GROUNDWATER INVESTIGATION REPORT

Ohio Department of Natural Resources
Division of Oil & Gas Resources Management
Richard J. Simmers, Chief

Mr. & Mrs. Jason Kline
9915 Silica Sand Road
Garrettsville, Ohio 44231
ID# 12-4150

October 18, 2013

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Executive Summary

The Ohio Department of Natural Resources-Division of Oil & Gas Resources Management (ODNR-DOGRM) has investigated a stray gas complaint for Mr. and Mrs. Jason Kline of Garrettsville in Portage County, Ohio. On December 21, 2012, Mrs. Debbie Kline filed a complaint with the DOGRM after accidently igniting natural gas mixed with tap water coming from the faucet in the master bathroom. The Klines were concerned the natural gas (methane) mixed with groundwater from their water well was due to recent oilfield drilling approximately 1,500 feet southeast of their home.

On August 28, 2012, Mountaineer Keystone began drilling the first of two horizontal natural gas wells on the Soinski property southeast of the intersection of Silica Sand and Frazier Roads in Windham Township. Each well was completed in the Utica Shale and constructed in accordance with the Ohio Revised Code chapter 1509 and Ohio Administrative Code chapter 1501. Three companies collected pre-drilling water samples at twelve homes. Nine of the twelve water wells tested had dissolved methane in the sample including the Kline water well.

Five post-drilling water samples were collected from the Kline water well by the DOGRM, Rettew, and Summit Environmental Technologies for the investigation. The concentration of dissolved methane varied from 10.2 mg/L to 58.2 mg/L. Isotopic analysis of the methane in the water well was performed on a sample collected by Rettew on February 12, 2013. Isotopic analysis involves measurement of stable isotopes of carbon (C) and hydrogen (H) in the methane (CH_4) molecule and related compounds, such as carbon dioxide (CO_2), water (H_2O), ethane (C_2H_6) and other hydrocarbons. Stable methane isotopes $\delta^{13}C$ and δD can provide some information on the thermogenic or biogenic origin of the gas. The analysis determined the methane in the Kline well to be genetically distinct from gas originating in deeper gas reservoirs such as the Clinton Sandstone and Utica Shale. The gas is biogenic in origin and consistent with a near-surface microbial gas and not thermogenic gas.

Interviews with water well professionals and area residents, reviews of water well logs, pre-drill water sample results, and professionally published papers all conclude that natural gas (methane) was present in the shallow bedrock aquifer(s) of Nelson and Windham Townships prior to the drilling of the Soinski gas wells. The concentration of dissolved methane in the groundwater is variable, including the Kline well. A number of factors may be contributing to the wide range dissolved methane levels in their water including natural fluctuation within the aquifer, the depth and development of the well, sampling methodology (i.e. purging time and sample containerization), variable pumping, and usage of their well prior to sampling, and the laboratory analytical methods.

The Division of Oil & Gas Resources Management has concluded the methane in the Kline water well is naturally occurring and not the result of oilfield activities by Mountaineer Keystone, LLC. Sampling of seventeen area water wells in February 2013 did not show any indications that oilfield contaminants had been introduced into the groundwater through the drilling of the Soinski wells. Dissolved methane levels in the neighboring water wells were consistent with the pre-drilling results. Wells with only post-drilling analysis have dissolved methane concentrations less than 2.5 mg/L with the majority having less than 0.5 mg/L. The concentration and fluctuation of dissolved methane the Klines are experiencing is isolated to their water well. Methane in water wells developed in shallow bedrock aquifers in Portage County is common and manageable using these safety precautions.

1. Install at least one carbon monoxide/combustible gas (LEL) detector in the home. Combustible gas detectors sound an audible alarm when the concentration of methane reaches 10% of the lower explosive level (LEL). Always follow the manufacturer's directions for installation.

2. Keep ignition sources away from the water faucets while in use.

3. Do not attempt to ignite the gas.

4. Ventilate bathrooms during and after bathing or showering.

5. Allow the methane to vent through the water wellhead by installing a vented well cap with a large diameter riser that extends above ground level to isolate the methane from potential ignition sources. A registered water well professional should install the vent so it meets the standards of the Ohio Department of Health.

GROUNDWATER INVESTIGATION REPORT

Mr. & Mrs. Jason Kline, 9915 Silica Sand Road, Garrettsville, Ohio 44231
ID# 12-4150

PURPOSE & SCOPE

This investigation was conducted to determine if oilfield activity at Mountaineer Keystone's Soinski well pad is the source of dissolved and free methane in the groundwater from a residential well at 9915 Silica Sand Road, Garrettsville, Ohio. See Figure 1. The water well is owned by Mr. and Mrs. Jason Kline.

STATEMENT OF PROBLEM

On December 21, 2012, Mrs. Debby Kline filed a complaint (#4150) with the Ohio Department of Natural Resources - Division of Oil & Gas Resources Management (ODNR-DOGRM) after igniting methane gas coming from a water faucet in the master bathroom of her home. Mrs. Kline expressed concern that the drilling of two Utica Shale wells approximately 1,500 feet southeast of her home was the source of the stray gas.

