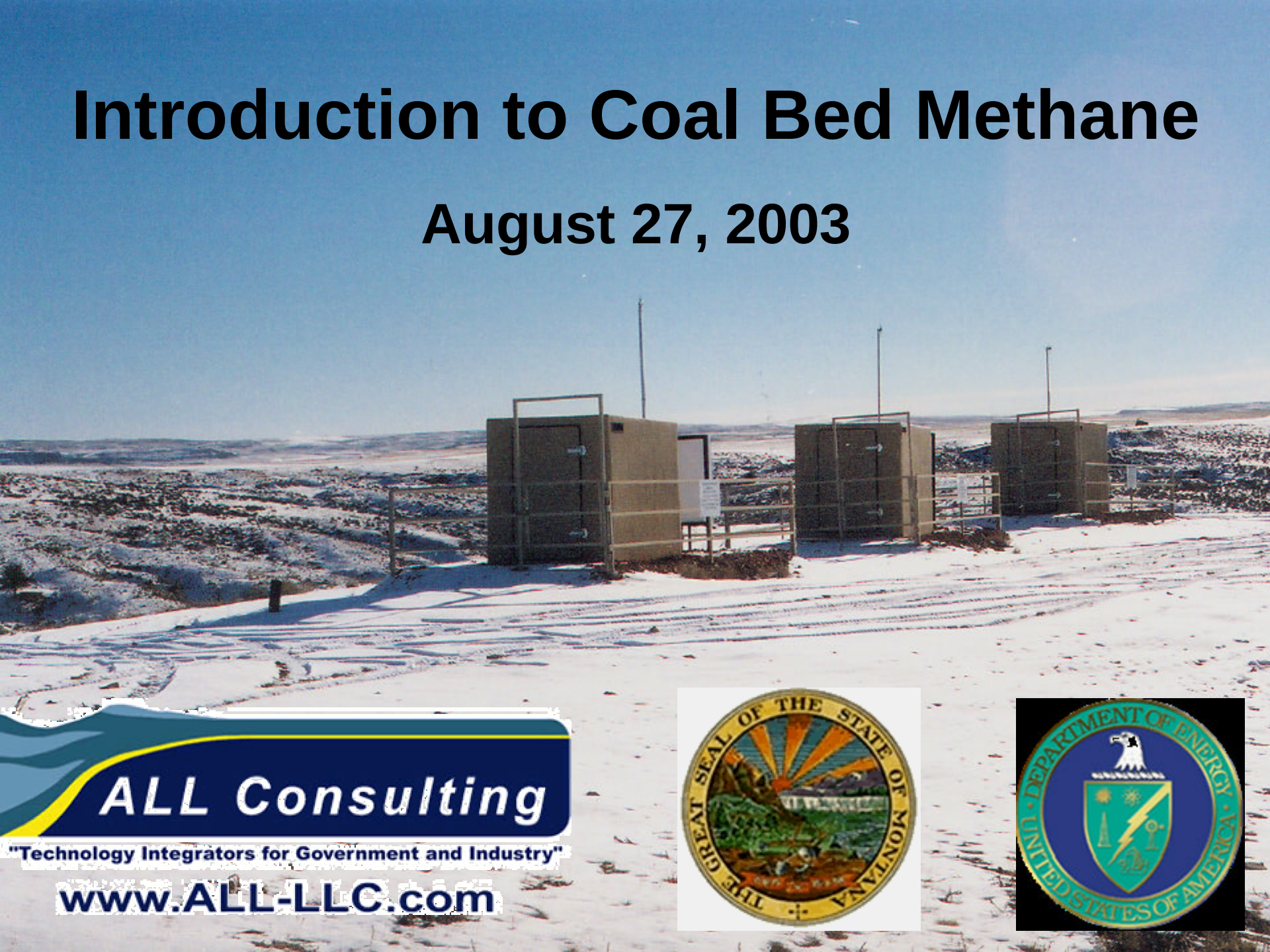
Introduction to Coal Bed Methane

August 27, 2003



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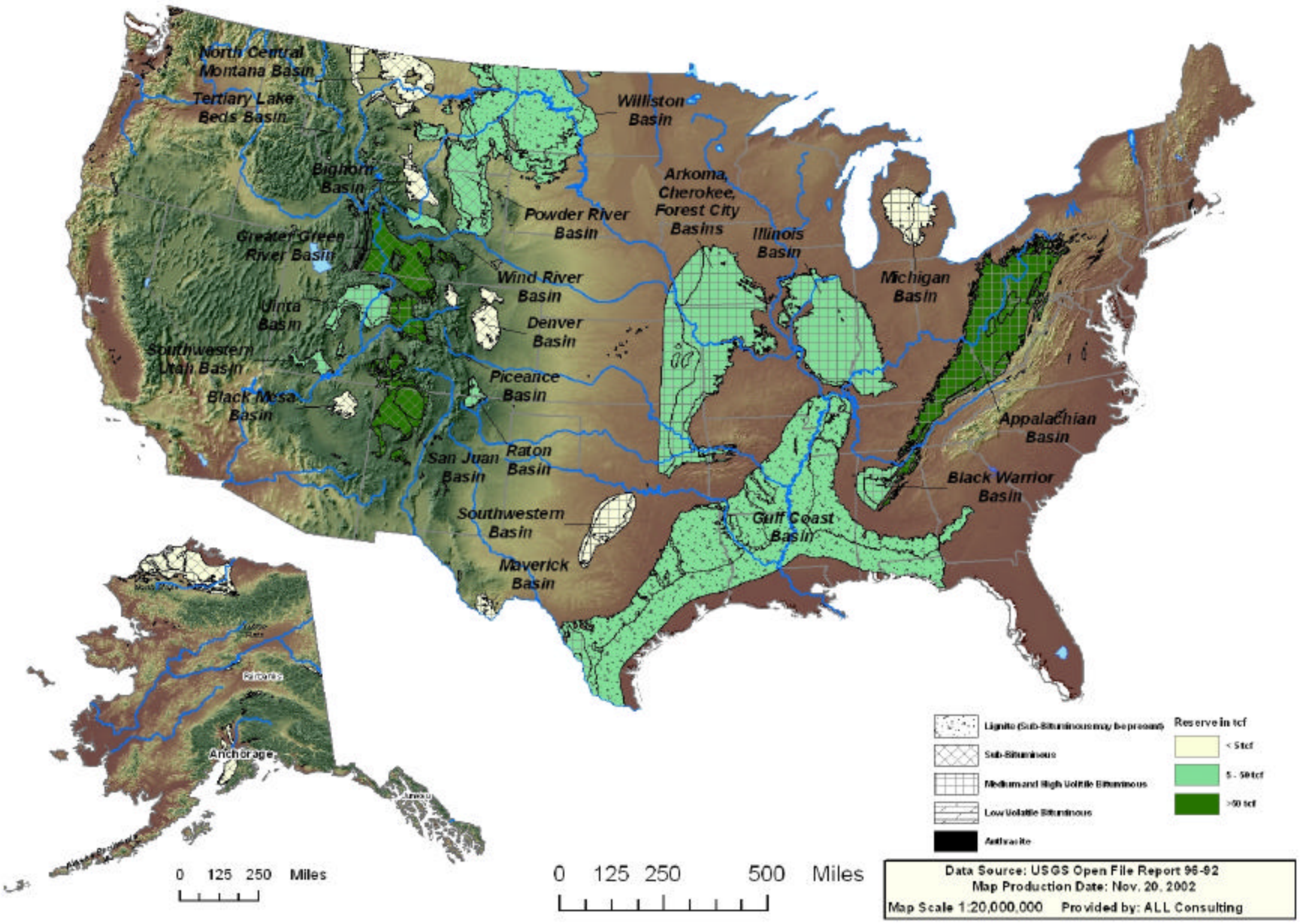
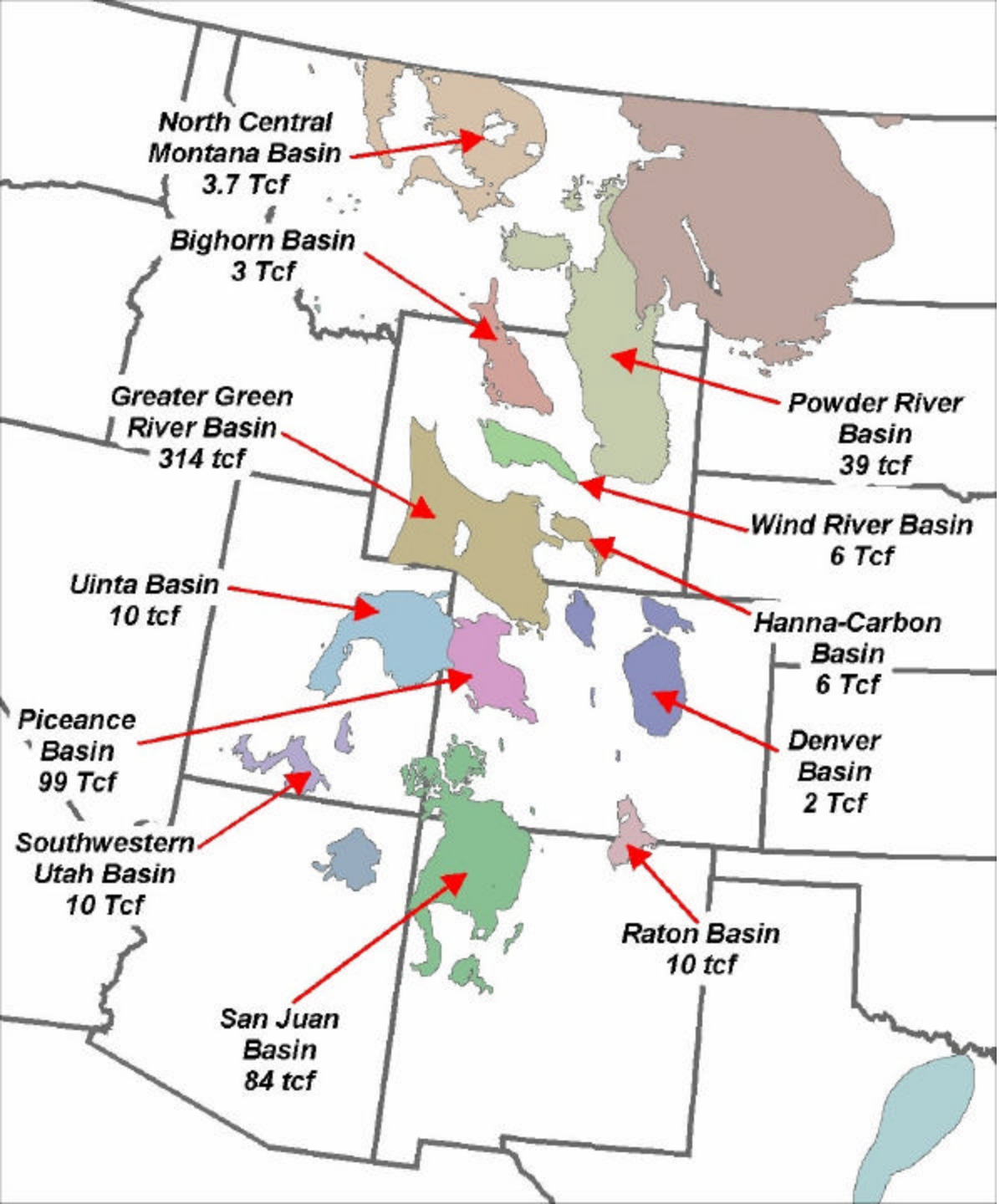
Coal Bed Methane:

What is it? Where is it?


North Central Montana Basin
Tertiary Lake Beds Basin
Bighorn Basin
Williston Basin
Arkoma, Cherokee, Forest City Basins
Illinois Basin
Powder River Basin
Greater Green River Basin
Wind River Basin
Michigan Basin
Uinta Basin
Denver Basin
Southwestern Utah Basin
Piceance Basin
Black Mesa Basin
Appalachian Basin
San Juan Basin
Raton Basin
Black Warrior Basin
Southwestern Basin
Gulf Coast Basin
Maverick Basin
Anchorage
0 125 250 Miles
0 125 250 500 Miles
Lignite (Sub-Bituminous may be present)
Sub-Bituminous
Medium and High Volatile Bituminous
Low Volatile Bituminous
Anthracite
Reserve in tcf
< 5tcf
5 - 50tcf
>50 tcf
Data Source: USGS Open File Report 96-92
Map Production Date: Nov. 20, 2002
Map Scale 1:20,000,000 Provided by: ALL Consulting

