Getting The Waters Tested
The Marcellus Shale Factor

Water Resources
Environment

Environment

Old Issues

New Issues

Working As a Community!
Presented by:

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B.F. Environmental Consultants Inc.
http://www.bfenvironmental.com

And

Water Research Center
http://www.water-research.net
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- Professional Consulting Services in the areas of water quality, soils, stormwater, geology, aquifer analysis, and land-development.
- Baseline – Chain-of-Custody
- Expert Testimony
- Water Treatment Process/ Product Development
- [http://www.bfenvironmental.com](http://www.bfenvironmental.com)
Water-Research Center

Education and Outreach Program funded by
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Outreach Programs

- Environmental and Professional Education and Training for Citizens and Local Municipalities
- Water Quality Help Guides – Information Library
- Community and Business Outreach Programs
- Low Cost – Informational Water Testing Program with National Laboratory
- Citizen Monitoring Programs- Developing Low Cost Water Quality Sensors

Website: http://www.water-research.net
EPA Sampling In Dimock
Water Treatment
And Reuse
Drilling Activity

Hydraulic Fracturing

Western PA
Old Gas Well

What is This?
Current Work

- Citizens Groundwater / Surfacewater Database – Certified Data Only- NOW!
  Be Part of the Solution.
  [http://www.water-research.net](http://www.water-research.net)

- New Booklet for Private Well Owners

- Radon Levels in Private Well – Goal is to Sample approximately 200 wells in Northeastern PA.

- Take the Survey:

- Lessons Learned A Review of the Data from Dimock PA
  From the EPA. – Well by Well Fact Based Review.
  [http://www.water-research.net/dimockwellwater.htm](http://www.water-research.net/dimockwellwater.htm)

NOTE – All Work NOT Funded (available soon)
Disclaimer/ My Goals

- This talk is based on my personal and professional experience.
- The presenter has not been compensated for travel or professional fees.
- This information is based on science and facts.
- The main goal of this presentation
  - Get the Waters Tested
  - Educate Citizens on Wellhead Protection/ Water Quality
  - Add to the Citizens Groundwater Database
  - Support Private Well Construction Standards
  - Fix Poorly Constructed Private Wells
  - Protect Our Groundwater Resources – My Making Positive Change
Target Audience

- Stakeholders
- Community Advocates and Scientists
- Municipal and Local Officials
- Water Supplies and State Regulators
Our Drinking Water

Marcellus Shale

The Match Of the Century – Pick a Side and Lets See Who Wins.

No – We don’t want this situation - This mindset is Causing all the Concern? We ALL Live Downstream!
Susquehanna County was glaciated and it is located within the Appalachian Plateau.

Appalachian Plateau Province

- Broad to Narrow Valleys
- Rounded Hills and Valleys Associated with Glaciation
- Valleys filled by glacial fluvial material

Unconsolidated Material (Un)
PA - Private Wells Not Regulated

- Private Wells Are Not Regulated under Safe Drinking Water Act
  - EPA – NO
  - PADEP – NO
  - County – Very Few Counties in PA
  - Townships – some have basic ordinance on placement- some have comprehensive requirements
- Where are these Wells?
Before Marcellus Shale Development
What was the Quality of Private Well Water?

A USGS survey found that 70% of private wells were contaminated. This contamination could result in acute or chronic health concerns (1996).


Testing Conducted by Wilkes University in throughout the United States indicates that 30 to over 50% may be contaminated – Mostly by Total Coliform Bacteria – 30% of these E. coli. Positive (1989 – 2010).

PSU – Master Well Owner Network suggests that 33 to 50 % of Private Well Owners in PA may have some Form of contamination.
What Did We Know Susquehanna County- Third Party Studies?

