STATE OF COLORADO
OIL & GAS
CONSERVATION COMMISSION

August 6, 2009

Certified Mail Return Receipt Requested # 7008 3230 0003 3234 7119

Ms. Gopa Ross
11111 Box Canyon Road
Weston, CO 81091

RE: Complaint 200206880
Water Well Analysis
Well Permit 256909
NESE 35 32S, 68W Las Animas County, Colorado

Dear Gopa:

In response to your concerns regarding possible impacts to water quality from coal bed methane (CBM) operations in the area near your home, the Colorado Oil and Gas Conservation Commission (COGCC) conducted a field visit to your property on March 31, 2009. Water samples were collected for general organic and inorganic water quality testing as well as for the analysis of dissolved methane and BART test kits. A summary of the results of the chemical analyses is presented below. The analytical results are also compared to published water quality standards.

FIELD TESTING

Christa Whitmore of Whetstone Associates and I visited your property on March 31, 2009. The pump was started at 9:35 at approximately 7.5 gallons per minute and allowed to run for 43 minutes. The samples were collected at 10:18 after the measured pH, the measured temperature and the measured conductivity of the pumped water had been stable for 20 minutes. A summary of the field observations is included in Table 1. The water was clear with a slight odor of hydrogen sulfide. The samples for general chemical analyses were shipped on ice to ALS Paragon in Fort Collins, CO and received by them on April, 1, 2009. The sample for analysis of dissolved gas composition and isotope ratio determination was sent to Isotech Laboratories in Champaign, IL. on ice, and received by them on April 2, 2009.

Visual inspection of small particulates that settled from the water pumped from your well indicated that the particles were likely to be manganese (and possibly iron) oxides. The environment in and around the well is disturbed by the relatively lengthy pumping that was done to sample the well. Sediment from the bottom of the well may be resuspended as water is drawn into the pump. Particles adhering to the sides of the well may flake off during turbulent flow of water into the well. A further discussion of manganese and its behavior is included in the conclusions section below.

Table 1. Field Observations

Date	Time	pH (s.u.)	Temperature (°C)	E.C. (µS/cm)	Disolved Oxygen (%)	Disolved Oxygen (mg/L)	Depth to Water (ft btoc)	Comments
3/31/09	9:35	---	---	---	---	---	52.10	Water on
3/31/09	9:38	8.24	9.5	455	13.1	1.49	---	
3/31/09	9:40	8.31	9.6	456	6.4	0.72	---	
3/31/09	9:45	8.38	9.8	456	3.7	0.43	---	
3/31/09	9:50	8.33	10.0	455	4.3	0.48	---	
3/31/09	9:55	8.31	10.1	455	3.8	0.44	---	
3/31/09	10:00	8.30	10.1	454	3.6	0.41	---	
3/31/09	10:05	8.30	10.0	454	4.3	0.49	---	
3/31/09	10:10	8.31	10.1	453	4.6	0.53	---	
3/31/09	10:15	8.31	10.2	453	4.8	0.55	---	
3/31/09	10:18	---	---	---	---	---	---	collect sample

COMPARISON OF INORGANIC ANALYTICAL RESULTS TO CDPHE INORGANIC STANDARDS

The Water Quality Control Commission (WQCC) of the Colorado Department of Public Health and Environment (CDPHE) has established "Domestic Use-Quality" human health standards and drinking water standards. Analytical data for the samples from your water well was compared to these standards. This information is summarized in Table 2 which is located in Attachment 1 and discussed in narrative form below. Please keep in mind that these "Domestic Use-Quality Standards" were established for **municipal public** drinking water supplies and often people use and consume ground water from private wells that exceed these standards. The analytical reports from ALS Paragon are included as Attachment 2. The analytical report from Isotech Laboratories is included as Attachment 3.

- **Antimony (Sb):** The CDPHE human health standard for antimony is 0.006mg/l. Antimony is a contaminate metal.

  Antimony was not detected in the sample collected from your water well.

