



## US EPA Region 8

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# Powder River Watershed Stream Water Quality Pre- and Post-CBM Development

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# Powder River Watershed Questions

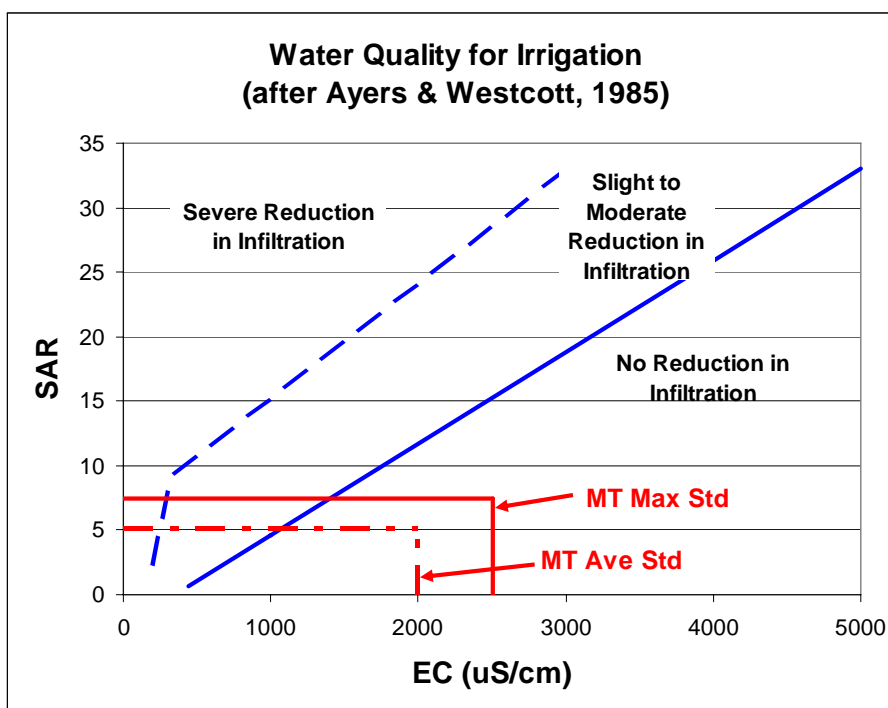
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1. What is the water quality of the permitted CBM discharge?
2. What is the ambient stream water quality?
  - What is the time period that represents “natural” background?
  - What impact has the drought had on water quality?
  - What are the relationships between flow and water quality?
3. What has been the impact of CBM discharge on stream water quality?



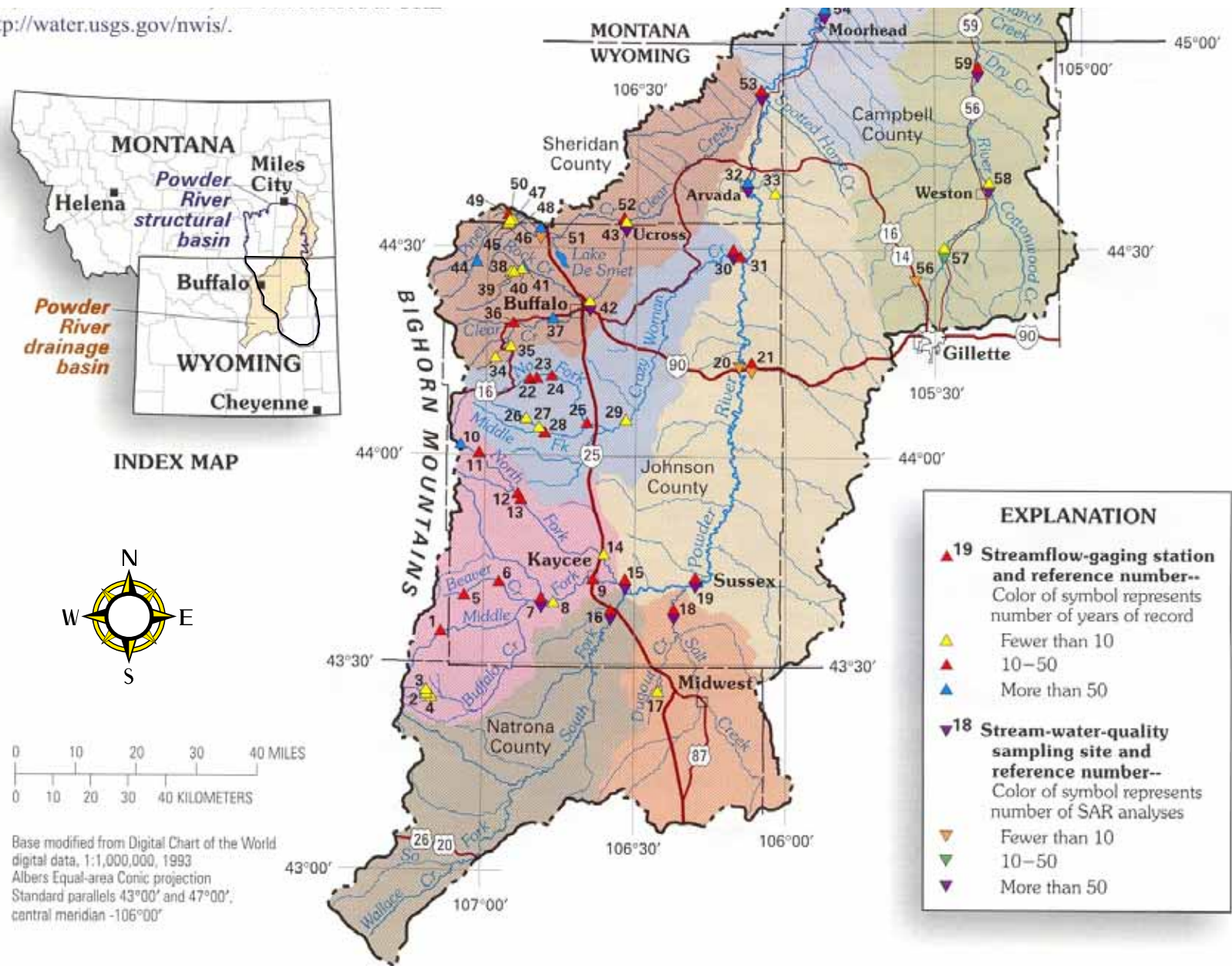
# MT WQS for EC & SAR

- Powder River
  - EC: Irrigation Season
    - Average: 2000
    - Maximum: 2500
  - SAR: Irrigation Season
    - Average: 5.0
    - Maximum: 7.5



EC at 25°C = specific conductance (SpC).

<http://water.usgs.gov/nwis/>.



**Figure 2.** Location of streamflow-gaging stations and stream-water-quality sites in the Powder River Basin, Wyoming and Montana.



# Powder River Watershed Questions

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# CBM Water Quality

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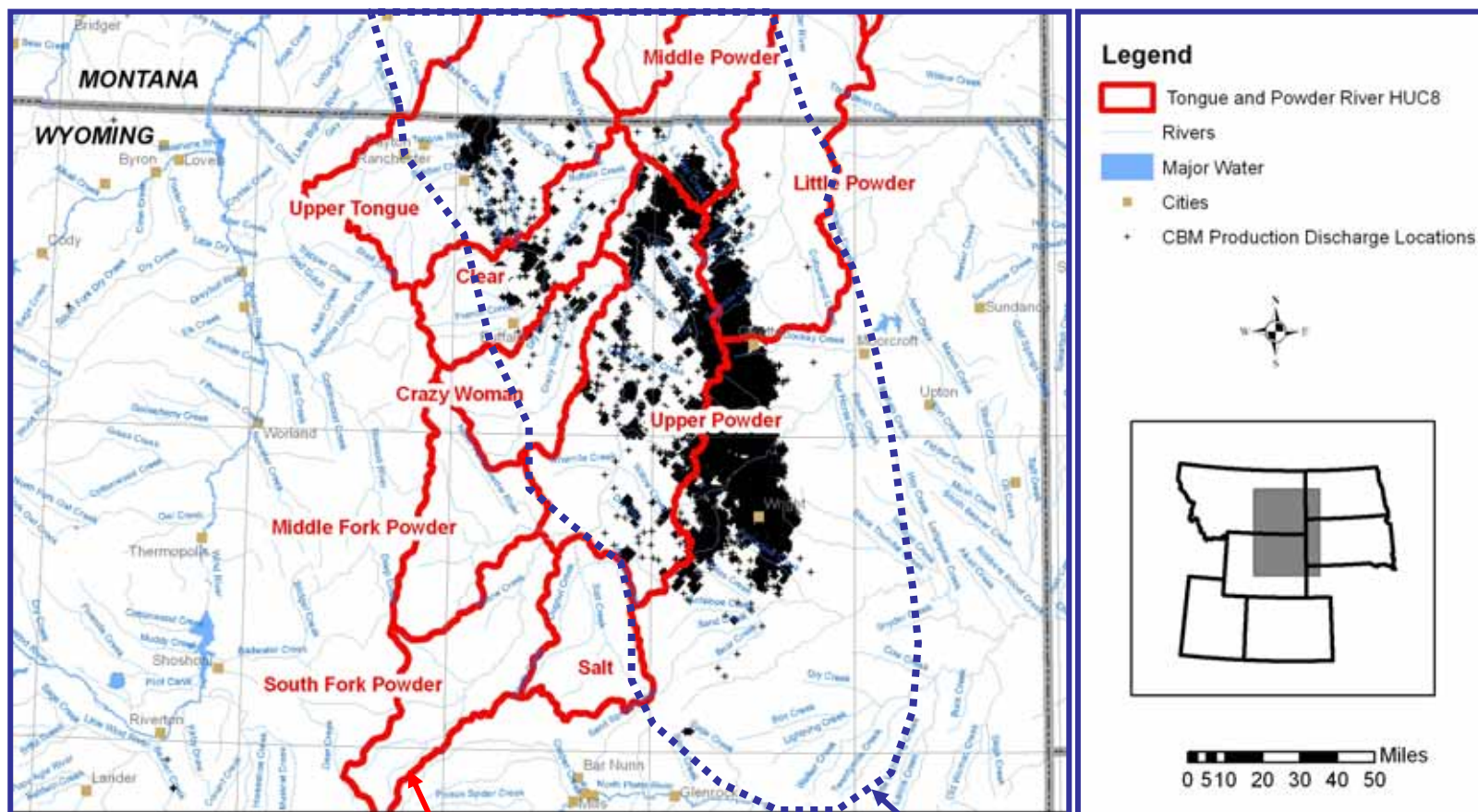
- CBM Production
- SpC (= EC at 25°C)
- SAR
- SpC - SAR Relationship



