# Shallow ground water in Christchurch: What affects it and how sea level rise will change it

Helen Rutter

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# Climate change

- Area of increasing concern
  - Coastal erosion
  - Sea level inundation
  - Extreme events
    - Flooding
    - Drought
- City, district and regional councils grappling with the implications

ENVIRONMENT

**Calls for 'managed retreat' law due to climate change**

***The review of the Resource Management Act has recomme law be added to the books to handle adaptation to change, Marc Daalder reports***

A new law to provide a legal fram from coastlines and other onsidered, an ex

**Moving day at Matatā - the end of one family's fight against managed retreat**

Nikki Macdonald · 05:00, Oct 31 2020

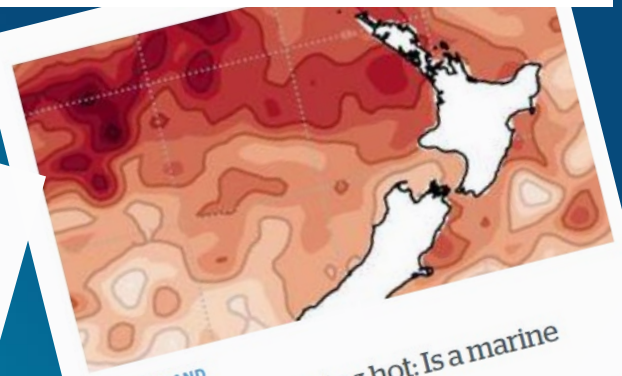
**Politicians have a 'mandate' for climate action, how do their policies stack up?**

6:27 pm on 13 October 2020

Leith Huffadine, Digital Journalist
leith.huffadine@rnz.co.nz

Share this

Before the 2017 election, Jacinda Ardern called climate change her generation's "nuclear-free moment". Three years later, do the climate policies on offer ahead of the election reflect that? Leith Huffadine reports.



NEW ZEALAND

**NZ's seas are running hot: Is a marine heatwave coming?**

4 minutes to read

29 Oct, 2020 12:27 PM

Some seas around NZ are running 3C above normal. Is another marine heatwave coming?

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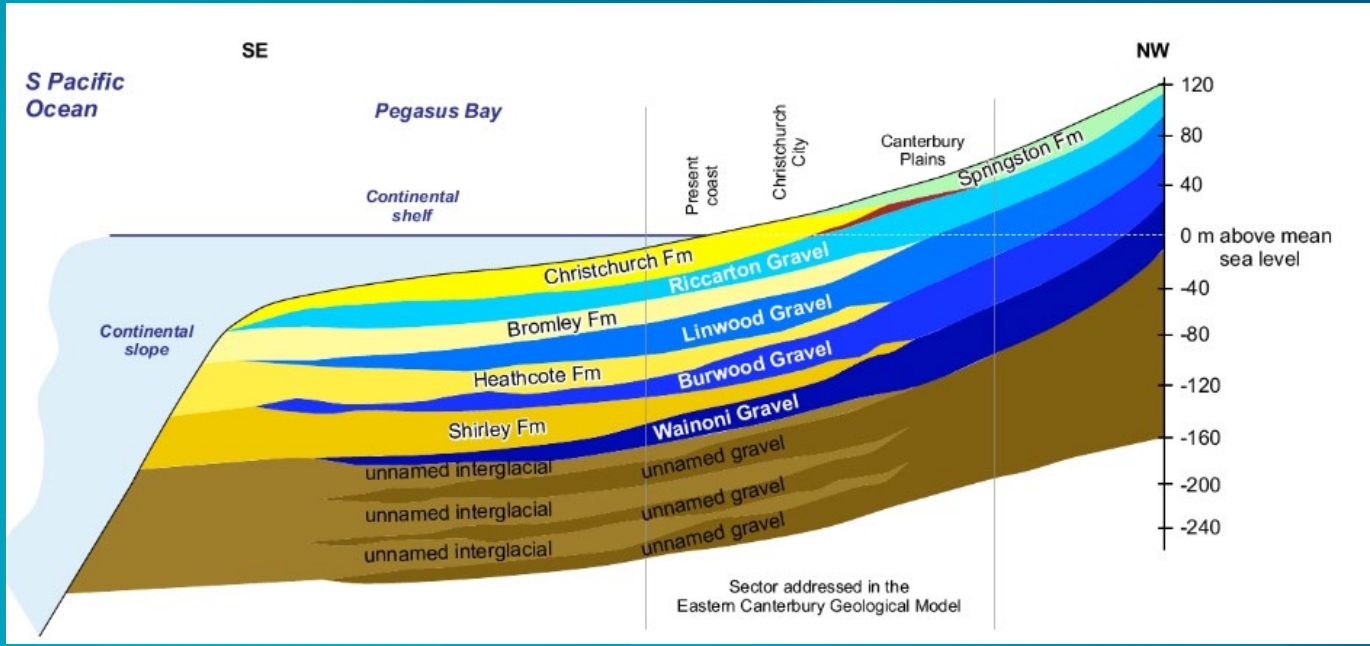
# Groundwater

- Out of sight, out of mind
  - Often overlooked
- Varies in space, with depth, with time
- Changes can occur relatively slowly
  - What happens this year may reflect what has happened in previous years
  - Within a season, levels may change slowly

# What's under Christchurch?




# What does climate change mean for groundwater?

- Might be less recharge
- More extreme events
  - More recharge
    - Rise in GWLs – impacts on shallow groundwater
  - More rapid recharge
    - Water quality/water safety issues
  - Less recharge
    - Drought and inability to access groundwater
- Sea level rise
  - Impacts groundwater further inland than inundation effects

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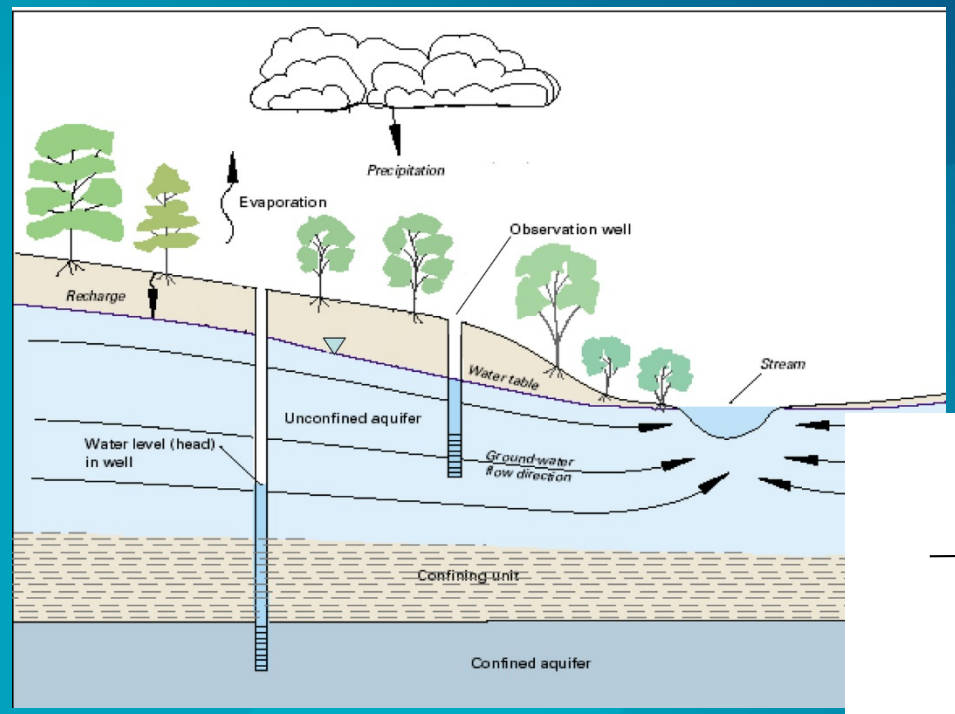
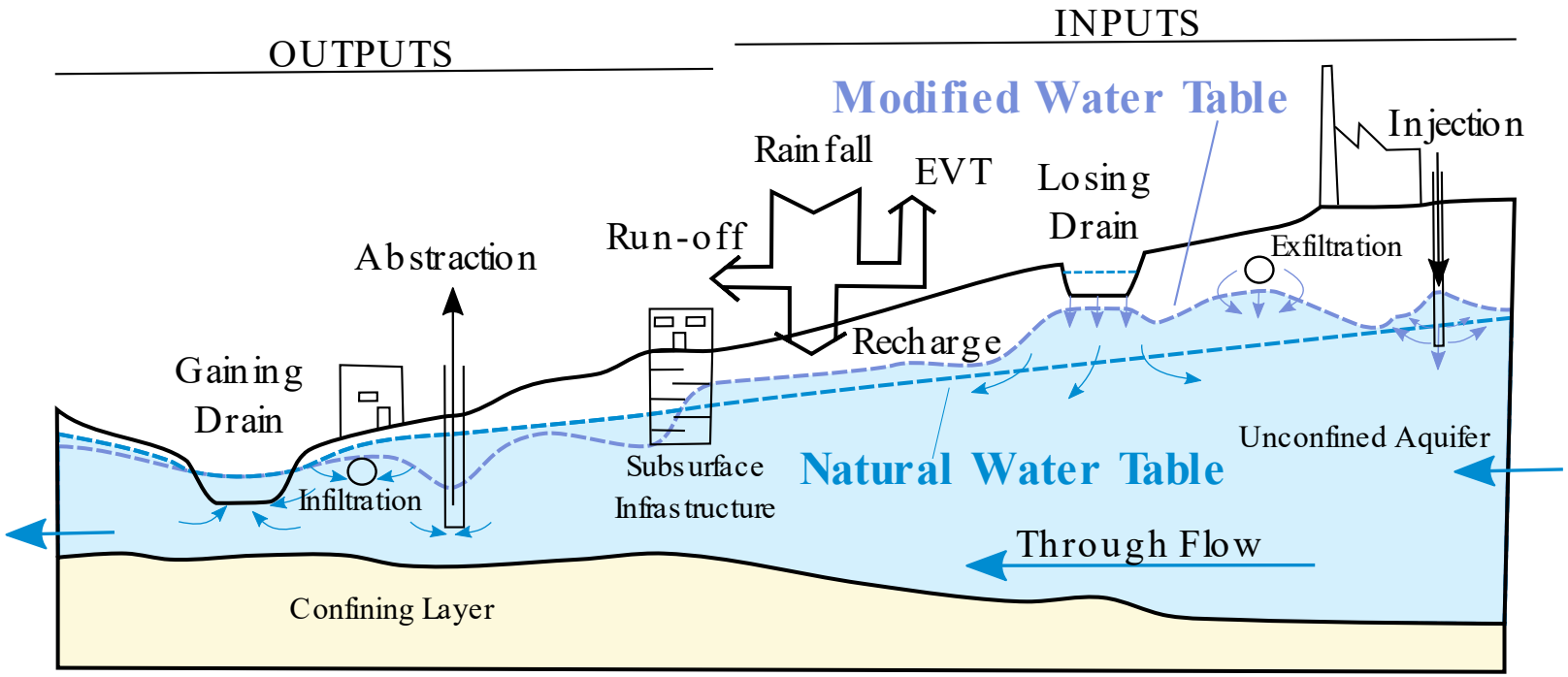
# Urban shallow groundwater

- Shallow groundwater - when is there a problem?
  - Groundwater “daylighting” and contribution to surface flooding
  - Waste water infiltration
  - Damage to roading
  - Unexpected groundwater levels for horizontal infrastructure work
  - Contribution to liquefaction hazard
  - Building/foundation design
  - Issues with damp/health
  - Vegetation dying
- How will these change with climate change?
  - When will infrastructure fail/areas be unliveable?

