West Coast Lifelines

Vulnerability and Interdependency Assessment

Supplement 12:

Westland District Council

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: Franz Josef Oxidation Ponds, March 2016. Photo from West Coast Regional Council

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Westland District Council Lifeline Assets

1 OVERVIEW

The Westland District Council (WDC) manages the following lifeline assets:

1. Transport systems,
2. Water supplies,
3. Sewerage systems, and
4. Storm water systems.

This supplement provides a summary of the assets including descriptions of the assets and explores their vulnerability to three natural disasters; major earthquake, major storm and a large tsunami. Details of the earthquake, storm, including heavy rain and strong winds, and tsunami scenarios used to assess the WDC assets are provided in *Supplements 2, 3* and *4* of the report. It is important to note here 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. Bearing this in mind, though, they do also 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 primary focus is on vulnerabilities that delay recovery of the district. These are summarised, and upgrades and improvements are provided to address them.

2 TRANSPORTATION

2.1 Overview

Transportation assets managed by Westland District Council are:

- District roads.
- Aerodromes. The Hokitika airport is an important lifeline and provides regular daily flights. There are also three aerodromes for local small plane and helicopter operations.
- A wharf at Jackson Bay for small ships.

The district road network is closely linked to and dependent on the State Highway (SH) system managed by NZTA. This is described in *Supplement 6 - Transportation.*

2.2 Roads

The Westland District is characterised by its long narrow shape and the road network, by low traffic volumes, by frequently mountainous or hilly terrain with high rainfall, and by the many rivers and streams that cross the main routes. There are only five links to the rest of the South Island; three bridges across the Taramakau River into the Grey District, and the Arthur's Pass and Haast Pass crossings over the mountains. There is some interconnection of roads north of Arahura and inland from Hokitika but south of Ross there is essentially a single road (SH 6) with short side branches serving south Westland.

Table 2.1: Westland District Road Statistics

	NZTA (SH)	Westland District[1]
Roads		
Total length (km)	445	677
Urban sealed (km)		58
Urban unsealed (km)		1
Rural sealed (km)		316
Rural unsealed (km)		302
Bridges & Large Culverts		
Number	151	287[2]

1. WDC Roading AMP 2015 (Table 2.2)
2. Includes foot bridges

Relative traffic volumes on the state highways in the district are indicated in Figure 2.1 below.

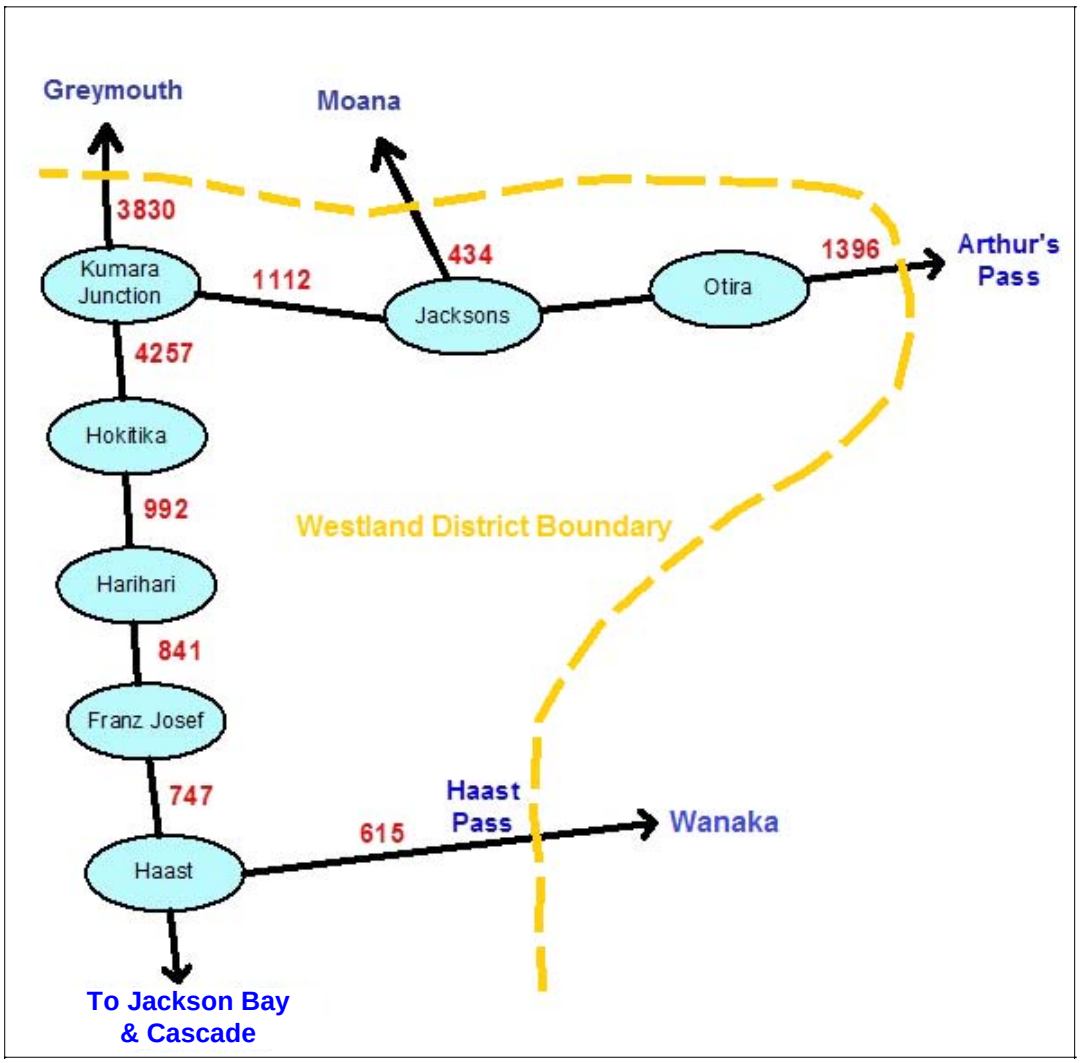

Figure 2.1: Annual Average Daily Traffic Volumes (NZTA for 2015)[1]

Westland District roads can be grouped as follows:

- A number of roads between the Taramakau and Arahura rivers connecting Turiwhate, Arahura, Stafford and Kumara, which also provide some redundancy to the State Highway network (SH 73 & SH 6);

- Roads inland from Hokitika: at Kaniere the old state highway road crosses the Hokitika River and links with SH 6 inland from Ruatapu, a road serves the settlements at Lake Kaniere, and a third road follows the east bank of the Hokitika River to Kokatahi and Kowhitirangi. The Kokatahi Road links to the south end of Lake Kaniere and the road on the east side of the lake. The Kowhitirangi area of about 40km^2 of farmland is accessed by a single bridge across the Kokatahi River.

- Bold Head Road, which provides some redundancy to SH 6 between Mikonui River and Kakapotahi.

- Local roads branching off SH 6 to serve:

    - Farming areas in the Waitaha Valley, at Harihari, Whataroa, Lower Waiho and Cook valleys,

    - The small community at Okarito, and

    - Okuru, Hannahs Clearing, Neils Beach and Jackson Bay.

