



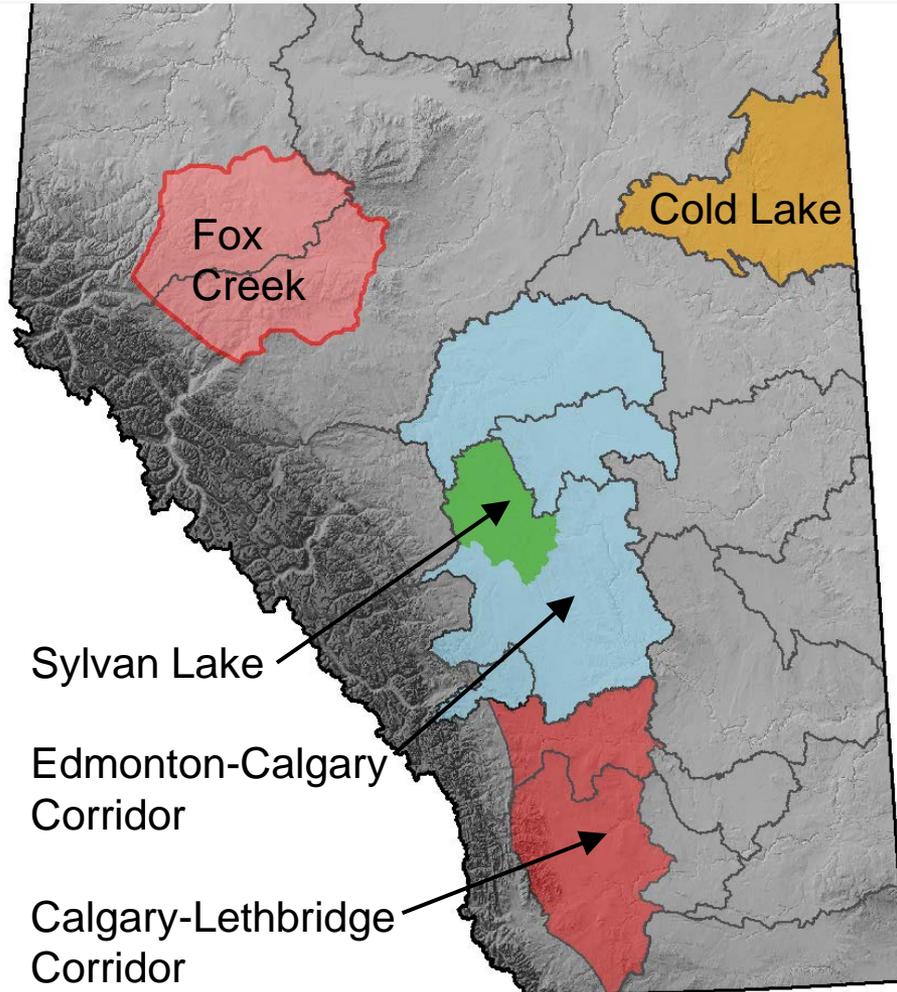
Providing geoscience to enable a better understanding of groundwater and surface water interaction in Alberta

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Alberta Geological Survey

CWRA Alberta Branch Annual Conference 2016

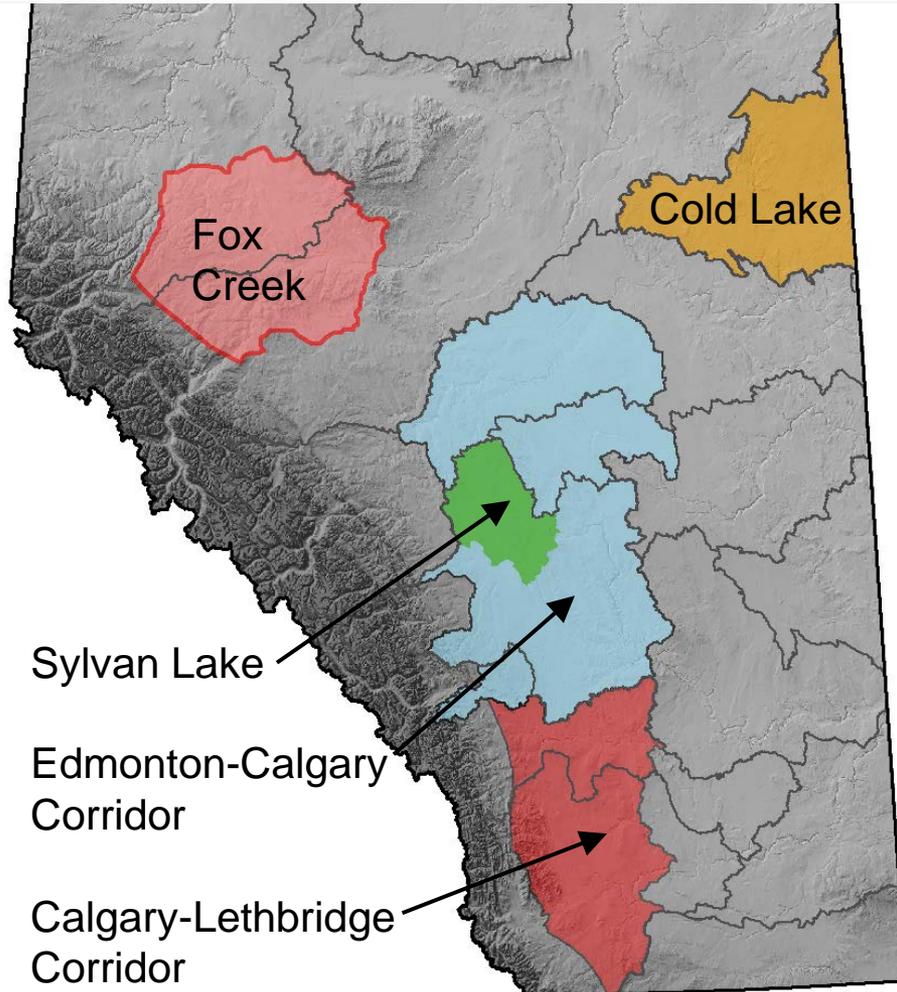
Provincial Groundwater Inventory Program



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

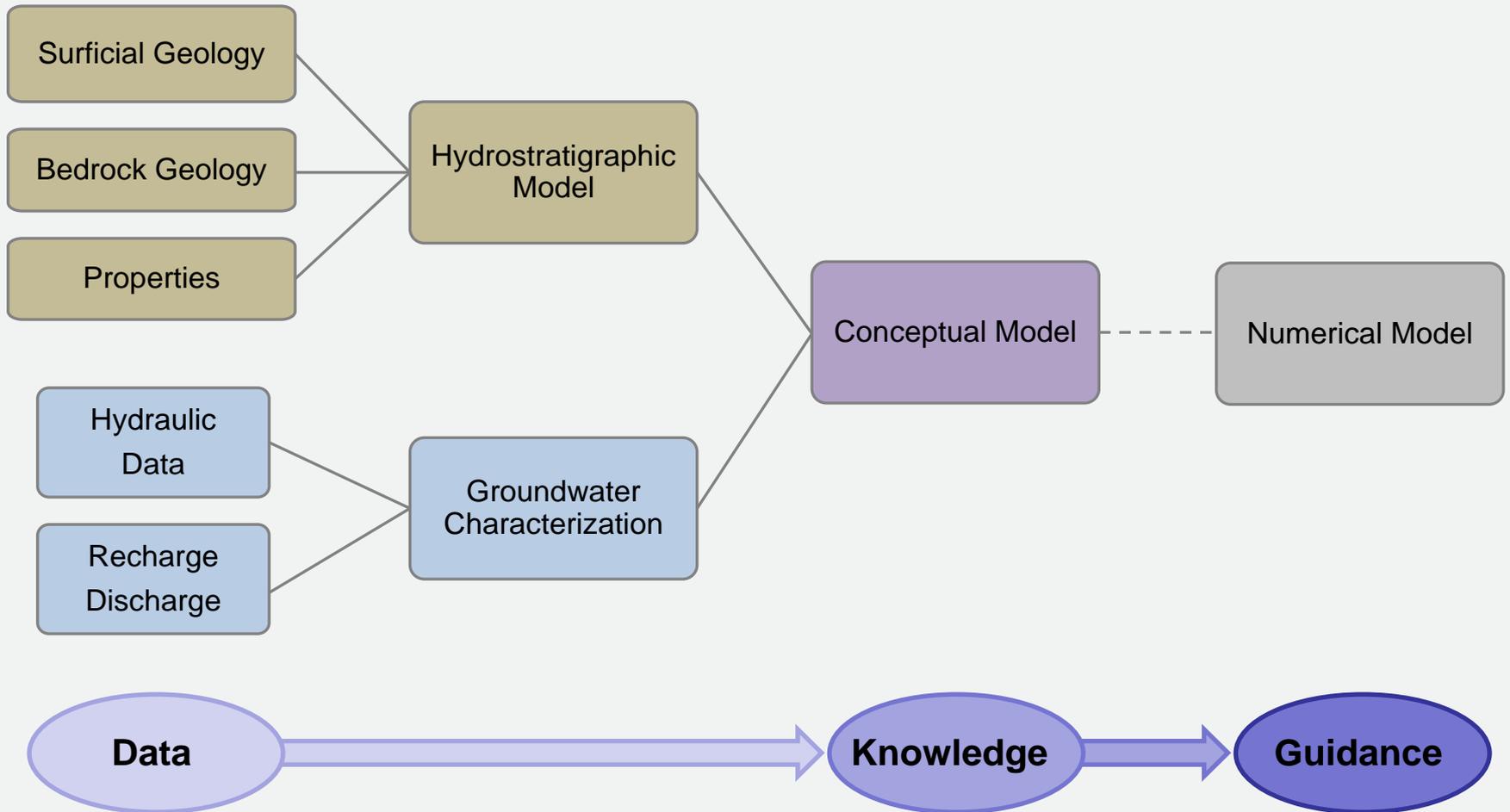
Scale Equivalent to Management



- › 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

Conceptual Model Development

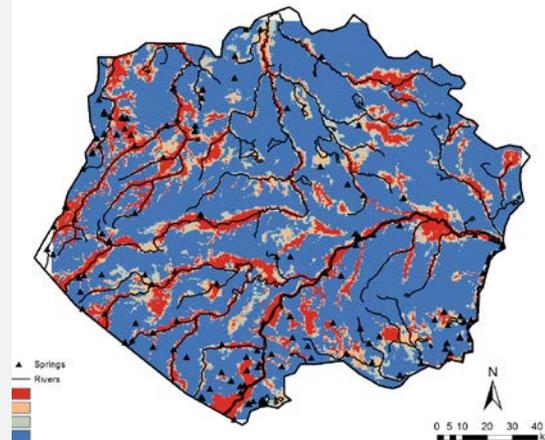
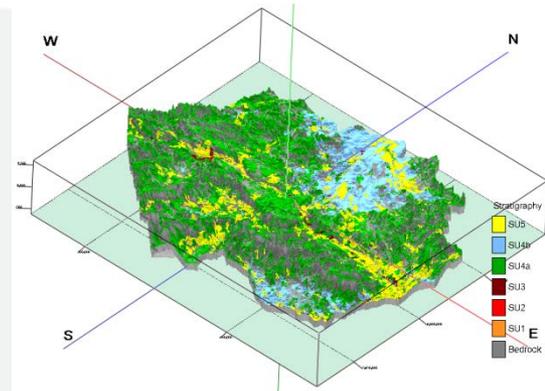


Modelling and Mapping Approach

- 》 Delineate groupings of unconsolidated sediments with common texture
 - Laterally-connected fine- or coarse-grained units
 - Can be recognized at a regional scale (> 1 km)

- 》 Evaluate distribution of bedrock properties
 - Identify permeable zones

- 》 Map hydrogeological data within new framework
 - Hydraulic heads, water chemistry
 - Regional recharge and discharge areas



