Managing Coal Bed Methane-Produced Water for Beneficial Uses

Sandia National Laboratories
New Mexico Tech-Petroleum Recovery Research Center
New Mexico State University-Ag. Research Center, Farmington

Project Update

February, 2004

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.

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Background

CBM-Produced Water Treatment Costs and Impacts

- **Treatment of produced water for beneficial use has significant appeal in most arid western states to conserve valuable water and as a way to reduce costs.**
- **In the San Juan Basin, CBM-produced water disposal costs $1-4/bbl because of the limited infrastructure.**
- **Presently that averages about $150,000/day and could double as further CBM wells are developed and produced.**
- **Similar costs exist or could occur in other basins.**
- **Treatment of produced water for rangeland or agricultural applications has the most appeal for many CBM areas. (Final water quality needs are not too restrictive and the infrastructure needs are minimized)**

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Project Tasks
Year 1

- Task 1: Develop a team of national laboratory, university, producer, and resource management and environmental personnel to support and provide industry direction for this effort.
- Task 2: Determine hydrologic and chemical characteristics of the San Juan and Raton Basins with respect to CBM-produced water quality ranges and constituent ranges. Identify with resource management agencies the treated water quality needed for agricultural, rangeland habitat improvement, and livestock watering beneficial uses in the San Juan and Raton Basins.
- Task 3: Using San Juan and Raton Basin CBM-produced water (2,000 mg/l TDS to 24,000 mg/l TDS), evaluate the ability of combinations of pre-treatment technologies; desalination technologies such as ion sorption, nano filtration, and capacitive deionization to meet identified, rangeland rehabilitation, and livestock water standards in bench scale testing.

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Project Tasks
Year 2 and 3

- Task 3. (continued) Assess overall operational performance and costs of appropriate combinations for a range of produced water comparisons.
- Task 4: Based on the bench scale results in Task 3, coordinate and conduct a pilot operation on location at an industry partner site. This will include cooperation with the NM State University Agricultural Research Center at Farmington, and the BLM on use of the treated water for rangeland rehabilitation and will also include application and the permit approvals needed.
- Task 5: Extend future work to other CBM Basins.

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Industry and Regulatory Participants

CBM Producers

ConocoPhillips
Williams Production
Burlington Resources
Dugan Production
XTO Energy
DJ Simmons
Terra E&P
Aztec Well Service
Synergy Operating
D. J. Simmons
Merrion Production
Bayless Production

Water Users

Public Service Company of New Mexico (Cooling Water)
Williams Pipeline (Cooling Water)
Aztec Well Servicing (Disposal Site)
RODI Systems (Desal Equipment)
Tri Energy (Desal Equipment)

Resource Managers

US Bureau of Land Management
NM Oil Conservation Division

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Budget

Participants	FY2004 (Request)		FY2005 (Request)	
	DOE	In Kind	DOE	In Kind
Sandia National Laboratories				
Labor	$140K [1,2,3]	$ 40K	$195K[3,4,5]	$40K
Equipment	$ 20K	$ 20K		$20K
Computation				
Tec Transfer		$20K		$20K
Travel	$ 10K		$10K	
New Mexico Tech - Petroleum Recovery Research Center				
Labor	$45K[1,2]	$20K	$55K[1,2,4]	$20K
Equipment		$20K		$20K
Computation		$20K		$20K
Tech Transfer		$10K		$10K
Travel	$ 5K		$ 10K	
New Mexico State University - Agricultural Science Center at Farmington				
Labor	$ 20K[3,4]	$30K	$20K[3,4]	$30K
Equipment		$20K		$20K
Computation				
Total DOE	**$240K**		**$290K**	
ConocoPhillips		$20K		$20K
Burlington Resources		$20K		$20K
Bayless Production	Field site	$20K	Field site	$40K[4]
EnerGen Resources		$20K		$20K
Dugan Production Corp		$20K		$20K
Merrion Oil and Gas		$20K		$20K
Terra Exploration and Production		$20K		$20K
D. J Simmons		$20K		$20K
XTO		$20K		$20K
Williams Petroleum		$20K		$20K
Total In Kind	**$400K**		**$420K**	

