly discussed and management procedures reviewed before a major earthquake.

It is recommended that the District Council meet with Transit, and any other important stakeholders, to review the prioritisation of bridges and the need for any mitigation measures. The criteria for prioritisation should be agreed by the parties involved, but should probably include:

- Average annual daily traffic (traffic volume as indicator of importance and possible disruption),
- Percentage of heavy vehicles (as indicator of economic impact),
- Detour routes (are there any, how far and in what condition),
- Services supported by the bridge (water, sewer, telephone ,power etc),
- Role of bridge in access to key lifeline facilities in an emergency, and
- Impact on community and overall social resilience.

7.3 Airports

7.3.1 Buller District Airports

There are two aerodromes listed with the Civil Aviation Authority within the Buller District:

- Karamea
- Westport (part certified 139)

Karamea Aerodrome is a non-certified facility 2 km north of Karamea. It has a grass runway 945m by 60m with a sealed runway within it 945m by 8m width. There is a second grass runway 655m long. There are no lights or facilities. It is operated by Karamea Airport (Inc).

The Westport Airport (owned by BDC and MoT) is managed by the Buller District Council who operate the airport on a day to day basis. The airport is serviced by regular commercial flights as well as charter and industry users. This is the only airport on the West Coast certified under part 139 of the civil aviation authority rules for operation of an aerodrome, allowing regular air transport with aircraft of seating capacity of more than 30 passengers. It has a single sealed runway 1,280m by 30m with two grass taxiways to associated buildings. The runway does not have lighting. However there is a retro reflector system for use in emergencies with pilot activated strobe lights indicating an extended runway centre line.

There are numerous smaller private grassed airstrips on the District able to be used by light aircraft, that are not on the civil aviation register. These include the following as shown on 1:50,000 maps,

- Cape Foulwind (3 no.)
- Inangahua Landing
- Larrys Creek
- Reefton, 3km and 8km north of the town
- Maruia, Creighton Rd, 10km north of school

7.3.2 Airport Vulnerability

Westport airport appears to be on old storm beach deposits which are probably gravel and non-liquefiable. Karamea airfield is on a slightly raised alluvial surface, which is likely to have a low probability of liquefaction damage.

For the Alpine Fault earthquake, it is likely that Westport and Karamea airfields will sustain very little damage and can be made operational immediately. Access might be an issue at Karamea, though, as the bridge over Baker Creek could be vulnerable.

7.4 Ports

7.4.1 Westport Harbour

General

The Westport Harbour assets are fully owned by the Buller District Council with Buller Port Services, a wholly owned subsidiary of Holcim New Zealand Ltd, appointed to manage the day to day operations. The assets of the harbour include a dredge, pilot vessel/tug, all wharves, jetties and navigation aids, harbour office and assorted buildings, and an engineering workshop. The tug is 14m long with a 3 ton bollard pull. The dredge is 55m long, 915 tonne gross with a hopper capacity of 635 m^3. The port maintains one electric travelling crane on the wharf, which has a 12 tonne capacity. There is flat storage area of 20,000m^2 and a merchandise shed of approximately 3,500m^3. The fishing harbour includes unloading and refuelling facilities.

The harbour is regularly used by two ships carrying bulk cement that combined make 144 visits per year, loading out 450,000 metric tons of cement per annum. Between 1997 and 2000, coal shipments to Australia were made through the port using a 16,000 tons dead-weight barge, the largest in the Southern Hemisphere. The maximum sized vessel to use the port is 131 metres, with a beam of 25 metres. This vessel's loading was 10,800 metric tons on average draft of 5 metres.

The harbour is limited by the river bar entrance which can cause problems with river currents setting up very steep, short breaking waves and dangerous cross sets across the entrance. The harbour was effectively closed to large vessels for two months in 2005 because of low river flows allowing the bar to build up and limit the available draft depth.

Asset Risks

- Damage to the ageing wharf structures and back structures;
- Damage or failure of the Holcim wharf with the cement silos supported on a piled wharf structure; and
- Liquefaction at the fishing harbour, which is on or very close to known liquefiable soils. Liquefaction here would cause failure of the steeply battered stop bank at the rear of the harbour, lateral spread and damage to the jetties and mooring facilities.

7.4.2 Other boat transport

Boat access up some of the rivers could be an immediate alternative to damaged roads. For instance, jet boat travel up the Buller River could allow early inspection of the road through the gorge and the situation at Inangahua if the road was blocked.

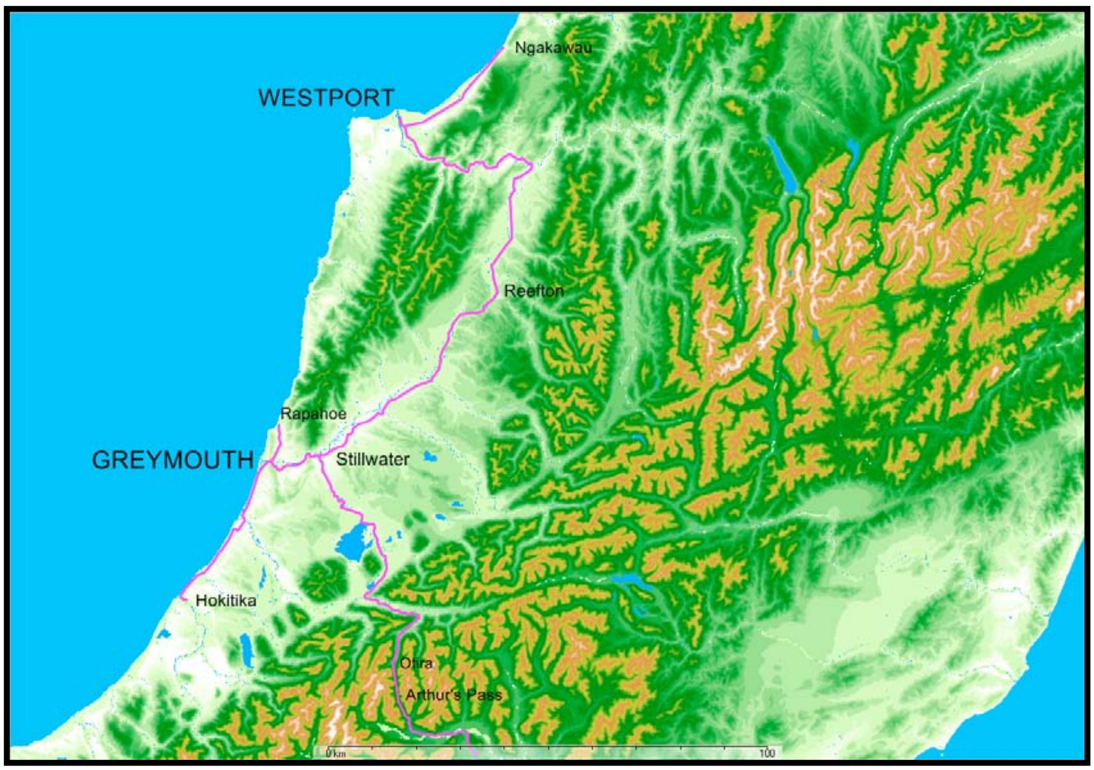
7.5 Railways

7.5.1 General Description

The West Coast railway network is shown in Figure 7.2. The West Coast is linked to the national rail network via the Midland Line from Rolleston (Christchurch). At Stillwater it splits to a north line to Westport and Ngakawau. A south line leads to Greymouth, Rapahoe and Hokitika. The line is single tracked with numerous passing loops and varies considerably in age and condition. The major traffic on the line is coal transport from Ngakawau (Stockton Mine) and Rapahoe (Spring Creek Mine) through Otira to Christchurch.

The railway network has recently been split with rails and infrastructure reverting back to Government ownership (ONTRACK) and the rolling stock and transport business being owned by Toll Holdings. Significant investments are currently being made in replacing bridges, upgrading track and extending crossing loops to allow this traffic to be increased.

Figure 7.2: West Coast Rail Network



7.5.2 Significant Asset Risks.

The railway network on and to the West Coast, like the highways, passes through mountainous and in places unstable country. This means that even with the best intent, it is not practicably possible to safeguard the railway against unexpected land slips and bridge damage. With railways, alignment and gradients are much more critical than for roads, and therefore it is particularly vulnerable to disruption. Temporary bypasses are much harder to implement and sometimes completely impractical. Therefore it must be assumed that the railway will take a significantly longer time to reinstate than the highway system[3].

7.5.3 Earthquake effects on Railway

The Midland line will be severely damaged, to the extent that it is likely to be closed for a long time. The line from Westport to Greymouth and beyond to Hokitika will be less damaged, and could be made operable again within a month. However, it seems unlikely that without the transalpine connection the railway could not provide any advantage over the road system, and it is likely that little effort would be expended on it in the short term.

7.6 Transport Improvement Schedule

Improvements identified in Section 7.1to Section 7.5 are summarised in Table 7.4. Note the priorities and completion dates are provided as a guide only.

Table 7.4: Improvement Schedule -Transport

Importance[1]	Action	Completion date	Responsible
H	***General*** Establish fast and flexible contract procedures with contractors, and establish availability of plant and equipment, and professional engineers where appropriate.	Dec '06	BDC
M	***Airports*** *Westport:* Assess seismic resilience of the airport, including building contents and power supply. Implement identified measures to ensure the airport can function within a short time following an earthquake. Assess seismic resilience of access including the Buller Bridge. *Karamea:* Assess seismic resilience of access, particularly bridge over Baker Creek.	Assess Dec '08 Implement Dec '11	BDC
H	***BDC Bridges*** Recommend that all bridges on critical routes or if carrying other services be structurally audited for seismic robustness and behaviour followed by a progressive survey of remaining significant structures from most to least important.	Dec '07	BDC
H	A plan should be prepared based upon the above audit to progressively upgrade weak bridging over a reasonable but achievable period of time.	Dec '07	BDC

1. H = High Priority; M= Medium Priority; L = Low Priority

[3] Since preparing the scenerio ONTRACK have been contacted. ONTRACK state that they can reinstate railway track after an earthquake faster than roads can be reinstated.

Table 7.4: Improvement Schedule –Transport (continued)

Importance[1]	Action	Completion date	Responsible
	Transit Bridges		
	Liase with Transit about SH bridges which are of critical importance to Buller District with respect to access and/or other services (eg Buller bridge at Westport).		BDC & Transit
	Roads		
M	In conjunction with the other West Coast Councils, Tasman District Council and Transit screen SH6 between the West Coast and Nelson and SH7 over the Lewis Pass for specific vulnerabilities and prioritise works that might reduce risk to earthquake damage.	Dec '10	WCRC, BDC, GDC, WDC & Transit
L	Recommend that BDC prepare a route hazard map to identify which roads may become damaged or impassable. Hazards should include slips on cuttings and embankments, landslide and rock fall potential, potential liquefaction areas and areas within those where lateral spreading of the road is possible	Dec '12	BDC
H	In conjunction with the bridge audit, below, prepare a damage assessment strategy to be followed after the earthquake to quickly identify, prioritise and manage immediate clearing and repairs. Establish a database for major cuttings and embankments within the Buller District so that a programme of progressive upgrading and improvements can be established and periodic inspections can be formalised.	Dec '06	BDC
H	Liase with Transit about key routes in the district and establish contacts for good co-operation after an earthquake. In conjunction with the bridge audit, below, prepare a damage assessment strategy to be followed after the earthquake to quickly identify, prioritise and manage immediate clearing and repairs.	Dec '06	BDC
H	Establish a database of owners and operators of earthmoving resources that could be used in a major disaster for road and bridge repair.	Dec '06	BDC
	Port of Westport		
	Continue to maintain port to an appropriate standard so that it would remain useable in the event of an emergency	Ongoing	BDC
M	Have the ground tested for liquefaction potential in the port area	Dec '10	BDC
H	Assess the likelihood of the crane being operational after the major earthquake and examine alternative (back-up) options	Dec '07	BDC
H	Consider forming an emergency plan with fuel companies for supply via the Port of Westport and ONTRACK.	Dec '07	Fuel companies
H	Consider some form of emergency power for navigation system and a crane at the Port	Dec '07	BDC/Holcim
	Railway		
L	Assess in more detail the likely time required to restore rail access to Canterbury.	Dec '15	Councils / Ontrack

1. H = High Priority; M= Medium Priority; L = Low Priority

8 WATER SUPPLY

8.1 Introduction

While the Alpine Fault earthquake predicted in the scenario (refer Section 4) will be less significant in the Buller District than in Grey District and Westland District, Buller District has experienced devastating earthquakes in the past (Buller and Inangahua earthquakes, discussed in Section3) and it is assumed the District will experience them again. The focus of this water supply section is therefore not exclusively on the Alpine Fault earthquake but rather on any MM VIII or greater magnitude earthquake.

Water supplies are provided in Buller District through community water supplies and rainwater storage at individual dwellings. The list of the supplies managed by BDC, including some relevant data, is presented in Table 8.1.

Table 8.1: BDC Managed Water Supplies

System	Popn Served (people)	Source Gravity/pumped	Treatment	Storage (m^3)	Dominant pipe materials[1]
Little Wanganui	100	Stream – Gravity supply	None	44	PE 56% AC 44%
Mokihinui	100	Stream – Gravity supply	None	50	AC 100%
Ngakawau – Hector	317	Deans Stream – Gravity supply	None	110	PVC 81% Poly 19%
Waimangaroa	300	Tributaries of Waimangaroa River and Conns Creek Gravity supply	None	110	PVC 100%
Westport	5,600	Giles Stream – Gravity supply	Coagulation Filtration pH correction chlorination	Raw water 130,000 Treated 3,000	AC 28% CI 28% GS 18% Steel 10%
Cape Foulwind	30	Omau Creek – Gravity supply	Rapid sand filtration	Individual	PVC 100%
Reefton	1,200	Shallow – Inagahua River Bore pump to reservoir Gravity to distribution	None	1,152	CI 59% GS 18% PVC 10%
Punakaiki	125	Creek – Gravity supply	Disc filter UV disinfection	4 x 10	PVC 100%
Inangahua Junction	-	Shallow bore Bore pump to reservoir	None	30	-

1. PE = Polyethylene, PVC = Poly vinylchloride, AC = Asbestos Cement; GS = Galvanised Steel; CI = Cast Iron

There are four other community water supplies in the District not operated by BDC:

- Waimangaroa School
- Maruia School
- Granity School
- Karamea

8.2 Level of Service – Water Supply

Target levels of service to be provided to communities after a significant earthquake are presented in Table 8.2. These targets represent minimum levels of service to be established after any earthquake event in the district. In the event of the Alpine Fault earthquake Little Wanganui, for example, is not expected to be significantly effected and it is likely that a normal level of service will continue. However, it is expected that the impact of the Alpine Fault earthquake on Reefton will be significant, the water supply will be damaged and an emergency level of service for the water supply will need to be established.

Table 8.2: Levels of Service – Piped Community Water Supplies

Service Description	Target period for Achieving Level of Service			
	Community Category[1]			
	1	2	3	4
Emergency Level of Service One standpipe in community per 100 people supplying 60L/person/day. The water may not be treated. Fire fighting capacity may not be available.	3 weeks	2 weeks	1 weeks	4 days
Interim Level of Service Emergency level of service continued to residential areas. Reticulated supply to selected facilities supplying 200L/person/day.[2] The water may not be treated. Fire fighting capacity may not be available.	-	3 weeks	2 weeks	1 weeks
Normal Level of service	6 months	6 months	4 months	3 months

1. Refer to Table 6.4: Township Importance Categories
2. Selected facilities may include regional and district emergency facilities include CDEM centres, hospitals & medical centres, police stations, CD sector posts, essential businesses and industry and government offices (existing or established after the emergency) meeting needs arising from the disaster. Essential business and industry should be determined before the earthquake.

It is important that key facilities such as CD centres and CBD areas, out of which support agencies, food and building material distribution centres etc will operate, are given higher priority than residential and rural areas as the key facilities will be providing services to the community at large.

BDC will be directly responsible for Council owned supplies and will provide assistance to reinstate other community water supplies and individual point source supplies such as wells and rainwater tank systems as resources allow and as required.

The target periods for achieving these levels of service apply to communities that are not evacuated. The target periods are measured from the time of the earthquake occurring.

8.3 Strategy – Water Supply

The success of the proposed emergency and interim levels of service for piped water supplies and return to normal supply will depend on the following measures being in place before a major earthquake event occurs:

- Strengthening of intake infrastructures so that water supply sources can function again as quickly as possible after the earthquake;
- Identifying, and upgrading where necessary, key mains between the water sources and/or water storage sites and strategically located community standpipes, important industry and business, and Civil Defence posts and other emergency facilities. It is important that the key mains suffer minimal damage during the earthquake. It should be noted that key mains might not necessarily be primary trunk mains. Where key mains are not primary trunk mains it is not essential to size the key main to primary trunk main capacity as emergency flows are likely to be significantly less than primary main flows;
- Installing burst control valves on reservoirs to prevent water loss from the reservoirs after the earthquake. The burst control valves will be activated during the earthquake;
- Where supplies are dependent on pumps, establishing reliable alternative power sources at individual water supplies with adequate fuel supply;
- Establishing alternative sources for fire fighting water supplies;
- Establishing a formal response plan that identifies;
    - Key tasks and who is responsible for them. The plan will need to take into account the need for flexibility given that some personnel might not be available following the earthquake. Almost certainly the actual situation will not match the planned or theoretical expectation;
    - Backup plans;
    - Methodology for assessing damage and prioritising of repairs;
    - The location of as-built drawings, backup copies and updating requirements; and
    - Training requirements.
- Ensuring adequate spare parts are in stock to allow repairs to key water supply assets e.g. key mains, to be undertaken after the earthquake so that emergency and interim levels of service can be

achieved. Given the large distances between supplies and the likely difficulty of access after the earthquake consideration should be given to a store of spare parts at each water supply location;

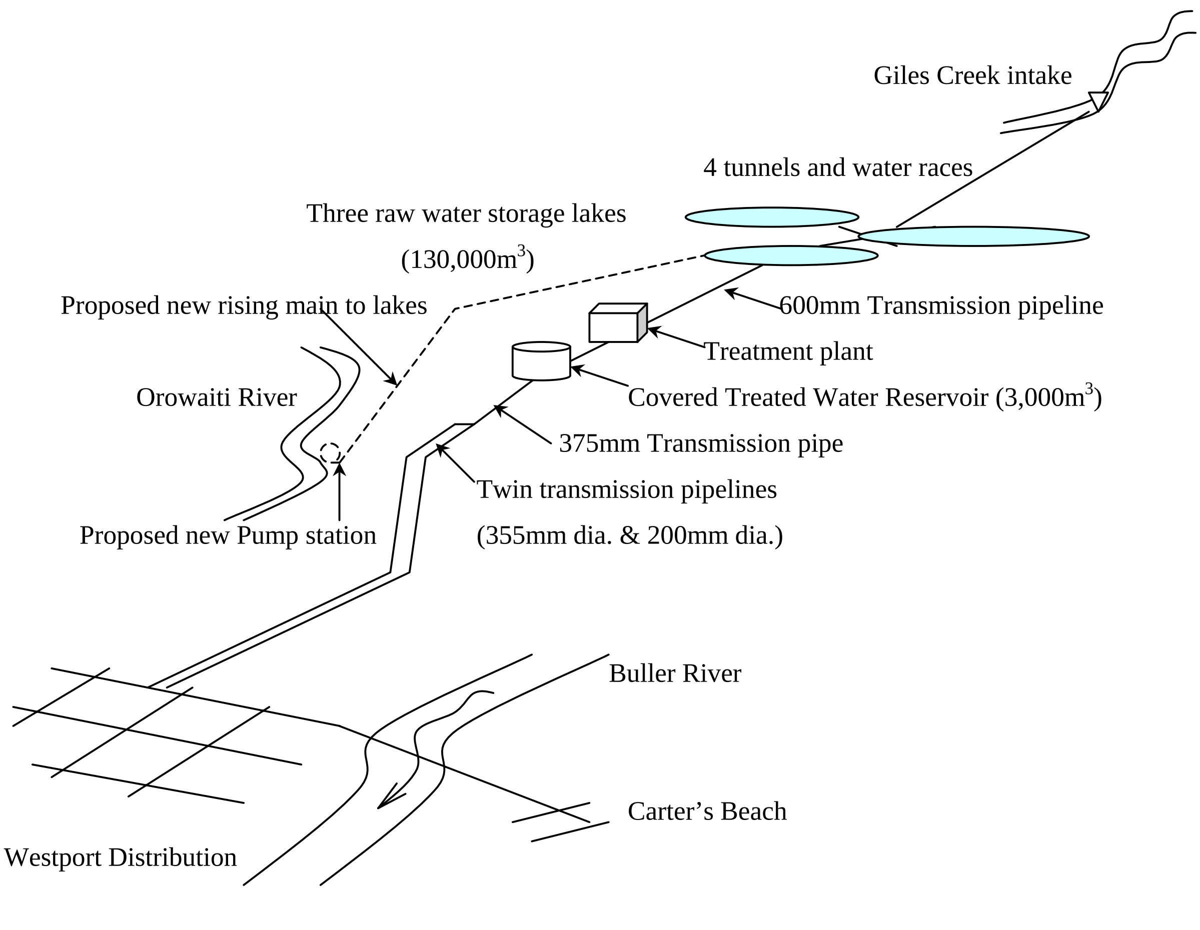
- Ensuring operation manuals are located on site at all supplies; and
- Reviewing water supply pump stations and treatment plants to ensure all equipment and plant are adequately secured against movement in the event of an earthquake.

