

# The importance of long-term monitoring around energy development:

Lessons learned about the value  
of water monitoring around coal  
and CBM development in  
southeastern Montana

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# Long-term monitoring: Structure

- The impetus:
  - Local Concern
    - Coalbeds serve multiple purposes
    - Mixed reactions from landowners based on Wyoming's experience with CBM development
  - CBM Environmental Impact Statement (EIS)
    - Co-written by the US BLM and MT Board of Oil and Gas
    - Stipulated monitoring through development and recovery by an agency like the MBMG
    - Monitoring modeled after the MBMG coal monitoring program
  - Controlled Groundwater Basin
    - PRB CGWA applies only to CBM wells
    - Established a Technical Advisory Council to monitor for impacts and MBMG supplies an annual report of monitoring

# Long-term monitoring: Structure

- The impetus:

## Coal Mine Bond Release: MT ARM 17.24.1116

- Phase I: backfilling, grading and drainage control.
- Phase II: soil replacement, two seasons of established vegetation, control of noxious weeds, farmland returned to a predetermined level of production.
- Phase III: Responsibility period has elapsed, vegetation is established, landscape is stable.
- **Phase IV:** Fish and wildlife habitats have been restored. ***Hydrologic balance disturbance has been minimized.*** Alternative water supplies to replace those that were adversely affected are functional. ***The reestablishment of essential hydrologic functions*** and agricultural productivity on alluvial valley floors ***has been achieved.***

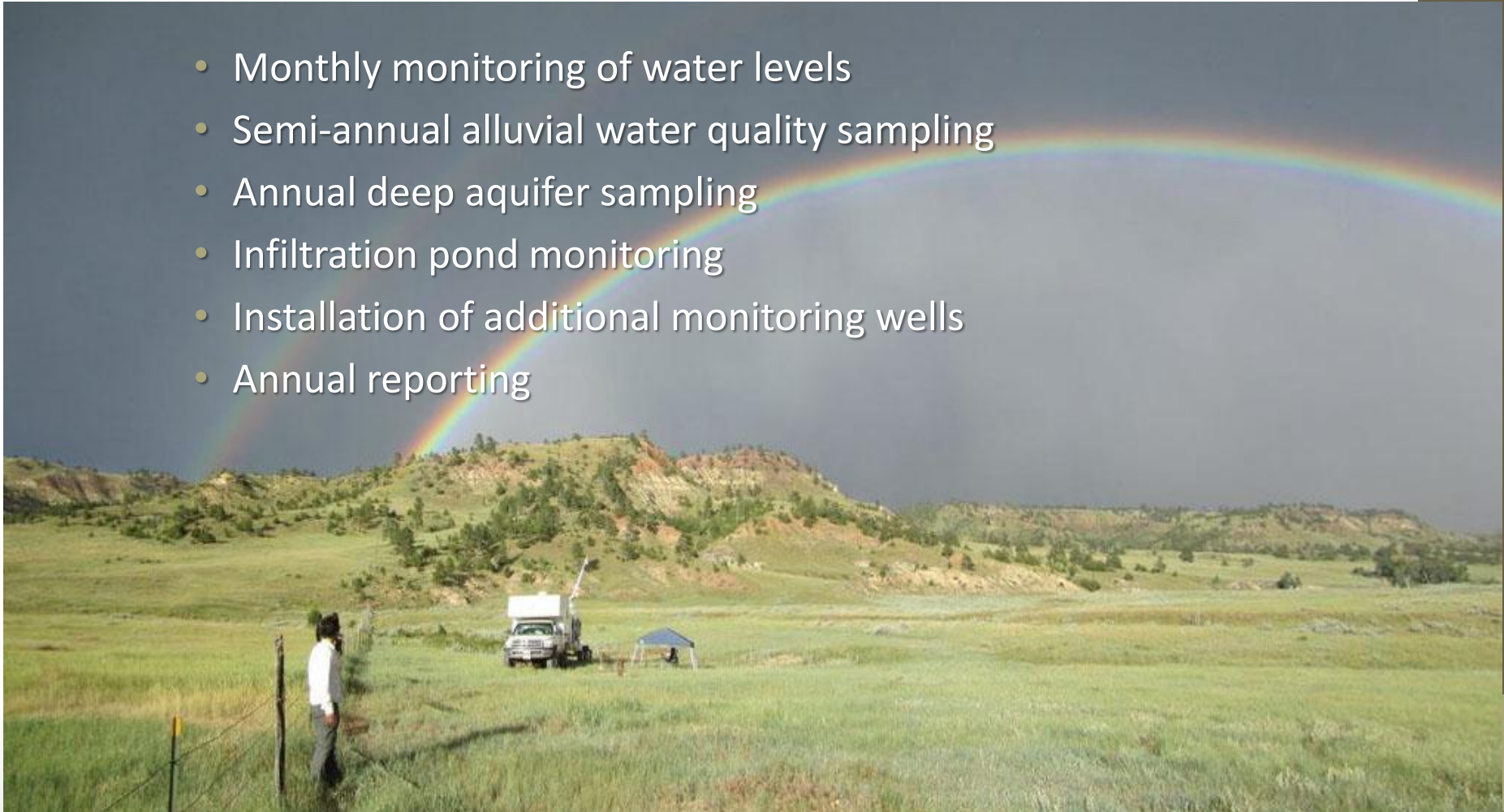
(Of the 34,484 disturbed acres, 50 acres have received MT Phase IV bond release – 0.1%, June 30, 2010)

# Long-term monitoring: Structure

- Partners:
  - Resource agencies – BLM, DNRC, USFS
  - Landowners
  - Industry
- The funding:
  - Bureau of Land Management (long-term)
  - US Forest Service (long-term)
  - Montana State (project specific)
  - Local Conservation Districts (long-term & project specific)
  - US EPA (project specific)
  - US DOE (project specific)

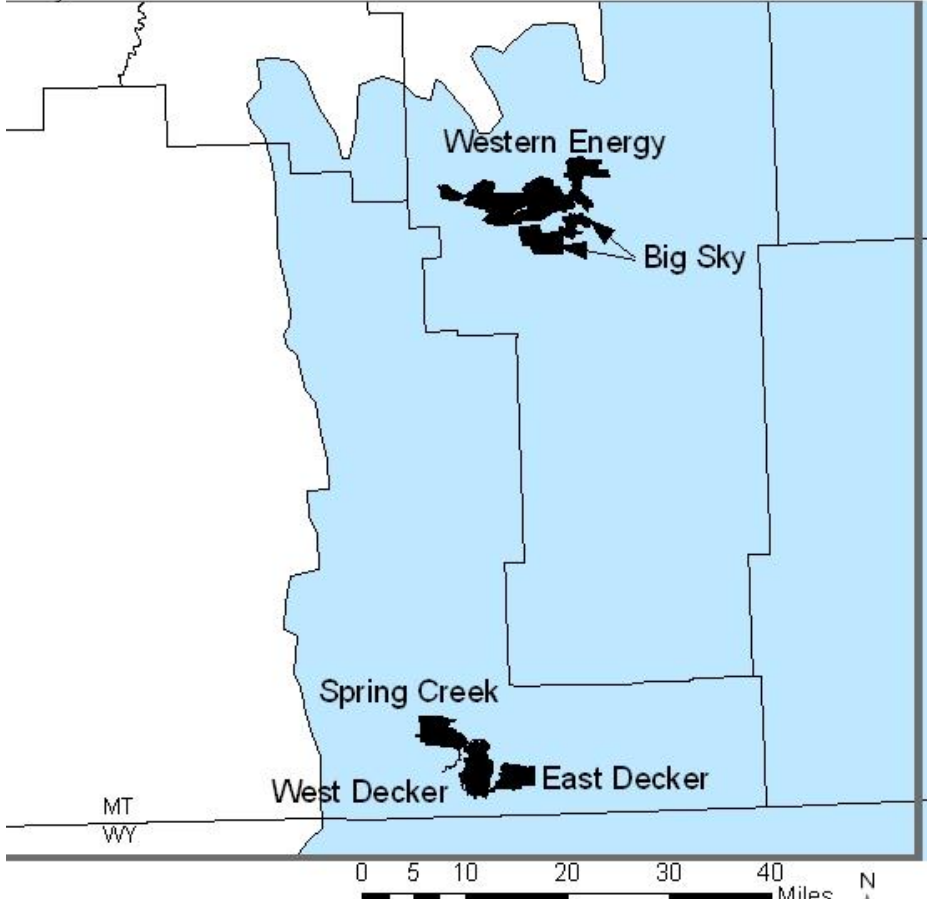
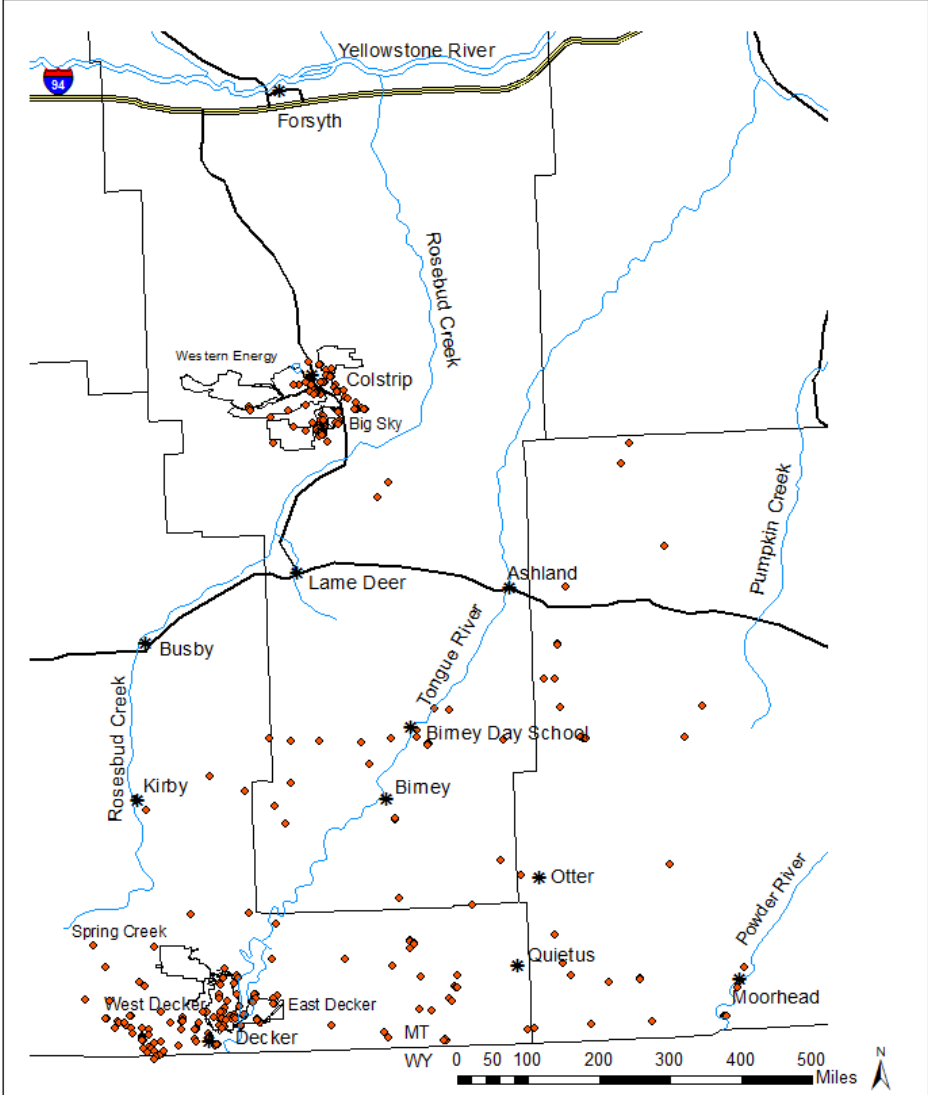
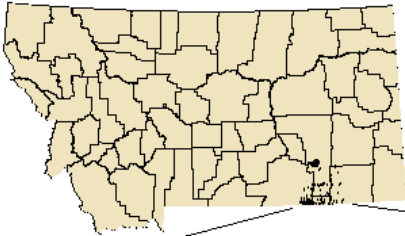
# Long-term monitoring: Structure

