

# **Development of deep Vs profiles and site periods for the Canterbury region**

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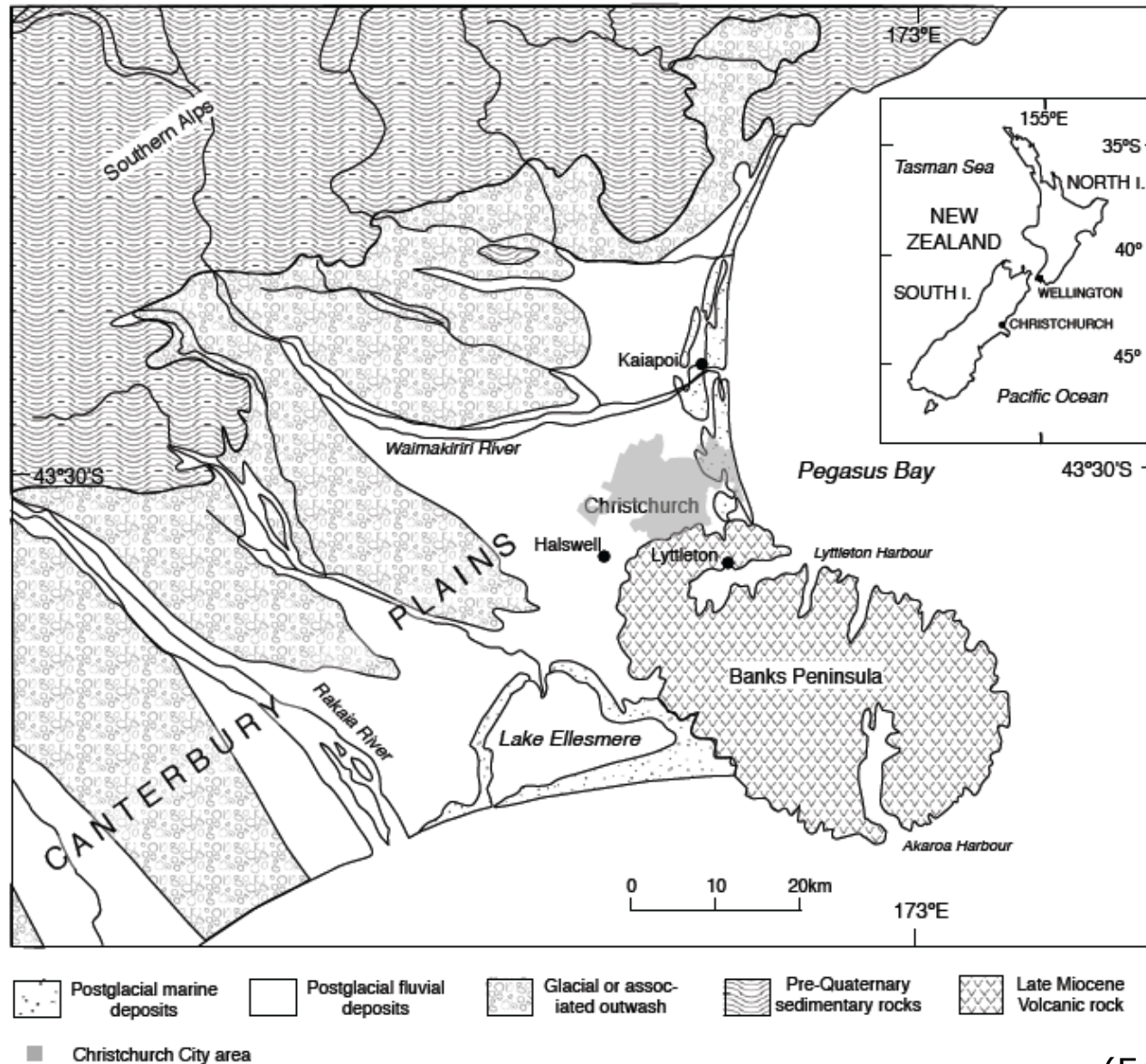


