CBM Development and Water Issues

Dave Brown

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our guy is in here, he downloads data which is accumulated every second. So he has all kinds of information. Water data, temperature, pressures and it's recorded. He takes all that data and e-mails it to Denver every single day for all 750 wells. Because our system is—our formation is very, very under pressure, we have a very large pipe in place which takes gas of the basin. Then we have an infrastructure pipe throughout the field going to eight compressor stations. And this is a pipe that's over eight inches in diameter. Typical gathering construction crew along the highway. And this is what the right-of-way looks like when it revegetated. This one is contained within a building. That particular unit is 3,000 horsepower—it moves about 10.8 million cubic feet a day. All the compressor stations have emergency shut down for high pressure, high temperature. It's a system that shuts off the computers and then phones automatically to the field office, which sends a signal to about 15 different maintenance guys to come fix the compressor.

Water management is, of course, one of our key issues. Water quality. We test the water from COGCC earthen pits. We offer the chance to home owners to have their water wells sampled, and we give them water quality data. We test the water from the producing wells also. Colorado Department of Health, we test all the permitted outfall points.

Surface water, there's a program where we have a data base of water, samples from all the rivers and also the Trinidad reservoir. We test water using an independent laboratory, so it puts some distance between the operator and the Department of Heath and Environment. With only 700, 800 wells in production, we have well over 20,000 data points of water collected. With our current operations, we have 640 pits that are permitted with the Oil and Gas Commission and 678 out of the Colorado Department of Health and Environment. We have seven active disposal wells; two wells are being completed right at the moment. As I mentioned before, we have independent companies who collect data for us so that we have a good data base to work from.

Thank you.

CBM DEVELOPMENT AND WATER ISSUES

DAVE BROWN, Environmental Specialist, BP

I was assigned the topic of CBM development and water issues in the San Juan Basin of Colorado. I'm going to talk about this today because that's where a lot of water issues are occurring right now in terms of people's concerns.

First, here is a brief overview of BP for those who may have lost track. BP is a multinational company formed as a result of recent mergers involving BP, Amoco, ARCO, Vastar, and Castrol. So those of you who are familiar with Amoco, that's who BP is now. BP is the largest oil and gas producer in the United States, so we're quite involved here in the lower 48 states and in Alaska in terms of energy supply in the U.S.

In Colorado, we are the biggest natural gas producer, and we market quality fuels at retail service stations. The gasoline BP markets in Colorado is the same Amoco product as we've always sold.

In La Plata County, we operate 900 natural gas wells, and we have 114 employees who live and work in the area. So we have a lot of folks committed to producing natural gas in the most environmentally responsible manner possible. What I want to discuss is the potential

<table>
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<th>WHO ARE WE?</th>
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<tbody>
<tr>
<td>• BP has merged with Amoco, ARCO, Vastar, and Castrol.</td>
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<tr>
<td>• In the U.S. BP is the largest producer of oil and gas based upon offshore, Alaska, and the lower 48 states.</td>
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<td>• In Colorado BP is the largest natural gas producer, and we market quality fuels at retail service stations.</td>
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impacts to groundwater and the preventative actions. There’s some other issues going on, but that is one that stands out.

I’ve been working in this area since we got started in the late 80s, and the one issue that keeps coming up is: What are the impacts from coalbed methane development? And, you know, I heard that in ‘87, and we’re hearing it now. It’s an ongoing concern we address on a daily basis.

What I want to give you are some background and tell you how and what kinds of things are being done to protect those shallow aquifers. I want to give you a comparison about where those shallow aquifers are and where we produce the natural gas. And then I want to talk about some preventative actions and talk about well construction. Dennis got into that a little bit. We also have a water well testing program similar to Raton Basin, so I’m going to get into a little bit more detail about that.

I picked the three main types of aquifers where people get their water from, in the general area where coalbed methane development is occurring. The first example is called a river aquifer. These slides show that loose gravels have been deposited over time. This is an aquifer that has unlimited water, and its quality is based on how good the water is in the river. So this is a very good, high-yielding type of water.

This is an agricultural mesa with a lot of that type of activity going on.

This aquifer is more complicated. This is the Animas and Nacimiento aquifer. What you have are shale and sandstone with subsurface lenses of more permeable material where water has collected over time. The difficulty with this aquifer is the fact that once the water is used up, it’s not going to be replaced very quickly.

