ALLARM Background

Empower communities with scientific tools to monitor, protect, and restore PA streams.

Volunteer Monitoring

- Citizens involved in data collection
- US: 1890 – 2011

Georgia Adopt-A-Stream
GEORGIA'S VOLUNTEER WATER QUALITY MONITORING PROGRAM

National Weather Service
WORKING TOGETHER TO SAVE LIVES

NJ Watershed Watch Network

Citizen Stewards Water Quality Monitoring Program

TEXAS STREAM TEAM
PA Volunteer Stream Monitoring

Rich history – 1980s
Marcellus Monitoring

A. Citizen surveillance
B. Baseline monitoring
C. Continuous monitoring

Great network of partners
### Exhibit 11: Comparison of Data for the Gas Shales in the United States

<table>
<thead>
<tr>
<th>Gas Shale Basin</th>
<th>Barnett</th>
<th>Fayetteville</th>
<th>Haynesville</th>
<th>Marcellus</th>
<th>Woodford</th>
<th>Antrim</th>
<th>New Albany</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Basin Area, square miles</td>
<td>5,000</td>
<td>9,000</td>
<td>9,000</td>
<td>95,000</td>
<td>11,000</td>
<td>12,000</td>
<td>43,500</td>
</tr>
<tr>
<td>Depth, ft</td>
<td>6,500 - 8,500</td>
<td>1,000 - 13,500</td>
<td>4,000 - 8,500</td>
<td>4,000 - 11,000</td>
<td>600 - 2,200</td>
<td>500 - 2,000</td>
<td></td>
</tr>
<tr>
<td>Net Thickness, ft</td>
<td>100 - 600</td>
<td>20 - 200</td>
<td>200 - 300</td>
<td>50 - 200</td>
<td>120 - 220</td>
<td>70 - 120</td>
<td>50 - 100</td>
</tr>
<tr>
<td>Depth to Base of Treatable Water, ft</td>
<td>~1200</td>
<td>~500</td>
<td>~400</td>
<td>~850</td>
<td>~400</td>
<td>~300</td>
<td>~400</td>
</tr>
<tr>
<td>Rock Column Thickness between Top of Pay and Bottom of Treatable Water, ft</td>
<td>5,300 - 7,300</td>
<td>500 - 6,500</td>
<td>10,100 - 13,100</td>
<td>2,125 - 7,650</td>
<td>5,600 - 10,600</td>
<td>300 - 1,900</td>
<td>100 - 1,600</td>
</tr>
<tr>
<td>Total Organic Carbon, %</td>
<td>4.5</td>
<td>4.0 - 9.8</td>
<td>0.5 - 4.0</td>
<td>3 - 12</td>
<td>1 - 14</td>
<td>1 - 20</td>
<td>1 - 25</td>
</tr>
<tr>
<td>Total Porosity, %</td>
<td>4 - 5</td>
<td>2 - 8</td>
<td>8 - 9</td>
<td>10</td>
<td>3 - 9</td>
<td>9</td>
<td>10 - 14</td>
</tr>
<tr>
<td>Gas Content, scf/ton</td>
<td>300 - 350</td>
<td>60 - 220</td>
<td>100 - 330</td>
<td>60 - 100</td>
<td>200 - 300</td>
<td>40 - 100</td>
<td>40 - 80</td>
</tr>
<tr>
<td>Water Production, Barrels water/day</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>5 - 500</td>
<td>5 - 500</td>
</tr>
<tr>
<td>Well spacing, acres</td>
<td>60 - 160</td>
<td>80 - 160</td>
<td>40 - 560</td>
<td>40 - 160</td>
<td>640</td>
<td>40 - 160</td>
<td>80</td>
</tr>
<tr>
<td>Original Gas-In-Place, tcf</td>
<td>327</td>
<td>52</td>
<td>717</td>
<td>1,500</td>
<td>23</td>
<td>76</td>
<td>160</td>
</tr>
<tr>
<td>Technically Recoverable Resources, tcf</td>
<td>44</td>
<td>41.6</td>
<td>251</td>
<td>262</td>
<td>11.4</td>
<td>20</td>
<td>19.2</td>
</tr>
</tbody>
</table>

Hydraulic Fracturing ("Fracking")

Hydraulic fracturing, or "fracking," involves the injection of more than a million gallons of water, sand and chemicals at high pressure down and across into horizontally drilled wells as far as 10,000 feet below the surface. The pressurized mixture causes the rock layer, in this case the Marcellus Shale, to crack. These fissures are held open by the sand particles so that natural gas from the shale can flow up the well.
Marcellus Shale Drilling Permits

99 permits in 2007

Marcellus Center for Outreach and Research, Penn State
www.marcellus.psu.edu
Current Gas Drilling