- Topographic and Geologic Survey, PA – 1937
  - Salt seepage in Franklin Forks following 10 gpm with high iron and methane.
  - Methane gas can be ignited and used by homeowner for cooking.
  - Middletown Township – Saline and brine water with “gas” at 300 feet
  - Salt springs reported in Apolacon, Auburn, and Franklin Township

http://www.water-research.net/susquehanna/groundwater.htm
“At the base of the gorge is a bubbling salt spring, traces of an 1850s woolen mill, and mid-19th century farmhouses and barns.”

By Brian Oram, Fall 2010

http://www.friendsofsaltspringspark.org
This is Drinking Water in PA?

- Iron / Manganese
- Sediment / Gases

- Corrosion
- Bacteria

50% Other 50%
Based on the geology of the NEPA and my 20 years experience, the common water quality problems are as follows:

- Corrosive Water
- Low pH
- Soft Water
- Iron and Manganese
- Total Coliform Bacteria
- Sulfur Odors
- Methane (Tends to be < 7 mg/L)
- Radon Gas (Up to 2000 pCi/L)
- Barium (< 2 mg/L)
- Bromide (< 0.07 mg/L)
- Sodium (< 15 mg/L)

Contamination by VOCs, SOCs, Glycols, Saline Water ( < 3 %), and Radionuclides are NOT COMMON!
Lets Be Honest – We have Problems in Pennsylvania with Private Wells

- Wells Poorly Constructed – either poor casing, inadequate casing, or annular space not grouted.
- Wells Too Deep – Mixing Fresh and Saline Aquifers
- Wells in the Wrong Place
- Poorly Constructed and Sited Wells – Indirectly Influence Properly Constructed Wells.
Properly Constructed Wells and Poorly Constructed Wells

Proper Construction

- Unsaturated Zone
- Unconfined Aquifer
- Confined Aquifer
- Confined Bed

600 to 1200 ft

Fresh Water

Poorly Constructed

- Confining Bed
- Barium, Strontium, etc

Stagnant Water – no to little flow

Sea Level

Brine Water
How Contaminants Can Get In to the Aquifer (Surface)

- Ungrouted Well Pit
- Sanitary Well
Things I have found within 100 feet of a private well – Just a Few

Free Artesian Well Water

By the way – these two photos are only 200 feet apart
Groundwater is Safe and Pure – Really?
Not Just a Marcellus Shale Issue and in some cases other Private Wells are Part of the Problem
Some Private Well Photos
What is the Marcellus Shale Factor?

- We have been educating private wellowners for 20+ years- but it was difficult to get citizens to test their well water. It looks clear – I am not sick – It is fine.

- The Marcellus Shale Factor – Baseline Testing for Natural Gas Development is conducting Testing and Citizens are be told they have a Problem NOW.

- Based on Private Well Construction and Placement - Some Private Wells may be the pathways for Contamination.

- WE NEED TO PROTECT OUR SOURCE WATER- not just from Marcellus Shale Development and other hazards, but from “us” and our past.

- How do we track an unregulated activity – such as: Private Wells and Identify Zones or Areas that are Vulnerable to Contamination.

- This lead to the idea for creating the Citizen Groundwater / Surfacewater Database

WE Support the Citizen Groundwater Database!
Citizen Database

What is in the Database? How you can contribute (anonymously to the database) And it is Free.
Goal of the Database

- Provide a Central Location to Store Baseline Pre-Drilling and/or Post-Drilling Water Quality Data for the Region
- Document Quality by Geological Formation
- Identify Existing Regional Issues or Concerns
- Provide an Un-Biased Community Resource
- Provide a Mechanism to Track Temporal, Spatial, and other Geospatial Variation in Water Quality.
II. Guidelines for Data Submission

1. Third Party Samplers following chain-of-custody to certified laboratory.

2. Submit detailed reports from certified laboratory with a GPS position for the well.

3. The water sample must be collected ahead of any water treatment system.

4. other conditions – Learn More about the Wilkes University Role or at http://www.water-research.net or bfenviro@ptd.net.

