IJNRD.ORG ISSN : 2456-4184

INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG

An International Open Access, Peer-reviewed, Refereed Journal

Coal bed Methane Produced Water Quality and its Management in Rajhara Coalary

Manoj Kumar Singh

Research Scholar, Department of Chemistry, R C I T, University of R C U Bishrampur, Palamu, Jharkhand.

Dr. K.K Mishra

HOD, Department of Chemistry, R C I T, Bishrampur, Palamu, Jharkhand

K. Swarnim

HOD, Dept. of Zoology Ranchi Women's College, Ranchi University, Ranchi

Abstract

Natural gas produced from coal beds (coal-bed methane, CBM) accounts for about 7.5 percent of the total natural gas production in the United States. Along with this gas, water is also brought to the surface. The amount of water produced from most CBM wells is relatively high compared to conventional natural gas wells because coal beds contain many fractures and pores that can contain and transmit large volumes of water. In some areas, coal beds may function as regional or local aquifers and important sources for ground water. Coalbed methane (CBM) recovery is associated with production of large quantity of groundwater. The coal seams are depressurized by pumping of water for regular and consistent gas production. Usually, CBM operators need to pump [10 m3 of water per day from one well, which depends on the aquifer characteristics, drainage and recharge pattern. In India, 32 CBM blocks have been awarded for exploration and production, out of which six blocks are commercially producing methane gas at 0.5 million metric standard cubic feet per day. Large amount of water is being produced from CBM producing blocks, but no specific information or data are available for geochemical properties of CBM-produced water and its suitable disposal or utilization options for better management. CBM operators are in infancy and searching for the suitable solutions for optimal management of produced water. CBM- and mine-produced water needs to be handled considering its physical and geochemical assessment, because it may have environmental as well as long-term impact on aquifer. Investigations were carried out to evaluate geochemical and hydrogeological conditions of CBM blocks in rajhara coalary. Totally, 15 water samples from CBM well head and nine water samples from mine disposal head were collected from Rajhara coalray.

Totally, 15 water samples from CBM well head and nine water samples from mine disposal head were collected from Rajhara coalary. The chemical signature of produced water reveals high sodium and bicarbonate concentrations with low calcium and magnesium, and very low sulphate in CBM water. It is comprehend that CBM water is mainly of Na–HCO3 type and coal mine water is of Ca– Mg–SO4 and HCO3–Cl–SO4 type. The comparative studies are also carried out for CBM- and mine-produced water considering the geochemical properties, aquifer type, depth of occurrence and lithological formations. Suitable options like impounding, reverse osmosis, irrigation and industrial use after prerequisite treatments are suggested. However, use of this huge volume of CBM and mine-produced water for irrigation or other beneficial purposes may require careful management based on water pH, EC, TDS, alkalinity, bicarbonate, sodium, fluoride, metals content and SAR values.

