

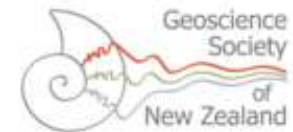
# PATA DAYS 2017: 8<sup>th</sup> International Workshop on Paleoseismology, Active Tectonics and Archeoseismology

Blenheim, New Zealand

November 13 – 19, 2017



GEOLOGICAL SURVEY



[geology.utah.gov](http://geology.utah.gov)

# PATA Days 2017

- Focused on the ground effects from November 2016 M7.8 Kaikōura Earthquake.
- 300<sup>th</sup> anniversary of AD 1717 (+/- 5 yrs) M ~8.0 Alpine Fault Earthquake.
- 130 participants from 21 countries
- 2 field trips, 3 days of oral/poster sessions, 1 public lecture



# Geographic Setting

- North Island
  - Auckland
  - Wellington- Capitol
- South Island
  - Southern Alps
  - Christchurch
  - Blenheim
  - Kaikōura



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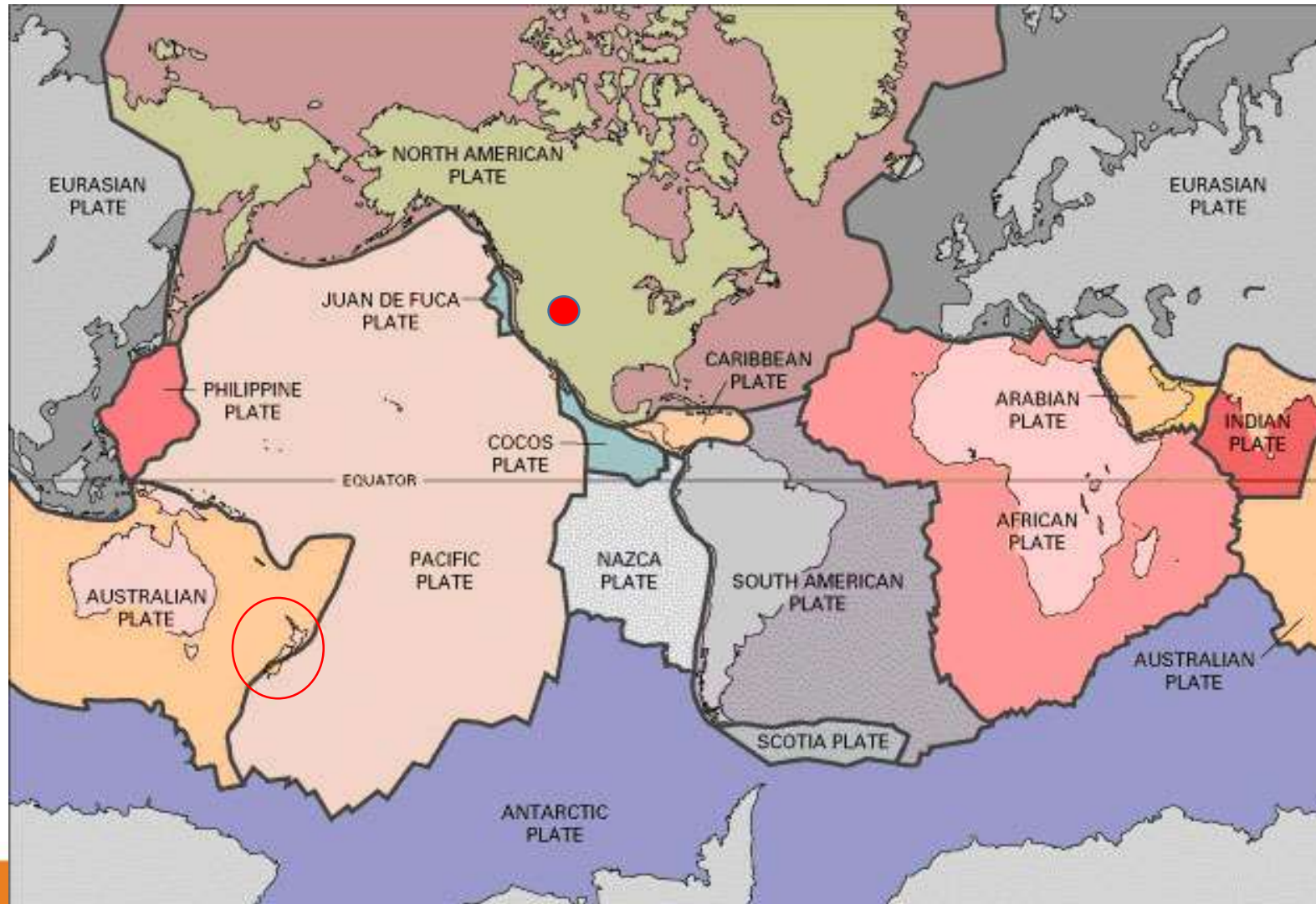


