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IMPACT OF CLIMATE CYCLES AND TRENDS ON SELWYN DISTRICT WATER ASSETS

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GROUNDWATER | IRRIGATION | RESOURCE CONSENTS | FARM ENVIRONMENT PLANS | EFFLUENT MANAGEMENT | WATER MANAGEMENT

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Introduction and outline

- SDC
- Aim of project
- Sources of data
- Cycles and trends
- Assessing effects on environmental variables
- Assessing impacts on council infrastructure

Selwyn District Council

Aims of the project

- Possible changes in climate in the light of observed cycles and trends
- Determine whether cycles and/or trends were likely to cause an issue to SDC assets
  - – up to 2048
- Focus on areas where greatest risk to assets
- Priorities guided by risk matrix

Asset sensitivity to changes in environmental factors

Environmental factor	Water	Wastewater	Stormwater	Land drainage	Water races
Ground water levels (upper plains)	High	Minor	Minor	Minor	Minor
Ground water levels (lower plains)	Low	High	High	High	Low
Annual rainfall	Moderate	Minor	Minor	Minor	Moderate
Extreme rainfall (Plains)	Moderate	High	High	High	Moderate
Extreme rainfall (foothills and alpine)	High	High	High	High	Moderate
Alpine river flows	Moderate	Minor	Minor	Minor	High
Foothill and lowland river flows	Moderate	Minor	Minor	Minor	High
Evapotranspiration (ET)	High	Minor	Minor	Minor	Minor
Sea Level rise <0.23m	Minor	Low	Low	High	Minor
Snow and ice (excl. alpine river flows impacts)	Minor	Minor	Minor	Minor	Low
Temperature (excl. ET impacts)	Minor	Minor	Minor	Minor	Minor
Wind (excluding ET impacts)	Moderate	Moderate	Minor	Minor	Minor

Climate Time Series Extension (CTSE) approach

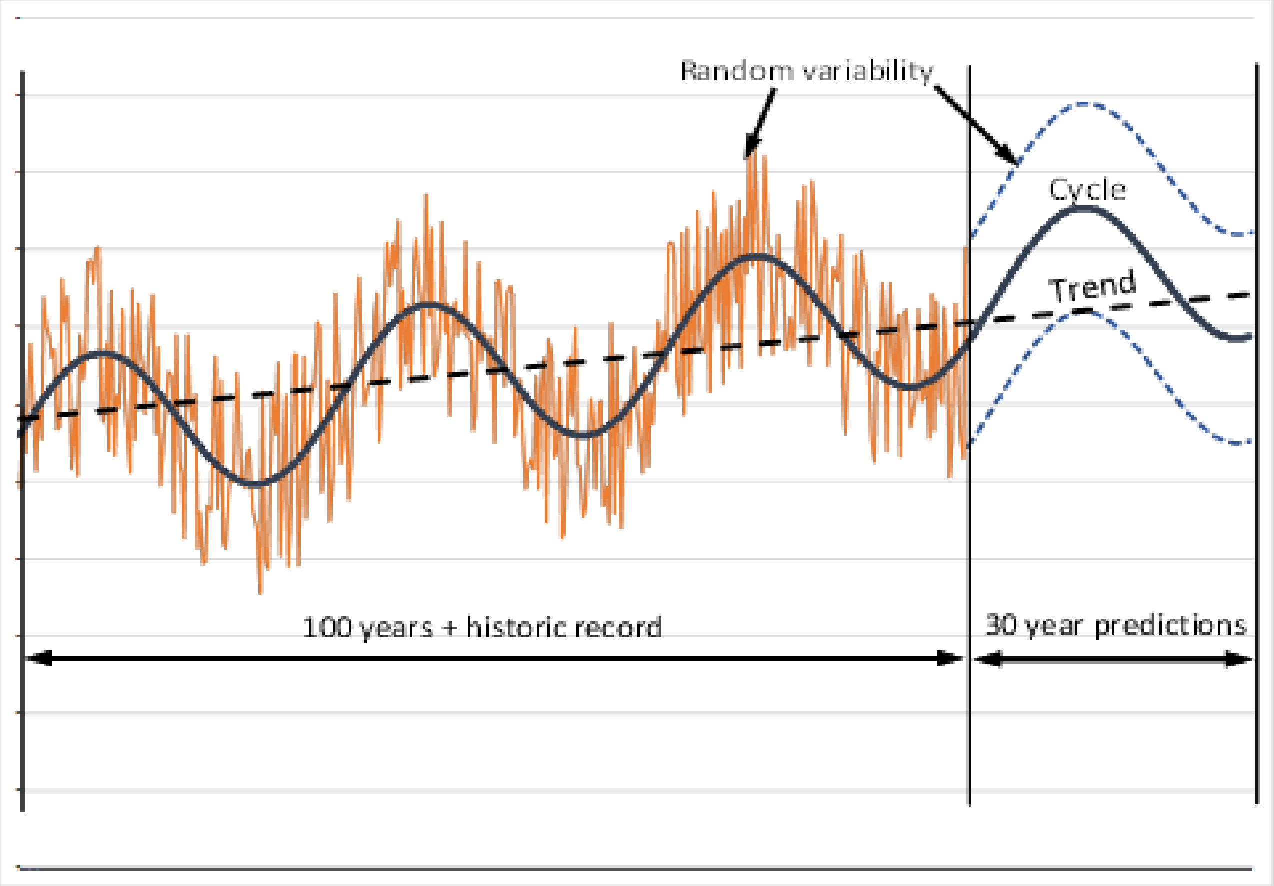
- Gap fill and extend climate time series data
- For each climate variable, identifies best correlated long term site for a shorter term site
- Data for shorter term site gap filled or extended
- If this doesn’t fill gaps, next best correlated site is used
- Interpolates temporally, then can be interpolated spatially
- Avoids step changes when sites added or removed

CTSE approach

Data type	Process	Period
Rainfall	Extended and gap filled with CTSE software	1892-2016
Minimum and maximum temperature	Extended and gap filled with CTSE software	1905-2016
Potential evapotranspiration (Penman)	Extended and gap filled with CTSE software	1960-2016
Potential Evapotranspiration (McGuiness-Bordne)	Generated from temperature and calibrated to NIWA Penman estimates	1909-2016
Groundwater	Modelled from rainfall and potential evapotranspiration and calibrated to post-earthquake observed groundwater levels.	1909-2016

Climate cycles and trends

- Natural variability of NZ climate
- Some variation due to large scale climate variability
  - Climate change
  - El Niño - Southern Oscillation (ENSO)
  - Interdecadal Pacific Oscillation (IPO)
  - Southern annular mode (SAM)

