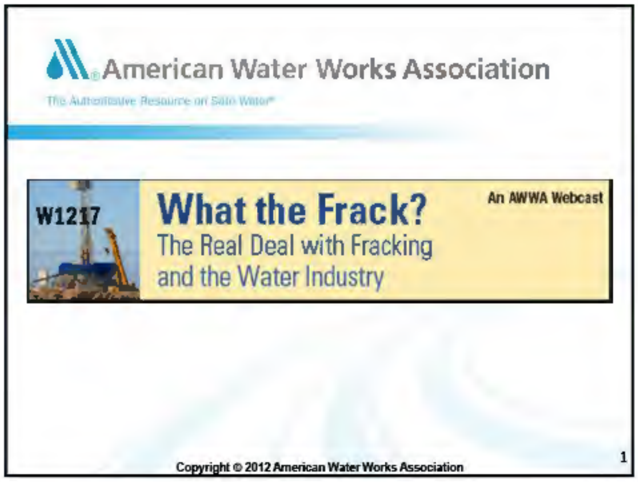

American Water Works Association

The Authoritative Resource on Safe Water®

W1217

What the Frack?

The Real Deal with Fracking and the Water Industry

An AWWA Webcast

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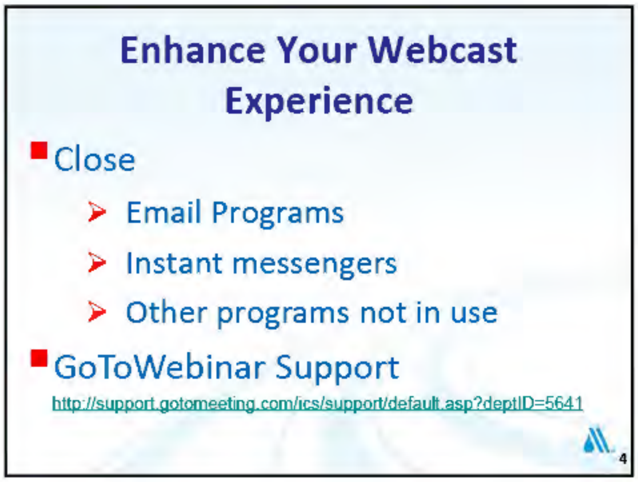
Agenda

I.	Webinar Introduction	Adam Carpenter
II.	Hydraulic Fracturing	John Satterfield
III.	Fracking: Fears and Facts…	Van Brahana
IV.	Bromide, TDS & Radionuclides…	Stanley States

Webinar Moderator

Adam Carpenter
Regulatory Analyst
American Water
Works Association



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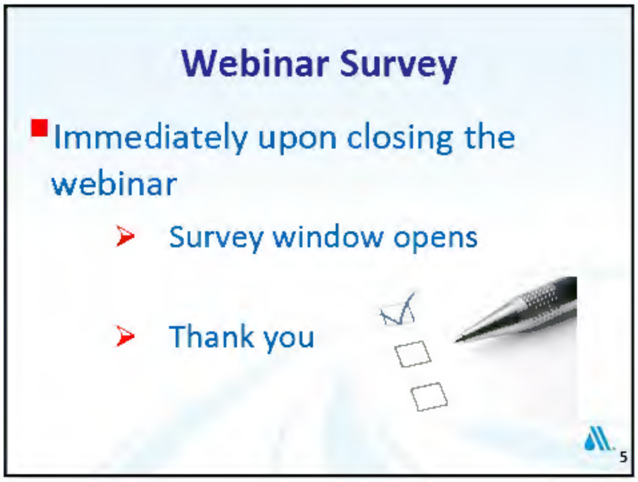

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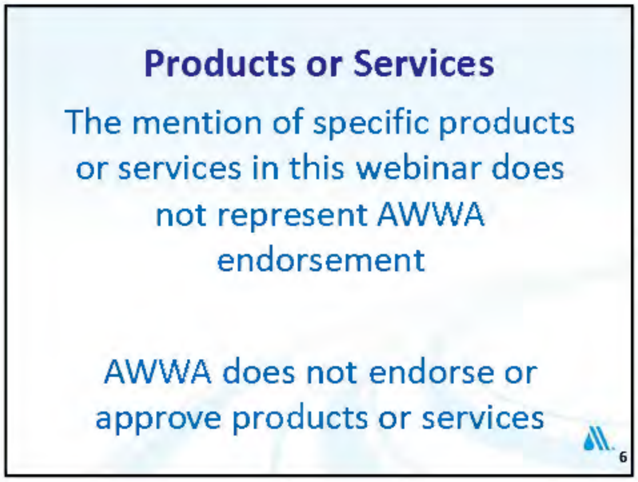

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Panel of Experts

John Satterfield
Director of Environmental & Regulatory Affairs
Chesapeake Energy

Van Brahana
Professor of Hydrogeology
University of Arkansas

Stanley States
Director, Water Quality & Production
Pittsburgh Water & Sewer Authority

Ask the Experts

John Satterfield

Van Brahana

Stanley States

Enter your question into the question pane at the lower right hand side of the screen.

Please include your name and specify to whom you are addressing the question.

Hydraulic Fracturing

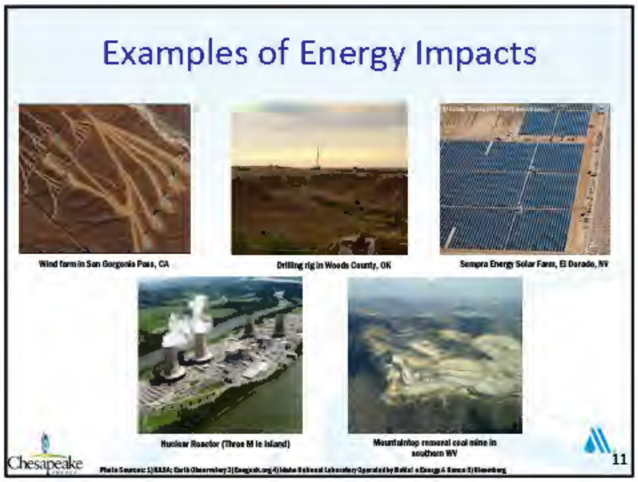
John Satterfield
Director of Environmental and Regulatory Affairs

Objectives

- To define key aspects of hydraulic fracturing
  - The benefits of using HF for natural gas and oil production
  - History of the practice
  - Safe, engineered, regulated process
- To address industry concerns facing hydraulic fracturing
  - Groundwater protection
    - Casing program
  - Fluid migration
    - Frac design and physics
  - Surface water protection
    - Site construction
    - Spill control
  - Water disposal/recycle/reuse
  - Water use

Chesapeake

10



Examples of Energy Impacts

Wind farm in San Gorgonio Pass, CA

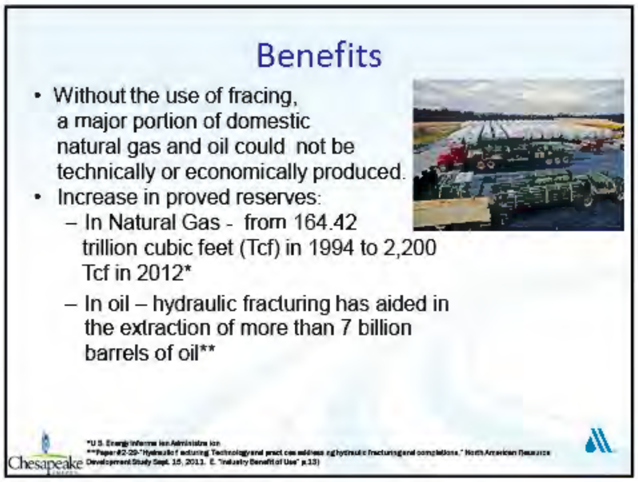
Drilling rig in Woods County, OK

Sempra Energy Solar Farm, El Dorado, NV

Nuclear Reactor (Three Mile Island)

Mountaintop removal coal mine in southern WV

Photo Sources: 1)NASA; Earth Observatory 3)Energyask.org 4)Idaho National Laboratory Operated by Battelle Energy Alliance 5)Bloomberg

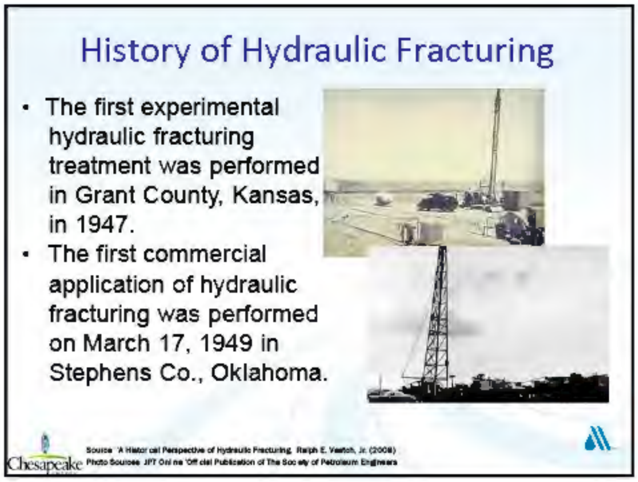


Benefits

- Without the use of fracing, a major portion of domestic natural gas and oil could not be technically or economically produced.
- Increase in proved reserves:
  - In Natural Gas - from 164.42 trillion cubic feet (Tcf) in 1994 to 2,200 Tcf in 2012*
  - In oil – hydraulic fracturing has aided in the extraction of more than 7 billion barrels of oil**

*U.S. Energy Information Administration

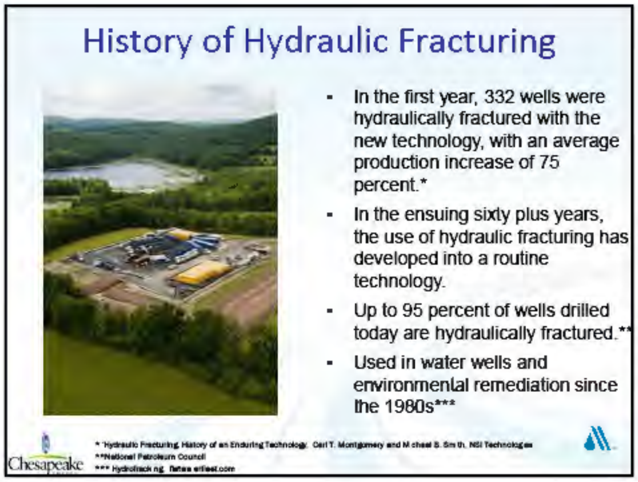
**Paper #2-29 "Hydraulic fracturing Technology and practices addressing hydraulic fracturing and completions," North American Resource Development Study Sept. 15, 2011. (I. "Industry Benefit of Use" p.13)



History of Hydraulic Fracturing

- The first experimental hydraulic fracturing treatment was performed in Grant County, Kansas, in 1947.
- The first commercial application of hydraulic fracturing was performed on March 17, 1949 in Stephens Co., Oklahoma.

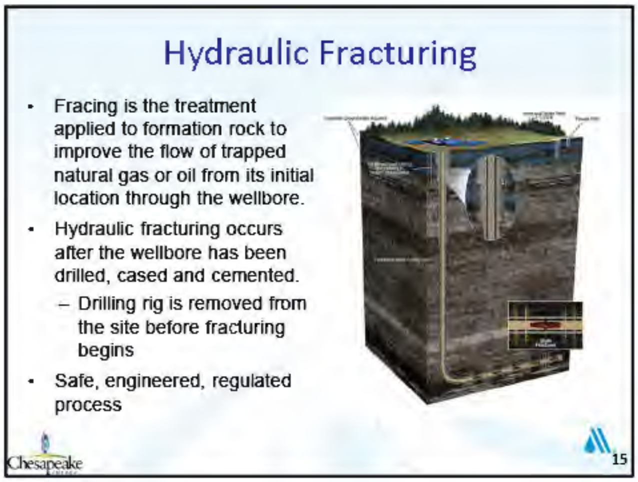
Source: 'A Historical Perspective of Hydraulic Fracturing,' Ralph E. Veatch, Jr. (2008)
Photo Sources: JPT Online 'Official Publication of The Society of Petroleum Engineers



History of Hydraulic Fracturing

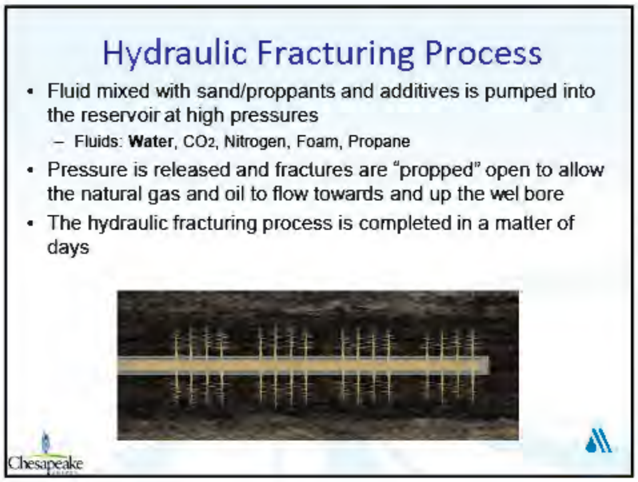
- In the first year, 332 wells were hydraulically fractured with the new technology, with an average production increase of 75 percent.*
- In the ensuing sixty plus years, the use of hydraulic fracturing has developed into a routine technology.
- Up to 95 percent of wells drilled today are hydraulically fractured.**
- Used in water wells and environmental remediation since the 1980s***

* 'Hydraulic Fracturing: History of an Enduring Technology,' Carl T. Montgomery and Michael B. Smith, NSI Technologies
**National Petroleum Council
*** Hydrofracking, [illegible]



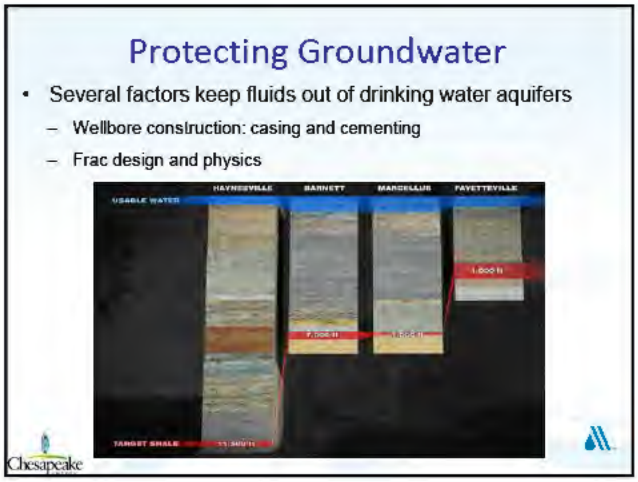
Hydraulic Fracturing

- Fracing is the treatment applied to formation rock to improve the flow of trapped natural gas or oil from its initial location through the wellbore.
- Hydraulic fracturing occurs after the wellbore has been drilled, cased and cemented.
  - Drilling rig is removed from the site before fracturing begins
- Safe, engineered, regulated process



