Aligning Groundwater Mapping with the Scale of Regulation in the Fox Creek Area

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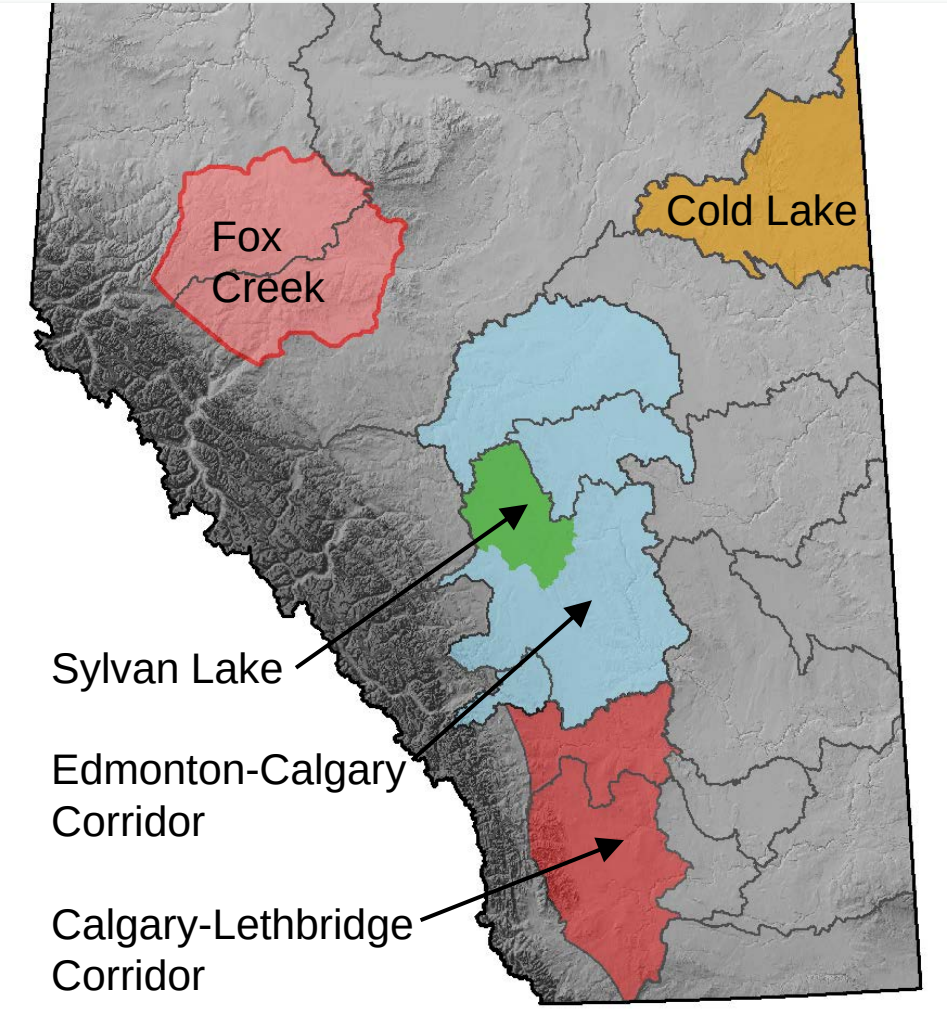
Alberta Geological Survey

WaterTech, 7 April 2016

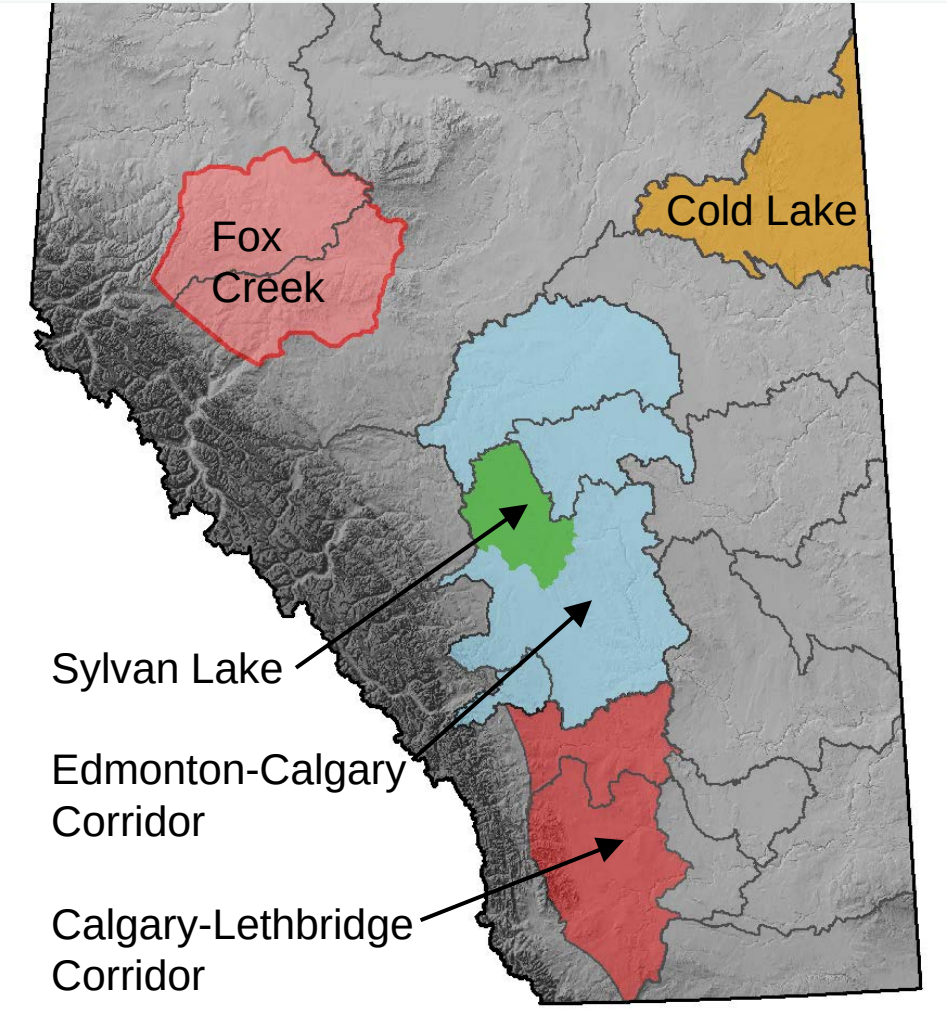
Provincial Groundwater Inventory Program



A partnership with Alberta Environment & Parks since 2008

- Map and inventory Alberta's groundwater resources
- Establish quantity and quality at regional scale
- Assist government in making informed decisions about groundwater
- Assess and understand cumulative effects of development

The Challenge of Spatial Scale



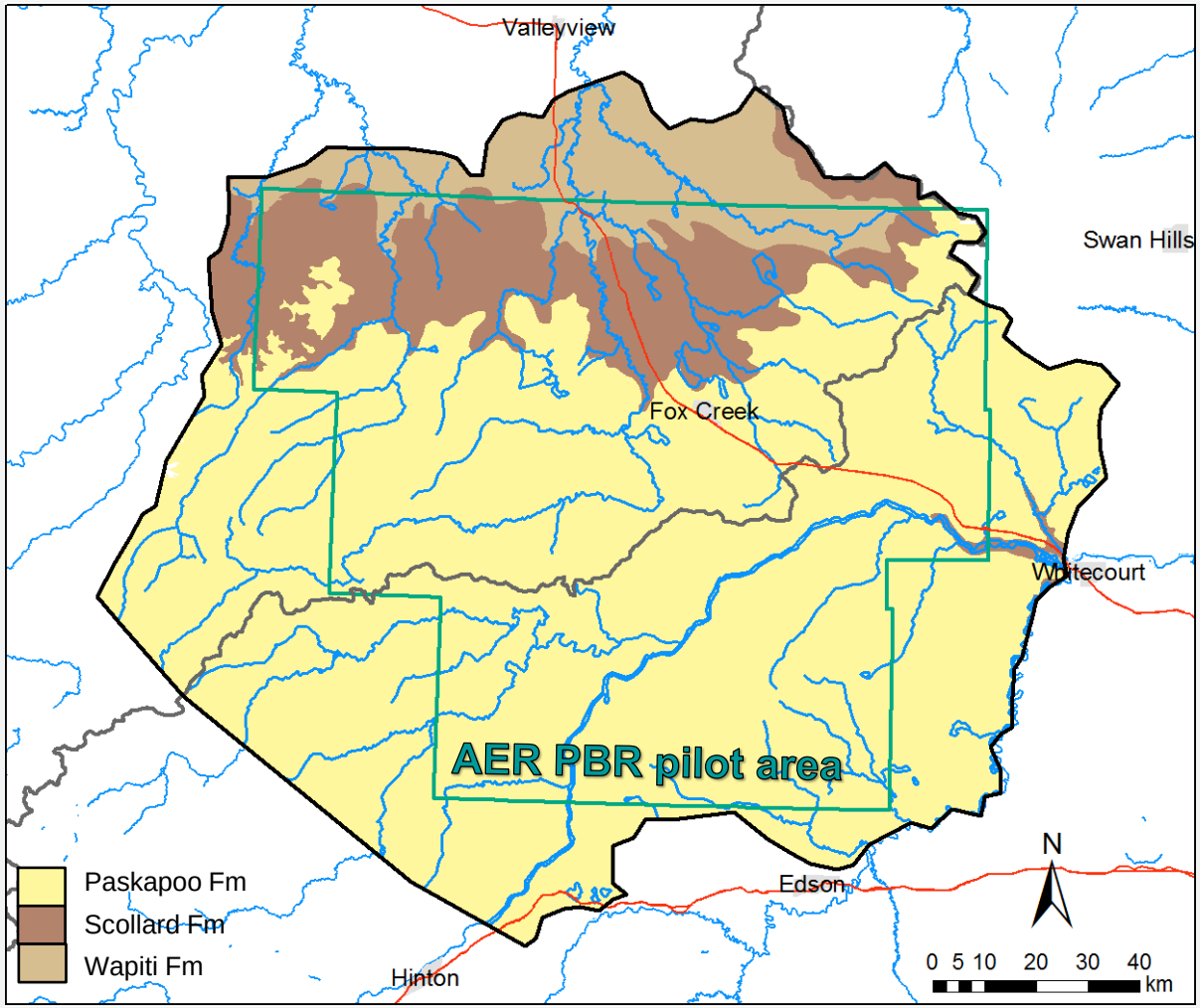
- Must recognize:
  - Policy and directives evaluated at a point
  - Transition to region assessment
- Ensure geoscience is meaningful at the ‘regional’ scale:
  - Area-based regulation
  - Land-use planning regions

