Groundwater in the Goulburn-Broken Catchment

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Groundwater: controlling catchment health

- Salinity
  - groundwater, surface water and soils
- Groundwater as a resource
  - aquifer behaviour, groundwater age, groundwater quality and quantity
- Groundwater as inputs to rivers
  - baseflow to streams, reservoirs and rivers

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Goulburn-Broken groundwater research

- Regional groundwater flow and aquifer quality
- Refining the dryland salinity model
- New research (CWLM)
  - groundwater and surface water in the upper Goulburn
  - solute loads in space and time

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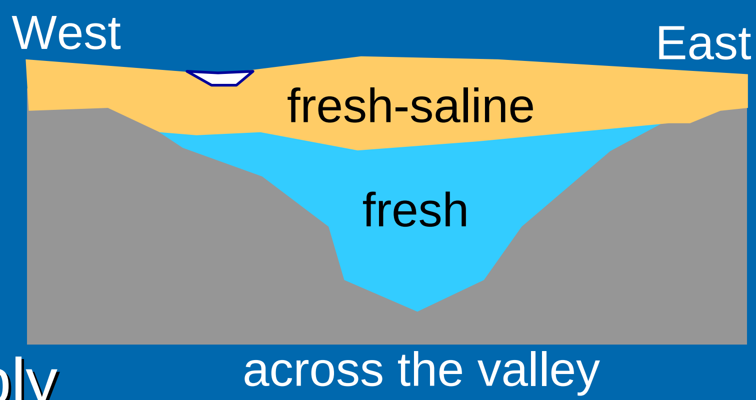
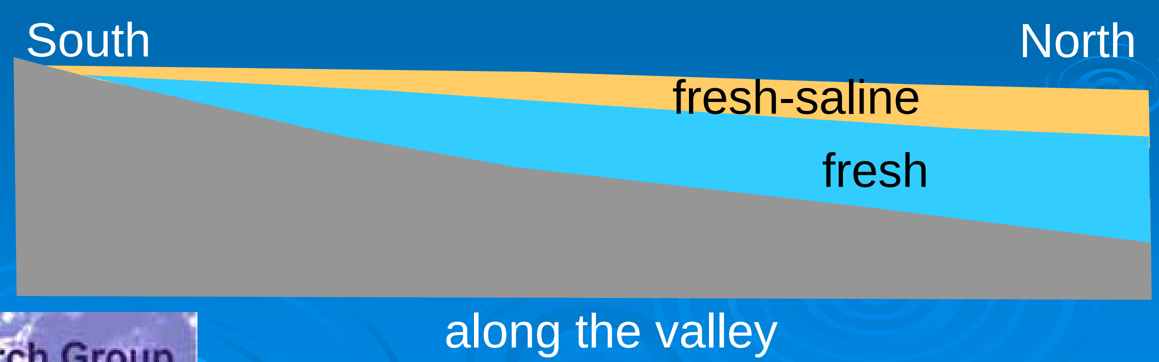
Regional groundwater resources



Two main aquifers in the Goulburn Catchment

- Shepparton Formation
  - sands and clays, local water supply
  - variable groundwater quality
- Calivil-Renmark (Deep Lead)
  - sands and gravels, major supply
  - high groundwater quality



Goulburn Valley

- Basement
  - sediments and granites
  - depth to basement increases northwards
- Renmark-Calivil sediments
  - up to 150 m thick in north
  - deep lead (in palaeovalley)
  - not at surface
- Shepparton Formation
  - up to 70-80 m thick in N
  - covers deep lead aquifer

