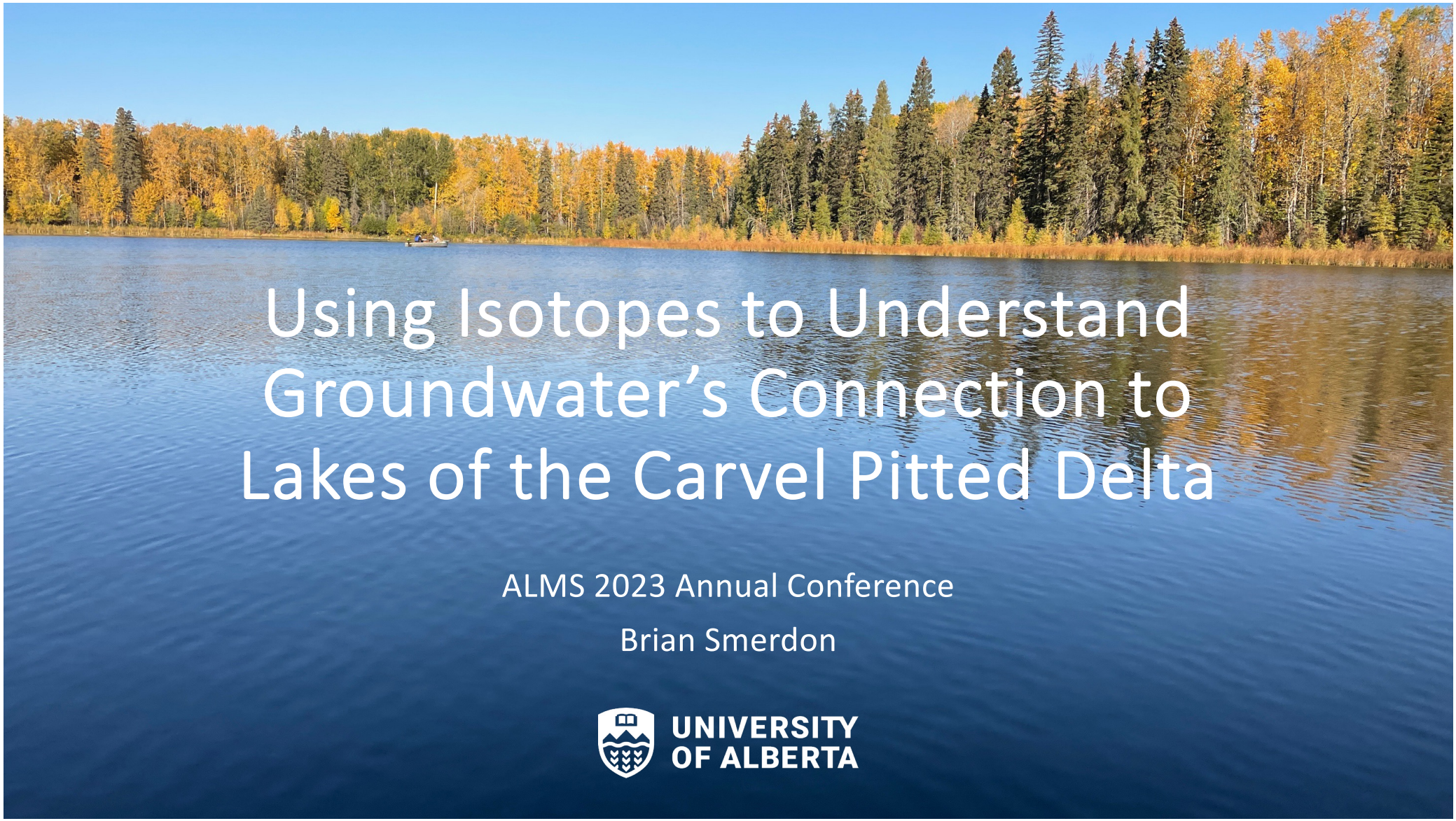

Using Isotopes to Understand Groundwater's Connection to Lakes of the Carvel Pitted Delta

ALMS 2023 Annual Conference

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Contributors

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- Lake stewardship & enthusiasm for citizen science
- Water sampling

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- Stable isotope analysis

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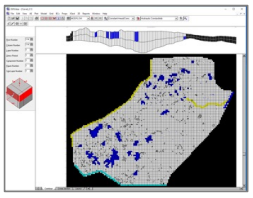
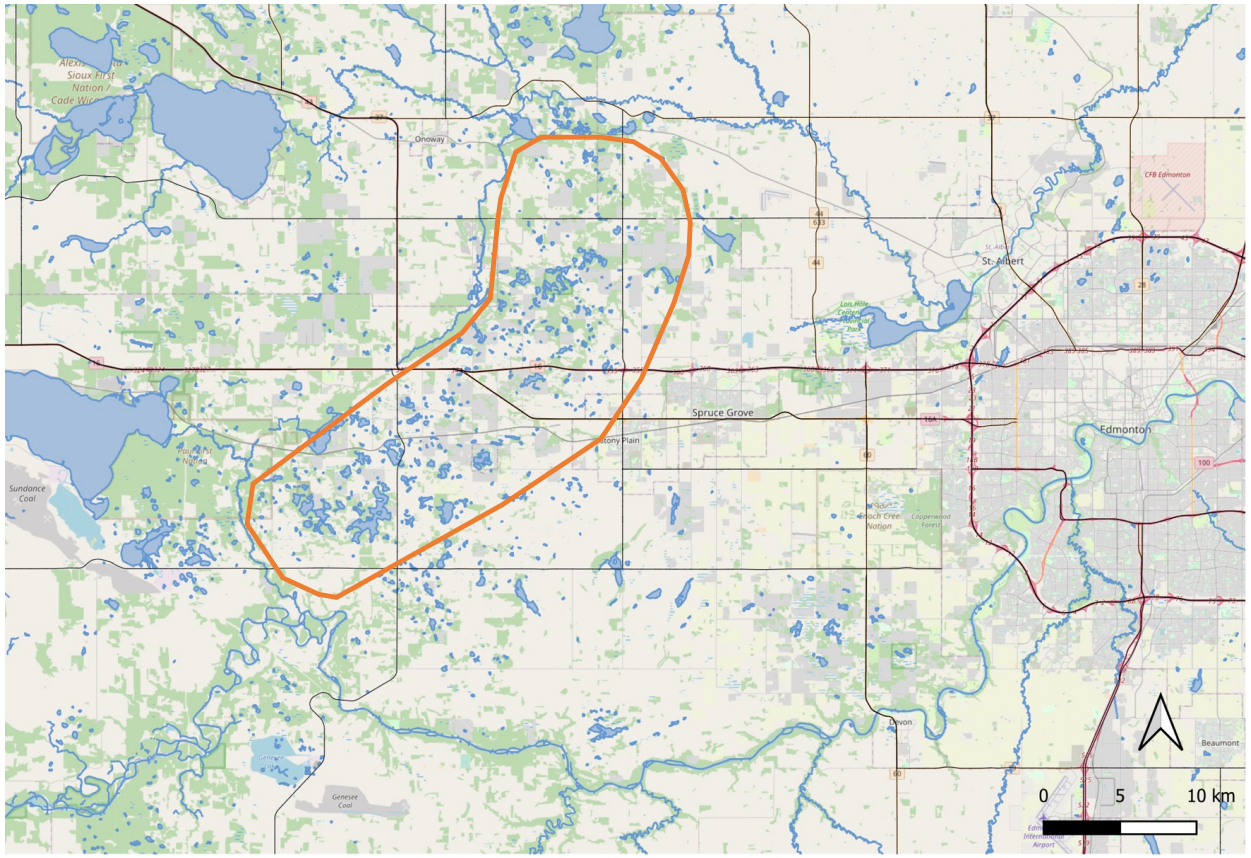
- MSc student
- Radon analysis

