

A Regional Assessment of Occurrences, Sources and Fate of Nitrate in Groundwater of Alberta

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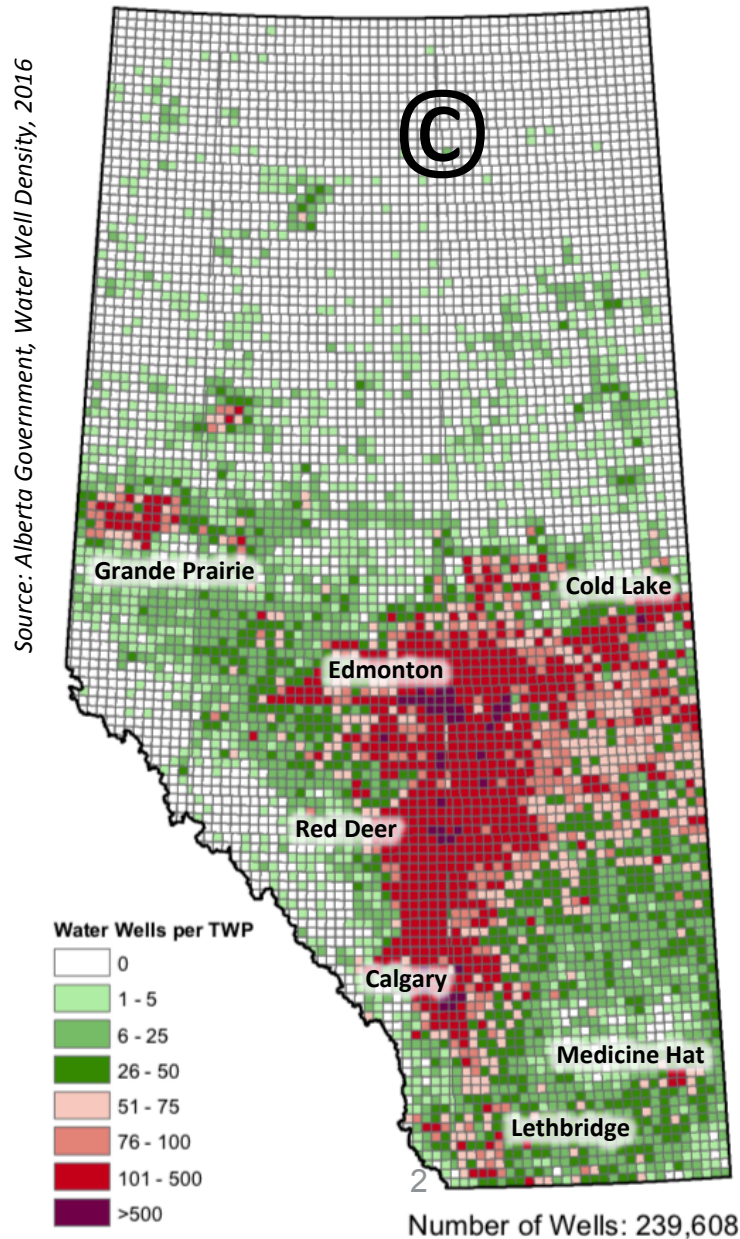
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Domestic groundwater wells in Alberta



- Over 20% of Albertans drink groundwater = 600,000 people in rural Alberta
- Well water quality in circa 240,000 landowner wells is not regulated
 - Only 10% test their groundwater quality annually
 - 15% of samples tested exceed bacterial guidelines
- Septic setback distance from well: 10-100m



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Objective

- Determine the extent to which elevated nitrate concentrations occur in Alberta groundwater
- Determine the sources of nitrate
- Determine the fate of nitrate (e.g. extent of denitrification)

