

SHALE GAS AND WATER IMPACTS

HEARING
BEFORE THE
SUBCOMMITTEE ON WATER AND POWER
OF THE
COMMITTEE ON
ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE
ONE HUNDRED TWELFTH CONGRESS
FIRST SESSION
TO
EXAMINE SHALE GAS PRODUCTION AND WATER RESOURCES IN THE
EASTERN UNITED STATES

OCTOBER 20, 2011



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SHALE GAS AND WATER IMPACTS

THURSDAY, OCTOBER 20, 2011

U.S. SENATE,
SUBCOMMITTEE ON WATER AND POWER
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The subcommittee met, pursuant to notice, at 2:59 p.m. in room SD-366, Dirksen Senate Office Building, Hon. Jeanne Shaheen presiding.

OPENING STATEMENT OF HON. JEANNE SHAHEEN, U.S. SENATOR FROM NEW HAMPSHIRE

Senator SHAHEEN. Good afternoon, everyone.

I apologize for the delay in starting this afternoon. As you know, we had some votes on the Senate floor. So hopefully we haven't delayed our panelists, and all of you who are here, too much.

We are here today at this water and power subcommittee to examine the effects of shale gas development on the water resources of the eastern United States.

As we all know, the last decade has seen a real dramatic change in the energy industry as technological advances have opened up vast new stores of previously unrecoverable natural gas.

Like many in Congress, I believe that natural gas has an important role to play as we move to a clean energy economy. That the benefits of abundant, domestically produced shale gas are clear, particularly in States like my home State of New Hampshire where 45 percent of the electricity is generated from natural gas.

Shale gas has the potential to provide significant amounts of affordable, clean electricity to both homeowners and businesses. However, serious concerns have been raised about the effects that shale gas production and hydraulic fracturing have on water resources, particularly here in the eastern United States.

The process of fracking just a single well requires millions of gallons of water, which is often sourced from local streams and rivers. In eastern shale formations, 20 to 40 percent of this water flows back up to the surface. The water can often contain radioactive elements such as radium or other materials that could be harmful to human health. Furthermore, Duke University researchers have suggested that the improper construction of shale gas wells can lead to methane contamination of nearby surface waters.

The purpose of today's hearing is not to focus exclusively on the risks associated with fracking, but rather, to hopefully take a more holistic view of shale gas production and its effects on water quality and supply. As our country becomes more reliant on shale gas,

it's critical that we examine the full range of issues affecting our water resources.

Recently, the full committee heard testimony from the President's Shale Gas Advisory Board, which stressed the need to address issues resulting from the acquisition, management and disposal of the water used in shale gas production. It's important to note that the board has found that, by and large, shale gas development is being conducted responsibly and that the public should not be alarmed about any danger of widespread contamination. It's the purpose of this hearing to further explore that analysis, and to examine any outlying issues that may be areas of concern.

Today we have a diverse panel of experts who will discuss how water is being handled in eastern shale gas plays, what steps are being taken to safeguard the public, which efforts are working and what more work needs to be done.

Our first panel includes Cynthia Dougherty, who is director of EPA's Office of Ground Water and Drinking Water, and David Russ who is the Northeast Regional Director at the U.S. Geological Service.

I'm going to go ahead and introduce our second panel prior to their coming up. They include Lori Wrotenbery, who is the director of the Oil and Gas Conservation Division of the Oklahoma Corporation Commission, as well as a board member of the State Review of Oil and Natural Gas Environmental Regulation or STRONGER, as it's known.

Tom Beauduy is the deputy executive director and counsel for the Susquehanna River Basin Commission.

Cal Cooper is the worldwide manager for Environmental Technologies, Greenhouse Gas, and Hydraulic Fracturing for the Apache Corporation.

Finally, Katy Dunlap is Eastern Water Program director at Trout Unlimited.

I look forward to hearing from each of our witnesses about their experiences with shale gas development, and the resulting impacts on water resources.

Before I ask our panel to begin, I will turn it over to Senator Lee for a statement.

[The prepared statement of Senator Casey follows:]

PREPARED STATEMENT OF HON. ROBERT P. CASEY, JR., U.S.. SENATOR FROM
PENNSYLVANIA

Thank you for holding this oversight hearing to examine shale gas production and water resources in the Eastern United States. We are incredibly fortunate to have the abundant domestic source of energy and jobs that shale gas represents. While I support the development of our natural gas resources, Pennsylvania still bears the scars of mining and drilling from decades past, which reminds us that we need to extract our energy resources responsibly. Although Pennsylvania is relatively gifted in water resources, we must protect and conserve them. In order to assure that this priceless commodity will be around as clean and plentifully as we have enjoyed it, we must treat our waters with the same sense of value that we give all other resources. That is why I introduced legislation, the Fracturing Responsibility and Awareness of Chemicals (FRAC) Act, S. 587 to repeal the exemption of hydraulic fracturing from the Safe Drinking Water Act. No industrial endeavor is entirely without risk, so we must strive for prudent development and proper monitoring, especially at the scale of Marcellus Shale.

While there are broader issues involved in shale gas production, awareness of water resources concerns have been at the forefront. Completing a typical Marcellus well requires millions of gallons of water. The increasing number of reports, rec-

ommendations and local efforts relating to shale gas demonstrate public demand for better oversight of the industry and protection of our vital water resources. Controls are needed to secure the quality and quantity of all water resources—underground or surface; sources of drinking water of fishable creeks. The full scope of potential public health, safety and/or environmental impacts should be fully assessed to plan for development that assures an acceptable level of comfort for the general public. One started, close monitoring of all operational parameters are needed to allay any possible risks to safety, public health and the environment.

Advances in technology have enabled us to get shale gas out of the ground, now we need to prove that technology is as effective as safeguarding our water, air, and communities. To prevent water quality and quantity impacts, gas wells should be built to unequivocally isolate underground aquifers and protect sources of drinking water. The amount of wastewater created and how it is disposed of needs to be closely watched. A growing network of pipelines, compressors, and metering stations are conveying the gas from wells to where it will be stored or used. To lessen waterway and wetland destruction, strategic location of pipelines, preferably within the same carefully selected corridors, should be planned for. Better coordination and communication among industry planners, federal, state and local oversight agencies, and the public on all of these aspects is critically needed to reduce safety, property and environmental impacts while ultimately reducing costs.

The FRAC Act I proposed also would require disclosure of the chemicals used in the hydraulic fracturing process. We must have transparent public disclosure for chemicals used in fracking fluids. Many companies have been overly cautious in releasing proprietary information about the ingredients in their fracturing fluids, contributing to a public perception that the industry is hiding something. I believe that the public's right to know extends to disclosure of all additives used in the complete lifecycle of a well even as drillers' intellectual property is protected. The public has the right to know about any risks in their community, and what is being hauled over their roads, or pumped through underground aquifers where their water wells may be located. Public disclosure of fracturing chemicals is also an easily achievable way to provide a measure of comfort to local communities.

While technology is advancing rapidly, there is still more that can be done. For instance, reduced water consumption and wastewater generation may be possible using the frac fluids other than water, such as nitrogen, carbon dioxide, or other foams, but advanced or alternative techniques that could reduce or substitute water use are not well understood. Alternative fracturing fluids and other "green completion" methods may pave a path to more efficient production techniques even while providing less significant environmental impacts.

Marcellus Shale natural gas has turned out to be Pennsylvania gold, but we must ensure that Pennsylvania and our country benefits from this newfound wealth of energy rather than being saddled with drinking water threats and other risks. I am confident that the proper standards to assure its prudent development will not hinder its development as a valuable domestic energy resource. I do not believe that this approach requires us to choose our economy over our environment. Taking the steps needed to assure that domestic energy production is done right, even though they may be labor intensive, will lead to greater national security and more jobs here at home.

STATEMENT OF HON. MIKE LEE, U.S. SENATOR FROM UTAH

Senator LEE. Thank you, Senator Shaheen.

I'd also like to thank our witnesses for joining us today.

To start, I think it's worth mentioning that today's hearing follows several similar hearings previously held in this committee over this month and in the EPW Committee. There is another field hearing scheduled for next month and we've looked quite closely at many of these issues.

Just about 2 weeks ago, our full committee held a hearing on a shale gas report requested by Secretary Chu. He asked a number of experts to spend 90 days identifying potential environmental impacts associated with shale gas development, as well as measures that can be taken to reduce those risks.

The testimony we heard at that hearing was encouraging and overwhelmingly positive for natural gas drilling. All of the wit-

nesses testified that the challenges involved in shale gas development, particularly the water issues, are manageable. They also determined that the States should continue in their roles as the primary managers and regulators of shale gas development.

Today, we're back for another bite at the same apple. We're here, again, to talk about the environmental implications associated with shale gas development and who should manage the risks. So as we hear testimony today, we ought to remember that the administration's own handpicked panel provided testimony consistent with the conclusion that the States are the appropriate body to regulate shale gas development. They've testified that the States are doing their job and doing it well. They've unanimously agreed that the environmental risks associated with shale gas development are being adequately managed at that level, even as continued improvement is called for.

I understand the desire to make sure that shale gas is produced safely, and I'm hopeful that this committee, if we continue to look at shale gas, will continue to and begin to broaden its focus. Instead of focusing as heavily and repeatedly on potential environmental impacts, we should also look at the significant economic benefits that are now rapidly apparent in places that are producing shale gas.

The members of our committee know I'm a strong advocate for the domestic production of natural gas. It's pretty simple. When we produce natural gas here in the United States when—then we necessarily create jobs here. We generate revenues here, and we help keep affordable energy here, and we need that right now. It helps Americans. It helps our families and our businesses. It helps attract investment. It helps our local and rural communities. It helps our Nation stay competitive, and it helps generate a revenue stream that's necessary to sustain, among other things, the budget of our Federal Government.

Not too long ago, many people thought that high natural gas prices were here to stay; a limited, natural gas supply to meet our growing demand. Most people thought that job-producing business—industries would suffer as a result of those escalating gas prices. It was also anticipated by many that the United States would begin to import large quantities of liquefied natural gas in order to keep up with the demand.

But instead, what has happened is that the United States has become mostly self-sufficient with regard to supplies of natural gas. Our natural gas prices have fallen, hundreds of thousands of jobs have been created, and industries that rely on natural gas have invested billions of dollars in the United States. Much of this is due to the development of shale gas.

So absolutely, we should make sure that natural gas is being produced safely, and at the same time, let's not forget that we have a commodity that everyone needs and in great abundance right here in the United States, and we ought to be producing all that we can while doing so in an environmentally responsible manner.

I'm confident the States should continue to regulate shale gas production and believe that industry should continue to strive to maximize production and minimize any environmental impacts.

I look forward to this hearing, but more than that, I look forward to future, to a future where the money benefits associated with natural gas production become even more apparent through our country.

Senator SHAHEEN. Thank you, Senator Lee.

I will now turn it over to our panel. Ms. Dougherty, would you like to begin?

STATEMENT OF CYNTHIA P. DOUGHERTY, DIRECTOR, OFFICE OF GROUND WATER, DRINKING WATER AND OFFICE OF WATER, ENVIRONMENTAL PROTECTION AGENCY

Ms. DOUGHERTY. Thank you.

Good afternoon Chairman Shaheen, Ranking Member Lee, and members of the subcommittee.

Thank you for inviting me to discuss natural gas extraction and production activities, and EPA's role in protecting public health and water quality.

As you said, I'm Cynthia Dougherty, Director of the Office of Ground Water and Drinking Water at EPA.

Let me first note that EPA and this administration have recognized the promise that natural gas holds as an important energy resource for our country. We believe that this resources, if accessed in an environmentally responsible manner, has the potential to improve air quality, stabilize energy prices, and provide greater certainty about energy reserves.

In the last year as we've talked to people about hydraulic fracturing and shale gas extraction, we've heard from many citizens across the country about their concerns for their families, their communities, and their water resources regarding the potential impacts of natural gas production. But we've also heard from citizens about how much their communities sorely need the income that would be gained by natural gas production.

We believe this important resource can be and must be extracted responsibly in a way that protects drinking water sources and surface waters. These considerations were laid out in the president's Blue Print for Secure Energy Future and are also consistent with the Secretary of Energy's advisory board's recommendations for the safe development of natural gas resources.

We also know that if improperly managed, natural gas extraction, including hydraulic fracturing, can impact our water resources and potentially endanger public health.

The EPA has an important role to play in protecting water resources and we remain committed to working with State officials who are on the front lines of permitting and regulating natural gas production activities.

I'd like to highlight some of the key research and programmatic activities our agency is currently undertaking.

At the request of Congress last year, EPA launched a research study to understand the relationship between hydraulic fracturing and drinking water resources. The EPA study will look at 5 stages of water use in the hydraulic fracturing process. These include: water acquisition, the mixing of chemicals, injection at the well, flowback and produced water, and the disposal of wastewater. We will be evaluating information such as the characteristics of hy-

draulic fracturing fluids and their behavior if released into the environment.

For the injection process itself, we will examine if well construction is effective at containing fluids and gasses, and will assess the potential for fluids or gasses to migrate to drinking water resources.

The draft study plan was recently reviewed by EPA science advisory board, and the final study plan will be released shortly. The EPA plans to release the results of the study in 2 reports: one in 2012 and one in 2014.

In addition to these research activities, the EPA has several regulatory authorities that can be used to ensure that natural gas production is carried out safely and responsibly.

The Safe Drinking Water Act's underground injection control program and the Clean Water Act's permitting and pretreatment programs are examples of authorities we use to regulate certain activities related to oil and gas production to protect public health and water quality.

The EPA works with States to ensure that gas extraction is carried out consistent with the Clean Water Act and Safe Drinking Water Act requirements to protect surface water, ground water, and drinking water. This year under the clean water programs, we produced a "Frequently Asked Questions" document to assist State and Federal Clean Water Act permitting authority within the Marcellus Shale region in addressing treatment and disposal of wastewater from shale gas extraction.

In addition, the EPA is developing a guidance to help States address water quality issues related with that, the wastewater treatment plants that accept that oil and gas wastewater.

Today, as part of our planning process for technology based standard on the Clean Water Act, we announced this morning our decision to develop national pretreatment standards for wastewater from shale gas extraction operations. The EPA will develop these standards with the input of stakeholders including States, industry, and public health groups. We plan to issue the proposed rule in 2014. These pretreatment regulations will ensure that shale gas wastewaters receive proper treatment and can be handled by wastewater treatment plants before the water is discharged to surface waters.

For the underground injection control program, the Energy Policy Act of 2005 contains an exclusion from permitting requirements for hydraulic fracturing for oil and gas. But this exclusion does not extend to oil and gas hydraulic fracturing activities when diesel fuels are used in the fracturing fluid.

The EPA is developing guidance for how to write permits for wells that inject diesel fuel using hydraulic fracturing. Separate from that, also under the underground injection control program, we're also coordinating with our State and tribal co-regulators to make sure that flowback and produced water, or the wastewaters basically from the extraction processes, are injected underground in a safe and a responsible manner when that's the chosen disposal method.

In closing, the EPA is committed to using its authority consistent with the law, and the best available science, to protect communities

across the Nation from impacts to water quality and public health associated with natural gas production activities.

Thank you again for the opportunity to testify.

[The prepared statement of Ms. Dougherty follows:]

PREPARED STATEMENT OF CYNTHIA DOUGHERTY, DIRECTOR, OFFICE OF GROUND WATER AND DRINKING WATER, OFFICE OF WATER, ENVIRONMENTAL PROTECTION AGENCY

Good morning, Madame Chairman, Ranking Member Lee, and Members of the subcommittee. I am pleased to be here today to discuss the EPA's role in ensuring that public health and water quality are protected during natural gas extraction and production activities.

Natural gas can enhance our domestic energy options, reduce our dependence on foreign supplies, and serve as a bridge fuel to renewable energy sources. If produced responsibly, natural gas has the potential to improve air quality, stabilize energy prices, and provide greater certainty about future energy reserves.

While natural gas holds promise for an increased role in our energy future, the EPA believes it is imperative that we access this resource in a way that protects drinking water sources and surface waters.

As we listened to citizens at public meetings across the country last year, we heard the concerns many have for their families, their communities, and their water resources. We also heard from citizens who expressed how much their communities sorely need the income that could be gained from natural gas production.

We believe that this important resource can be - and must be - extracted responsibly, in a way that secures its promise for the benefit of all. If improperly managed, natural gas extraction and production, including hydraulic fracturing, may potentially result in impacts to public health or our water resources. If we look at water across the entire shale gas extraction process, from water acquisition to wastewater treatment and disposal, some of the impacts on our water resources may include:

- stress on surface water and its uses and groundwater supplies from the withdrawal of large volumes of water used in drilling and hydraulic fracturing;
- potential contamination of drinking water aquifers resulting from faulty well construction and completion;
- compromised water quality due to challenges with managing and disposing of contaminated wastewaters, known as flowback and produced water, where contaminants could include organic chemicals, metals, salts and radionuclides

The EPA has an important role to play in protecting water resources and in working with federal and state government partners to manage the benefits and risks of shale gas production. We must effectively address the potential consequences of shale gas development on water resources using the best science and technology. To this end, we are working in the following areas and under the following authorities, among others, with stakeholders, including other federal and state agencies, the oil and gas industry, and the public health community, to evaluate and address the potential public health and water quality issues related to shale gas extraction. These actions are important pieces of the Administration's broader effort to ensure that natural gas production occurs in a safe and responsible manner, as laid out in the President's Blueprint for a Secure Energy Future. They are also consistent with the Secretary of Energy Advisory Board's recently released recommendations on steps to support the safe development of natural gas resources.

Research

At the direction of Congress, the EPA launched a study last year to better understand the potential impacts of hydraulic fracturing on drinking water resources. As part of this study, the EPA has engaged thousands of Americans across the country who currently live in areas where hydraulic fracturing is taking place. When complete, this peer-reviewed research study will help us better understand potential impacts of hydraulic fracturing on drinking water resources and factors that may lead to human exposure and risks, while reducing scientific uncertainties about environmental impacts from those processes.

As part of this effort, the EPA has used information gathered from oil and gas companies conducting hydraulic fracturing and from the many stakeholder outreach meetings the EPA held during development of the study plan. The draft study plan was recently reviewed by the EPA's Science Advisory Board, is in the last stages of being finalized, and is expected to be released soon. The EPA plans to release two reports, one in 2012 that will summarize existing data, intermediate progress re-

garding retrospective case studies, scenario modeling and laboratory studies; and one in 2014 that will provide additional scientific results on these topics and report on prospective case studies and toxicological analyses.

Examples of Authority to Protect Water Resources

While Congress specifically exempted selected oil and gas production activities from several environmental laws, a number of environmental protections continue to apply. The Safe Drinking Water Act (SDWA)'s Underground Injection Control (UIC) program and Sections 301(b) and 402(a) of the Clean Water Act (CWA) are two examples of laws the states and EPA use to regulate certain oil and gas production activities to protect public health and water quality. For example, the Energy Policy Act of 2005 contains an exclusion from the SDWA UIC program's permitting requirements for hydraulic fracturing for oil and gas, but this exclusion does not extend to oil and gas production activities when diesel fuels are used in fracturing fluids. The SDWA also regulates underground injection of flowback and produced water. The EPA and authorized states have the authority to regulate waste waters from oil and gas wells under Sections 301(b) and 402(a) of the CWA when they are discharged into publicly owned treatment works (POTWs) and surface waters. Under these two examples of authorities, the EPA has a number of activities underway, which I would like to outline for you.

Examples of Activities to Protect Water Resources

Under the CWA and SDWA, the EPA works with states to ensure that gas extraction is carried out consistent with CWA and SDWA regulations to protect surface water and drinking water. This year, the EPA produced a frequently asked questions (FAQ) document to assist state and federal permitting authorities within the Marcellus Shale region in addressing treatment and disposal of wastewater from shale gas extraction.¹ The document covers oil and gas extraction, centralized waste treatment, acceptance and notification requirements for publicly owned treatment works, pretreatment, and storm water. The FAQs have assisted the EPA and state personnel as we have worked with the regulated community to address shale gas extraction wastewater. In addition, the EPA is developing guidance to help states address water quality issues related to Centralized Waste Treatment Facilities or POTWs that accept oil and gas wastewater. As part of its effluent guidelines planning process under CWA section 304(m), the EPA is considering whether to initiate a rulemaking to revise these regulations to address natural gas extraction flowback waters.

Under SDWA's UIC program, the EPA is working expeditiously to ensure the SDWA programmatic requirements related to hydraulic fracturing when using diesel fuels are implemented appropriately. The EPA is developing guidance to provide information to the states and regulated community on permitting wells that inject diesel fuels during hydraulic fracturing. With regard to flowback and produced water, we are coordinating with our state and tribal co-regulators to ensure proper management of flowback and produced water disposed of via underground injection.

Conclusion

In conclusion, the EPA is committed to using its authorities, consistent with the law and best available science, to protect communities across the nation from impacts to water quality and public health associated with natural gas production activities. Where we know problems exist, the EPA will not hesitate to protect Americans whose health may be at risk.

We remain committed to working with state officials, who are on the front lines of protecting water resources and regulating natural gas production activities. By helping manage environmental impacts and addressing public concerns, natural gas production can proceed in a responsible manner, which protects public health and enhances our domestic energy options. We believe that as a Nation, we can provide for the safe and responsible development of this significant domestic energy resource whose use brings a range of other important national security, environmental and climate benefits.

Senator SHAHEEN. Thank you very much.
Mr. RUSS.

¹This document is available at <http://cfpub.epa.gov/npd/hydrofracturing.cfm>

**STATEMENT OF DAVID P. RUSS, REGIONAL EXECUTIVE FOR
THE NORTHEAST, U.S. GEOLOGICAL SURVEY, DEPARTMENT
OF THE INTERIOR**

Mr. RUSS. Chairwoman Shaheen, members of the subcommittee who—Chairwoman Shaheen and members of the subcommittee, thank you for the opportunity to appear before the subcommittee to discuss the USGS's role in studying, understanding, and assessing the potential effects of shale gas production on water resources.

The Department of the Interior supports responsible development of natural gas as a clean energy sources. So it is important to investigate and evaluate potential impacts to the environment associated with shale gas development.

The Marcellus Shale is a rock formation that occurs across the Appalachians containing a potentially large economic resource space. The USGS recently released a new assessment of the undiscovered, technically recoverable, gas resources of the Marcellus Shale. Results show that there is a mean value of 84 trillion cubic feet of gas within the Marcellus Shale system.

The USGS is coordinating ongoing and planned Marcellus Shale gas research and monitoring, a complement other Federal and State shale gas programs, particularly those of our sister bureaus within Interior. We are collaborating with the EPO—EPA on its ongoing national study on hydro fracturing and its potential impact on drinking water.

For example, we are drilling several observation wells in the vicinity of an EPA prospective wellsite in western Pennsylvania to provide a baseline on groundwater quality prior to the drilling of a nearby gas production well.

The USGS leads an ad hoc Federal Committee that is preparing a plan to help facilitate a coordinated Federal—State approach to evaluate the environmental effects of shale gas production in the Delaware, Susquehanna, and Ohio River Basins. USGS activities on the potential environmental effects of shale gas exploration and production include research to protect water supply and water quality, to measure baseline water quality conditions, and to conduct research on potential impacts to land cover and ecosystems. The USGS conducting studies to assess potential for this contamination.

In one study on water quality, the USGS is analyzing the composition of produced waters from the Appalachian Basin, focusing on the radium content in the water.

Another study investigated the occurrence of natural gas in private water supply wells in northern Pennsylvania using chemical and isotopic techniques to determine the nature and the source of the gas. The research showed the gas artificially injected into the deep storage reservoirs can migrate upward into shallow water wells, but that detailed studies are necessary to accurately identify the sources of this gas.

The USGS plans to develop a regional groundwater flow model for defined areas of the Marcellus Shale gas play to evaluate the fate of injected hydrofracture waters that are not recovered. Additional research is needed, however, to fully understand the potential fate of injected waters, particularly in areas where

hydrofracturing and resource production from shallow shale beds is permitted.

Because natural gas emanating from subsurface rock and alluvial formations can be both natural and man-generated, baseline monitoring before, during and after gas exploration and production activities is needed to detect the possible presence of the gas and to distinguish among gas sources. To meet this need, the USGS is conducting a number of baseline surface and groundwater studies.

One of the studies is characterizing the existing water quality of natural park supply wells or public wells serving these park units in order to provide a baseline of comparison with future water quality conditions.

To provide a basis for improved regional baseline monitoring, the USGS has enhanced its existing water quality monitoring network in Pennsylvania through support from the Pennsylvania Department of Environmental Protection. These activities are providing a snapshot of conditions at selected locations.

A more comprehensive, regional monitoring, assessment, and research program would provide the data and information to understand the relations among hydrofracturing, environmental setting, and management factors on water resources of the area.

USGS resource—research on potential impacts of shale gas production on biological resources is focused on assessing changes in land use patterns and possible impacts on forests and aquatic habitats.

The USGS is using airborne imagery to assess forest fragmentation caused by shale gas activities and its possible effects on the abundance of migratory bird populations. Research also is addressing the effects of habitat change on key aquatic species in the Marcellus Shale region, including eastern brook trout and the federally endangered dwarf wedge mussel.

There are a variety of additional issues related to water resources and shale gas production that warrant investigation by the appropriate agency, institution, or industry.

Thank you, Chairwoman Shaheen. I will be happy to answer any questions you, or the other members, may have.

[The prepared statement of Mr. Russ follows:]

PREPARED STATEMENT OF DAVID P. RUSS, REGIONAL EXECUTIVE FOR THE
NORTHEAST, U.S. GEOLOGICAL SURVEY, DEPARTMENT OF THE INTERIOR

Thank you Chairwoman Shaheen and members of the subcommittee for the opportunity to appear today to discuss with you the U.S. Geological Survey (USGS) role in studying, understanding, and assessing the potential effects of shale gas production on water resources and related scientific topics. I am David P. Russ, Regional Executive for the Northeast Area. I manage USGS science centers and activities in the northeastern U.S. and coordinate USGS shale gas studies in the Northeast. I represent the USGS in meetings of the Delaware and Susquehanna River Basin Commissions (DRBC & SRBC).

The USGS serves the Nation by providing reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; study and assess water, biological, energy, and mineral resources; and enhance and protect our quality of life. USGS conducts scientific investigations and assessments of geologically-based energy resources, including unconventional resources such as shale gas and shale oil. USGS programs to monitor and investigate the Nation's surface and ground water resources are fundamental in determining water availability and water quality, including the potential impacts of energy resource extraction on drinking water, healthy ecosystems, and the sustainability of

living species. The Department of the Interior (Interior) supports responsible development of natural gas as a clean energy source, so it is important to investigate and evaluate potential impacts to the environment associated with shale gas development.

USGS research related to shale gas development is an important part of the Administration's actions to ensure the natural gas production proceeds in a safe and responsible manner. These research activities are in line with priorities identified in the President's Blueprint for a Secure Energy Future, and are also consistent with the Secretary of Energy Advisory Board recommendations on research steps to support the safe development of natural gas resources.

Role of the USGS in Unconventional Energy Resource Studies in the Northeast

The USGS conducts research and assessments of the undiscovered, technically recoverable oil and gas resources of the United States (exclusive of the Federal outer continental shelf). Advances in drilling technologies and subsurface geophysical imaging techniques over the last 20 years have enabled a new class of petroleum systems, primarily coal, shale and tight sands, to become more easily accessible and economically viable as petroleum sources. These unconventional systems lack traditional oil and gas trapping structures, are regional in extent, occur in rock of extremely low permeability, and, therefore, require artificial stimulation such as hydrofracturing to produce the gas or oil (see attached *figure 1).

The Marcellus Shale is one of a number of shale formations that occur across a considerable area in the Appalachians. The Marcellus Shale is sufficiently thick and organically rich to contain a potentially large economic resource base. In August 2011, the USGS released a new assessment of undiscovered oil and gas resources of the Marcellus Shale. Results from the assessment found that there is a mean value of 84 trillion cubic feet of gas within the Marcellus Shale system, an amount that is significantly higher than the 2 trillion cubic feet estimate provided in an USGS assessment conducted in 2002 before the application of modern hydrofracturing and horizontal drilling technologies. By comparison, according to the Department of Energy's (DOE) Energy Information Administration, the total natural gas consumption for the United States in 2010 was about 24.1 trillion cubic feet. The USGS recently completed and is preparing for release a new assessment of the unconventional natural gas and natural gas liquid resources in the Mesozoic Basins of the Eastern U.S. The geological and groundwater characteristics of various shale gas formations vary significantly across the region and can affect production economics and potential environmental impacts in different ways. USGS is conducting research that should allow for an improved understanding of the local and regional variations in gas abundance, composition, and quality. The results could serve to guide exploration strategies and the resultant need and locations of water resources to support future gas and oil development efforts.

Focus of USGS Shale Gas Research in the Northeast

The USGS is coordinating ongoing and planned research activities that complement other Federal and State shale gas programs, with particular effort being made to support the decision-making needs of Interior resource management agencies. For example, the USGS is coordinating with the Environmental Protection Agency (EPA) in its ongoing national study on hydrofracturing and its potential impact on drinking water.

The USGS chairs a Federal committee, that includes representatives from Interior agencies, EPA and U.S. Army Corps of Engineers, that is preparing a plan to help facilitate a coordinated Federal-State approach to evaluate the environmental effects of shale gas production in the Delaware, Susquehanna, and Ohio River basins.

