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# Technical Review of Proposed Changes in Montana Water Quality Standards for Coal Bed Natural Gas Produced Water

Allan R. Sattler, Malynda A. Aragon, M. Michael Hightower

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550

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# TECHNICAL REVIEW OF PROPOSED CHANGES IN MONTANA WATER QUALITY STANDARDS FOR COAL BED NATURAL GAS PRODUCED WATER

Allan Sattler
Geotechnology and Engineering Department

Malynda Aragon
Geochemistry Department

Mike Hightower
Energy Systems Analysis Department

Sandia National Laboratories
P.O. Box 5800
Albuquerque, New Mexico

January 2006

ABSTRACT

In November 2005, the United States Department of Energy requested that Sandia National Laboratories provide a technical review and evaluation of proposed changes in the Montana Water Quality Standards related to Coal Bed Natural Gas produced water treatment and discharge. The goal of Sandia's technical evaluation was to assist the Department of Energy in understanding the technical feasibility and costs associated with meeting the proposed standards and the potential impact on coal bed natural gas production in the region and impacts on natural gas production and supplies nationally.

This report summarizes the results of the Sandia review of the proposed standards, with a focus on the technical issues associated with coal bed natural gas produced water reinjection and treatment. Based on our review, there appear concerns with the proposed new standards. These concerns include inconsistencies in treated water constituent standards, identification of treatment standards for arsenic and other constituents that are not currently attainable, lack of the use of EPA recommended methods to assess innovative treatment technology cost and performance impacts, limitations on the use of commonly recognized alternative water management options, and identification of water treatment levels that will make the treated water highly reactive and negatively impact use for irrigation and wildlife. The results of the Sandia review and the technical evaluations of various parts of the proposed standards are summarized in this report.

# ACKNOWLEDGEMENTS

The authors received technical, programmatic, and editorial support on this project from a number of individuals and organizations both inside and outside Sandia. We would particularly like to express our thanks for their support and guidance in the technical evaluations and development of this report.

To support the technical analysis required for this project, the authors worked with many organizations, including industry and state and federal agencies to collect background information on current operations, existing regulations, and technical data.

The following organizations were especially helpful in supporting our efforts, including:

Bureau of Land Management – Miles City Office

Wyoming Oil and Gas Commission

Montana Board of Oil and Gas Conservation

Montana Bureau of Mines and Geology

ALL Consulting – Tulsa Oklahoma

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| | |
|---|---|
| BER | Board of Environmental Review |
| CBNG | Coal bed natural gas |
| cm | Centimeter |
| DOE | Department of Energy |
| dS/m | Deci-Siemens per meter |
| EC | Electrical conductivity |
| EPA | United States Environmental Protection Agency |
| L | Liter |
| M | meter |
| mg | Milligrams |
| mg/L | milligrams per liter |
| MT | Montana |
| NETL | National Energy Technology Laboratory |
| NPRC | Northern Plains Research Council |
| PRB | Powder River Basin – Wyoming and Montana |
| S | Siemens |
| SAR | Sodium abruption ration |
| TDS | Total dissolved solids |
| WY | Wyoming |
| µS/cm | micro Siemens per centimeter |
| $K | Thousand dollars |
| $M | Million dollars |

# 1. EXECUTIVE SUMMARY

In September 2005, the Montana Board of Environmental Review announced proposed changes to the Montana Water Quality Regulations related to Coal Bed Natural Gas produced water treatment and discharge. The proposed regulations, if adopted in their current form, could significantly impact and possibly reduce CBNG development and production in Montana. The impact could also extend to CBNG production in other states, such as Wyoming, through greater restrictions on CBNG produced water quality.

The U. S. Department of Energy (DOE) reviewed the proposed changes and believed that they could significantly restrict CBNG production in Montana and Wyoming. To aid in the evaluation and assessment of the proposed changes, the DOE requested that both Argonne National Laboratory (Argonne) and Sandia National Laboratories (Sandia) review the proposed changes and prepare written evaluations on various technical, policy, and regulatory aspects. Argonne focused on regulatory and policy issues and their interrelationships with technology, and Sandia focused on major technical issues associated with the proposed water treatment requirements and the engineering, hydrologic, and geologic technical issues associated with the produced water discharge aspects of the proposed changes.

This report represents Sandia's review, observations, and assessments. The main themes of these comments address the technical issues associated with:

- The proposal to identify sodium adsorption ratio (SAR) and electrical conductivity (EC), measures of normal ionic constituents in all surface and ground water, as harmful parameters.

- The proposal to limit CBNG produced water disposal to shallow reinjection unless the reinjection is shown to be infeasible.

- The proposed strict treatment and discharge standards; the potential impact of these limits on the environment and ecology; and the maturity, performance, and cost effectiveness of technologies to meet the proposed effluent discharge standards.

- The proposal to limit the exemption for CBNG produced water reinjection or treatment to only livestock watering, neglecting other innovative or beneficial water management approaches and technologies.

The rationale presented for making the proposed changes to the water quality regulations does not appear to adequately address the severe technical and cost challenges associated with the proposed changes nor the impacts the proposed changes could have on use of the produced could have on wildlife and irrigation.

Based on our reviewed of both the proposal and the petition outlining the rationale for the proposed changes our evaluations include:

- Electrical Conductivity (EC) and the Sodium Adsorption Ratio are not harmful

parameters as the proposal relates. These parameters are used to describe chemical properties of any water and both EC and SAR provide a metric to help identify general overall water quality. EC and SAR can be used to identify safe levels, intermediate levels, and undesirable levels of water quality, but themselves are not harmful parameters or constituents. In reality, some level of chemical ions in a water are actually considered beneficial for human, plant, and wildlife uses.

- There appear to be limited systematic and successful approaches to reinjection into coal seams or injection into other formations of CBNG produced water in the Powder River Basin. Geology and other geotechnical factors severely limit injection options. The success rate of establishing reinjection wells based on today's available data is less that 30%.

- As written, the proposed waiver from zero discharge (Proposed New Rule III) process will be an extreme burden on both developers submitting the requests and the regulatory agencies having to review the numerous requests, which could severely curtail CBNG development and production.

There were several major technical and environmental issues with the proposed produced water effluent treatment limits. These include:

- Inconsistent effluent treatment levels for various parameters, especially for Ca, Mg, and Na,

- Water effluent levels that are far below commonly accepted water quality standards, especially for As, Ca, Mg, and Na,

- The proposed produced water treatment levels will create an effluent water quality that could negatively impact both aquatic species and irrigation,

- Identification of proposed treatment technologies that have not been fully demonstrated to meet the proposed effluent guidelines consistently in operational settings across the range of produced water qualities in the region following EPA recommended technology cost and performance verification guidelines, and

- The lack of consideration of the waste treatment costs and environmental impacts that could be generated from handling and moving the waste streams from the proposed water treatment processes.

Additionally, the proposed rule changes limit the use of innovative produced water management technologies. With only an exemption for CBNG water used for livestock watering, no other management options are permitted for CBNG produced water in the proposed changes. This limits several common produced management options and approaches and emerging approaches that might be applied in an environmentally sound and cost effective manner and reduce the use if fresh water resources. The issues identified include:

- The proposed restrictions effectively preclude the direct use of CBNG water without treatment for many beneficial purposes. The CBNG produced water quality in the PRB is appropriate for a number of applications with either little or no treatment. Some approaches have been used with CBNG produced water to provide affordable produced water management to operators while providing direct benefits to landowners. For example, managed water treatment and use for irrigation has proven successful in several Powder River Basin applications.

- Operators, land owners, and land management agencies may be interested in other uses of this produced water for a range of other applications including recreational opportunities, irrigation, oilfield make up water, electrical power generations, and use of water for other industrial or domestic applications to offset fresh water demands.

- The proposed provision also restricts the use of emerging innovative technologies that could be used to manage CBNG produced water in an environmentally and ecologically sound manner.

Overall, the proposed changes are inconsistent with the common understanding of water quality requirements for treating slightly impaired brackish surface or ground water, as exists with the CBNG produced water in the Powder River Basin, to meet various uses and applications. With minor adjustments of water quality, much of the CBNG produced water in the Powder River Basin can be used for a number of beneficial purposes.

# 2. INTRODUCTION AND PURPOSE

In May 2005, a group of petitioners led by the Northern Plains Resource Council (NPRC) submitted a petition to revise water quality requirements to the Montana Board of Environmental Review (BER). Under Montana law, the BER had to consider the petition and either reject it or propose it as a new regulation. In September 2005, the BER announced proposed changes to the Montana water quality regulations. The proposal, which is presented in Appendix A of this report, included almost the exact language found in the petition and was directed toward discharges of water from coal bed natural gas (CBNG) production. The key elements of the proposal included:

1. The Sodium Adsorption Ratio (SAR) and Electrical Conductivity (EC) would be reclassified as "harmful parameters," thereby greatly restricting the ability for CBNG discharges to be allowed under Montana's nondegradation regulations.

2. The Montana water quality standards for the SAR and EC would be evaluated using the 7Q10 flow (lowest 7-consecutive-day flow in a ten-year period) rather than a monthly flow that is currently used.

3. No discharges of CBNG water are allowed to Montana surface waters unless operators can demonstrate that injection to aquifers with the potential for later recovery of the water is not feasible. Producers would be required to provide extensive injected water rate and transport modeling, geologic evaluation data, and pump test data on aquifers and confining layers to prove injection was unfeasible.

4. When operators can demonstrate the injection is not feasible, the CBNG water to be discharged must meet very strict discharge limits for multiple constituents.

The proposed regulations, if adopted in their current form, could significantly impact and reduce CBNG development and production in Montana. The impact also extends to Wyoming CBNG production through much greater restrictions on water quality that must be met at the interstate border.

One of the U.S. Department of Energy's (DOE's) missions is to ensure an abundant supply of affordable energy for the nation. One way in which DOE supports that mission is to evaluate proposed federal and state regulatory actions that would restrict or impede energy production to assess whether the environmental or other benefits of those actions are commensurate with the energy impacts. DOE's National Energy Technology Laboratory (NETL) reviewed the BER proposal and believed that the proposal could significantly restrict CBNG production in Montana and Wyoming. To aid in the review of the proposal, DOE asked two other national laboratories – Argonne National Laboratory (Argonne) and Sandia National Laboratories (Sandia) – to prepare written evaluations on various aspects of the proposal. Argonne focused on regulatory and policy issues and their interrelationships with technology, and Sandia focused on the major technical issues associated with the proposed water treatment requirements and the engineering, hydrologic, and geologic technical issues associated with the zero discharge aspects of the proposal.

This report represents Sandia's review and observations. The main themes of these comments address the technical issues associated with:

- The proposal to identify sodium adsorption ratio (SAR) and electrical conductivity (EC), measures of normal ionic constituents in all surface and ground water, as harmful parameters.

- The proposal to limit CBNG produced water disposal to shallow reinjection unless the reinjection is shown to be infeasible.

- The proposed very strict treatment and discharge standards; the potential impact of these limits on the environment and ecology; and the maturity, performance, and cost effectiveness of technologies to meet the proposed effluent discharge standards.

- The proposal to limit the exemption for CBNG produced water reinjection or treatment to only livestock watering, neglecting other innovative or beneficial water management approaches and technologies.

The rationale presented for making the proposed changes does not adequately address the severe technical issues and challenges associated with the proposed changes. We have reviewed both the proposal and the petition outlining the rationale for the changes. Each of the sections discusses in detail the major technical issues that have been identified in both the proposal and the background information in the petition. These themes will be discussed sequentially.

# 3. PROPOSAL TO IDENTIFY SAR AND EC AS HARMFUL

One of the revisions included in the proposal is classifying the Sodium Adsorption Ratio (SAR) and Electrical Conductivity (EC) as undesirable substances with deleterious properties. The proposed language reads:

> *17.30.670 NUMERIC STANDARDS FOR ELECTRICAL CONDUCTIVITY (EC) AND SODIUM ADSORPTION RATIO (SAR)*
> *(1) through (5) remain the same.*
> *(6) EC and SAR are harmful parameters for the purposes of the Montana Water Quality Act, Title 75, chapter 5, MCA.*

EC and SAR are measures of the chemical characteristics of water. They provide information on the level of the quantity of total dissolved solids (TDS) or salts such as calcium, sodium, chloride, sulfates, carbonates, and other salts in a water sample (Israelsen 1950). All natural waters contain ions, salts, and TDS and the parameters EC and SAR are used to identify the level and ratio of dissolved salts in water. EC is simply a measure of the total amount of dissolved salts or salinity in a water sample. It does not measure a specific chemical substance that could be construed as harmful. SAR is a ratio of the levels of sodium, calcium, and magnesium dissolved in a water sample.