This report considers the Westport and Reefton water supplies in detail. Vulnerabilities of these two supplies in the face of a magnitude VIII earthquake or greater are considered and the proposed service level requirements are examined. Upgrades and improvements are identified to address the vulnerabilities. No details are provided for the remaining water supplies in Buller District.

8.4 Westport Water Supply

8.4.1 Description

Figure 8.1: Westport Water Supply



The Westport water supply is shown diagrammatically in Figure 8.1 and is described as follows:

- An intake on the south branch of Giles Creek abstracts water which flows through 6,000m of tunnels and water races to three open raw water storage lakes;
- The water flows from the lakes to the treatment plant via a 530mm concrete transmission pipeline;
- The treatment consists of coagulation with alum followed by rapid sand filtration. The pH of the water is adjusted using hydrated lime prior to disinfection with chlorine gas;
- The treated water is stored in a 3,000m^3 butynol-lined reservoir with a floating butynol cover.
- The treated water flows from the 3,000m^3 reservoir to the reticulation network in Westport via two parallel transmission lines. One transmission line is a 356mm diameter steel pipeline and the other is a 200mm diameter pipe cast iron pipeline.
- The supply to Carter's Beach is via a 100mm AC main attached to the bridge over the Buller River.

It is proposed to install a pump station and a new transmission pipeline to the existing raw water storage lakes. The pump station will have two pumps with provision for a third pump to be installed when required. It is known that the tunnels from the Giles Creek intake may fail any time in the future and it is intended that when a tunnel failure does occur the pump station will pump water from the Orowaiti River to augment the Westport water supply until the tunnels are repaired.

The composition of the Westport transmission and distribution systems is presented in Table 8.3. For the purposes of this document the transmission is defined as the pipeline from the intake to Westport. The pipe work within Westport and to Carter's Beach is considered to be reticulation.

Table 8.3: Composition of Pipes in the Westport Water Supply

Location	Pipe Material	Length	Percentage
Transmission	Concrete	600	3.0%
	Concrete RRJ	300	3.0%
	Steel	4,800	48.5%
	Cast Iron	4,800	48.5%
Total Transmission		**10,500**	**100.0%**
Reticulation	Asbestos Cement	13,336	35.8%
	Cast Iron	8,480	22.8%
	Galvanised Steel	8,567	23.0%
	Polyethylene	833	2.2%
	PVC	4,210	11.3%
	Other & Unknown	1,779	4.8%
Total Reticulation		**37,205**	**100%**

8.4.2 Vulnerabilities – Westport Water Supply

In the event of the major Alpine Fault earthquake described in Part II it is expected that Westport will experience intensity MM VII shaking. In the event that there is an earthquake like the Buller earthquake or the Inangahua earthquake it is expected that Westport will experience intensity at least MM VIII shaking.

Westport is located on geologically recent alluvial soils, with some ground settlement and distortion to be expected. In a strong earthquake (MM VII – VIII or greater) liquefaction can be expected in the area bounded approximately by Bright Street in the south and Forbes Street and Shelswell Street in the north. The remaining area of Westport is likely to sustain some settlement.

It is anticipated that the impact of the Alpine Fault earthquake on the Westport water supply is unlikely to cause widespread destruction. However, in the event of an MM VIII earthquake or greater the impact on the Westport water supply is likely to be as significant as occurred in the 1929 Buller earthquake and the water supply may fail partially or totally because of the following:

- Failure of part of the tunnel system from Giles Creek to the raw water storage lakes preventing water from flowing from the source to the lakes. The No. 2 tunnel and sections of the No. 4 tunnel are described as being in very unstable rock mass and potential landslide zones;
- Failure of the raw water storage lake resulting in draining of the lakes. The lake dams suffered some damage in the 1929 Buller earthquake. The earth filled dams predate modern earthquake design and probably do not contain any internal filtering. Possible failure mechanisms include internal cracking and piping and/or slumping of the steep batters leading to settlement of the fill and water over topping the dam;
- Failure of the treatment plant due to loss of power. Although the Westport water supply is essentially a gravity supply, the treatment plant relies on electricity for the back wash pumps, dosing pumps and treatment plant controls;
- Failure at the treated water reservoir. There is no automatic burst control valve on the pipe from the reservoir to prevent the reservoir draining due to pipe failure downstream caused by the earthquake;
- Transmission line failure between the lakes and the treatment plant and/or between the treated water reservoir and Westport.

Table 8.4: Estimate of Likely Transmission Pipe Failure

Pipe Material	Length (m)	Projection of Joint Failure	
		Optimistic	Pessimistic
Concrete	600	5.00% (approx. 5 joints)	10.00% (approx. 10 joints)
Concrete RRJ	300	3.00% (1 or 2 joints)	5.00% (2 or 3 joints)
Steel	4,800	1.35% (approx. 11 joints)	2.53% (approx. 20 joints)
Cast Iron	4,800	1.00% (approx. 8 joints)	2.00% (approx. 16 joints)
Total	**10,500**	**1.45% (approx. 25 joints)**	**2.78% (approx. 50 joints)**

From Table 8.4 it can be seen that the projected percentage of joint failures is between 1.45% and 2.78%. This is equivalent to been 25 and 50 joints failing. The highest percentage of joint failures is expected in the concrete pipes, particularly the concrete pipe between the storage lakes and the treatment plant, which have rigid joints. Significant failure is also expected in the older riveted steel and cast iron pipes sections of the transmission pipe on trestles.

- Failure of the reticulation network. Approximately 10% of Westport is located on soils that are prone to liquefaction in an MM VII – VIII earthquake or greater shaking intensity earthquake and the remainder of Westport is located on soils where settlement may occur as a result of seismic shaking. Projections of entry and junction failures have been calculated and are presented in Table 8.5.

Table 8.5: Estimate of Likely Reticulation Entry & Junction Failure

Pipe Material	Length (m)	Projection of entry and junction failure
Asbestos Cement	13,336	43.00%
Cast Iron	8,480	43.00%
Galvanised Steel	8,567	18.50%
Polyethylene	833	0.00%
PVC	4,210	18.50%
Other & Unknown	1,779	0.00%
Total	**37,205**	**31.57%**

From Table 8.5 it can be seen that around 32% of entries and junctions are expected to fail in the reticulation network. What is perhaps more critical is that as 85% of the larger diameter (>100mm diameter) reticulation mains are CI or AC where a higher percentage of junction failure is expected (43%). The larger diameter pipes are the backbone of the reticulation and a significant number of junction failures will impact on the reticulation system's ability to distribute water;

- The asbestos cement pipe main to Carter's Beach crosses the Buller River on the State Highway bridge. It is likely that there will be movement of the bridge abutments and the pipe may fail at the abutments or approaches;

- The water supply may not be able to be used to fight fires due to damage to and leakage from the reticulation network;
- Insufficient spare parts in stock to repair wide spread damage of pipelines; and
- Potential for damage due to inadequately restrained equipment at the treatment plant.

8.4.3 Upgrades & Improvements – Westport Water Supply

To address the vulnerabilities identified in the previous section the following improvements are proposed:

- Undertake a geotechnical assessment of the raw water storage lakes, particularly the dams and inlet and outlet structures to quantify earthquake risks and make recommendations on improvements to address these risks;
- Install provisions at the new Orowaiti River high lift pump station and the existing treatment plant to allow generator power to be connected. Consideration should be given to purchasing a standby generator to allow the treatment plant and the Orowaiti River high lift pump station to continue operating;
- Assess the need for replacing the 600m concrete main from the raw water storage lakes to the treatment plant. If the pipes are found to be in good condition options for replacing the joints should be considered as the joints are the highest failure risk of the pipeline in a large earthquake;
- Undertake a geotechnical assessment of the treatment plant and treated water reservoir to quantify earthquake risks and make recommendations on improvements to address these risks;
- Install burst control valves on the outlet pipe work from the raw water storage lakes and the treated water reservoir;
- Undertake a geotechnical assessment of the section of transmission line on trestles and identify options to improve the earthquake resistance of this section of pipeline. The review should include identifying all shut off valves to allow any section of these pipelines to be isolated as quickly and concisely as possible;
- List essential businesses and industry that require a water supply as a priority after the earthquake and identifying key mains. The characteristics of key mains are as follows:
    - Key mains are made of materials that withstand earthquake forces;
    - Key mains can be isolated from pipes made of materials that are likely to fail in an earthquake; and
    - Key mains distribute water to essential business and industry and provide a standpipe supply to residents of Westport and Carter's Beach (interim level of service). An example of a key main would be the main from Westport to Carter's Beach.

- Review spare part requirements and availability of stock. Spare parts should include a stock of materials for standpipes or standpipes that are already made up as well as a reasonable stock of treatment chemicals; and
- Review restraint of equipment at the treatment plant.

The raw water storage lakes and the 600m concrete main from the lakes to the treatment plant are key components of the Westport water supply. The loss the lake water through dam failure or failure of the concrete pipeline would prevent any raw water from reaching the treatment plant and seriously curtail the supply of water to Westport until they are repaired.

After the above improvements have been implemented it is anticipated that the recovery of the Westport water supply after a MM VII – VIII earthquake will take place as follows:

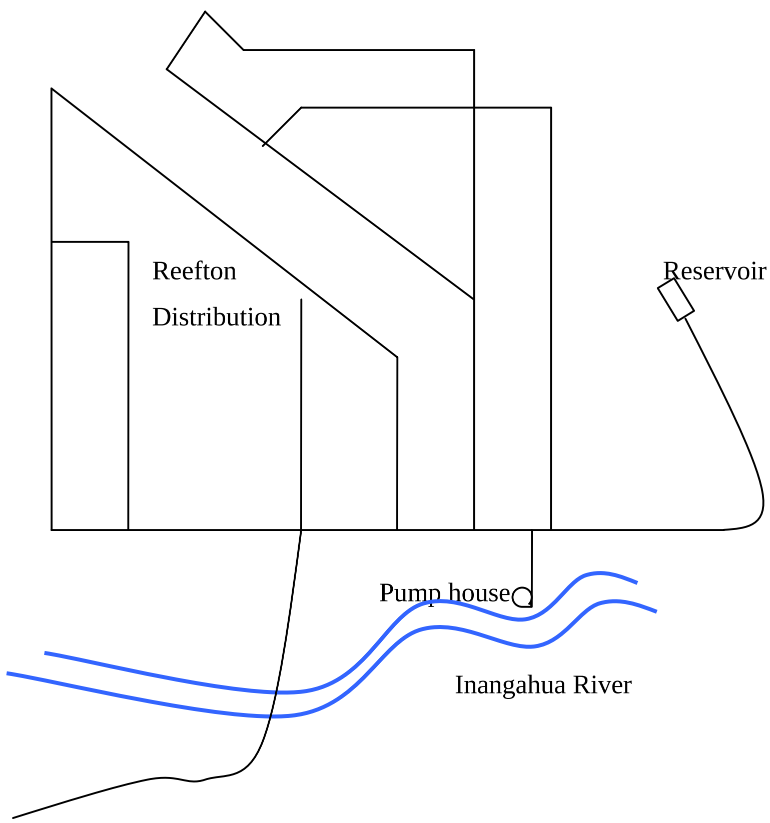
- Power to the pumps and treatment plant fail at time zero; the time of the earthquake;
- Geotechnical reports (refer Section 12) suggest there is likely to be significant collapse and failure of the tunnel system from Giles Creek preventing water from flowing to the raw water storage lakes;
- The lakes and the upgraded transmission line to the treatment plant remain largely unaffected although some minor repairs are required to the transmission line. The transmission lines to Westport also suffer some damage although the damaged sections can be quickly isolated and repaired;
- The lake and reservoir burst control valves are actuated and prevent water from flowing from the lakes and treated water reservoir;
- The water supply service staff manually shut down branch lines from the key mains in the reticulation and key main line valves. The reservoir burst control valves are opened and valves on the key main re-opened in stages assessing for leaks at each stage. Where leakage remains unacceptably on a key main it is shut down in favour of using one of the other key mains;
- Once one or all of the key mains are fully pressurised again standpipes can be set up probably at fire hydrants.
- Where fires have broken out every effort can be made to open valves on the key mains to direct flow to the fires to put them out. It is possible that there will be substantial leaks and the water may not reach the area of the fire with sufficient pressure.
- The lakes lose very little water in the earthquake. The lakes can hold up to 23 day’s supply at normal demand. After the earthquake, although there is potential for leakage to be higher, overall demand is likely to be low because of the following:
    - Water will only be reticulated via key mains during the interim level of service period; and

  - The restricted supply to residents via stand pipes only and to essential industry and businesses, which is a much lower demand than normal.
- In the worst case the water will be untreated. However the water treatment plant will be able to operate with the standby generator and there are adequate chemicals on site to run at the reduced flow rate for a number of weeks.
- Water supply will be progressively reinstated to all of Westport and Carter's Beach. Sections of pipe will be assessed for damage and where damage is considered to be extensive the whole main will be replaced rather than undertaking a repair.

8.5 Reefton Water Supply

8.5.1 Description

Figure 8.2: Reefton Water Supply



The Reefton water supply is shown diagrammatically in Figure 8.2 and is described as follows:

- Water is pumped from an intake gallery in the Inangahua River using two surface mounted pumps in a pump house adjacent to the river.
- The water is pumped untreated directly into the distribution system.

- An open concrete reservoir is located on a ridge immediately east of the township. The reservoir floats on the supply; when demand is greater than supply from the pumps the reservoir water makes up the deficit and when demand is less than the supply from the pumps excess water fills the reservoir.
- The Reefton water supply is not treated.

The composition of the Reefton distribution system (excluding laterals) is presented in Table 8.6.

Table 8.6: Composition of Pipes in the Reefton Water Supply

Pipe Material	Length	Percentage
Asbestos Cement	1,315	6.37%
Cast Iron	12,195	59.08%
Galvanised Steel	1,285	6.23%
Polyethylene	3,720	18.02%
PVC	2,125	10.30%
Total	**20,640**	**100%**

8.5.2 Vulnerabilities – Reefton Water Supply

Reefton experienced strong shaking in the Buller (1929) and Inangahua (1968) earthquakes and although reports are limited (refer Section 3.1.7) the water supply apparently survived the MM VIII shaking relatively well.

The developed area of Reefton, apart from the racecourse where the soils are more recent, is located on older glacial outwash material and river gravels. It is expected to be relatively stable i.e. Zone 2 even in strong earthquake shaking. Based on the impact of the two previous earthquakes and details about the assets it is anticipated that in an MM VIII or greater earthquake the Reefton water supply could sustain the following damage:

- The intake turbidity may be elevated due to expected high turbidity in the Inangahua River caused by earthquake induced landslides in the catchment and the prevalent West Coast rain;
- Failure of the pumps when the power supply in the grid network servicing Reefton is lost;
- Failure of distribution pipes. Estimated likely entry and junction failures are presented in Table 8.7.

Table 8.7: Estimate of Likely Pipe Failure – Reefton Water Supply

Pipe Material	Length (m)	Projection of entry and junction failure
Asbestos Cement	1,315	1.91%
Cast Iron	12,195	17.73%
Galvanised Steel	1,285	0.31%
Polyethylene	3,720	0.00%
PVC	2,125	0.00%
Total	**20,640**	**19.95%**

From Table 8.7 it can be seen that approximately 20% of joints and entries are likely to fail.

Most of the failures (almost 18%) are expected to occur in the cast iron pipe for the following reasons:

- Cast iron makes up most of the pipe network (almost 60%);
- More than 10,800m of the 12,200m of the cast iron pipe was install in 1925 making it more than 80 years old; and
- It is assumed that the 1925 cast iron pipes have lead joints which are more susceptible to failure than other types of joints e.g. rubber ring joints.

- While it is expected that the reservoir and 200mm diameter rising main to the reservoir will largely stay intact, some failure of the rising main and distribution is expected. There is no automatic burst control valve on the outlet from the reservoir to prevent the reservoir draining due to pipe failure;
- Failure of the asbestos cement at the bridge abutment where the pipe crosses the Inangahua River to the small community on the southern bank;
- Insufficient spare parts in stock to repair wide spread damage of pipelines; and
- Potential for damage due to inadequately restrained equipment at the pump house.

8.5.3 Upgrades & Improvements – Reefton Water Supply

To address the vulnerabilities identified in the previous section the following improvements are proposed:

- Undertake a geotechnical assessment of the reservoir to determine the risk of failure in a MM VIII earthquake and make recommendations on improvements to address these risks;
- Undertake a cost benefit analysis for purchasing a generator to power the water supply pumps during periods when national grid power is not available;
- Improve the capability of providing an emergency level of service after a strong earthquake by improving the ability of key mains to withstand strong shaking. The location of the proposed key mains is presented in Figure 8.3.

The key mains will allow water to be supplied to the hospital and to standpipes located (probably at fire hydrants) along the key main. They will also allow water to be supplied from the pump, the reservoir or both.

It is envisaged that key mains will be constructed of earthquake resistant pipe material such as polyethylene (PE) or PVC. It is noted that existing key mains will need to be replaced, however, these main pipes are reaching the end of their asset life and are likely to be due for replacement anyway.

- Install burst control valves on the outlet of the reservoir;
- Review spare part requirements and available stock including materials for stand pipes or standpipes that are already made up; and
- Review restraint of equipment at the pump house.

Figure 8.3: Key Mains – Reefton Water Supply

After the above improvements have been implemented it is anticipated that the recovery of the Reefton water supply after an MM VIII or greater earthquake will take place as follows:

- Power to the pumps will fail at time zero; the time of the earthquake;
- The reservoir will remain largely intact and the burst control valve will be activated preventing loss of water from the reservoir;

- Local Reefton water supply service staff will manually shut down branch lines from the key mains in the reticulation and key main line valves. The reservoir burst control valve will be opened and valves on the key main re-opened in stages assessing for leaks at each stage. Where leakage remains unacceptably on a key main it can be shut down and repaired;
- Standpipes will be installed on key mains that are fully pressurised.
- Where fires have broken out every effort can be made to open valves on the key mains to direct flow to the fires to put them out. It is possible that there will be substantial leaks and the water may not reach the area of the fire with sufficient pressure.
- The standby generator will be started up and water pumped to waste initially until the turbidity reduces to an acceptable level to allow it to be pumped into the reticulation.
- Water supply will be progressively reinstated to all of Reefton. Sections of pipe will be assessed for damage and where damage is considered to be extensive the whole main will be replaced rather than undertaking a repair.

8.6 Water Supply Improvement Schedule

A summary of improvements to the District's water supplies is presented in Table 8.8. Note the priorities and completion dates are provided as a guide only.

