



Regional Lifelines Study Executive Summary

Alpine Fault Earthquake Scenario

West Coast Engineering Lifelines Group

June 2006

IMPORTANT NOTES

Disclaimer

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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.

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Cover photograph: Damage to the abutments and piers of the Inangahua Bridge - 1968

1 INTRODUCTION

This Executive Summary has been prepared to cover four reports, three of which were commissioned by the West Coast Engineering Lifeline Group, and one by Grey District Council. These reports were written specifically for Buller District, Grey District, Westland District and West Coast Regional Council engineers and managers, and Councillors. However, the reports also contain material that is relevant to other lifeline operators on the West Coast along with those involved in CDEM.

The four reports are:

- Buller District Council Lifelines Study,
- Grey District Council Lifelines Study,
- Westland District Council Lifelines Study, and
- West Coast Engineering Lifelines Group Study.

The aim of the reports is to raise issues and make recommendations as to what should be done to make the Councils and hence the West Coast communities 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 reports identify 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 reports focus primarily on lifelines; regional water control assets and the network services of water, sewage, transport, power and communications that are essential to the functioning of a community. The reports provide:

- 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 reports use 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 the reports 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.

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.

2 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 riverfront 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 Councils' 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.

3 ALPINE FAULT EARTHQUAKE SCENARIO

The direct effects of an Alpine Fault earthquake on the West Coast Region are likely to be serious for the following reasons:

- It will have by far the greatest impact on the region than any other natural event and certainly any other earthquake, as the Alpine Fault runs virtually up the centre of the region.
- It will certainly occur at some stage, and has a high probability of occurring within the next 50 – 100 years.
- It will affect 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 West Coast Region.

The Alpine Fault runs virtually the entire length of the region, but for the purposes of this scenario, a rupture is assumed to start at Paringa, 125km north of the southern boundary to Westland District. The whole of Westland, most of Grey and the inland areas of Buller districts will experience strong shaking. It will be most intense closest to the Southern Alps and the fault trace. The townships of Springs Junction, Harihari, Whataroa, Franz Josef and Fox Glacier and the rural communities of Kopara – Haupiri, Rotamanu – Inchbonnie, Kowhitirangi – Kokatahi, Te Taho and north Franz Josef are all very

close to the fault trace and can expect the most intense shaking. However, with the exception of the coastal areas of Buller and the Haast area, nearly the whole of the region will all experience Modified Mercalli Intensity shaking of MM VIII or greater. There is no doubt that the shaking will be the strongest experienced anywhere within Grey and Westland Districts since settlement of the area. Parts of Buller District have been subjected to as strong or stronger shaking in 1929 with the Buller earthquake and in 1968 with the Inangahua earthquake.

The earthquake will result in:

- Ground rupture destroying buildings, roads and railways on or crossing the fault;
- Shaking damage to buildings, bridges and infrastructure;
- Landslides, particularly in the MM VIII and IX zones and in the mountains, are expected to be extensive, with some of them likely to create dams across rivers. Landslides are not expected to impact directly on urban areas to any significant extent, but will cause major damage to roads;
- Liquefaction in sandy areas within river valleys, in low swampy ground, and the coastal strip, particularly the estuary and river margin areas.
- Seiches (water waves generated by seismic oscillations) would be produced on Lake Kanieri and the other smaller 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 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 presented in the regional and district lifelines reports affect the region's infrastructure as follows:

1. **Transportation:** Most roads in the region are effectively closed due to landslides, destruction of the road surface or damage to bridges. The major towns are isolated from each other for the first 48 hours and it is almost a week before any transport can reach Westport, Greymouth and Hokitika from Nelson. Direct road access to Canterbury through the Lewis Pass is not restored until at least 16 days after the earthquake. Fuel shortage becomes a concern. In South Westland, extensive landslides and bridge damage effectively cuts the district into a series of isolated areas. An optimistic scenario has road access re-established over Arthur's Pass after 7 months, to Haast (over the Haast Pass) after 3 months, to Harihari after 2 months, Franz Josef after 4 months and Fox Glacier after 9 months. The airports at Westport and Hokitika are undamaged and can be used immediately, but the Greymouth airport is damaged by liquefaction and unusable to aircraft. The ports at Westport and Greymouth suffer some damage but remain useable. Railway authorities state that rail re-instatement can be faster than for roads. However, because the lines are damaged

in many places with severe damage on the Midland Line, and because of the anticipated ongoing debris flow hazard, it is assumed in the scenario that restoration of the rail connection to outside the district is not resumed for over 12 months. Access to the Grey Base hospital is likely to be cut.