Both EC and SAR provide a metric to help identify general overall water quality. Like most other water quality parameters, lower levels of EC and SAR suggest higher quality water and high levels suggest that the water can begin to pose a risk to aquatic life, humans, plants, and/or soils. In other words, EC and SAR can be used to identify safe levels, intermediate levels, and undesirable levels of water quality, but themselves are not harmful parameters. Table 1 lists general water quality data showing the level of EC considered beneficial and the levels considered detrimental for a few general water use applications taken from several sources including (Israelsen 1950)(Batmanghelidj 1995)(EPA 2005).

**Table 1. Electrical Conductivity Ranges for Various Water Uses**

| Application | EC, µS/cm | |
|---|---|---|
| | **Beneficial Level** | **Limitations on Use** |
| Drinking water | 200-400 | >1600 |
| Irrigation Water | 200-3000 | > 3000 |
| Livestock Water[1] | 500 - 3000 | > 5000 - 6000 |
| Fresh water Aquatic Species | Up to 5000 | > 8000-10000 |

[1] *Water quality parameters for most livestock is summarized here and in more detail in Table 4*

Therefore, from a technical perspective, EC as shown above is indicative of water quality, but very low to zero levels of EC are not necessarily the most beneficial level for water quality. Therefore, water with moderate EC and SAR levels are common and necessary for good water quality and should not be identified as harmful parameters as suggested in the proposal. Very low levels of EC and SAR could lead to infiltration problems, and potentially not provide the nutrients for both crops and aquatic life.

# 4. PROPOSAL TO REQUIRE INJECTION OF CBNG PRODUCED WATER

Proposed New Rule II requires zero discharge of CBNG produced water and directs that the water be re-injected to a suitable geologic formation. It appears that the requirement to re-inject is based on the desire to keep water in the aquifers from which it came or at least in other nearby aquifers from which it could be recovered later for beneficial uses. The proposed language reads:

> *NEW RULE II ZERO DISCHARGE REQUIREMENT*
> *(1) Except as provided in [New Rules III through IX], point sources of methane wastewater shall achieve zero discharge of pollutants, which represent s the minimum technology-based requirement. Zero discharge shall be accomplished by reinjection of methane wastewater into suitable geologic formations in the project area in compliance with all other applicable federal and state laws and regulations.*

The technical issues and challenges of reinjection of Montana's CBNG produced water into the same or another coal seam, or injection of the produced water into another receiving formation in the Powder River Basin (PRB) are discussed below. CBNG produced water is a valuable resource with relatively low TDS compared to waters of many naturally saline inland formations. Opportunities to save such a resource are important. The material presented in the following sections and certain cited references strongly suggest that reinjection of CBNG produced water into the coal seam being produced, as a rule, is not a reasonable option.

The Fort Union Formation (Rice et al 2001; Arthur et al 2005, Pritchett 2002) as shown in Figure 1 and presented in Table 2, contains all the water producing coal beds in the Montana PRB (MBMG 2001). In the Montana portion of the PRB the bulk of the coals are confined to the Tongue River Member of the Fort Union Formation. The Lobo and Tullock members are predominantly shale and shaley-sand (McLellan et al, 1990).

The following reinjection /injection schemes are potentially possible and were considered:

- Simultaneous reinjection into the same coal seam that is being produced,
- Simultaneous multiple coal seam production vs. sequential production and reinjection into vertically stacked coal seams,
- Reinjection into under-pressurized or non-productive coal seams,
- Injection into sandstones within the Fort Union formation and the formations above the Fort Union formation, and
- Other injection considerations.

The technical issues and concerns associated with produced water injection or coal seam reinjection options for each scheme are discussed. Additionally, the chemical compatibility between CBNG produced water and the waters of the receiving formation/aquifer are discussed.

**Simultaneous Reinjection into the Coal Seam That is being Produced**

Simultaneous reinjection of CBNG produced water into the coal seam that is being produced is not a reasonable option. Reinjection of CBNG produced water into the same coal seam that is being produced would be an ideal solution if it is feasible from an operational and technical basis. It would allow secure geologic storage of this valuable produced water in the aquifer from where it came, ideally matching with the remaining waters in that coal seam, and "put things back where they were." In most instances such an option is difficult in practice from an operational and process viewpoint, and may be unwise from a resource management viewpoint. It may have potentially negative environmental consequences.

**Figure 1. General Geologic Cross Section of the Powder River Basin (Rice 2000)**

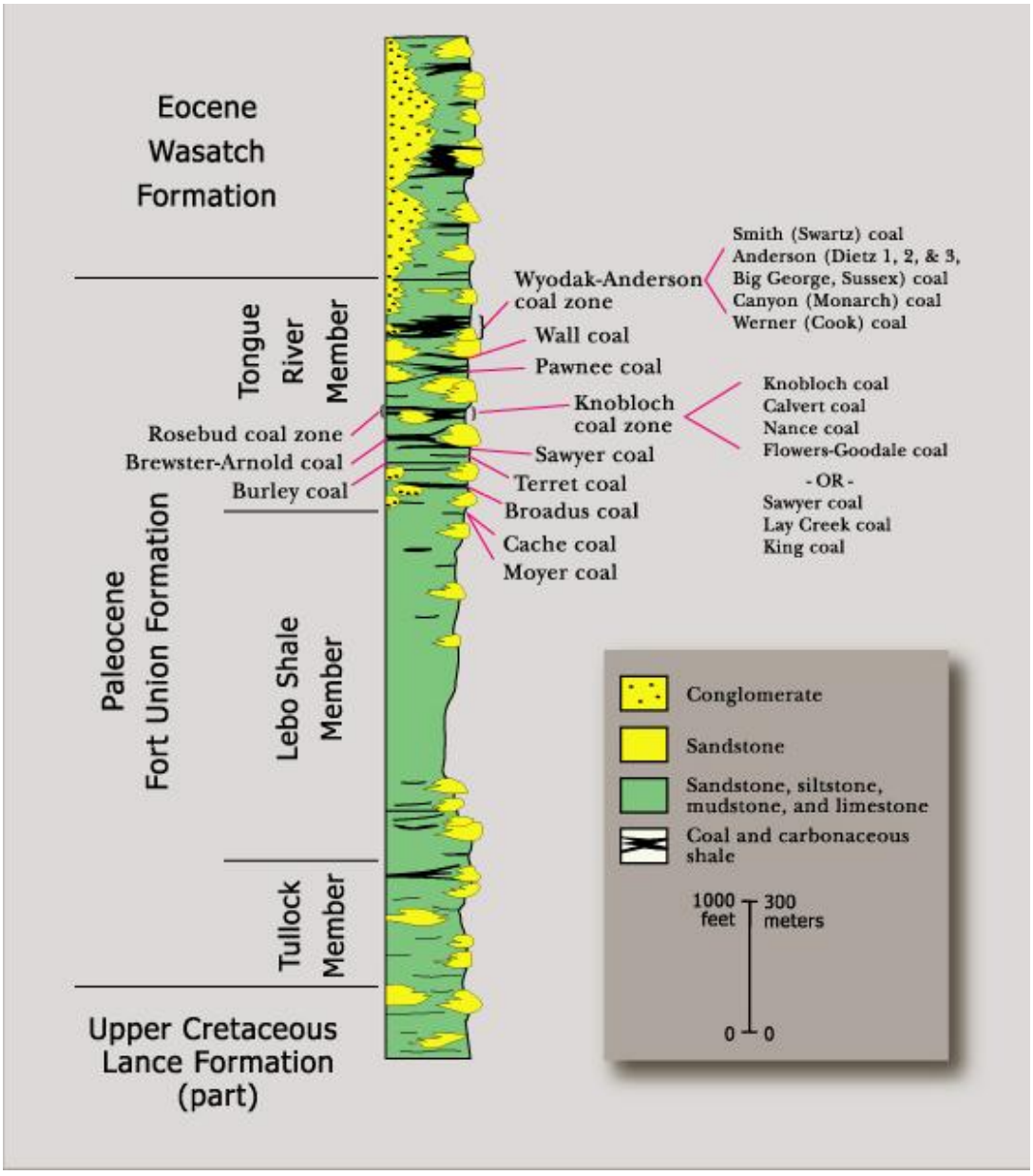

**Table 2. Typical Geologic Formation Depths in the Powder River Basin of Montana**

| Formation | Approximate Formation Depth in feet |
|---|---|
| Wasatch Sands, Quaternary Alluvium | <500 |
| Fort Union | ~50-2500 |
| Lance, Fox Hills | ~2500-4000 |
| Paleozoic Carbonates | ~10,000-14,000 |

Production of CBNG typically requires a reduction in the hydrostatic pressure. This is accomplished by producing water from the coal seam. Reinjection would require raising the hydrostatic pressure. This would directly impair production. Simultaneous injection and withdrawal from the same coal seam is analogous to emptying and filling a bucket at the same time.

A tendency has been noted for some coal seams to compact during the lowering of the hydrostatic pressure of the coal seam with subsequent degasification of the coal seam (Palmer and Varzi, 2004). This could impair the original water storage ability of the original coal seam implying attendant higher pressures necessary to re-inject into a seam whose storage capacity has been reduced by compaction. Attempts to re-inject produced water then would have the potential of hydrofracturing outside the coal seam resulting in water migration outside the injection zone, an unintended result and a potentially serious situation. Exceeding the fracture pressure is generally prohibited under EPA's Underground Injection Control program (EPA, 2002). The tendency to compact may vary from coal seam to coal seam. More research is necessary to determine which coal seams are more or less prone to compaction.

It has been estimated that 50% of the natural gas reserves are recoverable by present methods. Enhanced recovery methods such as $CO_2$ injection are possibilities that could be considered in future years. (Cox, 2001; ORNL, 2002). If the coal seam is first produced and the CBNG produced water is held on the surface in a holding pond, and then later reinjected into that same, now depleted, seam, the possibilities of enhanced recovery can be lost or significantly impaired. This is more of a sequenced scenario which will be detailed more in the subsequent section.

An Environmental Impact Statement (BLM 2003) relating in part to CBNG produced water in the Powder River Basin, written by the Bureau of Land Management (Miles City and Billings, Montana Field Offices), the Montana Board of Oil and Gas Conservation and the Montana Department of Environmental Quality mentions injection, treatment, impoundment, and discharge as options for handling CBNG produced water as disposal options in the preferred alternative. In this same EIS, Page 2-3, however, it specifically states that reinjection in the same coal seam being produced is not a suitable option.

**Simultaneous Multiple Coal Seam Production vs. Sequential Production and Reinjection into Stacked Coal Seams**

Simultaneous multiple coal seam production is more efficient and economically preferable to sequential production and reinjection into stacked coal seams. It allows exploitation of thin coal seams, disturbs the land surface less because it is more efficient, and it avoids potential leaseholder complications. When producible seams are stacked, the possibility exists to produce one seam and draw its hydrostatic pressure down and then produce a second seam above or below it and re-inject the water into the first seam that is called sequenced coal seam production. This option may appear desirable as water from the coal seams is placed back in coal seams. (In this scenario, the water from the first seam produced would have to be impounded in a holding pond or handled in some other manner). Before such a step by step production reinjection operation should be ventured, efforts should be first made to ascertain the geologic/hydrologic isolation of such coal seams from each other.

In practice there are several drawbacks to sequenced production from a resource extraction management and conservation perspective, also from an economic and environmental perspective. The utilization of the CBNG resource of the thinner coal seams could require extraction in a simultaneous production mode, as extraction of the CBNG from thin seams on an individual basis could be unattractive economically. The simultaneous production rather than sequenced production of the coal seams would normally be more efficient from a cost and operational point of view. Any injection from sequenced production/reinjection could impair possible future extraction of the remaining gas resource, is more expensive, and would keep the extraction operation on the land for a longer period of time with the attendant surface disturbance.

