



Bureau of Laboratories

# Advancing Operations at the Pennsylvania Environmental Bureau of Laboratories in Response to the Marcellus Shale Energy Era

Dr. Pamela J. Higgins

June 2, 2013

APHL National Meeting



# Appalachian Basin

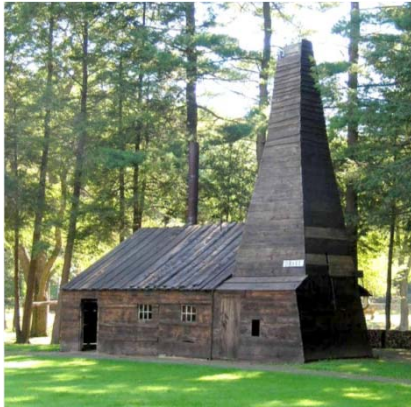
One of the biggest regions of fossil fuel resources in world.

Critical formation during the Devonian period.

Crosses 10 states  
-most of PA included



# PA Energy Milestones



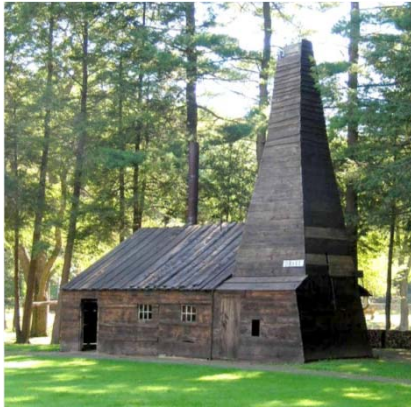
**#3** 1859  
First successful  
US oil well

**#2** 1775  
First PA anthracite  
coal mine



**#1** 1761  
First PA bituminous coal mine

# PA Energy Milestones



**#3** 1859  
First successful  
US oil well

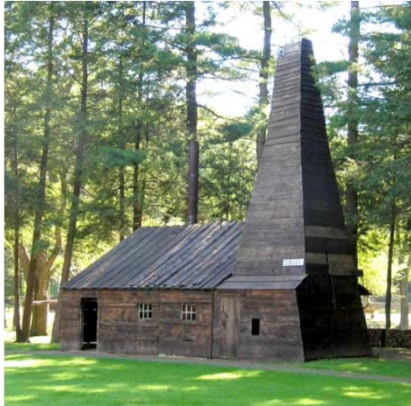
**#2** 1775  
First PA anthracite  
coal mine

**#4** 1957  
First US nuclear  
reactor reached  
criticality



**#1** 1761  
First PA bituminous coal mine

# PA Energy Milestones



**#3** 1859  
First successful  
US oil well

**#2** 1775  
First PA anthracite  
coal mine

**#4** 1957  
First US nuclear  
reactor reached  
criticality

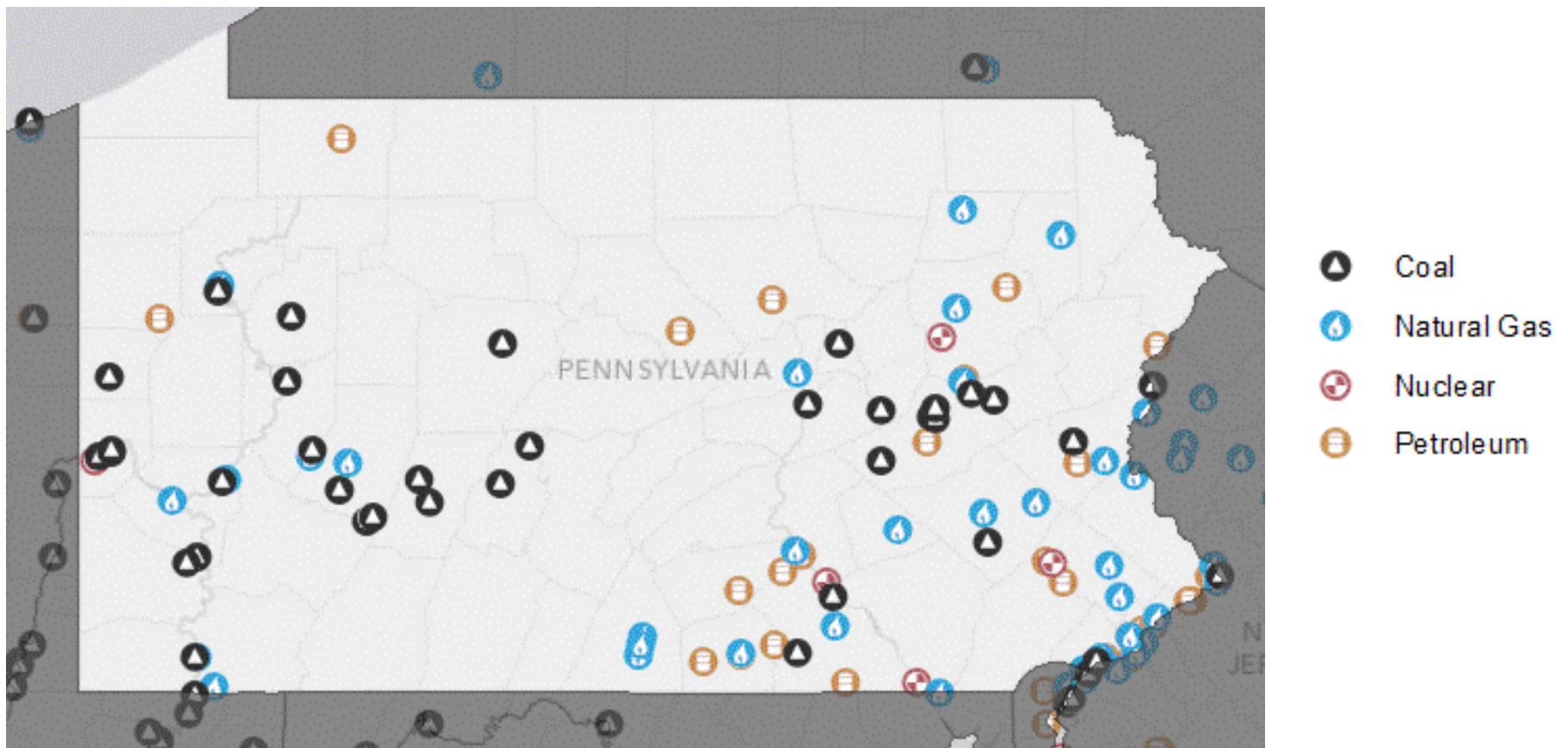
**#5** 2004  
First PA Marcellus  
shale gas well drilled



