Exceptional service in the national interest

SAND2011-9061C

Sandia National Laboratories

Water from the deep: Using terrigenic ^{4}He to identify the presence of ancient groundwater in river systems.

Payton Gardner

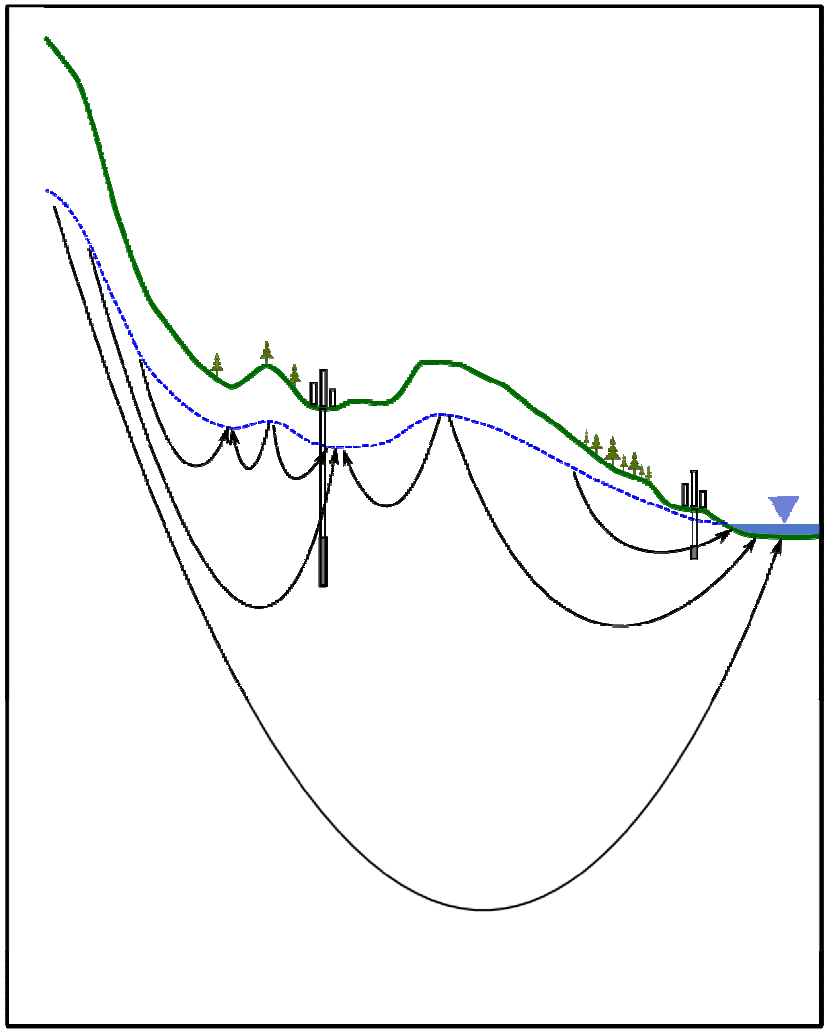
U.S. DEPARTMENT OF ENERGY | NNSA

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Acknowledgments

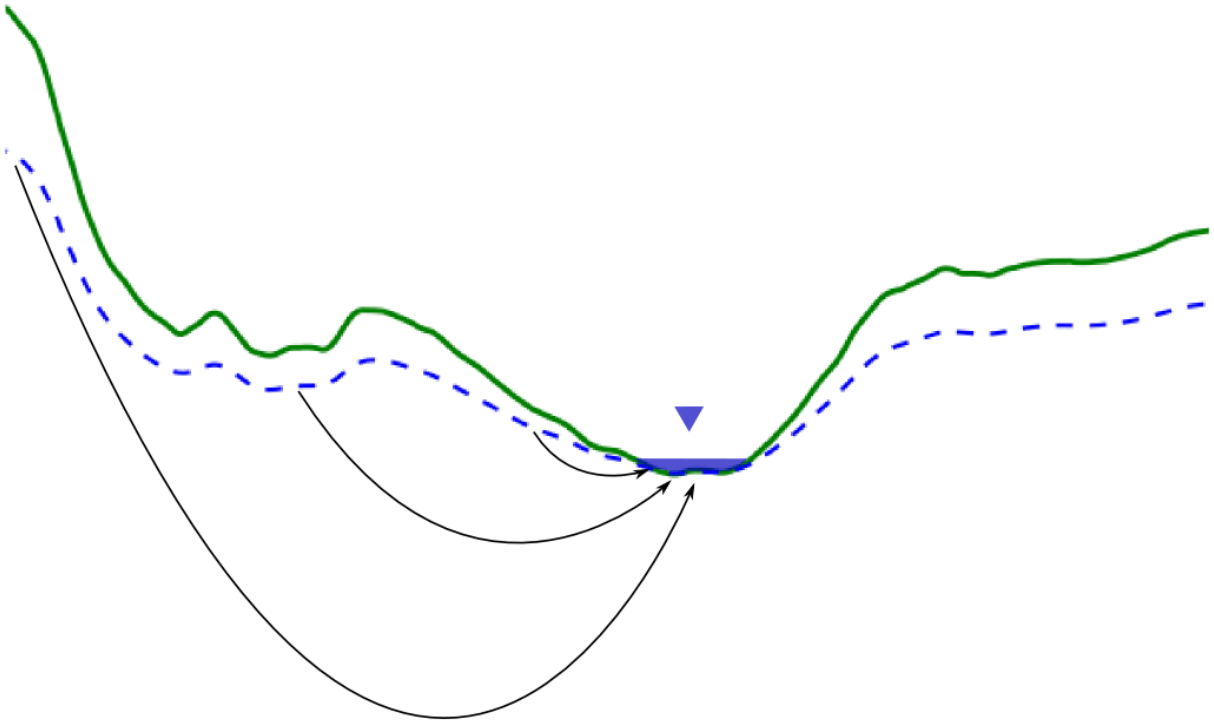
- I'd like to thank my colleagues who contributed to the sampling and field work: Glenn Harrington, Brian Smerdon, Sebastien Lamontaigne, Jordi Battle-Aguilar, Peter Cook
- CSIRO Water for a Healthy Country National Flagship provided much of the funding for this work
- I'd like to thank the numerous land owners and traditional owners who allowed to traipse across the country side.

A shallow view of stream water contributions?