2.3 Airports

There are four aerodromes listed with the Civil Aviation Authority in the Westland District:

- Hokitika
- Franz Josef
- Fox (helipad)
- Haast

Hokitika airport is owned by the Westland District Council through a subsidiary holding company. It is the busiest airport on the West Coast, serving both Hokitika and Greymouth with two regular commercial flights a day to and from Christchurch, as well as helicopter and charter flights. It has two sealed runways, one being 1,314m by 30m and the second 1,176m by 18m. Only the first runway and taxiway have lighting. There is a passenger terminal and fuel facilities and there is a standby generator for runway lights and communications only.

Franz Josef aerodrome consists of a single 800m by 9m sealed runway 5km SW of the township. There is no lighting but it does have a fuel facility. It is operated by Air Safaris and Services, based in Lake Tekapo. Helicopter operations are based on a helipad adjacent to the township that is operated by the Westland District Council holding company and has fuel on site.

Fox Heliport is operated by Glacier Southern Lakes Helicopters Ltd and is 1.5km west of the township. There is no lighting or facilities, and it is limited to 15m long helicopters. There is a grass airstrip about 700m long 0.5km north of the township.

Haast aerodrome is a 700m by 60m grass runway operated by Heliventures Ltd, 0.5km south of the Haast Hotel and Department of Conservation centre. It has no lighting but it does have a fuel facility.

[1] Data sourced from NZTA website https://www.nzta.govt.nz/assets/resources/state-highway-traffic-volumes/docs/2011-2015-AADT-Booklet2.pdf

There are numerous smaller private grassed airstrips on the West Coast 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, from north to south:

Kanieri 2.5km to SE near Taminelli Creek	Okarito
Milltown (upper Arahura valley)	
Kokatahi, Whites Rd, 2km north	Tatare, 2km north of Franz Josef township
Kowhitirangi, Stopbank Rd, 4km south	Fox, 6km west of township
Ruatapu Falls Creek Rd, 6km south	Karangarua, 1.5km west of the bridge
Okuru (Haast)	Neils Beach (Jackson Bay).

2.4 Ports

The Jackson Bay wharf is operated and maintained by the Westland District Council. The wharf is about 65m long, with a 145m long trestle approach from the shore. It is of timber construction and was built in 1937-38. The water depth and load capacity of the wharf are not known, but it would be adequate for the size of vessels able to use Greymouth port. Jackson Bay is currently used as a base for fishing boats.

The wharf's seismic capacity is not known. It should survive an Alpine Fault earthquake with rupture north of Paringa with little damage, but could be significantly damaged if the fault rupture extended south of the Arawhata River. It is recommended that its seismic strength be checked.

While currently of limited use, this wharf could be of great importance, for example after a major earthquake when all road access to the Haast area may be cut for a significant period. While the permanent Haast population is less than 300 people, from late August to mid-November the whitebaiting season swells the population to over 1,000, and numbers stay high through the summer from tourism.

2.5 Vulnerabilities – Transportation

This section discusses the vulnerability of the WDC transportation assets. Potential vulnerabilities of the transport network have been identified based on the earthquake, storm and tsunami scenarios set out in *Supplements 2, 3 and 4* respectively of this document. State highways are an integral part of the road network so are included here.

2.5.1 Roads

Earthquake:

The vulnerabilities to the road infrastructure to major earthquake are:

- Fault rupture offsetting the road vertically and horizontally;
- Structural damage to at least some bridges, in some cases resulting in prolonged bridge closure;
- Slumping of bridge abutment fill which may result in temporary bridge closure;
- Landslides that deposit material on the road or results in the carriageway falling away; and
- Liquefaction resulting in slumping and fissuring in local areas.

Some particular earthquake vulnerabilities in the WDC road network are:

- Lake Kanieri Road. This is the only road providing access to the Hokitika water supply intake at Lake Kaniere and the pipeline, as well as to the two small hydro stations and the settlement at Lake Kanieri. In a major earthquake like the AF8 (refer *Supplement 2*) there is a risk of landslips where the road closely follows the river. The nine bridges are all relatively small, except for the 3 span Kanieri River Bridge, but some damage is likely. (The Upper Kokatahi – Dorothy Falls Road is likely to be severely damaged with bridge damage or collapse, landslides and possible fault rupture.)
- Kowhitirangi Road. This is the only road giving access to the Kowhitirangi – Kokatahi farming communities (except the Dorothy Falls Road). In a major Alpine Fault earthquake it is likely that the section of road to Kokatahi will sustain little significant damage. There are five bridges, but all are relatively small. The Kaniere River Bridge is a 3 span bridge from 1961 and could suffer some damage, but an alternative ford should be easy to establish. Beyond Kokatahi, the roads are all close to the Alpine Fault trace and more damage would be expected, although apart from bridges this should not prevent vehicle access. The Kokatahi Bridge is a 310m long 15 span bridge built in 1949. In an AF8 scenario earthquake it is likely to be subjected to 0.8+ PGA and some significant damage is very likely. Alternative access across the river for heavy vehicles might be difficult given the size of the river.
- Haast – Jackson Bay Road. This road links the communities in the area with each other, the Haast aerodrome at the north end and the wharf at the south end. In a major earthquake like the AF8 scenario, damage is likely to be severe and road access out of Haast is likely to be cut for some time. Thus transport nodes and access between the communities for greater self-reliance become important. The road also provides access to the local power system. Slips on the coastal escarpment close to Jackson Bay could easily bury lengths of the road. Liquefaction could be severe in places, requiring some earthworks before access by even four wheel drive vehicles is possible. However the main problem would be the bridges. There are five large multi span bridges on the road. Four of these are reinforced concrete structures thought to date from the 1940s, and likely to suffer severe damage with the strong shaking

expected at their 4 – 7 km distance from the fault. The fifth is the 260m long Arawhata Bridge, only 1km from the fault line.

Storm:

Storm damage to roads can include the following. This type of damage can occur anywhere there is a suitable combination of road and terrain or road and rivers:

- All bridges and waterways are at risk of damage in a large flood event. Bridge waterways are typically designed for a 100 year flood, but many older bridges will not have had flood flows assessed and in any case, extreme events can result in problems such as:
    - Under-capacity waterway,
    - Debris caught on the bridge piers or superstructure placing high lateral loads on the structure,
    - Debris flow and aggradation reducing the waterway or even burying the bridge,
    - Scour, which could undermine the foundations to piers or abutments, and
    - Bank erosion resulting in the loss of abutment fill.
- Culverts are vulnerable to blockage with debris, which could result in uncontrolled flow over the road, scour and slips on the downhill batters.
- Landslides with saturated soils on hillsides burying roads from hillsides above.
- Washouts and dropouts removing the road from below.
- Bank erosion along larger streams and rivers.
- Flooding of roads, although this is generally a short term aspect that does not feature in the recovery period.
- Deposition of debris and local scour from floodwaters, including those areas normally protected by stopbanks which have been overtopped in an extreme event.
- Fallen trees across the road brought down by strong winds as well as damage to suspension bridges not adequately secured for strong wind events.

Some particularly vulnerable WDC roads are:

- Kokatahi: The Kokatahi – Kowhitirangi Road is vulnerable to flooding. There is potential for scour damage at any of the five bridges.
- Lake Kaniere Road: There is a risk of landslips where the road closely follows the river.
- Harihari – Herepo: There is potential for flooding and scour damage on the road serving the farming community. However there is road redundancy in the area.
- Whataroa: Roads serving the farming community. There is potential for flooding and scour damage and there is little or no redundancy.
- Haast – Jackson Bay: There is potential for scour damage at the Arawhata River Bridge and slips between Neils Beach and Jackson Bay.

