IAH 36th Congress, Toyama, Japan 30 October 2008

Development of an integrated conceptual model of a connected surface water-groundwater system using a hydrochemical approach at Maules Creek, NSW, Australia.

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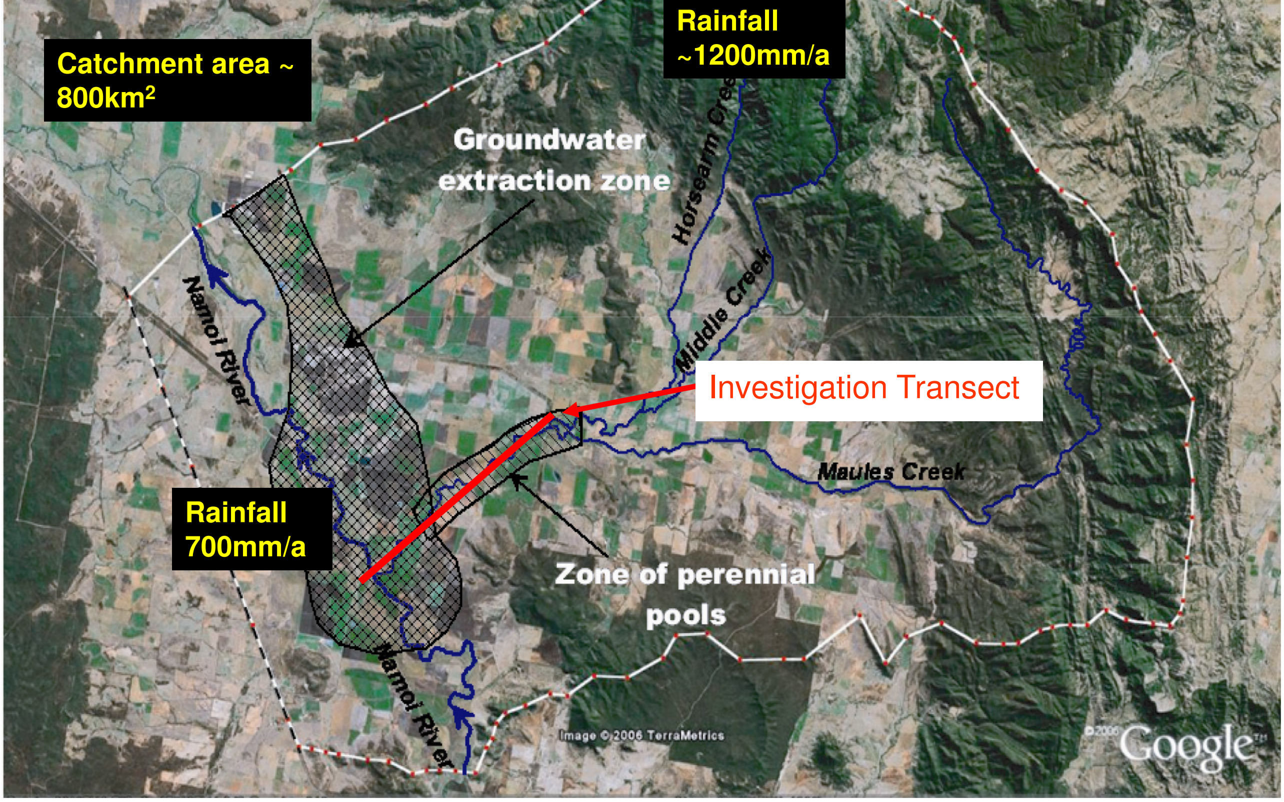
INTRODUCTION

