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Natural Resources in the Williston Basin, What Do We Know?

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Dickinson, ND
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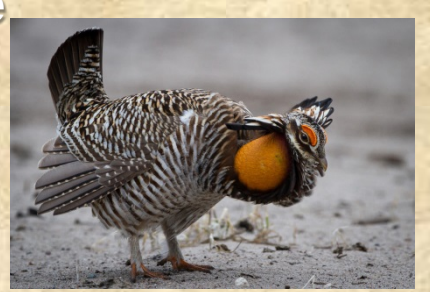
U.S. Department of the Interior
U.S. Geological Survey

Natural Resources



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Importance of Understanding Natural Resources

- Resource management
  - Permitting
  - Environmental and wildlife preservation
  - Sustainability of resources – for example, water supply, wildlife habitat
- Rapid energy development presented many resource management challenges to Federal, state, and local agencies

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Executive Order 13604- *Improving Performance of Federal Permitting and Review of Infrastructure Projects March 22, 2012*

- Improve the timeliness of permitting
- Determine reasonable measures to maximize environmental and community outcomes
- Bakken Federal Executive Group (BFEG)

US Army Corps of Engineers®

Bakken Federal Executive Group (BFEG)

- Initiated MOU to formally establish the group –June 2014
- Focused on EO 13604, Improving Performance of Federal Permitting and Review of Infrastructure Projects
- ***Recognized the need for a regional scientific report focusing on baseline status and trends in the Bakken region***

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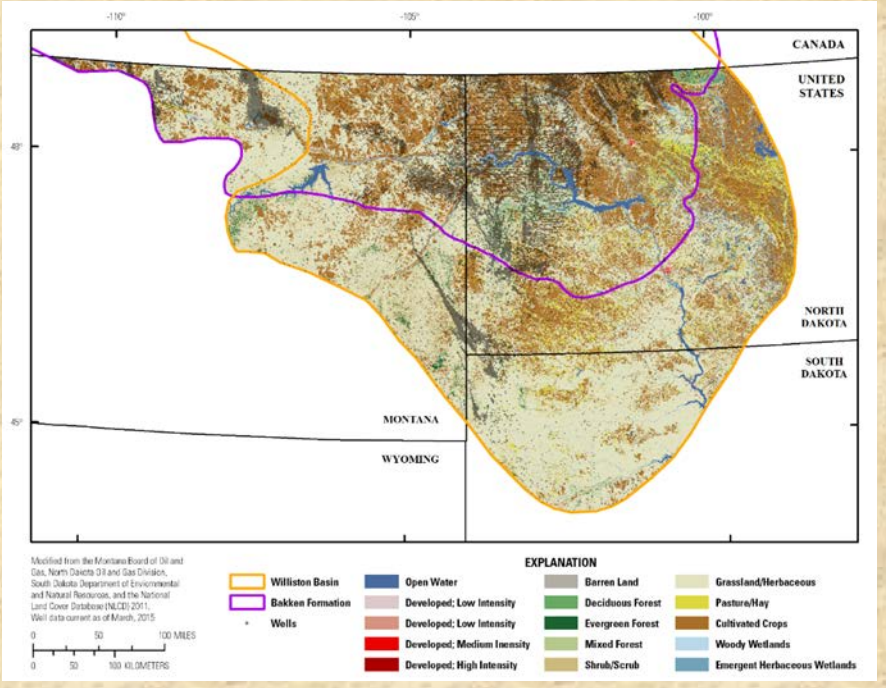
Bakken Environmental Status and Trends (BEST) Report

- Synthesize existing information
- Identify critical information gaps
- Provide easy access to critical data layers



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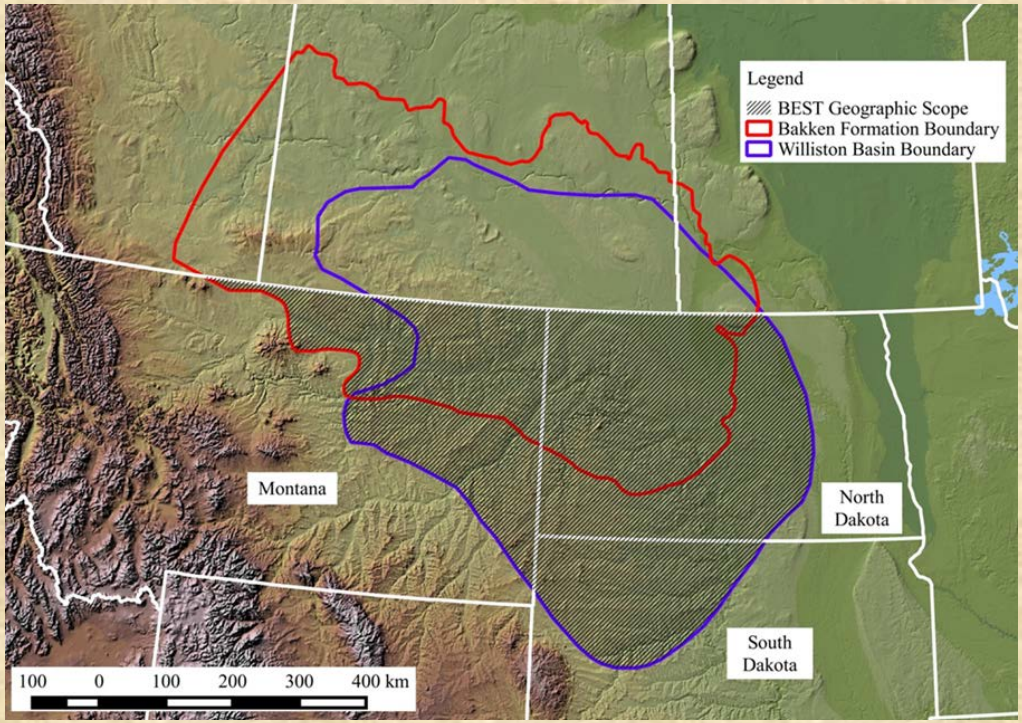
NATIONAL SYSTEM OF PUBLIC LANDS
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Structure of the BEST Report

- Chapter A: Executive Summary
- Chapter B: **General background**
- Chapter C: **Water Resources**
- Chapter D: **Biological Resources**



