West Coast Lifelines

Vulnerability and Interdependency Assessment

Supplement 8

Energy Lifelines Assets

West Coast Civil Defence Emergency Management Group

August 2017

IMPORTANT NOTES

Disclaimer

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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.

Cover Photo: Powerlines damaged in Ex Tropical Cyclone Ita, South Westland. Photo courtesy of Westpower from the Report on West Coast Weather Event – Ex Tropical Cyclone Ita

West Coast Lifelines

Vulnerability and Interdependency Assessment

Supplement 8: Energy Lifeline Assets

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Energy Lifeline Assets

1 INTRODUCTION

Energy is provided on the West Coast in the form of electricity and fuels.

This supplement provides a summary of the assets with descriptions of the assets managed by the different providers. It explores the vulnerability of the asset to three major disasters: major earthquake, major storm and a large tsunami. Detail of the earthquake, storm and tsunami scenarios used to probe asset vulnerabilities are provided in *Supplements 2, 3 and 4* of the report respectively. It is important to note that the scenarios are NOT real events nor are they predictions and should not be used as such. The scenarios have been prepared only to probe the lifeline assets to identify vulnerabilities and to give some indication of the general magnitude of the sorts of natural disaster that could conceivably happen.

The report looks at recovery rather than the immediate response during the first week following a disaster. Vulnerabilities that impact on the immediate response have been included for completeness. However the focus is on vulnerabilities that delay recovery. These are summarised, and upgrades and improvements are suggested to address them.

2 ENERGY – ELECTRICITY

2.1 General

The electrical power system in the West Coast consists of a regional supply from the national grid operated by Transpower, some regional power generation and local distribution networks.

The three main companies operating the distribution networks are:

- Westpower with its contracting subsidiary Electronet Services Ltd, servicing most of Westland, all of Grey and the central part of Buller Districts;
- Buller Electricity Ltd (BEL) serving the coastal area of Buller District; and
- Network Tasman which supplies Springs Junction and the Maruia Valley.

There is a network in Haast operated by NZ Energy Ltd. The Haast network is isolated from the national grid and the other local distribution networks. It is supplied by a small hydro station on the Turnbull River.

The 11 power generation sites on the West Coast supplying 32MW of power to the national grid, and the Westpower or BEL distribution networks are presented in Table 2.1. The power supplied by Transpower from the national grid to:

- The BEL network is 10MW, and
- Westpower is 23MW during off peak and 40MW during peak periods.

Table 2.1: West Coast Power Generation Supplying Westpower and BEL

Network[1]	Site	Owner	Year In Service	KW Generated
BEL	Rochfort	Kawatiri Energy	2013	4,200
Westpower	Amethyst	Westpower	2013	7,400
Grid	Arnold	Trustpower	1932	3,000
Grid	Dillmans	Trustpower	1978	3,500
Grid	Duffers	Trustpower	1979	550
Westpower	Fox	NZ Energy	2009	500
Westpower	Incbonnie	Inchbonnie Hydro	2015	1,700
Grid	Kaniere Forks	Trustpower	1931	500
Grid	Kumara	Trustpower	1978	6,500
Grid	McKays Creek	Trustpower	1931	1,100
Westpower	Wahapo	Trustpower	1991	3,100
TOTAL				**32,050**

1. All "Grid" sites are physically embedded in Westpower's Network

2.2 Networks

2.2.1 Transpower

Referring to Figure 2.1 it can be seen that the Transpower supply into the West Coast is by:

- Two transmission lines in parallel through the Buller Valley from the Kikiwa Substation, to Westport,
- Two 110kV lines from Inangahua down the Grey Valley to Dobson (Greymouth), and
- A single transmission line over Arthur's Pass to Otira and Arahura.

Since Holcim Cement closed its operations near Westport, Transpower has shut down the substation at Omau (Cape Foulwind), and is considering options to decommission the substation and the 110kV transmission line from Robertson Street to Omau.

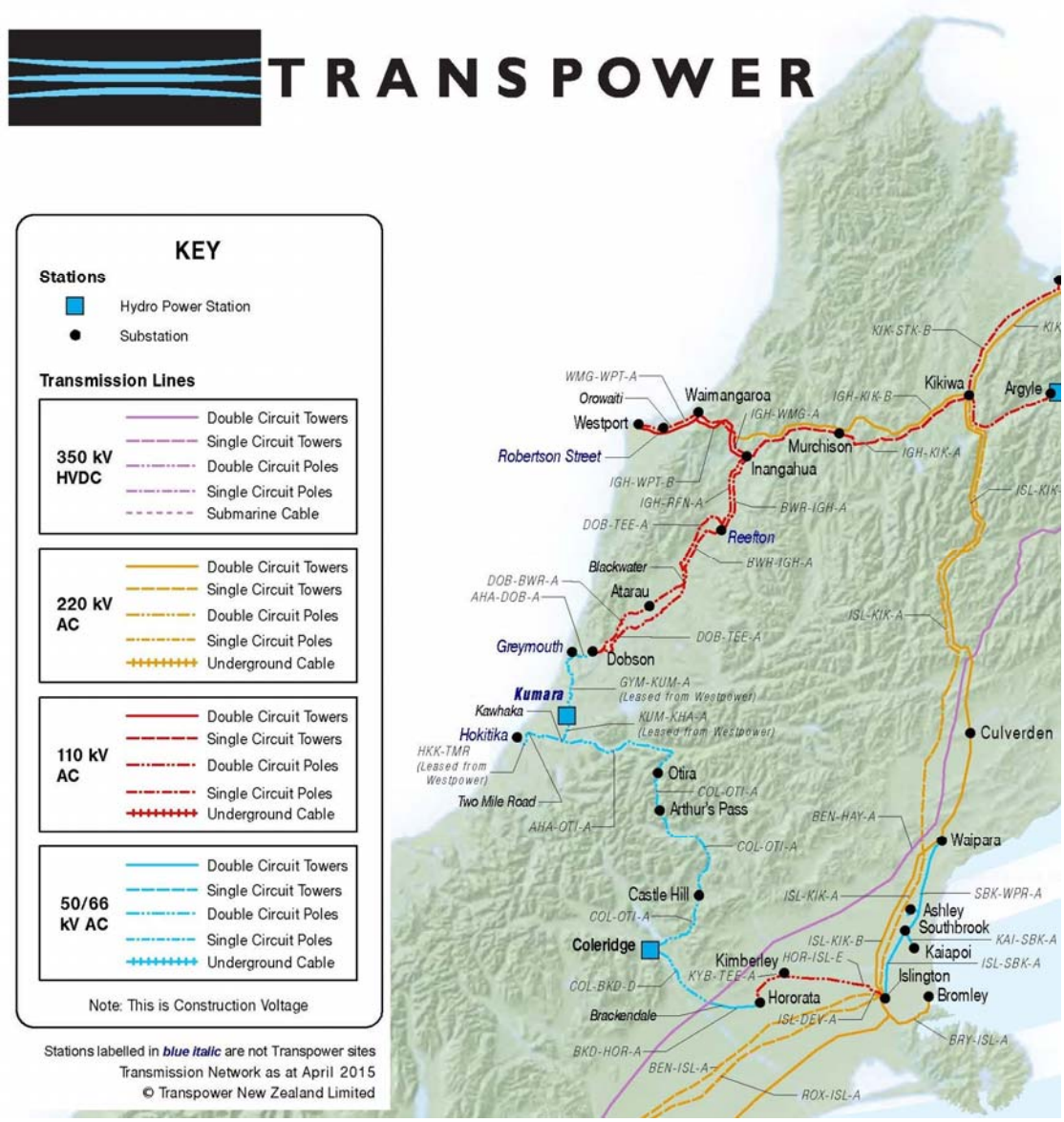

Figure 2.1: Transpower Network (From Transpower)

2.2.2 Trustpower

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).