Tsunami:

Tsunami damage to roads would only occur where tsunami inundation occurs. Roads are most vulnerable when located near to the shoreline, adjacent to drains, rivers and culverts, where flow is concentrated and hence velocity is higher, on elevated ridges and on poorly compacted subbase. Scouring of roads near the shoreline occurs particularly from the receding wave, and areas of severe inundation (>2m) often have coincident scouring. Roads are frequently blocked with debris after a tsunami and where waves are greater than 2m, building damage increases increasing the amount of debris in the flow.

Roads vulnerable to tsunami damage in the Westland District include:

- Bold Head Road. Bold Head Road is within 300m of the shore for almost 4km. Some scour damage could be expected.
- Okarito. There could be scour damage to the road in the Okarito community with the road blocked by debris. Housing in the area is likely to be badly damaged or destroyed and uninhabitable so road reconstruction might not be urgent.
- Haast Jackson Bay Road. There could be scour damage to the road where it runs parallel and close to the shore; the road is 200m or less from the shore for 12km. There could be possible scour damage at the Okuru, Turnbull and Hapuka River bridges. The road between Neils Beach and Jackson Bay could be inundated, blocked with debris and damaged by scour or slips.

Vulnerability to earthquakes, storm and tsunami and expected times to re-open are outlined in Table 2.2 for significant roads in the Westland District.

Table 2.2: Road Vulnerabilities

	Road		***Earthquake***	***Severe Storm***	***Tsunami***
	SH 73 Arthurs Pass to Turiwhate				
	Importance	High: shortest route to Christchurch, fibre optic cable route, Transpower line route.			
	Vulnerability		Very High	High	Nil
	Time to reopen		A few days to several months	A few days to a few weeks	
	SH 73 Turiwhate to Kumara Junction				
	Importance	High: part of Arthurs Pass route, main access to Kumara.			
	Vulnerability		Low	Moderate	Nil
	Time to reopen		A few hours	A few hours to several days	
	SH 6 Greymouth - Hokitika				
	Importance	Very high: main link to Greymouth, hospital, port, population. Regional fibre optic cable route			
	Vulnerability		Low	Moderate	Very High
	Time to reopen		A few hours to several days	A few hours to several days	A few days
	WDC Hokitika to Kaniere				
	Importance	Moderately High: main access to Kaniere and from there to Lake Kaniere and the Kokatahi and Kowhitirangi communities. Some redundancy as there is an alternative route.			
	Vulnerability		Low	Low	Nil
	Time to reopen		A few hours	Few hours	

Table 2.2: Road Vulnerabilities (Continued)

	Road		***Earthquake***	***Severe Storm***	***Tsunami***
	WDC Kaniere to Lake Kaniere				
	Importance	High: main access to Hokitika water supply intake and trunk main and hydro power. Alternative water supply source from gallery intake.			
	Vulnerability		High	Moderate	Nil
	Time to reopen		A few days to a couple of weeks	A few hours to a few days	
	WDC Hokitika to Kowhitirangi				
	Importance	Moderately high: main access to Kokatahi and Kowhitirangi communities and dairy farms.			
	Vulnerability		High Kokatahi Bridge likely to suffer significant damage	Moderate	Nil
	Time to reopen		A few days to a month	A few hours to a few days	
	WDC Kaniere to Ruatapu				
	Importance	Moderate; Alternative route to SH 6			
	Vulnerability		Low	Moderate	Nil
	Time to reopen		A few hours	A few hours to 1 – 2 days	
	SH 6 Hokitika to Ross				
	Importance	High; main link to south. Regional fibre optic cable route			
	Vulnerability		Low	Moderate	High
	Time to reopen		A few hours	A few hours to 1 – 2 days	A few days

Table 2.2: Road Vulnerabilities (Continued)

	Road		***Earthquake***	***Severe Storm***	***Tsunami***
	SH 6 Ross – Franz Josef				
	Importance	Very high: only road access to main centers of South Westland. Regional fibre optic cable route			
	Vulnerability		Very High	Very High	Low
	Time to reopen		1 – 3 months	1 – 3 weeks	A few days
	SH 6 Franz Josef to Haast				
	Importance	High; only road access to South Westland. . Regional fibre optic cable to Fox			
	Vulnerability		Very High	Very High	Very High
	Time to reopen		Several months	1 – 2 months	2 – 3 weeks
	WDC Haast to Jackson Bay				
	Importance	High: only road link between Haast communities, local power station and Jackson Bay wharf.			
	Vulnerability		High	Very High	Very High
	Time to reopen		Several months	1 – 2 months	1 – 2 months
	SH 6 Haast to Wanaka				
	Importance	High: only alternative road into South Westland.			
	Vulnerability		Very High	High	Nil
	Time to reopen		Several months	1 – 3 weeks	

2.5.2 Airport Vulnerability

Earthquake:

The Hokitika airport is located on a high terrace of consolidated outwash gravels and the other three aerodromes on alluvial surfaces with low probability of liquefaction damage.

In a major earthquake scenario the Hokitika airport is likely to sustain very little damage to the runway and aircraft areas but shaking could cause significant damage to the terminal building contents.

The Franz Josef runway is less than 5km from the Alpine Fault trace and would be subject to strong shaking in an Alpine Fault earthquake event. However it is likely to remain usable although there might be some distortions to the surface and seal damage. The major risk to utilising the aerodrome is losing access as it is located on the south side of the Waiho River. The bridge over the Waiho River from Franz Josef is likely to be damaged or destroyed and 1.5km of the road is vulnerable to debris from the adjacent steep battered stopbank, and flooding and debris from the river.

The Fox Glacier heliport is 1.5km from the fault line. Some damage to the hanger and fuel facility is probable. It should still be possible to land small planes on one or both of the airstrips.

There may be some damage to the Haast aerodrome but it is likely to remains functional.

Storm:

The Hokitika airport is unlikely to be affected by a major storm although there might be some damage to buildings if there are high winds.

There is a possibility of the stopbanks overtopping downstream of the Waiho River Bridge on the south bank damaging the road and making access to the Franz Josef airport very difficult. It is conceivable that the river would flow across the aerodrome until the river could be diverted back to its current path. Alternatively the river could overtop the stopbank immediately east of the aerodrome resulting in the Waiho River flowing close to or over the aerodrome, with resultant scour and debris damage.

No damage is expected to the heliport or runways at Fox or the aerodrome.

The Haast River could overtop the embankment along which SH 6 runs and flow through the Haast aerodrome site.

Tsunami:

None of the four aerodromes in Westland District are expected to be affected by tsunami.

2.5.3 Port Vulnerabilities

Earthquake:

The Jackson Bay wharf is likely to be badly racked by an Alpine Fault earthquake and be unsafe.

Storm:

There would be minor wave damage but otherwise little impact on the wharf, based on performance to date. Access up the coast road could be seriously compromised in a 500-year storm, however.

Tsunami:

The Jackson Bay wharf and all buildings could be flooded and partially or totally destroyed. Vessels moored at the wharf could be badly damaged.

3 WATER SUPPLY

3.1 Introduction

Water supplies are provided in Westland District through community water supplies and rainwater storage at individual dwellings. The list of the community supplies in the district and some relevant data are presented in Table 3.1.

