Effects of Irrigating With Treated Oil and Gas Product Water on Crop Biomass and Soil Permeability

Presented to:

Strategic Center for Natural Gas and Oil

US Dept. of Energy - NETL

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Who is WRI?

- **WRI is a research, technology development and contract services organization serving the energy and highway materials industries.**
- **WRI is a former U.S. DOE Energy Technology Laboratory specializing in oil shale and underground coal gasification.**
- **WRI has two major Federal contracts:**
  - **Cooperative Agreement with the U.S. DOE wherein we work jointly with industry to support the needs of the coal and power industries.**
  - **Contract with the FHWA to apply asphalt chemistry to specifications for better highway performance.**

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WRI History

1924 Petroleum Experiment Station Established

- To study characteristics of high-sulfur crude oil in Wyoming

1964 First Year of Asphalt Research

- Research has continued under Strategic Highway Program & FHWA

1977 Laramie Energy Technology Center (LETC)

- Lead for U.S. DOE oil shale & underground coal gasification programs

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- LETC is de-Federalized. Cooperative Agreement with DOE established

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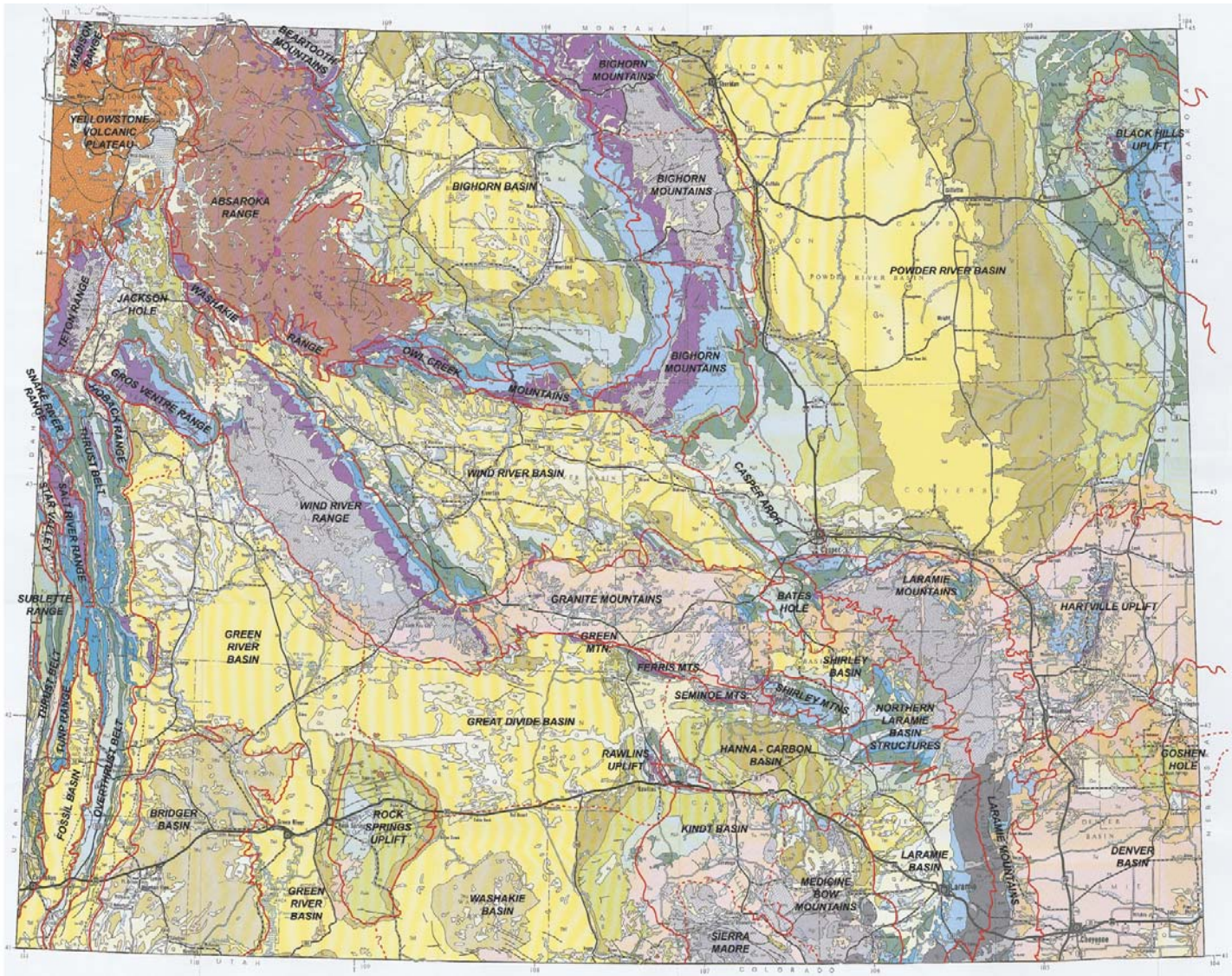
Project Background



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CBM Development in the PRB

- An estimated **25** trillion cubic feet of CBM is in the PRB of Wyoming and Montana alone. Equivalent to the gas reserves of the Gulf Coast.
- **51,000** wells are expected to be in service in the PRB area in the next 10 years.
- Surface disturbance of approximately **212,000** acres (3% of project area).
- An estimated **3.07** million acre ft of produced water generated over the next 10 years.
- An estimated **4-8** trillion gallons of CBM produced water is expected to be generated over the potential 30-35 year play of the Powder River Basin CBM.

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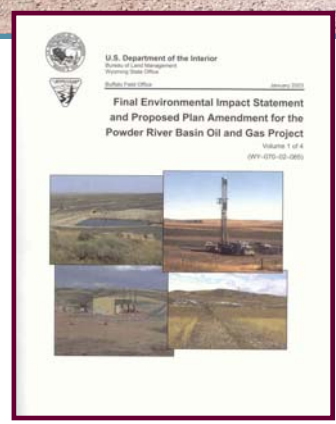
Economic Impact

- Federal Royalties - $1.7 billion
- State Royalties - $252 million
- Sales Tax - $124 million
- Severance to WY - $1.3 billion
- Ad Valorem (Counties) - $1.5 billion

