

Characterization of Groundwater and Surface-Water Quality within the Williston Basin

**Rochelle Nustad and Robert Lundgren, USGS-
North Dakota**
Greg Delzer, Dave Bender, USGS-South Dakota

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Matrices and Water-Quality Constituents

➤ **Matrices**

- **Groundwater**
- **Rivers and streams**
- **Lakes and reservoirs**

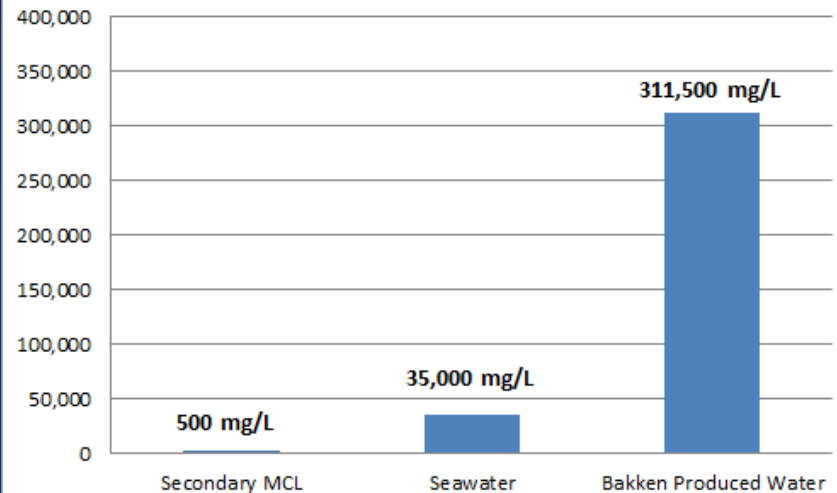
➤ **Water-quality constituents**

- **Five primary constituents: specific conductance, total dissolved solids (TDS), pH, sulfate, chloride**
- **Ten secondary constituents (trace metals): aluminum, arsenic, barium, chromium, copper, iron, lead, selenium, strontium, zinc**

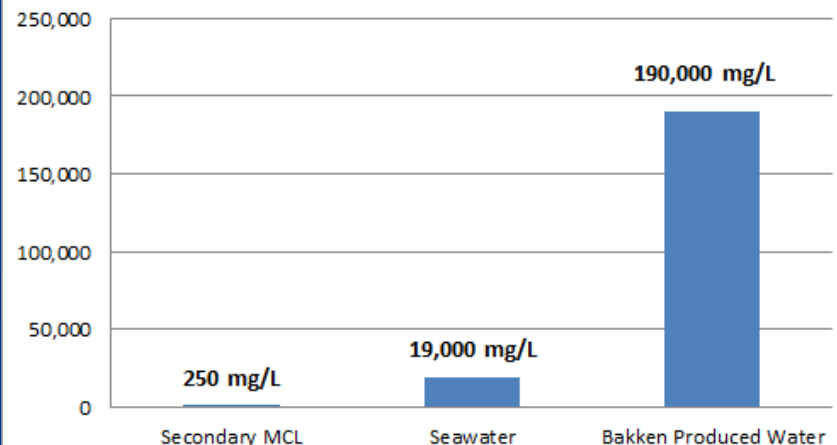
Water Quality of Produced Water

- Oil to water ratio is about 1:10
- Constituents in produced water can be indicators of contamination to natural water
- MCL (maximum contaminant level)

Comparison of TDS Concentrations



Comparison of Chloride Concentrations (mg/L)

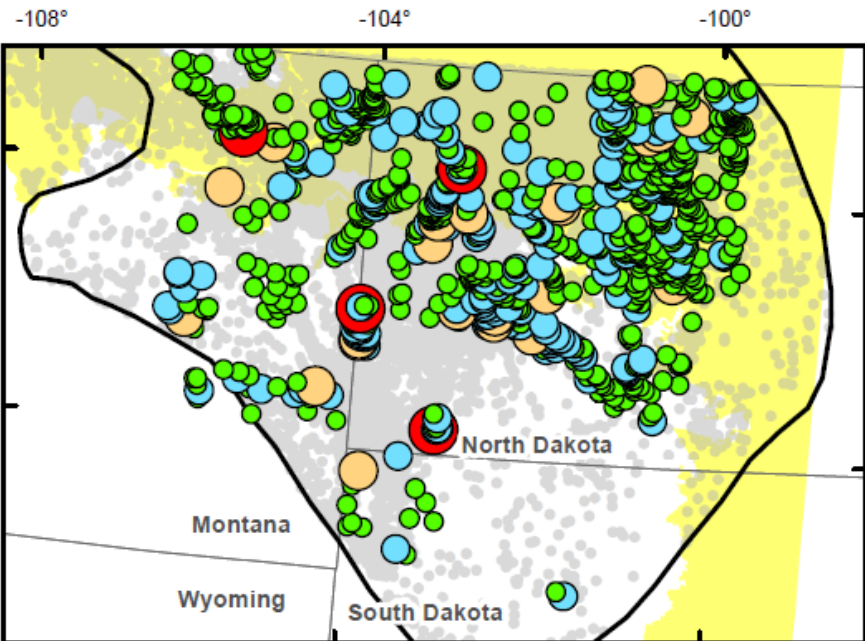


Characterization of Groundwater

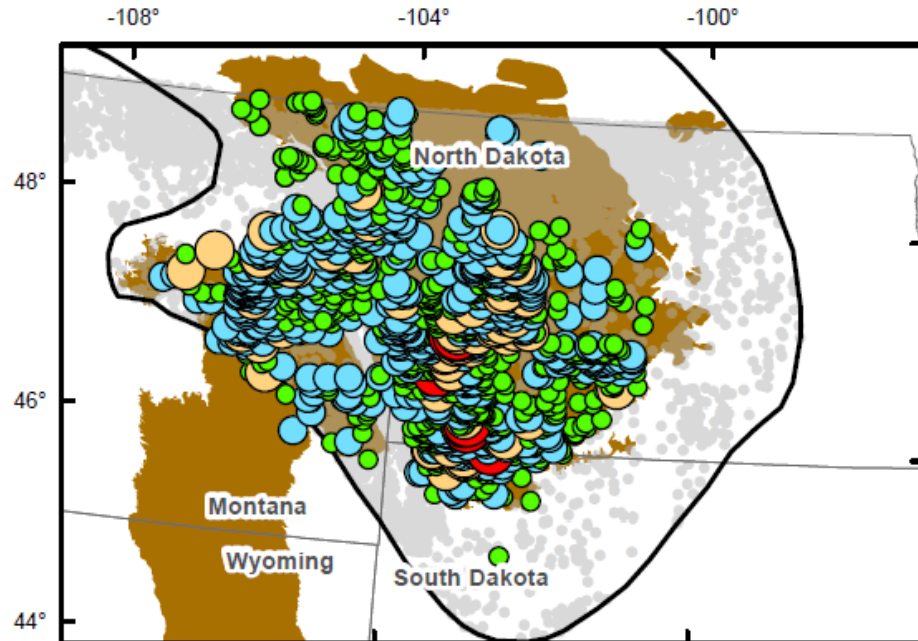
- **Data from 4,724 (pH) to 5,831 (total dissolved solids) wells were summarized**
- **Large ranges were observed for all constituents:**
 - **Specific conductance: 2.9 to 807,299 $\mu\text{S}/\text{cm}$**
 - **Total dissolved solids: not detected to 174,000 mg/L**
 - **pH: 0.8 to 13.3 standard units**
 - **Sulfate: not detected to 35,418 mg/L**
 - **Chloride: not detected to 100,000 mg/L**