The Trustpower power stations feed power into the Westpower network, with any excess generation fed into the national grid. Under normal operating conditions the national grid provides synchronisation. Only the Wahapo and the Amethyst stations are able to operate in isolation from the national grid (islanded mode).

2.2.3 Westpower

The Westpower network is the largest distribution network operator on the West Coast extending from Paringa in South Westland to Punakaiki on the coast in the north and to Lyell on the Buller River, servicing most of Westland District including Otira, all of Grey District and the central part of Buller District. The network is shown schematically in Figure 2.2 and on maps in Figures 2.3 and 2.4.

Westpower is a 100% West Coast community owned company. Westpower's contracting subsidiary, ElectroNet Services Ltd undertakes all the maintenance of the Westpower network.

Westpower network includes 2,180km of lines and cables, 18 zone substations and 2,443 distribution substations (5kVA – 1MVA), to deliver electricity to 13,445 customers with a current peak load of 43.5MW. Supply from Transpower is at the four Westpower owned substations (three 66kV: Greymouth, Hokitika and Kumara, and 110kV at Reefton) and the Transpower substations at Dobson (33kV), Atarau (110kV) and Otira (11kV). Westpower owns 42km of 66kV lines (Greymouth – Kumara – Kawhaka - Hokitka) which are leased to Transpower and operated as part of the national grid.

Westpower commissioned the 7.4MW Amethyst power station in 2013. The Amethyst station and the Wahapo station are able to run in islanded mode and provide enough power to synchronise the five Trustpower stations at Kaniere, Dillmans and Arnold along with the Inchbonnie and Fox power stations.

There is therefore reasonable redundancy in the network because of the number of lines feeding into the system and links within the system and the capacity to meet power demand independent of the national grid. The Amethyst and the Fox power stations are within 500m of the Alpine Fault trace and the remaining stations in Grey and Westland district are between 10km to 20km from the trace. South of Hokitika, the network is essentially a single 33kV transmission line to Fox Glacier with 11kV spur lines serving local areas including one from Fox Glacier to Paringa. A fault in the single 33kV transmission line, say between Ross and the Wanganui River, will break up the network so that if power was lost from the national grid, the network to the north could not receive synchronisation from the Amethyst and Wahapo stations and the network north of the break would not have power. Because of this vulnerability, Westpower endeavours to keep the 33kV transmission line to Fox Glacier well maintained.

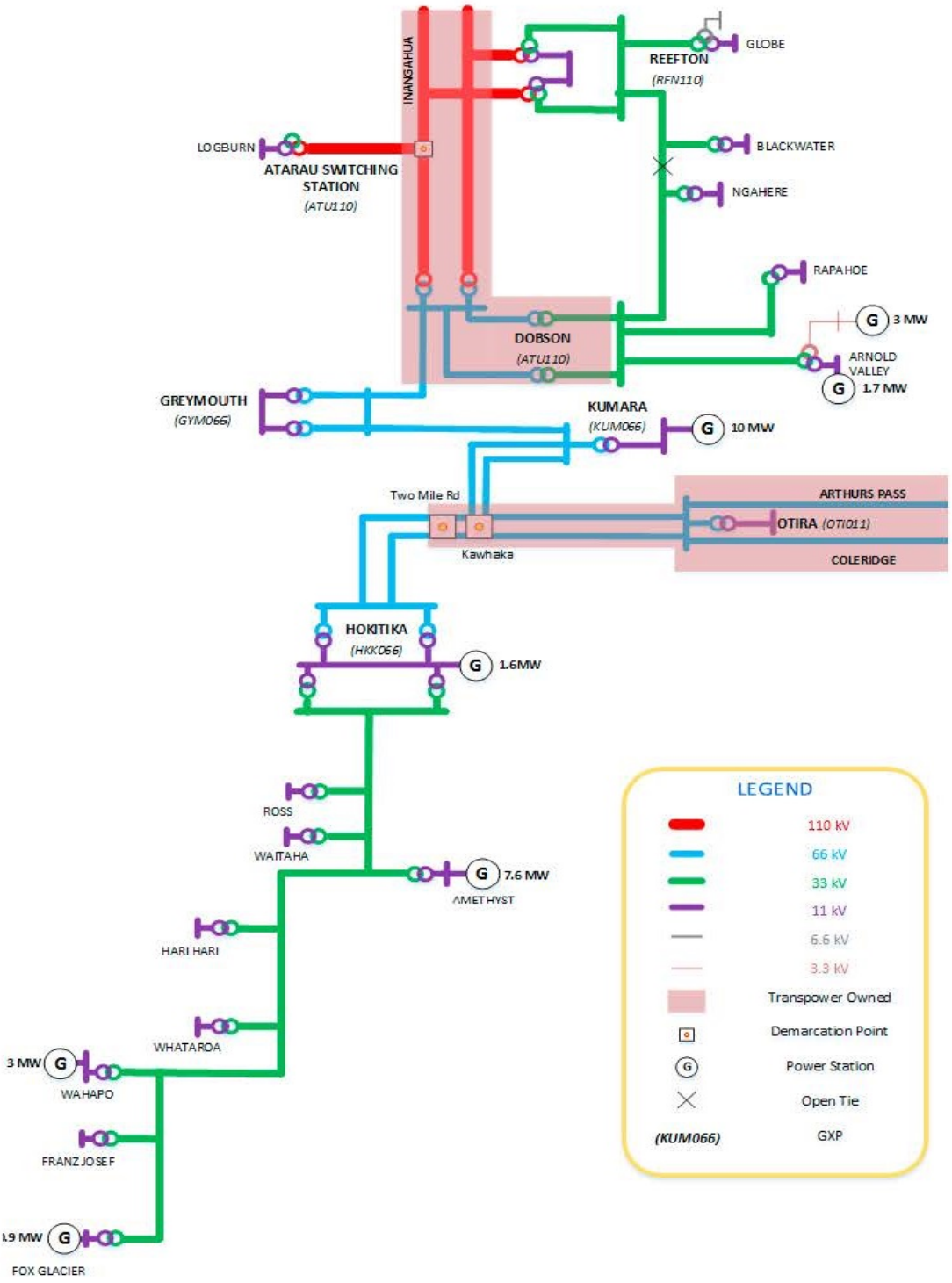

Figure 2.2: Schematic Diagram of Westpower Network (Westpower AMP 2017-2027)