**#1** 1761  
First PA bituminous coal mine

# 2011 Traditional Energy Profile

PA ranks 5<sup>th</sup> overall in total energy production  
but only 33<sup>rd</sup> in energy consumption per capita



# PA Marcellus Shale Boom

Shale gas compared to coal:

Easier to extract

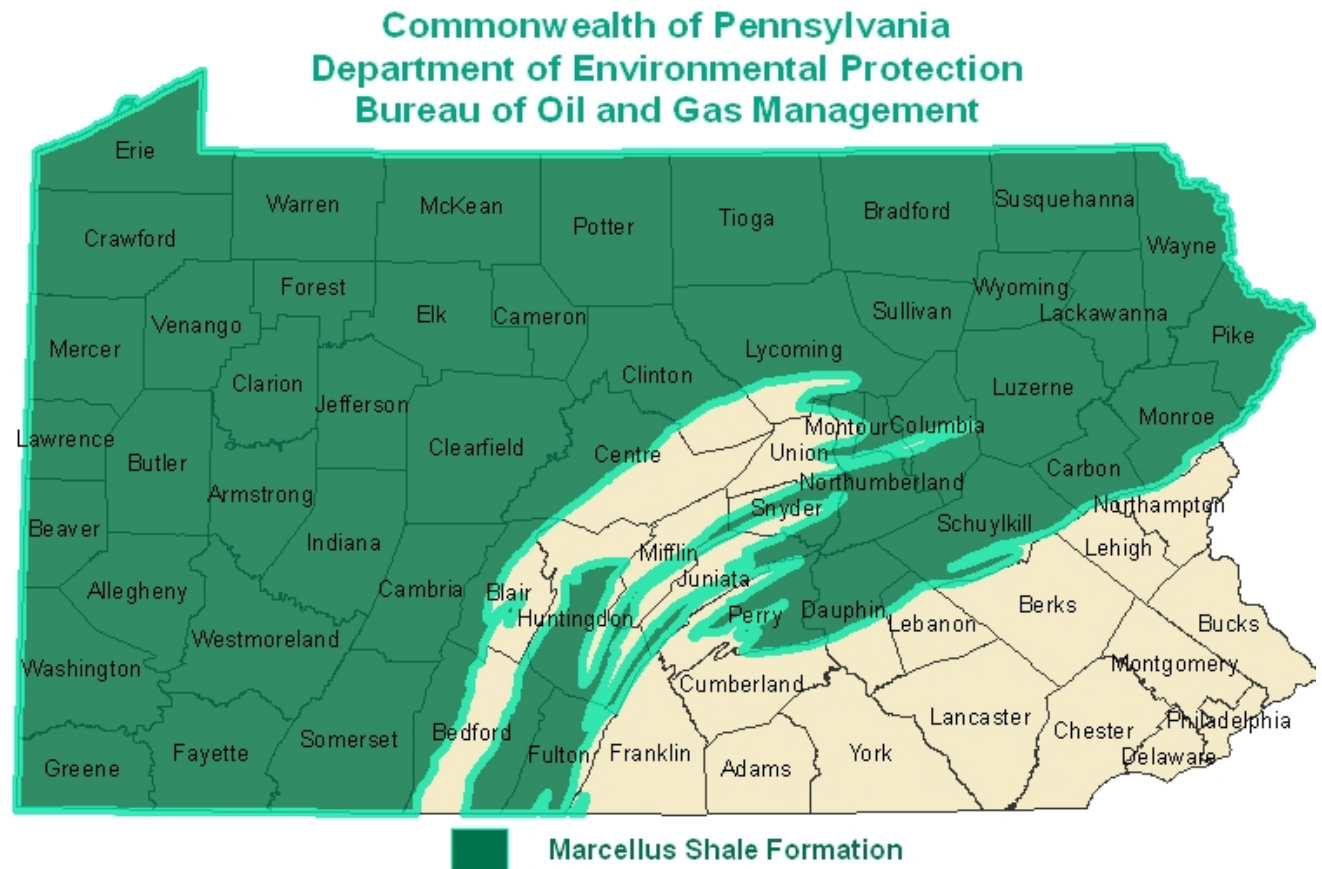
Lower operating costs

Lower greenhouse emissions

**2007- 2012**

Approx. 5700 wells drilled throughout the formation

[PSU animation](#)



# Potential impacts from hydraulic fracturing

## Air pollution

- construction vehicles and drilling equipment (dust, fumes, PM)
- uncontrolled release of methane, VOC's