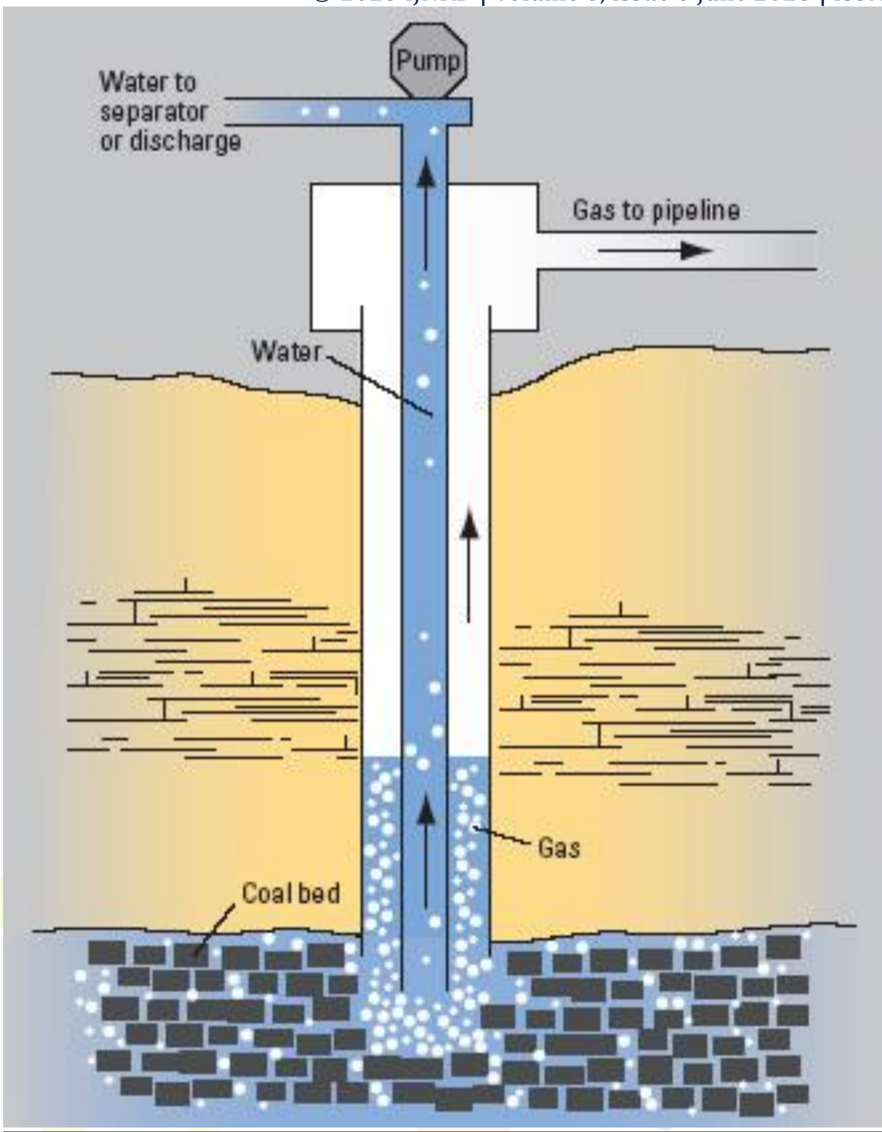
This paper presents the basic information on various physical and geochemical aspects of CBM- and coal mine produced water. It also focuses on, how it is to be managed and regulated using suitable suggested options under environmental settings at Rajhara Coalfield.

Keywords: CBM and coal mine, water Quality, Geochemical Utilization and disposal options.

INTRODUCTION

The water in coal beds contributes to pressure in the reservoir that keeps methane gas adsorbed to the surface of the coal. This water must be removed by pumping in order to lower the pressure in the reservoir and stimulate desorption of methane from the coal. Over time, volumes of pumped water typically decrease and the production of gas increases as coal beds near the well bore are dewatered. The need to decrease CO2 emissions favors the increased use of natural gas as an alternative to coal. The contribution of CBM to total natural gas production in the United States is expected to increase in the foreseeable future (Nelson, 1999). Estimates of the amount of recoverable CBM have increased from about 90 trillion cubic feet (TCF) 10 years ago to about 141 TCF, spurred by advances in technology, exploration, and production (Nelson, 1999). As the number of CBM wells increases, the amount of water produced will also increase. Reliable data on the volume and composition of associated water will be needed so that States and communities can make informed decisions on CBM development. Most data on CBM waters have been gathered at two historically large production areas, the San Juan Basin in Colorado and New Mexico (sparse data) and the Black Warrior Basin in Alabama (extensive data). Rapid development in basins with limited data on CBM waters—i.e., the Powder River Basin in Wyoming and Montana—is currently a concern of producers; land owners; Federal, State, and local agencies; coal mining companies; and Native Americans.