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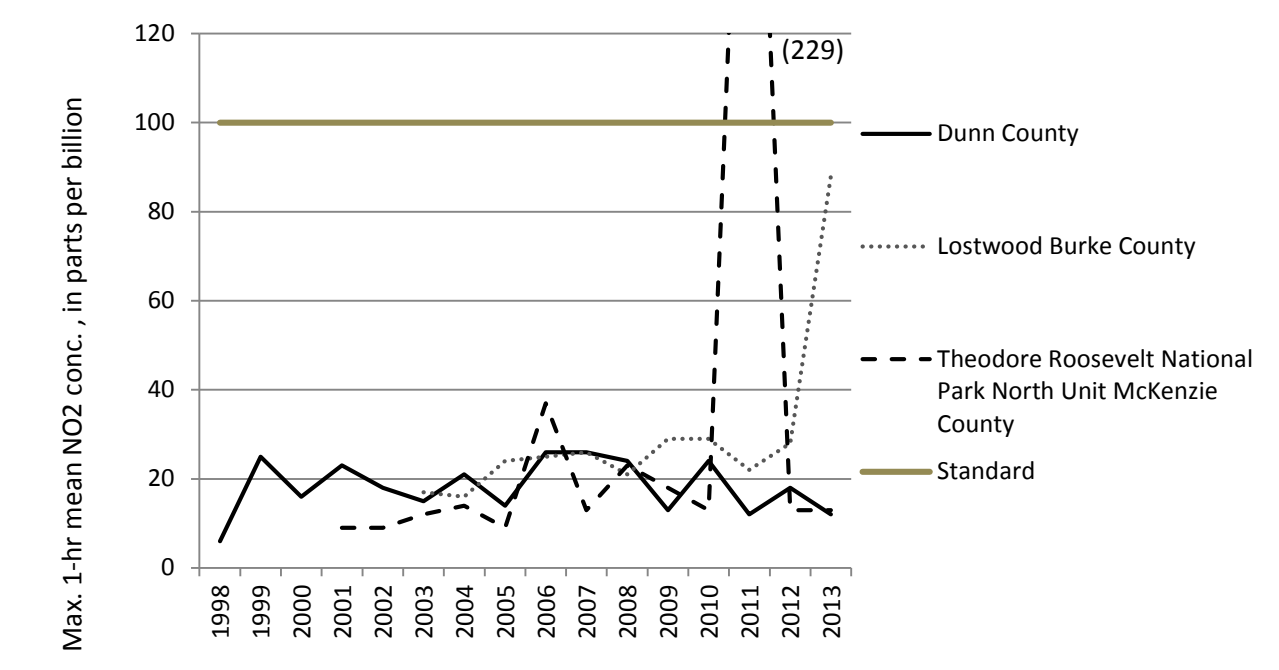
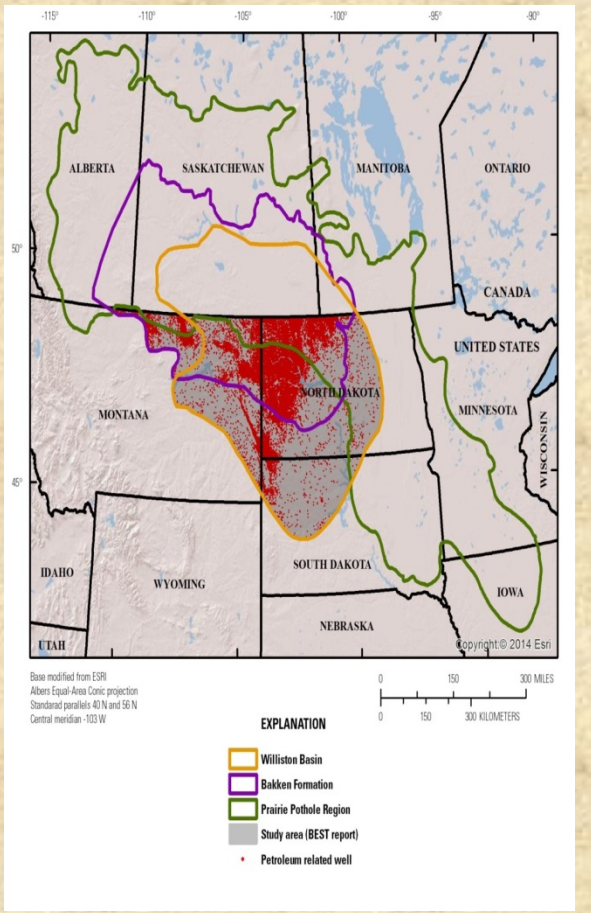
Chapter B: *Physiography, Climate, Land Use, and Demographics of the Williston Basin Energy Development Area*

This chapter provides a brief compilation of information regarding the natural setting, history of energy development, demographics, air quality data, and related studies in the Williston Basin area of North Dakota, Montana, and South Dakota.





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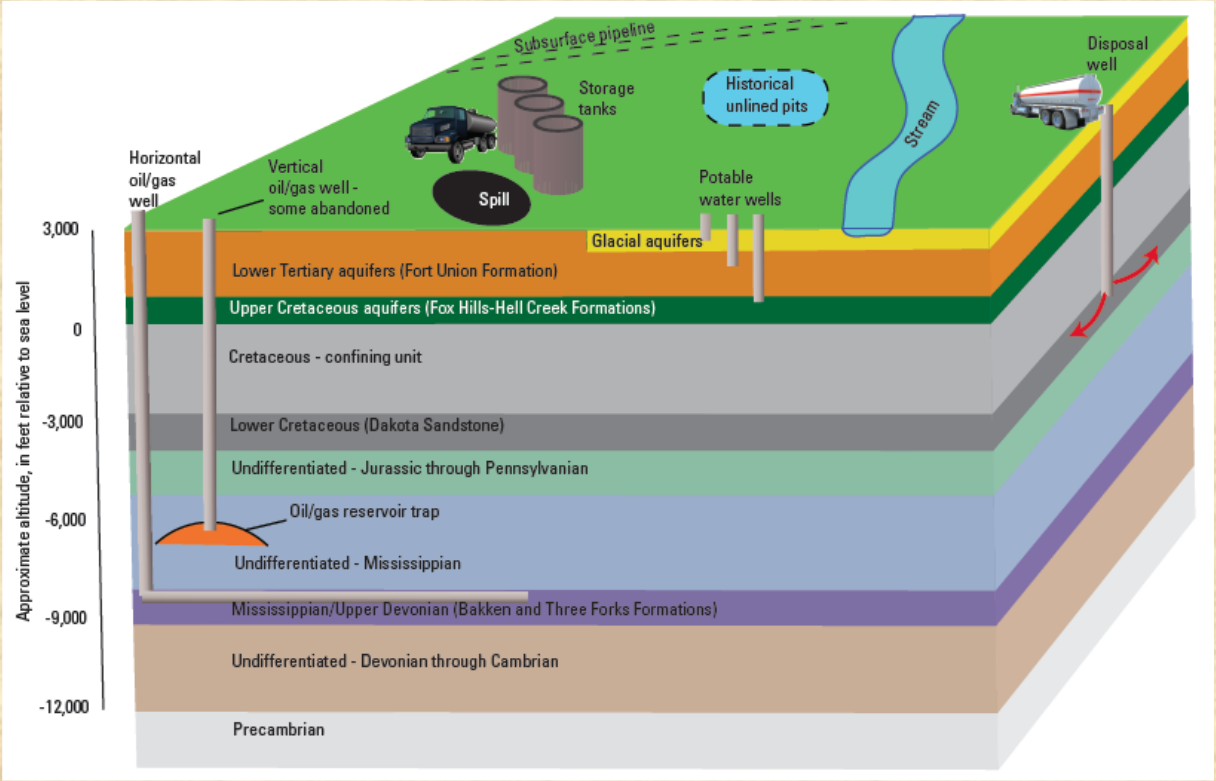
Chapter C: *Water Resources of the Energy Development Area of the Williston Basin*

Outline

- **Groundwater**
- **Rivers and Streams**
- **Lakes and Wetlands**
- **Quality of Water Resources**
  - Groundwater
  - Rivers and streams
  - Lakes and reservoirs
- **Produced Water**
- **Water use**