## Water pollution

### Surface

- on-site spill/leak
- fracturing fluids
- wastewater

### Groundwater

- on-site storage leaks
- pipe casing blowouts
- waste disposal

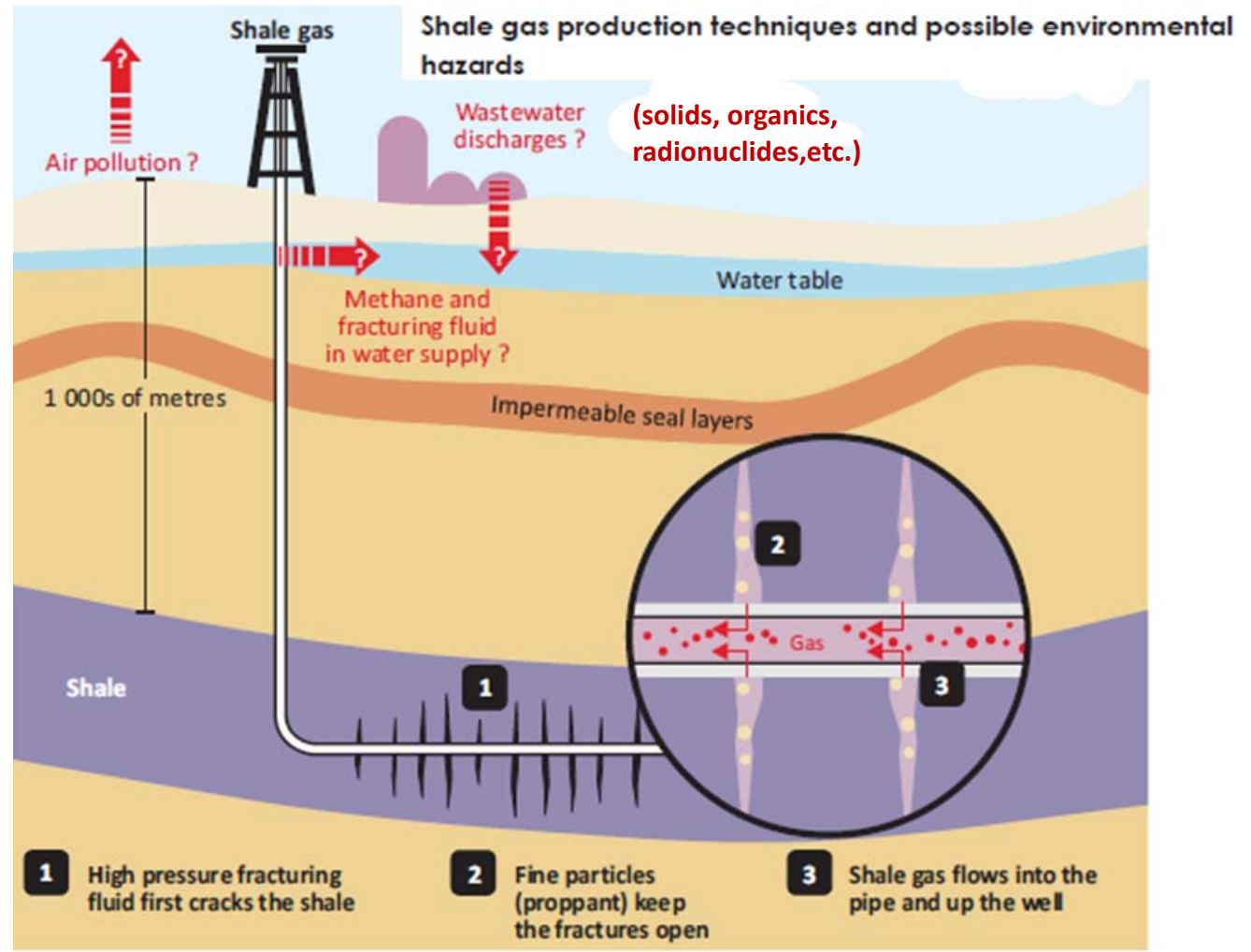


Figure 1.3 from *Golden Rules for a Golden Age of Gas*, IEA, May 2012



# Typical Fracking Well Site



*Hydraulic fracturing operation on East Resources well, eastern Tioga County.  
Photo Courtesy of Robert Hansen, 2010. <http://extension.psu.edu/water/marcellus-shale/hydrofracturing>*

# Identifying and Mitigating Impacts\*

	Air quality monitoring	Ground/well water	Surface water	Waste water/sludge
Pre-construction	X	X	X	NA
Drilling and Operation	X	X	X	X (storage, disposal)
Post-operation	NA	X	X	X (disposal)

\* Most likely candidates for potential environmental effects due to shale gas industry.

# PA Marcellus Shale Solid Waste 2012

Waste product	Total amount reported	Landfill	Recycle on-site
Drill cuttings	1.2 million tons	97 %	3 %
Flowback sand	50,000 tons	51 %	49 %

SAC	# tests	Total time (min)	Title (representative analytes)
971	15	92	<b>Marcellus Shale-Soil Samples/Drill Cuttings</b> (leach / acid digestion / % moisture and solids metals: Pb, Hg, Cr, Cd, Ba, Ag, As, Sr / Br-)

# Water Input During Fracturing Process

## What goes underground?

### Recycled Fluid 15%

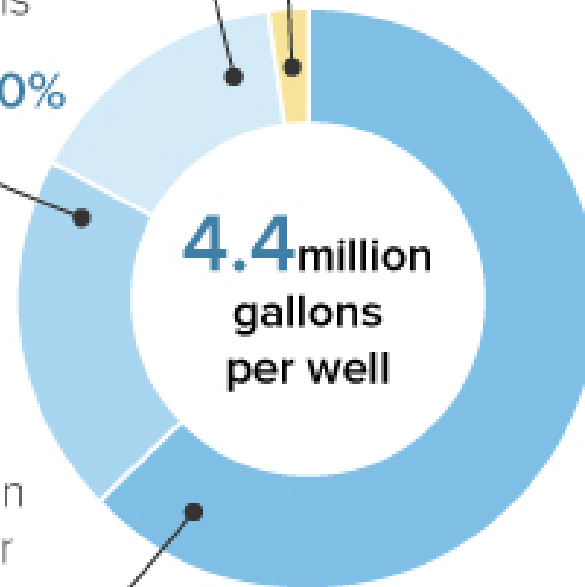
Flowback and treated wastewater from previously fracked wells

### Public Water Systems 20%

Water purchased from public water utilities

### Surface Water Withdrawal 63%

Water taken from rivers and streams requiring permission from the Susquehanna River Basin Commission

