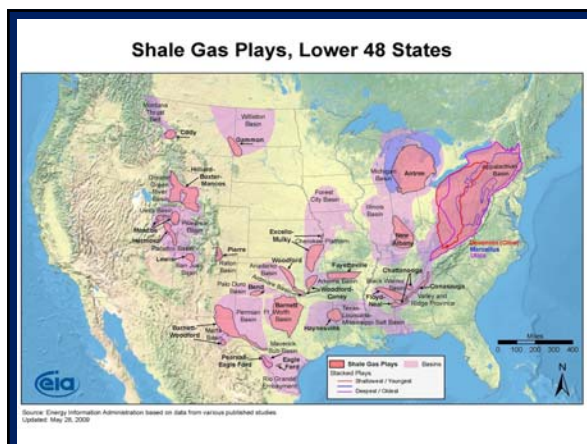


# GAS WELL/WATER WELL SUBSURFACE CONTAMINATION

**Rick Railsback**

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“And ye shall know the truth and the truth shall make you free.”

- Oil companies – “it has never been proven that an oil or gas well has contaminated an aquifer.”



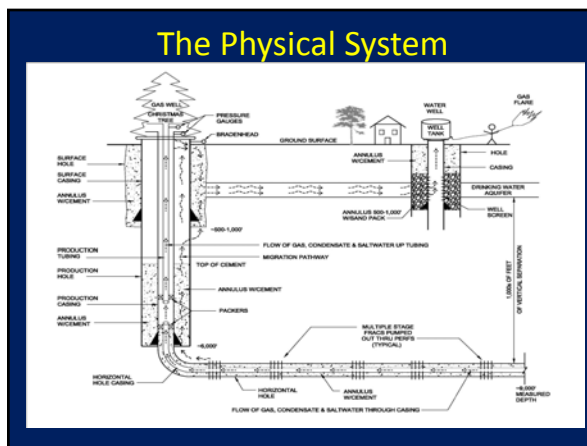
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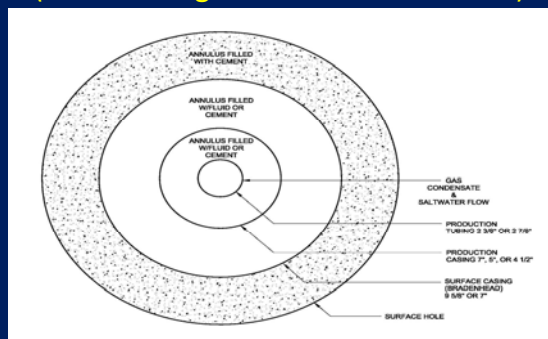


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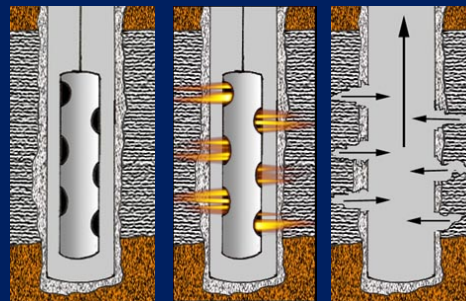
- Oil companies – “it has never been proven that an oil or gas well has contaminated an aquifer.”
- Environmentalists – “every oil and gas well has contaminated all our aquifers.”



## Well Geometry (view looking down on the wellhead)



## Jet Perforation



## Well Site during Frac



## Litigation Support

- Tools & methods for investigation
- Generally presented from simplest tools to more complex least expensive to most expensive

## Plan for Investigation

- Proximity
- Timing of the impact
- Other contaminant sources
- Oil & gas well records
- Pressure data from the gas well
- Pressure data from the water well

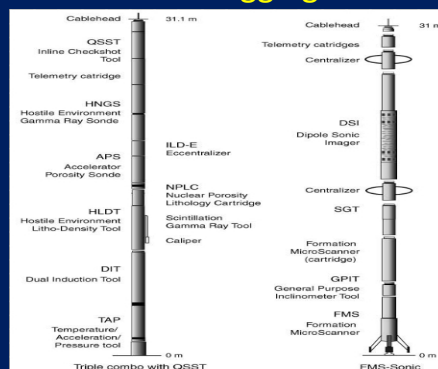
## Plan for Investigation

- Data on frac geometry
- Natural gas composition
- Condensate composition
- Water composition
- Seismic data
- Cement bond logs

