Shallow Groundwater Hazard in the Urban Environment

Monitoring, interpreting, and using high resolution data in an urban setting

Dr Helen Rutter
Dr Simon Cox

EQC
EARTHQUAKE COMMISSION
Kōmihana Rūwhenua

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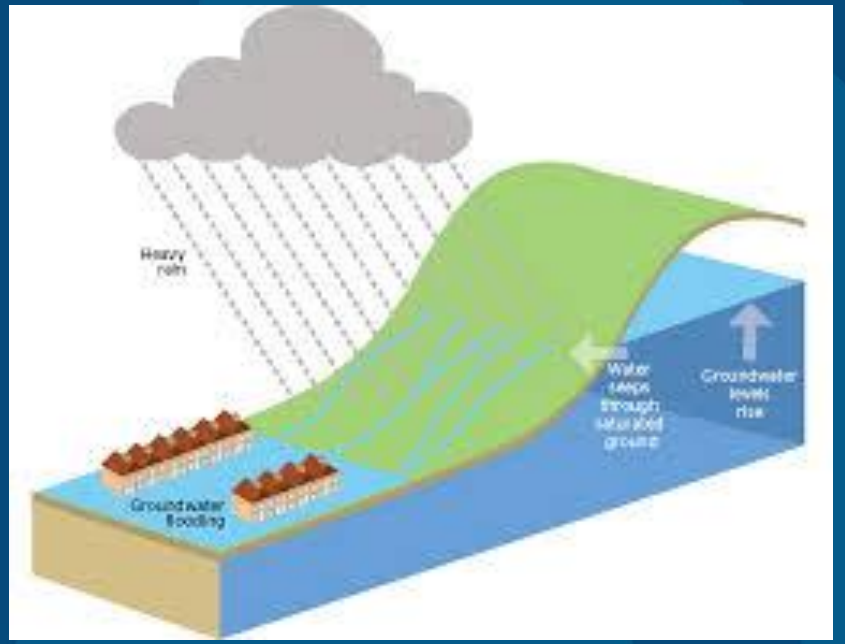
Shallow groundwater



- Groundwater in the shallow subsurface
- Until recently, more focus on water resources
- In terms of hazards, focus on surface water
- Shallow groundwater now becoming a focus
  - Limited understanding as to how it varies in space and time

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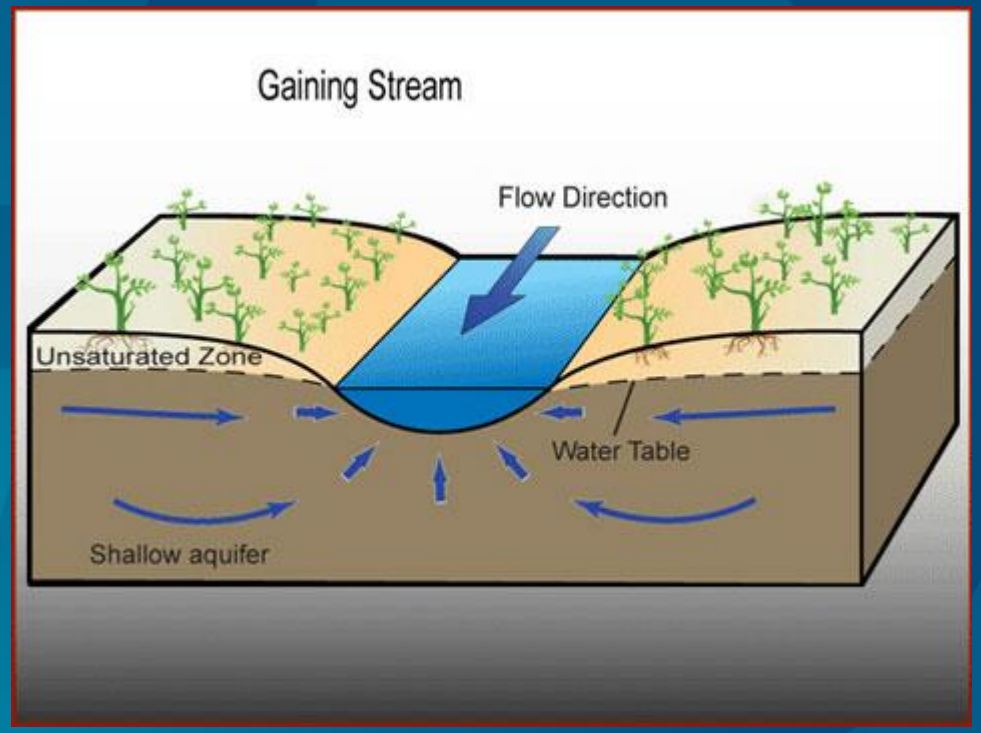
Why do we need to understand shallow groundwater?

- Shallow groundwater and surface water are linked
- Shallow groundwater is not far below ground
  - Out of sight, out of mind



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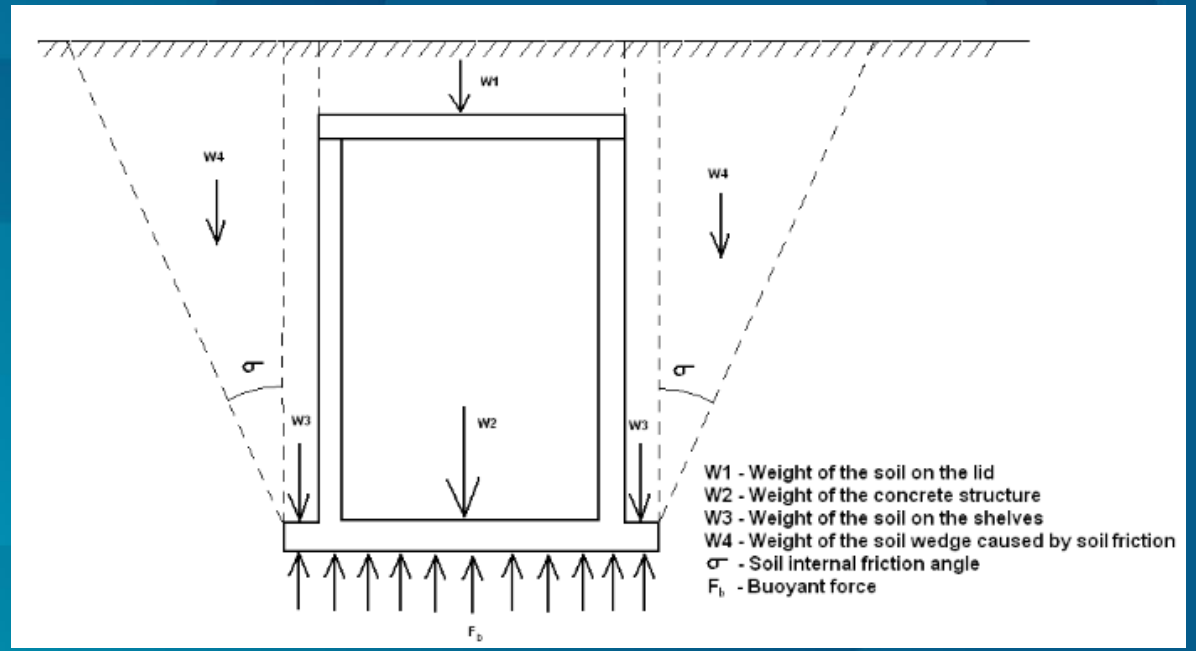
Consequences of higher-than-anticipated groundwater

- Flooding
- Liquefaction
- Inundation of services
- Roading
- Dewatering for construction
- Landscaping
- Bouyancy
- Flooded basements



