

***Piceance Basin Coalbed Methane
Stream Depletion Assessment:
Plan of Study
January 26, 2007***



Summary of Presentation

1. Study motivation and goals

2. Background

- a. CBM extraction industry
- b. Regulating agencies and jurisdiction
- c. Geologic setting

3. Plan of study

- a. Key study elements
- b. Schedule
- c. Communications

Study Team

- Colorado Division of Water Resources
- Colorado Oil and Gas Conservation Commission
- Colorado Geological Survey
- S.S. Papadopoulos & Associates, Inc.



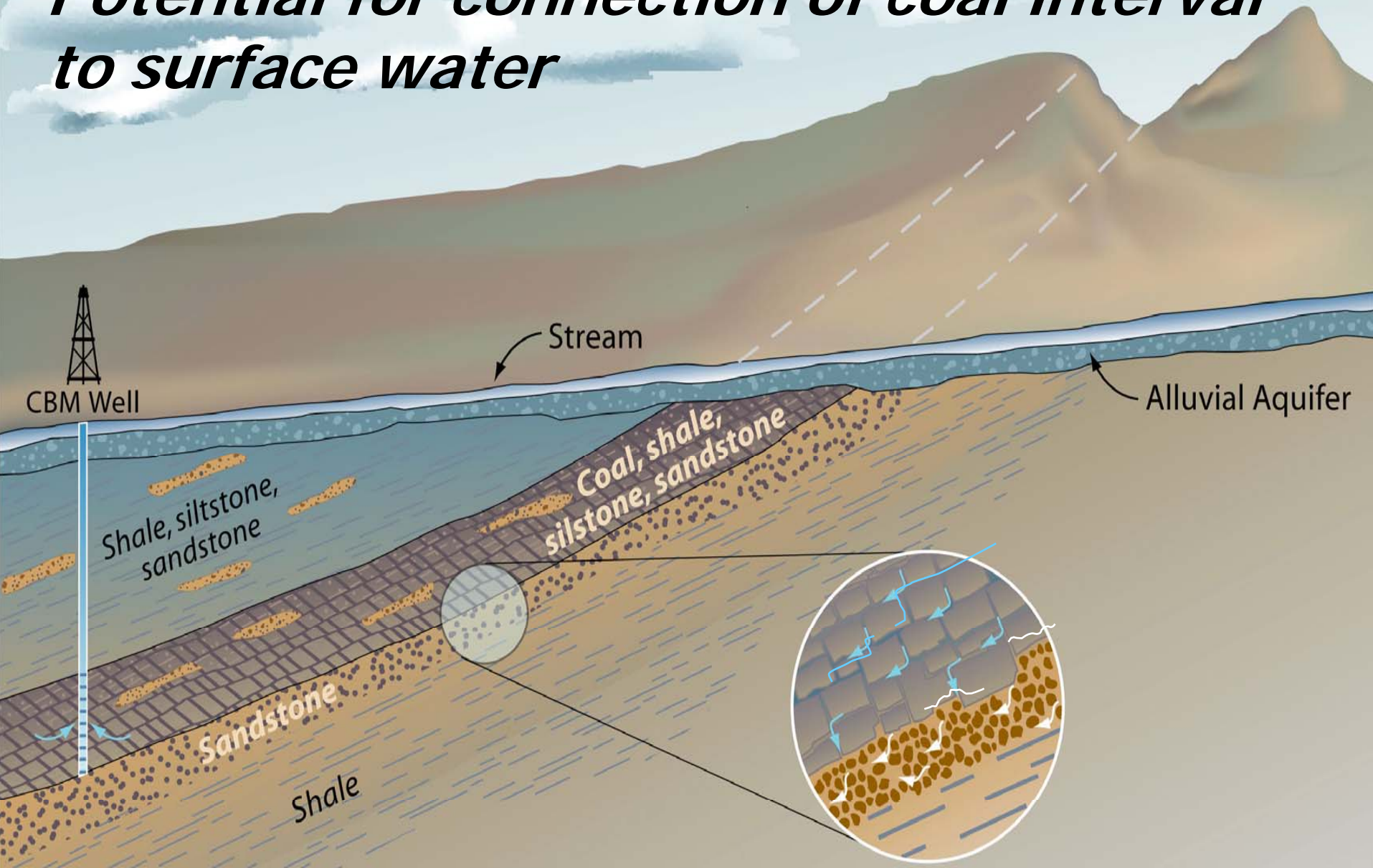
1. Study Motivation and Goals



Motivation for Stream Depletion Assessment Study

- **Local concerns**
 - Impact of coal bed methane extraction on water availability
 - Potential beneficial uses of extracted water
- **State responsibility**
 - Protection of existing water rights
 - Maintain compliance with interstate stream compacts and Water Rights Acts

Potential for connection of coal interval to surface water



Goals for Stream Depletion Assessment Study

- Determine magnitude of stream depletion, if any, from extraction of water and methane
 - Current and post-pumping
 - Regional and interstate
- Define areas from which extraction would be considered tributary vs. non-tributary, for purposes of regulating groundwater extraction under provisions of Colorado water law
- Provide framework for decision-makers regarding suitability of present level of regulation, primarily with respect to impacts on stream-related water rights

Other important issues, but not evaluated in this study

- **Environmental impacts of CBM**
 - Undesirable or hazardous methane migration
 - Mitigation or remediation
- **Local, site-specific impacts**
 - Questions regarding specific wells or springs
 - Detailed migration or depletion patterns
- **Wellfield longevity or production issues**
 - Spacing of wells
 - Operational procedures

Study Resources

- Knowledge of participating agencies
- Information provided by basin property owners/ public
- Data provided by oil and gas operators
- Other public domain reports



2. Background



Background:

