

eye on environment



DOE's Focus on Federal Lands

by David Alleman, Technology Manager
DOE Environmental Solutions

Much (68%) of the remaining domestic oil and gas resource is on Federal Lands, primarily in the Western United States. Exploring and developing these resources depends on improving access. Access covers a variety of issues, from obtaining leases and permits to protecting environmental and cultural resources.

Environmental concerns related to federal lands access are among the most pressing issues limiting U.S. oil and natural gas production. NETL's Oil and Natural Gas Environmental Program is working with regulators, industry, and academia to ensure that America can economically produce its oil and gas resources and protect the environment.

An area of particular concern is coalbed natural gas (CBNG) production in the Powder River basin of Wyoming and Montana. National gas supply forecasts have long expected natural gas from this region to meet an increasing portion of the U.S. demand for natural gas. However, concerns have been raised over the potential environmental impacts of produced water associated with CBNG. Because of these concerns, State and Federal regulators have not been able to issue the drilling permits that would allow production to increase.

NETL is working with regulators, industry, and citizens to fully characterize these potential impacts and determine what steps, if any, need to be taken to ensure that production can continue without harming the environment.

This issue of the newsletter describes one of the projects that NETL is funding to help resolve some of these issues and ensure a reliable, affordable supply of natural gas for the U.S.

A bonus article on p. 7 summarizes how NETL's Oil and Natural Gas Environmental Program benefits the states.

Powder River Basin of Montana & Wyoming Issue

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The Critical Role of Impoundment and Infiltration Systems in Coalbed Natural Gas Development in the Powder River Basin of Montana and Wyoming

by Dan Arthur, ALL, Consulting, Inc. Tulsa, OK

INTRODUCTION

U.S. Department of Energy-funded research targets the management of water produced from underground coal seams in association with methane production and development in the Powder River Basin. Since 1999, more than 20,000 well permits have been issued and over 15,000 wells drilled into Cretaceous coalbeds of the Ft. Union Formation. As development has progressed, water management has become the focal point and perhaps the greatest challenge currently hindering development. Conversely, because of the high quality of produced water in the basin, state and federal regulatory agencies have directed industry to seek beneficial uses for the water as the primary water management strategy and best practice. The use of surface ponds and reservoirs allows CBNG developers the flexibility to employ a variety of on-demand beneficial uses for produced water that would otherwise be unfeasible.



Researchers evaluate proposed new storage pond locations in Big Horn County, MT.

This issue of Eye on Environment focuses on research under way in the Powder River Basin of Montana and Wyoming that is co-funded by the Montana Board of Oil and Gas Conservation (MBOGC). The project is currently being expanded with funds from the Wyoming Department of Environmental Quality

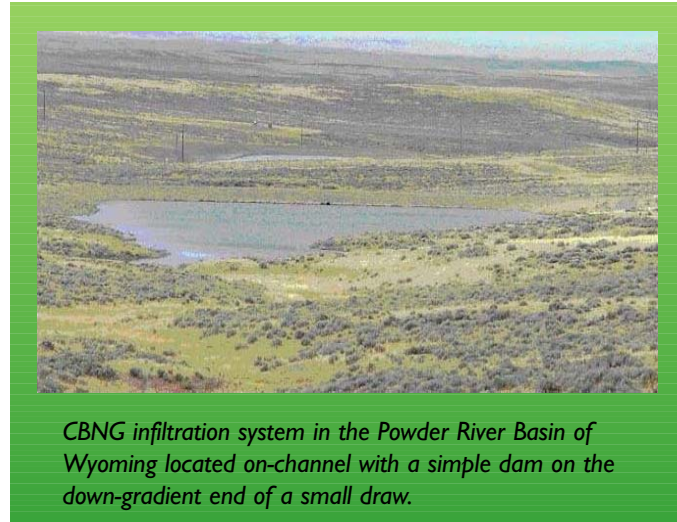
(WDEQ) and Bureau of Land Management (BLM). The lead researcher, ALL Consulting, also has developed collaborative relationships with the BLM (Miles City, MT, and Buffalo, WY, field offices), U.S. Geological Survey, DOE researchers studying airborne electromagnetic survey technology, and others. ALL Consulting is working in synergistic ways to share data collected through research efforts, with emphasis on water management practices.