# Urban Groundwater



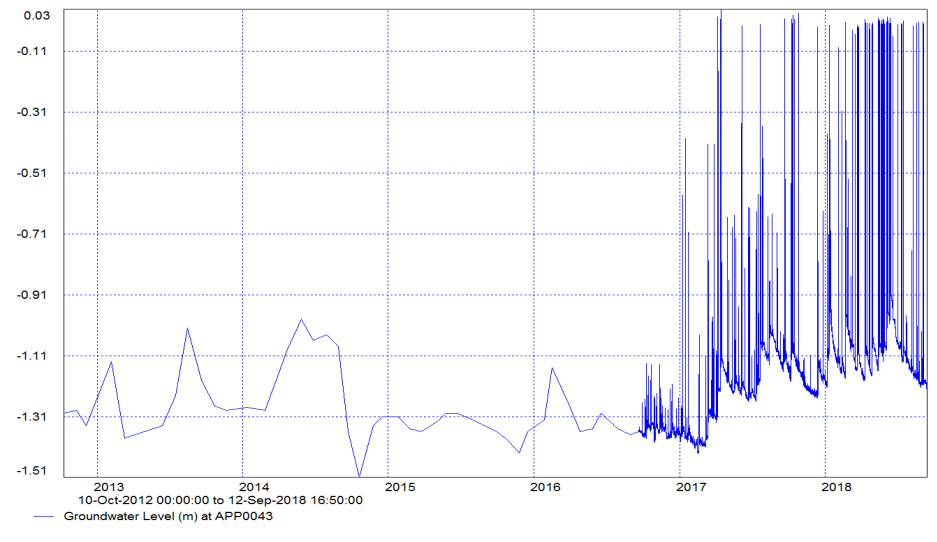

- Need to understand shallow groundwater response in order to manage it

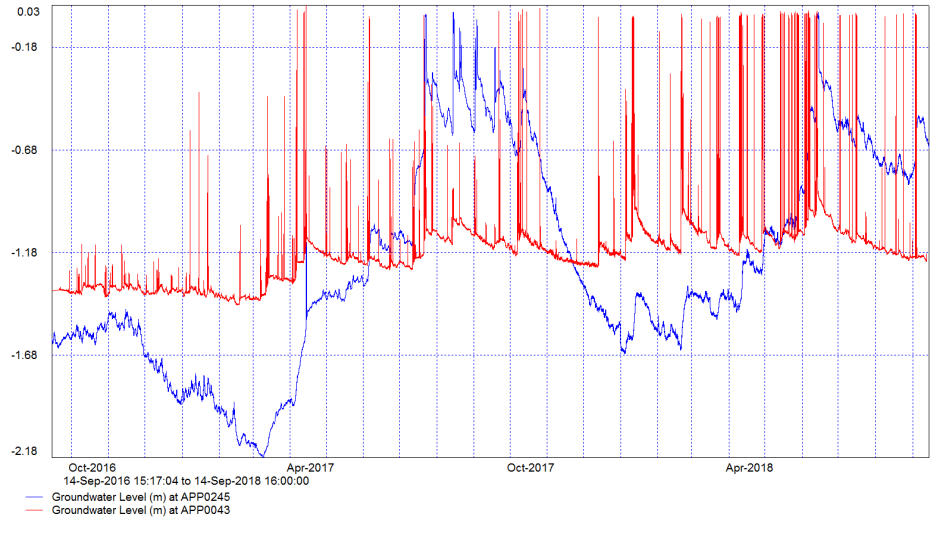



From Bosserelle

# Urban shallow groundwater

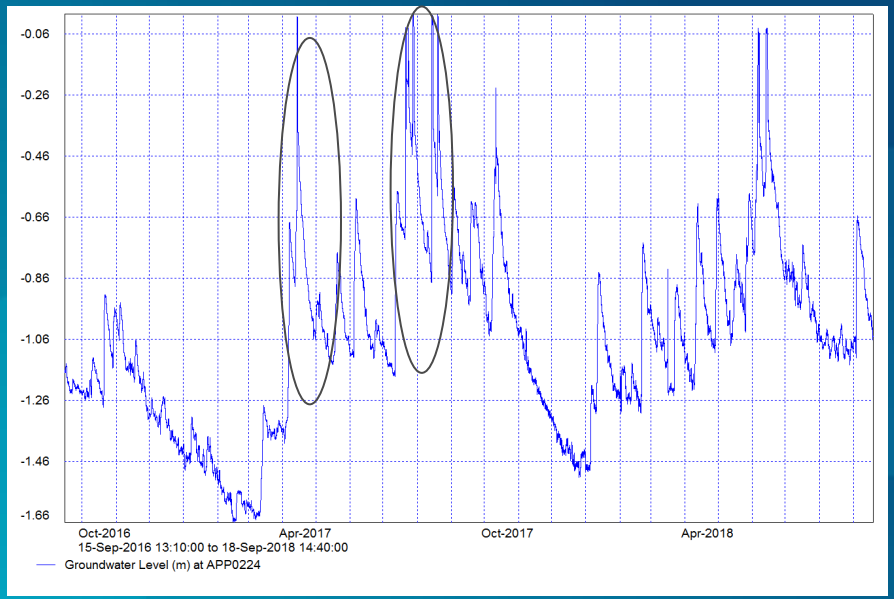
- Little is known
- What do we know?
  - Hugely variable
  - Surface water, groundwater and coast are linked
  - Short records are not useful
  - Low temporal resolution data doesn't tell the whole story
  - Antecedent conditions are really important

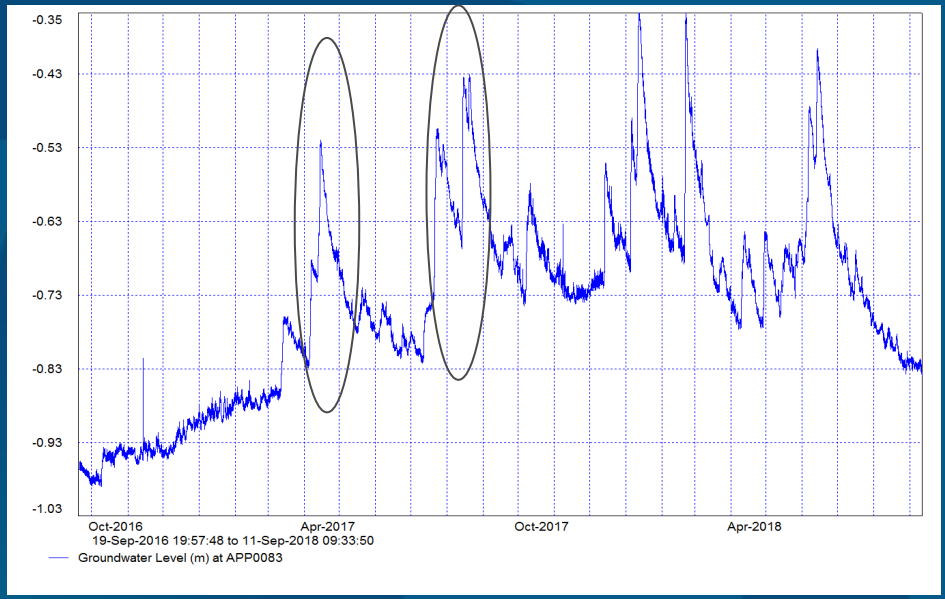


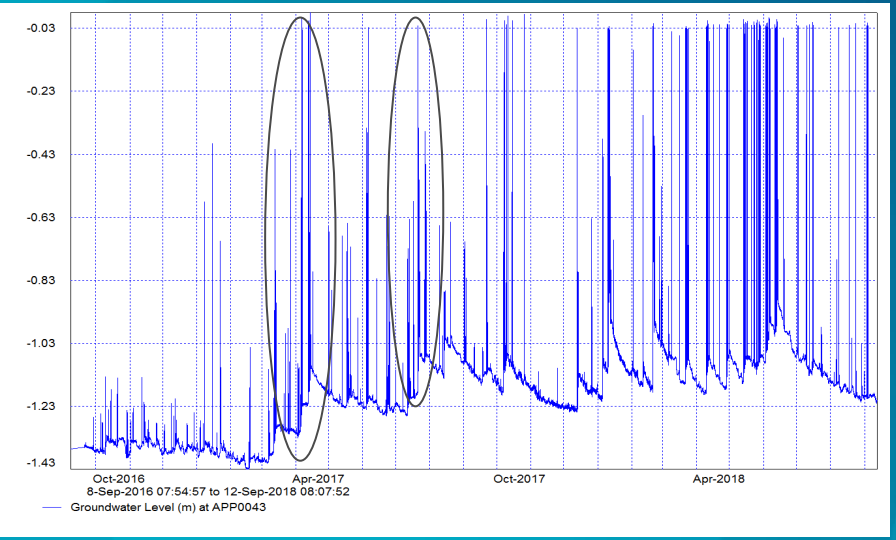



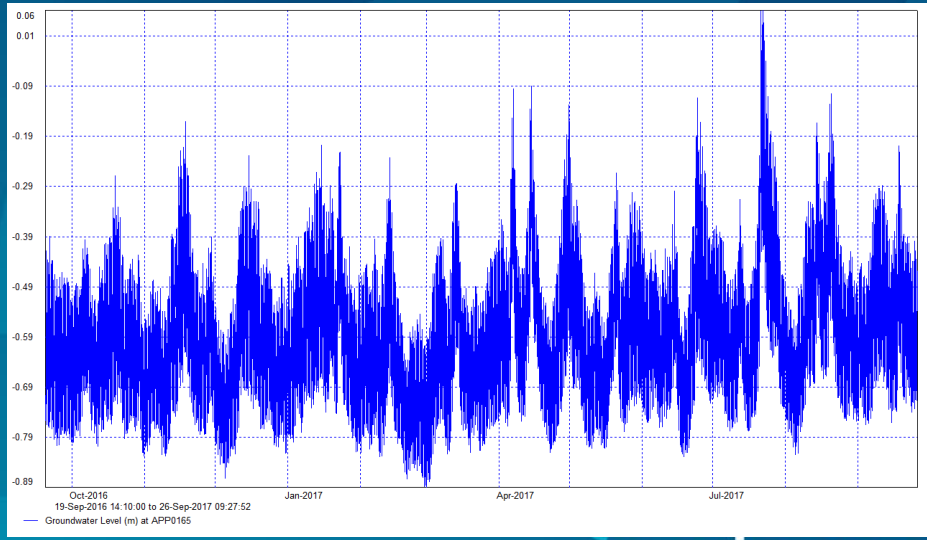
# Shallow groundwater level responses and drivers