# Geographic Setting

- Southern Alps
- Marlborough Sounds
- Christchurch
- Blenheim
- Kaikōura



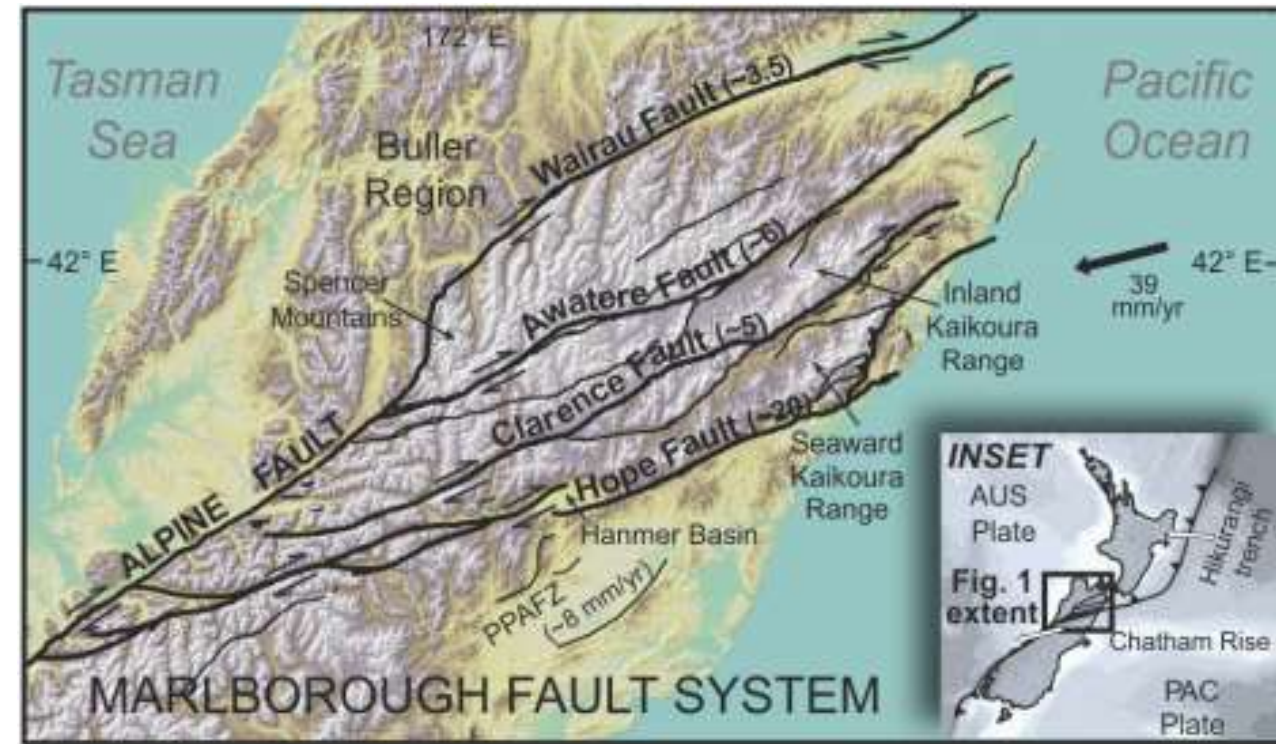
# Tectonic Setting





# Tectonic Setting

- Alpine Fault- right-lateral strike slip plate boundary fault.
  - 30 mm/yr of right-lateral movement, 7mm of uplift
- Marlborough Fault System (MFS)- Oblique-slip faults.
  - Concentrated area of right-lateral fault movement over time due to transition between Hikurangi trench and Alpine Fault.
  - 4 large right-lateral fault systems
    - 3 – 25 mm/yr of slip, depending on fault.

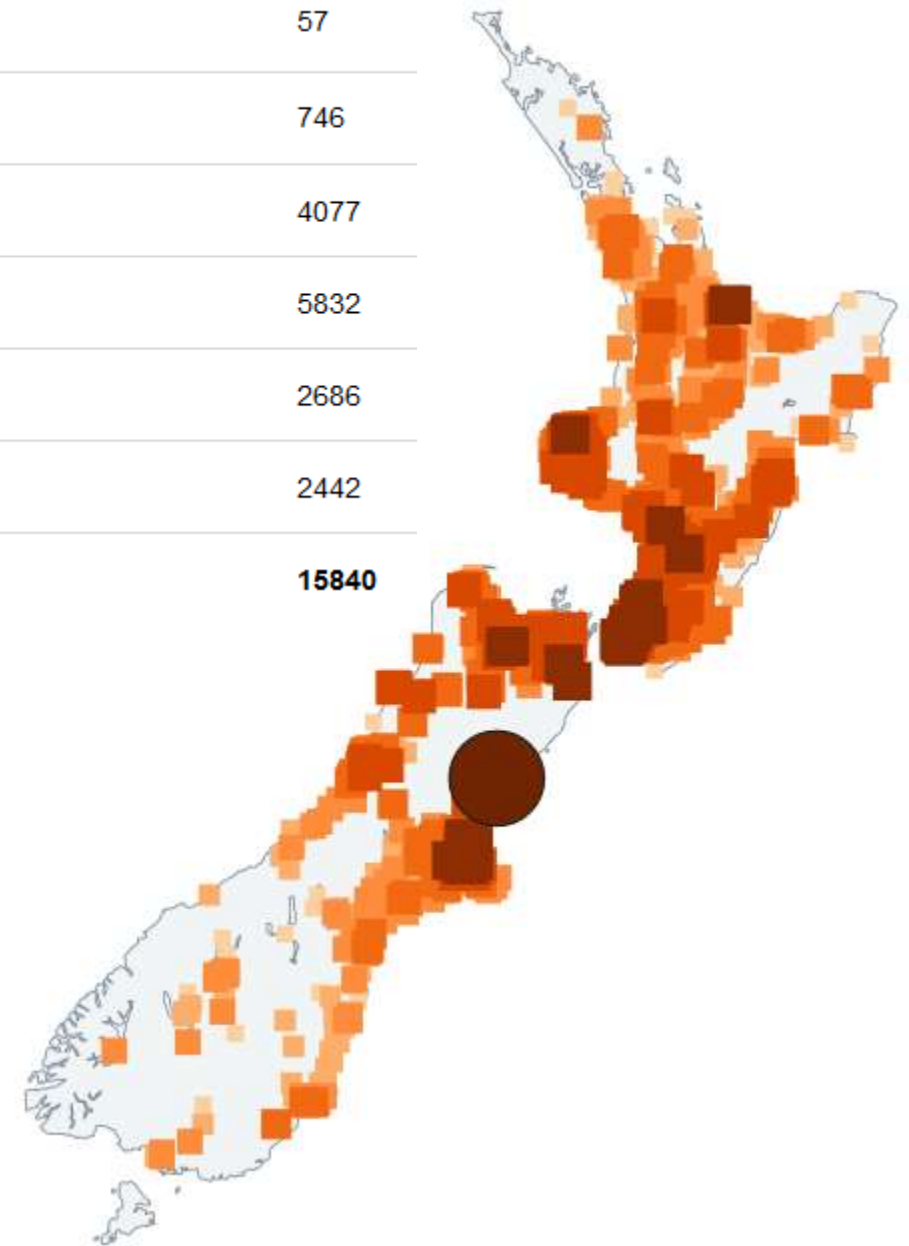


For comparison, Wasatch vertical slip rate is 1.1 – 1.4 mm/yr (Lund, 2005)

# M 7.8 Kaikōura Earthquake

- At 12.02 a.m., on Monday 14 November 2016 NZDT
- 15 km depth.
- Surface rupture on the northeast coast of the south island, and submarine faults.
- Strong ground motion effects in Wellington Harbor.

