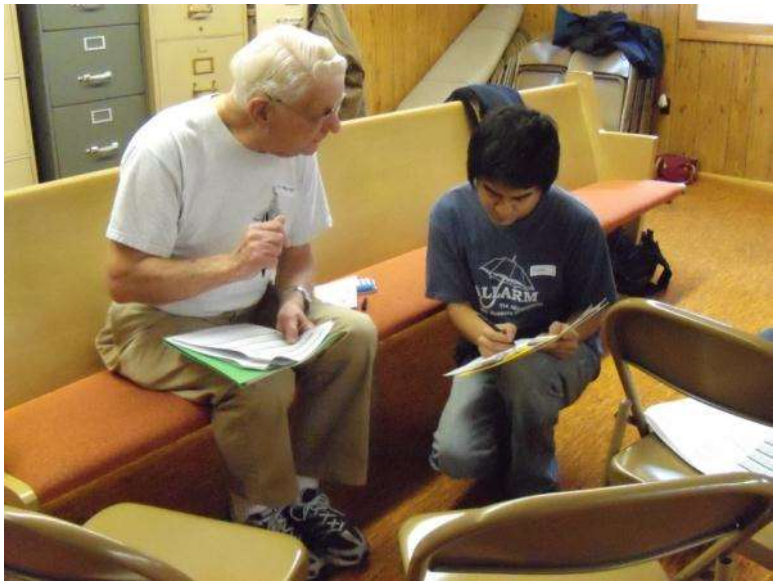
Science of Shale Gas Monitoring

Dickinson

Workshop funded by Colcom Foundation and
Consortium for Scientific Assistance to Watersheds (C-SAW)

ALLARM Background

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

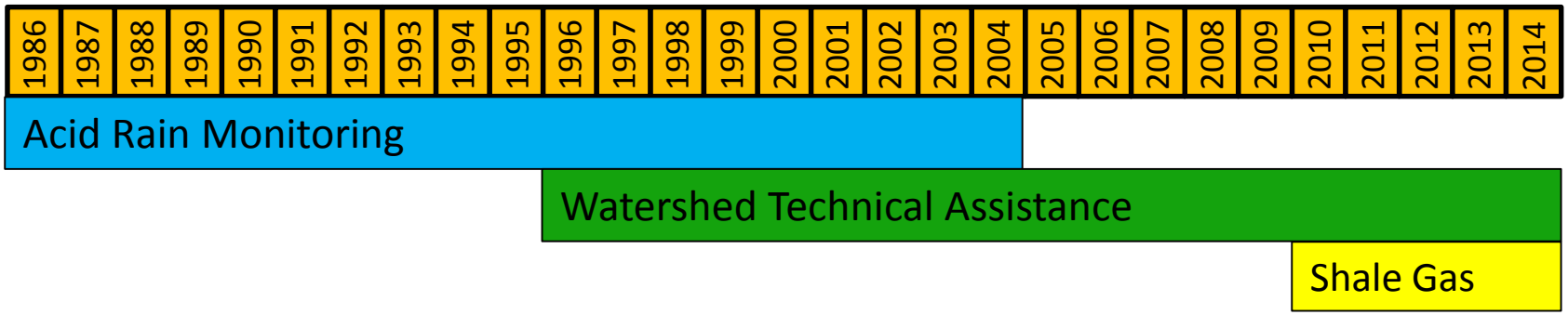


Educate. Engage. Empower.

Who we are

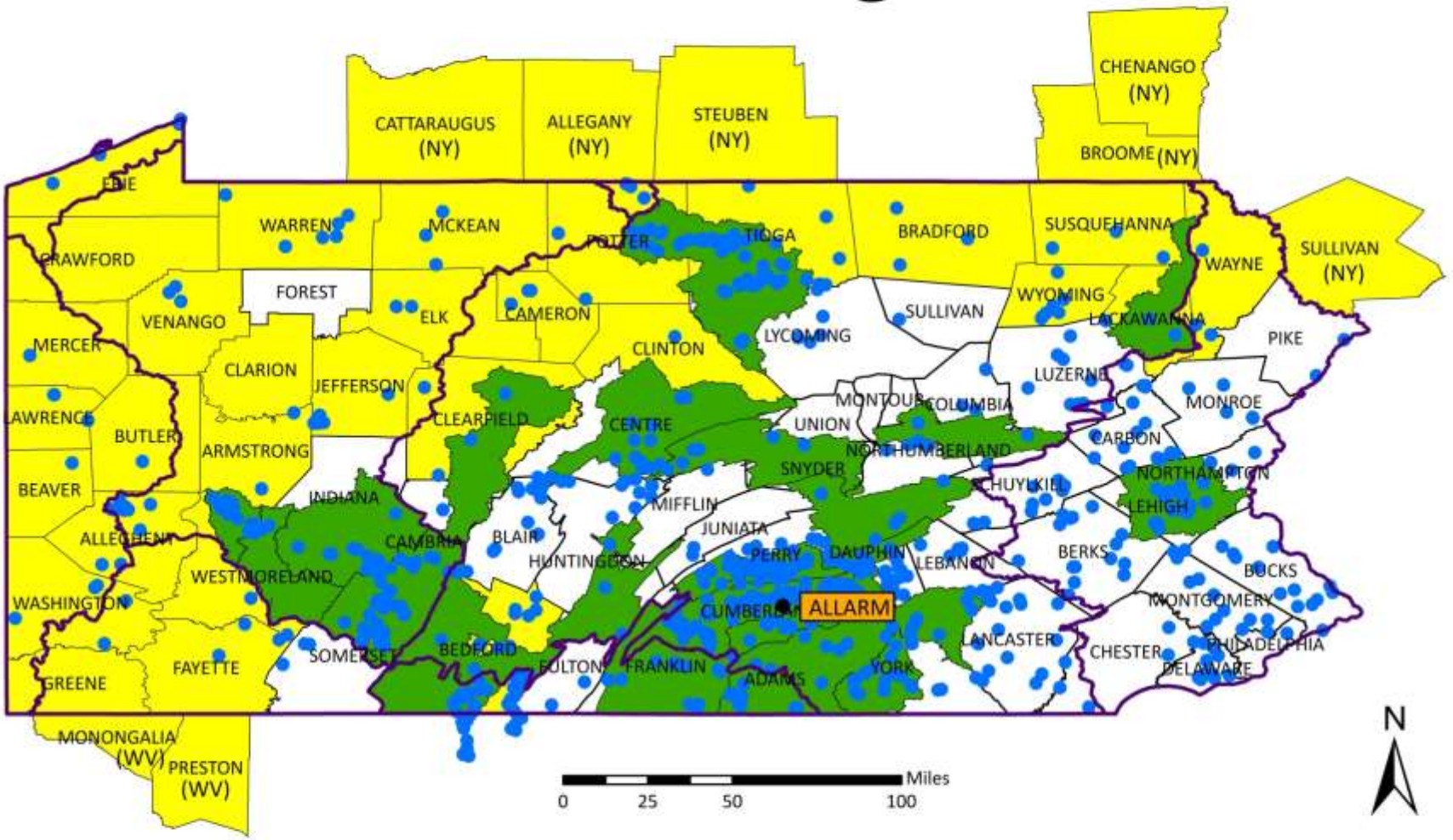
- Project of the environmental studies department (1986)
- 3 full time staff
- 1 science advisor/Dickinson faculty member
- 10 – 15 students

ALLARM History



Monitoring Program	Region	Volunteers	Model
Acid Rain	Statewide	Individuals	Contributory
Watershed TA	Southcentral PA	Groups	Co-created
Shale Gas	Marcellus & Utica	Groups & Individuals	Collaborative

ALLARM Monitoring Assistance



Alliance for Aquatic Resource Monitoring
Environmental Studies Department
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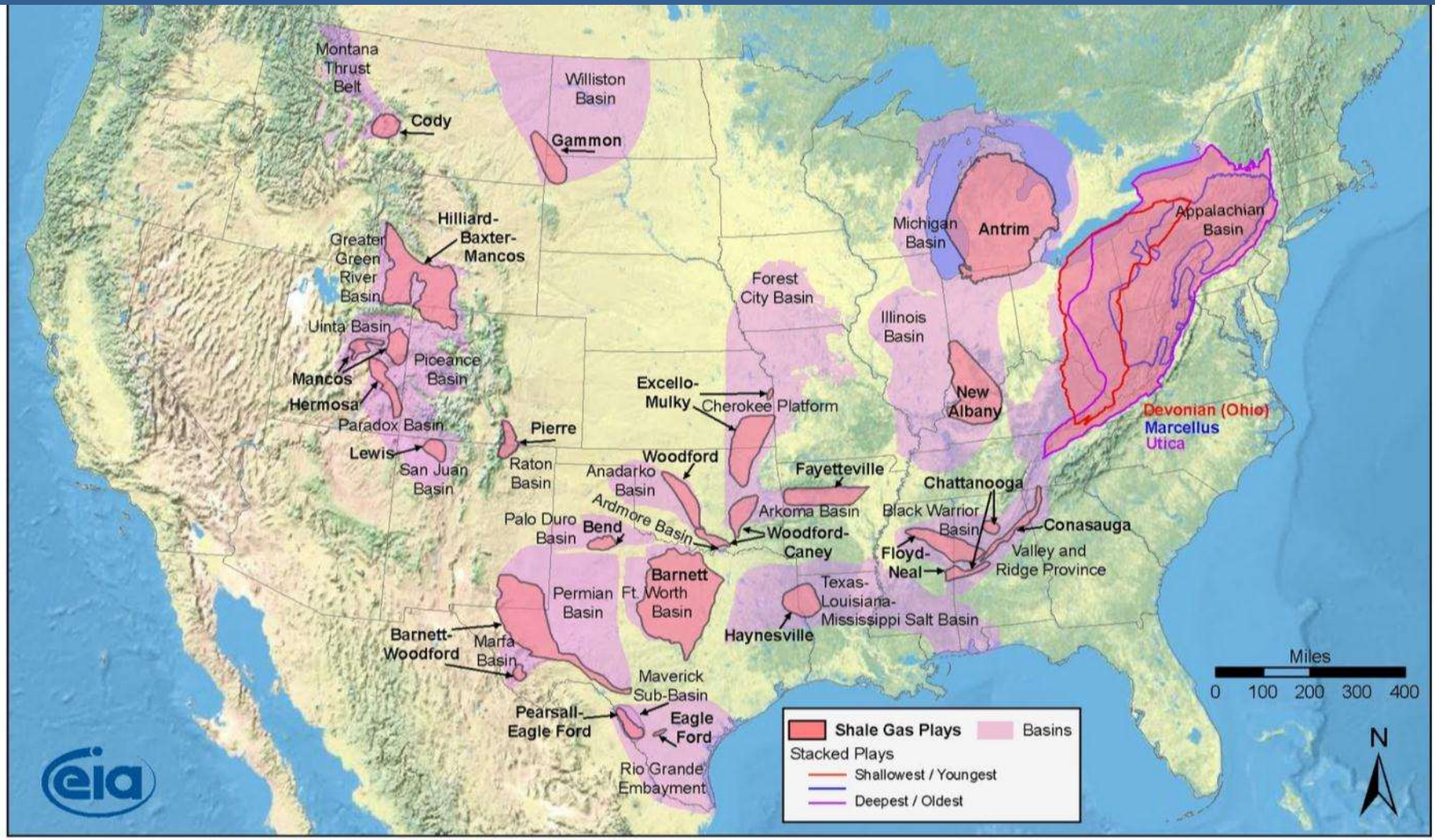
717.245.1565

August 2014

- Acid Rain Sites (734)
- Watershed Monitoring Groups (44)
- Shale Gas Monitoring Workshops (59)
- 6 Major PA Watersheds

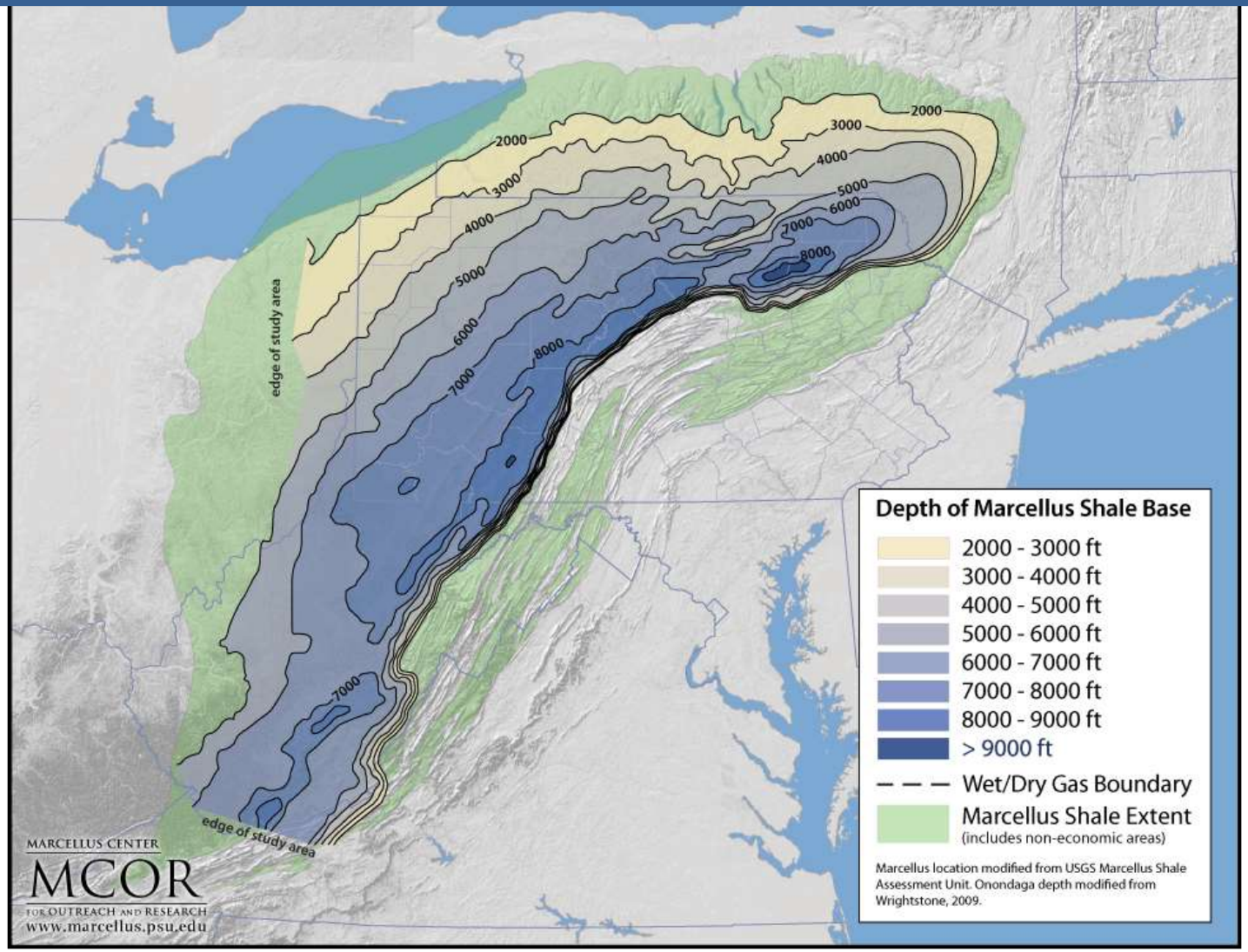
Data Sources: ALLARM, NYS Office of Cyber Security, PA DOT, PSU, USGS, WVDEP

Shale Gas Plays

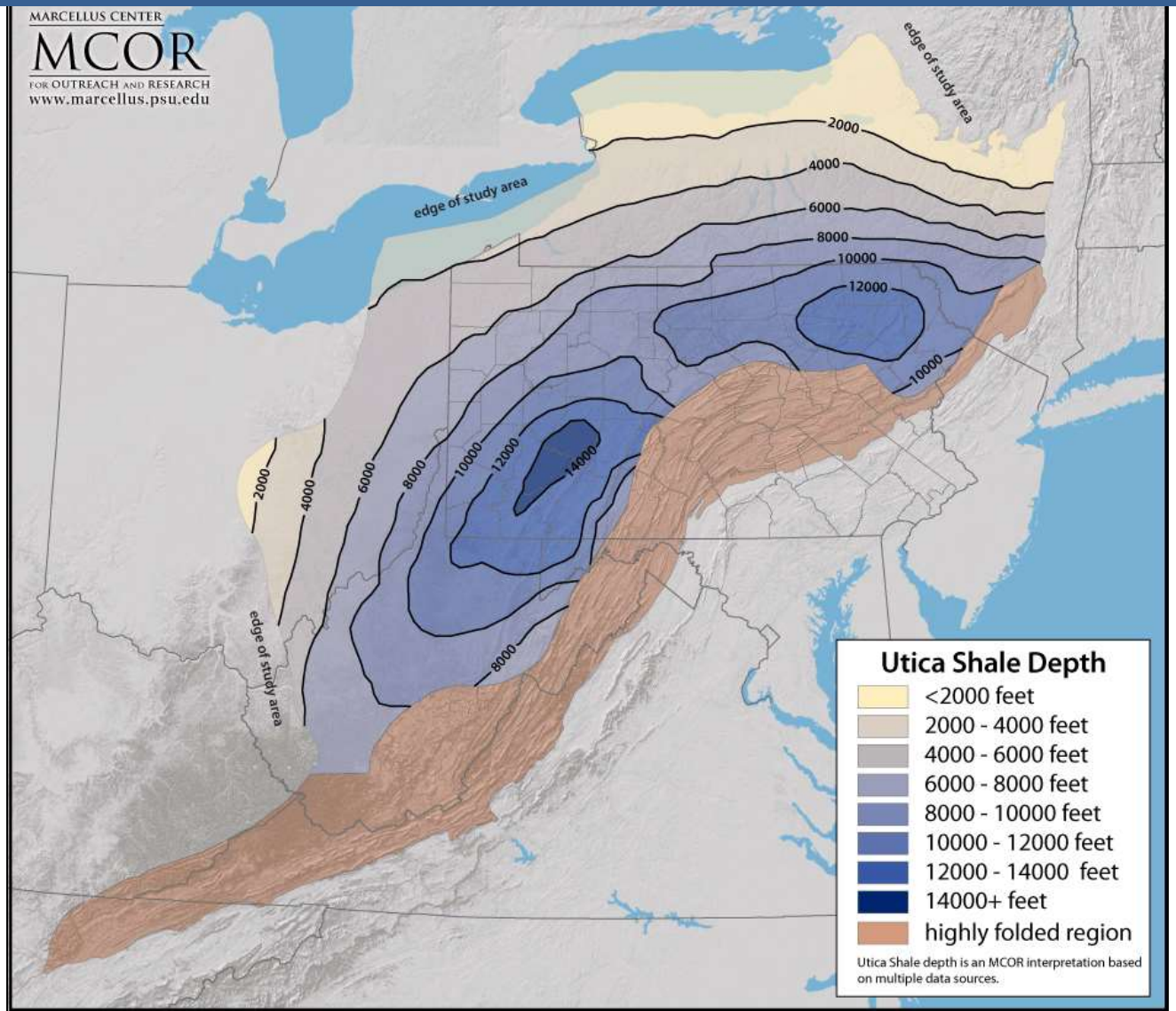


Source: Energy Information Administration based on data from various published studies
Updated: May 28, 2009