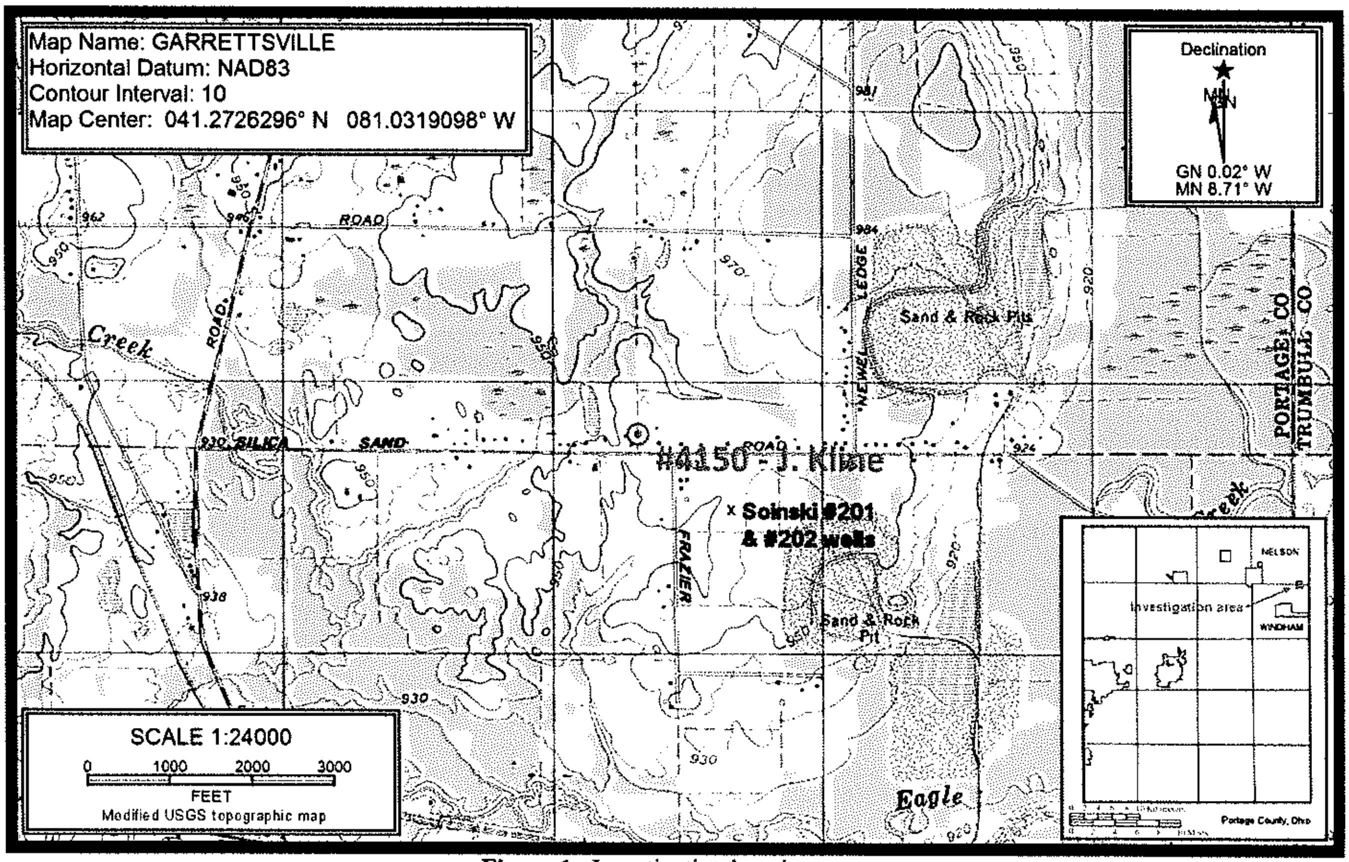

Figure 1. Investigation location map.

INVESTIGATION

The investigation included the following actions:

1. Multiple interviews/phone calls with the Klines.

2. Multiple site visits to the home and well pad by the DOGRM.

3. Multiple groundwater samples collected by DOGRM, Summit Environmental Technologies (SET), and Rettew Associates.

4. Downhole camera inspection of the Kline and Everhart water wells by the DOGRM.

5. Review of the local soils, geology, and hydrogeology.

6. Review of local and regional groundwater resources.

7. Review of ODNR-Division of Mineral Resources Management mine maps.

8. Review of the web-based Ohio Oil and Gas Well Locator for nearby wells.

9. Inspected all oil & gas wells within 2,500 feet of the Kline home.

10. Review of the Soinski wells (#201 & 202) construction, and cement bond logs.

11. Inspected the Soinski wells (post-drilling) for this investigation.

12. Review of ODNR water well logs within ½ mile for construction details, development, and lithology.

13. Review of the Centers for Disease Control (CDC) and Agency for Toxic Substances and Disease Registry (ATSDR) literature on methane (CH_4).

14. Interviews and meetings with officials from Mountaineer Keystone.

15. Multiple meetings with DOGRM's Portage County inspector and NE regional supervisor.

The Kline Complaint

Mrs. Kline told the DOGRM that on Friday December 21, 2012, she lit a candle near a faucet with the water running igniting methane gas. The fire department checked the home and confirmed there was methane gas in the water supply. They advised her to call the Portage County Health Department (PCHD). The PCHD then advised her to call the DOGRM. Mrs. Kline contacted the DOGRM Uniontown office and filed a complaint at approximately 10:45am. At 11:04am, the complaint was forwarded to a hydrogeologist who immediately contacted Mrs. Kline. During the call, she was advised of safety precautions her family should follow until the DOGRM could assess the situation.

The DOGRM conducted an interview with Mr. and Mrs. Kline. Mrs. Kline produced a copy of the pre-drill sample results, which were reviewed by the hydrogeologist. The report showed that dissolved methane was detected in the sample at 9.48 mg/L. Next, the air in the home was tested for methane (CH_4), hydrogen sulfide (H_2S), and carbon monoxide (CO) gases using a Sperian PhD6™ handheld gas detection meter. All rooms in the home were void of these gasses, therefore no immediate actions such as ventilation or evacuation were required.

The water well is in the rear of the home between the house and garage. See Figure 2. The well cap was removed to measure the static water level (swl) and check for methane venting through the wellbore. The swl was 43.3 feet from the top of the casing (toc) which is 10 inches above ground level. The Sperian PhD6™ detected methane in the well bore exceeding the 5% maximum detection limit of the infrared (IR) sensor. See Table 1. Upon completion of the measurements, the cap was placed loosely on the casing in order to allow the escaping methane to vent to the atmosphere.

In the northwest corner of the basement are the incoming water line, pressure tank, water treatment systems, and sump well with discharge pipe. See Figure 3. Water coming from the well passes through the pressure tank, goes through a sediment filter to remove any solids, then into a Kinetico Model 100 water conditioning system. From there it is distributed throughout the home and outside spigots.

Figure 2. Kline water well (ODNR #903235).

LOCATION	OXYGEN (O_2)	METHANE (CH_4)	METHANE LEL	CARBON MONOXIDE (CO)	HYDROGEN SULFIDE (H_2S)
	%	%	%	PPM	PPM
basement	20.9	0	0	0	0
kitchen	20.8	0	0	0	0
kitchen-hot water	20.8	0.10	2	0	0
kitchen-cold water	20.8	0.05	1	0	0
bathroom	20.7	0	0	0	0
daughter's bedroom	20.8	0	0	0	0
children's bedroom	20.8	0	0	0	0
master bedroom	20.9	0	0	0	0
master bathroom	20.8	0	0	0	0
water wellhead	18.8	>5*	100	no reading	0

ppm = parts per million *The IR sensor on the Sperian PhD6™ detects a maximum concentration of 5% methane.

Table 1. Field readings for gases in the Kline home on December 21, 2012.

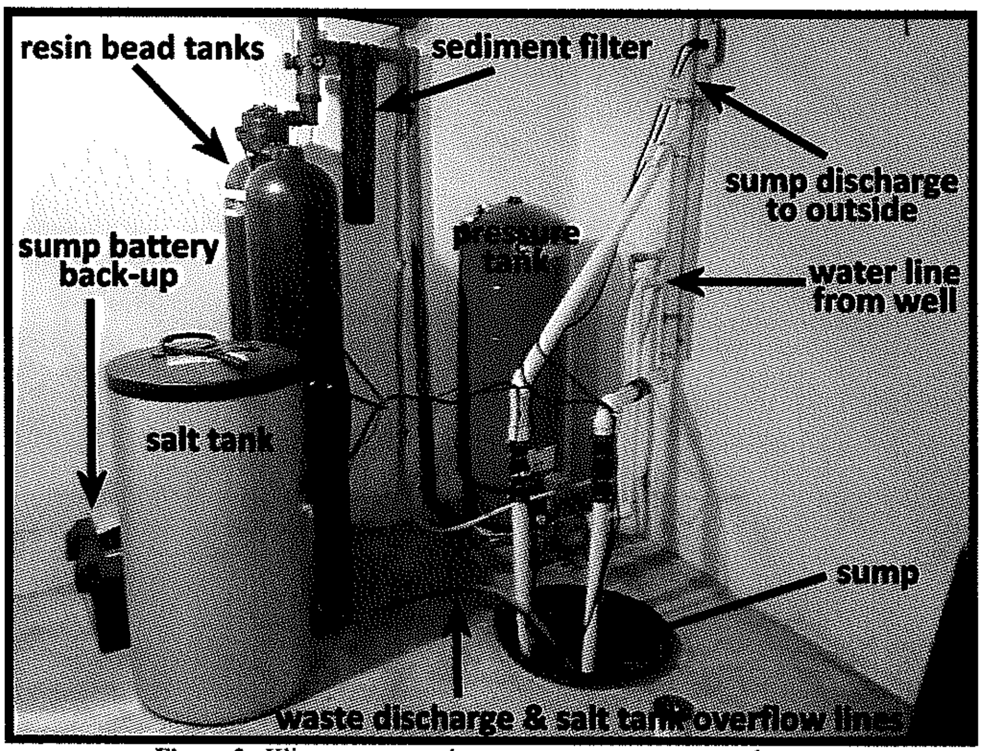

Figure 3. Kline pressure tank, water treatment system, and sump.

