STATE OF COLORADO
OIL & GAS
CONSERVATION COMMISSION

September 25, 2009

Certified Mail Return Receipt Requested # 7008 3230 0003 3234 7188

Cheryl Shilling
Stonewall Fire Protection District – Wet Canyon Station
Post Office Box 126
Weston, CO 81091

RE: Complaint 200213187
Water Well Permit 268191
Baseline Sampling – Groundwater Chemistry
SESE 28 32S, 67W Las Animas County, Colorado

Dear Cheryl:

COGCC staff collected water samples from your domestic well as part of our investigation of your complaint that concerning odors and flavors associated with water from the well at the fire station in Wet Canyon. Water samples were collected for general organic and inorganic water quality testing as well as for analysis of dissolved methane and volatile organic compounds and BART kit tests. Water samples for gas composition and isotopic analyses were also collected. 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

Peter Gintautas of the COGCC visited your property on June 22, 2009. With your assistance I collected samples from the outdoor hydrant near your office building. The pump had been active for approximately 17 minutes at 10 gallons per minute flow before the samples were collected. These samples for general chemical analyses were then shipped to Accutest Laboratories in Wheat Ridge, CO and received on June 23, 2009.
A second set of samples for analysis of volatile organic compounds, anions and dissolved gas analyses were collected on August 11. 2009. The well was pumped for approximately 28 minutes at 10 gallons per minute. The samples for analysis of volatile organic compounds and anions were shipped to Accutest Laboratories in Wheat Ridge, CO and received on August 12, 2009. The gas composition and isotopic sample was shipped to Isotech Laboratories in Champaign, IL and received on August 13, 2009.

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 1 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 Accutest Laboratories for samples collected in August, 2009 are included as Attachment 2. The analytical reports from Isotech Laboratories for the samples collected in August 2009 are included in 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 0.05 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 detected in the sample collected from your water well at a concentration of 0.272mg/l which is below the CDPHE human health standard.

- **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 0.00114mg/l which is below the drinking water 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 2.0mg/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. Common sources of nitrate in shallow groundwater are fertilizer use, leaching from septic tanks or from livestock operations.

Nitrate was detected in the sample collected from your water well at a concentration of 3.62mg/l which is below the CDPHE human health standard.

- **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 52.3mg/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 not detected in the sample collected from your water well.

- **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 39.2mg/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 in the water sample from your well with a value of 7.45 which is within the CDPHE drinking water and agricultural standards.

- **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 496mg/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 97.1mg/l which is above the recommended level.

- **Boron (B):**

  Boron was detected in the sample collected from your water well at a concentration of 0.0227mg/l.

- **Calcium (Ca):**

  The calcium concentration in the sample collected from your well was 60mg/l.

- **Magnesium (Mg):**

  The magnesium concentration in the sample collected from your well was 5.57mg/l.

- **Potassium (K):**

  The potassium concentration in the sample collected from your well was 1.43mg/l.

- **Molybdenum (Mo):**

  Molybdenum was not detected in the sample collected from your well.

- **Bicarbonate (HCO_3):**

  Bicarbonate alkalinity was measured in the sample collected from your well at a concentration of 292mg/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 concentrations of 3.1mg/l and 3.9mg/l. The concentration of methane in the water produced from the well is above the threshold level of 1.1mg/l that theoretically could allow methane to accumulate in small, confined, unventilated spaces and potentially be explosive. You do not have a vented outdoor cistern that could serve as a passive treatment system to reduce methane dissolved in water pumped from your domestic well and then on to your offices. You do not have flammable gas detectors inside your offices to alert you if methane were to build up to levels well below the lower explosive limit of approximately 5% methane in air.

VOLATILE ORGANIC COMPOUNDS ANALYTICAL RESULTS

Five volatile organic compounds were detected in water samples from your well collected in June, 2009. Four of the compounds detected are part of a group of disinfection byproducts called trihalomethanes. (THM's). After reviewing these results of the June 2009 sampling and analysis, I asked if you had recently performed a chlorination of the well. You reported to me that you had shock chlorinated your domestic well shortly before the June 2009 samples were collected. THM's form from organic matter, such as bacteria, during disinfection by strong oxidants such as hypochlorite present in many bleach solutions similar to the solution you reported to me that you used. Five volatile organic compounds were detected in water samples collected from the well in August, 2009. Four of these are the same THM compounds determined to be present in the June, 2009 samples.