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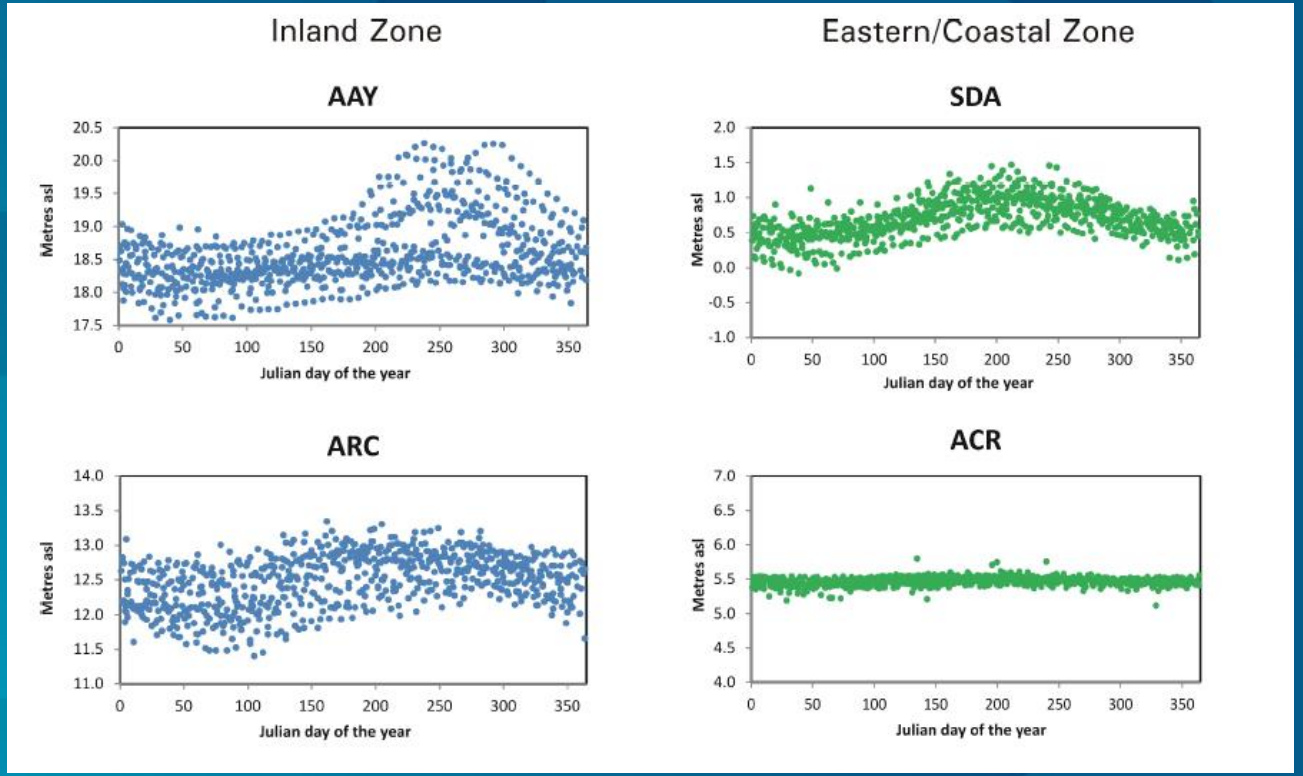
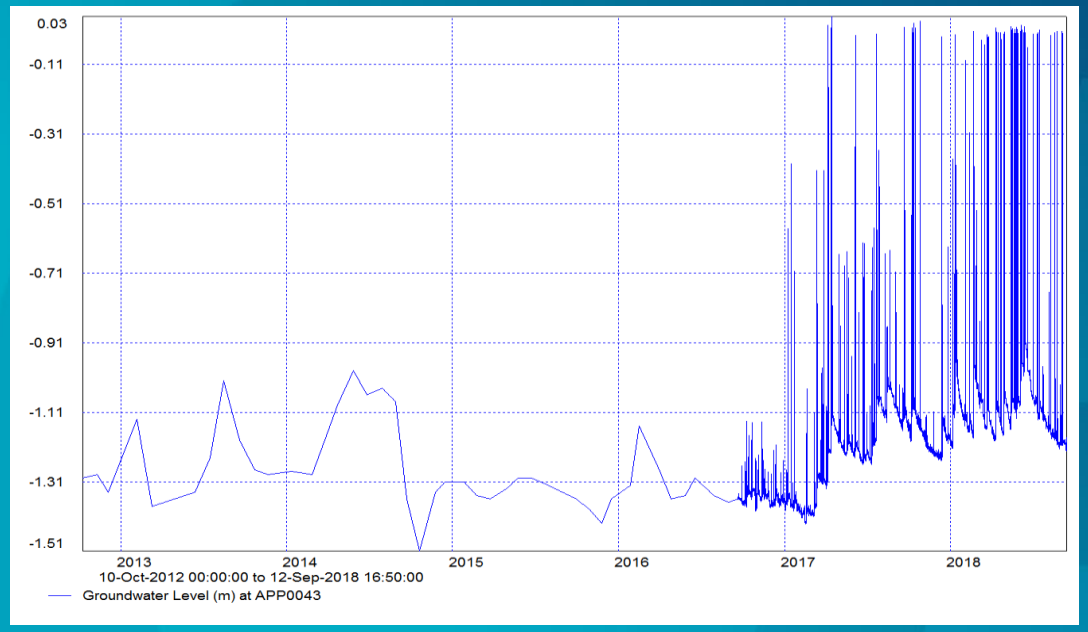
It's 4D problem!

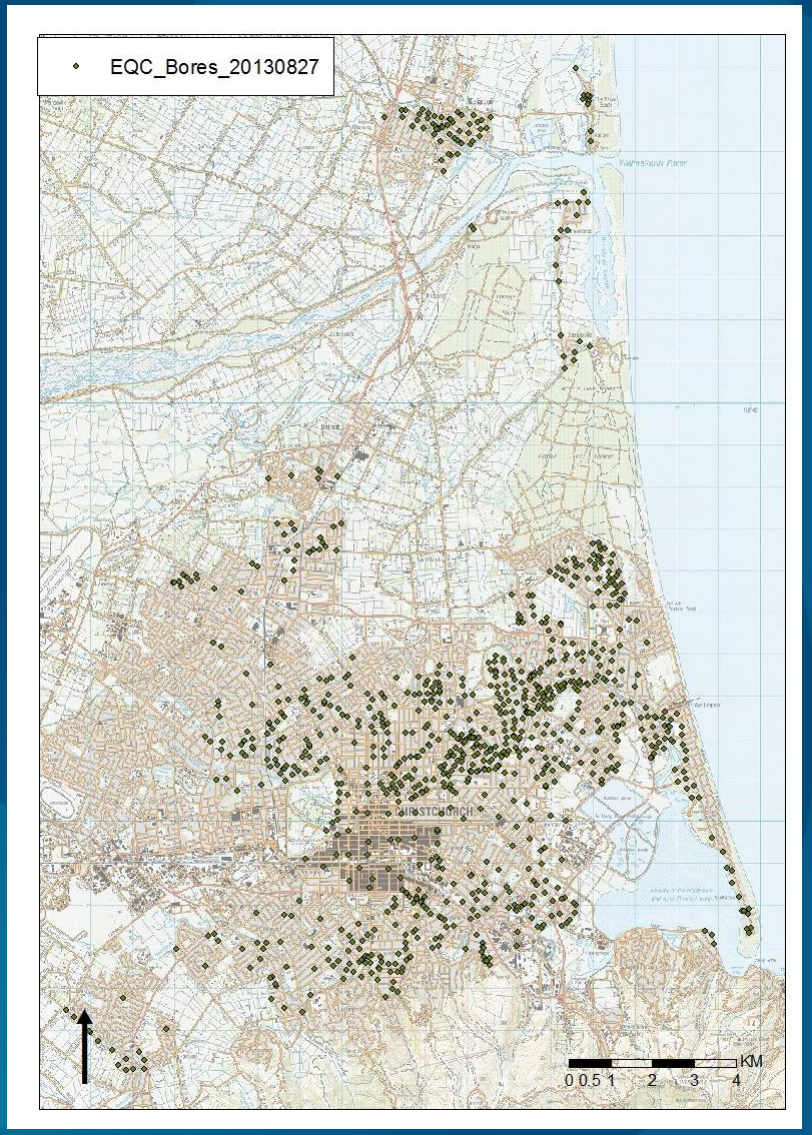
- Groundwater is a 4-dimensional issue
- Varies:
  - In space
  - With depth
  - With time
- One off GWL measurements/short time series are not adequate