1 Lab, bench scale work
2 Collection of CBM basin and produced water data
3 Examine beneficial uses of CBM water (agricultural experiment station)
4 Pilot demonstrations
5 Expand to other basins

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Little Infrastructure Exists in San Juan, Raton Basins

Sampling in Raton Basin (Filtered Overflow Drains to Local Canyon)

Many Sites in San Juan Basin Are Remote

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Deliverables/'Schedule

Second Quarter FY 04

Report(s)

- **San Juan, Raton Basin Produced Water Characteristics**
- **Baseline Range Rehabilitation Work**
- **Preliminary Results: Ion Sorption, Nano Filtration Desalination**

Second Quarter FY 05

Report(s)

- **San Juan, Raton Basin Pre-treatment & Treatment Technology, Cost Performance Evaluations (Compare with RO)**
- **Lessons Learned, System Advantages, Disadvantages Applications**
- **Additional Rangeland Improvement Work**

First Quarter FY 06

Report(s)

- **Rangeland Rehabilitation Results with Treated Water**
- **Pilot-scale Study Results**
- **Laboratory and Bench Scale Data from Other Basins**
- **Expected Full-scale Cost , Performance Predictions vs. Water Quality & Beneficial Use**

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CBM-Produced Water Sampling and Characterization

Wellhead at San Juan Basin

Wellhead at Raton Basin (Vermijo Formation)

A Centralized Disposal Well Site in the San Juan Basin

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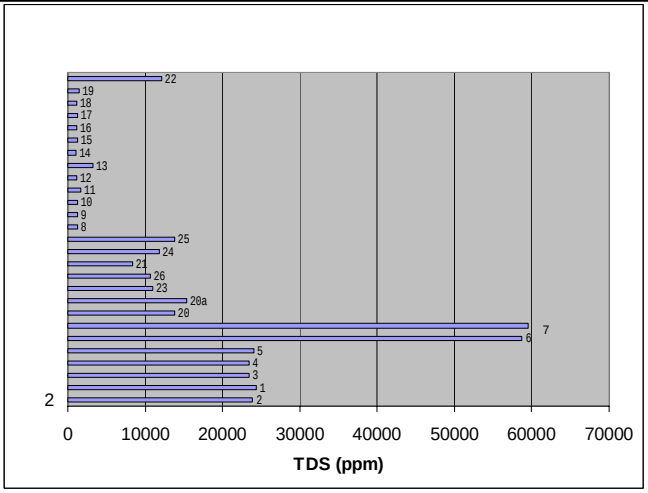
TDS Values in San Juan Basin Wells



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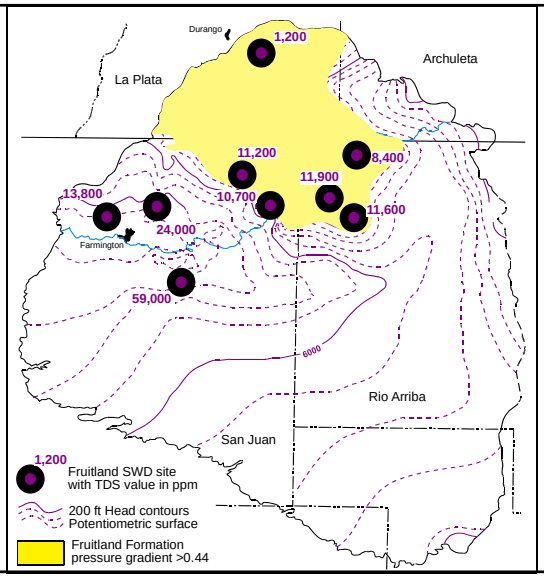
Sampling Results, San Juan Basin



