



DEPARTMENT OF NATURAL RESOURCES

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November 15, 2012

Jenny Turley
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Fort Lupton, CO 80621

RE: Water Quality Analytical Results for Water Well (permit #36205)
SESW Section 14– Township 2 North – Range 66 West
Weld County, Colorado; Complaint No. 200360246

Dear Ms. Turley:

On September 23, 2012, Terracon under direction of the Colorado Oil and Gas Conservation Commission (COGCC), sampled your water well and submitted these samples for laboratory analysis. The water samples collected by the COGCC were submitted to Test America Laboratories (TA) in Arvada, Colorado, for analysis of inorganic chemical constituents, organic compounds associated with petroleum hydrocarbons, and methane gas. A copy of the TA analytical report is enclosed. Additionally a sample of gas from the water well was collected for compositional and stable isotope analysis of methane gasses and submitted to Isotech Laboratories, Inc. (Isotech) in Champaign, Illinois. Those analyses are currently in process by the laboratory and will be provided in a separate letter when completed.

As you are aware, on February 7, 2012 your water well was sampled by Noble Energy and the results of that sampling sent to your attention in later February 2012. Where applicable, this letter will compare the COGCC September 23, 2012 sample results with the earlier results from the Noble Energy sampling.

The Water Quality Control Commission (WQCC) of the Colorado Department of Public Health and Environment (CDPHE) has established drinking water standards for the protection of human health. The analytical results from the water samples from your well have been compared to applicable ground water and/or drinking water standards and are summarized below. Please keep in mind that these water standards were established for **municipal public** drinking water supplies (wells providing 15 or more households) and not private water wells. Often people use and consume ground water from private wells that can exceed these standards.

COMPARISON OF INORGANIC ANALYTICAL RESULTS TO STANDARDS

- Total Dissolved Solids (TDS): CDPHE has established a TDS standard for human drinking water of 500 milligrams per liter (mg/l). The standard is called the secondary maximum contaminant level (SMCL) and is based on the aesthetic quality of the water (such as taste and odor) and is intended as a guideline for public water supply systems and is not an enforceable

standard. Although CDPHE does not have an agricultural standard for TDS, other agencies recommend concentrations below 2,000 mg/l for irrigation, and below 5,000 mg/l for most livestock watering. TDS concentrations are related to the presence of naturally occurring elements and chemical compounds such as chloride, sodium, potassium, calcium, magnesium, and sulfate.

TDS was detected in the water sample from your well at concentration of 3,300 mg/l, which is greater than the CDPHE SMCL, greater than the recommended maximum concentration for irrigation, and less than the recommended maximum concentration for most livestock watering. The Noble Energy sample had a concentration of 2,200 mg/l.

- **Sodium (Na):** Although CDPHE does not have a standard for sodium, people on salt restricted diets should be aware of the Na concentration in the water they drink. A concentration of drinking water with a concentration of sodium less than 20 mg/l is recommended by some for people on salt restricted diets or for people suffering from hypertension or heart disease. Sodium occurs naturally in the ground water in many areas at concentrations that exceed the recommended level.

Sodium was detected in the water sample from your well at a concentration of 870 (B) mg/l, which is greater than the recommended level for people of salt restricted diets. The Noble energy sample had a concentration of 440 mg/l.

- **Fluoride (F):** CDPHE has established a fluoride (F) standard for human drinking water is 4.0 mg/l. Where fluoride concentrations are in the range of 0.7 mg/l to 1.2 mg/l, health benefits such as reduced dental decay have been observed. Consumption of fluoride at concentrations of greater than 2.0 mg/l can result in mottling of teeth. Consumption of fluoride at concentrations greater than 4.0 mg/l can increase the risk of skeletal fluorosis or other adverse health effects.

Fluoride was detected in the sample from your water well at a concentration of 0.12 mg/l, which is less than the CDPHE maximum drinking water standard. Fluoride was not analyzed for in the Noble sample.

- **Chloride (Cl):** The CDPHE chloride standard (SMCL) for drinking water is 250 mg/l. Chloride concentrations in excess of 250 mg/l usually produce a noticeable taste in drinking water.

Chloride was detected in the water sample from your well at a concentration of 260 mg/l, which is greater than the CDPHE SMCL. The Noble Energy sample had a concentration of 159 mg/l.

- **Sulfate (SO₄):** The CDPHE sulfate standard for drinking water is 250 mg/l (SMCL). Although CDPHE does not have an agricultural standard for sulfate, other agencies recommend a concentration below 1,500 mg/l for livestock watering. Waters containing high concentrations of sulfate, typically caused by the leaching of natural deposits of magnesium sulfate (Epsom salts) or sodium sulfate (Glauber's salt), may be undesirable because of their laxative effects. Sulfate occurs naturally in the ground water in many areas in Colorado at concentrations that exceed the drinking water standard.

