Dr. W. Thomas Goerold Comments on BLM's Draft EIS

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Bureau of Land Management
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Dear Sirs:

Below is a set of comments detailing my viewpoints about some of the economic, socioeconomic, and cost/benefit aspects of your recent EIS for the Powder River Basin. I also enclose a report that I prepared that examines the profitability and costs of some representative CBM projects in the Powder River Basin of Wyoming and Montana.

My attached financial analysis of Powder River Basin Coalbed Methane operations uses two regions to represent the large majority of current PRB CBM production. This report has five major conclusions. (1) Six water disposal techniques were modeled: (a) surface water disposal (ERG data), (b) shallow injection (ERG data), (c) deep injection (ERG data), (d) shallow injection (Hodgson data), (e) deep injection {l0% of produced water) combined with surface treatment (90% of produced water) (Pritchett data), and (f) reverse osmosis (80% of produced water) combined with shallow disposal (20% of produced water) (Pritchett data) (for more detailed citations please see the attached report). (2) Using a current gas price of $3.61 per Mcf.all water disposal techniques in all regions were profitable and yielded ROIs ranging from 20 to 44 percent that represent above-normal profits of about $59.000 to about $158.000 (NPV). (3) Regional variations between PRB East and PRB Northern regions were not large ($O .07 to $0.20 per Mcf). (4) Surface water disposal was the least costly option and deep injection the most costly, for both regions. Additionally. (5) Pritchett data shows that deep injection of 10 percent combined with surface treatment of 90 percent of produced water was significantly less costly than injecting all produced water. This produced-water-disposal technique shows promise because it minimizes the quantity of water that needs to be injected into costly deep wells and can produce significant amounts of drinking-water-quality water for beneficial consumption.

The Powder River Basin Coalbed Methane Financial Model (PRB-CBM-FM) described in the attached paper is a "work-in-progress." Feedback from government, industry, conservation, and other public and private sources will help to refine the assumptions, scenarios, and conclusions of this financial modeling effort.

Additional Comments on the Draft Environmental Impact Statement and Draft

Planning Amendment for the Powder River Basin Oil and Gas Project By the Bureau of Land Management, Buffalo (WY) Field Office

By W. Thomas Goerold, Ph.D.

The EIS contains three different major scenarios: (1) relatively unfettered development of all coalbed gas resources in the Powder River Basin of Wyoming. (2) Development with reduced emission levels and expanded produced water-handling scenarios, and (3) no action - or no leasing of federal coalbed methane.

Alternative (1) projects recent coalbed methane trends in the region in a "business-as-usual" scenario based on current trends.

Alternative (2) A and (2) B would mandate more stringent water disposal methods and require that 50 percent of the gas compression stations be electrified-rather than gas-fired. Current water disposal practices allow about 55-75 percent of produced water to be discharged without treatment. Of the remaining water that is treated, infilration impoundment, land application disposal (LAD), and containment impoundment are the most common alternative water-disposal methods, in roughly decreasing frequency. Alternatives (2) A and (2) B would mandate that very little produced water be untreated, and that infiltration impoundment would become the most prevalent treatment method, roughly followed by active and passive treatment, LAD, injection, and containment impoundment.

Alternative (3) assumes that no further natural gas development would be allowed on Federal oil and gas leases. This scenario was not seriously considered in the EIS.

I. General Comments and Questions

1. There is no systematic or comprehensive economic, cost/benefit, or socioeconomic analysis in the document. Yet, despite this lack of analysis, the document routinely asserts that certain actions are too costly, are not worth the cost or effort, or are not justified.
2. Why doesn't the EIS investigate and cost-out downhole separation of gas and water? This technology exists and is being rapidly enhanced on off shore oil and gas platforms. Downhole separation of water and gas would avoid a large number of the most pressing environmental concerns related to CBM development.
3. The EIS speaks about one well per 80 acres and a total of 39,400 new wells. Does this include dry holes? If a hole is drilled but is not found to intersect a producing zone can another hole be drilled in the same 80 acres. If so, is that additional well above and beyond the 39,400 new wells?
4. As described in the EIS, an ultimately producing well is drilled, de-watered and allowed to vent methane to the atmosphere until it produces enough methane to cap it and drive a production apparatus. Are there estimates about

the cumulative impacts of all this vented methane to the atmosphere and its hazards? In the absence of economic markets, other historical oilfields with excess methane flared (burned) the excess gas at the wellhead to avoid the explosive hazard. Of course, burning methane at the wellhead is wasteful and produces air pollution without any significant benefits. I don't know the potential volumes of this vented gas and if it is a significant health, safety, or environmental risk. Especially, when you multiply it by the number of proposed wells in the area.