Learn More –
http://www.water-research.net/privatewellpa.htm
About 49% - Do NOT Meet Drinking Water Standards!

- Total Coliform
- pH < 6.5
- Lead
- Manganese
- Iron
- e. coli
- Phthalates
- Arsenic
- TDS
- Sodium (> 200 mg/L)
- Chloride
- Gross Alpha

bis(2 ethylhexylphthalates)
What?
Plasticizers?

Well Influenced by Saline Water
Most Contamination appears to be associated with Total Coliform Bacteria

- Insects, Larvae and Nests / Egg Masses
- Mouse Colonies
- Snakes
- Beehives
- Mud - when casing to close to ground

Therefore – In some cases - the Private Wells are Facilitating Groundwater Contamination.
Corrosive Water

- Chemical or Biochemical Reaction between the water and metal surfaces.

- The corrosion process is an oxidation/reduction reaction that returns refined or processed metal to their more stable ore state.

- Corrosion can also be accelerated by:
  1) low pH and high pH;
  2) high flow rate within the piping;
  3) high water temperature;
  4) chemistry of the water/ Nuisance Bacteria;
  5) methane gas migration; and
  6) presence of suspended solids, such as sand.

Copper – Typically Blue or Blue-Green Staining

May also have elevated levels of Lead and Zinc.
Water Hardness, Iron, Manganese

- The hardness of a water is a measure of the concentration of the multivalent cations (Ca$^{+2}$, Mg$^{+2}$, Fe$^{+2}$, Mn$^{+2}$, etc) associated with carbonates (HCO$_3^-$).

- Hardness is typically reported as mg/L as CaCO$_3$ (calcium carbonate).

- Grains per gallon (1 gpg (US) = 17.12 mg CaCO$_3$/L).

- Hardness Classification:
  - Soft: 0 to 17 mg CaCO$_3$/L
  - Slightly Hard: 17 to 60 mg/L;
  - Moderately Hard: 60 to 120 mg/L
  - Hard: 120 to 180 mg/L
  - Very Hard: > 180 mg/L

Secondary Drinking Water Standard
- Iron – 0.30 mg/L (red or black) 8%
- Manganese – 0.05 mg/L (black) 11%
What are Phthalates?

- Used as Plasticizers- is a substance which when added to a material, usually a plastic, makes it flexible and easier to handle.

- Bis(2ethylhexylphthalate) (DEHP) – DW Standard – 6 ppb – GI problems, possible endocrine disruptor and carcinogen.

- Recent Testing – Highest Value was 60 ppb.

- How did this get in the aquifer?
Arsenic- up to 6% Elevated Levels

- The drinking water MCL is 0.010 mg/L.
- Arsenic can result in the formation of malignant tumors on skin and lungs and may cause nervous system disorders.
- Observable symptoms of arsenic poisoning are: thickening and discoloration of the skin, stomach pain, nausea, vomiting, diarrhea, numbness in hands and feet, partial paralysis, and blindness.
- For this particular parameter within Northeastern Pennsylvania (NEPA), it would be advisable to retest the water for dissolved and total arsenic.
- In many cases, the arsenic has been leached from a colloid or particle that could be more cost effectively removed by standard filtration. It is also typically bound to iron oxide complexes.
Comments on Sodium

- Sodium – Not regulated by the EPA – not a primary or secondary drinking water standard.
- Sodium – Background Levels – Mean 15 mg/L (Pre-drilling - < 1 to 630 mg/L)
- Most Pre-Drilling Elevated Levels of Sodium associated with Road Salt or Saline Water Intrusion.
Comments on Bromide

- Bromide – Not regulated by the EPA – not a primary or secondary drinking water standard.
- Bromide – Background Levels – Mean 0.07 mg/L (Pre-drilling - < 0.01 to 6.2 mg/L)
- Most Pre-Drilling Elevated Levels of Bromide associated with Saline Water Intrusion.
Glycols- not a common problem – no real drinking water standard