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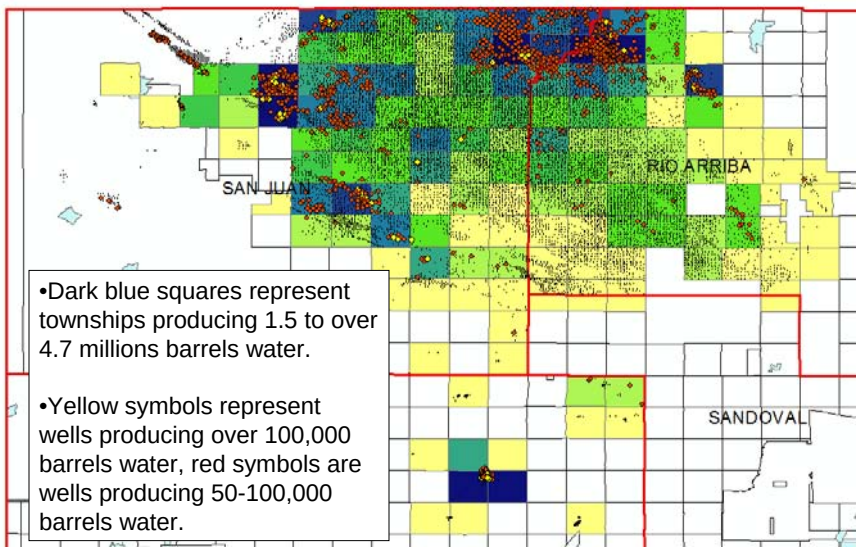
San Juan Basin Produced Water Volumes.

(Township and Well, 1/01 through 7/03. Data from NM OCD.)



- Dark blue squares represent townships producing 1.5 to over 4.7 millions barrels water.
- Yellow symbols represent wells producing over 100,000 barrels water, red symbols are wells producing 50-100,000 barrels water.

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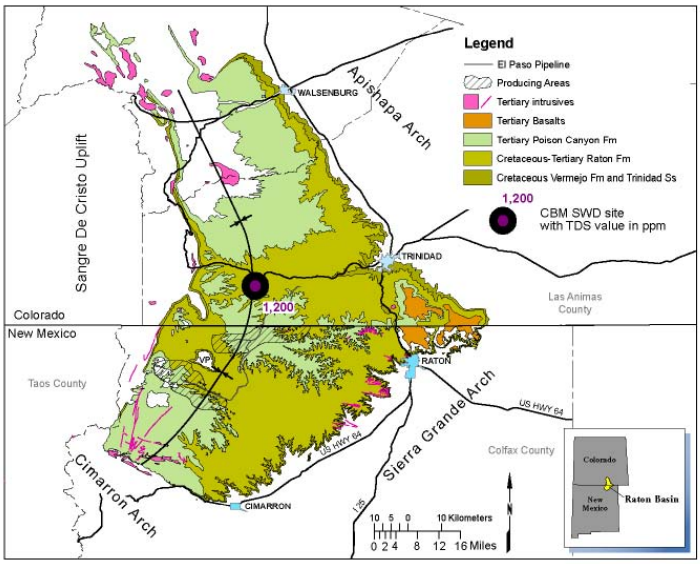
Sampling Results, Raton Basin



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Produced Water Application: Rangeland Study Assessment

(Williams Production in San Juan Basin)
(Range Improvement via Pump, Tank, and Running Sprinklers, 8-19-03) (640 BBL of ~5700 TDS Pumped on Planted Grass, SAR > 100)

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Rangeland Study Assessment (continued)

1200 BBL of ~4600 TDS Produced Water Pumped on 0.25 Acres of Grasses on 400/BBL/Watering, 8-21-03 (SAR > 100)

Sprouting San Luis Slender Wheatgrass 10-8-03

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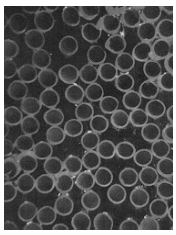
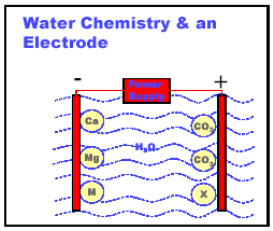
Treatment System Element Evaluation

- Pretreatment
  - Surface modified zoeolites and emerging pervaporation/micro filtration for low-energy reduction of organics
- Treatment
  - Capacitive deionization
  - 15-20% less energy than RO
  - Better match for basin ionic loadings
  - Several electrode configurations will be studied
- Post treatment
  - smectites and surface-modified zeolites for SAR adjustment
- Rangeland reseeding applications
  - Treat produced water to ~2,000-24,000 ppm TDS and appropriate SAR