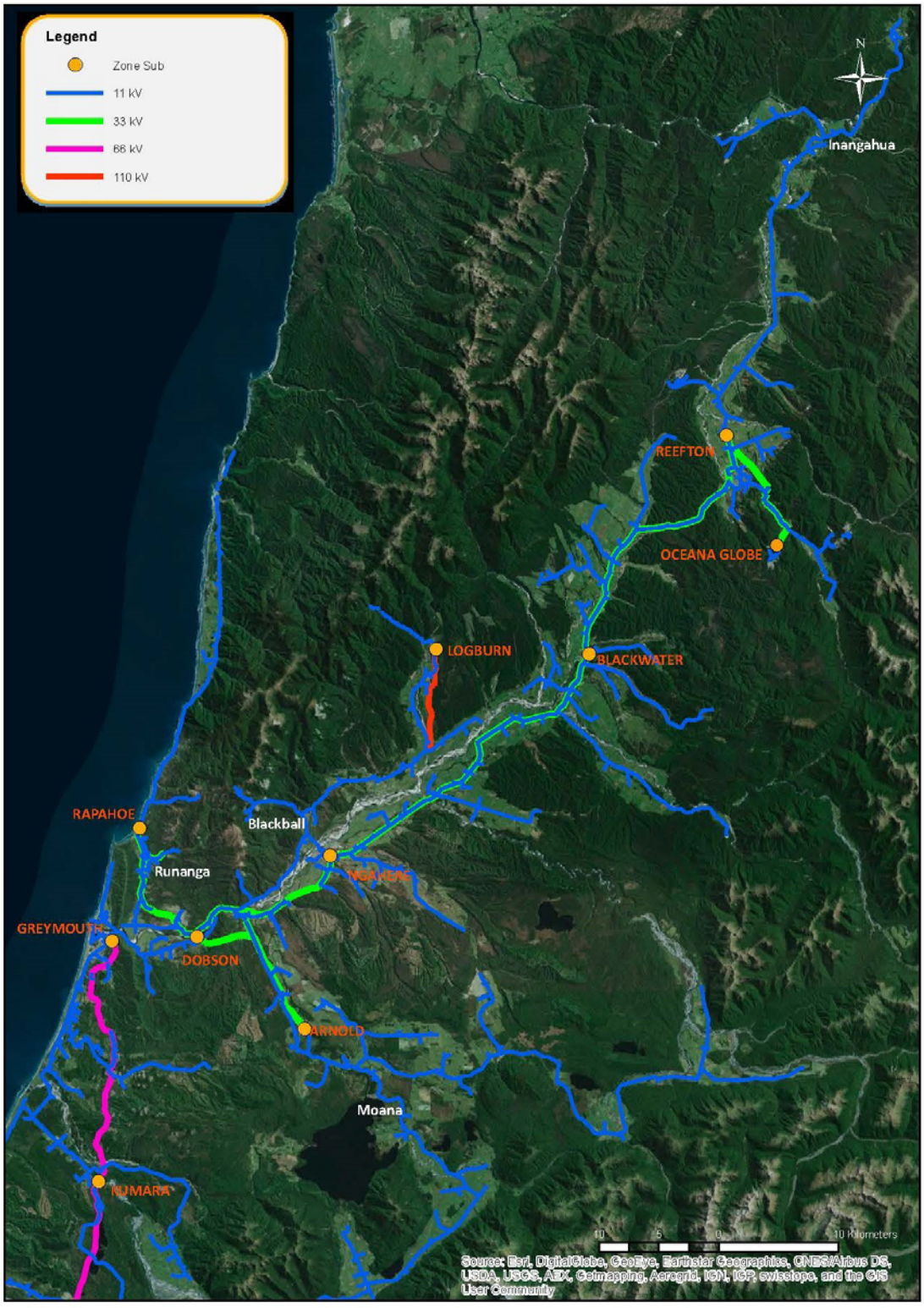

Figure 2.3: Westpower Network - Northern Section (Westpower AMP 2017-2027)

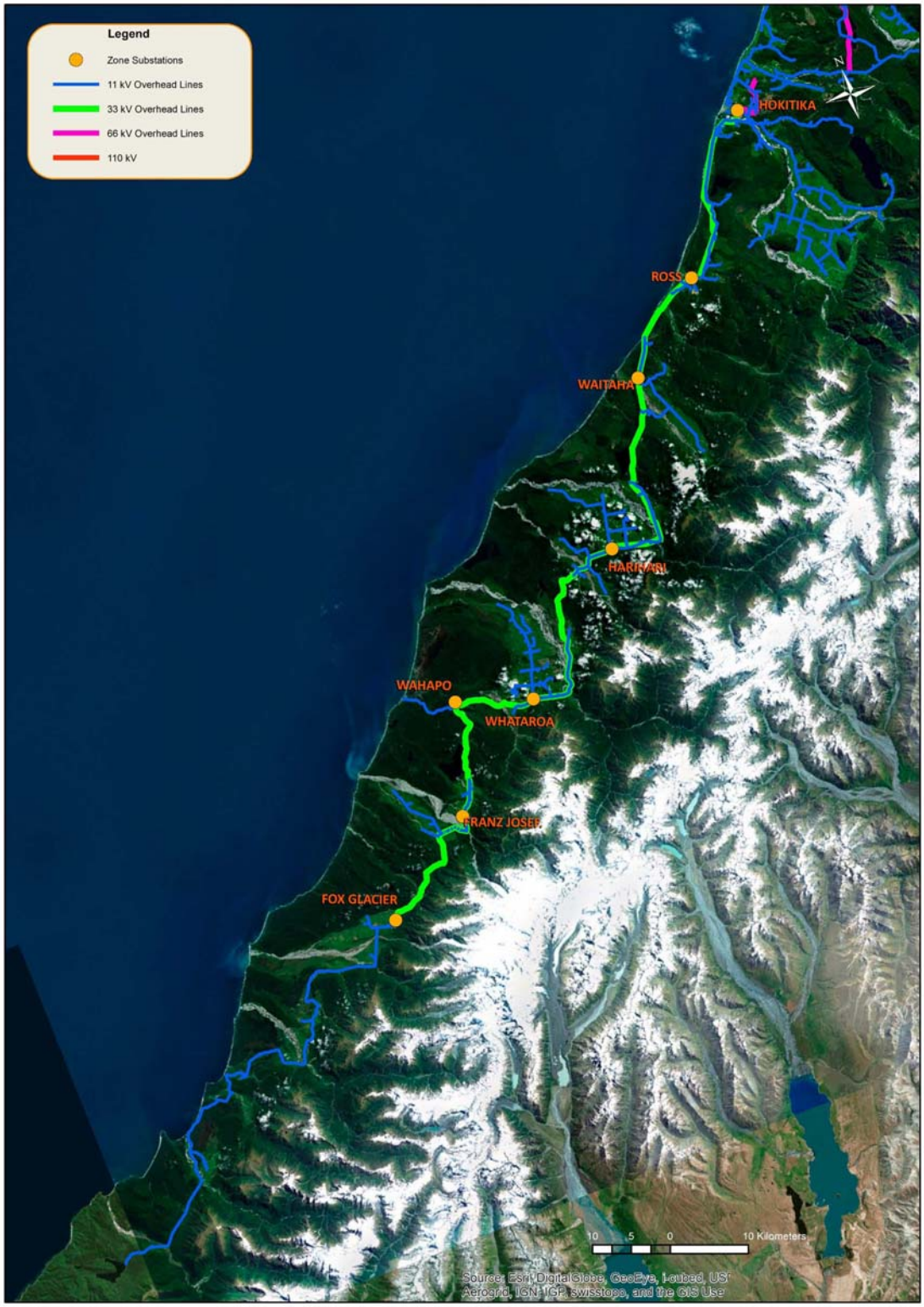

Figure 2.4: Westpower Network - Southern Section (Westpower AMP 2017-2027)