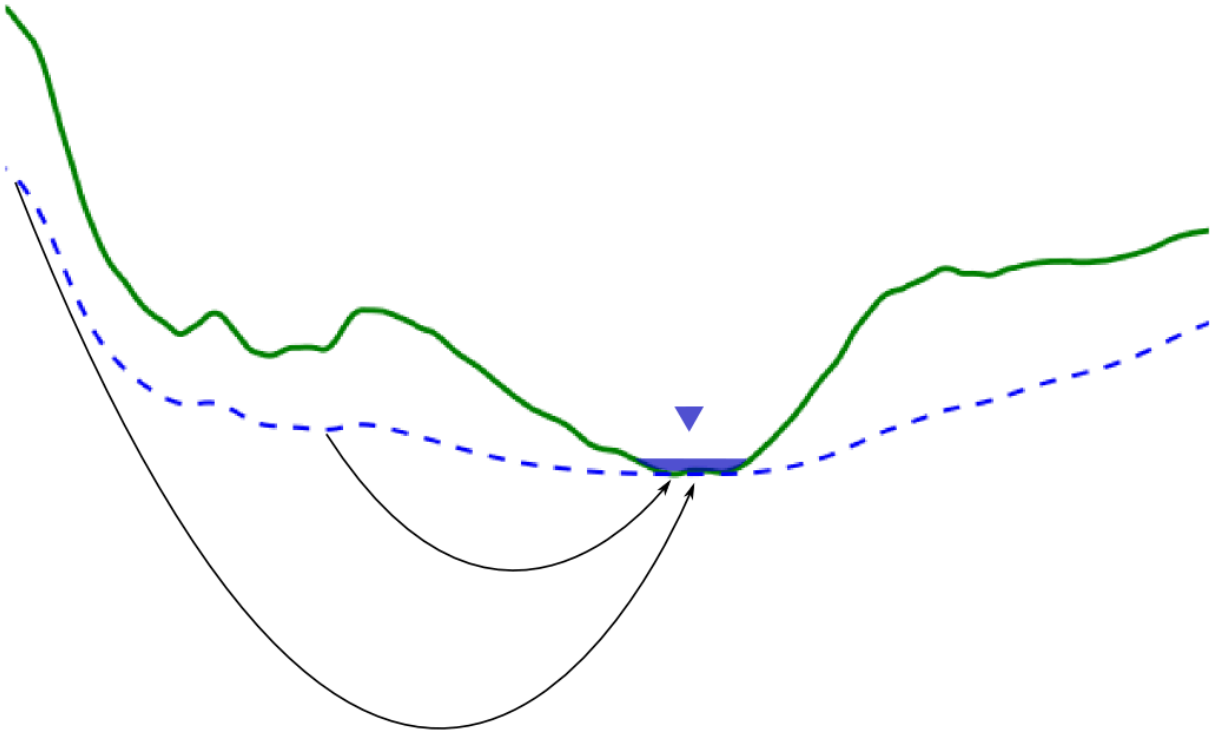


- Many conceptual models of stream flow generation include only surface runoff and shallow soil flow above an impermeable bedrock – i.e. no groundwater.
- If groundwater is considered, it is often from a homogenous, shallow system.
- The role of deeply-circulating regional groundwater discharge has largely been unexplored.
- Recent work e.g. - Gleeson & Manning, 2008, Frisbee et al., 2011 and Gardner et al., 2011 have shown that regional discharge can play a significant role in river systems.

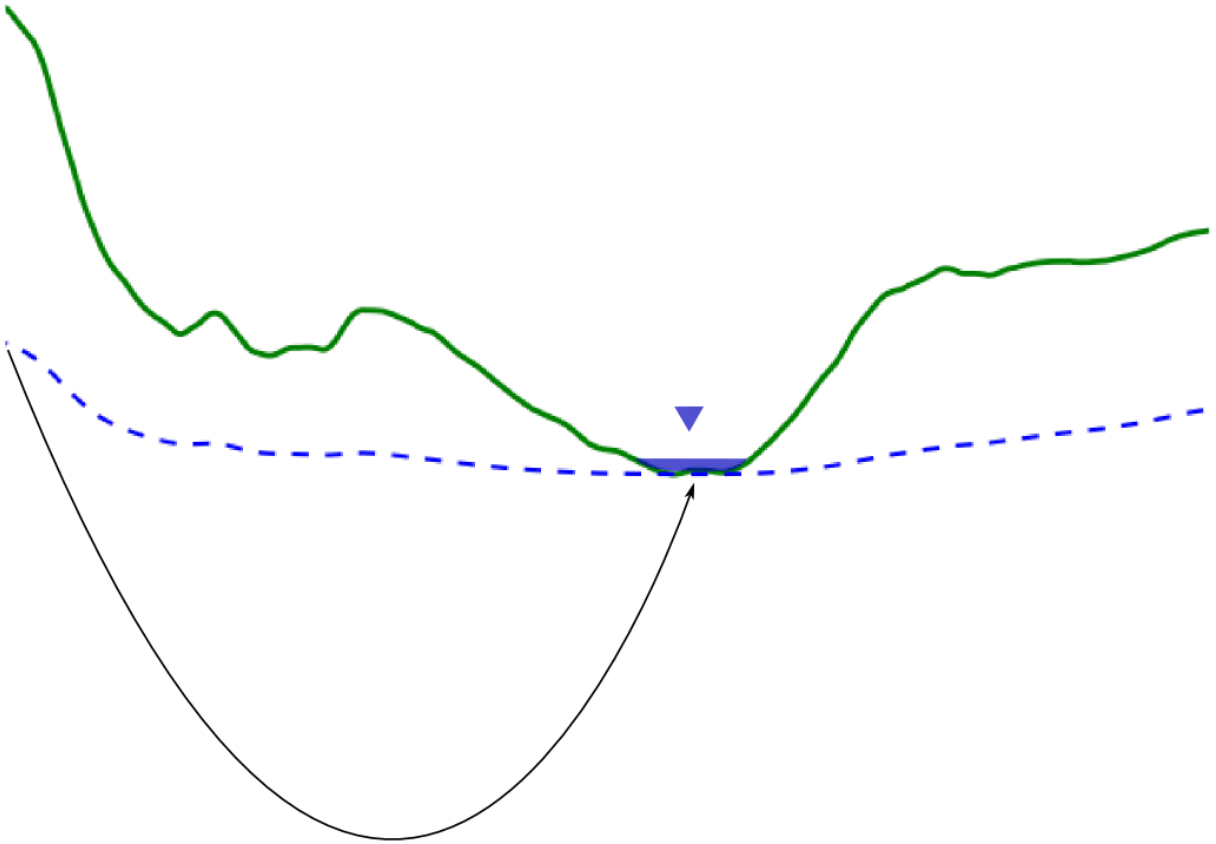
Why do we care?