The focus of the research is to develop an understanding of storage and infiltration ponds used in the management of CBNG produced water and their environmental implications. The research is structured to document and analyze current and future uses of impoundment and infiltration ponds. Characterizing the hydrogeological conditions for ponds in the basin and analyzing potential and actual impacts have been priorities. Collecting applicable water statistical information and defining approaches for balancing the combination of management alternatives have provided a basis for the research. Geochemical modeling and analysis is ongoing to assess and forecast the environmental impacts common to these types of ponds. Results of this work will be collated in an effort to develop risk-based analysis procedures for pond placement, construction, and reduction of potential impacts to soil and water resources.

The Powder River Basin was once thought to be an area where CBNG development lacked feasibility due to the volume of water that must be produced in order to recover methane from the coal. Although industry has developed strategies for developing the resource, management of the water continues to be the main constraint to development. In 2004, the Wyoming Oil and Gas Conservation Commission reported over 530 million barrels of water and 325 billion cubic feet (BCF) of gas produced in the Wyoming portion of the basin. Production values in 2004 were substantially

less in the Montana portion of the basin, including 15.7 million barrels of water and 12.2 BCF of gas. Based on current research, ALL Consulting has estimated that approximately 50 percent of the water produced from coal seams is managed through surface ponds and reservoirs.

Figure 1 shows the distribution of “off-channel” ponds that receive CBNG produced water in the Powder River Basin. The Wyoming State Engineer’s

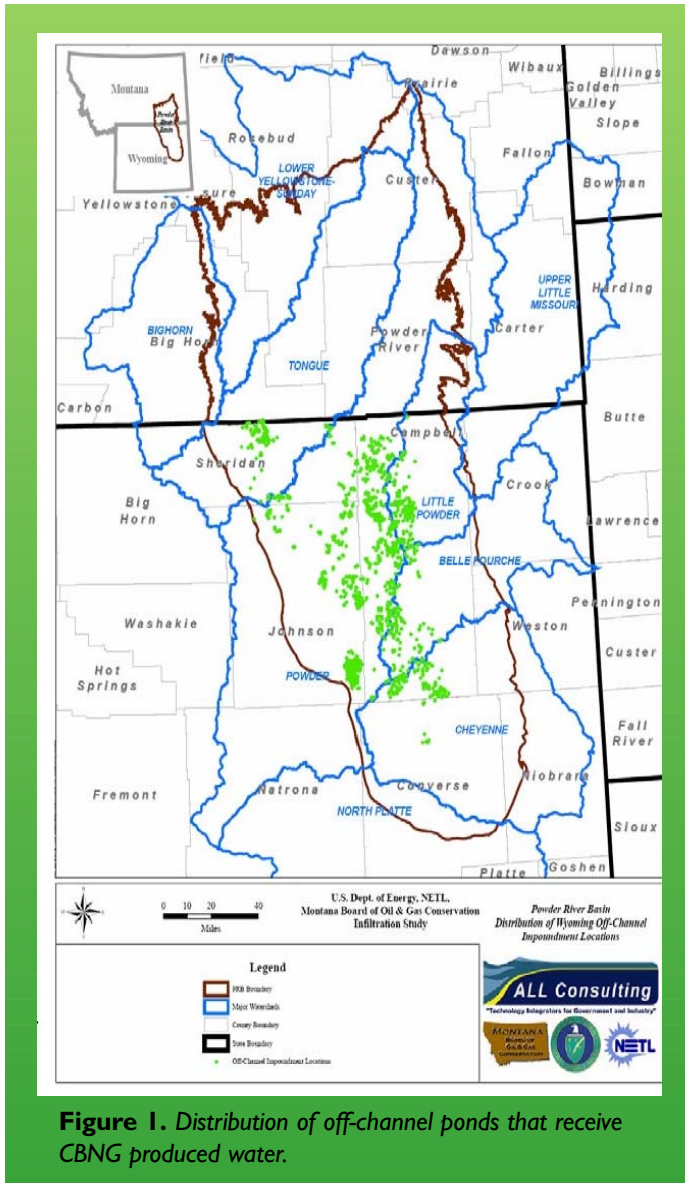


Cheyenne, and Little Powder River watersheds each account for approximately 11 percent of the total number of impoundments. The Tongue River watershed includes the lowest number of impoundments, approximately 9 percent, while the Powder River watershed accounts for an estimated 58 percent of all the permitted impoundments. As development continues to expand to levels that could exceed 75,000 wells, it is expected that ponds and reservoirs will remain a primary water management alternative.