In fact, it’s going to be a long time, possibly hundreds of years. The water is recharged mainly from precipitation. The previous aquifer, Florida Mesa Aquifer, is recharged by irrigation and the first aquifer, River Aquifer, is recharged from the leaking of the river to the aquifer. Now, this is when it really gets tough, because what’s happening is, if you get development going on in that area where you have the Animas and Nacimiento aquifers, you can really stress or overuse the aquifer to the point that it’s going to dry up.
Again, it's going to be a long time before it's replenished. So that's the reason why water management, in terms of these particular types of aquifers, is very important in educating the users that you don't want to overuse these aquifers. I'm going to put this in perspective now. This is a cartoon, but it is to scale. This is the Fruitland formation here where the coalbed methane is produced. This is the northern part of the San Juan Basin, and this is to the New Mexico state line. I just showed you these aquifers on the slide, and what we're trying to show here are the coalbed methane wells. These are depicted by the tubular looking features on the slide. We'll talk about this in more detail.

These coalbed methane wells are constructed in such a way that there is no way, or shouldn't be a way, for these wells to communicate with shallow drinking water aquifers. And I'll show you how we're doing that in a second, but it's important to note that the distance between the shallow aquifers and the Fruitland formation in this case can range from 1,500 to 2,000 feet in depth. So there's quite a bit of geological separation, which forms a seal that prevents any movement of fluids from down here, Fruitland formation, in the productive natural gas interval to where the drinking water aquifers exist. So I'm just trying to give you a sense of that. We talked about those aquifers. And again, water wells can vary in depth, with the deepest I found being 400 feet, which is depicted on the slide. Most, though, are in the 100 to 200 feet range on depth.

Now, I want to talk about the wellbore construction. Dennis touched on it with his slides. We'll look at this and see what's going on here in terms of how wellbores are constructed. I'm also here to talk about this from a historical perspective. There was a time where there was some drinking water aquifer contamination from subsurface leaks from conventional natural gas wells. We'll talk about what caused that and what was done to fix it. The next slide is of the surface and the wellbore we drill. This is this upper part of the hole. This is what we call our surface casing. Surface casing is set at a depth of 450 feet for this...
example. How we determine the depth to set surface casing is by researching the State Engineer records for a depth of the nearest water well. Then we set surface casing 50 feet deeper than the depth of the nearest water well.

Then we pump cement down the bottom and up the backside to surface to get the seal between this wellbore and the casing, which fills the annulus. Again, these drinking water aquifers I spoke about before are up in here (pointing to the upper part of slide above the surface casing).

As I mentioned, the deepest drinking water aquifers are up in here (the upper portion of the slide above the surface casing). So at this point, we have two levels of protection. Steel casing and then the cement that encases it. Now, the next stage, we go ahead and drill the well to total depth, which in this case, is approximately 2,700 feet.

The casing is run inside this particular wellbore, and then cement is pumped down the bottom and back up to the surface to seal the annular space between the wellbore and the casing. So now we’re up in this area (pointing to upper part of slide above the surface casing) where the drinking water aquifers are being used. Now, there are actually four layers of protection, two strings of casing with both sets cemented into place. Then tubing is run and the casing is perforated across the coal formation (pointing at the bottom of the slide where the perforations are shown). This is the Bradenhead valve (pointing to the wellhead configuration at the top of the slide), which monitors pressure between the surface casing and the long string or production casing. We’ll talk about more shortly.

Now, let’s look at the history of what happened when there were problems from natural gas development and water wells. Back in the 1950s and 60s, there were conventional wells being drilled. The practice in those days was to not cement the section above here, leaving a portion of annulus behind the long string uncemented.

In other words, that annular space was open in that portion of the long string or production casing. There was really never a problem with this practice for a long time. But when the Fruitland development started in the 1980s, they began dewatering the Fruitland which in turn allowed, in very isolated cases, for gas to migrate up the backside of the casing, and if conditions were right, for gas to make its way to a water well. Despite the rarity of this event, programs were developed to prevent a reoccurrence.

