Working Paper Series

A Comprehensive Economic Impact Analysis of Natural Gas Extraction in the Marcellus Shale

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Framework for Assessing Water Resource Impacts from Shale Gas Drilling

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Summary

Recovering natural gas in the Marcellus Shale currently involves withdrawing large volumes of surface water, using large quantities of chemicals in close proximity to surface and ground water, disposing of waste water and preventing gas and other formation fluids from entering potable groundwater during drilling and hydrofracing. Here, a framework for organizing and assessing these impacts on water resources is presented that identifies impacts that are certain, which can be planned for, as well as impacts that are uncertain, which must be addressed through risk assessment, preventative practices, and reporting and monitoring structures.

Keywords

Marcellus shale; hydraulic fracturing; WRI framework; hydrofracing; water resources

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What is the issue?

In 2009, 23 percent of total energy, including 40 percent of electricity, consumed in the United States was derived from natural gas. In New York State, natural gas supplies about 30 per cent of the total energy consumed, and 25 per cent of the electricity generation. Since 2007, the proportion of domestic gas supplies coming from shale formations has steadily increased, relieving the need to meet demand for natural gas with imports. The Marcellus Shale, a geologic formation found under much of Southern New York, may contain more recoverable natural gas than any other shale formation in the United States. It is imperative, therefore, that policy makers understand the process of shale gas drilling and its relationship to water resources in order to protect the residents and environment of the State while responsibly ensuring that New York's energy needs are met. This policy brief will provide a framework for understanding and managing the potential impacts and risks to water resources as a result of shale gas activities.

Drilling Activities

Activities associated with the recovery of natural gas from shale have significant impacts on water resources and include construction of multi-acre drill pads, vertical drilling- often through potable groundwater supplies, and horizontal drilling within the shale formation. For high volume hydrofracing operations, millions of gallons of water need to be acquired and transported to the drilling site, mixed with chemicals, and pumped at high pressure into the well bore in order to fracture the rock. Some of this water is quickly brought back to the surface (flowback water), where it is sometimes reused for hydraulic fracturing of other gas wells. Flowback water that is not reused, as well as water that is returned to the surface over the life of the gas well (produced water), must be stored and then treated.

The public, regulators and industry are all concerned with minimizing the impacts associated with shale gas drilling. However, developing a clear understanding of potential impacts is difficult because a) shale gas development entails a wide array of activities and risks, and b) there are few rigorous evaluations of risk and impacts. To help provide clarity and to assist regulators and other stakeholders, the New York State Water Resources Institute (WRI) has developed a simple framework for considering important water resource impacts from natural gas drilling.

Categorizing Water Impacts

One simple way to categorize gas drilling impacts on water resources is to distinguish between events that occur at the surface and events occurring below ground.

Surface events include:

- well pad, road and pipeline construction
- water withdrawals (whether from surface or groundwater)
- treatment and disposal of flowback and produced wastewaters
- surface spills that may occur during transportation, storage and handling of chemicals and waste

Subsurface events include:

- drilling and well casing
- hydraulic fracturing

A distinction between surface and subsurface events could be used to determine who should be responsible for regulating various aspects of shale gas drilling. For example, the Mineral Division of the NYDEC is likely to be tasked with all below surface regulation of shale gas drilling, but other agencies or DEC divisions could be tasked with regulating and monitoring various above ground activities associated with shale gas drilling, such as transportation,

storage and treatment of chemicals and wastewaters, and storm water pollution prevention controls. Clear and appropriate delegation of regulatory responsibilities of different aspects of shale gas activities will be helpful in building a system of accountability that addresses public concerns.

Gas drilling impacts on water resources can also be classified as arising from ***certain*** or ***uncertain*** events. Events that are certain include those integral to the drilling process such as water withdrawal and wastewater production and treatment. These events can be planned for and closely regulated, and their magnitude is directly related to the pace and scale of gas drilling development. Uncertain events can be considered accidents. While they can be anticipated, in the sense that they are likely to occur at some point, their occurrence and consequences are highly uncertain over time and space. Uncertain events include surface runoff, spills and leaks, as well as subsurface events related to well integrity. The distinction between certain and uncertain events is useful for developing and prioritizing strategies for preventing, mitigating and monitoring for water resource impacts.