2. **Drainage:** Large landslide dams are formed throughout the region as a result of the earthquake. Intermittent heavy rainfall in the following weeks causes some dams to breach and the resulting flood waves cause flooding and further damage. All stop bank systems are damaged. Debris flows out of small catchments cause major problems with roads close to the fault and in other areas where extensive landslides have occurred. Aggradation in all rivers is an ongoing problem, with flooding and damage to farmland, changing river courses and loss of waterway at bridges. The Greymouth floodwall sustains longitudinal fissure damage and the crest is lowered by a metre in two places. The Inchbonnie stop bank requires immediate and regular attention to hold back the threat of the Taramakau River diverting into Lake Brunner and the Grey River.
3. **Sewerage:** Greymouth, Moana and Hokitika sewers, oxidation ponds and some pump stations are affected in areas subject to liquefaction. Rain exacerbates sewer damage causing isolated pockets of sewage flow on the ground surface. The Franz Josef system is severely damaged.
4. **Water Supply:** Water supplies throughout the region are affected, particularly in Grey and Westland Districts. There is wide spread damage to older AC reticulation, and some damage to reservoirs. It takes two weeks for supply to 50% of the urban areas of Hokitika and Greymouth to be reinstated. Turbidity in lakes and rivers affects water quality at the intakes for a long time. Other supplies are all affected by some damage, slips and turbidity.
5. **Power Supply:** Power supply is lost throughout the region. Resumption to full power from local generation is delayed due to lack of national grid support for synchronisation to control the frequency, while damage to the distribution network cannot be fixed due to poor access. A reduced power supply is reinstated from the north to the Westport, Greymouth and Hokitika areas after 48 hours. In Westland the power is reinstated to Waitaha after 1 week, Harihari after 2 weeks and one month to Franz Josef. The Haast area is supplied by the local hydro station with minimal interruption.
6. **Telecommunications:** There is widespread network failure including the mobile phone network. Damage to all fibre optic cables out of the region effectively isolate the West Coast region. Telecommunications are re-established to much of the district within a week. However, they continue to be unreliable for some time due to reduced capacity, aftershocks, and landslides.

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 Councils. One area of District Councils' 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 District Council responsibility.

4 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 three reports is on the effects of a major earthquake on district and regional lifelines and physical assets and what the Councils need to address. The scenario is used as a means of identifying what the Councils should address to best prepare themselves for an earthquake. In so doing they 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 district and regional lifelines after any serious earthquake, such as the Alpine Fault earthquake described in the scenario, are as follows:

1. **Airport.** Immediately after the earthquake the Westport and Hokitika airports are likely to be relatively undamaged and become the main routes for getting expertise and urgent supplies into the West Coast region, and for getting the severely injured out for medical assistance. The Greymouth airport runway is likely to have sustained damage due to liquefaction that may take a few days to repair. It is likely that air access to areas such as Franz Josef, Fox and Haast will be very important particularly for evacuating tourist as road access to these areas is unlikely to be open for months.
2. **Roads.** The West Coast is totally reliant on the State Highway system to provide arterial access throughout the region. In addition to roads, State Highway bridges sometimes have other important network functions in that they can provide structural support for telecommunications, power, water supply and other services. Examples of such bridges are the Buller Bridge at Westport and Cobden Bridge at Greymouth. Both bridges form critical road links; the Buller Bridge between Westport, its airport and the rest of the South Island and the Cobden Bridge between Greymouth and destinations north of the Grey River including the water source for the Greymouth water supply. The bridges also provide support for water supply and sewerage pipe work, and electricity and communication cables. Because of issues such as these, it is essential that Councils and Transit agree beforehand on road reinstatement priority, mitigation work that should be undertaken now, and how the Councils 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 the airport, critical communication infrastructure and medical centres. These will be followed by access between Westport, Greymouth and Hokitika and then between higher population centres such as Reefton, Moana, and Whataroa. Other forms of transport, possibly boat, but more likely aircraft, are likely to play an important role during the initial response period. Road access will also be required to important utilities such as communication and power infrastructure and water supply systems to get them functioning.

In the scenario presented in the report the infrastructure in the Haast area remains largely intact. However, it is isolated from the rest of the South Island because of damage to SH roads. The

wharf at Jackson Bay and its associated district roads and bridges take on an elevated level of importance as a transport link into the area.

