ENVIRONMENTAL ISSUES AND CHALLENGES IN COAL BED METHANE PRODUCTION

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ABSTRACT

Coal bed methane (CBM) is a significant source of methane in the United States. In 1999, the proven reserve of CBM in the conterminous United States was about 13.2 Tcf (–7.5% of total U.S. proven reserves), and the annual U.S. production of CBM was about 1.25 Tcf (–6.3% of U.S. non-associated gas production). Current CBM development is focused on the Powder River Basin in Wyoming and Montana. Today, there are –3,000 CBM wells in the Wyoming portion of the Powder River Basin, but planners forecast as many as 81,000 additional CBM wells there, and an additional 9,500 wells in the Montana portion of the basin. Environmental issues surrounding the development of CBM resources in the Powder River Basin and elsewhere have provoked conflict among mineral leaseholders, owners of the surface estates, and the public at large. Citizen suits under the Clean Water Act and the Safe Drinking Water Act, and private tort actions, complicate the development of CBM resources. Despite geographic and geologic differences among areas in which CBM resources have been developed, the core environmental issues are consistent: (1) Groundwater table draw down due to pumping large quantities of groundwater; (2) disposal of large volumes of produced water; (3) methane contamination of shallow groundwater; (4) noise pollution from compressors and other sources; (5) air pollution from compressor exhaust gases, methane leakage, and dust; and (6) surface disturbance from construction of roads, pipelines, and other facilities. In CBM production, water is produced in large volumes and must be disposed of. Because waters produced from coal beds are often fresh, and subsurface disposal is expensive, disposal to surface drainages, wherever possible, carries a strong economic incentive. Such disposal may erode soils and sediments, change microclimate, create unsustainable aquatic habitats, or salinize soils. Additionally, the organic and inorganic chemistry of coal waters has not been studied comprehensively; dissolved contaminants in coal waters, such as phenols or arsenic, may damage the environment. In areas where coals are shallow, withdrawing the large volumes of water necessary to effect methane production from coals may result in extensive groundwater drawdown. Such drawdown could remove water from springs and streams and make the production of groundwater from wells more difficult and expensive. The upward migration of methane released during CBM production but not captured by CBM wells can, and in some instances has, polluted shallow groundwater. A more dramatic phenomenon is the spontaneous combustion of coal in dewatered coal seams. The operation of compressors and other oifiled equipment produces noise pollution that rural residents have not experienced previously. Compressor operations also produce polluting exhaust gases, and leaks from production, gathering, and transmission systems release methane to the atmosphere. The construction of roads, pipelines, and other facilities disturbs the surface, and in the case of roads, creates easy access to areas that were formerly difficult to reach. Road traffic

and construction activities result in particulate contamination of the environment. Surface disturbance degrades wildlife habitat, and easy access increases human contact pressure on wildlife and its habitats.

INTRODUCTION

The term "coal bed methane" (CBM) refers to the gas that is generated during coalification and sorted within the coal on internal surfaces. CBM is generally referred to as an unconventional source of fossil fuel. Today, CBM is a significant source of methane in the United States and worldwide. In 1999, the proven reserve of CBM in the conterminous United States was about 13.2 Tcf (–7.5% of total U.S. proven reserves), and the annual U.S. production of CBM was about 1.25 Tcf (–6.3% of U.S. associated and non-associated gas production).' Worldwide estimates of in-place resources are as much as 7,500 Tcf, but the scarcity of basic data on coal resources and gas content make this number u n

Attempts to commercially exploit CBM began in the United States in the 1970s, as an outgrowth of the U.S. Bureau of Mines' efforts to improve mine safety by extracting methane in advance of mining ~perations. As recently as 1982, CBM production in the United States was virtually non-existent. In 1983, the Gas Research Institute initiated field-based research that helped stimulate the development of CBM resources. At the end of 1983, CBM production was about 6 Bcf from about 165 wells, but by 1994, it had grown to 851 Bcf fiom more than 6,000 wells, and by 1999, to 1.252 T c ~ Currently, there are thousands of CBM wells in the United States, and active exploration, development, and/or production is being carried out in France, Belgium, Poland, Ukraine, Australia, Russia, Peoples Republic of China, India, South Africa, Poland, Ukraine, Indonesia, and Kazakhstan.'

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1 Energy Information Administration, U.S. Crude Oil, Natural Gas, and Natural Gas Liquids 1999 Annual Report, Table 12. U.S. Coalbed Methane Proved Reserves and Production, 1989-1999; Table 19. Natural Gas Proved Reserves, Reserve Changes and Production, Wet After Lease Separation, 1999.

2 Rice, D.D. 1997. Coalbed methane – *An* untapped energy resource and an environmental concern. U.S. Geological Survey Fact Sheet FS-019-97, **http://energy.usgs.gov/factsheets/Coalbed/coalmeth.html.**

3 Schraufnagel, R.A., and P.S. Shaver. 1994. The Success of Coal Bed Methane, *in* A Guide to Coalbed Methane Reservoir Engineering, http://www.gri.org/pub/oldcontent/tech/e+p/cbm/gri94 0397/chl.htm.

4 **See:** Schraufimgel, R.A, and P.S. Shaver. 1994. The Success of Coal Bed Methane, *in* A Guide to Coalbed Methane Reservoir Engineering, hthx//www.~.ordpub/oldcontent/tech/e+p/cbm/~ti 9 0397/chl.hm; Coalbed methane *gas* drainage, Surton Technologies, httd/www.imdex.com.au/surtron/dDrillinght m; Energy Information Administration, U.S. Crude Oil, Natural *Gas,* and Natural Gas Liquids 1999 **Annual** Report, Table 12. U.S. Coalbed Methane Proved Reserves and Production, 1989-1999.

5 Coalbed methane **gas** drainage, Surton Technologies, http://www.imdex.com.au/surtron/dDrilling.htm; EuroGas completes drilling of first coal-bed methane well ever in Ukraine, Alexander's Oil and Gas Connections, Volume *5*, issue #4 - March 09, 2000, http://www.gasandoil.com/goc/company/cnr01052.htm; Coal-bed methane: A bed of roses? Tata Energy Research Institute, August 2000, **http://www.teriin.org/enernv/cbm.hti;** China awards coal-bed methane contract to US

CBM is a more environmentally acceptable energy source than coal. Production of CBM does not produce the environmental damage of coal mining, and combustion of CBM does not produce waste ash or sulfur. Further, CBM resources are widespread, often basinwide, and because coal can store 6 to 7 times more gas than the equivalent rock volume of a conventional gas reservoir, CBM is characterized by large in-place resources.[6] An additional attraction of CBM development is the low cost of drilling and completing CBM wells. Often, substantial CBM resources can be reached at very shallow depths, and because of the often spatially broad occurrence of suitable coals, exploration costs for CBM development are minimal.

Development of CBM resources does carry substantial environmental risk. As with the production of natural gas from conventional reservoirs, CBM development results in surface disturbance from the construction of roads, well pads, pipelines, and other facilities. Traffic on lease access roads and human activities at well sites and facilities can disturb wildlife. Likewise, CBM production may result in air pollution from compressor exhaust gases, methane leakage, and dust, and the operation of pumps, compressors, and other machinery generates noise pollution. The chief environmental concerns from CBM production, however, arise from the requirement to dispose of large volumes of produced water, from the potential for the uncontrolled release of gas from the coal reservoir to shallow groundwater, from the potential for drawdown of shallow groundwater, and from the potential for certain well completion technologies to affect shallow groundwater.