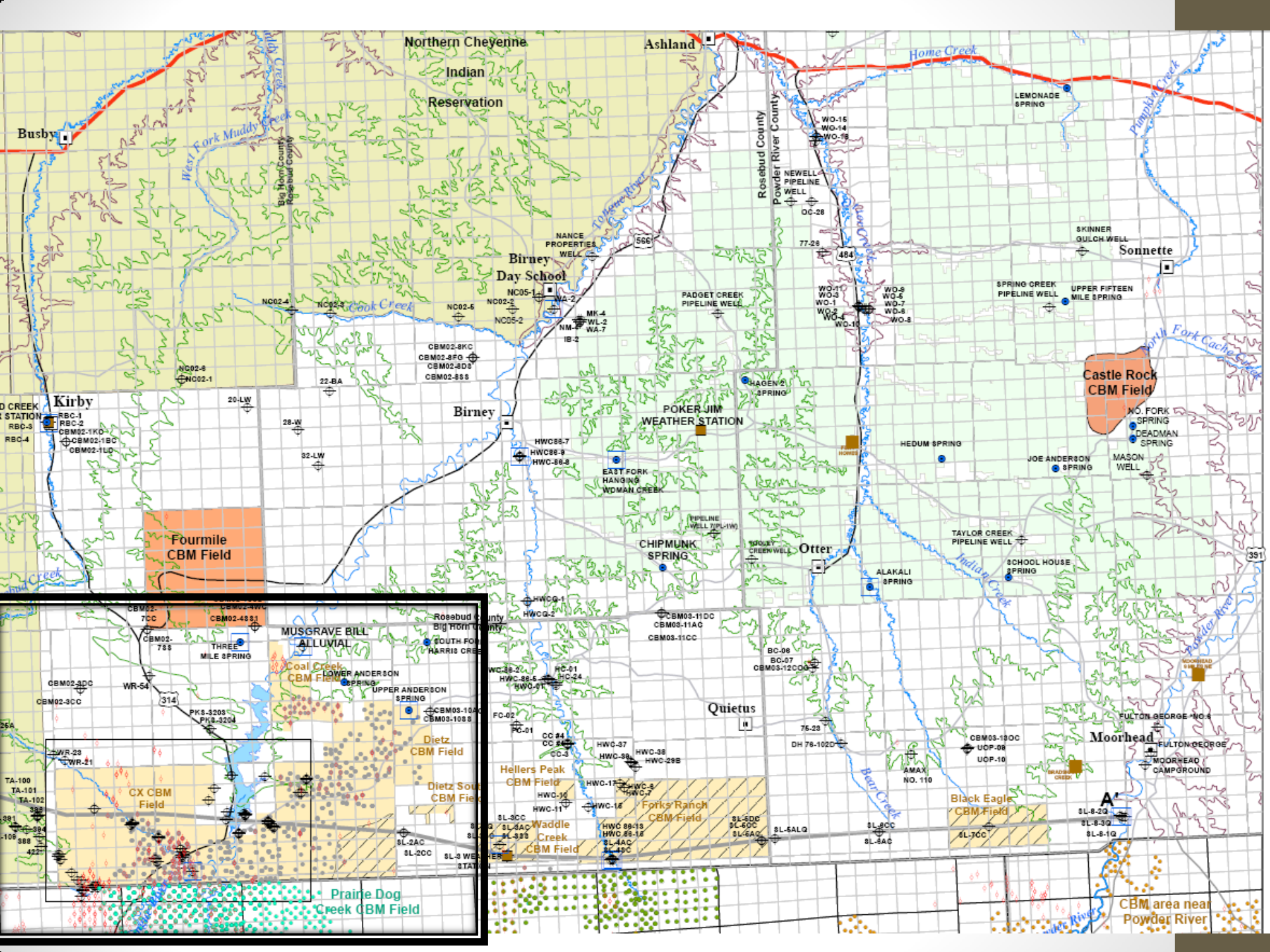
- Monthly monitoring of water levels
- Semi-annual alluvial water quality sampling
- Annual deep aquifer sampling
- Infiltration pond monitoring
- Installation of additional monitoring wells
- Annual reporting