CBM wells, in comparison with conventional oil and gas wells, produce large volume of water early in their life, and the water volume declines over time (Khatib and Verbeek 2003). Usually, CBM-produced water is discharged into associated unlined holding ponds (Reddy et al. 2003). Management of CBM-produced water is associated with challenges, and it is also very expensive for operators. Understanding about produced water characteristics can help in increasing the production and also knowledge of its chemical constituents; operators can determine the proper application of scale inhibitors and well treatment chemicals as well as identify potential wellbore or reservoir problem areas (Breit et al. 1998). The geochemical properties of CBM-produced water vary with the original depositional environment, depth of burial and coal type, and it vary significantly across production areas (Jackson and Myers 2002). CBM-produced water can be beneficially used, but the presence of some of the chemical parameters and their concentrations may limit the use of these waters in certain areas (Shramko et al. 2009). The suitability of CBM-produced water for agricultural purposes generally irrigation or stock watering will depend not only on the quality of the produced water but also on the conditions of the receiving areas (ALL 2003).



- **Process of CBM production**

Methane occurs in adsorbed state within the micro pores of coal; in order to recover it, the CBM reservoirs are depressurized by pumping of water (Mendhe et al. 2010). Typically, water must be produced continuously from coal seams to decrease the reservoir pressure and release the gas (Dart Energy International 2013). Once the pressure in the cleat/fracture system is lowered by water production to the ‘‘critical desorption pressure’’, gas gets desorbs from the coal matrix. The CBM reservoirs are of low pressure and initially produce large quantity of water to reach desired rate of gas production. The produced water needs to be managed considering its geochemical properties, surface drainage pattern and low-cost methods for its treatment and use, because the cost of treatment and disposal of the produced water may be a critical factor in the economics of a coal bed methane project.

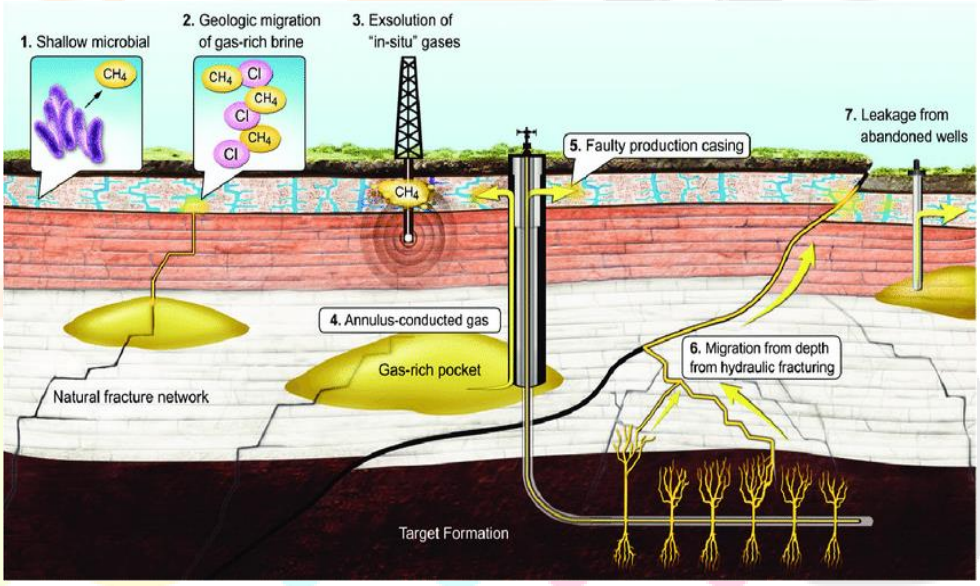
- **CBM-produced water disposal options**

Management of large volumes of associated water with CBM production is a potential concern due to the presence of elevated water salinity and sodicity. The produced water is managed in different ways in different areas of the USA and other countries. Existing production in the Powder River Basin utilizes a variety of options to manage CBM produced water. Deep injection, aquifer storage, surface water discharge, land application (irrigation with amendments), livestock watering and impoundment are all being used to manage produced water. Land application of the CBM-associated high saline–sodic water is a common management method that has been practiced in the Powder River Basin of Wyoming and Montana. The agricultural use of the co-produced waters from CBM is another management option.

However, the use of produced water for irrigation can result in deterioration in soil quality and changes in physical and chemical parameters of the soil (Veil and Clark 2011).