a) Coal Bed Methane Extraction Industry

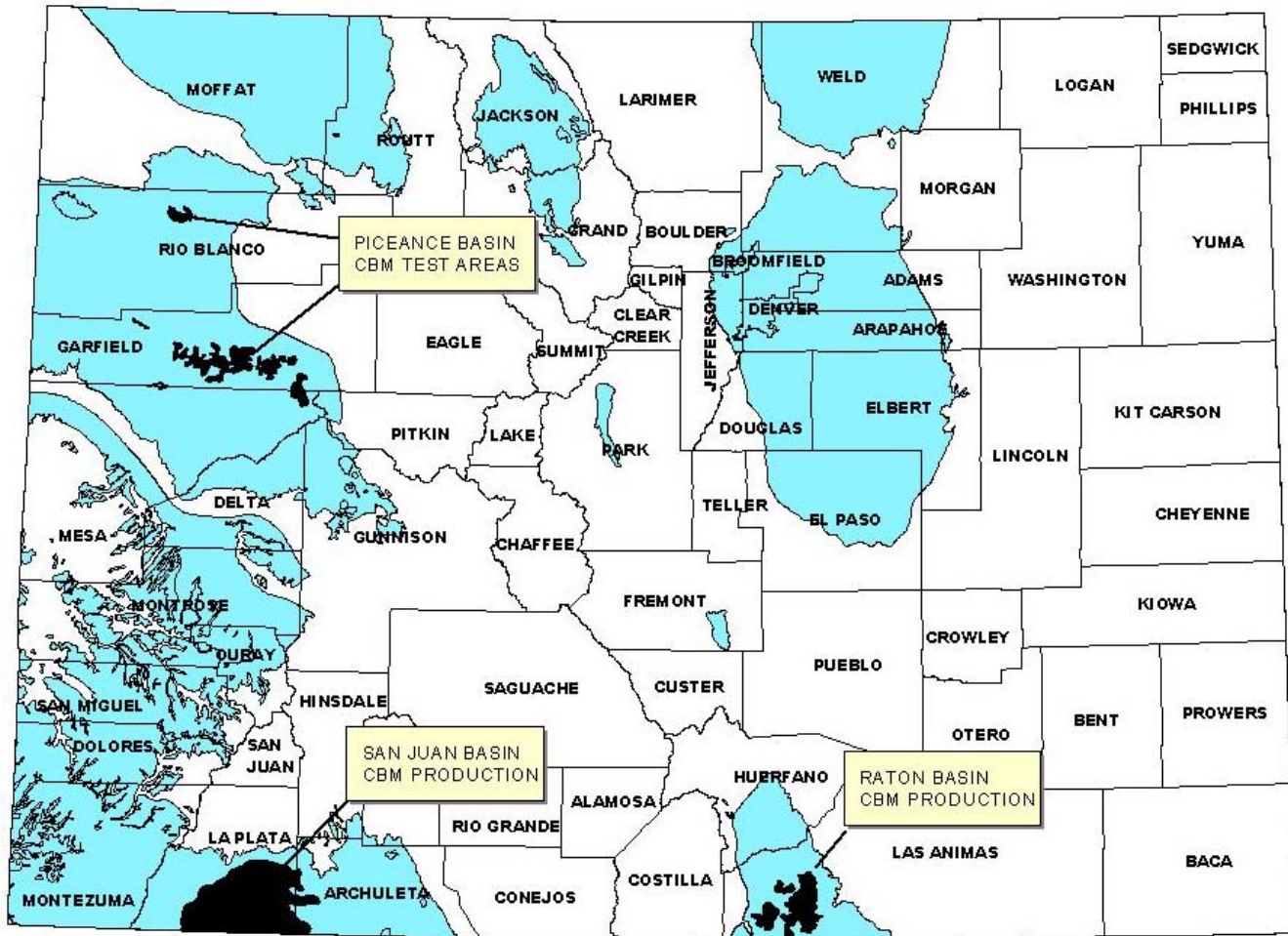


3,909 Coalbed Methane (CBM) Wells in Colorado

1,836 CBM Wells in San Juan Basin

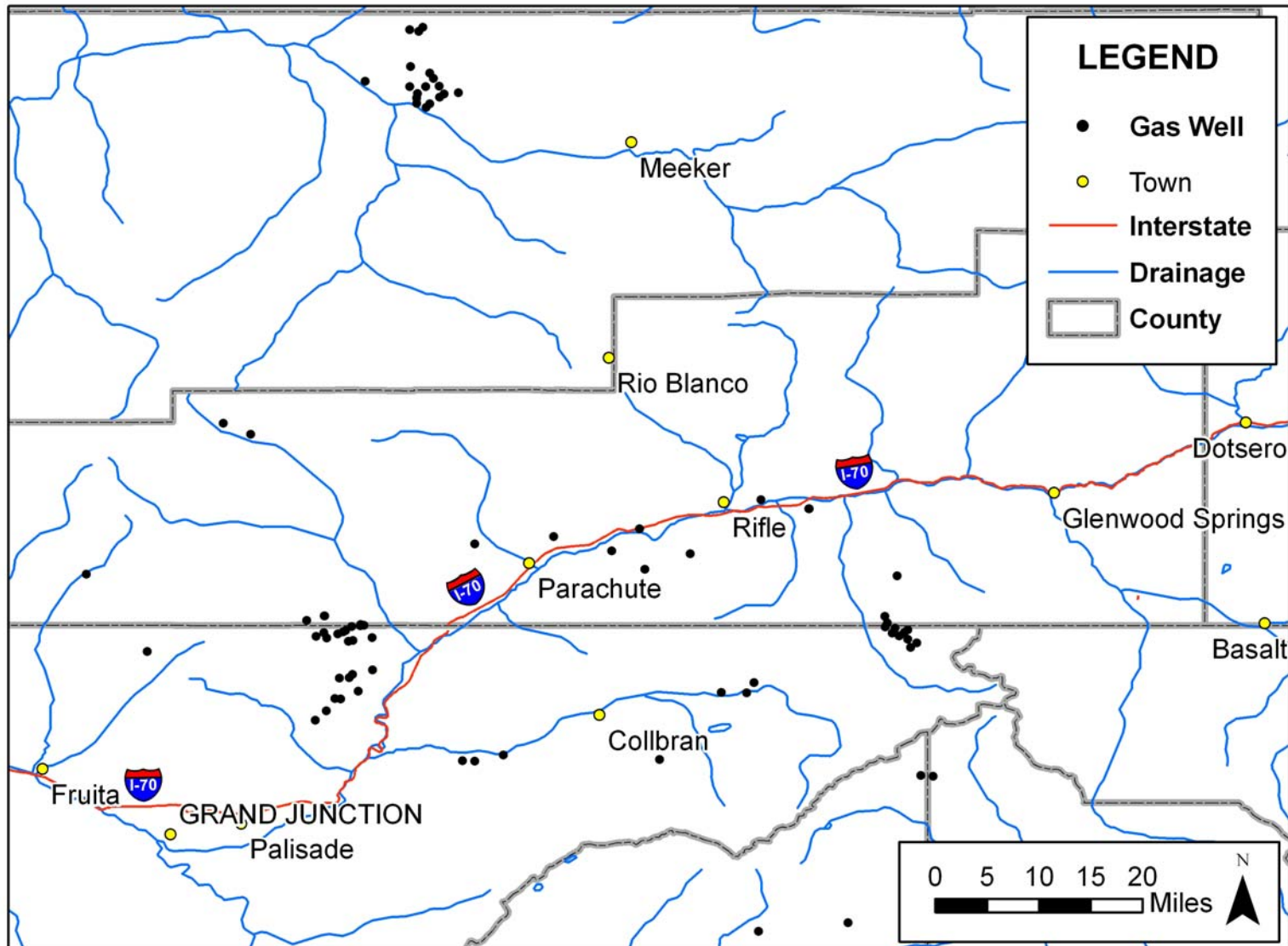
1,994 CBM Wells in Raton Basin

79 CBM Wells in Piceance Basin



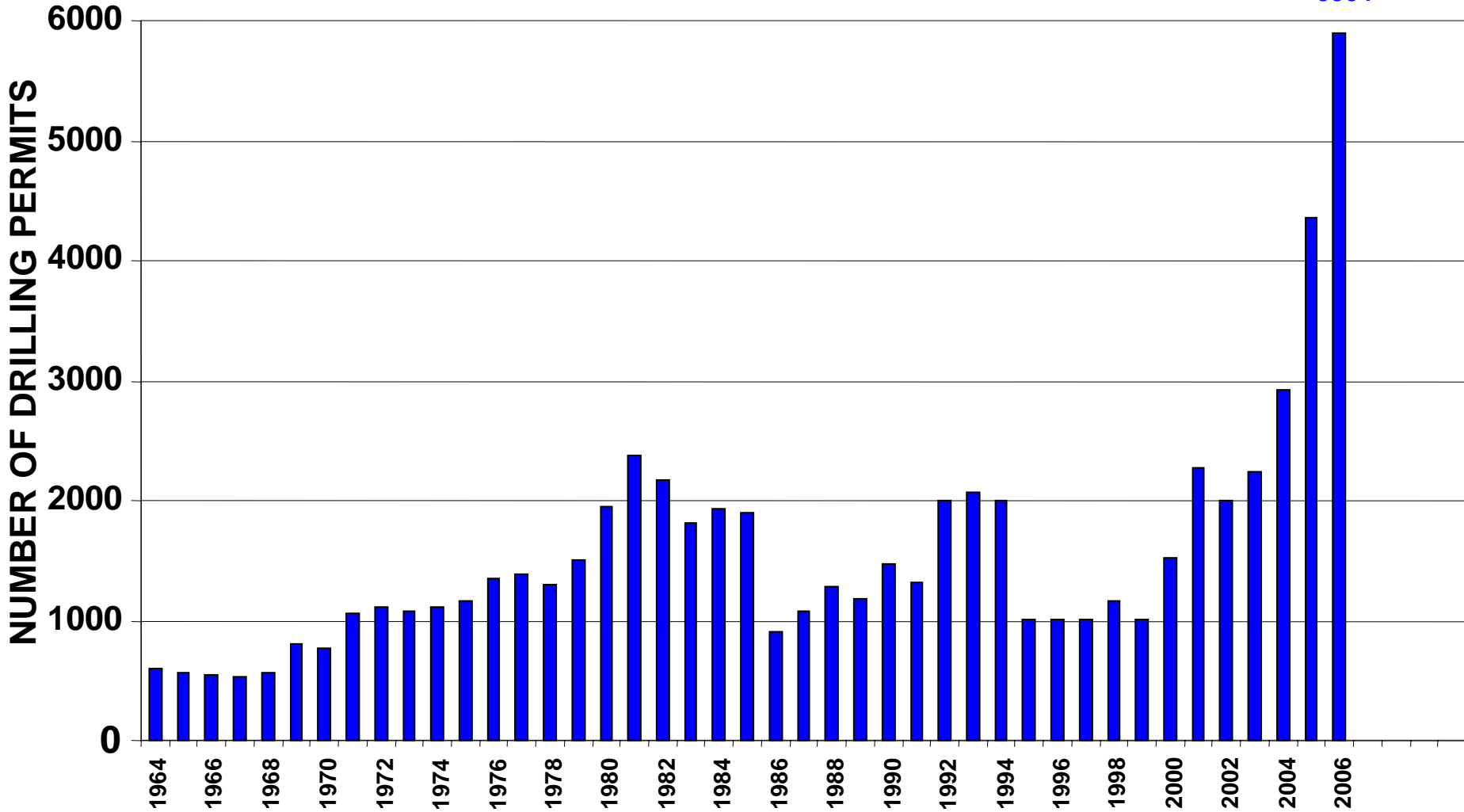
COAL REGIONS

CBM Wells in the Piceance Basin, Colorado



Historic Annual Colorado Drilling Permits

1-10-07

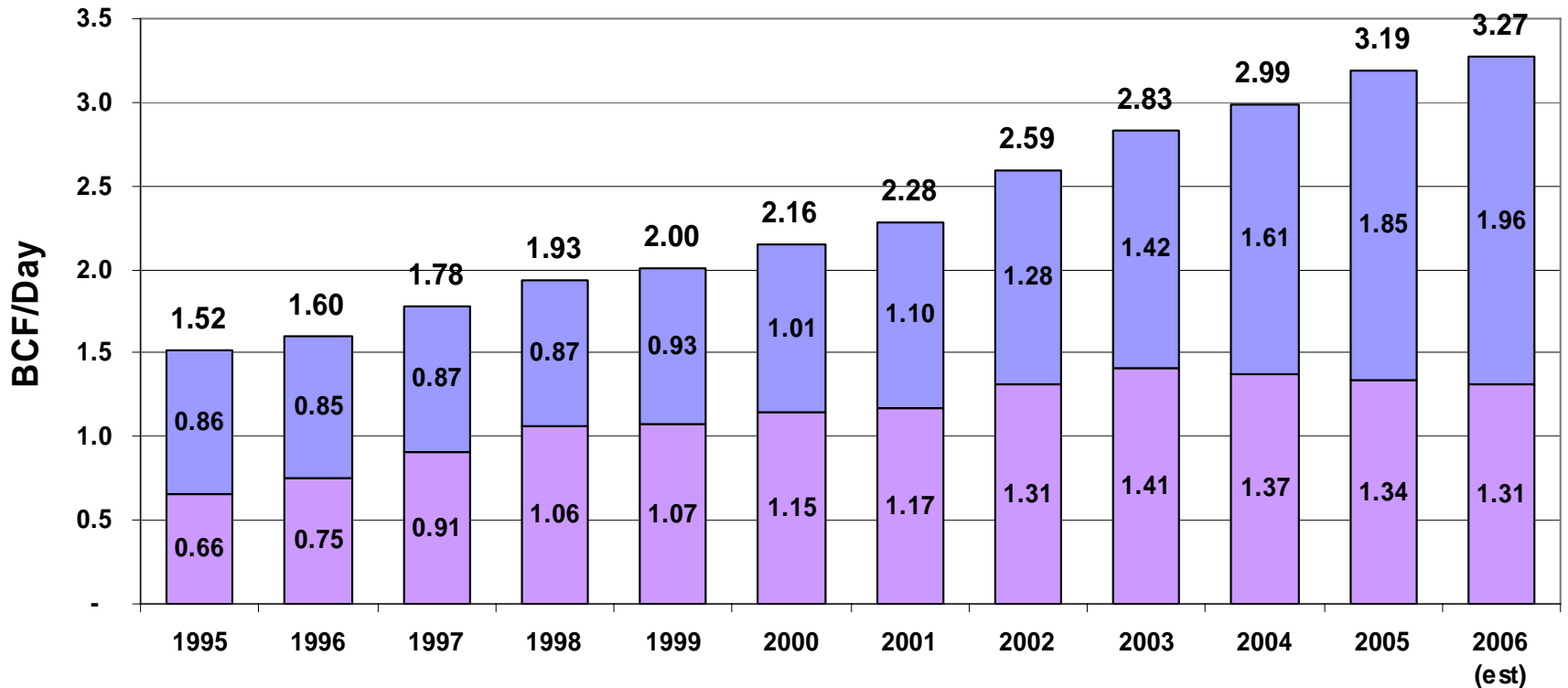


COLORADO GAS PRODUCTION 1995-2006

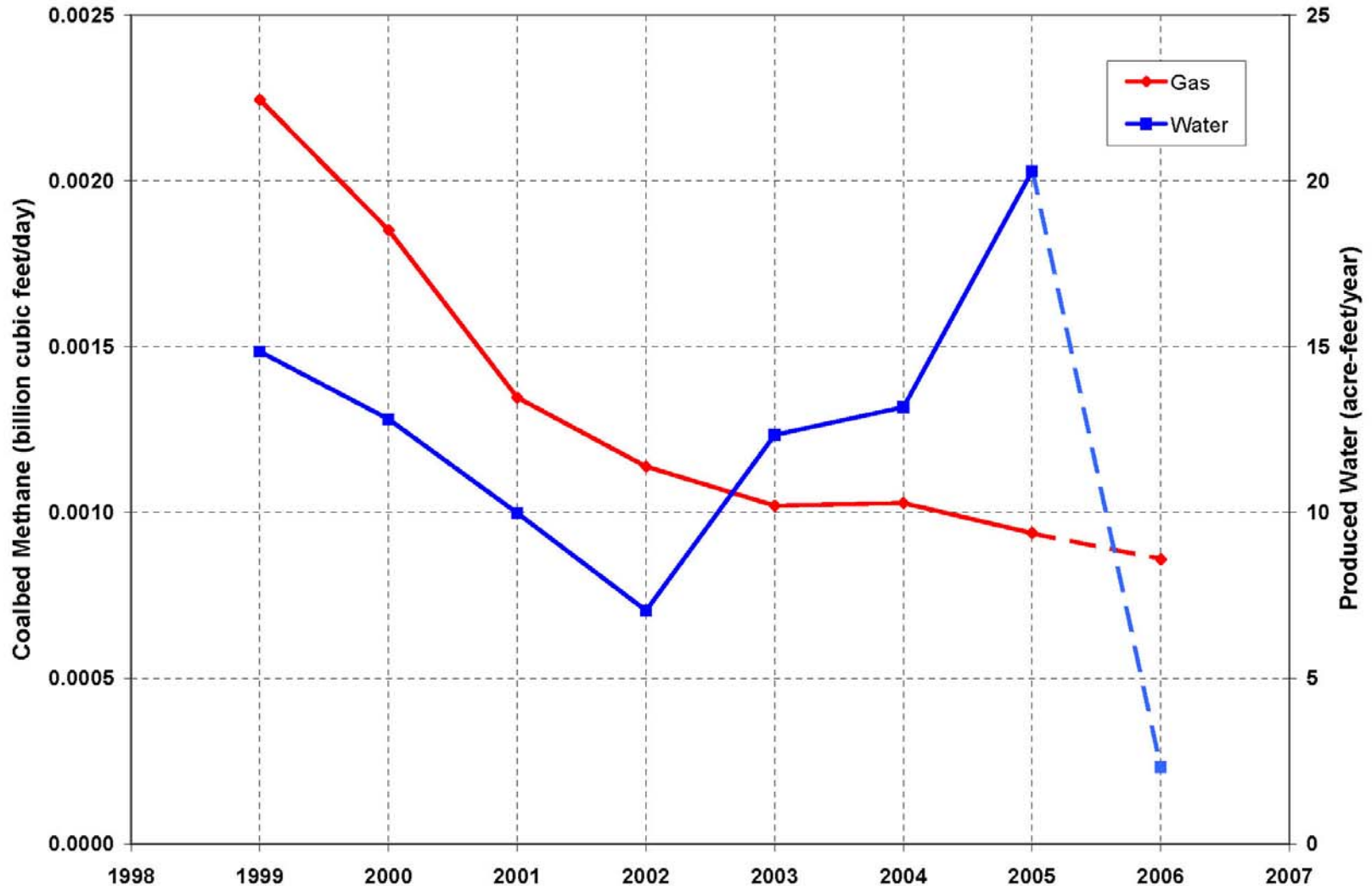
BILLION CUBIC FEET (BCF) PER DAY

■ CONVENTIONAL NATURAL GAS
■ COALBED METHANE
■ TOTAL NATURAL GAS

NOTE: Chart Does Not Include Carbon Dioxide Production



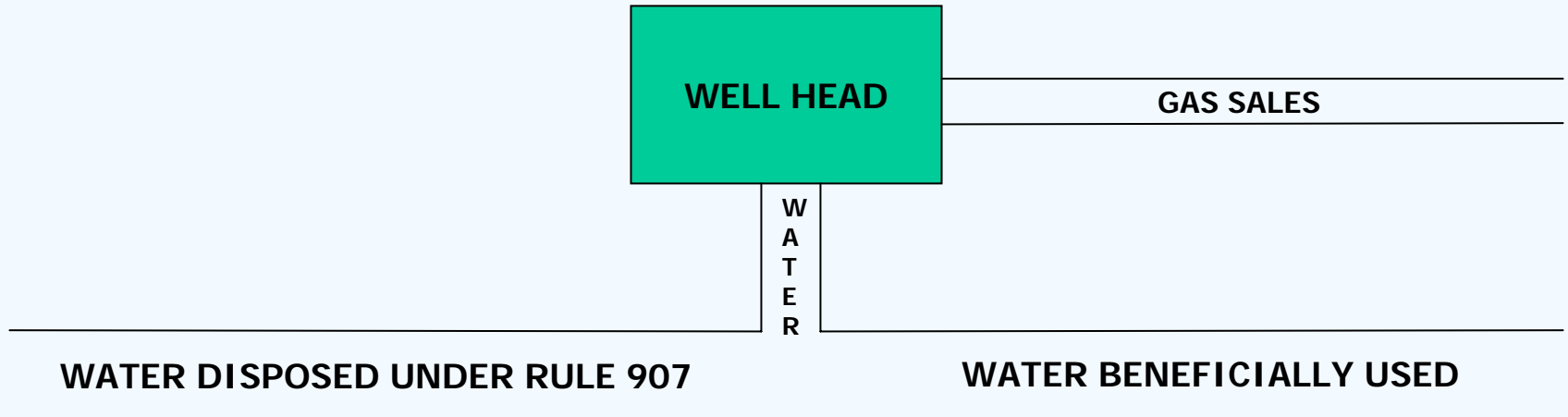
CBM and Water Production Volumes, Piceance Basin, Colorado



Background:
b) Regulatory Setting and Jurisdiction



Who Regulates Produced Water?



These water disposal methods are under the jurisdiction of the **Colorado Oil and Gas Conservation Commission**.

Approval to discharge water to surface streams is under the jurisdiction of the **Colorado Department of Public Health and Environment - Water Quality Control Division**.

After the water is discharged it is under the jurisdiction of the **Division of Water Resources** for issues concerning water rights.

Subject to the Water Rights Act under the jurisdiction of the **Division of Water Resources**.

Regulatory Considerations

- CBM wells are treated just like any other O&G wells in Colorado
- Water quality is often poor
- Unreliable as long-term source

Oil and Gas Commission Regulates:

- Location of wells
- How wells are constructed
- Production operations
- Management of E&P waste
- Plugging wells