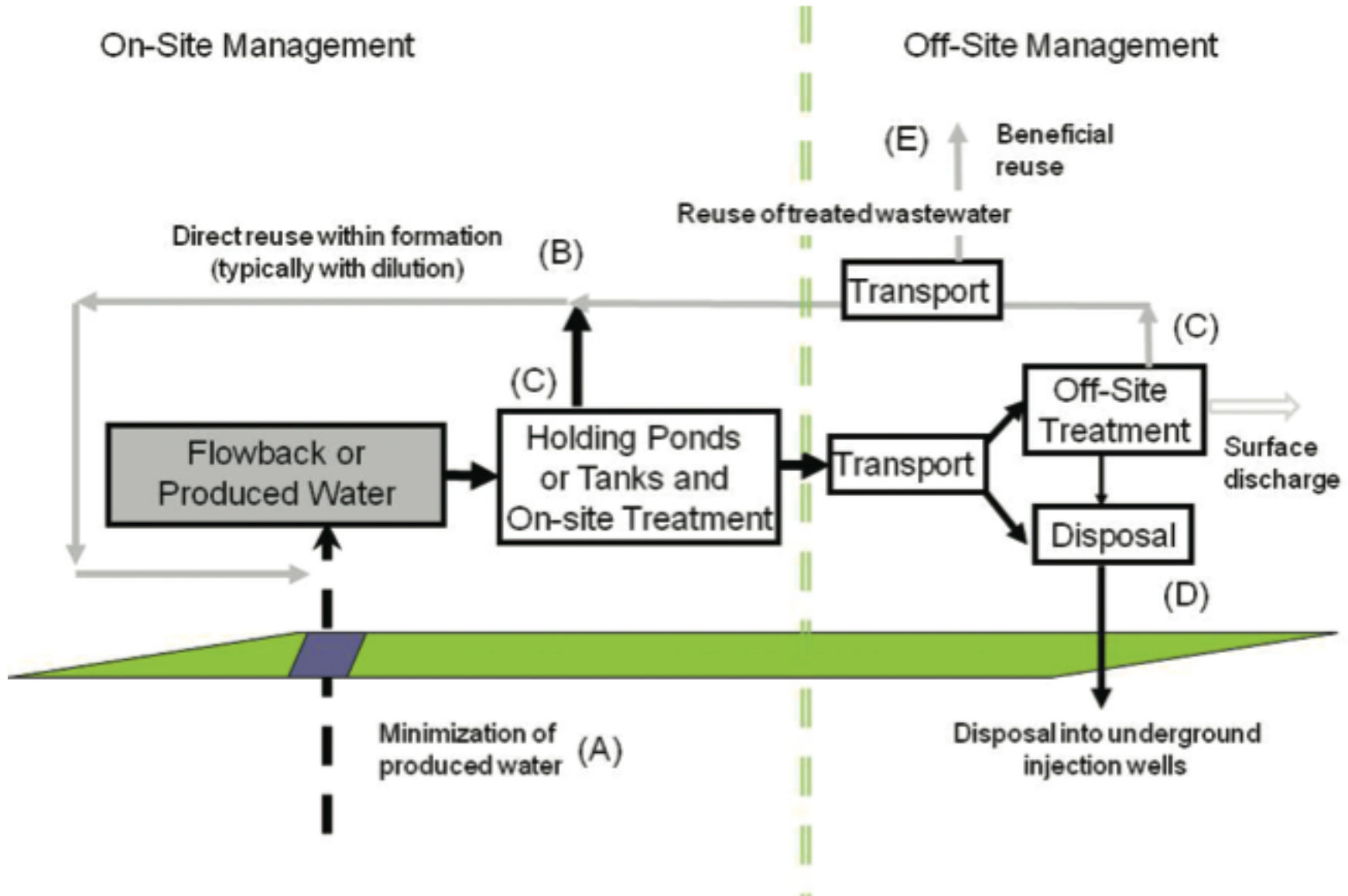


### 2% Proppants and Chemicals

**Proppants** are sand material that keeps bedrock fractures open to allow gas to flow out

**Chemicals** are used to dissolve minerals, kill bacteria, thicken the fluid, prevent corrosion of pipe, and otherwise aid the fracking process

# Water Output During Production Process



# PA Marcellus Shale Fluid Waste 2012

Waste product	Total amount reported	Landfill	Recycle on-site	Reuse off-site	Injection Disposal Well
Drilling fluid	2.0 million barrels	6 %	54 %	38 %	2 %
Flowback fluid	9.7 million barrels	N/A	15 %	84 %	N/A
Produced fluid	17 million barrels	N/A	13 %	67 %	<b>20 %</b>

# ▶ Marcellus Shale Produced Water Major Constituents

Constituent	Concentration range (mg / L) 5 - 14 days post fracturing
Total Dissolved Solids	38,500 – 261,000
Chloride	26,400 – 181,000
Sodium	10,700 – 95,500
Hardness (as CaCO <sub>3</sub> )	5,100 – 95,000
Barium	21.4 – 13,600
Strontium	345 – 3,580
Bromide	185 – 1,600
TENORMs	Non-detect -2,460 pCi / L

mostly brine,  
other salts

-high level of  
conductance

*Adapted from T. Hayes (2009: "Sampling and Analysis of Water Streams Associated with Marcellus Shale Gas" and Rowen et.al. 2011: "Radium Content of Oil-and Gas-Fields Produced Waters in Northern Appalachian Basin ")*

# Marcellus Shale Water Standard Analysis Codes

SAC	matrix*	Total # analytes	Total time (min)	Title (representative analytes)
46	SW	27	118	<b>Marcellus Shale</b> (pH/SPC/alk/BOD/TSS/TDS/nutrients/ metals/Br-/OSpress)
942	DW	14	44	<b>BOGM update</b> (pH/SPC/Alk/Hardness/TDS/Ca,Mg,Na,K,Fe,Mn,Ba,Sr/Cl-)
944	WW	45	258	<b>Marcellus Inorganic Survey</b> (pH/BOD/COD/oil&grease/nutrients/color/cyanide/sulfide/ F-/24 metals /phenols/TDS/Hg)
946	DW	23	86	<b>BOGM Drinking Water Analysis</b> (942 + Br-/sulfate/As/Zn/Al/Li/Se/Residue/Turbidity)

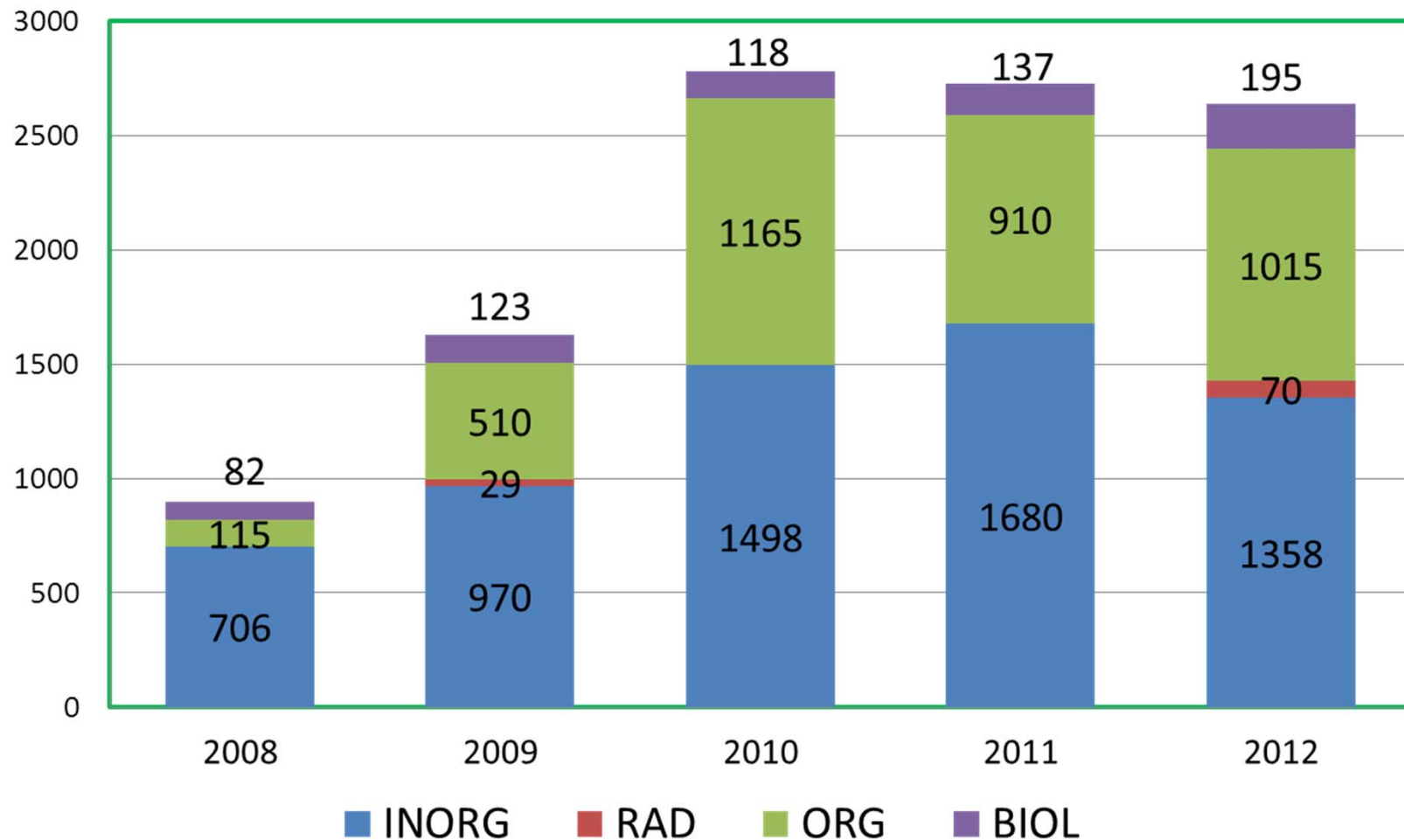
\*SW = surface water, DW = drinking water, WW = wastewater