➢ Volumes and Compositions of CBM Water

The amount of water produced, as well as the ratio of water to gas, varies widely among basins with CBM production. Causes of variations include the duration of CBM production in the basin, original depositional environment, depth of burial, and type of coal. Relatively recent regulations concerning disposal and withdrawal of produced water have led to more accurate reporting of water data. Volume data for produced water from specific coal beds has the potential to provide information on exploration and production of CBM. Compositional data is commonly limited to the major dissolved ion species in water (cations and anions), whereas information on trace metals and isotopic composition is sparse. Generally, dissolved ions in water coproduced with CBM contain mainly sodium (Na), bicarbonate (HCO3), and chloride (Cl). The composition is controlled in great part by the association of the waters with a gas phase containing varying amounts of carbon dioxide (CO2) and methane. The bicarbonate component potentially limits the amount of calcium (Ca) and magnesium (Mg) through the precipitation of carbonate minerals. CBM waters are relatively low in sulfate (SO4) because the chemical conditions in coal beds favor the conversion of SO4 to sulfide. The sulfide is removed as a gas or as a precipitate. The total dissolved solids (TDS) of CBM water ranges from fresh (200 mg/L or parts per million) to saline (170,000 mg/L) and varies among and within basins. For comparison, the recommended TDS limit for potable water is 500 mg/L, and for beneficial use such as stock ponds or irrigation, the limit is 1,000–2,000 mg/L. Average seawater has a TDS of about 35,000 mg/L. The TDS of the water is dependent upon the depth of the coal beds, the composition of the rocks surrounding the coal beds, the amount of time the rock and water react, and the origin of the water entering the coal beds.



➢ Fate of CBM Water

Water coproduced with methane is not re injected into the producing formation to enhance recovery as it is in many oil fields. Instead, it must be disposed of or used for beneficial purpose:

The choice depends in large part on the composition of the water. Important composition information should include TDS (often equated to the amount of "salt" water contains), pH, concentrations of dissolved metals and radium, and the type and amounts of dissolved organic constituents. If, with minor to no treatment, the water is of sufficient quality, it may be used with caution to supplement area water supplies. This water must meet requirements under several Federal and State regulations, including the Clean Water Act, the Safe Drinking Water Act, and the Resource Conservation and Recovery Act. If the water does not meet Federal and State standards for reuse, or if the cost of treatment is excessive, the water is disposed of by injection into a compatible subsurface formation or by surface discharge. Disposal of CBM water is also regulated by Federal and State agencies and must meet criteria for each type of disposal. For example, subsurface injection requires compatibility studies of the proposed injection formation and the water that is injected, whereas discharge to surface streams must meet daily effluent limits on constituents such as chlorides along with other criteria. For any CBM field, the cost of handling coproduced water varies from a few cents per barrel to more than a dollar per barrel and can add significantly to the cost of gas production. In some areas, the volumes of water produced and the cost of handling may prohibit development of the resource.

➢ USGS Studies of CBM-Produced Water

The U.S. Geological Survey (USGS) has on-going studies designed to provide information on the composition and volumes of CBM water in some of the most active areas of production in the United States. Data obtained on CBM waters provides information on the heterogeneity of the CBM reservoir, the potential flow paths in the reservoir, the source and evolution of the water, and the quality of the water prior to disposal or reuse. The USGS Energy Resources Team is conducting multidisciplinary studies in the Uinta and Powder River Basins that include sampling waters coproduced with CBM. These studies combine investigations of regional geology and hydrology as well as reservoir-specific studies such as coal fracture orientation, coal composition, gas composition and isotopic values, methane desorption, and water composition and isotopic values. Researchers from the USGS, Bureau of Land Management, Bureau of Indian Affairs, State agencies, and private companies are cooperating in an effort to provide a better understanding of CBM resources and associated water.