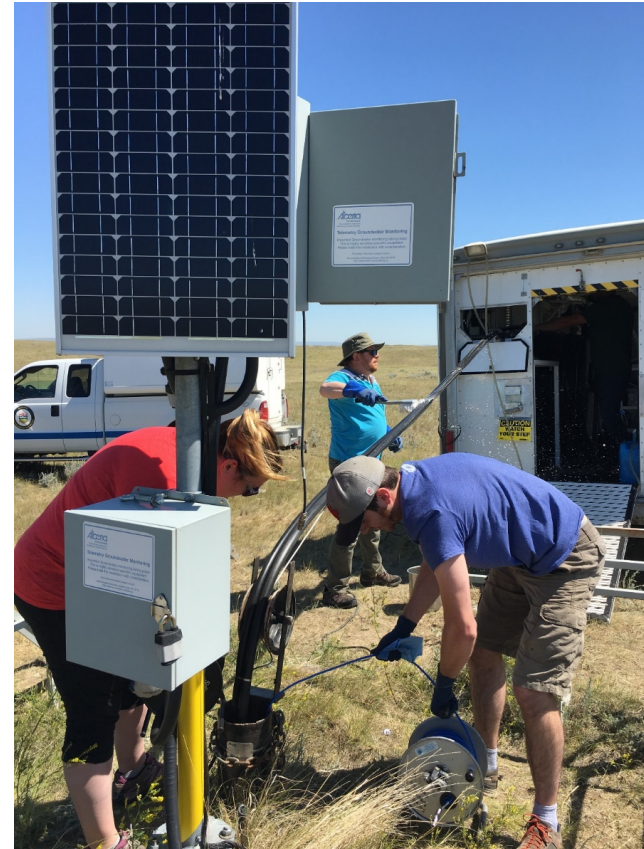
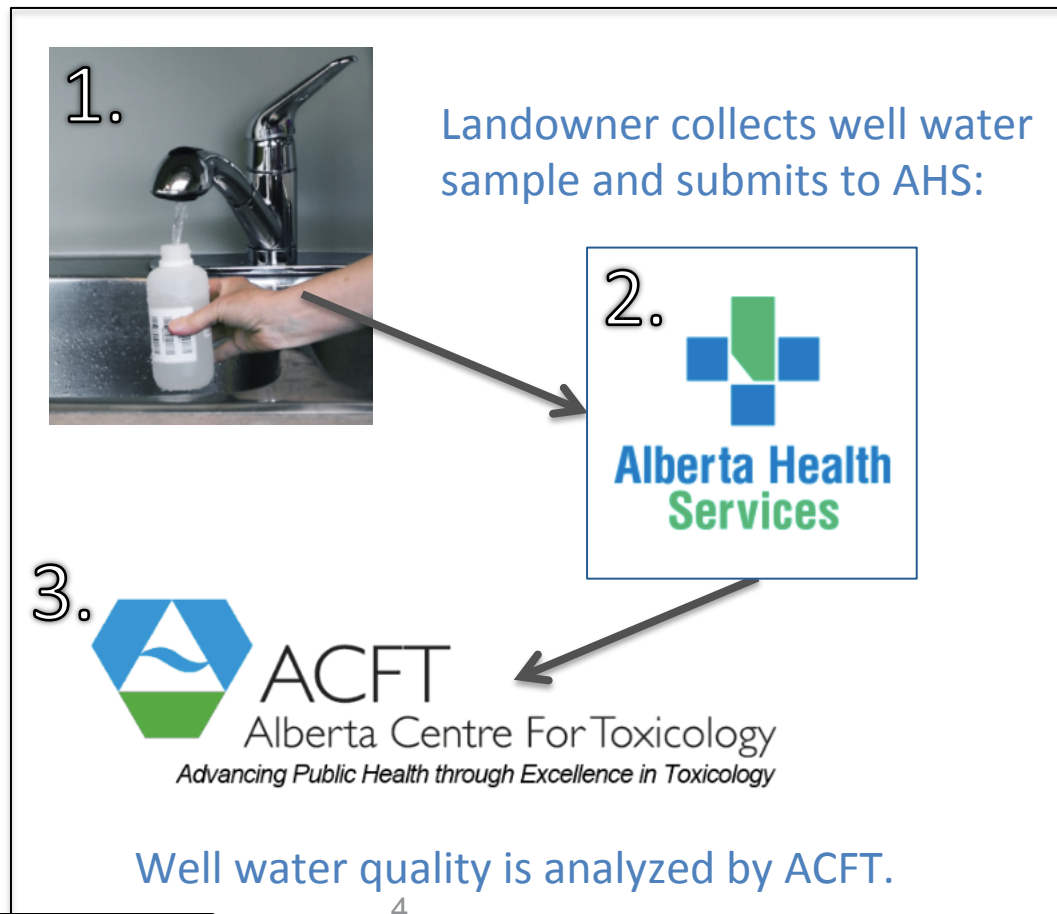