Table 3.1: Westland District Water Supplies[1]

System	Popn Served (people)	Source Gravity/pumped	Treatment	Pumps[2]	Storage (m^3)	Dominant pipe	
						Length (m)	Materials[3]
Arahura	85	Shallow bore	None	N/A	60	2,390	PE & PVC (100%)
Fox Glacier	306	Creek	Filters, Chlorination	N/A	900	1,418 6,143	AC (19%) PE & PVC (81%)
Franz Josef	341	Creek	Filters, UV disinfection, Chlorination	N/A	1,800	1,465 245 7,119	AC (16%) Steel (3%) PE & PVC (81%)
Haast	80	Shallow bore	Filters, UV disinfection	N/A	227	4,270	PE & PVC (100%)
Harihari	327	Shallow bore	UV	N/A	255	77 14,160	Steel (1%) PE & PVC (99%)
Hokitika Kaniere	3887	Kaniere Lake intake & shallow gallery wells	Membrane filtration, chlorination	11	7,120	12,500 2,681 54,804	AC (18%) Steel (4%) PE & PVC (78%)
Kumara	309	Stream	Filters and UV disinfection	N/A	247	807 358 5,494	AC (12%) Steel (5%) PE & PVC (83%)
Ross	297	Minehans Creek & Jones Creek	Membrane filtration, chlorination	0	540	397 8,057 68	AC (5%) Steel (1%) PE & PVC (94%)
Whataroa	145	Bore	UV	N/A	150	5,167	PE & PVC (100%)

1. Data from WDC 3 Waters Asset Management Plan 2014 WDC data base
2. Excluding pumps that are an integral part of treatment plants. na = data not available
3 PE = Polyethylene, PVC = Poly Vinylchloride, AC = Asbestos Cement

The following communities use rainwater tanks:

- Arahura Marae
- Bruce Bay Marae
- Haast School
- Kokatahi School

3.2 Hokitika Water Supply

Description – Hokitika

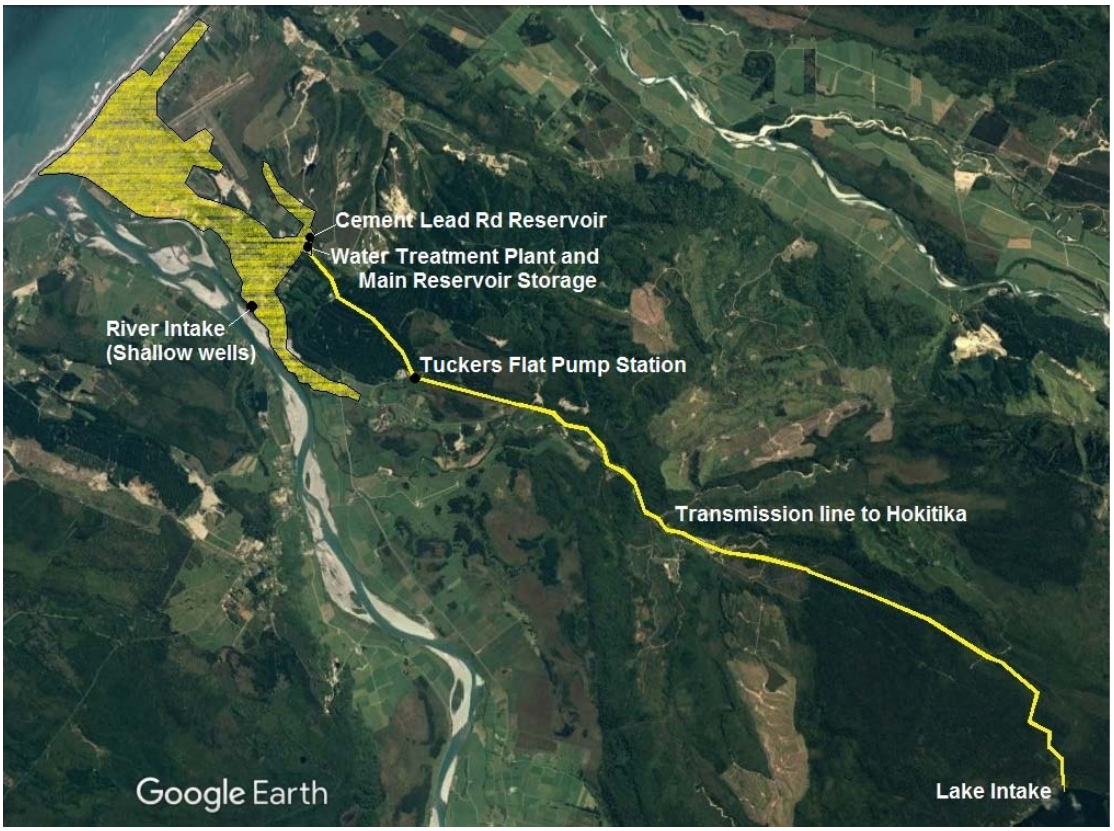

Figure 3.1: Hokitika Water Supply

The Hokitika water supply is shown in Figure 3.1 above and described as follows:

- An intake pipe extends into Lake Kaniere and is located approximately 10m metres below normal lake level.
- Water flows under gravity from the lake to the Pine Tree Road water treatment plant (WTP) and reservoir site. When the lake level is low the supply capacity is increased using the pumps at the Tuckers Flat pump station.
- There are two wells at the lower end of Pine Tree Road that are angled down at approximately 45° to below the Hokitika River. Water is pumped from the wells up Pine Tree Road to the WTP. As the water from the wells is of poorer quality than from the lake the WTP capacity reduces as more well water is treated.
- The WTP consists of membrane filtration followed by chlorination. After treatment the water flows to the treated water reservoirs.
- Water from the Pine Tree Road reservoirs is distributed as follows:
    - Water flows under gravity via a 200mm steel pipe to the West Coast Dairy Factory;

  - Water flows via a 250mm main asbestos cement pipe under gravity to the Kaniere distribution and the Hokitika distribution. Excess water from the Hokitika distribution can also be supplied to the West Coast Dairy Factory; and
  - Water is pumped to the Cement Lead Road Reservoir.
- Water from the Cement Lead Road Reservoir is distributed as follows:
  - Water is pumped to the Brickfield Estate, and
  - Water flows under gravity to the airport distribution. Water can also flow from the airport distribution via a pressure-sustaining valve to the Hokitika distribution as demand from the Hokitika distribution dictates.

3.2.1 Vulnerabilities - Hokitika

Earthquake

- Transmission pipeline failure. Damage is likely to the transmission line between the lake intake and the Pine Tree Road reservoirs with breaks likely in weak sections and at bridge abutments;
- There would be a significant chance of loss of grid electricity. Electricity is required to power the pumps at the Pine Tree Road wells and the WTP. The water from Lake Kaniere flows under gravity to the WTP. However if the main from Lake Kaniere failed there might not be water available until power was restored or a generator was in place to power the pumps in the Pine Tree Road wells and the WTP.
- Failure at the reservoirs. There are no automatic burst control valves on the pipelines from the reservoir sites or between the nine tanks making up the treated water reservoirs to prevent the reservoirs draining due to pipe and/or reservoir failures caused by the earthquake. Pipe connections between the reservoirs are thought to be rigid and damage at the reservoir entries is probable.
- Much of Hokitika is located on geologically recent alluvial soils, with some ground settlement and distortion to be expected. Some liquefaction could be expected in the area bounded approximately by Revill Street, Tudor Street and Fitzherbert Street. The soils are firmer in the area north of approximately Stafford Street and east of Fitzherbert Street and structures in this area are likely to sustain less damage than in other parts of Hokitika. From Table 3.1 it can be seen that 78% of the pipework is PE and PVC which performs reasonably well in earthquakes. However 18% of the distribution network is asbestos cement (AC) pipe including the trunk main from the reservoir site. AC is rigid and performs poorly in earthquakes. While there are likely to be some breaks in the PE and PVC pipework a significant number of breaks could be expected at junctions and connections in the AC pipework. The greatest number of breaks is likely in AC pipework in liquefiable areas. A significant number of breaks could lead to loss of water and pressure in the distribution system.
- Loss of pressure in the distribution network might mean there would be no capacity to fight fires after the earthquake.