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Produced Water Treatment and Desalination Research Effort Summary

- **Ion Sorption/Ion Exchange Method**
  - Initial testing looks promising for both rangeland and industrial applications
- **Nano Filtration**
  - Initial testing looks promising for industrial applications and possibly rangeland applications
- **Capacitive Deionization**
  - Electrode manufacturers to date have been unable to provide equipment for evaluation
  - Magnetic separation technology evaluation scheduled for April 04

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An Ion Sorption/Ion Exchange Subsystem Using Field Regenerable Media

- Several media evaluated, preference given high capacity media at room temperature
- Lime softening
  - Precipitates Ca and Mg if carbonate is in excess
  - Excess carbonate alkalinity converted to hydroxide
  - Interest by industrial users
- Cation exchange: Permutite
  - Used for water softening prior to ion exchange resins
  - Amorphous aluminosilicate, made from waterglass and alum
  - Very high exchange capacity
  - Easily regenerated
  - High selectivity for ions of interest
- Anion exchange: Hydrotalcite
  - Made as amorphous Mg/Al hydroxide
  - Sequesters anions, releases hydroxide as it crystallizes
  - Can be regenerated by heating
  - Very high exchange capacity
  - High selectivity for ions of interest

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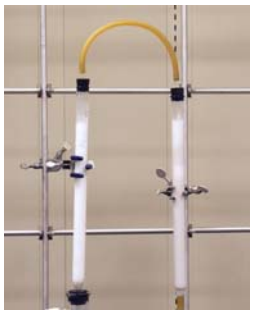
Results of Ion Sorption Desalination Method

- Brackish water was obtained from the San Juan Basin, with composition:
  - TDS~11,000 ppm, pH = 8.4
  - Ca2+-22 ppm
  - Mg2+ -17 ppm
  - Na+-4500 ppm
  - Cl- -2200 ppm
  - SO_4^{2-}- -<1 ppm
  - HCO_3-8300 ppm
- *Lime softening* reduced TDS, ~ 8,000 ppm, ph was increased to 12.4
- Putting the water through *cation exchange* column, TDS ~ 2,600 ppm, pH was 2.9
- Putting water through the *anion exchange* column, TDS ~ 600 ppm, pH increased to 5.0
- Various combinational have benefit for rangeland and industrial needs



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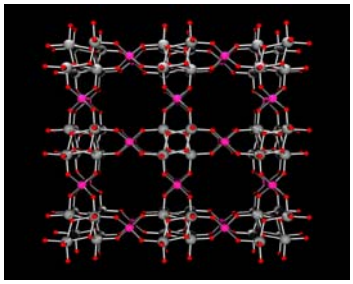
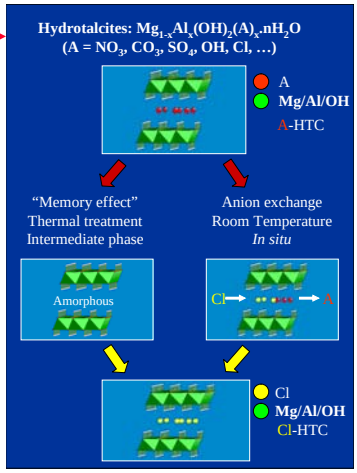
Ion Sorber/Ion Exchanger Material :

Zoelite **Hydrotalcite**





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Lab Test Results
Microfiltration/Nanofiltration Process

- **Feed**
  - Ca 632 mg/l
  - Mg 148 mg/l
  - Sodium 3137 mg/l
  - Sulfate 2944 mg/l
  - Chlorides 4118 mg/l
  - pH 6.33
  - TDS 11,158 mg/l
  - Cond* 18,000 umhos
  - TOC 11.9 mg/l
- **Permeate**
  - Ca 98 mg/l
  - Mg 16 mg/l
  - Sodium 3201 mg/l
  - Sulfate 50 mg/l
  - Chlorides 3976 mg/l
  - pH 6.43
  - TDS 6,835 mg/l
  - Cond* 15,000 umhos
  - TOC 7.71 mg/l