Coal Basins and CBM In-place Reserves



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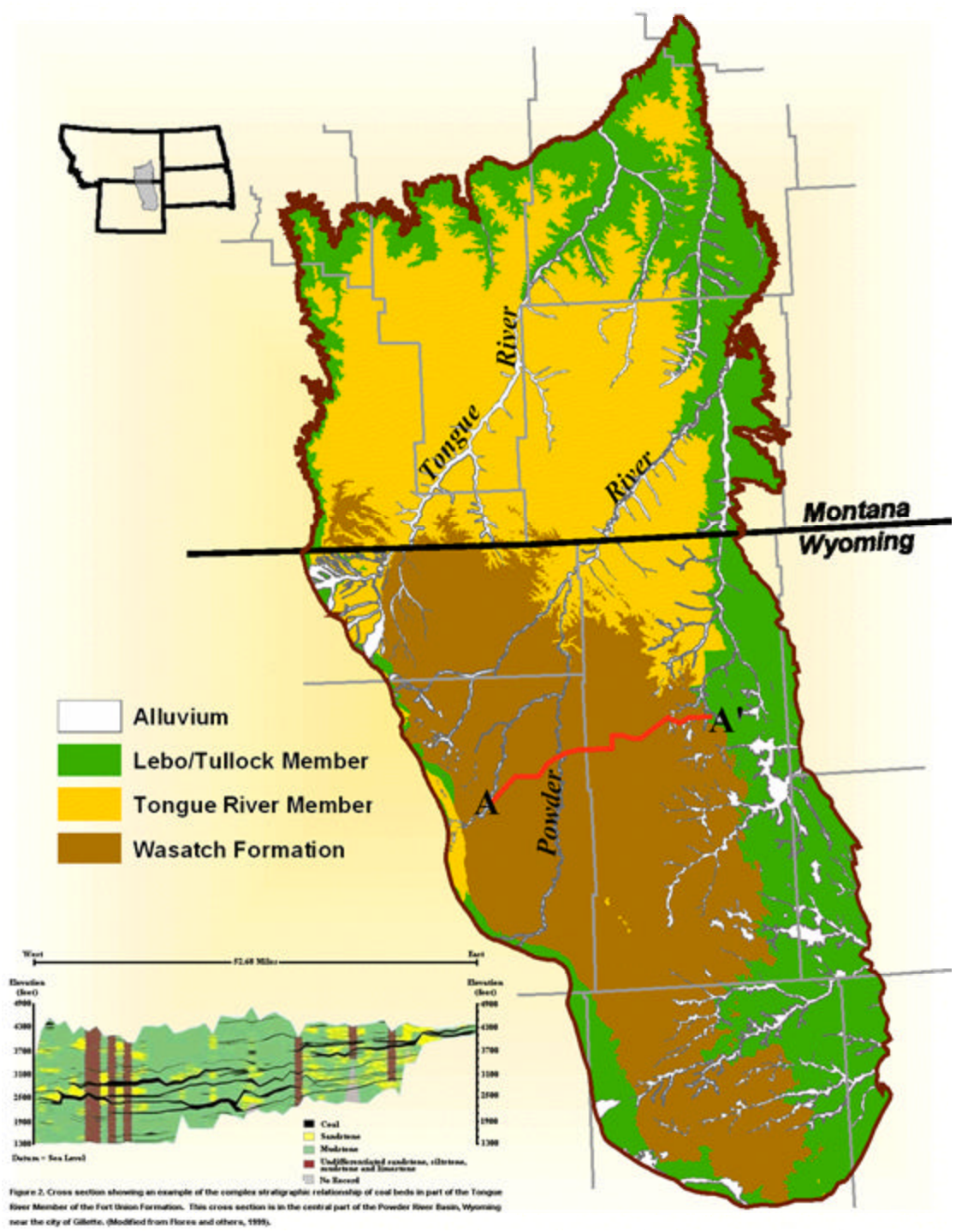
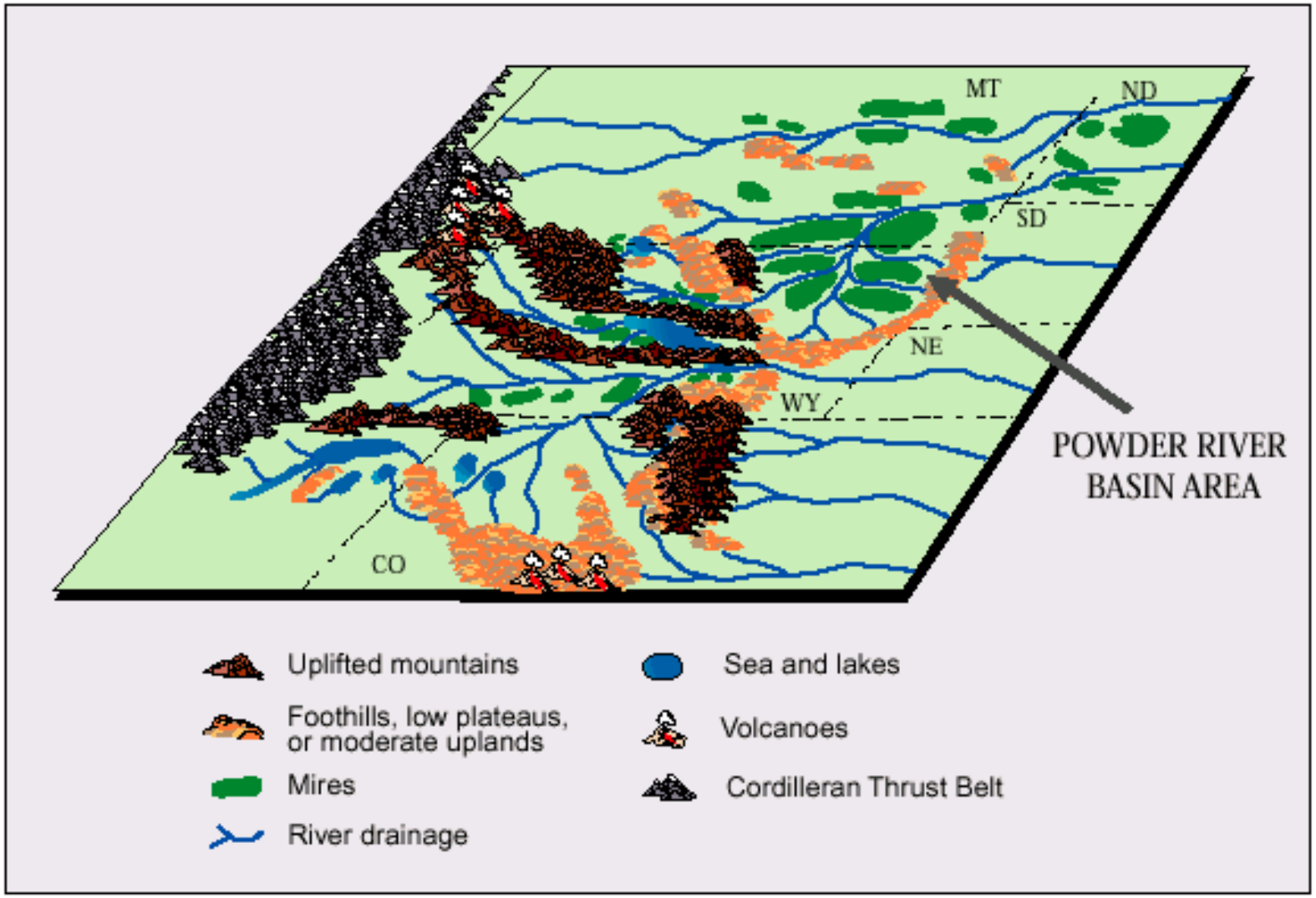
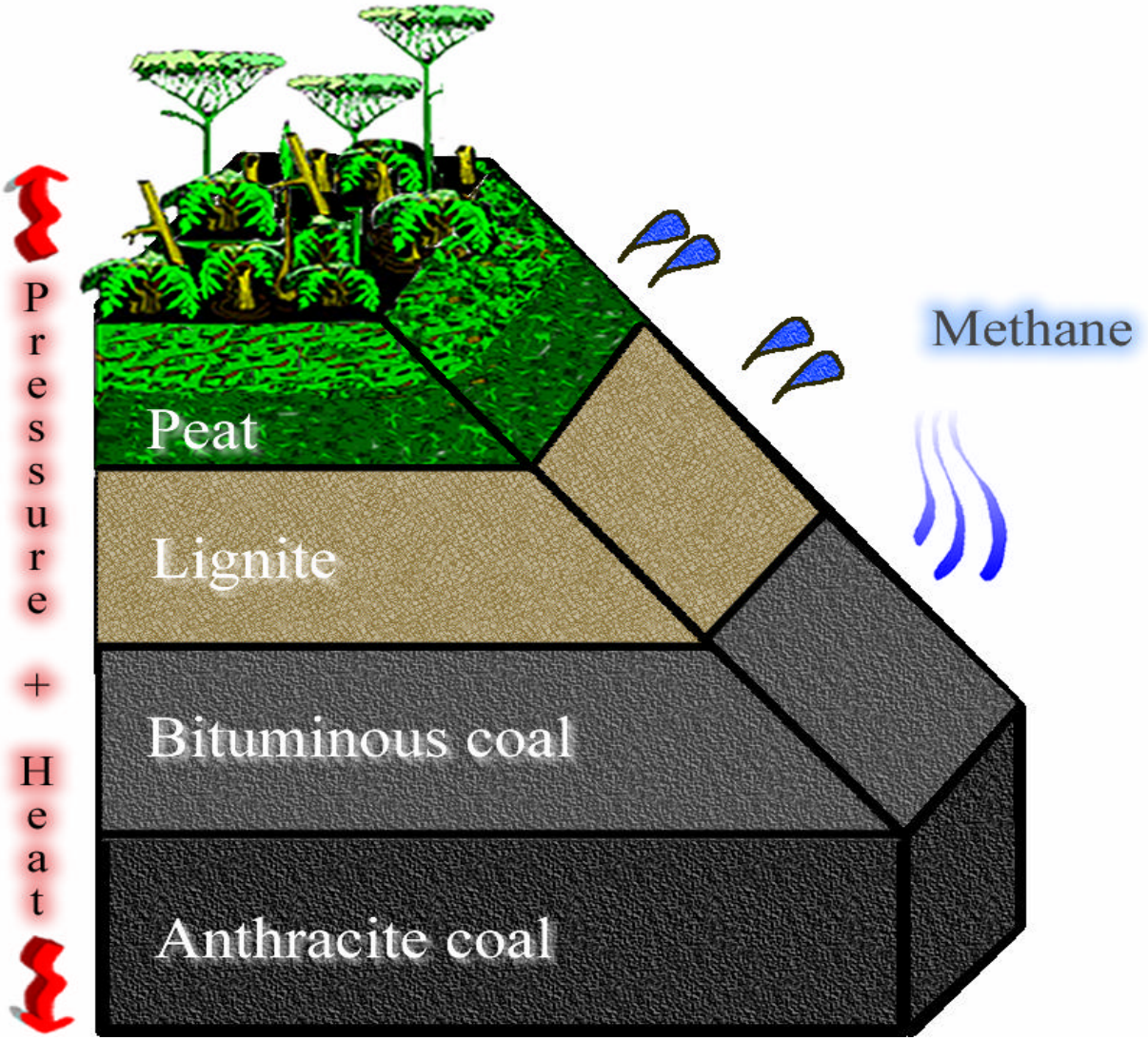