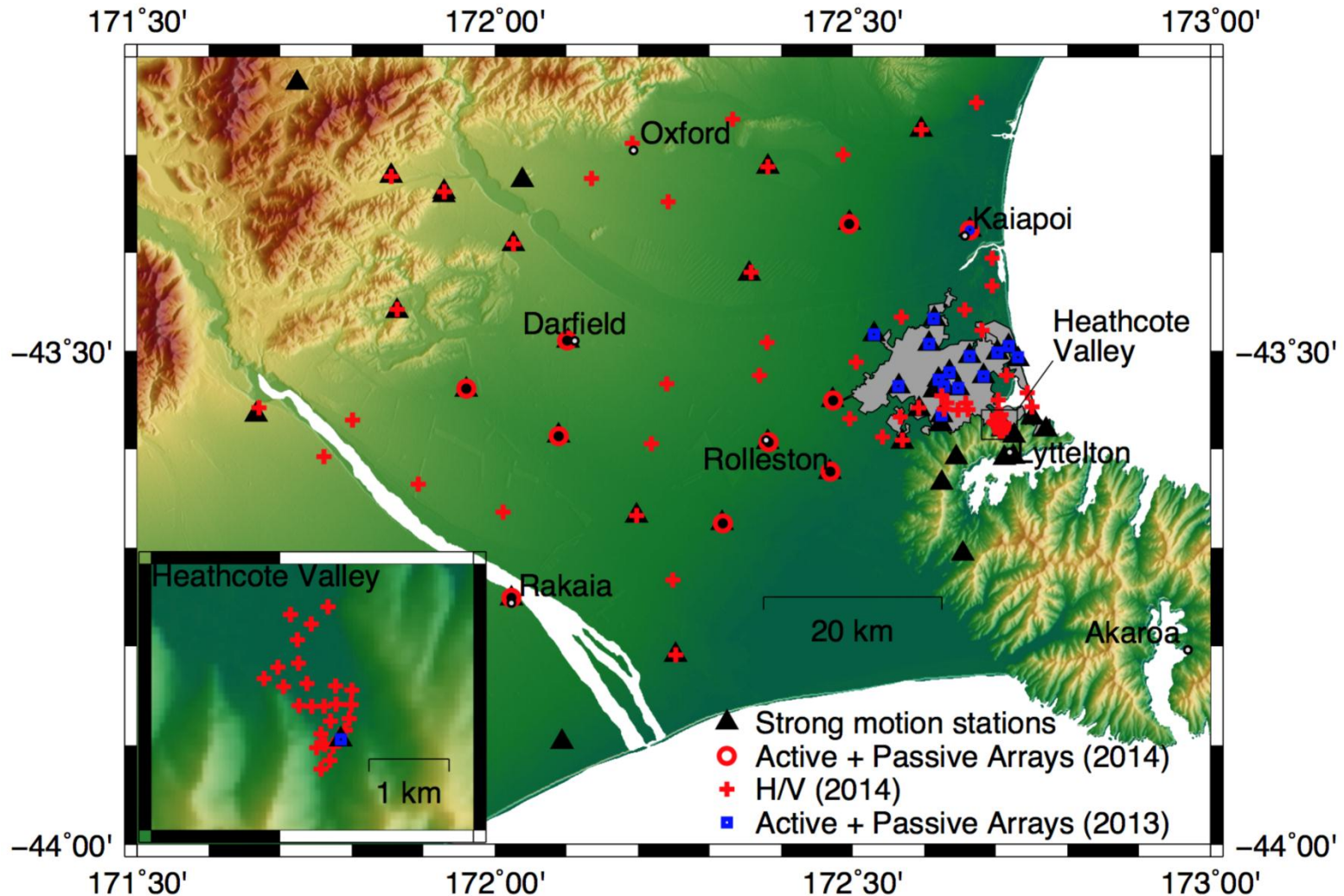
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- Deep geophysical and geotechnical characterisation of the Canterbury Plains
  - Shear wave velocity profiles
  - **Site period**
- Combine with other studies to provide a better understanding of ground motions recorded during CES and forward modelling of future events
- Assess NZS1170.5 framework and other international site classification approaches
- Application of best practice surface wave investigation techniques in New Zealand

# Canterbury Geology







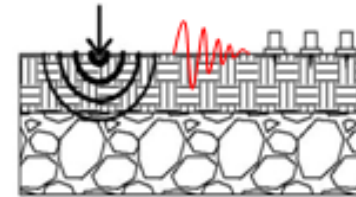
# Shear Wave Velocity Testing at each Site

To develop  
(MAM)

## Acquisition

Field Data Collection:

Measurement of stress waves at the ground surface

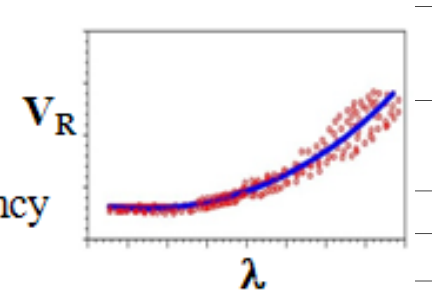


and Passive

## Processing

Dispersion Curve:

Rayleigh Wave Phase Velocity vs. Wavelength/Frequency

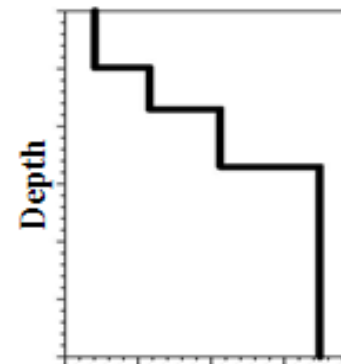


## Inversion

Shear Wave Velocity Profile:

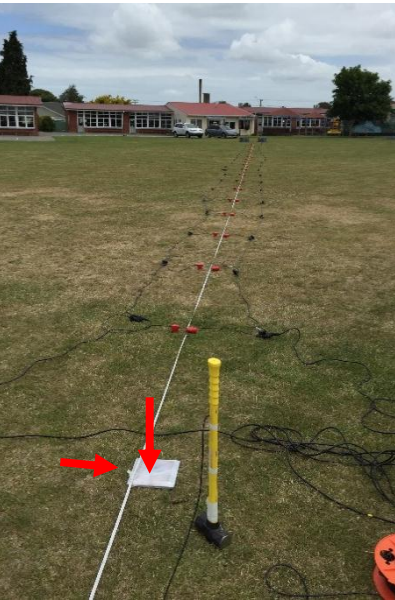
Variation of Small Strain Shear Modulus vs. Depth