Table 8.8: Improvement Schedule – Water Supply

Importance[1]	Action	Completion date	Responsible
	General		
M	Review the proposed levels of service and strategy to ensure they are appropriate and achievable.	Dec '08	BDC / CDEM
M	Assess the remaining piped water supplies in the District including non BDC supplies and document as for Westport and Reefton.	Dec '08	BDC
H	Establish a formal response plan that identifies those responsible for key tasks, backup plans and training requirements. It may be important to identify local people at the smaller supplies especially the remote supplies that can undertake repairs. The plan should identify the location of as-built drawings as well as backup copies of the drawings. Finally the plan should be inherently flexible and should provide a methodology for assessing damage and prioritising of repairs.	Dec '07	BDC
H	Review options for multi-tap standpipes and assess the number required for each water supply. Fabricate adequate multi-tap standpipes for all supplies and identify where the standpipes are to be stored.	Dec '07	BDC
H	Define high fire risk/high value areas and identify appropriate secondary fire fighting options.	Dec '06	NZ Fire Service

1. H = High Priority; M= Medium Priority; L = Low Priority

Table 8.8: Improvement Schedule – Water Supply (Continued)

Importance[1]	Action	Completion date	Responsible
H	List emergency centres as well as essential business and industry that require a water supply as a priority after the earthquake.	Dec '07	BDC
M	Identify key mains and establish a program to strengthen them	Dec '08	BDC
H	Review spare part requirements and strategic storage locations	Dec '06	BDC
	Westport		
M	Undertake geotechnical assessments of the raw water storage lakes, the treatment plant and treated water reservoir to quantify earthquake risks and make recommendations on improvements to address these risks.	Dec '08	BDC
M	Install provisions for generator power supply to the new Orowaiti River high lift pump station and the Treatment plant. Consider purchasing a standby generator.	Dec '10	BDC
M	Assess the 600m concrete main from the raw water storage lakes to the treatment plant and determine options for earthquake strengthening.	Dec '09	BDC
M	Install burst control valves on the raw water storage lakes and treated water reservoir.	Dec '08	BDC
H	Review restraint of equipment at the treatment plant.	Dec '06	BDC
M	Review and document the location of shutoff valves and their maintenance schedule.	Dec '12	BDC
	Reefton		
M	Undertake a geotechnical assessment of the reservoir to determine the risk of failure in a MM VIII earthquake and make recommendations on improvements to address these risks.	Dec '08	BDC
M	Install a burst control valve on the Reefton reservoir.	Dec '08	BDC
L	Undertake a cost benefit analysis for purchasing a generator to power the water supply pumps.	Dec '12	BDC
M	Replace existing key mains with more earthquake resistant pipe material.	Dec '12	BDC
H	Review restraint of equipment at the pump house.	Dec '06	BDC

1. H = High Priority; M= Medium Priority; L = Low Priority

9 SEWERAGE

While the Alpine Fault earthquake predicted in the scenario (refer Section 4) will be less significant in the Buller District than in Grey District and Westland District, Buller District has experienced devastating earthquakes in the past (Buller and Inangahua earthquakes) and it is assumed the District will experience them again. The focus of this section on sewerage schemes is therefore not just on the Alpine Fault earthquake but also on another Buller or Inangahua or greater magnitude earthquake.

Buller District Council manages three sewerage schemes:

- Westport (including Carter's Beach)
- Reefton
- Little Wanganui

There are privately owned community sewerage schemes operating at a new subdivision off Oparara Road in Karamea and at the Holcim Cement Co at Cape Foulwind.

9.1 Level of Service – Sewerage Schemes

The minimum target levels of service to be provided to communities after a major earthquake are presented in Table 9.1.

Table 9.1: Levels of Service – Community Sewerage Schemes

Service Description	Target period for Achieving Level of Service			
	Community Category[1]			
	1	**2**	**3**	**4**
Emergency Level of Service CD centres, residential & rural areas – individual pit latrine CBD areas – no service Surcharge areas will discharge to natural water ways	4 days	4 days	4 days	4 days
Interim Level of Service Residential & rural areas – e.g. individual pit latrine CD centres & CBD areas – normal service Surcharge areas will discharge to natural water ways	-	-	-	2 weeks
Normal Level of service	12 months	12 months	8 months	6 months

1. Refer to Table 6.4: Township Importance Categories

It is important that key facilities such as CD centres and CBD areas, out of which support agencies, food and building material distribution centres etc will operate, are given higher priority than residential and rural areas as the key facilities will be providing services to the community at large.

The target periods for achieving these levels of service apply to communities that are not evacuated. The target periods are measured from the time of the major earthquake occurring.

9.2 Strategy – Sewerage

The strategy for achieving effective recovery of sewerage schemes after the earthquake is as follows:

Pre-earthquake

- Establishing a formal response plan that identifies;
  - Those responsible for key tasks. The plan will need to take into account the need for flexibility given that some personnel may not be available following the earthquake. Almost certainly the actual situation will not match the planned or theoretical expectation;
  - Backup plans;
  - Adequate provisions are in place to sanitise areas contaminated by sewage overflows e.g. quicklime for household spills;
  - Methodology for assessing damage and prioritising of repairs;
  - The location of as-built drawings, backup copies and updating requirements; and
  - Training requirements.
- Ensuring adequate spare parts are in stock to allow repairs to sewerage assets e.g. sewers from CD centres & CBD areas, to be undertaken after the earthquake;
- Discharge requirements of major waste water contributors will be assessed and any necessary provisions put in place to manage identified problems with sewage flows immediately after the major earthquake;
- Surcharge areas will be identified and likely public health risk assessed. Appropriate emergency discharge arrangements will be identified and implemented as required;
- Sewerage asset replacement will continue to follow normal asset replacement principles. However where sewer pipe replacement is planned priority should be given to replacement immediately upstream of discharge points. This will reduce the risk of surcharging at locations where new pipe work resistant to earthquake failure meets older rigid downstream pipes that fail completely in the earthquake; and
- New sewerage scheme structures will be adequately designed for earthquake loads.

Post-earthquake

- It is assumed house occupiers will dig their own pit latrines for use following the earthquake. Where they are unable to do so neighbours and friends will assist with support from Council as resources allow e.g. Council may arrange to supply of quicklime to reduce public health risk;
- It is unlikely that CBD businesses, hotels etc will be able to set up emergency toilet facilities such as pit latrines. It is unlikely that these place can function until an interim level of service can be established;
- During the interim level of service in areas where offices are established to assist in the recovery effort (EQC and other insurance assessors, WINZ and other financial assistance organisations, distribution/logistics centres), sewers will be made operable. This may involve some repairs to allow sewage to drain away. The repairs should be co-ordinated with the re-establishment of water supply;
- Repair and replacement of sewerage schemes components after achieving the interim level of service will be based on assessment of the assets e.g. CCTV inspection of pipes. Lateral failures are known to have been an issue at other earthquake locations (Edgecumbe) and will require assessment if inflow and infiltration (I/I)[4] flows are to be kept at a manageable level; and
- BDC will be responsible for Council owned schemes. Council will provide support to owners of individual sewage schemes e.g. septic tank systems as required and as resources become available.

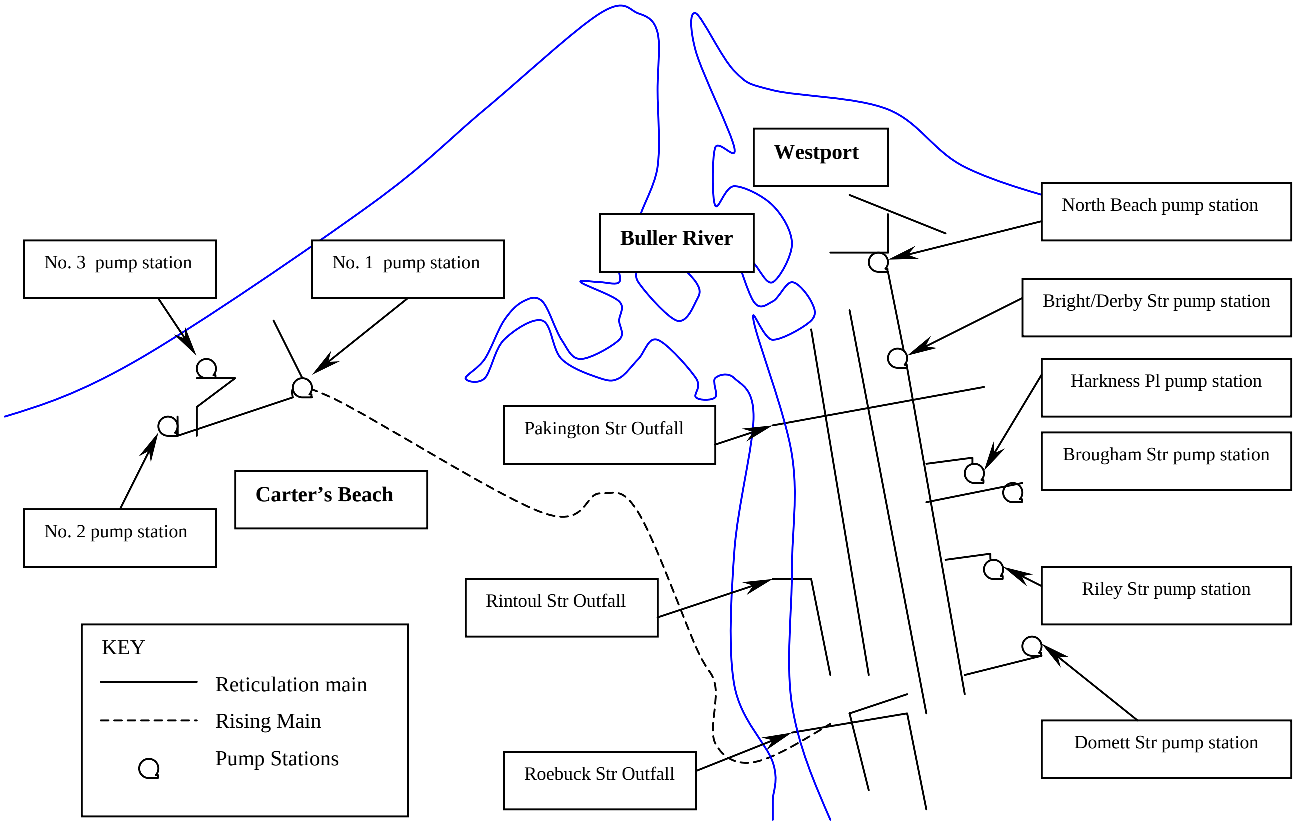
In the following sections a detailed description is provided of the Westport and Reefton sewerage schemes, their vulnerabilities in the face of an MM VIII intensity earthquake and upgrades and improvements that can be made to address vulnerabilities. No details are provided for the remaining sewerage schemes.

[4] Inflow and infiltration. Inflow is the flow of rainwater from the surface directly into the sewer either through illegal connections or breaks in the pipe. Infiltration occurs where there are breaks in a sewer and ground water can flow into the sewer. Both inflow and infiltration increase the flow in the sewer reducing the capacity of the sewer to carry sewage.

9.3 Westport Sewerage

9.3.1 Description

Figure 9.1: Westport Sewerage Scheme



The Westport sewerage scheme is shown in Figure 9.1 and can be described as follows:

- The Westport sewerage scheme collects sewerage from Westport and Carter's Beach. The sewage is not treated and is discharged to the Buller River via three outfalls; Pakington Street, Rintoul Street and Roebuck Street.
- The **Pakington Street** outfall discharges sewage into Buller River from the Westport gravity sewerage reticulation. As well as collecting sewage in the Westport reticulated area five subsystems discharge into Westport gravity sewerage reticulation:
  - North Beach: Sewage (80 houses) from the North Beach area drains to the North Beach Pump station. The North Beach pump station pumps the sewage into a gravity main flowing to the Bright/Derby Street pump station;
  - Harkness Place: Sewage (12 houses) from the Harkness Place area discharges to the Harkness Place pump station;
  - Brougham Street: Sewage from the Brougham Street area (9 houses) discharges to the Brougham Street Pump station;

    - Riley Street : Sewage from Riley Street subdivision (100 houses) discharges to the Riley Street pump station; and
    - Domett Street: Sewage from the south end of Domett Street (10 of houses) discharges to the Domett Street pump station.
- Sewage collected at the Bright/Derby Street, Harkness Place, Brougham Street, Riley Street and Domett Street pump stations is pumped into the Westport gravity sewer network.
- **Rintoul Street** outfall discharges sewage into Buller River from a small number of houses along The Esplanade.
- **Roebuck Street** outfall discharges sewage received from two systems; a small reticulation in south Westport in the vicinity of the State Highway Bridge and sewage from the Carter's Beach community:
    - South Westport: Sewage flows in gravity mains to the Roebuck Street outfall;
    - Carter's Beach: Carter's beach was reticulated in 1994 and is made up of a gravity reticulation along with two sub systems;
        - Sewage from the area around Martin Place flows under gravity to pump station No. 2 on Cape Foulwind Road at the western end of Carter's Beach. Sewage is pumped from pump station No. 2 via a rising main into the Carter's Beach reticulation; and
        - Sewage from the Public Hall and toilets on Marine Parade flows to No. 3 pump station. This sewage is pumped from No. 3 pump station into the Carter's Beach reticulation.

    Sewage collected in the Carter's Beach reticulation flows under gravity to the No. 1 pump station. The sewage is pumped from the pump station via a 4,000m long 150mm PVC main along Cape Foulwind Road and discharged at the Roebuck Street outfall.

A sewerage treatment plant is proposed for Westport and Carters Beach. It is to be built at a site off McPadden Road.

The composition of the pipe network in the Westport sewerage scheme is presented in Table 9.2.

Table 9.2: Composition of Pipes in the Westport Sewerage Scheme

Pipe Material	Length[1]	Percentage
Reinforced Concrete	3,848	9.10%
Earthenware	28,543	67.47%
PVC	9,911	23.43%
Total Reticulation	42,302	100.00%

1. Laterals not included.

9.3.2 Vulnerabilities – Westport Sewerage Scheme

In the event of the major Alpine Fault earthquake described in Part II it is expected that Westport will experience intensity MM VII shaking. In the event that there is an earthquake like the Buller earthquake or the Inangahua earthquake it is expected that Westport will experience intensity MM VIII shaking or greater.

Westport is located on geologically recent alluvial soils, with some ground settlement and distortion to be expected. In a strong earthquake (MM VII – VIII or greater) liquefaction can be expected in the area bounded approximately by Bright Street in the south and Forbes Street and Shelswell Street in the north. The remaining area of Westport is likely to sustain some settlement.

It is anticipated that the Westport sewerage scheme will suffer only minor to moderate damage from the Alpine Fault earthquake presented in the scenario (refer Section 4). However, in the event of an MM VIII earthquake or greater the impact on the Westport sewerage scheme is likely to be as significant as occurred in the 1929 Buller earthquake and the Westport sewerage scheme may fail partially or totally because of the following:

- Reticulation pipeline failure. Projections of likely damage to the reticulation network is presented Table 9.3;

Table 9.3: Estimate of Likely Reticulation Entry & Junction Failure– Westport Sewerage

Pipe Material	Length (m)	Projection of entry and junction failure
Reinforced Concrete	712	20% of reinforced concrete pipes
Earthenware	12,273	43% of earthenware pipes
PVC	1,834	20% of PVC pipes
Total	14,819	35% of all pipes

From Table 9.3 it can be seen that around 35% of the entries and junctions may fail in the Westport/Carter’s Beach sewerage reticulation network. Failures are likely at the pipe joints as well as at connections to the manholes, the nine pump stations and laterals.

- It is almost certain that the power supply will fail and there will be no power to the nine pump stations;
- Manholes and pump station structures are likely to move, particularly structures that are empty in saturated soils and that have not been designed for earthquake lifting forces. This movement is likely to cause pipes to fail at entries and exits, especially were joints are rigid. This may allow soil material to be washed into the pipes and structures when pumps are started again; and
- Some damage to the outfalls.

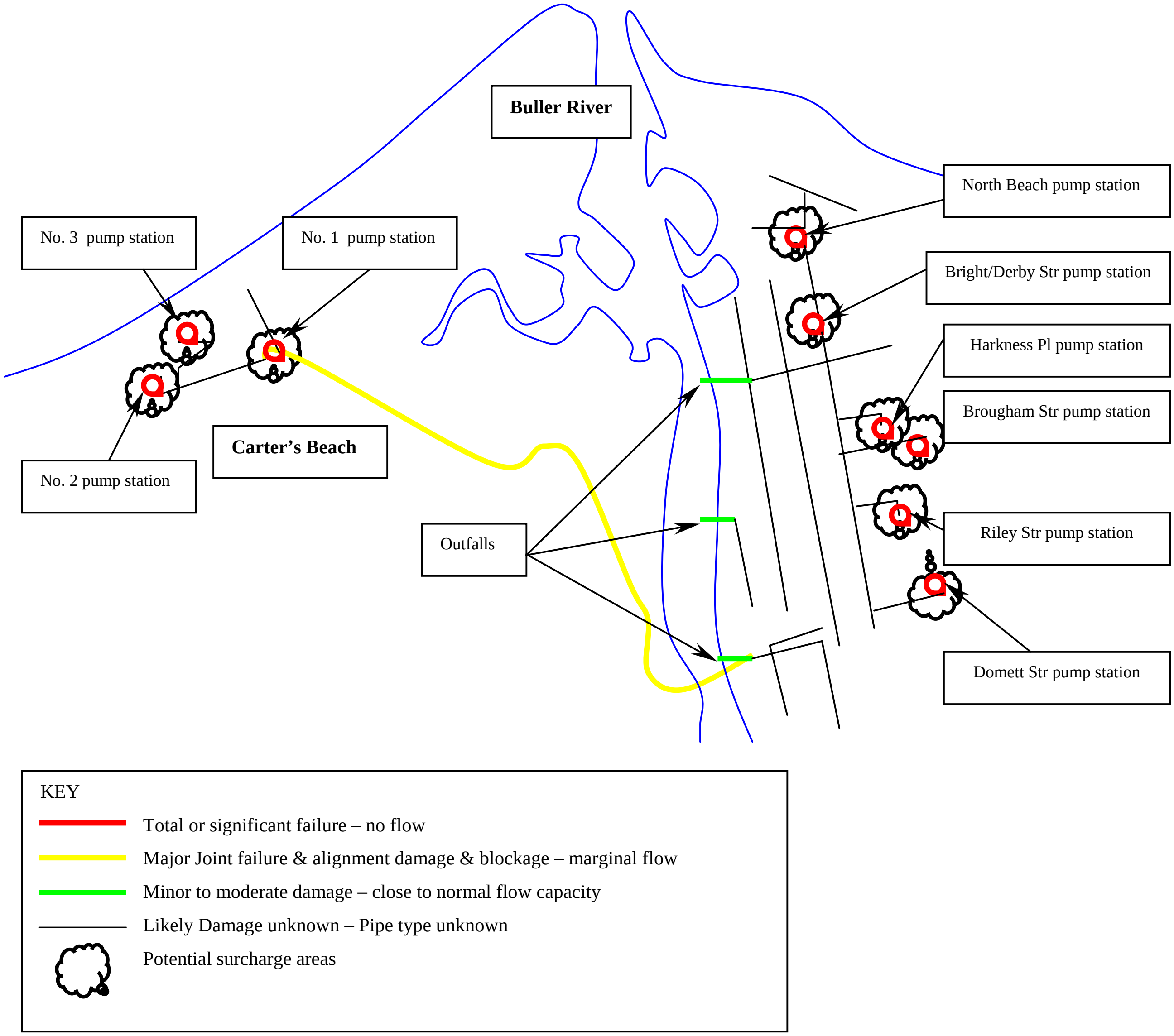
After the earthquake flow to the sewer and to the pump stations will be influenced by the following:

- The pump stations will fail due to loss of power;
- Flow from domestic sources will continue for a short while but will essentially cease once flow from the water supply fails;
- Where sewers are located below the water table and joint failure occurs infiltration to the sewer is likely to increase; and
- Flow in the sewers will continue although where serious pipe or joint failure occurs that results in blocking of the pipe some surcharging is likely at nearby manholes in low areas.

An assessment of failure of scheme components and resultant surcharging of sewage (9 locations) is presented in Figure 9.2 and described as follows:

- The worst surcharging in Westport is likely to occur at Riley Street pump station. This pump station receives sewage from approximately 100 houses and is located in a low-lying area with limited to no natural waterways draining the area. Surcharges are likely to pond into the streets and drain to the storm water system.
- Sewage is likely to surcharge at the Bright/Derby Street pump station and at properties discharging to this pump station. Surcharges are likely to pond in the streets and drain to the storm water system.
- Surcharging at Harkness Place and Brougham Street pump stations is likely to be minor as there is only a small number of houses discharging to these pump stations; Harkness Place 12 houses and Brougham Street 9 houses. Again sewage that surcharges is likely to pond in the streets and drain to the storm water system.
- Surcharging at North Beach and Domett Street pump stations is not likely to be a problem. Surcharging at the North Beach pump station can discharge to The Lost Lagoon while surcharging from the Domett Street pump station can discharge overland to a nearby drain.
- Surcharging at Pump Stations No. 1 will discharge to a surcharge pond adjacent to the pump station. This is normally pumped out. If the surcharge pond overflows sewage will flow onto the verge and the State Highway.
- Surcharging at Pump Station No. 2 will discharge onto the State Highway where it is likely to pond.
- Surcharging at Pump station No. 3 Carter's Beach, is likely to be minor. The pump station is low lying but only receives a small volume of sewage from the public hall and toilets.

Figure 9.2: Assessment of Westport Sewerage Scheme Failure and Surcharging



The rising main from Carter's Beach to the Roebuck Street outfall is PVC pipe and crosses the Buller River on the State Highway Bridge. There is potential for liquefaction in the soils near Carter's Beach and some settlement is likely over the remainder of the pipe length. The rising main has a history of failures attributed to inferior pipe material and poor workmanship during installation. The soil conditions and the condition of the pipe suggest the rising main is very susceptible to failure during a major earthquake and afterwards when pumping starts again and the pipe is pressurised. Some movement of the bridge abutments is also likely which could lead to failure of the rising main at the bridge.

