THE "BAINEBRIDGE NATURAL GAS INCIDENT" IN GEAUGA COUNTY, OHIO:
WHAT REALLY HAPPENED!

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Early on the morning of December 15, 2007, an explosion occurred in the home at 17975 English Drive, Bainbridge Township, Geauga County, Ohio.

The Bainbridge Township Fire Department, Geauga County Health Department, and Ohio DNR, Division of Mineral Resources Management responded to the incident immediately.

It was determined that natural gas had caused the explosion and had also migrated into a number of water wells in the area from the English #1 natural gas well. Families were evacuated and a number of water wells were taken out of service due to the presence of natural gas in the groundwater.
THE ENGLISH #1 NATURAL GAS WELL

- The permit to drill the English #1 oil and gas well was issued to Ohio Valley Energy Systems Corporation by the Division of Mineral Resources Management on October 2, 2007. The permit was subject to House Bill 278 Urban Drilling regulations and required drilling on fluid only.

- 8-5/8” surface casing was set at 263 feet and cemented to the surface and witnessed by the Division’s inspector. The depth of the surface casing was 63 feet below the Berea Sandstone which is deepest underground source of drinking water in the area.
Wellbore Schematic
English No. 1 Well

Depth (ft.)  | Formation |
-----------|-----------|
0          | Shale and sandstone |
1,000      | "Ohio Shale" |
2,000      | "Big Lime" |
3,000      | "Huntley" |
4,000      | "Packer Shell" |

Casing description:
- Conductor casing 11.75 in. at 98 ft.
- Surface casing 8.625 in. at 283 ft.
- Production casing 4.5 in.
Drilling continued to total depth of 3926 feet into the Clinton sandstone, which was the targeted oil and gas reservoir. Due to problems with the logging tool, could not get a complete open hole geophysical log suite.

Ran 3873 feet of 4-1/2" production casing and had to wash down from 3659 feet due to bridging of the borehole. Lost circulation.

Cemented production casing with 175 sacks of Unitropic cement. Due to higher pressures and lost circulation on running the production casing a cement bond log was run.
TOP OF CEMENT WAS AT 3648 FEET AND CLINTON SANDSTONE WAS PERFORATED FROM 3720 – 3740 FEET
HYDRAULIC FRACTURING JOB CONDUCTED ON NOVEMBER 13, 2007

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FRAC JOB

- During the frac job, the well circulated after 46,700 gallons of fluid and 290 sacks of sand had been used. The original frac job called for 105,000 gallons of fluid and 600 sacks of sand.

- From November 13th to the 16th, swabbing and flowing back well. Pressure on the surface-production casing annulus ranged from 40 to 180 psi, but by day four had reached 330 psi.

- From November 17th to December 12th surface-production casing annulus was occasionally blown down and then shut-in.
Gas pressure on English #1 well measured on the production casing was 720 psi and 360 psi on the surface-production casing annulus.

Tried to blow down surface-production casing annulus and the well flowed.

Supposed natural gas detected in some water wells
THE DAY OF THE INCIDENT

- At around 2:45am on December 15th, natural gas enters the basement of the house at 17975 English Drive and causes an explosion. No one is injured.
- At 7:30am the Geauga County Emergency Management Agency notified the Division of Mineral Resources Management (Division) inspector of the explosion.
- By 11:00am, the Division had three inspectors on site. Early on responders recognized that gas was entering the homes via the water wells.
- A total of 19 homes were evacuated by that evening.
On December 15th, Ohio Valley Energy attempted to squeeze cement off the gas in the surface-production casing annulus of the English #1 natural gas well.

The production casing was perforated at 3600 to 3602 feet and 800 sacks of cement was squeezed into the annular space. Calculated fill-up was 4530 feet, but after running another cement bond log, the top of cement was at 2656 feet.

A second squeeze cement job was conducted on December 17th and had 41 barrels of cement returned to surface.
THE INVESTIGATION

- Division inspectors evaluated all oil and gas wells within one mile of the incident to identify any potential sources of the problem.
- All surface-production casing annuli were evaluated for the presence of natural gas.
- Inspectors also evaluated the area for unplugged orphan wells, improperly plugged oil and gas wells, seismic event that may have released natural gas, and naturally-occurring natural gas zones.
During the first week, the Division initiated a monitoring program to: 1) identify water wells with detectable natural gas; 2) define an area for water samples to be collected; 3) Monitor in-house gas concentrations for the protection of public health and safety; and 4) measure the response of water wells to the corrective action at the English #1 gas well.

A total of 26 domestic water wells were disconnected between December 17th and the 22nd and Ohio Valley Energy installed 1500-gallon storage tanks and provided water to those residences.
NATURALLY OCCURRING GAS

- It was confirmed by the Division that some of the existing water wells completed in the Berea Sandstone in the area had naturally-occurring natural gas.