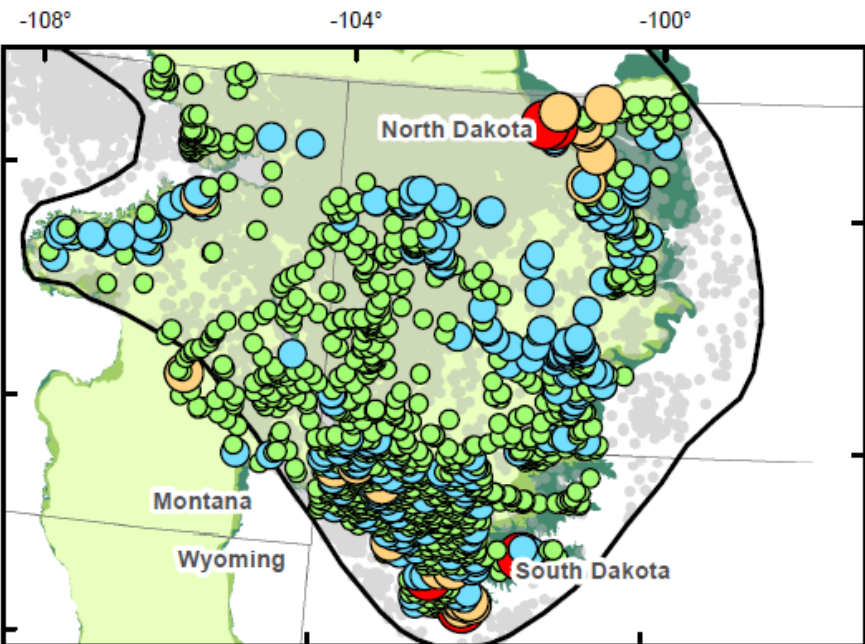
Quaternary



Lower Tertiary



Upper Cretaceous



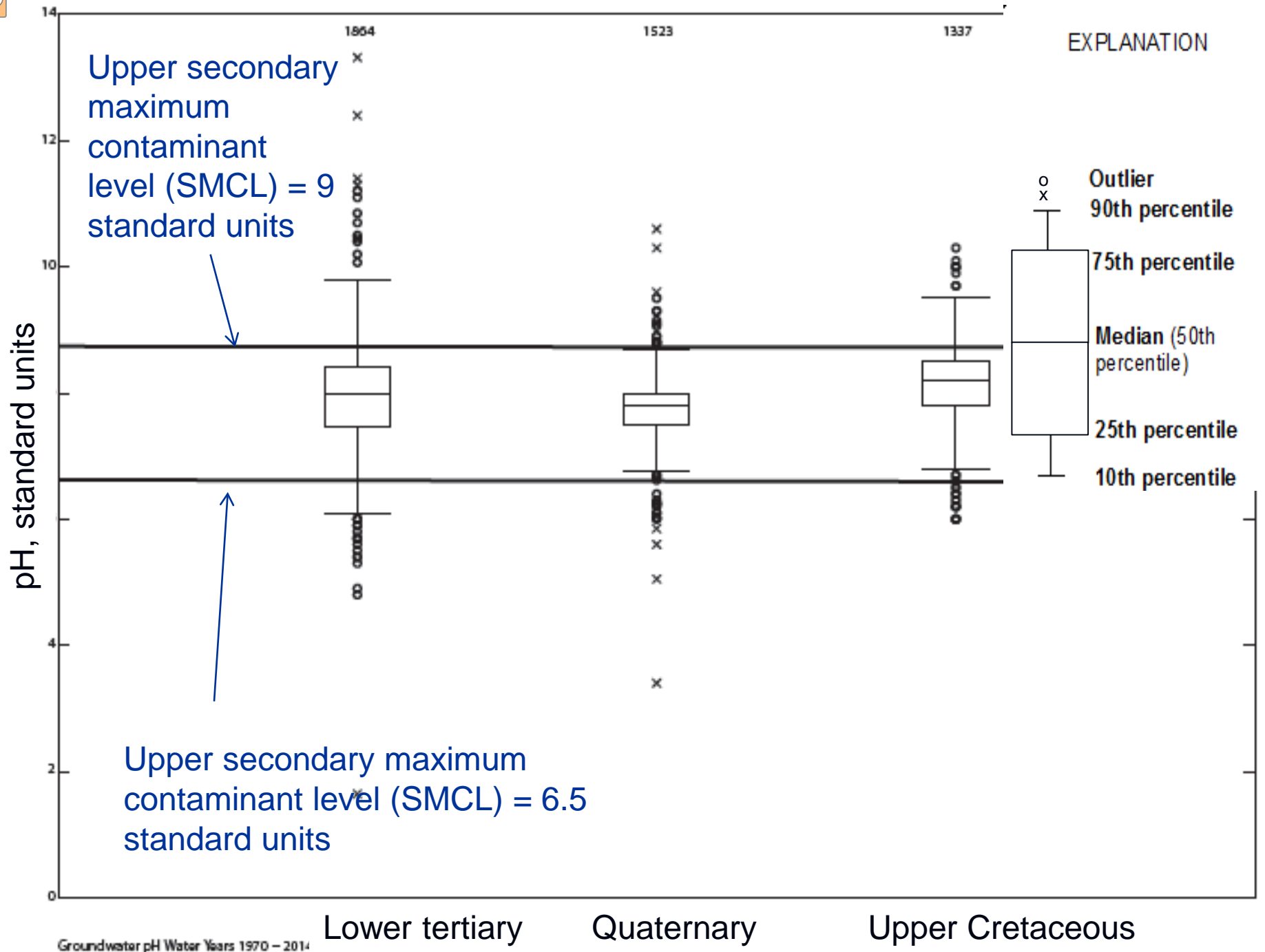
Median specific conductance in microsiemens per centimeter at 25 degrees Celsius

- Less than 2,500
- 2,500 - 5,000
- 5,000 - 10,000
- 10,000 - 82,700

- Glacial Deposits
- Lower Fort Union
- Middle Fort Union
- Upper Fort Union
- Upper Hell Creek
- Lower Hell Creek
- Fox Hills
- Williston Basin study area

Values generally are smaller in Upper Cretaceous units and larger in the Lower Tertiary units.

