Williston Basin BaselineGroundwater Quality Assessment, 2013

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U.S. Department of the Interior
**U.S. Geological Survey**

Energy Development

- Domestic oil and gas production and clean water are critical for economic growth, public health, and national security of the United States

- The Bakken and Three Forks Formations have been rapidly increasing due the recent identification of significant oil and gas resources and technological advances
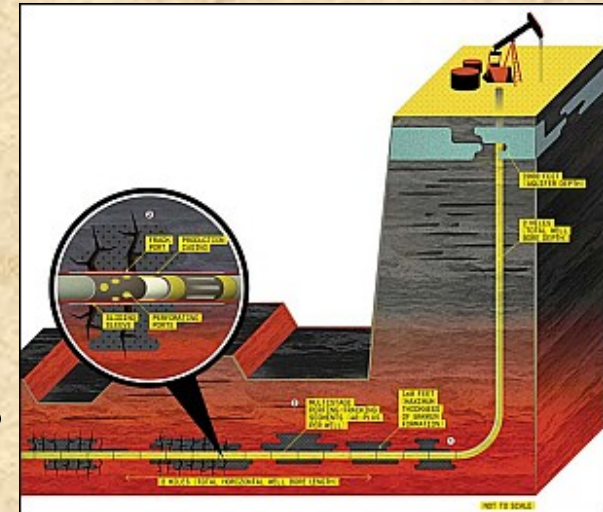
Questions

- ## What are the current conditions of the water resources in the area of energy development?
  - Groundwater
  - Surface water
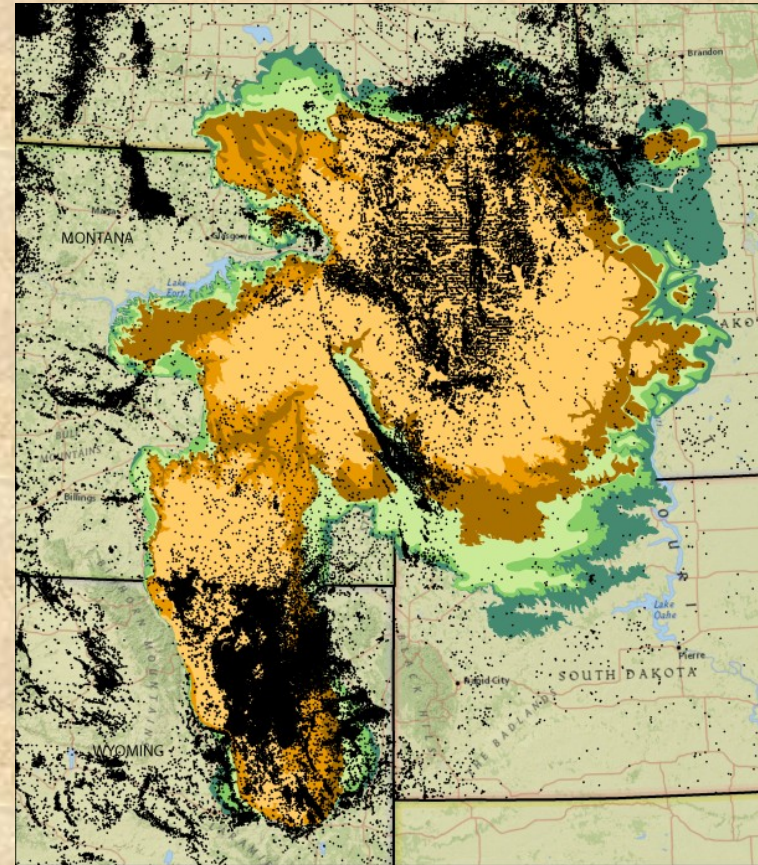
Oil and gas wells drilled through 2012
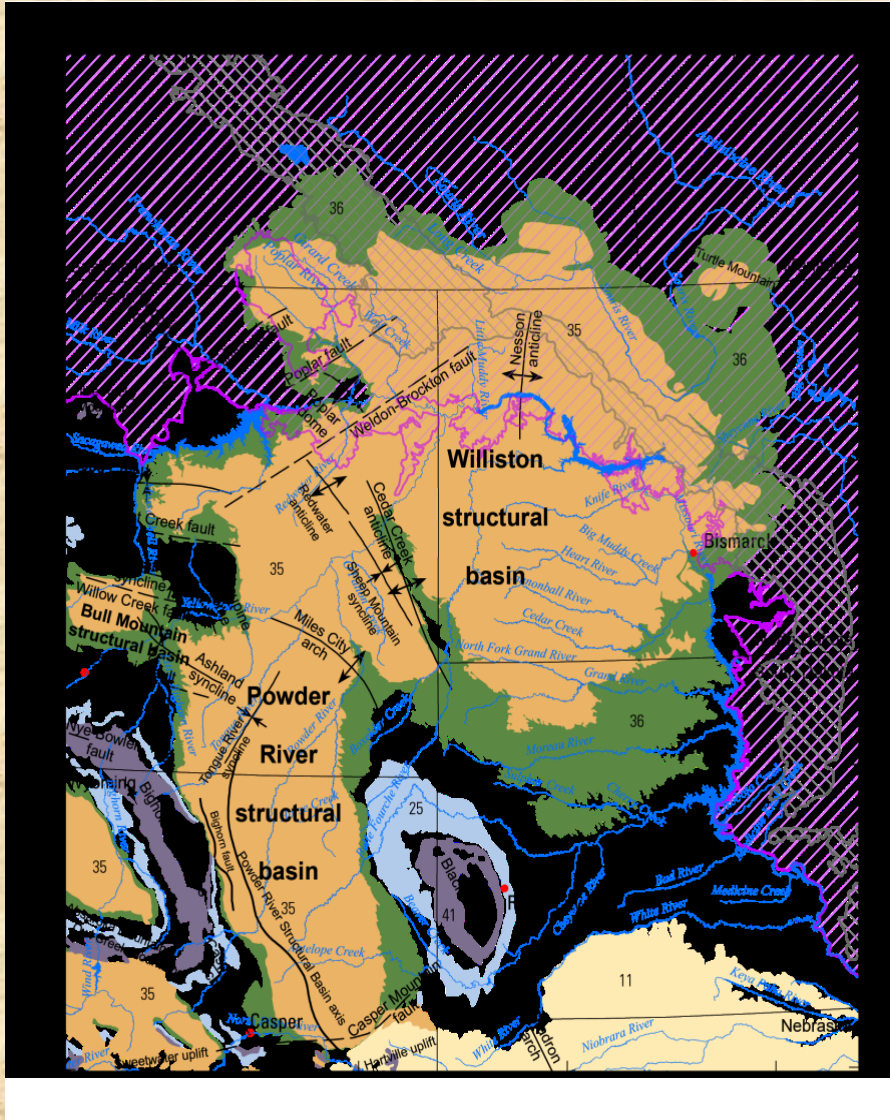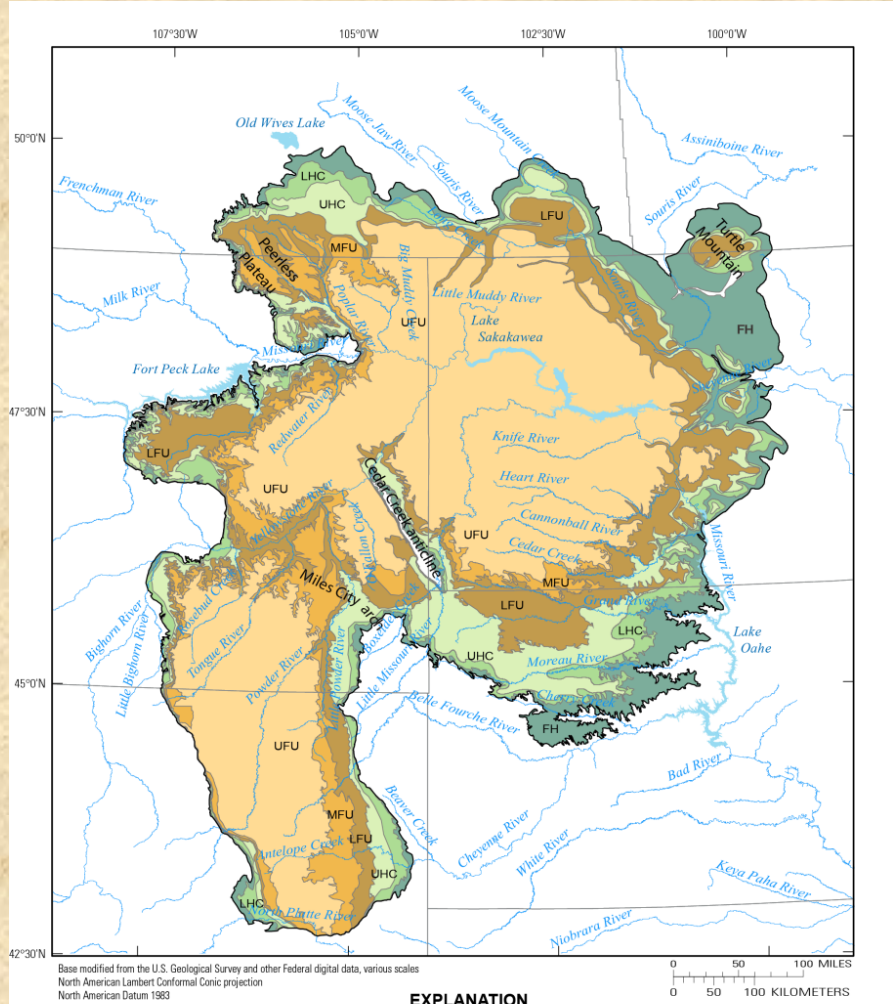(Wyoming is through 2010)