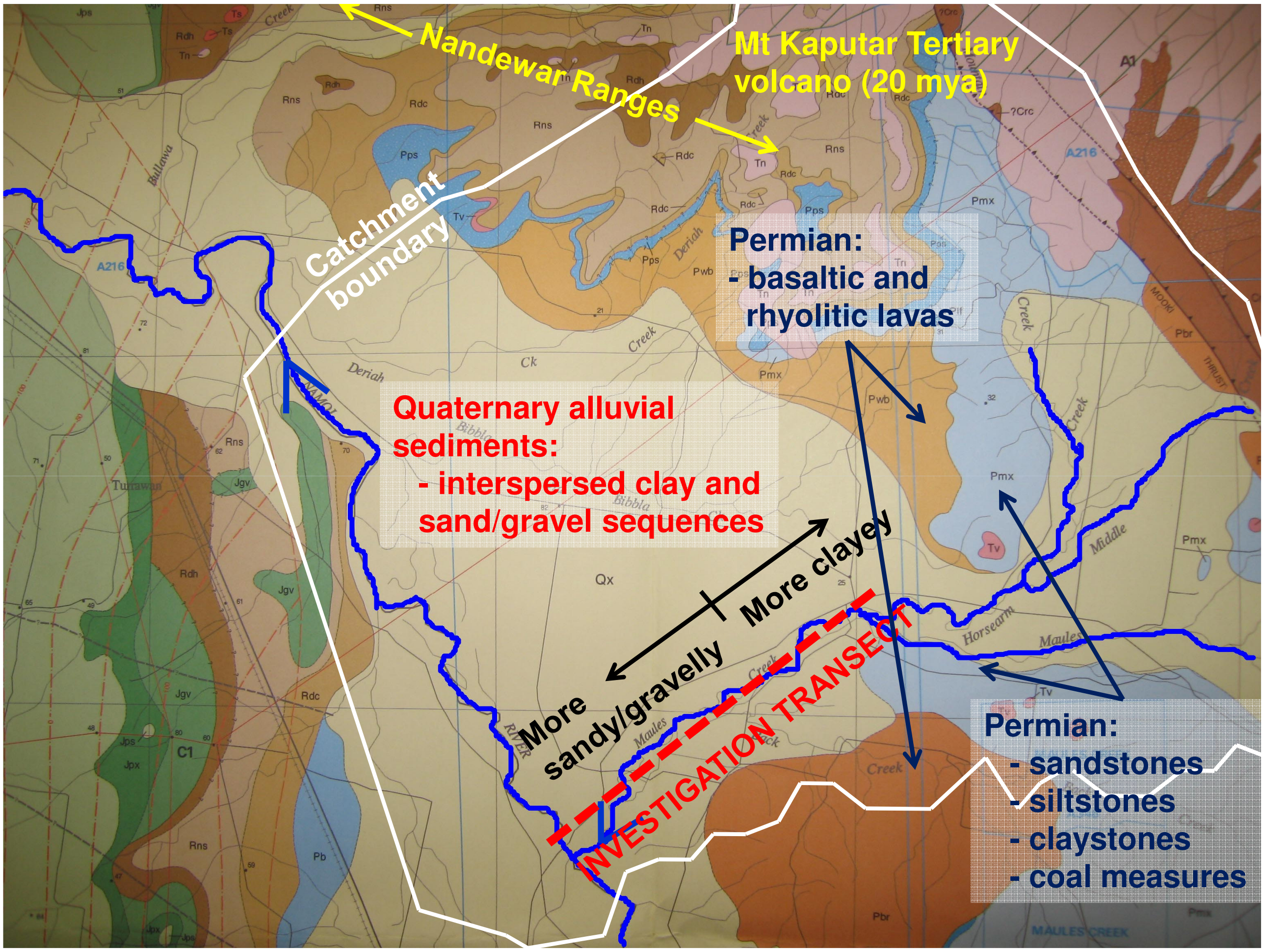
- Surface water-groundwater interactions important for water allocations
  - Anthropogenic needs
  - Environmental needs
- Separate allocation of surface water and groundwater resources can produce problems in connected systems
  - Reduced baseflow in streams
    - Groundwater dependant ecosystems (aquatic, terrestrial, phreatic)
  - Reduced surface water yield
- Challenge of linking SW-GW interactions into more typical hydrogeological investigations