Fox Creek Project Objectives

- Advance the understanding of the near-surface hydrogeology and map groundwater conditions within deeper formations as related to source water and disposal

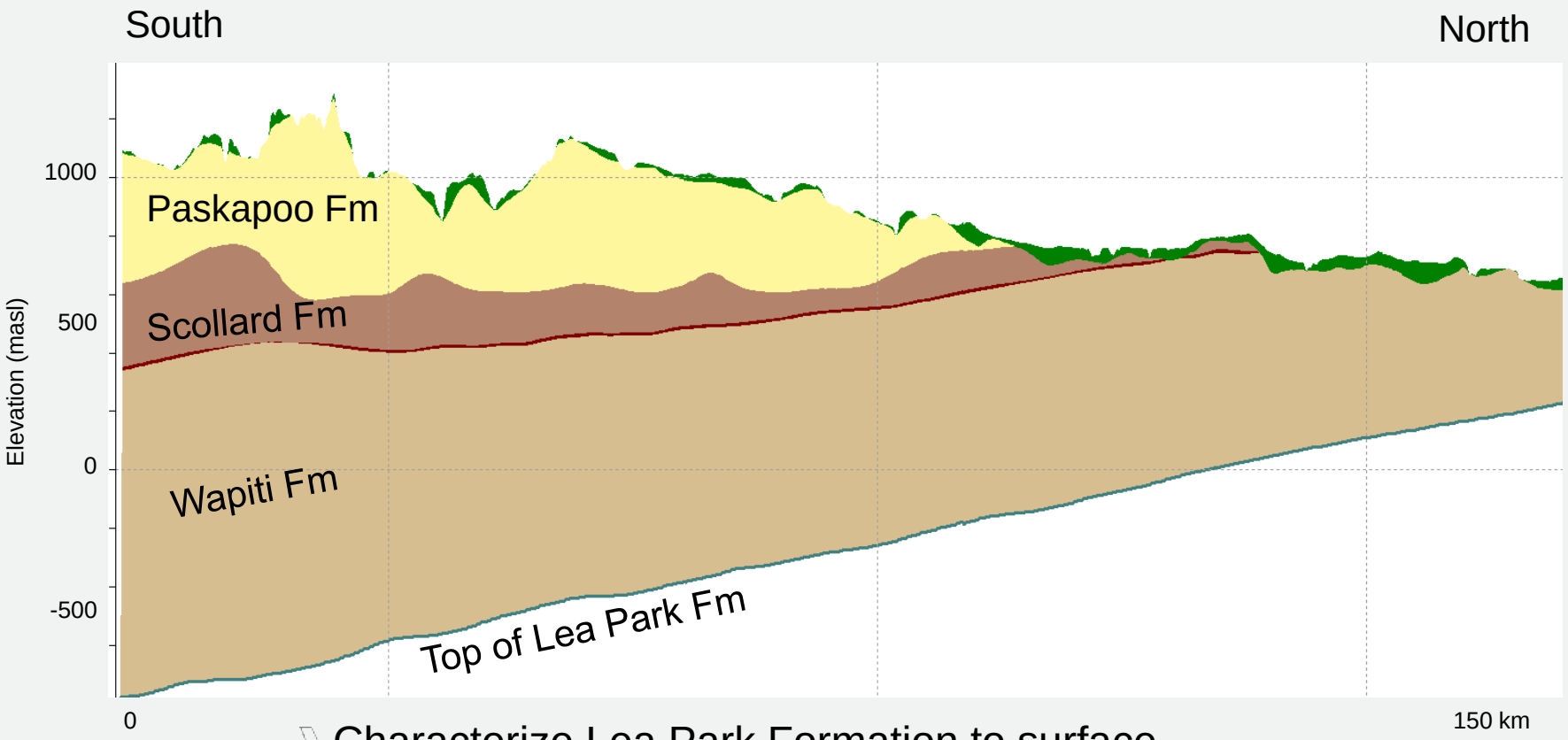
- Outcomes will include:
  - A 3D hydrostratigraphic framework model of the Quaternary, Neogene, and Upper Cretaceous formations;
  - An assessment of groundwater recharge and discharge rates, as well as the interaction between surface water and groundwater;
  - A conceptual model of nonsaline groundwater circulation, including a water balance; and
  - Maps of salinity, potentiometric surfaces, and water driving force for saline formations.

Fox Creek Study Area (extent)



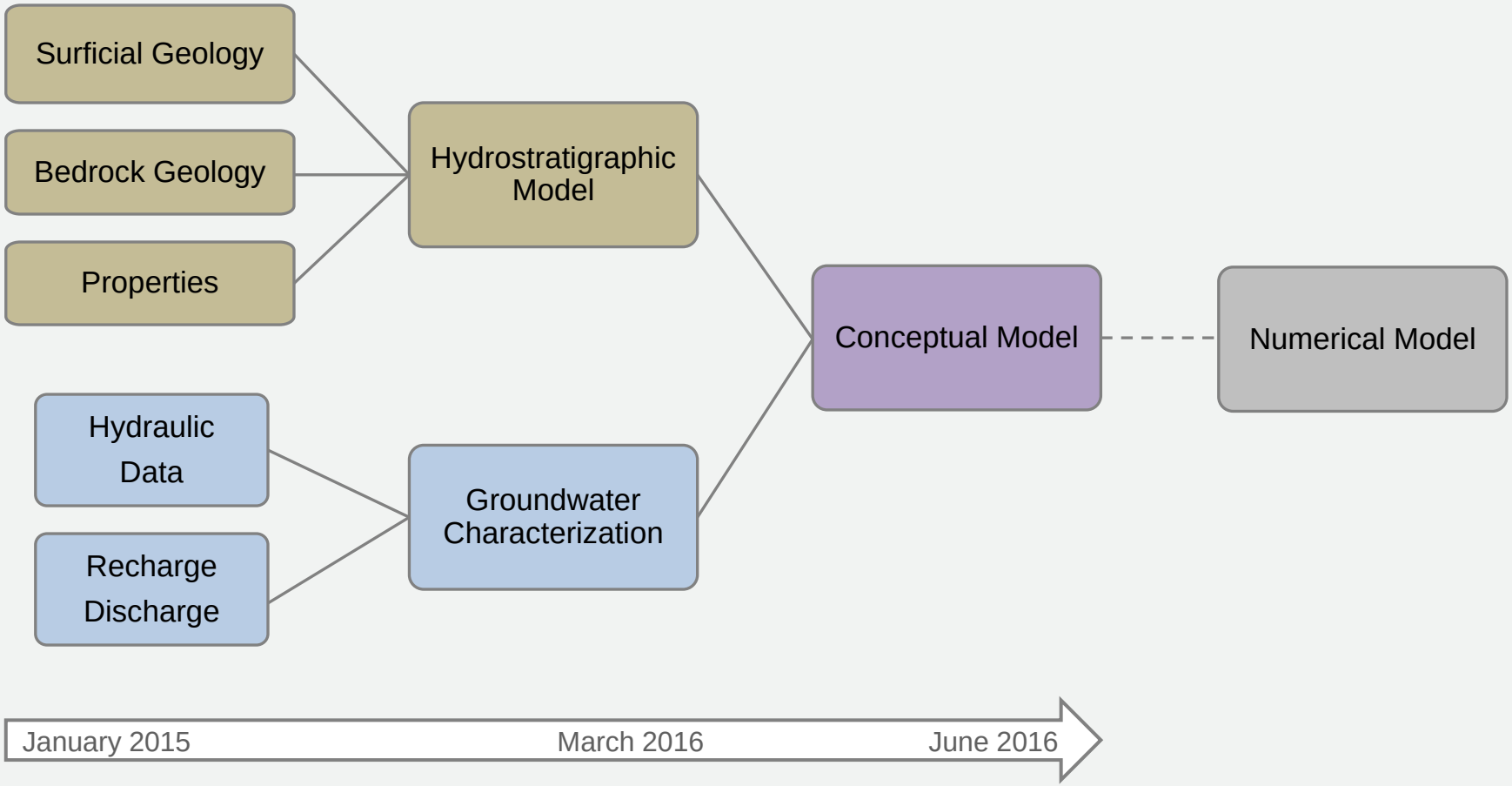
- Spans Peace and Athabasca basins
- Defined by sub-basin drainage
- Encompasses AER PBR pilot area
- 22,000 km^2

Fox Creek Study Area (depth)