- **Arsenic (As):** The CDPHE human health standard for arsenic is 0.01 mg/l. Arsenic is a highly poisonous metal.

  Arsenic was not detected in the sample collected from your water well.

- **Barium (Ba):** The CDPHE human health standard for barium is 2.0 mg/l. Barium is a contaminate metal.

  Barium was not detected in the sample collected from your water well.

- **Beryllium (Be):** The CDPHE human health standard for beryllium is 0.004mg/l. Beryllium is a contaminate metal.

  Beryllium was not detected in the sample collected from your water well.

- **Cadmium (Cd):** The CDPHE human health standard for cadmium is 0.005 mg/l. Cadmium is a contaminate metal.

  Cadmium was not detected in the sample collected from your water well.

- **Chromium (Cr):** The CDPHE human health standard for chromium is 0.1 mg/l. Chromium is a contaminate metal.

  Chromium was not detected in the sample collected from your water well.

- **Lead (Pb):** The CDPHE human health standard for lead is 0.05 mg/l. Prolonged exposure to this metal can result in serious health effects.

  Lead was not detected in the sample collected from your water well.

- **Nickel (Ni):** The CDPHE human health standard for nickel is 0.1mg/l. Nickel is a contaminate metal.

  Nickel was not detected in the sample collected from your water well.

- **Selenium (Se):** The CDPHE human health standard for selenium is 0.05 mg/l. Selenium is a contaminate metal.

  Selenium was not detected in the sample collected from your water well.

- **Silver (Ag):** The CDPHE human health standard for silver is 0.05 mg/l. Excess amounts of silver may cause a permanent gray discoloration of the skin.

  Silver was not detected in the sample collected from your water well.

- **Thallium (Tl):** The CDPHE human health standard for thallium is 0.002 mg/l. Thallium is a contaminate metal.

  Thallium was not detected in the sample collected from your water well.

- **Uranium (U):** The CDPHE human health standard for thallium is 0.03 mg/l. Uranium can be present due to erosion of natural deposits of this element.

  Uranium was detected in the sample collected from your water well at a concentration of 0.00037mg/l which is below the CDPHE human health standard.

- **Fluoride (F)**: The CDPHE human health standard for fluoride 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 occurs naturally in the ground water in many areas in Colorado at concentrations that exceed the drinking water standard.

  Fluoride was detected in the sample collected from your water well at a concentration of 1.8mg/l which is below the CDPHE human health standard.

- **Nitrate (NO_3):** The CDPHE human health standard for nitrate is 10.0 mg/l. Nitrate can cause cyanosis in infants; a household water supply should not contain nitrate concentration in excess of 10 mg/l.

  Nitrate was not detected in the sample collected from your water well.

- **Nitrite (NO_2):** The CDPHE human health standard for nitrite is 1.0 mg/l. Nitrite concentrations exceeding 1.0 mg/l should not be used for feeding infants.

  Nitrite was not detected in the sample collected from your water well.

- **Copper (Cu):** The CDPHE secondary drinking water standard for copper is 1 mg/l.

  Copper was not detected in the sample collected from your water well.

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

  Chloride was detected in the sample collected from your water well at a concentration of 7.5mg/l which is below the CDPHE drinking water standard.

- **Iron (Fe):** The CDPHE secondary drinking water standard for iron is 0.3mg/l. Small amounts of iron are common in ground water. Iron produces a brownish-red color in 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 sample collected from your water well.

- **Manganese (Mn):** The CDPHE secondary drinking water standard for manganese is 0.05mg/l. Manganese produces a brownish color in laundered clothing, may stain fixtures and affect the taste of coffee or tea.

  Manganese was detected in the sample collected from your water well at a concentration of 0.012mg/l which is below the CDPHE human health standard.

- **Sulfate (SO_4):** The CDPHE sulfate secondary standard for human drinking water is 250mg/l. 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 was detected in the sample collected from your water well at a concentration of 74mg/l which is below the CDPHE drinking water standard.