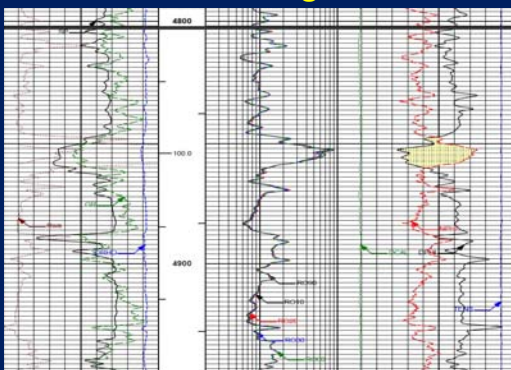
## Wireline Logging Truck



## Wireline Logging Tool



## Well Log



## Plan for Investigation

- Noise logs
- Temperature logs
- Gamma ray logs
- Radioactive tracers
- Pressure interference tests
- Installation of monitoring wells

## Proximity

- Radius of influence of wells dependent upon geology:
  - Porosity (void space in the rock that is filled with fluids and/or gas)
  - Permeability (ability of the rock to transmit fluids and/or gas)
  - Pressure gradients
  - Special geologic conditions (faults, fractures, etc.)

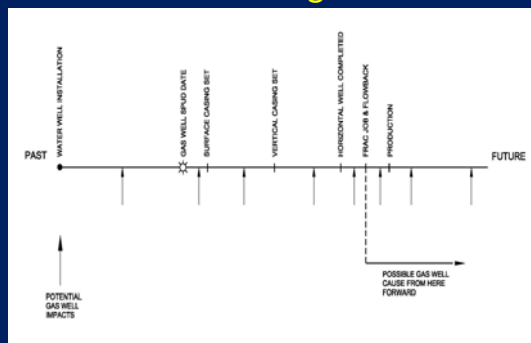
## Proximity



### Timing

- Water well installation
- Gas well installation:
  - Spud date
  - Surface casing set
  - Vertical casing set
  - Horizontal well completed & casing set
  - Frac job and flow back
  - Production
- Time of impact to water well

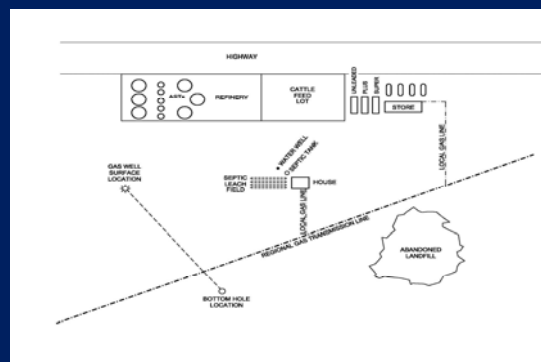
### Timing



### Other Contaminant Sources

- A variety of other sources may be available
- Common sources are usually shallow – within 50 feet of surface
- Impact to deeper aquifers from shallow sources unlikely due to shallow water table & impermeable layers
- Minor amounts of methane occur naturally in aquifers & may be generated by organics in the water well & equipment

### Other Contaminant Sources



### Oil & Gas Well Records

- W-1 Drilling Permit Application
- G-1 or W-2 - Gas or Oil Well Completion Test
- G-5 Gas Well Classification Report
- Railroad Commission Online Research
  - <http://www.rrc.state.tx.us/data/index.php>
- Railroad Commission Public GIS Map Viewer
  - <http://gis2.rrc.state.tx.us/public/startit.htm>

Well No.	Depth	Pressure	Flow Rate	Other Data
1	1,124	1,124	1,124	1,124
2	1,124	1,124	1,124	1,124
3	1,124	1,124	1,124	1,124

**WELL LOG**

WELL NAME: **BRADENHEAD**

WELL NO.: **4311**

DATE: **08/28/2009**

OPERATOR: **Frontier Energy Company**

WELL TYPE: **Gas Well**

WELL STATUS: **Producing**

WELL DEPTH: **11,488'**

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**RAILROAD COMMISSION OF TEXAS**