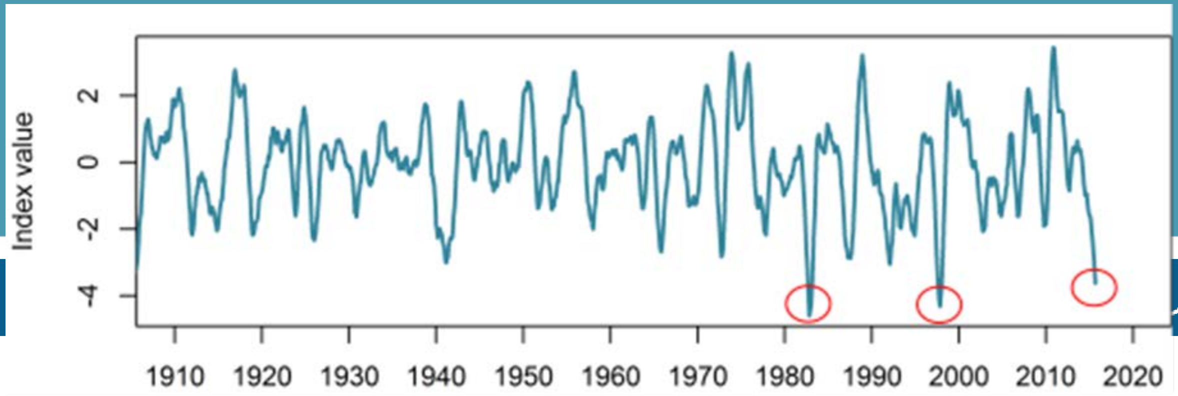


ENSO

- Climate characteristic related to sea surface temperature
- El Niño phase - lower seasonal temperatures for NZ, and drier conditions in the NE
- La Niña opposite - higher temperatures, and wetter conditions in the north and east of NI
- Note
  - Effects are overlaid on high variability
  - any one specific El Niño year will not necessarily have classic El Niño characteristics

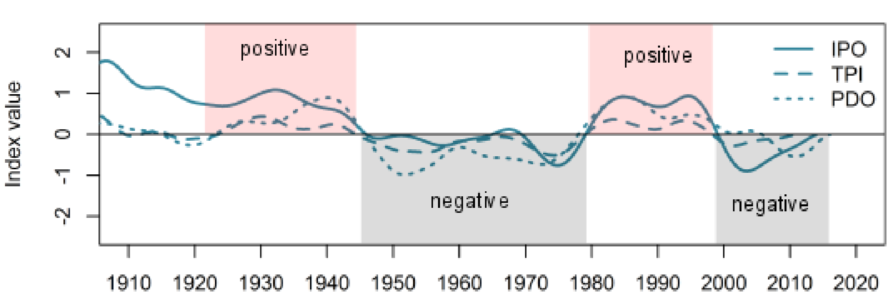
La Niña

El Niño



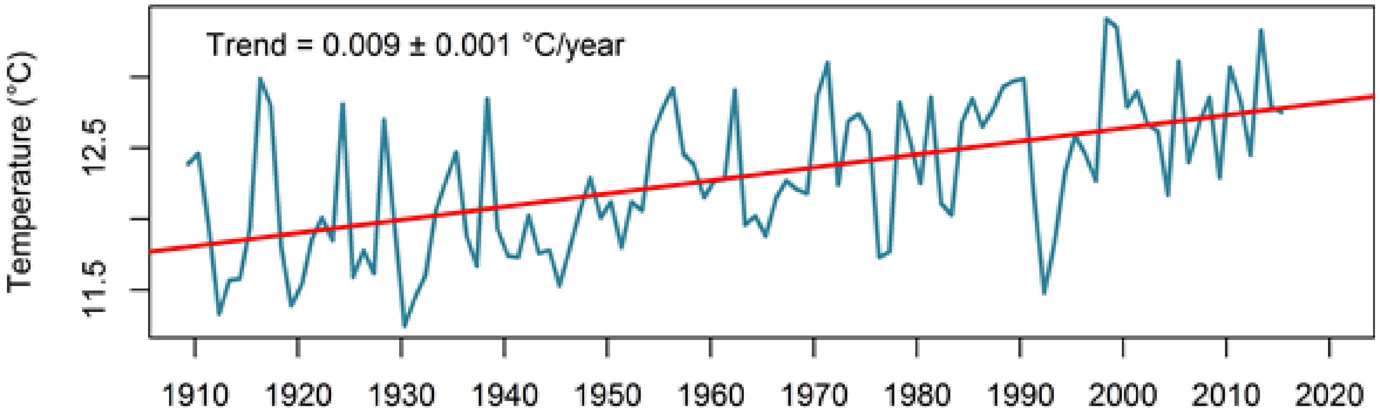
Interdecadal Pacific Oscillation (IPO) and Southern Annular Mode (SAM)

- IPO - Pacific sea surface temperatures show variation on a multi-decadal timescale
  - Long-lived fluctuations in rainfall and temperature coincide with IPO variations
  - Increase in temperatures around 1950 coincides with change from +ve to –ve phase IPO
  - Switch from negative to positive IPO in the late 1970s coincided with significant rainfall changes
- SAM - Measure of strength and position of the westerly winds around the mid-latitudes of the Southern Hemisphere
  - Expressed as strength, frequency and location of the westerly winds across SI
  - Higher SAM index, weaker westerly winds over SI