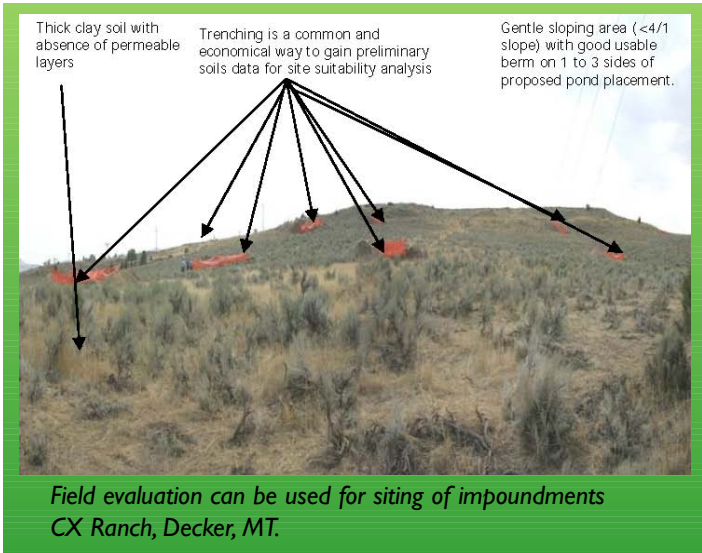
RESEARCH OVERVIEW

In arid to semi-arid regions of the western U.S. such as the Powder River Basin, water produced in association with the production of natural gas from underground coal seams can be a valuable resource. The beneficial use of produced water is a priority to the CBNG industry and includes, but is not limited to, watering livestock, managed irrigation, recreation, industrial uses, and promoting habitat for wildlife. Throughout the development of CBNG in the Powder River Basin, ponds and reservoirs have become a critical aspect of managing produced water. In fact, few (if any) projects are successfully developed without the use of ponds. Without the availability of surface ponds and reservoirs, the feasibility of many other water management options also would be eliminated.

Since the inception of CBNG development, the use of ponds and reservoirs has raised environmental concerns from the Wyoming Department of



office estimates that there are approximately 2,000 permitted impoundments receiving coal seam water. Current estimates suggest that the Belle Fourche,



Environmental Quality and Montana Department of Environmental Quality. Specifically, these agencies have questioned the potential degradation of usable quality groundwater and the potential for non-point source discharges to surface water bodies. These and other concerns, such as dam safety and water rights, were used to focus the research effort. Some of the more significant accomplishments and research aspects of the project include:

- **Water Statistics.** To provide a foundation for analysis, the research team gathered water statistical information for the entire basin. Data on water usage, water quality, treatment, and other relevant factors were compiled. This included analyzing the disposition of CBNG produced water throughout each of the watersheds in the basin.

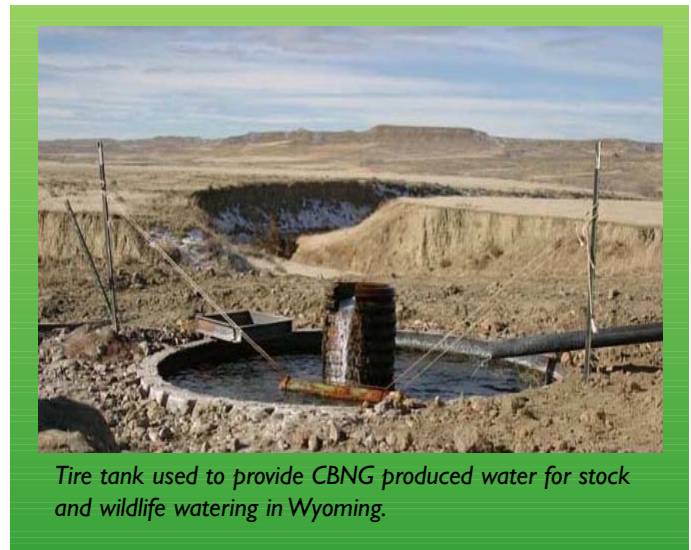
- **Siting and Design.** Siting and design of ponds and reservoirs for CBNG produced water management have evolved substantially since the initial stages of development, and they continue to evolve. The use of on-channel reservoirs is much more limited today than was previously the case. Both the states of Montana and Wyoming as well as the Bureau of Land Management have adopted monitoring requirements applicable to the use of surface ponds and reservoirs. Defining efficient and environmentally sound methods for siting, designing, and constructing impoundment and infiltration systems in a manner to promote beneficial uses continues to be a research priority.

