SHALE GAS VOLUNTEER MONITORING PROGRAM
Data Results and Findings, Phase 1, 2010 – 2013

Introduction

Shale gas volunteer monitoring efforts have multiplied in the Marcellus and Utica Shale region as concerned individuals and organizations seek to learn more about how shale gas development may impact their local streams. In 2010, the Alliance for Aquatic Resource Monitoring (ALLARM), an organization based at Dickinson College, developed a protocol for volunteers to monitor small streams for shale gas extraction impacts, specifically to detect pollution events. Since then, ALLARM has held 65 workshops and has trained over 2,000 volunteers in Pennsylvania, New York, and West Virginia to monitor water quality both instream and certified lab analysis (conductivity, barium, strontium, and total dissolved solids) and physical (stream stage and visual observations) parameters prior to, during, and after shale gas wells have been developed.

ALLARM Shale Gas Volunteer Monitoring Program

Over the course of its 29 year history, ALLARM has worked with regional communities to address a myriad of water quality questions through three major volunteer monitoring program areas – acid rain, baseline watershed analysis, and shale gas. ALLARM's philosophy is centered around bottom-up community engagement and capacity building by involving Pennsylvania communities in every step of the scientific process.

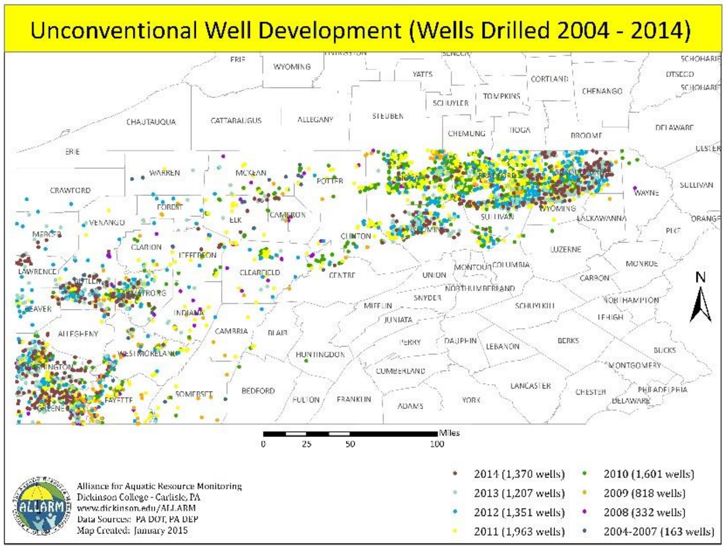


Figure 1: Shale gas well development in Pennsylvania.

Many people living in the shale gas region have expressed concern about the potential impact shale gas extraction activities may have on local stream health. Since 2010, more than 1,200 unconventional wells have been drilled in Pennsylvania each year (Figure 1). To address community concerns, ALLARM developed its Shale Gas Volunteer Monitoring Program in 2010.

The goals of the program are to detect flowback water contamination events and physical environmental impacts caused by the development of shale gas wells. Volunteers are trained to monitor streams weekly and report pollution incidents to the appropriate enforcement agency. They also record their observations in order to document and assess cumulative impacts and regional patterns over time.

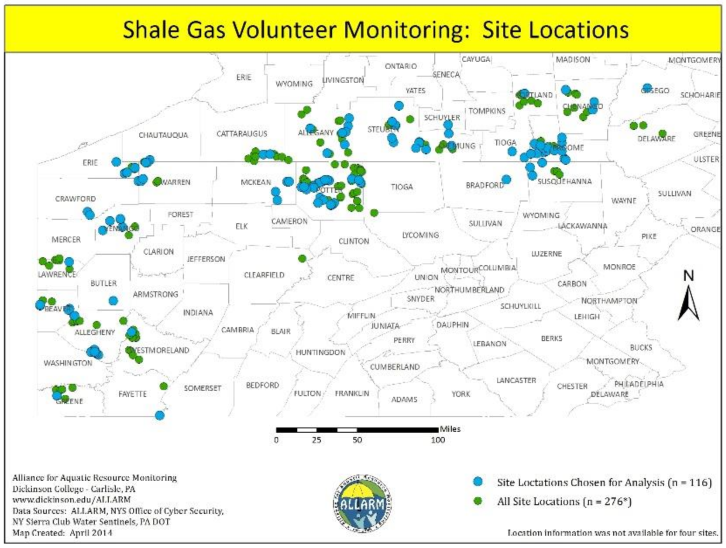
Photo credit: Kathy Allio, ALLARM volunteer monitor

