ANL/EVS/R-06/2

Observations on a Montana Water Quality Proposal

prepared by
Environmental Science Division
Argonne National Laboratory

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Observations on a Montana Water Quality Proposal

for
U.S. Department of Energy
National Energy Technology Laboratory

by
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TABLE OF CONTENTS

TABLES

FIGURES

Executive Summary

During the fall of 2005, the Montana Board of Environmental Review (BER) announced proposed changes to the Montana water quality regulations. The proposal, which was based on a petition from the Northern Plains Resource Council, was directed toward discharges of water from coal bed natural gas (CBNG) production. The proposed regulations, if adopted in their current form, are likely to substantially reduce the amount of CBNG 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.

The U.S. Department of Energy (DOE) reviewed the BER proposal and believed that the proposal could restrict CBNG production in Montana and Wyoming. To aid in the review of the proposal, DOE asked two of its national laboratories — Argonne National Laboratory and Sandia National Laboratories — to prepare written evaluations on various aspects of the proposal. This report contains Argonne's review and observations on the proposal.

The proposal inconsistently characterizes the value of CBNG produced water. In some places, the proposal refers to it as "wastewater" and emphasizes that some of its constituents are "hazardous parameters." In other places, the proposal acknowledges the water's value in both quantity and quality and implements measures to ensure that the water is available for future beneficial use. This inconsistency is misleading.

The Clean Water Act (CWA) allows the U.S. Environmental Protection Agency (EPA) to delegate National Pollutant Discharge Elimination System (NPDES) authority to states. Montana applied for and received the authority to administer the federal NPDES program. To administer the NPDES program, the state uses regulations that either adopt EPA's regulations directly by reference or it has promulgated similar and consistent state regulations. The proposal does not follow the CWA guidelines for establishing technology-based limits. The most notable excursion from the guidelines is the proposal's attempt to force the use of just one or two specific technologies. The BER is within its rights to require zero discharge, assuming that it can show that appropriate water management alternatives are available and affordable. However, the BER may not specify the type of technology that must be used to achieve zero discharge. In addition to the procedural issues raised by the proposal, this strategy effectively blocks the opportunity for other beneficial and innovative technologies to be used.

The proposal includes numerical technology-based effluent limits. They are very stringent, and no detailed rationale is provided to explain why they were selected. Traditional methods to evaluate best available technology economically achievable (BAT) and best professional judgment (BPJ) technology-based limits were not followed. BAT is not a specific technology but rather is the performance that can be produced by properly operated "BAT model technology." BAT limits are not set at the level of performance of one or a few particularly well-operated treatment facilities on a good day or at the theoretical level of performance claimed by an equipment manufacturer. Rather they reflect the performance of multiple facilities using proper technology in actual industrial circumstances over a long period of time. Typically, statistical calculations are used to determine appropriate average and maximum limits. BPJ limits are expected to follow similar procedures to those that EPA uses to establish BAT.

The proposal and the petition make various claims about the affordability of reinjection and treatment to achieve the proposed limit as they relate to the overall wellhead price of natural gas. Some of these cost estimates were derived from a 2003 draft EPA study that has never been released. Relying on data from an unpublished report is not a sound basis for setting new stricter regulations. Further, the BER and the petitioners appear to have overlooked the fact that the draft EPA study evaluates the cost of achieving a different, and much less stringent, set of discharge standards from those required by the proposal. The cost for treating water or wastewater increases as the target treatment standards are made more stringent. Thus the costs estimated by the draft EPA report underestimates the actual costs that would be associated with meeting the proposal's strict limits, and therefore are not fully relevant as rationale for supporting new limits.

The proposed effluent limits are much stricter than necessary to meet water quality standards in Montana water bodies. If the proposal had properly demonstrated that these strict limits represented BAT, they could be employed. The proposal does not make such a demonstration, and therefore the limits appear to be unnecessarily stringent. For several of the parameters in the proposed effluent limits (calcium, magnesium, sodium, bicarbonate, and total dissolved solids or TDS), there are no water quality standards. For the other parameters that do have water quality standards, the proposed effluent limits are far stricter than water quality standards in all cases. In other words, dischargers must treat to levels significantly cleaner than the receiving waters.

The proposal contains several apparent logical inconsistencies. First, the proposal calls for "<u>minimum</u> technology-based effluent limitations" [emphasis added]. The proposed numerical limits are most likely intended to be maximum limits, not minimum limits. Second, for several parameters, the average concentrations must be kept within a range (e.g., the calcium average concentration must be between 0.1 mg/L and 0.2 mg/L. There is no apparent reason to set a "minimum" standard as a range, nor is there any reason to limit concentrations to a range. Under this provision, a calcium average of either 0.08 mg/L or 0.3 mg/L is out of compliance. Third, the proposed limits create an internally inconsistent situation. The sodium adsorption ratio (SAR) is calculated by a formula that combines sodium, calcium, and magnesium. If the proposed average effluent limits for each of these parameters are entered into the SAR equation, they result in SAR values of 2.5 to 5.3. The proposed SAR effluent limit is 0.5 maximum. Thus it appears that discharges complying with the three component parts of the SAR equation will still be in violation of the SAR limit.

Introduction

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 included almost the exact language found in the petition, was directed toward discharges of water from coal bed natural gas (CBNG) production. The key elements of the proposal included:

1. 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.

2. When operators can demonstrate the injection is not feasible, the CBNG water to be discharged must meet very strict technology-based limits for multiple parameters.

3. The Montana water quality standards for the sodium adsorption ratio (SAR) and electrical conductivity (EC) would be evaluated using the 7Q10 flow (lowest 7-consecutive-day flow in a 10-year period) rather than a monthly flow that is currently used.

4. SAR and EC would be reclassified as “harmful parameters,” thereby greatly restricting the ability for CBNG discharges to be allowed under Montana’s nondegradation regulations.

The proposed regulations, if adopted in their current form, are likely to substantially reduce the amount of CBNG 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.

Purpose of This Report

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 restrict CBNG production in Montana and Wyoming. To aid in the review of the proposal, NETL asked two other DOE 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 water treatment and engineering and hydrologic and geologic technical issues.

This report represents Argonne’s review and observations. The main themes of these comments include:

- Does the proposal consider CBNG produced water as an undesirable pollutant or as a valued resource?