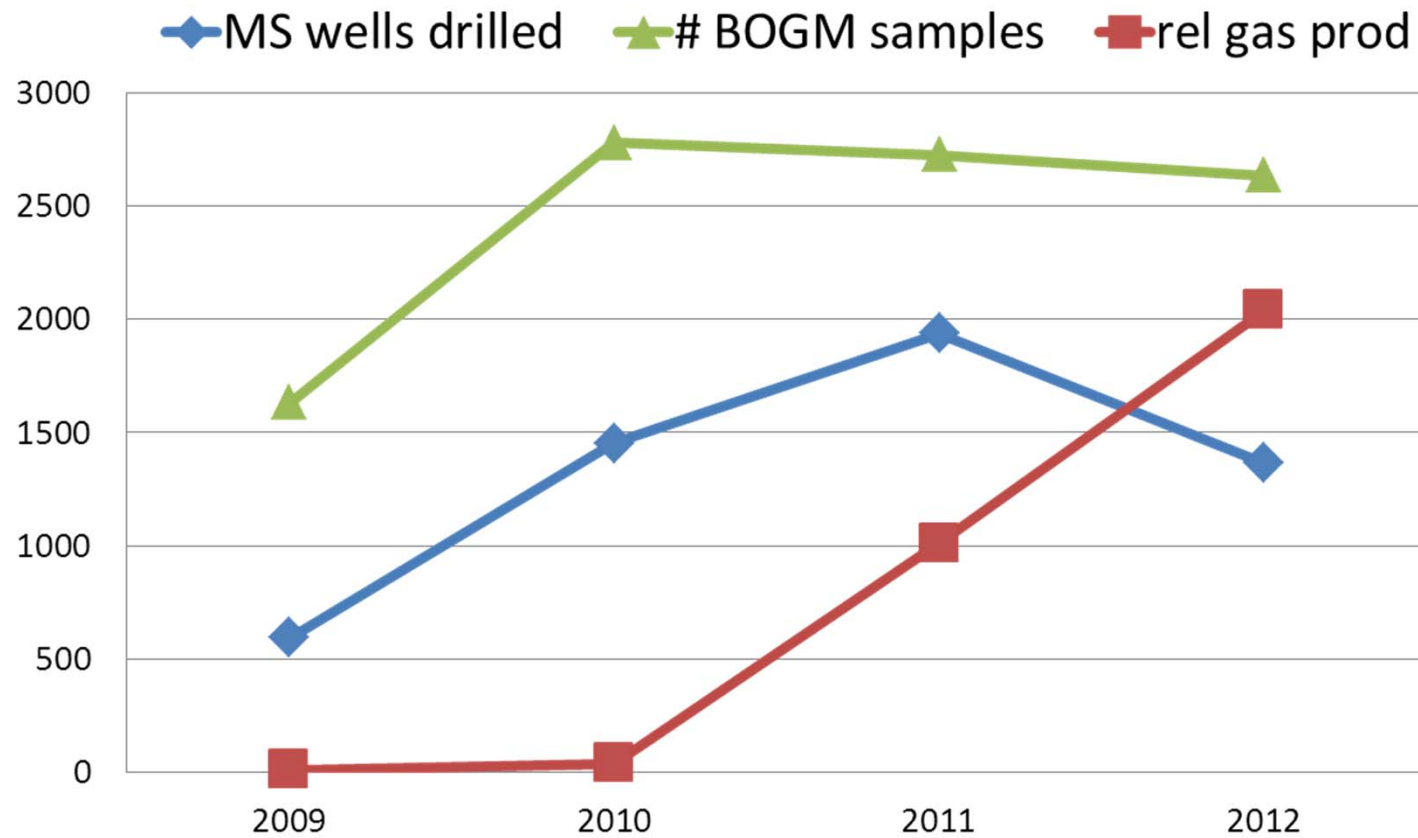
# Marcellus Shale Activity Increased Sample Analyses

Samples submitted to the BOL by PA Bureau of Oil & Gas Management

**200 % increase** in total samples since 2008



# BOGM Sample Submission and Shale Well Drilling



Why did BOGM sample submission to BOL remain steady when well drilling dropped 30 % in 2012 ?

