COMMITTEE ON EARTH RESOURCES

BOARD ON EARTH SCIENCES AND RESOURCES

NATIONAL RESEARCH COUNCIL

MEETING ON THE STATUS OF DATA AND MANAGEMENT REGARDING THE EFFECTS OF COALBED METHANE PRODUCTION ON SURFACE AND GROUND WATER RESOURCES

LOCATION:

ADAM'S MARK HOTEL
1550 COURT PLACE
DENVER, COLORADO

DATE:
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MR. HITZMAN: Well, welcome everyone. There's no microphones up here, so I hope you can hear me. Good morning. My name is Murray Hitzman. I'm the professor at the Department of Geology and Geological Engineering at the Colorado School of Mines, just to the west of here, and I'm also Chair of the Committee on Earth Resources of the National Research Council of the National Academies. I'd like to welcome everyone to this public meeting on the status of data and management regarding the effects of Coalbed Methane production on surface and ground water resources. Thank you very much.

This meeting has been organized by the Committee on Earth Resources at the request of the Bureau of Land Management to gather information on and facilitate a discussion of this topic. This is an issue of great interest both here in the west and on Capitol Hill. The local interest is exemplified by all of you, who have taken the time to sit with us here today and participate in the meeting.

You may have also taken from the table at the back a copy of the letter from Senator Bingaman to the President of the National Research Council expressing the Senator's interest in this matter, as well. The intent of this meeting is to provide a forum for information exchange. It is hoped that the discussions and information presented at this meeting will help inform BLM's decisions regarding the need and scope for additional independent study on the effects of CBM production on water resources, as specified in Section 1811 of the Energy Policy Act of 2005.

The mandate, copies of which are also on the back table, requires the Secretary of the Interior in consultation with the Administrator of the Environmental Protection Agency to arrange for the National Academy of Sciences to conduct a study on the effects of Coal Bed Natural Gas, also known as "Coalbed Methane," or "CBM" production on surface and ground water resources in the states of Colorado, Montana, New Mexico, North Dakota, Utah, and Wyoming.

I'd like to briefly explain the role of the National Academies and this Committee before giving a brief overview of today's agenda and the meeting structure. I would refer you to some of the background information that you may have picked up on the table as you came into the room. The National Research Council is the principal operating arm of the National Academies, which includes three very well known honorary societies, the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

The National Research Council, or the "NRC," is a non-profit, non-governmental organization that was chartered by Congress to ensure that independent advice on matters of science, technology, and medicine are provided to the nation. Those seeking such advice may include Congress itself, federal or state agencies, the Executive Office, or the general public or, in fact, any combination of these. The NRC primarily conducts policy studies. It functions by assembling the voluntary assistance of scientists and engineers and other experts throughout the nation, or indeed throughout the world, who serve pro bono on various committees related to the topic of interest. These committees are ad hoc and are assembled specifically to address a certain prescribed topic. You may be familiar with some of the Academies' reports, and a few of them are actually on the table in back for you to took at. The recommendations in these study reports often form the basis for government policy decisions.

On a particular committee, sitting here in the front, is not an ad hoc committee, but a standing committee, and it's another one of the Academies' means to assist the nation in gathering information. Standing committees of the Academies usually exist for a long period of time. In our case, our committee has been in existence since 1991. Unlike study committees, assembled to focus on a single topic, standing committees are permanent, or somewhat so, and do not conduct studies on their own. Most members serve on a standing committee for three years and memberships are staggered to ensure continuity. As with the other of the Academies' committees, our members also serve pro bono.

Our committee is responsible for organizing and especially overseeing studies on issues relevant to the supply, delivery and associated impacts of hydrocarbon metallic and non-metallic mineral resources, and mineral and non-mineral energy resource systems. Importantly, our committee does not itself conduct studies and is not constituted to do so. Our purview is to monitor the status of mineral and energy resource issues to identify study opportunities and to respond to requests from federal agencies, and to provide a forum for discussion and exchange of information among scientists, engineers, and policymakers from governments, universities, and industry.

I'd like to take a moment for our committee members to introduce themselves and their affiliations and we'll start at this end.

MR. DOGGETT: Hi. My name is Mike Doggett. I'm an Independent Minerals Economics Consultant based in Vancouver, Canada. My main area of focus is on exploration, primarily in the hard rock sector and I serve as an independent director for the Junior Land Development in Vancouver.

MS. MUCOLLOUGH: Hi. I'm Elaine Mucollough. I graduated from NIOSH last month. I've been working for the government for nearly seven years. I am a consultant. My field is health and safety.

MR. BURKE: Hi. My name is Frank Burke. I'm an independent consultant on carbon base energy issues. Prior to my retirement in 2006, I was vice president of research and development for energy and land use, primarily coal.

MR. MINK: Roy Mink, recently retired from the Department of Energy and the general energy program. Right now we're consulting in water resources and energy.

MR. SPILLER: Good morning. My name is Reggie Spiller. I'm a hydrogeologist by training, a petroleum geologist by profession. I'm currently the executive vice president of Ontario Resources, who is an independent oil and gas company. I was the former

Deputy Assistant Secretary for Gas and Petroleum Technologies at the U.S. Department of Energy and I've been a member of this community for about three years.

MR. FAULK: I'm Tom Faulk. I'm a retired Chairman and CEO of Berwind National Resources Corporation, which is in coal and natural gas and a lot of other things like that. Previous to that I was head of the U.S. Bureau of Mines and I'm doing a little bit of consulting, also.

MR. JUCKET: Good morning. My name is John Jucket. I'm the Coordinating Director for the Office of Geo Science and Energy and the American Association of Geologists in Washington, also a board member in a small exploration company based in Houston, the Exploration of China. Many years prior to that, the Department of Energy and the Office of Energy and an additional 15 years in the private sector of exploration, as well.

MS. TRARE: Good morning. My name is Sam Trare. I'm a professor of Science and Engineering and the vice chancellor for a search at the University of California and my own research is in the area of geochemistry.

MR. VINEGAR: My name is Harold Vinegar. I'm the chief scientist of Royal Dutch Shell and I'm headquartered in Houston, Texas in the exploration and production arm of Westchase Shell. My field of expertise is in unconventional resources.

MR. CONDIT: My name is Bill Condit. I'm a retired geologist, as well, and member of the white hair club here. And my career is with the federal government, about half with the Forest Service of BLM, and then the latter half of my career, I was a staffer at the U.S. House of Representatives on a Committee that had jurisdiction over the disposition of federally-owned mineral rights.

DR. MAEST: My name is Ann Maest. I'm an aqueous geochemist and I work with Stratus Consulting in Boulder, Colorado and my main area of expertise is looking at the impact of petroleum, oil and gas, and especially hard rock mining on the environment and restoration of the environment impacted by those activities.

MS. EIDE: My name is Elizabeth Eide. I'm with the staff of the National Research Council. I've been there for 2-1/2 years. Prior to that, I was 12 years in Norway, where I was a staff scientist/geologist with the Geological Survey of Norway.

MR. MINK: And as I said, my name is Murray

Hitzman. I'm professor at Colorado School of Mines and Geology and Geological Engineering. I spent much of my career with Chevron Corporation doing mineral exploration worldwide and then 3-1/2 years in Washington, first a year on the Senate as a staffer and then a year and a half in the White House Office of Science and Technology Policy.

Ann and Bill will be the moderators for today's meetings and Ann is going to moderate this morning's session; Bill will take the afternoon session.

In order provide assistance to BLM, we've invited experts from federal and state government from academia, industry, citizens' groups and other organizations to speak in two panel sessions and to participate in discussions over the course of this meeting day. As you're all aware, this is a public meeting. A short oral summary session tomorrow morning will conclude the public proceedings.

In advance of this meeting, we followed our usual practice in sending announcements to a variety of individuals and organizations with potential interest in this topic and who might have an interest in being in the audience. We've held the meeting here in Denver in order to facilitate greater public participation from the states most directly relevant to the items identified in the mandate. We are very, very grateful to the panelists for taking valuable time and agreeing to assist us today.

By way of preparation, they have been forwarded sets of questions, which are also in your agenda that derive directly from the language of the Energy Act Mandate to help the organization of their presentations. Because of the time constraints and our desire to hold some discussion after the presentations, the panelists have been asked to keep their remarks to 20 minutes.

We have forwarded a couple of questions regarding points of fact directly after the individual panelists make their presentations, but we would like to save most questions until the discussion period at the end of all the presentations. We very much want to ensure that each panelist has their full, allotted time to speak.

Given the need to hold this meeting during only one day and the variety of prospectus in which we thought it would be useful to hear, the panelists have had a challenging job to try and prepare a 20-minute presentation that was both adequate in depth and breadth to address the issues. We have not guided the detail of any of the presentations. We simply asked them to do the best they can within the available time constraints. We anticipate that we can pick up any specific details that may not have been brought out during the presentation as we proceed with the discussions.

Because we are an Academy Standing Committee and not a study committee, no written account of the proceedings will be produced by this committee, the National Academies or the NRC. However, BLM has engaged a court reporter to transcribe the meeting proceedings. We can obtain information from BLM with regard to the manner in which this transcript will be made available and get it to those of you who are interested.

As for questions, I would ask you all, whoever asks a question, to step up to the podium so it can be recorded by the court transcriber, and could you please state your name and affiliation before asking the question.

Since I don't want to take any more time from any of our speakers, I'd like to now ask Dr. Ann Maest to introduce our first set of panelists. Ann?

DR. MAEST: Should we get the panel up here?

MR. HITZMAN: Yeah. If they -- the first

panelist could come up?

DR. MAEST: Okay. Thank you very much for joining us this morning. We're going to have panelists discussing several questions and the main question is: What are the potential impacts of Coalbed Methane production activities on surface water and ground water resources?

We also want to get an overview of the geography of the Coalbed Methane Basins and I think some of the panelists will address that, what kind of data are available to evaluate these questions both on water quantity and water quality impacts, and then what are the impacts themselves to water quality and quantity? What do the data tell us about these impacts?

We also want to hear about regulations. We have representatives from federal agencies and state agencies and they will bring different perspectives on regulations and which are available and used at the federal and the state level. And finally, the best management practices: What are these and how do they differ between states and federal agencies and within -- you know, among the states and so what are the best management practices available to minimize the impacts on the environment?

This is a lot to cover in a one-day session and it's a lot to ask to have this in 20-minute bite-size pieces, but we'd like each panelist, if possible, to keep to the 20 minutes, so that we can have a nice half-hour or so discussion at the end.

So this panel, we're going to first hear from the federal representatives. We have BLM and EPA and then we're going to hear from a representative from industry and then three representatives from three of the six states that Murray mentioned in the beginning: Montana, Wyoming and Colorado.

The first speaker will be Matt Janowiak from the Bureau of Land Management. Matt is the Assistant Center Manager for Physical Resources for the Bureau of Land Management in Durango, Colorado, and also in Miles City, Montana. Matt?

MR. JANOWIAK: Good morning. As Ann said, I'm the Assistant Center Manager for the BLM and the Forest Service in Durango, Colorado. My purview is lands, realty, oil and gas, mining, et cetera, for both agencies.

I want to thank the Academy for arranging this panel and hope that my presence here helps the Academy achieve their goals. As many of you know, the BLM manages the CBM development on the federal and

Indian mineral estates in many regions of the Western U.S., including the San Juan and Raton Basins of Colorado and New Mexico, the Power River Basin of Wyoming and Montana. We also have some emerging place of our price field office in Utah and some ongoing exploration work over in our Peance Basin in Utah and Colorado. We also are looking at the Green River Plains, as well. They're emerging.

Each basin has it's own unique matters, which either serve to reduce or magnify impacts to water resources when CBM is developed. Produced water management concerns are largely focused on the Powder River Basin of Montana and Wyoming and to a lesser degree the other basins of the Western U.S. This concern is justified because of the large geographic area of the Powder River Basin and the relatively large amounts of produced water generated by CBM development in that basin. Water management techniques that are employed in the Powder River Basin are different compared to some of the other basins, and we'll touch on that, and the impacts associated with water management in the Powder River Basin are largely different.

As I go through my responses to the questions, I'm going to defer to my fellow panelists when it comes to questions relating to State or EPA regulations for produced water, and also, I will defer to Debbie Baldwin and others when it comes to discussions on the Raton Basin. I'm not very familiar with the Raton Basin in Colorado and New Mexico.

What I'd like to do is kind of take the questions out of sequence a little bit and save number one for last. So the first question is: How does CBM-produced water managed and how the best management practices apply to CBM water production, treatment and disposal?

CBM-produced water management is complicated by mineral and land ownership patterns, complex regulatory structures, multiple state agencies, BLM, BIA, EPA, Forest Service, we've got multiple operators and varying geologic and hydrologic factors across each basin and on top of that, we have the public reception of the CBM development varies basin by basin, so (loud noise interruption) -- there's good things and bad things about going first. I'll just have to pipe up.

When we talk about the San Juan Basin, and I think in other basins, as well, when we talk about like the price field office of the BLM, Peance Basin and a few of these other basins, the vast majority have produced waters injected into deeper geologic strata.

You know, this is just one of those situations where there's a low amount -- relatively low amount of low quality water that's being produced and convention oil and gas development has relied on deep injection for disposal of salt water and so that's just carried forward into the CBM development in a lot of these basins.

We've tried -- in the San Juan Basin we've tried lime evaporation ponds. They were ineffective due to our long winters. There was a proposal to use CBM-produced water for sod farming. That was never implemented, but they did have everything ready to go. And I'm aware of one permitted use of CBM water for use of water for livestock watering in the Northern San Juan Basin and that's where the water quality near the outcrop recharge area is sufficient to use it for livestock.

Interestingly, during the Missionary Ridge fire of 2002, which burned over 75,000 acres north and east of Durango, the CBM operators were trucking in their produced water to remote slurry mixing stations, which allowed firefighters to mix slurry without removing water from our local rivers and streams, which were already running dangerously low. When we get into the production, best management practices, in most of these basins, aside from the Powder River now, we can talk about water and gas lines installed in common trenches, you know, relating to the production of water. We're trying to reduce the disturbance there, several operators using common or shared injection wells, again, reducing overall surface impacts, and reducing the number of injection wells. We considered water flow lines actually a better alternative than trucking the water, even though some of these wells in the San Juan Basin are producing a quarter a gallon a minute or less, putting that flow line in reduces a lot of truck traffic out there, a lot of dust and things like that, so we feel that's a better alternative. Operators have been doing that as just a matter of course for most of their wells out there.

And then we get into treatment in San Juan and into the other basins, the Peance Basin, for example, treatment is not being used. It was tried, reverse osmosis was tried, didn't work. So now they're just relying on deep injection. We get into the disposal again. It's just your deep injection. There's really insufficient water volumes being produced to even think about irrigation in most of these basins. You just simply don't have the volumes to even bother with treating it and using it for irrigation or some other use like that.

Then we get into the 800-pound gorilla Powder River Basin. In the Powder River Basin, the produced water is managed in many different ways. You know, we'll just touched on a few of these. We do see irrigation of crops using sprinklers and subirrigation. We do see discharge to rivers and streams of treated and untreated water, and evaporation and infiltration impoundments. There's some emerging interest in injection of the water into aquifers. There has been constructed wetlands as a method of water management. And I'm sure there's others that I haven't thought of as I was writing this up.

When we get into the best management practices, we talk about irrigation, we're looking at operators and surface owners who are going to be doing it in a managed irrigation scenario where you have soil and water compatibility testing, soil amendments added where there might be some incompatibilities. Soil water chemistry testing, you know, this is just to make sure that when you define your incompatibility between the chemistries of soil and water and the amendments you add, that you were right and that you're not doing any damage to the soils long term.

Long-term monitoring and balancing of

amendment versus the water application rates: No run-off projects, basically applied water -- your applied produced water stays where you're putting it on the ground. It doesn't runoff to streets and rivers. There's consideration of after effects and soil productivity after irrigation water is no longer available. Looking at final edition of amendments and reclaiming the soil structure because that produced water will not always be there in those volumes and so eventually that land is going to have to be returned to a healthy status.

We talk about best management practices for evaporation and infiltration ponds. One of the BMP's is selecting the sites to minimize surface disturbance and this is on-channel versus off-channel siting. When you go off-channel, typically you're on ridge crests and you have a much larger footprint when you're building those impoundments. On channel, you have a much smaller footprint. You're just building a berm or a small low-level dam across a channel and using that as your footprint for the water storage.

We get into building ponds to reduce mosquito breeding habitat. This is especially important in the Powder River Basin where the West Nile Virus is now becoming prevalent and is no friend to the sage grounds. The monitoring effects of infiltrating waters on shallow aquifers, looking at mobilization of salts and metals, water mounding, things like that. Is the water going where we thought it would go? What -- you know, is it mobilizing and in training metals and salts down into the aquifers? Those questions all are addressed through the best management practices.

Siting impoundments to avoid local hydrologic impacts, such as creating new seats and springs. Spraying water to accelerate evaporation during summer months, when you're talking about evaporation ponds. If you're going to build one, you want to build just as small a footprint as you need, so accelerate evaporation when you can.

Consideration of after effects of chemistry and the reclamation potential: We may need a very different approach to reclaim dried up impoundments. You know, we're looking at soil amendments, imported topsoils, different plant assemblages.

When we talk about best management practices for surface discharges, we're looking at locating discharge points to avoid incising drainages. That's probably one of the most critical things when you look at surface discharge. Putting in energy dissipation structures, again working with the natural topography to make sure you're not making things worse. Selecting discharge points at perennial streams, not in ephemeral drainages or intermittent streams when possible. It's not always possible in the Powder River Basin.

Treatment prior to discharge: Basically we're looking at Montana, in particular, treatment of all CBM water before it's discharged. Monitoring is performed. That's in one of our BMP's. Aquatic assemblage monitoring, making sure we're not having effects on the aquatic life. Sodium absorption ratio monitoring to protect downstream irrigators, constructive wetlands can also help mitigate some of the impacts associated with chemical and incompatibilities and erosion.

We get into best management practices for injection: Shallow injection in the Powder River Basin is just sort of emerging right now, but it's becoming -- looks like it might be becoming more economically viable as an option and it's attractive as surface discharge permits are becoming more stringent, the application of injection is highly dependent on local geology. Operators are now actively looking for injection zones during the initial exploration phases. If suitable zones are found, then the injection facilities could be designed into the overall field plan of development. This reduces the need for additional water lines impoundments and other facilities.

I will defer to Debbie on the Raton Basin, as far as the BMP's there.

When we get into the price field office area in Utah, it's kind of interesting. I know they use deep injection and what I'm finding out, though, is that with the booming of CBM development out there, they're actually running out of capacity in some of the deeper saline aquifers that are in the injection zones. So I think they will be looking at other produced water management options as time goes on.

We talk about Question Number 3: Which production techniques for CBM minimize impacts on water resources and what are the costs associated with mitigation techniques?

I think it's important to note that in CBM basins such as the San Juan, the Peance Basin and others, there really are no production techniques that are employed specifically to minimize impacts on water resources because the overall impacts are very low to begin with. In other words, production techniques are focused on maximizing gas recovery. When we talk about the Powder River Basin, production techniques are focused on gas recovery and minimizing costs associated with produced water management, not necessarily minimizing impacts on water resources, but this is changing in the PRB.

And I think we'll talk a little bit more about some of these production techniques as we talk about the impacts of mitigation measures as part of Question Number 4.

In the Powder River Basin, there's an emerging interest on the part of operators to develop production techniques that effectively reduce the volumes of produced water brought to the surface. One production technique that they're looking at, that's being explored, is a well bore that serves as a production well and an injection well in one. Basically bringing the produced gas up to the surface and letting gravity pull the water from the coal zones down into a deeper strata and pushing it down into a deeper strata of pressure, thus not even bringing produced water to the surface.

And so they're looking at that, and again, you know, I think it's important to emphasize there's no silver bullet. There's no one size fits all everywhere in the Powder River Basin or in every basin. It's all determined by the geologic conditions. You have to have an injection zone that you can move that water into and it's -- you can't do it when there's shale down below you. So it's just one of those things to keep in mind and I think operators are now looking, you know, beyond the coals as they're doing their exploration programs to see if there are zones down there that they can actually inject into.

The costs associated with this production technique are unknown at this time. I think one of the neat things about injection of produced water, especially in the PRB, is that you're taking water out of one aquifer zone, putting it into a nearby or adjacent hydrostratagraphic unit and what you do is you keep ground water as ground water and the surface and ground water interactions remain relatively undisturbed, not entirely so, but you're doing little -- much less to upset the balance between those.

I think when we talk about the best technique is really more pre-production and that is in BLM we require operators to submit a plan of development when they go into develop a CBM field. In a plan of development, we want to see all of your wells, all of your compressor facilities, all your water treatment facilities, all your impoundments laid out on a map before we even turn that first spoonful of dirt. And that way, we get to make the adjustments on the ground before the project even goes in and I think that's probably the best -- one of the best techniques that we can look at.

We talk about the data that we have available to us. There's a huge volume of data available. The data collection efforts, the regional cooperative efforts, the BLM, USGS, EPA, the state agencies, multiple state agencies, ranging from Department of Environmental Quality to the Oil and Gas Conservation Commission, Fish and Game, Fish and Wildlife Service, industry, landowners, irrigators, counties, contractors, tribes, are all teaming up with us to get the right data. Literally billions of chemical, physical and biological observations are made annually in the producing basins.

Tons of geologic data, well logs, all kinds of well logs from thousands of wells, permeability and porosity, gas content of coals, hydrologic data. We've got stable isotopes. We have tritium analyses. We do 3-D ground water flow modeling studies, 3-D multi-phase or two-phase flow modeling studies, surface water monitoring, chemical or chemistry and flows. We look at toxicity testing, lab and field tests on the biota. We inventory wells before we drill the domestic and livestock wells. We look at water quality data from ground water, produced water, surface water. Tons of that data is being collected: Shallow ground water monitoring data around impoundments, biological data, soils data, on and on it goes.

Then the effects when we talk about Question Number 1: What are the effects and well, the CBM production on surface water and ground water resources?

Well, first of all, production: We see a reduction in the head and regional aquifer systems. It dries up some springs and water wells, depending on the level of interconnectivity between the producing zone and the surface water features or shallow wells. It reduces aquifer discharge into local streams. Stream depletion, that's been documented in the San Juan to some degree and the Raton Basin, I believe, as well. It releases methane into shallower wells in some areas. You do see some methane seeps at the outcrop. When we talk about the impacts related to disposal, we can say it alters flow regimes and local streams. Discharges have produced water will increase flows. It can alter the chemistry in streams. Monitoring is shown apparently not to be the case in the Tongue River, as far as I know, and discharge permit conditions can effectively mitigate the impact.

It can alter soil. Disposal can alter soil structure due to the sodium absorption ratio in produced water. It increases breeding habitat for West Nile Virus mosquitoes. Another impact related to disposal is it increases habitat for water fowl, and it also increases the overall surface disturbance of our CBM projects, which in turn impacts other resources: Wildlife habitat and things like that.

I think some of the other things that we've seen in the Powder River Basin is we've seen mobilizing salts in the unsaturated zones at infiltration basins and again, I think that's more a temporal effect and limited in its area, or the extent of its effect. Like I said before, the West Nile Virus breeding grounds, and we see the impacts to the Greater Sage-Grouse populations out there. That's something that we really have to be aware of.

And I think we talked about the regulations. BLM, we have Onshore Order Number 7, which basically is our regulations which BLM retains authority to approve the produced water dispersal method. And you know, in effect, we're not permitting for surface discharge. We're not, you know, issuing an MPDS permit, but if an operator comes in and says, "I want to surface discharge produced water," we have to either approve it or deny it. So we look at the overall impacts of it and say whether or not we agree with it. Similarly, deep injection or infiltration ponds or things like that, all come to BLM for approval of the method of disposal.

If they do go to infiltration ponds, we have some very strict limits as to the volumes that they can put in and it's dealing with CBM, as well as with conventional oil and gas. We require monitoring of the shallow aquifer system and things like that for these types of things.

NIPA is another act that we follow as we go through the permitting process. And it requires us to analyze and disclose impacts associated with projects on federal lands, including split estate and we do this through EIS's which cover large projects and potentially significant impacts and evaluates smaller projects or site specific impacts. We are not allowed to permit undue environmental degradation under NIPA.

And so as we get into significant impacts, we still have to go in and mitigate where we can, meaning reduce those impacts where we can, and so that's -- NIPA is one of the drivers of that, and that's why when I talked about production BMP requiring a plan of development, plans of development is kind of important to note, they cover either -- you know, they can be as small as one section, 640 acres, and is larger than half a township. So it all depends on the operators and if you have one operator owning the -- or leasing the mineral rights under a township, you can actually have a layout of a plan of development covering 18 sections, which is, in our minds, a real benefit because we get to see a bigger picture. We get to have more flexibility as to where we can move things to reduce those impacts.

It also, under NIPA, allows us to look at the bigger picture in terms of the impacts on the landscape and then once the operator gets a green light to go ahead and gets those permits, he might several hundred wells permitted after a plan of development has been analyzed and approved. So he knows going in that there's going to be several years worth of field work going on out there and have everything planned and laid out in preparation for that, instead of doing these smaller, little plans of development. The bigger ones are actually more effective from our perspective and I think from the operators, it takes a little longer to do the analysis.

We must follow and adhere to the Clean Water Act, the Endangered Species Act, Clean Air Act, all those other good things. I'm not sure if the Migratory Bird Treaty Act comes into play here, but we will have to follow it. And that's it.

DR. MAEST: We have time for one, if there are any quick questions to clarify any of the points that Matt has made? Bill?

MR. CONDIT: Yes. Do you mind if I just sit here? Bill Condit, I just after I retired, I became aware that a citizens group in the Wyoming side of the PRB, sued BLM over its adequacy, if you will, of environmental documentation relating the differences to its CBM production and tax versus convention, given all the way to the Tenth Circuit here in Denver and the Tenth Circuit side of the environmental group, and has the BLM now finished the redo of the RMP to allow the reading public to see a new analysis of CBM prospectus? The CBM impacts as it folds into that Resource Management Plan for Buffalo?

MR. JANOWIAK: Let me get this straight. I think -- my understanding is that the environmental impact statement for the Buffalo Field Office was done and a record of decision was signed. And so they are now developing a CBM in the Buffalo -- in the Wyoming portion of the Powder River Basin and that's all, you know, basically public information. It's out for anyone in the public can get ahold of the EIS and the Record of Decision.

And I believe the Record of Decision predates Chris, Chris's tenure; is that true, Chris? Chris is our field office manager in Buffalo, and Miles City, which is the Montana portion of the Powder River Basin, we've been supplementing the EIS and that was looking at phase development alternatives and a few other things. And I believe now that has gone through the entire public comment period and Record of Decision is now being drafted, but they are not doing full scale development in the Montana portion.

DR. MAEST: Can everyone hear in the back there? Is that loud enough? Okay.

Okay. Our next speaker will be Mary Smith from the Environmental Protection Agency. Mary is responsible for effluent guideline programs that set national standards for wastewater discharge into surface water and to publicly owned works. And if anybody has anything to add to what -- I'm just going to keep it very short in the way of introduction, just please feel free to add what you would like.

MS. SMITH: Okay. I've got a presentation and it probably takes more than 20 minutes, so some of the slides I'm going to skip over. I have given a copy to the Committee and hopefully they'll use that as reference. There's also much more information on our website in terms of this issue.

First, I wanted to thank the Committee for allowing me to come here and speak, particularly about the detailed study we're doing on the Coalbed Methane industry, as part of our guidelines planning process.

Let's see if I can get this right. Okay. My presentation is basically going to probably skip over some of the statutory stuff pretty quickly, give you an overview of Coalbed Methane issues, as we see them, particularly about produced water and the impacts of it, and then provide you some detail about what data we're going to collect, as opposed to what we know right now.

We have two principle statutes in the Office of Water at EPA that we operate under. One is the Clean Water Act. The pertinent parts are for point source dischargers of waste water. We implement the Clean Water Act through national regulation and individual facility discharge permits. Any discharge to the surface water needs to comply with a more stringent of a technology-based regulation set federally or water-quality based limits that are set locally. And then the Clean Water Act, which is pertinent to our study, gives us very broad general information gathering authority.

Turning to the safe drinking water because you wanted to know about hydraulic fracturing and I'll get to that in more summary later. The pertinent sections of that Act are 1421 to 1425 that authorizes EPA directly or through EPA authorized states to protect underground sources of drinking water, better known as "USDW's," by ensuring that fluids injected into the ground do not endanger underground sources of drinking water. The focus is on contaminants that are regulated under drinking water regulations, but there's a provision to protect generally public health. Prior to 1997 it wasn't clear to us that we have authority to deal with fluids that are injected for purposes of Coalbed Methane exploration, but a court case in the Eleventh Circuit, which involved the State of Alabama's program, made it clear that we did.

However, then we did a study, which we issued in 2004, which I'll get into a little bit later, but then 2005 rolled around and the Hill passed the Energy Policy Act and excluded hydraulic fracturing fluids from Safe Drinking Water Act authority. There is some press lately that indicates some people on the Hill and other groups would like to repeal that Legislation.

Turning now to the Clean Water Act, which is going to be most of my presentation, as I said before, discharges of water are principally regulated through individual facility permits. Most of the permits are issued based on national technology based regulations. They don't exist for all discharges and so when they don't the permitting authority, whether it be EPA or the States will then, of course, decided based on the best professional judgment what technology might be appropriate for that facility and they'll take into account costs of implementing that technology. When a State or other permitting authority decides that the technology based limit is not stringent enough to meet local water quality limits, then they can impose a more stringent limit, based on those local water quality concerns.

I want to talk to more my area of expertise because in my division we issue the effluent limitations for industrial discharges. These are national regulations. They are issued by industrial category. Over the past 30 years, EPA has issued some 56 of these regulations. The one more pertinent to this discussion is the oil and gas extraction industry, which we originally issued in 1979 mostly for onshore oil exploration, but then extended it to offshore and coastal later on in the `90s; however, we have determined that while Coalbed Methane extraction is probably a subcategory of this large category of regulation, there isn't anything in the current reg that addresses Coalbed Methane, so as you heard earlier and will probably hear from some of the states who were on the panel, we now issue permits on a case-by-case basis and look at the available technology and the affordability of that technology.

This gives you a sense. I heard earlier that you're just concerned about the western portion of Coalbed Methane. We're obviously are concerned more across the country. The red spots there are the largest Coalbed Methane producing basins, which is the San Juan in New Mexico, Colorado, Powder River in Wyoming, Montana, and the Black Warrior in Alabama.

From an environmental perspective obviously, we're very concerned about the produced water. As you heard earlier, it's a complex issue, this produced water. It can vary from time to time in the production of a well, principally the greatest produced water being ejected in the very start, in the very early portion of the well's development and then it tapers off from there. I'll have a slide in a minute about that.

Also, the pollutants vary from well to well. Potentially they certainly vary from basin to basin, but even within basins the types of pollutants and also the level of the pollutants in the discharged water do vary. TDS is one of the components we measure in the produced water. TDS includes dissolved mineral salts, metals and other solids. In the Eastern United States, you can see TDS concentrations ranging from 500 to 27,000 milligrams per liter. In the Western U.S. from 400 to 2,000 in the Powder River, and often up to 50,000 in the San Juan Basin. This will impact, of course, the kinds of treatment technologies that might be available in each of those basins.

To kind of give you a comparison, in terms of what these numbers mean, generally it's thought that potable water should have a TDS level of 500 milligrams per liter or less. And for irrigation, a maximum of 1,000 to 2,000 milligrams per liter. Obviously Coalbed Methane can contain small amounts of other metals, et cetera, and there are a couple of other parameters by which we measure the quality, SAR, which is sodium absorption rate, and EC, which is electrical conductivity.

The next slide, just is pictorially telling you how for one particular well over a two-year time frame from start to two years out, how the blue is the water -- how the water -- produced water varies in terms of volume.

The next slide for the Powder River Basin just kind of pictorially tells you for TDS what are the various TDS levels within this one basin. So they do vary, complicating any kind of regulation or issuance of permits greatly.

The potential environmental impact: Again, my colleague from BLM touched on these a little bit. Obviously they can vary a great deal. You can get produced water that is of very good quality and can be used directly -- directly discharged into streams, or can be used for irrigation or livestock watering. Then you can get very low quality Coalbed Methane. You saw it on a slide earlier about how low the quality can get and that's going to have a particular impacts on aquatic and benthic communities, which can't tolerate the high saline content of the water. This can lead to kind of a different diversity in the stream favoring organisms that are more tolerant of salt and decreasing the species that are less tolerant of salt.

It can damage streams that are previously used for livestock watering or irrigation. And you know, a long-term build-up of sodium on land can reduce plant diversity and alter the surface hydrology. While we do have some instances of how these things occurring, we don't really have a good handle on the extent of the impacts environmentally. There are a number of technologies to treat it. We've certainly got several discharge options that were laid out by my colleague from BLM. There's the reinjection or injection into Class 2 wells.

In our technical support document for our 2006 planning cycle, which I'll get into and explain later, we estimated the 2006 costs of reinjection on average being anywhere from 15 cents per barrel of water to $1.89. And as indicated earlier, about 95 percent of the wells in the San Juan Basin and the Raton Basin use injection or reinjection. There's also storage or evaporation ponds, which they got into earlier. We find the 2006 cost of this probably anywhere from six to seven cents per barrel. The water either evaporates in the ponds or is used later for irrigation purposes.

There's often -- some people haul water. I experienced that in Pennsylvania, when I did a site visit there. They actually collect the water and haul it off for somebody else to dispose of it. I don't have a good sense of cost on that. It's not used that often.

Then there's treatment options. The most common one is iron oxidation. You precipitate the iron to eliminating staining of streams when you discharge the water. It's done through aeration or chemical oxidation. Then there are more advanced technologies that I mentioned on the slide, like reverse osmosis or ion exchange and they generally cost anywhere from 15 cents to 51 cents per barrel of water.