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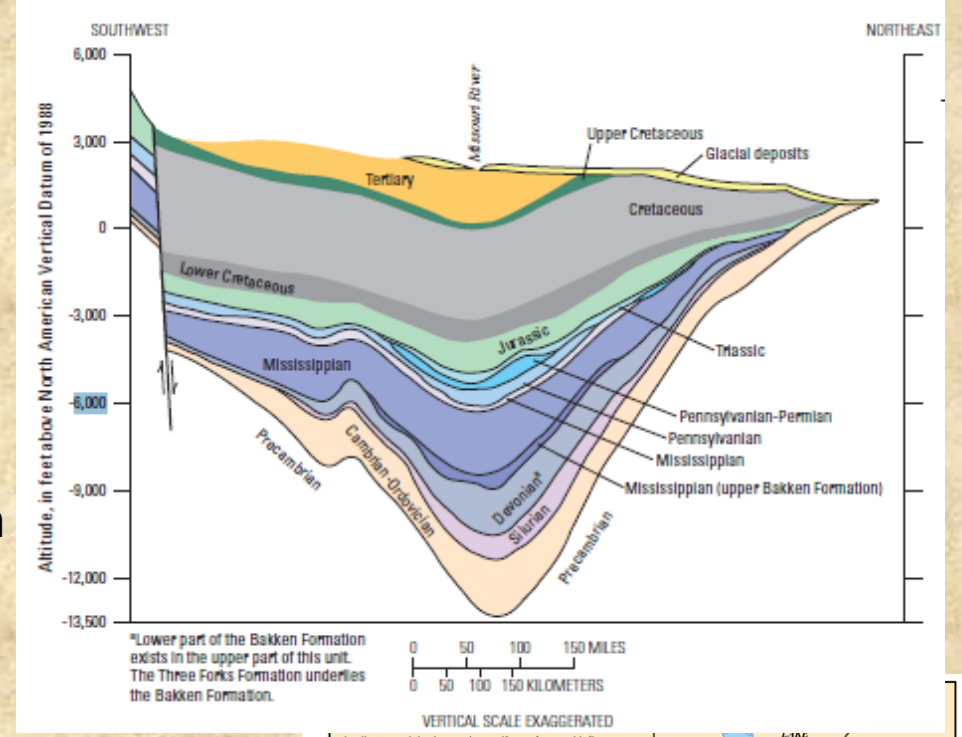
Groundwater

- **Summarized of data from major hydrogeologic units**
  - Glacial Aquifer
  - Lower Tertiary Aquifer
  - Upper Cretaceous Aquifer
  - **Provided detailed information on other hydrogeologic (deeper) units**
- **Major Findings:**
  - **Identified aquifers with useable water**
  - **Identified aquifers that may be used as reservoirs for injection and sources of minerals and energy resources**
  - **Provided generalized groundwater budget and flow system for each unit**



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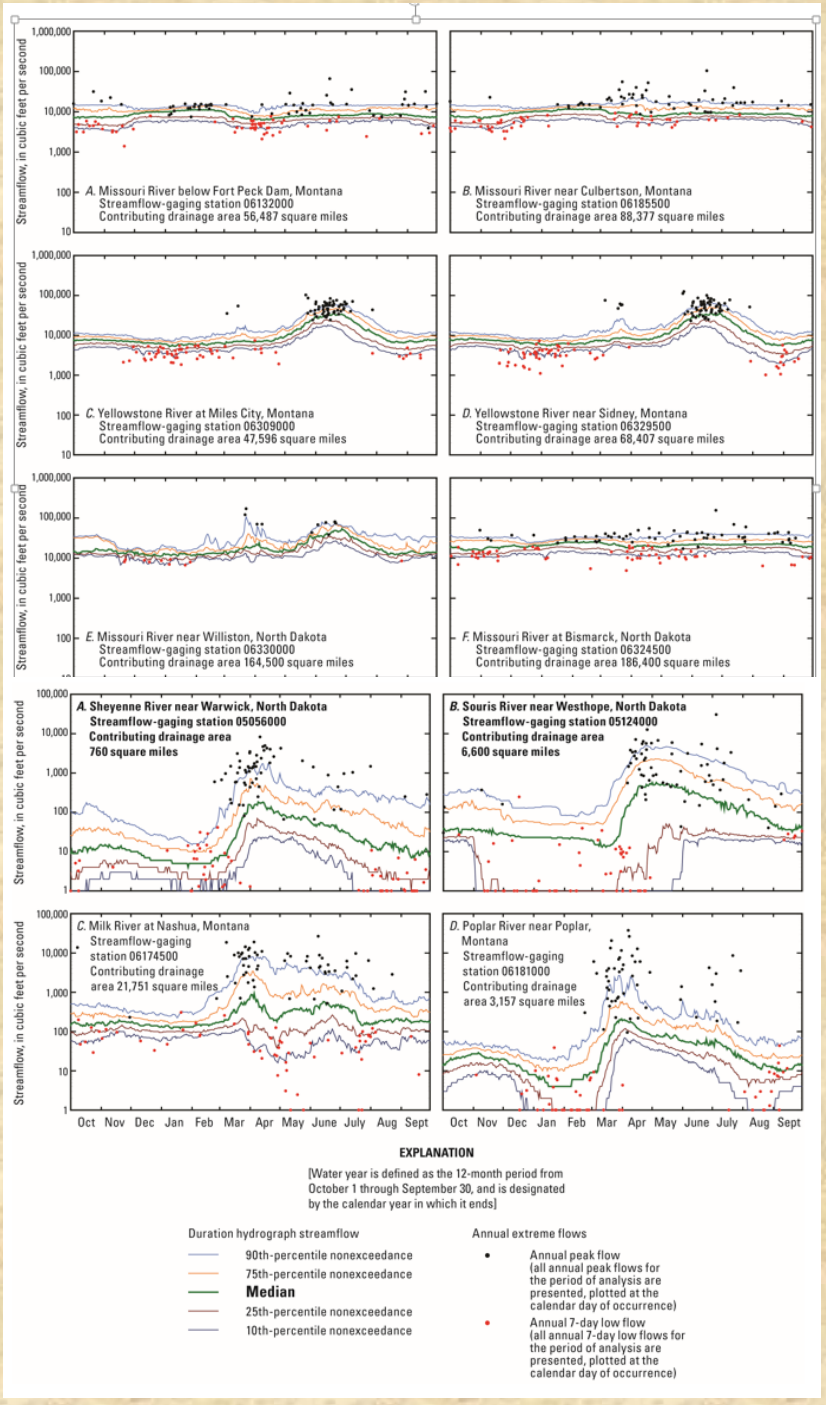
Streams and Rivers

- **Summarized available streamflow data**

- **Streamflow characteristics**
  - Subset of representative sites
  - Monthly and annual characteristics
  - Daily streamflow and extreme flows (peak and low flow)