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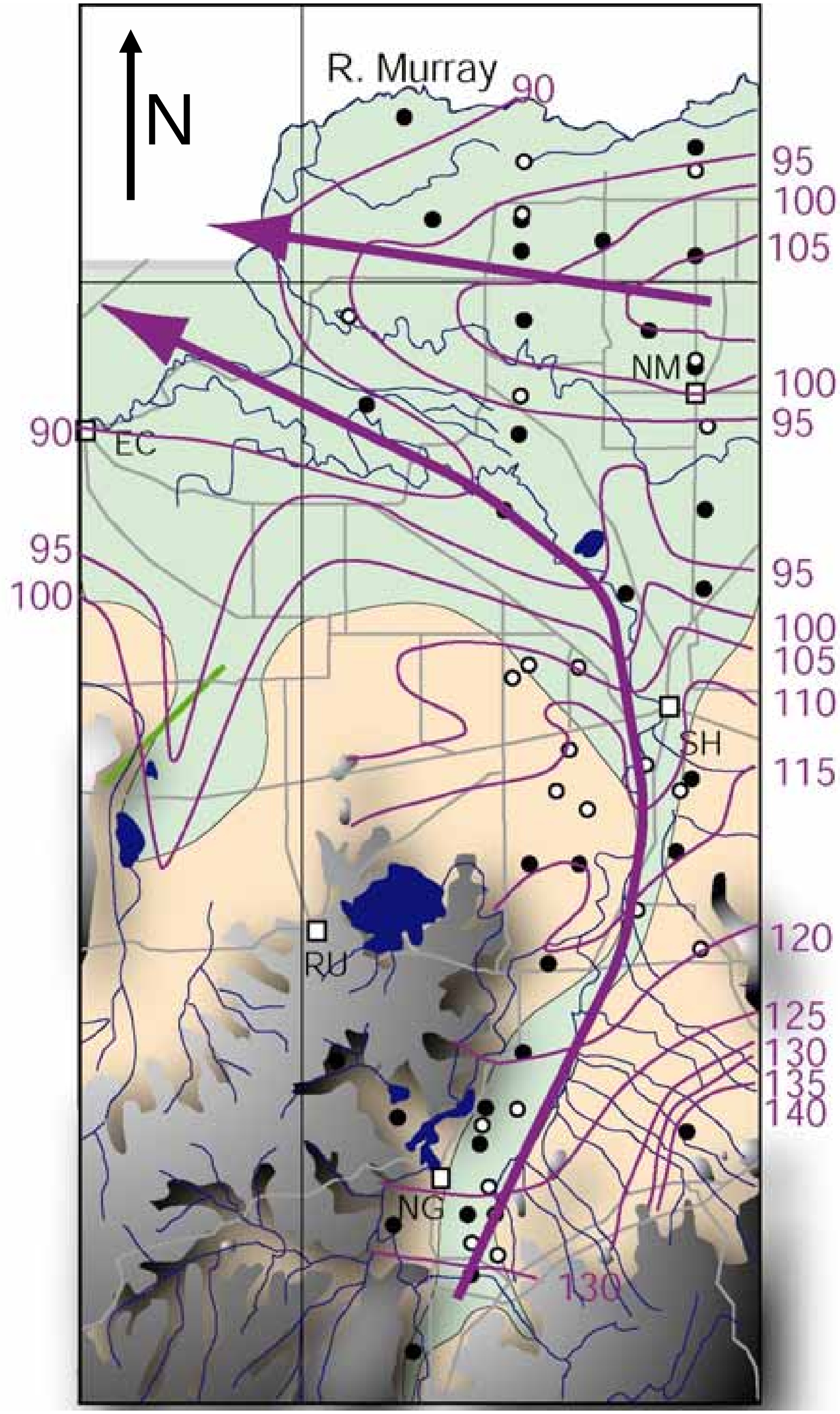
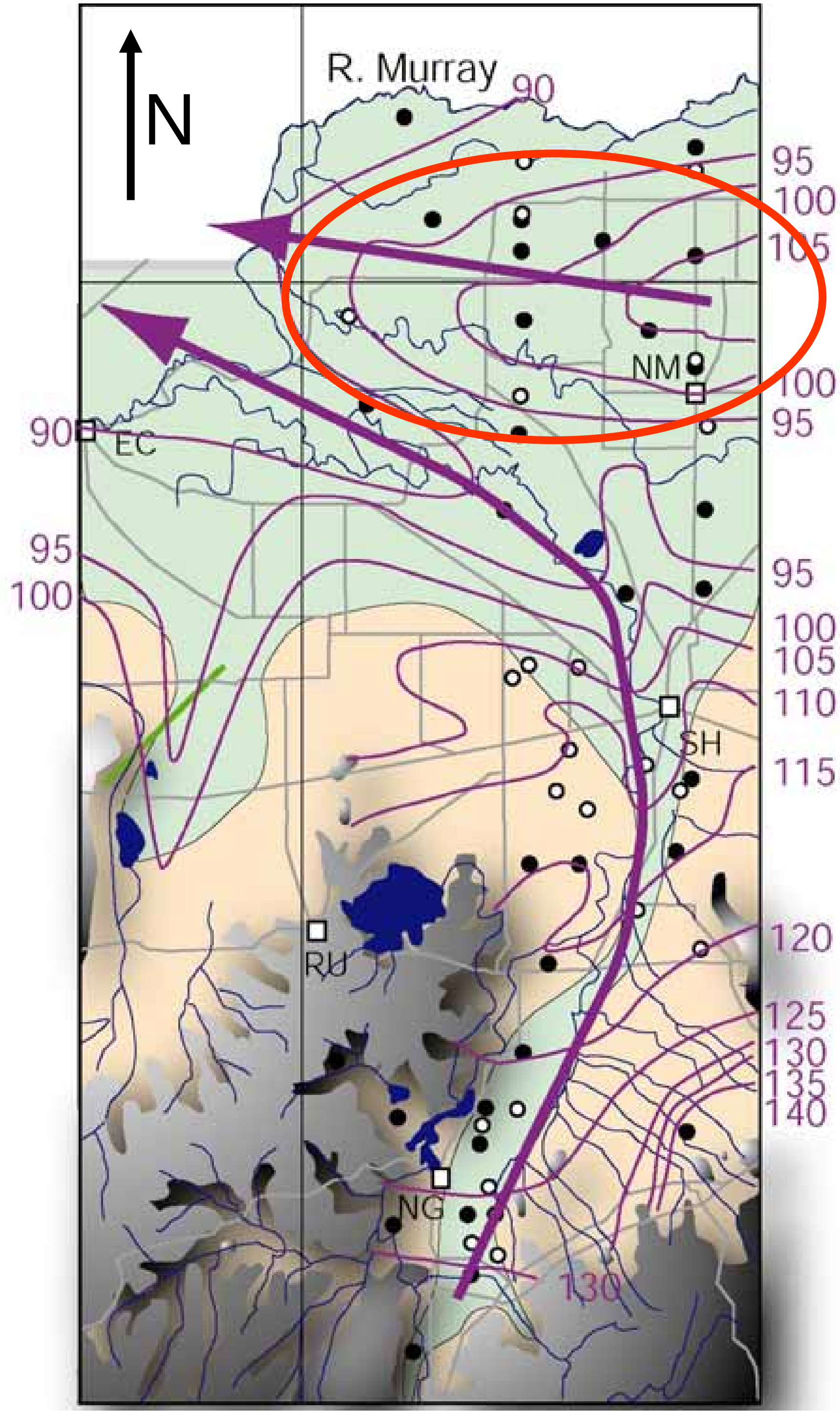