There's some other technologies that are detailed in both our 2004 and 2006 document -- technical support documents.

I would note that reverse osmosis and ion exchange are not common treatment technologies and have some technical difficulties and cost issues associated with them.

Okay. Now I think I skipped a page. Okay. Let me explain a little bit about our effluent guidance planning process in order to identify either old guidelines that need to be updated or new guidelines that have never been created. Congress enacted the 304(M) in the Clean Water Act in the mid-80's. It requires us to publish a plan every two years and to take comment in between times, which we do in the odd number of years. We call that a "preliminary plan."

In these biennial plans, we'll announce an annual review of an existing guidelines we're supposed to do and then announce what new guidelines we might be redoing.

Sometimes instead of announcing it, we'll do a rule making or revised a rule making. We'll decide to do a detailed study because we don't have enough information by which to make a decision to go forward with rule making. Rule making is complicated and it's expensive and lots of stakeholder dynamics, so we want to be careful that we've got enough information that says, "This industry or this subcategory of an industry merits a rule making."

How do we come about to identify Coalbed Methane for further study? Well, clearly in the `90s when we were amending the oil and gas extraction regulations, there wasn't much Coalbed Methane development. It only became a more viable industry in the late `90s and early 2000s when natural gas prices increased a lot and drilling technology advanced so that it made it a much more viable industry. According to 2006 figures, Coalbed Methane accounts for about a little over 90 percent of the natural gas production of this country. There's some figures here about the production in several of the states and it's expected to continue to be a significant source of natural gas in this country.

Generally when we do our planning process in our annual review, we look at two significant national databases. One, a database, used to be called the "PCS System." That's the old version. The new version is "ISIS." It contains monitoring data from a lot of the major permits across the country. States input it into a database that exists at EPA headquarters. Unfortunately, we looked at that database in terms of Coalbed Methane, what we could see about the discharge data, there wasn't much there. In large part the PCS database tends to favor major facilities and many of the Coalbed Methane production facilities are not in the major category.

The type of relief inventory area is a huge data set that has pollutant discharge information from all sorts of media: air, water, and solid waste. Unfortunately, there's an exemption to inputting it to TRI for oil and gas extraction, so there's nothing in TRI relating to Coalbed Methane.

So lacking anything in these national databases, we just did some information gathering of our own in terms of searches. We looked at some publicly available permits on state websites, et cetera, received a number of comments as part of our planning process from some community groups, and decided in late 2006 to do a detailed study of Coalbed Methane, feeling like we didn't have enough information. As I indicated earlier, this is a complex industry. There's lots of different basins. The production of water and the quality of water varies between basin and within basins doesn't make it an easy analytical job and so we decided we would do a detailed study that would better profile the industry.

As we look at things like available technologies and costs, we have to kind of really get at a micro level. So our detailed study that we have already started is going to profile the industry, look at geographical differences and the characteristic of produced water, look at current regulatory controls that, say, permitting agencies have imposed, look at treatment technology options, both those that are commonly used and those that are not as commonly used because some of the focus for a national guideline is to try to force the industry to move towards the best technology, if it's affordable.

And then the economics are always a complicated matter. This is not publicly available information and so it's hard to make decisions. We do have the authority under the Clean Water Act to ask for information from individual facilities, even if it's confidential business information.

In particular, one of the ways in the effluent guidelines planning process and our rule makings, we collect very detailed data is through an "Information Collection Request," authorized under federal law. It requires approval from the Office of Management of Budget. Their focus is to make sure this is not a duplication of effort, that it's not a burden on the entities that we're requesting information from, and to make sure that it's targeted to what it needs to address.

In order to better design our survey, we start a good of outright reach this last year. We conducted a series of teleconferences with a whole host of stakeholders, acquainting them with our study so they know what's going on and what they might expect and to solicit initial input from them. We also did a number of site visits in five Coalbed Methane basins in the latter part of last year. And these -- the purpose of these visits was to provide an opportunity for interested parties to share their thoughts and data with us, for us to observe and actually go out into the field and observe treatment technologies that work, and to discuss issues associated with the industry.

We also had separate meetings, other than the site visits with interested stakeholders. A full range of them are listed on the slide. All the information for these site visits and meetings are on our website and the website URL is up there on the slide.

I'll probably skip over these next -- this next one, we just talked about, the ICR. One thing about the ICR issue to note is that the federal law, the Paperwork Reduction Act in the second slide there, requires us to do two public notice comments. The first one just started. We'll do another one later this year. This is to solicit information from the public on the survey design and on the actual questions that we will pose to the industry. These surveys are multi-page, let's say, surveys getting into a lot of detail. And I'll talk a little bit about the kind of detail we're going to be asking for. We're going to be asking for permit information from each of the facilities surveyed. You know, what are the limits in your permit, for what pollutants, et cetera. We're going to ask about production levels and produced water characteristics. To the extent there's monitoring data out there, we'll have people submit it so we'll have a real sense of the variety of water production and pollutants of concern and the levels of those pollutants.

We're going to ask about treatment technologies, what's currently used at the facilities, and most importantly, what you can't get any place, is very detailed economic information about revenues and net incomes, operating costs and expenses. This goes into the economic analysis as to what is affordable for this industry as a whole.

I'll probably skip over the next slide. It just talks a little bit about our economic analysis. I'd say for new facilities, what we look at economically is barrier to entry, which is -- will a technology option actually be a barrier for entry for new facilities and for existing facilities we look at how many businesses, what would the cost of the technology be in terms of the business's revenues. We look at a cut point of about 3 percent of revenues. If the costs are over 3 percent of the revenues, we start worrying about that. So those are the kind of economic information will be generated and why we need that detailed economic analysis across the industry.

Our schedule for the study is that we just issued the first public notice of the ICR, that actually has a copy of the survey instrument in the public docket. Comments are due later this month. We'll do a second Federal Register. Notice is required by law. Later in the spring we hope to get OMB approval in mid-summer and send out the survey late summer, and then we hope to again get all the survey information in, analyze it, and have kind of a preliminary sense of where we're going in the fall of 2009.

The committee wanted to know a little bit about hydraulic fracturing. Hydraulic fracturing is a technique used to increase production efficiencies of Coalbed Methane wells. You know, there was a lot of interest in this issue and it's concern about contamination of underground drinking water sources, so because of that a case, which is called the "Leaf Case" in 1997 because of Congressional and other public interest, EPA in about 2000 decided to do a study of Coalbed Methane hydraulic fracturing. We looked at various water quality incidents that had been reported in existing literature. We did some site visits, interviewed people, worked with citizens and citizen groups, took public comment on the study and actually convened an expert panel to review the work.

At the conclusion of that study, which we issued in July of 2004, EPA concluded that there was no viable incidents of drinking well contamination from hydraulic fracturing; however, the study did find that some diesel fuels were being used in the fracturing fluids and there was a lot of concern about that because some of these components of diesel fuel are actually used, are actually regulated under the Safe Drinking Water Act and so in late 2003, EPA entered into an MOU with the major companies conducting hydraulic fracturing and they agreed to basically eliminate diesel fuel from the fracturing process. The companies continue to abide by the agreement. The Ground water Protection Council, which is a national organization of state ground water management, recently surveyed all the states indicating that there is currently no use of diesel fuel in Coalbed Methane injection fluids.

And that concludes my presentation. Hopefully it wasn't too fast for all of you and more information can be gotten on the Coalbed Methane study and all those site visits that we did in the first website up there and the whole study about hydraulic fracturing can be found at the second citation on the last slide here.

DR. MAEST: Thank you very much.

We have time for maybe one question -- one or two?

MS. SPEAKER: Well, I have a question. It seems that your initial finding was that there was not enough data available for -- maybe you could expand on that a little bit. Does that also include data for evaluating impacts on ground water and surface water, produced water discharge or was it broader than that?

MS. SMITH: Well, I think that the focus of the FO guidelines planning process was only on surface water. Ground water is Safe Drinking Water Act and of course, now it's not, of course, regulated under Safe Drinking Water because of the 2005 Energy Policy Act, so our focus in the FO guidelines planning process is surface water discharges. We lack good information on economic impacts. We lack good information on exactly what are the elements and the levels in produced water. We lack information on the geographic diversity. Some of those ranges that I gave you are just that. They are ranges from public published literature indicating a small amount of monitoring data or tests that were done by private organizations or universities that indicated some level of TDS in produced water, but we think there's a wider variability out there and we'd like to know more about that before we go forward.

DR. MAEST: Any other clarifying questions?

Frank?

MR. BURKE: I thought I heard Matthew's presentation saying that there's a huge amount of data out there. And you're saying we get an ICR request because the data -- at the federal level, the database at the federal level, is that really what you expect as you go through this participation. I guess maybe the first part of my question is, is that speculation?

MS. SMITH: Well I think, for example, the kinds of information out there that aren't readily accessible to us, hence the ICR, would be monitoring data under each of the individual permits. While that's all out there, it's not collected in one source that's easily accessible. For example, yeah, financial information is out there on facility level basis, but there's no way anybody -- any facility is going to disclose its financial data to the general public. So again, it needs to be gathered and again, a lot of that's confidential, plus sensitive information, but we have safeguards at my office. We get that kind of information all the time when we do other rule makings and so we do protect it.

So I agree that there's a lot of information out there, but it's not readily available in one source that we could analyze and so the purpose of the ICR is basically to put it together in one place.

DR. MAEST: And when you gather the information, some of it is confidential business information. How will that be -- how will you present that to the public? Does it get massaged in a way that protects that?

MS. SMITH: Yeah, there will be a variety and we do ask facilities who report to us to designate what's confidential and what's not. It's certainly the agent's position and in regulations that monitoring data is never confidential, so that would be readily available, or clearly financial information is the sort of information that's very arguably confidential. What we would do is we would collect and group the information in a non-CBI way. We wouldn't give out individual data if the company claimed it confidential.

So we have ways and we have done this for years in our other regulations where we aggregate data so that it loses its confidential flavor, you might say. So that there's enough companies in the aggregation that it doesn't give away. And to the extent that there's a couple of companies, which we aggregate together, we actually consider it not to be public data, as you can -- you're only looking at a couple of industries and you can actually probably slice it and dice it to get the confidential aspect out of the information. So it's going to be a large aggregation of a lot of data, but will give us ranges, et cetera.

DR. MAEST: Thank you.

And our next speaker is Jon Jaffe from Anadarko Petroleum. Anadarko is one of the largest producers of Coalbed Methane in the Powder River Basin. And Jon is an engineer that deals extensively with water management, so he'll be talking to us about produced water management.

MR. JAFFE: Good morning. I'm going to talk about Anadarko's approach to water management. We think we're on the cutting edge of water management. I'm going to limit my talk to that Question 2: Best practices in water management.

I'm sure most of you know where the Powder River Basin is. Here's a quick map of Wyoming and the Powder River Basin. There's two Coalbed Methane fairways, the Wyodak and the Big George. I'm not going to talk about the Wyodak. That's mostly depleted. Most of the work done in the Wyodak is finished for water management. As a general rule, the constituents of concern that we're talking about is sodium and how it affects the SAR ratio. As a general rule, it gets the water quality is better in the south and east and it gets worse as it goes north and west.

Anadarko employs many methods for treatment. We have aquifer recharge or water storage project. We do a fair amount of ion exchange. We have reverse osmosis plants and we do a limited amount of irrigation. And we also do a very small amount of direct discharge.

With water storage and aquifer recharge, Anadarko put in a fairly extensive project that takes water from the middle of the Powder River Basin, 50 miles south to Salt Creek -- 50 miles south to Salt Creek and then we reinject that water into two formations, the Madison formation and the Ten Sleep formation for potential reuse. It's very difficult to find suitable aquifers up in the area that we're developing our Coalbed Methane. So that's why we developed this project.

Here's a quick pictorial. It's a screen dot from one of our projects, but we gather water from the Coalbed Methane field. We take it through some small pumps, some filters. We put it into a giant tank to give us capacity to pump it. We increase the pressure. It says, "750 psi's." Sometimes it's higher than that. And then we pump it the 48 miles down the pipeline to Salt Creek for injection.

So we have 48 miles of 24-inch steel pipeline. It has a design capacity of 450,000 barrels per day. We're not anywhere near that. Right now our capacity, based on pumps, is somewhere around 240,000 barrels per day. We have three injection wells that size for our water.

And I'm going to show a graph later in the presentation and that'll answer the question of why this is oversized and why we're only at 240,000 barrels.

There's a picture of the typical pipe used. It's hard to show a picture of a pipeline because the next picture, here's the pipeline after a couple of years, a typical reclamation area. So after the pipe is in the ground, you don't see much. There's not much of a picture.

So this is our pump station and it doesn't do it justice because those are four Sulzer pumps and each one has the capacity of 60,000 barrels a day so those are monster pumps. Doing the math in my head, it's about -- it's greater than 2,000 gallons a minute. So those are big pumps and we have a big storage tank. The storage tank has a nitrogen blanket to keep bacteria from growing, and as you can see on the storage tank, that's a tracker there. So to give it some scale size on that tank, it's a big tank.

We also do ion exchange for direct discharge. We currently have 11 different sites doing ion exchange with two styles. We have a Higgins Loop and a packed bed system. These systems remove sodium, calcium and magnesium. They remove the cations out of the water because the constituent that we're after is the sodium and it's also going to pull out the other cations, the calcium and magnesium.

So I don't know how familiar everyone is with ion exchange, but you use a resin. This is a picture of a Dow resin, small, little beads. These resin beads are charged and then the CBM water comes in contact with them, it grabs the sodium, and than you have treated water. So you have very pure water being discharged. And then you regenerate by using acid. We typically use hydrochloric acid and you reap the hydrogen and the acid, it recharges the resin beads. And we use two processes. We use a Higgins Loop process, a continuous process. This is one of our vendors, Exmouth [phonetic]. They're a contractor that does a fair amount of -- they have ten sites for us and they do a lot of water treatment for us. And they use the Higgins Loop, the resin beads are contained in this vessel and it's a continuous counter-current frequency.

And then we have a packed bed skit. Here's a picture that shows it. We have three ion exchangers. It's just a packed bed. Three ion exchangers can filter the water and we put the water through there and we remove the sodium.

We have two reverse osmosis units and these are your standard. Here's a picture of one bank, but we have a three-stage reverse osmosis and an electrical coagulator in there to try and minimize the brine because we pay for brine disposals and we're getting our brine, in theory, less than 5 percent, and we're doing much better than that, but these are startup units and we're having the typical startup issues, so we can't really talk too much about RO until we've had some time on it.

We do do surface irrigation. We have two pivots. I couldn't get a picture of one of our pivots. This is one of our competitor's with our pump station in the background and one of our wells in the front, but that's what a surface irrigation pivot looks like. Like I said, we don't do much surface irrigation.

We are doing subsurface strip irrigation where we do have a pilot plan. We get to implement that in one of our remote areas. We're going to have subsurface irrigation and the advantage of this is that it's a year-around system. While surface irrigation is not, we can continue to use your drip irrigation in the winter. Most of these tubes are plowed in with typically three feet below the ground and you -- here's another picture of a beautiful alfalfa field. You can get four cuttings. It's higher than anywhere else in the valley that they've had success with these subsurface drip irrigation systems.

This is the company that does some work for us, the contractor. We're not really experts at subsurface irrigations and we've hired a contractor to do that for us and that's their system.

I was talking before about the challenges. If you look, this is typical of how water is produced in the basin. Let's say you start out at 500 barrels. Within a year, you'll be at 250 barrels. And within another year, you'll be at 125 barrels. So it's barrels per day per well. So it's difficult to size a unit, put capital investment in place to keep that unit full. So you have to have infield drilling to keep your water level, level.

So that is one of our biggest challenges is all these capital investments to get to pay off these units, because most of these units have three or five-year contracts and it's difficult to keep them full.

For our aquifer recharge projects, not many of the other players in the basin can afford the capital investment that it takes for a pipeline, deep injection wells for aquifer recharge and power throughout the basin is always a challenge. It's power is limited so when you're putting in new treatment sites, it's difficult to get power and running generators is very hard on the economics.

Challenges to treatment: With our ion exchange, we've got limits on the amount of sodium you can treat economically. That's probably somewhere a cation load of 1300 milligrams per liter. There are numerous vendors in the basin offering ion exchange. Some of these offer it with sulfuric acid versus hydrochloric acid. Sulfuric acid has an advantage in that it has two hydrogens with that exchange process, but it also has that sulfate on the end, and if you have any barium in the water, you'll end up with ferrite, which is very hard on your disposal wells. So we're happy with our primary ion exchange vendor. They use hydrochloric acid. They do a good job for us, so we'll probably not be going to try some of the newer, different styles of ion exchange.

Brine disposal is always a problem. Some operators have pits and lime containment areas for evaporation. We typically takes ours to commercial disposal wells. And again, power is a problem or a challenge for treatment, to get power and infrastructure into your treatment sites.

And then the ability to adapt with the regulatory landscape changing, we feel we have the ability to adapt to a fair amount of uncertainty and change by having multiple tools in our toolbox. We were constantly looking at new technology and we continue to manage our water.

And that's my 20 minutes.

DR. MAEST: Thank you. We've got some --

MR. SPEAKER: How many of the wells that you talked about that Anadarko has, producing wells?

MR. JAFFE: In the Wyodak or?

MR. SPEAKER: Well, in the whole basin?

MR. JAFFE: We have certainly more than 2,000.

DR. MAEST: Tom?

MR. FAULK: If I understood you correctly, you said you were developing 240,000 barrels?

MR. JAFFE: That's the capacity of the pipeline. That's no where near full.

MR. FAULK: Okay. I guess the data that you mentioned, how much -- what volume are you treating?

DR. MAEST: Don asked what volume you're treating by ion exchange on a daily basis?

MR. JAFFE: It's over 100,000 barrels a day.

MR. FAULK: Okay, so a significant volume?

MR. JAFFE: Yes.

DR. MAEST: I think Debbie had a question?

MS. BALDWIN: Yeah, I had a question. You were talking about the -- you were piping the water up to the Salt Creek Field and are you using that for enhanced recovery in the Madison or Ten Sleep or just for disposal?

MR. JAFFE: No. It's neither.

MS. BALDWIN: Oh, okay.

MR. JAFFE: It's aquifer storage for potential reuse. Those reservoirs have been used for water floods in the past, so those aquifers have been depleted so there's space. So we're storing that water. Those are not injection projects. It's aquifer recharge.

MS. BALDWIN: Thank you.

DR. MAEST: Yes, sir?

MR. SPEAKER: You mentioned you take your waste brine from your ion exchange sites and send them to a commercial disposal well? Why don't you put them down your Salt Creek disposal well?

MR. JAFFE: It's a aquifer injection and we don't want to put -- by permit we're not allowed to and we want to keep those wells for potential reuse. It would be nice because it would be a huge cost savings, because that's the biggest cost savings. If we could find wells, disposal wells in the are, that would be the way to go, but with $4 a gallon diesel fuel and you're trucking brine, it gets expensive.

MR. SPEAKER: Are you allowed to put the waste brine into a Class 2 disposal well if you had a suitable one?

MR. JAFFE: I don't know the answer to that.

DR. MAEST: Well, let's get names first, just for the recorder. Go ahead.

MR. HOSTER: My name is Jay Hoster. I was wondering, could you expound? When you said you do infield drilling to keep the water volumes up? I assume you meant infield drilling for gas recovery.

MR. JAFFE: Right, but the point is you have to stagger it because if you have all your wells producing at once, you're going to be at the peak of water production and then within a year, you're going to be at half a bank, so how do you handle your water for the peak? So you just have to stagger your drilling and your connections to feed one of these plans, but it's all -- it was discussed earlier about how these units when they go for BLM approval are all mapped out. They tell when -- well, not when the wells, but what wells we're going to be drilling. So they're all mapped out. It's just how you bring them on and how you time continue to smooth your water production to limit those peaks.

DR. MAEST: Okay. Maybe stand up and say who you are would help? Now this -- if everyone could step up to the podium, I think you're okay there, but -- because that microphone is working and then we can make sure who is asking the question and what the question is. Thanks.

MR. SPEAKER: You mentioned that you're having startup problems with your reverse osmosis system. What are the problems that your system is actually having? Why are they reliable for desalinating sea water, yet they seem to have problems with this type of application?

MR. JAFFE: That's a softball question, easy. When you're desalinating sea water, you're putting your brine back into the ocean. Since we're paying certainly greater than $4 a barrel to dispose of our brine, we're taking it through instead of a single pass RO, we're taking it through two more layers and an electric coagulator to try and get that brine minimized as much as possible because that's where all the cost is. A simple, single-pass RO would be feasible and most of these come out of a -- or ours come out of a pond. And in the spring you get tadpoles and tadpoles do terrible things to your pumps and to your bacteria problems and it's a difficult challenge.

I'll go back to EMID again. EMID has figured out that problem of how to eliminate the problem with tadpoles and bacterial problems in their treatment, so the ion exchange, they have two years ahead of RO on the curve so they've worked out quite a bit of it.

DR. MAEST: Ann Maest. I just had a question. Somehow we've managed to get this far without talking about the chemistry very much and you've mentioned sodium and sodium absorption ratio. Are there other constituents that you find in the produced waters that would be different types of treatment techniques to address and my understanding is these are sodium bicarbonate solutions largely? Is that true in all the basins or does that vary from basin to basin?

MR. JAFFE: That varies from basin to basin, but in the Powder River, it is a sodium bicarbonate solution and I'll get back to your question, but that brings up a point that every new vendor in the field says, "Ah, you've got sodium bicarbonate. That's a marketable product. We can sell that sodium bicarbonate. They do it in Green River. They do it elsewhere. We can do it."

And then when you -- and we've looked at it numerous times, flash evaporators, solar evaporators, all sorts of ways to do it, but the problem is that most of the rail transportation in the Powder River is tied up by the coal companies and to truck anything makes it a non-economic product, but it certainly would be nice if it was an economic product because we're producing a fair amount of sodium bicarbonate.

And some of the other constituents are the chloride and the Higgins Loop was originally invented to treat or to enhance ammonia in fertilizer production and it was designed as an anion exchange instead of a cation exchange. So as you remove the anions, you're percentage of chlorides go up. So you have to be very careful to stay under your discharge limit.

In other basins they do -- we're looking at two-stage processes. We put it through a cation removal and then an anion removal, but that -- it may not double your cost, but it certainly increases your cost.

DR. MAEST: You're a large operator and do some of these treatment techniques cause economic issues for smaller operators or do you think these techniques are relatively accessible economically?

MR. JAFFE: As I said, the majority of our treatment is done by a contractor and the contract -- and there's at least four of them selling ion exchange in the basin and our contractor is always trying to get the small operators to join in to either sign up for a contract, but it's a daunting task when you're committing yourself for that, but smaller operators could certainly use these techniques. It affects their bottom line because the cost of treatment is more than direct discharge for a pond or an irrigation.

But with Coalbed Methane wells, it's not good to turn them on and off and most of these treatments require summer treatment and winter turning the wells off. So we avoid that with some of these methods I showed you.

DR. MAEST: Okay. Thank you.

We're going to take about a five-minute break to stretch and the bathrooms are down this way and to the left and then on the right. And we'll see you back here in about five minutes.

(Recess from 10:03 a.m. to 10:18 a.m.)

DR. MAEST: Let's have everyone take their seats and I'm going to ask anyone who asks a question to actually go up to this podium because we're having a hard time hearing the question and it'll help the recording and everything. So if you don't mind just walking up and stating your name and affiliation briefly and then a question and that'll be fine. It looks like the microphone is working again, so we'll have Art.

In the second half of the morning session is going to be devoted to the state's perspectives and the first speaker is Art Compton from Montana Department of Environmental Quality. Art is the administrator from Planning Division of the Montana Department of Environmental Quality and he's going to talk to us about Coalbed Methane in Montana.

MR. COMPTON: Thanks, Ann.

You know, you'll see as each speaker gets up just how carefully the panelists coordinated each one of our presentations, and of course, the fact is we didn't, but I'm impressed with how -- I think at the end of this first session, you're going to have about five or six different pieces that seem to me like they'll fit pretty well together.

For instance, Mary talked about technology based water quality limits. In other words, water quality standard in the form of a effluent limit guideline that represents how good a job on water treatment can we do? I'm going to talk about Montana's approach, which is the other kind of water quality standard that Mary mentioned and that is a water quality base limit. It's not based on fuel deployable and economic technologies. It's based on the beneficial use you're trying to protect. And again, a very different from the technology-based water quality limit, Mary explained we're going that direction. In 2010 EPA may promulgate some ELG's. Right now that hasn't happened yet and what's left of the states then is this water quality case approach, based on the beneficial use.

You've seen this map before. Essentially the Rose Bud Creek drainage, the Tongue River drainage, and the Powder, interesting that when you're talking -- when you hear Bill from Wyoming talk after me, Wyoming has about 80 to 90 percent of the CBM resource. Montana has about 10 to 20 percent of the resource. So just as CBM development has come first to Wyoming and we can learn from their mistakes and their successes, Montana will not experience the level of CBM development that Wyoming has.

I think the federal EIS -- the joint state/federal EIS's predicted somewhere along the lines of 50-some-odd-thousand wells ultimately in Wyoming. The EIS predicted about 26,000 wells in Montana. If you ask somebody from industry, one of our producers, they tell you maybe one-third that many, eight to 9,000 wells ultimately in Montana.

It's dry country. This is irrigated alfalfa on the Lower Tongue before it empties into the Yellowstone. Irrigation water in southeastern Montana is the lifeblood of economic engine that agriculture provides to eastern Montana. As you can see here, it's dry country, and the whole notion and the reason -- it's one reason that beneficial uses, such as irrigated agriculture drive water-quality based standards. It's not just the law, as in Clean Water -- the Federal Clean Water Act, it's also a good idea because this water is so critical to Montana agriculture.

You've seen some of these numbers before, a lot of water out there. Matthew mentioned the difference between CBM development in the Southern Rockies and the Northern Rockies, Powder River Basin. Down in the south, New Mexico, Colorado, a little bit of really bad water. Reinjecting it is a no-brainer. Up in the Powder River Basin, we've got a whole bunch of water that's not that bad. It's got some beneficial uses that it can support.

When you look at increasing salinity and sodium -- two very different things, as I know most of you understand -- the first beneficial use to be effected is its ability to support agriculture, irrigated crops and the soils that support those. You can drink this water. You can water your livestock with it. You can use it for dust suppression, a whole bunch of uses. But again, with increase in salinity and sodium, the most sensitive beneficial use is its effect on plants and sensitive soils. So that's why water quality standards -- water quality based standards are really subject to beneficial uses -- are really driving by beneficial uses.

Everybody, I believe, knows that EC is. Mary talked about TDS. Remember, TDS is electric or specific conducting times about .7, so an EC of -- or TDS of about 1,000, or EC of about 1,000 is a TDS of about 700. I think everybody understands that and again, Ann, you asked the question, we all know about salinity and sodium, what are the other parameters in CBM water that are at issue. Montana's water quality based rule making was based on our two prime constituents of concern. Salinity, and again, when you think salinity as expressed by -- in decicemens per centimeter, electric conductivity, think plants, okay? The EC in the soil is what inhibits a plant's roots from being able to draw water out of that soil.

As you can see, the EC of the Tongue River is pretty darn good. It's pretty low and the Powder is a step above that. The EC is considered high quality water. I'll get into that in a second and the Powder is more marginally supportive of irrigated agriculture. The producers along the Powder, they all have conductivity meters. They're all very good at using those meters, about knowing that the flows increase after a precipitation event, that they need to stay away from the leading edge of that and wait a day before they turn on the pumps that feed their siphons that support their flooding -- flood irrigation. And again, the problem is the EC of produced water in the Northern Powder River Basin is around 2,000 decicemens per centimeter.

Our rule making looked at specific crops, different in the Tongue and the Powder, and that's why the numbers are different on each river and it includes the amount of water that you put on -- that an irrigator will put on the crop that moves past the root zone, is not included in that crop's agronomic uptake and therefore, it tends to flush salts away from the soil.

An example, the reason this is important is very different numbers in the Powder and Tongue. On the Tongue River we have mechanical irrigation, wheel lines and center pivots. It's more efficient. It's leaching fraction, we estimated at about 15 percent; whereas on the Powder where they use flood irrigation predominantly, that is a less efficient means of irrigation, which more water is put on. There's more water available to flush roots from the soil system.

And then finally, rainfall obviously dilutes the salt concentration of irrigation water, but it also has a very adverse effect, which is a real important consideration in rule making and I'll hit that here in a sec.

Sodium absorption ratio, again most of you know what that is. Just as we thought with salinity, we thought plants, whether it's field beans or corn or alfalfa, when we're talking sodium, we're talking impacts to soils. In fact, it impacts the sensitive soils. When we went about our standard setting process, we looked at the most sensitive soil type that was widely distributed across the basin and we found montmorillonite clays in about 50 percent of the soil associations in the Powder River Basin. That is a clay soil and it's those type soils that are the most susceptible to the dispersion that elevated sodium levels in irrigation water can cause.

Again, when that soil disperses, the hard -- it reduces both the infiltration on the surface and the ability of water, irrigation water, or rain water to percolate through the soil horizons to roots. So again, salinity is a plant issue. Sodium is a soils issue.

Again, the reason the numbers are important and the reason that agricultural use protections are important, you can see in the Tongue the SAR is very low. The Powder, it's still fairly modest CBM produced water in the Northern Powder River Basin is quite high, around an order of magnitude above the level necessary to protect beneficial uses.

We talked about soil sensitivity. This is what I referred to as far as the adverse effect that rainwater can have on your crop, or on the beneficial use. The higher the salinity, the more sodium a soil can accept without dispersing and breaking down and having its infiltration and other things affected.

Everybody that's in the business that knows what this diagram is, this is the infamous Hansen

Diagram. It comes out of Airs and Westcott and it shows that as salinity increases, the amount of sodium that a tight soil can tolerate without dispersing also increases. Now the problem with this, and the reason I mentioned that rainfall can have this nefarious effect is, is the EC of rainfall is about zero and we have -- we went about our water quality standard setting process. We used a very able technical staff at DEQ. We hired Dr. Oster from the University or from the USDA's California Soil Salinity Lab to help us, and I have to tell you, somebody who's trying to keep a record of evidence easy to understand and intuitive and defendable, I always got concerned as the technical issues became more and more complex and when we're talking about a state standard setting process, when I first heard about the rainfall effect, I was a little bit concerned that perhaps we were getting a little academic until I have a Powder River irrigator tell me, "You know, I've got to be really careful in the month of August about what water I irrigate with. If I push the limit" -- which down there was about an EC of about 2,000 -- "If I push that limit and we wind up having a thunderstorm pass through and get a quarter inch of rain out of that, I can't get my finger down through the soil -- the surface of the soil the next morning."

And when I heard that, I went, "Well, there you go." You know, it became a little bit less academic to me and a little bit more real world and as a regulator setting standards, you want things real world. Right now we are -- we've hired Dr. Jim Bowder [phonetic] at Montana State University Soil Science Department to investigate something on a little bit deeper basis than just anecdotal evidence of a potential soil collapse we had in the Lower Tongue River Basin last August that was the result of clay soil, a good heavy flood irrigation during the month of August and some -- a September cold front that came through and dropped an inch and a quarter of rain, which is very unusual for this part of the Powder River Basin and the suspected soil collapse we had as a result of that. So again, not academic. It's real world.

Hansen and Airs and Westcott told us that we had to be concerned about that. He was right.

Again, Mary talked a little bit about technology based limits. We were petitioned to go down that road when we established our state water quality standards. We declined to do that by virtue of the fact that a couple of years ago, the treatment -- some of the treatment technologies that John talked about were in their infancy. There was really only one vendor and one technology being deployed in the Powder River Basin a few years ago. There are more vendors and more technologies being deployed now. John mentioned that some of those are in their startup phase.

Mary gave you the idea of just how big and elaborate and involved the federal process is to promulgate ELG's, technology based limits. They use hundreds of data points to do that. They query hundreds of industrial entities to do that. We just don't have that number of producers, that number of technologies, that number of vendors in the Powder River Basin and you know, hopefully by the time EPA gets through that ELG promulgation business, there will be more data points to go on.

Again, back to water quality standards being driven by beneficial uses, an example is irrigated agriculture is a beneficial use we're trying to protect. We used a pretty involved, but a very standard mathematical formula to take all the available rainfall, the soil type, the crop type, the rainfall effect into consideration and came up with the following as an example. Sodium absorption ratio in the Tongue during the irrigation season can be a 3 before it starts affecting sensitive soils there and that's a 30-day average. No sample may exceed 4.5 during the irrigation season. Non-irrigation season, October through March, those numbers jump up by about 50 percent because the most critical thing you're trying to protect at that point is the health of repairing the vegetation, as opposed to a crop. So again, both an irrigation standard -- irrigation season standard and a non-irrigation season standard.

Nobody has mention non-deg and non-deg, a non-degradation policy and that is critically important. I'll have a slide here that illustrates that in a second.

Just as a water quality standard protects the beneficial use, the non-degradation or the federally required anti-degradation policy protects high quality water and essentially here is the ambient condition. This generic pollutant, let's say it's concentration in stream is 10 milligram per liter, 10 parts per million. That's the ambient water quality. Here's the standard up here that protects the beneficial use. The difference between the ambient and the standard is what we call high quality water in Montana, EPA, the Feds, under the Federal Clean Water Act call it "Tier 2 water," I think.

There is a great deal of environmental and social and intrinsic value to this increment of high quality water. And the reason that the federal government requires every state to have an anti-degradation policy is that there is value to this increment of high quality water, and I think it's recognized that as water qualities degraded from its ambient quality, up to the limit to protect beneficial uses, that something is lost there. Something is given up. And that's why every state is required to promulgate, develop it's own anti-deg policy and then that is federally approved before it's implemented.