- Restoration of the surface

Methods of Use and Disposal

- **COGCC Rule 907**
 - Inject into a disposal well
 - Place in lined or unlined pit
 - Dispose at a commercial facility
 - Road spreading
 - Discharge into waters of the state
 - Reuse for recovery, recycling and drilling
 - Mitigation

DWR regulates groundwater withdrawal for beneficial use:

- **Types of Beneficial Uses**
 - Irrigation
 - Municipal
 - Domestic
 - Stock watering
 - Minimum streamflows
 - Augmentation

CBM Water Rights and Ownership

- Doctrine of Prior Appropriation (First in time-first in right)
- DWR has jurisdiction over administration of water – right of use
- Comply with the “Water Rights Acts”
 - Ground Water Management Act
 - Water Right and Determination and Administration Act

CBM Water Rights and Ownership

- **Surface Water Discharge**
 - Must comply with Water Rights Act
 - Must have intent to use
 - Must be diverted in priority
 - Must be beneficially used
 - Must not waste
 - Must prevent material injury to vested water rights

CBM Water Rights and Ownership

- **Beneficial Use by Well-Tributary**
 - §37-90-137(1) & (2), CRS (2005)
 - Permit required
 - Must determine if unappropriated water is available
 - Must prevent material injury to vested water rights (may require augmentation)

CBM Water Rights and Ownership

- **Beneficial Use by Well-Nontributary**
 - §37-90-137(7), CRS (2005)
 - No permit required unless beneficially used
 - Use not based on land ownership
 - Do not need to determine if unappropriated water is available
 - Must determine by modeling if nontributary

Background

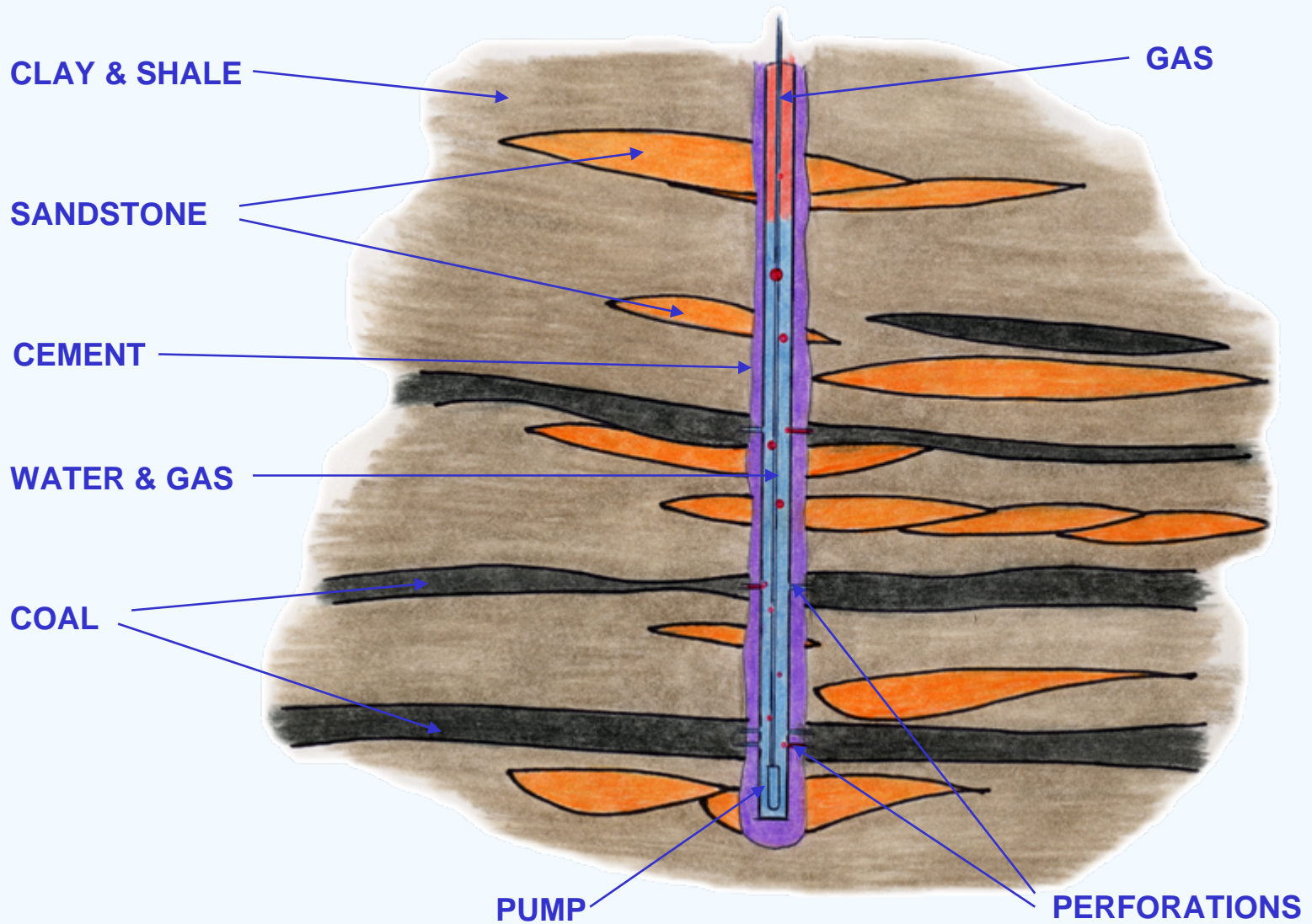
c) Geologic Setting



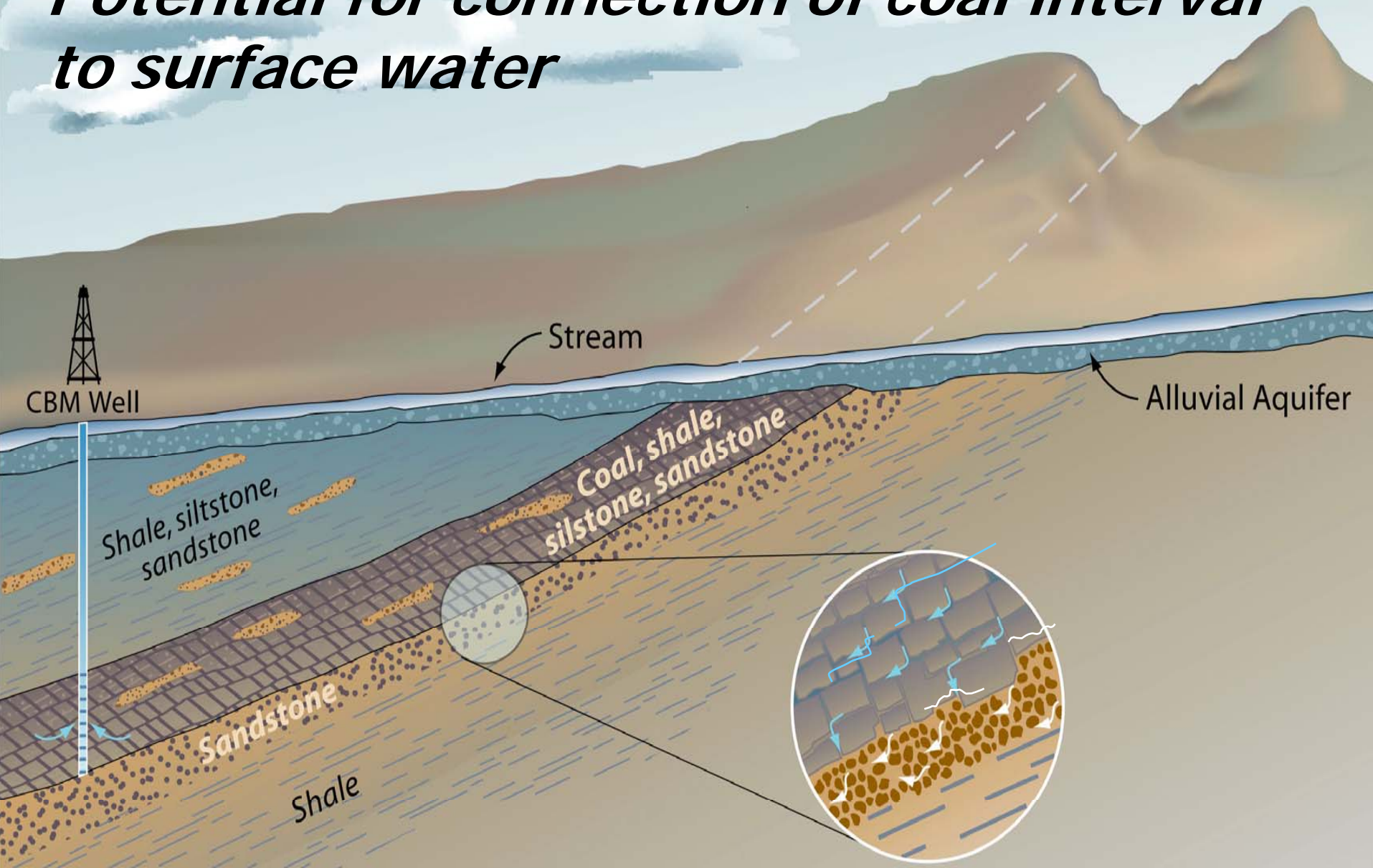
How is Coalbed Methane Extracted?