DRAFT: Preliminary Observations



# CBM Water Production Discharge Locations

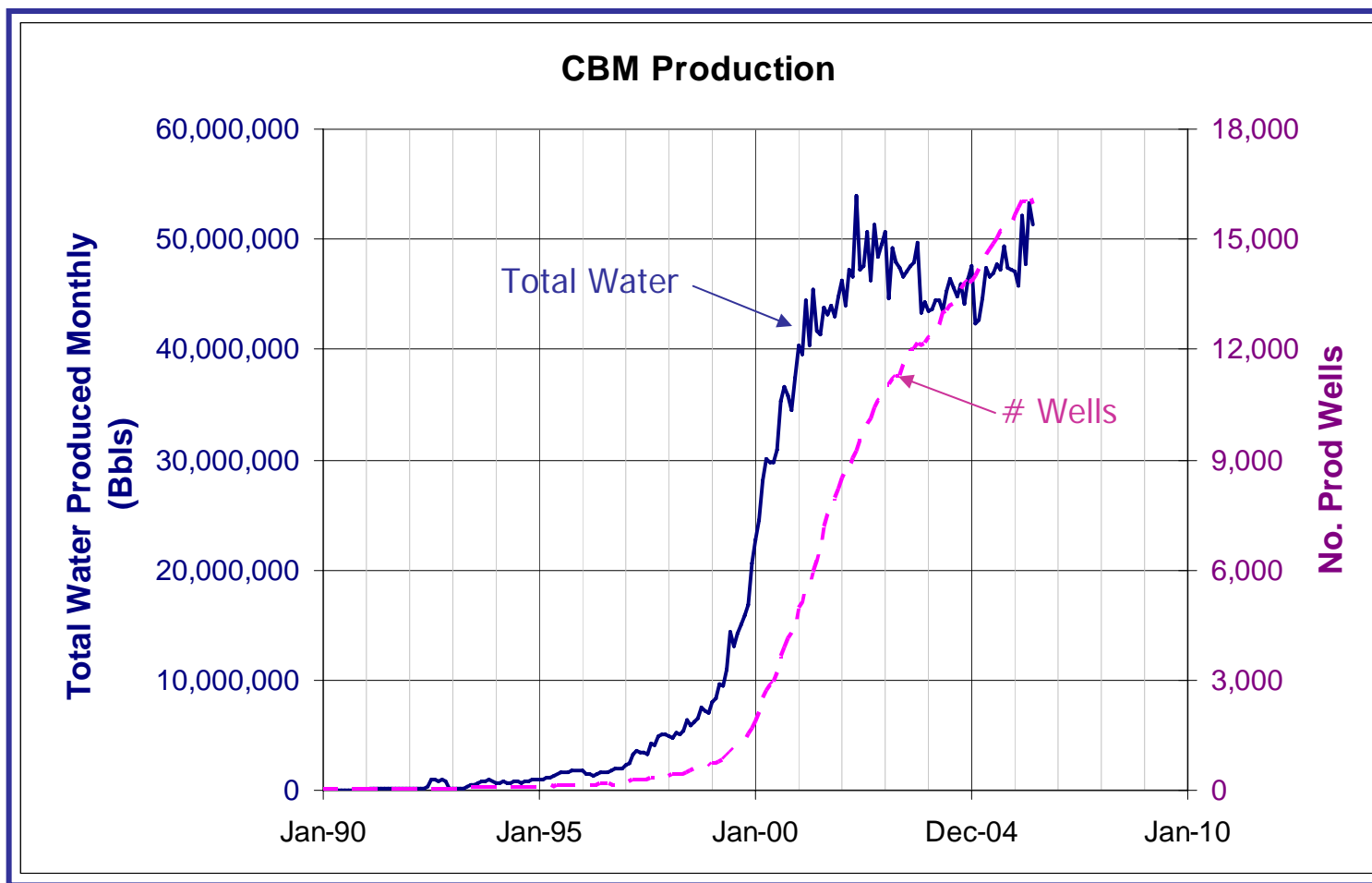


Powder River Watershed

Powder River Basin



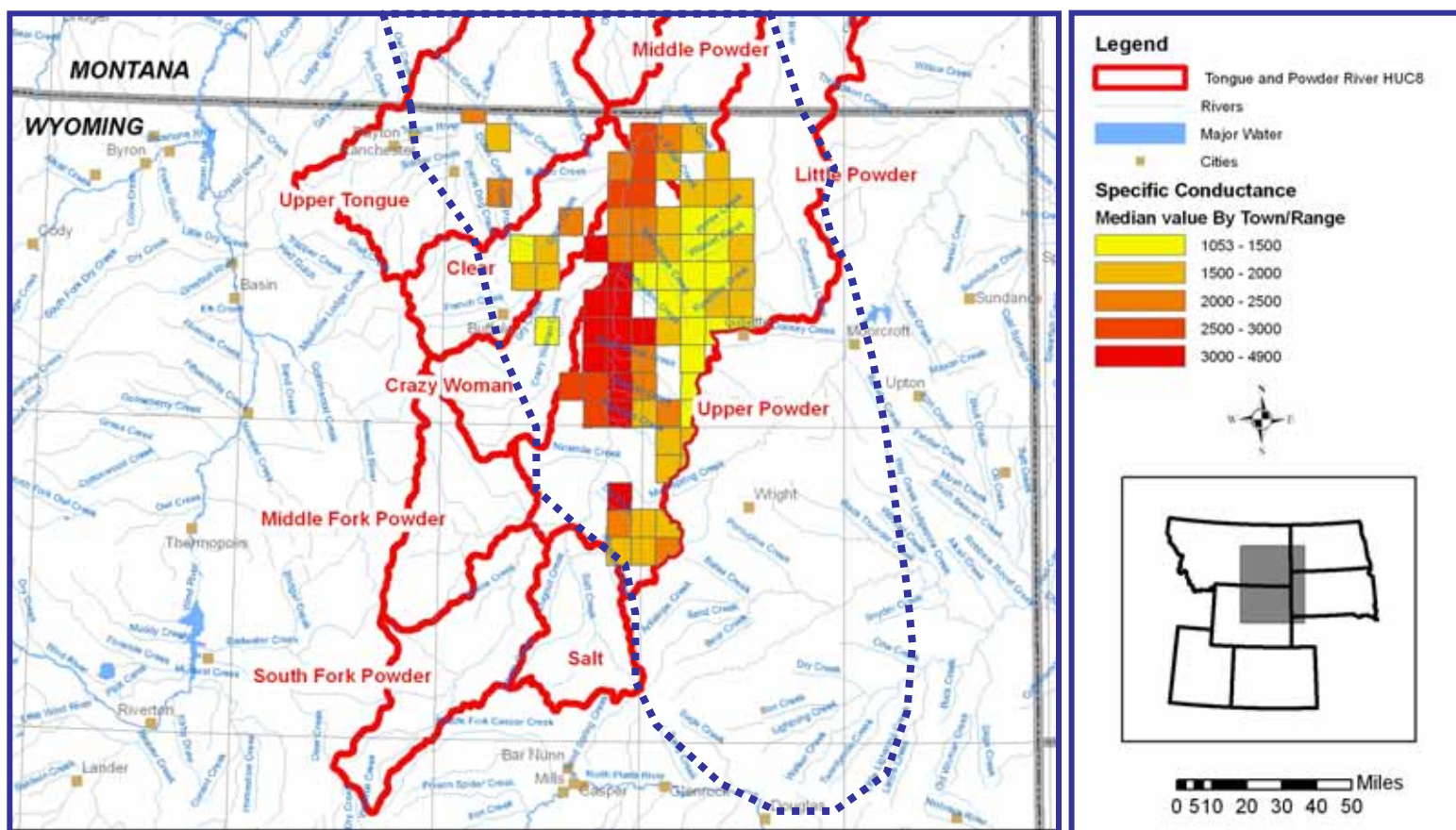
# CBM Water Production Powder River Basin