The storage capacity of the receiving, produced coal seam would have to be reinvestigated in each case. Production can alter the storage capacity of a given seam as described in the previous section. The sequential production mode could also be a cause for leaseholder concern and complications. Lease ownership often resembles a checkerboard between federal, state, and private holders. Unless the production sequence of these individual seams is coordinated among different holders, draw-down possibilities across lease boundaries could create concerns.

The above referenced EIS encourages multiple seam completions from the same well as technology permits. Multiple seam completions from the same well would create less attendant land disturbance. Otherwise, Montana resource managers and oversight agencies have shown no additional preference in the EIS between simultaneous multiple seam production and staggered coal seam production. In the record of decision the Montana Board of Oil and Gas and the BLM both restated no preference for sequential vs. simultaneous production of stacked seams (BLM 2003a) (MBOGC 2003).

**Reinjection into Under-pressurized or Non Productive Coal Seams**

Reinjection into an under-pressurized coal seam could be potentially environmentally harmful if the seam has no hydraulic seal. Injection into a naturally under-pressurized coal seam is another possibility to handle produced CBNG water. Under-pressurized coal seams, if geotechnically suitable, would be a good option for handling CBNG produced water. However, such an under-pressurized coal seam may be under-pressurized for a reason, specifically the lack of a hydraulic seal. As such, an under-pressurized seam may be caused by a number of reasons. These could include the outcropping of the seam into a stream or spring or elsewhere. Faulting and fracturing can impair the seam's ability to hold pressure and water. Injection into such a seam has the potential to lead to potential unintended release of injected water. Standard reservoir tests in such a situation may not give a complete geologic/hydraulic picture of the under-pressurized coal seam.

It should be mentioned that there are a series of under-pressurized coal seams in the Wyoming portion of the Powder River Basin. A preliminary account of this feature has been given by Geoff Thyne at the Petroleum Environmental Research Forum (Thyne, 2005). The data is presently being synthesized and analyzed at Stanford University. The geologic circumstances of such potential sources for reinjection are not yet fully understood.

Whether an analogy of this Wyoming Powder River Basin system exists in the Montana Powder River Basin is as yet unknown. As more data from Montana coal seams is accumulated, the existence or non existence of such an analogous system will become known. If a Montana analogy exists, the detailed geologic settings of such seams must still be determined to find out whether such systems would be suitable for CBNG produced water reinjection.

The above referenced EIS mentions the possibility of injection into non-productive coal seams but does not elaborate.

**Injection into Sandstones within the Fort Union Formation and the Formations above the Fort Union Formation**

The geology of the shallow Fort Union and overlying sand formations generally make reinjection possibilities limited. The sandstones of the Fort Union Formation (~50-2500 ft) are terrestrial (Arthur et al, 2005) in nature; the sandstones are not continuous and are relatively small. The chances of finding suitable sandstones in these formations that can take the required volumes of water are quite small. Many of these sandstones in the Fort Union adjoining the coals are also water saturated and as a rule these sandstones are less extensive than the coal seams. Attempts to inject in such situations could entail relatively high injection pressures with a diminished chance of injecting reasonable amounts of CBNG produced water. On a general basis injection into these formations is difficult but this has been done in a few cases (Likwartz, 2005).

The Montana Bureau of Mines and Geology very recently began investigating and documenting large channel sands in the Lower Tongue River Member (~50-500 ft) of the Fort

Union Formation. These individual sands may be extensive individually, but generally are not laterally continuous, rather more compartmentalized (John Wheaton and David Lopez, 2005).

Lower saturation and less injection pressure may exist in the sands overlying the Fort Union Formation, or in the Wasatch Sands/Quaternary Alluvium (<500ft). These sands are also terrestrial in nature. Well logs could be examined to determine the vertical extent of such Wasatch sands. Models exist to make estimates of the lateral extent of any lenticular sands seen on the logs based on sedimentalogical principles. Widespread existence of such unsaturated sands, extensive enough to be an adequate injection target in this sedimentological environment is not the rule. However there may be some instances where such suitable injection sands overlying the Fort Union Formation Coals could exist.

**Fluid Compatibility**

The compatibility of CBNG produced water being re-injected back into the original formation or injected into another formation/aquifer needs to be considered in each case. The CBNG produced water injection must be chemically compatible with the receiving formation and generally should have no adverse effect on the water quality of the injected formation. The design of any reinjection system into a given formation/receiving aquifer should account for possible vertical and horizontal variations of the water chemistry. When CBNG produced water is brought to the surface, carbon dioxide and methane can be released, and the pH can rise. The chemistry of the water can be altered, and it may become aerated. A determination should be made to see that the altered state of the produced water brought to the surface for later reinjection is compatible with the original water chemistry before reinjection.

Treatment of the produced water prior to injection or reinjection may improve its compatibility with the receiving formation. Any concentrate resulting from such treatment would have to be handled separately however, such as injection into a class I or II injection well. Moreover the treatment/handling of any concentrate disposal will add significantly to operation costs,

**Success Rate of Drilling Injection Wells**

The overall success rate of establishing successful reinjection wells is quite limited. Ample statistics on the success rates of injection wells are not available on either side of the Wyoming/Montana Powder River Basin. Some preliminary data was provided on the similar Wyoming Powder River Basin formations by the Wyoming Oil and Gas Commission (Likwartz, 2005). Forty four (44) injection wells were actually drilled. Among these 44 wells there were 24 in the Fort Union, 4 in the Fox Hills 1 in the Lantz/Fox Hills Formations. Of these only 12 were in operation after one year. The accumulated injection of these wells accounts for only about 2% of the current Wyoming CBNG produced water.

Commonly, an injection well is expected to function for about four years. While injection may seem to be a desirable way of handling the CBNG produced water, the available data indicate that the success of a given injection well venture cannot be guaranteed in the geologic

formations available in the Power River Basin region. Failures mean additional expense and land disturbance and injection wells can be expensive. Completed well costs in the shallow Fort Union Formation can be in the one hundred fifty thousand dollar range depending on depth while those drilling costs in the Lance/Fox Hills Formation can range around one million dollars. Unfortunately, the success ratio of disposal wells at these shallower depths has been limited, driving up overall produced water injection costs. An injection well in the Paleozoic Carbonates of the Powder River Basin at depths ~12,000 ft, drilled today, would cost in the neighborhood of five and one half million dollars, completed, with surface facilities. Dry hole drilling costs would comprise approximately 50% of the costs, completion 30%, and surface facilities just under 20%.

**Conclusions on the Technical Feasibility of CBNG Produced Water Reinjection as the Primary Water Management Option**

Reinjection of CBNG produced water into the coal seam being produced as a rule is not a reasonable option. The above referenced EIS, prepared by Montana resource managers and oversight agencies concur with this conclusion

Sequential production and reinjection of stacked coal seams is less efficient than simultaneous coal seam production. It is not preferable economically; especially if relatively thin coal seams are involved. The EIS prepared by the three above agencies encourages multiple seam production technology but otherwise shows no preference on which extraction mode should be utilized. Sequential production has the potential of causing leaseholder complications. The storage capacity of one or more of the produced seams may be altered during production.

The desirability of reinjection into an under-pressurized coal seam depends largely on whether that coal seam has an adequate hydraulic seal. However, the fact that the seam is under-pressured may be an indication that the hydraulic seal is inadequate and could allow injected water to flow into other formations, streams, or springs.

The geology of the shallow Fort Union and overlying sand formations generally make reinjection possibilities in those formations limited.

There appear to be limited systematic and successful approaches to reinjection into coal seams or injection into other formations of CBNG produced water in the Powder River Basin. Geology and other geotechnical factors limit options. These options must be considered on a case-by case basis. Nonetheless, when successful, reinjection or injection would at least in principle preserve the produced water for future use.

While some reinjection in the Montana and Wyoming Powder River Basins is feasible, the overall success is limited. The success rate, based on today's available data is less than 30%. The results of these 44 wells drilled indicate reinjection or injection options are generally limited in the Powder River Basin. Thus the proposed regulations would require roughly three injection wells drilled for one successful injection well with very substantial environmental disturbance in the form of surface disturbance, air emissions, noise, and vehicle traffic.

While produced water injection may be feasible in other geologic settings across the western oil and gas producing states, produced water injection must be considered on a case by case basis and feasibility will be controlled by water and gas volumes per well, infrastructure requirements, produced water quality, and regional geology. In some regional settings in Montana, injection will be feasible, but in most cases produced water injection opportunities currently appear to be geologically limited. It is therefore technically inappropriate, based on the current understanding of the subsurface geology, to identify injection as the primary disposal option for CBNG produced water in Montana.

**Waivers for CBNG Produced Water Injection**

New Rule III recognizes that there may not be suitable geologic formations available to receive some or all of the water to be injected. It allows operators to apply for a waiver under those circumstances. The proposed language reads:

> *NEW RULE III WAIVER FROM ZERO DISCHARGE REQUIREMENT*
> *(1) The department may grant a waiver from the zero discharge requirement if the owner or operator of a point source discharge of coal bed methane wastewater demonstrates by clear and convincing evidence to the department through site specific studies that the requirement is not technically feasible because estimated wastewater production rates exceed the estimated cumulative reinjection rates of all suitable geologic formations in the project area.*
> *(2) The department shall limit the waiver to the volume of methane wastewater for which the owner or operator shows that zero discharge is not technically feasible. The volume of methane wastewater for which the department grants a waiver from the zero discharge requirement shall be limited to the difference between estimated wastewater production rates and the estimated cumulative reinjection rates for all suitable geologic formation in the project area.*
> *(3) The department may limit the waiver to the initial phases of development when the volume of methane wastewater produced by wells is highest, which may make reinjection of all such water technically unfeasible.*
> *(4) The department may also grant a waiver from the zero discharge requirement if the EPA will not authorize the reinjection pursuant to a permit under the Safe Drinking Water Act (SDWA), 42 USC 300f to 300j-26(5). The operator shall attain zero discharge for the volume of methane wastewater for which the department does not grant a waiver.*

New Rule IV outlines the information that must be provided in the waiver application.

> *NEW RULE IV INFORMATIONAL REQUIREMENTS FOR WAIVER DETERMINATION (1) An owner or operator requesting a waiver from the zero discharge requirement for coal bed methane wastewater shall submit an application to the department for the department to make a determination on whether to grant the waiver.*
> *(2) The application shall include, but is not limited to, the following:*

*(a) a description and map of the coal bed methane project and project area showing the location of wells, pipelines, roads, compressors, and related infrastructure;*
*(b) a description of the surface owners in the project area;*
*(c) an estimate of pumping rates for coal bed methane wells in the target coal seams and an estimate of the volume of wastewater likely to be produced per well per year;*
*(d) for each targeted coal seam, data showing areas characterized by high concentrations of vertical fractures where wastewater production wells may be higher;*
*(e) an inventory and map of geologic formations, aquifers, and confining layers including significant fractures, fissures, and faults within the project area. The following information is required for each geologic formation and aquifer in the project area:*
*(i) lateral extent, thickness, and depth. Maps and cross sections indicating the vertical and lateral limits of each formation;*
*(ii) hydraulic properties including, but not limited to, transmissivity, storage coefficient, effective porosity, and hydraulic conductivity. The results of pump tests, analysis of core samples, and other geophysical studies;*
*(iii) water quality characterization including the geochemical compatibility of the receiving aquifer minerals with methane wastewater;*
*(f) an inventory and map of the locations of natural recharge in the project area and near the reinjection location;*
*(g) an inventory of the wells, springs, and seeps in the project area including pumping rates for wells. A tabulation of data on all wells within the project area including a description of each well's type, construction, date drilled, location, depth, record of plugging and/or completion, and any additional information known about the well;*
*(h) the results of ground water modeling showing the relationship and hydrologic connectivity of the identified geologic formations and aquifers, the effects of fractures, fissures, faults, and other significant geologic features on ground water movement in the project area;*
*(i) the results of pump tests of confining layers quantifying potential leakage through such layers;*
*(j) a description of all potentially suitable geologic formations for reinjection within the project area. For each such suitable geologic formation, the operator shall submit the following information:*

> *(i) the results of reinjection well testing;*
> *(ii) based upon the results of testing and other studies, an estimate of the short-term and long-term reinjection rates that each suitable geologic formation is capable of receiving;*
> *(iii) the results of ground water modeling showing the effects of reinjection into suitable geologic formations on other aquifers, surface waters, and regional flow systems; and*

*(k) all other information required by the EPA as part of the Class V UIC Program.*

*(3) The department shall notify the applicant in writing, within 60 days after receipt of an application for a waiver, that the application does or does not contain all the information necessary for the department to make a determination. If the information from the supplemental submittal or any subsequent supplemental submittal is inadequate, the department shall notify the applicant in writing, within 30 days of receipt of the supplemental submittal, what additional information must be submitted. The department shall notify the applicant in writing when the application is deemed complete.*

As discussed previously, zero discharge through reinjection will be technically and economically feasible well less than 30% of the time and therefore waivers for reinjection infeasibility will probably be the norm rather than the exception. As written, the proposed waiver process will be an extreme burden on both developers submitting the requests and the regulatory agencies having to review the numerous requests, which could severely curtail CBNG development and production.