The Arahura – Harihari line was built by the NZED in the mid-1960s for 66kV. It was leased by Westpower in 1993 and then sold to them in 2001. It currently carries 33kV and Westpower may upgrade the line to 66kV again if a proposed new power station is built.

The power supply to Logburn from the Atarau switching station was to supply power to the Pike River Mine. With shutting down of the mine the 110kV supply to Logburn is to be decommissioned.

Westpower is working with CDEM to establish a "Controllers Net" radio network (refer *Supplement 7*) which will allow communication coverage of the whole West Coast.

The risk management section in the Westpower Asset Management Plan notes that a seismic withstand report was prepared in 2004. The recommended strengthening measures were assessed and actioned as necessary.

In the event of a transformer failure, the system can be reconfigured to allow a unit to be re-deployed from elsewhere on the network. Westpower has a mobile 33/11/3.3kV substation that has increased network security and reliability as it can be deployed and used in areas served by a single transformer.

2.2.4 Buller Electricity Ltd (BEL)

Buller Electricty Ltd (BEL) network shown in Figure 2.5 extends 150km from Meybille Bay in the south to Karamea in the north. It is essentially a linear network, supplying electricity to 4,600 customers via three substations, 640km of power lines and cables and 680 distribution transformers. Around a half of the customers are located in Westport. The remainder of the supply area is sparsely populated and rural in character. Significant industries are dairy farms and coal mining with an average combined maximum demand of 11 MW for all consumers on the network.

BEL is supplied by two Transpower 110kV lines from Inangahua via the old Transpower Waimangaroa grid exit point (GXP) substation to a single GXP substation (Robertson Street) owned by BEL. The Waimangaroa GXP substation has been decommissioned and is now a switching station only. The Robertson Street GXP is located above the 100-year flood level. The GXP at Cape Foulwind has been shut down as noted earlier and now the network south of the Buller River is supplied from Robertson Street substation via two 11 kV cables across the Buller Bridge.

BEL's three major substations are all new and incorporate modern seismic design. The Robertson Street substation was built in 2004 with two 20MVA transformers, the substation at Ngakawau in 2005 with two 2MW transformers and at Kongahu in 1995 with one 1.5MW transformer. A 1MW standby generator is located at the Kongahu substation to provide power during outages on the single 33kV line supplying the Karamea area over the Karamea Bluffs. Fuel storage is limited to 3,200 litres, which is adequate to supply the generator for 24-36 hours. Getting additional fuel to the site is problematic if road access is cut. Previously during extended outages BEL has been able to gain additional diesel supply from the Karamea garage and local farmers.

The network is linear, point-to-point in nature and areas where redundancy exists are limited to the Westport Township, and rural areas between Westport and Ngakawau, Cape Foulwind - Wilson's Lead Road, and the Karamea - Oparara ring.

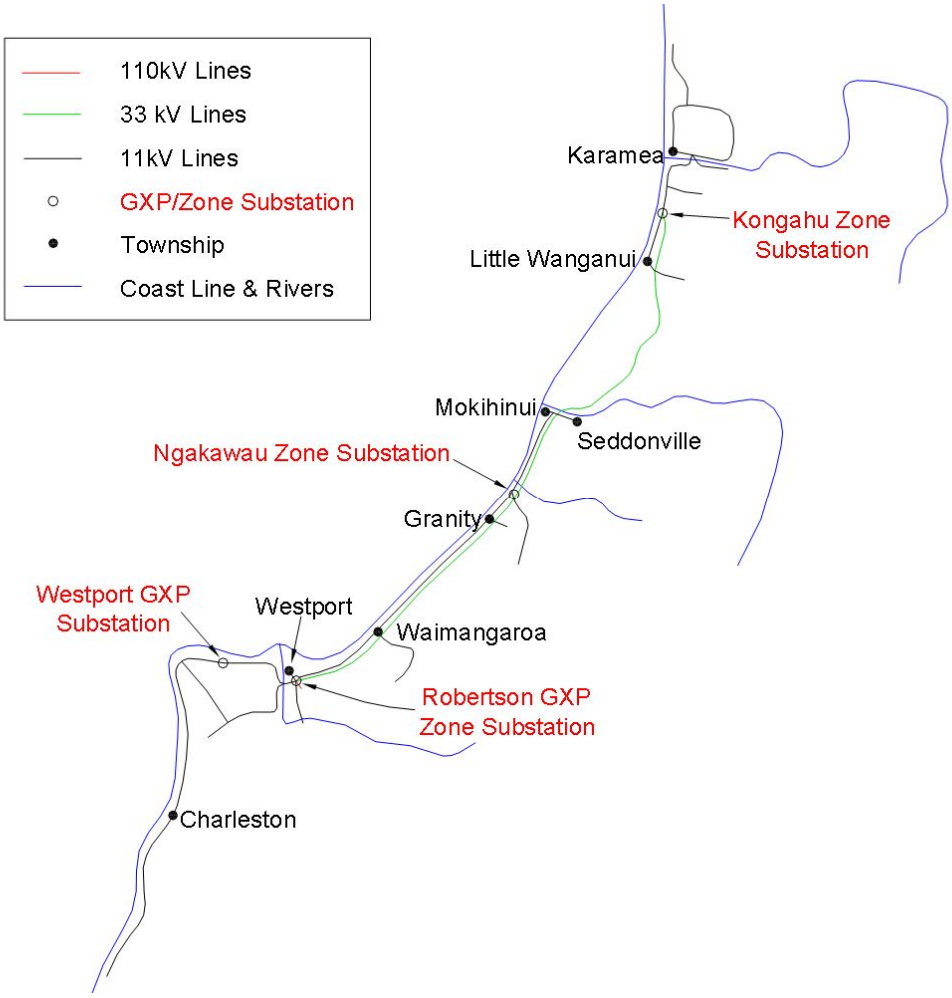

Figure 2.5: BEL Network

Embedded within the BEL distribution system is the 4MW Rochfort hydropower station owned and operated by Kawateri Energy Ltd at the top end of Powerhouse Road at Fairdown. At present this is not capable of operating in islanded mode. Investigations are in progress to enable islanded mode supply to limited sections of the BEL network when disconnected from the grid.

