Marcellus Monitoring: Small Streams

Alliance for Aquatic Resource Monitoring

Dickinson College

Carlisle, PA

ALLARM Background

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

Educate. Engage. Empower.

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

Friends of Casco Bay
BAYKEEPER

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

Shale Basins in the US

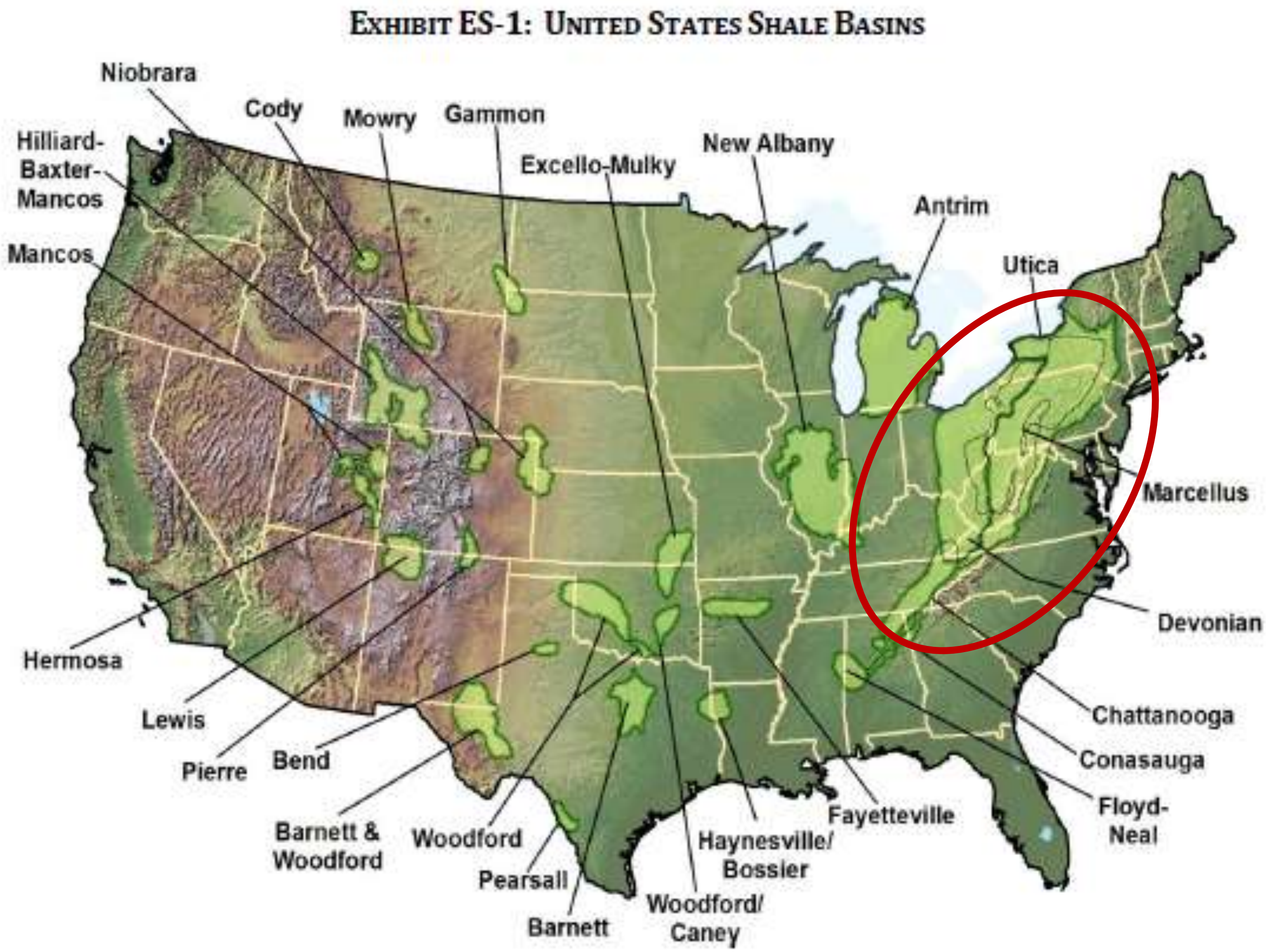
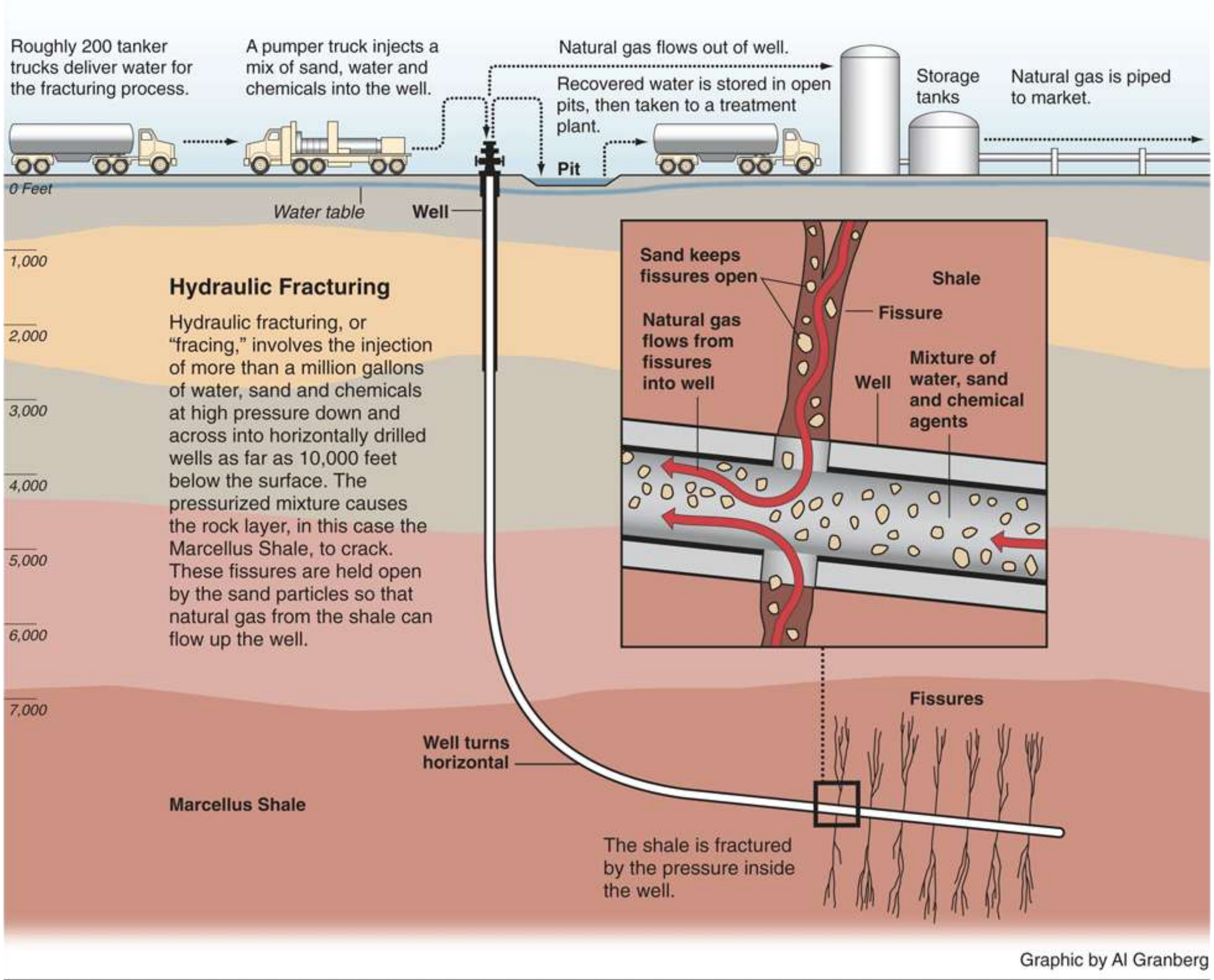