- Methane gas is trapped in the coal beds by the pressure of water in the cleats (fractures)
- To release methane gas, water pressure is reduced by removing water from coal-bearing intervals
- Coal-bearing intervals can be interbedded with known aquifers, may be aquifers themselves, or are connected with surface water systems

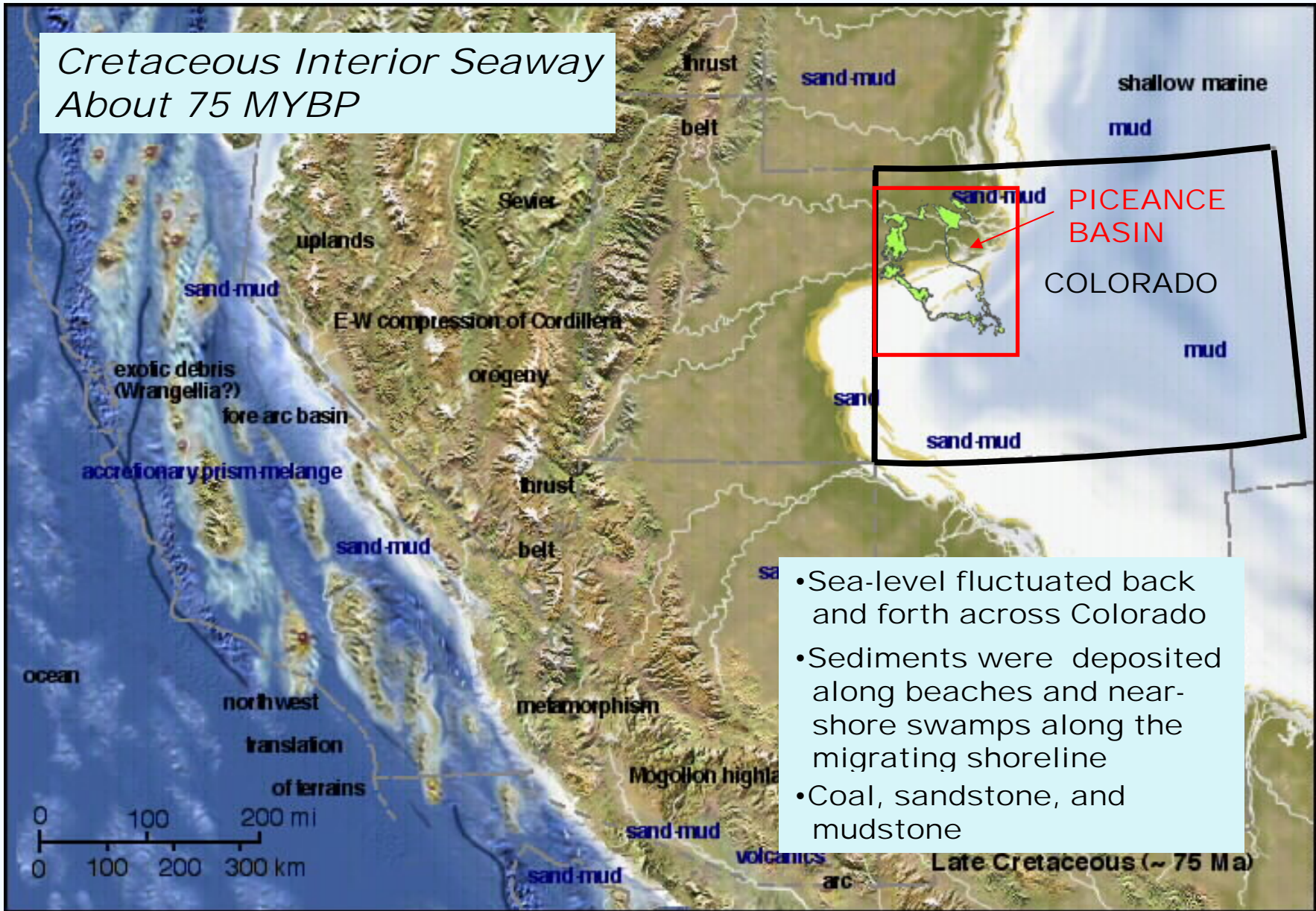
Typical CBM Well Completion



Potential for connection of coal interval to surface water



Cretaceous Interior Seaway About 75 MYBP



PICEANCE
BASIN

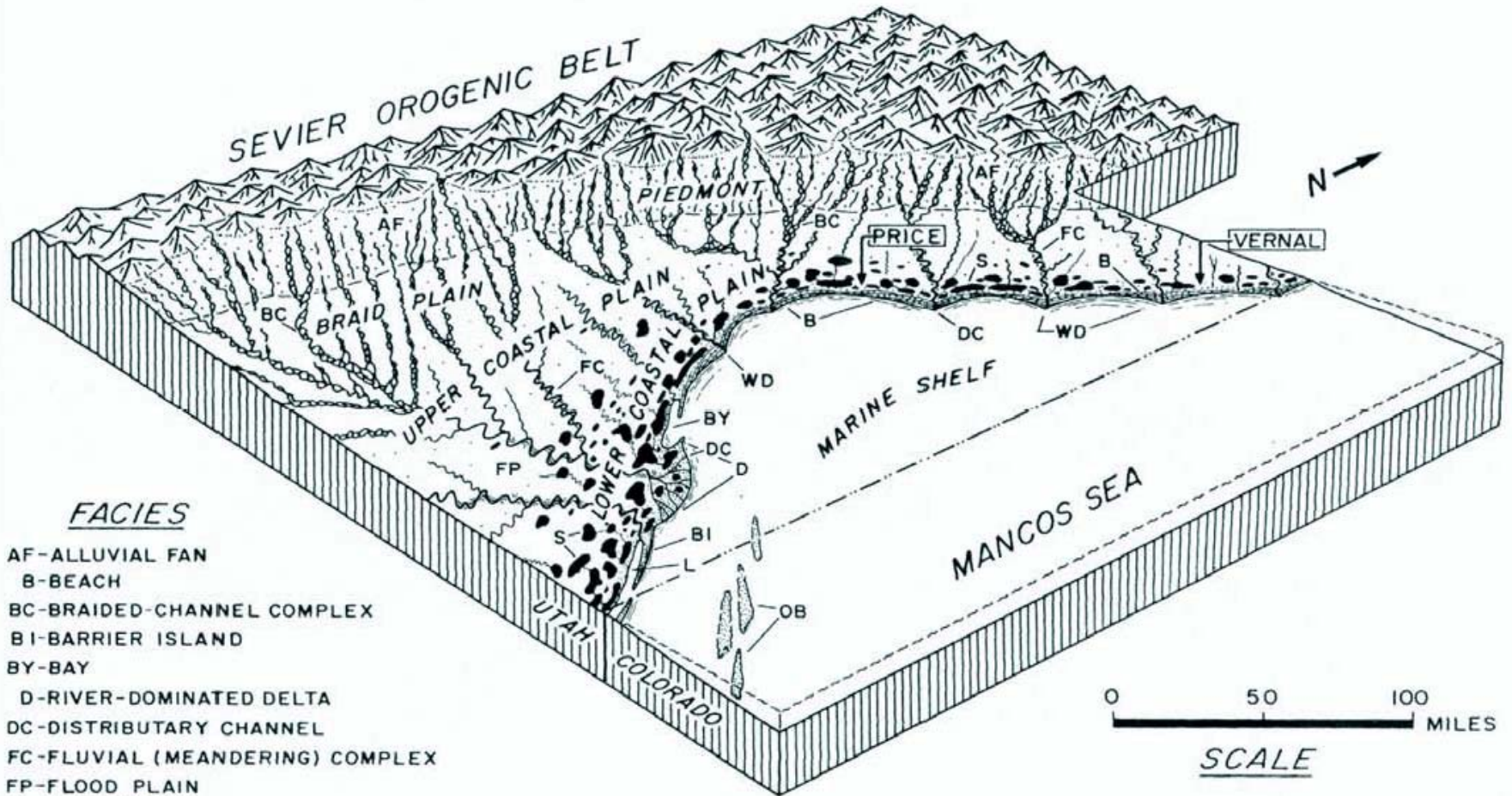
COLORADO

- Sea-level fluctuated back and forth across Colorado
- Sediments were deposited along beaches and near-shore swamps along the migrating shoreline
- Coal, sandstone, and mudstone