Darby Burns

- Research Assistant
- Water table mapping

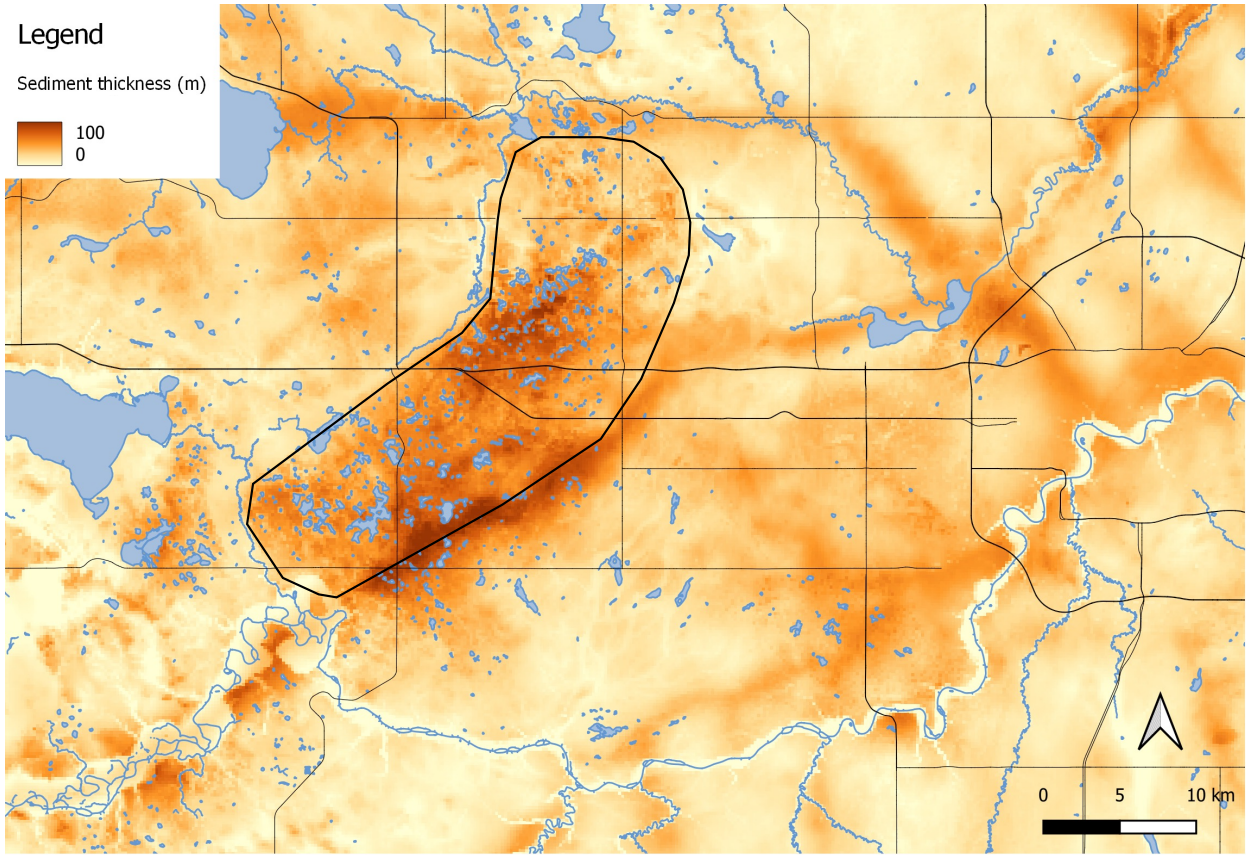


Lakes of the Carvel Pitted Delta



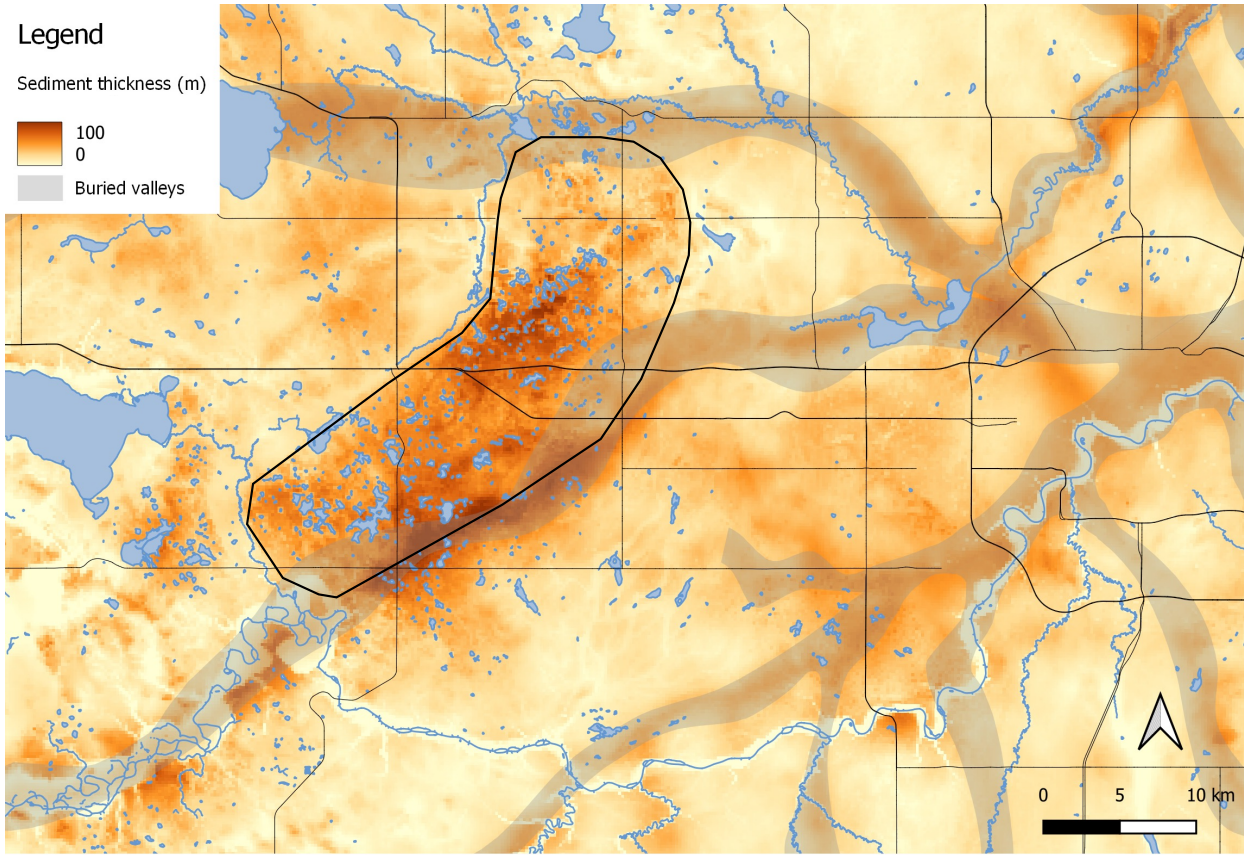
- Dozens of ***small*** kettle lakes with unique ecological value
  - Support fish, wildlife and waterfowl
  - Recreation
- Threatened by a changing landscape
  - How will they respond to anthropogenic development?
- Limited information led to citizen-science water quality surveys in 2021 and 2022
  - *From "I don't know" to Idano: How Visiting a Little Known Lake Instigated a Lake District Survey*

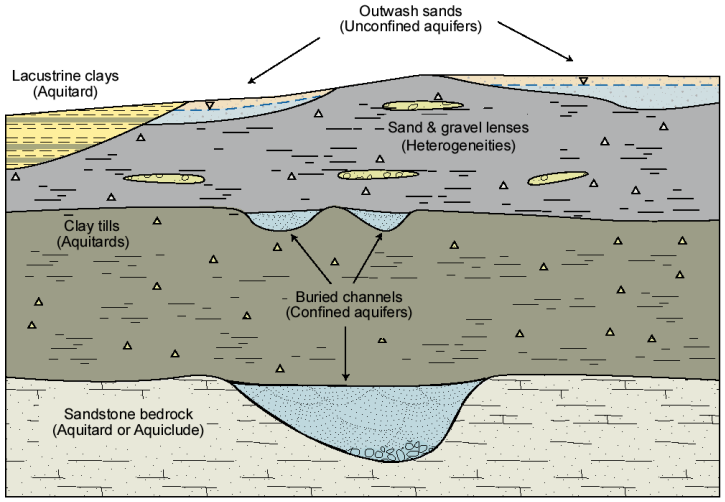
What is the Carvel Pitted Delta?