II. Adequacy of Reasonably Foreseeable Development Scenario

1. CBM well estimates in the EIS range as high as 139,000 by 2010. EIS estimates apparently are largely derived from a BLM document "Reasonably Foreseeable Development Scenario for Oil and Gas Development in the Buffalo Field Office Area, Campbell, Johnson, and Sheridan Counties, Wyoming." At a minimum, this document is outdated (it uses DOE estimates from 1998) and it appears to use flawed gas price projection methods (average oil price change per year)
2. An important omission in the BLM "Reasonably Foreseeable" document is that it fails to account for expiration of tax credits (due to expire at the end of 2002) in Powder River Basin drilling activity forecasts. The Section 29 Tax Credits have been a very significant factor in coalbed methane revenues for many years. At least one reports says that over 50 percent of coalbed methane revenues have come from the so-called Section 29 tax credits (EIA, 2002, Coalbed Methane and Section 29 Tax Credits). Because these tax credits expire at the end of 2002, the economics of coalbed methane production throughout the U.S. may undergo a significant change.
3. A very limited set of water disposal options is addressed in the EIS. And, of the few water disposal options presented, none is analyzed in enough detail to be able to determine the economic viability of the options.

III. Cost and Benefit Estimates

1. The Agency claims that the "business-as-usual" Alternative 1 is the preferred alternative. BLM claims that this alternative "provides for the best balance of effects to costs and development of the CBM." Yet, the EIS does not provide either a full accounting or an explicit cost/benefit analysis to support this assertion.
    a. Critical data that are lacking in the EIS but are needed to quantify the costs and benefits. At least some of the missing data includes:
        i. Capital and operating costs and profitability of currently operating wells and fields in all different parts of the Powder River Basin.
        ii. Capital and operating costs and profitability of new wells and fields, including the costs of different water production and

disposal options.

iii. Profitability estimates of CBM ventures. What risks are the communities undertaking when they tie their futures to corporate CBM production? Crucial data should be available to estimate (1) What is the lowest price at which new CBM development can proceed? (2) What is the lowest price that already existing CBM wells can continue to produce? (3) Is the bonding adequate to cover all of the impacts of CBM whenever it might occur? (i.e., what if the gas price drops in the middle of the CBM "boom"? (4) Would the bonding collected to that point be sufficient to cover the entire costs of remediation? (5) How is the bonding calculated for each well and project?

iv. How much money would the project generate that could be provided for more effective remediation? E.g., is the typical Powder River CBM project profitable enough to be able to re-inject produced water into subsurface aquifers? Would it be perform downhole gas and water separation?

b. Estimates of the value of **all** resources on both sides of the cost and benefit equations is also lacking. The EIS should not just quantify the market values of the gas, but should also attempt to the estimate the value of the other resources that would be impacted.

i. Not only should the revenues from CBM production be quantified but also the foregone and opportunity cost of resources should be counted. For example, currently unquantified resources include water that would be produced from the CBM formations. This water would not be available for future economic activities such as ranching, farming, or even to support potential future human and animal populations in the region. CBM production would produce permanent changes in the aquifers and the water quality and quantity in the region.

IV. Socioeconomic Impact Estimates

1. BLM has not shown how they arrive at their socioeconomic impact estimates. Critical input assumptions and methodologies are not disclosed in the EIS. Even though the EIS assumes a "boom" is driving its preferred alternative, the Agency claims that "most of the jobs would be hired from the local labor force." To believe the local-hire assertion one must assume that **all** of the following conditions would be met: (1) despite the very small population of the region (Wyoming has the smallest population of any state) and the relatively low current unemployment rate, enough willing workers would be found from the current residents of the region to meet the CBM boom requirements. (2) The currently unemployed or otherwise employed people of the study region would have the proper education, skills, and training to fill

most of the job positions involving the exploration, development, construction, operation, and reclamation of CBM fields. (3) No significant additional immigration from other areas would occur as news of the CBM boom spreads. (4) Few or no unsuccessful job seekers would move into the area hoping to land any of these new jobs. (5) the "limited" number of successful and unsuccessful in-migrating job seekers would have any appreciable impact on the region's infrastructure, including roads, social services (especially unemployment assistance for unsuccessful job seekers), police, schools, fire, hospital, etc.

The source of CBM employees is absolutely critical to estimating the project's impacts. Workers hired from existing residents (those that already reside in the study area) minimize additional demands on the region's infrastructure. But, every worker and family that migrates to the region creates additional demands on his new county of residence. Each additional person has an impact-whether they end up being a worker in the CBM field, an employee's family member, or even an unsuccessful job seeker. The project will also require additional services for the indirect population brought into the region by CBM. These people are represented by the additional workers needed at the grocery stores, dry cleaners, as well as additional doctors needed to support the larger population related to increased CBM activity.

The EIS does not fully reveal the sources of critical assumptions such as the local hire rate and the number of unsuccessful job seekers that are expected. Also, the study does not adequately show the methodology that calculates the indirect employment. This does not allow one to critique the inputs, methodology or conclusions.