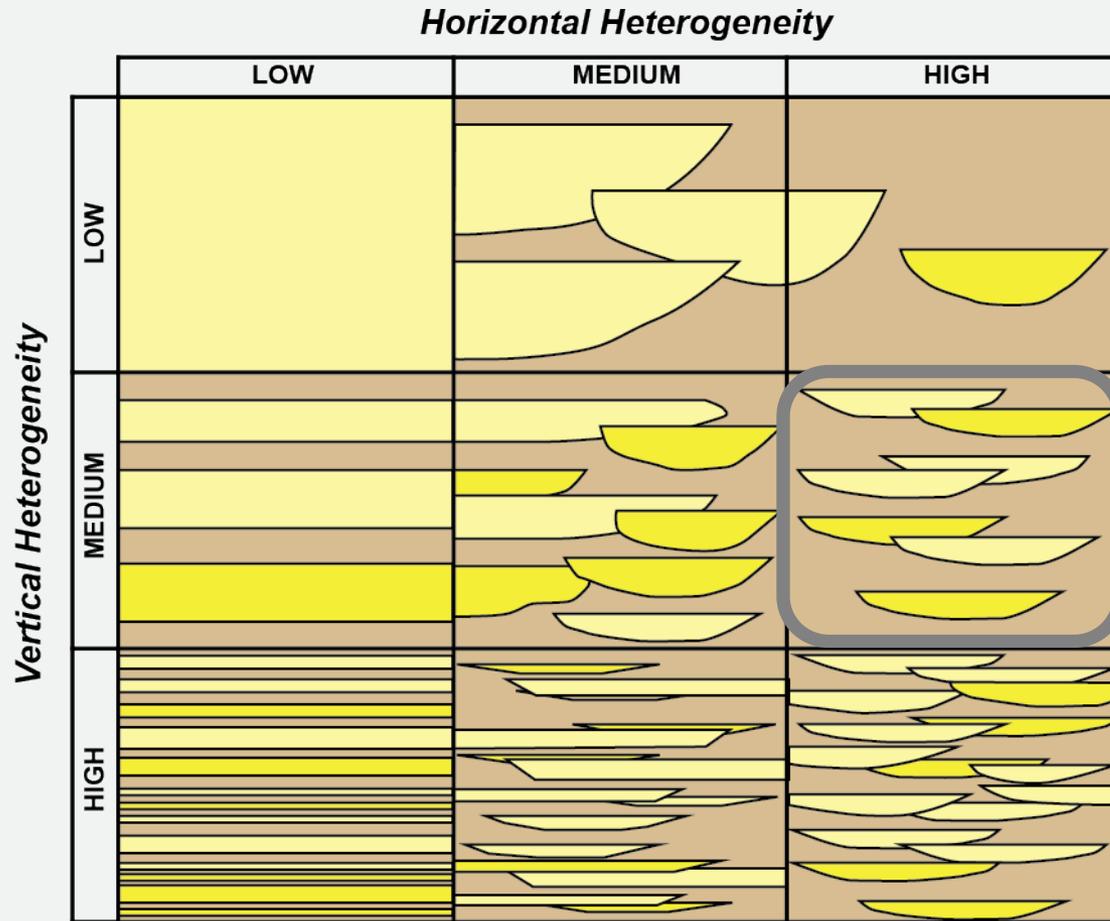
Scale and Detail:

Finding the Sweet Spot

Provincial scale
geological framework



High-resolution
geophysical logs



Tyler and Finley 1991; SPE-22670-MS

Calgary-Lethbridge Corridor

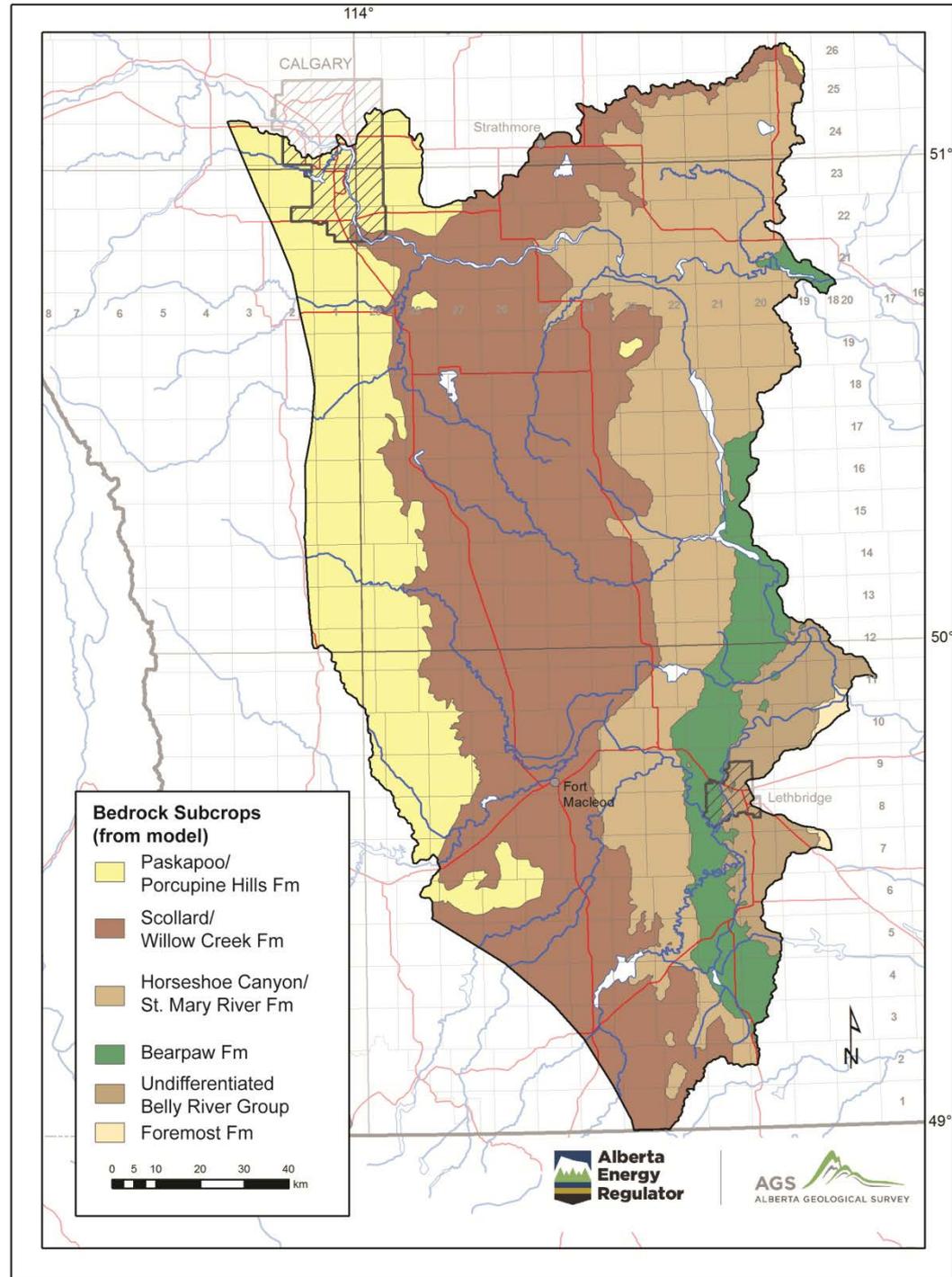


St. Mary River

CLC Study

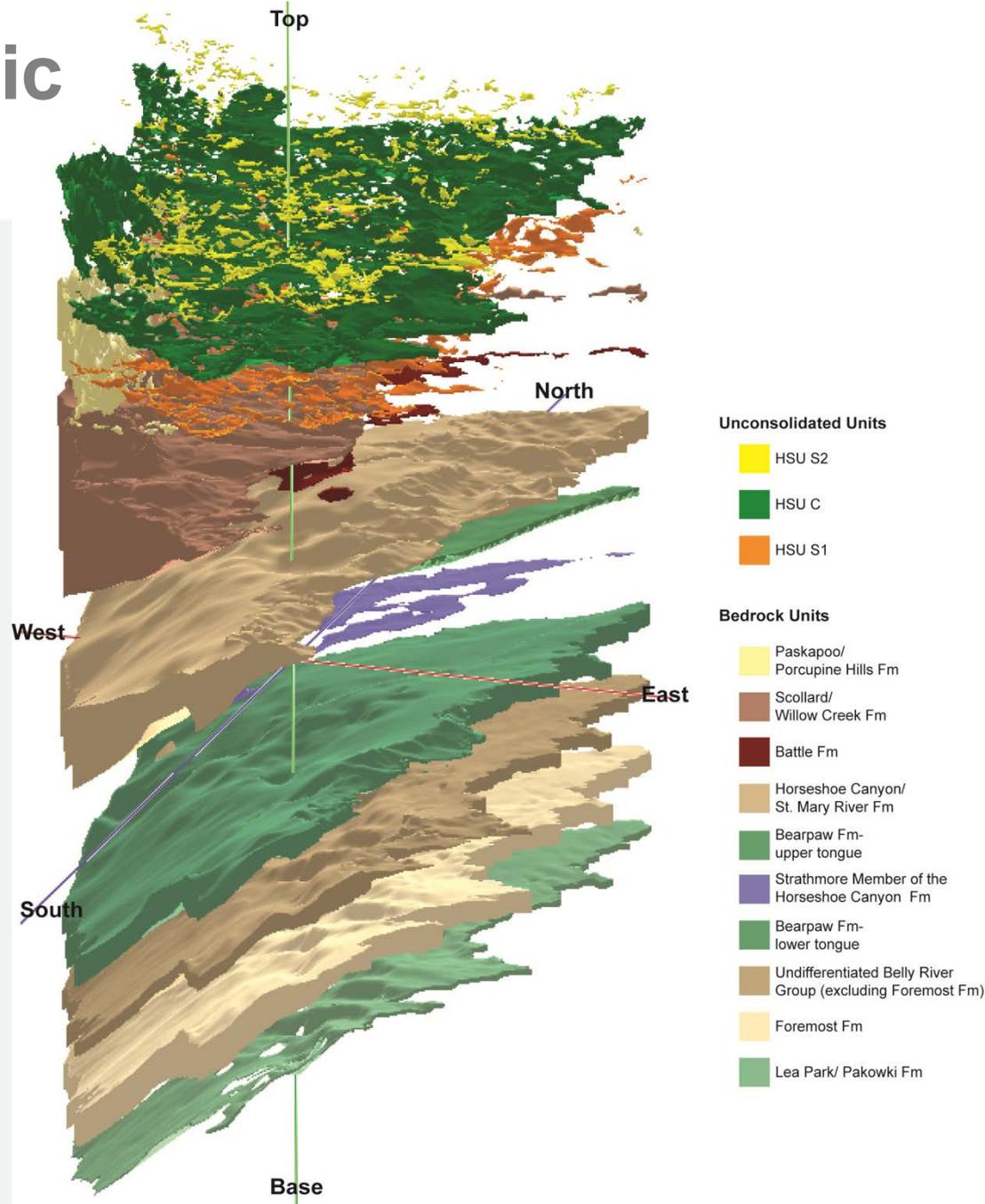
- › Develop a digital hydrostratigraphic framework
- › Regional characterization for South Saskatchewan Regional Plan
- › Defined by 8 sub-basins and deformation belt to the west
- › 21,159 km²

AGS



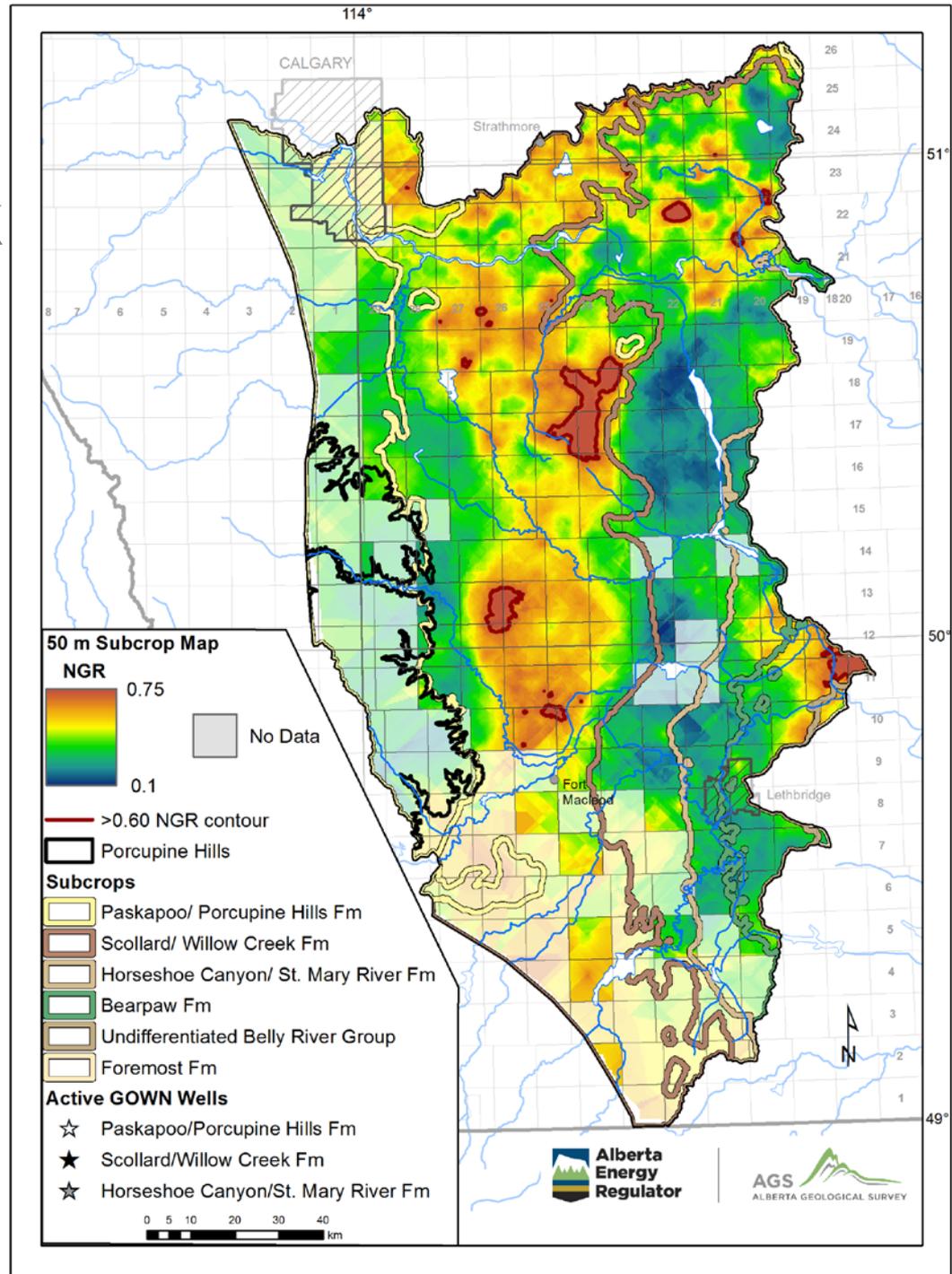
Hydrostratigraphic Model

- › 3 HSU's developed for unconsolidated sediments
- › Each bedrock formation defined as an HSU
- › Updated bedrock topography and paleovalleys