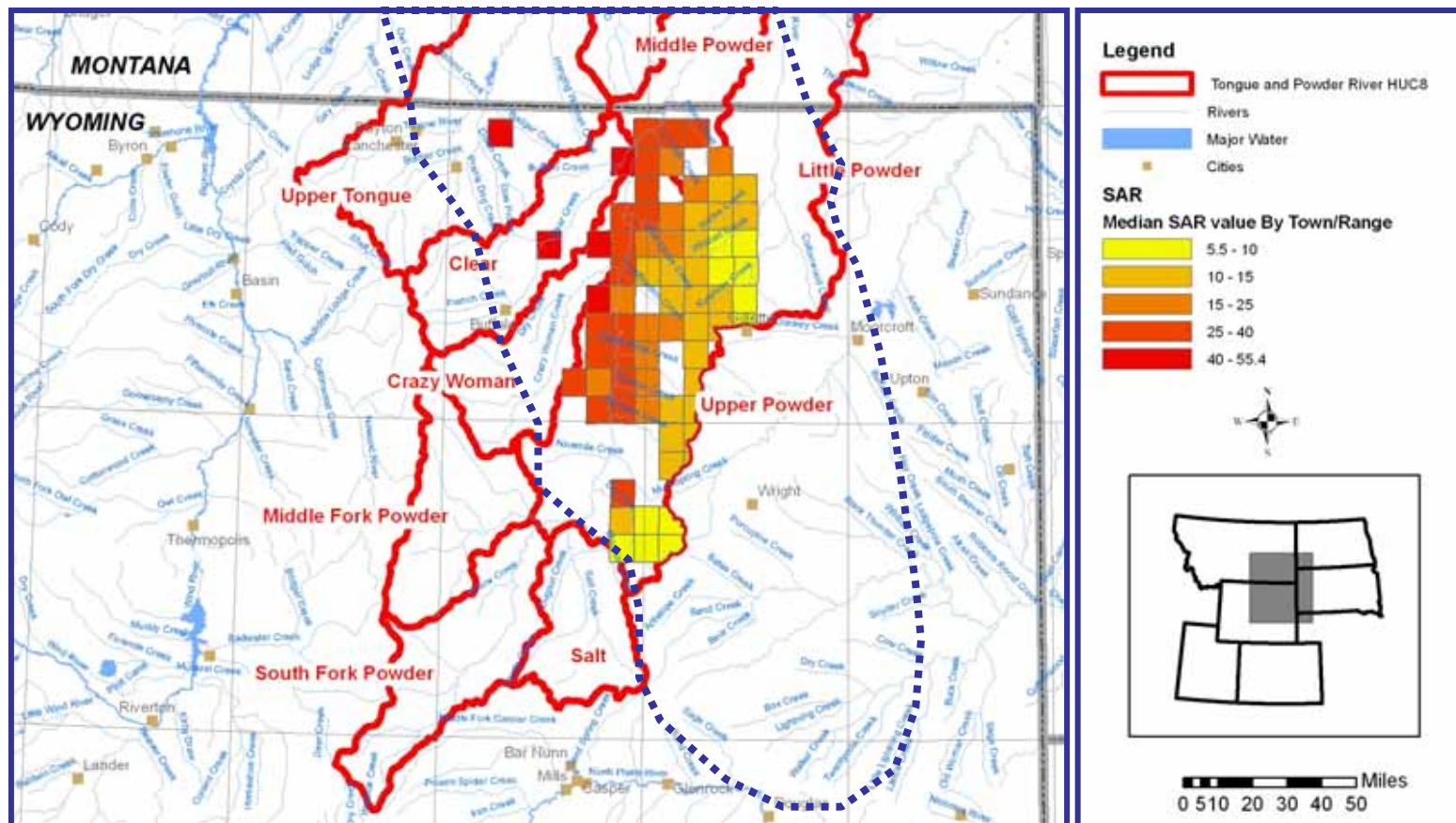


# CBM Water Quality SpC



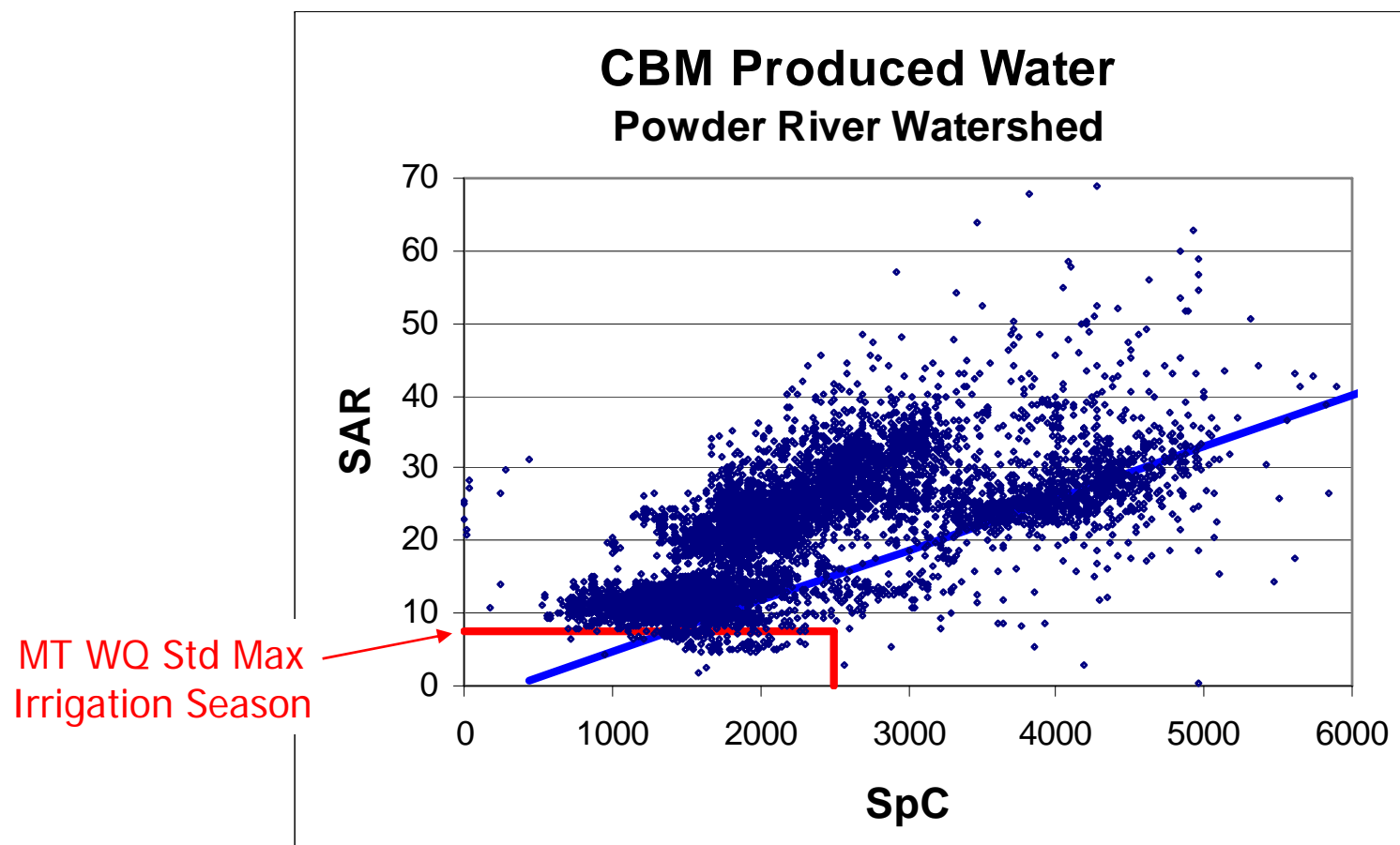


# CBM Water Quality SAR





# CBM Produced Water Quality SpC – SAR Relationship



Data Source: WY DEQ DMR



# CBM Water Quality Data Summary

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- SpC:
  - Median: 1900
  - Range (5% - 95%): 1000 to 4300
  - Lowest concentrations occur in southeast portion of basin.
  - Concentrations generally increase to northwest.
  
- SAR
  - Median: 20
  - Range (5% - 95%): 8 – 35
  - Lowest concentrations occur in southeast portion of basin.
  - Concentrations increase to northwest.



# Powder River Watershed Questions

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# Ambient Stream Water Quality

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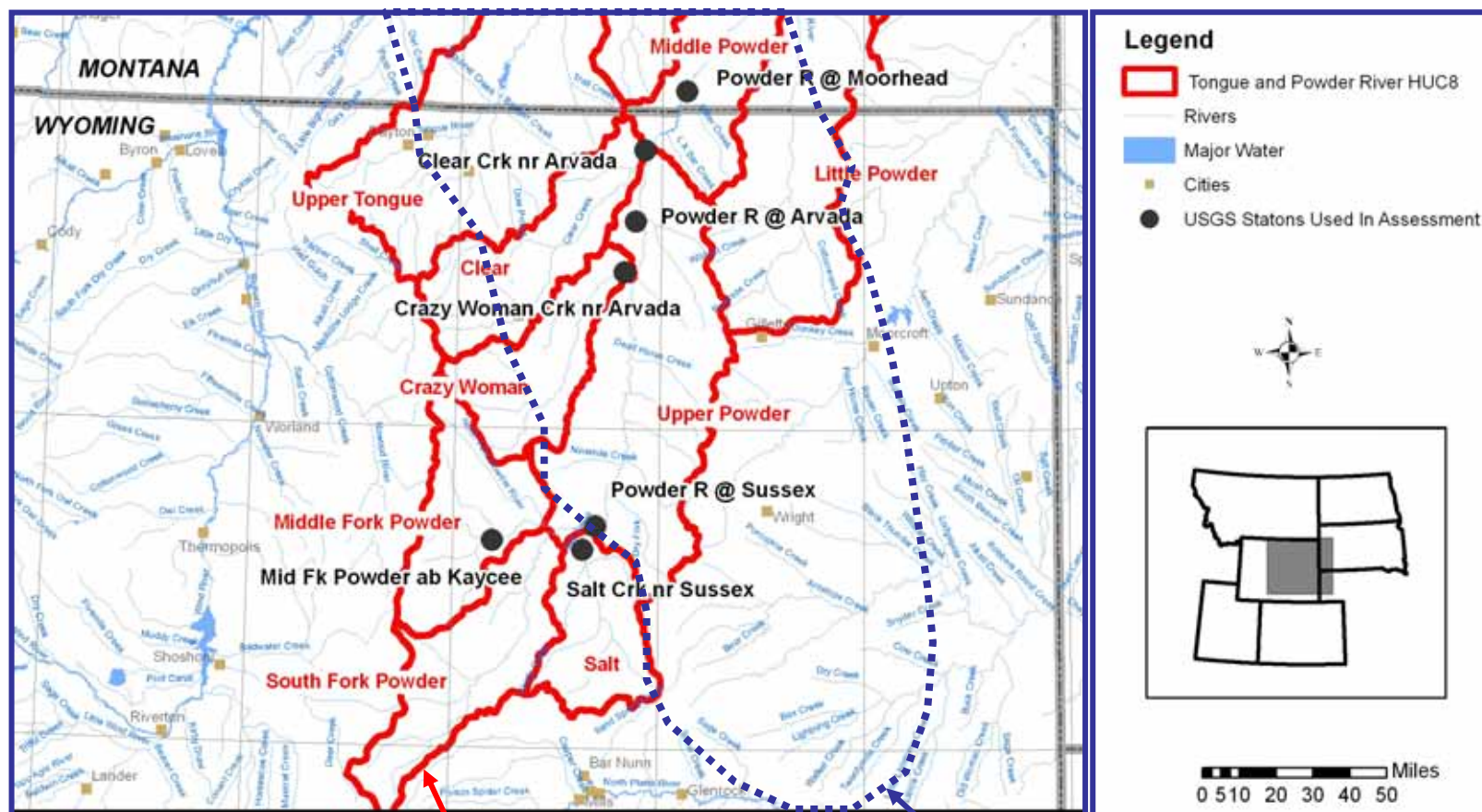
- USGS long term stations
- SpC, SAR, SpC & SAR relationships
- Time series analysis
- Flow versus concentration relationships
- Month statistics
- Comparison to MT WQ Stds