The EIS does talk about some of the non-local transient construction workers with specialized oilfield skills needed. But the study claims that they will reside in area motels. But, there is no motel capacity estimate included in the study. Also, what would happen to the non-construction worker motel clients (e.g, recreation and tourism) that would otherwise fill those motel rooms? This analytical oversight is indicative about the lack of candor and specificity in the analysis. Despite this lack of documented analysis and estimates, the EIS does not shy away from sweeping claims. For example, in Section 4, the EIS states that "[t]he project is not expected to result in significant short - or long-term effects to local population conditions."

2. A document written by Petersen Planning Consultants and titled **"Community Issues and Recommendations Concerning Future Energy Developments"** reveals the results of many interviews with government and community leaders living in counties that are now in the midst of the CBM boom. Some of the more pertinent observations from that document are presented below.

Campbell County, WY is perhaps the most CBM-impacted county in the region. This county has experienced 3 booms since late 1950s: (1) oil, late 1950s through mid-1960s, (2) surface coal mines late 1970s to early 1980s, and (3) CBM late 1998 to the present. The Pedersen document argues that the current CBM boom is less site-specific and in therefore more pervasive than earlier energy booms.

Some of the primary impacts of current CBM boom include:

A. **Housing**
   1. There is lack of "affordable housing" - Gillette, WY is already the second most expensive county in Wyoming to live in
   2. Developers are afraid to build for fear of experiencing the "bust" experienced by apartment complex developers in the mid-1980s
   3. Current plan is to build an 800-man construction camp in Wright-will this segregate and isolate CBM workers from other communities, and what impacts will this have on both the CBM workers and the other residents of the region?
   4. There are no building permits required in the unincorporated parts of Campbell County, so the effect of CBM in the county outside of incorporated areas in not known or controllable.
   5. CBM brings increased opportunity to employ low-income residents in higher-paying jobs, but increased housing costs may limit these career growth opportunities

B. **Infrastructure**
   1. Roads-In Campbell county, WY about 250-300 miles out of 1000 miles of county roads have been impacted by CBM activity
      a. Dust problem
         1. Particulate standards (PM-10) need to be addressed by WY or EPA may step in and hinder CBM development to comply with pollution issues
         2. There is at least anecdotal evidence that CBM-related traffic has created "non-grazable" corridors bordering well-traveled roads where cattle do not eat the grass
      b. Markedly increased wear from CBM-generated traffic
         1. Some CBM developers are paying for

additional wear from CBM-generated traffic, but many times there are a number of smaller CBM operators that collectively cause wear and who may individually be reluctant to pay for an entire industry's impact on roads

2. Police/fire
    a. Increase in crime coincident with latest CBM boom-primarily attributed to alcohol and drug problems
    b. Major crime increases for larceny, destruction of private property, family violence, and child abuse
    c. There is an increased demand for fire and Emergency Medical services, but not up-front funding
3. Social Services
    a. Additional demand for dealing with large influx of unsuccessful job seekers
        1. e.g., growth in food services supplied to low-income population

C. **Revenues**

a. Mineral tax revenues may eventually find their way to the impacted counties, but their may be a lag time of 18 months or more between when impacts first occur and when revenues are forthcoming
b. The WY Industrial Siting Act only works when impacts come from one or more large scale projects - large cumulative impacts from many smaller projects are not covered under this legislation.

D. **Labor Force**

0. Less stability in public and municipal labor force as CBM boom moves experienced people out of public sector jobs and into higher-paying CBM-related jobs

V. Boom/Bust Possibility

1. Without a full accounting of project assumptions and methodologies, it is impossible to assess whether or not the proposed project might lead to a boom/bust cycle. The report itself refers to the "boom" in CBM, yet the EIS asserts that "[t]he potential for the Project to result in a substantial economic boom/bust cycle is low." There simply is not enough known and/or revealed about the proposed project in the EIS to make that statement. Among other

things, a boom/bust cycle might be characterized by (1) an over-reliance of a local economy on one commodity, (2) a remote location with an isolated economy, (3) a low population that can support a relatively fixed level of services provided by the community, and (4) the primary commodity of importance is subject to large price swings and changes in demand outside of the control of the community. One can certainly make the argument that each of these four criteria may be met in the proposed CBM project.