- Deposits of sand and gravel with hummocky topography
  - > 100 m thick in some places
- Formed where rivers flowed off glacial ice into Glacial Lake Edmonton
- Sitting on bedrock of the Horseshoe Canyon Formation
- Sediments are up to 100 m thick

Buried Valley Aquifers

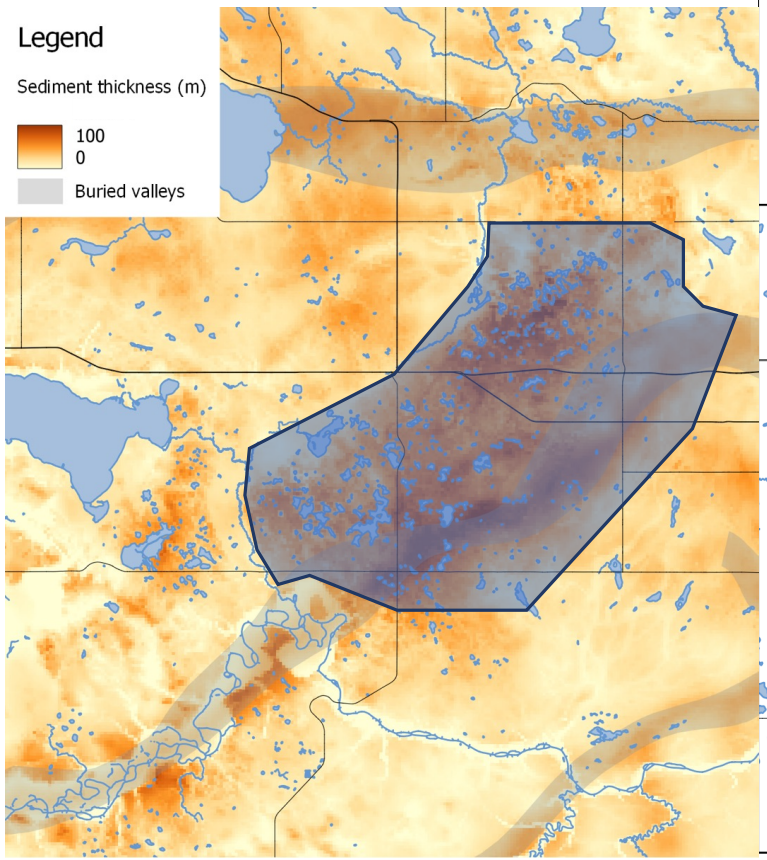


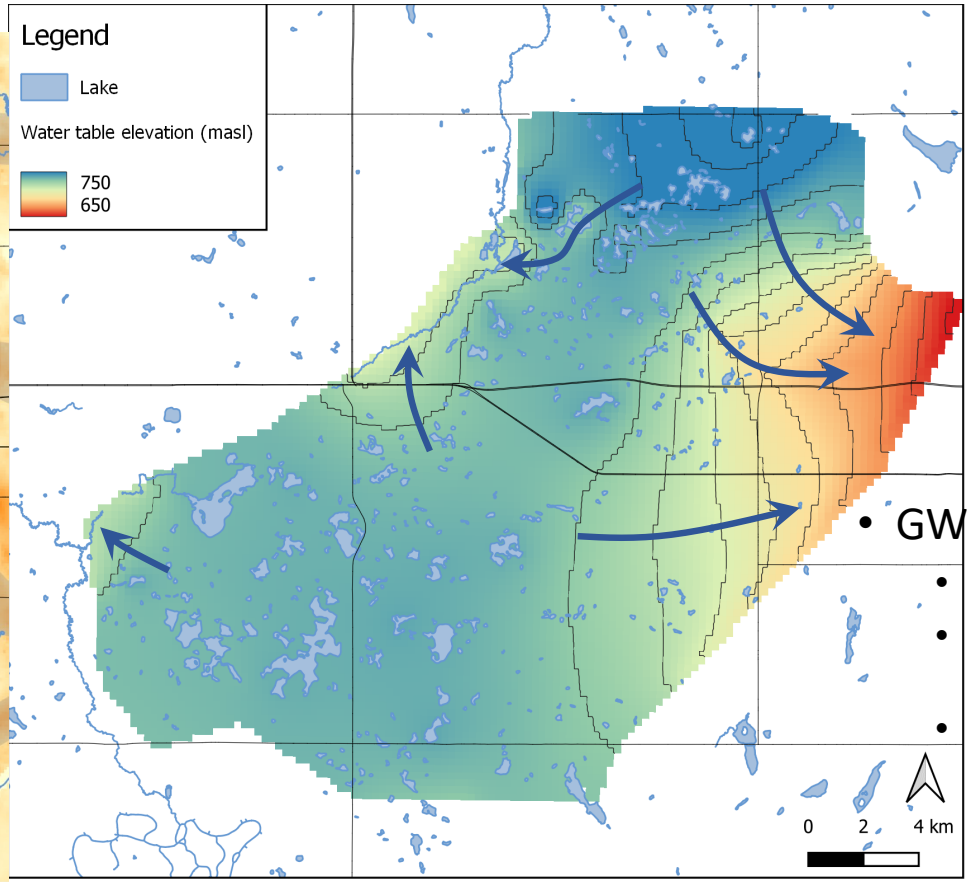


- Situated between 2 buried valleys
- Ancestral rivers that eroded in the bedrock
- Often filled with sand and gravel
- Covered by glacial sediments

Groundwater Movement

- The Carvel Pitted Delta is an area of groundwater recharge
- The water table surface is ‘saddle shaped’



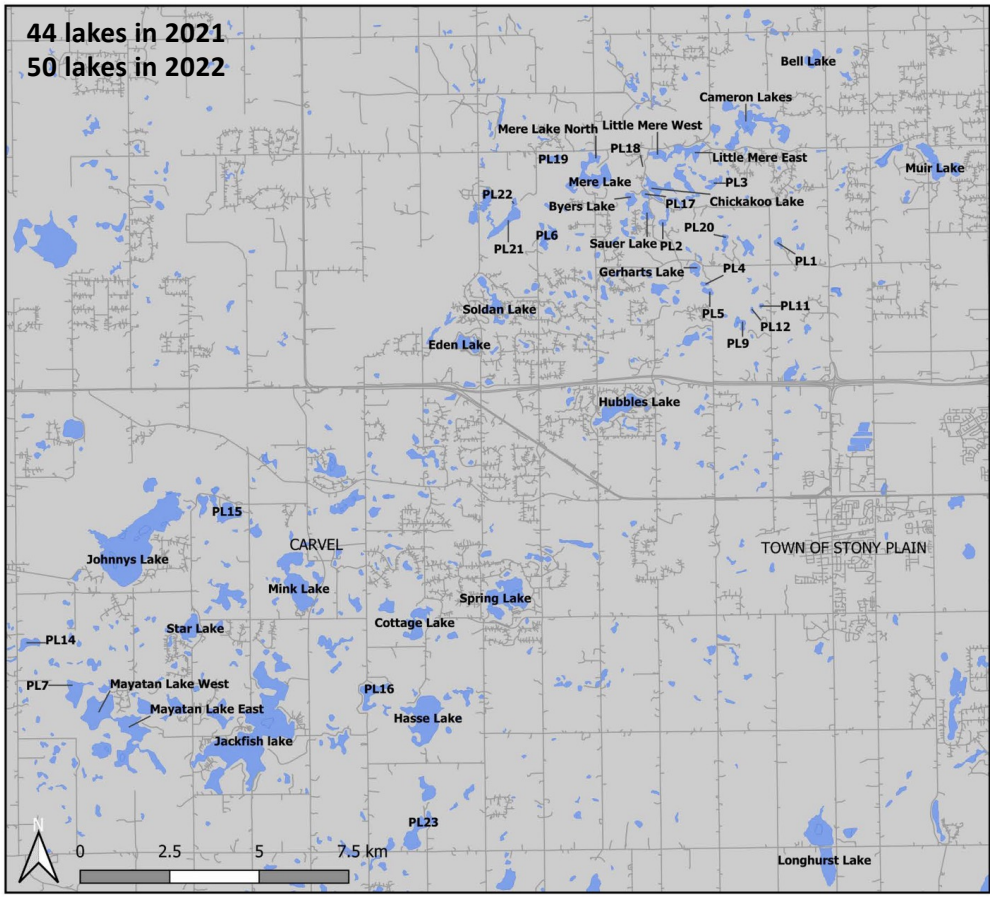


- GW flow directions:
  - East towards Big Lake
  - West towards Kilini Creek
  - Downwards into the underlying bedrock

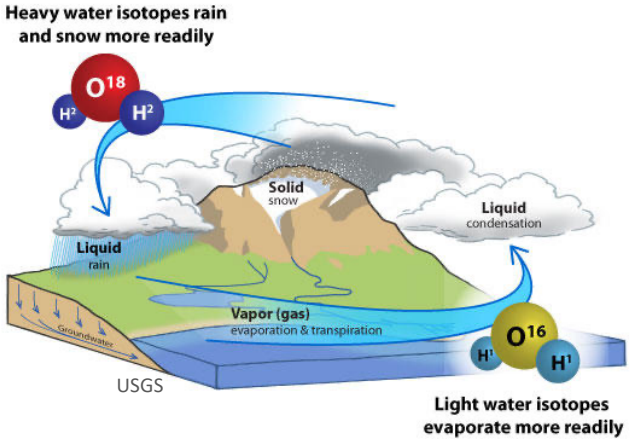
Community-based Water Quality Survey

- Developing a regional overview of lake quality
- Lots of limnological data (clarity, T, DO, chemistry, nutrients…)