Following DOGRM standard procedure an untreated water sample was collected. To avoid releasing methane into the home a hose was attached to the outside spigot at the rear of the house to purge the well prior to collection of the sample. Three volumes of water (approximately 426 gallons) were purged to collect a sample representative of groundwater in the aquifer. The sample (KLT-158) was collected from the sampling valve at the pressure tank in a clean stainless steel pail. Two plastic sample containers were filled from the pail using sterile technique. One 250-milliliter (mL) bottle was preserved with nitric acid (HNO_3), and one 1-liter (L) cubitainer was preserved on ice. Water for the dissolved methane analysis was collected using the "submersion technique" in four 40 mL clear glass vials with septum caps. The vials were submerged in a three-gallon bucket, filled with water flowing through tubing from the sampling valve, and sealed under water. Effervescence and a slight sulfur odor were noted while collecting the sample. All bottles were placed in an ice-filled cooler at or below 4°C (39°F) until relinquished at the laboratory.

Toilet tanks were inspected for signs of mineral staining/deposits, sediments from the well, and iron, sulfur and slime-forming bacteria. The inspection revealed the presence of iron bacteria, iron staining, and sediments in the tank. See Figure 4.

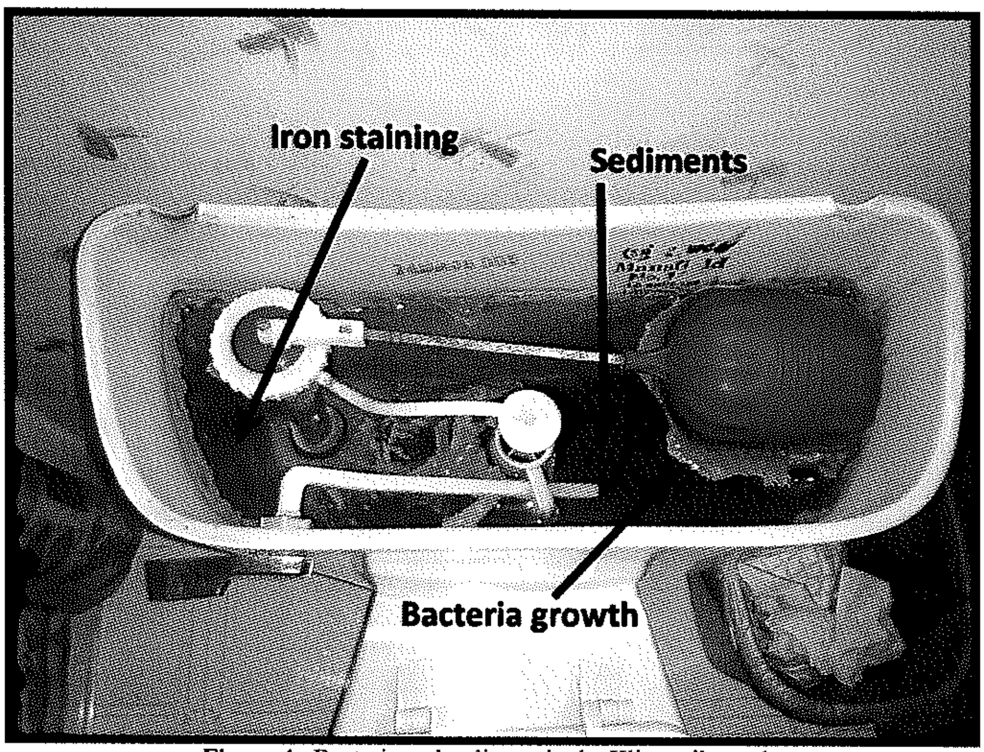

Figure 4. Bacteria and sediment in the Kline toilet tank.

Two air samples were collected for laboratory analysis in 10 mL glass vacuum tubes. Air sample KLT-A1 was collected at the master bathroom sink with the cold water flowing. The second sample, KLT-2A was collected at the pressure tank sampling point during collection of KLT-158.

Before leaving, the DOGRM advised the Klines of the following safety precautions and recommendations to follow until the investigation was completed:

1. Install at least one carbon monoxide/combustible gas detector in the home. Combustible gas detectors sound an audible alarm when the concentration of methane reaches 10% of the lower explosive level (LEL).

2. Keep ignition sources away from the water faucets while in use.

3. Do not attempt to ignite the gas.

4. Ventilate the bathrooms during and after bathing or showering.

5. Allow the methane to vent through the wellhead.

6. Install a vented well cap with a large diameter riser that extends at least six feet above ground level to isolate the methane from potential ignition sources.

Air in the home was tested for methane, carbon monoxide, and hydrogen sulfide gases, none of which were found. Based on the safety recommendations adopted from the Department of the Interior's Office of Surface Mining Reclamation & Enforcement (Eltschlager 2001), the DOGRM determined no immediate action, such as increased ventilation or evacuation, was necessary. The OSMRE action levels are listed in Table 2.

% LEL Range	Action
1-4	No immediate action necessary
5-9	Increase ventilation, continue to monitor to see if the % LEL continues to rise
10-19	Shut off water; and monitor to see if % LEL continues to rise
>20	Keep water shut off; increase ventilation; evacuate the premises; call the Fire Department for an inspection; notify DOGRM at (330) 896-0616

Table 2. Decision matrix for ambient methane in confined spaces. (Eltschlager 2001)

Groundwater Resources in the Investigation Area

The Ohio Department of Natural Resources - Division of Soil & Water Resources map titled *Ground- Water Resources of Portage County* (1979) indicates the investigation area in southern Nelson Township is an area where water wells are drilled into "sandstones of the Pottsville group" which may yield 25 to 100 gpm. The main aquifers are the Massillon sandstone and the Sharon conglomerate. Water wells on Silica Sand and Frazier Roads are developed in unconsolidated sands or bedrock and range from 46 to 200 feet deep but average less than 100 feet. Groundwater flow direction in the bedrock aquifer is to the east, based on potentiometric surface data from the ODNR-Division of Soil & Water Resources for Portage and Trumbull Counties. See Figure 5.