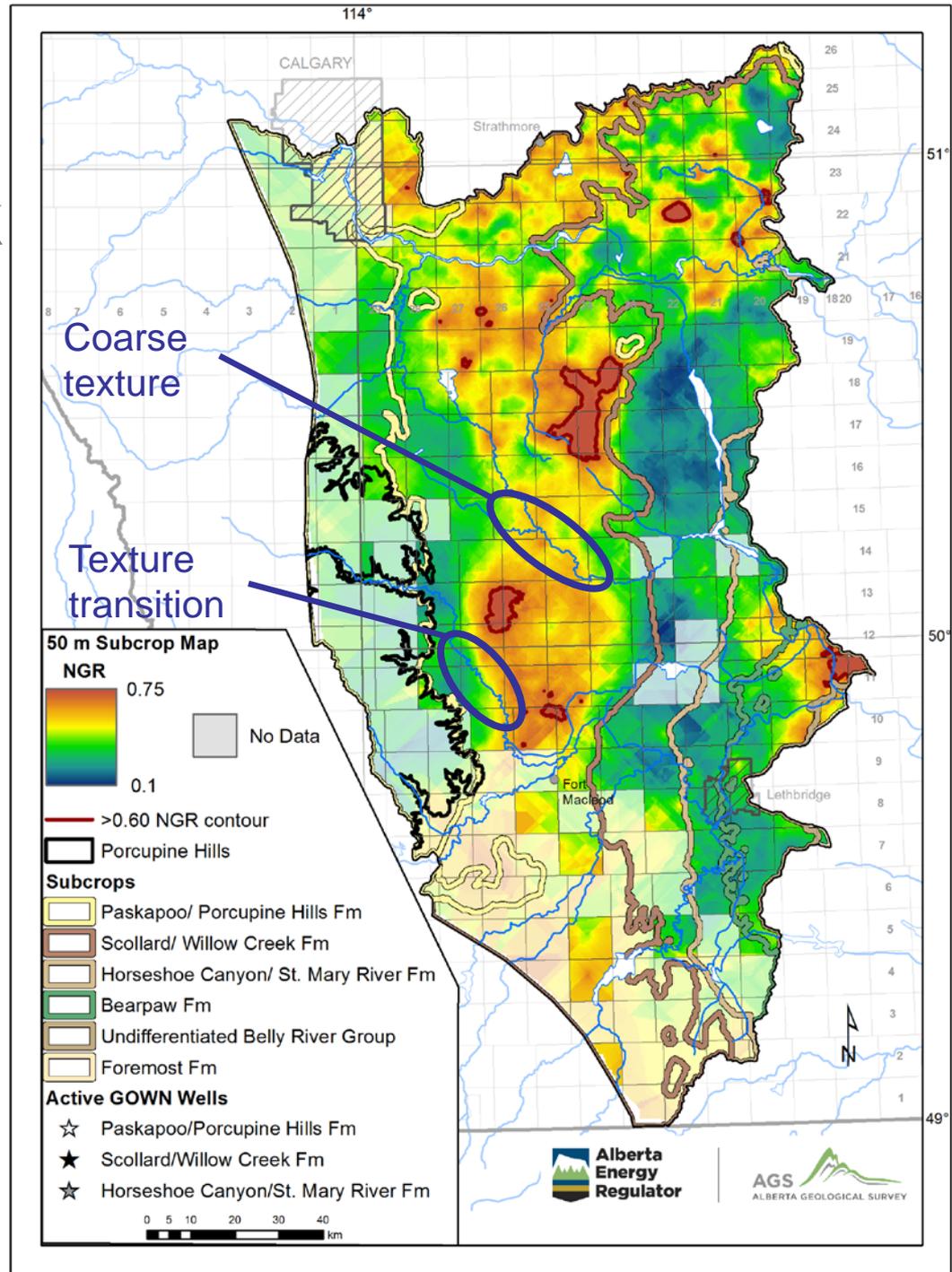
Distribution of Permeable Bedrock

- › Identify major sandstone trends → *aquifer potential*



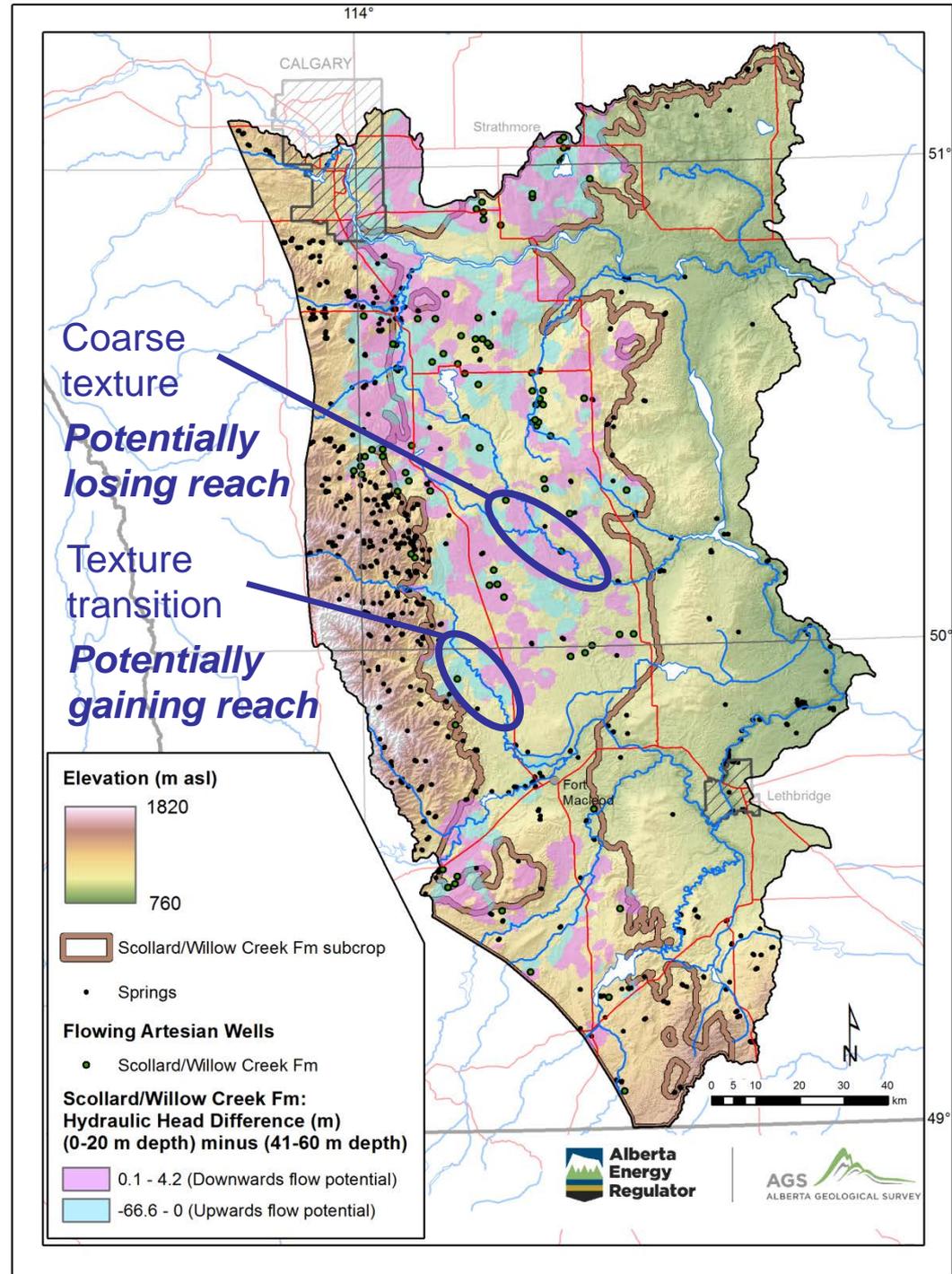
Distribution of Permeable Bedrock

- › Identify major sandstone trends → *aquifer potential*
- › Locate where permeable bedrock could intersect rivers
- › Framework for mapping gaining/losing reaches at regional scale

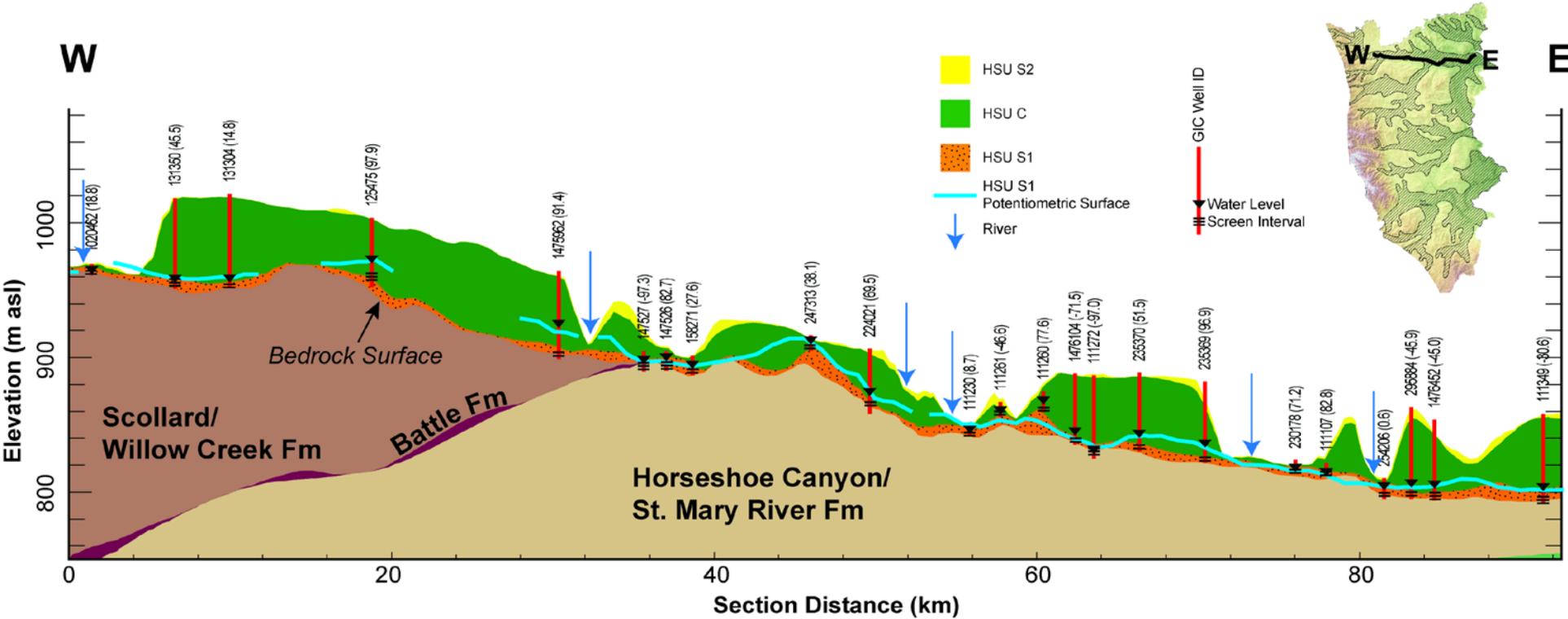


Potential Recharge Discharge Areas

- › Potentiometric surfaces developed from water well database
- › Analysis of hydraulic head difference
- › First-order mapping of groundwater and surface water interaction