- ***How about some isotopic tracers too!***



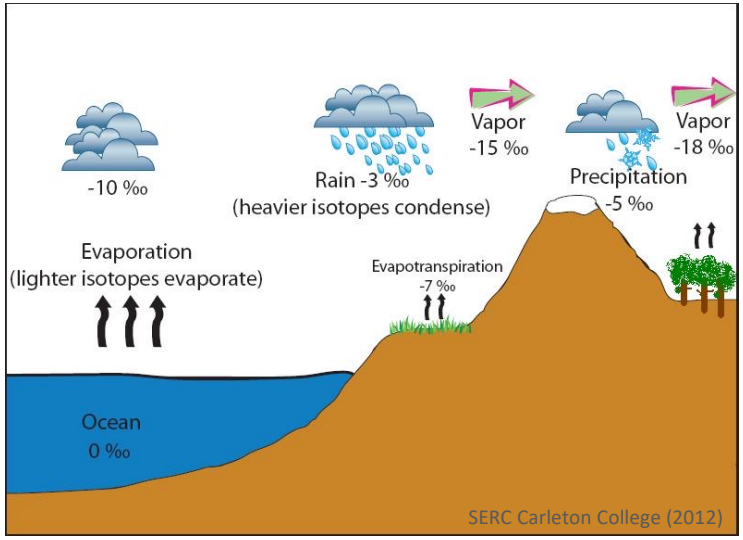
Stable Isotopes of Water: $\delta^{18}O$, $\delta^{2}H$



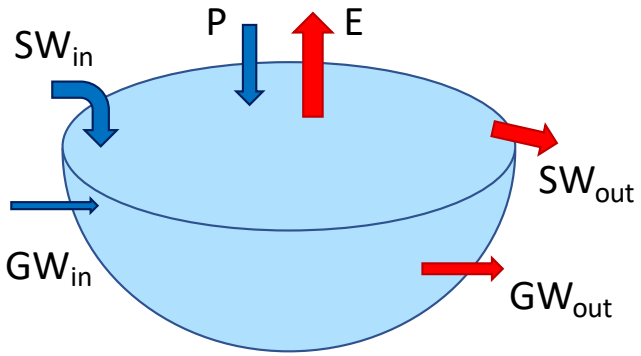
- Family of an element that have same number of protons but different number of neutrons
  - Slightly different atomic mass
  - Lighter isotopes evaporate more readily
  - Heavier isotopes condense more readily

- Relatively easy to measurement of isotopic ratio (heavy/light; $^{18}O/^{16}O$; $^{2}H/^{1}H$)
  - Expressed in delta units (δ) as per mille (parts per thousand; ‰)

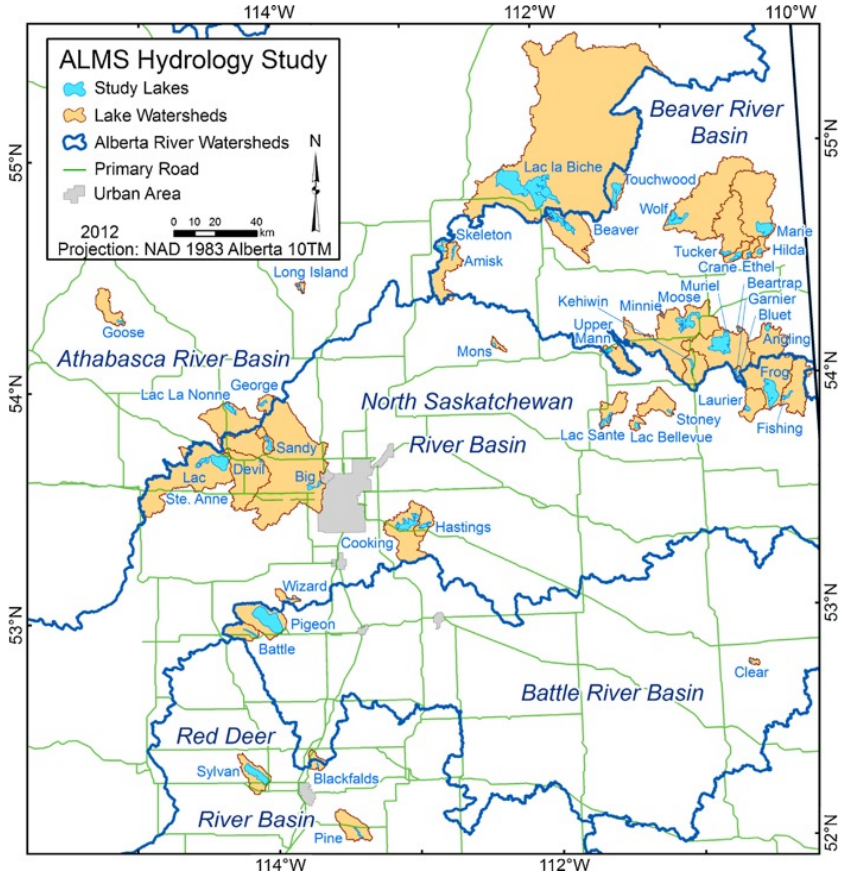
- **KEY POINT:** A useful tracer of water movement through the hydrologic cycle



Isotope Mass Balance

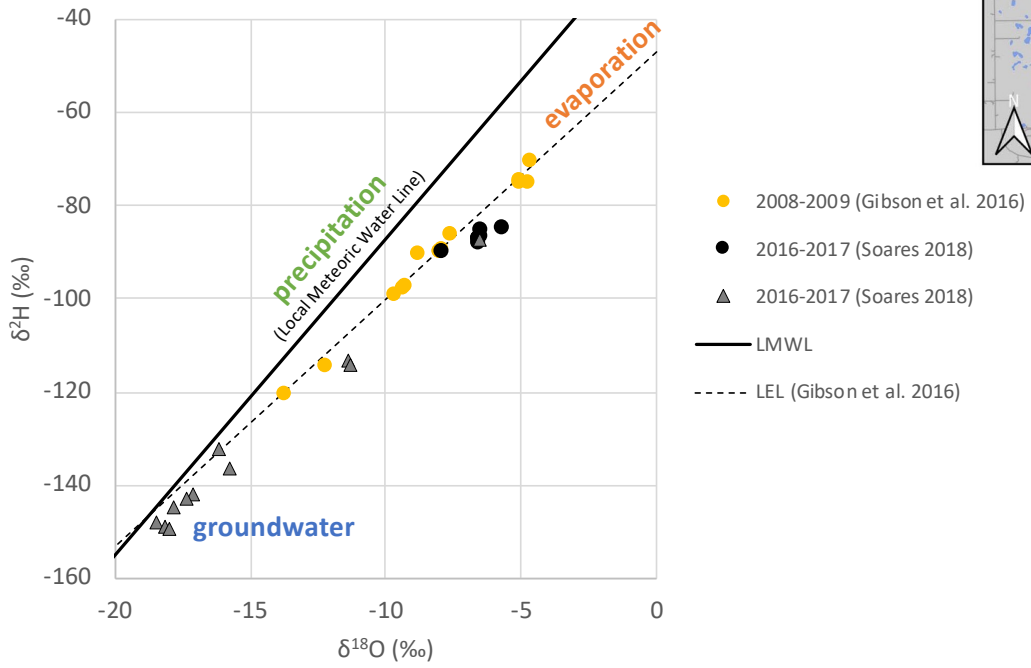


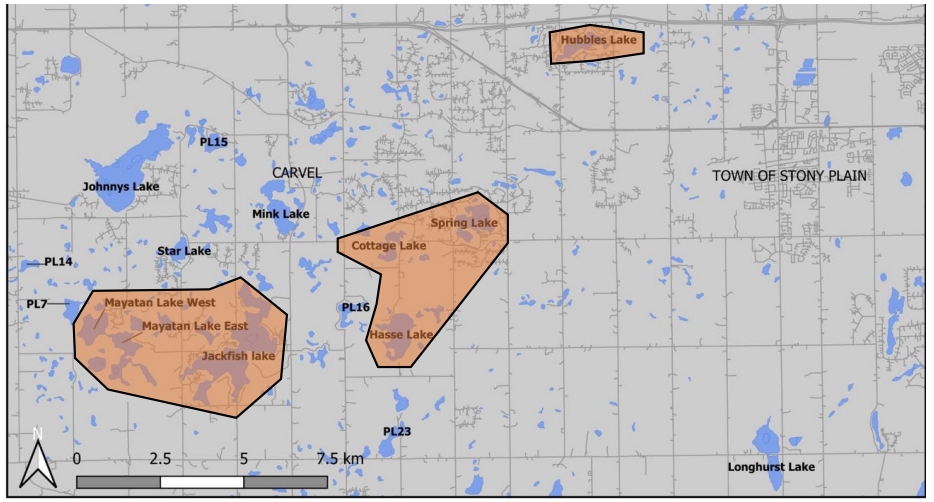
- Degree of evaporation can be determined from stable isotopes of water
- Can inform water sources and budget for lakes
- Isotope mass balance used to describe:
  - Evaporation/Inflow ratio (E/I)
  - Could help identify groundwater connection

