Penn State Marcellus Shale Law and Policy Symposium
February 10, 2011

Managing the Water Resource Impacts of Marcellus Shale Development In the Susquehanna River Basin

Thomas W. Beauduy
Deputy Executive Director & Counsel
Susquehanna River Basin Commission
1721 N. Front Street
Harrisburg, PA 17102

I. Introduction

Save for that attributable to public water supply systems, the energy sector dominates water withdrawals and consumptive water use[1] in the Susquehanna River Basin.[2] While most of that water use is for energy production (primarily for the generation of electricity), the development of energy resources continues to place increasing demands on the basin's water resources as well.

Nowhere is that more evident than with the recent development of natural gas resources contained in the Marcellus shale formation, which underlies 72% of the 27,512 square miles comprising the basin. Given the renewed interest in moving the United States more aggressively toward energy independence, and given the boldness of the estimates of recoverable gas from the Marcellus[3], the rush is now on to extract that resource.

Accompanying that rush is a new demand for water, at quantities sufficient to trigger the regulatory authority of the Susquehanna River Basin Commission (SRBC) and the need to monitor and assess the cumulative effect of this new demand on the water resources of the basin.

---

[1] The Susquehanna River Basin Commission (SRBC) defines consumptive use as the loss of water "due to transpiration by vegetation, incorporation into products during their manufacture, evaporation, injection of water or wastewater into a subsurface formation from which it would not reasonably be available for future use in the basin, or any other process by which the water is not returned to the waters of the basin." 18 CFR §806.3.

[2] *See* SRBC Consumptive Use Mitigation Plan (March, 2008).

[3] Engelder, T. and Lash, G.G., *Marcellus Shale Play's Vast Resource Potential Creating a Stir in Appalachia,* American Oil and Gas Reporter, May, 2008, and Engelder, T, *Appalachian Gas Reserves,* Platts Appalachian Gas Conference, October, 2008, estimates range from 50 to 400 trillion cubic feet of recoverable natural gas.

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

The SRBC 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.[4] Formed as a federal-interstate compact commission, the SRBC is vested with broad statutory authority to manage the water resources of the basin, including the authority to allocate the waters of the basin.[5] The SRBC serves as a forum for the joint exercise of the sovereign authorities delegated to it by its member jurisdictions.[6]

The SRBC has utilized its Compact authority to develop a regulatory program[7] 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.[8]

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,[9] or the consumptive use of 20,000 gpd or more, also based on a 30-day average.[10] By definition, diversions of water out of the basin are considered to be a consumptive use[11] and are subject to a similar 20,000 gpd threshold.[12] Diversions into the basin, regardless of quantity, are likewise subject to review and approval.[13] As expressly provided in the Compact, no allocation made pursuant to the authority of the SRBC constitutes a prior appropriation of the waters of the basin or confers any superiority of right with respect to the use of those waters.[14]

With regard to groundwater withdrawals, the SRBC 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.[15]

For withdrawals generally, limitations are imposed on approved amounts (both quantity and rate) needed to meet the reasonably foreseeable needs of the project without causing

---

[4] Susquehanna River Basin Compact, P.L. 91-575; 84 Stat. 1509 et seq. (1970).
[5] Susquehanna River Basin Compact, Article 3, *Powers and Duties of the Commission*.
[6] "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.
[7] 18 CFR Parts 806-808.
[8] Susquehanna River Basin Compact, §1.3.5 and §3.10.
[9] 18 CFR §806.4(a)(2).
[10] 18 CFR §806.4(a)(1).
[11] 18 CFR §806.3.
[12] 18CFR §806.4(a)(3)(i).
[13] *Id*.
[14] Susquehanna River Basin Compact, §3.8 and §3.10.
[15] 18 CFR §806.12. *See also* SRBC, *Aquifer Testing Guidance*, Policy No. 2007-01 (December 7, 2007).

adverse impacts.[16] 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.[17]

In taking action on requests for withdrawals, both surface and groundwater, the SRBC relies on guidelines it has developed to make determinations on appropriate passby flow and conservation release values to include as conditions to approvals.[18] The guidelines are used to protect aquatic resources, competing users, instream flow uses downstream from the point of withdrawal, and prevent water quality degradation.[19]