USGS activities on potential environmental effects of shale gas exploration and production is focused on three primary topics: 1) research to protect water supply and water quality, 2) measurement of baseline water-quality conditions, and 3) research leading to improved management of short term and cumulative impacts to land quality and terrestrial and aquatic ecosystems. The USGS currently is focusing monitoring and research on documenting and understanding the conditions of water quality and availability and habitat conditions prior to land disturbance and shale gas development. In the Marcellus Shale gas area, the USGS is focusing on the potential effects of hydrofracturing and gas production to water quality and the occurrence of natural gas in private water wells (so-called "stray gas"). Concerns about the possible presence of gas and hydrofracturing chemicals in private water-supply wells have been raised by citizens living in areas where shale gas production is underway.

*All figures have been retained in subcommittee files.

Protecting Water Supply and Water Quality

The possibility of surface and ground water contamination from drilling practices at the well pad, accidents, groundwater transport, and the construction of pipelines and support facilities to collect and convey gas has been a prevailing topic in public discussion. Drilling regulations and permits issued by federal and state agencies and water basin commissions, as well as industry best management practices, are designed to minimize these potential problems. However, whether these practices and regulation are adequate to protect water supplies and water quality during drilling and production are still a concern and the need to review and modernize regulations and best practices was noted in the Secretary of Energy Advisory Board Shale Gas Production Subcommittee—90-Day Report. Some of the key water supply and quality concerns related to Marcellus Shale gas production include:

- Effect of water withdrawal for well construction and hydrofracturing on local water resources,
- Effects of land disturbance from road, bridge, and drill pad development and from heavy equipment travel on stream sedimentation and small watershed degradation,
- Safe storage and disposal of the large quantities of fluids recovered from the wells, which may contain salt and radioactive elements,
- Composition and fate of chemicals introduced into the well bore during hydrofracturing and the potential effect of these chemicals on public drinking water supplies, groundwater, wetlands, and sensitive habitats.

Examples of ongoing USGS Studies

- The USGS is analyzing the composition of produced waters from the Appalachian Basin (waters that flow into the well after well completion and during the gas production phase) and recently released a publication on this topic that focuses on the radium content in the produced waters.
- USGS is studying the occurrence of natural gas in private water-supply wells in northern Pennsylvania, using chemical and isotopic techniques to determine the nature and source of the gas. This “stray gas” can emanate from a variety of natural and human produced sources, which may include abandoned oil and gas wells, subsurface fluid injection wells and water wells. Because there are tens of thousands of abandoned wells in Pennsylvania, the potential occurrence of abandoned well leakage is a significant issue. Stray gas also can be released naturally by various organic-rich rock formations, abandoned coal mines, landfills, and decaying vegetative matter in alluvial fill (biogenic gas).
- The USGS is collecting water resource data from the Marcellus Shale gas region and is using these data to assess the potential effects of hydraulic fracturing on water resources in the Marcellus Shale area.

Planned USGS Research

- The USGS plans to use its modeling capabilities to develop a regional groundwater flow model for specific areas of the Marcellus Shale gas play to evaluate the fate of injected hydrofracture waters that do not return up the wellbore to the surface as “flowback waters” (a relatively small proportion of the water in Marcellus wells currently returns to the surface). Additional research is needed to fully understand the potential fate of the injected waters, particularly in areas where hydrofracturing and resource production from shale beds as shallow as 2,000 feet from the surface is permitted. For example, a recently published USGS study shows that artificially injected deep gas can and does migrate into shallow water wells in the Marcellus Shale gas area in northern Pennsylvania.

Baseline Water Quality and Natural Gas Measurements

Because natural gas can and does emanate from a variety of subsurface rock and alluvial formations (for example, organic shales, abandoned coal mines, conventional oil-and gas-bearing rocks, landfills, and river valley alluvial fills), baseline monitoring for natural gas occurrence is needed for research purposes prior to, concurrent with, and following gas exploration and production activities in order to detect and/or distinguish among these gas sources. Given the challenge of conducting such monitoring that would cover the entire extent of the Marcellus Shale gas area with sufficient instrumentation for meaningful analysis, USGS recommends that several representative pilot areas be instrumented to support the collection of baseline water quality and gas data. It is important that the monitoring be maintained for

an extended period of time to ensure a scientifically adequate sample size to detect water quality anomalies and determine possible trends.

USGS is conducting a number of baseline surface water and groundwater quality studies, including:

- Groundwater quality baseline monitoring and simulation of groundwater sources to wells is underway at the USGS Northern Appalachian Research Lab in Wellsboro, PA.
- Improvements to the USGS water-quality monitoring network in Pennsylvania have been made to enhance monitoring in headwater streams near drilling operations. Through support from the Pennsylvania Department of Environmental Protection, eleven new sampling sites were added in small headwater streams during FY 2011, and the frequency of sample collection and analysis was increased at existing sites. Ten new continuous monitors were added for temperature, dissolved oxygen, specific conductance, and pH that will improve the baseline of water quality in the State.
- Baseline water quality in National Park units within the Marcellus and Utica Shale gas plays is being assessed. This work is characterizing the existing water quality and radiochemistry of National Park supply wells or public wells serving these park units in Pennsylvania, New York and West Virginia in order to provide a basis of comparison with future conditions, including identification of the potential effects of hydrofracturing (see figure 2).
- Construction of several observation wells near an EPA prospective research site in western Pennsylvania is underway to provide background data on groundwater quality prior to the drilling of a primary Marcellus Shale gas well nearby. This project is part of USGS's collaboration with EPA on its national study regarding the potential impacts of hydrofracturing operations on drinking water supplies.
- USGS is monitoring baseline surface water and groundwater quality in the Lycoming Creek watershed in northeastern Pennsylvania and in Blair County in central Pennsylvania.

The activities are providing a snapshot of conditions at selected locations. A more comprehensive regional monitoring, assessment, and research program would provide the data and information to understand the relations among hydrofracturing, environmental setting, and management factors on water resources of the area.

Managing Short-Term and Cumulative Impacts on Land Use, Wildlife, and Ecosystems

Potential impacts to biological resources and the water resources available to sustain them due to activities associated with shale gas development are also being investigated. The use of large volumes of freshwater for drilling, completion of shale gas wells, and for hydrofracturing purposes will result in a net loss of available freshwater. To reduce freshwater use, most companies recycle fracture water that has been "rehabilitated" after initial use, however, impacts to freshwater resources may remain. Additionally, fragmentation of the forest canopy due to Marcellus Shale gas development in the region could potentially create challenges for plants and wildlife and open avenues for invasive species.

For biological resources, landscape scale research is important to quantify responses of key species and ecological communities to the impacts resulting from development of energy resources within the Marcellus Shale and to develop best management practices to identify and mitigate impacts. In addition to traditional biological and ecological research, new interdisciplinary approaches linking ecology, economics, and geospatial modeling frameworks can be applied to assess impacts across the full suite of ecosystem services and provide the science decision-makers need to prioritize management decisions.

As a first step, USGS research on potential impacts of shale gas production on biological resources is focused on using remotely sensed airborne imagery to assess forest fragmentation and effects of shale gas activities on land use patterns and the abundance of migratory bird populations in key areas where shale gas production is underway. Research also is addressing the effects of habitat change on key aquatic species in the region affected by Marcellus Shale production, including eastern brook trout and the federally endangered dwarf wedge mussel.

General Research and Development Needs

There are a variety of important issues related to water resources and shale gas production that warrant investigation by the appropriate agency, institution or industry. These include:

- Characterization of the physical processes by which rock fractures are formed and propagate during the hydrofracturing pressurization process. The USGS previously has conducted research on hydrofracturing in an effort to characterize the Earth's natural stress fields as part of its Earthquake Hazards Reduction Program. Controlling the propagation of induced fractures is important to limiting water use required in hydrofracturing, minimizing the potential for the formation of large contiguous fracture sets that could potentially serve as conduits to transmit hydrofracturing fluids to or near aquifers and/or the Earth's surface, and maximizing the yield of gas from the reservoir.
- Assessment of water requirements necessary to re-hydrofracture gas wells that are declining in gas production. This research would address the important topic of re-use of existing wells, thereby reducing the need to drill new wells and minimizing additional impacts on the environment. Important components of this research would be the application of advanced microseismic techniques to better understand how the original fractures formed during the hydrofracturing process and whether re-hydrofracturing might simply open up existing fractures rather than generate new ones, which would significantly reduce the potential gas yield from the well.
- Investigation of the effects of water flowing through fractures generated by hydrofracturing on gas yield. As gas production in a well diminishes over time, there is reduced gas pressure in the fractures, so the water in the fractures could act as a "flow retardant." Pressure, however, is necessary to drive water and gas out of the rock and into the well. The research would address mechanisms to enhance gas flow.
- Understanding induced seismicity triggered by the injection of shale gas waste fluids into the subsurface. The USGS has conducted research on induced seismicity as part of the Earthquake Hazards Reduction Program. USGS has partnered with the Arkansas State Geological Survey to evaluate a series of earthquakes during the past year and assess whether they may have been generated by waste water fluid injection in wells in the Fayetteville Shale gas play area.

Thank you, Chairwoman Shaheen, for the opportunity to share USGS research activities and plans on the very important topic of the potential effects of shale gas production in the Northeast on water resources. I will be happy to answer any questions you or the other Members may have.

Senator SHAHEEN. Thank you very much, Dr. Russ.

Since this hearing is supposed to be addressing gas development and water resources in the eastern United States, and much of the previous hearing has dealt with gas development out West, perhaps you could start by talking a little bit about what's different about shale gas development in the East versus the West as we look at the geology?

Mr. RUSS. Right. The shale gas development in the East largely relates to the Marcellus Shale gas and the Utica Shale. Because of the demonstrated existence of high amounts of shale gas in the Marcellus, this has really taken off in the last few years as a primary target.

The thickness of the shale potentially accommodates a large amount of gas. The amount of gas in the enriched organic matter within that gas makes it a truly attractive target.

There are some differences in the types of gas between the northern part of the area in New York and Pennsylvania versus the southern part into West Virginia, but still, it's an attractive target.

The gases in other parts of the United States, whether it's the Barnett Shale in Texas or the Fayetteville Shale in Arkansas, are also very attractive targets. They have been, I think, under production for a bit longer period of time than Marcellus. But certainly the recent ability to do hydrofracturing and horizontal drilling, and the recognition of the target for opportunity in the Marcellus is making that an area of significant current play.

Senator SHAHEEN. Can you talk about whether the geology of water in the eastern United State is different, and how that might affect production?

Mr. RUSS. One I am—can remark upon, Senator, is the fact that the Marcellus Shale has higher salinity levels in the water related to where the gas is than of the other oil and gas reservoirs that we are familiar with in the United States. So that high level of salinity must be dealt with, of course, by industry, but it also is a potential for mobilizing higher levels of radium than perhaps in some of the other basins and areas of production. So it's something that we're looking at and studying at this point in time.

Senator SHAHEEN. Thank you.

Ms. Dougherty, did you want to add? Is there anything that you would like to add to, as we look at—

Ms. DOUGHERTY. Yes, I would like to say that the—

Senator SHAHEEN. The differences?

Ms. DOUGHERTY. The higher levels of salinity may create issues that need to be dealt with in terms of the produced water discharges and what's done with the produced water. It is an issue that's come up in Pennsylvania that Pennsylvania DEP and EPA are working together to look at.

Senator SHAHEEN. Does the level at which groundwater can be accessed have any impact that's different in the East than the West?

Mr. RUSS. I don't know of any difference in the impact. It's of interest to us to understand where is the groundwater moving? Is it flowing in some regional fashion? If so, where is it moving to?

In some areas, you can hydrofrac and develop shale resources of shale is 2,000 feet. So understanding, given those relatively shallow depths what the groundwater regime is, we believe it's important. That's why in my testimony, I mentioned the development of a regional groundwater flow model.

Senator SHAHEEN. Thank you.

Ms. Dougherty, you talked or you mentioned that just today, the EPA is proposing new standards for wastewater disposal for shale gas. That this process will likely take until 2014?

Ms. DOUGHERTY. To get to the proposal, yes. Yes.

Senator SHAHEEN. Can you talk a little bit about—

Ms. DOUGHERTY. Sure.

Senator SHAHEEN. What's going to be involved in that?

Ms. DOUGHERTY. Sure. EPA has under the Clean Water Act permit—there are permits required for discharge of wastewater to surface waters in the United States. Those permits are set up in terms of technology-based standards which apply across the country, and then water quality-based standards which States apply based on the standards they've set in their State. So the technology-based standards are the floor, basically.

There are no such standards for wastewaters from shale gas extraction. Right now, the standard that applies to them does not allow direct discharge of those wastewaters. But the wastewaters are being taken to sewage treatment works or to the centralized waste treatment works to have treatment before they're discharged.

There really isn't a good treatment right now available for some of the things that are in the wastewater, and so we need to work through what can't—what should be done in terms of those technology-based standards that everyone can use. This is an issue we've been working, particularly with Pennsylvania on, because there were a number of sewage treatment plants that were being asked to accept the waste and they could create problems, both for the sewage treatment works working, as well as for the water quality were they discharged.

Senator SHAHEEN. Do we know what treatment methods are out there that can address—

Ms. DOUGHERTY. There's some treatment methods that are out there, but the purpose of doing the regulatory process is to find out what treatment exists and what treatment would be usable to the industry. In some cases—and what they've done previously is they decided that the best, the most economical way to dispose of the waste was through injection, which is covered under the underground injection control program. So, they've got to sort out whether or not it could be done through the sewage treatment plant.

Senator SHAHEEN. Thank you.

Senator LEE.

Senator LEE. Dr. Russ, as I understand it, the U.S. Geological Survey has been conducting some well water testing in Van Buren County, Arkansas within the Fayetteville Shale gas play looking for possible links between concerns over drinking water and natural gas drilling.

Can you tell us a little bit what—about what you found after testing in what I understand to be 71 samples? What did you find there?

Mr. RUSS. Yes, in fact, this is quite recent information. You're quite right, Senator, and what we found is we detected no evidence of any contamination or materials from the hydrofracturing process or drilling effort that have gotten into any of the wells that were sampled. These wells are peripherally right in the area of where the drilling is ongoing.

Senator LEE. So do you know what it is you're looking for? I mean, what is it you're looking for? Are there specific chemical markers you're trying to identify when you conduct those samples?

Mr. RUSS. Yes. We look, certainly, for evidence of salinity, which would be an indication potentially of mobilized salt related to the shale gas and the hydrofracturing process being able to get into shallow private water wells, for example. Any anomalous chemicals that otherwise were not expected to be in the groundwater. I don't know right off the top just which chemicals are we're looking for.

Senator LEE. So how would you characterize the quality of the water that you sampled, then?

Mr. RUSS. We would say that there's no demonstrable change whatsoever from the natural, native water that's there before the drilling.

Senator LEE. OK. Do you plan to conduct additional tests in the Fayetteville play or in other plays around the country?

Mr. RUSS. We have not made those decisions yet, Senator.

Senator LEE. OK. How—and then, do you store that data? I guess the plan is to store that data and compare it to data you might collect in the future to see if anything changes?

Mr. RUSS. We would store it, but most probably would also release it in the form of a report, a technical report or a published—a publication of some sort.

Senator LEE. OK. But you were, I assume, somewhat relieved by the findings that you did make, by what you discovered, the lack of contamination that you saw?

Mr. RUSS. We—in the USGS, we try to maintain a non-advocacy neutral position. We report what we find and then let others make the decisions.

Senator LEE. Free of any positive or negative emotion, in other words.

Mr. RUSS. Yes.

Senator LEE. OK. That's good to know.

Ms. Dougherty, I've got a question for you. So you issued a press release that says that you're proposing a schedule to develop new standards for wastewater discharges produced by shale gas extraction. Is the NPDES program insufficient in some way in order to cover that kind of concern or is this?

Ms. DOUGHERTY. Right now, under the NPDES program, this will be covered by the pretreatment part of that program, because there's no direct discharge allowed.

But under the pretreatment part of the program, there are no technology-based standards for what someone who would be bringing that produced water to a sewage treatment plant would need to do beforehand. Usually, you would have to pretreat industrial wastewater so that you wouldn't have what we call interference or pastures.

So interference would be, you don't want to screw up the sewage treatment plant because then you'd have raw sewage going into the water. Pasture is you don't want contaminants going directly into the surface water that don't get treated in some way if they're going to cause harm to the surface water.

So right now, in order to deal with that, the EPA or the State, or actually in the case of Pennsylvania, it's EPA and the State because the State has the permitting program, but EPA runs the pretreatment program. Would have to have the town or the sewage treatment plant would have to develop local limits for what they would do on a plant by plant basis, as opposed to having the underlying technology standards that could then be used whenever someone brings that waste to a source stream or plant. That's the point of doing it.

Senator LEE. Is it your perception that the State departments of environmental quality are inadequate in this regard, that they not capable?

Ms. DOUGHERTY. I wouldn't say that they're inadequate, but they can use the help. In fact, the State of Pennsylvania—the commissioner from the State of Pennsylvania requested that EPA do these rules.

Senator LEE. Requested that they do them so it could give them—

Ms. DOUGHERTY. That EPA do the national pretreatment standards for shale gas.

Senator LEE. So—

Ms. DOUGHERTY. I believe. I don't have a copy of the letter with me, but a few months ago or something like that.

Senator LEE. OK. So as to give them some guidance; they were looking for guidance?

Ms. DOUGHERTY. So, well to give them that technology-based standard that that would then be used, so that those sewage treatment plants that would be receiving the wastewater would know that it had been pretreated or what kind of limits they need to put on it to make sure they don't do something to the plant. That they don't end up putting wastewater out of the treatment plant that will cause problems in the water.

There have been some issues in terms of bromide levels, in particular, that can create problems for downstream drinking water plants.

Senator LEE. OK. Thank you. Thank you. Chair.

Senator SHAHEEN. Thanks. I'm going to try and follow up on some of those questions because I know, Ms. Dougherty, that in your opening statement, you referred to some of the Federal legislation under which the EPA gets involved in the issue of shale gas production. You talked about the pretreatment standards this afternoon.

Can you layout very easily the aspects of production that the Federal Government has jurisdiction over versus those that the State is involved in? Where they overlap, is that an easy—

Ms. DOUGHERTY. Sure. It's not easy.

Senator SHAHEEN. Description?

Ms. DOUGHERTY. I'll give you—let me just, I'll just talk about EPA. So I'm not going to talk about the Department of Interior where BLM has—

Senator SHAHEEN. Yes, good. That's fine.

Ms. DOUGHERTY. Their own authorities. The States have the authority to deal with oil and gas production. The EPA doesn't deal with permitting and doesn't have authority to say, "Yes, you can drill here." That's the authority—

Senator SHAHEEN. Right.

Ms. DOUGHERTY. Of the State. So the EPA gets involved and since you're dealing with water, I'm not going to talk about the air program either if that's OK, but I can—we can answer that later. From a water standpoint, as I said when I was talking about our study, there's water withdrawals. That, again, is a State function. In some cases, like in Pennsylvania, the Susquehanna River Basin Commission deals with water withdrawals or other commissions might do that. So that's not an EPA function.

There is storage of the water and the fluids that they use for hydraulic fracturing on the site. If there are spills from that storage, there may be things that either EPA or the State might be involved in. There's the actual injection for hydraulic fracturing to begin the drilling and the production. In that case, the Safe Drinking Water Act does apply where the driller is using diesel fuel as part of the hydraulic fracturing fluids. Otherwise, the EPA does not have an authority over the hydraulic fracturing injection itself.

The CHAIRWOMAN. Can you just explain why that's the case, relative to the diesel fuel?

Ms. DOUGHERTY. Congress in 2005 made the decision to exempt hydraulic fracturing from the definition of injection under the Safe Drinking Water Act. So under the Safe Drinking Water Act, any injection of basically anything is covered by the underground injection control program requires a permit for that injection to take place.

Now I should say when I'm talking about injection, be it for hydraulic fracturing or for the produced waters that I'll get to in a minute, in most States that have a lot of oil and gas production, the State is the permitting authority under the underground injection control program under the Safe Drinking Water Act for all the activity.

So even though it's a Federal law, the State has set State laws which we've approved—which EPA, over the years, actually decades ago in most cases, has approved as either as stringent as, or as effect as EPA's rules for them to carry out the program. So in most States the State is carrying out the underground injection control permitting program, and EPA retains an oversight responsibility, but basically, the States are the people on the ground who are doing the work. It's very much in a lot of States, it's in concert with the work that they're doing on the oil and gas production side as well. Is often, if not usually, in the same part of the State in the same department. So it may not be in the environmental department at all; it may be in a different department of a State.

So then, once the hydraulic fracturing is done, there's what's called flowback water. You correct me whenever I get this wrong. That's called—there's flowback water that comes up right after the hydraulic fracturing is done, which includes a portion of the hydraulic fracturing fluid and a portion of the water, as you said in your opening statement, somewhere in the 20 percent range; sometimes more, sometimes less.

What happens with that water probably—is likely covered by either the Clean Water Act or the Safe Drinking Water Act. If they reinject it, which is often done and has historically been what's been done further west, than the UIC program, the Underground Injection Control program covers. Again, that's the thing, the program the States are usually carrying out that we've approved.

If it is taken either trucked or somehow taken to a sewage treatment plant or a centralized waste treater for discharge to surface water, we talked about that just a few minutes ago, the NPDES program and the pretreatment program related to that would apply, and there are requirements, and in most cases the—but in not all States. The State is the permitting authority under NPDES. There are 11 States that have the NPDES program where EPA is the pretreatment authority. Then there's still a few States where EPA is the NPDES authority as well.

Then there's produced water, which is as they're producing the gas, there's more water that comes out. The disposal of that water is the same—is in the same kind of thing.

Now in both of those cases, there are other choices that could be made. They could recycle the water. Based on what's been happening in Pennsylvania, there's been a lot of effort for the drillers

in the Pennsylvania area to look at recycling as a choice, and I think that's been happening across the country.

EPA in getting information from the people who have been sending their produced water to the wastewater treatment plants in Pennsylvania had been telling them that they planned by this year to be recycling up to 90 percent of their produced water. I don't know whether that's actually happened or not, but there's definitely a movement to do that.

So if they recycle it, then there's not a permit that applies under either the Clean Water Act or the UIC program. That water's reused for the next hydraulic fracturing along with the other water. They need to replenish it since there won't be as much as they would need. So that, I think, that covers pretty much everything.

But the States, you know, the States are doing their normal permitting program in terms of oil and gas, and they have requirements in terms of—they have requirements not just in terms of the sighting of the wells, but also the construction of the gas wells and the operation of those wells. Those vary, depending on the State.

Where the UIC program comes into play, there are a number—there are obviously lots of criteria that we have in terms of what happens. If there are other issues, there are emergency response authorities that we have. There are other issues that I didn't mention in terms of air. There are some issues in terms—there are some authorities in terms of TSCA that might apply in terms of the kinds of chemicals that might be used. NEPA will apply if Federal lands are involved, which happens with BLM.

Senator SHAHEEN. So not an easy delineation.

Ms. DOUGHERTY. No.

Senator SHAHEEN. Thank you. That's very helpful. I have, actually, some follow up questions on that, but my time is over, so I'm going to turn it over to Senator Lee first.

Senator LEE. How often is diesel fuel used in the injection fluid?

Ms. DOUGHERTY. I don't actually know. We believed back when the Energy Policy Act was passed in 2005 that it was not going to be used a lot, because we had an agreement with 3 major hydrofracking companies that they wouldn't use diesel fuel any longer in their coal bed methane hydrofracking. But then as the world changed in terms of what was happening with shale gas, we understand from discussions with people and from things that people have said in meetings and from information that some Members of Congress have collected that it's being used a lot more than we thought it was. How much, I'm not—

Senator LEE. Do you—

Ms. DOUGHERTY. It's part of the fracking fluid, which is not a huge part of the volume, but it is being used.

Senator LEE. Right. Once that's used in the fracking fluid, then that changes the regulatory framework that you apply.

Ms. DOUGHERTY. That does change the regulatory framework, yes.

Senator LEE. That's as a result of the language of the exemption placed in the Energy Policy Act—

Ms. DOUGHERTY. Yes.

Senator LEE. Of 2005.

Ms. DOUGHERTY. Yes.

Senator LEE. Which provided that the exemption would not apply, but did it specifically mention diesel fuel or was it?

Ms. DOUGHERTY. Diesel fuel

Senator LEE. OK.

Ms. DOUGHERTY. Specifically.

Senator LEE. OK. Thank you.

Senator SHAHEEN. I want to go back to a couple of things that—to make sure I understood you correctly. When you were talking about the water that was being used, you said, “Now about 90 percent of it is being recycled,” or that’s at least what—

Ms. DOUGHERTY. That’s what the companies—

Senator SHAHEEN. That’s been suggested.

Ms. DOUGHERTY. That have called our regional office in—that deals with Pennsylvania. So that’s not necessarily the case elsewhere.

Senator SHAHEEN. Right, and—

Ms. DOUGHERTY. That may not be the case in Pennsylvania yet either, but that’s what they said they had—they intended to do.

Senator SHAHEEN. Is there any jurisdiction over that recycling of water, or does it matter because it’s all being used for the same process and?

Ms. DOUGHERTY. There would be 2 places where there might be jurisdiction. One is if it’s recycled in a way that it’s treated before it’s reused, then there might be a residual from the treatment, and then what happens to that residual would be probably covered by either a State and possibly EPA, but by some State authority.

If the residual is used or the water is used in another way to—in some cases there have been brine waters from gas production that have been used for deicing, there would be State requirements related to that.

Senator SHAHEEN. There have been some press reports that the brine, when it gets reused, actually maybe the States are not regulating, but there has been some suggestion that it’s being used without a real examination of what the impact might be. So if it were used on roadways for deicing or if it were used in other circumstances that there’s no real regulation of what the content of that might be.

Ms. DOUGHERTY. I don’t have information for every State, but I do have some information from Ohio and Pennsylvania both where they have—where they permit any use of brine for, I believe, for deicing. They have limits in terms of what the quality of that, of the brine can be. It’s quite likely that Marcellus Shale brine would not meet the requirements, or at least in the case of one of the permits. You don’t know any? I don’t know any more about that.

Senator SHAHEEN. Do you want to add to that, Dr. Russ? Do you have any additional information?

Mr. RUSS. I know that in most of the examples I’m familiar with from visits to the area that most of the flowback water is secured in tanks, or sometimes through pipeline and sent to other well sites.

I’ve been told that on one or so occasions when some flowback water is received that samples are taken for analysis to see what might be in it. But before the analysis are made or at least received back for consideration, that the water is consigned for other

uses, including things like spraying as dust suppressant on roads in upstate Pennsylvania, for example.

Senator SHAHEEN. What would be in that brine that might make it harmful?

Mr. RUSS. Things such as radium.

Senator SHAHEEN. That would come up as the result of drawing the water out of the ground. So it would be existent in the water as it was in the ground?

Mr. RUSS. Possibly. Each flowback water situation is different, as Ms. Dougherty said. The amount of flowback varies well to well, and therefore the composition of what might be in the water varies as well.

Senator SHAHEEN. OK. Casing and cementing are obviously key as we look at the potential for seepage into the water table. Can you, either of you, speak to whether well design including the casing and the cementing is being adequately regulated at the State level?

Ms. DOUGHERTY. Actually, Lori might be able to help you better more on—

Senator SHAHEEN. OK. I will—

Ms. DOUGHERTY. That one, when you talk to her.

Senator SHAHEEN. Reserve that for the next panel then.

Ms. DOUGHERTY. Where there's a UIC permit involved, we have specific requirements related to well casing and cementing, but that's where a permit's required.

Senator SHAHEEN. OK. Thank you. I don't have any further questions for either of you. Senator Lee?

Thank you both very much.

Ms. DOUGHERTY. Thank you.

Mr. RUSS. Thank you.

Senator SHAHEEN. I appreciate it.

Mr. RUSS. Thank you.

Senator SHAHEEN. If we could ask the next panel to come up.

Good afternoon, everyone. Thank you all for joining us, and hopefully we won't be too much later than you were anticipating for this panel.

I am going to start with you, Ms. Wrotenbery, for your testimony. So if you would like to begin.

STATEMENT OF LORI WROTENBERY, DIRECTOR, OIL AND GAS CONSERVATION DIVISION, OKLAHOMA CORPORATION COMMISSION

Ms. WROTENBERY. Thank you, Chairman Shaheen and Ranking Member Lee.

Appreciate the opportunity to come talk to you today about what the States are doing to review and update their regulations to make sure that shale gas development is being conducted safely. There is a lot of work going on at the State level across the country.

In my written testimony, I went into some detail about some things going on in Oklahoma, but I understand the focus today is on the eastern United States, so I'll just say that I provided that information as just an example of the kind of work that's going on. I do know the same kind of effort is underway in the Marcellus

Shale States. I have heard reports, actually earlier this week from a number of my counterparts in States, in Marcellus Shale States about what they have going on and what the status of their efforts are.

We had a meeting of the Interstate Oil and Gas Compact Commission in Buffalo earlier this week, and my counterparts from New York, and Pennsylvania, and Ohio, and other States were there and gave reports on the status of their regulatory development work.

They also talked about the challenges they're facing, and we are all addressing challenges that are associated with shale gas development. The challenges vary from State to State, and region to region. So the particular character of the challenges, you have to look at the individual State and see what's underway there to really understand them. But there are some things in common with horizontal drilling and the multistage hydraulic fracturing operations that are being used to free up the gas from the shale reservoirs.

You've got a lot of water involved. You've got a lot of freshwater that's required to make up the hydraulic fracturing fluid. Then when you flowback the water, in order to begin producing the well, you have a large volume of wastewater to manage. That scenario is being addressed by a number of States. I will say the States are all acting to address those challenges, and I would refer you to some of the reports that STRONGER has issued over the last year.