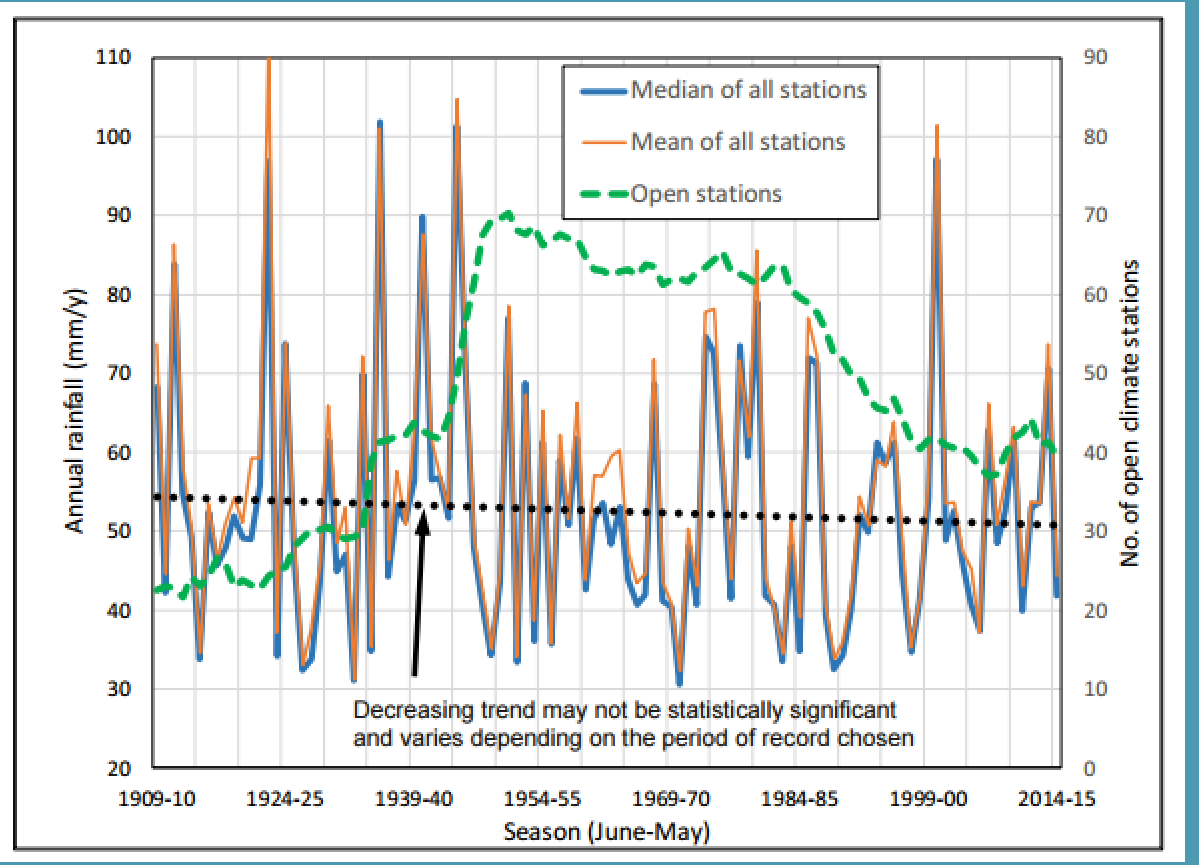
Climate trends

- Global climate is undergoing change
- 1^0 change in temperature in NZ over the last 106 years (Mullen et al, 2010) based on 7 climate stations
  - Confirmed through analysis of temperature data from CTSE data
- Current MfE guidelines suggest 8% increase in extreme event magnitude for each degree rise in T
- Possible 0.8^0 change to 2048



Impacts of climate cycles/trends on extreme rain events

- Looked at trends in extreme rainfall for stations with extended data across the Plains
  - No observable relationship with climate cycles/trends

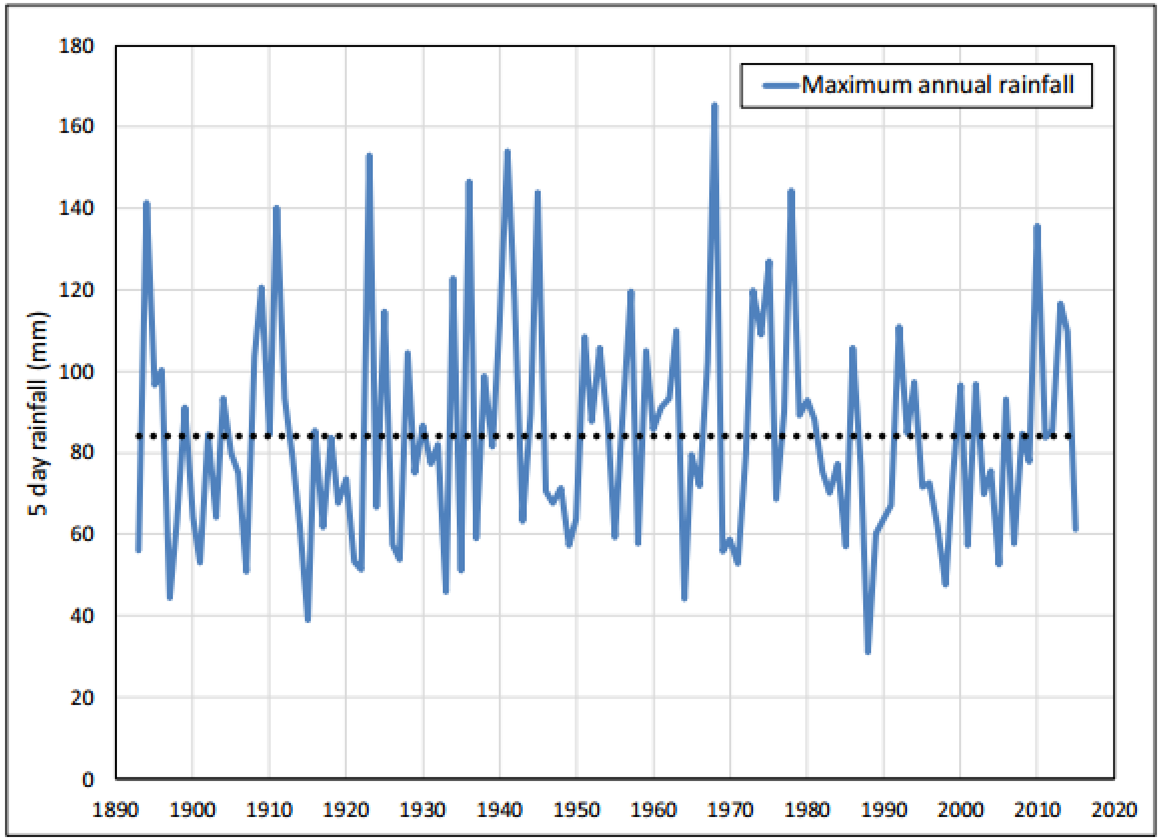


Impacts of climate cycles/trends on extreme rain events

- High rainfall change with temperature:
  - ChCh airport
    - High rainfall days decreased with increase in temperature
    - Expect 5% reduction in number of high rainfall events by 2048
  - Arthurs Pass
    - High rainfall days increased with increase in temperature
    - Opposite with an increase of 5% by 2048
  - Castle Hill and Lake Coleridge – no statistically significant change