$$G_{\max} = \rho V_s^2$$

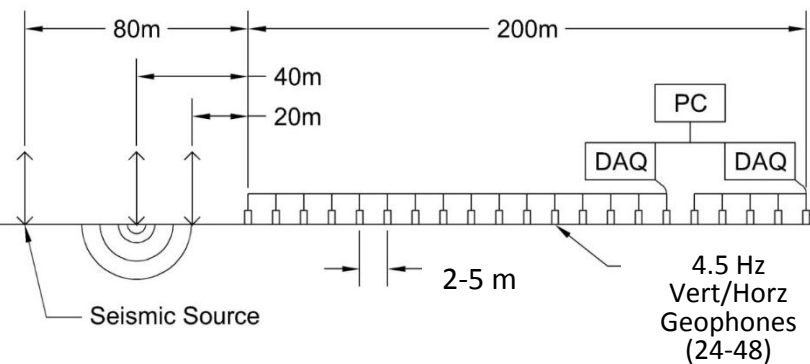


Joint Inversion  
Develop V\_s Profile

Geologic Period	Geologic Group	Geologic Formation	Geologic Age	Geologic Description
Cenozoic	Quaternary	Albion	Recent	Light-gray silty clay
		Lower	Recent	Tan silt and clay
	Pleistocene	Jackson	Recent	Perruquous, fine-
		Lower	Recent	Light-gray to buff, silty sand, inter-
	Holocene	Lower	Recent	Light-gray to light with medium-
		Upper	Recent	Light-gray to light with variable amounts
	Eocene	Clatsop	Recent	Fine- to very coarse quartzose sand, rock fragments.
		Memphis	Recent	Medium- to light-containing thin l sand; commonly mica.
	Paleocene	Wilcox	Recent	Fine- to very coarse commonly con-
		Wilcox	Recent	Light gray, sandy
Mesozoic	Cretaceous	Midway	Recent	Steel-gray to dark disseminated or mottled yellow-l common; becom near the base.
		Midway	Recent	Light green-gray, interbedded with
	Jurassic	McNary	Recent	Fine- to coarse-gr pyrite, mica, and of glauconite lat micaceous silty c
		McNary	Recent	Massively-bedded marls.
	Triassic	Denopolis	Recent	Well-sorted, brown laminated to shi carbonaceous cl
		Denopolis	Recent	
	Permian	Coffee	Recent	
		Coffee	Recent	
	Carboniferous	Unknown	Recent	
		Unknown	Recent	
Paleozoic	Cambrian (?)	Unknown	Recent	White to dark-gray, fine- to coarse-crystalline dolomite; locally recrystallized; trace vuggy porosity; pyrite common; trace quartz crystals.
		Unknown	Recent	



- Linear array of 24-48 4.5-Hz vert/horz geophones
- Equal spacing of 2m (94 m long array)
- Four different source-offset locations (5, 10, 20 & 40m)



## Active Source MASW using Rayleigh and Love Waves and P-wave Refraction

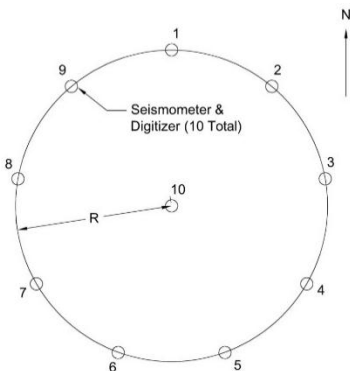
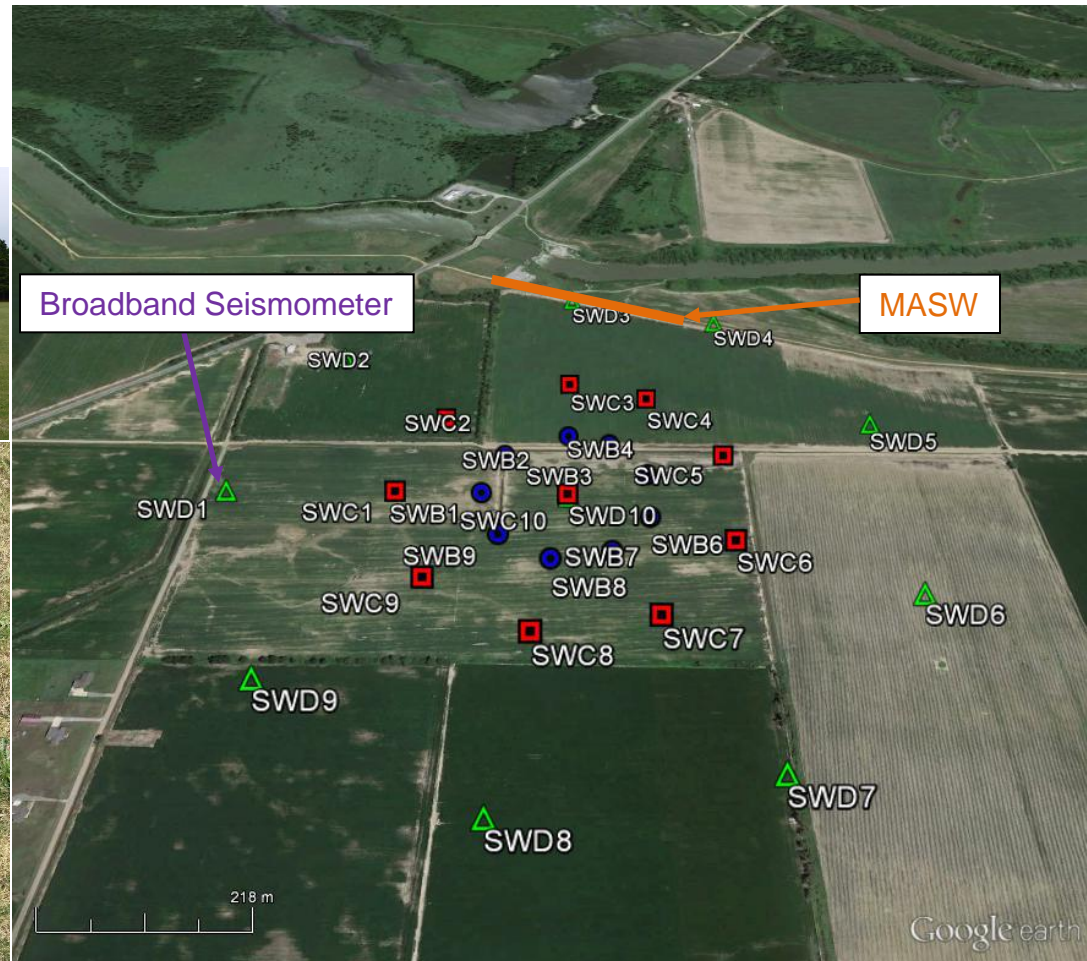