- **pH:** pH is the measure of the hydrogen ion concentration in water. The pH of water in its natural state is generally from 5.5 to 9.0. The CDPHE standard for domestic and agricultural water is a range of 6.5 to 8.5. Seven (7) represents neutrality, while values less than 7 indicate increasing acidity and values greater than 7 indicate increasing alkalinity.

  pH was measured at the laboratory in the water sample from your well with a value of 8.32 which is within the CDPHE drinking water and agricultural standards. The pH measured during sampling was approximately the same as the pH measured at the lab.

- **Total Dissolved Solids (TDS):** CDPHE's TDS standard for human drinking water is 500 milligrams per liter (mg/l). Although CDPHE does not have an agricultural standard for TDS, other agencies recommend concentrations below 1500 mg/l for irrigation, and below 5,000 mg/l for most livestock watering. TDS occurs naturally in the ground water in many areas of Colorado at concentrations that exceed the drinking

water standard.

TDS was measured in the water sample collected from your well at a concentration of 280mg/l which is below the drinking water standard.

- **Zinc (Zn):** CDPHE's Zn standard for human drinking water is 5 milligrams per liter (mg/l) and the agricultural standard is 2mg/l.

  Zinc was not detected in the sample collected from your water well.

The following parameters were also measured as part of the laboratory analysis although there are no CDPHE standards.

- **Sodium (Na):** People on salt restricted diets should be aware of the sodium concentration in the water they drink. A concentration of 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 of Colorado at concentrations that exceed this health advisory level.

  Sodium was detected in the water sample from your well at a concentration of 82mg/l which is above the recommended level.

- **Boron (B):**

  Boron was not detected in the sample collected from your water well.

- **Calcium (Ca):**

  The calcium concentration in the sample collected from your well was 13mg/l.

- **Magnesium (Mg):**

  The magnesium concentration in the sample collected from your well was 2.4mg/l.

- **Potassium (K):**

  Potassium was not detected in the sample collected from your water well.

- **Molybdenum (Mo):**

  The molybdenum concentration in the sample collected from your water well was 0.014mg/l.

- **Bicarbonate (HCO_3):**

  Bicarbonate alkalinity was measured in the sample collected from your well at a concentration of 160mg/l.

- **Bromide (Br):**

  Bromide was not detected in the sample collected from your water well.

METHANE GAS ANALYSIS

Methane was detected in the sample collected from your well at a concentration of 2.1mg/l. The concentration of methane in the water produced from the well and that could enter your house from your well is above the threshold level of 1.1mg/l that theoretically could allow methane to accumulate in confined unventilated spaces and potentially be explosive. At the time of the sampling you said that you were not using water from your domestic well.

VOLATILE ORGANIC COMPOUND ANALYSIS

A target list of sixty-nine volatile organic compounds (VOC) was utilized during analysis of water from your well. None of the target list compounds were present above the method detection limit in samples from your well. No tentatively identified compounds were detected during the volatile target list analysis of water from your domestic well.

SEMI-VOLATILE ORGANIC COMPOUND ANALYSIS

A target list of seventy-two semi-volatile organic compounds (SVOC) was utilized during analysis of water from your well. None of the 72 target compounds were detected in water samples from your well. One semi-volatile tentatively identified compound was detected in the water samples from your well. The analyst tentatively identified the TIC as an oxygenated hydrocarbon. The one semi-volatile TIC may be an artifact of the analytical process as the same TIC was present in the method blank prepared and analyzed with the sample from your well.

TOTAL VOLATILE AND EXTRACTBALE HYDROCARBON ANALYSIS

Total volatile hydrocarbons (gasoline range) were not detected above the method detection limit in water from your well. Total extractable hydrocarbons (diesel range) were not detected above the method detection limit in water from your domestic well.