VI. Alternatives Dropped from BLM Consideration

1. Return all produced water to aquifers- According to the EIS, "[t]he feasibility of an all re-injection alternative appears to be limited." Where is the economic analysis to support this contention? What would be the costs and benefits of this action?
2. Capture and treat produced water for additional beneficial uses- BLM asserts that the treated water production would occur in a relatively short time-frame and that this fact somehow disqualifies this alternative from consideration. In addition to having no economic analysis to support this assertion. BLM does not provide a full accounting of the possibility of water storage. (above or below-ground) which could stretch out the availability of produced water for longer periods of time.
3. Staged rated of development-BLM only gives a legal argument to support dropping this alternative. Doesn't the EPA have a duty to protect the quality and quantity of water resources? Can't the BLM put conditions on development to avoid "unnecessary and undue degradation?" Also, what happens if the gas price decreases and coalbed methane wells become prematurely abandoned? Wouldn't the consequences of this gas price decline scenario be magnified with greater rates of CBM development? What impact on the rate of development might the expiration of Section 29 tax credits have? Isn't it a more prudent course of action to impose staged development so that deleterious effects can be more easily understood and mitigated? Why is it so critical to lease the entire region all at once, without even having an idea of its impacts on the economy, the environment, and on local communities? What would be the costs and benefits of staged development?

Thank you for your consideration of my comments.

Sincerely,

W. Thomas Goerold

Revised Powder River Basin Coalbed Methane Financial Model

(PRB-CBM-FM)

By Lookout Mountain Analysis

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I. Objectives and Structure of this Study

This paper is a revision of a preliminary financial analysis of Powder River Basin (PRB) Coalbed Methane (CBM) operators. A previous paper was given before the University of Colorado Natural Resources Law Center conference on April 6, 2001. The ultimate objective of this and possible subsequent papers is to (1) construct representative models of different CBM operations throughout the PRB region, (2) examine costs of different water disposal options, and (3) compare the results of this financial model with other cost estimates from the U.S. EPA, the CBM industry, conservation groups, and other sources, and (4) construct a series of different project scenarios that will accurately illustrate the financial impact of a multitude of possible regulatory and other project actions. The resulting financial model, as described in this paper is termed the Powder River Basin Coalbed Methane Financial Model (PRB-CBM-FM).

Subsequent sections of this paper discuss data sources, financial model methodology, financial model assumptions, characteristics of different modeled PRB CBM regions, model results, conclusions, references, and an appendix.

II. Data Sources

Five major sources supplied data that were used to evaluate the costs and project structure of CBM operations throughout the Powder River Basin. They are; (1) A report by Morgan Stanley Dean Witter Research on Coal Bed Methane (4/10/00) (Morgan Stanley Dean Witter, 2000); (2) Several descriptive documents from the U.S. EPA on their website that give some economic parameters, assumptions, and basic proposed EPA financial model structures and scenarios (EPA, 2002); (3) A Report by Brian Hodgson of Marathon Oil that lays out in detail the costs of a number of water treatment scenarios for PRB CBM wells (Hodgson, 2001); (4)

Two reports that were commissioned by the EPA that surveyed the PRB CBM operators on many economic aspects of CBM operations in that region. The first report (ERGa) was later revised and updated by a subsequent report (ERGb); Finally (5) Ron W. Pritchett, a hydrologist commissioned by one of the PRB CBM operators, prepared a report that exhaustively examined the geologic formations—from shallow to deep—to find possible candidate formations that would be able to receive quantities of water produced during the CBM de-watering and gas-production process and the costs associated with filling them with produced water (Pritchett, 2001).

III. Methodology

The financial model used in this study (PRB-CBM-FM) is based on a class of financial models called discounted cashflow (DCF) models. DCF models are probably the most commonly used tools used by companies, stock researchers, and others to evaluate the financial viability of different projects (as well as different scenarios within projects). It is very likely that most or all of the CBM operators in the Powder River Basin use DCF models to evaluate different coalbed methane project scenarios.

A DCF model implicitly recognizes the time value of money—a cost or revenue that occurs now is given more weight than a similar cost or revenue that occurs in the future. The further into the future that a cost or revenue occurs, the less the weight given to it by a DCF model. The basis for this differential weighting is explained by the observation that, for example, a dollar invested today will be worth more in five years than a dollar invested next year. So—a dollar in-hand today is worth more than a dollar in-hand tomorrow. Thus, the costs and revenues that occur today have a greater impact on overall project profitability than costs and revenues that occur further out into the future.

Another useful feature of a DCF model is that it can compare projects and scenarios that have very different patterns of costs and expenditures and evaluate them all on a common footing. For example, Project A may require that an investor pay \$500 today to start a project that will return \$150 in each of the next four years and \$25 for each of the succeeding two years. Alternatively, Project B may need investments of \$300 in each of the next two years that would yield returns of \$125 in each of the following six years. Which project is the most attractive? DCF models assign weights, based on the timing of the costs and revenues. A discount rate, based primarily on what the firm must pay to acquire investment funds, is used to calculate the weightings of the costs and revenues. Then, a DCF model can look at the entire proposed project and calculate the "life-of-project" or annualized values for each of the project's cost or revenue categories.

In the above example, a DCF analysis could calculate annualized values for the revenue streams for each of the different projects. Also, one could use a DCF model to obtain annualized values for the cost streams. Even though they contain different values in different years, the annualized values for Project A can be directly compared to those of Project B. With a DCF analysis tool one can then critically evaluate the likely total financial viability of different projects, and can also compare different cost and revenue components to help determine the causes of different project financial viabilities.