Flow Paths

- Flow paths
  - N to NW along deep lead system
  - groundwater mound in North
  - recharge area for Shepparton aquifer



Groundwater chemistry

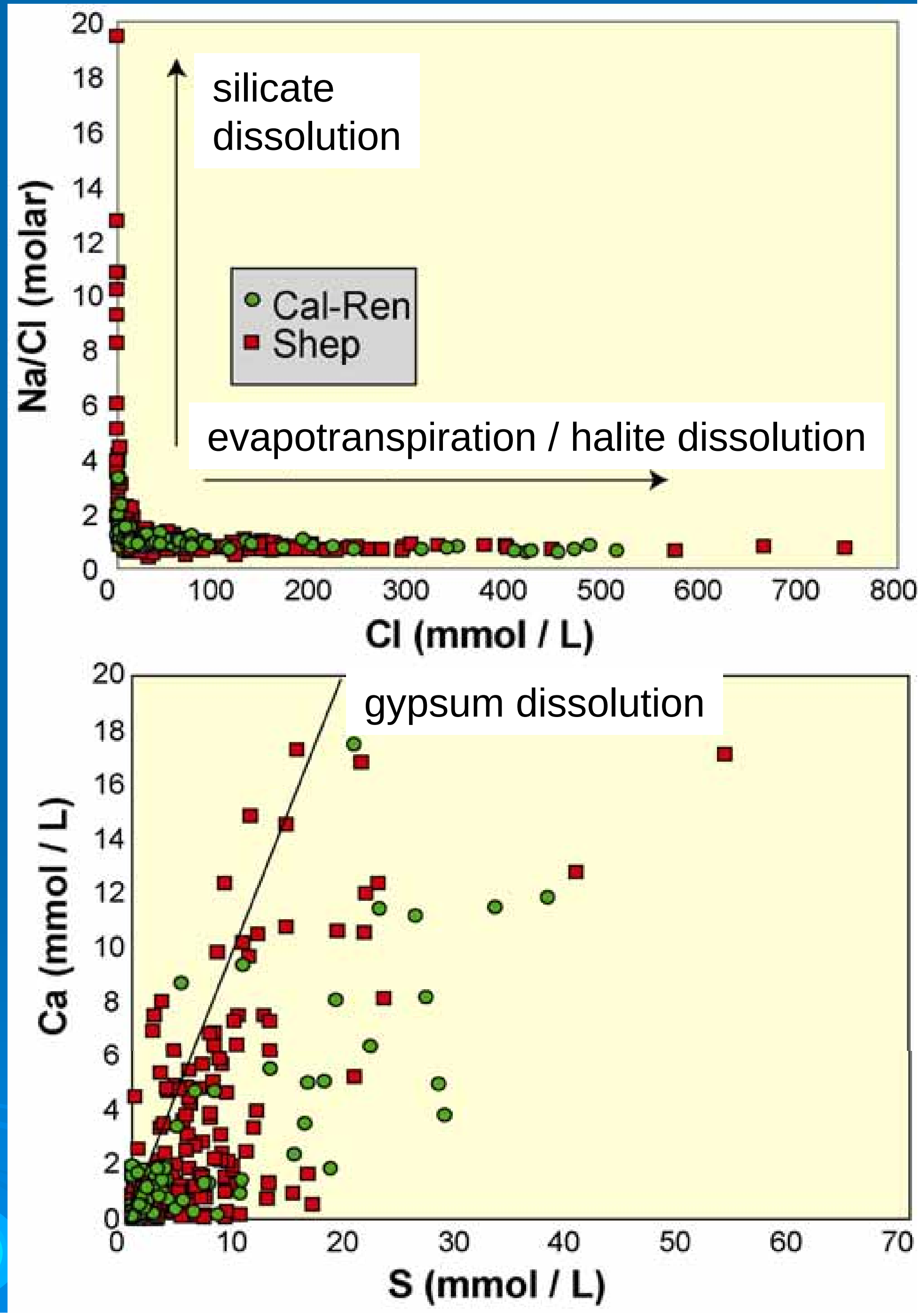
- Why is the groundwater quality the way it is?
  - reactions with rocks along flow
  - evapotranspiration during recharge or discharge
  - mixing between shallow and deeper aquifers

What we measure

- Major and minor ions
  - Cl, SO_4, HCO_3, Ca, Mg, Na, K
  - nitrate, bromide, fluoride, strontium
- Isotopes
  - stable isotopes of water (δ^2H, $\delta^{18}O$)
  - carbon isotopes (^{14}C, $\delta^{13}C$)
  - strontium isotopes (^{87}Sr/ ^{86}Sr)
- Hydraulic head, EC, pH, dissolved oxygen

Sources of solutes

- both formations similar
  - fresh to saline
- most solutes from rainfall
- silicate weathering adds more sodium (Na)
- minor dissolution of gypsum ($CaSO_4$)