## 2012 BOL Dimock Sample Analyses

Received a total of **568 samples** during a **two month** timeframe

- **12 analytes** required a 5 day turn around time
  - coliform bacteria
  - four glycol species
  - methane
  - metals (Al, As, Li, Mn, Na, & Fe)
- remaining **250 analytes** to be completed within 15 days (including gamma, gross alpha/beta radiation)



[http://old.postgazette.com/images/20101222dimock\\_pa\\_235.png](http://old.postgazette.com/images/20101222dimock_pa_235.png)

Philadelphia

## 2012 BOL Dimock Sample Workload Impact

Completion of all samples required:

1032 analytical hours	}	190 working
~300 incidental hours		days needed

43 actual working days during 9 weeks of project

4.5 full time staff required

33 total full time analytical staff at BOL

Roughly **15 % increase** in staff workload

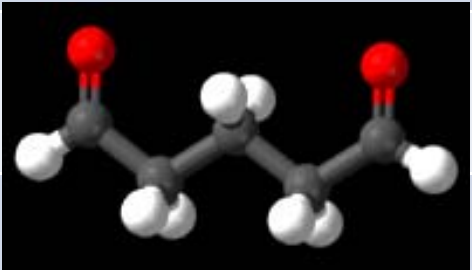
## All 2012 BOGM Samples Analytical Hours

<b>BOL Section</b>	<b>Total samples</b>	<b>Total analytical tests</b>	<b>Total analytical hours</b>
<b>BIOLOGICAL</b> ( <i>E. coli</i> , total coliforms)	195	308	58
<b>RADIOLOGICAL</b> (gamma, gross alpha/beta)	70	210	47
<b>ORGANIC</b> (methane, semi/volatiles)	1015	32,900	811
<b>INORGANIC</b> (ions, pH, solids, metals)	1358	29,900	2017

**2012 Total Analytical Time = 2933 hr**

# Advancing Marcellus Shale Monitoring

## Addition of indicator compounds to current methods

Flowback fluid:	Impoundment fluids:
diethylene glycol	glutaraldehyde*
triethylene glycol	
2-butoxyethanol	

\* May also be present in flowback fluids

# Advancing Marcellus Shale Monitoring

## Developing methane detection methods

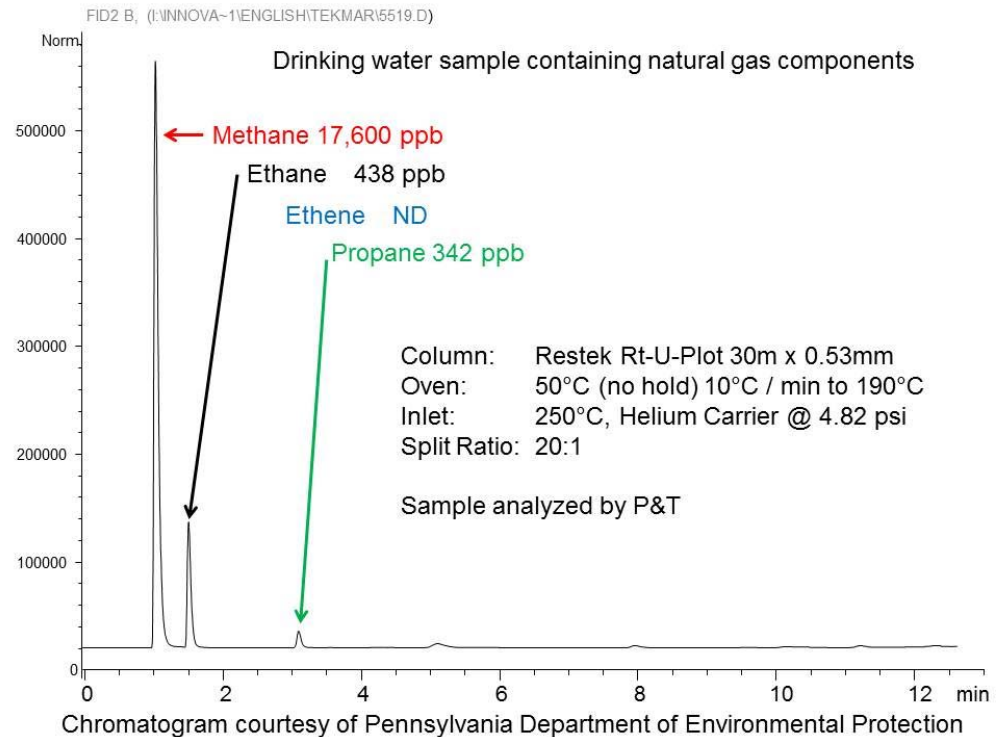
### Purge and trap analysis of methane concentration in water

(collaboration w/ Teledyne Tekmar)

- purge and trap apparatus more common and involves less sample manipulation than headspace equilibrium techniques

Potential to add methods for isotopic analysis?

- useful for methane migration investigations



# Advancing Marcellus Shale Monitoring

## Adapting radiological detection methods

Georgia Tech Method for Ra-226/228 in Drinking Water

- co-precipitation method
- decreased preparation and in-growth time

Gamma Spectroscopy of TENORM  
(modified USEPA 901.1)

