

# RNC/QuakeCoRE Distributed Infrastructure

13<sup>th</sup> May 2019

## 2010 -2011 Canterbury Earthquake Sequence Impact on 11KV Underground Cables – Research Update

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Project Coordinator, University of Canterbury: Matthew Hughes

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- Earthquakes
- Issues related to Power System Network

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- Orion cable Network
- Type of 11KV Underground Cables

## Research

- Digitising Repair Joints and Cable Network
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RESILIENCE  
TO NATURE'S  
CHALLENGES

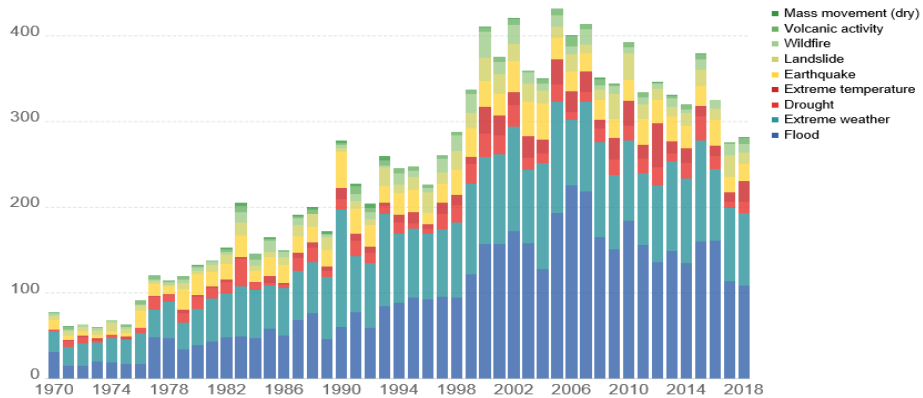
Kia manawaroa –  
Ngā Ākina o  
Te Ao Tūroa

# Motivation

## Global reported natural disasters by type

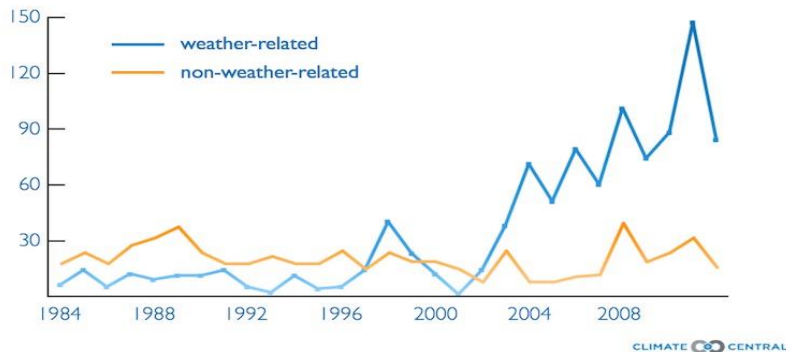
The annual reported number of natural disasters, categorised by type. This includes both weather and non-weather related disasters.

Our World  
in Data



Source: EMDAT (2017): OFDA/CRED International Disaster Database, Université catholique de Louvain – Brussels – Belgium  
OurWorldInData.org/natural-disasters • CC BY-SA

## Weather-Related Power Outages Increased Dramatically in the 2000s



# Earthquakes

## Darfield earthquake

- 04 September 2010 at 4:36 AM
- Magnitude: 7.1 MW, Depth: 10 Km
- Location: 40 Km west of Christchurch near Darfield