- Climate
- Rivers
- Tides



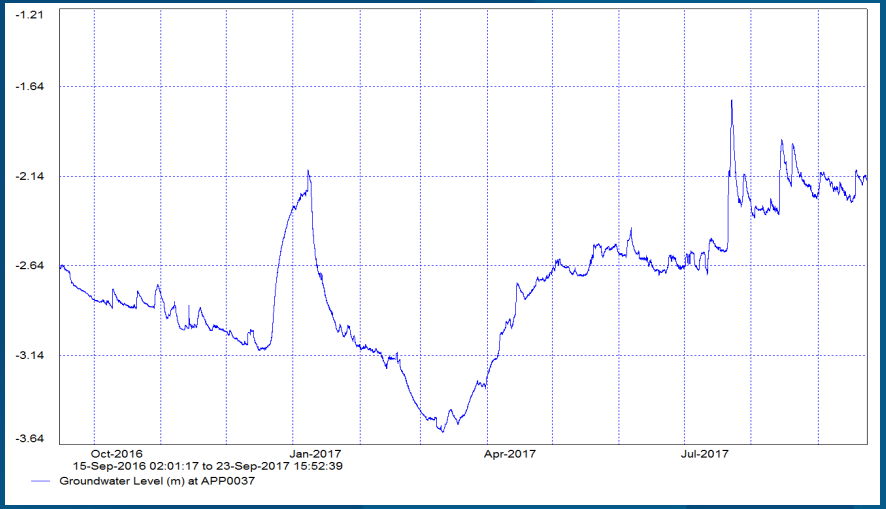



# Shallow groundwater responses and drivers

- Earthquakes
  - Subsidence
  - Dynamic responses
- Urban infrastructure
  - Dewatering for infrastructure works
  - Repairing infrastructure to reduce infiltration
- Ground source heat pumps
- Climate change and sea level rise

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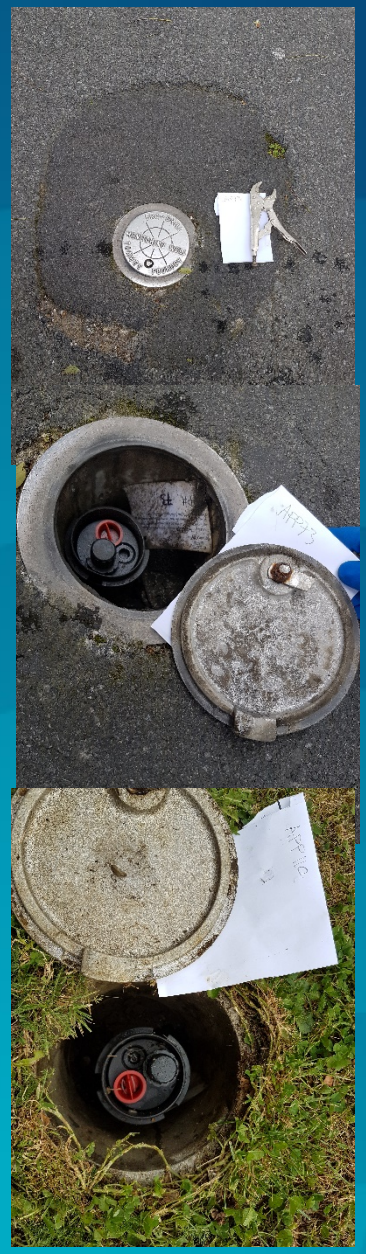
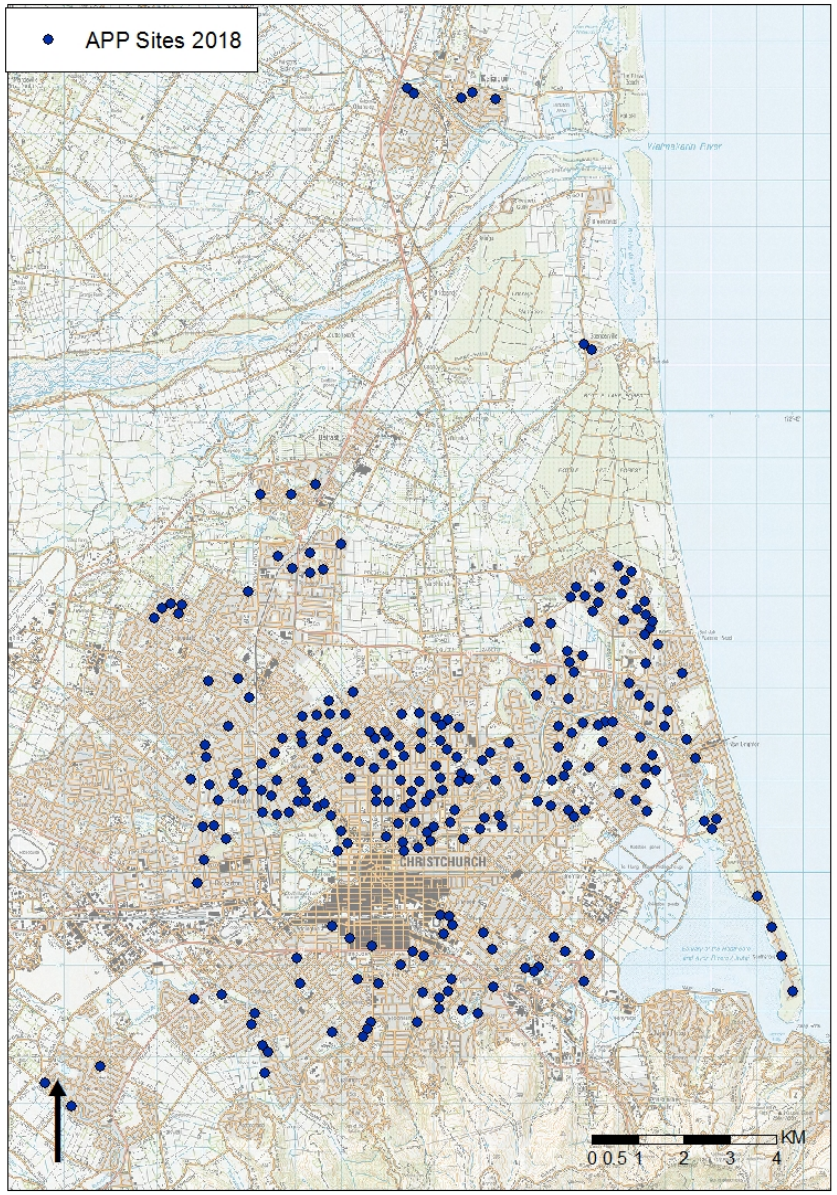
# EQC network

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# The network and available data

- EQC GWL dip data from the NZGD, from 2011 to 2016 (monthly data)
  - 1036 holes
  - Declined to 786 (March 2016)
  - Rate of attrition slowed to near zero
- EQC high resolution (10 minute) APP data from 2016 – 2017
  - 249 holes (85 new)
  - Reducing with time
- Overlap of 2-3 months in 2016
- Dipping now ceased
- Network now taken over by CCC

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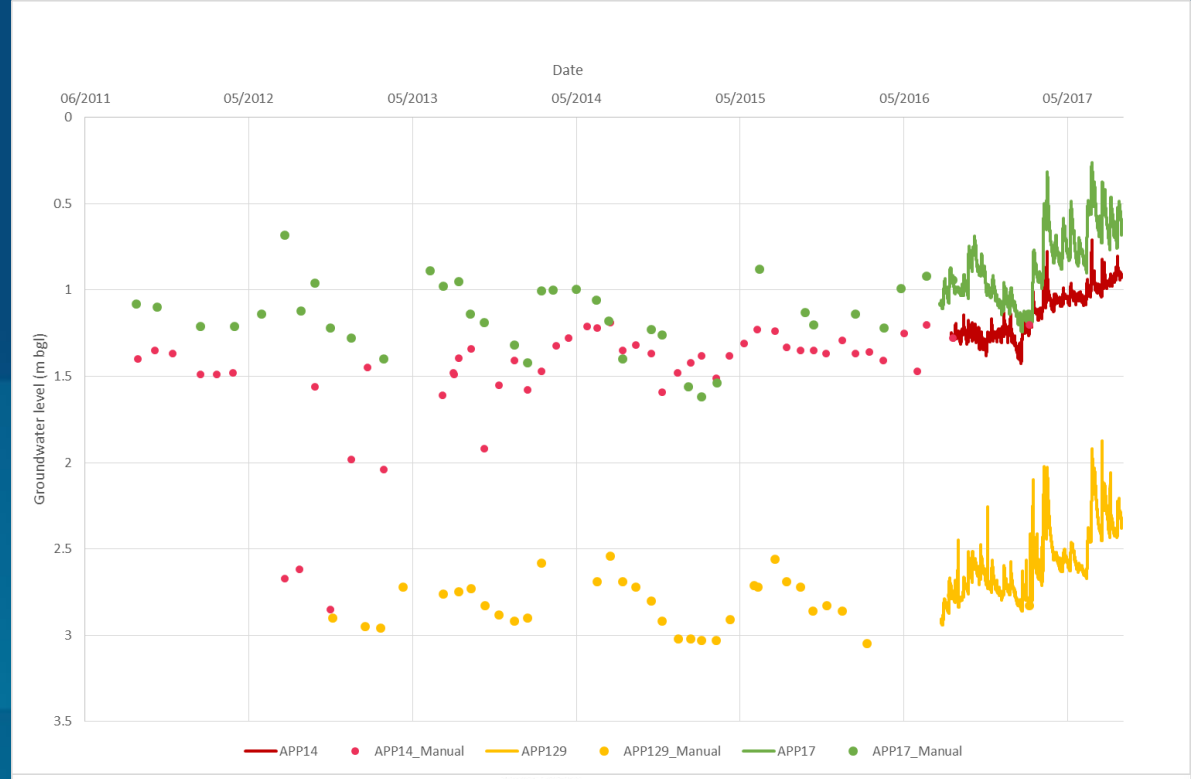
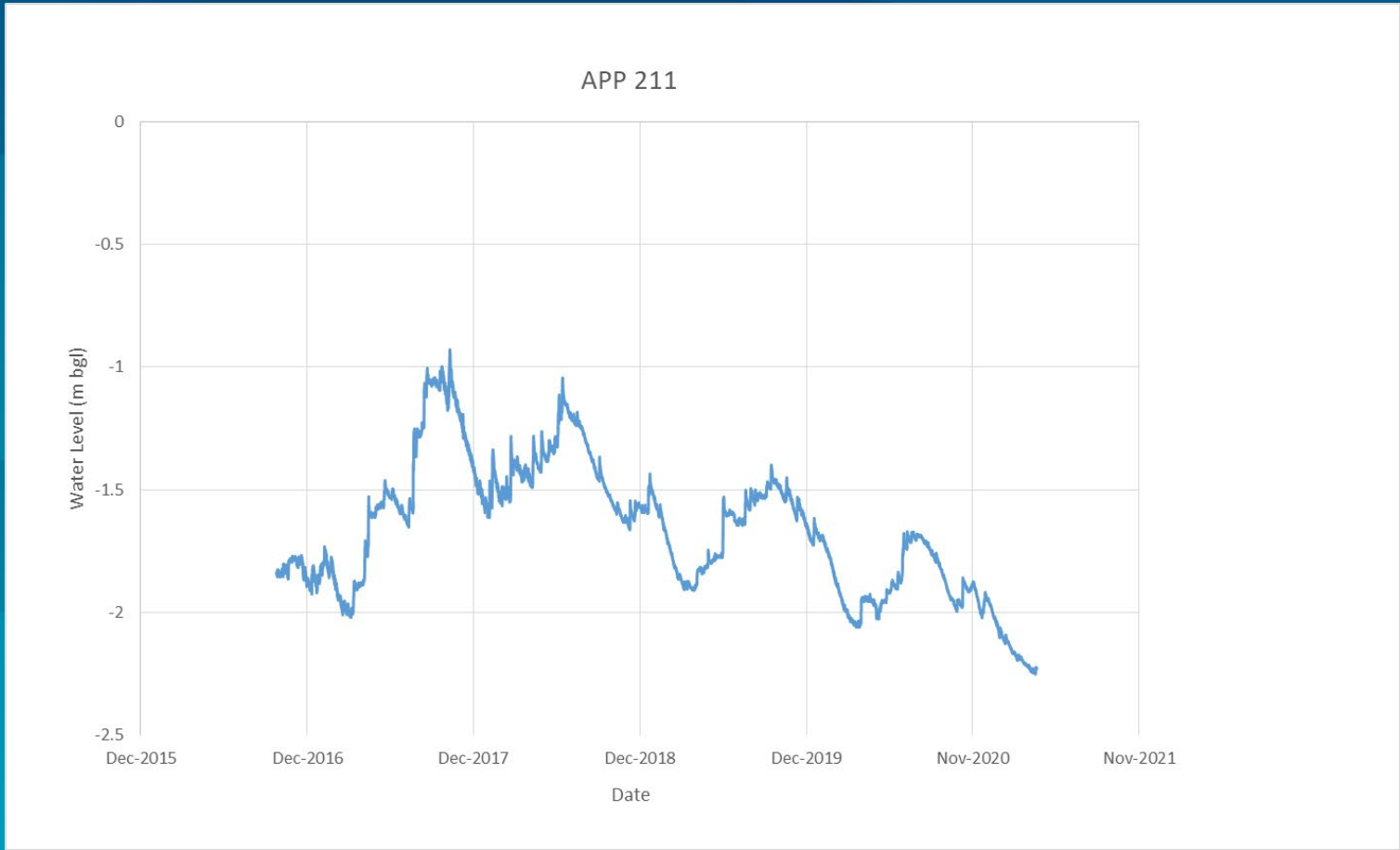
# What are the data showing us?