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Focus for Year Two
CBM Produced Water Utilization for Agricultural Applications

Treatment System Elements

Types of water selected	System Matrix: Pre-treatment	Treatment	Post-Treatment
~2000 ppm TDS	NONE	NONE	SAR Compatibility, metals
~12,000 ppm TDS	Organics, H2S metals	desal technology	SAR Compatibility, metals
~24,000ppm TDS	Organics, H2S metals	desal technology	SAR Compatibility, metals, and concentrate disposal

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Focus for Year Two

Rangeland Improvement

- Additional Plantings with a matrix of 16 types of grasses
  - Planting with ~3000 TDS-produced water
  - Planting with ~10,000 TDS-produced water seedlings
- Work on “passive” sodium removal scheme using a smectite bed to improve SAR as part of produced water treatment

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Focus for Year Two

Innovative Desalination Research

- Optimize Synthesis and Exchange Capacity of Ion Exchangers
  - Improve Ion Exchange Process Engineering for “Scale Up”
  - Develop into Pellet Configuration
- Continue Nano Filtration Process with Varying Pretreatments
- Reassess Capacitive Deionization Process with Additional Commercial Vendors or Internally
- Optimize Use of Surface Modified Zeolites for SAR Adjustment

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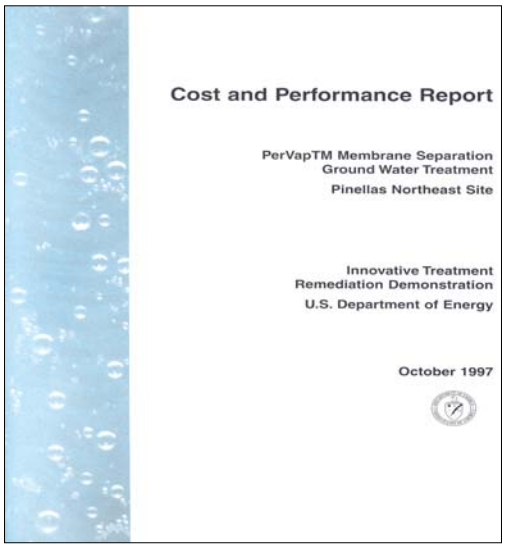
Cost Performance Reporting



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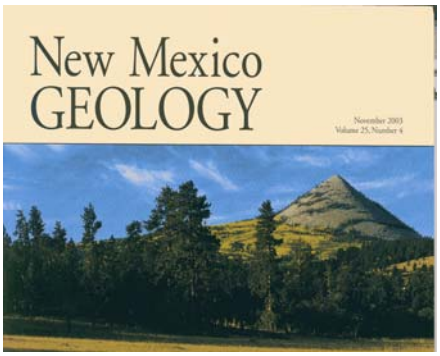
Much Project Work on Basin Characterization and Rangeland Improvement Published



New Mexico's Raton Basin Coalbed Methane Play

Gretchen K. Hoffman and Brian S. Brister, New Mexico Bureau of Geology and Mineral Resources,
New Mexico Institute of Mining and Technology, 801 Leroy Place, Socorro, NM 87801

Revegetation of Pipeline Right-of Way and/or Well Sites with Selected Cool and Warm Season Cultivar's and Forbes for Palatability, Stand Establishment, and Erosion Control in the Intermountain Region of Northwest New Mexico.

BY: Richard N. Arnold
New Mexico State University
Agricultural Science Center

February 3, 2004

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Additional Statewide/Regional Activities in Reclaiming Produced/Brackish Water for Beneficial Uses

- New Mexico & Southwest Regional Forum on Reclaiming Produced/Brackish Water for Beneficial Uses, July 03
- Planning and Conduct the New Mexico Brackish Groundwater Assessment Program Workshop, February 04
- Major Participant in, “Water in the Desert: Engineering, Legal/Logistical Study to Implement the Conversion of Produced Water to Usable Water in Permian New Mexico”, 2003
- Organize Southwest Regional Forum on Institutional, Legal, and Regulatory Aspects of Produced and Brackish Water, Spring 04
- Major Partner in the Tularosa Basin National (Inland) Desalination Research Facility, Now Under Construction

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