Marcellus Shale Drilling Stats:
- 2005–2010: 6,082 Marcellus Shale permits issued (2,596 wells drilled)
- 2008: 5% of all oil/gas wells drilled were in Marcellus Shale Formation (195/4,192)
- 2009: 30% of all oil/gas wells drilled were in Marcellus Shale Formation (768/2,543)
- 2010: 50% of all oil/gas wells drilled were in Marcellus Shale Formation (1,386/2,755)
Drilling Sites

Marcellus Shale Drilling Site Stats:
• Drilling pads typically 3-5 acres, each pad containing 5-6 horizontal wells
• 2-9 million gallons of water used per well (depending on depth and number of times fracked)
• 200-1400 truck trips to supply water per well
• Drilling pads must be >200 feet from structures, >100 feet from streams and wetlands

Volunteer Monitoring

- Feasibility
- Affordability
- Scientifically robust

www.dickinson.edu/ALLARM
Why Are You Monitoring?

1. Early detection and prevention of contamination
2. Document stream quality – long term impacts
3. Community education

The data collected using this monitoring protocol are not intended to be used for legal purposes.
What Will You Monitor?

1. **Chemical Monitoring:**
   Indicator and signature chemicals

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Median concentrations in flowback samples (mg/L)</th>
<th>PA water quality criteria (mg/L)</th>
<th>PA drinking water criteria (mg/L)</th>
<th>Potential health &amp; environmental effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Dissolved Solids</td>
<td>93,200</td>
<td>500</td>
<td>500</td>
<td>Variable; includes many chemicals</td>
</tr>
<tr>
<td>Barium</td>
<td>661</td>
<td>10</td>
<td>2</td>
<td>Increase in blood pressure</td>
</tr>
<tr>
<td>Strontium</td>
<td>821</td>
<td>0.050</td>
<td>none</td>
<td>Musculoskeletal toxicant</td>
</tr>
</tbody>
</table>

2. **Visual Assessment:**
   Land disturbances
   Spills and discharges
   Water withdrawals
   Gas migration/leakages

3. **Surrogate Flow Monitoring:**
   Relationship to TDS

   http://www.rocketcourier.com/pictures/rivergas.jpg
Flowback Water Concentrations

TDS: 70,000 mg/L
TDS: 211,000 mg/L
TDS: 132,000 mg/L
TDS: 217,000 mg/L

Source: Amy Bergdale, USEPA
Conductivity and Total Dissolved Solids

- Conductivity measures the ability of water to pass an electrical current.
- Total Dissolved Solids (TDS) measures the amount of ions dissolved in the water. (PA standard – 500 mg/L)

Voltage is applied between two probes to measure conductivity in microSiemens/centimeter (µS/cm)
Dickinson students help test conductivity/TDS meters to determine which meter is most accurate, precise, and easy to use.
Barium and Strontium

- Naturally-occurring metals found deep underground
- Indicate contamination from Marcellus Shale activities (signature chemicals)
Surrogate Flow Monitoring

Cross-sectional area – understand relationship between amount of water in stream and TDS
Visual Assessment

- Earth Disturbances
- Spills and Discharges
- Gas Migration/Leakages

Marcellus Shale Well Sites in Dimock, PA; 2010
Earth Disturbances: Drill Pad, Storage Pond, & Staging Areas

Outlets of sediment control structures are NOT stabilized

Outlets of sediment control structures are stabilized

Photo courtesy of PA Council of Trout Unlimited
Drilling fluid spill at Cabot site
Dimock, PA
September 2009
Where Will You Monitor?

Considerations: How will volunteers determine where drilling is occurring?

Volunteers have a wealth of information about their local surroundings
Determining Well Locations

**Step 1:**
Find where drilling permits have been issued (lat/long)
- eNOTICE/eFacts/eMap PA
- DEP reports

**Step 2:**
Find issued drilling permit locations on map
- Google Maps
- Topographic map

**Step 3:**
Choose monitoring site based on important features
- Well locations
- Stream access
Data Use: Decision Trees

Chemical Monitoring
*  Visual Assessment
*  Surrogate Flow

Baseline data available

- Is TDS > 3x baseline TDS at comparable flow?
  - YES
    - Is either Ba or Sr > 3x baseline concentrations at comparable flow?
      - YES, then notify
      - YES, then notify
    - YES, then notify
  - SEA
    - Is either Ba or Sr > 3x previous week or upstream TDS?
      - YES, then notify
      - YES, then notify

Report monitoring information when values exceed criteria in decision trees

PA DEP Regional Office
PA Fish and Boat Commission
Local Watershed Association
Facility Owner/Operator
Quality Assurance/Quality Control

Considerations: What is feasible for volunteers?

Standard QA/QC Practices:
- Training requirements
- Care/calibration of equipment
- Replicates
- Documentation of procedures
- Split sample analysis
Data Management

Considerations: What tools and methods are available to volunteers?

ALLARM created easy to use templates for volunteers to store their chemical, surrogate flow, and visual assessment data.
Building a Monitoring Force

- 600 people trained since the start of 2010
- ALLARM, DRN, PACTU, & Waterdogs