Can river water data be leveraged to understand groundwater circulation for a large area?

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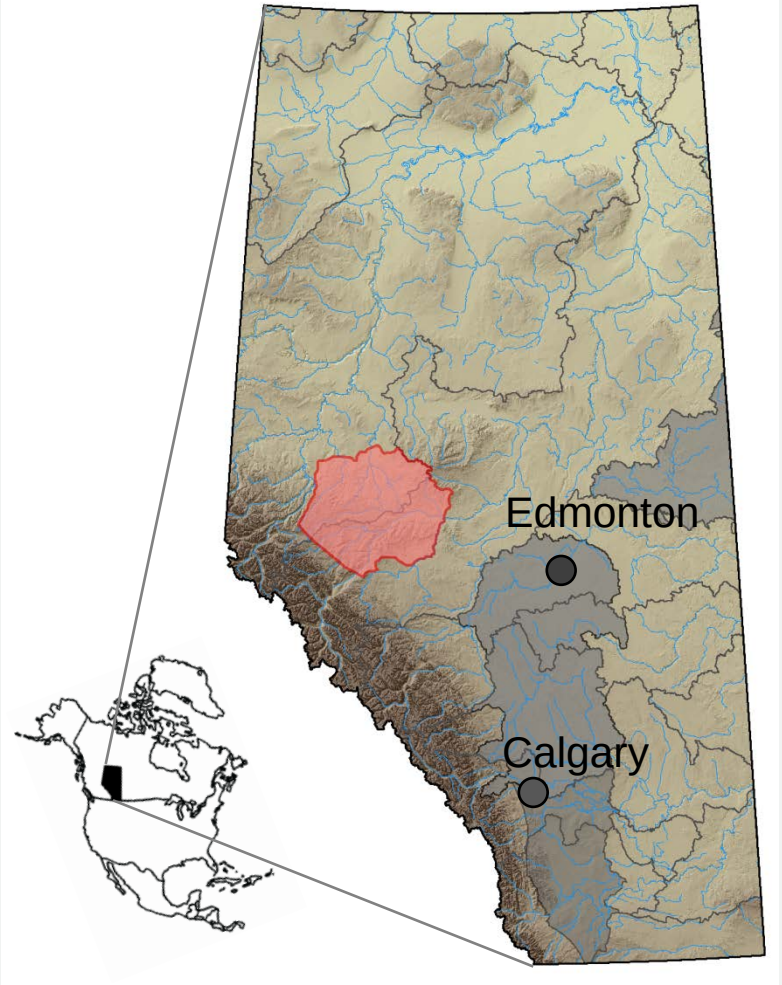
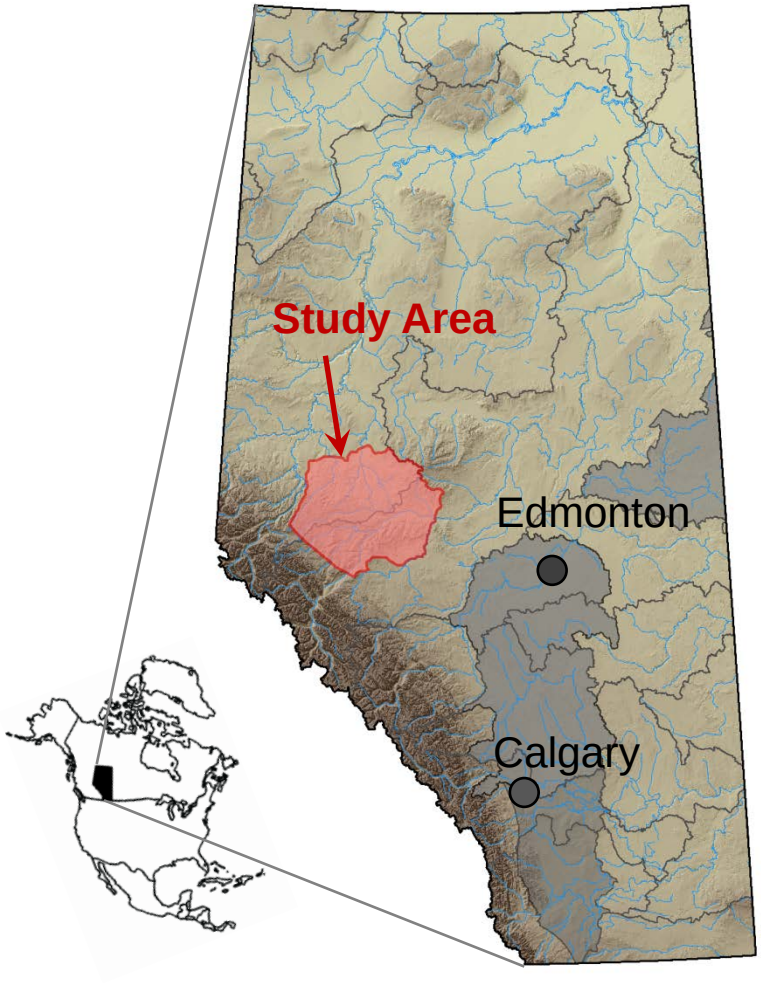
GSA 2016

Provincial Groundwater Inventory Program



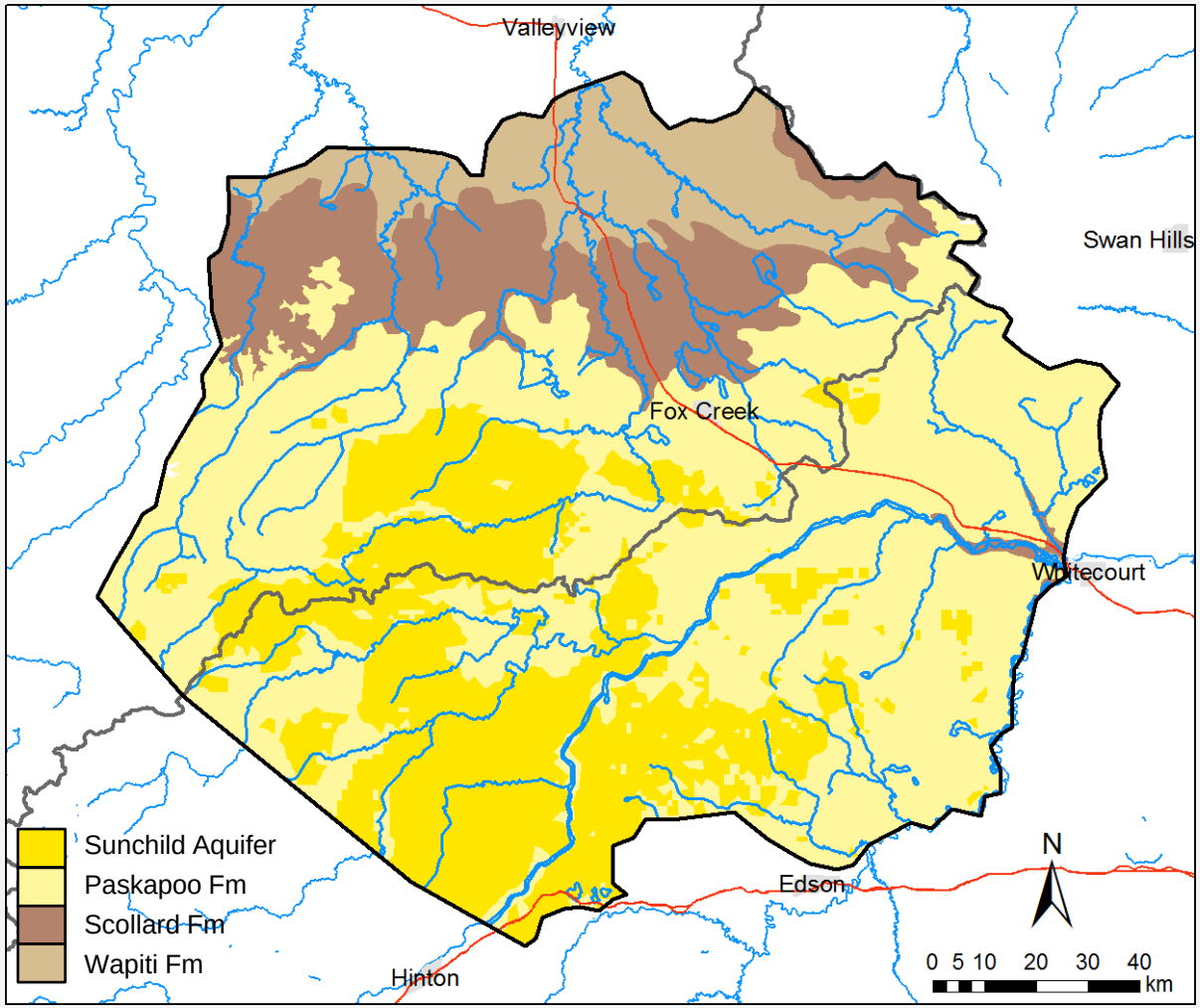
- Characterize Alberta's groundwater resources
  - Regional-scale mapping and inventory
  - Basis for assessing cumulative effects of development
- Ensure geoscience is meaningful at the 'regional' scale
  - Area-based regulation
  - Land-use planning regions
- Established techniques:
  - 3D geomodelling (HSUs)
  - Hydrodynamic data
  - Hydrochemistry (TDS)