INTRODUCTION

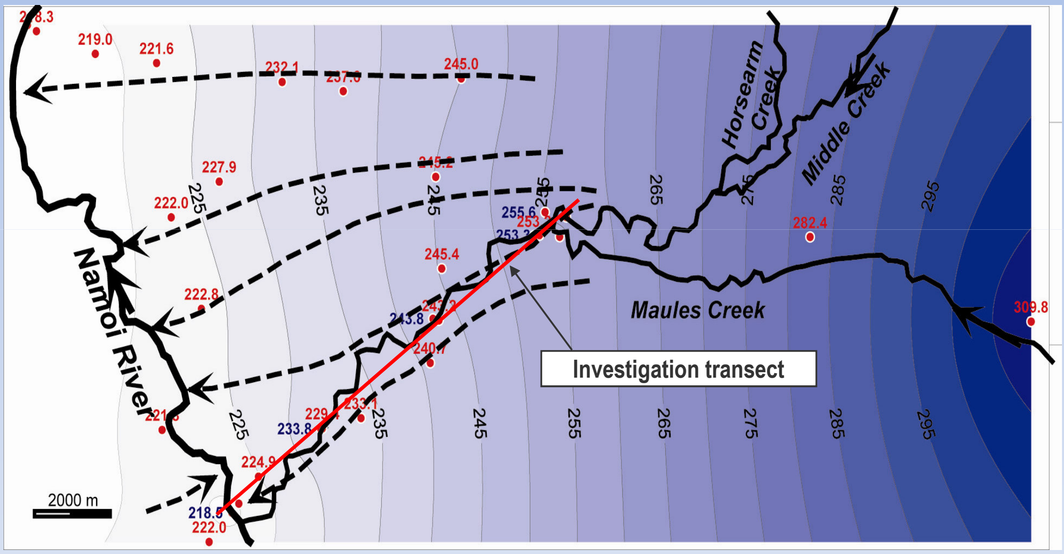
- Need to integrate SW-GW exchange and aquifer processes
- Hydrochemical approach used
  – Major ions (Na^{+}, Ca^{2+}, Mg^{2+}, K^{+}, Cl^{-}, HCO_3^{-}, H_4SiO_4) and
  – Water characteristic parameters (pH, dissolved oxygen, dissolved CO_2, dissolved organic carbon)
  ➢ used as natural tracers and to characterise chemical processes in the aquifer system
- Developed process-based conceptual model: hydrochemical and hydrogeological processes