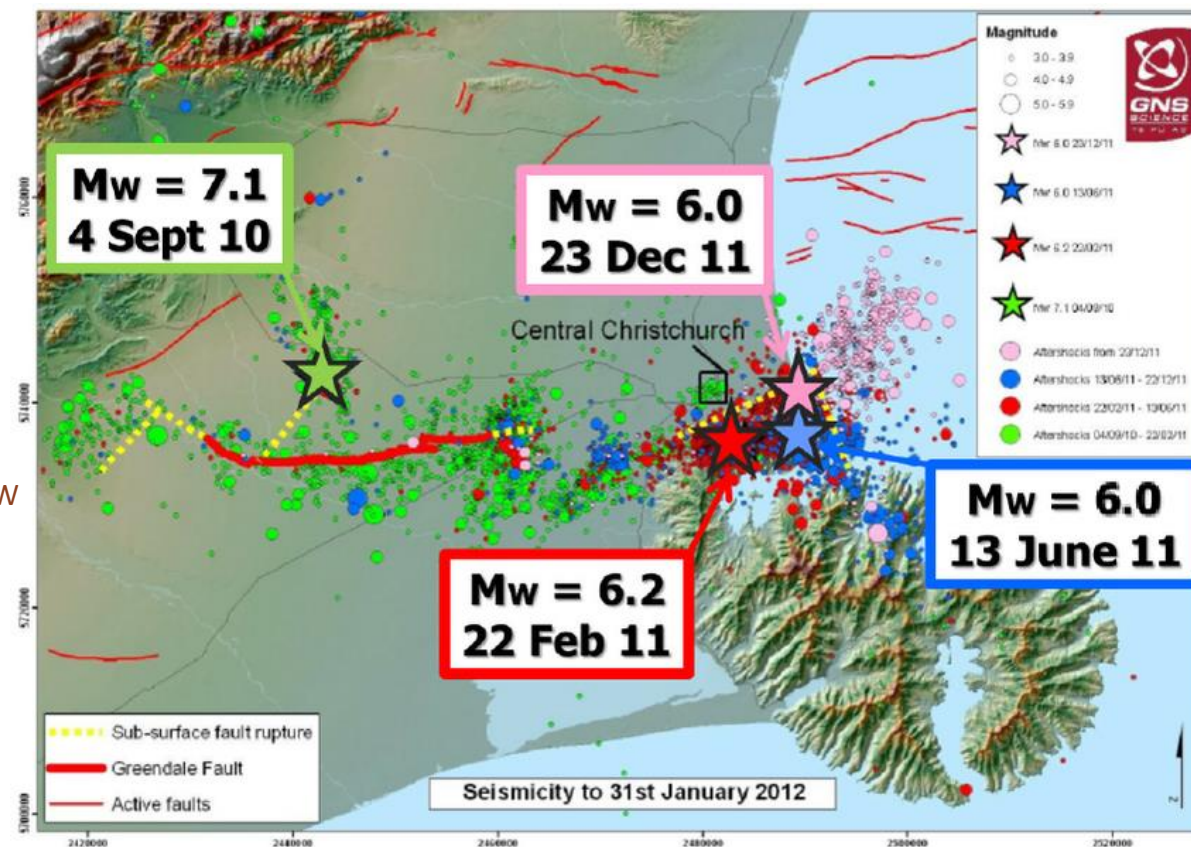
## Christchurch earthquake

- 22 February 2011 at 12:51 PM
- Magnitude: 6.2 MW, Depth: 5 Km
- Location: 10 Km south-east of Christchurch near Lyttelton