West-Central Alberta Project



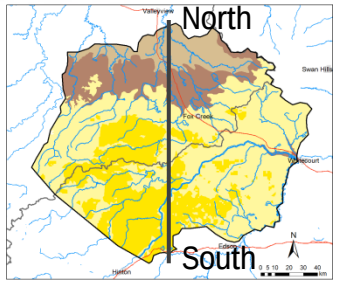
- Forested, unpopulated region
- Unconventional hydrocarbon development
- Surface water and non-saline groundwater used for hydraulic fracturing
- **Utilize river water as integrator of groundwater circulation?**
- Combine environmental tracer findings with established techniques to develop conceptual model

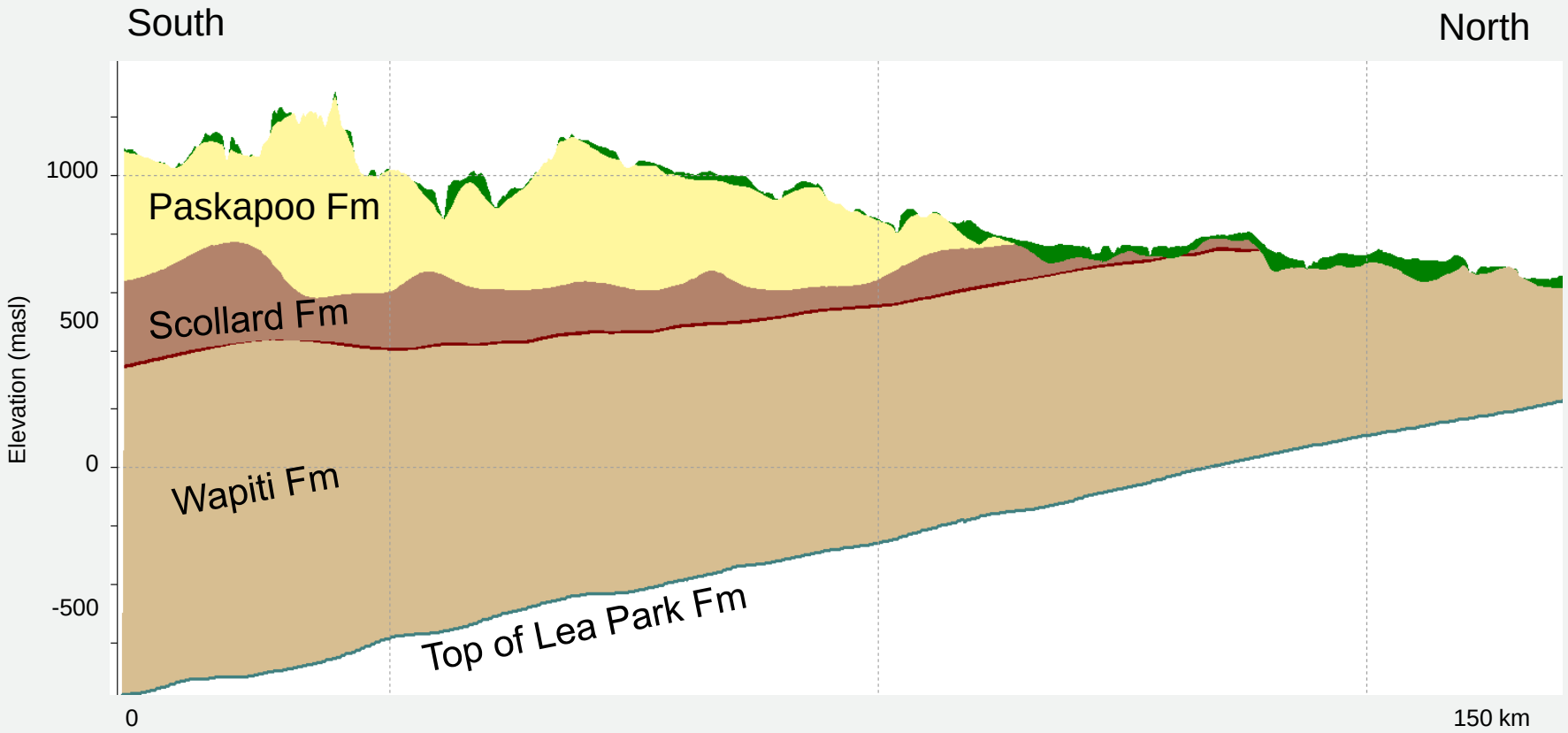
Study Area Extent



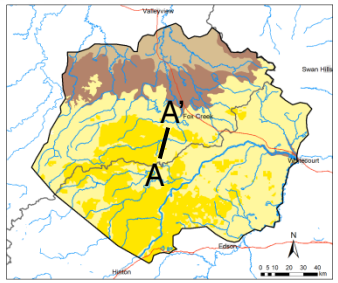
- Relatively shallow bedrock
- Uppermost bedrock forms a major aquifer system
- Headwater rivers incised into bedrock
- 22,000 km^2