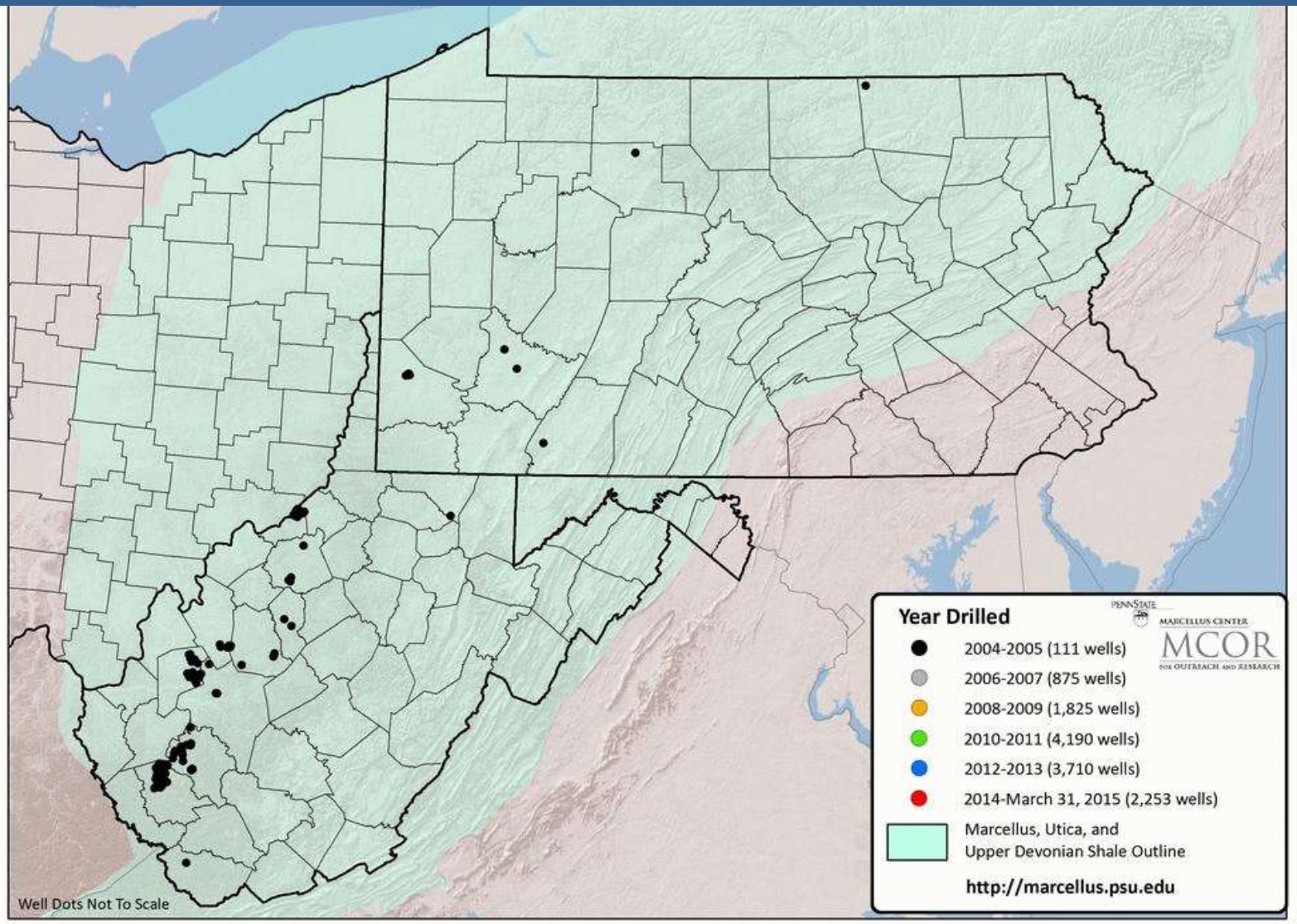
Depth of Marcellus Shale



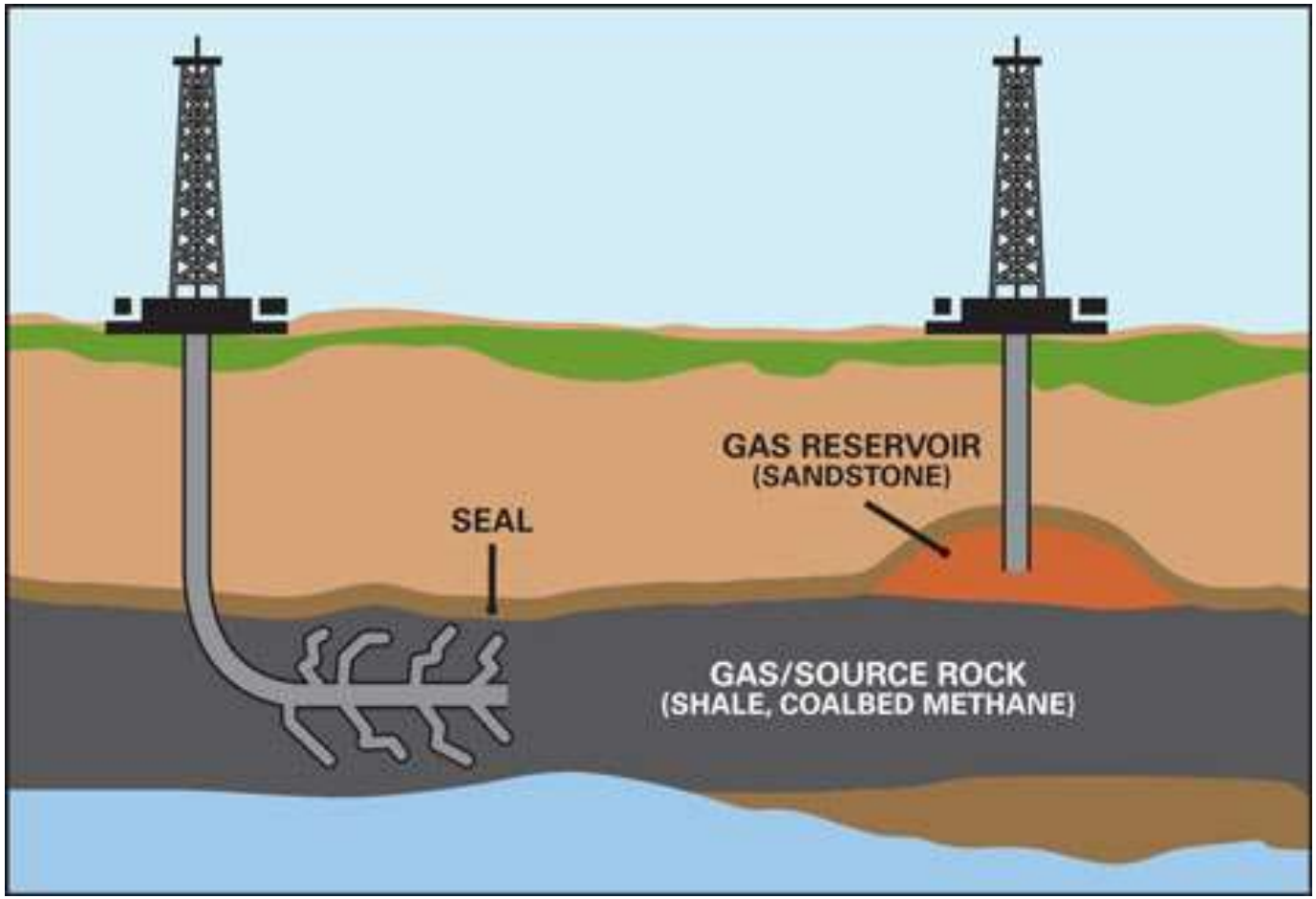
Depth to Utica Shale



Shale Gas Wells in Region



Unconventional vs. Conventional



http://seekingalpha.com/article/131641-unconventional-natural-gas-just-a-frac-away

Differences in Drilling

Traditional Hydrofracking

- In traditional hydrofracking, typically 20,000 to 80,000 gallons of fluid were used each time a well was hydrofractured.
- Traditional hydrofracking used 700 to 2,800 lbs. of chemical additives
- 1940s

High Volume Hydrofracking (HVHF)

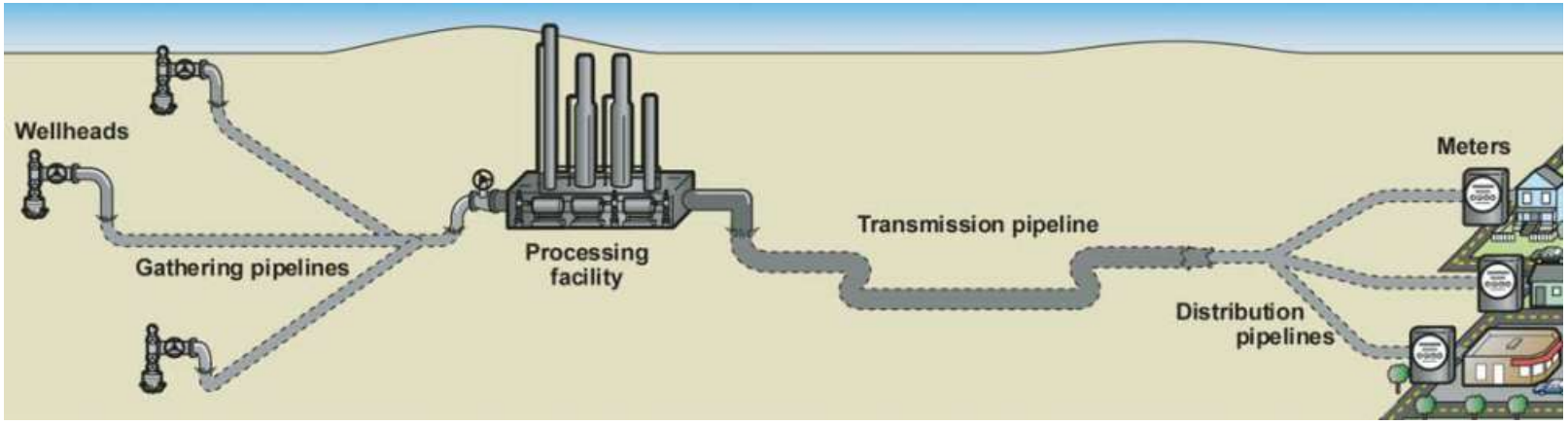
- HVHF uses between 2 and 10 million gallons of fluid (on average 5.6 million), the exact amount depends upon the length of the well bore and the number of fractures created along the lateral extent.
- HVHF uses between 205,000 and 935,000 lbs. of chemical additives, per well many of which are toxic to humans and wildlife.
- Late 1990s

3 Types of Pipelines

1. Gathering: Usually 6-24 inches in diameter. Carry gas at about 715 psi. These pipelines can travel long distances and there is no requirements to mark them or continually make sure they are cleared of vegetation etc. May clear rights-of-way of 30 to 150 feet wide.

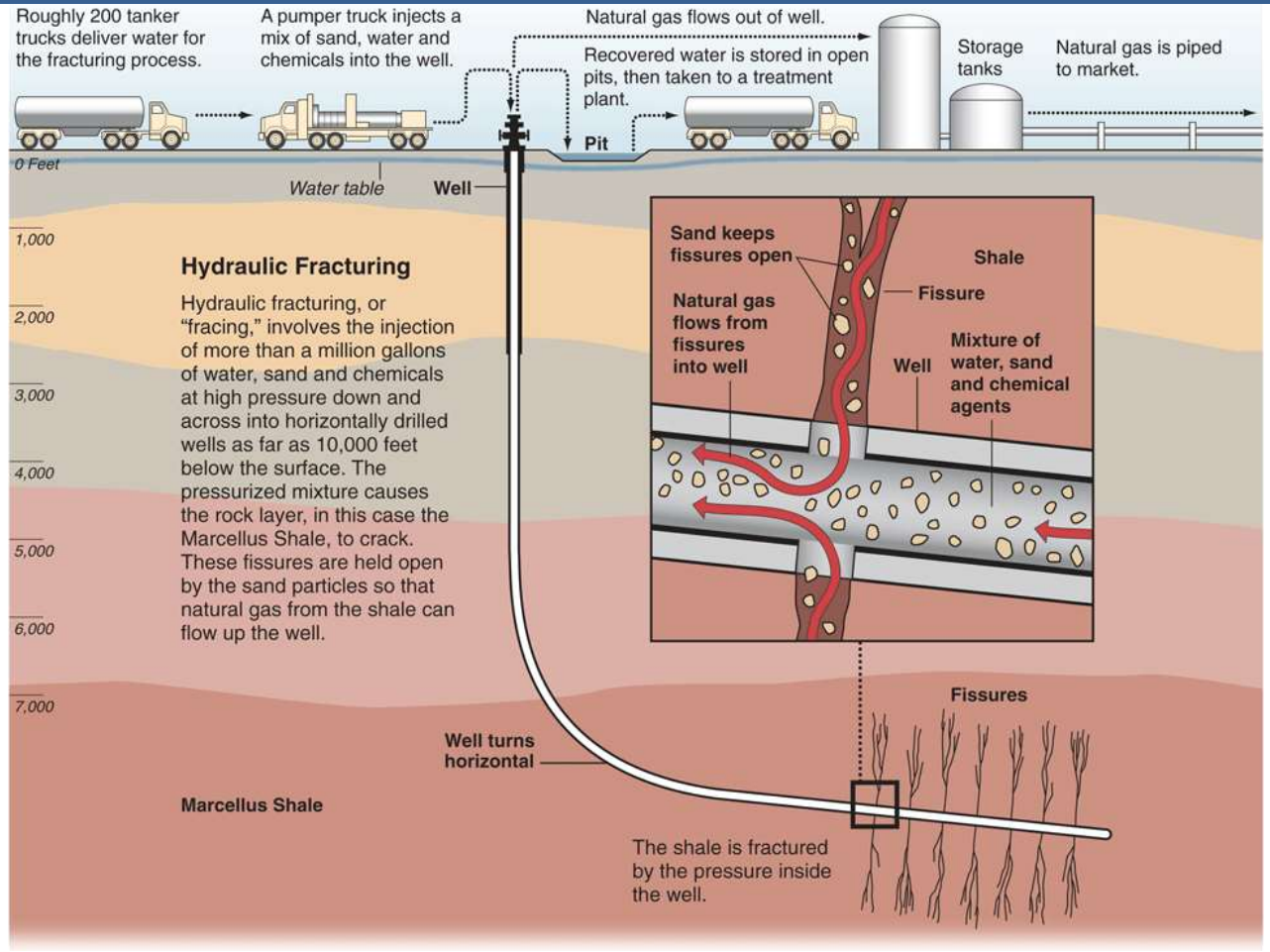
2. Transmission: Large steel pipes (usually 24-48" in diameter), carry gas 200-1200psi. These federally regulated pipelines fall under eminent domain so don't need land owner permission. The land is periodically cleared of large vegetation. Permanent structures and trees may never be placed there. Right-of-way widths of up to 200 feet.

3. Distribution: Small pipes (2-24" in diameter) that can be made of steel, cast iron, plastic or copper. Pressure of gas is reduced to less than 200psi. Mercaptan is added to the gas to give it a rotten egg odor at the city gate prior to being sent through distribution lines.



Source: Pipeline and Hazardous Materials Safety Administration

Hydraulic Fracturing (Fracking)



This protocol documents flowback pollution and visual observations in small streams.

Protocol Overview

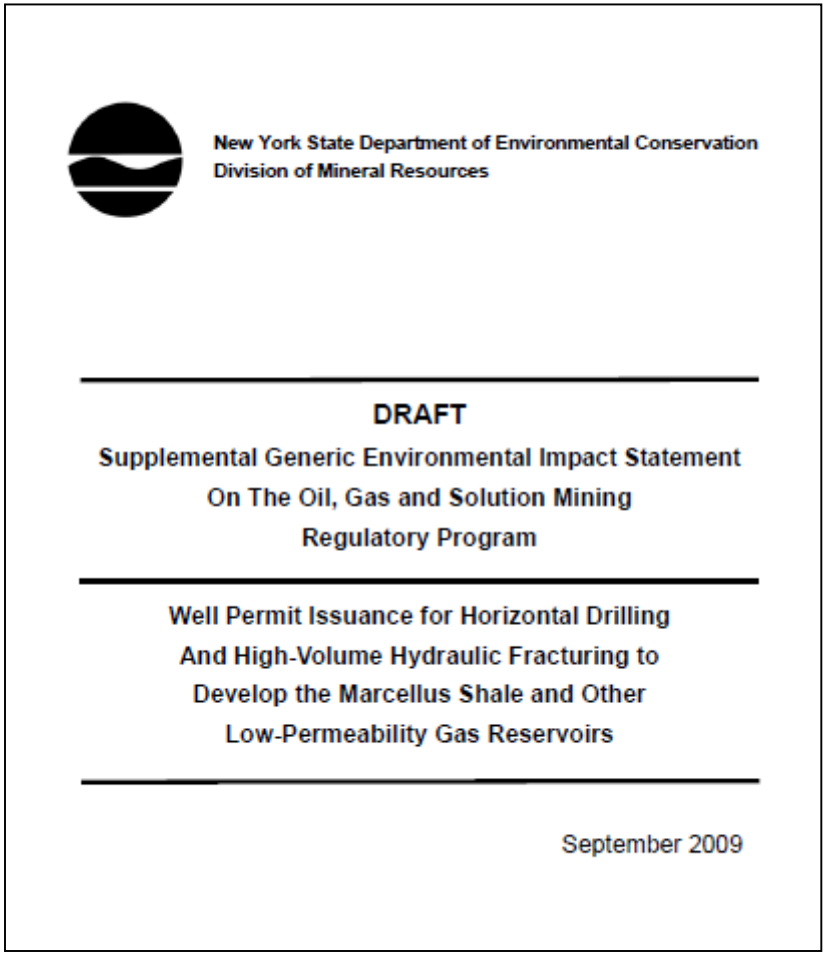
Survey Type	Parameters	Methodology	Frequency
Chemical	• Conductivity and total dissolved solids • Barium and strontium	• LaMotte PockeTester • Certified lab analysis	• Weekly • Twice a year and to confirm contamination event
Water quantity	• Stage	• Stream stage measurement	• Weekly
Physical	• Gas Related Earth Disturbance • Spills and Discharges • Gas Migration or Leakage • Pipelines	• Visual survey	• Weekly





Drilling Wastewater

- Frack water
  - Fluid that goes down the well
  - 160+ known hazardous materials
- Flowback water
  - Fluid that comes back out of the well
  - Steel and power companies can't use it because TDS levels are too high
  - Recycled
  - Inject water into ground or caverns/mines
  - Treat at authorized treatment facilities



New York State Department of Environmental Conservation
Division of Mineral Resources

DRAFT

Supplemental Generic Environmental Impact Statement
On The Oil, Gas and Solution Mining
Regulatory Program

Well Permit Issuance for Horizontal Drilling
And High-Volume Hydraulic Fracturing to
Develop the Marcellus Shale and Other
Low-Permeability Gas Reservoirs

September 2009

Flowback water

Flowback water: water that returns to surface it consists of frack water plus chemicals released from underground rock formations.

- Quantity: 10-15% of frack water flows back
- Quality:
  - Brine (salty water) including high concentrations of chlorides, sulfates: very high TDS
  - Metals, e.g. barium iron, manganese, arsenic, strontium, lead, cadmium, chromium, aluminum
  - Naturally occurring radioactive materials such as uranium, radium, and radon
  - Bacteria
  - Methane
- Pathway to environment: spills, incomplete treatment, well casing leaks, migration through bedrock, illegal dumping

Why Volunteer Monitoring?