IV. Assumptions

A. Regional Gas Fields Modeled - Two different regions are modeled by PRB-CBM-FM—the Eastern Region, and the Northern Region. These geographic sections are represented by the Fairway North, and Northern Production Area model scenarios, respectively. Collectively, these two regions host the large majority of PRB CBM production. This model assumes that all PRB projects occur in Wyoming. Montana PRB projects may show slightly different results.

B. Scale and Duration - The financial model described in this paper is constructed at the well level. That is, costs, revenues, and profits are calculated as they are produced from a single well. PRB CBM operators usually configure CBM operations so that a series of wells from contiguous regions tie into a single node (or "pod"). These pods then feed their gas into successively higher-pressured pipelines. Ultimately the gas produced from the PRB CBM is transported to gas marketing sites from Wyoming to Louisiana. These marketing sites then distribute the gas to the final end users (or to storage). PRB-CBM-FM model base cases assume that each well operates for 9 years. An alternative financial model scenario allows one to use a 15 year CBM well life.

C. Revenues - Revenues in the PRB-CBM-FM are modeled starting with an assumed price for gas delivered to a site in Louisiana called Henry Hub. Working backwards from the Henry Hub price, the PRB-CBM-FM deducts costs for (1) transportation from Cheyenne Hub (WY) to Henry Hub (LA), (2) "shrinkage" and fuel costs for powering the compressors that compress and transport gas from the wellhead and through various pipelines, and (3) adjustments for differences of the BTU content and impurities of the PRB CBM gas, as measured against national natural gas standards.

D. Costs - Costs are broken down as follows: (1) capital costs of constructing a well and the pro-rata portion of a pod (excluding water-disposal facilities); (2) capital costs of constructing the water disposal facilities; (3) costs of operating a well (excluding water-disposal facilities); (4) costs of operating water-disposal facilities; (5) costs of leasing land and payment of royalty rights to owners of the CBM; (6) severance tax payments to the State of Wyoming; (7) payment of incomes taxes to the U.S. Government and the State of Wyoming. Collectively, with one exception, these are all of the costs that a typical PRB CBM operator will face during the CBM production process. In this preliminary stage of modeling, final reclamation costs are not calculated. Because the actual length of operations at a given CBM facility is based on changing costs and revenues that occur during the CBM operations, the actual shut-down date of each well is difficult to calculate. Also, under current law and practice, reclamation costs for these types of facilities are typically not large and therefore do not have a significant impact on overall profitability of CBM wells.

E. Profits - PRB CBM profits are calculated by subtracting project costs from project revenues during each year of operation. A convention of DCF models is that the discount rate (cost of obtaining investment funds for each firm) is considered to define a "normal profit." In this instance and in most economic applications, a normal profit is the minimum expected profit that is expected from CBM firms operating in the PRB. So, in addition to representing the firm's cost of obtaining investment funds, the discount rate also represents a firm's expected (or "normal") profit. In the PRB-CBM-FM I have used a discount rate of 10 percent.

Thus, if a firm earns a return on investment (ROI) of 10 percent, it has earned a normal profit. In this financial model, if a firm earns in excess of 10 percent, the excess is called an "above-normal" profit. One can think of the 10 percent rate as being a benchmark—if a project earns 10 percent or more, it fully covers the cost of obtaining the investment funds and can be considered a profitable project. Conversely, a project yielding an ROI of less than 10 percent is unprofitable because obtaining investment funds costs the firm 10 percent per annum.

F. Selected Gas Field Characteristics – Selected characteristics of the two gas fields are: (A) ultimate gas production in 9-year life: 0.418 billion cubic feet (bcf)-(Northern), and 0.364 bcf (East), (B) ultimate water production: 343,000 barrels-(Northern), and 854,000 barrels-(East), (C) well depth: 850 feet-(Northern), 1000 feet-(East), (D) well and pro-rata pod costs: $98,500-(Northern), $95,000-(East), (E) base case gas decline rate: 13 percent per annum-(Northern and East), (F) base case water decline rate: 50 percent per annum-(Northern and East), and (G) number of wells per pod: 8-(Northern and East).

G. Water Disposal Facilities Modeled – At this time the PRB-CBM-FM model features six different water disposal technologies (1) surface water disposal (data from ERGb), (2) shallow injection (data from ERGb), (3) deep injection (data from ERGb), (4) shallow injection (data from Hodgson), (5) deep injection (10% of produced water) combined with surface treatment (90% of produced water) (data from Pritchett), and (6) reverse osmosis (80% of produced water) combined with shallow disposal (20% of produced water) (data from Hodgson). Technical details pertaining to these water disposal techniques is beyond the scope of this paper. For additional details please refer to the referenced source of each water disposal technique.