- The Bainbridge Police Department well had significant gas in it prior to the “Bainbridge Incident”. 
ONGOING INVESTIGATION

- In January of 2008, the Division implemented new oil and gas permit conditions for broad areas of northeastern Ohio to address issues like the “Bainbridge incident”.
- Continued to monitor for the presence of natural gas.
- Implemented a comprehensive water quality testing program to thoroughly evaluate for contamination by fluids related to hydraulic fracturing.
- Conducted initial downhole video camera work in water wells to identify gas source zones within the aquifers.
WATER SAMPLING PARAMETERS

- Water samples were analyzed for dissolved gases, volatile organic compounds, metals, inorganic parameters, and hydraulic fracturing components.
- All samples were taken to EPA certified labs for analysis.
- Water quality reports were sent to homeowners with the summary of the results.
- Background water quality assessments were conducted.
Most groundwater in the area is dominated by bicarbonate and typically hard water. Iron and manganese concentrations exceeded secondary standards in over half of the water wells sampled. Iron-precipitating and sulfur-reducing bacteria were common. There was no contamination of groundwater by oilfield brines, crude oil, or hydraulic fracturing fluids.
Concerns were continuing to be raised that the English #1 gas well may be leaking.

In order to address these concerns, the Division required an additional cement bond log to be run.

A segmented bond log was run on March of 2008.

The deep gas source was cemented off, but we still had gas-cut cement from around 548 feet to surface.
In January and March of 2008, the Division ran their downhole video camera in six impacted water wells.

The videos showed bacterial slimes, rusted casings, vertical joints, and bedding planes where gas was entering the boreholes.
STATUS OF THE INVESTIGATION

- In September of 2008, the Division issued a report with its account of the events, causes of the overpressurization, natural gas invasions, regional geologic and hydrogeologic information, background and site-specific water-quality data, corrective actions, and recommendations.
In January of 2009, a law firm representing 42 property owners, filed a civil lawsuit in Geauga County court against Ohio Valley Energy and other companies involved in the English #1 gas well. The law firm hired a consultant who evaluated the natural gas incident and disputes arose between the Division and consultant and law firm over interpretations of data, designation of impacted and non-impacted residences, and predictions of long-term consequences.
The Expert Panel

- In order to address the issues in dispute between the Division and the consultant for the law firm, the Division agreed to form an expert panel to evaluate the dispute issues.
- The panel consisted of five experts in the fields of groundwater hydrology, petroleum engineering, petroleum geology, groundwater chemistry, and geomicrobiology.
- These experts consisted of three professors and two scientists from the U.S. Geological Survey.
FOUR MAIN ISSUES OF DISPUTE

- Whether overpressurization of the English #1 gas well created a conical network of far-reaching, shallow and deep fractures extending throughout the Ohio Shale and into the overlying and underlying geologic units.
- Whether said network of fractures created a perpetual source of invasive gas in the residential water wells.
- Whether measurement of natural gas concentrations at the water wells can be used to characterize and delineate said network of fractures.
- Whether subsurface fluid pressures were sufficient to force particles of Ohio Shale from the creation of the conical fracture network upward into the aquifers resulting in the reports of the “black goo” in some of the water wells.
TASKS GIVEN TO THE EXPERT PANEL

- To evaluate the disputed issues.
- Determine what conclusions best explain the gas impacts and long-term consequences.
- Recommend any measures that could help remediate the impacted area.
- The panel was given the ability to request and oversee the Division staff in the collection of additional field, lab, and geologic data.
- Rather than approach this task to evaluate the disputed issues as would a jury, the expert panel chose to apply the scientific method to test the dissimilar conclusions reached by the Division versus the consultant for the law firm.
Division staff spent 15 days in the field assisting panel members measuring joints at local outcrops and quarries, sampling water and sediments from residential water wells, measuring water levels, natural gas concentrations, and conducting additional downhole videos of water wells.
MEASURING JOINT SETS
TAKING WATER LEVEL MEASUREMENTS
COLLECTING WATER SAMPLES
ADDITIONAL DOWNHOLE VIDEOS

BUDDENHAGEN
WELL
BAINBRIDGE
TWP. GEAUGA
TWP 5/14/09
NATURAL FRACTURES

- Measurements of 95 joints were taken at local rock outcrops and quarries.
- Dominant joint trends were N55E and N45W.
- These dominant joint trends are consistent with joint bearings taken in eastern Ohio, western Pennsylvania, and southwestern New York.
An additional 24 downhole borehole videos were taken in 21 water wells in the Bainbridge impact area.