Volunteer Monitoring

- Citizens involved in data collection
- US: 1890 – 2016
- 48 states
- PA Streams: 1980s

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

Friends of Casco Bay
Casco BAYKEEPER

Citizen Stewards Water Quality Monitoring Program

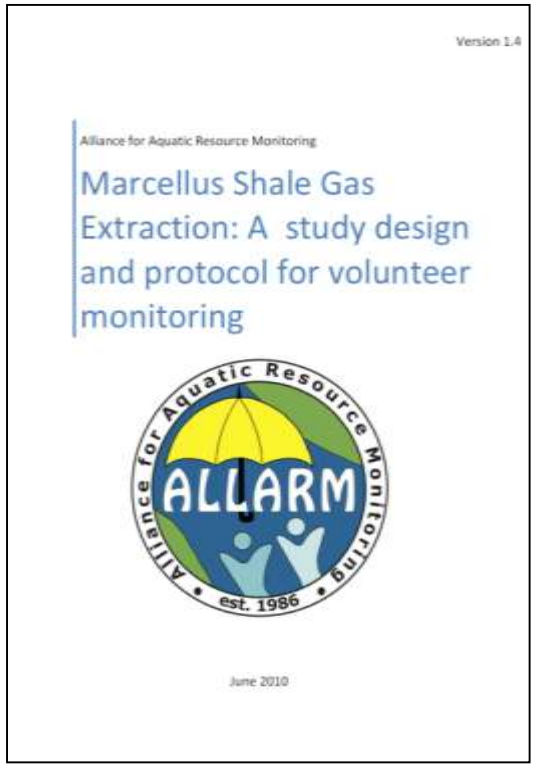
National Weather Service
WORKING TOGETHER TO SAVE LIVES

NJ Watershed Watch Network

TEXAS STREAM TEAM

Volunteer Monitoring

- Feasibility
- Affordability
- Scientifically robust



ALLARMwater.org

Red Flag Protocol: What Will You Monitor?

1. Flowback Monitoring:

Chemical Parameters

<u>Indicator chemicals</u>

Conductivity & TDS

<u>Signature Chemicals</u>

Barium

Strontium

Stage Monitoring

Relationship to conductivity

2. Physical Impacts

Visual Observations:

- Land disturbances
- Spills and discharges
- Gas migration/leakages
- Pipelines

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)

Why Conductivity and TDS?

- Frack water mixes with natural brine, found in the shale
- Flowback water contains higher concentrations of salts and metals

Picture by Amy Bergdale, US EPA

Meter Trials

Dickinson students, faculty, and staff helped 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]

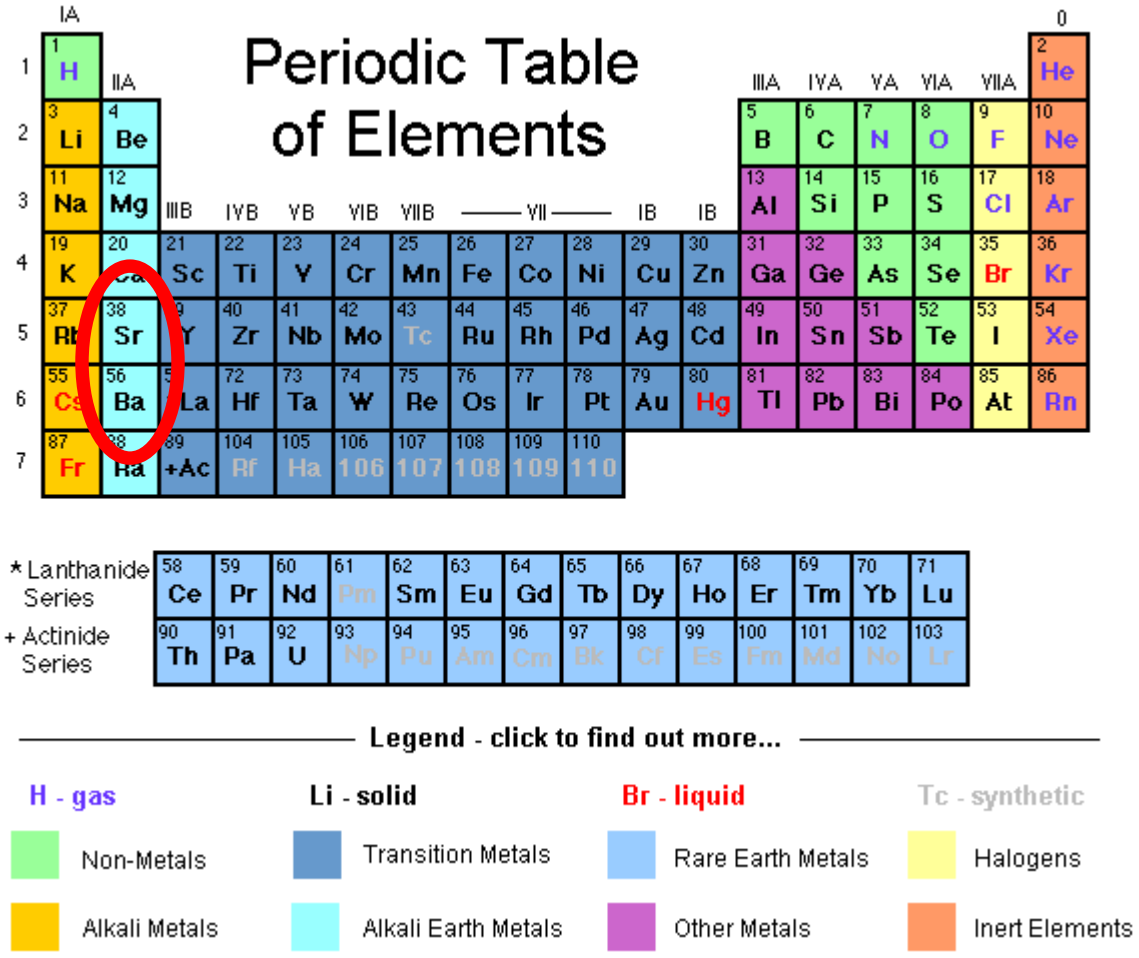
1 2 3 4 5

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

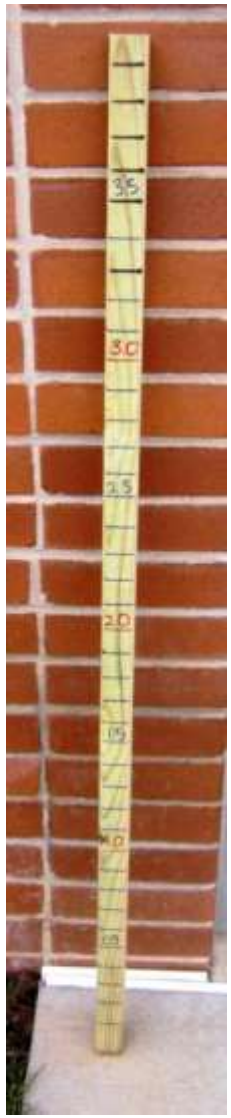
Barium and Strontium

- Naturally-occurring metals found deep underground
- Indicate contamination from shale gas activities (signature chemicals)



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

Stage Monitoring



Visual Observations

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

Marcellus Shale Well Sites in Dimock, PA; 2010

Determine Monitoring Locations

Step 1:

Find where drilling permits have been issued, or identify priority streams or existing pollution issues:

- PADEP map/reports
- PADEP eNotice
- FracTracker

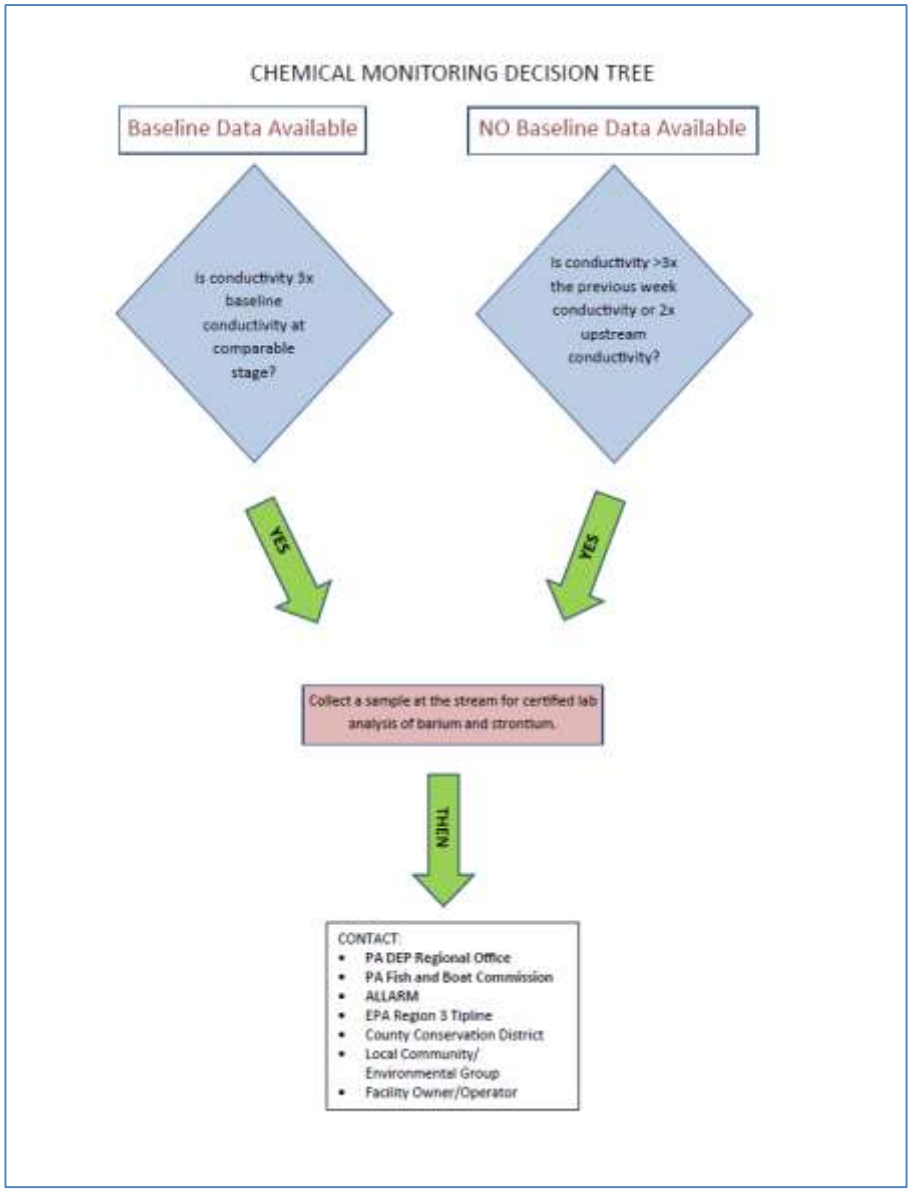
Step 2:

Find coordinates and choose monitoring site based on important features:

- Well locations
- Stream access
- Availability

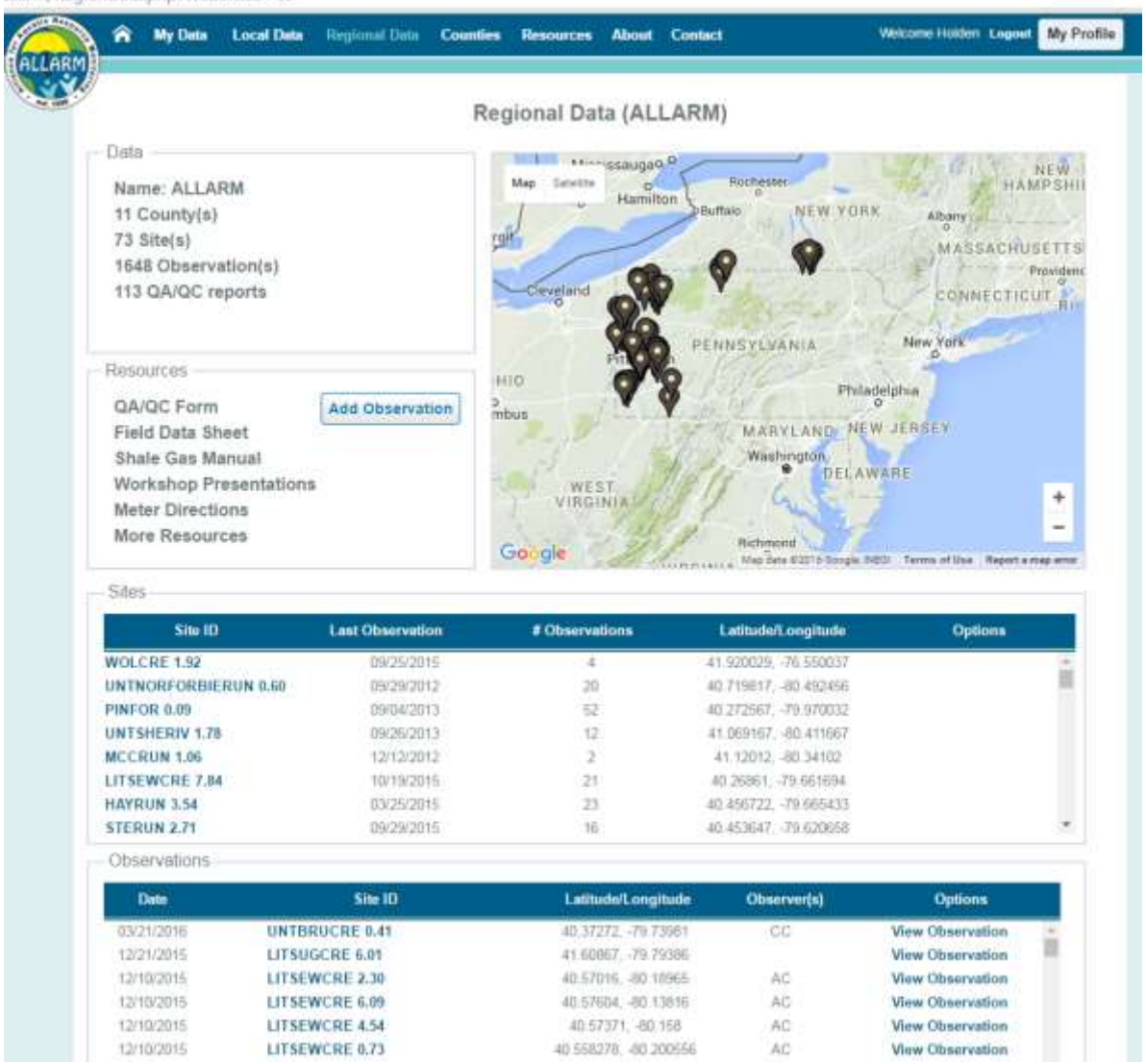
Data Use: Decision Trees

Chemical Monitoring
*
Visual Observations
*
Pipelines



Report monitoring information when values exceed criteria in decision trees

Online Database and Toolkit



ALLARMwater.org

Building a Monitoring Constituency

- Movement - 2000 people trained since the start of 2010
- ALLARM, DRN, PACTU, PASA, MWA, Sierra Club, Waterdogs

Questions?

Alliance for Aquatic Resource Monitoring (ALLARM)
Dickinson College
P.O. Box 1773
Carlisle, PA 17013
717.245.1565
allarm@dickinson.edu
dickinson.edu/allarm

ALLARMwater.org

Identifying your monitoring location

Overview

We will be discussing:

- Tools for finding and tracking wells
- Considerations for monitoring sites
- Volunteer roles for the group

Determine Monitoring Locations

Step 1:

Find where drilling permits have been issued, or identify priority streams or existing pollution issues.

- PADEP map/reports
- PADEP eNotice
- FracTracker

Step 2:

Use reports and coordinates to choose monitoring site based on important features

- Well locations
- Stream access
- Availability

PA Oil and Gas Mapping

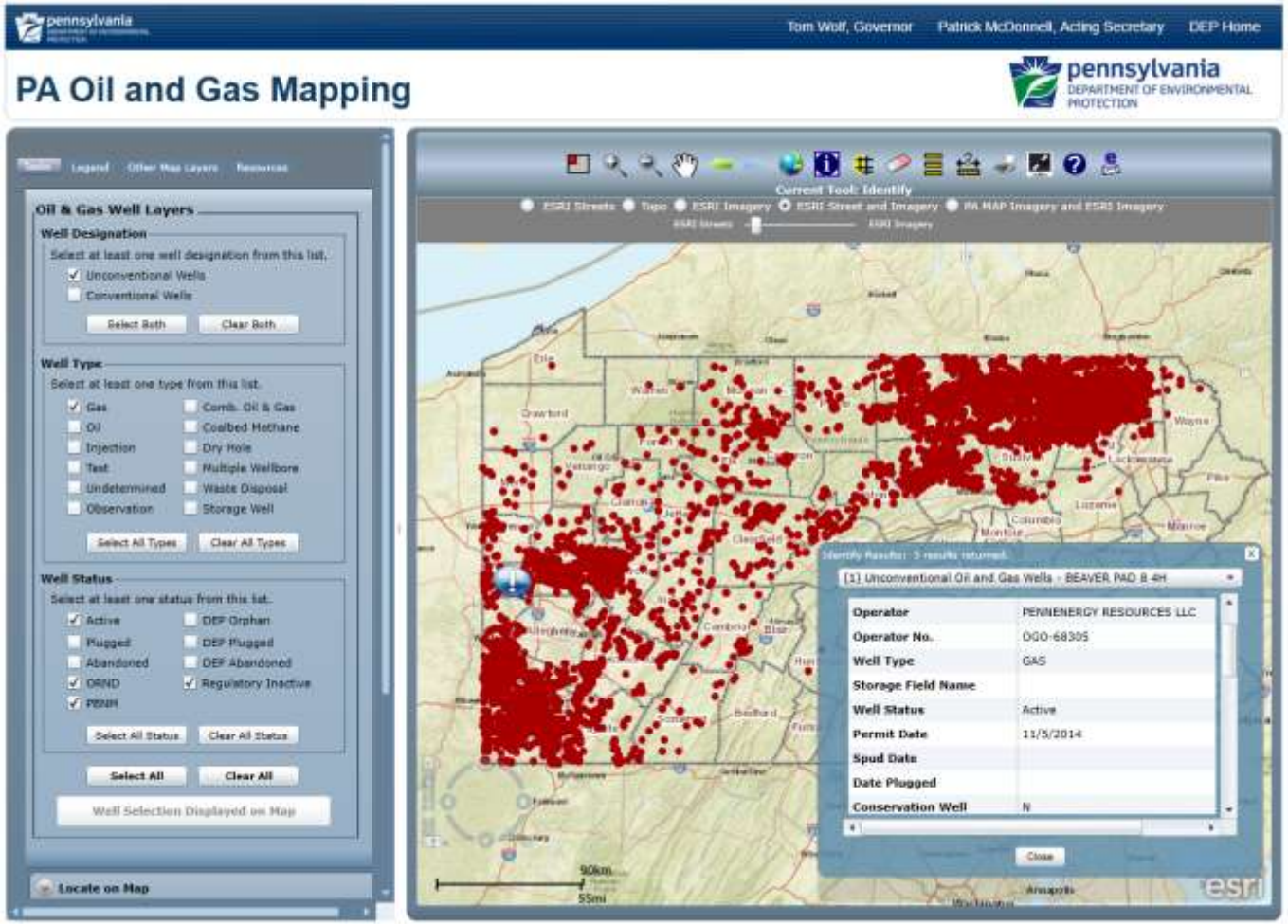
http://www.depgis.state.pa.us/PaOilAndGasMapping

Pros:

- Most current information
- Many options for searching (can search by well status, operator, permit number)

Cons:

- Somewhat clunky interface (but does have help page with definitions and guides)
- May have limited browser support