BEL has at its disposal one trailer mounted diesel generator able to supply 500kVA at 11kV and 400V. Additionally BEL has another 500kVA 400V generator and multiple smaller 400 volt generators available for use in emergency situations.

BEL has three radio repeater stations sited at Cape Foulwind, Millerton and Karamea for voice and SCADA communications. These provide coverage to approximately 90% of the BEL distribution area. Each repeater has standby battery capacity to provide approximately 48 hours of operation without

mains supply; these are also fitted with sockets for portable generator connection for operation during extended outages.

2.2.5 Network Tasman

Network Tasman supplies power to the Maruia Valley and Springs Junction area by an 80km long 11kV feeder parallel to the main road from the Transpower substation at Murchison. 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 proposes to upgrade the line to carry 22kV when demand increases sufficiently. Network Tasman has a risk management plan. The effect of major earthquakes on overhead and ground distribution substations was reported on in 1998. As a result there is ongoing strengthening of zone sub-station buildings with around 60% now completed. Mobile generators of 1250kVA, 500kVA, 300kVA and 150kVA capacity are available to provide emergency power supply.

2.2.6 NZ Energy

The supply power system to the Haast area is owned by NZ Energy Ltd, a small family company, which also owns the Fox power station. The Haast area system is isolated from the national grid. It has lines between Snapshot Creek, inland of Haast Township, and Jackson Bay. Power is generated at the 800kW hydro scheme on the Turnbull River, but there is also a 375kW backup diesel generator at Okuru. The maximum load currently is 700kW. All the major consumers, such as the hotels, motor camp, and fishing services at Jackson Bay, have their own emergency generators.

The network is essentially a single line with a spur into the power station. Many of the power lines are located close to the coast. There is an ongoing programme to move sections of the power line back from the shore where coastal erosion encroaches.

2.3 Energy – Fuels

The availability of an adequate fuel supply for vehicles, generators and aircraft is a critical issue both immediately after any major natural disaster and in the longer term. The source of fuel supply varies with each of the five fuel companies operating in the region. The five companies are Z, Caltex, Mobil, BP and Challenge.

There is bulk storage of LPG at most service stations and Rockgas in Greymouth. It is predominantly used for cooking and some heating. Electricity is probably needed to extract fuel from storage so generators would be needed if grid power is not available.

Fuel 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 as well as individual farmers. There is no strategic fuel supply held on the West Coast following the removal of the Caltex tank farm at Karoro. Some of the companies routinely supply the West Coast from Christchurch via Arthur's Pass or the Lewis Pass, while others supply fuel from Nelson.

3 VULNERABILITIES

3.1 Earthquake

The vulnerabilities of the energy supply network have been assessed based on the earthquake scenarios presented in *Supplement 2: Earthquake Scenario*. The scenarios adopted are the Alpine Fault scenario (AF8[1]), and the Inangahua earthquake for the Buller District. These scenarios subject the West Coast energy supply network to shaking of intensity MMVIII or greater.

Electrical and fuel supply vulnerabilities to a major earthquake include:

- Damage to generation or transmission lines remote from the region;
- Damage to power stations within the region preventing generation;
- Damage to transformers inadequately restrained 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 on to 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;
- 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; and
- Vulnerability of the power supply networks, particularly in Westland and north of Westport, because their linear nature increases vulnerability: one fault makes the whole system "downstream" inoperative.

[1] Project AF8 commenced in July 2016 and is a risk scenario-based earthquake response planning project focused on the South Island Alpine Fault. The project is funded by the Ministry of Civil Defence & Emergency Management's Resilience Fund.

Transpower has comprehensive emergency management procedures to manage outages and restore service. It has a policy of diversification of equipment 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 could be stretched with possible damage to the Upper Waitaki generation and transmission facilities and potential widespread damage of the transmission lines in the mountainous areas of Canterbury, Marlborough, Nelson and Westland.

In the AF8 scenario it could be several days before any power could be supplied from the hydro stations in the Upper Waitaki. Drawing on power from the North Island if needed may also not be straight forward. Power would be sent by the DC cable to Benmore where it would be converted to AC and distributed out via the Transpower network. Supplying power from the North Island however, would be contingent on:

- There being sufficient power available;
- The DC cable remaining intact after the Alpine Fault earthquake; and
- The DC converter at Benmore being operational.

The twin transmission lines from Kikiwa to Inangahua provide redundancy. 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. However the area is mountainous with potential for landslides to damage towers. All assets have been seismically assessed at Inangahua and upgraded if required but some damage can be expected to the inherently brittle components in switchyards such as bushings and insulators.

The twin transmission lines from Inangahua to Dobson also provide redundancy and the terrain is more benign.

In the AF8 scenario it would be highly likely that the line from Coleridge to Arahura over Arthur's Pass would be cut, with pylons and poles destroyed by landslides. Access for repair and reinstatement would be extremely restricted for weeks or even months afterwards. It would be safe to assume that Transpower supply would only be possible via Kikiwa and Inangahua for several weeks and possibly some months following an earthquake.

In summary although there is transmission line redundancy after an Alpine Fault earthquake there are concerns about power availability and it would be wise to assume that there would be no grid power to any of the West Coast for at least two to three days, with Buller being reconnected first. Westland might well have no grid power for more than a week. Westland is at the end of the line from Canterbury through Marlborough and Nelson and Buller, and efforts to re-establish supply to larger populations on the way might delay supply to the West Coast. Local generation from hydro stations supplying the Westpower network can provide on average 24MW and could meet demand with some load shedding. However it is likely the Amethyst power station would sustain significant damage. It is

possible the Wahapo power could be a synchronising source as it has a large flywheel with considerable inertia. It would be limited in range, however, and this might be problematic. Synchronisation from Wahapo would not be possible at all if the transmission line north were damaged/severed. A more detailed study is about to be carried out through the National Science Challenge.

On the local level, the effects of an AF earthquake could include:

- Intensity MMVII shaking (or greater) in the Springs Junction area causing damage to the long 11kV feeder, both from equipment damage and loss of poles from landslides. Network Tasman resources would be stretched with damage elsewhere in the system. Although damage elsewhere could be less severe, the number of people affected would be much greater than in Springs Junction, and hence reinstatement of the Springs Junction feeder would be low on their priority list, as well as much more difficult because of access constraints. It could well take many days for power to be restored to this part of Buller District.
- The Reefton – Inangahua area would suffer damage with MMVII shaking. The dual high voltage supply to the area greatly enhances reliability of supply. Some damage could be expected, but at least a reduced service should be possible once the national grid power into the district is re-livened.
- 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 would be the time needed to re-establish Transpower grid power; the Rochfort hydropower station cannot operate in islanded mode. In a Buller earthquake BEL infrastructure would suffer significant damage.
- Westpower's system in the Grey District and north of Ross would suffer somewhat greater damage with some pole and substation damage. The ends of lines approaching the fault would be the worst affected and the system inland of Moana and Kanieri might take some weeks to be re-established to all customers.
- South of Ross, intensity MMVIII - IX shaking (or greater) would cause damage to the transmission system. Landslides would cut the lines in many places, but particularly around Mt Hercules and Cook Saddle. The line would also be vulnerable at the east side of the Wanganui River near Harihari, at Franz Josef and at the Karangarua River where it crosses and then re-crosses the fault trace. The large ground displacements would strain the cables to the extent of causing failure of the cables or supporting poles. The line between Franz Josef and Fox Glacier follows close to the fault trace and is likely to cross the fault rupture in several places. Extensive damage to this section is almost certain and as the road would similarly be destroyed in places, reinstatement would be slow and could take many months. Fox Glacier and further south would therefore probably be without power for months. The small Fox hydro station could suffer sufficient

damage to prevent its operation, and lack of any road access for the supply of repair plant and material would prevent its repair before the transmission line could be repaired.