The rapid development of CBM resources in the United States, the short experience with this type of gas production, and the potential and actual environmental impacts attendant to such development have produced an adversarial climate between CBM developers, surface owners, surface resource users, and environmental groups.

COAL BED METHANE PRODUCTION

The production of CBM differs from conventional gas production. In conventional gas production, the pressure of the gas in the reservoir drives the gas to the wellbore and, ultimately, to the surface. Conventional gas production does not typically produce a large volume of water. In contrast, water permeates coal beds, and the pressure exerted by this water holds methane within the coal. Consequently, to produce CBM, the water

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Company, Peoples Daily, January 10,2001. http://english.peopledaily.com.cn/200101/10/eng20010110_60094.html; 7 coal bed methane blocks for exploration, Frontline (India's National Magazine), April 21,2001, http://www.blonnet.com/businessline/2001/04/21/stories/1421506d.htm; A Positive Contribution from Coal, World Coal Institute, presented by WCI at the World Bank Energy Week 99, Washington, USA - 6-8 April 1999, http://www.wci-coal.com/speeches/textonly/world_bank_6_4_99.htm; Coal Report Indonesia 2000, Embassy of the United States, Jakarta, October 2000, http://www.usembassyjakarta.org/download/coal2000.pdf; Unconventional Extraction in European Energy – a Focus on Coal, OCDE/AIE, 1999, http:www.energy-coal-eur.com/Technology/unconventional.htm; SA firm set to sink $5b in methane gas mine, The Financial Gazette, March 22,2001, http://www.fingaz.co.zw/fingaz/2001/March/March22/1093.shtml

[6] Rice, D.D., 1997. Coalbed methane – An untapped *energy* resource and an environmental concern. U.S. Geological Survey Fact Sheet FS-019-97. http://energy.usgs.gov/factsheets/Coalbed/coalmeth.html

pressure must be reduced by pumping water from the coal. Once the water pressure is lowered, methane can flow from the coal. The production of CBM typically produces a substantial volume of water.

COAL BED METHANE PRODUCTION AND DEVELOPMENT IN THE UNITED STATES

The initial focus of CBM development in the United States was the Black Warrior basin in Alabama. This focus shifted in the late 1980s and early 1990s to the San Juan Basin in New Mexico and Colorado. In 1995, approximately 94% of CBM production in the United States was from the San Juan Basin and the Black Warrior Basin.[7] Today, although New Mexico, Colorado, and Alabama still account for 90% of CBM production, the focus of CBM development is the Powder River Basin in Wyoming and Montana. At present, there are approximately 3,000 CBM wells in the Wyoming portion of the Powder River Basin, but planners forecast a staggering number of new wells; under what is described as a moderate scenario, a total of 81,000 CBM wells are projected for Wyoming, with 50,000 of these to be drilled by 2010.[8] Based on recent proposals by operators, about 9,500 CBM wells will be drilled in the Montana portion of the Powder River Basin by 2010.[9] These projected 90,500 new CBM wells in the Powder River Basin would constitute a 29% increase from the 307,449 producing gas and gas condensate wells operated in the United States in 1999.[10] CBM is also produced in Oklahoma, Virginia, West Virginia, and Pennsylvania.

ENVIRONMENTAL ISSUES

Overview

Environmental groups believe that the extraction, production, and distribution of CBM can have severe impacts on rural agricultural communities. At the heart of these groups' concerns is the superiority of the mineral estate. The owner or lessor of mineral rights must be able to enjoy the economic value of those minerals. Consequently, the owner or lessor of mineral rights can enter private land, drill wells, and build roads, pipelines, and compressor stations, even in the face of a landowner's objections. As with any development, CBM development can affect land, water, wildlife, and communities in

[7] Stevens, S.H., Kuuskraa, J.A., Schraufnagel, R.A., 1996, Technology spurs growth of U.S. coalbed methane: *Oil* & Gas Journal, January 1, 1996, pp. 56–63.

[8] Reasonably foreseeable development scenario for oil and gas development in the Buffalo Field office Area, Campbell, Johnson, and Sheridan Counties, Wyoming. Wyoming State Office – Reservoir Management Group, February 2001.

[9] Reasonably foreseeable development scenario for oil and gas development in the Buffalo Field office Area, Campbell, Johnson, and Sheridan Counties, Wyoming. Wyoming State Office – Reservoir Management Group, February 2001.

[10] Energy Information Administration, U.S. Crude Oil, Natural Gas, and Natural Gas Liquids 1999 Annual Report, Table 5. Number of Producing Gas and Gas Condensate Wells by State as of December 31, 1995–1999.

many ways. Illustrative of some of the types of impacts felt by a community is this excerpt from the Sheridan County, Wyoming County Bulletin dated August 22,2001.[11]

> "Coal Bed Methane is beginning to have its effect on Sheridan County. The development of Coal Bed Methane is beginning to impact Sheridan County both in positive and negative ways. Sheridan County is beginning to see increased revenues generated by the development of methane. Currently Sheridan County has increased its sales tax revenue roughly 20% over last year. Total property valuations have increased throughout the County although property valuations have not yet reached levels seen by other counties experiencing Coal Bed Methane. Negatively, Coal Bed Methane development seriously impacts roads in Sheridan County. Conservatively, traffic on some of our county roads has increased 5 to 6 times their normal usage. Recognizing the impact that Coal Bed Methane developers have in Sheridan County, Sheridan County Commissioners are requiring Coal Bed Methane developers to sign Road Use Agreements that address these developers' impacts on various county roads. Most of these agreements at a minimum ask for the roads to be returned to their original condition prior to Coal Bed Methane development. Sheridan County Commissioners are also asking for whatever dust measures can be provided, this includes the distribution of Coal Bed Methane water on these roads. Due to all the recent Coal Bed Methane development, there is an increase of population in Sheridan County, and our jail is experiencing an increasing level of inmates. Sheridan County Commissioners are recognizing these impacts and are striving to mitigate the effects of Coal Bed Methane development in Sheridan County."

Produced Water Disposal

Compared to conventional natural gas production, CBM production is accompanied by an enormous amount of water. In 1990, for example, CBM water production in the United States was 61 MMbbl (15% of the conterminous onshore water production associated with gas in 1990!).[12] Because more water is produced early in the life of a CBM well, the greatest water production in CBM exploitation comes early in the life of that development. The amount of water produced by a CBM well and the ratio of gas to water in the produced fluid depends on many factors, including the duration of CBM production, original depositional environment, depth of burial, and type of coal. Water production statistics for some major CBM-producing basins are given in Table 1. Note that the water:gas ratio in all instances for CBM would be classified as high (bbl/Mcf 0.03 – 0.1) to very high (bbl/Mcf >0.1) by the Gas Research Institute.[13]

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[11] http://www.sheridancounty.com/commiss/bulletin.html

[12] Gas Research Institute, 1995. Atlas of gas-related produced water for 1990: Gas Research Institute Topical Report GRI-95/0016.