STRONGER is a stakeholder organization. It was originally set up by the Interstate Oil and Gas Compact Commission and the U.S. Environmental Protection Agency to help benchmark State regulations for oil and gas waste management. To develop guidelines for effective State regulatory programs and to review State programs against those guidelines. Over the years this process, this stakeholder process has been used to evaluate State programs. In fact, 21 States over the years have been reviewed under the STRONGER process.

Most recently, STRONGER convened a workgroup to develop some guidelines specifically addressing hydraulic fracturing and some of the issues that have arisen concerning hydraulic fracturing, and the safety of hydraulic fracturing operations, and the effectiveness of the State regulations.

The guidelines were developed by a stakeholder workgroup. Everything STRONGER does is done by stakeholder teams and stakeholder workgroups with equal numbers of representatives from the State regulatory community, the industry, and the environmental community.

So it was a stakeholder process. Guidelines were developed and then since then, STRONGER has done reviews of already 5 States using the hydraulic fracturing guidelines. Pennsylvania and Ohio were first and they were shortly followed by Oklahoma, Louisiana, and Colorado. The Colorado report just came out earlier this week. A STRONGER team is going to Arkansas in November to review the hydraulic fracturing regulations there.

But if you look at the State reports, I think you'll see documented there what kinds of challenges the States are facing in regulating shale gas development, and how the States are addressing those challenges.

I also wanted to just mention briefly FracFocus. This is another State effort that's underway to try to address the public's desire for information about hydraulic fracturing and what kind of chemicals are used in hydraulic fracturing fluids. This is a Website that was set up by the Ground Water Protection Council and the Interstate Oil and Gas Compact Commission to provide information about hydraulic fracturing and also to set up a chemical registry where companies can report the chemical constituents of their hydraulic fracturing fluids.

I've given you the latest statistics on that site, but we've got over 5,000 wells now that have been reported on the FracFocus wellsite—Website.

Also I should say, right now the system is a voluntary system. It was set up that way, but a number of the States are adopting requirements that operators use that system to report on the chemical constituents of their frac fluids. So we are seeing more and more of the companies reporting their wells through that FracFocus Website.

That's a very quick summary of my written testimony, but I'll end there and be happy to address any questions.

[The prepared statement of Ms. Wrotenbery follows:]

PREPARED STATEMENT OF LORI WROTENBERY, DIRECTOR, OIL AND GAS
CONSERVATION DIVISION, OKLAHOMA CORPORATION COMMISSION

Thank you for the opportunity to testify today about the actions being taken by states to address the potential impacts on their water resources from the development of their shale gas resources. I very much appreciate your interest in hearing the perspective of a state regulator on how states are working with oil and gas operators, local communities, environmental organizations, and other stakeholders to realize the economic potential of our natural gas resources while ensuring public safety and protecting the environment.

Recent technological developments have given us access to natural gas resources held tightly in shale formations. We welcome this new opportunity. We also recognize the challenges it presents, particularly to those of us who work on a daily basis to manage and protect our precious water resources. To address these challenges, states across the nation are actively reviewing and updating their regulatory standards and procedures to ensure that shale gas drilling and production operations are conducted safely. States are also continually testing, evaluating, and strengthening the mechanisms they have in place to develop, implement, and enforce sound regulations.

To give you a sense of the breadth and vitality of these state efforts, I would like to briefly summarize activities in three areas: (1) recent regulatory developments in the State of Oklahoma, which are in many ways specific to the particular circumstances there, but also have much in common with efforts underway in other shale gas states, including those in the eastern United States; (2) the work being done through the stakeholder process called "STRONGER" to assist the states in benchmarking and improving their environmental regulations for oil and gas drilling and production operations; and (3) the development by the Ground Water Protection Council (GWPC) and the Interstate Oil and Gas Compact Commission (IOGCC) of the website called FracFocus and the chemical registry and other information available to the public on that website.

Regulatory responses to development of the Woodford Shale in Oklahoma

Oklahoma has a long history of oil and gas exploration and production. The first commercial oil well was completed in 1897. Subsequently over half of a million oil and gas wells are estimated to have been drilled in the state.

I've attached a *fact sheet to this testimony to give you an idea of the nature and extent of oil and gas operations in the State of Oklahoma. We presently have about 190,500 active wells in Oklahoma—roughly 115,000 oil wells, 65,000 gas wells, and

* Fact sheet has been retained in subcommittee files.

10,500 injection wells. They are widely distributed throughout most of the 77 counties in the state.

In the early days most of the wells were drilled for oil. In recent decades, however, natural gas has dominated the exploration and production activity in Oklahoma. While crude oil is still a vital and highly valued component of the state's economy, Oklahoma today is truly a natural gas state. Assisted by advances in horizontal drilling and hydraulic fracturing technology, oil and gas operators in Oklahoma are actively developing the Woodford Shale.

The Oklahoma Corporation Commission (OCC) was established at statehood in 1907 and was first given responsibility for regulating oil and gas production in Oklahoma in 1914. OCC regulates public utilities, trucking, pipelines, petroleum storage tanks, and various other activities as well as oil and gas drilling and production.

The OCC is headed by three statewide-elected officials who serve staggered five-year terms. The Commission sets policy by adopting rules. The Commission also meets in public on a daily basis to issue orders based on the record created through formal, evidentiary hearings in various permitting, ratemaking, and enforcement proceedings.

My division, the Oil and Gas Conservation Division, is responsible for implementing and enforcing the rules and orders of the Commission for oil and gas exploration and production operations. Regulating the drilling, completion, and production of the multitude of oil and gas wells in the state requires a full complement of specialists: engineers, geologists, hydrologists, attorneys, technicians, and inspectors. These are the professionals I work with every day to ensure oil and gas operations in Oklahoma are conducted in compliance with the Commission's rules and orders.

All of these individuals, from the Commissioners on down, play key roles in our organization, and I don't wish to slight any of them, but I wish to emphasize the importance of our field staff. Our most fundamental regulatory operations occur in the field, not in an office. I believe our field inspectors are the single greatest strength of our regulatory program.

Our 58 field inspector positions cover the state. Field inspectors are required by statute to live within 37.5 miles of their territories. They work out of trucks that are fully equipped as mobile offices with computers, GPS units, field sampling kits and other equipment they require on a daily basis. They are the first point of contact for most of the people we serve—oil and gas operators, landowners, local government officials, and others. Our field inspectors are truly members of the communities they serve—indeed many of them grew up in the same or nearby communities. They are required to have prior experience working in the oil and gas field, so they understand the operations they are inspecting. And they spend most of their working hours traveling the area lease roads, so they know their territories like few others. In case of an emergency, they can be on location within an hour in all but the most remote parts of the state.

Our field inspectors must meet high standards of conduct and performance—they are expected to inspect the operations and enforce the rules fairly, consistently, and appropriately. And they strive to meet these standards. They have earned our trust and respect, and the trust and respect of their communities, time and again. They don't always get the recognition and respect they deserve, so I'm pleased to have the opportunity to highlight their contribution here today.

Our field inspectors are our greatest strength, but they are not our only strength. Other strengths I would like to emphasize today relate to: (1) the complementary nature of our regulatory functions; (2) the way we have adjusted rapidly to new technologies and other emerging issues; and (3) our ability to tailor our rules to address unique areas and special circumstances.

Complementary regulatory functions

OCC regulates oil and gas exploration and production to conserve oil and gas resources, protect the rights of mineral interest owners, and protect public health and the environment. In the early days, our regulations no doubt focused on protecting the oil and gas resources. In fact, some of the earliest requirements to case wells with steel pipe were designed to keep water from damaging the oil and gas zones rather than to protect the water zones. Regardless, the requirement to separate the water zones from the oil and gas zones served to protect both.

The complementary nature of these requirements has become increasingly apparent over the decades as we have worked to ensure that our precious water resources are protected from oil and gas and associated saline waters. The same casing and cementing requirements that isolate the gas

in its formation until it can be produced up through tubing and casing and into pipelines for transportation to market don't just prevent waste of oil and gas and protect mineral rights, they also protect our fresh water resources.

As another example, the spacing requirements that are designed to ensure the orderly development of our oil and gas resources play a role in controlling the surface impacts of oil and gas development. In its 2011 Regular Session, the Oklahoma Legislature established new mechanisms for the creation of special units and the drilling of multiunit wells to allow the drilling of horizontal shale gas wells across section boundaries. These new mechanisms will facilitate the drilling of longer laterals, which will also reduce the surface footprint of shale gas development in the state.

Evolution of regulation

The example of the new legislation for shale gas drilling illustrates how the State of Oklahoma has rapidly adapted to new technologies and addressed emerging issues. In recent years the OCC has engaged in an annual review of its oil and gas regulations and adopted changes to address new technologies, emerging issues, and other developments. Through this process of continuing assessment and adjustment, the OCC ensures that its rules remain current and effective.

For example, perhaps the biggest environmental issue associated with development of the Woodford Shale in Oklahoma has been how to accommodate the recycling of flowback water. We encourage recycling of flowback water as a way to reduce the demand on our freshwater resources. Recycling on a large scale, however, has required the use of pits for temporary storage of flowback water. Oklahoma rules did not allow for storage of produced waters in pits. In 2009 the OCC initiated a rulemaking process to develop standards and procedures for the permitting, construction, operation, and closure of pits for the recycling of flowback waters. The new rules went into effect in July 2010. And we continue to evaluate how they are working. Based on our initial experience with the new rules, the OCC has already made some amendments that went into effect in July 2011.

Special area rules

Most communities in the State of Oklahoma are well acquainted with the nature of oil and gas drilling and production operations. The City of Oklahoma City, where I live, is the location of one of the state's largest oil fields and dealt early on with the challenges of drilling and production in an urban environment. Oklahoma City is also recognized nationally for the quality of its tap water. Oklahoma City draws its drinking water from surface water supplies of exceptionally high quality and works effectively with the OCC and others to ensure that oil and gas operations do not adversely affect those supplies.

The OCC has procedures for special area rules to protect municipal water supplies. Any municipality or other governmental subdivision may apply for a Commission order establishing special area rules to protect and preserve fresh water. The Commission has issued hundreds of these special orders over the years.

Of particular relevance to our discussion today, the OCC recently reviewed, updated, and strengthened the special area rules for oil and gas operations in the watersheds of Lake Atoka and McGee Creek Reservoirs. These truly pristine lakes in southeast Oklahoma supply water to Oklahoma City about 100 miles away. Special area rules had been initially adopted in 1985, but the recent upswing in drilling activity in the area raised issues that need to be studied and addressed.

As is typical of our rulemaking proceedings, a rather large workgroup of stakeholders, including the City of Oklahoma City, rural water districts, counties, tribes, oil and gas operators, and others, assisted OCC staff in identifying the issues, considering options, and developing recommendations for consideration by the Commission. On the basis of those recommendations, the Commission proposed rule amendments that were ultimately adopted with the support of the stakeholders.

The amended rules, which became effective in July 2009, established new setback requirements from the shores of the lakes, required containment structures around drilling locations, and included other provisions to prevent runoff of soil, salt, and other pollutants into the lakes. They also gave oil and gas operators some additional flexibility in meeting pit liner require-

ments in those locations far enough from the lakes that the use of pits is allowed. These special area rules illustrate the kinds of accommodations that can be reached when the stakeholders work together to figure out how to develop our oil and gas resources while protecting our water resources.

I have given you examples of the work we are doing in Oklahoma to ensure that development of our shale gas resources does not impair our water resources. Similar efforts are well underway in shale gas states across the country, including the states within the Marcellus and Utica Shale Basins. For five states already, including Pennsylvania and Ohio, these efforts are reflected in reports issued by the STRONGER stakeholder organization on its review of their hydraulic fracturing regulations.

STRONGER reviews of state oil and gas regulations

STRONGER has completed hydraulic fracturing reviews in five states now: Pennsylvania, Ohio, Oklahoma, Louisiana, and Colorado. A STRONGER team will be meeting in Little Rock early next month to conduct a review of the Arkansas hydraulic fracturing regulations. I have participated as a team member in each of the reviews, except of course in Oklahoma where I sat on the other side of the table. I wish to share with you what I've learned as a participant in the STRONGER hydraulic fracturing reviews, but first, please allow me to give you a little background on STRONGER.

The name, STRONGER, is short for State Review of Oil and Natural Gas Environmental Regulations, Inc. STRONGER is a multi-stakeholder collaborative effort to: benchmark state regulatory programs; develop guidelines for effective state regulatory programs; and conduct reviews of state regulatory programs against those guidelines.

STRONGER is governed by a board of stakeholders. A copy of the current board roster is attached to this testimony. The board includes three representatives from each of three stakeholder groups: state regulators, environmental organizations, and oil and gas producers. Likewise, all STRONGER efforts, such as guidelines development workgroups and state review teams, involve the same balanced representation of the stakeholder groups.

When STRONGER reviews a state's hydraulic fracturing regulations, the STRONGER stakeholder review team takes the time to review the materials provided by the state describing its hydraulic fracturing regulations, listen to a presentation by the state on its standards and procedures, and discuss with the state how the state addresses the key program elements laid out in the STRONGER hydraulic fracturing guidelines. The review team then prepares a report that discusses the state program and makes findings and recommendations based on the STRONGER guidelines. In the report, the review team highlights the program strengths and accomplishments, as well as identifying areas for improvement. All of the STRONGER hydraulic fracturing reports are posted on the STRONGER website (www.strongerinc.org).

The reports prepared by the stakeholder review teams speak for themselves, and the observations I am about to share with you are my own, not those of STRONGER or of any particular review team. Having participated in each of the hydraulic fracturing reviews completed to date, however, I believe the reports document the fundamental strengths of the state programs as well as the decisive actions states are taking to meet the challenges of shale gas development. The findings of the Oklahoma hydraulic fracturing review and similar stakeholder reviews conducted in other states show that the states are well equipped to regulate hydraulic fracturing. These reports also document that each state has experienced challenges in regulating hydraulic fracturing in today's environment, that the specific nature of the challenges varies from state to state, and that each state has taken actions in a manner appropriate to its particular circumstances to ensure that hydraulic fracturing operations are conducted safely.

Most importantly, the reports contain specific recommendations for improvement. The STRONGER stakeholder organization looks forward to returning to the states to learn how they have responded to the STRONGER recommendations. At this point, I can tell you that Oklahoma has already made one rule amendment recommended by the STRONGER review team and made an additional appropriation for field staff based in part on another STRONGER recommendation. My division has convened a workgroup to address our reporting requirements for hydraulic fracturing operations and will be considering the STRONGER recommendations on those requirements as well as other developments. So, I can attest that the process is working to help the states in their ongoing efforts to maintain strong, effective regulatory programs.

Please note that the hydraulic fracturing reviews have been the principal focus of STRONGER's effort for the last couple of years, but STRONGER has a broader mission. STRONGER's hydraulic fracturing guidelines are but one chapter in its guidelines for state oil and gas environmental regulations. The state review process was originally established by the Interstate Oil and Gas Compact Commission and the U.S. Environmental Protection Agency to address the management of wastes associated with the exploration and production of oil and gas. Over the years the process has addressed other significant issues, including abandoned sites, naturally occurring radioactive material (NORM), stormwater management, spill risk management, and program planning and evaluation. And STRONGER continues to review and update the guidelines as needed to address emerging issues. In addition to reviewing the hydraulic fracturing guidelines to make adjustments based on the experience gained through the hydraulic fracturing reviews, STRONGER is now convening a workgroup to consider developing guidelines to address the air issues that have arisen in the shale gas basins.

To date, 21 states have been reviewed under the full set of guidelines. The attached map of the United States shows the status of reviews in the various states. The states that have been reviewed account for over 90% of onshore production in the U.S.

North Carolina has volunteered to be the 22nd state to undergo a full review. The in-state portion of the North Carolina review will occur next week. North Carolina's request for a STRONGER review is one of several steps the state is taking to prepare for the future development of the Marcellus Shale there.

STRONGER also conducts follow-up reviews to determine how the states have responded to review team recommendations. Ten of the 21 states that have been reviewed have had at least one follow-up review. Through the follow-up reviews, the review teams have found that fully three-quarters of the recommendations from prior reviews have been met. The review teams also found that work on other recommendations was in progress though not yet complete. For an entirely voluntary process, I find that record of accomplishment most impressive.

FracFocus

In addition to working with stakeholders to evaluate and improve their programs, the states are working collectively to provide information to the public on hydraulic fracturing operations. Two state organizations have led this effort: the Ground Water Protection Council (GWPC), an organization of state ground water protection agencies, including oil and gas regulatory agencies like mine; and the Interstate Oil and Gas Compact Commission (IOGCC), a compact of the Governor's of the oil and gas producing states.

In September 2010, the GWPC Board of Directors passed a resolution expressing GWPC's intent to develop, in concert with other state organizations, a web-based system to enhance the public's access to information concerning chemicals used in hydraulic fracturing. The GWPC then partnered with IOGCC to develop the chemical registry and website called FracFocus.

Over the next six months a system was developed that allows oil and gas companies to upload information about the chemicals used in each hydraulic fracturing job. This system was augmented by a website that provides a way for the public to locate and review records of hydraulic fracturing conducted on wells after January 1, 2011. The website also contains information about the process of hydraulic fracturing, groundwater protection, chemical use, state regulations, and relevant publications. It provides links to federal agencies, technical resources, and each participating company.

And FracFocus will continue to evolve. A recent enhancement to the site is a Geographic Information System interface that will aid the public in locating well records. Future enhancements to the site will include expanded search capabilities and links to more publications, state agencies, and other resources.

The FracFocus website, www.fracfocus.org, was launched on April 11, 2011. Within its first six months of operation, 66 companies have agreed to participate in the effort, more than 5200 wells have been loaded into the system by 49 of these companies, and the website has been visited more than 65,000 times by people in 125 countries. To give you an idea of the kind of information being reported to FracFocus, attached is an example of a report on the hydraulic fracturing fluid composition for a well in Pennsylvania.

The states are informing their oil and gas producers about the FracFocus chemical registry and encouraging them to use it. In addition, a number of states are now adopting or considering chemical reporting requirements that incorporate the FracFocus chemical registry.

Senator SHAHEEN. Thanks very much.
Mr. BEAUDUY.

**STATEMENT OF THOMAS W. BEAUDUY, DEPUTY EXECUTIVE
DIRECTOR & COUNSEL, SUSQUEHANNA RIVER BASIN COM-
MISSION**

Mr. BEAUDUY. Thank you. Appreciate it. Thank you. We appreciate it, Ranking Member Lee as well, and members of the committee for the opportunity to testify in front of you today.

The Susquehanna River Basin Commission, some may not know, is a fairly unique animal of government. It is a Federal interstate compact commission. There are lots of interstate water commissions across the country. There are only a few of us that are Federal interstate compact commissions with the Federal Government as a full voting member along with the member jurisdictions. We have full water resource management authority that's been delegated to us, the sovereign authority of our member States to act and exercise that authority on behalf of the entire Basin.

The Marcellus Shale play underlies about 72 percent of the Susquehanna Basin which, by the way, extends from Cooperstown, New York to the top of the Chesapeake Bay at Havre de Grace, Maryland, and comprises 27,500 square miles. It's a large area. It's a fairly rural area. It's a fairly mountainous area.

The Marcellus Shale play underlies 72 percent of that and we consider ourselves to be sort of in the sweet spot of Marcellus Shale activity. We've done a lot of it. It came to town, it came to our Basin in mid 2008. We've got 3 years of effective operating history with it, and I'd like to share a little bit of that information with you, because I do think there are some distinctions between what's happening here in the eastern part of the play versus other plays across the country.

First, I'll tell you that when this industry came to town we, like some of the States, were not that well prepared to deal with it, and so this has been a very dynamic process. You just heard about the States streamlining their regulatory programs to meet these challenges. We have modified our regulatory package 3 times in the last 3 years trying to make sure that we have the right set of management controls in place to allow this activity to occur and at the same time, avoid any impact.

We developed a special set of rules for Marcellus, not so much because of the total quantities of water involved, and I'll speak to that in a second, but because of the timing and location of the withdrawals. Most of this activity is occurring in very rural, mountainous areas where there are lots of headwater streams, a lot of pristine trout streams. So special safeguards need to be built in because unlike most other industrial activity, which is down on the valley floor along the main stem river along main tributaries, this activity is an industrial activity is occurring up in the hinterland, so to speak, and so we had to develop some special rules.

The first thing we did was our standard 100,000 gallon a day threshold for when you have to come in to get an approval. We set it aside and we said for the natural gas industry, "We need to regulate you starting at gallon one," and the industry accepted that and

we regulate every single withdrawal that's occurring throughout the Basin on a gallon one basis.

We did a number of other things given the nature of this industry as well. We saw the opportunity to incentivize water sharing amongst the companies because we didn't need 15 companies lining up on the same watershed to get water on 1 or 2 locations that they could share those locations would work. So we incentivize water sharing.

We incentivize the use of lesser quality water. The unfortunate reality in the Susquehanna Basin is we have some legacy to deal with from coal extraction. We've got acid mine drainage in some of our streams, and to be able to utilize AMD instead of freshwater seemed to make sense.

The use of effluent, the recycling of flowback and production fluids, you heard some of that from the last panel. We provide incentives for that to occur and we are seeing it occurring in a very significant way in our Basin.

What are we seeing? So far, we have issued 150 water withdrawal approvals for this industry. We regulate water withdrawals and consumptive use. The consumptive use of water occurs at the drilling pad site, and we have issued approvals for 1,600 drilling pads in this Basin so far.

We also require event-specific, post-hydrofracture reporting in addition to a quarterly monitoring reporting above withdrawals and consumptive use. Based on what we're seeing with the post-hydrofrac data, so far we've got—we've had over 1,000 wells fracked in the Basin. I'm going to share a few numbers with you that are based on the last 4 quarters because the 8 preceding quarters, a lot of the frac data was mixed in with exploratory work and the like. So, the numbers aren't as reflective as the current pattern, the most mature production pattern that we've seen over the last 4 months—4 quarters, I'm sorry.

First of all in terms of quantity of water, this industry right now is withdrawing approximately 7 million gallons a day of water. It's consumptively using about 10 million gallons a day. How does this stack up?

When we looked at the industry, we looked at water use in the Barnett, in the Hayneville, in the Fayetteville Shales. We tried to extrapolate that data to our Basin to develop an estimate because from a cumulative impact standpoint, we wanted to get a handle on, at least make an estimate of what we thought the potential was here. That estimate is 30 million gallons per day. Right now, there are 10 million, but they haven't gone to full production yet. So whether we modify that estimate moving forward or not, I can't tell you, but I think we need to be looking at it dynamically all the time.

Additionally, I will tell you that the amount of water being utilized on a per-well basis is running about 4.5 million. It's—quite honestly, what we're seeing, the correlation that we see is for every 1,000 feet of horizontal lateral, we're seeing 1 million gallons of water use. So we're seeing wells running anywhere from 4 to 8 million gallons, if they have extreme horizontal laterals in their design. But the average over the last 4 quarters has been about 4; a little less than 4 1/2 million gallons of water.

What's unique to the eastern part of this play is that it's very dry. It's extremely dry. Unlike other areas of the country, this gas comes out pipeline ready. It doesn't have to be treated. It's that clean. But that means those formations are not only tight, they're dry and they hold back the water.

So when you looking at 4 1/2 million gallon frac job, the flowback that comes from that, once they release the pressures, is about 5 percent right now. It's been ranging between 5 and 12 percent, which is unlike most of the other return flows in the country. But right now, where the activity is in our Basin, we're down around 5 percent. So there's very little flowback coming back and virtually all of it is being recycled. I can tell you that as well.

As a result of the rules that Pennsylvania is working on and the request that was made by the Governor until his new rules got into effect, the industry no longer takes any flowback or production fluid to wastewater treatment plants in our Basin; publicly owned wastewater treatment plants in our Basin.

There are treatment plants. We had permitted some. We're not involved in water quality permitting, but we have permitted any of those treatment facilities that are adding water as part of the treatment process. But all the flowback and production fluid is going from pad to pad, or alternatively, from pad to treatment facility and then back to pad for down hole purposes for hydrofracture stimulation on the next well. That's what we're seeing.

I will also just tell you that we have deployed a remote water quality monitoring network because—and we provide a support function to our member jurisdictions who have the lead on water quality controls for this industry. But we play a support role and we have deployed a 50 station remote water quality monitoring network; 50 watersheds throughout the Marcellus Shale play where we have real time data. We're analyzing for 6 parameters every 5 minutes, 24 hours a day, 365 days a year. That data is going to a Website. We make that available to all the water resource agencies, to the industry, and to the general public in, you know, in an attempt to be as transparent as possible.

We are monitoring all these locations. We started putting them in, in January 2010. The last one went in, in August of this year. We have at least 37 of those stations that have enough data now that we can begin to do analyses. We should have our first report published in approximately 4 months. Sometime in January, we will have the first report out.

I can tell you, based on what the data is showing us, that water quality is remaining within normal ranges. We also do grab sampling to look at specific parameters related to this industry: barium, a whole series of constituents that, as well as gross alpha and beta, the radionuclides and the like. What we are seeing is that the water quality is staying within normal limits. We have seen a few spikes that have resulted in additional investigations. But by and large, that monitoring network is there for the public to see, for the resource agencies to use, and thus far, we're seeing things generally staying in normal range.

Thank you.

[The prepared statement of Mr. Beauduy follows:]

PREPARED STATEMENT OF THOMAS W. BEAUDUY, DEPUTY EXECUTIVE DIRECTOR &
COUNSEL, SUSQUEHANNA RIVER BASIN COMMISSION

I. Introduction

Let me start off by thanking the Chair, Senator Shaheen, as well as Ranking Member Lee and all subcommittee members for the opportunity to appear before you today on behalf of the Susquehanna River Basin Commission (Commission) to address water resource issues associated with shale gas development in the eastern United States.

The Susquehanna River basin is in the heart of the Marcellus shale play, which underlies 72% of the land area of the basin. The basin itself is 27,512 square miles and extends from Cooperstown, New York, to the head of the Chesapeake Bay at Havre de Grace, Maryland. Attachment 1 depicts the basin and the geographic extent of the Marcellus shale formation.

Geologically, the basin is home to a number of other tight shale formations that have, as of yet, an undetermined amount of recoverable natural gas. The level of recoverable gas beyond what is currently anticipated from the Marcellus, and the level of development activity and water use associated with it will become better known as information becomes available from exploratory work that is currently underway. These formations, in combination with the Marcellus, underlie 85% of the basin.

My comments today will reflect the management controls we have developed in response to shale gas development activity generally, and what we are currently seeing with regard to development of the Marcellus shale formation specifically.

II. Background—Water Allocation and Consumptive Use Management in the Basin

The Commission was created in 1971 as a result of the enactment of the Susquehanna River Basin Compact (Compact) by the states of Maryland, Pennsylvania and New York, and by the United States.¹ Formed as a federal-interstate compact commission, the Commission is vested with broad statutory authority to manage the water resources of the basin, including the authority to allocate the waters of the basin.² It serves as a forum for the joint exercise of the sovereign authorities delegated to it by its member jurisdictions.³

The Commission has utilized its Compact authority⁴ to develop a regulatory program to manage the resource impacts of projects using the waters of the basin, to avoid conflicts, and to provide standards to promote the equal and uniform treatment of all water users without regard to political boundaries.⁵

Fundamentally, the regulatory program requires review and approval of any project proposing to withdraw 100,000 gallons per day (gpd) or more, based on a 30-day average, from groundwater or surface waters, or the consumptive use of 20,000 gpd or more, also based on a 30-day average.⁶ By definition, diversions of water out of the basin are considered to be a consumptive use and are subject to a similar 20,000 gpd threshold.⁷ Diversions into the basin, regardless of quantity, are likewise subject to review and approval.⁸ As expressly provided in the Compact, no allocation made pursuant to the authority of the Commission constitutes a prior appropriation of the waters of the basin or confers any superiority of right with respect to the use of those waters.⁹

With regard to groundwater withdrawals, the Commission requires project sponsors to conduct a 72-hour, constant-rate aquifer test pursuant to a pre-approved test plan with provisions for a groundwater availability analysis to determine the availability of water during a 1-in-10 year recurrence interval.¹⁰

For withdrawals generally, the Commission may limit, condition or deny a request to avoid significant adverse impacts, including cumulative adverse impacts, to the water resources of the basin. Limitations are imposed on approved amounts (both

* Attachments 1–5 have been retained in subcommittee files.

¹ Susquehanna River basin Compact, P.L. 91-575; 84 Stat. 1509 et seq. (1970).

² Susquehanna River basin Compact, Article 3, Powers and Duties of the Commission.

³ "The water resources of the basin are subject to the sovereign rights and responsibilities of the signatory parties, and it is the purpose of this compact to provide for a joint exercise of these powers of sovereignty in the common interest of the people of the region." Susquehanna River Basin Compact, §1.3.2.

⁴ Susquehanna River Basin Compact, §1.3.5 and §3.10.

⁵ 18 CFR Parts 806-808.

⁶ 18 CFR §806.4(a)

⁷ Id.

⁸ Id.

⁹ Susquehanna River Basin Compact, §3.8.