- Widespread damage is expected in the Haast area to both the hydro station and distribution lines, which would prevent the power supply from being re-established for months after the earthquake.
- Of the power stations on the West Coast, the 4.2MW Rochfort station is some distance from the Alpine Fault and unlikely to be damaged but could not operate in islanded mode. The 3MW Arnold station was deemed to have been poorly constructed soon after commissioning 75 years ago, and could suffer damage sufficient to prevent generation for some time. The 1.7MW Inchbonnie station is some distance from the AF8 rupture scenario. It is a small scheme without any large structures and unless landslides destroy a section of the pipeline or penstock, it should not suffer serious damage. However the station is practically on the Alpine Fault and would suffer would suffer significant damage if the rupture passed this point. The 10.5MW Dillmans scheme at Kumara could survive with minimal damage, but would not be able to generate without synchronisation. As with all the generating stations, owners would probably not want to restart them without a careful inspection by engineers, and this might take a few to many days to take place. The smaller 1.5MW station on the Kanieri River could be expected to be disabled for at least a few days. It is probable that this plant could operate independently of the grid. The Amethyst power station could sustain significant damage from landslide at the intake and ground displacement within the penstock route and require some months to repair. The 3.1MW Wahapo station should survive the earthquake, and could be used to supply power to most of South Westland with appropriate load management once the station and lines have been checked and repaired. The Fox and Turnbull River schemes are likely to be severely damaged.
- Fuel might be available from the service stations or companies that have fuel on site such as Solid Energy at Stockton and Evan Birchfield's gold mining operations at Ross. LPG would also be available. However further supplies of fuel are unlikely to be available to the Grey and Westland Districts for a week when reasonable road access is in place again. In South Westland, the situation would be much more severe, with road access unlikely to be re-established to Harihari for perhaps a month, and to Fox Glacier for perhaps over six months. The service station at Franz Josef is located on the fault, and it is very likely that any supplies there would be lost.
- The preparation of a plan for supply of fuel to the West Coast region after a major natural disaster is co-ordinated at a national level. At the time of preparing this document no fuel plan for the West Coast had been sighted.

3.2 Tsunami

Vulnerabilities of electrical supply and fuel supply to a major tsunami include:

- Shorting of buried cables if they become exposed to the water and have pre-existing casing damage;
- Damage to exposed cables due to scour, such as at bridge abutments and connections in buildings at foundation level;
- Damage to lines due to failure by toppling of poles from scour and/or debris impact;
- Damage to substations due to foundation scour, debris impact and submergence in saltwater;
- Damage to petroleum and gas terminals located in coastal areas including damage to pipe networks and tank farms where tsunami depths are 2m or greater; and
- Damage to roads preventing access to undertake repairs to electrical assets.

The tsunami event presented in *Supplement 4: Tsunami* assumes that all of the West Coast coastline is affected by a tsunami depth at the shoreline of about a 1:500 year return period. The wave depth varies around the coastline from 3m to almost 5m (run up height of 6m to 10m). A single source tsunami is unlikely to produce the same return period event over the whole coastline. However the probing scenario event does allow local vulnerable locations of the power network and fuel supply to be identified. These include:

- Karamea to Little Wanganui. The 11kV line along the Karamea Highway and the Kongahu substation and backup generator are located within 400m of the shoreline. Inundation and scour damage would be expected.
- Summerlea to Granity. The 11kV and 33kV lines are located on low land close to the shoreline. The substation at Ngakawau is located within 200m of the shore. Inundation and scour damage would be expected.
- Westport. The estimated tsunami inundation area is shown in Figure 3.1. The Robertson grid exit point and substation, the Mobil fuel station in Stafford Street and the BP and Caltex fuel stations in Palmerston St are unlikely to be affected.

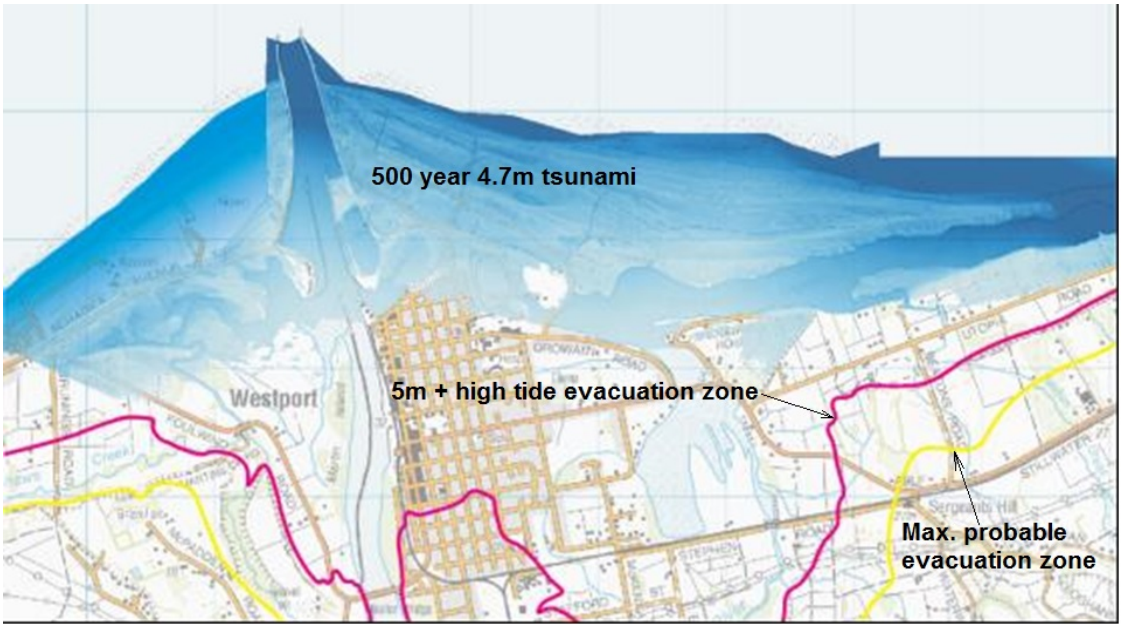

Figure 3.1: Westport - Estimated Inundation Area for 1:500 Tsunami Event

- Carters Beach. The tsunami wave is anticipated to travel 1km inland in low lying areas. The 11kV line and some of the 110kV transmission towers along with the Westport grid exit point and substation near the Holcim plant are within 1km. However they are on elevated land so are unlikely to be affected.
- Carters Beach to Rapahoe. The 11kV line could be inundated and damaged along low lying beach fronts where it is within 1km of the shoreline.
- Greymouth. Damage could be expected to assets in the inundation area shown in Figure 3.2. All four fuel stations (Z, Challenge, BP, Mobil petrol station) as well as the Mobil outlet in the Fulton Hogan yard are unlikely to be affected.