Cretaceous Interior Seaway Coastal Environments

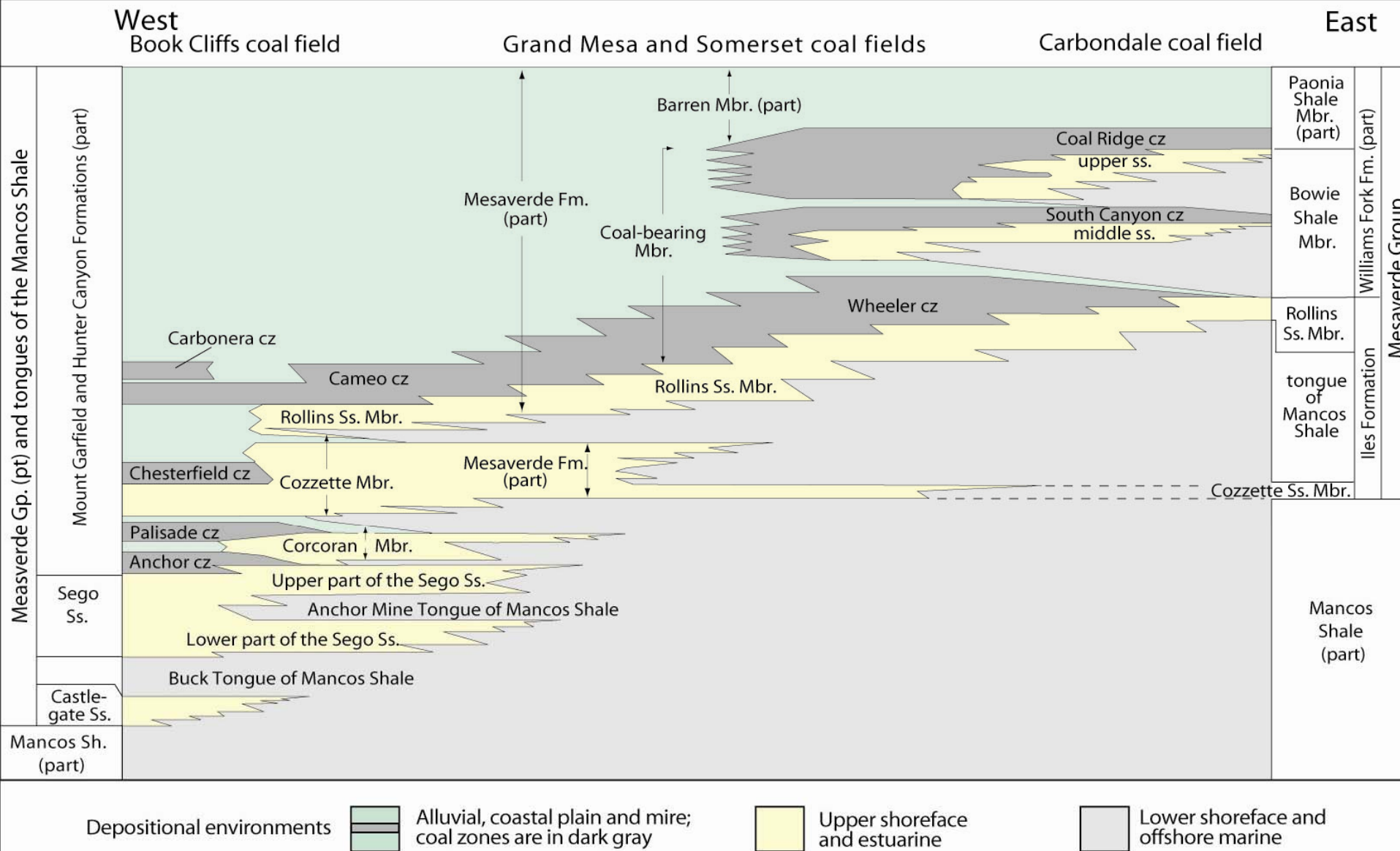


Cretaceous Interior Seaway Coastal Environments of Deposition

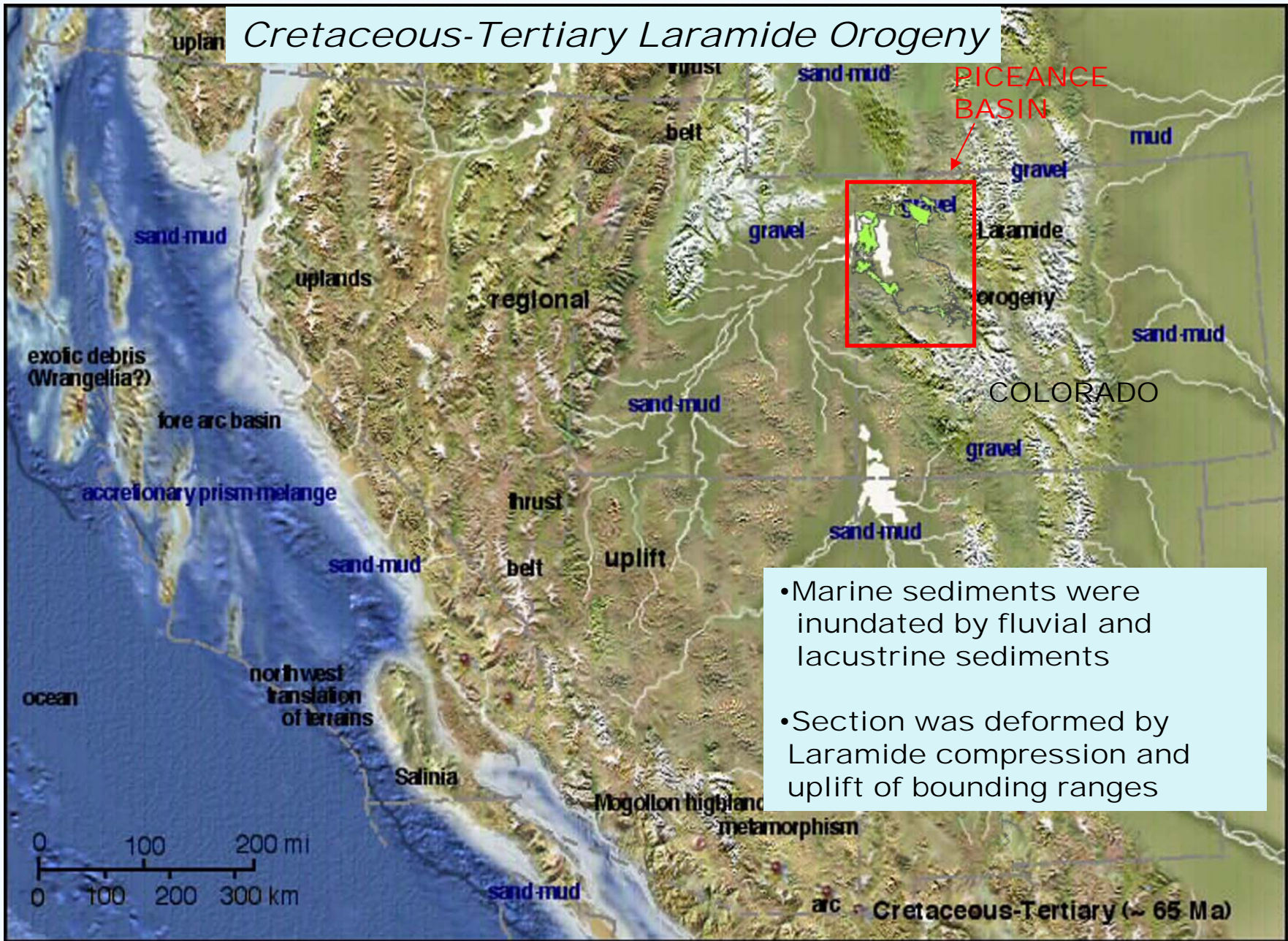


Single Cretaceous Coal Seam



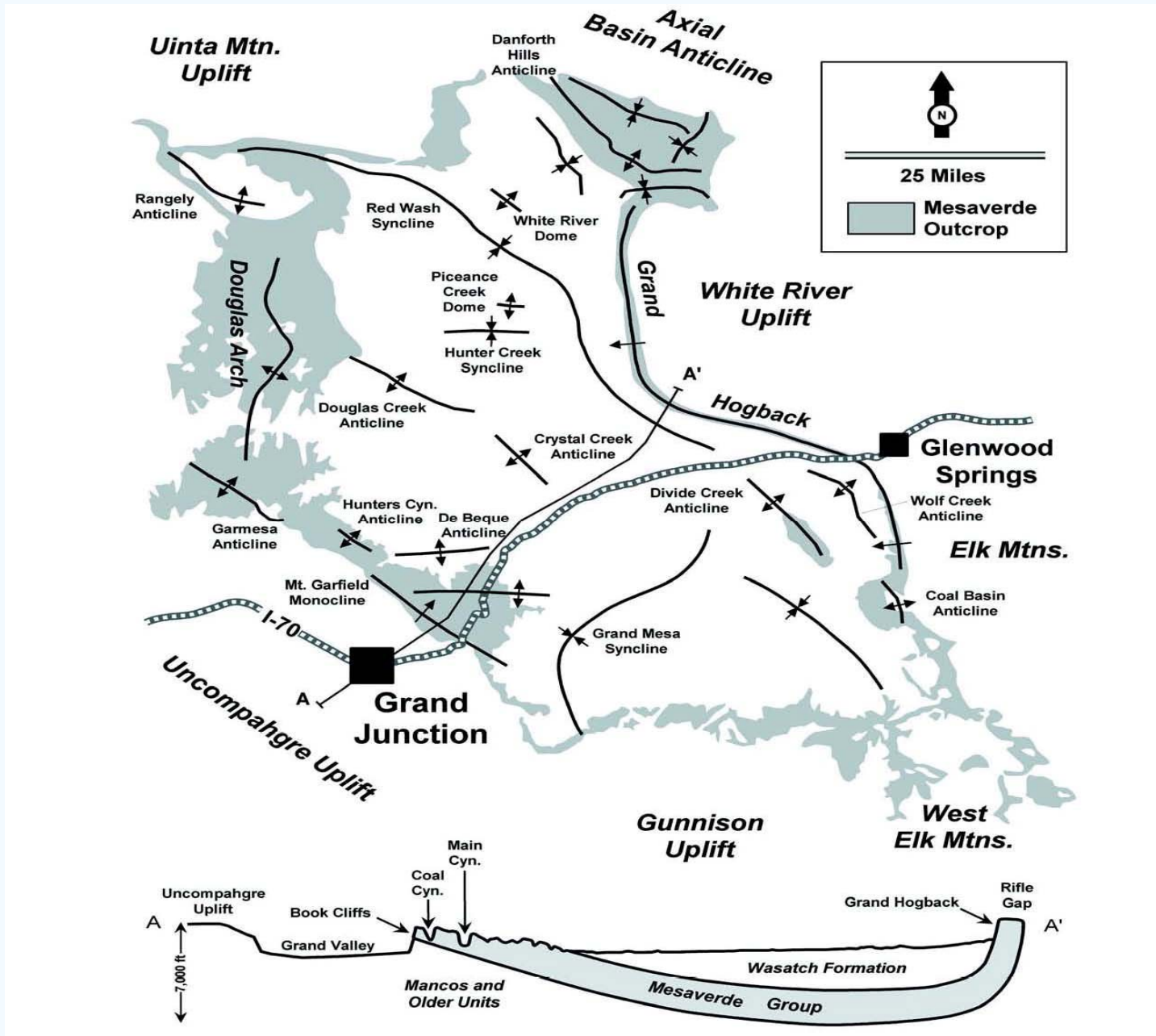


Stratigraphic correlations and facies relationships in the Mesaverde Group, southern part of the Piceance Basin, Colorado. Line of section drawn perpendicular to depositional strike; stratigraphy is based on Gill and Hail (1975), Dunrud (1989a, 1989b), and Kirschbaum and Hettinger (1998). Modified from Hettinger and others (2000).

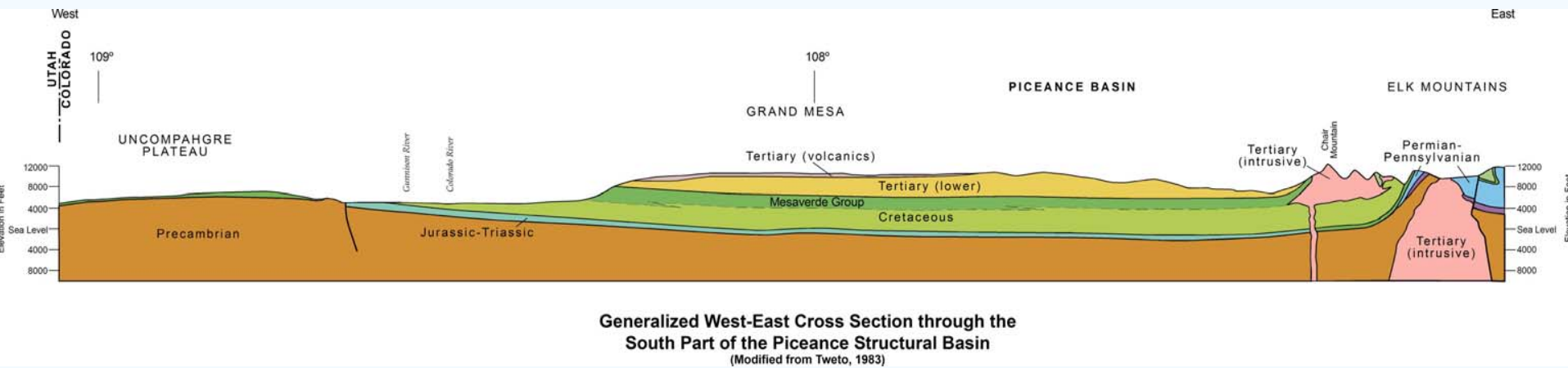
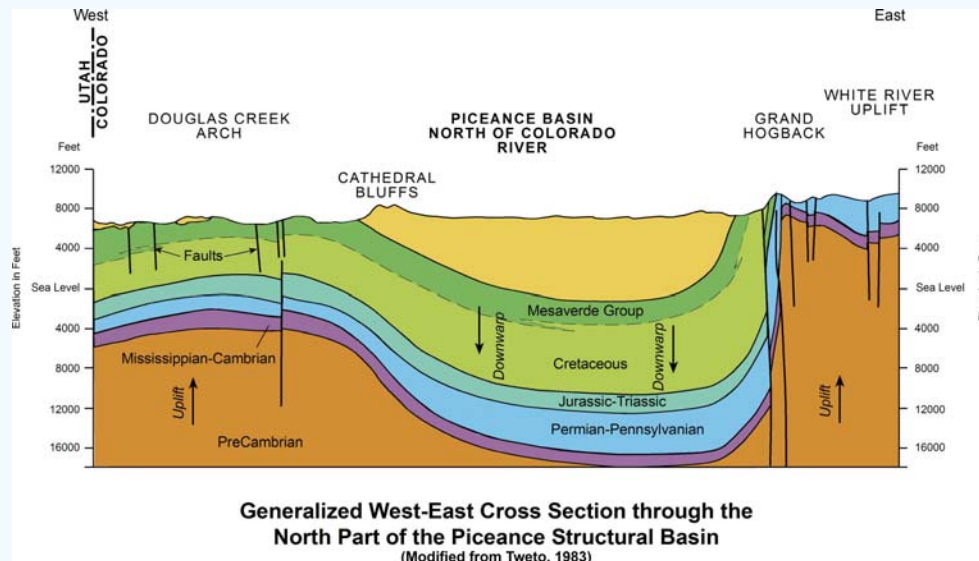


- Marine sediments were inundated by fluvial and lacustrine sediments
- Section was deformed by Laramide compression and uplift of bounding ranges

