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Water and Power Subcommittee

To Examine Shale Gas Production and Water Resources in the Eastern United States

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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 in 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.

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.

References

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Attachments

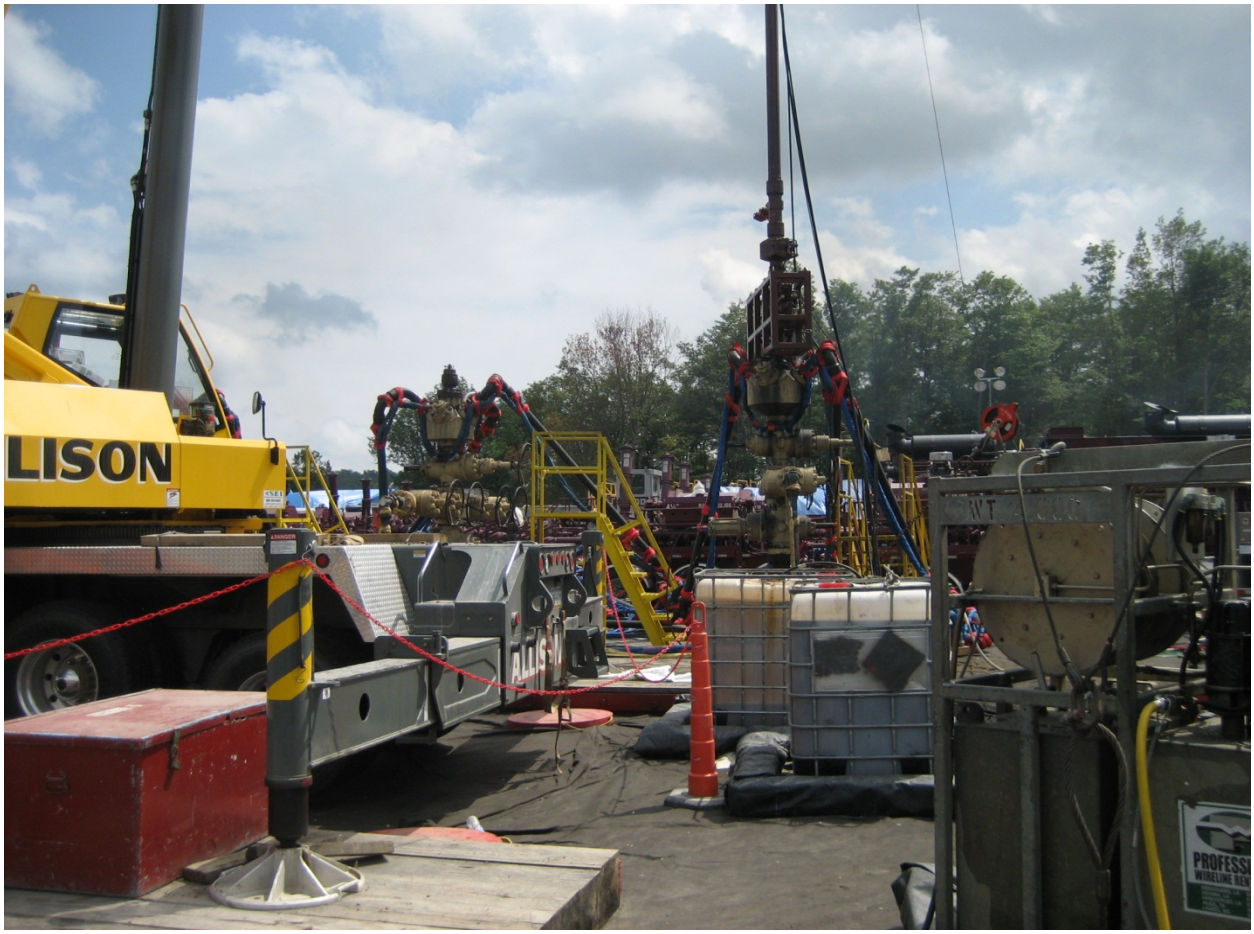

Figure 1– Hydrofracturing site near Wellsboro, PA (D. Russ, July, 2011)