- Monthly measurements are of limited use
- Extreme variability of the shallow groundwater response across the city
- Shallow groundwater can respond very rapidly to rainfall/river flow/tides
  - Highly dynamic
- Short term data measurements are also of limited use
- What we saw in 2017 wasn't typical




# APP211

- “Typical” groundwater response
- Summer recession/winter recovery
- High groundwater levels sustained for 1-2 month
- Declining GWLs through recent years

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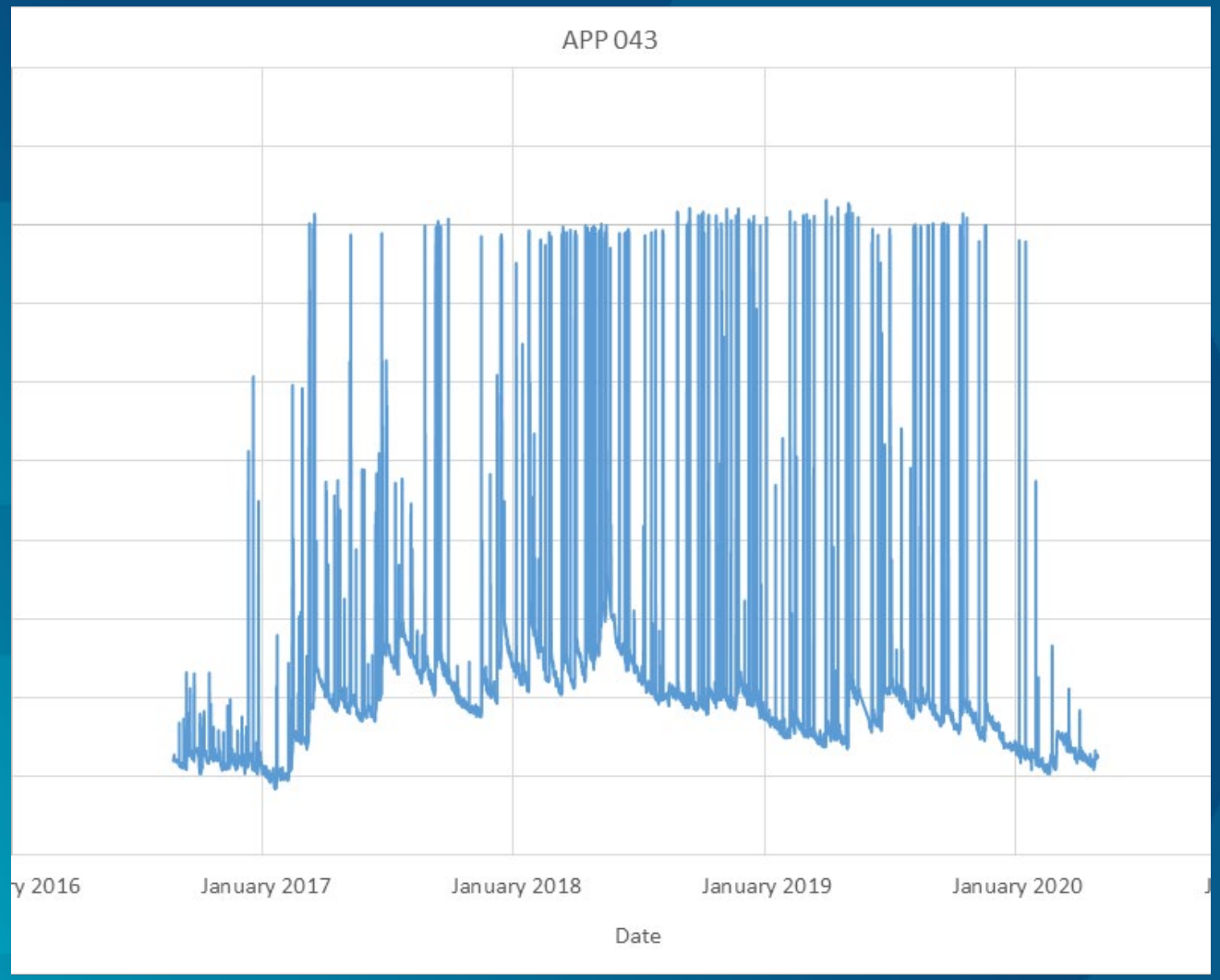
# APP043

- Flashy response to rainfall
  - “baseflow” shows underlying groundwater response
- More similar to streamflow
- Short-lived response to rainfall
- May be effects of infrastructure

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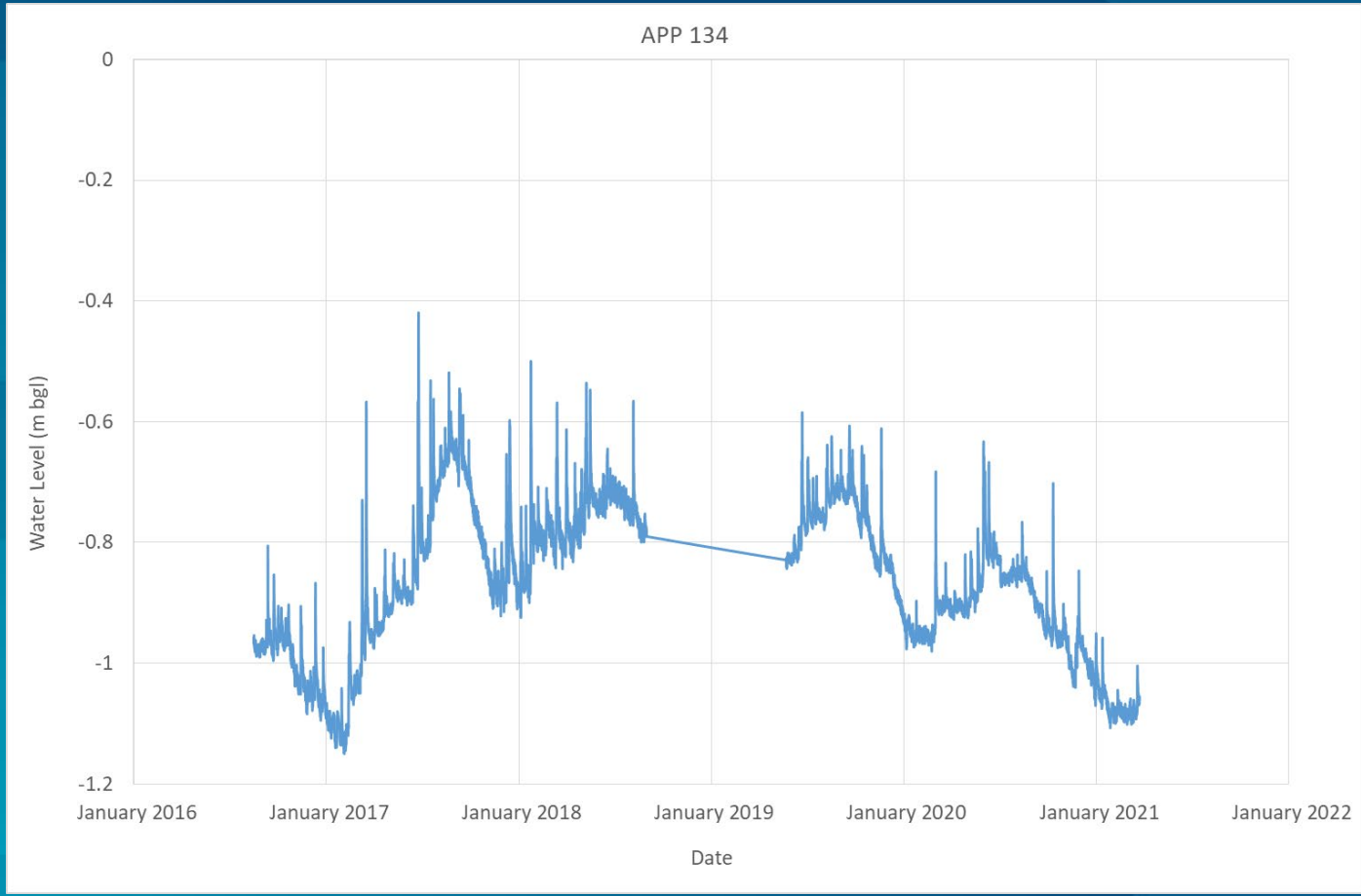
# APP134