- Did the BER proposal adequately follow federal Clean Water Act (CWA) authority and guidance concerning technology-based effluent limits?

- Does the proposal preclude the use of other innovative or beneficial technologies?

- Are the proposed discharge standards stricter than needed to meet Montana water quality standards?

The rationale included with the proposal for making the proposed changes is not very specific or detailed. The language in the proposal is taken nearly word-for-word from the petition, but the petition is longer and provides more details for the proposed actions. We therefore reviewed the petition as well, and much of the discussion in this report is based on statements and positions contained in the petition.

1. CBNG Produced Water: Undesirable Pollutant or Valued Resource?

The proposal is not consistent in how it views CBNG produced water. It characterizes the water in different ways to support different portions of the proposed revisions. It suggests that CBNG is wastewater and contains harmful properties when attempting to make the water quality standards and nondegradation requirements more stringent. Yet when the proposal pushes for reinjection of the CBNG produced water whenever practicable, it treats the water as a valuable commodity for current and future purposes.

Some of the revisions included in the proposal are geared toward emphasizing that CBNG produced water is an undesirable substance with deleterious properties. Two examples are shown below:

> *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.*

and

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

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

In the first example, the term “harmful parameter” leads to stricter consideration under the Montana nondegradation regulations, but more directly, a “harmful parameter” sounds much more dangerous or sinister than a parameter without the “harmful” designator. The parameters EC and SAR are not inherently harmful. EC is a measure of the level of dissolved materials or salinity in a water sample. It does not measure a specific or single chemical substance that could be construed as harmful. SAR is calculated by a ratio of sodium, calcium, and magnesium. The Montana Numeric Water Quality Standards, as listed in *Circular WQB-7*, do not contain any standards for sodium, calcium, or magnesium. None of the three individual chemicals are individually listed as harmful parameters.

Neither EC nor SAR is harmful under all or even most situations. It is impossible to make a determination of risk or harm without establishing a specific context. Both parameters, like most other water quality parameters, have little or no effect at some level, but begin to pose a risk to aquatic life, humans, plants, and/or soils at a higher level. In other words, EC and SAR can be present at safe levels, intermediate levels, and undesirable levels. The magnitude of specific values in relation to the threshold between low risk and high risk is the key in determining whether the parameters are harmful or not.

In the second example, the term “wastewater” carries a different connotation than “produced water” or “unaltered ground water from coal bed methane development.” The latter term is used to describe the substance in question in the existing BER regulations. Clearly, the petition and likewise the proposal are trying to send a message that the water brought to the surface during CBNG production is a waste stream.

The previous examples indicate that the proposal seems to treat the CBNG produced water as an undesirable substance that is “wastewater” and contains “harmful parameters.” However, the proposal is not consistent in that characterization. The following excerpt from the proposal suggests that the water withdrawn during CBNG production represents a beneficial material that should not be discharged and lost from the state’s water resources.

> *REASON: Why Minimum Technology-Based Controls and Treatment Requirements are Necessary*
>
> *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."

The rationale expressed in BER's Item 3 is that the CBNG produced water has value for its volume. The proposal suggests that, wherever technically feasible, the water should be reinjected into suitable geologic formations. The rationale also suggests that wells and springs currently in use by petitioners would be affected by withdrawing and discharging the CBNG produced water from the coal seams. This particular point is not documented by specific examples; in fact, most of the potable and irrigation water supplies in the region are taken from depths shallower than the depths at which the coal seams are located.

The rationale expressed in Item 4 goes even further, suggesting that the CBNG produced water has value as a future beneficial resource. Although not specifically stated in Item 4, if the water is anticipated to have a future beneficial use, its current quality must be clean enough that it could be used either "as is" or after treatment with some readily available and affordable technology. To further emphasize this perspective, New Rule IX of the proposal permits some of the CBNG water to be reused for livestock watering.

2. Proper Consideration of CWA Authority and Guidance Relating to Technology-Based Discharge Limits

The proposal does not follow the CWA guidelines for establishing technology-based limits. The most notable excursion from the guidelines is the proposal's attempt to force the use of just one or two specific technologies. The BER is within its rights to require zero discharge, assuming that it can show that appropriate water management alternatives are available and affordable. However, the BER may not specify the type of technology that must be used to achieve zero discharge. The proposal includes numerical technology-based effluent limits. They are very stringent, and no detailed rationale is provided to explain why they were selected. Traditional methods to evaluate best available technology economically achievable (BAT) and best professional judgment (BPJ) technology-based limits were not followed.

The following sections describe the federal legal requirements concerning technology-based limits, the relationship between federal and Montana laws and regulations, the language used in the proposal to establish technology-based limits, and how the proposal differs from the federal requirements.

A. Background

The CWA established the framework for regulating wastewater discharges through the National Pollutant Discharge Elimination System (NPDES) program. The U.S. Environmental Protection Agency (EPA) was given authority to establish regulations for the program using the general guidelines in the CWA. States can be delegated as authorities to administer the NPDES program if they can demonstrate that they have adequate state laws and regulations to equal or exceed the NPDES requirements.

Some of the features of the CWA and the NPDES program that are relevant to the BER proposal include:

- All point source discharges of wastewater made to surface water bodies must be authorized by NPDES permits. Discharges made to other places (e.g., land surface via irrigation, underground injection, evaporation) are not subject to federal NPDES permits. Underground injection activities are regulated under a separate federal program (the Underground Injection Control, or UIC, program) that can also be delegated to able and willing states. Some states have developed separate state groundwater discharge permit programs.

- Irrigation return flows to surface water bodies are exempted from needing NPDES permits. Nevertheless, they can have a water quality impact and may be controlled through water quality programs other than through NPDES where necessary. Irrigation return flows are made to some of the rivers in the region.

- Permits must contain numeric limits for parameters of concern. The limits are calculated using both a technology basis and a water quality basis; whichever basis results in stricter limits for each pollutant is used in the permit.

- The CWA directs EPA to establish effluent limitations guidelines (ELGs) for most major industrial sectors. Where these are available, they are used as the national minimum technology-based limits. Although EPA has developed ELGs for the oil and gas industry and the coal mining industry, it has never developed ELGs specific to discharges of CBNG produced water.