The waiver information needed to show infeasibility for injection or reinjection as proposed are extremely cumbersome, expensive, and time consuming. They require data on all wells in the vicinity, local and regional ground water modeling, pump test data, and injection well data. The requirements are redundant, in that the same information is required for every injection well, even if in similar formations, regions, and similar conditions.

Overall, the proposed process needs to be significantly streamlined and more realistically follow accepted EPA guidelines for underground injection control and oil and gas produced water injection wells.

## 5. Proposed CBNG Produced Water Treatment and Discharge Standards

The proposal acknowledges that the geologic formations in reasonable proximity to the coal seams may not be able to accept all of the CBNG produced water that has been withdrawn, and therefore has allowed the waiver process, albeit through a lengthy and complicated application procedure. When a waiver is granted, the produced water discharge limits are intended to represent a level of treatment. New Rule VIII establishes the numerical water discharge standards for CBNG produced water that is not reinjected and is granted a waiver. The proposed language reads:

> *NEW RULE VIII TREATMENT-BASED EFFLUENT LIMITATIONS*
> *(1) If the department grants a waiver from the zero discharge requirement for all or a portion of the wastewater pursuant to [New Rules II and III], the amount of wastewater that obtains the waiver shall achieve the following minimum technology-based effluent limitations at the end of the pipe prior to discharge:*
> *(a) calcium average concentration between 0.1 mg/L and 0.2 mg/L;*
> *(b) magnesium average concentration between 0.1 mg/L and 0.6 mg/L;*
> *(c) sodium average concentration of 10 mg/L;*
> *(d) bicarbonate average concentration of 30 mg/L and instantaneous maximum concentration of 115 mg/L;*
> *(e) sodium adsorption ratio instantaneous maximum of 0.5;*
> *(f) electrical conductivity average concentration of 233 µmhos/cm;*
> *(g) total dissolved solids average concentration of 170 mg/L;*
> *(h) ammonia average concentration of 0.1 mg/L and instantaneous maximum concentration of 0.3 mg/L; and*
> *(i) arsenic concentration of <0.0001 mg/L.*

There are several major technical and environmental issues with these proposed effluent limits. These include:

- Inconsistent effluent treatment levels for various parameters,
- Water effluent levels that are far below commonly accepted water quality standards,
- Treatment levels that will create an effluent water quality that will negatively impact both aquatic species and irrigation in the region,
- Identification of treatment technologies that have not been fully demonstrated to meet the proposed effluent guidelines consistently in operational settings across the range of produced water qualities in the region, using recommended EPA technology cost and performance verification guidelines,
- the proposed treatment requirements could significantly increase environmental issues associated with waste disposal, and
- The proposed water quality standards are ambiguous in discussing minimum and maximum allowed levels.

Each of these major technical, environmental, and cost issues and concerns associated with the proposed produced water treatment guidelines are discussed below. For reference, Table 3 summarizes the proposed treatment standards, and compares them to several current effluent standards.

**Table 3. Comparison of Common Water Quality Standards with the Proposed Montana CBNG Treatment Standards**

| | Current MT Water Quality Standards | Proposed MT CBNG Effluent Standards | WY CBNG Produced Stds into Class II Water | EPA Aquatic Life Stds |
|---|---|---|---|---|
| Conductivity (μS/cm) | 2000-2500 | 233 | 7,500 | <21,000[a] |
| Ca (mg/L) | No Standard | 0.1-0.2 | No Standard | No Standard |
| Mg (mg/L) | No Standard | 0.1-0.6 | No Standard | No Standard |
| Na (mg/L) | No Standard | 10 | No Standard | No Standard |
| SAR | 5.0-7.5[b] | 0.5[c, d] | 10[e] | No Standard |
| Bicarbonate (mg/L) | No Standard | 30 average<br>115 maximum | No Standard | >20[f] |
| As (mg/L) | 0.15 average,<br>0.34 maximum | <0.0001 | No Standard | 0.15 (acute)<br>0.34 (chronic) |

[a] Based on primary source of dissolved solids from NaCl, reduce to 2900 if Ca, Mg, and K chlorides are present

[b] Monthly average SAR, depends on season

[c] Instantaneous maximum SAR

[d] Calculated SAR based on proposed Ca, Mg, and Na levels is 2.5 to 5.3

[e] Requires site–specific PR

[f] Criterion Continuous Concentration (CCC), chronic level for freshwater fish is 20,000 mg/L

**Inconsistent Treatment Limits of Various Parameters**

The two major inconsistencies are the treatment limits for EC and SAR. EC is based on the ionic concentrations of salts, such as the cations Ca, Mg, Na, and the anions Cl, sulfate, and carbonate, and other ions in water. Ca and Mg are the most common anions in fresh water, and removing Ca, Mg, and Na to the levels identified in the proposed standards will create an EC value much less than the 233 μS/cm level proposed.

Since there is a minimum value given for Ca and Mg, attaining a maximum value of SAR of 0.5 would violate these standards. The proposed maximum value for SAR of 0.5 can not be attained using the proposed average treatment standards for Na, Ca, and Mg. SAR is calculated as a ratio of the Na, Ca, and Mg ionic concentrations in water as shown below:

$$SAR = Na / [(Ca + Mg)/2]^{0.5}$$

*Where: Na, Ca, and Mg are in meq/L*

[a]The formula for calculating SAR, an explanation of milliequivalents vs. mg/L, and a handy SAR calculation tool are provided at: http://www.coopext.colostate.edu/TRA/PLANTS/index.html#http://www.colostate.edu/Depts/CoopExt/TRA/PLANTS/sar.html

As indicated in Table 3, the SAR range based on the proposed limits for Na, Ca, and Mg would be about 2.5 to 5.3. Therefore, several of the proposed treatment limits are inconsistent.

**Proposed Water Effluent Levels far below Accepted Water Quality Standards**

The extremely low effluent limits proposed could actually create water that could be detrimental to humans, animals, and the environment as discussed in detail below.

As shown in Table 1, some level of ions in water, such as Ca and Mg, are beneficial for most uses and therefore limits on these constituents are often not specifically controlled. Limits on these ions and salts is generally controlled through the development of EC or TDS levels, putting minimum and maximum levels on salts in a water. Common TDS criteria for drinking water consider Ca and Mg concentrations of 100 mg/L as appropriate and beneficial, with levels above 300 mg/L as near upper limits. Levels below this are not recommended because of the aggressiveness due to the resulting water's ability to leach heavy metals and toxic minerals into the water. In addition, the low alkalinity level will significantly reduce the buffering capacity of the water.

For irrigation purposes and livestock uses, Ca, Mg, and EC values can be significantly higher than for drinking water as shown Tables 1 and 4. Therefore, the proposed treatment standards for Ca and Mg of 0.1-0.6 mg/L, depending on the ion, are at least 1000 times below the generally accepted levels for drinking water and almost 10,000 times below the general levels appropriate for livestock and irrigation use.

The proposed arsenic treatment limit of less than 0.0001 mg/L is 100 times lower than the current arsenic standard of 0.010 mg/L for drinking water and over 1000 times lower than required for ecologic impacts. The proposed level cannot be accurately measured by current monitoring technology, and is lower than current technology treatment performance by a factor of ten.

**Table 4. General Livestock Water Quality Requirements**

| Conductivity (µS/cm) | Rating | Comments |
|---|---|---|
| <1,500 | Excellent | Usable for all classes of livestock and poultry. |
| 1,500 – 5,000 | Very Satisfactory | Usable for all classes of livestock and poultry. May cause temporary diarrhea in livestock not accustomed to such water; watery droppings in poultry. |
| 5,000 – 8,000[a] | Satisfactory for Livestock | May cause temporary diarrhea or be refused at first by animals not accustomed to such water. |
| | Unfit for Poultry | Often causes watery feces, increased mortality and decreased growth, especially in turkeys. |
| 8,000 – 11,000 | Limited Use for Livestock, unfit for Poultry | Usable with reasonable safety for dairy and beef cattle, sheep, swine and horses. Not acceptable for poultry. |
| 11,000 – 16,000 | Very Limited Use | In general, use should be avoided although older ruminants, horses, poultry and swine may subsist on waters such as these under certain conditions. |
| >16,000 | Not Recommended | Risks with such highly saline water are so great that it cannot be recommended for use under any conditions. |

[a] Water less than 5000 µS/cm is suitable for most livestock,

**Negative Environmental and Ecological Impacts of Proposed Water Quality Standards**

Treatment to the levels identified could be detrimental to the environment and ecology of the area. As mentioned above, treatment to the very low proposed levels of SAR of 0.5, EC of 233 µmhos/cm, and alkalinity of 30 mg/l will create water that is very aggressive and will tend to leach minerals and metals from the soil. This could impact downstream water quality and toxicity and have a negative impact on stream and river habitat. It will also have a potential negative impact on irrigation efficiency.

From a river and surface water ecology standpoint, EPA recommends water alkalinity of greater than 20 mg/L and up to 20,000 mg/L and an EC of about 2900 µS/cm for inland surface waters such as the Powder River Basin with high levels of Ca and Mg. Based on aquatic life parameters, the proposed treatment levels for both alkalinity and EC are substantially below the minimum recommended thresholds set by EPA and could be expected to negatively impact aquatic ecology. This is an issue in Wyoming where the Wyoming Department of Game and Fish has objected to the level of discharges of very low TDS water because of the impact on aquatic ecosystems in the region (Osborne and Adams 2005).

Treating the water to the required SAR and EC will negatively impact water infiltration in soils and negatively impact irrigation. As identified in Table 1, irrigation water quality with an EC of 500 to 3000 µS/cm can be appropriately used. As shown in Figure 2, treating the water to the identified SAR and EC values will create a water quality with very poor

infiltration characteristics, and therefore negatively impact irrigation efficiency. The information in Figures 2 and 3 suggest that significantly higher values of SAR and EC (a factor of ten or more) would be much more beneficial to irrigation efficiency without negatively impacting crop yields for most of the common crops in this region.