DRAFT: Preliminary Observations



# Powder River Watershed Powder River Basin

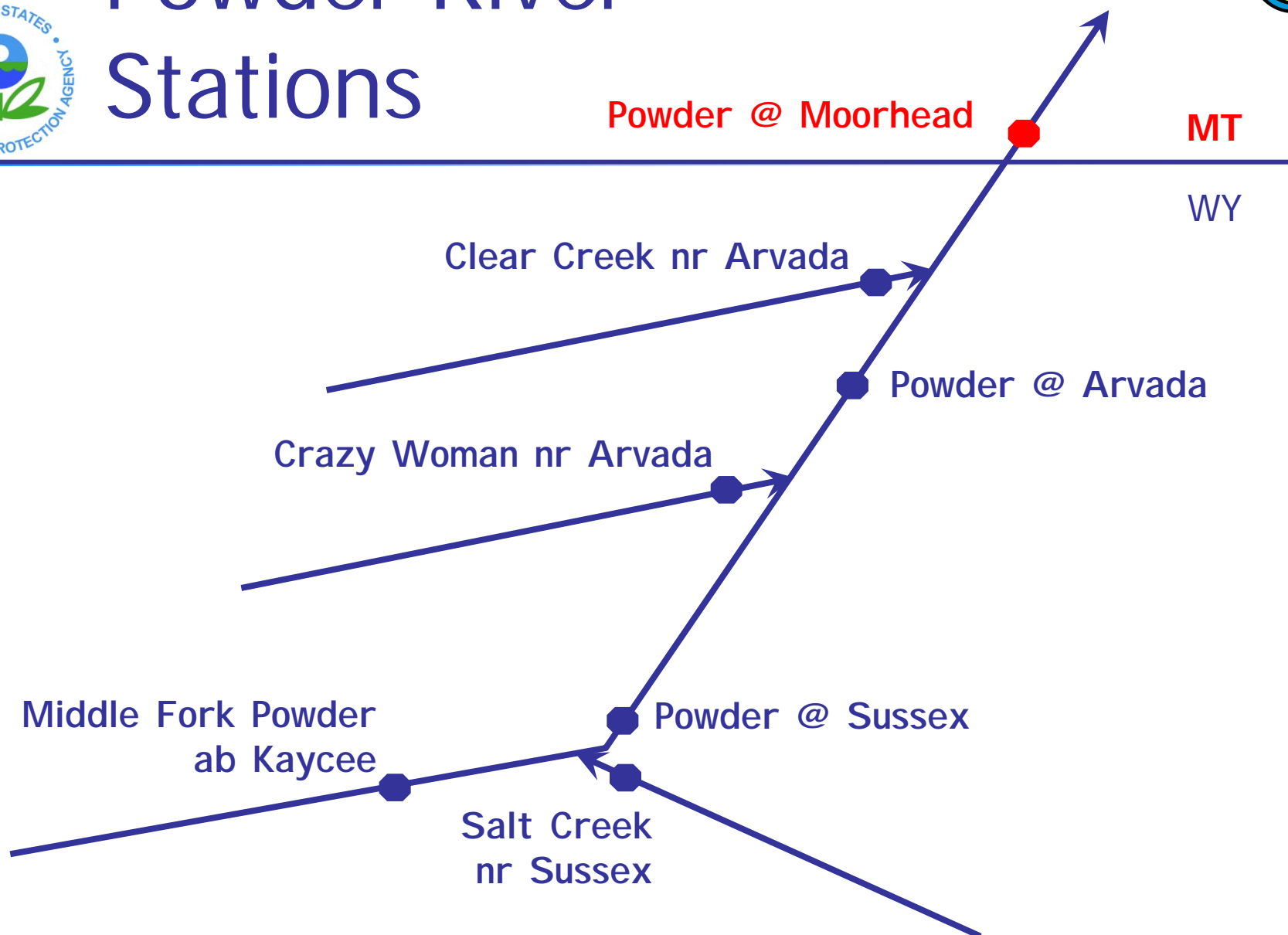


Powder River Watershed

Powder River Basin



# Powder River Stations



# DRAFT: Preliminary Observations

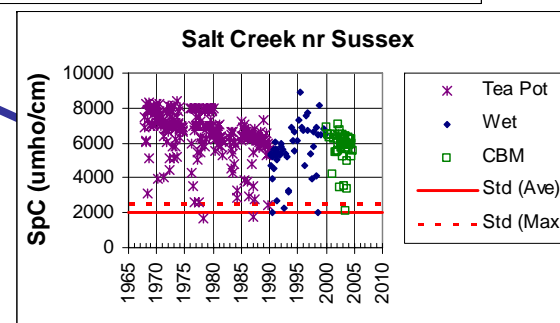
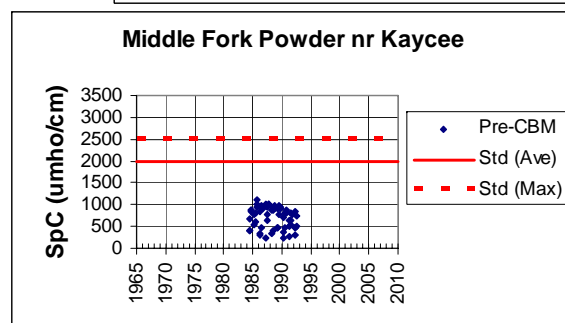
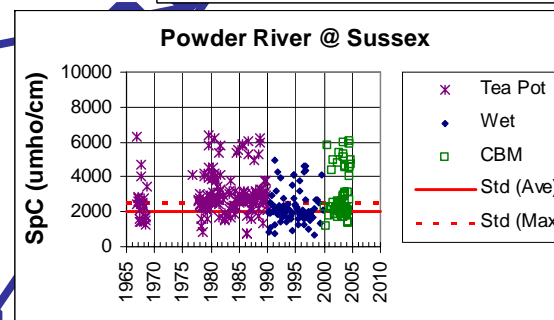
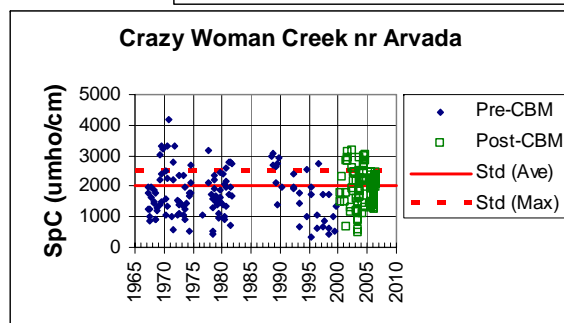
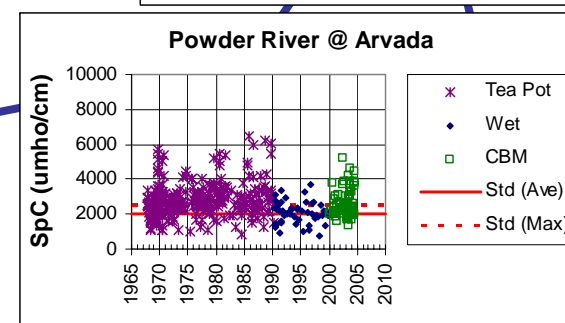
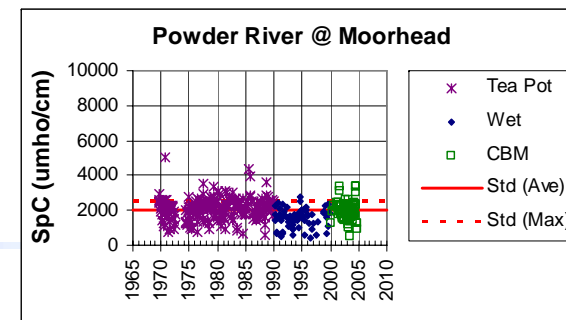
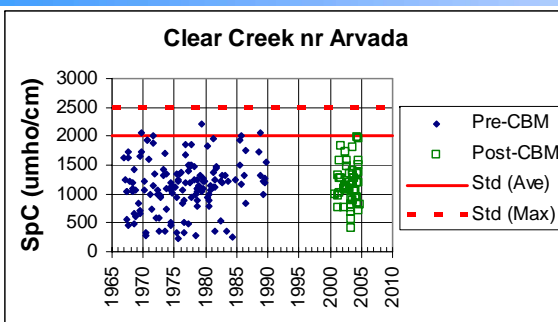


## SpC

**Tea Pot:** < Feb 1990

**Wet:** 1990 – 1999 (No O&G Discharge)

**CBM:** >= 2000 (CBM Production)



# DRAFT: Preliminary Observations

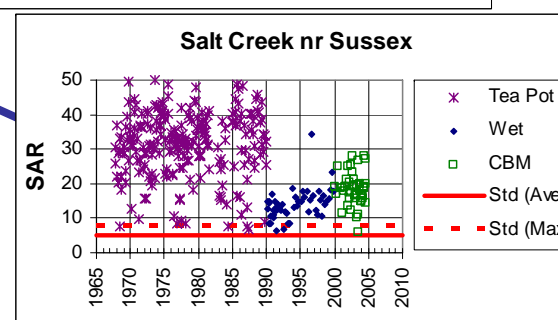
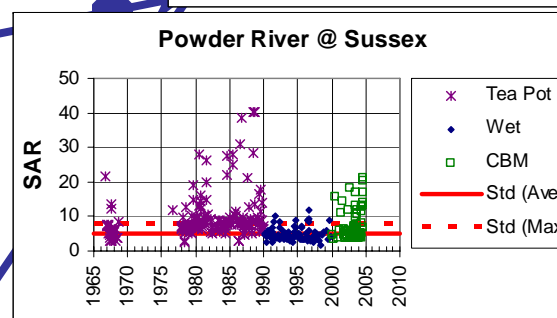
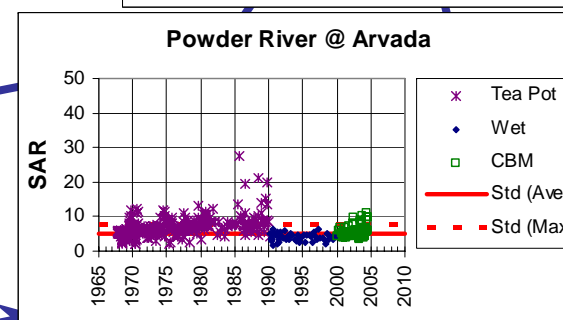
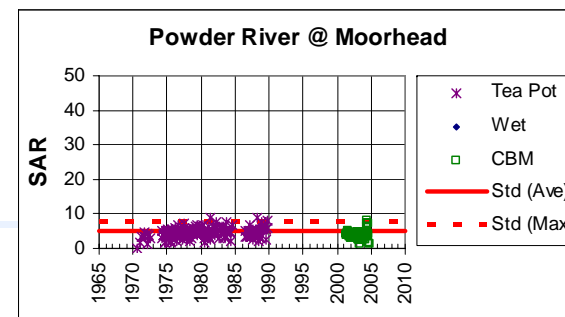
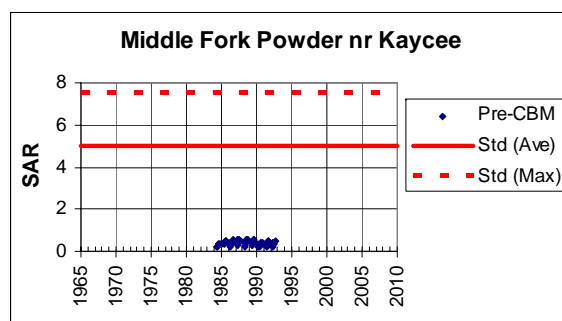
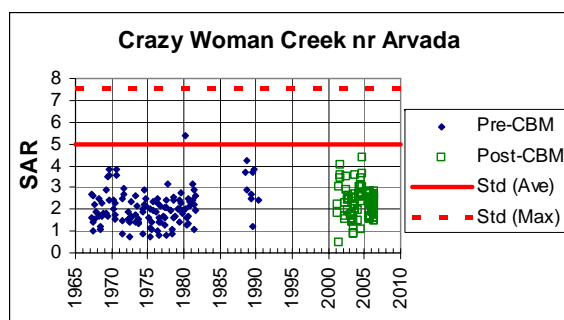
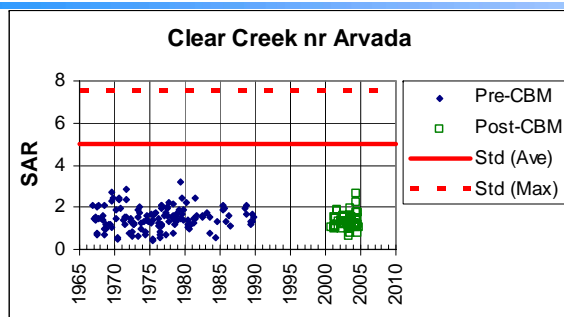