Limitations of available data

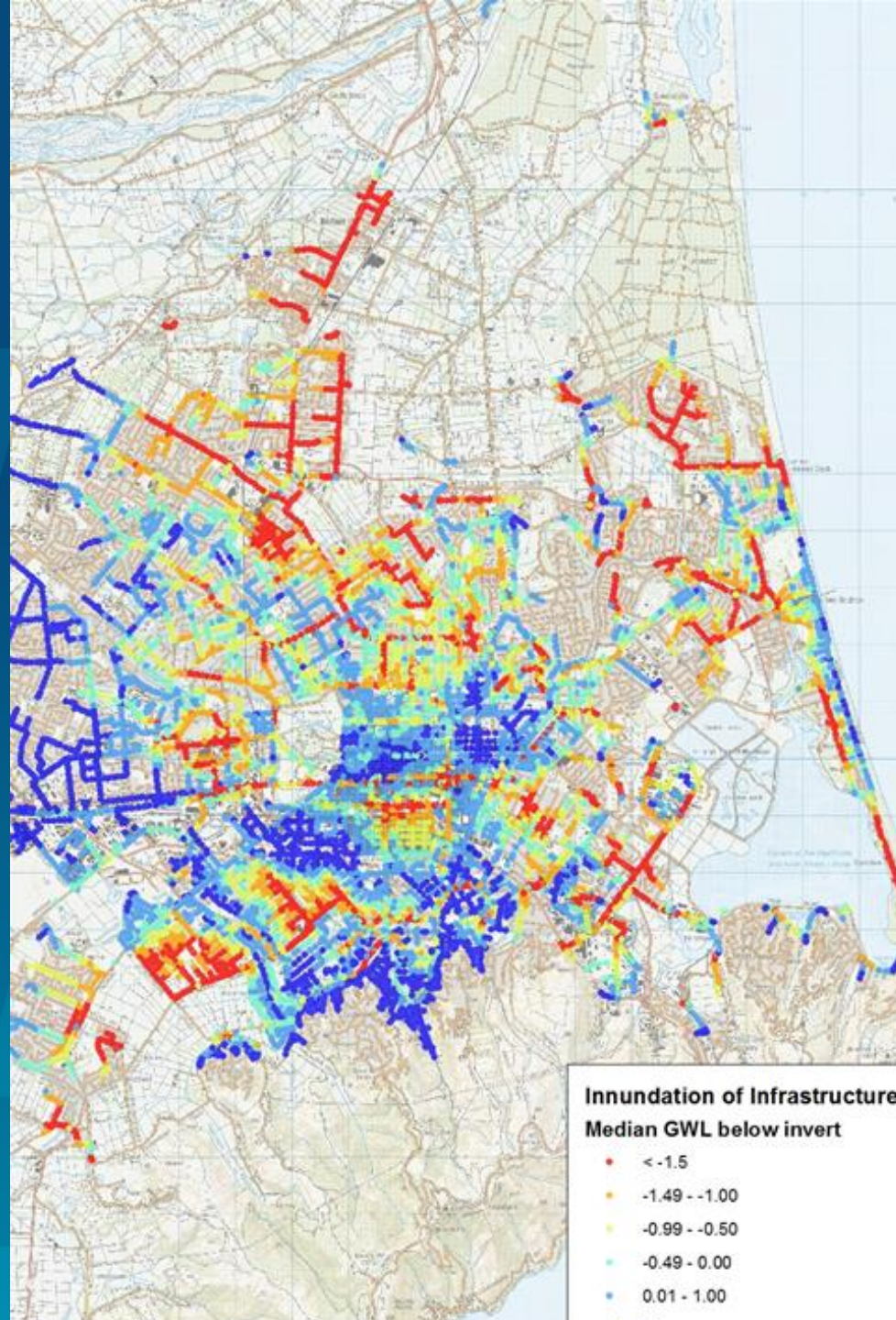
- Spatial distribution
  - Not usually optimum – developed for other purposes
- Temporal distribution
  - Representativeness
  - What do occasional GWL measurements data tell us?





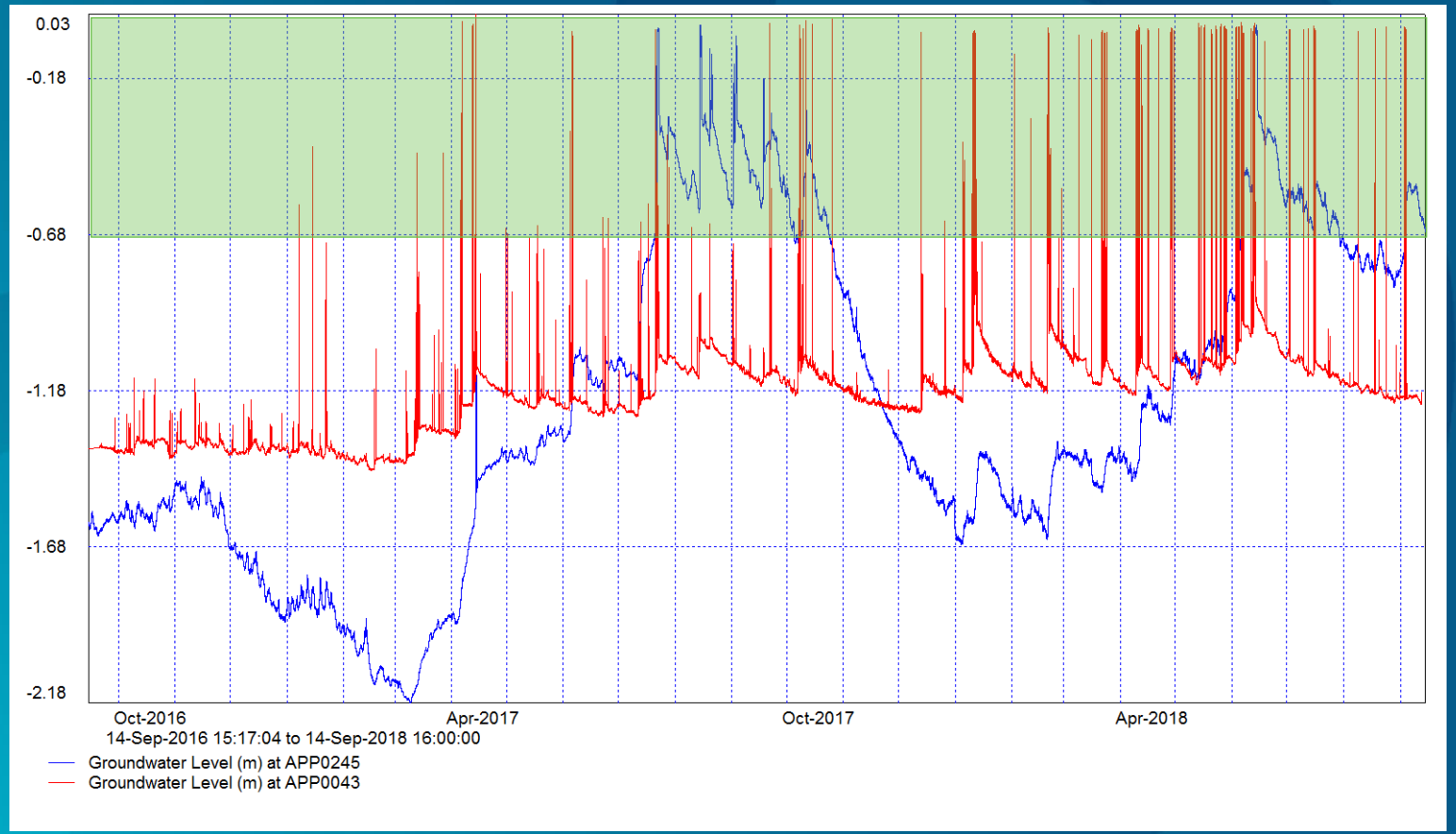
Developing our understanding

- If sufficient data, can develop “static” surface
  - High, low, mean groundwater levels
- Need good spatial coverage
- Adequate temporal coverage
- Useful for an overview



Hazard

- Hazard has magnitude and frequency
  - How long and how much are important
- Increasing concern about impacts of climate change and sea level rise
- Need to understand the dynamics much better



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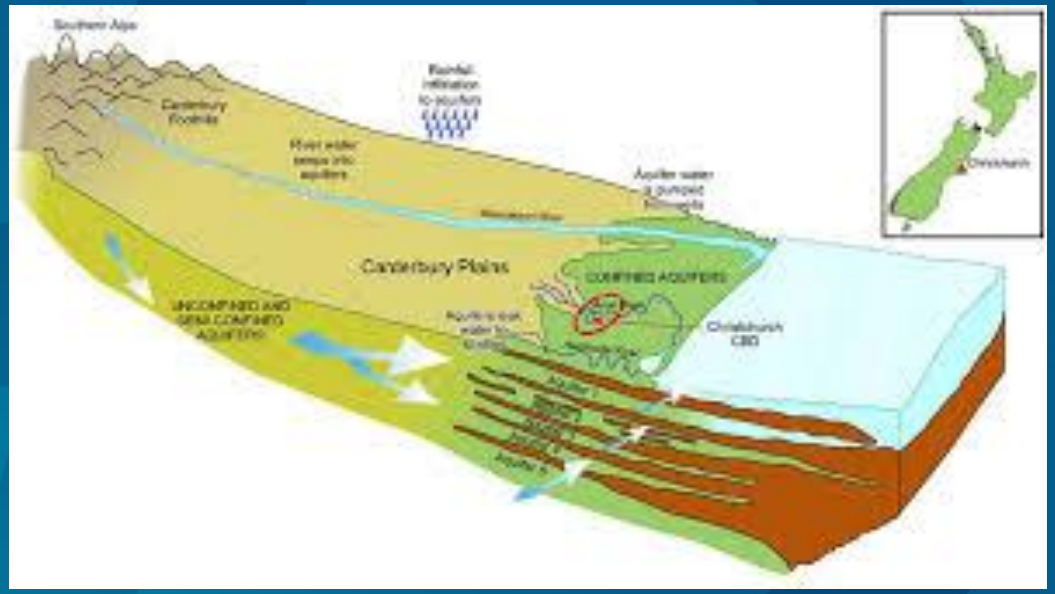
The Christchurch experience

- Setting
  - Multi-layered aquifer system at the end of the Canterbury Plains
- Shallow subsurface
  - Mixed sediment types – gravels, sand silt, clays
  - Cut through by meandering rivers
- Earthquakes
  - Increased groundwater level monitoring
  - Unique shallow groundwater dataset