Figure: Groundwater sampling conducted by a team from AEP

Alberta Health Services (AHS) dataset

– ~79,000 water chemistry samples

- Landowner submitted samples
- Years: 2001 – 2015
- *Major ions, TDS, pH, depth, location...*



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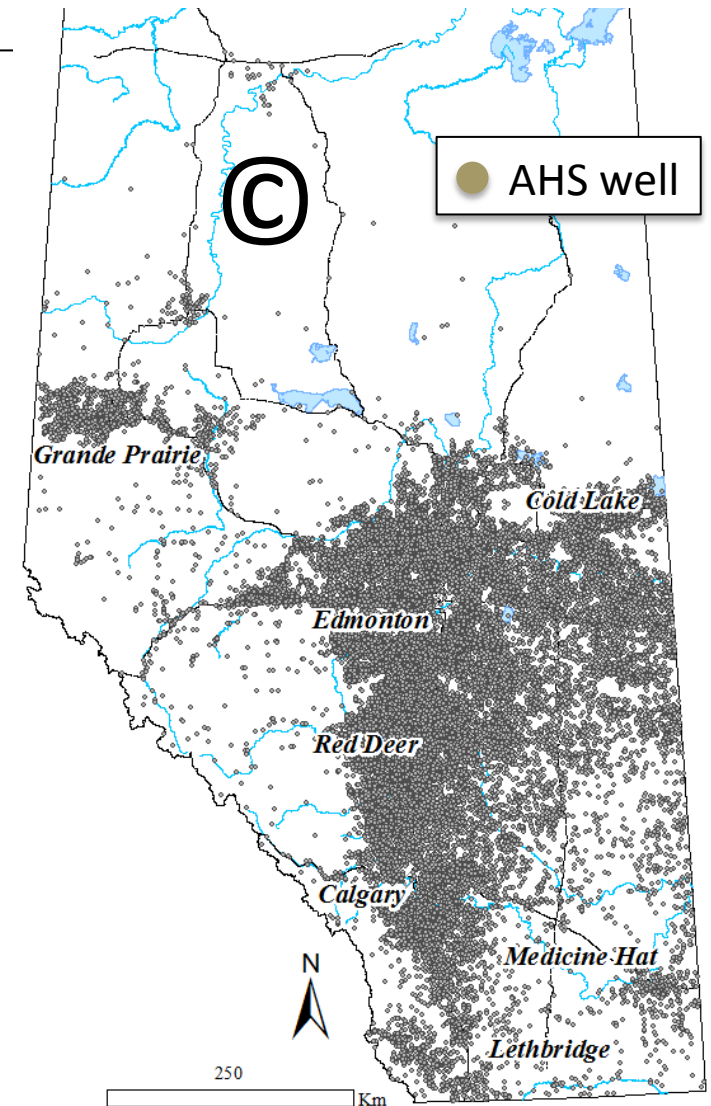


Figure: Map of Alberta with AHS sampling sites.

Alberta

Nitrate occurrence and distribution in Alberta groundwater

<34 % of all groundwater samples contained nitrate, predominantly at low concentrations (<4 mg/L);

The maximum allowable concentration (MAC: <45mg/L) for nitrate was exceeded in <4% of the samples

Elevated nitrate concentrations occur predominantly in the south-east quadrant of the province, where agricultural land use is predominant