http://mt.water.usgs.gov/projects/WaPR/

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Study Objective

Characterize water-quality conditions of groundwater in the energy development area of Eastern MT and Western ND

Hydrogeology

http://mt.water.usgs.gov/projects/WaPR/

Figure 1-1. Precipitation, recharge from precipitation, and gaining and infiltrating stream reaches in the study area
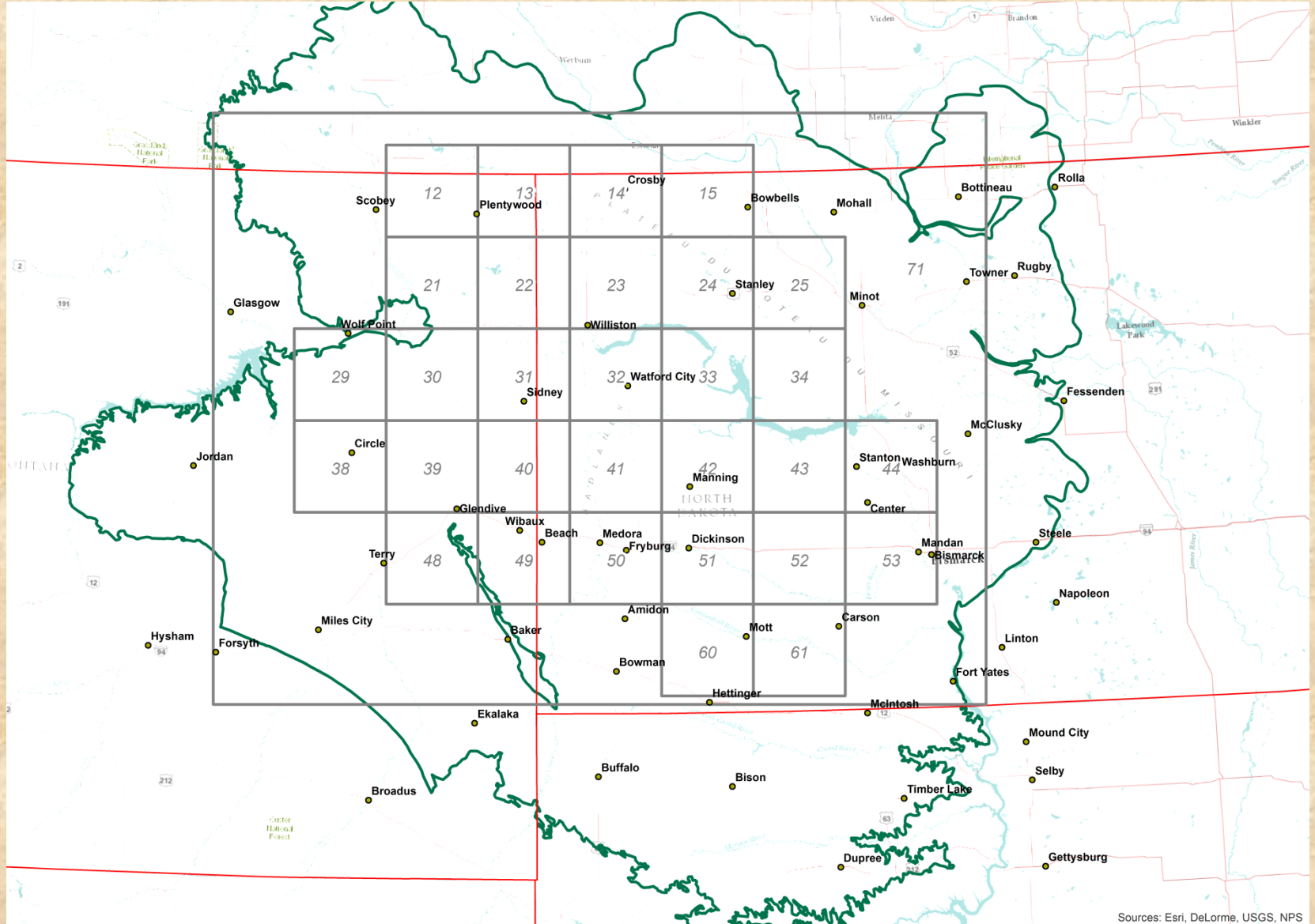
Well Selection