If water quality falls up here above the standard, that water is I think EPA calls it "Tier 1 water." We call it impaired water body. You-all know about the 303-D list. Those are the streams that if the impairment is caused by anthropogenic or human causes, we prepare a TMBL to provide a watershed restoration plan to try and provide a mechanism to return that water to meeting the standard and fully supporting its beneficial use.

I'm going to skip over this slide. It's how we administer a significant threshold to a non-deg. It is complex. It is not intuitive at all, and it's really -- the water quality professional's realm. If anybody has any questions about how we actually go about implementing significance for parameters like salinity and sodium, come talk to me later today or tomorrow or I'll -- I can get you a copy of the slide, too.

Yes, Ann?

DR. MAEST: No, just asking.

MR. COMPTON: There is a provision for an anti-degradation wavier. There has never been an application for an non-deg waiver in Montana, so we have no experience in implementing that, but there is that ability on the books. In other words, the ability to exceed the anti-deg threshold, which is the regulatory limit, the regulatory criteria and go up to the standard, but it requires some pretty compelling economic and technical demonstration that there's no alternative to doing that.

All the numbers that Montana came up with, again they're different for every water body and their different for the season of the year. They were all derived with the same formula, but again the inputs were different. Target crop, soil type, leaching fraction, all make a difference in what each river and stream can support and still be viable for use as irrigated agriculture.

And again, graphics that represent the same thing. This one for the Tongue and Rose Bud Creeks, Powder and Little Powder, EC standards for the same water bodies, and again, a little technical here, but that information is available if you're interested in it.

The issues now on both our 2003 standard rule making and our 2006 numeric anti-degradation modifications were challenged by a Wyoming producer in the State of Wyoming. There was five lawsuits, one in state court. That was ruled for in Montana's favor last year. That's been appealed to the Montana Supreme Court. In federal court in Wyoming, there are four federal cases pending. Again, generally Wyoming producers and the State of Wyoming versus EPA for approving Montana standards. We worked for the last year and a half to try and settle that. We were not able to do that. So those federal cases are pending.

Data: Everybody wanted to know about data and there is a lot out there. There's diverse sources. Don't, please, anybody try and write these websites down. I'll have this information in back later. I'll have the laptop open, but as far as surface water hydrology for each date, it's there and available. Hydrochemistry, again, available. Non-point source data, permit data from each state, all online and all there to get gathered and again, I'll have this information in the back of the room, and finally additional data sources are available as well, and I wanted to close with showing what I think is one of the most remarkable -- go ahead -- remarkable data sets there and you can scroll down, if you could, Nick, down to where the actual numbers.

This is real time salinity information that is updated every 15 minutes. It is fed up to a satellite and then it's posted to the web. It's provisional data since it is real time. This is this morning, as you can see, at you know, 6:00, 7:00 o'clock this morning. You can look at the Tongue River starting in Wyoming and move downstream on both the mainstream Tongue and the important tributaries where CBM development is occurring and look at what the real time salinity is and then a sodium absorption ratio that is based on -- it's just a guess as to what that SAR is based on the salinity that's red.

Unfortunately this morning the state line station was out, but you can see that salinity sort of increases as you move down between Central Wyoming and the mouth of the Tongue at Mile City and again, the tribs, a limited data this early in the year, all these areas where it says, "discontinued," is a result, I believe of a Congressional earmark expiring last year. We're working with USGS now to get those sites back up and running. This is a critical resource. It's critical for regulators. It's critical for producers. It's critical for NGO's. You can see what's going on in the river with a click of a mouse, and again, we're working to try and get the funding restored to USGS to get those sites back up and running.

Thanks very much.

DR. MAEST: Okay. Do we have a question for Art? If you can please go up to the microphone?

MR. SPEAKER: I get to be the microphone guinea pig. Is this on? Apparently not. Just a quick question: Do you have baseline information to comparatively show what it is pre-CBM and post-CBM in terms of the incremental movement downstream on both the Tongue and the Powder River?

MR. COMPTON: We do. Several entities have looked at that. U.S. EPA Region 8, Helen Dawson there did a study on both the Tongue and the Powder. I believe -- I'm not sure whether it was a BLM study or a study that was done for the BLM. They came to similar conclusions and that is that we have not yet seen water quality trends at the border at either the Tongue or the Powder that are attributable to CBM production, and that's essentially in -- again two studies to look at that. That data is out there and we have not seen a trend at the border from this point.

Bill DiRienzo will talk about Wyoming's permitting approach and I think you'll see they're being pretty cautious in how they go about authorizing discharges to the surface that may wind up in perennial flow in the Tongue River and Powder River.

DR. MAEST: Thank you, Art.

Okay. Our next speaker will be Bill DiRienzo from the Wyoming Department of Environmental Quality. Bill is the Wyoming Pollution Discharge Elimination System Program Manager at the DEQ in Wyoming.

MR. DIRIENZO: Good morning. I just need to figure out how this works before I get started.

Okay. Yes, what I do now is I manage the surface water discharge program and enforcement and all of that sort of thing. I've been doing that for about two years. I've been involved with Coalbed Methane and development in Wyoming, well, pretty much since it started. My previous job I was responsible for the Wyoming surface water standards. They work pretty much like Art just explained in Montana, except there are some differences on the approaches that we take.

What I'm going to talk about today is, I'm just going to kind of lay out what's been going on in Wyoming, what some of the issues are that we've seen. I want to put it into some kind of geographic context and historic context for both Coalbed Methane development in relation to the other conventional oil and gas development that has historically occurred. I'll have a bullet list of issues. There are many issues that we face trying to write the permits. This will be nothing -- I won't be able to get too much into that. I'll talk a few sentences about each issue that comes up and how it affects ultimately how we regulate and what the discharge permits look like, and then finally some of the permitting tools that we are trying to develop to handle this kind of development.

This is pretty much Wyoming, as you've seen a bunch of maps already. This quarter of the state, essentially, when people talk about the development in the Powder River Basin, that's what they're talking about. It's not specifically the Powder River drainage, which is this drainage here. It also includes development in the Belle Fourche and Cheyenne and the Tongue River drainage. It's right here.

This drainage in here, this is the Bighorn drainage. Down here is the Great Divide Basin, essentially the Continental Divide comes down this ridge, splits in two directions, comes back together before continuing on down the Colorado. This is an enclosed basin. There is a little bit of interest in Coalbed development there, and also, in the Green River Basin here, there's a little development on this Bitter Creek arm of the Green River and also in this area, it's call the "Little Snake." Both those drain into the Colorado River system.

That pinkish color basically, that shows the distribution of historic conventional oil development. We see a lot of it has occurred in the Powder River Basin and in the Bighorn Basin. In a lot of ways it's similar and in a lot of ways it's different from Coalbed Methane. A lot of water is produced. It has been produced historically. These fields have been in operation some of them as long as 100 years. They've always discharged water to the surface. A lot of this water has been put to beneficial use.

The way it works though is somewhat different than Coalbed in that I don't know what the water production numbers are. I wouldn't be surprised if water production from conventional oil is equal to the amount that's being produced now from Coalbed Methane. One of the differences is in an oilfield, typically, you'll have a lot of wells producing oil and water and it all has to be brought to a single place. Some treatments units where they separate the oil from the water, take the oil off and sell it, and then either discharge, reinject or manage that waste stream water.

So there's not as many discharges. It's all brought to a single place and it's a little easier to manage. Coalbed Methane, a lot of the water discharges occur across the basin, close to the wellheads and so you have a greatly disbursed discharges through many drainages affecting much larger areas of land. And that is one of -- in my opinion, one of the big differences in why there seems to be a lot more issues with landowners, with water quality, with uses with Coalbed Methane discharges than there is with oil discharges.

Actually, the oil -- the Coalbed Methane water produced in the Powder River Basin is generally of a much better quality than oil produced water that has historically been discharged and used in the state.

This shows the distribution of conventional gas development, deep well, not Coalbed Methane. There's a lot of it. I lumped that together with the conventional oil, but actually with gas, conventional gas, water issues are not all that great. It doesn't produce nearly as much water. They are deeper wells. Generally water is a lower quality. There's no consideration of surface discharge. Most of the water that gets produced through the gas fields gets reinjected. We do have some places where it does get treated or it is high enough quality where it can be discharged to the surface, but there are very few discharge permits associated with the conventional gas.

And then there's the Coalbed Methane. I don't know how well that just showed up with these colors, but that's how it is pretty much distributed. Of course, there's the major development up in the Powder River Basin. This eastern half here, someone had a slide previously. This was some of the earlier stuff that was developed that's really in the Belle Fourche and Cheyenne Basins, really high quality water, not much of a discharge issue, and production of water in that area is fairly low now. I think maybe a year ago or two years ago, we calculated what the total volume of water in the Bell Fourche drainage is and it's a total of maybe about 10 CFS, cumulatively being produced. So it's not that big of a deal.

The main issues, of course, now are in the Tongue. It's where -- I mean, in the Powder River and the Big George coal seam. It's a real heavy water producer. When they develop in there, they produce a lot of water and there are a lot of management considerations as to what to do with that water and also, in the Tongue River Basin, it's the same thing. And as the water as you develop going towards the west, the ground water becomes lower and lower in quality.

There is the other areas where there's actually some significant production happening in development is really starting to take off is down in the Little Snake Basin, down in this area, and like I said, over in this Bitter Creek arm of the Green River. All of this water right now is being reinjected. There is no surface discharge. We've issued two permits out of this field over here, but they were going to be treated. The treatment plants have not yet been built. It hasn't really occurred yet. So all of the production now is being injected there.

Like I said, these are in the Colorado River Basin and there are additional permitting requirements in the Powder than there are -- I mean, in the Green River than there are in the Powder because of Colorado Basin's salinity agreements among the seven states that share that river. It's a long 30-year program on managing salinity in the Colorado River Basin and discharge requirements in that basin are much tighter than they would be in the Powder.

This is kind of what I was talking about. Out of all of that -- all of the green and pink development, it amounts to 451 total permits and under those permits, 476 outfalls. So generally for a conventional oil facility, there's one permit and one outfall. The Coalbed Methane currently we have about 908 permits. This number keeps on changing as we consolidate permits and change our regulatory scheme. The more important number there is the number of outfalls and this is what I was saying. It really amounts to an enormous regulatory load. This is where we spend all of our time.

Some of the issues that we have encountered over the years trying to develop our permitting schemes and our water quality standards are these. There was quite -- there's an ongoing issue. This is an administrative thing on rules versus policy. It's a new kind of development. We're seeing new issues and we started in trying to develop our Ag protection provisions, we developed it as a policy. As a program manager, as a bureaucrat, I like a policy. It gives us a chance to learn. It gives us a chance to practice with the regulation before it's hardwired into a rule.

Once you adopt a rule, the rule making -- I don't know what I want to do -- the rules on rules on Wyoming, the process you have to go through to adopt a rule or amend a rule takes a long time. We can't get any -- it takes three years to get through it and so with a policy it's a little more reactive, a little more -- you have more flexibility with it, but we right now, though we develop our protection provisions as policy, we right now are at a process of adopting them as rules because though people like me like policy, the lawyers like rules. And so that seems to be where we are going with that right now.

There's a lot of issues on water quality versus water quantity. Our agency is specifically supposed to address water quality. Separating the quantity issues from the quality issues are not all that easy. We don't -- and we don't have a direct ability to regulate the quantity of water discharge. It gets regulated in certain ways. A little later on, I'll talk about a similar capacity where there are load limits on the total amount of TDS, total amount of salt or the total amount of sodium, that we will allow to be discharged into the main stream of the Powder. So that's a load limit. It's a pollutant load, but my managing the load, you are, in effect, managing the amount of water that can be discharged.

Bottom land protection: This is a really big thing. On the Wyoming end of the river, irrigation -- all of this is occurring up in the upper tributaries, and when we first started writing the rules, we have this irrigation as a designated use. Well, most of the water use in that basin is not truly irrigated. There are points of diversion. There are water rights associated with it. A great deal of the forage for livestock just comes from bottomlands, from the flood plains, any streams that flood would runoff, and that's where all the production is.

So we came up with a process to identify what types of bottomlands are large enough to be significant, to have a significant effect on agriculture and we apply irrigation protections to those. It's a very controversial issue.

Access to a lot of these lands is a problem for data collection. In order to determine what is the proper water quality for the Ag use in any particular drainage, we need access in there to do soil sampling, to do water sampling, to do studies and try and figure that out. It's not always available.

Science: Science is always an issue. That's all I'm going to say about it.

There are many experts with many different viewpoints and when it comes down to try to build them into a regulatory program, it gets to be tough.

And of pipe limits. This is a big deal, maybe the biggest one that we have. The idea of the regulation is that the water quality to protect irrigation, say, is of sufficient quality where it reaches some irrigated land, where it reaches the bottomlands where it actually hits that use.

We started writing permits. In the early years, we would write permits without end of pipe limits for, way, EC and SAR. We would just have basic livestock watering limits, which are less stringent. We had in-stream monitoring points down near points of use and that is the point where we would try to enforce compliance and that was the target. We found that to be time manageable because if you had exceeded, if you really weren't getting the target water quality where it was being used, you now had 15 operators above that point. You had all these intervening factors with rain, with changes with irrigation occurring in between. So we had these limits, but we had no realistic way to enforce them, so we are now moving away from that, requiring all the limits to be met at the end of pipe, trying to model on downstream as to what the effect would be. It's a large issue to the industry and the downstream stage, this is pretty much what Art was talking about. Wyoming has different standards on the Powder River and on the Tongue River for agriculture. We are cognizant that we have to meet their standards and there are a lot of issues and we have some programs in place to try and verify and assure that that is occurring.

I'll just -- everything on here has been talked about. These are the practices that are in place right now for managing water. A good number of discharges are direct discharge out of the ground and the high quality water comes out of your well, gets discharged. There's a lot of instances of treatment and discharge, ion exchange, and the reverse osmosis is the most common treatment. There are some point just right at point of discharge, passive treatments for iron and barium that aren't really too big of a deal. The biggest problem is, of course, the EC and the SAR.

There is summary injection going on in the Powder River, like I said, down in the Colorado Basin, where it's all reinjection. People are looking at those shallow drip systems as a valuable kind of disposal system and then there's an awful lot of containment. This is probably the most common practice. There's off channel pits, which are total containment and we have 50-year containment reservoirs. Those are built on-channel, but they pretty much have to be built way up in the headwaters and we treat them as though they are complete containment, as though they were off channel, if they are built to hold both the amount of Coalbed water that is discharged to them, and all the runoff from the 50-year precipitation down.

And then there are on-channel reservoirs, which are filled and managed and water is released under a whole variety of schemes.

We tried to -- we've gotten involved in trying to write the watershed based permits, and this is an interesting thing. I kind of think it's the best idea we've ever had that doesn't work. And I say that because it's in litigation right now. We'll be having a hearing at the end of the month. We did issue a couple of watershed permits. They have been appealed by all sides. The idea of it is to break it down into smaller pieces and into the local watersheds. It's a stakeholder process. We bring in all the operators, invite every landowner who wants to participate, along with the agencies, trying to identify what specific issues in each one of these smaller watersheds that we've delineated.

There are based there -- they're originally based on a USGS Part 10, Hydrologic Unit. The idea is bring everybody in, identify what's going on in there, what crops are being groomed, where irrigation is, what the channels are like, how much water they can perhaps take, and in the end come up with the general permit in which everybody who was operating in that particular watershed would operate under.

The advantages of that is it's a really streamlined permitting process. Everybody in there would have basically the same kind of limits. All of the permits in a unit would expire and be renewed at the same time. If there were changes in limits, it would apply to all of the dischargers at the same time, so there are all of those kinds of advantages.

We've completed them in the Fence Creek -- oh, yeah -- well, no, they've been completed in Pumpkin Creek, Willow Creek, and four-mile creek. Those permits are done. They're signed. They could be used and those are the subject of the current appeal. And I guess that will be hopefully getting that deal cleared up at the end of the month and know where do we go on from there.

This area in here, Fence Creek and Clear Creek are already done. They've just not been signed and in the Tongue River, Crazy Woman Creek, and Dead

Horse Creek, we were well along in that process, but it's stalled now because of the appeals.

Last thing that I'll talk about is the limit of capacity. This will get to the meeting those Montana standards. It's a program that we kind of put together. The idea of it is, we've calculated essentially what are the added pounds of sodium and TDS that can be added to the mainstream of the Powder River in any month. And then we came up with a process for allocating that load among all of the operators.

This is a GIS cover of the coal within the Powder River drainage, and it's isometric coverage fo the coal thickness. If you take that area, this is a map of leases. Operators just give us their surface lease information. We have the coal depth. We overlay this over that previous thing and you can come up with a percentage of coal over which their leases lie and whatever percentage that is, that is the percentage of that total assembly of capacity pie, the tons of sodium and TDS that are allowable. And this is what that looks like.

For instance, in January we could add 116 million tons of TDS and 7 million tons of sodium and not bust the standards at the Montana line. What gets critical is in August and September, there really is no assembly of capacity. So in those months, there can be -- the only options for the producers will be either to treat the background conditions on the Powder River or to contain and that's it. There can't be any discharges that would reach the river in those months.

And I think my time is up, so I'm going to try to stick with that.

DR. MAEST: Thank you, Bill.

One question for Bill? And if you could go up to the podium there and say your name?

MS. GIONOICKUS: Just two quick comments to kind of follow up on a couple of things to all of the information that's been given to us today. One is -- my name Laura Gionoickus. I'm in the Rawlins Field Office of Wyoming and I'm in the south central area that Bill was alluding to that's going crazy right now with Coalbed Methane in lesser -- to a lesser degree than the Powder River Basin obviously, but one of the things we are doing with our produced water -- and it's not taking care of all of it obviously, but is to use it in the makeup of drilling fluids.

So just for to mention that we're doing that and that is for use obviously below the setting of surface casing so that, you know, you want to protect your freshwater zones and your surface casings, so we're recycling the produced water pit to pit to pit and making it filling fluids. We've had some initial talks between the big boys in hopes that maybe we could pipe some of that water westward to where there will be some major infill projects in the next couple of years with deep gas drilling fluid makeup. Who knows? We don't know if that will happen, but that's just another use of our produced water in our area.

One other thing I wanted to mention to follow up with Bill's mention of the difficulty of water quality versus water quantity, specific to Question Number 1, to the west, to surface discharge, and to the complex water quality and quantity regulatory frameworks and specifically outside of beneficial use considerations, it's important to note a real gray area that I operate in at BLM, not in terms of the science that's known, but in terms of the NIPA disclosure process and regulatory jurisdiction of -- for better, for worse, the channel geomorphological type of zone and Riparian area impacts that are associated with the conversion of very flashy, snow-melt driven desert, ephemeral and intermittent water courses to perennial flow systems.

So that's just another topic to think about and I think some of this afternoon's speakers will probably bring some of that up.

DR. MAEST: Thank you.

One more question? In the back there, if you could?

MR. JOHNSON: My name is Pete Johnson and this question is for you or Mr. Compton from Montana and my question is: We heard the EPA first talk about some issues with hydraulic fracturing and both of your presentations focused largely on produced water issues and what the woman from the EPA said, was that the EPA study that's going on right now is largely focusing on surface water issues because injection -- deep well injection issues are largely governed by the surface drinking water -- or the Safe Drinking Water Act; however, all hydraulic fracturing practices are exempt from the Safe Drinking Water Act so my question is: Are the states willing to follow the EPA's guidance and sort of ignore the issues that hydraulic fracturing represents to state water quality or the things that the states are doing independently to address that issue?

MR. DIRIENZO: I really don't know myself. I don't work that ground water program or underground injection program. I don't know exactly how they regulate it. Certainly, if you are going to inject, you would need a permit from them and they would comply with the Federal regs, so I really can't answer your question.

MR. COMPTON: And I can give you the same answer. It's largely I don't know. Montana does not have primacy in the UIC program. EPA administers that in Montana so I just don't know.

MR. JOHNSON: Okay.

MS. GIONOICKUS: The BLM is responsible in its analysis of a fracturing program, as well, in addition to all other, the makeup and the recipe of the fluids that will be used relative to ground water protection, as well.

DR. MAEST: Okay. One quick question?

MR. SPEAKER: Just to correct a little bit of information, the Montana Board of Oil and Gas does have Class 2 primacy in Montana, except for Indian lands, and they do have rules against using diesel in crack fluids for CBM wells. So that certainly would at least regulatorily would address that issue of problems in the drinking water.

MR. COMPTON: Thank you.

DR. MAEST: Okay. Thank you.

Okay. The last speaker is from our host State of Colorado, Debbie Baldwin, from the Colorado

Oil and Gas Conservation Commission. Debbie is an environmental manager. She's been with the Commission for 13 years and has worked extensively in the San Juan and Raton Basins and has fielded hundreds of complaints about impacts or potential impacts to ground water and surface water from Coalbed Methane.

MS. BALDWIN: Hello, and welcome to Colorado. I just want to try this and see if it works.

Okay. I might just say a couple of quick -- or make a quick response, although it really wasn't in my talk to the fellow's question about fracking and so the Oil and Gas Conservation Commission also has delegated authority for the UIC Class 2 program from the EPA, except on Indian lands, but in addition to that, we have broad regulatory authority over insuring that oil and gas operations don't impact ground water and surface water. And in fact, we're the delegated -- we have -- we're called the "implementing agency" for ground water standards and classifications that are set by the water -- the Colorado Department of Public Health and the Environments Water Quality Control Commission.

And so we have investigated lots of allegations of impacts to ground water and to water wells related to fracturing -- hydraulic fracturing and at this moment, we have never detected any impacts from or any instances where hydraulic fracturing has impacted a ground water or water well.

So anyway -- this brief outline is what I'm going to be talking about and maybe I'm going to be talking about some things that haven't been brought up yet, but we'll give you a little overview of oil and gas development, including CBM in the State of Colorado, the production of oil and gas, effects of CBM operations on water resources and mitigation of some of those during the construction phase, drilling phase, drilling and completion, production and post-completion, potential impacts from the migration of Coalbed Methane on ground water and some of the available data that we have -- the Oil and Gas Conservation Commission has, potential impacts of produced water disposal and available data, methane seepage and potential impacts and then the potential for stream depletion and I may not make it through all of that, but anyway, we'll try our best.

So this is the State of Colorado. We're here, up here in Denver, right on the edge of what's called the "DJ Basin -- Denver/Jewelsburg Basin." These are all the geological basins in the state. The red dots are active oil and gas wells -- all oil and gas wells in the state. The green dots are wells that have been plugged and abandoned.

Currently there are about more than 34,000 active oil and gas wells in the state and so you can see from over the last seven or eight years, we've just seen, like all the rest of the Rocky Mountain region, just a tremendous growth in the number of active wells in the state, approximately 51,000 of those 34,000 wells are Coalbed Methane wells. Down here in the San Juan Basin, there are about 2400 Coalbed Methane wells. Over here in the Raton Basin, about 2600 Coalbed Methane wells. Up here in the Peance Basin, there have been a number of attempts to produce gas from coal seams. There are a couple of small projects up there, but for the most part, we consider those just test projects.

There are some huge coal reserves up here in the DJ Basin. One of the -- fortunately, in my opinion, no one has ever been -- or we haven't had any successful development of Coalbed Methane there because a real conflict there would come because the coal seams are in the Laramie Fox Hills formations, cretaceous formations, and those are also major aquifers for the DJ Basin used by agriculture so that may be a train wreck right there.

This is a distribution of the well permits in the state, recent permits. All of this information is available on the Oil and Gas Conservation Commission website, too, which I neglected to add -- put up there, but anyway, so we can see that, you know, we've got Coalbed or permits for oil and gas wells all over the state and all the producing basins and there's certainly some permits down here in the San Juan Basin and over here in the Raton Basin.

This is a little pie chart that shows -- or it's a big pie chart that shows the distribution of those oil and gas drilling permits that the state has processed so far in 2008. Most of the lion's share of those permits are out in Garfield County. That's in the Peance Basin, tight gas sands out there, huge number of wells being drilled currently there.

Up in Weld County, again northeast of Denver, up in the DJ Basin, a large number of wells -- conventional oil and gas wells, gas wells, and then down here in La Plata County and Las Animas County are a more meager number of permits being issued in those basins.

This slide shows the overall production of gas in the state. The purple is Coalbed Methane produced gas. The blue is conventional natural gas and so you can see where up to -- this is in billion cubic feet per day up to about 3.16 Bcf of gas a day and almost a trillion cubic feet of gas a year. And between 1997 and about 2003, you can see that, you know, at least 50 percent and in some years more of the gas -- the total gas produced in the state came from Coalbed Methane and if you remember, the proportions there were -- back in those years there may have been two or 3,000 CBM wells versus 20 or 30,000 conventional gas wells. So we really have a prolific resource and primarily in the San Juan Basin for Coalbed Methane.

This is a produced water slide. Again, I have to admit, I haven't QA'd a lot of these slides, so you know, we're pretty sure this would be the distribution. And the numbers for 2007, operators are still getting information in and there's a lag between when we get the production reports and when the data are actually entered, but again, these statistics are available on our website, so overall about -- these are the annual produced waters so about 370 million barrels of water a year are produced in the state. Of that, about, you know, maybe a little more than a third is CBM produced water.

That sounds like a lot of water. This is a slide from the -- that's a combination of information, some from the Division of Water Resources that is the regulatory agency in Colorado that administers water rights and then our data and I didn't have time -- or I didn't take the time to update their slide, but for the surface water sources in the State of Colorado, there used -- we're talking about 16 million acre feet of year of surface water, so that's here. Ground water that's used is about 2.3 million acre feet of water per year. The water that is produced by both non-CBM and CBM wells is this tiny little line here that then has been expanded to show that, in fact, in some basins CBM water there is -- especially in the Raton Basin, there is a substantial amount of water produced, but relative to the total water that's used by the state, it's a really very small amount and I think that Matt may have mentioned that as part of his discussion.

So this is a little matrix that I put together that's going to discuss some of the other aspects of Coalbed Methane development, but in fact, a lot of these things apply to not just the Coalbed Methane development, but to any oil and gas development and these activities and their potential impacts -- or the potential to impact surface and ground water resources.

So we have, you know, during the construction phase of the well, you've got big earth-moving equipment. If you don't have proper stormwater management practices in place, you're going to have a high likelihood of impacting surface water, drilling and completion, especially well completions. If you don't properly isolate your well, you run the risk of impacting surface water, ground water. Again, during drilling and completion, stormwater management is extremely important. Again, if you're not implementing stormwater management practices, you have a high likelihood of impacting surface water.

Management of waste, both the E&P waste and non-E&P waste, you know, there are exploration and production wastes. Produced water is one of the major exploration and production wastes, but there are also non-E&P wastes. At a site, there's solid waste, trash, human waste, whatever, so if you're not managing those properly, you can impact surface water, you can impact ground water. You had the potential to do that.

Again, materials management, so these are non-wastes, you know. Drilling muds brought on location, frack fluids are brought onto location, various other additives, drilling additives are brought onto a location and used during the drilling and completion. If you're not managing those properly, you run a risk of impacting surface water or ground water.

During the production phase, you move the drilling rig off so now the well is happily producing away. If you're not getting your interim reclamation done quickly, shrinking the pad size and re-establishing as much vegetation as you can, and stabilizing areas that are used by trucks and other equipment. If you're not accomplishing that, you run a risk of having impacting surface water and stormwater management is important. Same thing, waste and materials management, similar issues related during the drilling and completion process and then post-completion or post-production, the plugging and abandonment of the well. Really critical. If you don't properly plug and abandon your wells, you run a risk of causing impacts to both surface and ground water and then the final reclamation to re-establish all of the vegetation. So we're going to whizz through some examples of this.

So here we are during a construction phase of -- or the stormwater management portion of the construction phase. The Oil and Gas Conservation Commission has some very broad, general rules under our reclamation rules. That's the 1,000 series rules where we require the use of that stormwater best management practices, minimizing surface disturbances, minimizing erosion, minimizing alteration of natural features and minimizing the removal of surficial material.

So those are our broad, general rules, but in addition to that, the Colorado Department of Public Health and the Environment, the Water Quality Control Division also is responsible for -- has authority over issuing stormwater permits and so for any oil and gas operation that disturbs greater than an acre of land during the construction phase, they must obtain a stormwater management permit from the Water Quality Control Division. So that's actually more stringent than the national standard and it was the Water Quality Control Commission decided to make this state's requirement for oil and gas operations stricter -- more strict than the national standard.

Stormwater discharge: Best management practices need to be used to minimize erosion and offsite sedimentation by controlling stormwater -- and this is the big one that lots of people forget: Run on. And if you're drilling in an area at a high altitude where you've got lots of snowfall and that snowfall, you get one warm day in April and all of the snow melts, if you're not diverting all of that stormwater run on or potential stormwater run on away from your site, you run a risk of, you know, having all that stormwater run -- sweep across the site, fill up pits, overflow pits, and then cause -- move on down the valley and generally cause some significant impacts.

So this run on best management practices to control run on is crucial as in my opinion even more crucial -- well, as crucial as controlling runoff best management practices, a lot of you know this for stormwater management, a variety of things that it can be used. This is an example during construction that shows the challenges of stormwater management in steep terrain, steep canyons. It's kind of hard to see, but there's a little ephemeral drainage that's coming down here, very steep, rugged terrain in the Raton Basin.

Where can the operator put a road that's going to get you to a drill site? Well, you're going to have to hug up against the side of that cliff and if you don't, you're going to be making huge cuts up the hill and there are problems with doing that, so this operator has not only installed the silt fence around here to keep a runoff from this road, but also this, you know, concrete barricade to keep trucks -- to make sure that this silt fence is held in place. So again, these are best management practices to protect that surface water.

During drilling and completion: Again, we talked about it. You need stormwater management. COGCC has rules, Water Quality Control Commission -- I mean, Water Quality Control Division stormwater permit stays in place until final stabilization and final stabilization for this definition is when 70 percent of the disturbed area has been revegetated. So those stormwater permits remain in effect, but in addition to that, the Oil and Gas Conservation Commission does have these broad regulatory authority over protecting surface water and ground water.

Again, materials management: COGCC has a variety of rules. My favorite rule is in the 300-series rule. It's 324(a), "Thou shalt not pollute." It seems like a pretty simple rule and if people would follow it, we'd all be happy. So that's a good rule and we probably don't need a whole lot more, but we also have a 900-series of rules that discusses the management of exploration and production waste. The Colorado Department of Public Health and the Environment has solid waste rules and they also have hazardous waste rules. So the operators are obligated to be in compliance with all of those.

As far as well completions are concerned, we have both rules and orders about how that needs to be done.

An example of best management practices for stormwater at a drilling site, so here's a drilling rig. We've got a silt fence around the whole area. We've got a lined pit down here. They're going to be using that for drilling. It's maybe not as obvious, but there's a little trailer here that's got drilling mud and other additives piled up on top of it so these neatly stacked sacks, not just dumped on the ground. So they're keeping, you know, water from -- you know, stormwater from flooding these. Easy to cover if you get a storm event.

This area here, although it's within the silt fence, hasn't been disturbed and again, that's sort of that minimizing surface disturbance that wasn't needed to level the land here and so trucks can drive on this, but when the trucks are gone, this will be an area that really won't need much reclamation. They haven't disturbed the topsoil.

Port-a-potty for management of human waste.

Interim reclamation: Extremely important for protection of surface water. This isn't a CBM well, but it's up here in the DJ Basin and so an irrigated crop land, interim reclamation is pretty easy to achieve, but you've got up here on these irrigated fields, the well pads are shrunk back to just a five-by-five fence, a five-foot fence around the wellhead. So it makes the farmer can -- or the rancher can farm up right up to that well, eliminate stormwater runoff from that site.

Stormwater management, interim reclamation on non-crop lands in the western part of the non-irrigated land is definitely more challenging. Here's the wellhead. You can see the site has bee recontoured. The site has been roughed up and mulch has been crimped in and now the operator is sitting there crossing their fingers, hoping that it will rain and so they'll get a vegetation to help stabilize those slopes. So there are definitely challenges in drilling in this aired part of the United States.

Another -- I think somebody else brought up pipelines. Well, this is a pipeline right-of-way along a county road, a lease road. Again, these are interim reclamation standards. This pipeline has been -- this is down in the Raton Basin. The pipeline has been recontoured and revegetated. It's been reseeded. You've got waddles along the barrow ditch to prevent stormwater erosion from -- or least reduce the velocity of the water running down the bar ditch. In the background, there's a creek coming down across the slide this way and those are these straw mats that are used to put on the banks where the pipeline is cut down in through the valley, again to minimize stormwater runoff.

Well completion: The first line of defense in protecting water resources and so these are lessons learned in the Powder River Basin, and I'm going to start on the right and move left. Before the Coalbeds of the Fruitland Formation were recognized as a resource for Coalbed Methane, conventional wells were drilled. They were drilled down to Mesa Verde, Dakota Formation deeper, you know, conventional oil and gas reservoirs.

Not much may have been known back then about where the ground water aquifers actually were. We currently have rules that say that surface casing has to set down below the -- 50 feet below the bottom of these aquifers, but as rural residential development has moved people out into remote areas and big ranches are being subdivided, more water wells are being drilled and a lot of water wells are being drilled to depths deeper than they may have been in the past.

So here we've got this convention well that doesn't have surface casing covering the aquifers. They don't have cement over the coal seams, and a few years go by and Coalbed Methane development begins and we're starting to produce the water out of this well. We've got surface casing that covers the aquifers in this well, as well as cemented from the bottom of the hole all the way to the surface. We've got several lines of protection of these shallower ground water resources.

Water is being produced. Eventually gas desorbs out of the coal and those pesky little methane molecules look for ways to escape. And since no well is 100 percent efficient, these little pesky molecules might move over here to this convention well and just kind of slide up the back side of the casing here. Some of them get into the aquifers. If you've got a water well drilled here, you will end up potentially with methane in your water well that would be Fruitland gas, that has moved from the coal seams using this conventional gas well as a conduit, get into the reservoir.