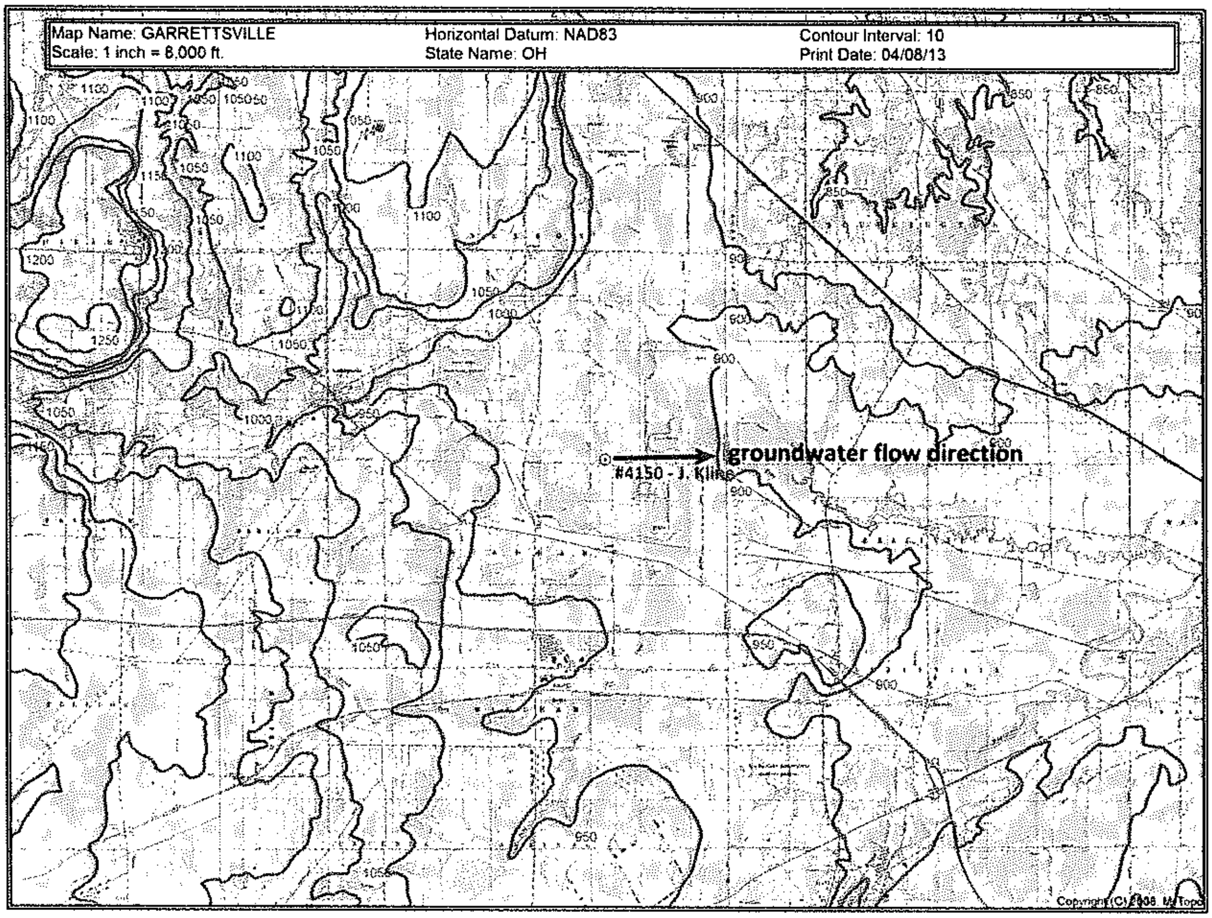

Figure 2. Potentiometric surface map data for Portage and Trumbull Counties from the ODNR Division of Soil & Water Resources (www.dnr.state.oh.us/tabid/3621/Default.aspx)

Figure 5. Potentiometric surface map for Portage and Trumbull Counties from the ODNR-Division of Soil & Water Resources (www.dnr.state.oh.us/tabid/3621/Default.aspx)

<u>Ambient Groundwater Quality</u>

Water wells drilled north and south of Silica Sand Road, and west of Newel Ledge Road are typically developed in the Berea Sandstone aquifer since the Massillon sandstone and Sharon conglomerate are wanting. Water wells drilled into the Berea aquifer typically have their storage capacity increased by extending the wellbore into the underlying

Devonian shale. The Devonian age Ohio Shale is a known natural gas reservoir in the area. Ohio Geological Survey oil and gas well completion cards indicate that operators have attempted to complete natural gas wells in the Ohio shale in Lot 29 of Nelson Township, approximately 1.5 miles north of Silica Sand Road. The wells, drilled in 1976, ranged from 550 to 675 feet deep. One well (permit No. 915) lists production of 90 thousand cubic feet (MCF) of natural gas from a depth of 426 feet.

Water well driller notations on ODNR-Division of Soil & Water Resources logs for wells drilled along Silica Sand Road between 1973 and 2000 describe the water quality as "oily", "gassy," and/or "cloudy." Completion cards for oil and gas wells drilled during the 1970s often note that water encountered while drilling through the Berea Sandstone in Nelson Township is brackish. An Ohio Geologic Survey (OGS) water resources report by Wilber Stout et al. in 1943 states that "all deep tests below the Sharon conglomerate encounter sulfur water and brine in the vicinity of Windham, Garrettsville, and Mantua of Portage County. S. J. Winslow and G. White of the USGS wrote the following in 1966 about groundwater quality in the Berea Sandstone of Portage County.

> *"Few water wells have been drilled deeper than the Berea Sandstone, and for this reason no samples of water were obtained from the formations below the Berea Sandstone. Brine has been reported in records of oil and gas wells as being in the deeper formations, and brine may be expected at any depth below the Berea Sandstone in the northern part of the county and at any point below the conglomerate unit of the Sharon Member of the Pottsville Formation in the remainder of the county.*
>
> *Samples of water collected from three wells drilled into the Berea Sandstone show an average total hardness of 194 ppm as compared with the average total hardness of 247 ppm for all the ground water analyzed. The dissolved solids in the three samples ranged from 287 to 1,350 ppm and consisted principally of calcium and magnesium bicarbonate, and significant amounts of sodium, sulfate, and chloride ions. No non-carbonate hardness was present in any of the three samples.*
>
> *The chloride content of the water in the Berea Sandstone is shown by the three analyses to range from 17 to 520 ppm, the 520 ppm value being the highest reported in the analyses of ground water in the county. The sodium content of the water is similarly high, the maximum being 468 ppm."*

Ms. Esta Everhart, a neighbor of the Klines, who has lived on Silica Sand Road since 1958 stated the water from her well has always had gas in it. She also told the DOGRM about a water well drilled in the 1950s at 10688 Silica Sand Road that had both natural gas and crude oil in it.

Mr. Don Burrows of Charles Burrows & Sons Well Drilling told DOGRM investigators that well drillers familiar with the area typically try to complete wells in the unconsolidated sand and gravel deposits to avoid the natural gas in the bedrock. He recounted an event where a resident on Silica Sand Road accidentally ignited the natural gas (methane) venting from the well cap destroying the PVC casing.

The Kline Water Well

Two water well logs exist for 9915 Silica Sand Road. The first water well (ODNR #814004) was drilled by Charles Burrows & Sons Well Drilling of Mantua, Ohio on December 10, 1999. According to Don Burrows, the well was drawing in "fine sand" which caused issues with the water quality and submersible pump. The well was plugged and the current well was drilled into the bedrock (ODNR #903235). It is located at coordinates N41.27259, W81.03191 (±10ft, NAD83). Surface elevation of the well is approximately 959 feet above mean seal level (amsl). The well is 140 feet deep with 97 feet of 6-inch welded steel casing. Approximately 10 inches of the casing is above ground. A submersible pump capable of 10 gpm was set at approximately 120 feet.

Soinski Well Pre-drill Water Well Sampling

Background water samples were collected by Mountaineer Keystone representatives from eleven homes. The Soinski well permits were issued prior to the effective date of Senate Bill 315 (September 12, 2012), therefore, Mountaineer Keystone was not required to sample all water wells within 1,500 feet of the pad. Some of the sampled water wells were beyond 1,500 feet of the pad. See Appendix A for complete results.

Methane and LEL

Methane (CH_4) is the largest component of natural gas generally comprising 70-90% of the volume followed by ethane (C_2H_6), propane (C_3H_8), and butane (C_4H_{10}) along with other minor gasses. It is frequently found in varying concentrations dissolved in groundwater. In Ohio, there are shallow bedrock aquifers that contain naturally occurring methane. Methane can also be found in water wells developed in glacial drift deposits. In rare instances, a groundwater aquifer can be charged with methane from an abandoned or improperly constructed natural gas well. The majority of water wells containing free or dissolved methane are due to naturally occurring conditions. Processes near the earth's surface (e.g., decomposition of organic matter in swamps and wetlands) can also produce methane, so the mere presence of dissolved methane in groundwater or free gas venting from a water well does not necessarily indicate contamination related to oilfield activities.