- Well data obtained from USGS, NDSWC, and MT databases

- 30 wells selected in Upper Fort Union Formation ("Primary" wells)

  – The Fort Union aquifer (lower Tertiary) is used more broadly for domestic and municipal supplies in comparison to aquifers within the upper Cretaceous units (Fox Hills).

  – Fewer unique water-quality constituents have been sampled from the Fort Union aquifer in comparison to those in the upper Cretaceous.

  – Potential exists for collaboration with cooperators in MT, ND, and SD due to planned sampling of wells in the Fox Hills or wells considered "high risk".

  – Current interest in better understanding the interaction of groundwater between glacial and bedrock aquifers, the shallowest of which is the Fort Union aquifer.

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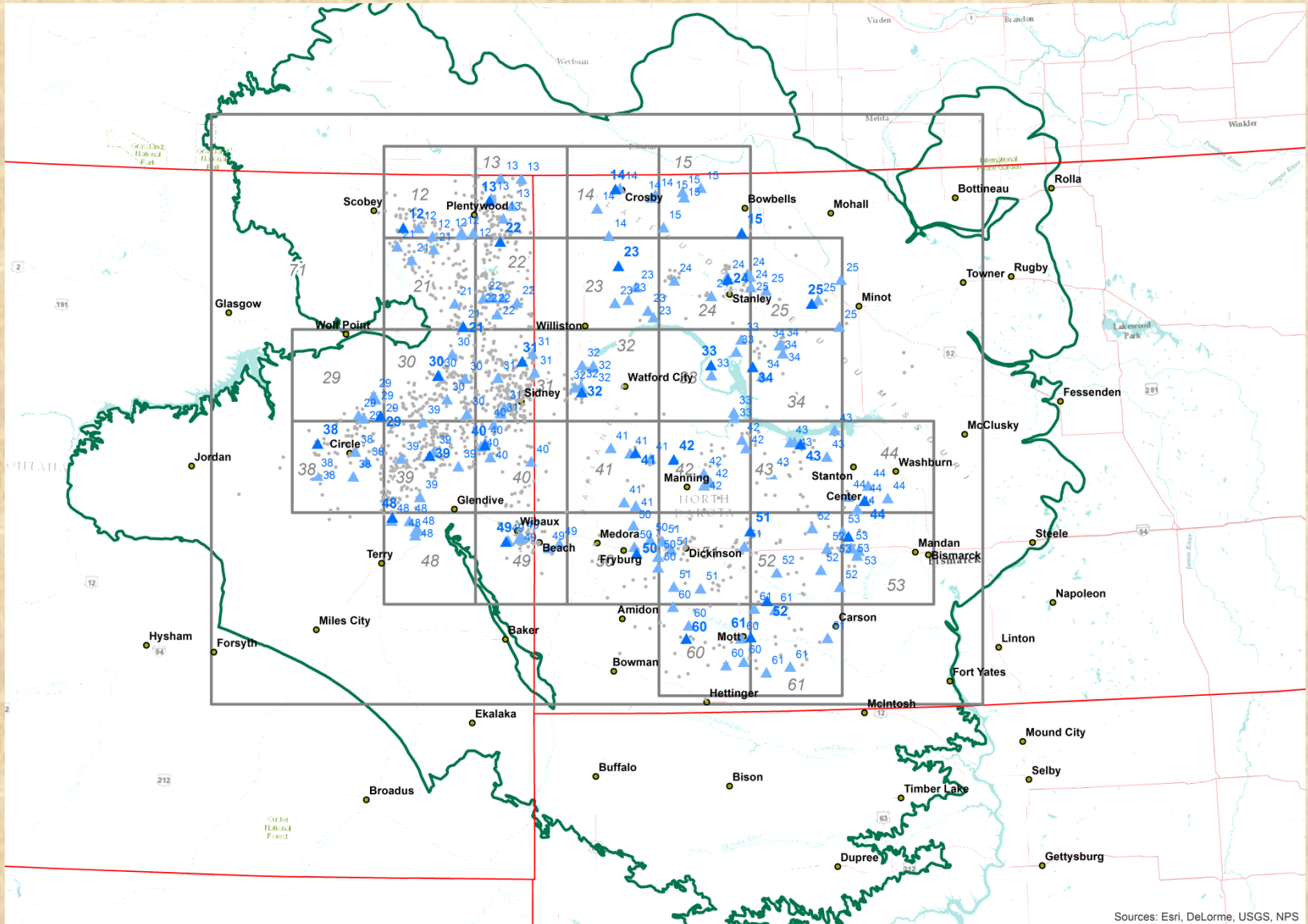# Selection of sampling sites
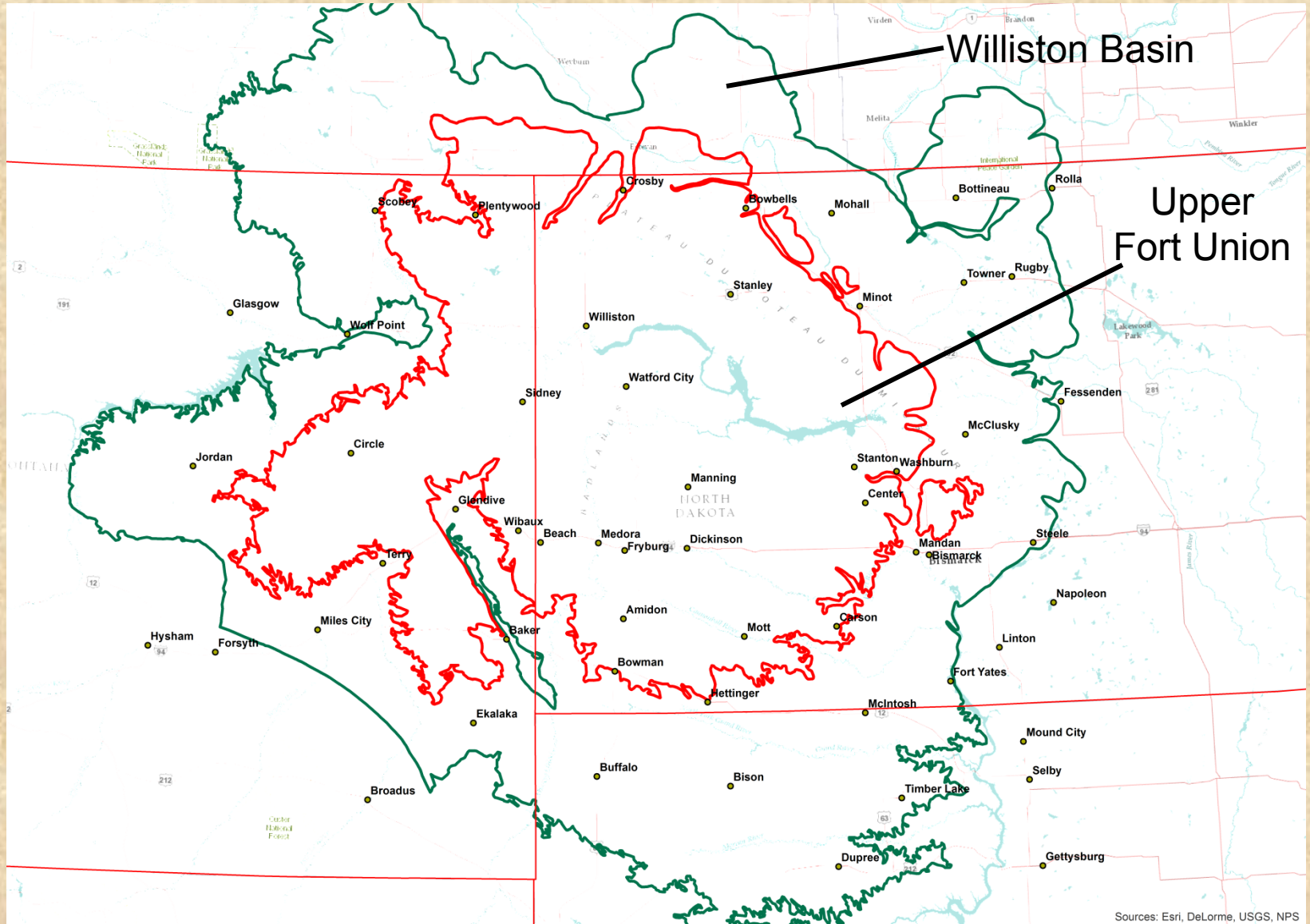
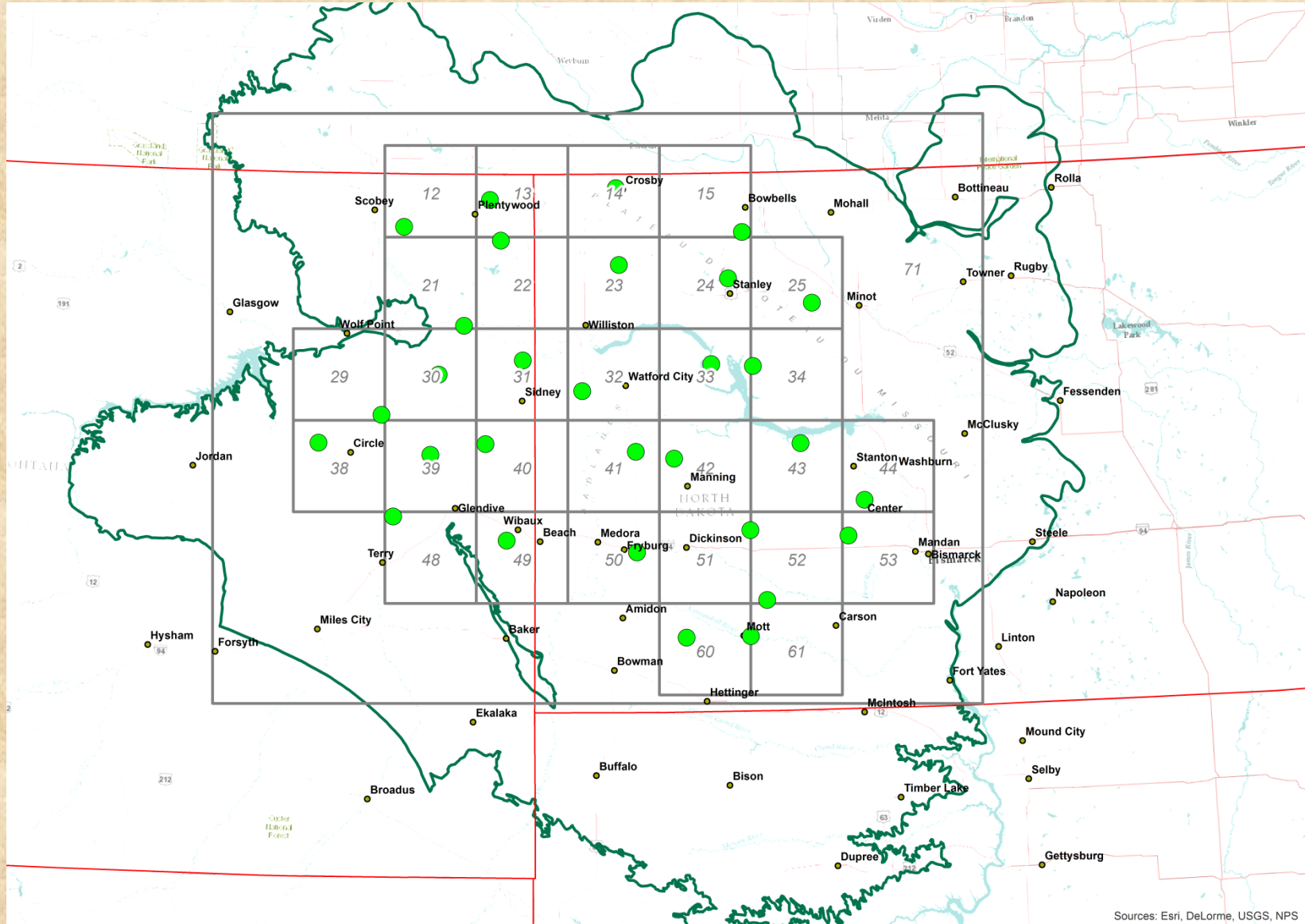# Selection of sampling sites