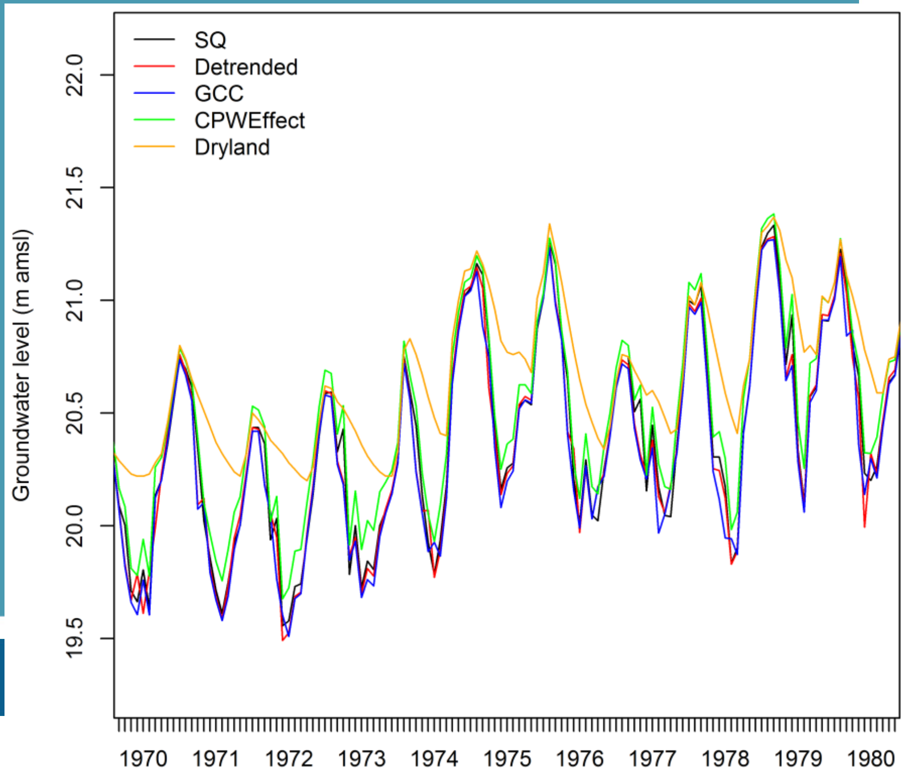
Impacts of climate cycles/trends on extreme rain events

- Little evidence of increase in extreme rainfall events as a result of the past 100 years' increase in temperature
- Guidelines may be conservative for Selwyn District



Climate effects on Environmental Variables: Groundwater levels

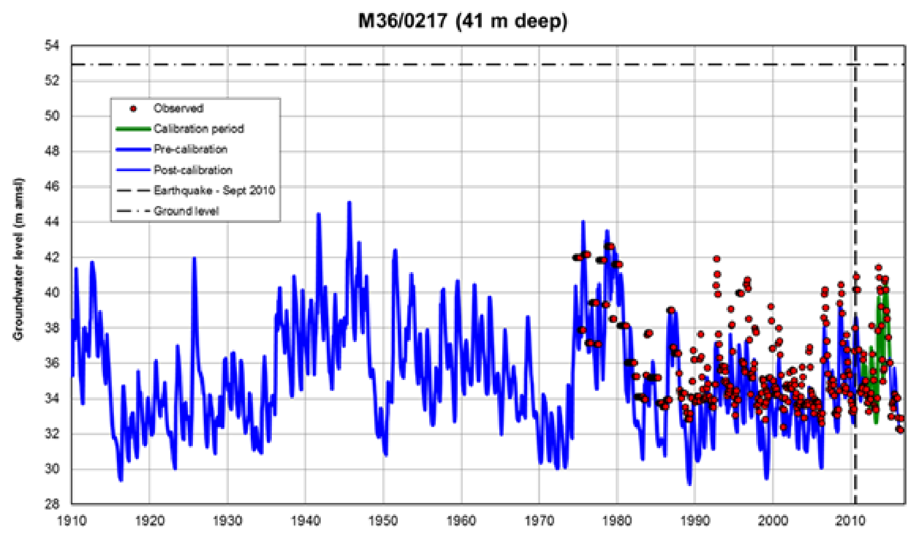
- Of interest:
  - Minimum levels in the upper Plains for water supply
  - Maximum levels in the lower Plains - stormwater, drainage and wastewater
- Recharge generated and input to eigen models
- Calibrated to groundwater time series and extended back in time
- Can then apply climate trend to recharge data to assess changes
- Some evidence for a change in ET



Climate effects on Environmental Variables: Groundwater levels

- No statistically significant relationships identified between:
  - Climate indices (SAM and ENSO) and annual maxima and minima for GWLs
  - Annual series’ for GWLs and different phases of the IPO
- Possible increasing trend in ET

  -- But no trend in the annual extremes of groundwater levels

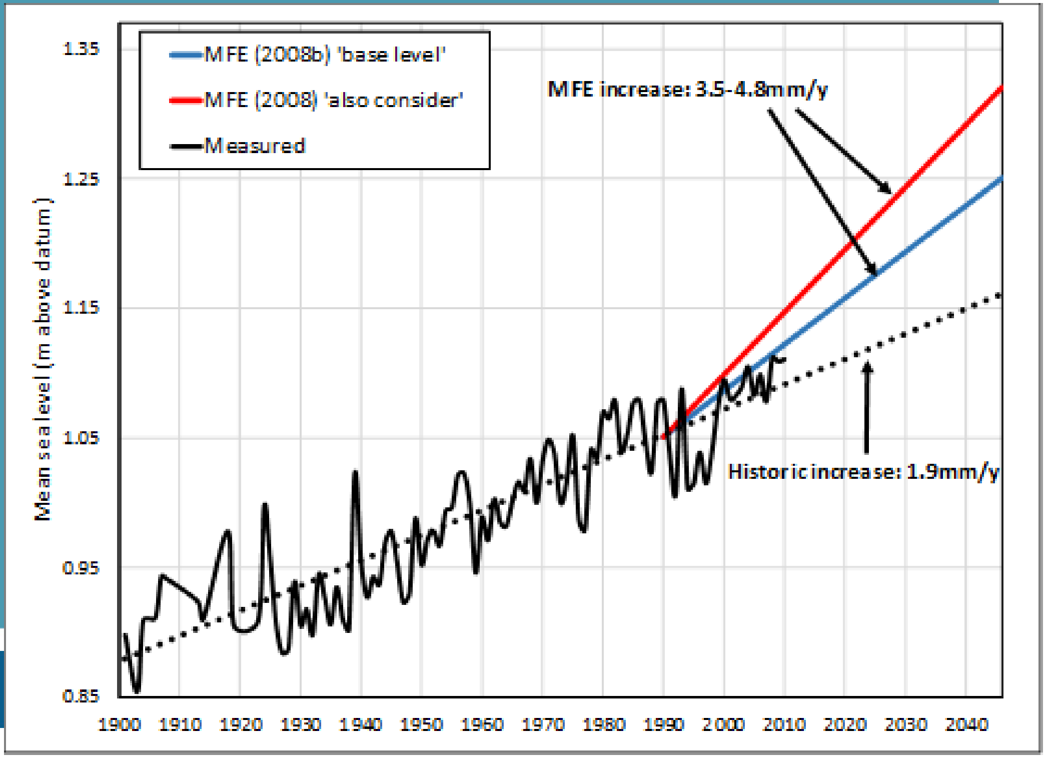


Climate impacts on groundwater levels

- The lack of any significant projected impact is primarily because
  - Do not expect large change in annual rainfall characteristics over the next 30 years
  - Only a small possible increase in ET during summer
- Inter-annual variability is high relative to mean annual range
  - Any change masked by natural variability