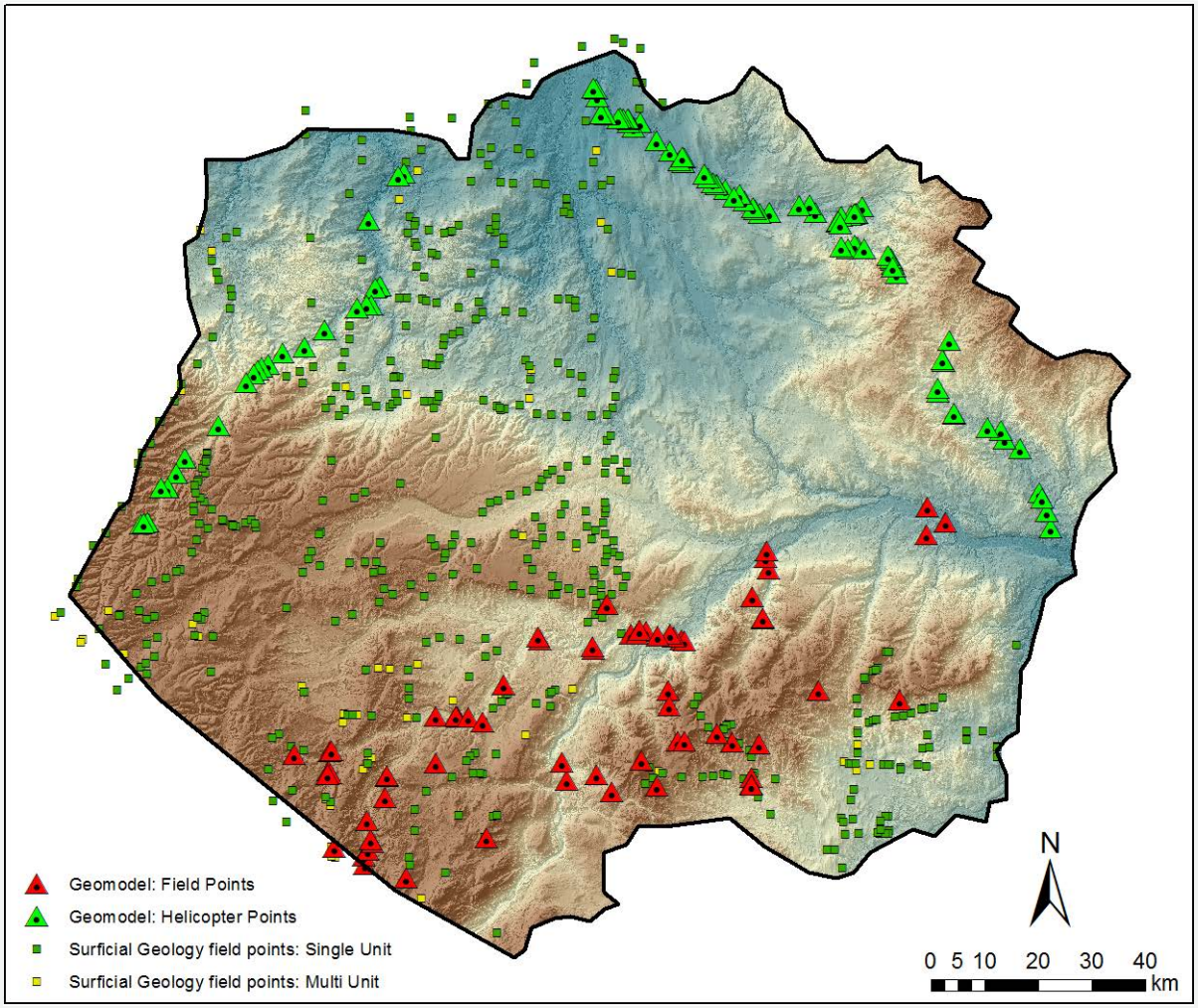


- Characterize Lea Park Formation to surface
- Map groundwater conditions within deeper formations

Conceptual Model Development



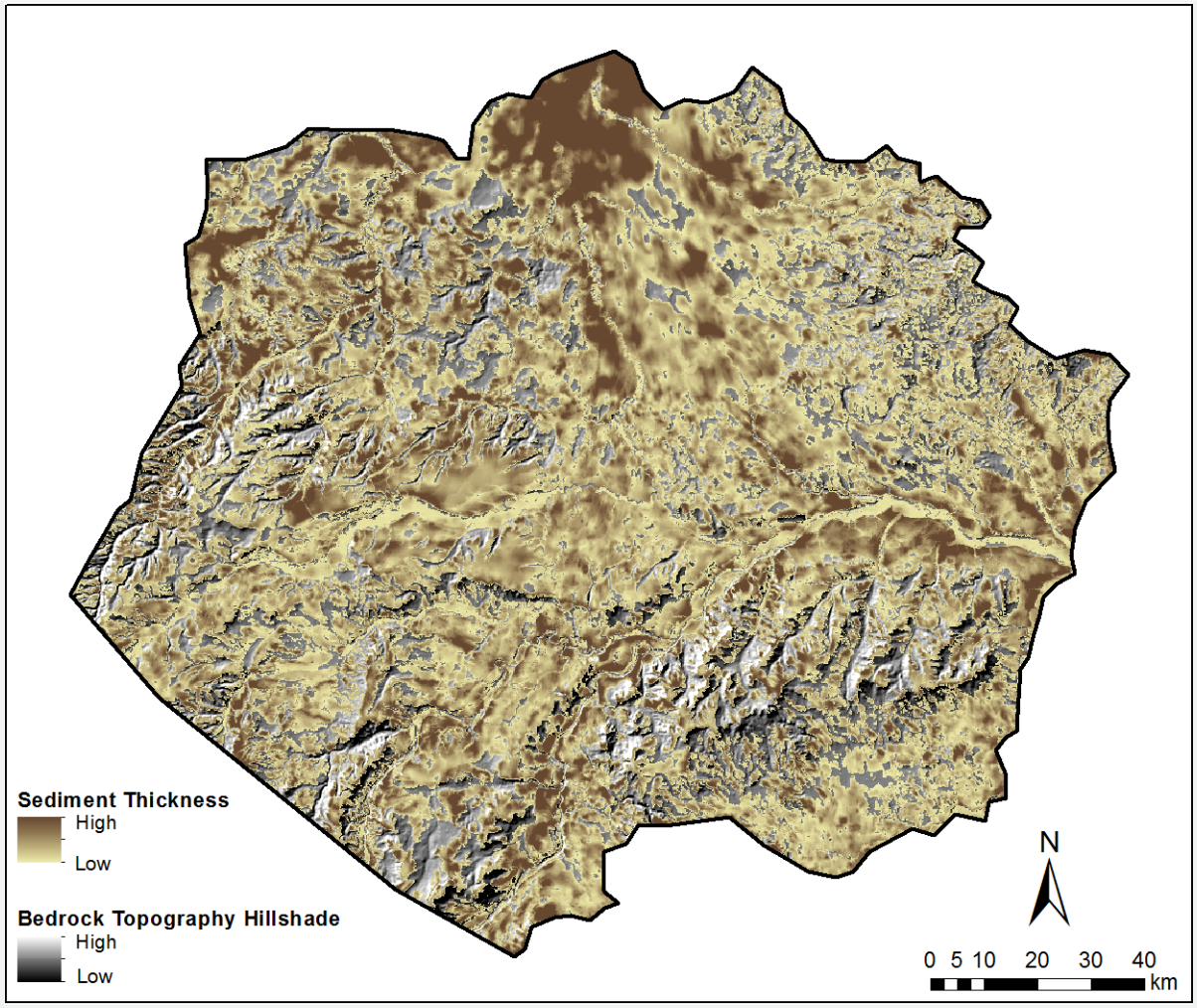
Hydrostratigraphic Modelling



Data Sources:

- 2015 field mapping
- Surficial geology field mapping
- Gamma logs to ground surface
- Legacy boreholes (e.g. ARC coal)
- Water wells (used to infill as needed)