- There might be insufficient spare parts in stock to repair damage to the pipelines.

Storm

- There is a potential for slips that might take out the trunk main from the lake where it passes through steep country beside the Kaniere River.
- Increased turbidity in the Hokitika River due to landslides in the catchment might mean the water from the Pine Tree Road wells could not be treated.
- A major storm would be unlikely to affect the distribution although inundation of any cabinet would probably damage instrumentation and electrical equipment, e.g. equipment monitoring bulk flow in the distribution system in low lying areas.

Tsunami

The Hokitika water supply is unlikely to be significantly affected by a tsunami. Debris created by the tsunami and deposited in low-lying areas in the CBD might prevent access to valves until it was cleared.

3.3 Other Water Supplies

The Arahura, Haast, Harihari and Whataroa supplies all use ground water sources and rely on pumps. All the supplies except Arahura rely on electricity to operate their treatment plants. The supplies generally have a high percentage of PE and PVC pipes, which are pipe materials that are relatively resilient to ground movement; the Fox and Franz Josef supplies have the highest percentage of rigid asbestos cement distribution pipe at 19% and 16% respectively. There are no earthquake valves fitted to the supply reservoirs.

3.3.1 Vulnerabilities

Earthquake:

- Turbidity might initially increase at the bores. However the quality should improve with pumping.
- Water from creek and stream sources with landslides in their catchments would be likely to have increased turbidity lasting for longer periods than normal after rain events.
- Landslides and debris might damage stream intakes.
- Movement of reservoirs might break reservoir pipe connections resulting in the reservoirs emptying. Even if the pipework did not break there are no earthquake valves and a major break or breaks in the associated distribution network below a reservoir might quickly empty a reservoir. Loss of the integrity of the reservoir and pipework might mean the supply could not function.
- The supplies might lose power. Generators would need to be organised to maintain supply until power is restored.

- The high percentage of PVC and PE pipe in the networks make the supplies relatively resilient to ground shaking. However some breaks could still be expected. Pipework most vulnerable to failure contains pipes that cross a fault trace, rigid pipes such as AC and old corroded steel, and pipes laid in soft and liquefiable soils. The Fox and Franz Josef supplies would be particularly vulnerable to an Alpine Fault earthquake as they are very close to or straddle the fault trace.
- There may be insufficient spare parts in stock to repair damage to the pipelines.

Storm

- Fox Glacier, Franz Josef and Ross use stream and creek intakes, which are vulnerable to damage from sediment and debris carried in the stream flow or scouring out of the intake during the storm event.
- Landslides in the catchment are likely to make stream and creek sources turbid for some time after the event until the catchment stabilises.
- Any pipelines that pass through steep country are vulnerable to damage from slips.
- There might be flooding of cabinets or buildings in low lying areas.
- There might be an insufficient supply of spare parts in stock to repair damage to the pipelines.

Tsunami

The Arahura community water supply is vulnerable to tsunami. The building at the Arahura bore might be damaged. However many homes in the Arahura community might also be badly damaged and uninhabitable so that reinstating the water supply might not be urgent.

4 SEWERAGE

4.1 Introduction

Westland District Council manages four sewerage schemes:

- Hokitika
- Franz Josef
- Fox Glacier
- Haast

A summary of details for each of the scheme is provided in Table 4.1.

Table 4.1: Westland District Sewerage Schemes

Scheme	Popn Served[1] (people)		Pipe		Pump stations	Treatment
	Residents	Peak Popn. Served	Length (m)	Materials[2]		
Hokitika and Kaniere	3,887	5,000	37,513 264 18,365 3,427	AC 63% Misc 0% PE/PVC 31% RCRJ 6%	7	Oxidation ponds
Franz Josef	341	1,750	3,732 3,044	AC 55% PE/PVC 45%	1	Oxidation ponds
Fox Glacier	306	1,070	4,023 47 669	AC 85% EW 1% PE/PVC 14%	0	Oxidation ponds
Haast	80	200	54 1,511 440 1496	AC 2% Cer 43% EW 13% PE/PVC 42%	1	Oxidation ponds

1. From Table 4 of the 2014 3 Waters Asset Management Plan

2. AC = Asbestos Cement; Cer = Ceramic, EW = Earthenware, PE = Polyethylene, PVC = Polyvinylchloride, Misc = Miscellaneous

4.2 Hokitika Sewerage

4.2.1 Description

Sewage is collected from Kaniere and Hokitika as well as from properties as far as north as West Drive. The Westland Milk Products dairy factory has its own waste water processing plant.

The sewer network and seven pump stations deliver the sewage to the oxidation ponds. Treated effluent from the oxidation ponds is discharged to the sea via an ocean outfall.

The Hokitika sewerage scheme is shown in Figure 4.1.