Climate impacts on sea level rise

- SLR has the potential to impact on coastal communities and Te Waihora/Lake Ellesmere.
- MFE (2008) projected SLR over the next 100 years of one to three times historic rate
- If SLR rise follows historical trajectory, rise would be limited to 0.08 m by 2048
- Conservative approach allows for 0.23 m rise by the 2040s relative to the period 1980-1999

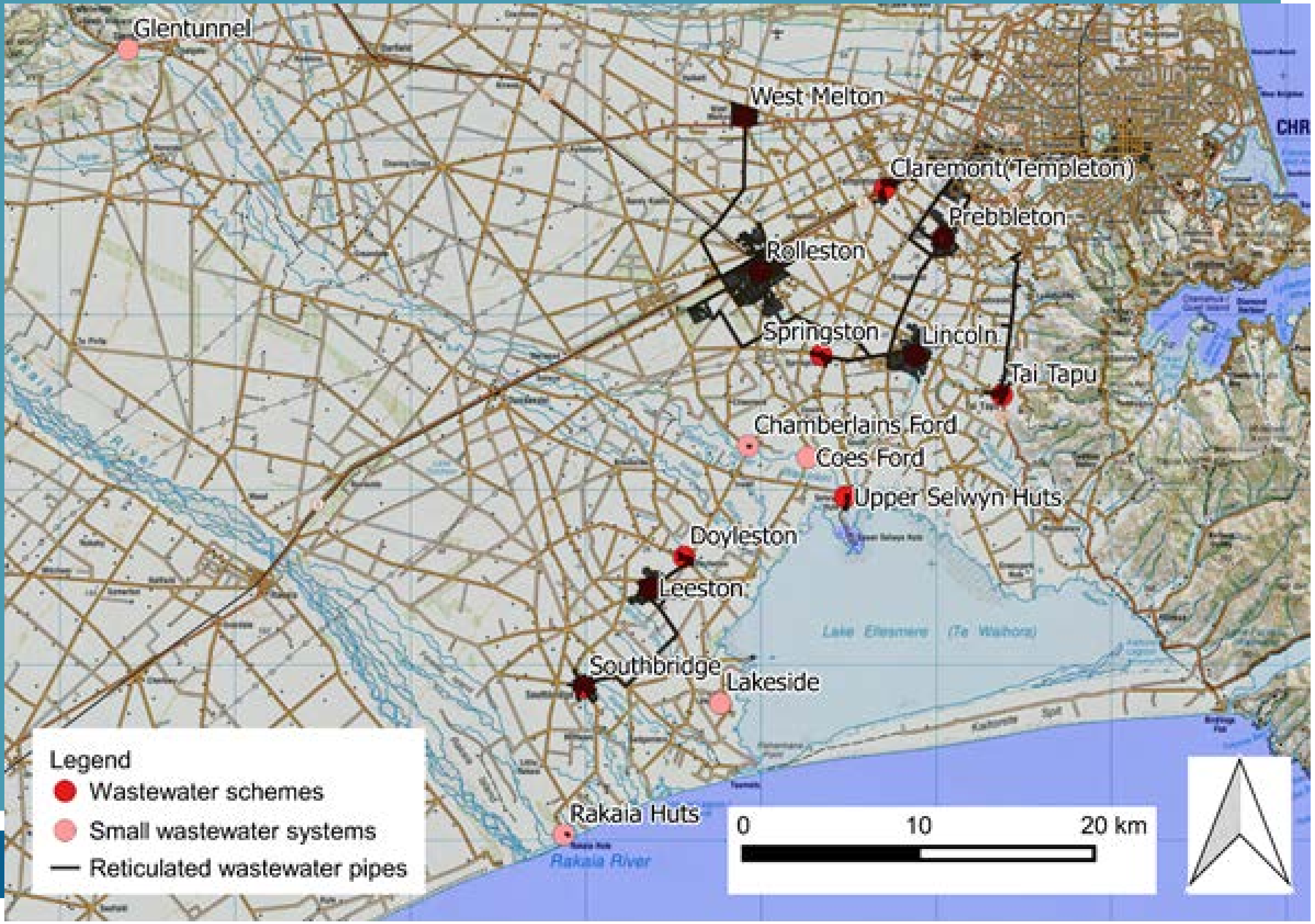


Lake Ellesmere/Te Waihora

- Higher sea levels will affect Te Waihora/Lake Ellesmere water levels
  - SLR will result in changes to lake operating procedures
- Lake levels could rise 0.08 m (the historic trend in sea level rise) to 0.23 m (the MFE 2008 sea level rise upper limit guide) by 2048
- Additional to increases caused by flood events

SLR and Lake Ellesmere/Te Waihora

- Potentially affected communities
  - Upper and Lower Selwyn Huts and Raikaia
  - Stormwater, waste water and drainage networks will have reduced efficiency.