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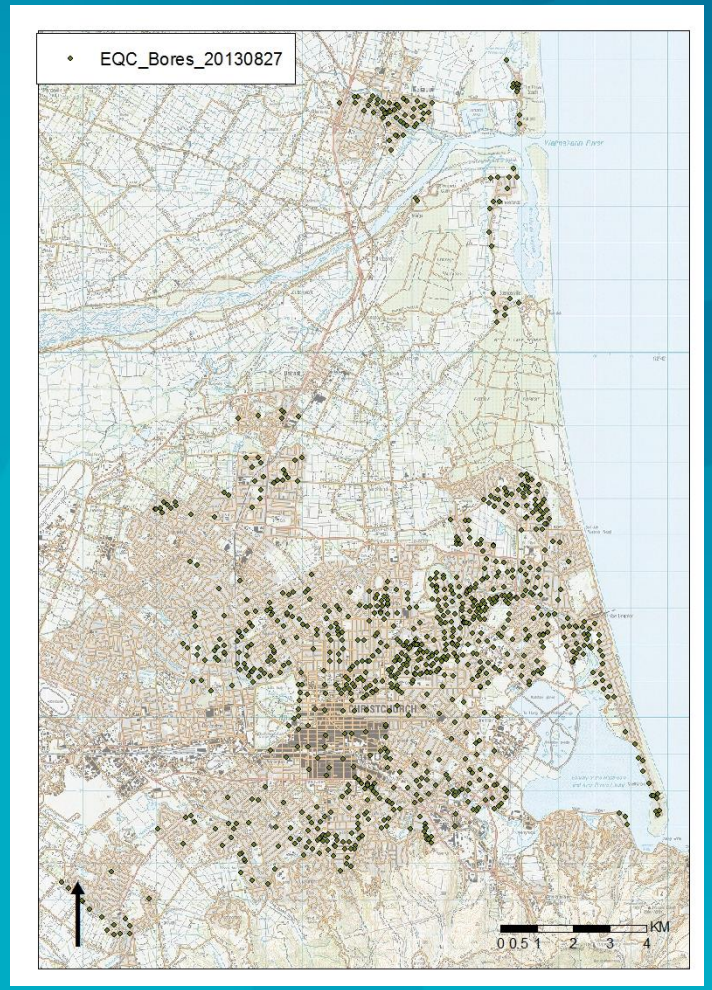
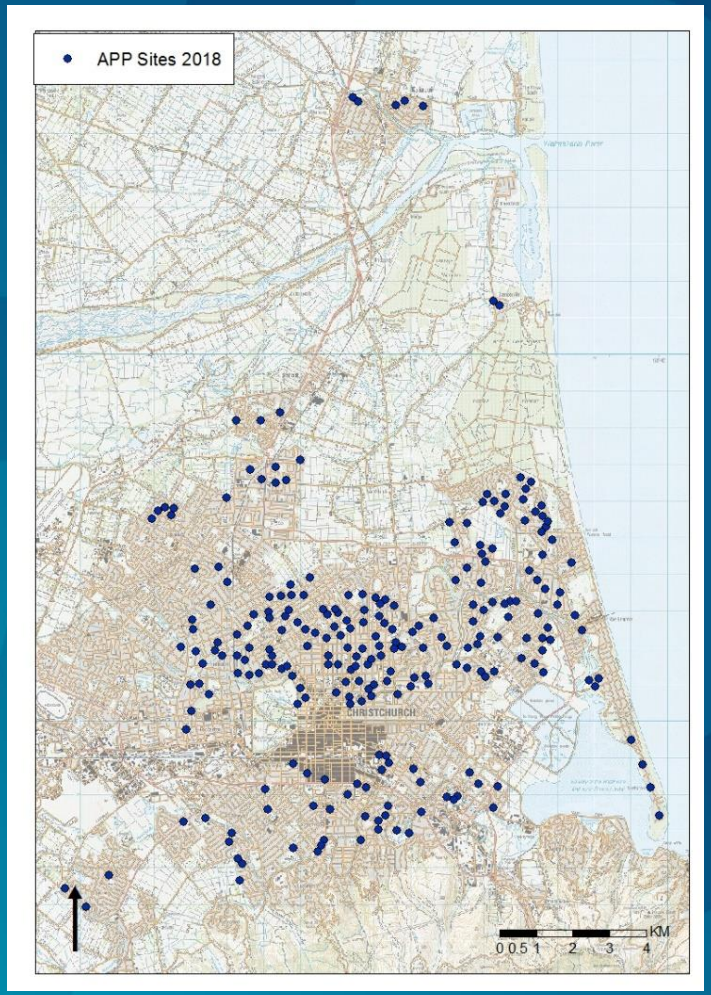
Christchurch: shallow groundwater network

- EQC network – 2011 - 2016



- APP network 2016 - present



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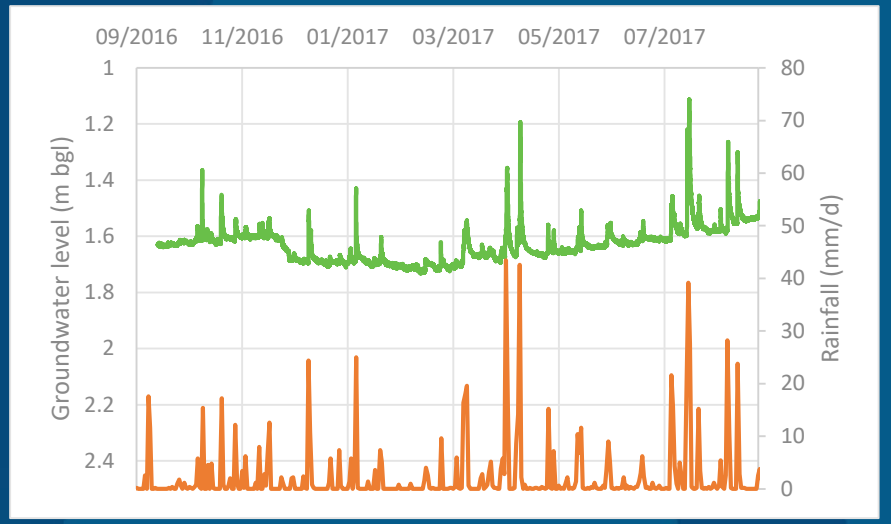
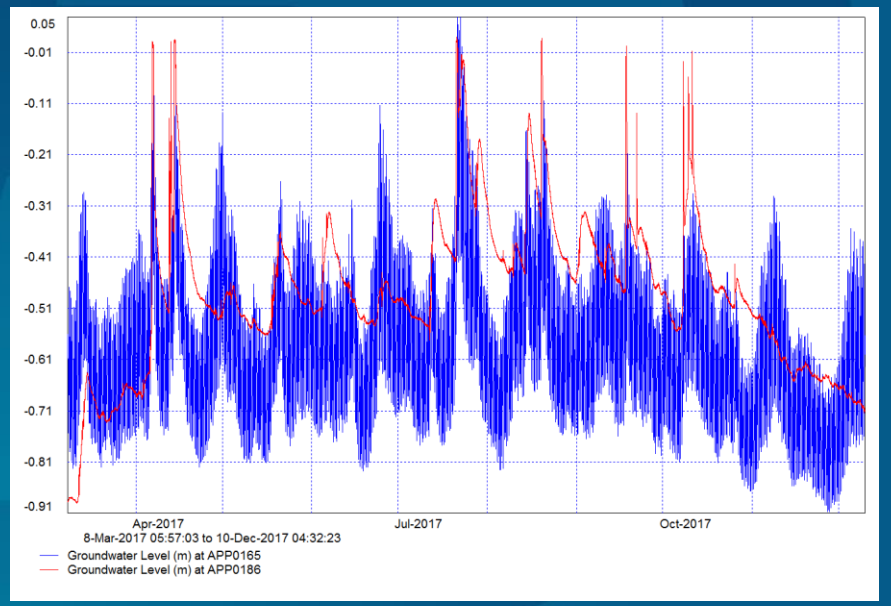
Shallow groundwater data

- High resolution data (10 minute) collected for 3 years
- Dynamic nature
- Variability of responses

- Influences on GWLS
  - Rainfall recharge
    - Seasonal
    - Inter-annual
  - River recharge
  - Tides