Sources: Esri, DeLorme, USGS, NPS

Selection of sampling sites

Selection of sampling sites

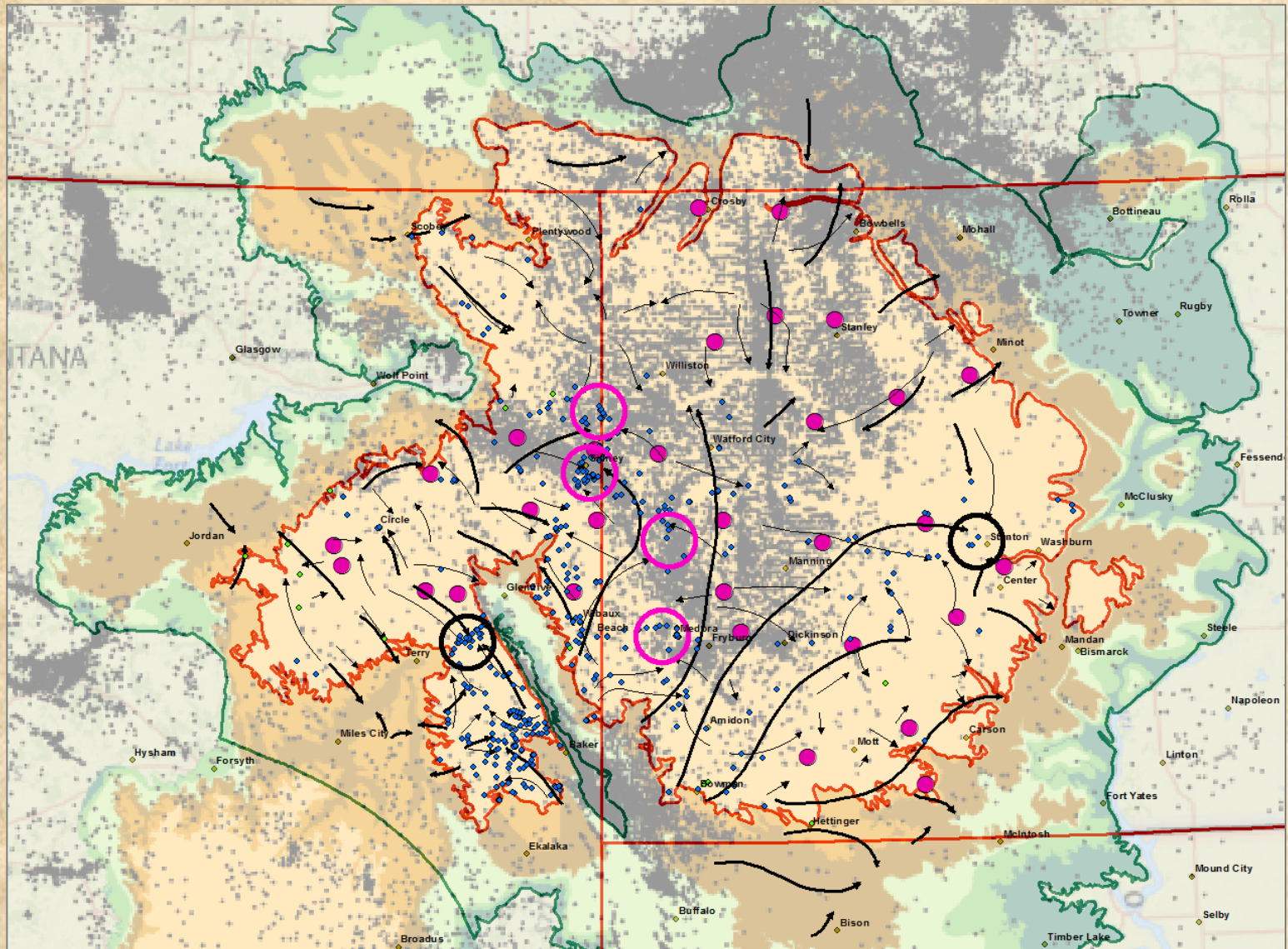Sources: Esri, DeLorme, USGS, NPS
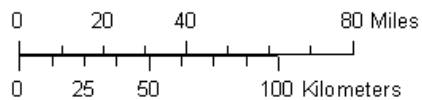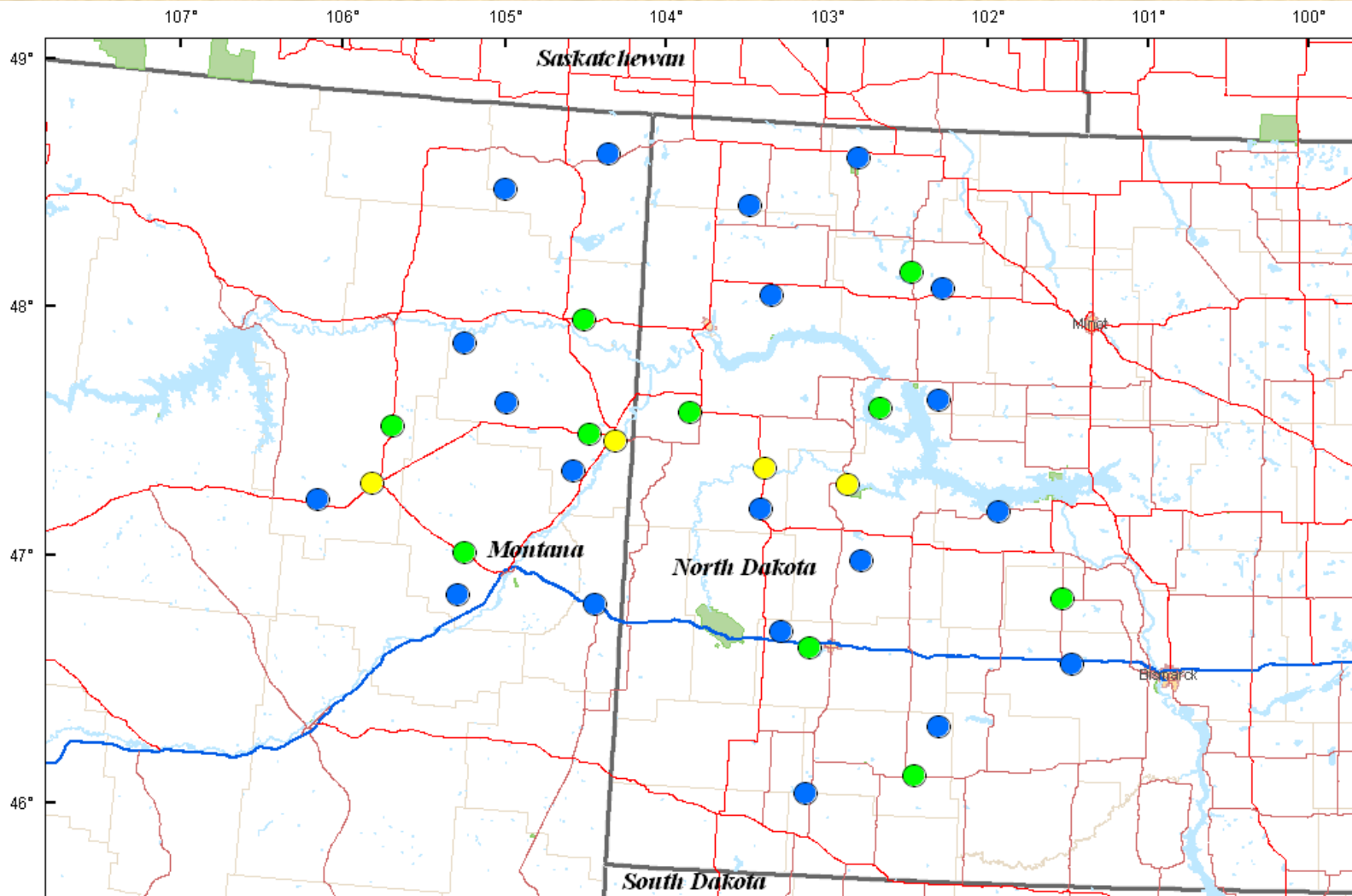
Well Selection - continued