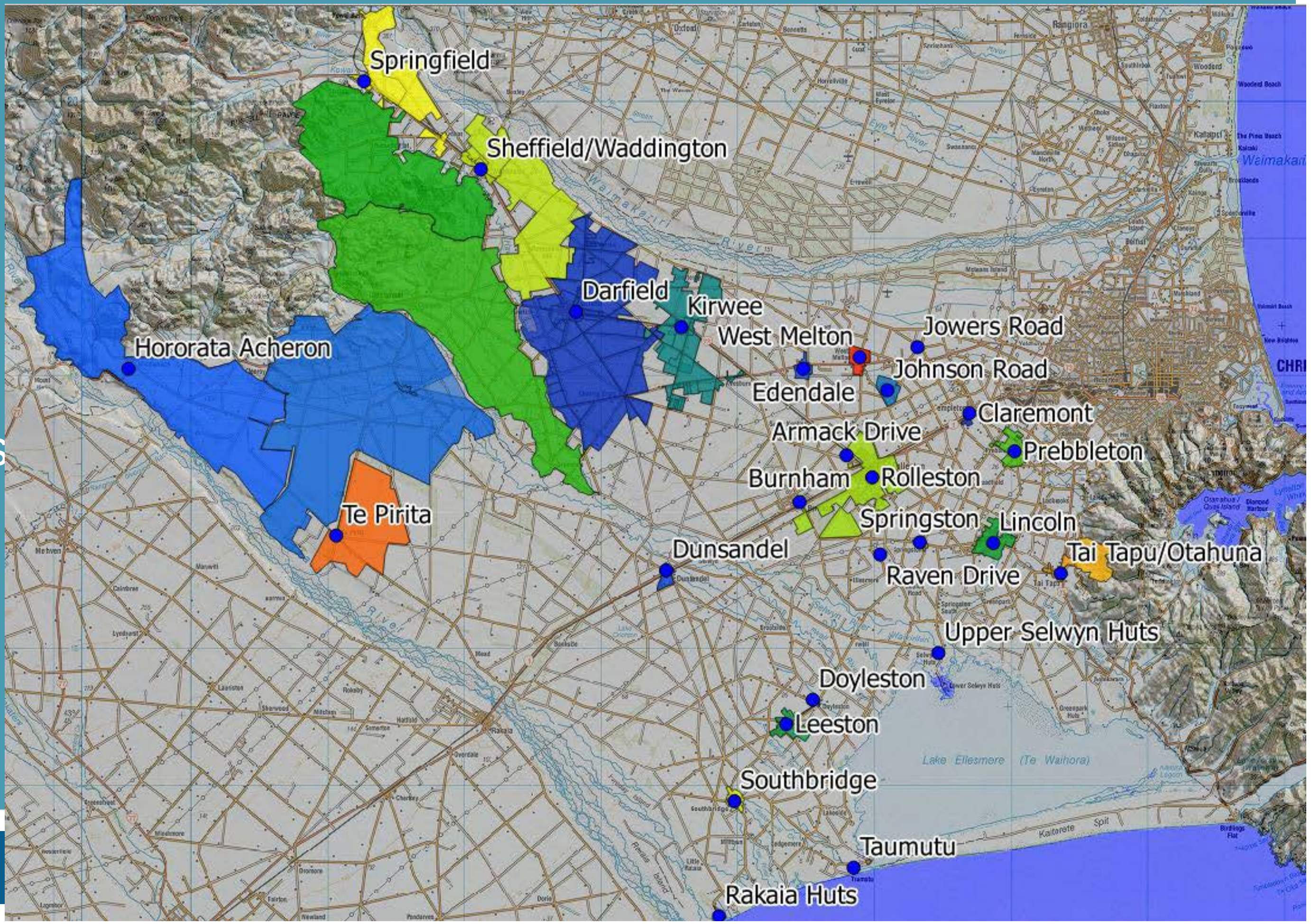


SLR impacts on groundwater levels

- Effect of sea level rise on groundwater levels greatest at the coastal boundary
- At increasing distances inland from the coast, the rise reduces
- Specific modelling of groundwater level rise as a result of sea level rise was not conducted for this study, though ongoing for another project
- From other studies, SLR of 1 m was estimated to lead to a 0.2 m GWL rise approximately 3 km inland
- For this study, estimated that no more than ~0.05 m (20% of 0.23 m maximum rise) might propagate 0.5-1.0 km inland from the coastal boundary

Impacts on potable water supply

- Projected CC predicted to cause a slight decrease in groundwater levels across the Plains
- Main factor that is projected to change is ET
  - Possibly slightly longer and more frequent periods of water restrictions

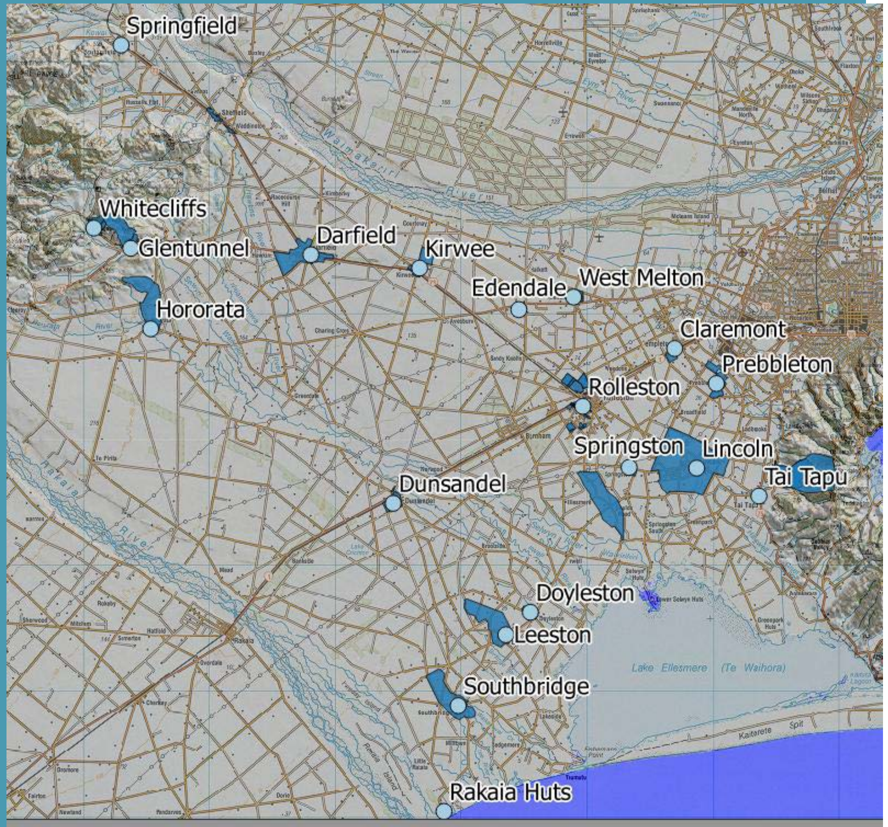


Impacts on potable water supply

- In alpine areas, CC may have more significant impact
- Increase in mean annual rainfall and flood flows
- May have some impact on Arthurs Pass, Castle Hill and Lake Coleridge water supplies
  - Actual impact will depend on the individual vulnerability of the sources to floods
- SLR of 0.23 m could result in minor increased risk of saltwater intrusion at Rakaia Huts' shallow bore