**Legend**

- \* Towns
- Streams
- Wells and springs
- Coal mines





Northern Cheyenne

Ashland

Home Creek

Busby

Indian Reservation

LEMONADE SPRING

Birney

Day School

POCKET CREEK PIPELINE WELL

Sonnette

Fourmile CBM Field

Castle Rock CBM Field

POKER JIM WEATHER STATION

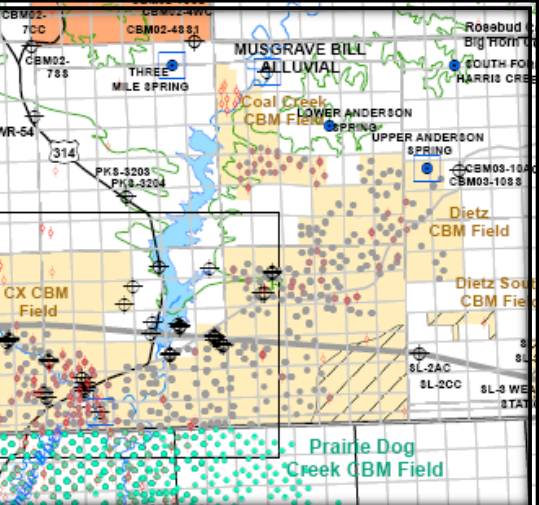
Birney

CHIPMUNK SPRING

Otter

NO. FORK SPRING

DEADMAN SPRING



Quietus

Moorhead

Black Eagle CBM Field

FULTON GEORGE NO. 4

FULTON GEORGE

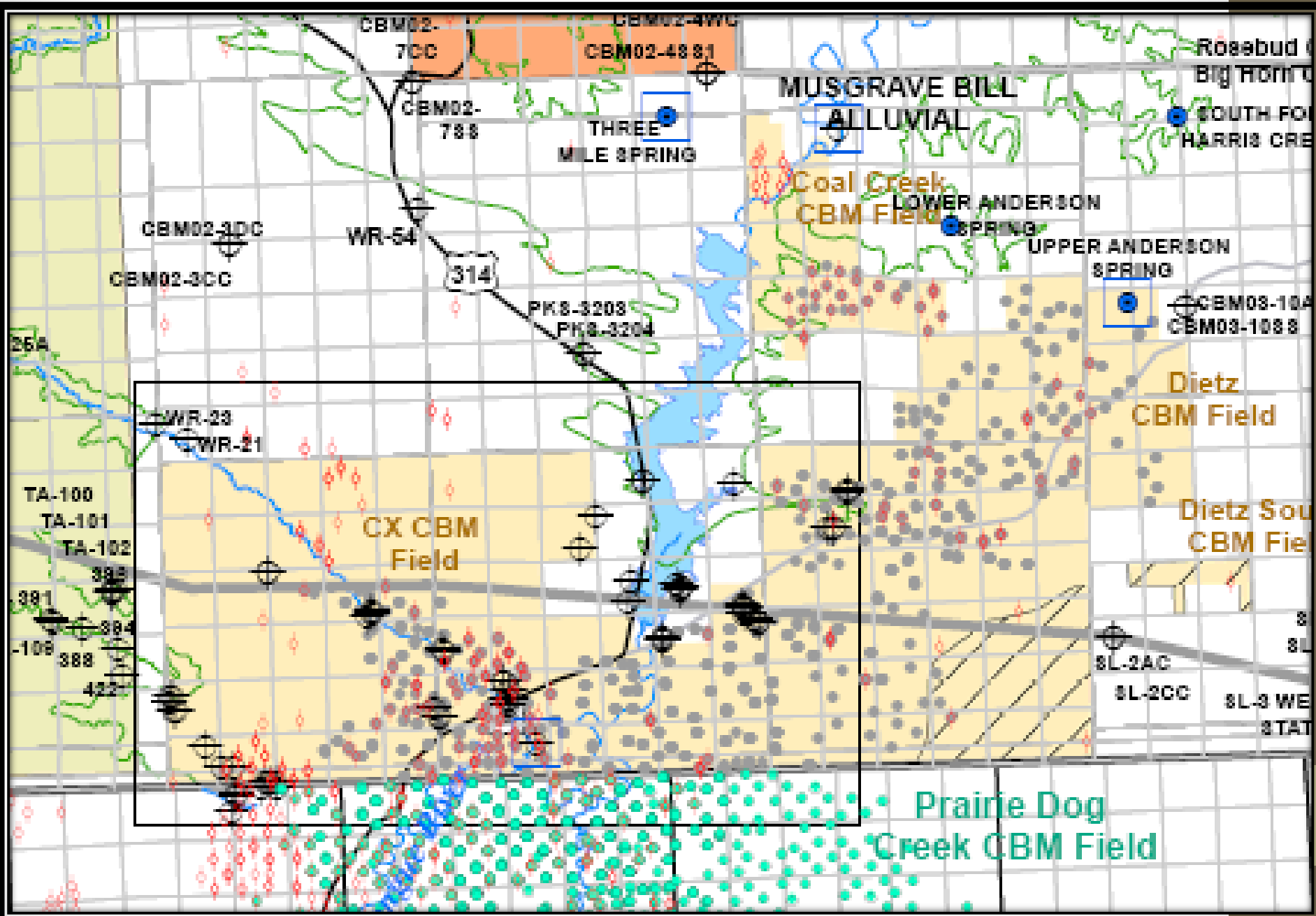
MOORHEAD CAMPGROUND