BACTERIAL ANALYSIS

The COGCC collected samples to analyze for the presence of iron, slime and sulfur bacteria in your water well. Samples from your water well were tested for the presence of iron-related (IRB), sulfate reducing (SRB) and slime forming (SLYM) bacteria using Biological Activity Reaction Test (BART) kits. In addition to detecting the presence of bacteria the BART Kits allow for an estimation of the size of the population and/or the rate at which they can metabolize and/or grow through an observable change or reaction. This reaction rate is referred to as the "aggressivity" of the bacterial population. The aggressivity levels of the bacteria are described as **Not Detected, Background, Moderately Aggressive, Very Aggressive, or Extremely Aggressive Levels**. The results of the tests are provided below and documented in Photographs 1, 2 and 3. The progress of the bacterial growth one day after the cultures were started is seen in Photograph 1. Photograph 2 shows the progress of the bacterial tests six days after the cultures were started. Photograph 3 shows the progress of the tests eight days after the cultures were started.

- **Iron-Related Bacteria (IRB):** Although not harmful, iron-related bacteria 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 appears to be a sheen on standing water. Signs that may indicate an iron bacteria problem include "yellowish, red or orange colored water, rusty deposits in toilet tanks and strange smells resembling fuel oil, cucumbers or sewage. Sometimes the odor will only be apparent in the

morning or after other extended periods of non-use" (CDPHE, Laboratory Services Division).

***Moderately Aggressive* levels of IRB bacteria were detected in the water sample collected at this well. The orange cloudy layer, at the bottom of the IRB tube (red cap) and the foam at the top in Photograph 2 developed after six days. This development of foam and orange color indicates Moderately Aggressive levels of IRB population present in the water from your well.**

- **Sulfate Reducing Bacteria (SRB)**: Sulfate reducing bacteria 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 (H_2S) gas as they grow. In turn, the hydrogen sulfide (H_2S) gas is a nuisance because it smells like rotten eggs, initiates corrosion on metal surfaces and reacts with dissolved metals such as iron to generate black sulfide deposits.

SRB were not detected in your well water as shown by the lack of black particulates at the bottom of the black capped vial in Photograph 3. The culture turns black if SRB are present and this culture remained clear for eight days.

Photograph 1. BART Kits April 1, 2009

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

SLYM bacteria were detected at Background levels in the water sample collected from this well as indicated by the cloudy yellow liquid seen in the green capped vial in Photograph3 after eight days.

Iron related and slime bacteria were present in your well. Since two types of bacteria were detected in the water distribution system or the well you should consider treating the well and distribution system with disinfecting solutions in the near future. Once bacterial colonies are established they are difficult to

eliminate; therefore, you may need to establish a schedule for periodic disinfection of your well system to help control the bacteria present in it. The chlorination process is more easily accomplished if you have a frost-proof hydrant near the well head that you can use to remove the chlorinated water from the well. One technique that water well professionals use is to re-circulate the chlorine solution down the sides of the well shortly after adding the chlorine. This helps to kill bacteria on the sides of the well and on the pipes in the well.

Photograph 2. BART Kits April 6, 2009

Pamphlets published by the CDPHE that provide more information concerning the treatment of iron and sulfur bacteria and shock chlorination treatment of bacteria are included as Attachment 4. You may also want to contact a licensed water well contractor for additional information or for help in disinfecting your well and distribution system. Additional information and assistance can be provided through the State of Colorado Health Department. Contact information for the agency is provided below.

Colorado Department of Public Health and Environment
Colorado Drinking Water Program
4300 Cherry Creek Drive South
Denver, CO 80246-1530
Phone: 303-692-3500
Fax: 303-782-0390

Photograph 3. BART Kits April 8, 2009

CONCLUSIONS

Table 1 shows a comparison of results from the sample collected from your well in 2009 to groundwater standards established by the Water Quality Control Commission. None of the parameters exceeds the groundwater standards. There are numerous sampling and analyses events at your water well since 2005. Table 3 compares the March 2009 results to data in our water quality database from a sampling and analysis event in 2005 conducted by Tom Glibota on your behalf.