- For industries or specific waste streams for which ELGs have not been developed by EPA, the permit writer is expected to establish appropriate technology-based limits by using BPJ. The NPDES regulations describe the types of features that must be considered in a BPJ determination. The BER proposal uses a BPJ process to establish a "state-equivalent ELG."

Additional detail on several of these topics is provided in the following sections.

B. Equivalence of Federal and Montana Regulations

Federal NPDES provisions and requirements are identical to those in Montana for most or all of the relevant sections. Montana applied for and received authority to administer the NPDES program in its state waters. The Montana Water Quality Regulations, Subchapter 13, cover the Montana Pollutant Discharge Elimination System (MPDES permits). Section 17.30.1303 (incorporations by reference) of those regulations describes the strong equivalence between the federal NPDES and the state MPDES regulations. Many of the regulations are incorporated word-for-word through reference.

(1) In accordance with the federal Clean Water Act, this subchapter of Title 17, chapter 30, establishes a permit system (MPDES) which is essentially the equivalent of the federal permit system (NPDES) administered by the EPA.
(2) In view of the federal Clean Water Act's requirement of equivalence with the federal permit system, and in order to simplify the rulemaking process and make the rules less cumbersome, the department has relied heavily upon incorporation and adoption by reference of federal requirements as set forth in Title 40 of the Code of Federal Regulations (CFR) and in the federal Clean Water Act, 33 USC 1251, et seq.
(3) Where the department has adopted a federal regulation or statute by reference, the following shall apply:

> *(a) References in the federal regulations to "administrator", "regional administrator", or "US environmental protection agency", or the like, should be read to mean "department".*
> *(b) Where the department incorporates by reference a subpart of a federal regulation, both the subpart and its constituent sections and subsections are also incorporated by reference.*

(4) All of the incorporations by reference of federal agency regulations listed in the table in (7) of this rule shall refer to federal agency regulations as they have been codified in the July 1, 1991, edition of Title 33 and 40 of the Code of Federal Regulations (CFR).

Section 17.30.1344 (establishing limitations, standards, and other permit conditions) lists specific EPA regulations relevant to permit limits that are incorporated by reference.

(1) In addition to the conditions established under ARM 17.30.1342, 17.30.1343, 17.30.1346, 17.30.1350, and 17.30.1351, each MPDES permit must include conditions meeting the requirements stated in 40 CFR 122.43, 122.44, 124.56 and 124.57 (July 1, 1991).

(2) The board hereby adopts and incorporates herein by reference (see ARM 17.30.1303 for complete information about all materials incorporated by reference):

> *(a) 40 CFR 122.43 (July 1, 1991), which is a federal rule that establishes applicable permit conditions in general;*
> *(b) 40 CFR 122.44 (July 1, 1991), which is a federal agency rule setting forth additional permit conditions which may be applicable to a point source. Such conditions include technology-based and water-quality-based standards, toxic and pretreatment standards, reopener clause, reporting and monitoring requirements, permit duration and reissuance, test methods, best management practices, conditions concerning sewage sludge, privately owned treatment works, and conditions imposed in EPA grants to POTW's;*
> *(c) 40 CFR 124.56 (July 1, 1991), which describes requirements for fact sheets;*
> *(d) 40 CFR 124.57 (July 1, 1991), which describes the public notice that must be provided for draft permits;*
> *(e) 40 CFR chapter 1, subchapter N, (July 1, 1991), which sets forth federal effluent limitations and standards and new source performance standards;*
> *(f) 40 CFR Part 125 (July 1, 1991), which states standards and criteria for the national point discharge elimination system;*

(12) The board hereby adopts and incorporates herein by reference (see ARM 17.30.1303 for complete information about all materials incorporated by reference):

> *(a) 40 CFR 122.44(j)(2), which is a federal agency rule setting forth a requirement for the submittal by a publicly owned treatment work (POTW) of a local pretreatment program;*
> *(b) 40 CFR 122.45(b)(2)(ii)(A), which is a federal agency rule setting forth the availability of alternate permit limitations, standards, or prohibitions based on varying production levels;*
> *(c) 40 CFR 136, which is a series of federal agency rules setting forth guidelines for testing procedures for the analysis of pollutants;*
> *(d) 40 CFR 125.3, which is a federal agency rule setting forth technology-based treatment requirements for point source dischargers;*

C. Technology-Based Limits

Having shown the similarity between the federal and Montana laws and regulations regarding water quality and permitting, we now review the federal basis for requiring and establishing technology-based limits. The first citation of importance is CWA Section 301 (b)(2)(A):

> *(2)(A) for pollutants identified in subparagraphs (C), (D), and (F) of this paragraph,[1] effluent limitations for categories and classes of point sources, other than publicly owned treatment works, which (i) shall require application of the best available technology economically achievable for such category or class…*

Best available technology economically achievable is often abbreviated as BAT; consequently, the "economically achievable" modifier may be overlooked. It is important to understand that EPA must select as the basis for BAT a technology that is already in use in a particular industry (or sometimes in a related industry) with a proven long-term track record of performance under the conditions associated with the type of discharge in question. Furthermore, the technology has to be affordable.

EPA's NPDES regulations include the mandate for technology-based limitations at Section 122.44 (establishing limitations, standards, and other permit conditions):

> *In addition to the conditions established under Sec. 122.43(a), each NPDES permit shall include conditions meeting the following requirements when applicable.*
> *(a)(1) Technology-based effluent limitations and standards based on: effluent limitations and standards promulgated under section 301 of the CWA, or new source performance standards promulgated under section 306 of CWA, or case-by-case effluent limitations determined under section 402(a)(1) of CWA, or a combination of the three, in accordance with Sec. 125.3 of this chapter.*

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[1] These are all pollutants other than biological oxygen demand, suspended solids, fecal coliform, and pH, which are classified as conventional pollutants and are subject to best conventional technology standards.