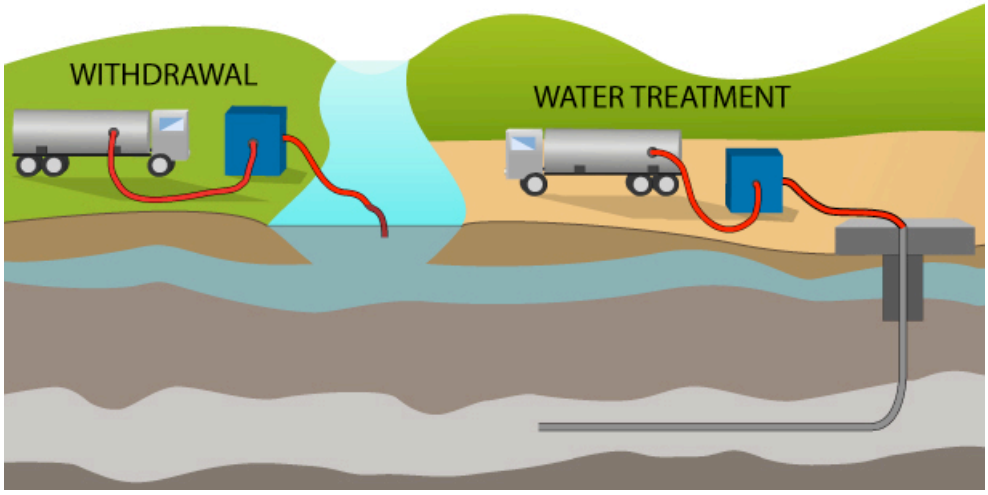

Figure 1: Certain events can be planned for; their magnitude is directly

related to the pace and scale of gas drilling.

Events that are certain, such as water withdrawal, and the subsequent storage, handling and treatment of water and waste fluids, occur at the surface and are a necessary part of shale gas drilling activities. It is in the best interest of both industry and regulators to have accurate data and comprehensive strategies for addressing the water resource impacts of these activities. Clear policies regarding when and where water withdrawals will be permitted and how disposal of waste fluids will occur provide industry with planning certainty. For regulators, certain events provide an opportunity to influence the pace and scale of gas drilling activity through established permitting and compliance systems.

The water withdrawal permitting structure established by the Susquehanna River Basin Commission (SRBC) is a good example of how water withdrawal impacts can be evaluated and managed in the context of basin wide consumptive water use. By collecting data on water volumes being used, as well as descriptions of waste fluid flows and compositions, the SRBC manages the location and timing of withdrawals so as to ensure stream health. A similar permitting and data management system should be established in other river basins of New York outside of the Susquehanna and Delaware Basins.

Certain events also include the handling and treatment of flowback and produced wastewaters. Historically, gas drilling flowback and produced water has either been treated at permitted publicly owned waste water treatment plants (POTW's) or disposed of in underground injection wells. However, due to the increased volume of wastewater generated by modern hydraulic fracturing techniques and their high concentration of total dissolved solids (TDS), neither of these solutions will be adequate. In New York, POTWs are not designed to treat fluids high in TDS, and underground injection wells are scarce. Mobile or temporary water treatment plants, designed specifically for treating water from shale gas operations, could be built in New York. Given increasing economic and public pressure to recycle water, together

with inherent uncertainty with respect to the longevity of the shale play in general, a temporary or flexible approach to developing these facilities is appropriate.