Calgary Valley Paleochannel



- ▷ Some intersection with modern Bow River valley
- ▷ Spatially variable connection of paleochannel and river
- ▷ HSU's provide a framework for mapping gaining/losing reaches

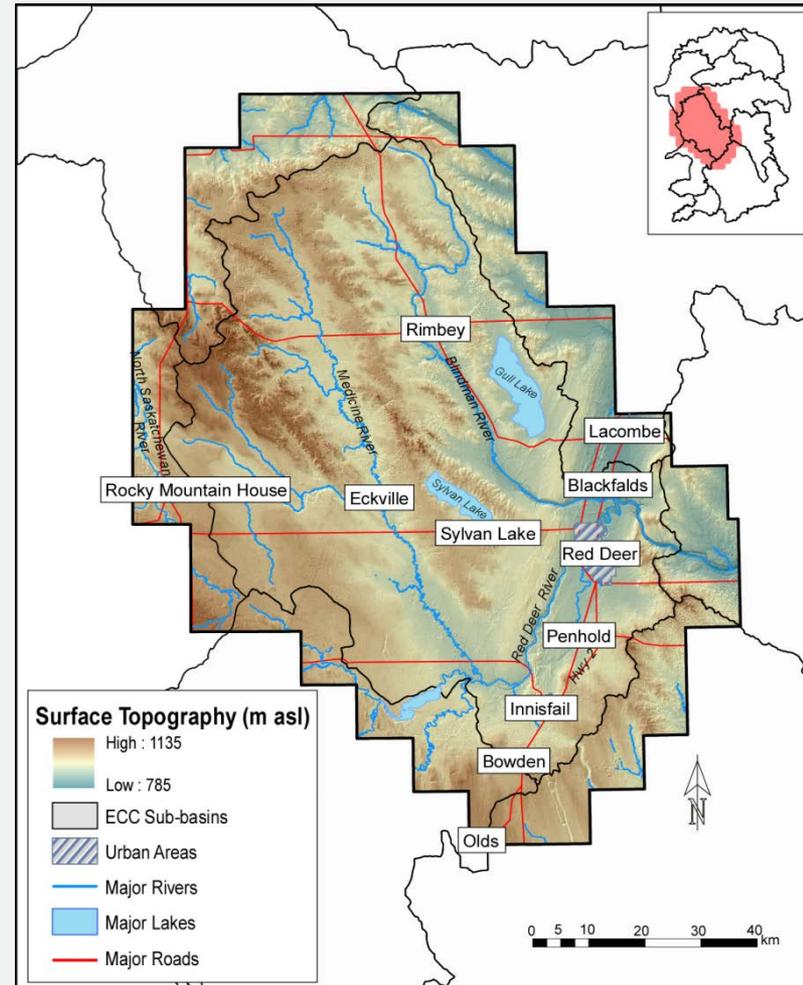
Sylvan Lake Region



Blindman River

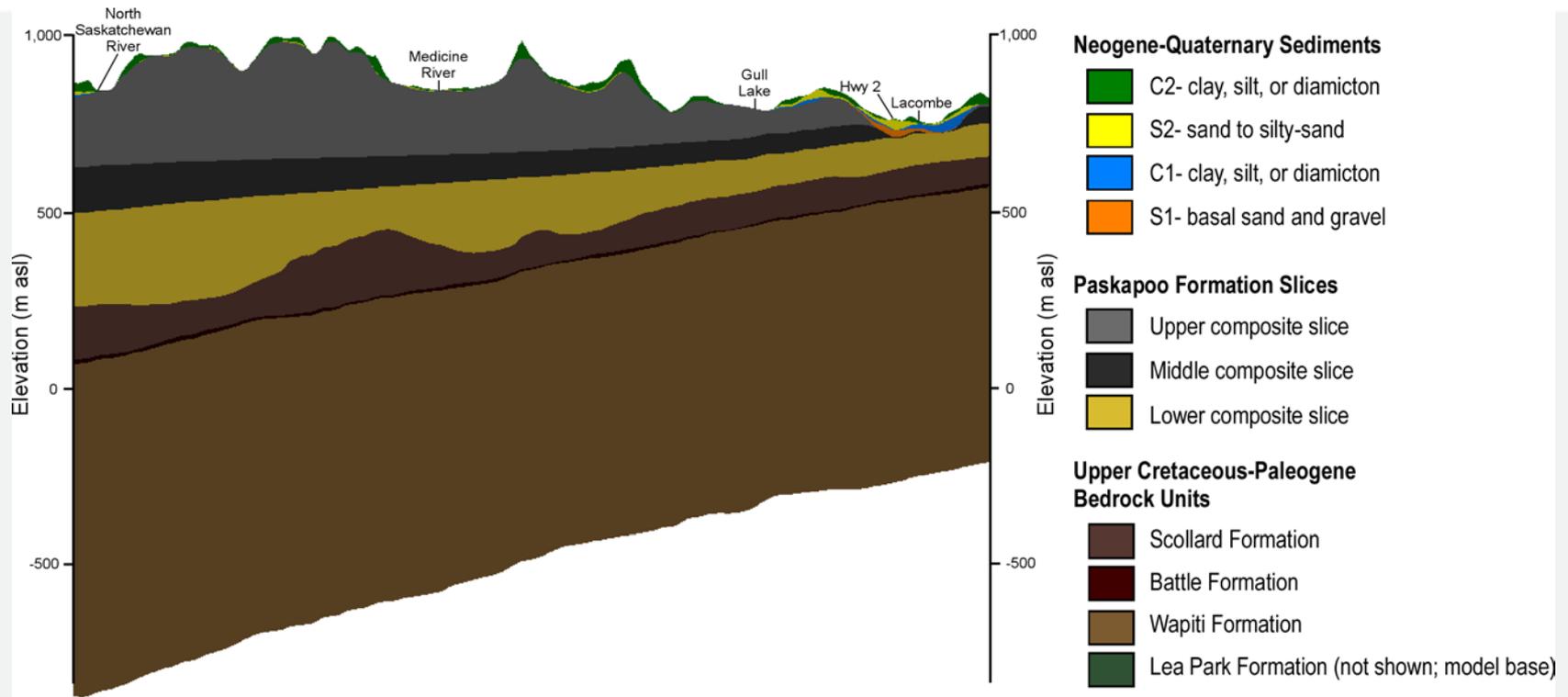
Sylvan Lake Region

- › Medicine-Blindman sub-watershed (5,933 km²)
- › Growing population dependent on water resources
 - › Agriculture
 - › Recreation
 - › Municipal, domestic
- › Groundwater resources within unconsolidated sediments and shallow bedrock
 - › Unconsolidated sediments vary from 0 to 130 m thick



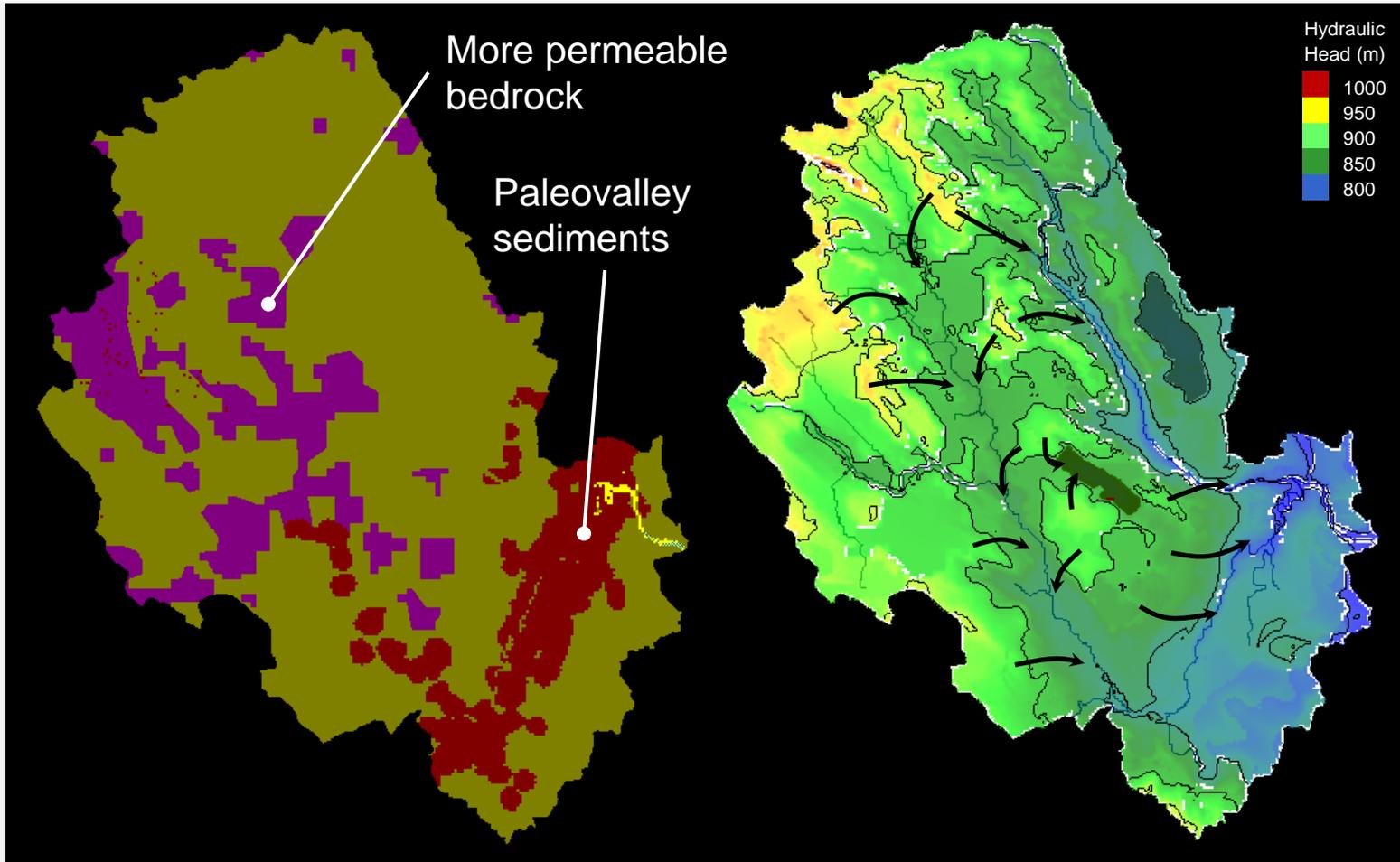
Atkinson and Glombick, 2015; AGS OFR 2014-10

Hydrostratigraphic Model



- 4 HSU's developed for unconsolidated sediments
- Each bedrock formation defined as HSU, with some differentiation in the Paskapoo Formation
- Hydrostratigraphic model used directly in groundwater model