Sulfate was detected in the sample from your well at a concentration of 1,700 mg/l, which is greater than the CDPHE SMCL. The Noble Energy sample had a concentration of 1,010 mg/l.

- **Total Nitrate (NO₃) + Nitrite (NO₂) as Nitrogen (N):** The CDPHE total nitrate (NO₃) + nitrite (NO₂) as nitrogen (N) for standard for human drinking water is 10 mg/l. Nitrate and nitrite are common contaminants in ground water from agricultural sources, such as fertilizer and animal, including human, wastes. They are known to cause infant cyanosis or “blue baby disease” in humans and, at concentrations greater than 100 mg/l as nitrogen (N), may be dangerous to livestock. High concentrations of nitrate and nitrite in ground water are known to occur in agricultural areas in Colorado.

Total nitrate/nitrite, as N was detected in the water sample from your well at a concentration of 7.5 mg/l, which is less than the drinking water standard. The Noble Energy sample had a concentration of 11.8 mg/l*. **note: The February sample concentration exceeds the CDPHE drinking water standard.*

- **Iron (Fe):** The CDPHE standard for human drinking water for iron is 0.3 mg/l (SMCL). Small amounts of iron are common in ground water. Iron may produce a brownish-red color in standing water, discolor laundered clothing, can leave reddish stains on fixtures, and impart a metallic taste to beverages and food made with it. After a period of time iron deposits can build up in pressure tanks, water heaters, and pipelines, reducing the effective flow rate and efficiency of the water supply.

Iron was not detected in the water sample from your well in the COGCC sample or the earlier Noble Energy sample.

- **Selenium (Se):** The CDPHE selenium standard for human drinking water is 0.05 mg/l and the agricultural standard is 0.02 mg/l. Excessive selenium (Se) (concentrations greater than 0.05 mg/l) can cause loss of hair and/or fingernails as well as adverse effects on the central nervous system. Selenium (Se) occurs naturally in the ground water in many areas of Colorado at concentrations that exceed the drinking water standard.

Selenium was not detected in the sample from your water well in the COGCC sample. The earlier Noble Energy sample had a detection of 0.02 mg/l, which is less than the CDPHE drinking water standard.

- Calcium (Ca) and Potassium (K) were also tested for in your water. There are no standards from CDPHE for these parameters. In addition, the COGCC also collected samples for other metals than those discussed above and the Table 1 presents the analytical laboratory results. Please note that Primary standard (P) is the CDPHE Human Health Standard and the Secondary standard (S) is the CDPHE secondary maximum contaminant level (SMCL).

**Table 1
 TURLEY WATER WELL**

METAL/INORGANIC	February 7, 2012 Noble Energy Sample (Concentrations in Milligrams per liter [mg/l])	September 23, 2012 COGCC Sample	CDPHE Water Quality Standard (P – Primary S-Secondary)
Arsenic (As)	NA	0.0054 JB**	0.01 (P)
Barium (Ba)	NA	0.047	2.0 (P)
Bromide (Br)	NA	1.3	NS
Cadmium	NA	ND	0.005 (P)
Calcium (Ca)	145	210	NS
Chromium (Cr)	NA	ND	0.1 (P)
Lead (Pb)	NA	ND	0.05 (P)
Magnesium (Mg)	46.2	52	NS
Manganese (Mn)	0.11	0.091	0.05 (S)
Potassium (K)	6.7	11 J*	NS
Silver (Ag)	NA	ND	0.05 (P)
Uranium (U)	NA	0.047	0.03 (P)
pH	7.45 pH units	NA	6.5 – 8.5 (S)

Bold – exceeds standard

NS – no standard

ND – not detected in the sample

NA – not analyzed

J* - result is below the reporting limit (RL) but greater than or equal to the method detection limit (MDL) and the concentration is an approximate value.

JB** - blank detection and estimated concentration (As – **0.0053 mg/l**)

ORGANIC COMPOUNDS ASSOCIATED WITH PETROLEUM HYDROCARBONS

A target list of sixty-six volatile organic compounds (VOC) was used during analysis of the water from your water well. One of the 66 target compounds (methylene chloride) was detected in the sample from your water well (0.37 JB micrograms per liter [$\mu\text{g/l}$]). Methylene chloride usage is common in analytical laboratories and this blank detection (**B**) is attributable to laboratory contamination and is not present in your water well.