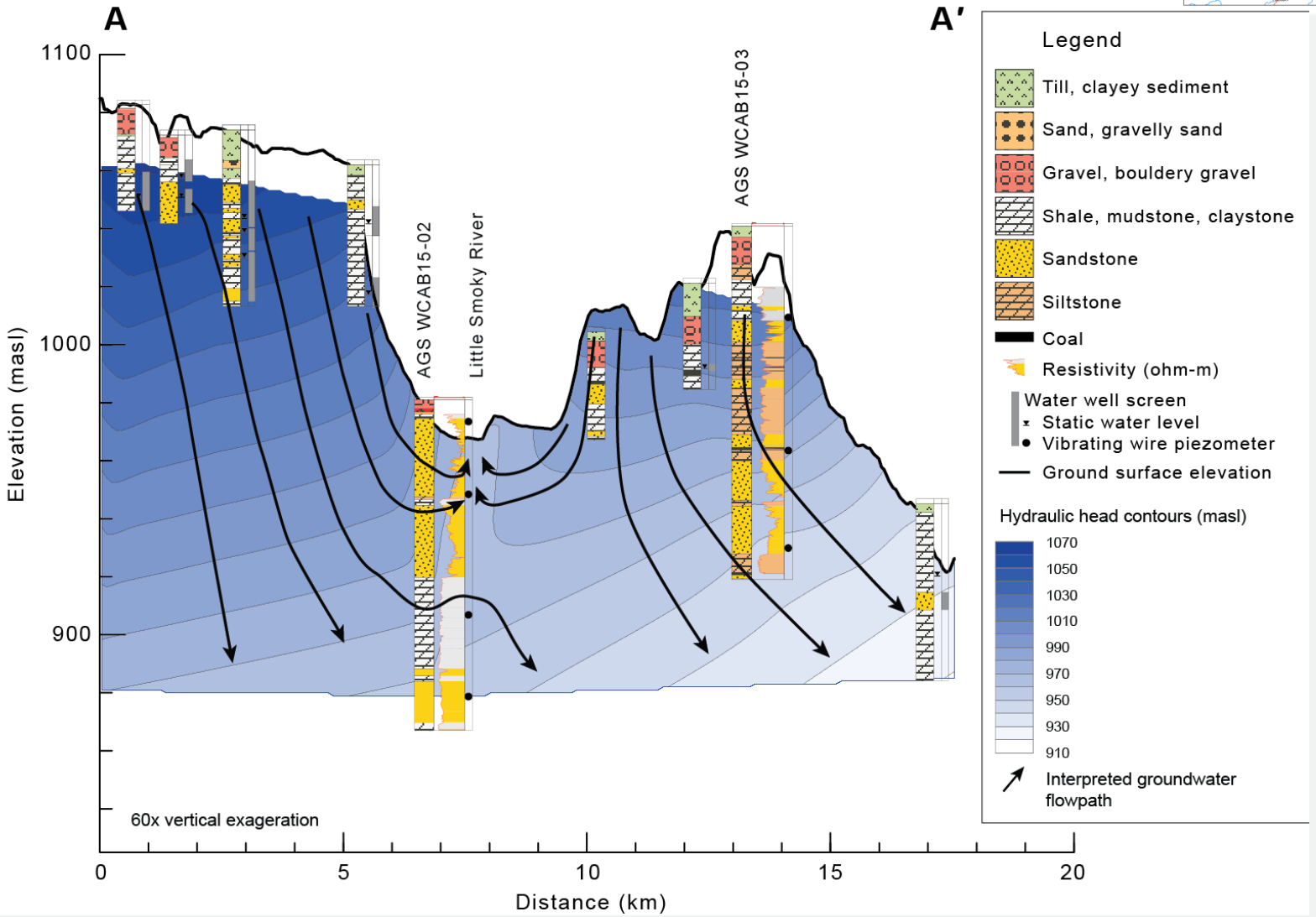
Study Area Depth Interval





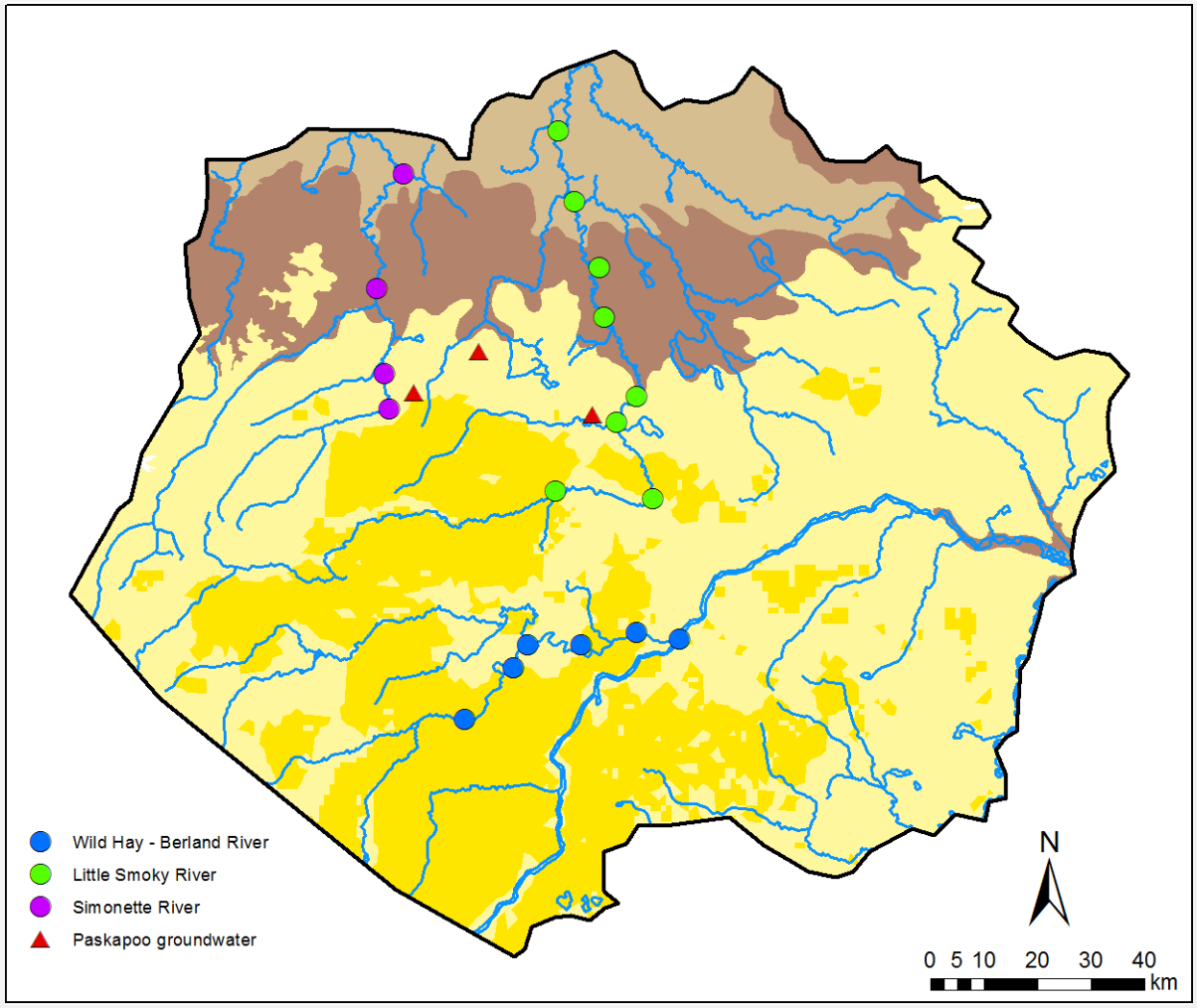
Bedrock Hydrogeology





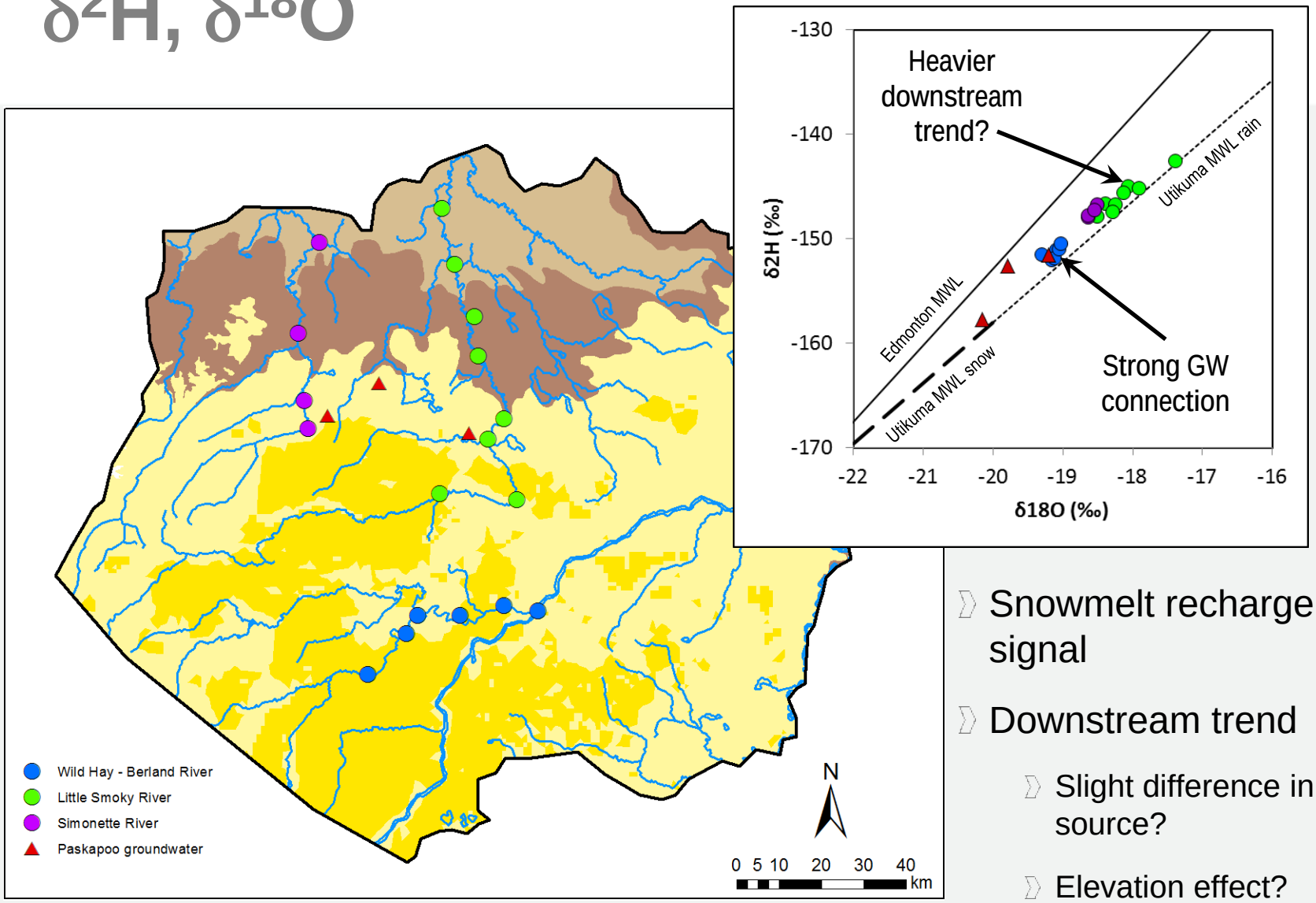
Smerdon et al., 2016; AGS OFR 2016-02

Environmental Tracer Sampling