Exhibit 11: Comparison of Data for the Gas Shales in the United States

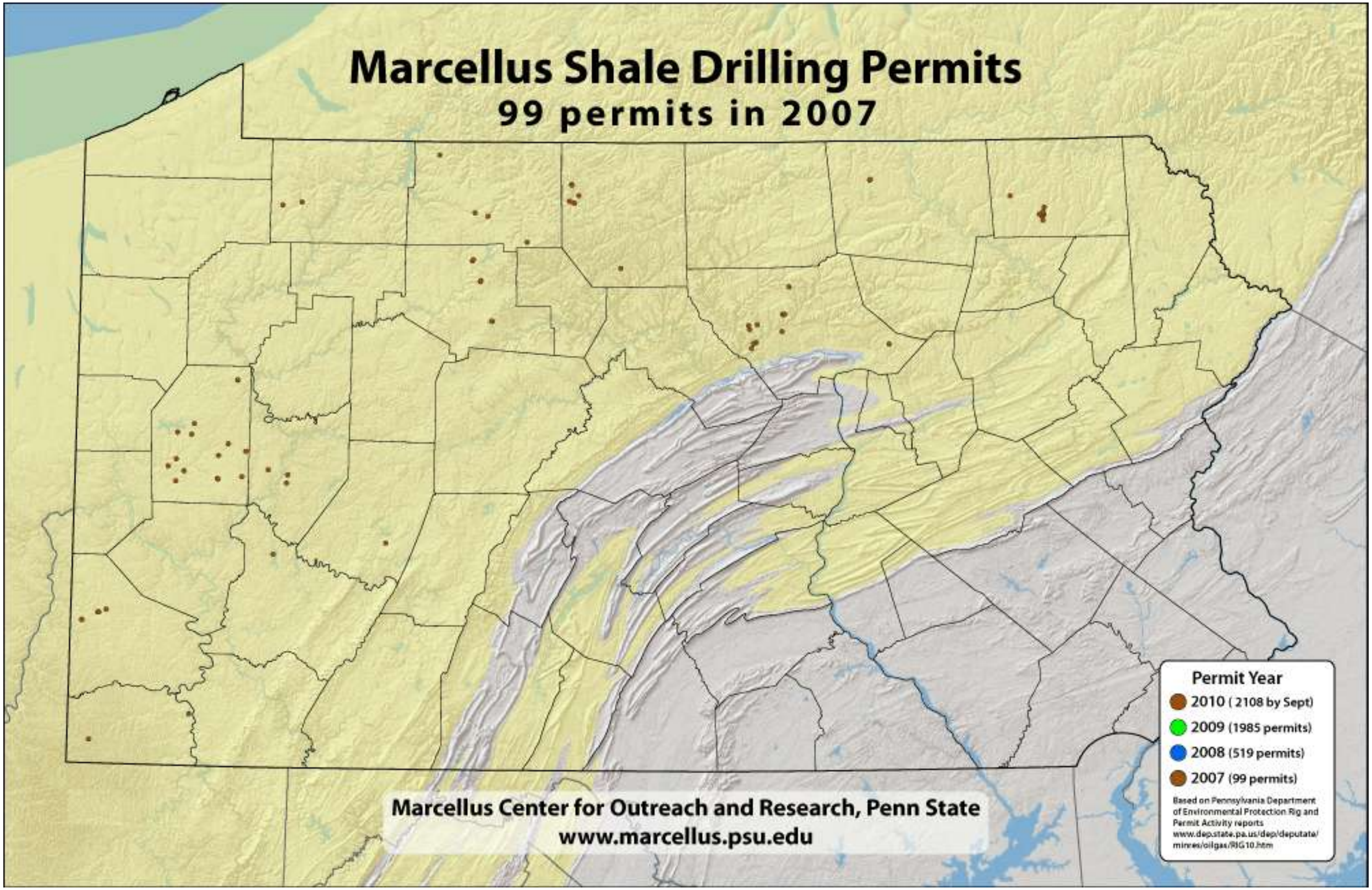
Gas Shale Basin	Barnett	Fayetteville	Haynesville	Marcellus	Woodford	Antrim	New Albany
Estimated Basin Area, square miles	5,000	9,000	9,000	95,000	11,000	12,000	43,500
Depth, ft	6, 500 - 8,500[82]	1,000 - 7,000[83]	10,500 - 13,500[84]	4,000 - 8,500[85]	6,000 - 11,000[86]	600 - 2,200[87]	500 - 2,000[88]
Net Thickness, ft	100 - 600[89]	20 - 200[90]	200[91] - 300[92]	50 - 200[93]	120 - 220[94]	70 - 120[95]	50 - 100[96]
Depth to Base of Treatable Water[#], ft	~1200	~500[97]	~400	~850	~400	~300	~400
Rock Column Thickness between Top of Pay and Bottom of Treatable Water, ft	5,300 - 7,300	500 - 6,500	10,100 - 13,100	2,125 - 7650	5,600 - 10,600	300 - 1,900	100 - 1,600
Total Organic Carbon, %	4.5[98]	4.0 - 9.8[99]	0.5 - 4.0[100]	3 - 12[101]	1 - 14[102]	1 - 20[103]	1 - 25[104]
Total Porosity, %	4 - 5[105]	2 - 8[106]	8 - 9[107]	10[108]	3 - 9[109]	9[110]	10 - 14[111]
Gas Content, scf/ton	300 - 350[112]	60 - 220[113]	100 - 330[114]	60 - 100[115]	200 - 300[116]	40 - 100[117]	40 - 80[118]
Water Production, Barrels water/day	N/A	N/A	N/A	N/A	N/A	5 - 500[119]	5 - 500[120]
Well spacing, acres	60 - 160[121]	80 - 160	40 - 560[122]	40 - 160[123]	640[124]	40 - 160[125]	80[126]
Original Gas-In-Place, tcf[127]	327	52	717	1,500	23	76	160
Technically Recoverable Resources, tcf[128]	44	41.6	251	262	11.4	20	19.2

From: US Dept of Energy, *Modern Shale Gas Development in the US: A Primer*, 2009