**GAS WELL CLASSIFICATION REPORT**

Form G-5

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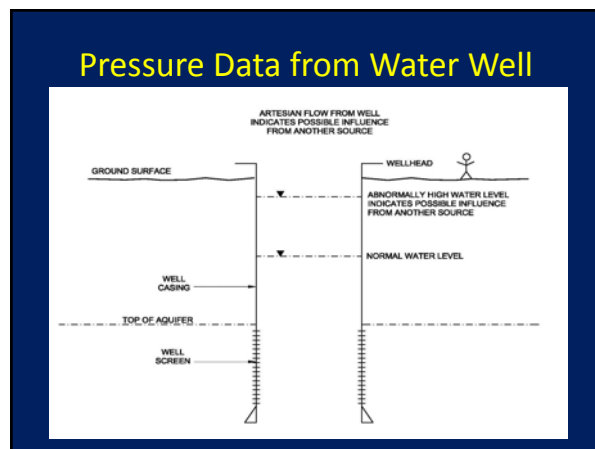
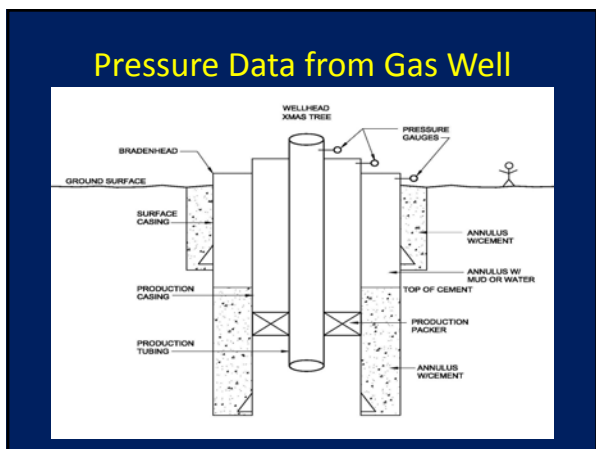
WELL STATUS: **Producing**

WELL DEPTH: **11,488'**

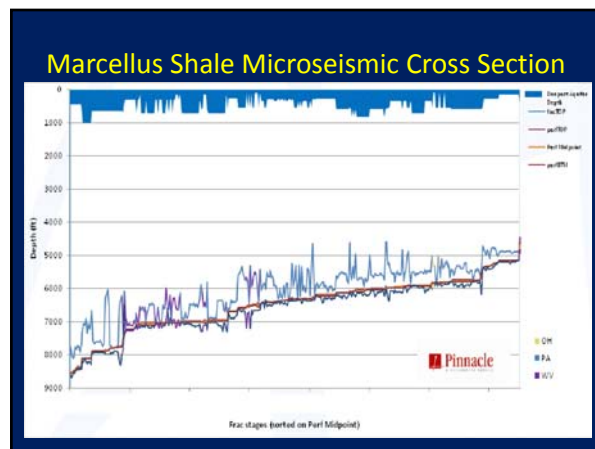
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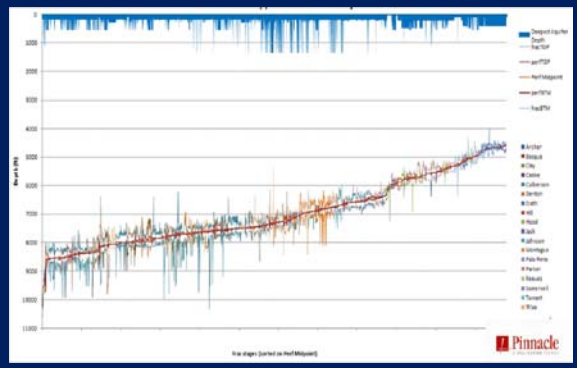


- ### Data on Frac Geometry
- Microseismic records the location of the mini-earthquakes generated by frac creation
  - Microseismic not routinely run on frac jobs
  - Data presented by industry based on relatively few data points
  - Fractures may extend a max of 2,000' above or below perfs (usually only a few 100')
  - Fractures 3,000' + below deepest aquifer