[13] Gas Research Institute, 1995. Atlas of gas-related produced water for 1990: Gas Research Institute Topical Report GRI-95/0016.

Table 1. Water production in some major CBM-producing basins[14]

Basin	State	Number of CBM Wells	Av. Water Production (bbl/day/well)	Water:gas ratio Bbl:Mcf	Primary Disposal Method
Black Warrior	AL	2,917	58	0.55	Surface discharge
Powder River	WY, MT	2,737	400	2.75	Surface discharge
Raton	CO	459	266	1.34	Injection
San Juan	CO, NM	3,089	25	0.031	Injection
Uinta	UT	393	215	0.42	Injection

The volume of water co-produced with CBM creates an enormous disposal problem. Depending on local regulations and the salinity of the water, CBM waters are disposed of by injection into geologic formations, though evaporation and/or percolation in disposal pits, and by road spreading and surface discharge.

From experience with disposal of produced water from conventional oil and gas production operations, disposal of produced water by injection into geologic formations is, from an environmental viewpoint, the most favorable option. In the Powder River Basin, several companies have been experimenting with reinjecting the produced water into sandstones and coal beds in the Wasatch and Fort Union Formations.'' In an effort to put CBM-produced water to a beneficial use, Pennaco Energy is currently reinjecting CBM water into an aquifer used by the city of Gillette.'6 The wisdom of this method of handling CBM water is, however, suspect. Links between coal, lignite, or coaly material in aquifers used as drinking water supplies and adverse human health effects are well known. Water produced from aquifers that contain coal lignite or coaly material have been linked, or are suspected to be linked, to goiter[17,18,19], patterns of multiple sclerosis

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[14] Rice, C.A and Nuccio, V. 2000. Water produced with Coal-Bed Methane. USGS Fact Sheet FS-156-00, http://geology.cr.usgs.gov/pub/fact-sheets/fs-0156-00/fs-0156-00.pdf; Data for Black Warrior Basin from Alabama State Oil and Gas Board as of 5/00; data for Powder River Basin from Wyoming Oil and Gas Commission as of 5/00; data for Raton and San Juan Basins from Colorado and New Mexico Oil and Gas Commissions as of 2/00; data for Uinta Basin from Utah Division of Oil and Gas as of 6/00.

[15] Flores, RM. et al. 2001. A field conference on impacts of coalbed methane development in the Powder River Basin, Wyoming. USGS Open File Report 01-126.

[16] Tollefson, J., 2000, Petition seeks to stall permits: Water, property rights cause for concern: Casper Star Tribune.

[17] Edmunds W.M., and Smedley P.L. 1996. Groundwater geochemistry and health: An overview. In Appleton, J.D. and others, editors. Environmental Geochemistry and Health. Geological Society of London Special Publication No. 113, pp 91–105.

[18] Gaitan E., et al. 1993. Antithyroid and goitrogenic effects of coal-water extracts from iodine-sufficient goiter areas. Thyroid 3(1):49–53.

[19] Lindsay RH., et al. 1992. Antithyroid effects of coal-derived pollutants. Journal of Toxicology and Environmental Health 37:467–481.

occurrence[20,21], Balkan Endemic Nephropathy (an incurable renal disease)[22, 23], urotheial cancer[24], and high cancer mortality rates[25].

In the San Juan Basin, CBM-produced water, because of its relatively elevated salinity, is typically disposed of by downhole injection.[26] Unfortunately, downhole injection is also the most expensive way to dispose of produced water. In the San Juan Basin of New Mexico and Colorado, disposal by deep-well injection costs around $1.75 per barrel.'' In addition to its high cost, downhole disposal also requires accessible formations that will readily accept the injected water. **Further,** because CBM exploitation produces more water early in development than later, downhole injection also requires a substantial early investment in disposal wells.

Evaporation and/or percolation pits are generally viewed as an inexpensive means of disposal, but very large pits can be required, and the percolation of produced water into the shallow subsurface can contaminate shallow groundwater. A promising commercial technology for produced water disposal is **freeze-thaw/evaporation.** This technology reduces the volume of water to be disposed through injection by evaporation during summer months and by factional freezing during the winter. It has been implemented successfully as a pilot in the San Juan Basin[28] and is in the early stages of commercial development in the San Juan Basin and elsewhere.''

Road spreading can only dispose of a limited volume of produced water, because water can be spread only to the extent there is no pooling or direct runoff. If the water is saline,

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[20] Dunn C.E., Irvine D.G. **1993.** Relevance of a lithogeochemical database to epidemiological studies in central Saskatchewan, Canada. Applied Geochemistry Suppl. Issue No. **2,** pp **215–222.**

[21] Irvine D.G., et al. **1993.** Geotoxicology of multiple sclerosis: Correlation of groundwater chemistry with childhood homes and prevalence of MS patients, Saskatchewan, Canada. **Applied** Geochemistry **Suppl. Issue** 2:235–240.

[22] Tatu C.A., et al. **1998.** The etiology **of** balkan endemic nephropathy: Still more auestions and answers, Environmental Health Perspectives 106:689–700.

[23] Theisen J. **1995.** Balkan **turmoil** delays BEN research: Disease links to low-rank coals remain speculative. **TSOP** Newsletter 12(3):5–7.

[24] Tatu C.A., et al. **1998.** The etiology of balkan endemic nephropathy: **Still** more Questions and answers. Environmental Health Perspectives 106:689–700.

[25] Keller E.A **1985.** The **geologic aspects** of environmental health. Environmental Geology, 4th Edition. Columbus, **OH.** C.E. Merrill Publishing Company, pp **279–306.**

[26] Cold Weather Helps Researchers Transform Salt Water into Fresh Water. DOE Techline, April **17, 1997,** http://www.fe.doe.gov/techline/tl_fte.html.

[27] Bustamante E., and A. Carrol. 2001. New technique developed by Tech researchers for economical desalinization of produced water. Horizon **2001,** New Mexico Tech Research and Economic Development Office.

[28] Cold Weather Helps Researchers Transform Salt Water into Fresh Water. DOE Techline, April **17, 1997,** http://www.fe.doe.gov/techline/tl_fte.html.

[29] Boysen, J.E., Boysen, D.B., and Harju, J.A., 2000. "Produced Water Management in Wyoming Using the FTE® Process," Proceedings of the 7th International Petroleum Environmental Conference, November **7-10,** Albuquerque, NM; Boysen, J.E., Canfield, M.T., Grisanti, A.A., **1997.** "Treating Produced Waters in the San Juan Basi With the Freeze-Thaw / Evaporation Process," Fall Issue, GasTIPS, Gas Research Institute, V. **3,** No. **3,** Chicago; Boysen, J.E., Walker, K.L., Mefford, J.L., Kirsch, **J.R.,** and Harju, J.A., **1996.** "Evaluation of the Freeze Thaw / Evaporation Process for the Treatment of Produced Waters," Topical Report, Gas Research Institute, Chicago, August, **GRI-97/0081.**

leachate fiom road spreading *can* damage vegetation, and infiltratoin of salts fi-om the produced water can contaminate shallow groundwater.