Outcrop Geology and Tertiary Coals of the Powder River Basin

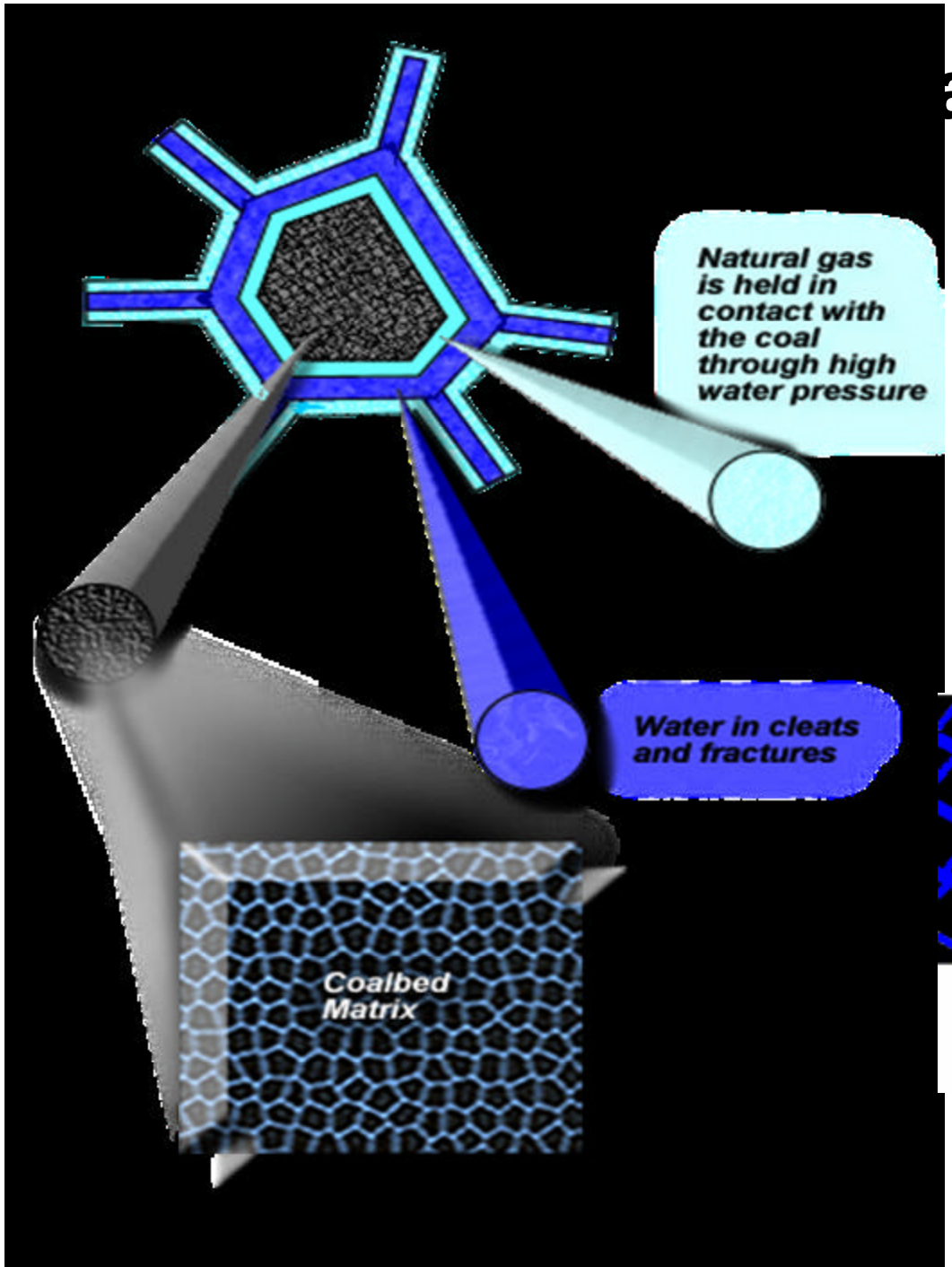
Environments of Coal Deposition

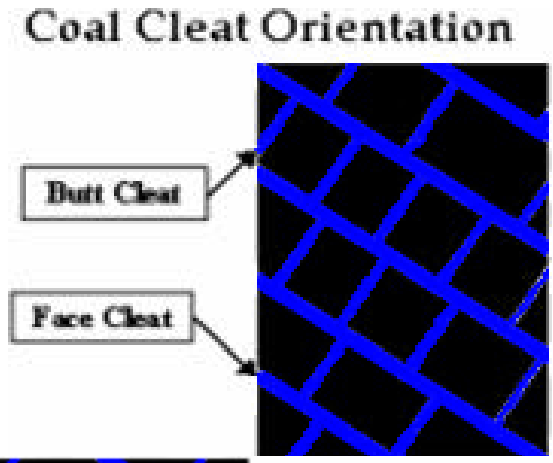


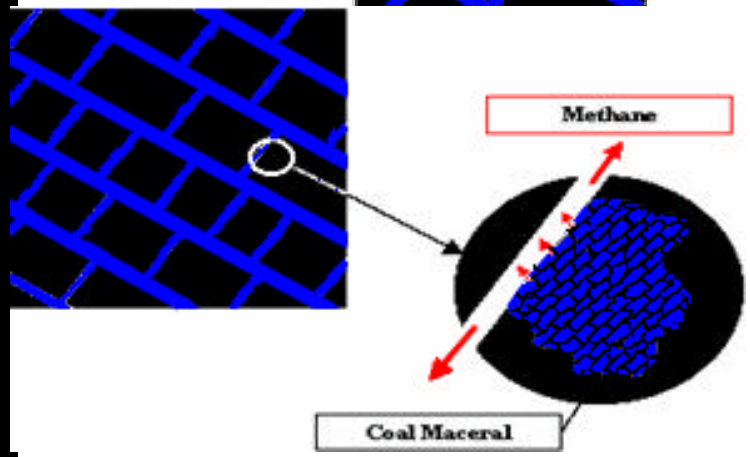
Evolution of CBM



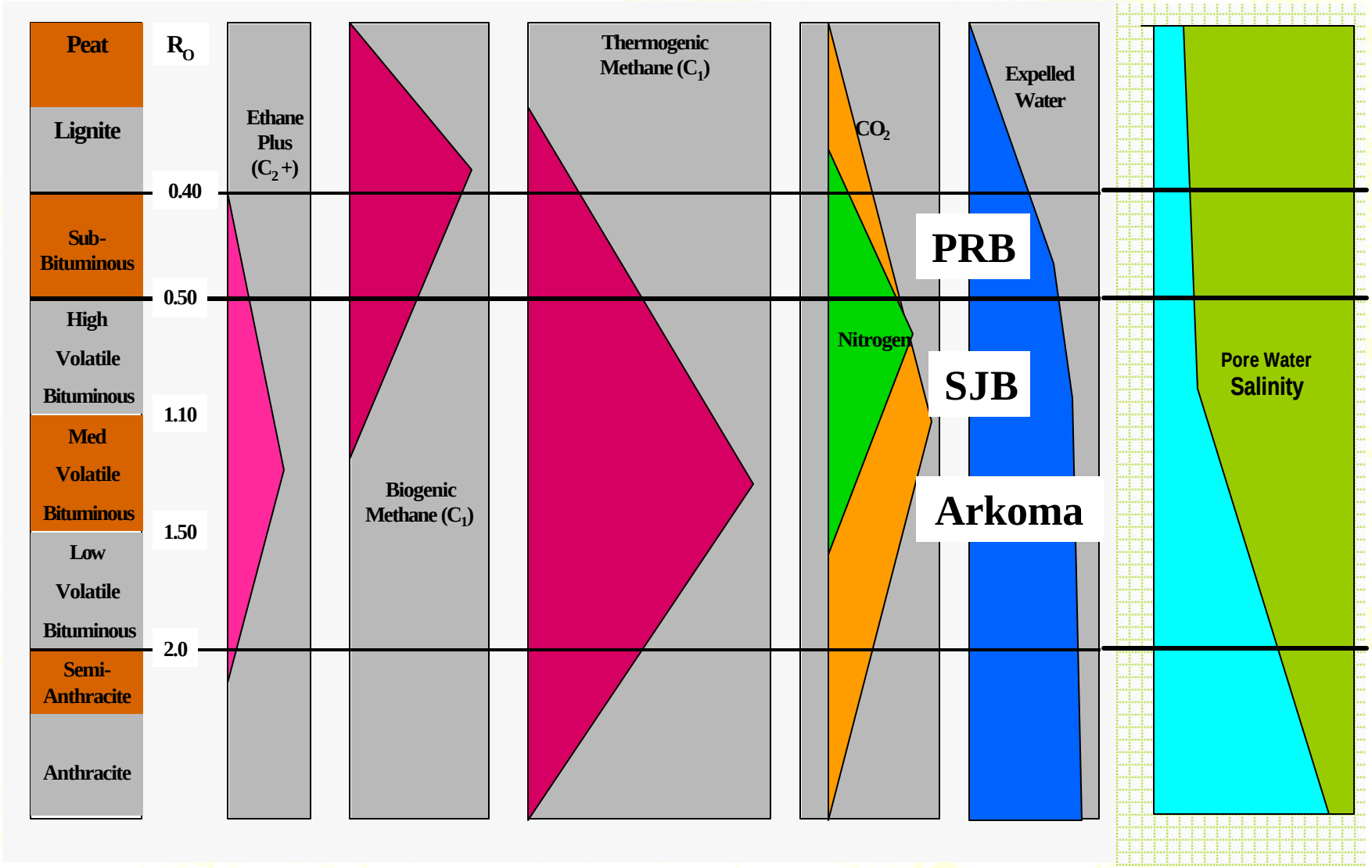
ane in Coal


Natural gas is held in contact with the coal through high water pressure
Water in cleats and fractures
Coalbed Matrix

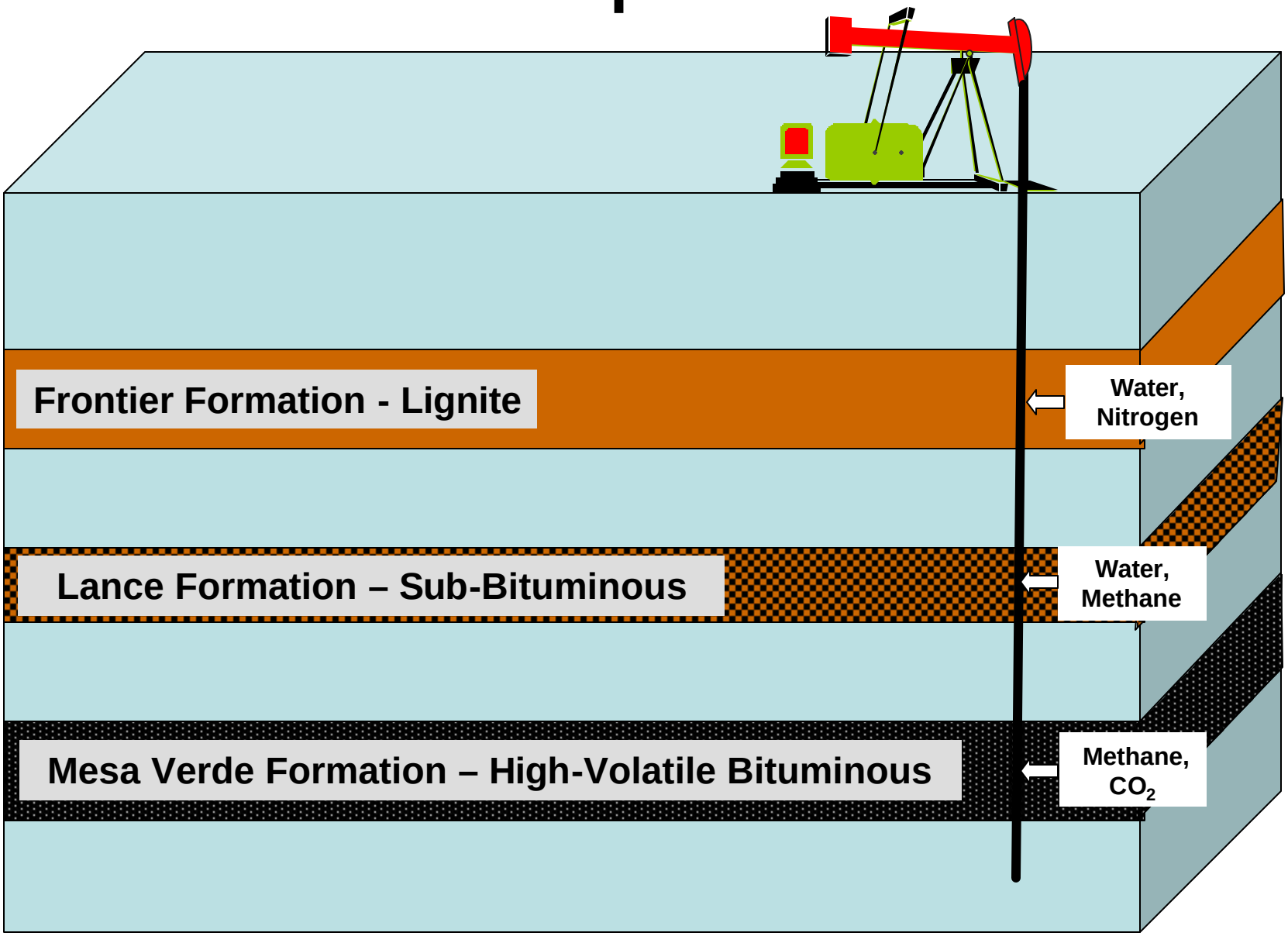

Coal Cleat Orientation
Butt Cleat
Face Cleat


Methane
Coal Maceral

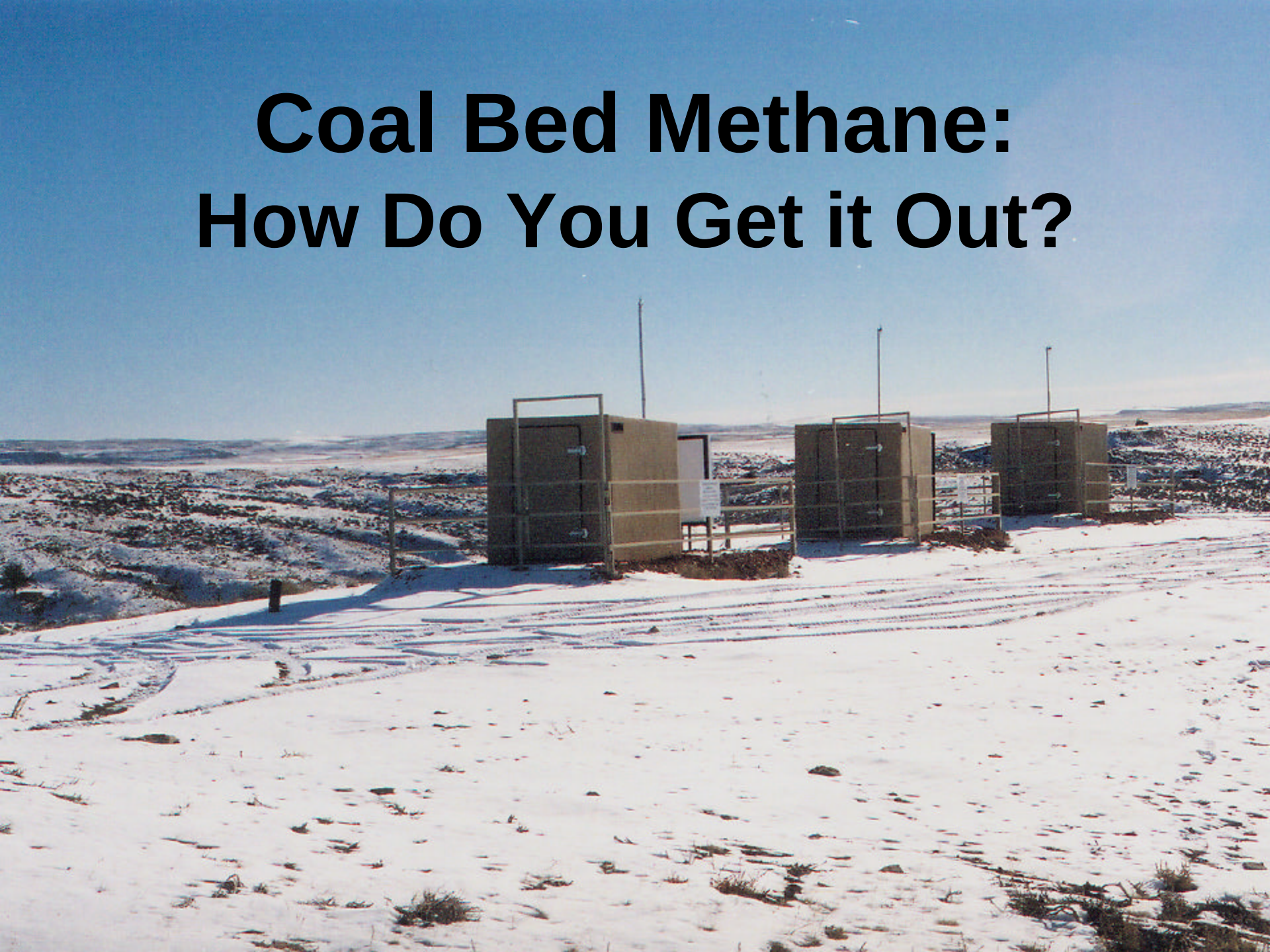
Evolution of Expelled Fluids Related to Coal Rank



Coal Fluids and Depth

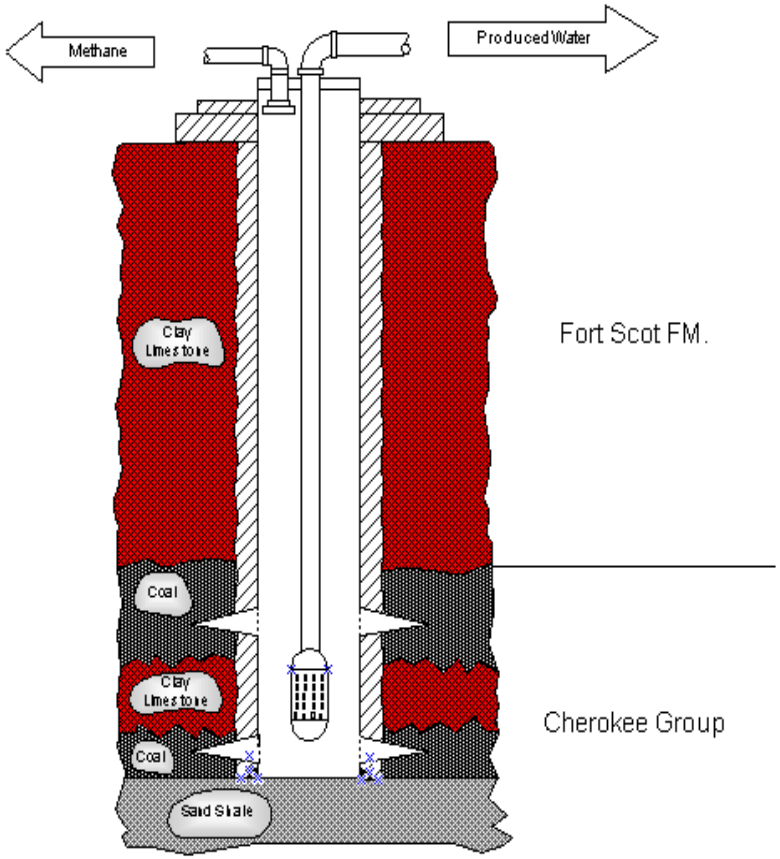


Coal Bed Methane:
How Do You Get it Out?