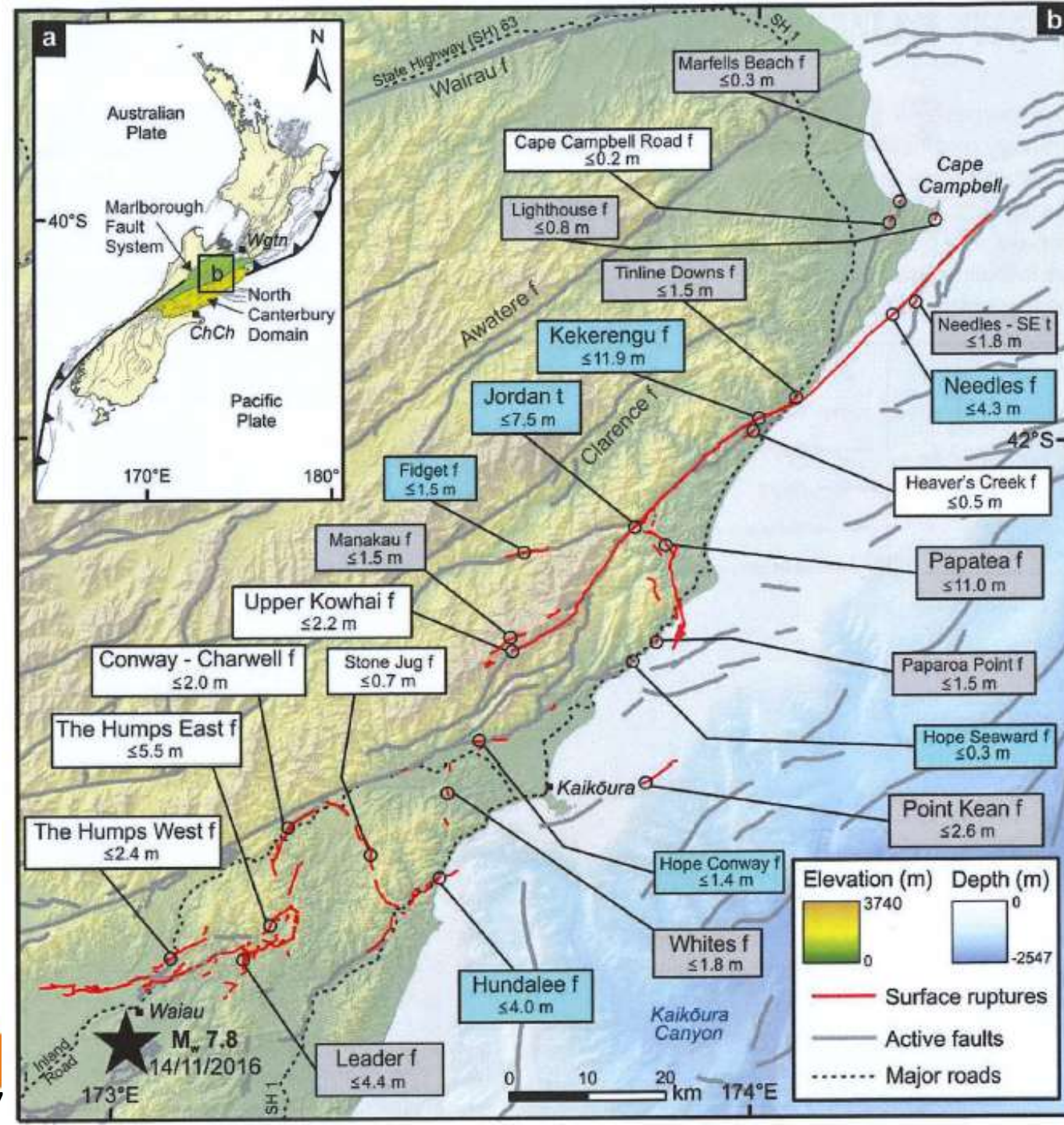
■	Extreme	57
■	Severe	746
■	Strong	4077
■	Moderate	5832
■	Light	2686
■	Weak	2442
Total		15840