Surface discharge is certainly the least expensive means of produced water disposal. It is also the most controversial. In arid regions, the surface discharge of even highquality water may be environmentally damaging. Such discharge can grossly alter the natural hydrographic behavior of and-region surface streams, threaten fish and other aquatic life, and could actually alter local climate by increasing humidity. In addition, surface discharge of produced water may result in erosion or drowning of drainage draws and associated vegetation.[30] Surface discharge of saline produced waters or produced waters containing organics or inorganic toxins, such as ammonia or hydrogen sulfide, may be substantially environmentally damaging if there is insufficient natural flow to dilute the discharged water. Further, if discharged produced waters have a high ratio of sodium to calcium and magnesium (termed the sodium absorption ratio, SAR), even waters of low salinity can be deleterious to soils and vegetation. This is because waters with an elevated ratio of sodium to calcium and magnesium will alter the chemical composition of clays and may reduce soil permeability. In a study of 47 water samples from the Powder River Basin in Wyoming, –40% of the samples tested exceeded a SAR of 10. Water having a SAR of 10 or more should not be used for prolonged irrigation, even if the dissolved solids content is low.[31]

Despite these concerns about surface discharge of waters co-produced with CBM, surface discharge remains the preferred method of disposal. In Montana, more than 100 wells are currently discharging directly into the Tongue River upstream fiom the Tongue River dam. In Wyoming, co-produced water fiom CBM development is being discharged either directly into surface waters or to drainages.[32] The Wyoming Pollutant Discharge Elimination System (WPDES) permits surface discharge, because the water is generally low in total dissolved solids, and otherwise of good quality. Total dissolved solids, pH, chloride, and sulfate concentrations in the produced water are near or lower than the levels recommended for drinking water standards.[33]

Groundwater Withdrawal

A substantial environmental concern in the production of CBM is that water production from the coal will result in the drawdown of shallow groundwater.[34] Groundwater withdrawal from aquifers is a particularly sensitive issue to landowners who "beneficially use" groundwater for their livestock and for irrigation. Estimated groundwater drawdown can be locally severe. The Bureau of Land Management modeled a

[30] Flores, R.M. et al. 2001. A field conference on impacts of coalbed methane development in the Powder River Basin, Wyoming. USGS Open File Report 01-126.

[31] Follett, R.H. and Soltanpour, P.N. 2001. Irrigation Water Quality Criteria. Colorado State Univ. Extension Fact Sheet No. 0.506 ,http://www.ext.colostate.edu/pubs/crops/00506.html.

[32] Flores, R.M. et al. 2001. A field Conference on impacts of coalbed methane development in the Powder River Basin, Wyoming. USGS Open File Report 01-126.

[33] Rice, C.A Ellis, M.S., and Bullock, J.H., Jr. 2000. Water co-produced with coalbed methane in the Powder River Basin, Wyoming: Preliminary compositional data. USGS Open File-Report 00-372.

[34] Bureau of Land Management and State of Montana. 2001. Draft planning criteria for the oil and gas environmental impact statement and amendment of the Billings and Powder River resource management plans, Miles City, Montana.

groundwater draw down attributed to CBM development for the Wyodak-Anderson coal zone in central Campbell County, Wyoming for the period 1975 to 2015 of as much as 550 feet.[35] In the San Juan basin, there is observational evidence of groundwater draw down due to CBM production in domestic and monitoring wells drilled into basin-rim coals.[36]

Two potential ancillary impacts of groundwater withdrawal resulting from CBM production are subsidence and coal-seam fires.[37] Subsidence effects appear to be negligible. For the Powder River basin, preliminary estimates of subsidence due to aquifer draw down are insignificant (–0.5 inches).[38] Although coal-seam fires have been alleged to result from CBM production, their link to CBM production is circumstantial. Along the northern outcrop edge of the Fruitland Coal in the San Juan Basin, there are five coal-seam fires of recent origin located within the Southern Ute Indian Reservation.[39] The venting of steam and the presence of moribund trees and recent surface collapse features mark the surface expression of these fires. Spontaneous combustion of coals is related to their heatsf-hydration. Coal most susceptible to self-heating is characterized by high intrinsic moisture and oxygen content, as found in low-rank coal such as sub-bituminous coal and lignite.[40] The heat of wetting can be greater than the heat of oxidation.[41] If the coal bed is an aquifer (as in the case of the Fruitland Coal in the San Juan basin), and the water table normally fluctuates with seasonal precipitation recharge, the heat-of-wetting potential is increased dramatically by water removal. When water levels drop in these confined aquifers, ambient air is drawn into the coal beds, and the conditions to support combustion or further oxidation of the coals are established. *Once* the lower self-heating temperature of the coal is breached, the self-heating tendency of the coal produces a **sustained** exothermic reaction that eventually results in smoldering and combustion.[42] Surface heating from coal bed fires, accompanied by the venting of steam and sulfurous gases, produces vegetation kill zones. Combustion also results in a reduction in the mass and mechanical strength of the coal and may produce subsidence. Coal-seam fires are notoriously difficult to extinguish, and the adverse environmental impact from such fires can grow and persist.

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[35] Bureau of Land Management. **1999.** Wyodak coal bed methane project draft environmental impact statement: U.S. Department of Interior, Bureau of Land Management, Buffalo Field Office.

[36] Bureau of Land Management, San Juan Field Office. **1999.** A brief history and environmental observations, a working document. http://oil-gas.state.co.us/blm_sjb.htm.

[37] Darin, T.F., and Beatie, A.W. **2001.** Debunking the **natural *gas*** "clean energy" myth: Coalbed methane in Wyoming's Powder River basin. Environmental Law Review, May, **2001,** 31 ELR **10566.**

[38] Case, J.C., Edgar, T.V., and De Bruin, R.H. 2001. Subsidence potential related to water withdrawal in the Powder River Basin. Wyoming State Geological Survey, http://www.wsgsweb.uwyo.edu/oilandgas/subsidence.html.

[39] Bureau of Land Management, San Juan Field Office. **1999.** A brief history and environmental observations, a working document. http://oil-gas.state.co.us/blm_sjb.htm.

[40] Sarnecki, J.C. **1991** Formation of clinker and its effects on locating and limiting coal resources, in: Geology in Coal Resource Utilization, Tech Books.

[41] Kuchta, J.M., Rowe, V.R., and Burgess, D.S.. **1980.** Spontaneous combustion susceptibility of U.S. coals. U.S. Bureau of Mines Report of Investigations, **RI-8474**.

[42] Smith, A.C. **1989.** Bureau develops spontaneous combustion formula. Coal **26(7)**:**73**.

Methane Venting

The movement of methane from coal reservoirs to the shallow subsurface, and through the surface, is of substantial environmental concern. Seeping methane can disturb and contaminate shallow groundwater, kill vegetation, and produce a fire and explosion hazard within structures. Seepage *can* take place through natural fractures, in uncemented annular spaces behind existing well casings, through water wells, and through improperly abandoned oil and gas or mineral exploration wells.