FEIS, Jan. 2003

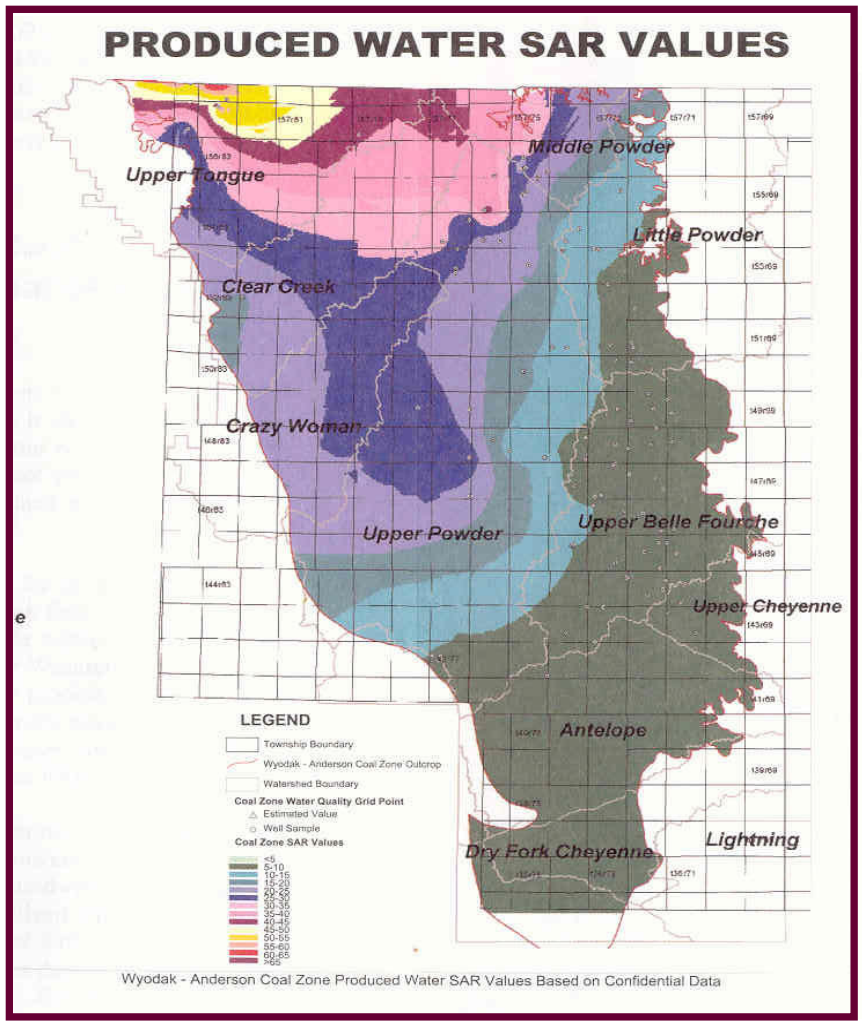
Produced Water Mgmt. Costs

- Surface Discharge - $818 million
- Infiltration - $505 million
- Containment - $593 million
- Land Application Disposal - $26 million
- Injection - $130 million
- Total Est. Cost for CBM Produced Water Management - **$1.57 billion**



FEIS, Jan. 2003

Implications to Development



FEIS, Jan 2003

LEGEND

Coal Zone SAR Values

- <5
- 5-10
- 10-15
- 15-20
- 20-25
- 25-30
- 30-35
- 35-40
- 44-45
- 45-50
- 50-55
- 55-60
- 60-65
- >65

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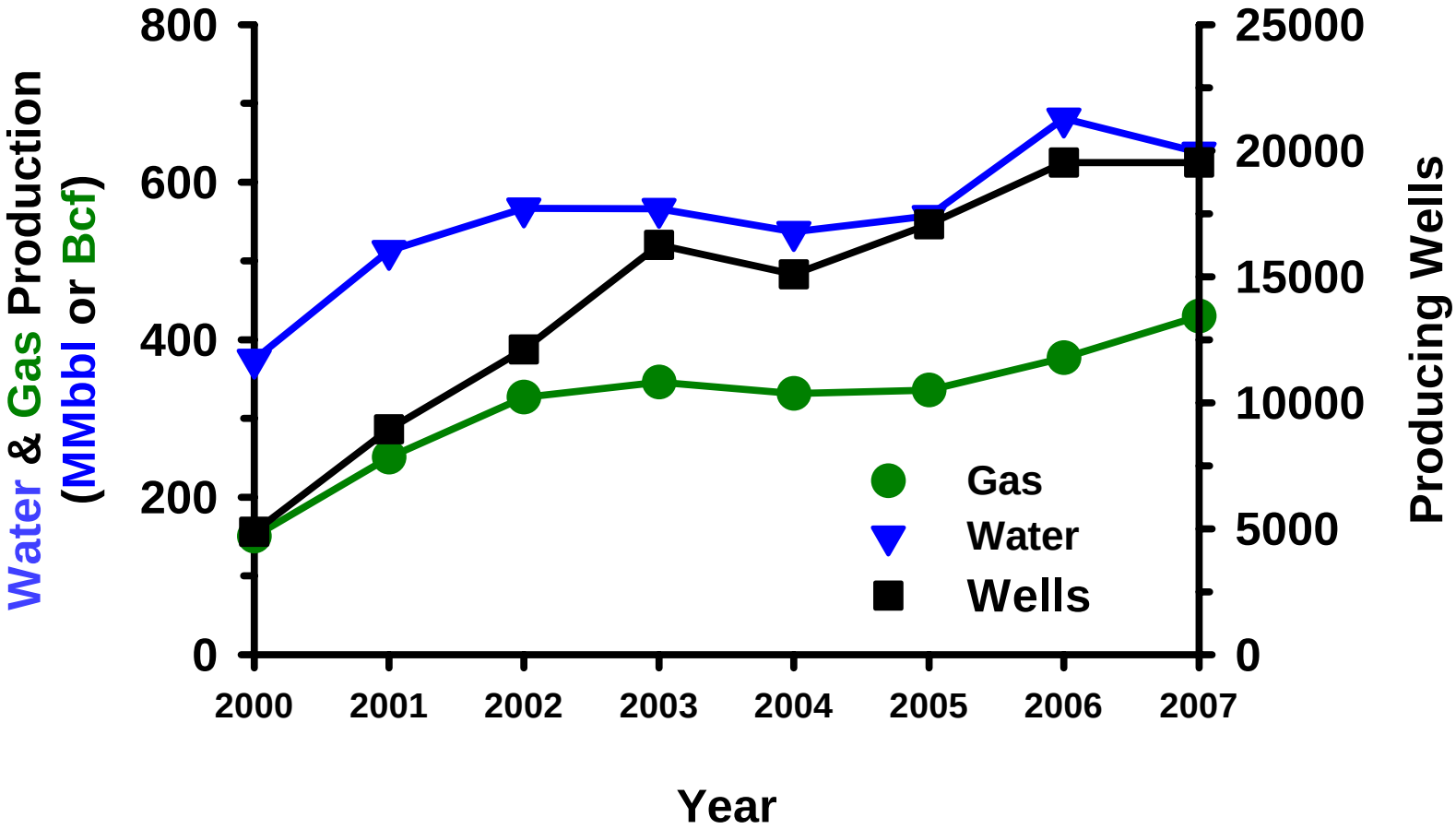
Gas/Water Production in PRB



Data obtained from Wyoming Oil and Gas Conservation Commission website

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WRI & Produced Water

- Field and laboratory evaluations of land applications of CBM produced water (e.g., mineral amendments to soil and water)
- CBM produced water treatment (e.g., barium)
- Enhanced methane production
- Remote sensing

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Produced Water Management

Land Application of Produced Water

- Near Buffalo, WY
- Feasibility study using soil columns in the laboratory
- Pilot-scale field irrigation project employing soil and water amendments

