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Regional groundwater monitoring well network Peace Region, NE BC

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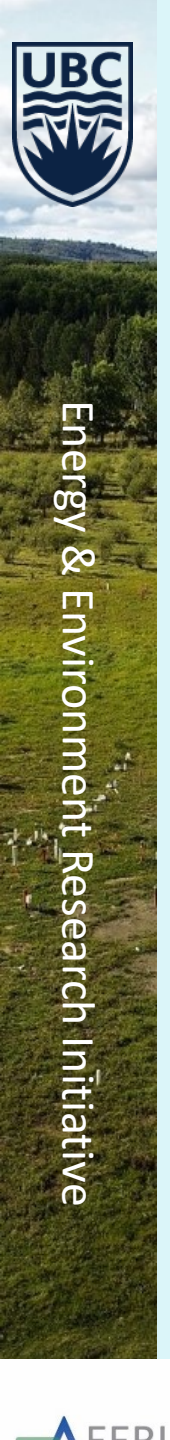


Goals

1. Determine groundwater quality on a regional scale
   - Emphasis on determining distribution, concentration and origin of dissolved methane in shallow groundwater
   - Assess potential impacts from oil & gas development

2. Provide groundwater monitoring infrastructure to the region as a legacy, and a platform for future research activities

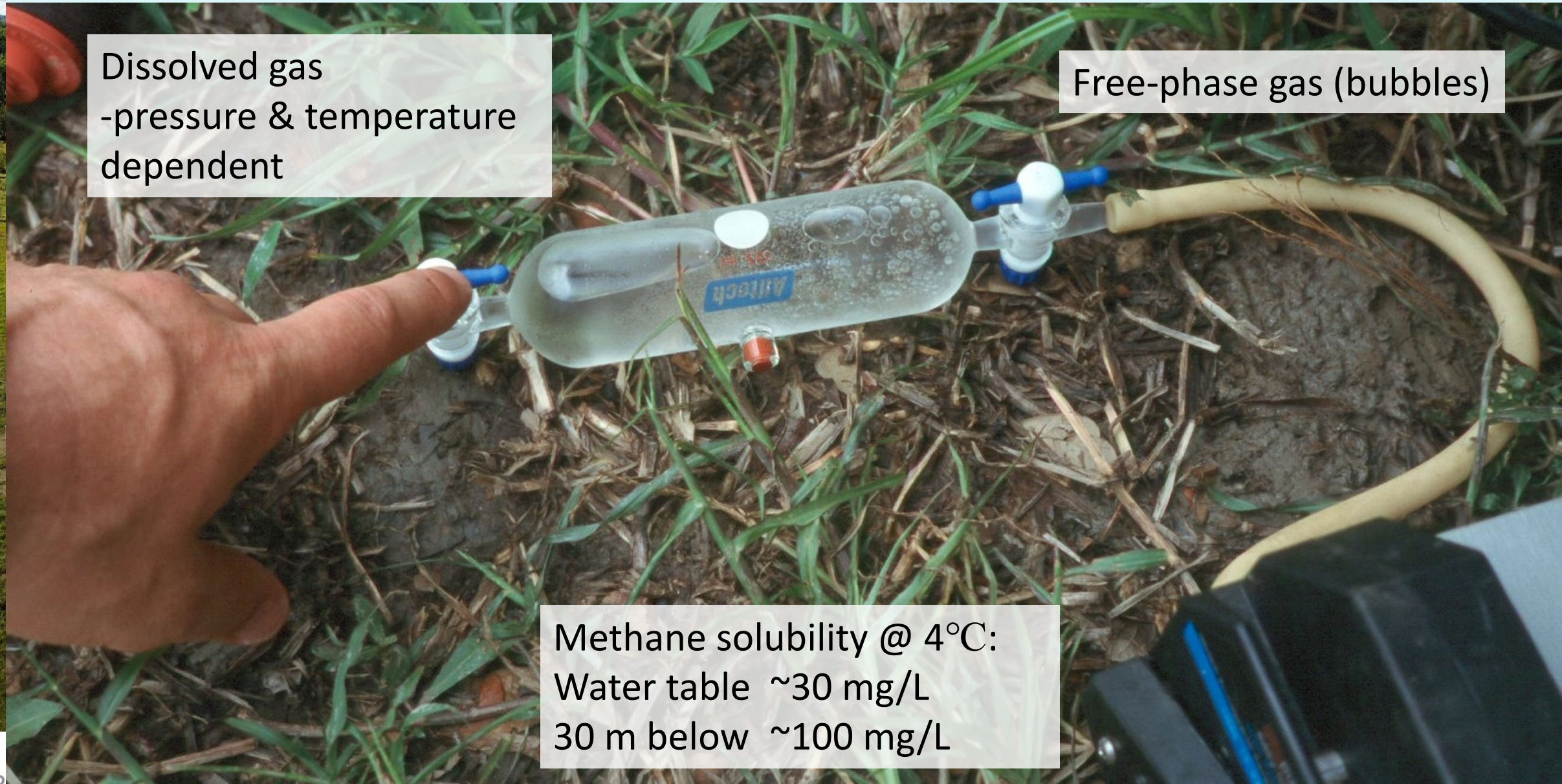
Natural gas

Forms via decomposition of organic matter

	Formation process	Typical composition	Environment
Shale gas	Heat + pressure	85% Methane 9% ethane 3% propane Trace gases	Shale Coal
Biogas	Microbial activity under anoxic conditions	methane + carbon dioxide	Compost piles Landfills Sewer systems Swamps Aquifers