Numerous aftershock occurred later, several with magnitude greater than 5 MW

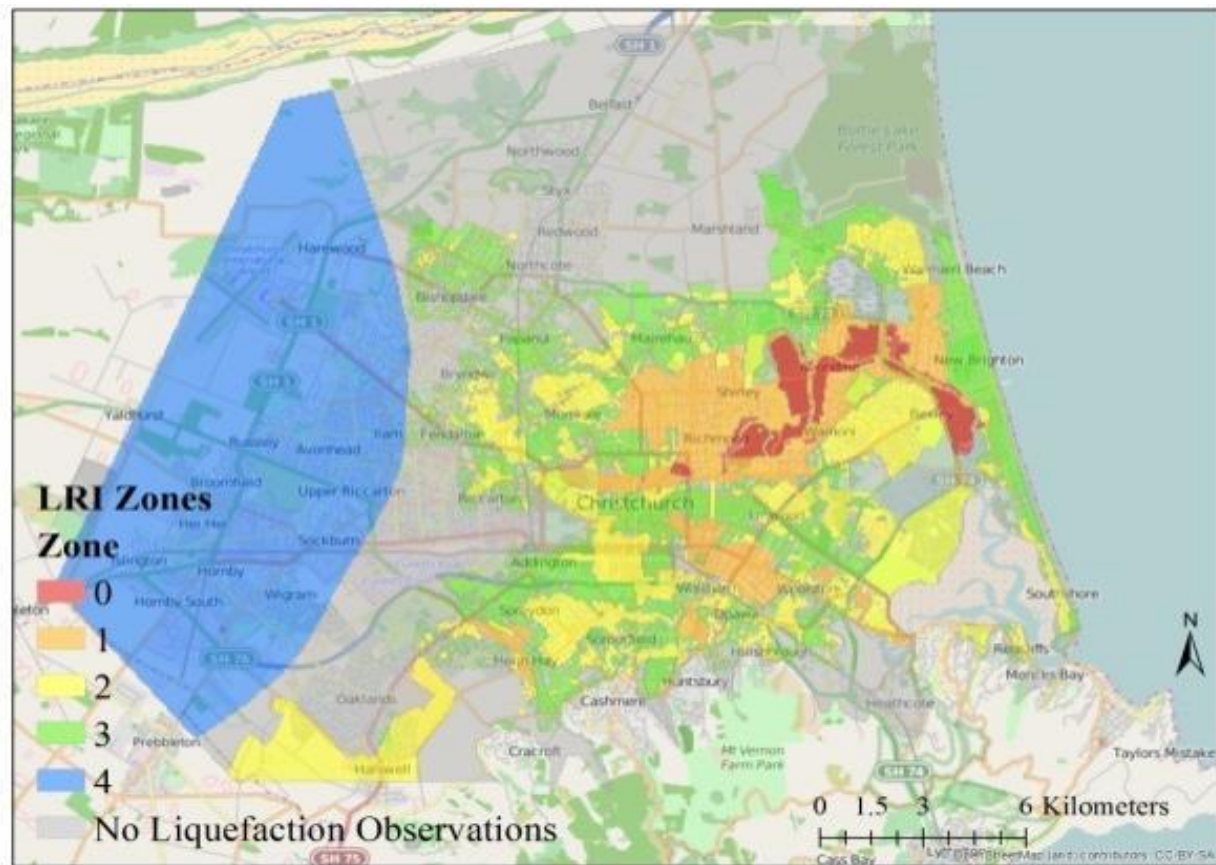
## Impact of an Earthquake

1. Liquefaction
2. Land Slide
3. Ground Deformation
4. Tectonic Uplift

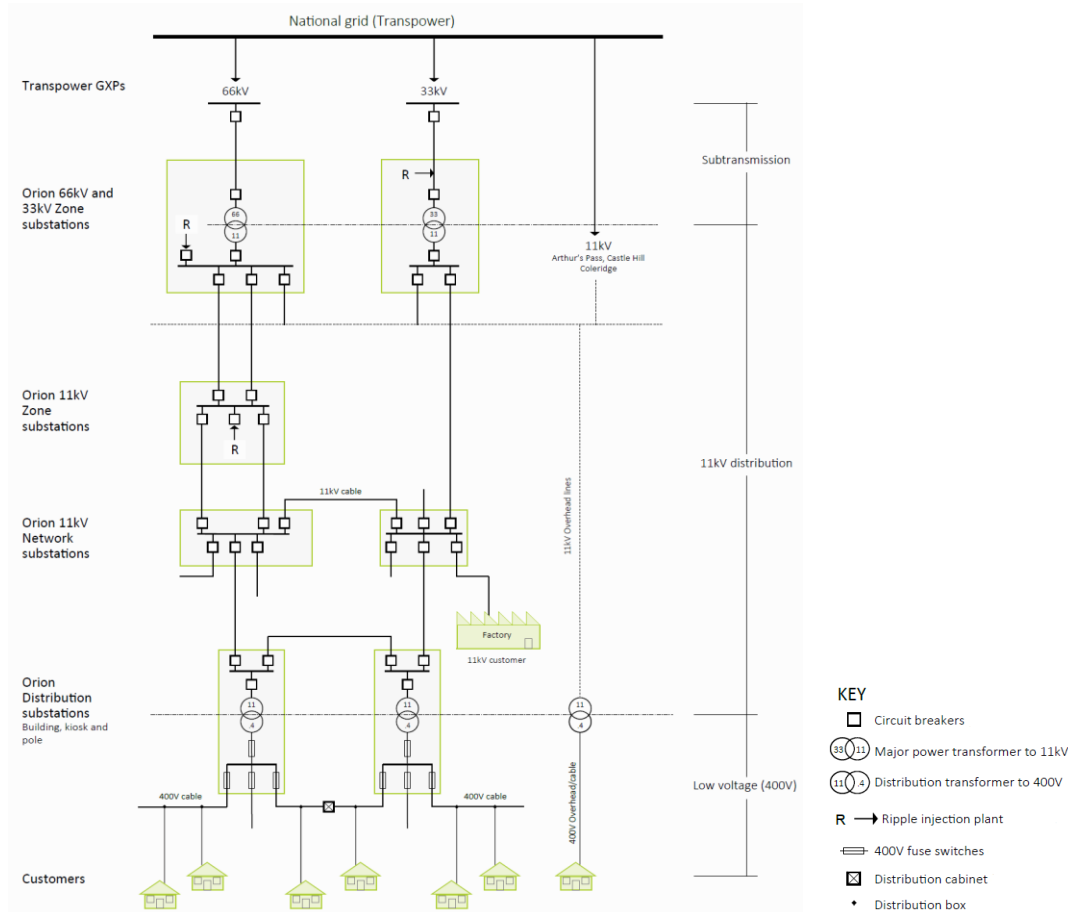


# Intensity Measures (IM)

1. Peak Ground Acceleration ( PGA )  
(Relates to inertia forces)
2. Peak Ground Velocity ( PGV )  
(Relates to Ground Strain)
  - Vertical Ground Deformation ( PGD<sub>v</sub> )  
(Relates to differential vertical settlement)
  - Horizontal Ground Deformation ( PGD<sub>fH</sub> )  
(Relates to lateral spread)