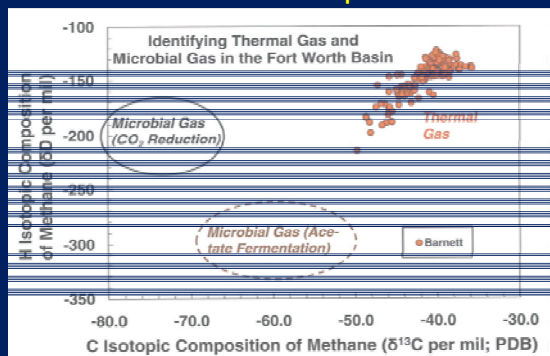
### Barnett Shale Microseismic Cross Section



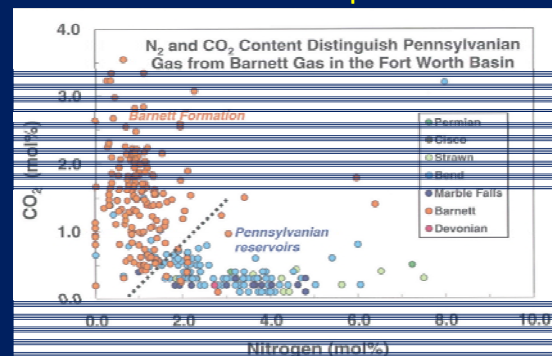
### Natural Gas Composition

- Methane – CH<sub>4</sub> – natural gas
  - Microbial gas
  - Thermal gas
  - Carbon & hydrogen isotopic composition
- Heavier gases
- N<sub>2</sub> and CO<sub>2</sub> content

### Natural Gas Composition



### Natural Gas Composition



### Condensate Composition

- Gas well condensate composed of:
  - TPH (total petroleum hydrocarbons) mainly gasoline range organics
  - BTEX (benzene, toluene, ethylbenzene, xylenes) – marker constituents
  - VOC (volatile organic compounds)
  - PAH (polycyclic aromatic hydrocarbons)

### Water Composition (dissolved constituents)

- TPH - gas, diesel, & oil range organics
- BTEX – benzene, toluene, ethylbenzene, xylenes
- VOC – volatile organic compounds
- PAH – polycyclic aromatic hydrocarbons
- TPH, BTEX, VOC, & PAH not normally present in water well water

## Water Composition (dissolved constituents)

- Methane – CH<sub>4</sub> – natural gas
  - Lab analysis for methane & other gases
  - Flame ionization detector with carbon filter
  - Methane meter
  - Explosimeter
  - Light it?
  - Methane not normally present in high concentrations in water well water

## Water Composition (dissolved constituents)

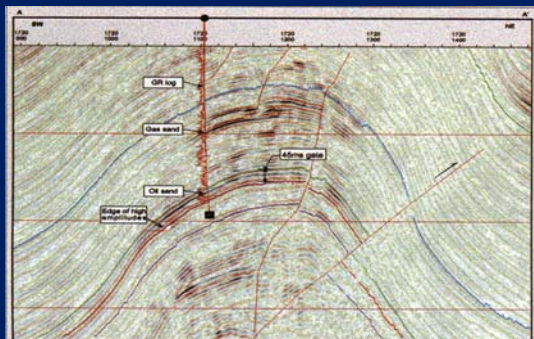
- Minerals & salts – naturally occurring
- TDS (total dissolved solids) & chlorides measure dissolved minerals & salts in water
- TDS – total dissolved solids
  - Water wells (500 – 1,800 ppm)
  - Gas wells (typically > 20,000 ppm)
- Chlorides
  - Water wells (20 - 500 ppm)
  - Gas wells (typically > 20,000 ppm)

## Seismic Data

- Seismic or sound waves used to image the subsurface
- Analogous to sonograms
- Gas accumulations give a “bright spot” amplitude anomaly
- 3D seismic is available over most oilfields



## Seismic “Bright Spots”



## Seismic Data (Potential Problems)

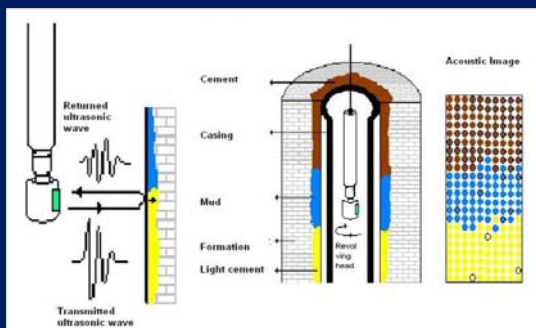
- Timing of data acquisition relative to gas accumulation
- Seismic data focus may not yield useable data in shallow subsurface
- Zone of gas accumulation too thin for seismic resolution
- “Bright spot” not a unique solution for gas