The material and condition of the remainder of the sewer network is unknown at the time of preparing this report.

A preliminary assessment of the outfalls indicates that they are likely to suffer only minor to moderate damage and be able to function after the earthquake.

9.3.3 Upgrades & Improvements – Westport Sewerage

The following improvements are proposed to address the vulnerabilities identified in the previous section:

- Undertake an assessment of public health risk posed by sewage surcharges at pump stations particularly if the surcharges combined with storm water from a significant rainfall event (refer Section 10.3.2). Review options if sewage surcharges are likely to pose a public health risk and implement preferred options; and
- Undertake a geotechnical and structural assessment of all pump stations and quantify earthquake risks at each site and implement appropriate improvements to address these risks.

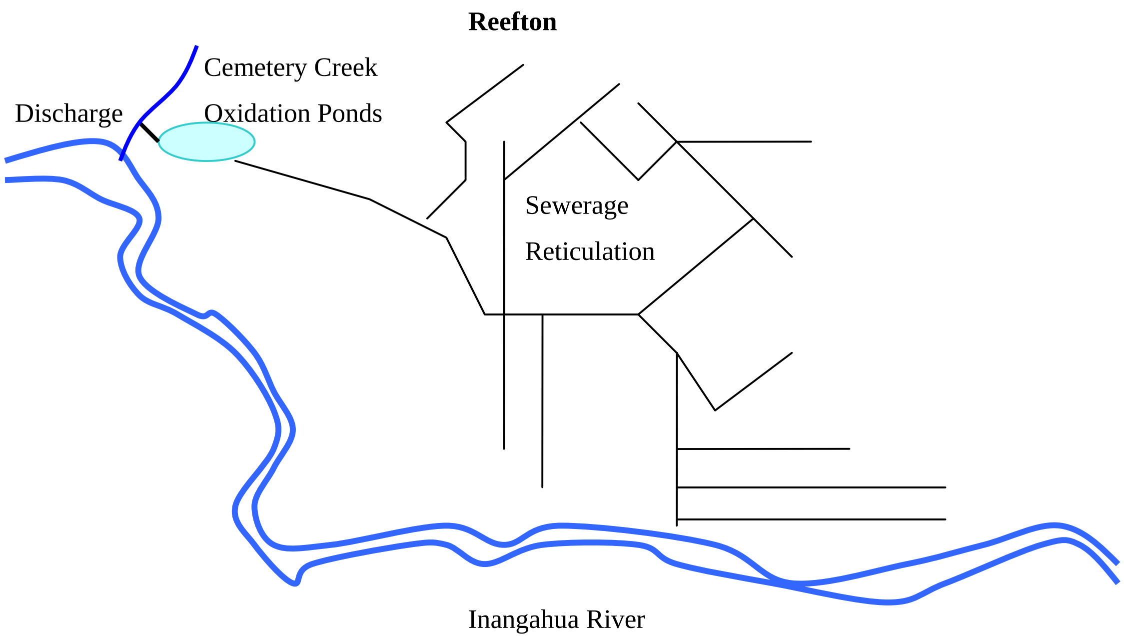
With the above improvements in place it is anticipated that recovery of the Westport and Carter's Beach sewerage scheme will proceed as follows after a severe earthquake;

- Power to the sewage pump stations will fail shortly after the earthquake;
- Surcharging is likely to occur to some degree at the nine locations identified in Figure 9.2;
- Surcharging in Westport will discharge to the Buller River via the storm water system or overland to surface drains. Provisions will be in place to address areas where sewage ponding is likely to be a public health risk e.g. portable sewage pumps or a standby generator at pump stations;
- Some failures are expected in the sewer reticulation network particularly in older pipes in soils where liquefaction is more likely. Workmen will check the network for surcharging caused by sewer failures and ensure that they are discharged safely away;
- The community will be notified not to use their WCs or discharge any other wastewater to the sewerage scheme. The community will be informed on setting up toilet facilities e.g. pit latrines at CD centres and at their own homes;
- The sewers servicing offices/buildings established to assist in the recovery effort will be made operable within 2 weeks undertaking repairs where necessary. Sewage collected will be discharged to the Buller River;
- The sewerage pipe network will be progressively assessed using techniques such as CCTV assessment and contracts let to repair the scheme. Where repair is uneconomical, sewers will be replaced. Stocks of disinfection chemicals will be maintained both for those households that need pit latrines, and also for use following ponding or repair work.

9.4 Reefton Sewerage

9.4.1 Description

Figure 9.3: Reefton Sewerage Scheme



The Reefton combined sewerage/storm water scheme is shown in Figure 9.3 and can be described as follows:

- Sewage flows under gravity from homes, shops, offices and small businesses through the Reefton sewer network to the Reefton oxidation ponds;
- The Reefton oxidation ponds are under construction at the time of preparing this study. Until now sewage has discharged directly into Cemetery Creek to the Inangahua River. Once complete sewage will be treated in the ponds;
- The ponds consist of an aeration lagoon, followed by two maturation ponds. Treated effluent from the ponds will flow through a rock filter prior to being discharged to Cemetery Creek; and
- During light rain the combined sewage/storm water flow will enter the ponds. However, during heavy rainfall events the ponds are bypassed and the combined flow is discharged directly to Cemetery Creek.

The composition of pipes in the Reefton sewerage scheme is presented in Table 9.4.

Table 9.4: Composition of Pipes in the Reefton Sewerage Scheme

Pipe Material	Length	Percentage
Earthenware	6,717	72.87%
Reinforced Concrete	2,501	27.13%
Total Reticulation	**9,218**	**100.00%**

9.4.2 Vulnerabilities – Reefton Sewerage Scheme

Reefton experienced strong shaking in the Buller (1929) and Inangahua (1968) earthquakes and although reports are limited (refer Section 3.1.7) the water supply apparently survived the MM VIII shaking relatively well. It is likely that the sewerage scheme would have been similarly affected.

The developed area of Reefton, apart from the racecourse where the soils are more recent, is located on older glacial outwash material and river gravels. It is expected to be relatively stable i.e. Zone 2 even in strong earthquake shaking. Test bores results for the area where the oxidation ponds have been constructed also indicate that the ground is relatively stable i.e. Zone 2.

Based on the impact of the two previous earthquakes and details about the assets and ground conditions it is anticipated that in an MM VIII or greater earthquake the Reefton sewerage scheme could sustain the following damage:

- Reticulation pipeline failure. Projections of likely damage to entries and junctions in the reticulation network is presented Table 9.5;

  Table 9.5: Estimate of Likely Reticulation Entry & Junction Failure – Reefton Sewerage

Pipe Material	Length (m)	Projection of entry and junction failure
Earthenware	6,717	21.86%
Reinforced Concrete	2,501	1.36%
Total	**9,218**	**23.22%**

  From Table 9.5 it can be seen that approximately 23% of the entries and junctions may fail in the Reefton sewerage reticulation.
- Manholes structures may move particularly structures that are empty in saturated soils and that have not been designed for earthquake lifting forces. This movement is likely to cause pipe failure at manhole entries and exits; especially where joints are rigid. This may allow soil material to be washed into the pipes and structures.
- Reinforced concrete pipes in Caples Street have failed in the past. When the area of failure was excavated no pipe was found and instead just a tunnel in the soil. If other reinforced concrete pipes in Reefton have disappeared in a similar way, or even just been weakened, it is very likely

that the pipes (or remaining tunnels) could fail completely in an earthquake, blocking the flow. The reinforced concrete pipes are the large trunk mains in the sewer network. Widespread failure of these pipes could prevent sewage reaching the ponds at all.

Reefton is however located on sloping land it is likely that any surcharging will find an overland flow path (probably down streets) to nearby streams and waterways. The only known location where ponding may occur is in a low-lying area in the vicinity of Church Street between Anderson Street and Kelly Street. Ponding in this area may be a problem if there is significant sewer failure and significant rain falls in the short term after a major earthquake.

It is anticipated that there will be minimal or no damage to the oxidation ponds.

9.4.3 Upgrades & Improvements – Reefton Sewerage

The following improvements are proposed to address the vulnerabilities identified in the previous section:

- Undertake an assessment using CCTV cameras of the Reefton sewer pipes particularly the reinforced concrete pipes and prepare a renewal and upgrade program. It is noted that the low number of manholes in the system will make an assessment using CCTV difficult in some areas. It is understood that BDC propose to implement a number of new manholes in the system; and
- Undertake an assessment of public health risk posed by potential overland flow of sewage and ponding locations e.g. the Church Streeet area.

With the above improvements in place it is anticipated that recovery of the Reefton sewerage scheme will proceed as follows after a severe earthquake;

- Workmen will check the network for surcharging caused by sewer failures and ensure that they are discharged safely away. Ponding may occur to some degree in Church Street, however provisions will be in place to address this;
- The community will be notified not to use their WCs or discharge any other wastewater to the sewerage scheme. The community will be informed about setting up toilet facilities e.g. pit latrines at CD centres and at their own homes;
- The sewers servicing offices/buildings established to assist in the recovery effort, such as the hospital, will be made operable within 2 weeks undertaking repairs where necessary;
- If vulnerable pipes have been identified and replaced or upgraded before a major earthquake, damage to sewer pipes is likely to be minimal. However, there may still be some damage a joints and junctions. The sewerage pipe network will be progressively assessed using techniques such as CCTV assessment and contracts let to repair the scheme. Where repair is uneconomical, sewers

will be replaced. Stocks of disinfection chemicals will be maintained, both for those households that use pit latrines, and also for use following ponding or repair work.

9.5 Sewerage Scheme Improvement Schedule

Improvements identified in Section 1 are summarised in Table 9.6. Note the priorities and completion dates are provided as a guide only.

Table 9.6: Improvement Schedule - Sewerage

Importance[1]	Action	Completion date	Responsible
	General		
M	Review the proposed levels of service and strategy to ensure they are appropriate and achievable.	Dec '08	BDC/CDEM
M	Assess the remaining sewerage schemes in the District including non BDC schemes and document as for the Westport sewerage scheme	Dec '08	BDC
H	Establish a formal response plan for sewage disposal after a severe earthquake including: • Key tasks and those responsible for them. The plan should be flexible enough so that if some key personnel are not available the plan is still robust; • Backup plans, • Methodology for assessing damage and prioritising and managing repairs; • The location of as-built drawings, backup copies and updating requirements, and • Training requirements.	Dec '07	BDC/CDEM
H	Ensuring adequate spare parts are in stock to allow repairs to sewerage assets e.g. sewers from CD centres & CBD areas to be undertaken after the earthquake, and means for disinfecting areas polluted by sewage.	Dec '06	BDC
M	Discharge requirements of major wastewater contributors will be assessed and any necessary provisions put in place to manage identified problems with sewage flows immediately after the Alpine Fault earthquake.	Dec '08	BDC & major wastewater contributors
L	Review planned sewer pipe replacement and give priority to replacement immediately upstream of discharge points	Dec '10	BDC

1. H = High Priority; M= Medium Priority; L = Low Priority

Table 9.6: Improvement Schedule – Sewerage (continued)

Importance[1]	Action	Completion date	Responsible
	Westport		
M	Map the Westport sewer by pipe material and diameter and undertake a staged CCTV assessment of the network starting with primary sewer lines. Use this information to assist prioritising sewer replacement.	Dec '10	BDC
H	Replace the rising main from Carter's Beach to Westport.	Dec '08	BDC
H	Identify surcharge areas and assess the likely public health risk. Appropriate emergency discharge arrangements will be identified and implemented as required.	Dec '07	BDC
L	Undertake a geotechnical and structural assessment of all pump stations, quantify earthquake risks at each site and implement appropriate improvements to address these risks.	Dec '12	BDC
M	Determine the need for standby generators and purchase where need identified	Dec '10	BDC
	Reefton		
H	Undertake an assessment using CCTV cameras of the Reefton sewer pipes particularly the reinforced concrete pipes and prepare a renewal and upgrade program. Additional manholes are to be installed on the system to allow a complete CCTV inspection of the sewer network.	Dec '07	BDC
H	Undertake an assessment of public health risk posed by potential overland flow of sewage and ponding locations e.g. the Church Streeet area.	Dec '07	BDC

1. H = High Priority; M= Medium Priority; L = Low Priority

10 STORM WATER

Buller District Council manages two storm water systems: Westport and Reefton.

Reefton is a combined sewerage/storm water system and is discussed in Section 9.4.

There are other storm water infrastructure assets such as open channels and culverts. However, these are small and isolated and not considered as systems as such.

10.1 Level of Service – Storm Water Schemes

The minimum target levels of service to be provided to communities after a major earthquake are presented in Table 10.1.

Table 10.1: Levels of Service – Storm Water Schemes

Service Description	Target period for Achieving Level of Service			
	Community Category[1]			
	1	2	3	4
Emergency Level of Service Surface flood water will be safely managed and disposed of in communities not evacuated	3 days	3 days	3 days	1 days
Normal Level of service	12 months	12 months	8 months	6 months

1. Refer to Table 6.4: Township Importance Categories

The implication of the emergency level of service is that although storm water pipe networks and/or pump stations may have failed due to the earthquake there will be adequate emergency provisions in place, or that can be put in place in the target time period, to safely manage and dispose of storm water.

The target periods for achieving these levels of service apply to communities that are not evacuated. The target periods are measured from the time of the major earthquake occurring.

10.2 Strategy – Storm Water

The strategy for achieving effective recovery of storm water systems after the earthquake is as follows:

- In the short term no attempt will be made to repair storm water pipe networks. Prior to the earthquake areas will be identified where flooding is likely to occur particularly where it may hamper access to vital facilities e.g. the hospital, CD headquarters etc. Provisions will be in place to safely manage and dispose of surface floodwater as defined in Table 10.1;

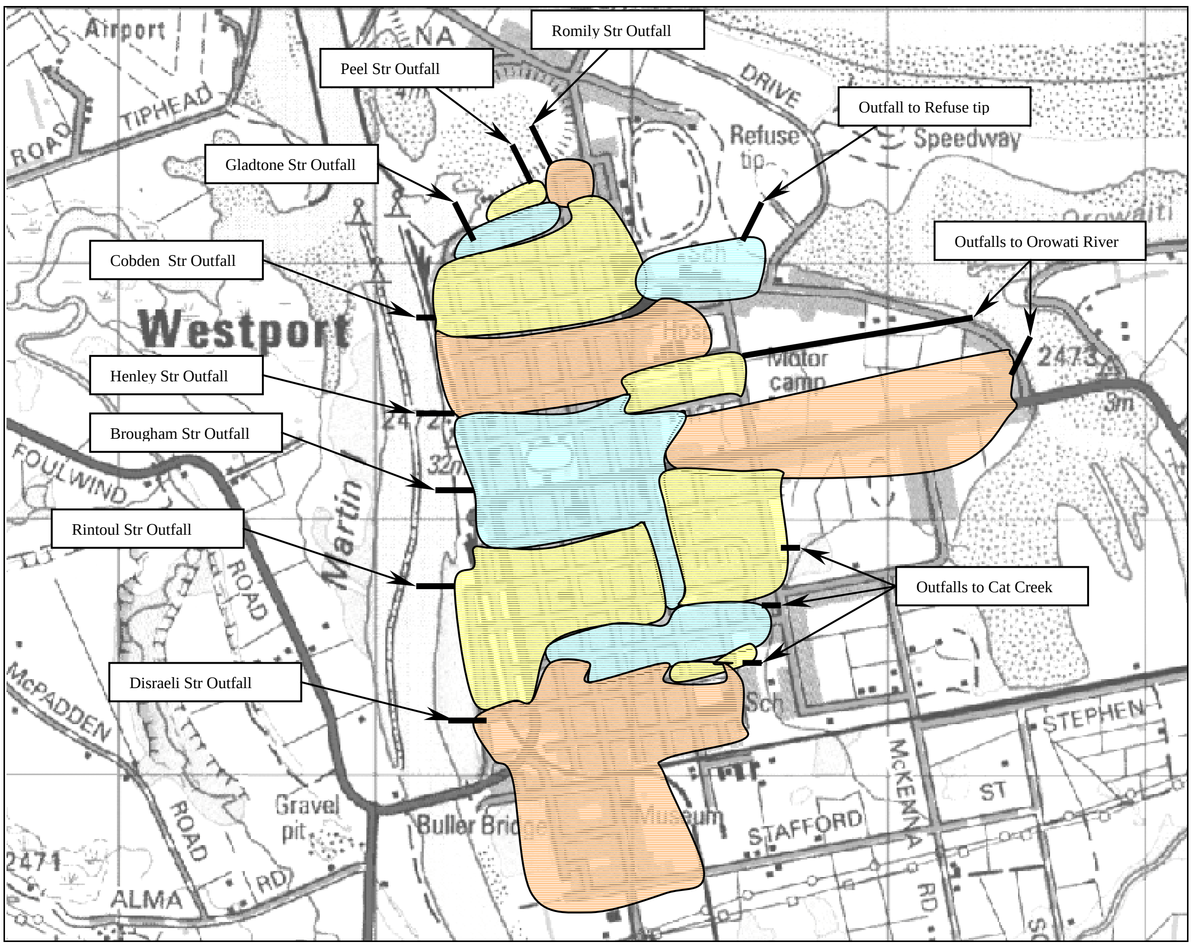
- Continue replacement of storm water system assets following normal asset management principles; and
- Ensure earthquake loads are adequately addressed in the development of new storm water systems.

In the following sections a detailed description is provided of the Westport storm water system, its vulnerabilities in the face of an MM VIII intensity earthquake and upgrades and improvements that can be made to address vulnerabilities. Details of the Reefton combined sewerage/storm water system are provided in Section 9.4.

10.3 Westport Storm Water

10.3.1 Description

Figure 10.1: Westport Storm Water System



The Westport storm water system can be described as follows:

- Westport storm water either discharges west to the Buller River (or tributaries of the Buller River) or east to the Orawati River (or tributaries of the Orawati River).
- Five storm water outfalls discharge directly to the Buller River and three discharge to The Lost Lagoon which flows into the Buller River.
- Two storm water outfalls discharge directly to Orowatti River, three to Cat Creek which flows into the Orowati River and one to the refuse tip which is adjacent to the Orowati River.

There are no storm water pump stations.

Carter's Beach is not included in the Westport Storm water system. It does not have a storm water system and instead relies on natural soakage.

The composition of the pipe network in the Westport storm water system is presented in Table 10.2.

Table 10.2: Composition of Pipes in the Westport Storm Water System

Pipe Material	Length	Percentage
Earthenware	16,100	70%
Reinforced Concrete	7,000	30%
Total Reticulation	**23,100**	**100%**

10.3.2 Vulnerabilities – Westport Storm Water System

In the event of the major Alpine Fault earthquake described in Part II it is expected that Westport will experience intensity MM VII shaking. In the event that there is an earthquake like the Buller earthquake or the Inangahua earthquake it is expected that Westport will experience intensity MM VIII shaking or greater.

Westport is located on geologically recent alluvial soils, with some ground settlement and distortion to be expected. In a strong earthquake (MM VII – VIII or greater) liquefaction can be expected in the area bounded approximately by Bright Street in the south and Forbes Street and Shelswell Street in the north. The remaining area of Westport is likely to sustain some settlement.

It is anticipated that the impact of the Alpine Fault earthquake on the Westport storm water system will be relatively small, with minor to moderate damage only. However, in the event of an MM VIII earthquake or greater the impact on the Westport storm water system is likely to be at least as significant as occurred in the 1929 Buller earthquake.

The alignment of pipes and manholes is likely to be affected particularly in the area of expected liquefaction. An estimate of the likely percentage failure of pipe entries and junctions is presented in Table 10.3.

Table 10.3: Estimate of Reticulation Entry & Junction Failure – Westport Storm Water System

Pipe Material	Length (m)	Projection of entry and junction failure	
		Optimistic	Pessimistic
Earthenware	16,100	30%	70%
Reinforced Concrete	7,000	5%	5%
Total	**23,100**	**35%**	**75%**

From Table 10.3 it can be seen that between 35% to 75% of entries and junctions may fail in the storm water system. It is also likely that some older earthenware pipes may fail completely.

It should also be noted that surface storm water is likely to be contaminated with sewage because of surcharging at failed sewage pump stations. It is also important to note that some areas are totally reliant on the storm water system operating effectively to discharge ponding sewage that surcharges from failed pump stations (refer Section 9.3.2).