Soil Core Study in the Laboratory

- Reconstructed soil cores from A horizon material
- Soil left untreated or amended with equivalent of 2.5 tons gypsum/acre
- CBM produced water percolated through cores for 75 hours

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Soil Cores

EC & SAR

- Electrical Conductivity (EC)
- Sodium Adsorption Ratio (SAR):

$$SAR = \frac{[Na]}{\sqrt{\frac{[Ca]+[Mg]}{2}}}$$

EC & SAR

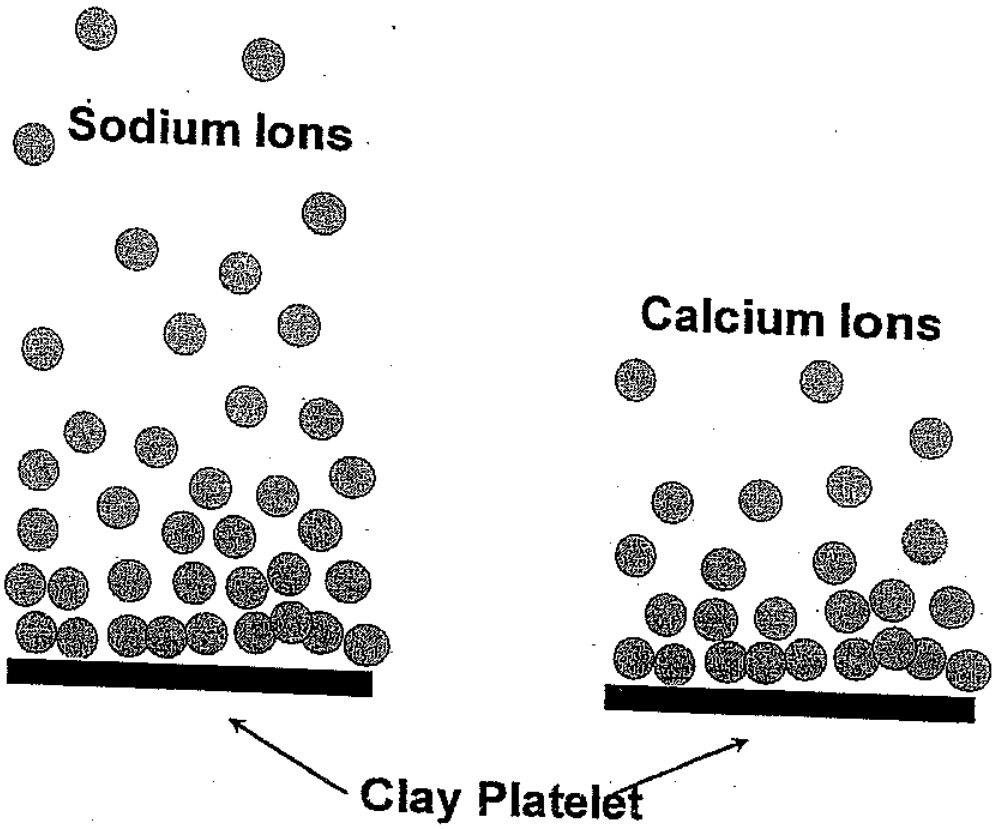

Figure 1. Concentration of ions is greatest immediately adjacent to the platelet and decreases with distance from the platelet.

From: Hanson et al. 1999

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Water Quality

Parameter	Creek	CBM
SAR $mmol^{1/2} L^{-1/2}$	0.7	24
EC µS/cm	636	1,380
	mg/L	
Alkalinity	207	802
TDS	470	910
HCO_3	237	853
CO_3	8	62
Cl	3	13
F	0.2	0.9
SO_4	137	<1
Ca	75	9
Fe	100	560
K	6	3
Mg	30	4
Na	28	344

Water Quality

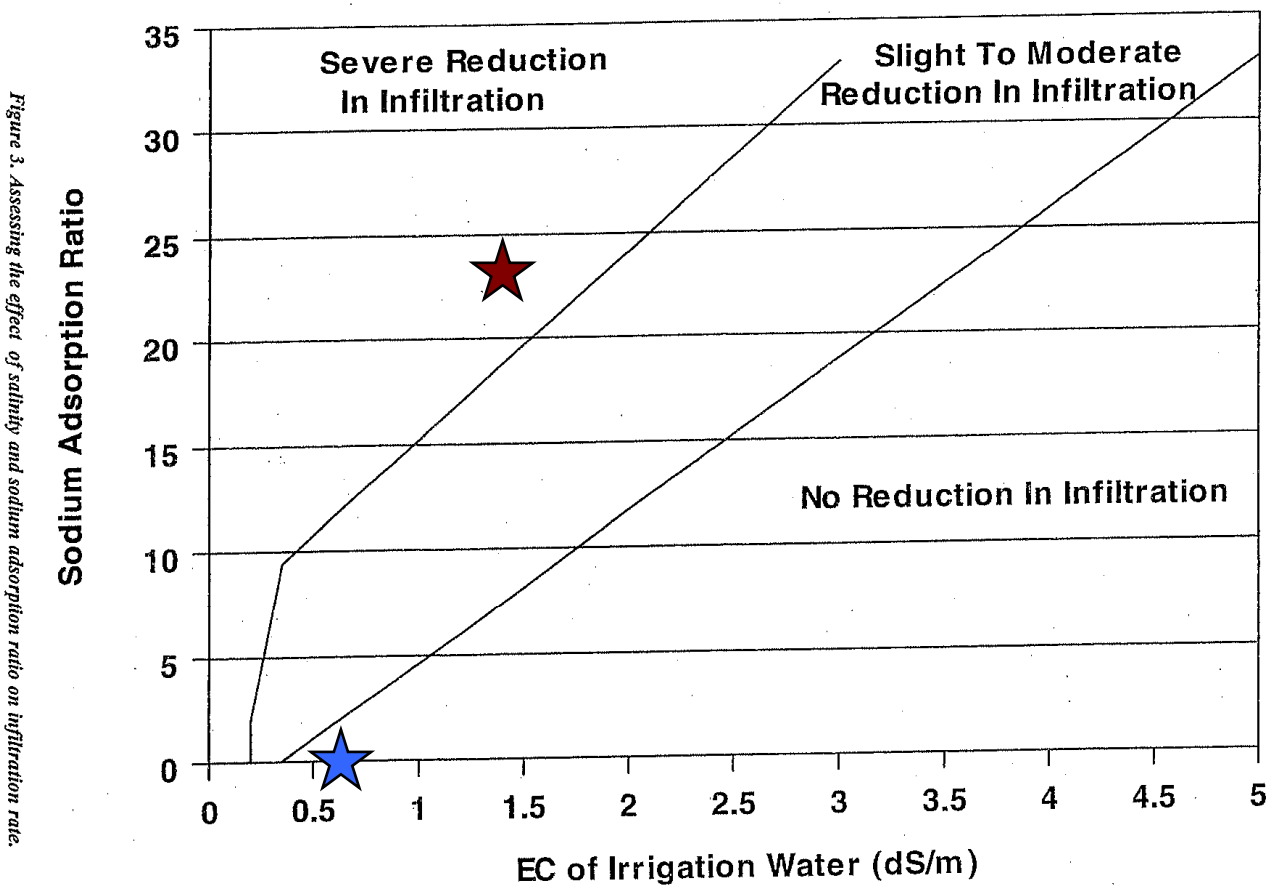

Figure 3. Assessing the effect of salinity and sodium adsorption ratio on infiltration rate.