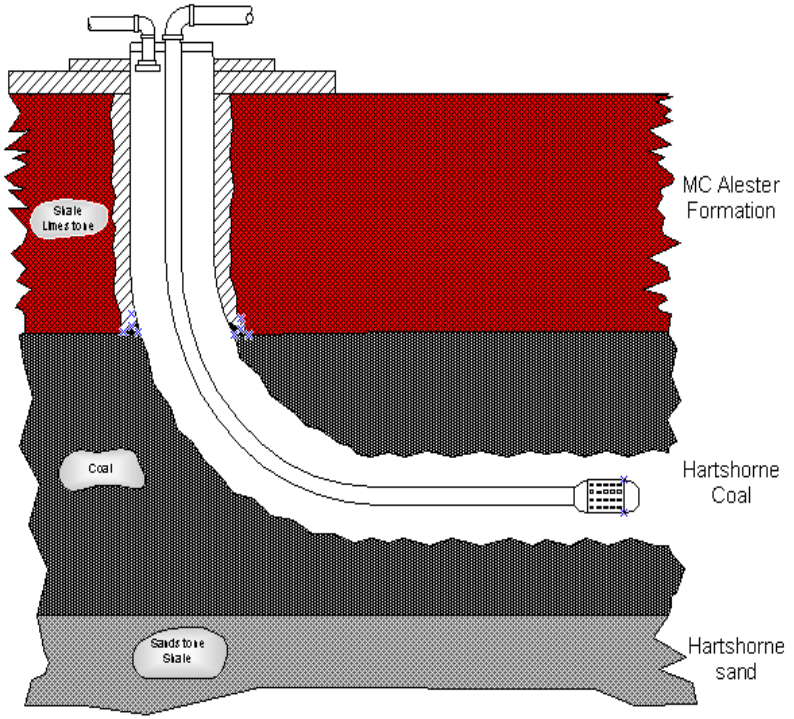


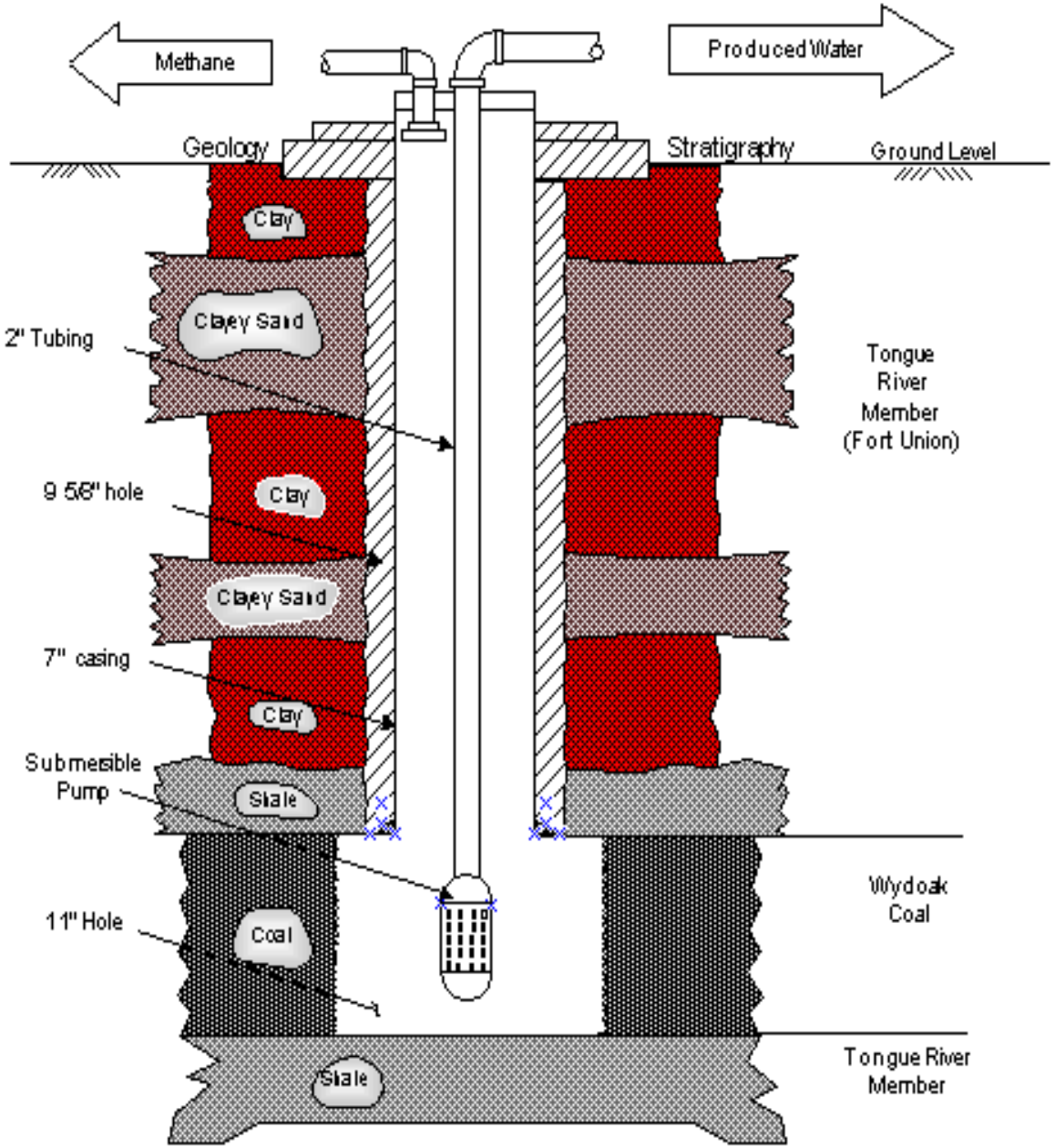
Typical Hard Coal Completions

Cherokee Basin (KS)



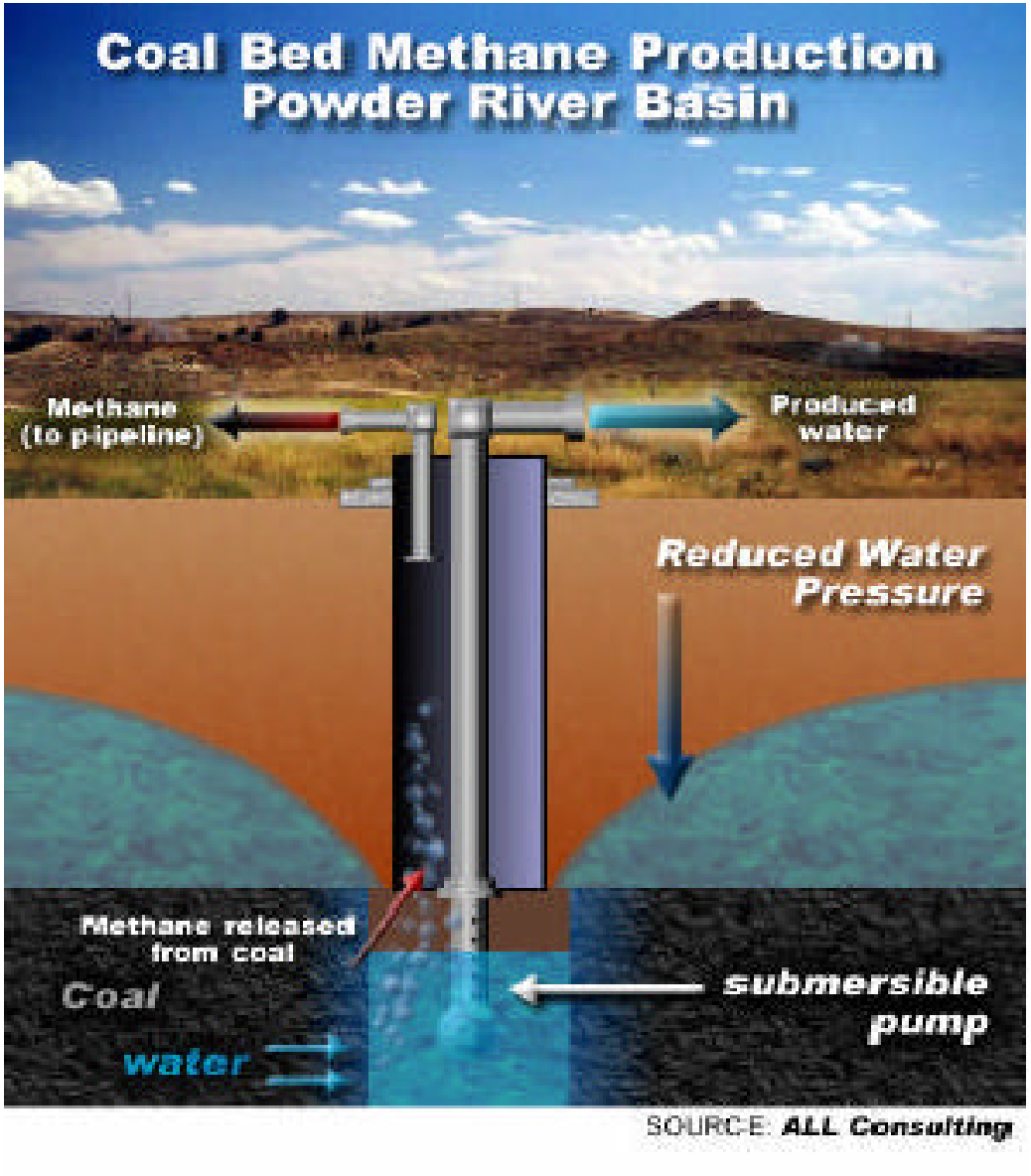
Arkoma Basin (OK)





Typical CBM Completion

(Powder River Basin)