Coalbed Methane Produced Water Management and Beneficial Uses

Coalbed methane (CBM) produced water can be managed as a waste product or put to beneficial use, depending on water quality and quantity, legal and regulatory issues, permitting constraints for discharge and use, the local environment and climate, and economic considerations. This chapter addresses the management of CBM produced water, including options for beneficial use, and provides context which addresses effects of CBM produced water on the environment. Reviews specific water treatment options and associated costs for managing CBM produced water.

➢ OPTIONS FOR CBM PRODUCED WATER MANAGEMENT

CBM produced water management includes (1) disposal, storage, or treatment as a waste product of methane recovery or (2) application in one of many beneficial use opportunities, with or without treatment. Several factors, alone or in combination, determine whether CBM produced water is disposed of, stored, treated, and/or put to beneficial use:

- Produced water quality;
- Produced water volumes;
- Reliability of assurances of sustained supply over time;
- Proximity of location of produced water in sufficient quantities for beneficial use (such as irrigation) to suitable land parcels;
- Degree of compatibility between produced water quality and potential receiving landscapes, irrigable land parcels, and receiving water bodies;
- Availability of suitable storage and disposal sites;
- Legal or regulatory factors concerning the discharge, management, and use of CBM produced water;
- Economics of storage and disposal versus options for treatment and beneficial use; and Concern on the part of the CBM operator over liability associated with produced water management, including water use, discharge, and transfer.
- National Academies of Sciences, Engineering, and Medicine. 2010. Management and Effects of Coalbed Methane Produced Water in the Western United States. Washington, DC: The National Academies Press. https://doi.org/10.17226/12915.

Commercially available water treatment techniques can be employed individually or in combination to attain the water quality to support any beneficial use, but at variable costs (Veil, 2009 ;). Disposal and storage options include direct discharge to surface water bodies (depending on produced water quality and quantity and relevant regulations), deep- or shallow-well reinjection and/or storage in surface impoundments, evaporation, and land application. Summarizes the strategies used to manage produced water in the western CBM-producing basins.

Two broadly contrasting approaches to produced water management are highlighted in this the Powder River Basin, where substantial water volumes and relatively low salinity have yielded a variety of options for eventual use of treated or untreated CBM produced water, and the San Juan Basin, where low water volumes and relatively high CBM produced water salinity have made deep-well injection of untreated produced water a standard practice.

The volume of water produced annually from Powder River Basin CBM wells is substantially greater than that of any other western basin. The large number of wells with high water production from relatively shallow depths has thus focused much of the attention regarding management of CBM produced water and its impacts on this basin, particularly the Wyoming portion of the basin where most CBM production currently occurs. However, as outlined in within each of the CBM producing basins where water is being brought to the land surface, volume is not the only factor taken into consideration in the context of produced water management. State natural resource and regulatory agency statutes and administrative rules, in addition to U.S. Environmental Protection Agency (EPA) permitting requirements for disposal or beneficial use application, dictate or regulate which disposal and management strategies may be employed by the operators and water management contractors.

Existing infrastructure, transportation costs associated with shipment of water, and the present-day value of water all influence the extent to which either treated or untreated CBM produced water is perceived or used as a resource. Because the vast majority of CBM produced water is managed by disposal and storage, very little is currently treated for beneficial use. A large majority of the treatment is completed as a requirement for permitted disposal by discharge to surface water.

➢ **INDUSTRIAL AND MUNICIPAL USE OPPORTUNITIES FOR PRODUCED WATER**

Although constrained by available infrastructure, transportation costs, and costs of treating water, CBM produced water is also a candidate for beneficial or supplemental use in a number of industrial and municipal applications. Such industries and municipalities would likely need to be located near methane- and water-producing areas, to assure minimal costs for transporting water. Currently, no CBM produced water in the Powder River Basin of Wyoming is used for municipal or industrial activities other than for dust control at nearby coal mines and on rural gravelled roads. The committee is aware of only a few cases in which produced water from any oil and gas activity—not CBM produced water was used for potable supplies (Stewart, 2006; Stewart and Takichi, 2007). As mentioned previously, a small amount of CBM produced water in Montana is used for industrial dust control.