Distinguish shale gas from biogas by composition and isotopes

Natural gas



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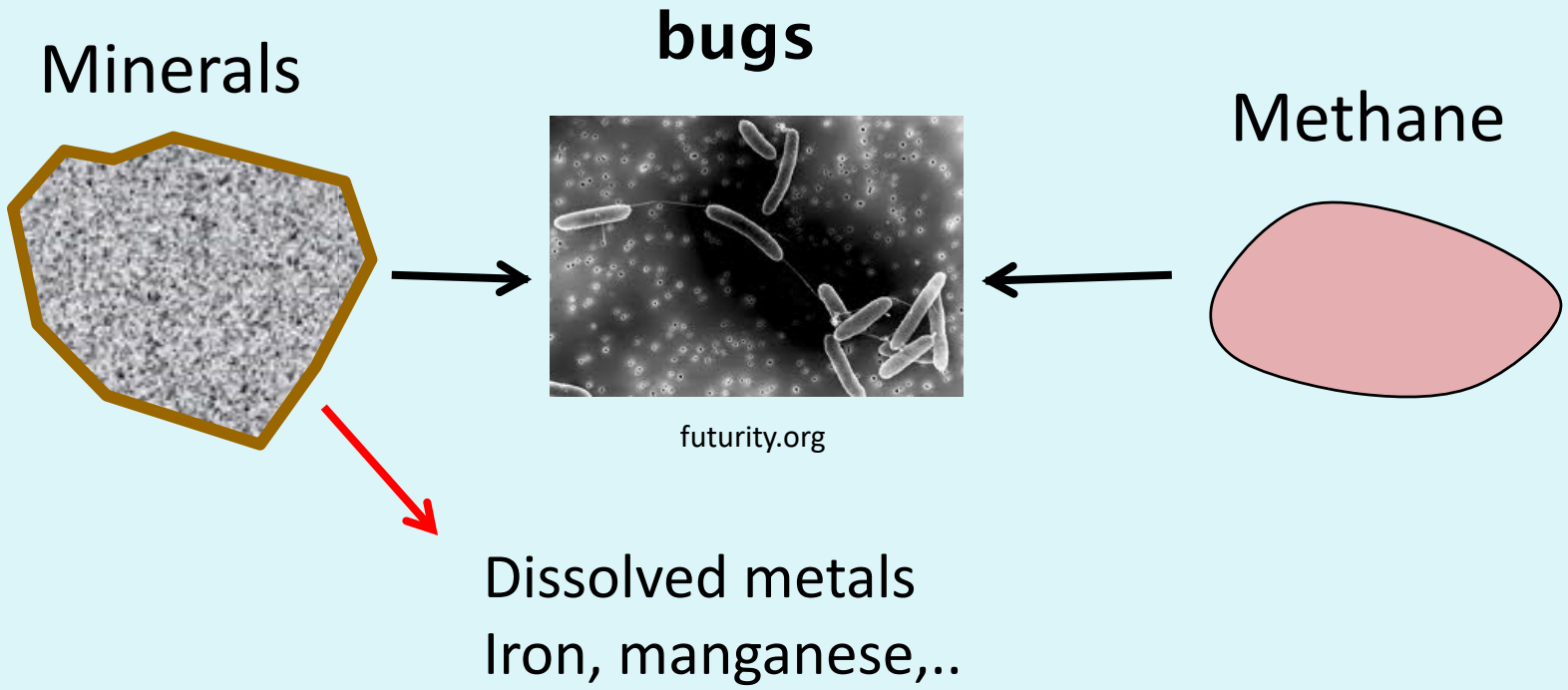
Water-quality impacts

- Methane can be consumed by microbes
  - “breathing” oxygen ➔ carbon dioxide
  - “breathing” minerals ➔ carbon dioxide, dissolved metals



Baseline and proximal wells

- “Baseline” monitoring wells
  - Confirm and augment understanding of baseline groundwater conditions.
  - > 1km from nearest energy well
- “Proximal” monitoring wells
  - Near existing and future O & G development
  - < 400m from nearest energy well
- Project technical advisory committee
  - Well locations, project strategy and oversight

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Well installation

Drilling campaign	Dates	EERI wells completed	Drilling Methods
1	August 2018	1 to 4	Sonic
2	February 2019	5 to 6	Air Rotary
3	June/July 2019	7 to 14	Sonic, Air Rotary, Diamond HQ
4	August 2019	15 to 23	Sonic, Air Rotary, Diamond HQ
5	September 2019	24 to 29	Sonic, Air Rotary
5+	November 2019	n/a	Sample Hudson's Hope town well

