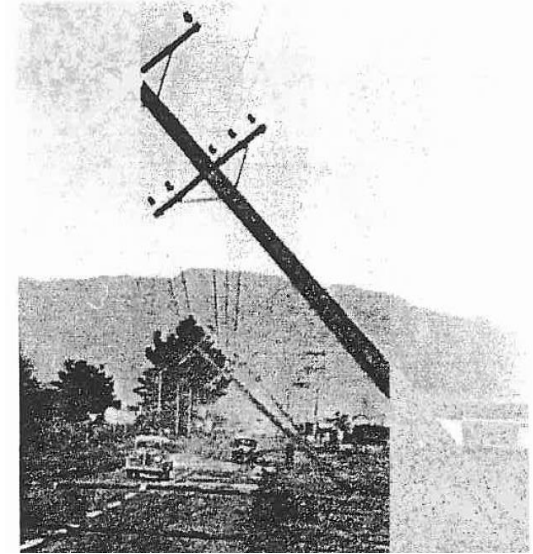


# Characterization of soils at sites of historical liquefaction, West Coast, New Zealand

Sarah Bastin, Sjoerd van Ballegooy et al

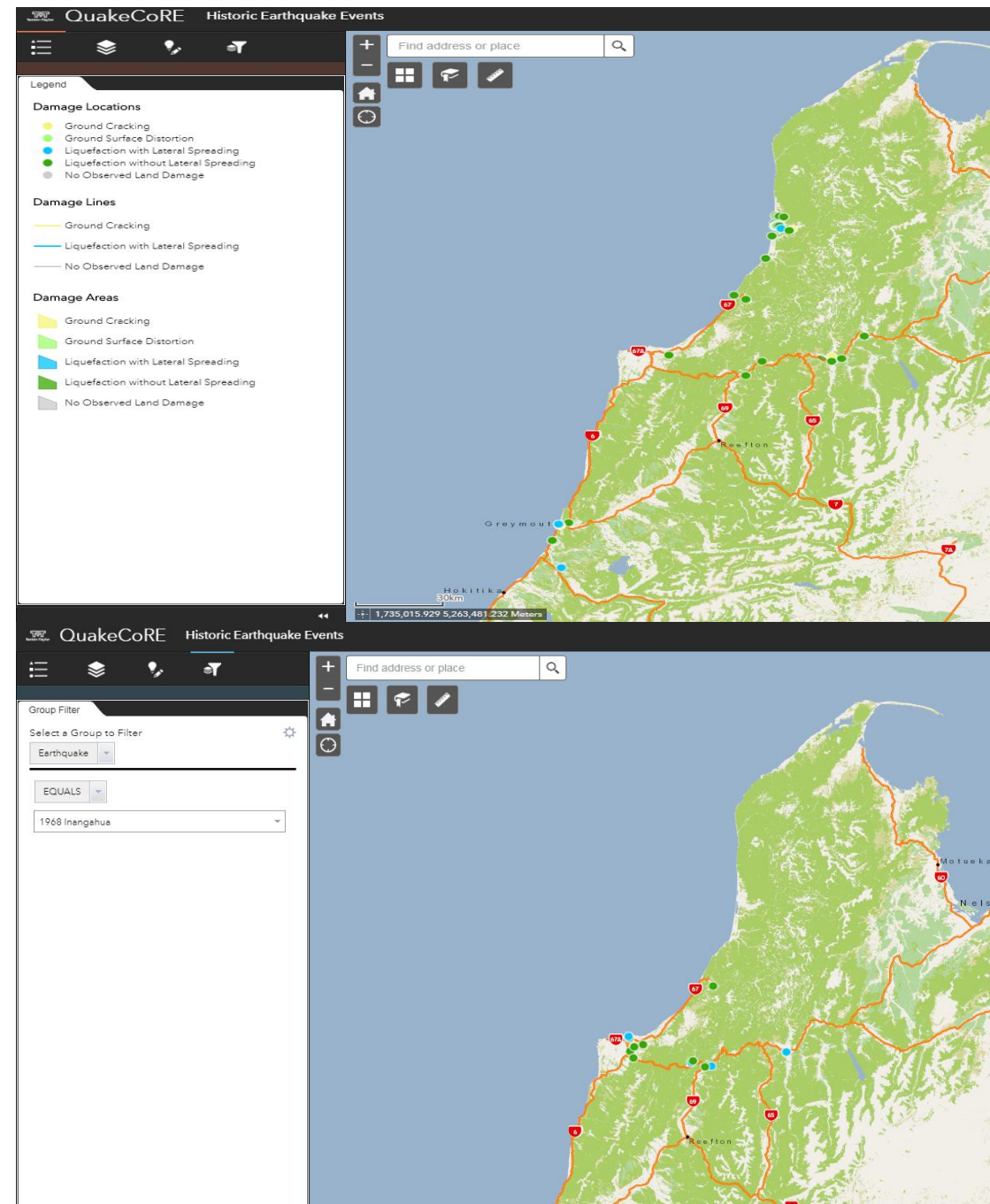
# Liquefaction during historical earthquakes