Today, conventional gas wells -- and actually for the last probably 15 years, convention gas well, new conventional gas well drilled, again surface casings set to protect the ground aquifers, cementing across the Fruitland formation to make sure that this wellbore is isolated from the coal seams and drilling down here so that we have several lines of defense, intermediate casing and cement to keep gas that might be coming from the coal seams and using this conventional well as a conduit.

All right. Well, this is what can happen if you aren't careful with plugging your wells and so this is an explosion that did occur as a result of gas migrating up an orphaned gas well in the San Juan Basin. Well, anyway, some examples of -- this is a map of the area where this orphaned well was located. We found the well. These contours show the aerial extent of the gas concentrations in the soil. After we cut the well off, reentered the well and completed it, gas concentrations at the ground surface are now down to zero where explosive obviously concentrations did exist.

Unfortunately in this area, there are a number of water wells that still have very high concentrations of methane in them. Oil and Gas Conservation Commission considered treatment -- attempting institute treatment of that and decided it was just not cost effective. There are -- methane detectors have been placed in those water -- in the wells and the houses and the water is treated above ground.

Analytical data: And this is analytical data for water wells and samples that the Oil and Gas Conservation Commission has in our database. It is a stand-alone database. It isn't something that is accessible yet on the internet, but it's there for people to use if you make a request. So we have data from water wells all over the state, but for the major Coalbed Methane producing counties, La Plata County, Las Animas County, and Huerfano County, numbers of wells sampled and then the number of samples that we have in our database.

You can go online. Our website, the GIS-enabled portion of it, the map, you can pull up whatever area of the state you're interested in. There's one of the layers of samples in the COGCC database. The blue are water wells that have been sampled, so we have water well analyses, oil and gas wells that have been sampled. There might be gas samples or other kinds -- water -- both water and gas. This was just a little slide I put together for comparing methane concentrations in water wells.

Oh, yes, okay. Disposal of produced water: And the Oil and Gas Conservation Commission allows injection to discharge the surface water. If you have a Water Quality Control Commission Division permit, so we don't permit surface water discharges. They're permitted by the Health Department, but we do permit produced water pits, centralized E&P waste management pits, commercial disposal facilities are used by some operators. Some water used for dust depression, and operators can reuse or recycle water again to make up drilling mud and those kinds of things.

This is a slide of the disposal of the of produced water, just kind of -- well, we'll keep going. So in the San Juan Basin, almost all of the water in the San Juan Basin is disposed of by injection. That's my preferred method. There are some injection wells in the Raton Basin, very few issues or complaints related to injection, although you always run the risk of having a pipeline leak or a pipeline spill and that can cause impacts to water.

A nicely operated injection well site. Surface water discharges: Again, we don't issue those permits, but the complaints that we do get from landowners, complain to us. We try and help them out as best we can, but usually we direct them to the Water Quality Control Division. We've talked about it. Erosion, odors, growth, the temperature of the water, SAR impacts to soil, drowned vegetation, impacts to surface water and impacts to ground water.

We've had at least once instance where a discharge did impact a person's water well. That discharge was -- the permit for that discharge was rescinded by the Water Quality Control Division.

You know, again, pictures of things you've seen, the problem of discharging water in these aired places: If you're not doing it properly, you get a great deal of erosion. This is an example of maybe a little better discharged water, armor, you know, rocks being used to armor the channel in settling ponds to allow water to -- or some of the sediment to settle out of it.

Produced water quality: Again, we've got a large quantity of data again available on our database, so this is just a graph of the numbers of samples here, the different counties and the -- I guess that's the total dissolved solids, bicarbonate, sodium, chlorides, so just to, you know, show you we have quite a bit of data.

Some maps that we made: This is a total dissolve solid map. This is the San Juan Basin, San Juan Basin sodium concentration. This is the edge of the San Juan Basin. The green in both slides is the low concentration, so again, you can see up close to the outcrop, the salinity and the sodium concentration lower, up close to the outcrop, where recharge is occurring, gets higher as you move deeper into the basin.

It's a similar map for the Raton Basin using information we have there. I think Ann asked about other parameters. I didn't summarize it, but we do have quite a bit of information on at least metals that have -- analyses of produced water and this just shows how many samples we have.

Gas seepage: You know, if you have -- this is an area where surface water is being -- methane is seeping into surface water from the coal seam sub-crop. Lots of controversy about whether Coalbed Methane development is causing additional gas seeps to occur. The Oil and Gas Conservation Commission working with the BLM, the Southern Ute Indian Tribe industry and the local government have decided to put aside the arguments or the debate about whether that's happening or not and we're working on mitigation of those gas seeps at the outcrop. One of the things that occurs with gas seepage is that it will -- if there's enough gas, it will actually kill the vegetation so it stresses vegetation if you've got a house that's sitting on top of a place that's seeping, you can have gas seeping up into your confined spaces. So this is a simple ventilation system.

Potential for CBM seepage along other geologic features: These are igneous dikes down in Huerfano County. They are the largest radial dike swarm, I think in the world, of coming off the Spanish Peaks. We have some indication that there are places where those dikes might act as conduits for gas migration. This is a map of Huerfano County down in the northern part of the Raton Basin. This is the outcrop of the coal seams there. The little red dots are CBM wells. All of these wells have currently been shut in because of the little red triangles and blue triangles are water wells that were impacted by gas -- the gas from the producing formation, that at least staff, COGCC staff, believes has probably migrated up some of these igneous dike swarms in this area, so it's a very serious matter.

Stream depletion: This is getting to the last part. The quantity issue, the Division of Water Resources, the Colorado Geological Survey and the COGCC has co-funded a study, hired third-party consultants to study the interaction between the coal seams and surface water and to determine whether or not there is a potential for Coalbed Methane, the removal of water at Coalbed Methane wells to effect the outflow from the formation or actually deplete the stream and so the results of those studies, again, available on our website on the CGS's, Colorado Geological Survey's website, study found that approximately 150-acre feet per year of depletion occurred in the San Juan Basin, possibly up to 2500 acre feet of depletion in the Raton Basin, and then in the Peance Basin, very little depletion there. The operators in the San Juan Basin and the Raton Basin are currently -- they've hired third party -- additional hydrogeologic consultants to have a look at these preliminary studies and to do a more detailed, three-dimensional models in those areas to refine the results.

And that's it.

DR. MAEST: Thank you.

I know that was a lot of great information. Why don't we hold questions for Debbie until the open session and take a quick break here, five minutes and then I think we'll have enough time to have about a 40-minute open session before lunch.

(Recess from 11:43 a.m. to 11:59 a.m.)

DR. MAEST: Okay. We've got about a half an hour for an open discussion for the first panel, so we can start by kind of looking at the questions and maybe summarizing what we've heard so far in seeing what else it is that we'd like to ask the panelists and we're just going to open it up to the public.

Them main question, of course, is what are the effects of Coalbed Methane production on surface water and ground water with quality and quantity? And we've heard quite a bit about the composition of produced water, what the elements of concern are, and I think we've heard maybe a little bit less on the actual water quality and water quantity impacts and my sense is that there's a lot of data out there in the states, and possibly also at the federal level, but the way it's gathered and the accessibility to the data may be the issue.

So -- and I think Mary Smith mentioned that we know there are impacts out there, but we don't know the extent and hence, her information request, as part of the effluent limitation guidelines, and whether or not those are needed specifically for Coalbed Methane.

So does anybody have any questions about the impacts to Coalbed Methane, water quality and water quantity? If I could ask you to go up to the podium and just state your name and affiliation briefly, if you care to, and then ask your question?

MR. GOODWIN: My name is Richard Goodwin. I'm affiliated with myself. I'm a landowner down in

Huerfano County, and the one question I haven't heard any answers to at all, the first gentleman alluded to it, was the drying up of springs and local domestic water wells. That's happening down in Huerfano County, but I haven't heard any more -- anybody else. We're all talking about produced water coming out of the CBM well, but nothing about the impact of sucking down the shallow aquifer down into that deep water and drying up all of these water wells that are up at the top?

DR. MAEST: Okay. And I know that Montana has some information on water levels and how they have decreased over time at some locations as a result of Coalbed Methane production, but I think you're right. We've had more of a focus on the water quality side and maybe a little less on the water quantity.

Do any of the panelists have any information that would address this question on water levels?

Matt, you go first.

MR. JANOWIAK: Well, I guess first of all, in the San Juan Basin and other basins, we see that there's a ceiling unit above the Coalbeds that are probably down around deficit of about 3500 feet and overlain by about 1,000 feet of shale, which is impermeable. We've got a lot of pressure data that shows that that's a very good ceiling unit. When we get over into the Raton Basin, I think -- well, let me just say that in San Juan, we're not seeing wells drying up, but I think in other areas, you're going to see the potential there.

Before I turn over to Debbie in the Raton Basin, in the Powder River Basin, Montana and Wyoming require that the operators within a certain distance of a domestic water supply or livestock water supply or spring, that they offer water well mitigation agreement before they even start producing Coalbed Methane, meaning that is something goes wrong with that well as a result of Coalbed Methane development, that landowner and the owner of that water source is made whole, meaning that that water source is replaced somehow, whether it's a deeper well or truck water or what-have-you.

When I was in Mile City, I actually entered into a couple of water well agreements because the BLM owned water wells. So as the development started to progress into those areas, we were parties to those agreements.

MR. COMPTON: And the mechanism that Matt referred to is called a controlled ground water area, and that there is well-for-well replacement as a mitigation strategy there. The problem -- the only down side to that is that it requires that the landowner have a good feel for what the produced water -- what the water yield was from both springs and stock wells and domestic wells and what-have-you to make the case that there's been an impact.

So yes, there is a mitigation agreement in place and operators are responsible for one-for-one replacement in Montana for sources that are affected by CBM drilling, but again I think it does require some knowledge or some inventory, if you will, on the part of the landowner as to what the yield of those water sources were.

MS. BALDWIN: I'd say -- this is Debbie Baldwin. In the wells that you folks are talking about are wells that are actually water wells that were completed in the coal seams or in the alluvium that's receiving discharge from the coal seams. That's a question that I was stating.

MR. JANOWIAK: No, even in the Powder River Basin shallower completed water wells and aquifers above the coal seams are protected by a water well agreement and the springs, as well.

MS. BALDWIN: So in the -- to go on with what Matt said in the San Juan Basin, there's a very limited area where the coal seams actually come to outcrop.

And so if you have a water well completed in those coal seams, then the Coalbed Methane depletion studies would say that there may be some potential for depleting those water wells.

In the Raton Basin, there are places where there are water wells that are completed in the same formations that the Coalbed Methane wells are completed, and so the potential there for a water well being -- you know, drying up or not, as a result of Coalbed Methane production, maybe that risk is increased a little bit, but what Arthur was saying is that as a person is using their own water well, they are actually depleting the water themselves and so if you're not keeping good records proving that a water well has been impacted by a CBM well or an oil and gas well of any kind is a very difficult thing to do. I've been involved in trying to sort that out.

It is difficult to prove because the owner of the well is also using the water and so I don't -- that's probably not giving you any level of comfort, Dick. I know in Huerfano County we have other indications that there may be other conduits that are allowing certainly the gas from the Coalbed Methane wells to migrate up into those water wells, but whether or not we have -- we do have pressure data that would suggest that there isn't communication of water from the surface -- you know, water going the other way as the gas is coming up. So we're using the data that we have available and that's what it seems to indicate to us that that's not the case, that there is isolation at least of the liquid fluids, even though there is migration of gas.

MR. GOODWIN: Is this the only location in the country where the CBM wells are about -- I think they're down to 2500 feet, if I remember right? And our domestic water supply wells are from 400 to 600 and these 400 to 600 foot wells are drying up?

MS. BALDWIN: In La Plata that would be the case, also. CBM --

MR. GOODWIN: Same case?

MS. BALDWIN: Yeah. The Fruitland Formation could be from, you know, 1500 to 1,000 feet below the ground surface, down to 3500 feet below the ground surface; water wells from shallow down to six, 700 feet and we're not seeing an indication that those wells are --

MR. JANOWIAK: I think one of the most important things in Colorado, especially in La Plata County is we're going from agriculture and flood irrigation, which is a great recharge mechanism for shallow water -- or shallow aquifers. All of that Ag land is being converted and people are getting their five-acre ranchettes. They're no longer flood irrigating, so the recharge is going away and every one of them is putting in their own private domestic well, putting more straws in the aquifer with less water going in and it's not the CBM companies that are dewatering the aquifers, it's your neighbor. All of your new neighbors around you are dewatering that aquifer so as wells are going dry, people are blaming a lot of the CBM operations, when, in fact, the CBM well, you know, on your property might be producing half a gallon a minute or a quarter of a gallon a minute. It's really your neighbors next door are really the ones that are intercepting more of that water that should have been coming to your well.

MR. GOODWIN: I think that's a point open for discussion on a lot of areas.

MR. JANOWIAK: And I don't know if Huerfano -- you know, what's going on in your county, but just the water balance in the shallow aquifer.

MR. GOODWIN: You're all great minds here. If, as Debbie's chart showed, I'm dewatering, releasing the pressure, and not only is the Coalbed Methane traveling over to my dewatering well, but it's also traveling over to my domestic well, as she showed on the chart, and coming up that way, which would mean to me that the less pressure down here in the bottom, why wouldn't that cause my domestic water to come down, because it's being more or less sucked down because there's less pressure underneath there and dry up my water well?

MR. JANOWIAK: It ties back to a phenomenon called "two phase flow," and as soon as you free up gas in a Coalbed, you stop water -- in effect, you stop water flowing through those coals because the free gas in the coal seams make your relative permeability with respect to water trend to zero and so in effect what happens is as you dewater or desorb gas in a coal seam, the amount of water that you can transmit goes down to zero and especially in the San Juan Basin.

MR. GOODWIN: Sure.

MR. JANOWIAK: I can just tell you this right now: They are no longer pumping water out of a lot of those Coalbed Methane wells. Water that is coming out, hits the separator as a mist and entrained in the coal.

MR. GOODWIN: Right.

MR. JANOWIAK: And they're lucky to see a quarter of a gallon a minute. Physically, even if you've got low pressure down here in a Coalbed, to get water from here down to here is a physical impossibility because you cannot transmit water through gas saturated Coalbeds. So it's just one of those things where it won't work. And if it were happening, those Coalbed wells that are producing Coalbed Methane, they would be pumping water for 20, 40, 50 years and just taking all that water from the shallow aquifers through the Coalbeds to that wellbore. We're not seeing that happen.

MR. GOODWIN: Uh huh [affirmative].

DR. MAEST: Are there requirements at the state or the federal level to monitor water elevations in the area around a Coalbed Methane production area and keep track of that, or you mentioned that it's the landowner's responsibility to show the water has been affected, but how can you know that that's tied in with the Coalbed Methane production? Is there anything at the state or federal level?

MR. JANOWIAK: Quantity-wise, I don't think that we have anything at the federal level to monitor water levels along the outcrop where we know or where we anticipate impacts to occur in the San Juan Basin, and we do monitor methane levels predevelopment and during development in the shallow domestic wells to make sure that there's nothing that we're contaminating shallow waters. Quantity-wise, there's really no requirement there.

MR. GOODWIN: Should that be part of the study? Is this an area that the study is not going to concentrate on as to the impact of dewatering operations on domestic water supplies?

MR. JANOWIAK: Let me back up.

DR. MAEST: Wait. Let me just say right now there is no additional study, if you're talking about an NRC study. We're just talking about the workshop. So if that's what you're referring to.

MR. GOODWIN: Okay.

MR. JANOWIAK: In the Powder River, there's no requirement, per se, but in the Powder River Basin there is a requirement that BLM has that requires operators to put in a series of monitoring wells before they start producing methane, Coalbed Methane.

MR. GOODWIN: Before they start?

MR. JANOWIAK: Before they start. And I think the rule of thumb was -- Chris, correct me, if I'm wrong, please. But the rule of thumb was if you're the first operator in a township, you get to buy those monitoring wells and put them in. Lucky you.

MR. GOODWIN: Lucky you.

MR. JANOWIAK: Before you get to produce your first cubic foot of gas. And those monitoring wells are what we call a nester or clustered monitoring well network, so you're monitoring the shallow aquifer.

MR. GOODWIN: Uh huh [affirmative].

MR. JANOWIAK: You're monitoring interspersed sands within the coals and deeper aquifers just to see what kind of drainage effects you might see from adjacent aquifers as a result of Coalbed Methane development. So that's been going on in the Powder River Basin quite extensively.

Like I said, in the San Juan we're just not -- you know, we've seen tons of data -- pressure data and production data to tell us that we've got 1,000 feet of impermeable shale sitting on top of those Coalbeds we're not too worried about.

MR. GOODWIN: Good for the sample.

MR. JANOWIAK: Yes, great for sample.

MR. GOODWIN: Over in the Raton, I don't think we have that. We seem to be a geological wonder, is what I heard it expressed as, and a geological mystery by both the COGCC's staff, plus the oil company itself. So I'm coming from the fact that I'm a landowner. I have a well. Every so often methane comes bubbling up through it. I'm fortunate enough not to be in an area that I've lost my water well, but neighbors of mine in the same development have -- their wells have just dried up and there's nothing but pure methane just venting out of the top of the wellhead itself.

And so if all of you in your infinite wisdom are going to look at something, water quality is good. The salinity and the toxicology of it, those are great things and those really would help a lot, but there's another advent, another whole part of this Coalbed Methane dewatering and that's what I just expressed to you. And I think to look at one side of it and not the other side doesn't give you a complete picture of the impacts of Coalbed Methane on water supplies. Thank you.

DR. MAEST: Right. That's a very good point and we're -- we are interested in both water quality and the water quantity side and there are -- there's potential for decrease in water, the amount of water in aquifers from Coalbed Methane production, but also increases in waters in other areas. And we had someone in the audience from BLM mention impacts to the hydrographic streams as a result of discharge of produced water. And I'm not sure the extent to which that's been monitored or reviewed, but that's, you know, kind of -- it was both sides of the fence that water quality decreases and increases. Also, potential for reuse, irrigation as well.

Yes, sir?

MR. HANSEN: If I could just expand on what was said there a little bit? Powder River Basin and what's going on in the Powder River Basin doesn't apply to every basin. Every basin's stratigraphy is different. You have to look at it differently; however, we do have a monitoring system in the Powder River Basin. That was required and came about as part of the 2003 EIS and that was exactly right. It's one per township. Industry puts the money up. BLM actually does the monitoring, but they put enough money up for long-term monitoring, as well as the plugging and final abandonment of that well. It's put into a fund, which we keep track of.

At this point, there are 112 wells drilled in the Powder River Basin for monitoring purposes; 58 are coal wells, 13 are deep sand wells, and 41 shallow sand wells because what we're looking at is the relationship of not only the coal and where you have these domestic water wells into the old coal, but into those adjacent correlative sandstone seams that are directly either on top of or below the coal seams.

So that is going on. We have an additional

12 locations, probably another 20 or 30 wells that will be installed in the Powder River Basin before it's all over with out there. What we anticipated in the Powder River Basin EIS was withdrawal of a total of about four percent of the recoverable ground water in the basin. And what we're finding so far is we're running and we have it broken down by watershed, but we're running about 20 to 25 percent of what we predicted is the actual draw down and water produced in those areas.

Now we've collected over five years of data to date and one of the accusations of BLM is you've got all this data and you haven't really analyzed it. We recently contracted with the Wyoming Geological Survey to look at and analyze this data. The draft of that report was due to us a week ago. We haven't quite seen it yet, but it is imminent, so we will have that information available shortly. But I wanted the panel to be aware of the fact that there is a monitoring system in the Powder River Basin and we're now starting to analyze that data and that data report should be available shortly.

DR. MAEST: And sir, what's your affiliation, please?

MR. HANSEN: I'm sorry. I'm Chris Hansen. I'm with the BLM in the Buffalo Field Office, Powder

River Basin.

DR. MAEST: Okay. Thank you. Yes?

MS. GIONOICKUS: Laura Gionoickus, Rawlins. It's also very important on this topic. This isn't going to solve any of the problems, but to not forget the nexus of this issue to the respective state engineering offices, water well permitting processes and their rules and regs and how that works because there's a lot of very complicated things that go along with water well permitting and whether or not you are covered if you do have, you know, if you have impact to your water well based on oil and gas production.

I don't know if you have any SEO representatives or anything?

DR. MAEST: Reggie, did you have a question?

MR. SPILLER: Yes. As a member of the National Academy, I just wanted to address this question to both Debbie and Matt: Do you have isopach maps, pressure surface isopach maps from these individual producing reservoirs that you can definitely show over large areas? So for example, let's talk about a specific coal layer where we're producing. Are we able to generate a pressure history and isopach map of a pressure, let's say, over 10, 12 kilometers?

MS. BALDWIN: You know, the BLM, the COGCC, Southern Ute Indian Tribe and industry have collaborated on a number of studies. We ended up lumping the entire Fruitland Formation into one unit because the CBM wells are producing that way. They're not -- there was no way to get discreet pressure measurements from the different coal zones.

MR. SPILLER: Right.

MS. BALDWIN: So we conducted a large reservoir simulation and ground water simulation using tremendous amounts of data for the San Juan Basin. And we've installed pressure monitoring wells along the outcrop of the formation. I have to be honest, we haven't updated the model recently, but I think industry may be doing some of the updating.

MR. SPILLER: Uh huh [affirmative], yeah.

MR. SPEAKER: Just a quick clarification there, Debbie. Is the section fully in communication?

MR. JANOWIAK: Yes. We've looked at that and the Coalbeds are actually a higher permeability than the intervening strata. So what happens is if you look at Graham's work on interconnectivity in these kinds of bodies, if you concentrate greater than 20 percent of a higher conductivity body --

MR. SPILLER: Right.

MR. JANOWIAK: -- there is usually the

assumption of interconnectivities, but it's valid.

MR. SPILLER: Right.

MR. JANOWIAK: The Court in the 1970's I think before CBM put together potential metric surface map of the Fruitland aquifer, his work showed a very nice thermal -- increase in the thermal radiant across the Fruitland telling us there's heat transported in the Fruitland.

MR. SPILLER: Right.

MR. JANOWIAK: It's an active aquifer system. So his map was, I think, one of the first ones. Benny Barry, I think, might have been one of the first ones, his Masters Thesis. All of these pressures taken from conventional oil and gas wells that were drilled, and so all the way up through present now we can say that depletion of those pressure field.

And I guess what I was mentioning to the other gentleman earlier was those very early maps showed artesian pressures with literally heads rising above -- several hundred feet above ground surface, 20 to 30 miles from the outcrop, which was telling us that's a wonderful ceiling, before they ever popped in here.

MR. SPILLER: Uh huh [affirmative]. I mean, just let me kind of let you in my head where I'm thinking. I'm a petroleum geologist and I've worked on some of the largest oil and gas fields in the world and I do know that as we reduce reservoir pressure in confined aquifers is we could find reservoirs. If we start looking at what those are connected to laterally, let's say a fault. Faults can be very good conduits for transmitting fluids or a sub-crop map where we see the Coalbed of the reservoir. There may be 1,000 meters of shale directly above us, but as we go into the basin, we see in a sub-crop map that those sub-crops could be connected to shallow reservoirs.

Debbie, I think you gave us a very good example of how it's possible to actually dewater a stream. If the stream is coming across a Coalbed Methane layer and you're sucking on that Coalbed Methane, you reduced the pressure. You can actually suck a portion of the stream into the section. We've seen this in a lot of places in the world with oil and gas fields.

So that, I'm wondering, if we start thinking about these sorts of geologic phenomenon, while we may be looking at pressure differences from wells directly above and directly below, but really what's happening five, 10, 15 kilometers away, we've really reduced the overall pressure laterally in a reservoir. I can think of some geologic phenomenon where that potentially could occur.

Now pressure is not the only issue. There's chemistry here. If that's happening, we should see changes -- lateral changes in the chemistry of water. So I can start to imagine if there ever were to be a study, I think that that would be -- there's some geology potentially to be looked at and really maybe, Matthew, you've done that. You seem to be a pretty good handle on what's happening on some of these basins. I'm not familiar with either one of these basins, but something to think about and consider.

DR. MAEST: Thanks, Reggie.

Okay. I think we have a question back here first?

MR. BARKMAN: Yes. I'm Peter Barkman of the Colorado Geological Survey and we worked with Debbie Baldwin of the COGCC on the stream depletion studies and I might be able to address this gentleman's concerns over here is that when we did the work on the Raton Basin, we realized there was a lot of data missing to really understand and characterize these connections well, so we have put in -- we've got a scope of work and they're trying to get the funding to do some additional studies to start to gather more data. These studies were not the end of the road for trying to understand this.

And we're also, you know, in the San Juan Basin and the Raton Basin, we started to realize what's going on later in the game and you start to recognize that boy, it would have been nice to have a lot more data to understand this as this is progressing. So we're also trying to get a better handle on some of the other basins and looking at the Wyoming with the -- was it the Little Snake as it runs down into our Sand Wash Basin. Well, this area, you know, we may be seeing some growing interest in CBM, so we'd like to get a head start on this and start to collect that data because I do think it's very important to understand the systems before we get going on them.

So stay tuned. I think we're going to try to get more data to get a better handle on this as we can. You know, it's just, you know, things happen quickly, especially in the energy producing world, that we'd like to catch up to where it. So hopefully that addresses some of that.

And one of the things that did come out of the Raton Basin study is it looks like most of the Raton Basin, in the water loss scenario of Colorado, is tributary. And it is too bad we don't have some representatives here of Division of Water Resources to address that and in a tributary system, if you're depleting the tributary system by your activity, you have to augment what you're doing and it may be that what will happen out of this is there will have to be some recognition that senior water rights are being impacted by the CBM development and there will have to be some sort of provision to augment those offsets. It doesn't guarantee protecting water levels, but it will augment the loss of water from the system and that's yet to be resolved by these further modeling studies that will come up. Hopefully, that addresses it.

DR. MAEST: So you it sounds like you think that there's been a lack of baseline data up to this point, but that is improving?

MR. BARKMAN: Yes, ma'am. We're going to try to get better data to get a better handle on what the system is. A little catch-up we're playing here, but we're --

DR. MAEST: Okay.

MR. BARKMAN: -- so that's what we'll try to do.

DR. MAEST: Okay. Let's -- we've got a little bit of time. Sir, you had a question and then if we could start directing a question or two to the production and management techniques.

MR. OSWALD: I don't have a question. My name is Carl Oswald. I'm a geologist with the BLM's Wyoming Reservoir Management Group and I just wanted to add a comment to Mr. Spiller's observation.

At the reservoir scale, in this case the Coalbed, we use in standard practice a structured isopach maps, as well as isotherm maps, that in the course of proving the unitization of the reservoir where we have a majority of federal interest, that data comes from industry. It also comes from the larger body of scientifically available information, from such as DOE, USGS.

We also invest in a larger wave of ongoing research activities to develop better ideas of the occurrence of the Coalbed natural gas resource and we applied that in a larger sense to our planning area scale to input on development. So we're all source users of data; however, the burden of integrating that and manipulating that falls primarily on our geologists in the reservoir group.

DR. MAEST: Thank you.

Do we have any questions on production and management techniques that might minimize impacts on water quality and quantity? We heard quite a bit about treatment methods and even some ways to minimize the amount of produced water that comes up out of wells. Are there any questions or comments in that area? Yes, sir?

MR. OTTON: Jim Otton, U.S. Geological Survey. I have a question for the Anadarko representative, and I know that for a while they were using zeolite fixed bed treatments and I'm wondering are they still using that? What's been their success with that, and so on?

MR. JAFFE: Zeolite is a naturally occurring mineral that is similar to exchange resin, but it is not as efficient and we were using an open bed system and we saw a lot of channeling, channelization and basically it was a bust for us. We couldn't get that or our series of systems to work. We have much better results when we use a controlled method of contacting our reaction agent with the water. In our fixed bed, we have fractal distributors and in the Higgins Loop, we get an even flow through it.

So the short answer is no, we're not using zeolite any more. Those systems have been shut down and reclaimed.

DR. MAEST: Anyone else? Yes?

MS. CRAMER: My name is Nicole Cramer and I'm with Williams, Porter, Day and Deville in Casper, Wyoming. I usually represent Devon Energy.

I just wanted to bring up one point as far as water management techniques and uses of Coalbed water and I know that you're looking at the adverse impacts of water production and water management, but in the Powder River Basin, the water resource has much more value as livestock watering quality -- or for livestock watering because there is not -- as Bill mentioned, there's not a lot of traditional irrigation there and so I know that a lot of the landowners that we work with actually mandate in their surface use agreements that all of the water stays on their property and that's because they want to use that to not only use the water for watering their livestock, but to spread the water out over the property to increase the efficiency of their livestock management and move their herds out to areas where they don't usually have water and they can use the land better by spreading their herds out and end up getting more forage that way.

So even in the cases where there have been some controversy about water going over the bottomlands, usually the landowners will get much more efficient uses and increase in productivity by using that water for livestock water. And most of the water that's produced in the Powder River Basin is already suitable for livestock water.

DR. MAEST: Okay. Thank you.

Have there been any studies on the use of produced water for irrigation and maybe some of the drip irrigation techniques that we heard about and mobilization of salts to the ground water? Has there been any?

MS. SPEAKER: I was just going to ask a related question: Do you have tail water management issues associated with using this water for irrigation? So are you familiar? You have to exceed the leaching potential, but do you have a cumulation of salt waters down below the ridges? So it's kind of the same question.

DR. MAEST: Same question, uh huh [affirmative].

MR. COMPTON: I guess I would just say I know a lot of the -- I know John referred to managed irrigation. In the early days, that was it generally entailed using some type of calcium, magnesium and gypsum was a common used. I think that is pretty successful, using a soil amendment along with the water, and I know that Matt, you were nodding your head over the drip system that John referred to. We saw some information on that, as well, that is -- looked really promising and that water tends to be released below a root zone and no higher than the root zone, and therefore, tends to, you know, be less disruptive to soil horizons above it.

So again, I don't know about industry experience with irrigation that does not require some management or soil amendment or what have you, but I know Fidelity has done some on that.

DR. MAEST: Okay. Anyone else? I think we're -- okay. Why don't we break for the morning. I appreciate everyone's attention and we're going to hear more this afternoon about research and data and water production and management techniques.

So we'll see you after lunch, which is at 1:30.

(Lunch recess from 12:35 p.m. to 1:39 p.m.)

MR. CONDIT: My name is Bill Condit and I'm a member of the Committee on Earth Resources, but Murray, our Chairman, has asked me to be the moderator for this afternoon session and so I shall. We're going to slightly change a little bit from this morning session and the theme of it is: Research, technology and data to understand and mitigate the effects of CBM production on water resources; what exists and where are the gaps?

In other words, what we're going to try to do with this afternoon's session and of course, also, with this morning's session is allow the BLM to establish a record, if you will, of what to do next towards getting down the road on the mandated study, Section 18 of the Energy Act of 2005. So we have six panelists here that have a range of interests and expertise.

Our first is Bill Hochheiser from DOE and I guess most of you have the hope of panelists biographies here and Bill's is rather long, or it should be. I've know him for some time now, and he's going to tell us tale of what DOE can do for us and you in terms of Coalbed Methane strategy.

Thanks, Bill. And Bill, if you would summarize in 20 minutes or so and I'll try to give you a --

MR. HOCHHEISER: I'll try.

MR. CONDIT: -- a high sign for when you have five minutes left.

MR. HOCHHEISER: Okay. Is it that microphone here?

MR. CONDIT: Yeah, I think it just can't be moved.

MR. HOCHHEISER: It can't be moved?

MR. CONDIT: You can just put it right on the podium.

MR. HOCHHEISER: Okay. I was going to walk around with it, so I won't walk far. Okay. Let's see if that works.

Okay. Like Bill said, I'm Bill Hochheiser. I'm the Oil and Gas Environmental Research Program Manager in DOE in the Office of Fossil Energy. We are a research program and our office in DOE doesn't regulate oil and gas E&P. As I said, we do research and I'll show you in a minute kind of the size of our project and what it's made up of. I'm having flashbacks here because two of my former bosses are on the committee, Reggie and Don, and it just seems like one of our old program reviews, like we were followed.

MR. SPILLER: We won't ask difficult questions.

MR. HOCHHEISER: Okay. I'm going to talk about Coalbed Methane environmental research that we've been doing in DOE, mainly things that are now coming to fruition. In 20 minutes, I'm going to necessarily just be able to skim the highlights of these research projects and not go into a lot of detail, but I'll point out where there's more detail available.

And our -- just to give kind of a highlight of where -- how our program is organized and where our funding comes from now, this is a 2008 funding, which totals about $97 million. Our traditional program of which we've gotten appropriations for oil and gas research and our staff does solicitations and manages the project has been decreased. In fact, we have almost no money in 2007. The Bush Administration has asked -- requested Congress to terminate this program over the last three years. Congress has not done that and in the sausage-making, that was the omnibus budget bill for 2008, at the last minute we got $47 million, which was a surprise to us.

Of that, what's relevant here is the environmental work is $5 million that's dedicated -- according to Congressional direction, dedicated to water management research, Coalbed Methane and other oil and gas water management. Now in EPAC, which is the same law that brought us here, Section 999 of EPAC created a ultra-deep water and unconventional natural gas and other petroleum resources research program. I've got that memorized. And what was new for us, if that had actually provided mandatory funding from oil and gas royalties that are collected by MMS, doesn't have to go through an appropriations committee.

So that's $50 million a year for -- it was supposed to be ten years. Turns out there's a sunset provision that makes it eight years, but this $50 million here is split up between management by a private consortium that DOE hired, which was required under the law and they have three program areas, ultra-deep water research, unconventional natural gas, and unconventional oil, but in the beginning they will only be address gas because of the limited funds and the technology challenges of small producers. Then there's some administrative funds.

And then at our National Energy Technology Laboratory, which is in Morgantown, West Virginia and Pittsburgh, gets $12-1/2 million for in-house research and under that, there's an environmental section, which is looking at water management primarily.