In general, methane gas dissolved in groundwater does not present a health risk. Methane gas does not have any known toxic, poisonous, or carcinogenic properties, and there is no known or demonstrated human health effects associated with drinking or bathing with well water that contains methane. The United States Environmental Protection Agency (US EPA) recognizes methane gas as a non-toxic substance. For that reason, it does not appear in the list of primary drinking water standards. Furthermore, the US EPA does not included methane gas in the secondary drinking water standards. The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency of the United States Department of Health and Human Services who provides information to the public to prevent harmful exposure and diseases related to toxic substances. ATSDR, like the US EPA, does not identify methane as a toxic substance to humans. Methane does present an explosion hazard and can be an asphyxiant by displacing oxygen when the concentration exceeds 15% of the volume of air in a confined space.

Methane gas becomes explosive when the concentration is between 5% and 15% of the volume of air in a confined space. The lowest concentration at which a gas is explosive is referred to as the "lower explosive limit" or "LEL." A LEL reading of 100% means the gas concentration is at or above the explosive limit. For methane gas, a LEL of 100% means the concentration of methane is at least 5%. 100% LEL does not mean an air space has a 100% concentration of methane.

The Ohio Department of Health (ODH) is the jurisdictional authority for private water wells in the state. Ohio Administrative Code (OAC) chapter 3701-28-10(O) sets a 10.0 mg/L standard for dissolved methane concentration in well water. The rule requires private well owners to mitigate their well with a vented cap if it produces water containing 10.0 mg/L or more of dissolved methane. However, a vented well cap will only allow free methane gas to escape the wellbore. It will not remove methane dissolved in the water. Methane can be removed from water and safely used. The water well industry has developed numerous treatment systems to remove methane from groundwater. A state or federal standard regarding how much methane a water well can emit before it is unusable does not exist.

DOGRM December 21, 2012 Sample

Laboratory results from water sample KLT-158 were compared to the US EPA's primary (pMCL) and secondary maximum contaminant levels (sMCL) for drinking water. The US EPA established the National Primary Drinking Water Regulations (NPDWRs or primary standards) as part of the Safe Drinking Water Act. They are legally enforceable standards that apply only to public water systems, not private water wells. Primary standards are scientifically developed to protect public health by limiting the levels of contaminants in drinking water. National Secondary Drinking Water Regulations (NSDWRs) established non-mandatory water quality standards for fifteen contaminants to assist the public in managing their drinking water for aesthetic considerations, such as taste, color, and odor. These contaminants are not considered to present a risk to human health at or below the sMCL. Neither the US EPA, Ohio EPA, nor the Ohio Department of Health enforces these "secondary maximum contaminant levels."

The analyses showed the concentration of total dissolved solids (TDS), total chloride, and total iron exceeded their recommended sMCL. All other tested parameters were below their respective pMCL and sMCL. The four vials collected for dissolved methane analysis were analyzed by Test America using testing method RSK-175. Dissolved methane in the sample, which bypassed the treatment system, was 22.8 mg/L.

Comparing these results to the pre-drilling sample of August 10, 2012 is problematic due to the pre-drilling sample being chemically altered by the water treatment system. Despite the pre-drilling sample not being representative of water quality in the aquifer it does show the quality of water being used by the Klines. When the pre-drilling sample is compared to the primary and secondary drinking water standards, the concentrations of TDS and chloride exceed their respective sMCL. Iron concentration in the pre-drill sample is below the sMCL because the water conditioning system is effectively removing it.

DOGRM January 8, 2013 Sampling

Investigation and review of the August 10, 2012 pre-drilling sample collected and analyzed by Summit Environmental Technologies (SET) showed the sample was collected after the water had passed through the water treatment systems. Line item #4 on SET's "Normal Tier 3 Sampling Checklist," which accompanies the sample results, incorrectly indicates the sample was collected prior to any treatment system. Water that has passed through a treatment system has its chemistry altered and is no longer representative of conditions in the aquifer.

The DOGRM interviewed a representative of SET to document the methodologies used to collect the pre-drill sample. SET used the outside spigot at the back of the home as the collection point. Water was purged for fifteen minutes prior to collection of the sample in multiple containers. 40 mL glass vials with hydrochloric acid (HCl) preservative were used for the water that underwent dissolved methane analysis. The vials were filled in the same manner volatile organic compound (VOC) samples are collected. Each vial was filled directly from the tap allowing the water to flow slowly down the side of the container until full, then sealed with a septum cap.

On January 8, 2013, the DOGRM returned to collect additional samples. Sample KLT-159 was collected using the same purge time and methods as the pre-drill sample. Sample KLT-160 was collected using the same sampling methods and purge volume as sample KLT-158. Both samples (KLT-159 & KLT-160) were intentionally passed through the treatment systems. Laboratory results from samples KLT-159 and KLT-160 were compared to the US EPA's primary (pMCL) and secondary maximum contaminant levels (sMCL) for drinking water. The concentrations of total dissolved solids (TDS) and total chloride (Cl^-) exceed their recommended sMCL in both samples as they did in sample KLT-158 from December 21. All other tested parameters were below their respective pMCL and sMCL.

Comparing these results to the pre-drilling sample of August 10, 2012 shows they have a similar chemistry. Small variations seen in the results are typical in groundwater samples. Variability in the chemistry can be attributed to a number of factors. First, the background sample was taken during aquifer discharge season (April-September) and these samples were collected during aquifer recharge season (October-May). Second, all of the samples were collected after passing through a treatment system. Third, water well purging and sampling techniques can introduce variability to the results. Last is the laboratory analysis itself. Laboratories analyzing the same sample can report different results because they use different analysis methods and sample preparations.

Downhole Camera Water Well Inspections

On January 16, 2013, the DOGRM used a downhole video system to inspect the Kline well and the well of next-door neighbor Ms. Esta Everhart at 9901 Silica Sand Road. Ms. Everhart's well is approximately 90 feet southwest of the Kline well. A Sperian PhD6™ portable gas detection meter was used to test the Everhart home for the presence of methane (CH_4), carbon monoxide (CO), and hydrogen sulfide (H_2S) gas at the water wellhead, throughout the home, and the sampling location. CO and H_2S gas were not detected at any of the locations. CH_4 was detected at 0.05% (1% LEL) while running hot water in the kitchen sink.

The Everhart water well (ODNR #370792) is located at N41.27242, W81.03217 (±8 ft, NAD83) at an approximate elevation of 957 feet (±1 ft). According to the well log, it is 102 feet deep and the DOGRM measured the static water level at 21.70 feet below the top of casing (toc). The well bore contained approximately 117.9 gallons of water in storage. Flow rate at the outside spigot sampling point on the northern end of the east side of the house was measured at 7.5 gallons per minute (gpm). Water at the sample point was clear with some sediment, and no odor. Three volumes of water (approximately 354 gal) were purged from the well prior to the collection of the sample in a clean stainless steel pail. The sample (KLT-161) was field-filtered with a 0.45-micron high-capacity polyethersulfone QuickFilter® to remove the suspended solids. Water for the dissolved methane analysis was not filtered and collected in three 40mL clear glass vials with septum caps. One 250-milliliter (mL) bottle was preserved with nitric acid (HNO_3), three 40 mL VOA vials for dissolved methane analysis were preserved with hydrochloric acid (HCl), and one 1-liter (L) cubitainer was preserved on ice. All bottles were placed in a cooler at or below 4°C (39°F) until relinquished at the laboratory. Pre-purge air sample KLT-E1 and post-purge air sample KLT-E2 was collected from the wellhead. Each sample consisted of two 10 mL vacuum tubes.

A GeoVision Nano color downhole camera was used to inspect the Kline and Everhart water wells. The Everhart well was completed first and recorded on one DVD. The well casing was heavily corroded. Large pieces of the rusted casing frequently sloughed off as the camera descended into the well. The static water level was located 21.70 feet below the top of casing. Bacteria colonies were present in the upper 20 feet of the water column, which was turbid with a yellow tint. There was no sign of free gas bubbles rising through the water column. The top of the submersible pump was located inside the casing at 88.2 feet (toc). Due to the pump being located inside the casing, the camera was unable to advance further.