## Cement Bond Logs

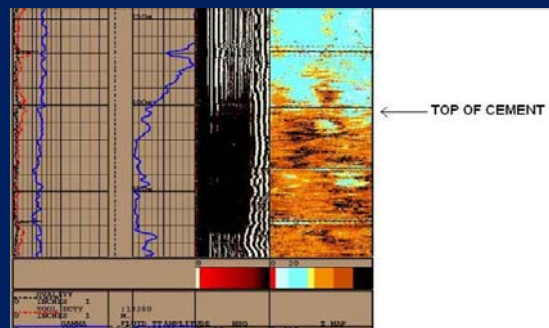
- Acoustic (sonic) device utilizes sound waves to image
- Analogous to sonograms
- Free pipe returns a much greater amplitude signal than cemented pipe
- Amplitude display
- VDL (variable density log) display



### Principles of the Cement Bond Log



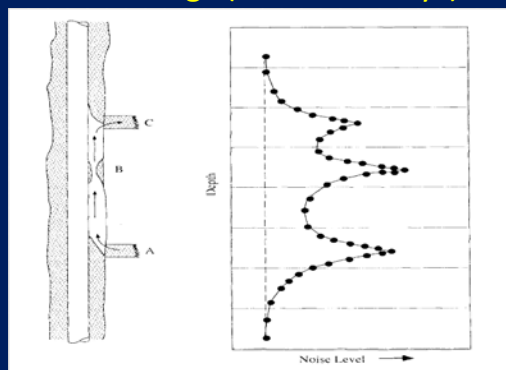
### Cement Bond Log Presentation



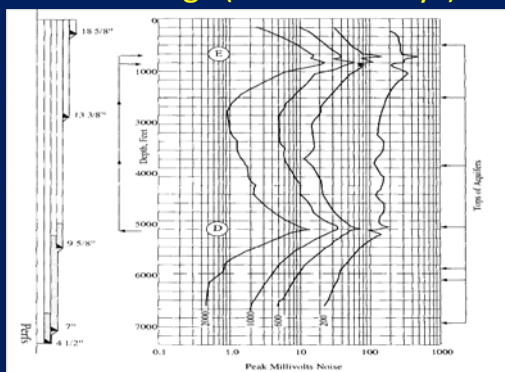
### Noise Logs (Sound Surveys)

- Sensor is an underwater microphone (hydrophone)
- Will detect flow within wellbore or behind pipe
- Turbulent fluid flow
- Gas expansion
- Disturbance of gas/liquid interface

### Noise Logs (Sound Surveys)



### Noise Logs (Sound Surveys)



### Temperature Logs

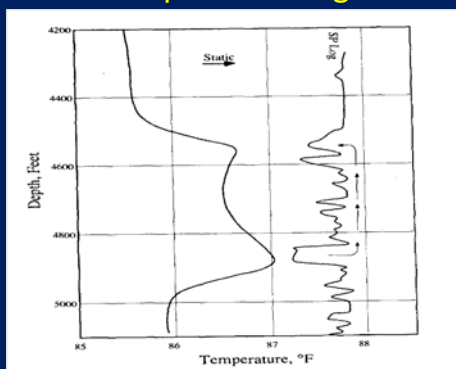
- Temperature increases with depth – normal geothermal gradient
- Anomalies created by fluids or gas entering wellbore or annulus or exiting into formation
- Identify zones producing or taking fluid
- Evaluating cement jobs
- Evaluating frac jobs



### Temperature Logs

- EPA Underground Injection Control (UIC) program approves temperature logs to demonstrate well mechanical integrity – “no significant fluid movement into an underground source of drinking water through vertical channels adjacent to the injection wellbore”.