SL-8-20

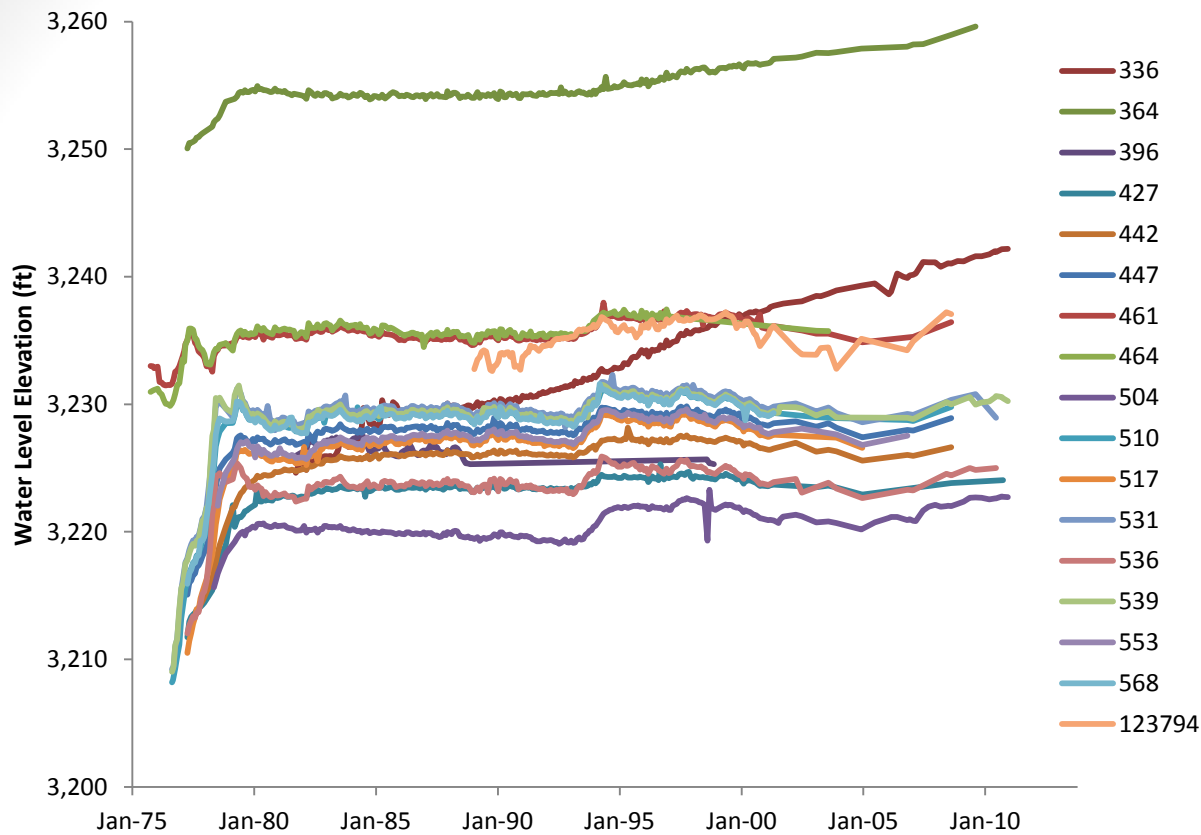
SL-8-30

SL-8-10

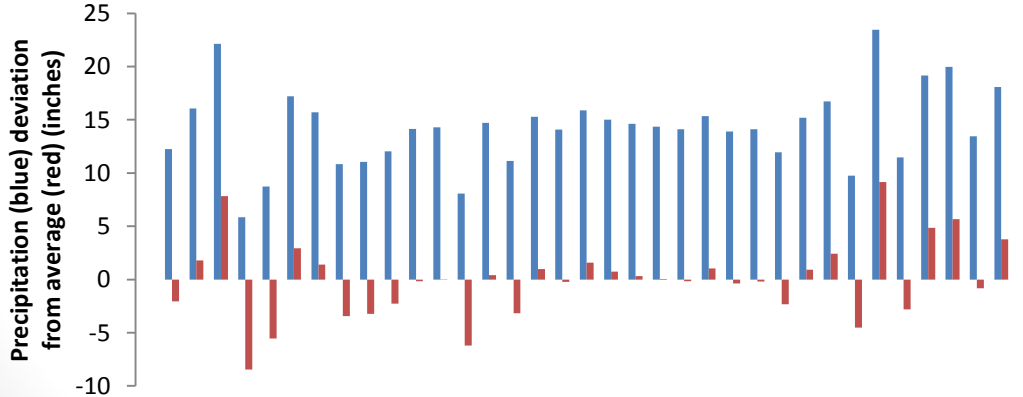
CBM area near Powder River

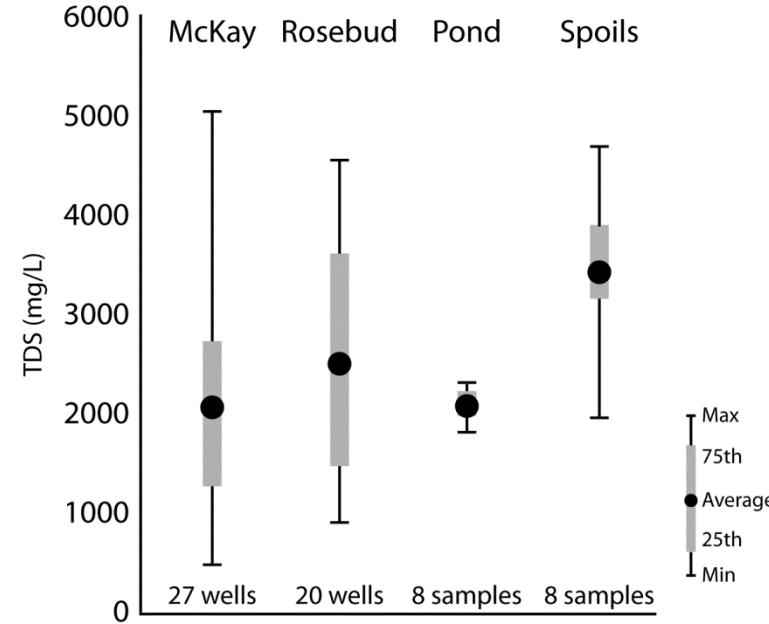
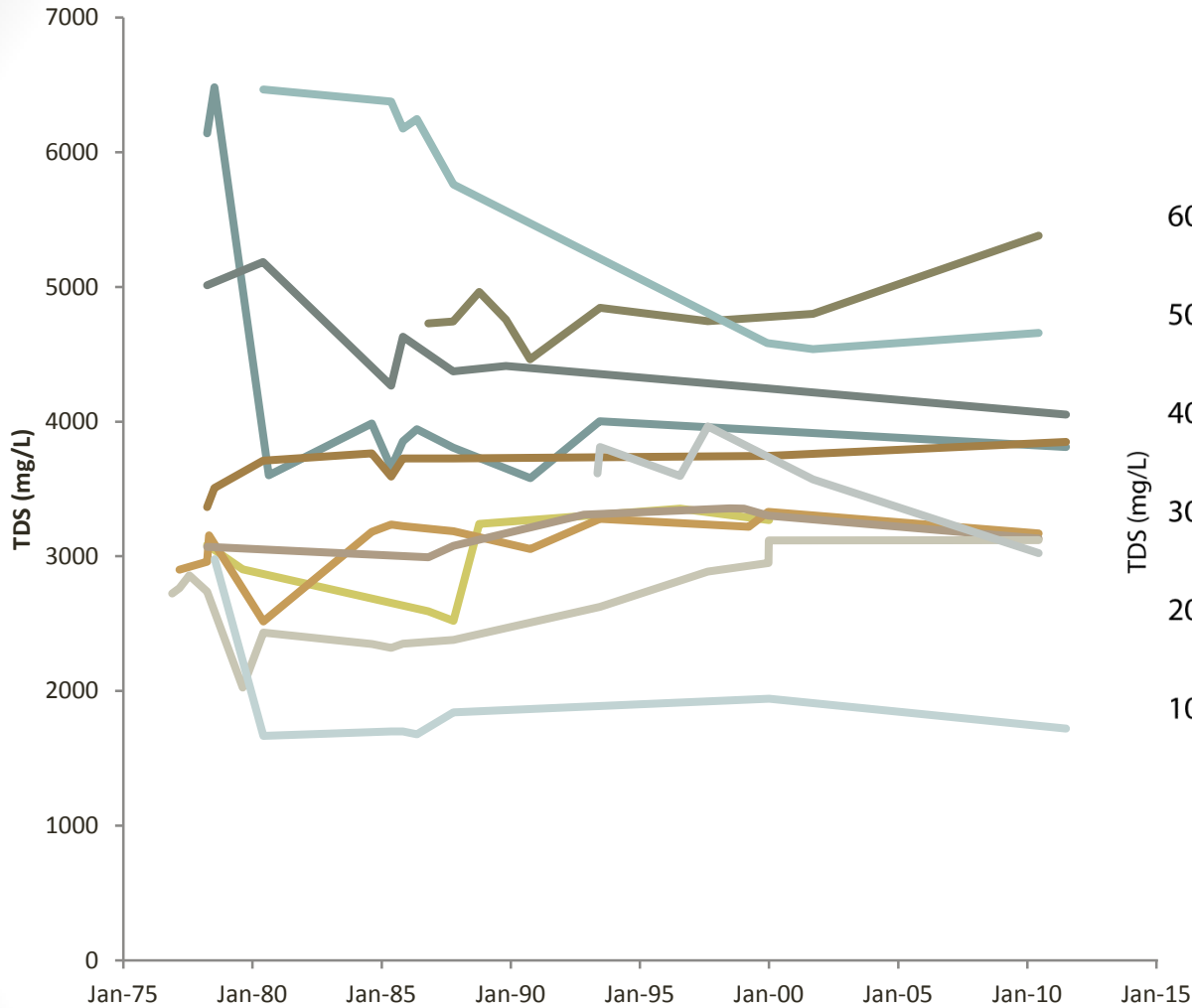




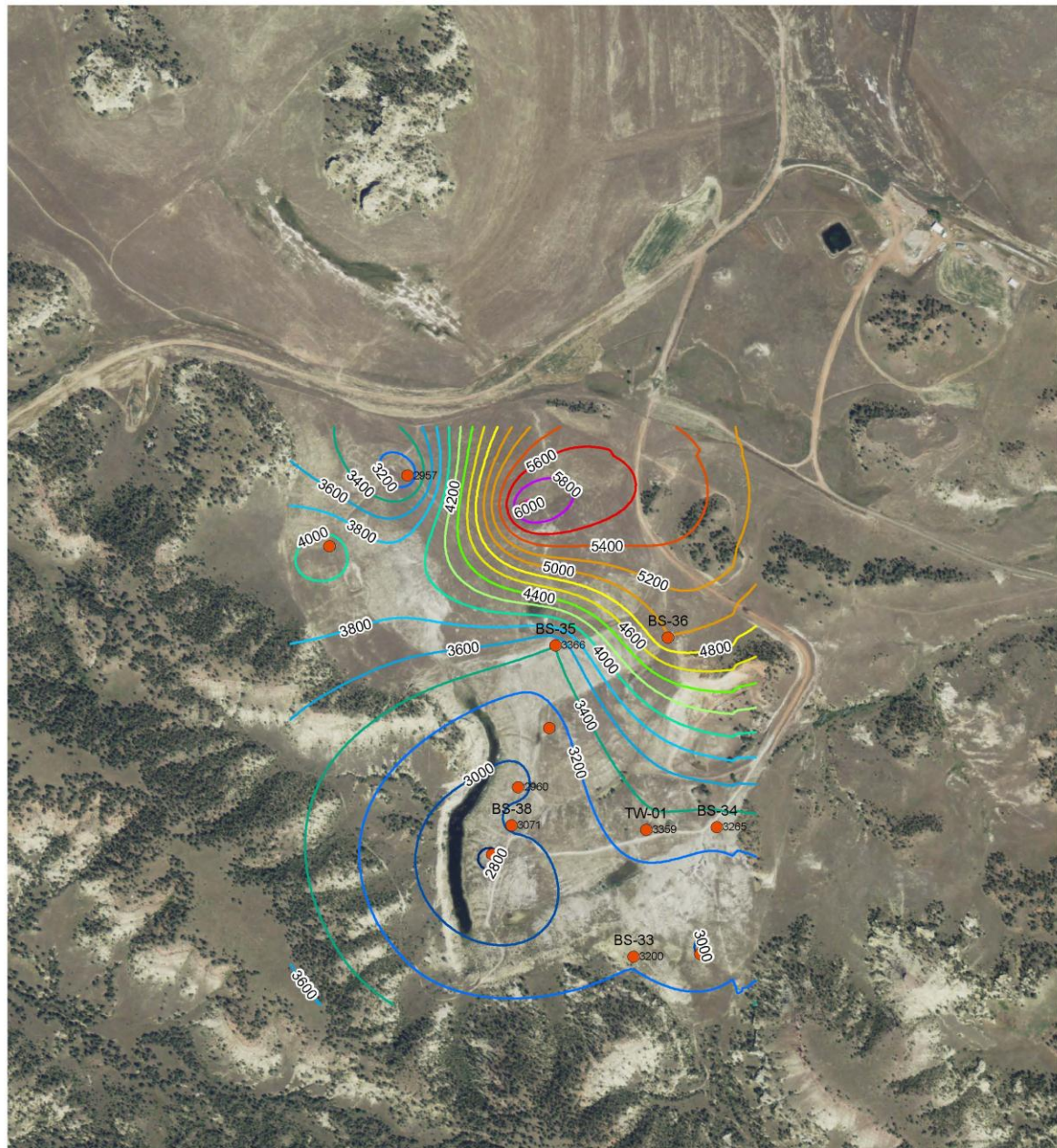


Water levels in the Big Sky spoils aquifer quickly reached a new equilibrium



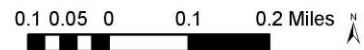


**Groundwater salinity in the Big Sky spoils aquifer stabilizes quickly but is spatially variable in the ultimate water quality.**