Main Piceance Basin Structural Features



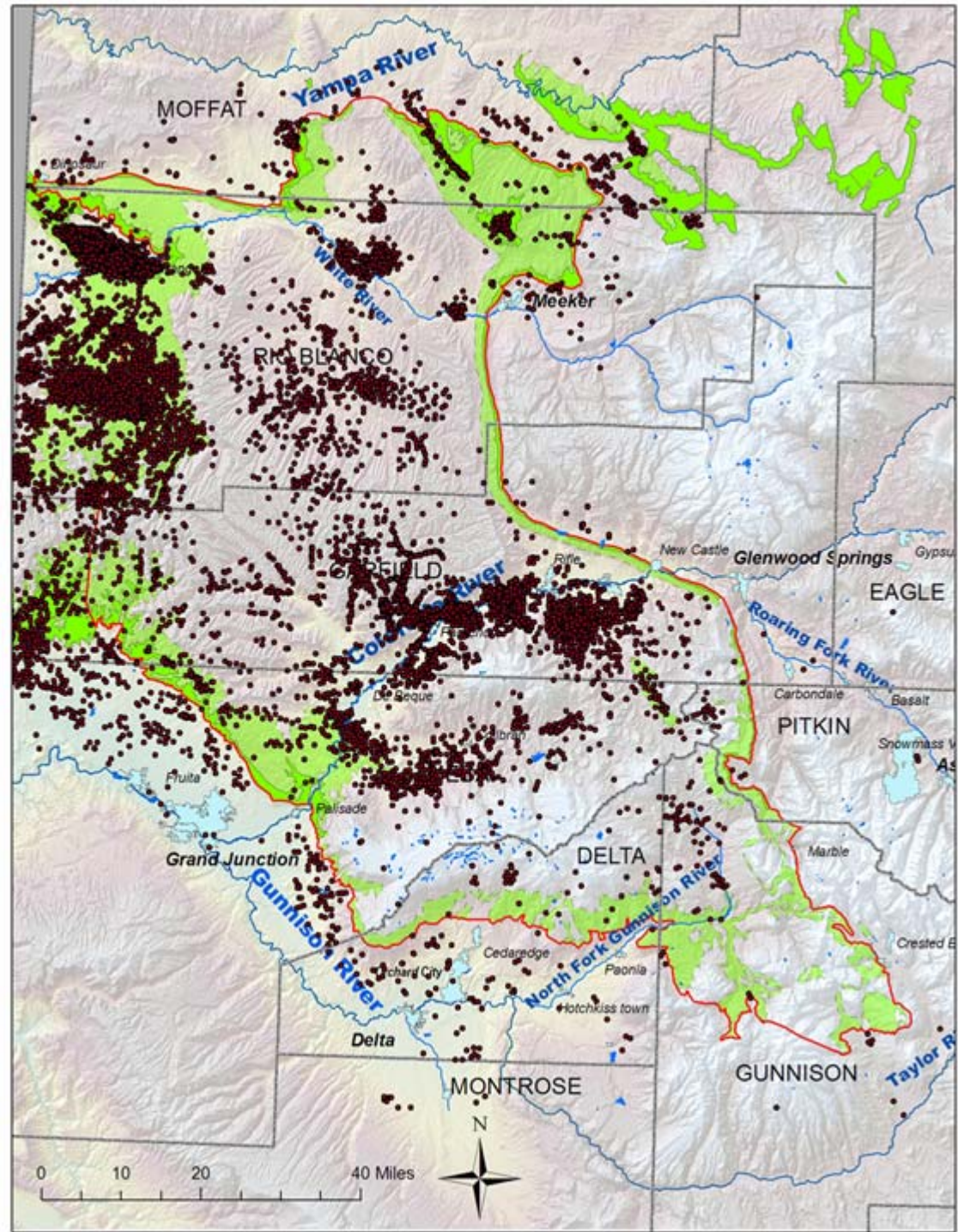
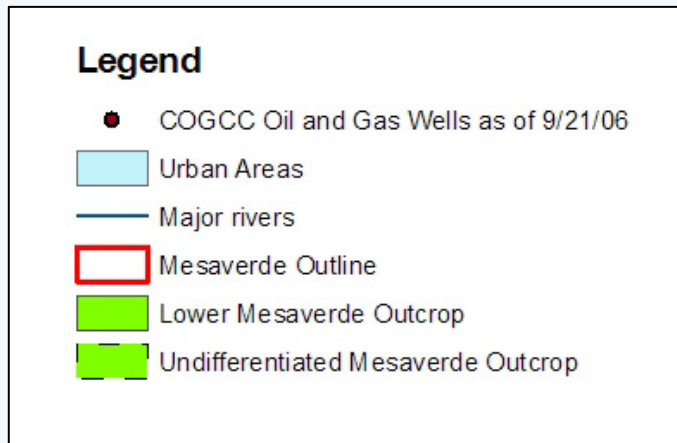
Piceance Basin Diagrammatic Cross-Sections



Steeply Dipping Coal Seam at Grand Hogback



Oil and Gas Wells in Piceance Basin Region



Piceance Basin-Centered Gas Model - Present Day

Grand Junction

Debeque

Grand Valley

Parachute

Rulison

Roan Cliffs

Grand Hogback

Removed

Overburden

Mesaverde

Green River

Wasatch

UWFSM

Cameo




Iles

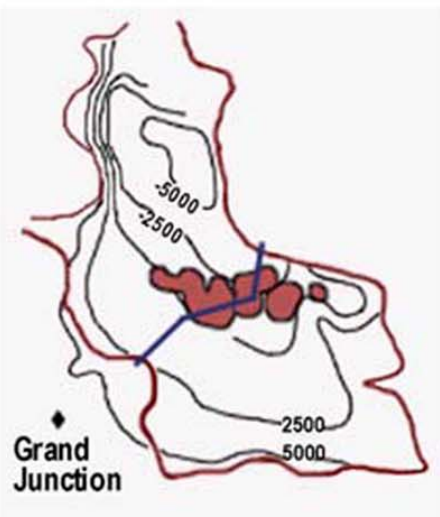
10,000'

5,000'

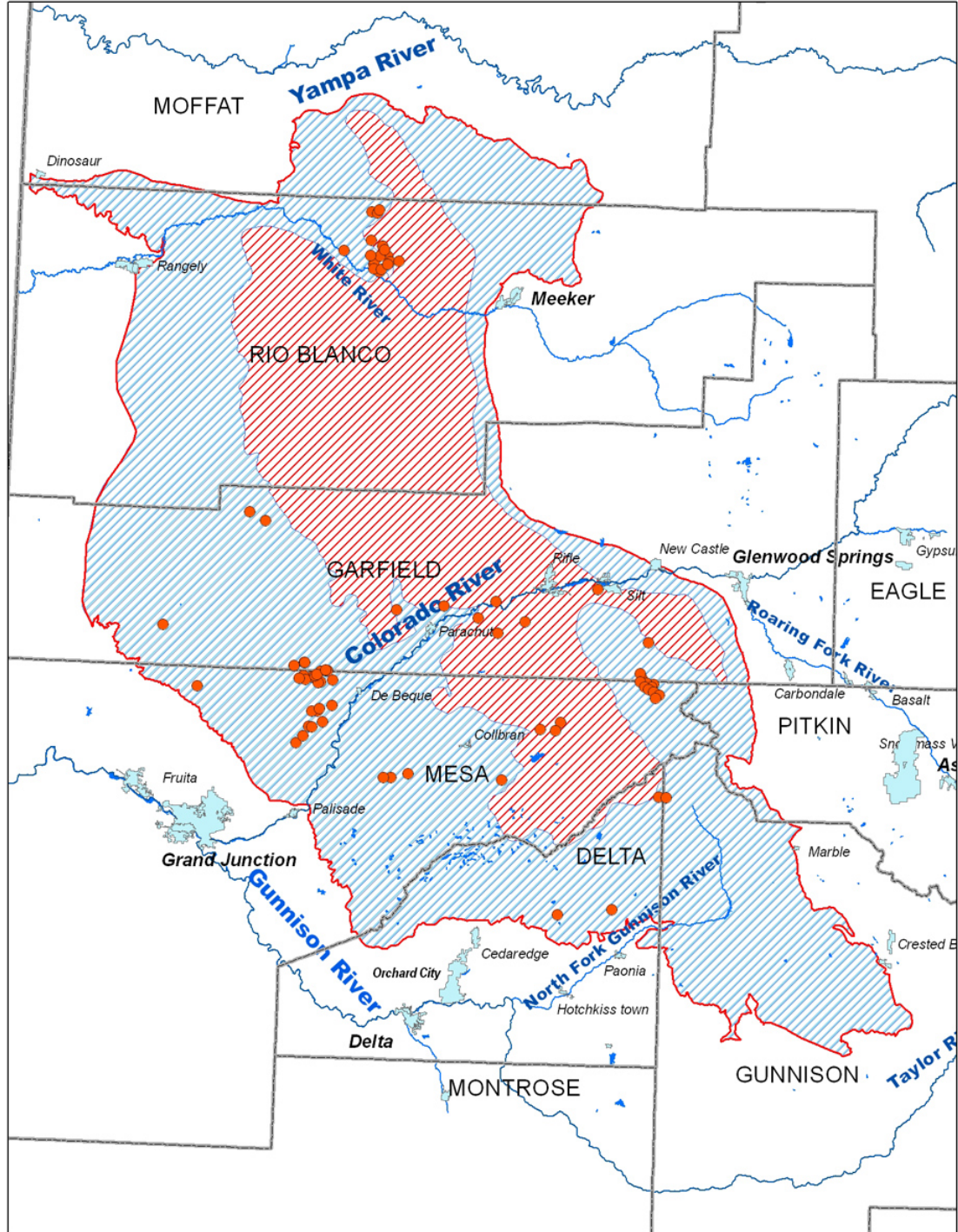
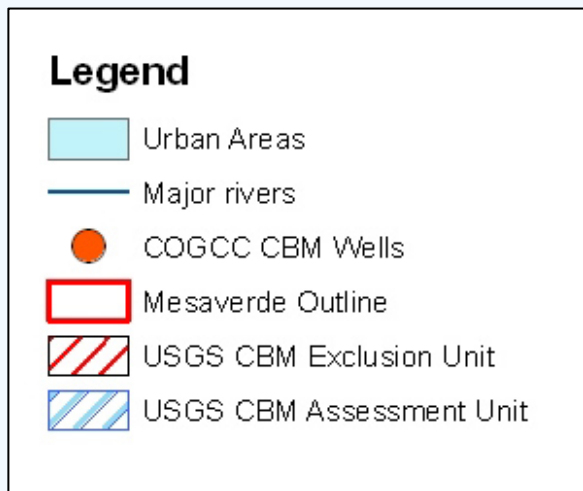
0'

-5,000'

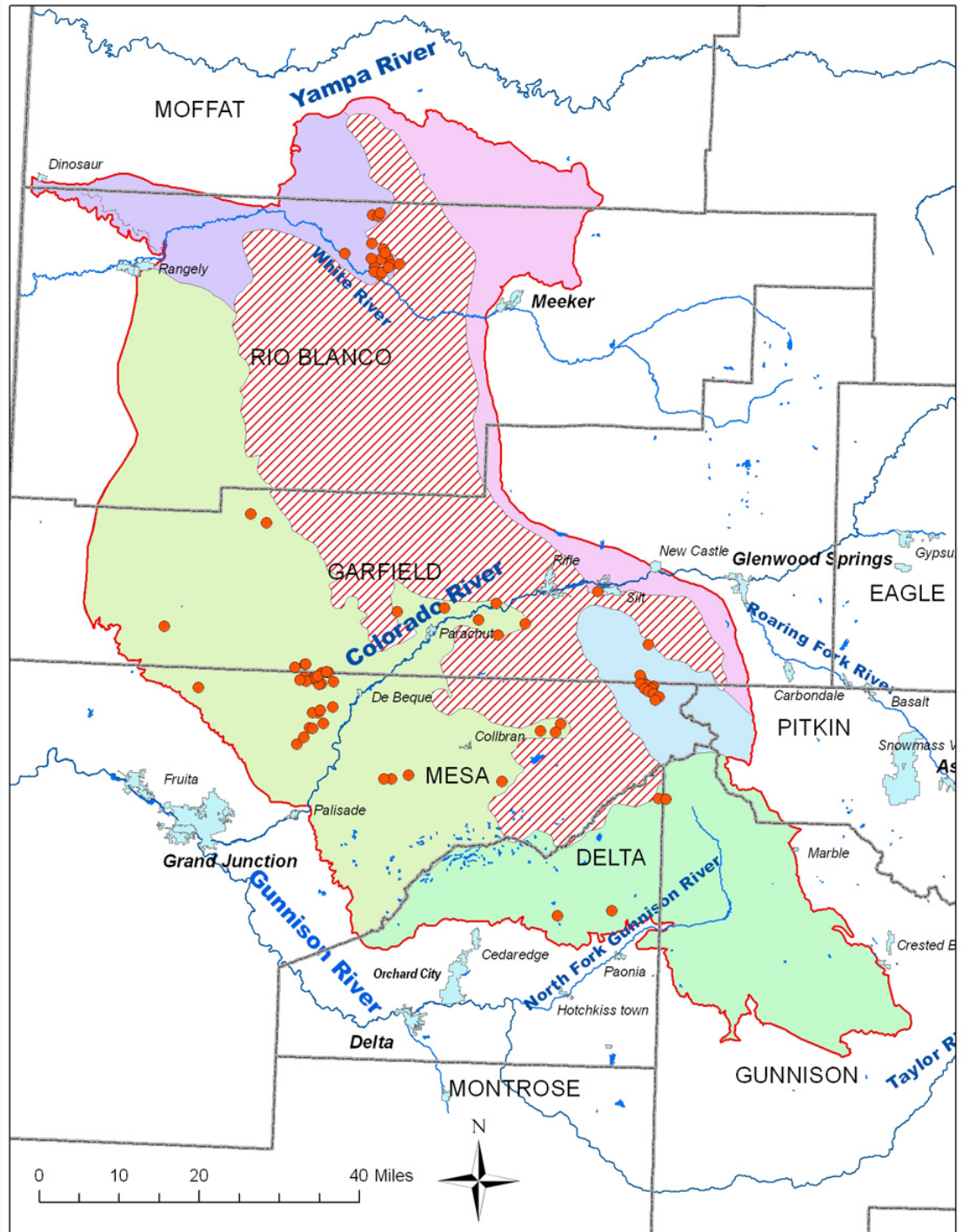
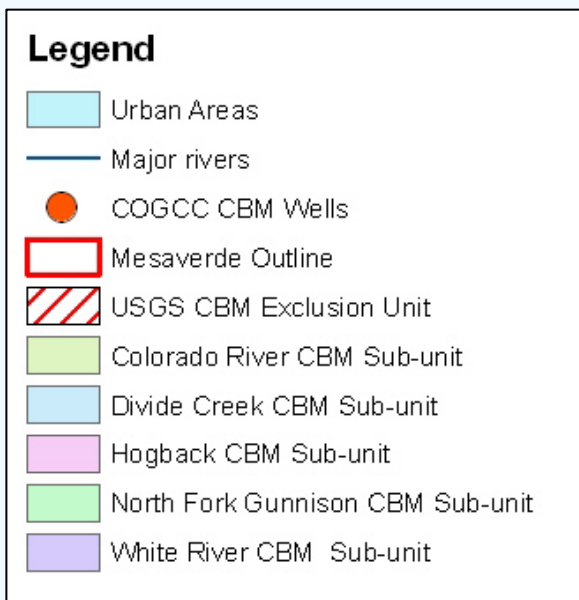
-  Basin-centered gas accumulation
-  Transition zone - downdip water movement flushes some gas sands
-  Wet sands with some stratigraphic trapping of gas moving updip