FracTracker

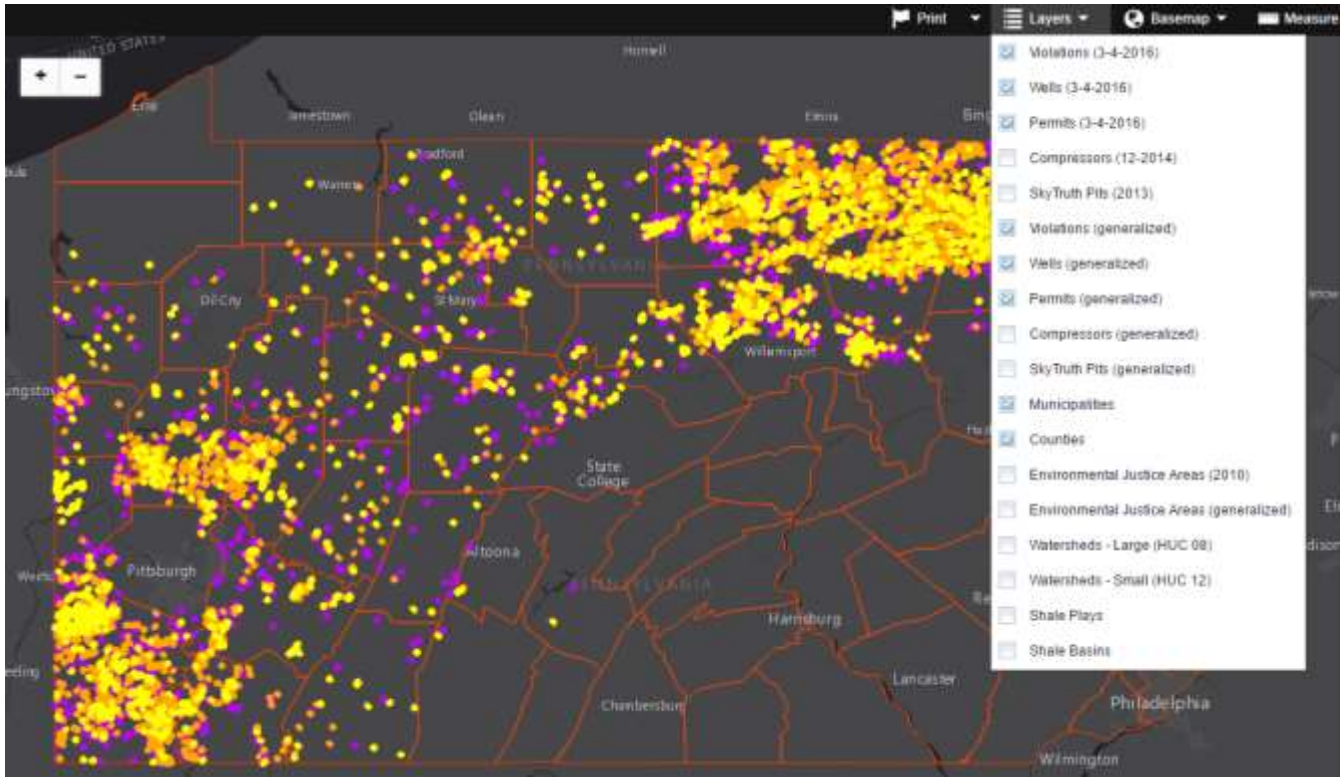
https://www.fractracker.org/map/us/pennsylvania/pa-shale-viewer/

Pros:

- Wider browser support
- Easier to use

Cons:

- Not always the most up-to-date information



DEP Reports

http://www.depweb.state.pa.us

DEP Reports


PA.GOV
CITIZENS
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DEPARTMENT OF ENVIRONMENTAL PROTECTION
TOM WOLF, GOVERNOR | PATRICK MCDONNELL, ACTING SECRETARY
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DEP Reports

DEP > Data and Tools > Reports

REPORTS

In an effort to maximize transparency and improve efficiency, DEP provides easy access to dozens of online reports and key data about the many programs the agency administers.

DEP Reports

Oil and Gas Mapping

INTERACTIVE REPORTS

Interactive Reports Data Dictionary

Permits Issued Detail Report

Monthly – Permits Issued by County and Well Type Report

Year to Date – Permits Issued by County and Well Type Report

Oil and Gas Operator Well Inventory

Oil and Gas Compliance Report

SPUD Data Report

- Wells Drilled By County
- Wells Drilled By Operator

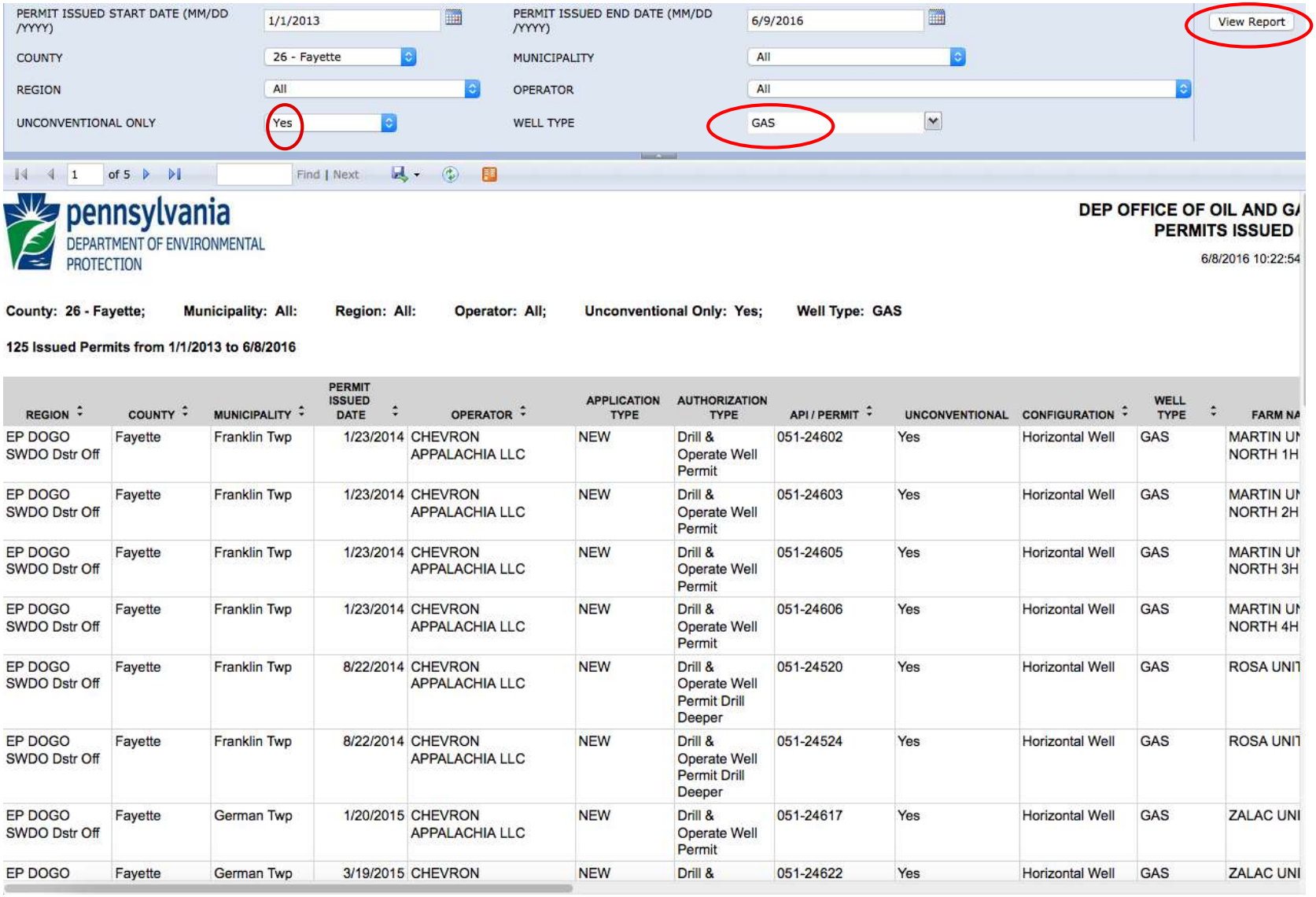
Oil and Gas Production Reports

Oil and Gas Well Production Status

Oil and Gas Electronic Notifications

DEP Orphan and Abandoned Wells

DEP Reports



PERMIT ISSUED START DATE (MM/DD /YYYY): 1/1/2013
PERMIT ISSUED END DATE (MM/DD /YYYY): 6/9/2016
View Report
COUNTY: 26 - Fayette
MUNICIPALITY: All
REGION: All
OPERATOR: All
UNCONVENTIONAL ONLY: Yes
WELL TYPE: GAS

1 of 5 Find | Next

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

DEP OFFICE OF OIL AND GA
PERMITS ISSUED
6/8/2016 10:22:54

County: 26 - Fayette; Municipality: All: Region: All: Operator: All; Unconventional Only: Yes; Well Type: GAS

125 Issued Permits from 1/1/2013 to 6/8/2016

REGION	COUNTY	MUNICIPALITY	PERMIT ISSUED DATE	OPERATOR	APPLICATION TYPE	AUTHORIZATION TYPE	API / PERMIT	UNCONVENTIONAL	CONFIGURATION	WELL TYPE	FARM NA
EP DOGO SWDO Dstr Off	Fayette	Franklin Twp	1/23/2014	CHEVRON APPALACHIA LLC	NEW	Drill & Operate Well Permit	051-24602	Yes	Horizontal Well	GAS	MARTIN UN NORTH 1H
EP DOGO SWDO Dstr Off	Fayette	Franklin Twp	1/23/2014	CHEVRON APPALACHIA LLC	NEW	Drill & Operate Well Permit	051-24603	Yes	Horizontal Well	GAS	MARTIN UN NORTH 2H
EP DOGO SWDO Dstr Off	Fayette	Franklin Twp	1/23/2014	CHEVRON APPALACHIA LLC	NEW	Drill & Operate Well Permit	051-24605	Yes	Horizontal Well	GAS	MARTIN UN NORTH 3H
EP DOGO SWDO Dstr Off	Fayette	Franklin Twp	1/23/2014	CHEVRON APPALACHIA LLC	NEW	Drill & Operate Well Permit	051-24606	Yes	Horizontal Well	GAS	MARTIN UN NORTH 4H
EP DOGO SWDO Dstr Off	Fayette	Franklin Twp	8/22/2014	CHEVRON APPALACHIA LLC	NEW	Drill & Operate Well Permit Drill Deeper	051-24520	Yes	Horizontal Well	GAS	ROSA UNIT
EP DOGO SWDO Dstr Off	Fayette	Franklin Twp	8/22/2014	CHEVRON APPALACHIA LLC	NEW	Drill & Operate Well Permit Drill Deeper	051-24524	Yes	Horizontal Well	GAS	ROSA UNIT
EP DOGO SWDO Dstr Off	Fayette	German Twp	1/20/2015	CHEVRON APPALACHIA LLC	NEW	Drill & Operate Well Permit	051-24617	Yes	Horizontal Well	GAS	ZALAC UNI
EP DOGO	Fayette	German Twp	3/19/2015	CHEVRON	NEW	Drill &	051-24622	Yes	Horizontal Well	GAS	ZALAC UNI

DEP Reports

Contains information about oil & gas wells:

- Permits issued (by operator and county, updated weekly)
- Active well inventory (by county)
- Spud reports/date drilling begins (updated weekly)

DEP's Active Well Inventory: All of the active oil & gas wells in Washington County

COUNTY	MUNICIPALITY	PERMIT ISSUED DATE	OPERATOR	APPLICATION TYPE	WELL API	UNCONVENTINONAL	HORIZONTAL WELL	WELL TYPE	LATITUDE DECIMAL	LONGITUDE DECIMAL
Washington	Buffalo Twp	6/27/2012	RANGE RESOURCES APPALACHIA LLC	NEW	125-24793-00-00	Yes	Yes	GAS	40.169305	-80.350775
Washington	Hanover Twp	6/13/2012	RANGE RESOURCES APPALACHIA LLC	NEW	125-24787-00-00	Yes	Yes	GAS	40.421611	-80.511644
Washington	Hanover Twp	6/13/2012	RANGE RESOURCES APPALACHIA LLC	NEW	125-24788-00-00	Yes	Yes	GAS	40.42163	-80.511538
Washington	Independence Twp	6/26/2012	RANGE RESOURCES APPALACHIA LLC	NEW	125-24692-00-00	Yes	Yes	GAS	40.226336	-80.445855
Washington	Independence Twp	6/26/2012	RANGE RESOURCES APPALACHIA LLC	NEW	125-24692-00-01	Yes	Yes	GAS	40.226336	-80.445855
Washington	Independence Twp	6/26/2012	RANGE RESOURCES APPALACHIA LLC	NEW	125-24693-00-00	Yes	Yes	GAS	40.226369	-80.445952
Washington	Independence Twp	6/26/2012	RANGE RESOURCES APPALACHIA LLC	NEW	125-24693-00-01	Yes	Yes	GAS	40.226369	-80.445952

eNOTICE

- DEP's Electronic Notification system
- Receive information and track changes to oil & gas permits
- http://www.ahs2.dep.state.pa.us/eNOTICEWeb/

Group Roles – Checking Permits

- It may be effective to designate one person to check for new permits in the area
  - Can be someone who is already checking permits, or someone interested in permitting information, and report information to the group

Safety Considerations for Shale-Gas Volunteer Monitoring

http://farm3.static.flickr.com/2405/1516087369_fb0226bc11.jpg

General advice

Develop language as a group that describes what you are doing…

"Monitoring stream health" vs. "Tracking down fracking polluters"

http://www.alicia-logic.com/email/Close%20Encounter%20with%20a%20Pit%20bull.jpg

Property Access

- Public land, such as State Game Lands or state forests, are open to the public
  - Access rights are not a concern
  - However, you are not allowed on active drilling sites due to safety concerns (industrial site)
- For private properties, always ask the landowner's permission

http://unitednuclear.com/images/sign3.jpg

Personal Safety

- Do *not* make contact with water or soil that could be contaminated unless you have protective clothing
  - Wading boots
  - Latex gloves
- Do not put yourself into a situation that may be dangerous.

http://3.bp.blogspot.com/_aJqybhzJII4/TCmffCsTpsI/AAAAAAAAAMo/Bv7vB1LsJWw/s1600/NZRACH2+431.jpg

Personal Safety

- When out in the field, bring a cell phone and *leave it on*
- Steer clear of confrontation. Leave the area if someone confronts or threatens you.

http://www.jaimesmcneal.com/Jaimes_McNeal/Blog/Entries/2009/12/21_Conflict,_it%E2%80%99s_not_just_for_breakfast_anymore!_files/shapeimage_2.png

Visual Observation Checklist

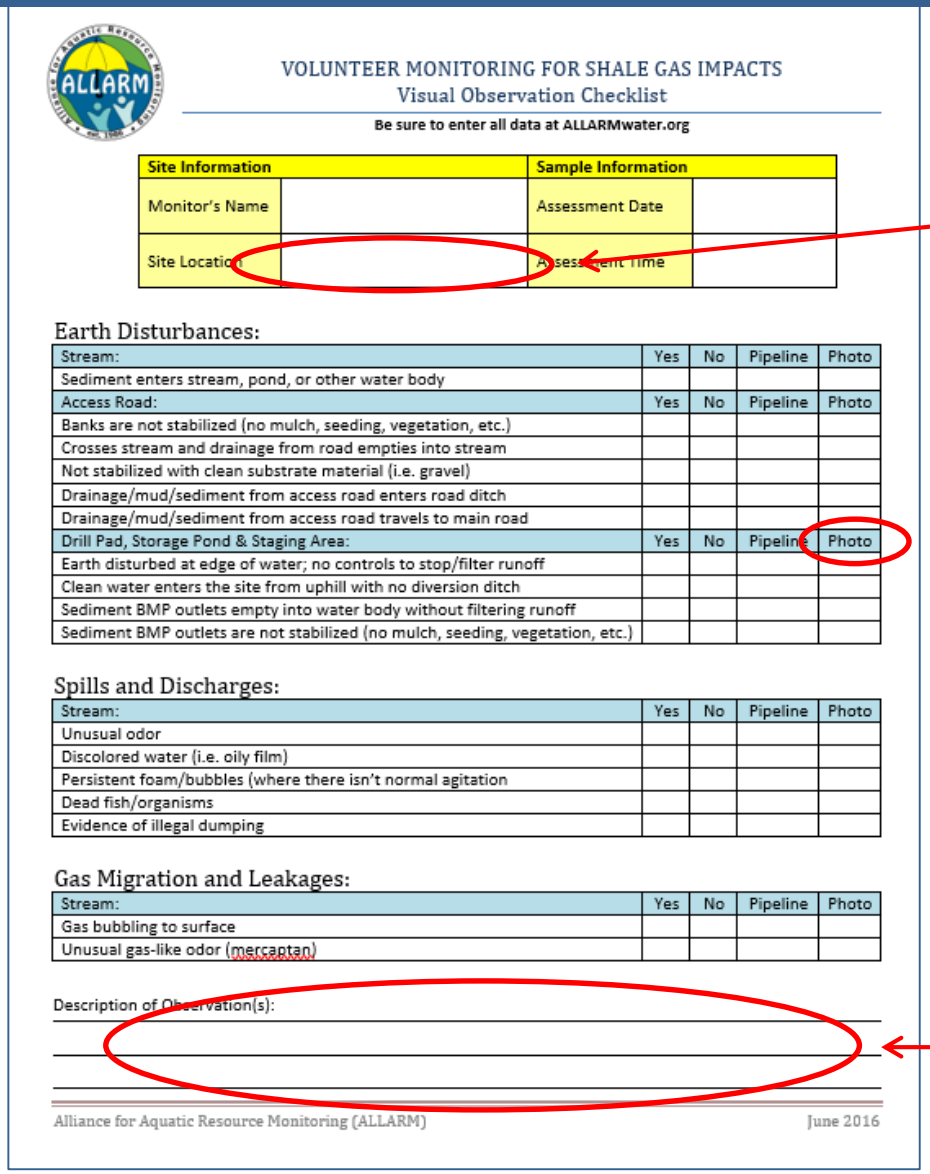
Protocol developed alongside:

- Bradford County Conservation District
- Mountain Watershed Association
- PA Trout Unlimited
- Pine Creek Waterdogs
- EarthJustice

Visual Observations

- Document physical status of the stream
- Identify potential impacts/pollution events
- Report violations and/or suspicious activity

Recording Observations: Data Sheet



VOLUNTEER MONITORING FOR SHALE GAS IMPACTS
Visual Observation Checklist

Be sure to enter all data at ALLARMwater.org

Site Information		Sample Information	
Monitor's Name		Assessment Date	
Site Location		Assessment Time	

Earth Disturbances:

Stream:	Yes	No	Pipeline	Photo
Sediment enters stream, pond, or other water body				
Access Road:	Yes	No	Pipeline	Photo
Banks are not stabilized (no mulch, seeding, vegetation, etc.)				
Crosses stream and drainage from road empties into stream				
Not stabilized with clean substrate material (i.e. gravel)				
Drainage/mud/sediment from access road enters road ditch				
Drainage/mud/sediment from access road travels to main road				
Drill Pad, Storage Pond & Staging Area:	Yes	No	Pipeline	Photo
Earth disturbed at edge of water; no controls to stop/filter runoff				
Clean water enters the site from uphill with no diversion ditch				
Sediment BMP outlets empty into water body without filtering runoff				
Sediment BMP outlets are not stabilized (no mulch, seeding, vegetation, etc.)				