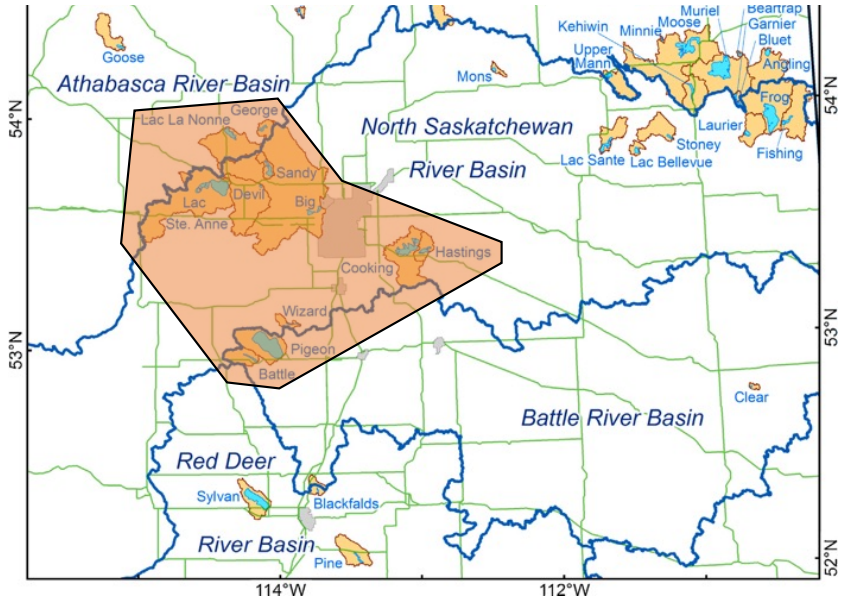


Gibson et al., 2016 JofH

Stable Isotope Results



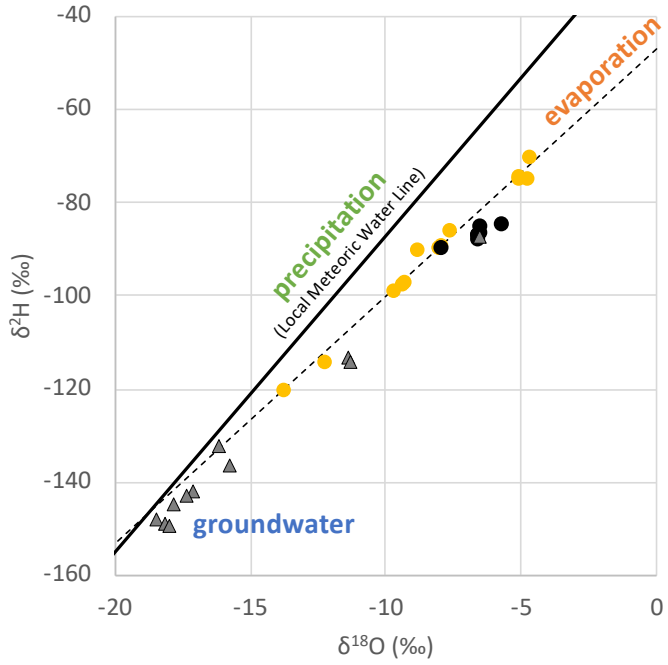


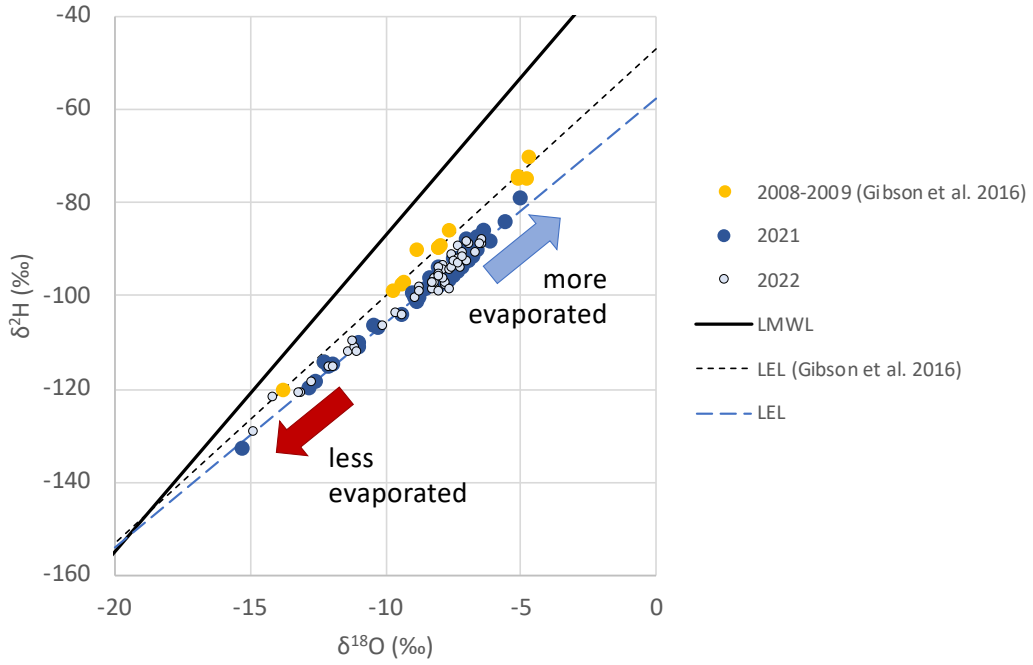


Gibson et al., 2016 JofH

Stable Isotope Results

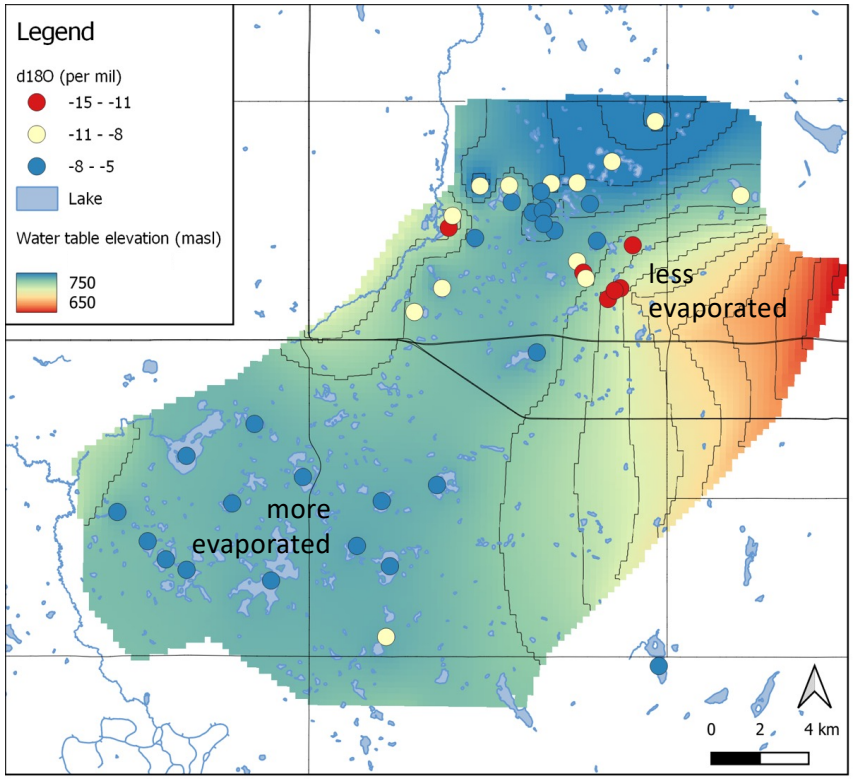
- All the lakes are experiencing some degree of evaporation
- Highly variable lake-to-lake, but consistent year-to-year