The general inorganic chemistry of water from your well has changed since 2005 to present. In July 2006 there were significant changes to major cation concentrations in comparison to the 2005 sampling and analysis. The sodium adsorption ratio (SAR) is one means of examining the ratio of sodium to calcium and magnesium in water. Sodium, calcium and magnesium are the three main cations present in the water produced by your well. Figure 1 below shows that the calculated SAR for your domestic well water and the nearby Dolores domestic well water have very similar changes particularly in the large increase between 2005 and July 2006 followed by steady decrease after the Molokai incident. I do not have data from after March of 2007 for groundwater from the Dolores domestic well to compare to more recent results from your domestic well. The SAR calculated for groundwater produced by your domestic well steadily increase again after the decline in late 2006. The rise in SAR is accompanied by a rise in dissolved methane concentrations between May 2007 (0.047mg/l) and February 2009 (5.4mg/l) just as occurred in July 2006. I consider the increase in SAR and dissolved methane to be indicative of impacts to groundwater caused by nearby oil and gas operations.

From the data available to the COGCC, manganese has been detected in the dissolved and total fractions during metals analysis of water from your well since 2005. The presence of manganese oxides particles mentioned in the field sampling section above may be the source of the dissolved manganese that has been present in water produced by your well. Or conversely, the presence of dissolved manganese in the water could be the source of the manganese oxide particles.

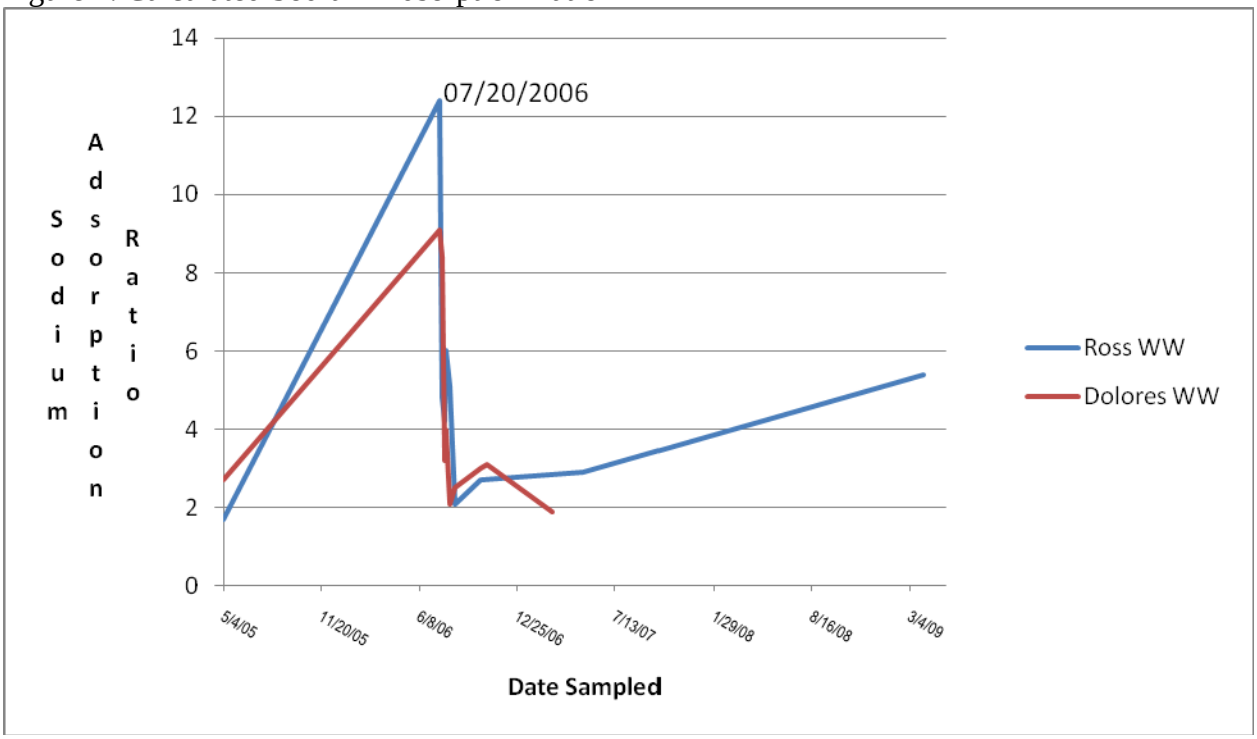
Moderately reducing conditions can induce dissolution of manganese oxides. Bacteria colonies present in a well or nearby aquifer can create localized reducing conditions that are capable of dissolving manganese oxides particles even if the overall conditions are oxidizing. A sudden or sustained influx of the reducing agents present in water or in gases flowing to your domestic well may initiate dissolution of manganese oxides present in the aquifer from which your well draws water. Alternatively, dissolved manganese present in the water could be oxidized during shock chlorination with bleach (which contains a strong oxidant) or during the natural influx of shallow, probably oxygenated groundwater when the well recharges after pumping.