V. Results

Two broad classes of scenarios were analyzed for each base case in the PRB-CBM-FM—(1) current gas price, and (2) breakeven gas price. The current gas price case uses a recent value for the Henry Hub (LA) gas price ($3.61 per thousand cubic feet [Mcf]) as an indicator of the profitability of each region's projects with the six different water disposal variants. The breakeven gas price varies the gas price needed for each region's projects to reach a 10 percent return on investment (ROI). A 10 percent ROI is considered the minimum rate of return needed for a project to be considered profitable.

By comparing the different ROIs returned by each region's projects under the current gas price scenarios, one can find the impact on overall project profitability of each of the six different water disposal options. One can find out the individual impact of any water disposal technique, or any other cost or revenue category on project profitability. If a project exceeds a 10 percent ROI, one can also calculate the "above-normal" profits that the project generates.

One might assume that all above-normal profits would be available for other purposes. For example, if under a particular scenario a project ROI is 15 percent, the additional profits above a "normal profit" of 10 percent might be available to pay for a more expensive water disposal technique.

A. Current Gas Price Scenario – Appendix A of this report shows PRB-CBM-FM (a) assumption section, (b) water disposal cost section, and (c) results section. Examples of these model elements are shown for an East region model run for a scenario embodying base case assumptions, current gas price, and surface water disposal.

Selected results of the East region model runs are shown in Table 1.

Table 1 – Return on Investment (ROI), PRB East Region, Base Case Assumptions, Current Gas Price

Water Disposal Techniques	Return on Investment	"Above-Normal" Profits (NPV)
1 - Surface Disposal (ERG data)	44 Percent	$158,414
2 - Shallow Injection (ERG data)	38 Percent	$137,735
3 – Deep Injection (ERG data)	21 Percent	$71,117
4 - Shallow Injection (Hodgson data)	36 Percent	$139,152
5 – Deep Injection + Surface Treatment (Pritchett data)	25 Percent	$95,510

6 - Reverse Osmosis + Shallow Injection (Hodgson data)	27 Percent	$104,822

Source: PRB-CBM-FM model runs, see individual references for additional details.

Table 1 assumes that each of these East PRB projects receives $3.61 per Mcf of gas produced. This gas price is relatively high by historical standards—although gas prices in 2001 reached levels more than double that value. Note that all projects exceeded a 10 percent ROI. And, as expected, the most profitable project used surface disposal techniques for produced water (project 1). PRB East model projects handle significantly more water than PRB Northern projects.

The 44 percent ROI for the surface water disposal indicates that "above-normal" profits of $158,414 exist (as expressed in present-day dollars or "net present value [NPV]). Expressed another way, if $158,414 in revenues was removed from the surface water project, the overall ROI of the project would drop to 10 percent. Or, expressed another way, if the project were required to use more expensive water disposal techniques, as much as $158,414 would be available for additional remediation, while still allowing for a minimum ROI of 10 percent.

Note that the least profitable project (project 3) uses deep injection water disposal techniques and results in an ROI of 21 percent and above-normal profits of $71,117. Comparing project 1 with project 3 shows that the net effect of using deep injection costs an additional $87,297 and lowers the ROI from 44 to 21 percent.

Other water disposal techniques fall in between these two extremes. In order of decreasing profitability, the projects use (A) surface disposal, (B) shallow injection (ERG data), (C) shallow injection (Hodgson data), (D) reverse osmosis + shallow injection (Hodgson data), (E) deep injection + surface treatment (Pritchett data), and (F) deep injection (ERG data).

Table 2 shows results for Northern PRB projects. PRB Northern project model runs show a very similar pattern to PRB East projects. The span of ROIs is smaller (20-38 percent for PRB Northern versus 21-44 percent for PRB East), but the profitability ranking of each water disposal technique is virtually identical. The only difference is that PRB Northern project 6 (reverse osmosis + shallow injection) is the third most profitable technique whereas PRB East project 4 (shallow injection) is the third most profitable technique.

Table 2 – Return on Investment (ROI), PRB Northern Region, Base Case

Assumptions, Current Gas Price

Water Disposal Techniques	Return on Investment	"Above-Normal" Profits (NPV)
1 - Surface Disposal (ERG data)	38 Percent	$123,543
2 - Shallow Injection (ERG data)	36 Percent	$114,344
3 – Deep Injection (ERG data)	20 Percent	$59,099
4 - Shallow Injection (Hodgson data)	23 Percent	$75,040
5 – Deep Injection + Surface Treatment (Pritchett data)	22 Percent	$70,982
6 - Reverse Osmosis + Shallow Injection (Hodgson data)	31 Percent	$104,269

Source: PRB-CBM-FM model runs, see individual references for additional details.