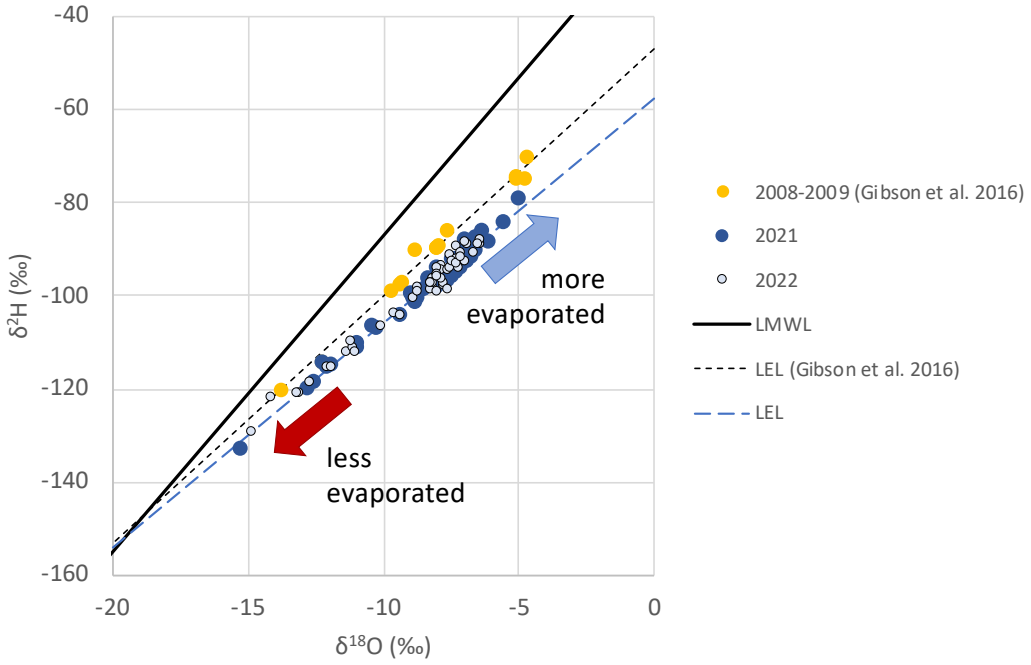




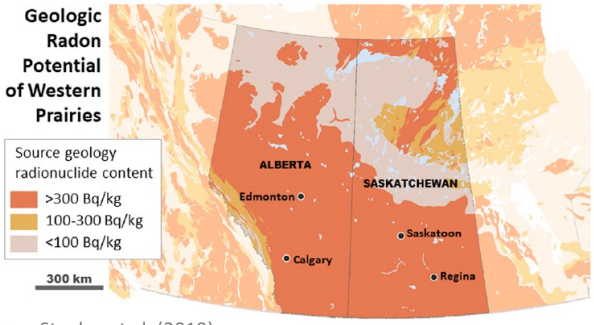
Spatial Trend

- Lake-to-lake variability appears to have a spatial pattern



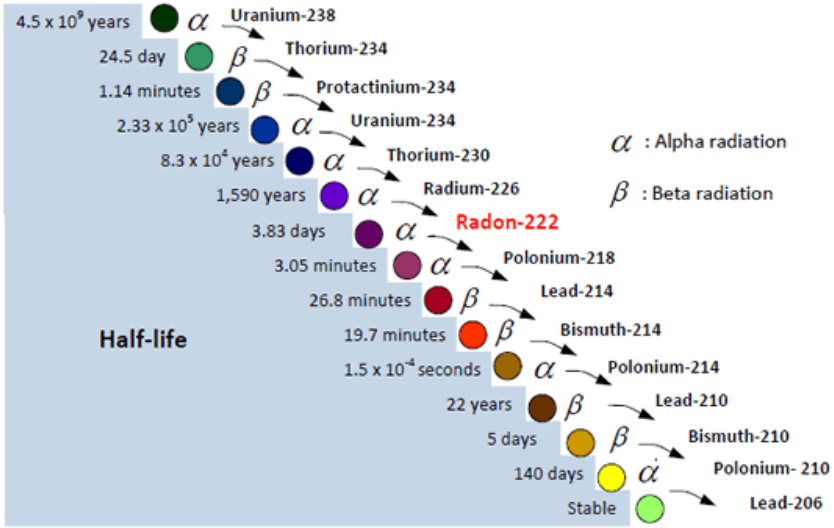


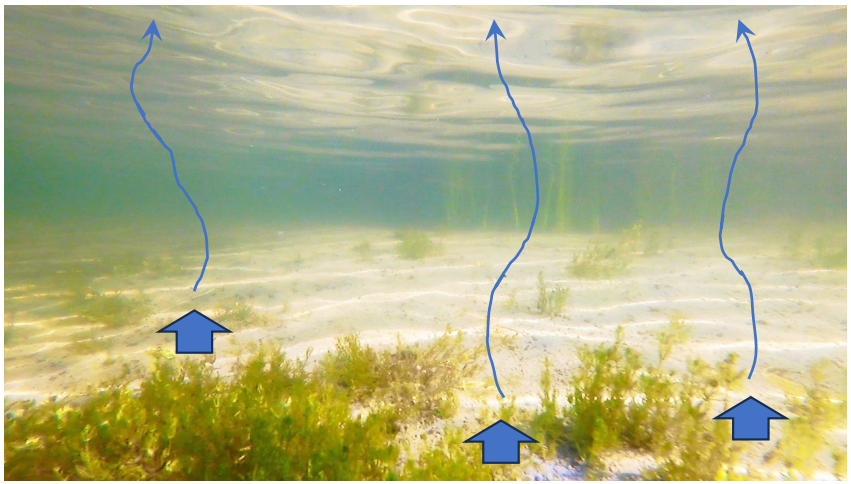
Radon: ^{222}Rn



Stanley et al. (2019)

- Generated from geological material
- Seems to be widespread in the Western Prairies
- Radioactive decay
  - $t_{1/2}$ = 3.8 days





- Travels with groundwater as a dissolved gas
- Enters lakes then degasses to the atmosphere

- **KEY POINT:** a useful indicator of groundwater connection

^{222}Rn Results

- Average groundwater concentration is 15 Bq/L in the Edmonton area
- Some of the lakes have 8 to 12 Bq/L
- Again, lake-to-lake variability appears to have a spatial pattern