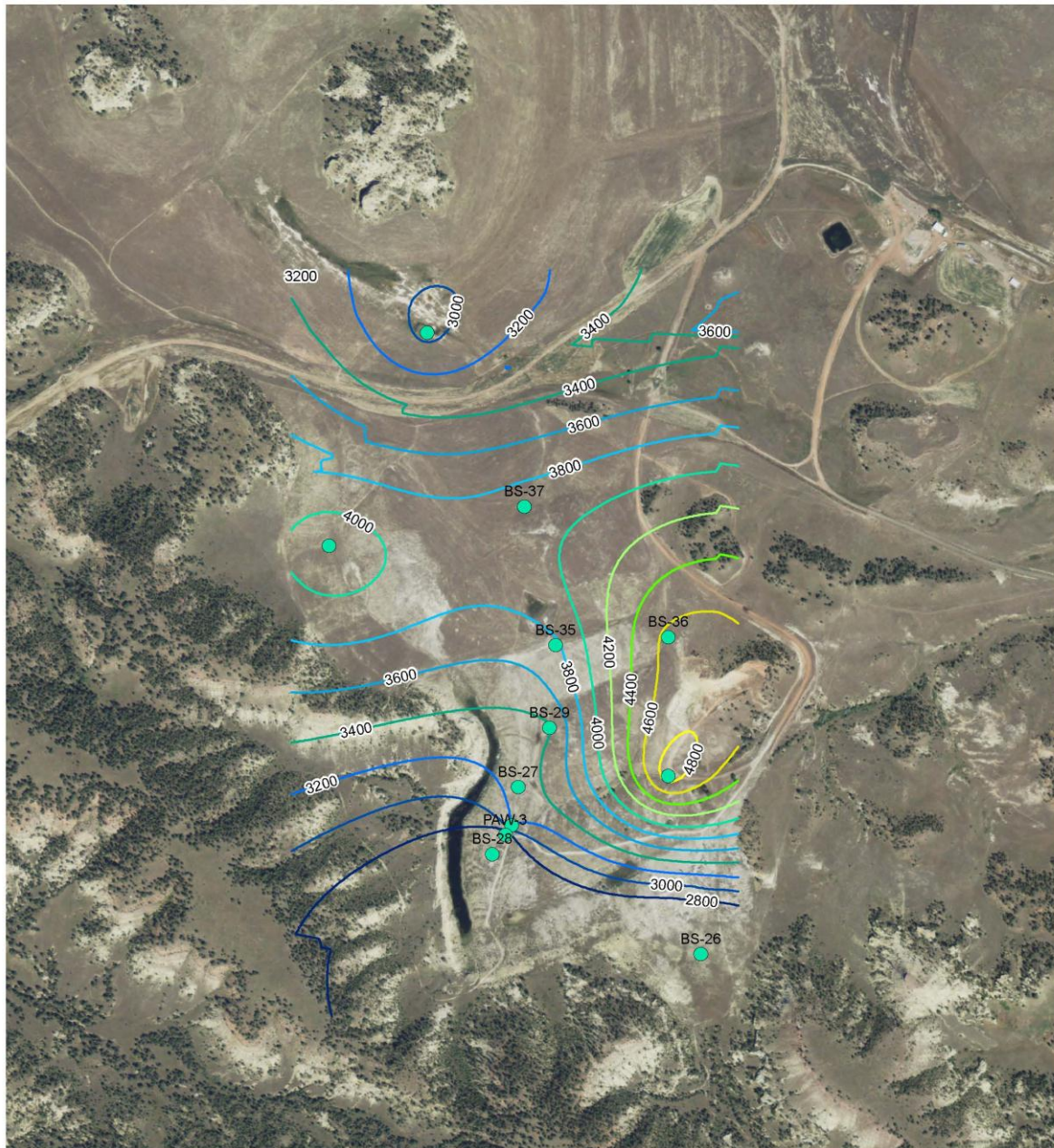


**Legend**

● Wells sampled in the 1970's

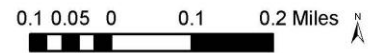


Selenium concentrations

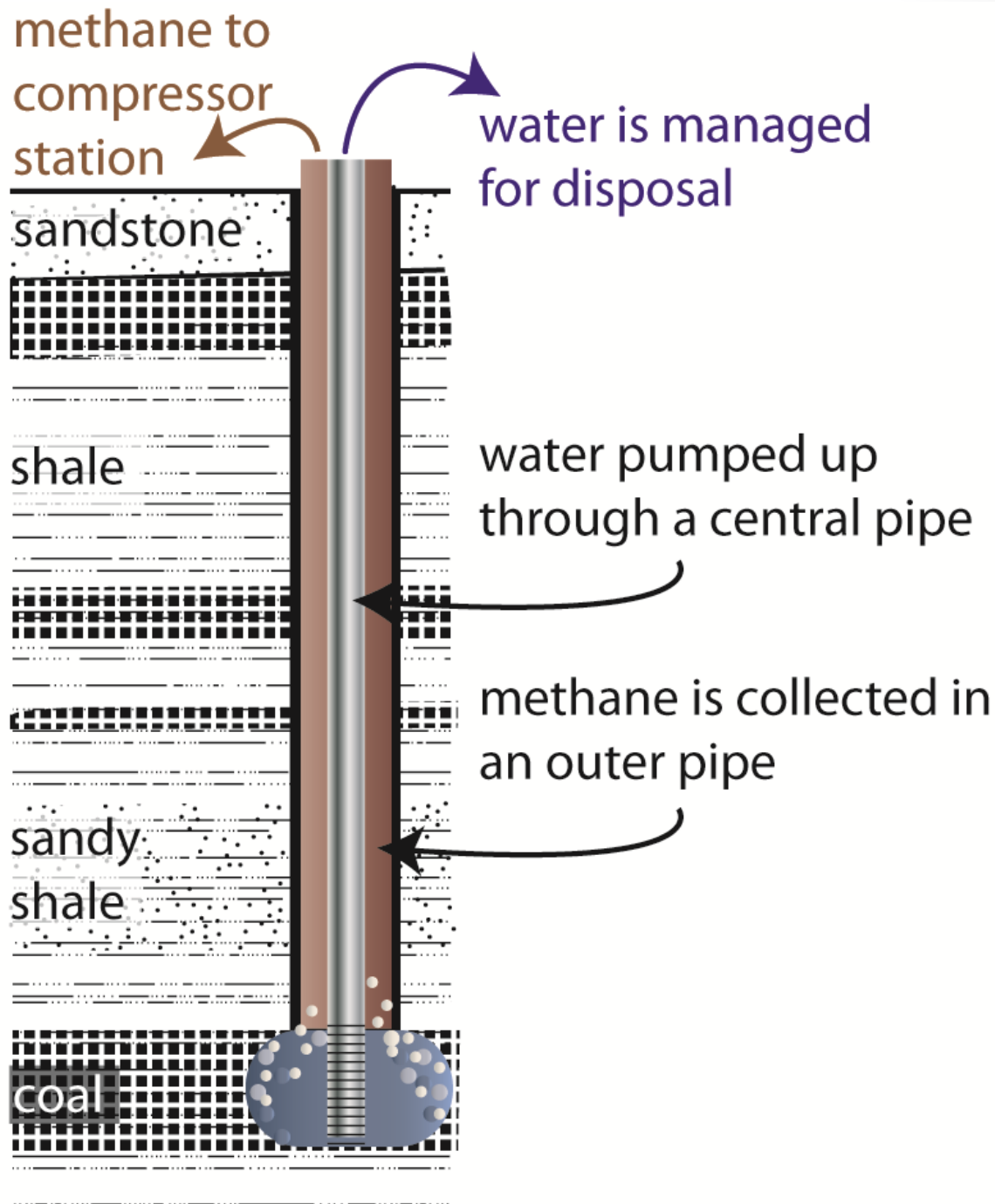


**Legend**

● Wells sampled in the 1990's

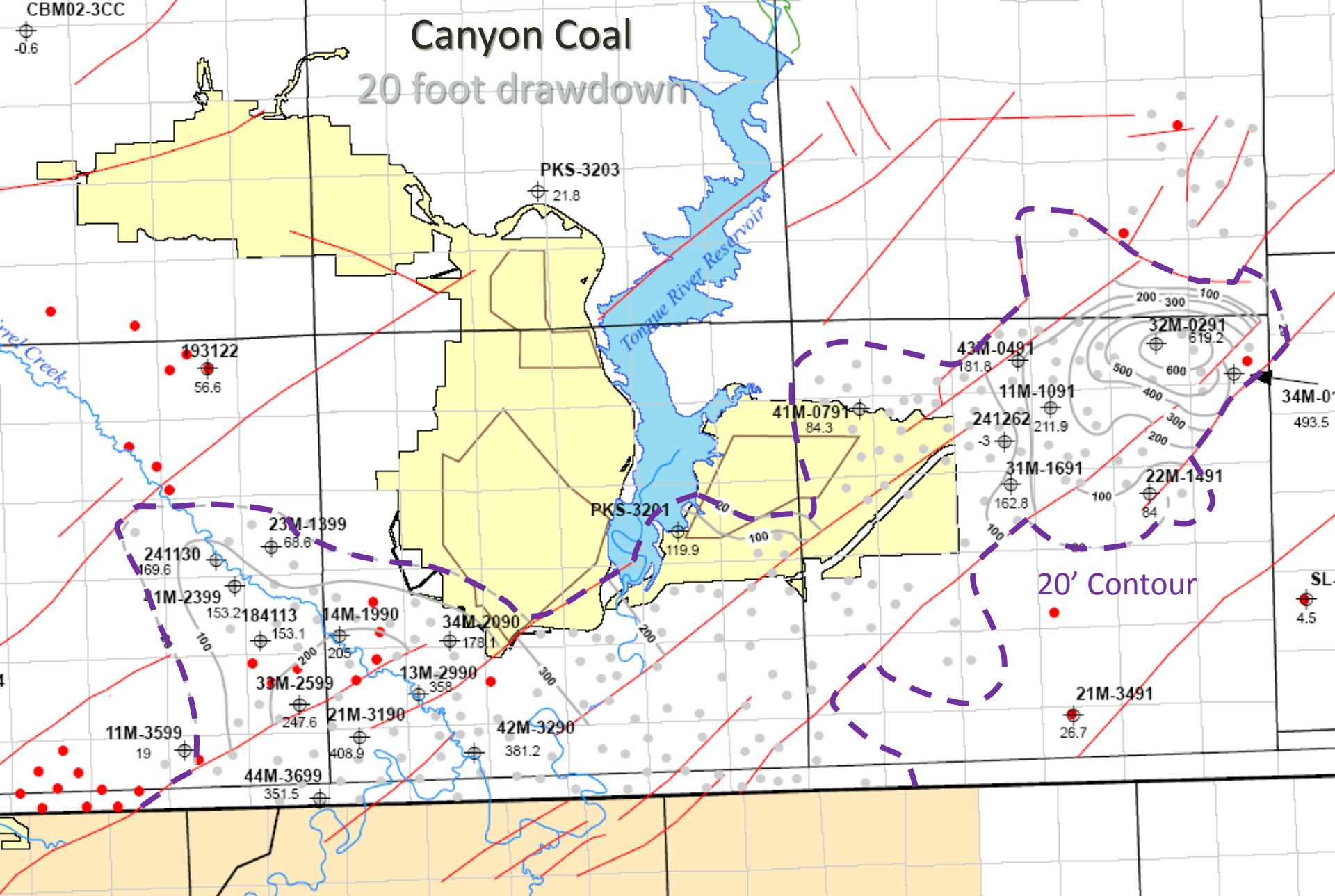


Selenium concentrations



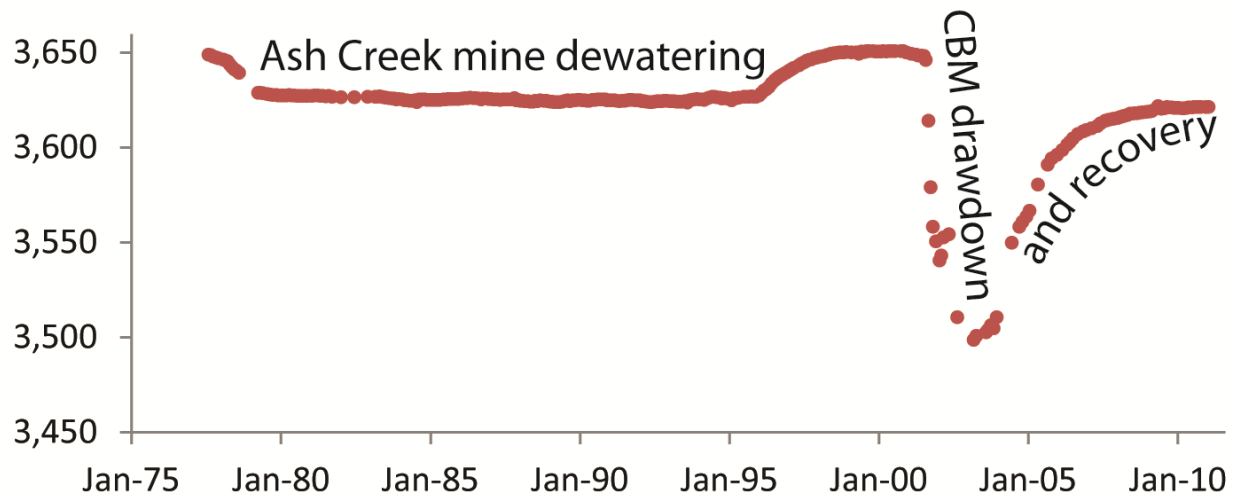
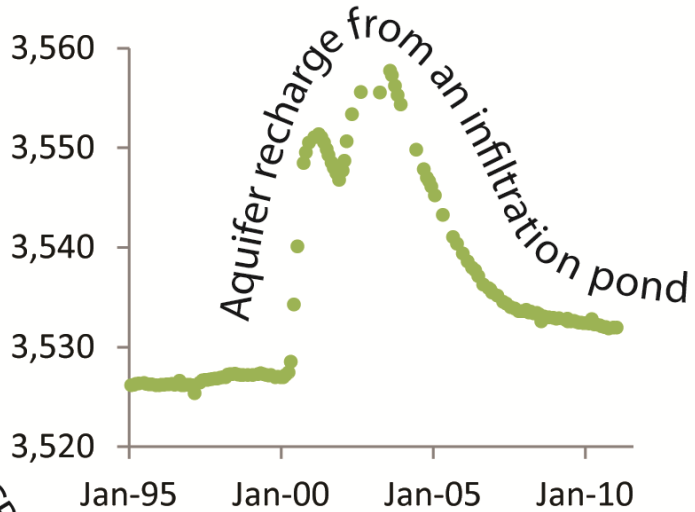
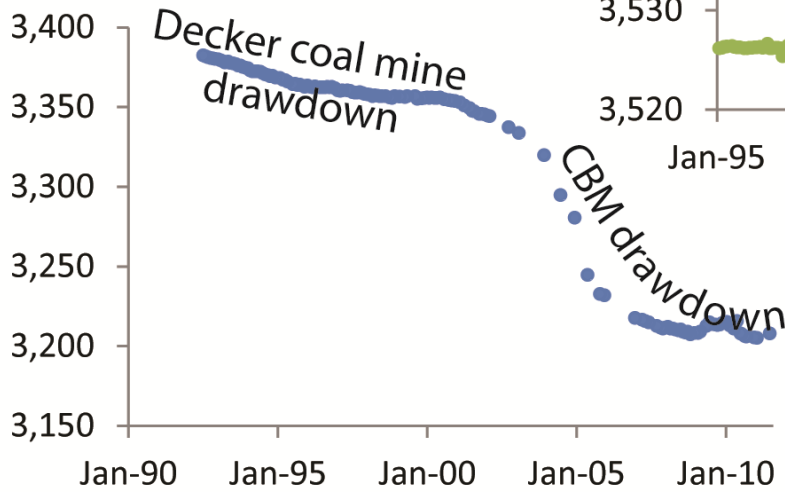
- **What was known in 2001:**
  - CBM requires water-level drawdown to near the top of the coal
  - Water quality will be slightly saline and highly sodium rich
- **What was unknown:**
  - Would the drawdown extend to other aquifers?
  - What would be the impact to surface water and near-surface groundwater from produced water management?

<b>Water-level drawdown</b>					
	<u>CBM Predicted</u>		<u>Mont. coal mines</u>	<u>Wyo. coal mines</u>	<u>Mont. computer model</u>
Years	early	20	20	15	20
Drawdown (ft)	10	10	10	5	10
Distance (miles)	1 to 2	5 to 10	2 to 4	2 to 14	3 to 4
<b>Water-level recovery</b>					
	<u>CBM Predicted</u>	<u>CBM Predicted</u>	<u>Mont. coal mines</u>	<u>Mont. computer model</u>	
Years	5	10 to 15	3 to 4	2 to 3	10 to 12
% Recovery	90	70	90+	90	70
Distance (miles)	1+	0	0	2	0