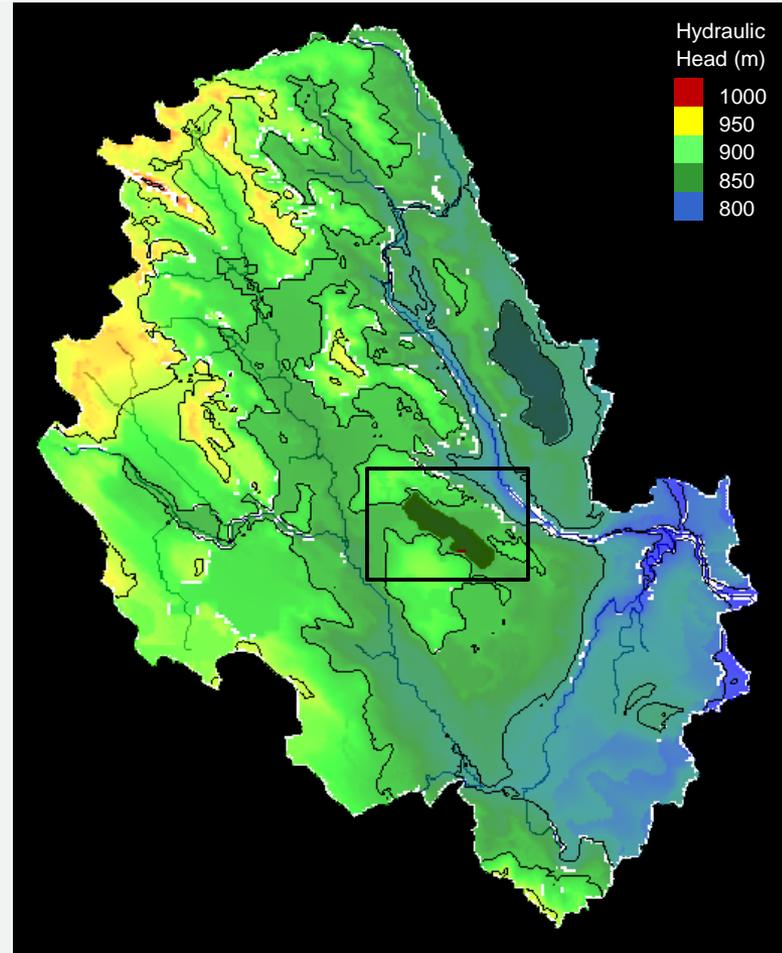
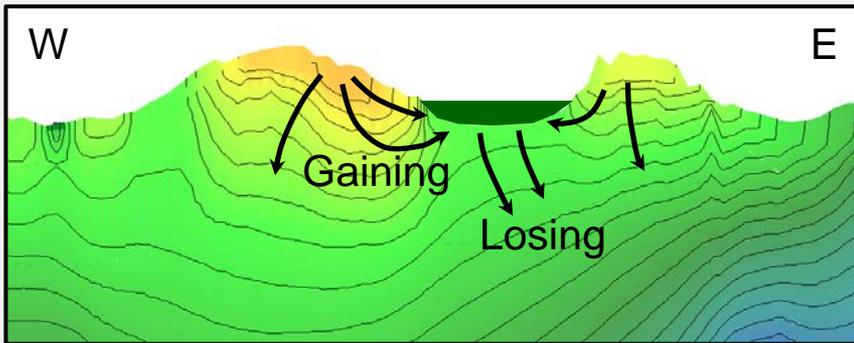
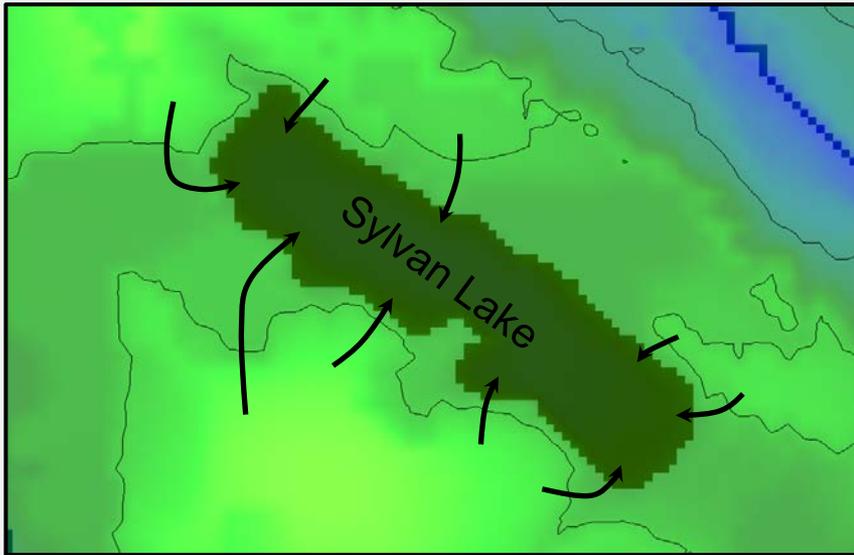
Groundwater Model



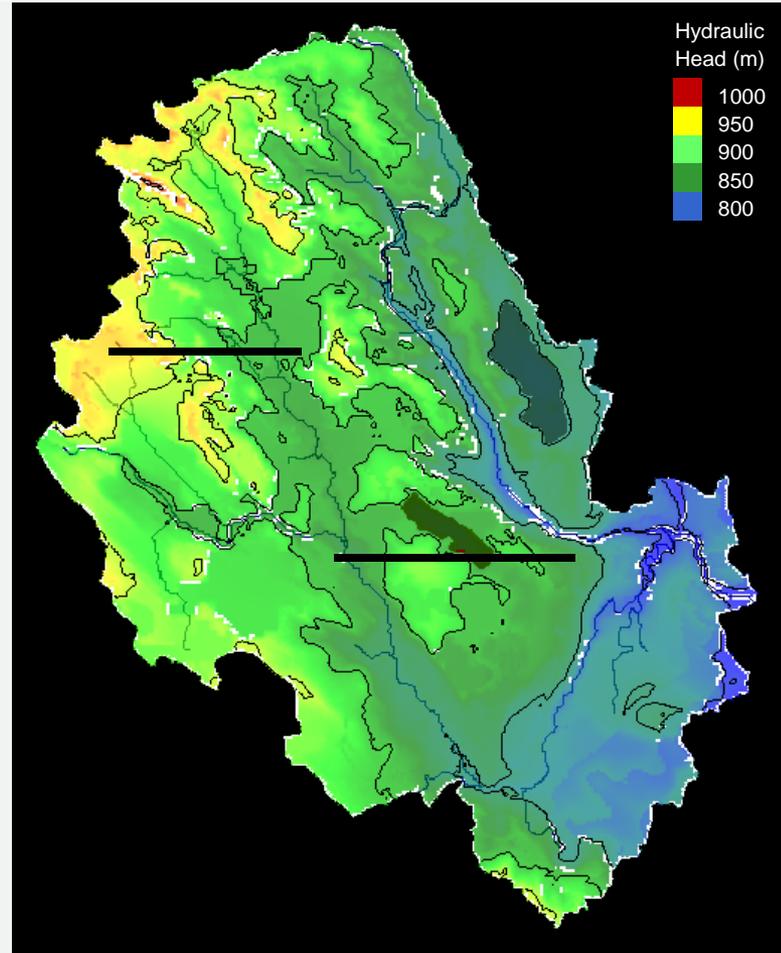
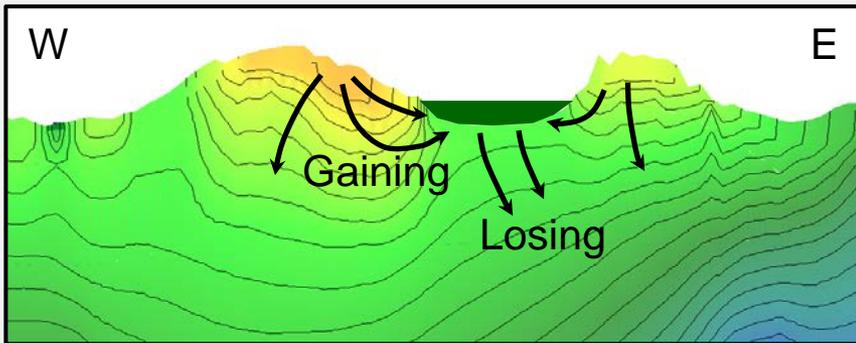
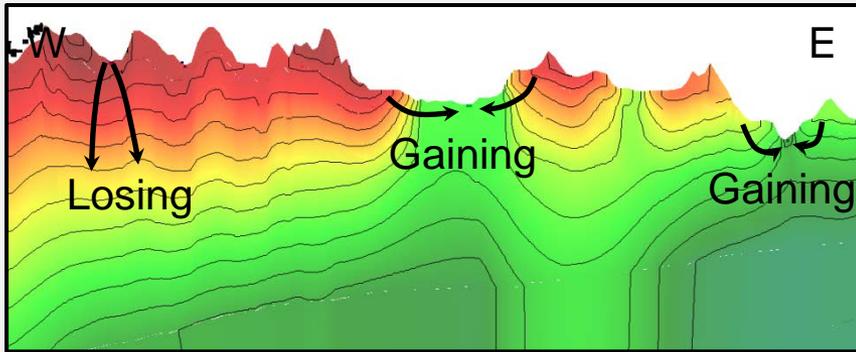
HSU's → property zones