10.3.3 Upgrades & Improvements – Westport Storm Water

The following activities are proposed to address the vulnerabilities identified in the previous section:

- Define key storm water pipelines and inspect (probably with CCTV cameras). Develop a key storm main replacement programme based on the assessment of pipe material and condition; and
- Undertake an assessment of public health risk posed by potential sewage surcharges combining with storm water and ponding where sewage pump stations fail (refer Section 9.3.2) and storm water pipes fail. Identify and implement appropriate emergency provisions.

With the above activities completed it is anticipated that recovery of the Westport storm water system will proceed as follows after a major earthquake;

- Emergency provision will be put in place or be permanently in place to ensure ponding storm water/sewage can be safely discharged e.g. temporary diesel powered waste water pumps or generators to drive sewage pumps;
- The storm water pipe network will be progressively assessed for earthquake damage using techniques such as CCTV assessment and contracts will be let to repair the system. Where repair is uneconomical, pipelines will be replaced.

10.4 Storm Water System Activity Schedule

Activities identified in Section 10 are summarised in Table 10.4. Note the priorities and completion dates are provided as a guide only.

Table 10.4: Activity Schedule – Storm Water

Importance[1]	Action	Completion date	Responsible
L	Review the proposed levels of service and strategy to ensure they are appropriate and achievable.	Dec '12	BDC/CDEM
L	Establish a formal response plan for storm water disposal after an Alpine Fault earthquake including: • Key tasks and those responsible for them. The plan should be flexible enough so that if some key personnel are not available the plan is still robust; • Backup plans, • Methodology for assessing damage and prioritising of repairs; • The location of as-built drawings, backup copies and updating requirements, and • Training requirements.	Dec '12	BDC/CDEM
L	Review planned storm water pipe replacement and give priority to replacement immediately upstream of discharge points	Dec '12	BDC
M	Define key storm water pipelines in the Westport storm water system and inspect (probably with CCTV cameras). Develop a key storm main replacement programme based on the assessment of pipe material and condition	Dec '10	BDC
M	Undertake an assessment of public health risk posed by potential sewage surcharges combining with storm water and ponding. Identify and implement appropriate emergency provisions.	Dec '10	BDC

1. H = High Priority; M= Medium Priority; L = Low Priority

11 OTHER LIFELINES

11.1 Telecommunications

11.1.1 General

(a) Landlines and Cellphones

Figure 11.1: Telecom Networks – West Coast

Telecom operates the largest landline system on the West Coast together with a cellular network and support services for other telecommunication companies. The integrity of the Telecom network, both landlines and mobile is managed from from Hamilton. The West Coast area is connected to the national network by three principal core or transport network paths. These are shown in Figure 11.1 and are described as follows:

- Between Greymouth and Nelson: a fibre optic cable routed to Stillwater on the Southern bank of the Grey River and subsequently along the main road of the Grey Valley to Reefton thence to Springs Junction over the Rahu Saddle and North to Nelson via Murchison;
- Between Greymouth and Christchurch: a fibre optic cable from Christchurch over the Arthur's Pass, then via Moana and Stillwater progressing down the northern bank of the Grey River and back over the Cobden Bridge into Greymouth;
- Between Westport and Reefton: There is a Digital Microwave Radio link to Mt Rochfort, repeatered to Reefton Radio and thence over fibre to the Reefton where there are links to Greymouth and Nelson.

Cables follow the major roads to link all the other towns and smaller centres in the region.

The three principal telephone exchange buildings are at Greymouth, Westport, and Hokitoka. They are generally built to a high standard and the equipment within is restrained in accordance with national Telecom standards. Back up power generation is provided in larger exchanges and back up battery banks in smaller exchanges.

In the event of failures of both core cables out of the region local calling will still work provided the exchange is operational, i.e. they don't need a link to the rest of the network to operate. The situation is similar with Fleetlink[5]. Fleetlink has good coverage, especially of tracts of the Lewis Pass and Arthur's Pass, and depends on the integrity of the landline network. However, the repeater sites will function in isolation from the network allowing emergency traffic locally in the event of a major earthquake.

Cellular and Paging are a different matter. These depend entirely on the survival of the fibre network to outside the region as each Cell Site requires a high capacity data link back to the Main switch centre in Christchurch to function. The normally survival time of the twelve Cell Sites is about 5 hours, except for Mt Rochfort and Westport which both have generators.

Clear Communications and Telstra Saturn provide an alternative service to telecom, but having no physical assets on the West Coast access their customers through the Telecom network. Both companies on-sell Vodafone mobile telephone services. Vodafone's use of GSM technology with its limited cell site coverage radius has required them to build many radio base station sites to achieve coverage. This has resulted in an extensive network of sites, connected with medium and low capacity back haul microwave links to carry the traffic to their cellular switch nodes.

[5] Fleetlink is a combined radio and telecommunications system used in vehicle fleets

Transpower operate a fibre-optic communication network over part of their power network. It is not known if this network extends into the Buller District.

While landline coverage extends over the whole region, the cell phone coverage is limited to relatively small areas around the population centres. The coverage areas, which are similar for both Vodafone and Telecom, are: Franz Josef; Whataroa – Harihari; Hokitika and a small area inland; Greymouth and a the Grey Valley as far as Moana and Ikamatua; Reefton and its immediate area; Springs Junction and the Maruia Valley; and the coastal area between Charleston and Granity, including Westport and extending inland to Stockton and Denniston.

(b) BCL

Broadcasting Communications limited (BCL) is a 100% owned subsidiary of Television New Zealand (TVNZ). BCL has a national transmission network, based principally on high capacity microwave radio between their high sites, with some fibre optic capacity. Their many high sites with high power TV and FM radio transmitters and lower level transposer and translator sites provide geographic coverage to over 99% of the population in occupied dwellings. However, this coverage reach is principally for VHF television transmission (one way transmission from a high power transmitter to adequate external, fixed antennas). The range of UHF TV transmissions is reduced due to increased signal propagation loss at the higher frequency.

On the West Coast, BCL operate a Digital Microwave Radio (DMR) link from Sewell Peak, north east of Greymouth, to Nelson, plus 26 “high” sites. These high sites comprise towers and supporting infrastructure and are classified (G1-G5) by the level of population coverage, linking capacity, back-up power capacity and the type of infrastructure. On the West Coast there are 3 G3 sites (Mt Rochfort near Westport, Reefton and Sewell Peak near Greymouth), 10 G4 sites and 13 G5 sites. In the Buller District, G4 sites are at Karamea, Maruia and Razorback (Punakaiki) and G5 sites at Waimarie, Seddonville, Hector, and Inangahua. Generally, the BCL infrastructure can be expected to be relatively robust in the face of a major earthquake.

We note, moreover, the increased use of direct satellite television broadcasting. As this trend develops, the ability of the local community to receive television broadcasts will become less dependent on land-based transmission infrastructure.

The BCL network could be utilised in an emergency for telecommunications if a link was placed between the Telecom facilities on Sewell Peak and those of BCL. Up to this point such an arrangement has not been considered due to commercial sensitivity considerations.

(c) Radio

Radio communication can provide backup in the case of telecommunications disruption or failure, and provide mobile communication to areas that are not accessible by the telecommunications network. (refer to West Coast CDEM for more details on emergency communications).

There is wide coverage over the West Coast by a number of Very High Frequency (VHF) radio networks. The Department of Conservation and St John operate through the VHF ES Band. Users of the VHF E Band include the West Coast Regional Council, Territorial Authorities, Timberlands West Coast and Electronet. These organisations have both base and mobile sets, with 105 vehicle and 225 hand held units over the whole of the West Coast. Repeater stations for VHF are at Mt Fredericks , Cronadun and Karamea (all WCRC), Mt Rochfort, and Mt Victoria (both BDC) and Mt Glasgow (BDC and DOC). Known black spots in VHF coverage occur in areas around Karamea, north of Granity, Seddonville, sections of the Coast Road between Westport and Greymouth and areas of the Rahu Saddle. Although these areas have been identified as not having VHF coverage by the Territorial Authorities, the Department of Conservation Network does cover these areas.

The CDEM HF radio network on the West Coast is managed jointly between the Ministry of Civil Defence and Emergency Management and the West Coast CDEM Group. Within Buller District there are sets at Reefton, Inangahua, Seddonville and Karamea.

Contact with offshore vessels has been identified as a potential means to access information or to get messages out of the region. The VHF marine frequency is compatible with new generation radios but only to the line of sight distance from repeaters. Once past line of sight, HF is required.

(d) Satellite Phones

Satellite phones are independent from terrestrial communication infrastructure and provide increased reliability for satellite phone to satellite phone use, provided that the phone location can sight the satellites. CDEM register have 3 satellite phones in Reefton (Police, St John, Airwest Helicopters) and one private satellite phone in Ikamatua.

11.1.2 Vulnerabilities

Local telephone service networks are mainly by underground cables using copper conductors. This type of reticulation is susceptible to damage, particularly to some types of cable that are now obsolete and more likely to give problems. Significant differential ground movement, which is common at bridge abutments, is likely to cause severe damage.

The core supply is via fibre optic cables installed in ducts, and microwave systems. The cables are vulnerable to fracture if there is significant ground movement i.e. liquefaction, in rock if movement occurs along rock joints, and at bridge abutments, and radio systems may have support structure failure or antennae misalignment as well as equipment damage. Damage may also occur where cables and ducts enter buildings due to differential movement. Also, buried cables are particularly vulnerable to earthquake induced landslip or subsidence. The trunk cabling is often attached to highway bridging and is vulnerable to damage due to approach settlement or structural damage.

Loss of electrical power for a long time will impact significantly on the telecommunications network. While key facilities have emergency generation, these are dependent on fuel supplies. Telecom exchanges with diesel generators and indicative survival times (assuming full diesel tanks) are as follows:

- Greymouth (120 hours),
- Hokitika (120 hours),
- Whataroa (240 hours),
- Westport (120 hours),
- Granity (240 hours), and
- Karamea (240 hours).

Alternative communication systems, including satellite phones, are reliant on batteries, and if power is cut for a prolonged period, it may not be possible to recharge batteries.

11.1.3 Effect of an Earthquake

It is expected that in an Alpine Fault earthquake, most of the telecommunication networks in the coastal area of Buller district will suffer little damage. The Reefton area will be more damaged, and network components in the Springs Junction area will be significantly damaged. This includes the fibre optic cable link to Nelson resulting in most of Telecom's services out of the region being shut down. This in turn includes all trunk landline, cellular and Fleetlink services out of the region. Alternative wire cabling from Inangahua to Murchison is likely to suffer less damage and be more accessible to repair than trying to reinstate the Springs Junction area in the first instance, but being much lower capacity than the fibre optic cables it could result in the Fleetlink system remaining inoperable. Moreover, once fuel for the back up generators runs out and batteries fail, exchanges will become inoperable and again all communications including Fleetlink will be lost.

Microwave links can be shaken out of alignment, requiring physical re-alignment. Back up batteries and generator fuel may be insufficient to last the period before mains supply can be re-instated, and exchanges and repeaters may fail through lack of power.

Telecom's priority would be to restore the "Core" routes as collectively they carry all of the communications to the West Coast. Specifically, as well as forming the backbone for the exchange networks, they carry Data (EFTPOS, Private Office Networks), Cellular (both Telecom and Vodafone) and other miscellaneous connections such as Paging and TeamTalk where those services require connection to a centralised server.

In parallel with restoring core routes Telecom would also be restoring the main exchanges at Greymouth, Hokitika, and Westport. Greymouth is the highest priority exchange as all of the minor exchanges rely on the survival of the Greymouth exchange for both connections outside of the West Coast and for inter-calling between themselves.

There after the priority would be to restore minor exchanges and remote line units such as Franz Josef, Whataroa, Paroa, Runanga, Reefton, Granity and Karamea would be stabilised, followed by the large number of electronic cabinets and distributed radio systems that are connected to these exchanges. Cellular restoration falls into this category.

A number of communications networks operate in the District; Telecom, BCL, satellite telephones, private operators, and there may be others. Identifying the extent, resilience and redundant capacity of all these networks is beyond the scope of this report. However it is vital information that should be made available to members of CDEM. Communications is identified as a most important lifeline in Section 6. CDEM members, including BDC, need to now work with the communication networks to allow optimal emergency planning to be undertaken now to maximise the number of potential communication options available in the response and recovery periods after the Alpine Fault earthquake.

11.1.4 Upgrades and Improvements

Although telecommunications lie outside the direct influence of BDC, there are some issues that BDC should encourage to have addressed.

- Establish better communications between organisations and companies with communication services on the West Coast, including the power companies, Telecom, DOC and Regional Council. Advise contact personnel to build relationships and co-operative effort before and after the earthquake;
- Establish who have VHF facilities and establish a common channel for use in emergencies;
- Telecom should ensure arrangements for a national level response, and train staff outside the West Coast on the nature of the West Coast network so that they can be effective in assisting recovery;

- Identify sites with interdependencies with other lifelines such as bridges. Also establish where access might be needed;
- Review access and fuel supplies to key facilities;
- Confirm that control equipment such as computers are properly restrained; and
- BDC to have access to satellite phones, and spare batteries or recharging facilities, as link to outside the district in the event that all other links fail.

11.2 Energy – Electricity

11.2.1 General

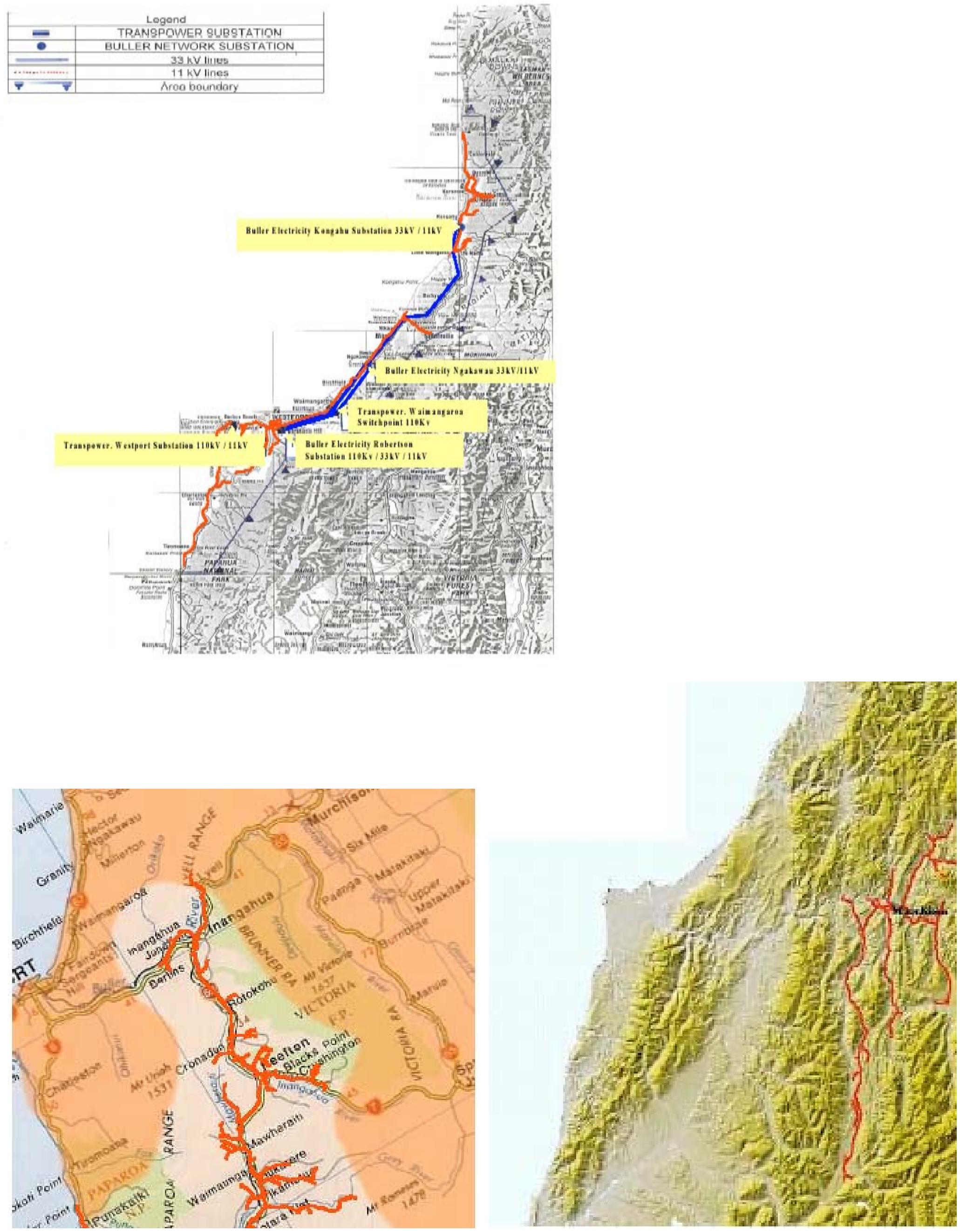
The Buller District is serviced by way of a Transpower high voltage transmission line from Murchison to Inangahua where it splits to Westport and Dobson, and thereafter by local distribution networks operated by Buller Electricity Ltd in the coastal area, Westpower (Electronet) in the Ikamatua – Reefton - Inangahua area, and Tasman Energy in the Maruia valley to Springs Junction.

The three distribution systems are not connected, with supply taken independently from the national grid at different locations. There are no distribution lines between Punakaiki and Meybille Bay, through the Lower Buller Gorge, and between Crushington and Springs Junction. There is no generation within the district and all power comes via the national grid that is operated by Transpower.

Trustpower operates power stations in Grey and Westland districts that supply the national grid and meets a portion Buller District's power demand. The remainder of the demand is met by other power stations in New Zealand that supply power to the national grid.

Transpower supply into the Buller District is from the north east down the Buller valley from the Kikiwa Substation. This supply is by two transmission lines in parallel with substations at Inangahua, Robertson St, and Westport (Cape Foulwind). The latter two substations supply the Buller Electricity network. The Inangahua substation does not supply the northern end of the Westpower network, but switches power to the Transpower 66kV line to Dobson. Transpower is currently upgrading the latter line to 110kV and Westpower is constructing a second 110kV line from Inangahua to Reefton. It is planned to build a new substation from the 110kV lines to the distribution system in Reefton as part of the new work for the Globe gold mine.

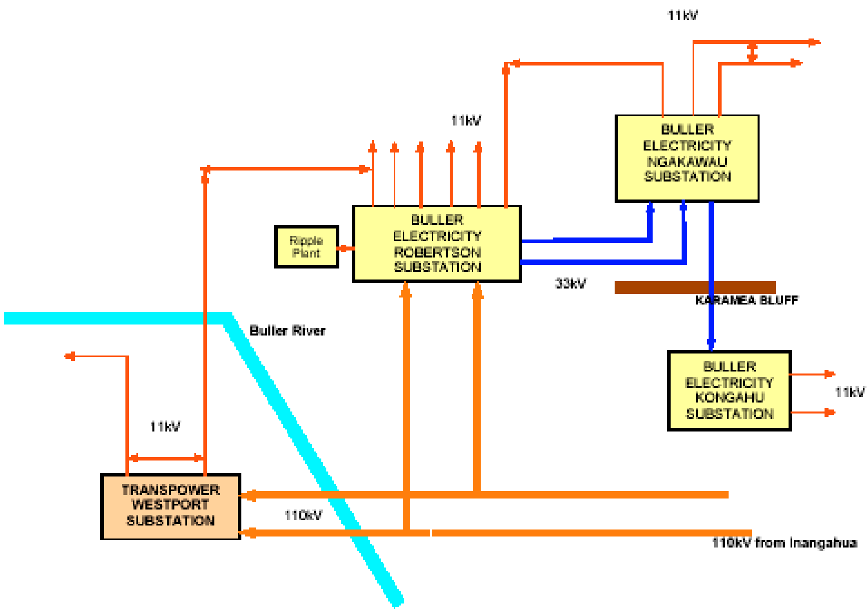
Figure 11.2: Power Networks – Buller District



(a) Buller Electricity Ltd ***(b) Westpower*** ***(c) Network Tasman***

Buller Electricty Ltd (BEL) network extends from Meybille Bay in the south to Karamea in the north. It is essentially a linear network, supplying electricity via about 575 km of power lines and cables to about 4170 customers, of whom only a few are major industries, with an average combined maximum demand of 7 MW.

Figure 11.3: Buller Electricity Ltd Network



Flow Chart of Transpower Grid Exit Point and Buller Electricity Zone Substations

BEL receives power from the Transpower grid at Westport, Robertson St and Cape Foulwind (Westport). The Cape Foulwind substation feeds two 11kV feeder lines, one of which is interconnected with a feeder in Westport. Two 33 kV feeders supply the Ngakawau zone substation from Roberston Street, with a tee-off at Ngakawau supplying the Kongahu zone substation near Karamea. The latter line traverses the Karamea bluff

11 kV feeder lines radiate from each zone substation, and are predominantly overhead. Some interconnection is possible in the urban areas. The 13 feeders supply 557 distribution transformers, which range from pole mounted 5 kVA units to 750 kVA units on the ground. The 230/400 volt reticulation is mainly overhead. The replacement cost of the system was valued at $33.5 million in December 2004.