## SAR

**Tea Pot:** < Feb 1990

**Wet:** 1990 – 1999 (No O&G Discharge)

**CBM:** >= 2000 (CBM Production)

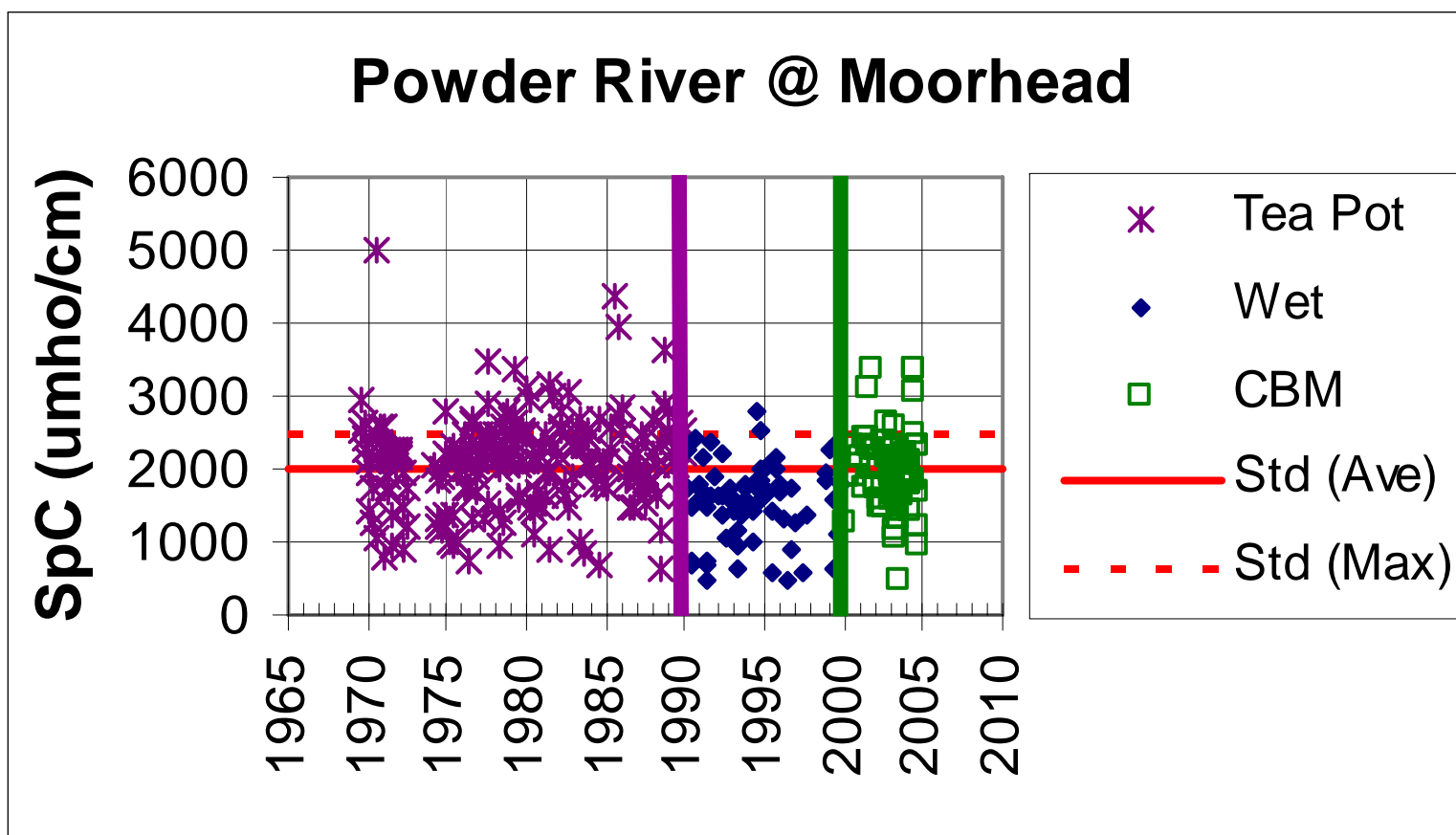




# SpC

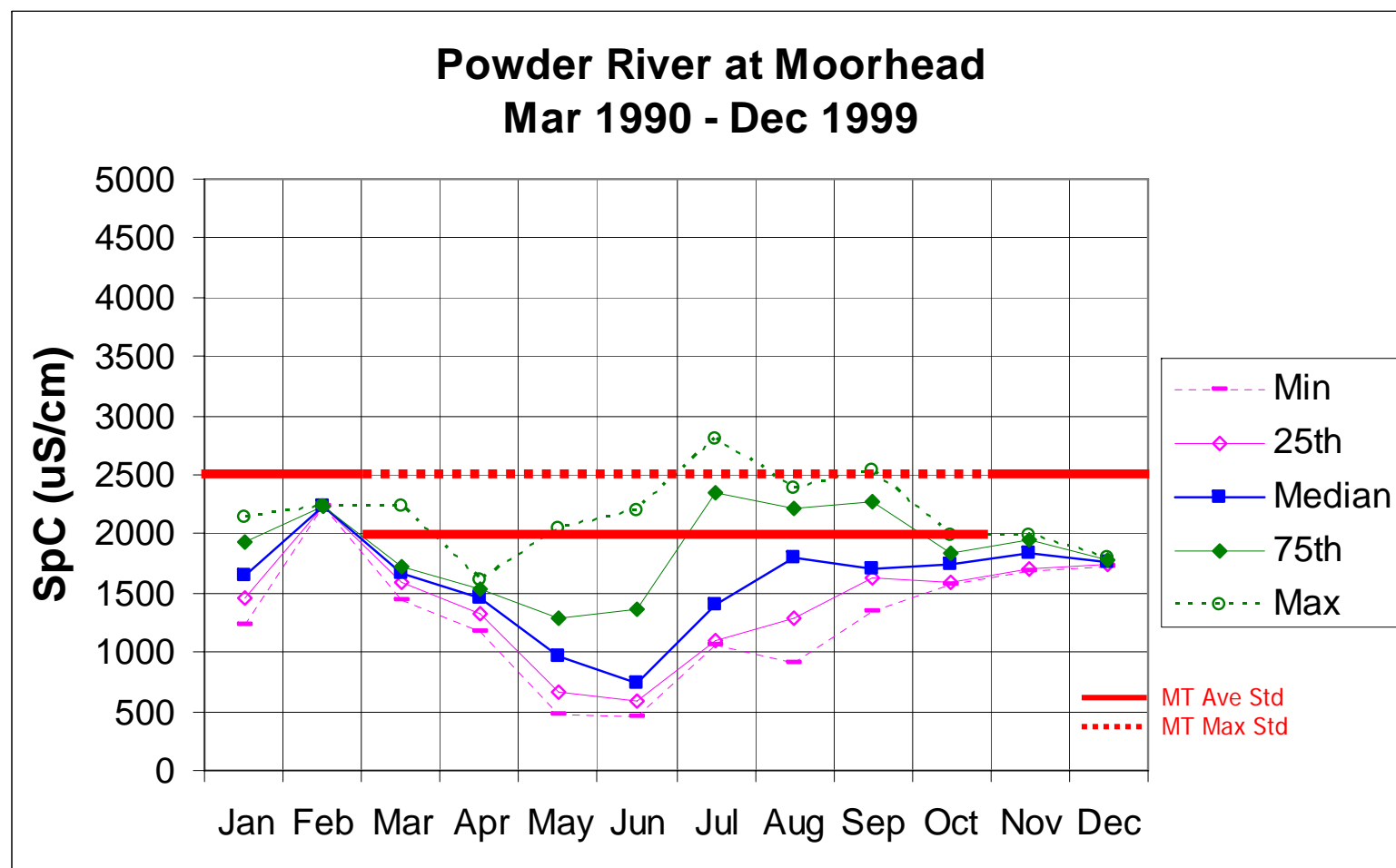
## Powder River at Moorhead

- What is the time period that represents “natural” background?





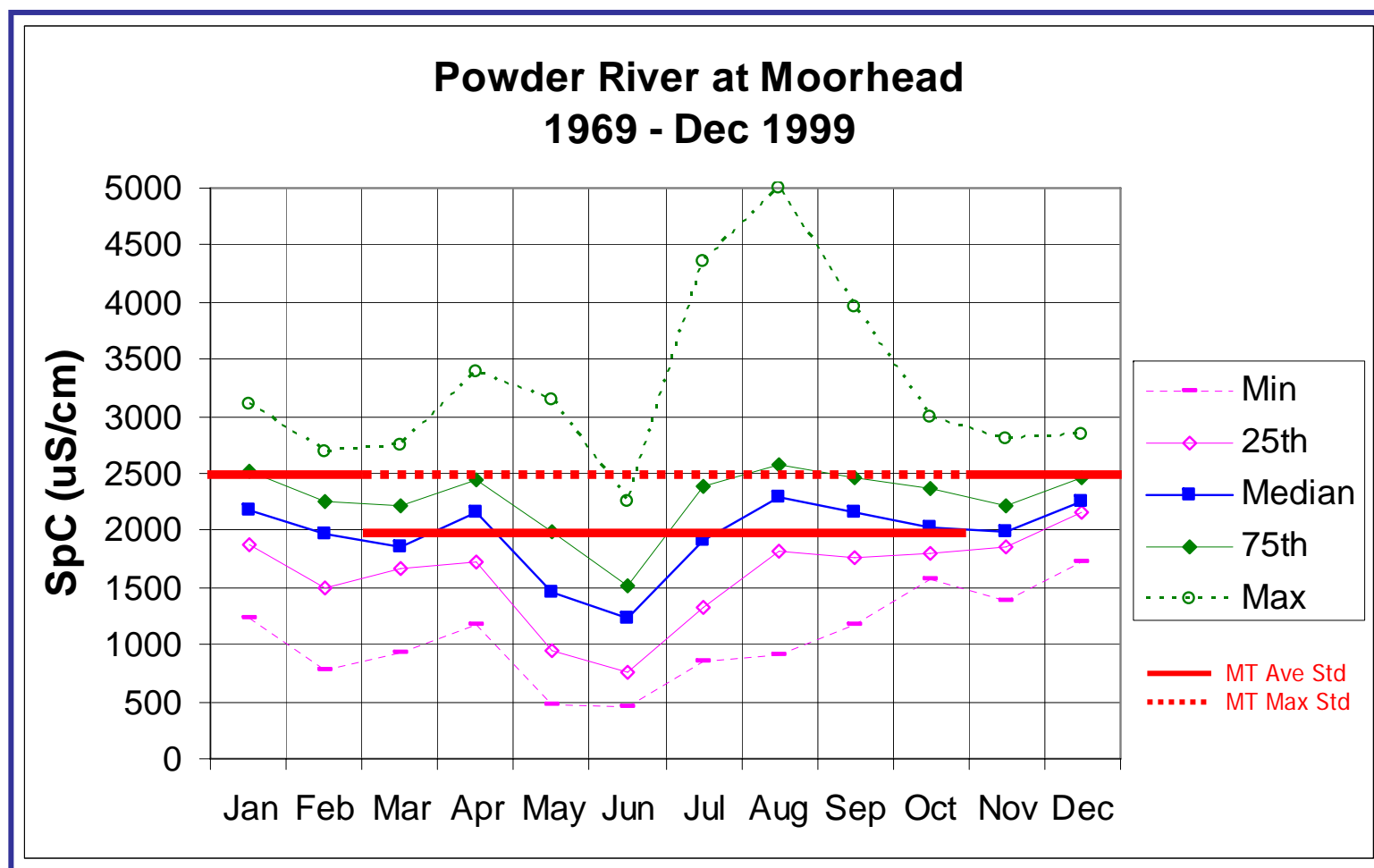
# Powder River at Moorhead SpC Statistics 1990-1999 by Month







# Powder River at Moorhead SpC Statistics 1969-1999 by Month





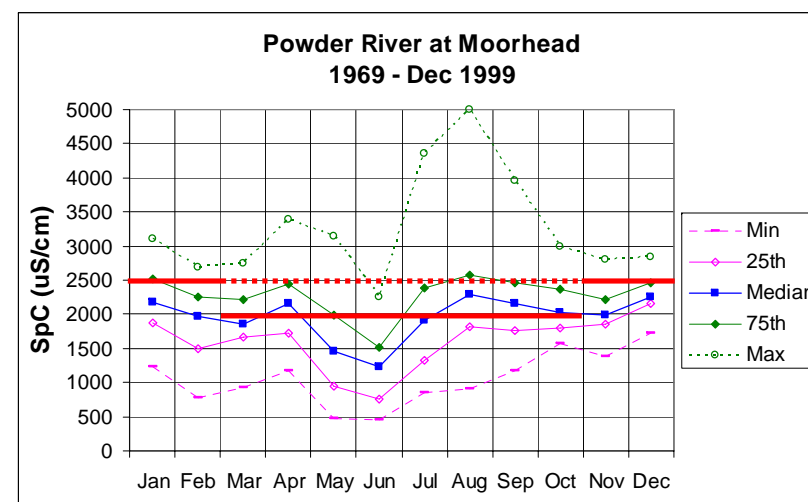
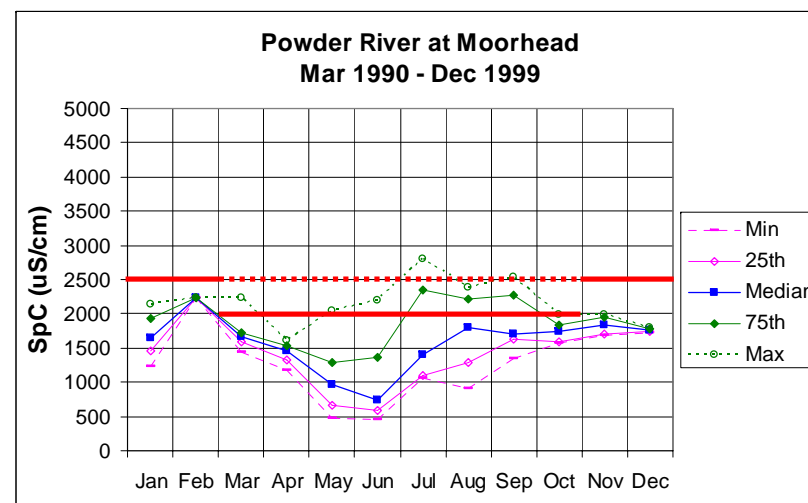
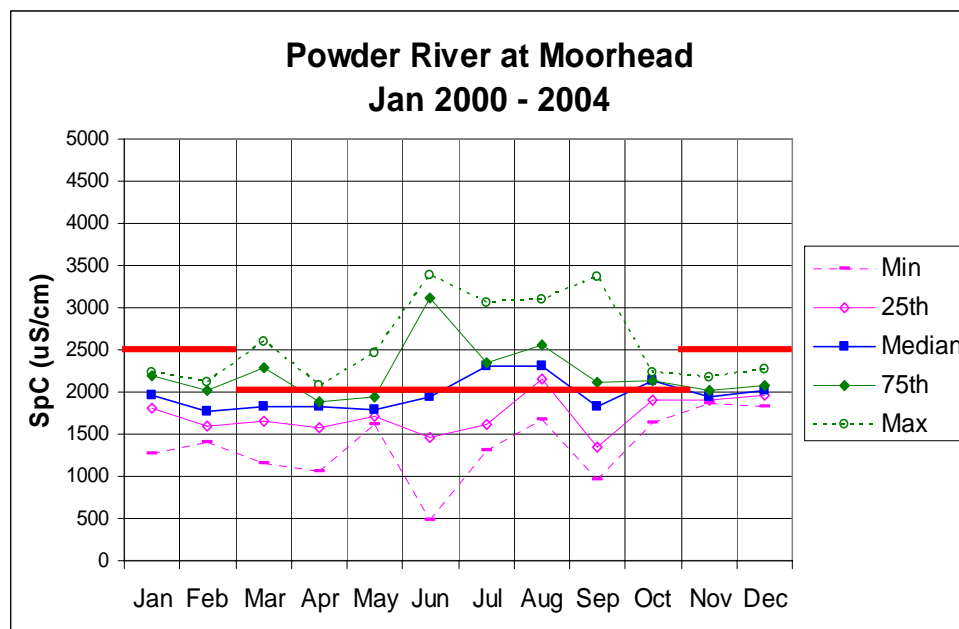
## Powder River Watershed Questions