¹⁰ 18 CFR §806.12. See also SRBC, Aquifer Testing Guidance, Policy No. 2007-01 (December 7, 2007).

quantity and rate) needed to meet the reasonably foreseeable needs of the project without causing such impacts.¹¹ Adverse impacts include: excessive lowering of water levels; rendering competing supplies unreliable; causing permanent loss of aquifer storage capacity; degradation of water quality that may be injurious to any existing or potential water use; adversely affecting fish, wildlife or other living resources or their habitat; and substantially impacting the low flow of perennial streams.¹²

In taking action on requests for withdrawals, both surface and groundwater, the Commission relies on guidelines it has developed to make determinations on appropriate passby flow and conservation release values to include as conditions to approvals.¹³ The guidelines are used to protect aquatic resources, competing users, instream flow uses downstream from the point of withdrawal, and prevent water quality degradation.¹⁴

Parenthetically, I should note that the Commission is now undertaking a re-evaluation of its existing guidelines related to flow protection following the completion of a recent basin study conducted by The Nature Conservancy that addressed how aquatic systems can be sustained by preservation of the long-term natural hydrologic variability of streams through ecosystem-based flow goals.¹⁵ We anticipate that the Commission will be releasing an updated policy within the next 3 to 6 months that reflects this new, contemporary science.

For each application seeking surface water withdrawal approval, the Commission undertakes a site-specific aquatic resource survey to establish baseline conditions and determine appropriate limitations, unless a similar study was conducted for the site within the past five years and can provide useful data. The Commission then utilizes these data to formulate conditions related to (1) limits on the quantity, timing or rate of withdrawal; (2) limitations on the level of drawdown in a stream, well, pond, lake or reservoir; and (3) streamflow protection measures.

Projects involving the consumptive use of water (i.e., where water withdrawn from the basin is used in such a manner that it is not returned to the basin undiminished in quantity) are required to mitigate the loss of water to the basin, particularly during low flow conditions.¹⁶ Essentially, mitigation is required on a 1-to-1 basis by employing one of several options:

- Reducing withdrawals during prescribed low flow periods in an amount equal to the project's total consumptive use, and withdrawing from other secondary source(s) that have sufficient capacity to sustain withdrawals without impact to surface water flows for a period of at least 90 days.
- Releasing water during prescribed low flow periods from secondary source(s) for flow augmentation in an amount equal to the project's total consumptive use, provided the release can be sustained for at least 90 days without impact to surface water flows.
- Discontinuing the consumptive use during prescribed low flow periods.
- Using as the primary source for consumptive use water a storage impoundment that is subject to the maintenance of an acceptable conservation release requirement.
- Providing consumptive use mitigation fee payments to the Commission, which utilizes such funds for the acquisition and maintenance of water storage used to provide streamflow augmentation during low flow periods.¹⁷

The general regulatory framework noted above is applicable to natural gas development activity throughout the basin, except as modified by the regulatory enhancements described below.

III. Special Regulation of Marcellus Shale Development Activity

As exploratory well development of the Marcellus Shale formation got underway in the second half of 2008, the Commission experienced a dramatic increase in the number of applications seeking approval for water withdrawals and consumptive water use. It also saw the potential for this activity to create adverse, cumulative

¹¹ 18 CFR §806.23(b)(1).

¹² 18 CFR §806.23(b)(2).

¹³ SRBC, Guidelines for Using and Determining Passby Flows and Conservation Releases for Surface-Water and Ground-Water Withdrawal Approvals, Policy No. 2003-001 (November 8, 2002).

¹⁴ *Id.*

¹⁵ Ecosystem Flow Recommendations for the Susquehanna River Basin (The Nature Conservancy, 2010).

¹⁶ 18 CFR §806.22

¹⁷ *Id.*

adverse or interstate effects to the water resources of the basin, regardless of whether individual projects met or fell below its regulatory thresholds.

Why the concern? Save for the bottled water industry, which tends to focus on pristine watersheds for high quality water, the vast majority of projects regulated by the Commission have historically located themselves alongside the mainstem river, or major tributaries, or at least down in the valleys along streams with appreciable flow characteristics. Furthermore, the typical project could be analyzed for impact based on withdrawals from specific locations to feed adjacent operations with attendant calculations of return flow and consumptive loss.

But the natural gas development industry is different, fundamentally different. It takes water from multiple de-centralized locations, on an inconsistent basis, and uses it at any one of dozens of ever-changing locations, based on its operational needs. Perhaps most significantly, and what sets it apart, is the fact that it engages in water-demanding activity in remote, often environmentally sensitive headwater areas.

Quantities of water that one could otherwise consider inconsequential on a major tributary can represent an important component of the flow regime in headwater areas. When you overlay the extent of headwater streams in our basin with the extent of the Marcellus shale formation, as depicted graphically in *Attachment 2, you can see that alignment.

As a result of that alignment, coupled with the operational nature of the industry, the Commission elected to modify its regulatory approach for this industry. It took administrative and regulatory actions in 2008, 2009 and 2010, all of which were intended to implement and refine a set of management controls it felt were necessary to avoid adverse impacts to the water resources of the basin, yet allow the industry to proceed with development activity.¹⁸ Those modifications include the following:

- The regulatory threshold for initiating Commission review and approval authority commences at gallon one, rather than the traditional regulatory thresholds noted above.¹⁹
- Although the threshold changed from 100,000 gallons to gallon one for water withdrawals, the Commission did not modify any of the current standards or requirements associated with the review and approval of water withdrawals. They continue to be subject to the same standards noted above that all withdrawals across the basin are subject to, and we believe are appropriate, to protect the basin's water resources and simultaneously allow for their utilization by this new industry.²⁰
- Consumptive use approvals to go through a new administrative Approval by Rule process specifically applicable to the natural gas development industry.²¹
- ABRs are issued on a drilling pad basis, regardless of the number of wells developed on the pad, and include appropriate monitoring, reporting and mitigation requirements.²²
- In addition to water withdrawal approvals, the industry may obtain source approvals under the ABR process, including approvals to including public water supplies and wastewater sources.²³ It is the policy of the Commission to incentivize the use of lesser quality waters, including effluent discharge and acid mine drainage, for hydrofracture stimulation in lieu of fresh water sources. This incentive also extends to the reuse or recycling of flowback and production fluids for that purpose.
- The industry is authorized to utilize any of its approved water sources at any ABR site so as to provide operational flexibility.²⁴
- The industry is incentivized to share source approvals between companies by providing for a simple registration process to facilitate that sharing and limit the number of withdrawal locations in a given watershed or area.²⁵

¹⁸ First, the Commission's Executive Director issued a Notice of Determination for Natural Gas Well Development Projects, August 14, 2008 (as revised October 8, 2008), pursuant to 18 CFR §806.5(a), that all natural gas well development projects in the Susquehanna River Basin targeting the Marcellus or Utica shale formation, and involving the withdrawal or consumptive use of water, are subject to review and approval regardless of whether they otherwise meet existing regulatory thresholds, effectively establishing a "gallon one" regulatory threshold.

¹⁹ 18 CFR §806.4(a)(8).

²⁰ 18 CFR §806.4(a)(2).

²¹ 18 CFR §806.22(f).

²² Id.

²³ 18 CFR §806.22(f)(12)(ii).

²⁴ 18 CFR §806.22(f)(11).

²⁵ 18 CFR §806.22(f)(12)(i).

As a final point on the scope of its regulatory program, and beyond the water quality considerations taken into account in issuing withdrawal approvals, it should be noted that the Commission relies on its member jurisdictions to generally manage the water quality aspects of this activity. This is consistent with its Compact mandate to properly utilize the functions, powers and duties of the agencies of its signatory members.²⁶

Given that its member states all have comprehensive well permitting, construction and hydrofracture stimulation standards, erosion and sedimentation control, and disposal and treatment standards, the Commission does not regulate these aspects of natural gas well development activity. Instead, and so as to not duplicate those efforts, it requires the industry to comply with the applicable requirements of state and federal law.²⁷

IV. The Marcellus Water Use Profile

The development of the Marcellus shale in the basin unquestionably represents both a tremendous opportunity and a series of water resource-related challenges. On the economic side, there are numerous studies and projections that attempt to quantify the significant economic value of Marcellus development activity. On the water resource side, the bigger challenges focus on cumulative impact, from both a water quality and water quantity perspective.

From a management perspective, there is value in viewing these challenges in the broader context of energy water use demands and impacts basin-wide. The amount of water withdrawn and consumed by the energy sector, principally for power production, dominates all other industry sectors save for that attributable to public water supply in the basin.²⁸ Of the 563 mgd of total approved consumptive use in the basin as of 2005, 149 mgd, or 26%, was for power generation.²⁹ Deducting from that total the amount authorized as an out-of-basin diversion to the City of Baltimore, Maryland for public water supply (250 mgd), power generation jumped to 47%, or nearly half, of the total approved consumptive use occurring in the basin as of the date of that report.³⁰ Since then, the quantity of approved consumptive use for that industry has increased from 149 mgd to 192 mgd.

With regard to the energy profile, the current basin power production capacity is 15,300 megawatts, of which 37.5% is nuclear, 31% is coal, 15.5% is natural gas, 12% is hydroelectric and the remaining 4% is other (wood, ethanol, solid waste, etc.).³¹ Combined, these projects are approved to withdraw 3.44 billion gallons per day (gpd), which does not include an additional 814 mgd that is currently grandfathered.³²

So how does Marcellus shale development activity compare in a relative sense? First, it should be noted that the full extent of potential activity has yet to be empirically documented. Estimates have varied widely, and the Commission will continue to monitor them and rely on the most contemporary estimates, particularly to enable a more objective analysis of potential cumulative impact.

Preliminarily, in 2008, it looked at the production build-out of the Barnett shale in Texas, and other shale plays across the United States such as the Haynesville and Fayetteville, in order to develop some estimation of that potential.³³ It originally estimated the consumptive use potential at full build-out level to be 28 mgd, on an annualized basis, and then revised that number to 30 mgd.

This estimate still holds based on what has transpired to date, but will no doubt be modified over time as more objective criteria become available, particularly in-basin development data over a sustained period of time.

Interestingly, and for comparative purposes, it should be noted that air quality control upgrades (scrubbers) at typical power plants in the basin each consume 4 to 5 mgd, and single plant generation upgrades can require 30 mgd or more.³⁴ None-

²⁶ Susquehanna River Basin Compact, §3.2.

²⁷ 18 CFR §806.22(f)(8).

²⁸ See SRBC Consumptive Use Mitigation Plan (March, 2008). Data contained in the plan are as of 2005.

²⁹ *Id.* at pg. A-6. When (unregulated) consumptive use associated with grandfathered power generation facilities are added in, the number increases from 149 mgd to 180.5 mgd.

³⁰ *Id.*

³¹ SRBC, Water Resource Challenges from Energy Production, June, 2008.

³² *Id.* Groundwater withdrawals for this industry only total 14.2 mgd, and are generally limited in uses to non-thermal related aspects.

³³ Galusky, Jr., L. Peter, Ph.D., P.E., "Fort Worth Basin/Barnett Shale Natural Gas Play: An Assessment of Present and Projected Fresh Water Use", prepared for Gas Technology Institute, April, 2007.

³⁴ SRBC, Water Resource Challenges from Energy Production, June, 2008.

theless, and even though it represents a little more than half of the amount currently used consumptively by the recreation sector (golf courses, water parks, ski resorts, etc.)³⁵ on a seasonal basis, it does represent a 19% increase in the amount attributable to the energy sector.

For planning purposes, the Commission recently undertook an analysis of energy sector trends and has estimated a potential 2025 demand of 230 mgd of increased consumptive use for power production.³⁶ This does not include the Marcellus projection noted above since it is not power production-related, but it does add to the overall energy water use demand.

A second comparison to note is the water withdrawal demand for the Marcellus as it relates to the power production sector. Given the assumption that every gallon withdrawn by the natural gas industry is consumptively lost to the system, the estimate of 30 mgd is equally applicable to both withdrawals and consumptive use.

Completion of natural gas wells involves a one-time use of water for hydrofracture stimulation of the well (which may be repeated over the life of the well to re-stimulate production). On the other hand, power generation, especially base load operations, require water on a constant basis (generally 24/7 year round). Currently, 3.44 billion gallons per day is authorized for withdrawal from the basin for power generation.

Using the estimate of 30 mgd, Marcellus shale development activity would require slightly less than 11 billion gallons per year. Comparing that to the amounts approved for power production withdrawals, the annual volume for Marcellus development would be slightly more than what is authorized for withdrawal in a single 3-day period for power production. Accordingly, the concern with regard to water demand associated with development of the Marcellus shale is not focused on the total quantity, but more on the location and timing of withdrawals and their impact on smaller order streams.³⁷

So what does the current data reported to the Commission tell us about the nature and amount of actual water use by this industry? *Attachment 3 provides summarized information concerning withdrawals and consumptive use for the first three years of development activity in the basin. *Attachment 4 provides profile information on a per well basis for the last four reported calendar quarters. Of note are the following:

- Thus far, over the past three years, the industry has withdrawn 3.6 billion gallons of water from the basin.
- Based on average daily withdrawal rates per quarter, average daily withdrawals over the most recent four quarters equals 7.1 mgd.
- Consumptive use, including water obtained from withdrawals and all other approved sources, totals 4.5 billion gallons for the past three years.
- Based on average daily consumptive use rates per quarter, the average daily consumptive use over the past four quarters equals 8.5 mgd, with the most recent quarter representing approximately 10 mgd.
- The pattern for consumptive water use continues to trend upward, for water withdrawals it is more variable.
- Over the most recent four calendar quarters, the average total water volume for hydrofracture stimulation, per well, is 4.24 mgd.
- During that same period, the average recovery of flowback, as a percentage of total injected water, ranges from 5% to 12%. More recently, and possibly attributed to formation characteristics in the area of the play where most activity is occurring, the reported numbers have been consistently close to 5%.
- During that same period, the average amount of flowback reused per well fracturing event is approximately .5 mgd, or 12% of the total volume.

These data are derived from quarterly monitoring reports over the past three years and the 654 event-specific post-hydrofracture reports filed over the past four quarters by the industry.

V. Water Quality Monitoring

As noted above, the Commission is relying on its member jurisdictions to provide water quality regulatory oversight of the natural gas development industry. Consistent with its history, the Commission provides water quality monitoring and assessment support to its members. As natural gas development activity unfolded

³⁵ SRBC Consumptive Use Mitigation Plan at pg A-6.

³⁶ Id. at pg. A-14. (Original published amount of 134 mgd updated to 230 mgd by SRBC, 2010).

³⁷ Power production facilities, on the other hand, are generally located along the mainstem river or major tributaries.

across the basin, the Commission saw the need for additional monitoring in the more remote areas where this activity was occurring.

In January 2010, the Commission began deployment of a Remote Water Quality Monitoring Network (Network) designed to monitor water quality conditions to maintain and protect surface waters in selected remote portions of the Susquehanna River basin. The monitoring network uses state-of-the-art monitoring and communication technology to collect and transmit real time water quality data, including the following parameters: temperature, pH, conductance, dissolved oxygen, turbidity, and relative water depth. The data is made available continuously on the Commission's website, www.srbc.net, and is accessible to resource agencies and the general public. Additional details concerning the network are provided in *Attachment 5.

At present, the network consists of fifty (50) monitoring stations in the Pennsylvania and New York portions of the Susquehanna basin. These stations were installed over a period of a year and a half, with the last station installed in August 2011.

While we have been monitoring the data being reported by the Network on an ongoing basis, the Commission has just now started to analyze the data in earnest, especially given the need to acquire an adequate amount of data to work towards establishing baseline conditions. Thirty-seven (37) stations had sufficient data records to begin more rigorous analyses. Upon completion of the very initial stage of the analyses, the dataset is proving to be very complex given the range of possible influences within each of the monitored watersheds and the lack of historical data.

In addition, the range of hydrologic conditions experienced in the Susquehanna River basin over the last year and a half, during the period of record for the first set of stations, shows the importance of characterizing water quality conditions over the longer term prior to making any cause/effect determinations. Although generalized summary statistics for the entire Network's dataset could be considered within normal ranges, a select subset of stations have not exhibited what might be considered predictable water quality conditions based on their physical setting (geology, land use, topography, soils, etc.). Also, a subset of stations experience occasional "spikes" in certain parameters not readily explained by typical natural conditions. At present, seven (7) stations fall into this category and will require more extensive data collection and analyses. However, in all cases, it is important to note that natural gas development is not the exclusive activity within the monitored watersheds, and that irregular water quality conditions do not necessarily equate to impacts from human activities.

Beyond the continuous water quality data, we have also been monitoring for a more extensive suite of parameters more indicative of natural gas activity (i.e., chloride, barium, bromide, radionuclides) through the collection of "grab" samples throughout the year. Staff also just completed the first round of biological and habitat data collection at each of the stations, and will be including those data in future analyses as well. Upon completion of these comprehensive analyses, we will be in a better position to characterize conditions in each of the monitored watersheds. We anticipate publication of our first analytical report in January, 2012, and we would be happy to provide it to the subcommittee.

V. Conclusion

As noted above, development of the Marcellus shale formation represents both an opportunity and challenge for the Susquehanna River Basin. The Commission's water withdrawal regulations are designed to allow proper development, utilization and protection of the basin's water resources. Instream uses, competing uses, localized cumulative impact analyses and water quality considerations are comprehensively addressed.

The Commission believes the regulatory adjustments it has made in response to the industry have been appropriate and it continues to refine its management controls as it gains more experience. Additionally, its ongoing work in the area of ecological flows will also help to assure that we are applying the best science in making management decisions, whether for this industry or any other.

With regard to water quality issues, the Commission will continue to look to its member jurisdictions to take the primary regulatory role, we will continue to provide monitoring support, and we will continue to participate in the necessary planning and assessment initiatives attendant with this activity.

The cumulative impact of consumptive use by this new activity, while significant, appears to be manageable with the mitigation standards currently in place. This demand, coupled with that anticipated for public water supply and other industry sectors, represents a challenge for the Commission, the water users who have an obligation to mitigate, and for the basin generally. As part of its consumptive use strat-

egy for the basin generally, the Commission will continue to evaluate and refine its mitigation standard and pursue additional opportunities for low-flow augmentation.³⁸

Combined, these efforts will help to insure the proper and sustainable utilization of the water resources of the basin for this new energy resource development opportunity.

On behalf of the Commission, I will be happy to respond to any questions, comments or informational requests of the subcommittee. Thank you for this opportunity to testify.

Senator SHAHEEN. Thank you very much.

Mr. COOPER.

STATEMENT OF CAL COOPER, WORLDWIDE MANAGER, ENVIRONMENTAL TECHNOLOGIES, GREENHOUSE GAS, AND HYDRAULIC FRACTURING, APACHE CORPORATION, HOUSTON, TX

Mr. COOPER. Thank you, Madam Chairman Shaheen and Ranking Member Lee.

After that testimony, I think mine will be a lot briefer. We're going to say a lot of the same things. I think the big conclusion that I just heard from Tom's testimony is that the Susquehanna River Authority is doing a great job, and we shall applaud them.

So today, I was asked to focus on the impact shale gas production would have on water resources in the eastern United States. I wanted to talk about protecting water resources from chemical pollution, balancing competing needs for water resources, and finally, to talk about something a little different, how water requirements for natural gas stack up compared with other major players in the energy and power section—sector.

So I think all of us agree that we absolutely must protect water resources, especially drinking water, from chemical pollution, and that's really fundamental. We've heard from others that oil and gas operations everywhere address the protection of aquifers. This includes the disposal of produced water in a responsible way. The safest, and most efficient, and economical way is to reinject it.

In the Marcellus area, we've heard there are very few disposal wells. Initially, the industry disposed of produced water by trucking it to treatment plants. With the scale up of operations, that proved unsustainable. It's really not done anymore. Now, nearly all operators report that they store, treat, and reuse water, putting it into the next frac job a mile below the surface. This is a best practice and it's been an evolution.

Many have asked why companies didn't recycle water to start with, and a couple of factors played a major role. Operators were familiar with the chemistries and functional expectations of using freshwater at facilities to treat water for reuse were rare and costly. It takes treatment to make flowback and produced water suitable as base fluids for fracturing. As the saying goes, necessity is the mother of invention and there's been a lot of innovative problem solving in this area.

Others have addressed the committee about chemical disclosure and the merits of FracFocus. This effort also encouraged companies to think more about what they use in specific chemicals, and how they can minimize risk by changing chemical components.

³⁸ SRBC Consumptive Use Mitigation Plan, at pg. 23.

Basically, no one wants to pay for chemicals they don't need, and we have found that we can often replace non-biodegradable biocides with much less intrusive additives. A good thing here is that the slick water fracs from dry gas common in the Marcellus, lend themselves to really pretty simple formulations.

I think I'm skipping most of this page. But I'd like to turn to the size of all of that water that we're withdrawing. You heard some excellent statistics from Tom, and I really want to ask: does it all add up to something that's really huge? It just depends where. If it's in a trout stream up in the top of the mountains, it's a big deal. But estimates suggest that the Marcellus Basin total water usage exceeds 3 trillion gallons of water per year used by people and industry. So in a big picture, looking at the really big use of water, even 1,000 frac jobs don't add up to much more than a big drop.

Another way to think about that is that a typical frac job uses about 1.5 seconds of the Mississippi River discharge into the Gulf of Mexico. So location is really everything.

In Texas where Apache has a very significant presence, record drought is impacting everything and operators are scrambling to manage a scarce resource. So recently, we learned a great deal from our Canadian operations about relatively high saline water to be used as frac fluids instead of fresh water, contrary to the general practices and expectations in the industry, and contrary to what's going on in the Marcellus.

Senator SHAHEEN. Can you just explain the difference between the 2?

Mr. COOPER. Why certainly. So we use—in the Marcellus area, the industry uses fresh water, which is usually surface water. In Canada in our operations, we decided it was much better to use saline brines derived from about 3,000 feet below that are completely unusable as fresh water. We found, actually, that it worked better for us than using fresh water. We are going to do our very best to completely stop using fresh water in Canada except as sort of emergency backup water.

That required a really huge investment and a lot of innovation, but we think that things like that can work in some parts of the United States. Apache is very actively looking at that in the Permian Basin of west Texas where it's very important to us. We're not sure whether that would even work in the Marcellus or not, but somebody needs to really investigate it.

Now, I'd like to turn to that other part of big use of water and that's power generation. I'm not an expert in power generation. I'm a geoscientist, but I can look at numbers for water use and it seems especially pertinent for this committee to consider the water budget of energy from shale gas compared to other sources.

The natural gas revolution, after all, is about providing power to America. In a combined cycle power plant fueled by natural gas from shale requires less than half the water used for fuel and cooling compared with thermal coal steam power plants, a less than a third of nuclear steam turbine requirements, and even a smaller fraction that's required for solar condensing plants.

So if we look at natural gas, it uses less water to generate power. If we look at other fuels, natural gas from both shale gas and conventional sources requires less water per million BTUs of power

and energy in its combustion than any other common fuel. That's a pretty good deal.

So thank you for allowing me to share some of my thoughts with you today.

[The prepared statement of Mr. Cooper follows:]

PREPARED STATEMENT OF CAL COOPER, WORLDWIDE MANAGER, ENVIRONMENTAL TECHNOLOGIES, GREENHOUSE GAS, AND HYDRAULIC FRACTURING, APACHE CORPORATION

Mr. Chairman, and members of the committee,

Today I have been asked to focus on the impact shale gas production will have on water resources, especially in the Eastern United States. It is a topic I care passionately about, and I believe it is a fundamental piece of ensuring the future health of our families and the economic strength of our country. Some however, are convinced that shale gas production will ruin everything they cherish. The task before us is to envision a much more positive outcome, and ensure that we get there. Shale gas development offers America an opportunity to demonstrate what it does best. It will improve living standards in many communities by expanding employment in a variety of industries and provide income to royalty owners and tax revenues to state and local governments. It will be done responsibly, and the process will drive a lot of innovation, while setting new standards for environmental sustainability. Already a lot of that is underway. The ultimate timeline may be the next 100 years, but industry appreciates the imperative of getting things right, and is rapidly moving forward to respond to the challenge. For our discussion today, some areas of general priority interest: protecting water resources from chemical pollution, balancing competing needs for water resources, providing perspective on what alternatives we have or in other words investigating how water requirements for natural gas stack up compared with other major players in the energy and power sector.

Protecting water resources

Protecting water resources, especially drinking water from chemical pollution is part of our fundamental commitment to safe operations and protecting the communities where we live and work. In traditional oil and gas states, the safest, most efficient and economical way to deal with water is not so practical in many areas of the Marcellus. Generally water is sourced from surface or groundwater, and after use all flow-back and produced water is disposed of into state permitted deep injection wells.

In the Marcellus area there are very few disposal wells and initially the industry disposed of produced water by trucking it to treatment plants. With the scale-up of operations this has proved unsustainable. Now nearly all operators report that they store, treat and re-use water, putting it into next frac job a mile below the surface. As operations expand toward Ohio and western West Virginia, geology is likely to be more conducive to deep subsurface injection of waste water.

Many have asked me why companies didn't re-cycling water to start with. A couple of factors played a major role. Operators were familiar with the chemistries and functional expectations of using "fresh" water, and facilities to treat water for re-use were rare and costly. It takes treatment to make flow-back and produced waters suitable as base fluids for fracturing. As the saying goes necessity is the mother of invention, and there has been a lot of innovative problem solving in this area.

Others have addressed this committee about chemical disclosure and the merits of the IOGCC-GWPC FracFocus.org website. From an industry insiders perspective, this effort has also encouraged companies to think more about why they use specific chemicals and how they can minimize risks by changing chemical components. Several major vendors have developed more environmentally sensitive formulations and some have developed scoring systems to better quantify and communicate the advantages of particular chemicals. Nation-wide there is a lot of variability in the specific chemical needs based on problems of local geology, reservoir temperature and pressure and the presence of specific minerals or metals in the reservoir rocks or fluids. In addition operators have conducted performance-based comparisons to aid in the selection of chemical additives. Basically, no one wants to pay for chemicals they don't need, and we have found that we can often replace non-biodegradable biocides with much less intrusive chemicals or even with ultraviolet light in some circumstances. We frequently eliminate clay control additives without detrimental reactions.

The slick-water fracs for dry gas common in the Marcellus lend themselves to simpler formulations.

Balancing competing needs for water resources

No doubt, hydraulic fracturing requires a lot of water, and the amount depends on the size and depth of the well, and the specifics of the competition technique. Water is a local resource and withdrawal must be managed on a local basis to ensure that the ecological health of riparian systems and the needs of other major users are met. All states have significant powers and organizations in place to protect these rights.

In the Marcellus area most operators report frac jobs requiring 4-8 million gallons of water. That sounds huge considered in isolation, but compared with the estimates exceeding 3 trillion gallons of water per year used by people and industry in the Marcellus basin it not so big even if done 1000 times. Another way to think about it is that a typical frac job uses 1.5 seconds of the Mississippi River discharge into the Gulf of Mexico. In the Eastern US, the volumes of water required for hydraulic fracturing are not likely to dominate decisions about water use except in very local circumstances. Texas on the other hand is not so lucky; record drought is impacting everything.

Apache operates in states and provinces where we are permitted to re-inject 100 percent of flow-back and produced water into deep underground reservoirs completely isolated from freshwater aquifers. In Oklahoma and Texas, we normally make-up our frac fluids by mixing fresh water produced from shallow groundwater sources and surface sources that are purchased from land owners. Recently, we have learned a great deal from our Canadian operations about using relatively high saline water instead of fresh water, contrary to the general practices and expectations of the industry. In the Horn River Basin, working with our partner EnCana, we have developed a system for extracting water from a saline aquifer in the Debolt formation and treating it in a built for purpose plant to eliminate H₂S. The water is piped to our well pad where we add a minimum of chemicals to create an effective frac fluid. After fracing we then re-inject the flow-back and produced water into the Debolt formation in a closed-loop system. This water source provides many operational advantages, and compliments efficiencies provided by innovative high-density well pads that allow a minimum surface footprint. We intend to continue to innovate to protect a pristine environment using a minimum of surface water and disposing of none into waterways.

High-flow-rate brackish or salt water aquifer systems are not present everywhere. In the Permian Basin, Apache believes the brackish Santa Rosa groundwater system can be adapted for a similar purpose as the Debolt in parts of the Horn River Basin. We are currently investigating tests of our concept for frac systems in oil reservoirs using recycled brackish water as a base fluid. This has many environmental advantages, and well as practical reservoir management efficiencies, but it is especially good because if we are successful, we will minimize our need for fresh water. This is a clear example where technology enables our business and we aggressively explore what is possible in order to succeed. So do many others, and we all benefit.

Hydraulic Fracturing, water and power

Although I'm not an expert in power generation, it seems especially pertinent for this committee to consider the water budget of energy from shale gas compared with other sources. The natural gas revolution is about providing power to America. Natural gas from shale powering a NG combined cycle power plant requires less than half the water used for fuel and cooling of IGCC and Coal steam Power plants (without CCS), less than a third of Nuclear steam turbine requirements, and an even smaller fraction of water required by solar condensing plants.

Consider water requirements for other fuels. Natural gas, from both shale gas and conventional reservoirs requires less water per MMBtu of energy generated from combustion than any other common fuel.¹

The real water "water-hog" it seems is not hydraulic fracturing, but biofuels derived from irrigated corn ethanol or irrigated soy biodiesel.

Thank you for allowing me to share some of my thoughts with you today. Certainly shale gas has reputational issues, but a closer examination of the facts and consideration of the alternatives underscores what a giant and positive opportunity shale gas production will have for the eastern United States and the country as a whole.

Senator SHAHEEN. Thanks very much.
Ms. DUNLAP.