## Shear Wave Velocity Testing

### Ambient-Wavefield (MAM) and Horz to Vert Spectral Ratio (HVSr) Testing

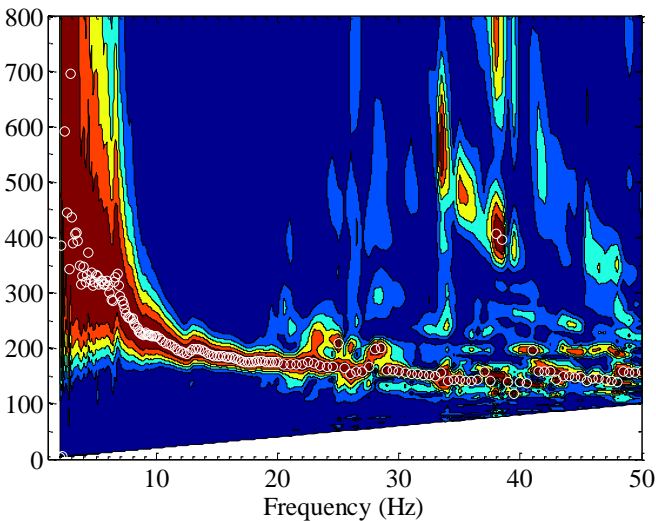
- Circular Arrays of 10 broadband seismometers (20s T)
- Array diameters of 50, 250, 500, and 1000 meters
- Recording time of 30-240 mins per array





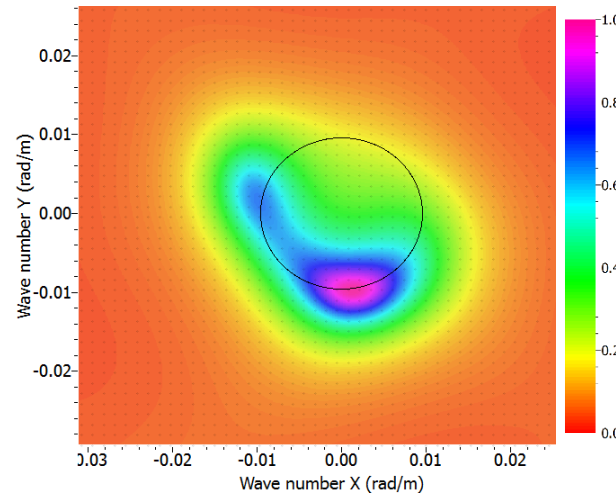
## MultiChannel Analysis of Surface Waves (MASW)

Frequency Domain Beamformer (FDBF)  
Analysis



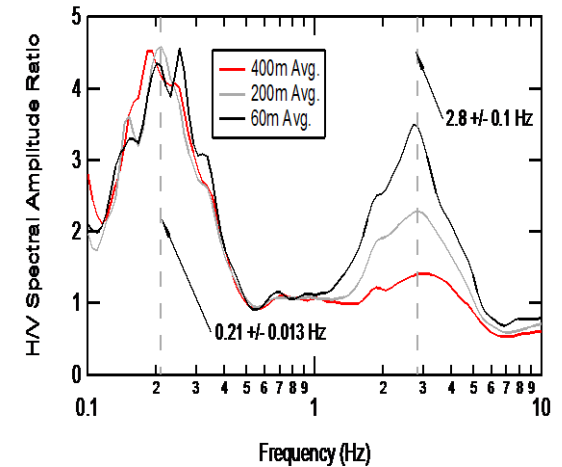
## Microtremor Array Methods (MAM)

High Resolution f-k (HFK) and Modified  
Spatial autocorrelation (MSPAC)

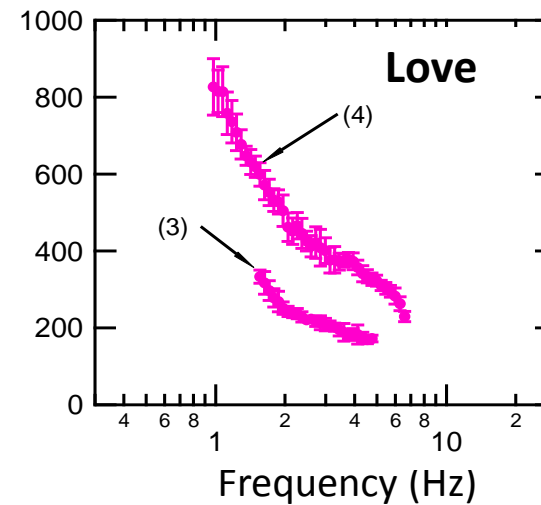
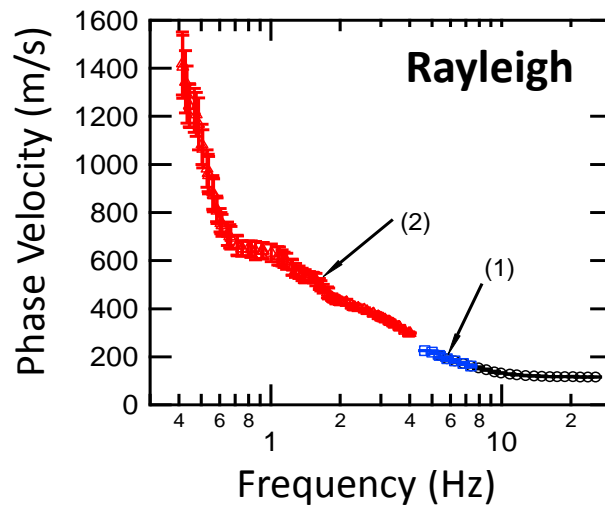