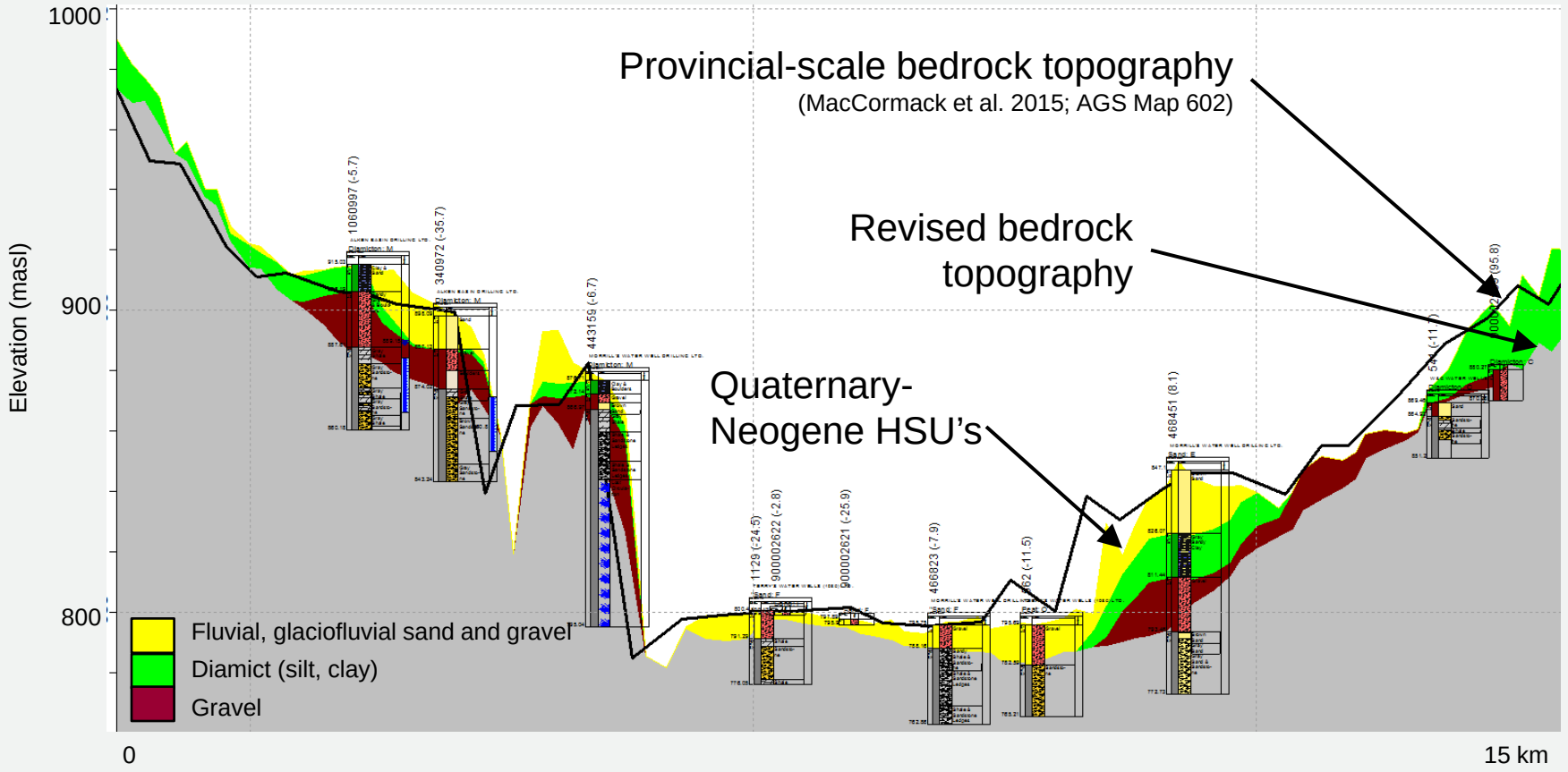
Hydrostratigraphic Modelling



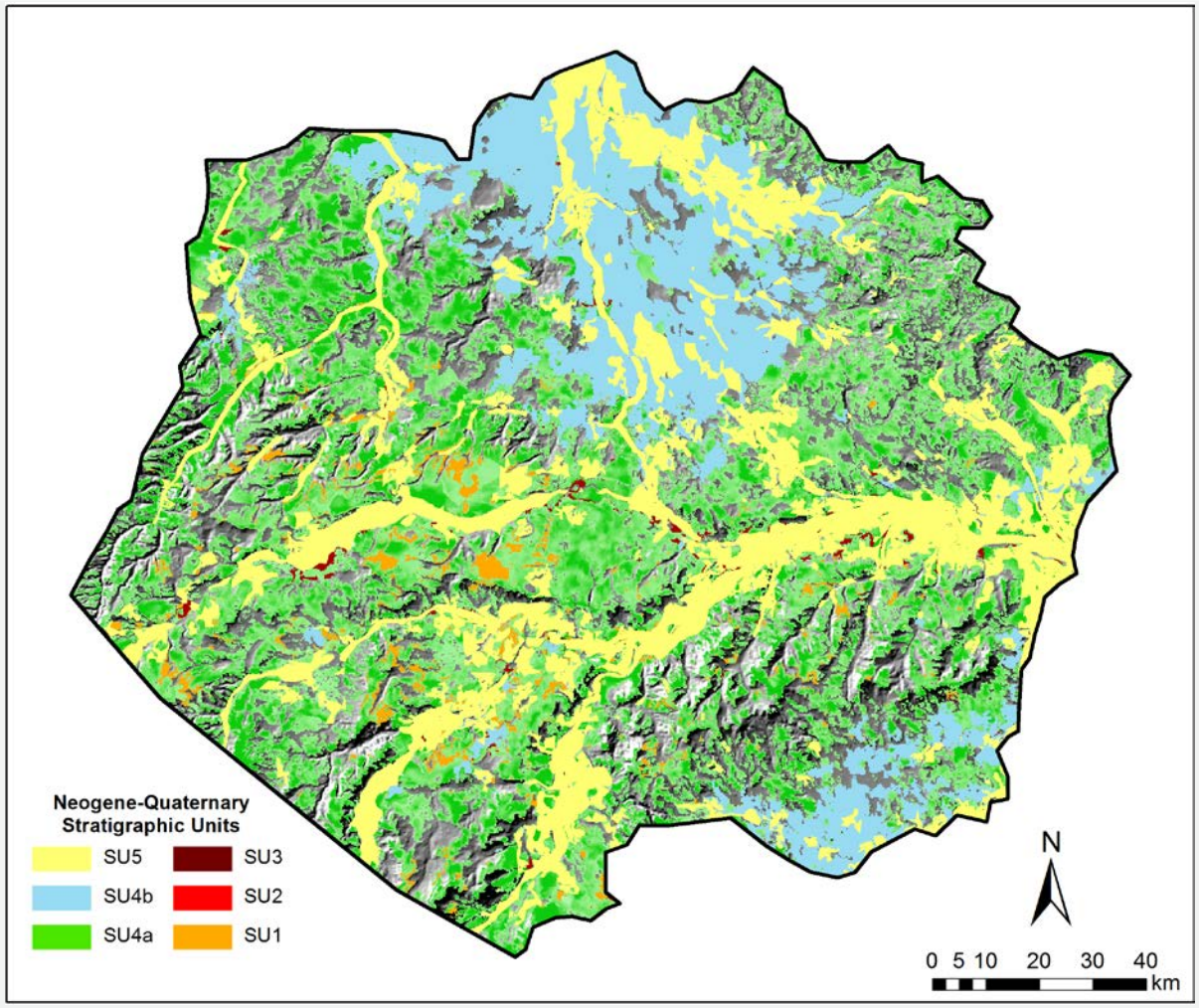
Process:

- Revise bedrock topography to fit new data
- Define Quaternary-Neogene hydro-stratigraphic units (HSU's)
- Sand slice mapping (Lea Park Fm to bedrock top)
- Generate 3D block model

Updated Bedrock Topography

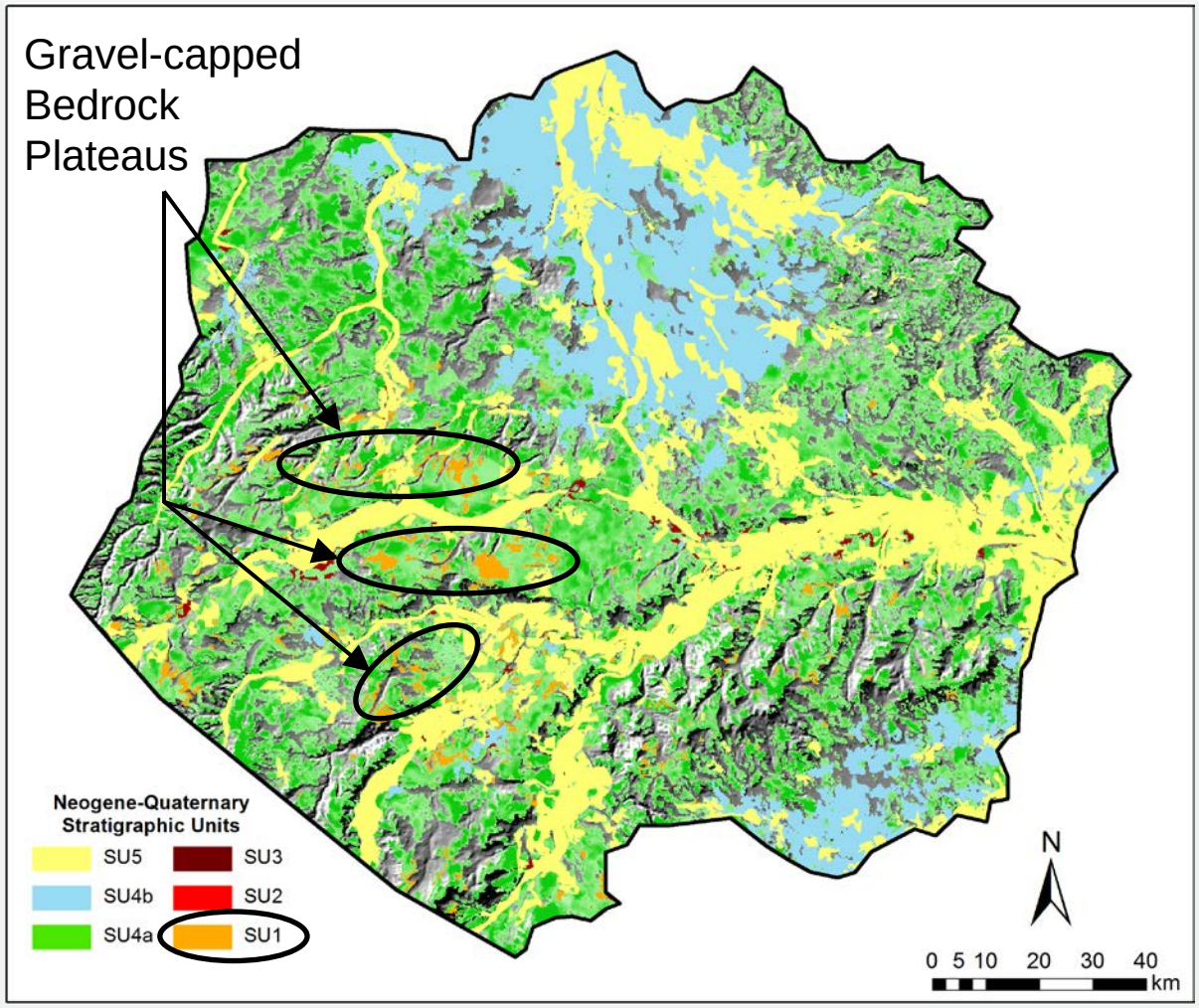


Quaternary-Neogene HSU's



- Broadly similar to surficial geology
  (Fenton et al. 2013; AGS Map 601)
- 3D representation of units important for water cycling