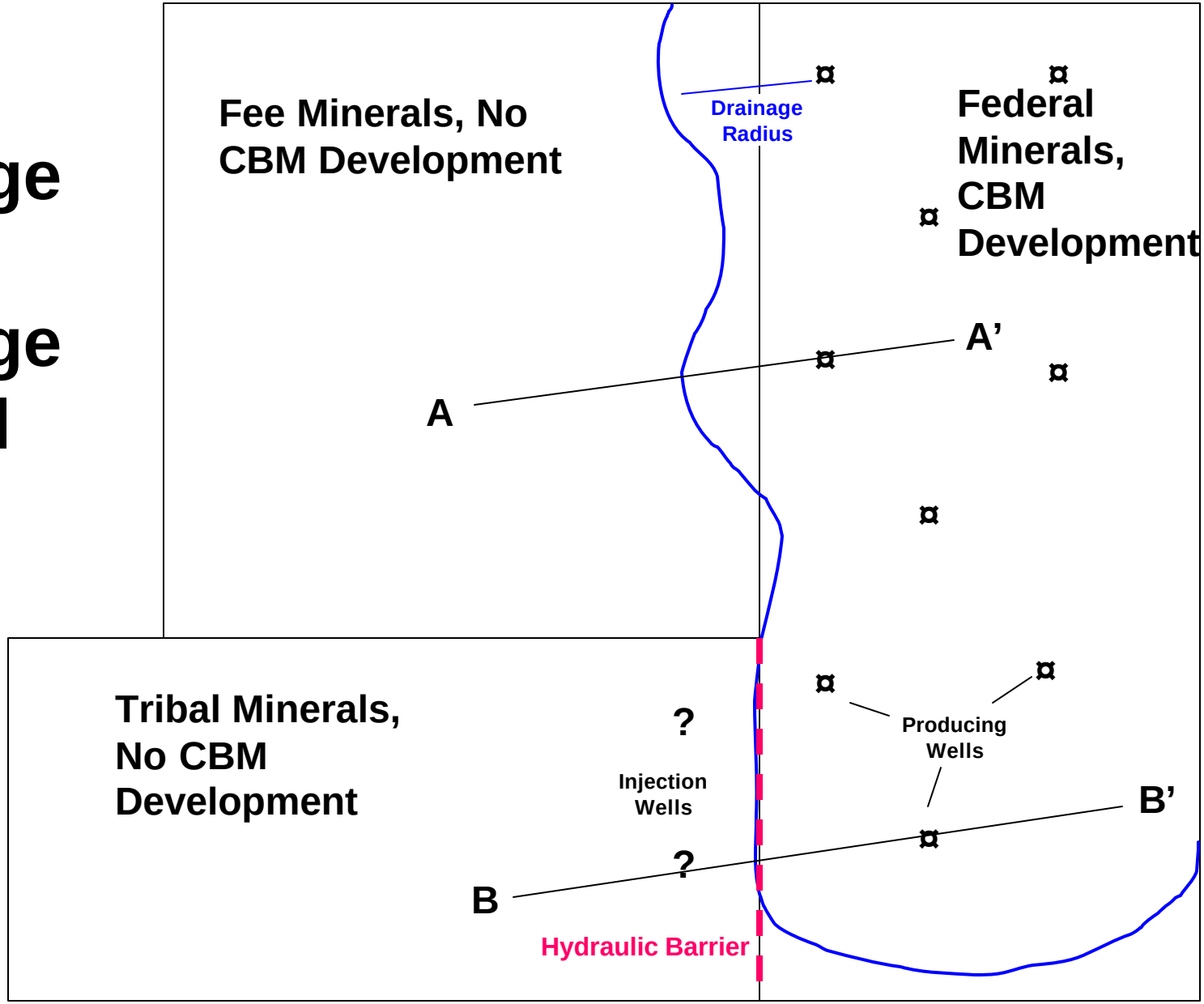


CBM Production Characteristics

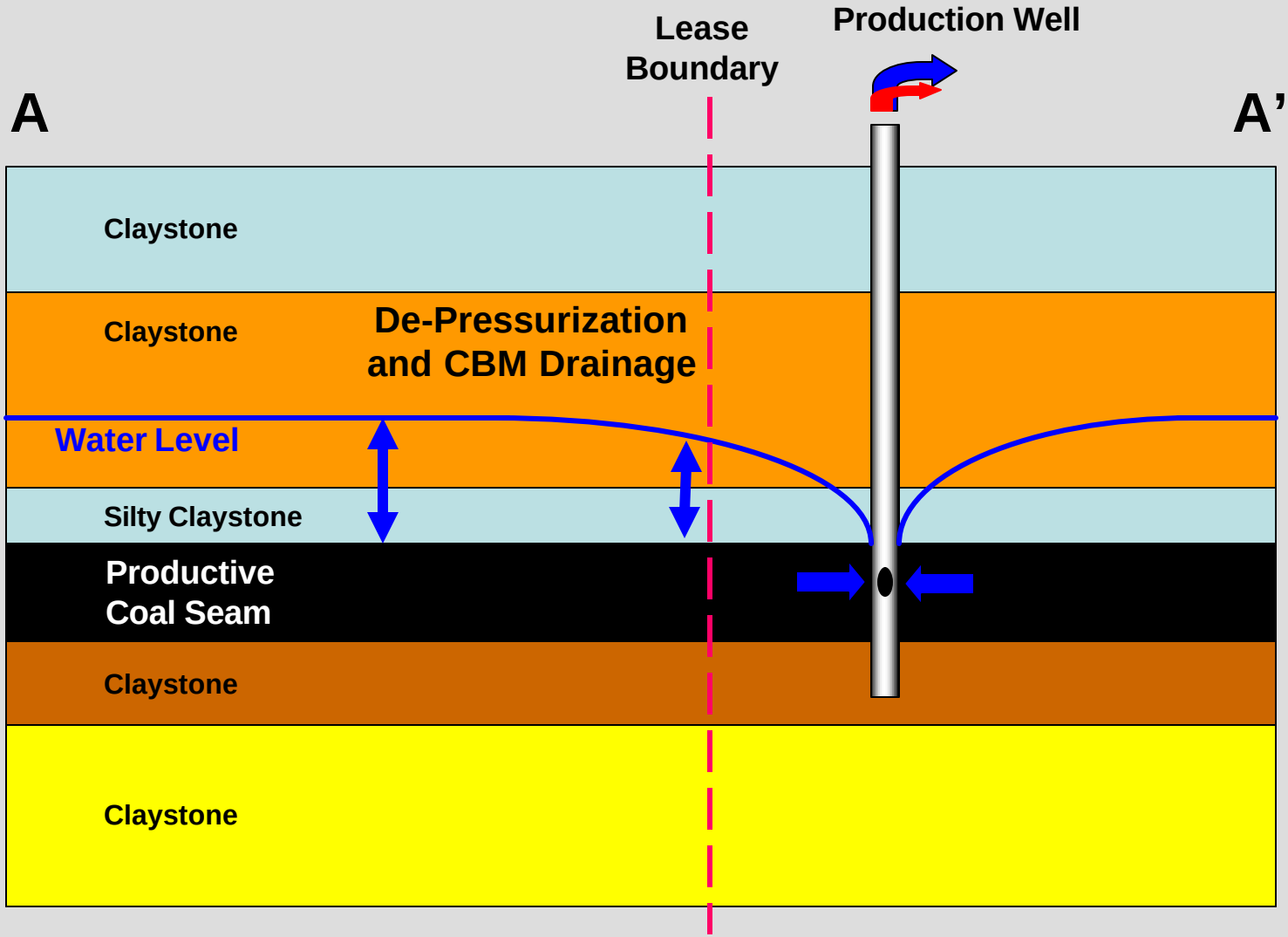
Methane is held in place by reservoir water pressure.

To produce methane, water is drawn off.