Virtually all energy projects involve the consumptive use of water. As such, they are required to mitigate the loss of water to the basin, particularly during low flow conditions[20]. 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.[21]

- 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.[22]

- Discontinuing the consumptive use during prescribed low flow periods.[23]

- Using as the primary source for consumptive use water a storage impoundment that is subject to the maintenance of an acceptable conservation release requirement.[24]

- Providing consumptive use mitigation fee payments to the SRBC, which utilizes such funds for the acquisition and maintenance of water storage used to provide streamflow augmentation during low flow periods.[25]

---

[16] 18 CFR §806.23(b)(1).
[17] 18 CFR §806.23(b)(2).
[18] 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).
[19] *Id.*
[20] 18 CFR §806.22
[21] 18 CFR §806.22(b)(1)(i).
[22] 18 CFR §806.22(b)(1)(ii).
[23] 18 CFR §806.22(b)(1)(iii).
[24] 18 CFR §806.22(b)(2).
[25] 18 CFR §806.22(b)(3).

As the development of the Marcellus shale began to unfold in the basin during 2008, it was the consumptive use threshold noted above that essentially brought well drilling and development operations under the SRBC's regulatory purview. And while much of the accompanying surface water withdrawal activity occurring at that time was below the 100,000 gpd threshold, it too became subject to review by virtue of a provision that requires review and approval of any withdrawal supplying a regulated consumptive use project, regardless of amount.[26]

III. Special Regulation of Marcellus Shale Development Activity

Marcellus shale gas well development activity generally requires the use of considerable quantities of water, particularly for hydrofracture stimulation of the shale formation, which can range from hundreds of thousands of gallons for vertical well fracturing, to millions of gallons for horizontal well fracturing. According to the industry, and as substantiated by monitoring reports submitted to SRBC, the typical Marcellus horizontal fracture treatment utilizes 3 to 5 million gallons, generally occurring over a 24 to 48 hour period.[27]

As exploratory well development of the Marcellus Shale formation got underway in the second half of 2008, the SRBC saw 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 adverse or interstate effects to the water resources of the basin, regardless of whether individual projects met or fell below the SRBC's regulatory thresholds.

In response to this wave of development activity, the SRBC undertook a number of steps to simultaneously be responsive to the needs of the industry and be protective of the basin's water resources. First, it activated a previously unused rule the SRBC had adopted in 2006 that authorized an administrative Approval by Rule (ABR) process for projects consumptively using water obtained solely from public water supply systems.[28]

ABR's were issued on a drilling pad basis, authorizing the use of water from specific public water supply system(s) for an 18-month term. The use of water sourced from public water supply systems may have some long-term viability, but this was seen as a short-term measure to allow activity to continue while requests for surface water approvals underwent review and consideration by the SRBC. In the first six months of use, concluding December 31, 2008, the SRBC issued 74 ABR's to a rapidly developing industry.

In response to the potential impact on water resources from projects falling below its standard regulatory thresholds, the SRBC's Executive Director utilized his regulatory

[26] 18 CFR §806.4(a)(2)(iii).
[27] Marcellus Shale Coalition website, http://marcelluscoalition.org/marcellus-shale/production-processes/fracture-stimulation/
[28] 18 CFR §806.22(e).

authority[29] to issue a Notice of Determination that all natural gas well development projects in the Susquehanna River Basin targeting the Marcellus or Utica shale formations, and involving the withdrawal or consumptive use of water, are subject to review and approval regardless of whether they otherwise meet the SRBC's existing regulatory thresholds.[30]

In support of the determination, and to formalize its incorporation into its regulatory program, the SRBC took action in 2008 to propose and adopt final rulemaking[31] subjecting all Marcellus or Utica shale well development to regulatory review, starting at gallon one.[32] The final rulemaking also incorporated a number of other changes:

- It required all requests for consumptive use approvals to go through a new administrative ABR process specifically applicable to the natural gas development industry, rather than the SRBC's existing ABR process or its standard consumptive use application and docketing process.[33]

- The new process represented an expansion of the original (2006) ABR process in that it allows project sponsors to utilize a broader range of water sources as part of their approval, including public water supplies, wastewater and withdrawals from other sources approved separately by the SRBC.[34]

- It regulates all projects on a drilling pad basis, regardless of the number of wells developed on the pad.[35]

A major objective of the new rule was to streamline the approval process for consumptive use, yet simultaneously require the monitoring, reporting and mitigation requirements that all consumptive users in the basin comply with, so as to enable the SRBC to better manage the cumulative impact of such use.