- Liquefaction reported during historical earthquakes on West Coast
  - 1929 Murchison earthquake
  - 1968 Inangahua earthquake
  - 1991 Hawks Crag earthquake
  - Minor liquefaction during 1962 Westport earthquake
- Collated as part of previous research projects overseen by John Berril (i.e. Carr, 2004; Yiqiang and Berril, 1992)
  - Collated into the online Historical liquefaction database
- Studies limited by a lack of geotechnical data on the West Coast



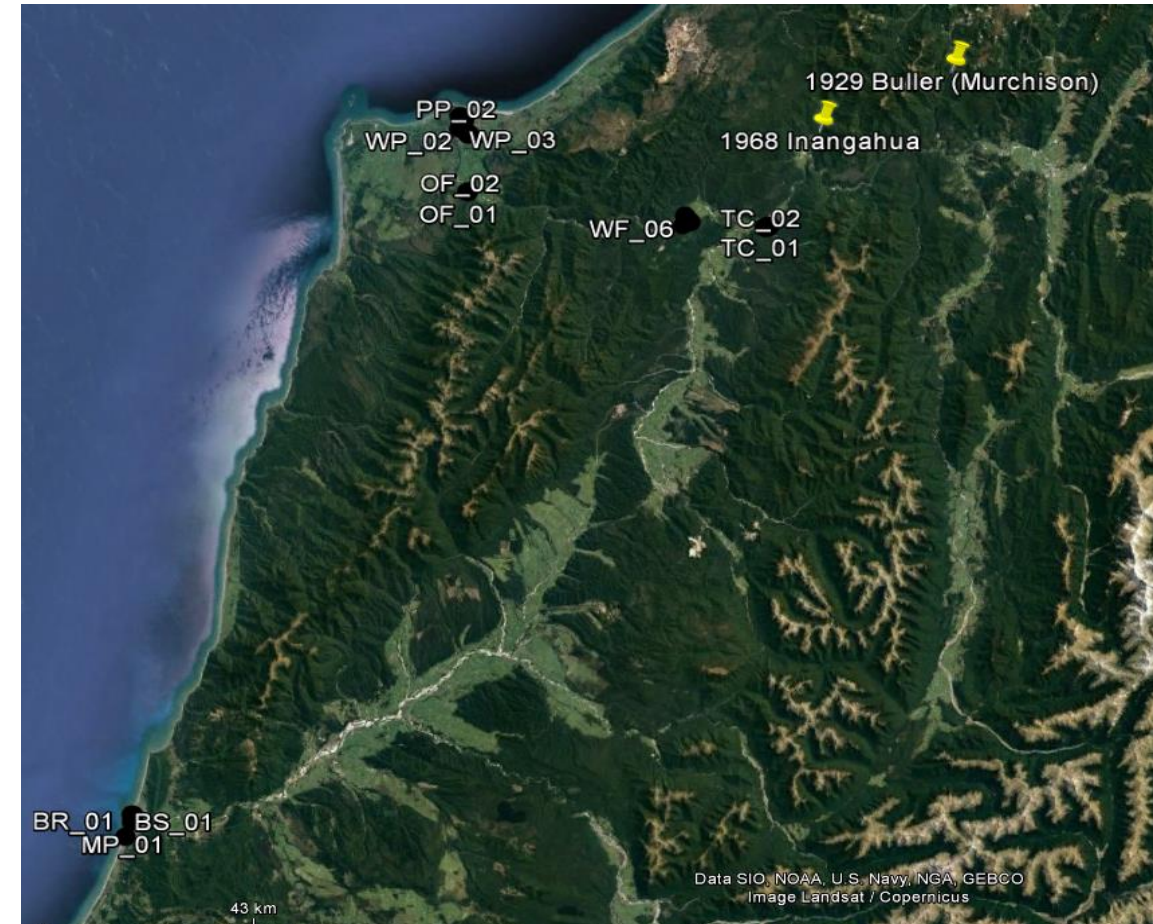
# Liquefaction during historical earthquakes