Detailed borehole logs were completed for each well and identified bedding planes, joints, gas bubbles, gas source zones, changes in lithology, bacterial colonies, and degree of corrosion of steel well casings.
INTERPRETED DOWNHOLE VIDEO LOG CROSS SECTION
STRATIGRAPHIC SECTION AND IMAGES OF NEAR-SURFACE GEOLOGIC UNITS
HYDROGEOLOGY AND AQUIFERS

- The predominant aquifers in the Bainbridge area are the Sharon Sandstone and the Berea Sandstone.
- Some of the water wells are completed in the Cuyahoga Shale and provides water through the fractures and bedding planes.
GROUNDWATER FLOW IN THE BAINBRIDGE AREA

- Sharon Sandstone
- Cuyahoga Shale
- Berea Sandstone
- Bedford Shale

EXPLANATION:
- Double porosity medium
- Fracture porosity only
- Well
- Casing
- Open borehole
- Water table elevation in Sharon Ss
- Potentiometric surface in Berea Ss
- Direction of groundwater flow
LOCAL GEOLOGY

- To further understand the movement of the fugitive natural gas, additional geologic work was undertaken.
- A structural map on top of the Berea Sandstone was construction.
- Detailed geologic cross sections were developed.
TOP OF BERE A STRUCTURE MAP

Approximate high point on Berea Sandstone structural top

Approximate position of saddle in Berea Sandstone structural top

Payne well

English #1 Gas Well

0 500 ft
GEOLOGIC CROSS SECTION
ANNULUS OVERPRESSURIZATION

- In the 1980s, Dr. Samuel Harrison of Allegheny College published two papers in *Ground Water* dealing with natural gas invasion from overpressurized annuli of gas wells in northwestern Pennsylvania.
AN OVERPRESSURIZED SURFACE-PRODUCTION CASING ANNULUS CREATES LARGE PRESSURE GRADIENTS ENABLING GROUNDWATER AND FREE GAS TO MOVE RADially OUTWARD INTO MORE PERMEABLE STRATA (MODIFIED FROM HARRISON, 1985)
GAS MIGRATION IN THE BAINBRIDGE AREA ALONG BEDDING PLANE CHANNELS THAT INTERSECT A WELL (MODIFIED FROM RASMUSSON AND NERETIEKS, 1996)
Mid-November 2007
gas starts to rise up into Berea Sandstone near English well

Explanation
- Top of Berea Ss contour
- High point in Berea Ss top

Approximate position of saddle in Berea Sandstone structural top

English #1 gas well

Gas cap
Late November 2007
gas cap ≈ 2 feet thick
near English well

Explanation
- Top of Berea Ss contour
- High point in Berea Ss top
- Berea / Cuyahoga well
- Cuyahoga well

Approximate position of saddle in Berea Sandstone structural top

English #1 gas well
Gas cap
December 15, 2007

gas cap ≈ 4 feet thick near English well

Explanation
- Top of Berea Ss contour
- X: High point in Berea Ss top
- Blue circle: Berea / Cuyahoga well
- Light blue circle: Cuyahoga well
- Purple circle: no information about well

Approximate position of saddle in Berea Sandstone structural top

English #1 gas well

Gas cap
Early January 2008
near English well gas
still rises but under
lower pressure

Explanation
- Top of Berea Ss contour
- High point in Berea Ss top
- Residential well used to
  purge gas (Jan–Jun 2008)

Approximate position of
saddle in Berea Sandstone
structural top

English #1
gas well

Gas cap
March 2008
gas cap spreads and
dissipates upward

Explanation
- Top of Berea Ss contour
- High point in Berea Ss top
- Residential well used to
  purge gas (Jan–Jun 2008)

Approximate position of
saddle in Berea Sandstone
structural top

English #1
gas well

Gas cap
**Explanation**
- Top of Berea Ss contour
- High point in Berea Ss top
- Berea well

**Approximate position of saddle in Berea Sandstone structural top**

**Summer 2009**
- Gas cap splits apart at 3 places

**English #1**
- Gas well
WATER SUPPLY REPLACEMENT

- Ohio Valley Energy constructed a public water line into the neighborhood impacted by the English #1 gas well.
- In the spring of 2010 the water line was completed and 26 homes have now been connected to the water line.
HOUSE WITH THE EXPLOSION
WHY AN EXPLOSION AT THE HOUSE?
CONCLUSIONS OF THE EXPERT PANEL

- Overpressurization of the surface-production casing annulus in the English #1 gas well caused the gas to migrate into the natural fractures and bedding planes.
- Natural gas in the aquifers are dissipating and the deeper gas source has been eliminated.
- Wellhead gas readings are non-diagnostic in terms of characterizing subsurface geologic conditions.
- Water from private water wells in the area have not degraded in water quality due to the subsurface gas invasion.
- The black sediment or “black goo” is typically a combination of corroded steel casing particles, rock fragments, or bacteria that is commonly found in many water wells in Ohio.
CURRENT STATUS

- The Division continues to investigate new water well complaints in the Bainbridge area and makes determinations.
- Ohio Valley Energy connected all of the residences to the water line that were determined to be impacted by the gas invasion and plugged all water wells in the basements of the houses.
- Ohio Valley Energy is working with Ohio EPA to obtain a discharge permits to pump and try to speed up the degassing of the aquifers through seven water wells left for this purpose.
QUESTIONS?