- Benzene: CDPHE's basic ground water standard for benzene is 5 micrograms per liter ($\mu\text{g/l}$). **Benzene was not detected in the COGCC sample from your water well or the earlier Noble Energy sample.**

- Toluene: CDPHE's basic ground water standard for toluene is 1,000 µg/l. **Toluene was not detected in the COGCC sample from your water well or the earlier Noble Energy sample.**
- Ethylbenzene: CDPHE's basic ground water standard for ethylbenzene is 680 µg/l. **Ethylbenzene was not detected in the COGCC sample from your water well or the earlier Noble Energy sample.**
- Total Xylenes (sum of m,p, and o-xylene): CDPHE's basic ground water standard for total xylenes is 10,000 µg/l. **Total xylenes were not detected in the COGCC sample from your water well or the earlier Noble Energy sample.**

Because you expressed some concern that oil might be present in your water well, the COGCC also collected samples of your water for both gasoline and diesel range organic compounds.

- Gasoline Range Organic Compounds (GRO): **Gasoline range organic compounds were not detected in the sample from your water well.**
- Diesel Range Organic compounds (DRO): **Diesel range organic compounds were not detected in the sample from your water well.**

METHANE GAS CONCENTRATION

- **Methane was detected in the sample from the water well at a concentration of 5.7 mg/l. The concentration in the Noble Energy sampling was 3.8 mg/l.**

Methane gas alone is physiologically inert and non-toxic to humans. Normal breath exhalation contains 1 to 99 ppm of methane (parts per million [ppm] is the same units as mg/l). The presence of methane in drinking water does not present a known health hazard to humans or other animals via ingestion; however, methane in domestic water supplies can be associated with undesirable and potentially serious side effects. Methane gas dissolved in water “exsolves” when exposed to the atmosphere and dissipates rapidly because it is lighter than air. This is often responsible for the “fizzing” observed in water wells that may contain methane gas. If the methane occurs at a high enough concentration and if it is allowed to accumulate in a confined space, such as a well pit, crawl space, closet, etc., an explosion hazard can be established. In addition, if methane concentrations in well water are high, then pockets of free gas form within the water and cause the well pump to cavitate and no longer bring water to the surface.

Methane gas is very common in water wells in Colorado. It occurs naturally and the source of the methane is commonly from one or more of the sources listed below.

1. Methane is commonly found as a gas in coal or black shale seams in the subsurface.

2. Methane is commonly found as a byproduct of the decay of organic matter and the presence of bacteria in water wells can provide the conditions favorable for the production of methane either from the activity or decay of bacteria.

As the result of extensive testing for methane gas in water wells throughout Colorado, concentrations of methane gas below 1 mg/l are harmless, with concern for possible hazards from the methane increasing at concentration levels in well water at 7 mg/l and higher. You should be aware that the methane gas in your water well is at a high enough concentration that precautions should be taken to adequately vent the water system to avoid potential gas accumulations.

GAS COMPOSITION

The gas produced from the oil/gas wells in the Denver Basin is thermogenic methane. Thermogenic methane gas is formed by the thermal breakdown of organic material in rocks resulting from high temperatures created by deep burial. Biogenic methane gas occurs in most near-surface environments and is a principal product of the decomposition of buried organic material. The occurrences of coal zones in most of the Denver Basin water aquifers often means that water wells in those aquifers may contain biogenic methane gas. The following discussion is from the analysis provided by **Noble Energy** for the February 7, 2012 sample. As discussed earlier, the COGCC gas sample (September 23, 2012) is currently undergoing analysis and those results will be provided in a separate letter when the analyses are completed.

Laboratory results of the Noble Energy collected gas sample from your water well show that methane (34.2 percent), and ethane (0.021 percent) were detected along with nitrogen (60.55 percent), carbon dioxide (2.82 percent), oxygen (1.73 percent), and argon (0.683 percent). The nitrogen, carbon dioxide, oxygen, and argon are components of air, and the presence of methane (C1) with ethane (C2) is typical of the **naturally occurring biogenic gas** often found in the Fox Hills aquifer in which your water well is completed.

Isotopic Analysis of Methane

- The deuterium/hydrogen isotope ratio for the methane in the water sample from the water well is -277.1 parts per mil (‰).
- The carbon-13/carbon-12 isotope ratio for the methane in the water sample from the water well is -70.58 ‰.

Isotopic Cross-Plot

I have included the cross-plot of the stable methane isotopes for the water well sample (Noble Energy sample letter) to help discuss the sample results for the well. On the cross-plot you will notice the area near the top right corner as defined a "Thermogenic Gas". This is the area of the cross-plot that the natural gas produced by the gas wells in the Denver Basin plot. The sample

from your water well plots in the area to the left defined as “Sub-surface/ Near Surface Microbial Gas” which is **methane gas of a biogenic origin**.