Also, it 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 all withdrawals across the basin are subject to, and the SRBC believes are appropriate, to protect the basin's water resources and simultaneously allow for their utilization to support this important new industry.

---

[29] 18 CFR §806.5(a).
[30] Notice of Determination for Natural Gas Well Development Projects, August 14, 2008 (as revised October 8, 2008), Paul O. Swartz, Executive Director, SRBC. The determination also included the Utica shale formation within its scope given its presence in the basin and it similarity in terms of well development processes, including horizontal hydraulic fracture treatment, and potential adverse impacts.
[31] The final rule was published at 73 FR 78618 (December 23, 2008), and became effective January 15, 2009. The rule also applies to wells developed in the Utica shale formation, or any other formation for which the Executive Director issues a determination pursuant to 18 CFR §806.5(a). *See* 18 CFR §806.4(a)(8).
[32] 18 CFR §806.4(8).
[33] 18 CFR §806.22(f)(1).
[34] 18 CFR §806.22(f)(9) and (11).
[35] 18 CFR §806.3 (*see* "project" definition).

As a result of further rule changes in 2009, [36] the industry was given the flexibility to utilize all its approved water sources at any ABR site so as to provide operational flexibility,[37] and 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.[38]

More recently, in September, 2010, the SRBC approved final rulemaking clarifying rules related to notice requirements for applications and transfers of approvals as further refinements to its rules.[39]

As a final point on the scope of SRBC regulation, and beyond the water quality considerations taken into account in issuing withdrawal approvals, it should be noted that SRBC 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.[40] Given that its member states all have comprehensive well permitting and construction standards, erosion and sedimentation control, and disposal and treatment standards, the SRBC does not regulate these aspects of natural gas well development activity. Instead, and so as not to duplicate those efforts, it requires operators to comply with those requirements and certify that all flowback and produced fluids, including brines, have been treated and disposed of in accordance with applicable state and federal law.[41]

IV. Marcellus Development in Relation to the Broader Energy Water Use Portfolio

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, current studies show that the oil and gas industry in Pennsylvania (half of which is located in the basin) already accounts for $7 to $8 billion in annual economic value[42], and that is before the Marcellus development activity moves out of the exploratory phase and into a full production phase, which is anticipated to generate $1 trillion in value throughout the play.[43] On the water resource side, the bigger challenges focus on cumulative impact, from both a water quality and water quantity perspective.

---

[36] Final rule published at 74 FR 49812 (September 29, 2009), effective November 1, 2009.
[37] 18 CFR §806.22(f)(11).
[38] 18 CFR §806.22(f)(12)(i).
[39] Final rule published at 75 FR 190 (October 1, 2010), effective November 1, 2010.
[40] Susquehanna River Basin Compact, §3.2.
[41] 18 CFR §806.22(f)(8).
[42] Pennsylvania Economy League of Southwestern Pennsylvania, LLC, *The Economic Impact of the Oil and Gas Industry in Pennsylvania,* November, 2008. Considine, T., Watson, R. and Blumsack, S., *The Economic Impacts of the Pennsylvania Marcellus Shale Natural Gas Play: An Update*, Pennsylvania State University, May, 2010.
[43] Testimony of John Hanger, Pennsylvania Department of Environmental Protection, before the Pennsylvania House of Representatives Environmental Resources and Energy Committee, September, 2008.

From a management perspective, there is value in viewing the challenges in the broader context of energy water use demands and impacts basin-wide.