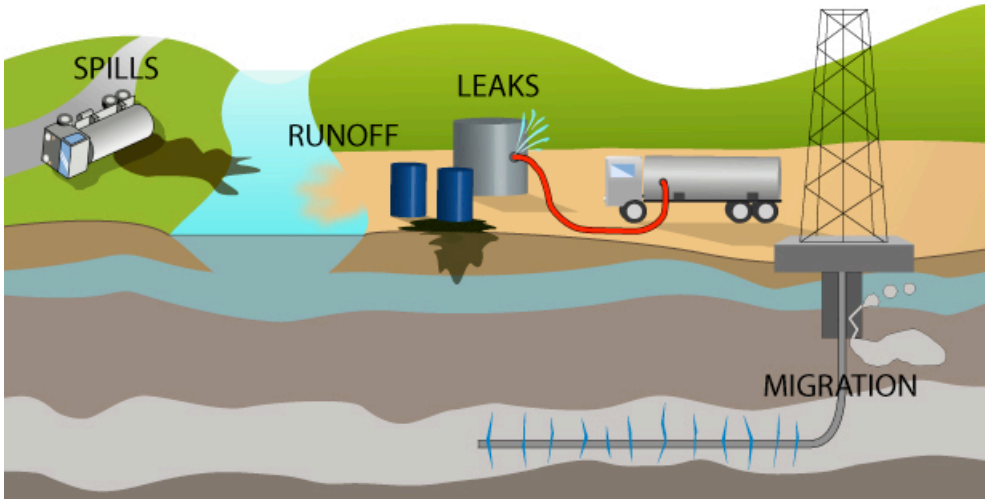

Figure 2. Uncertain events are likely to occur, but their occurrence and consequences are highly uncertain over time and space.

Uncertain events can be thought of as accidents, and may occur at or below the surface. Surface events, such as leaks and spills, have the potential to impact water resources in ways that are characteristic of industrial activity in general. While spills may result from a wide variety of activities, they can be categorized according to the risk they pose to water resources. Regardless of where a spill originates, three basic characteristics should be considered: containment, toxicity, and volume. If a spill is contained, there is little chance it will pose a threat to water resources. Uncontained spills, such as those that enter soils or water bodies, must be further evaluated. Toxicity refers to the degree to which a material can damage organisms, while volume simply describes the quantity of material released. Highly toxic spills present a risk

regardless of their volume. Conversely, high volume spills may pose a risk regardless of their toxicity. Understanding spills as a combination of these characteristics - containment, toxicity and volume - results in a reasonably simple and robust approach to assessing and minimizing the risk an event poses to water resources.

To prevent spills from impacting water resources, encouraging or requiring best management practices with respect to containment of chemicals and waste fluids should be a priority . When spills cannot be contained, they must be managed and remediated in other ways. Timely data on toxicity and volume of spills is essential for the mobilization of effective spill responses from both industry and regulators. A fast, reliable and transparent reporting system is crucial for making sure that all stakeholders have the right data to respond to spills effectively. Reducing or restricting the use of highly toxic chemicals and taking precautions against high volume spills are additional preventative actions that could minimize risk to water resources.

Uncertain subsurface events resulting from drilling and hydraulic fracturing activities also have the potential to impact water resources, and appear to generate the most public concern. Direct contamination of groundwater as a result of fracturing procedures appears to be highly unlikely; however, subsurface impacts as a result of faulty wellbore cementing practices and improper balancing of well pressures can and have occurred. While these events may be rare, they can result in significant contamination of local drinking water sources. Testing of private drinking water wells pre and post gas drilling is necessary for establishing a link between drinking water quality and drilling related impacts. Industry, regulators, and private and academic institutions all appear to recognize the value of this type of monitoring and have helped to make it an increasingly accepted practice. Regulators could take other precautionary steps to reduce the risk of subsurface impacts, such as requiring cement logs to ensure well integrity and the proper separation of drilling fluids and drinking water. Again, restricting the use of highly toxic chemicals could reduce risk to water resources.

Recommendations for Protective Management

The WRI framework presented here can be used to help stakeholders better understand the wide range of events associated with shale gas drilling that will or could potentially impact water resources. Distinguishing between certain and uncertain events is important from both a public policy and communications perspective, and supports the following recommendations:

- Certain events (water withdrawal and waste disposal) can be managed and regulated to minimize or avoid impairments to surface and groundwater, and also to control and monitor the scale and pace of development.
- Impacts from uncertain events (spills and leaks, contaminant migration) can be minimized by targeted regulations, encouragement of preventative best management practices, and establishment of accurate and timely reporting guidelines.

Unfortunately, events having negative impacts on water resources will occur. New York has an opportunity to plan for and mitigate these impacts, as well as an obligation to communicate to residents both the risks and responsibilities inherent in gas development and its regulation. Industry and regulators can employ methods that address and manage the range of possible negative impacts on water resources associated with shale gas drilling, as well as develop transparent monitoring and reporting systems that assure the public that shale gas drilling is occurring in a manner that protects our water resources.

Resources

- New York State Water Resources Institute.
  http://wri.eas.cornell.edu/index_13_1255454827.pdf
  Annotated bibliography of information on Marcellus Shale natural gas extraction and water resources