EPA explains the ways in which technology-based limits can be developed in 40 CFR 125.3 (c):

> *(c) Methods of imposing technology-based treatment requirements in permits. Technology-based treatment requirements may be imposed through one of the following three methods:*
> *(1) Application of EPA-promulgated effluent limitations developed under section 304 of the Act to dischargers by category or subcategory….*
> *(2) On a case-by-case basis under section 402(a)(1) of the Act, to the extent that EPA-promulgated effluent limitations are inapplicable. The permit writer shall apply the appropriate factors listed in Sec. 125.3(d) and shall consider:*
> *(i) The appropriate technology for the category or class of point sources of which the applicant is a member, based upon all available information; and*
> *(ii) Any unique factors relating to the applicant.*
> *[Comment: These factors must be considered in all cases, regardless of whether the permit is being issued by EPA or an approved state.]*
> *(3) Through a combination of the methods in paragraphs (d) (1) and (2) of this section.*

The CWA does not specifically mention BPJ limits, but EPA uses the general provisions of CWA Section 402 (a)(1)(B) as its justification to require BPJ:

> *(a)(1) Except as provided in sections 318 and 404 of this Act, the Administrator may, after opportunity for public hearing, issue a permit for the discharge of any pollutant, or combination of pollutants, notwithstanding section 301(a), upon condition that such discharge will meet either (A) all applicable requirements under sections 301, 302, 306, 307, 308 and 403 of this Act, or (B) prior to the taking of necessary implementing actions relating to all such requirements, such conditions as the Administrator determines are necessary to carry out the provisions of this Act.*

CWA Section 304(b)(2)(B) outlines the factors that EPA must consider when developing BAT standards in formal ELGs:

> *(B) specify factors to be taken into account in determining the best measures and practices available to comply with subsection (b)(2) of section 301 of this Act to be applicable to any point source (other than publicly owned treatment works) within such categories of classes. Factors relating to the assessment of best available technology shall take into account the age of equipment and facilities involved, the process employed, the engineering aspects of the application of various types of control techniques, process changes, the cost of achieving such effluent reduction, non-water quality environmental impact (including energy requirements), and such other factors as the Administrator deems appropriate*;

These are echoed in EPA's NPDES regulations at 40 CFR 125.3 (d), which explain the procedures that must be used by permit writers to establish BPJ limits:

> *(d) In setting case-by-case limitations pursuant to Sec. 125.3(c), the permit writer must consider the following factors:*

(3) For BAT requirements:

(i) The age of equipment and facilities involved;
(ii) The process employed;
(iii) The engineering aspects of the application of various types of control techniques;
(iv) Process changes;
(v) The cost of achieving such effluent reduction; and
(vi) Non-water quality environmental impact (including energy requirements).

D. What Is BAT and How Is It Expressed?

Section C describes what factors should be considered when establishing BAT requirements. It does not describe how BAT is actually expressed. This section provides some discussion on what BAT is and how it should be expressed. BAT limits are not set at the level of performance of one or a few particularly well-operated treatment facilities on a good day or at the theoretical level of performance claimed by an equipment manufacturer. Rather they reflect the performance of multiple facilities using proper technology in actual industrial circumstances over a long period of time.

EPA develops ELGs by reviewing entire industrial categories and processes. EPA determines which technology or group of treatment processes most closely reflects the criteria for BAT. This technology is considered to be the "BAT model technology." EPA then evaluates the long-term performance of that technology and uses a statistical method to estimate the level of performance that a well-operated facility employing the BAT model technology could achieve under actual industrial conditions. EPA recognizes that even well-operated facilities do not perform at exactly the same level day after day and seasonally. Thus the statistical method considers the degree of variability inherent in the production and treatment processes. The key point here is that BAT is the *level of performance* achievable by the model technology, not the specific treatment process, equipment, or steps that make up the model technology. In other words, BAT is expressed in terms of a performance (e.g., 20 mg/L) rather than as a process (e.g., reverse osmosis).

EPA's ELG program has collected data from thousands of different facilities for more than 30 years. Within a particular industry, it may review data from a few to hundreds of facilities. Often the data from each facility contain long-term records over months to years. EPA has found that many sets of effluent data constitute a lognormal distribution. This looks much like the typical normal distribution (i.e., the bell curve — see Figure 1 in Appendix A), but the lognormal distribution has a much longer and flatter tail on the high end (see Figure 2 in Appendix A). This pattern is reflective of treatment systems that perform within reasonable boundaries most of the time but which experience occasional high values that cause the upper edge of the distribution to extend outward and flatten out.

In many of its ELG evaluations, EPA has chosen to use the 95th percentile of the lognormal distribution as the average BAT limit and the 99th percentile as the maximum BAT limit. EPA has used some sophisticated statistics to describe key values of the lognormal distribution. An abbreviated version of this method is shown in Appendix A. This was developed by the lead author of this paper while managing the State of Maryland's industrial NPDES permit program in 1987.[2] That procedure was used by Maryland NPDES permit writers from 1987 until at least 1990, when he left the agency.

E. The Distinction between BAT and BPJ

Section D describes BAT. While the term BAT is often used generically to describe any sort of technology-based limits, BAT as an acronym for *best available technology economically achievable* is correctly used only in the context of EPA's national ELGs. Any other effort to develop technology-based limits or standards, while comparable, should be called BPJ. A permit writer or, in this case, a state regulatory agency, can develop technology-based limits that reflect the criteria for BAT limits, but the limits themselves are correctly characterized as BPJ limits. This is not a critical issue for the BER proposal, but this section is added for additional clarification.

F. The Proposal's Version of Technology-Based Limits

Having reviewed and described the federal requirements for establishing BAT and BPJ technology-based limits in Sections C, D, and E, we now examine how the proposal establishes technology-based limits. The treatment-based effluent limitations (i.e., technology-based limits) contained in the BER proposal are shown below. New Rule II requires zero discharge of CBNG produced water and directs that the water be reinjected to a suitable geologic formation.

> *<u>NEW RULE II ZERO DISCHARGE REQUIREMENT</u> (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.*

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

> *<u>NEW RULE III WAIVER FROM ZERO DISCHARGE REQUIREMENT</u>*
> *(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.*

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[2] Lead author John Veil worked for the State of Maryland Department of Natural Resources, Office of Environmental Programs, and then the Department of the Environment from 1980 to 1990. During those 10 years, he wrote about 200 industrial NPDES permits. For most of that time, he managed Maryland's industrial NPDES program and reviewed more than 1,000 NPDES permits. He wrote and revised some of Maryland's water pollution control and NPDES regulations. From 1988 to 1990, he also managed Maryland's UIC and oil control programs.