- 4 additional wells selected in lower units- Fox Hills or Hell Creek Formation ("Understanding" wells)

    - 2 in relatively low energy development areas
    - 2 in relatively high energy development areas

- Domestic wells selected only

    – Less time for sampling

    – Less equipment

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Well Selection - continued

Well Selection - continued

Sampling Approach

- Used standard protocols outlined in USGS National Field Manual
  http://water.usgs.gov/owq/FieldManual/

- 30 primary wells and 4 understanding wells

Samples analyzed for:

  - Major ions – *USGS NWQL*

  - Trace elements– *USGS NWQL*

  - Nutrients– *USGS NWQL*

  - Volatile organic compounds (VOCs) (23 compounds) – *USGS NWQL*

  - Methane and Ethane - *Test America*

  - Hydrogen and carbon isotopes of hydrocarbon- *Isotech*

  - Hydrocarbon composition – *Isotech*

  - Field measurements –pH, SC, temperature, DO, turbidity, alkalinity, sulfide

USGS

Sampling Approach - continued

- 10 of the 30 primary wells ("intensive sites") selected for additional analyses - samples analyzed for:
    - Gasoline Range Organics (GRO) – Test America
    - Diesel Range Organics (DRO) – Test America
    - Dissolved organic carbon (DOC) – USGS NWQL
    - Isotopes:
        - Strontium 86/87 – USGS – Menlo Park
        - Carbon-14 – Woods Hole
        - Hydrogen and Oxygen – USGS Reston Stable Isotope Lab
        - Sulfur hexafluoride (SF6) – USGS Reston CFC Lab
        - Tritium – USGS Noble Gas Lab
    - Dissolved gases – USGS Reston CFC Lab
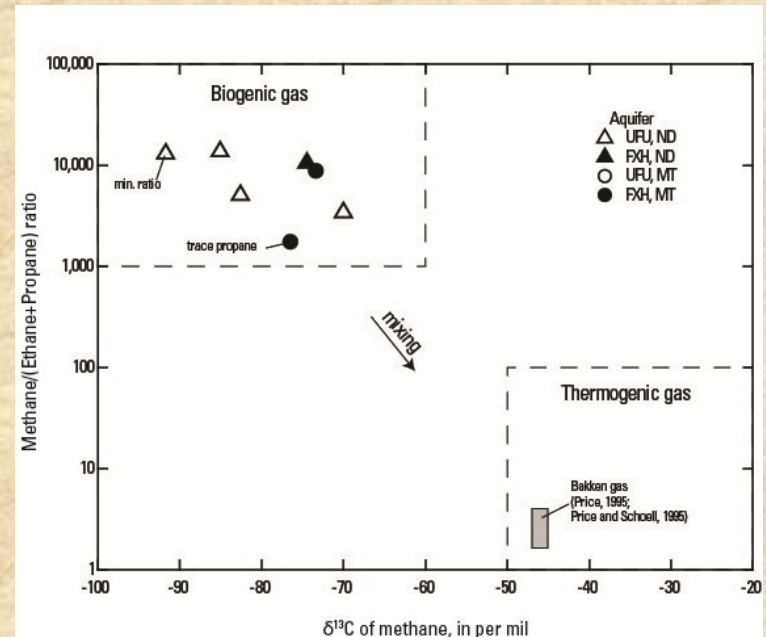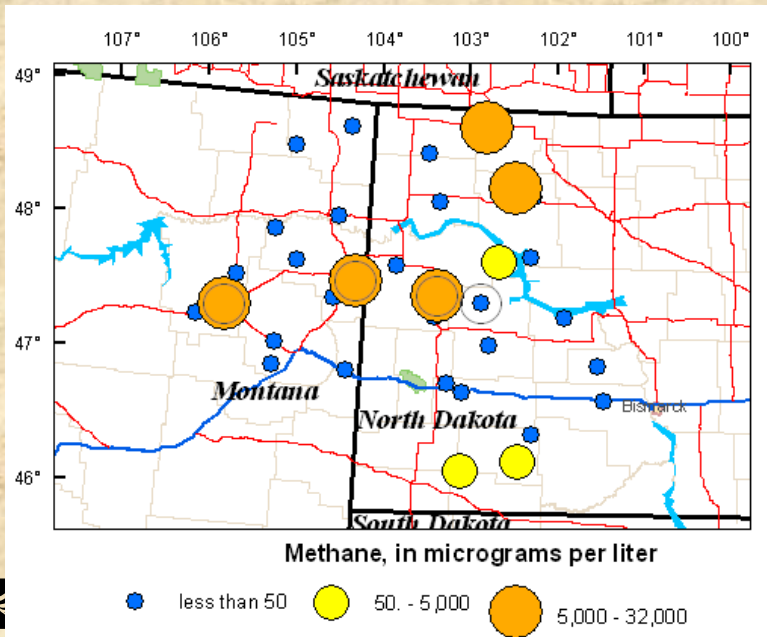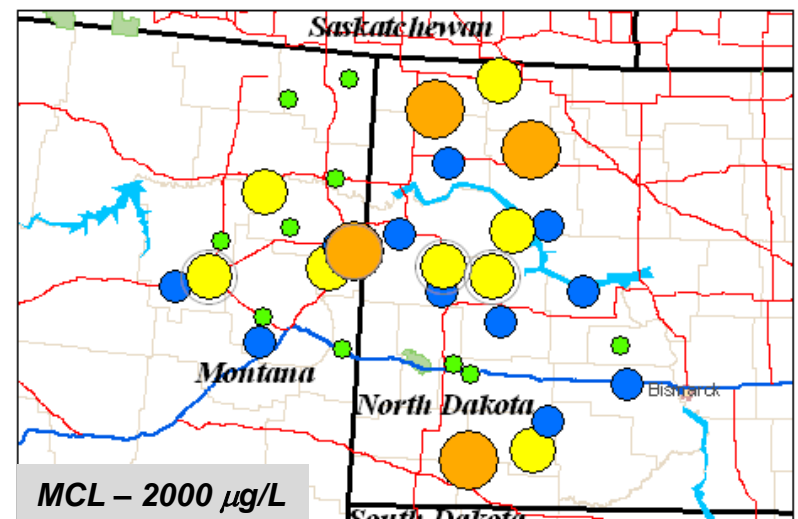   - Noble gases – USGS Noble Gas Lab