EERI-1 - baseline

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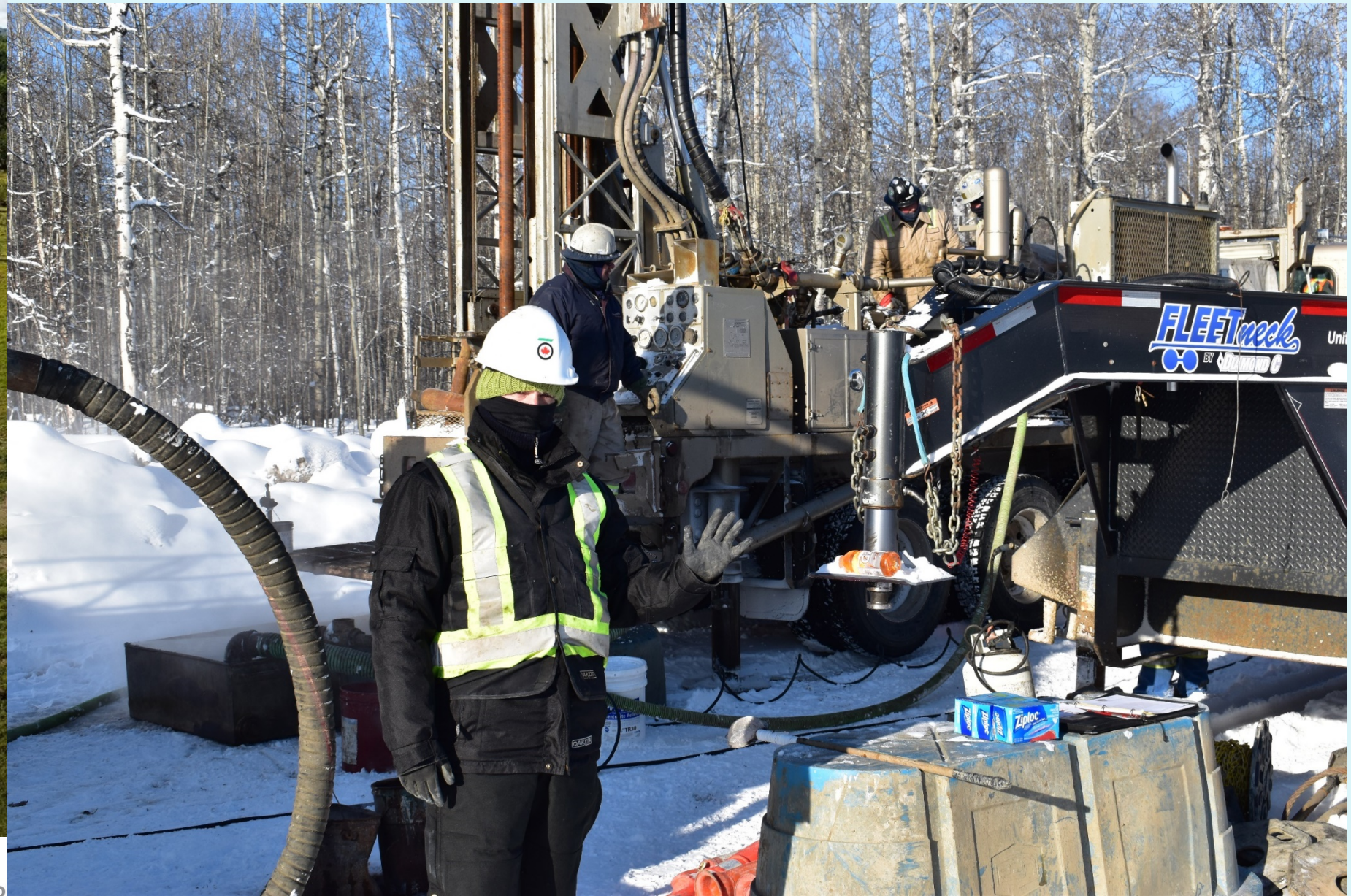
Groundbirch, August 2018