## Horz to Vert Spectral Ratio (HVSZ)

Processed based on SESAME  
recommendations



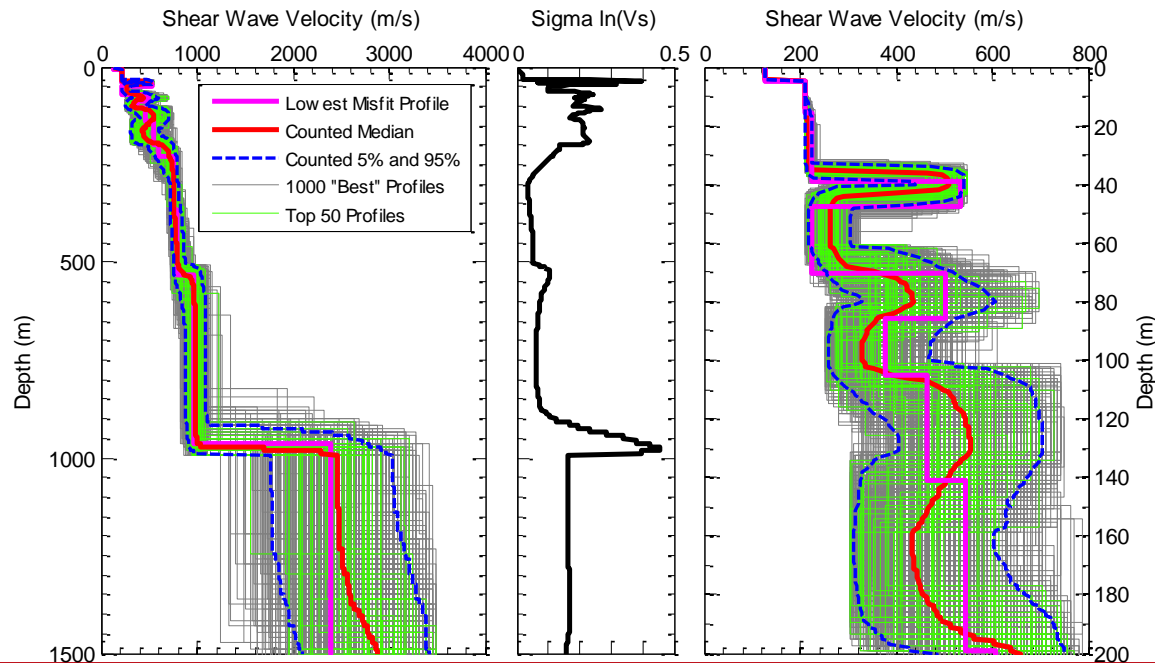
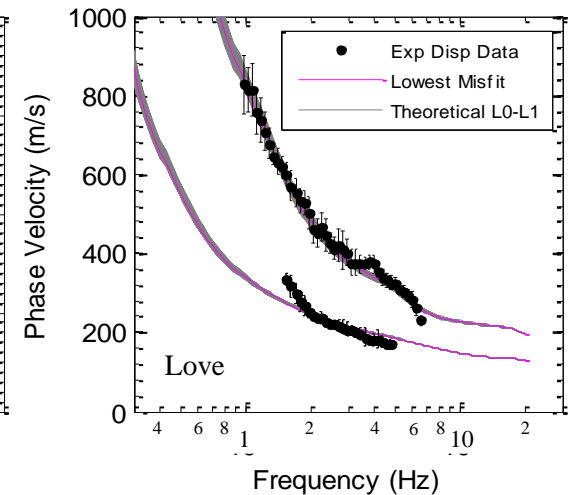
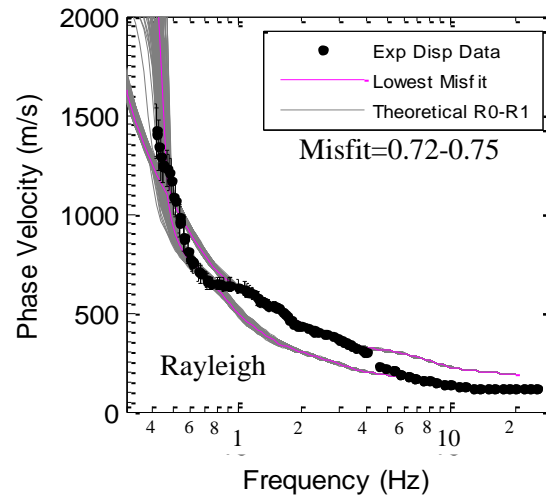
## Experimental (Field) Dispersion Curves





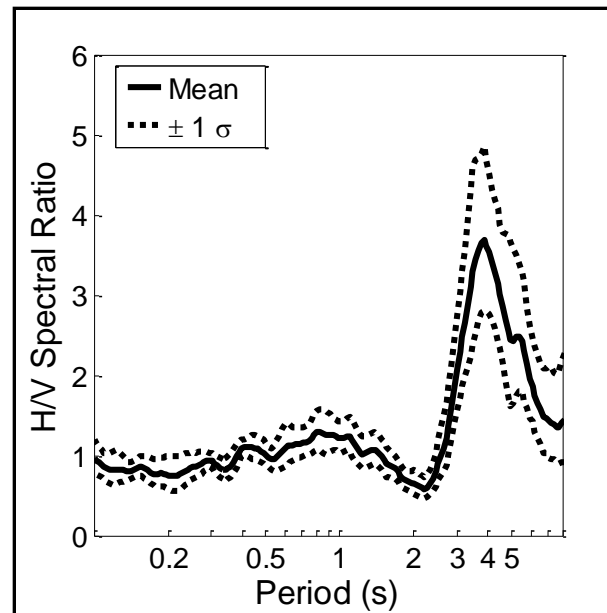
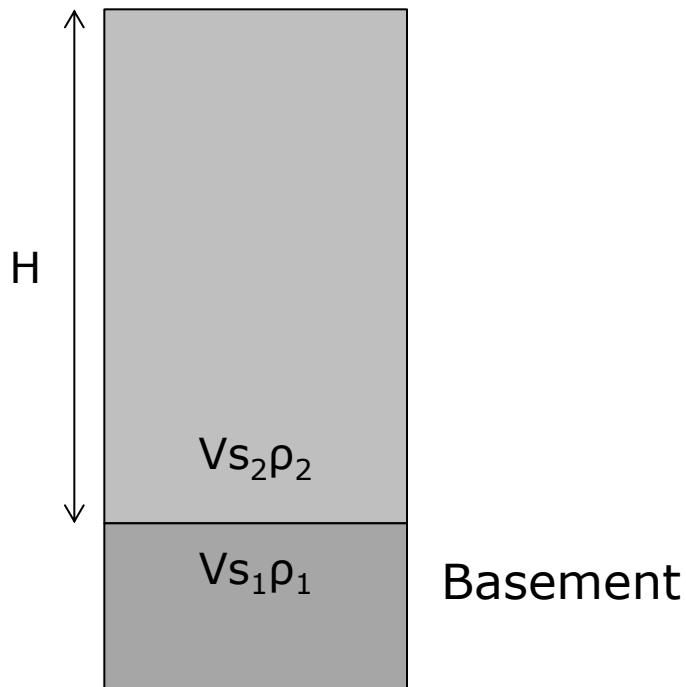
# Inversion Process