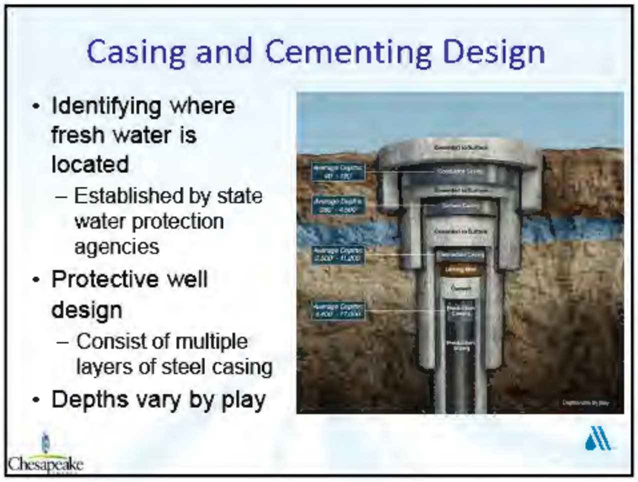
Hydraulic Fracturing Process

- Fluid mixed with sand/proppants and additives is pumped into the reservoir at high pressures
  - Fluids: **Water**, CO_2, Nitrogen, Foam, Propane
- Pressure is released and fractures are "propped" open to allow the natural gas and oil to flow towards and up the well bore
- The hydraulic fracturing process is completed in a matter of days



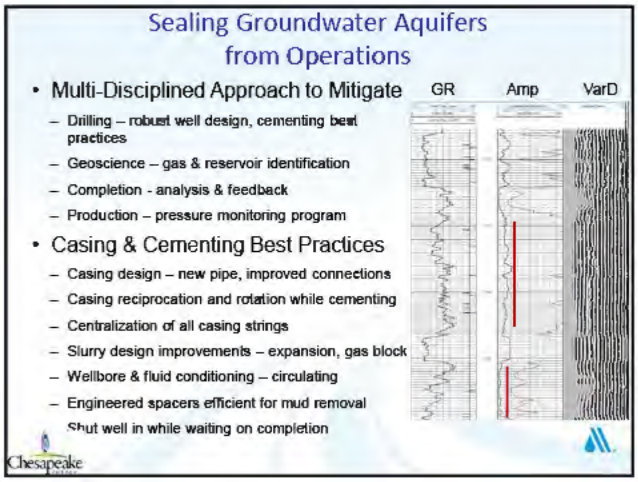
Protecting Groundwater

- Several factors keep fluids out of drinking water aquifers
  - Wellbore construction: casing and cementing
  - Frac design and physics



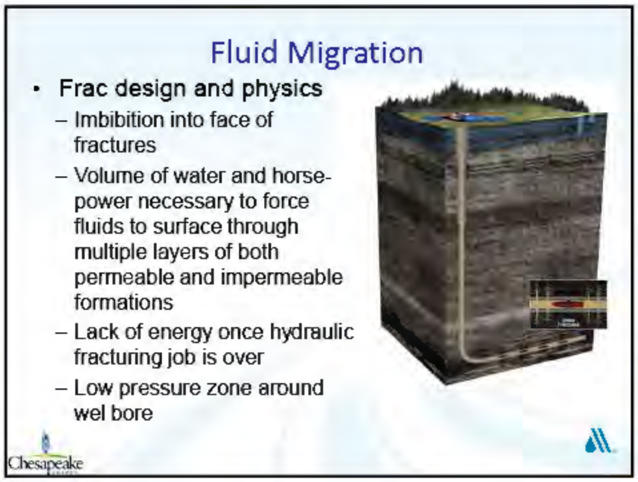
Casing and Cementing Design

- Identifying where fresh water is located
  - Established by state water protection agencies
- Protective well design
  - Consist of multiple layers of steel casing
- Depths vary by play



Sealing Groundwater Aquifers from Operations

- Multi-Disciplined Approach to Mitigate
  - Drilling – robust well design, cementing best practices
  - Geoscience – gas & reservoir identification
  - Completion - analysis & feedback
  - Production – pressure monitoring program
- Casing & Cementing Best Practices
  - Casing design – new pipe, improved connections
  - Casing reciprocation and rotation while cementing
  - Centralization of all casing strings
  - Slurry design improvements – expansion, gas block
  - Wellbore & fluid conditioning – circulating
  - Engineered spacers efficient for mud removal
  - Shut well in while waiting on completion

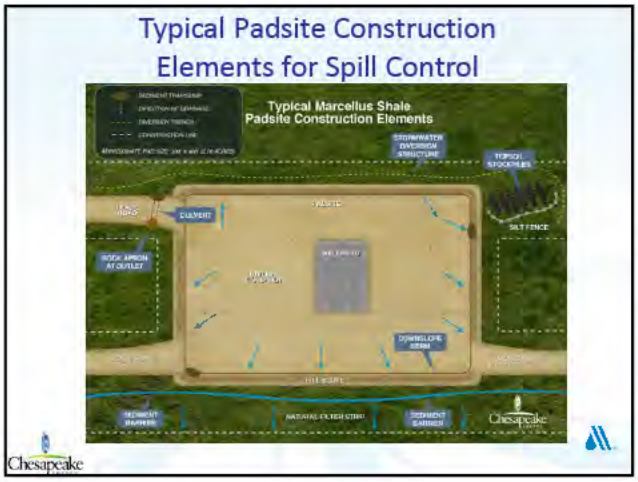


Fluid Migration

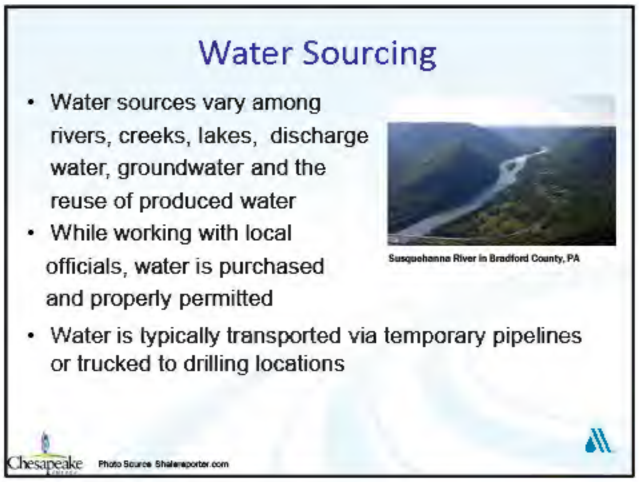
- Frac design and physics
  - Imbibition into face of fractures
  - Volume of water and horse-power necessary to force fluids to surface through multiple layers of both permeable and impermeable formations
  - Lack of energy once hydraulic fracturing job is over
  - Low pressure zone around wel bore

Site Erosion Control & Protection of Surface Water Resources

- Diversion ditches
- Berms
- Drainage ditches and ditch checks
- Sediment traps and basins
- Culvert pipes and outlet protection
- Sediment barriers such as silt fences and windrows of brush
- Stockpiling of topsoil
- Temporary and permanent revegetation
- Regular inspection and maintenance of controls



Typical Padsite Construction Elements for Spill Control

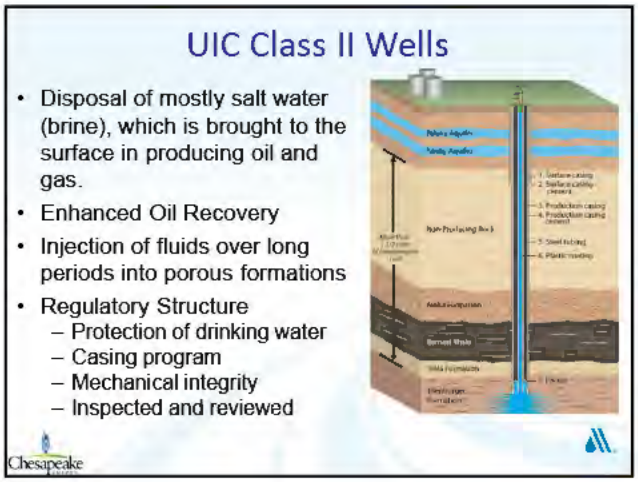


Water Sourcing

- Water sources vary among rivers, creeks, lakes, discharge water, groundwater and the reuse of produced water
- While working with local officials, water is purchased and properly permitted
- Water is typically transported via temporary pipelines or trucked to drilling locations

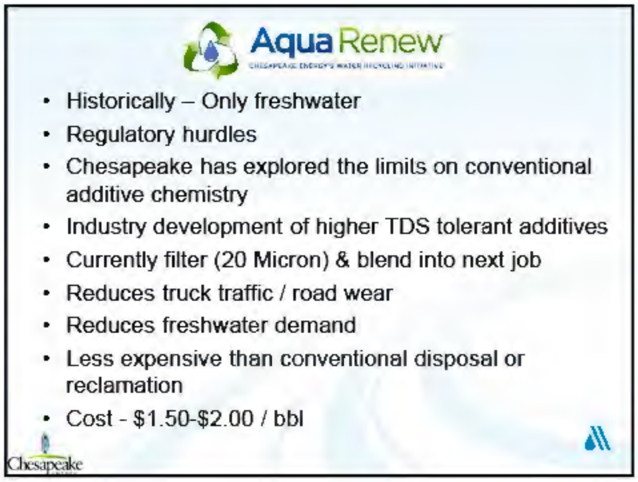
Susquehanna River in Bradford County, PA

Photo Source Shalereporter.com



UIC Class II Wells

- Disposal of mostly salt water (brine), which is brought to the surface in producing oil and gas.
- Enhanced Oil Recovery
- Injection of fluids over long periods into porous formations
- Regulatory Structure
  - Protection of drinking water
  - Casing program
  - Mechanical integrity
  - Inspected and reviewed

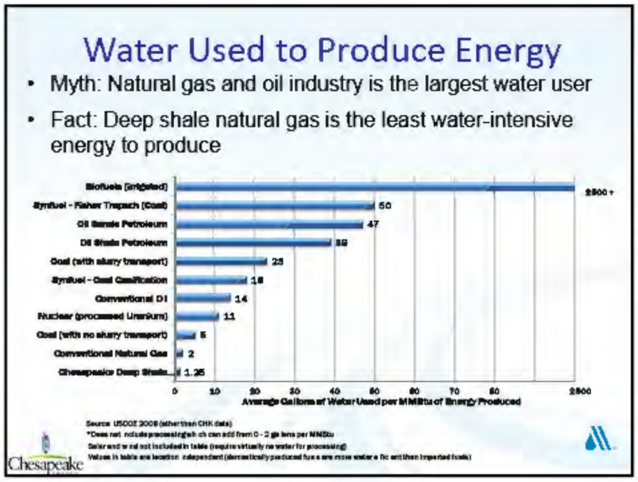


Aqua Renew

CHESAPEAKE ENERGY'S WATER RECYCLING INITIATIVE

- Historically – Only freshwater
- Regulatory hurdles
- Chesapeake has explored the limits on conventional additive chemistry
- Industry development of higher TDS tolerant additives
- Currently filter (20 Micron) & blend into next job
- Reduces truck traffic / road wear
- Reduces freshwater demand
- Less expensive than conventional disposal or reclamation
- Cost - $1.50-$2.00 / bbl

Chesapeake

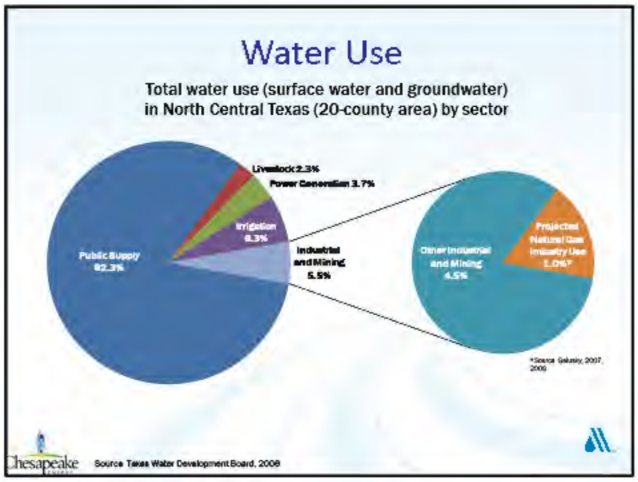


Water Used to Produce Energy

- Myth: Natural gas and oil industry is the largest water user
- Fact: Deep shale natural gas is the least water-intensive energy to produce

Source: USDOE 2006 (other than CHK data)
*Does not include processing which can add from 0 - 2 gallons per MMBtu
Solar and wind not included in table (require virtually no water for processing)
Values in table are location independent (domestically produced fuels are more water efficient than imported fuels)

Chesapeake



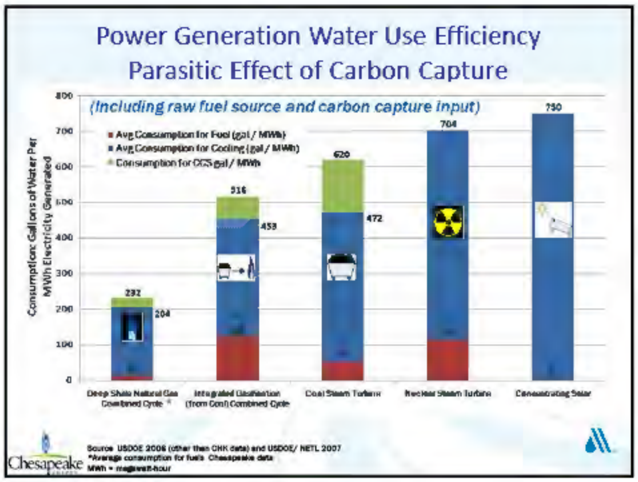
Water Use

Total water use (surface water and groundwater) in North Central Texas (20-county area) by sector