Spills and Discharges:

Stream:	Yes	No	Pipeline	Photo
Unusual odor				
Discolored water (i.e. oily film)				
Persistent foam/bubbles (where there isn't normal agitation				
Dead fish/organisms				
Evidence of illegal dumping				

Gas Migration and Leakages:

Stream:	Yes	No	Pipeline	Photo
Gas bubbling to surface				
Unusual gas-like odor (mercaptan)				

Description of Observation(s):

Alliance for Aquatic Resource Monitoring (ALLARM) June 2016

Record latitude and longitude or Site ID/ location description

Take photograph (date and time stamp) and record on the data sheet

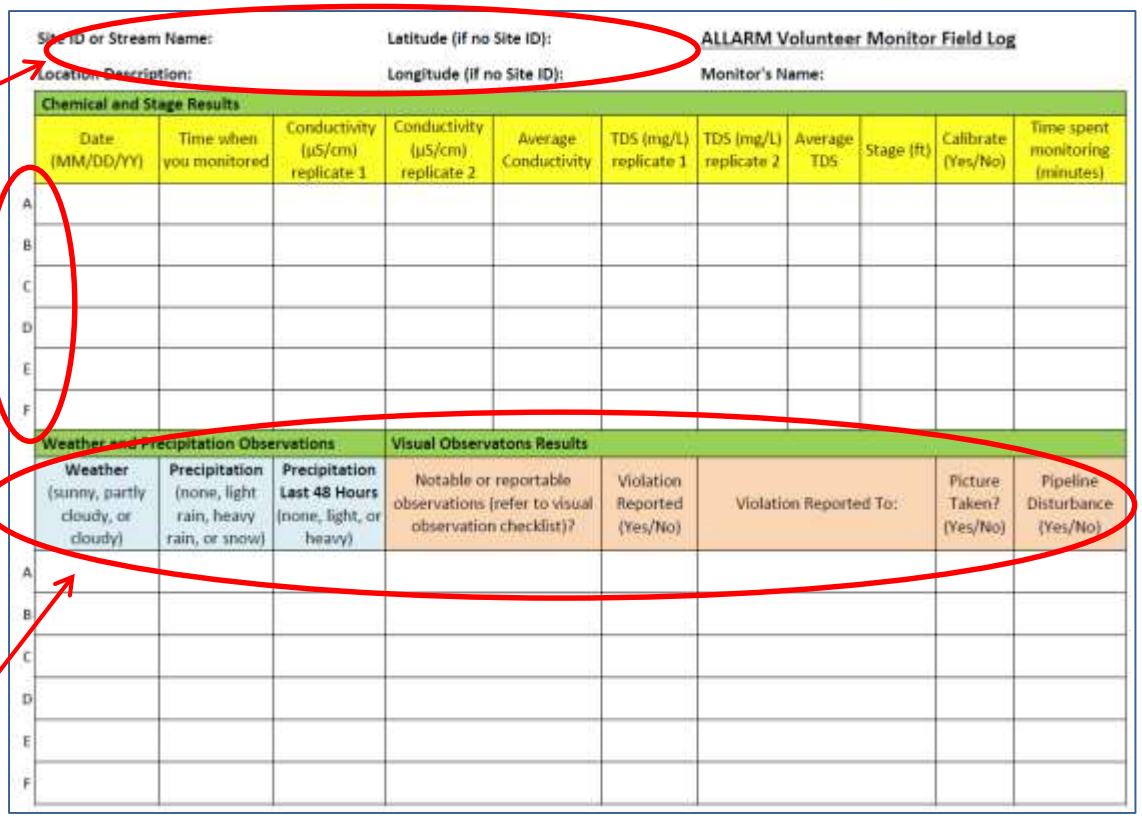
Record thorough description of the observation

Recording Observations: Field Data Log

Record Site ID or latitude and longitude

Record multiple times or locations

Record visual observation description and outcomes



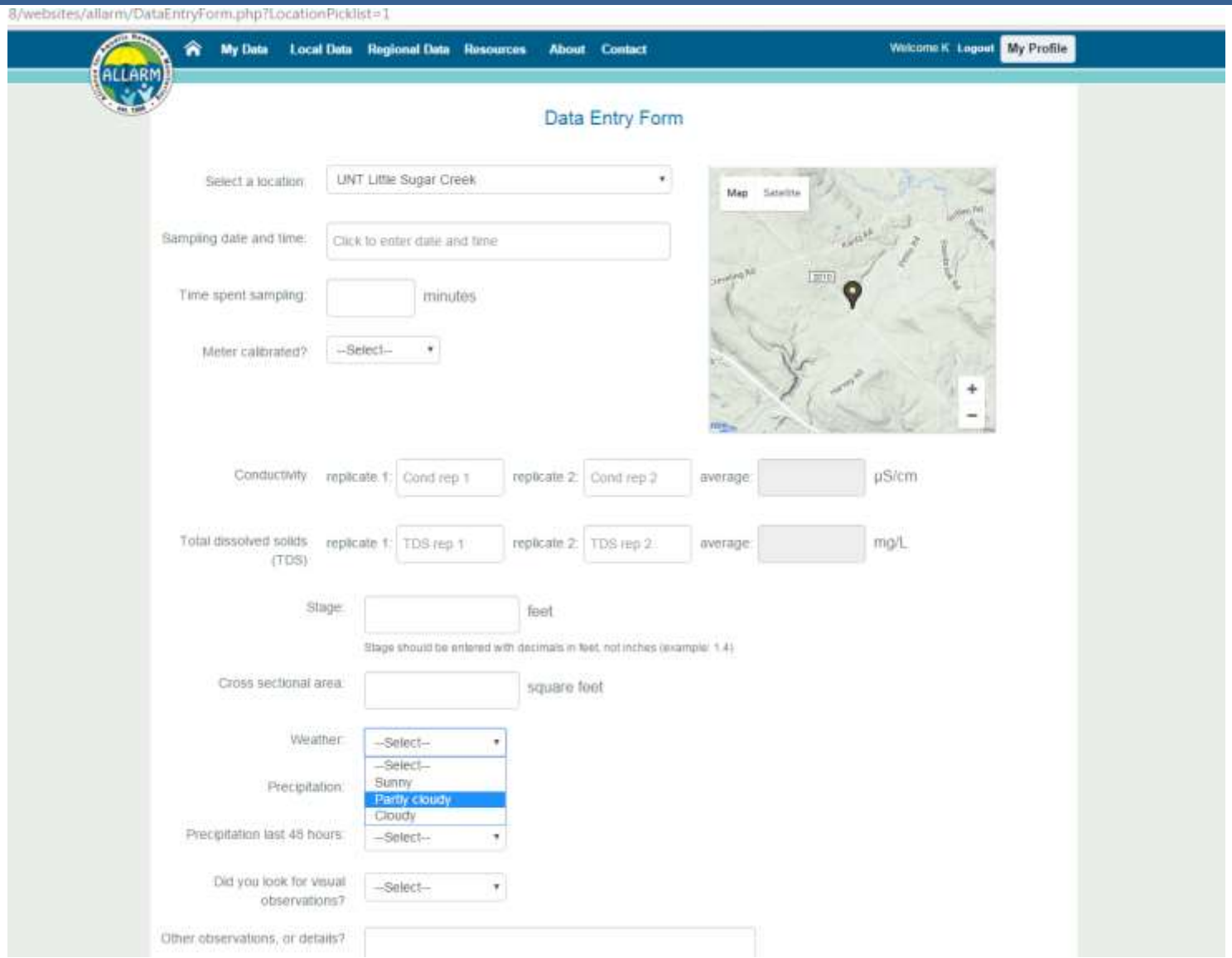
Site ID or Stream Name: Latitude (if no Site ID): ALLARM Volunteer Monitor Field Log

Location Description: Longitude (if no Site ID): Monitor's Name:

	Chemical and Stage Results										
	Date (MM/DD/YY)	Time when you monitored	Conductivity (µS/cm) replicate 1	Conductivity (µS/cm) replicate 2	Average Conductivity	TDS (mg/L) replicate 1	TDS (mg/L) replicate 2	Average TDS	Stage (ft)	Calibrate (Yes/No)	Time spent monitoring (minutes)
A											
B											
C											
D											
E											
F											

	Weather and Precipitation Observations			Visual Observatons Results				
	Weather (sunny, partly cloudy, or cloudy)	Precipitation (none, light rain, heavy rain, or snow)	Precipitation Last 48 Hours (none, light, or heavy)	Notable or reportable observations (refer to visual observation checklist)?	Violation Reported (Yes/No)	Violation Reported To:	Picture Taken? (Yes/No)	Pipeline Disturbance (Yes/No)
A								
B								
C								
D								
E								
F								

Recording Observations: ALLARMwater.org



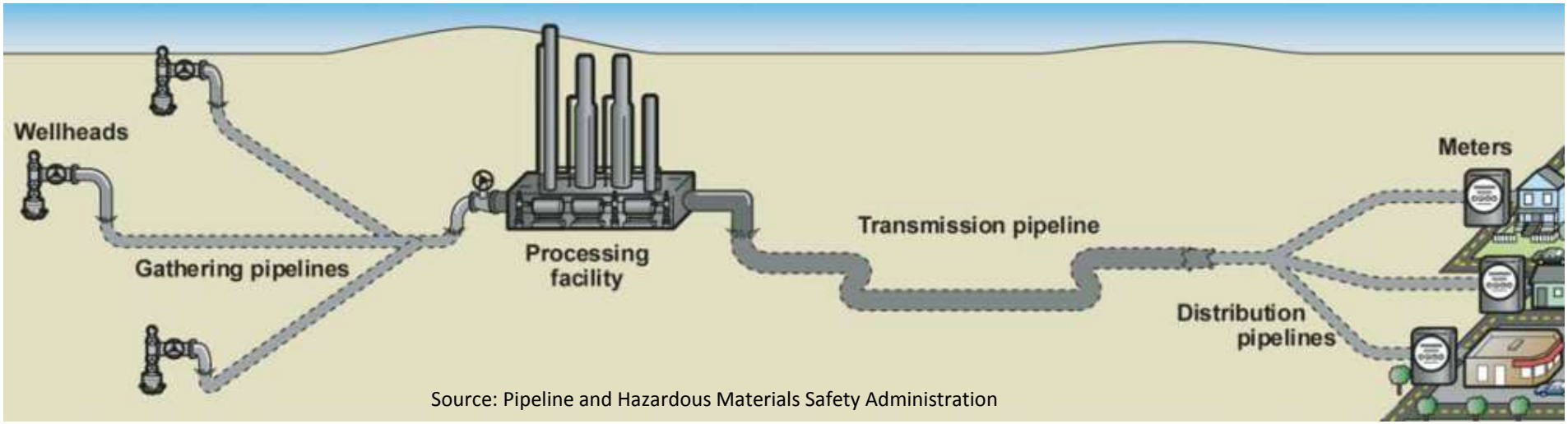
Visual Observation Categories

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

Marcellus Shale Well Sites in Dimock, PA; 2010

Pipelines

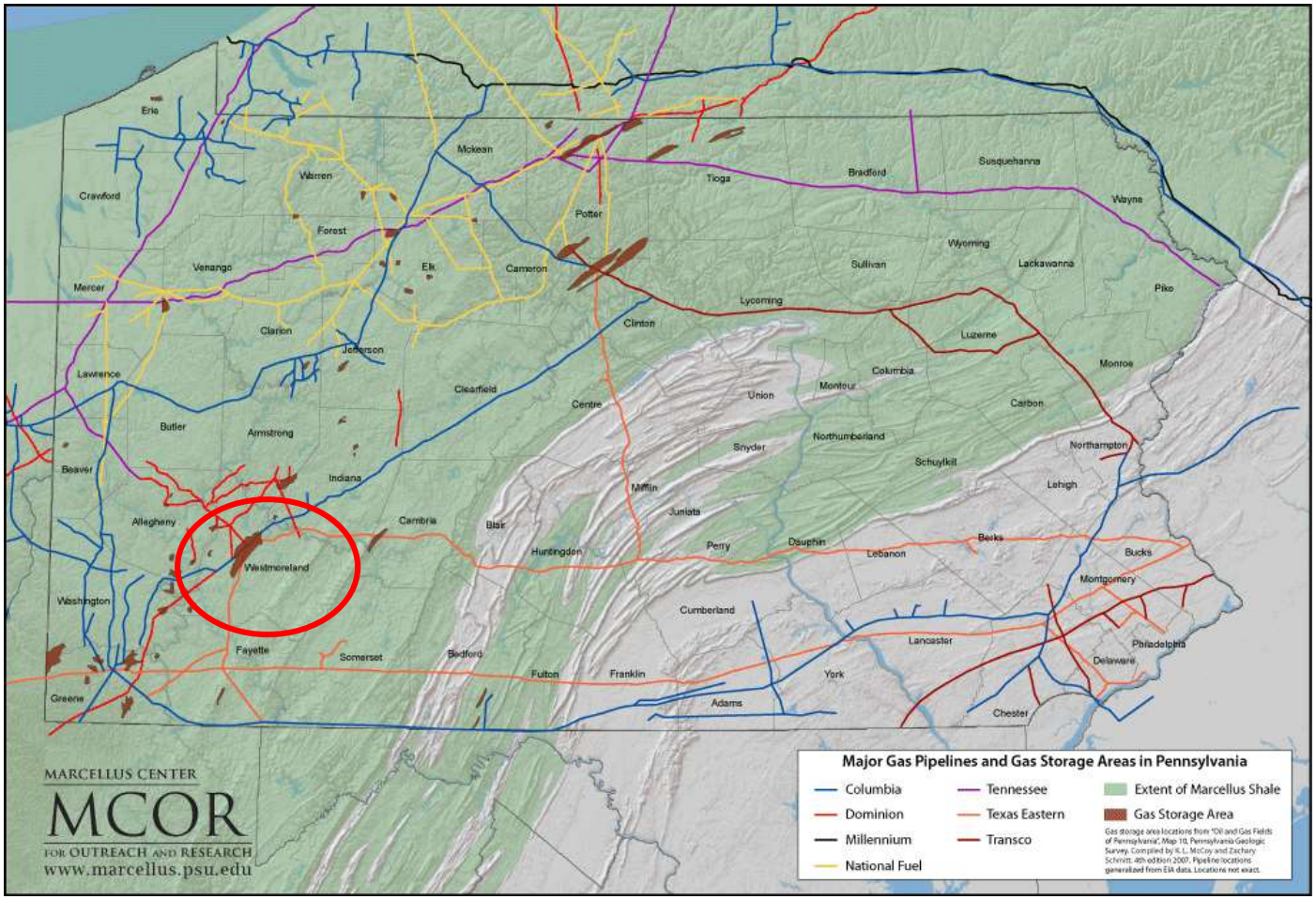
Types of Pipelines



Source: Pipeline and Hazardous Materials Safety Administration

- **Gathering Lines**: Small lines from wells.
- **Transmission Lines**: Larger lines that transport gas long distances, compressor stations every 40-60 mi to keep gas at a high enough pressure for travel.
- **Distribution Lines**: Small lines going into homes, businesses etc.

Major Pipelines



Environmental Concerns

- Erosion and sedimentation (largest concern, most common violation)
- Loss of riparian zones – vegetated buffer along the stream
- Stream geomorphology impacts (changes in stream shape)
- Habitat fragmentation
- Methane leakages

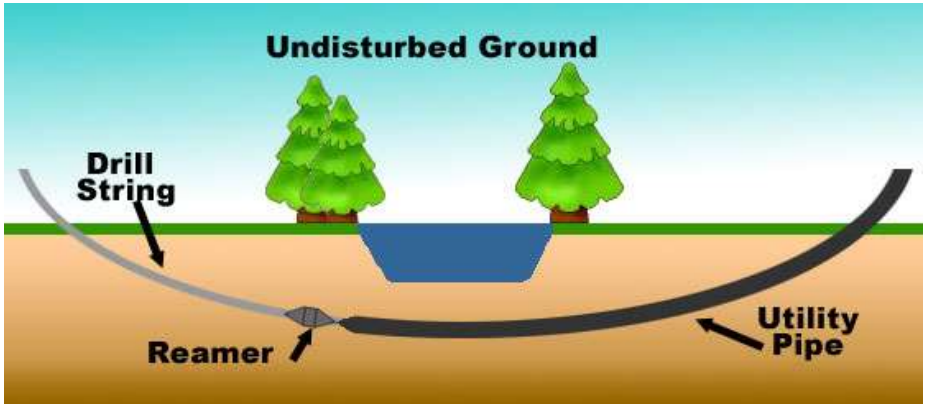
ALLARM

Stream Crossings

Through the stream

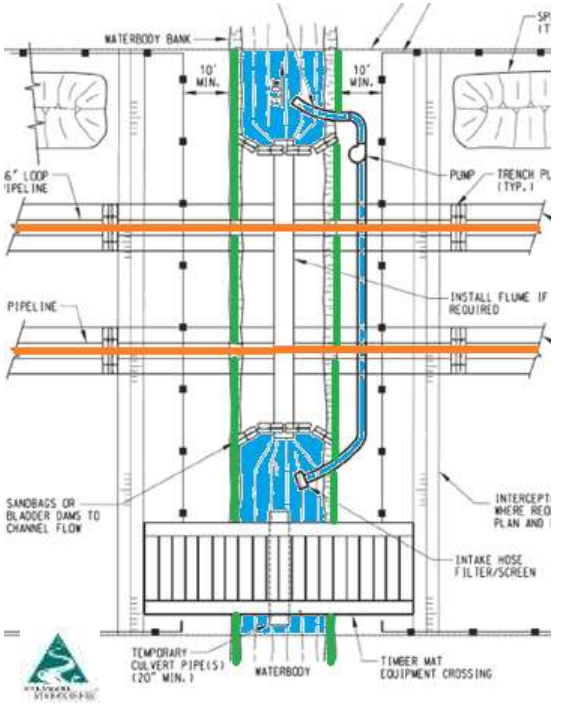
https://www.ontras.com/cms/fileadmin/Dokumente_Unternehmen/Presse/Download/dueker_weisse-elster.jpg

Under the stream



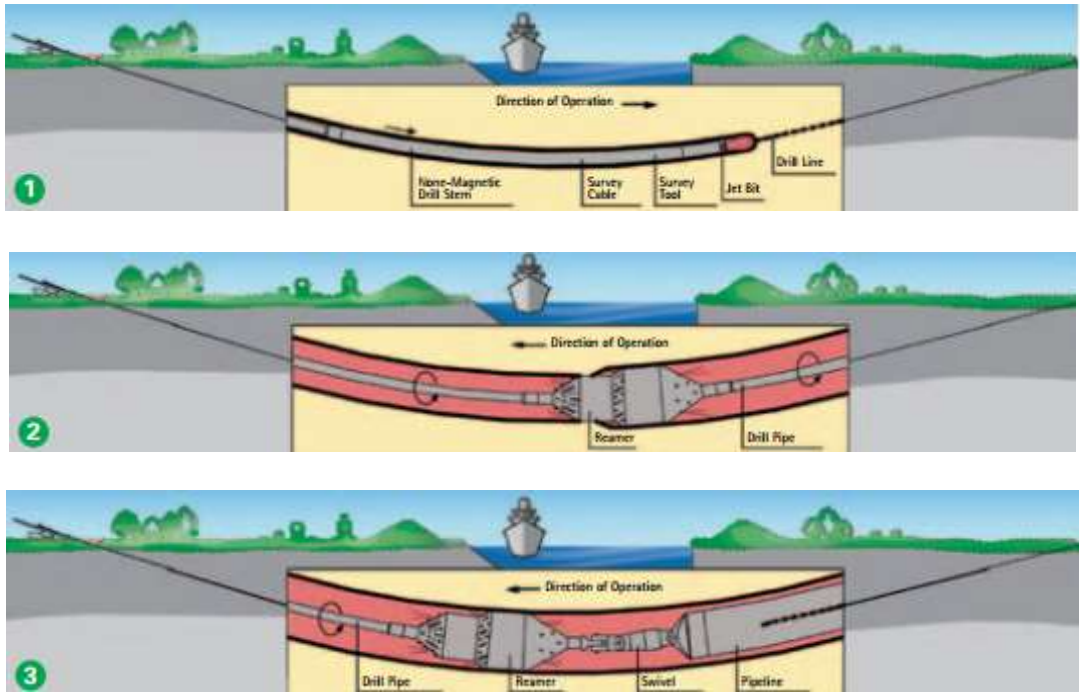
Through the Stream

- Open-cut
- Flumed or Partial Diversion
- Dam & Pump method



Under the Stream

Horizontal Directional Drilling



(Nacap, 2014)

(Direct Industry, 2014)

DELAWARE RIVERKEEPER®

Earth Disturbances

http://www.postcarbon.org/reports/shale-gas-well.jpg

Earth Disturbances

- Sediment entering streams as a result of any earth disturbance

- Sediment on/from access roads, well pads.