- Geopsy software used for inversion
- Neighborhood search algorithm (Wathelet et al. 2004)
- Multi-mode, joint inversion of:
  - Rayleigh wave dispersion data
  - Love wave dispersion data
  - H/V peak (theoretical Rayleigh wave ellipticity)
- 10-20 layer velocity model (based on geology and nearby boring information)
- > 2 Million velocity models for each analysis
- Median of top 1000 profiles used as site profile

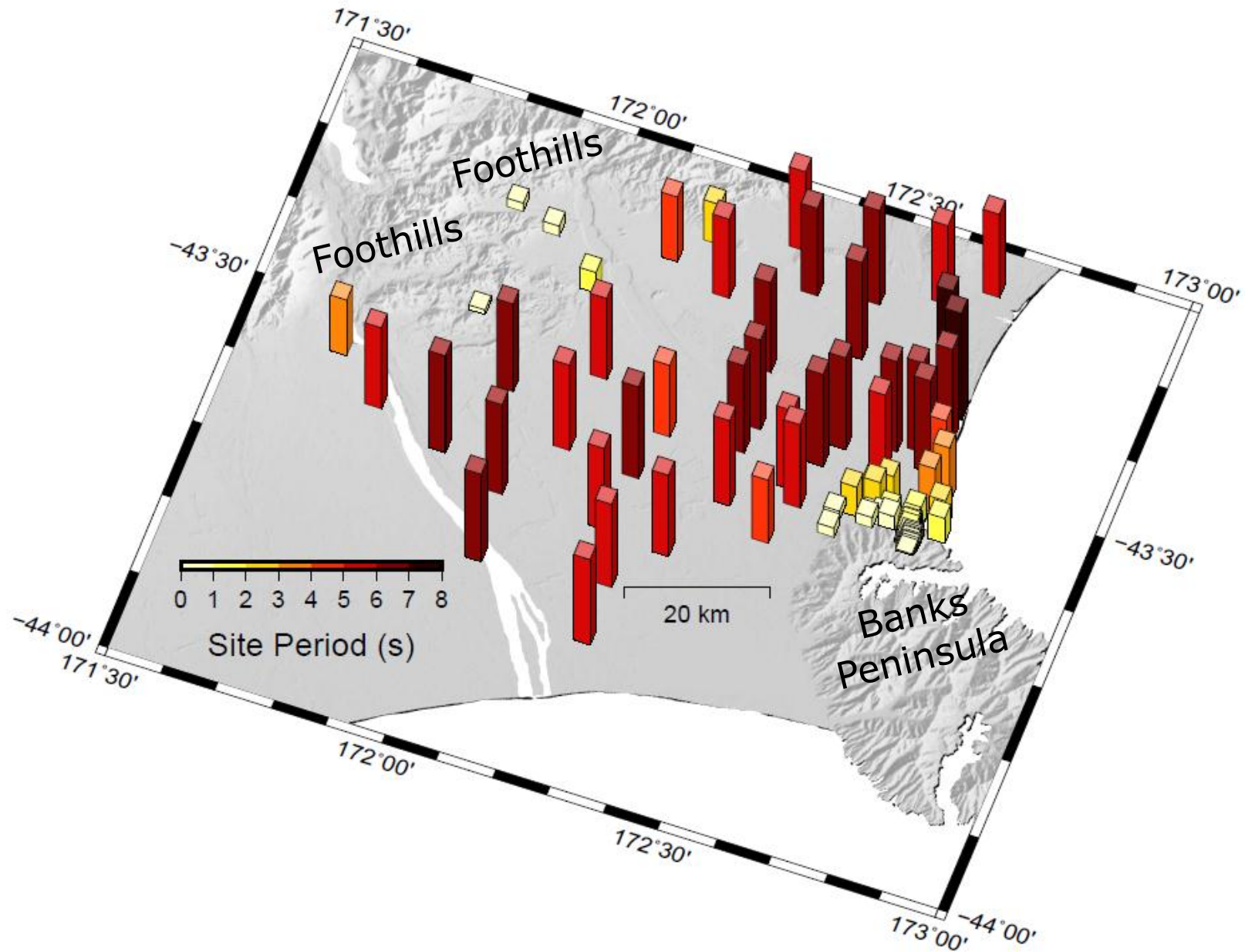


# H/V Spectral Ratio

- Site period estimates based on H/V spectral ratio
- Broadband seismometers (20 s period +)
- 30-60 min ambient noise records
- Site period to basement (NZS1170.5 site period)