So we have this and under the unconventional gas part of the consortium program, when this is done by competitive solicitation, there is an area specifically for Coalbed Methane water management. So we have this in different parts of our program, all kind of coming together and there is solicitations that just were newly closed and selected here. There's solicitation on the street here and the complimentary program is putting their plans together.

So I'm going to talk about today is work that's been kind of coming to fruition under the traditional program for the last two years, kind of with this funding that we've had traditionally under this natural gas research program. And as I said, I'll pretty much kind of skim the highlights.

Now for Coalbed Methane our work in DOE is primarily environmentally related. We don't do the production-related research. We did that back in the `70s. Once it became a commercial endeavor in the `80s, we kind of phased that out. There are a couple of production-related tasks that I'll show you, but they're also related to water minimization and we look at where minimization impact studies best management practices and we have partnerships with BLM Ground water Protection Council to do research projects, also.

So I'm going to go through some of the major projects that we have ongoing or just finishing up. First, is the Montana State University and Jim Bowden, who was mentioned this morning. This was a Congressional set-aside for this money. It started in 2001 and it's totaled about $3 million. Originally their major work was looking at federal remediation to constructed wetlands and the idea was that to see if this could be a viable and economic treatment method, and they did identify a number of species that would take up the salt. They looked at how over a number of seasons the dynamics of the plant community, the initial species were decreased and then took over.

And what they found was rather than being relying on so much for the treatment of the water to reduce the salinity was actually most effective as a volume reduction mechanism. The plants really took up a lot of the water and so what was discharged at the end, which in their case they found under Montana rules would still need some treatment, but it was a much smaller volume.

And they also looked at hydrological assessments of water impoundments and measure the infiltration characteristics under the impoundments. The -- one thing that came out of this as a spin-off was a group, Drake Engineering, that was working with developed a -- this was part of looking at treatment on the tail end of the constructive wetlands, a fluid bed resin exchange system, which they patented and they're now marketing, and to tell you the truth, I don't know to what success. I don't know how many installations - - commercial installations, if any, they have out there.

One of our biggest projects is through the Colorado School of Mines. This is really a consortium of research groups. The Colorado School of Mines is the prime contractor that competitively divide a $3 million project, but they have ten tasks under that. We're going to talk about them because some of our major and most current work in this area and I'll talk about who is doing this. They've got solicitations from the University of Wyoming, from Stamford University, from Penn State and from Montana.

This first one is interesting. They're looking at -- you know, we're talking about water minimization. They're looking at actually membranes that could be installed down hole that are gas permeable and could actually prevent the production of water and let the gas flow to the wells. And they're doing this so far in the laboratory setting. They've identified some membrane materials that are promising that have the right characteristics that permit a level of flow that would be economic. What they're looking at right now is the logistics and the economics of actually installing it down hole, and that's still up in the air as to whether that can be done economically. But they're calling it "waterless CBM completion of production."

GTI, Grants Technology Institute, and Ergo National Lab have been working together on electro-dialysis. They have a laboratory unit that does show promise. It's technically working well. They're estimated treatment costs scaled up. It is also promising 12 cents a barrel of water treated and they're looking now towards doing some field work with that.

And I don't remember who's doing the third one here, but looking at isotopic tracing of Coalbed Methane water, it turns out that ratio of strontium isotopes is a good discriminator of a source of the water. It's very different for Coalbed Methane water than for surface water and for ground water and so they're looking at how to determine whether Coalbed Methane water is getting into other aquifers, whether it's infiltrating into ground water, what it's contribution is to stream flow and conveyance losses and so on using that. They've also identified some -- they're looking at carbon, oxygen and hydrogen isotopes as also possible tracers.

They've done some looking also at confining coals versus non-confining coals and how you can determine through these tracers whether the water is communicating from other aquifers in adjacent sand scopes.

Yes. Stamford is looking at minimizing the connection between the coals and adjacent sands. Now we talked about hydraulic fractioning earlier and generally the Powder River Basin hasn't been a part of that to date because the Powder River coals are very permeable and generally are not fractured; however, they do something called "water enhancement," which is to clean up the wellbore after drilling to get rid of that impermeable surface in the inside of the wellbore and do some fracturing that way and there's some questions in some locations as to whether those fractures leave the coals and go into the adjacent sandstones, if you don't have the shale confining layer. And Stanford is looking at the least principle stress regimes in these strata and trying to determine whether these fractures are going out of the coals.

PVES, Incorporated, Terry Brown used to be with the University of Wyoming, now has this company, and they're looking at application of Coalbed Methane waters wherein one of the -- and they're looking at the kind of soil amendments that have been talked about this morning, gypsum. Also, sulfur is used to amend the soil and with multi-year monitoring of the soils, they've found out using produced water and soil amendments has worked in keeping the soil viable. One thing they found is the overuse of sulfur in that regime can deplete lime and use of agriculture lime is needed in order to make that up.

Montana Bureau of Mines and Geology has been looking at regional setting criteria for infiltration ponds. They have been using satellite imagery to identify candidate sites and monitoring ponds. They've found reduced infiltration over time from some of these service impoundments because that soil that's lining the pond does get plugged up. They're also monitoring for salt mobilization and they found generally that the salts will go about 15 to 30 feet below and stop there.

There's treatment to reduce SAR. They were using leonardite, which I read is a weather coal and in the laboratory running through the Coalbed Methane water through these cores of leonardite to see if it would produce SAR and they found some -- you know, some effectiveness there, but not necessarily anything that could be used in economic or commercial scale.

So the next one, Penn State is looking at the impacts on shallow aquifers. They've been -- they have one site that has a lot of good data over three years and they've been looking at the -- I forget which creek it is, but it's one of the creeks in the Powder River

Basin and looking at the type series data. They're looking at conveyance losses and they have found that one, conveyance losses down this drainage on the order of about 50 percent. They found over time increased transpiration rates from plants to plants gets established in these drainages of water that increases the losses and also decreased infiltration rates over time.

Again, the Montana Bureau of Mines and Geology is looking at standardize testing -- with their standardized testing of water treatment systems. What they're doing is putting together, based on some USGS technology that's out there, basically camper truck mounted testing system that can be brought around to the fields and can be used by both producers and by vendors to do standardized testing of these water treatment methods that we've been talking about this morning. So there is a need to kind of cut through the claims of the vendors and for the producers to understand what's going on in their field and this would be a standardized way of doing that with mobile systems that could be brought around to the fields.

The water treatment by injection basically referred that it's difficult in the Powder River Basin to find injection targets and Montana Bureau of Mines and Geology is working on this with them, is identifying channel sandstones that could serve as deep injection targets for the Coalbed Methane water. They've identified six general formations in the area that could serve; however, they're limited in their airless den. So it's only certain locations that would have ability to inject this water that they -- and it's not -- other places just don't have that ability. It's not feasible just everywhere.

And Argon National Lab is kind of cross-cutting all of these tasks with regulatory analysis that affects these technologies so that researchers understand the regulatory context in which they're working on some of the water quality rules and regulations and laws that we heard about this morning, as well as the national regime.

Another resource for information and data that has been developed for our program is by Argon National Lab. It's called, "A Produced Water Management Information System." We know it as "PWMIS." And it's an online resource that has -- here's a screen shot of the home page. And it has three main modules. Technology descriptions for just about every technology that -- and this is not just Coalbed Methane waters. This is oil and gas produced water in general, so every technology that is being used or considered for being used for management of oil and gas produced water. There's a section on federal and state regulations. You can click on a U.S. map and you get the state's regulations from any state. Also, all the federal regulations are there for both surface discharge and underground injection.

And then a tool, which is a decision treating tool where a producer can go in and put in their information, their current situation, and get advice from the tool on what their options are for water management within their situation.

Now this next one is kind of one of these high-tech, high-risk projects that R&D managers love to fool around with. Oakridge National Lab and a company called "BC Technologies," are working on the use of hydrate formation for Coalbed Methane water management. And it's using a hydrate injector that Oakridge has been developing and the idea is that under the right conditions, higher pressure, lower temperatures, which are controlled, the injector, using the mist of Coalbed Methane water mixed with methane actually form hydrates and what that does, it's like when, you know, ice is formed, the salinity separates from the hydrates and drips out to an attachment below and so it's another way of taking a brine out and then when you disassociate the hydrate, you get basically fresh water and methane.

It's a high-tech, high-risk project right now and it has to be done under pressure. There are a lot of technical questions about how you do that in the field and whether you could do it continuous process or would have to be a vast process, how you disassociate the hydrates and so on. They're currently working with CO2 in the lab. It has very similar characteristics to methane in terms of hydric formation, but they are -- they do have a prototype and BC Technologies is currently looking for a site for field testing in the Powder River Basin.

University of Wyoming, we've got a commercially directed project four years ago, a million and a half dollars. Harold Bergman at the University of Wyoming Merkel's House Institute is working with us and they've put together a number of tasks that they're working on and nearing completion. They're looking at estimation of recharge in the whole Powder River Basin, the recharge of those aquifers using something called the "water assessment tool." They're looking at leaching from impoundments and where trace elements may be reaching the ones they've identified at the moment that they can see are traveling to some extent are barium and manganese.

They're also using tracers to quantify soil impacts. They've sampled the whole length of the -- and they're also looking at that strontium isotope ratio -- sampling the whole length of the Powder River from the baseline measurements, understanding the geographic length of the river and seasonal variability and looking -- and one of the things they've identified is the natural SAR and EC levels in the Powder River currently exceed those Montana water quality standards.

They're also, one of the things that they're excited about is this toolbox that will be web based coming out next months that will allow producers to get online, put in their particular situation and their parameters for production in their field and their environment and for different water management technologies, get an estimate of what the performance and cost would be for their field.

They are also looking at the use of Coalbed Methane produced water for enhanced oil recovery. They've been gathering the data up from Wyoming Commission on all of the oil fields in the area, looking at the characteristics, looking at the proximity of Coalbed Methane fuels and going to be recommending what the potential is for EOR using that water.

Another task is looking at zeolite. Zeolite was mentioned this morning, but zeolite lining ponds as a way of treating water.

And then also looking at the toxicity of Coalbed Methane water. So far, not finding any acute toxicity. I think they're using larva, minnow larva as their indicator species doing that and then a risk assessment of West Nile Virus because that has become an issue in that basin, especially with Sage-Grouse and some question as to whether CBM water impoundments are breeding grounds. So they are infield sampling and also remote sampling potential water bodies.

And just finishing up. So we have other research that's not directly Coalbed Methane research, but is related and some of those results could apply membranes for reserve osmoses, looking at advanced membranes, looking at self-cleaning membranes, a lot of the things we are doing here relate to pretreatment, which is more related to oil and gas and oil production, but that could be also, you know, RO is a candidate technology here.

And we also -- and there was questions about cross. We have a white paper done by John Frail [phonetic] of Argon National Lab. It was 2004, so it's a few years old. But he looked at costs for offsite commercial facilities and these are old costs from `97, but I think -- and then he looked at different management options and while the costs, I'm sure, have changed over time, I think looking at the relative costs of different options is instructive.

And then we have partnerships. There's a couple favorite partnerships. We work with BLM. We're trying to get a number of Coalbed Methane research projects and we do on wildlife, on agriculture, on stream communities, and work with the Ground water Protection Council and with the -- and we are working with EPA on that capital and limitation guidelines, work that Mary Smith talked about this morning. There's been somebody with DOE on each of their field strips. We're working with them on the questionnaire. We will be working with them on their economic analysis, also using their expertise that we have at our disposal.

And for more information, those projects I talked about, I obviously couldn't go into much detail, but there are project fact sheets on our NETL website and the URL is like three lines long, so I gave you more of a Google roadmap on how to get there. Our user's program in general and information for both myself and for John Dutta [phonetic], who is director of our NETL, Chief Center for Natural Gas and Oil and that's it.

MR. CONDIT: Thank you, Bill.

Does anyone have a question at this time for Bill? You going to stick around through it?

MR. HOCHHEISER: I'll be here, yeah. I'm here.

MR. VOLKS: I'm Andy Volks [phonetic] with BLM out of Mile City. You mentioned a membrane to separate the gas and water down hole?

MR. HOCHHEISER: Yeah.

MR. VOLKS: And I was just wondering because my understanding is you have to reach out from the bore hole in order to cause the methane to desorb from the coal in the first place and get to the bore hole, so how does that do that?

MR. HOCHHEISER: Well, the idea would be once the pressure is reduced and the gas has been desorbed, you wouldn't be producing any more water. You'd just produce the gas.

MR. VOLKS: So you'd still have to depressurize the aquifer initially in order to get?

MR. HOCHHEISER: You'd have to depressurize, sure.

MR. VOLKS: Thank you.

MR. CONDIT: Anyone else? I'm going to save my question for later.

Yes?

MS. BALDWIN: Debbie Baldwin with the Oil and Gas Conservation Commission and I had a question about that isotope tracing, the strontium -- using strontium isotope?

MR. HOCHHEISER: Uh huh [affirmative].

MS. BALDWIN: Would you have available on the website or some reference that, you know, for the results of that?

MR. HOCHHEISER: There are projects -- there will be a project fact sheet for that --

MS. BALDWIN: Okay.

MR. HOCHHEISER: -- on the website and I can work with you to point that out and also get you in touch with the researchers who are doing that.

MS. BALDWIN: Okay. Because we've done some isotopic analysis and always ended up puzzled by the results, I mean, at least as far as the water isotopes, so I'd be interested to talk to a professional. Good. Thanks.

MR. HOCHHEISER: Yes.

MR. CONDIT: I just have one more question, Bill, and that is when you and I were speaking on the telephone several months ago, you mentioned a success story off the top of your head about a producer or a company in Farmington in Mexico that was successfully treating.

MR. HOCHHEISER: Yeah, that's not one of our projects, but actually I was thinking of that as part of the EPA field trip in the San Juan Basin and while there isn't any commercial scale treatment and discharge in the basin, there are a couple -- a few pilot projects going on and there's one company, I think it's Otello [phonetic]. It's in Farmington and they also have another one in another land. They're using thermal distillation, which we think of it as fairly economic, but this is an issue that I think maybe you'll want to discuss it at some point or in the morning, having to do with the cost of hauling water for injection, which is in that area about $5 a barrel. And the two areas of the water rights laws there.

They actually are taking Coalbed Methane water, treating it to fresh water and putting it down the sewer POTW and the reason that works for the city is the city is allowed to take a certain amount of water out of the river and they use it and then they put the discharge back. And their, you know, according to the state their standard use is 10 percent of the water. Well, if they can put, you know, 10 barrels of fresh water into the river at discharge end, that let's them take 100 barrels out on upstream because they only used 10 barrels of that. And it's letting the city actually increase their water usage from the river because they can on a nominal end because if they're competing with $5 a barrel transport costs, they're actually able to use thermal distillation and right now make it economic, as they claim.

It hasn't gone widespread yet, but it seems to be promising for them. But it's the peculiarities and the economics and the regulation laws there.

MR. CONDIT: Thank you.

Okay. If there's no other questions, we'll go on to our next speaker. That would be Kathy Lynch from Trout Unlimited, Rocky Mountain Energy Council. She is the Energy Counsel and TU promotes responsible management of water resources produced in conjunction with Coalbed Methane development in the west and her work includes legal, regulatory, and policy analysis and advocacy, and getting on the backs of producers -- no, that doesn't say that.

MS. LYNCH: And I bite.

MR. CONDIT: The rest is organizing. Kathy, if you could summarize in 20 minutes and I'll give you a five-minute high sign.

MS. LYNCH: As Bill said, I'm Kathy Lynch and I work for Trout Unlimited. I work primarily on Coalbed Methane issues in the west and how that development relates to fish and wildlife and particularly sportsmen's ability to enjoy fish and wildlife resources. I oftentimes joke that if I had a quarter for every time somebody asked me why Trout Unlimited cared about Coalbed Methane, that I would be able to retire because most of the areas where we have a lot of CBM production right now, the Powder River Basin is associated more with a tour water fisheries and the San Juan Basin, which is associated with cold water fisheries, has most of the deep water reinjections.

Where we're coming from is we want to make sure that we're ahead of the curve and that we're involved and that we're participating now in helping influence policy on a precedential level that when we do get into continued CBM development throughout the west where there are cold water nexus, that we're prepared for that. And so as part of that, what I'm going to talk about today really is going to be mostly about surface water discharges of produced water in the Powder River Basin.

We've heard a lot already today of some of the things I'm going to talk about, and it's funny because on the list, I thought I was going to go last and I thought, boy, I'm really going to be redundant by then, but at least I'm only going to be partially redundant early in the afternoon.

We talked a little bit. Every basin has unique attributes and it's not just the water quality. We're talking topography, surface use, soils. This is really important to what we can do with the water. It's also kind of interesting to think about this produced water. Is it a waste or is it something that we can beneficially use? And I think traditionally how this development has proceeded over history has been to look at it as more of a waste product regulated by Oil and Gas Conservation Commissions throughout the west and how are we going to get rid of it? How are we going to dispose of it?

That applies a lot of the time, but it's also I think something just to put in your brain to think about how can use this as a beneficial use in some areas?

And then the interested parties, of course, I put Fish and Wildlife first because I work for Trout Unlimited, but we also need to make sure that operators, landowners and other parties are all stakeholders at the table.

This is a map that I put together -- had put together and I hope you can see it pretty well, but basically the gray areas are the known potential CBM places in the west and the purple areas are existing CBM wells, that show up on the map, but there's a well that kind of maps out on the GIS system about a quarter of a mile. And the rivers I had overlaid on here also because from a fish and wildlife standpoint, the river systems and the river basins are very important.

So up here in here in the Powder River Basin obviously we have the Powder and the Tongue River that we talked about, traditionally warm water fisheries, although I did see a recent analysis that they found two brown trout in some of the Powder River tributaries, which is kind of fun.

Down here in the Atlanta ramp area of Wyoming, we're starting to see some potential for some surface discharge and Bill DiRienzo talked about this a little bit this morning, but if there's some permits there. They're still building the facility, but that might be something that we're going to see more of.

And another area in Wyoming that I want to point out is really hard to see. It's right there. And that's called the "Riley Ridge Development." And that is in very prime cold water fisheries. Down here in the San Juan, I talked a little bit, we've got cold water fish, not a lot of surface depletion from what the initial studies have shown and most of that water is reinjected. Over here in the Raton, we do have some surface discharge and I'm honestly not really sure what the entire fisheries issue is down there.

Just for comparison, just to show you, everything that's not purple, those are just other types of conventional oil and gas developments that's existing and again, I put this map in there just to give an overview of sort of the cumulative impacts that we're looking at west-wide and again, how they're focused around some of these river systems. One that I didn't highlight with the CBM, although there is some in there is this Colorado Lower Green River system and there's a lot of conventional development, especially gas in the Peance Basin right now.

Looking at landscape level impacts is very important and I think as scientific conservation industry development perspective, we're all starting to realize that it's really important to look at the bigger picture. One thing that Bill DiRienzo talked about this morning is Wyoming's efforts to look at watershed based water quality permitting, still ironing out a few wrinkles in there, but it's one example of trying to look at things from a broader overview. Just a couple of other examples, just kind of a lot more than anything else, the National Landscape Conservation System and the Western Governor's Association, both are examples of other programs where we're really trying to look at the overall landscape impacts, not just one specific discharge point; for example, migration corridors, wildlife uses, et cetera.

The other 800-pound gorilla hasn't come up yet today. That would be climate change and I just wanted, again, to throw this out there as something for people to think about. This article just came out a couple of weeks ago in the L.A. Times and a study came out that showed over the last five years, globally we saw a temperature increase of one degree Fahrenheit in the west and this was for the 11 western states, kind of Colorado over. The average was an increase of 1.7 degrees. And as you can see, these dark red colors are where the increase was the most.

And this goes back really to what I said about is this water a waste or is it something that we can beneficially use? Water in the west is a scare resource and we've talked about this already today after really interesting interplay between are we drying ground water out and depleting somebody's source and at the same time are we putting too much of it somewhere else? And it's a really delicate balance.

Today I'm going to talk about aquatic life, soils, and vegetation and as I said a second ago, really focus on surface water discharge impacts.

When we talk about surface water, I just showed this on the map, most of our information comes from the Powder River Basin. There's a lot of things that have been done well in the Powder River Basin. There are a lot of things that have not been done well there and it's a really good learning laboratory, I think, for all of us going forward as we go into some of these other areas that are going to have surface discharge.

One of the biggest, I think, is that some of the times our existing water quality standards don't necessarily paint the whole picture. Maybe there are other constituents of concern that aren't being regulated and then also we talked about this today already. We've got quality and quantity impacts that are going to affect things from a landscape level.

Aquatic life, we talked a little bit about warm water fish, cold water fish. We've got to remember also in a lot of these systems, we've got macroinvertebrates which are a very important food source for fish and also for some bird species. We've got amphibians. We've got fresh water muscles. Two of the primary constituents of concern that I want to talk about in a little bit more depth are bicarbonate and selenium, and then after I talk about those, we're going to talk a little bit more about quantity.

This is really interesting. Just a second ago, Mr. Hochheiser, I think said that the University of Wyoming had been doing some studies and I'm not familiar with those, and they hadn't really found any toxicity yet with whatever parameters those were studied.

Here's one example of an ongoing series of studies that the USGS is doing in partnership with Montana Fish, Wildlife and Parks, and they're looking at the toxicity of the bicarbonate anion on fish, warm water fish so far. It's kind of interesting, too, we talked a little bit earlier today, the gentleman from Anadarko mentioned that they've got the treatment systems where they're taking the cations out because traditionally we've really thought about the sodium as kind of the big constituent that we need to treat out of the water.

Well, there's a negative recharged ion, which is bicarbonate and that is in a lot of the produced water. It can range anywhere from 100 milligrams per liter, up to 3,000 milligrams per liter, just again, depending on where you are and what the particular water quality happens to be.

This study, they looked at both acute and chronic toxicity of bicarbonate on these three warm water fish and they found acute toxicity levels between 1,000 and 1600 approximately milligrams per liter and chronic, which is more of a long-term exposure toxicity, as low as 400 milligrams per liter.

So some of the gaps that I see anyway associated with this bicarbonate is first of all, the studies are ongoing and the head scientist working on this from USGS told me that this summer they're hoping to do amphibians and fresh water muscles and develop similarly to those standards that we just saw, develop standards that would apply to those animals, as well.

I'm not aware of any bicarbonate acute or chronic toxicity studies on cold water fish and that's something that I think would be useful going forward or likewise, on macroinvertebrate. I believe that we need to continue these studies so that we know what a range is of the bicarbonate that is potentially toxic to aquatic life.

None of the five western states that have CBM production have a bicarbonate standard. I know that some years ago there was a petition in Montana without bicarbonate included. It wasn't done at the time and frankly, I don't know that we would have had the numbers at that time and this is just something that we're looking at now. Hopefully we can develop some criteria that are adequately protective of aquatic life.

The other constituent of concern is selenium, which is a naturally occurring element. It can be toxic to large animals, also, cattle, sheep, in much larger concentrations, but also to fish and birds in smaller concentrations obviously depending on different factors and again where are we? Where's the water coming from? Where's the selenium coming from? What are the levels?

There are a number of existing studies out there. U.S. Fish and Wildlife Service is one proponent of this and I believe I've seen it in some USGS literature as well. The 2 micrograms per liter is the necessary dissolved water standard, but it's necessary to be in place to prevent bioaccumulation of selenium; in other words, if down as far as 2 micrograms per liter can be enough selenium in water that over time you can get bioaccumulation in fish and bird species and what oftentimes that means is you can have large effects on reproductive success of those species, as well as it can just accumulate in their tissue, as well.

Here is an example of a study that the U.S. Fish and Wildlife Service did. I think it came out a couple of years ago. They looked at the suitability of CBM product water for wetland creation and enhancement projects. And they sampled several closed containment ponds in the Powder River Basin and they found, not in every sample, but in a number of samples that there were exceedances of acute copper toxicity levels, iron and selenium.

They also found in the bottom of some of these ponds, concentrations of trace elements, like arsenic, cadmium, nickle, zinc, that settle out of the produced water and then they become part of that benthic community, which is the bottom of the pond, so to speak. And that's where you're going to get a lot of your vegetation growing out of and that's where you're going to get your macroinvertebrates living.

So just a summary of some of the findings that they had: Six of seven of their study sites, the selenium exceedances -- the selenium amounts exceeded what's considered a safe level for bioaccumulation and the real sort of interesting issue is here you're creating this lovely-looking wetland or pond, and it's very attractive to aquatic birds and migratory birds and so they want to come and they use those and I don't think it's something where they come and it's like the Berkeley Mining Pit in Butte where they land once and forget about it. I think it takes more chronic over time, maybe even some of the vegetation and some of the invertebrates to actually accumulate it, but it can be a health risk to the fish and bird species.

So the recommendations out of that report that I was talking about, is that water with greater concentration than 2 micrograms per liter of selenium should not be discharged into closed containment ponds because the bioaccumulation risk is too great. And another finding that they had, which is a little bit off topic from the aquatic life, is that sometimes soils naturally have selenium in them also and it may not be the product water. It may just be maybe the product water is being used for managed irrigation or maybe there's just natural discharge or surface discharge of the product water, but sometimes that can leach out existing selenium that can then move downstream and you can find it in wetlands or other benthic environments.

So it's kind of a two-edged sword. It's not always the produced water that has the selenium, but it may be the application of the produced water that's leaching the selenium.

This current standards in Montana, Wyoming and New Mexico, these is are the state water quality numeric standards, are 5 micrograms per liter and then we've got 4.6 in Colorado and Utah, higher than the recommended levels that I was saying a number of studies have come up with as the 2 micrograms per liter. And like I said, basically in an ideal world from my perspective, the standards would reflect the 2 micrograms per liter.

Quantity of discharge: This came up a little bit earlier today. Laura from the Rawlins Field Office, I think made a couple of comments on this. We've got these ephemeral and intermittent streams that have evolved over thousands of years in response to very infrequent sort of flash storm events. And what happened is now we're changing them to perennial systems and we've got high flow over prolonged periods of time. Some of the potential impacts from that, we can have reduction of available habitat for fish and macroinvertebrates because they can literally be flushed out of the system. Oftentimes shallow reaches in intermittent streams or end of perennial streams also, are really important for small fish while they're rearing and even for adult fish, if they're out foraging. And the increase of the quantity of water in these stream systems can impair the ability of it in the adults and again, with the benthic macroinvertebrates, which is fish food basically, could get flushed out of the system.

I see a little data is available. I think more than anything, there is some data out there, but we don't really have anything in place, as far as what is an acceptable level of discharge that isn't going to cause these effects to some of the aquatic life communities. There's one study that I'm aware of out there that looked at the effects of large volumes of discharge on sturgeon, but other than that, there's actually not a lot of information that I've seen, and if anyone out there is aware of any others, please do let me know.

Regulatory mechanisms should account for the ecological function of these landscapes in addition to just what may be physically consistent. There's been some look at Wyoming recently about limiting the quantity discharge to the bank full capacity so that it doesn't overflow and flood landowner's property and from a landowner's perspective that's not such a bad deal because at least it's going to stay in the channel, but from an ecological standpoint even having that channel fill the bank flow 24/7/year around, does have ecological consequences.

Soils: Erosion and sedimentation, that's very closely related to what I was just talking about on the quantity side. I'm going to talk a little bit about land application and surface impoundments.

Alteration of natural flow regime from the high flows, I just talked about that a little bit.

The physical channel characteristics: You've got erosion. You've got what's called "channel armoring," and that's when some of the constituents in the CBM water filter out and they kind of plug up the channel a little bit and then the channel itself becomes less -- it becomes more impervious and infiltration rates go down.

Upstream erosion of head cuts: If you've got a certain amount of small flow of water over a head cut and then that become -- the quantity increased and it's more of a perennial flow. As you can imagine, as I'm kind of going like this, it'll kind of cut away at the head cut and pretty soon it gets wider and it tends to move upstream.

This photo I clipped from a BLM environmental assessment done on the Atlantic Rim. I think the photos actually come from a pilot project in the Seminole Road Project, but I'm just throwing that out there.

Just an example of what I was talking about, here is a sort of pre-discharge head cut and this just really shows an example of the widening, deepening, and moving back upstream, and that was only a produced water discharge of 1.35 cubic feet per second.

I'm going to just skip over that.

Land application: Bicarbonate, not only can it be toxic to aquatic species, but it reacts with soils and basically replaces the calcium in clay soils. And they become swollen and less permeable. We talked about land application by adding gypsum and elemental sulfur. We've seen some potential success of that in the Carribean. I know they're irrigating successfully up there right now and growing quite a bit of alfalfa with that addition to the water.

Some gaps in the land application picture, we've got broad areas of land that for thousands of years have had very little precipitation and we're putting the water onto them now and even with the amendments that we're doing to protect sort of the upper level of soil structure, you've got to imagine all of this water is now coming down through the soils and there's the potential to leach out elements in the soil that have been there for a long time. We don't really know the extent of that. We don't know the extent of the salts leaching. We don't know the extent of some of the metals that naturally occur in the soil that might be leaching out and so one suggestion I would have would be some more studies to understand some of the long-term mobilization.

Surface impoundments: Again, this has been covered. I'm trying to bust through here, Bill. I'm sorry if I'm going a little over.

MR. CONDIT: Okay.

MS. LYNCH: The water, we access the soils and you get an impervious surface. We've talked about that in a couple -- we talked about it with blend application. We talked about it in some of these discharge channels.

The same thing can happen in these surface impoundments that are used for infiltration or evaporation. And so what happens is it leaks out. It kind of makes that impervious plain and then the water leaks out and then you can have mass wasting of sides of erosion. There's been some efforts in the Powder River Basin to actually install drains below where it's leaking and pump the water back into the reservoir.

And then again, we talked a little bit about how these deconcentrate selenium and be sort of an attractive nuisance for birds.

The big one here, I think, is as far as we know a lot of this information. We know what's going on. There might be some additional studies regarding surface impoundments. For the most part on this one, I think a potential gap is really having the political will to say, "We know what these effects are and because of that, we're going to consider them, at least during the permitting." I'm not going to say don't build them anymore, but take it into account during the permitting.

Vegetation: This one really fast. Nonnative species for vegetation seem to come in when you have site disturbance no matter -- it doesn't have to be Coalbed Methane development. It can be any site disturbance. You just happen to get evasive species there and the problem is a lot of them can out-compete the native vegetation, especially because a lot of the invasives are more water tolerant and salt tolerant.

Sage brush and juniper tend to not do as well with a lot of water. Salt cedar loves water as an invasive species. It's terribly difficult to get rid of once you've got it in drainages. So again, just something to keep in mind. That's another issue.

My conclusions and recommendations for the aquatic life soils and vegetation, I've sort of gone over this. This is really just a summary so I'm going to skip through it.

Overall, general recommendations from an ecological standpoint are to really perform meaningful surveys, population surveys, species presence surveys, stream morphology, et cetera, prior to development. I know that in some cases this is done. I don't think it's done in every case.

And then this has also been talked about a little bit today, but let's try to get -- all this data real time available on the web is just amazing and I think it helps everyone from operators to landowners to NGO's, et cetera.

Water really is a potential resource, but traditional permitting factors don't cover all the impacts of CBM. I've talked about that a little bit, especially with quality and quantity. Once size doesn't fit all and because of that, this is a very time consuming and expensive process for all of us, and really the bottom line is with the data that we do know is having political well to implement protective standards for fish and wildlife.

So I would entertain any questions or wait for the open session.

MR. CONDIT: Anyone have a question for Kathy at this point? Well, I do and I want to know what Trout Unlimited's position was on the release of the dam water and that experiment?

MS. LYNCH: You know, I don't know that we have an official position on that.

MR. CONDIT: The cold water fishery is 16 miles below the dam.

MS. LYNCH: You know, that is outside of the scope of my work, but I can look it up.

MR. CONDIT: All right. All right. I'll let you off the hook. Thank you.

Okay. Our third speaker is Jim Kuipers and Jim didn't provide me with a -- I know a little bit about him from a study that his consulting firm had produced, but he assures me that he's going to introduce himself to everyone personally. So have at it, Jim.

MR. KUIPERS: Thank you very much. I appreciate the opportunity to speak this afternoon and I think it's a very unique opportunity because a lot of us have been working on the Coalbed Methane issue for five, six years now, even longer than that in some cases, and a lot has kind of come together. I find it very interesting, the advancements that have been made, despite the arguments that are going on and I think some of that has been happening today.

I just need to give you a bit of background, unlike some of the other speakers, because my perspective really comes from my background and it's somewhat unique. The point I would make is I'm from a traditional Western U.S. resource-using family. My family was a mining family. I was raised by my grandfather, learning to muck, drill and blast underground. He convinced me to become a mining engineer and I graduate from Montana School of Mines with a degree in Mineral Process Engineering. In 1983 we didn't have a lot of environmental engineers. So in addition to being a mineral Process engineer, by default I became an environmental engineer at many of the mine sites I worked at.

I'm a registered professional engineer in

Montana and Colorado and I spent the last 25 years working on mining and other natural resource issue permitting operations, as well as reclamation and closure issues.

The key is in 1996 after spending pretty much 36 years of my life in the mining industry, I was very frustrated with the degree or rate of change that was occurring. Basically to put it simply, I felt like I was dealing with a neanderthal attitude at a time that required a very progressive movement by the mining industry, so I decided to help them out, if you will, by joining the other side and so in 1996, I formed a firm and we provide consulting services, technical engineering and associated scientific services to the environmental community, as well as to government.

I didn't plan on getting involved in Coalbed Methane by the way when I formed this company. Our main focus is in the mining arena. That's where we spend most of our efforts. I want to just back up maybe a bit and mention that as the consulting firm, it really is leading to the next part. There were two key aspects that I want to mention -- or three. The first is one of our major accomplishments was the Good Neighbor Agreement between Stillwater Mining Company and Northern Plains Resource Councils. Northern Plains

Resources Councils, as many of you are aware, is one of the major litigants of Coalbed Methane issues in Montana, but they formed a Good Neighbor Agreement with Stillwater Mining. We helped negotiate that. We've facilitated that since 2001. It's been very successful, and it's a good example of how we can create win/win situations and work things out.