As noted in the introduction, 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.[44] Of the 563 mgd of total approved consumptive use in the basin as of 2005, 149 mgd, or 26%, was for power generation.[45] 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.[46] 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.).[47] 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.[48]

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 SRBC is currently attempting to work with the industry to develop reasonable 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, in order to develop some estimation of that potential.[49] Comparing the size of the Barnett play to that of the Marcellus in the basin, and conservatively doubling the amount of water use needed to support this (gross) assumption, the consumptive use is estimated by SRBC to be 28 mgd, on an annualized basis.

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. For a summary of water use profile data submitted to the Commission by the natural gas industry as part of its post-hydrofracture reporting requirements, please see ***Attachment 1***. The data in ***Attachment 1*** represent reported quantities for the first 30 months of development activity in the basin. To date, the industry has used approximately 1.5 mgd on an annualized basis, which

---

[44] *See* SRBC Consumptive Use Mitigation Plan (March, 2008). Data contained in the plan are as of 2005.
[45] *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.
[46] *Id.*
[47] SRBC, *Water Resource Challenges from Energy Production*, June, 2008.
[48] *Id.* Groundwater withdrawals for this industry only total 14.2 mgd, and are generally limited in uses to non-thermal related aspects.
[49] 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. Annually, approximately 1500 wells are drilled per year in the Barnett shale.

suggests that there is considerable head room in the 28 mgd estimate for further expansion of this developing industry.

Interestingly, and for comparative purposes, it should be noted that air quality control upgrades (scrubbers) at typical power plants in the basin each consume 4-5 mgd, and single plant generation upgrades can require 30 mgd or more.[50] Nonetheless, 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.)[51], it represents a 19% increase in the amount attributable to the energy sector.

For planning purposes, the SRBC 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.[52] 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. 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).

Using the Barnett-extrapolated assumptions noted above, the Marcellus shale development activity would require slightly more than 10 billion gallons per year (28 mgd x 365). Comparing that to the amounts approved for power production withdrawals, the annual volume for Marcellus development would be equal to what is withdrawn in a 3-day period for power production (3.44 B gpd x 3). 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.[53]

V. Conclusion

As noted at the outset, development of the Marcellus shale formation represents both an opportunity and challenge for the Susquehanna River Basin. The SRBC'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. Other water quality issues, including proper treatment and disposal of flowback and other produced fluids, including brines, are being effectively managed by its member jurisdictions. SRBC will continue its coordination efforts with member

[50] SRBC, *Water Resource Challenges from Energy Production*, June, 2008.
[51] SRBC Consumptive Use Mitigation Plan at pg A-6.
[52] *Id.* at pg. A-14. (Original published amount of 134 mgd updated to 230 mgd by SRBC, 2010).
[53] Power production facilities, on the other hand, are generally located along the mainstem river or major tributaries.

jurisdictions and 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 SRBC, the water users who have an obligation to mitigate, and for the basin generally. As part of its consumptive use strategy for the basin generally, the SRBC will be re-evaluating its regulatory thresholds for mitigation, appropriate ecological flow regimes for the basin and its major sub-basins, and pursuing the development of addition storage for low-flow augmentation.[54]

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.

[54] SRBC Consumptive Use Mitigation Plan, at pg. 23.

Attachment

Summary of data as reported on Post-Hydrofracture Reports filed during the specified period with the Susquehanna River Basin Commission:

Water Use Profile Data

For the period July 1, 2008 to December 22, 2010

- Total water withdrawn: 1343 mgal
  - 466.1 mgal from public water supply (35%)
  - 877.3 mgal from surface water sites (65%)
- Average volume of use per well: 4.2 mgal
  - Average fresh water used per well: 3.7 mgal
  - Average flowback reuse per well: 0.4 mgal
  - Max use reported: 8.26 mgal
- Average flowback recovered per well: 9%
  (first 30 days)

Water Use Profile Data (cont.)

- Water use in frac operation
  - 1 mgal per 1000 feet of horizontal lateral
- Disposal volumes
  - 35.6 mgal, represents <3% of total water used
- Recycling/re-use of flowback
  - Use at 70% of wells
  - Use by 64% of companies
  - Emerging use pattern: 80% - <100%
- Overall water use by natural gas industry
  - 1.47 mgd on an annualized basis
  - Current estimated max: 28 mgd

As of Dec 22, 2010