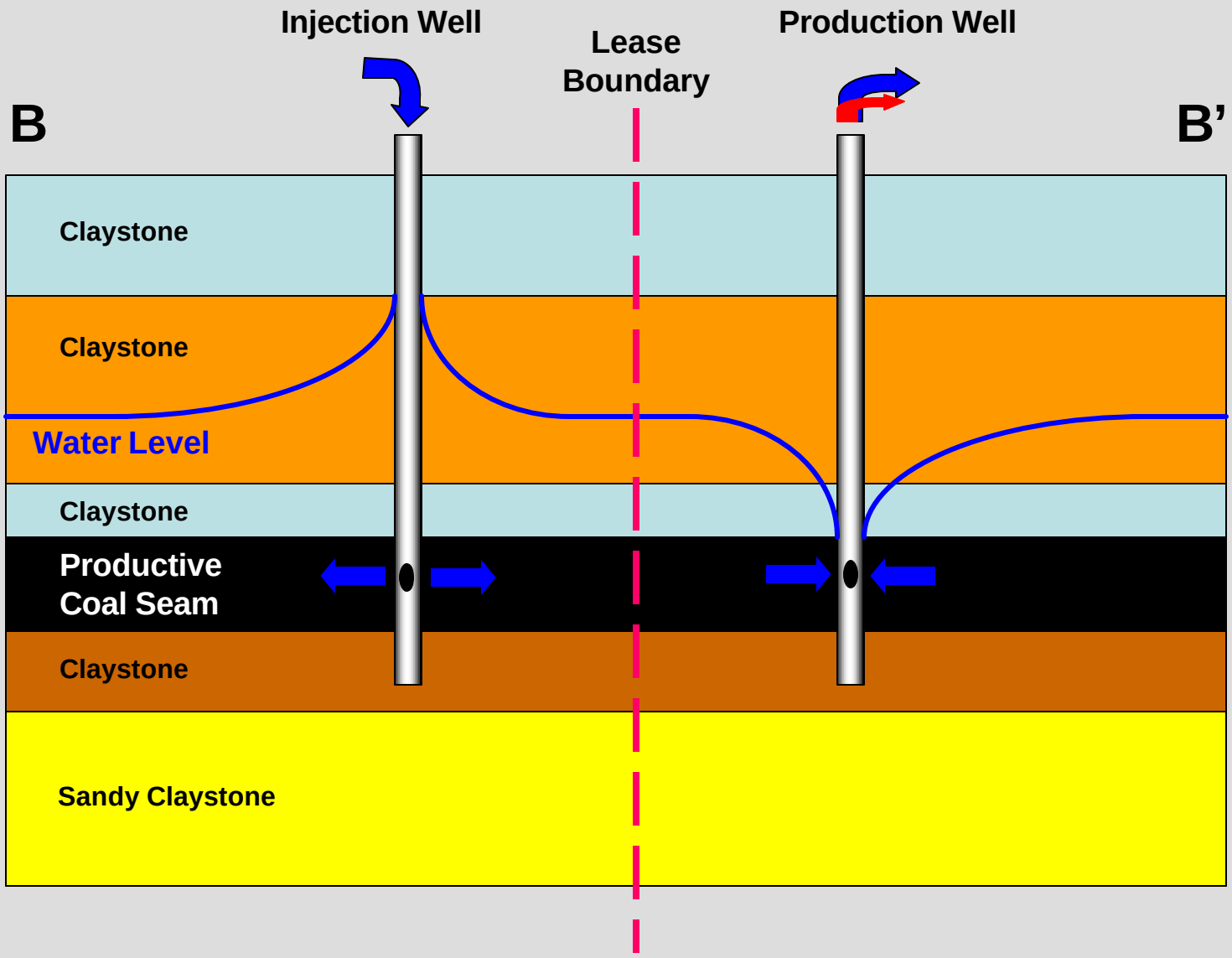
CBM Drainage and Drainage Control

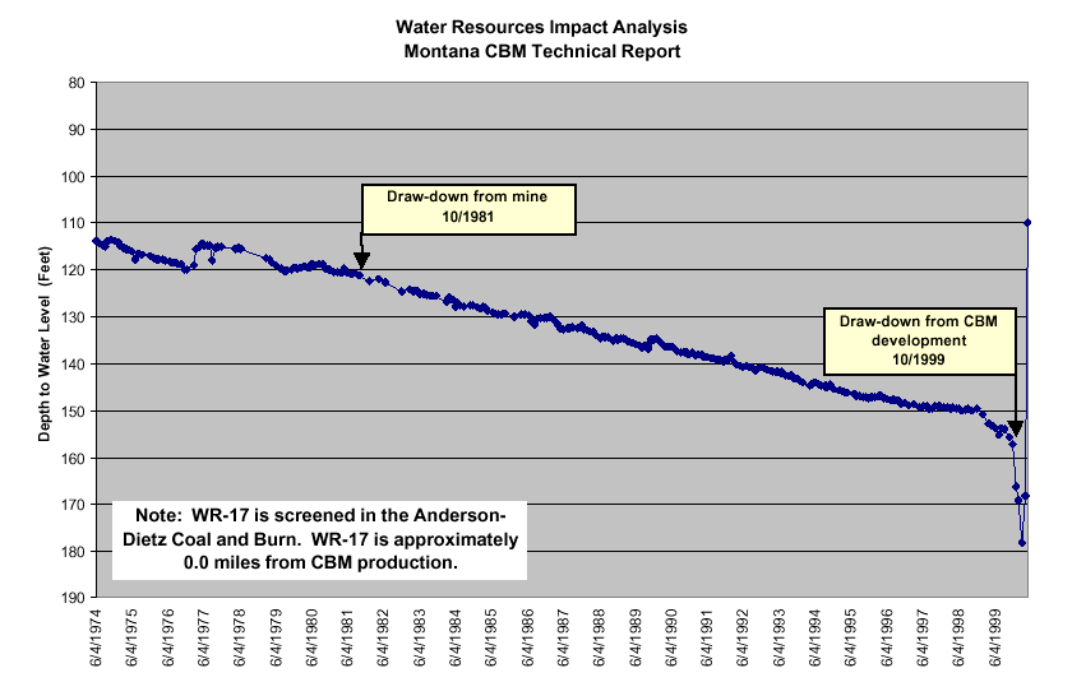


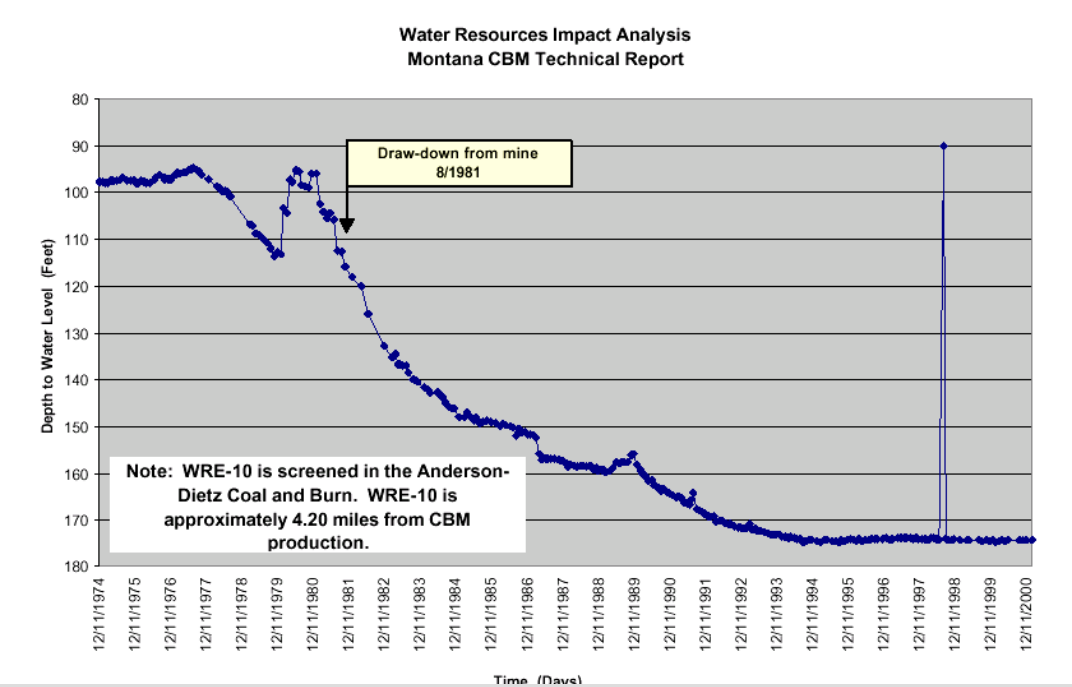
On-Lease and Off-Lease Drainage



Hydraulic Barrier to Control Drainage



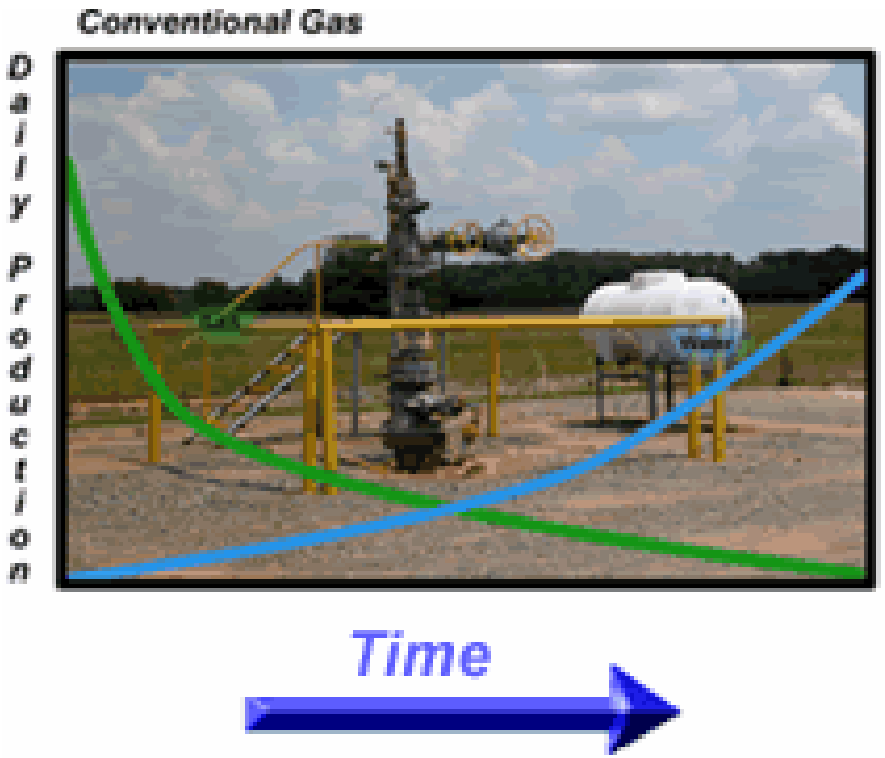


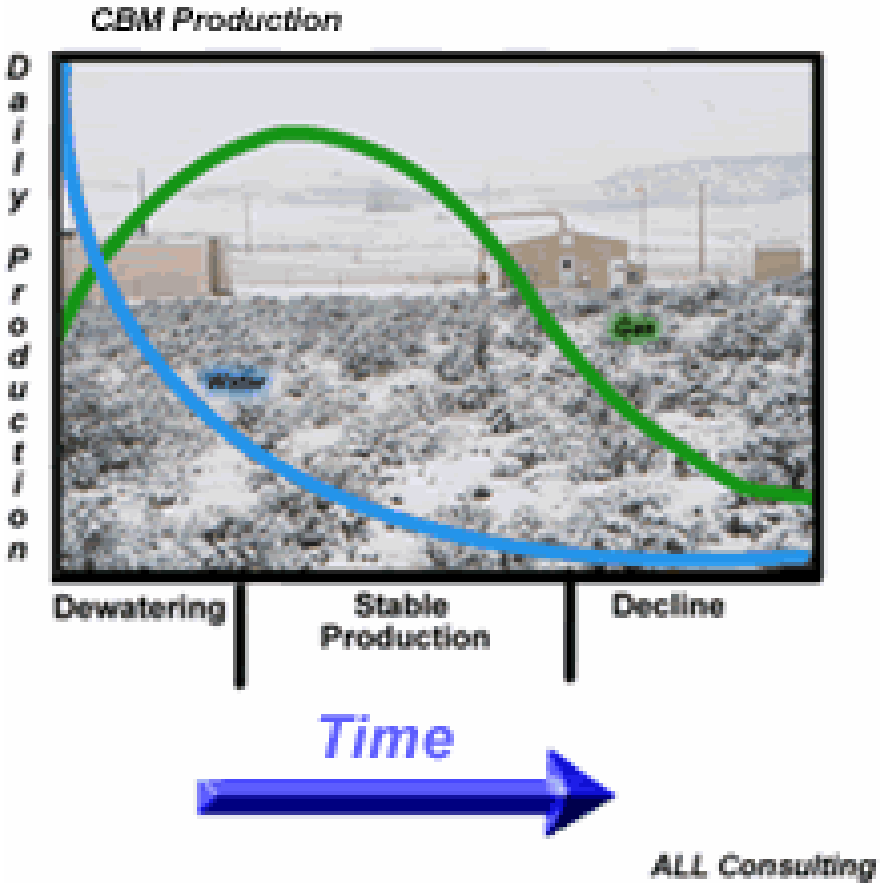


Water Management

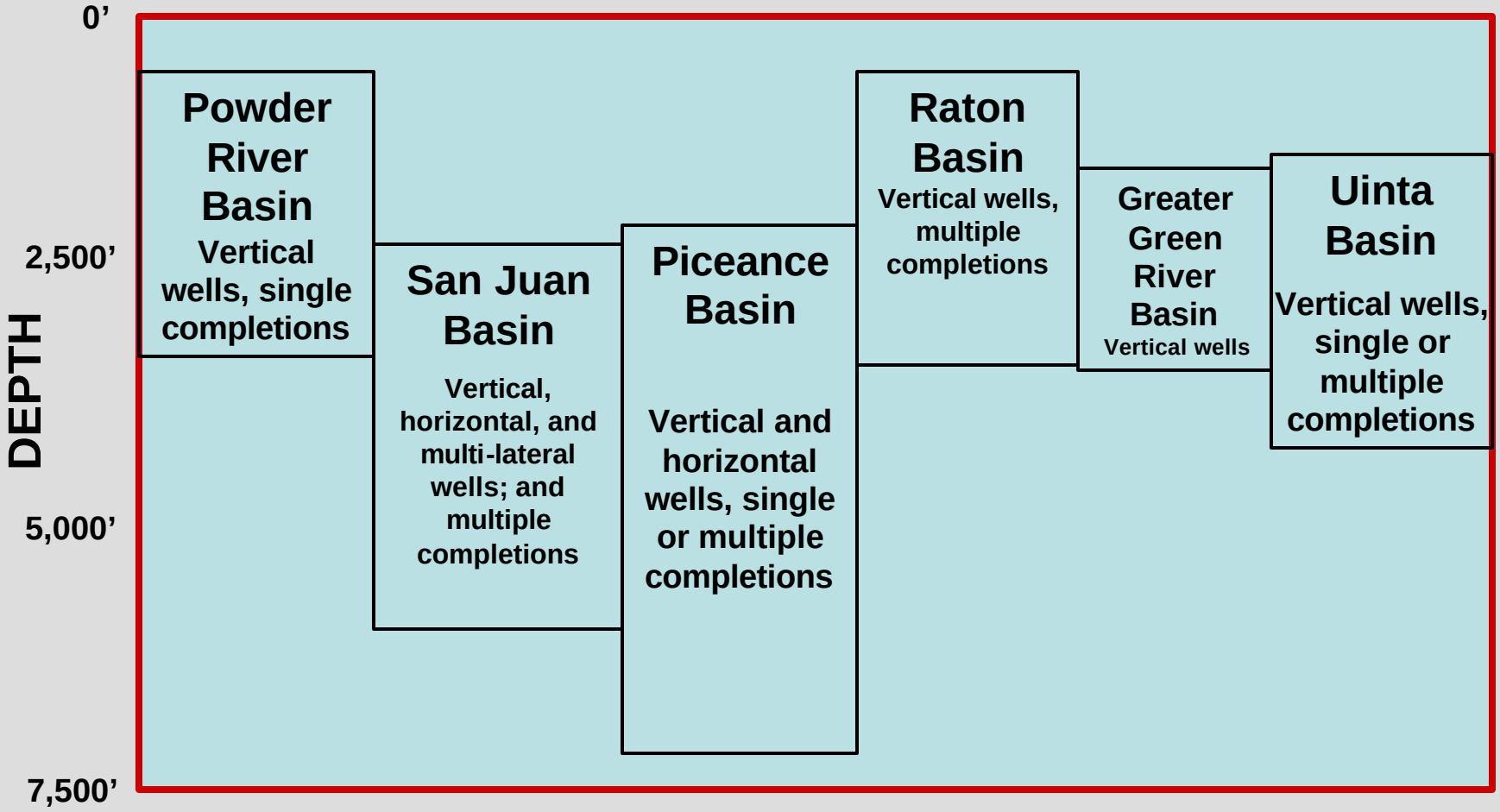
CBM production can cause de-watering of nearby water wells or springs. These impacts will need to be remediated by the CBM operator.

Natural Gas Production Characteristics: Conventional Reservoir vs CBM

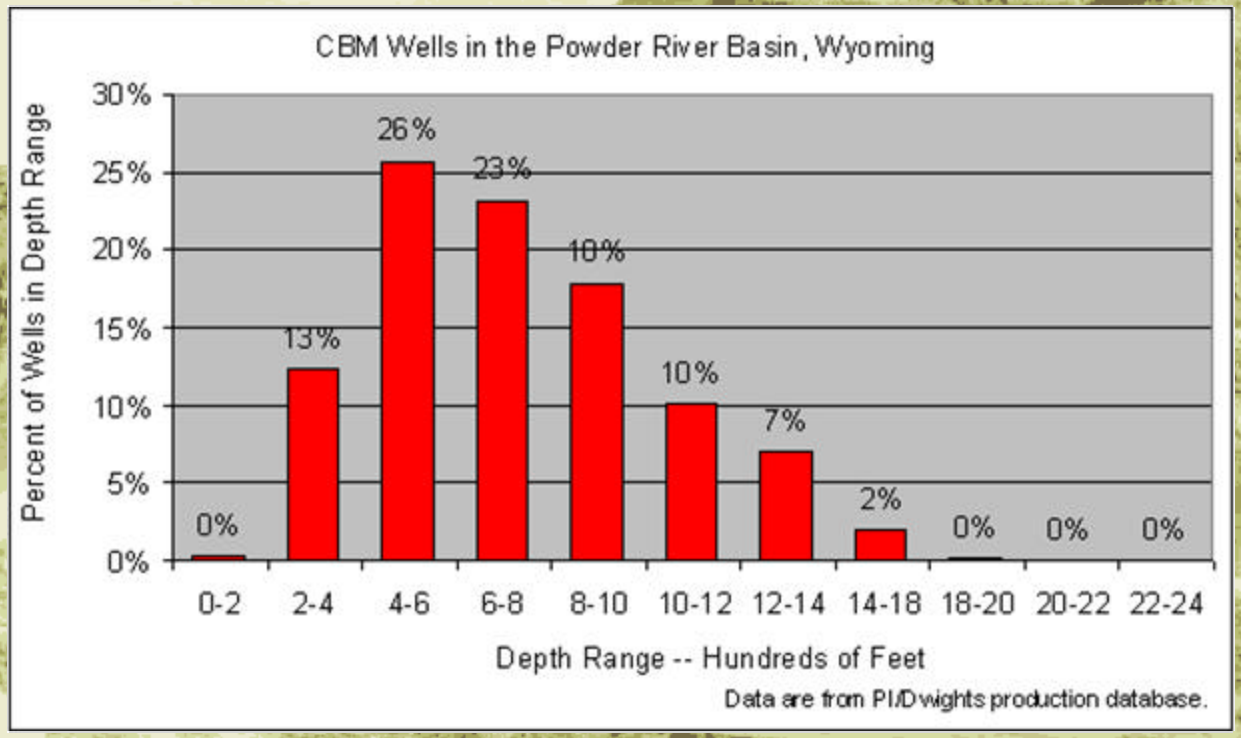




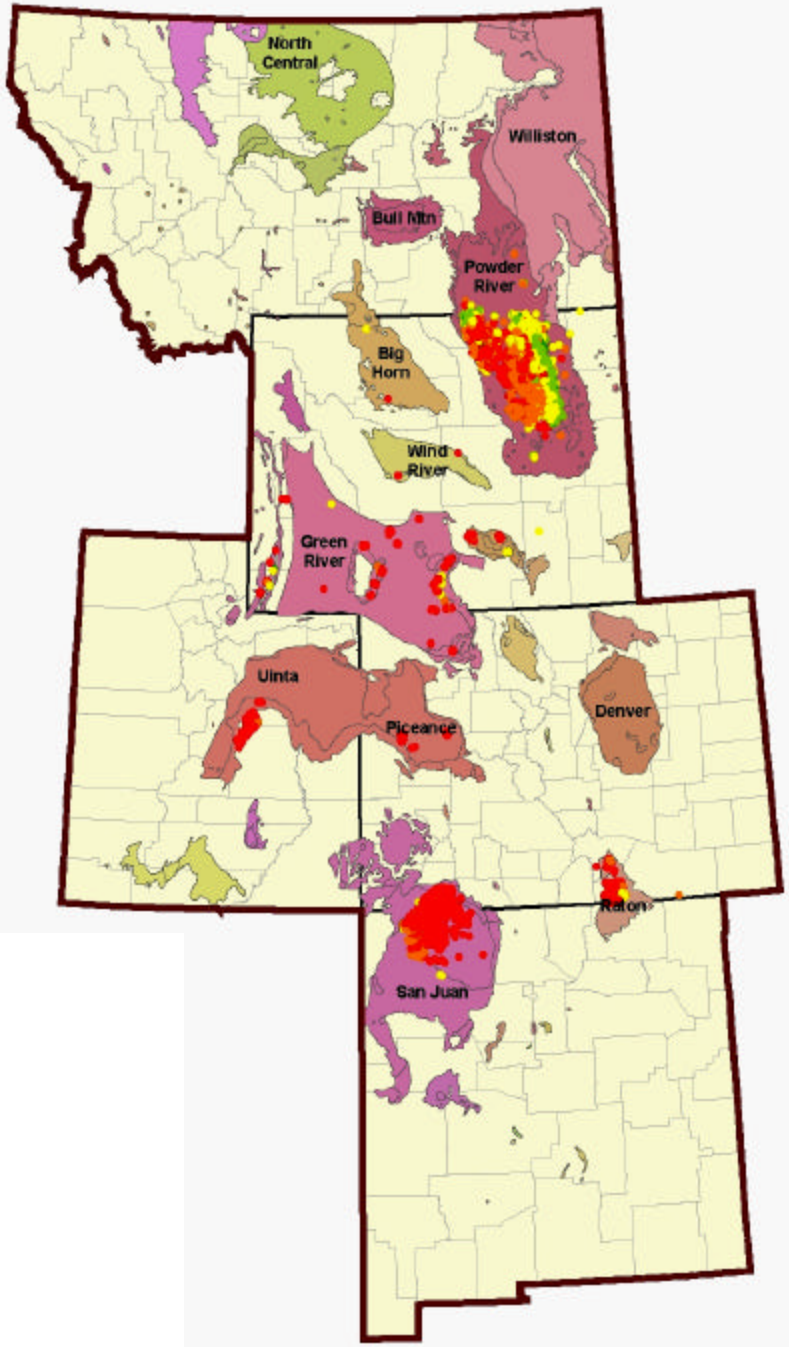
CBM Drilling and Completion Technology Options



Coal Depths and CBM



In the Powder River Basin, coals range in depths to below 2500' but cleat reduces with depth and the majority of CBM is produced at shallower depths. At the same time, many coals outcrop at the surface but many shallow coals have undergone burning and most have expelled their methane.