# M 7.8 Kaikōura Earthquake Effects

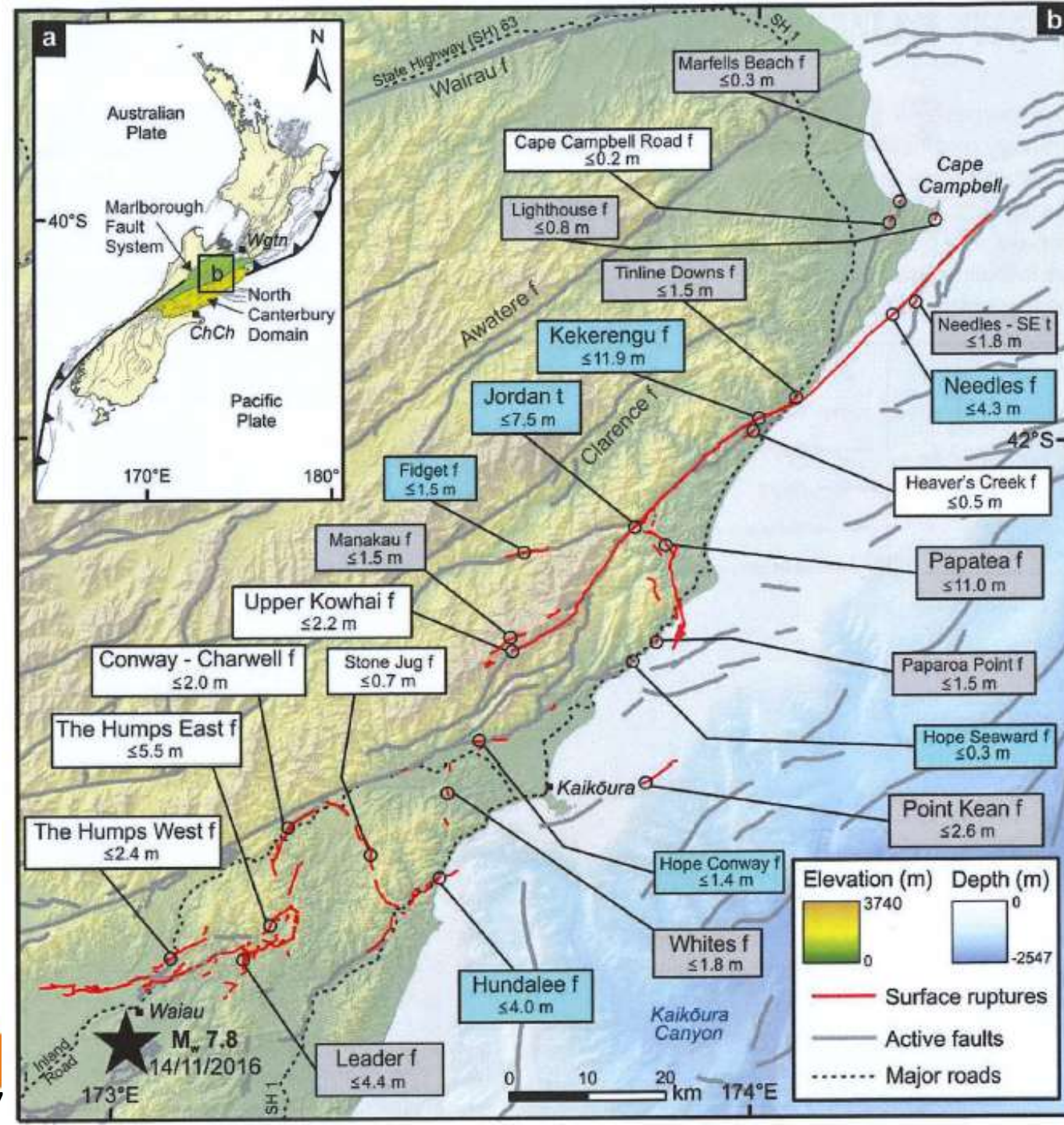
- 2+ minutes of strong shaking at epicenter.
- Rupture propagated to the north at ~2km/second
- 100 km of coastline uplifted.





# M 7.8 Kaikōura Earthquake Effects

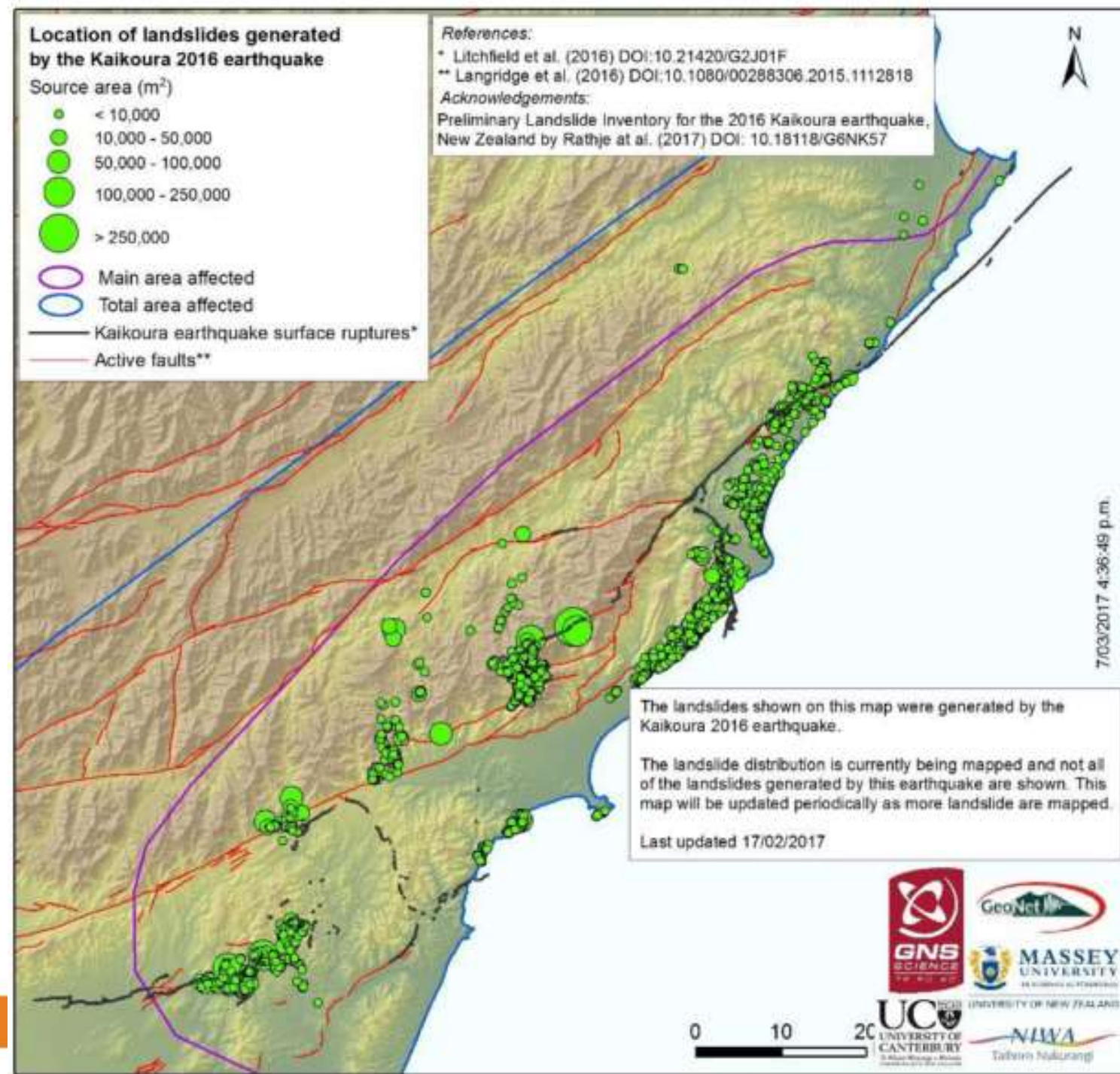
- One of the most complex surface fault rupturing earthquakes ever recorded.
- 180 km of surface rupture on 12+ major crustal faults.
- Seismic hazard models for NZ did not have this complex of a rupture accounted for.