- 1929 Murchison earthquake
  - Ms 7.8; 20 km depth
  - Widespread and severe liquefaction reported along the West Coast
- 1968 Inangahua earthquake
  - $M_L$  7.0-7.1; 15 km depth
  - Damage comparably more localized; confined to Westport and Inangahua
- 1991 Hawkes Crag
  - Three events within 2 days -  $M_L$  6.1, 6.2, 5.9
  - Liquefaction reported near Westport, and Inangahua
- 1962 Westport Earthquake
  - $M_L$  5.7; 12 km depth
  - Reports of localized liquefaction at Keoghans and O'Connor Farms near Westport – also had liquefied during Inangahua



# CPT at sites of recurrent liquefaction and no liquefaction

- Limited geotechnical data on West Coast
- 2018 QuakeCoRE project to undertake CPT at sites where historical liquefaction documented, and no liquefaction documented



# Inangahua

- **Walkers Flat**

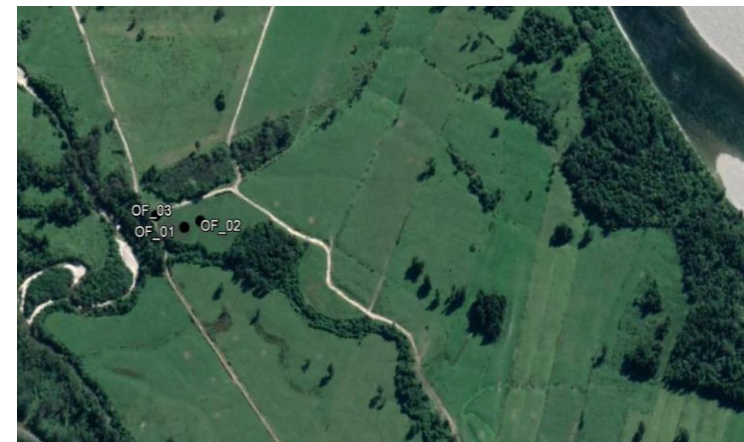
- Liquefaction reported at the site during
  - 1968 Inangahua earthquake – site located 12-15 km from epicentre; distribution indicated by grey polygons
  - Minor liquefaction reported near WF\_06 following 1991 Hawks Crag earthquake

- **Three Channel Flat**

- Liquefaction reported at the site during
  - 1929 Murchison earthquake – site 23 km from epicentre
  - 1968 Inangahua earthquake – site 10 km from epicenter
  - 1991 Hawks Crag earthquake