DESCRIPTION OF THE SITE





HEAD DISTRIBUTION AND GROUNDWATER FLOW



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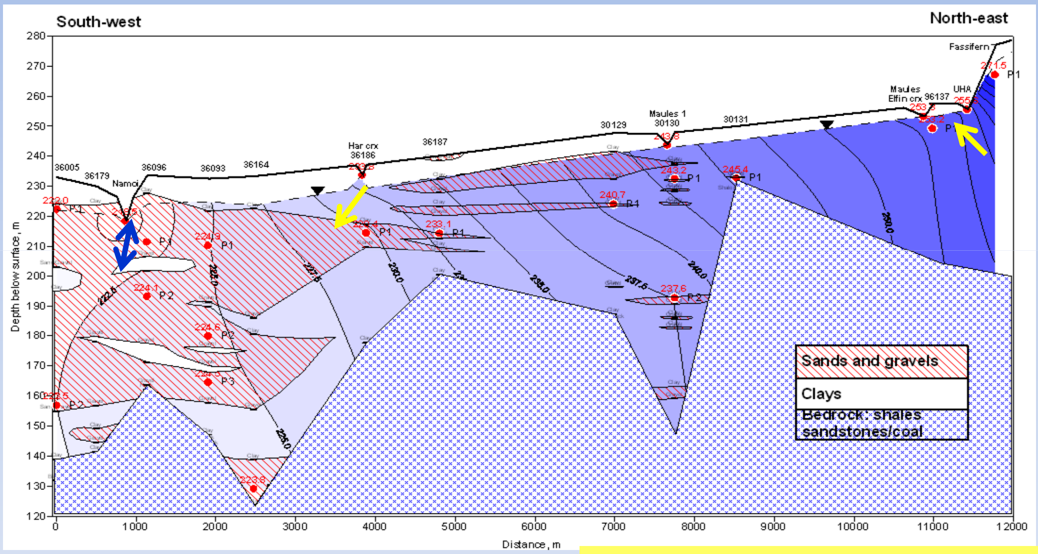
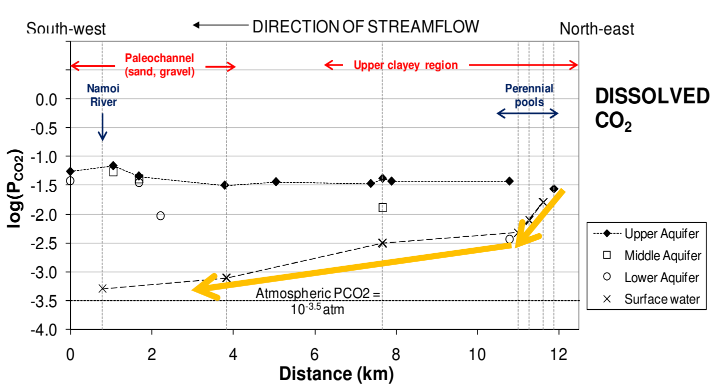
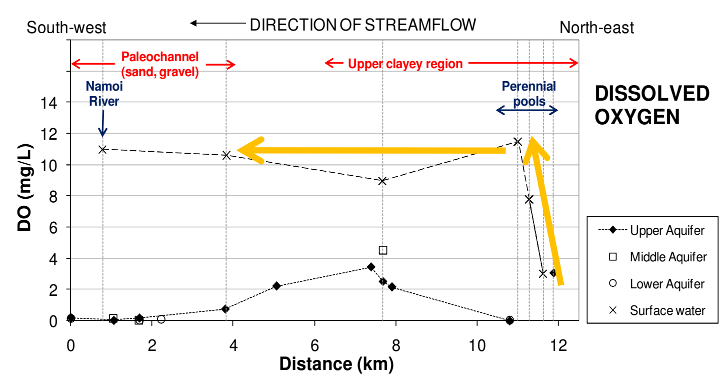


Defined:
Upper aquifer: <30m
Middle aquifer: 30-60m
Lower aquifer: >60m

RESULTS: PCO_2 and DO

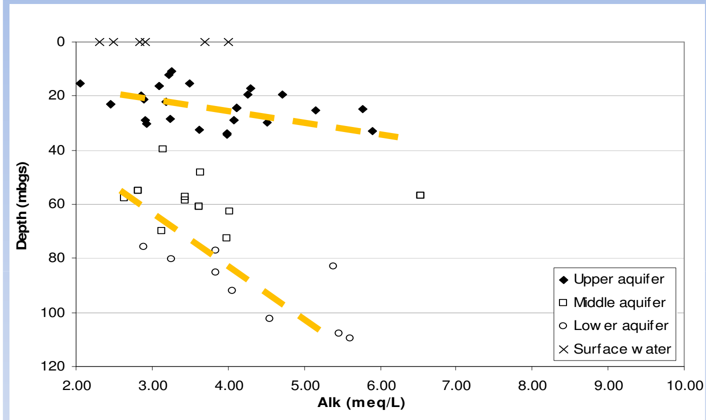




- Dissolved CO_2:
  - Relatively constant in Upper aquifer
  - Decreases in Middle and Lower aquifer
  - Surface water trend
- Dissolved oxygen:
  - Oxic to anoxic along transect
  - Low DO in upstream surface water