BEL's major substations are all new and incorporate modern seismic design. The Robertson Street substation was built in 2004 with two 20 MVA transformers, the Ngakawau substation in 2005 with two 2MW transformers and Kongahu in 1995 with one 2 MW transformer. There are two 400KW generators at the Kongahu substation for planned and unplanned outages on the single 33 kV line supplying the Karamea area over the Karamea Bluff. As the existing peak demand at this station is 1MW, the two generators can supply the bulk of the district demand.

Table 11.1: Buller Electricity Ltd Distribution Lines

Feeder	Voltage (kV)	Length (km)	Type	Customers	Date	Condition	Comment
Meybille bay	11	25	Rural	25	1987	Good	
Cape	11	38	Rural	131	1965 on	Good	Ring connected to Carters
Carters	11	57	Rural	330	1965 on	Good	Dual circuit Cape Foulwind to Buller R. 2km gap to Cape feeder to be closed
Russell	11	4	Urban	594		Good	
Derby	11	5.2	Urban	966		Good	
Pakington	11	6.5	Urban	561	1998 upgrade	Good	
Domett	11	6.6	Urban	466		Good	
Whareatea	11	50.4	Urban	365		Good	60% dual circuit with 33kV
Waimangaroa	11	35.6	Rural	207		Average	30% dual circuit with 33 KV. Mt Rochfort section supplies Buller communications translator.
Solid Energy	11	-	Rural	2		Good	Line to Stockton mine owned by Solid Energy
Seddonville	11	22	Rural	261		Average	50% dual circuit with 33kV
Little Wanganui	11	20.5	Rural	94		Good	20% under 33kV
Karamea	11	58	Rural	305		Good	
NGKW/Km 1	33	45	Rural	410	1965 approx	Average	Rugged terrain spans up to 1km, highest outage line
Rob/NGKW 2	33	31	Rural	468		Good	
Rob/NGKW 1	33	31	Rural	468		Good	

BEL has considered seismic risks to the network. The Asset Management Plan states that BEL carried out a comprehensive in-house review in 2000, and has been involved with the BDC Civil Defence team. Seismic risks were mitigated through a redesign and refurbishment process at Kongahu and Robertson Zone substations.

Being a largely linear system, any breaks in a feeder line could affect a large area. The only areas with some redundancy are the two 33 kV lines to the Ngakawau substation, six 11 kV feeders supplying Westport and the dual supply to Carter's Beach line. An interconnection is planned between Carter's Beach and Cape Foulwind feeders. Urban overhead substations will be replaced with ground mounted units. The most vulnerable section is clearly the line over the Karamea Bluff, but BEL has standby generators at Kongahu. One of the two 400 kW generators, which were installed in 2005, will be upgraded within the next few years with a 650 kW unit mounted on a trailer for use during emergencies. A container is also planned to be installed for station and line spares.

BEL has a SCADA control system installed in 2002. BEL has three repeater stations to provide SCADA control to 90% of the switch sites.

Westpower network consists of a 33kV single circuit line from Dobson to Reefton and a 11 kV distribution system following the state highways and with short spur lines. Currently it is vulnerable as this system has no redundancy of supply. However Westpower is planning to build a new substation in Reefton to supply the new Globe gold mine, which will strengthen this supply area considerably. The majority of the distribution network is overhead on concrete poles, although there are parts of Reefton with overhead wires on old timber poles and some streets with underground cable. Westpower has a risk management section in the Asset Management Plan. A seismic withstand report was prepared in 2004 for most zone substations and strengthening has started on identified weaknesses. In the event of a transformer failure, the system can be reconfigured to allow a unit to be redeployed from elsewhere on the network. A mobile 33/11kV substation is also being constructed.

Network Tasman supplies power to the Maruia valley and Springs Junction area by a 80km long 11 kV feeder from the Transpower substation at Murchison, which parallels the main road. This line is one of the longest 11kV feeder lines in the country. To limit voltage swings at Springs Junction, a capacitor bank was installed at Springs Junction in 2003 and a second regulator in 2004. Network Tasman is also upgrading the line to carry 22kV. Network Tasman has a risk management plan. The effect of major earthquakes on overhead and underground distribution substations was reported on in 1998. A mobile 1,250kVA generator is available for emergency power supply (location not known but presumably in the Nelson-Richmond area).

Trustpower owns and operates a number of power stations on the West Coast in Westland and Grey Districts at Wahapo (1 station), Kaniere (2 stations), Dillmans (3 stations), and Arnold (1 station). On their own these stations can provide between 40% to 60% of the present electricity demand on the West Coast.

The Trustpower power station feed power into the national grid. Under normal operating conditions the national grid provides synchronisation, however the station are able to operate without synchronisation from the grid. Wahapo, for example, is often used to supply Franz Josef and Fox on its own when that network is isolated from the national grid. The power station at Kumara has capacity to produce 6 Megawatts, however, without national grid synchronisation, although it could be made to provide some power, it would be significantly less than 6 Megawatts, and possibly only about 1MW.

11.2.2 Vulnerabilities

Vulnerabilities to electrical supply include:

- Damage to generation or transmission lines remote from the district, which has no generation capacity within its boundaries;
- Damage to transformers from being unrestrained for seismic loads;
- Damage to substation buildings and their contents because of poor seismic performance;
- Failure of brittle components in substations such as bushings and insulators;
- Damage of switchgear and control panels because of inadequate supports;
- Cable damage at points where they pass from ground into or onto structures (such as buildings and bridges);
- Poles being carried away or pushed out of alignment by landslides;
- Poles carrying overhead wires moving out of alignment due to soft ground, which in turn could break insulators and lines; and
- Pole mounted transformers exerting large seismic forces and breaking the supporting poles.
- Damage to emergency generators, loss of fuel supply or loss of access to them for refuelling or operating staff.
- Damage to control equipment such as computers if not properly secured.
- The linear nature of the power supply in Buller increases the vulnerability, as one fault makes the whole system "downstream" inoperative.

For the Alpine Fault scenario, the electricity system will be affected. Shaking of intensity MM VIII or greater can be expected to result in damage to both overhead and underground reticulation with simultaneous faults in many areas.

A major vulnerability is the Transpower supply lines, as the Transpower network, and the major generating plants in the South Island will be affected. Transpower has comprehensive emergency management procedures to manage outages and restore service. It has a policy of diversification of equipment and spares storage and has temporary transmission towers available. The reinstatement goal is for at least partial service within five days following a major disaster. However in an Alpine Fault earthquake, Transpower resources are expected to be stretched with widespread damage around the Upper Waitaki generation and transmission facilities, and the transmission lines and access to them in the mountainous areas of Canterbury, Marlborough, Nelson and Westland. The twin transmission lines from Kikiwa to Inangahua may survive with minimal damage, provided landslide damage does not destroy any towers. The towers are well founded, and those west of Murchison have been tested in the 1968 Inangahua earthquake with shaking intensity of MMVIII or greater. The transformers at

Inangahua have had their seismic restraint recently strengthened, but the inherently brittle components in switch yards such as bushings and insulators could be damaged. It could be several days before any power can be supplied to Kikiwa from the main South Island hydropower schemes.

Intensity MMIX shaking (or greater) in the Springs Junction area will cause damage to the long 11 kV feeder, both from equipment damage and loss of poles from landslides. Network Tasman resources will be stretched with damage elsewhere in the system. Although damage elsewhere will be less severe, the number of people affected will be much greater than in Springs Junction, and hence reinstatement of the Springs Junction feeder may be low on their priority list, as well as much more difficult because of access constraints. It may well take many days for power to be restored to this part of the district.

The Reefton – Inangahua area will suffer damage with MMVIII shaking. With the upgrades in the high voltage supply to the area, security will be greatly enhanced within the next couple of years. Some damage must be expected, but at least a reduced service should be possible once the national grid power into the district is made live again.

The BEL system along the coastal area is likely to suffer only minor damage in an Alpine Fault earthquake. Some pole damage is possible, particularly in the northern area of Westport susceptible to liquefaction. The constraint to re-establishing supply to most of the system will be the time needed to re-establish Transpower grid power.

For more severe shaking from an earthquake centred close to or within the District, damage is expected to be more severe, particularly from landslides affecting both poles and towers and access roads.

11.3 Fuels

The availability of an adequate fuel supply for vehicles, generators and aircraft is a critical issue both immediately after an earthquake and in the longer term. The source of fuel supply varies with each of the five fuel companies operating in the West Coast. The five companies presently operating in the area are Shell, Caltex, Mobil, BP and Challenge.

Supply is by road tanker on an as needed basis. The only fuel stock is that within the service station tanks and tanks operated by private companies such as contractors and miners at any one time. There is no strategic fuel supply held in the West Coast following the removal of the Caltex tank farm in Karoro. The companies routinely supply the West Coast from Christchurch via Arthur's Pass or the Lewis Pass, or from Nelson via Murchison.

The likely damage to the road network, both within the region and to the road links out of the region is such that it could well be several days to a week before fuel can be supplied by road to Buller District from Nelson. This will place severe constraints on fuel availability. Alternative supply methods could be by sea or air. It could take three days or longer for mobilization, loading and travel of a suitable barge and tug to enable fuel to be brought into the Port of Westport, from New Plymouth for instance. Air transport could bring in limited amounts to Westport.

The storage of such fuel would have to be considered. There are service station holding tanks and there are also likely to be at least some road tankers that could be used for temporary storage. In addition to this, it may be possible to use other private storage such as transport firms or borrow some transportable type of above ground fuel storage tanks from mines sites etc in the area.

While the electricity supply is lost, it will not be possible to remove fuel from existing underground fuel tanks service stations. Alternative methods of retrieving fuel, such as portable generators, should be established before a major emergency. Security of fuel will be another issue, to ensure that remaining stocks are conserved and used for essential purposes and not removed by individuals.

11.3.1 Effect on BDC

Ideally, sufficient fuel would be stockpiled to enable the generators to function for a period of approximately five days under the required operational loading. The BDC should also ensure that an adequate supply of fuel is available following an earthquake in order to ensure that the necessary plant and equipment can be operated for up to one week. This may include provision of some means of extracting fuel from underground tanks in the absence of a mains electricity supply e.g. portable generators and the ability to connect them up.

11.4 Other Lifelines Improvement Schedule

Improvements identified in Section 11.1 to Section 11.3 are summarised in Table 11.2. Note the priorities and completion dates are provided as a guide only.

Table 11.2: Improvement Schedule –Other Lifelines

Importance[1]	Action	Compeltion date	Responsible
	Telecommunications		
H	Establish better communications between organisations and companies with communication services on the West Coast, including the power companies, Telecom, DOC and Regional Council. Also determine telecom interdependencies with other lifelines e.g. bridges.	Dec '06	Telecom/ BCL/DOC / Transit etc
H	Confirm who have VHF facilities and establish a common channel for use in emergencies.	Dec '06	BDC
H	Telecom to ensure arrangements for a national level response, and train staff outside the West Coast on the nature of the West Coast network so that they can be effective in assisting recovery.	Dec '07	Telecom
H	Review access and fuel supplies to key telecommunications facilities.	Dec '07	BDC
H	BDC access to satellite phones and spare batteries as link to outside the district.	Dec '07	BDC
	Power		
M	Continue programme of upgrading and renewing equipment, buildings and communications to minimise vulnerability to earthquake damage. (Transpower, Buller Electricity, Westpower, Tasman Energy).	On-going	
H	Establish better communications between organisations and companies in the power sector on the West Coast, including the communication companies, Telecom, DOC and Regional Council. Also determine power supply interdependencies with other lifelines e.g. bridges, road access etc	On-going	Transpower/ Buller Electricity/ Westpower /Tasman Energy /Transit etc
	Fuel supply		
M	Consider alternative methods of supplying fuel to the area (eg barge).	Dec '07	Fuel co's
H	Consider means of extracting fuel from service station tanks in the absence of mains power e.g. small petrol generator to drive fuel pumps or manual pumps.	Dec '06	Fuel co's
H	Consider forming database of available fuel storage tanks in the area that could be used in emergency.	Dec '07	BDC
H	Consider providing sufficient fuel for emergency generation to keep basic services operational.	Dec '07	BDC

1. H = High Priority; M= Medium Priority; L = Low Priority

12 SUMMARY

12.1 Introduction

This report aims to raise issues and make recommendations as to what should be done to make the Council and hence the community better able to withstand the effects of a major earthquake disaster and to recover from it more effectively. It focuses primarily on lifelines; the network services of water, sewage, transport, power and communications which are essential to the functioning of a community. However, it also considers some broader issues such as leadership, which have been shown to have a major effect on the ability of a community to recover.

In order to help understand the likely effects of an earthquake and what can be done to reduce its effects, we have used a scenario approach. Thus, we have postulated a major earthquake on the Alpine Fault, and explored its consequences. It is important to realise that we are **not suggesting** that this is the earthquake that will actually occur. Any actual earthquake will be different from the scenario earthquake. However, there is no doubt that some day, a major earthquake will occur and the community must be as ready for it as possible.

Accordingly we have developed the Alpine Fault earthquake scenario as a means of, or tool for, exploring the issues and their relative importance. The scenario was developed in two stages. The first considers the physical effects of the earthquake and what it does to the lifelines. The second stage looks at the effects on people and their likely responses and needs with the aim of further teasing out the community needs and priorities and of improving our understanding of them.

This summary provides the following:

- Comments on general issues arising from the study,
- Summaries of our recommendations on things to be done of a generally concrete nature,
- A list of things that have to be determined, and
- Matters to be addressed; that is, to be considered and resolved, and where we ourselves cannot give a definitive recommendation as to what should be done.

12.2 General Issues

When considering lifelines and appropriate response to disaster, various issues need to be considered which are general and overarching, and are at a broader level than the individual lifelines. Most have been mentioned in passing in the report, but here we draw them together. They are discussed here under the headings of interdependence, ordering, leadership, communication, attitude and applicability.

12.2.1 Interdependence

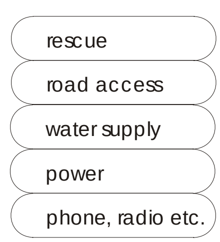
The various services and lifelines are not independent but are connected in various ways. Some are more obvious than others. It is important to take the interdependencies into account in the response and recovery stages of disaster management, and this requires that they are well understood beforehand. Protocols and linkages will have to be established in preparation. Because the interdependencies can be subtle in their detail and will be very dependent on the actual situation on the ground, we cannot, in this report, give a comprehensive review. Rather, we recommend that the matter be considered carefully by the groups and individuals concerned, possibly by means of a workshop.

Some possible interdependencies are, in no particular order:

1. Road access requirements and constraints;
2. Common causes of failure. For instance, a slip might take out telecommunications, water and other services as well as roads, or a bridge failure might do the same;
3. Failure of backup. For example, under normal conditions if sewer pumps or pipes fail surcharging sewage would flow over land and drain via the storm water system. However, in a strong earthquake the storm water system might also have failed;
4. Dependence on a common need for contractors, plant, personnel, equipment, materials, fuel, transport (surface and air) and so on;
5. Storage and accessibility of information;
6. Facilities which need several services to be up and running in order to function effectively – a hospital, for instance; and
7. Information channels.

12.2.2 Ordering and prioritisation

There is likely, for each situation, to be a "stack" of things to be done in order of priority, for instance:



The order of the stack, and its components, will be different for different situations; and for any one location, it will change with time. The changing nature and order of priorities must be borne in mind as it could easily be forgotten in the stress of disaster response. It would be helpful to establish typical stack orderings beforehand.

12.2.3 Leadership

The importance of leadership in a crisis was emphasised by participants in the Punakaiki workshop. Following the September 11 terrorist attacks on the New York World Trade Centre, the city resumed its basic functioning in a remarkably short space of time. A major reason for this was the leadership shown by the Mayor, Robert Giuliani. He was able to make strategic decisions, and to be seen to do so, while at the same time not being involved in detailed direction of the response effort. This is in contrast to the situation in New Orleans following hurricane Katrina, where lack of leadership by the mayor, the governor of the state and at the national level by the Bush administration turned a serious disaster into a national catastrophe.

The two quite separate results of good leadership are sound co-ordination and direction of response and reconstruction efforts, and heightened morale among all stakeholders. Both are important, but their implications are different. A great deal of the effort in response, co-ordination, and direction lies in fairly technical issues and requires management and administrative skills. On the other hand, heightened morale can only come through good communication – see the points made in Section 12.2.4 below. In our view, sound administration and high morale are both equally important in achieving a good outcome following a disaster.

Clearly, there are two distinct leadership roles. There is an analogy here with leadership in a company, where the Chairman of the Board and the CEO have different and complementary parts to play. At the District level, the two roles could well be played by the mayor and the chief executive. In both cases, a thorough consideration must be given beforehand to the responsibilities and expectations of the roles. The present report necessarily focuses more on the managerial and technical aspects of response and recovery. Nevertheless, we strongly recommend that the requirements of strong post-disaster leadership be thoroughly explored by such means as workshops, exercises and, noted below with regard to communication, the engagement of expert help.

12.2.4 Communication

Communication is of paramount importance. It has many aspects and issues. Controllers need to know what is happening, and so in fact do all stakeholders. Instructions, assessments, information, requests all need to be routed to the right recipient. Leaders need to be seen and heard to be leading. And those operating locally need to be aware of the overall extent of the disaster and the wider situation outside their own area. The three main aspects to be considered are:

1. WHO needs to communicate, and to WHOM?
2. WHAT needs to be communicated, and WHY?
3. HOW is the communication to be achieved?

Some other points to be considered are that:

1. Communication requires a sender, a receiver and a message. All three must be clearly understood;
2. Communication should ideally be in the form of a three-way loop. The sender sends the message. The sender then needs to know that the receiver has received the message. The receiver then needs acknowledgement that his or her response has been received. Of course, all three legs are not always possible or even expected;
3. It is easy for a message to be blocked or distorted by emotional factors, prejudice etc;
4. When communicating with the public, great care needs to be taken to use the right language, and to convey the right message. Facts are seldom sufficient. Considerable skill is needed here.

It should be noted that these points are only touched on briefly. They could be expanded at length as the issues are complex and much work has already been done on them by others. However, both because we see our role as identifying the issues rather than providing detailed and case-specific solutions, and also because we ourselves do not claim to be experts in the area, we have not pursued the matter further.

Nevertheless, because good communication is so centrally critical following a disaster, it is strongly recommended that;

- The above issues should be thoroughly explored where they relate to technical communication between personnel and organisations in the response and recovery periods; and
- Expert-led training sessions should be held regarding post-disaster communication with the public, with a particular emphasis on those who would be expected to provide community leadership.

12.2.5 Attitude

There are two particular attitudes, which are helpful if not vital for all those involved in disaster response and recovery. They are adaptability and co-operation.

Adaptability is necessary because every emergency is different and has aspects, which have never before been encountered. Moreover, it is likely that key people will not be available, records will be missing and so on. The best approach is to expect the unexpected. We believe that the culture of the West Coast is such that people are used to adapting to the conditions they meet in creative ways, and this will stand them in good stead in a disaster.

They will also need to co-operate. Individuals will have to work together, and so will organisations. Co-operation does not always come naturally in today's competitive corporate world, at least in the West. In an emergency, of course, organisations will co-operate fully. However, it is also important to co-operate beforehand in the preparatory stage. Information should be shared and joint plans of action worked out, together with protocols of what should be done. In this regard we would encourage joint civil defence workshops as well as one-to-one discussions.

12.2.6 Applicability

The final general point to be made is that the issues raised here relate to any major disaster, and not just the Alpine Fault earthquake which is, as we have said, merely an arbitrary scenario to help identify what needs to be done to help respond to and recover from a disaster. Some of the things we have said do indeed relate specifically to earthquakes, and this must be so in that a major earthquake will certainly hit all or part of the West Coast at some stage. Nevertheless the general points we have made, and also many of the detailed recommendations, will apply to any disaster.

12.3 Things to be determined

Here we list recommendations for things that have to be found out or assessed, or where plans must be developed. Note the priorities and completion dates are provided as a guide only.