AGRICULTURAL SALINITY AND DRAINAGE — How Water Quality Affects Infiltration

From: Hanson et al. 1999

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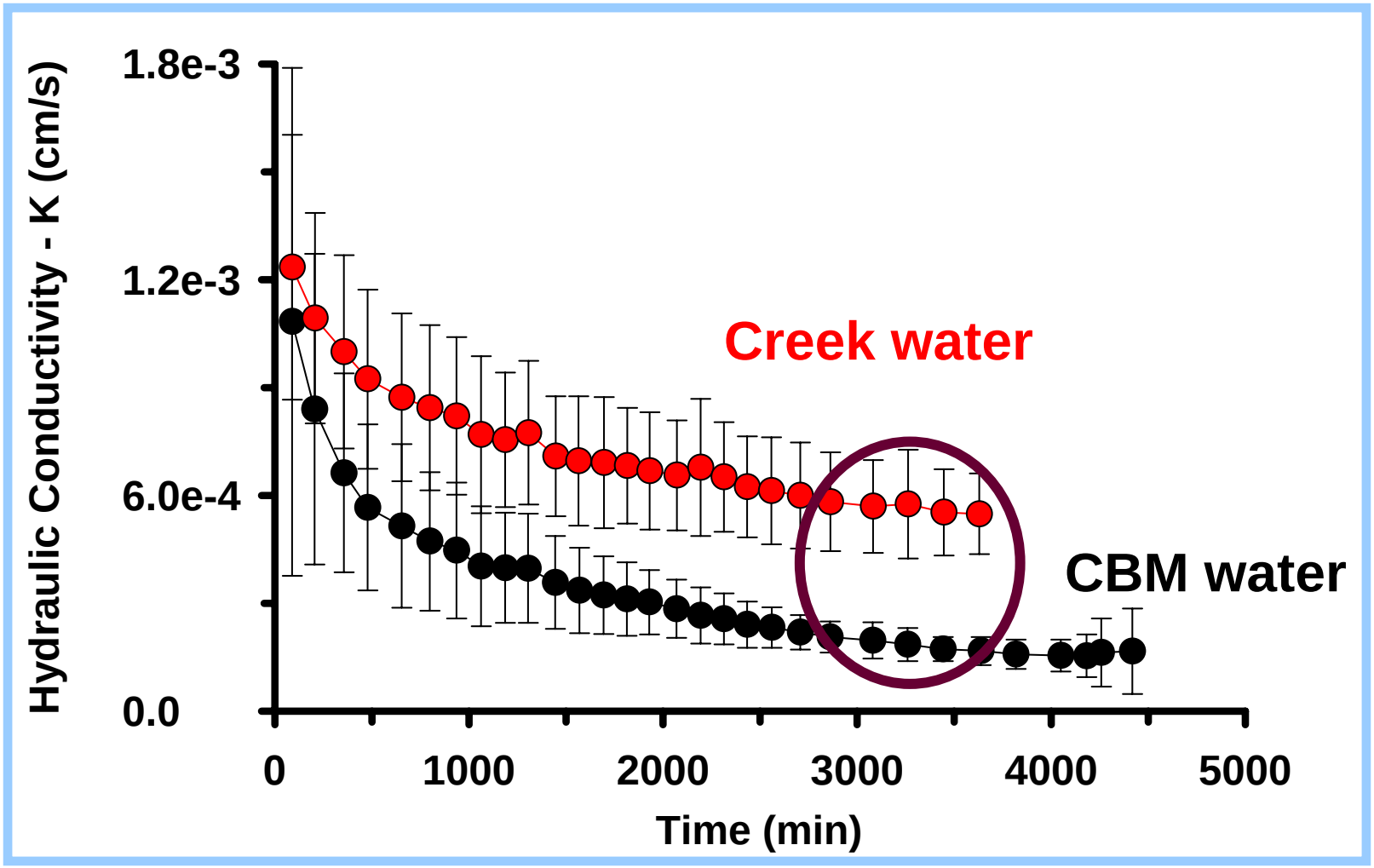
Saturated Hydraulic Conductivity



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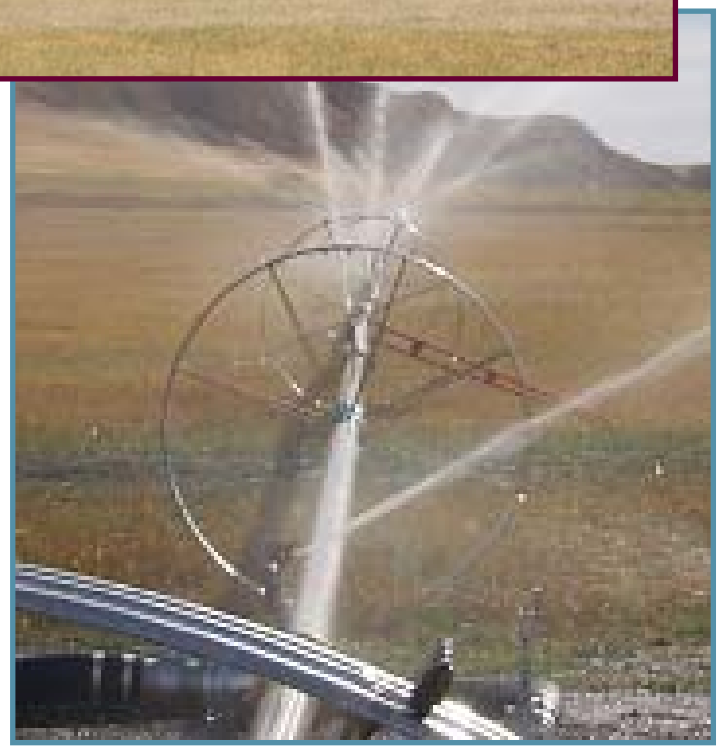
Field Study