EERI-5 - baseline



Aaron Cahill

-35 C
February 2019

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EERI-10 - baseline

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EERI-18 – proximal

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Legend

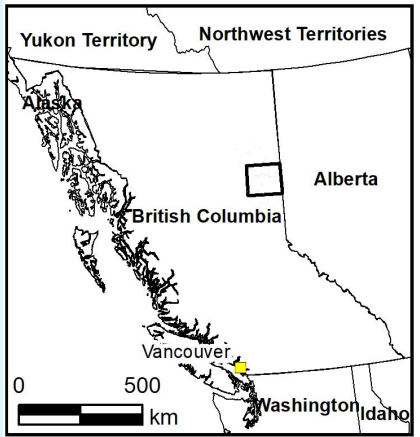
Energy well density per 10km²

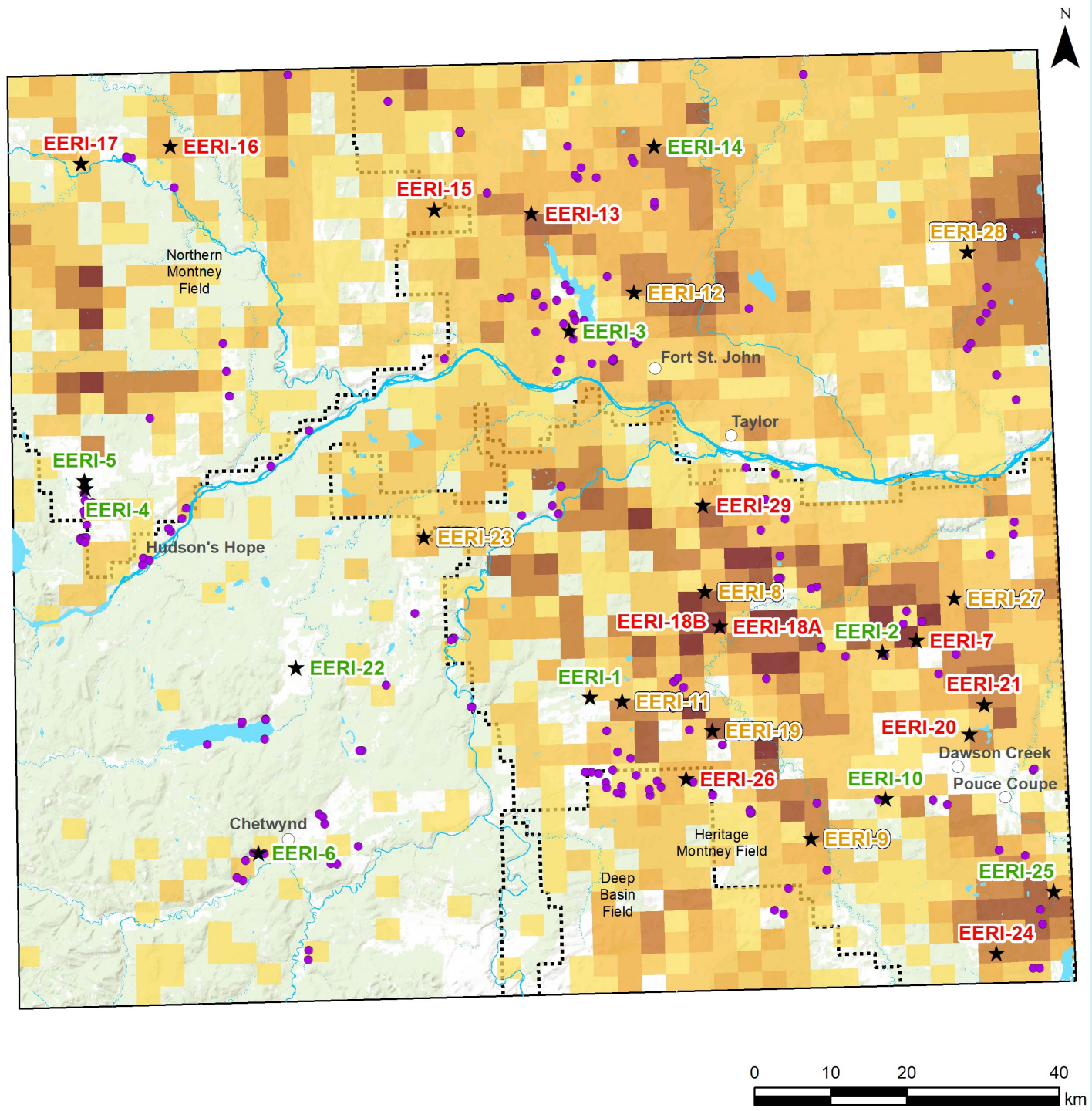
- 0
- 1
- 1 - 5
- 5 - 10
- 10 - 20
- 20 - 30
- >30
- MWIP boundary
- Regional resource play
- City/town
- ★ EERI monitoring well
- ● Sampled domestic well

Proximity to nearest energy well

EERI >500 m
EERI 200-500 m
EERI <200 m

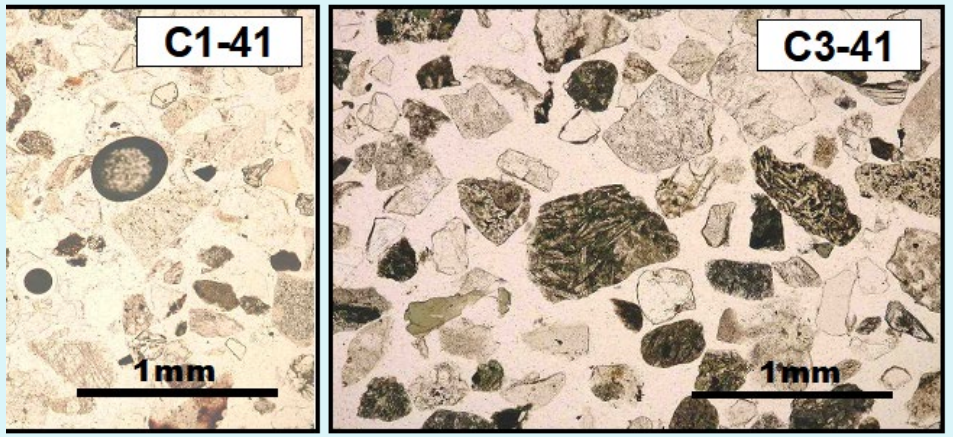
7579 energy wells within MWIP boundary





Analyses

- Sediment properties:
  - Mineralogy
  - Reactivity (eg extractions)
  - Grain size
  - Permeability (where possible)
- Water:
  - Dissolved gases
  - Dissolved metals, anions
  - Water isotopes (age)
  - Hydrocarbon isotopes (provenance)