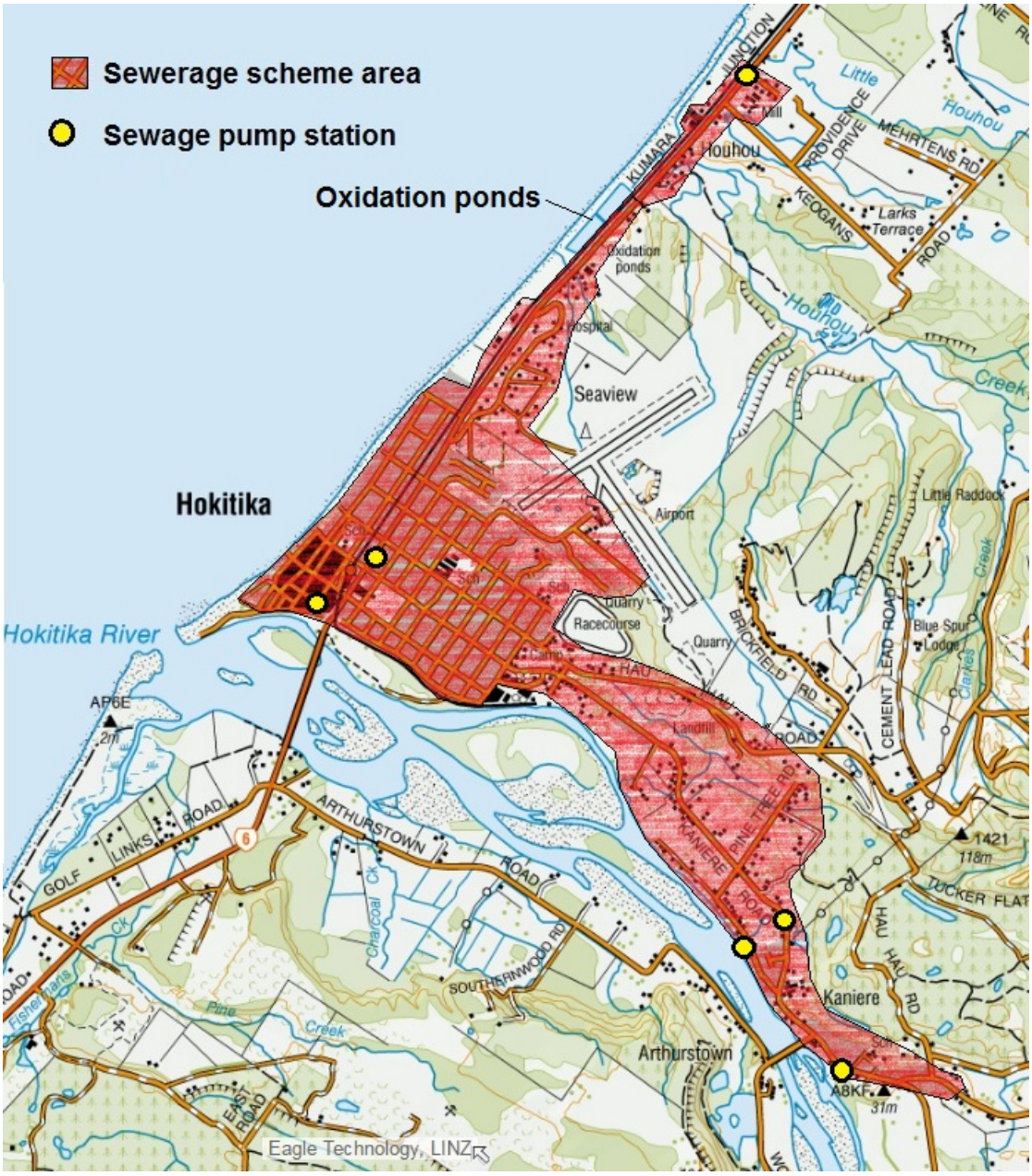

Figure 4.1: Hokitika Sewerage Scheme

4.2.2 Vulnerabilities – Hokitika Sewerage Scheme

Earthquake

- Most of the sewer network (69%) is constructed from rigid materials: asbestos cement pipe (63%) or concrete (6%), which are prone to failure when exposed to strong ground shaking. The rest of the network (31%) is PVC or PE pipe which is likely to have fewer failures in a major earthquake. Failure of rigid materials and some PVC and PE pipe can be expected at junctions and at connections with structures like manholes and pump stations. Movement of pipes might affect pipe grade. Failure rate and change of pipe grade would be greater in areas of liquefiable and soft

soils. Sewer pipes are far more vulnerable to liquefaction than water pipes because they mostly carry air, so that they are floated upwards.

- Power would probably be lost after a major earthquake and would not be reinstated for some time. This would lead to surcharging and ponding at some pump stations.
- There could be damage at the oxidation ponds site including failure of the aerial discharge pipe into the ponds and the aerial ocean outfall pipe due to shaking and also lateral spreading of the pond embankments particularly the northeast end.

Storm

A major storm could cause the following damage to the Hokitika sewerage scheme:

- Damage to the electrical and control systems in the pump stations' cabinets in Sewell Street and possibly also in Fitzherbert Street due to flooding.
- Inundation of pump stations by flood water carrying sand, silt and debris into the wet wells.
- There might be some storm surge damage to the aerial ocean outfall pipe and possibly the oxidation ponds.
- Wind damage might cut grid electricity so that pump stations could not operate, leading to surcharging.

Tsunami

A major tsunami could cause the following damage to the Hokitika sewerage scheme:

- Damage to the electrical and control systems in the pump station cabinets in Sewell Street and possibly also in Fitzherbert Street.
- Sand and debris carried by the tsunami wave might enter the pump station wet wells.
- Inundation of the oxidation ponds, with seawater partially filling them with sand and gravel from the beach. The embankment on the northern end might be washed out. All above ground assets including the aerial discharge pipe into the ponds and the aerial ocean outfall pipe might be destroyed.

4.3 Other Sewerage Scheme

There are three other sewerage schemes in Westland District: the Franz Josef scheme, the Fox Glacier scheme and the Haast scheme.

All three schemes serve the resident population and peak season populations; in Franz Josef the peak season population is more than five times the resident population. All three schemes use oxidation ponds for final treatment. The oxidation ponds at Franz Josef were damaged in 2016 by a large storm and are currently leaking. WDC is reviewing upgrade options.

The Franz Josef sewer network collects sewage from the township and includes one pump station. Sewage from the Fox Glacier community flows under gravity through the sewer network to the oxidation pond. The Haast sewer network collects sewage from the Haast community and the pump station in Tahutahi Road pumps the sewage to the oxidation ponds.

The sewer networks are predominantly of rigid materials: asbestos cement, ceramic and earthenware pipes, ranging from around 55% to 58% in Franz Josef and Haast and up to 86% in Fox. The remaining pipes are PE and PVC.

4.3.1 Vulnerabilities of Other Sewerage Schemes

Earthquake

- In an Alpine Fault earthquake event such as the AF8 scenario (refer *Supplement 2*) much of the Franz Josef sewer network would be destroyed and the oxidation ponds badly damaged. Fox Glacier is within 1km of the fault trace and as 86% of the sewer network is constructed of brittle materials (asbestos cement and earthenware pipes) it is likely there would be substantial failure of the network. Haast is around 5km from the fault trace and it is likely many rigid pipe junctions and connections to manholes would be damaged. There would also be some damage to the PVC and PE pipework at junctions and connections.
- The oxidation ponds, pump stations, manholes and pipe alignment are likely to be affected particularly in soft soils. Damage could occur to the oxidation pond banks resulting in sewage breaching and escaping from the ponds.
- The pump station in Franz Josef in an AF8 scenario earthquake would be likely to be seriously damaged or destroyed. Power would be lost to the Haast pump station which would probably lead to surcharging at the pump station assuming enough of the network would be sufficiently intact to deliver sewage to the pump station.

Storm

It is unlikely the sewer network in Franz Josef would be damaged by a storm although high winds might bring a tree down on the pump station. The storm in 2016 demonstrated the vulnerability of the Franz Josef oxidation ponds. Alternative options for treatment are now under consideration.

The sewer network in Fox Glacier township would be unlikely to be affected by a major storm. However the oxidation ponds are located on the Fox River fan and it is possible the river could burst its banks upstream and flow through the location of the ponds inundating them and causing scour damage.

The Haast community and the oxidation pond are protected from the Haast River by high ground upstream of the township, which directs flood flows away from the township.

There might be some inundation damage to the electrical and control systems of some low lying pump stations.

High winds could cut power to Franz Josef, Fox and Haast. The Franz Josef pump station relies on power from the national grid. The pump station might be vulnerable to surcharging if power were lost for an extended period. The Haast community has generators and could probably organise power to the pump station until power was restored provided there was sufficient fuel.

Tsunami

The Franz Josef, Fox and Haast communities are all far enough from the coast that they would not be affected by a tsunami.

5 STORM WATER

Westland District Council operates one reticulated storm water system in Hokitika. The remaining systems are predominantly roadside drainage located in:

- Fox Glacier
- Franz Josef
- Haast
- Harihari
- Kaniere
- Kumara
- Ross
- Whataroa

The composition of pipes and open drains that make up the storm water systems is presented in Table 5.1.