➢ GW discharge to SW upstream of perennial pools

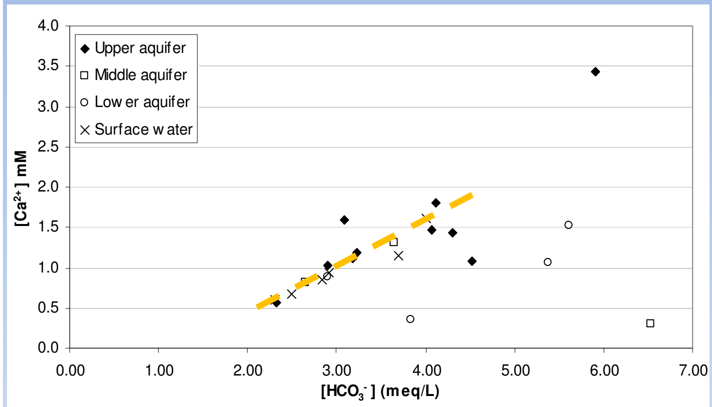
RESULTS: HCO_3^- with depth

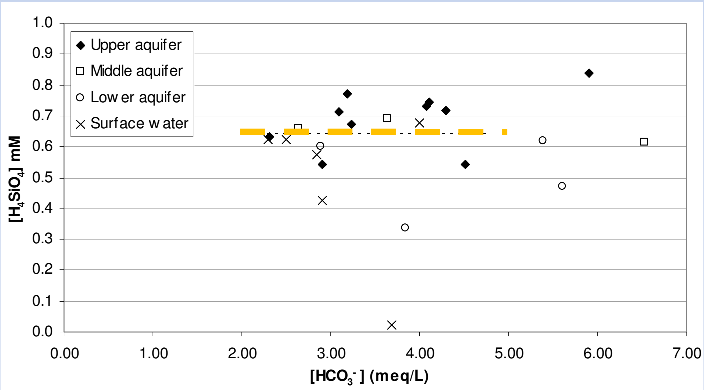


- Relatively linear increase in HCO_3^- with depth in Middle and Lower aquifers
- HCO_3^- variable in Upper aquifer

➢ Return flow of irrigation water sourced from aquifer

RESULTS: Ca^{2+} and dissolved silica

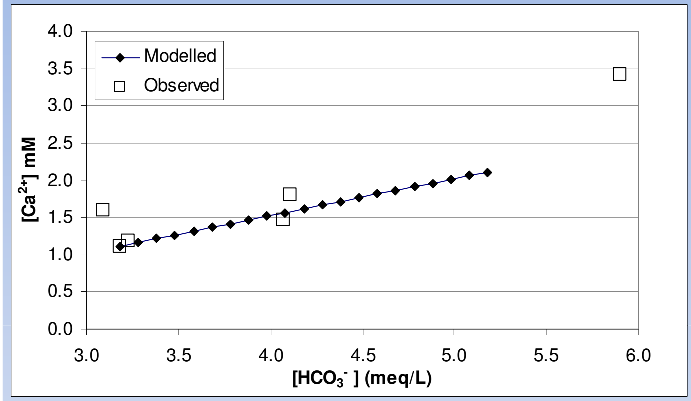


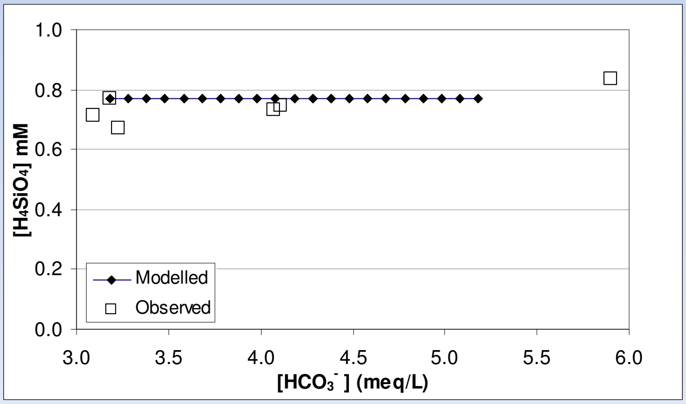


- Ca acquired relatively linearly against HCO_3^-
- Dissolved silica relatively high (17mg/L), constant, and supersaturated with respect to some silica oxide phases