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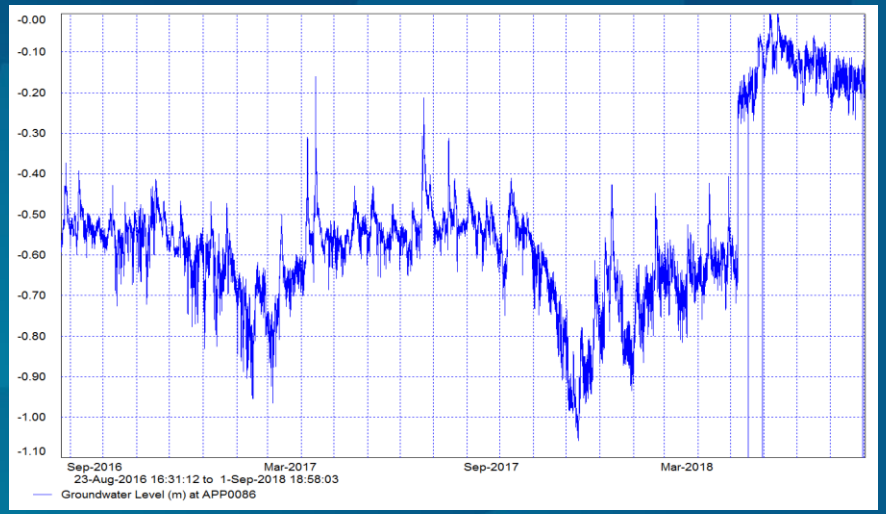
Other influences on groundwater levels

- Evapotranspiration
- Earthquakes
  - Subsidence
  - Dynamic responses
  - Long term changes
- Urban infrastructure
- Rebuild efforts
- Ground source heat pumps
- Climate change and sea level rise



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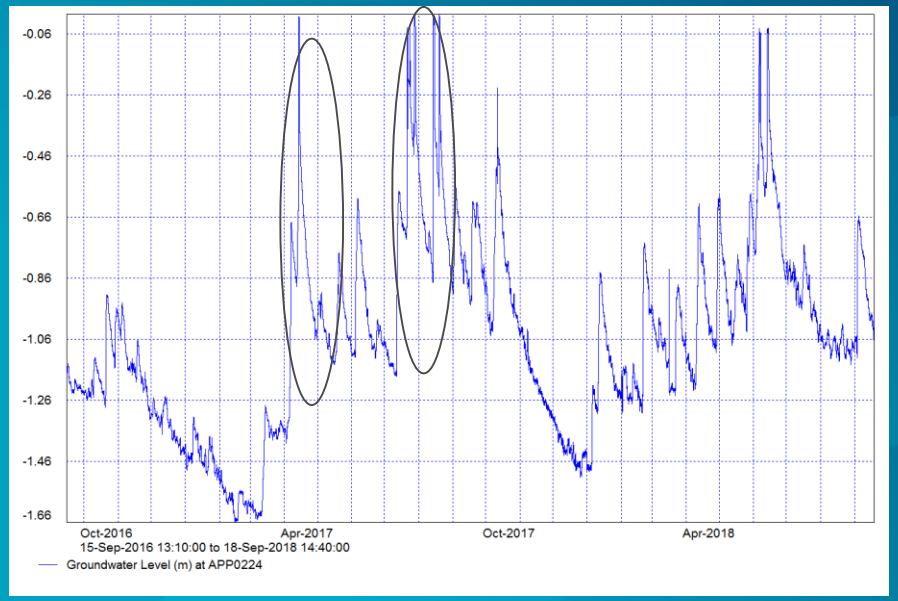
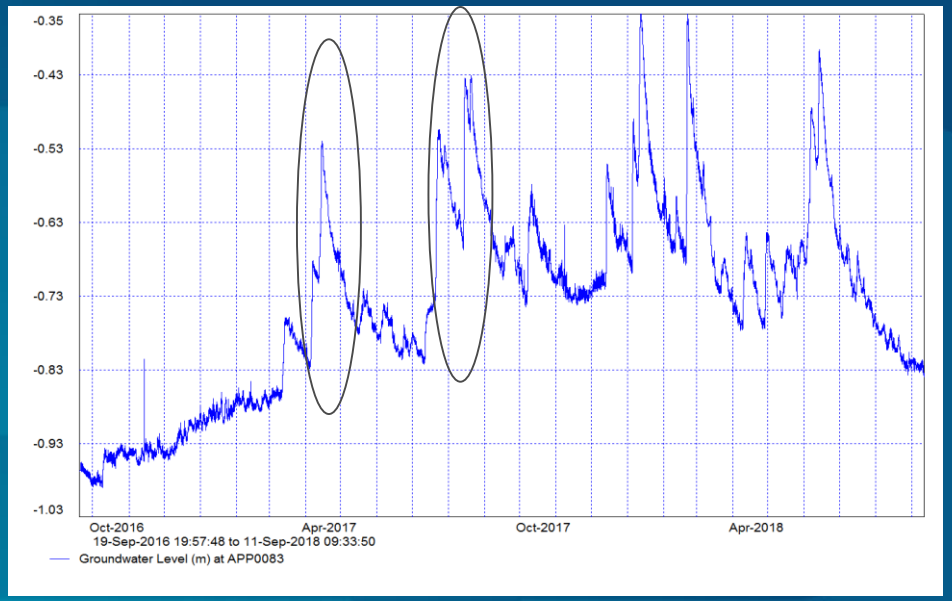
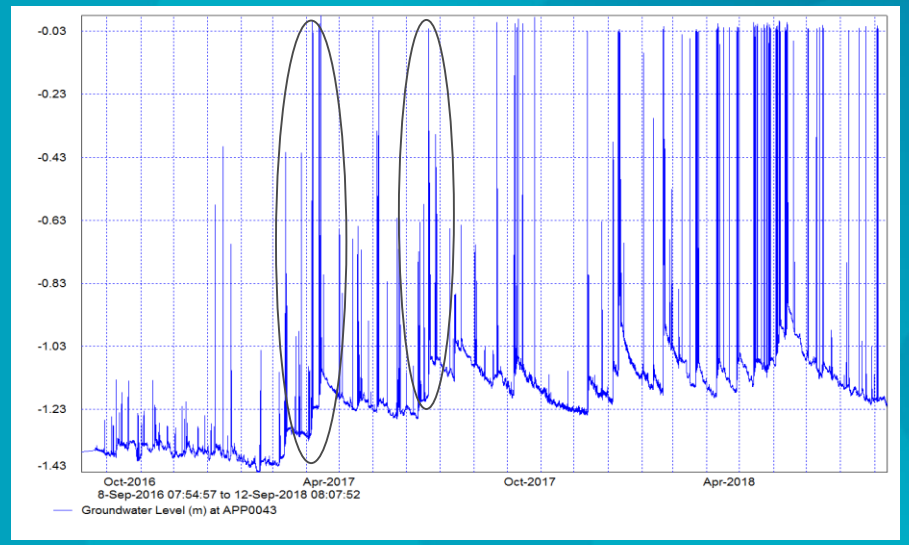
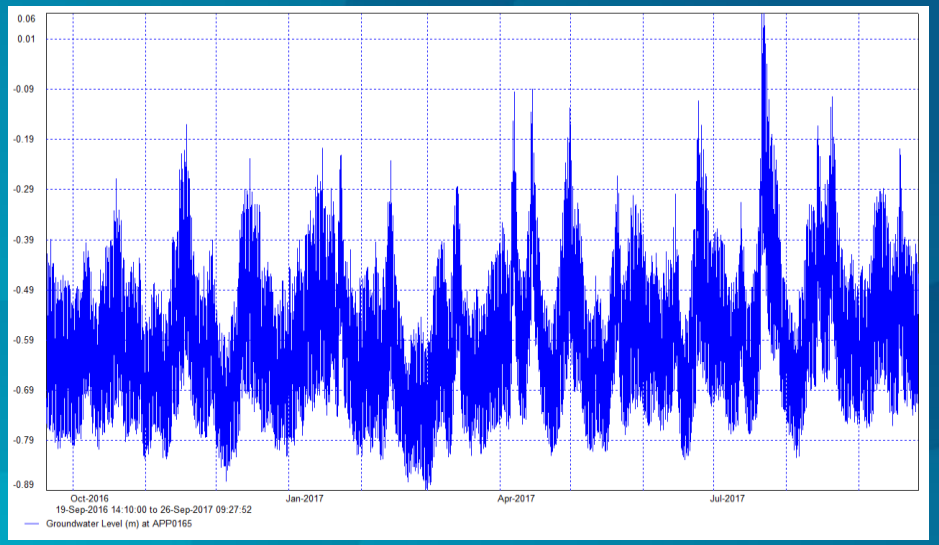
Groundwater level responses and drivers