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# Powder River at Moorhead SpC Statistics by Month

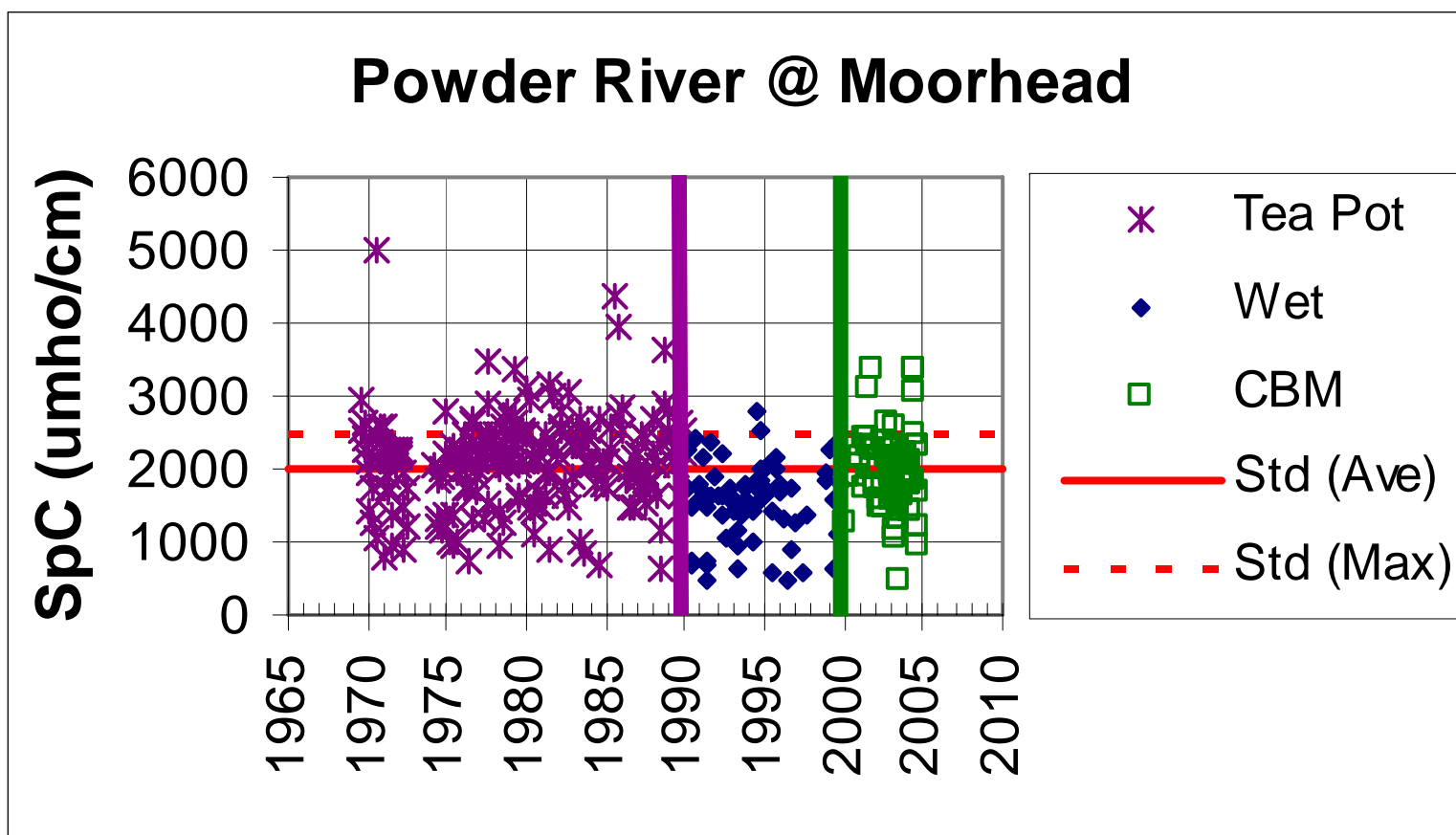




# SpC

## Powder River at Moorhead

- What is the time period that represents “natural” background?

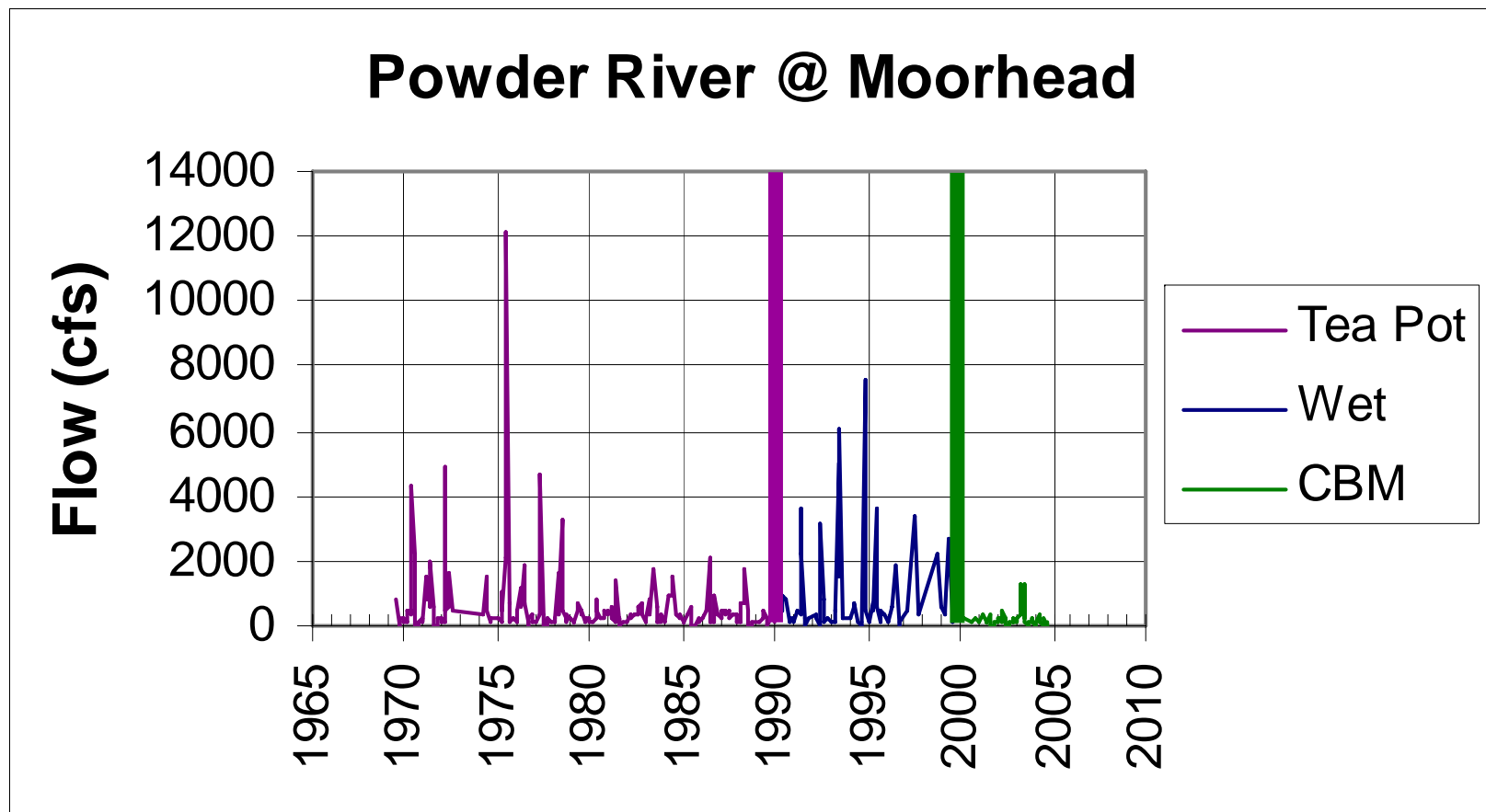




# Flow

## Powder River at Moorhead

- What impact has the drought had on water quality?