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Field Study

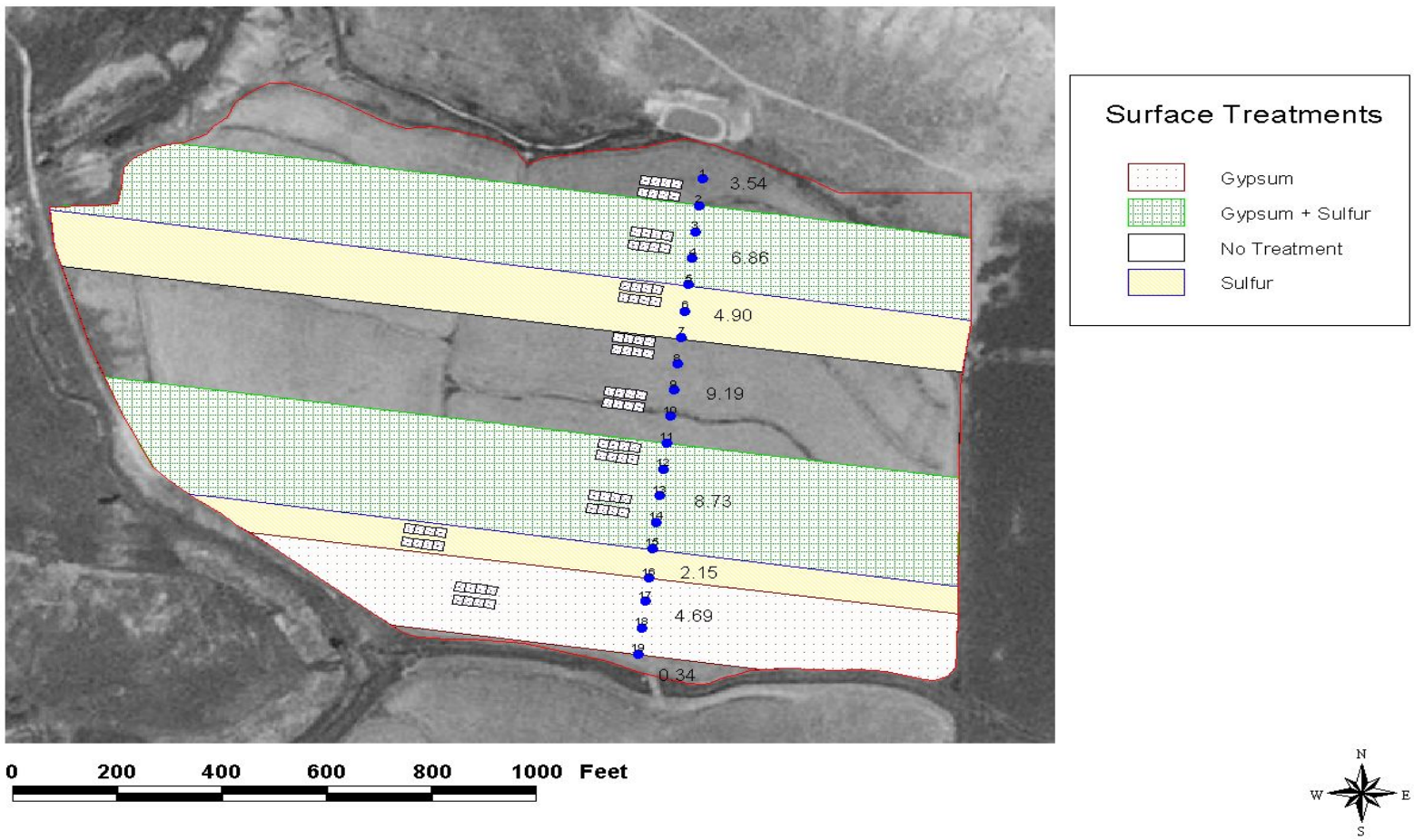
Soil Amendments

- 0.5 tons sulfur/acre
- 1.5 tons gypsum/acre
- Combination
- None

Water Amendments

- Sulfur burner
- Gypsum injection
- Combination
- 50:50 blend with Creek water
- None

Amendment Application Areas



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Soil Horizons

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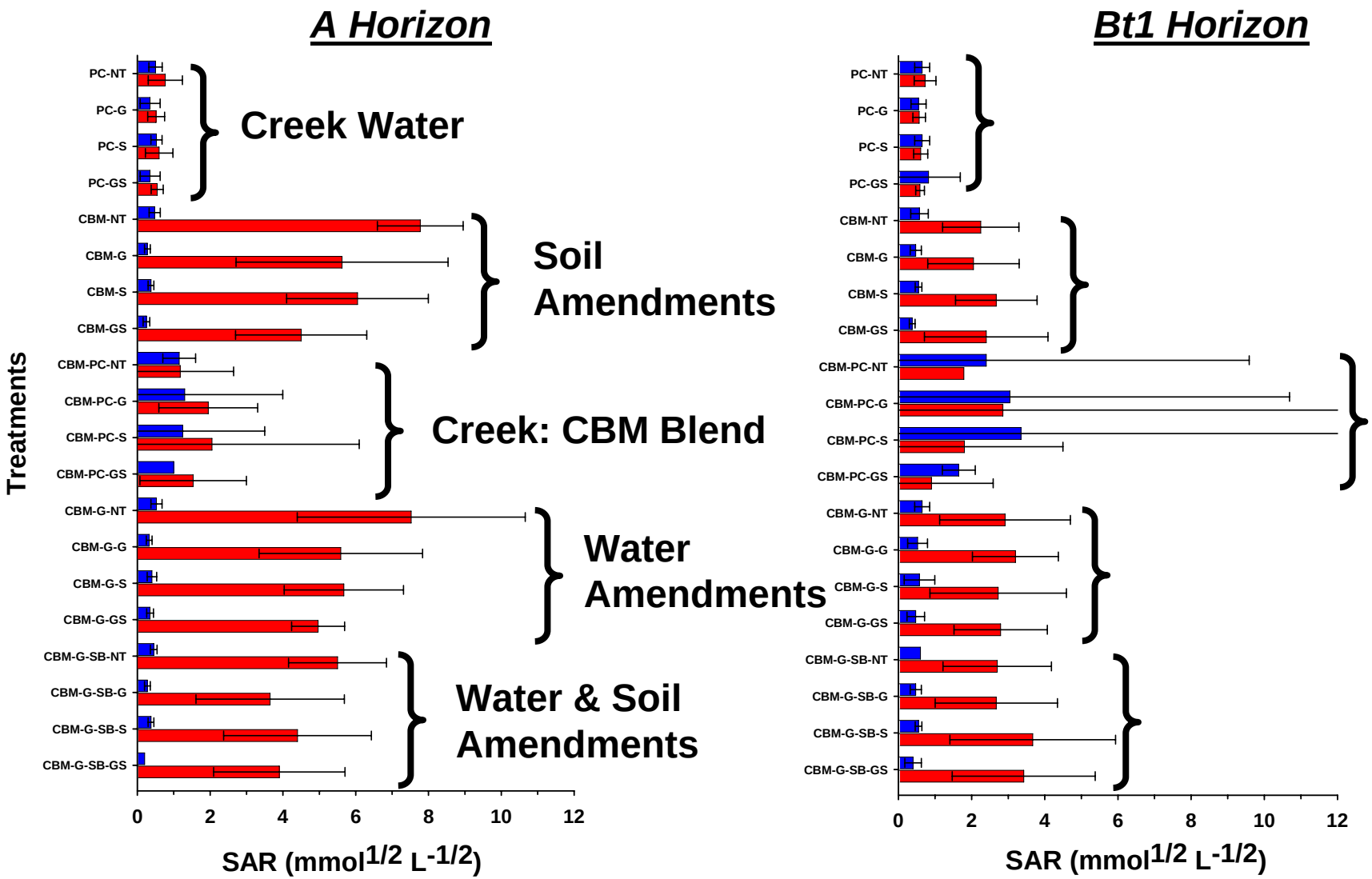
Soil SAR