# Site Period - Canterbury



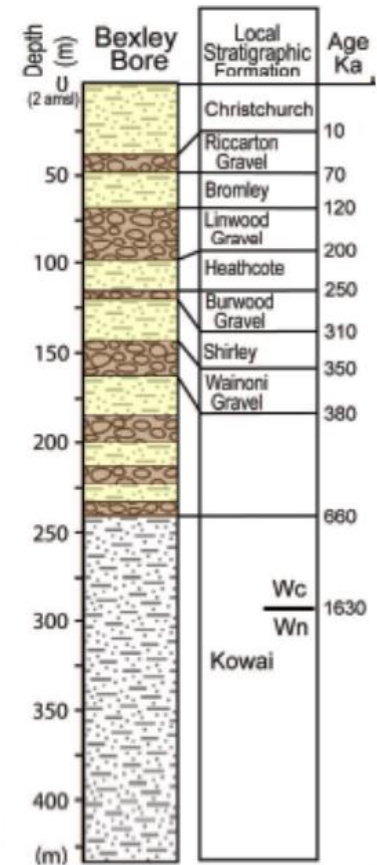
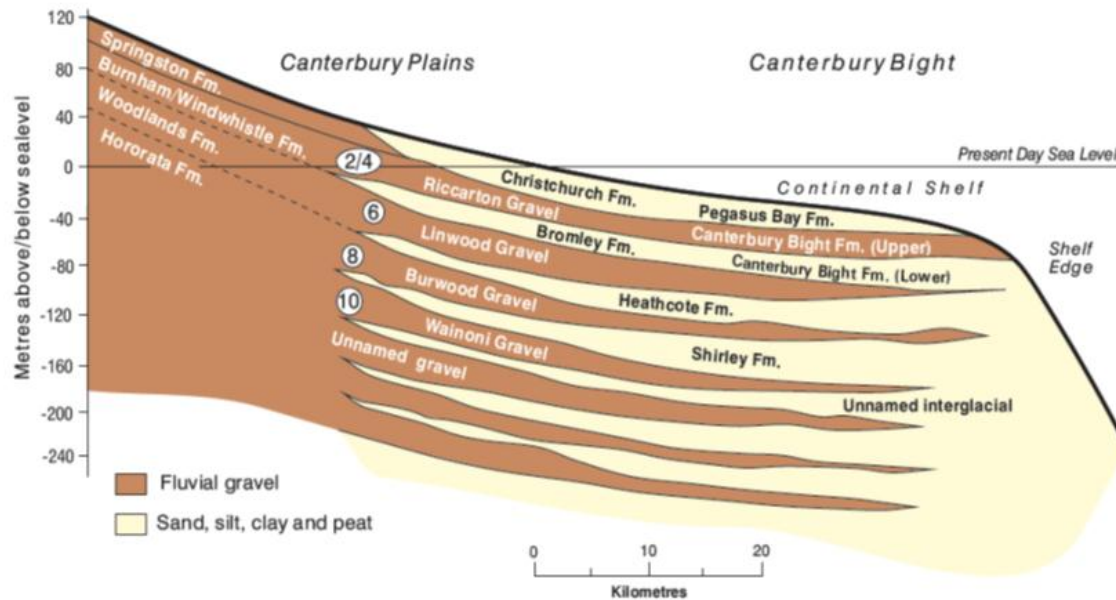


# Christchurch Geology



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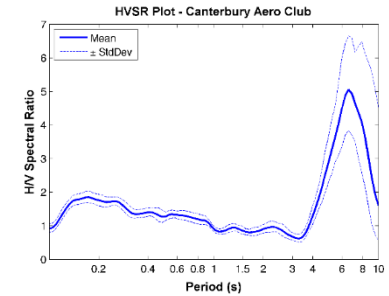
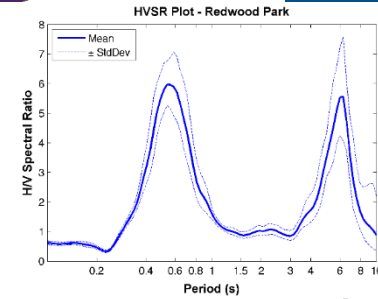
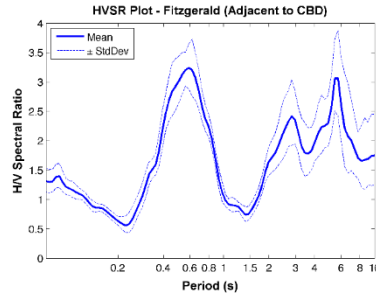
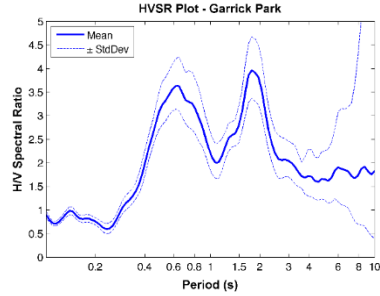
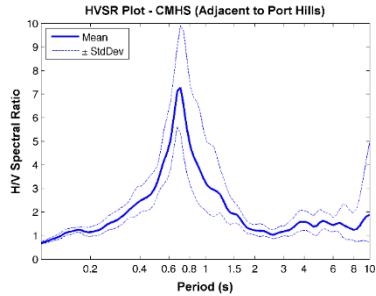
(Forsyth et al. 2008, Cox et al. 2015)