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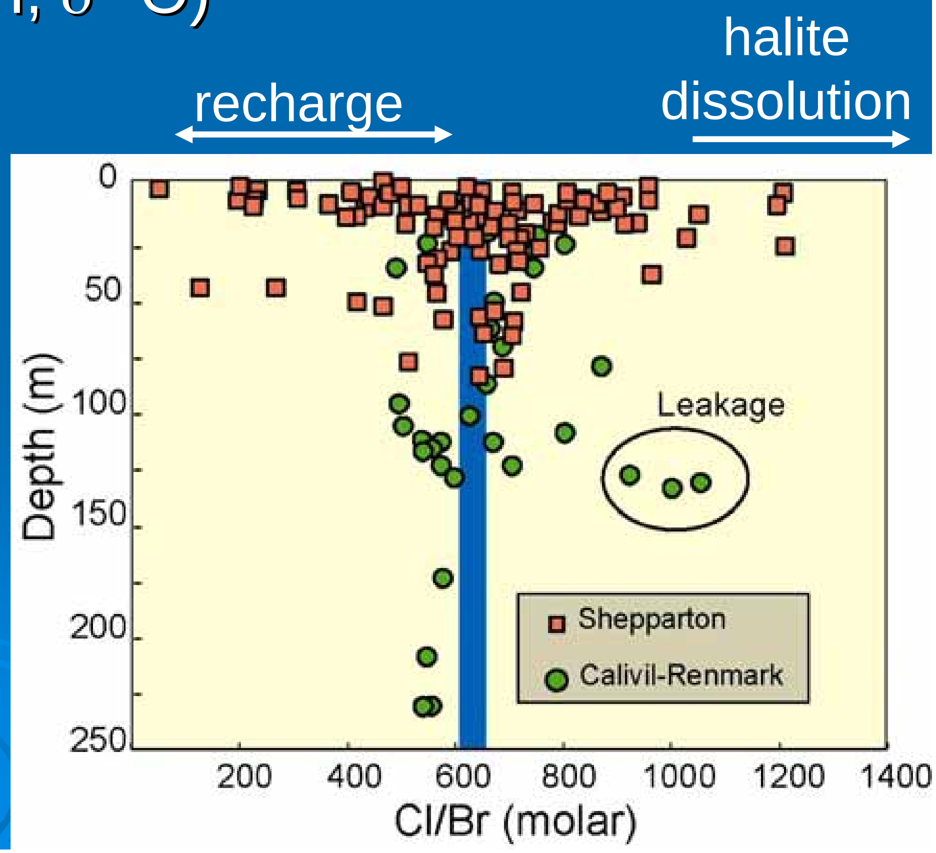
Salinity development along flow paths

- evaporation & evapotranspiration vs halite (NaCl) dissolution
  - Cl (conservative) vs Br (more conservative)
  - stable isotopes of water (δ^2H, $\delta^{18}O$)
- Increase total dissolved solids (TDS) by evapotranspiration
  - must occur during recharge into Calivil or through Shepparton to Calivil



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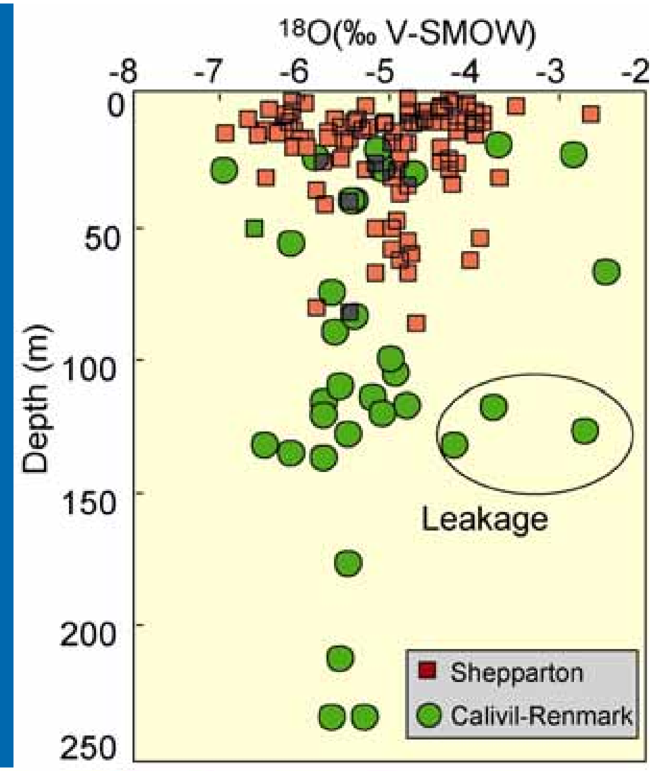
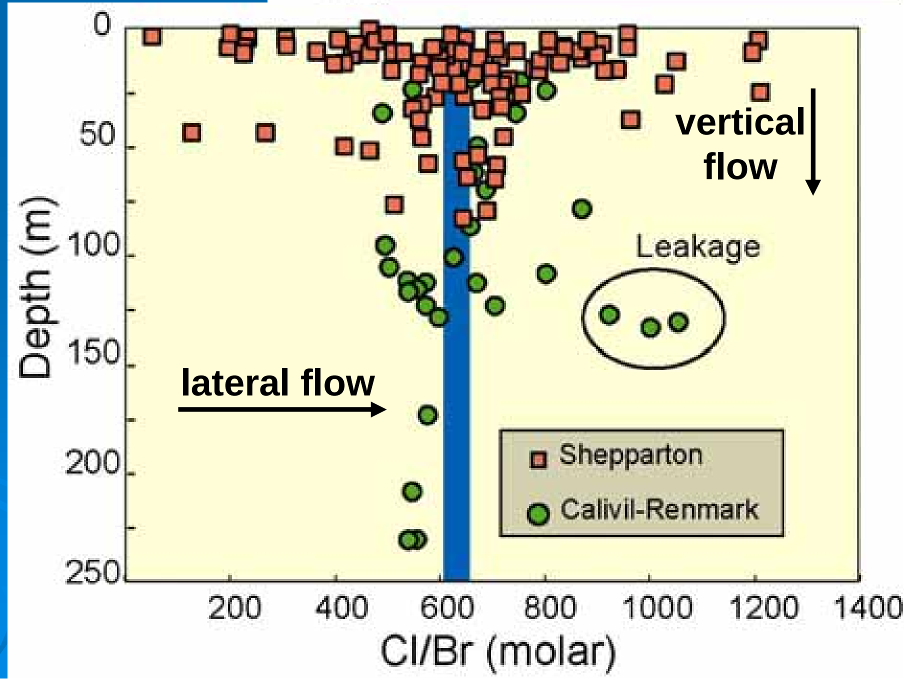
Solutes and flow paths