Importance[1]	Activity	Completion date	Reference
	Transportation		
H	***General*** Establish fast and flexible contract procedures with contractors, and establish availability of professional engineers where appropriate.	Dec '06	Table 7.4
	Airport		
M	Westport Airport – Determine the seismic resilience of the airport, including building contents and power supply. Westport and Karamea – Assess seismic resilience of access particularly of bridges	Dec '11	Table 7.4
	Roads & Bridges		
M	With other stakeholders screen SH 6 between the West Coast and Nelson and SH 7 over the Lewis Pass for vulnerabilities and prioritise works that might reduce risk to earthquake damage.	Ongoing	Table 7.4
H	Prepare a route hazard map to determine roads, which may become damaged or impassable in an earthquake.	Dec '07	Table 7.4
H	Determine key routes in the District with Transit and identify bridges which are of critical importance to the BDC with respect to access and /or other services	Dec '06	Table 7.4

1. H = High Priority; M= Medium Priority; L = Low Priority

Importance[1]	Activity	Completion date	Reference
	Roads & Bridges (Continued)		
H	Undertake a structural audit of bridges and road structures on key routes and prepare a plan based on the audit to progressively upgrade bridges & road structures. Prioritising structures should proceed using critieria such as that suggested in Section 7.2.5 and should include particular attention to multiple use bridges carrying other lifelines.	Dec '07	Table 7.4
	Port of Westport		
M	Have the ground tested to determine the potential for liquefaction in the port area	Dec '10	Table 7.4
	Railway		
L	Assess in more detail the likely time required to restore rail access to Canterbury.	Dec '15	Table 7.4
	Water Supply		
M	Assess the remaining water supplies in the district to determine vulnerabilities and improvements required	Dec '08	Table 8.8
M	Prepare a list of emergency centres and essential businesses/industry that will require a water supply as a priority after the earthquake	Dec '08	Table 8.8
M	Identify key mains and establish a program to strengthen them	Dec '08	Table 8.8
H	Determine spare parts requirements and strategic storage locations	Dec '06	Table 8.8
	Westport Water Supply		
M	Undertake a geo-technical assessment of the reservoirs and treatment plant to determine vulnerabilities in an earthquake and identify improvements	Dec '08	Table 8.8
M	Assess the concrete main from the storage lakes to the treatment plant and determine options for earthquake strengthening	Dec '09	Table 8.8
	Reefton Water Supply		
M	Undertake a geo-technical assessment of the reservoir to determine vulnerabilities in an MM VIII earthquake and identify improvements	Dec '08	Table 8.8
	Sewerage		
M	Assess the remaining sewerage schemes in the district including non-BDC schemes to determine vulnerabilities and improvements required	Dec '08	Table 9.6
H	Ensure adequate spare parts are in stock to allow repairs to sewerage assets and adequate means to disinfect areas polluted by sewage.	Dec '06	Table 9.6
L	Review planned sewer replacement and give priority to replacement immediately upstream of discharge points	Dec '10	Table 9.6

1. H = High Priority; M= Medium Priority; L = Low Priority

Importance[1]	Activity	Completion date	Reference
	Westport Sewerage		
M	Map the Westport sewer by diameter and material. Underatake a staged assessment of the network and use the information gathered to prioritise sewer replacement	Dec '10	Table 9.6
H	Identify surcharge areas and assess likely public health risk. Determine appropriate emergency discharge arrangements	Dec '07	Table 9.6
L	Undertake a geo-technical assessment of pumps stations and determine vulnerabilities in an earthquake and identify improvements	Dec '12	Table 9.6
M	Assess the need for standby generators and purchase where need identified	Dec '10	Table 9.6
	Reefton		
H	Undertake an assessment of the Reefton sewer pipes particularly the reinforced concrete pipes and prepare a renewal and upgrade program.	Dec '07	Table 9.6
H	Undertake an assessment of public health risk posed by potential overland flow of sewage and ponding locations e.g. the Church Streeet area.	Dec '07	Table 9.6
	Storm Water		
L	Review planned storm water pipe replacement and give priority to replacement immediately upstream of discharge points	Dec '12	Table 10.4
	Telecommunications		
H	Determine telecom interdependencies with other lifelines e.g. bridges	Dec '06	Table 11.2
H	Review access and fuel supplies to key telecommunication facilities.	Dec '07	Table 11.2
H	BDC access to satellite phones and spare batteries as link to outside the district.	Dec '07	Table 11.2
	Fuel Supply		
M	Consider alternative methods of supplying fuel to the area (eg barge).	Dec '07	Table 11.2
H	Consider means of extracting fuel from service station tanks in the absence of mains power e.g. small petrol generator to drive fuel pumps or manual pumps.	Dec '06	Table 11.2

1. H = High Priority; M= Medium Priority; L = Low Priority

12.4 Things to be Done

This table lists recommended actions to be taken.

Importance[1]	Activity	Completion Date	Reference
	Transportation		
M	Westport Airport – Implement measures determined from the seismic assessment to the airport can function within a short time following an earthquake	Dec '11	Table 7.4
H	Prepare a road and bridge damage assessment strategy to be followed after a major earthquake to quickly identify, prioritise, and manage immediate clearing and repairs.	Dec '06	Table 7.4
H	Establish a database of owners and operators of earthmoving resources	Dec '06	Table 7.4
H	Undertake a structural seismic audit of all district bridges starting with bridges on critical routes. Undertake a survey of remaining significant structures from most to least important.	Dec '07	Table 7.4
	Water Supply		
H	Prepare a formal response plan for water supplies after a significant earthquake	Dec '07	Table 8.8
	Westport Water Supply		
L	Install provisions for generator power supply at the new Orowati River high lift pump station and the treatment plant.	Dec '10	Table 8.8
M	Install burst control valves at the raw water storage lakes and the treated water reservoir.	Dec '08	Table 8.8
H	Review equipment restraints at the treatment plant	Dec '06	Table 8.8
M	Review and document the location of shut off valves and confirm their maintenance schedule	Dec '12	Table 8.8
	Reefton Water Supply		
M	Install burst control valves on the Reefton reservoir.	Dec '08	Table 8.8
M	Replace existing key mains with more earthquake resistant pipe material.	Dec '12	Table 8.8
H	Review restraint of equipment at the pump house	Dec '06	Table 8.8
	Sewerage		
H	Prepare a formal response plan for sewage disposal after a significant earthquake	Dec '07	Table 9.6
	Westport Sewerage		
H	Replace the rising main from Carter's Beach to Westport	Dec '07	Table 9.6
	Storm Water		
L	Prepare a formal response plan for storm water management after a significant earthquake	Dec '12	Table 10.4

1. H = High Priority; M= Medium Priority; L = Low Priority

Importance[1]	Activity	Completion date	Reference
	Telecommunications		
H	Telecom to ensure arrangements for a national level response, and train staff outside the West Coast on the nature of the West Coast network so that they can be effective in assisting recovery.	Dec '07	Table 11.2
	Power		
M	Continue programme of upgrading and renewing equipment, buildings and communications to minimise vulnerability to earthquake damage. (Transpower, Buller Electricity, Westpower, Tasman Energy).	On-going	Table 11.2

1. H = High Priority; M= Medium Priority; L = Low Priority

12.5 Things to be addressed

Importance[1]	Activity	Completion Date	Reference
	Leadership and Communication		
H	***Improve understanding of leadership and communication issues*** Responsible: CDEMG Consider how communication can best be achieved after a major earthquake. Consider running a seminar/workshop on leadership and communication issues.	Jun '07	Section 9
H	***Improve understanding of how outside help will be co-ordinated, serviced and directed.*** Responsible: CDEMG What are the priorities? What will be the best way to communicate? What requirements will they have for accomodation, food, transportation, and fuel?	Jun '07	Section 9
M	***Improve understanding of how lifeline services repair will be co-ordinated*** Responsible: CDEMG with advice from Lifelines group Which lifelines should be repaired first? How will the Council get plant and manpower to where it is needed? How will plant and manpower be prioritised and managed? What assessment and monitoring strategies and means need to be put in place?	Dec '10	Section 9
L	***Establish how building/housing repairs will be co-ordinated*** Responsible: CDEMG and Council Regulatory Department How will material supplies (window glass, timber etc) along with plant, manpower and supplies be controlled and managed? Who will undertake inspections of buildings and what will be the priority? How activities that would normally require a consent be approved during the response and recovery periods?	Dec '12	Section 6

1. H = High Priority; M= Medium Priority; L = Low Priority

Importance[1]	Activity	Completion Date	Reference
	Transportation		
L	Establish a database for major cuttings and embankments so that a programme of progressive upgrading and improvements can be established and periodic inspections can be formalised.	Dec '12	Table 7.4
H	Establish contacts with Transit and ONTRACK for good co-operation after an earthquake	Dec '06	Table 7.4
H	Determine the likelihood of the crane being operational at the Port of Westport after a major earthquake and look at alternative backup options.	Dec '07	Table 7.4
H	Consider forming an emergency plan with fuel companies for supply via the Port of Westport and ONTRACK	Dec '07	Table 7.4
H	Consider some form of emergency power for navigation systems and a crane at the Port	Dec '	Table 7.4
	Water Supply		
M	Review the proposed levels of service and strategy for water supplies to ensure they are appropriate and achievable	Dec '08	Table 8.8
H	Review options for standpipes and assess the number required	Dec '07	Table 8.8
H	Define high fire risk/high value areasa nd identify appropriate secondary fire fighting options.	Dec '06	Table 8.8
	Westport and Reefton Water Supply		
M	Consider purchasing a generator for the Westport water supply	Dec '10	Table 8.8
	Sewerage		
M	Review the proposed levels of service and strategy for sewage disposal after a major earthquake to ensure they are appropriate and achievable	Dec '08	Table 9.6
M	Consider discharge requirements of major waste water producers after a significant earthquake and determine any provisions necessary to manage these discharges	Dec '	Table 9.6
	Storm Water		
L	Review the proposed levels of service and strategy for storm water management after a major earthquake to ensure they are appropriate and achievable	Dec '12	Table 10.4
	Telecommunications		
H	Establish better communications between organisations and companies with communication services on the West Coast, including the power companies, Telecom, DOC and Regional Council.	Dec '06	Table 11.2
H	Confirm who have VHF facilities and establish a common channel for use in emergencies.	Dec '06	Table 11.2

1. H = High Priority; M= Medium Priority; L = Low Priority

Importance[1]	Activity	Completion Date	Reference
	Power		
H	Establish better communications between organisations and companies in the power sector on the West Coast, including the communication companies, Telecom, DOC and Regional Council.	On-going	Table 11.2
	Fuel Supply		
H	Consider forming database of available fuel storage tanks in the area that could be used in emergency.	Dec '07	Table 11.2
H	Consider providing sufficient fuel for emergency generation to keep basic services operational.	Dec'07	Table 11.2

1. H = High Priority; M= Medium Priority; L = Low Priority

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APPENDIX A: DAMAGE ASSESSMENT CHART

Buller District Council Lifelines Study

Damage Assessment Chart

1 Reference Report

The Chart has been compiled for use with the Buller District Lifelines Study, June 2006. It should be read in conjunction with Section Two of that report. Section Three outlines an earthquake scenario, and it is recommended that this is also read to provide a perspective on the chart contents.

2 Chart Zones

The chart has been set out for each of the three Ground Shaking Zones as described in Table 2.4 of the above report. Because of the large area of the District, and the range of expected earthquake shaking intensities for any single earthquake event, indicative damage is shown for a range of shaking intensities for each zone. The damage is indicative only and a wide variation can be expected within each zone due to variations in sub-surface conditions, geology, terrain and orientation of the site with respect to the earthquake source.

3 Chart Limitation

The Damage Assessment Chart is an indicative guide only. The damage to structures should be read in conjunction with the description of damage in the Modified Mercalli Intensity Scale, Appendix B, and the description of building types, Appendix B, of the Report. There is little information on damage ratios for structures or infrastructure other than buildings, and the relative damage is necessarily somewhat subjective. It may be used for coarse screening of effects, but must not be used as the basis for any design. Any decision involving expenditure or engineering design requires a more detailed evaluation of the conditions pertaining at that particular site.

4 Liquefaction

The Damage Assessment Chart includes comments on possible liquefaction damage for Zone 1 only, as there is expected to be little liquefaction outside this zone. If liquefaction in Zones 2 and 3 does occur, damage will be similar to that outlined for Zone 1 in the corresponding shaking intensity.

Buller District Council Lifelines Study - Damage Assessment Chart

A - Structures IMPORTANT: Refer notes on the first page this Appendix

Zone	Shaking Intensity	Structures (Refer Appendix B for definition of building types)	Fixings designed for seismic loads	Equipment not fixed or fittings not designed for seismic loads	Liquefaction damage (where site is liquefiable and structure not specifically designed)
1	MM VI	Slight damage to Type I buildings	Little to no damage	Movement probable, 10% failure	Minimal
	MM VII	Minor damage except for poorly constructed weak material Type I buildings	Minor damage	Movement expected, 30% failure	Some damage with foundation tilting and settlement
	MM VIII	Well designed structures serviceable, but with at least minor damage. Many non seismically designed structures damaged and unserviceable.	Considerable damage, 25% failure	70% failure	Large settlement, tilting, damage to foundations
	MM IX	Damage and distortion to even modern, well designed structures, some may be unserviceable. Non seismically designed structures likely to be seriously damaged and poorly constructed weak material structures collapse.	Widespread damage 40% failure	90% failure	Large settlement (many cm)and foundation distortion to cause major damage to structure
2	MM VI	Intermediate between Zone 1 and 3			
	MM VII				
	MM VIII				
	MM IX				
3	MM VI	As for Zone 1, with some small reduction in severity possible			
	MM VII				
	MM VIII				
	MM IX				

Buller District Council Lifelines Study - Damage Assessment Chart

B - In Ground Pipework IMPORTANT: Refer notes on the first page this Appendix

Zone	Shaking Intensity	Welded Steel and polyethylene	Moderately ductile pipes. Concrete with rubber joints. Steel and cast iron with rubber joints	Low strength/ low ductility pipes. Earthenware with rubber joints Asbestos cement. Cast iron with lead joints	Non-ductile pipes. Ceramic with cement joints. Brick
1	MM VI	Should be OK	Should be OK	Occasional mains damage and entry and junction failure	Minor mains damage 5% entries and junctions fail
	Liquefiable site	Liquefaction unlikely at this level of shaking			
	MM VII	Should be OK	Little mains damage, 5% entries and junctions fail	Little mains damage, 10% of entries and junctions fail	Mains damage possible, 20% entries and junctions fail
	Liquefiable site	*Possible damage at entry to structures and at junctions*	*Mains damage possible, 15% of entries and junctions fail*	*Moderate mains damage, 40% of entries and junctions fail*	*Significant damage*
	MM VIII	Should be OK, minor damage	Some mains damage, 15% entries and junctions fail	Mains damage likely, 40% entries and junctions fail	Mains damage widespread
	Liquefiable site	*Likely damage at entry to structures and at junctions*	*Mains damage likely,50% entries and junctions fail*	*Mains damage, 70% entries and junctions fail*	*Mains failure*
	MM IX	Damage possible at entry to structures and at junctions	Mains damage likely, 40% entries and junctions fail	Mains damage probable, 60% entries and junctions fail	Mains damage
	Liquefiable site	*Likely damage at entry to structures and at junctions*	*Mains damage likely,70% entries and junctions fail*	*Mains damage, 80% entries and junctions fail*	*Mains failure*

B - In Ground Pipework (Continued) IMPORTANT: Refer notes on the first page this Appendix

Zone	Shaking Intensity	Welded Steel and polyethylene	Moderately ductile pipes. Concrete with rubber joints. Steel and cast iron with rubber joints	Low strength/ low ductility pipes. Earthenware with rubber joints Asbestos cement. Cast iron with lead joints	Non-ductile pipes. Ceramic with cement joints. Brick
2	MM VI	As for Zone 1 but with 10 – 15% reduction in severity			
	MM VII				
	MM VIII				
	MM IX				
3	MM VI	As for Zone 1 but with 30% reduction in severity			
	MM VII				
	MM VIII				
	MM IX				

Buller District Council Lifelines Study - Damage Assessment Chart

C - Transport

IMPORTANT: Refer notes on the first page this Appendix

Zone	Shaking Intensity	Roading	Railway	Bridge Structure	Bridge Abutments
1	MM VI	Little to no damage	Little to no damage	Refer Section A - Structures	Little to no damage
	Liquefiable sites	*Liquefaction unlikely at this level of shaking*			
	MM VII	Minor damage to kerbs and cracking of seal. Small slips on steep batters.	Minor damage to alignment		Minor slumping
	Liquefiable sites	*Some damage to kerbs and cracking of seal. Lateral spread of fill possible*	*Lateral spread of embankments possible*		*Lateral spread possible.*
	MM VIII	Some damage to kerbs. Some distortion and cracking of seal. Slips in batters	Distortion of rail lines, some spreading of embankments		Some slumping of abutment fill common
	Liquefiable sites	*Damage to kerbs. Sumps damaged. Widespread distortion and cracking of seal. Lateral spread of fills*	*Some distortion of rail lines. Spreading of embankments*		*Slumping and lateral spread of fill, abutment failures possible if not piled. Pile damage possible*
	MM IX	Damage to kerbs, distortion and cracking of seal, Landsliding in steep slopes and batters, cracking of ground	Distortion of rail lines, both horizontal and vertical, significant embankment damage		Slumping of abutment fill at most bridges, many of significant magnitude. Translational or rotational movement at some abutments.
	Liquefiable sites	*Extensive damage to kerbs. Sumps damaged. Extensive distortion and cracking of seal. Lateral spread*	*Distortion of rail lines. Spreading of embankments*		*Slumping and lateral spread of fill, abutment failures likely if not piled. Pile damage likely.*

C - Transport (Continued) IMPORTANT: Refer notes on the first page this Appendix

Zone	Shaking Intensity	Roading	Railway	Bridge Structure	Bridge Abutments
2	MM VI	Intermediate between zones 1 and 3			
	MM VII				
	MM VIII				
	MM IX				
3	MM VI	Little to no damage	Little to no damage		Little to no damage
	MM VII	Rockfall and small slips on steep batters.	Minor damage to alignment		Minor slumping
	MM VIII	Rockfall and slips in steep batters	Distortion of rail lines, some spreading of embankments		Some slumping of abutment fill common
	MM IX	Landsliding in steep slopes and batters, cracking of ground, large volume rockfall possible	Distortion of rail lines, both horizontal and vertical, significant embankment damage		Significant slumping of abutment fill at most bridges. Translational or rotational movement at some abutments.

APPENDIX B: MODIFIED MERCALLI INTENSITY SCALE

Construction Categories for Damage Assessment as Used in Modified Mercalli Intensity Scale

After Eiby (1966) Categories of non-Wooden Construction	After Study Group (1992) Categories of Construction
Masonry A Structure design to resist lateral forces of about 0.1g, such as those satisfying the New Zealand Model Building Bylaw, 1955. Typical buildings of this kind are well reinforced by means of steel or ferroconcrete bands, or are wholly of ferro-concrete construction. All mortar is good quality and the design and workmanship is good. Few buildings erected prior to 1935 can be regarded as in category A. **Masonry B** Reinforced buildings of good workmanship and with sound mortar, but not designed in detail to resist lateral forces. **Masonry C** Buildings of ordinary workmanship, with mortar of average quality. No extreme weakness, such as inadequate bonding of the comers, but neither designed nor reinforced to resist lateral forces. **Masonry D** Buildings with low standard of workmanship, poor mortar, or constructed of weak materials like mud brick and rammed earth. Weak horizontally. **Windows** Window breakage depends greatly upon the nature of the frame and its orientation with respect to the earthquake source. Windows cracked at MM5 are usually either large display windows, or windows tightly fitted to metal frames. **Water Tanks** The "domestic water tanks" listed under MM7 are of the cylindrical corrugated-iron type common in New Zealand rural areas. If these are only partly full, movement of the water may burst soldered and riveted seams. Hot water cylinders constrained only by supply and delivery pipes may move sufficiently to break the pipes at about the same intensity.	**Buildings Type I** Weak materials such as mud brick and rammed earth; poor mortar; low standards of workmanship (Masonry D in other MM scales). **Buildings Type II** Average to good workmanship and materials, some including reinforcement but not designed to resist earthquakes (Masonry B and C in other MM scales). **Buildings Type Ill** Buildings designed and built to resist earthquakes to normal use standards, i.e. no special damage limiting measures taken (mid –1930's to c. 1970 for concrete and to c. 1980 for other materials). **Buildings and bridges Type IV** Since c. 1970 for concrete and c. 1980 for other materials, the loadings and materials codes have combined to ensure fewer collapses and less damage than in earlier structures. This arises from features such as "capacity design" procedure, use of elements (such as improved bracing or structural walls) which reduce racking (i.e. drift), high ductility, higher strength. **Windows** Type I – Large display windows, especially shop windows. Type II - Ordinary sash or casement windows. **Water Tanks** Type I - External, stand mounted, corrugated iron water tanks. Type II - Domestic hot-water cylinders unrestrained except by connecting pipes. **H - (Historical)** Important for historical events. Current application only to older houses, etc. **General Comment** “Some” or a “few” indicates that the threshold of a particular effect has just been reached at that intensity.