Table 5.1: WDC Storm Water Systems Composition (Lengths in meters)

Composition	Fox Glacier		Franz Josef		Haast		Harihari		Hokitika		Kaniere		Kumara		Ross		Whataroa		Total	
	Length	%age	Length	%age	Length	%age	Length	%age	Length	%age	Length	%age	Length	%age	Length	%age	Length	%age	Length	%age
Ceramic									83	0%									83	0%
Conc	271	35%	1631	66%	172	27%	1,468	93%	21,583	54%	1,095	60%	539	43%	509	31%	242	91%	27,510	55%
EW									4,304	11%	14	1%	28	2%	346	21%			4,692	9%
GI									24	0%									24	0%
Open Drain	26	3%	30	1%	42	7%	6	0%	1,408	4%	83	5%							1,596	3%
PVC	335	44%	699	28%	66	10%	36	2%	6,177	16%	332	18%	121	10%	372	23%	23	9%	8,161	16%
RC	12	2%			363	56%	75	5%	3,786	10%			562	45%	415	25%			5,212	10%
RCFJ									646	2%									646	1%
RCRR	122	16%							842	2%									964	2%
RCRRJ									228	1%									228	0%
Stormboss			100	4%					525	1%	313	17%							938	2%
Total	**766**		**2460**		**643**		**1,585**		**39,607**		**1,837**		**1,251**		**1,642**		**265**		**50,054**	

Concrete is the predominant pipe material making up 55 % of the district's storm water systems and rigid pipe materials such as asbestos cement, concrete and earthenware make up 77% of the systems. Around 18% of the systems are plastic pipes and the remaining 3% are open drains.

5.1 Hokitika Storm Water System

The Hokitika storm water system is shown in Figure 5.1.

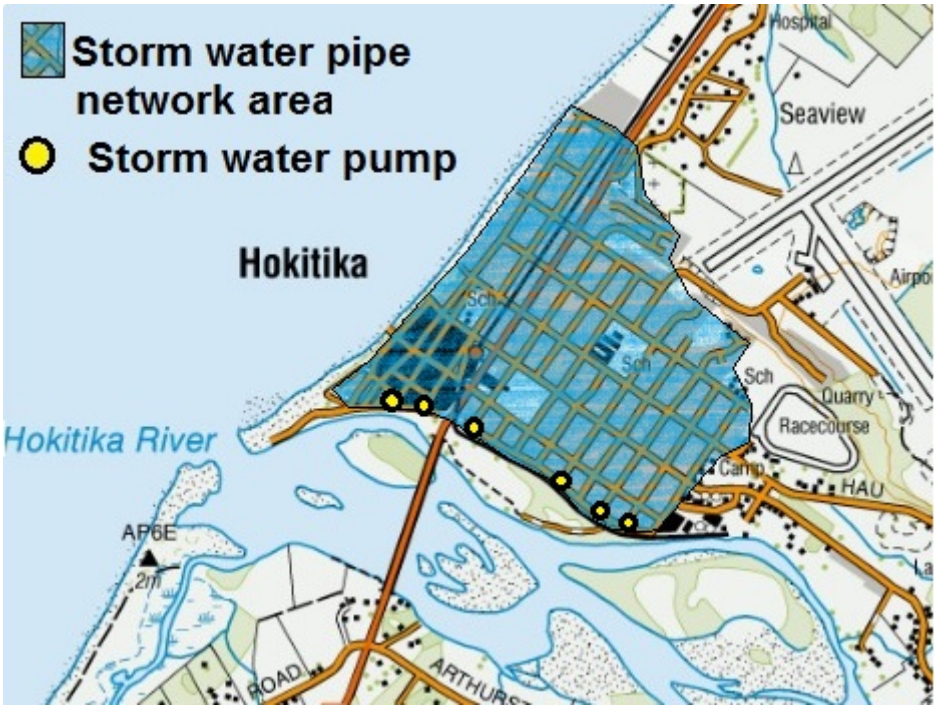

Figure 5.1: Hokitika Storm Water Scheme

The Hokitika storm water system drains storm water towards the six storm water pumps located along Gibson Quay. The pumps discharge the storm water into the Hokitika River.

5.1.1 Vulnerabilities

Earthquake

- Rigid pipe materials make up almost 80% of the Hokitika storm water network. Significant pipe and joint failure as well as failure at connections to manholes and pump stations would be expected particularly in areas of soft or liquefiable soils, i.e. the area bounded approximately by Revell Street, Tudor Street and Fitzherbert Street.
- Power would be likely to be lost after the earthquake and might not be reinstated for some time. If there were a major storm in this period then generators would need to be brought into each pump site.

Storm

- In the event that the Hokitika stopbanks were breached all six storm water pumps might be inundated and damage could be expected to the electrical and control systems.

- Breaching of the stopbanks would be likely to lead to scour damage.
- Inundation of storm water might wash sand, silt and debris into storm water drains and wet wells.

Tsunami

- In the scenario presented in *Supplement 4* the pump station on Sewell and Tancred streets would suffer impact damage and inundation while the pump station on Bealey Street would be inundated. Inundation could damage the electrical and control components at the pump stations and wash sand and debris into wet wells and storm water drains.
- There might be some scour damage to the storm water stopbanks.

6 VULNERABILITY SUMMARY

Table 6.1A gives a summary of vulnerabilities of infrastructure assets in Westland District Council that would impact on recovery of the district, i.e. that would result in disruption for longer than one week.

Table 6.1: Westland District Council Infrastructure Vulnerabilities

<table>
<tr><th>No.</th><th colspan="4">Description</th></tr>
<tr><td colspan="5">Transportation - Roads</td></tr>
<tr><td rowspan="5">1</td><td colspan="4">The following district roads have been identified as being likely to be closed for more than a week by an earthquake, major storm or tsunami. Potential closure times are shown.</td></tr>
<tr><td>Route</td><td>Earthquake</td><td>Storm</td><td>Tsunami</td></tr>
<tr><td>WDC Kaniere to Lake Kaniere</td><td>Up to couple of weeks</td><td>Up to a few days</td><td>-</td></tr>
<tr><td>WDC Hokitika to Kowhitirangi</td><td>Up to a month</td><td>Up to a few days</td><td>-</td></tr>
<tr><td>WDC Haast to Jackson Bay</td><td>Up to months</td><td>Up to months</td><td>Up to months</td></tr>
<tr><td colspan="4">WDC Haast to Jackson Bay</td><td>Up to months</td><td>Up to months</td><td>Up to months</td></tr>
<tr><td colspan="5">Transportation - Airport</td></tr>
<tr><td>2</td><td colspan="4">Earthquake:
Significant damage to the Hokitika terminal building contents.
Difficult access from Franz Josef to the aerodrome if the Waiho River Bridge is damaged or the Waiho River stopbank is damaged and SH 6 is flooded.
Some damage to the hanger and fuel facility at Fox Glacier.</td></tr>
<tr><td>3</td><td colspan="4">Storm: Possible overtopping of the Waiho River stopbanks downstream of the bridge on the south bank making access to the airport very difficult and potentially flooding the aerodrome. Alternatively the river could overtop the stopbank east of the aerodrome resulting in the Waiho River flowing close to or over the aerodrome.</td></tr>
</table>

Table 6.1: Westland District Council Infrastructure Vulnerabilities (Continued)