# Orion Cable Network – Case Study



Category	Description	31 March 2017
Total network	Lines and cables (km)	15,623
	Zone substations	51
	Distribution substations	11,361
Overhead lines (km)	66kV	246
	33kV	279
	11kV	3,209
	400V	1,804
	Street lighting	917
Underground cables (km)	66kV	89
	33kV	37
	11kV	2,602
	400V	2,974
	Street lighting	2,434
	Communication	1,031
	Total cables	9,168
Zone substations	66kV	27
	33kV	19
	11kV	5
Distribution substations	Building	468
	Ground mounted	4,724
	Pole mounted	6,397
Embedded generation	Greater than 1MW	10 Customer-owned sites
Major business customers	Loads between 0.3MW and 11MW	325

# Rationale

Impact	Darfield Earthquake	Christchurch Earthquake
Date & Time	04 Sep 2010 4:36AM	22 Feb 2010 12:51PM
Magnitude & Depth	7.1 Mw, 10 KM	6.2 Mw, 5 KM
Location	40 KM west	10 KM south-east
Damage (%)	1-3	7-10
Restoration Time (90%)	1 Day	10 Day
Direct Cost	\$4 Million	Over \$40 Million
Customer Minutes Lost	88 Million	630 Million

Hazard	Overhead Asset	Underground Asset
Liquefaction	Minor/Moderate	Major
Lateral Spreading	Minor/Moderate	Major
Ground Deformation	Minor	Major
Tectonic Uplift	Minor	Major



# Types of 11 KV Underground Cables

## Metal Core



## Insulation Material



## Damage to 11KV underground cables

- Bending
- Stretching
- Insulation damage
- Being pulled-off equipment
- Joints breaking

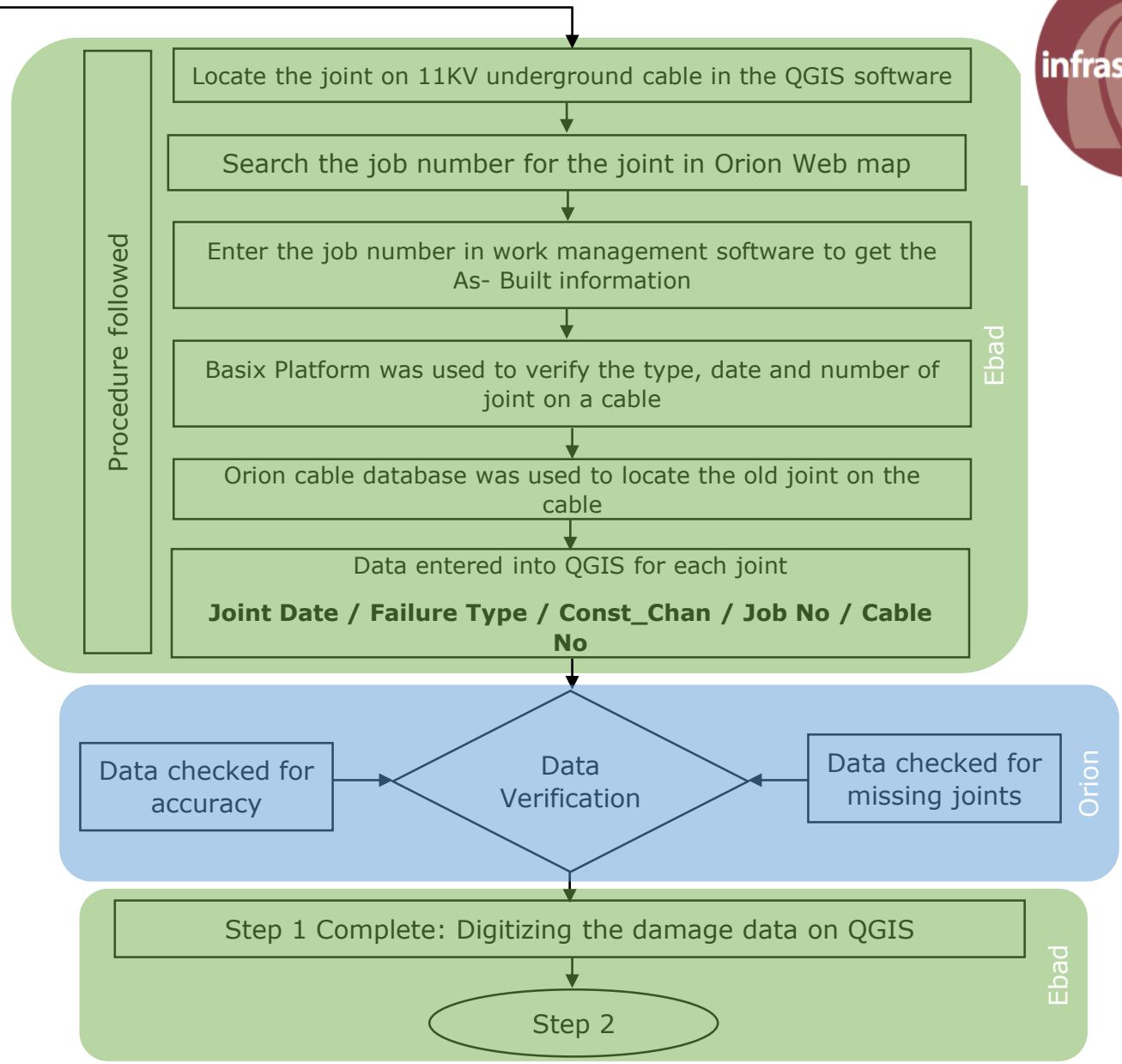
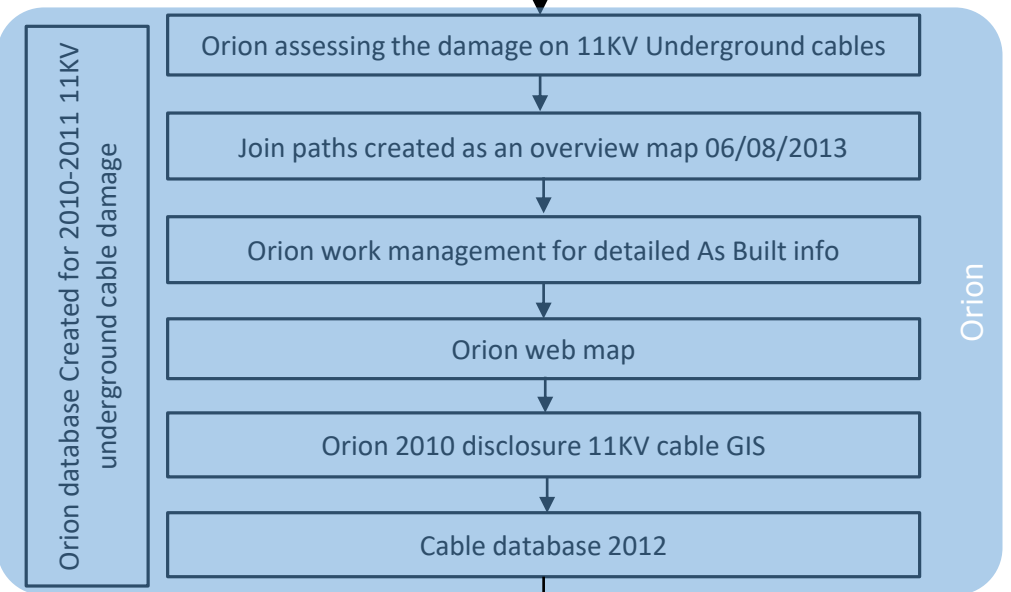