- **Operations.** The research team has worked collaboratively in an effort to identify efficient and environmentally sound practices that can be employed during the operation and closure of impoundment and infiltration systems.

- **Fate and Effects.** A primary focus of the research is to evaluate the fate and effects of produced water managed in ponds and reservoirs. The research team is employing a variety of approaches in an attempt to better define environmental impacts, environmental risks, anticipated impacts, and fate and effects.

- **Modeling.** Computer modeling is being conducted in an effort to further assess how infiltrating produced water may impact soil, groundwater, and surface water.

- **Injection/Re-Injection.** At the request of the Montana Board of Oil & Gas Conservation, ALL Consulting prepared a technical paper specific to injection and re-injection of CBNG produced water. The feasibility of injection into non-coal seams or re-injection into underground coal seams is not fully defined. For example, shallow zones capable of receiving produced water are limited, deeper zones have poorer quality water—making the high-quality produced water unusable—and the use of injection/re-injection as a primary water management option could significantly increase the total number of wells in the basin.



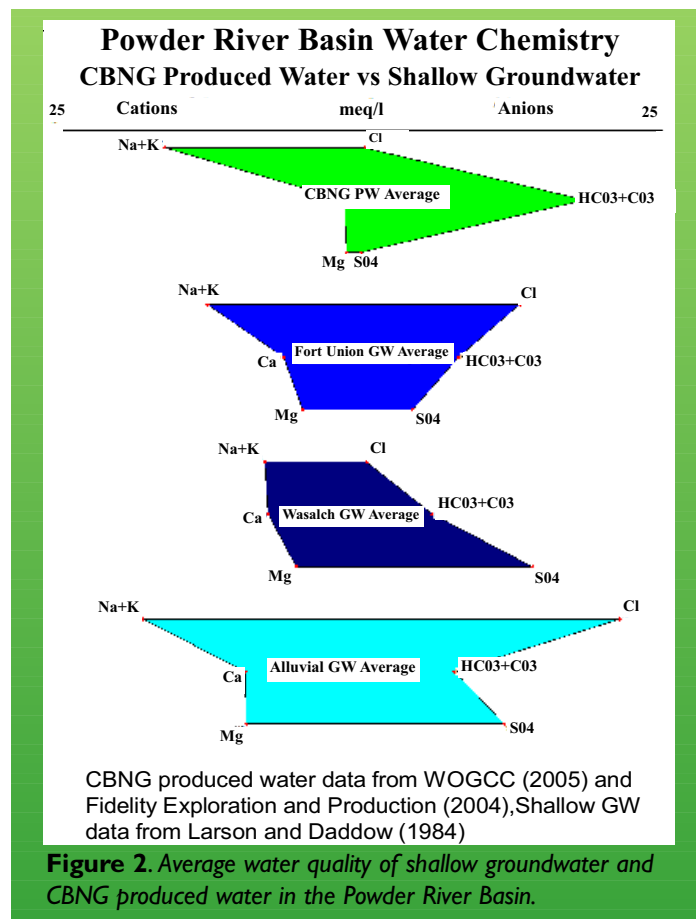
LEVERAGING RESEARCH EFFORTS

Leveraging multiple ongoing and recent research efforts has been important in the success of the current study of CBNG ponds and reservoirs. For example, in 2003, the Ground Water Protection Research Foundation and ALL Consulting completed a DOE- and BLM-funded feasibility study of beneficial use alternatives specific to CBNG development. This feasibility study was the first to document the critical nature of surface ponds and reservoirs to produced water management (ALL Consulting, 2003) and their interconnection with other water management alternatives.