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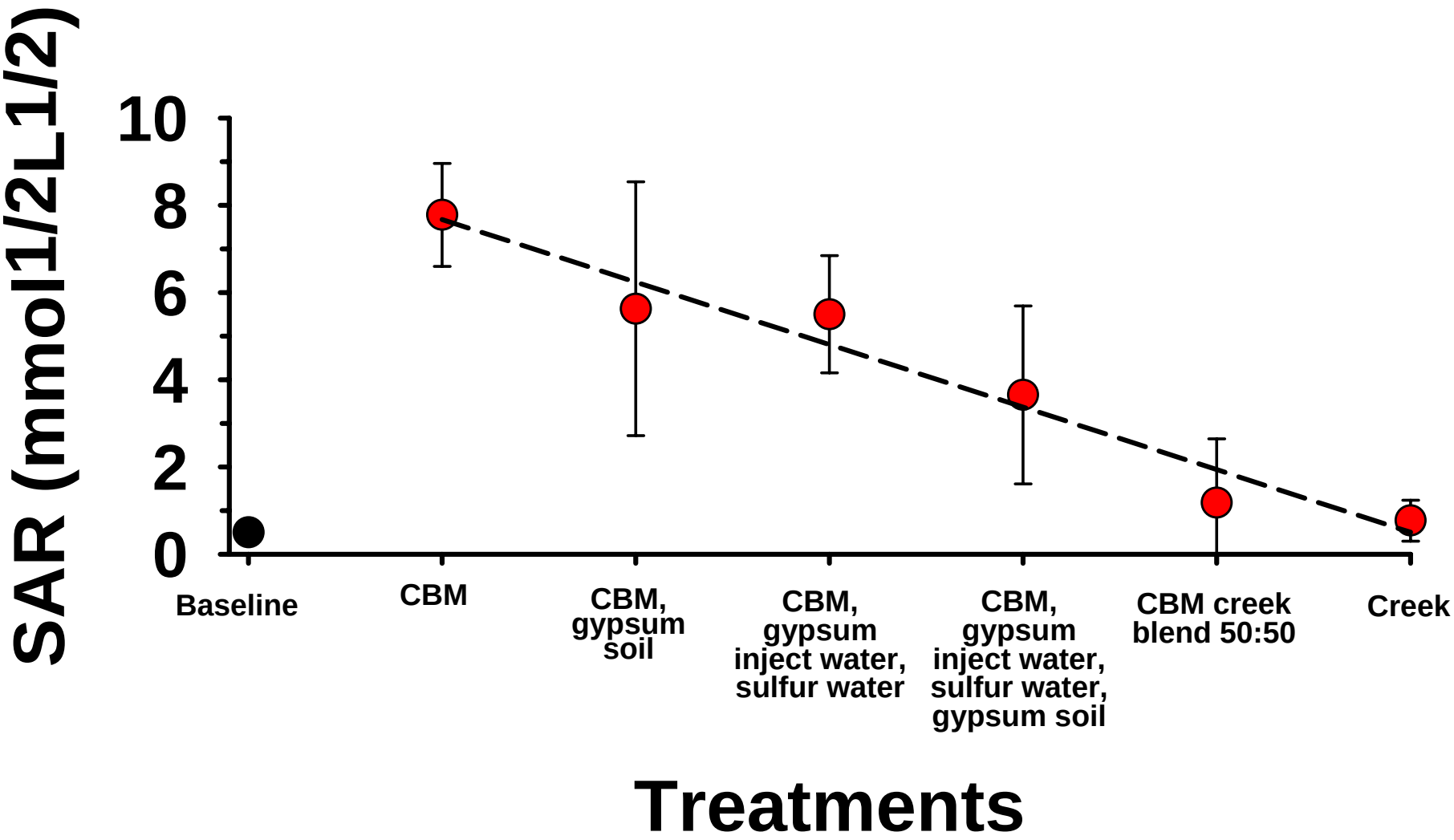
Soil SAR



Conclusions

- CBM - Elevated sodium concentrations and SAR values in first two soil horizons
- Creek water or blend – No difference
- Combination of water and soil treatments most effective for reducing Na and SAR

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Cooperative Agreement: No. DE-NT0005681

- **WRI submitted to NETL in June 2008**

  Regarding RFP DE-PS26-08NT00209-00: *Environmental and Unconventional Oil – Technology Solutions for Oil and Gas Resource Development*

  Under CFDA No. 81.089 Fossil Energy Research and Development.

- **Accepted August 2008**

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Cooperative Agreement: No. DE-NT0005681

- Funded in September 2008
- ~2-year project
- Effects of Irrigating with Treated Oil and Gas Product Water on Crop Biomass and Soil Permeability

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Collaborators

- MWH Americas, Inc. – Fort Collins, CO
- Poudre Valley Environmental Sciences, Inc. – Fort Collins, CO

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Project Goals

1. Assess RO and EDR as viable treatment technologies for CBM and conventional oil and gas produced water.

2. Determine optimal blends of treated/ untreated produced water for irrigation with regards to good crop quality/health and soil permeability.

Synopsis

- Treat CBM and conventional oil/gas produced water using pretreatment (as necessary) and RO and EDR.
- Use various blends of treated/raw water to irrigate crop species in 2 soils from production areas in Wyoming.
- Use same blends to irrigate soil columns with 1, 2, and 3 year's worth of water

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Project Tasks

1. Project Management Plan (accepted)
   Technology Status Assessment (accepted)
2. Experimental & analysis plan development (in progress)
3. Conduct irrigation experiments
4. Data analysis and final report