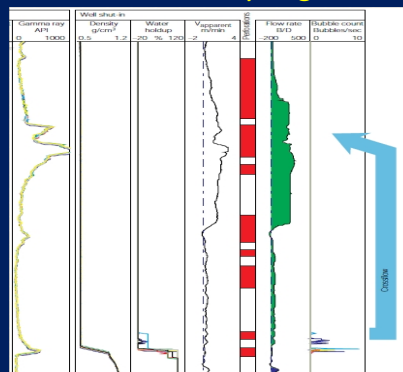
### Temperature Logs



### Gamma Ray Logs

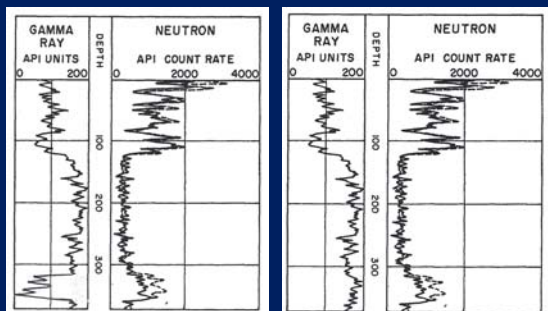
- Measures natural gamma ray emissions from the formation
- Shales – high gamma ray emissions
- Sands, limestones – low gamma ray emissions
- Migration of fluids within & adjacent to the wellbore deposits radioactive salts & zones of migration often marked by high gamma ray emissions

### Gamma Ray Logs



### Gamma Ray/Neutron Logs

2000                      2010



### Radioactive Tracers

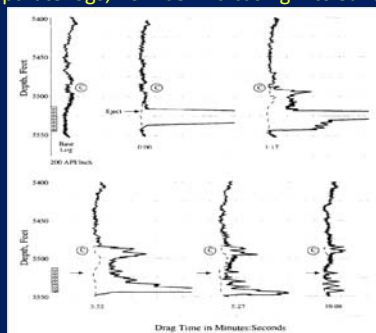
- Tracer is a radioactive isotope that is soluble in gas, oil, and water (iodine; half life 8.1 days)
- Gamma radiation emitted by the tracer is detected by a gamma ray tool
- Gamma radiation penetrates steel, PVC pipe, cement, & formation
- 90% of gamma radiation recorded originates within 1 foot of the detector

### Radioactive Tracers

- Tool can inject tracer and record gamma emissions simultaneously
- Fluid movement & velocity & volume can be monitored within a well, behind casing, & between wells

### Radioactive Tracers

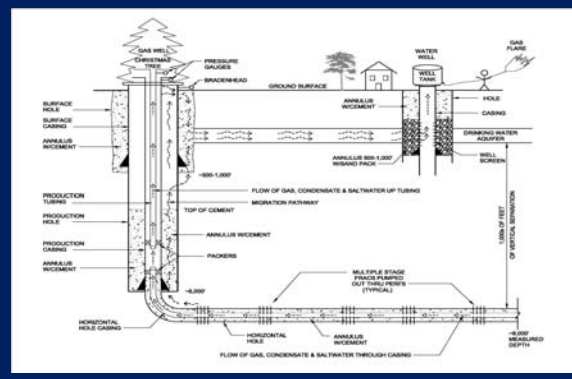
(Well on injection into perfs; 5 logs runs presented on separate logs; flow behind casing into Sand C)



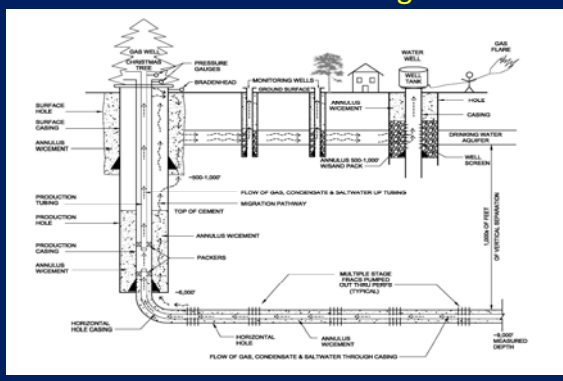
### Pressure Interference Tests

- Downhole pressure gauge installed in the water well
- Pressure wave created in gas well by producing well & shutting it in intermittently
- Pressure changes recorded in water well
- Cross contamination requires hydraulic connection between gas well & water well

### Pressure Interference Tests



### Installation of Monitoring Wells



### Summary

- 18 different investigative tools – can we solve the contamination problem??
- Choose the most time effective tools
- Choose the most cost effective tools
- Choose the tools that will support our case
- Find the “truth”

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