- Flashy response to rainfall
  - Gradual recession after each event
- Underlying “groundwater” response

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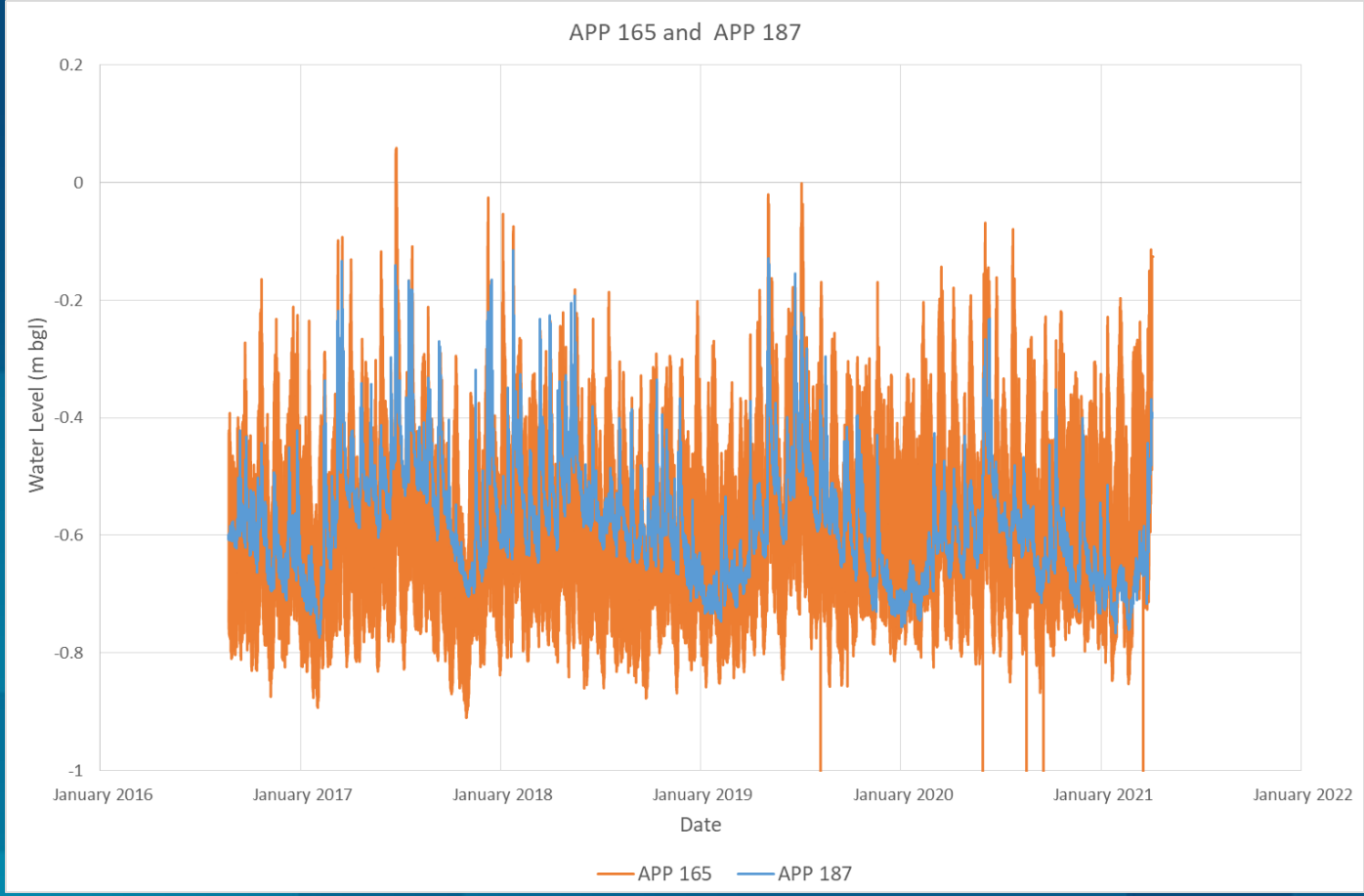
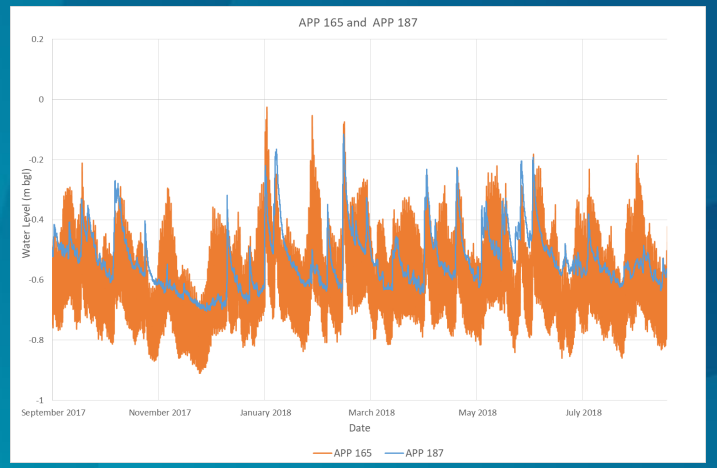
# APP165 and APP187

- Tidal effects
- Inland bore showing declining GWLs due to lack of rehcage
- Coastal bore more controlled by sea level
  - But still influenced by recharge
- Can end up with twice-daily GWLS close to surface
  - May be saline

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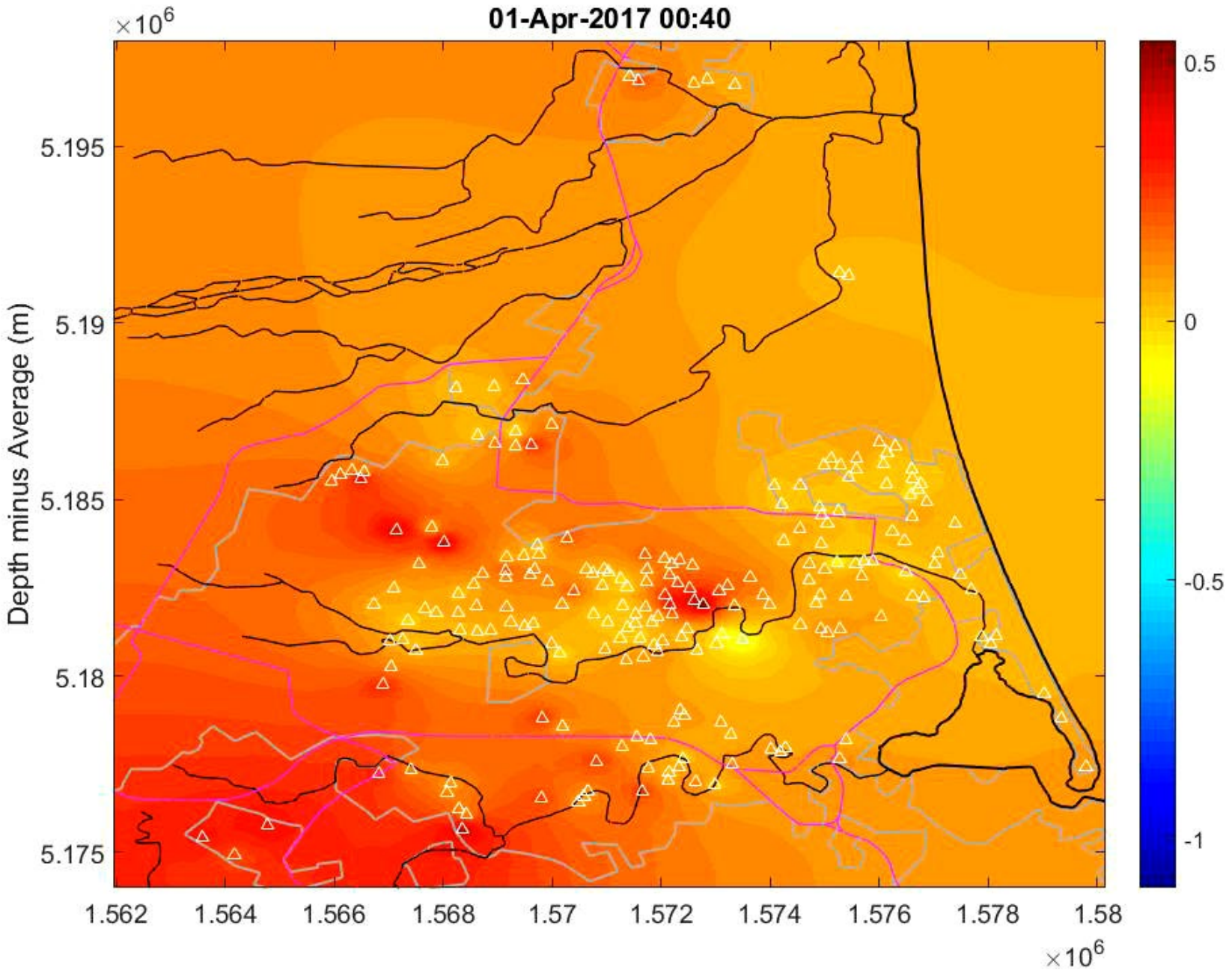