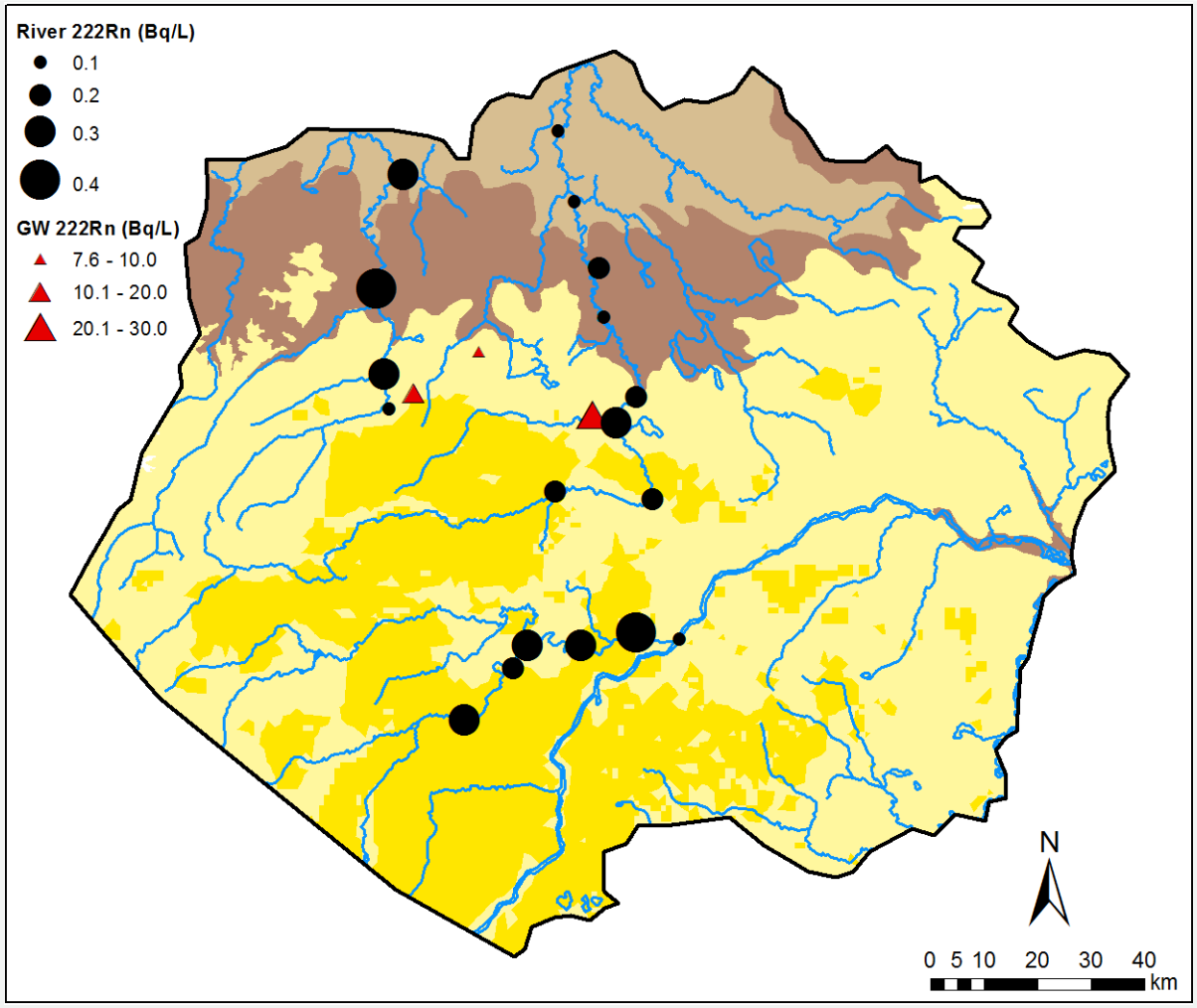
- 3 rivers spanning geological formations
- Sampled at low flow (September 2015)
- ~20 km sample spacing
- 3 groundwater samples
- Analytes:
  - Major ions
  - $\delta^{2}H$, $\delta^{18}0$
  - ^{222}Rn
  - SF_6, ^{3}H
  - Noble gases