  ➢ Appears that substantial primary silicate weathering is occurring and releasing cations to solution

RESULTS: PHREEQC



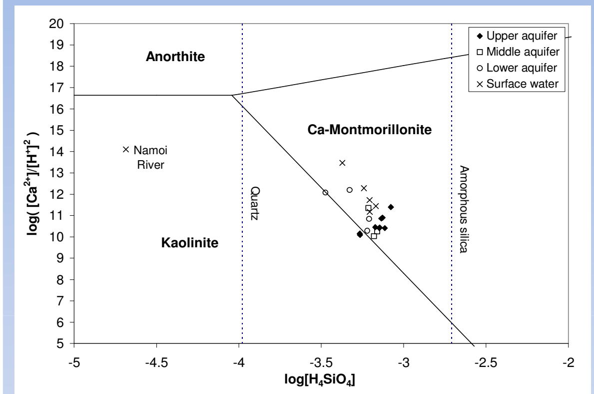


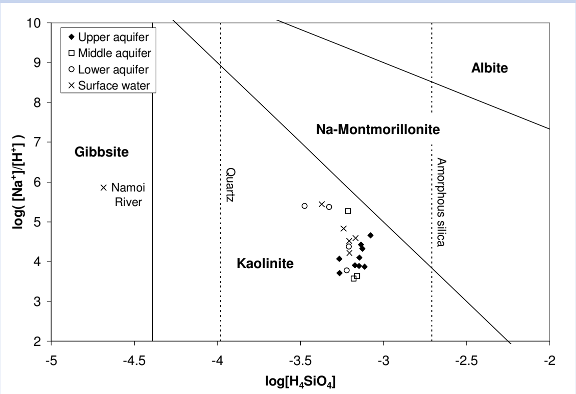
- PHREEQC Batch reaction model to test hypothesis of primary silicate weathering
  - Upper aquifer water
  - Dissolve 1mM Anorthite (an idealised pure-phase Ca-plagioclase feldspar)
  - Look at general trends – are they reasonable?

➢ Appears plausible process

➢ Silica conserved in solid phase with Kaolinite precipitation indicated

RESULTS: STABILITY DIAGRAMS





- Secondary weathering products important from process-perspective
- Stability diagrams very idealised, give indication only
- Montmorrillonite and kaolinite weathering products (vs PHREEQC model indicated kaolinite)

➢ Likely to be heterogeneous mixture of co-existing secondary products

GEOCHEMICAL PROCESSES

- Weathering of primary silicate reactions important eg the pure-phase Ca- and Na-plagioclases were idealised cases considered:

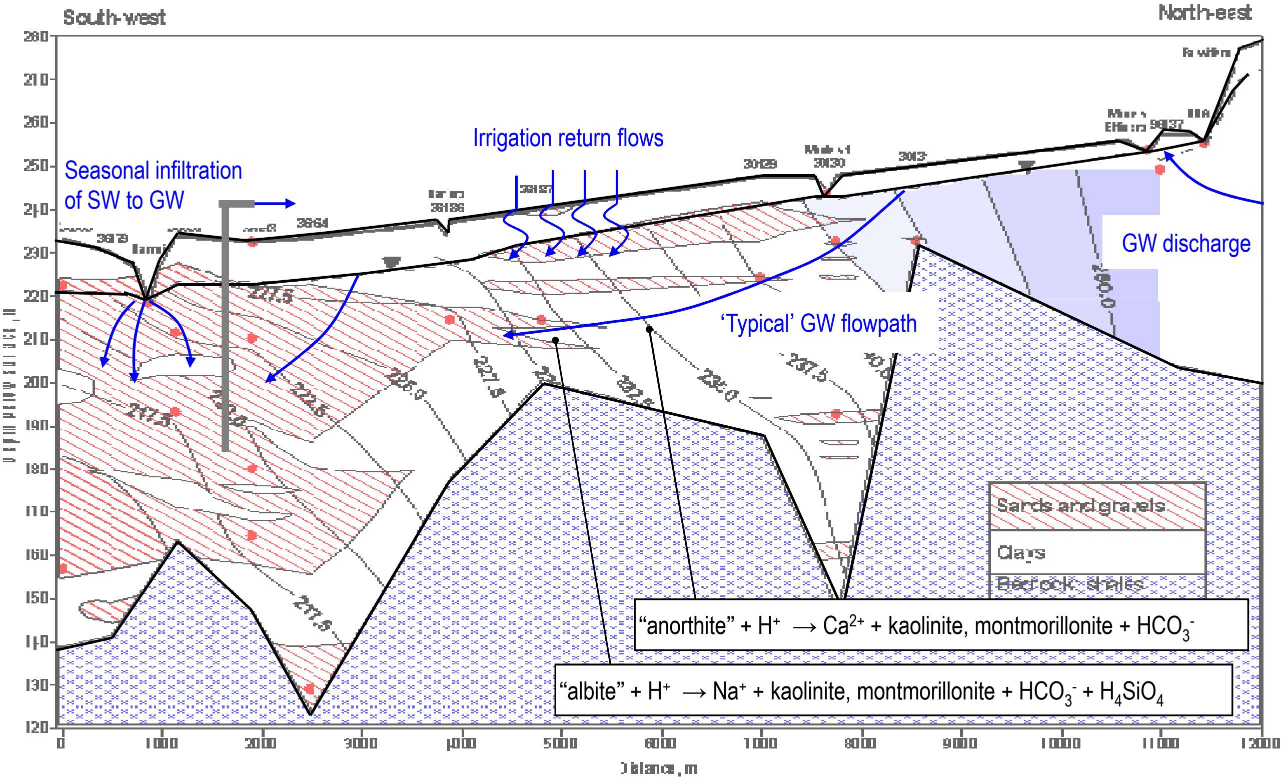
$7CaAl_2Si_2O_8 + 12H^+ + 8H_4SiO_4 \rightarrow 6Ca_{0.165}Al_{2.33}Si_{3.67}O_{10}(OH)_2 + 6Ca^{2+} + 16H_2O$

anorthite **Ca-montmorillonite**

$2NaAlSi_3O_8 + 2H_2CO_3 + 9H_2O \rightarrow Al_2Si_2O_5(OH)_4 + 2Na^+ + 2HCO_3^- + 4H_4SiO_4$

albite **kaolinite**

CONCEPTUAL MODEL



CONCLUSIONS

- Some key geochemical processes deduced
- Linked with previous investigations into SW-GW interactions and strengthened knowledge of hydrogeological processes
- Presented results as a conceptual model that integrates key hydrochemical and hydrogeological processes
- Useful for future aquifer system modelling

ACKNOWLEDGEMENTS

- CCC-CRC for funding
- Department of Natural Resources access to sample monitoring wells and for supplying basic data from their archive

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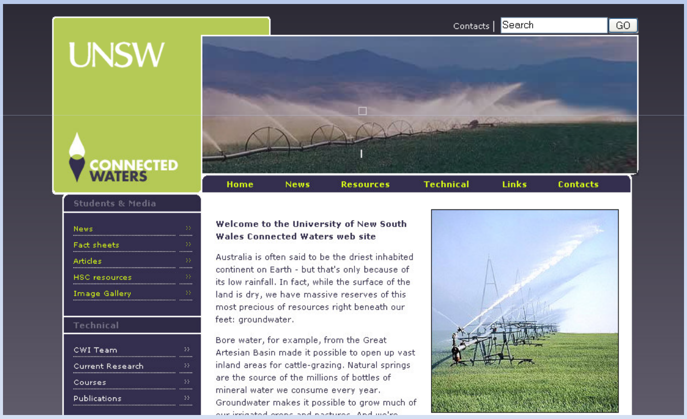

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