A recent infamous instance of CBM seepage was the subject of a civil action in the late **1980s** by residents of the Rawhide Village subdivison, located about **10** miles north of Gillette, Wyoming, against AMAX. In their open-pit mining operation immediately adjacent to the Rawhide Subdivison, AMAX removed overburden and then began dewatering the Ft. Union Coal. Shortly after dewatering began, Rawhide Subdivision residents noted gas seeping into their homes.'' Based on field and laboratory investigations, it was determined that the entire subdivision was underlain by potentially explosive concentrations of **methane**.[44,45] The Rawhide Village subdivision was subsequently abandoned.

In the San Juan basin, increases in the methane content of soil gas overlying Fruitland coal bed subcrops, alignment of recently killed vegetation with underlying coal subcrops, and an apparent intensification of naturally occurring methane/hydrogen sulfide seeps have all been noticed since the early **1990s.** Chemical and isotopic analysis of soil and groundwater methane suggests that methane found in these soils and groundwater originated in the Fruitland Coal, but the long history of natural seepage of natural gas in the San Juan Basin[46] makes problematic an assertion that gas seeping into the shallow subsurface in this area is the result of CBM development.

In the San Juan basin, as early as **1980–1985,** new seeps not associated with basin-rim outcrops, but interior to the Basin, were found in pastures in the Animas River Valley south of Durango near Bondad, Colorado and Cedar Hill, New **Mexico**.[47,48] Rural

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[43] Jones, RW., and Taucher, P.J. 1989. **Coal** geology, geophysical logs, and lithologic descriptions from a drilling program at the Rawhide Village subdivision, Campbell County, Wyoming. Geological Survey of Wyoming Open-File Report **89-2**, **59** pp.

[44] Glass, G.B., Jones, R.W., and De Bruin, R.H. 1987. Investigation of the potential for near-surface explosive concentrations of methane to occur in the Rawhide Village Subdivision, Campbell County, Wyoming. Geological Survey of Wyoming, report for the Wyoming Department of Environmental **quality** (unpublished).

[45] Jones, RW., De Bruin, RH., and Glass, G.B.. **1987.** Investigations of venting methane and hydrogen sulfide ***gas*** at Rawhide Village, Campbell County, Wyoming, ***in*** Rawhide 11 Project Report, Appendix I. Geology. Geological Survey of Wyoming, Laramie, Wyoming (unpublished), **23** pp.

[46] Bureau of Land Management, San Juan Field Office. 1999. A brief history and environmental observations, a working document. http://oil-gas.state.co.us/blm_sjb.htm.

[47] Shuey, C. 1990. Policy and regulatory implications of coal-bed methane development in the San Juan Basin, New Mexico and Colorado, ***in:*** International Symposium on Oil and ***Gas*** Exploration and Production Waste Management Practices, 1st, Proceedings, New Orleans, pp. **757–769.**

[48] Beckstrom, J.A., and Boyer, D.G. 1991. Aquifer protection considerations of coalbed methane development in the San Juan **Basin,** ***in:*** Proceedings of Low-Permeability Reservoirs Symposium; Denver, Colorado, April **1991,** Society of Petroleum Engineers, pp. **371–386.**

property owners in the Cedar Hill and Bondad areas noticed bubbles in the Animas River and in their tap water. Water well pumps cavitated as natural gas exsolved from the groundwater so rapidly that some pumps failed to perform. Several pump houses exploded when methane gas accumulated in the confiied spaces and were ignited by a spark, possibly generated by a pressure switch or electric motor brushes. Gas seeps in soils that overlie Mesaverde sandstone outcrops were noted in the mid-1990s as manifesting patches of dead grass in pastures northeast of Durango along CR #240.[49] Some cathodic protection wells on Amoco Production Company CBM production locations in New Mexico flowed water to the surface either continuously or intermittently.[50] In August 1993, a resident of Pine River Ranches Subdivision south of Durango, Colorado notified the Colorado Oil and Gas Conservation Commission (COGCC) of gas contamination in his shallow (34-ft-deep) water well, and of his recent observation that streams of gas bubbles were rising through the water of the nearby Los Pinos (Pine) River. Significant concentrations of entrained methane were detected in samples of water from the well in question and from several other nearby domestic wells. This is in a topographically low area where the Los Pinos River has scoured a valley through the hogback at the northern rim of the San Juan Basin. Nine to thirty-five feet of alluvium overlie the Fruitland Formation subcrop in this valley. Four residences were situated over the Fruitland subcrop in the Pine River Ranches Subdivision. Explosive levels of methane were detected in the crawl spaces of two. The δC^{13} signature of isotopic methane collected from water wells in the Pine River Ranches Subdivision matched those of methane produced from the Fruitland Coal." In addition, soil gas samples in the area of the Pine River Ranches Subdivision were found to contain high levels of methane (up to 97%).[52] Initially, shrubs and bushes located in a well-defined strip parallel to the strike of the subcrop of specific coal seams began showing signs of stress, presumably due to oxygen depletion in the soils. Later, numerous large, mature Ponderosa Pine trees also showed signs of stress, and gradually died, many within a three-year period.[53]

The U.S. Geological Survey has conducted extensive geologic work pertaining to gas seepage in the San Juan Basin. Chafin, in 1994, made extensive analysis of gases in groundwater and soils.[54] On the basis of gas chemistry and the isotopic composition of methane recovered from these gases, gas collected from some domestic wells was similar to gas produced from the Fruitland Coal. Chafin concluded that the Fruitland Coal was the probable source of this gas.[55] In a 1997 report[56] concerning basin-edge seeps, USGS

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[49] Bureau of Land Management, San Juan Field Office. 1999. A brief history and environmental observations, a working document. http://oil-gas.state.co.us/blm_sjb.htm.
[50] Personal observations, 1992–1993.
[51] Bureau of Land Management, San Juan Field Office. 1999. A brief history and environmental observations, a working document. http://oil-gas.state.co.us/blm_sjb.htm.
[52] Bennett, P., and Lee, R 19%. Pine River Ranches, Colorado; soil gas investigation, final report. Prepared for the Colorado Oil and Gas Conservation Commission, Department of Geological Science, University of Texas at Austin.
[53] Bureau of Land Management, San Juan Field Office. 1999. A brief history and environmental observations, a working document. http://oil-gas.state.co.us/blm_sjb.htm.
[54] Chafin, D.T. 1994. Source and migration pathways of natural gas in near-surface ground water beneath the Animas River Valley, Colorado and New Mexico. USGS Water Resources Investigations Report 94-4006.
[55] Chafin, D.T. 1994. Source and migration pathways of natural gas in near-surface ground water beneath the Animas River Valley, Colorado and New Mexico. USGS Water Resources Investigations Report 94-4006.

researchers concluded that in the Pine River seep area, where the subsurface geological data were most complete, geological evidence indicated that the gas seeps were probably not related to the presence of nearby gas wells. In the Florida River, Carbon Junction, and Basin Creek seep areas, subsurface geologic data were not sufficiently detailed to warrant positive conclusions regarding the relation of the gas seeps to nearby producing gas wells. To map, monitor, and model significant environmental and reservoir effects of Fruitland coal bed development, the COGCC in 1999 launched the 3M Project[57] as a continuation of the efforts by the Southern Ute Indian Tribe and the Bureau of Land Management. This effort to understand basin dynamics related to CBM development is viewed by all stakeholders as critical to continued development of CBM in the San Juan Basin because of the potential for human health and safety issues, vegetation losses, environmental degradation, and oxidation of coal reserves as consequences of intensified CBM development.