Now, I want to talk about that Bradenhead Valve. Again, it exists at the surface but monitors pressure that could indicate gas migrating between the surface casing and the production or long string of casing. If that condition existed, an option is to perforate the casing and pump cement behind the casing to seal the open annular space so that it resembles the same type of current wellbore.
construction used for Fruitland wells. What we basically have then is a cased and cemented well from the surface all the way to total depth. It is important to note that those wells that needed to have this type of corrective action taken have been identified and the wellbores have been remediated. So this problem has been addressed.

Remember the conventional well we just saw? Every year, we go out and check the Bradenhead valves on conventional wells to determine if there's any pressure on it. There are areas that are designated as “critical” which means there are a concentrated number of water wells in the vicinity. In those cases, you're only allowed five pounds on the Bradenhead. For coalbed methane wells, we test them when they're completed and then every other year after that. Just to give you an idea, we did over 900 Bradenhead tests in 2001. So we were very busy with this program last year. But we also recognized that, even with the Bradenhead program, many people were not convinced their wells were not being affected by coalbed methane development.

Despite explanations of proper wellbore construction and monitoring using Bradenhead testing, many people were still saying, “I'm still not convinced that my water well is not being affected.” We felt strongly about that and we listened. What was developed, as part of the infill order for 160 acre density for CBM wells, was a program whereby the industry would test the two closest water wells within a quarter of a mile of new proposed coalbed methane well.

**WATER WELL TESTING**

- Infill order requires water well testing
- Originally included in industry’s health, safety, and welfare plan
- Test two closest water wells within 1/4 mile of:
  - Conventional gas well, or if none
  - Proposed CBM well, or
  - Extend radius to 1/2 mile if no water well within 1/4 miles.

What is done for this program is as follows: If you have a coalbed well proposed in a designated 160 acre spacing window, and there’s also a conventional gas well within a quarter mile radius of a proposed Fruitland coalbed well, you select the nearest two water wells within a quarter of a mile of the conventional well and possibly out to a half a mile. But if there's no conventional gas well within a quarter of a mile of a new coalbed methane well, then you select the nearest water well no more than one-half mile from the proposed coalbed methane well. I believe there's only been a couple of cases of new CBM wells where we have not found at least one water well to test. These are the infill windows (pointing to yellow shaded areas). We checked the Colorado State Engineer’s records to identify all of the water wells shown on this map.
Looking at this particular site, here is the proposed gas well. Here is the water well selected (pointing to the map). In this case, selecting that particular water well was a slamdunk because it is so close to the new coalbed methane well. We try and select the wells on opposite sides of the proposed new coalbed methane well, which in this case was this well right there (pointing to a water well). So in this case, these two water wells are on opposite sides of the proposed coalbed well.

Here is the water well test procedure. First, there are prescribed analytical parameters that are based upon the infill order. We use a third party contract water tester to sample the water wells. We have to collect samples from the water well before the drilling starts on the nearby coalbed methane well. We also conduct post-tests from the water well within one year after the coalbed methane well is completed. Ideally we try to sample within eight to nine months after completion of the new gas well, but at least within a year. After that, we test a given water well at three and six-year intervals as required in the COGCC infill order. There is another important aspect of this testing program. We share the results with the well owners with an explanation about water quality. This is very constructive. They are now aware of aspects about their water well and water quality that they may not have known before.

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<th>WATER WELL TEST PROCEDURE</th>
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<tr>
<td>• Prescribed analytical parameters</td>
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<tr>
<td>• Pre-test before drilling</td>
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<tr>
<td>• Post-test after drilling within one year</td>
</tr>
<tr>
<td>• Post-tests at three- and six-year intervals</td>
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<tr>
<td>• Share results with water well owner</td>
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<tr>
<td>• Methane levels &gt; 2 mg/L require isotopic analysis</td>
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Where you have that exchange of information, it has been valuable, particularly for local residents. Some post-tests have been completed recently and those results would essentially demonstrate if any changes in the water quality from their water well has occurred after drilling the new coalbed methane well. We have seen virtually no change in the post-tests from the pre-tests in the water wells that have been sampled pursuant to this program.