The increase in dissolved iron and manganese seen in data from 2005 in comparison to July 2006 indicates that the scenario involving sudden influx of reductants mentioned above is more likely to have occurred. The creation of strongly reducing conditions by exact cause unknown but temporally related to drilling problems at the Molokai 13-36 induced dissolution of iron and manganese oxides present as individual particles or as coatings on mineral particles in the aquifer.

The concentration of methane detected in water from your well was above the threshold that can lead to buildup of combustible gases to explosive levels in the analysis of samples collected by the COGCC in March and by your consultant in February 2009. **Methane concentrations measured in your well water are at levels that could pose an explosion hazard if that water is brought directly into your home or other confined spaces. If you plan to bring the well water into a building then I recommend that you install methane detectors in your home if you do not already have such devices. If you plan on bring the well water into a building then installation of a vented outdoor cistern is also recommended to lessen the potential for explosion or fire caused by methane in your water.**

The isotopic composition of methane in groundwater from your well is shown graphically in Attachment 6. The isotopic composition of the methane present in groundwater from your sampled in 2009 is similar to the isotopic composition of the methane present in groundwater from your well sampled in October, 2006. The isotopic ratio indicates a mixed thermogenic/biogenic origin.

Figure 1. Calculated Sodium Adsorption Ratio



The increasing SAR and dissolved methane concentrations in groundwater at your well indicate new or continued impacts from nearby oil and gas operations. As a result of these impacts the staff of the Colorado Oil and Gas Conservation Commission has issued a notice of alleged violation (NOAV) to Pioneer Natural Resources with respect to issues raised in your complaint (document 200215905) on August 6, 2009. This complaint will be closed with the issuance of the NOAV. A copy of the notice of alleged violation is included as attachment 7. Should you be unsatisfied with COGCC staff's handling and resolution of your complaint, Rule 522.b. (4) allows you as the complainant to file with the Commission an application for an Order Finding Violation.

If you have any questions or would like to discuss these matters further, please contact me at 719-846-3091 or by email at peter.gintautas@state.co.us .

Sincerely,
Colorado Oil and Gas Conservation Commission

Peter Gintautas
Environmental Protection Specialist

Attachments:
Attachment 1 - Table 2 - Analytical Summary
Attachment 2 - ALS Laboratory Group – FC data reports
Attachment 3- Isotech Laboratories data report
Attachment 4 - CDPHE pamphlets
Attachment 5 - Table 3 – Comparison of 2005 and 2009 results
Attachment 6 - Plot of Isotopic Composition of water from the Ross Domestic Well
Attachment 7 - Notice of Alleged Violation 200215905

cc: David Neslin, COGCC Director w/o attachments
Debbie Baldwin, COGCC Environmental Protection Manager w/o attachments
Margaret Ash, COGCC Environmental Protection Supervisor w/o attachments
Dave Holland, Pioneer Natural Resources w/o attachments