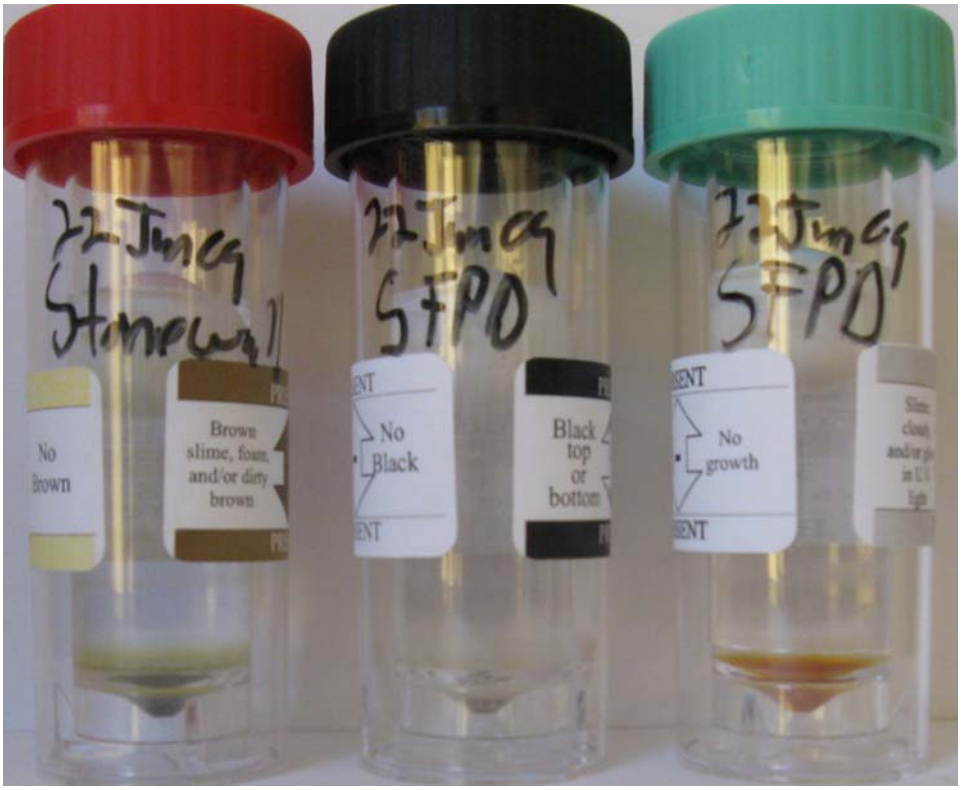
BACTERIAL ANALYSIS

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 and 2. The progress of the bacterial growth the day the cultures were started is seen in Photograph 1. Photograph 2 shows the progress of the bacterial tests nine 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).

  IRB bacteria were not detected in the water sample collected at this well. IF IRB are present, an orange cloudy layer, at the bottom of the IRB tube (red cap) and foam at the top develop within eight days.



Photograph 1. BART Kits June 22, 2009

- **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 <u>not detected</u> in your well water as shown by the lack of black particulates at the bottom of the black capped vial in Photograph 2. The culture turns black if SRB are present and this culture remained clear for the duration of the test.

- **<u>Slime Forming Bacteria (SLYM)</u>**: 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 not detected in the water sample collected from this well as indicated by the clear yellow liquid seen in the green capped vial in Photograph 2 after nine days.

The lack of bacteria in these samples is presumably the result of the shock chlorination performed shortly before the samples were collected. However, the persistence of and recurrence of odors associated with water from your well indicate the likelihood that bacteria are re-entering the well bore soon after the shock chlorination takes place.

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. Odor and taste problems with water wells are frequently caused by the presence of bacteria in the system.

Photograph 2. BART Kits July 1, 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

CONCLUSIONS

Table 1 in Attachment 1 compares the results of the recent sampling and analysis event to the groundwater standards promulgated by the Water Quality Control Commission of the Colorado Department of Public Health and the Environment. All parameters tested are below the groundwater standards. No standard exists for dissolved methane in groundwater or drinking water. The concentration of nitrate is relatively high in comparison to most water or CBM wells in the Raton Basin. The continued presence of bacteria in the well as indicated by the recurrent odors associated with the water and the presence of nitrate in the water produced by your domestic well indicate the strong possibility of a connection with a septic system or a possibility of input from surface waters receiving livestock wastes. The static water level in the well was reported as at 20 feet when the pump was installed. The reported age of the well (>40 years) could indicate that the is not a seal between the surface casing and near surface waters which means the well may not be sealed in a sanitary manner as would be done under current water well drilling rules. Table 2 in Attachment 5 includes results from a second sampling for selected compounds that was done to confirm the level of nitrate and THM's present in water from your domestic well. The concentration of nitrate was higher in the samples collected in August, 2009 in comparison to the June, 2009 samples. The concentrations of THM's were lower in the August samples than in the June samples which is likely to be related to the longer time after chlorination for the August samples in comparison to the relatively short time after chlorination when the samples were collected in June.