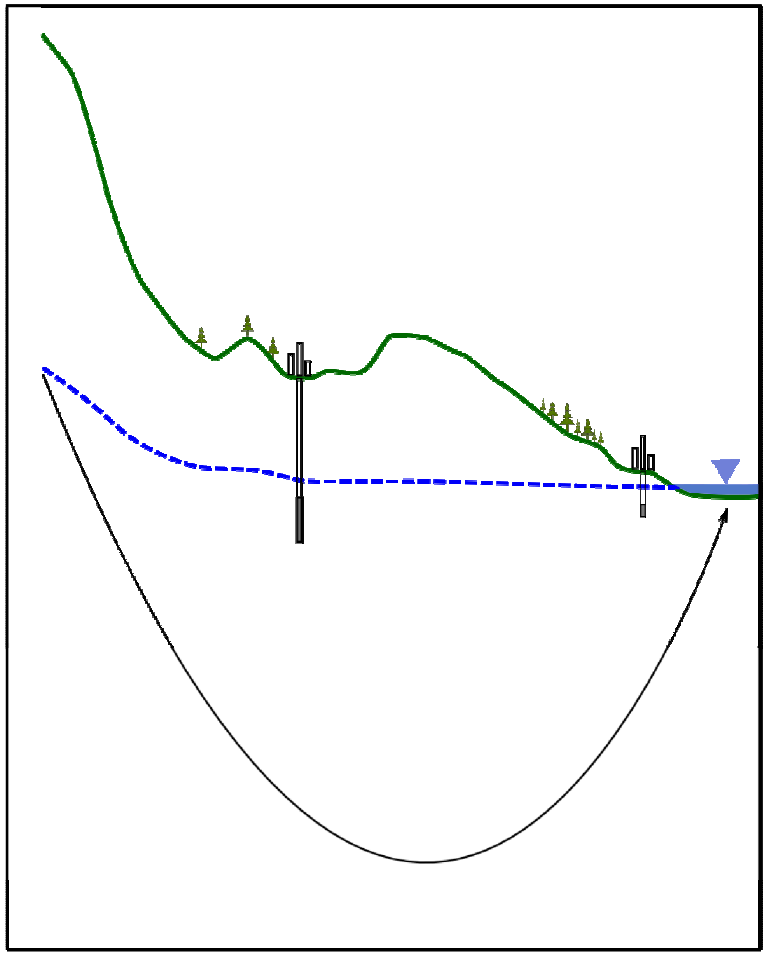
The Drought Continues…



And Continues

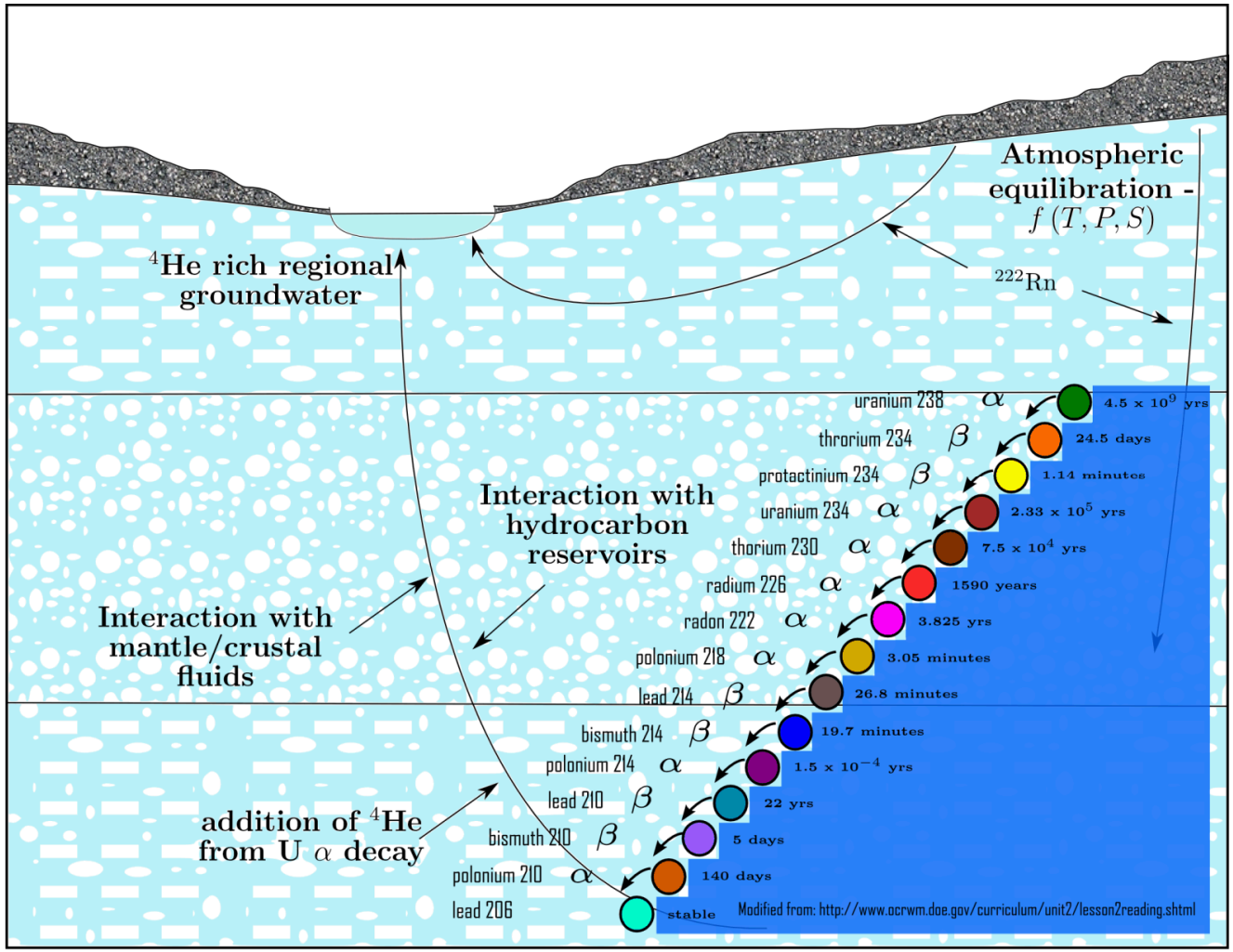


Why do we care about deep groundwater?



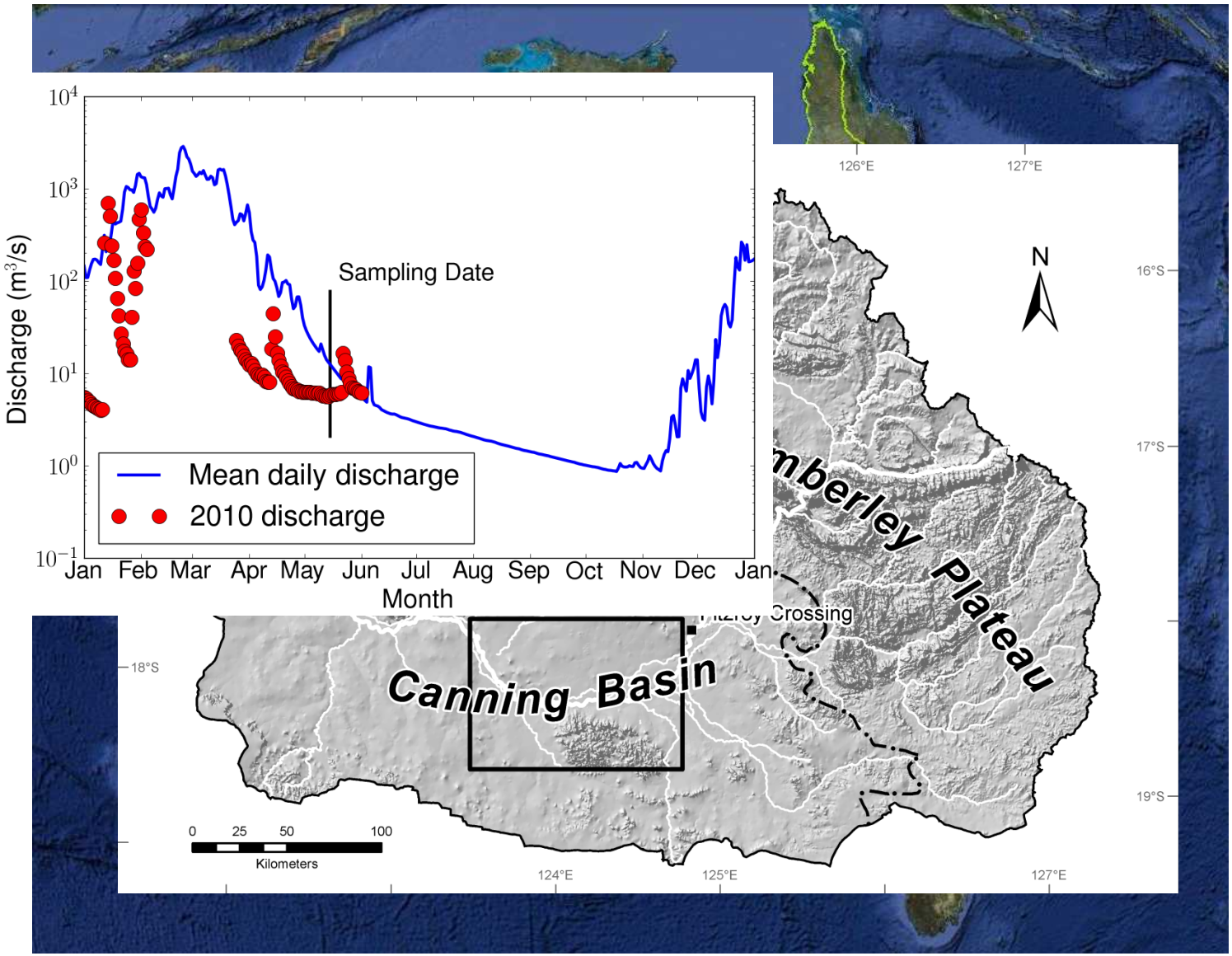
- Regional groundwater storage provides the buffering capability during long term drought
  - Critical flowpaths for the long term existence of groundwater dependent ecosystems
  - Prediction of stream flow under climate change
- Crucial knowledge for proper management at the watershed scale
  - Have to extend the boundaries of co-management of the resource
- Prediction of long term fate of deeply sourced contaminants
  - Released – energy production
  - Stored – CO_2 and Used Nuclear fuel

How can we separate local and regional groundwater discharge?