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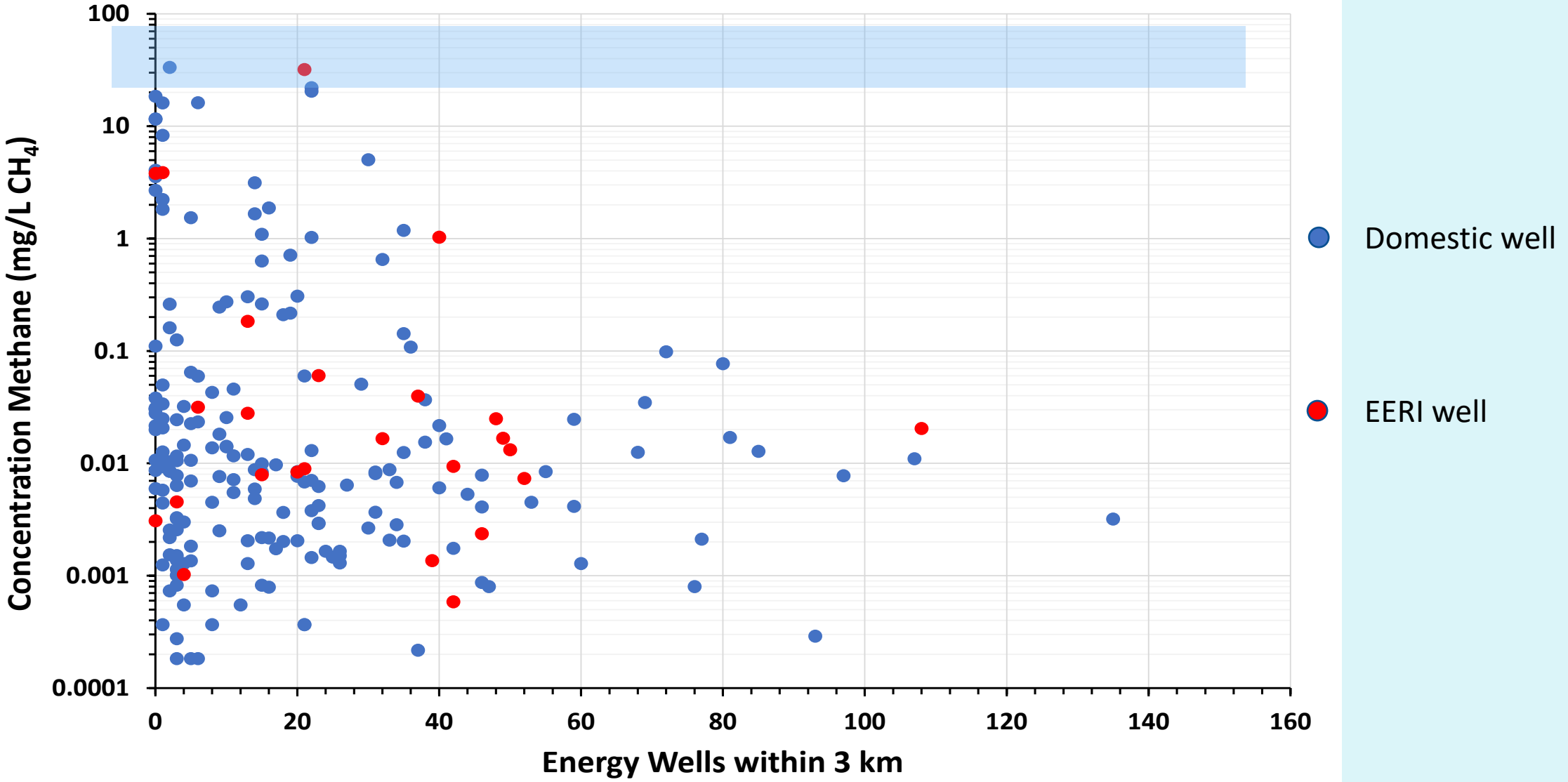
Ubiquitous methane