¹ <http://www.sandia.gov/energy-water/docs/121-RpToCongress-EWwEIAcomments-FINAL.pdf>

STATEMENT OF KATY DUNLAP, ESQ., EASTERN WATER PROJECT, DIRECTOR FOR TROUT UNLIMITED, ARLINGTON, VA

Ms. DUNLAP. Thank you, Madam Chair and Ranking Member Lee.

My name is Katy Dunlap, and I'm the Eastern Water Project Director for Trout Unlimited. We are a 140,000 member organization dedicated to conserving, protecting, and restoring North America's trout and salmon fisheries.

I thank the members of the subcommittee for holding this hearing today and for the opportunity to testify.

Trout Unlimited supports natural gas development that is done right, in the right way, and in the right places. Improperly sited to poorly management natural gas development, however, can have impacts on water resources. Trout Unlimited is actively involved at the local, State, and Federal level trying to find solutions which will promote responsible energy development.

For example in Pennsylvania, more than 200 Trout Unlimited members are conducting stream surveillance for impacts associated with Marcellus Shale gas development. In the field, our members are witnessing impacts that do not always make the headlines. My testimony today will focus on the Marcellus Shale and highlight a few of the surface impacts of gas drilling in Pennsylvania, where more than 1,600 wells are currently in production, and where the State has already issued 925 violations to Marcellus well operators this year alone.

By far, the most prominent and concerning impact that our members are seeing on the ground is the failure or lack of erosion and sediment controls on wellpad constructionsites and access roads. Due to an exemption that was mentioned earlier provided through the Energy Policy Act of 2005, oil and gas constructionsites and the roads that service those sites are not covered by the Clean Water Act's storm water provisions.

In addition to affecting the quality of public water supplies, erosion and sedimentation can gravely impact high quality coldwater habitat.

In March 2011, erosion from the development of a gas well site in Potter County resulted in the significant discharge of sediment and silt from the site into a stream that feeds a water source serving 1,400 people in the burrow of Galeton. That incident forced the Galeton Water Authority to switch to another permitted drinking water source.

Sedimentation also impacts fish by reducing food sources and spawning habitat, and causing reductions in growth and direct mortality. Earlier this month Pine Creek, a world renowned trout stream and a federally designated wild and scenic river, experienced severe turbidity as a result of the El Paso pipeline construction happening in Potter County. The open ditches running up and down the mountain failed to include appropriate erosion management controls, resulting in excessive sediment loading that will likely diminish trout spawning this season.

These are just 2 examples of pollution incidents that have resulted from DEP inspection at sites where an erosion and sediment control permit was required. In reality, there are many more of these types of pollution incidents that go unnoticed and

uninvestigated by the State largely because oil and gas development sites less than 5 acres are not required to receive a permit under current Federal or State law. Collectively, these impacts will result in the overall degradation of water resources.

Blowouts, spills and leaks related to drilling activity can also cause significant short and long term impacts on water resources. In 2009, several leaks and spills from a single site caused contamination of groundwater springs and high quality trout waters. Leaks from hoses, tanks and storage pits resulted in thousands of gallons of water and fracking fluid contaminating 3 trout streams and Reed Springs, a drinking water source for nearby camps, hunting camps in Clearfield County. The same site experienced a blowout in June 2010, which released at least 35,000 gallons of brine and toxic fluid into the air for over 16 hours.

The several incidents of contamination to surface and groundwater from this one site demonstrate the risks that may be posed by the 50,000 to 80,000 wells that are projected for Pennsylvania alone.

Other surface impacts from gas drilling relate to the locations of wellpads, wastewater storage areas, and pipelines. State law, at least in Pennsylvania, does not prevent infrastructure from being sited in the 100 year flood plain and in close proximity to streams, in some cases, within 100 feet.

As Mr. Beauduy pointed out earlier, large consumptive water withdrawals from small, headwater streams can threaten trout fisheries and downstream water supplies. State regulators and the industry have failed to develop and implement comprehensive wastewater management treatment and disposal plans.

We applaud the EPA's announcement today of a schedule to develop consistent shale wastewater effluent standards.

In closing, Trout Unlimited urges this Congress to take a more careful look at the full range of gas development impacts on water resources, require disclosure of chemicals used in hydraulic fracturing, and reinstate the Clean Water Act storm water and Safe Drinking Water Act provisions that should right now be at work on the ground protecting valuable resources from gas development.

Thank you.

[The prepared statement of Ms. Dunlap follows:]

PREPARED STATEMENT OF KATY DUNLAP, EASTERN WATER PROJECT DIRECTOR,
TROUT UNLIMITED

Madam Chair, ranking member Lee, and members of the subcommittee:

My name is Katy Dunlap, and I am the Eastern Water Project Director for Trout Unlimited-the nation's largest coldwater conservation organization dedicated to conserving, protecting and restoring North America's trout and salmon fisheries. I thank the members of the subcommittee for holding this important hearing and for the opportunity to testify.

Most of Trout Unlimited's 140,000 members like to fish, and they give back to the rivers and streams by dedicating more than 600,000 volunteer hours each year. We are fortunate to have such a committed group of volunteers, as the challenges we face are great: nearly half of the rivers and streams in the U.S. are considered to be impaired.

Natural gas development is occurring in several regions in the Eastern half of the United States, including the Antrim Shale in Michigan, Fayetteville Shale in Arkansas, and Marcellus Shale in the northern Appalachians. My testimony today will

focus on the Marcellus Shale, and specifically on the impacts of development in Pennsylvania, where more than 1,600 wells are in production.¹

Trout Unlimited supports natural gas development that is done the right way, and in the right places. Improperly sited or poorly managed natural gas development, however, can cause serious harm to water resources, which I will explain in greater detail later in my testimony. Declines in water quality directly affect Eastern brook trout, the East's only native trout, and a species whose survival depends on a steady supply of clean, cold water. A recent assessment found that brook trout are either greatly reduced or have vanished from 50 percent of their historic range, and are at risk of disappearing from other areas. The report found that two of the major impacts to brook trout are habitat fragmentation and sedimentation due to road crossings and construction—two impacts that are also associated with drilling in the Marcellus Shale.

With our state and federal agency partners, as well as our conservation allies, Trout Unlimited members are working hard to reverse the decline in brook trout populations all along the Appalachian mountain range, from Georgia to Maine. In Pennsylvania, Trout Unlimited's 12,000 members and staff have been diligently working for more than a decade to restore trout streams that suffer the legacy impacts of past coal mining. And we are making progress. For example, work to remediate acid mine drainage in the Babb Creek in Tioga County, Pa. restored water quality to the point that brook trout were able to repopulate the stream for the first time in decades. Yet in 2011 alone, 181 Marcellus Shale wells have been drilled in Tioga County. As we work to achieve hard-won fishery restoration gains, it is imperative that we avoid additional losses that can result from poorly managed natural gas development.

The potential for natural gas development to impact water resources and trout fisheries exists at several stages of the development process. While Trout Unlimited is concerned about the potential contamination of water resources that can be directly caused by the hydraulic fracturing process, we are equally concerned about the surface impacts that can result from the associated activities of hydraulic fracturing and natural gas development. Specifically, we are concerned about the locations of well pads, wastewater storage areas, and pipelines; well pad, pipeline, and access road construction; water withdrawals from small headwater streams; spills and leaks of toxic substances; and the management, storage and disposal of drilling wastewater.

State and local governments are almost entirely responsible for regulating gas development in the Marcellus Shale region. Federal regulation of the stormwater and drinking water aspects of gas development could have been helpful, but were eliminated by the 2005 Energy Bill passed by Congress. With the lack of any federal oversight, states have taken very different regulatory paths, as I'll explain below. But in the heart of the Marcellus development area, in places such as Pennsylvania, well intentioned state regulatory programs are struggling mightily to keep up with the challenges posed by rapid gas development.

From what we see on the ground, regulation of gas development is not adequate to protect water resources, and we are working hard to fill the gaps. From cradle to grave, water use management for drilling and hydraulic fracturing needs significant improvement to eliminate or reduce incidents of water-related pollution and to ensure overall protection of water resources. My testimony today will illustrate a few examples of drilling-related surface impacts occurring on the ground, including: erosion and sedimentation; blowouts, leaks, spills and illegal discharges; impacts of water withdrawals from headwater streams; and insufficient regulation of wastewater management. I will then discuss what Trout Unlimited is doing to prevent harm to water resources and aquatic habitat, and the policy changes that are needed in Pennsylvania and beyond to facilitate responsible energy development while sustaining the healthy ecosystems that support \$76.7 billion in hunting-and fishing-related economic activity across the United States.

I. Water Quality and Quantity Impacts

Of the 925 violations issued by the Pennsylvania Department of Environmental Protection (DEP) to Marcellus well operators, from January to August of this year, the greatest percentage of violations issued were related to spills, leaks, and illegal discharges. However, by far the most prominent and concerning impact that Trout Unlimited members are seeing on the ground is the failure or lack of erosion and sediment controls on well pad construction sites and access roads.

¹ <http://www.prweb.com/releases/Marcellus/Production/prweb8855519.htm>

A. Erosion and sedimentation

Erosion and sedimentation can lead to the overall degradation of water supplies and irreversible impacts on valuable and irreplaceable trout streams. In March 2011, development of a gas well site in West Branch Township, Potter County, led to an erosion problem that resulted in the DEP issuing a cease-work order to Chesapeake Energy. A significant amount of sediment and silt was discharged from the site into a stream that is a tributary to a water source serving the Borough of Galeton. The Galeton Water Authority was forced to use another permitted drinking water source. If the water supply operator had not been on site to shut off an intake valve, the water supply for 1,400 Pennsylvanians would have experienced irreparable damage. DEP issued a violation to Chesapeake for failure to implement erosion and sediment controls required in the permit.

In addition to affecting the quality of public water supplies, erosion and sedimentation can greatly impact high quality coldwater habitat. At least 15 different direct negative effects from sedimentation have been demonstrated to impact trout and salmon, ranging from stress, altered behavior, reductions in growth and direct mortality:

Suspended sediment blocks light affecting feeding and movement of fish and causes direct gill damage (if concentrations are high enough) that may lead to death. Excessive sediment in the stream bottom may act as a physical barrier and stop the emergence of fry or prevent proper flow of water to redds . . . Proper water flow is necessary to carry dissolved oxygen to incubating eggs and to remove waste products from developing embryo.²

Earlier this month, a world-renowned trout stream in north central Pennsylvania was seriously impacted by the construction of a Marcellus natural gas pipeline. Pine Creek—a federally-designated Wild and Scenic River—experienced severe turbidity as a result of vegetation clearing for the El Paso pipeline in Potter County. The open ditches running up and down the mountain failed to include appropriate erosion and sediment management controls, resulting in excessive sediment loading that will likely negate spawning in the exceptional value trout stream. This incident is currently being investigated by Pennsylvania’s DEP, Fish & Boat Commission and the Potter County Conservation District to determine the ultimate impact on Pine Creek and its coldwater fishery.

These are just two examples of sedimentation pollution incidents that have resulted from DEP inspection at sites where an erosion and sediment control permit was required. In reality, there are numerous sedimentation pollution incidents that go un-noticed and uninvestigated by the state—largely because oil and gas development sites less than five acres are not required to receive a permit under current federal and state law. Collectively, these impacts will result in the overall degradation of water resources.

It is estimated that by 2030 between 38,000 and 90,000 acres of Pennsylvania’s forest cover will be cleared by Marcellus gas development.³ The loss of forest cover will leave bare soil exposed and lead to significant increases in erosion and potential water quality impacts, if left unregulated and unchecked. Without oversight on oil and gas development-related construction sites of one acre or more, this pollution problem will perpetuate.

B. Blowouts, leaks, spills and illegal discharges

Blowouts, spills, and leaks related to drilling activity make the news much more often than erosion and sediment control violations. These activities may cause immediate short-term impacts to water resources and contribute to overall water resource degradation in the long-term.

On April 19, 2011, equipment failure at a Chesapeake Energy gas well site near LeRoy Township, Pa. caused a leak, resulting in the release of 30,000 gallons of salty flowback water from the site and into a tributary to Towanda Creek. The well site was located less than 500 feet from the tributary that drains into Towanda Creek—too close to prevent drilling fluid from entering the creek. Towanda Creek is a well-known trout stream that meets the Susquehanna River about 16 miles downstream of the spill. The Susquehanna River supplies 45 percent of the fresh water in the Chesapeake Bay.

²Lloyd, D.S. 1987. Turbidity as a water quality standard for salmonid habitats in Alaska. Pages 34-35. North American Journal of Fisheries Management. American Fisheries Society. Bethesda, MD.

³Johnson, Nels (2010). Pennsylvania Energy Impacts Assessment, Report 1: Marcellus Shale Natural Gas & Wind, p.9. The Nature Conservancy, Pennsylvania Chapter.

In March 2010, Airfoam HB-a wetting chemical used in gas drilling was discharged into Pine Creek near Waterville, Pa. The material originated from a Pennsylvania General Energy Company LLC (PGE) well site approximately 2,000 feet uphill from Pine Creek and was found by local citizens in Pine Creek. Pennsylvania Fish & Boat Commission investigators determined that the surfactant was pumped down the well during the drilling process and, in all probability, accumulated in a void in the sedimentary rock layers. The surfactant was then flushed laterally through the underground rock strata by heavy rain runoff before emerging as a soapy discharge at a spring, on the mountainside approximately 2,000 feet away.⁴

In Clearfield County, Pa., several leaks caused contamination of groundwater springs and high quality trout waters in 2009. At a well site owned by EOG, a small hole in a drilling wastewater hose allowed gas and flowback water to leak and percolate onto the ground and into Little Laurel Run for over two months, contributing to the contamination at Reed Springs and Alex Branch. Another accident occurred at the site, when almost 8,000 gallons of water and fracking fluids leaked from a tank and into the Alex Branch and Trout Run. Alex Branch is a tributary of Trout Run, one of the area's better fishing creeks, which flows into the West Branch of the Susquehanna River. Investigations by the DEP and the Pennsylvania Fish & Boat Commission subsequently determined that several accidental discharges of contaminated water and fluids at EOG's Marcellus operations, including leakage from the pit over a two-month period from August through October 2009, had caused the contamination of Reeds Spring.⁵ That same EOG well experienced a blowout in June 2010, releasing at least 35,000 gallons of brine and toxic fluids from hydraulic fracturing into the air over 16 hours. The DEP shut down the company's drilling operations for 40 days statewide, and six weeks later, fined EOG and a drilling contractor a total of \$400,000.⁶ Just this one well site alone caused several incidents of contamination to surface and ground water sources, demonstrating the potential contamination that may be caused by the 50,000 to 80,000 wells that are projected for Pennsylvania alone.

C. Water quantity concerns

While the states overlying the Marcellus Shale region are blessed with abundant rivers and streams, these water resources are not infinite. Large, consumptive withdrawals for gas drilling can have deleterious effects on sensitive watersheds and their aquatic life. To hydraulically fracture each Marcellus well, approximately five million gallons of water is needed. The timing and location of water withdrawals for gas drilling, as well as consideration of other major withdrawals in the basin during the same period, will determine the short- and long-term impacts on the watershed. Because many of the more productive Marcellus drilling areas are in or nearby smaller watersheds containing headwater streams, such large water withdrawals could be devastating to coldwater habitat and other aquatic resources.

For example, Horton Run, a tributary of the East Fork of Sinnamahoning Creek and classified as an "Exceptional Value" trout stream, was virtually de-watered by water withdrawals for gas well development. Fish kills have occurred as a result of water withdrawals that de-watered Cross Creek and Sugarcamp Creek in Washington County, Pa. Four gas companies have paid a total of \$1.7 million to settle charges of illegal water withdrawals from Pennsylvania trout streams, including Chief Oil & Gas, which took 3.5 million gallons from a tributary of Larry's Creek, and Range Resources, which took 2.2 million from Big Sandy Run. Additionally, water withdrawals have damaged Meshoppen, Pine and Sugar creeks. These examples clearly demonstrate the risk that water withdrawals from small headwater streams pose to aquatic habitat.

D. Wastewater management

Marcellus Shale operators in Pennsylvania have reported that approximately 15 percent of the roughly 5 million gallons of water used to fracture a well is returned to the surface during the initial flowback period, and the Secretary of Energy Advisory Board's (SEAB) 90-day report found that ". . . in the Marcellus, primarily in Ohio, New York, Pennsylvania and West Virginia, the flow-back water is between 20 and 40 percent of the injected volume."^{7,8} Flowback from Marcellus Shale hydraulic fracturing contain pollutants of concern—particularly high levels of dissolved salts, often several times saltier than sea water. High Total Dissolved Solids (TDS)

⁴ http://www.fish.state.pa.us/newsreleases/2011press/pge_settle.htm

⁵ <http://www.post-gazette.com/pg/11156/1151527-503.stm>

⁶ <http://www.post-gazette.com/pg/11156/1151527-503.stm#ixzzlasSTB7RA>

⁷ <http://www.pagopolicy.com/Display/SiteFiles/112/2011Hearings/>

112 4 21 11 Jugovic DEP Testimony.pdf

⁸ The SEAB Shale Gas Production Subcommittee Ninety-Day Report-August 11, 2011, p.9.

levels can have significant impacts on trout populations and the waterways they rely upon.

Hauling fresh water and wastewater to and from a well pad site is a service that is often sub-contracted to several hauling companies. Each of those trucking crews may be operating several trucks, and each of those drivers may be making several trips a day. In southwest Pennsylvania, one such hauler was recently charged with illegally dumping millions of gallons of Marcellus Shale drilling wastewater into holes, mine shafts and waterways in a six-county region between 2003-2009. Robert Shipman and his company, Allan's Waste Water Services, are collectively facing 175 criminal charges.⁹

While the return water (flowback plus produced water) is increasingly being re-used and recycled by the industry, ultimately decreasing the demand for freshwater, there continues to be a lack of a comprehensive treatment plan for wastewater generated from hydraulic fracturing and drilling practices. In Pennsylvania, the DEP asked drillers to voluntarily stop taking wastewater to municipal treatment plants, as these facilities are designed to treat biological agents and not equipped to treat the chemicals and high salts found in drilling wastewater. Several companies have complied. However, there is still a need for long-term wastewater management planning, as even recycled wastewater must be partially treated before re-use and will eventually need to be disposed. Other avenues for wastewater disposal have been underground injection wells. In general, Pennsylvania drillers have been sending their wastewater to Ohio for underground injection.

In the face of these hazards for water resources, states in the region have responded differently. Pennsylvania and West Virginia have the most active Marcellus Shale gas development and the most active state regulatory programs. Conversely, not one horizontal Marcellus gas well has yet been developed in Maryland or New York, and in fact, drilling will not be permitted in the drinking watersheds for New York City and Syracuse because of water quality concerns. New York has been working on a study of the impacts of gas development since 2008, and is on the verge of allowing active development in other parts of the state in 2012. Maryland is undergoing a study to determine whether and how Marcellus Shale gas development might occur in the state. A final report is expected by August 2014.

II. Solutions

TU is actively involved at local, state, and federal levels to find solutions which will allow well sited, well planned, and well executed gas development. The large numbers of wells being developed in Pennsylvania, and the hugely important trout fisheries which are a hallmark of the state and its \$1.3 billion angling-related economy,¹⁰ make it ground zero for our work.

To address the next challenge facing Pennsylvania's coldwater streams, Trout Unlimited launched a Marcellus Shale campaign aimed at working with state agencies and the industry to identify, avoid and mitigate the impacts of gas development on trout populations and coldwater habitat. Trout Unlimited and other sportsmen and women have met with state regulators to discuss protections for ecologically-sensitive watersheds and opportunities for improving monitoring, oversight and enforcement of drilling related activities. We have developed a partnership with a drilling company in southwest Pennsylvania to create a model well pad site and demonstrate how best management practices and appropriate well siting and design can increase the likelihood that water resources and trout populations are protected.

To provide an extra set of eyes and ears on the ground, Trout Unlimited initiated the Pennsylvania Coldwater Conservation Corps in 2010. We have trained more than 200 volunteers to conduct stream surveillance to monitor the impacts of Marcellus Shale development on the commonwealth's valuable water resources. Our members conduct water quality testing on sensitive coldwater streams and survey watersheds for impacts associated with drilling-related activity where Marcellus development is occurring or is projected to occur in the near future. In the field, Trout Unlimited members are witnessing impacts that do not always make the headlines.

Volunteer efforts and industry best practices form two legs of the stool, with the third being effective regulations. Trout Unlimited recommends the following changes to deal with the problems identified above.

A. Erosion and sedimentation

Unlike other construction sites, due to an exemption provided through the Energy Policy Act of 2005, oil and gas construction sites are not covered by the Clean Water

⁹ <http://www.post-gazette.com/pg/11077/1132812-454.stm>

¹⁰ <http://www.census.gov/prod/2008pubs/fhw06-pa.pdf>

Act's stormwater provisions.¹¹ This exemption prevents the application of Clean Water Act stormwater runoff rules to the construction of exploration and production facilities by oil and gas companies and the roads that service those sites. In light of the impacts of construction-related stormwater from natural gas development on fish habitat and water resources, this exemption makes little sense and should be repealed.

In Pennsylvania, an erosion and sediment control permit is required only if a well operator is proposing five acres or more of earth disturbance. However, the average Marcellus Shale well pad size in Pennsylvania is approximately three acres—making the majority of well pads exempt from the state's erosion and sediment control permit requirements.¹² Due in large part to gaps in regulatory oversight, streams are turning turbid and muddy from the erosion, sedimentation and runoff from nearby Marcellus construction sites.

B. Blowouts, leaks, spills and illegal discharges

Steps should be taken to reduce the risk of impacts to water, including removal of the exemption to the Safe Drinking Water Act for hydraulic fracturing. Some spills and other accidents may be unavoidable. For these, we should reduce their direct impacts on water resources by requiring setbacks from waterways for natural gas infrastructure. Construction of well pads, compressor stations, storage pits and other drilling infrastructure should not be authorized, at a minimum, within 300 feet of surface waters. Well pad development and construction of impoundments should be prohibited in 100-year floodplains.

C. Water quantity concerns

In Pennsylvania, one-third of the state does not have a comprehensive water withdrawal permitting program. While the state requires each company to submit a Water Management Plan for drilling within a region, the plan only requires identification of the source, the amount, the counties where the water will be used and a low flow analysis. The plan does not require monitoring to ensure compliance with the permit or signage at the withdrawal site, making it difficult for the public to know whether a withdrawal is legally permitted. Additionally, while the plan is valid for five years, there is no specific time restriction associated with the withdrawal and the operator has 30 days to notify the DEP after initiation of the withdrawal. At that point, the damage could be done. In the Ohio River basin, the DEP established "guidelines" similar to the Susquehanna River Basin Commission, but these are merely guidance-not requirements-and DEP inspectors do not visit water withdrawal sites to ensure compliance with the water management plan.¹³ Furthermore, the DEP has never suspended a water withdrawal approval for drilling because of inadequate streamflow conditions, even during recent drought declaration periods.

Pennsylvania's current water quantity management fails to comprehensively manage the impacts on stream flows. State regulators should conduct a cumulative impact assessment to determine how taking billions of gallons of water out of a watershed will impact the small headwater streams that provide integral ecosystem services for downstream users and that support trout spawning. And where necessary, the state should establish ecologically-based withdrawal limitations to prevent damage to headwater streams.

D. Wastewater management

A comprehensive management plan for wastewater generated during the drilling process, using a cradle-to-grave approach including disclosure, tracking and proper treatment and disposal, must be developed to protect valuable water resources. Trout Unlimited supports the SEAB Committee's recommendation that regulators begin working with industry and other stakeholders to develop and use an integrated water management system. An integrated water management system should include common principles, such as adoption of a life-cycle approach for tracking and reporting all water flows throughout the process; measurement and public reporting of the composition of water stocks and flow throughout the process; and manifesting of all transfers of water among locations.¹⁴ Real-time tracking systems should be required for trucks hauling fresh water, flowback water and chemicals, including GPS systems and electronic manifest systems, to allow for regulatory entities and emer-

¹¹ Section 323 of the Energy Policy Act of 2005, P.L. 109-58.

¹² Johnson, Nels (2010). Pennsylvania Energy Impacts Assessment, Report 1: Marcellus Shale Natural Gas & Wind, p.9. The Nature Conservancy, Pennsylvania Chapter.

¹³ Information provided by Scott Perry, Chief of Pennsylvania DEP Bureau of Oil & Gas Management (12/28/10).

¹⁴ The SEAB Shale Gas Production Subcommittee Ninety-Day-Report—August 11, 2011, p. 22.

agency personnel to track and respond to potential accidents and to prevent haulers from disposing of drilling wastewater illegally.

In Pennsylvania, permits were issued, drilling began and wastewater was generated before the industry or the state had a solid plan for managing and treating wastewater. To date, short-term fixes have been utilized to dispose of wastewater. However, as with any commercial industrial sector, the natural gas drilling industry must invest in long-term wastewater treatment and disposal solutions.

Finally, Trout Unlimited supports the SEAB Committee's recommendation that regulatory entities immediately adopt rules for full disclosure of the chemicals used in the fracturing process and the chemical composition on a well-by-well basis. Such disclosure should be made on a publicly available website.

The management actions described above would do much to reduce the risk of harmful impacts on water resources and aquatic habitat from natural gas development. However, it will never be possible to fully eliminate the impacts of intensive energy development. The SEAB 90-Day Report stated that: "The combination of impacts from multiple drilling and production operations, support infrastructure (pipelines, road networks, etc.) and related activities can overwhelm ecosystems and communities." Due to unavoidable impacts, Trout Unlimited supports the SEAB recommendation to "Declare unique and/or sensitive areas off-limits to drilling and support infrastructure as determined through an appropriate science-based process." Such areas include high quality brook trout habitat identified through Trout Unlimited's Conservation Success Index,¹⁵ for example key watersheds in the Monongahela National Forest in West Virginia where no wells have yet been permitted, and the George Washington National Forest, which now is considering adopting a strong policy on horizontal drilling for natural gas.

III. Conclusion

Trout Unlimited thanks the subcommittee for holding this timely hearing, and for its interest in the issue. There is no doubt that natural gas is now, and will be, a major component of the nation's energy supply. But gas development in the Marcellus region is harming fish habitat and water resources, and the long term cumulative impacts are not being adequately studied. Both of these facts are troubling to those of us who care about balanced resource extraction.

We urge this Congress to take a more careful look at the full range of gas development impacts on water resources, and to consider reinstating the Clean Water Act stormwater and Safe Drinking Water Act provisions that should right now be at work on the ground protecting those resources from gas development.

Thank you for the opportunity to provide testimony today.

Senator SHAHEEN. Thank you very much, Ms. Dunlap.

I want to start with where you ended, which is, are you suggesting that shale gas development should not have gotten an exemption when it did in 2005?

Ms. DUNLAP. I'm suggesting that perhaps at that time the potential for erosion and sedimentation was not known. Most of the development that is occurring in Pennsylvania is happening in the upland-highland areas, and the relatively undeveloped areas of Pennsylvania. This requires developing new roads to access those areas and, of course, clearing forests to put in place these wellpads, which are, on average, about 3 acres in size.

Senator SHAHEEN. Given what Ms. Dunlap has said with respect to some of the challenges that they've seen in Pennsylvania, Mr. Beauduy, how does—that seems to be in conflict with some of what you had to say about what the commission that you serve on has been doing with respect to overseeing and regulating what's going on with shale gas development. So can you talk a little bit about some of the concerns that she's raised, and what you've seen, and whether you think what is currently going on with respect to regulation is adequate?

Mr. BEAUDUY. She raises some very legitimate concerns. Our role in this is, particularly in the headwater areas, is trying to restrict

¹⁵ <http://www.tu.org/science/conservation-success-index>

withdrawals so that they don't cause impacts. Our member jurisdictions are responsible for the siting and location of pad sites, access roads, and ENS related to this activity.

Any time you have industrial activity in these areas, you're going to have to have extremely tight controls in order to be able to avoid impact. There have been impacts. We have a few poster child examples in our Basin, a town in Dimock and a few other places, where we've had well blowouts.

So we've had some activity like that, but the concern that is raised about erosion sedimentation control is a legitimate one. I indicated to you that our water quality monitoring network is showing, at least on the chemical side that things are staying within range, but some of the spikes that I mentioned have to deal with those sediment loads getting into the system. So, and we are providing that data to our member jurisdictions, and they continue to evolve those programs and those controls.

But I would agree that in terms of sensitive habitat in our Basin, in the headwater areas, the greatest threat is probably the issue of land disturbance more than anything else.

Senator SHAHEEN. So, should that be addressed through State regulation? Is it that we don't have adequate enforcement of current regulations? Should we expect that there should be more sharing of best practices in the industry to help address that? What's the answer to some of these concerns?

Mr. BEAUDUY. I think it's all of the above, quite honestly. Yes. It's been a dynamic process.

Some of the traditional ENS mechanisms that have worked elsewhere don't seem to be working with this industry. There have been modifications. Some of our jurisdictions have modified the delivery mechanisms and who's responsible for overseeing that activity and permitting that activity.

So there are—it's an evolution right now, I will tell you that. It's very dynamic, but that probably is the greatest threat to the system right now, and that's land disturbance activity. Particularly when you get into these mountainous areas where, you know, you don't have a piece of flat ground anywhere, and the potential for erosion is significant, and it's directly discharged into headwater streams.

Headwater streams by definition scientifically, and I'm not a scientist, but fundamentally what you'll see if you study the science is that headwater streams don't have any flood plain. You're talking about slopes that come right down to those streams, and so therefore, any level of discharge off of these sites is going to find its way into those streams, and can have an impact.