Simulated hydraulic heads

Groundwater - Surface Water Interaction



Groundwater - Surface Water Interaction

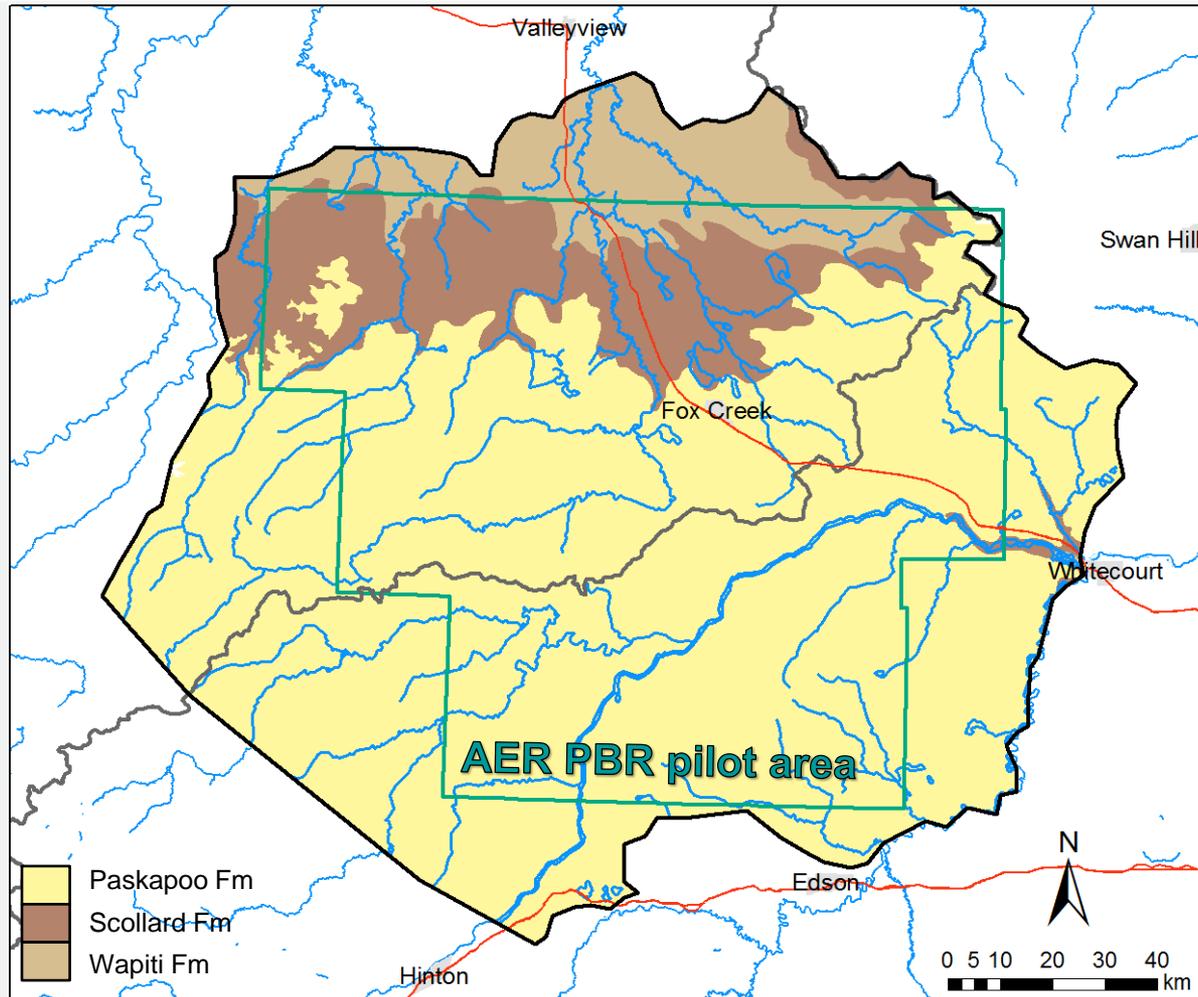


Fox Creek Area



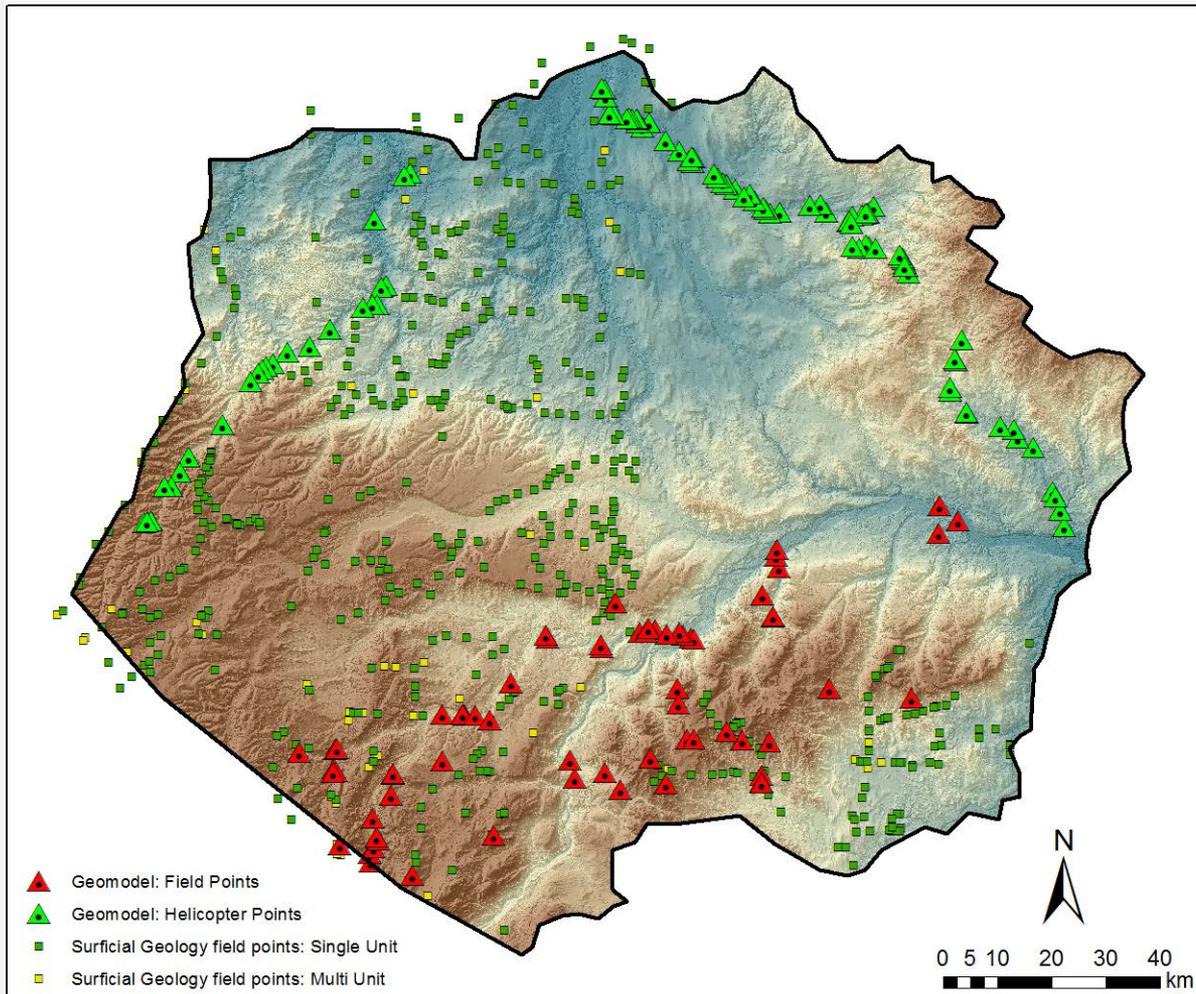
Little Smoky River

Fox Creek Area



- › Spans Peace and Athabasca basins
- › Defined by sub-basin drainage
- › Encompasses AER PBR pilot area
- › 22,000 km²

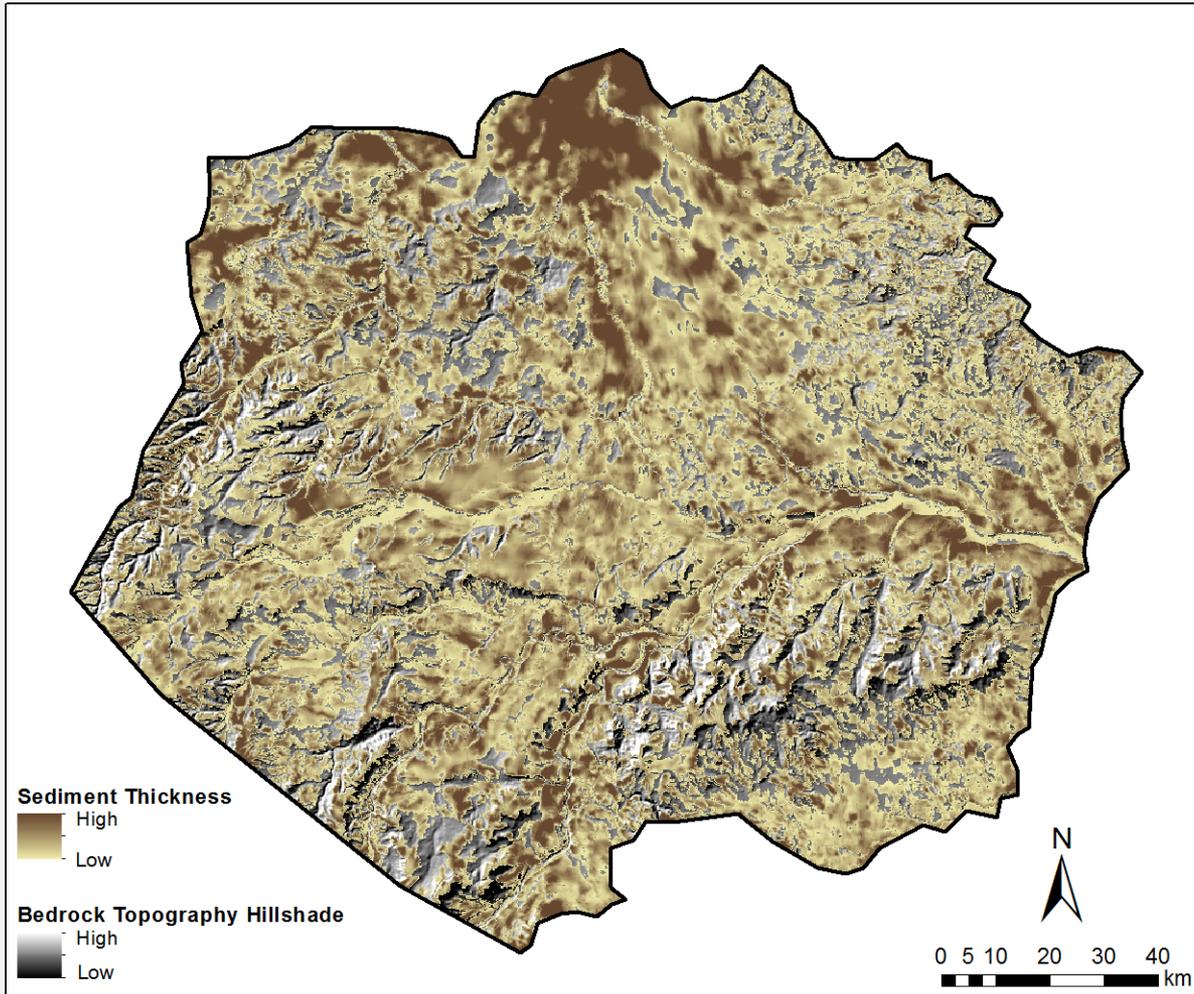
Hydrostratigraphic Modelling



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)

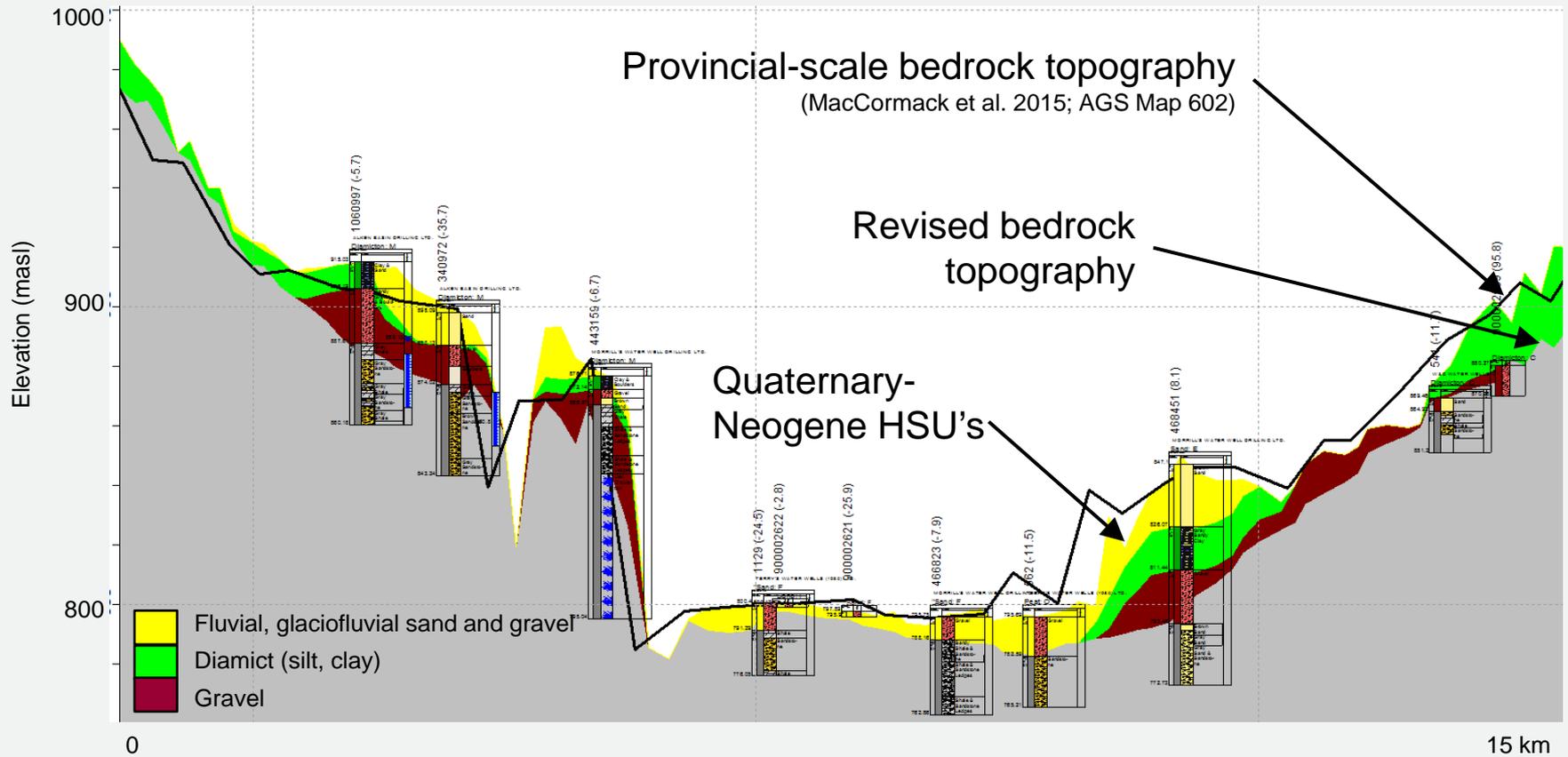
Hydrostratigraphic Modelling



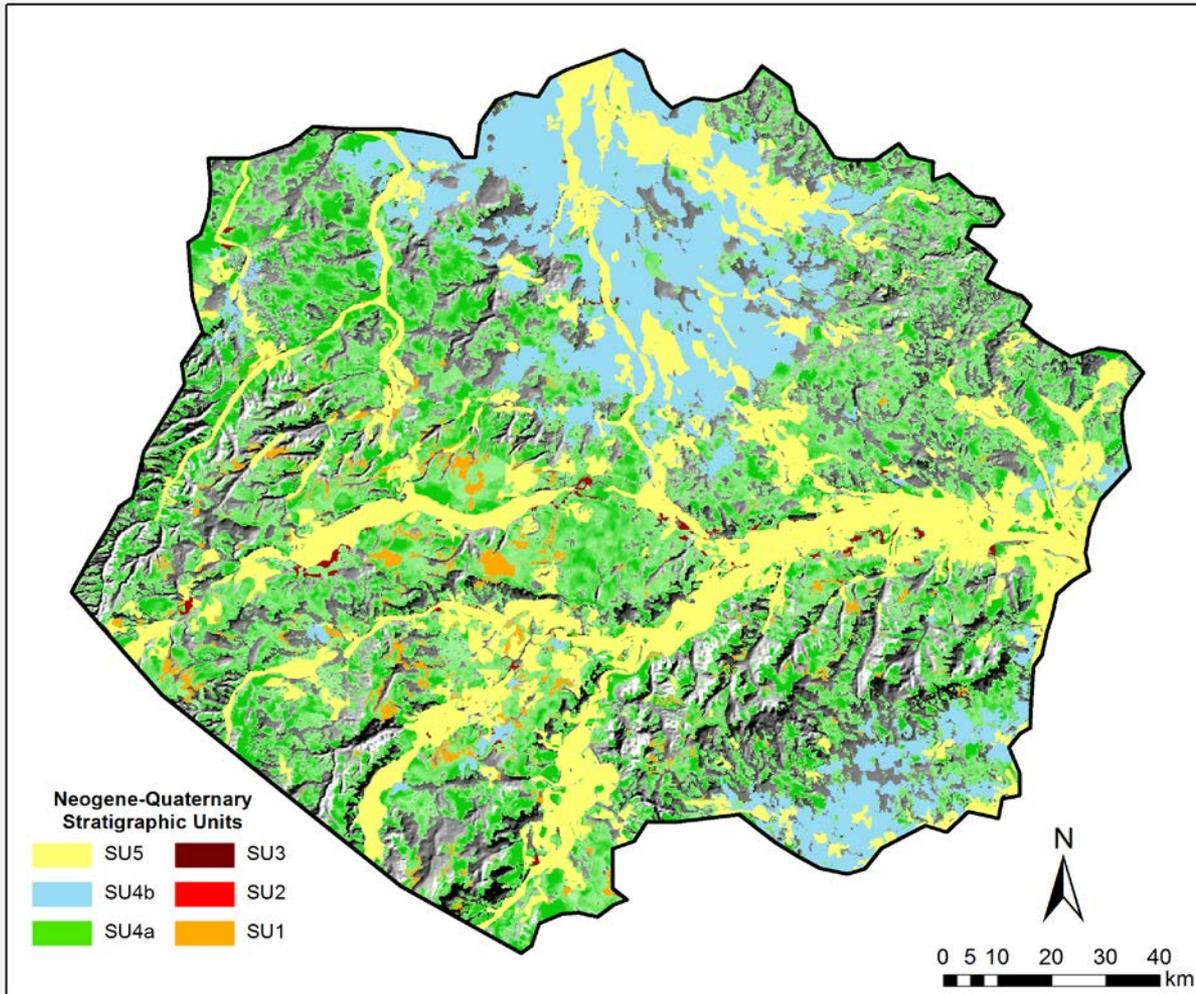
Process:

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

Updated Bedrock Topography

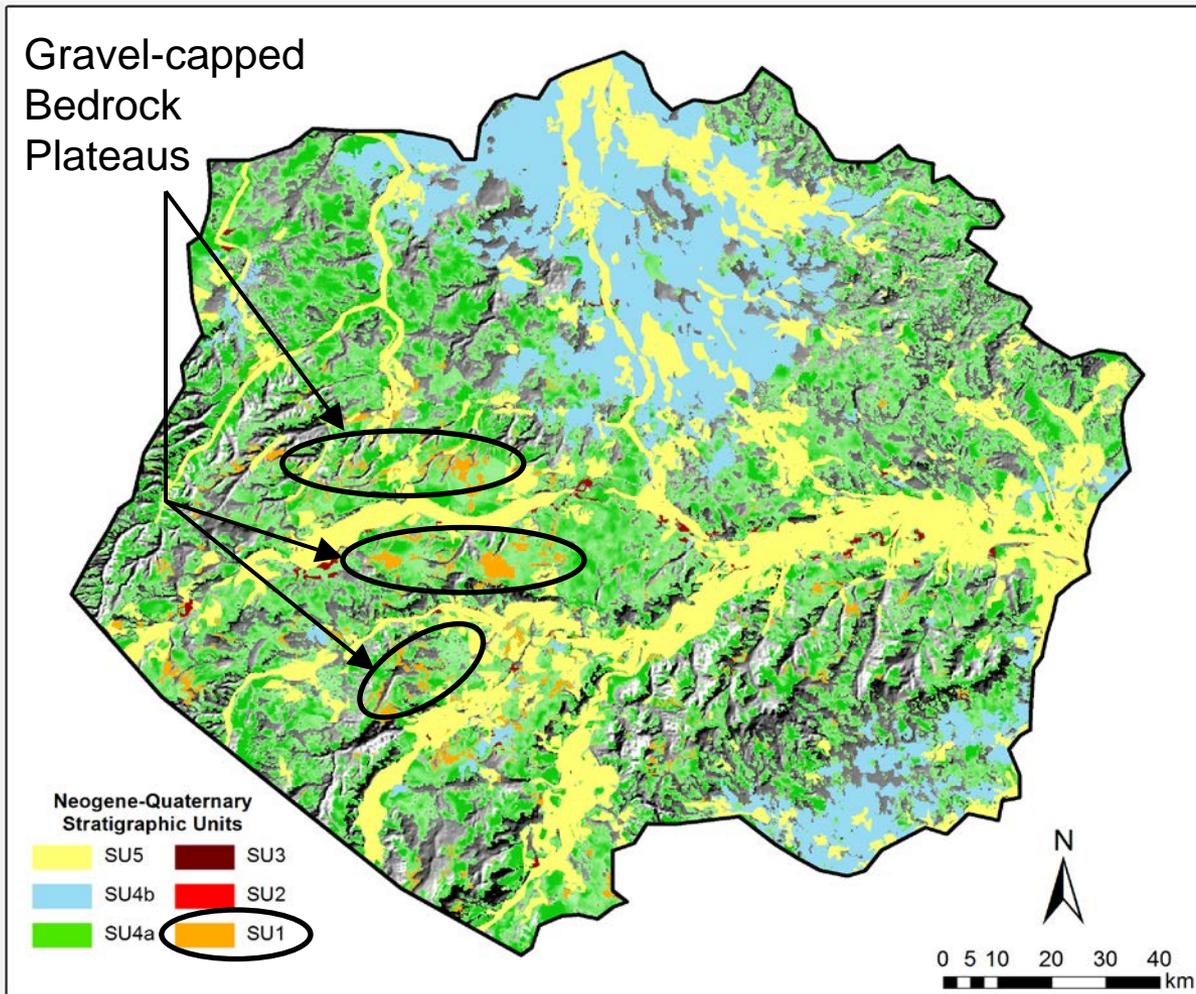


Quaternary-Neogene HSU's



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

Quaternary-Neogene HSU's

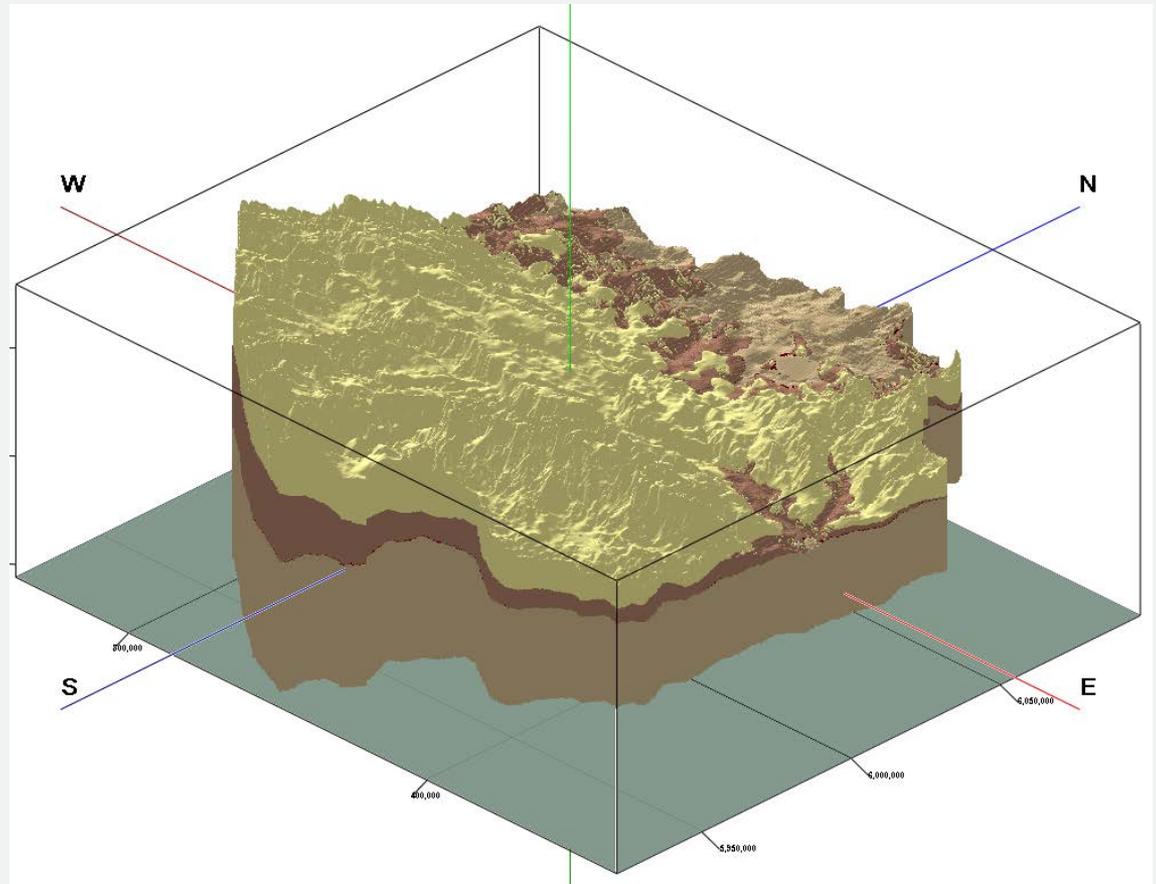


- › Broadly similar to surficial geology (Fenton et al. 2013; AGS Map 601)
- › 3D representation of units important for water cycling
- › Identify key features related to groundwater recharge