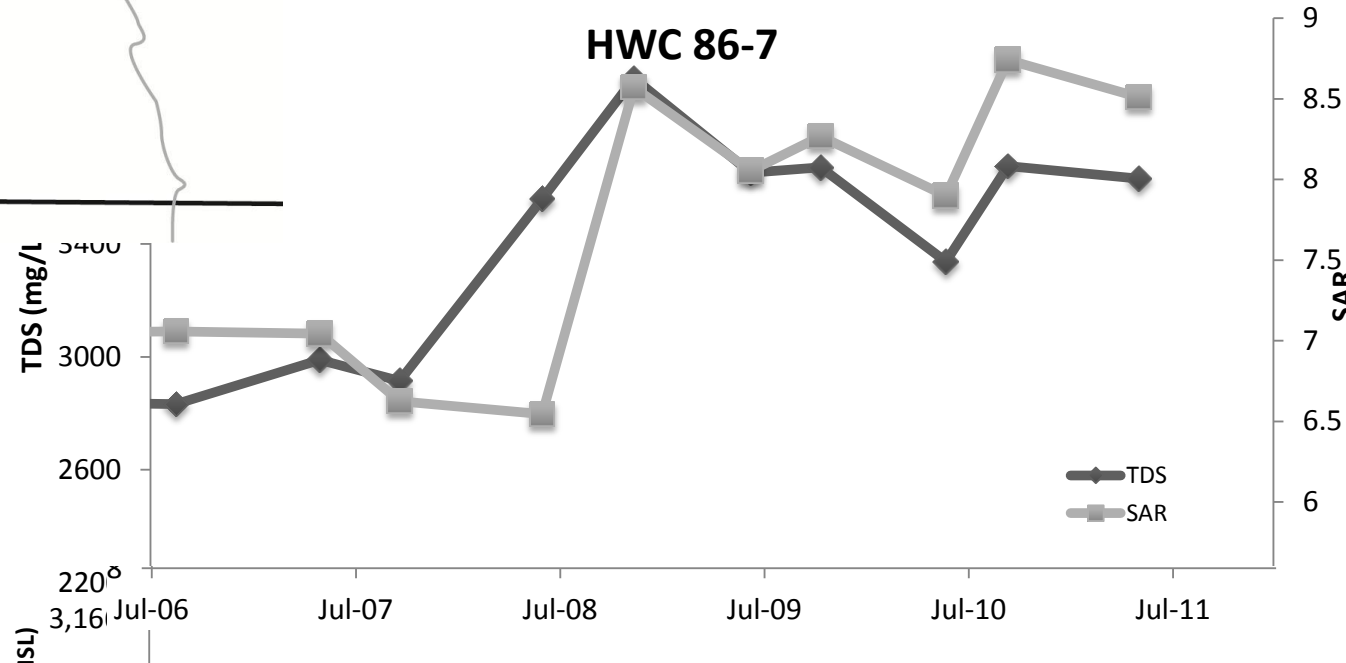
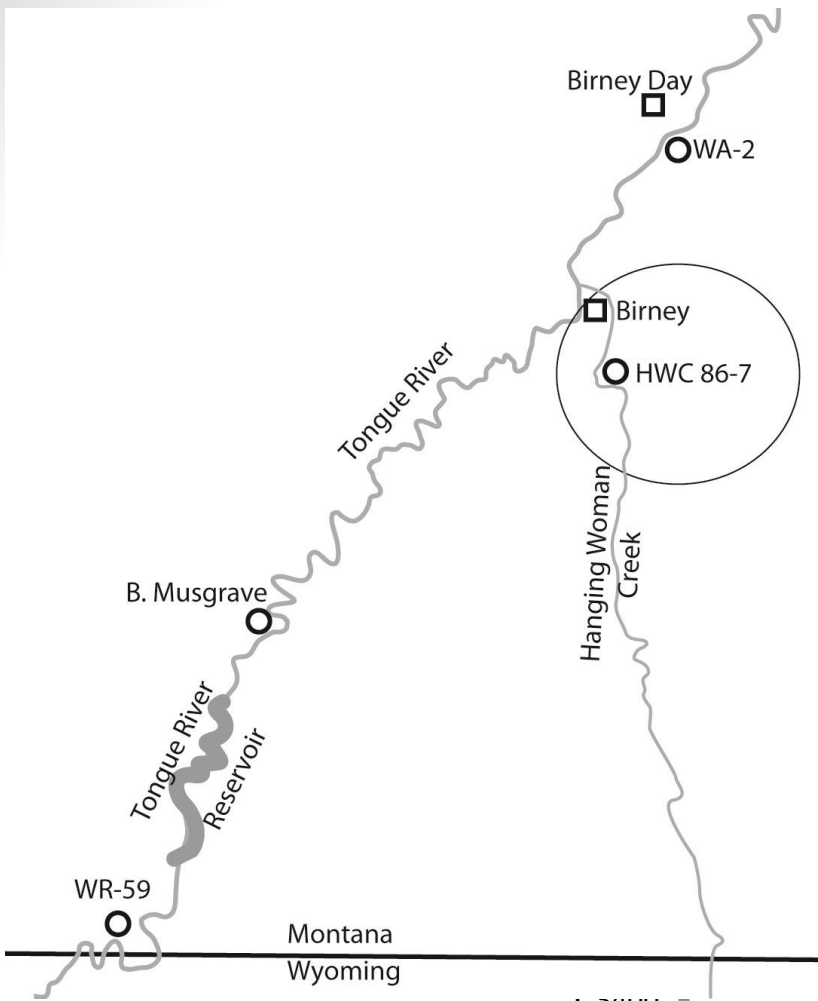


Dedicated Monitoring Wells & 48 hr Shut-in tests on CBM Wells

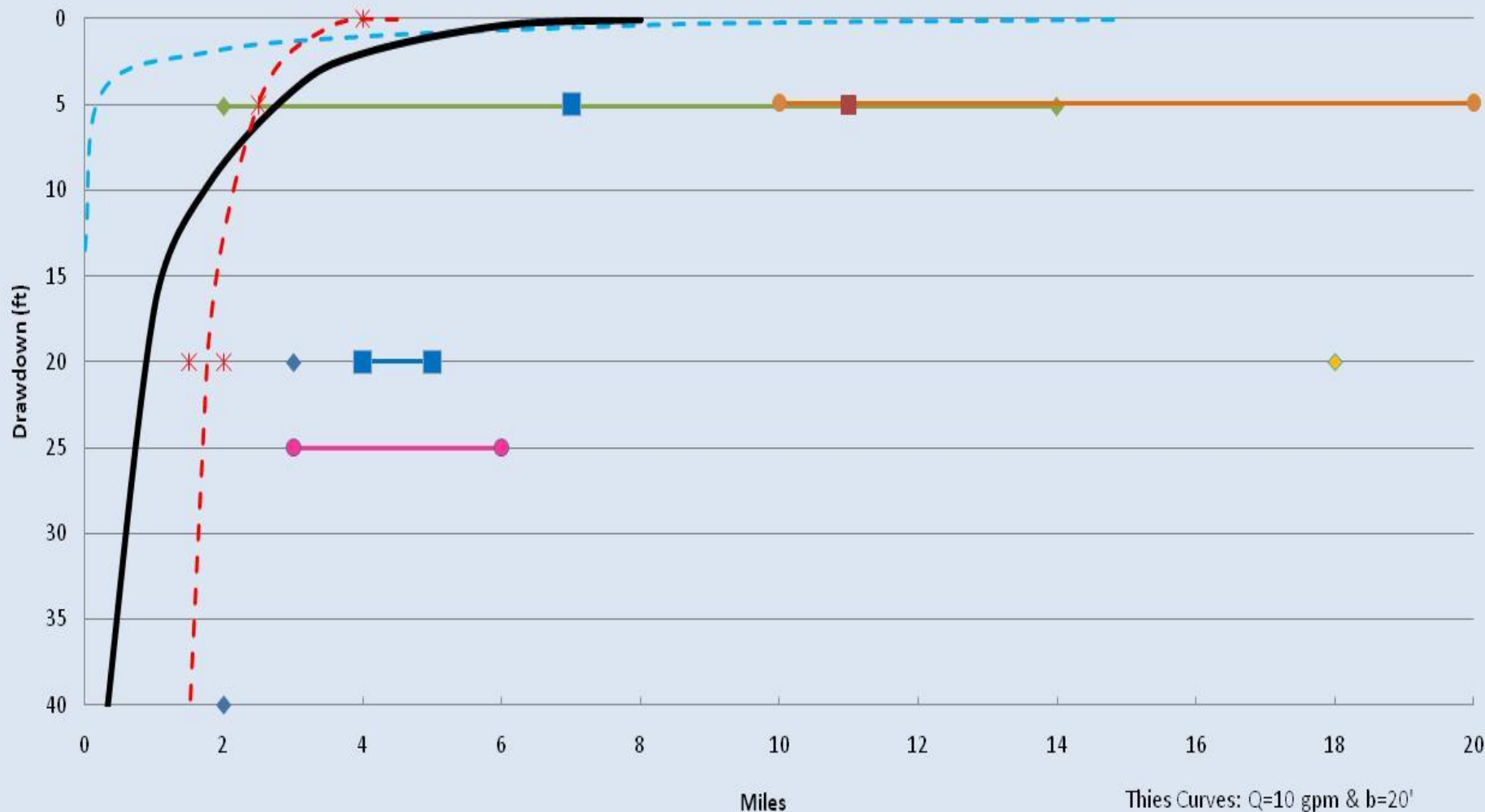
Groundwater elevation (feet above sea level)