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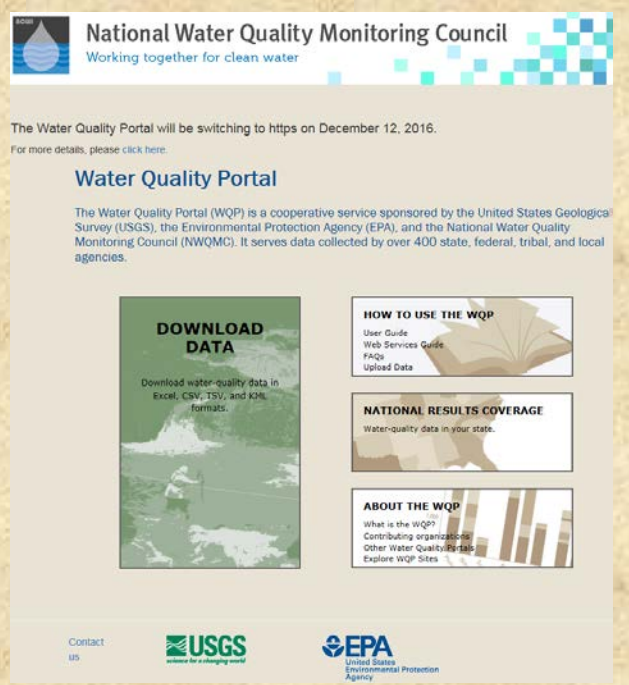
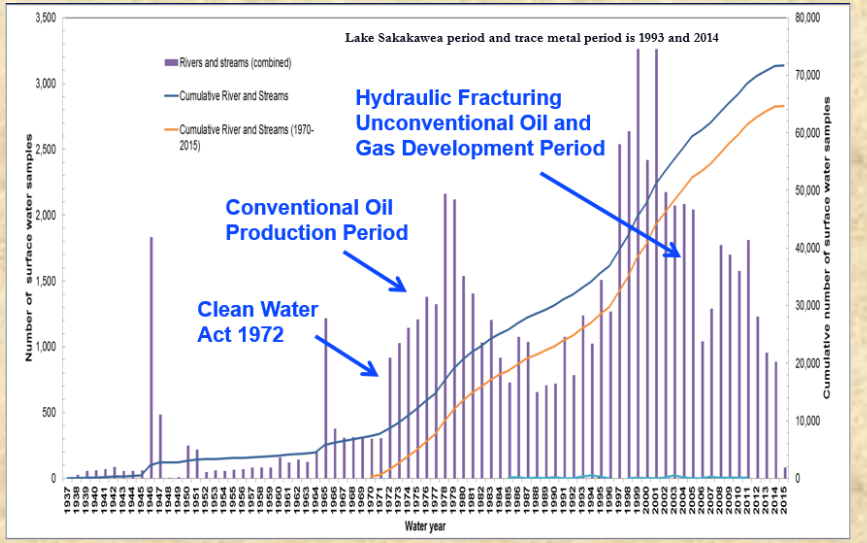
Quality of Water

- **Summary of data**

  Data aggregation/consolidation

  - **Development of dataset**
    - Water-Quality Portal (WQP)
    - USGS National Water Quality Assessment (NAWQA) Western States Data Aggregation (2012-13)
  - **Characterization of water quality**
    - Five most commonly measured constituents in GW and SW: Specific conductance, Total dissolved solids, pH, Sulfate, and Chloride
    - Ten trace metals “common” in produced waters: aluminum, arsenic, barium, chromium, copper, iron, lead, selenium, strontium, zinc
    - Numerous selection criteria
  - **Consolidated datasets included in data release**





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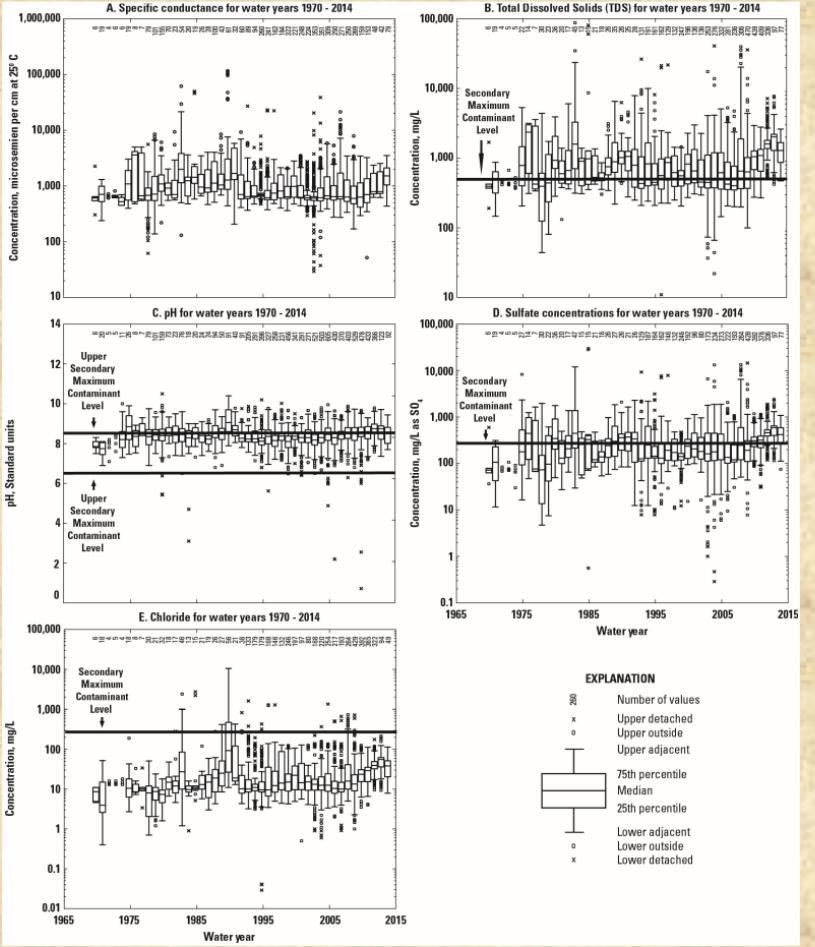
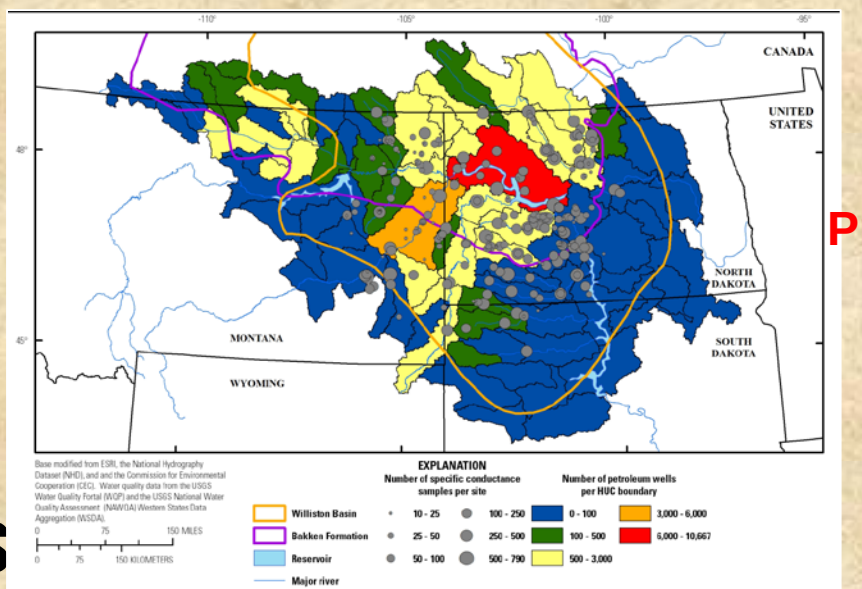
Quality of Water