# M 7.8 Kaikōura Earthquake Effects

- 100,000 + landslides triggered as a result of ground shaking.
- 200+ valley blocking landslides.
- Largest landslides were on or close to faults.

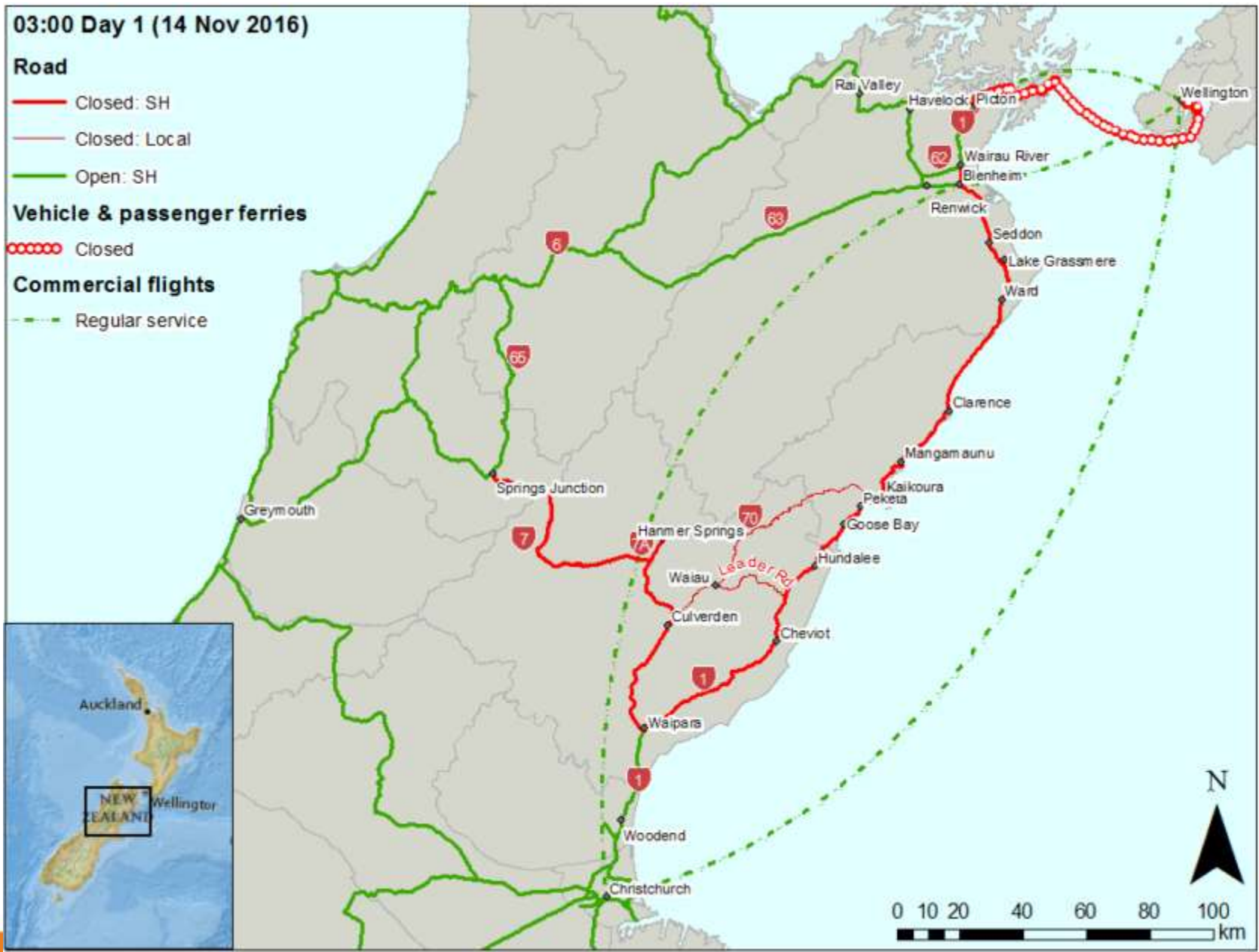




# M 7.8 Kaikōura Earthquake Effects

- State highway 1- runs entire east coast of New Zealand
- Highway 1 is the main on-land route from Picton (Ferry) to Christchurch.
- Railway connection between Picton and Christchurch.
- Major tourist attraction and roadway.