- ground-water heating and cooling systems, deicing agents, and natural gas development
- EPA guidance is \( \leq 7000 \text{ ppb or 7 mg/L (ethylene glycol)} \)

Recirculated Glycol in Plastic Piping surrounded by Sand with Clay No Construction Standards No Protective Casing

Private Well

Ground Source Well
Well A - 300 feet
Methane – 10 to 15 mg/L – the real problem, Barium 4 mg/L, Radon 577 pCi/L, Chloride 250 + mg/L, Bromide 1.5 mg/L, Strontium 5.57 mg/L, Iron – 3.2 mg/L

Well B – 200 feet
Methane – 6 mg/L, Chloride 30 mg/L, Barium 1.13 mg/L, Strontium 2.15 mg/L, Radon < 60 pCi/L, Iron – 1.39 mg/L

Well A may be Impacting Well B
Methane Gas Migration

- Shallow Gas
- Natural Migration
- Facilitated Path – because of Private Wells
- Induced Migration
Methane in Water

- Methane has been a hidden issue in NEPA.
- The gas is colorless, tasteless, and odorless and there are no known health effects.
- Potential concerns relate to flammability/explosiveness of gas.
- Background – appears to range from non-detect to over 20+ mg/L (highly variable) in Northeast Pennsylvania.
- I lit my first well water sample in about 1989- thanks to methane gas.
Methane Gas Migration - Not Related to Marcellus Shale

600 to 1200 ft

1200 to 3000+ ft

Gas from Non-Marcellus Shale

Groundwater Flow

Wetland

Landfill

Private Well

Lake
Methane (a little more)

- The Coal regions and northern portion of NEPA, and areas associated with the Mahantango / Marcellus Shale may have elevated levels of methane.

- No drinking water limit, but Office of Surface Mines recommends monitoring for concentrations from 10 to < 28 mg/L and immediate action for concentrations > 28 mg/L

- My Recommendations (Oram, 2009):
  - < 2 mg/L – Monitor annually with passive venting, annual testing
  - > 2 to 7 mg/L – Monitoring with active venting- Twice a Year for One Year (During Times Out-gassing is Severe).
  - > 7 mg/L to < 10 mg/L – active venting, pump shroud, isotphic analysis. Quarterly Testing for one year.
  - > 10 mg/L – Treatment, active venting with more aggressive management, isotopic analysis, and possible well rehabilitation- Monthly testing for up to one year.
Rock Sample from Quarry – West of Dimock

Sandstone Unit – Containing Plant Materials, Organic Muds – Possible Shallow Methane Source
Methane Variability - Actual Examples - Well Depths

- House
  - Septic system
  - Wells (2)

- 500 ft: 7 mg/L
- 300 ft: < 1 mg/L
Methane Gas Level – Change over Time- Time with Highest Levels

- barometric pressure is low and soils are saturated;
- when snow cover is just beginning to melt;
- the ground is frozen or ice covered; or
- under long-term pumping conditions for the well when the well is experiencing the lowest dynamic water level and greatest drawdown.
It looks like background methane levels may follow a linear/curvilinear trend.
How Many Private Well Owners Normally Let Water Run for 45 minutes

Methane Increases with Purge Time.

1 WBV = 45 minutes
Specific Capacity = Gpm/ft of drawdown

gpm = 5 gpm
Static Water Level – 50 feet
Dynamic Level – 200 feet
Sc = (5 gpm/ (150 ft)) =
Sc = 0.03 gpm/ft drawdown

Less head pressure
More methane will be released.
Ok – I get the outgassing – by why is it brown?
Part of the Reason for the Discolored Water May be Iron Bacteria

Iron Related Bacteria is a common problem in NEPA – About 50% of Wells with an Iron Problem or Coliform Problem have IRB.