I would mention, this is an agreement between private parties and industry, not government. A lot of the talk here has been about how government is going to solve our problems. I don't think that's the only answer here. And so I want to mention that.

Another thing just to mention, I have actually collaborated with Jared Diamond on his book, Collapse, Chapter 16 in particular, which compares the mining and the oil and gas industries. The reason I mention that is if you read that chapter, you'll see the oil and gas industry painted in very glowing terms, the mining industry in not so glowing terms. Well, Jared and I have had a number of conversations over the last couple of years about why my experience in Wyoming with the oil and gas industry is just the opposite. I'd give anything to deal with the mining industry compared to the reception the public issues have gotten, in particular in Wyoming, but also throughout the Western U.S. by oil and gas industry.

By the way, Jared's answer is: He was dealing with Royal Dutch Shell in a very highly ecologically sensitive area and our conclusion is big companies are more likely to do a better job than the smaller companies, at least in these circumstances.

Finally, I want to mention that one of your committee members, Ann Maest, and I recently completed a report that looked at the comparison of predicted and actual water quality impacts in the mining industry and we found a couple of very important areas. One is there is certain inherent characteristics that lead to greater problems than others. Well, guess what? Coalbed Methane, we have the same situation.

When we talk about the Powder River Basin versus other basins, you can see there's an inherent characteristic in the Powder River Basin that leads to more issues. More importantly, I might even suggest, we saw that if you don't do an adequate job characterizing the site, collecting base site information, understanding the geochemistry, the hydrology, things like that, you're predicted versus actual just might as well save your time. And that's one of the bigger issues I think we have here. So just needed to kind of give that as context, if you will, for some of the suggestions I'm going to make.

Since 2003, I've been working on Coalbed Methane. I was originally contracted by Northern Plains Resource Councils to write first, a paper that basically outlined the management options for sustainable development, trying to look at produced water, the issues around it, and what we could do to improve the situation so that we have a sustainable industry, also so that those impacts don't affect ranches, farms, and others dependent upon that area.

We also produced a technology based ELG. I need to mention that there was an effluent limitations guidelines produced. In 2003 apparently the Cheney Administration more or less torpedoed that publication. I did receive that publication from a gentleman in the environmental publication agency and did release that in 2004. If any of you would like to avail yourselves of all that information, it is publicly available, even though it was never officially produced.

I've also written another publication called, "How to Improve Oil and Gas Reclamation and Reduce Taxpayer Liability," for Western Organization and Resource Council that primarily deals with the reclamation and bonding issues surrounding Coalbed Methane, as well as oil and gas production. Simply we don't have the same parity, if you will, in oil and gas that we do in mining and other resource extraction issues when it comes to reclamation and bonding. I present these results at professional conferences and a number of other quorums. I've also testified as an expert witness in both Montana and Wyoming on these issues.

Unfortunately, I have to tell you that's where most of the science, if you will, is taking place, is in the litigation arena. That is not the ideal place by far for that to be the case.

So with respect to the first question: What are the effects of CBM production? You know, I think we've heard a tremendous amount already about those impacts, as well as about benefits. I think you need to understand in each case that we have water production, how the water is actually disposed of varies from site to site. The effects can be both positive and negative.

This is just a table that we've used for the last three or four years to try to demonstrate that. For the different disposal methods, we have benefits. We have impacts. And literally you can take and change this from site to site to site, as to whether the impacts or the benefits are greater. When we talk about basin to basin and even sites within a basin, literally what I've seen is winners and losers in full spectrum. It doesn't just fit one side or another.

With respect to the data itself, in terms of what's available to assess the effects, we heard today that there's an abundance of data, but an abundance of data -- actually, I'd almost suggest it's lead to a lack of knowledge, rather than the opposite. I'd rather have a very little data and have it first designed in its collection to actually meet an objective. Much of the data being collected, if you actually get down to what is the scientific validity of it, and can it be actually utilized to tell us something, in most cases the answer is going to be no. It was simply monitoring for the sake of monitoring, not for really trying to get to an end result objective.

And I don't want to -- you know, somewhat apology up to the regulators, I just can't agree with your assumptions in this respect. You seem to have it all figured out and the science world I come from always recognizes uncertainty and I think you can always find an exception to everything and when I keep hearing absolutes about, Well, we're certain the basin is not permeable," there are exceptions. There are fractures. There are anomalies, and I think the more mature side of oil and gas industry has come to learn this. The Coalbed Methane side, particularly the regulators, seem to just still wanting to paint a particularly rosie picture for us all.

We have a lot of current projects underway. I was very encouraged to hear of the projects that DOE had going on. I wasn't aware of some of those. What we really need to do is do some things with some strict rigorous analysis, assessment intended at the end. And we need to get the science involved versus just the opinions of whether we should produce or not produce.

What really concerns me more than anything of where we're at with Coalbed Methane is production is far advanced. Wyoming -- I fly over the Western U.S. at least once a month on my way to New Mexico or elsewhere from Montana and literally each month you can see the progression happening and on a yearly basis, it's actually quite incredible. We're already into some of the most sensitive environments that we could be into and what I'm hearing here is we still don't understand the characterization, the impacts, how to mitigate these things and we've already maybe gone too far in some places.

So this is where we need to very careful, on characterization. Really needs to be done beforehand and the reason for that is, we talked about mitigation, but if we don't know what's going to go wrong, how can we set up the mitigation to do it? What you're going to find is a history of violations or exceedances or impacts, if you will, corrected by lawsuits. That's not the way for all of us to do this, but I can tell you is that is what's going to happen. As mistakes are made, realization of water quality impacts are discovered. Under the present circumstances, lawsuits will follow and we'll just continue to muck this up.

One of the things that's very important is baseline data and I heard several times today, "We're collecting baseline data." That discussion pertained to areas where they've been producing for five or ten or more years. That's not baseline data, folks. You can't get it anymore, particularly in these sensitive areas, we need to collect baseline data before we start production.

This is just one of example of what we're dealing with. This is showing an area in Wyoming that was applied with Coalbed Methane produced water and the impact of sodium absorption ratio. Now again, I've seen sites where it looks wonderful and I would have to argue for industry that yes, you can have compatibility of agriculture and produced water. We've seen other sites where things are not so wonderful. We've even seen sites such as Art Compton described, where things blew out, if you will and to what degree that would continue to happen in the future, get bigger or worse? Right now all anybody can do is speculate. We really have few, if any, facts to lend to that.

This is actually one of the bigger issues that I think exists. What I'm showing here is a containment pond and then right here we have the Powder River. Now EPA, what we're hearing is they're going to do a study on the surface water impacts. They're not going to look at ground water. Ground water and surface water are combined or intermingled in these situations without any question. This is a pond that has no discharge permit and yet, you can see hydraulically it's situated just above the river, adjacent to the river, and it's mined according to Wyoming standard, which can mean either no liner or essentially the equivalent of a heavy weight garbage bag.

When I hear the statements that our ponds don't discharge, I practically had to not laugh. All liners leak. All ponds discharge. That's something damage engineers understand very well; therefore, we put in mitigation to capture that seepage, to capture that discharge and deal with it. We have discharges going on to surface water that aren't even recognized at all. In fact, the big picture of ground water to surface water connections with CBM seems to have just been ignored, and again, that's where I predict you'll see a lot of lawsuits and litigation if we don't get on top of that.

Which production techniques may minimize the impacts? We've heard a lot about that today. Different production techniques and in fact, five years ago, I was very pleased to hear some of the producers touting some of the technologies they would use in looking at where things would go, but things that haven't happened that are disappointing are sequence development. It's literally possible with Coalbed Methane if we were to take our time and develop it in a sequence fashion to reinject or otherwise avoid surface water discharges of 50 percent or more of the water.

Unfortunately, it somewhat argues against free market economies where we're allowing everybody to do their thing all at once, but in terms of sustainability, this is one of the bigger issues. It does have some solutions. I'm going to suggest that in Montana because of our regulations, the way we're looking at things, we're going to sequence production whether folks like it not. It's just going to be a fact. I believe as a result, our industry will be much more sustainable. Fifty years from now, we can have that argument and see who wins, but that's at least my prediction.

The directional drilling for optimization category, that's one which we continue to hear a lot of encouragement in, but the fact is, we just haven't seen the results yet. I don't know why we haven't seen more encouraging results. I don't know what's going on with the technology. Again, it's being touted by certain companies and certain situations. It should be something that's much more broadly applicable, particularly the fracture optimization, but we don't hear a lot about it in general, although we did hear that DOE is doing some work in that direction.

One of the more important things and this is an area that is always true in all resource extraction areas is resource optimization. Avoiding high water-to-gas ratios, and perhaps the most encouraging thing I've heard in several years was the opinion by the Wyoming State Engineer recently that said, "Don't turn on those wells in the Big George Basin where we're simply pumping water for years and years waiting for the gas to come about." Avoiding that high water-to-gas ratio, may account or may allow us to decrease the water volume by as much as 25, 30 percent based upon the work I've done and really only involve one or two percent less gas being captured. So that's the type thing we look at.

But the bottom line is ensuring water quality and what I heard today, what I've been touting for five years or more now is we can treat the water. It can be done economically. And we should be doing it in every single case to meet end of the pipeline standards. It's very interesting to me when we listen to companies like Anadarko, they're doing it. Now their situation allows them to do it. But that's what we're looking for is companies whose situations allow them to do the right thing, to do it right. It's ridiculous that we still have companies out there saying, "We can't treat the water." And that just doesn't go anymore.

We knew five or ten years ago, we'd get to the point today where we are treating the water. Now we just need to optimize that stage. I would mention the same thing happened in the mining industry. In 1996 the mining industry said, "We can't treat the water." There are over 50 different mine sites in the U.S. today, a little over 10 years later, that are treating the water and meeting standards and meeting end-of-the-pipe requirements. It can be done just about anywhere. Again, it's a matter of will and also a matter of economics, I'll be the first to recognize that.

This is just some of the information on costs out there. I think the biggest problem with the cost information is that it's incomplete. We really don't have good costs. I think the biggest challenge for EPA, as well as industry, will be to ferret out costs that are meaningful. We had a discussion earlier today with a person that, you know, reminded me that the way industry accounts for costs is not going to make it easy to ferret out site-by-site production costs relative to produced water. In fact, it may just simply not be possible. You can see the variability of costs based upon examples that we had just five years ago and I'm sure today we would find the same variability.

Impacts to profit: I'll just give a very, very simple example here. In fact, almost too simple, but the idea being that if we just had an incremental cost of 15 cents, then what we're basically doing is impacting the return on investment by three percent. Now probably everybody expects the higher cost of $2.50

in MCF. I just used that as an example based upon the 40 percent ROI and an impact to a minimum 40 percent return on investment the industry might be looking for. You can show this same graphic with a much higher gas price and simply show that windfall profits are being barely, if at all, affected by the additional costs.

With respect to federal and state regulations, the bottom line is that at least in my opinion, unless we have adequate characterization, unless we really understand the problems and are willing to admit that there are problems, in their current state, all the federal and state regulations are inadequate. This is why, at least in Montana, I think we've taken the very pragmatic choice. It may not be a choice really, but just the reality, that development is going to be slow. I think locations with high competing values in Montana, I think we view all of our land uses as having high competing values, and we're going to wait for the science and regulation to catch up. Now in other places, we're not going to do that. In fact, we haven't done that and we've proceeded, but I think it's one of the big issues we have is some places we're going to just go ahead and proceed full steam ahead like Wyoming. Other places like Montana, almost the opposite approach. It gets very complicated when one is downstream of the other, as we have heard today.

The examples are the discharge limit disputes between Montana and Wyoming that are out there. That's something that as long as the two different states are taking two pretty much different views or approaches, we're going to have those issues. The reclamation planning and financial assurance gap, I feel is a huge issue. It's one thing and we always see this, the resource extraction industries go crazy. When the price is up, everything is good. Things drop, the economy changes. We enter a recession. Suddenly some folks go bankrupt, that's when we'll see the impact of this shortage.

I think one of the more important things is surface owner protections and in that respect, again, going back to why isn't the oil and gas industry employing more good neighbor agreement type approaches with groups of landowners, with individual landowners. I've been amazed the cases I've had to show up and testify in. The cost the companies in most cases to fix the problem would have been less than the one day of work in a hearing that all of us undertook and we all know that there are actually ten days of preparation for those one day of hearings. It's ridiculous, and it just doesn't speak well for the industry to not step up and do the right thing, and I would say that's not true with all of industry. There's a huge division between those that seem aggressive and those that seem to want to do things in a different way.

Thank you.

MR. CONDIT: We have time to entertain some questions for Jim. That's someone walking up to the podium there.

MS. GIONOICKUS: I just have a quick comment. I appreciate your comment on base line because I just want everybody to keep things in perspective. You know, it's a complete flatlining of the snow melt hydrographs in the Western U.S. starting basically in the `30s and the `40s has done more to irretrievably alter permanently and the loss of our cottonwood forests, the Riparian function in the Western U.S. probably forever, trout fisheries, et cetera. So the effects of Coalbed Methane discharge on the surface at this point are but a very small fraction of landscapes that have already been essentially irretrievably altered and so just, you know, for everybody to keep those things in perspective. For example --

MR. KUIPERS: If I could? That's a great

example of it because without the baseline, people are going to blame that on CBM.

MS. GIONOICKUS: And like, just as an example, the photo that Kathy showed that I'm in charge of mitigation of that head cut and it's a bummer because a couple hundred yards downstream of that head cut is Seminole Reservoir, which has been way, way, way, way low and your head cuts are affects by your base level in your, you know, hydrologic system there and so that Coalbed Methane water definitely affected those soils, which are highly erodible, but there was a huge combination of factors there and that whole thing fell apart in about two seconds and a good part of why it fell apart was very unnatural conditions below it in the reservoir that summer.

So just for everybody to keep perspective of, you know, there's --

MR. SPEAKER: Typical --

MS. GIONOICKUS: Yeah, that's what I'm saying. I mean, there's millions of components that come into this and there's two naturally -- natural hydrographs left in the Western U.S. You've got the Yellowstone River and the Red River and that's about it. Everything else has been done for a long time, so keep it in perspective.

MR. CONDIT: I'd like the court reporter to note that Laura -- how do you say your last name?

MS. GIONOICKUS: Gionoickus.

MR. CONDIT: Gionoickus, so when BLM is reading it, they can know one of their own was talking that way.

MS. GIONOICKUS: All right. I'm busted. I would have been gotten rid of a long time ago.

MR. CONDIT: I appreciate your comments. They're dead on.

Anyone else? I'd like to pose a question to Jim and that is, I'm a little confused. I, too, have heard that comment out of the State Engineer's Office; likewise, I was -- I mean, I heard it from a friend that lives in Wyoming and she called me in Sante Fe and said, "You won't believe this." And I didn't, but she assured me. I went on the website and couldn't find any records, but you're saying it is true?

MR. SPEAKER: It's actually the State Geologist.

MR. CONDIT: State Geologist, okay. That is a big difference.

MR. SPEAKER: And there's actually a report out, so it's in writing. It's not on the web yet.

MR. KUIPERS: That's interesting because the newspaper did report it originally as the State Engineer.

MR. SPEAKER: Right. The State Engineer would have regulatory authority.

MR. KUIPERS: Right.

MR. SPEAKER: But has not chosen to exert it yet.

MR. SPEAKER: And the State Geologist is a part of the University of Wyoming system tenure.

MR. SPEAKER: No. He serves at the pleasure of the Governor.

MR. CONDIT: But I am curious about in the larger, what he was saying. Do I hear you saying, Jim, that somehow delaying Big George clay will lead to when production does occur, a lower water-to-gas ratio?

MR. KUIPERS: No. It leads to it now because Big George has the highest water and gas production ratio. So by not basically running that play, you're going to keep the larger produced water ratio down. It's if you actually put that in combination with everything else right now, I think you might simply overwhelm the system and so it's a good move in a way, I think.

MR. CONDIT: So make sure there's not one methane molecule left in the viaduct before you start tagging on --

MR. KUIPERS: I would be -- I'm not sure that's -- I wouldn't go that far, okay? I'm pretty sure of that. But I think it's don't start Big George now while you've got so many other things going in, if your produced water is tapering off later, I wouldn't be surprised if they say, "Now is the time to put Big George into play."

MR. CONDIT: And is that because there will be some of the infrastructure and likely some of the other technology that we've heard about either from Bill Hochheiser or this morning what Anadarko is doing?

MR. KUIPERS: I think that would be the case and that would be my argument for why it's a good decision, but I don't know that that actually had any bearing on it.

MR. CONDIT: Or maybe shale unconventional resources will come in and start it.

MR. KUIPERS: Yeah, there you go.

MR. CONDIT: If no further questions for this witness? Oh, by the way, how do they let you testify in Wyoming cases if you're licensed in Montana and Colorado?

MR. KUIPERS: We don't really want to talk about that right now. That's under litigation.

MR. CONDIT: Let's have -- uh, excuse me, a discharge break.

(Recess from 3:03 p.m. to 3:21 p.m.)

MR. CONDIT: Our next speaker is lead geologist and hydrologist for A-L-L Consulting. He has over 40 years experience in petroleum exploration and production, including work in conventional oil and gas at CBM, shale, gas and coal geology. He also worked as a consultant to the Oklahoma Corporation Commissions Underground Injection Program and is the leading authority on the use of down hole oil water separators. And then there's several more sentences here, but I need to get to the meat of it, if you don't mind, Bruce.

And so at 20 minutes, I'll give you the high sign.

MR. LANGHUS: Great. Thank you, Bill. I appreciate the invitation. I also appreciate that the audience keeps getting higher and higher quality here as time goes on. We weed out the chaff.

I should make the logo a little bit bigger here. I don't think you can see it from the hallway. That's the company I work for, A-L-L. We do consulting for industry, as well as government clients such as the BLM and the Department of Energy. I'll get on with that a little bit later, but I have spent a good part of the last ten years of my professional life working on CBM issues in several areas of the country: Oklahoma and Kansas, as well as the Montana, Wyoming, Colorado, New Mexico areas.

Here are the panel questions that I'll try to address in order. For the first question here: What are the effects of CBM production? Just to orient you a little bit here, there are, of course, all of these basins, some of which have CBM production currently. Some of them are sort of prospective for CBM production. Some of the interesting things there, like the Appalachian Basin currently has a fair amount of CBM production with some awfully low quality water and hardly any water, so it's not really an issue.

Some of the other areas like the Arkoma, Cherokee, Forest City Basin in eastern Oklahoma and eastern Kansas, some of this water is kind of medium quality, but there's hardly any to speak of, so it's -- this isn't an issue.

Go over to the San Juan Basin, the water is really pretty crappy and so it's disposed of in deep wells -- not an issue.

It's not will we get to the Powder River Basin really that has a lot of production and it has --

it's kind of the perfect storm of the CBM business, where you have a lot of water. It's pretty good quality. Some of it is excellent quality. The City of Gillette used to use it as drinking water back when they were -- their well fields started to give out. They used CBM water, but it was the Wyodak shallow coal water that's quite high quality.

And the Powder River Basin is kind of a strange animal in that it has had a fair amount of conventional oil and gas produced in it, but not a lot of water and so there's not a lot of formation water here. So the big fields in that basin, the operators had a hard time water flooding. So for instance, the Vail Creek Field, which is the biggest field in the basin, they had to use essentially drinking water -- quality water out of the Madison Formation in order to get makeup water to makeup the water flood work. And there are a lot of those kinds of fields within the basin.

Some of the fields -- some of the oil fields are currently using CBM water to water flood, but the compatibility is not good. Most of the CBM water is too fresh and so, like you've heard the soil people talk about, the waters will make the smectite, the swelling clays, swell. And so the operator if he wants to use this high quality water, has to add chemicals to it, which of course just raises the cost.

So the Powder River Basin here is really what we're talking about here in terms of the problems with produced water. And this slide kind of illustrates the real problem here. This is from the Tongue River and that's -- behind the graph is a photograph of the Tongue River that I took one winter when I was walking down the river with a landowner, who was complaining about the fact that he could hear these small field compressors all over his farm and so he wanted that thing gone, out.

And so I was employed by one of the operators and so I walked out with him one day and just to see how loud that thing was. And so we started at the compressor and yeah, it's fairly loud. We got out about a quarter of a mile, and yeah, I could still hear it. We got a half a mile and seemed like I could still hear that damn compressor and we went out another mile, I thought do I hear that compressor a mile away?

So I stood there and stood there and finally realized I was hearing the snow fall. It was so quiet because he was so far away from the highways there that you know, you could hear the snow fall and you could hear the sleeping porcupines snoring. It's a beautiful area. We saw lots of Bald Eagles nesting in the winter there, but it has it's own problems.

And this is one of them right here. This is a hydrograph of the Tongue River, which is a perennial stream filled with extremely high quality water that runs kind of through the middle of the western half of the basin. And so it shows in this case the -- just the flow within the stream, averaged over about 40 years of monitoring history. The USGS has a monitoring site. This is the state line station, which is just barely in Montana. And so it shows the nature of the water within the Tongue River and you can see that almost all the water here is coming from snow melt in the Wind River Mountains.

And so here at state line, I don't know. You must be 40 miles away, I guess, from the mountains and you've got this big spike in the summer when all the runoff hits and other than that, you've got this base flow that's made up of runoff, just kind of miscellaneous runoff and also ground water inflow into the river.

And so one of the things and somebody -- we've talked about a little bit this morning is what is the effect of the CBM production? And there's several thousand wells that are around the Tongue River. Most of them are in Wyoming, but some of them are in Montana, also. And they're contributing something to the river. And so here we have on this one plot a fairly simple kind of a demonstration. The pre-CBM flow, that is, the flow in the stream prior to about 1998, when before that there was no CBM production. And so you see the plot there.

And then the averaged flow in the river after the onset of CBM and you can see that the flow is less. So obviously the CBM water is causing the drought. Well, that's probably not the case. That's -- we're looking at something else and probably that's not a drought either. It's been going on for too many years. We're looking at climate change of some sort here.

The other thing is the ambiguous data, and I'll be talking about that more and more as we get into it, but that's what we're looking at here is how do you tell if the CBM discharge or CBM impoundments near the river, are they having an effect? What the hell is the natural flow of that river? If we go a little bit farther east, this now is the Powder River, which everybody says it the last of the prairie rivers that haven't been impounded. I don't know if that's important or something, but it's worth talking about, I guess. The Powder River has not been impounded.

That's certainly true.

But it's called the Powder River for a reason. In the summer it gets really low, and what we've got here, there's a plot by the EPA looking at the history of the monitoring since 1965 and just what kind of -- in this case we're looking at specific conductance. Essentially it's a surrogate for PDS. And so we're looking at -- and some historical points here. The big purple -- the big vertical purple line here is the end of discharge into the river at Salt Creek, which is the Teapot Field and they were original operator -- I don't know who it was. It wasn't Anadarko, but it was somebody else and I don't recall. But they were discharging pretty high chloride water directly into the Salt Creek. I mean, "Salt Creek." I guess they thought that was a good deal.

And that stopped in 1980. From 1990 to 2000, roughly, that's labeled "wet." And so these are conditions within the Tongue River where there's no salt water being -- I'm sorry, the Powder River, where there's no salt water being put in the head waters and yet you had pre-drought conditions and then again, the CBM is in green there from about 2000 onwards and that corresponds to the drought, or whatever it is. And so you see that there's -- you know, once the -- what's the -- what are the natural conditions here in the Powder River? That's yet to be determined, I think.

So which data are available? I'll talk about some of the research projects that are ongoing that have been done. Several of them have been funded by the DOE, and a lot of them were under the tutelage of Bill Hochheiser, who spoke just before me. And of course, modesty prevents me from saying how much A-L-L had to do with these things, but they had a fair amount.

So we've got a handbook on uses -- beneficial uses and best management practices for using Coalbed Methane water, not just in the Powder River, but all through the aired west. There's a methane primer about how a collection of best management practices to use throughout the aired west.

Another thing on a handbook for Coalbed Methane, that's primarily a regulatory handbook. And then the latest one, "Sighting Design and Construction of CBM Impoundments." And this is looking at the -- among other things, the fate and transport of infiltrate under these CBM impoundments and it's got some really interesting data. Of course, there's a world of research that can be done with these things, but this is a start and it's got some good data about how, depending upon what kind of impoundment you've got, whether it's an in-channel impoundment built on alluvium, or whether it's built on bedrock.

And what kind of infiltration you've got, how the water changes with infiltration. And how it reacts historically and it looks like some of these impoundments, as the water infiltrates through it, it starts picking up salts from the soil -- subsoil and bedrock and it's TDS builds. But then as the infiltration continues, the TDS drops off like there's a cleaning up of the infiltration pathway, perhaps something like that.

One of the things -- a couple of the things that I didn't mention here, don't have pictures of, but a couple of projects that we've done: One for the Wyoming Governor looking at large scale, that is, you might even say, utility scale management of produced water and one of the projects that turned out to have a lot of promise was taking the Big George water that was talked about before here, which is not only good water, but it's extremely high in volume. There's something like a half million barrels a day of Big George water coming to the surface.

And one of the ways of handling that water would be to pipeline it down to the North Platt River in kind of south, southern part of Wyoming, which is a large river that the State of Wyoming has over-allocated to both the coal fire power plants and irrigators. So the State of Nebraska is annoyed that they're not getting about 100,000 barrels a day of water coming out of this feature and one way of correcting that, I think, would have been to put partially treated CBM water into the river. That would have also allowed some of the power plants there, like there's a huge power plant at Laramie Station, just right outside of Wheatland, and it's about a gigawatt-and-a-half-sized coal fire power plant that's running out of water because of climate change, because of drop off in shallow local reservoir -- or aquifers, all kinds of things. So this would have taken some of the heat, so to speak, off that power plant to use that for cooling power water.

However, that's not been built yet and it's really doesn't seem like it's -- the people are serious about doing that, but it's certainly a kind of a project. And another thing that we did for the Montana DEQ was looking at the possible truck traffic in the Montana portion of the Powder River Basin from all of these water treatment plants. If you suddenly had to treat all the water that you produced with CBM, how many trucks would be running around that county that maybe has 20,000 people living in it? And it would be something approaching 1,000 truck trips a day running around there, which would be a non-trivial impact on the local environment.

USGS is doing a lot of research here using their own data, their own monitoring data on the streams. The yellow one is the Tongue River. Then you've got the Powder River over there.

It was mentioned before that the operators are required to do some monitoring and reporting. This is a report -- an annual report from a consortium of operators.

This is a report done by the Mile City Office of the BLM, the good Andy Volks does this every year and it's looking at the quality of water within -- he does one on each of the three major rivers, the Tongue, the Powder and the Little Powder.

And a current piece of major research done by a number of academics here, looking at some of the detail statistics of the water quality changes that might be due to CBM water within the Powder and Little Powder watersheds. And so they've come out with a number of findings. These are, of course, preliminary. They say that CBM development has adversely affected water quality in the Powder River and it has, indeed, left elevated stream sodicity, as indicated by a statistically significant increase in the trend of the sodium absorption ratio and there are a number of things here. And there are a number of things there.

And so this is -- there's another group of very reputable researchers and their findings. Are they correct? I don't know. This is certainly something that needs to be looked at though and Mr. Bobes [phonetic] has pointed out in several of his reports that this is something that needs to be looked at from year to year to see what the results are, what the trends are, because these -- there is still the overwhelming footprint of the drought on these three rivers. That is the big effect. Everything else is at the present time fairly minor, but maybe in five years, those effects will be much larger.

Which production techniques? And I took this to mean, which new production techniques for CBM might minimize things? And so this is a -- I can't remember now. It was about a year and a half ago, I did a UIC, a disposal well application for an operator, Pinnacle Gas Resources, to inject water -- produce water into some dry coals. These are shallow coals that don't have any water in them and because they don't have any water in them, they don't have any methane either.

And so this is map of the area. There's a fairly major fault here and it's getting shallower to the north side up there. At the top of the map you can see some blue triangles. These are springs within the coal and the coal is the Anderson or its nickname is the Deets-1. And so it starts our fairly deep here and there's some CBM production on the south side of the fault. Then you go on the north side and it's dry. Three permitted disposal wells within it.

Here's a cross-section looking at that same thing. This is the producing side here. And you can see that this is the top of the coal and an elevation map or an elevation cross-section, the top of the coal. So it's riding somewhere around 3500 feet from being sealable. And this is the elevation of the ground in red.

So here at the southside of the cross-section, the coal is 150 feet deep. There in the middle it's something like 400 feet deep and then over there in the extreme right-hand side, the coal outcrops because there's a stream cut there that cuts down to the coal and that's what makes the springs. And so where they're wanting to inject is on the uphill side of the fault, a couple of wells in there that are injecting into the coal with the idea that you can see the miles across the bottom. We've got a big area here. The coal is 20-feet thick. It's got a fair amount of porosity, two, three percent, something like that, maybe more. So it will hold an awful lot of liquid -- a lot of water and the water that's going in there is pretty much the same sort of water that was in there originally before it leaked out, probably leaking out at the outcrop at the spring.

And so they've been charged with the Montana Board of Oil and Gas to monitor those springs to make sure that they're not gushing huge quantities of water. So that's what they're doing. It seemed like a good idea and the initial tests showed lots of water being able to inject, but I think that's cooling down now and they've been operating the wells for -- or the initial well for several months and it's not taking very much water, meaning that there's just not a lot of permeability in a regional sense, but there's permeability right around the well. But once that fills up, they're having a hard time getting that water to move. But it's a good idea. There are a lot of smart coals that are dry and I think it's something worth trying.

Some of the new drilling techniques, I'm not going to talk about casing drilling, but this is just something that's being tried in San Juan Basin, could be tried in other basins. This is where they turn the casing, rather than a drill strain. The whole idea of drilling lateral wells in coal seams, they do it now again in the San Juan Basin. It should be tried in other basins. There's the science of drilling muds moves ahead every single day. There are muds that they talk about as mud casing, could be used with horizontal drilling, where the mud actually forms a structure, a polymeric structure around the bore hole to protect it from filling in, from falling in.

Smart wells haven't been tried on CBM producing wells, but they certainly could be, depending upon the economics where you have -- here's a typical well that's both an injector or a disposing well and injection well, as well as a producing well. It's producing from these two coals and it's injecting water into another formation. And you could certainly have some dedicated seismic, tomographic bore holes around your projects to look at, just bare the fluids are moving within that project, but you know, they cost money.

Enhanced CBM development: Some places in the world are indeed injection CO2 to enhance or to flush the methane out of the coals.

Federal and state regulations: This is one important piece of legislation regulation. This is the Montana Court Order 99-99 and this is the piece of regulation that demands water well and spring protection for landowners, as well as ground water monitoring reports on an annual basis.

Here's another one. This is the Clean Water Act and the 303(d) list. We just finished up part of the resource management plan for the Mile City Office and one of the things there was to put together a list of all the impaired water bodies and it was about 25 pages long. And by far, most of the impairment was due to agriculture, mostly cows walking on the sides of streams, not only walking, but doing their -- whatever cows do.

And it seems like there's not only the management of produced water here, but this has to be part of a rational way of looking at Riparian environment, as well as the environment of the whole Powder River Basin.

Thank you.

MR. CONDIT: Thank you. We'll take a minute here. Any questions for Bruce at this point?

MR. SPEAKER: I just wanted to ask you a

quick one. Early on you said that the monitoring station on the state line for the Tongue was getting snow melts in the Wind Rivers, but I think you mean the Bighorns.

MR. LANGHUS: The Bighorns, yes.

MR. SPEAKER: Because otherwise, it would be a neat trick.

MR. LANGHUS: That would be a hell of a lot of melt, yeah.

MR. SPEAKER: And you also mentioned that CO2 injection is being done elsewhere in the world.

MR. LANGHUS: Yes.

MR. SPEAKER: Are they putting stainless steel down the hole?

MR. LANGHUS: It has to be some kind of a -- something that's resistant to the corrosion, but there are chemicals that you can put in that protect the pipe for a certain amount of time and then they redo that.

MR. SPEAKER: Do you know off the top of your head where that is?

MR. LANGHUS: It's in Europe. There have been some trials in the United States also, but not -- I think Romania has been doing it.

MR. SPEAKER: I think Big Pete was looking at trying it.

MR. LANGHUS: They tried it briefly in the San Juan, yeah.

MR. SPEAKER: Then dropped it?

MR. LANGHUS: Right, right.

MR. CONDIT: All right. Thank you, Bruce.

Our next speaker continues in line of iconoclastic speakers for the afternoon session. It's Geoffrey -- is it Tyne or Thyne?

MR. THYNE: Thyne.

MR. CONDIT: Geoffrey Thyne. He's a registered professional geologist and senior research scientist at the Enhanced Oil Recovery Institute at the University of Wyoming. He's worked as a research scientist for ARCO Oil and Gas and taught at Cal-State Bakersfield. They must have a petroleum engineer program there, huh?

MR. THYNE: No.

MR. CONDIT: No? Okay.

MR. THYNE: Do I need this? Okay. Hopefully everybody can hear me. Thank you for coming this afternoon and staying so late. I'll try and be fairly brief. Fortunately Elizabeth told me I could talk about anything I wanted and so I didn't consult with any of the other people; however, it's been interesting to me how much overlap there is in our information and our basic set of knowledge that we have and so I think that's one thing that the council can take away -- the committee.

And I do want to agree that there is a lot of data out there, but what there isn't is a lot of knowledge. And so I think there is room to have a lot of things done.

I'll see this works. Okay. Powder River Basin, we all know where it is. I'm going to strictly talk about the Powder River Basin today. It's something I've worked on the last three or four years, so I wanted to stick to that.