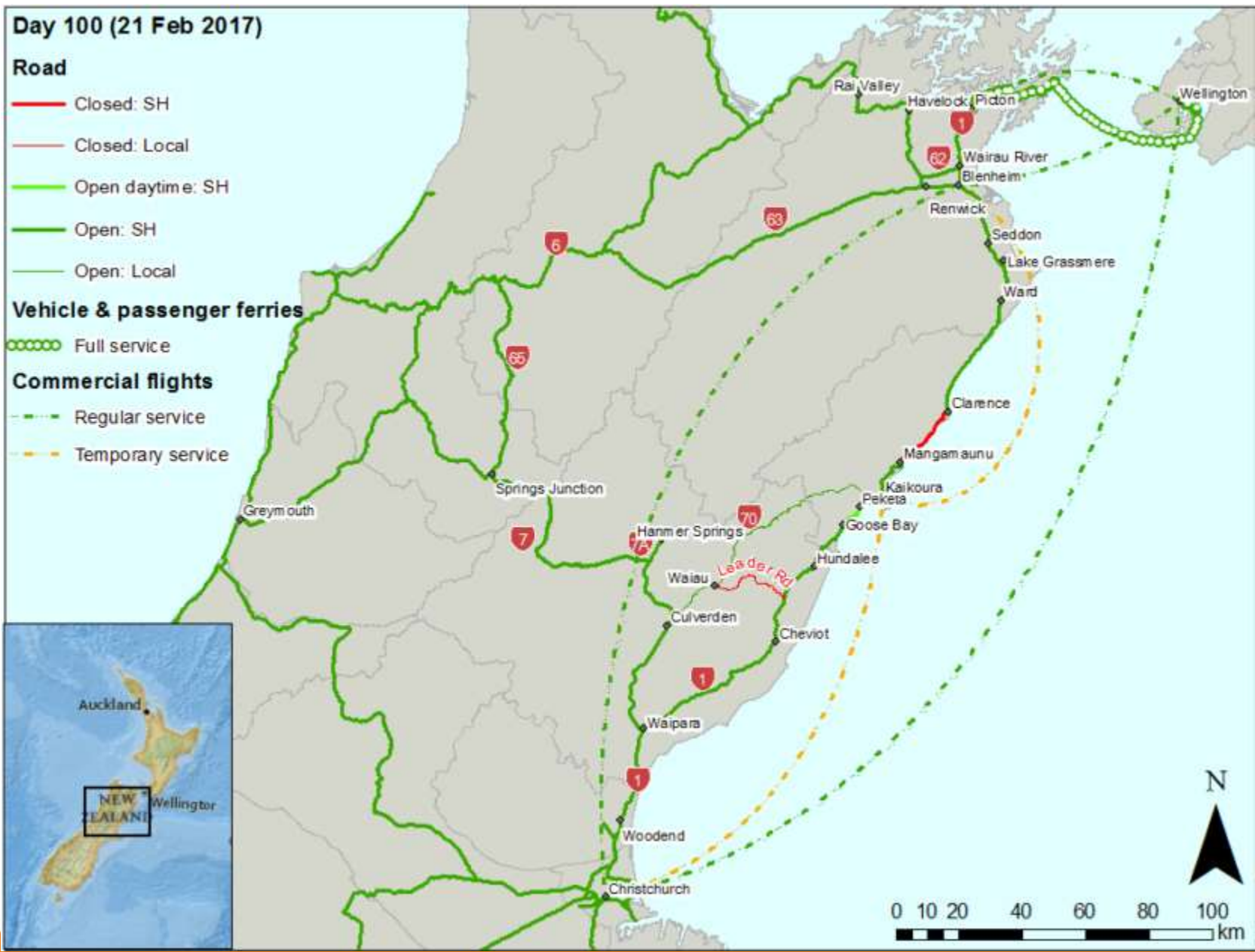


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Davies et al., 2017

geology.utah.gov





Davies et al., 2017





## Site 14, south of Kaikoura

January 2017

November 2017







## Slippy McSlip Face, north of Kaikoura

March 2017

September 2017

November 2017



New Zealand Government



KiwiRail

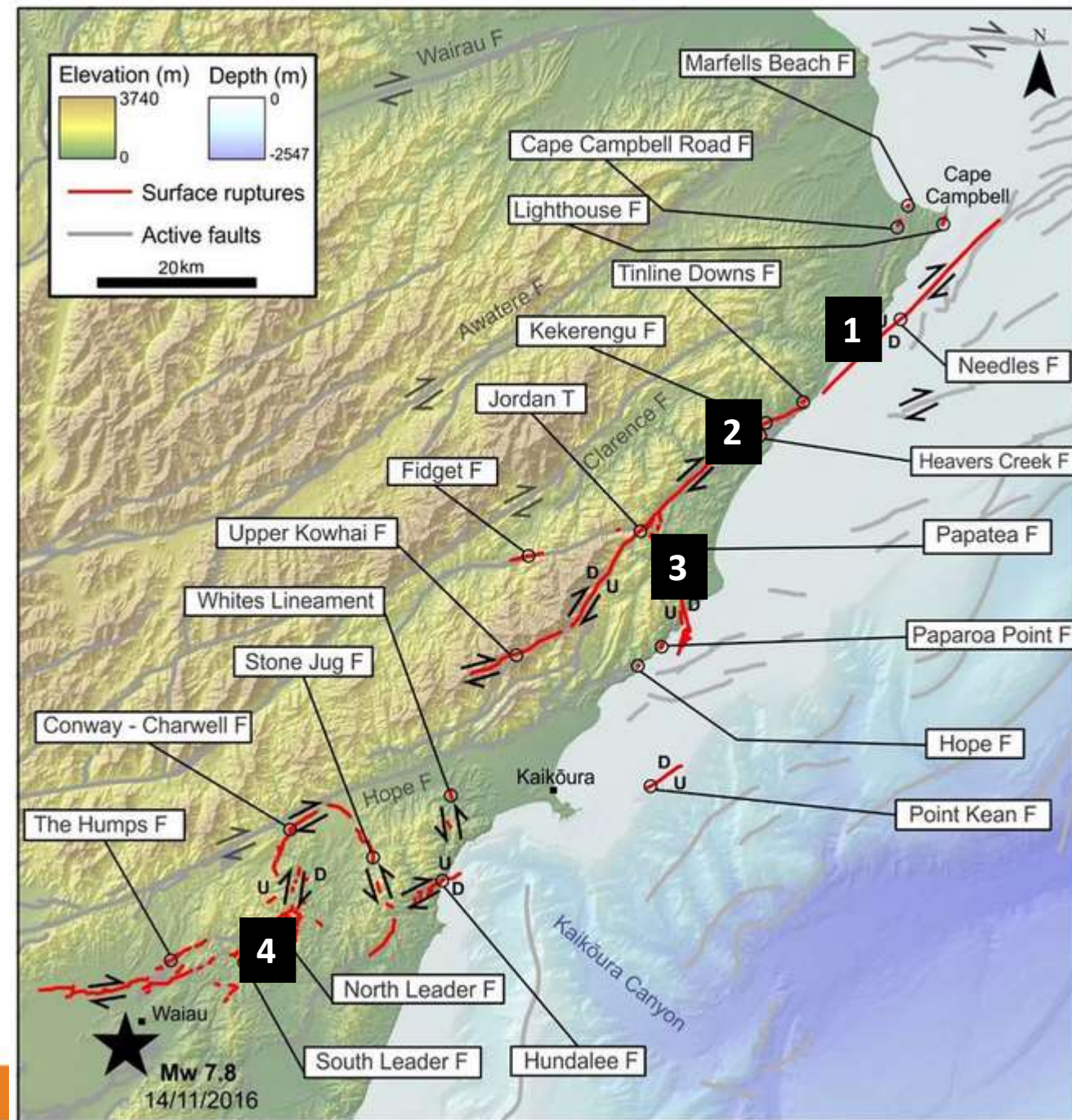
North Canterbury Transport  
Infrastructure Recovery