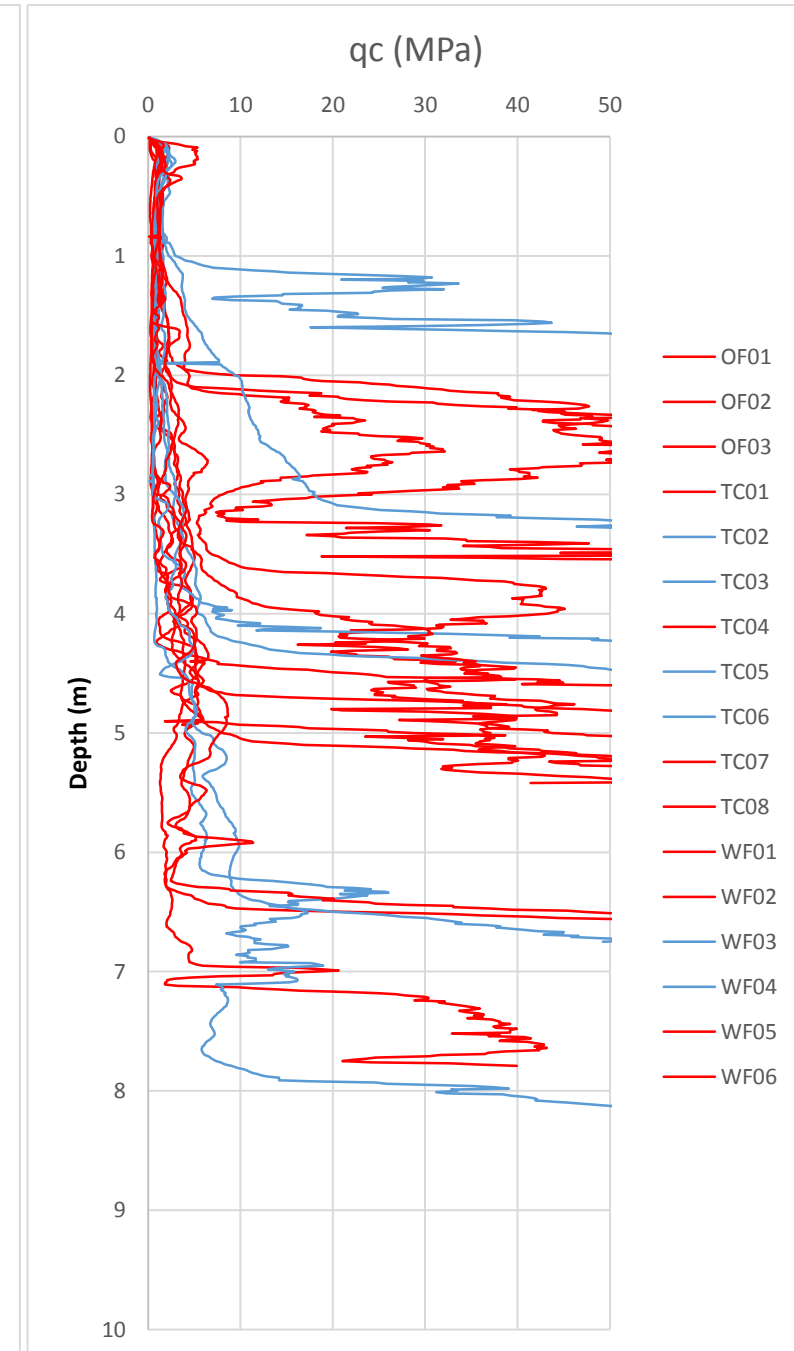
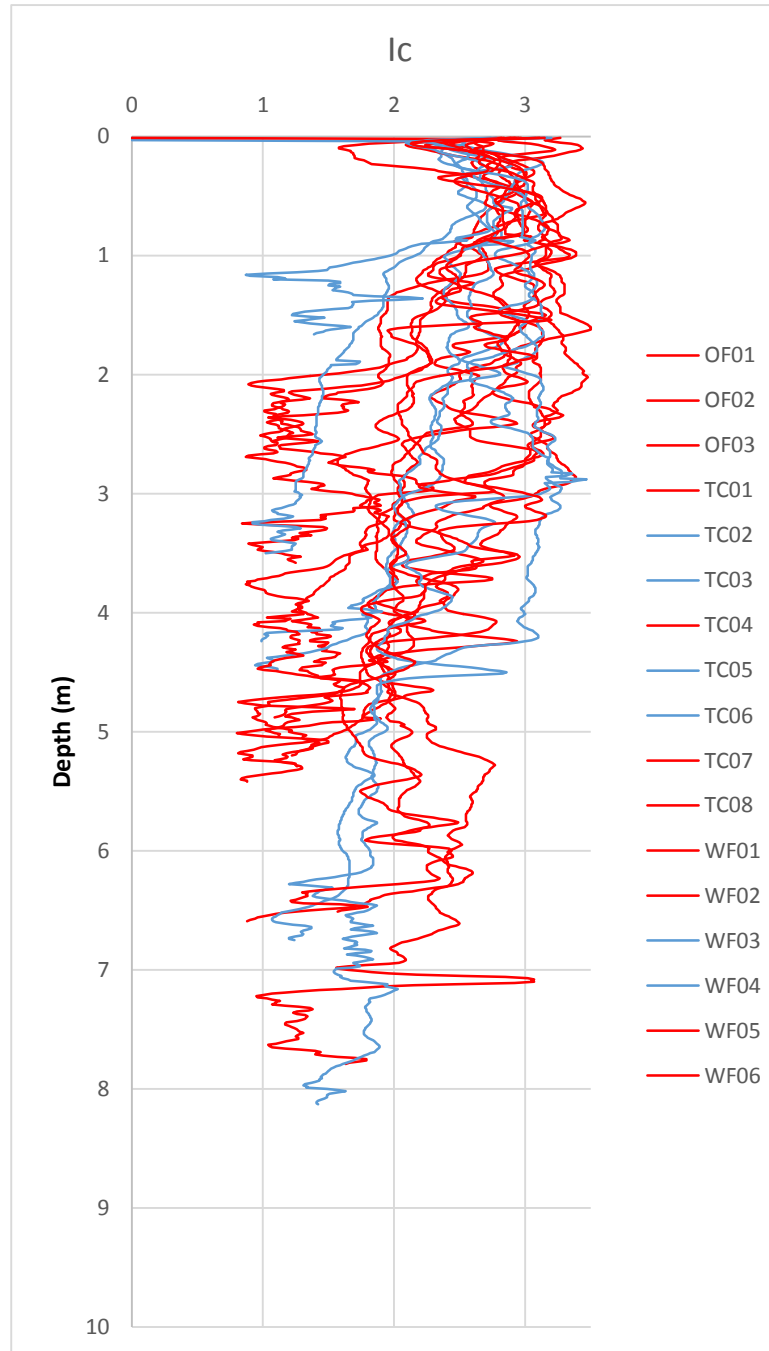
- **O'Connor Farm**