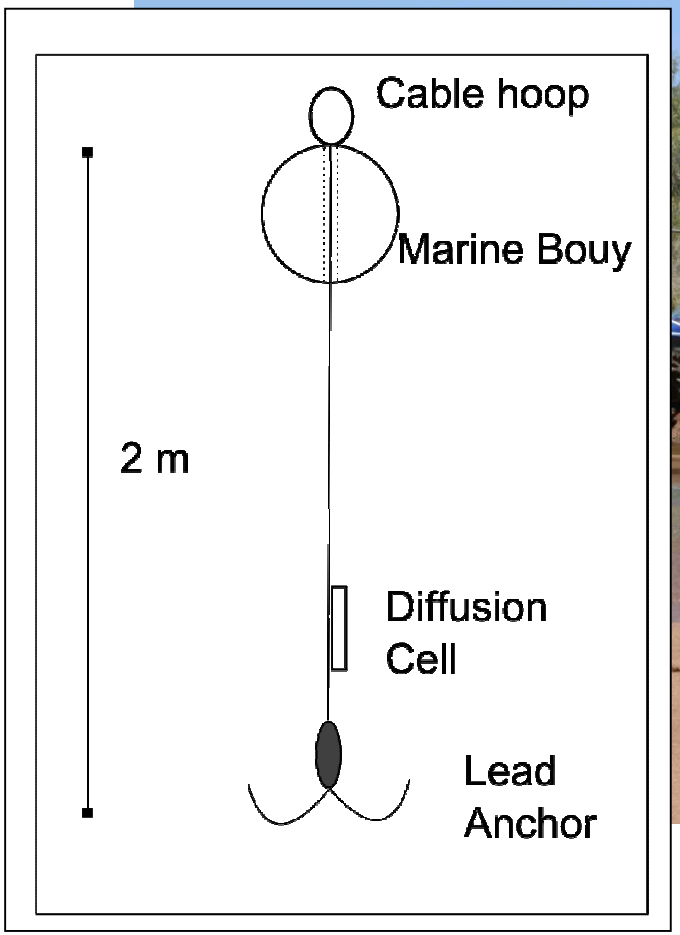


A Trip Around the Outback

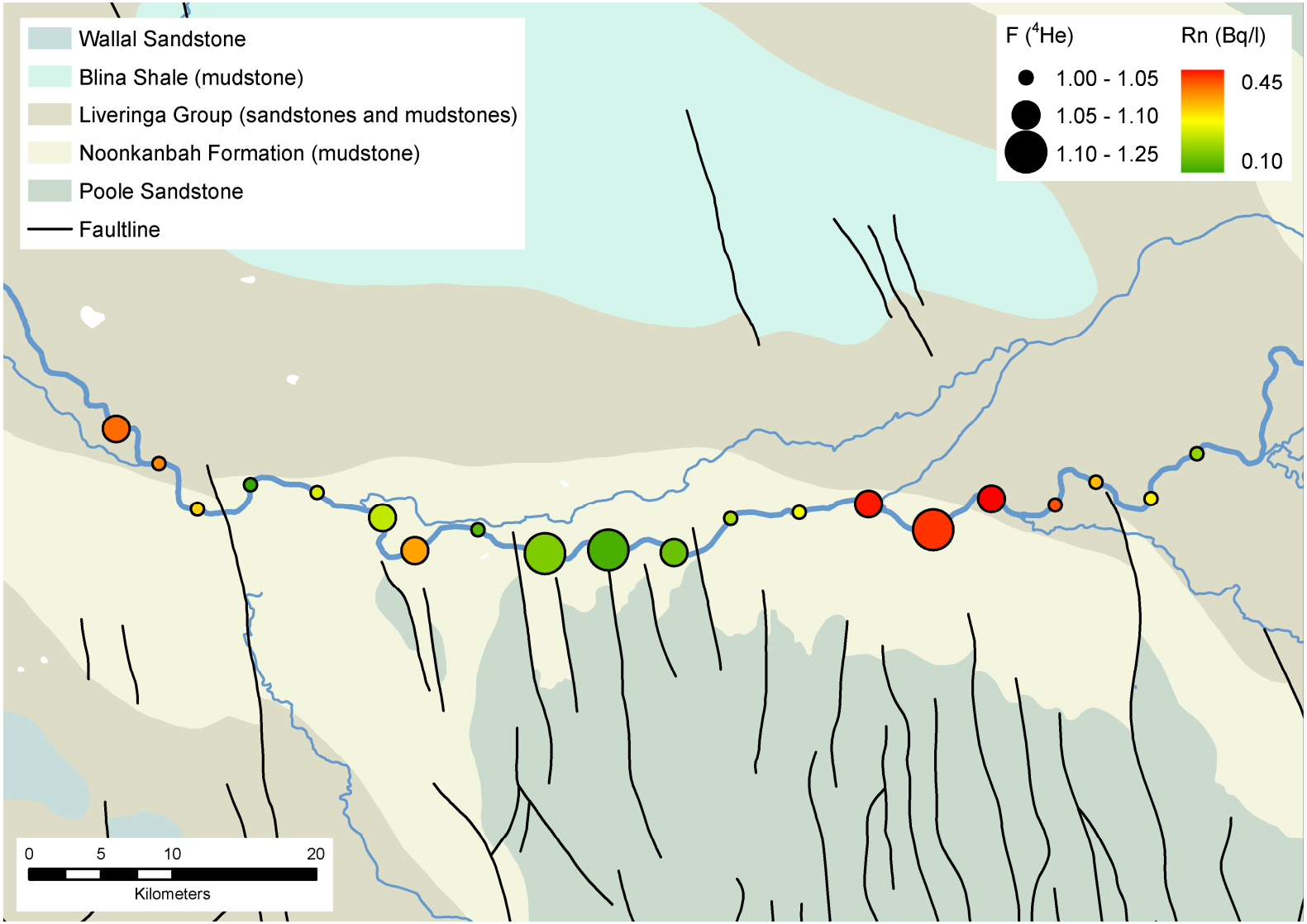
Fitzroy River, north Western Australia



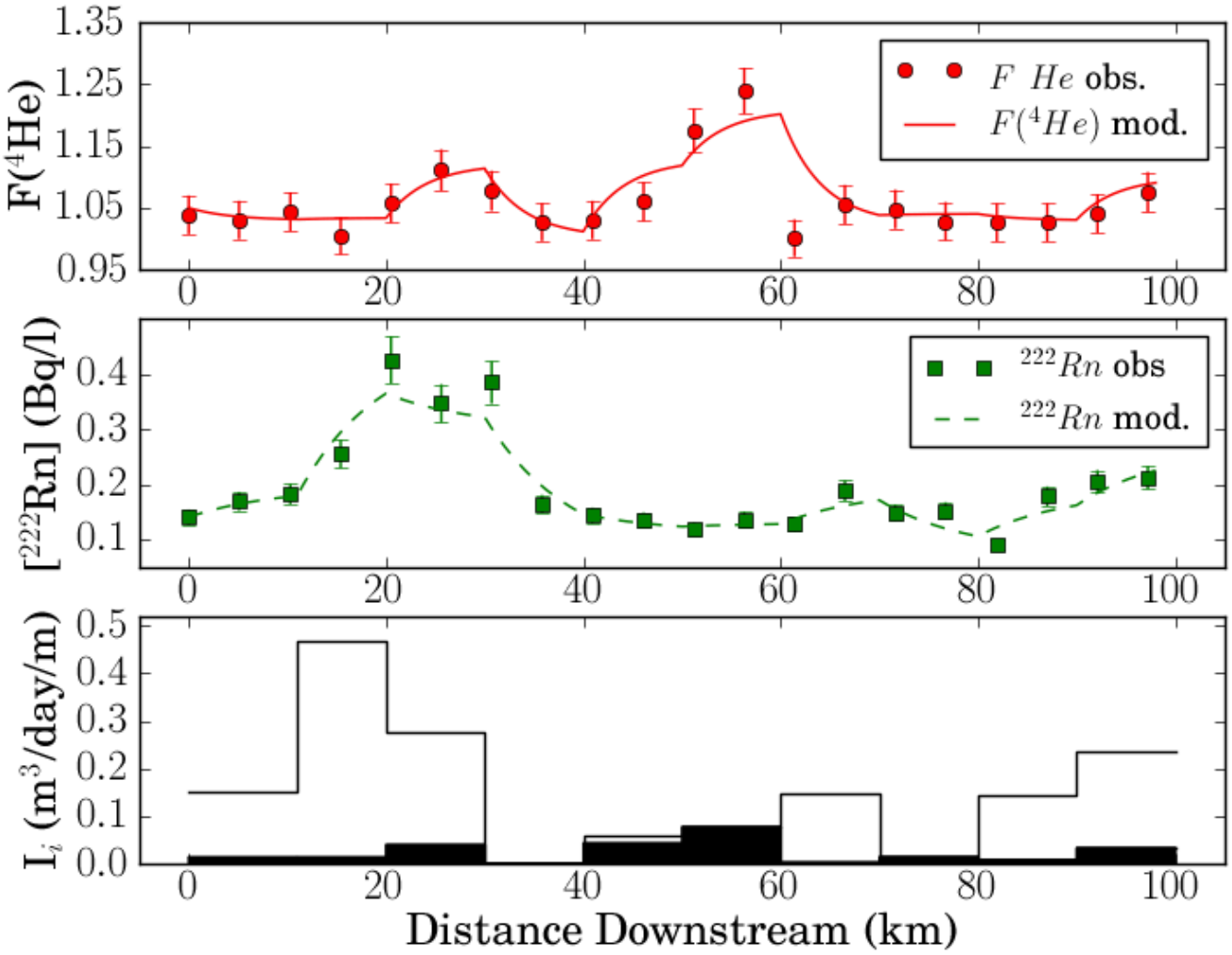