CBM Basins and Maximum Producing Depth

Well Depth

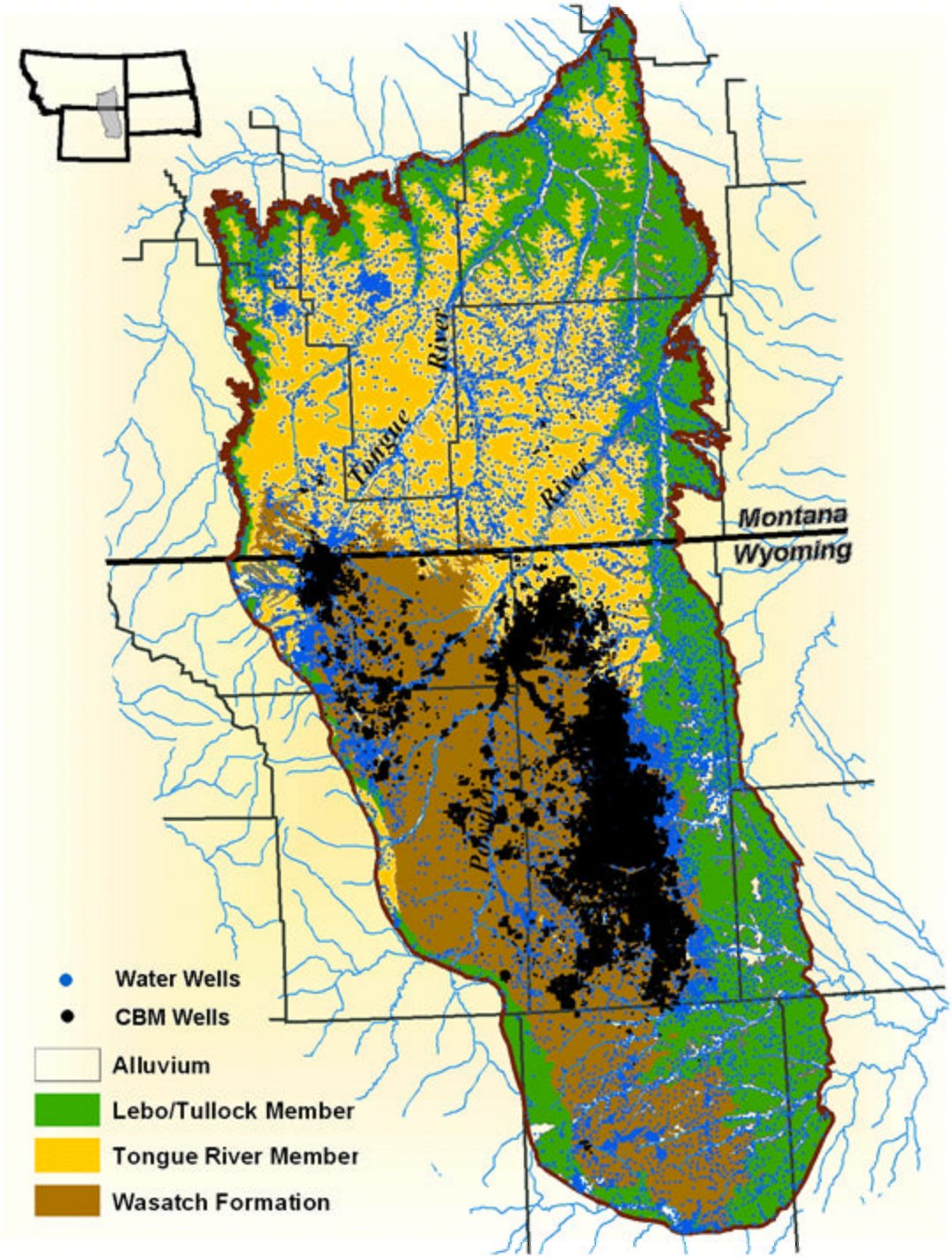
- < 250
- 251 - 500
- 501 - 1000
- 1001 - 1500
- > 1500

Comparison of Producing CBM Basins in the Rocky Mountain Region

Basin	San Juan	Raton	Uinta	Powder River
State Location	NM, CO	NM, CO	UT	WY, MT
Drilling Method	Air Percussion	Air Percussion	Air Percussion	Air-Water
Completion Methods	Cased Hole Perforate/Multistage	Cased Hole Perforate/Multistage N_2 Foam/Sand	Cased Hole Perforate/Multistage X-Link/Sand	Open-hole Under-ream
Producing Wells	2,550	694	558	10,358
Primary Water Disposal Methods	Injection	Deep Injection	Deep Injection	Surface Discharge, Beneficial Use
Water Lift Method	Rod Pump	Progressive Cavity and Rod Pump	Rod Pump	Electric Pump and Progressive Cavity
Average water Production per well	25 Bbl/day	266 Bbl/day	215 Bbl/Day	400 Bbl/day
Coal Rank	Sub-bituminous	high-volatile bituminous	high-volatile bituminous	Sub-bituminous
Well Depth (feet)	550-4000	400-4000	2000-7000	200-2500
Net Coal Thickness	20-80 feet	10-40 feet		75 feet
Gas Content	350-450 scf/ton	50-400 scf/ton	250-400 scf/ton	50 scf/ton
Well Spacing	320-160 acres	160 acres	160 acres	80 acres
Average Well Cost	$275,000	$330,000	$375,000	$75,000
Average Well Reserves	10 Bcf	1.8 Bcf	1.5 Bcf	0.4 Bcf
Average Well Gas Production Rate	800 Mscf/day	300 Mscf/day	625 Mscf/day	180 Mscf/day

Sources: PTTC Rockies 2000, GTI 2000, EPA 2002, USGS 2000, CO, NM, WY, MT Oil and Gas Commissions, Williams 2001,

CBM Produced Water:
Management Options



CBM Wells and Water Wells in the Powder River Basin

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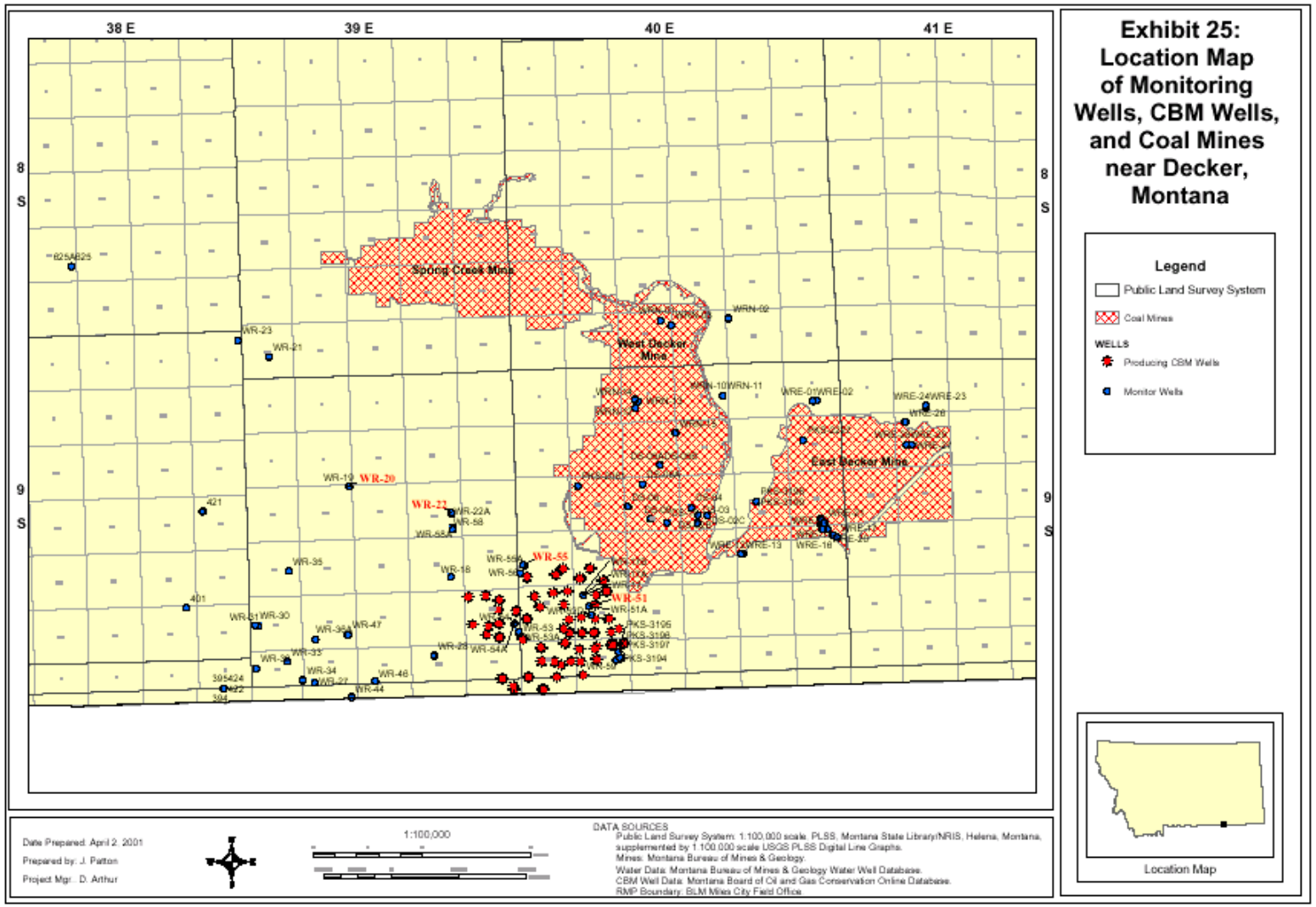
CBM and Water Management



CBM and Water Management

EXHIBIT 22 - GROUNDWATER QUALITY FOR THE MONTANA PORTION OF THE POWDER RIVER BASIN

Selected groundwater quality data collected from water supply wells located throughout Montana PRB

	Judith River Formation		Hell Creek/Fox Hills Formation		Fort Union Formation		Quaternary Alluvium	
County	Avg. TDS (mg/L)	Avg. SAR	Avg. TDS (mg/L)	Avg. SAR	Avg. TDS (mg/L)	Avg. SAR	Avg. TDS (mg/L)	Avg. SAR
Big Horn	936	54	1440	14	1658	8	2118	5
Rosebud	2465	31	1376	35	1595	16	1516	9
Powder River	No data	No data	890	35	1882	15	2783	5
Custer	No data	No data	896	37	1810	31	1665	8
Treasure	2312	64	1985	56	1782	32	2437	10
Weighted Average	2100	42	1148	37	1892	18	2014	7

Note: Avg. TDS = Average Total Dissolved Solids, Avg. SAR = Average Sodium Adsorption Ratio