Figure 3.2: Greymouth - Estimated Inundation Area for 1:500 Tsunami Event

Red line marks edge of 5m tsunami + high tide evacuation zone

Yellow line is edge of the maximum probable event evacuation zone

- Greymouth to the Taramakau River. Inundation and damage would be expected to the 11kV line where it is close to shoreline.
- Kumara Junction to Hokitika. There could be some damage to the 11kV line in low areas where it is close to the shoreline;
- Hokitika. Inundation and damage would be expected to the 11kV line within Hokitika on the lower terrace to 500m upstream of the SH 6 bridge. Both BP and Challenge fuel stations on Fitzherbert St could be inundated. The Hokitika substation and the BP Truckstop near Westland Milk Products are around 1.5km upstream and unlikely to be affected.

Figure 3.3: Hokitika - Estimated Inundation Area for 1:500 Tsunami Event

Red line marks edge of 5m tsunami + high tide evacuation zone

Yellow line is edge of the maximum probable event evacuation zone

- Hokitika to Ruatapu. Possible inundation and damage around poles carrying the 33kV and 11kV lines in low lying areas.
- Ross to Bold Head. Possible inundation and damage around poles carrying the 33kV and 11kV lines in low-lying areas along Bold Head Road.
- Okarito, Manakaiaua River Mouth and Bruce Bay settlements. There could be inundation around poles and damage to 11kV lines in these settlements as well as damage to the 11kV line for approximately 3km of the shoreline in Bruce Bay.
- The majority of the power lines in the Haast area would be inundated around the poles and badly damaged as they are in very close proximity to the shoreline. The generator for the supply located at Okuru is approximately 500m from the shore and could also to be damaged.

The tsunami scenario would impact on power supply and fuel for West Coast communities as follows:

- There is unlikely to be any damage to the Transpower network.
- The Ngakawau zone substation and Kongaha zone substation and generator, and sections of the 11kV distribution network and 33kV line between Granity and Summerlea and between Little Wanganui and Karamea would be inundated and damaged. As the road would also be damaged in these areas, access north of Granity might be limited for at least a day or two and to Mokihinui for up to a week. One possible recovery strategy would be to repair the 33kV line to Ngakawau to allow power to be provided to the Stockton mine. Generators would be taken to Seddonville and Karamea as soon as the road was open to provide power to those communities and provide power to dairy farmers for milking. Maintaining power to sites like milking sheds to allow milking to continue until BEL network electricity was available would mean at least a week's supply of fuel would be needed in the Karamea area for generators and enough generators to meet the power requirements of all the sites.
- Some sections of the 33kV line to between Ngakawau and Mokininui, and from the Little Wanganui River to Karamea would be likely to need replacement as failed poles would drop the wires into the tsunami surge resulting in loss of lines. If the substations at Ngakawau and Kongaha were inundated, transformers might need to be replaced. Unless spare ones were available, which is unlikely, there could be a lead time of 18 months to 2 years. The timing of replacement of the 11kV lines would be planned and coordinated with the expected arrival of new transformers. All new power line routes and the location of transformers should take into consideration natural hazards as well as any changes in demand after the event. For example the replacement lines and transformer between Little Wanganui and Karamea may be better located further from the sea, perhaps on the Wangapeka – Kongahu Swamp road.
- The BEL supply to Meybille Bay and the Westpower supply to Punakaiki would be disrupted due to damage to the 11kV lines. Many residents in the area would need to be evacuated due to damage / loss of homes. Re-establishing supply would be assessed in consultation with the affected communities.
- There would be disruption to supply to communities between Kumara Junction and Hokitika due to damage to the 11kV line.
- The impact to the network would be more serious further south due to damage to the 33kV line between Hokitika to Ruatapu and Ross and Bold Head: four kilometres of line along Bold Head Road is between about 250m and 450m of the high tide line. The line is supported on tall single poles with 140m spans and embedment depths sufficient to carry the wind load reduces the susceptibility to scour, but a break in the 33kV line would separate the network into two areas. The Amethyst and Wahapo power stations could power the southern area but a break in the 33kV line would mean they could not provide power northward. Although unlikely as a direct result of tsunami, if power from the national grid were lost, perhaps due to supply issues outside the region, the northern area would be without power as the hydro

station in the northern area requires the Amethyst and Wahapo station or the grid for synchronisation.

- The 11kV lines between Hokitika to Ruatapu and Ross and Bold Head might also be damaged resulting in loss of supply to community on these lines.
- Residents in Okarito Settlement, the settlement near Manakaiaua River Mouth and in Bruce Bay would need to be evacuated due to damage / loss of housing. Repair to the 11kV line to re-establishing supply would be assessed in consultation with the affected communities.
- Damage to the power lines in the Haast area would be significant because of the close proximity to the shoreline. The coastal settlements such as Hannah's Clearing and Neils Beach may be uninhabitable and Haast Township would need to rely on generators in the community until the power lines could be repaired. Re-establishment of the power supply lines from Haast Township could be implemented first and re-establishment to coastal settlements would need to be assessed in consultation with the affected communities.

3.3 Major Storm

Vulnerabilities of electrical supply and fuel supply to a major storm include:

- Landslides and debris flows carrying poles away or pushing them out of alignment;
- Damage to underground cables at locations vulnerable to scour such as bridge abutments and cable enter at building foundations;
- Damage caused by inundation of buildings, transformers, generators and switching and control equipment etc;
- Damage to roads preventing access to undertake repairs to electrical assets; and
- Damage to poles and lines from high winds and treefall.

The assessment of the impact of a major storm on the electricity and fuel supply is based on the storm event outlined in *Supplement 3*. It is unlikely that Transpower supply to the region would be interrupted due to the duplicate power lines through the Buller Gorge and down the Grey Valley providing good redundancy. There is also the 66kV line over Arthur's Pass.

Focusing on recovery after the flooding has receded, the following are identified vulnerabilities of the electricity and fuel supplies:

- The hydro power stations. There is potential for damage to the intake structures and transmission pipelines/penstocks due to landslides and debris flows as well as flooding;
- The BEL 33kV line over the Karamea Bluffs. Access could be difficult due to possible storm surge damage to the road between Granity and the Mokihinui River and landslides on the Karamea Bluffs. A possible scenario would be that the Granity to Mokihinui road is closed

for one week and the Karamea Bluffs road closed for one month so power supply from Westport might not be reinstated to Karamea for one month. Fuel for Karamea would be brought in daily by helicopter until the road was open.