Direct activity measurement  
Th-230, Ra-226

Inferred activity measurement  
Th-232, Ra-228, U-238

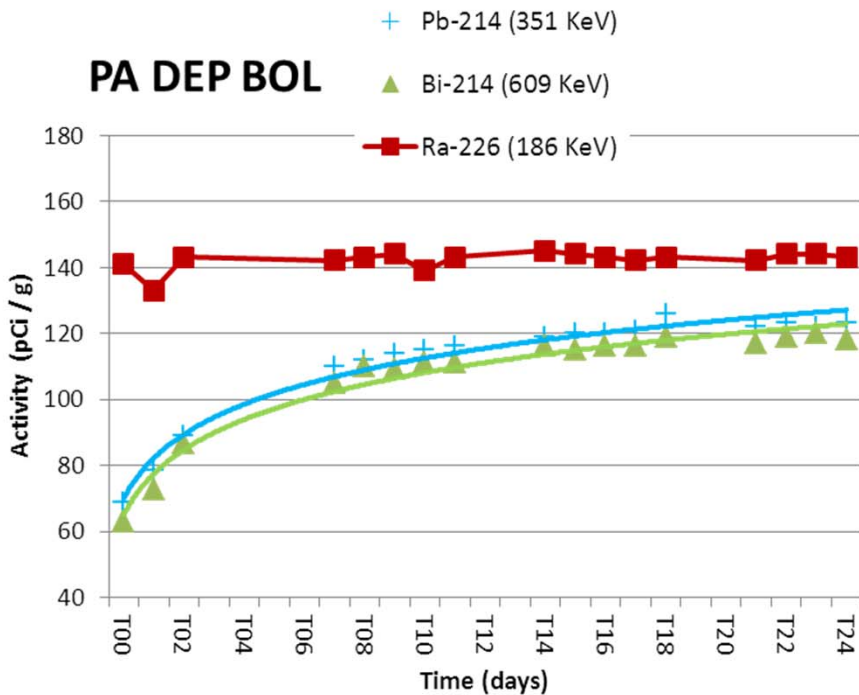




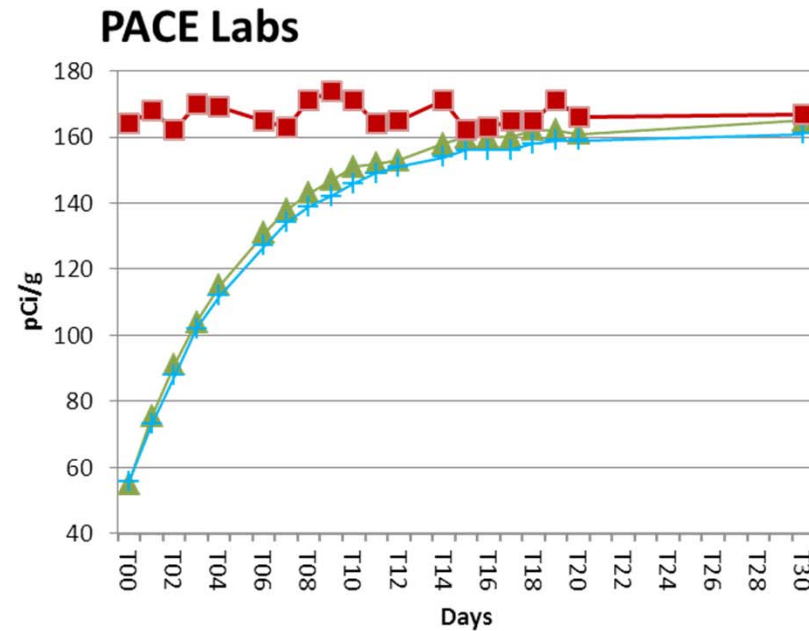
# TENORM Split Sample Study

## Sludge #1

	Ac -228 (911 KeV)	U -235 (185 KeV)
PA BOL	14.8 pCi / g	8.64 pCi / g
PACE Labs	21 pCi / g	0.10 pCi / g



500 g in 0.5 L Marenelli (4 $\pi$ )  
 1000 min count time  
 Measure most abundant line  
 MDL = 1 pCi/g

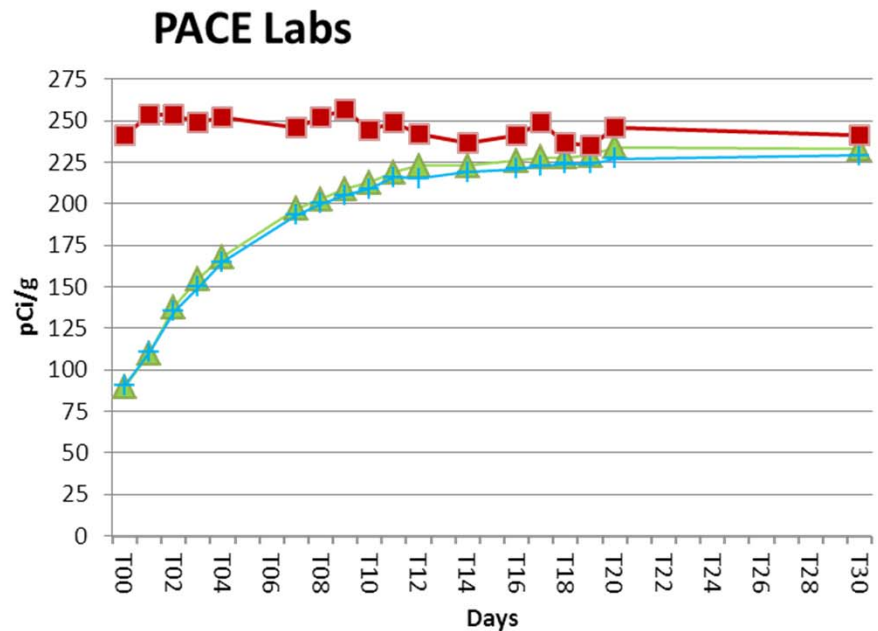
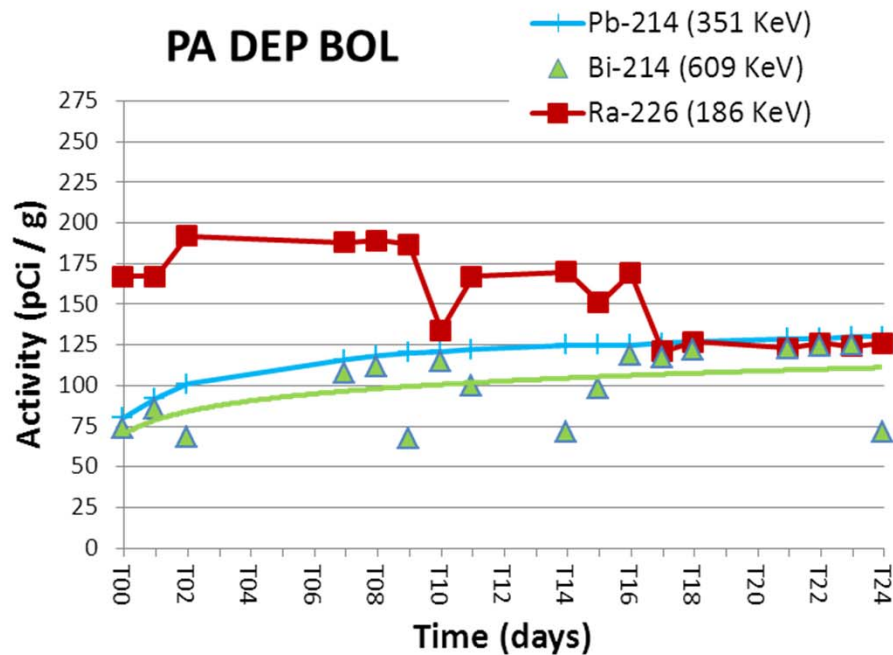


225 g in 8 oz cartridge (2 $\pi$ )  
 180 min count time  
 Measure all energy lines  
 MDL = 5 - 9 pCi/g