> *(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.

New Rules V and VI (not reprinted here) describe the administrative steps that the Montana Department of Environmental Quality (DEQ) must follow in reviewing and deciding upon a waiver application. The length of time needed to go through the steps can be in excess of one year before a final decision is reached, and can be even longer if an interested party requests a hearing on the application.

New Rule VIII establishes numerical discharge standards (BPJ limits comparable to BAT limits) for that portion of the CBNG produced water that cannot be reinjected and is granted a waiver.

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.*

The rationale provided in the proposal is not very extensive. Even the rationale in the petition is not particularly detailed. It appears that the requirement to reinject 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. BER 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 discharge limits are intended to represent a minimum level of treatment.

One other 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.*

G. Comparison of the Proposal to EPA Technology-Based Limits Procedures

As previously noted at the start of the discussion of Item 2, the proposal does not follow the CWA guidelines for establishing technology-based limits. In this section, the technology-based requirements contained in the proposal are compared with the federal requirements for establishing BAT and BPJ technology-based limits. Discrepancies from the federal requirements are noted in several key portions of the proposal. The economic justification for the limits is based on a draft report that estimates costs for a much less stringent set of discharge standards than those required in the proposal. Furthermore, the proposal contains several apparent logical inconsistencies and drafting errors that would make the proposal difficult to administer and enforce.

As a first step, the proposal imposes zero discharge. EPA has previously established BAT as zero discharge for some waste streams in its ELGs when it can make a compelling case that zero discharge is affordable and available to an industry. When EPA makes a zero discharge decision, it identifies at least one affordable and available alternative method for managing the effluent. However, in lead author Veil's extensive NPDES experience (see footnote 2), neither EPA nor a delegated state tells dischargers exactly what technology or management must be used to achieve zero discharge. As explained in Section D above, BAT is a level of performance not a treatment technology.

In contrast, the proposal not only requires zero discharge without a compelling justification but goes further to direct generators of CBNG produced water to reinject whenever possible. We are not aware of any justification for the injection mandate in the CWA, the NPDES regulations, or in the Montana regulations. We believe that this requirement oversteps the BER's authority. The injection requirements go even farther out-of-bounds by specifying the type of geologic formations into which the water must be injected.

The requirement to inject into a suitable geologic formation could introduce a shift in regulatory resources. If the CBNG produced water is discharged into Montana surface waters, the Montana DEQ will issue the permit and incur the administrative burden. On the other hand, if water generators are forced to inject into what presumably are shallow aquifers, the regulatory burden will shift to the EPA's Region 8 office because Montana does not have delegated authority for the UIC Class V program.

The second step of the proposal allows potential dischargers to apply for a waiver to the extent they can demonstrate that the suitable geologic formations either are not available nearby or do not have the porosity or other capacity-related properties to receive the water. Osborne and Adams (2005) recently reported that many of the shallow aquifers in the Powder River Basin do not readily accept injected water.[3] Earlier attempts to reinject CBNG produced water have had only limited success to date. It might be possible to enhance injection by injecting at very high pressures. However, EPA prohibits injection pressures that exceed the fracture pressure when injecting into Class I and Class V wells.

The rationale in the proposal uses the example of CBNG production in the San Juan Basin of New Mexico. In that basin, most of the CBNG produced water is reinjected. However, the water is much saltier than that found in most of the Powder River Basin. It is not amenable to beneficial reuse without expensive treatment. In the San Juan Basin, the CBNG is injected into deep formations where it cannot be readily retrieved. The San Juan Basin example is not similar to the Powder River Basin and should not be used to justify a dissimilar water management approach.

If a CBNG produced water generator wants to apply for a waiver, the application informational requirements outlined in New Rule IV are very complicated and rigorous. Assuming that the operator can cost-effectively compile appropriate information to justify a waiver, the review process is quite lengthy, possibly lasting for more than one year. The individual steps are shown

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[3] Osborne, T.J., and J.E. Adams, 2005, "Opportunities and Limitations of CBNG Produced Water Management Alternatives in the Powder River Basin," presented at the 12th International Petroleum Environmental Conference, Houston, TX, November 7–11.

in Table 1. Three steps, identified by A, B, and C in the table, have undetermined length and could extend the waiver approval process even longer.

Table 1 – Steps and time line for Montana DEQ review of waiver application

Step	Maximum Days for this Step	Cumulative Days
Application submitted	0	0
DEQ notifies applicant of completeness or incompleteness	60	60
If incomplete, applicant provides supplemental information	A (time needed to prepare and resubmit material)	60+A
DEQ notifies applicant of completeness	30	90+A
DEQ prepares preliminary decision	180	270+A
If EIS is needed	B (time needed to conduct EIS)	270+A+B
Public comment period	60	330+A+B
If hearing is requested, hearing is scheduled and held	C (time needed to schedule and hold hearing)	330+A+B+C
DEQ issues final decision	60	390+A+B+C
Final decision becomes effective	30	420+A+B+C

The Montana DEQ staff may not have the necessary resources to review and make decisions on numerous waiver applications in a timely manner, thereby adding to the length of the review schedule. Operators are likely to be reluctant to undertake projects when the regulatory outcomes are uncertain and will not be known for a year or more.

In the third step of the proposal, operators that have made a successful waiver application may discharge if they can meet the effluent limits outlined in New Rule VIII. This part of the proposal contains several apparent drafting errors. First, the proposal calls for "minimum technology-based effluent limitations" [emphasis added]. The numerical limits in (1) (a) – (i) are most likely intended to be maximum limits, not minimum limits. Second, for several parameters, the average concentrations must be kept within a range (e.g., the calcium average concentration must be between 0.1 mg/L and 0.2 mg/L. There is no apparent reason to set a "minimum" standard as a range, nor is there any reason to limit concentrations to a range. Under this provision, a calcium average of either 0.08 mg/L or 0.3 mg/L is out of compliance.