Coordinate System: NAD 1983 Albers
 Projection: Albers
 Datum: North American 1983
 False Easting: 0.0000
 False Northing: 0.0000
 Central Meridian: -96.0000
 Standard Parallel 1: 29.5000
 Standard Parallel 2: 45.5000
 Latitude Of Origin: 23.0000
 Units: Meter



Characterization of Groundwater: Trace Metals

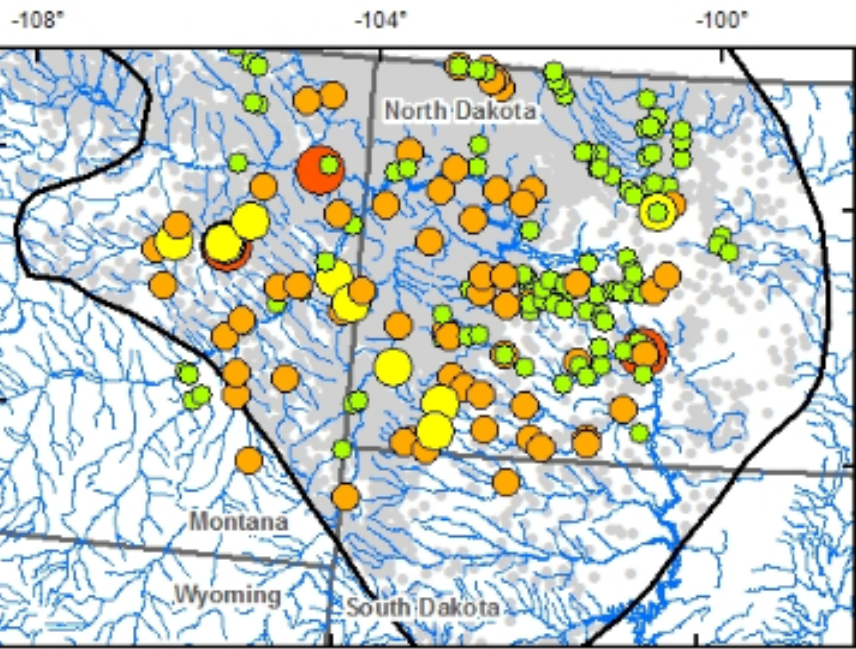
- Fewer data available, 83-156 sampled wells.
- Wells in the Quaternary had the most samples for the 10 trace metals.
- Most mean concentrations for trace metals were less than the USEPA primary MCL or SMCL, with the exception of aluminum, arsenic, iron and lead.

Characterization of Streams and Rivers

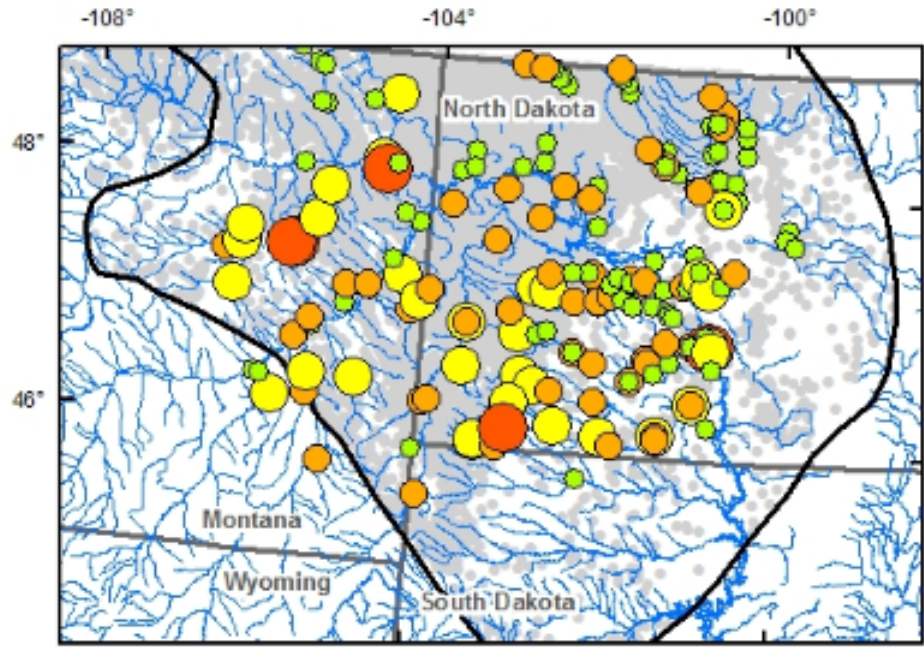
- **Data from 188 (sulfate) to 316 (chloride) sites were summarized. As an example site, Yellowstone River near Sidney, Montana (USGS gaging station 06329500) was summarized.**
- **Large ranges were observed for Williston Basin sites:**
 - **Specific conductance: 1.08 to 13,300 $\mu\text{S}/\text{cm}$**
 - **Total dissolved solids: 10 mg/L to 19,100 mg/L**
 - **pH: 1.78 to 13.14 standard units**
 - **Sulfate: 5 to 7,900 mg/L**
 - **Chloride: 0.1 to 510 mg/L**