- More variable composition in shallow Shepparton Formation
  - vertical flow into deeper formation
- More consistent in Calivil-Renmark
  - lateral flow from recharge area

Some leakage in groundwater mound



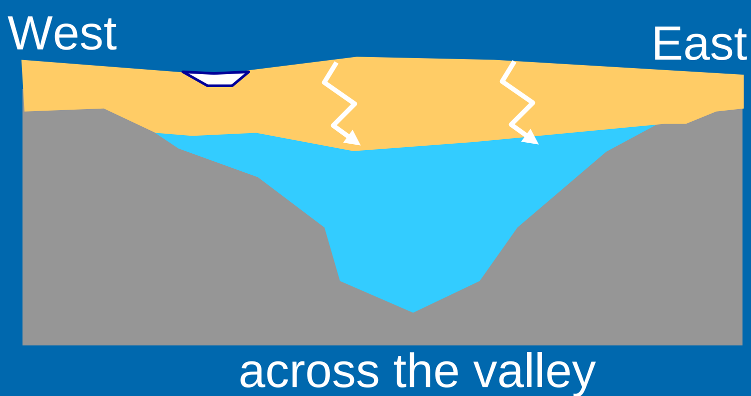


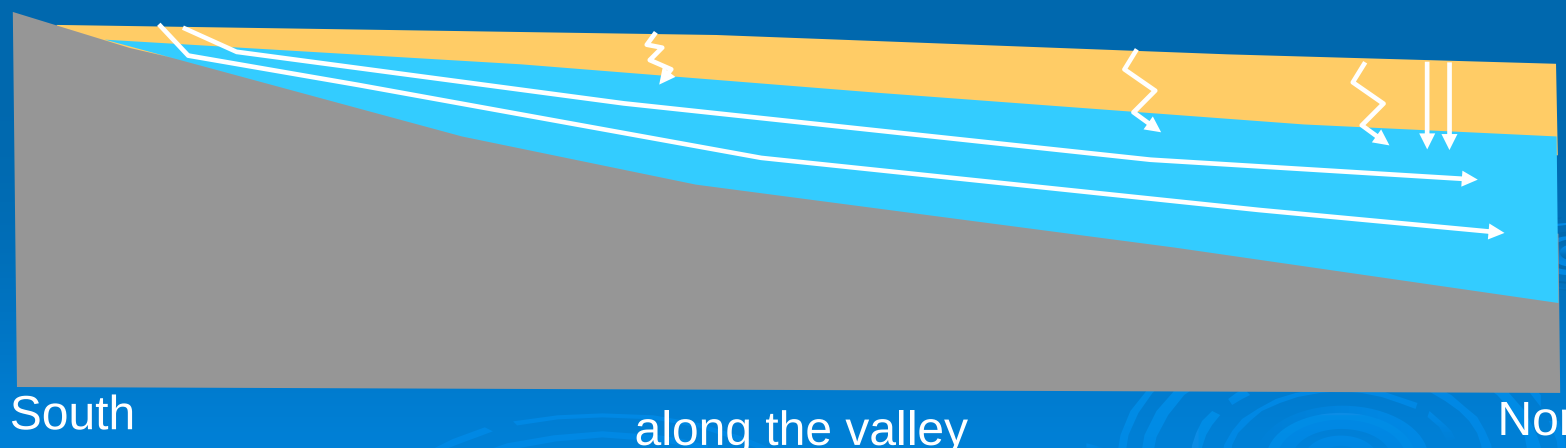
Summary to date

long-term leakage from Shepparton to Calivil-Renmark (regional)

shorter term local leakage from Shepparton to Calivil-Renmark

lateral flow within Calivil-Renmark (confined to semi-confined)





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Time frames for leakage & flow (^{14}C)