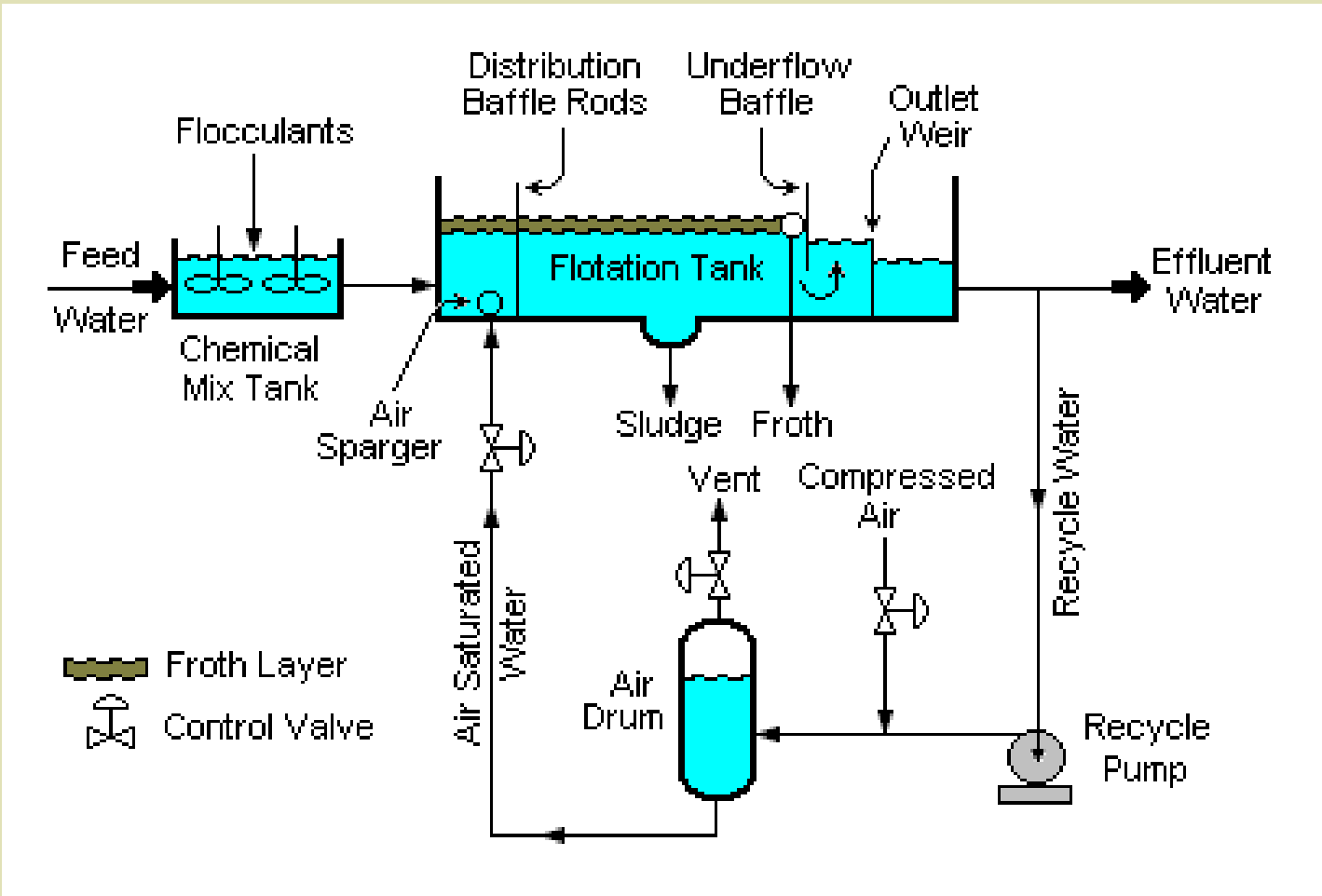
Task 3

1. Lease greenhouse space at UW facility (completed).

2. Collection of soil, water, and plant seeds.

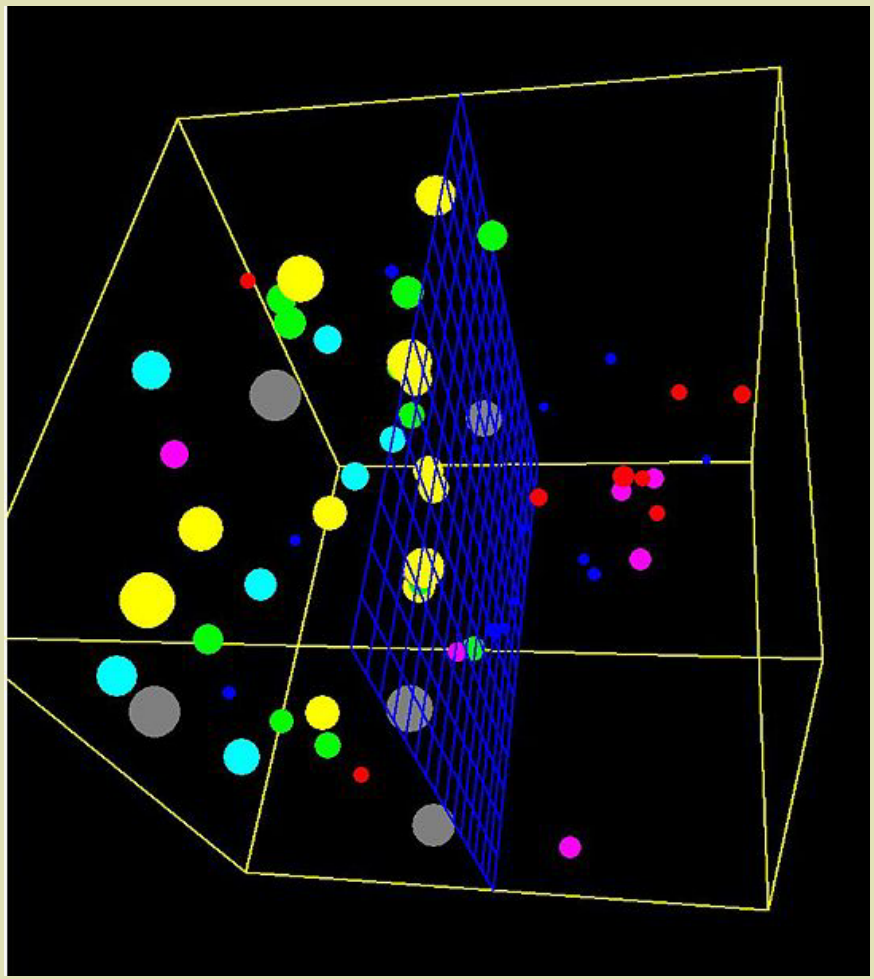
Task 3.3

Pretreat with DAF and organo-clay filtration (organics)