- The BEL 11kV line from Charleston to Meybille Bay and the Westpower 11kV line from Rapahoe to Punakaiki. A possible scenario is that access via SH 6 from Rapahoe to Punakaiki would be open after two weeks, while repairs would be completed to the Westpower line and power back on by week 3. Access from Charleston to Punakaiki would be open after one month and power from BEL to the area soon after.
- Grey Valley – Westpower 11kV lines. A possible scenario would be for supply to be restored to most properties after a week. The rate of restoration would be delayed due to the number of slips to be cleared to gain access. The areas where power resumption would be slower would be on the Kumara - Inchbonnie Road and Rotomanu to Jackson. Power would not be restored to these areas for two weeks.
- Otira. The Otira community relies on the Transpower 66kV line for its power supply. Road access to Otira could take 1 month to restore. Power supply could probably be restored before road access using helicopters to make repairs to the Transpower towers and power cables, and four wheel drive vehicles to access the Otira GXP and distribution network. Power is needed at Otira to operate the tunnel fans and allow the Midland line to operate.
- Hokitika to Franz Josef. The Wahapo and Amethyst power stations could continue running and supplying power even if the 33kV line fails, provided that large floods do not damage the headworks and that landslides do not impact on the schemes. Monitoring and control of these stations would be continuous provided the Westpower radio network, which is very robust (refer *Supplement. 7: Telecommunications*), continued to operate. However power would have to be shut down until the power stations and the lines could be assessed. The main vulnerability would be power poles knocked down by landslides or by flood water scouring. Access to south of the Wanganui Bridge to undertake any major repairs may not be possible until after the bridge is repaired, should it be damaged – one scenario has a two week period for this.
- Franz Josef to Lake Paringa. Similar to the Franz Josef area. The Fox power station might keep operating and could be monitored and controlled via the radio network. However power would have to be shut down until lines had been assessed. Any major repairs would not be undertaken until access was restored, which might be up to two month after the storm event.
- Haast. As with the other hydro stations the Haast power station could probably continue operating, provided a large flood did not obstruct the intake and landslides did not damage the pipeline. However power lines would need to be assessed and repaired; there might be damage from storm surge along the coast. Major repairs might not be undertaken until road access was reinstated one to three weeks after the storm event.
- Fuel supplies could be brought in by helicopter to meet emergency power requirements. However bulk fuel supplies would not be available until road access was restored. Health and

safety would be likely to make bringing in fuel supplies by sea or river impractical unless a suitable vessel designed for fuel transport was available.

3.4 Summary

Table 3.1 gives a summary of electricity and fuel vulnerabilities.

Table 3.1: Electricity and Fuel Vulnerabilities

No.	Description
1	There is no fuel plan publicly available outlining how fuel is to be provided to and within the region. After an Alpine Fault earthquake it is likely that land transport routes to the West Coast would be closed with the first route open to outside the region after a week or two weeks perhaps longer. Opening the road south of Ross to Franz Josef and beyond might take several months. The transport route to Karamea is likely to be closed for one month after a major storm event. Bringing fuel into the West Coast via the port of Greymouth or Westport requires a specialist vessel. After any major disaster there would be high demand for fuel particularly aviation fuel and diesel for earthmoving equipment and generators.
2	Power supply after a major earthquake like an Alpine Fault earthquake might not be restored from the national grid for a week or more. Generation capacity on the coast is likely to be reduced to 20MW or less. Many of the stations remaining cannot generate in islanded mode, further reducing capacity.
3	The Ngakawau zone substation, and Kongahu zone substation and diesel generator along with the following sections of power lines are vulnerable to inundation and damage from a major tsunami: • Little Wanganui to Karamea, • Granity to Summerlea, • Sections on low ground close to the shoreline from: o Charleston to Rapahoe, o Kumara Junction to Hokitika, o Hokitika to Ruatapu, o Ross to Bold Head, and o Haast to Jackson Bay Wharf

Table 3.1: Electricity and Fuel Vulnerabilities (Continued)

No.	Description
4	The following electricity infrastructure is vulnerable to damage in a major storm event: • Hydro power station intakes and transmission pipelines/penstocks due to flooding, landslide and debris flows; • The BEL 33kV line over the Karamea Bluffs due to landslide and debris flows; • The BEL 11kV line from Charleston to Meybille Bay and the Westpower 11kV line from Rapahoe to Punakaiki due to landslide and debris flow damage; • The Westpower 11kV lines in areas of the Grey Valley due to river scour, landslides and debris flows. • The Transpower 66kV line supplying the West Coast in particular the Otira community and the Midland line rail tunnel fans, due to landslide and debris flow damage; • The 33kV and 11kV line between Ross and Lake Paringa, due to landslide and debris flow damage; • The 11kV line of the Haast power supply, due to storm surge.
5	Repair to electricity infrastructure and supply of fuel for generators in areas cut off from network supply are likely to be significantly impeded by lack of road access in the following areas: • West Coast generally (Alpine Fault earthquake); • Karamea (earthquake, tsunami and storm); • Westport to Karamea if the Lower Buller Gorge and coast route (SH 6) are closed (earthquake and storm); • Communities between Charleston and Rapahoe (earthquake, tsunami and storm); • Otira (earthquake and storm); and • Communities from Ross to Makarora (earthquake and storm).

4 UPGRADES AND IMPROVEMENTS

The following upgrades and improvements are recommended:

- Ensure a West Coast fuel plan is prepared and provided as a matter of urgency. The plan should take into account fuel supply concerns raised in this report. In particular fuel supply options should be developed for remote locations such as Karamea and south of Ross where road access might be closed for a month or more.
- Prepare a best-estimate of time to re-establishing national grid electricity to the high voltage lines supplying the West Coast Region after an Alpine Fault earthquake given the possibility of infrastructure damage outside the West Coast Region.
- Assess the viability of improving the reliability of the hydro power stations after a major natural disaster including upgrades required to allow them to operate in islanded mode.

- Assess options for maintaining the functionality of assets (power lines, substations, generators etc) after a major natural disaster. Options could include:
    - Protecting the assets;
    - Making assets mobile so they can be moved out of harm's way. This would assume that sufficient warning could be provided, e.g. warning of a tsunami approaching;
    - Identifying alternative locations of power line routes out of the path of tsunami or flood water or away from areas susceptible to earthquake damage and moving the assets as opportunities arise, e.g. asset replacement or upgrading;
    - Detailed tsunami modelling for substations located within potential tsunami zones to better assess the risk and possibly allow for mitigation measures such as bunds to reduce exposure;
    - Considering installing solar power at communication sites that currently rely on grid generator power, especially remote sites; and
    - Arrange priority service from engineers familiar with the various generation stations to inspect following a major event, and protocols with MCEDM for transport and access (most engineers will be based outside the region).
- Review options to improve electricity supply recovery time after a major natural disaster such as:
    - Spare parts requirements. In particular review availability of transformers within New Zealand that are compatible with transformers utilised on the West Coast.
    - Storage of spare parts to ensure they are strategically located and easily accessible after a major natural disaster.
    - Ensuring components are adequately secured against earthquake shaking at all sites.

MAJOR INFORMATION SOURCES

Buller Electricity Ltd Asset Management Plan 2017 – 2027.

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