➢ **CBM Produced Water Management in the Powder River Basin**

CBM producers in the Wyoming portion of the Powder River Basin store the majority of produced water (about 64 percent) in surface impoundments to allow it to evaporate, to be sprayed into the air to enhance evaporation, or to infiltrate into the shallow subsurface or shallow alluvial aquifers. Twenty percent of the CBM produced water is discharged directly to surface water, either after treatment or without treatment if treatment is not required. Although the CBM produced water in the Powder River Basin generally has the lowest total dissolved solids (TDS) concentrations of all the produced water from the western CBM basins, only 13 percent is put to beneficial use, primarily as managed surface irrigation or subsurface drip irrigation. Use of produced water for subsurface drip irrigation requires an underground injection control (UIC) permit (see Chapter 3), inasmuch as the amount of water applied per unit of land is intentionally controlled to promote drainage below the crop root zone and into shallow alluvial aquifers. Only 3 percent of all Wyoming Powder River Basin CBM produced water is disposed of by deep-well reinjection, which also requires a UIC permit. Approximately 3,500 impoundments for storage of CBM produced water have been constructed in the Powder River Basin in Wyoming (Fischer, 2005)

DISCUSSION

The appraisal of CBM- and mine-produced water is useful for evaluating water quality from different geological formations, which normally have distinctly different geochemical signatures. Coal mine water is relatively higher in dissolved calcium (Ca2?), magnesium (Mg2?), chloride (Cl-) and sulphate (SO4 2-), whereas water from the deep coal beds associated with adsorbed methane gas is comparatively higher in dissolved sodium (Na?) and bicarbonate (HCO3 -). The CBM water is categorized as Na–K type, Na–HCO3 type and HCO3 type, whereas the coal mine water may be categorized as the Ca–Mg–HCO3, HCO3–Cl–SO4 and Na–HCO3 type in Rajhara Coalfield. The relevant options for management and surface/subsurface disposal of large volume of produced water from CBM wells are impounding, irrigation and drinking water on the basis of water pH, EC, TDS, alkalinity, bicarbonate, sodium, fluoride, metals content and SAR values. The effective management of CBM and coal mine water in Rajhara Coalfield required more specific scientific investigation before adoption of any disposal method. Water that is produced from deeper coal formations can contain NO3 -, Cl-, metals and high levels of total dissolved solids, which makes it unsafe for drinking purposes (Jamshidi and Jessen 2012)

The potential of economic, ecological, and environment value or benefits of CBM produced water, either in its present state or following necessary treatment, have not been fully evaluated. Intentionally simplistic calculations of the potential economic value of CBM produced water from the Powder River Basin, based on the past 15 years of reported water production; suggest commercial significance of this produced water for municipal purposes. While the specific dollar value of the water may change with different input parameters, the intrinsic value of the CBM produced water resides in the fact that it can be used and is irreplaceable.

CONCLUSION

CBM produced water is currently being managed either as a waste product or as water resource that can be put to beneficial use, although the management as a waste product far exceeds use of CBM produced water as a beneficial natural resource. Irrespective of which avenue is taken, production, handling, management, and/or disposal of produced water all contribute to the cost of production of CBM. Few instances are reported in the industry or scientific literature wherein CBM produced water constitutes an income stream for energy producers. In concept and on paper, putting CBM produced water to beneficial use would seem to be a desirable and relatively easy objective to achieve. In reality, management or discharge of CBM produced water for the specific purpose of achieving beneficial use is potentially economically burdensome, complex, and challenging. Produced water is a necessary by-product of CBM extraction, although the amount of water produced per unit of natural gas recovered and the quality of water produced vary significantly among CBM producing basins. Additionally, the amount of water produced per CBM well typically decreases as the life of the well are extended. These circumstances make CBM produced water an uncertainty and only a temporary source of water for beneficial use. Thus, although CBM produced water does have a value, and even though its availability is transient, this uncertainty in availability contributes to the difficulty of addressing opportunities for beneficial use.