Senator SHAHEEN. Thank you. I'm almost out of time, but I wanted to go back, Ms. Wrotenbery, because you talked about the Website for—

Ms. WROTENBERY. FracFocus?

Senator SHAHEEN. Yes. Thank you. I was—I had written it down. That 5,000 wells are—have currently, voluntarily posted on the Website the chemicals that they were using. How many wells? That's 5,000 out of how many? Do you know? Because Ms. Dunlap was just talking about 70,000 to 80,000, is that what you said?

Ms. DUNLAP. I said 50,000 to 80,000 projected in Pennsylvania.

Ms. WROTENBERY. I'll say. I will try to get that information for you. What I can tell you is the FracFocus site is available for wells that were hydraulically fractured since January 1. So, we've got 5,200 wells out of that universal well.

Senator SHAHEEN. I'm trying to get some sense of, and what we think is the percentage of companies that are voluntarily posting that information.

Ms. WROTENBERY. I can tell you that was 49 different companies that posted that information. We've got another 66 companies that have registered and intend to put information about their wells on that site, and the specific information is not up yet, but we expect it will be there.

As far as the percentage, I'll have to go back and do some analysis, but I will follow up on that question to try to give you a sense.

Senator SHAHEEN. Thank you. Dr. Cooper, did you want to add to that?

Mr. COOPER. Yes, sure. I recently listened to some testimony by Leslie Savage, the commissioner who works in the Texas Railroad Commission and she concluded that almost half of all hydraulically fractured wells in the Texas have been reported on the FracFocus Website.

My company is very proud to have reported all of their wells on the FracFocus Website. I realize that there are many smaller operators in some parts of the world, and even here in the Marcellus area that may not have been so generous with their information. But I think that also States like Texas have decided they're going to make everybody report, and I think that's really happening across a broad swath of States.

Senator SHAHEEN. For those people who aren't reporting and I certainly commend Apache for doing that, what's the impediment to that? Because it gets interpreted as, "They don't want to report because they're worried about what chemicals are being used and what the public's going to think about those chemicals." So that, I fear, is the perception that people have for those people not reporting.

Mr. COOPER. I think it's fair to say that everybody hates big change, and no one really likes a lot of regulation. So some people went kicking and screaming just for those reasons.

I think, though, that in reality when they got their heads around what they were being asked to do, they thought it was a really good idea. So, industry is rushing to provide that information. There are some things that are being protected. There are some really legitimate intellectual property issues, and it's confidential business information that has to be handled. So far, the proposals have had the State government agencies get access to that information, but it wouldn't be shared publicly.

I think that it's been a really good thing for companies themselves, and I can say that our company has learned a great deal about what we were buying from our vendors, and full disclosure is a really great thing.

Thank you.

Senator SHAHEEN. Thanks, very much.

Senator Lee, I appreciate your patience.

Senator LEE. Thank you.

Ms. Wrotenbery, tell me a little bit about how FracFocus is funded and what your funding requirements are on that?

Ms. WROTENBERY. FracFocus was developed initially with a grant from the U.S. Department of Energy. That was the seed money for the system. Along with that, there was an in-kind contribution from the State participants in the process, and the participation by other stakeholders.

Some of the enhancements that we've already seen to the system, for instance, just within the last couple of weeks, we've added a GIS component to that system. We've gotten some support from the industry in developing some of that enhancement. They've participated in the project on a kind of a cost share basis. So we've got some additional funding there.

But we have submitted requests to the Department of Energy, and EPA, and talked to some of the folks here on the Hill about needs going forward for the system.

Senator LEE. OK. So you see that as sort of a model moving forward to keep it going?

Ms. WROTENBERY. Definitely. It's a system that's in a state of evolution. As we use it, we learn more about what's there, and what's not there and what people need in order to be able to access the information.

Senator LEE. Then how, and to what extent, do you find the State regulators are using the system or taking advantage of it?

Ms. WROTENBERY. The—what's happening at the State level, States like Texas have recently adopted requirements that companies submit chemical information on their frac fluids. Typically what they've done is say if they use the FracFocus site, that will satisfy their reporting requirements.

Senator LEE. Right. But that's probably—

Ms. WROTENBERY. So the States individually have addressed their own funding needs there.

Senator LEE. Probably provides for a streamlining of their regulatory burdens, then?

Ms. WROTENBERY. It does, and I will say Oklahoma is one of the States that is considering a requirement that the companies in Oklahoma use FracFocus.

Senator LEE. OK. Thank you.

Then, Mr. Beauduy, can you explain your in-stream monitoring system a little bit, how that works? Particularly with—I'm kind of curious as to how it works with regard to this industry as compared to others.

Mr. BEAUDUY. The system—the system is comprised of, at these 50 stations, of a specialized probe that's called a data sonde that is put into the water. It's cabled to a data platform on the shore, powered by solar, and either via satellite or cell, it's—that data sonde is analyzing for 6 parameters on a continuous basis. Every 5 minutes, it's sending that data to the data platform. Once an hour, that data is uploaded to the computer system; that's to conserve battery life. So that the data is never more than 1 hour old that's in our system.

But we are looking at several parameters. One of the most notable ones is conductance, because conductance will give you an indication of metals and salt. So, if you see increases in conductance,

that means you've got an issue that doesn't necessarily mean it's a gas operation that's causing that problem, but—

Senator LEE. But it could be.

Mr. BEAUDUY. But it could be. These are indicators. This system isn't designed to establish causation or anything else like that. It is out there to monitor the system to see, is dissolved oxygen changing? Is turbidity changing? Is conductance changing? What are those values? You have to have enough data in the system over a certain period of time in order to be able to see basically background and what are the natural fluctuations, either natural or human-induced, that are normally going on in those watersheds. Then, how does that compare to what you're seeing, you know, when the industry comes into town and begins to frac, or begins to develop wellsites, or put in access roads, or develop pipelines, or anything else like that.

So it's—we're trying to build a baseline of data throughout this network of watershed so that we can see if there's any trend changes over time.

But also, there are alarms built-in to the system. So if any one of those parameters gets exceeded over a certain level, that triggers sampling and it triggers inspection. We notify the agencies, the other agencies that actually actively regulate water quality and provide them with that data so that they know that there may be some incident occurring in that watershed that needs an investigation.

Senator LEE. So once you can acquire that additional data and view your initial warning data in context, you can usually rule out the false, the possibility of a false-positive alert?

Mr. BEAUDUY. Yes, but it takes some time. It's a fairly complicated analytical process that you have to go through and a lot of QA/QC with the data. In fact, we pull those sondes every 6 to 8 weeks, replace them in the field on a continuous basis, bring them back to recalibrate just to make sure that they're being—that they're very accurate on an ongoing basis. We don't just stick them in and leave them there. Every 6 to 8 weeks they're being pulled, replacements put in, and then having those ones that come out of the field recalibrated at the lab.

Senator LEE. OK. I see my time's expired. Thank you, Madam Chair.

Senator SHAHEEN. Thank you.

I want to go back and to your comments, Mr. Beauduy, about virtually all of the water being recycled, the produced water being recycled—

Mr. BEAUDUY. Yes.

Senator SHAHEEN. At this stage. Ask if that's consistent, Ms. Dunlap, with what you've been seeing as you've looked at the wells that are being done in Pennsylvania.

Ms. DUNLAP. In large part, we believe that the industry is recycling most of the wastewater that's coming back out of the well. Now, we have—there's some discrepancy in exactly what's happening. That information's not really made available publicly.

We know that the Secretary of the DEP in May asked the industry to voluntarily stop taking their wastewater to the municipal treatment plants, and we know that many of them did comply. We

also know that the wastewater is being taken to Ohio and in injected in underground injection wells there.

But in terms of the amount of water that's being recycled and reused, I've been told through a report of the Marcellus Shale Advisory Commission that was done in Pennsylvania that about 15 percent of the water was actually being recycled and reused.

Senator SHAHEEN. That's different than what you're seeing, Mr. Beauduy, is that correct?

Mr. BEAUDUY. Yes. A number of the operations, the larger operations are already at 100 percent recycling, but that's not all of them. They all have that as an objective.

I think that what we don't have access to data-wise, but we can get, we can try to provide it to you is we know how much is being used/reused on frac operations. In fact, our profile data that comes in from the industry on every frac job shows us that over the last year, the industry is using about 1/2 million gallons of flowback per frac job.

So of a 4 1/2 million gallon total quantity of water being used for a frac operation, 1/2 million of that is flowback. So that's the extent. It's about 12 to 15 percent by volume, but that's not 12 to 15 percent of all the fluids being generated.

It's extremely costly for this industry to transport and treat flowback. So if they can reuse it and they have the ability to transport it from pad to pad to pad, that's what they do. We've tried to incentivize that because we don't want to see it going to discharge. But in our Basin, we don't have that discharge. We do have 3 or 4 treatment facilities that have been permitted to treat that material, but all that material goes back out into the field for reuse on the next frac job.

Senator SHAHEEN. OK.

Mr. BEAUDUY. But we are aware that there's a certain percentage that is going to Ohio for deepwell injection. They attempted to develop some deepwell injection capability in our Basin. The formations are much too tight; it just won't take it. Unless they give up the natural gas storage fields which supply the Northeast, and they don't want to do that, and so therefore deepwell injection is not an option in our Basin. So it's either reuse or shipment to Ohio, and that's one of the drivers for making sure that they recycle up to 100 percent of it.

Senator SHAHEEN. Thank you.

Dr. Cooper, we were talking earlier about the transparency with respect to use of chemicals in the process. I think, Ms. Wrotenbery pointed out that Texas has required that now for full disclosure. Should all States put in place that kind of a requirement?

Mr. COOPER. So to clarify a little bit, Texas passed a law, and the Texas Railroad Commission has proposed regulations, and they are in their final review of the proposed regulations, which they have suggested to industry, will be in force by the 1st of January. Certainly my company supports that Texas style reporting everywhere.

Senator SHAHEEN. Does—do others want to weigh-in? Is this something that should be done everywhere, Ms. Wrotenbery?

Ms. WROTENBERY. I will say there are other sites—States besides Texas that have adopted chemical disclosure and reporting require-

ments, and there are still others that are in the process of considering it.

In Oklahoma, we're considering it at this point. We're talking to the various stakeholders. There are—you talked about why some companies may not already be reporting their hydraulic fracturing chemicals on the Website yet.

I do know there are a number that are working on it, but it's a new system. We're in a transition process where they're trying to make sure they can get the information from the companies that supply the chemicals and perform the hydraulic fracturing operations for them. So, there is some work being done to make sure that they can compile this information, and get it reported fully and accurately to the system.

So it's an evolutionary process, and we're certainly supportive of all companies using this system to report the chemicals in their frac jobs.

Senator SHAHEEN. Should it be required by States?

Ms. WROTENBERY. That's something, you know, my agency is going to have to address. We're seriously considering doing that, but my commission hasn't made that call yet. So it would be premature for me to comment on that one.

Senator SHAHEEN. OK. Mr. Beauduy.

Mr. BEAUDUY. Our commission supports the maximum amount of transparency as possible. Particularly with this industry, there's a lot of concern, there's a lot of misinformation. The more transparent all of us that are involved in some aspect of this industry, the more transparent we are, I think that the better off we are as a country. I think that all of us are moving in that direction.

We have invested millions to put applications online, to put approvals online, to put monitoring data online of all types; water use as well as water quality data. We believe that as much data as can humanly possibly be made available and transparent to the general public is a good thing.

Senator SHAHEEN. So I'd put you in the "yes" column.

Mr. BEAUDUY. Yes.

Senator SHAHEEN. Ms. Dunlap?

Ms. DUNLAP. Yes, you can put Trout Unlimited in the "yes" column as well. We support full disclosure and that that information be available to the public on a Website.

Senator SHAHEEN. Thank you.

I wanted to go back to the question about well casing and cementing because I don't know if you heard me ask Ms. Dougherty that question, Ms. Wrotenbery, but she suggested that I defer it to you. So I wonder if you could respond whether that's being adequately regulated at the State level the well design including casing and cementing?

Ms. WROTENBERY. What I can tell you is the well casing and cementing requirements are a core part of the State oil and gas regulations.

We are in a process right now of reviewing whether our historical casing and cementing requirements are adequate in the shale gas development context, and what changes need to be made to ensure that, that the casing and cementing procedure is effective in isolating the fluids. You know, keeping them in the zones until they're

pped up to the surface and onto market, and that freshwater resources are protected in that process. Many States are in the process of evaluating those requirements.

Pennsylvania has already completed an evaluation. Ohio has done an extensive review of their requirements. We've been—we've amended some of our rules in the last couple of years to make sure we've got good, strong rules in place.

So it is a critical component of an oil and gas regulatory program, and the States are in the process of evaluating their requirements to make sure they're strong and effective.

Senator SHAHEEN. What have you learned in Pennsylvania, Mr. Beauduy?

Mr. BEAUDUY. The commonwealth has learned quite a bit. What we have seen in the Basin, the stray, we refer to it as the stray gas issue, has been the dominant issue in terms of impacts from this industry. Places like Dimock, Pennsylvania where we've got methane that's getting to fresh groundwater systems. That's the result of improper—one of the questions is are the standards adequate as opposed to whether they were—whether the activity was conducted properly within those standards?

What Pennsylvania found out after a series of stray gas incidents is that, as you just heard, newer technologies are brought to bear. They've enhanced their casing standards. We haven't seen any issues with the new standards. There have been incidents at the wells done under the older standards, and they've had to either shut them in or redo them.

But stray gas has been an issue and not so much Marcellus gas. This is, you know, when you're going down 7,000 feet, you get below the freshwater bearing table at, say, 300 to 700 feet, you hit other formations. They all have a certain amount of gas in them and it's these upper horizon formations that can leach and have gas go up the wellbore and into fresh groundwater. The new standards are designed to do that.

The other thing—aspect of the new standards, which I think I have to commend them for, is the testing that has to be done, the integrity testing to make sure that the construction was done properly. So as we get better capability, I think those will be improved even more.

But we were very pleased to see Pennsylvania move forward, once it realized that it had a problem, and upgrade. As far as I know, their standards are as strong as any in the country right now.

Senator SHAHEEN. Thank you very much.

I think this is a final question for you, Dr. Cooper. One of the things that has inhibited the ability to get data about some of the challenges and the problems that have occurred with fracking and getting access to shale gas has been that when there is an issue with a property owner, that often the property owner signs a non-disclosure agreement so that that information is then not available to add to the research, as we're thinking about how to solve those problems going forward.

Is there anything that you can talk about with respect to the industry that you think might help with that issue?

Dr. COOPER. I think they are very large issues that have nothing to do with fracking that you're talking about. You're talking about how knowledge is dispersed in our society, about how the media plays into it, about how people like sensationalism as opposed to sort of being calm and realizing what actually might have happened.

I think that, you know, in our society, I call it lawyering up." Around here, you probably all understand that.

Senator SHAHEEN. I'm not an attorney, so I—

Dr. COOPER. Neither am I, so. You know, when incidents happen, it's hard for everybody to be open about what's happening until legal issues are resolved.

I do think that the industry actually has a very good, long term understanding that sharing knowledge between companies about what went wrong is a central part of our business. We do that all the time. It's an ongoing thing. It isn't just to rush in and say, "Oh, it happened at that one well incident," but it's about the safety of our systems in general.

We do have professional organizations that very carefully analyze data to look at cement failure, for instance, and why it might happen under certain circumstances, and that information is shared across the industry.

You know, I tell people, you know, "You think that Apple is really innovative? The oil and gas business is pretty innovative too. You just don't notice it."

We don't stand still. We try to fix problems. We try to understand. We apply a lot of high technology to what we do and I think this is a very essential part of our business.

So lawyering up will always happen. But the industry is going to try to figure out why things happen and solve the problem.

Senator SHAHEEN. As you point out, most of us don't walk around with an "iDrill" like we have our iPad.

Mr. COOPER. I think that's right.

Senator SHAHEEN. Let me just, before I close, point out that I would be remiss if I didn't call attention to the story that appeared on the front page of "The New York Times" today about the challenges with respect to mortgages, and property owners who have signed agreements with—for gas drilling, and some of the issues that are expected going forward.

Is that anything that you've seen, Dr. Cooper, in your company?

Dr. COOPER. No. Actually, I was sort of amused by this story because my initial reaction was, "Gee, all of a sudden these guys have money to pay for their mortgages because they just got paid some sort of lease fee for their mineral rights."

I thought that in places like, you know, Oklahoma and Texas where people think those mineral rights are a really valuable resource, you know, sometimes they even get severed from property. I think they look at it as, you know, if you're a banker, you'd look at it as a reason that you'd get your money back as opposed to losing it on the guy's mortgage.

I'm not—I don't want to be flippant about anybody and the problems they have with the economy, and mortgages, and stuff like that. But I think the issue sounds a little strange to me.

Senator SHAHEEN. So you haven't seen it. Has anybody else heard that this is an issue? Ms. Dunlap?

Ms. DUNLAP. Yes, this is, of course, a little off topic from trout but.

Senator SHAHEEN. Right.

Ms. DUNLAP. I do live in the Finger Lakes region of New York State, and I do know that there are some banks who are concerned there that a person who has leased their subsurface mineral rights, who then goes to sell that house, the prospective buyer will not be able to obtain a mortgage. Apparently, that has to do with the set-back requirements under Fannie Mae/Freddie Mac mortgage requirements, some sort of secondary mortgage requirement.

So I have heard some—some stories in our region about concerns from banks and potential sellers.

Senator SHAHEEN. As you say, it's off topic of today's hearing, but it was an interesting story, and it doesn't sound like it's got too much—having too much impact on the industry.

So Senator Lee, any final comments you would like to make?

Hearing none. Thank you all very much. Your testimony's been very insightful and we really appreciate your staying with us a little later than expected.

At this time, I'll close the hearing.

[Whereupon, at 4:42 p.m., the hearing was adjourned.]

APPENDIX

RESPONSES TO ADDITIONAL QUESTIONS

RESPONSES OF CAL COOPER TO QUESTIONS FROM SENATOR SHAHEEN

Question 1. Can you speak to industry's process for implementing best management practices or standards to keep pace with the drilling and production activities with the bounds of sustainable water use?

Answer. We do have formal industry processes for reviewing innovation and establishing "best practices." Some of the most effective "best practice guidelines" have been established by technical committees of the API. Specifically for water, in nearly all oil and gas producing states there is little ambiguity about best management practices for sustainable water use. Water withdrawal is governed by local authorities from property owners to state agencies. As for the processes in place to ensure sustainable water use, we do not wait until something is formally declared a best practice before we adopt it. Best management practices are constantly evolving and responding to challenges in this industry. Someone tries something new or sees that some other operator has done something interesting, and broadens the scope. And there is productive dialogue between different companies regarding the success of technology. In a very practical sense, the structure of this industry allows companies to see something that works better and apply it. Sometimes this is encouraged by the observations of regulators.

For example, injection wells in Pennsylvania and the Marcellus Basin are simply not capable of dealing with the volumes of water required for drilling. In this area, best practices have significantly advanced over the past three to five years. Earlier this year, Pennsylvania required all operators to recycle fluids in subsequent frac jobs instead of disposing them in publicly owned treatment works (POTW). As development continues, so too does environmental sensitivity to emerging concepts like surface storage and enhanced wastewater treatment.

Question 2. In your experience, what steps can be taken to reduce erosion and sediment run-off into streams from road and pad construction?

Answer. Many construction related industries have developed effective controls for sediment erosion and stream runoff. And in most of these cases, success involves rather simple efforts to prevent and block sediment flow in unwanted areas. The oil and gas industry is really no different than any other construction industry in this regard. It continues to employ proven simple and effective measures to mitigate surface damage.

You mention better efforts by the industry to disclose the chemical composition of the fracking fluids.

Question 3a. What is prohibiting the industry from disclosing their fracking fluids prior to drilling so that communities can be made aware ahead of time?

Answer. In a general way, disclosure vehicles like FracFocus make it possible for the public to see chemicals used by companies in particular geographic areas. From a more practical point of view, the precise chemicals used in any given frac job are subject to changes in both planning and availability, which makes substitutions commonplace. Quite a bit can change in a matter of seconds and successful extraction depends upon adaptability. Furthermore, it is hugely expensive to stop or slow completion of any given frac job. If a state wishes to discourage or even ban certain chemicals, FracFocus provides solid information for them to use in the decision making process.

Question 3b. What steps is the industry taking to ensure their safe use and disposal?

Answer. Industry is committed to the safe transportation, delivery, and use of chemicals on well pads. In addition to protecting the surrounding environment, proper handling protects our people at work on these well-pads. It is a personnel issue as well as an environmental one. There are many strategies that ensure safe chemical transportation from the creation of impoundments to lining well-pads to

mixing chemicals in large blender machines. For further enumeration, I invite the committee to see examples at: <http://fracfocus.org/>.

Question 4. The NY Times recently published a story on the negative financial impacts to a local Pennsylvania community that showed residents weren't able to get the new high paying jobs associated with the industry due to a lack of skills. Is industry doing anything to close this gap and ensure that the local community derives maximum benefit?

Answer. We remind the committee that Apache does not operate in the Marcellus Basin. That being said, the industry generally has a range of training and educational requirements for jobs related to hydraulic fracturing. We need people from high school graduates to commercial truck drivers to highly specialized chemists and engineers. However, the financial benefit of shale gas development is not limited to the immediate area of drilling itself. While it certainly benefits local communities, industry presence also drives regional and statewide economies in a larger sense. As a result, the economic value of exploration spills over to all kinds of people who may or may not be directly linked to oil and gas.

Question 5. Are there any incentives that you can identify that would encourage operators to responsibly manage wastewater at the surface?

Answer. Operators are motivated by financial incentives as well as the continued license to operate in a region. They will immediately embrace economically advantageous ways of dealing with water that can include sensible and sustainable environmental practices. The notion that environmental sensitivity comes at greater cost to operation is flawed. At Apache, we are evolving practices that unite financial and environmental sensibility.

Question 6. Looking at the Pennsylvania Department of Environmental Protection's (DEP) own numbers for the past two years, every well inspection discovers roughly two violations. And these don't appear to be merely technical violations. Violations include:

- "Discharge of polluttional material to waters of Commonwealth."
- "Failure to report defective, insufficient, or improperly cemented casing w/in 24 hrs or submit plan to correct w/in 30 days"
- "Failure to report release of substance threatening or causing pollution"
- "Improper casing to protect fresh groundwater"

Answer. For response, see Question 7.

Question 7. Does two violations for every inspected well strike you as an acceptable level of industry compliance? Does the Apache Corporation have information on the number of violations per inspected well for its own wells?

Answer. We support the efforts of individual states to inspect and verify well sites. Two violations for every inspected well is not acceptable, although it does indicate the efficiency of state regulatory bodies in ensuring industry compliance.

Specific to Apache, we operate in Texas, New Mexico, Louisiana, and Oklahoma where in the past two years there have been more than 800 agency inspections performed at our operating sites. In total, there were 168 noted deficiencies (these include both administrative and operational items). Two compliance orders were issued and one penalty was paid to a regulatory agency. So on average Apache experiences a deficiency in one of every five recorded inspections. This also means that more than 79% of Apache's inspected operational facilities were found compliant with regulatory standards.

It is worth noting that while records indicate 807 inspections, the actual number was almost certainly greater. Regulatory agencies routinely visit sites at their own discretion. In unmanned facilities inspections are commonly conducted without our knowledge. In these cases, Apache is only notified if there is a deficiency.

RESPONSES OF CAL COOPER TO QUESTIONS FROM SENATOR LEE

Question 1. Dr. Cooper, you mentioned in your testimony that state permitted deep injection wells—the safest, most efficient and economical way to deal with water—are not practical because of the geology in many areas of the Marcellus. As you rightly point out, necessity is often the mother of invention and now nearly all operators report that they store, treat and re-use water, in subsequent hydraulic fracturing jobs, minimizing the need to transport produced water to water treatment facilities. Can you please describe this industry trend as you have seen it? Is this only going on in the Marcellus, or are you seeing the industry taking this step across the country?

Answer. In parts of the country with water access issues such as Texas and North Dakota, industry is identifying ways to recycle used water in subsequent frac jobs. It should be noted that this process is an emerging trend. Currently, it is standard

practice to re-inject extracted water into disposal wells. In coming years we expect that it will become more common for companies to treat water for reuse. With that said, movement towards recycling treated water depends heavily upon the comfort of regulatory agencies with this practice.

Question 2. Can you please describe Apache's water management approach throughout the hydraulic fracturing process?

Answer. In areas where Apache does not use saline brines, as we do in the Debolt formation, we purchase water from local owners and public suppliers. As a result, we are keenly aware of water quantity and use. The fresh water we purchase is often stored in holding ponds where it is kept for later use at the well site. At times this can require the transportation of water over several miles in irrigation pipes to a given well site. If water is trucked on to site, it is immediately put in to holding tanks or placed on trucks for direct mixture in to wells. Flow back and produced water is then sent to tanks on site where it is partially treated and then trucked to treatment plants offsite. It is then re-injected in to licensed disposal wells.

Apache is paying for this water and we aim to use it as efficiently as possible. We are currently investigating plans to build treatment facilities to recycle produced fluids for later frac jobs. This is an emerging concept and is sure to progress as available technology begins to keep pace with industry innovation.

RESPONSE OF CAL COOPER TO QUESTION FROM SENATOR COONS

Question 1. It is my understanding that there may be several new and innovative ideas and technologies that will reduce the environmental impact of hydraulic fracturing such as using saline instead of fresh water in the fracturing process or actually using natural gas in place of the liquid fracturing solution. What do you think are some of the most innovative emerging technologies on the horizon and how can the federal government work with private sector interests do to help bring these technologies into commercial operations?

Answer. The oil and gas production business has a long tradition of making enormous strides in both innovation and technology. Yet it is admittedly difficult to pinpoint the precise origin of many of these developments and even more challenging to predict future winners. The industry has a large number of inter-connected service companies and a lot of motivation to try things. In general, we all benefit from sustained innovation in the fields of science, technology and engineering in universities throughout the world. More crucially we rely on a talented and pioneering workforce that transforms practices in the private sector.

In the specific case of hydraulic fracturing related research and development, much of the success came from leveraging applied engineering, and the willingness of independent operators to risk trying new things. Neither major oil companies nor university research were needed to get started. Arguably, we have reached a stage where advanced technical innovations very well might make step changes in our processes. These will come from the technology development machine that includes universities and private companies. There are some latent concerns that regulations may stifle innovation due to hysterical exaggerations of risk.

The industry already engages in some very useful sponsored research initiatives at a number of universities, although it is rare for smaller companies to participate. Perhaps it would be helpful to have some matching funds program in order to broaden the base, without establishing a huge administrative bureaucracy. Perhaps R & D tax credits would encourage more spending in this area. Surely we will all benefit from programs that encourage youth to pursue their research interests in applied science and engineering in general. Investing in people is the key to sustaining future success.

RESPONSES OF KATY DUNLAP TO QUESTIONS FROM SENATOR SHAHEEN

Question 1. We have heard from several of our witnesses that the necessary regulations and procedures are in place to adequately protect public health and the environment but you have raised specific examples of contamination and in your opinion what accounts for this discrepancy?

Answer. Trout Unlimited's testimony at the hearing on Shale Gas Development and Water Resources in the Eastern United States focused largely on the surface impacts of Marcellus Shale development in Pennsylvania. Specifically, I explained that Trout Unlimited members are witnessing significant erosion and sedimentation runoff from well pad, access road and pipeline construction, as well as impacts from spills, leaks and illegal discharges of drilling wastewater. The reason for the discrepancy may be a tendency to overlook surface impacts such as those associated with erosion and sedimentation. In large part, the growing number of water re-

source pollution incidents from oil and gas development has resulted from the absence of federal and state regulation.

Due to an exemption provided through the Energy Policy Act of 2005, oil and gas construction sites, including the construction of exploration and production facilities by oil and gas companies and the roads that service those sites, are not covered by the Clean Water Act's stormwater runoff provisions. In Pennsylvania, the Department of Environmental Protection (DEP) only requires an erosion and sediment control permit for earth disturbances of five acres or more. As the average Marcellus well pad size in Pennsylvania is approximately three acres in size, the five acre threshold required to obtain a permit excludes the majority of well pads. The gap in erosion and sediment control regulation at both the federal and state levels is a contributing factor to the increasing volume of erosion and sedimentation pollution incidents and may lead to long-term water quality impacts and overall degradation in watersheds where drilling is prolific.

Spills, leaks and illegal discharges from Marcellus Shale-related development are posing risks to valuable trout streams and to groundwater resources. Regulation of the hydraulic fracturing process under the Safe Drinking Water Act could help to minimize these types of pollution incidents. While some accidents are unavoidable, in many cases, contamination of water resources could have been evaded if the well pad and other related infrastructure was set back an appropriate distance from waterways. In Pennsylvania, the well bore can be as close as 100 feet to a stream. Again, given that the average well pad is approximately three acres in size, this means that a well pad can be constructed right next to a stream. Additionally, well pads may be constructed in the 100-year floodplain meaning that when a major flood event occurs, contaminants on the well pad itself may be carried downstream with floodwaters. To reduce the risk of contamination from spills, leaks and illegal discharges, oil and gas-related development should not be allowed in the floodplain and adequate buffers-of at least 300 feet from the edge of a well pad-must be required.

Question 2. Do you think that hydraulic fracturing can be conducted in a responsible manner to enable extraction but prevent environmental impacts? If so, how?