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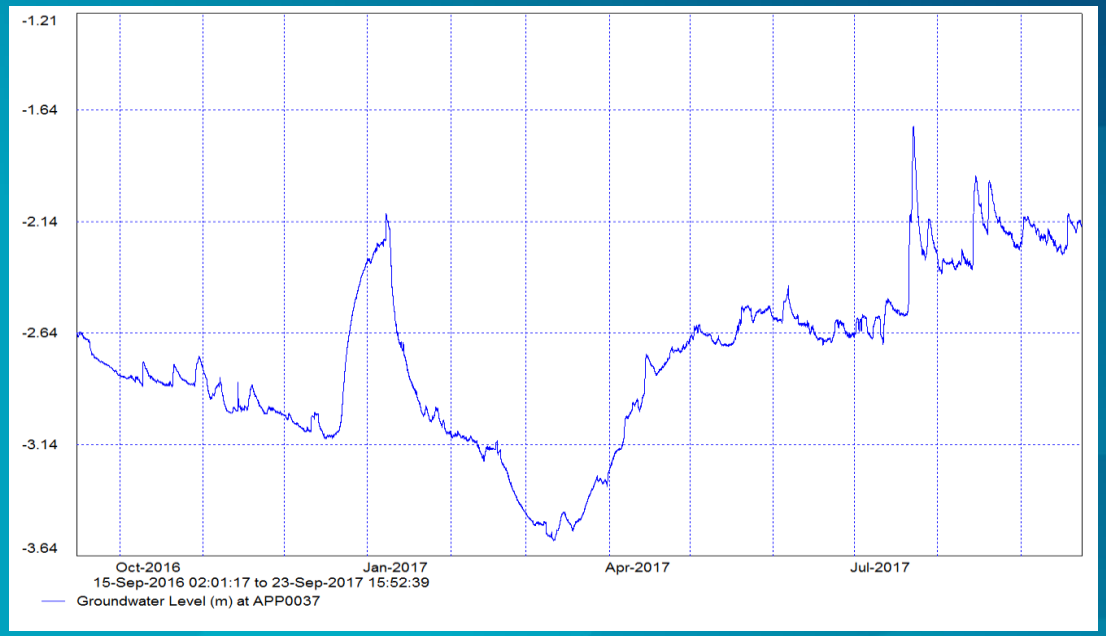
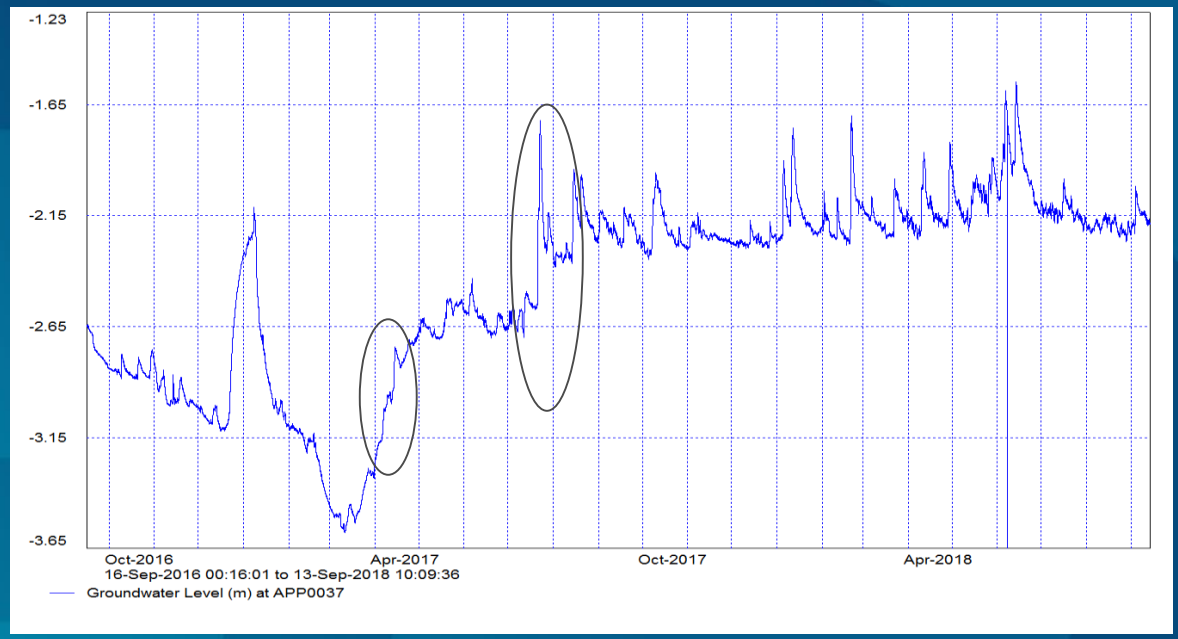
January high





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Analysis of responses

- Attempt to identify spatial patterns
- Important in terms of understanding responses in different areas and using the network for managing hazards
- Aim to classify areas that respond similarly
  - Average seasonal response to rain
  - Time to peak for different events
  - Time over threshold
- Complex
  - Different areas respond to different drivers
  - Cascading effects in any one area