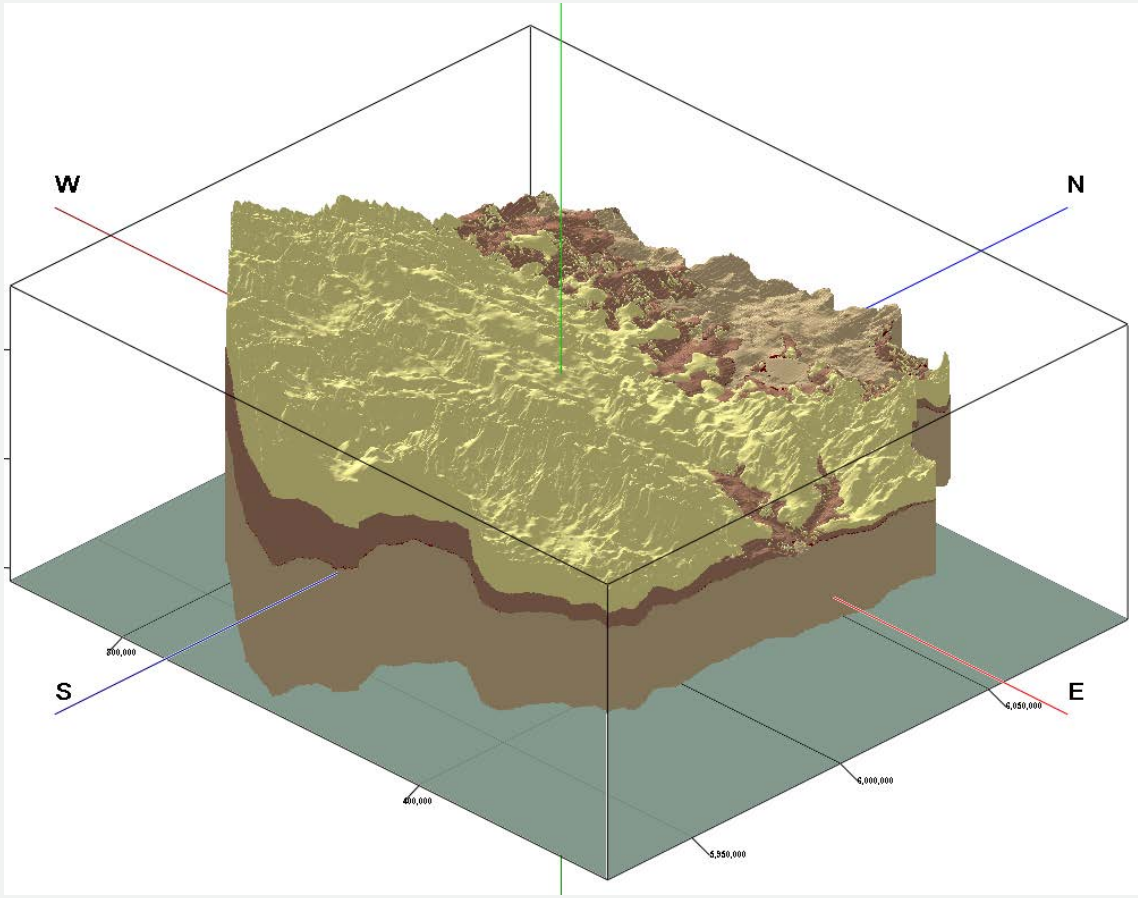
Quaternary-Neogene HSU's



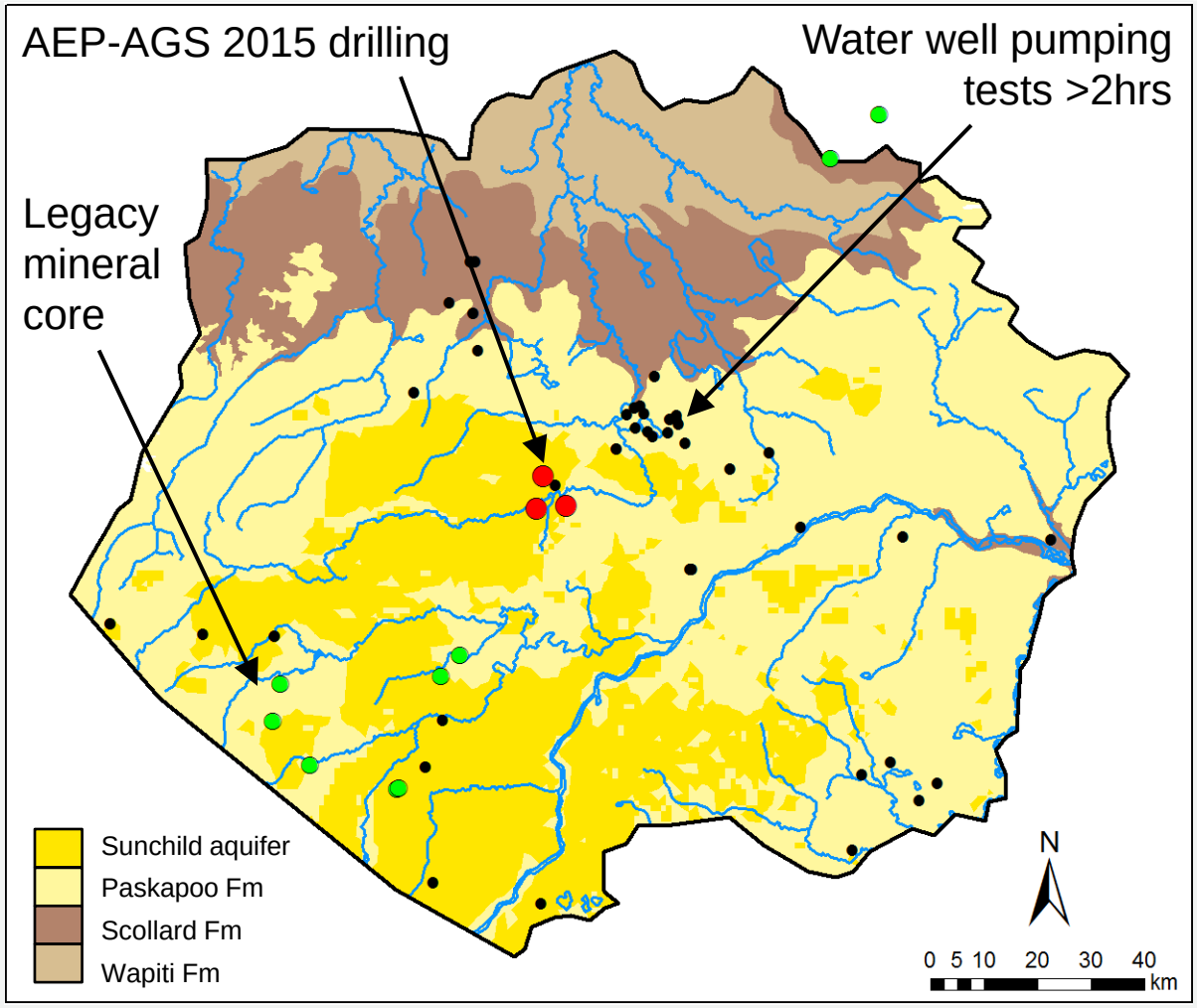
- Broadly similar to surficial geology
  (Fenton et al. 2013; AGS Map 601)
- 3D representation of units important for water cycling
- Identify key features related to groundwater recharge

Hydrostratigraphy: Next Steps

- Slice analysis
  - Lea Park Fm to bedrock top
  - Net-to-gross sandstone ratio from gamma ray and water well logs
- Generate 3D block model
  - Hydraulic properties
  - Evaluate trends in permeability



Hydrogeological Characterization



Data Sources:

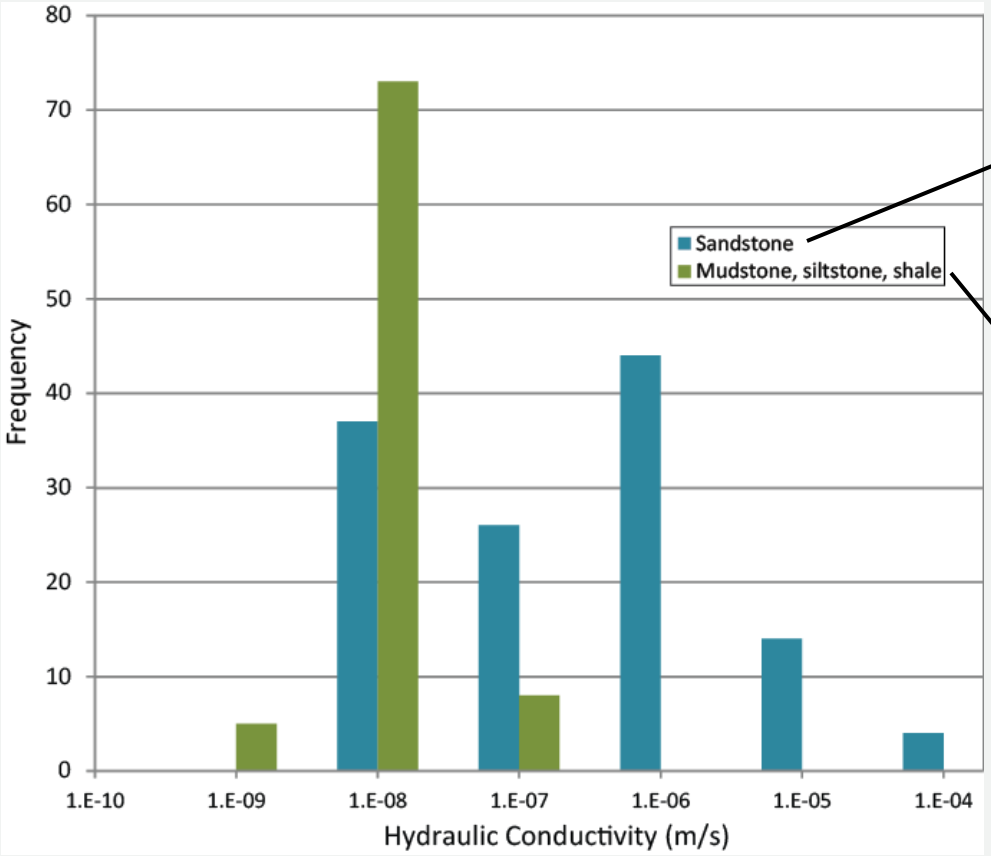
- 2015 drilling and field mapping
- Legacy core
- Water well database