# TENORM Split Sample Study

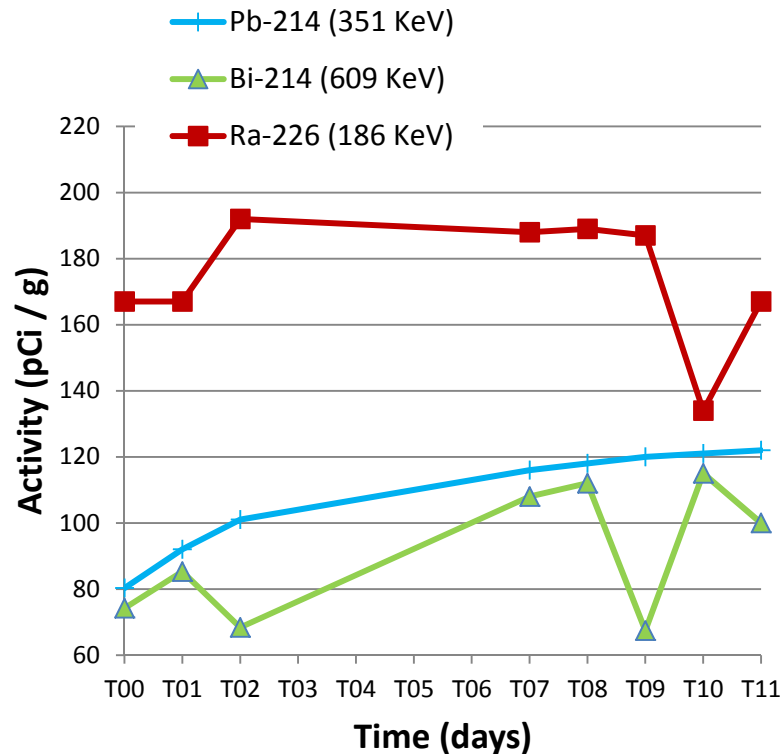
## Brine Sludge #2

	Ac -228 (911 KeV)	U -235 (185 KeV)
PA BOL	118 pCi / g	9.38 pCi / g
PACE Labs	188 pCi / g	-1.0 pCi / g



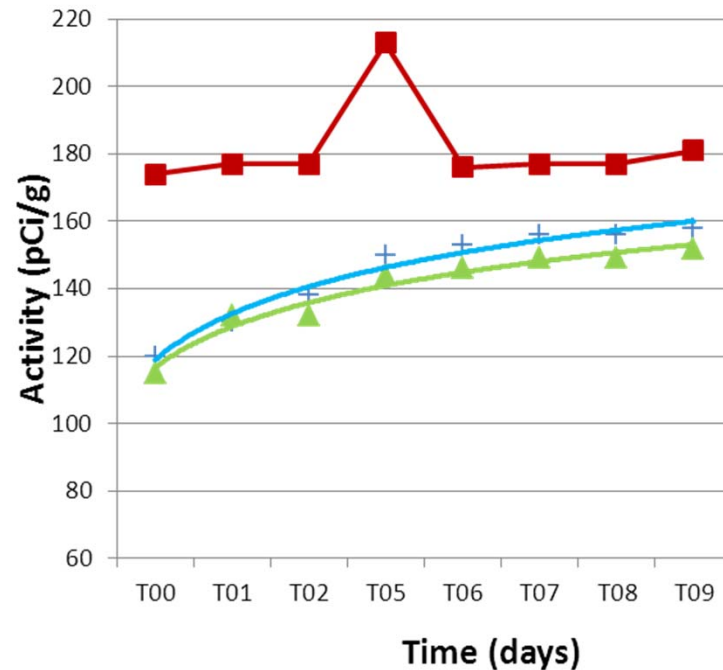
# PA BOL TENORM Re-Analysis

## Brine Sludge #2



Dried sample not ground

- less homogenous
- more variation in counts
- lower activity levels detected



Dried sample ground

- more homogenous
- less variation in counts
- higher activity levels detected

# PA TENORM Survey: Projected BOL Impact

	Gamma Spec	Gross Alpha/ Beta	Ra 226 / Ra 228	Alpha Spec	XRF / ICPMS
Soil/sludge sediment Smear	333	450	34	30	33
Water	497	497	50	50	0
Sample Total	830	947	84	80	33
Analytical time (hr)	471	406	562	380	8

1820 Analytical hours, one year time frame  
 (~ 40 fold increase for Radiation Section from 2012)

# Mitigating Media Misunderstanding

**Lawmaker** challenges Pa. DEP's reporting of gas well water safety

Pittsburgh Post-Gazette Nov 02, 2012

Pennsylvania Report **Left Out Data** on **Poisons** in Water Near Gas Site

NY Times Nov 02, 2012

Alleged Pennsylvania DEP **Cover-Up** of Possible Fracking Contamination an **Abomination**

Food and Water Watch Nov 02, 2012

Pennsylvania Caught **Cheating** on Water Test that Showed Fracking Poisons

AllGov Nov 06, 2012

**DEP Chief Krancer** defends agency from critics of water testing practices

Trib Total media Nov 12, 2012

Environmental groups urge **Corbett** to revamp Pennsylvania DEP's process for water testing

Pittsburgh Post Gazette Nov 14, 2012

DEP shelves more stringent water test

Times online Jan 22, 2013

Pennsylvania DEP **Ignores Stringent Testing**  
for Water Contamination from Fracking

Natural Resources Defense Council Feb 1, 2013

# Summary of BOL Operations Advancement

## **1) Update testing strategies as shale gas research advances**

Adjust SAC's to monitor specific types of impacts

Address new contaminants of concern as they emerge

## **2) Prepare for increased workload due to survey projects or emergency sampling related to shale gas activity**

## **3) Improve communication of laboratory practices/reports**

# Summary of BOL Operations Advancement

## **1) Update testing strategies as shale gas research advances**

Adjust SAC's to monitor specific types of impacts

Address new contaminants of concern as they emerge

## **2) Prepare for increased workload due to survey projects or emergency sampling related to shale gas activity**

Develop methods that improve sample turnaround time

Cross-train employees in various analytical methods

## **3) Improve communication of laboratory practices/reports**

# Summary of BOL Operations Advancement

## 1) Update testing strategies as shale gas research advances

Adjust SAC's to monitor specific types of impacts

Address new contaminants of concern as they emerge

## 2) Prepare for increased workload due to survey projects or emergency sampling related to shale gas activity

Develop methods that improve sample turnaround time

Cross-train employees in various analytical methods

## 3) Improve communication of laboratory practices/reports

Provide clear explanation of methodologies

Serve as a resource for understanding analytical reports





Bureau of Laboratories

# Questions? Contact us:

PA DEP Bureau of Laboratories  
(717)-346-7200

Martina Q. Mcgarvey, D.M.  
Director

[mmacgarvey@pa.gov](mailto:mmacgarvey@pa.gov)

Pamela J. Higgins, Ph.D.  
Special Assistant for Laboratory Operations

[pahiggins@pa.gov](mailto:pahiggins@pa.gov)