I am not saying there is no methane gas in the water.
Example of Nuisance Bacteria
Iron Related Bacteria Count - > 140,000 colonies per ml
Aluminum – 0.511 mg/L, Iron 1.87 mg/L, Manganese – 5.4 mg/L,
Lead 0.029 mg/L, Methane - < 0.001 mg/L
Key Points
1. Proper Casing and Cement of Marcellus Shale Wells
2. Knowing How Private Wells Are Constructed
3. Isolation Distances will not Solve This Problem.
4. Fixing Private Wells has to be part of the Solution.
5. This may account for the data on bromide from PSU.
6. The issue may not be well radial distance, but construction and drilling issue.
7. Recommend closed loop drilling with water within freshwater aquifer (no muds) or water-based muds.

Could this explain the Bromide Issue??
General Geology - Northern Tier PA

Water Table

Saline Water

Brine Water

Older

Younger

Most Private Well

New Regulations (2010)
Protective Casing – Do it Right!
Problems with Gas Migration and Cement

Does not Bound
Migration Concepts - Multiple Casements and Recreate Confining Layers - Need Good Cement Bonds - Cement up to Deepest Casement or Surface

- Water Table
- Private Well
- More Conventional Reservoir
- Target
- Younger
- Older
- Confining Layer
Methane Migration – Well Prior Regulation Change
Changes in the Regulations or other Work a Local Task Force Approach

- Require cement bond-logging.
- Require a self-contained liner system.
- Require cementing borehole to the surface or at a minimum the inner most string of casing with pressure monitoring.
- Require the development of private well owner impact plans that outline what is to be done and steps taken to address a suspected private well impact.
- Consider creating an information document that tells private well owners their rights, whom to call, when to call, and where to get help.
Migration Concepts- Multiple Casements and Recreate Confining Layers – No Uncemented Zones.

The other Problem – Private Wells that are Too Deep – I aware of some private wells that are over 900 feet deep.
Getting to The Natural Gas

5000 to 7000 feet

Freshwater Well

Brine / connate Water - Trapped in formation when deposited

Zone Should be Cemented!

Up to a few thousand feet
Changes in the Regulations

- Require Lined Sites with Containment.
- Require Data to be Posted on Frac Focus- [http://www.fracfocus.org](http://www.fracfocus.org) (Post data as percent and concentration)
- Require Cement Bond Logging.
- Require Cementing to Surface for all strings and production casing and protection of saline aquifer (Consistent with EPA UIC Program).
- Require Monitoring Private Wells During Drilling Process – Field Screening Only
- Increase baseline testing zone to cover the anticipated capture zone for the well pad- It is NOW – 2500 feet and 1 year – Good Start.
- More Cased Zones – Multiple Cement Casing
  - New Strings – Placed Based on Local Geology and Well Survey
    - Shallow Freshwater
    - Deeper Freshwater
    - Saline Zone Casing
Locating / Sealing/ Cementing – Old Gas Wells – Need to Be Part of the Solution – More of a Western PA Problem – but this can apply to very deep private wells in our region.
Frac Water Chemical Disclosures


- This website is a joint project of the Ground Water Protection Council
  Interstate Oil and Gas Compact
What Local Leadership Can Do?

- Promote Education and Outreach Programs and Get Informed
- Encourage Gas Companies to Have Copy of Permit Available Locally for Review
- Have Open Discussion with Gas Companies and Royalty Owners
- **Encourage Citizens to Participate in Baseline Testing**
- **Use Baseline Data to Make Decisions – it is not just a formality! Goals of the Citizen Database**
- **Private Well Construction and Siting Standards**
- **Develop a Way to Fix Poorly Constructed Private Well – “We all live downstream”**.
- **Develop Community Support Program – Central Location Where Citizen Can Call and Get Answers – NOT the Run-a-Round.**
- **Promote Solutions that fix a problem – not just treat the symptoms (New Fact Sheet Available)**
  - Cementing Portions of Wells that are too deep.
  - Pump Shrouds
  - Extending Casing – Using Liners in Private Wells
Again

Up to 1.5 Million - Citizens in PA Drink Water that may cause short term or chronic disease. This has nothing to do with Marcellus Shale Oil and Gas Development, Or Unconventional Gas.