δ^2H, $\delta^{18}O$



- Snowmelt recharge signal
- Downstream trend
  - Slight difference in source?
  - Elevation effect?

^{222}Rn



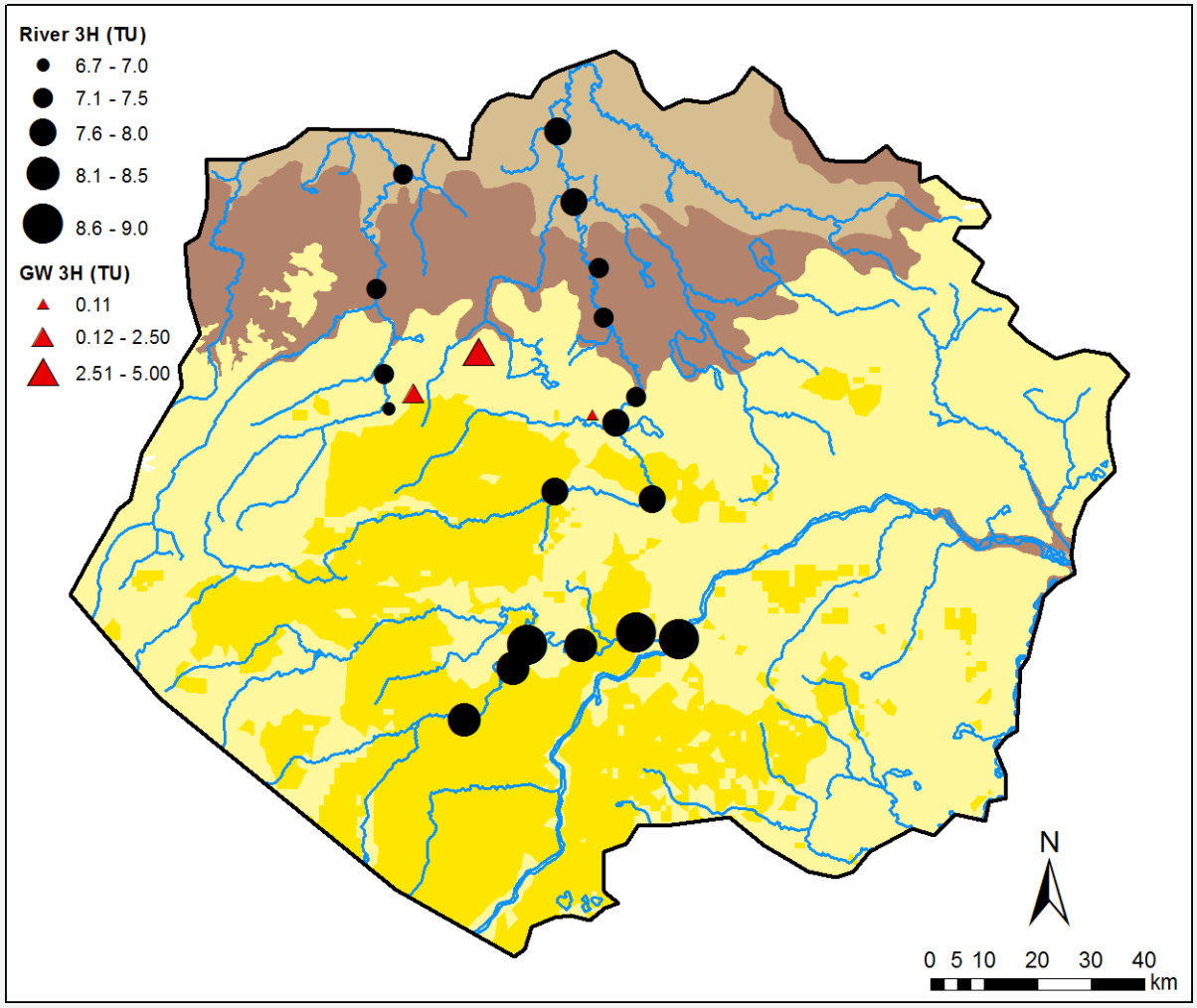
Method

- RAD7 detector

Result

- Low concentrations in river relative to groundwater
- Spatial variation could be related to discharge rate rather than bedrock geology