Volunteers monitor conductivity, total dissolved solids, and stream stage on a weekly, bimonthly or monthly basis (depending on proximity of extraction activities to their sites). In addition, they perform a visual assessment each time they visit their monitoring site, which includes documenting earth disturbances, spills and discharges, and gas migration and leakages caused by the development of gas wells or pipelines. Twice a year, volunteers collect a water sample at each site to be analyzed by a certified laboratory for barium and strontium (signature parameters of flowback water). Volunteers also participate in ALLARM's Shale Gas Quality Assurance/Quality Control Program twice a year where they send water samples to ALLARM (NY Water Sentinel volunteers send samples to a New York-based laboratory) for split sample analysis. This along with other requirements of the QA/QC Program helps to ensure the quality of the data being collected.

Data Analysis

Data collected between July 2010 and January 2014 were compiled into a single dataset for analysis. This included 4,220 observations from 280 different monitoring sites (Figure 2) in Pennsylvania and New York. The dataset was reduced to 2,995 observations from 116 sites for the analysis based on monitoring frequency and QA/QC participation guidelines.

	Entire compiled dataset			**Reduced dataset for analysis**		
	# of observations	# of sites	Average # of observations per site	# of observations	# of sites	Average # of observations per site
Pennsylvania	2,653	173	10	1,879	71	24
New York	1,567	107	11	1,116	45	18
Total	4,220	280	---	2,995	116	---


Shale Gas Volunteer Monitoring: Site Locations

Alliance for Aquatic Resource Monitoring
Dickinson College - Carlisle, PA
www.dickinson.edu/ALLARM
Data Sources: ALLARM, NYS Office of Cyber Security, NY Sierra Club Water Sentinels, PA DOT
Map Created: April 2014

Location information was not available for four sites.

Figure 2: Shale gas monitoring sites.

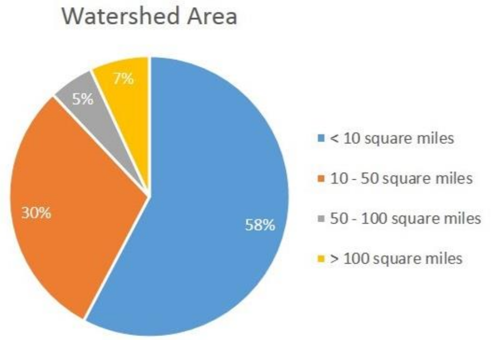
A computer mapping and analysis program, GIS, was used to delineate the watershed of each monitoring site as well as determine the primary geology and land cover types in the watershed. Conductivity values were then compared to watershed characteristics (watershed size, geology, land use, number of wells drilled in the watershed, and the density of wells in the watershed) to see if any of the factors influenced stream conductivity values.

Results

The majority of the data collected were from small, forested, headwater streams. Many sites (93 of 116) were monitored in areas where drilling had not yet occurred. The robust dataset of baseline conditions collected from these 93 sites will be especially useful for looking at changes in the watershed if drilling occurs in the future.

Four watershed characteristics were explored to see if they influence conductivity values. Multiple regression analysis determined that land use and geology influenced the conductivity the most, specifically developed areas and limestone geology. Both urban areas and limestone have the potential to contribute a large amount of ions to the stream, resulting in higher conductivity values.

Watershed Size



Most of the monitoring sites were in small, headwater streams.

- 58% of the watersheds were less than 10 square miles.
- 88% of the watersheds had a drainage area of less than 50 square miles.

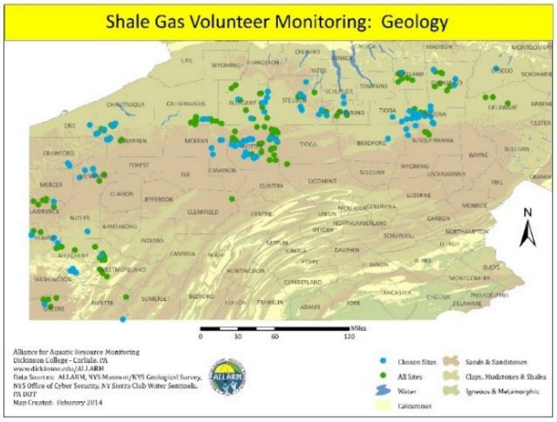
Watershed size did not influence conductivity values.