- **Major Findings:**
  - Large ranges were observed for all constituents
  - The large range in values also may be attributed to the large number of independent studies conducted for various reasons
  - Frequently historical sampling was not conducted in areas with increased energy development
  - Datasets will serve as good baseline for designing future monitoring programs





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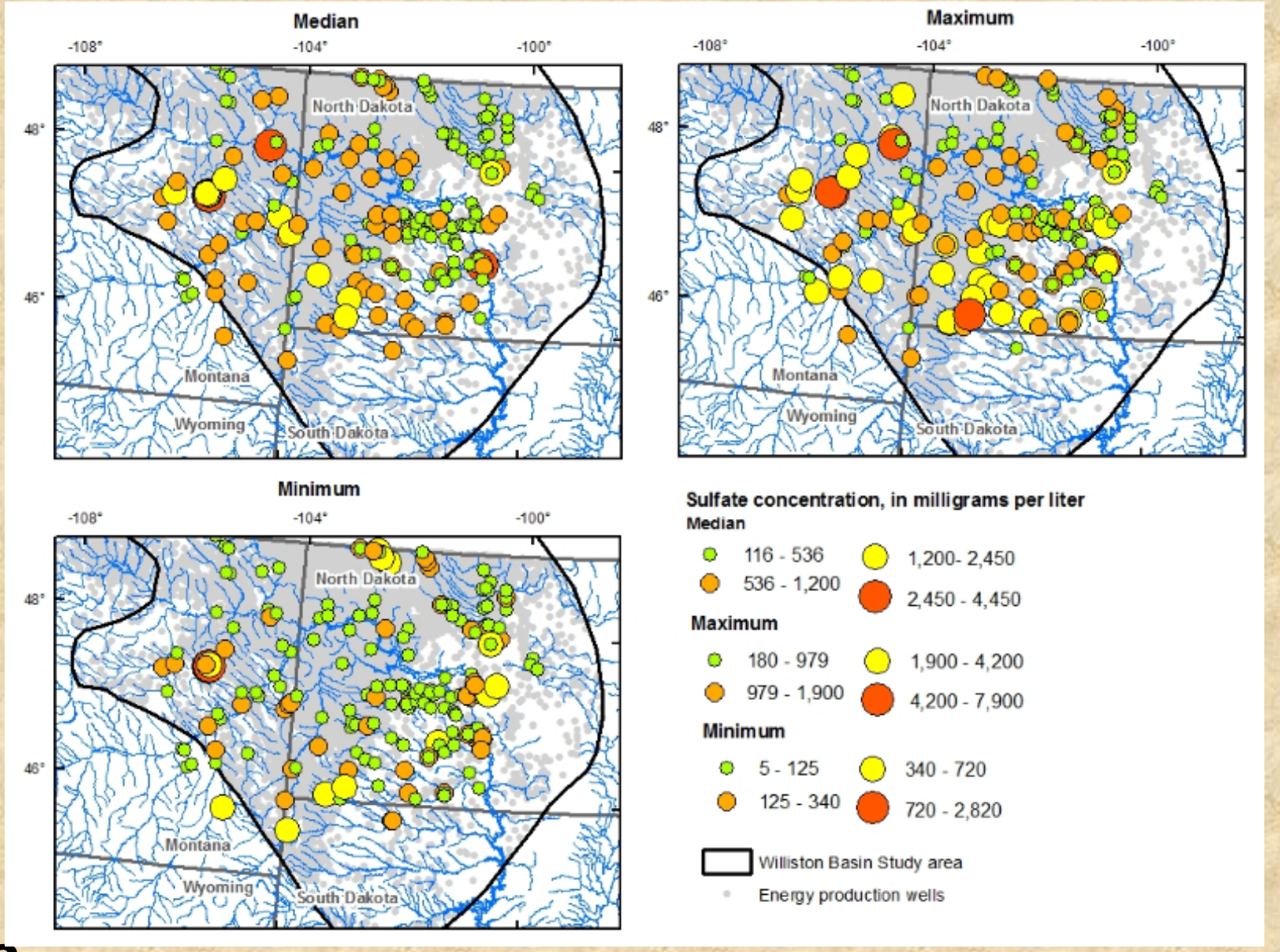
Quality of Water – *Sulfate in streams*



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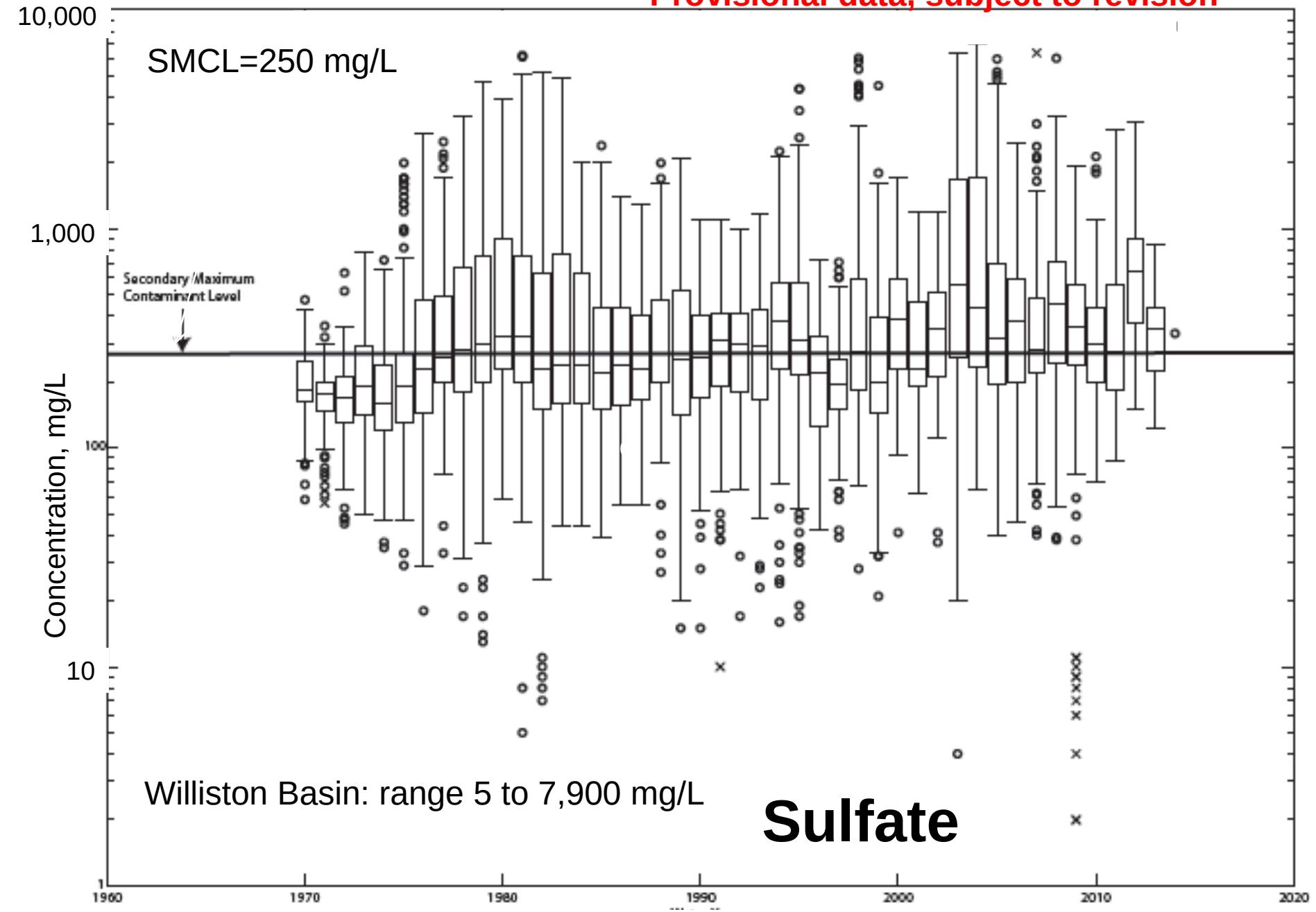