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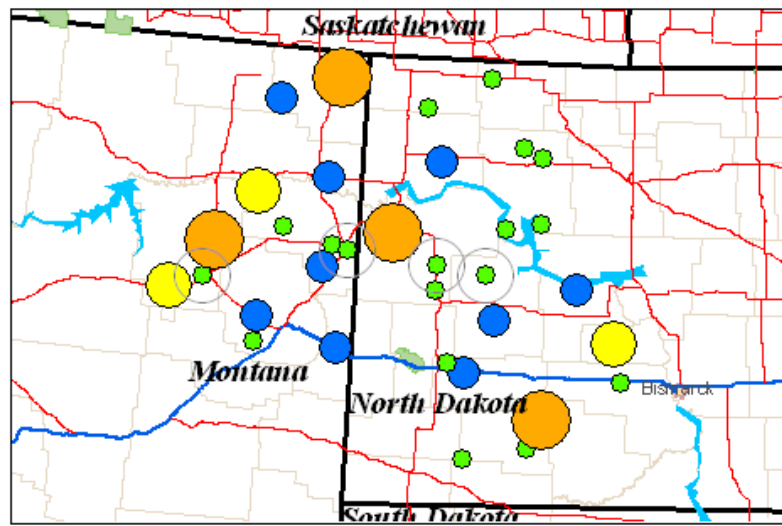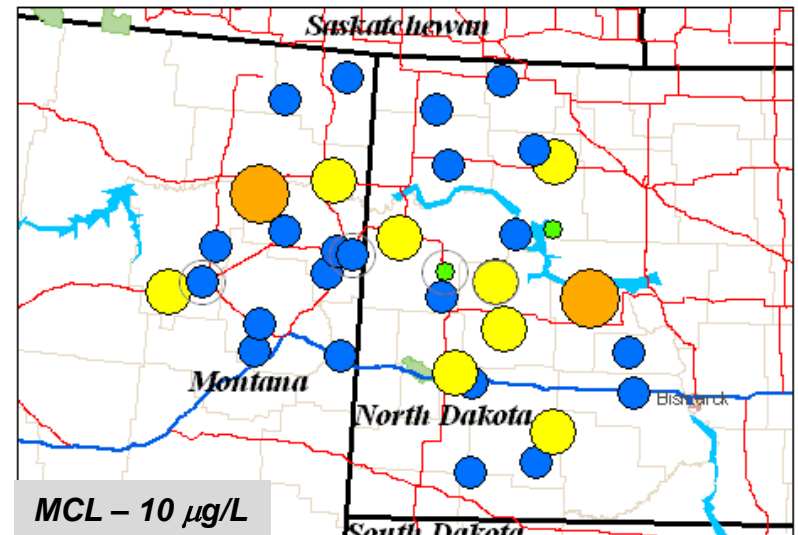
Preliminary Results

Results

- GRO and DRO
  - No values greater than reporting Limit (RL)
- VOCs
  - 1 detection of benzene -MT
  - 1 detection of toluene - MT
  - 1 detection of acetone – ND
  - All detections were only slightly above RL

Methane/Ethane

- 18 of 34 wells had detectable methane, 1 well had detectable ethane

- 7 samples had sufficient methane for isotopic analyses (>400 μg/L)
  - Isotopes indicated biogenic gas, or gas from local production in the aquifer
  - Thermogenic gas is what would be expected to be associated with Bakken oil and from deep hydrocarbon reservoirs

Iron, in micrograms per liter

less than 200 · 100 – 1,000 · 1,000 – 1,800 · 1,800 – 4,500

Arsenic, in micrograms per liter

MCL – 10 μg/L

less than 0.04 · 0.04 – 0.50 · 0.50 – 9.00 · 9.00 – 11.50

Manganese, in micrograms per liter

less than 20 · 20 – 150 · 150 – 300 · 300 – 1,100

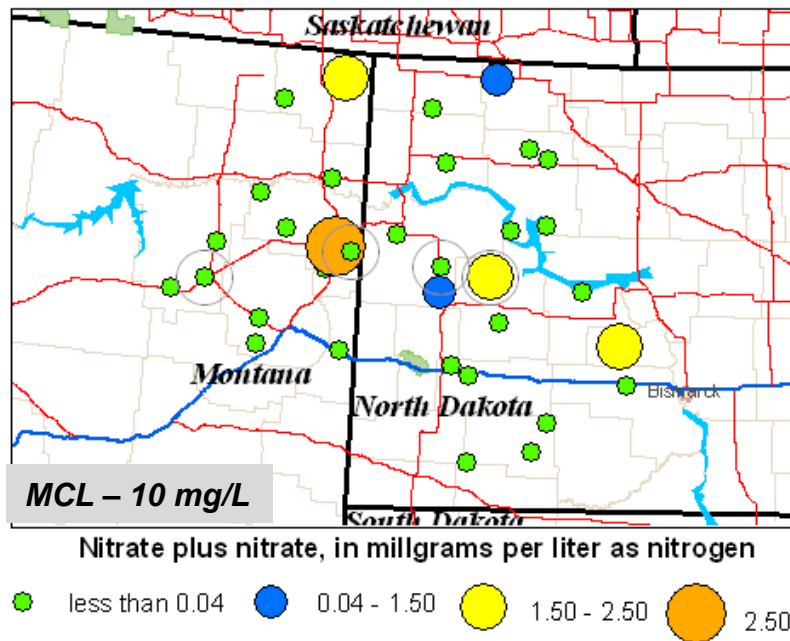Barium, in micrograms per liter

MCL – 2000 μg/L

less than 15 · 15 – 50 · 50 – 120 · 120 – 220

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Preliminary information, subject to revision