*Source: Galusky, 2007, 2009

Chesapeake

Source: Texas Water Development Board, 2006

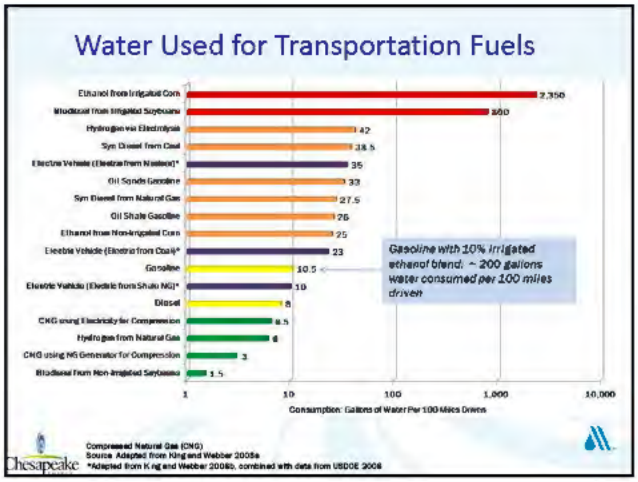


Power Generation Water Use Efficiency
Parasitic Effect of Carbon Capture

(Including raw fuel source and carbon capture input)

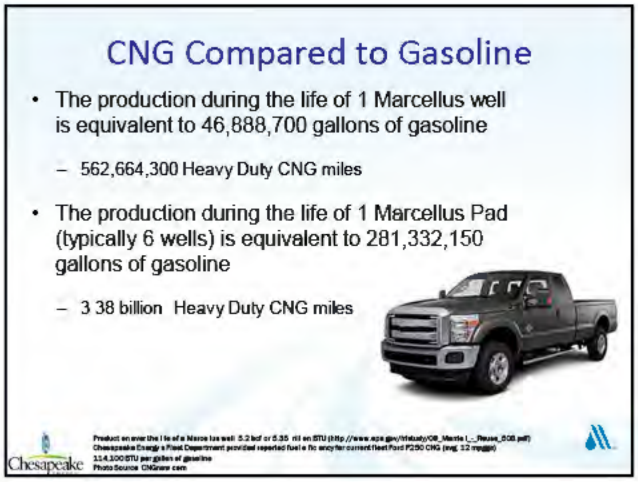
Source: USDOE 2006 (other than CHK data) and USDOE/ NETL 2007
*Average consumption for fuels: Chesapeake data
MWh = megawatt-hour

Chesapeake



Water Used for Transportation Fuels

Compressed Natural Gas (CNG)
Source: Adapted from King and Webber 2008a
*Adapted from King and Webber 2008b, combined with data from USDOE 2008



CNG Compared to Gasoline

- The production during the life of 1 Marcellus well is equivalent to 46,888,700 gallons of gasoline
  - 562,664,300 Heavy Duty CNG miles
- The production during the life of 1 Marcellus Pad (typically 6 wells) is equivalent to 281,332,150 gallons of gasoline
  - 3.38 billion Heavy Duty CNG miles

Production over the life of a Marcellus well: 5.2 bcf or 5.35 million BTU (http://www.epa.gov/hfstudy/09_Mantell_-_Reuse_508.pdf)
Chesapeake Energy's Fleet Department provided reported fuel efficiency for current fleet Ford F250 CNG (avg. 12 mpgge)
114,100 BTU per gallon of gasoline
Photo Source: CNGnow.com

Additional Resources

- www.AskChesapeake.com
- www.HydraulicFracturing.com
- www.NaturalGasWaterUsage.com
- www.NaturalGasAirEmissions.com
- www.FracFocus.org
- www.EnergyinDepth.com
- www.ANGA.com

Ask the Experts

John Satterfield
Van Brahana
Stanley States

Enter your question into the question pane at the lower right hand side of the screen.

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32

Fracking: Fears and Facts— Charting a Path to an Optimum Solution

Dr. Van Brahana
Professor, Department of Geology
University of Arkansas

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Overview

- A complex issue, with deeply held feelings, adversarial positions, and conflicting "science";
- This presentation will help you sort out the facts from the emotions to evaluate the overall benefits and drawbacks of hydraulic fracturing.

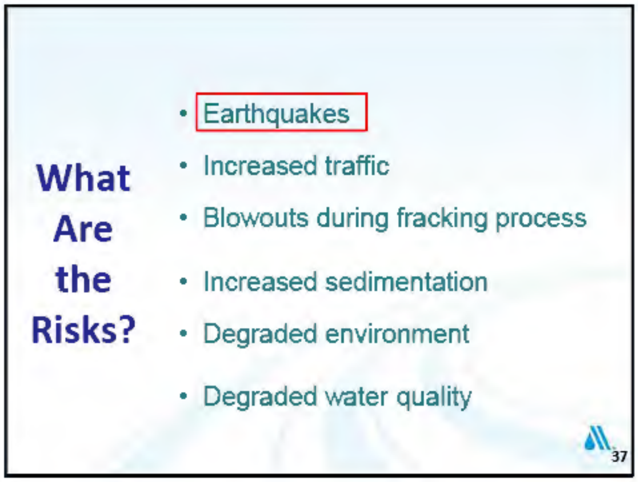
Learning Objectives

- As a result of this presentation, you will be able to assess 3 major questions about hydraulic fracking;
  1. you will learn about induced seismicity;
  2. you will see impacts from traffic; and
  3. you will gain facts about contamination.

The understanding gained should allow you to more effectively and accurately respond to stakeholder's concerns.

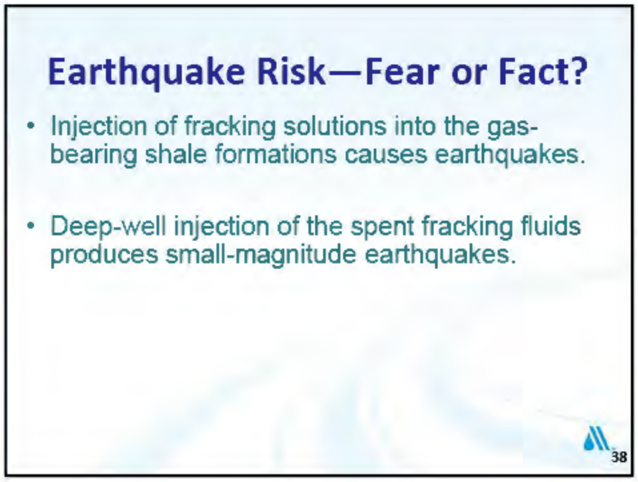
Agenda

1. Examine the risks, both real and perceived;
2. List limitations to our understanding;
3. Evaluate data from two "case-study" areas, the Marcellus and the Fayetteville;
4. Propose approaches to optimize both resource exploitation and environmental preservation.



What Are the Risks?

- Earthquakes
- Increased traffic
- Blowouts during fracking process
- Increased sedimentation
- Degraded environment
- Degraded water quality

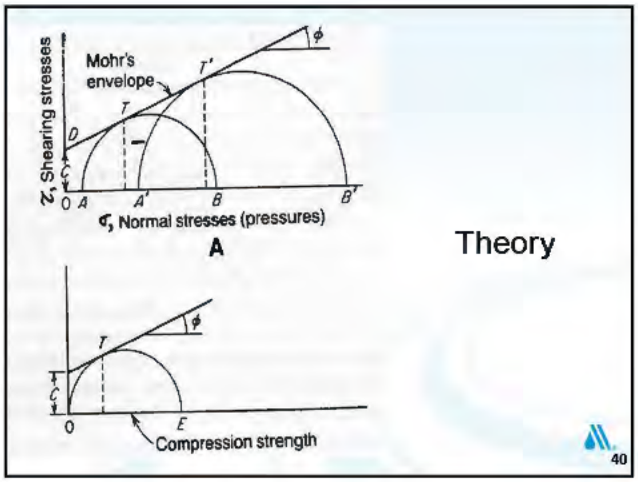


Earthquake Risk—Fear or Fact?

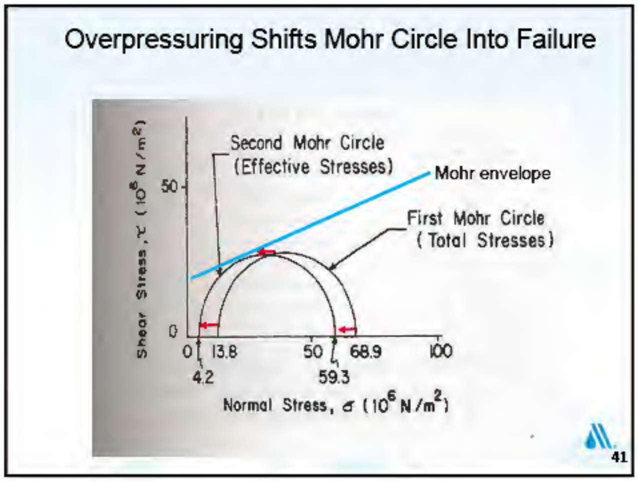
- Injection of fracking solutions into the gas-bearing shale formations causes earthquakes.
- Deep-well injection of the spent fracking fluids produces small-magnitude earthquakes.

Magnitude 7.4 Chi-Chi Earthquake 9/21/99 in Taiwan,

photo: Karl Meuller, Colorado Univ

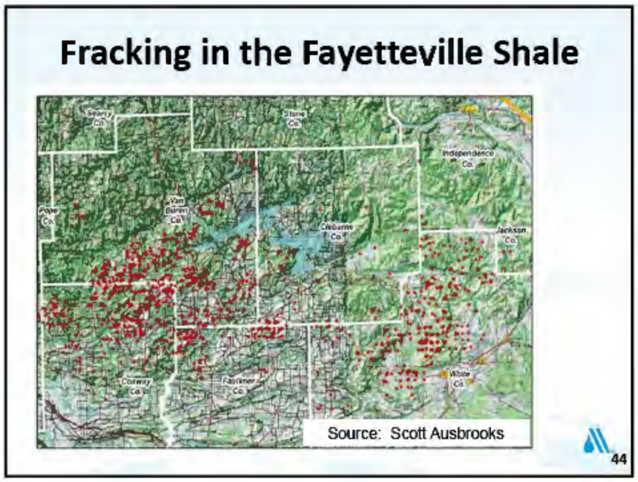


Theory



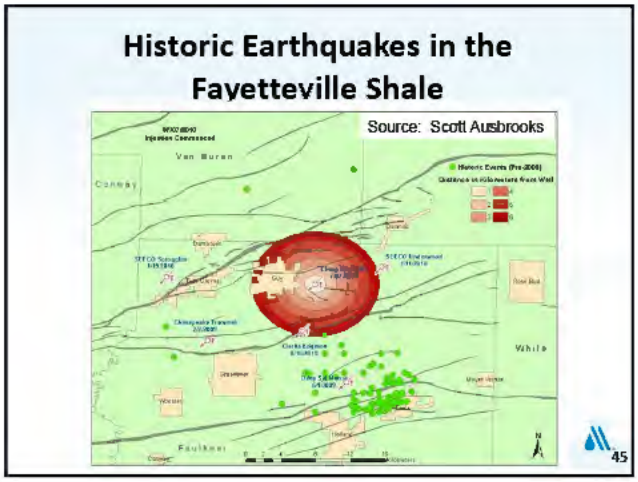
Overpressuring Shifts Mohr Circle Into Failure

Outcrop of Fayetteville Shale



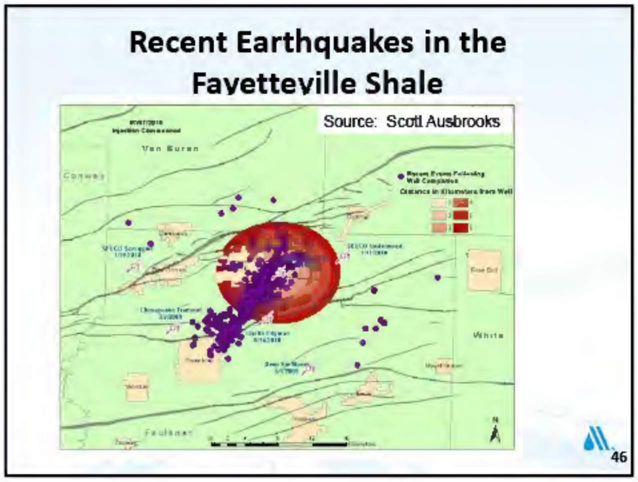
Fracking in the Fayetteville Shale

Source: Scott Ausbrooks



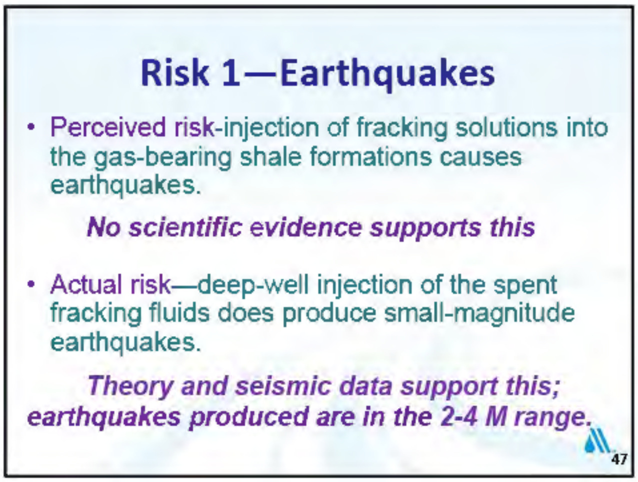
Historic Earthquakes in the Fayetteville Shale

Source: Scott Ausbrooks



Recent Earthquakes in the Fayetteville Shale

Source: Scott Ausbrooks



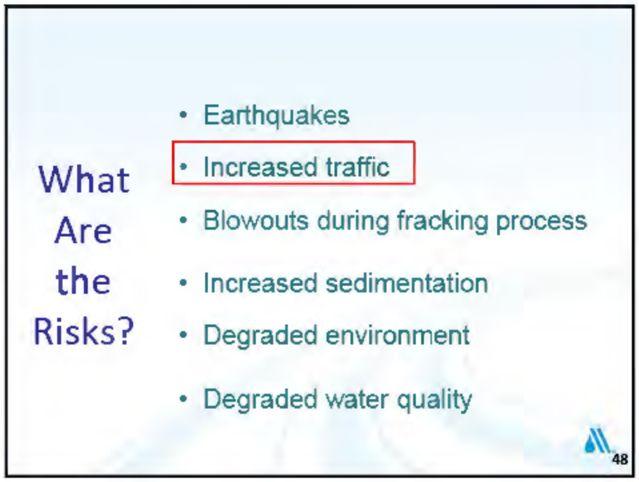
Risk 1—Earthquakes

- Perceived risk-injection of fracking solutions into the gas-bearing shale formations causes earthquakes.