Of greater concern are the actual numerical values that have been established for each parameter. Neither the proposal nor the petition explains how the numerical values were selected. The proposal does not identify any one model BAT technology but suggests that the limits can be achieved cost-effectively by both reverse osmosis and ion exchange. Either technology can achieve a wide range of results depending on the concentrations in the influent stream and how the system is operated and maintained. For example, different types of ion exchange resins are available that will yield different performance. The frequency of backwashing, replacement of resins, and the nature of pretreatment steps all contribute to how well the system will perform and how costly the treatment process will be. This is not reviewed in the proposal or in the petition.

Another consideration is the conditions under which the system must operate over the long term. Most systems will perform more effectively and consistently when they are situated in an environment that is sheltered from temperature and other climatic swings. A reverse osmosis system in a heated factory building is likely to perform better than a comparable system left outside at an exposed field site. In Section D above, the importance of long-term treatment performance and its inherent variability were discussed in relation to establishing valid BAT limits. The proposal offers no evidence that it considered either long-term performance variability at one facility or the variability from one facility to another when setting technology-based limits.

Section C above outlined the factors that EPA needed to consider when developing BAT limits. The same factors apply to BPJ limits that are set either by permit writers for individual permits or for this proposal as it sets BPJ limits for an entire category of effluent. The proposal offers limited discussion of these factors. Table 2 shows the factors and how they relate to several types of possible technology. There are many other approaches for managing CBNG produced water that have pros and cons. They are not shown in Table 2, but may be useful in certain site-specific cases. Examples of approaches that have been used can be found in ALL Consulting (2003)[4] and Veil et al. (2004).[5]

The proposal and the petition make various claims about the affordability of reinjection and treatment to achieve the proposed limit as they relate to the overall wellhead price of natural gas. Some of these cost estimates were derived from a 2003 draft EPA study[6] that was clearly marked "InterAgency Draft Report — DO NOT QUOTE OR CITE" on each page. EPA has never released that report; therefore, it is inappropriate to use the cost figures contained therein as the basis for supporting new regulations. There are at least two more recent reports that provide better-justified cost estimates. One was prepared by CDM in December 2004,[7] and the other report, prepared by Advanced Resources International, was released in January 2006.[8]

A related economic issue that appears to have been overlooked is that the draft EPA study as well as the CDM and DOE studies evaluate the cost of achieving a different, and much less stringent, set of discharge standards from those required by the proposal. The cost for treating water or wastewater increases as the target treatment standards are made more stringent. Thus the costs estimated by the cited reports underestimate the actual costs that would be associated with meeting the proposal's strict limits, and therefore are not fully relevant as rationale for supporting new limits.

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[4] ALL Consulting, 2003, "Handbook on Coal Bed Methane Produced Water: Management and Beneficial Use Alternatives," prepared by ALL Consulting for the Ground Water Protection Research Foundation, U.S. Department of Energy, and U.S. Bureau of Land Management, July.

[5] Veil, J.A., M.G. Puder, D. Elcock, and R.J. Redweik, Jr., 2004, "A White Paper Describing Produced Water from Production of Crude Oil, Natural Gas, and Coal Bed Methane," prepared by Argonne National Laboratory for the U.S. Department of Energy, National Energy Technology Laboratory, January, 87 pp.

[6] U.S. Environmental Protection Agency, 2003, "Guidance for Developing Technology-Based Limits for Coalbed Methane Operations: Economic Analysis of the Powder River Basin," draft, February.

[7] CDM, 2004, "Technical Review and Analysis of Kuipers'/NPRC Documents Related to the Management of CBNG Produced Water in the Powder River Basin," prepared for the Petroleum Association of Wyoming, December 21.

[8] Bank, G.C., and V.A. Kuuskraa, 2006, "The Economics of Powder River Basin Coalbed Methane Development," prepared for U.S. Department of Energy by Advanced Resources International, January.

Table 2 – Comparison of CBNG produced water management technologies in relation to the CWA factors for technology-based limits

BAT/BPJ Factor	Shallow Reinjection	Discharge after Treatment per Proposal	Deep Reinjection	Discharge after Less Stringent Treatment	Managed Irrigation
Age of equipment and facilities	New – not an issue	New – not an issue	New – not an issue	New – not an issue	New – not an issue
Process employed	Not technically possible in many locations; waiver provision is complicated and lengthy	May not be technically possible to meet the limits	Not technically possible in some locations	Process is possible if limits are based on actual long-term performance	Process is technically feasible
Engineering aspects of control technologies	Not technically possible in many locations	May not be technically possible to meet the limits	Not technically possible in all locations	Possible if limits are based on actual long-term performance	Requires careful oversight and management
Process changes	Need to look for suitable geologic formations to inject water; need to avoid formations that would impede CBNG recovery	Would not be able to produce CBNG if the water cannot be treated	Need to find formations to inject water	Need to construct and operate treatment system	Need to manage irrigation and provide chemical supplements
Cost	Cost of drilling and operating injection wells is medium to high, but may not be able to find suitable formations	If the technology is even possible, it is likely to have a high cost	Cost of drilling and operating injection wells is medium to high	Medium to high – depends on limits	Medium, but landowners see a benefit through enhanced crop yield
Non-water quality environmental impacts (including energy)	Injection may require fracturing of rocks; may require pretreatment before injection; some energy cost for injection	Loss of part of the water for future use unless it is subsequently taken out of the river; some will infiltrate; need to manage disposal of blowdown/ concentrate stream	Loss of water for future recovery; may require pretreatment before injection; some energy cost for injection	Loss of part of the water for future use unless it is subsequently taken out of the river; some will infiltrate; need to manage disposal of blowdown/ concentrate stream	Water is beneficially reused; some energy costs for irrigation; need to haul large amounts of chemical supplements

The proposed limits create an internally inconsistent situation. The SAR is calculated by a formula that combines the milliequivalents of sodium, calcium, and magnesium.[9] If the proposed average effluent limits for each of these parameters are entered into the SAR equation,

[9] 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.

they result in SAR values of 2.5 to 5.3. (The SAR is expressed here as a range because the calcium and magnesium limits are both expressed as a range.) The proposed SAR effluent limit is 0.5 maximum. Thus it appears that discharges complying with the three component parts of the SAR equation will still be in violation of the SAR limit. This presents an unreasonable regulatory burden.