# Depth to Water minus Average

**(Sept 2016-Aug2017)**

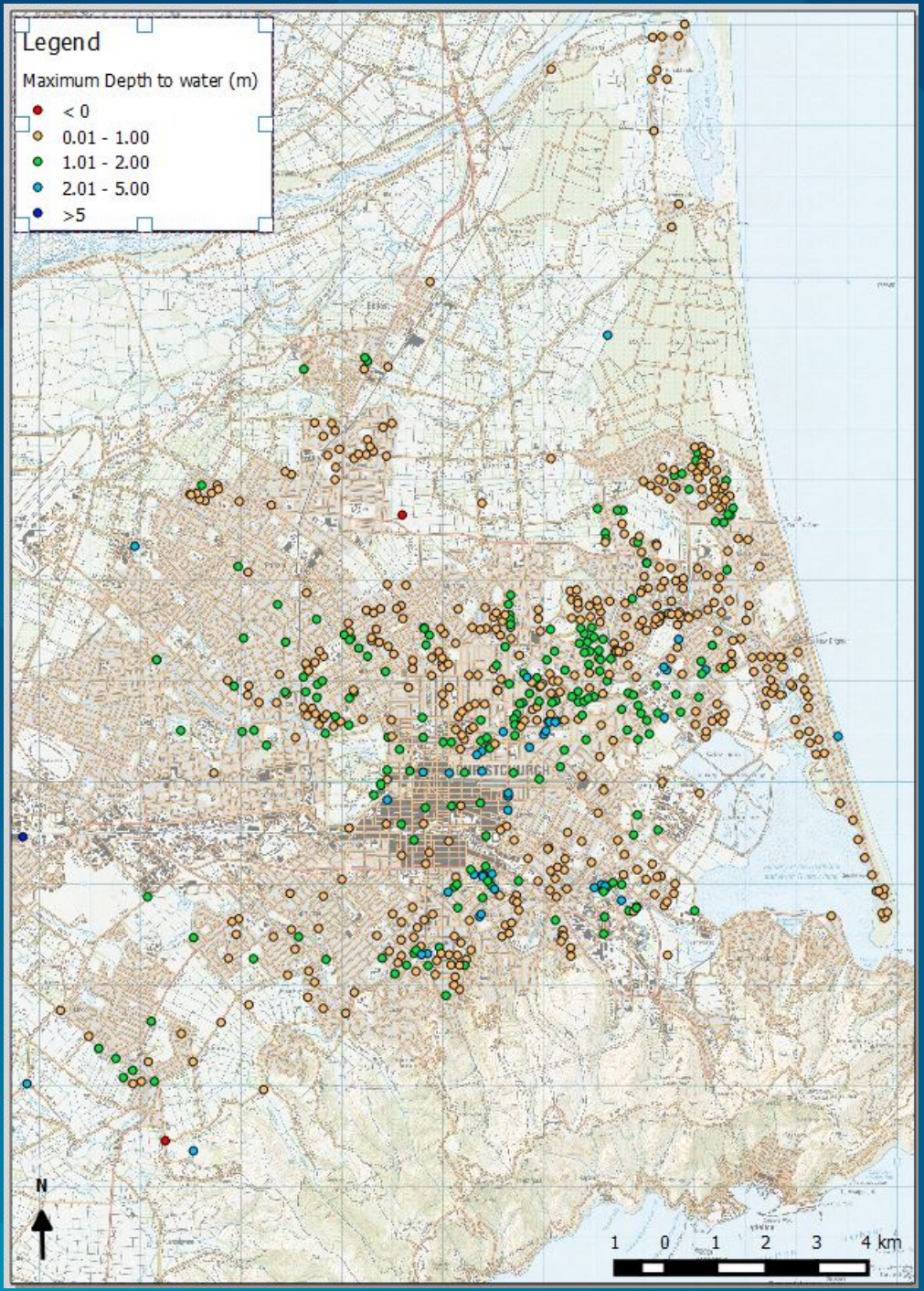
Drier conditions

Wetter conditions

Ex Trop. Cyclones
Debbie 5-6 April
Cook 14-15 April

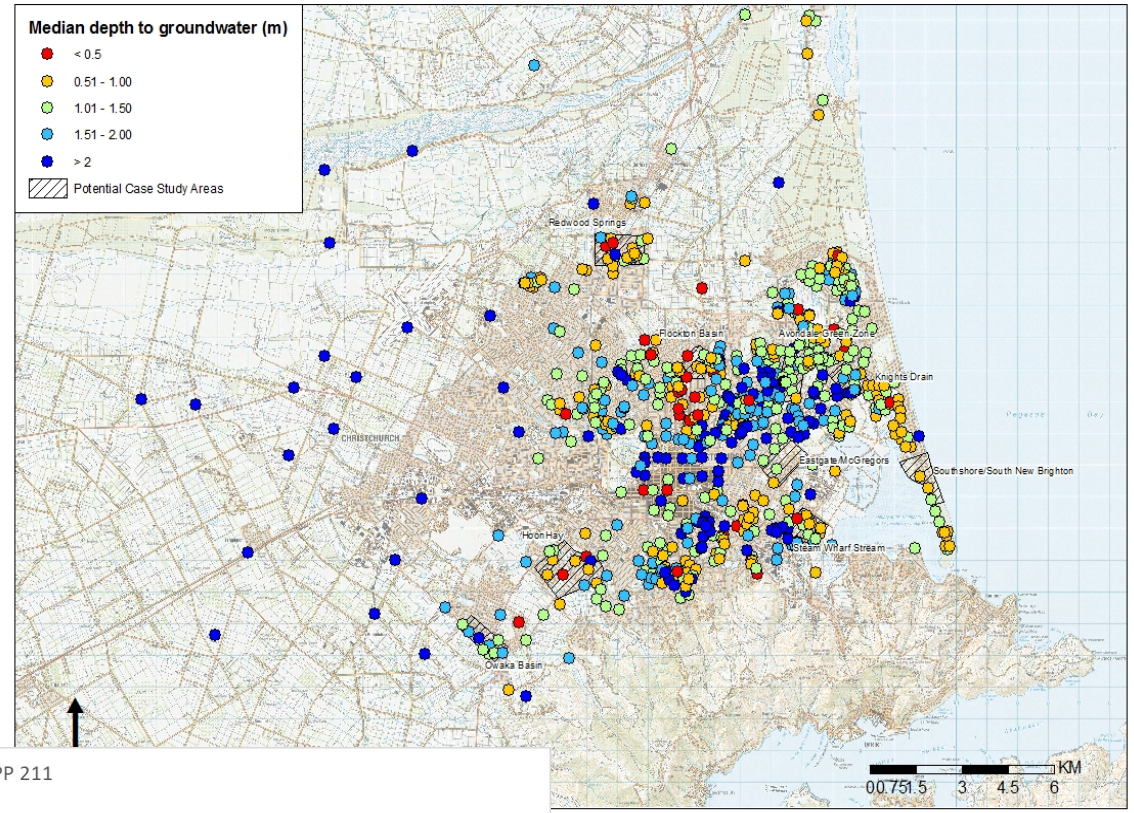
# Depth to groundwater – what have we observed?

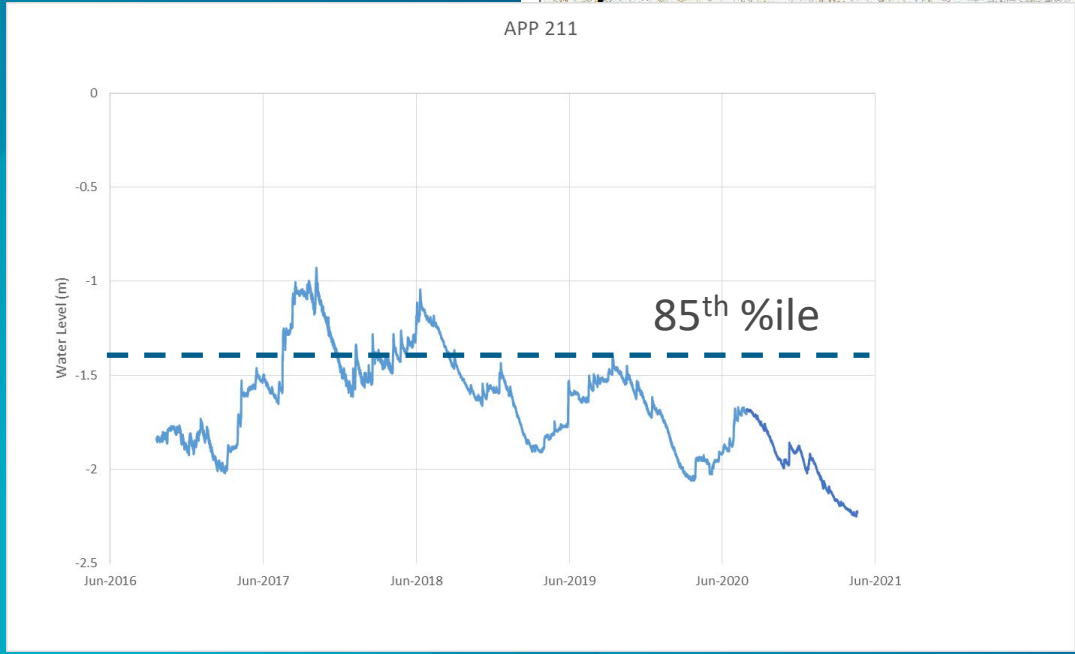
- Varies across Christchurch
- Varies with time
  - Seasonally
  - In response to drivers
- When is it a problem?



# Approach

- Data obtained across city
- Baseline surface developed with geostatistics
- Agreement on what was a problematic depth to groundwater
  - 85%ile
  - 0.35m depth to water

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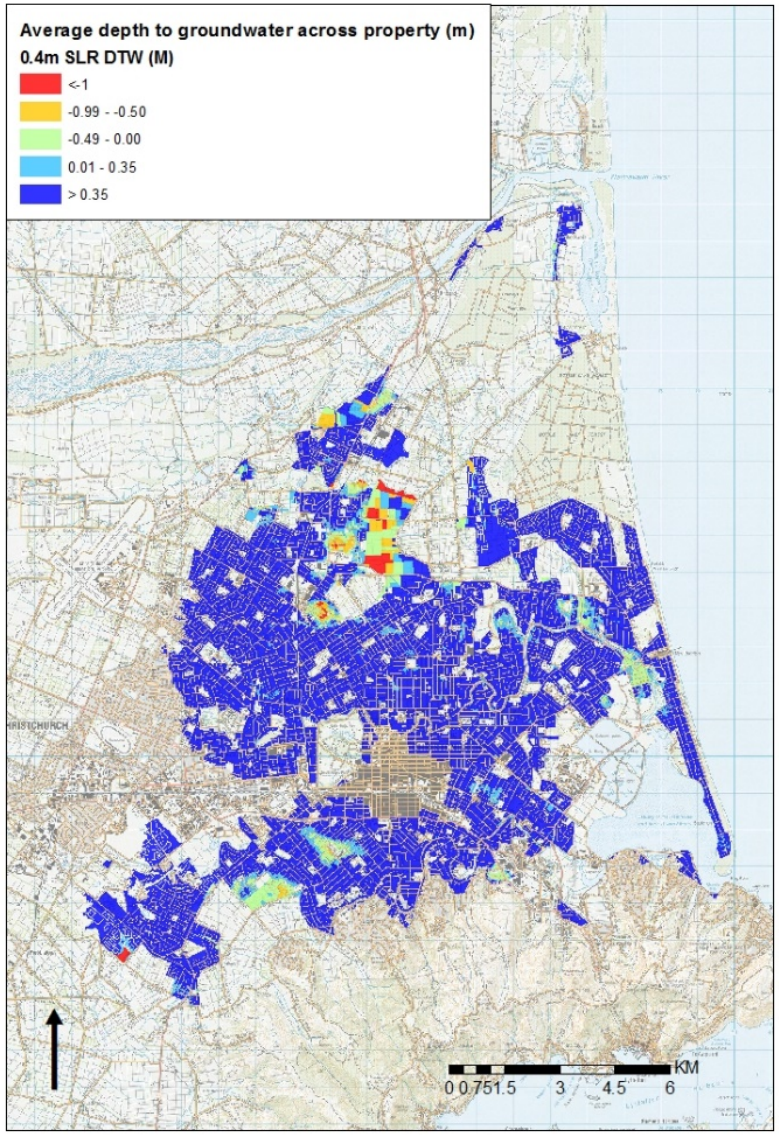
# Approach