^3H



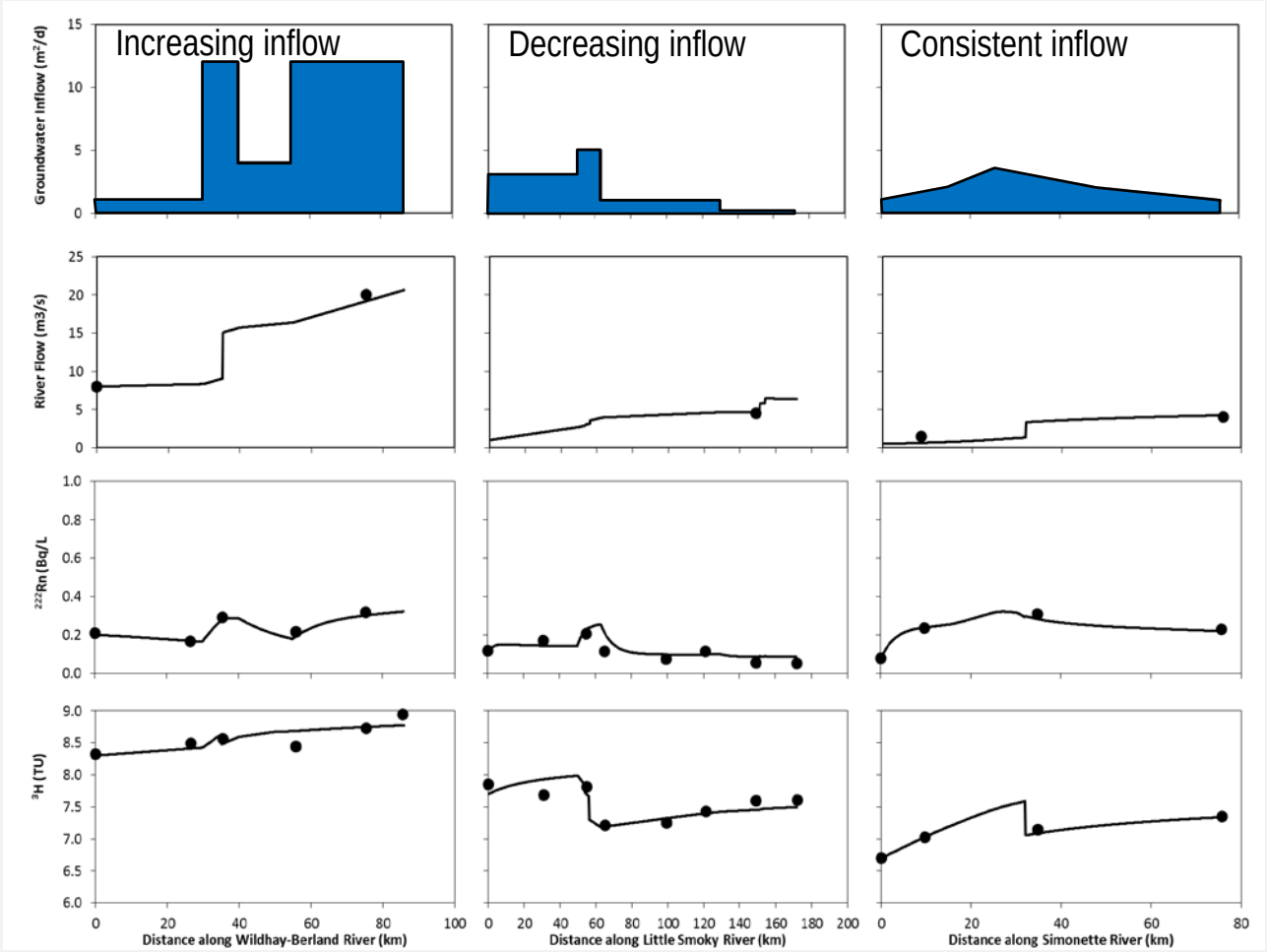
Method

- Helium in-growth
  - University of Utah

Result

- Concentrations represent modern input
- Spatial variation appears related to water circulation rate
  - Subtle differences
  - Locally recharged

Groundwater Discharge Modelling



Method

- Steady-state advective transport model
  - RADIN13, Peter Cook
  - Visual fit to ^{222}Rn, ^{3}H
- Assumed groundwater concentrations

Result

- High inflow areas align with known sandstone distribution
- Some insight, but needs more constraint

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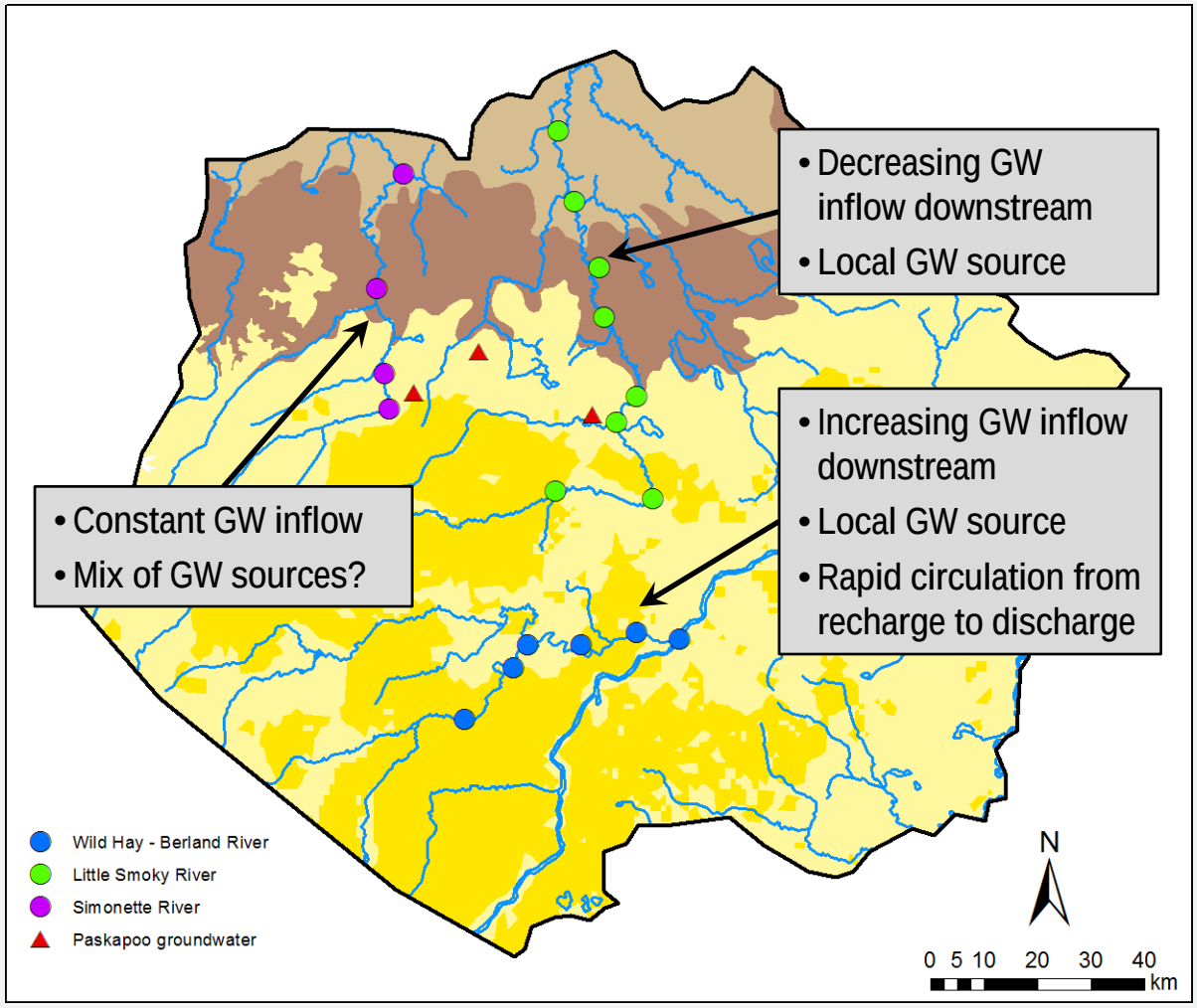

- Lean field program
  - Learned that rivers capture localized flow systems
  - 1st order GW inflow rates