Vulnerability

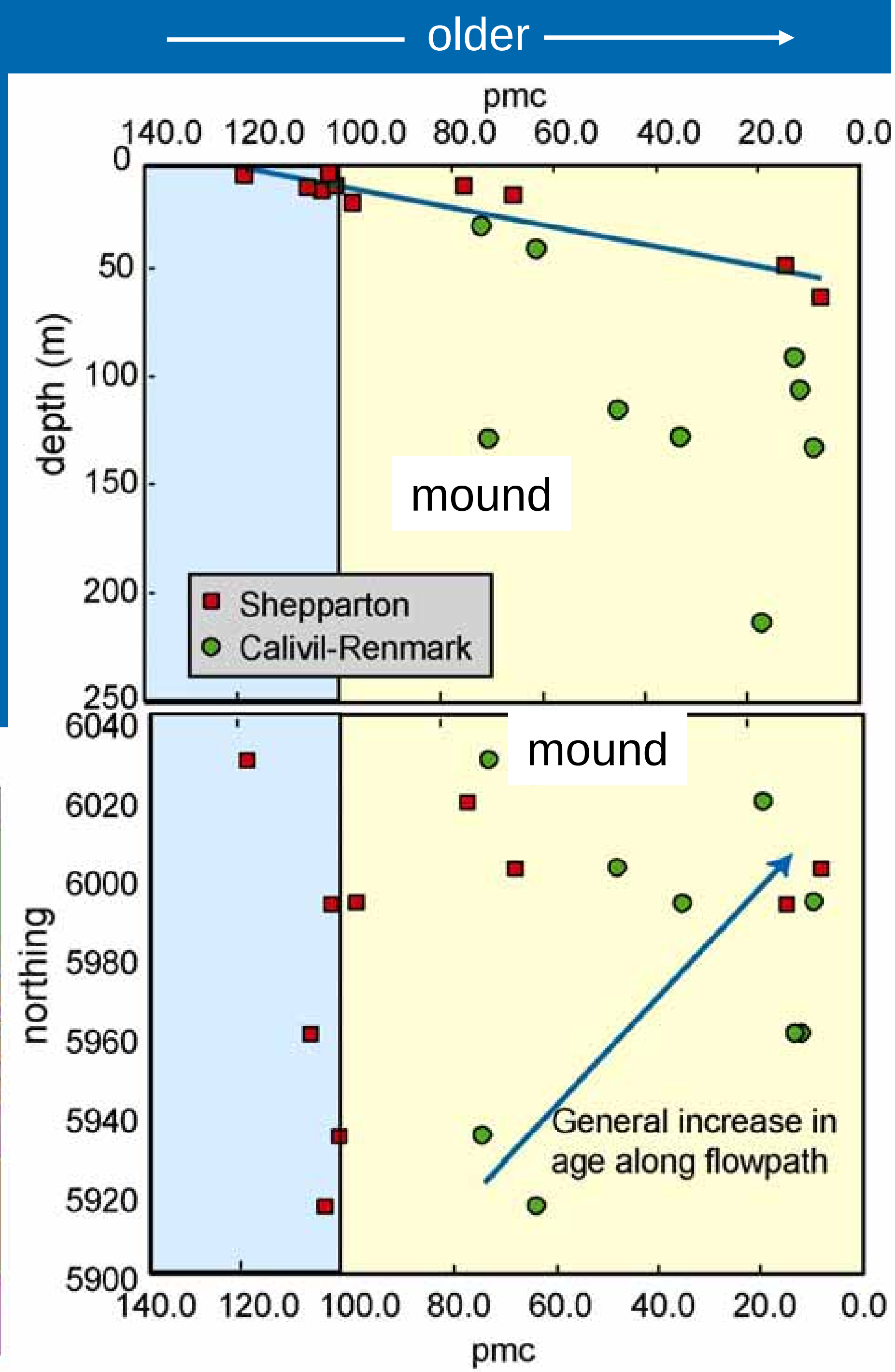
- What is long-term for leakage into Calivil-Renmark
- What is short-term for leakage through Shepparton

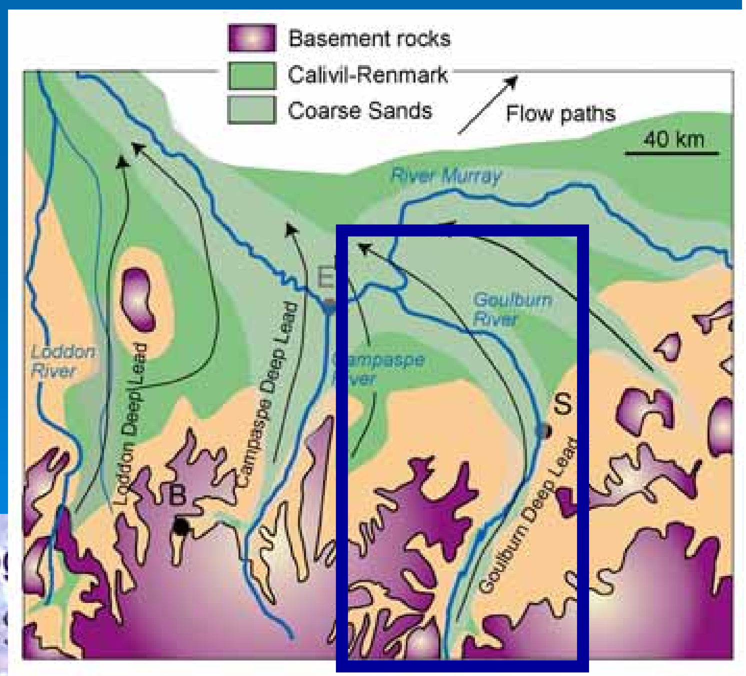
Sustainability

- What is groundwater residence time in Calivil-Renmark (sustainability)
- What is groundwater residence time in Shepparton (sustainability)