ANTICIPATED ENVIRONMENTAL IMPACTS

The geochemical differences between CBNG produced water and shallow groundwaters in the Powder River Basin were evident when the major ions were plotted on Stiff diagrams (Figure 2). Because groundwaters are typically in equilibrium with the soil or rock matrix in which they reside, it was apparent to the researchers that CBNG produced water in contact with the soil and rock materials of the shallow subsurface may lack equilibrium. Potential disequilibrium could result in dissolution of minerals from the soils and bedrock and/or precipitation of minerals from the infiltrating groundwater. Furthermore, the migration of the infiltrating water could be hydrostatically controlled as long as the impoundment continues to receive water and soil pores remain open. Produced water could continue to infiltrate horizontally and vertically until a boundary is reached. These boundaries could include discharge to a surface stream, contact with an aquitard, or hydrostatic equilibrium with groundwater. Once infiltrating water reaches another water source, either groundwater or surface water, the equilibrium conditions would again change as a result of the mixing of these two waters. If the infiltrating water reaches an aquitard, ponding of the water would ensue, which could result in the eventual slowing of infiltration from the impoundment or the water being redirected towards another boundary.

Various methods have been used to assess applicable fate and effects of the produced water. Methods for



modeling the anticipated impacts range from graphical and numeric analysis to complex numerical computer models. Figure 2 illustrates the ionic differences that exist between CBNG produced water and various other groundwaters existing in the basin. This type of analysis provides insight into the anticipated chemistry of these waters if they were to come into contact with one another. Simple mixing models were used to expand this analysis and to look at the resultant chemistry of waters at various ratios without equilibrium reactions occurring. Monte Carlo modeling was incorporated into the mixing model to evaluate how natural variations of the ions would affect the resultant mixed groundwater concentrations of individual ions (Figure 3).

The project is continuing to develop numerical models that incorporate equilibrium reactions and groundwater flow and transport into the evaluation of mixing produced water and groundwater. A theoretical groundwater flow and transport model has been used

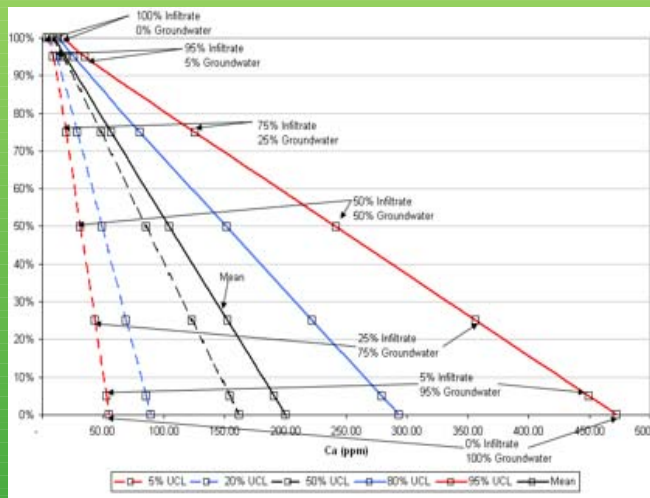


Figure 3. Monte Carlo simulation range of calcium at various mixing ratios.

to evaluate the extent of mounding expected to occur under an infiltration pond, the fate of infiltrating water as it migrates into the subsurface, and how groundwater quality changes over time once in the subsurface.

FIELD INVESTIGATION

The study was recently expanded to include additional field investigations to include the monitoring of groundwater around existing ponds and reservoirs in both the Montana and Wyoming portions of the basin. In a cooperative effort with the Wyoming Department



CBNG impoundment operated by J.M. Huber near the Wyoming/Montana boarder.

of Environmental Quality, the researchers are preparing to install monitoring wells and gather groundwater data to assess and characterize the extent of changes in groundwater quality of shallow aquifers. Groundwater monitoring wells are to be installed around CBNG pro-

duced water ponds and reservoirs to determine the extent to which infiltrating produced water is removing minerals from the soils beneath the impoundments and carrying these minerals to the shallow groundwater. Previous monitoring efforts conducted by the BLM, USGS, and Montana Bureau of Mines and Geology have shown that as produced water infiltrates through the subsurface soils, the characteristics of the infiltrated water changes. In some cases, tenfold increases in water quality parameters such as total dissolved solids have been observed.