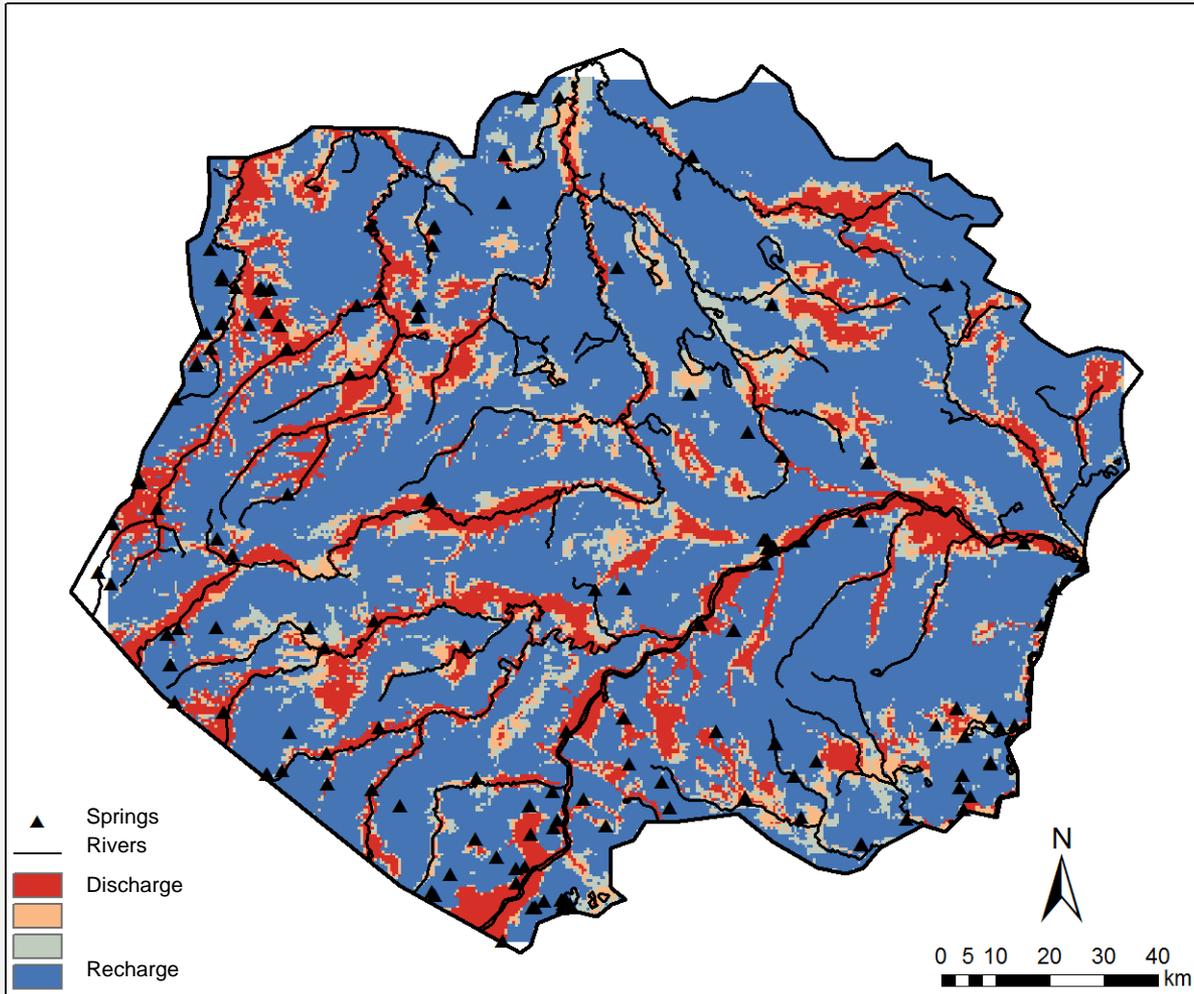
Hydrostratigraphy: Next Steps

- › 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

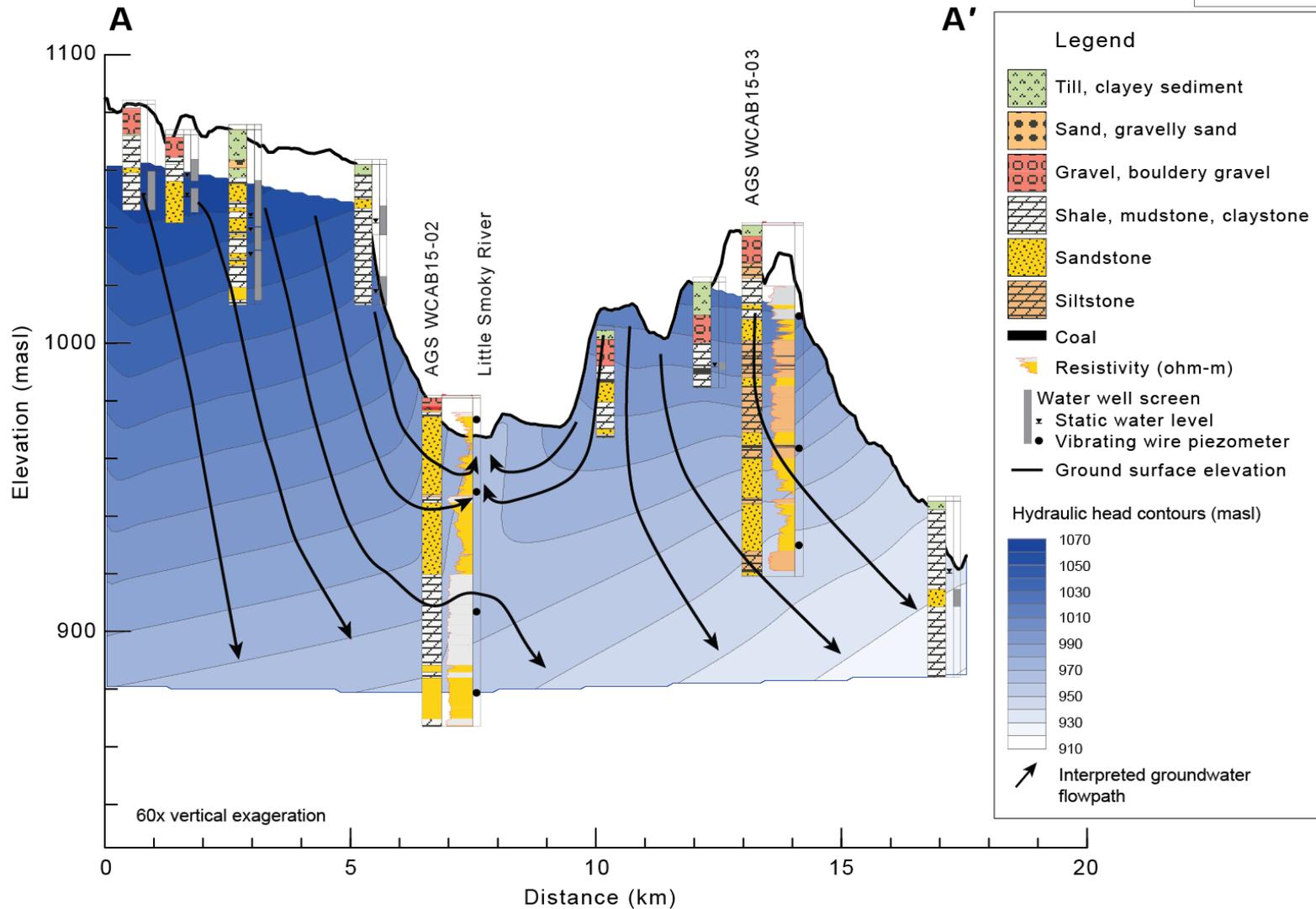
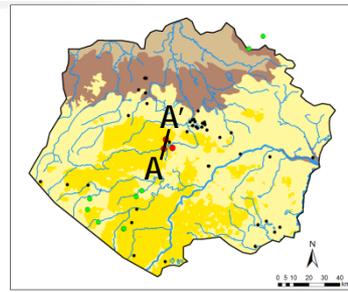


Paskapoo Hydrogeology



- › 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



Legend

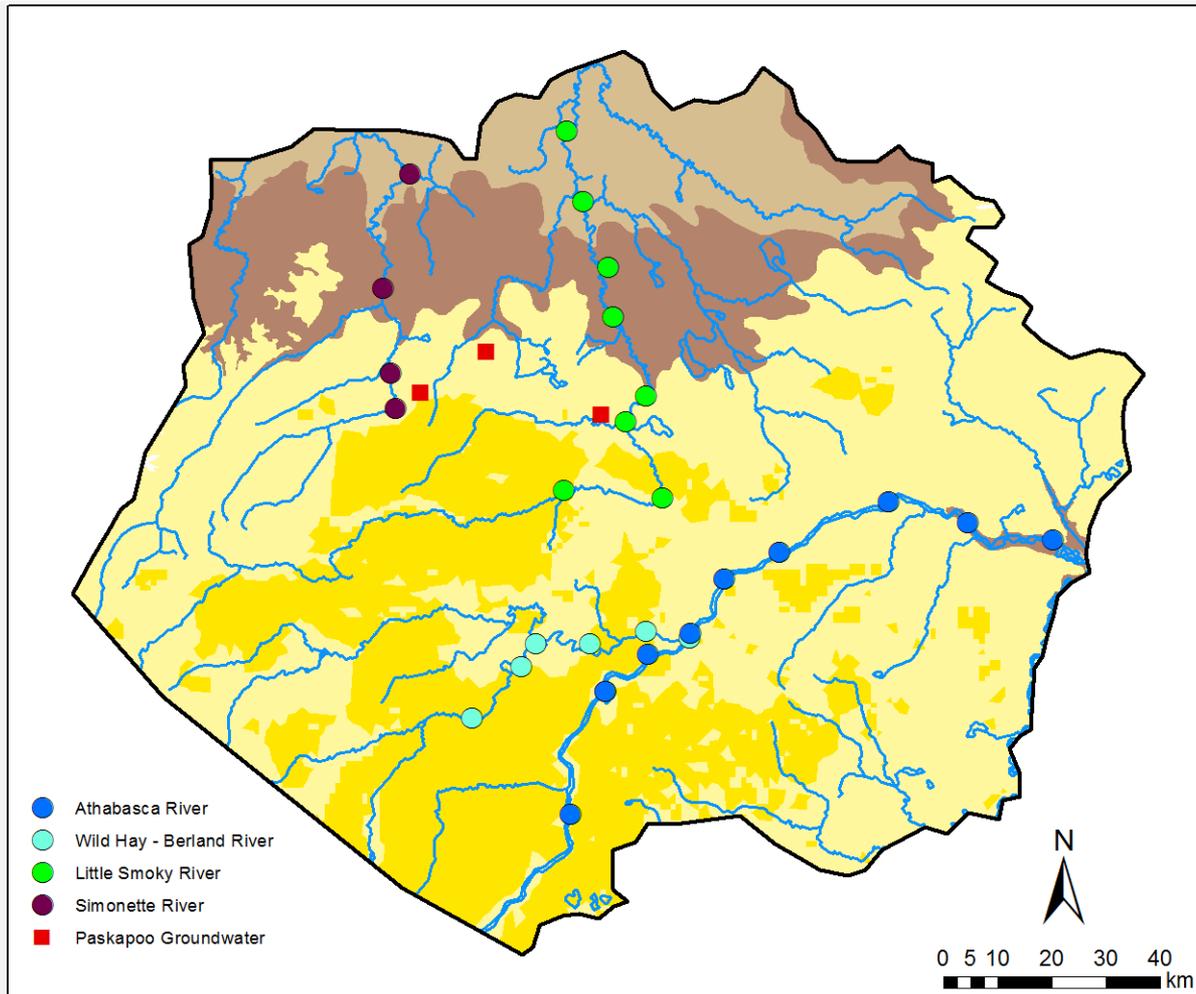
- Till, clayey sediment
- Sand, gravelly sand
- Gravel, bouldery gravel
- Shale, mudstone, claystone
- Sandstone
- Siltstone
- Coal
- Resistivity (ohm-m)
- Water well screen
- Static water level
- Vibrating wire piezometer
- Ground surface elevation

Hydraulic head contours (masl)

- 1070
- 1050
- 1030
- 1010
- 990
- 970
- 950
- 930
- 910

Interpreted groundwater flowpath

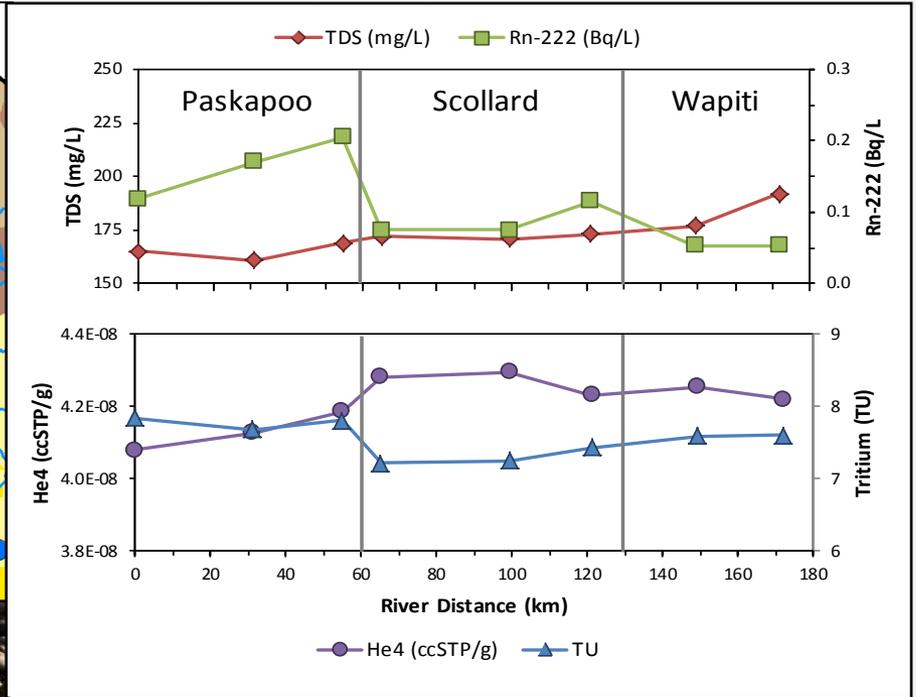
Environmental Tracer Sampling



Process:

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

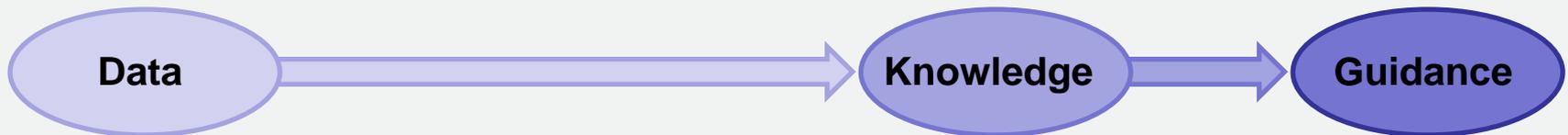
Environmental Tracer Sampling



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

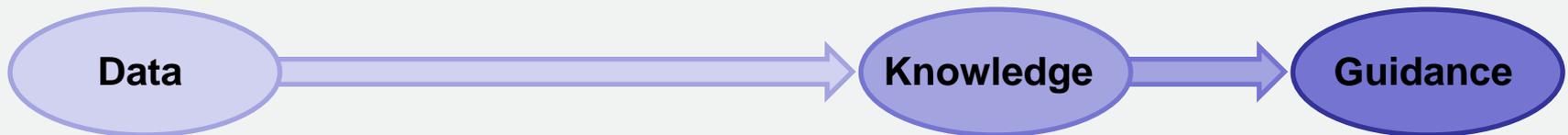
Geoscience for GW-SW Interaction

- › Mapping and modelling to develop the ‘big picture’
- 3D hydrostratigraphy
 - Conceptualization of hydrogeology
 - Framework for mapping gaining/losing reaches at regional scale
 - Providing guidance using numerical models for regulators and water policy managers



Geoscience for GW-SW Interaction

- › Mapping and modelling to develop the ‘big picture’
 - 3D hydrostratigraphy
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 - Framework for mapping gaining/losing reaches at regional scale
 - Providing guidance using numerical models for regulators and water policy managers



- › First-order mapping of groundwater interaction
 - Provides a basis and justification for more detailed investigation
 - Supports cumulative effects management initiatives



Questions





Thank you