Answer. Hydraulic fracturing for natural gas development requires a substantial amount of infrastructure development and carries the risk of spills, blowouts, and other impacts. The level of ground disturbance alone makes it impossible to prevent environmental impacts altogether. However, hydraulic fracturing can be conducted responsibly. Through proper siting and management, the risks can be reduced and the environmental impacts minimized.

- Much of the natural gas development in the East occurs in forested areas. When forests are cleared and roads, pipelines, and well pads are constructed, the hydrology in a watershed changes, and surface runoff increases. The affect of these changes on water resources and aquatic habitat can be reduced through consistent and effective stormwater controls.
- Road-stream crossings present a risk of aquatic habitat fragmentation. Constructing crossings with properly sized and designed culverts or bridges can prevent fragmentation and enable fish and other aquatic organisms to move freely up- and downstream.
- Water withdrawals, if taken from small waterways or during low flow conditions, can harm aquatic ecosystems. The right timing and location of water withdrawals can avoid such impacts.
- Waste water from shale gas development carries pollutants that can harm water resources if improperly treated and discharged. Sound wastewater management can reduce these risks.
- Well blowouts have introduced pollutants to waterways and caused harm to water resources. These can be reduced through proper well casing and pressure testing requirements.

The steps listed above are components of responsible development that can help to avoid or reduce the impacts of natural gas development on water resources. However, development will never be 100 percent risk-free or without impact. In recognition of this, it is important to properly site infrastructure so that when spills or blowouts occur, or runoff controls fail, the impact on water resources is minimized. For example, development should not be allowed in the floodplain and adequate buffers-of at least 300 feet from the edge of a well pad-must be required. Certain areas of high sensitivity or exceptional habitat value should be avoided altogether.

Finally, the disclosure of chemicals used in hydraulic fracturing would provide needed information to regulators, managers and the public to help avoid or mitigate impacts to water resources.

Question 3. In areas that have been impacted from shale gas development, what will be required to mitigate and/or reverse the damages?

Answer. Many of the impacts from shale gas development on water resources—both groundwater and surface waters—may not be known for decades. As we have seen with coal mine extraction in Pennsylvania, it takes time for the impacts of industrial energy extraction to materialize, and then decades to restore streams and waterways from the resulting pollution. In Pennsylvania, at least \$70 million in grant money has been distributed to conservation and restoration efforts over the past decade to try to clean up acid mine drainage that resulted from coal production. Much of the damage could have been avoided if adequate regulations were in place before the resource was developed. The same planning concept holds true for shale gas development. Marcellus Shale gas has been developed at a rapid pace and large scale across Pennsylvania over the past three years, before the state realized that its regulations were inadequate to assure protection of water resources. Pennsylvania has since recognized that it needs to update its regulations to address the new and different types of impacts that will result from shale gas development and is making strides toward that aim. Many of the impacts from shale gas development can be avoided up front, with the proper regulations.

Each company uses a proprietary blend of chemical, lubricants and other drilling fluid to fracture a well, and that ingredient list changes with each well depending upon the chemical and physical properties of the reservoir being accessed. Therefore, it is difficult to know at this time the precise level and severity of impacts that will result when specific fracturing chemicals are used in combinations or independently. In order to mitigate or reduce the risk of water quality impacts associated with contamination from drilling wastewater and fluids, shale gas development and hydraulic fracturing should be regulated under the Safe Drinking Water Act and the public disclosure of chemicals used during hydraulic fracturing should be made mandatory. Continued erosion and sedimentation will lead to degradation of water resources and loss of aquatic life. Oil and gas exemptions from the stormwater runoff rules under the Clean Water Act should be repealed to avoid the slow, long-term degradation of water resources.

If the appropriate regulations are not in place now—as Marcellus Shale gas resources are being developed—then it will take significant financial resources and time to restore waterways and aquatic life to pre-development condition.

Question 4. What happens to wildlife and ecosystem health if too much water is pulled from the water supply for industrial/municipal purposes—particularly during low water periods?

Answer. Healthy streamflows support native fish, wildlife and instream and streamside habitat. Streamflow is the principal driver for all stream ecology, directly affecting channel formation, habitat, fish migration, temperature, oxygen levels and numerous other critical factors. Water withdrawals for industrial and municipal purposes can alter naturally varying streamflows, and affect the amount of water available for stream function, aquatic life and downstream users. Trout and other aquatic life, as well as streamside wildlife, rely on natural fluctuations to support their life cycles.

The timing, location and volume of the water withdrawal will determine the level of impact on the river system and aquatic life. If significant volumes of water are withdrawn from small headwater streams during natural low flow periods, streambeds can dry up—killing the aquatic life that resides therein or affecting trout spawning, thereby influencing overall population stability. During summer months when stream flows are naturally low, large water withdrawals can also impact water quality and the ability of a stream system to dilute potential pollutants, and exacerbate water temperature increases.

Question 5. We heard from our first panel regarding issues that arise when produced water is sent to traditional treatment plants. Can you discuss whether this was happening in Pennsylvania and New York and whether it will be allowed going forward?

Answer. Until recently, several traditional wastewater treatment plants in Pennsylvania were accepting shale gas wastewater for treatment and then discharging treated wastewater into the commonwealth's waterways. Because most treatment plants were designed to treat biological wastes and not brine water containing chemicals used in hydraulic fracturing, the receiving streams were showing high levels of total dissolved solids and chlorides. Last week, Professor Jeanne VanBriesen, a civil and environmental engineering professor from Carnegie Mellon University, concluded a two-year study that found that bromide and chloride levels—both components of total dissolved solids—started to increase in 2010 in eight sam-

pling locations near public drinking water intakes in the Monongahela River.¹ Professor VanBriesen pointed to produced wastewater from Marcellus Shale drilling operations as a potential cause in the increased levels.

In early 2010, a specific incident along the Monongahela River that reportedly fouled a water intake of a large water supplier spurred attention to the pretreatment standards for shale gas wastewater that is ultimately sent to a wastewater treatment plant that intends to discharge its effluent into a stream. In response to that incident, the Pennsylvania Environmental Quality Board adopted changes to the rules generally, with specific rules for the natural gas industry. Wastewater from natural gas operations may not be discharged into a sewage treatment plant that in turn discharges to a stream unless that wastewater has a concentration of total dissolved solids (TDS) below 500 milligrams/liter. Some wastewater treatment plants were “grandfathered” and exempt from the TDS rule.

In New York, several wastewater treatment plants in the Finger Lakes region have, in the past, accepted Marcellus Shale wastewater. The City of Auburn Water Pollution Control Facility reportedly received more than 16 million gallons of gas well drilling process wastewater from 7/1/09 to 6/30/10, from more than eight gas companies and certain parameters known to be constituents of Marcellus Shale wastewater, like total dissolved standards, were not sampled.² The facility discharges into Owasco outlet, and reports have indicated that the estimated Chloride concentration in Owasco outlet downstream of Auburn WPCP outfall was elevated. The Canandaigua Wastewater Treatment Facility reportedly received 177,000 gallons of gas drilling wastewater generated in Pennsylvania by EOG Resources, Inc.³ These facilities have reported that they are no longer accepting Marcellus Shale wastewater.

As stated earlier, the overall degradation of water quality and related impacts that may be caused by years of discharging diluted Marcellus Shale wastewater into streams and rivers may not be known for decades.

Question 6. What steps are being taken by states in the Marcellus region to prevent or even prohibit produced water from going to wastewater treatment facilities that are not equipped to handle this kind of water?

Answer. In April 2011, the Secretary of the Pennsylvania Department of Environmental Protection (DEP) asked natural gas operators to stop taking wastewater from shale gas operations to wastewater treatment facilities and asked the operators to certify under penalty of law that they were no longer accepting shale gas wastewater. Several treatment facilities are exempt from the TDS rules adopted in 2010. To further restrict the number of exempt facilities that may accept shale gas wastewater, the DEP is proposing new chloride limitations for shale gas wastewater.

According to the Commissioner of the New York State Department of Environmental Conservation (DEC), no private industrial treatment plants or traditional wastewater treatment plants in New York are equipped to treat, or are permitted to accept, wastewater with the range of contaminants expected to be in fluids produced from high-volume hydraulic fracturing. In September, the DEC issued a revised draft supplemental generic environmental impact statement (revised DSGEIS) intended to assess the environmental impacts associated with high-volume hydraulic fracturing. In its environmental review plan, the DEC is proposing to require a comprehensive analysis demonstrating that wastewater treatment plants can safely treat the waste before DEC will grant or modify a State Pollution Discharge Elimination System (SPDES) permit. At this time, New York has not yet conducted a full cumulative impact assessment to determine how much wastewater will be generated, how it will be transported and how it will be treated and disposed of, and the state is essentially leaving it to the industry to find solutions for addressing treatment and disposal of wastewater from drilling operations.

Recycling has been widely hailed as a solution to many of the issues related to the problems associated with water consumption and waste water disposal.

Question 7. Yet, there have been reports that as recycling becomes more common, the result is a briny byproduct that is more concentrated with radioactive materials and other contaminants. It has been reported that these brine waste streams are being sold to Pennsylvania counties as road deicers or used as dust suppressants, from which they could wash into rivers and streams. Are you concerned that such uses threaten water quality and potentially endanger human health? What kind of reaction did these reports generate in the local communities?

¹ <http://www.post-gazette.com/pg/11308/1187389-113.stm>

² http://toxicstargeting.com/sites/default/files/pdfs/AubDEC_Jan09letter-NSmrkd.pdf

³ <http://toxicstargeting.com/sites/default/files/pdfs/EOG-26R-part-1-2-3-18.pdf>

Answer. Trout Unlimited is very concerned about the use of shale gas wastewater for de-icing and dust suppression purposes. A significant amount of the Marcellus Shale development is occurring in highland, largely undeveloped areas, with thousands of miles of dirt roads that run along streams. If nearby shale gas wastewater tanks or ponds are tapped to suppress dust on dirt access roads or to de-ice roads, there could be significant impacts to the headwater streams that support trout spawning and feed larger rivers and public drinking water supplies.

In New York, the DEC has permitted, with conditions, the "beneficial use" of wastewater from non-shale vertical wells for de-icing roads and suppressing dust on dirt roads. However, according to the new revised DSGEIS for high volume hydraulic fracturing, flowback water from any formation including the Marcellus may not be spread on roads. The revised DSGEIS states that beneficial use determinations for reuse of production brine from Marcellus Shale will not be issued until additional data on naturally occurring radioactive material (NORM) content is available and evaluated.

In Pennsylvania, a general permit (WMGR064) is required to apply natural gas wastewater to roads for de-icing purposes and the permit sets certain water quality parameters for known constituents of natural gas wastewater, such as total dissolved solids (>170,000 mg/l) or chlorides (>80,000 mg/l). The permit does not include parameters for other constituents of concern known to be present in Marcellus Shale produced water and flowback, such as strontium, bromide, radiologicals, surfactants and biocides. DEP staff has reported that they are not aware of any Marcellus Shale wastewater being used to de-ice roads pursuant to the general permit. However, the general permit does not include specific language prohibiting the application of Marcellus Shale gas wastewater to roads. In fact, DEP is currently accepting public comments on whether the permit should be expanded to include dust suppression purposes and whether the permit should be amended to specifically include or exclude application of Marcellus Shale wastewater on roads.

Communities are confused and are expressing concern about the use of Marcellus Shale wastewater for road application, whether for de-icing purposes or for dust suppression. Concerns stem in part from the lack of transparency and clear language prohibiting the use of Marcellus Shale gas wastewater for road application. In the northeast, the use of road salt in general contributes to the degradation of groundwater in urban areas and water quality in suburban streams and even in cleaner, rural streams. As shale gas wastewater could contain additional polluting contaminants, communities and conservation organizations are deeply concerned about the application of this brine source to roads.

RESPONSES OF KATY DUNLAP TO QUESTIONS FROM SENATOR LEE

Question 1. Are you working with State regulators to ensure that your interests are being addressed? What has generally been the process through which you have communicated your concerns?

Answer. Individually and through the Sportsmen Alliance for Marcellus Conservation, Trout Unlimited has developed a set of policy recommendations and regulations for improving oversight of Marcellus Shale gas development. Trout Unlimited has provided feedback and input to Pennsylvania regulators through meetings with the Secretary of the Department of Environmental Protection, the Lt. Governor, state legislators and representatives from the DEP Bureau of Oil and Gas Management. Additionally, Trout Unlimited has submitted written recommendations to the Governor's Marcellus Shale Advisory Commission and comments on state regulatory processes related to shale gas development, including proposed casing and cement standards and total dissolved solid standards for wastewater treatment plants proposing to accept shale gas wastewater.

Question 2. Please describe the process you undertake to train volunteers to do water quality sampling.

Answer. In 2010, TU launched its Coldwater Conservation Corps (CCC) program—a stream surveillance program designed to train TU members and other sportsmen and women to (1) conduct routine inspections of stream conditions in watersheds where shale gas development is occurring or is projected to occur, and (2) to report problems to the appropriate agencies. Trout Unlimited members spend considerable time on these streams, and thus are well positioned to monitor water quality in areas where Marcellus Shale development is occurring.

The CCC program is based upon a field manual developed by Trout Unlimited, with input and review by experts from the Pennsylvania Department of Environmental Protection, Pennsylvania Fish and Boat Commission, the Potter County Conservation District, the Alliance for Aquatic Resource Monitoring and the Pennsylvania Council of Trout Unlimited and local chapters. CCC volunteers undertake a

full-day training focused on material found in the field manual, including: (1) learning how to conduct water quality monitoring and collect soil samples; (2) determining what types of activities or impacts to look for during visual assessments; (3) learning about personal conduct and safety; and (4) determining whom to contact if a problem is suspected. Water quality parameters sampled include flow, pH, temperature, total dissolved solids (TDS) and conductivity. The Alliance for Aquatic Resource Monitoring (ALLARM), based at Dickinson College, provides quality assurance/quality control and technical support. TU staff members conduct trainings, provide monitoring kits to local TU chapters, assist volunteers in choosing monitoring sites, and assist with data collection and data storage. In the first year of the Coldwater Conservation Corps program, approximately 200 volunteers were trained to monitor sensitive watersheds throughout Pennsylvania's Marcellus Shale region.

Question 3. TU has recently established a partnership with the gas producing company EQT. Can you describe the parameters of your agreement and what are your primary areas of concern?

Answer. TU and EQT established a letter of understanding in April 2011 in order to develop a collaborative project between our two entities focused on the review, evaluation, and potential development of drilling siting and operation practices for the protection of sensitive trout habitat.

RESPONSES OF LORI WROTENBERY TO QUESTIONS FROM SENATOR SHAHEEN

Question 1. What regulatory steps/requirements pertaining to water are different in the East than elsewhere? Have these steps had a measureable affect on preventing industrial accidents and protecting citizens?

Answer. The regulatory structure pertaining to water is complex. Understanding what the requirements are and how they work to prevent and manage accidents and to protect water supplies requires an in-depth review of the specific set of requirements applicable in each jurisdiction. Key differences exist not just from West to East, but also from state to state within a particular region.

A comparative analysis of state regulatory programs would find many common elements in state oil and gas regulations across the country, but would also reveal that the states have tailored their regulations to address regional circumstances and issues. I would again refer you to the STRONGER reports on the regulatory programs in the states of Pennsylvania and Ohio to illustrate this point.

These reports show that both states have established regulatory programs designed to ensure that water resources are protected in the development of oil and gas resources. The two states share a number of basic regulatory requirements, such as the requirement to obtain a permit before drilling a well. There are also some key differences between the regulatory programs in these two neighboring states.

In Pennsylvania, for example, discharges to surface waters regulated under the federal National Pollutant Discharge Elimination System (NPDES) program have been a key concern. Due to the regional geology, Pennsylvania has limited capacity for the use of injection wells to dispose of oil and gas wastewaters underground. As a result, oil and gas operations in Pennsylvania have had to find other ways of managing oil and gas wastewaters. In Ohio, by contrast, almost all oil and gas wastewaters are disposed of in injection wells permitted under the UIC (Underground Injection Control) program of the federal Safe Drinking Water Act. Ohio, therefore, has not experienced the surface water issues that have received so much attention in Pennsylvania.

The ultimate disposition of oil and gas wastewaters is just one example of the differences from state to state. The STRONGER reports document others. The STRONGER reports also document how the individual states are addressing their particular issues. Pennsylvania, for instance, has already essentially eliminated the discharges that caused concern there. The regulatory responses of the states to the water protection issues raised by shale gas development demonstrate the unique ability of the states to respond quickly and appropriately to the special circumstances within their own borders.

Question 2. From your perspective, are there lessons learned from other regions that can be applied in Eastern shale operations?

Answer. Yes, there are always lessons to be learned and shared. State regulatory agencies routinely compare notes with their counterparts in other states on their experiences in responding to new developments in technology, the economy, and public policy. Much of this exchange occurs on an informal basis. Oil and gas regulators from different states regularly communicate with one another to share information on regulatory approaches and emerging issues. In addition, several national organizations facilitate this process, including the Interstate Oil and Gas Compact Com-

mission (IOGCC), the Ground Water Protection Council (GWPC), and State Review of Oil and Natural Gas Environmental Regulations, Inc. (STRONGER). STRONGER, in particular, provides an effective mechanism through which states can work collaboratively with other stakeholders to benchmark state regulatory programs and obtain recommendations for improvement.

Question 3. Given the more aggressive regulatory steps recently taken by NY, are there lessons learned that could be applied at other drilling sites in other regions?

Answer. My understanding is that New York is still in the process of completing the updates of the regulatory requirements that will enable shale gas development to proceed in that state. Through the exchange mechanisms mentioned in the response to the prior question, other states are monitoring developments in New York. Undergoing a STRONGER review would be an excellent way for New York to share lessons learned and best practices with the various stakeholders in other states.

Question 4. If the best-case scenario simultaneously allows successful extraction of natural gas while also ensuring that public health and the environment are preserved, how can this be achieved and maintained?

Answer. I believe my written testimony addresses this question directly. In summary, this is being done right now in states such as Oklahoma, and other states that regulate oil and gas exploration and production operations to achieve these very purposes. They have developed comprehensive oil and gas regulations, which they continually evaluate and refine to stay current with developments in the industry. They also work closely with the various stakeholders to address regional and local concerns. By being open and responsive and by always working to improve, states have built regulatory programs that ensure natural gas is produced safely.

Looking at the Pennsylvania Department of Environmental Protection's (DEP) own numbers for the past two years, every well inspection discovers roughly two violations. And these don't appear to be merely technical violations. Violations include:

- "Discharge of pollution material to waters of Commonwealth."
- "Failure to report defective, insufficient, or improperly cemented casing w/in 24 hrs or submit plan to correct w/in 30 days"
- "Failure to report release of substance threatening or causing pollution"
- "Improper casing to protect fresh groundwater"

Question 5. Does two violations for every inspected well strike you as an acceptable level of industry compliance? What is the comparable rate in Oklahoma and across the industry?

Answer. My understanding is that the Pennsylvania DEP's total inspection, violation, and enforcement numbers appear in the year-end workload reports available at the following link: <http://www.dep.state.pa.us/dep/deputate/minres/oilgas/reports.htm>. These reports indicate that, in the past two years, the DEP conducted a total of 30,743 inspections and identified 6065 violations. That is not a ratio of two violations to every inspection.

It appears to me that the ratio of two violations to every inspection may have been derived from a different set of reports available at the following link: <http://www.dep.state.pa.us/dep/deputate/minres/oilgas/OGInspectionsViolations/OGInspviol.htm>. Please note that these particular reports cover only those inspections during which an inspector found violations. Inspections during which no violations were identified are not included in these reports.

I urge anyone with further questions about the inspection and enforcement data for Pennsylvania to contact the Pennsylvania DEP. That agency is the best source of answers to questions such as what parameters are tracked, how these parameters are defined, and how they are tallied. Any meaningful analysis of the data will require answers to these kinds of questions.

Without doing a more extensive analysis of the data on violations, I am unable to draw conclusions about the level of compliance in Pennsylvania or to compare it with the level of compliance elsewhere. I'm not aware of a standard method of assessing this measure of performance in any federal or state regulatory program.

Your question is difficult for me to answer even for Oklahoma, where we continually assess our inspection and enforcement activities to evaluate our performance. Here we conducted 125,129 inspections over the past two years. Through those inspections we identified 6,977 violations that the inspectors considered serious enough to be documented on a formal report.

Are we satisfied with that level of compliance? I have to say no. We work with the operators, most of which are small businesses, to help them stay in compliance. However, we continue to find violations, and accidents do happen. We respond rapidly to accidents through a well-established emergency management structure. And we take swift and decisive enforcement action when necessary to achieve compliance and to deter repeat offenses.

A sound inspection and enforcement effort is a core component of any effective regulatory program, and my division dedicates most of its resources to this activity. I do not see the need for this kind of effort diminishing substantially in the future.

Health and safety regulations are complex and continually evolving. Human enterprises are complicated and constantly changing. When applying health and safety regulations to human enterprises, an experienced inspector can always find room for improvement. Our job is to make sure that improvement occurs, especially when a violation presents a risk to our people or our water resources.

RESPONSES OF LORI WROTENBERY TO QUESTIONS FROM SENATOR LEE

Question 1. You mentioned in your testimony that the states are well equipped to regulate hydraulic fracturing. I have heard that North Carolina, where there is a less developed regime surrounding oil & gas development, has actually reached out to STRONGER, requesting a review so that they can ensure that they have adequate regulations in place before any activities begin there. Are there many other examples of states reaching out to STRONGER in the interest of developing regulations?

The hydraulic fracturing review in Pennsylvania is another example of a review that was conducted at the request of a state that was in the process of developing regulations. Pennsylvania, of course, has a long history of oil and gas drilling and production, being the location of the first commercial oil well in the country. But drilling and production in the Marcellus Shale in Pennsylvania represented an entirely new type of development and necessitated a comprehensive review and revision of the existing oil and gas regulations. The Pennsylvania DEP invited STRONGER to conduct a review under the STRONGER hydraulic fracturing guidelines in order to assist the state in addressing the fundamental changes in the nature of oil and gas operations being conducted there.

STRONGER has had preliminary discussions with representatives of other states that have expressed interest in the possibility of using STRONGER's services in developing or updating oil and gas regulations. And STRONGER continues to offer its services to all oil and gas states. Even states like Oklahoma, with long-established and well-developed programs, must continue to evolve to address changing circumstances, and STRONGER provides a mechanism for obtaining recommendations for improvement from an independent and balanced group of stakeholders.

Question 2. Your testimony indicates that STRONGER is governed by a balanced board of stakeholders that includes state regulators, environmental groups, and oil and gas producers. You mentioned that STRONGER has now completed hydraulic fracturing reviews in five states. Given that your board members in some cases bring very different perspectives to the table, could you comment on how well you are all able to work together to achieve your common goals?

Answer. Based on my own experience, I can attest that the STRONGER process works. I have participated in eleven state reviews in eight different states, and I am currently participating in another hydraulic fracturing review. In four of those reviews, I was an employee of the state being reviewed. In the other eight, I have been involved as a member of the review team. I would characterize each of the reviews as being an educational and productive experience for all of the participants.

So how does the STRONGER process work when, as you say, the review participants bring so many different perspectives to the table? I believe it works because the various stakeholders come together in a collaborative endeavor. They get to know one another as people. They get to know the employees of the state regulatory agencies as people. They also have a specific task to complete, which is to learn how the state program works and to make findings and recommendations based on the STRONGER guidelines (which have themselves been developed by a stakeholder workgroup). Any recommendation must be tied to a specific provision of the guidelines or must be identified as beyond the scope of the guidelines. The review teams focus their attention on how the state regulatory program measures up against the guidelines rather than debating the personal opinions or organizational objectives of any particular review team members.

When the review team members sit down with one another and with the state officials under these circumstances, the conversations are usually extremely productive. Please do not surmise that the teams do not ask pointed questions of the state officials or carry on intense discussions among themselves. They certainly do. But the process of working through the key elements of the state regulatory program using the guidelines as a measuring stick promotes a deeper and more complete understanding of the way the state programs operate and the challenges they face. Furthermore, one of the key ground rules of the process is that any criticism made of a state program must be accompanied by a specific recommendation for improve-

ment, which requires the team to articulate what concrete actions the review team suggests the state take.

I'm sure other participants in the process would share with you their own ideas why STRONGER and the state review process work so effectively. They may emphasize different aspects of the process or point out some elements I have not mentioned. But I feel quite confident that they too would tell you that it works well.

RESPONSES OF TOM BEAUDUY TO QUESTIONS FROM SENATOR SHAHEEN

Question 1. How does SRBC prioritize competing water demands by different industries and municipalities especially at times of low water?

- Where does fracking rank in that priority list?
- Can you elaborate for the Committee what the process is for conducting an environmental review for water withdrawal?

Answer. The Commission applies uniform standards for all types of water withdrawal and use projects and does not prioritize the water use of different sectors. Applicants seeking Commission approval are required to demonstrate reasonable foreseeable need for the amounts requested, and the Commission needs to be satisfied that the request will not impact water resources or other water users. This is consistent with the requirement in the Susquehanna River Basin Compact to provide uniform treatment to all water users.

With regard to drought periods, the Commission relies on its member jurisdictions to impose restrictions on water use during drought and all of the member states recognize public water supply as a priority use in drought declarations. Also, in its own review and approval process, the Commission restricts the ability of projects to withdraw water during low flows to protect other downstream uses and aquatic resources, following standards set forth in its passby flow guidance. In this regard, fracking is treated like all other industrial water uses.

The timing and location of proposed withdrawals is critical to the technical review of applications, as are both potential individual and cumulative impacts within a watershed. In its environmental review, the Commission assesses the baseline stream condition at a proposed water withdrawal location. These data are used in conjunction with water availability and stream hydrology to determine whether the proposed withdrawal would adversely impact other water users, fish, wildlife, other living resources or their habitat, recreation and flows in streams; or cause water quality degradation that may be injurious to water uses. Staff recommends appropriate protective measures, as needed, to avoid or minimize impacts to the subject waterway.

If current data regarding aquatic resources are not available, Commission staff conducts a comprehensive field investigation at the proposed withdrawal site that involves a detailed assessment of the physical, chemical and biological components of the stream. More information about the Commission's aquatic resource surveys may be found at [http://www.srbc.net/pubinfo/docs/Aquatic%20Resource%20Surveys%20Info%20Sheet%20\(Oct%202011\).pdf](http://www.srbc.net/pubinfo/docs/Aquatic%20Resource%20Surveys%20Info%20Sheet%20(Oct%202011).pdf).

Question 2. What steps are being taken by states in the Marcellus region to prevent or even prohibit produced water from going to wastewater treatment facilities that are not equipped to handle this kind of water?

Answer. Currently, the Commonwealth of Pennsylvania is the only state in the Susquehanna River basin that has permitted development of natural gas in shales using unconventional technologies.

Pennsylvania has addressed the issue of disposal of produced water by upgrading its standards for treatment facilities. These require that any facility seeking to increase its discharge of treated wastewater or to any facility seeking to start accepting wastewater must treat the wastewater to the federal drinking water standard of less than 500 milligrams per liter of total dissolved solids prior to discharge. In addition, all facilities that accept shale gas extraction wastewater that has not been fully pre-treated to meet the discharge requirements must develop and implement a radiation protection plan. Such facilities must also monitor for radium-226, radium-228, uranium and gross alpha radiation in their effluent.

Produced fluids from Marcellus shale may only be transported to facilities that have been specifically approved to accept that waste for treatment or disposal. No flowback or produced fluids from the Marcellus are going to any publicly owned treatment facilities in the Susquehanna River basin. In New York, the draft SGEIS likewise proposes that flowback and produced fluids will be tracked in a manner similar to that for medical waste and only be directed to facilities permitted to accept those wastes.

Recycling has quickly emerging and the preferred (alternative) method, rather than disposal.

Question 3. Recycling has been widely hailed as a solution to many of the issues related to the problems associated with water consumption and waste water disposal. Yet, there have been reports that as recycling becomes more common, the result is a briny byproduct that is more concentrated with radioactive materials and other contaminants. It has been reported that these brine waste streams are being sold to Pennsylvania counties as road deicers or used as dust suppressants, from which they could wash into rivers and streams. Are you concerned that such uses threaten water quality and potentially endanger human health?

Answer. The Commission supports the reuse by this industry of flowback and produced fluids in hydrofracing as each gallon used represents a one-for-one reduction of fresh water that is injected downhole. These fluids must remain isolated from the fresh waters of the basin during any transport between drilling pads. Some water is reused without treatment. Any by-products of the treatment process must be disposed of following state requirements, and most fluid waste is currently shipped out of state for disposal through deep well injection. Crystallized brines created from the thermal distillation of wastewater is commonly landfilled at approved facilities.

Brines from the Marcellus Shale formation are not being used as dust suppressants.

As described in the fact sheet produced by the Pennsylvania Department of Environmental Protection (PADEP), <http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-84809/5500-FS-DEP1801.pdf>, brine produced from oil and gas wells and other sources such as brine treatment plants and brine wells has been used for beneficial use as a dust suppressant and road stabilizer on unpaved secondary roads for many years. This use does not include brine from shale formations. DEP regulates rates and frequencies of brine spreading to protect water quality; operators must develop alternative disposal options for excess brine and all brine produced from shale formations. Similarly, NYS in its draft SGEIS proposes to restrict the use of all brines related to Marcellus so that it is not spread on roads.

RESPONSE OF TOM BEAUDUY TO QUESTION FROM SENATOR LEE

Question 1a. If I understand correctly, it sounds like Pennsylvania has strengthened its water withdrawal regulations, has strengthened its drilling standards, now requires a buffer between operations and streams, has increased the fee required for an application for a drilling permit, and has increased its staffing from 88 to more than 200. How long did it take to do this and how do you expect the PA regulatory framework to continue to evolve?