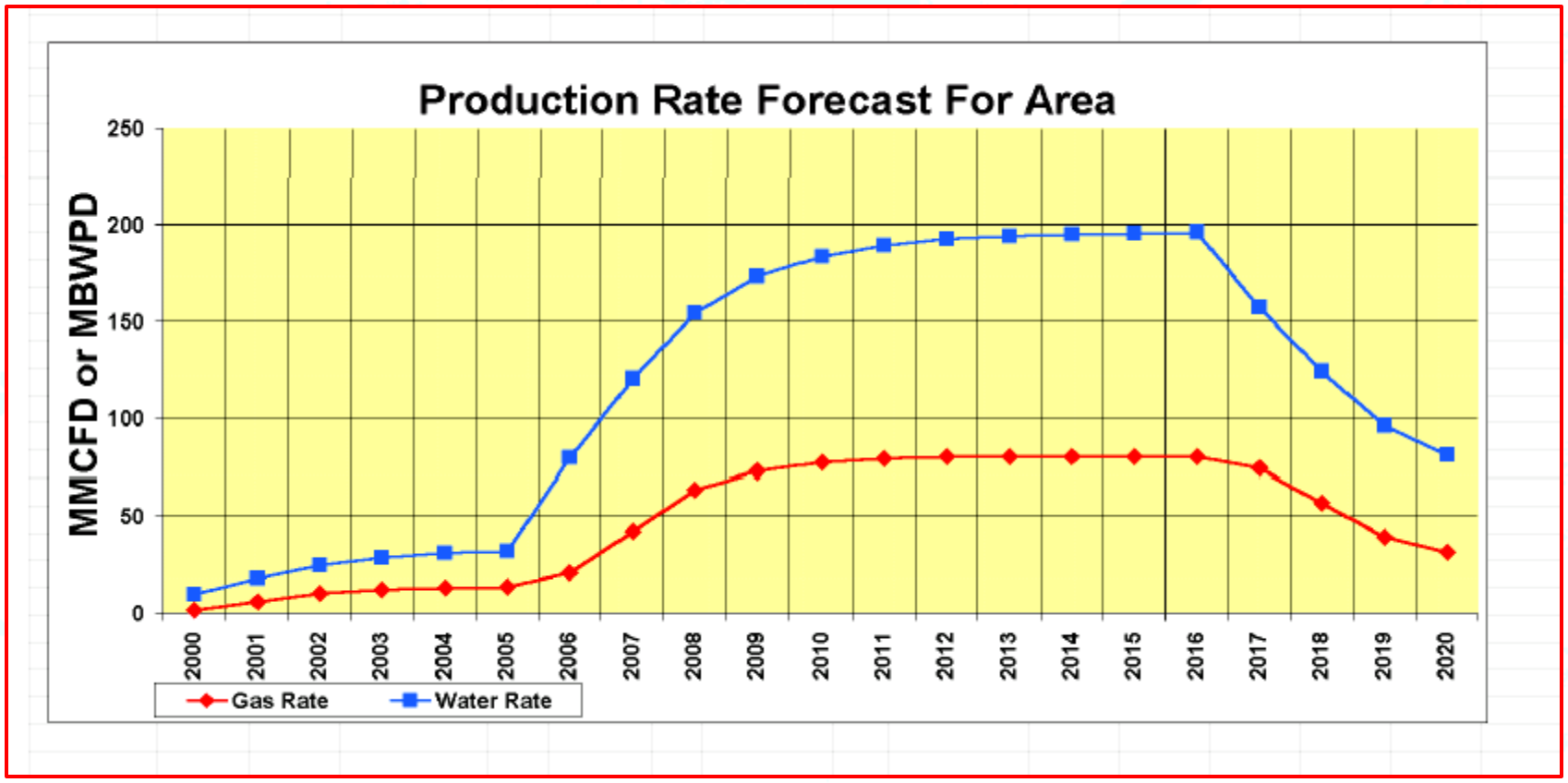
CBM and Water Management

Analyte	National Drinking Water Standards (primary unless noted)	MT. Water Quality Stds. for Livestock ppm (MSU 2001)	CX Ranch Average (MDEQ, 2000)
TDS mg/L	500 (secondary)	10,000	1,400
SAR			47
Sodium mg/L			558
Ammonia, Total mg/L			2.0
Chloride mg/L	250 (secondary)		19
Fluoride mg/L	2.0 (secondary)	2	2.5
Sulfate mg/L Aluminum, total mg/L	250 (secondary) 0.05 to 0.2 (secondary)	5	0.05
Arsenic mg/L	0.05	0.2	0.001
Barium mg/L	2.0		0.5
Beryllium mg/L	0.004		0.0005
Boron mg/L		5	0.07
Cadmium mg/L	0.005	0.05	
Chromium mg/L Copper mg/L	0.1 1.0 (secondary)	1 0.5	0.001
Lead mg/L Iron, dissolved mg/L	0.015 0.3	0.05	0.002 0.03
Iron, total mg/L			0.125
Manganese mg/L	0.05		0.01
Mercury mg/L	0.002	0.1	
Selenium mg/L Strontium mg/L	0.05	0.5	 0.43
Radium mg/L	5 pCi/L		0.2
Vanadium mg/L Zinc mg/L	 5 (secondary)	0.1 24	

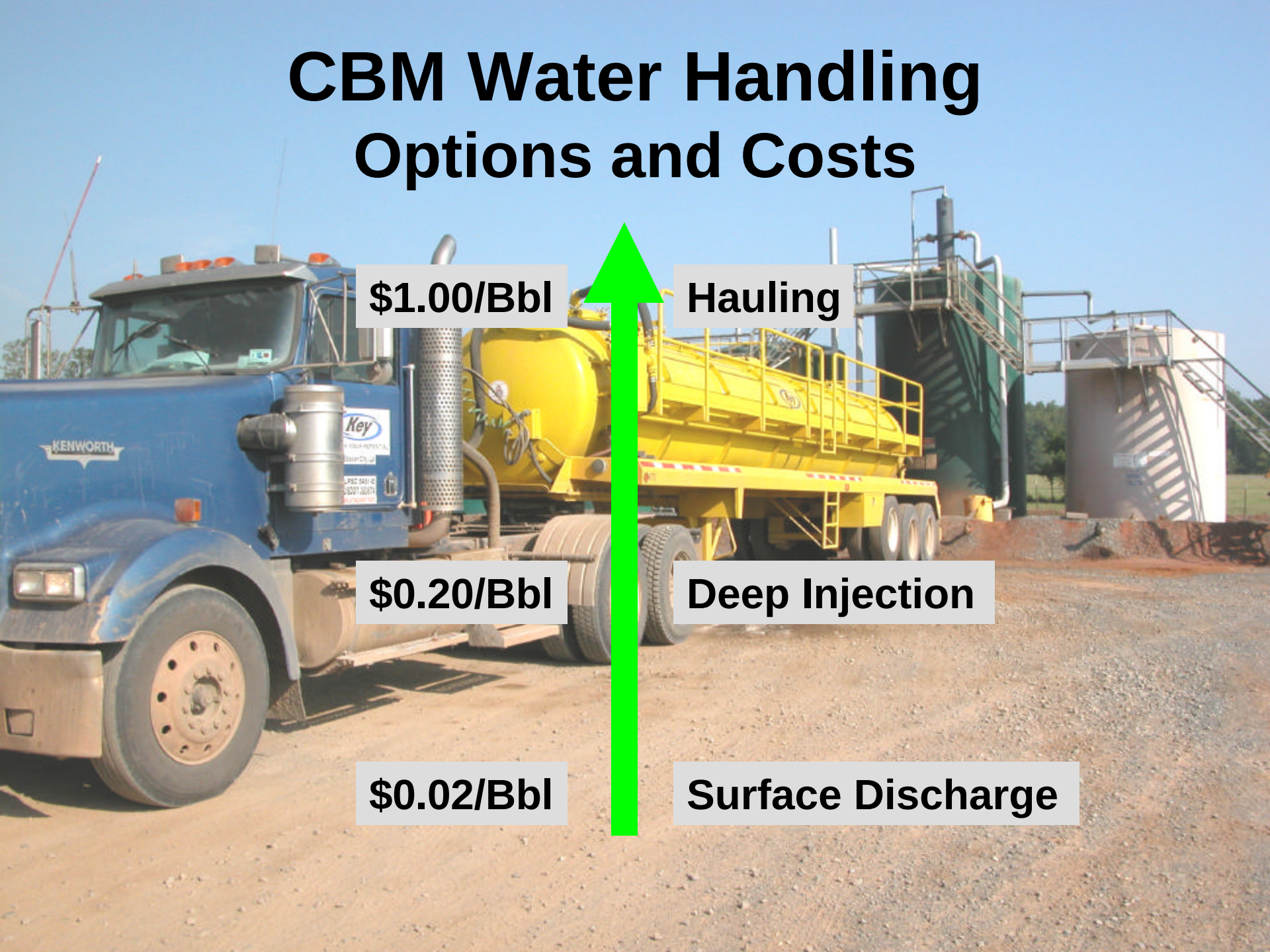
CBM produced water from Montana shows some exceedances of drinking and livestock standards. Total Dissolved Solids (TDS) is exceeded for humans but is acceptable for livestock in the state of Montana. Fluoride is exceeded for both humans and livestock.

The Sodium Adsorption Ratio (SAR) is important as a limiting factor for soil condition and sodium is a limiting factor for plant growth. Both constituents limit the use of this particular water for irrigation although water management can mitigate deleterious effects.

CBM and Water Management



CBM Water Handling Options and Costs



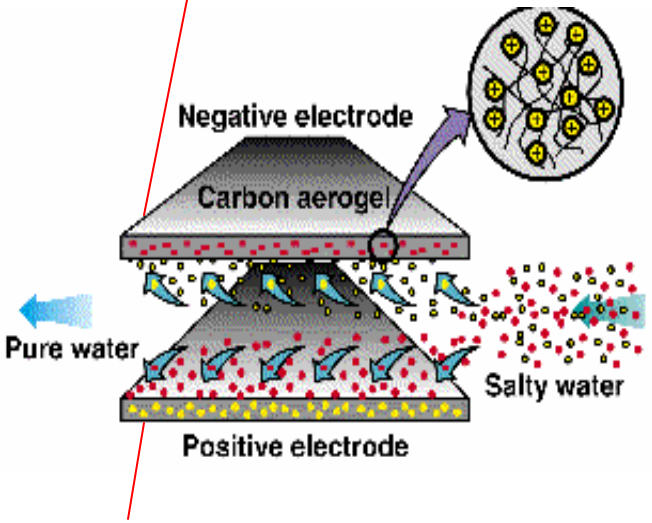
Treatment Processes

- Reverse Osmosis (RO)
- Electrodialysis Reversal (EDR)
- Ion Exchange
- Freeze Thaw Evaporation
- Artificial Wetlands
- Land-Based Wastewater Treatment
- Emerging Technologies
  - Capacitive Desalination (CDT or EWP)
  - Rapid Spray Distillation

CDT Technology: a New Solution

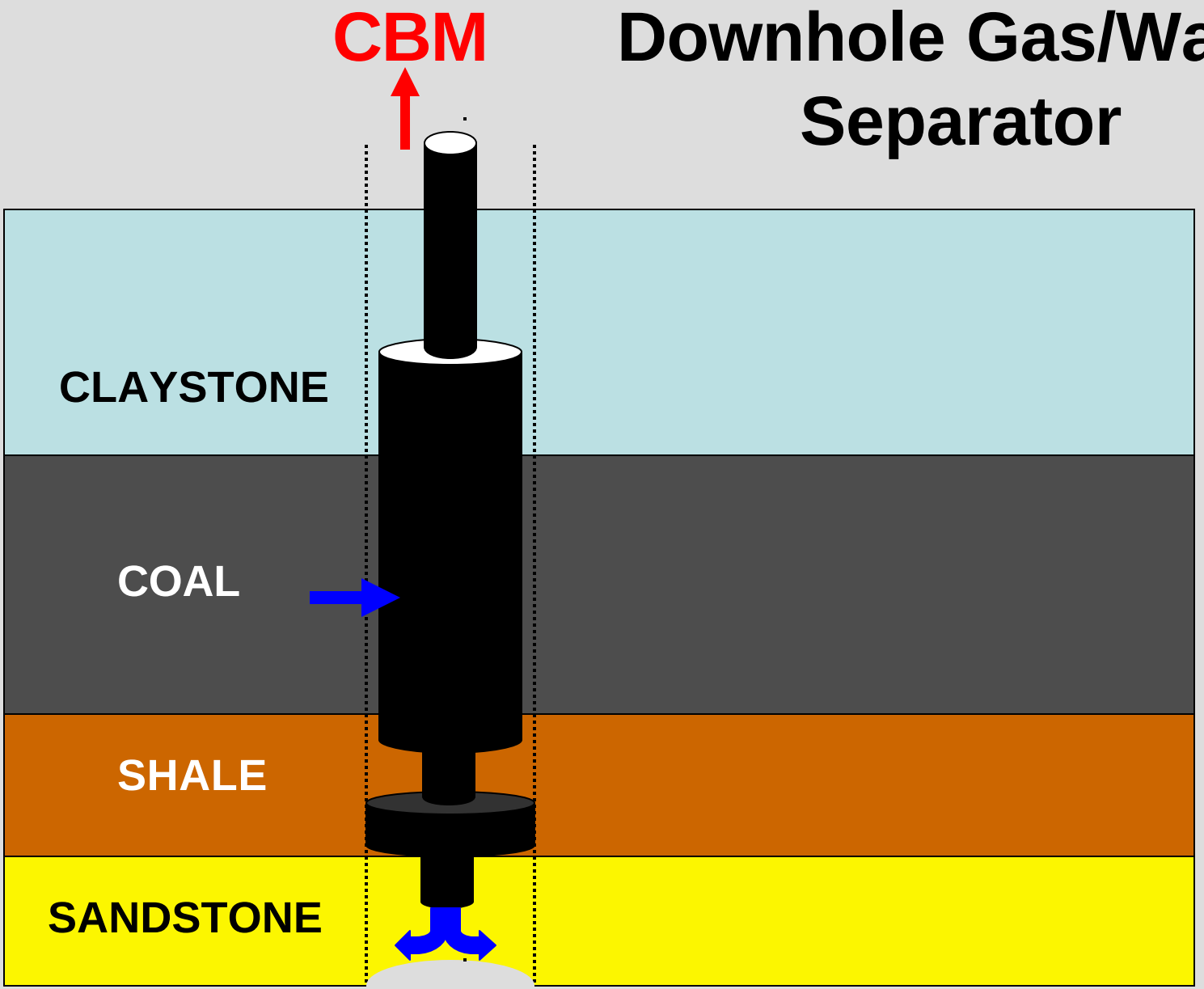
- "Capacitive Deionization Technology™"
  - Invented and patented by Lawrence Livermore National Laboratory
    - $40+ Million DOE investment
    - 10 years in development
  - Currently being developed commercially under license by CDT Systems, Inc.
- Operating Principle - Flow Through Capacitor
  - Liquid flows between high surface area electrode pairs having a potential difference of 1.3 vdc.
  - Ions and other charged particles are attracted to and held on the electrode of opposite charge for later release into a rinse stream.

Negative electrode attracts positively charged ions (cations)
Calcium (Ca)
Magnesium (Mg)
Sodium (Na)



Positive electrode attracts negatively charged ions (anions)
Chloride (Cl)
Nitrate (NO_3)
Silica (SiO_2)

Downhole Gas/Water Separator



CBM Development: An Attractive Component of America's Energy Mix