We’ve heard a lot about the potential for natural gas in the San Juan Basin, but there’s also a lot of shallow methane gas that is naturally occurring in this basin. Under the infill order—and I know this doesn’t mean a lot to some people—if you have two milligrams per liter of dissolved methane in a water well sample, you’re required to obtain an isotopic analysis. An isotopic analysis can differentiate between shallow naturally occurring biogenic methane and deeper thermogenic methane. I’ll just give you some statistics here. We have sampled more than 300 domestic water wells so far in this program. 55 percent of those had some level of dissolved methane. I want to point out one thing: We go really, really low on our methane detection levels, 0.0004 mg/L to be specific. This is a very low detection level. Anything over that level is part of the 55% number. Due to the number of ongoing samples taken, the percentage changes almost daily. However, I checked it today, and we’re down to less than 50 percent now of the water wells with dissolved methane over 0.0004 mg/L. However, any concentrations greater than 2.0 mg/L requires an isotopic analysis of the water. We do this so an understanding about the source of the methane gas in a water well can be made. Is it from a shallow biogenic source, or is it coming from thermogenic sources that could be associated with deeper production of natural gas? Isotopes are very valuable in terms of determining the source of the methane.

<table>
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<th>METHANE IN GROUNDWATER FACTS</th>
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<td>• &gt;300 domestic water wells sampled</td>
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<tr>
<td>• &gt;55% w/dissolved methane, 12% &gt; 2mg/L.</td>
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<tr>
<td>• Biogenic vs. thermogenic methane</td>
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<tr>
<td>- Biogenic D bacterially generated</td>
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<tr>
<td>- Thermogenic D deeper derived, associated with natural gas development</td>
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<tr>
<td>- All isotope results from wells &gt; 2mg/L have been of a biogenic source</td>
</tr>
<tr>
<td>• Isotopic analysis of both methane and CO₂ and compositional analysis are needed to distinguish Fruitland gas development</td>
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Here is a very important point from our testing program so far. All the isotopic results in water wells that are greater than two milligrams per liter have been biogenic or from shallow naturally occurring sources of methane and not associated with coalbed methane development. What I want to point out is that the isotopic analysis needs to look not just at methane, but also the carbon component of the CO2 since it will provide additional information about the source of the methane. Using isotopes allows “fingerprinting” to identify thermogenic methane vs. biogenic methane. This is something that has proven to be very valuable.

In summary, I think one of the things that should be pursued is public education about hydrology and how water wells function. That was done in La Plata County last year. A copy of the booklet that was handed out at the public information sessions last year in La Plata County is here and I would be glad to share these with anybody who wants one. This pamphlet was put together by two local consultants with input from five different agencies located in La Plata County. It’s called, “How Well Do You Know Your Water Well?” It’s pretty neat. Our third party water contractor delivers this informative pamphlet to the water well owners and reviews the water well testing procedure with them.

Another summary item is proper wellbore construction techniques. Something that will continue to be emphasized is continuing the use of the best techniques for wellbore construction and monitoring. This will ensure that wellbore integrity stands the test of time. We will also continue to baseline and post-test water wells that are selected for sampling as required under the infill order. And finally, isotopes are extremely valuable in terms of understanding what the source of gas is in water wells where it exists.

Thank you.

CBM DEVELOPMENT ON THE SOUTHERN UTE RESERVATION

BOB ZAHRADNIK, Southern Ute Growth Fund

The Southern Ute Indian Tribe is a small tribe. They have approximately 1,000 square miles, about 700,000 acres. It’s a 70 by 15 mile strip on the Colorado/New Mexico border here. Just to put this in perspective, the original deal with the Federal Court would be one million acres. It’s been reduced to about 700,000.

The tribe controls about half of that. The land is a victim of something called the Allotment Act, which was put into place by the Federal Court and the people of southwestern Colorado. The tribe is hung up within the exterior boundaries of the reservation. The red here is tribal acreage, so you see it has extremely interesting jurisdictional problems and a lot of government.

The red part is basically desert. This part is a waterless plateau. This part, where we have another big tract of land, is extremely rugged, mountainous terrain. So the tribe was left with this. Until 1982, development of energy on Indian land was controlled completely by the Federal government. After that, the tribe was then actually allowed to talk to oil companies about development on their land. They weren’t allowed to negotiate before then. Leasing on these lands began in 1949 and then basically we stopped in the 50s. And the tribes, therefore, had very little to do with that process. And the tribe in the 70s was faced with the prospect of living with deals the Federal government had cut.

So they were handed this situation they had to deal with. However, the tribe did support this in 1951 the