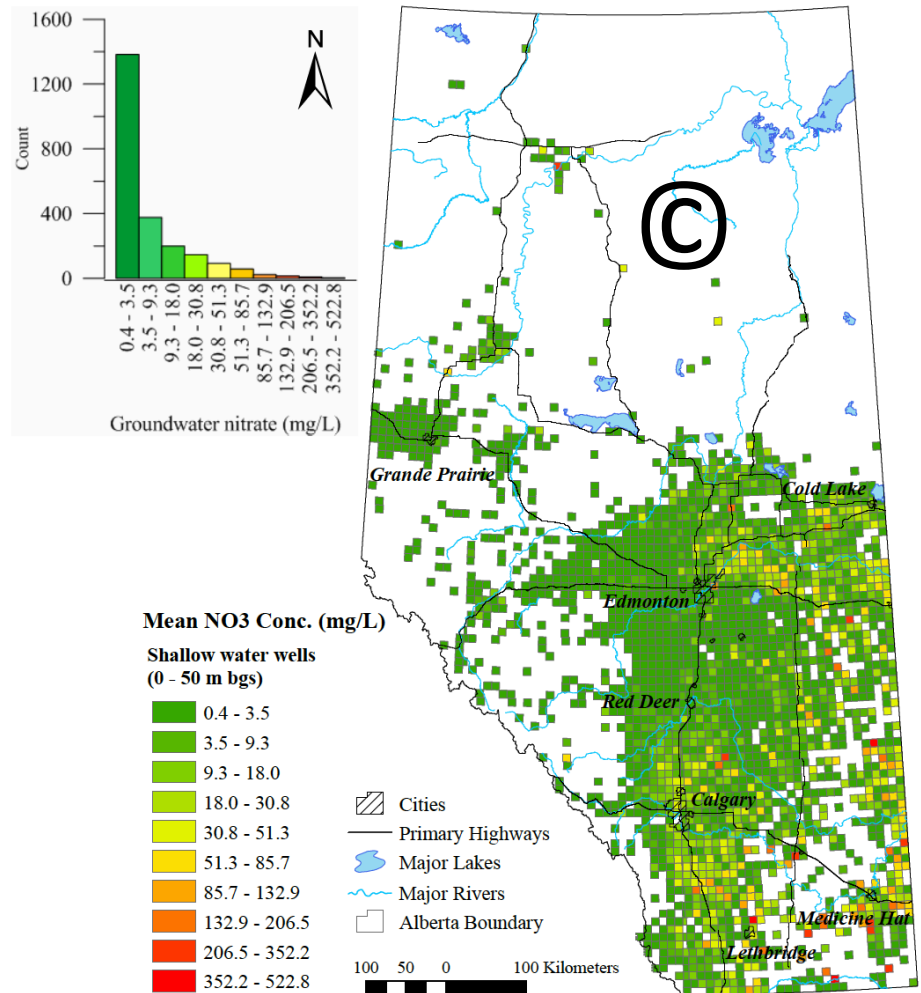


Figure: mean nitrate concentration in shallow groundwater (<50 m) per section

Ground Water Observation Well Network (GOWN)