# Modeled and Observed Drawdown from CBM in the Powder River Basin



Thies Curves:  $Q=10$  gpm &  $b=20'$

◆ Wyodack, 1999, Coal Mine Analog, 15 yr

● Wyodack, 1999, 3D, 20 years

■ Wheaton & Metesh, 2001, 2D, 5 yr

◆ Wheaton & Metesh, 2002, 3D, 10 yr

■ Wheaton & Metesh, 2002, 3D, 20 yr

● Applied Hydrology & Greystone, 2002, 3D, 7 yrs

◆ Meyers, 2009, 3D, 15 yrs

\* Observed, 10 years

- - - Thies: High K, High S; 10 yrs

— Thies: GeoMean K, Mean S, 10 yrs

- - - Thies Low K, Low S, 10 yrs

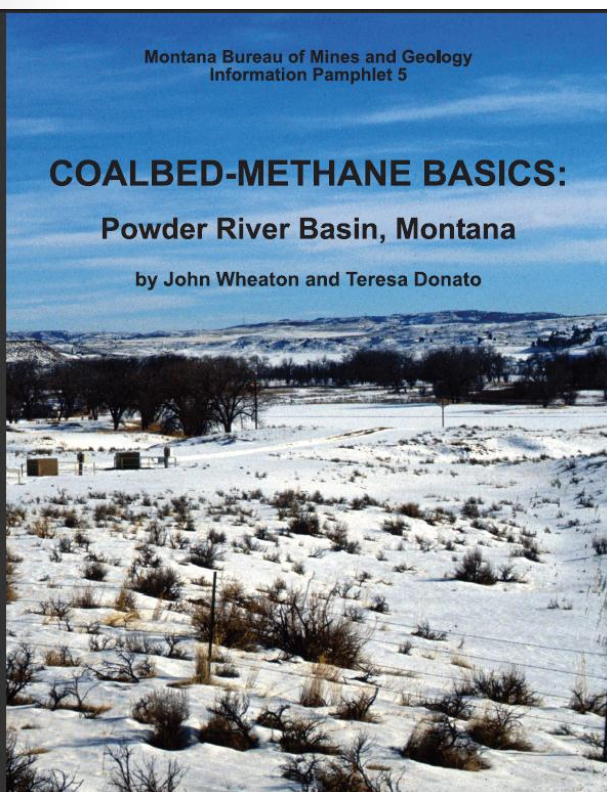
# 2001 vs 2012 Conclusions

- Impacts will occur for the life of production and during the years of recovery
  - **Recovery has been faster than anticipated but reflects on-going CBM production.**
- Less drawdown in overburden
  - **Overburden drawdown is rarely seen**
- About 10 feet of drawdown at 5 – 10 miles outside field
  - **About 20 feet of drawdown at 1 – 2 miles outside field, 0 drawdown at 5 miles.**
- Decrease flow of some springs
  - **Drawdown has not reached outcrop in any monitored location (springs)**
- Decrease water availability at wells
  - **Drawdown has decreased water availability in wells within the area of influence**

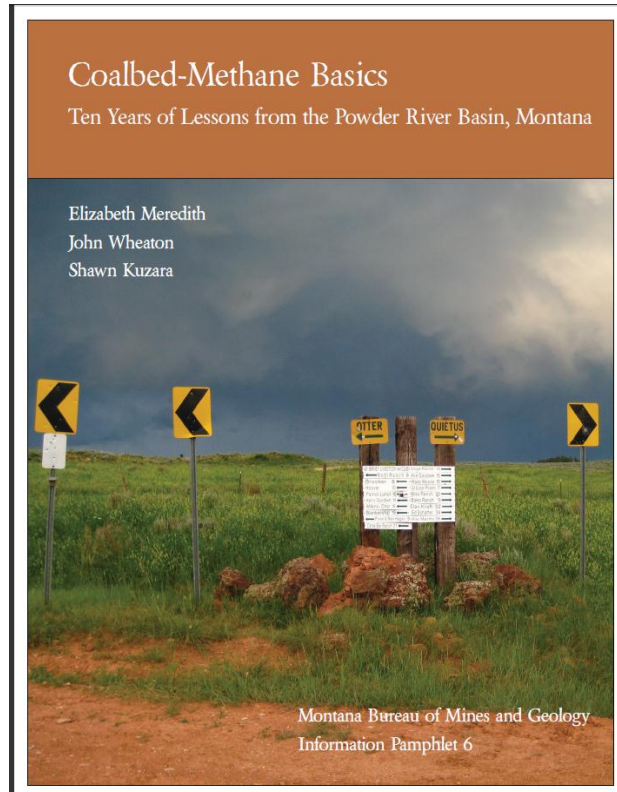
# How the information is used:

- Evaluating the adequacy of NEPA
  - The impacts described by the EIS and EAs have been shown to be reasonably accurate through on-going monitoring.
  - Improves confidence from outside.
  - Decreases risks of lawsuits.
- Evaluating impacts where data are scarce for future permitting
  - For example, pond permitting.
  - Transferability of environmental evaluations.
  - References for decision making.
- CBM Protection Act (Montana State program)
  - Landowners (Conservation Districts) tasked to determine financial impacts.
  - Look to government agencies and MBMG for data and assistance.
- Locally, Nationally, and Internationally
  - Used by landowners to identify drilling locations
  - Used at the Supreme Court level
  - Australian and Canadian monitoring modeled after PRB monitoring

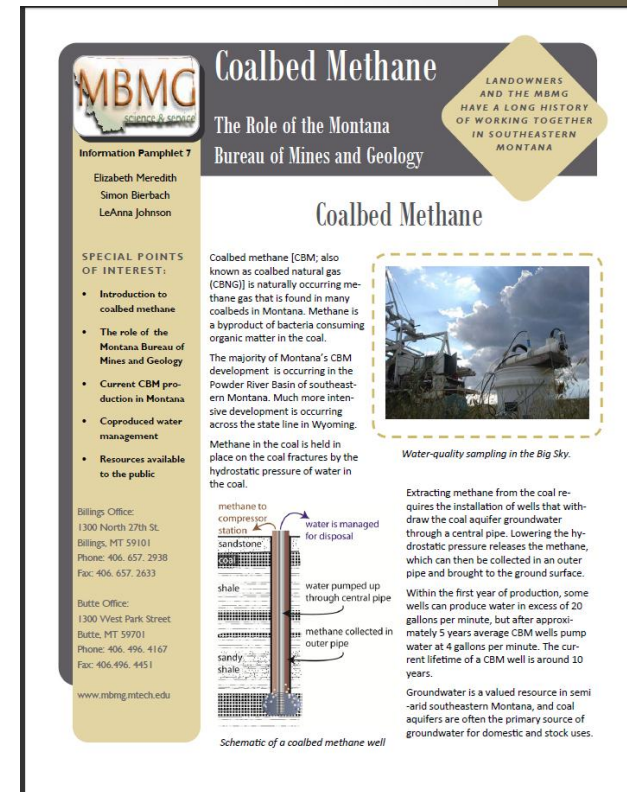
# Available Reports



IP-5 (2004)



IP-6 (2012)



IP-7 (2011)

Written for the general public.

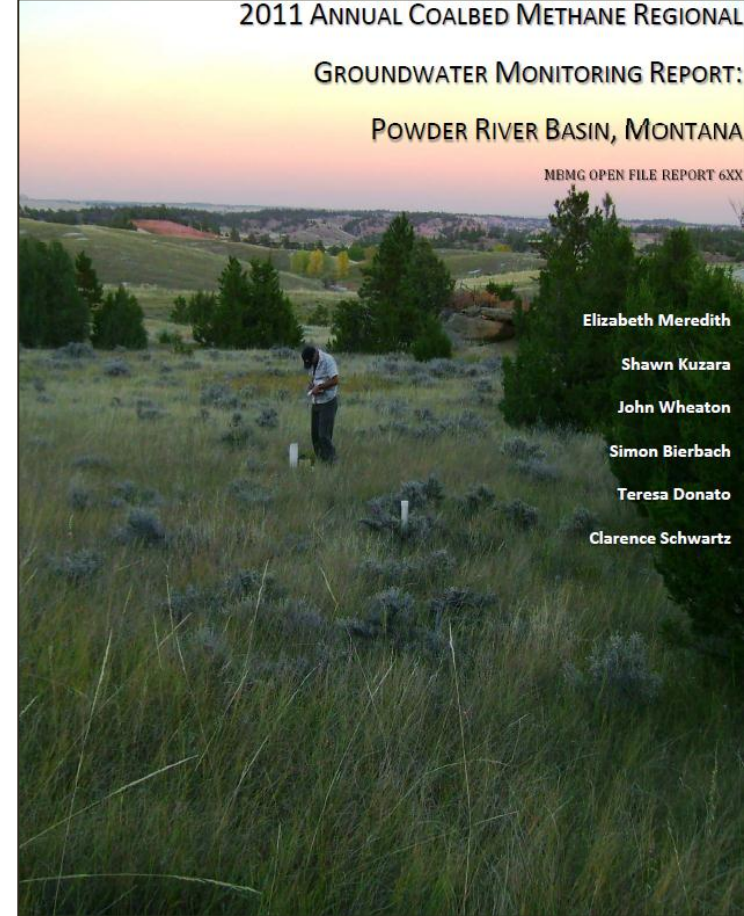
# Annual report of monitoring observations and interpretations

- Technical report written for stakeholders.
- 8 years of reporting beginning in 2003.

## Hydrogeologic Responses: Forty Years of Surface Coal Mining in Southeastern Montana

*With an emphasis on reclamation at Big Sky Mine  
Preliminary Report*

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## Long-term coal mine hydrology monitoring by the MBMG

- Summary report written for stakeholders, funding agencies, and scientists.
- Focuses on reclamation at Big Sky Mine.