Surface Disturbance

The development of CBM is similar to any other oil and gas development. The construction and operation of wells requires a network of access roads, drilling sites, pipelines, power lines, compressor stations, and containment pits. Oil and gas development fragments agricultural land, may disturb wildlife, and can disrupt ranch operations. In areas were extensive and rapid development take place, these changes can completely alter the landscape. In the Powder River Basin, it is anticipated that over 3,500 miles of roadway—not including spur roads to reach wellsites—will be built in the course of developing the CBM resource. Each wellsite in the Powder River Basin will disturb about 0.3 acres.[58] Surface disturbance by individual well sites, however, must be combined with road development, pipeline construction, and other construction. When the total potential surface disturbance is considered, the Powder River CBM development has the potential for a net disturbance of about 5.6 acres / CBM well.[59] With 90,500 CBM wells projected for the basin[60], the potential net disturbance of surface as a consequence of CBM development is 505,322 acres (about 790 mi^2, or just a little more than half the size of Rhode Island). Surface disturbance can lead to increased soil erosion, the introduction of undesirable plant species, and the destruction of wildlife habitat.

Most of the surface disturbance from a CBM development is due to the construction of pipelines and roads. Based on the proposed Wyodak development, about 89% of the surface disturbance potential is due to the construction of pipelines and roads. Not all

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[56] Fassett, J.E., Condon, S.M., Huffman, A.C., and Taylor, D. 1997. Geology and structure of the Pine River, Florida River, Carbon Junction, and Basin Creek Gas Seeps, La Plata County, Colorado. USGS Open-File Report 97-59.

[57] *See* http://oil-gas.state.co.us for the most recent reports and data.

[58] Bureau of Land Management, U.S. Department of the Interior. 1999. Wyodak Coal Bed Methane Project Final Environmental Impact Statement.

[59] This figure is based on the analysis presented in Tables 2-1 and 2-2 *in* Bureau of Land Management, U.S. Department of the Interior. 1999. Wyodak Coal Bed Methane Project Final Environmental Impact Statement. Under the "Proposed Action," 3,000 CBM wells will be developed, with a total potential surface disturbance of 16,75 1 acres.

[60] Reasonably foreseeable development scenario for oil and gas development in the Buffalo Field Office Area, Campbell, Johnson, and Sheridan Counties, Wyoming. Wyoming State Office – Reservoir Management Group, February 200 1.

surface disturbance will last for the life of a CBM development. In the proposed Wyodak development, about 61% of the surface disturbance will be of a short-term nature. When only long-term disturbance is considered, about 97% can be attributed to roads and pipelines.[61]

Noise

The production of CBM requires the operation of wellsite equipment. Although the noise generated by wellsite equipment is often a low hum, the humming can be an aggravation to those living nearby.[62] To take CBM to market, the gas must be compressed. Compressors are by far the noisiest aspect of CBM development. "Depending on wind direction, the roar of a field compressor can be heard three to four miles from the site. Near the compressor stations, people need to shout to make themselves heard over the sound of the engines."[63] Heavy vehicle traffic on access roads likewise produces noise, as well as dust.

Equipment noise can be mitigated though the installation of mufflers and, possibly, noise abatement structures. Additionally, the locations chosen for compressor stations can be selected to minimize their impact on the acoustic environment. Vehicle traffic is a more difficult problem. Reducing impacts on wildlife may require scheduling traffic so as to mitigate its impact on wildlife activities such as reproduction and feeding. Speed limits and road surface maintenance are important in mitigating dust.[64]

Air Pollution

Air pollution accompanies any oil and gas development. Concerns in the Powder River Basin are typical, but are heightened by the large number of wells that are projected to be drilled over a fairly short time. The use of internal combustion engines to drill and service wells, compress gas, and provide transportation will produce emissions of nitrogen oxides, carbon monoxide, sulfur dioxide, carbon dioxide, hydrocarbons, and particulate matter. These emissions will have a cumulative impact on air quality.[65] Stationary-source air pollution is also a concern. CBM processing requires an increase in processing plants to accommodate the volume of extracted methane.[66] Each of these processing plants will emit methane and carbon dioxide. Furthermore, traffic from the

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61 *See* Tables 2-1 and 2-2 *in* Bureau of Land Management, U.S. Department of the Interior. 1999. Wyodak Coal Bed Methane Project Final Environmental Impact Statement.

62 Parker, F. Coalbed methane drilling – local impacts. La Veta Signature, 9/5/00.

63 Powder River Basin Resource Council, picture caption, Coalbed Methane Monitor, Late Summer 2000, p. 7.

64 *See* Wyoming Department of Game and Fish. Sage and Sharp-tailed Grouse Considerations with Coalbed Methane Development at hthx//cbmcc.vcn.com//, and Wyoming Department of Game and Fish Wildlife Considerations for CBM Development at htW://cbmcc.vcn.com//.

65 The DOI's Budget Request for the BLM for fiscal year (FY) 2001 states: "'The BLM is also faced with critical air quality issues from the development and transportation associated with [CBM] and other energy development efforts in the [PRB] of Wyoming and Montana." *U.S. DOI, **Budget Justifications and Annual Performance Plan*** Fiscal ***Year*** 2001: ***Bureau of*** Land ***Management*** III-23 (Feb. 2000) [hereinafter ***Budget Plan***]; ***see also Methane Gas Traffic Crowds Roads, Casper Star Trib.,*** July. 26,1999, at A4 ("An abundance of gas is the main contributor to swelled traffic on Highway 50 and Highway 59 this spring. [CBM] gas.").

66 Bureau of Land Management, U.S. Department of the Interior. 1999. Wyodak Coal Bed Methane Project Final Environmental Impact Statement.

CBM boom in Wyoming is crowding roads. Much of the traffic is from the transient labor force arriving from all over the country to help lay pipeline and drill wells. Because well construction requires 7 to 25 people at a time, the construction of new wells requires substantial manpower. The BLM has noted that the increase in workers in high-extraction areas has created a problem for air quality in the area.[67] Other air impacts discussed in the Wyodak Environmental Impact Statement (Wyodak EIS) include impaired visibility standards. Specifically, the Wyodak EIS projected additional days of significant visibility impairment (more than 5%) due to the Wyodak CBM development alone for three Class I airsheds (Northern Cheyenne Reservation, Badlands National Park, and Wind Cave National Park) and five Class II airsheds (Black Elk Wilderness, Jewel Cave National Monument, Mt. Rushmore National Monument, Cloud Peak Wilderness, and Devils Tower National Monument).[68]

Other Issues

The development of CBM resources can compete with other mineral resource development. For example, CBM development affects the mining of the same coal beds along the eastern margin of the Powder River Basin.[69] There are 18 surface coal mines along the eastern part of Campbell County and the northernmost part of Converse County.[70] In 1999, these coal mines produced about 300 million short tons from the Wyodak-Anderson coal zone--the same zone that is being explored and developed for CBM by about 80 gas operators basinwide. The produced coal from these mines made up about 30 percent of the total United States coal production in 2000, and it was shipped to more than 140 electric-power generating plants in the western, midwestern, southern, and southeastern United States, with minor amounts shipped overseas.