3. Does the Proposal Preclude the Use of Other Innovative or Beneficial Technologies?

The proposal precludes the use of water management options other than reinjection, discharge following treatment to very strict standards, or use for stock watering with special permission. The proposal would also restrict the introduction of any future innovative technologies for managing CBNG produced water.

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. This intentional restriction of regulatory and management options effectively precludes the use of CBNG water for many beneficial purposes. Some of the existing uses of CBNG produced water provide affordable management for operators while providing direct benefit to landowners. For example, managed irrigation has proven successful in some Powder River Basin applications. In a recent paper, Harvey et al. (2005) describe several case studies of managed irrigation to beneficially reuse CBNG produced water.[10] Operators may be interested in other uses such as off-channel impoundments that can provide livestock watering and recreational opportunities for landowners. The wording of the proposal would not allow these valid and beneficial uses of water nor would it encourage development of more cost-effective water management technologies.

4. Are the Proposed Discharge Standards Stricter Than Needed to Meet Montana Water Quality Standards?

The proposed effluent limits are much stricter than necessary to meet water quality standards in Montana water bodies. Dischargers must treat to levels significantly cleaner than the receiving waters.

The proposal appears to blur the distinction between technology-based limits and water-quality-based limits. Technology-based limits ignore the potential impact on water quality and are only concerned with the performance of one or more technologies. Thus, it is inappropriate to justify a technology-based limit by saying it is necessary to achieve water quality. Water-quality-based limits, on the other hand, ignore the availability and cost of technology and rely solely on what is needed to protect water quality. In some situations, technology-based limits will be stricter, while in other situations water-quality-based limits will be stricter.

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[10] Harvey, K.C., D.E. Brown, and A.J. DeJoia, 2005, "Managed Irrigation for the Beneficial Use of Coalbed Natural Gas Produced Water in the Powder River Basin," presented at the 12th International Petroleum Environmental Conference, Houston, TX, November 7–11.

In the proposal, there is some question about the validity of the proposed technology-based effluent limits. Insufficient justification is presented about the achievability and affordability of the limits. The proposed effluent limits are compared with the existing Montana water quality standards in Table 3. For several of the parameters in the proposed effluent limits, there are no water quality standards. For those parameters in Table 3 that do have water quality standards, the water quality standards are in all cases more lenient than the proposed effluent standards. In other words, dischargers must treat to levels significantly cleaner than the receiving waters.

Table 3 – Comparison of proposed effluent limits to water quality standards

Parameter	Proposed Effluent Limits	Water Quality Standards[a]
Calcium	0.1 mg/L to 0.2 mg/L average	No standard
Magnesium	0.1 mg/L to 0.6 mg/L average	No standard
Sodium	10 mg/L average	No standard
Bicarbonate	30 mg/L average 115 mg/L maximum	No standard
SAR	0.5 maximum	a) From 11/1 to 3/1: i) Rosebud Creek and Tongue River – 5.0 average, 7.5 maximum ii) Powder and Little Power Rivers – 6.5 average, 9.75 maximum b) from 3/2 to 10/31: i) Rosebud Creek and Tongue River - 3.0 average, 4.5 maximum ii) Powder and Little Power Rivers - 5.0 average, 7.5 maximum
EC	233 µmhos/cm[b] average	a) From 11/1 to 3/1: i) Rosebud Creek and Tongue River – 1,500 µS/cm[b] average, 2,500 µS/cm maximum ii) Powder and Little Power Rivers– 2,500 µS/cm average, 2,500 µS/cm maximum b) from 3/2 to 10/31: i) Rosebud Creek and Tongue River – 1,000 µS/cm average, 1,500 µS/cm maximum ii) Powder and Little Power Rivers– 2,000 µS/cm average, 2,500 µS/cm maximum
Total dissolved solids	170 mg/L average	No standard
Ammonia	0.1 mg/L average 0.3 mg/L maximum	Expressed as a function of pH, temperature, and whether early life stage of fish is present. Average values range from 0.179 mg/L to 10.8 mg/L. Maximum values range from 0.885 mg/L to 48.8 mg/L
Arsenic	<0.0001 mg/L [presumed to be a maximum]	0.15 mg/L average 0.34 mg/L maximum

[a] Based on Montana Numeric Water Quality Standards Circular WQB-7.
[b] 1 µmho/cm = 1 uS/cm, although the units are written differently in the proposed effluent limits and the water quality standards.

If the proposed effluent limits truly represent BAT and encompass the necessary technology-based factors previously described, that situation is appropriate and acceptable, as noted above. However, until sufficient justification is provided, the proposed effluent limits should not be portrayed as BAT. It seems inappropriate to require treatment to levels far below water quality standards. Treatment to some less stringent effluent limits could be more available, more affordable, and would still ensure protection of water quality standards downstream from discharges.

5. Summary of Key Observations

- The proposal inconsistently characterizes the value of CBNG produced water. In some places, the proposal refers to it as "wastewater" and emphasizes that some of its constituents are "hazardous parameters." In other places, the proposal acknowledges the water's value in both quantity and quality and implements measures to ensure that the water is available for future beneficial use. This inconsistency is misleading.

- The proposal does not follow the CWA guidelines for establishing technology-based limits. The most notable excursion from the guidelines is the proposal's attempt to mandate the use of just one or two specific technologies. The BER is within its rights to require zero discharge, assuming that it can show that other water management alternatives are available and affordable. However, the BER may not specify the type of technology that must be used to achieve zero discharge. In addition to the procedural issues raised by the proposal, this strategy effectively blocks the opportunity for other beneficial and innovative technologies to be used.

- The proposal includes numerical technology-based effluent limits. They are very stringent, and no detailed rationale is provided to explain why they were selected. Traditional methods to evaluate BAT and technology-based limits were not followed. The economic justification for the limits is based on a draft report that estimates costs for a much less stringent set of discharge standards than those required in the proposal.

- The effluent limits are much stricter than necessary to meet water quality standards in Montana water bodies. If the proposal had properly demonstrated that these strict limits represented BAT, they could be employed. The proposal does not make such a demonstration, and therefore the limits appear to be unnecessarily stringent.