Sampling



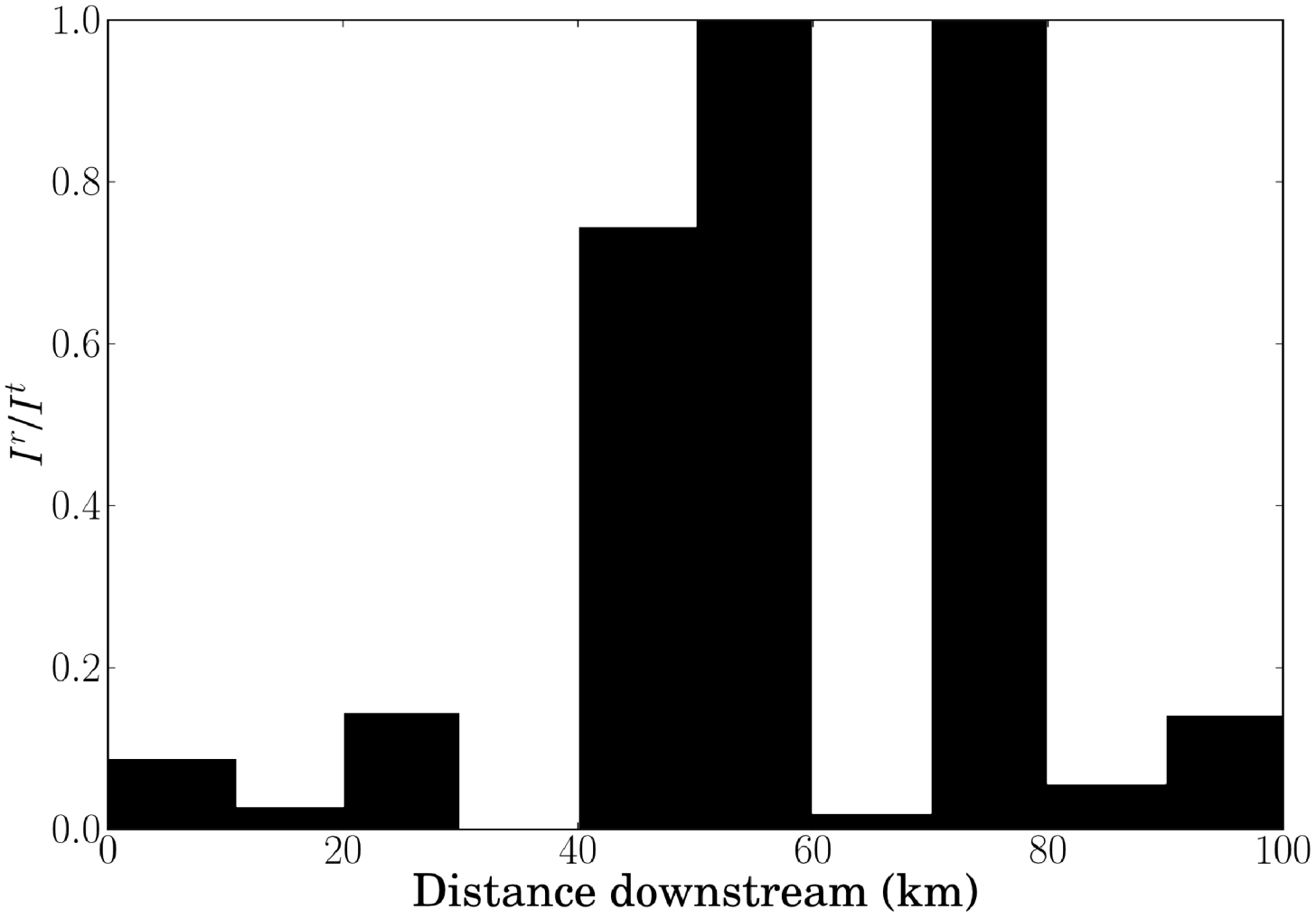
Fitzroy River, north Western Australia



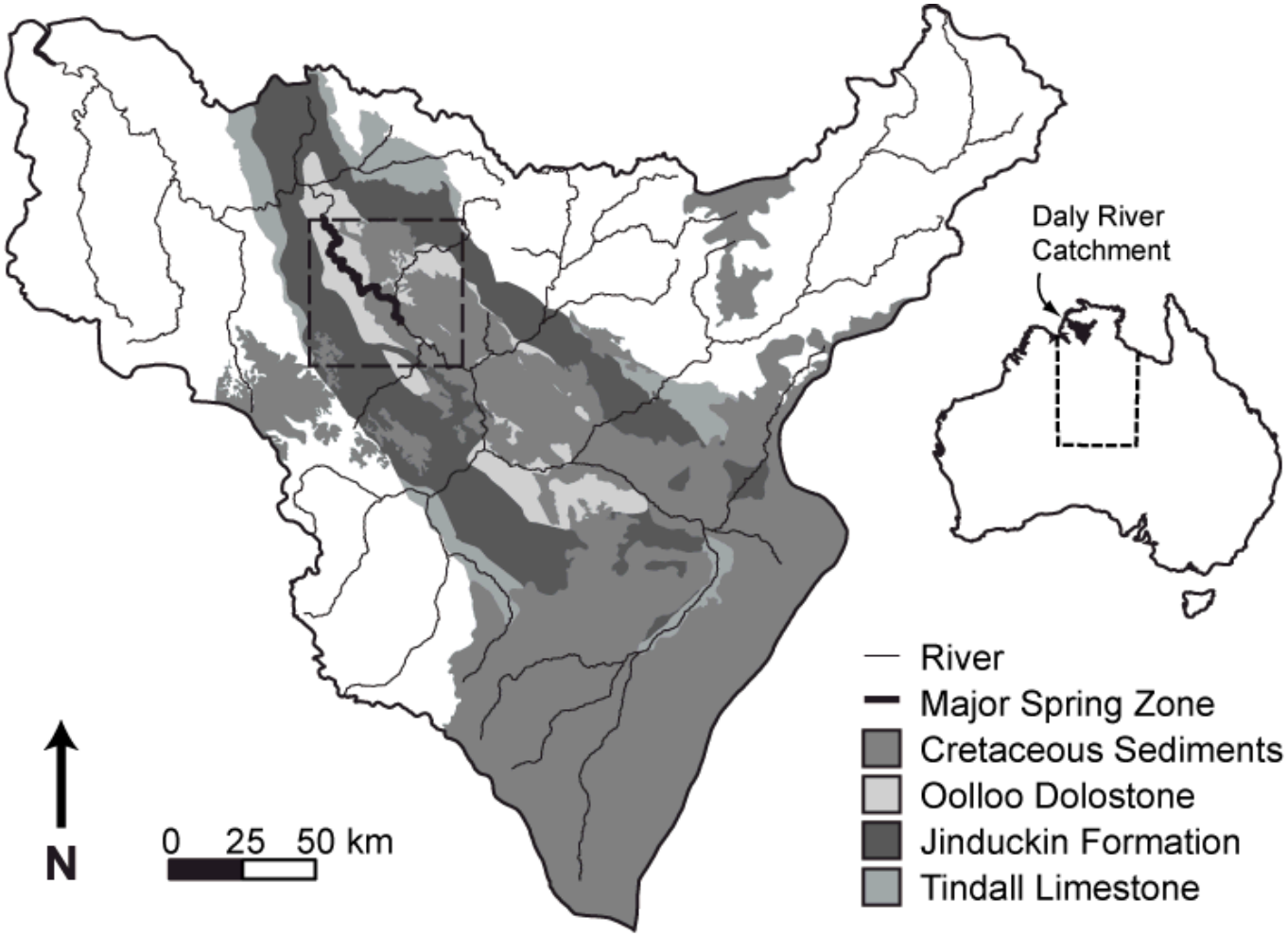
^{4}He in the Fitzroy River – (Gardner et al 2011, WRR)