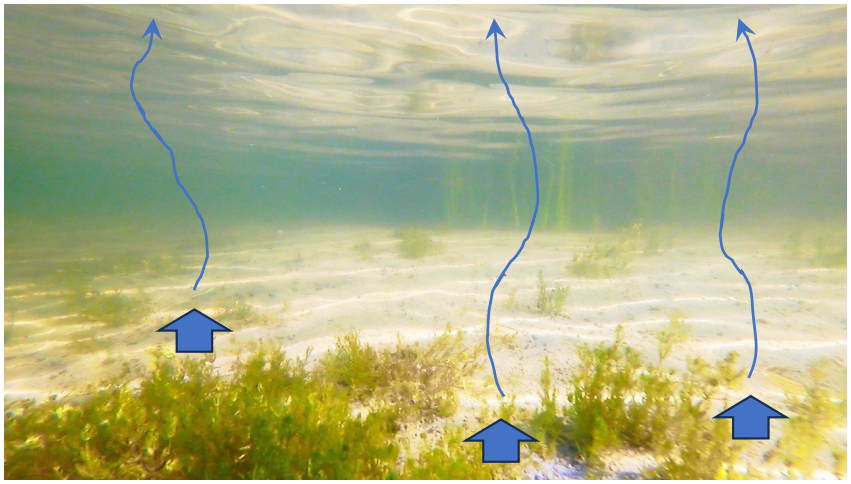
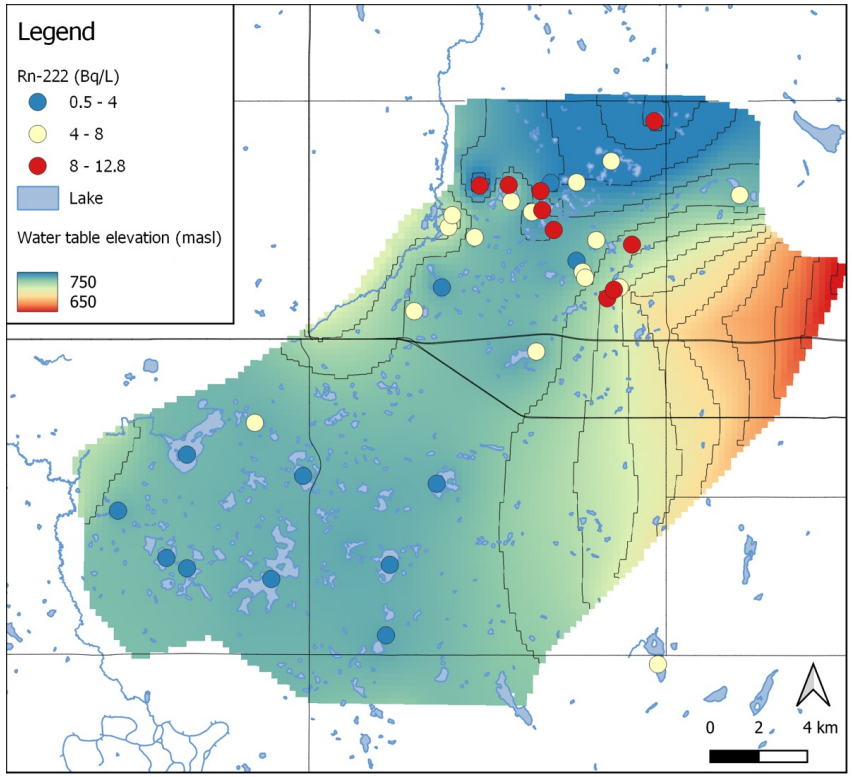
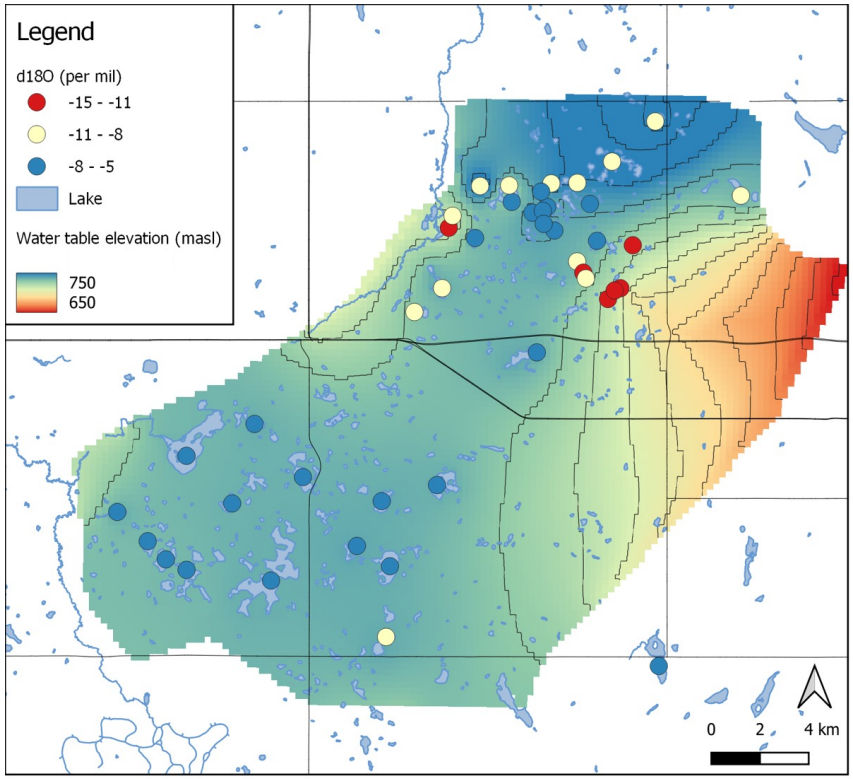
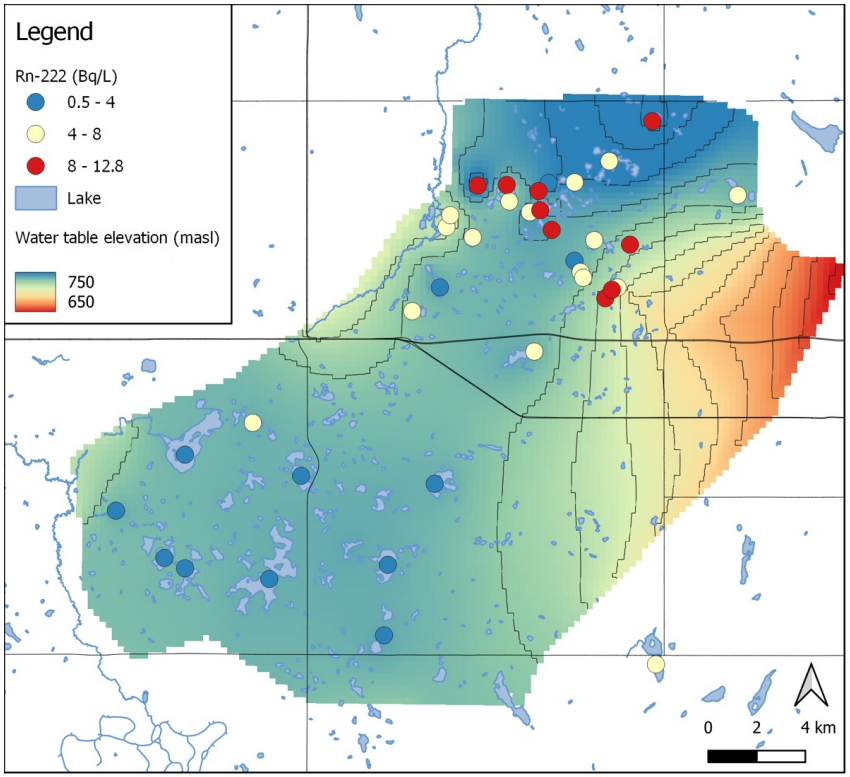