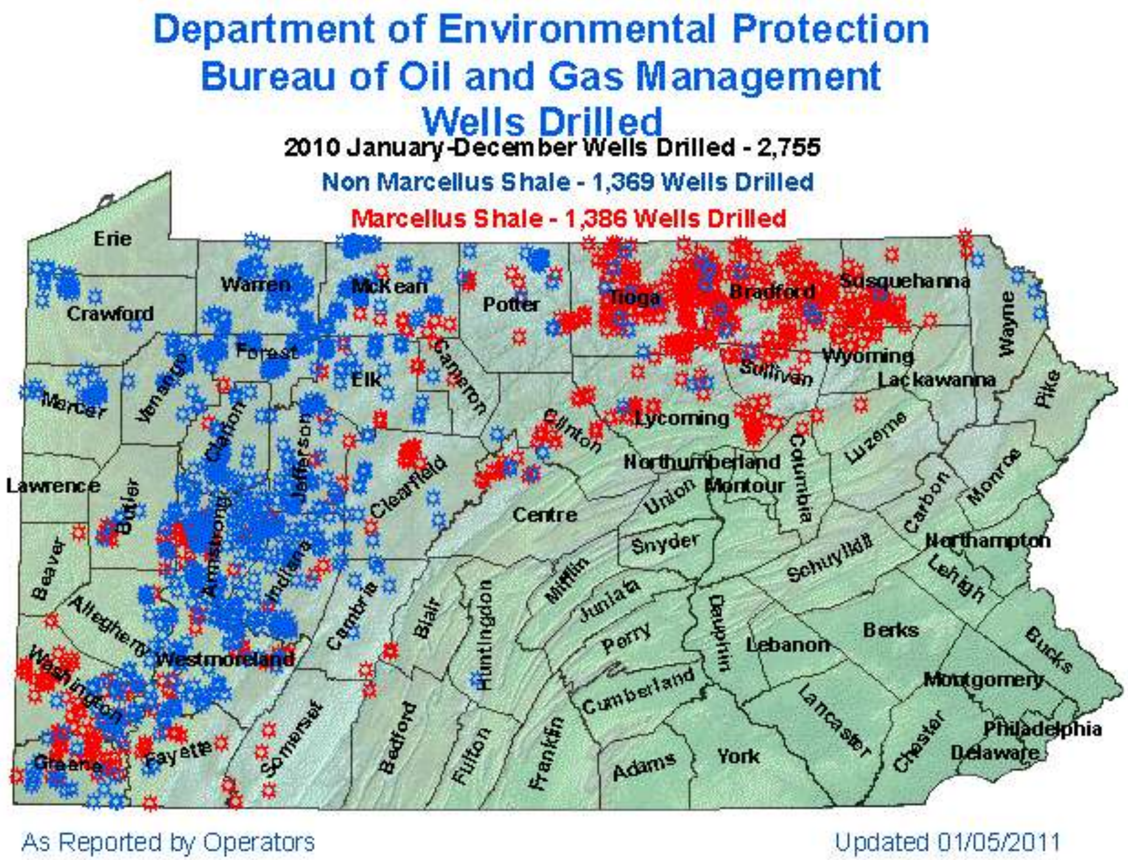
Hydraulic Fracturing ("Fracking")



Marcellus Shale Drilling Permits



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)

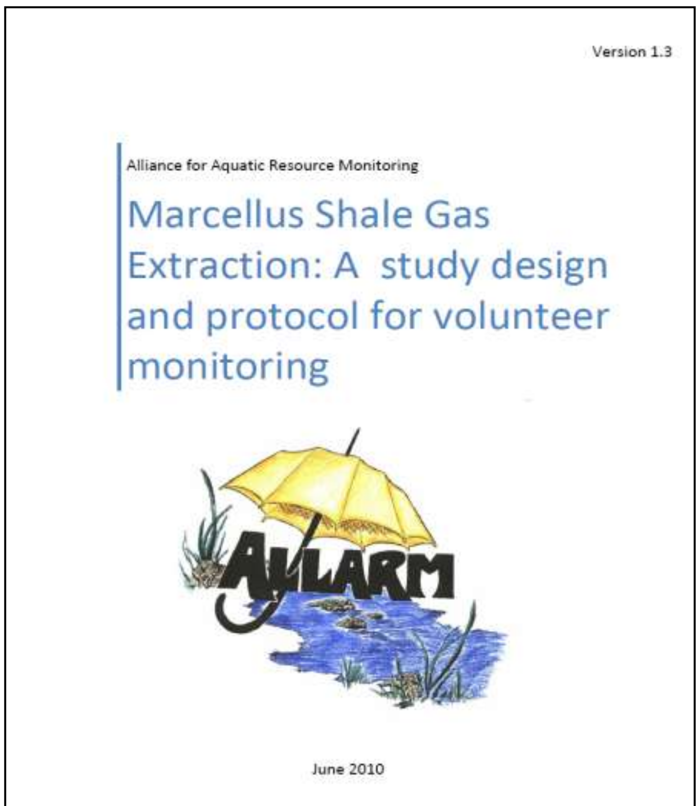
Drilling Sites

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



Version 1.3

Alliance for Aquatic Resource Monitoring

Marcellus Shale Gas Extraction: A study design and protocol for volunteer monitoring