No scientific evidence supports this

- Actual risk—deep-well injection of the spent fracking fluids does produce small-magnitude earthquakes.

Theory and seismic data support this; earthquakes produced are in the 2-4 M range.

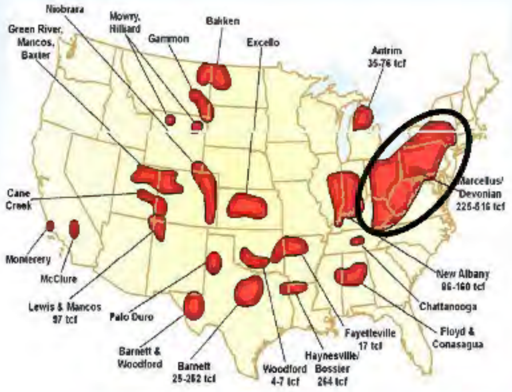


What Are the Risks?

- Earthquakes
- Increased traffic
- Blowouts during fracking process
- Increased sedimentation
- Degraded environment
- Degraded water quality

Traffic Risk—Fear or Fact?

- Fracking is a major industrial process, and the complete process is conducted in typically rural areas, using heavy equipment.
- Fracking is an *in situ* process, so the equipment must be transported to the site.
- Increased traffic occurs because of the need for large volumes of water used in the fracking process. In terms of tanker trucks, this typically can be from many tens to several hundred tanker trucks per frack job.



Fracking Traffic—Marcellus Shale

Fracking Traffic—Marcellus Shale


Source: MARCELLUS AIR@www.marcellus-shale.us

Risk 2—Increased Traffic

- Fact-Fracking is a major industrial process, and the complete process is conducted in typically rural areas, using heavy equipment.

  Observed-evidence supports this

- Fact-Fracking is an *in situ* process, so the equipment must be transported to the site.

  Observed-evidence supports this

- Fact-Increased traffic occurs because of the need for large volumes of water used in the fracking process. In terms of tanker trucks, this typically can be from many tens to several hundred tanker trucks per frack job.

  Observed-evidence supports this

Risk 2—Increased Traffic (2)

- Fact-It should be noted that the traffic to and from the well pad decreases significantly after the major construction phase, so that only operation, monitoring, maintenance, and security traffic occurs later in the history of each site. These latter activities do not require heavy equipment.

  Observed-evidence supports this

- Fact-It should also be noted that although major traffic occurs for a limited time at a single site, typically there are numerous sites within the area of a "play", and although the traffic increase of a single site has a relatively short duration, traffic in the entire play occurs over an extended period.

  Observed-evidence supports this

What the Risks Are

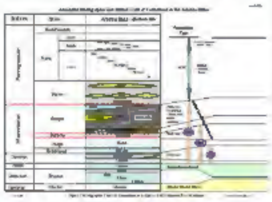
- Earthquakes
- Increased traffic
- Blowouts during fracking process
- Increased sedimentation
- Degraded environment
- Degraded water quality

Water-Quality Risk—Fear or Fact?

- Injection of fracking solutions will create gas and brine contamination pathways into the shallow aquifers that serve as drinking-water supplies.
- Fracking fluids contain "poisons".
- Unmapped faults and unplugged, abandoned wells are present, and these are leakage pathways.
- Failure of cement/casing couple will allow blowouts, which contaminate streams and shallow aquifers.

Subsurface Zones and Fracking in the Subsurface—Fayetteville Shale

Source: Sandia Technologies, LLC



Source: KB Amber LLC

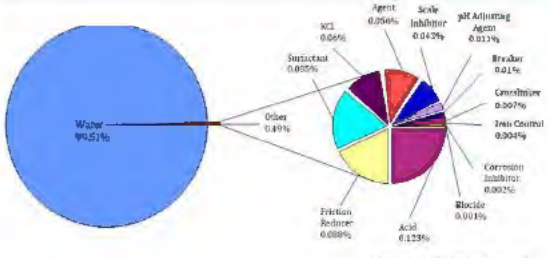
Shallow Groundwater Monitoring Fayetteville Shale

- Nottemeier (2012) sampled more than 100 wells from the ***Fayetteville Shale*** in north-central Arkansas, and found no evidence of groundwater contamination from fracking;
- Kresse et al. (2012) sampled more than 120 shallow wells in the major area of development of the ***Fayetteville Shale*** play and found no evidence of groundwater contamination from fracking.

Shallow Groundwater Monitoring Marcellus Shale

- Researchers from Duke University took hundreds of samples from groundwater aquifers in six counties overlying the ***Marcellus Shale*** in northeastern Pennsylvania and found elevated brine, biogenic gas (***NOT thermogenic***), but no evidence of fracking fluids.
- The study says it is unlikely that the elevated salinity is connected to hydraulic fracturing, or "fracking", but they are concerned that the presence of the brine suggests "natural pathways" leading up to aquifers from far below the surface, [unmapped faults] and that these pathways might allow gases from shale-gas wells to put drinking-water supplies at risk. (Osborn et al., 2011; Warner et al., 2012)

Composition of Fracking Fluids



Source: ALL Consulting, 2008

Suspect Appearances—The 2005 Bush-Cheney energy policy bill excluded fracking and the chemicals used in the process from the Safe Drinking Water Act.

Unmapped Faults & Unplugged Abandoned Wells

- In the tectonically deformed region of the ***Marcellus Shale*** (described earlier), unmapped faults might allow "gases from shale-gas wells to migrate and put shallow wells at risk." (Warner et al., 2012)
- Bertetti and Green (2012) indicated that "abandoned wells pose the greatest potential threat in deep-well disposal of waste fluids" … in the area of the ***Eagle Ford Shale*** play in south Texas.
- "Migration via an existing borehole (i.e., an abandoned, open well) is possible, particularly if an abandoned well is not identified, is reasonably close to the disposal well, and the contaminant is injected into the same horizon as the screened section of the abandoned well." (Bertetti and Green, 2012)

Blowouts

"ALLENTOWN - A blowout at a natural gas well in rural northern Pennsylvania spilled thousands of gallons of chemical-laced water Wednesday, contaminating a stream and forcing the evacuation of seven families who live nearby as crews struggled to stop the gusher."

No injuries; no explosion; no fire; no natural gas emissions; no fish kill in Towanda Creek, which is stocked with trout.
The point to be made is that the company experienced failure in the cementing job, but had followed regulations, thereby preventing any contaminated water to reach the stream.

Risk 3—Water-Quality Degradation

- Perceived risk-Injection of fracking solutions will create gas & brine contamination pathways into the shallow aquifers that serve as drinking water supplies.

  No scientific evidence supports this at this time, although it is a possibility
- Perceived risk-Fracking fluids contain "poisons".

  Fracking fluids and formation brines contain undesirable constituents, but these are not toxic or "poisonous"

Risk 3—Water-Quality Degradation (2)

- Actual Risk-Unmapped faults and unplugged, abandoned wells are present, and these are leakage pathways.

These appear to represent a real risk of unknown probability. Characterization, monitoring, and mitigation strategies should be in place, and rules rigidly enforced.

- Actual Risk-Failure of cement/casing couple will allow contamination of shallow aquifers & streams.

These appear to represent a real risk of unknown probability. Characterization, monitoring, observation and mitigation strategies should be in place, and rules rigidly enforced.

Summary

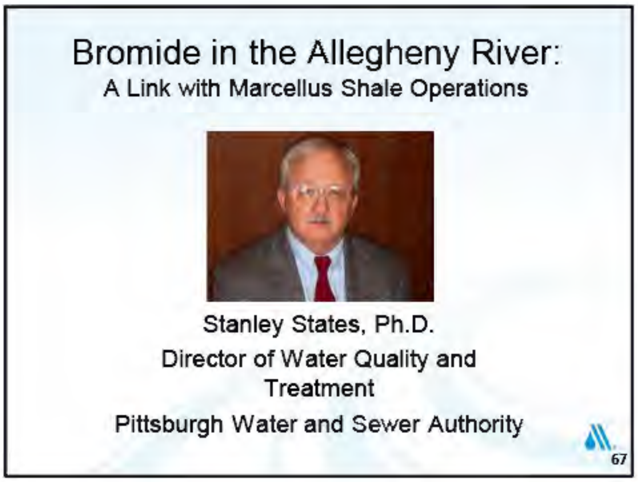
1. With fracking, there are risks that are both real and imagined. We need to share our understanding with all stakeholders, and be open and respectful.
2. Our understanding of the groundwater systems is limited, especially for subsurface conditions that are impossible to view directly. Those risks that occur at land surface appear to be well understood; those risks that deal with the subsurface should have a level of safety built in to protect the environment.
3. Based on natural variations in the tectonic setting and hydrogeologic framework of different areas, water-quality conditions should be fully characterized, monitored, observed, and if necessary, mitigated. We should implement and rigorously enforce regulations.
4. To optimize both resource exploitation (which will occur because the energy from this resource is fairly clean and fairly inexpensive) and environmental preservation (which is necessary because of our need to protect our water supplies in the shale-gas areas), we need to work together for long-term solutions built on the best understanding available. We need to overcome fear, share information openly, develop mutual respect, include all stakeholders, and technically strive to educate all.

Ask the Experts

John Satterfield Van Brahana Stanley States

Enter your question into the question pane at the lower right hand side of the screen.

Please include your name and specify to whom you are addressing the question.



Bromide in the Allegheny River:

A Link with Marcellus Shale Operations

Stanley States, Ph.D.
Director of Water Quality and Treatment
Pittsburgh Water and Sewer Authority

Pittsburgh Water and Sewer Authority

- Stanley States
- Gina Cyprych
- Mark Stoner
- Faith Wydra
- Jay Kuchta

University of Pittsburgh School of Engineering

- Leonard Casson
- Jason Monnell

Rationale

This presentation will help the viewer recognize drinking water quality problems that may be associated with fracking

This may help drinking water personnel deal with similar issues at their treatment plants

Learning Objectives

As a result of this presentation, viewers will become familiar with specific source water and finished water parameters that may change as a result of fracking

Viewers should also become aware of specific sources of contaminants in the raw water

Disinfection Byproduct Formation

Natural Organic Matter (NOM) + Chlorine + Bromide →

Trihalomethanes:
Chloroform ($CHCl_3$)
Dichlorobromomethane ($CHCl_2Br$)
Dibromochloromethane ($CHClBr_2$)
Bromoform ($CHBr_3$)

Total THMs and % Bromoform Contribution for PWSA Distribution Sites (Sept 2010)

SAMPLE LOCATION (Date)	TTHM (ppb)	% CONTRIBUTION OF BROMOFORM
Brashear Tank Influent (10 Sept)	132	59
4061 Perrysville Ave (16 Sept)	226	60
2000 Mt. Troy Rd. (16 Sept)	191	46
4620 Evergreen Rd. (17 Sept)	270	60
928 Chartiers Ave. (21 Sept)	225	48
Chestnut St. (21 Sept)	205	50
159 Homestead St. (21 Sept)	145	43

Questions

1. What effect does excess bromide in the river have on THM formation in drinking water?
   - Total THM concentration
   - % brominated species
2. How effective are drinking water plants in removing bromide from source water?
3. How much bromide is in the Allegheny River; how much does it vary; and what is the source of excess bromide?
   - Coal- Fired power Plants
   - Steel Mills
   - POTWs treating Marcellus Shale flowback water
   - Industrial ww plants treating Marcellus Shale flowback water
   - Abandoned mine drainage

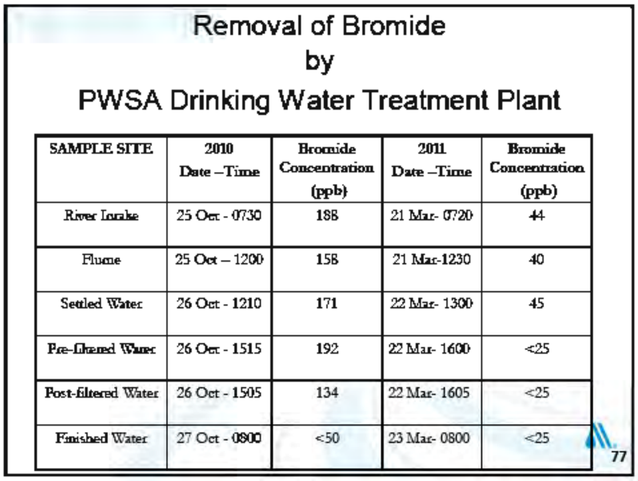
Effect of Excess Source Water Bromide on THM formation

TTHM Formation Potential Study (Effect of Experimental Addition of Bromide)

Bromide Supplement (ppb)	Total THMs (ppb)	% Concentration of Bromoform	% Concentration of Brominated Species
0*	102	1	22
20	88	1	31
60	121	1	44
100	113	3	58
150	129	5	69
200	133	10	77
300	123	27	89

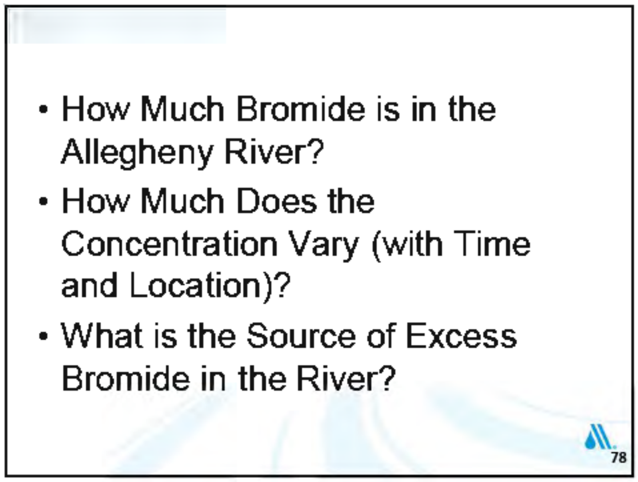
*Baseline bromide concentration= 39ppb

Effectiveness of Conventional Drinking Water Treatment in Removal of Bromide from Source Water