No.	Description
Transport - Port	
4	Earthquake: Severe damage possible to the Jackson Bay wharf.
5	Tsunami: Jackson Bay wharf could be significantly damaged.
Three Waters - General	
6	Insufficient spare parts in stock to repair widespread damage of pipelines.
7	Insufficient spare parts in stock for repair of pump station electrical and control systems.
8	Damage to inadequately restrained equipment delaying recovery.
9	Loss of power and insufficient standby generators to meet the power need for the 3 waters treatment plants and pumps. This could lead to loss of adequate treated water, surcharging at sewage pump stations and inundation where storm water pumps could not operate.
Water Supply - Earthquake	
10	High turbidity in Lake Kaniere and elevated turbidity in the Pine Tree Road wells leading to difficulty in treating adequate water.
12	Damage to the transmission line between the lake intake and the Pine Tree Road reservoirs.
13	Damage to reservoirs and/or reservoir pipework due to movement of the reservoirs.
14	Failure of distribution pipework leading to draining of the reservoirs.
15	Failure of pipes of rigid materials (AC and steel pipes); older pipes in liquefiable areas are most at risk; 22% of the network is AC or steel. If failure/breaks are widespread in the distribution network, supply may be lost for drinking as well as firefighting. The area that is particularly vulnerable is bounded approximately by Revell Street, Tudor Street and Fitzherbert Street.
Water Supply - Storm	
16	Damage to the transmission line from Lake Kaniere caused by slips.
17	Increased turbidity in the Hokitika River leading to increased turbidity in the Pine Tree Road wells.
18	Damage to stream intakes of the Fox, Franz Josef or Ross supplies.
19	Flooding damage of low lying buildings and cabinets.
Water Supply - Tsunami	
20	Inundation damage to the bore at Arahura.
Sewerage - Earthquake	
21	Failure of pipes of rigid materials (AC and concrete) which make up almost 70% of the Hokitika sewer network and 86% of the Fox network; older pipes in liquefiable areas are most at risk. Areas that are particularly vulnerable in Hokitika include the area bounded approximately by Revell Street, Tudor Street and Fitzherbert Street.
23	Failure of much of Franz Josef network and pump station in an Alpine Fault earthquake due to their close proximity to the fault trace.
24	Alignment of pump stations and pipelines might be affected particularly where liquefaction occurs.
25	Damage to oxidation pond embankments.

Table 6.1: Westland District Council Infrastructure Vulnerabilities (Continued)

No.	Description
Sewerage - Storm	
26	Damage to the electrical and control systems in the pump stations cabinets due to flood inundation.
27	Damage to the Fox Glacier oxidation ponds if the Fox River breached its banks and the new river path flowed through the oxidation ponds site.
Sewerage – Tsunami	
28	Damage to the electrical and control systems in the pump stations cabinets due to impact and inundation by tsunami waves; the Sewell Street and Fitzherbert Street pump stations are most vulnerable.
29	Inundation of the Hokitika oxidation ponds, partially filling them with beach sand and gravel, and damaging the embankment, and destroying the aerial discharge pipe into the ponds and the aerial ocean outfall pipe.
Storm Water - Earthquake	
30	Failure of pipes of rigid materials (concrete, earthenware and reinforced concrete); older pipes in liquefiable areas are most at risk. The average percentage of rigid pipe materials in the WDC storm system is 77%: 79% of pipes the Hokitika storm water system are constructed of rigid materials.
Storm Water - Storm	
31	Loss of power for a time at the time of a large storm event could lead to surface flooding as the six Hokitika storm water pump stations would be unable to operate and may be inundated.
32	Failure of the Hokitika stopbank could lead to inundation of the six pump stations and damage to the pumps' electrical and control systems.
Storm Water - Tsunami	
33	Impact and inundation damage to the pump station on Tancred and Sewell streets from the tsunami waves and inundation damage at the Bealey Street pump station electrical and control components.
34	Probable scour damage to the storm water stopbanks.

7 UPGRADES AND IMPROVEMENTS

Potential upgrades and improvements that could reduce the recovery period for the infrastructure assets managed by WDC include:

General

- Review programmes for routine assessment of sites that are key to the functionality of lifeline assets. Establish protocols to ensure identified vulnerabilities are addressed.
- Review equipment restraints at the airport, the port, treatment plants and pump stations.
- Review flooding risk of important assets in particular vulnerable aerodromes (Franz Josef and Haast) and oxidation ponds (Franz Josef and Fox).
- Tsunami:
    - Carry out tsunami inundation modelling to better understand the hazard, likelihood of scour and most vulnerable areas.
    - Where possible locate key facilities outside the tsunami inundation areas.
- Storm and Tsunami:
    - Build facilities, buildings and structures of concrete in tsunami and storm inundation areas.
    - Place electrical and control equipment in water tight areas/cells or at a height above inundation.
    - Locate spare parts outside inundation areas, e.g. pipe spares, and spares for electrical and control equipment.
- In the long term consider a strategy to withdraw from the Hokitika CBD as it is vulnerable to flood, tsunami, coastal erosion and sea level rise.

Roads and Bridges

- Improve robustness of WDC roads and bridges by ensuring the potential impact of earthquakes, storms and tsunamis are taken into consideration when designing and implementing upgrade and renewal works. For roads this would include:
    - Using well compacted granular bases to better resist scour from flood flows and tsunami, and
    - Protecting coastal roads from tsunami and storm surge with sea walls and riprap etc.
- Maintain redundancy of the road network and increase where possible.
- Review the location of plant, fuel and materials in the Westland District to ensure they are well placed to allow quick access for road and bridge repairs after a major natural disaster.

Jackson Bay Wharf

- Review the seismic strength of the existing wharf. As required, design and strengthen to withstand earthquake and tsunami forces.

Water Supply, Sewerage and Storm Water

- Prioritise replacement of rigid pipes beginning with aging key mains, such as the trunk main from the reservoir site to the distribution, and pipes in soft or liquefiable soils. Revise asset management plans to reflect these priorities.
- Review likely spare part requirements for response and recovery after a major event such as an earthquake, tsunami or storm event; in particular spare parts for pipe repairs and spare parts to replace electrical and control components damaged by water inundation. Allowance should be made for having in stock large numbers of spare parts or for obtaining them at short notice.
- Review generator and fuel requirements for response and recovery after a major disaster such as an earthquake, tsunami or storm event.

Water Supply

- Investigate in more detail the potential of earthquakes to cause movement of WDC reservoirs, in particularly the Hokitika reservoirs. Consider installing earthquake burst valves at reservoirs.
- Prepare a formal plan for recovery of WDC water supplies after a major natural disaster.

Sewerage

- Assess options for protecting pump station power supply and control cabinets componentry from inundation (tsunami or flood).
- Review options for minimising damage to the Hokitika oxidation ponds from a damaging tsunami.
- Undertake an assessment of public health risk posed by potential sewage surcharging at pump stations leading to overland flow and ponding. Identify solutions as required including a formal plan for sewage disposal after a major natural disaster.

Storm Water

- Identify options to protect the Tancred and Sewell streets pump stations from tsunami waves.
- Prepare a formal plan for storm water management after a major natural disaster.

MAJOR INFORMATION SOURCES

Westland District Council Transport Asset Management Plan 2015.

Westland District Council 3 Waters Asset Management Plan 2014.

Dewhirst R.A., Elms D.G. and McCahon, I, (2006) *Westland District Lifelines Study – Alpine Fault Earthquake Scenario*.