This needs to have attention – NOW!

This is not a Marcellus Shale Issue- it is a Health Care and Economic Issue for the State of Pennsylvania.

We NEED to Work as a Community and Fix The Problems We Created.

Do we really want to Control Health Care Cost??

This is not a Marcellus Shale Issue – It is a HEALTH Issue!
Certificate of Completion

Training Event
Getting The Waters Tested The Marcellus Shale Factor
Working as a Community
6/16/2012
3 – hour PDH or 0.3 CEUS
Presented by
Mr. Brian Oram, PG

B.F. Environmental Consultants Inc
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More Online Training @
http://www.bfenvironmental.com
Presented by:

Mr. Brian Oram, Professional Geologist (PG),
B.F. Environmental Consultants Inc.
http://www.bfenvironmental.com
And
Water Research Center
http://www.water-research.net

Private Well Owner – Watershed Survey
Free Radon in Water Test (200 samples)
http://www.surveymonkey.com/s/NMG6RQ3
Suggested Baseline- For Citizens

- Testing Package # 1 Recommendations
  Total Coliform with e. coli confirmation, chloride, sodium, bromide, barium, pH, total dissolved solids, MBAS, iron, manganese, and methane/ethane.

- Testing Package # 2 Recommendations
  Package # 1- plus T. Hardness, Magnesium, Selenium, Strontium, Conductivity, Calcium, Zinc, Alkalinity, Arsenic, Nitrate, Total Suspended Solids, Sulfate, Oil & Grease, and 21-VOCs/MTBE.

- Testing Package # 3 Recommendations
  Package #1 and # 2 - plus Potassium, Sulfide, Ammonia, Acidity, Nickel, Gross, Alpha/Beta, Lead, and Uranium.

It may be advisable to add Glycols, Radon in water, and other organics and inorganics. Depending on surrounding land-use, use of geothermal wells, and past history.
Consider Vulnerability Analysis

- Is the Well Shallow?
- Is the Well Cement Grouted?
- How deep is the Casing?
- Does the Well Show Signs of Saline Water or Elevated Methane? – Pre-Drilling
- Does the well have an elevated level of bacteria, chloride, sodium, or intermittent discolored water?
- If so – this may be a well that is vulnerable to surfacewater or near surface influence and act as a pathway to contamination or a pathway for “saline water”.
- This well should be inspected, fixed, upgraded, or abandon.
How Contaminants Can Up into a Shallow Aquifer

Problem is Some Private Wells are Too DEEP!
Radon Exposure

Radon in Water – no Standard, but proposed range 300 to 4000 pCi/L

Recent testing in Susquehanna/ Luzerne County at 577 to 2200 pCi/L – 100% over 300 pCi/L

Recommendations
1. Test indoor radon in air levels.
2. If radon in air > 2 pCi/L- test the radon level in the water.
3. Add to Community Baseline Testing Program
Bedrock Fractures and Fractured Zones

High Yielding Well
(High Methane ?)

Fractured Zone

Lower Yielding Well
(Low Methane?)
Migration Concepts - Non-Marcellus Shale - While Drilling - Proper Casement Placement

- Private Well
- Water Table
- Confining Layer
- Shallow Gas
- Marcellus Shale
- Younger
- Older
Problems with Iron, Manganese, and Sulfur – May be Bacterially Related

In Northeastern PA- “Nuisance Bacteria may be associated with an Odor, Iron, Manganese, or Sulfur problem. Up to 50% of the time.

Make sure to test for total coliform, standard plate count, and Nuisance Bacteria.

Natural Gas Companies should add this to their screening tests.