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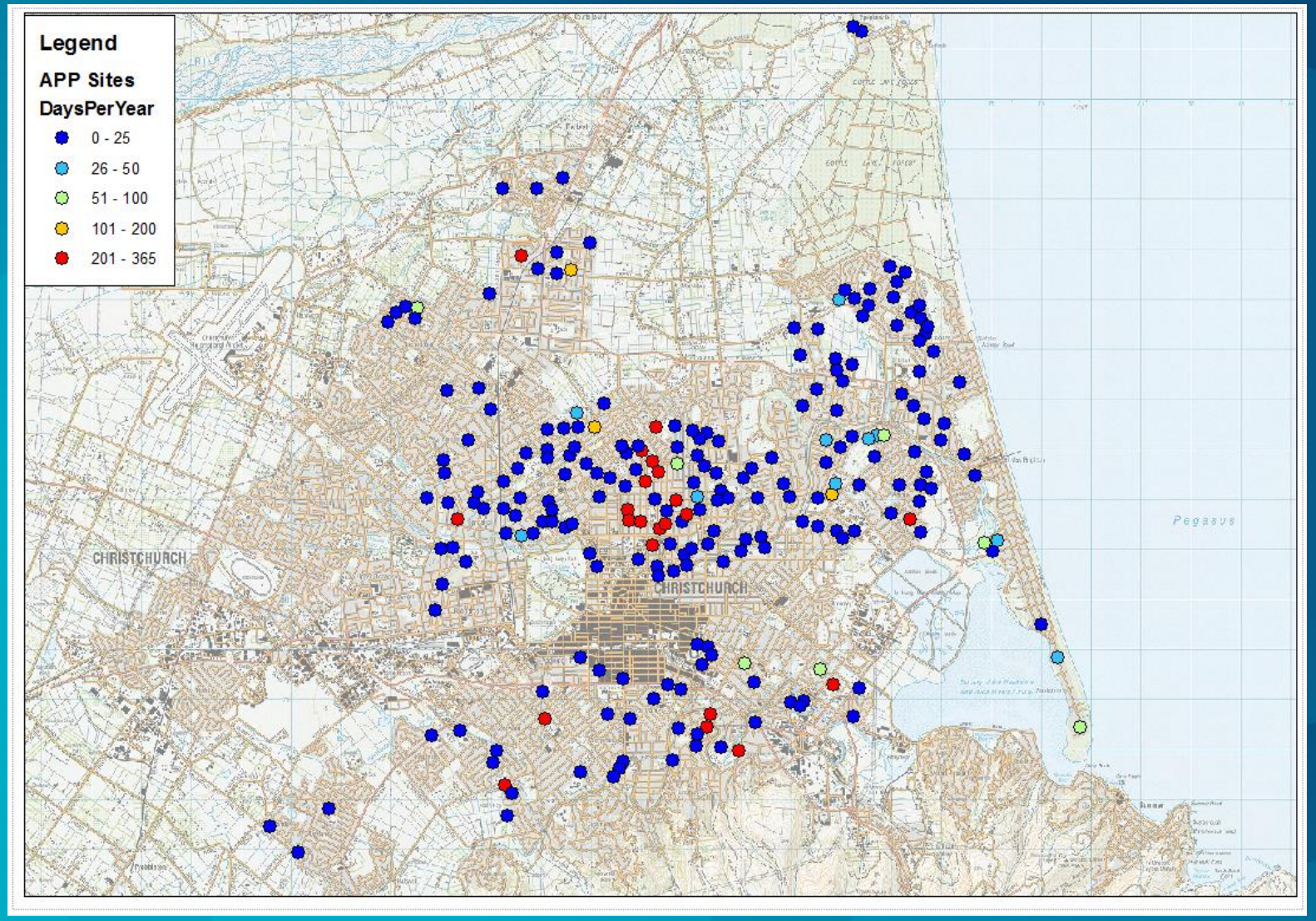
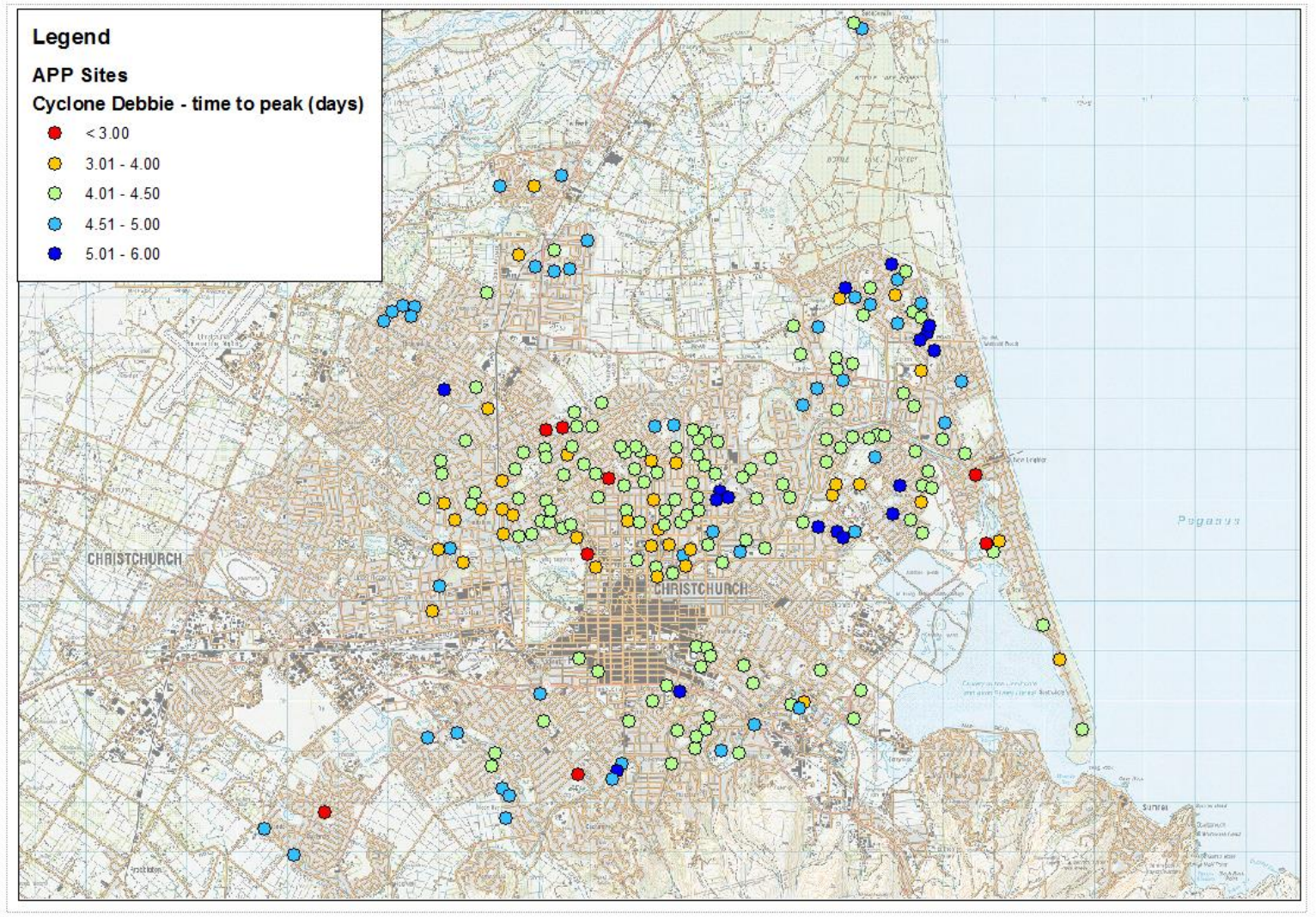
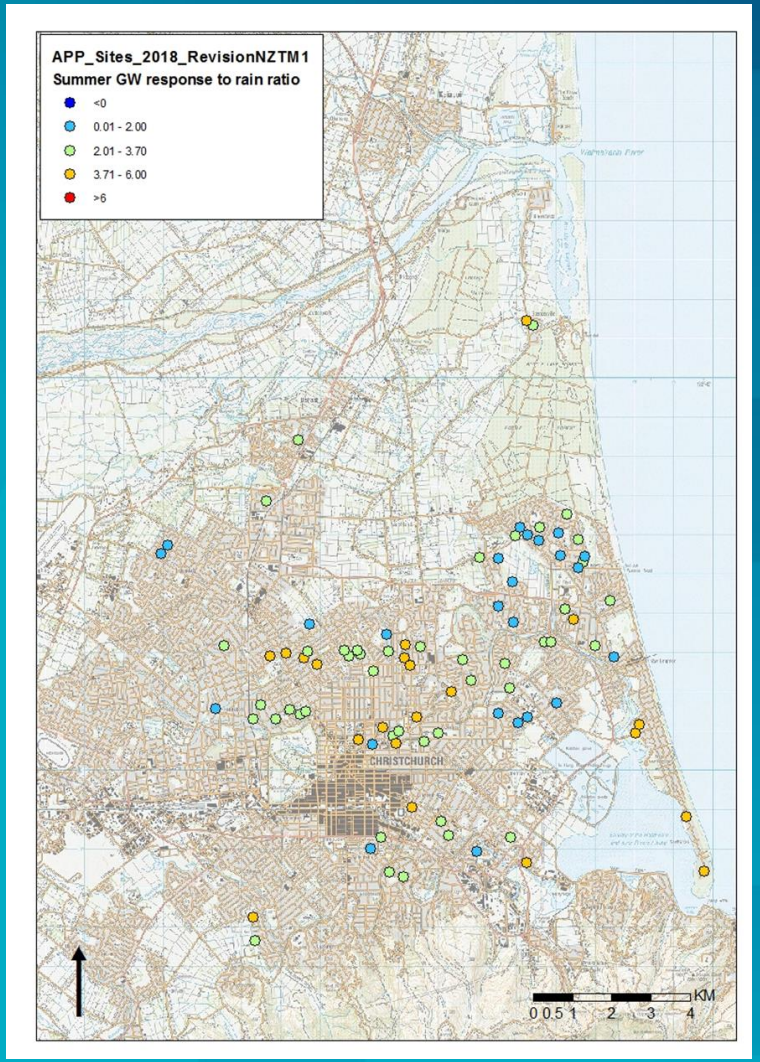
Days per year over threshold