ALLARM

June 2010

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

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

2. Visual Assessment:

Land disturbances

Spills and discharges

Water withdrawals

Gas migration/leakages

http://www.rocketcourier.com/pictures/rivergas.jpg

3. Flow Monitoring:

Relationship to TDS

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)

TDS conversion ratio factor

TDS value (mg/L)

Meter Trials

Dickinson students help test conductivity/TDS meters to determine which meter is most accurate, precise, and easy to use.

Conductivity/Total Dissolved Solids Meter Testing

Thank you for participating in this meter testing session sponsored by the Alliance for Aquatic Resource Monitoring (ALLARM). Please answer the questions on page 1 about each water quality meter. Additional questions are found on page 2 – please provide as much feedback as possible!

Meter A: LaMotte Tracer PockeTester

Results	Solution A	Solution B	Solution C
Conductivity	________	________	________
TDS	________	________	________

Did the reading stabilize? YES NO

How difficult was it to calibrate the meter?
[1 = very difficult; 2 = difficult; 3 = medium 4 = easy; 5 = very easy]

1 2 3 4 5

How difficult was it to understand the directions?
[1 = very difficult; 2 = difficult; 3 = medium 4 = easy; 5 = very easy]

1 2 3 4 5

Meter B: Oakton Multi-Parameter PCSTestr 35

Results	Solution A	Solution B	Solution C
Conductivity	________	________	________
TDS	________	________	________

Did the reading stabilize? YES NO

How difficult was it to calibrate the meter?
[1 = very difficult; 2 = difficult; 3 = medium 4 = easy; 5 = very easy]