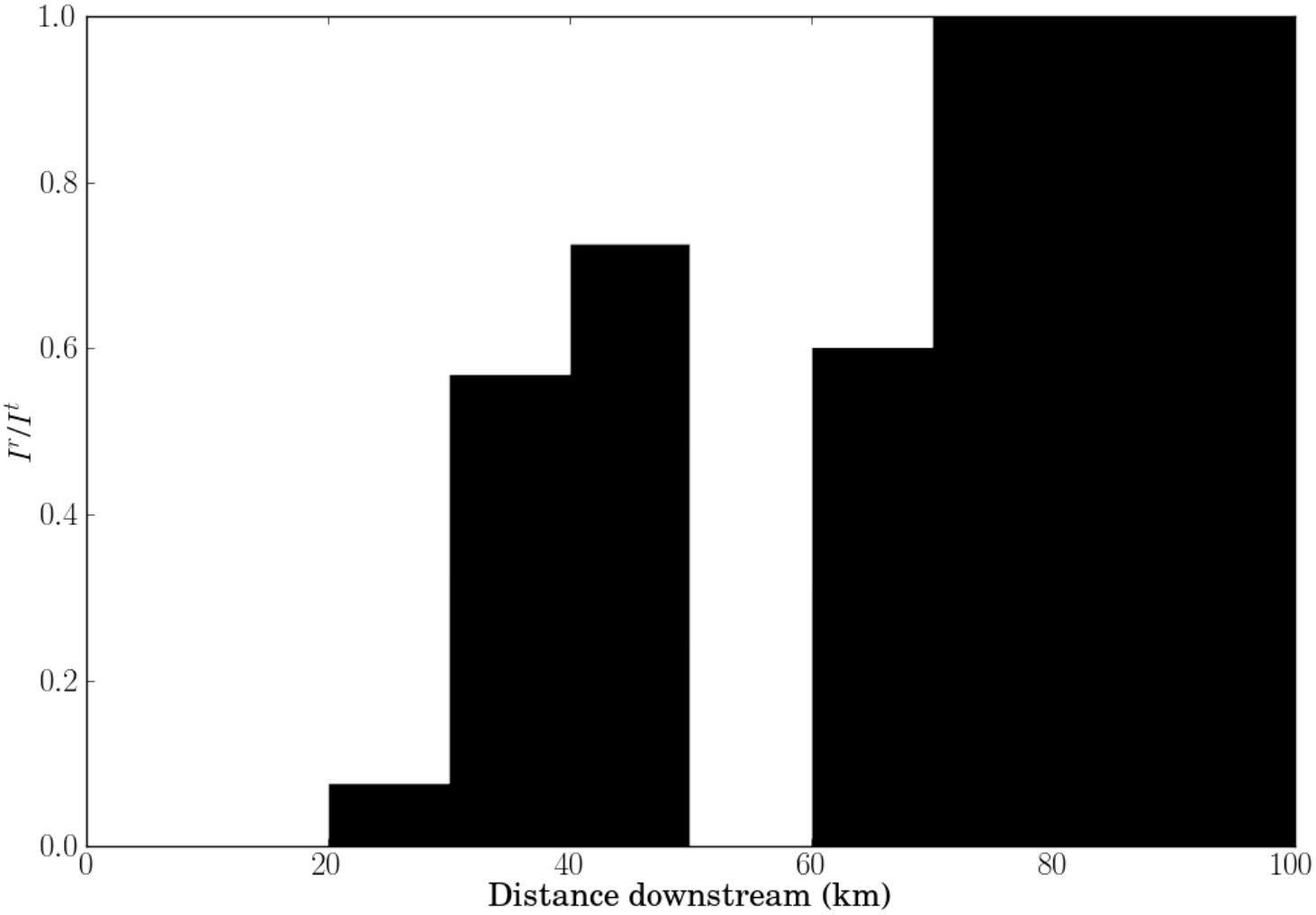
Regional Fraction



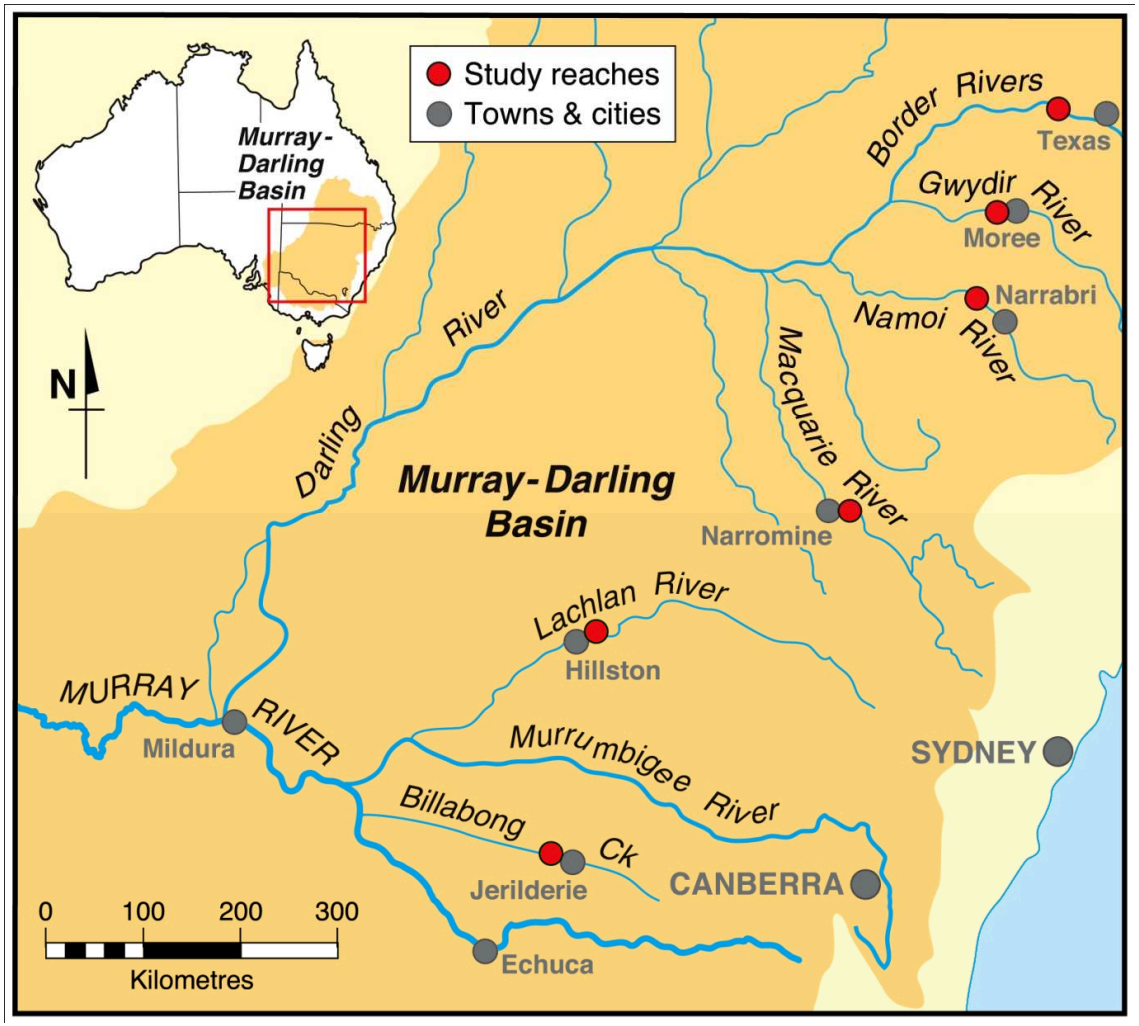
Daly River


Daly River
Catchment
River
Major Spring Zone
Cretaceous Sediments
Oolloo Dolostone
Jinduckin Formation
Tindall Limestone
N
0 25 50 km