Groundwater Age -1

- Shepparton aquifer ■
  - ^{14}C increases with depth
  - vertical flow
  - residence times up to 28,000 years





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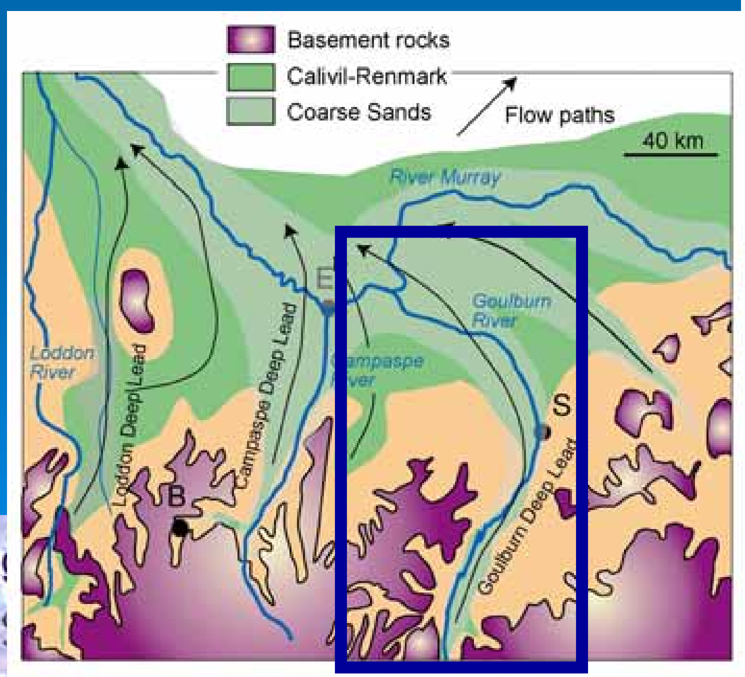
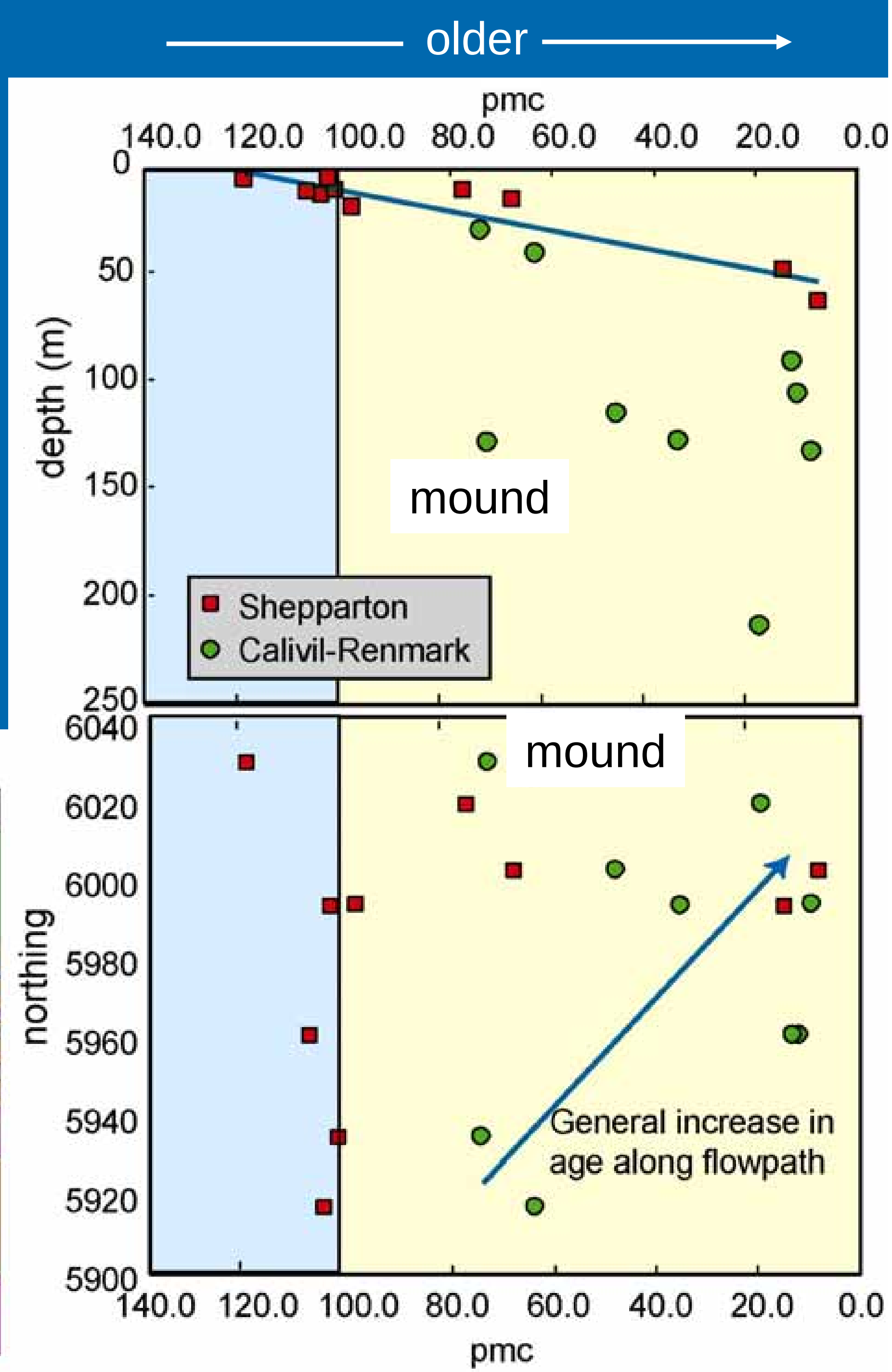
Groundwater Age -2