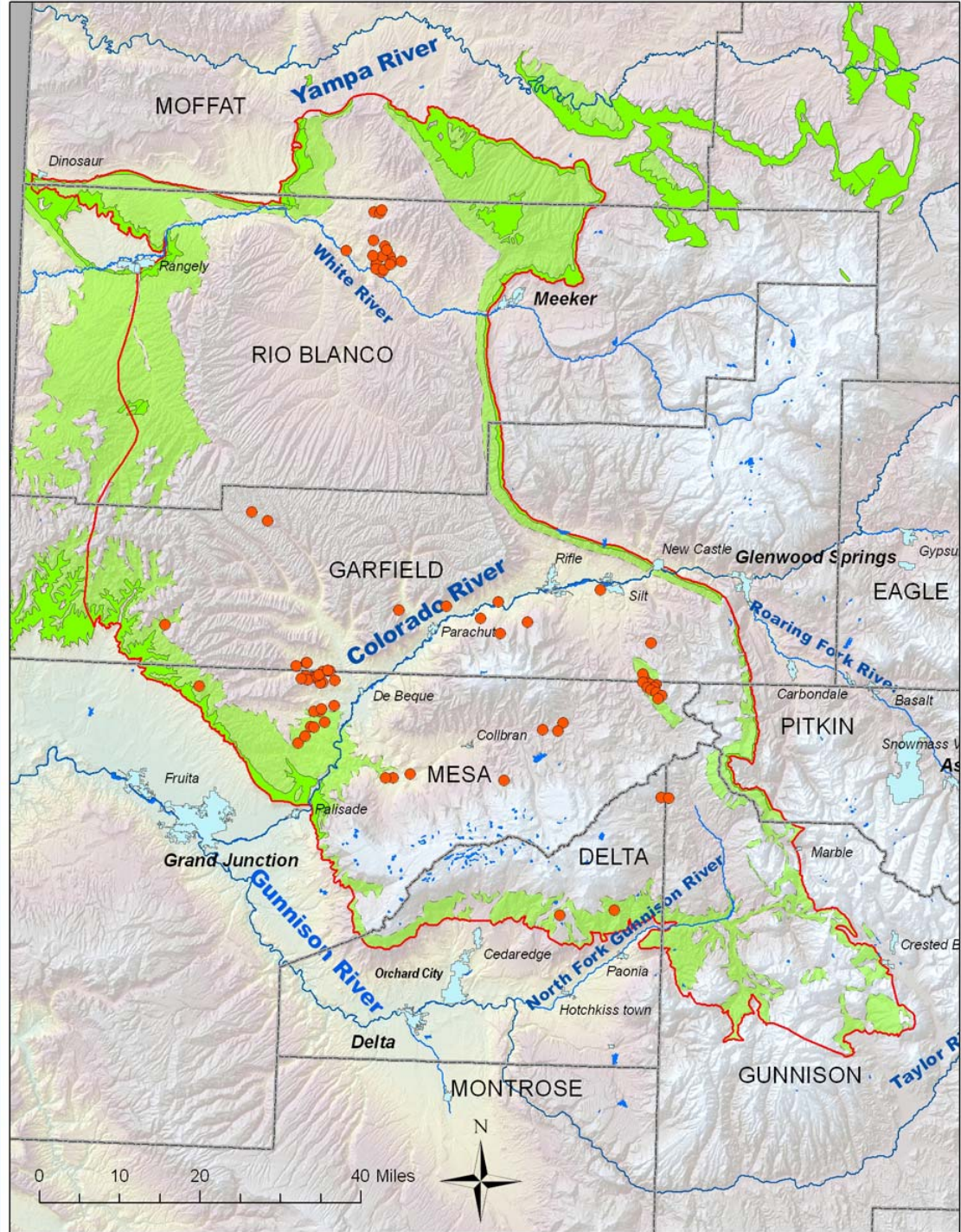
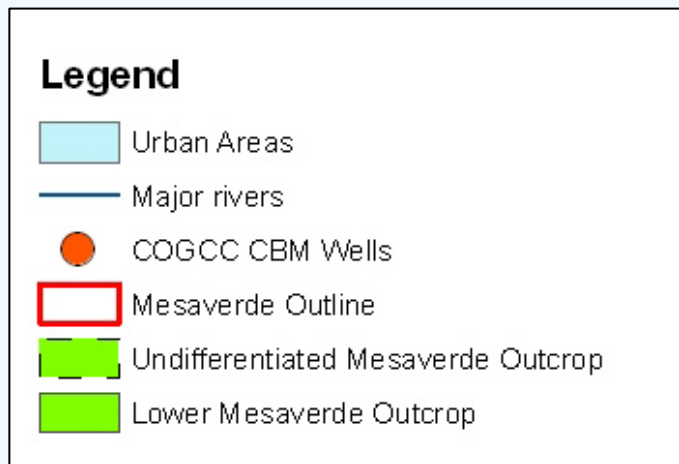
USGS CBM Resource Assessment Areas



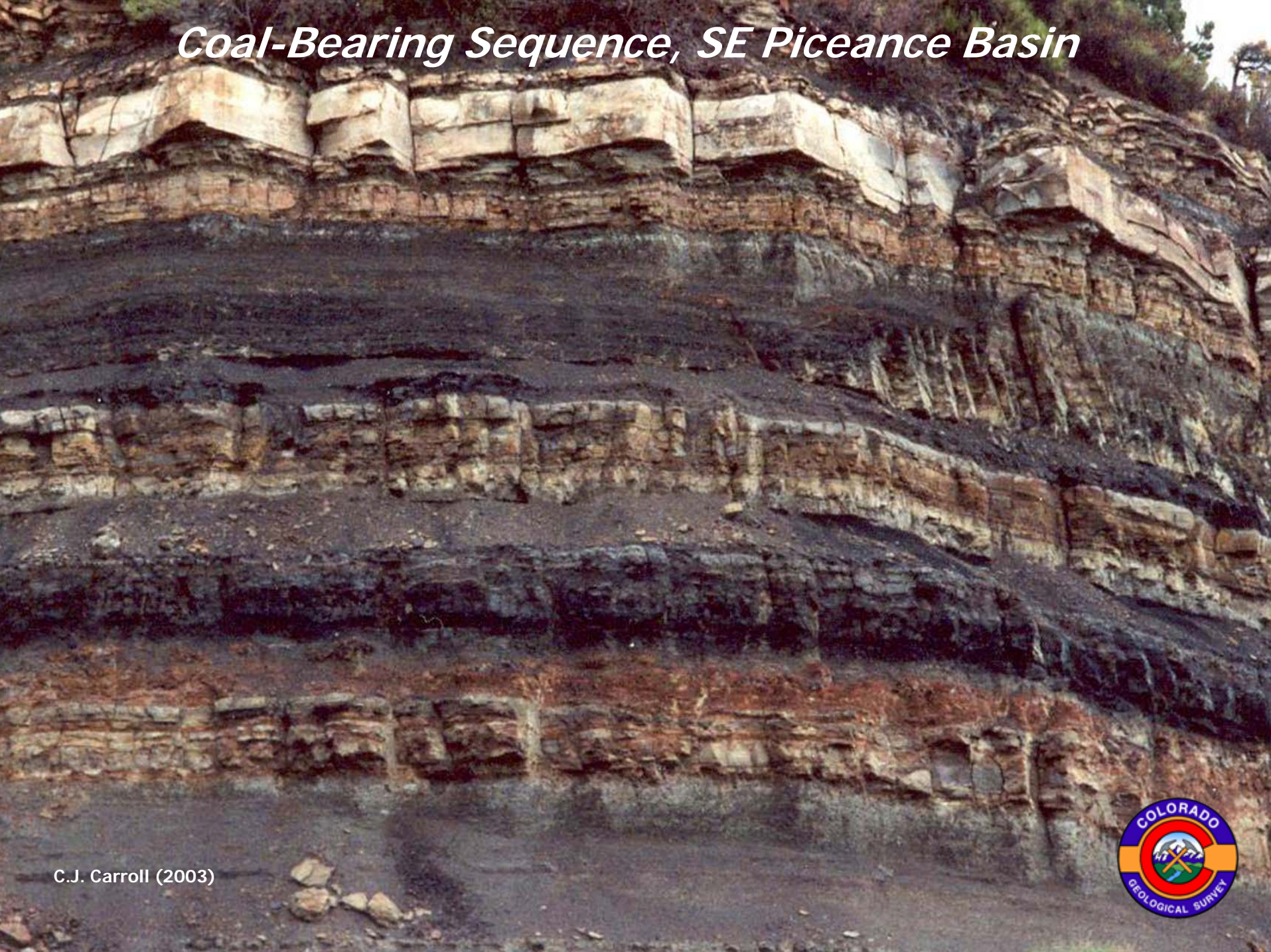
CBM Stream Depletion Study Sub-Units



CBM Stream Depletion Study Outcrop Map



Coal-Bearing Sequence, SE Piceance Basin



C.J. Carroll (2003)



3. Plan of Study



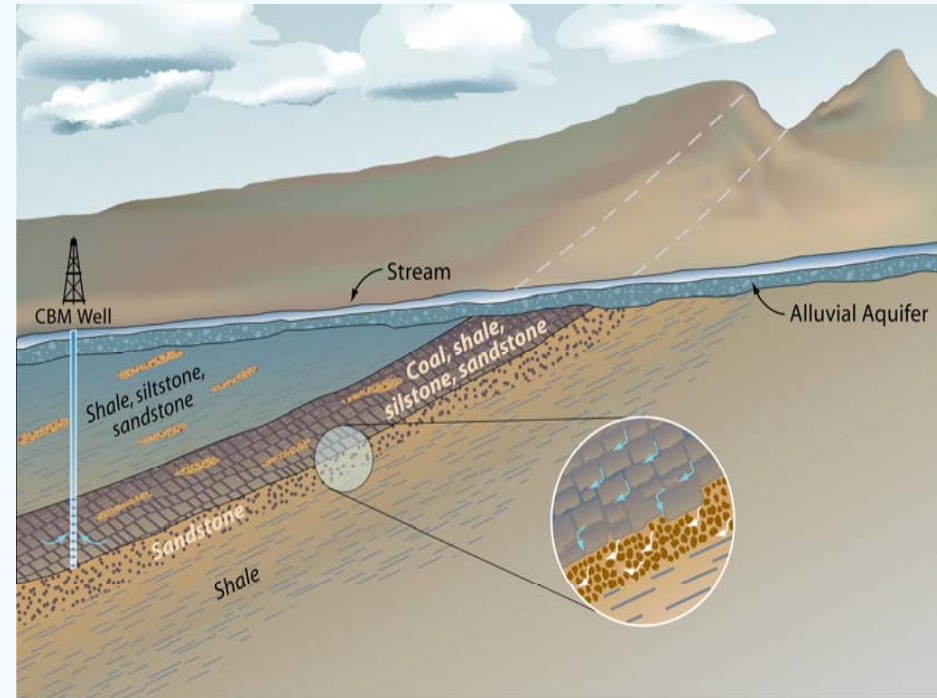
Scope of Work

Stream Depletion Assessment Study

- Review available data and studies
- Describe regulatory framework
- Describe hydrogeologic setting
- Characterize extraction activity
- *Assess impact of extraction on regional water conditions, particularly, impacts to streams*
- Provide analysis and assessment in report
- Provide framework for decision-makers regarding suitability of present level of regulation, primarily with respect to streamflow impacts