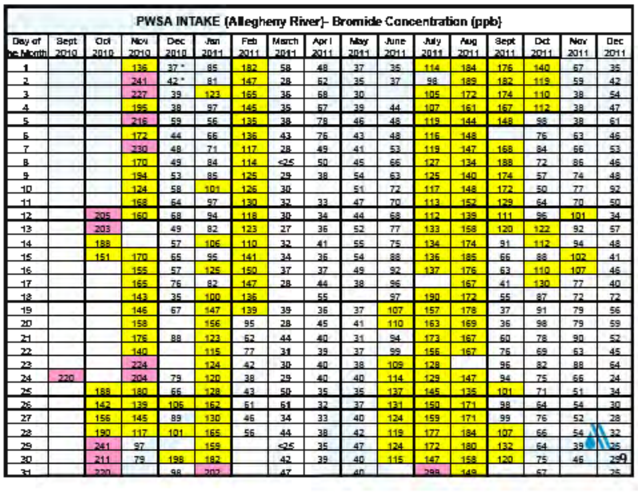


Removal of Bromide
by
PWSA Drinking Water Treatment Plant

SAMPLE SITE	2010 Date –Time	Bromide Concentration (ppb)	2011 Date –Time	Bromide Concentration (ppb)
River Intake	25 Oct - 0730	188	21 Mar- 0720	44
Flume	25 Oct – 1200	158	21 Mar-1230	40
Settled Water	26 Oct - 1210	171	22 Mar- 1300	45
Pre-filtered Water	26 Oct - 1515	192	22 Mar- 1600	<25
Post-filtered Water	26 Oct - 1505	134	22 Mar- 1605	<25
Finished Water	27 Oct - 0800	<50	23 Mar- 0800	<25

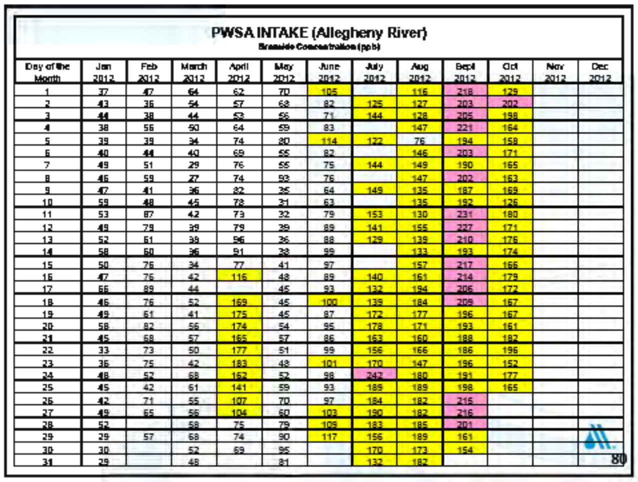


- How Much Bromide is in the Allegheny River?
- How Much Does the Concentration Vary (with Time and Location)?
- What is the Source of Excess Bromide in the River?



PWSA INTAKE (Allegheny River)- Bromide Concentration (ppb)

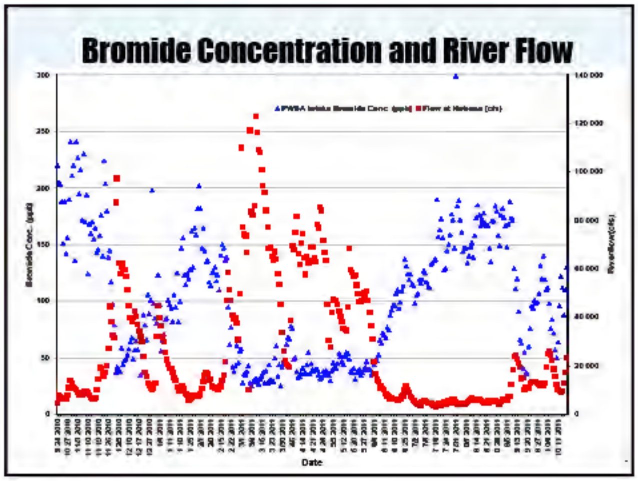
Day of the Month	Sept 2010	Oct 2010	Nov 2010	Dec 2010	Jan 2011	Feb 2011	March 2011	Apr l 2011	May 2011	June 2011	July 2011	Aug 2011	Sept 2011	Oct 2011	Nov 2011	Dec 2011
1			136	37 *	85	182	58	48	37	35	114	184	176	140	67	35
2			241	42 *	81	147	28	62	35	37	98	189	182	119	59	42
3			227	39	123	165	36	68	30		105	172	174	110	38	54
4			195	38	97	145	35	67	39	44	107	161	167	112	38	47
5			216	59	56	135	38	78	46	48	119	144	148	98	38	61
6			172	44	66	136	43	76	43	48	116	148		76	63	46
7			230	48	71	117	28	49	41	53	119	147	168	84	66	53
8			170	49	84	114	<25	50	45	66	127	134	188	72	86	46
9			194	53	85	125	29	38	54	63	125	140	174	57	74	48
10			124	58	101	126	30		51	72	117	148	172	50	77	92
11			168	64	97	130	32	33	47	70	113	152	129	64	70	50
12		205	160	68	94	118	30	34	44	68	112	139	111	96	101	34
13		203		49	82	123	27	36	52	77	133	158	120	122	92	57
14		188		57	106	110	32	41	55	75	134	174	91	112	94	48
15		151	170	65	95	141	34	36	54	88	136	185	66	88	102	41
16			155	57	125	150	37	37	49	92	137	176	63	110	107	46
17			165	76	82	147	28	44	38	96		167	41	130	77	40
18			143	35	100	136		55		97	190	172	55	87	72	72
19			146	67	147	139	39	36	37	107	157	178	37	91	79	56
20			158		156	95	28	45	41	110	163	169	36	98	79	59
21			176	88	123	62	44	40	31	94	173	167	60	78	90	52
22			140		115	77	31	39	37	99	156	167	76	69	63	45
23			224		124	42	30	40	38	109	128		96	82	88	64
24	220		204	79	120	38	29	40	40	114	129	147	94	75	66	24
25		188	180	66	128	43	50	35	35	137	145	135	101	71	51	34
26		142	139	106	162	61	61	32	37	131	150	171	98	64	54	30
27		156	145	89	130	46	34	33	40	124	159	171	99	76	52	28
28		190	117	101	165	56	44	38	42	119	177	184	107	66	54	32
29		241	97		159		<25	35	47	124	172	180	132	64	39	35
30		211	79	198	182		42	39	40	115	147	158	120	75	46	29
31		220		98	202		47		40		298	149		67		25

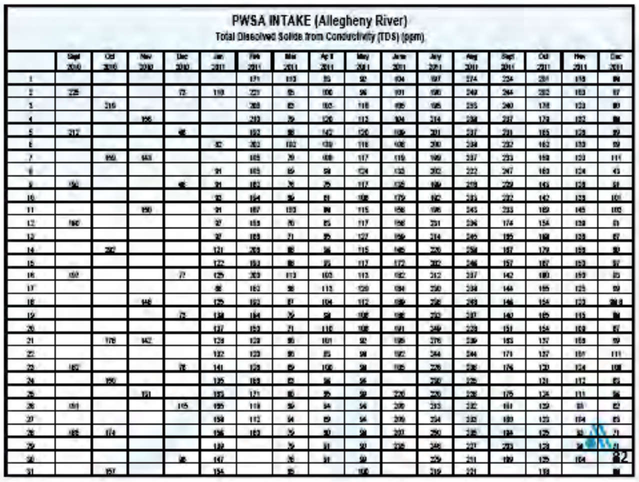


PWSA INTAKE (Allegheny River)

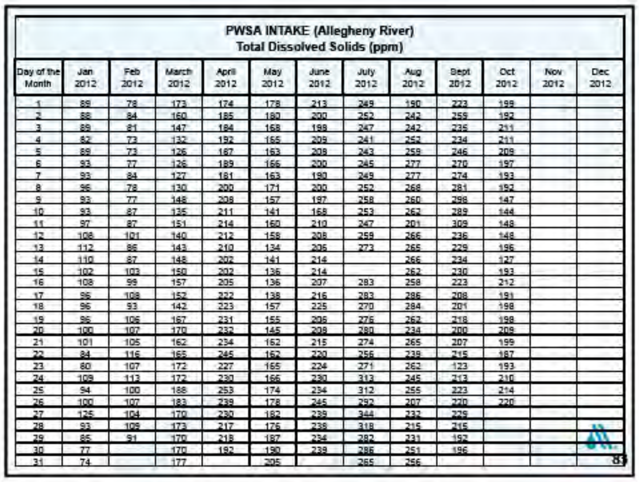
Bromide Concentration (ppb)

Day of the Month	Jan 2012	Feb 2012	March 2012	April 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
1	37	47	64	62	70	105		116	218	129		
2	43	36	54	57	68	82	125	127	203	202		
3	44	38	44	53	56	71	144	128	205	198		
4	38	56	50	64	59	83		147	221	164		
5	39	39	34	74	80	114	122	76	194	158		
6	40	44	40	69	55	82		146	203	171		
7	49	51	29	76	55	75	144	149	190	165		
8	46	59	27	74	93	76		147	202	163		
9	47	41	36	82	35	64	149	135	187	169		
10	59	48	45	78	31	63		135	192	126		
11	53	87	42	73	32	79	153	130	231	180		
12	49	79	39	79	39	89	141	155	227	171		
13	52	61	39	96	36	88	129	139	210	176		
14	58	60	36	91	38	99		133	193	174		
15	50	76	34	77	41	97		157	217	166		
16	47	76	42	116	48	89	140	161	214	179		
17	66	89	44		45	93	132	194	206	172		
18	46	76	52	169	45	100	139	184	209	167		
19	49	61	41	175	45	87	172	177	196	167		
20	58	82	56	174	54	95	178	171	193	161		
21	45	68	57	165	57	86	163	160	188	182		
22	33	73	50	177	51	99	156	166	186	196		
23	36	75	42	183	48	101	170	147	196	152		
24	48	52	68	162	52	98	242	180	191	177		
25	45	42	61	141	59	93	189	189	198	165		
26	42	71	55	107	70	97	184	182	215			
27	49	65	56	104	60	103	190	182	216			
28	52		58	75	79	109	183	185	201			
29	29	57	68	74	90	117	156	189	161			
30	30		52	69	95		170	173	154			
31	29		48		81		132	182				



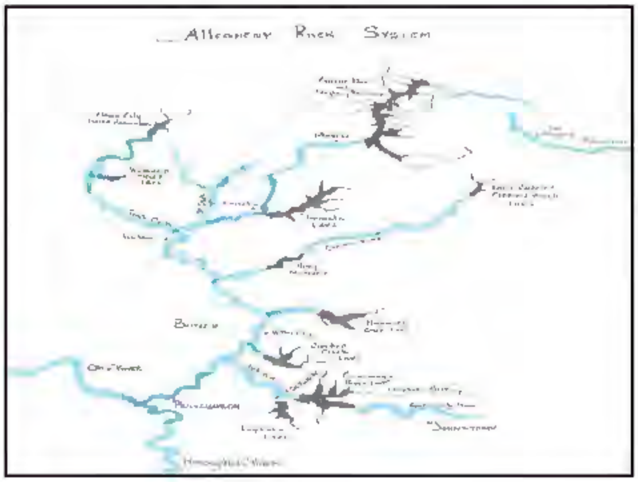

PWSA INTAKE (Allegheny River)

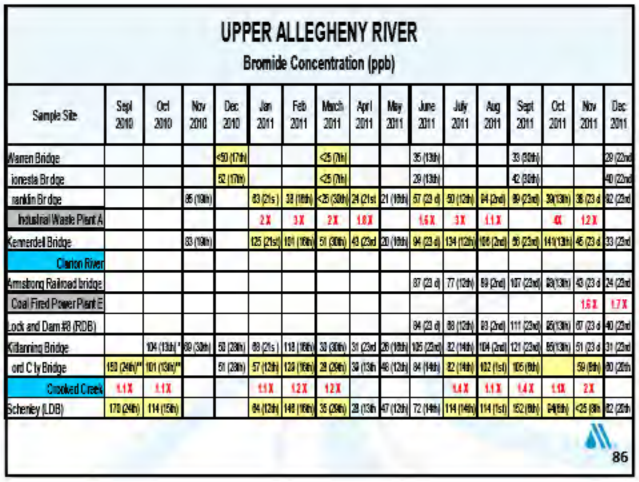
Total Dissolved Solids from Conductivity (TDS) (ppm)


PWSA INTAKE (Allegheny River)

Total Dissolved Solids (ppm)

Day of the Month	Jan 2012	Feb 2012	March 2012	April 2012	May 2012	June 2012	July 2012	Aug 2012	Sept 2012	Oct 2012	Nov 2012	Dec 2012
1	89	78	173	174	178	213	249	190	223	199		
2	88	84	160	185	180	200	252	242	259	192		
3	89	81	147	184	168	198	247	242	235	211		
4	82	73	132	192	165	209	241	252	234	211		
5	89	73	126	187	163	208	243	259	246	209		
6	93	77	126	189	166	200	245	277	270	197		
7	93	84	127	181	163	190	249	277	274	193		
8	96	78	130	200	171	200	252	268	281	192		
9	93	77	148	208	157	197	258	260	298	147		
10	93	87	135	211	141	168	253	262	289	144		
11	97	87	151	214	160	210	247	201	309	148		
12	108	101	140	212	158	208	259	266	236	148		
13	112	86	143	210	134	206	273	265	229	196		
14	110	87	148	202	141	214		266	234	127		
15	102	103	150	202	136	214		262	230	193		
16	108	99	157	205	136	207	283	258	223	212		
17	96	108	152	222	138	216	283	286	208	191		
18	96	93	142	223	157	225	270	284	201	198		
19	96	106	167	231	155	206	276	262	218	198		
20	100	107	170	232	145	208	280	234	200	209		
21	101	105	162	234	162	215	274	265	207	199		
22	84	116	165	245	162	220	256	239	215	187		
23	80	107	172	227	165	224	271	262	123	193		
24	109	113	172	230	166	230	313	245	213	210		
25	94	100	188	253	174	234	312	255	223	214		
26	100	107	183	239	178	245	292	207	220	220		
27	125	104	170	230	182	239	344	232	229			
28	93	109	173	217	176	238	318	215	215			
29	85	91	170	218	187	234	282	231	192			
30	77		170	192	190	239	286	251	196			
31	74		177		205		265	256				

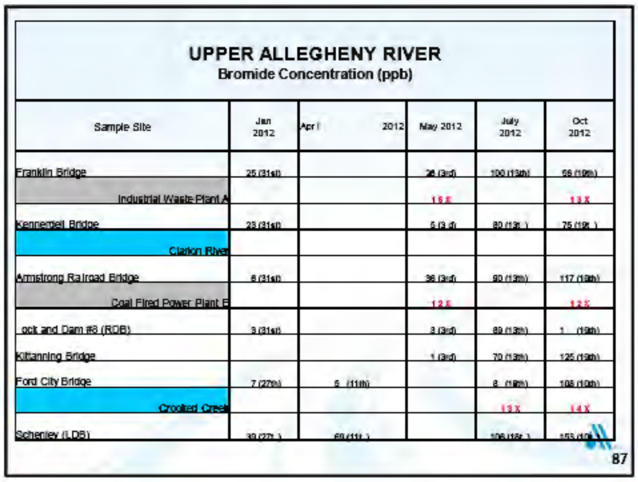




UPPER ALLEGHENY RIVER

Bromide Concentration (ppb)