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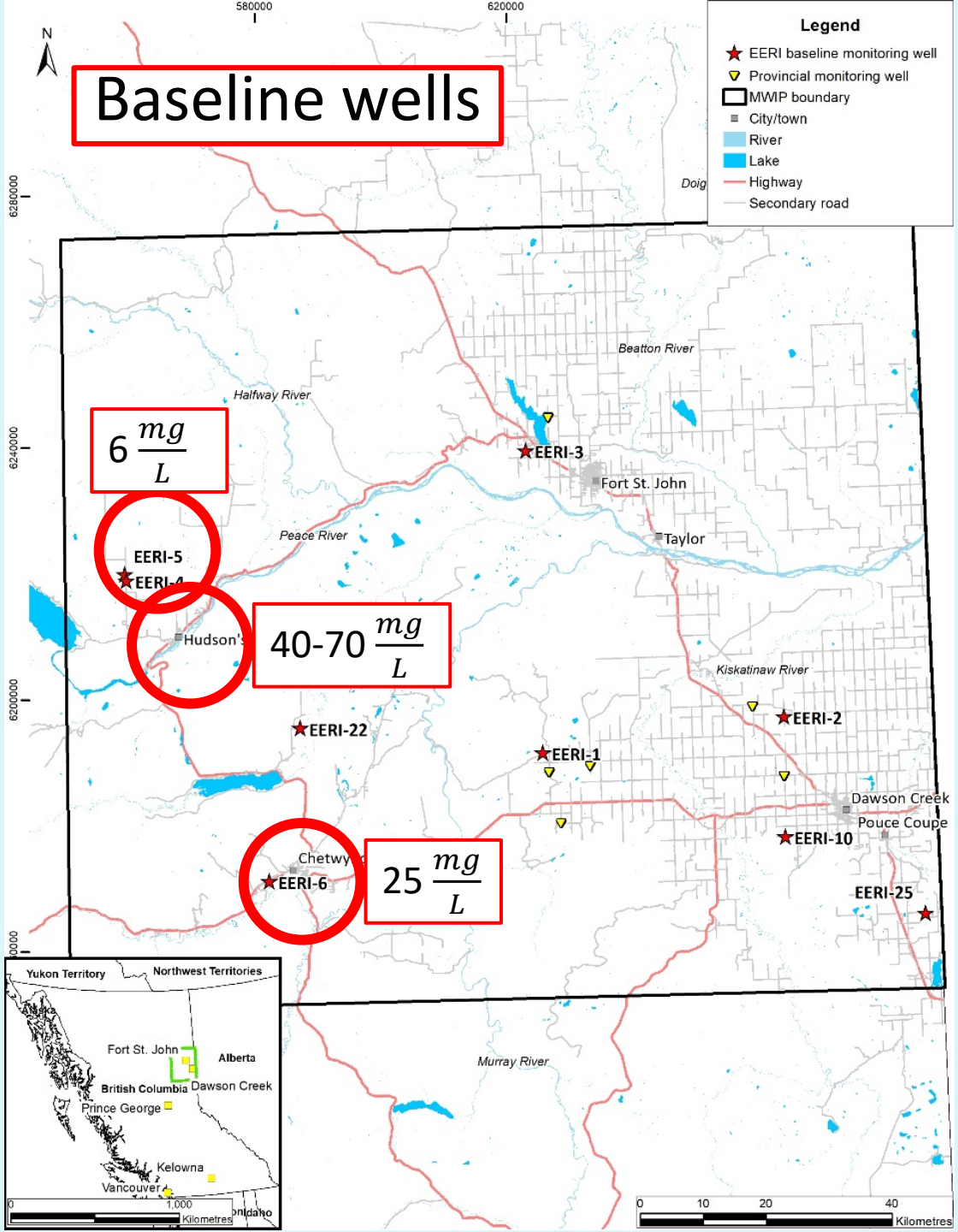
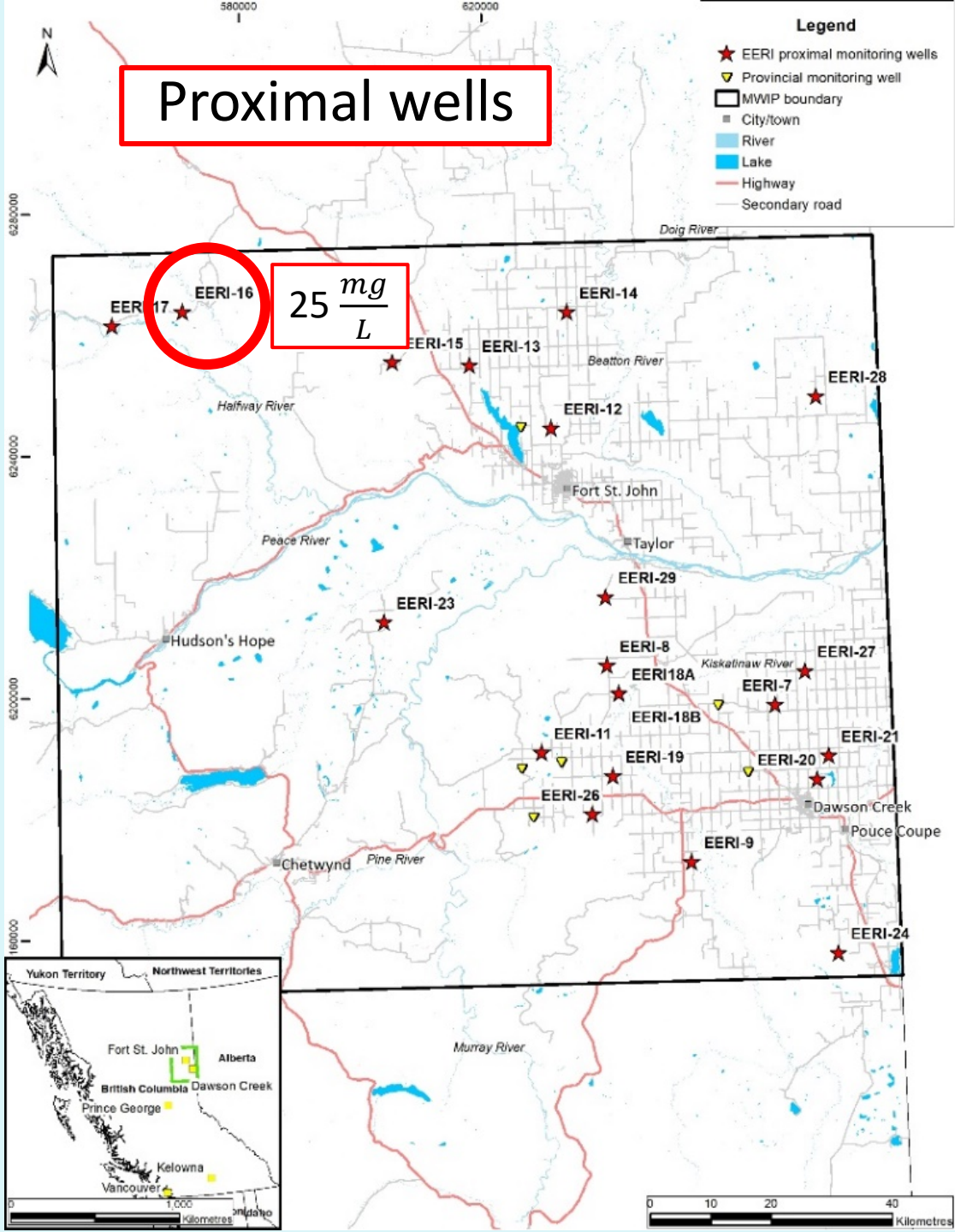
Baseline wells