ABOUT THE RESEARCHERS

Lead researchers for the project are the Montana Board of Oil & Gas Conservation and ALL Consulting. ALL Consulting is a small business with staff who have been involved in DOE's oil and gas environmental research program since 1990 as the lead technical contractor for the Ground Water Protection Council's



Representatives of USGS, DOE's NETL, and ALL Consulting at the Skewed reservoir site in Wyoming.

Risk-Based Data Management System. ALL Consulting has and continues to maintain a high level of research on issues involving CBNG, produced water management, national environmental policy act streamlining, water treatment technologies, and other oil and gas environmental issues.

ALL Consulting also has supported DOE's National Energy Technology Laboratory as a technical support contractor. Headquartered in Tulsa, OK, ALL Consulting also maintains staff in Billings, MT; Houston and Austin, TX; and Edwardsville, Illinois. For more information, visit www.all-llc.com. ■

DOE Oil & Gas Environmental Research Benefits States

DOE funding of research projects to private companies, universities, State agencies, and Federal agencies reflects economic benefits in a number of states. In some cases the money is funneled through cooperative agreements with other Federal agencies (Bureau of Land Management, Minerals Management Service, and Environmental Protection Agency) to state and regional offices and universities or consultant groups.

The current focus of DOE's Oil and Gas Environmental Program is three-fold: access to Federal Lands, Produced Water, and Regulatory Streamlining. The majority of the funds goes for research into solutions for environmental problems ranging from developing sophisticated equipment to monitor gas leaks in pipelines and other facilities to resolving issues concerning coalbed natural gas (CBNG) production and disposal of produced water. A small portion of the funds was used in technology transfer efforts, including supporting public meetings and conferences on environmental issues.

One hundred and two environmental projects were active in fiscal years 2004-2005. Funding for these projects reflects long-term efforts and begins as early as 1998 and extends to 2007. Most research projects are spread over three years to allow time for data collection, analysis, and results. Long-term funding to several National Laboratories and cooperative agreements with other Federal agencies reflect research on a variety of environmental topics, including analysis to provide recommendations to EPA or BLM on regulatory issues such as use of synthetic muds offshore, underground injection, length of drilling seasons, and protection of wildlife.

DOE funds for these 102 projects total \$92.3 million. The cost-share amount from the companies and organizations was \$38.8 million, for a total of \$131.1 million. Many projects have their offices in one state and conduct environmental research in one or more states. For example, the Interstate Oil and Gas Compact Commission is headquartered in Oklahoma but has interests and research benefiting 37 states.

Access to Federal Lands focuses primarily on the 507 million acres of Federal Land in the Western Interior U.S. and in Alaska. Sixty-eight percent of all oil and gas reserves in the U.S. is held on Federal Lands. Access to these lands and protection of the environment go hand in hand with DOE's Produced Water program.

Produced Water management concentrates on improving treatment and disposal options for water produced by oil and gas operations. With the expansion of CBNG development in the past decade in the Rocky Mountain states, the Gulf Coast, and the Illinois and Appalachian basins, DOE has placed emphasis on developing beneficial uses for produced water.



BLM estimates 60,000 new CBNG wells in next 10-20 years.

Regulatory Streamlining provides improved data management, assists states to modernize electronic permitting, and allows agencies and operators to more quickly and cost-effectively implement oil and gas operations on private, state, and Federal Lands. Recommendations made through funded research projects also provide regulatory agencies such as the EPA and BLM with sound scientific data for decisions.

Upcoming Events/Meetings

August 17, DOE

DOE Microhole Integration Meeting

Houston Research Center

Houston, TX

Contact: www.doe.gov

August 17, DOE

Workshop on Alaskan North Slope R&D Issues

Anchorage, AK

Contact: www.doe.gov

September 18-20, IOGCC

2005 Annual Meeting

Jackson Hole, WY

Contact: www.iogcc.state.ok.us

October 24-26, IPAA

2005 Annual Meeting

Houston, TX

Contact: www.ipaa.org

**November 8-11, International Petroleum
Environmental Conference (IPEC)**

Houston, TX

Contact: <http://ipec.utulsa.edu>

EoE features highlights of DOE's Oil and Gas Environmental Research Program

Visit our website for more information

<http://www.netl.doe.gov>

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