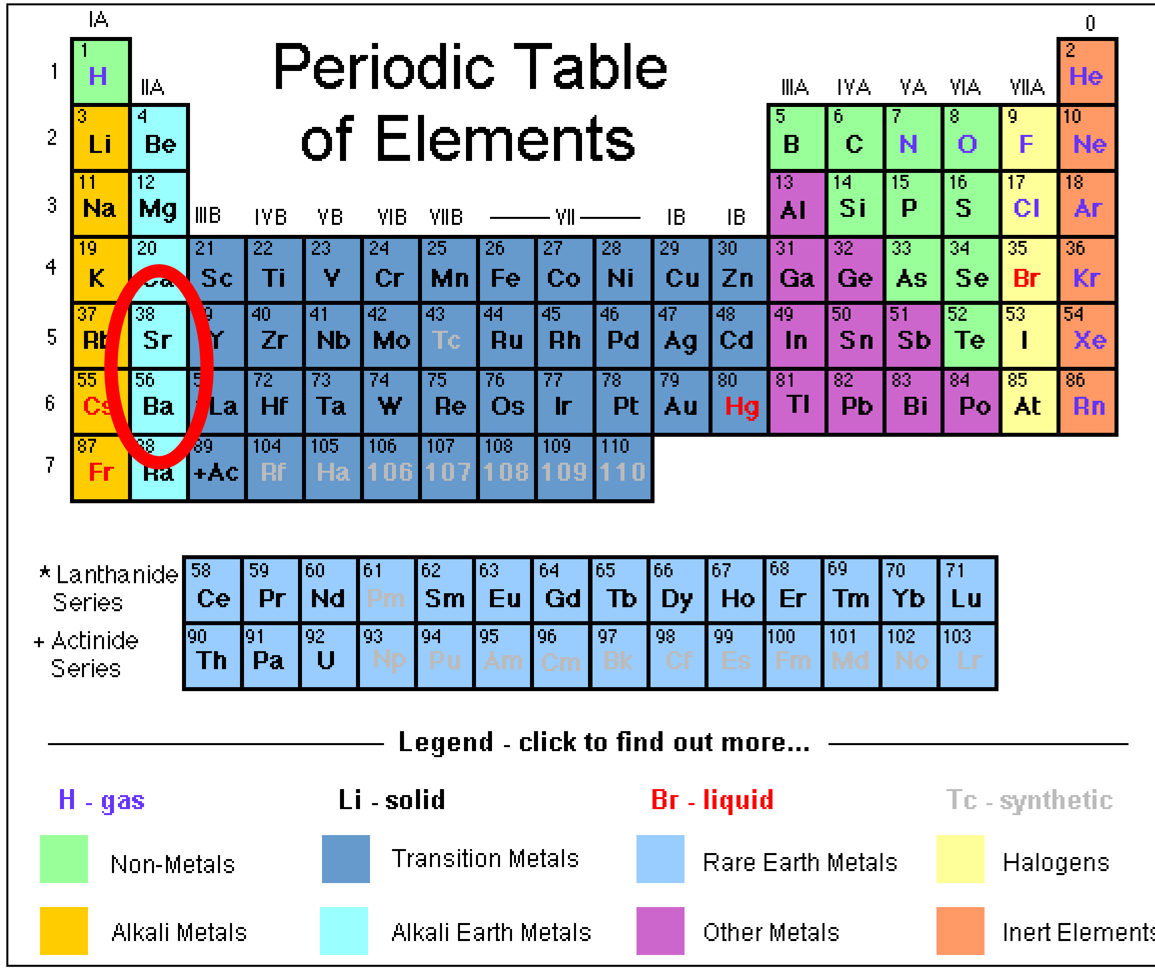
1 2 3 4 5

How difficult was it to understand the directions?
[1 = very difficult; 2 = difficult; 3 = medium 4 = easy; 5 = very easy]

1 2 3 4 5

Barium and Strontium

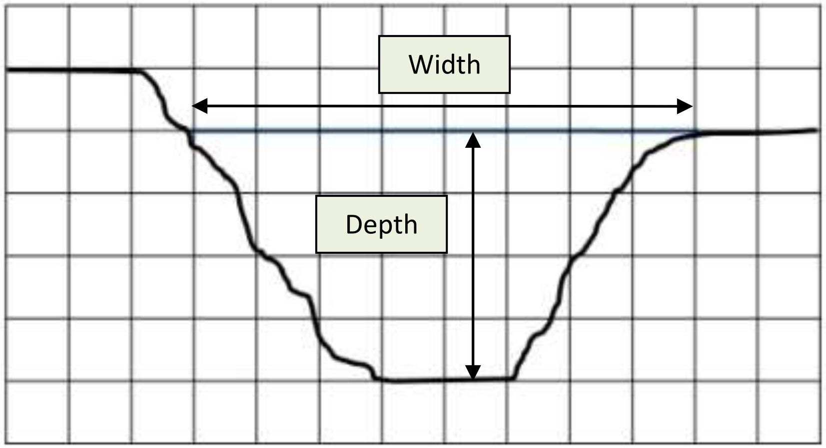
- Naturally-occurring metals found deep underground
- Indicate contamination from Marcellus Shale activities (signature chemicals)