- Located near Westport (indicated in Figure 6) however in similar setting to Inangahua sites.
- Liquefaction reported at the site during
  - 1968 Inangahua earthquake – located 30 km from epicentre
  - Minor liquefaction reported following 1991 Hawks Crag earthquake - Testing targeted these areas
    - Shallow gravels encountered during testing suggesting may have missed location where liquefaction was reported



# Collated CPT

- Red = liquefaction observed  
Blue = no liquefaction observed
- Ground water surface varies from 1.25 to 5 m depth
  - Shallower at locations where liquefaction observed
- Shallow gravels encountered at every location
- PGA listed in Carr, 2004
  - Murchison – 0.64 g
  - Inangahua – 0.6 g
  - Hawkes Crag – 0.19 g



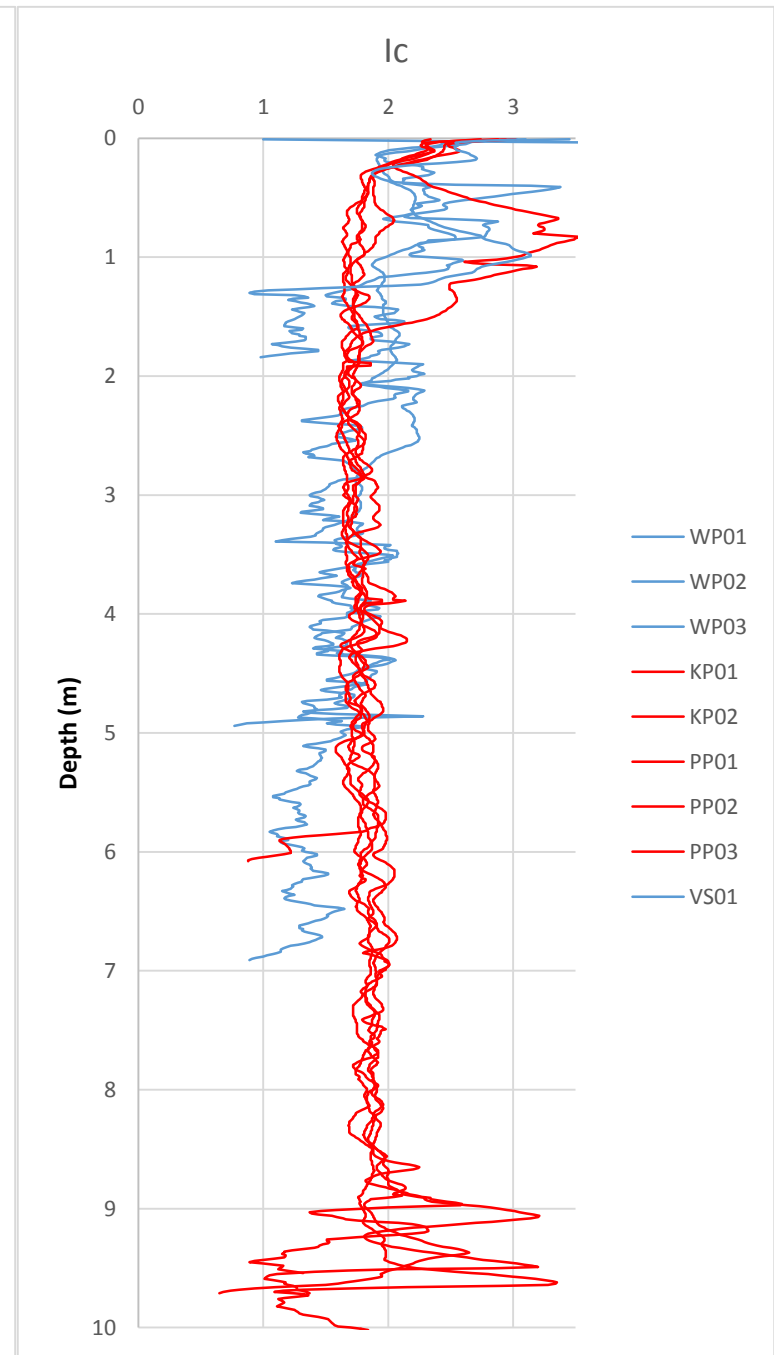
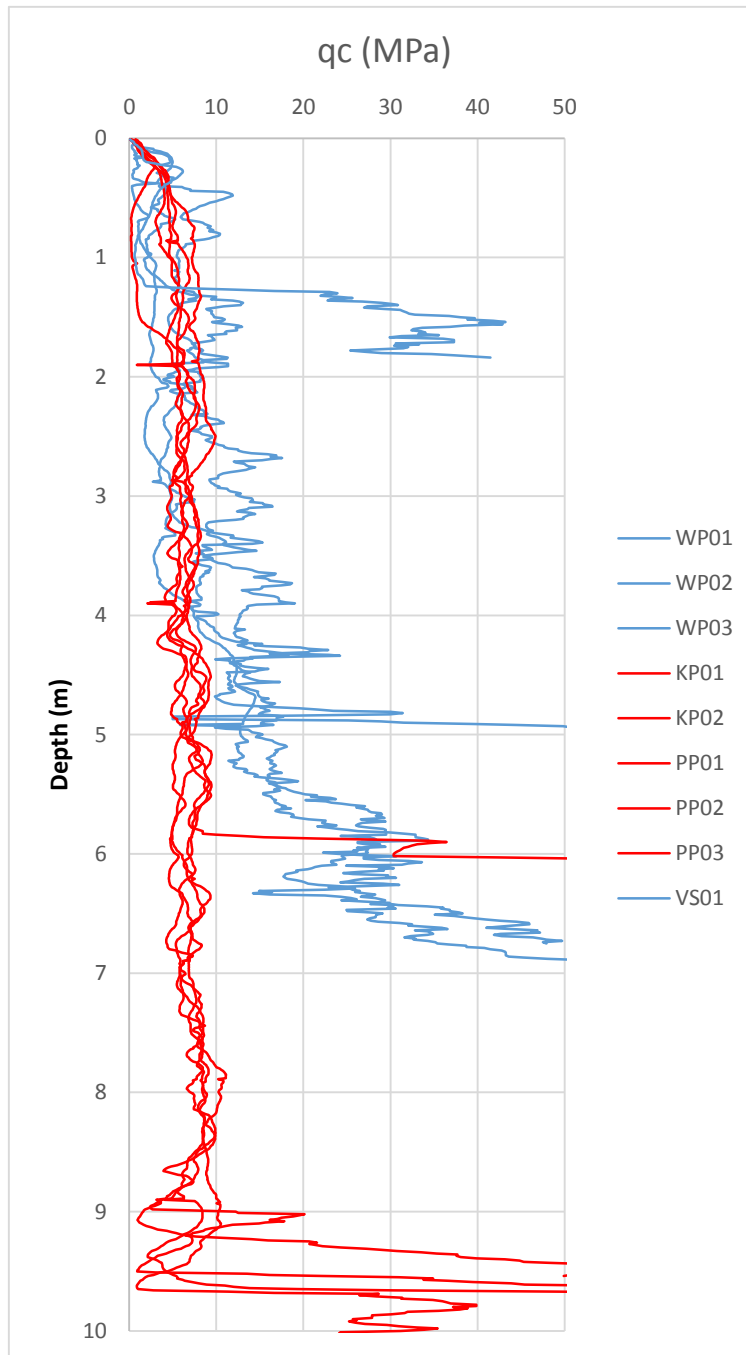
# Westport