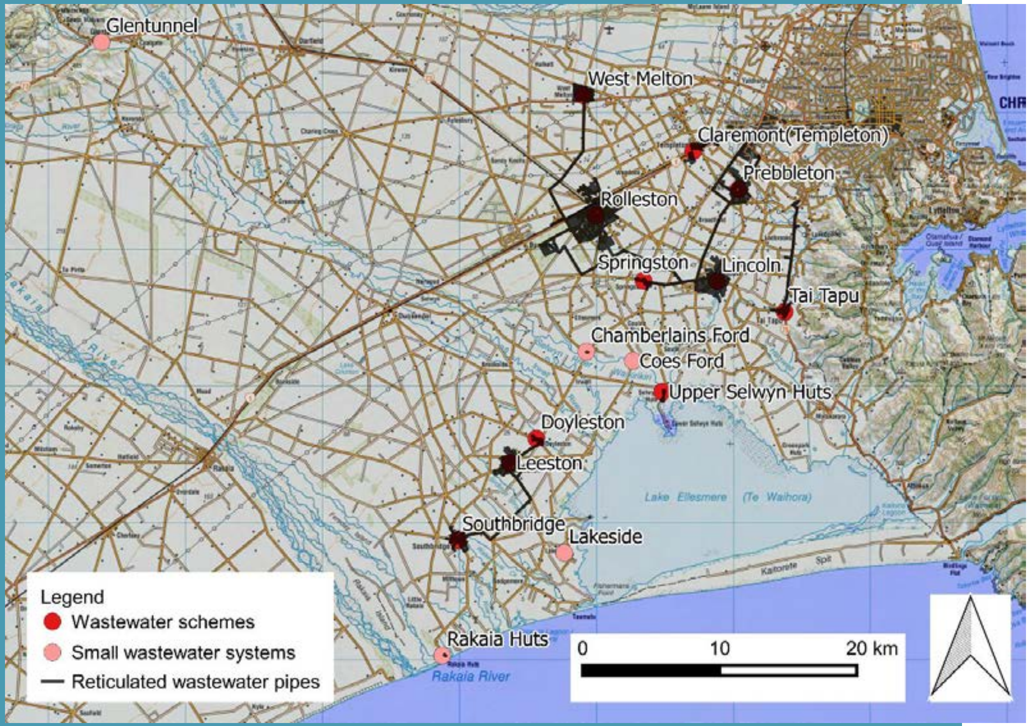
Impacts on stormwater systems

- Changes in extreme events not anticipated to have a noticeable impact on most stormwater assets
  - Potential changes in extreme rainfall small
- In the mountain areas of the district
  - Greater likelihood of increased rainfall
  - Resulting impact on stormwater systems
- SLR could also have an impact on stormwater drainage systems in the lower plains (Rakaia Huts)



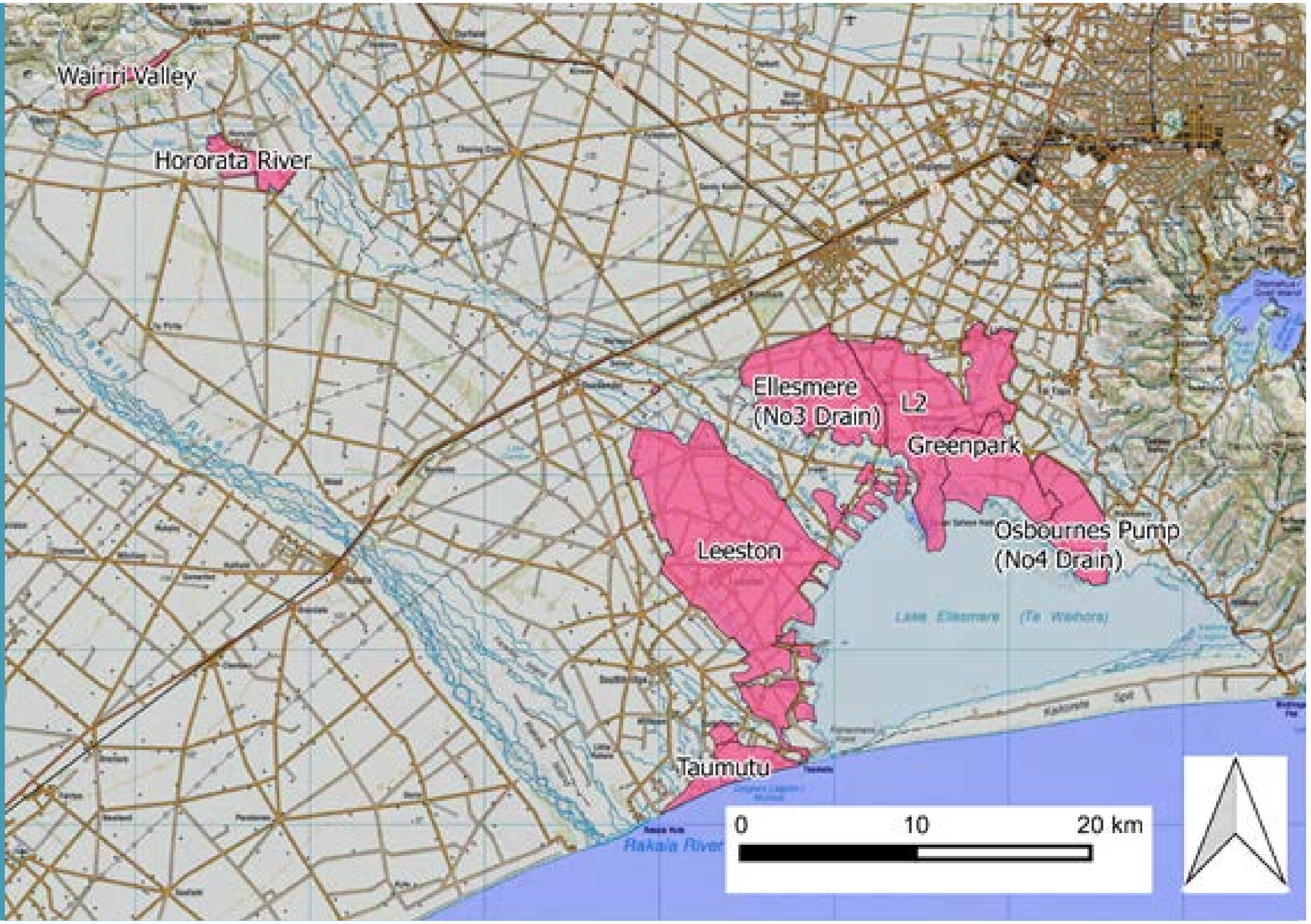
Impacts on waste water

- Main environmental factor is sea level rise
  - Upper Selwyn Huts , Rakaia Huts and Lakeside wastewater system
  - Small positive impact on the Leeston sewage treatment plant
- In mountain areas, increase in rainfall may have some impact



Impacts on land drainage

- Increased sea levels and increase in lake levels in Lake Ellesmere/Te Waihora
  - Impact on the effectiveness of council's land drainage network around the lake
  - Higher lake level could flood the land in the immediate vicinity of the lake, and also result in increased backwater effects