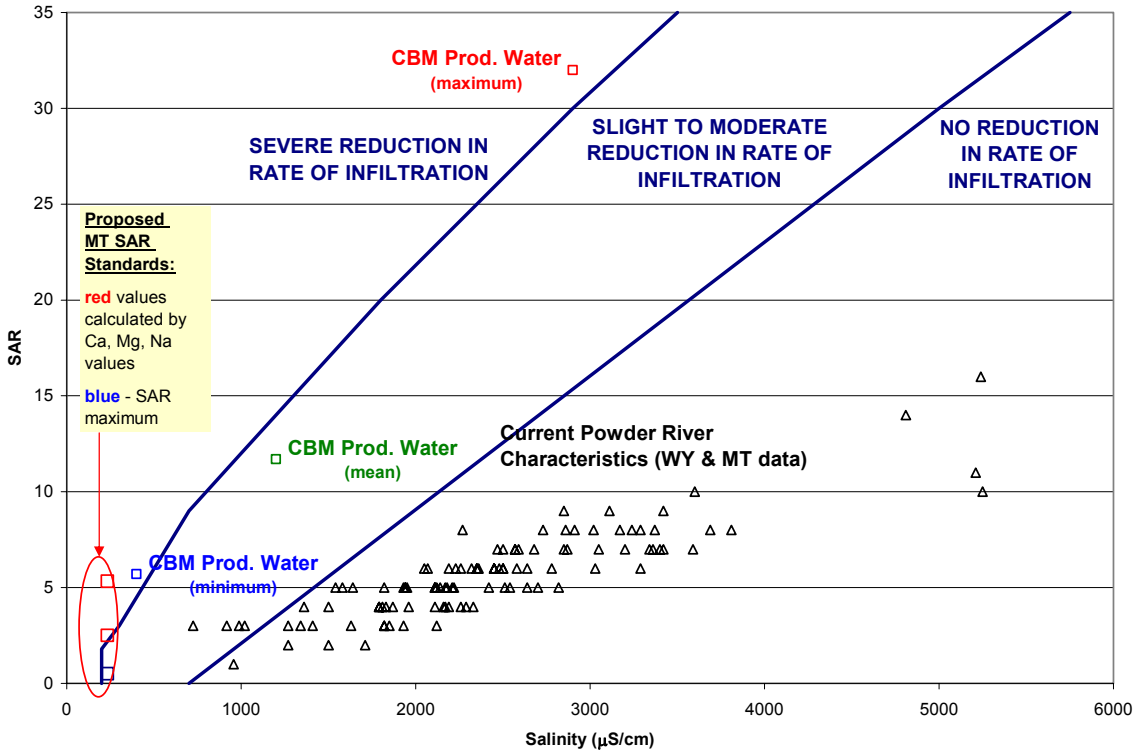


**Figure 2. Soil Infiltration Impact based on SAR and Salinity**
**(modified from Ayers and Westcott)**
**(CBM Produced Water and Powder River Characteristics from USGS)**

## Concerns with the Performance and Cost of the Proposed Water Treatment Technologies

To meet the proposed treatment guidelines, reverse osmosis and ion exhange were identified as the technologies recommended meeting the proposed "technology-based standards". Technology-based requirements must insure that the proposed technology is cost-effective, and economically, environmentally, and technologically feasible. Before a technology can be recommended for use, it must be demonstrated that the proposed treatment limits can be consistently met across the range of expected waste stream parameters and characteristics under typical field and operating conditions. While some data do exist on the evaluation of the performance of these technologies for some produced water treatment applications, these data are limited, and neither of the technologies identified has been evaluated fully following the current EPA guidelines for verification of the cost and performance data of innovative treatment technologies (EPA 1997).

The problems with verification of the cost and performance of the proposed treatment technologies is highlighted by the fact that the proposed treatment level identified for arsenic is a factor of ten lower than currently available technology performance.

From an economic and cost-effectiveness standpoint, the proposed technologies can be expensive. Table 5 provides better information on the expected costs of reverse osmosis treatment for brackish water. These are based on Bureau of Reclamation data discussed in the Desalting Handbook for Planners (BoR 2003). It provides a baseline for cost estimates for a small brackish water Reverse Osmosis (RO) plant with similar chemistry and disposal needs as the PRB. Pretreatment and other site-specific costs would have to be included. The values are based on a water gathering and treatment system to handle about one million gallons per day from about 96 CBNG wells.

**Table 5. Estimated PRB CBNG Produced Water Treatment Costs**

| Water Disposal Method | Water Disposal Costs | | |
|---|---|---|---|
| | Total Capital Costs[a] | Capital Costs/Well | O&M Costs/Bbl[b] |
| Active Treatment (RO) with pipelines, | $1-2 M | $10-20K | $0.13-0.16 |
| Injection Disposal of Concentrate | $1-2M | $10-20K | $0.05-0.10 |
| Trucking of Concentrate and Deep Disposal | $200-300K | $2-3K | $0.20- $1.00 |

[a] Includes building, equipment, water gathering, and infrastructure
[b] Assumes 320 bbl/day per well, 96 wells, during first 2 years of operation

The proposed treatment technologies, based on current practices, would generate large volumes of concentrate, approximately 10-20% of the water treated, that would have to be disposed. This will significantly increase the cost and impact of the proposed treatment processes and could have major impacts on the environment. Since injection disposal options are limited, other concentrate disposal options, such as trucking to a disposal site will be required. This could require extensive infrastructure including additional roads, storage tanks, and could generate significant tanker truck traffic. These will have negative impacts on the environment, landscape, and increase erosion, dust, and noise.

**Conclusions on Proposed CBNG produced water treatment and effluent discharge standards**

The proposed treatment standards for the CBNG produced water identify very low effluent levels for SAR, electrical conductivity, calcium, magnesium, sodium, and extremely low levels for arsenic. The levels identified in the proposal in many case are from 100 to 1000 times lower than recommended for appropriate concentrations.

The proposed treatment levels for SAR, EC, Ca, Mg, and Na, are ambiguous, inconsistent, and will create an effluent water quality that is not appropriate for drinking water or irrigation

use, is aggressive in picking up metals and soil constituents, and could have a negative impact to aquatic ecology and river and stream habitat.

The technologies identified have not been evaluated using EPA technology verification guidelines for developing cost and performance data on treatment technologies. Therefore, it is unknown whether the proposed treatment levels are technically feasible, cost effective, or consistently achievable across for the range of CBNG produced waters in the region. In the case of the arsenic treatment level it is doubtful that this level can be consistently met with current technology.

The treatment technologies identified, and the level of treatment needed to meet the proposed standards, will generate significant amounts of wastes that must be managed and could lead to unintended environmental impacts from handling and moving these waste streams. Therefore, a much broader approach to developing standards for handling, treating, and managing CBNG produced water should be considered. As written, the proposed effluent standards will have significant ecological, environmental, and cost impacts that were not fully considered.

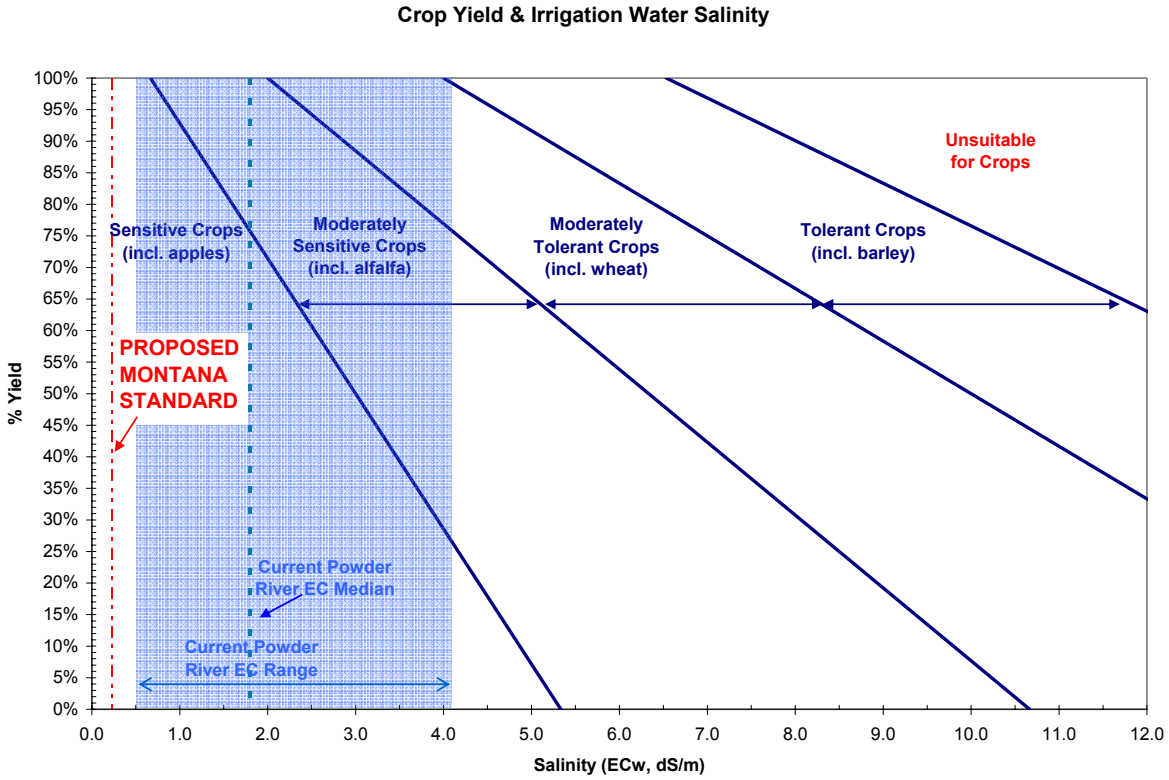


**Figure 3. Crop Yield and Irrigation Water Salinity (modified from Ayers and Westcott)**

# 6. PROPOSED LIMITS ON CBNG PRODUCED WATER MANAGEMENT OPTIONS

The proposal requires reinjection to suitable geologic formations wherever possible. When reinjection is not possible, and if the operator can make a successful waiver application, some or all of the CBNG produced water can be discharged as long as the effluent meets some very strict standards. With the exception of New Rule IX, which provides an exemption for CBNG water used for livestock watering, no other management options are permitted for CBNG water. Another portion of the proposal offers some degree of flexibility and relief, where applicable. New Rule IX allows some of the CBNG produced water to be used for livestock watering.

> *NEW RULE IX STOCK WATERING EXEMPTION (1) The requirements of [New Rules I through VIII] shall not apply to any quantity of wastewater used for stock watering purposes if all the following conditions are satisfied:*
>
> *(a) the surface owner and operator sign a written agreement to use the wastewater for stock watering purposes;*
>
> *(b) the wastewater is stored in a stock tank; and*
>
> *(c) the surface owner has obtained a beneficial use permit from the department of natural resources and conservation pursuant to Title 85, chapter 2, MCA.*
>
> *(2) The stock watering exemption shall be limited to the quantity of water for which the department of natural resources and conservation issues a beneficial use permit.*

This proposed restriction effectively precludes the direct use of CBNG water without treatment for many beneficial purposes. Some of these existing uses of CBNG produced water provide affordable produced water management to operators while providing direct benefits to landowners. For example, managed irrigation has proven successful in several Powder River Basin applications. In a recent paper, (Harvey et al. 2005) describes case studies of managed irrigation to reuse CBNG produced water in an ecologically sound manner without treatment.

Operators, land owners, and land management agencies may be interested in other uses such as off-channel impoundments that can provide livestock watering and recreational opportunities for landowners, use of water for industrial uses to offset fresh water demands, or other applications. The proposed provision also restricts the introduction of future innovative technologies for managing CBNG produced water in an environmentally and ecologically sound manner.

Water quality standards should incorporate the best available technology and allow for beneficial use of the CBNG water directly where possible. The CBNG produced water quality in the PRB is appropriate for a number of applications either with little or no treatment. As discussed in Tables 1 and 4, beneficial uses could include not only livestock watering, but irrigation, supplemental water for aquatic systems, and makeup water for other oil and gas industry uses such as drilling and completions, use by other industries such as electric power generation, or other purposes and should not be minimized nor ignored.

# 7. CONCLUSIONS

Electrical Conductivity (EC) and the Sodium Adsorption Ratio are not harmful parameters as the proposal relates but rather can be used to describe certain chemical properties of the CBNG produced water.

There appear to be limited systematic and successful approaches for produced water reinjection into coal seams or injection into other formations of CBNG produced water in the Powder River Basin. Geology and other geotechnical factors limit options. Moreover the success rate of establishing reinjection wells, based on today's available data, is less that 30%.

As written, the proposed waiver from zero discharge (Proposed New Rule III) process will be an extreme burden on both developers submitting the requests and the regulatory agencies having to review the numerous requests, which could severely curtail CBNG development and production.