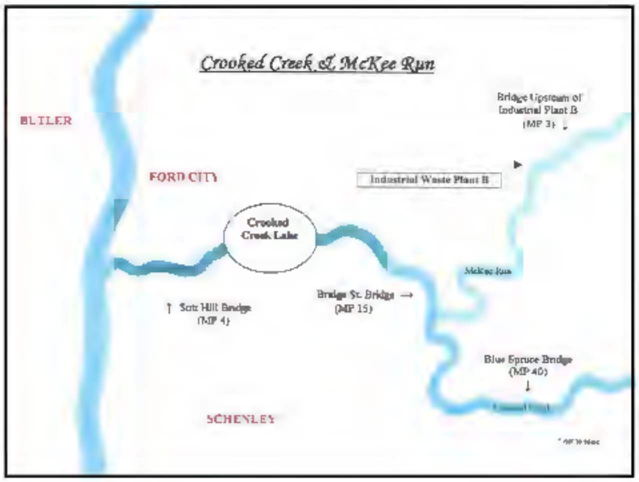
Sample Site	Sept 2010	Oct 2010	Nov 2010	Dec 2010	Jan 2011	Feb 2011	March 2011	April 2011	May 2011	June 2011	July 2011	Aug 2011	Sept 2011	Oct 2011	Nov 2011	Dec 2011
Warren Bridge				<50 (17th)			<25 (7th)			35 (13th)			33 (30th)			29 (22nd
ionesta Bridge				52 (17th)			<25 (7th)			29 (13th)			42 (30th)			40 (22nd
ranklin Bridge			85 (19th)		83 (21s)	38 (18th)	<25 (30th)	24 (21st	21 (19th)	57 (23 d	50 (12th)	84 (2nd)	89 (23rd)	39(13th)	36 (23 d	82 (23rd
Industrial Waste Plant A					2 X	3 X	2 X	1.8 X		1.6 X	3 X	1.1 X		4X	1.2 X	
Kennerdell Bridge			83 (19th)		125 (21st)	101 (18th)	51 (30th)	43 (23rd	20 (19th)	94 (23 d)	134 (12th)	108 (2nd)	56 (23rd)	141(13th)	45 (23 d	33 (23rd
Clarion River																
Armstrong Railroad bridge										87 (23 d)	77 (12th)	89 (2nd)	107 (23rd)	89(13th)	43 (23 d	24 (23rd
Coal Fired Power Plant E															1.6 X	1.7 X
Lock and Dam #8 (RDB)										84 (23 d)	88 (12th)	88 (2nd)	111 (23rd)	85(13th)	67 (23 d	40 (23rd
Kittanning Bridge		104 (13th)*	89 (30th)	50 (28th)	88 (21s)	118 (16th)	33 (30th)	31 (23rd	26 (19th)	105 (23rd)	82 (14th)	104 (2nd)	121 (23rd)	85(13th)	51 (23 d	31 (23rd
ord City Bridge	150 (24th)**	101 (13th)**		51 (28th)	57 (12th)	128 (16th)	28 (29th)	39 (13th	48 (12th)	84 (14th)	82 (14th)	102 (1st)	105 (8th)		59 (8th)	80 (20th
Crooked Creek	1.1 X	1.1 X			1.1 X	1.2 X	1.2 X				1.4 X	1.1 X	1.4 X	1.1X	2 X	
Schenley (LDB)	178 (24th)	114 (15th)			84 (12th)	148 (16th)	35 (29th)	28 (13th	47 (12th)	72 (14th)	114 (14th)	114 (1st)	152 (8th)	84(8th)	<25 (8th	82 (20th

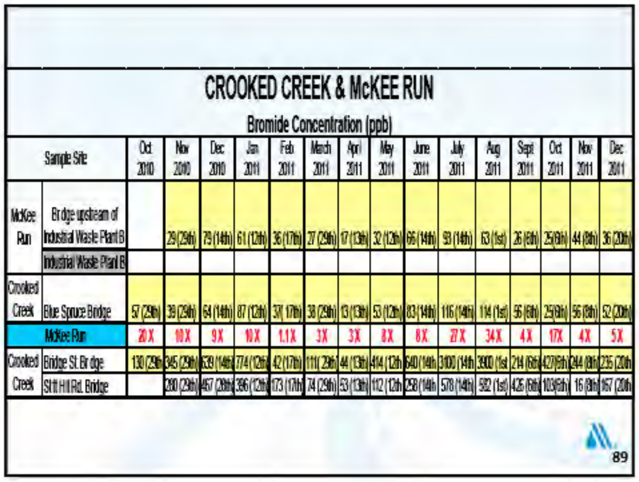


UPPER ALLEGHENY RIVER

Bromide Concentration (ppb)

Sample Site	Jan 2012	April 2012	May 2012	July 2012	Oct 2012
Franklin Bridge	25 (31st)		28 (3rd)	100 (13th)	66 (19th)
Industrial Waste Plant A			1.6 X		1.3 X
Kennerdell Bridge	23 (31st)		5 (3rd)	80 (19th)	75 (19th)
Clarion River					
Armstrong Railroad Bridge	6 (31st)		36 (3rd)	90 (13th)	117 (19th)
Coal Fired Power Plant E			1.2 X		1.2 X
ock and Dam #8 (RDB)	3 (31st)		3 (3rd)	89 (13th)	1 (19th)
Kittanning Bridge			1 (3rd)	70 (13th)	125 (19th)
Ford City Bridge	7 (27th)	6 (11th)		8 (18th)	108 (10th)
Crooked Creek				1.3 X	1.4 X
Schenley (LDB)	30 (27th)	60 (11th)		106 (18th)	153 (10th)

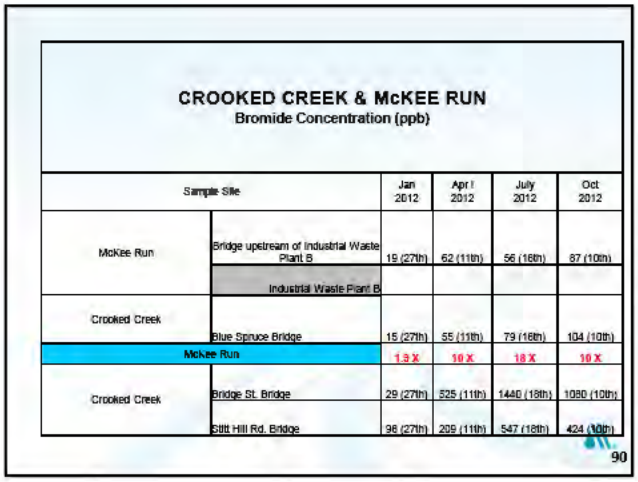




CROOKED CREEK & McKEE RUN

Bromide Concentration (ppb)

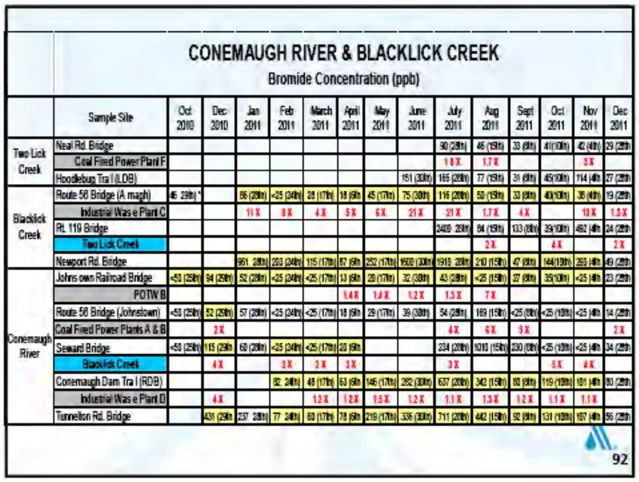
Sample Site		Oct 2010	Nov 2010	Dec 2010	Jan 2011	Feb 2011	March 2011	April 2011	May 2011	June 2011	July 2011	Aug 2011	Sept 2011	Oct 2011	Nov 2011	Dec 2011
McKee Run	Bridge upstream of Industrial Waste Plant B		29 (29th)	79 (14th)	61 (12th)	36 (17th)	27 (29th)	17 (13th)	32 (12th)	66 (14th)	93 (14th)	63 (1st)	26 (6th)	25(6th)	44 (8th)	36 (20th)
	Industrial Waste Plant B															
Crooked Creek	Blue Spruce Bridge	57 (29th)	39 (29th)	64 (14th)	87 (12th)	37 (17th)	38 (29th)	13 (13th)	53 (12th)	83 (14th)	116 (14th)	114 (1st)	56 (6th)	25(6th)	56 (8th)	52 (20th)
	McKee Run	20 X	10 X	9 X	10 X	1.1 X	3X	3X	8X	8X	27 X	34 X	4 X	17X	4 X	5 X
Crooked Creek	Bridge St. Bridge	130 (29th)	345 (29th)	639 (14th)	774 (12th)	42 (17th)	111 (29th)	44 (13th)	414 (12th)	640 (14th)	3100 (14th)	3900 (1st)	214 (6th)	427(6th)	244 (8th)	235 (20th)
	Stitt Hill Rd. Bridge		280 (29th)	467 (28th)	396 (12th)	173 (17th)	74 (29th)	53 (13th)	112 (12th)	258 (14th)	578 (14th)	592 (1st)	426 (6th)	103(6th)	16 (8th)	167 (20th)



CROOKED CREEK & McKEE RUN

Bromide Concentration (ppb)

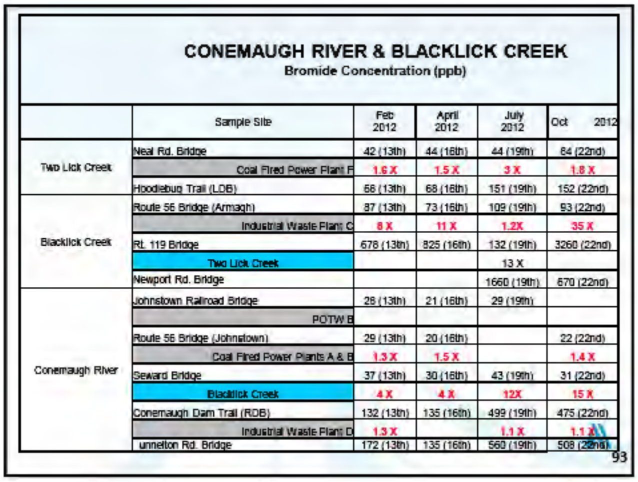
Sample Site		Jan 2012	April 2012	July 2012	Oct 2012
McKee Run	Bridge upstream of Industrial Waste Plant B	19 (27th)	62 (11th)	56 (18th)	87 (10th)
	Industrial Waste Plant B				
Crooked Creek	Blue Spruce Bridge	15 (27th)	55 (11th)	79 (18th)	104 (10th)
McKee Run		1.3 X	10 X	18 X	10 X
Crooked Creek	Bridge St. Bridge	29 (27th)	525 (11th)	1440 (18th)	1080 (10th)
	Stitt Hill Rd. Bridge	98 (27th)	209 (11th)	547 (18th)	424 (10th)



CONEMAUGH RIVER & BLACKLICK CREEK

Bromide Concentration (ppb)

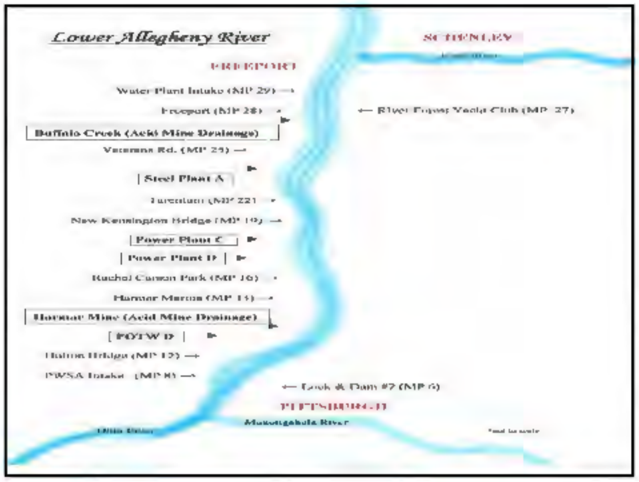
	Sample Site	Oct 2010	Dec 2010	Jan 2011	Feb 2011	March 2011	April 2011	May 2011	June 2011	July 2011	Aug 2011	Sept 2011	Oct 2011	Nov 2011	Dec 2011
Two Lick Creek	Neal Rd. Bridge									90 (28th)	46 (15th)	33 (8th)	41(10th)	42 (4th)	29 (28th)
	Coal Fired Power Plant F									1.8 X	1.7 X			3X	
	Hoodlebug Trail (LDB)								151 (30th)	166 (28th)	77 (15th)	31 (8th)	45(10th)	114 (4th)	27 (28th)
Blacklick Creek	Route 56 Bridge (Armagh)	46 (29th) *		86 (28th)	<25 (24th)	28 (17th)	18 (6th)	45 (17th)	75 (30th)	116 (28th)	50 (15th)	33 (8th)	40(10th)	35 (4th)	19 (28th)
	Industrial Waste Plant C			11 X	8 X	4 X	5 X	6X	21 X	21 X	1.7 X	4X		13 X	1.5 X
	Rt. 119 Bridge									2400 (28th)	84 (15th)	133 (8th)	39(10th)	492 (4th)	24 (28th)
	Two Lick Creek										2X		4X		2X
	Newport Rd. Bridge			951 (28th)	203 (24th)	115 (17th)	67 (6th)	252 (17th)	1600 (30th)	1910 (28th)	210 (15th)	47 (8th)	144(10th)	250 (4th)	49 (28th)
Conemaugh River	Johnstown Railroad Bridge	<50 (25th)	94 (29th)	52 (28th)	<25 (24th)	<25 (17th)	13 (6th)	20 (17th)	32 (30th)	43 (28th)	<25 (15th)	27 (8th)	35(10th)	<25 (4th)	23 (28th)
	POTW B						1.4 X	1.8 X	1.2 X	1.3 X	7 X				
	Route 56 Bridge (Johnstown)	<50 (25th)	52 (29th)	57 (28th)	<25 (24th)	<25 (17th)	18 (6th)	29 (17th)	39 (30th)	54 (28th)	169 (15th)	<25 (8th)	<25 (10th)	<25 (4th)	14 (28th)
	Coal Fired Power Plants A & B		2X							4X	6X	9X			2X
	Seward Bridge	<50 (25th)	115 (29th)	60 (28th)	<25 (24th)	<25 (17th)	20 (6th)			234 (28th)	1010 (15th)	230 (8th)	<25 (10th)	<25 (4th)	34 (28th)
	Blacklick Creek		4X		3X	2X	3X			3X			5X	4X	
	Conemaugh Dam Trail (RDB)				82 (24th)	48 (17th)	53 (6th)	146 (17th)	282 (30th)	637 (28th)	342 (15th)	80 (8th)	119 (10th)	101 (4th)	80 (28th)
	Industrial Waste Plant D		4X			1.2 X	1.2X	1.5 X	1.2 X	1.1 X	1.3 X	1.2 X	1.1 X	1.1 X	
	Tunnelton Rd. Bridge		431 (29th)	237 (28th)	77 (24th)	60 (17th)	78 (6th)	219 (17th)	336 (30th)	711 (28th)	442 (15th)	92 (8th)	131 (10th)	107 (4th)	56 (28th)