Photo by Dave Mussell

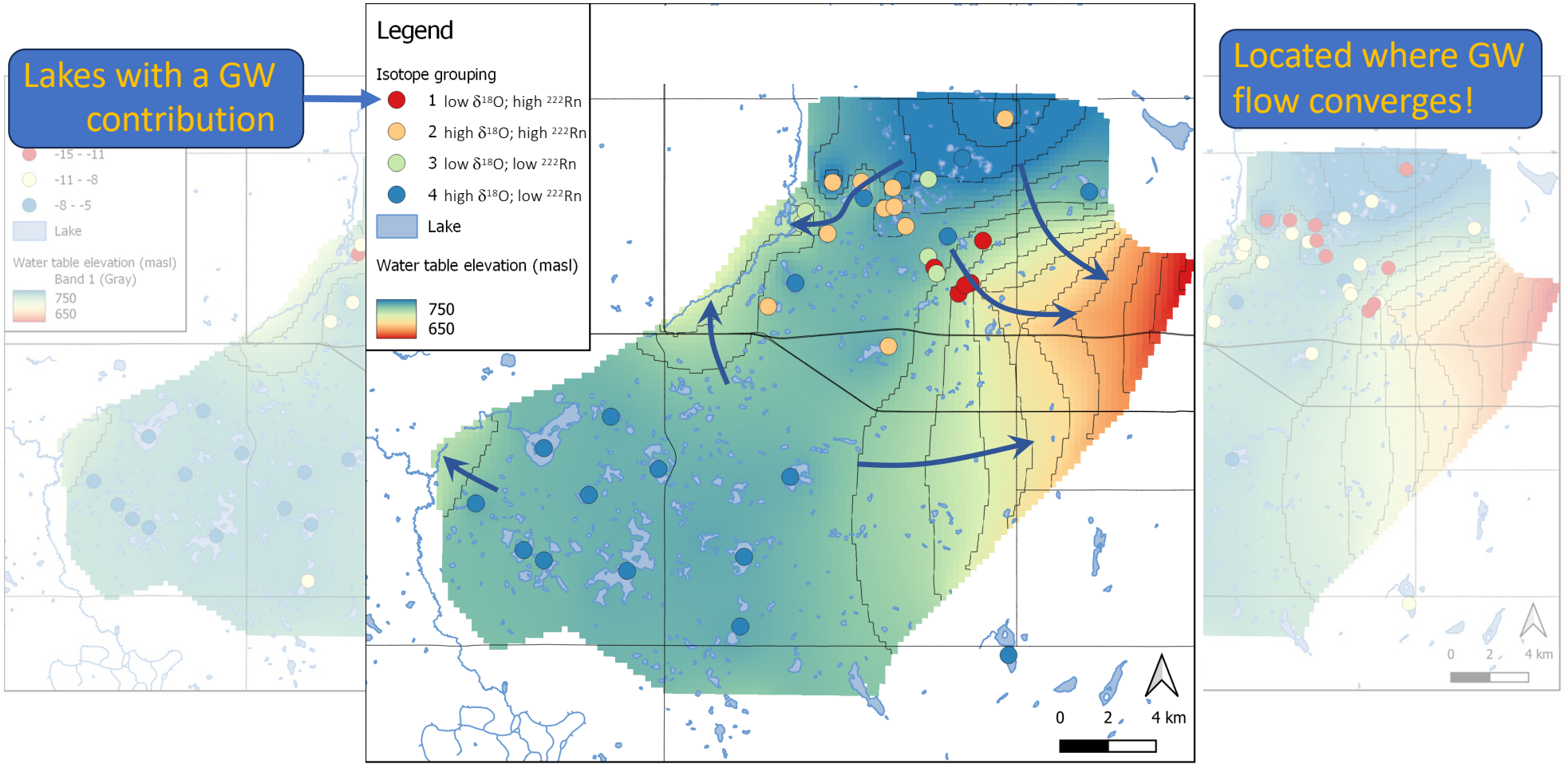


Different isotopes, yet a similar pattern

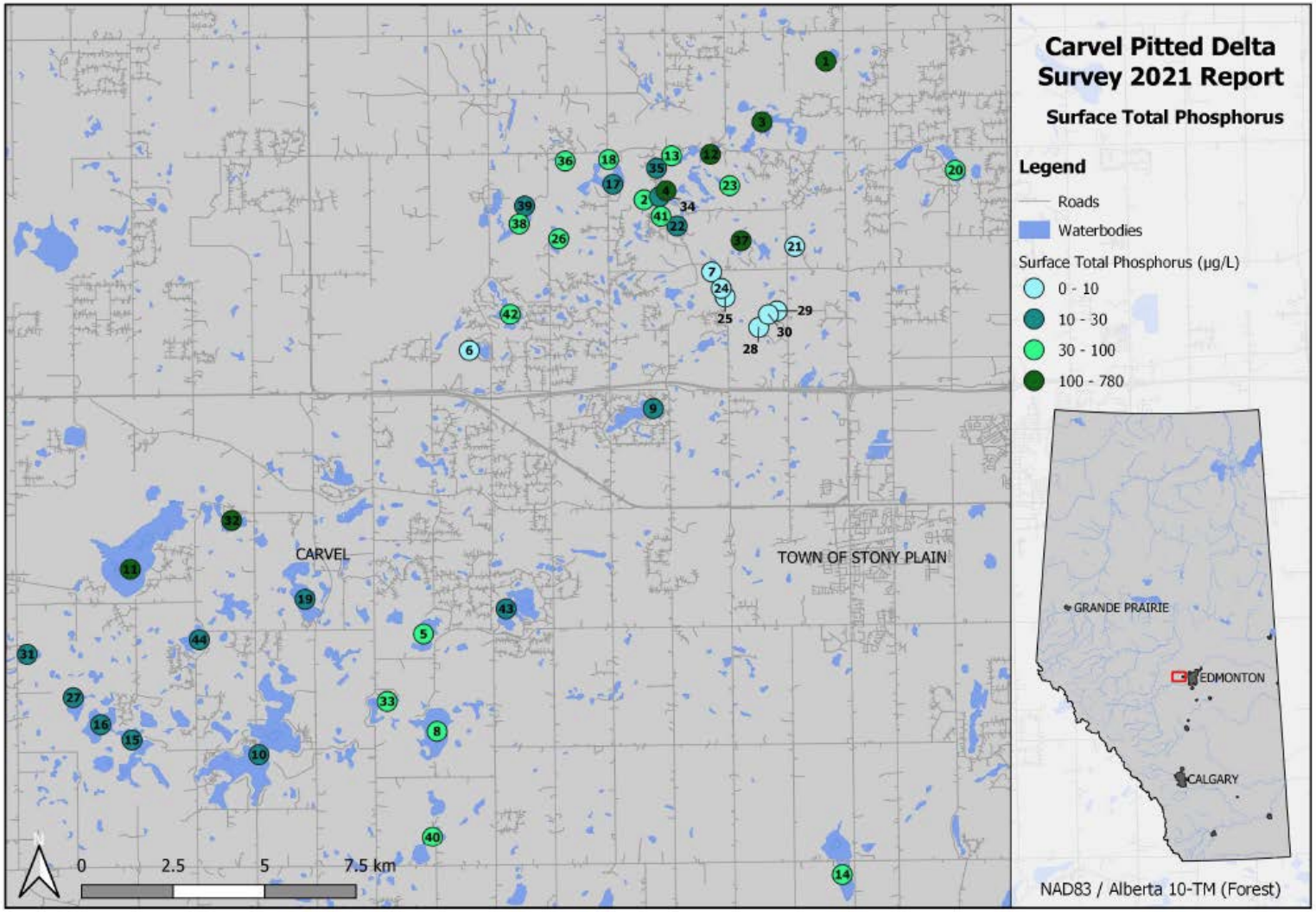


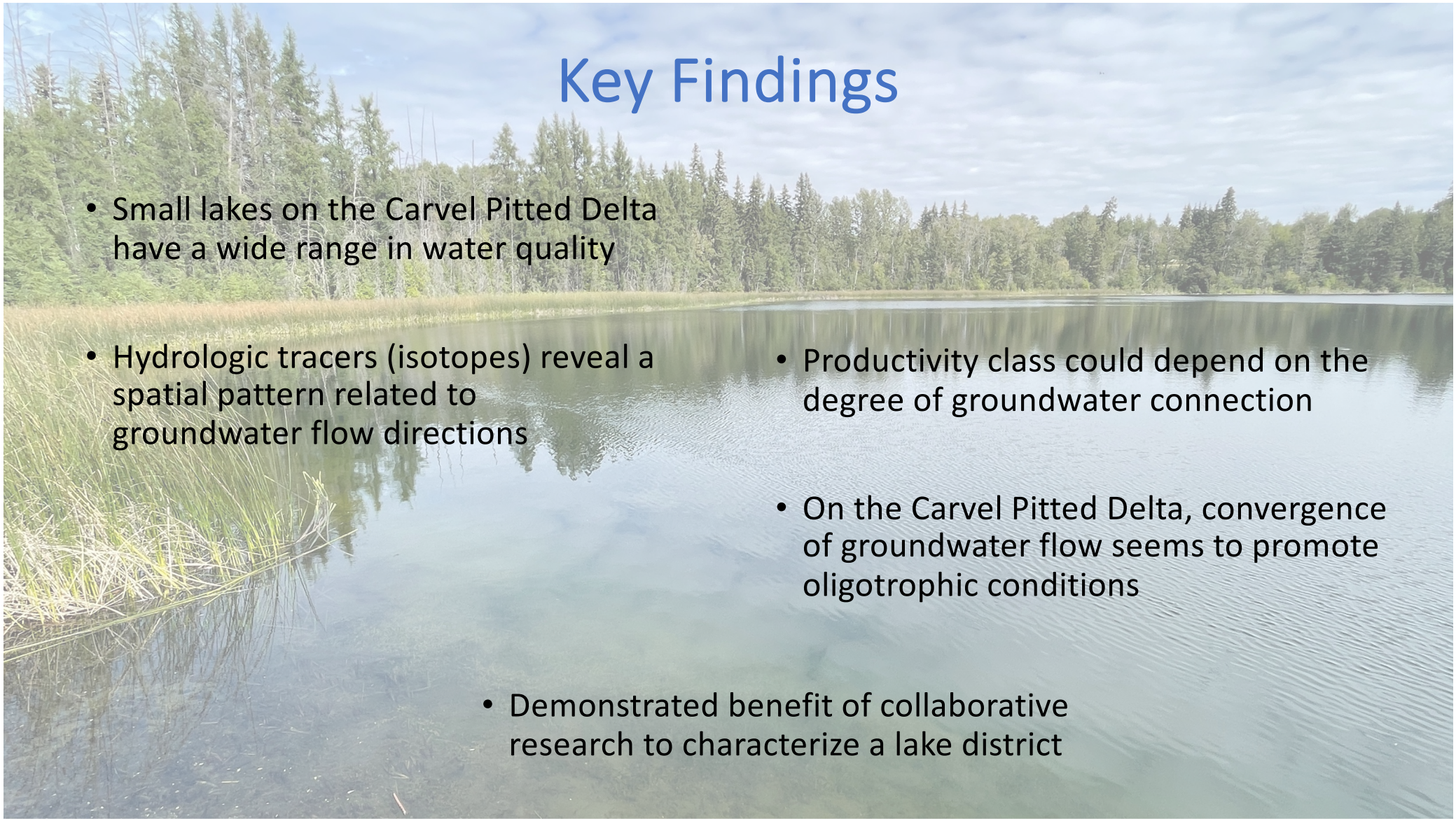


Isotope grouping indicates degree of groundwater connection



- Similar pattern observed in lake productivity
  - Total P
  - Chlorophyll-a





Key Findings

- Small lakes on the Carvel Pitted Delta have a wide range in water quality
- Hydrologic tracers (isotopes) reveal a spatial pattern related to groundwater flow directions
- Productivity class could depend on the degree of groundwater connection
- On the Carvel Pitted Delta, convergence of groundwater flow seems to promote oligotrophic conditions
- Demonstrated benefit of collaborative research to characterize a lake district