Above-normal profits in the PRB Northern region projects range from $70,982 to $123,543 as compared to $59,099 to $123,543 for PRB East projects. Thus, under the current gas price scenario, PRB Northern projects are typically from 17 to 22 percent less profitable than analogous PRB East projects.

B. Breakeven Gas Price Scenarios – Table 3 depicts the gas price needed to yield an ROI of 10 percent for the most- and the least-profitable water disposal techniques for both PRB East and PRB Northern projects.

Table 3 – Breakeven Gas Price Scenario, Base Case Assumptions, Selected PRB East and PRB Northern Projects

Water Disposal Techniques	Project Location	Breakeven Henry Hub (LA) Gas Price ($2002/Mcf)
1 - Surface Disposal (ERG data)	PRB East	$2.25
3 – Deep Injection (ERG data)	PRB East	$2.98
1 – Surface Disposal (ERG data)	PRB Northern	$2.47

3 – Deep Injection (ERG data)	PRB Northern	$3.05

Source: PRB-CBM-FM model runs, see individual references for additional details.

Interpreting the data in Table 3 shows that the Henry Hub (LA) gas prices needed to breakeven for all water disposal techniques ranges from $2.25 to $3.05—a range of $0.80 per Mcf. PRB Northern projects require a gas prices of from $0.22 (surface water disposal) to $0.07 (deep injection [ERG data]) more than analogous PRB East projects. Thus, the regional differences in water disposal techniques range tend to be relatively small. And, the cost differences between disposal techniques in all regions is about $0.80 per Mcf--about 22 percent of the current gas price of $3.61.

VI. Conclusions

Five major conclusions come from financial modeling using two regions to represent the large majority of current PRB CBM production. (1) Six water disposal techniques were modeled: (a) surface water disposal (ERG data), (b) shallow injection (ERG data), (c) deep injection (ERG data), (d) shallow injection (Hodgson data), (e) deep injection (10% of produced water) combined with surface treatment (90% of produced water) (Pritchett data), and (f) reverse osmosis (80% of produced water) combined with shallow disposal (20% of produced water) (Pritchett data). (2) Using a current gas price of $3.61 per Mcf, all water disposal techniques in all regions were profitable and yielded ROIs ranging from 20 to 44 percent that represent above-normal profits of about $59,000 to about $158,000 (NPV). (3) Regional variations between PRB East and PRB Northern regions were not large ($0.07 to $0.20 per Mcf). (4) Surface water disposal was the least costly option and deep injection the most costly, for both regions. Additionally, (5) Pritchett data shows that deep injection of 10 percent combined with surface treatment of 90 percent of produced water was significantly less costly than injecting all produced water. This produced-water-disposal technique shows promise because it minimizes the quantity of water that needs to be injected into costly deep wells and can produce significant amounts of drinking-water-quality water for beneficial consumption.

The Powder River Basin Coalbed Methane Financial Model (PRB-CBM-FM) described in this paper is a “work-in-progress.” Feedback from government, industry, conservation, and other public and private sources will help to refine the assumptions, scenarios, and conclusions of this financial modeling effort.

VII. References

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Appendix A: Powder River Basin Coalbed Methane Financial Model, East Region, Showing the (a) Assumptions Section, (b) Water Disposal Options Section, and (c) Results Section

A1. Assumptions Section

East-(Fairway North) Model	
ASSUMPTIONS	
NYMEX Henry Hub Current Gas Price ($2002/Mcf)	$ 3.61
Basis Differential (Cost of Transportation of Rocky Mountain Gas to Marketing Hub [$/Mcf])	$ 0.30
BTU Cost Adjustment ($/Mcf as BTU adjustment cost)	$ -
Shrinkage/Compression/Field Use (%)	7.75%
Netback to Wellhead ($2002/Mcf)	$ 2.81
WY Severance Tax (% of sales) (1st 2 years	6.0%

@ 2% if <=360 Mcf/Day)	
Percentage Depletion Allowance (%)	15%
Depletion Type (0=Percentage Depletion,1=Cost Depletion)	0
Federal Income Tax Rate (%)	34%
WY Income Tax Rate (% of taxable income)	6.6%
Water Disposal (0=Surf. Dish.,1=Sh. Inj.,2=Deep Inj,3=Sh Inj2,4=Deep Inj.+S.T.,5=RO + Sh Inj.)	0
Independent Operator (60% costs expensed,1=Indep. Prod. [yes],0=Integ. Prod. [no])	0
Federal or Private Royalty (0=Private,1=Federal,2=Weighted Average)	2
PRB CBM Barrel of Oil Equivalent Multiplier (Mcf/Bbl)	5.56
Real Discount Rate	10%
EAST (FAIRWAY N) CHARACTERISTICS	
Avg. Well Depth (feet)	1,000
Peak Gas Prod (Mcf/Day)	170
Avg, Water Prod (Bbl/Day)	
Peak Water Prod (Bbl/Day)	750
Avg. Water Prod Volume (GPM)	
Peak Water Prod Volume (GPM)	22