Williston Basin: range 5 to 7,900 mg/L

Sulfate

Produced Water

- **Summarized produced water datasets**
  - Geochemical database
  - Produced waters data 2010 – 2014
  - **General quality of produced water**
  - **Characterization of produced waters**
- **Major Findings:**
  - **Geochemical database useful for a general understanding of chemistry**
  - **Extreme salinity and potentially elevated concentrations of other constituents could negatively impact resources if released**
    - Arsenic, barium, cadmium, lead, zinc, radium-226/radium-228, ammonia
  - **Unique chemical (isotopic) signature may be useful in tracking the water produced from the Bakken Formation**
    - Oxygen/deuterium and strontium values distinct from other brines produced in the Williston Basin

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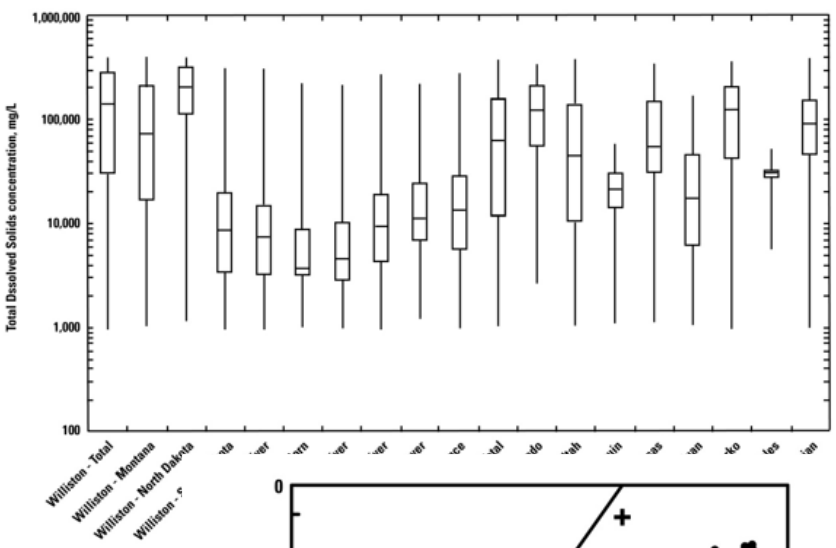

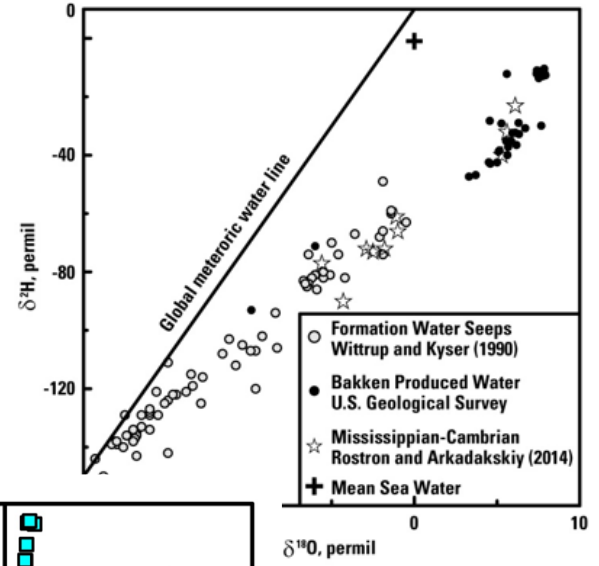

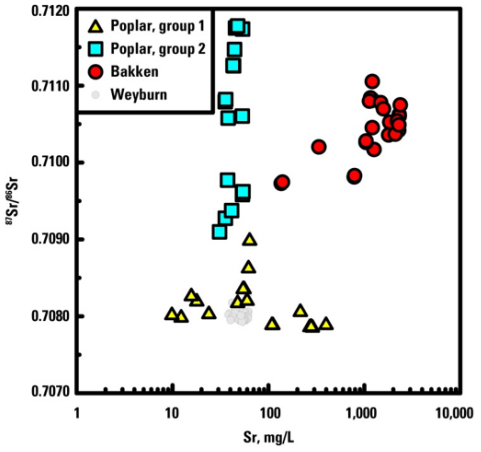

Water Use

- **Summary of data:**
  - **Energy development and water use**
    - Not limited to oil and gas production but all facets of energy resources
    - Development and associated water use is cyclic
  - **Water-use regulations**
    - Regulations on State by State basis
    - Issue for shared resources
- **Major Findings:**
  - **Large amount of water used for oil and gas well development and post processing**
  - **Associated public supply increases**

Table 19. Active Drilling Rig Counts for North Dakota, Montana, and South Dakota based on average count for January, 2005 – 2015.

	Active Drilling Rig Counts for the month of January, 2005 - 2015			
January (Year)	North Dakota	Montana	South Dakota	
2005	20	22	0	Drilling intensity focused on Elm Coulee Field – middle Bakken Formation in eastern Montana
2006	27	25	0	
2007	34	19	0	
2008	48	12	1	
2009	68	6	0	
2010	71	5	0	
2011	154	8	0	Drilling intensity switches to Bakken – Three Forks Formation in North Dakota
2012	154	8	0	
2013	176	18	1	
2014	170	9	1	
2015	155	8	0	

Resource Sustainability	Resource (Fuel) Type	Resource Material	Development Type	Development Process	General Water-Use Requirements for Resource	2011/2014 U.S. Energy Consumption, in percent[1,2]
Non-renewable	Fossil	Coal (including lignite)	Conventional	Surface / strip or underground mining	Coal washing to improve quality / dust abatement for mine roads / equipment maintenance / Re-vegetation of surface mines. / Long-distance transport via coal slurry / coal-fired powerplants (once-through and closed loop [or recirculating] / cooling ponds)	20.4 / 18.3
Non-renewable	Fossil	Crude Oil	Conventional	Primary recovery - vertical well	Drilling, well completion / Injection into the reservoir in secondary and enhanced oil recovery / Upgrading and refining into products.	36.2 / 35.4
Non-renewable	Fossil	Crude Oil	Unconventional	Primary recovery - vertical well, horizontal well, hydraulic fracturing	Drilling, well completion and hydraulic fracturing. / Injection into the reservoir in secondary and enhanced oil recovery / Oil sands mining and in-situ recovery / Upgrading and refining into products.	36.2 / 35.4
Non-renewable	Fossil	Natural Gas	Conventional	Primary recovery - vertical well	Drilling, well completion / Injection into the reservoir in secondary and enhanced oil recovery / Upgrading and refining into products.	25.5 / 27.9
Non-renewable	Fossil	Natural Gas	Unconventional (including shale gas, coal bed methane, gas hydrates)	Primary recovery - vertical well , horizontal well, hydraulic fracturing	Drilling, well completion and hydraulic fracturing. / Injection into the reservoir in secondary and enhanced oil recovery / Oil sands mining and in-situ recovery / Upgrading and refining into products.	25.5 / 27.9
Renewable	Hydro	Water	Conventional (dam and reservoir)	Turbines	Electricity generation. / Storage in a reservoir (for operating hydro-electric dams or energy storage) / Discharge through water turbines in dam	3.3 / 2.5
Renewable	Biofuels	Organic matter	Conventional	Crops (ethanol)	Water-use requirements for crops / Irrigation for feedstock crop growth. Wet milling, washing and cooling in the fuel conversion process.	4.5 / 4.9
Renewable	Wind	Wind	Conventional	Windmills (wind farms)	Minimal water-usage unless in manufacturing of turbine parts in area	1.5 / 1.7
Renewable	Geothermal	Geothermal	Conventional	Small scale – homes / schools	Use in heating systems / maintenance	.22 / .22
Renewable	Solar	Solar	Conventional	Photovoltaics / concentrated solar power	Use in manufacturing systems / maintenance	<.01 / <.01