What do you notice?


Photo courtesy of PA Council of Trout Unlimited


Photo courtesy of PA Council of Trout Unlimited

Access Roads


Photo courtesy of PA Council of Trout Unlimited


Photo courtesy of PA Council of Trout Unlimited

What do you notice with these access roads?

Main Roads

What's the issue here? Is this reportable?

Best Management Practices for E&S

Silt fence

Silt Sock

Diversion Ditch

Monitoring E&S BMPs: need to confirm that they are installed correctly and maintained properly.

Sediment from Earth Disturbances


Photo courtesy of PA Council of Trout Unlimited


Photo courtesy of PA Council of Trout Unlimited

Is there a problem with these best management practices?

E&S Best Management Practice

Is there anything wrong with this?

PA: Publicly available information

- E&S plans are on site & are available to the public.

Pipeline Erosion & Sedimentation

Tioga County, PA - Mudslides

Tioga County Conservation District

Spills and Discharges

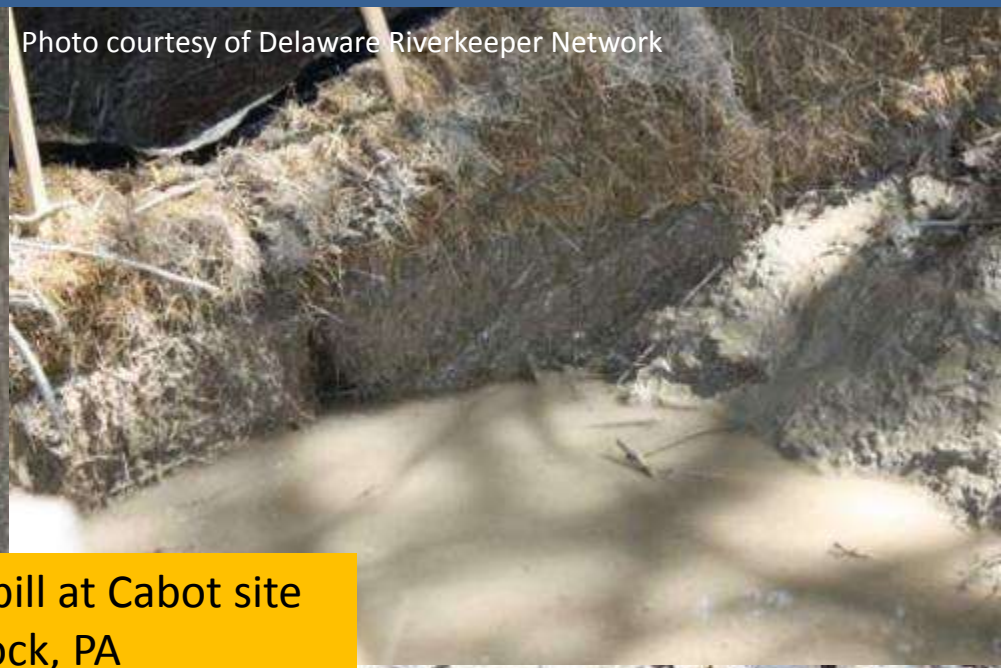
http://www.theintelligencer.net/photos/news/md/587542_1.jpg

Spills and Discharges

Unusual odor, color, foam and/or bubbles

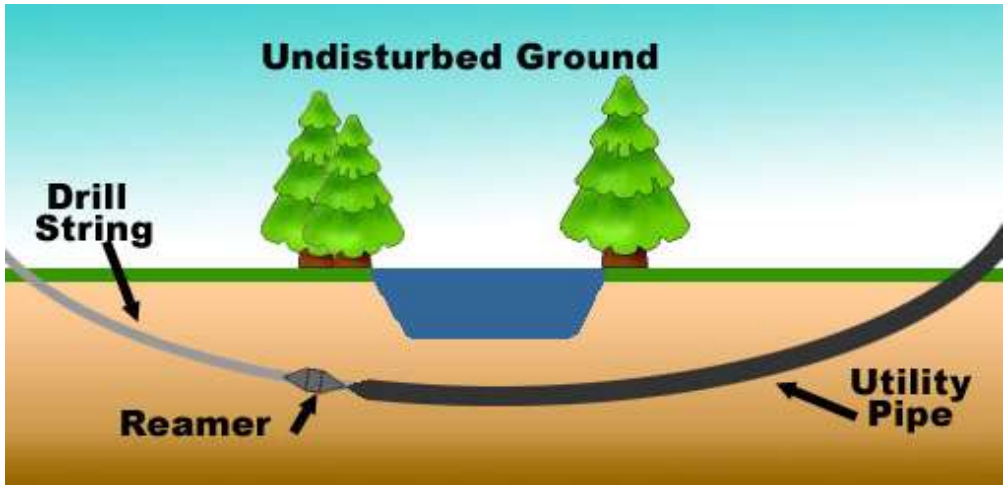
Dead fish and/or other organisms

Spills and Discharges



Drilling fluid spill at Cabot site
Dimock, PA
September 2009

Pipeline Spills and Discharges
Bentonite Blowouts



Illegal Dumping into Streams

- No pump running
- Bubbling at end of hose
- Unusual odors
- Discoloration of water near hose

http://www.shaleshockmedia.org/wp-content/uploads/2010/11/P1010356-300x2251.jpg

Illegal Dumping

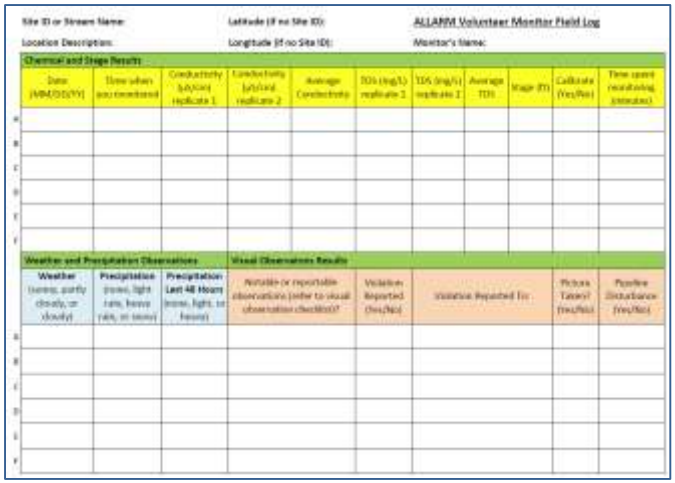
Which is illegal dumping?

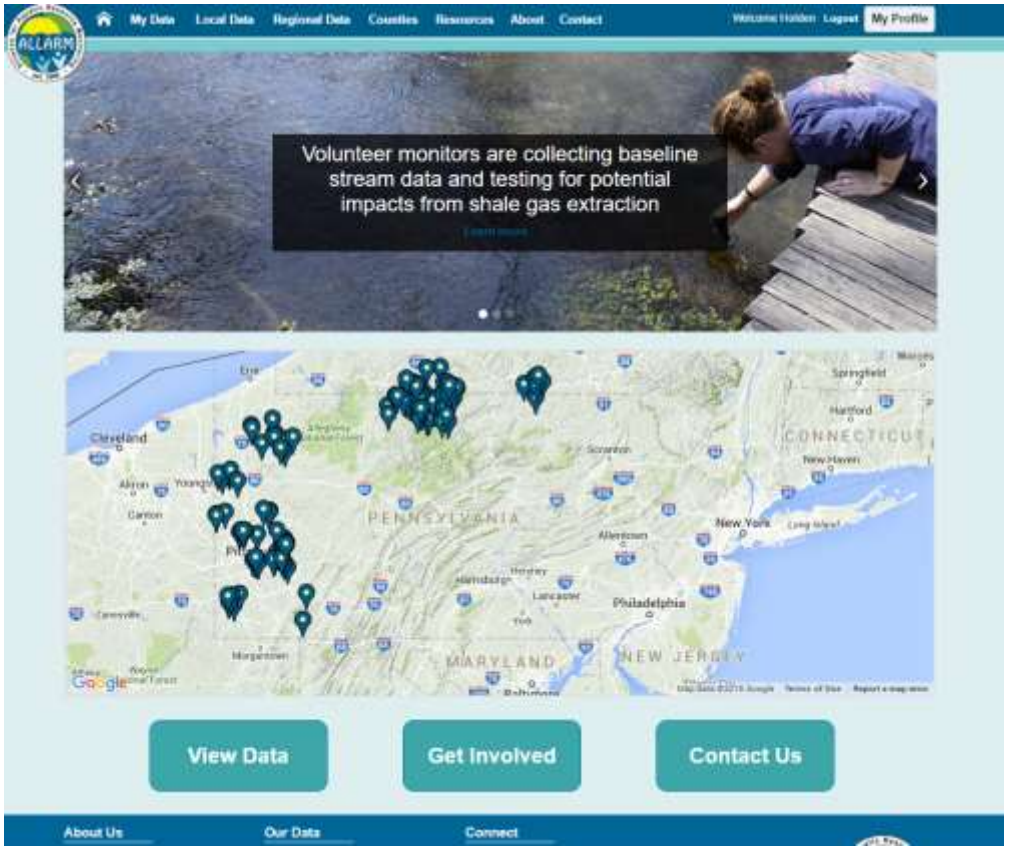
Mountain Watershed Association

Gas Migration or Leakages

What do you see?

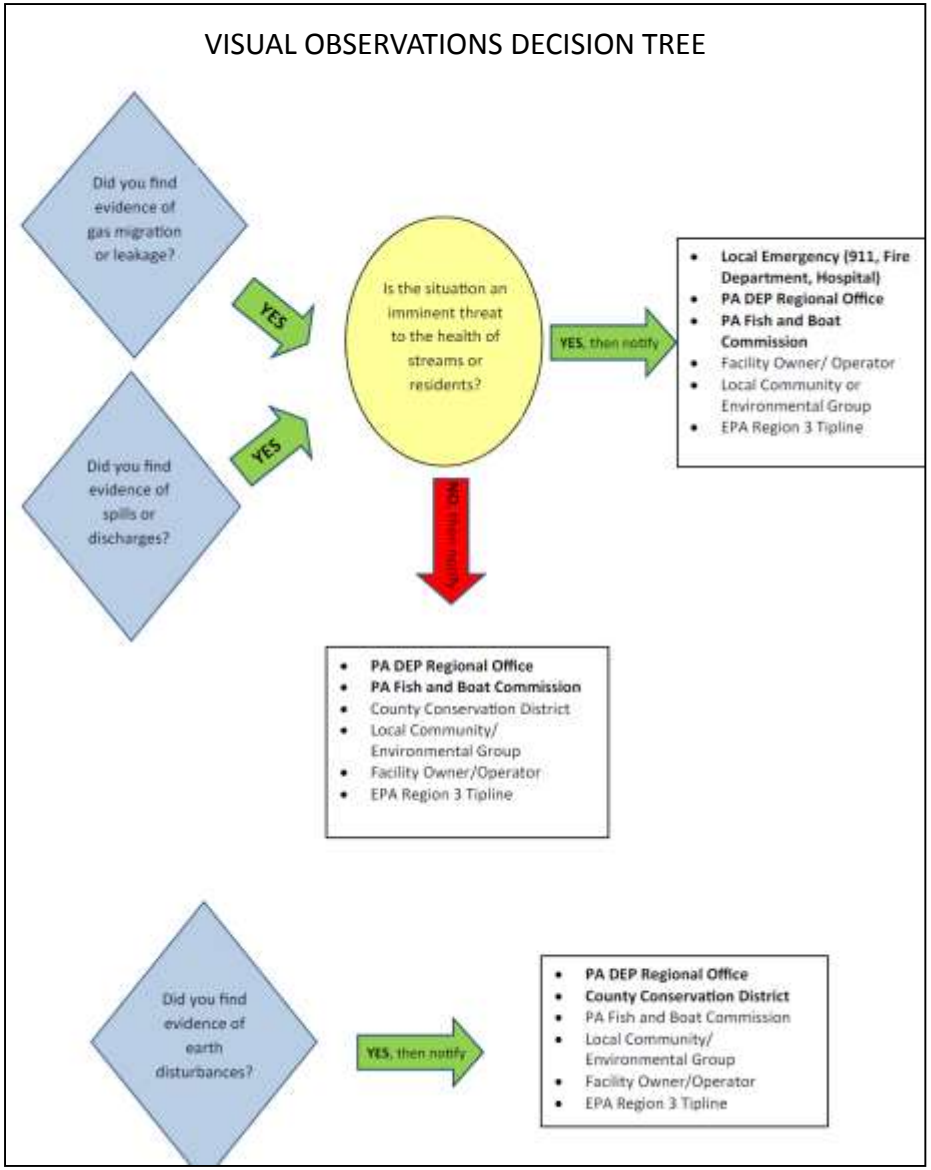
Data Management: Record Results



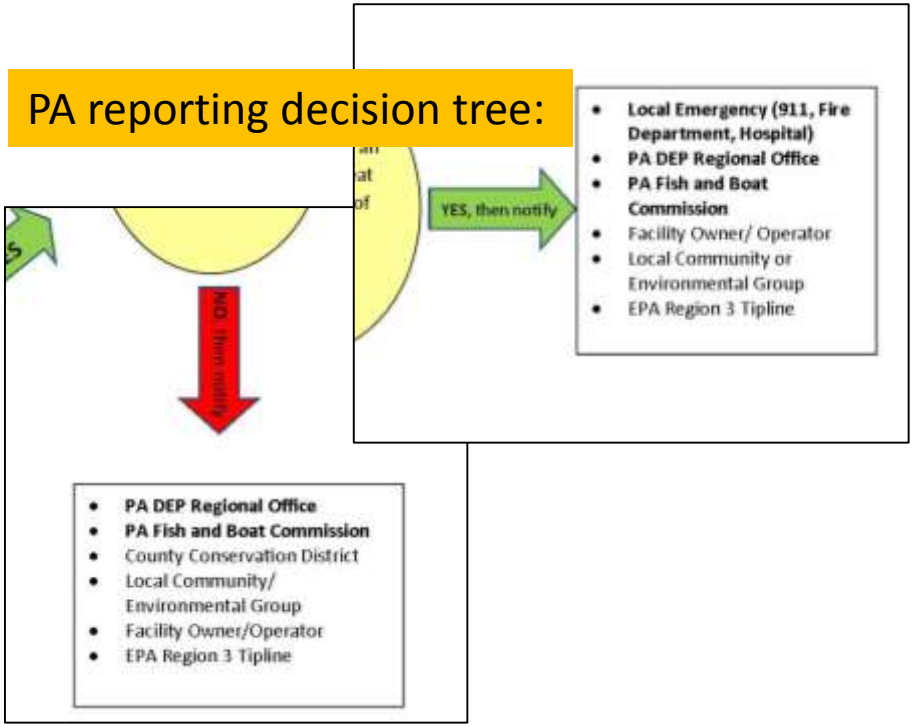


ALLARMwater.org

Reporting Observations

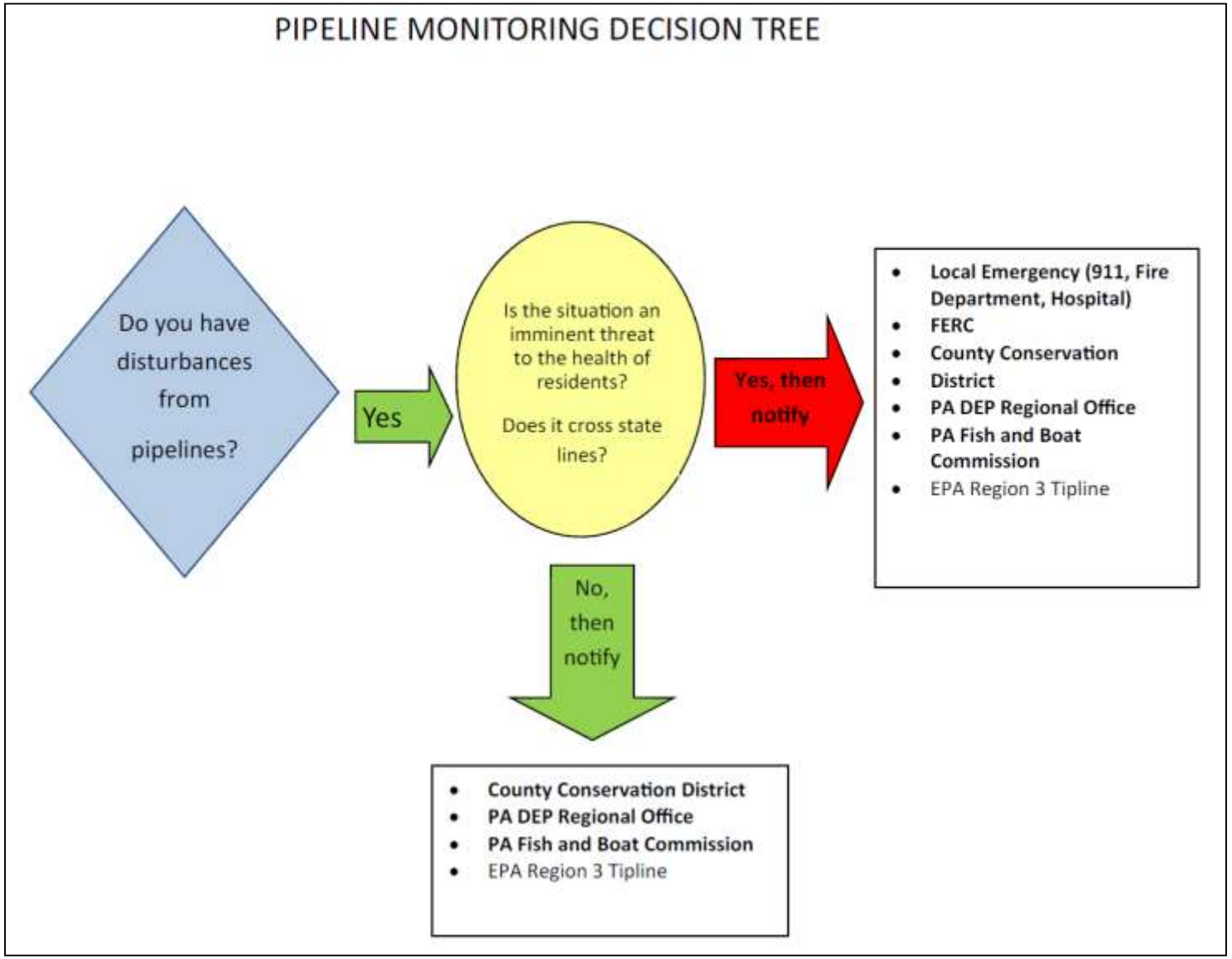


PA reporting decision tree:



It is important to communicate with your local agencies – "hey, we're here and we're monitoring."