Maximum extent that lake levels could affect land drainage

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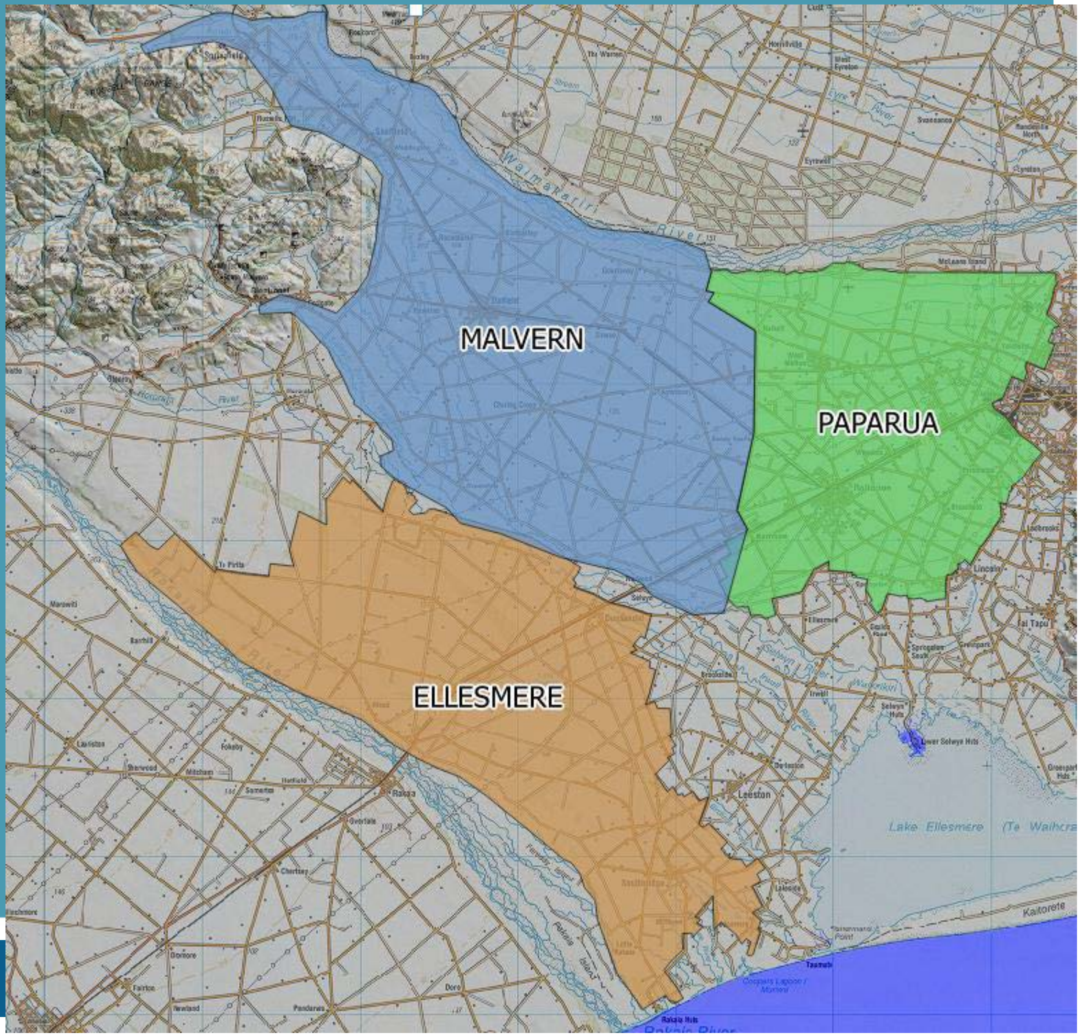
Impacts on water races

- Climate change will probably have only a minor impact on most aspects of the council's water race assets
- Potential positive impact is that the higher Rakaia and Waimakariri flows would improve the reliability of supply



Discussion

- Climate change is likely to cause an increase in:
  - Temperature, ET, mountain rainfall and sea level
- As a result, we are likely to see:
  - Slight decrease in groundwater levels across the Plains
  - Increase in summer water demand
  - Increase in mountain rainfall
    - Water intake damage
    - Impacts on flood protection infrastructure
  - Increased vulnerability to flooding and impacts on waste water, stormwater and land drainage in lowland areas due to SLR
  - Minor increase in potential for saline intrusion in shallow bores

Asset vulnerability to changes in environmental factors

Environmental factor	Water	Wastewater	Stormwater	Land drainage	Water Races
Ground water levels (upper plains)	High	Minor	Minor	Minor	Minor
Ground water levels (lower plains)	Low	High	High	High	Low
Annual rainfall	Moderate	Minor	Minor	Minor	Moderate
Extreme rainfall (Plains)	Moderate	High	High	High	Moderate
Extreme rainfall (foothills and alpine)	High	High	High	High	Moderate
Alpine river flows	Moderate	Minor	Minor	Minor	High
Foothill and lowland river flows	Moderate	Minor	Minor	Minor	High
Evapotranspiration (ET)	High	Minor	Minor	Minor	Minor
Sea Level rise <0.23m	Minor	Low	Low	High	Minor
Snow and ice (excl. alpine river flows	Minor	Minor	Minor	Minor	Low positive
Temperature (excl. ET impacts)	Minor	Minor	Minor	Minor	Minor
Wind (excluding ET impacts)	Moderate	Moderate	Minor	Minor	Minor

Likely impacts on assets over the next 30 years

Environmental factor	Water	Wastewater	Stormwater	Land drainage	Water Races
Ground water levels (upper plains)	Moderate	Minor	Minor	Minor	Minor
Ground water levels (lower plains)	Minor	Moderate	Moderate	Minor	Minor
Annual rainfall	Minor	Minor	Minor	Minor	Minor
Extreme rainfall (Plains)	Minor	Minor	Moderate	Minor	Minor
Extreme rainfall (foothills and alpine)	Moderate	Moderate	Moderate	Minor	Minor
Alpine river flows	Minor	Minor	Minor	Minor	Minor
Foothill and lowland river flows	Minor	Minor	Minor	Minor	Minor
Evapotranspiration (ET)	Minor	Minor	Minor	Minor	Minor
Sea Level rise <0.23m	Minor	Minor	Moderate	Moderate to high	Minor
Snow and ice (excl. alpine river flows impacts)	Minor	Minor	Minor	Minor	Minor
Temperature (excl. ET impacts)	Minor	Minor	Minor	Minor	Minor
Wind (excluding ET impacts)	Minor	Minor	Minor	Minor	Minor

Conclusions

- Large scale climate cycles show little relationship with various water asset-affecting environmental variables
- Climate trends are apparent in historic temperature and sea level records and are projected to continue to increase
  - In spite of this historic increase statistically significant trends were limited in the environmental variables assessed
- Projected climate change will likely only have a minor impact on most aspects of Selwyn District Council’s water assets over the next 30 years
- Lack of impact is likely to be a result of the high natural variability of climate, particularly rainfall, for the region

Acknowledgements

- Peter Brown
- Caroline Ellis

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