EIA, Monthly Energy Review, March 2012 & 2014, Table 1.3 Primary Energy Consumption by Source (Quadrillion BTUs) Accessed as of January 29, 2016, at *tp://www.eia.govtotal energy/data/monthly/pdf/mer.pdf*
Nuclear energy not present in Williston Basin therefore absent from this table so percent values do not total 100 percent because of omission.

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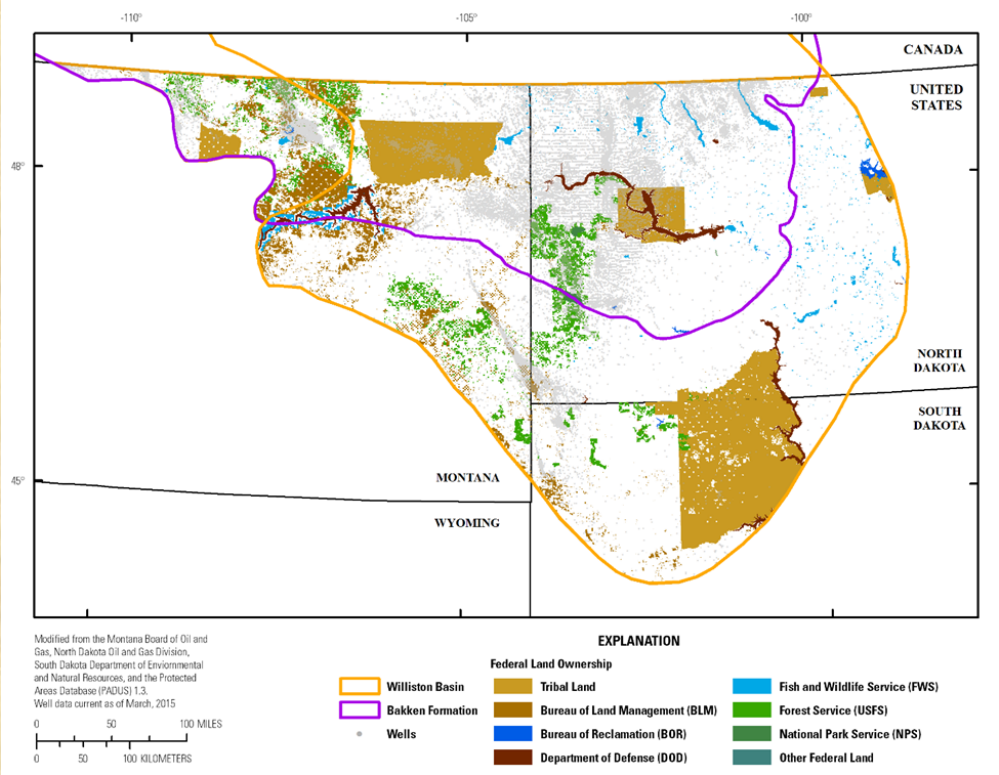
Data Gaps

- **Streams and rivers:**
  - Little information on ice-jam flooding despite potential for impacts to infrastructure (pipelines, roads, facilities)
  - Understanding of the cumulative effects of largely undocumented stock and diversion dams
- **Quality of Water**
  - Availability of consistently collected, systematically processed and reported data over large portions of the Williston Basin is limited
  - Limited water-quality sampling sites in Montana and South Dakota portions of the Williston Basin
  - Limited data on effects of energy development on Lake Sakakawea and other reservoirs
- **Produced water**
  - Need for standardized sample collection, processing, and laboratory analytical methods, collection of ancillary data
  - Additional characterization of the range of chemical, microbial, and isotopic compositions and quantities of “end-member” produced waters
  - Collection of time-series datasets to document the changes in produced waters during and following well development
- **Water use**
  - Voluntary submission of water use data related to hydraulic fracturing limited
  - No comprehensive study of groundwater and surface-water sources using consistent methodologies across entire basin.
  - Basin boundaries span several political boundaries—regulations, reporting, and monitoring controls vary by State

Chapter D -*Biological Resources of the Energy Development Area of the Williston Basin*

- Overview of energy development in WB and public land
- Ecosystems of WB
- Species of concern in WB
- Potential effects of development on species of concern
- Mitigation of effects
- Critical information needs



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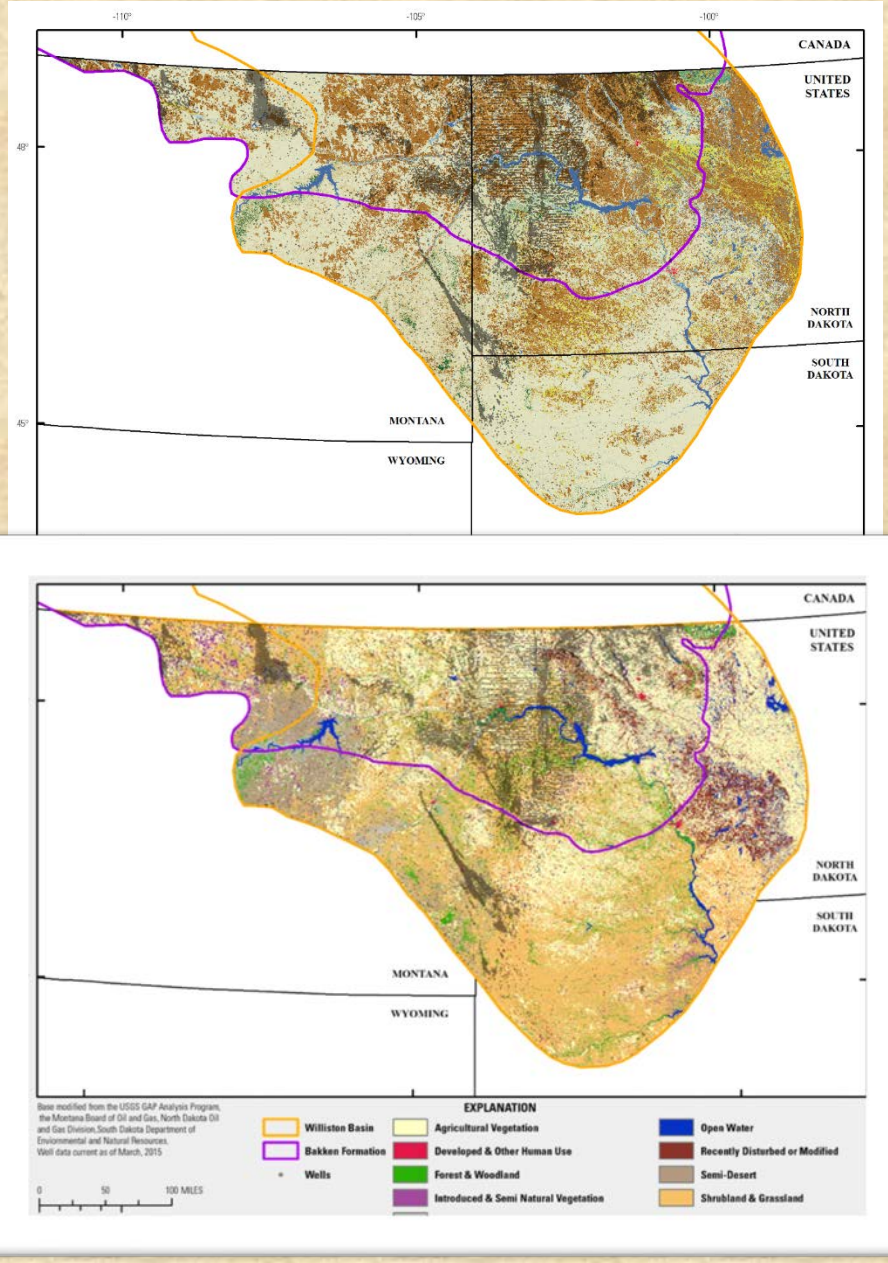
Ecosystems of the WB