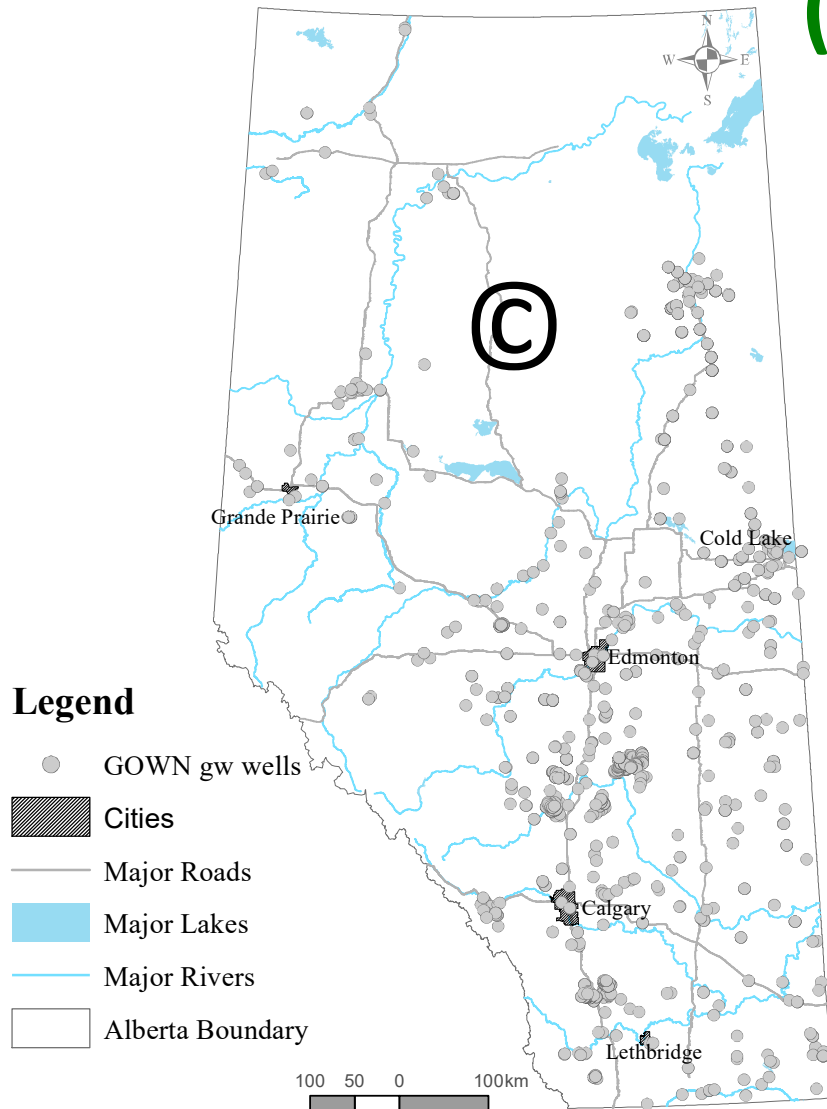


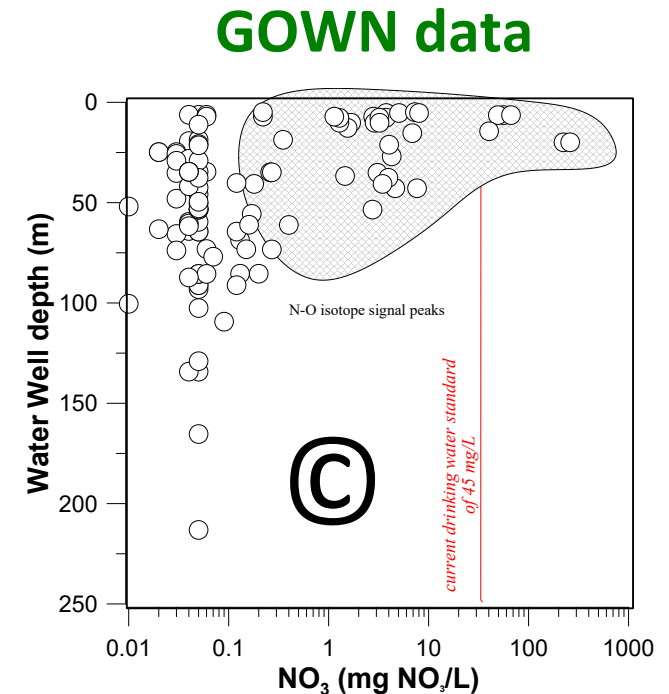
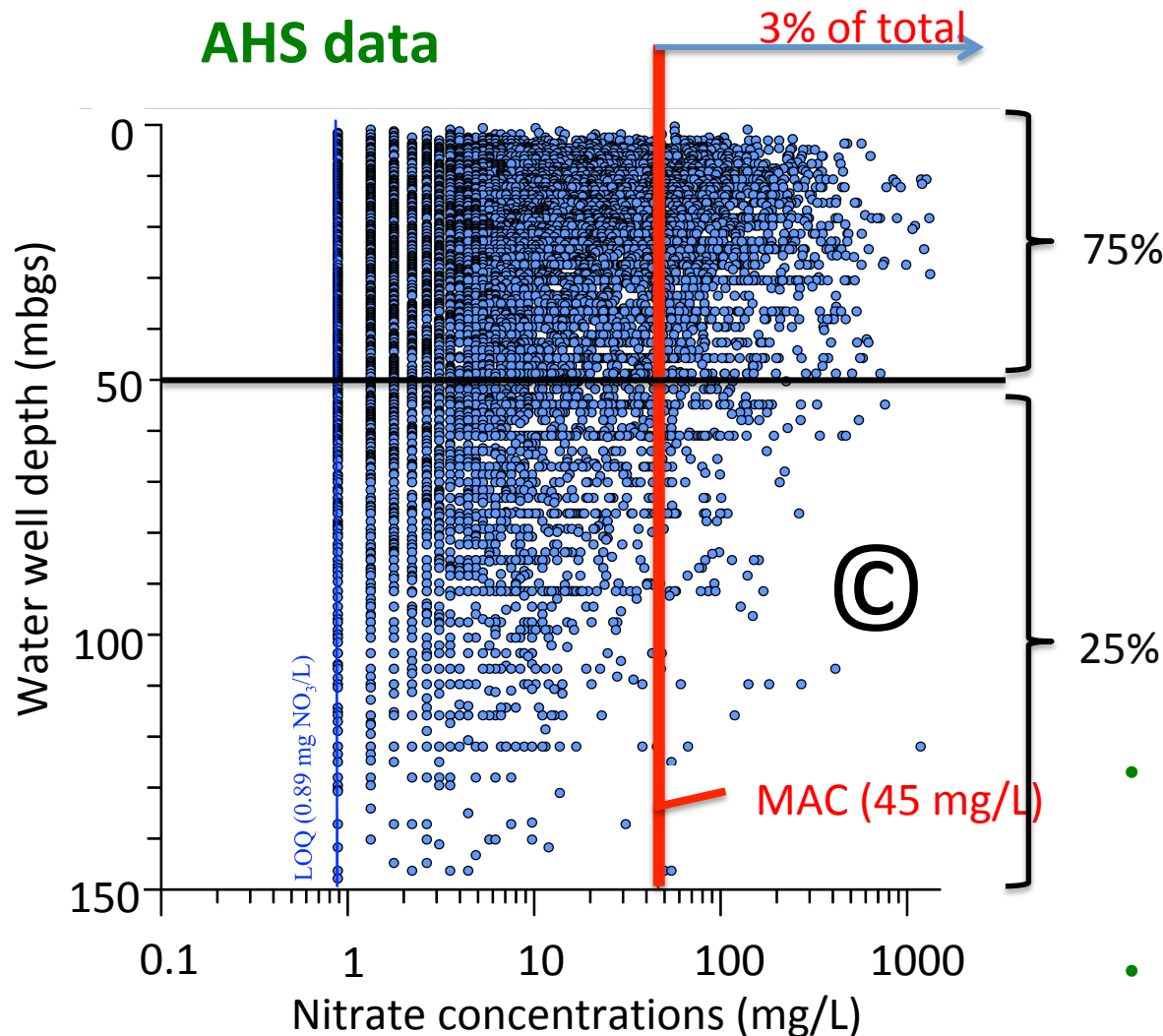
Figure: Map of Alberta with GOWN sampling sites.

- GOWN includes 340 active observation wells located mainly in the southern half of the province
- Wells completed in various shallow aquifers
- Groundwater samples obtained and analyzed for nitrate concentrations and isotope compositions, among others



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Nitrate concentrations versus well depth



- Elevated nitrate concentrations predominantly observed in shallow groundwater (<60 m)
- Nitrate contents low to negligible in groundwater > 100m

Figure: Nitrate concentrations in groundwater obtained from AHS (left) and GOWN wells (right) versus well depth



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Isotopic composition of nitrate