# Step 1: Digitising Repair Joints



Christchurch Earthquake  
2010-2011

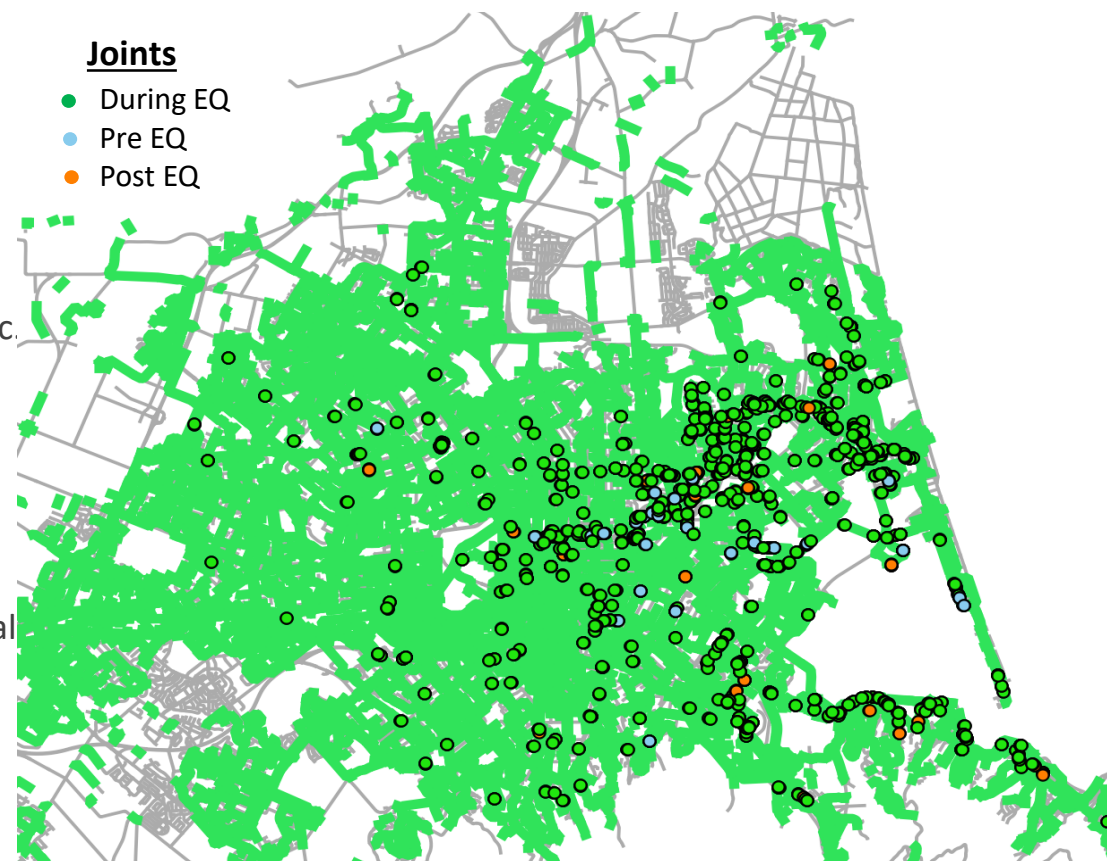


# Digitising Data

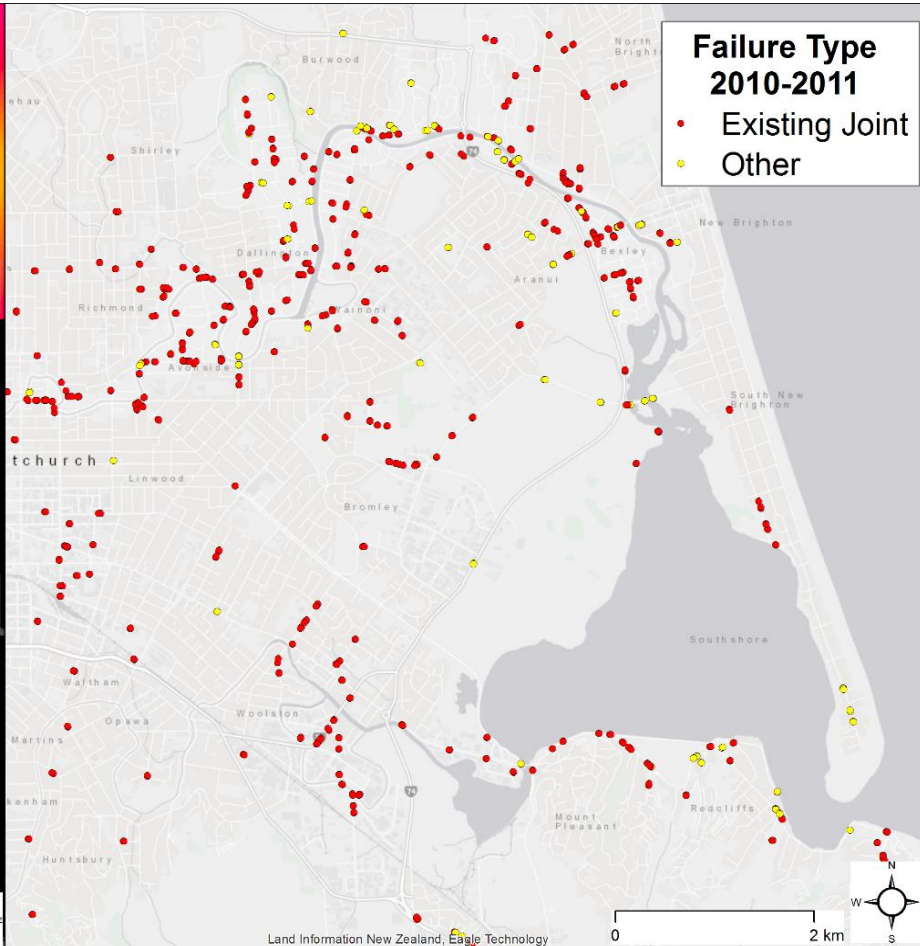
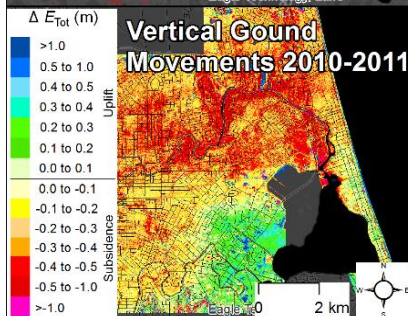
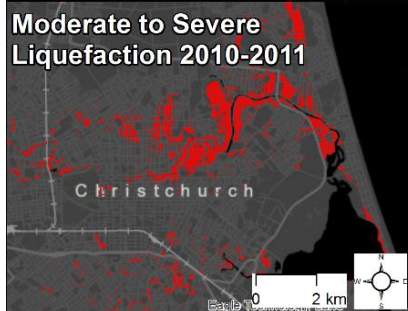
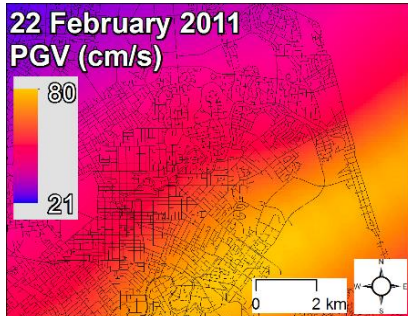
Post-Earthquake database development - Compilation of a detailed geospatial database of component and network repairs.