INTENSITY SCALES

MODIFIED MERCALLI (MM) INTENSITY SCALE
(Table from Downes, 1995)

	After Eiby (1966)	After Study Group (1992)
MM I	Not felt by humans, except in especially favourable circumstances, but birds and animals may be disturbed. Reported mainly from the upper floors of buildings more than 10 storeys high. Dizziness or nausea may be experienced. Branches of trees, chandeliers, doors, and other suspended systems of long natural period may be seen to move slowly. Water in ponds, lakes, reservoirs etc. may be set into seiche oscillation.	*People* Not felt except by a very few people under exceptionally favourable circumstances.
MM II	Felt by a few persons at rest indoors, especially by those on upper floors or otherwise favourably placed. The long-period effects listed under MM I may be more noticeable.	*People* Felt by persons at rest, on upper floors or favourably placed.
MM III	Felt indoors, but not identified as an earthquake by everyone. Vibration may be likened to the passing of light traffic. It may be possible to estimate the duration, but not the direction. Hanging objects may swing slightly. Standing motorcars may rock slightly.	*People* Felt indoors; hanging objects may swing, vibration similar to passing of light trucks, duration may be estimated, may not be recognised as an earthquake.
MM IV	Generally noticed indoors, but not outside. Very light sleepers may be wakened. Vibration may be likened to the passing of heavy traffic, or to the jolt of a heavy object falling or striking the building. Walls and frame of buildings are heard to creak. Doors and windows rattle. Liquids in open vessels may be slightly disturbed. Standing motorcars may rock, and the shock can be felt by their occupants.	*People* Generally noticed indoors but not outside. Light sleepers may be awakened. Vibration may be likened to the passing of heavy traffic or to the jolt of a heavy object falling or striking the building. *Fittings* Doors and windows rattle. Glassware and crockery rattle. Liquids in open vessels may be slightly disturbed. Standing motorcars may rock. *Structures* Walls and frame of buildings, and partitions and suspended ceilings in commercial buildings may be heard to creak.

	After Eiby (1966)	After Study Group (1992)
MM V	Generally felt outside, and by almost everyone indoors. Most sleepers awakened. A few people frightened. Direction of motion can be estimated. Small unstable objects are displaced or upset. Some glassware and crockery may be broken. Some windows cracked. A few earthenware toilet fixtures cracked. Hanging pictures move. Doors and shutters may swing. Pendulum clocks stop, start, or change rate.	*People* Generally felt outside, and by almost everyone indoors. Most sleepers awakened. A few people alarmed. Direction of motion can be estimated. *Fittings* Small unstable objects are displaced or upset Some glassware and crockery may be broken. Hanging pictures knock against the wall. Open doors may swing. Cupboard doors secured by magnetic catches may open. Pendulum clocks stop, start or change rate (H*). *Structures* Some windows type I* cracked. A few earthenware toilet fixtures cracked (H)
MM VI	Felt by all. People and animals alarmed. Many run outside. Difficulty experienced in walking steadily. Slight damage to Masonry D. Some plaster cracks or falls. Isolated cases of chimney damage. Windows, glassware and crockery broken. Objects fall from shelves, and pictures from walls. Heavy furniture moved. Unstable furniture overturned. Small church and school bells ring. Trees and bushes shake, or are heard to rustle. Loose material may be dislodged from existing slips, talus slopes, or shingle slides.	*People* Felt by all. People and animals alarmed. Many run outside. Difficulty experienced in walking steadily. *Fittings* Objects fall from shelves. Pictures fall from walls (H*). Some furniture moved on smooth floors. Some unsecured free-standing fireplaces moved. Glassware and crockery broken. Unstable furniture overturned. Small church and school bells ring (H). Appliances move on bench or table tops. Filing cabinets or “easy glide" drawers may open (or shut). *Structures* Slight damage to Buildings Type I*. Some stucco or cement plaster falls. Suspended ceilings damaged. Windows Type I* broken. A few cases of chimney damage.

	After Eiby (1966)	After Study Group (1992)
MM VII	General alarm. Difficulty experienced in standing. Noticed by drivers of motorcars. Trees and bushes strongly shaken. Large bells ring. Masonry D cracked and damaged. A few instances of damage to Masonry C. Loose brickwork and tiles dislodged. Unbraced parapets and architectural ornaments may fall. Stone walls cracked. Weak chimneys broken, usually at the roofline. Domestic water tanks burst. Concrete irrigation ditches damaged. Waves seen on ponds and lakes. Water made turbid by stirred-up mud. Small slips, and caving-in on sand and gravel banks.	*People* General alarm. Difficulty experienced in standing. Noticed by motorcar drivers who may stop. *Fittings* Large bells ring. Furniture moves on smooth floors, may move on carpeted floors. *Structures* Unreinforced stone and brick walls cracked. Buildings Type I cracked and damaged. A few instances of damage to Buildings Type II. Unbraced parapets and architectural ornaments tall. Roofing tiles, especially ridge tiles may be dislodged. Many unreinforced domestic chimneys broken. Water tanks Type I* burst. A few instances of damage to brick veneers and plaster or cement-based linings. Unrestrained water cylinders (Water Tanks Type II*) may move and leak. Some Windows Type 11* cracked. *Environment* Water made turbid by stirred up mud. Small slides such as falls of sand and gravel banks. Instances of differential settlement on poor or wet or unconsolidated ground. Some fine cracks appear in sloping ground. A few instances of liquefaction.

	After Eiby (1966)	After Study Group (1992)
MM VIII	Alarm may approach panic. Steering of motorcars affected. Masonry C damaged, with partial collapse. Masonry B damaged in some cases. Masonry A undamaged. Chimneys, factory stacks, monuments, towers and elevated tanks twisted or brought down. Panel walls thrown out of frame structures. Some brick veneers damaged. Decayed wooden piles broken. Frame houses not secured to the foundation may move. Cracks appear on steep slopes and in wet ground. Landslips in roadside cuttings and unsupported excavations. Some tree branches may be broken off. Changes in the flow or temperature of springs and wells may occur. Small earthquake fountains.	*People* Alarm may approach panic. Steering of motorcars greatly affected. *Structures* Buildings Type I heavily damaged, some collapse. Buildings Type II damaged, some seriously Buildings Type Ill damaged in some cases. Monuments and elevated tanks twisted or brought down. Some pre-1965 infill masonry panels damaged. A few post-1980 brick veneers damaged. Weak piles damaged. Houses not secured to foundations may move. *Environment* Cracks appear on steep slopes and in wet ground. Slides in roadside cuttings and unsupported excavations. Small earthquake fountains and other manifestations of liquefaction.

	After Eiby (1966)	After Study Group (1992)
MM IX	General panic. Masonry D destroyed. Masonry C heavily damaged, sometimes collapsing completely. Masonry B seriously damaged. Frame structures racked and distorted. Damage to foundations general. Frame houses not secured to the foundations shifted off. Brick veneers fall and expose frames. Cracking of the ground conspicuous. Minor damage to paths and roadways. Sand and mud ejected in alluviated areas, with the formation of earthquake fountains and sand craters. Underground pipes broken. Serious damage to reservoirs.	*Structures* Many buildings Type I destroyed. Buildings Type II heavily damaged, some collapsing. Buildings Type III damaged, some seriously. Damage or permanent distortion to some buildings and bridges Type IV. Houses not secured to foundations shifted off. Brick veneers fall and expose frames. *Environment* Cracking of ground conspicuous. Landsliding general on steep slopes. Liquefaction effects intensified, with large earthquake fountains and sand craters.
MM X	Most masonry structures destroyed, together with their foundations. Some well built wooden buildings and bridges seriously damaged. Dams, dykes and embankments seriously damaged. Railway lines slightly bent. Cement and asphalt roads and pavements badly cracked or thrown into waves. Large landslides on river banks and steep coasts Sand and mud on beaches and flat land moved horizontally. Large and spectacular sand and mud fountains Water in rivers, lakes & canals thrown up the banks	*Structures* Most unreinforced masonry structures destroyed. Many Buildings Type II destroyed. Many Buildings Type Ill (and bridges of equivalent design) seriously damaged. Many Buildings and Bridges Type IV have moderate damage or permanent distortion.
MM XI	Wooden frame structures destroyed. Great damage to railway lines and underground pipes.	

	After Eiby (1966)	After Study Group (1992)
MM XII	Damage virtually total. Practically all works of construction destroyed or greatly damaged. Large rock masses displaced. Lines of sight and level distorted. Visible wave-motion of the ground surface reported. Objects thrown upwards into the air.	

APPENDIX C: NEEDS ASSESSMENT

Hokitika Business Person

Needs	First 3 days			End of 1st Month			End of 1st year			First 3 days	End of first month	End of first Year
	Need	Reliance	Importance	Need	Reliance	Importance	Need	Reliance	Importance			
Leadership	3	3	9	3	3	9	3	2	6	Business totally reliant on other's leadership to look after his business/employees	Very high need for leadership in the business sector to see a way forward	As for "End of first month"
Info. in/out	3	3	9	2	3	6	2	3	6	Very high need to know what is happening to his company/staff and totally reliant on others	Less need for information in & out but still totally reliant on others	As for "End of first month"
Rescue/Med. Aid	3	3	9	0	3	0	0	3	0	Ditto	Rescue & med aid is over	Rescue & med aid is over
Evacuation	3	3	9	1	3	3	0	2	0	Assume evacuation required as business at locations severely effected by EQ.	Evacuation of valuable equipment	Evacuation is over
Security	3	3	9	2	1	2	1	1	2	Vulnerability and Security of business as buildings will have been damaged	High need for security because operating on minimum staff but low reliance on others	Normal security
Relocation	0	0	0	3	2	6	1	2	2	Not yet considering relocation - concerned about immediate impact	Many staff & perhaps business require relocation to other centres for work/income	Relocation out is over. Not yet looking at relocating family of staff back to area
Counselling	0	0	0	3	2	6	2	2	4	No counselling at this stage	Business person needs support/advice to re-establish business. Staff need support	As for "End of first month"
Income & Insurance	0	3	0	3	3	9	3	3	9	Concern about immediate impact - not yet organising insurance claims and planning future income sources	Income required to retain staff. Insurance required to rebuild business	As for "End of first month"
Water	1	2	2	1	3	3	1	3	3	Normal need but high reliance on others for drinking quality water for employees	Normal needs and higher reliance in others	As for "End of first month"
Sanitation	1	1	1	1	3	3	1	3	3	Low reliance on others for sanitary system for employees	Normal needs & increasing need for reliance on formal sanitary system	As for "End of first month"
Food	2	3	6	1	3	3	1	3	3	Employee in EQ effected areas have high reliance on others for food	Normal needs and higher reliance in others	As for "End of first month"
Shelter	2	2	4	1	2	2	2	3	6	Potentially higher need. Depends on weather conditions	Assume business is not viable at this stage and only marginal in Westport. Premises demolished in Franz Josef (Health & safety issues) made safe but basically shut down in Hokitika	Re-building of business not yet underway because of small number of tourists. Businesses that are re-building have a high reliance on roads, trades people etc
Lighting & Heat	3	2	6	1	2	2	1	3	3	Higher need for lighting for security	Normal needs and less reliance on others because have small gensets	Normal needs and returning to high reliance on normal supply (national grid). Lower demand because people & businesses have left the area

Kokatahi Farmer

Needs	First 3 days			End of 1st Month			End of 1st year			First 3 days	End of first month	End of first Year
	Need	Reliance	Importance	Need	Reliance	Importance	Need	Reliance	Importance			
Leadership	3	1	3	3	3	9	3	3	9	Strong need for leadership but provided in local farming community	Focus for leadership now outside the community as a clear regional path out of the emergency needs to be defined	Leadership still important as recovery is going to take years
Info. in/out	3	3	9	2	3	6	2	3	6	Feeling of isolation being cut off. High need for information from outside and total reliance others for the information	Less need although still high and now greater reliance on normal communication channels	Need still high because of future uncertainties and family now temporarily relocated. Total reliance on normal communication channels
Rescue/Med. Aid	3	3	9	0	3	0	0	3	0	High need and total reliance on others	Rescue & med aid phase is over	Rescue & med aid is over
Evacuation	2	3	6	0	1	0	0	1	0	Only medical evacuees but totally reliant on others i.e. airlift	Evacuation phase is over	Evacuation phase is over
Security	1	1	1	1	1	1	1	1	1	Security not an issue	Security not an issue	Security not an issue
Relocation	0	0	0	3	2	6	1	2	2	Relocation not important at this early stage	Relocation of children with their mothers for schooling and because ongoing after shocks are frightening	Relocation out is over. Starting to relocating family members back to area as schools and others services are established again
Counselling	2	1	2	2	3	6	3	2	6	High need but rely on neighbours for support	Range of counselling required for trauma as well as advice on how to move forward/re-establish	Need still high but less reliance on professionals and more on family and neighbours etc
Income & Insurance	0	3	0	3	2	6	3	3	9	Concern about immediate impact - not yet organising insurance claims and planning how to recover	Very high need and high reliance. Not total reliance because of West Coast independence / entrepreneurial approach.	No farm income to speak of. High need and almost total reliance on outside agency for income and capital to rebuild.
Water	1	0	0	1	0	0	1	0	0	Normal need and high but use own drinking water sources	Temporary and adequate supply established	Permanent private supply re-established.
Sanitation	1	0	0	1	0	0	1	0	0	Spade and a patch in the back yard adequate	Long drop facility established in back yard	Individual septic tank system operating again
Food	1	0	0	1	3	3	1	3	3	Self reliant	Normal need for food with some reliance on others for bread, cooking ingredients etc	Returned to normal needs and normal reliance on others
Shelter	2	1	2	1	2	2	1	1	1	Need for shelter but relatively self sufficient to arrange own temporary shelter	Starting to return to home; however moderate reliance on outside agencies for building materials	Majority of repairs to home completed
Lighting & Heat	2	1	2	1	2	2	1	3	3	Higher need for lighting & heating because of emergency shelter conditions but low reliance on other	Normal need for lighting and heat with increasing reliance on others (national grid) as supply returns to normal	Normal need and return to total reliance on others (national grid + fuel suppliers)

Franz Josef Tourist

Needs	First 3 days			End of 1st Month			End of 1st year			First 3 days	End of first month	End of first Year
	Need	Reliance	Importance	Need	Reliance	Importance	Need	Reliance	Importance			
Leadership	3	3	9	1	0	0	0	0	0	Foreign country, very high need and total reliance on others for leadership	Normal need but now in home country so no reliance on West Coast	Normal need but now in home country
Info. in/out	3	3	9	1	0	0	1	0	0	Very high need for information in and out and total reliance on others	ditto	ditto
Rescue/Med. Aid	3	3	9	0	0	0	1	0	0	Very high needs and total reliance on others	Now in home county	ditto
Evacuation	3	3	9	0	0	0	1	0	0	ditto	ditto	ditto
Security	3	2	6	2	0	0	1	0	0	Very high need and high reliance on others	Normal need but now in home country so no reliance on West Coast	ditto
Relocation	0	3	0	0	0	0	0	0	0	NA evacuation only	NA	ditto
Counselling	3	1	3	3	0	0	0	0	0	High need but rely on immediate community support	High need but now in home country so no reliance on West Coast	ditto
Income & Insurance	1	1	1	1	0	0	1	0	0	Very worried about this but insurance and income not a high need in first three days	Now in home county	ditto
Water	1	1	1	1	0	0	1	0	0	Normal need but natural water sources are found to be adequate	ditto	ditto
Sanitation	1	1	1	1	0	0	1	0	0	Normal need but forced to use a designated location	ditto	ditto
Food	2	3	6	1	0	0	1	0	0	High need and total reliance on other because don't have any food.	ditto	ditto
Shelter	2	3	6	1	0	0	1	0	0	High need because of likely poor weather and total reliance on other as most build are un-useable	ditto	ditto
Lighting & Heat	2	3	6	1	0	0	1	0	0	High need because of likely poor weather and total reliance on other as most build are un-useable	ditto	ditto

Hokitika Resident

Needs	First 3 days			End of 1st Month			End of 1st year			First 3 days	End of first month	End of first Year
	Need	Reliance	Importance	Need	Reliance	Importance	Need	Reliance	Importance			
Leadership	3	3	9	3	3	9	3	3	9	Strong need for leadership to direct people and co-ordinate community effort	Still a high need and reliance on leadership for morale and to get things heading back to normal	Still a high need and high reliance on others to provide the leadership
Info. in/out	3	2	6	2	3	6	2	3	6	High need for information (in/out) but local and word of mouth is working	Less need; however greater reliance on normal communication channels	Still a high need for information and total reliance on normal communication channels
Rescue/Med. Aid	2	3	6	0	2	0	0	2	0	High reliance on expert help and high need. Not as severe as Franz Joseph as further from epicentre	Rescue & med aid phase is over	Rescue & med aid is over
Evacuation	2	3	6	0	3	0	0	3	0	Only medical evacuees but totally reliant on others i.e. airlift	Evacuation phase is over	Evacuation phase is over
Security	2	3	6	1	3	3	1	3	3	High need for security and high reliance on others to organise	Security returns to normal	Normal security
Relocation	0	3	0	2	3	6	1	3	3	Relocation not important at this early stage	Relocation of children with their mothers for schooling and because ongoing after shocks are frightening	Relocation out is over. Starting to relocate family members back to area
Counselling	0	3	0	2	3	6	2	3	6	No counselling at this stage	Range of counselling required for trauma as well as advice on how to move forward/re-establish	As for "End of first month"
Income & Insurance	1	1	1	3	2	6	2	2	4	Concern about immediate impact but not yet organising insurances claims or planning future income source	Very high need and high reliance. Not total reliance because of West Coast independence/entrepreneurial approach.	Less need but still high reliance.
Water	2	3	6	1	2	2	1	3	3	Normal need for water and high reliance on others. At CD posts almost total reliance on others.	As for 3 days but wanting to return to normal. Total reliance on other or drinking water	Return to normal need and total reliance on public water supply
Sanitation	2	2	4	1	1	1	1	3	3	Spade and a patch in the back yard adequate	Long drop facility established in back yard	Almost everyone has returned to using public sewerage scheme
Food	2	3	6	1	3	3	1	3	3	High need for food and high to total reliance on others	Normal need for food and total reliance on others	As for "End of first month"
Shelter	2	2	4	1	2	2	1	1	1	Normal need for shelter and high reliance on other because of unknown stability of home and continuing after shocks	People starting to return to their homes where habitable but still high reliance on others for shelter	Re-building of homes well under way. People have moved to their own temporary accommodation where required
Lighting & Heat	2	2	4	2	3	6	1	3	3	Higher need for lighting & heating because of emergency shelter conditions but low reliance on national grid - use gas bottles, wood & coal stores	Still higher than normal need; however reliance on outside energy sources very high as locally available stock has been used up	Return to relatively normal demand as in better accommodation and now total reliance on other for energy souces

APPENDIX D: WORKSHOP ATTENDANCE LIST

<u>Lifelines Workshop Attendance 20 & 21 September 2005</u>

<u>Lifelines</u>

Peter Kingsbury	MCDEM	(2 days)
Simon Chambers	MCDEM	(2 days)
Steve Griffen	BDC	(2 days)
Rob Ruiter	Telecom	(2 days)
Mel Sutherland	GDC	(1 days)
Peter McConnell	GDC	(2 days)
Rob Daniel	WDC	(2 days)
John McKenzie	Transpower	(2 days)
Neville Higgs	Transit/Opus	(2 days)
Thomas O'Callaghan	Electronet	(2 days)
Rodger Griffiths	Electronet	(2 days)
	Buller Electricity	(2 days)
Chris Ingle	WCRC – Recovery Manager	(2 days)
Mary Trays	WCRC - Hazards Analyst	(2 days)
Nichola Costley	WCRC - EMO	(2 days)
	WCRC – Councillor	(Day 1)
Dave Brunsdon	National Lifelines Coordinator	(2 days)
Doug Truman	Regional Controller	(Day 1)

<u>CEG</u>

Brian Fancourt	St John	(morning day 1)
John Canning	Police	(Day 1)
Dave Hyde	NZFS	(Day 1)

<u>Grey District</u>

Mark Thomas	Councillor CD / NZFS	(2 days)
Allan Wilson	Controller GDC	(2 days)
Albie Rose	GDC CDO	(Day 1)

<u>Buller District</u>

Reg Barrell	BDC CDO	(2 days)
Luke Murphy	BDC Asset Engineer	(2 days)

Graham Crase (Day 1)

Others

Chris Cowan Coastwide Helicopters (Day 1 weather dependent)

Apologies

Terry Archer – Annual leave