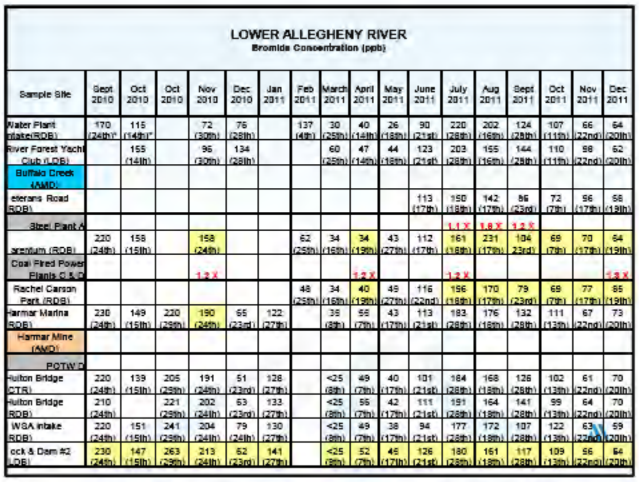


CONEMAUGH RIVER & BLACKLICK CREEK

Bromide Concentration (ppb)

	Sample Site	Feb 2012	April 2012	July 2012	Oct 2012
Two Lick Creek	Neal Rd. Bridge	42 (13th)	44 (16th)	44 (19th)	84 (22nd)
	Coal Fired Power Plant F	1.6 X	1.5 X	3 X	1.8 X
	Hoodlebug Trail (LDB)	66 (13th)	68 (16th)	151 (19th)	152 (22nd)
Blacklick Creek	Route 56 Bridge (Armagh)	87 (13th)	73 (16th)	109 (19th)	93 (22nd)
	Industrial Waste Plant C	8 X	11 X	1.2X	35 X
	Rt. 119 Bridge	678 (13th)	825 (16th)	132 (19th)	3260 (22nd)
	Two Lick Creek			13 X	
	Newport Rd. Bridge			1660 (19th)	670 (22nd)
Conemaugh River	Johnstown Railroad Bridge	26 (13th)	21 (16th)	29 (19th)	
	POTW B				
	Route 56 Bridge (Johnstown)	29 (13th)	20 (16th)		22 (22nd)
	Coal Fired Power Plants A & B	1.3 X	1.5 X		1.4 X
	Seward Bridge	37 (13th)	30 (16th)	43 (19th)	31 (22nd)
	Blacklick Creek	4 X	4 X	12X	15 X
	Conemaugh Dam Trail (RDB)	132 (13th)	135 (16th)	499 (19th)	475 (22nd)
	Industrial Waste Plant D	1.3 X		1.1 X	1.1 X
	unnelton Rd. Bridge	172 (13th)	135 (16th)	560 (19th)	508 (22nd)

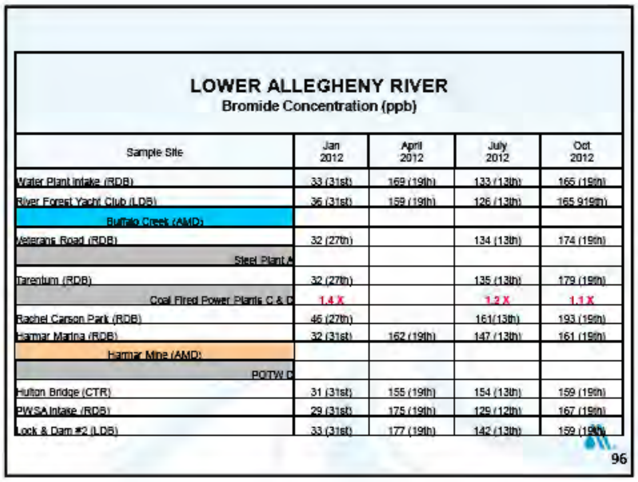




LOWER ALLEGHENY RIVER

Bromide Concentration (ppb)

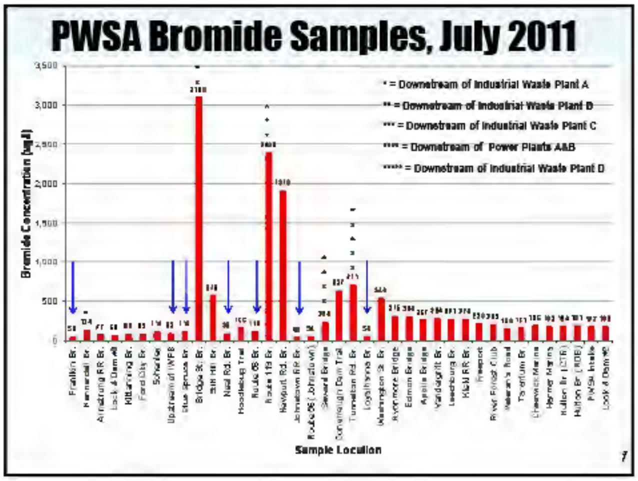
Sample Site	Sept 2010	Oct 2010	Oct 2010	Nov 2010	Dec 2010	Jan 2011	Feb 2011	March 2011	April 2011	May 2011	June 2011	July 2011	Aug 2011	Sept 2011	Oct 2011	Nov 2011	Dec 2011
Water Plant ntake(RDB)	170 (24th)*	115 (14th)*		72 (30th)	76 (28th)		137 (4th)	30 (25th)	40 (14th)	26 (18th)	90 (21st)	220 (28th)	202 (16th)	124 (28th)	107 (11th)	66 (22nd)	64 (20th)
River Forest Yacht Club (LDB)		155 (14th)		96 (30th)	134 (28th)			60 (25th)	47 (14th)	44 (18th)	123 (21st)	203 (28th)	155 (16th)	144 (28th)	110 (11th)	98 (22nd)	62 (20th)
Buffalo Creek (AMD)																	
eterans Road RDB)											113 (17th)	150 (18th)	142 (17th)	86 (23rd)	72 (7th)	96 (17th)	58 (19th)
Steel Plant A												1.1 X	1.8 X	1.2 X			
arentum (RDB)	220 (24th)	158 (15th)		158 (24th)			62 (25th)	34 (16th)	34 (19th)	43 (27th)	112 (17th)	161 (18th)	231 (17th)	104 23rd)	69 (7th)	70 (17th)	64 (19th)
Coal Fired Power Plants C & D				1.2 X					1.2 X			1.2 X					1.3 X
Rachel Carson Park (RDB)							48 (25th)	34 (16th)	40 (19th)	49 (27th)	116 (22nd)	156 (18th)	170 (17th)	79 (23rd)	69 (7th)	77 (17th)	85 (19th)
Harmar Marina RDB)	230 (24th)	149 (15th)	220 (29th)	190 (24th)	65 (23rd)	122 (27th)		39 (8th)	55 (7th)	43 (17th)	113 (21st)	183 (28th)	176 (18th)	132 (28th)	111 (13th)	67 (22nd)	73 (20th)
Harmar Mine (AMD)																	
POTW D																	
Hulton Bridge CTR)	220 (24th)	139 (15th)	205 (29th)	191 (24th)	51 (23rd)	128 (27th)		<25 (8th)	49 (7th)	40 (17th)	101 (21st)	184 (28th)	168 (18th)	126 (28th)	102 (13th)	61 (22nd)	70 (20th)
Hulton Bridge RDB)	210 (24th)		221 (29th)	202 (24th)	63 (23rd)	133 (27th)		<25 (8th)	56 (7th)	42 (17th)	111 (21st)	191 (28th)	164 (18th)	141 (28th)	99 (13th)	64 (22nd)	70 (20th)
WSA Intake RDB)	220 (24th)	151 (15th)	241 (29th)	204 (24th)	79 (24th)	130 (27th)		<25 (8th)	49 (7th)	38 (17th)	94 (21st)	177 (28th)	172 (18th)	107 (28th)	122 (13th)	63 (22nd)	59 (20th)
ock & Dam #2 LDB)	230 (24th)	147 (15th)	263 (29th)	213 (24th)	62 (23rd)	141 (27th)		<25 (8th)	52 (7th)	49 (17th)	126 (21st)	180 (28th)	161 (18th)	117 (28th)	109 (13th)	56 (22nd)	64 (20th)



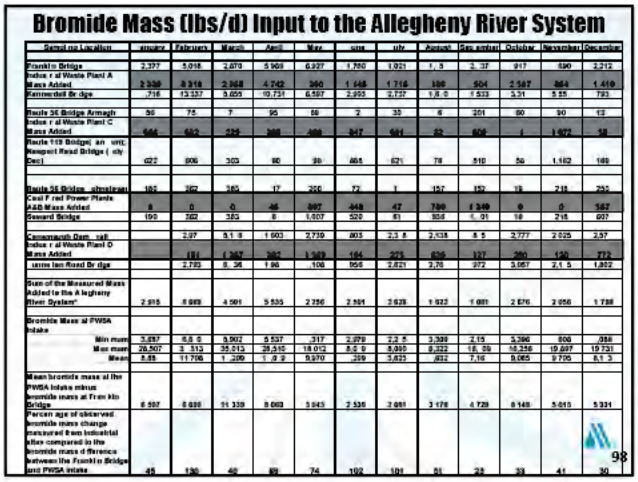
LOWER ALLEGHENY RIVER

Bromide Concentration (ppb)

Sample Site	Jan 2012	April 2012	July 2012	Oct 2012
Water Plant Intake (RDB)	33 (31st)	169 (19th)	133 (13th)	165 (19th)
River Forest Yacht Club (LDB)	36 (31st)	159 (19th)	126 (13th)	165 9(19th)
Buffalo Creek (AMD)				
eterans Road (RDB)	32 (27th)		134 (13th)	174 (19th)
Steel Plant A				
Tarentum (RDB)	32 (27th)		135 (13th)	179 (19th)
Coal Fired Power Plants C & D	1.4 X		1.2 X	1.1 X
Rachel Carson Park (RDB)	46 (27th)		161(13th)	193 (19th)
Harmar Marina (RDB)	32 (31st)	162 (19th)	147 (13th)	161 (19th)
Harmar Mine (AMD)				
POTW D				
Hulton Bridge (CTR)	31 (31st)	155 (19th)	154 (13th)	159 (19th)
PWSA Intake (RDB)	29 (31st)	175 (19th)	129 (12th)	167 (19th)
Lock & Dam #2 (LDB)	33 (31st)	177 (19th)	142 (13th)	159 (19th)

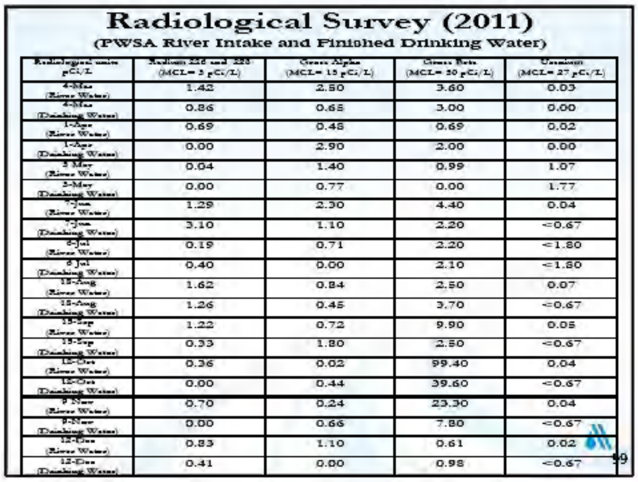


PWSA Bromide Samples, July 2011



Bromide Mass (lbs/d) Input to the Allegheny River System

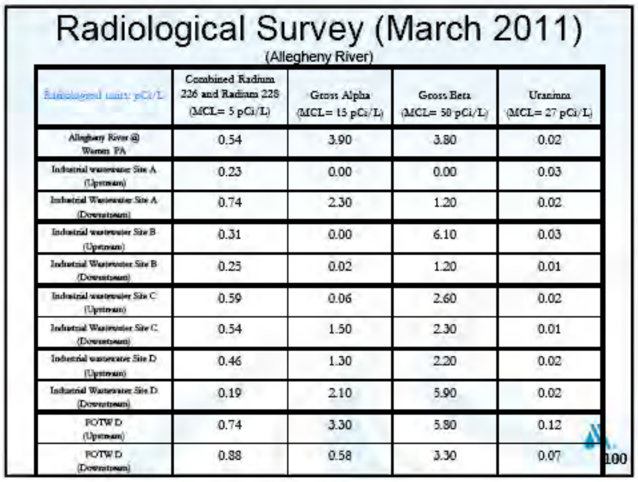
Sampling Location	January	February	March	April	May	June	July	August	September	October	November	December
Franklin Bridge	2,377	5,016	2,070	5,969	6,927	1,780	1,021	[illegible]	[illegible]	917	690	2,212
Industrial Waste Plant A Mass Added	[illegible]	[illegible]	[illegible]	4,742	360	[illegible]	1,716	[illegible]	904	[illegible]	[illegible]	1,410
Kennerdell Bridge	[illegible]	13,337	5,055	10,731	6,597	2,993	2,737	[illegible]	1,533	[illegible]	[illegible]	793
Route 56 Bridge Armagh	56	75	7	95	69	2	30	6	201	60	90	13
Industrial Waste Plant C Mass Added	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	847	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Route 119 Bridge (Jan-June); Newport Road Bridge (July-Dec)	622	806	303	80	90	466	621	78	510	56	1,162	169
Route 56 Bridge Johnstown	185	362	385	17	260	72	1	157	152	19	218	250
Coal Fired Power Plants A&B Mass Added	[illegible]	0	0	[illegible]	[illegible]	[illegible]	47	[illegible]	[illegible]	0	0	[illegible]
Seward Bridge	190	362	383	8	1,007	520	61	936	[illegible]	18	218	607
Conemaugh Dam Tail		[illegible]	[illegible]	1,603	2,739	803	[illegible]	2,138	[illegible]	2,777	2,025	[illegible]
Industrial Waste Plant D Mass Added		[illegible]	[illegible]	[illegible]	[illegible]	164	275	[illegible]	127	280	130	772
[illegible] Road Bridge		2,793	[illegible]	[illegible]	[illegible]	956	2,821	[illegible]	972	3,067	[illegible]	1,802
Sum of the Measured Mass Added to the Allegheny River System*	2,915	[illegible]	4,501	5,535	2,256	[illegible]	2,628	1,622	[illegible]	2,076	2,056	[illegible]
Bromide Mass at PWSA Intake												
Minimum	[illegible]	[illegible]	5,902	5,537	[illegible]	2,079	[illegible]	3,309	[illegible]	3,396	[illegible]	[illegible]
Maximum	26,507	[illegible]	35,013	28,510	18,012	[illegible]	[illegible]	8,322	[illegible]	16,256	[illegible]	19,731
Mean	[illegible]	11,706	[illegible]	[illegible]	9,970	[illegible]	[illegible]	[illegible]	[illegible]	9,065	9,706	[illegible]
Mean bromide mass at the PWSA Intake minus bromide mass at Franklin Bridge	[illegible]	[illegible]	11,339	[illegible]	[illegible]	2,530	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5,331
Percentage of observed bromide mass change measured from industrial sites compared to the bromide mass difference between the Franklin Bridge and PWSA intake	45	[illegible]	[illegible]	[illegible]	74	102	101	[illegible]	[illegible]	33	41	30