- Liquefaction reported following Murchison, Inagahua, and Hawks Crag earthquakes
- Testing undertaken at sites where liquefaction was and was not reported
  - No liquefaction
    - George Craddock Memorial Park (WP)
    - Victoria Square (VS)
  - Liquefaction reported
    - ***Kilkenny and Patterson Parks***
      - Liquefaction reported following 1968 Inangahua earthquake – site located 34 km from epicentre; distribution indicated in figure
      - Likely liquefied during 1929 Murchison earthquake although report not conclusive in exact location
      - Nothing reported following 1991 Hawks Crag earthquake
      - Testing targeted areas where liquefaction ejecta was mapped as reports suggest that much of the area experienced liquefaction



# Collated CPT

- Red = liquefaction observed  
Blue = no liquefaction observed
- Ground water surface
  - No liquefaction sites -2.25-2.8m
  - Liquefaction sites – 0.8 – 1m m
- Refusal possibly due to denser sands (paleo-dunes (?))
- PGA listed in Carr, 2004
  - Murchison – 1.13 g
  - Inangahua – 0.34 g
  - Hawkes Crag – 1.58 g





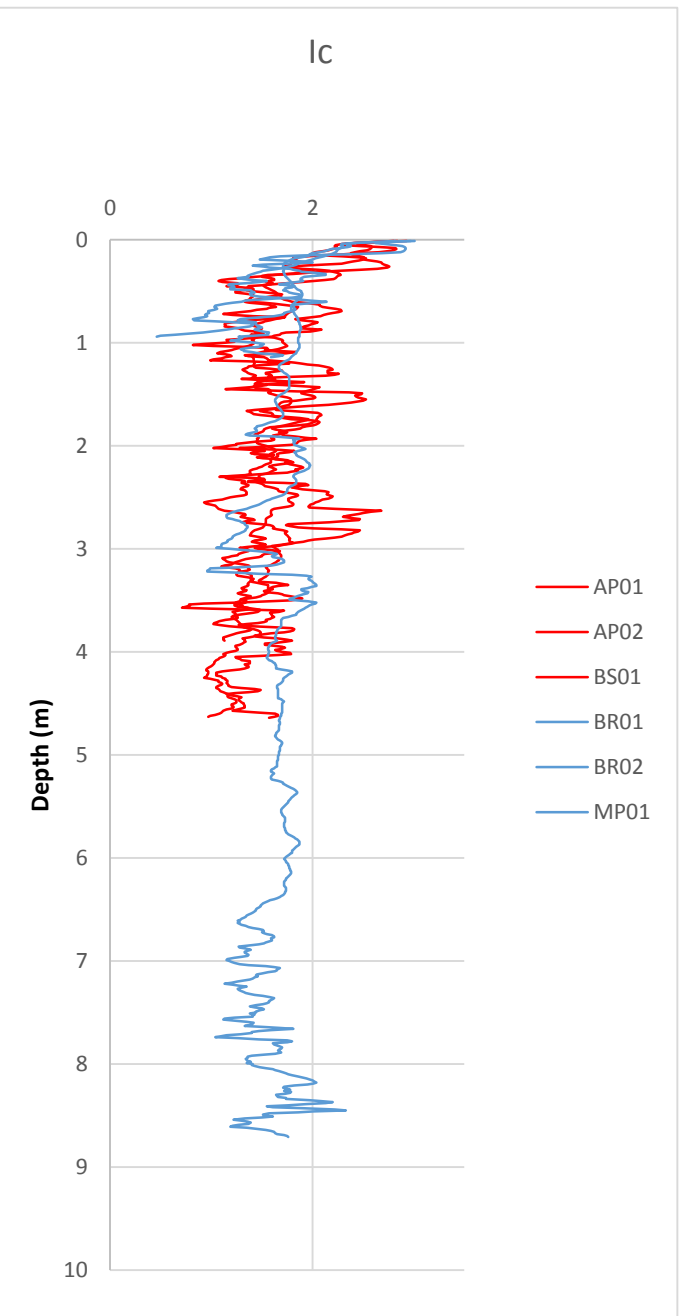
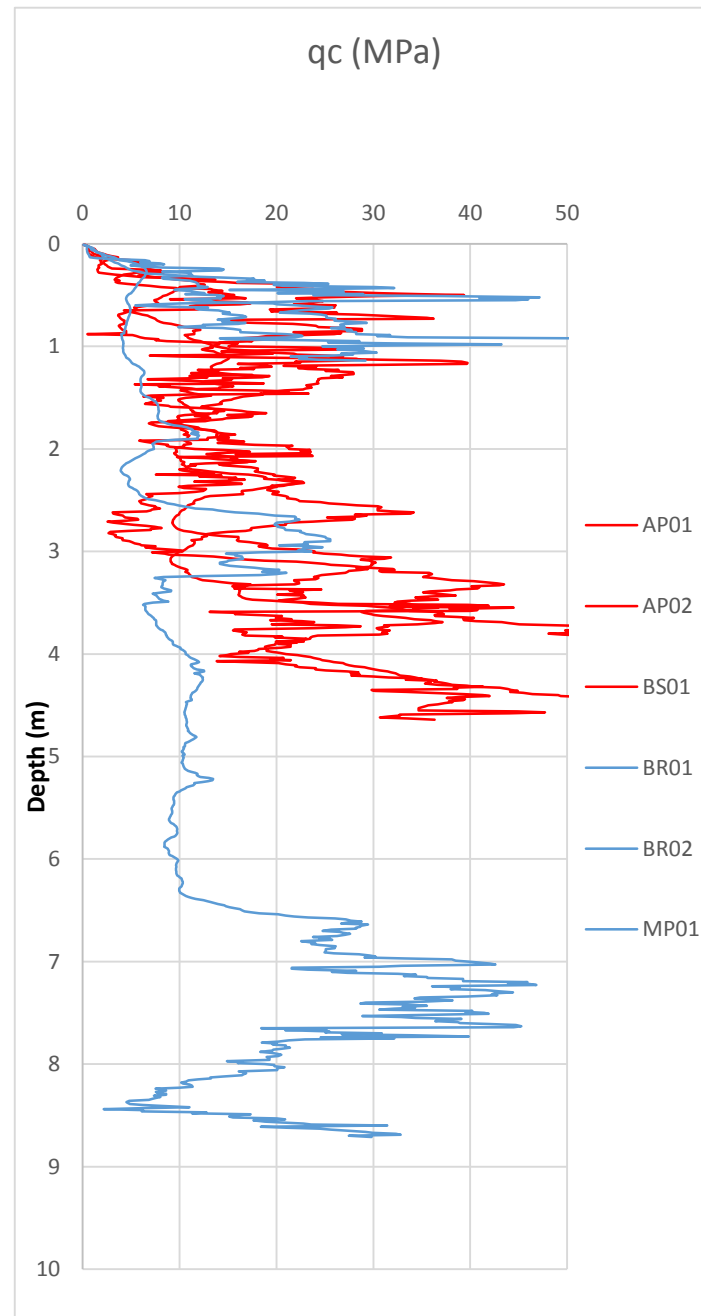
# Greymouth

- Liquefaction reported during Murchison earthquake
- No liquefaction reported following Inangahua earthquake
- Testing targeted sites where liquefaction was documented and sites where no damage was reported
  - Liquefaction sites
    - Airport
    - Blake Street
    - Messenger Park
  - No Liquefaction sites
    - Blaketown Rugby club
- Site selection was limited by the availability of greenfield sites in which testing could take place, and inability to pinpoint exact localities of reported liquefaction



# Collated CPT

- Red = liquefaction observed  
Blue = no liquefaction observed
- Ground water surface
  - No liquefaction sites – 3.8 m
  - Liquefaction sites – 2.8-3.2 m
- Refusal possibly due to denser sands (paleo-dunes (?))
- Frustrating day of testing due to shallow refusals
- PGA listed in Carr, 2004
  - Murchison – 0.4 g
  - Inangahua – 0.4 g
  - Hawkes Crag – 0.06 g



# Summary

- Liquefaction consistently observed proximal to waterways in areas hosting shallow waterways and underlain by recent fluvial and estuarine sediments
- Testing provided additional geotechnical data to characterize soils in areas of reported liquefaction and no reported liquefaction
- Next step is to constrain PGA and run simplified analyses
  - Collate and summarize results as a journal publication