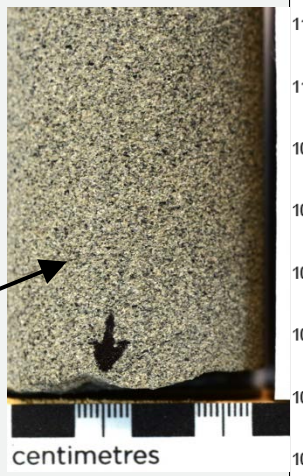
Process:

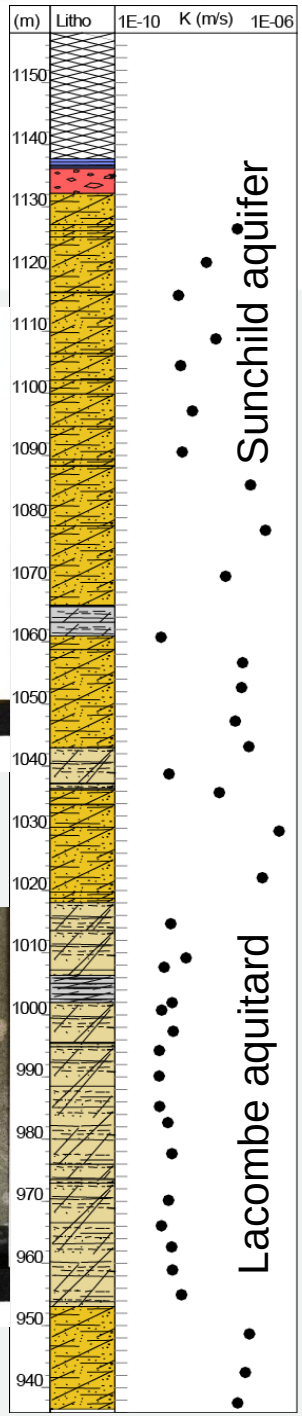
- Map potentiometric surface of uppermost bedrock
  - 2000 – 2015 period
- Determine hydraulic properties