Proximal wells



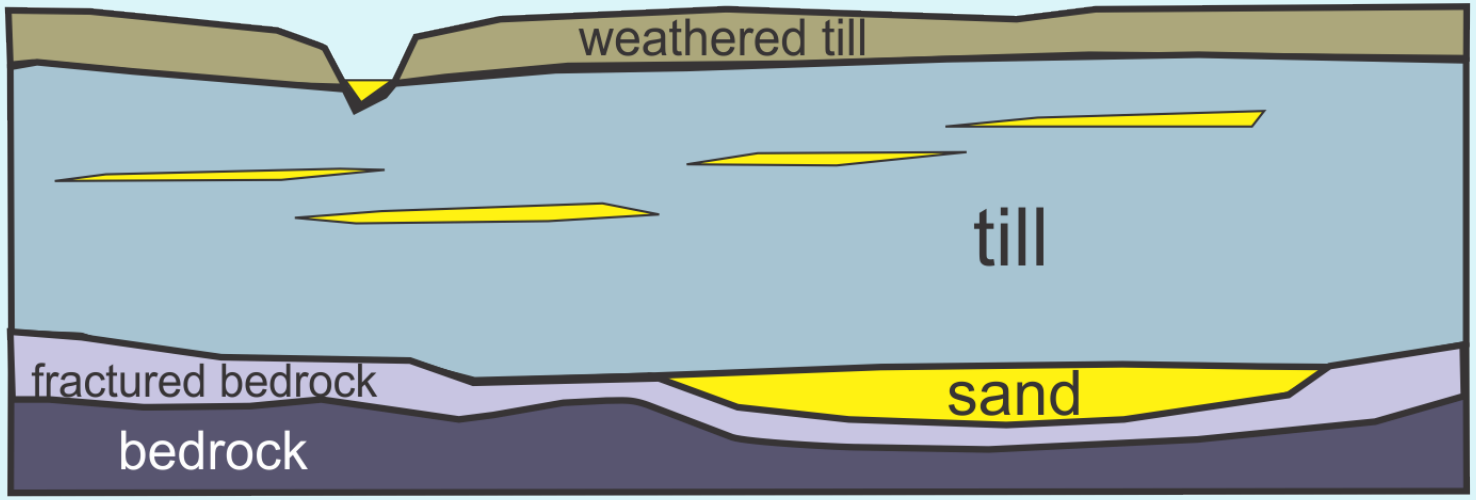
Highly heterogeneous

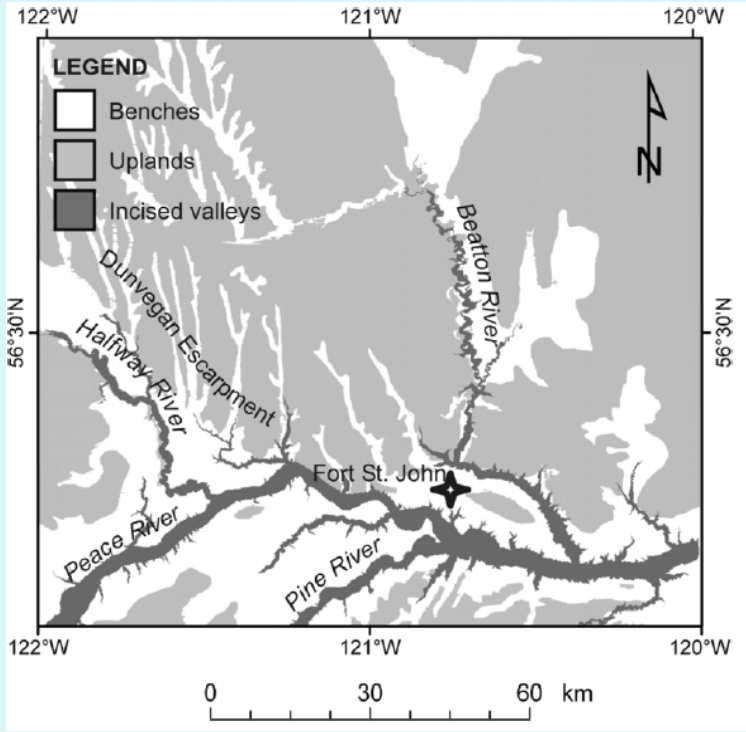
Typical: glacial sediments overlying bedrock

Low-permeability tills pervasive at surface

Most significant aquifers:

- Buried sand or sand/gravel paleovalleys
- Fractured bedrock





Hartman and Clague, 2008

Discontinuous units

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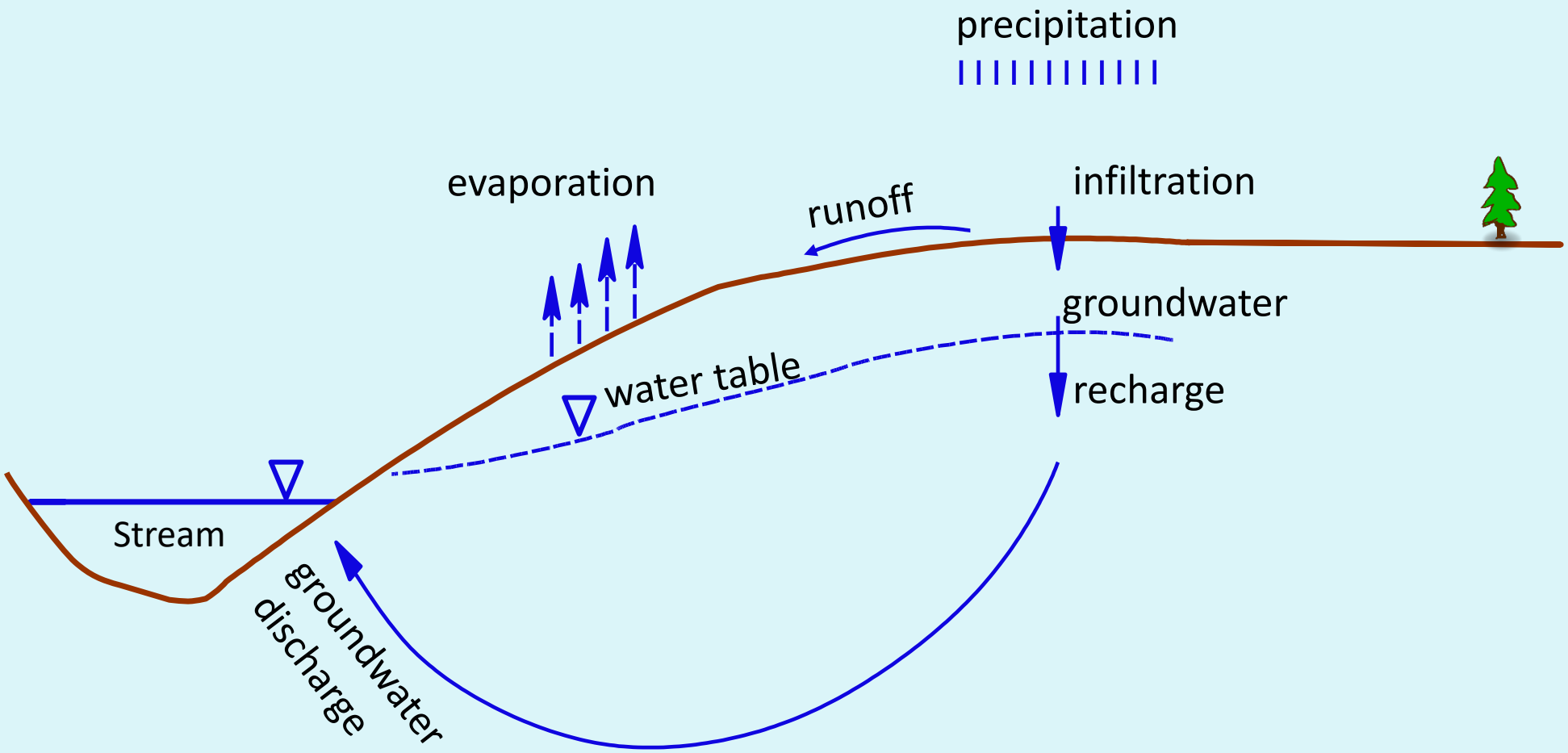
Groundwater conceptual model