Several major technical and environmental issues exist with the proposed new effluent limits which include:

- Inconsistent effluent treatment standards,
- Effluent levels far below commonly accepted water quality standards,
- Treatment levels that will create an effluent water quality that could negatively impact aquatic species and irrigation,
- Identification of treatment technologies that have not been fully demonstrated using recommended EPA technology cost and performance verification guidelines, and
- The treatment needed to meet the proposed standard will generate significant amounts of waste and waste water that must be managed.

The proposed limits on the use of innovative produced water management technologies also raise serious concerns.

- The proposed restrictions preclude the direct use of CBNG water without treatment for many beneficial purposes. Some of these existing uses of CBNG produced water provide affordable produced water management to operators while providing direct benefits to landowners.
- Operators, land owners, and land management agencies may be interested in other uses such as off-channel impoundments, use of water for power generation or industrial uses to offset fresh water demands, or other applications. The proposed provision restricts the introduction of future innovative technologies for managing CBNG produced water in an environmentally and ecologically sound manner.
- The CBNG produced water quality in the PRB is appropriate for a number of applications either with little or no treatment, thus, with water site-specific water analysis much of the CBNG produced water could be used for beneficial purposes.

# APPENDIX A

Proposed Changes to Montana Water Quality Regulations

As announced in September 2005
by the Board of Environmental Review
of the State of Montana

BEFORE THE BOARD OF ENVIRONMENTAL REVIEW
OF THE STATE OF MONTANA

| | | |
|---|---|---|
| In the matter of the amendment of ARM 17.30.670 and 17.30.1202 pertaining to nondegradation requirements for electrical conductivity (EC) and sodium adsorption ratio (SAR) and definitions for technology-based effluent limitations, and the adoption of new rules I through X pertaining to minimum technology-based controls and treatment requirements for the coal bed methane industry | ) ) ) ) ) ) ) ) ) ) ) | NOTICE OF PUBLIC HEARING ON PROPOSED AMENDMENT AND ADOPTION<br><br>(WATER QUALITY) |

TO: All Concerned Persons

1. On November 9, 2005, at 10:30 a.m., at the Lame Deer Charging Horse Casino, 1/2 Mile East Lame Deer Hwy. 212, Lame Deer, Montana; November 10, 2005, at 8:00 a.m., at Miles City Community College, Room 106, 2715 Dickinson, Miles City, Montana; and December 1, 2005, at 1:30 p.m., at the Metcalf Building, Room 111, 1520 East Sixth Avenue, Helena, Montana, the Board of Environmental Review will hold public hearings to consider the proposed amendment and adoption of the above-stated rules.

2. The Board will make reasonable accommodations for persons with disabilities who wish to participate in these public hearings or need an alternative accessible format of this notice. If you require an accommodation, contact the Board no later than 5:00 p.m., November 1, 2005, to advise us of the nature of the accommodation that you need. Please contact the Board Secretary at P.O. Box 200901, Helena, Montana 59620-0901; phone (406) 444-2544; fax (406) 444-4386; or email ber@mt.gov.

3. The rules proposed to be amended provide as follows, stricken matter interlined, new matter underlined:

17.30.670 NUMERIC STANDARDS FOR ELECTRICAL CONDUCTIVITY (EC) AND SODIUM ADSORPTION RATIO (SAR) (1) through (5) remain the same.

(6) ~~Changes in existing surface or ground water quality with respect to EC and SAR are nonsignificant according to the criteria in 75-5-301(5)(c), MCA, provided that the change will not have a measurable effect on any existing or anticipated use or cause measurable changes in aquatic life or ecological integrity.~~ EC and SAR are harmful parameters for the purposes of the Montana Water Quality Act, Title 75, chapter 5, MCA.

(7) For purposes of determining compliance with the water quality standards and nonsignificance criteria for all parameters of concern in ~~any new or increased~~ discharges ~~of unaltered ground water from coal bed methane development~~ of methane wastewater, the department shall determine ~~effluent or~~ compliance limits ~~(e.g., evaluate the design of disposal systems) by using a flow based analysis that considers a range of flows or monthly flow probability. With respect to EC and SAR, the department shall also use the median chemistry for the specified flow range or monthly flow~~ by using 7Q10 flows.

~~(8) If any of the provisions of (6) or (7), or both of them, are declared to be invalid, then the numeric water quality standards and requirements specified in (1) through (7) shall be void.~~

AUTH: 75-5-301, 75-5-303, MCA
IMP: 75-5-301, 75-5-303, MCA

17.30.1202 DEFINITIONS For the purposes of this subchapter, the following definitions apply:

(1) ~~"Board" means the Montana board of environmental review established by 2-15-3502, MCA.~~ "Average" means the highest allowable average of daily discharges over a calendar week, calculated as the sum of all daily discharges measured during a calendar week divided by the number of daily discharges measured during that week.

(2) ~~"Department" means the Montana department of environmental quality established by 2-15-3501, MCA.~~ "Coal bed methane extraction" means the extraction of methane gas from any coals or associated geologic formations.

(3) "Daily discharge" means the discharge of pollutants measured during a calendar day or any 24-hour period that reasonably represents the calendar day for purposes of sampling. The daily discharge is calculated as the average measurement of the pollutant over the day.

(3) and (4) remain the same, but are renumbered (4) and (5).

(6) "Geologic formation" means a body of rock characterized by a degree of lithologic homogeneity which is prevailingly, but not necessarily, tabular and is able to be mapped on the earth's surface or traceable in the subsurface.

(7) "Instantaneous maximum" means the maximum concentration measured in any single sample of the discharge effluent.

(8) "Methane wastewater" means water produced from coal bed methane extraction during exploration or development activities.

(5) remains the same, but is renumbered (9).

(10) "Project area" includes the entire geographic area leased by the operator or any person legally related to the operator for coal bed methane extraction.

(11) "Reinjection" means putting methane wastewater back into a suitable geologic formation.

(12) "Suitable geologic formation" means a geologic formation with water quality similar enough to that of the methane wastewater in the project area to ensure that, after reinjection of methane wastewater, the water of the receiving formation will remain suitable for the same beneficial uses as the methane wastewater.

(13) "Surface owner" means the person who holds record title to or has a purchaser's interest in the surface of the land.

AUTH: 75-5-305, MCA
IMP: 75-5-305, MCA

REASON: ARM 17.30.670 and 17.30.1202 are being amended for the following reasons:

ARM 17.30.670

The Board is proposing the amendment of ARM 17.30.670 in response to a petition filed by Northern Plains Resource Council, Tongue and Yellowstone Irrigation District, Surface Owners of the Wolf Mountains Area, Bear Creek Council, Stillwater Protective Association, Bull Mountain Land Alliance, Rosebud Protective Association, Dawson Resource Council, Carbon County Resource

Council, Bones Brothers Ranch, Muggli Brothers, Huggo Muggli Inc., Golder Ranch, Greenleaf Cattle Company, Rocker 6 Cattle Company, FL Ranch, and Fix Ranch (collectively referred to as "petitioners").

The petitioners are requesting that the Board amend ARM 17.30.670(6) to modify the nondegradation criteria applicable to electrical conductivity (EC) and sodium adsorption ratio (SAR); to amend ARM 17.30.670(7) to clarify that determining compliance with water quality standards and nondegradation thresholds for discharges of coal bed methane wastewater shall be done using 7Q10 flows; and to delete the non-severability clause in ARM 17.30.670(8).

The existing nondegradation criteria for EC and SAR are based upon a narrative criteria that provides: "changes in existing surface or ground water quality with respect to EC and SAR are nonsignificant . . . provided that the change will not have a measurable effect on any existing or anticipated use or cause measurable changes in aquatic life or ecological integrity." The petitioners argue that the narrative criteria effectively exempt methane discharges, including discharges from methane development in Wyoming, from the state of Montana's nondegradation policy. Montana's nondegradation policy is necessary to protect the existing water quality of the Tongue River from degradation from methane discharges in Montana and Wyoming. Montana's nondegradation policy will be critical to protect the existing water quality of rivers such as the Clark Fork of the Yellowstone, Rock Creek, Stillwater River, Flathead River, and the pristine streams of Park County if methane development occurs in these watersheds.

The proposed amendments also restore a conservative approach to determining compliance with numeric water quality standards and nondegradation thresholds by requiring the Department to require compliance at low flow events. The Department uses this conservative approach for all other dischargers. The methane industry should not be granted special treatment.

Since salinity, as measured by EC and SAR, is harmful to soils, vegetation, and aquatic life, the appropriate nondegradation criteria for EC and SAR are the criteria for harmful parameters. For harmful parameters, changes in existing water quality are considered nonsignificant, if the change is less than 10% of the applicable standard and the existing water quality in the receiving stream is less than 40% of the applicable standard. See ARM 17.30.715(1)(f). If a proposed discharge of EC and SAR will exceed the criteria for harmful parameters, then the permittee must request the Department to issue an authorization to degrade pursuant to 75-5-303, MCA.

ARM 17.30.1202

The definitions in ARM 17.30.1202 are being amended to add definitions that will be necessary to clarify the technology-based controls and treatment requirements the Board is proposing to adopt in New Rules I through X. The new definitions are being added to ARM 17.30.1202, because that rule contains the Board's existing definitions applicable to effluent limitations for point source discharges to surface waters.

4. The proposed new rules provide as follows:

NEW RULE I APPLICABILITY (1) The requirements of [New Rules II through IX] are applicable to those facilities engaged in exploration, drilling, production, and development in the coal bed methane industry.

AUTH: 75-5-305, MCA
IMP: 75-5-305, MCA

NEW RULE II ZERO DISCHARGE REQUIREMENT (1) Except as provided in [New Rules III through IX], point sources of methane wastewater shall achieve zero discharge of pollutants, which represents the minimum technology-based requirement. Zero discharge shall be accomplished by reinjection of methane wastewater into suitable geologic formations in the project area in compliance with all other applicable federal and state laws and regulations.

AUTH: 75-5-305, MCA
IMP: 75-5-305, MCA

NEW RULE III WAIVER FROM ZERO DISCHARGE REQUIREMENT

(1) The department may grant a waiver from the zero discharge requirement if the owner or operator of a point source discharge of coal bed methane wastewater demonstrates by clear and convincing evidence to the department through site specific studies that the requirement is not technically feasible because estimated wastewater production rates exceed the estimated cumulative reinjection rates of all suitable geologic formations in the project area.

(2) The department shall limit the waiver to the volume of methane wastewater for which the owner or operator shows that zero discharge is not technically feasible. The volume of methane wastewater for which the department grants a waiver from the zero discharge requirement shall be limited to the difference between estimated wastewater production rates and the estimated cumulative reinjection rates for all suitable geologic formation in the project area.

(3) The department may limit the waiver to the initial phases of development when the volume of methane wastewater produced by wells is highest, which may make reinjection of all such water technically unfeasible.

(4) The department may also grant a waiver from the zero discharge requirement if the EPA will not authorize the reinjection pursuant to a permit under the Safe Drinking Water Act (SDWA), 42 USC 300f to 300j-26(5). The operator shall attain zero discharge for the volume of methane wastewater for which the department does not grant a waiver.

AUTH: 75-5-305, MCA
IMP: 75-5-305, MCA

NEW RULE IV INFORMATIONAL REQUIREMENTS FOR WAIVER DETERMINATION (1) An owner or operator requesting a waiver from the zero discharge requirement for coal bed methane wastewater shall submit an application to the department for the department to make a determination on whether to grant the waiver.