3. **Ports.** The ports of Westport and Greymouth may suffer some damage. However, damage to the ports is unlikely to be significant in an Alpine Fault earthquake event. It is anticipated that the ports may become key transport route for bringing in bulk supplies such as fuel for the West Coast Region;
4. **Water Control Assets.** After a major earthquake some water control assets such as stop banks may be severely damaged. In an Alpine Fault earthquake water control assets close to or crossing the fault trace, such as stop banks at Franz Josef or Inchbonnie, are likely to suffer significant damage. Many water control assets are likely to be affected over the following months and even years as debris mobilised by the earthquake is washed down to the water control structures. Coastal water control structures are unlikely to be effected by an earthquake unless they are within the zone of strong shaking or are damaged by a tsunami generated by the earthquake. The proposed emergency level of service will be established within three days to two weeks after a major earthquake depending on the size of the community effected. The emergency level of service will provide flood protection or protection from the ocean even if only temporary e.g. sand bags. Return to normal level of service is anticipated to take between six to twelve months.
5. **Water supply.** After a major earthquake like an Alpine Fault earthquake affected water supply systems are likely to have no power to drive pumps. Water supplies close to the fault trace, such as the Franz Josef water supply, are likely to suffer significant damage. It is anticipated that an emergency water supply for affected supplies will be established according to size of community. The target for re-establishing water supply systems to regional and district centres like Westport, Greymouth and Hokitika is four days. In sub-district towns like Reefton, Runanga, and Ross, the target for re-establishing water supply systems is one week, for local centres like Karamea, Moana, and Kumara, 2 weeks, and up to 3 weeks for local community centres like Punakaiki, Ngahere, and Hannah's Clearing. Return to a normal water supply level of service is anticipated to take between three to six months.
6. **Sewerage.** As for water supplies it is expected that after a major earthquake power to drive pumps will be lost and sewerage schemes close to the fault like at Franz Josef will suffer significant damage. Initially, priority will be given to dealing with the public health risk that may be caused by ponding of sewage. Priority will then be given to providing a normal sewerage service to the CBDs of Westport, Greymouth, and Hokitika where it is anticipated recovery efforts will be based. The remainder of the district centres' sewerage system and the other systems will be assessed and repaired or components replaced as required. It is anticipated that where necessary and possible individuals will arrange their own toilet facilities e.g. pit latrines. Normal levels of service are expected to be reinstated in 6 to 12 months.
7. **Storm Water.** It is unlikely that much will be done about storm water systems after a major earthquake, as efforts will be focused elsewhere. However, provisions for drainage are expected to be in place within 24 hours at critical facilities such as the Greymouth airport and hospital,

emergency and CDEM centres and low lying areas. This is particularly important in parts of Greymouth, Hokitika and Westport where failure of both the sewerage and storm water systems may lead to ponding of storm water mixed with sewage.

5 RECOMMENDATIONS

To be more prepared for a large and devastating earthquake West Coast district and regional councils should address the recommendations resented in the three reports. The recommendations 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 the reports 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. Examples could include:
 - Failure of the Inchbonnie stop bank resulting in the Taramakau River diverting its course through Lake Brunner and to the Grey River; or
 - Widespread failures and inadequate or slow re-building of infrastructure and services leading to a large exodus of people from the West Coast effecting the long-term sustainability of the West Coast economy.

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 be 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; and
- Protocols be developed for fuel allocation, and
- Consideration is given to how fuel will be supplied to where it will be needed.

5. **Critical Infrastructure:** It is recommended that councils 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 (Karamea, Westport, Greymouth, Hokitika, Franz Josef, Fox and Haast) including access to the airports,
 - Westport and Greymouth ports and Jackson Bay wharf;
 - Access via rivers; and
 - Roads and bridges managed by Transit and the districts including the preparation of hazard maps to identify roads that may become damaged or impassable.
- Bridges and bottlenecks involving multiple lifelines;
- Key water control assets (flood and ocean wave protection structures). In particular the Inchbonnie stop bank, and the Greymouth floodwall and associated pump stations. Some key water control assets may not be owned by WCRC e.g. major road embankments owned and maintained by Transit, and pump stations associated the Greymouth floodwall;

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 the West Coast district and regional councils.

6. **Strategy and Response:** It is recommended that the council prepare detailed strategies and response plans for recovery of council lifelines after a significant earthquake or other disaster as well as the councils' 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 the West Coast region so that they can be mobilised to the region and effectively assist in the recovery effort allowing district and regional staff to attend to their own and their familys' 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 the reports;

- 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, communication, 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 councils 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 councils 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 a 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 airports and ports.