The major impact of CBM development on coal mining is groundwater withdrawal from the coal. Although this does not affect the amount of coal that is produced, it reduces the available water for mining operations. Additional conflicts between coal mine operators and CBM operators arise as a consequence of gas lost during mining. Because water is withdrawn from the coal during surface mining, reservoir pressures can be reduced. As a consequence, gas stored in the coal is released and escapes. This issue is currently being addressed.[71]

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[67] **Bureau of Land Management, U.S. Department of the Interior. 1999. Wyodak Coal Bed Methane Project Draft Environmental Impact Statement.**

[68] **Bureau of Land Management, U.S. Department of the Interior. 1999. Wyodak Coal Bed Methane Project Draft Environmental Impact Statement.**

[69] **Flores, RM., et al. 2001. A field conference on impacts of coalbed methane development in the Powder River Basin, Wyoming. USGS Open File Report 01-126.**

[70] **Fort Union Coal Assessment Team. 1999. 1999 Resource assessment of selected Tertiary coal beds and zones in the northern Rocky Mountains and Great Plains region: U.S. Geological Survey Professional Paper 1625-A, Discs 1 and 2, version 1.1.**

[71] **Flores, RM. et al. 2001. A field conference on impacts of coalbed methane development in the Powder River Basin, Wyoming. USGS Open File Report 01-126.**

RECENT ACTIONS AGAINST CBM DEVELOPMENT

The development of CBM resources has met substantial resistance. Some local residents and environmental groups fear that their air, land, and water will be irrevocably damaged by CBM development. The number of environmental interest organizations that oppose or watchdog CBM development is surprising. Among the more significant organizations are: East of Huajatolla Citizens Alliance (Raton Basin, Colorado), Powder River Basin Resource Council (Sheridan, Wyoming), Northern Plains Resource Council (Billings, Montana), Legal Environmental Assistance Foundation (Tallahassee, Florida), Green Mountain Alliance (Bozeman, Montana) and Citizens for Responsibility to the Environment (Bon Carbo, Colorado). Citizens and interest groups have brought a number of suits against CBM operators and CBM interests. Some of the larger or more important actions are discussed below.

San Juan Basin

In 1993, a citizen group in LaPlata County, Colorado, filed a class-action lawsuit charging Amoco Production Company, Meridian Oil Inc., Southland Royalty Company, Phillips Petroleum, and others with recklessness and deliberate disregard for the safety of local residents. The suit claimed that the companies had ignored their own tests that showed that CBM development had resulted in methane pollution of shallow aquifers.[72] The issues raised in this suit have yet to be fully resolved, and monitoring of water quality and water levels related to CBM development continues within the San Juan basin.[73]

Raton Basin

Gas Compressor Suit[74]

In 1996, Southern Colorado Citizens for a Responsible Environment (CURE; then known as Canyon Communities for a Quiet Environment) filed suit against the Las Animas County Commissioners and Amoco Production Company over the granting of an amendment to a conditional use permit to place two additional gas compressors in an area zoned as Ranchette (a zoning designation that encourages agricultural and compatible development and may include up to two single-family dwellings per tract). A major part

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[72] Fouled water leads to court. High Country News, April 19,1993 (Vol. 25 No. 7), http://www.hcn.org/servlets/hcn.Article?article_id=2203.

[73] Monitoring project proposed for Fruitland outcrop. Durango Herald, Dec. 11,1998; see also http://oil-gas.state.co.us for the most recent reports and data. Bureau of Land Management, San Juan Field Office. 1999. A brief history and environmental observations, a working document. http://oil-gas.state.co.us/blm_sjb.htm; also see San Juan Basin Summary of Bradenhead Testing and Ground Water Quality; San Juan Basin 3M Project Summary Report. Late Cretaceous Fruitland Formation Geologic Mapping, Outcrop Measured Sections and Subsurface Stratigraphic Cross Sections. Northern La Plata County, Colorado; 3M Project - CBM Model Final Report; 3M Project – Hydrologic Model Final Report.

[74] The Gas Compressor Law Suit, Southern Colorado CURE, http://www.sococure.org/newson.htm.

of the suit centered around the large amount of noise generated by the compressors and the impact of the noise on residents living nearby.

In a June **1,1999** decision by District Court Judge Claude Appel ruled in favor of CURE, writing that it was unclear in the Commissioners' granting of the amendment to the permit that the Commissioners considered the impact on local residents of the noise generated by the additional compressors. The Judge then remanded the matter back to the Commissioners to apply the correct legal standard under Las Animas County's Land Use Development Guide.

Clean Water Act Suit[75,76,77,78,79]

During the first half of **1998,** CURE made several attempts to meet with Evergreen Operating Company, the major CBM producer operating in Las Animas County, and state and county agencies and officials, to negotiate agreements to protect the local environment and residents around Bon Carbo from any potential adverse impacts from Evergreen's operations. These negotiations were unsuccessful.

On July **13, 1998,** CURE, feeling it had exhausted all other remedies, filed a citizens' suit against Evergreen Operating Corporation for violations of the Clean Water Act in connection with Evergreen's CBM operations in Las Animas County, west of Trinidad, Colorado. The violations alleged in the suit focus on Evergreen's efforts to store, dispose **of**, and transport water effluent produced in association with the company's drilling and gas production operations. These activities have resulted in the formation of large lakes and ponds surrounding the community of Bon Carbo, Colorado. In the suit, CURE alleged that Evergreen's mostly unpermitted and unmonitored discharges, which have failed aquatic toxicity tests and have been shown to contain contaminants such as benzene, pose dangers to the Purgatoire River and Trinidad Reservoir downstream. Because many areas where the discharges occur are zoned rural residential or ranchette, CURE has also alleged that they pose a potential danger to water wells used by local residents.

On May **19, 1999** Federal District Court Magistrate Judge Patricia Coan denied Evergreen's August **13, 1998** motion to dismiss CURE's Clean Water Act Suit. The judge's denial of Evergreen's motion reasserts the validity of CURE's claims against Evergreen and puts the case back in motion to eventually go to trial.

On July **31, 1998** Evergreen Operating Corporation and several land owners in Bon Carbo (all with Evergreen wells on their property) filed suit against four members of CURE's leadership, against CURE itself, and against **all** of CURE's members for supposedly making false, misleading, and damaging allegations concerning Evergreen and the landowners. CURE's attorney, Lori Potter, submitted the case to the Colorado Supreme Court for their review in early **1999.** The Court agreed to review the case, ostensibly because of the First Amendment issues that may be germane to the suit.

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[75] The Citizens Clean Water **Suit,** southern Colorado CURE, http://www.sococure.orn/clean.htm.

[76] News on the Clean Water Act **Suit,** Southern Colorado CURE http://www.sococure.org/clean1.htm.

[77] Status of the **SLAPP Suit,** Southern Colorado CURE, http://www.sococure.org/toppage13.htm.