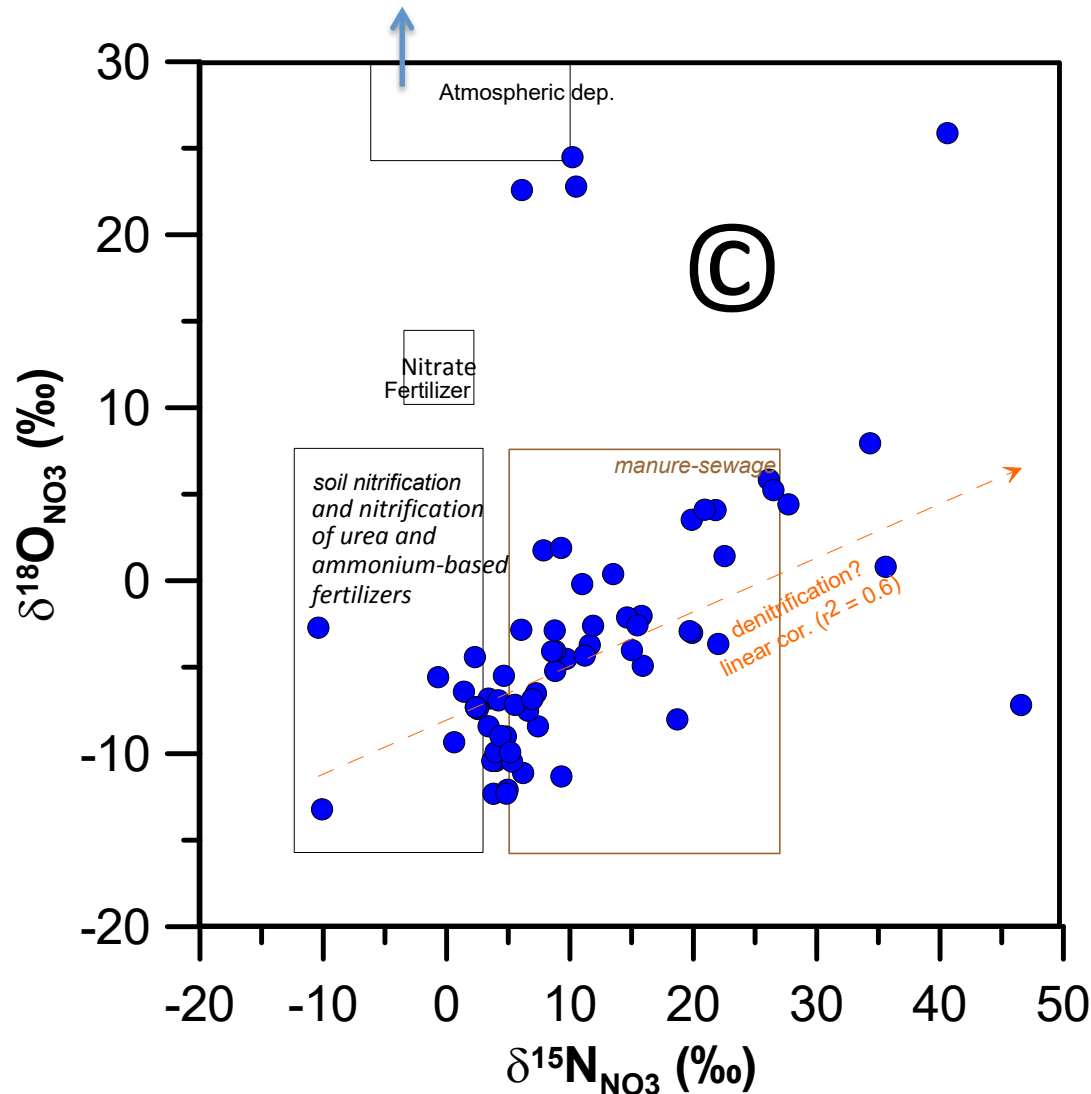


Figure: Isotopic composition of groundwater nitrate

- Isotope analyses reveal that nitrate is derived from nitrification of soil organic N and urea and NH_4 -based fertilizers and from manure.
- Increasing $\delta^{15}\text{N}$ and $\delta^{18}\text{O}$ values of NO_3^- indicate that some samples are affected by denitrification



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Potential for nitrate attenuation

- Analysis of aqueous geochemistry groundwater data was used to assess redox conditions in the respective aquifers;
- The majority of the aquifers are very reducing suggesting that nitrate would be rapidly denitrified