Less than 5 percent of all CBM produced water in the six western states considered here is directly or intentionally beneficially used for irrigation of agricultural lands. With the exception of livestock watering, essentially all other beneficial uses of this water are ancillary or consequential to disposal through discharge e.g., streaming flow augmentation, wildlife and aquatic habitat enhancement, aquifer recharge, and wildlife watering. Nearly 85% of all CBM produced water in the Powder River Basin (Wyoming and Montana combined) is disposed of either by storage in constructed impoundments or direct, permitted discharge to ephemeral drainages and perennial streams. This approach to produced water management is driven by large volumes and relatively low salinities of produced water and the regulatory ease and environmental suitability of discharge or storage.

REFERENCES

1. ALL (2003) Handbook on coal bed methane produced water: management and beneficial use alternatives. Prepared by ALL Consulting for the Ground Water Protection Research Foundation, U.S. Department of Energy, and U.S. Bureau of Land Management.

2. Breit G, Klett TR, Rice CA, Ferderer DA, Kharaka Y (1998) National compilation of information about water co-produced with oil and gas. In: 5th international petroleum environmental conference, Albuquerque, NM, Oct 20–23

3. Datta D (2003) Coal resources of West Bengal. Bulletin of the Geological Survey of India, Series 'A', No. 45, Coalfields of India, Volume V.

4. Fischer, D. 2005. Potential Groundwater Impacts from Coalbed Methane Impoundments. Presentation to the Wyoming Department of Environmental Quality, Water Quality Division, Third Watershed Stakeholders' Meeting, Buffalo, WY, November Available at deq.state.wy.us/wqd/wypdes_permitting/WYPDES_cbm/Pages/CBM_Watershed_Permitting/Clear_Creek/Clear%20Creek%20Downloads/Clear%20Creek%20Meeting%203/Clear%20Creek%20Don%20Fi scher%20Presentation%2011-14-05.pdf (accessed February 24, 2010).

5. Jamshidi M, Jessen K (2012) Water production in enhanced coalbed methane operations. J Petrol Sci Eng 92–93:56–64

6. Jackson L, Myers J (2002) Alternative use of produced water in aquaculture and hydroponic systems at Naval Petroleum Reserve No. 3. In: Ground Water Protection Council produced water conference, Colorado Springs, CO, Oct 16–17

7. Khatib Z, Verbeek P (2003) Water to value—produced water management for sustainable field development of mature and green fields. J Pet Technol 55(1):26–28

8. Mendhe VA, Mishra P, Varade AM (2010) Coal seam reservoir characteristics for Coalbed Methane in North and South Karanpura Coalfields, Jharkhand, sedimentary basins of India: recent developments. Gondwana Geol Mag 12(2010):141–152

9. Reddy KJ, McBeth I, Skinner QD (2003) Chemistry of trace elements in coalbed methane product water. Water Res 37:884–890

10. Shramko A, Palmgren T, Gallo D, Dixit R, Swaco M-I (2009) Analytical characterization of flow-back waters in the field. In: 16th annual petroleum & biofuels environmental conference (IPEC), Houston, November 3–5 2009

11. Stewart, D.R. 2006. Developing a new water resource from production water. Presentation at the International Petroleum Environmental Conference, San Antonio, TX, October 17-20. Available at ipec.utulsa.edu/Conf2006/Papers/Stewart_18.pdf (accessed January 27, 2010).

12. Stewart, D.R., and L. Takichi. 2007. Beneficial use of produced water—Water as a valuable by product. Presentation at the International Petroleum Environmental Conference, Houston, TX, November 5-9. Available at ipec.utulsa.edu/Conf2007/Papers/Stewart_74.pdf (accessed January 27, 2010).

13. Veil, J.A. 2009. Regulations and Impediments for Treatment and Beneficial Use of CBM Produced Water. Presentation at the International Petroleum Environmental Conference, Houston, TX, November 2-5. Available at ipec.utulsa.edu/Conf2009/Papers%20received/Veil_Regs.pdf (accessed January 27, 2010).

14. Veil J, Clark CE (2011) Produced-water-volume estimates and management practices. SPE Prod Oper 26(3):234–239