Avg. Water Pump prior to production (months)	12
Avg. time to reach Peak Gas Prod (months)	12
First Gas Prod % of Peak (% of Peak Gas Prod)	75%
Ultimate Gas Recoveries (Bcf/well)	0.2-0.4
Typical gas decline rates/well (%/year)	13%
Typical water decline rates/well (%/year)	30%
Average Life of well (years)	9
Avg. Drilling & Completions Cost/Well	$ 95,000
Additional pod infrastructure costs	$ -
Avg. Total Well + Pro Rata Pod Costs (avg.)	$ 95,000
Gathering Fees per Mcf (includes treatment + transportation to	$ 0.50

Cheyenne Hub) ($/Mcf)	
Gas Lifting Costs per Month ($/Month)	$ 1,500
Land Costs ($, assuming 80 acre lease)	$ 32,000
Private Royalties (%)	20.0%
Federal Royalties (%)	12.5%
Weighted Average Royalty Rate (%)	15.65%
Number of Wells per Pod	8

A2. Water Disposal Options Section

WATER DISPOSAL OPTIONS	
Option 0	
Capital - Surface Water Disposal ($) (Source:ERG,1/02)	$ 300
O & M - Suface Water Disposal ($/BW) (Source:ERG,1/02)	$ 0.0040
Option 1	
Capital - Shallow Injection ($) (Source:ERG,1/02)	$ 6,250
O & M - Shallow Injection ($/BW) (Source:ERG,1/02)	$ 0.0450
Option 2	
Capital - Deep Injection ($) (Source:ERG,1/02)	$ 62,500
O & M - Deep Injection ($/BW) (Source:ERG,1/02)	$ 0.0950
Option 3	
Capital -Shallow Disposal Well ($/BW Capacity) (Source:Marathon Oil)	$ 28.57
O & M - New Shallow Disposal Well ($/BW) (Source:Marathon Oil)	$ 0.014
Piping Per Well (Miles) (Source:EPA)	0.06
Piping Cost ($/ft.) (Source:EPA)	$ -
Option 4	
Capital - 11,200 foot injection well / 25 wells	$ 58,480
Capital - 10% Deep Injection + 90% Surface Treatment ($/BW Daily Capacity) (Source:Caribou)	$ 9.75
Capital - 10% Deep Injection + 90% Surface Treatment ($/BW Daily Capacity) (Source:Caribou)	$ 6,384
O & M - 10% Deep Injection + 90% Surface Treatment ($/BW)	$ 0.0400

(Source:Caribou)	
Option 5	
Capital - Reverse Osmosis + WDW (20%) ($/BW Capacity) (Source:Marathon Oil)	$ 77.14
O & M - Reverse Osmosis + WDW (20%) ($/BW) (Source:Marathon Oil)	$ 0.033
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A3. Results Section

9 YEAR PROJECT RESULTS			**Annualized**
			2002 Dollars
Category	**M 2002 Dollars**	**NPV M 2002 Dollars**	**Per Mcf**
COST ITEMS			
Drilling, Completion, Pro-Rata Pod Capital Costs	$ 95,000	$ 95,000	$ 0.44
Chosen Additional Water Disposal Capital Cost	$ 300	$ 300	$ 0.00
Gas Lifting Cost	$ 144,000	$ 87,299	$ 0.41
Chosen Additional Water Disposal Operating Cost	$ 3,415	$ 2,571	$ 0.012
Gathering Cost	$ 181,859	$ 116,213	$ 0.54
Land Rental & Lease Cost	$ 32,000	$ 20,477	$ 0.10
Royalty Cost	$ 173,809	$ 111,069	$ 0.52
Severance Tax Cost	$ 66,636	$ 42,582	$ 0.20
Intangible Drilling Costs	$ 40,026	$ 40,026	$ 0.19

Depreciation (Capitalized Drilling Costs)	$ 55,274	$ 36,250	$ 0.17
Depletion Allowance	$ 166,590	$ 106,456	$ 0.50
Federal Income Tax Cost	$ 102,770	$ 63,462	$ 0.30
State Income Tax Cost	$ 19,950	$ 12,319	$ 0.06
Cost Total	$ 819,739	$ 551,290	$ 2.57
REVENUE ITEMS			
Gross Revenue	$ 1,313,018	$ 839,055	$ 3.91
BTU Adjustment	$ -	$ -	$ -
Shrinkage, Compression, Field Use Cost	$ (101,759)	$ (65,027)	$ (0.30)
Basis Differential (Rocky Mountain Gas Price Differential)	$ (100,659)	$ (64,324)	$ (0.30)
Revenue Total	$ 1,110,601	$ 709,705	$ 3.31

Above-Normal Profit	$ 290,862	$ 158,414	$ 0.74
		IRR	44%