Pipeline Decision Tree



Parameter Overview

Alliance for Aquatic Resource Monitoring

Objectives

- Learn about water quality parameters.
- Build basic skills for monitoring.
- Learn about quality assurance/quality control.

Indicators

Water Quality:

- Conductivity
- Total Dissolved Solids (TDS)

Water Quantity:

- Stage (water depth)

Meter Trials

Dickinson students, faculty, and staff helped 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

Calibration

- Calibrate every day you monitor
- Dispose of calibration fluid after use

Conductivity (μS/cm)

- Conductivity measures the ability of water to carry an electrical current/presence of ions:
  - Inorganic compounds = good conductors
    - Example: dissolved salts and heavy metals
  - Organic compounds = poor conductors
    - Example: pesticides
- Conductivity is measured with a meter. Voltage is applied between two electrodes in a probe immersed in water.

Ranges	
Distilled Water:	0.5 – 3 μS/cm
US Streams:	15 – 500 μS/cm
US Rivers:	50 – 1500 μS/cm
Industrial Waters:	up to 10,000 μS/cm

Total Dissolved Solids (mg/L)

- TDS measures the amount of ions in the water.
    - Example: dissolved salts, nutrients, heavy metals
- Meters first measure conductivity and calculate TDS using an equation.
- TDS can be measured directly using the gravimetric method (actual weight).

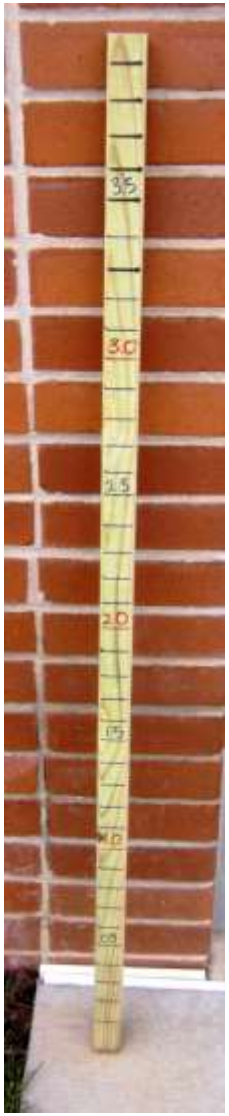
Ranges	
Fresh Water:	< 1,500 mg/L
Brackish Water:	1,500 – 5,000 mg/L
Saline Water:	> 5,000 mg/L

Why Conductivity and TDS?

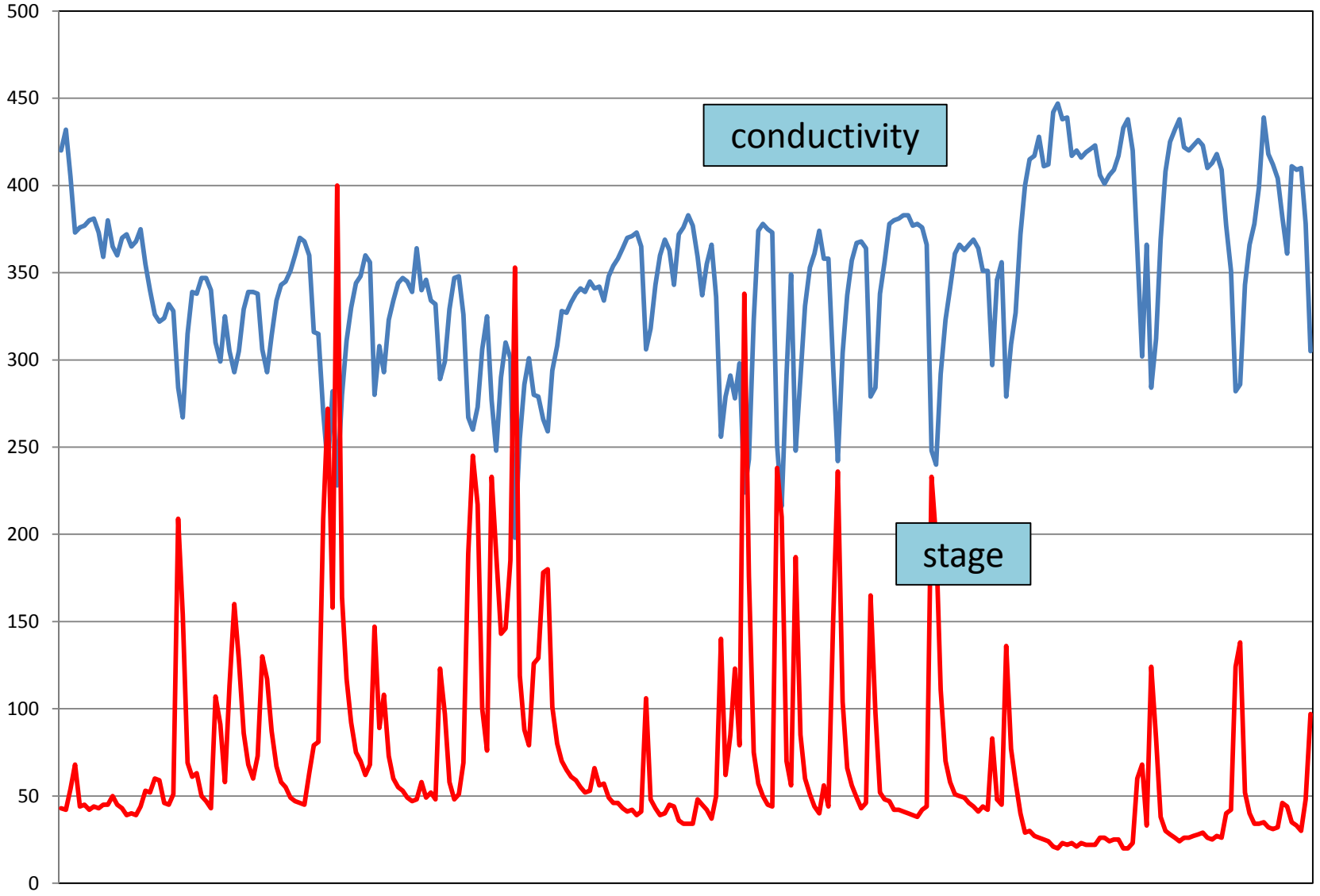
- Frack water mixes with natural brine, found in the shale
- Flowback water contains high concentrations of salts and metals

Picture by Amy Bergdale, US EPA

Stage Monitoring (ft)



Conductivity and Stage Relationship



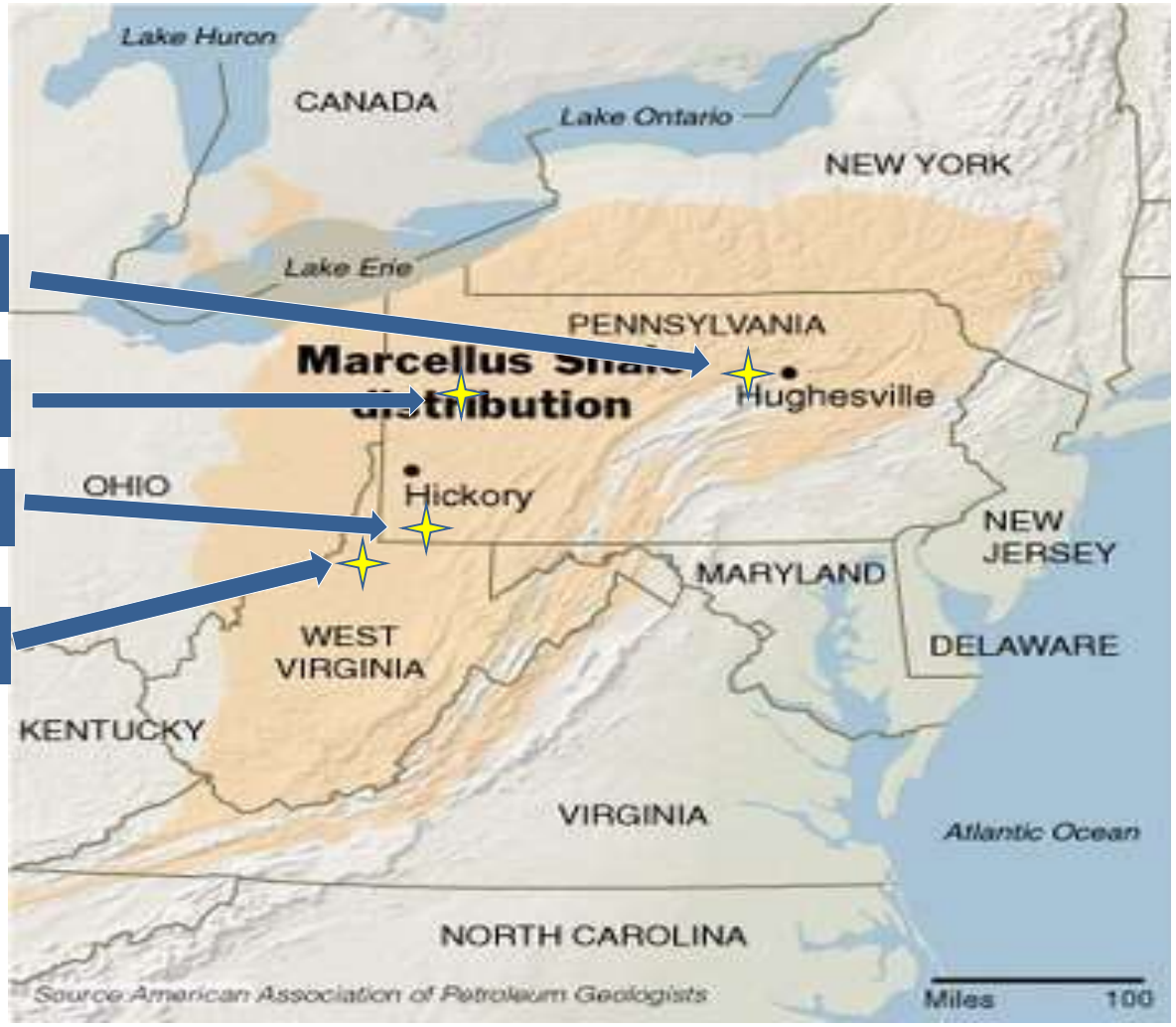
Flowback Water Concentrations

TDS: 70,000 mg/L

TDS: 211,000 mg/L

TDS: 132,000 mg/L

TDS: 217,000 mg/L



Source: Amy Bergdale, USEPA

Reportable Event

A conductivity level 3x or higher than a measurement at a comparable stage.

Date	Stage	Conductivity
2/6/2016	1.7	119.3
2/15/2016	1.7	132.3
3/7/2016	0.8	361
3/13/2016	1.7	670

What do you do if you have a reportable event?

Reporting Events

Reportable Event Steps:

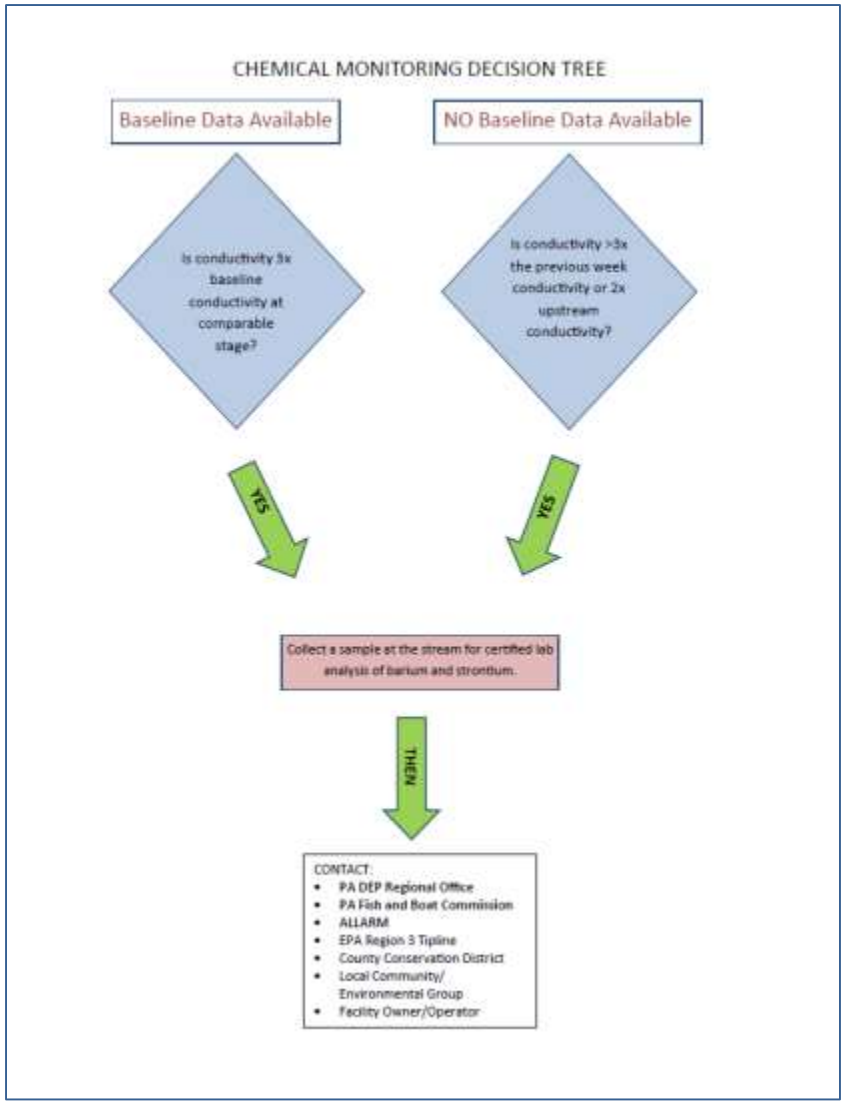
1. Re-calibrate meter and re-test your water.
2. Collect a sample for barium & strontium analysis (to send to a local, certified lab).
3. Contact your local group leaders.
4. Contact enforcement agencies.
5. Contact ALLARM.

Barium & Strontium: Signature Chemicals

- If Conductivity/TDS levels increase, that ***could*** mean pollution from shale gas flowback water.
- Data are confirmed by analyzing samples for Ba & Sr

It is important to obtain baseline data for conductivity/TDS and barium/strontium. It is also important to understand how they relate under different flow conditions.

Reporting Events



CONTACT:

- PA DEP Regional Office
- PA Fish and Boat Commission
- ALLARM
- EPA Region 3 Tipline
- County Conservation District
- Local Community/ Environmental Group
- Facility Owner/Operator

Baseline Monitoring Steps

2. Conductivity & Total Dissolved Solids In-stream testing

1. Visual Observation Checklist

3. Stage Monitoring

Stream Testing

- Test stream water with meter
  - Walk into middle of the creek
  - Or sample from a bridge using a bucket

Creekside vs. Home testing

Mandatory Creekside Testing

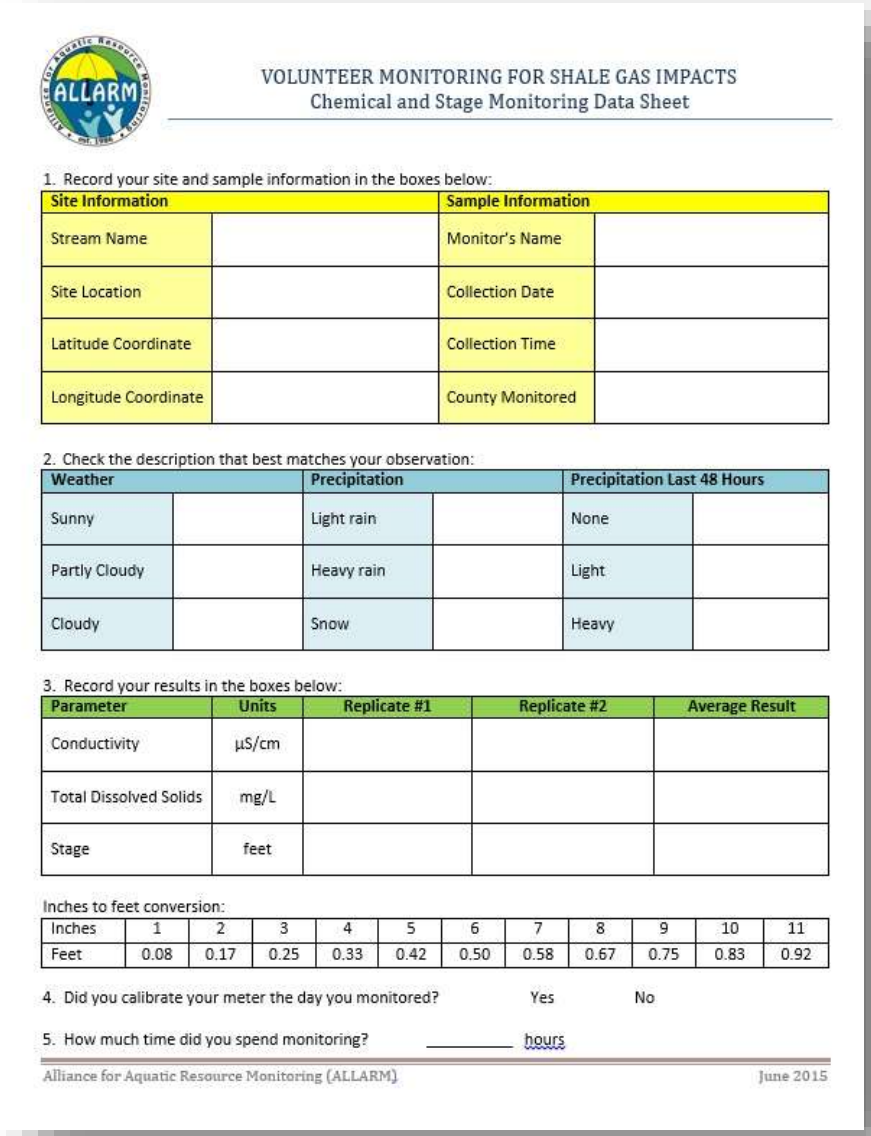
- Stage
- Visual observations

Can do at home in bad weather

- Calibration
- Conductivity/TDS

Meter does not stabilize quickly in freezing temperatures, turn the meter on when you arrive at the site or let the water warm to room temperature test at home or in the car.