The inspection of the Kline water well was recorded on two DVDs. The well casing was heavily corroded. The static water level was 42.3 feet below the top of casing (toc). Small bubbles of methane were observed breaking the water surface. See Figure 6. The water was turbid with an orange tint. Bacteria colonies were present in the upper portion of the water column, but decreased with depth. See Figure 7. The bottom of the casing was at 94.3 feet below the toc. The top of the submersible pump was encountered at 113.6 feet (toc) in the open borehole. Bedrock below the casing was encrusted with what appeared to be white mineral scale. At 132.0 feet, (toc) gas bubbles were observed entering the wellbore from a bedding plane. See Figure 8. The DOGRM's GeoVision Nano camera does not have the capability to determine the direction from which the gas is entering the well. Total depth was reached at 133.7 feet (toc). Sediment has accumulated at the bottom of the well decreasing its total depth. See Figure 9.

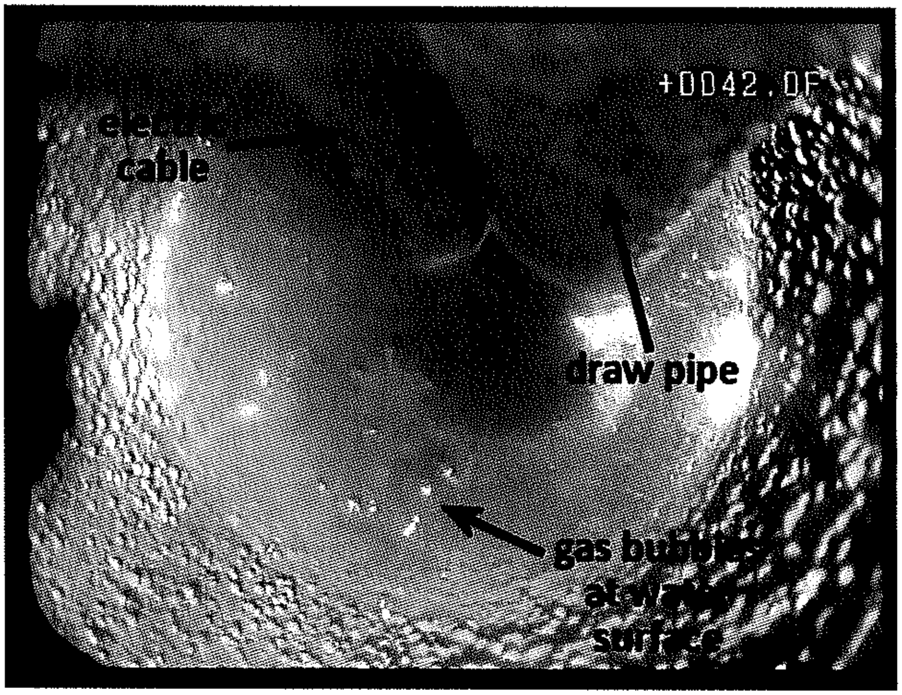

Figure 6. Water surface in Kline water well.

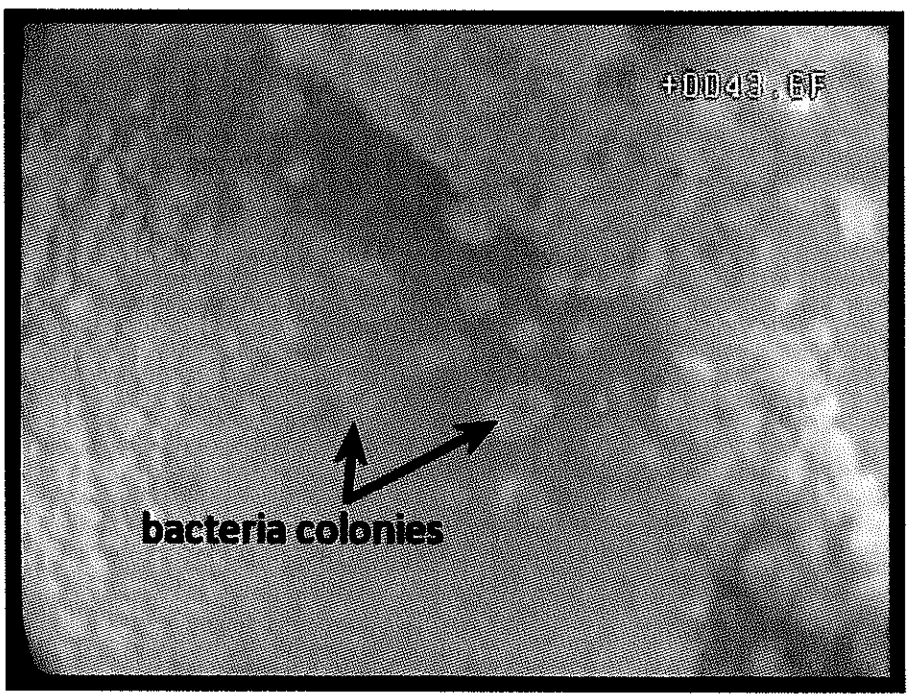

Figure 7. Bacteria colonies growing in the Kline well.

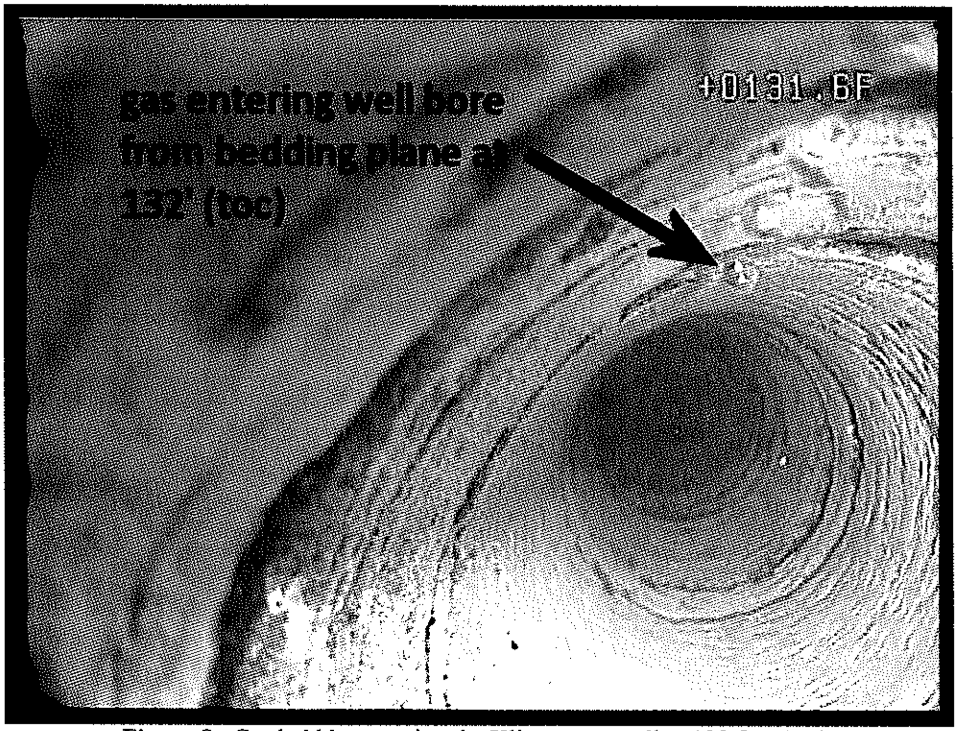

Figure 8. Gas bubbles entering the Kline water well at 132 feet (toc).