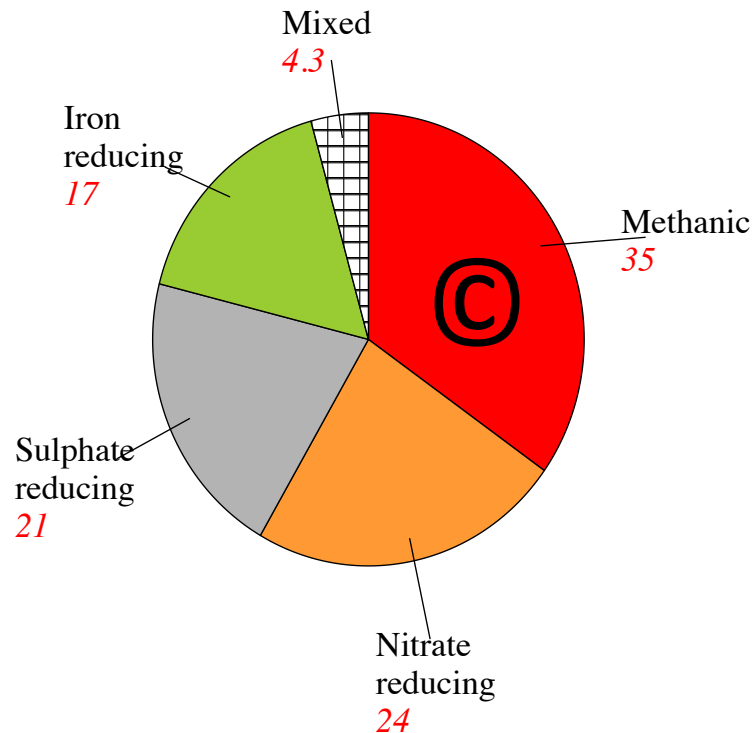


Figure: Assessment of redox conditions in Alberta groundwater

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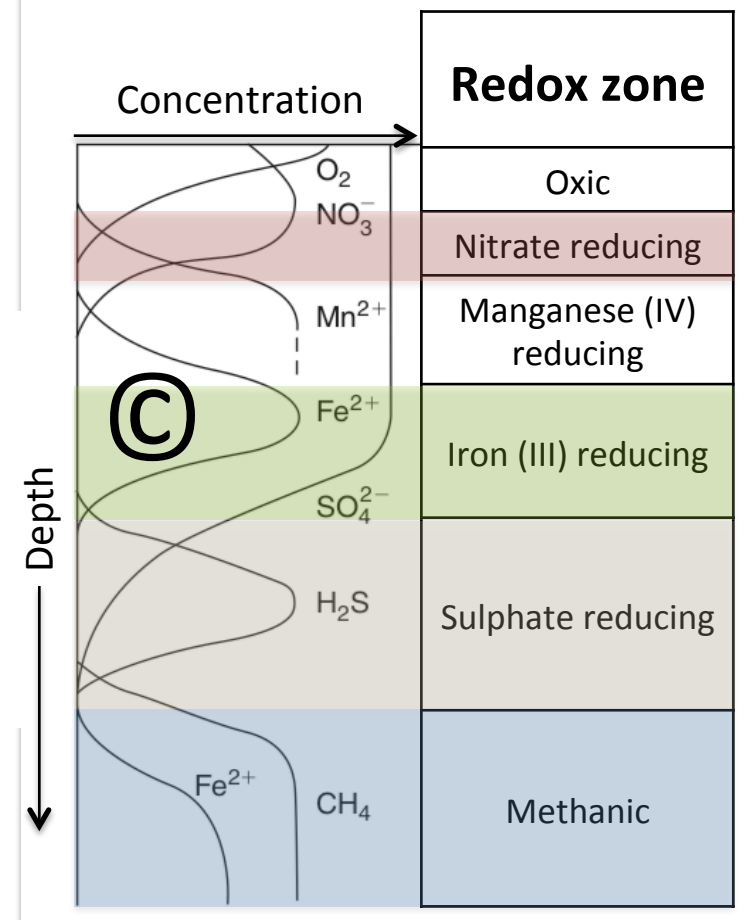


Figure: Classification of redox zones

Conclusions

- “Only” <34% of Alberta’s groundwater contains nitrate, and <4% of the groundwater samples exceed the MAC for nitrate;
- Nitrate is predominantly derived from nitrification of soil organic N and urea and NH_4 -based fertilizers and from manure;
- Nitrate is frequently undergoing denitrification according to stable isotope data;
- In many aquifers, groundwater is too reducing for nitrate to be stable and persist.



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