Hydraulic Properties

- Core analyses (n = 9)
  - Permeability, porosity, mineralogy

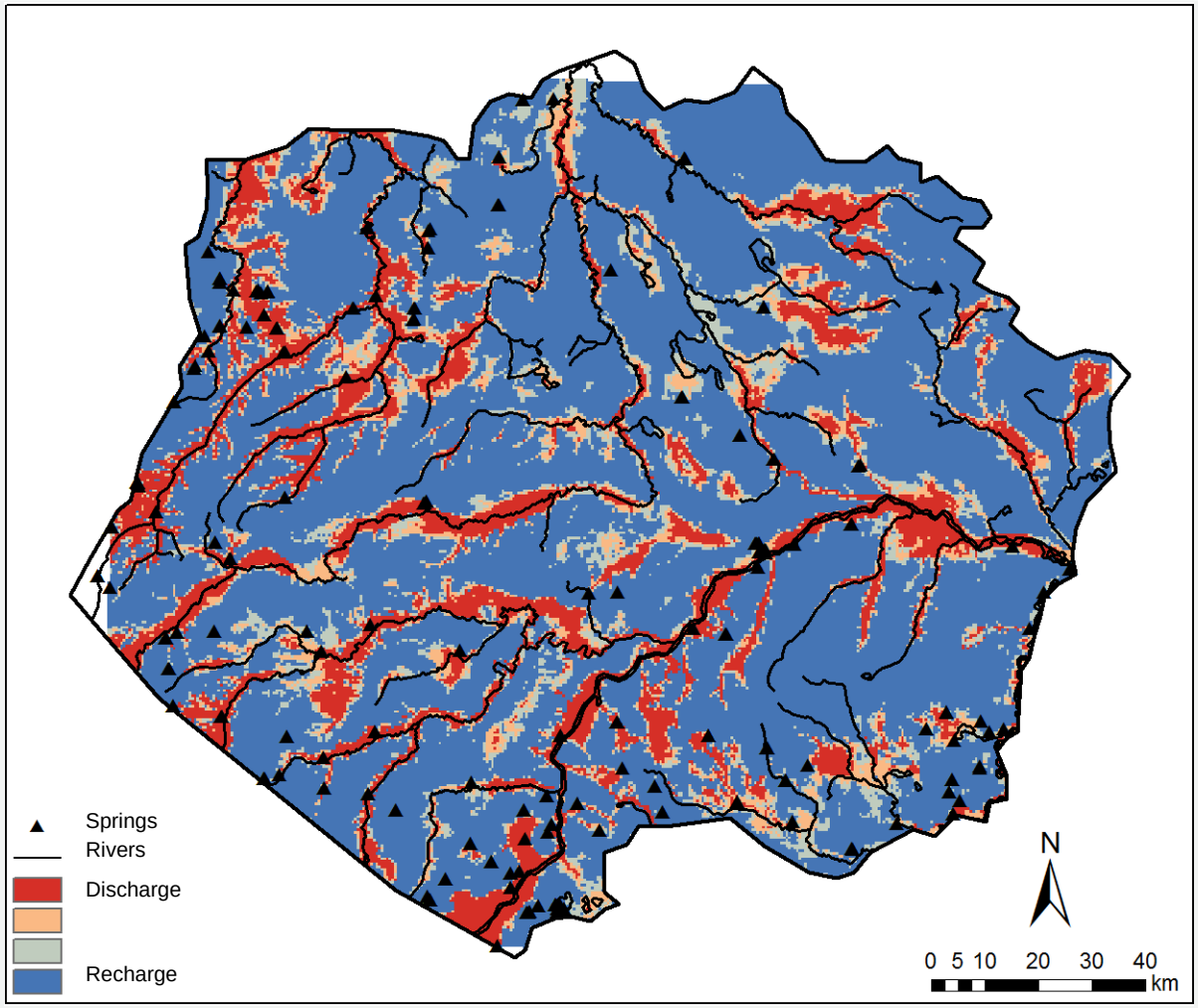






Hughes et al., 2016; AGS OFR 2016-xx

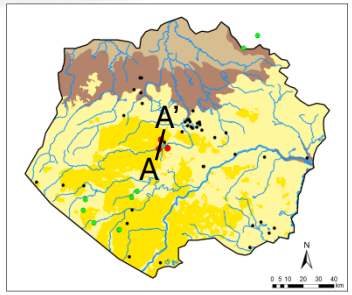
Paskapoo Hydrogeology

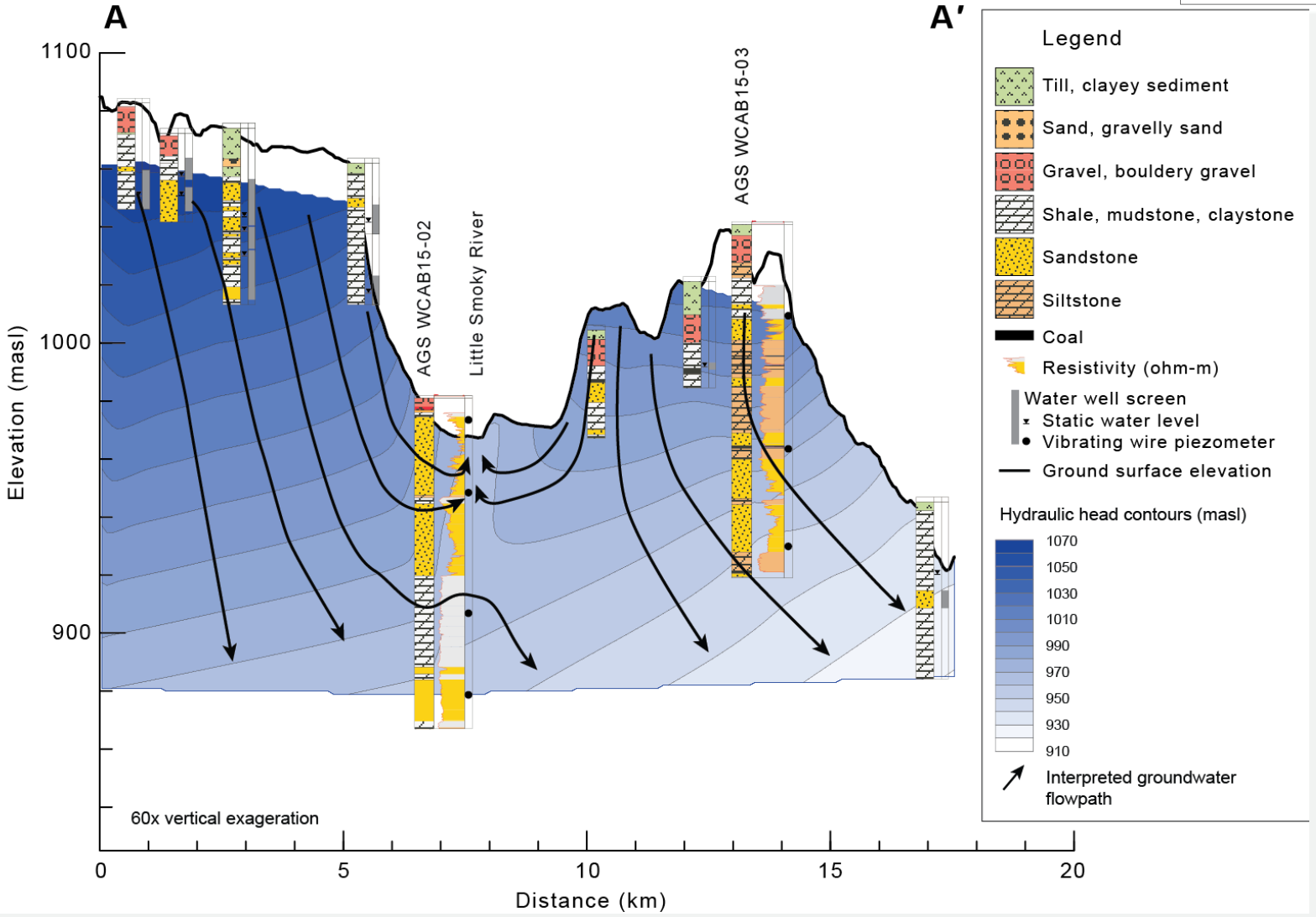


- Potentiometric surface of uppermost bedrock relative to ground surface
- Estimate of recharge-discharge potential
- Dominance of groundwater recharge
- Localized flow systems provide base flow to rivers

Paskapoo Hydrogeology

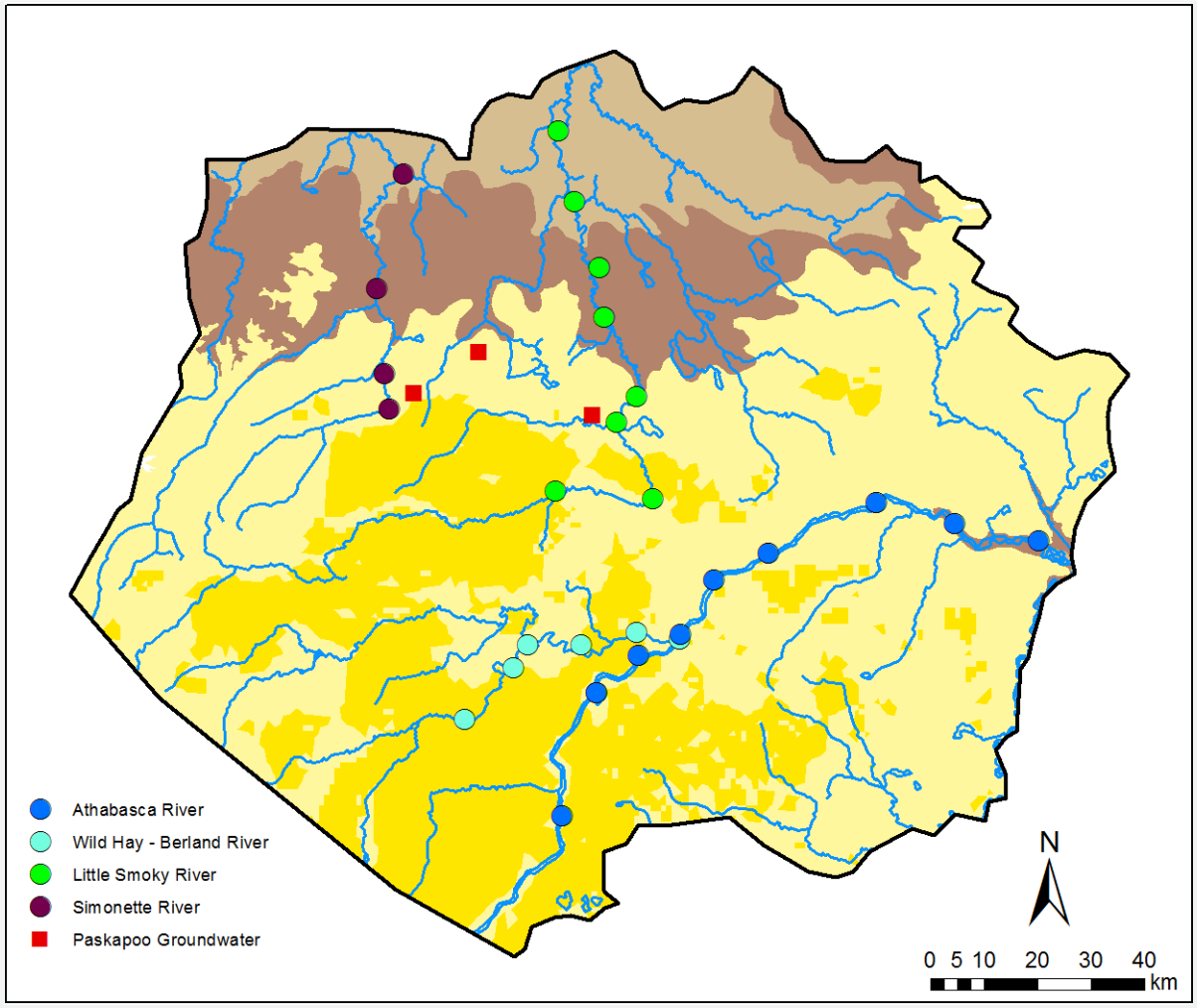
Paskapoo Hydrogeology





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

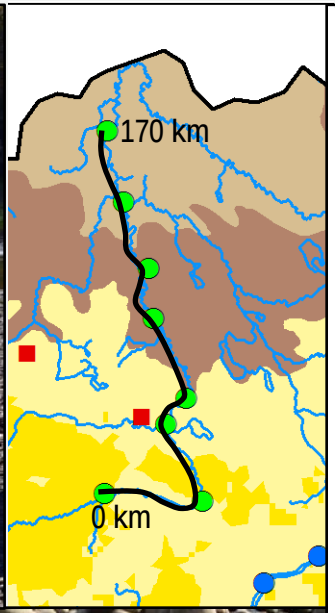
Environmental Tracer Sampling

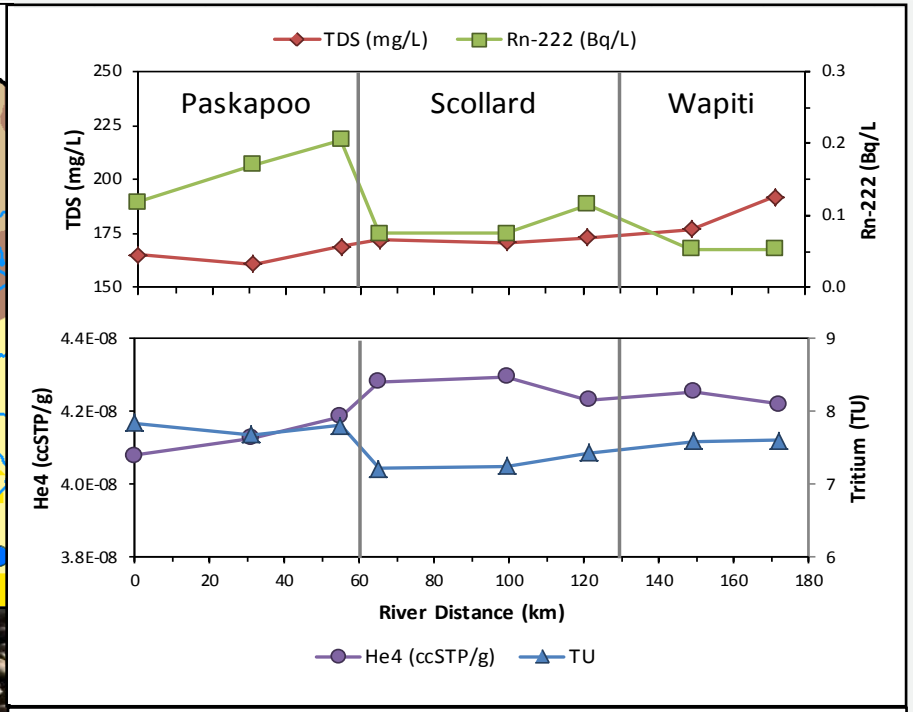


Process:

- Rivers as an integrator of the groundwater circulation
- Sample river water at low flow (September 2015)
- Analyze for naturally occurring tracers (noble gases, ^{3}H, SF_6, ^{222}Rn, stable isotopes)