- Numerical groundwater model used
  - Calibrated to measured groundwater levels
- ‘Boundary” conditions changed
  - Sea level rise at coast
  - Backwater effects up rivers
- Modelled changes added to baseline
- Depth to groundwater maps developed

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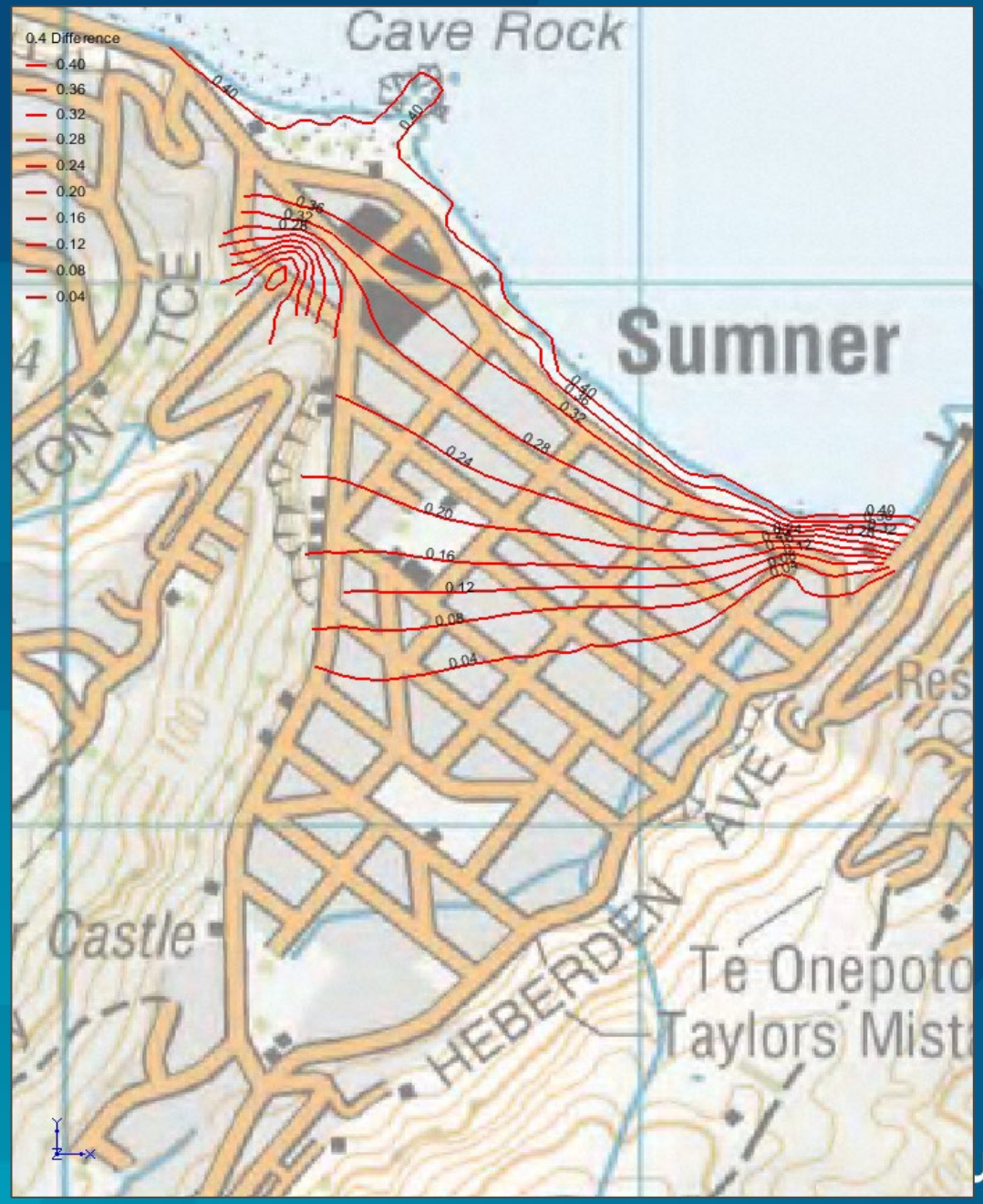
# Results

- Determine inland extent of sea level rise on groundwater levels
- Including effects of drains and rivers

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# Issues/Uncertainties

- Lack of confidence in water level data
- Local effects
  - Effects of rivers/drains
  - Urban infrastructure
- How helpful is it?
  - Indicates areas of concern
    - Areas where sea level rise will start to impact
  - Focus more detailed investigations
  - Adds to other assessments

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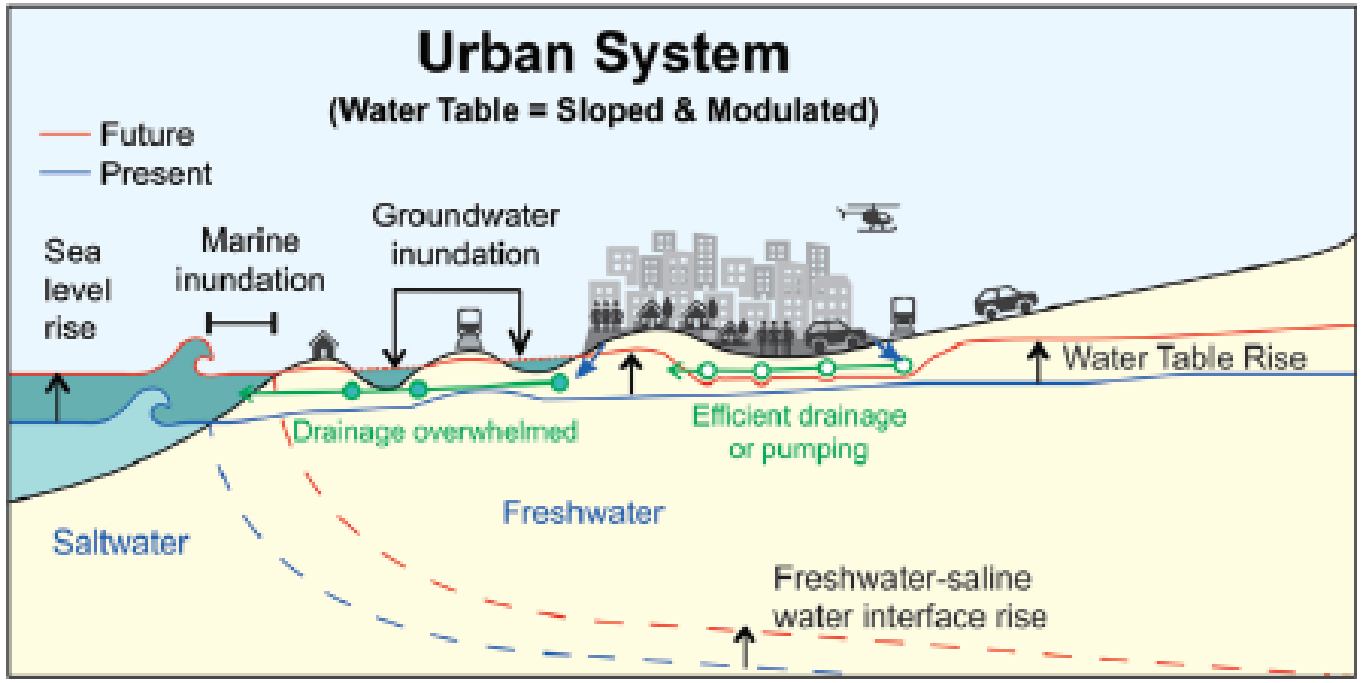
# Urban shallow groundwater and climate change

- Increased extreme events will add to shallow groundwater responses
- New Zealand's coastal cities
  - Sea level rise adding to the shallow groundwater problems
  - Problems may extend much further inland than coastal inundation




Cox et al., 2019

# Building resilience in terms of climate change

- In order to manage climate change impacts and build resilience
  - Understand risk – now and into the future
    - Monitoring
    - Interpretation/Modelling
  - Investigate mitigation
  - Enable better decision making and management of the risks

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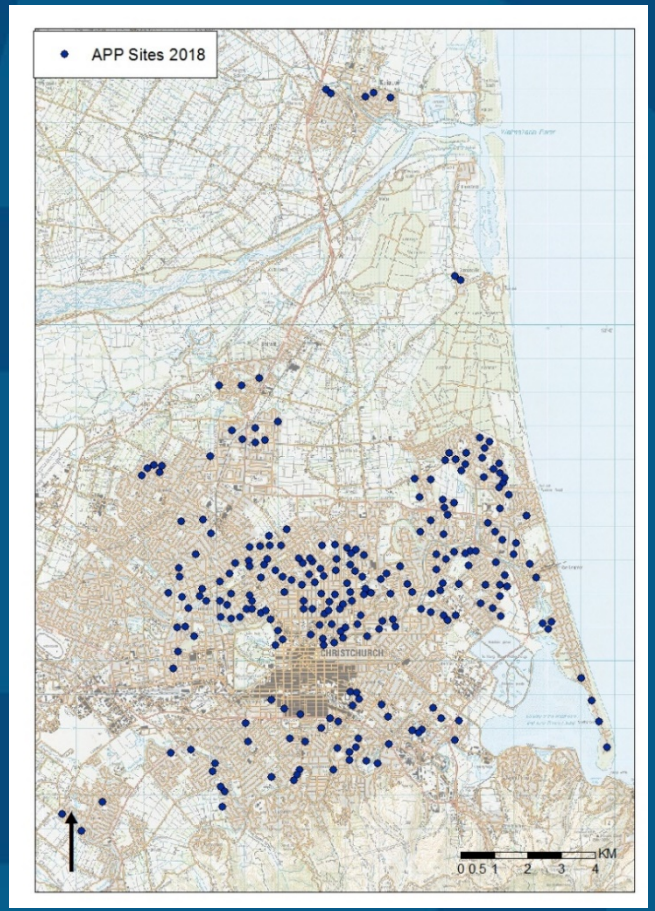
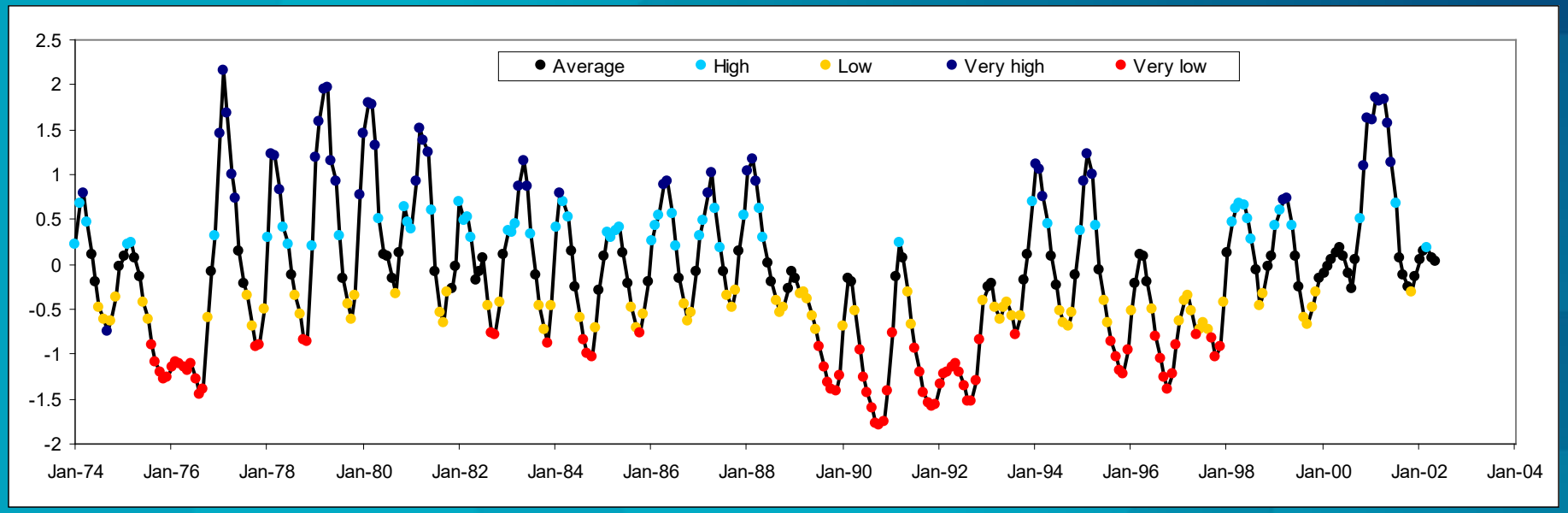
# Monitoring