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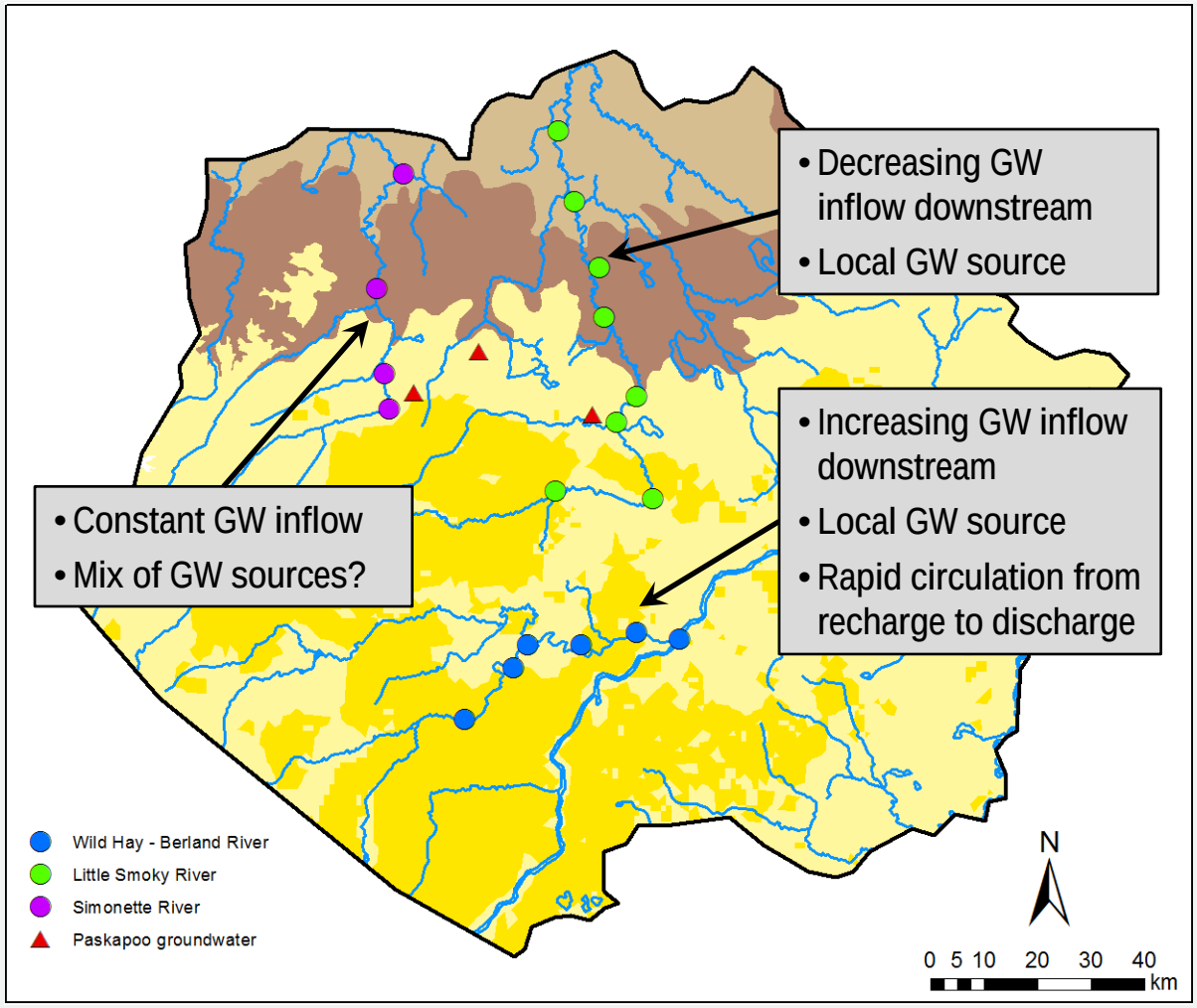
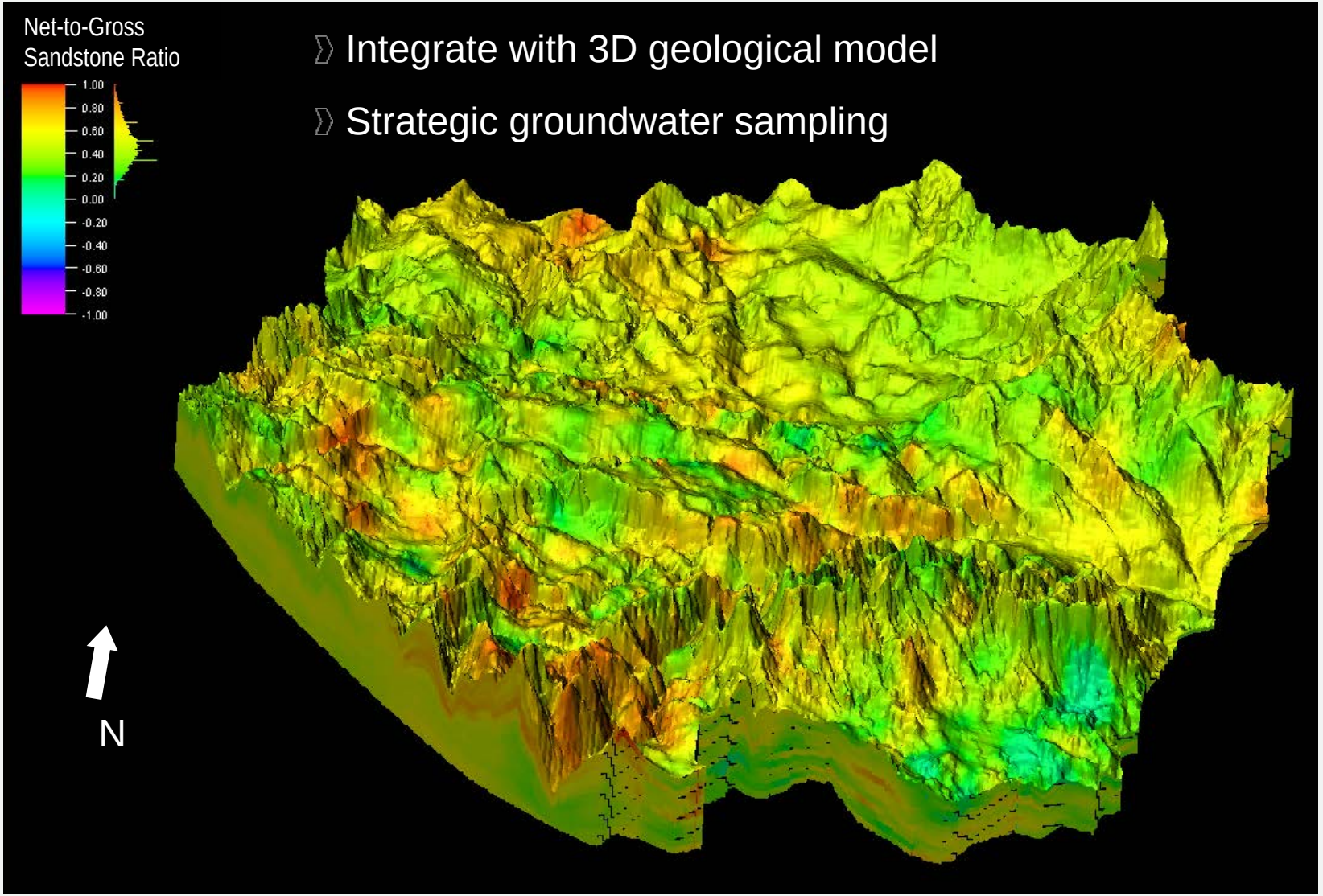


- Lean field program
  - Learned that rivers capture localized flow systems
  - 1st order GW inflow rates
- Has this helped?
  - Additional information at a suitable scale
  - Reinforced concept of water movement
  - Knowledge → guidance for regulation