Answer. Please review the following PADEP fact sheet, <http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-84024/0130-FS-DEP4288.pdf> which details a number of ways that Pennsylvania has increased its oversight of gas drilling in the Marcellus shale over the last 3 years. In addition to the provisions noted above, PADEP has also required every application for a Marcellus Shale drilling permit to include a mandatory water management plan that covers withdrawal and disposal, the disclosure of chemicals used in fracking, implemented strong blow-out prevention policies, and undertaken greater enforcement practices. These changes have been implemented over the past three years.

It is anticipated that PADEP will continue to revise its regulations and strengthen its program as necessary to keep pace with the natural gas industry. There are also a number of legislative proposals being actively considered in the Pennsylvania General Assembly at the current time that will result in a number of enhanced provisions Pennsylvania's Oil & Gas Act, if and when approved, and which will likely result in additional regulatory modifications.

Question 1b. Can you please explain your in-stream water monitoring system? I am specifically interested in understanding more about water withdraws for shale gas development compared to other industries/uses.

Answer. The Commission has deployed a remote water quality monitoring system to track water quality conditions within smaller rivers and streams throughout the portion of the basin experiencing natural gas development. The network consists of fifty (50) monitoring stations in the Pennsylvania and New York that continuously monitor and record the following five parameters: temperature, pH, conductance, dissolved oxygen, and turbidity. This advanced technology provides real-time data to effectively monitor rapid changes in water quality conditions that will enable water resource agencies, water users, and the public to make informed decisions regarding management and use of the resource.

The Commission estimates that at full build out, the natural gas industry may withdraw and use, as an annual average, 30 million gallons of water per day. Cur-

rent usage for the second quarter 2011 is approximately 10 million gallons of water of per day. To provide context with other uses, approved consumptive water use for power generation is approximately 192 millions of gallons of water per day.

Question 1c. What do your regulations say about low-flow days and how has the industry has responded?

Answer. In its review and approval process, the Commission restricts the ability of projects to withdraw water during low flows to protect other downstream uses and aquatic resources, following standards set forth in its passby flow policy. Most natural gas withdrawals have been approved with a protective passby flow condition and the withdrawal is interruptible during predetermined low flow conditions. The Commission has conducted numerous inspections of withdrawal locations and strenuously enforced these protective conditions; the industry as a whole has a good compliance record.

As a result of these protective provisions, the industry has responded by developing centralized storage capacity for water supply, and it draws on that storage during low flow conditions.

RESPONSE OF TOM BEAUDUY TO QUESTION FROM SENATOR COONS

Question 1. Currently the Delaware River Basin Commission (DRBC) is in the process of developing new rules to manage hydraulic fracturing in the Delaware River Watershed. One issue that I hope the Commission addresses carefully is the substantial effect on water resources such as reduced flows in streams and aquifers used to supply the significant amounts of water necessary in the hydraulic fracturing process. I understand that the Susquehanna River Basin Commission has an approval process in place for companies to attain permission to take water from a tributary or ground source. Are you aware of the efforts underway by the DRBC? Have the regional river basin commissions communicate on issues related to energy production and environmental impacts? What recommendations would you have for the DRBC as it moves forward with a plan to balance the increased demand for water with the need to maintain minimum levels in streams and aquifers?

Answer. The Commission is very much aware of activity in the Delaware and the efforts of the DRBC. We have shared all of our data, data management strategies, and policies with the DRBC. We have also shared our experiences and noted those aspects of our program that have worked well with this industry. Our objective is to give DRBC the benefit of what we have learned about the natural gas industry, and we will continue to do that in the future.

As far as recommendations for DRBC, we would suggest that they utilize the best available science to make informed decisions about what is necessary to protect water resources and other users in their basin. Another recommendation might be to invest in information technology systems/ applications as we have found them to be critical to effectively and efficiently regulate natural gas development projects.

RESPONSES OF DAVID P. RUSS TO QUESTIONS FROM SENATOR SHAHEEN

Question 1. Water availability does not seem to be a barrier to development of shale gas in the East at the moment but given USGS's latest projected assessments of economically recoverable gas in this country, what does this mean for future demands on water availability and the likely impacts in the East?

Answer. As stated above, water availability does not appear to be a barrier to shale-gas development in the Northeast, but water availability is a region by region issue. In the East, water use is largely a seasonal, and a very localized issue. Although there are likely hotspots for natural gas drilling, it is not clear exactly where future drilling and hydrofracturing will take place.

The Susquehanna River Basin Commission (SRBC) has projected the consumptive use of water by the gas industry within the Susquehanna Basin will be about 28 million gallons per day at the peak future demand, which is a little more than half the current consumptive use for recreation in the basin. Accommodating a New Straw in the Water: Extracting Natural Gas from the Marcellus Shale in the Susquehanna River Basin. [http://www.srbcc.net/programs/docs/Marcellus%20Legal%20Overview%20Paper%20\(Beauduy\).pdf](http://www.srbcc.net/programs/docs/Marcellus%20Legal%20Overview%20Paper%20(Beauduy).pdf)

Though the total water use by the gas industry will not make a large impact on total water use in the Susquehanna River (or other major basins in the Northeast), withdrawals will need to be managed to prevent overdraft from local aquifers or small streams during low-flow summer months and during periods of drought. For example, though 2011 will surely be one of the wettest years on record in Pennsylvania, during a drought period in July 2011, water withdrawals were prohibited at 36 of the permitted surface-water intakes used by the gas industry because stream

flows were less than the pass-by criterion prescribed by the SRBC for these locations. Potential effects on the quality of water can also impact the quantity of freshwater that is available for human and ecological uses. The careful stewardship and judicious use of water are critical to minimizing the impacts of shale-gas development on the region's water resources.

Question 2. One of the key differences between shale gas production in the East vs. the West is water scarcity. We have a lot more water in the East. However, such surpluses may not always be available. What does long term production of shale gas mean for water consumption, particularly in light of climate change and its impact on water availability?

Answer. Water withdrawn for shale-gas development is generally considered a 'consumptive use', that is, it is not returned to the water cycle. In reality, some of this water either is returned just following the hydraulic fracturing process (flowback water), or is recovered over time during gas production (produced water). Flowback water is currently being recycled by the gas industry, thereby somewhat reducing the need for new water for hydraulically fracturing the next well. Flowback water usually represents about 5 to 12 percent of what was injected into a Marcellus well, according to data recently summarized by the SRBC in northeastern Pennsylvania. Produced water from Marcellus wells in Pennsylvania is generally minimal - several hundreds of gallons per one million cubic feet of gas produced from the well, according to the gas industry.

In relation to potential effects of climate change, it is expected that changes in precipitation patterns due to climate variability would govern the judicious withdrawal of water for shale gas production. It would be expected during periods of drought that water needed for shale-gas development would be curtailed as is currently the case when, during seasonal dry periods, flows that fail to meet pass-by criteria result in restrictions on water withdrawals for shale gas applications.

Question 3. What steps should be taken to prevent harm to our water resources, particularly due to cumulative withdrawals from headlands or when there are drought-like conditions?

Answer. The amount of water to be withdrawn depends on the number of wells drilled, when the wells are drilled (seasonally), where they are drilled, and over what period of time they will be drilled. Assessing the cumulative impact is extremely difficult due to these and other unknowns.

Protecting the Nation's water resources will require decision makers to use scientific research and monitoring data when considering actions for determining where, when, and to what degree (or amount) water is withdrawn from any particular water resource. Water managers will need to ensure appropriate consideration of the various potential users, including the gas industry, water consumers (drinking water), agricultural production, waste assimilation, and ecological needs. Additional protection of the water resource may be needed during 'extreme' water resource conditions, while allowing users the ability to judiciously utilize water during periods of high water availability. Understanding the limitations on withdrawals and the flow requirements of other water use needs depends on a network of long-term streamgages and groundwater monitoring wells to provide baseline data.

Question 4. Different sources report that fracking fluids are either a "benign" mixture of water, sand, bleach, and other household agents, or that they contain known neurotoxins and carcinogenic compounds. What is your understanding?

Answer. Each 'service company' (that is, a company that performs the hydraulic fracturing process) has its own 'recipe' for hydraulic fracturing fluids. These mixtures will change dependent on the properties of the rock being fractured and the fluids encountered in the bedrock. Changes to the formulation might occur during the fracturing process at the site. While most of the chemical compounds are easily found on company websites or at FracFocus (<http://fracfocus.org/>), the proprietary chemicals are not divulged; therefore, it is difficult to determine the toxicity of all the chemical compounds used by these different companies.

The U.S. Environmental Protection Agency's national "Plan to Study the Potential Impacts of Hydrofracturing on Drinking Water Resources" will characterize the toxicity and human health effects of fracturing fluids¹.

Question 5. Recently a USGS scientist, Zachary Bowen, heading one of the agency's water quality studies stated that "there's very, very little information in the scientific literature, there are very few studies looking at potential effects [on water quality] of these activities." Would you agree that there are many unresolved questions in this area and that more needs to be done to understand potential adverse effects of shale gas development on water?

¹Environmental Protection Agency: Nov. 2011, Plan to Study the Potential Impacts of Hydrofracturing on Drinking Water Resources, p. 71-72.

Answer. Yes. In order to understand potential adverse effects of shale gas development on water resources, scientists would need access across the region to surface water and groundwater quality data. It would be necessary to use monitoring wells to test for the potential presence of natural gas and to determine how the chemistry of waters is altered deep within the bedrock as they are injected and create the micro-fractures. It would be important to attain and analyze samples of the flowback and formation waters and to monitor where and how these wastes are treated and ultimately disposed of. It would also be necessary to sample surface waters to evaluate the possible contamination of these waters from accidental spills and/or by elevated amounts of sediment generated by pipeline and road construction.

Question 6. Typically when a company that settles with a property owner who claims that their water has been contaminated by shale gas production, the property owner is forced to sign a non-disclosure agreement. Given the need for further study in this area, do you believe the use of non-disclosure agreements inhibits your and other state regulatory bodies' ability to collect adequate data? Wouldn't this lack of information affect our ability to ensure that regulations designed to protect public health and the environment are sufficient?

Answer. As a Federal science agency, the USGS does not have regulatory responsibilities. The general lack of scientific data can and does limit our ability to effectively evaluate the potential effects of the consequences of shale gas development across the United States. The impact of different stressors on water quality and quantity requires targeted monitoring and data collection and analysis. Access to gas company data would improve our ability to evaluate, understand, and communicate to the public the potential impact of shale gas production.

RESPONSES OF CYNTHIA C. DOUGHERTY TO QUESTIONS FROM SENATOR SHAHEEN

Question 1. Is the EPA testing or monitoring ground water and/or drinking water in the vicinity of drilling operations before and after fracking operations commence? If so, what chemical constituents are monitored?

Answer. At the direction of Congress, the EPA launched a study last year to better understand the potential impacts of hydraulic fracturing on drinking water resources. To establish baseline conditions in the EPA's study areas, the EPA will conduct prospective case studies which will include sampling of the areas before hydraulic fracturing is initiated as well as after hydraulic fracturing occurs. The types of chemicals¹ and other analytes to be considered in the case studies can be found in Appendix H of the study plan² and include groups such as volatile organic compounds, semi-volatile organic compounds, metals, radionuclides, and polycyclic aromatic hydrocarbons. The complete list of chemicals is included in the Quality Assurance Project Plans³

Question 1a. Are there known health implications for exposure to any of these constituents? If yes, what is the minimum "safe" level?

Answer. Examining the possible health implications of exposure to potential contaminants is one of the goals of the study. As part of the study, the EPA will summarize existing data regarding the toxicity and potential human health effects associated with these possible drinking water contaminants. The EPA may pursue additional studies to screen and assess the toxicity associated with chemical contaminants of concern.

As part of the "Plan to Study the Potential Impacts of Hydraulic Fracturing on Water Resources"³, the EPA has compiled a list of chemicals that are publicly known to be used in hydraulic fracturing. Though this list does not represent the entire set of chemicals used in hydraulic fracturing activities, a number of the chemicals included are regulated as contaminants under the Safe Drinking Water Act's National Primary Drinking Water Regulations (NPDWR). NPDWRs protect public health from potentially acute and chronic effects by limiting the levels of contaminants in drinking water. The table below contains NPDWR contaminants that appear in the study list.

¹ <http://epa.gov/hydraulicfracturing>

² <http://epa.gov/hfstudy/qapps.html>

³ http://epa.gov/hfstudy/HF_Study_Plan_110211_FINAL_508.pdf

NPDWR Category	Contaminant
Disinfection Byproducts	Bromate
Inorganic Chemicals	Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Copper, Cyanide, Fluoride, Lead, Mercury, Selenium, and Thallium
Organic Chemicals	Arcylamide, Atrazine, Benzene, Benzo(a)pyrene (PAHs), Chlorobenze, 1,1-Dichloroethylene, Epichlorohydrin, Ethylbenzene, Styrene, Tetrachloroethylene, Toluene, and Xylenes
Radionuclides	Radium 228 and Uranium

Question 2. There is a long history of oil and gas exploration in the east. With that, there have been many hundreds (if not thousands) of wells that were drilled prior to the current shale gasboom. I am aware that abandoned wells can pose health and environmental risks if they are not properly plugged prior to abandonment. Can you comment as to how much of an issue you feel this could be for shale gas production in the same area?

Answer. The Interstate Oil and Gas Compact Commission (IOGCC) estimated, in 2008, that proper closure was needed for approximately 50,000 orphaned oil and gas wells nationwide. At the time of the study, New York, Pennsylvania, and West Virginia (the eastern states most directly experiencing the current shale gas boom) had 4,800, 8,700, and 1,260 orphaned wells on their plugging lists, respectively.⁴

The EPA recognizes that orphaned and improperly abandoned wells can be a risk to underground sources of drinking water (USDWs) and human health because the wells are a potential conduit for contamination. Under the Safe Drinking Water Act (SDWA), the EPA's Underground Injection Control (UIC) program covers underground injection activities related to oil and gas, including enhanced recovery, fluid disposal, hydrocarbon storage and diesel fuel hydraulic fracturing. The majority of oil and gas production activities fall outside of UIC requirements.

A useful technical resource addressing well construction, plugging, and abandonment of injection wells covered by the UIC program authorized by SDWA is technical guidance available on the EPA's website.⁵ This guidance, which pertains to the UIC program more broadly (not specific to oil and gas production activities), may provide useful technical guidance for operators and states, regardless of the regulatory context in which they operate.

In addition, states may have their own requirements for addressing abandoned wells under their oil and gas regulations. For those wells associated with the UIC program, well owners and operators must perform corrective action (e.g., proper plugging) on improperly abandoned and/or orphaned wells within the prescribed "Area of Review" before receiving an injection permit.

Question 3. A number of potential mechanisms—such as improper well construction and casing on abandoned wells nearby newly producing shale gas wells—have been identified by which fugitive methane might escape into drinking water wells. Could you explain these potential mechanisms? Have these mechanisms been comprehensively studied in order to quantify the risks of well water contamination? Is more study warranted?

Answer. Common pathways for methane migration may include movement through faulty well casing or movement through the annulus located between the casing and well bore. In addition, wells drilled into adjacent, shallower formations that are not plugged, or are improperly plugged, could potentially become pathways for methane migration.

The EPA has experience and data on methane migration from underground injection wells through its Underground Injection Control (UIC) program. In establishing

⁴ <http://iogcc.myshopify.com/products/protecting-our-countrys-resources-the-states-case-orphaned-well-plugging-initiative-2008>.

⁵ These documents can be found at <http://water.epa.gov/type/groundwater/uic/guidance.cfm>.

the UIC Program, the agency recognized that potential endangerment of underground sources of drinking water (USDWs) could occur via these pathways and designed federal requirements to mitigate these risks. In the current Hydraulic Fracturing Research Study, the agency is studying the potential risks to water resources that will include risks from faulty well construction and improper plugging and abandonment.

Question 4. What are the potential harms arising from fugitive methane emissions? Has anyone studied the health effects of consuming water contaminated by methane?

Answer. According to the National Institute for Occupational Safety and Health (NIOSH), methane exposure poses fire, explosion, and inhalation hazards.⁶ Methane is extremely flammable and forms an explosive mixture with air at concentrations of 5%-15% by volume. Other factors such as water temperature, ventilation of the well, air movement, and the percent composition of the gas determine the exact concentration that is capable of producing an explosive hazard. There is no federal standard for methane in drinking water and the risk of ingesting methane is unknown.

Question 5. A Congressional investigation recently found that between 2005 and 2009, hydraulic fracturing companies had injected 32 million gallons of diesel and diesel laced fluids in hydraulic fracturing operations in 19 different states. The investigation showed that companies had not obtained the required permits for injecting diesel under the Safe Drinking Water Act. EPA has the authority to regulate both diesel injections in hydraulic fracturing and the disposal of wastewater. Are you investigating these incidents? What will EPA do if it finds that these companies did violate the law?

Answer. The EPA is aware that the investigation found that a number of oil and gas service companies collectively injected 32.7 million gallons of diesel fuels and fluids containing diesel fuels into wells between 2005 and 2009. The EPA will evaluate on a case-by-case basis potential violations from the injection of diesel fuels into wells and the disposal of wastewater that it discovers, including whether to initiate follow-up enforcement action.

Question 6. Recently a USGS scientist, Zachary Bowen, heading one of the agency's water quality studies stated that "there's very, very little information in the scientific literature, there are very few studies looking at potential effects [on water quality] of these activities." Would you agree that there are many unresolved questions in this area and that more needs to be done to understand potential adverse effects of shale gas development on water?

Answer. The EPA agrees there are unresolved questions about the potential impacts of hydraulic fracturing on water resources. As described in the final study plan, the agency has identified a number of key primary and secondary scientific questions associated with the five stages of the hydraulic fracturing water cycle: water acquisition, chemical mixing, well injection, flowback and produced water, and wastewater treatment and waste disposal. Answering questions associated with each of these stages will enable the agency to assess the potential impacts of hydraulic fracturing on drinking water resources, and the specific causes of any identified impacts.

Question 7. Typically when a company that settles with a property owner who claims that their water has been contaminated by shale gas production, the property owner is forced to sign a non-disclosure agreement. Given the need for further study in this area, do you believe the use of non-disclosure agreements inhibits your and other state regulatory bodies' ability to collect adequate data? Wouldn't this lack of information affect our ability to ensure that regulations designed to protect public health and the environment are sufficient?

Answer. Non-disclosure agreements could hinder the EPA's access to data on contamination due to shale gas production. For example, landowners with non-disclosure agreements may feel that they are unable to cooperate voluntarily with the EPA's requests for information or access to well sites for sampling.

RESPONSES OF CYNTHIA DOUGHERTY TO QUESTIONS FROM SENATOR LEE

Question 1. Ms. Dougherty, in 2004, when EPA completed its study of hydraulic fracturing of coal bed methane reservoirs, your agency reported that diesel fuel was sometimes used in fluids for hydraulic fracturing within underground sources of drinking water. Congress responded by giving EPA the authority to regulate hydraulic fracturing under the Safe Water Drinking Act if diesel fuel is used. Five years after it was granted this authority, EPA began to act—first issuing a notice that it would consider all wells that fracture with fluids containing diesel fuel as

⁶See <http://www.cdc.gov/niosh/ipcsneng/nengO291.html>

Class II wells under the Underground Injection Control program, and second by initiating the development of guidance for implementing its Safe Water Drinking Act authority. Clearly, the definition of diesel fuel is critical to EPA's regulatory action, yet EPA has not yet provided this definition and has consequently created an ongoing environment of uncertainty. Do you agree that the definition for diesel fuel should be clear, specific and narrow, and should use the already established Chemical Abstract Service numbers?

Question 1a. Can you please tell us when EPA plans to provide this clarification and whether EPA will use Chemical Abstract Service numbers?

Answer. The EPA is in the process of developing draft guidance for permitting hydraulic fracturing when diesel fuels are used in fluids or propping agents. The EPA anticipates that the guidance will include recommendations for a permit writer to consider when determining if diesel fuels are being used. We have heard a wide range of stakeholder views about how to define diesel fuels, including to only use the few Chemical Abstract Service Registry Numbers for diesel fuels 1 and 2, and to be as broad as including substances with any of the physical or chemical properties of petroleum-based diesel. Once the draft guidance is ready, it will go out for public comment (planned for 2012).

Question 2. The press release you issued on October 20th states that you are proposing a schedule to develop new standards for wastewater discharges produced by shale gas extraction. Is the NPDES program insufficient in some way?

Question 2a. Why is EPA doing this and not simply working with states to ensure that state regulations are adequate?

Answer. The National Pollutant Discharge Elimination System (NPDES) program, as prescribed by the Clean Water Act, is sufficient; however, as industries evolve, changes to requirements need to be considered to keep the program consistent with new technologies and changes in industry practices. Currently, except in limited circumstances, wastewater associated with shale gas extraction is prohibited from being directly discharged to waterways and other waters of the U.S. While most of the wastewater from shale gas extraction is reused or re-injected, a significant amount still requires disposal. Shale gas extraction wastewaters may be indirectly discharged into waters of the U.S. through sewer systems connected to publicly owned treatment works (POTW) that discharge directly to waters of the U.S. or by being introduced by truck or rail into a POTW that discharges directly. Shale gas extraction wastewater may also be disposed of at centralized waste treatment facilities and then discharged directly or discharged to a sewer system connected to a POTW that discharges directly. As a result, some shale gas wastewater is transported to treatment plants, some of which may not be properly equipped to treat this type of wastewater effectively prior to discharge to surface waters. In a November 22, 2011 letter to the EPA commenting on the 2010 Effluent Guidelines Plan, the American Petroleum Institute (API) said:

API supports the development of pretreatment standards for existing and new sources in the SGE subcategory. SGE wastewater generators should have the alternative of discharging to publicly owned treatment works (POTW) provided that the produced waters do not interfere with treatment operations and the SGE pollutants do not pass through to the POTW to cause adverse receiving water quality impacts.

The EPA has been, and will continue to, provide support to states and permitting authorities. Under the Clean Water Act statutory and regulatory framework, POTWs must establish requirements for any introduction of wastewater to the POTW or its collection system if it either would cause "pass through" or "interference" (e.g., cause the POTW to violate its permits limits, or interfere with the operation of the POTW or the beneficial use of its sewage sludge). POTWs are subject to the secondary treatment effluent limitations at 40 CFR part 133, which do not address the parameters of concern in shale gas extraction wastewater (e.g., TDS, chloride, radionuclides, etc), and site-specific local limits as necessary to protect water quality. Therefore, the EPA is developing a categorical pretreatment standard and has provided other guidance to assist NPDES permitting authorities to develop appropriate permit requirements for facilities that accept this wastewater.

To ensure that the EPA proposes environmentally and cost-effective rules that satisfy all applicable Clean Water Act and other regulatory process requirements, the EPA will gather data, consult with stakeholders, including ongoing consultation with industry, and solicit public comment on a proposed rule for coal bed methane in 2013 and a proposed rule for shale gas in 2014.

Question 2b. Why is EPA proposing these standards ahead of the completion of your study?

Answer. The EPA's study and this rulemaking are complementary. Any data collected pursuant to this new rulemaking will be shared with the Office of Research and Development that is conducting the congressionally-directed study and any relevant information that is gathered as part of the study will be shared with the EPA's Office of Water that is working on the rulemaking.

Question 3. EPA announced in June that it had selected seven case studies for its Draft Hydraulic Fracturing Study Plan that the Agency believes will provide the most useful information about the potential impacts of hydraulic fracturing on drinking water resources. We have been hearing, through industry, state regulator sources, and the media that EPA has already begun field work on one of the prospective sites. What is the schedule for releasing the Final Study Plan?

Question 3a. Would it be safe to assume that EPA's Draft Study Plan is the Final Plan, since EPA is already in the field taking samples?

Answer. The EPA's draft study plan is not identical to the final study plan, which was released on November 3, 2011. However, the core research questions and general research approach are unchanged. The final study plan includes more details about the research activities being undertaken to improve the public's understanding of how the agency is carrying out the study.

To ensure that the study is complete and results are available to the public in a timely manner, the EPA initiated some activities this summer to provide a foundation for the full study. Importantly, all of these initial activities were explicitly described in the draft study plan and supported by the agency's Science Advisory Board during its peer review. As laid out in both the draft study plan and the final study plan, we have conducted an initial literature review, requested and received information from industry on chemicals and practices used in hydraulic fracturing, discussed initial plans for case studies with landowners and state, local and industry representatives, and conducted baseline sampling for retrospective case studies using scientifically sound approaches that have been shared with collaborators. This work will enable us to provide timely and scientifically sound results in our 2012 and 2014 reports.

Question 4. What is EPA's overall schedule for both the retrospective and prospective case study analysis and will you make that schedule available to the public by posting it on the EPA website?

Answer. The overall schedule for the five retrospective and two prospective case studies is shown below:

Retrospective Case Studies

Killdeer, ND:	3 rounds of sampling and analysis through mid-2012, with additional sampling as necessary
Southwest PA:	2 rounds of sampling and analysis through mid-2012, with additional sampling as necessary
Wise Co., TX:	2 rounds of sampling and analysis through mid-2012, with additional sampling as necessary
Raton Basin, CO:	1 round of sampling and analysis through mid-2012, followed by 2 additional rounds of sampling in late 2012, with additional sampling as necessary
Northeast PA:	2 rounds of sampling and analysis through mid-2012, with additional sampling as necessary

Prospective Case Studies

DeSoto Parish, LA and Washington County, PA:	3 rounds of sampling and analysis, with additional sampling as necessary, through mid-2014
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This general schedule assumes continued cooperation from relevant parties. The 2012 report will include some sampling results and data analysis for each of the five

retrospective case studies, based on information collected and analyzed by mid-2012. The 2014 report will include the final results for all seven case studies.

Specific sampling dates are shared with local property owners, state authorities and wellowner/operators who are conducting studies in parallel with the EPA. The sampling dates will not be posted on the website, as specific dates for site visits are subject to change. We will, however, keep the public updated on our progress on all seven of the case studies throughout the process.

Question 5. Do you have an estimate of how much EPA's study will cost?

Answer. In fiscal years 2010 through 2012, a total of \$12.3 million has been either already enacted by Congress (FY2010, \$1.9M obligated; FY2011, \$4.3M enacted; FY2012, \$6.1M). Further expenditures will be required in 2013 and 2014 to complete the study, but a budget has not yet been proposed.

Question 6. What additional opportunities is EPA undertaking to involve stakeholders in this "public process?"

Answer. As the study progresses, the EPA will continue to engage multiple stakeholder groups, including the public; industry; non-governmental organizations; federal, state, and tribal agencies; and interstate organizations. Examples of planned activities include quarterly progress updates that may take place in a variety of formats, including web postings and briefings via webinars. Additionally, the results of the study will be synthesized in a 2012 report and a 2014 report that will both undergo a thorough peer review process. The reviews will be conducted by the Science Advisory Board, and opportunities for the public to submit comments to the peer review panel will be provided.

Question 7. For the sake of transparency, will EPA provide a list of the operators you have contacted to participate in both the retrospective and prospective studies and make that list available to the public?

Answer. The EPA posted the list of operators with interests in the retrospective and prospective case studies on our website.⁷ For the retrospective case studies, these companies include: Denbury Resources, Inc.; XR-5, LLC; White Stone Energy, LLC; Aruba Petroleum, mc; Primexx Energy Partners, Ltd; Chesapeake Energy Corporation; Range Resources Corporation; Atlas Energy, L.P.; Pioneer Natural Resources Company; Petroglyph Energy, mc; Cabot Oil and Gas Corporation; and Chief Oil and Gas, LLC.

Answer. Our partners in conducting the prospective case studies are: Range Resources Corporation in Washington County, PA and Chesapeake Energy Corporation in DeSoto Parish, LA.

RESPONSE OF CYNTHIA C. DOUGHTERY TO QUESTIONS FROM SENATOR COONS

I am encouraged by the ongoing EPA study that is intended to more comprehensively examine the environmental and other challenges posed by hydraulic fracturing. Your testimony indicates that two reports will be completed. One will be released in 2012 summarizing existing data and other laboratory studies. Another will be finalized in 2014 that will provide additional scientific results on these topics and report on prospective case studies and toxicological analyses. Though the full results of the study will not be released until 2014, I am hopeful that this study will help the federal government, states, communities, industry and environmental groups better manage natural gas production in the Marcellus Shale and across the country.

Question 1. The Delaware River Basin Commission (DRBC) is set to finalize its new rules for managing hydraulic fracturing in the next month, and every state with gas production and a variety of river basin commissions have conducted studies and produced rules for how to manage hydraulic fracturing. Are you aware of the work being done by the DRBC? In the course of this study, how is the EPA planning to incorporate the work that has already been done by river basin commissions and other similar entities as it seeks to better understand the effects of hydraulic fracturing?

Answer. The EPA is aware of DRBC's efforts to finalize its natural gas regulations as well as efforts by other state and interstate agencies to collect water quality data in areas where hydraulic fracturing is occurring. The DRBC gas drilling regulations will address protective measures to be undertaken during natural gas development. We do not expect that it will result in short-term data being collected that will prove useful in the Hydraulic Fracturing Research Study. However, as a result of meetings with several key state and federal agencies, the EPA has identified work underway by others that the EPA can use to inform its study. Information such as the collection of water quality or water use data, may be used to inform the EPA's

⁷ <http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/case—studies.cfm>

study. The EPA continues to discuss opportunities to collaborate in information gathering and research with other agencies.