Data dictionary construction, information will include:

1. Job date and time
2. Job location (based on address and/or other location information)
3. Infrastructure type – e.g. buried cable type/material, substation etc.
4. Failure cause – e.g. earthquake-induced transient and-or permanent ground deformation
5. Failure mode – detailed description of component/material failure – use photographs taken by repair crews
6. Repair – detailed description of repair action/components and material used - use photographs taken by repair crews
7. Other information – e.g. details on pre/post-repair lines testing (other?)

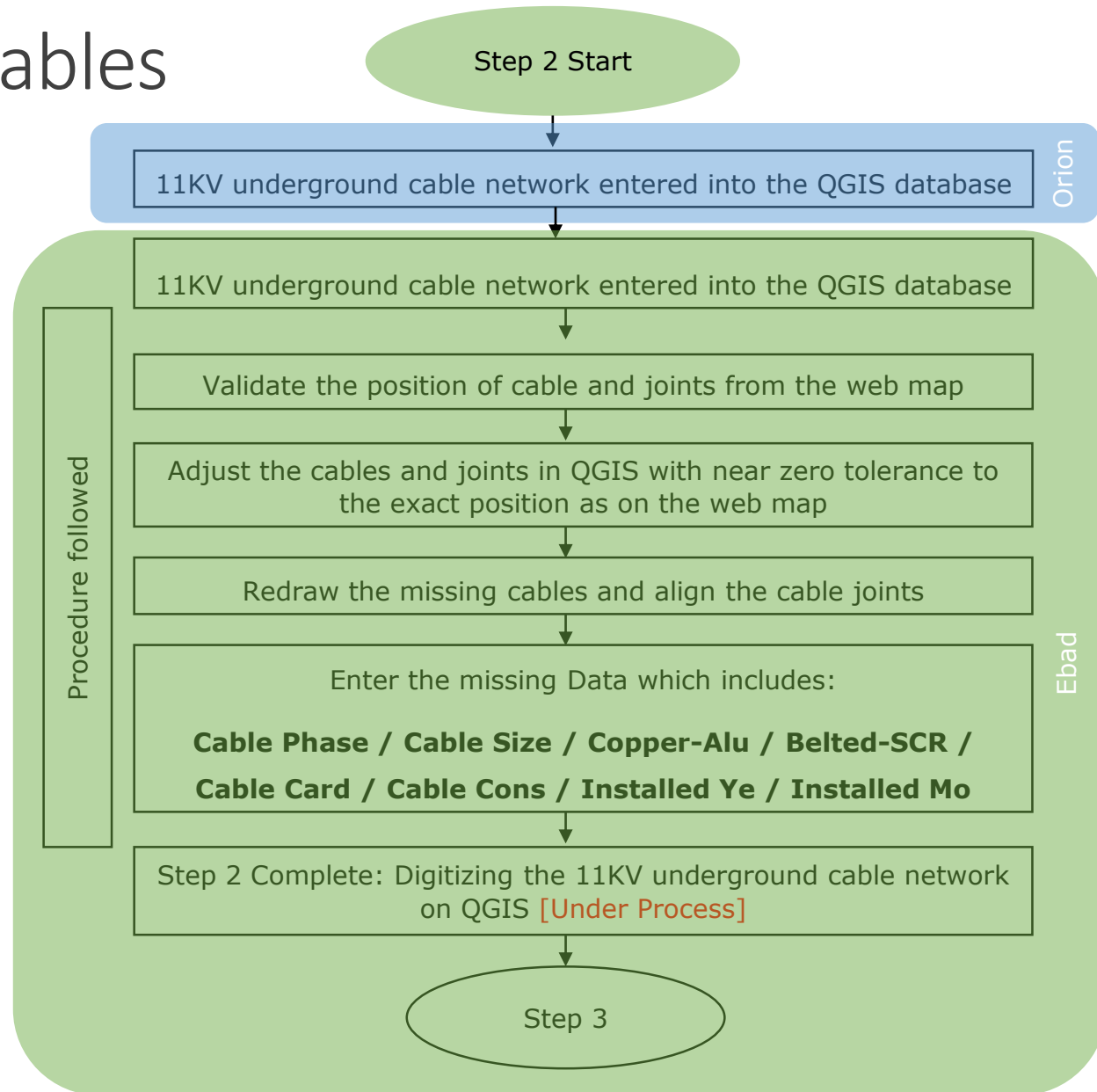
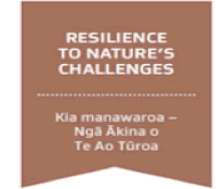