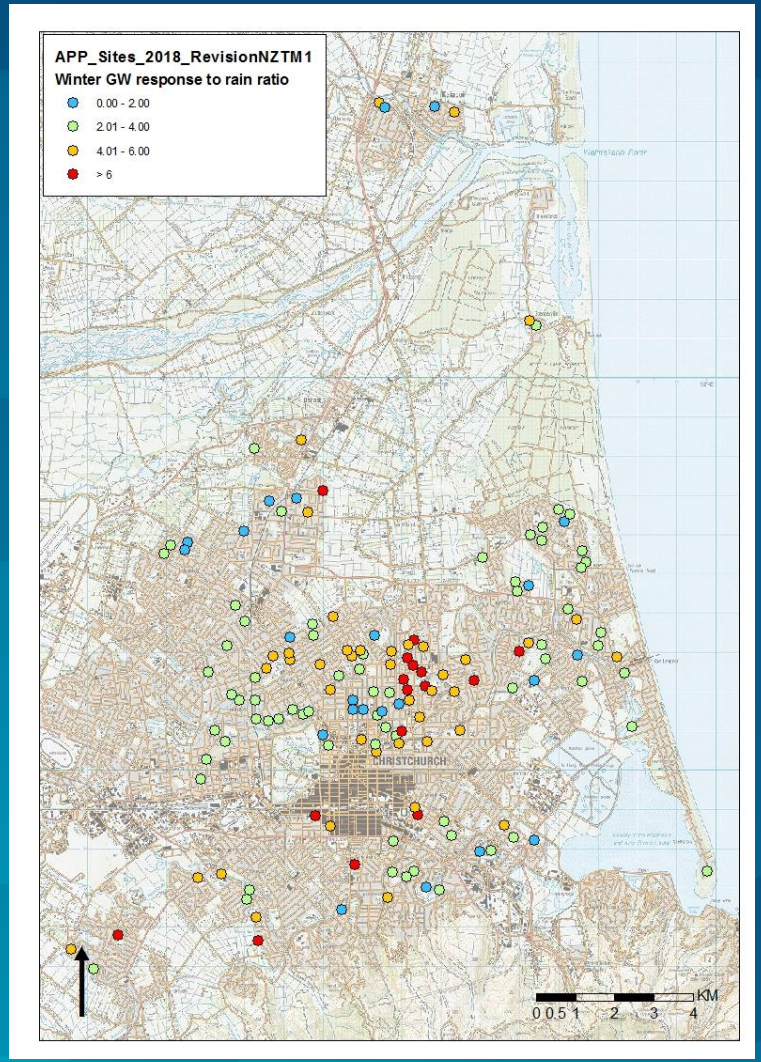


Time to peak – Cyclone Debbie



Seasonal response to rainfall





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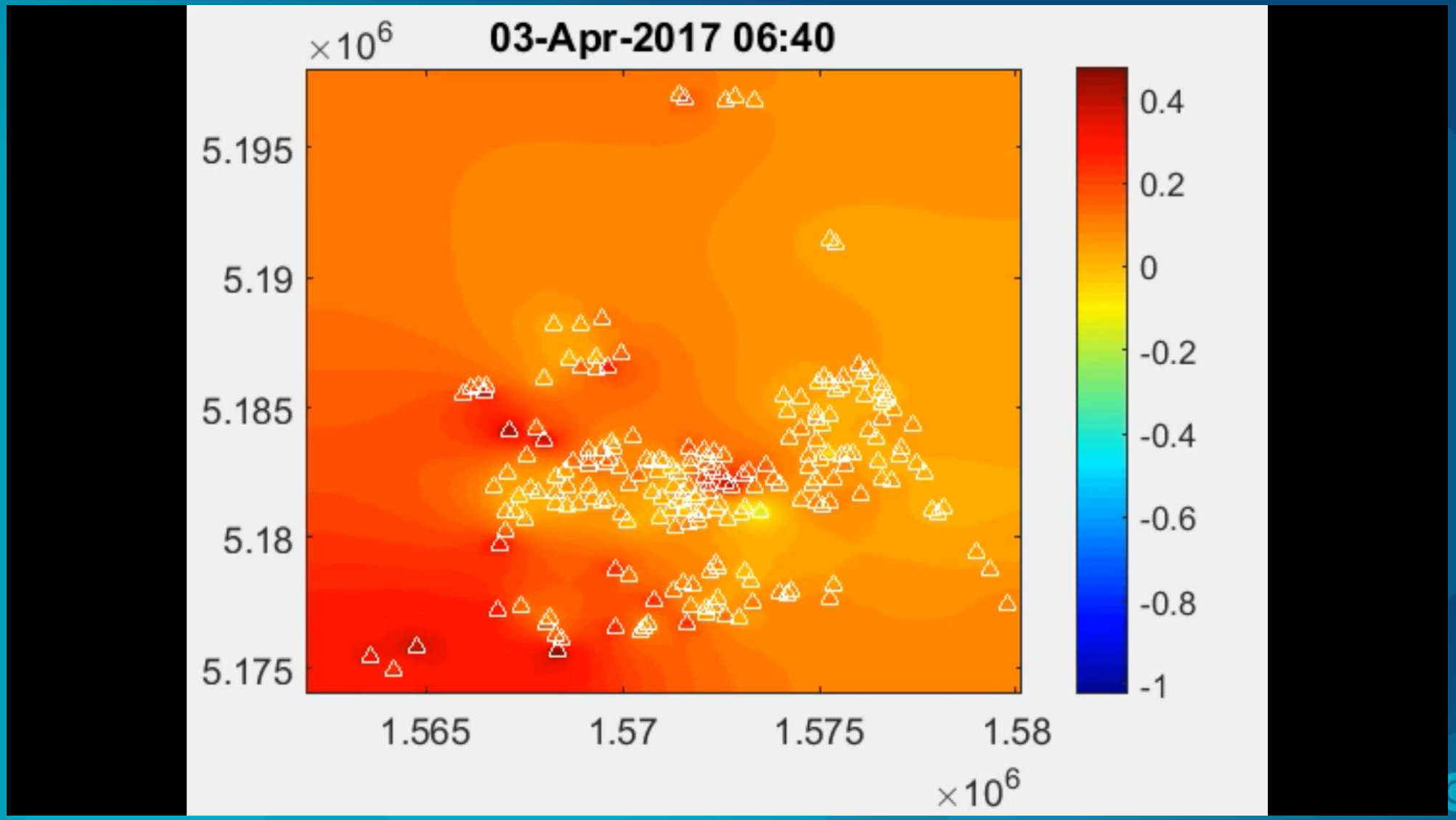
Integrating spatial and temporal data



Hazard

- Need to define hazard in terms of depth to groundwater
- Hazard is complicated due to:
  - Many drivers of water level change
  - Different antecedent conditions
  - Spatial variability of lithologies
  - Superposition of anthropogenic systems
    - Infrastructure; Ongoing rebuild work and dewatering; Ground source heat pumps

- Each location will have a different combination of drivers and controls on groundwater levels, and hence on hazard

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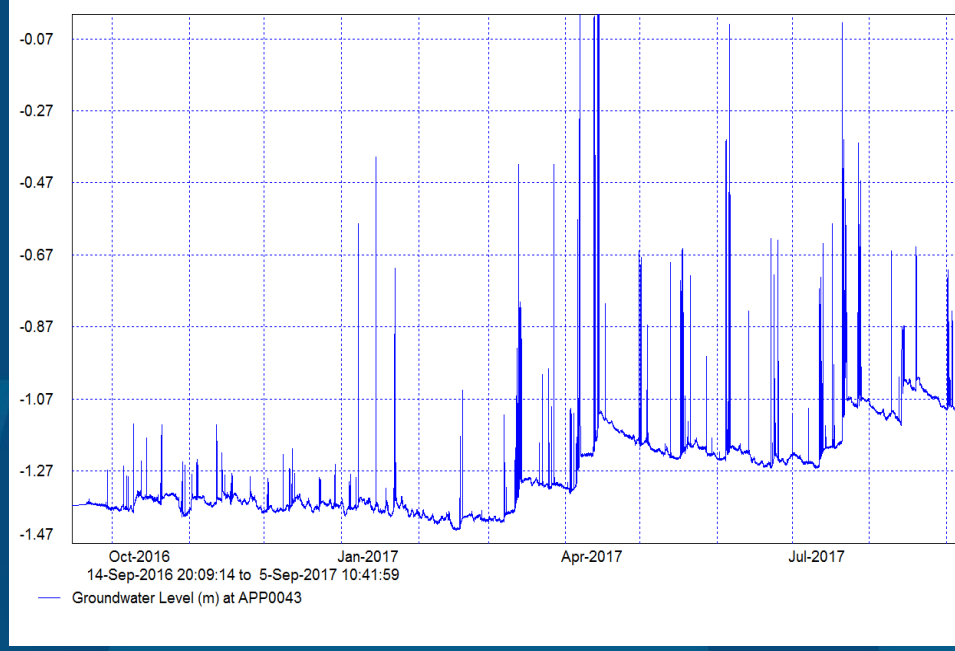
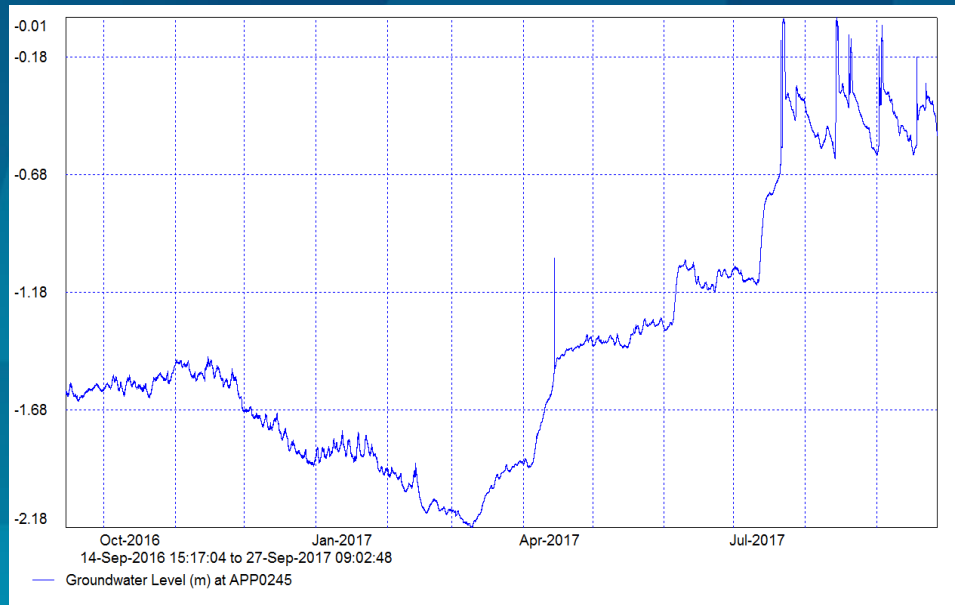
How can data/modelling be used?

- Operational
  - Contribute to operational flood forecasting and management
  - Focus Civil Defence responses to earthquakes and flooding
- Develop understanding of
  - Sewer infiltration
  - Longevity of groundwater flooding
  - Impacts of climate change on council infrastructure
- Infrastructure maintenance
  - Impacts of shallow groundwater on roads and pipe networks
- Construction - decisions about
  - Timing of infrastructure works
  - Dewatering requirements
  - Design of basements and buildings
  - Planting





Take home messages

- Groundwater is a significant hazard and issue in the urban environment
  - 4D problem
- We don't understand it fully now
  - We are in a changing environment
  - Lost opportunity cost
- Need to collect data now
  - Focus on areas where there is a problem – now or future
  - Ensure good practices
    - Piezometer construction
    - Data collection
    - Data processing and maintenance
  - Think about how the data are going to be used – future modelling

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Acknowledgements

- EQC
- GNS
  - Prof John Haines

Questions?

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