- Calivil-Renmark ●
  - ^{14}C varies with distance
  - lateral flow along valley
  - older to north
  - residence times to 28,000 years





Recharge rate estimates

- ^{14}C long term recharge rates
  - Deep leads = 0.5 to 1.4 mm/yr
  - Intermediate areas = 0.1 to 0.4 mm/yr
- similar to Cl mass balance recharge rates

- Today's recharge rates
  - higher because of increased hydraulic gradient due to land clearing
- Sustainability
  - conservatively based on long-term, lower recharge rates

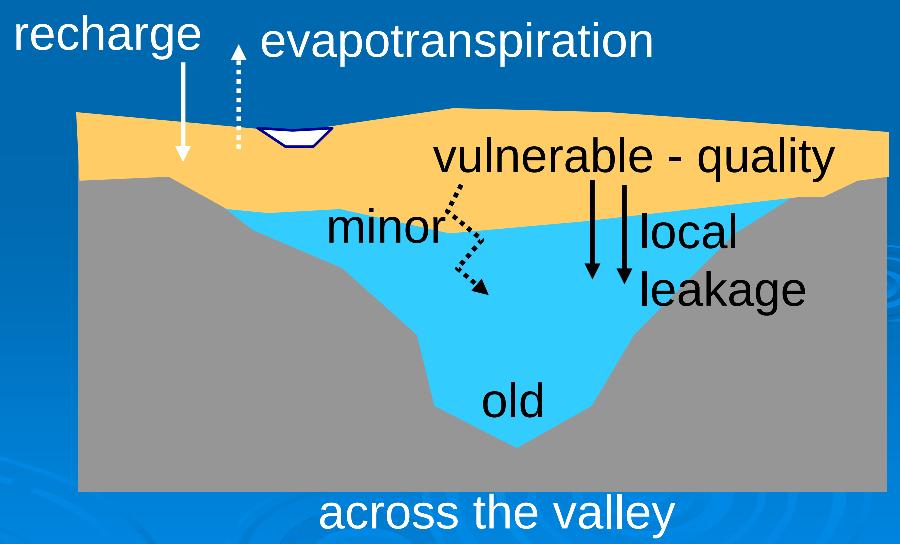
Results

- Groundwater levels show that flow to deep lead aquifer is *possible* in most of the region
- Chemistry shows that minor long-term leakage has occurred throughout region
- Dating shows that deep groundwater gets older to middle and towards north (up to 28,000 yr)
  - supports minor leakage
  - indicates limited recharge to deep aquifer
- BUT in *some* areas
  - nitrate (from agriculture), higher EC (from surface), younger groundwater (from shallow aquifer)

all show that *modern* leakage has occurred (mainly in north of catchment)

Groundwater vulnerability

- So, at the moment, deep lead aquifer is protected compared to Shepparton
  - Shepparton is vulnerable
- Care re pumping deep lead
  - cause more vertical flow
  - overpumping of limited resource (old)
- Other areas of vertical flow may be present (only some wells sampled)



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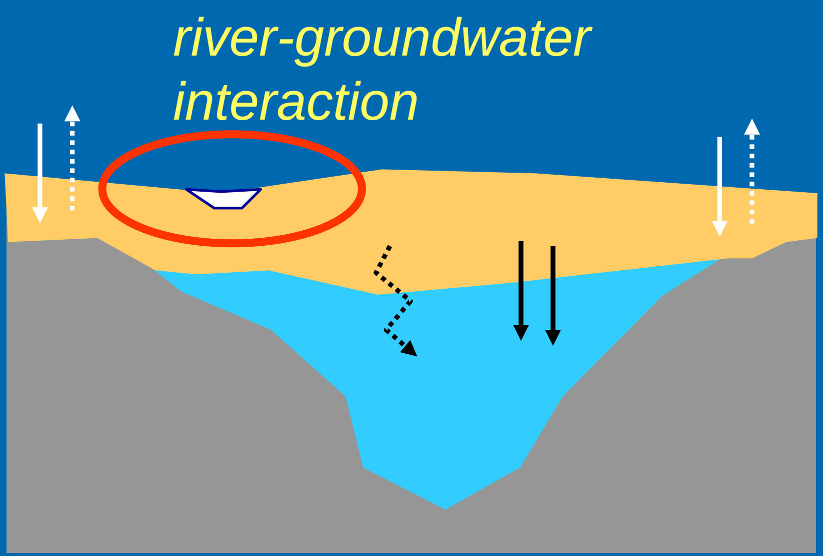
Current research



Focus on salt loads / chemistry into upper Goulburn River (CWLM)

- average vs extreme events
  - temporal variability of inputs
- chemistry and isotopes
  - processes
  - spatial variability
- groundwater, surface water, interflow, rainfall

tie in with

- current dryland salinity research (local scale)
- regional groundwater framework (larger scale)
- groundwater-river interaction and in-river chemistry (Ovens River)