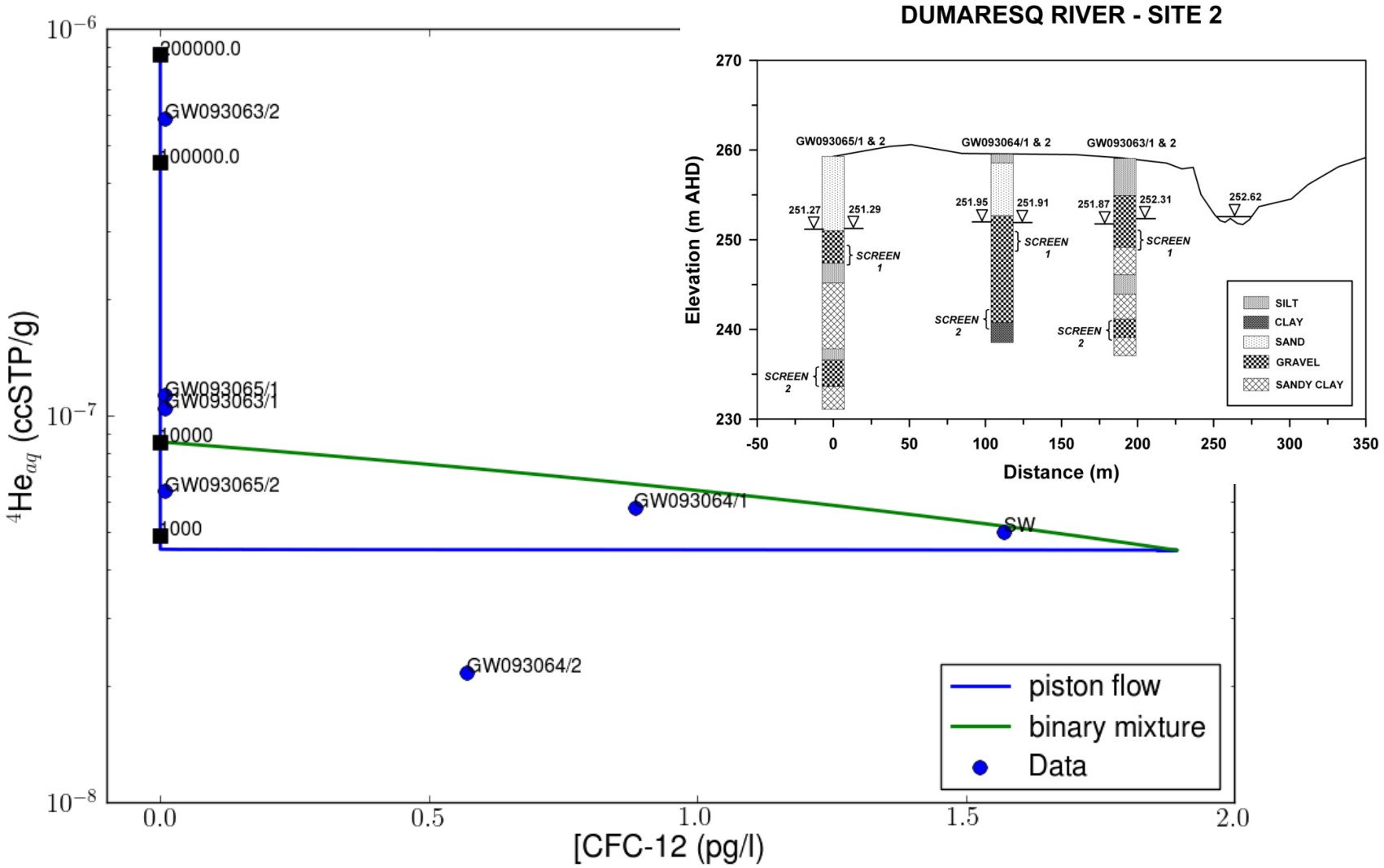
Daly River Sampling Results



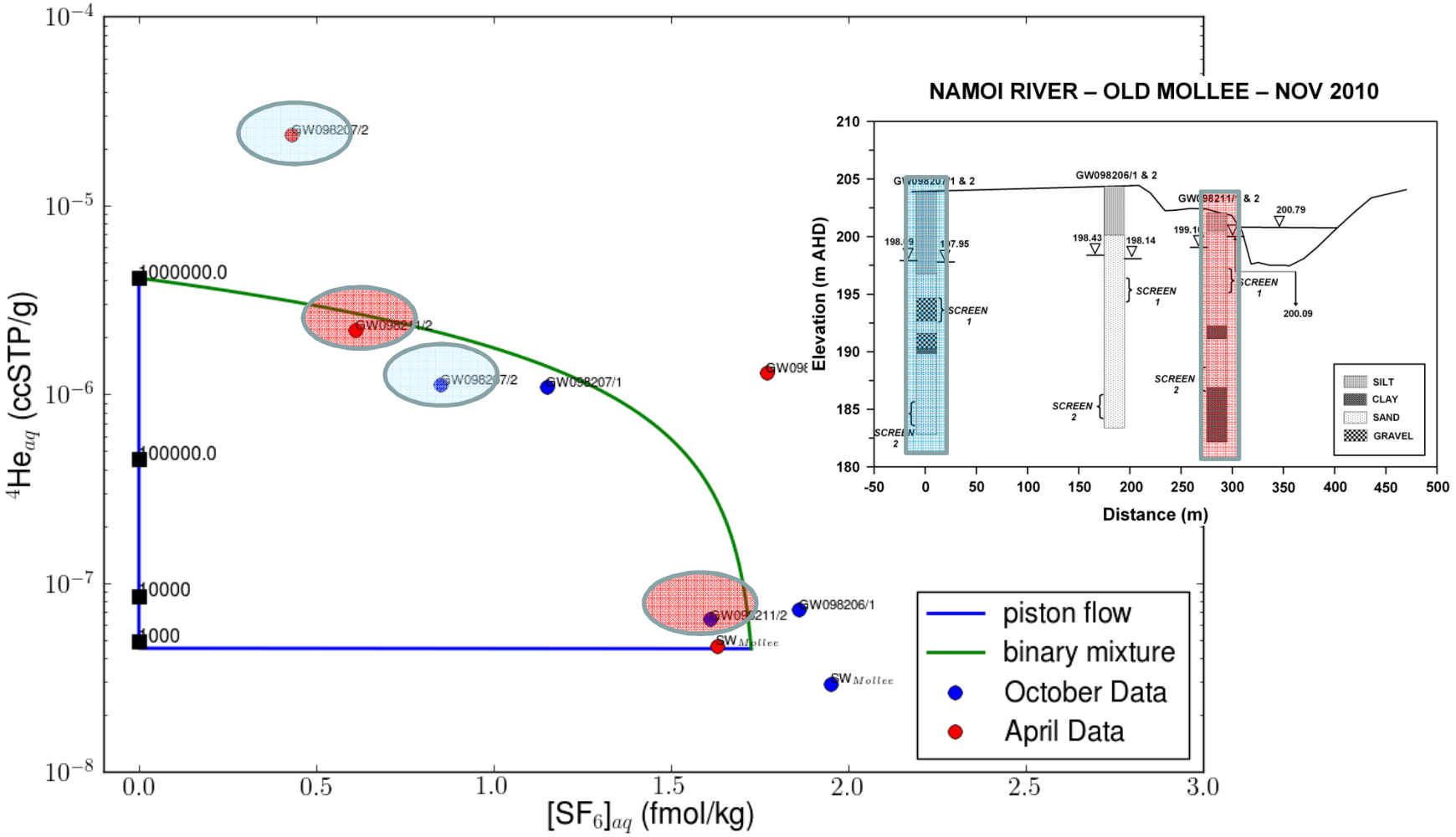
Murray-Darling Basin



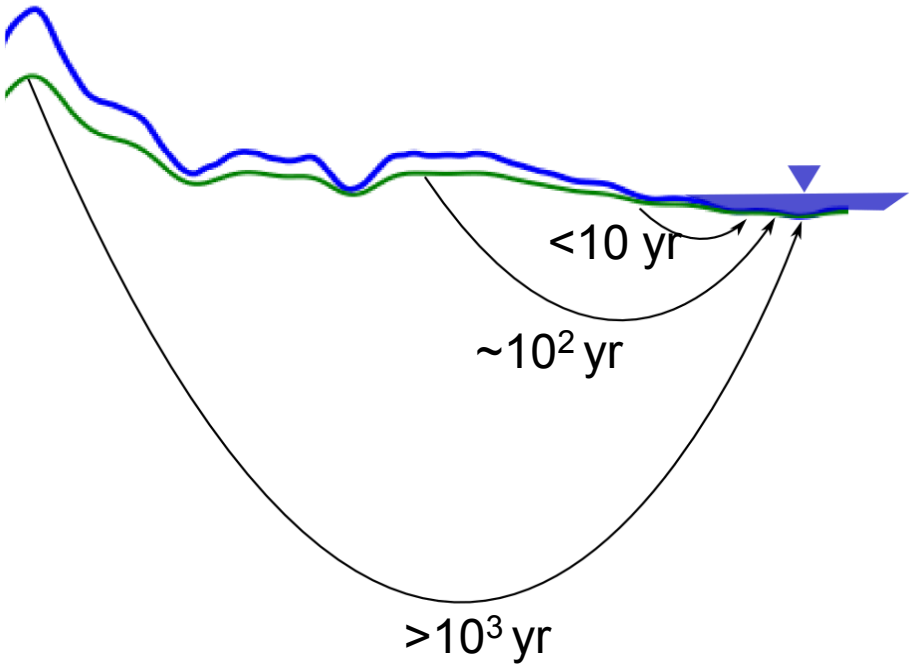
^{4}He vs. CFC-12 in the Dumaresq



Namoi River – Temporal changes



Conclusions



- Elevated terrigenic helium has been observed in river water and shallow alluvial aquifers in several catchments around Australia.
- Clear indication of regional groundwater discharge to shallow alluvial systems.
  - Groundwater with apparent ages in excess of 1000 years.
  - Management implications.
- We can calculate regional discharge and separate regional fraction.
  - Regional discharge is very hard to measure.
- We can see temporal changes in the gw/sw interactions.
- If we had not “looked” for old water, we never would have seen it!

Thanks…

Sandia National Laboratories

References:

Frisbee, Marty D., Phillips, Fred M., Campbell, Andrew R., Liu, Fengjing, & Sanchez, Steve A. 2011. Streamflow generation in a large, alpine watershed in the southern Rocky Mountains of Colorado: Is streamflow generation simply the aggregation of hillslope runoff responses? *Water Resour. Res.*, **47**(6), W06512–.

Gardner, W. Payton, Harrington, Glenn A., Solomon, D. Kip, & Cook, Peter G. 2011. Using terrigenic ^{4}He to identify and quantify regional groundwater discharge to streams. *Water Resour. Res.*, **47**(6), W06523–

Gleeson, Tom, & Manning, Andrew H. 2008. Regional groundwater flow in mountainous terrain: Three-dimensional simulations of topographic and hydrogeologic controls. *Water Resour. Res.*, **44**(10), W10403–.

Daly River sampling - photo by Dr. Brian Smerdon CSIRO Land and Water