Interesting, there are about 2300 wells at present so we heard today. I think there were about 170 monitoring wells and 2300 production wells. So you tell me how good a job we're doing monitoring the production.

There are probably going to be 60 to 75,000 wells that build out in this basin. That's what's project in the latest report by the State Geologic Survey, based on permits that are already applied for or planned developments that have been documented.

Cumulative production at this point is about 2.3 trillion cubic feet of potential resources estimated by the USGS, someplace between 10 and 15 trillion cubic feet. So you could look at this as how far are we along the path? We're someplace around 20 percent of the way through the path for development of the entire basin. And this assumes that Montana will be developed as extensively as Wyoming and as we've heard, that may or may not be the case.

We have produced 4.2 billion barrels of water to this point and so I put a lot of these barrels in -- a lot of the water in barrels because the oil industry works in barrels. But you'll see later that can also be converted to acre feet. And Montana has had very limited development. They have a very different perspective than Wyoming, as you have heard.

It looks like this or this out there. Wyoming permits any surface disposal as beneficial use. That was the original reading, as I understand the legislation and that has lead to problems. So now there's a much more conscious effort to define beneficial use more carefully and not simply permit any surface discharge.

We have mostly ranching and farming. And as people have noted, we both an aired and extreme climate and this is having a pretty significant effect, when you start putting this much water on the ground in a place that isn't used to having a lot of water.

The typical Coalbed Methane development, water you pump for a year or two. Most of the water production falls off and you get a lot of gas, all right? And now this is a traditional, typical well. There are lots of wells that produce gas faster. There are some wells that produce just gas almost right from the get-go and there are some wells that have been pumped for years and don't produce any gas and that could be one way to look at, and I'll talk about that later, managing production.

Normally about 400 barrels of water gets you 100 Mcf of gas, all right? And if you put a price on water, and we do not have a price for water in this country, but if you put a price on this water, there might be a totally different picture looking at development. That's neither here, nor there, I guess.

And the production of water in general is 10 to 100 times higher than traditional wells. So what we have is an industry that's come in, started to develop a resource in a traditional manner and is hit with a problem, which is: We've got all this extra water. What the heck do we do with it? Normally we reinject the water, but in this particular case, you can reinject back into the formation that is a coal bed because that will kill your production off and that's what industry normally does, reinjects their water back into the reservoir. It's called a water flood. Nor do we have adjacent sandstones that are sufficiently large to reinject the water into them. That's why surface water disposal becomes such a methodology at this point.

So how do you dispose of the water? Surface discharge, infiltration, agricultural application or reinjection. So I was going to talk a little bit about each one and what we've seen and the project that Bill talked about this morning? I used to work at the Colorado Energy Institute, the Colorado School of Mines, and so I was involved in that project for a while. So I'll try to fill in just a few of the facts that he didn't have a chance to get to.

So cumulative production, we've talked about that before. This is from the Wyoming Oil and Gas Conservation Commission website. So if you are interested in data on oil and gas production in Wyoming, the state website is a very, very good resource. You can get a tremendous amount of information out of this and it's kept pretty much up-to-date like the Colorado one.

1.25 million acre feet, that's how much water that billions of barrels comes out to be. That's a lot of water, no matter how you look at it. It's much more variable with volume, that is the production of water over time. It starts out high, goes down low. What we're used to in the petroleum industry is a fairly constant production; that is, the water cut goes up through time, but the volume of fluid removing stays the same. In this case it's very different. So that's a big problem in managing this.

And when I heard somebody talk about sequential or sequence development, that's a very attractive option in my mind, to deal with some of this problem.

The TDS of the water is low. I put 1200 to 2500. It is, in fact, the case that there have been some water produced that is low as 400, even drinking water quality. That's less the case nowadays than it used to be. At that time it was easy to get rid of because it was drinking water; however, there are issues with using drinking water and permitting it so that as -- CBM water as drinking water. So people have moved away from that.

And this is a big point I would give to the committee to look at and I echo this fact that Kathy made: Western U.S. soils contain a lot of near surface salts. This is a result of the fact that most of the rain that falls does not get you down to the ground water. In fact, it evaporates away. So the solutes that come in with the rain water are left in the soil.

There's been some recent work in the last four or five years about USGS which has demonstrated that if you go down 10 to 30 meters, you find a layer of salt, nitrates and chlorides, that may have been in place for eight to 10,000 years and only during the pluvial events that we see seasonally in climate -- not seasonally, but long-term climate, are these salts mobilized and washed away.

And so what we're doing now with impoundment ponds, for instance, is we are liberating that salt and moving it out of the way and in fact, you do see exactly that. You see the salinity that's infiltrating go up and then as those salts are dissolved away, go down through time. However, where is all that salt go? How mobile will it be and are we going to eventually add to the salt load of our rivers is a really fascinating research question.

This is one of these discharge ponds. This what it looks like in July, remind ourselves this is what it looks like in December. One problem is surface discharge doesn't work in the winter in Wyoming, okay? Everything gets frozen. This particular ponds are being monitored. This is part of that DOE project and the main problem they've seen besides that initial flush of salts is there is, in fact, a hydraulic connection between the surface water and the ground water in spite of the fact that ponds are lined are not, they all leak, is that you may mound up on a less permeable layer here and then get discharge seepage and seepage may develop laterally away from these ponds and suddenly you have a problem, particularly on soils and vegetation and topography that was never designed or never had that seep there previously.

So sighting these ponds is important and where the water goes is very important. And don't forget during this time of year, there's a lot of evaporation. So salinity is going up, and as Kathy noted, birds look at this and they go, "Oh, yeah." Wildlife looks at this. Everybody comes and look at this. People go out in their little rubber rafts on this stuff, okay? So we do have an evolving situation here.

Surface discharge down ephemeral drainages. Again, in the winter it doesn't work too well, freezes right up.

This is a typical type of CBM discharge. You see in the background a pond and you'll note there's kind of a reddish coating here on this gravel. That's the iron. So the water comes up to the surface, is oxidized, iron precipitates out. So iron that you heard is one of the issues.

So we have surface erosion features. Seasonality is not maintained. We're not getting that normal just big peak seasonal runoff. We're starting see longer term runoff through the year.

Increased salt loading in the river: As you put the water coming down the stream, part of the water evaporates away increasing the salinity. Some of these salts are picked up out of the soil, so if you do get to the river, you may increase the salt loading in the river. Thus far, the data is a little spotty to absolutely demonstrate that.

You do absolutely disturb the natural system. You start to have different flora and fauna injected into this system or that migrate in and colonize this resource that they see, which is a wetter, longer term flow. And you do get soil damage.

This is some from the Beaver Creek study. This is the DOE sponsored study that Bill was talking about, managed by Colorado School of Mines. You could see the change in evaporation versus infiltration runoff through the three critical months, July, August and September in Lake Wyoming. And in fact, runoff decreases, infiltration slightly increases and evaporation decreases through this time. So we have a mix of processes going on there that are changing water quality and remember, the infiltration is all going back into the ground water system. The runoff is going out to the surface water system and the evaporation is just simply adding salt load, if you want to look at it that way, by removing water and leaving the solutes behind in the main water.

And this data is now, I believe, published by Danny and Safer [phonetic] at Penn State and I believe DOE also has a report that will come out pretty soon on the conclusion of all this three years of study.

This is also very important. The soil type that you run over. Different soils and there are up to 60 soils in the Powder River Basin will allow water to be infiltrate very quickly or keep that water in the stream and conduct it down river. So sighting your discharge location and understanding what soil types are going to be encountered along that surface water discharge path, has a great deal to do with how much infiltration versus water delivered to the stream and so this type of data may be very useful to design expert systems or help sight things in a more sustainable fashion.

Now, surface disposal increases surface water flow. We just saw a graph that said just the opposite, that CBM is causing the drought. And in fact, we know that's not true. But what's important to realize is, look at some of these numbers. These are wet years and of course, somehow or another compacts, which apportion water are always made during wet years. That's where they get the numbers, knowing when we get dry years, we've got a lot of trouble.

So here's some wet years figures for the Tongue, the Powder, the Little Powder, total here, and this is the same number of barrels. And so when you starting, gee, eight billion barrels, then oil companies get really excited. It's not oil, though. It's water. In normal years, we're down considerably and then in dry years, you can see the enormous difference in discharge between these dry years and the Yellowstone River compact of 1950, of course, was probably based on these kinds of years, which makes a lot of trouble.

Now what does this really mean for us? Here's the total discharge. This is from the Wyoming Oil and Gas Conservation Commission website. This is total amount of water that CBM is pumping out down here. And you can see it took off, of course, you know, around 1998. There it goes. And this is the discharge on the Powder River. This is the dry year. This is a normal year. And you can see just normally, we have a great deal of variability. But the real problem is, is we start to get into dry years. There's the Powder River and here's out total discharge from CBM. We start to get to a condition and here's the CBM discharge and here's the discharge percent of total. We start to see that the amount of Coalbed Methane water being produced is starting to be a significant fraction of normal background flow. And that's where the worry comes in because the water quality of that CBM water starts off as primarily a sodium bicarbonate water, which is a little unusual and then that salinity may be raised as it picks up salts during discharge and evaporation and now we start to have significant potential for salt loading because of the volumes. We're making 20 or 30 percent of the potential volume up. I will note that this volume is total water discharge. Part of that is evaporated. Part of it is held in ponds. Part of it goes in surface releases, and a very small part is reinjected at present.

In terms of reinjection, however, this is a map of sands that would be suitable for reinjection.

Because of the quality of the water, you cannot reinject it into some place you can't get back out in the future, all right? This is an EPA guideline. We could make this water into drinking water with treatment; therefore, you can't inject it 20,000 feet down and forget about it. It has to be injected shallow enough that you could retrieve it some day in the future.

And these sand bodies that are, say, very close stratigraphically to the coals, tend to be very narrow and discontinuous. So we just simply don't have the volume of sand to stick that water back into that we would, say, in a normal oilfield situation.

Application in agriculture: Here's year one. Before this particular farmer realized his soils were not going to react well to the sodium load. Here's year three. Whoops, sorry. Here's year three out here. This has been the story in some cases. Other parts of the basin have salt tolerant soils; that is, soils that naturally don't have much swelling clay, so they're not a problem. But when you get into a case like this. This guy wanted all the water he could get. A couple of years later he wants to sue the company that they messed up all his fields. So this could be a real problem going forward if we wanted to just use it for Ag.

So again, there's limited availability to dispose of this water in agriculture senses. Soil amendments do help this. That study the DOE is doing, is showing some promise in some soils, but agriculture amendments cost money, cut into your profit.

So what do you do? Water treatment or volume minimization? Water treatment, lots of different ways have been tried. The zeolite towers and we heard from Anadarko today. Zeolites didn't work out.

Example of iron removal by simple aeration. That's useful, but that only takes care of the iron. That's not another type of water treatment. Probably the best one the EPA study found so far is referred to was Argon National Labs electrodialysis. Electrodialysis seems to have a lot of positives and not many negatives, even compared to reverse osmosis. Unfortunately this is not at a commercial scale yet. This is only at a test bed scale and I think DOE is trying to find the money to go out and put a field study out there to show what this stuff can really do. This would be nice.

Fractured mineralization: This is the Stanford study that was referred to. The fact that how do you complete the well if you fracture or stimulate the permeability too much, you may reach out into the adjacent sandstones and now what you're doing is pumping out aquifer water and it takes much, much longer to produce this.

Now I'd like to get to the thing that was mentioned, which was the State Geologist's recent study. As far as I know this is not available on the web yet, but there is a paper copies. So everybody call the State Geologist and tell them to put it on the web.

What they basically did was take the public domain data and do a simple straightforward analysis of it and they found some really interesting things. Not all producers on CBM wells out of the 22,000 wells are, in fact, effective producers. The average well makes about 1.8 barrels of water per Mcf of gas, okay? 68 percent of the gas for the Powder River is produced with wells with a water-to-gas ratio of less than five. And so that's a good thing. You get lots of gas, not much water.

Some wells over two years old are still only producing water. Those would not be, I think, profitable wells; however, they're still producing water. Many of them shown here in white, and what you can't see very well are the gray lineament tend to lie along the junctions of fractured lineaments. So there seems to be a structural control on poor quality producing wells. So if you were the Oil and Gas Conservation Commission you might not want to permit wells in those areas, knowing that the history has been they're not going to produce much gas. They're going to make lots of water. That adds to the problem.

And these wells are located primarily so far, they map along the northwest/southeast and northeast/southwest lineaments. So there's one thing we could do right away to manage water: minimalization strategies.

The report also recommends these two drainages here, the Crazy Woman and Clear Creek, and these little numbers here, and I'm sorry it's a little out of focus, are the projected wells over these three periods of time, 2007 to 10, 11 to 15, and 16 to 20. These are projected wells based on permits already applied for and what's interesting is the Crazy Woman drainage is expected to have 4300 wells; Clear Creek, 6300 wells by 2020. These drainages based on present production will produce only .15 percent of the total gas, okay, 9 Bcf, which sounds like a lot of gas if you're in the oil business, and a total of 20 percent of the water, all right? So hello?

So the State Engineer has received a recommendation from the State Geologist that wells of this type not be permitted and that didn't go over well, so you asked when he had a political appointment, he does. So that was modified to say, "After two years, those wells would become water wells." And the State Engineer would regulate them as water wells, which allows him to say, "Hey, you're not meeting the standards for water wells. Shut them down," which is a politically doweled compromise in my mind and I'm probably going to be in trouble for that.

MR. SPEAKER: Did the court reporter get that?

MR. THYNE: Wells -- this always happens to me. Wells greater than two years old with greater than two barrels per Mcf produced 4.6 percent of the gas and 38 percent of the water.

So clearly we have two classes of wells: Wells that are very productive of gas and don't produce much water, and wells that produce a lot of water and not much gas. And it appears that both the structural control, these east/west lineaments is a detail and these two basins which happen to lie up here in the far northwest corner, are going to be places where we're going to have these wells that produce very little gas and lots of water.

Finally, this is also a map of the water quality and you'll note the water quality declines and SAR goes up as you move into these areas that are identified by the State Geologist as a potential problem regions of the Powder River Basin.

I don't know what this says about Montana, which would be up here, okay, but probably not good. Also, the coal is getting deeper as you go this way, so your production costs are going up, the exploration costs are going up. You have higher SAR water to dispose of. It gets more saline, so bottom line is, the survey has recommended the State Engineer reclassify all wells older then two years with barrels to Mcf greater than three, to be regulated as water wells. And that would allow the State Engineer to take those wells out of service at CBM and then the question would be: What would you do with all that water? Well, you wouldn't pump it to the surface because you have no place to dispose of it, nor you have no customers for it.

So conclusion: My conclusion is there's no single answer. Continued gas production will require water production. Some of this water can definitely have a beneficial use and it should be used in a beneficial fashion. Overall water quality though has to be maintained. That's the bottom line that you can look at. If you can do that, and I believe that should be the test, that should be applied to any development, if you can do that, then you are producing a benefit for the country in terms of natural gas and you are not harming the region's sustainable -- sustainability, I should say, sustainability.

So thank you, and I'll take any question at that time.

MR. CONDIT: Thank you, Geoff.

MS. BALDWIN: Debbie Baldwin with the Oil and Gas Conservation Commission here in Colorado. I may not have been paying close enough attention. So the Crazy Woman Canyon wells are the wells that it would have a high water to --

MR. THYNE: Crazy Woman and Clear Creek.

MS. BALDWIN: Right. Okay, but the salinity is increasing in that direction. The salinity of that water is kind of opposite of what we've seen in Colorado where the really high water producing wells tend to be, you know, also producing fresher water. So I'm just curious. Do you have any reason? An explanation?

MR. THYNE: That's a regional trend. That salinity trend is regional. So I think it's just fortuitous that you know, we get into the higher salinity areas at the same time as we're getting into the wells that are going to produce less gas and more water.

MS. BALDWIN: Yeah.

MR. THYNE: And this gas/water ratio is strictly just a production thing, as far as I can tell --

MS. BALDWIN: Yeah.

MR. THYNE: -- rather than any specific -- the implication to me is, the question I have as a scientist is, is there less methane in that coal, that deeper coal? Is there something controlling that?

And the one thing I didn't mention about the Powder River Basin that no one has mentioned yet that's unique, compared to the San Juan and the Colorado experience is the Powder River Basin all the gas is biogenic. All right? Now the other, as far as I'm aware, other Coalbed Methane basins, the gas is not biogenic. It's thermogenic. It's entrapped there by the function of the coal absorbing it.

In Powder River it is biogenic, meaning it is created by microbial action. And so one question that popped up on the DOE radar when I said that the first time is: Do you mean it's a renewable resource?

And I don't have an answer to that. I know that companies, however, are working -- private companies are working to answer that question and try to isolate the microbial community that seems to be responsible.

The other thing in the Powder River Basin you see is you see hot spots in terms of high gas production and low gas production area and that may have something to do with the answer to your question, Debbie, in the sense of maybe that's too deep for the microbial communities to be happy, you know, up there, or salinity. Microbes can be pretty finicky about what they want.

MS. GIONOICKUS: You have a flank of a huge mountain range right there. You have it.

MR. THYNE: Right.

MS. GIONOICKUS: I mean, it's that edge right there is right at the basin.

MR. THYNE: And that's all of the recharge zone there, too.

MS. GIONOICKUS: Yeah.

MR. THYNE: Forcing everything down deep, so it may be a geologic or micro -- Murray would like that -- "microgeobiologic" sort of thing.

MR. CONDIT: I'd just like to ask you, Geoff, do you know where there are any of these other basins like Raton or the San Juan, people have looked at these structural lineaments idea to see if there could be an analyst shutting down some wells, or not committing, that is, wells that's unique to the Powder River Basin?

MR. THYNE: That's a great question, Bill. Debbie may know the answer to that.

MS. BALDWIN: You know, in one particular area, some of the reservoir modeling and ground water modeling that we've done, it does appear that in some cases there is communication between in the San Juan Basin, the picture close, which is the sandstone that sits below the group formation, communication between the sandstone and the coals -- basin coal in the Fruitland Formation that maybe some of the really high water production is actually not -- you know, there's too much water produced to only be attributable to water coming out of the coal and that either, you know, there may be natural fracture communication between or it's a leaky system and therefore, you're getting water coming out.

There were some studies done where a couple of the really high water producing wells in a particular area of the San Juan Basin were shut in and what ultimately happened was water production increased in some of the adjacent wells. So the system definitely was in communication with each other.

Maybe -- and then up in the Huerfano County in the Raton Basin, water -- a tremendous amount of water was pumped there before they ever were able to desorb, get the pressure in the coals to be low enough to desorb the coal and probably 20/20 hindsight what we were seeing is maybe, you know, a system that was being recharged rather rapidly.

MR. CONDIT: Coming from Mr. Goodwin's well, I believe.

MR. SPILLER: Bill, I just think that Debbie has just answered for us and you just answered for us another way of hydrogeological being able to connect an shallow water well to a Coalbed Methane. There's another very good way of doing it. You know, just even though we've got impermeable -- 1,000 feet of impermeable shale above and below it, if we're seeing selenium in it at the surface and it's straight, it means it's vertical and if we're seeing it at the surface, it mean it extends through sandstones and through gravels, so there's another way of physically doing that so we don't have to go through lots of geological conniptions to lower the pressure in those wells.

MR. HITZMAN: I'll give you another one, Geoff, if I could? Obviously one of the reasons we produce CBM is because it's relatively shallow and relatively inexpensive and what that means is we don't shoot 3-D or 4-D seismic in these fields, right? We just drill them.

In your example from Wyoming, which I haven't seen, how many wells does it take before they actually can start seeing that geologic picture? It obviously was many, many wells. How do you think we get there? How could you characterize something like that more cheaply than drilling 1,000 wells? Any ideas?

MR. THYNE: You know, the question this morning about the pressure mass? I think the answer is no, yet. That that data isn't gathered regularly to create those --

MS. SPEAKER: Well, I thought that they told us that they were. The geometric maps have existed for tens of --

MR. THYNE: Right. And it's not very continuous, so it's very hard to draw conclusions. The State Geologist report tried to do that, tried to look at that sort of thing. I think the way to gather this information, and I'll go back to characterize before, and not after development, is to look because we're looking in coal measures, which are often aquifers, look at the water wells, all right? And the State Engineer generally is in most states controls the water well information. It is not as complete and detailed as we might wish, but it is certainly the first place we can look for this kind of information pre-development, and then guide the placement of monitoring wells to answer these exact questions, predevelopment and that way I would argue if I was on one side, the environmental side, if there's a side, and I had a resource company come in and say, "This expense is unacceptable." I'd say, "No, you're going to save money by doing this because every well we site for you with this information is going to maximize gas production and minimize water production and that makes you money."

So in that overall sense of things, you're going to save a lot of money by taking this time ahead of time and I'd also say to you, you think the price of gas is going down? All right?

DR. MAEST: Ann Maest from the Committee, just a quick question? Geoff, you mentioned something about reinjection that you had to be able to retrieve it and this was something EPA was requiring. I hadn't heard about that. Could you elaborate on that?

MR. THYNE: Yeah. I understood from the people working on the DOE project, and I wasn't aware of this before, and in particular, these are the people at MSU. They said because the water quality meets safe water drinking, which is less than 10,000 parts per million, if that is the case, you are not allowed to dispose of the water in a means that renders it unable to ever be retrieved and that meant no deep injection. So they had to look for these shallower sands, but I'm not familiar enough with the regulations and I'm sorry somebody's not here from EPA that could speak to that.

MR. SPEAKER: There is somebody.

MS. GIONOICKUS: The difference between the Class 2 and the Class 5 injection.

MR. THYNE: There you go.

MS. GIONOICKUS: There's five classes of injection wells based on potential future beneficial use and it's industrial source. That's probably mainly the difference there.

MR. THYNE: Okay. So it's class of well injection.

MS. SPEAKER: So it's UIC?

MS. GIONOICKUS: Yeah.

MR. THYNE: Right.

MR. OSWALD: Carl Oswald, BLM Wyoming. The point about looking at predevelopment versus development is going to be very hard in a place like the Powder River Basin because over the past some 110 years, just about every section -- every square mile has had a well drilled through it. Also on top of that, there are thousands and thousands of uranium and coal core holes that have been drilled and many of these were done long before we had any kind of regulations and oversight over them. So those shallow aquifers and even deeper aquifers have been disturbed to some degree and it's going to be very hard to back out that signal.

MR. THYNE: No, Carl, I completely agree, and I think one of the questions before the Committee was: Are regulations adequate? And I'm kind of in the middle on this. If we enforced all the regulations, they might be adequate, but enforcement as you noted has been "lagging behind," I would put it. You know, the requirement is there to get the data in often and -- but keeping up with all that data having the staff to catalog and analyze that information, it just hasn't happened in the state agencies, Wyoming, Colorado. You know, you could double the stats and they'd still have a backlog and so you're right. Predevelopment is going to be hard to ever get, but does that mean we shouldn't start now? And you know, I would argue, "Yeah." I would argue that the Governor of every state should just start funding the state agencies that are in charge of doing this at a level that would enable them to try and do it. And if you guys on a national level can prod that, then good. It's all to the benefit because the questions are only going to get more complicated, not less.

MR. CONDIT: Frank, did you have a question?

MR. BURKE: Yeah, it was just kind of a minor point. Your example of where you're talking about one area where the two creeks were?

MR. THYNE: Uh huh [affirmative].

MR. BURKE: You're talking about 9 Bcf of gas?

MR. THYNE: Yeah.

MR. BURKE: Was that annual production or?

MR. THYNE: No, that's total production.

MR. BURKE: You had 10,000 wells.

MR. THYNE: Approximately.

MR. BURKE: So that ballpark, that would only work out to be 900 Mcf per well. There must be something wrong with one or the other numbers there.

MR. THYNE: It could be. I yanked them out of the report, so I didn't QC the report.

MR. BURKE: You might check that.

MR. THYNE: Yeah.

MR. BURKE: That doesn't make sense.

MR. THYNE: But I mean in the sense of you know, my first shot at that was, well, it's 10 trillion cubic feet total production out of the basin. 9 Bcf is a pretty small part of that.

MR. BURKE: I think that 9 Bcf number may be wrong.

MR. THYNE: Low?

MR. SPEAKER: Yeah, low. 9 Bcf is very, very low.

MR. THYNE: Yeah, I know. Well, they said .15 percent.

MR. SPILLER: Again, these don't produce a lot of gas.

MS. SPEAKER: A lot of water.

MR. THYNE: A lot of water, yeah.

MS. SPEAKER: Yeah, but they're not producing gas.

MR. THYNE: Correct. Some of them have water-to-gas ratios in excess of 50 to 100.

MR. CONDIT: You've got a few more. I guess we're going to continue on with this. We've got a comment, if Jim can hold on -- our last speaker, to let Geoff.

MR. OTTON: Whatever you need to do.

MR. CONDIT: Yeah, okay. In the back there, the gentleman with the blue shirt?

MR. VOLKS: Andy Volks with the BLM in Mile City again. I just wanted to say first of all, I think there's probably a lot of validity to the idea that there are certain wells out there with geologic controls on the water-to-gas ratio and those very well should be taken off the books; however, you have to keep in mind that it's going to be a little bit more complicated, even if you had a simple 2-D aquifer you're dealing with, you're going to have the wells on the edges are going to produce more water relative to gas than the ones in the center because they're intercepting the recharge. So anytime you have a hard-and-fast number of three-to-one or something like that, I'm not sure that's going to be a great approach because you're always going to have wells that have a higher water-to-gas ratio than others.

MR. THYNE: Yeah. I wouldn't disagree. I'm just saying the State Geologist, this is his bag. So we'll let Ron sort of defend himself, if he needs to with the Governor. And I think he -- he actually told me he originally recommended two. So he's already been worked up to three.

MR. CONDIT: Anyone else?

MS. BALDWIN: Debbie Baldwin again. I just made a comment that the Oil and Gas Conservation Commission does require operators to collect pressure data before the initial shut in on-hold pressures prior to their drilling wells and then like the pressure data appearing for the well. So there are regulatory ways to gather data, asking or requiring it to be collected gives us a huge amount of data. That's why we have so much data in the San Juan Basin.

MR. DOGGETT: Just to follow up from one -- from the last question, in terms of the cutoff of whatever it is, 3-to-1, 2-to-1, do you think -- how do you think that would be impacted if this were actually high quality water, rather than low quality water? Do you think that would actually impact this? Because we've got the double whammy here, or actually you sort of suggested it was a double good thing because it sort of makes it -- puts it out of the range of even being considered, but it went back to Murray's point of being able to identify these lineaments and rule things out, is that going to be impacted on whether it's high quality water or low quality water and would that sort of rule out just using a basic sort of -- some sort of geophysical tool?

MR. THYNE: Well, the math suggests that that's a general water quality and not focused on the lineaments, per se. So I think --

MR. DOGGETT: But if you want to use it for other, as an analog?

MR. THYNE: Yeah, if you want to use it for other uses -- well, okay. If it was 200 TDS, I'd bottle it, as much as I could get and sell it as Wyoming Wild Water. Yeah, it would probably make a difference; however, at these quantities, I think the real issue that I've seen so far is the disposal of this large quantity of water in an area that is aired.

MR. DOGGETT: Even if it's high quality?

MR. THYNE: Even if it's high quality. If it was that high quality in the other hand, you might get Colorado to build a pipeline and bring it down to the front range. And you heard, A-L-L Consulting has done a study of taking some of this water down for the power plant and you know, that's obviously of beneficial use that would relieve a lot of problems. So in some ways maybe it's good. It's not good quality.

MR. CONDIT: I want to know the Governor of Wyoming's reaction to sending water to Colorado.

DR. MAEST: Just the bad water.

MR. THYNE: Yeah. I don't believe he's actually said anything about that yet.

MR. CONDIT: I didn't either.

MR. THYNE: He's sent it to Montana, though.

MR. CONDIT: Okay. We're going to have our final speaker of this panel and this -- indeed, this workshop today. That would be Jim Otton, who's been a research geologist with the U.S. Geological Survey, which is you go to their website, you will see, is the premiere Earth Sciences Agency in the entire Galaxy.

MR. OTTON: It's on the website, something like that.

MR. CONDIT: And since 1974 and this project worked from 1994 to 2006 involved studies of produced water and releases at oil and gas production sites and their effects on soil, surface water and grown water.

Okay, Jim?

MR. OTTON: Thank you, Bill. We're going to talk about some of the -- fairly narrowly focus on USGS research, which mostly takes a look at impacts and also talks about water data availability and those are the two areas where we have some expertise. I'm not going to discuss at all regulation implications, the effects on wildlife, and those sorts of things. While some of the things that I will say allude to those indirectly.

And hopefully we can figure out how this thing works.

This presentation represents the work of many other people besides myself. There's very little of my work in here, but includes the USGS researcher, Cindy Rice, Rick Healy, Bruce Smith, Tim Bartos, Bill Orem and then staff of the Wyoming Water Science Center and the Montana Water Science Center of USGS, who manage the gauging stations where a great deal of data is being gathered.

A great deal of our work is collaborative with DOE's NETL folks and we've been -- have had a fair amount of funding from those folks for some of the geophysical studies and some other things.

I'm going to talk about volumes and chemistry of produced waters, mostly talking about the Powder River Basin, but also alluding to some of the other basins where oil and gas production and Coalbed Methane production occurs. I'll talk about impacts and then talk about data. Several of my slides have already been shown by others and so we will go ahead and only speak very briefly of those.

Take a look at trying to compare water volumes. There's some interesting basis of comparison and this is mainly 2005 data, but the CBM wells in the Powder River Basin generated a little bit over 70,000 acre feet of water in 2005 and drainage area of about 57,000 kilometers square. And so if you take a look at the average annual runoff -- long-term average annual runoff of for the four rivers that drain the Powder River Basin, this is about 10 percent of that average stream flow. Most of these waters are released to the surface directly/indirectly in various ways.

Compare that to the Upper Colorado River Basin, which has also been talked about here, which includes CBM production and the San Juan Basin and Utah and new development in the Green River Basin and the Peance Basin and this larger area over 280,000 square kilometers, there's less water that the total was produced roughly 53,000 acre feet of produced water was generated in 2005 from all oil and gas operations, CBM and conventional. This is only at a .4 percent of the average annual Colorado River flow at Lees Ferry, which marks the -- that demarcates the Upper Colorado River Basin from the Lower Colorado River Basin.

Virtually all this water is reinjected, which is a major difference, so large quantities of water, significant percentage of stream flow, and there's been a little bit of stream flow discussion in a couple of area papers.

Another view of this relative water production, again, this is the 2005 data, mostly from state sources. If you take a look at the far right-hand column, the San Juan Basin in Colorado, .44 barrels per Mcf; New Mexico portion, .33 barrels; Uinta production, .2 barrels; Powder River Basin, 1.66 barrels per Mcf, but take a look at the variation in the number of wells, at least in 2005, were active. Powder River Basin Coalbed Methane wells generated about a little over a half million barrels of produced water in 2005, so lots and lots of water being generated and this is easiest some feeling for the relative proportions of water which has been discussed at some length.

Composition of water in these major basins: Some of this has been alluded to, but here we can make some comparisons with water quality and the relative in terms of some major, some specific attributes and then the water types. Those of you that can perhaps take a look at this, Black Warrior Basin, where the Coalbed Methane production was initiated, sodium chloride bicarbonate water on the southeastern flank of that basin is relatively fresh water because you're close to the hydrologic inputs for the water as the north -- the western portion of that basin is much more saline.

Water quality varies from 160 milligrams per liter up to 31,000 and that's an east to west progression. Powder River Basin sodium bicarbonate, and you can see the range in numbers there from waters that are essentially drinkable to waters that have potential beneficial uses. Raton Basin, another sodium bicarbonate basin, a little bit greater range on the TDS. San Juan Basin is sodium bicarbonate chloride, substantial range in TDS from very low to very, very high and it's basically the operators in that basin said, "We're just going to inject everything."

And then Uinta Basin in the Fairplay -- sorry, Uinta Mountain areas and then Fairplay, another sodium bicarbonate chloride water with a substantial range and with the base being low and going up modestly high, all waters there are reinjected. So there are reasons why certain basins have water injection. Sometimes that historical. There are some waters that could be used, but the operators decided very early on because of the historical oil and gas production used injection, that they simply inject everything based on when they started the Coalbed Methane development.

Switching now to take a look at the Coalbed Methane or Coalbed natural gas in the Powder River

Basin, this is a diagram that talks about some of the very specific parameters and ranges that have been observed by the USGS that's specifically seen the studies, doesn't come out very well, but the ones of specific concern are shown in red and barium is one of the concerns, iron is one of the concerns, and the SAR is one of the concerns. You can see that there are several other. You can see what the ranges are in these various waters and there are some other components that would be of concern if they were much higher, for example, lead, selenium, cadmium, arsenic, chromium and mercury, all of which have toxicity at certain levels, but in general these values show there's no toxicity issues for those trace elements, even though they are present.

However, if you're concentrating these waters and you're concentrating some of these waters with higher initial levels, you might end up with material that -- or waters that end up approaching toxicity. General SAR, iron, and barium have been at issue and we've heard discussions of how those have been dealt with in terms of water treatment.

This is a diagram you've seen before. This is the Hansen diagram stolen from the recent EPA publication and again, the SAR's. You notice on the previous diagram that the SAR in the Powder River Basin has been measured ranging from 5.6 to 69. Here's where we start off and it goes off the -- the values go off the chart and normal range for a lot of the Powder River Basin waters is in this area. So you can see, it doesn't take much SAR before you get to slight to moderate problems, or in many cases, severe reduction in infiltration of soils where these waters might be applied.

And this is a diagram that Cindy Rice put together. Again, showing the southeast to northwest increases in TDS and we've seen this diagram and various incarnations about four or five times so far.