Radiological Survey (2011)

(PWSA River Intake and Finished Drinking Water)

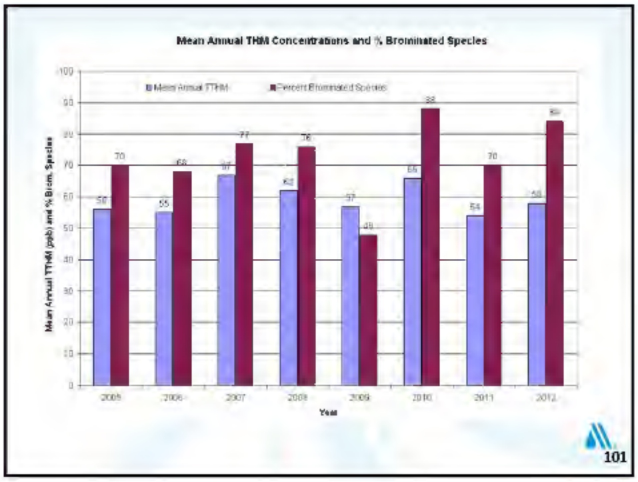
Radiological units pCi/L	Radium 226 and 228 (MCL= 5 pCi/L)	Gross Alpha (MCL= 15 pCi/L)	Gross Beta (MCL= 50 pCi/L)	Uranium (MCL= 27 pCi/L)
4-Mar (River Water)	1.42	2.50	3.60	0.03
4-Mar (Drinking Water)	0.86	0.65	3.00	0.00
1-Apr (River Water)	0.69	0.48	0.69	0.02
1-Apr (Drinking Water)	0.00	2.90	2.00	0.00
3-May (River Water)	0.04	1.40	0.99	1.07
3-May (Drinking Water)	0.00	0.77	0.00	1.77
7-Jun (River Water)	1.29	2.30	4.40	0.04
7-Jun (Drinking Water)	3.10	1.10	2.20	<0.67
6-Jul (River Water)	0.19	0.71	2.20	<1.80
6-Jul (Drinking Water)	0.40	0.00	2.10	<1.80
15-Aug (River Water)	1.62	0.84	2.50	0.07
15-Aug (Drinking Water)	1.26	0.45	3.70	<0.67
15-Sep (River Water)	1.22	0.72	9.90	0.05
15-Sep (Drinking Water)	0.33	1.80	2.50	<0.67
12-Oct (River Water)	0.36	0.02	99.40	0.04
12-Oct (Drinking Water)	0.00	0.44	39.60	<0.67
9-Nov (River Water)	0.70	0.24	23.30	0.04
9-Nov (Drinking Water)	0.00	0.66	7.80	<0.67
12-Dec (River Water)	0.83	1.10	0.61	0.02
12-Dec (Drinking Water)	0.41	0.00	0.98	<0.67

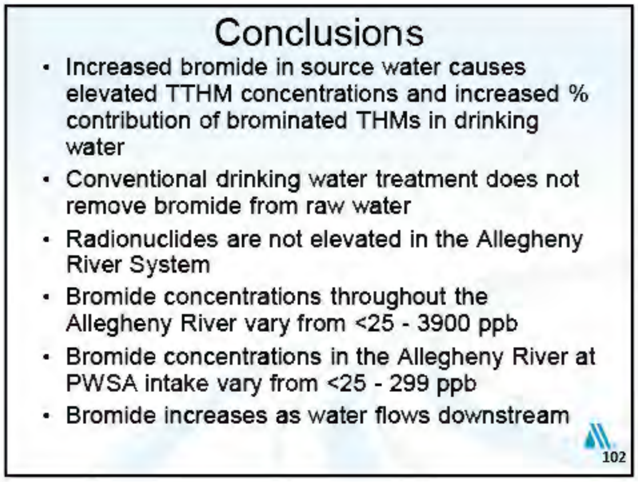


Radiological Survey (March 2011)

(Allegheny River)

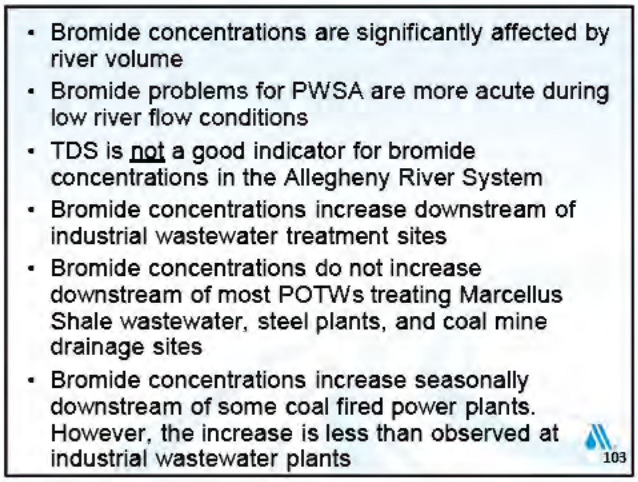
Radiological units: pCi/L	Combined Radium 226 and Radium 228 (MCL= 5 pCi/L)	Gross Alpha (MCL= 15 pCi/L)	Gross Beta (MCL= 50 pCi/L)	Uranium (MCL= 27 pCi/L)
Allegheny River @ Warren PA	0.54	3.90	3.80	0.02
Industrial wastewater Site A (Upstream)	0.23	0.00	0.00	0.03
Industrial Wastewater Site A (Downstream)	0.74	2.30	1.20	0.02
Industrial wastewater Site B (Upstream)	0.31	0.00	6.10	0.03
Industrial Wastewater Site B (Downstream)	0.25	0.02	1.20	0.01
Industrial wastewater Site C (Upstream)	0.59	0.06	2.60	0.02
Industrial Wastewater Site C (Downstream)	0.54	1.50	2.30	0.01
Industrial wastewater Site D (Upstream)	0.46	1.30	2.20	0.02
Industrial Wastewater Site D (Downstream)	0.19	2.10	5.90	0.02
POTW D (Upstream)	0.74	3.30	5.80	0.12
POTW D (Downstream)	0.88	0.58	3.30	0.07





Conclusions

- Increased bromide in source water causes elevated TTHM concentrations and increased % contribution of brominated THMs in drinking water
- Conventional drinking water treatment does not remove bromide from raw water
- Radionuclides are not elevated in the Allegheny River System
- Bromide concentrations throughout the Allegheny River vary from <25 - 3900 ppb
- Bromide concentrations in the Allegheny River at PWSA intake vary from <25 - 299 ppb
- Bromide increases as water flows downstream

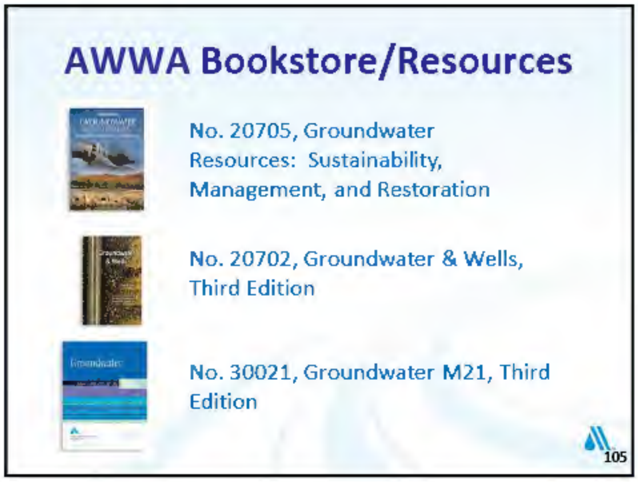


- Bromide concentrations are significantly affected by river volume
- Bromide problems for PWSA are more acute during low river flow conditions
- TDS is not a good indicator for bromide concentrations in the Allegheny River System
- Bromide concentrations increase downstream of industrial wastewater treatment sites
- Bromide concentrations do not increase downstream of most POTWs treating Marcellus Shale wastewater, steel plants, and coal mine drainage sites
- Bromide concentrations increase seasonally downstream of some coal fired power plants. However, the increase is less than observed at industrial wastewater plants

Ask the Experts

Enter your question into the question pane at the lower right hand side of the screen.

Please include your name and specify to whom you are addressing the question.



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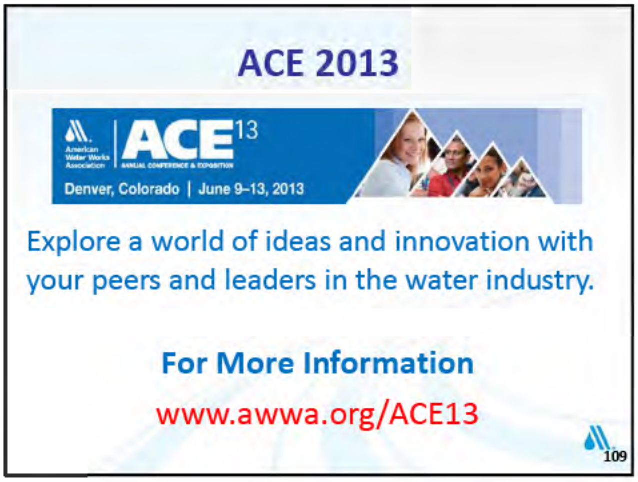

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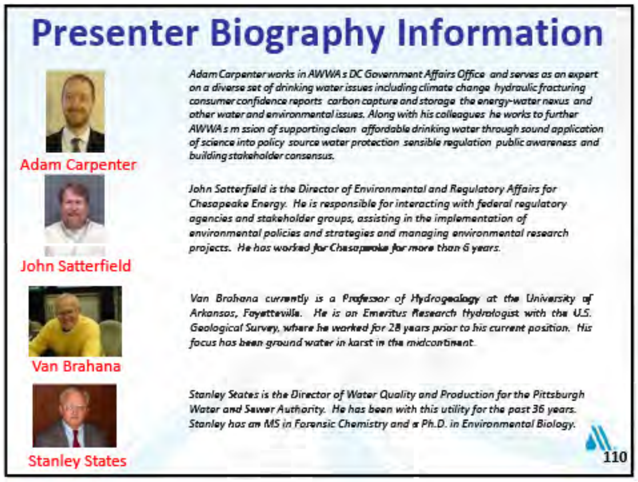


Presenter Biography Information

Adam Carpenter

Adam Carpenter works in AWWA s DC Government Affairs Office and serves as an expert on a diverse set of drinking water issues including climate change hydraulic fracturing consumer confidence reports carbon capture and storage the energy-water nexus and other water and environmental issues. Along with his colleagues he works to further AWWA s mission of supporting clean affordable drinking water through sound application of science into policy source water protection sensible regulation public awareness and building stakeholder consensus.

John Satterfield

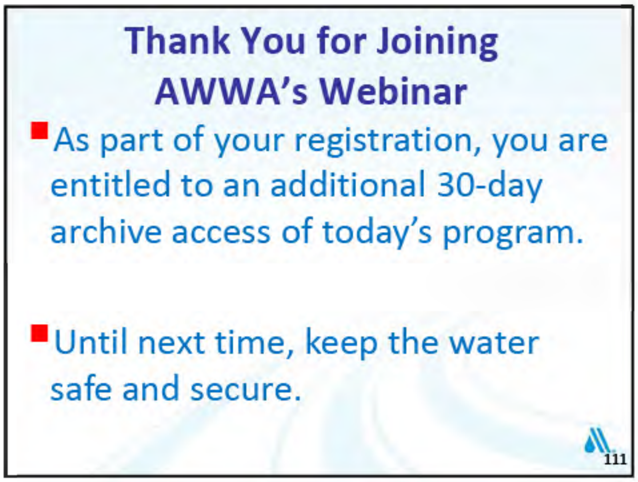
John Satterfield is the Director of Environmental and Regulatory Affairs for Chesapeake Energy. He is responsible for interacting with federal regulatory agencies and stakeholder groups, assisting in the implementation of environmental policies and strategies and managing environmental research projects. He has worked for Chesapeake for more than 6 years.

Van Brahana

Van Brahana currently is a Professor of Hydrogeology at the University of Arkansas, Fayetteville. He is an Emeritus Research Hydrologist with the U.S. Geological Survey, where he worked for 28 years prior to his current position. His focus has been ground water in karst in the midcontinent.

Stanley States

Stanley States is the Director of Water Quality and Production for the Pittsburgh Water and Sewer Authority. He has been with this utility for the past 36 years. Stanley has an MS in Forensic Chemistry and a Ph.D. in Environmental Biology.



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