BACTERIA OCCURENCE

Samples of the well water were collected for the determination of the presence of bacteria using the Biological Activity Reaction Test (**BART™**) for the following; **Iron Related Bacteria (IRB)**, **Sulfate Reducing Bacteria (SRB)**, and **Slime Forming Bacteria (SFB)**. The **BART™** tests are a type of a “Petri dish” for bacteria in water. Positive results allows for an estimation of the size of the existing bacteria population and the rate at which they can metabolize and/or grow and also for bacteria types. This reaction rate is referred to as the “aggressivity” of the bacterial population. The aggressivity levels of the bacteria are described as **Not Present, Non-Aggressive (Background), Moderately Aggressive, Very Aggressive, or Extremely Aggressive** Levels. The well water showed the presence of IRB and SLB bacteria. Please see attached photograph.

Iron Related Bacteria (red cap): Although not usually harmful, iron related bacteria (IRB) can become a nuisance by plugging the well pump, causing red staining on plumbing fixtures and laundered clothing, building up red, slimy accumulations on any surface the water touches, and causing what may appear to be a oily sheen on standing water. In rare cases, IRB may cause sickness.

- **Non-Aggressive IRB bacteria were detected in the water sample from the well.**

Sulfate Reducing Bacteria (black cap): Sulfate reducing bacteria (SRB) are serious nuisance organisms in water since they can cause severe taste and odor problems. These bacteria reduce sulfate that occurs naturally in the water and generate hydrogen sulfide (H₂S) gas as they grow. In turn, the hydrogen sulfide (H₂S) gas is a nuisance because it **smells like rotten eggs**, it initiates corrosion on metal surfaces, and it reacts with dissolved metals such as iron to generate black sulfide deposits.

- **SRB bacteria were not detected in the water sample from the well.**

Slime Forming Bacteria (green cap): Although not usually harmful, Slime Forming Bacteria (SFB) also can become a nuisance by plugging well pumps and causing slimy accumulations on plumbing fixtures and standing water. Slimes often are gelatinous in nature and may range in color from white, to red, to black. As slim bacteria mats grow they create an environment in which complex associations of other strains of bacteria can develop.

- **SFB bacteria were not detected in the water sample from your well.**

Water Well Records Review

I reviewed the water well records for your water well. I believe that the current well is actually a replacement well for a previous well that “collapsed” (*November 4, 1999 letter from Dreiling*

Drilling Company to the Office of the State Engineer, Division of Water Resources –copy attached). I could not find any record on the abandonment of the previous well or any record as to the location of the replacement well in relationship to your abandoned well. Based on the overall water quality of your water well (especially the presence of nitrates/nitrites which is likely from surface agricultural activities), it is possible that the old well bore (if not properly abandoned) could be providing a conduit for surface waters to penetrate down to the Fox Hills aquifer and impacting your replacement well or the replacement well may not have sufficient sealing to isolate the surface from the Fox Hills aquifer in which the well is screened.

Your new well has an open well screen from 605- to 805 feet below the ground surface (bgs), which is shown on the Geologic Log (Item 5 of the Well Construction and Test Report – copy attached) to contain sandstone mixed with coal and grey shale zones. Coal, and to a lesser extent shale, often produce water that is very high in sulfate due to the occurrence of the mineral gypsum (calcium/sodium sulfate) found in the coal and shale. Many water well installers isolate these coal and shale zones during well construction to help avoid problems related to poor water quality supplied by coals. It appears that your well driller/installer did not isolate these zones (such as no well screen for those intervals) when your well was constructed. As discussed earlier, coal zones in water wells can also be a source of natural occurring methane gas in water wells which can be a nuisance at high concentrations.

CONCLUSION

Because the water exceeded the health advisory for sodium (**Na**), the human health standard for **Nitrate/nitrites** as N and uranium (**U**), and the CDPHE drinking water (SMCL - based on the aesthetic quality of the water [such as taste and odor]) standard for Total Dissolved Solids (**TDS**), chloride (**Cl**), and manganese (**Mn**), and because you or livestock and/or pets drink the water, you may wish to discuss the possible health effects of continued consumption with your physician and/or veterinarian.

As noted earlier, the water well has concentrations of natural occurring **biogenic** methane present at concentrations that could present a safety concern. Methane can be easily eliminated via venting of the well and/or household water system. The *How Well Do You Know Your Water Well* pamphlet (enclosed) includes some information on methane mitigation.

Your water well was positive for bacteria (**IRB**) which may be present at populations high enough to cause some nuisance issues. The National Water Well Association, and the CDPHE, and US EPA suggest periodic (usually yearly) treatment of water wells to keep bacteria occurrences from becoming a problem. The *How Well Do You Know Your Water Well* pamphlet contains information on a “do it yourself” bacteria treatment for water wells using household chlorine bleach.

There is **no indication** on any oil & gas impacts to your water well.

If you have any questions or would like to discuss these matters further, please contact me at the COGCC in Denver via e-mail (robert.chesson@state.co.us) or by phone at 303-894-2100, extension 5112.

Respectfully,

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Environmental Protection Specialist

cc: J. Milne, Denver