gy.utah.gov



# Fault Ruptures

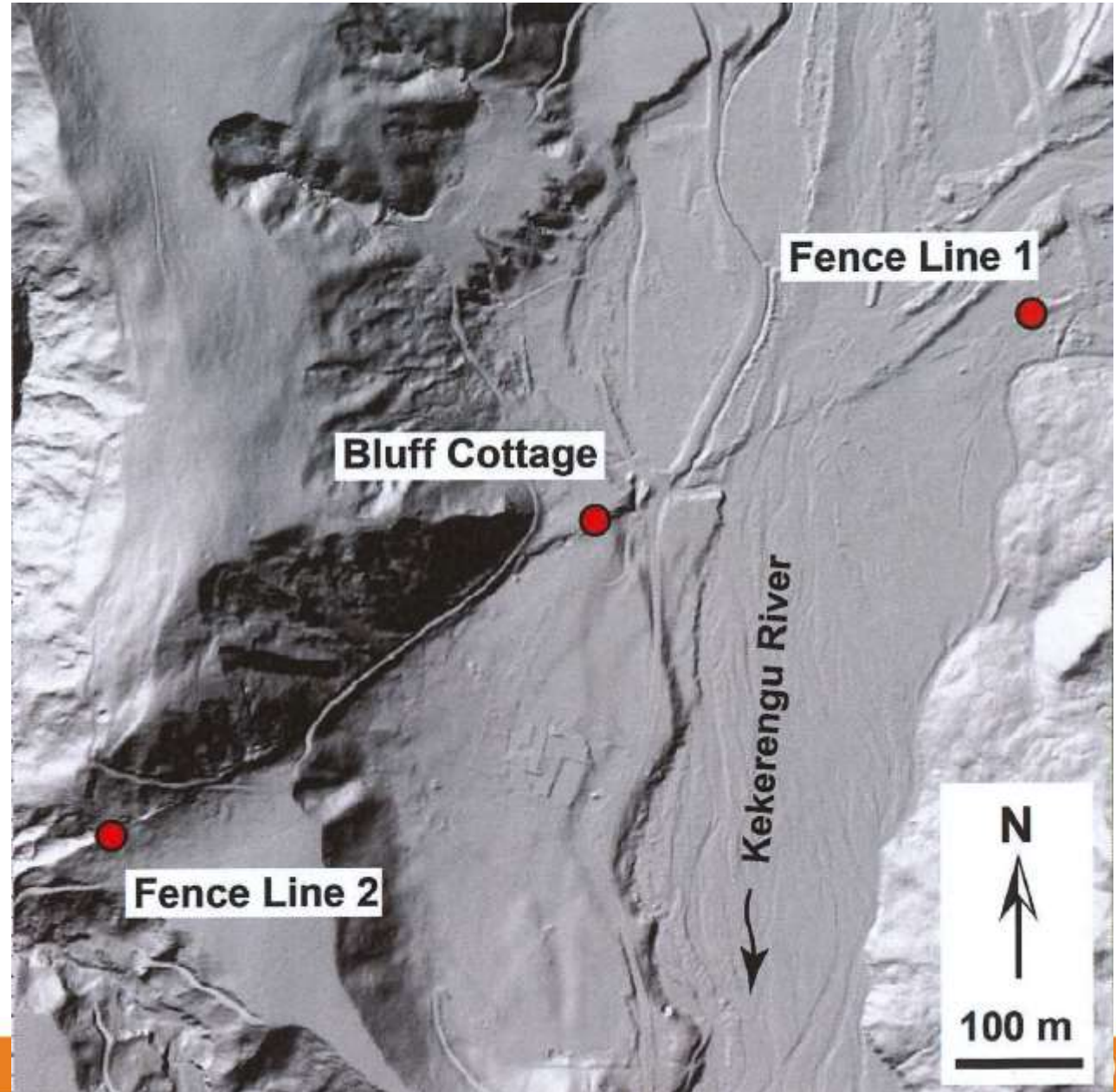
- 4 field trip stops to see surface rupture and effects from Kaikōura earthquake