# Impedance contrasts



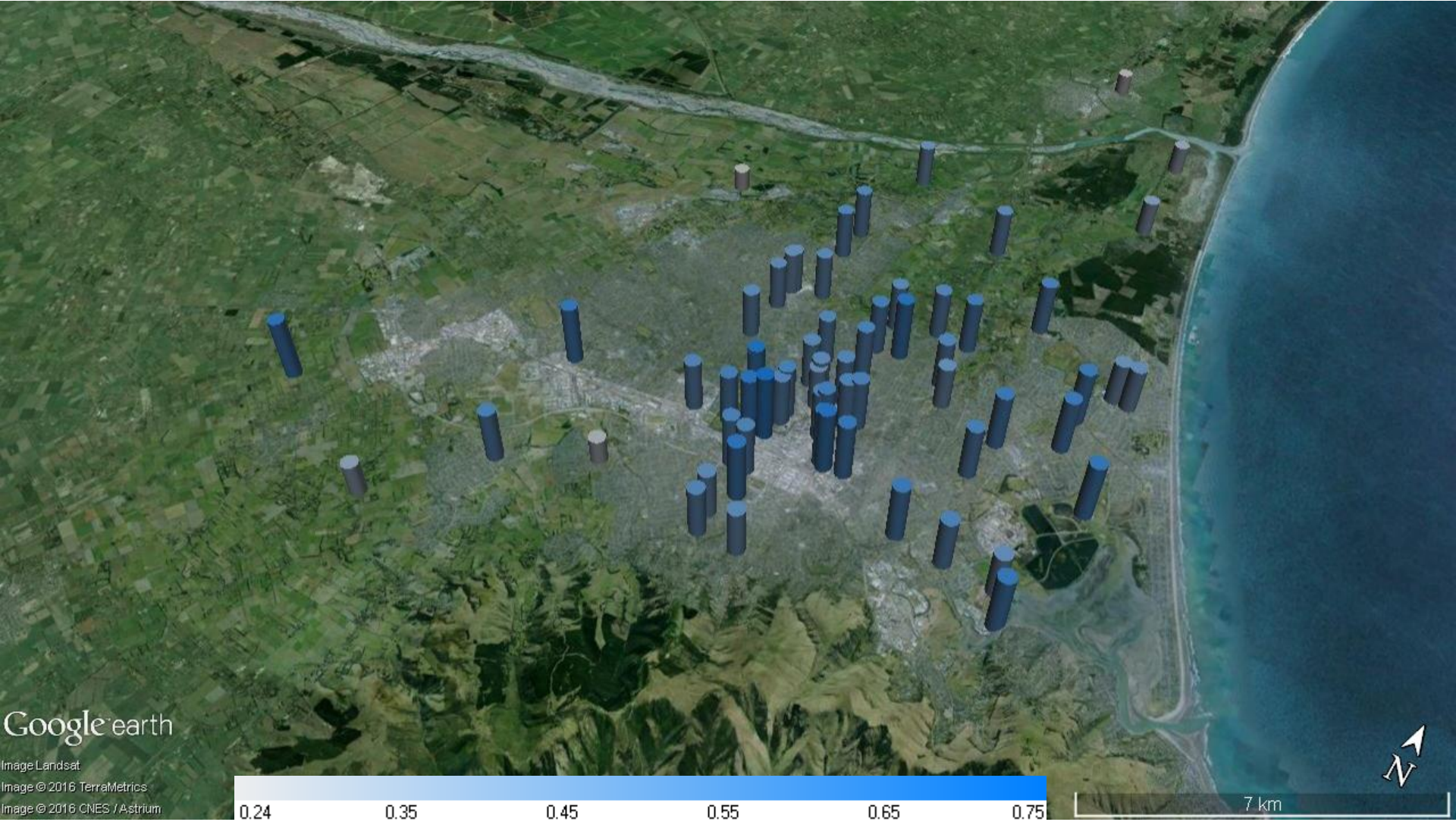
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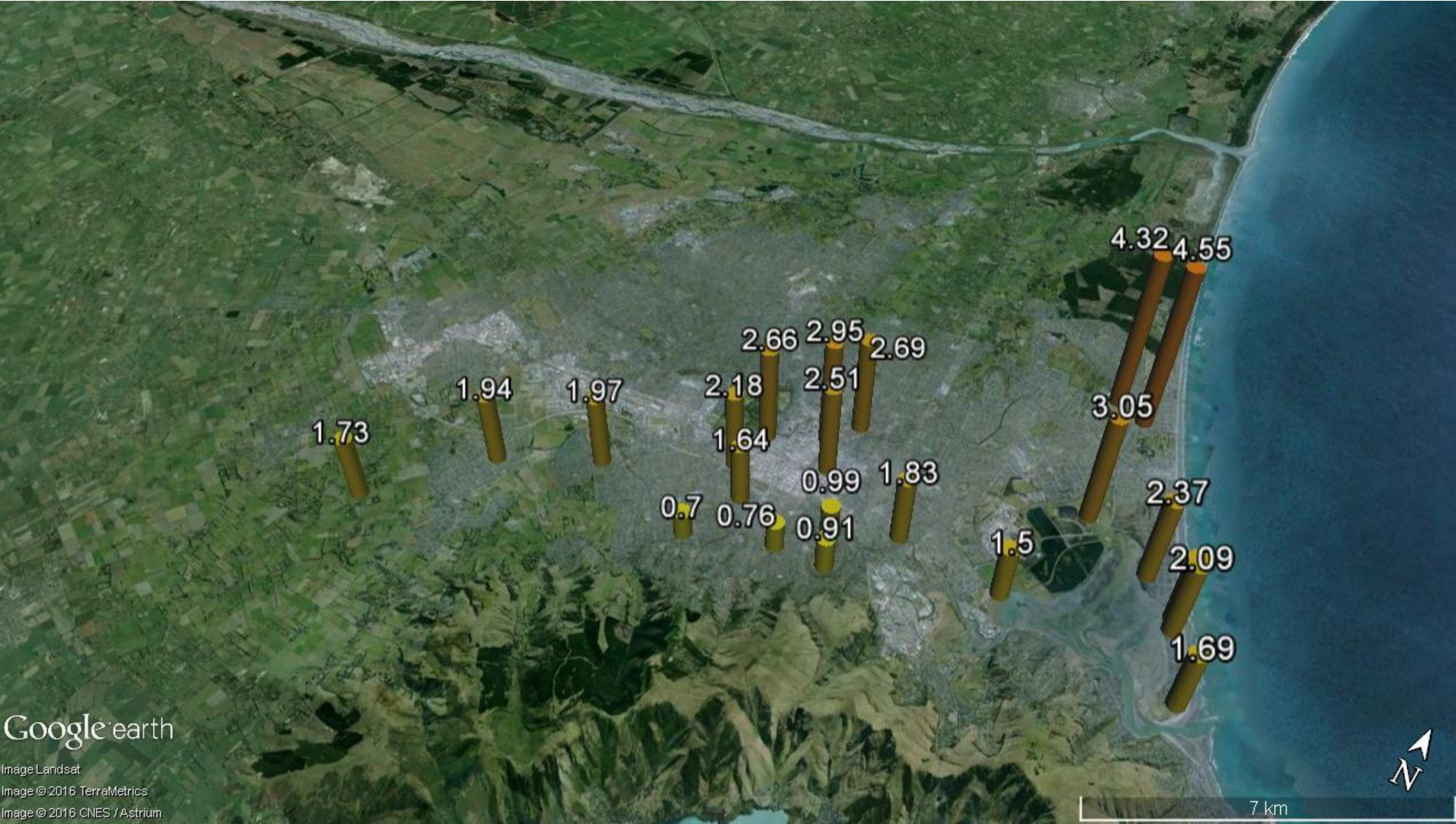
NS Cross  
Section

# Site Period – Gravel





# Site Period – Volcanics





# Site Period – Basement