(2) The application shall include, but is not limited to, the following:

(a) a description and map of the coal bed methane project and project area showing the location of wells, pipelines, roads, compressors, and related infrastructure;

(b) a description of the surface owners in the project area;

(c) an estimate of pumping rates for coal bed methane wells in the target coal seams and an estimate of the volume of wastewater likely to be produced per well per year;

(d) for each targeted coal seam, data showing areas characterized by high concentrations of vertical fractures where wastewater production wells may be higher;

(e) an inventory and map of geologic formations, aquifers, and confining layers including significant fractures, fissures, and faults within the project area. The following information is required for each geologic formation and aquifer in the project area:

(i) lateral extent, thickness, and depth. Maps and cross sections indicating the vertical and lateral limits of each formation;

(ii) hydraulic properties including, but not limited to, transmissivity, storage coefficient, effective porosity, and hydraulic conductivity. The results of pump tests, analysis of core samples, and other geophysical studies;

(iii) water quality characterization including the geochemical compatibility of the receiving aquifer minerals with methane wastewater;

(f) an inventory and map of the locations of natural recharge in the project area and near the reinjection location;

(g) an inventory of the wells, springs, and seeps in the project area including pumping rates for wells. A tabulation of data on all wells within the project area including a description of each well's type, construction, date drilled, location, depth, record of plugging and/or completion, and any additional information known about the well;

(h) the results of ground water modeling showing the relationship and hydrologic connectivity of the identified geologic formations and aquifers, the effects of fractures, fissures, faults, and other significant geologic features on ground water movement in the project area;

(i) the results of pump tests of confining layers quantifying potential leakage through such layers;

(j) a description of all potentially suitable geologic formations for reinjection within the project area. For each such suitable geologic formation, the operator shall submit the following information:

(i) the results of reinjection well testing;

(ii) based upon the results of testing and other studies, an estimate of the short-term and long-term reinjection rates that each suitable geologic formation is capable of receiving;

(iii) the results of ground water modeling showing the effects of reinjection into suitable geologic formations on other aquifers, surface waters, and regional flow systems; and

(k) all other information required by the EPA as part of the Class V UIC Program.

(3) The department shall notify the applicant in writing, within 60 days after receipt of an application for a waiver, that the application does or does not contain all the information necessary for the department to make a determination. If the information from the supplemental submittal or any subsequent supplemental submittal is inadequate, the department shall notify the applicant in writing, within 30 days of receipt of the supplemental submittal, what additional information must be submitted. The department shall notify the applicant in writing when the application is deemed complete.

(4) The application for a waiver submitted pursuant to this subchapter shall comply with the signature and certification requirements of ARM 17.30.1323. The board adopts and incorporates by reference ARM 17.30.1323, which sets forth signature and certification requirements for MPDES permit applications. Copies of ARM 17.30.1323 may be obtained from the Department of Environmental Quality, P.O. Box 200901, Helena, Montana 59620-0901.

AUTH: 75-5-305, MCA
IMP: 75-5-305, MCA

NEW RULE V DEPARTMENT PROCEDURES FOR MAKING WAIVER DETERMINATIONS

(1) Upon a determination by the department that an application submitted under [New Rule IV] is complete, the department shall prepare a preliminary decision approving or denying the waiver pursuant to the procedures in [New Rule VI].

(2) The department shall deny an application for a waiver unless the applicant has affirmatively demonstrated and the department finds, based on clear and convincing evidence, that reinjection is not technically feasible, using the standards set forth in [New Rule III]. The department shall consider an analysis by the applicant and any substantive relevant information either submitted by the public or otherwise available.

(3) The department shall make its preliminary decision either authorizing or denying the waiver within 180 days after receipt of a complete application from the applicant. This time period may be extended upon agreement of the applicant or whenever an environmental impact statement must be prepared pursuant to Title 75, chapter 1, parts 1 and 2, MCA.

(4) To the maximum extent possible, the department shall coordinate any application for a waiver with the permitting and approval requirements of other laws or programs administered by the department or by any other local, state, or federal agency.

AUTH: 75-5-305, MCA
IMP: 75-5-305, MCA

NEW RULE VI DEPARTMENT PROCEDURES FOR MAKING PRELIMINARY AND FINAL WAIVER DECISIONS (1) The department shall issue a preliminary decision either denying or authorizing a waiver from the zero discharge requirement and shall provide a 60-day public comment period prior to issuing a final decision. The department's preliminary and final decisions shall include the following:

(a) a description of the proposed coal bed methane project and project area;

(b) a determination of the estimated methane wastewater production rate for the project and the scientific basis supporting such determination;

(c) a determination of the reinjection rate for each suitable geologic formation, determination of the cumulative reinjection rate for all suitable geologic formations in the project area, and the scientific basis supporting such determinations;

(d) a determination that the waiver from the zero discharge requirement is necessary because estimated methane wastewater production rates exceed estimated cumulative reinjection rates for all suitable geologic formations in the project area or because the EPA will not authorize the reinjection pursuant to the SDWA;

(e) a determination of the volume of methane wastewater for which reinjection is not technically feasible (and thus a waiver is necessary) and the scientific basis supporting such determination;

(f) a detailed description of all the conditions applied to any waiver from the zero discharge requirement including, but not limited to, the conditions required in [New Rule III(2) through (4)], monitoring requirements, reporting requirements, limitations on the waiver granted, and methods for determining compliance with the waiver;

(g) a description of the procedures for reaching a final decision on the waiver including:

(i) the beginning and ending dates of the comment period and the address where comments will be received;

(ii) procedures for requesting a hearing and any other procedures by which the public may participate in the final decision; and

(iii) name and telephone number of a person to contact for additional information.

(2) The preliminary decision, accompanying a statement of basis, must be publicly noticed and made available for public comment for at least 30 days, but not more than 60 days, prior to a final decision. In providing public notice, the department shall comply with the following:

(a)procedures for public notice set forth in ARM 17.30.1372; and

(b) procedures for the distribution of information set forth in ARM 17.30.1041.

(3) During the public comment period, any interested person may submit written comments on the preliminary decision and may request a public hearing. A request for a public hearing must be in writing and must state the nature of the issues proposed to be raised at the hearing. The department shall hold a hearing if one is requested. Any public hearing conducted under this section is not a contested case hearing under the provisions of the Montana Administrative Procedure Act, Title 2, chapter 4, MCA.

(4) Within 60 days after the close of the public comment period, the department shall issue a final decision accompanied by a statement of basis for the decision and, if applicable, a statement of conditions. The final decision and statement of basis will be prepared according to the requirements of this section. In addition, the statement of basis for a final decision must include the following:

(a) which provisions, if any, of the preliminary decision have been changed in the final decision and the reasons for the change; and

(b) a description and response to all substantive comments on the preliminary decision raised during the public comment period or during any hearing.

(5) Upon issuing a final decision, the department shall notify the applicant and each person who has submitted written comments or requested notice of that decision. The notice must include reference to the procedures for appealing the decision.

(6) The final decision is effective 30 days after the service of notice of the decision unless:

(a) a hearing is requested pursuant to [New Rule VII], in which case the decision is effective 30 days after the final decision of the board; or

(b) no comments are received on the preliminary decision, in which case the decision is effective upon issuance.

(7) The board adopts and incorporates by reference ARM 17.30.1041, which sets forth requirements for distribution and copying of public notices and permit applications, and ARM 17.30.1372, which sets forth procedures for issuing public notices of MPDES permit applications and hearings. Copies of ARM 17.30.1041 and 17.30.1372 may be obtained from the Department of Environmental Quality, P.O. Box 200901, Helena, MT 59620-0901.

AUTH: 75-5-305, MCA
IMP: 75-5-305, MCA

NEW RULE VII REVIEW (1) An interested person wishing to challenge a final department decision may request a hearing before

the board within 30 days of the final department decision on a waiver. The contested case procedures of Title 2, chapter 4, part 6, MCA, apply to a hearing under this rule.

AUTH: 75-5-201, MCA
IMP: 75-5-201, 75-5-305, MCA

NEW RULE VIII TREATMENT-BASED EFFLUENT LIMITATIONS

(1) If the department grants a waiver from the zero discharge requirement for all or a portion of the wastewater pursuant to [New Rules II and III], the amount of wastewater that obtains the waiver shall achieve the following minimum technology-based effluent limitations at the end of the pipe prior to discharge:

(a) calcium average concentration between 0.1 mg/L and 0.2 mg/L;

(b) magnesium average concentration between 0.1 mg/L and 0.6 mg/L;

(c) sodium average concentration of 10 mg/L;

(d) bicarbonate average concentration of 30 mg/L and instantaneous maximum concentration of 115 mg/L;

(e) sodium adsorption ratio instantaneous maximum of 0.5;

(f) electrical conductivity average concentration of 233 µmhos/cm;

(g) total dissolved solids average concentration of 170 mg/L;

(h) ammonia average concentration of 0.1 mg/L and instantaneous maximum concentration of 0.3 mg/L; and

(i) arsenic concentration of <0.0001 mg/L.

AUTH: 75-5-305, MCA
IMP: 75-5-305, MCA

NEW RULE IX STOCK WATERING EXEMPTION (1) The requirements of [New Rules I through VIII] shall not apply to any quantity of wastewater used for stock watering purposes if all the following conditions are satisfied:

(a) the surface owner and operator sign a written agreement to use the wastewater for stock watering purposes;

(b) the wastewater is stored in a stock tank; and

(c) the surface owner has obtained a beneficial use permit from the department of natural resources and conservation pursuant to Title 85, chapter 2, MCA.

(2) The stock watering exemption shall be limited to the quantity of water for which the department of natural resources and conservation issues a beneficial use permit.

AUTH: 75-5-305, MCA
IMP: 75-5-305, MCA

NEW RULE X SEVERABILITY (1) If any provision of [New Rules II through IX] is determined to be invalid or unenforceable, such provision shall be fully severable and the other provisions thereof shall remain in full force and effect. The remaining provisions shall be liberally construed to carry out the provisions of this subchapter.

AUTH: 75-5-305, MCA
IMP: 75-5-305, MCA

REASON: Why Minimum Technology-Based Controls and Treatment Requirements are Necessary

The Board is proposing the adoption of New Rules I through X to establish minimum technology-based controls and treatment requirements for the coal bed methane industry in response to a petition filed by Northern Plains Resource Council, Tongue and Yellowstone Irrigation District, Surface Owners of the Wolf Mountains Area, Bear Creek Council, Stillwater Protective Association, Bull Mountain Land Alliance, Rosebud Protective Association, Dawson Resource Council, Carbon County Resource Council, Bones Brothers Ranch, Muggli Brothers, Huggo Muggli Inc., Golder Ranch, Greenleaf Cattle Company, Rocker 6 Cattle Company, FL Ranch, and Fix Ranch (collectively referred to as "petitioners").

The minimum technology-based controls and treatment requirements proposed by the petitioners are a combination of "zero discharge" and treatment-based effluent limitations. The effluent limitations proposed by the petitioners will prohibit the discharge of wastewater by requiring reinjection into suitable geologic formations unless the operator can demonstrate that site-specific geologic conditions make zero discharge technically unfeasible. To the extent zero discharge is not technically feasible because of site-specific geologic limitations, the rules impose effluent limitations at the end of the pipe prior to discharge based upon existing treatment technologies such as ion exchange or reverse osmosis.

The reasons for adopting minimum technology-based controls and treatment requirements for the coal bed methane industry are stated in the petition and are summarized as follows:

1. Currently, there are no technology-based treatment requirements for the coal bed methane industry adopted by the U.S. Environmental Protection Agency (EPA) under the federal Clean Water Act (CWA). Since the Board has the authority to adopt treatment requirements for a particular industry when EPA has failed to do so, the petitioners have requested the Board to initiate rulemaking to establish technology-based controls and treatment requirements for discharges from the coal bed methane industry. See 75-5-305(1), MCA.

2. The purpose of the treatment requirements is to require coal bed methane operators to use the best available technology that will minimize the discharge of wastes and make substantial progress toward the ultimate national goal of eliminating the discharge of all pollutants.

3. The reason for requiring reinjection of all coal bed methane wastewater into suitable geologic formations (unless re-injection is technically unfeasible) is to maximize the volume of water that will be put back into aquifers from which it was taken. This requirement will alleviate the draining of aquifers and the drying up of wells and springs that are used by petitioners.

4. The reason that water must be reinjected into "suitable geologic formations" (i.e., aquifers with water of similar quality to coal bed methane wastewater) is to ensure that the water resource is available for beneficial use in the future. For this reason, reinjection into deep geologic formations that are considered Class II wells under the Safe Drinking Water Act's Underground Injection Control (UIC) program is not allowed under the rules because the water quality in those formations typically will not qualify as being "suitable geologic formations."

5. The reason for adopting technology-based effluent limits for discharges of coal bed methane wastewater to surface water is to ensure that treatment to a minimum level is used on the volume of methane wastewater that cannot be reinjected due to technical infeasibility.