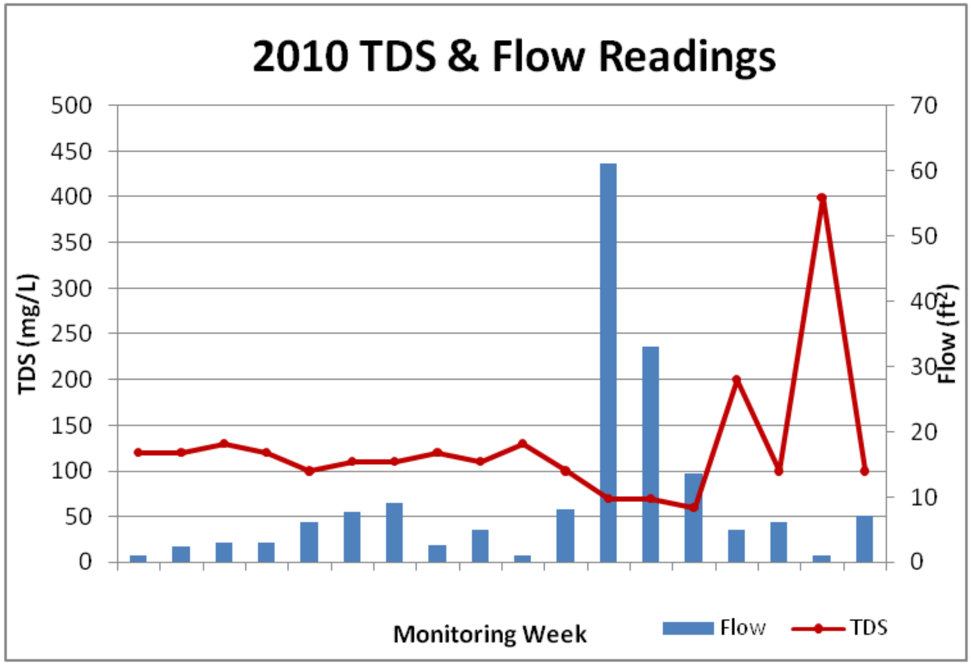


https://www.msu.edu/~zeluffjo/periodic_table.gif

Flow Monitoring

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





Visual Assessment

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

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

Spills & Discharges

Photos courtesy of Delaware Riverkeeper Network

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

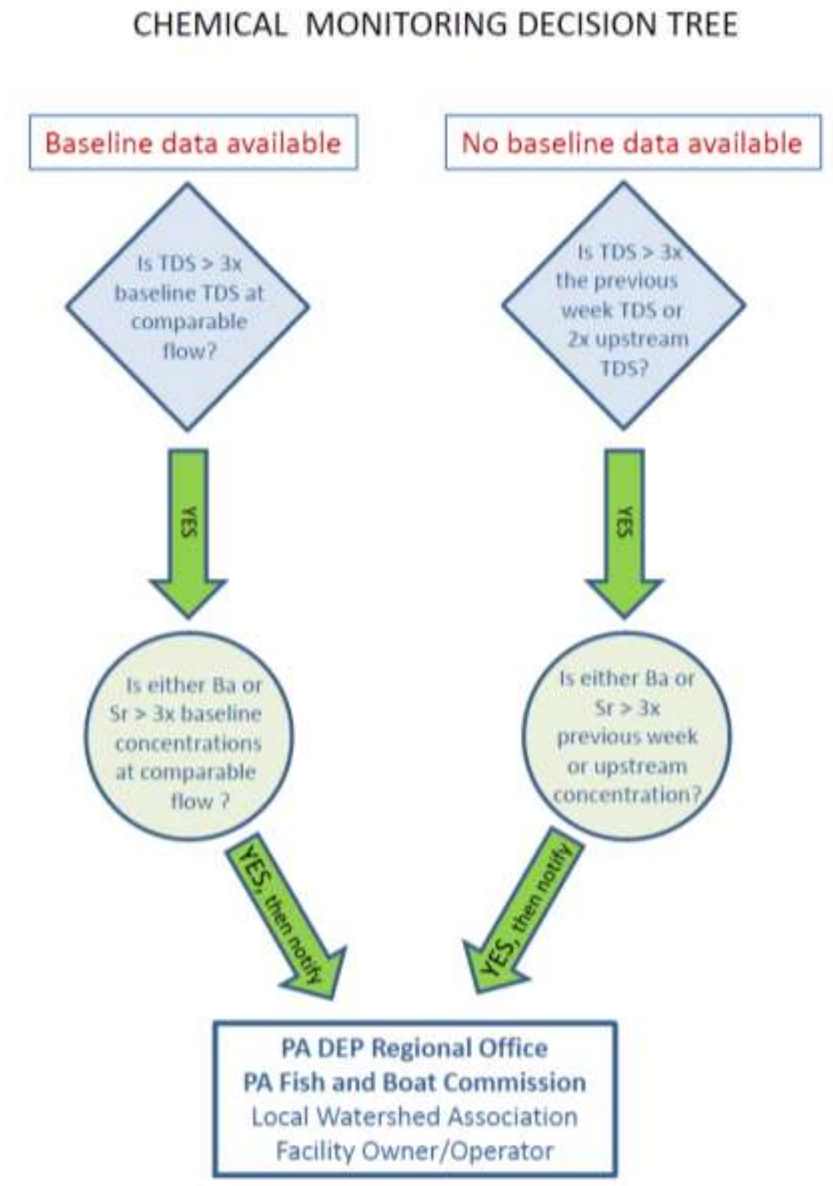
Step 3:

Choose monitoring site based on important features

- Well locations
- Stream access

Data Use: Decision Trees

Chemical Monitoring
*
Visual Assessment
*
Flow



Report monitoring information when values exceed criteria in decision trees

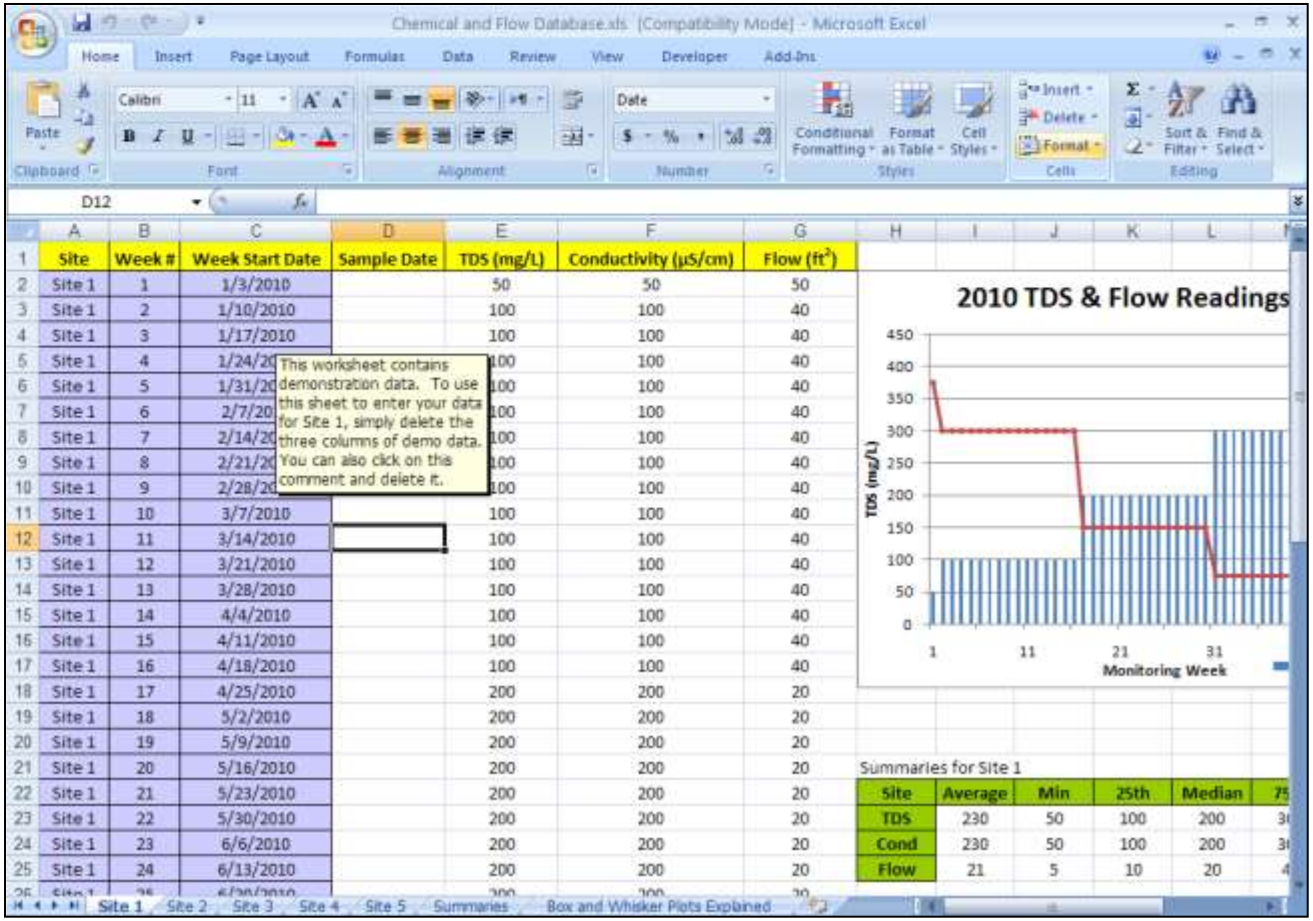
Quality Assurance/Quality Control

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

<u>Considerations</u>: What tools and methods are available to volunteers?



Site	Week #	Week Start Date	Sample Date	TDS (mg/L)	Conductivity (µS/cm)	Flow (ft³)
Site 1	1	1/3/2010		50	50	50
Site 1	2	1/10/2010		100	100	40
Site 1	3	1/17/2010		100	100	40
Site 1	4	1/24/20		100	100	40
Site 1	5	1/31/20		100	100	40
Site 1	6	2/7/20		100	100	40
Site 1	7	2/14/20		100	100	40
Site 1	8	2/21/20		100	100	40
Site 1	9	2/28/20		100	100	40
Site 1	10	3/7/2010		100	100	40
Site 1	11	3/14/2010		100	100	40
Site 1	12	3/21/2010		100	100	40
Site 1	13	3/28/2010		100	100	40
Site 1	14	4/4/2010		100	100	40
Site 1	15	4/11/2010		100	100	40
Site 1	16	4/18/2010		100	100	40
Site 1	17	4/25/2010		200	200	20
Site 1	18	5/2/2010		200	200	20
Site 1	19	5/9/2010		200	200	20
Site 1	20	5/16/2010		200	200	20
Site 1	21	5/23/2010		200	200	20
Site 1	22	5/30/2010		200	200	20
Site 1	23	6/6/2010		200	200	20
Site 1	24	6/13/2010		200	200	20

Site	Average	Min	25th	Median	75
TDS	230	50	100	200	3
Cond	230	50	100	200	3
Flow	21	5	10	20	4

ALLARM created easy to use templates for volunteers to store their chemical, flow, and visual assessment data.

Building a Monitoring Force

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

Questions?

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Marcellus Shale Monitoring Manual