Simplified Modeling Analysis

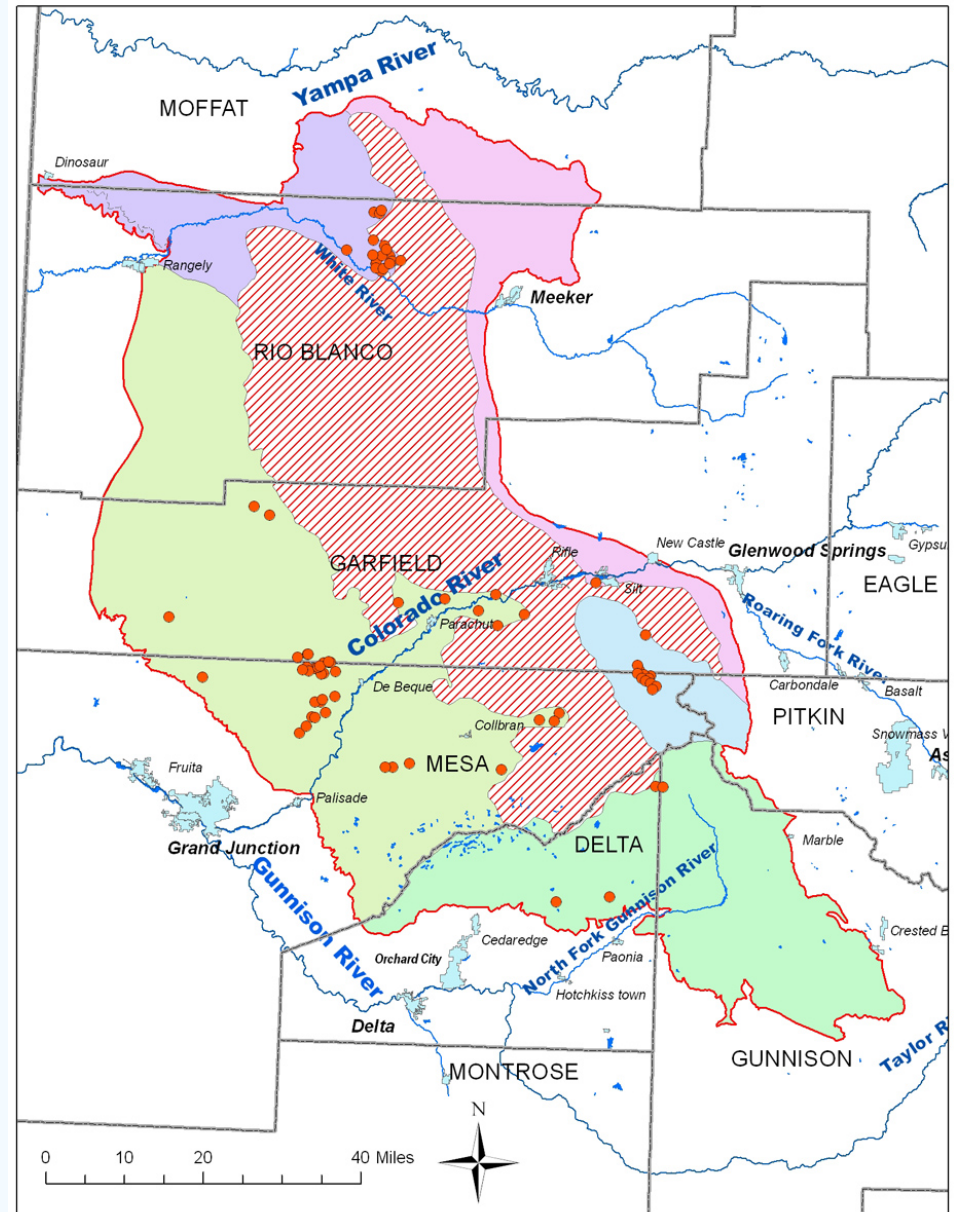
- Lead agencies have specified an analytical approach, if plausible, based on Glover method
- Analysis set-up:
 - *Characterize the flow geometry and flow barriers*
 - *Quantify aquifer properties*
 - *Quantify produced water volumes, present and projected*



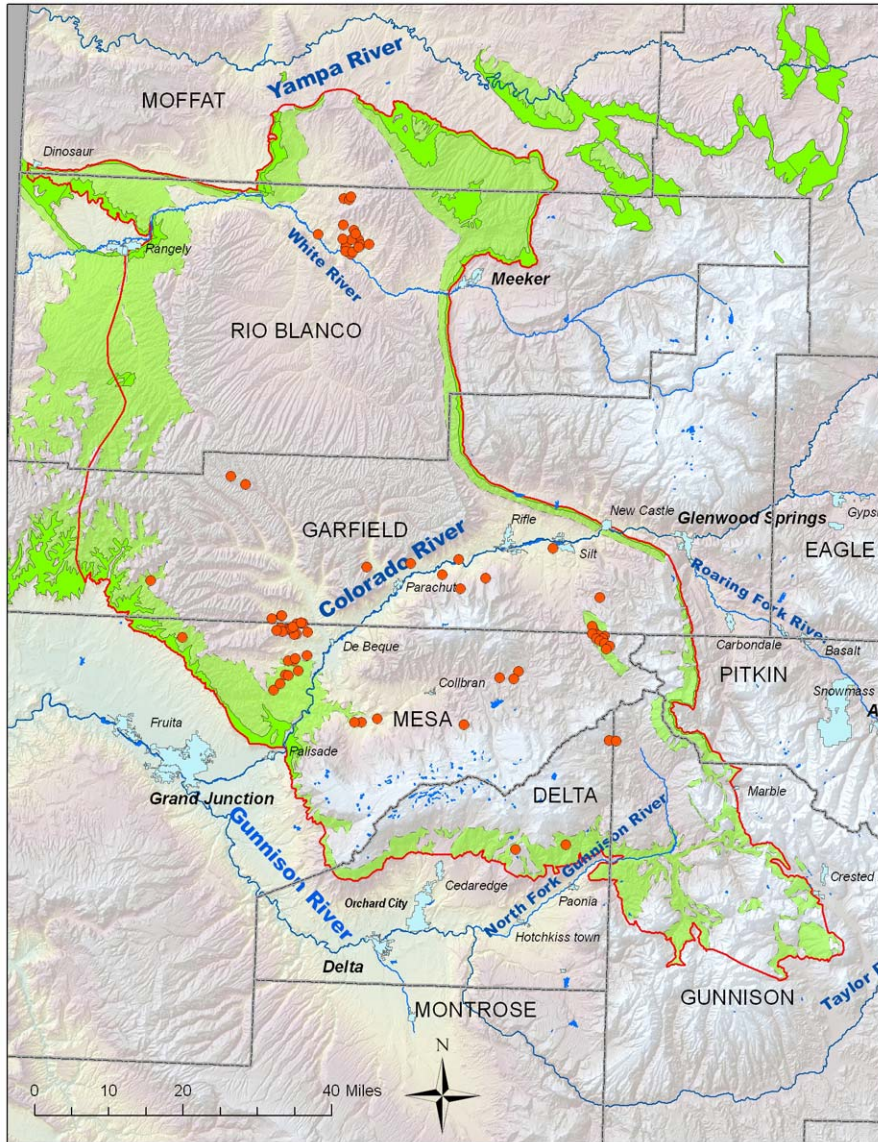
Conceptual Model Development, Step 1

Identify potentially impacted surface water features:

- *River valley alluvium of major streams?*
- *Locally incised streams?*
- *Springs, seeps?*
- *Outcrops traversed by streams?*



Conceptual Model Development, Step 2

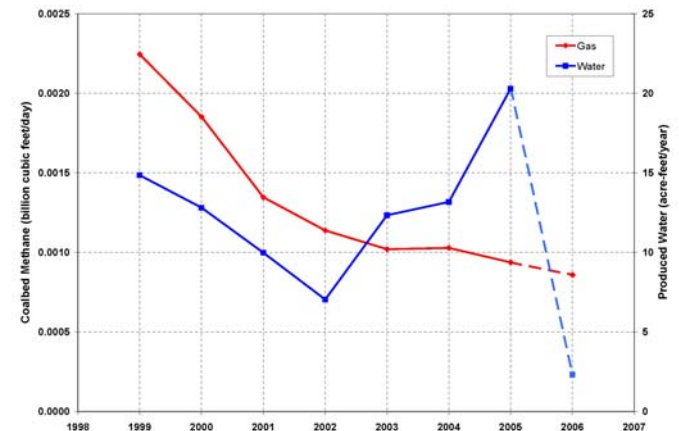
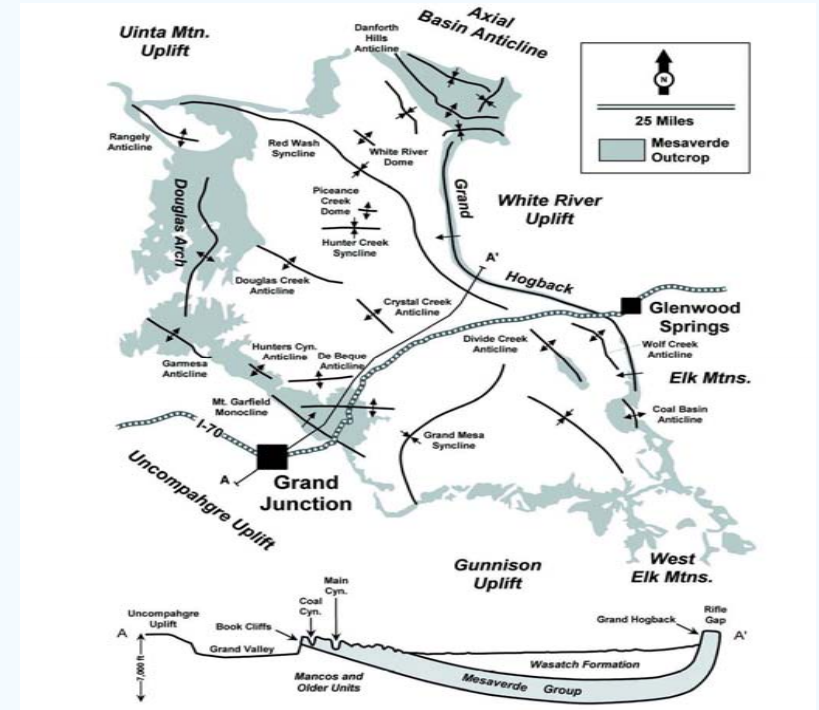


Characterize hydraulic connection between CBM water production intervals and potentially impacted surface water features

- *Horizontal, vertical, or both?*
- *Internal or external formation boundaries?*

Preliminary Observations

- The timing and magnitude of stream depletion from CBM water production will be dependent on "effective average" horizontal and vertical hydraulic conductivity, and formation storage characteristics
- Spatial differences exist among preliminary sub-units
- The quantity of produced water at present is low; present impacts to streams will be similarly low
- COGCC will provide possible scenarios for future development and based on these, the potential for future impacts will be assessed.



Work in Progress

- Compilation and review of data
 - Well tests
 - Shut-in pressures
 - Formation properties
 - Shallow aquifer conditions
- Evaluation of horizontal and vertical hydraulic conductivity; storage properties
- Evaluation of formation geometry with reference to surface streams

Related Analyses

- Suitability of Glover method for regulatory purposes (regional emphasis, not site-specific)
- Other methods, correlations, or indicators that might serve to identify tributary vs. non-tributary zones
- Issues unanswered – areas for further study

Report

Stream Depletion Assessment Study

- Summary of available data and studies
- Regulatory framework
- Hydrogeologic setting
- Extraction activity and projections
- Stream depletion assessment
- Conclusions / Recommendations



Schedule

- Project start, December 2006
- Public Meeting, Rifle, January 26
- Compile, assess data, through April
- Report to lead agencies, June
- Report posted on website, TBD
- Final public presentation, TBD

Communications

- Public Meeting, Rifle, January 26, 2007
- Concerns, observations or information from any interested party is of value to the study team and will be reviewed – best to submit within next 2 weeks, boulder@sspa.com
- Study report will be available through links on DWR and COGCC websites
- Post-study comments will be received by DWR and COGCC
- Post-study meeting will be scheduled

*Your interest is appreciated, contact us at:
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