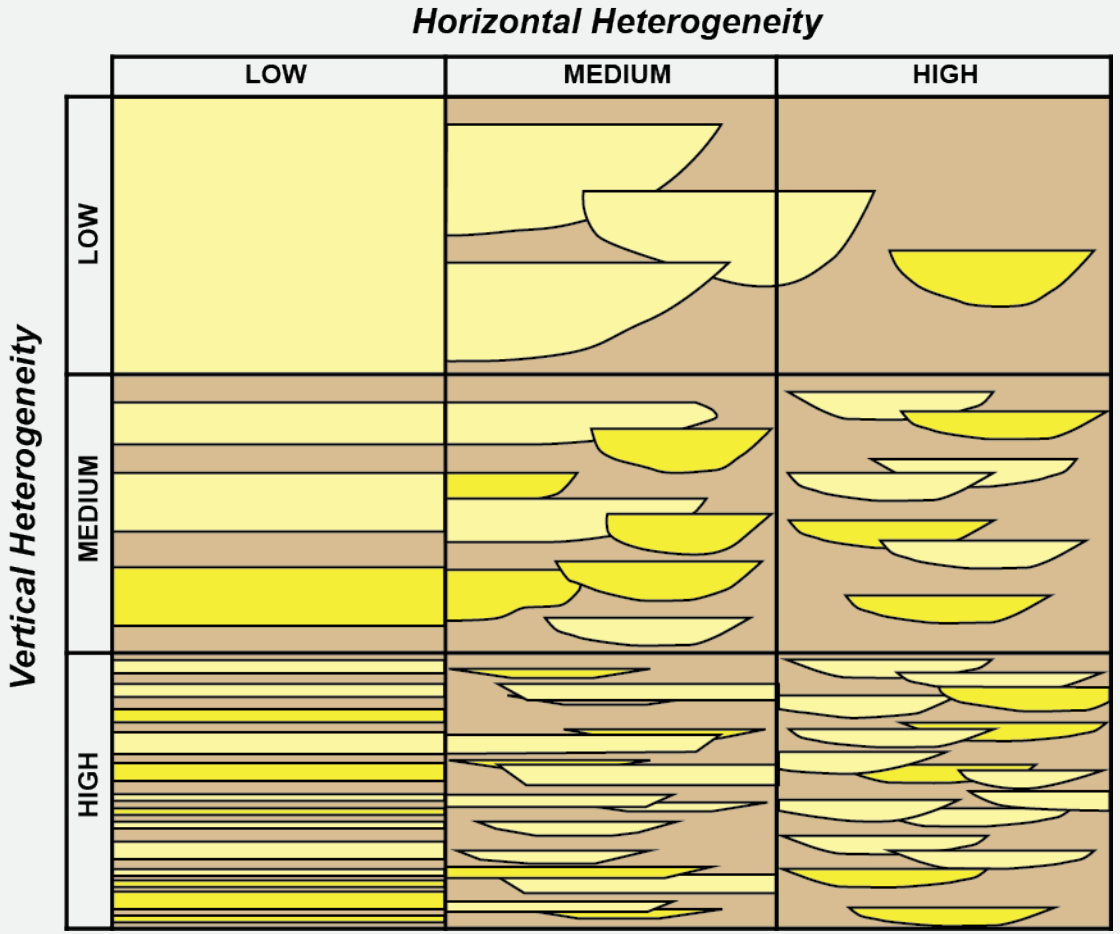
Environmental Tracer Sampling





- Quantify proportion of baseflow at scale of geological formations
- Better conceptual understanding
- Incorporate new knowledge into models

Scale and Detail:
Finding the Sweet Spot

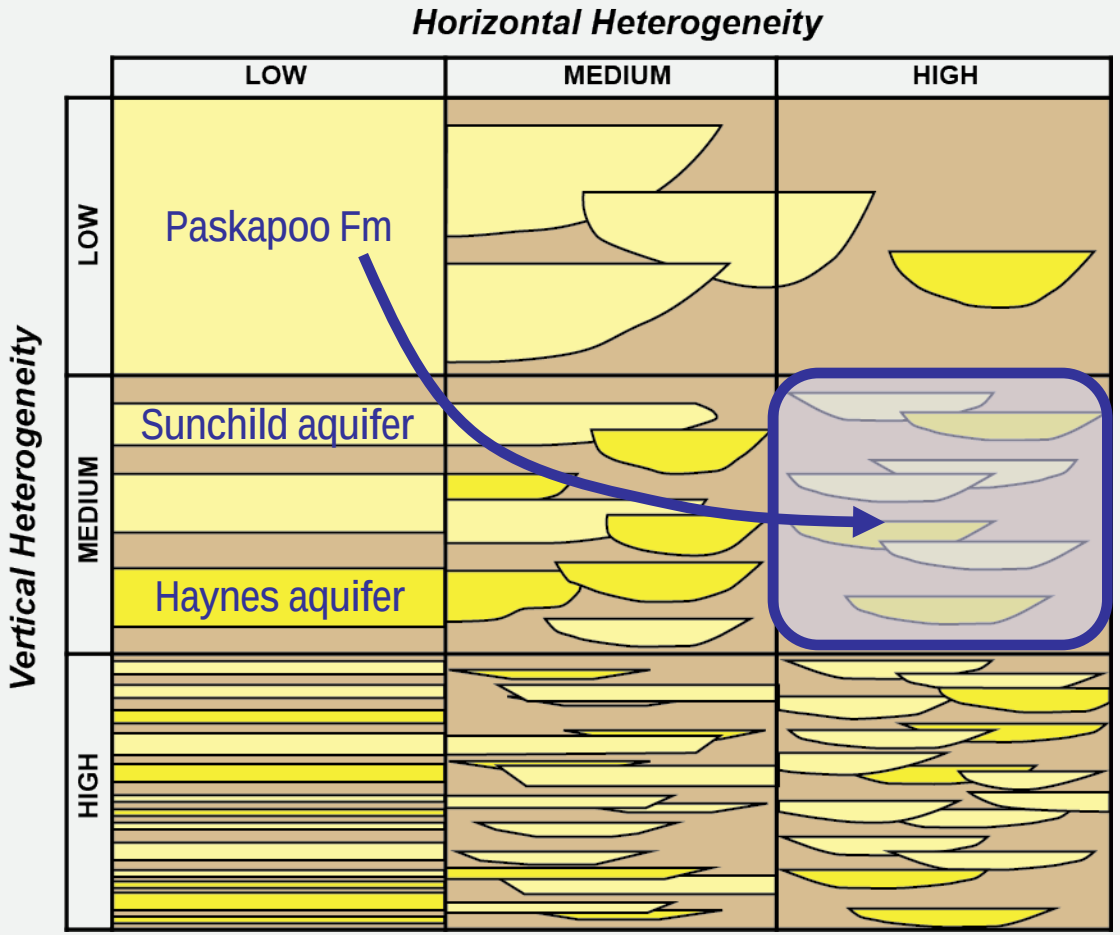


Tyler and Finley 1991; SPE-22670-MS

Scale and Detail:
Finding the Sweet Spot

Provincial scale
geological framework

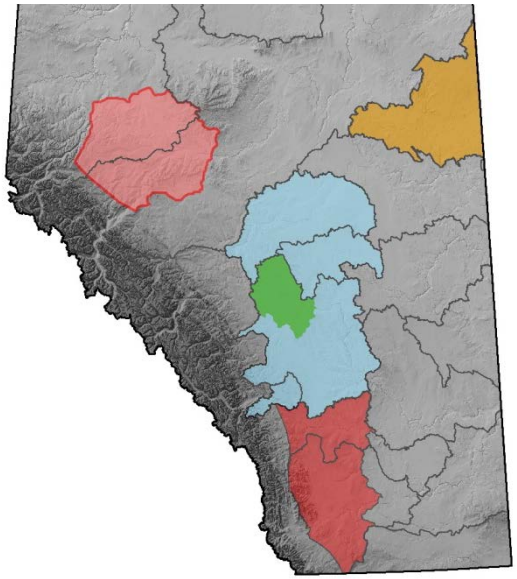
High-resolution
geophysical logs



Tyler and Finley 1991; SPE-22670-MS

Aligning Groundwater Mapping with the Scale of Regulation

- Anticipate the needs of regulators, industry, other users
  - What is the scale of development?
  - What level of detail will be informative?



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- Anticipate the needs of regulators, industry, other users
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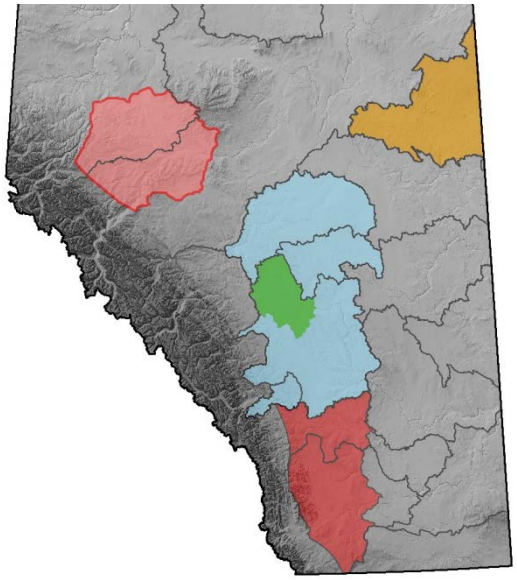
  - What level of detail will be informative?
- Make strategic detailed measurements that help form the ‘big picture’
  - Maximize available data sources
  - Develop lean field programs



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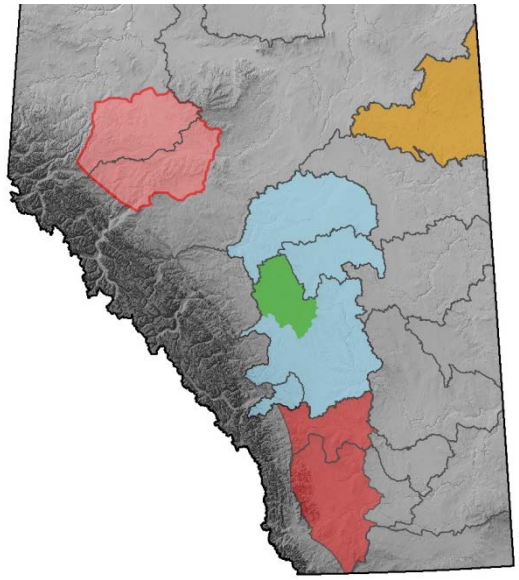

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  - What is the scale of development?
  - What level of detail will be informative?
- Make strategic detailed measurements that help form the ‘big picture’
  - Maximize available data sources
  - Develop lean field programs
- Deliver the geoscience to support cumulative effects management initiatives

Questions

Thank you