The Board's Authority to Adopt Minimum Treatment Requirements

Under 75-5-305(1), MCA, the Board may adopt minimum treatment requirements for an industry when there are no federally promulgated treatment requirements for the industry. Prior to adopting such requirements, the Board must ensure that: (1) the technology-based standards address parameters that "are likely to affect beneficial uses;" and (2) the technology-based requirements are "cost-effective and economically, environmentally, and technologically feasible." The petitioners' scientific, economic, and technical basis for the Board's adoption of minimum treatment requirements are described in the Petition and are summarized as follows:

1. Parameters that are likely to affect beneficial uses

The proposed new rules will establish effluent limitations for the following parameters found in methane wastewater: Sodium adsorption ratio (SAR) and its individual constituents (sodium, magnesium, and calcium); salinity as measured by electrical conductivity (EC); ammonia; bicarbonate; total dissolved solids (TDS); and arsenic. All of these parameters are likely to affect beneficial uses of surface waters.

Specifically, high levels of salinity, as measured by EC and SAR, may adversely impact native soils, native vegetation, and irrigated crops. Water with high salinity levels causes changes in soil structure that make water less available to plants and, at very high levels, can directly harm or kill plants. The EC levels of methane wastewater have a high salinity hazard with a mean value of between 2000-2300. The SAR value affects plant production by reducing the permeability of soils and slowing water infiltration. This lower availability of water reduces plant productivity. The SAR level of methane wastewater is high with a mean value of 34 to 51. Soils with high clay content or with poor drainage are most vulnerable to these impacts.

Salinity levels (EC) can also adversely impact aquatic life. During the 2003 rulemaking process, the Montana Department of Fish, Wildlife, and Parks raised these concerns.

Bicarbonate can also be harmful to aquatic life. Methane discharges from Fidelity’s CX Field are characterized by bicarbonate concentrations of between 1400-1600 mg/L.

Ammonia is listed as a toxic pollutant in Montana's Water Quality Standards. Ammonia can pose acute and chronic toxicity to aquatic life at extremely low levels. Methane discharges are characterized by ammonia concentrations averaging 2.0 mg/L.

2. Technological feasibility of the treatment requirements

(a) Reinjection

Reinjection of methane wastewater is a widespread control technique in many geologic basins, including the Wyoming portion of the Powder River Basin. The methane industry employs two types of reinjection. Where the water quality of the methane wastewater has extremely high salinity levels and is not suitable for any beneficial uses, the wastewater is reinjected into deep geologic formations through Class II injection wells under the Safe Drinking Water Act (SDWA), 42 USC 300f to 300j-26, Underground Injection Control (UIC) program. Where the water quality of the methane wastewater has lower salinity levels and is marginally suitable for some beneficial uses, the wastewater is reinjected into shallower

geologic formations through Class V injection wells under the UIC program. The purpose of the UIC program is to protect aquifers from the adverse impacts of reinjection and to protect aquifers that serve as sources of drinking water.

In the San Juan Basin of Colorado almost 100% of methane wastewater is reinjected to deep geologic formations through Class II injection wells. In the West Uinta Basin of Utah, approximately 97% of the methane wastewater is reinjected to deep geologic formations through Class II injection wells. In the Raton Basin of Colorado, approximately 30% of methane wastewater is reinjected to deep geologic formations through Class II injection wells. In the Raton Basin of New Mexico, 100% of methane wastewater is reinjected to deep geologic formations through Class II injection wells including methane development on Ted Turner's Vermejo Ranch.

In the Wyoming portion of the Basin, there are approximately 160 active reinjection wells of the approximately 324 permitted by WDEQ, most of which are shallow Type V injection wells. The WDEQ has drafted three general permits authorizing reinjection. According to John Passehl (Personal Communication April 15, 2005), the Program Principal of UIC program at WDEQ, about 25 companies have done reinjection including Anadarko, JM Huber, Bill Barrett, Continental Industries, Devon, Double Eagle, Marathon, McCartney, Merritt, Northwestern, Petrox, Prima, and Wolverine. Nance Petroleum is reinjecting wastewater from its methane operations into shallow sandstone formations just south of the Montana board in Hanging Woman Basin, a tributary of the Tongue River.

Achieved reinjection rates are highly dependent on site-specific conditions and vary widely within a range of 12 to 117 gpm per reinjection well. Currently approximately 150,000 gallons/day/well is being reinjected. The WDEQ limits reinjection to aquifers with the same classification as methane wastewater to ensure the water remains suitable for beneficial use.

(b) Reverse Osmosis

Reverse osmosis is used to treat methane wastewater in the San Juan and Raton Basins of Colorado. The WDEQ has approved one NPDES permit requiring treatment using reverse osmosis prior to discharge. The EPA issued a permit requiring reverse osmosis treatment of methane wastewater on the Southern Ute Indian Reservation (NPDES Permit COG-075000). Encana Oil and Gas, Inc. is also using reverse osmosis to treat methane wastewater in Colorado, Permit No. COG-600633, Colorado Water Quality Control Division, Department of Public Health and Environment.

Devon Energy has submitted an application with Region 8 of the EPA for a NPDES permit for 5-15 pilot projects on the Wind River Indian Reservation and is proposing to use reverse osmosis. The EPA is currently drafting the NPDES permit.

Hydrometrics, Inc., has demonstrated a system by which 95% of treated water may be discharged to the surface as usable quality water. The company uses a Weak Acid Cation Resin treatment as part of their "High Efficiency Reverse Osmosis" (HERO) process to treat methane wastewater to remove major cations, anions, and trace constituents.

(c) Ion Exchange Technology

Several companies in the Wyoming portion of the Basin are using Higgins Loop and Emit ion exchange technology to treat methane wastewater prior to discharge.

The Montana Department of Environmental Quality recently approved a MPDES permit for Powder River Gas, LLC, which intends to implement ion exchange treatment technology prior to discharging to the Tongue River. Fidelity has proposed using a similar ion exchange technology to treat wastewater prior to discharge into the Tongue River. Ion exchange technology is capable of reducing sodium levels to less than 0.5 mg/L and SAR levels to below 0.1. The treatment technology is capable of reducing EC levels to about 233 µmhos/cm and total dissolved solids to about 170 mg/L.

In summary, reinjection into suitable geologic formations to the maximum extent feasible based on site-specific conditions and treatment of the remaining wastewater prior to discharge is technologically feasible. As demonstrated above, reinjection and treatment are being employed by methane operators in the Basin of Montana and Wyoming and other geologic basins in the West.

3. Economic feasibility

Reinjection and treatment is not only economically feasible, but also profitable for the methane industry. Assuming a gas price of $3.61 Mcf, methane companies will still earn a 23%-36% return on investment in Montana when reinjecting wastewater into suitable shallow geologic formations to meet the zero discharge requirement. If an operator obtains a limited waiver from the zero discharge permit requirement because reinjection of 100% of the wastewater is not technically feasible, and uses a combination of shallow reinjection wells to meet the zero discharge requirement and reverse osmosis technology to treat the volume of wastewater, the operator will still earn a 27%-31% return on investment in Montana. While cost data on ion exchange treatment technology are not available from the industry, use of such technology is clearly profitable for the industry given the fact that Powder River Gas, LLC, is currently using the technology in Montana and Fidelity has proposed using it.

The petitioners rely upon the EPA Region VIII draft economic analysis for several control and treatment options being considered for the coal bed methane industry, including zero discharge through reinjection and reverse osmosis treatment technology. See Petition, Exhibit C, "Guidance for Developing Technology-Based Limits for Coal bed Methane Operations: Economic Analysis of the Powder River Basin". The EPA document was prepared using economic and engineering data provided by the methane industry. The EPA report assesses economic impacts on the methane industry caused by implementing technology-based requirements in terms of impacts to economically recoverable methane reserves, number of projects developed in the basin, and royalties and taxes generated. Where applicable primary source information was available in the draft document, it was used.

The EPA Report found that wellhead gas price had a significant effect on the economic impact of technology-based effluent limitations. The EPA assessed the economic impacts of the methane industry assuming a conservative wellhead price of $1.75 Mcf. The average wellhead price between 1986-1999 was $2.05 per Mcf. The EPA estimated an equilibrium wellhead price of $2.72 per Mcf. The average realized well head price in 2001 was $4.12 per Mcf. The Department of Energy conservatively predicts a wellhead price of $2.88 per Mcf in 2005 and $3.29 in 2010 Mcf. In recent years, realized wellhead prices in the Basin have exceeded $5.00 Mcf.

At a conservative well head price of $1.75 Mcf, the Petitioner's estimate that methane production in the basin will generate almost $30 billion in profits to the industry. If the wellhead price of gas remains above $1.75, the predicted economic

impacts on methane industry will be significantly less than those predicted by EPA.

4. Environmental Feasibility

The proposed rules establish minimum treatment requirements that minimize the degradation to the environment compared to other disposal methods typically used for coal bed methane wastewater. See next section.

5. Other Alternatives to the Proposed Control and Treatment Requirements Considered by the Petitioners

Alternatives to the requirements to reinject CBM wastewater into Class V wells as a means to achieve zero discharge have been rejected for the following reasons:

a. Reinjection into Class II wells would make it impossible for farmers and ranchers to use the reinjected water due to the expense of drilling and operating deep wells. In addition, the CBM water would likely become contaminated by the much worse water quality found in most deep geologic formations.

b. Evaporation pits were eliminated as a means to achieve zero discharge due to the loss of the water resource to future generations and the fact that such impoundments disturb large areas that would need to be reclaimed.

c. In-channel impoundments using infiltration and evaporation as a means of disposal were rejected because such impoundments could result in unauthorized discharges to surface waters resulting from impoundment failure or overflow and would also cause saline seep.

d. Off-channel impoundments using infiltration and evaporation as a means of disposal were rejected because such impoundments would capture natural surface runoff, interfere with the hydrological cycle, and cause impacts to vested water rights.

e. Land application of CBM wastewater was rejected because such disposal methods could adversely impact soil structure, kill native vegetation, contaminate shallow aquifers, and increase salt loading to nearby streams through return flows.

5. Concerned persons may submit their data, views or arguments, either orally or in writing, at the hearings. Written data, views or arguments may also be submitted to the Board Secretary at Board of Environmental Review, 1520 E. Sixth Avenue, P.O. Box 200901, Helena, Montana, 59620-0901; faxed to (406) 444-4386; or emailed to ber@mt.gov, no later than 5:00 p.m., December 2, 2005. To be guaranteed consideration, mailed comments must be postmarked on or before that date.

6. The Board of Environmental Review will preside over and conduct the hearings.

7. The Board maintains a list of interested persons who wish to receive notices of rulemaking actions proposed by this agency. Persons who wish to have their name added to the list shall make a written request that includes the name and mailing address of the person to receive notices and specifies that the person wishes to receive notices regarding: air quality; hazardous waste/waste oil; asbestos control; water/wastewater treatment plant operator certification; solid waste; junk vehicles; infectious waste; public water supplies; public sewage systems regulation; hard rock (metal) mine reclamation; major facility siting; opencut mine reclamation;

strip mine reclamation; subdivisions; renewable energy grants/loans; wastewater treatment or safe drinking water revolving grants and loans; water quality; CECRA; underground/above ground storage tanks; MEPA; or general procedural rules other than MEPA. Such written request may be mailed or delivered to the Board Secretary at Board of Environmental Review, 1520 E. Sixth Ave., P.O. Box 200901, Helena, Montana 59620-0901; faxed to (406) 444-4386; emailed to ber@mt.gov; or may be made by completing a request form at any rules hearing held by the Board.

8. The bill sponsor notice requirements of 2-4-302, MCA, do not apply.

Reviewed by: BOARD OF ENVIRONMENTAL REVIEW

*John F. North* BY: *Joseph W. Russell*
JOHN F. NORTH JOSEPH W. RUSSELL, M.P.H.,
Rule Reviewer Chairman

Certified to the Secretary of State September 26, 2005.

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10 William Hochheiser, Manager
Oil and Gas Environmental Research
U.S. Department of Energy
Office of Fossil Energy (FE-30)
1000 Independence Ave. SW
Washington, DC 20585

Sandia National Laboratories