- No simple solution
- Focus on reasons for monitoring
- Fill in data gaps/extend time series based on long term data

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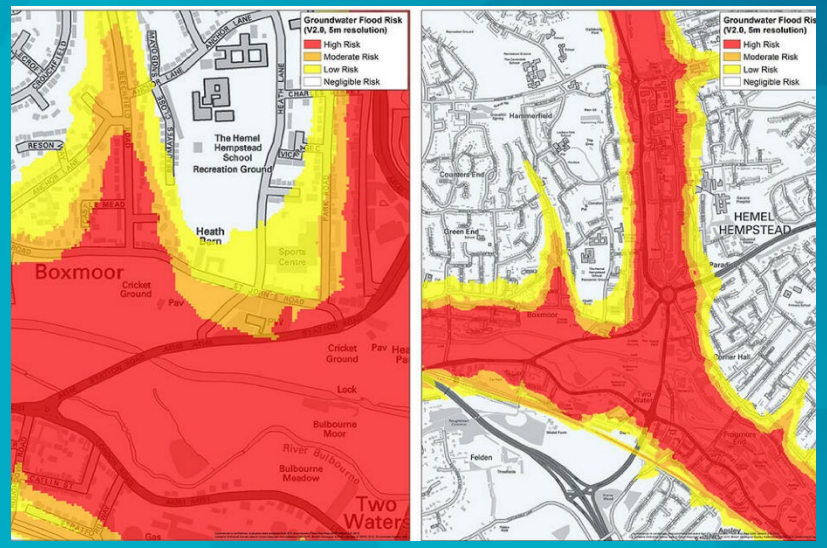
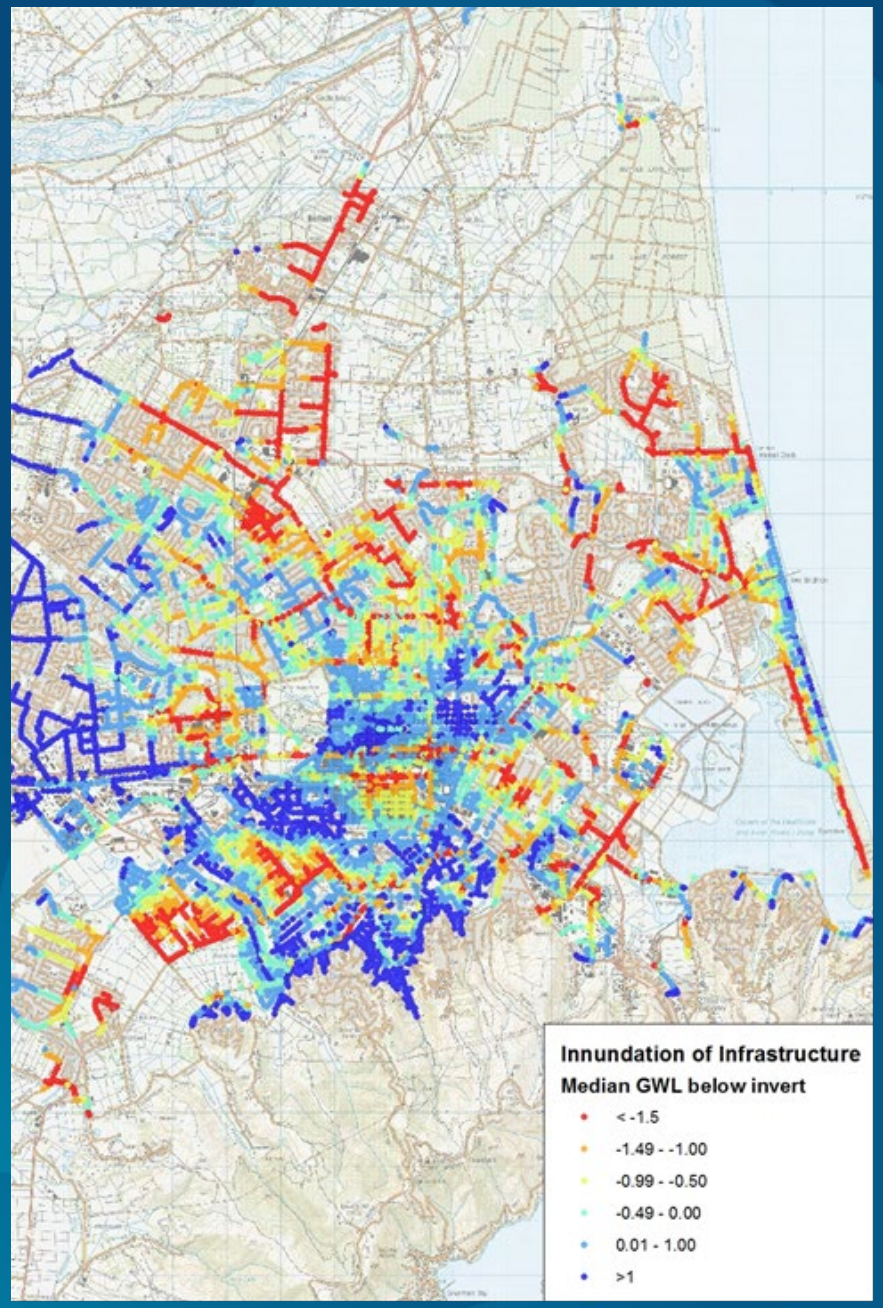
# Interpretation and modelling

- Derive depth to water surface and map areas at risk
- Map areas of likely inundation of infrastructure

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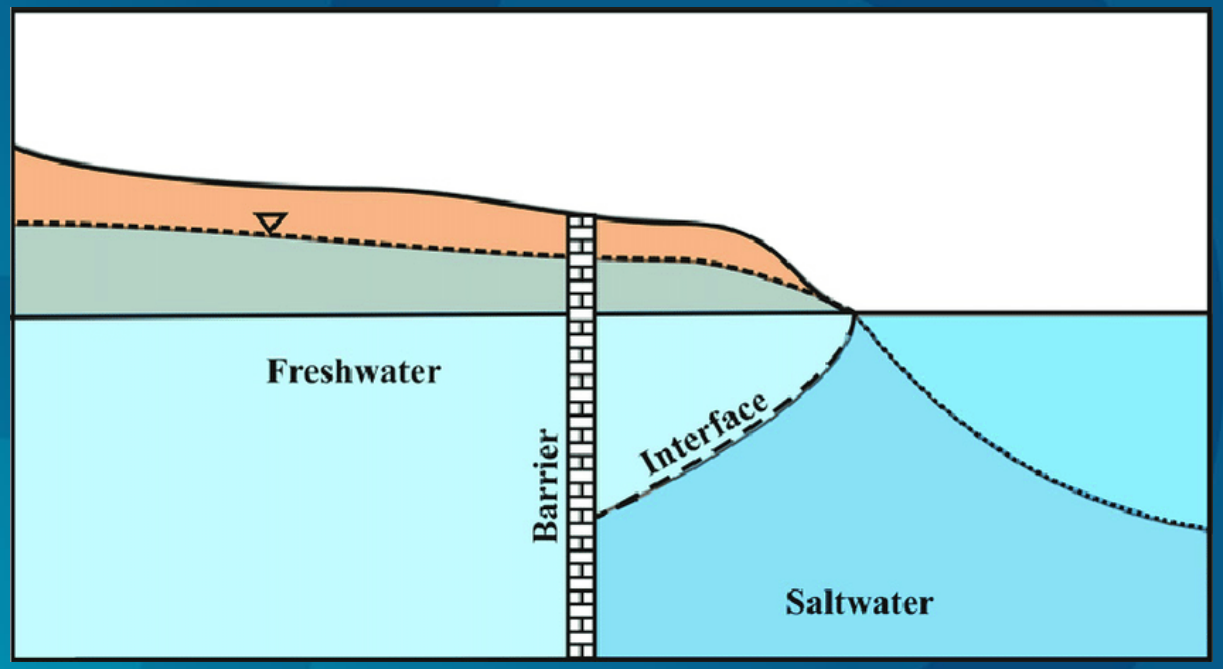
# Mitigation options

- Options
  - Open drains
  - Subsoil drains
  - Dewatering wells
  - Cut-off walls
  - Managed retreat?

- Issues
  - Costs
    - Capital
    - Operational
  - Asset life
  - Variable performance
  - Saline intrusion

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# Benefits of improved understanding – avoid the issues!

| Outcome | Economic | Environment | Social | Cultural |
|---|---|---|---|---|
| **Better land use decisions** | X | | X | |
| Determining liquefaction risk | X | X | X | |
| Less loss of useful land | X | | | |
| Better understanding of insurance exposure | X | | | |
| More efficient asset management planning | X | | | |
| Other impacts on asset life e.g. wetting drying cycles, saline content vs. concrete | X | | | |
| Reducing waste water overflows | X | X | | |
| Improved operational flood management | X | X | X | |
| Understanding the longer term the impact of sea level rise | X | | | |
| Optimise construction work. | X | | | |
| Minimise/plan for road pavement maintenance. | X | | | |
| Predicting and managing human health consequences | | | X | |
| Reduce likelihood of damage through the management of various hazard sensitive activities | | | X | |
| Rehabilitation of mahinga kai sites | | | | X |

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# Summary/Take home

- Groundwater is out of sight, out of mind
  - Effects can be long lasting
- Shallow groundwater can be highly dynamic
- Groundwater levels will be affected by climate change and sea level rise
  - Monitor and model now
  - Understand areas to avoid
  - Consider mitigation

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# Questions?

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