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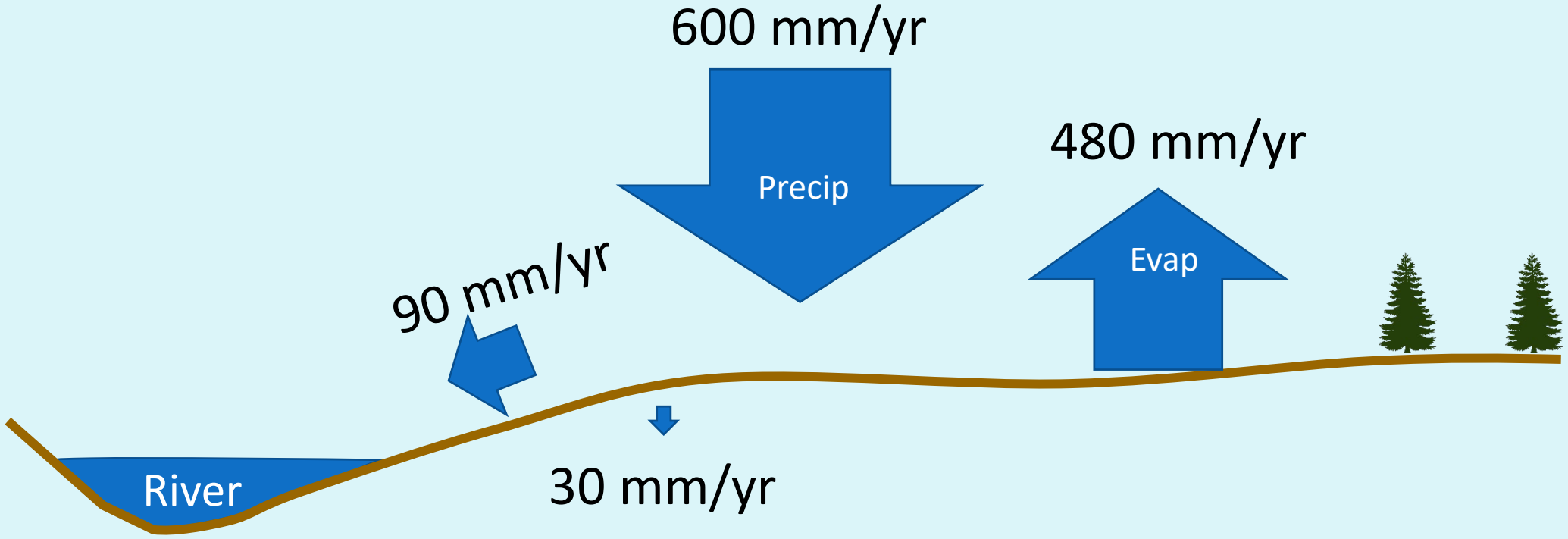
Regional water balance



5 % of precipitation becomes groundwater

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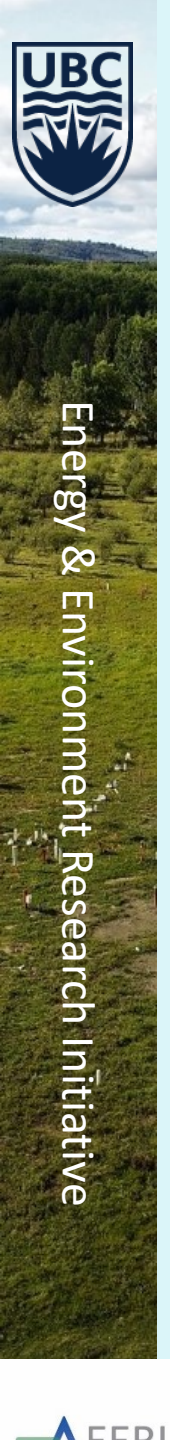
Thank you



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