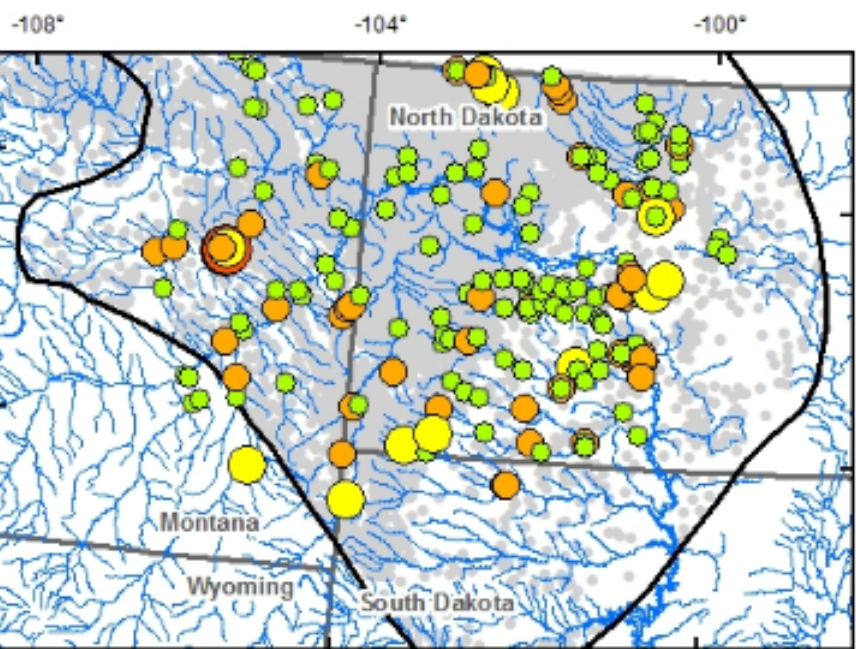
Median



Maximum



Minimum



Sulfate concentration, in milligrams per liter

Median

- 116 - 536
- 536 - 1,200
- 1,200 - 2,450
- 2,450 - 4,450

Maximum

- 180 - 979
- 979 - 1,900
- 1,900 - 4,200
- 4,200 - 7,900

Minimum

- 5 - 125
- 125 - 340
- 340 - 720
- 720 - 2,820

Williston Basin Study area

Energy production wells



10,000

SMCL=250 mg/L

Secondary Maximum Contaminant Level



Concentration, mg/L

600

Sulfate

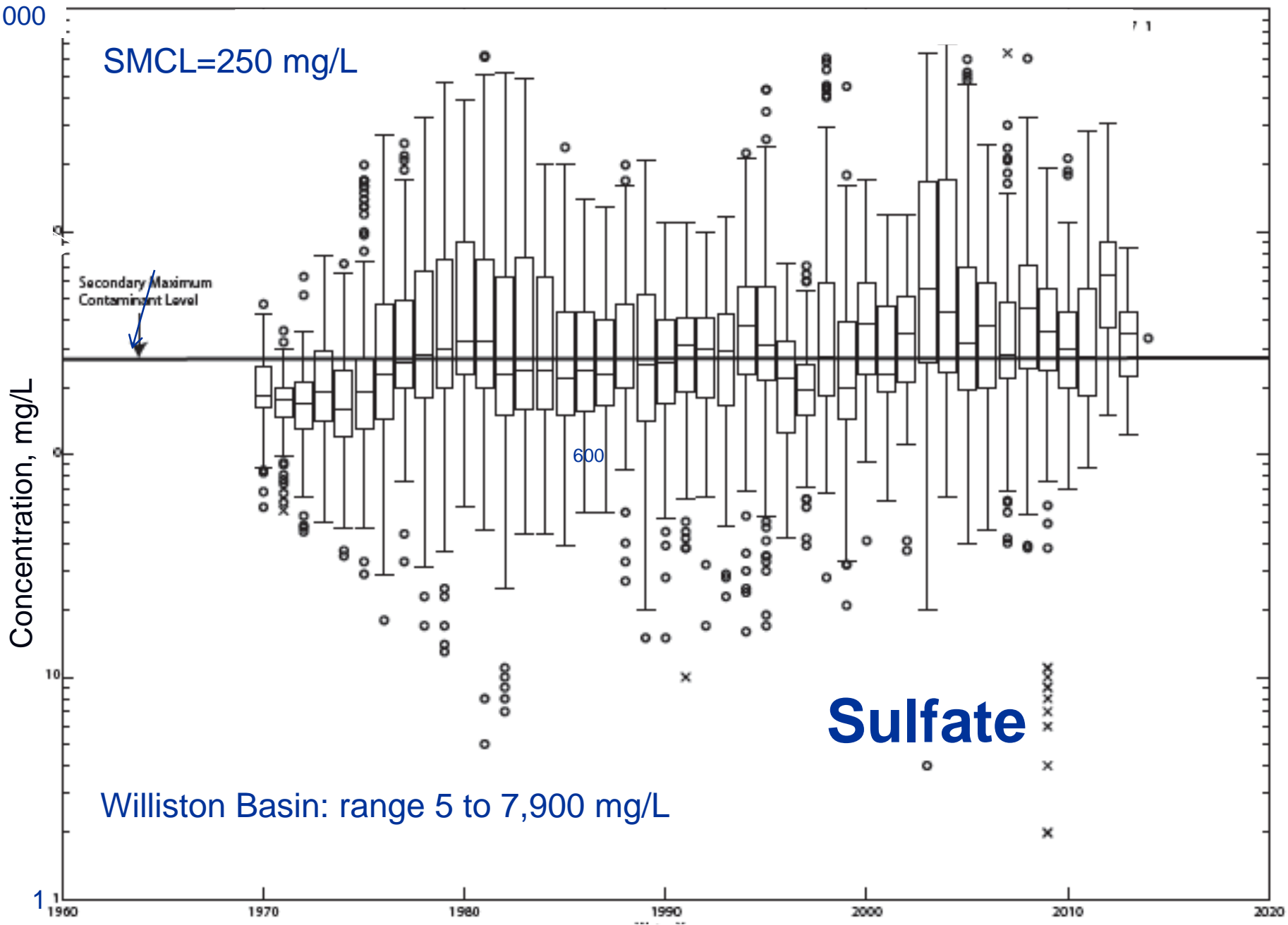
Williston Basin: range 5 to 7,900 mg/L

1

1900 1970 1980 1990 2000 2010 2020

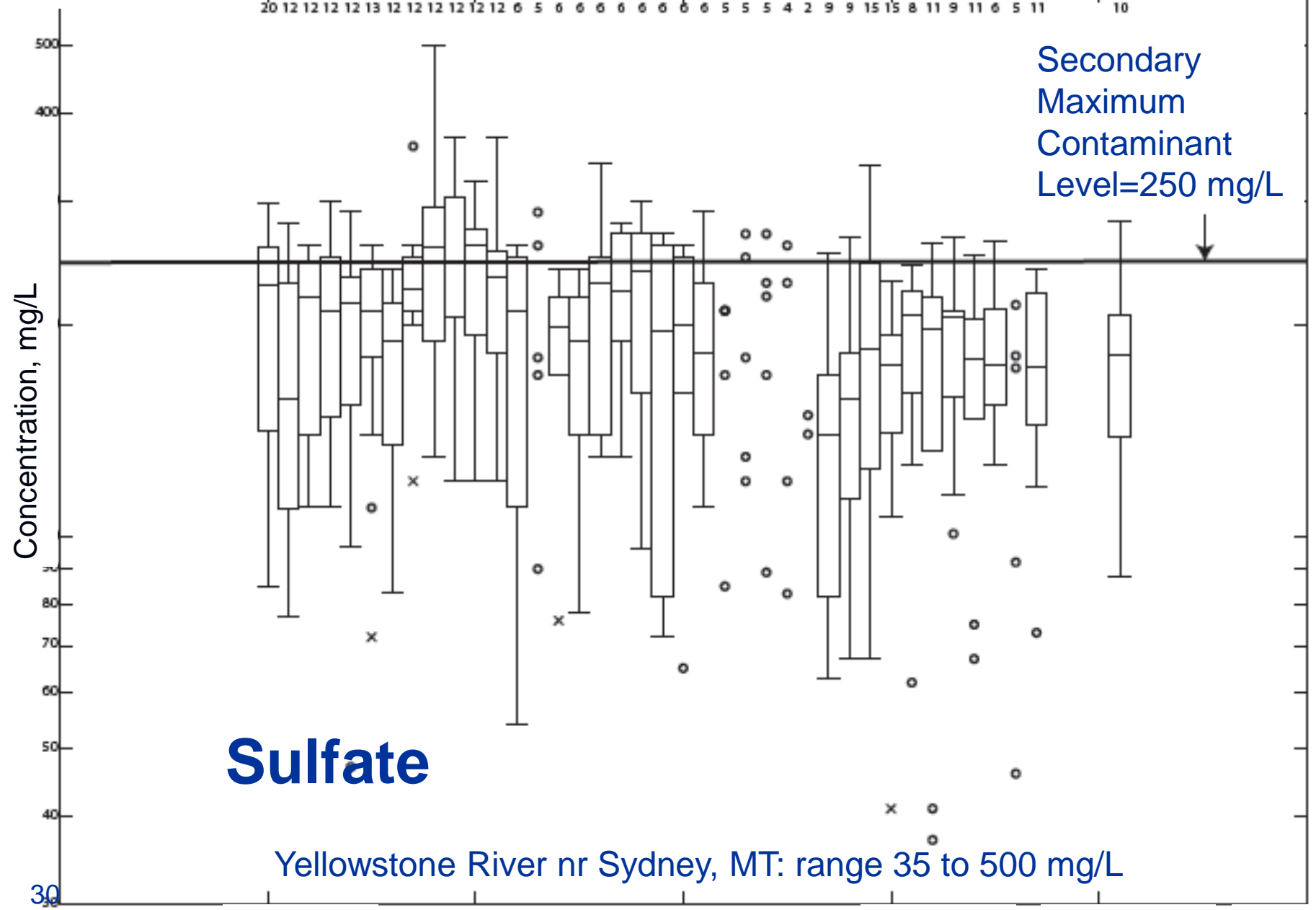
ALL Surface Water Sulfate Water Year 1970-2014