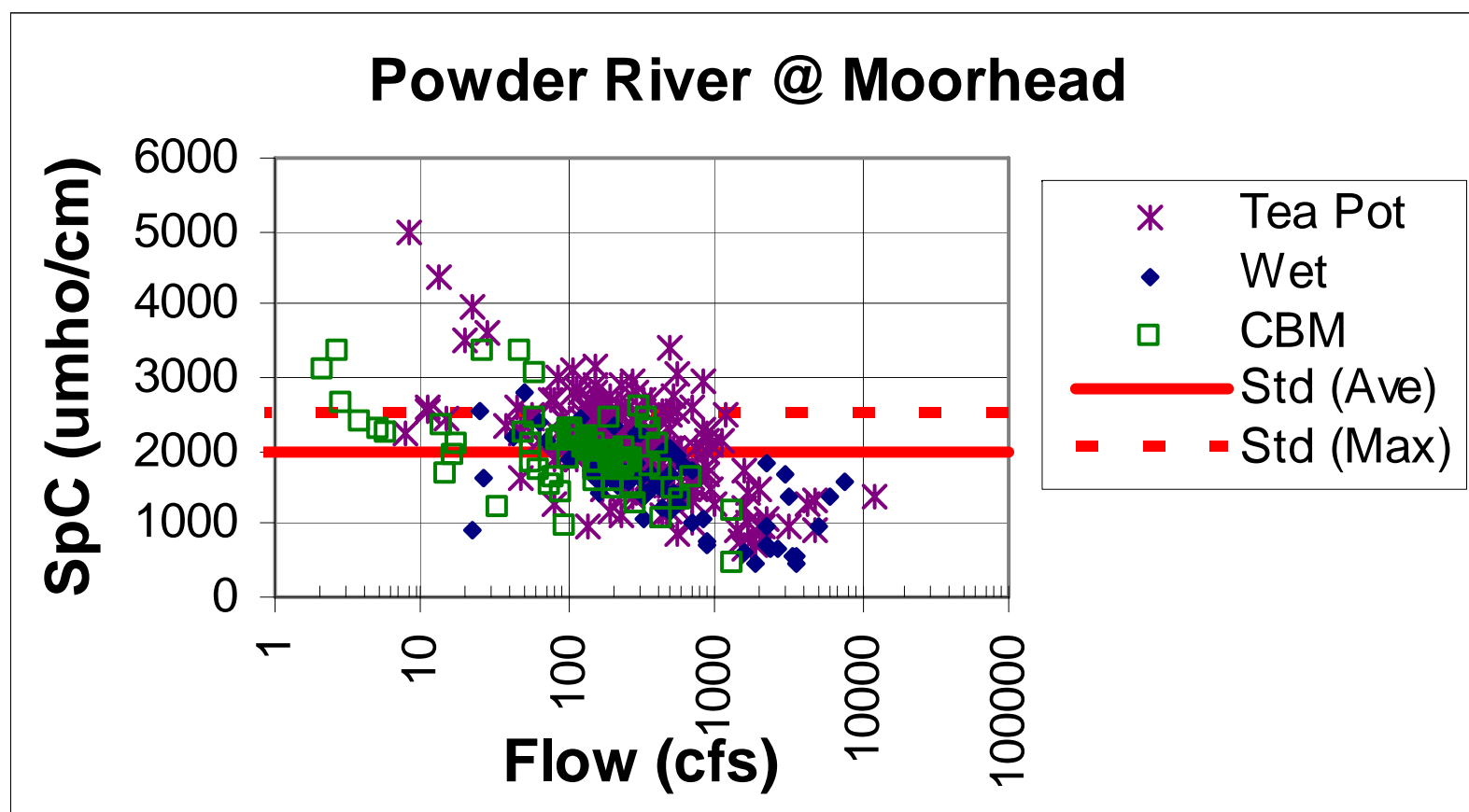




# Flow vs SpC

## Powder River at Moorhead

- What are the relationships between flow and water quality?







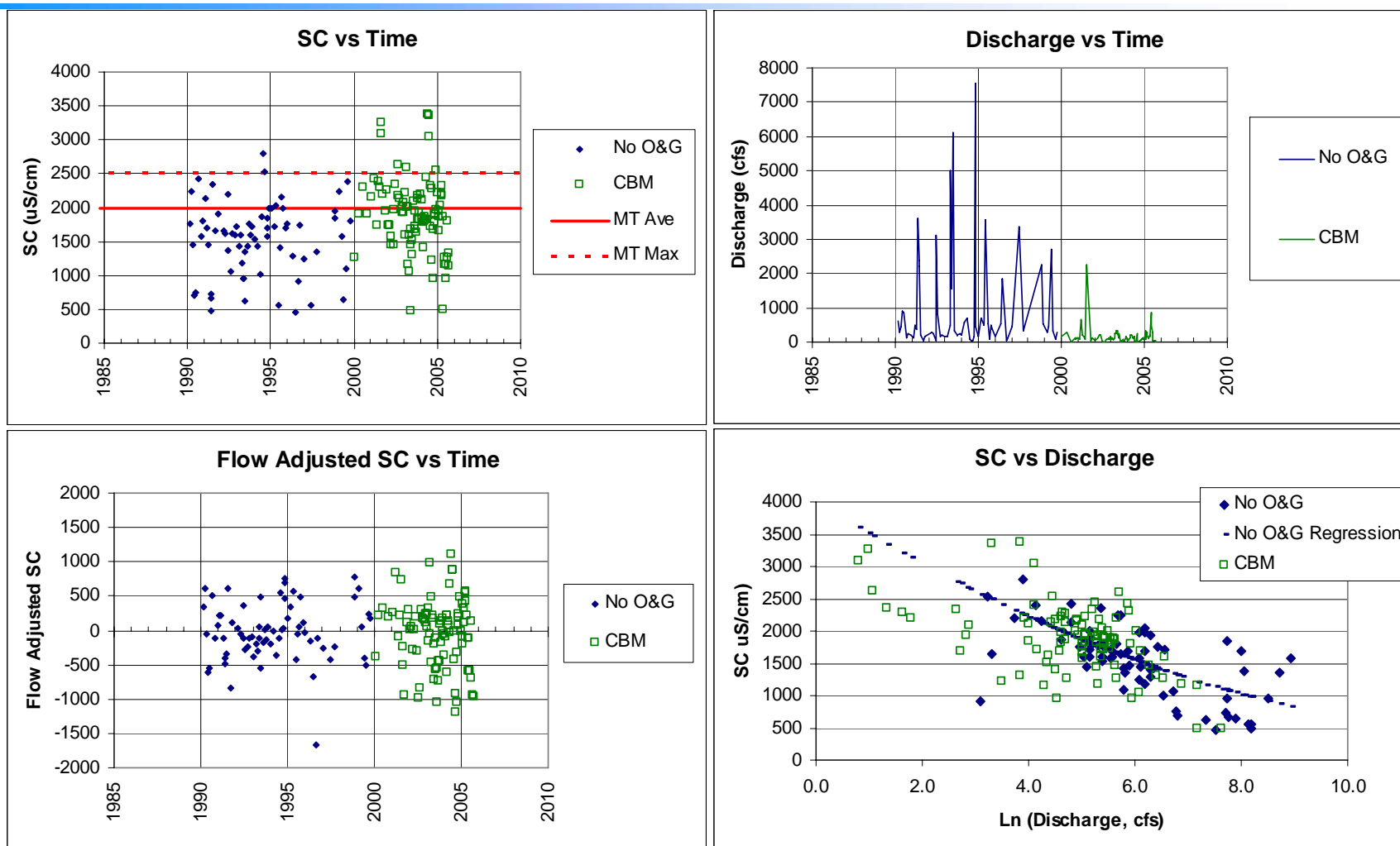
# Flow-Adjusted Concentration Technical Approach

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1. Apply regression analysis to unambiguously, un-impacted, "wet" time period data.
2. Calculate predicted and residual (flow-adjusted) concentrations for all time periods using regression equation fit to "wet" time period data.
3. Verify validity of regression by comparing predicted and residual concentrations.
4. Evaluate flow-adjusted concentrations using parametric and non-parametric statistical tests to compare data from different time periods.



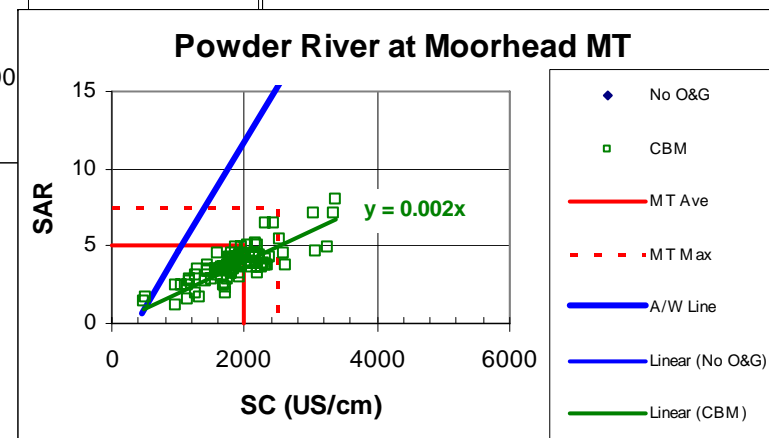
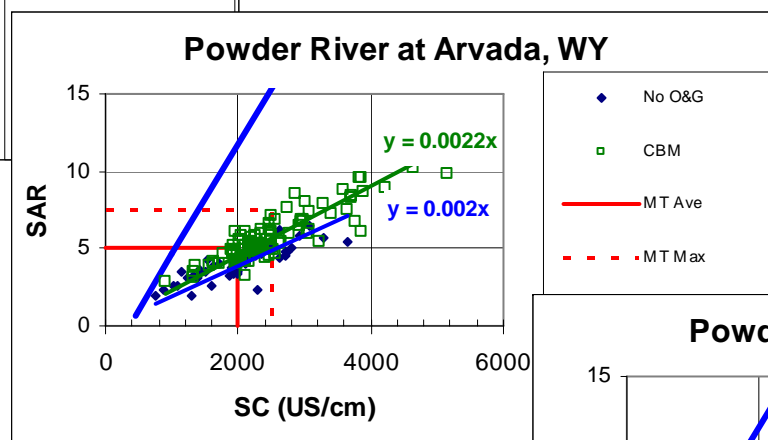
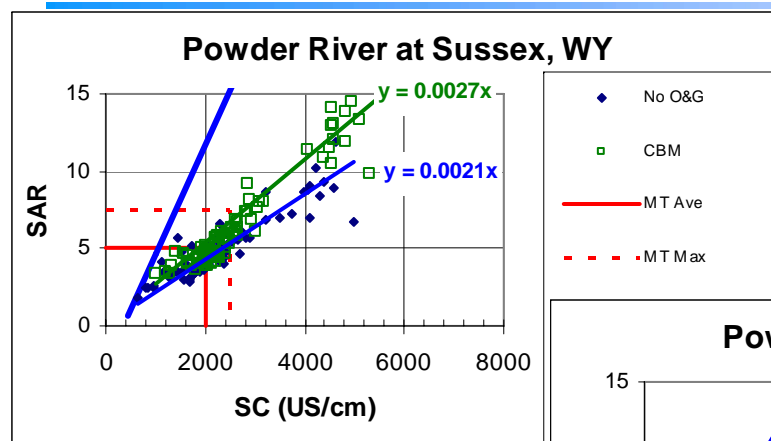
# Flow Adjusted SpC Powder River at Moorhead



# SAR?



(Not analyzed 1990-99 at Powder River at Moorhead)

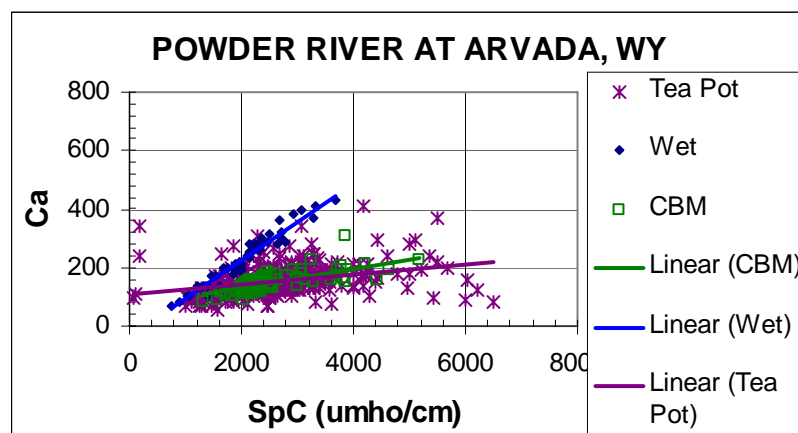
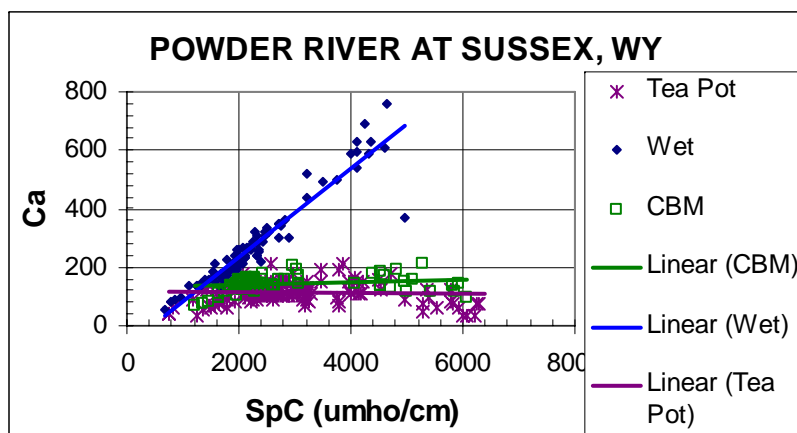