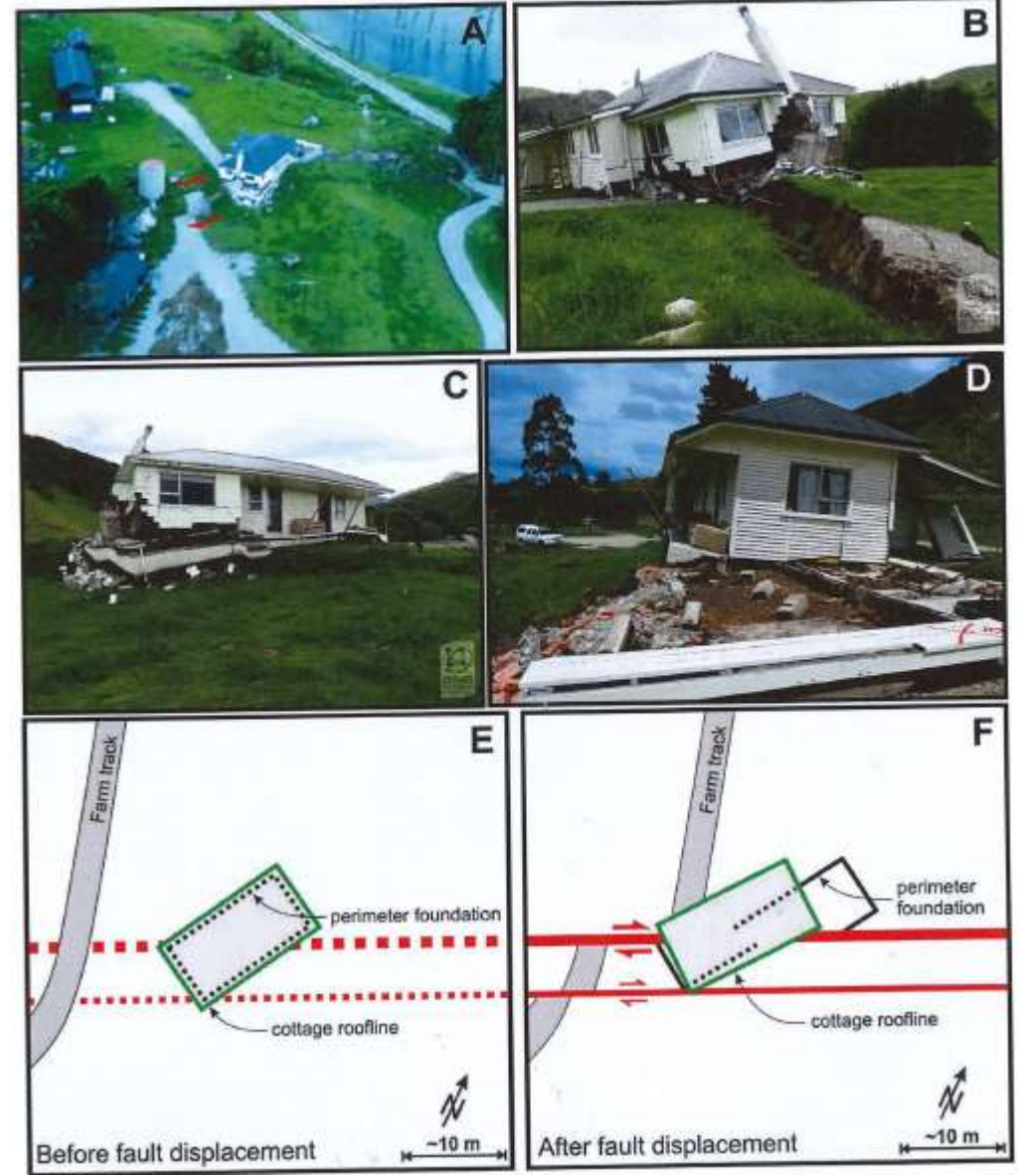
# Stop 2- Kekerengu Fault

- Offset man-made features
- Fences and a cottage





# Stop 2- Kekerengu Fault Bluff Cottage



10 meters of localized horizontal fault displacement extended through the cottage.



# Stop 4- South Leader Fault Zone - The Wall

- 3.3 m of offset
- A- Nov 26, 2016
- B- Dec. 6, 2016
- C- Sept. 9, 2016









# Stop 4- Leader River landslide





# Stop 4- Leader River landslide





# M 7.8 Kaikōura

## Earthquake Effects

- Psychological – Many New Zealanders lived through 2011 Canterbury earthquake sequence in Christchurch.
- Insecurity, uncertainty, **loss of trust in scientific information**, continued hyper-vigilance, and poor sleep.
- Scientists became “first responders.”



# Science Lessons Learned from 2016 M7.8 Kaikōura Earthquake

- The Kaikōura earthquake defies many conventional assumptions about fault segmentation.
- Paleoseismology
  - An event of this complexity could be interpreted as multiple events in the paleoseismic record.
- Seismic Hazard models
  - Segment Boundary ruptures- Kaikōura earthquake had multiple segment ruptures over great distances.
  - Seismic Hazards cannot capture the complexity of this faulting sequence.





# Response Lessons Learned from 2016 M7.8 Kaikōura Earthquake

- Technical experts can sometimes be the “first responders.”
- Public Trust- Making post-event data available online is incredibly valuable and important to the public.
  - But make sure it is clear (ie. no conflicting data).
- Authentic collaboration with local communities goes far.
  - Farmers/landowners know more about what their land looked like before an event.



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# Long Term Effects- Christchurch Earthquake Sequence

- M7.1 September 2010 Darfield Earthquake (~40 km from Christchurch)
  - Strongest ground-shaking earthquake ever recorded in New Zealand.
  - No deaths. Earthquake occurred at night.
  - Strong pattern of aftershocks.
- M6.3 February 2011 Christchurch Earthquake (<10 km from Christchurch City Center)
  - Aftershock of the Darfield earthquake.
  - 185 deaths due to close proximity of earthquake to population center, and time of day (noon).
- 26 aftershocks >5.0 magnitude recorded from 2010 - 2012





2011



2016



Stuff.co.nz, 2016





Thank you.





# References

Davies, A.J., Sadashiva, V., Aghababaei, M., Barnhill, D., Costello, S.B., Fanslow, B., Headifen, D., Hughes, M., Kotze, R., Mackie, J., Ranjitkar, P., Thompson, J., Troitino, D.R., Wilson, T., et al., 2017, TRANSPORT INFRASTRUCTURE PERFORMANCE AND MANAGEMENT IN THE SOUTH ISLAND OF NEW ZEALAND, DURING THE FIRST 100 DAYS FOLLOWING THE 2016 M W 7.8 " KAIKŌURA " EARTHQUAKE: Bulletin of the New Zealand Society for Earthquake Engineering, v. 50, p. 271–299.

Litchfield, N., Clark, K., Ries, W., Vilamor, P., Van Dissen, R., Langridge, R., Barrell, D., Jones, K., Heron, D., Lukovic, B., Townsend, D., Pettinga, J., Nicol, A., Khajavin, N., Little, T., Kearse, J., Rowland, J., Canva, A., Stirling, M., Williams, M. 2017. Kaikoura Earthquake Short-Term Project: Inventories of onshore surface fault ruptures and coastal uplift. Final Report. Lower Hutt (NZ): GNS Science. 19 p. (GNS Science miscellaneous series 111).  
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New Zealand Transport Agency, <https://www.nzta.govt.nz/projects/kaikoura-earthquake-response/>