Geology

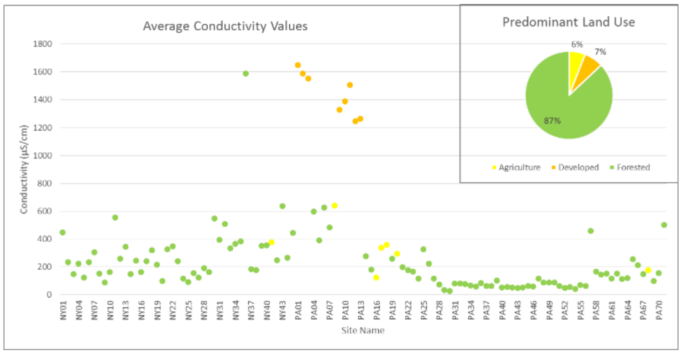
For the purpose of the analysis, the bedrock geology was categorized as:

Geology Type	Predominant Geology of all Watersheds
Shale	49%
Sandstone	46%
Limestone	5%
Igneous & Metamorphic	0%

There was a strong relationship between conductivity and the percent of limestone in the watershed.



Land Use



Most of the watersheds were predominately in forested areas (101 of 116).

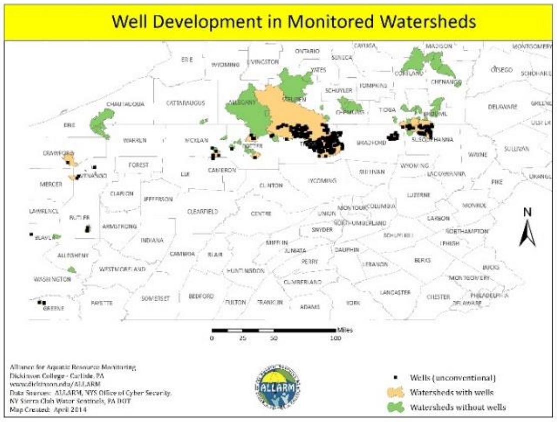
Sites with the highest average conductivity values (1245 – 1647 µS/cm) were generally found in developed areas. The seven urban sites also had a large amount of limestone geology in the watershed.

Drilled Wells

Only 23 (of 116) sites were downstream from a shale gas well.

The number of wells drilled in each watershed ranged from 1 – 475, although only two watersheds had more than 12 shale gas wells.

Conductivity was not influenced by the number of wells or the density of wells in the watershed.



Conclusion

The analysis concluded that average conductivity values in streams are related to the amount of land development and limestone bedrock in the watershed, and is not significantly related to the size of the watershed or the number or density of drilled wells (although only 23/116 watersheds had wells drilled at the time of sampling).

Photo credit: ALLARM

Shale gas extraction may have an impact on local streams, especially during the early stages of development. The act of clearing land, creating roads, and transporting large volumes of water over dirt roads to the well site creates the opportunity for large amounts of sediment to mobilize and enter nearby streams. In addition, methane migration and bentonite blowouts have been attributed to shale gas well and pipeline development. Through December 2013, volunteers reported forty cases of visual pollution related to shale gas activities (see table below) but did not identify flowback water contamination events based on stream water chemistry.

Type	# of Reports
Erosion & sedimentation	29
Pipeline	7
Methane migration	3
Spills & discharges	1

The ALLARM Shale Gas Volunteer Monitoring Program has demonstrated the value of a large volunteer-collected dataset in detecting patterns of conductivity as related to watershed characteristics. The dataset shows similar patterns to data reported in the scientific literature by professional researchers, which adds credibility and robustness to volunteer methods and data collection.

Future Considerations

The results from this analysis have identified potential next steps for the ALLARM Shale Gas Volunteer Monitoring Program.

1. Develop and implement a study design to monitor the watersheds that have well documented baseline conditions (93 sites) once wells are permitted and drilled.
2. Target watersheds whose characteristics are under-represented in this database.
3. Consider adding additional parameters to the ALLARM Shale Gas Volunteer Monitoring Protocol for high-risk systems.
4. Develop a central, user-friendly online database for volunteers to enter their data and receive preliminary analysis.
5. Partner with other volunteer data collectors to collaborate with data analysis and interpretation.

For more information on the ALLARM Shale Gas Volunteer Monitoring Program, including the monitoring manual, voice-over PowerPoint presentations, and demonstration videos, please visit the Shale Gas Monitoring Toolkit at: http://blogs.dickinson.edu/marcellusmonitoring/.

ALLARM would like to thank the many shale gas volunteer monitors in Pennsylvania and New York for collecting and sharing their monitoring data and Dickinson College's GIS Program for their support in the GIS analysis.