Water Year





600



Secondary
Maximum
Contaminant
Level=250 mg/L

Sulfate

Yellowstone River nr Sydney, MT: range 35 to 500 mg/L

30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300 310 320 330 340 350 360 370 380 390 400 410 420 430 440 450 460 470 480 490 500 510 520 530 540 550 560 570 580 590 600

1960 1970 1980 1990 2000 2010 2020

Water Year

Characterization of Streams and Rivers: Trace Metals

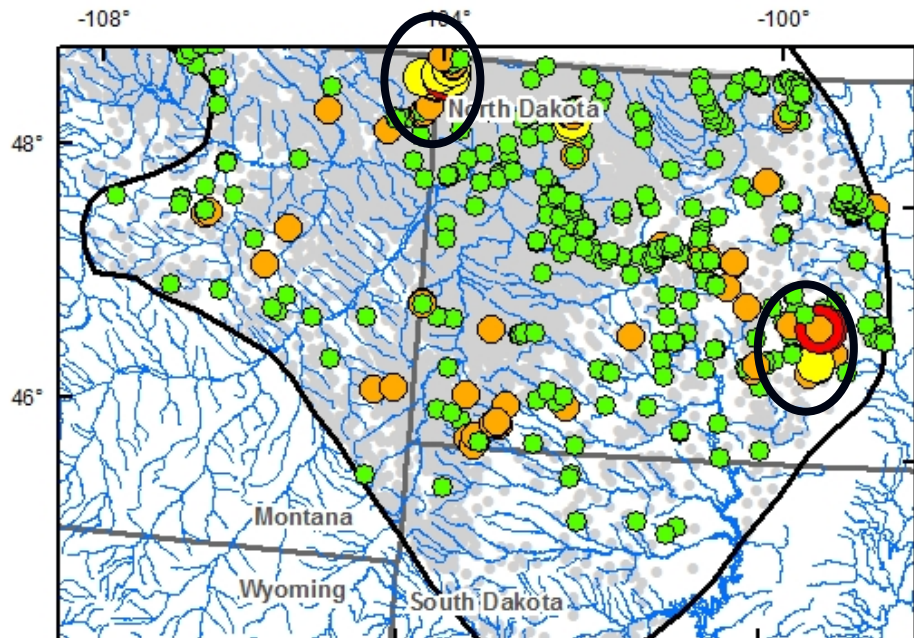
- **Fewer data available, 45-63 sites with ten or more samples**
 - **Maximum detected concentrations exceed the USEPA primary MCL or SMCL for: aluminum, arsenic, iron, lead, selenium.**