# Digitizing the Damage Points on 11KV Underground Cable



Failure Type	Total
Cable Faults	156
Existing Joints	1,050
Bridge Movement	29
<b>Grand Total</b>	<b>1,234</b>

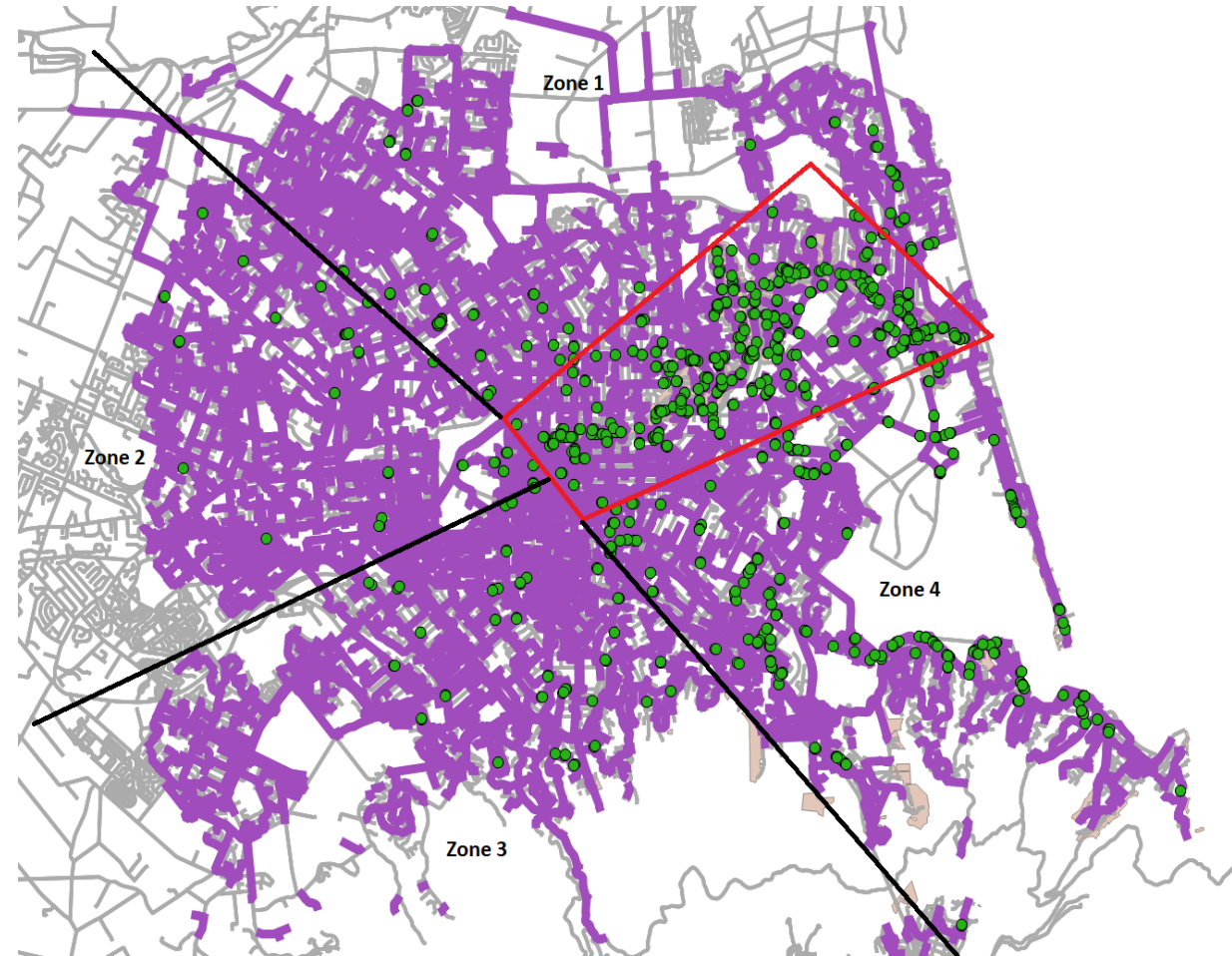
# Step 2: Digitising Cables





# Future Work

- Develop fragility curves to determine the damage caused by the earthquake.
- Determine the health of the asset.
- Study on the LV network effected during the 2010-2011 Canterbury earthquake



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**Orion**



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DEPARTMENT OF ELECTRICAL,  
COMPUTER, AND SOFTWARE ENGINEERING