There's one topic that's not been broached so far that I think needs to be thought about a little bit more seriously and that is Bill Orem of the USGS in Western Virginia has done us a fairly quick survey a few years ago sampling waters and then taking a look at the organic components of these waters. Any water that's in contact with oil and natural gas or in contact with coals will dissolve certain amounts of various organic compounds.

And this is his sort of quick list. You'll notice in some cases it says, "Various [indiscernible]." That means these compounds are extremely complex and highly varied and just a small change in the number of carbon added changes the character of the compound. This is a list of basically individual compounds, plus groups of compounds that have been detected by Bill in in produced water strictly from the Powder River Basin.

And the amounts that you see here are nanograms per milliliter. These are levels of these compounds that are trace constituents. They are not -- they don't approach levels where you might have acute toxicity, but one of the issues is where it might not be chronic toxicity; however, the waters vary significantly. And here's two of the chromatograms for water that had a fairly high levels of -- a wide variety of organic compounds and a chromatogram for water that had much fewer in total amounts and then much less variety.

You'll notice these pumps that you see here, there is so many organic compounds that are so -- that come together so closely on the chromatogram that you're basically seeing small peaks all piled up on top of one of another and they yield these humps in the chromatogram. There's probably 10,000 or 20,000 organic compounds that are represented by this kind of diagram and it's these peaks where you have -- may have some specific compounds that are present in high amounts that can give you some very specific feeds.

So water -- considerably variable waters. This particular -- there is a applied geochemistry paper published in November of 2007 that was edited by myself and used in Curacao in which Bill gives a great deal more of this information. So one of the issues is the levels vary with these organics.

The levels seem to be below those that cause acute effects in humans, but the chronic effects or the potential chronic effects are not known. Health data for Wyoming suggests that people who are drinking coalbed waters may have long-term chronic effects that aren't very well documented. And there are some laboratory studies that Bill Orem has been involved with showing that there are impacts using Coalbed Methane waters from the Powder River Basin. There are some effects on human kidney tissues. So this is one aspect of the Coalbed Methane waters that may be significant and it hasn't really been examined very closely.

I think anyone thinking about, perhaps, kidney disease or related diseases in Wyoming should be thinking about whether Coalbed Methane -- drinking Coalbed Methane aquifer waters is a good idea and then that begs the question: If you're releasing these waters to the surface, what happens -- what's the fate of transport and effects of these compounds on surface waters? Do they degrade rapidly within a few feet of surface water discharge and then go away? Or do they persist in the surface water and have potential impacts on the fish, invertebrates, and the other organisms that rely on that water?

These are things -- this is an area of unknown issues that may be totally meaningless and not have much impact, but this is an area where there needs to be a great deal more research.

Thinking about these water volumes and these trace metals and major elements and so that we come back to here. What are the main issues then? And a lot of this has already been talked about. Enormous water volumes and there's impacts on the landscape and the surface and ground water for the Powder River Basin. So this would be SAR, barium and iron seem to be issues.

There are beneficial use potentials, but what are the problems associated with it? In the San Juan Basin where everything is injected just about, we have different kinds of problems and perhaps and one of the studies USGS did was to assist companies with an injectability problem. They found that the Coalbed Methane waters were incompatible with the waters that they were trying to do deep injection with when they have plugging formation. So USGS did some studies back in in the 1990's taking a look and trying to resolve injection problems. And we have other things such as surface reuses of methane that impact the San Juan Basin, loss of shallow ground water supply, some of which has been talked about here.

As you maybe have already thought about, Coalbed Methane -- I'm sorry, coalbed natural gas produced water is disposed of under EPA regulations. Earlier developments on direct discharge and later development has emphasized impoundments and now we're thinking about whether impoundments are such a great idea. 2900 impoundments were in use in late 2005. I don't know if that number has grown. Perhaps some of you that may have some updated data.

Water impacts where the surface releases, these all have been talked about. Direct discharge, changes in the hydrograph impacts stream and Riparian ecosystems and one of the data sets that can be very useful for those that are trying to understand that aspect of things is to take a look at the stream engaging data for water levels in the stream in both

Montana and the Wyoming Water Science Center have extensive data sets going back through time, taking a look at basically what the water levels are in the stream.

These elevated water levels may mobilize bank stored salts that go back into the channel down in the valley. And this has been alluded to. We'll talk a little bit more detail about this. Salt stored in Nevada zones can be leached by infiltration water from the flood plain and upland reservoirs and affects both surface and ground water quality. Some of those ground water quality -- some of those effects may not be realized for several tens of years in some situations.

The USGS has been conducting geophysical studies in collaboration with DOE, basically doing helicopter EM surveys over selected areas and one of these studies -- we're going to review one of these studies over the Powder River Basin where there were two years of studies and what we see here on the left is a geophysical survey that was run along the flood plain of the Powder River and from the conductivity data that was -- that's inferred from the helicopter EM data, they extrapolated that to an inferred TDS and the values range from a little bit less than 1,000 milligrams per liter to greater than 10,000 milligrams per liter in this particular graph here.

And then they flew the survey once again for a much small portion of the basin -- of the flood plain, I should say, and the inferred TDS's, the range is a little bit over 800 to a little bit over 8,000 so you get a little bit of a feeling for snapshot of 2003 and then perhaps some of the changes in 2004. And what you see superimposed upon here is a paleochannel and which -- sorry, paleochannel is here. The main channel of the Powder River, the moderate channel flows through here and one of the correlations that was seen is that paleochannels seem to be areas where there is higher salinity accumulation here and up here and areas outside of these paleochannels don't seem to have the high salinity ground waters.

And then the paper that is being published within the next few weeks talks about why that is and this particular stream appears to be a losing stream. You can see it's adjacent to the watering channel. There tends to be less TDS or less conductive zones; whereas, it's away from that, that you have the higher salinities. And then there may be evapotranspiration processes and other things that are influencing the areas away from the current channel. So you get a snapshot view, if you will, just kind of an image of what the ground water -- shall ground water salinity looks like on the flood plain of the Powder River.

Taking a look in detail, you couldn't quite see it in the previous image. There are a series of impoundments that are along the flood plain and these are flood plain impoundments. These are not upland impoundments and there seems to be a varied effect of the impoundments on the shallow ground water salinity and here, for example, is an impoundment that has a load conductivity, load TDS bull's-eye around it in an area that's otherwise fairly saline and the notion is, is that impoundment -- infiltrating waters coming out of that impoundment are actually lowering the TDS of the shallow ground waters nearby simply because the shall ground waters have been there. Their salinities have gone up because of the evapotranspiration processes and prior interactions with the sediment.

And then this upper one, you can see a bull's-eye of a high salinity with a sort of a trailing to the north, possible high salinity plume and there may be a reason behind that. This particular case down here, there appears to be no impact of that particular infiltration pond on the surrounding shallow ground waters. And the authors of this particular papers suggests there might be three different scenarios, depending on where you are in the landscape. On the flood plain, in the upper scenario, if you have a natural system with a high saline layer above the water table in the Nevada zone and you put the impoundment on it, that is mobilized, gets down into the water table and then it impacts the hydrologic radiant of the salinity conditions.

In another situation, you may have a highly saline ground water, the infiltrating water doesn't pass through a salt-bearing zone and it actually lowers the overall TDS of the water it encounters. In other situations, you have a modestly saline ground water on the flood plain and it very closely matches the infiltrating water and there is essentially no effect.

And so there are three scenarios that may offer an explanation of what's going on there.

This is the Skewed Reservoir Study and the Skewed Reservoir Study was an attempt to take a look at before and during and after an impoundment infiltration situation. They put in a series of licemeters on the footprint of the proposed reservoir series of monitoring wells down valley, some across radiant weld or two to try and understand what happens in an impoundment that's in an upland setting. This was initially a dry wash and they basically took a look at the before and after situation with the licemeters and various monitoring wells.

This is the ground water prior to infiltration. You can see TDS's for the CBM G-water was about a little bit over 2,000. Chloride was modest. Nitrate was modest. Sulfate, calcium, magnesium, and sodium, it was relatively high. This was undoubtedly a sodium bicarbonate water, as most of these waters are. Ground water, two different monitoring stations were a little bit different. This one was considerably more saline than those. These are fundamentally magnesium sulfate waters in this particular case. The other one was a sodium sulfate water, and not too unusual situation to have these two, sodium and magnesium, being the dominating cations and sulfate being the predominant anion in this type of geologic setting.

This is substantively in place. This reservoir and they saw very substantial changes in the character of the ground water. This is a licemeter below the footprint of the reservoir. Then these are two wells nearby. There is dramatic increases in the licemeter. In this case the licemeter didn't have a pre-water analysis. It only had water analysis after the infiltration started. You see severe TDS's, 57,000. The one ground water that was just down valley went from 1,000 to over nearly 22,000 PPM TDS. Again, these are dominantly sulfate waters and you saw only modest increases in one of the wells that a little bit farther down -- I can't remember if it was farther down or cross-gradient.

So the system that was -- the ground water system was strongly altered by the pick up of salts in the strata zone below the infiltration impoundment and the question can be asked: What happens in the long term if these kinds of waters are to be found in the impoundments -- the kind of situation that occurs in the impoundment among these many of these 2900 impoundments; however, we don't know how many of these 2900 salt issues beneath them and how many of them are relatively clear of that ozone salts and so there's an unknown issue there. I think some people are starting to look at.

This is another study taking a look at the Burger Draw. It's one of the small dry washes, into which there was water being placed and you see the outfall here with a rocks with a lot of iron oxide -- iron oxyhydroxide staining. You see the conductivity values. Those are in millicedes [phonetic] per centimeter and do you have to -- if you're working with microcedes per centimeter, you'll be looking.

But if these waters contain ammonia, nitrates, some DOC and a fair amount of iron and there's two years' worth of values being recorded there with sundry availability and the water quality. But the ammonium is present in a lot of Powder River Basin CBM G-water. One of the issues is if you're doing surface discharge, what impact does the ammonia or perhaps the nitrate that's derived from the ammonia have and of course, nitrate is one of those water quality concerns once it gets into the surface waters because of potential impacts.

And here is the surface water discharge here into this ephemeral situation down in the Burger Draw to other discharge plains over here is going from the ephemeral situation to a continuous flow situation and you see the data over here on the right. You can see a lot of sulfate being added as you go down valley. DOC appears to be going up. Chloride seems to be relatively level, but take a look at the change in the nitrogen species. You basically have ammonium at the -- immediately at the outflow and then a rapid increase down valley of nitrates and nitrite as the ammonium oxidizes along the stream drainage between Point A and Point B. And of course, nitrate has some issues associated with it in terms of water quality.

And then we've seen this little guy before. This -- we're now going to switch gears a little bit and talk about data availability and this is a study put out by the water -- the two Water Science Centers taking a look at the water years 2001 and 2005. And there's a great deal of data packed into these kinds of reports. There's mostly water quality characteristics without a great deal of analysis, but there's a great -- a tremendous amount of information piled into these kinds of reports for the four major range basins that impact -- that drain the Wyoming portion of the Powder River Basin.

So this kind of data and then the source of information that this represents, that a lot of update is available -- a great deal of it is available online and again, this is one of the figures from the report and that's USGS SIR Report 2007-5146. If you go to the Wyoming.USGS.gov, you'll find this particular report available online.

Other reports of interest include Water Investigations Reports. This one takes a look at -- they did isotopic studies and the isotopic studies were published. Again, lots of data available in these kinds of reports. Two additional reports, this is by

Tim Barcross [phonetic] of Wyoming Water Science Center, and Cindy Rice in our group, and again, you're taking a look at chemical and isotopic composition from the formations and again, providing basic data, baseline data in many cases that evaluate subject that changes.

And this report that you see below here is the report, some of which -- the data from which I briefly alluded to and this is Bill Orem's study that's published in applied geochemistry late last year.

This is the USGS of Montana Water Science Center showing their monitoring sites. You can go online and get water quality data, specific conductance and calculated SAR's for those particular stations in real time. Some of these stations have been shut down due to budget problems and it was alluded to earlier, we'd like to get -- see some of those stations come back up as the funding is made available.

Another study, Measure and Estimated Sodium Absorption Ratios for the Tongue River and its Tributaries, 2004/2006. Basically taking the data that's been gathered and then putting it out there as an SAR report. This is SAR 2007 5027.

So there's lots of data available. We have geophysical studies. The take away from the geophysical studies is that the EM data that's often used for monitoring individual stream flow or somebody's well that's pumping out of the creek, that data can be looked at even on a regional scale, if you use some of these more sophisticated EM techniques to evaluate what's happening in a particular zone or environment.

Sodium impacts are significant and certainly impact the ability to use the Powder River Basin produced waters for beneficial use. And movement of large volumes of water to the Nevada zone is capable of moving large quantities of salt to ground water and possibly to surface waters and the magnitude of that phenomenon that is how widespread these large zones of subsurface salt are in the Nevada zone is not really well understood, while it sounds like some people claim interest to be characterizing that.

Potential impact on the several minor trace solutes including organics and inorganics, nutrients in organic species in CBM waters is still not very well known. And a substantial pass to ongoing real time hydrograph is simple water quality data available for evaluation of impacts.

One comment, Anadarko and perhaps some others are thinking about reinjection as being -- and this was

-- this has already been discussed in some detail early on.

And present USGS activities: Cindy Rice has retired and we are asking her to still put together her CBM produced water data clearinghouse that she was working on when she retired, get that up online and she would not only put up USGS data, but link -- establish links to several of the other potential data sources, some of which we've talked about during this meeting and Mark Ingles, who is present here today, is starting a collaborative study with DOE and some other partners to take a look at the subsurface drip irrigation studies to see how effective those can be, how we might be able to better manage subsurface drip irrigation to resolve some of the issues again that have been talked about here in terms of using CBM produced waters for irrigation.

Thank you very much.

MR. CONDIT: Anybody have any questions for Jim? In the back there?

MR. HANSEN: Chris Hansen, BLM out of Buffalo. I guess a couple of comments.

MR. OTTON: Sure.

MR. HANSEN: First of all, there are some additional studies going on. They're on the biological side of the house and one of them that's going on -- by the way there is an interagency working group in the Powder River Basin that's been ongoing for almost five years now and it has four task groups, one of which is the aquatics group, and as part of that aquatics group task, there is a study going on looking at some of the fisheries issues, some inverts and amphibians.

MR. OTTON: Yes.

MR. HANSEN: And with respect to CBM produced water development. Now we did get an preliminary feedback from -- and I can't remember the lady's name. I believe she's out of Fort Collins -- last summer. She needed to add in the last field study from last year before we get a final report on that, but anyway that is going on.

The other comment I'd like to make is -- in a part of adaptive management as a result of the Skewed Reservoir Study there, the State of Wyoming, as well as BLM, now require monitoring or core drilling around those reservoirs to determine the class of water and if you keep the reservoir there, then the core holes are kept as monitoring for that. So that's something that's now been implemented that we're requiring those core drilling to determine if that is an appropriate site for a reservoir. And by the way, our numbers are that there's almost 3900 reservoirs.

MR. OTTON: 3900 nowadays, yeah. Doesn't surprise me.

The Skewed Reservoir -- after this particular work was published was actually dismantled. They felt like it was just too much of a problem so they took down the Skewed Reservoir and that's something that's no longer there.

MR. HANSEN: Right. Skewed, if I remember right, was over a Class 2 or 3 water. And that was one of the problems. It was theirs. They were actually degrading the quality of the water there.

MR. SPEAKER: Is that the name of the reservoir, Skewed Reservoir?

MR. OTTON: Skewed Reservoir was the name that was applied to that infiltration pond, but that's purely -- it was constructed by the company and that's --

MR. SPEAKER: Was it named because the data is skewed?

MR. OTTON: That I don't know. I do not know where the term "skewed" came from.

MR. CONDIT: If there's no one else? I have question about whether your colleague, Bill Orem, that you mentioned -- is there anybody looking out whether it's the biogenic -- the biogenesis that is of the river basin that Geoff spoke about that may be affecting those numbers? Has anybody looked at organics in the water in the San Juan Basin, for example?

MR. OTTON: Not that I'm aware of. They don't want to know. The fact that it's being reinjected means that it's out of sight. It's out of mind, so it can't possibly have an impact. Whereas here, we don't know whether there were impacts or not.

Bill has a slide that I decided not to show because it's somewhat inflammatory and that is that the State of Wyoming has among the highest of kidney disease incidents in the United States and part of the problem with that, however, is there's a lot of things that affect kidneys and one of them is you can't have Coalbed Methane produced waters that people are drinking that perhaps may be an impact, but you also have uranium and plenty of other trace elements in the ground waters in the state and then you have the fact that it's an aired climate means that many people don't basically hydrate themselves well enough that there may be kidney problems related to dehydration.

So you'd have to tease out a lot of things. You'd have to take a look at the specific etiologies of the kidney disease to know whether it's likely to be caused by organics or it could be caused by a number of parameters.

There are some parts of the world, for example, in the Balkans where people drink Coalbed Methane -- just like coalbed waters and just about everybody in these small villages -- rural villages develops kidney disease. But these are very, very high concentration of toxic organics.

There are now studies going on in China where there's a series of issues related to use of coal inside people's private residences, but also coalbed waters are consumed as -- from aquifers in many parts of China and they seem to have many incidents of kidney disease. So there's -- that needs to be looked at, but no one I'm aware of is planning on looking into that.

MR. CONDIT: It would seem to me that if indeed the folks in Gillette were drinking that water for a while that there's a ready made data set there.

MR. OTTON: We think so.

MR. CONDIT: We hope to collaborate on that.

MR. OTTON: That would be very helpful if there were enough -- if there were high enough quality epidemiological data to work with.

MR. CONDIT: Back to?

MR. SPEAKER: Just quickly, I was wondering if you know how volatile the organic compounds that we're concerned with are?

MR. OTTON: I do not know.

MR. SPEAKER: Just in a relative sense?

MR. OTTON: I don't know that.

MR. SPEAKER: And some people would say -- that matters not because people in San Francisco are drinking gin laced water from stuff that's been flushed down toilets.

MR. OTTON: Thank you very much.

MR. CONDIT: Thank you.

MR. CONDIT: I wanted to take this opportunity now -- I want to -- we thank all of our speakers both this morning and this particular -- like I say, this group of iconoclasts here for the afternoon. But I also want to recognize the work that Nick Rogers here, who works for the Committee, has done to put all the logistics together for this.

That's a lot of workload, too. Let's give him some CBM water to drink.

MR. ROGERS: No CBM water.

MR. CONDIT: I guess at this juncture -- Murray, do we want to -- let's see. It's 5:09 and we're scheduled to go to 5:30, so if we want to get a little discussion going to any and all of this panel members, or if you recognize somebody from the morning panel that hasn't escaped yet, you can ask them questions, as well.

And this is all to help us and as you know, we're planning to gather back again here tomorrow morning and after the Committee members meet in secret and discuss what we think of all you people. Then we let you back in and we hope to have a discussion then that can -- and it really on BLM and to a certain extent, EPA's benefit because they are the folks that are the focus in the mandate in Section 1811 of the Act to engage the National Academy of Sciences in a study.

So what we hope that the morning panel and the afternoon panel in some fashion we can distill what we've learned this afternoon and help to guide BLM when they go to work with the Academy should this happen to guide the makeup of the ad hoc committee that would be established to study and then write a report and to steer them down to where we think that there are gaps in our data knowledge and that's certainly something we learned this afternoon that we've got lots of gaps maybe because of the CBM holes in our brains.

DR. MAEST: Test our data. Yeah, holes in it.

MR. CONDIT: So we can discuss some of that now. I intend to go take some distillate after this session. I find that the distillation of the information that I've received is a little easier to distill with some distillate and so I'll come back better prepared tomorrow.

But pre-distillate, let's get some background data, I guess, any background thoughts anyway pre-distillate?

How about any members of the Committee?

MR. SPEAKER: Just don't let USGS run a gas chromatogram on it before you drink it -- maybe different enthusiasm.

MR. CONDIT: I'd be under one of those humps.

Anybody else on the Committee want to pose any questions to this panel? You, too, want to chew on it, I suppose.

Murray, come on. You're good for something. I'm dying up here.

MR. HITZMAN: I'll have something.

MR. CONDIT: Okay. Well, Debbie. I knew Debbie is good.

MS. BALDWIN: And I just don't remember, the down hole membrane that was used to try and -- that was gas permeable that is actually being tested someplace or it's just developing the membrane?

MR. KUIPERS: No, they've been testing it in laboratory.

MS. BALDWIN: Yeah, it doesn't pick up well.

MR. KUIPERS: No. But we have a project fact sheet on that and I know they're developing their final report, but --

MS. BALDWIN: Any operator step up and volunteer to let you try this?

MR. KUIPERS: I just don't know what the details of their search for a field site area.

MR. SPEAKER: I have a question. What's the relative energy use of the electrodialysis system?

MR. KUIPERS: I know we have some numbers, again, in the fact sheet, but there was -- it was fairly low, yeah, yeah. That's one of the advantages of it.

MR. SPEAKER: So what's being done with the commercial development of that?

MR. KUIPERS: I don't know, to tell you the truth.

MR. SPEAKER: It simply has never been done at a field beyond a laboratory scale.

MR. SPEAKER: You've got to go through the scale?

MR. SPEAKER: Yeah. You simply have to go through the art of these stages.

MR. KUIPERS: I think it's just the development.

MS. SPEAKER: I know there's a version of it that's been done at the Hansen site for a total.

MR. KUIPERS: Uh huh [affirmative], yeah.

MS. SPEAKER: So I'd to be looking at that.

MR. CONDIT: There's a gentleman in -- oh, Ann?

DR. MAEST: Okay.

MR. CONDIT: And then the gentleman standing up in the back? You have a question as well, or you're just putting your jacket on? He's trying to escape. Lock that door. Don't let him out.

DR. MAEST: I had a question for Kathy Lynch. I was interested in your information on the toxicity of the bicarbonate to aquatic biota and that seems to be -- I mean, it's an important issue because it's the main anion in all of these basins that we've been talking about today.

Do you know if there's some way to -- I mean, I'm assuming that the toxicity tests were done as a sodium bicarbonate solution? I don't know if you know?

MS. LYNCH: That's my understanding. But I don't -- I mean, the woman who did it, her name is Ieta Ferric [phonetic] and she works for the USGS, actually at the Jackson Hole Fish Hatchery.

DR. MAEST: Okay.

MS. LYNCH: And she's been leading that up and so she -- and she's wonderful to talk to and she's very helpful, so she would be a good one to follow up. I don't know. They did both samples in the lab and then they also did some institute sampling and testing out in the field.

DR. MAEST: Okay.

MS. LYNCH: And so I don't know. I'm assuming it's sodium bicarbonate, but I don't know if in the solution of it's just bicarbonate.

DR. MAEST: Okay. I could give her a call, but the question is how can you separate out the impact of sodium and bicarbonate on the toxicity when you're doing it that way? I was wondering if there was some kind of control that was done to ensure that the result was actually bicarbonate, as a result of bicarbonate toxicity, rather than something else?

MS. LYNCH: I don't know the answer to that.

DR. MAEST: Okay.

MR. CONDIT: Are you going to go into your pantry and throw all of your bicarbonate of soda away?

Yes?

MR. SPEAKER: I have a question for Kathy, also. In a previous life, I worked in the Florida phosphate industry. I mean, we ponded our finds and the water in there at that time wasn't the best water in the world, but we grew some of the biggest fish, bass, that I've ever caught. We didn't eat them, though.

So my question is: On some of these holding ponds, are there fish growing in there?

MS. LYNCH: You know, I think there are and in fact, I've heard anecdotally that there are -- yeah, I think the women -- this is an aside. I think the women's prison in Wyoming is farming Tilapia and I've always thought that the CBM water would be a really good water source for that, but that's an aside.

MR. SPEAKER: Yes, there are. There are trout and various others.

MS. LYNCH: There are and a number of landowners, my understanding is, have created surface ponds for aesthetic looks and have stocked them with trout and I think the big difference there in looking at toxicity to fish is that an adult fish has a much higher tolerance over time for chronic exposures to, say, bicarbonate. And the real health issue is in the reproductive system and it's the really young fish that this USGS study that I was talking about, those fish were newly hatched, two days old, four days old. They were really young, and that's where you have a problem. So over time you might not see much recruitment of new age classes, even though adult fish can live with much higher tolerance.

MR. SPEAKER: Did they check the chemistry of the fish and see what's in them?

MS. LYNCH: I'm thinking -- I'm actually thinking that there needs to be a field trip over there to catch some of them, but I don't -- you know, I don't know. I mean, this is all anecdotal, but there are adult fish living in some of those areas and I think it's the juveniles that have a lot harder time.

MR. SPEAKER: And actually in the bicarbonate study, they found that the one week old minnows didn't have much of a problem at all, but it was the one day old to two to three day olds where the real issue came up.

MS. SPEAKER: Those minnows?

MR. SPEAKER: Those were minnows.

MS. LYNCH: Yeah.

MR. COMPTON: That's correct. The whole effluent toxicity testing or the wet testing, which is common permitting protocol in Montana, I think for fairly modest levels of sodium bicarbonate, they were getting close to 90 percent mortality in their very young, day old and two day old fish. The adults do fine, but you know, you're not going to sustain a population at this time.

MR. SPEAKER: Another question for Kathy. You mentioned the -- some of the negative parts of that, but in some of this Coalbed Methane discharges, sounds like it was a pretty good quality of water. The beneficial aspect of [indiscernible] on the cleaner waters?

MS. LYNCH: Well, that's the million dollar question really. We've got so much water coming out and it seems that there are some beneficial uses and I think, especially larger wildlife and ungulates, the toxicity levels are much less, even if at all with some of this water, unless I guess they're going to get kidney disease maybe.

But I think that there are some beneficial use for large wildlife especially and that's one of the things that the State of Wyoming looks at and sort of presumes that livestock and wildlife are beneficially using a lot of that water. I think when you look at sort of more of an aquatic life stage, you know, maybe with some treatment down the road, if we can figure out some of these standards for some of the water quality standards that are already in place and decide if we're going to have a bicarbonate standard or if we're going to have an improved selenium standard.

Maybe with some treatment, then there could be some beneficial uses, but the caveat to that is that you've got to be really careful with how much flow you're putting on because a little bit might be fine, but too much all of a sudden, we've got some of those morphology changes that we talked about in the stream system.

So and I don't know the answer to those questions. I wish I did. And I think maybe there's a lot of data out there that could be compiled. I think that there's probably also some gaps.

MS. GIONOICKUS: There's also some concerns that conditioning of large species -- I mean, I know this sounds crazy, but I mean this is a temporary water source and there are some concerns that the conditioning of the larger species to those sources that are not going to be a long-term source for them, in terms of how they handle movement in a given basin area.

MS. LYNCH: Kind of like feeding your deer molasses in the winter. You're not supposed to.

MR. SPEAKER: I think it's important that you keep in mind though that supposed in the Powder River you took a discharge of high quality water to it and actually caused the TDS to go down. That doesn't necessarily mean that the native species that are present are going to be happy with that when you talk about treated water discharges going into the Powder River and decreasing the turbidity and so you've got your site feeders. You said your bottom feeders, I've got that right? You've got a geologist trying to talk about ecology here, but the critters that are happy change, if you change the salinity and turbidity of the water so less isn't always best.

MS. LYNCH: Yes. And you know, that's another thing that the USGS is looking at and in some conversations I've had with Ieta Ferric, they also looked at exactly what you're saying that almost when you dilute it too much even, then you've got an invasive species potential problem. You're right.

MR. CONDIT: Which is okay, as long as they're cold water fish.

MS. LYNCH: That's right, yeah. Yeah, those really hardy cutthroats are going to move in.

MR. CONDIT: Yes?

MS. SPEAKER: As far as data gas are concerned, it seems to me that there's been a lot of oil and gas discharges for decades in Wyoming and there can be some lessons learned there. Specifically in the Bighorn Basin, there's more water discharge -- surface discharge than there is in all of the Powder River Basin and that's used for irrigation, livestock watering, but that's been there since sometimes the `40s and `50s.

Have any of you, I guess this would go to the researchers on the panel, considered using some of that data or collecting data from those areas to look at what the long-term effects are?

MR. THYNE: I can answer that in part. There's a discharge that is near Cody, Wyoming that's used to enhance the wetland system and Pete Ramirez of the Fish and Wildlife Service in Wyoming has studied that. Since then I lost the name of the particular wetland complex, but they've taken a look at -- they've tracked from the discharge point through the small stream into the wetland radium and a series of other components -- trace metal components, this particular wetland complex -- I think it's the Lock Katrine Wetland Complex. It is they've traced these series of contaminants through the entire system all the way into the waterfowl tissues and so there has been some study. What they don't seem to see is toxicity. They see modest levels of the contaminants going through the entire system, including the sediment substrate, the plant and then the ducks, but they don't seem to see toxicity.

So there has been that kind of study on conventional water -- conventional produced water releases, but throughout the inner mountain west, for the most part the TDS's of produced waters are less than 10,000 parts per million with the vast majority of produced waters and that's in large part because most of the oil and gas producing basins have been invaded by meteoric waters over the last several tens of millions of years and it's only in a few areas like Salt Creek, the Paradox Basin in Colorado, where you have high TDS waters and that's usually where there's salt beds in the subsurface that are being dissolved by the evading ground waters and so you maintain those high TDS waters just by the fact that there's been meteoric waters moving through the section for millions of years.

So there has been some studies in the Lock Katrine Wetland Complex. I think Pete's done some other studies. If you look up Pedro Ramirez, you can go out online and do a Google search on him, you ought to turn up at least a couple of his papers and so there has been studies of conventional water releases, at least a few studies in Wyoming.

MS. SPEAKER: And I guess one of the other -- kind of a follow up to that is that in the Bighorn Basin, there seems to have been a net environmental benefit to the discharge waters and I wondered if anyone has looked at that in its consideration of how to handle the Coalbed Methane question?

MR. LANGHUS: We did look at the -- at some of the users of the produced water there in the Bighorn Basin and it's in the beneficial use book that I put out there. It's on our website. If you just go to A-L-L-L-M-C.com, you can find all of those publications in there. There is a fair amount of data there. It's especially potent there in the Bighorn Basin because the rainfall is extremely low and if there hadn't -- if there isn't any produced water being used, there just is no hay being developed there. So it's a big boom for the local ranchers.

MR. SPEAKER: Do you know chemically of Bighorn water is?

MR. LANGHUS: I don't know. I think it would be in that write-up, though.

MR. SPEAKER: There's for conventional oil and gas production, there's a substantial USGS produced water, geochemistry database that's available online and many of you have seen it. There's roughly 58,700 water chemistry data available for the entire U.S. with the exception of the Appalachian Basin, which operators in the Appalachian Basin essentially did not participate or get themselves involved in the study. This was the U.S. Bureau of Mines study, by the way, run out of the Bartlesville Lab and several years ago, the USGS inherited that database and decided to go through it and cull it and bring it up to modern data quality standards and so that database is online. We can thank the U.S. Bureau of Mines for doing work in a Bartlesville Lab many, many years ago, but we finally got that database online.

MR. SPEAKER: My question is for Jim. You mentioned the lack of looking at both the surface water and ground water, were you afraid to do data collection and research, or is there a management strategy?

MR. OTTON: Well, really it was the almost blind idea that the ground water and surface water are interconnected. Again, EPA can look at surface water, but they don't look at ground water because it makes up surface water in those streams. We're simply missing it. So the idea from BLM that these ponds basically are perfect in their statements, and that's just not true and it leads to basically not addressing what may be a major contributor, particularly with the subsurface salt load. It may be the major contributor, not a major contributor.

MR. CONDIT: Yes, Carl?

MR. SPEAKER: I was just going to add in regard to the Bighorn Basin, that in USGS former conservation division in the 1940's and `50s documented the associate formation waters for the oil and gas producers that were in that basin. And some of that data can still be found in a library collection in various libraries.

MR. CONDIT: Yes?

MR. SPEAKER: And there's a certain amount of discharge data from Bighorn Basin. We can look at all of the constituents that we are now beginning to look at in the Coalbed Methane for its TDS, sulfate, chloride, radium. Generally waters of the Bighorn Basin are much more saline and have higher TDS, maybe twice as high, as what we see in the Powder River Basin generally lower in sodium, higher in chloride.

MR. CONDIT: Yes?

MR. INGLES: Mark Ingles, USGS, West

Virginia. Are there any -- you know, in terms of the Powder River Basin if you're adding this water back to the system, in some cases you're adding more water than the systems have seen since the ice was seen and you're normally adding 10 or 20 years and then turn it back off. Are there studies going to look at the rebound times for these systems to regain the state they were at before the production of CBM?

MR. HITZMAN: None that we're aware of.

MR. CONDIT: Sounds like a data gap to me.

MR. SPEAKER: What are the long term, 10,000 years, what are the effects of climate change and changes in distribution of precipitation on CBM production?

MR. CONDIT: Murray, do you want to say a few words to close out today's session?

MR. HITZMAN: I can, even though you're much better at getting everybody to laugh.

The main thing I'd like to do is thank everyone for participating today. I hope that BLM found it useful since they are the main client for this and I encourage many of you as you can to come tomorrow to the session at 8:30 we start, correct? And go for an hour and half. So if you can get down, that would be great, and as Bill said, I think now at least the

Committee will go off to distill itself and distill its thoughts.

Thank you very much for your participation and hope to see you tomorrow.

STATE OF COLORADO)
) ss. CERTIFICATE
COUNTY OF DENVER)

I, Christopher Boone, Digital Reporter and Notary Public within and for the State of Colorado, certify that the foregoing is a correct transcription from the digital recording of the proceedings in the above-entitled matter.

I further certify that I am neither counsel for, related to, nor employed by any of the parties to the action in which this hearing was taken, and further that I am not financially or otherwise interested in the outcome of the action.

In witness whereof, I have affixed my signature and seal this 29th day of April, 2008.

My commission expires August 16, 2010.

CHRISTOPHER BOONE NOTARY PUBLIC STATE OF COLORADO

Christopher Boone, Digital Reporter