Characterization of Lakes and Reservoirs

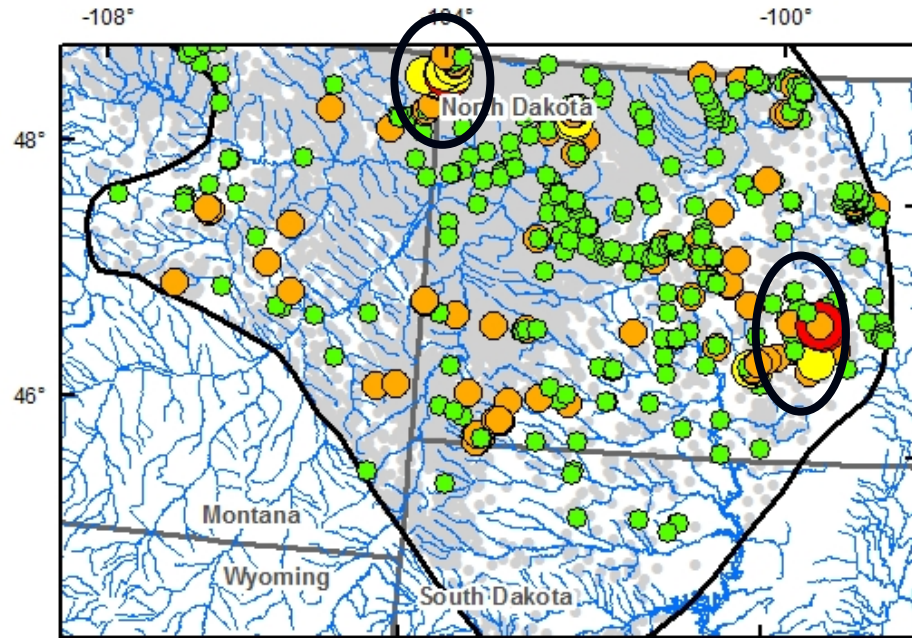
- **Data from 474 (sulfate) to 714 (pH) sites were summarized. In addition, 4 sites on Lake Sakakawea were summarized.**
- **Large ranges were observed for Williston Basin sites:**
 - **Specific conductance: 30 to 116,000 $\mu\text{S}/\text{cm}$**
 - **Total dissolved solids: 11 to 84,500 mg/L**
 - **pH: 0.8 to 13.3 standard units**
 - **Sulfate: not detected to 35,418 mg/L**
 - **Chloride: not detected to 100,000 mg/L**



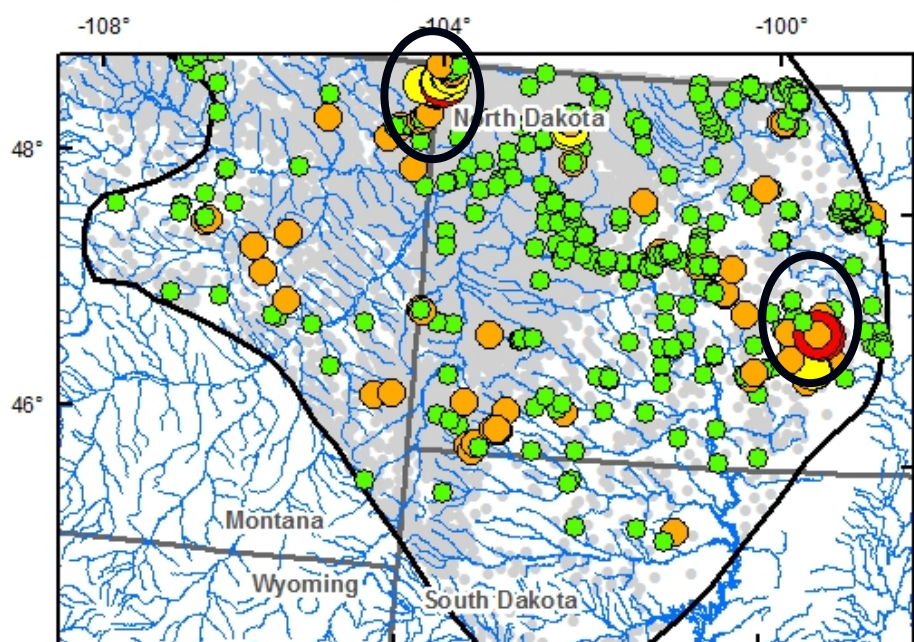
Median



Maximum



Minimum



Total dissolved solids, in milligrams per liter

Median

- 36 - 2,272
- 2,272 - 11,105
- 11,105 - 40,744
- 40,744 - 84,500

Maximum

- 36 - 2,360
- 2,360 - 13,826
- 13,826 - 40,744
- 40,744 - 84,500

Minimum

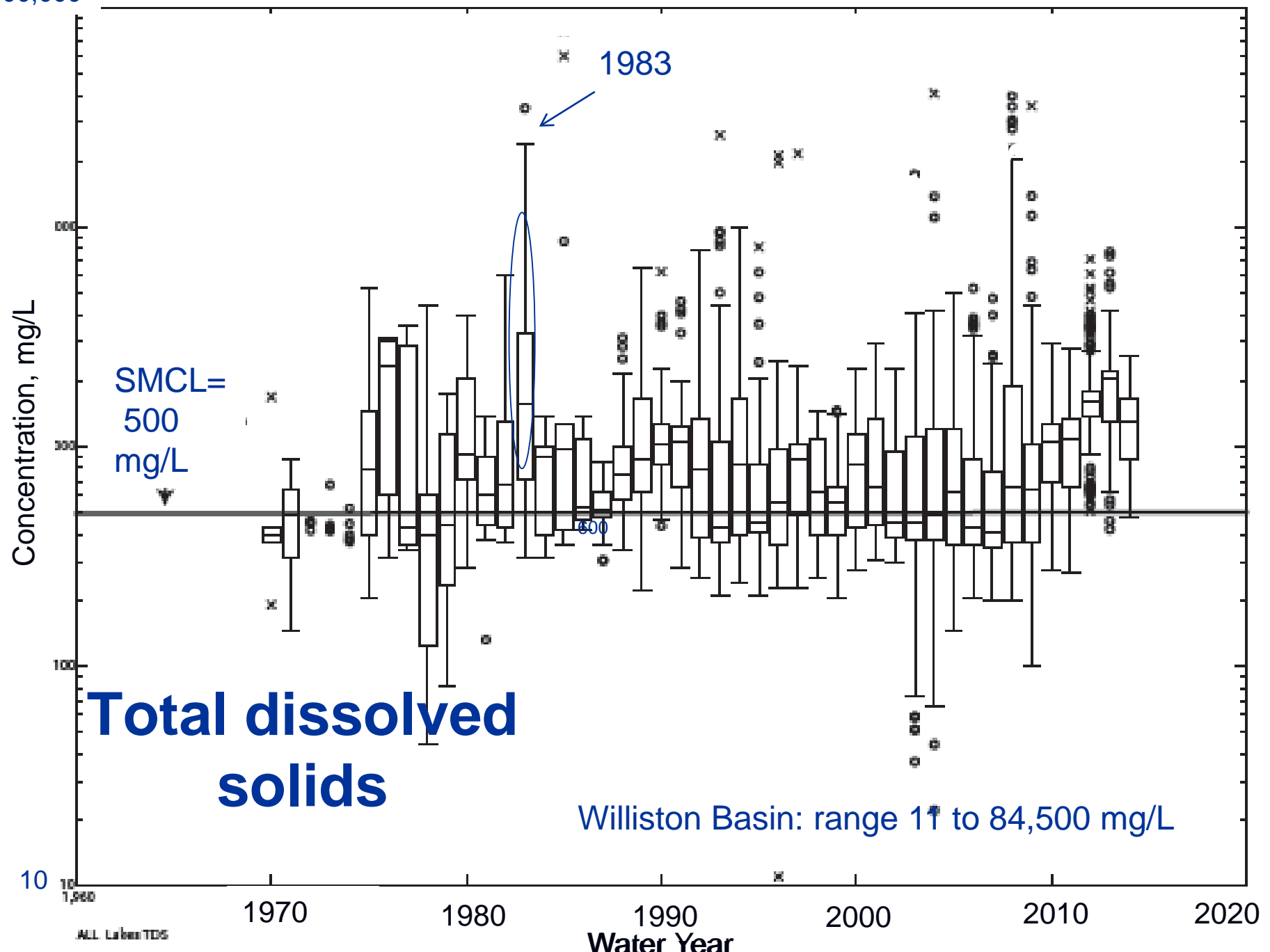
- 11 - 1,880
- 1,880 - 11,105
- 11,105 - 40,744
- 40,744 - 84,500