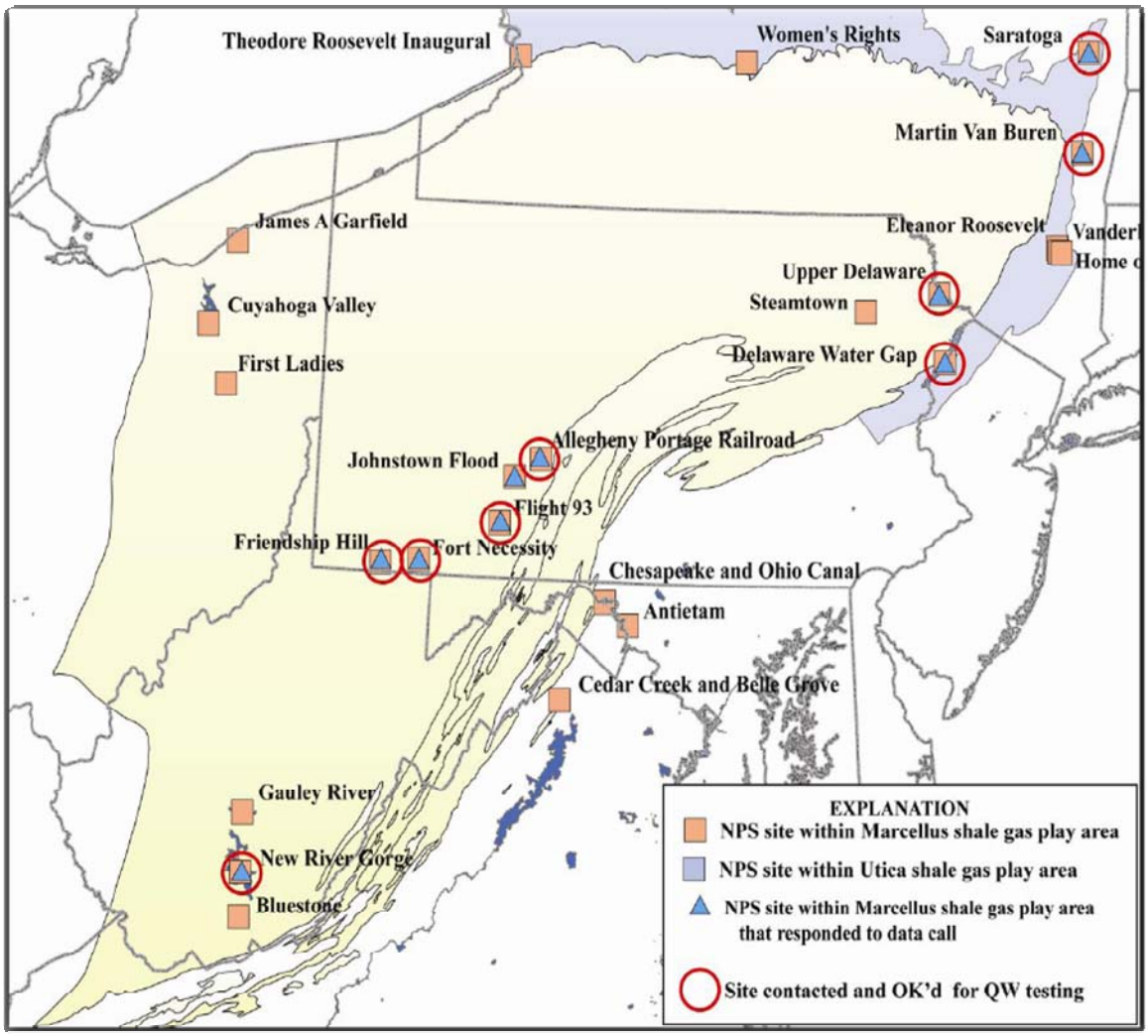

Figure 2 – Map showing locations of NPS units where USGS is conducting baseline water quality testing