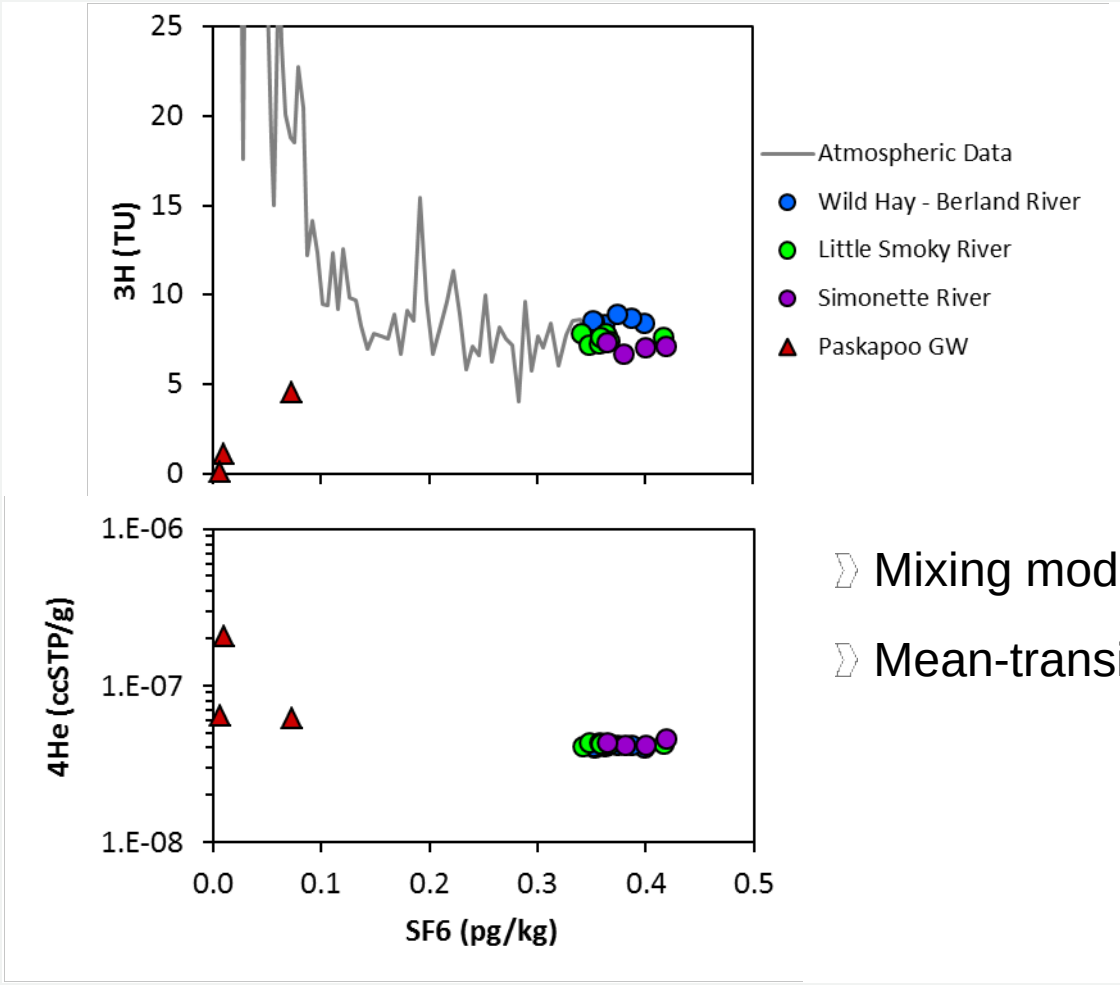
Future Work



- Integrate with 3D geological model
- Strategic groundwater sampling

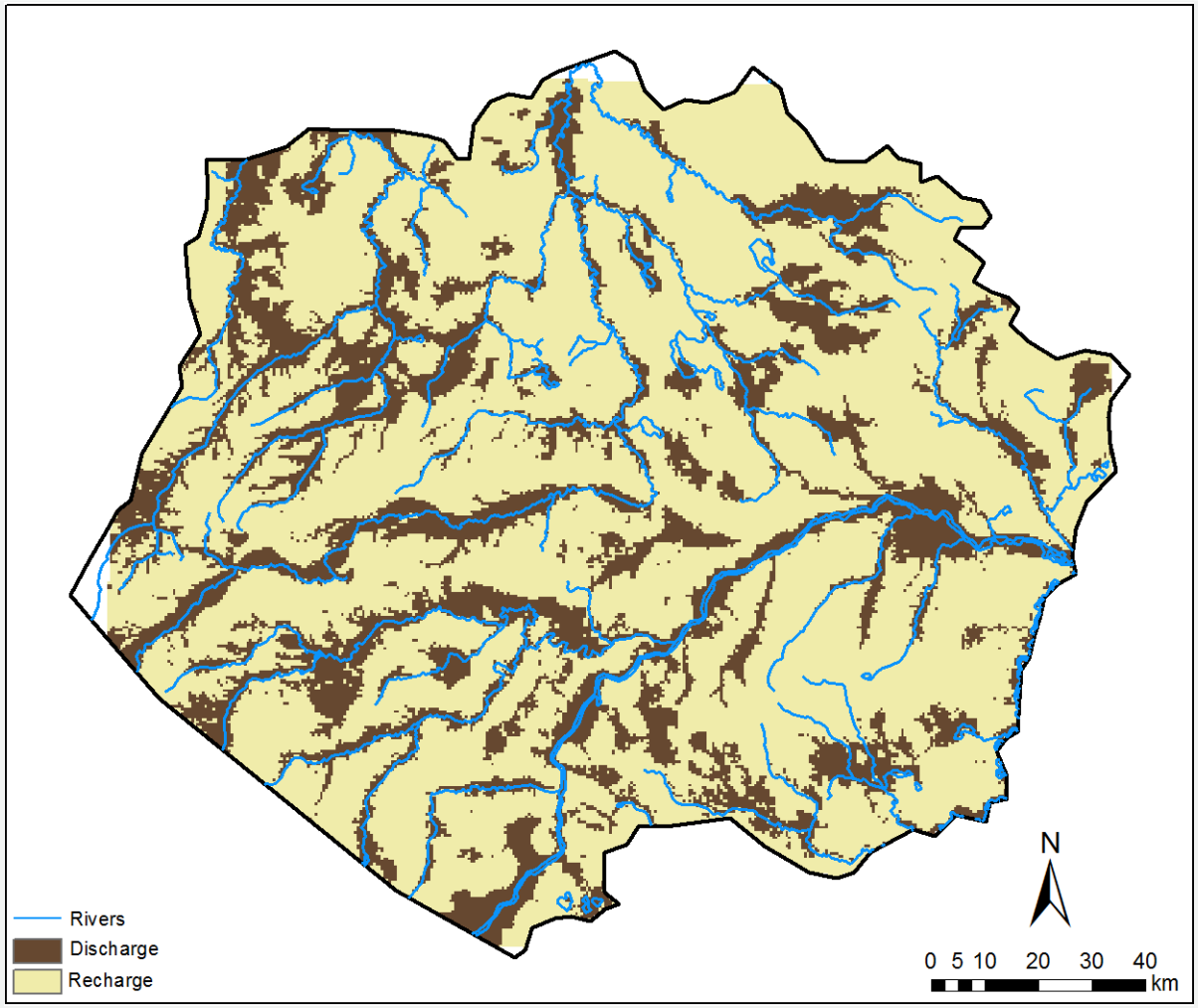
Thank you

Future Work



- Mixing models
- Mean-transit-time

Recharge-Discharge Mapping



- Estimate of recharge-discharge potential
  - Potentiometric surface of uppermost bedrock relative to ground surface