Total nitrogen, in milligrams per liter as nitrogen

● 0.28 - 0.50   🔵 0.50 - 1.00   🟡 1.00 - 2.50   🟠 2.50 - 7.00

Ammonia, in milligrams per liter as nitrogen

● 0.28 - 0.50   🔵 0.50 - 1.00   🟡 1.00 - 2.50   🟠 2.50 - 7.00

MCL – 10 mg/L

Nitrate plus nitrate, in milligrams per liter as nitrogen

● less than 0.04   🔵 0.04 - 1.50   🟡 1.50 - 2.50   🟠 2.50 - 6.50

Orthophosphorus, in milligrams per liter as phosphorus

● less than 0.04   🔵 0.04 - 0.15   🟡 0.15 - 0.30   🟠 0.30 - 0.64

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Preliminary information, subject to revision

Total dissolved solids, in milligrams per liter

less than 800 | 800 - 1500 | 1500 - 2500 | 2500 - 3600

Sulfate, in milligrams per liter

less than 100 | 100 - 500 | 500 - 1,000 | 1,000 - 1,900
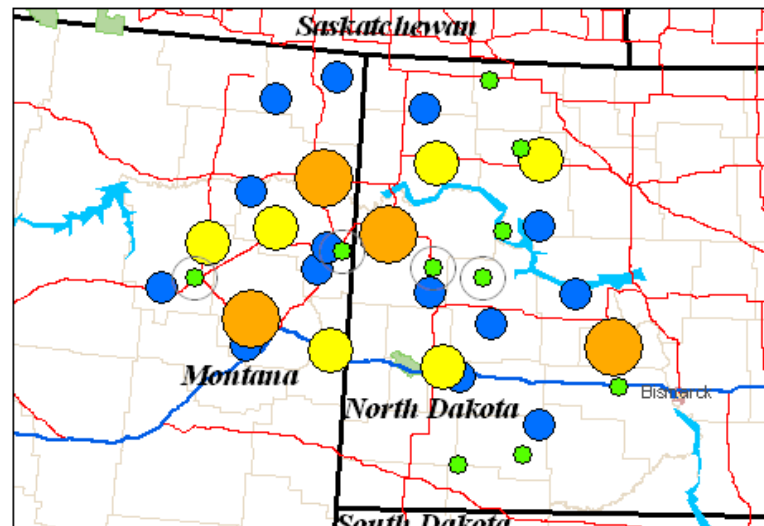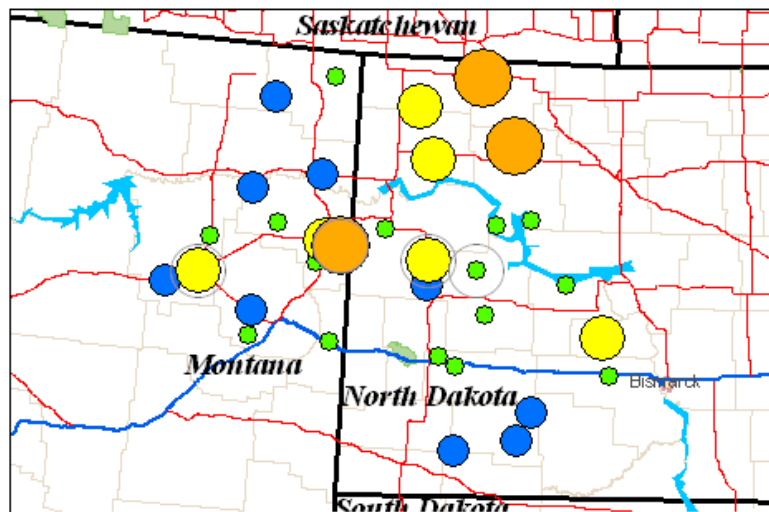
Chloride, in milligrams per liter

less than 10 | 10 - 25 | 25 - 100 | 100 - 166

Boron, in micrograms per liter

60 - 200 | 200 - 500 | 500 - 1,000 | 1,000 - 1,500

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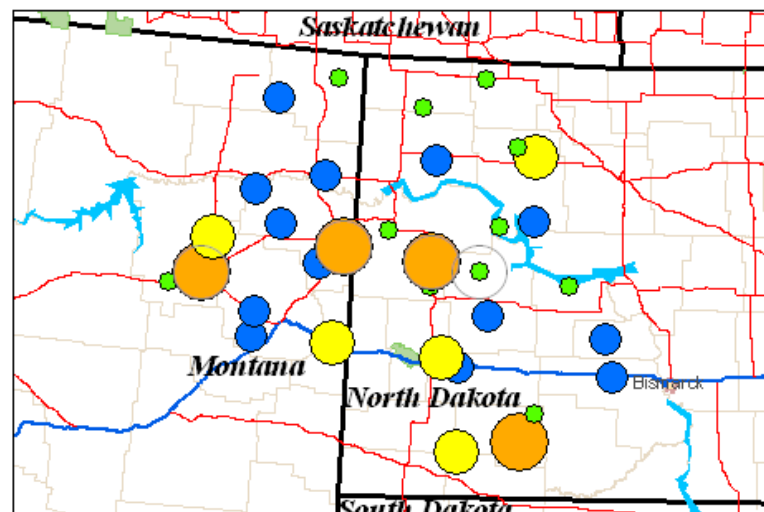
Next Steps

- Data Analysis
  - How the data compare to previously collected data or other studies
  - Analyze dissolved gas/isotope data
  - Where do we go from here?
    - Collect data on other Aquifers? - Glacial units?
    - Develop collaborations with other agencies, industry, other scientists to address GW issues in energy development area
    - Use techniques in other energy development areas

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ANY QUESTIONS?

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