Williston Basin Study area

Energy production wells



100,000





800

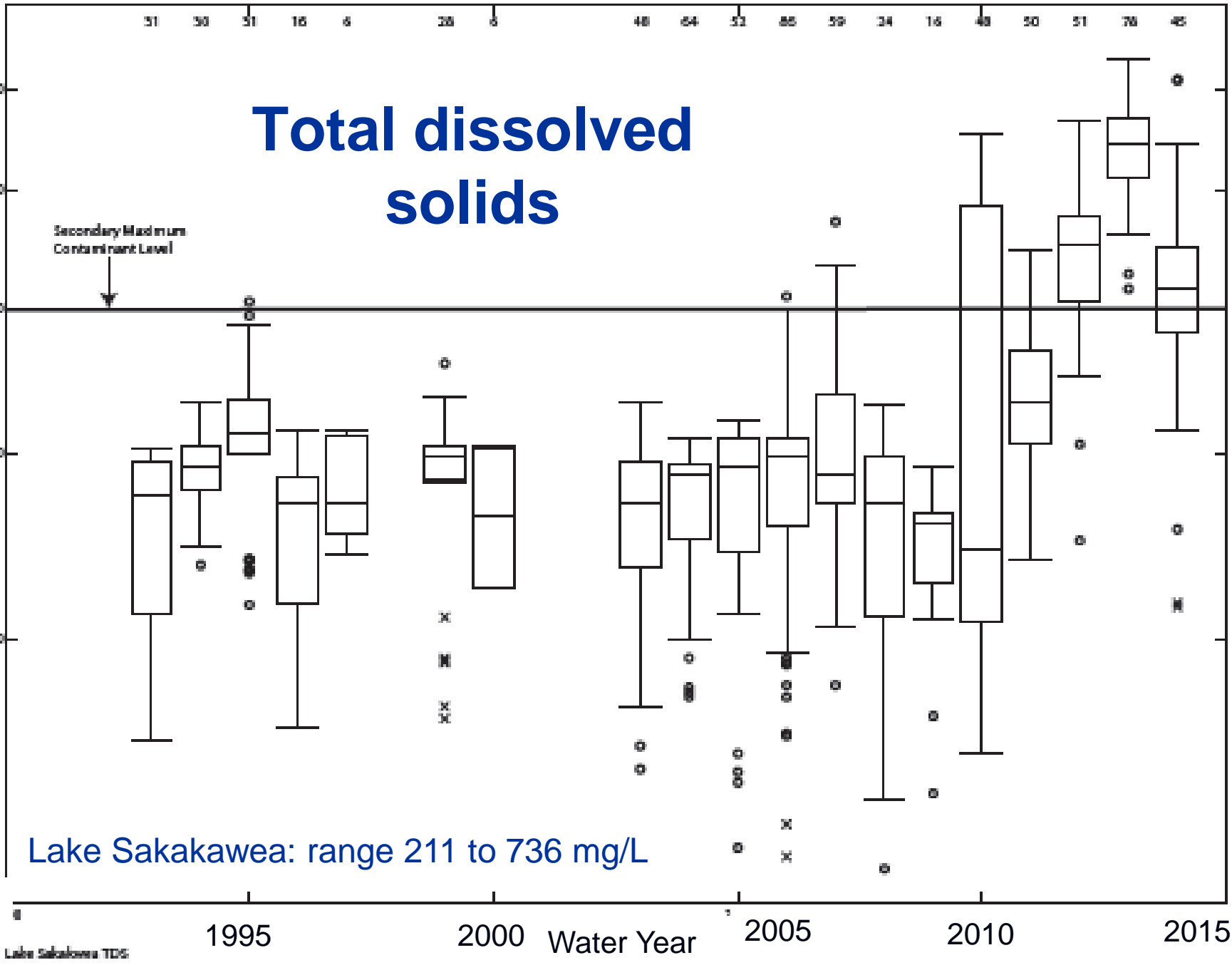
Total dissolved solids

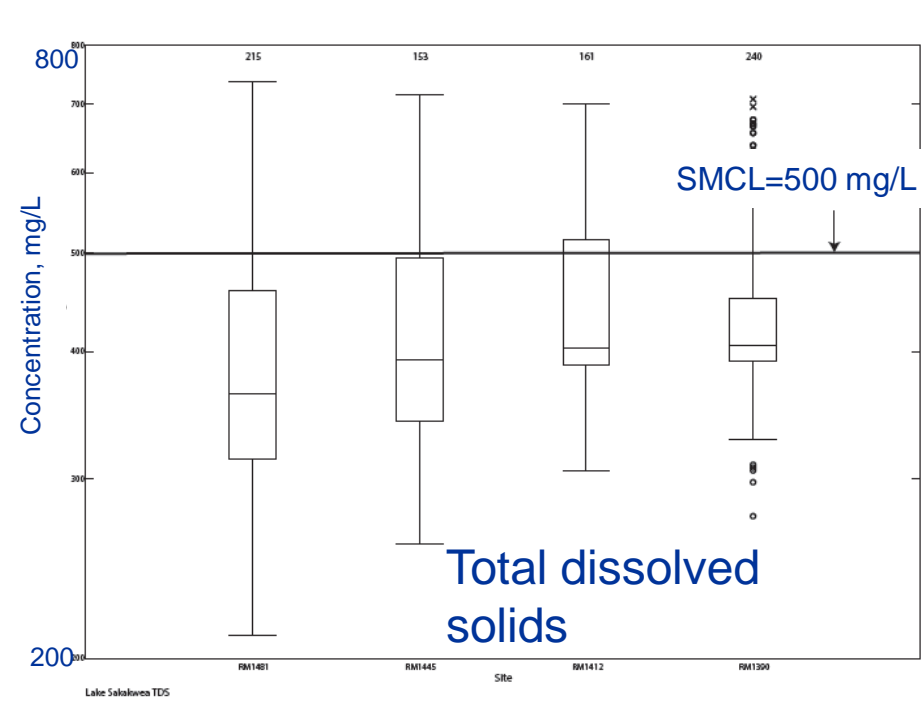
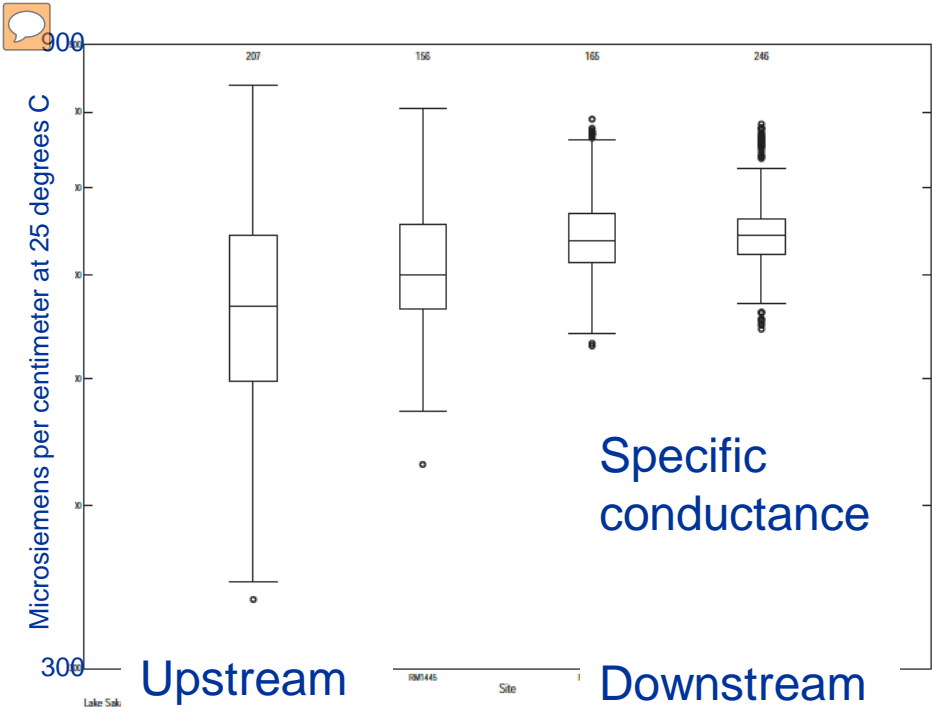
Concentration, mg/L

Secondary Maximum Contaminant Level

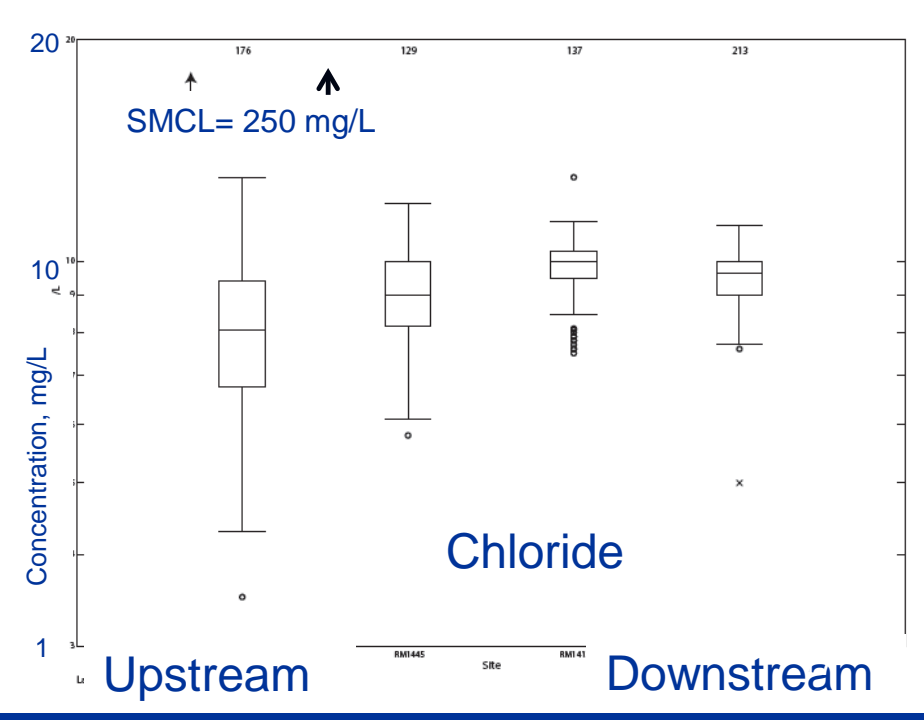
300

Lake Sakakawea: range 211 to 736 mg/L





Lake Sakakawea



Characterization of Lakes and Reservoirs: Trace Metals

- **Fewer data available 33-396 sites**
 - **Maximum detected concentrations exceed the USEPA primary or secondary MCL for: aluminum, arsenic, and iron.**

Gaps

- **Inconsistent collection and processing of data for large portions of the Williston Basin for detecting contamination from energy-development activities.**
- **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.**

Gaps, *cont.*

- **Data required for performing trend analysis.**
- **Further evaluation of groundwater depths for identifying aquifer units.**
- **Further evaluation of lake data by depth.**