Figure 9. Sediment at the bottom of the Kline water well.

The camera was recording as the well was purged prior to sampling the water. Often natural gas trapped in an aquifer will move toward a well as water is withdrawn. Drawdown of water in the aquifer by the submersible pump creates an area of low pressure. According to Boyle's Law as pressure on a gas is decreased, the volume of the gas will increase. In a water well penetrating a formation containing natural gas the amount of gas venting from the wellhead will often increase as the water in the aquifer is lowered. This phenomenon was observed in the Kline well. As the water was drawn down the gas, entering the well at 132 feet became more robust.

February 2013 Post-drilling Water Sampling

A meeting was held March 27, 2013, between the DOGRM and representatives of Mountaineer Keystone regarding this investigation. Mountaineer Keystone agreed to resample water wells tested prior to drilling and sample additional wells not previously tested if given consent by the homeowner. During the second week of February 2013, contractors Rettew Associates, Inc. and SET sampled water wells for Mountaineer Keystone near the Soinski wells.

Seventeen wells were sampled on Silica Sand, Frazier, and Newel Ledge Roads. Six wells with pre-drill samples were resampled. The six wells, excluding the Kline well, which will be discussed separately, with pre and post-drilling samples, show no change in water chemistry beyond those due to seasonal fluctuation and sampling variability. The remaining wells, which were not sampled prior to drilling, also show no indicators of oilfield impact. Typical indicators of oilfield impact are changes in the concentrations of barium, strontium, bromide, potassium, and chloride. Wells with both pre and post-drilling samples, with the exception of the Klines, do not show an increase in the concentration of dissolved methane. The Everhart well, which had a similar pre-drilling dissolved methane concentration to the Klines, had a 49.7% decrease in the post-drilling sample.

Kline Post-drilling Samples from February 12, 2013

Two water samples were collected from the Kline well on February 12, 2013. One sample was collected by SET at 11:27am and the other by Rettew at 2:30pm. SET collected and analyzed the pre-drilling sample and was instructed to collect the post-drilling sample using the same methodologies. Rettew collected additional samples, which included one for isotopic gas analysis. The Rettew sample analysis was performed by Fairway Laboratories and the isotopic gas analysis was performed by Isotech Laboratories.

The DOGRM reviewed the results of the analyses and found a significant increase in the chloride concentration of the SET sample (1302445-01) and a significant drop in the concentration of sodium in the Fairway Laboratories' results. These changes occurred without corresponding changes in other parameters. DOGRM completed two sets of calculations from the *Standard Methods for the Examination of Water & Wastewater* (SMEWW) to check the correctness of the analyses. These quality assurance/quality control (QA/QC) calculations are used on every sample analyzed at the ODNR Cambridge Environmental Lab.

The SET results did not pass the QA/QC check. DOGRM contacted SET and requested they review their results. An error was found in the chloride (Cl^-) and bromide (Br^-) results due to a dilution calculation error. SET revised their report and sent out corrected results with a notation explaining the need for the revised report. DOGRM repeated the calculations for the corrected results and they met the QA/QC calculation checks.

Fairway Lab's analysis also did not pass the QA/QC calculation check. Mountaineer Keystone requested Fairway Lab review the results for errors. A representative of Fairway Lab assured Mountaineer Keystone personnel the results were correct and they stand behind them. The issue is the sodium concentration reported at 20.2 mg/L, which is almost 23 times lower than the average for all the treated samples from the Kline well. Despite the questionable result for sodium, it does not render the remaining results invalid.

A water sample can be analyzed for multiple parameters. To do this the sample must be collected in different containers with the appropriate preservation method for each. Non-metals, metals, volatile organics, and dissolved methane all have different preservation requirements such as the addition of nitric acid (HNO_3), hydrochloric acid (HCl), ascorbic acid ($C_6H_8O_6$), or simply chilled to 4°C. Water intended for dissolved methane analysis is collected in 40 mL clear glass vials with septum caps. The sample can be preserved with HCl or unpreserved. Acid preservation of the vials increases the holding time of the vials from seven days to fourteen days. Non-acid preserved samples are chilled to 4°C.

The SET and Rettew samples were analyzed for dissolved methane using lab method RSK-175. Two collection methods are typically used when filling the 40 mL glass vials for dissolved methane analysis. One method is to collect the sample like a volatile organic compound (VOC) sample where the flow of water from the tap is decreased to minimize agitation. Next, the vial is held at an angle to allow the water to gently flow down the inside of the vial until full then capped. The main drawback to this method is it permits the sample to be exposed to the atmosphere where methane in the water can be lost as the vial is filled. Laboratory analysis reports what is in the sample and cannot account for what was lost during collection therefore the results can underrepresent the concentration of dissolved methane actually in the groundwater. SET and Rettew collected their respective samples using this technique. Dissolved methane in the SET sample was reported at 34.23 mg/L and the Rettew sample at 10.20 mg/L.

The second method is a "submersion technique" where the vial is filled while submerged in a bucket of the water to be sampled. It diminishes the loss of gas from the sample as the vial is being filled. The process starts with filling a bucket of water through small diameter tubing from the sampling tap. Water is continuously flowed through the tubing and water is allowed to overflow the bucket. Next, an uncapped vial is submerged to the bottom of the bucket where the tubing is inserted into the inverted vial to flush it with at least two-volumes of water. Keeping the vial near the bottom of the bucket the tubing is slowly removed then the vial is capped. The process is repeated until all the vials are filled. Acid preservation is not possible with this technique.

In addition to the "tier 3" sample, Rettew also collected a sample for isotopic methane analysis. Isotopic analysis involves measurement of stable isotopes of carbon (C) and hydrogen (H) in the methane (CH_4) molecule and related compounds, such as carbon dioxide (CO_2), water (H_2O), ethane (C_2H_6) and other hydrocarbons. Stable methane isotopes $\delta^{13}C$ and δD can provide some information on the thermogenic or biogenic origin of the gas.

Thermogenic gas it is created when organic matter is compressed deep in the earth, at very high temperature and pressure for millions of years. This type of methane is referred to as natural gas, which is the target of gas well drillers. Coalbed methane also falls into the category of a thermogenic gas. Biogenic gases are formed at shallow depths and at low temperatures by anaerobic bacteria decomposing organic material. The first type of biogenic gas is 'near-surface microbial gas' formed through the acetate fermentation process in the near-surface environment. Marsh gas, swamp gas, and landfill gas are examples of near-surface microbial gas. Second is 'sub-surface microbial gas' which uses the chemical process of carbon dioxide (CO_2) reduction to produce methane. This type of methane is referred to as 'drift gas' since it is formed in glacial drift deposits. Biogenic gas is considered a 'dry gas' since it consists almost entirely of methane. In contrast, thermogenic gas can be dry, or it can contain significant concentrations of 'wet gas' components such as ethane, propane, and butane.

The analysis determined the methane in the Kline well to be genetically distinct from gas originating in deeper gas reservoirs such as the Clinton Sandstone and Utica Shale. The gas is biogenic in origin and consistent with a near-surface microbial gas and not thermogenic gas. See Figure 10. Even though isotopic analysis can be very informative, it is not a definitive test upon which a conclusion can be solely drawn. The results must be considered along with the geologic, hydrogeologic, and well construction evidence.