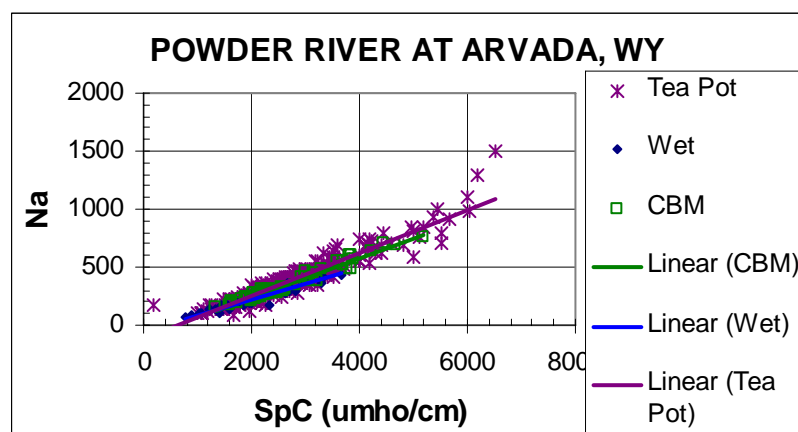
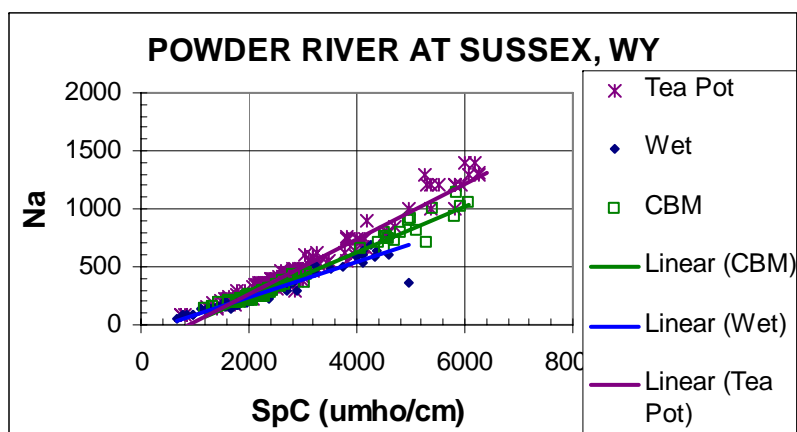
# SpC vs Calcium & Sodium

## Powder River at Sussex & Arvada

CALCIUM



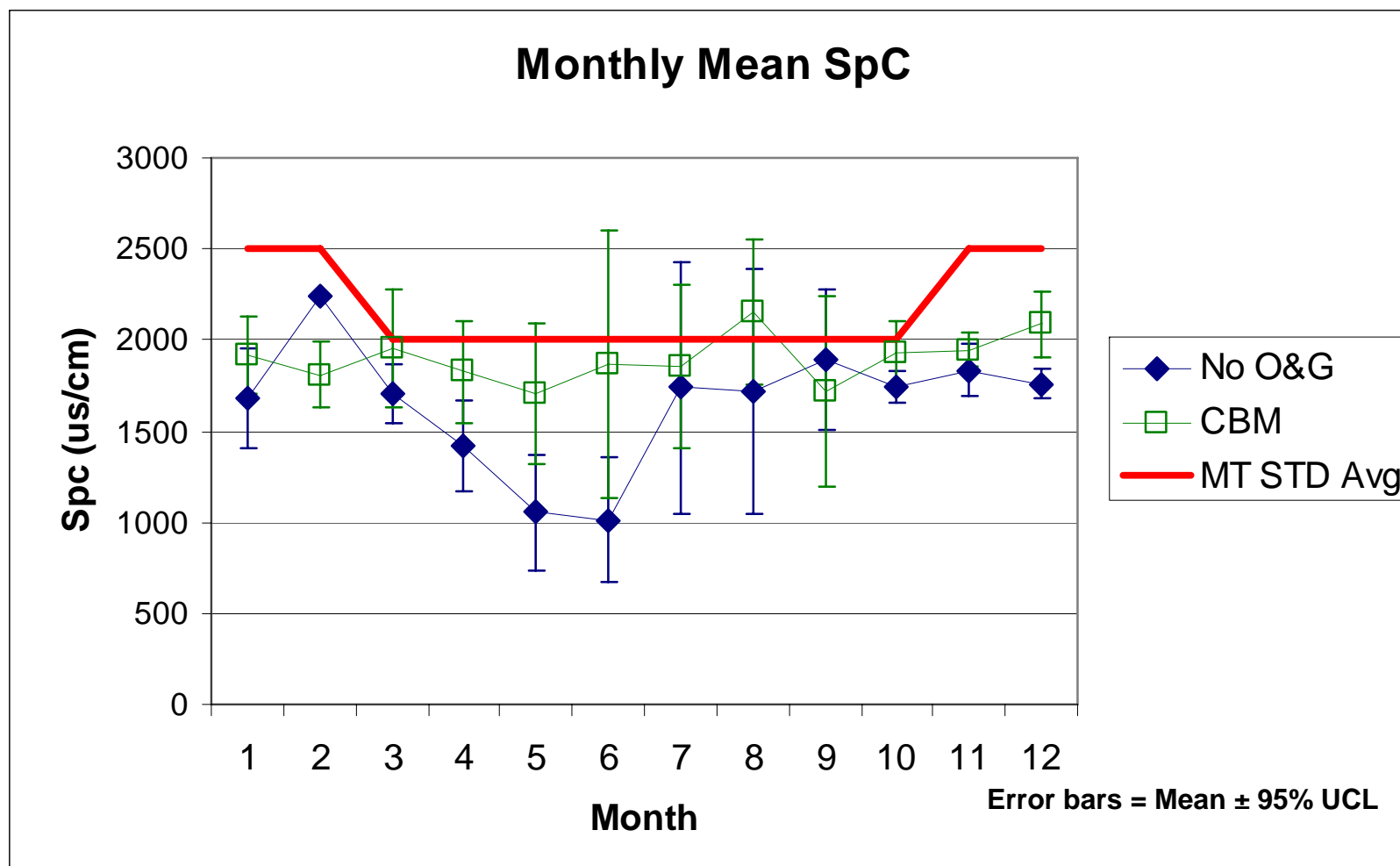
SODIUM





# Powder River at Moorhead

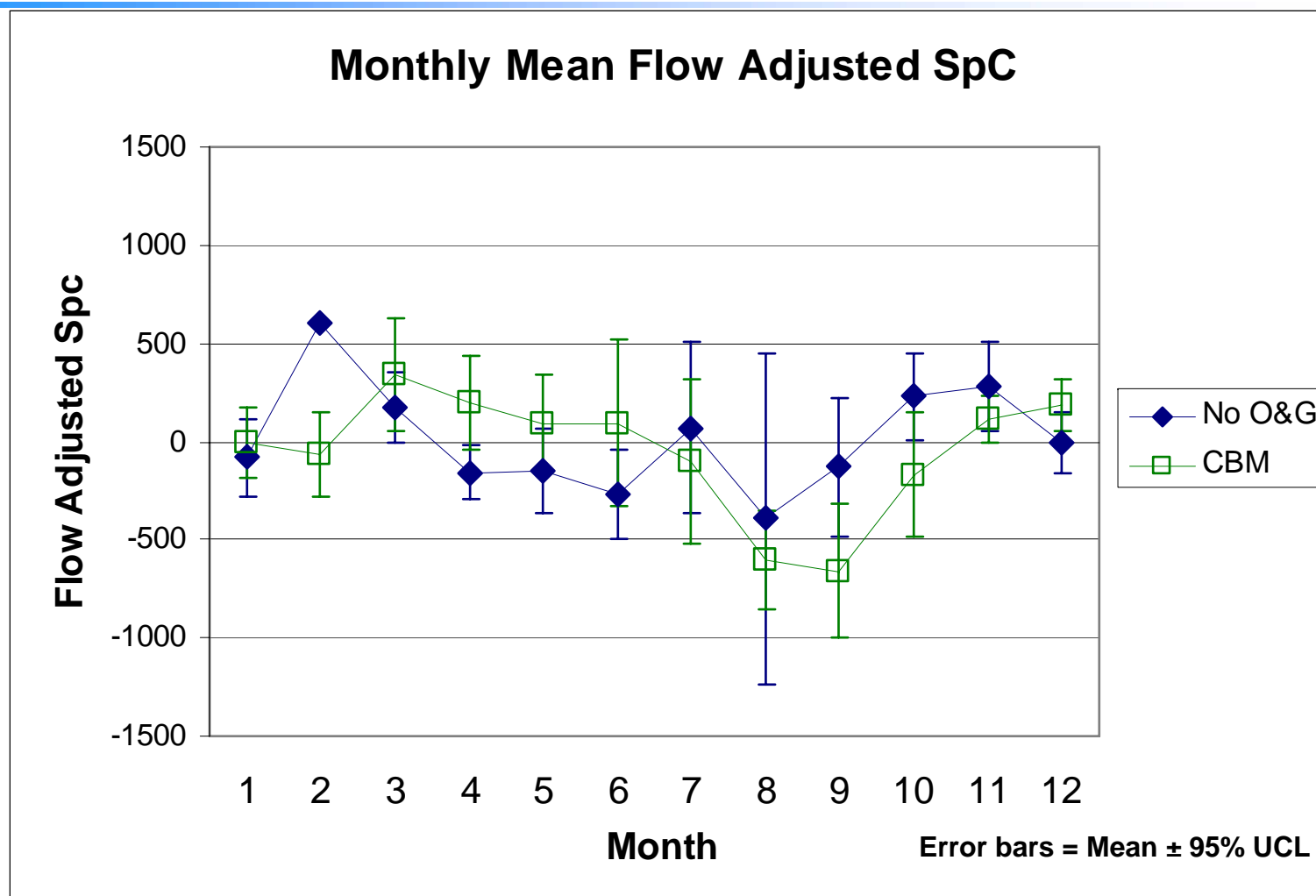
## Monthly Mean SpC





# Powder River at Moorhead

## Monthly Mean Flow Adjusted SpC







# Technical Summary

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- Because of varying climate conditions and historical oil and gas operations in the basin, the available data do not allow an unambiguous determination of the impacts of CBM discharge on SpC and SAR in the Powder River at Moorhead.
- When the data are considered in aggregate, existing discharge and SpC relationships appear to suggest that there has been no statistically significant impact from CBM operations on SpC in the Powder River at Moorhead.
- Also, when the data are considered in aggregate, existing SAR and SpC relationships appear to suggest there has been no significant impact from CBM operations on SAR in the Powder River at Moorhead.
- When monthly flow adjusted SpC statistics for the Powder River at Moorhead are considered, most months show no statistically significant impact from CBM operations. The exception is April, where flow adjusted SpC since CBM operations commenced is statistically greater than that of the period 1990-1999 when there was no discharge due to oil & gas operations.
- The quality of discharge from CBM activities in the Powder River may deteriorate as development moves west and north, due to increased salinity in groundwater, and therefore may impact stream water quality in the future.