Appendix A – Permit Limit Guidelines Used by Maryland Department of Environment in Late 1980s

A New Statistical Method for Calculating Permit Limits

John A. Veil
March, 1987

Introduction

From time to time, we use statistical analysis to develop permit limits. We have typically used the 95th percentile of actual effluent data to represent the average permit limit. The maximum permit limit is set at either twice the average limit or at the 99th percentile of effluent data. We have been using a simple method of estimating the 95th percentile and the 99th percentile. Our calculators can provide the mean ($\bar{x}$) and the standard deviation (SD) of the data. The 95th percentile = $\bar{x}$ + 1.65 SD.

The underlying assumption of these approximations is that the effluent data is normally distributed (see Figure 1). While this may be true of biological data, it is rarely accurate for effluent data. It is not uncommon to see most data points clustered within a normal distribution, but having several points with much higher values (e.g. an upset at the treatment plant or a heavy storm water event). This type of data is better expressed by a lognormal distribution (see Figure 2).

Calculation Method

In developing the national effluent limitations guidelines, the EPA has used the lognormal distribution and the 95th percentile and 99th percentile. I am going to outline the additional steps necessary to calculate Best Professional Judgement permit limits based on the lognormal distribution and then give an example.

1. Calculate mean ($\bar{x}$) and standard deviation (SD).
2. Calculate the coefficient of variance $CV = SD/\bar{x}$
3. Calculate the standard deviation of the logarithms of the data $S = \sqrt{\ln (1.0 + CV^2)}$
4. Calculate the variability factor $VF = e^{[S(Z-0.5S)]}$ where Z is a factor derived from the normal distribution. Z = 1.65 for the average VF (VFa) and Z = 2.33 for the maximum VF (VFm).

5. Calculate the effluent limits.

Average limit = VFa ($\bar{x}$).

Maximum limit = VFm ($\bar{x}$)*

Example

The following example illustrates the calculations. The data presented is actual DMR data from one of our major facilities.

BOD values (kg/day)

avg.	max.
3.3	6.6
2.5	5.9
2.3	6.4
3.4	6.8
3.6	6.3
2.3	7.5
3.4	9.9
3.1	6.6
3.4	5.7
4.1	6.8
3.3	4.1
3.4	6.4
2.6	3.9
3.4	5.8
3.0	5.1
4.5	8.0
5.0	9.8
1.9	2.5
2.0	3.1
2.9	5.2
3.3	4.8
2.7	3.9
2.4	3.3

*In some cases, the maximum limit is calculated as twice the average limit to conform with many effluent guidelines.

The first question is, which set of data should be used the average or the maximum? If at all possible, do not use either of these, as both have drawbacks. Try to get all of the individual sample data from the facility. For example, if sampling in the above case was weekly, the average data is the mean of the four monthly samples and does not show very high or very low data points which will influence the standard deviation. The maximum datum does not accurately reflect the performance of the whole month. Make an attempt to get each of the weekly samples. This will be the most accurate data to use in the calculations.

If the individual data cannot be obtained, then use the average data column. In this example, we have no access to the individual data, so the average data is used.

1. $\bar{x} = 3.12$ and SD = 0.757. These can be computed by many calculators with basic statistical capabilities.

2. $CV = SD/\bar{x} = 0.757/3.12 = 0.243$

3. $S = \sqrt{\ln(1.0 + CV^2)}$

   $= \sqrt{\ln(1.0 + .059)}$

   $= \sqrt{.0572}$

   $= 0.239$

4. $VF = e^{[S(Z - 0.5S) \quad (.239))]}$

   $VFa = e^{[.239(1.65 - (0.5)(.239))]}$ $\qquad$ $VFm = e^{[.239(2.33 - (0.5)(.239))]}$

   $= e^{.366}$ $\qquad$ $= e^{.528}$

   $= 1.44$ $\qquad$ $= 1.70$

5. Average limit = $VFa(\bar{x})$ = 1.44 (3.12) = 4.49 kg/day

   Maximum limit = $VFm(\bar{x})$ = 1.70 (3.12) = 5.30 kg/day
   or 2 x average limit = 2 x 4.49 = 8.98 kg/day

Discussion

The average limit appears to be a fairly good estimate of the 95th percentile. 21 of 23 data values (91.3%) are below the limit and the 22nd data value is almost exactly at the limit (4.5 vs. 4.49). Only one of 23 data points exceeds the value (95.6% compliance).

Discussion (continued)

The calculated maximum limit, on the other hand, does not accurately estimate the 99th percentile. The calculated limit of 5.3 kg/day is exceeded 14 of 23 times for only 39% compliance. The maximum limit developed from twice the average limit better estimates the data (21 of 23, 91.3%).

The reason that the maximum estimates are off is that monthly average data was used as the data set for the calculations. By averaging each set of four monthly data points, the standard deviation and hence the calculated limits have been kept artificially low.

As an interesting comparison, let's see how the current calculated limits match up with limits calculated by our previous method.

	Old Method		New Method
Average	$\bar{X}$ + 1.65 SD	= 4.37	4.49
Maximum	$\bar{X}$ + 2.33 SD	= 4.88	5.30

In this case, as in nearly all cases, the new method will yield higher, but more accurate limits. The reason for this is that the lognormal method better takes into account the occasional high values that usually occur in effluent data. We should begin using this technique in place of the former method.

Figure 1 - Normal Distribution

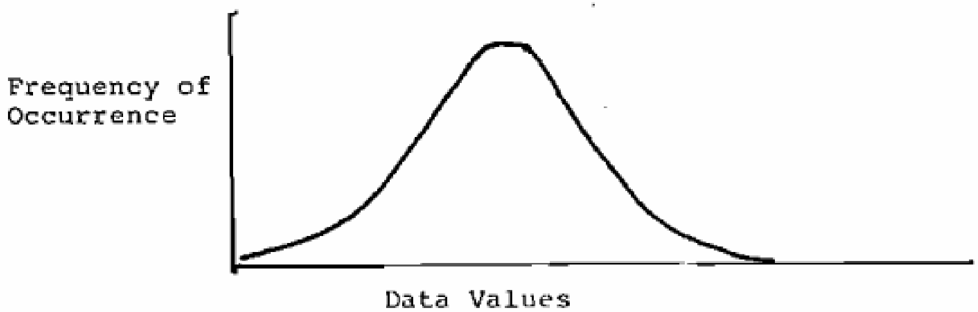

Figure 2 - Lognormal Distribution