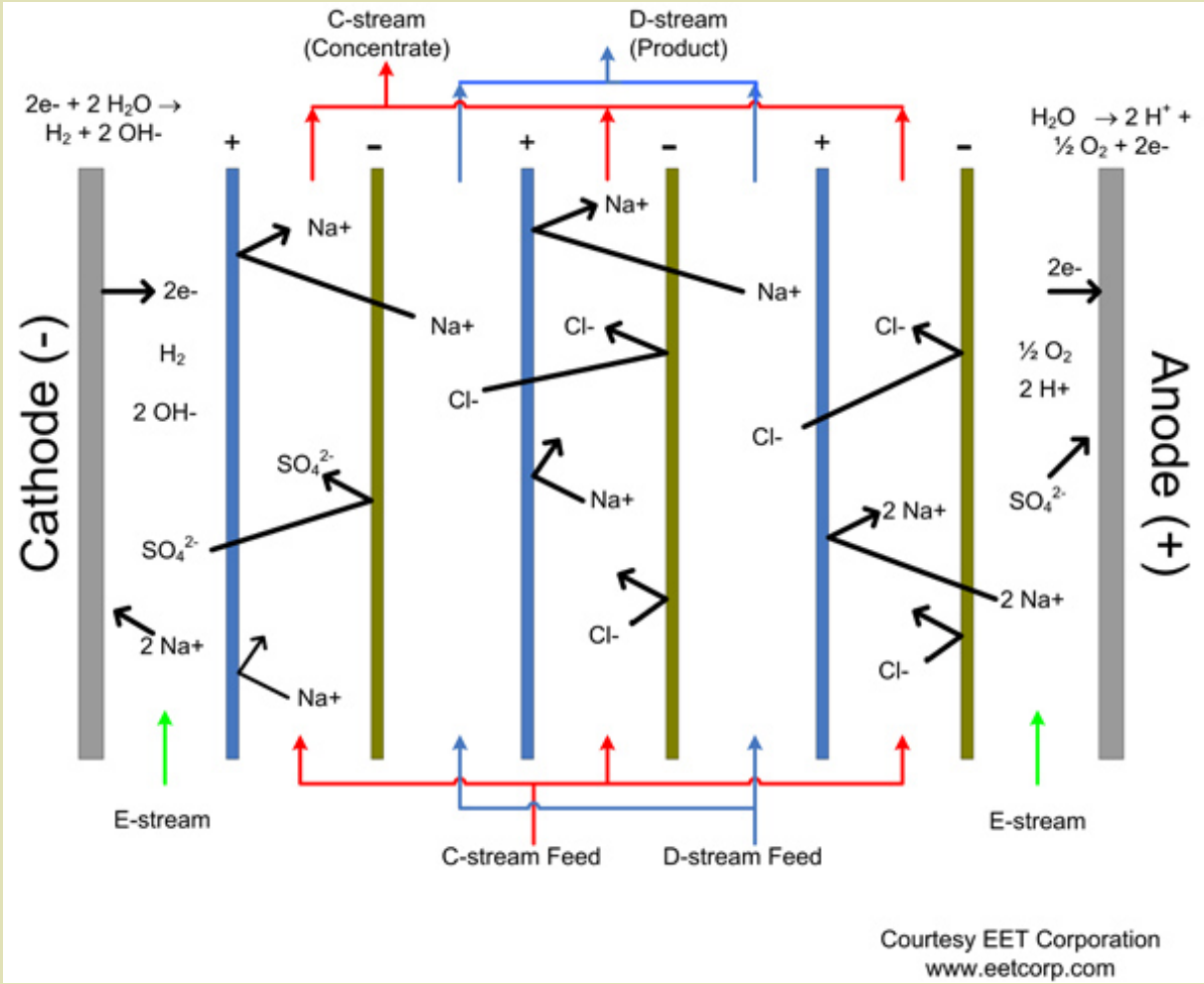
Task 3.3 (cont)

Reverse Osmosis (inorganics)



Task 3.3 (cont)

Electrodialysis Reversal (inorganics)



Task 3.3 (cont)

- **Irrigate crop species (i.e., alfalfa & western wheat grass) planted in representative soils from production areas in Wyoming in greenhouse with blends of treated/untreated water.**

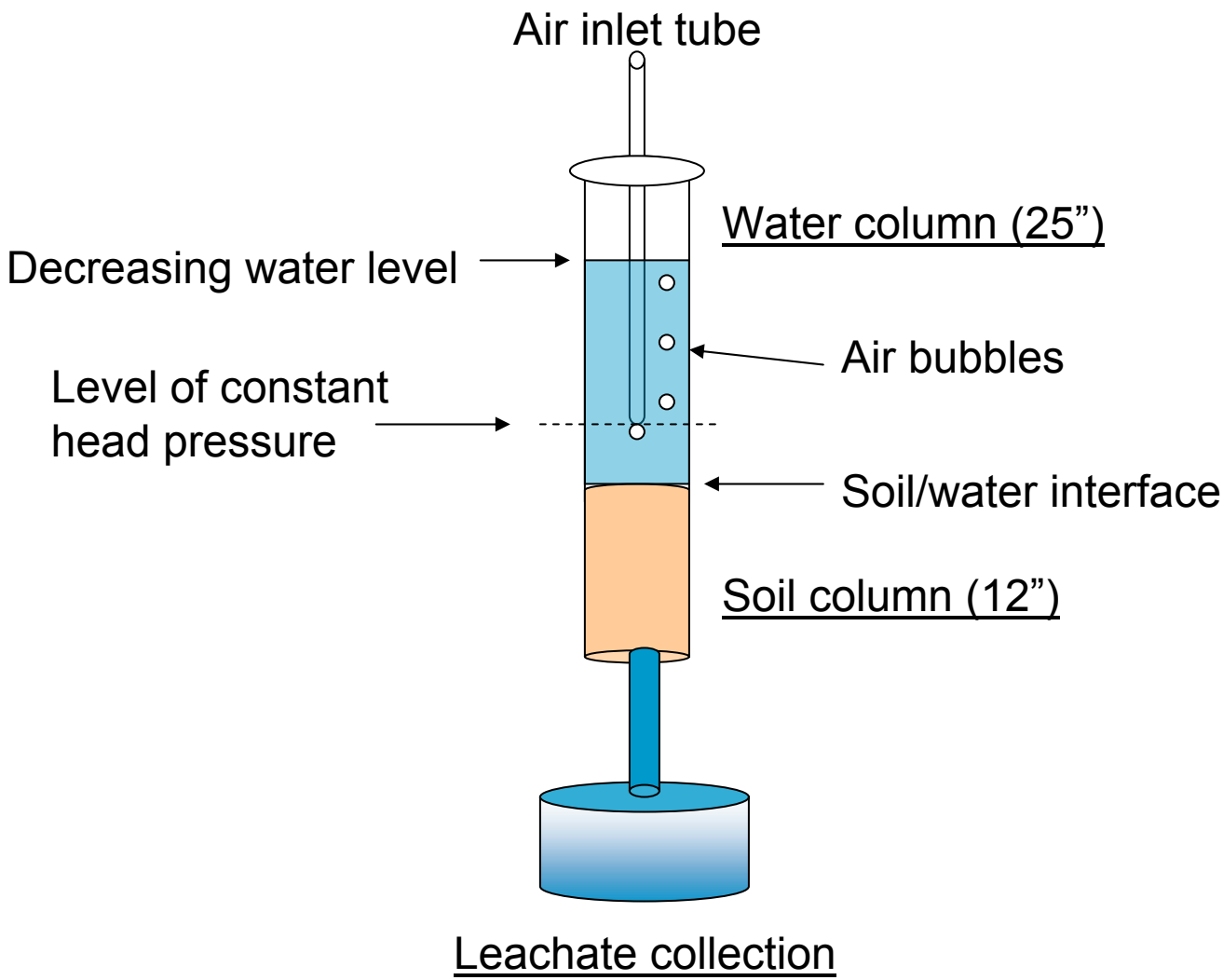
  Endpoints: Tissue chemistry & health/forage quality.

Task 3.3 (cont)

- **Irrigate soil cores with blends of treated/untreated water (1, 2, & 3 season's worth of water).**

  Endpoints: Soil/leachate chemistry & soil hydraulic conductivity.

Task 3.3 (cont)


Air inlet tube
Water column (25”)
Decreasing water level
Air bubbles
Level of constant
head pressure
Soil/water interface
Soil column (12”)
Leachate collection


Questions/Comments/Advice?