Recording Results



VOLUNTEER MONITORING FOR SHALE GAS IMPACTS
Chemical and Stage Monitoring Data Sheet

1. Record your site and sample information in the boxes below:

Site Information		Sample Information	
Stream Name		Monitor's Name	
Site Location		Collection Date	
Latitude Coordinate		Collection Time	
Longitude Coordinate		County Monitored	

2. Check the description that best matches your observation:

Weather		Precipitation		Precipitation Last 48 Hours	
Sunny		Light rain		None	
Partly Cloudy		Heavy rain		Light	
Cloudy		Snow		Heavy	

3. Record your results in the boxes below:

Parameter	Units	Replicate #1	Replicate #2	Average Result
Conductivity	µS/cm			
Total Dissolved Solids	mg/L			
Stage	feet			

Inches to feet conversion:

Inches	1	2	3	4	5	6	7	8	9	10	11
Feet	0.08	0.17	0.25	0.33	0.42	0.50	0.58	0.67	0.75	0.83	0.92

4. Did you calibrate your meter the day you monitored? Yes No

5. How much time did you spend monitoring? _____ hours

Alliance for Aquatic Resource Monitoring (ALLARM) June 2015

Record site information

Record weather information

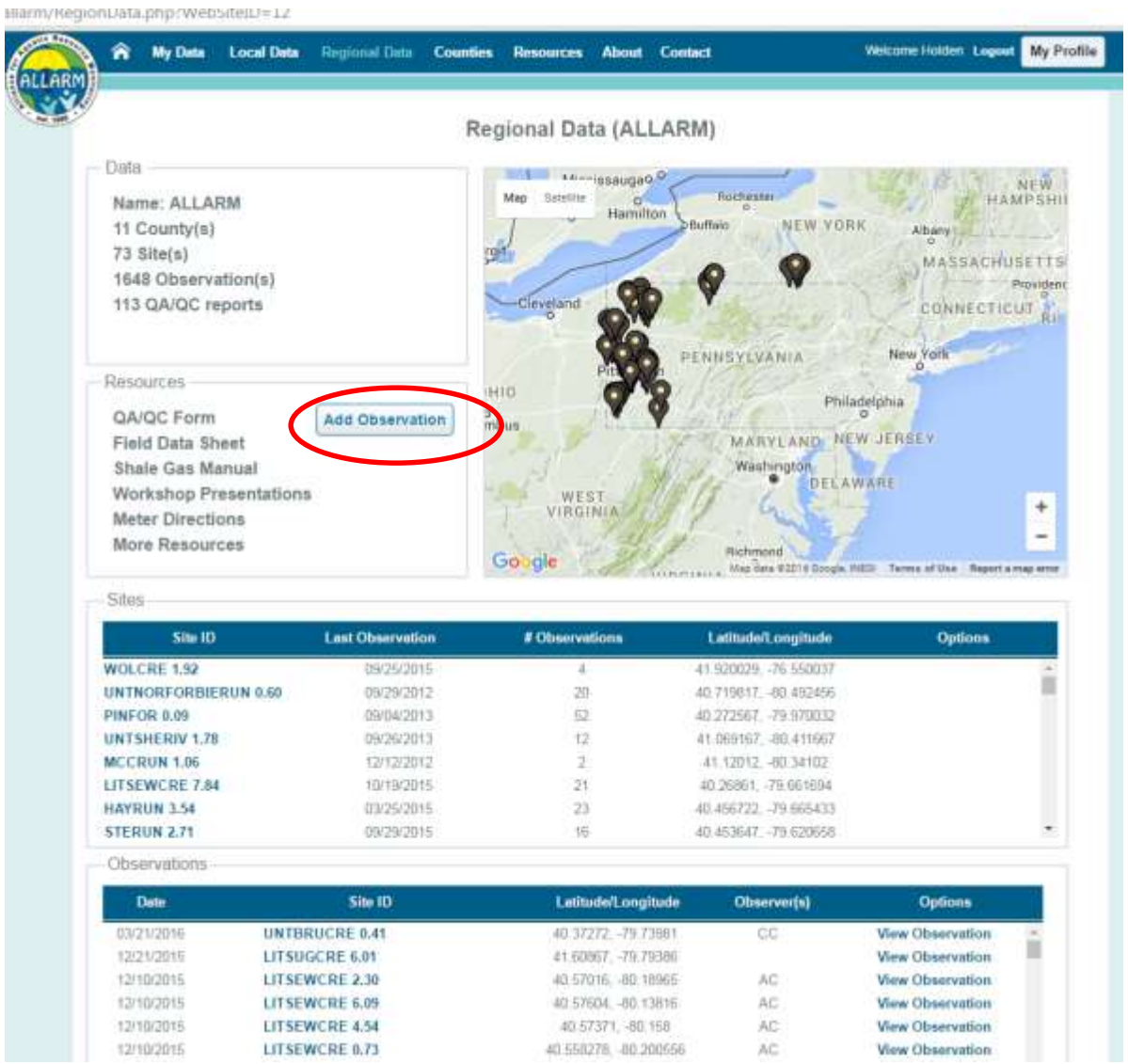
Record conductivity, TDS, and stage results

Record calibration and volunteer time.

Data Management

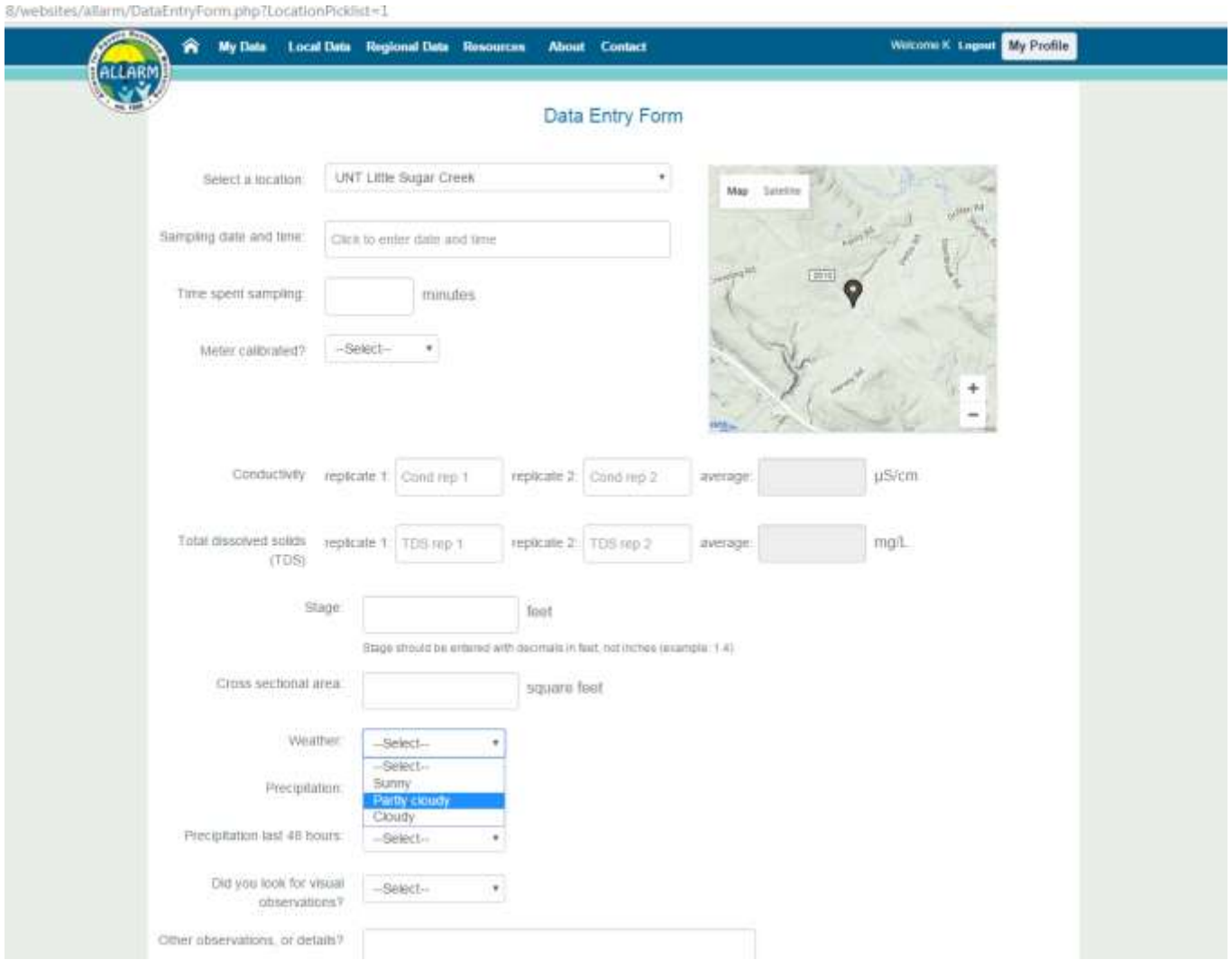
ALLARMwater.org

- ‘My Data’ profile page
- Submit data through site
- Can view data and create graphs
- Resources, research and forms all housed on site



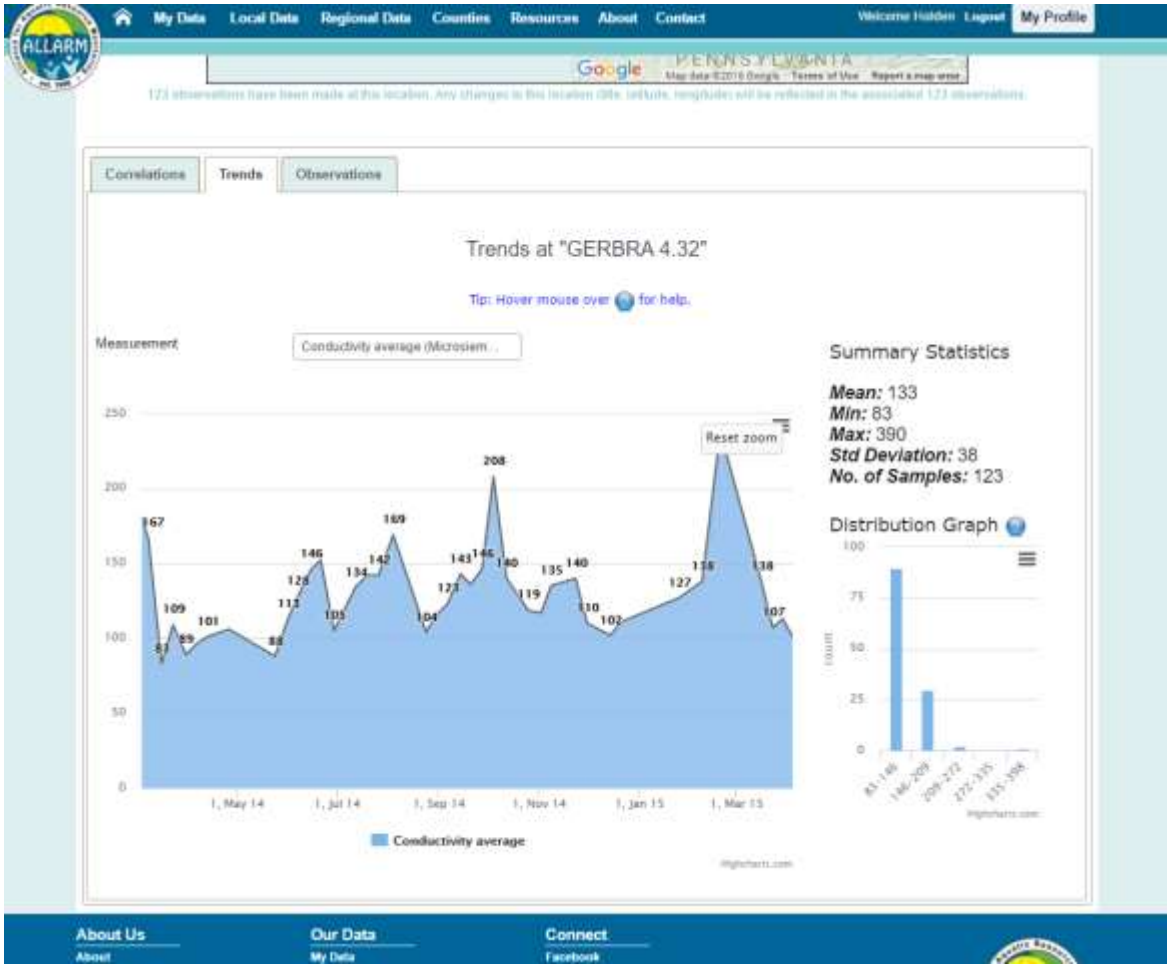
Data Management: ALLARMwater.org

- Submit data through site
- Checks values and tests for reportable events



Data Management: ALLARMwater.org

- Can create data and create graphs
- Resources, research and forms all housed on site



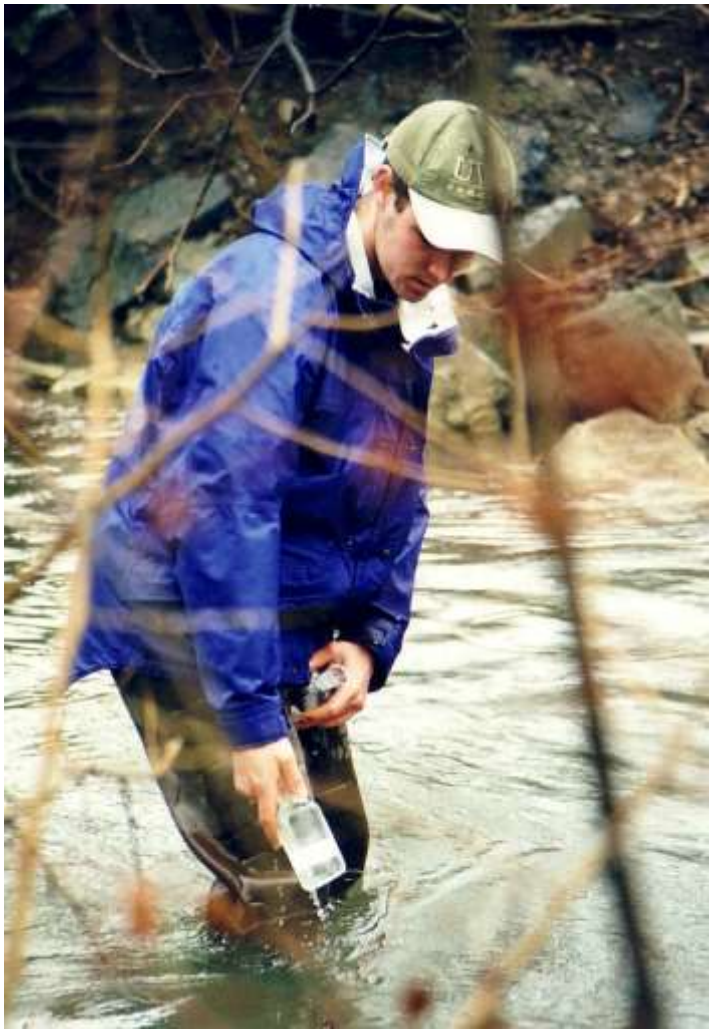
Quality Control Program

- Ensures the credibility of the data collected.
- ALLARM will test the water using the same equipment as well as other methods.
- Compare monitor's results to ALLARM's results.

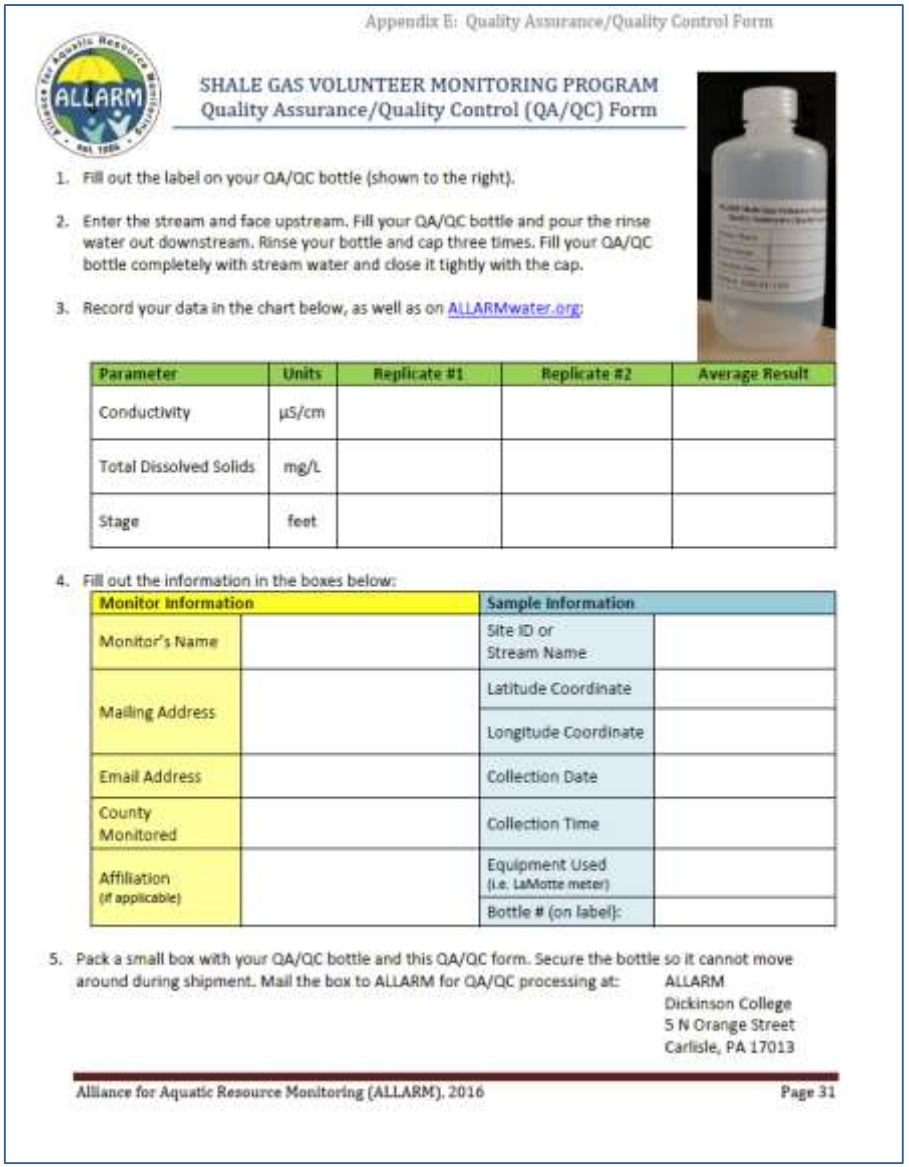
	Conductivity (LaMotte)	Conductivity (Accumet)	TDS (LaMotte)	TDS (Accumet)
Monitor	X		X	
ALLARM	X	X	X	X

QA/QC Sampling

- Fill out QA/QC form
- Collect sample
- Send form and sample to ALLARM lab
- Do twice a year – high stage & low stage



Quality Control



Appendix E: Quality Assurance/Quality Control Form

SHALE GAS VOLUNTEER MONITORING PROGRAM
Quality Assurance/Quality Control (QA/QC) Form

1. Fill out the label on your QA/QC bottle (shown to the right).
2. Enter the stream and face upstream. Fill your QA/QC bottle and pour the rinse water out downstream. Rinse your bottle and cap three times. Fill your QA/QC bottle completely with stream water and close it tightly with the cap.
3. Record your data in the chart below, as well as on ALLARMwater.org:

Parameter	Units	Replicate #1	Replicate #2	Average Result
Conductivity	µS/cm			
Total Dissolved Solids	mg/L			
Stage	feet			

4. Fill out the information in the boxes below:

Monitor Information		Sample Information	
Monitor's Name		Site ID or Stream Name	
Mailing Address		Latitude Coordinate	
		Longitude Coordinate	
Email Address		Collection Date	
County Monitored		Collection Time	
Affiliation (if applicable)		Equipment Used (i.e. LaMotte meter)	
		Bottle # (on label):	

5. Pack a small box with your QA/QC bottle and this QA/QC form. Secure the bottle so it cannot move around during shipment. Mail the box to ALLARM for QA/QC processing at:

ALLARM
Dickinson College
5 N Orange Street
Carlisle, PA 17013

Alliance for Aquatic Resource Monitoring (ALLARM), 2016 Page 31

Send water sample to ALLARM within <u>first month of monitoring</u> for QA/QC and barium/strontium analysis.

In your kit

1. LaMotte Tracer PockeTester and calibration solution vial
2. 84 µS/cm & 1413 µS/cm standard calibration solution
3. Distilled water wash bottle
4. Stream testing bottle
5. 3 sample bottles
   - Two sample bottles for QA/QC
   - One bottle for pollution event Ba and Sr analysis
6. Gage Stick