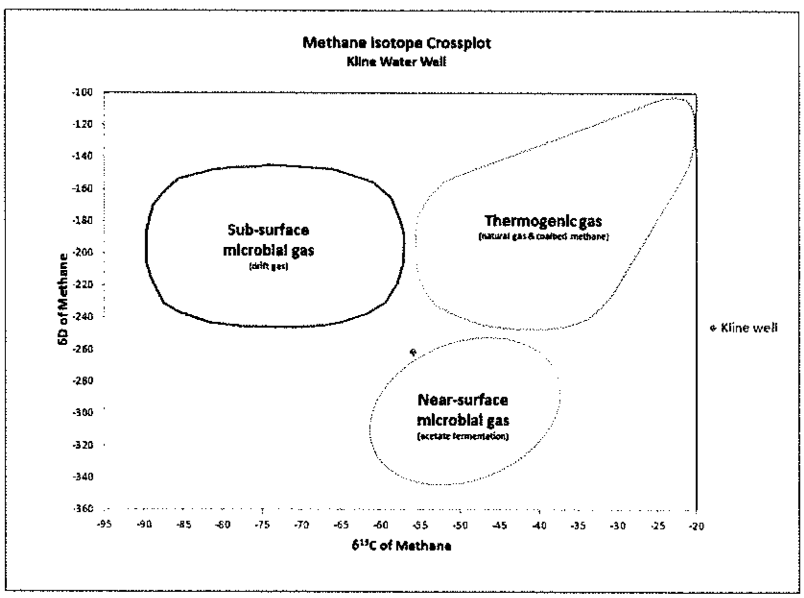

Figure 10. Methane isotope plot for gas in the Kline water well.

Soinski #201 & #202 Well Construction

The wells at the center of the investigation are the Soinski 99-04-06 #201 and Soinski 99-04-06 #202. The #201 well is assigned permit numbers 34-133-2-4440-00-00 (stratigraphic) and 34-133-2-4440-01-00 (horizontal) and the #202 is assigned permit number 34-133-2-4441-00-00 (horizontal). Construction began on August 15, 2012, when conductor casings for both wells were set into bedrock prior to moving in the horizontal drilling rig. On August 28th, Union Drilling Incorporated (UDI) Rig #48 spudded the surface hole on the Soinski #201 and completed construction of this well on October 7th. On October 11th, Rig #48 spudded the surface hole on the Soinski #202 and completed construction of this well on November 7th. Both wells are constructed in accordance with 1501:9-1-08 of the Ohio Administrative Code (OAC).

During the inspection of the wells for the investigation, the annulus between the intermediate casing and the surface casing had a minimal amount of bubbling when water was placed over the cement. The other casing strings showed no signs of bubbling. Gas emanating from cement is caused by a phenomenon called 'gas channeling.' Gas channeling most commonly occurs during the time the cement cures from a liquid state to a solid state. Cement in its liquid form provides hydrostatic pressure to prevent gas from entering the cement. As long as the hydrostatic pressure of the cement is greater than the pore pressure of the gas-bearing zone, the gas will not enter the cement. The ability of the cement to maintain its hydrostatic pressure is a function of its gel strength. As the cement slurry transitions from a liquid, at full hydrostatic strength to a gel-like material to develop a cohesive structure the slurry no longer provides hydrostatic pressure. The hydrostatic pressure of the cement is now contained inside cement pores. If fluid loss during cement hydration or fluid loss to the formation lowers the hydrostatic pressure of the cement pores below that of the formation pore pressure gas channeling can occur.

Although there was minor gas channelization in the cement, it occurred inside the surface casing where it is isolated from the groundwater aquifers. Based on the depth of the surface casing, the origin of the gas is from a shallow geological formation below the Berea Sandstone and not the targeted Utica Shale.

DISCUSSION

Methane gas can be found dissolved in groundwater in many regions of Ohio. The most common way gas enters the groundwater system is through natural processes such as the decomposition of organic material in swamps or glacial deposits. Other natural sources include coal beds, organic-rich shale bedrock, and reservoir bedrock such as the Berea Sandstone. To a lesser degree, methane can enter the groundwater through industrial processes such as landfills, and oilfield exploration and production.

The Kline pre-drilling sample from August 2012 showed dissolved methane in the water, which scientific studies, water well logs, and water well drillers have all demonstrated is common in the area. The dissolved methane concentration rising from 9.48 mg/L to 58.2 mg/L is an increase; however, the science of dissolved methane in groundwater is more complex than a simple comparison of two or more numbers. Research from Pennsylvania presented at the Ground Water Protection Council's (GWPC) *Stray Gas*

Conference in Cleveland, Ohio (July 24-26, 2012) cautioned that investigators must recognize variability in dissolved methane concentrations from a number of factors when interpreting water quality data. Some of those factors include:

- natural fluctuation (temperature, barometric pressure, seasonal variation)
- domestic usage (variable pumping and usage prior to sample collection)
- sampling point
- sampling methodology
- sample transport and storage
- laboratory analytical methods

Three pre-drilling water samples for the Soinski wells did not contain dissolved methane, six had concentrations between 0.01 mg/L and 0.29 mg/L, one was 9.11 mg/L and the Kline's was at 9.48 mg/L. Based on these data, it can be seen that methane in the groundwater near Silica Sand Road is quite variable.

Dissolved methane concentration in the six water samples collected from the Kline well varied from 9.48 mg/L to a high of 58.2 mg/L and back down to 10.2 mg/L. Understanding the factors behind the variability in this particular well is difficult, especially when compared to other wells in the area that do not exhibit this same large fluctuation. Factors such as the geology, the development of the water well (i.e. how deep it is drilled and what geologic formation(s) it penetrated), and the water treatment system sets the Kline water well apart from other area water wells. It is one of the deepest wells within the study area and penetrates a bedrock aquifer known to contain methane.

Sampling technique, seasonal variations, temperature, barometric pressure, variable pumping of the well, and the analytical technique of the laboratory are expected to cause the concentration of dissolved methane to vary from one sample to the next. The three highest dissolved methane concentrations were in samples collected by the DOGRM. One factor sets the DOGRM sample results apart from the others, which is the way the samples were collected. The DOGRM used the submersion technique whereas SET and Rettew used a VOC-style sampling technique.

CONCLUSIONS & RECOMMENDATIONS

The Ohio Department of Natural Resources-Division of Oil & Gas Resources Management has concluded that the methane in the Kline water well is naturally occurring and is not the result of oilfield activities by Mountaineer Keystone, LLC at the Soinski well pad. Isotopic analysis of the methane in the Kline well was identified as near-surface microbial gas that is genetically different from thermogenic gas produced in deeper geologic formations like the Utica Shale.

Sampling of seventeen area water wells in February 2013 did not show any indications that oilfield contaminants had been introduced into the groundwater through the drilling of the Soinski wells. Dissolved methane levels in the water wells were consistent with the pre-drilling results. Wells with only post-drilling analysis have dissolved methane concentrations less than 2.5 mg/L, with the majority having less than 0.5 mg/L. The concentration and fluctuation of dissolved methane the Kline's are experiencing is isolated to their water well. Factors including natural fluctuation within the aquifer, sampling methodology, variable pumping, usage of their well prior to sampling, and the laboratory analytical methods may be contributing to the wide range of dissolved methane levels in their water.

Studies show that the presence of natural gas is well documented in the groundwater in Nelson and Windham Townships going back to the 1940s. Methane in water wells developed in shallow aquifers is common and manageable. The best available technology to remove methane from groundwater is an aeration system. A number of manufacturers make these units, which agitate the water liberating the methane from the water. Water from the well enters a large tank through a nozzle that sprays the water into a mist. Methane gas is lighter than air, therefore, it accumulates at the top of the tank while the water collects at the bottom. A pipe at the top of the tank allows the methane to be vented safely outside the home above the roofline. Water at the bottom of the tank is transferred into a holding tank until needed. Most water well professionals, water treatment specialists, and the Ohio Department of Health can offer assistance in the pursuit of a methane mitigation system.