[78] Trespass Suit Remains Alive, Trinidad **Plus,** July 13,1999, http://www.trinidadco.com/stories99/news/07/13/evrgcure.html.

[79] Troubled water: Evergreen Resources sues four who forced cleanup of discharge **from** oil and gas fields. Denver Rocky Mountain News, June 27,1999.

The Supreme Court's acceptance of the case "stayed" it, or took it out of the hands of the district court judge, so no trial, discovery, or other proceedings are occurring now. The Colorado Supreme Court is currently considering the briefs of both parties and may rule at any time.

In January 2000, a settlement was proposed under which Evergreen agreed to construct a treatment system that would make drinking water available to persons living around Bon Carbo. Evergreen agreed to construct the system in lieu of paying $173,720 in fines assessed by the Colorado Department of Public Health and Environment for environmental law violations at 37 well sites.''

Black Warrior Basin

In 1994, the Legal Environmental Assistance Foundation (LEAF), believing that hydraulic fracturing should be regulated under the Safe Drinking Water Act's (SDWA's) Underground Injection Control Program (UIC), petitioned EPA to withdraw Alabama's SDWA Section 1425 UIC program. EPA rejected **LEAF's** petition, and LEAF litigated. In 1997, the 11th Circuit Court of Appeals ruled that hydraulic fracturing of coal beds in Alabama should be regulated under the SDWA as underground injection.[81] The State was required to modify its UIC program, and in December 1999, EPA approved this revision.[82]

Powder River Basin[83,84]

In March 2000, the Northern Plains Resource Council (NPRC) filed a lawsuit against the Montana Board of Oil and Gas Conservation (BOGC) for violating the Montana Environmental Policy Act by permitting coal bed methane drilling without completing an environmental review of the impacts of methane development. In a settlement agreement, the BOGC agreed to a moratorium on further coal bed methane drilling permits pending completion of an environmental impact statement (EIS). Meanwhile, NPRC agreed to allow Redstone Gas Partners (now Fidelity Exploration and Production Company) to develop its CX Field (325 wells), and to allow the BOGC to grant an additional 200 permits for exploratory wells to collect information necessary to evaluate the impacts of development in the EIS.[85]

In June 2000, NPRC filed a lawsuit against Redstone Gas Partners (now Fidelity) for violating the Clean Water Act by discharging untreated wastewater into the Tongue River

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[80] All's not well. Westword, March 23,2000, http://www.westword.com/issues/2000-03-23/news.html.

[81] LEAF v. EPA, 118 F. 3d 1467.

[82] Study of potential impacts of hydraulic fracturing of **coalbed** methane wells on underground sources of drinking water , U.S. EPA Office of Water, http://www.epa.gov/safewater/uic/cbmstudy.html.

[83] Coal Bed Methane Lawsuits to Date, Northern Plains Resource Council, http://www.nprcmt.org/Issues/CBM/CBM-lawsuits.asp.

[84] BLM charged with illegally leasing coal bed methane, Press Release, Northern Plains Resource Council, http://www.worc.org/pr BLM%20charged.html. The actual complaint can be accessed at http://www.nprcmt.org/media/2001/BLM-lawsuit%20complaint.asp.

[85] NPRC Sues to Stop Permits for Hundreds of New Gas Wells Northern Plains Resource Council, http://www.nprcmt.org/media/2000/PR-CBM-BOGC-Lawsuit.asp.

and its tributaries without a permit. Prompted by NPRC's lawsuit, Redstone applied for, and received, the necessary permit from the Montana Department of Environmental Quality for current discharges to the Tongue River. However, Fidelity has still not applied for a permit for its discharge of wastewater into unlined impoundments along Squirrel Creek, a tributary of the Tongue. Still at issue with this lawsuit are the ongoing discharges along Squirrel Creek, along with damages fiom the 6 to 12 months of illegal discharges into the Tongue River.[86]

In April 2001, NPRC and the Montana Environmental Information Center (MEIC) filed a lawsuit challenging the validity of a water discharge permit issued to Fidelity Exploration and Production Company (formerly Redstone Gas Partners) by the Montana Department of Environmental Quality (DEQ). The Tongue River Water Users Association, which oversees delivery of 60,000 acre-feet of water to irrigators and the Northern Cheyenne Tribe from the Tongue River Reservoir, filed a similar suit. According to both suits, the DEQ discharge permit allows Fidelity to dump millions of gallons of untreated wastewater into the Tongue River in violation of the Montana Water Quality Act, the Montana Environmental Policy Act, the Water Use Act, and the Montana Constitution.[87]

In June 2001, the Northern Plains Resource Council filed suit against the Bureau of Land Management (BLM). In their complaint, NPRC charged BLM with violating the National Environmental Policy Act, the Federal Lands Policy and Management Act, the National Historic Preservation Act, and the Clean Water Act, because the BLM had leased over 600,000 acres of CBM in Montana without observing the very laws designed to guide such decisions.[88]

CONCLUSIONS

Environmental issues surrounding the development of CBM resources have provoked conflict among mineral leaseholders, owners of the surface estates, and the public at large. Citizen suits under the Clean Water Act and the Safe Drinking Water Act, and private tort actions, cloud and complicate the development and economics of CBM resource development. Despite geographic and geologic differences among areas in which CBM resources have been developed, the core environmental issues are consistent. There are two key concerns peculiar to CBM. First, CBM development requires the disposal of large volumes of produced water. When these waters are fresh, surface discharge is the preferred method of disposal. Such disposal may alter aquatic habitats, modify the climate of arid areas, enhance erosion, and salinize soils. Second, whenever CBM development involves shallow coals in hydrogeologic communication with shallow groundwater, there is a concern that the groundwater table will be drawn down. Such draw down will make the production of groundwater for agricultural purposes more

[86] MDU Subsidiary Charged With Water Pollution From Methane Wells. Northern Plains Resource Council, http://www.nprcmt.org/media/2000/PR-CBM-RedstoneLawsuit-6-00.asp.

[87] Family Agriculture Group & Conservationists Join Irrigators to Challenge Coal Bed Methane Discharge Permits. Northern Plains Resource Council, http://www.nprcmt.org/media/2001/CBM-MPDES-Lawsuit-4-24-01.asp

[88] BLM Charged with Illegally Leasing Coal Bed Methane. Northern Plains Resource Council http://www.nprcmt.org/media/2001/PR-CBM-BLMlawsuit-6-13-01.asp

expensive and may deny the use of shallow groundwater resources for an extended period of time.

Other environmental concerns voiced by opponents of CBM development are not unique to CBM development. Among these Concerns is methane contamination of shallow groundwater; surface disturbance from the construction of well pads, roads, pipelines, and other facilities; noise pollution from compressors and other sources; and air pollution from compressor exhaust gases, methane leakage, and dust. Among these latter concerns, the most serious is methane contamination of shallow groundwater. Unlike conventional hydrocarbon reservoirs, in which reservoir pressure is greatest at the beginning of hydrocarbon production, reservoir pressure in CBM builds as the hydrostatic load is removed. Consequently, whether or not the geologic units overlying a coal reservoir will trap any released gases cannot be fully determined until those gases are released by CBM development.