- Overview of major ecosystems
  - Grasslands (39%)
  - Shrublands and Woodlands (17%)
  - Wetlands, lakes, streams (5%)
  - Agricultural lands (37%)



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Species of conservation concern

- Synthesis of Federal and State Species of Conservation
  - Endangered Species Act, noxious weed lists, State Wildlife Action Plans, State Natural Heritage Program lists, etc.

- 357 species likely in WB
- Relied mostly on records in NatureServe or in literature.

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Species of conservation concern

- Native and non-native plants
- Terrestrial invertebrates
- Migratory birds
- Mammals
- Amphibians
- Aquatic species

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Critical Information Needs

- Assessing cumulative effects…
  - Assumption that site-level management can mitigate cumulative effects
  - Coordinated planning efforts may be an effective way to mitigate cumulative effects
- Informing cumulative assessments…
  - Most species do not have adequate data to model distributions.
  - Some sources exist for a few species
    - But requires setting priorities and developing rigorous modeling frameworks.

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Critical Information Needs

- Informing cumulative assessments…
  - Most literature is focused on birds or large mammals
    - Poorly replicated in space and time
  - More landscape-scale long term population studies needed
  - More information on basic life history info

Bakken Environmental Status and Trends (BEST) Report

- Many authors have contributed to report
- Report is in technical and editorial review process
- Tentatively planning on report completion by June 2017
- Planning associated short USGS Factsheet to accompany report
- Report can hopefully provide a base reference for managers to make informed decisions and help plan further monitoring/studies to help address data gaps

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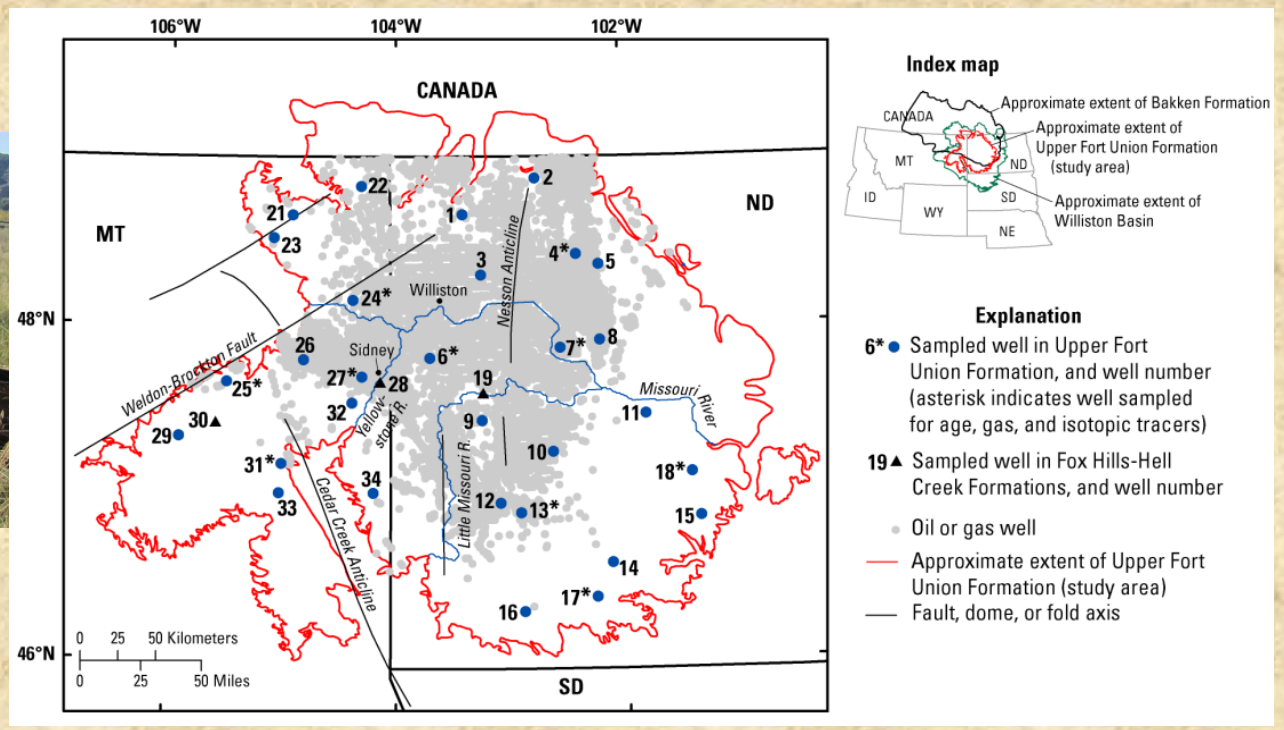
2013 Groundwater Study

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



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Study Conclusions

- No indication that energy-development activities affected groundwater quality in the upper Fort Union Formation
- **Limitation:** only 34 wells sampled over a 38,000 mi^2 area
- Important to consider these results in the context of groundwater age
  - Groundwater ages in depth zone of the upper Fort Union Formation used for domestic supply predate recent increases in energy development
  - Old groundwater ages indicative of slow groundwater velocities (10 to 25 meters per year)
- Domestic wells were not suited for detecting local contamination from spills or oil well activities

Implications:

- **Monitoring needed closer to energy-development activities**
- **Monitoring needed as a long-term commitment**

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2013 Groundwater Study:

http://onlinelibrary.wiley.com/doi/10.1111/gwat.12296/pdf

McMahon, P.B., Caldwell, R.R., Galloway, J.M., Valder, J.F., and Hunt, A.G, 2014, Quality and Age of Groundwater in the Bakken Formation Production Area, Montana and North Dakota: Groundwater, v. 53, Issue S1, p. 81-94

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