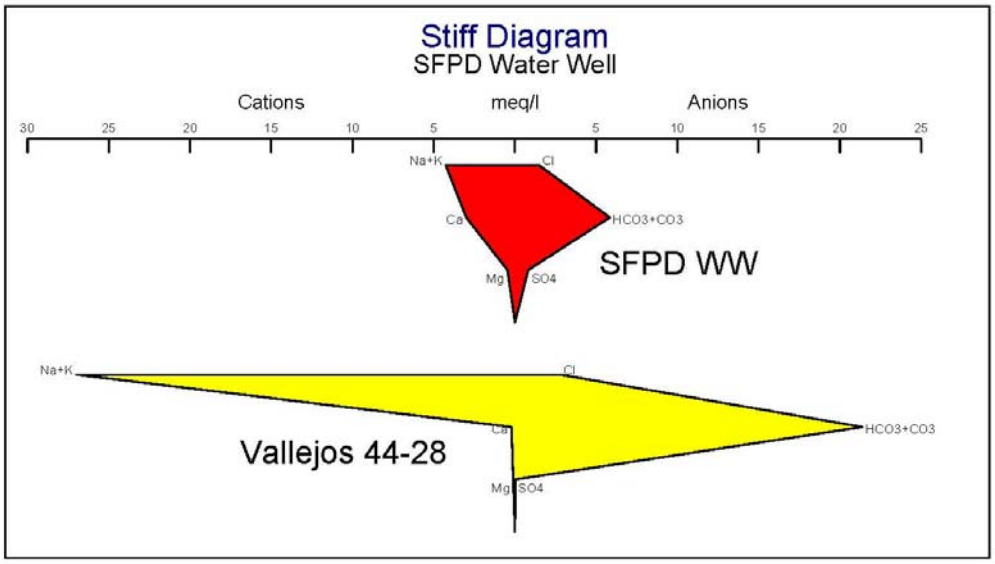
Attachment 6 includes a graph of isotopic composition of methane dissolved in water from your well in comparison to surface seep methane, and methane from CBM and water wells in the Raton Basin. The dissolved methane in your well is likely of thermogenic origin but is notof similar isotopic composition to three CBM wells also plotted and labeled. These three CBM wells are the closest wells for which I have isotopic data. The isotopic composition of methane from two nearby water wells is included on the chart and labeled.

The Stiff diagram graphs below illustrate the major ion composition of the water in your well in comparison to the major ion composition of a nearby CBM well. Stiff diagrams are a means of visualizing the major ion chemistry of water. The plot below shows that the water from you well is dominantly of sodium-calcium-bicarbonate-sulfate character. Produced water from coal bed methane (CBM) wells typically show higher concentrations of total dissolved solids than your well

water contains. CBM produced water in the Raton Basin is characteristically of a sodium-bicarbonate nature (with lesser chloride) as seen in the diagram below. Sulfate is typically not detected or present at relatively low concentrations in most CBM produced water from the Raton Basin but is present at moderate concentration in your well.

The reported depth of your well is 147 feet below ground surface and may be completed in the Raton Formation. The nearby CBM wells (approximately 800 to 950 feet east and west of your domestic well are perforated into the Raton Fm and the deeper Vermejo Fm. The shallowest perforations in the two closest CBM wells are at depths of approximately 800 to 1500 feet below ground surface. As seen above the differences in chemistry of water in your well and the nearby CBM well indicates different sources of water are being accessed by your domestic well and the CBM wells. The Raton Fm. in your area does have several small coal seams present and has been noted in the mud logs from nearby CBM wells.

At present there is no data that would indicate the water quality in your domestic well has been impacted by nearby CBM drilling and operations.



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
Digitally signed by Peter Gintautas
DN: cn=Peter Gintautas, o=Colorado Oil and Gas Conservation Commision, ou, email=peter.gintautas@state.co.us, c=US
Date: 2009.09.25 15:38:46 -06'00'

Peter Gintautas
Environmental Protection Specialist

Attachments:
Attachment 1 - Table 1 - Analytical Summary
Attachment 2 - Accutest Laboratories Reports
Attachment 3 - Isotech Laboratories Report
Attachment 4 - CDPHE pamphlets
Attachment 5 - Table 2 – Comparison of Results from 2009 Sampling Events
Attachment 6 - Isotopic Composition

cc: David Neslin, COGCC Director w/o attachments
Debbie Baldwin, COGCC Environmental Protection Manager w/o attachments

TABLE 1
ANALYTICAL SUMMARY
Complaint 200213187
Stonewall Fire Protection District Wet Canyon Water Well

Parameter	Water Sample		CDPHE Standards		
	Sample Date				
	22-Jun-09				
	Result	Unit	Domestic	Agriculture	Units
Antimony	ND	mg/l	0.006	NS	mg/l
Arsenic	ND	mg/l	0.01	0.1	mg/l
Barium	0.272	mg/l	2.0	NS	mg/l
Berylium	ND	mg/l	0.004	0.1	mg/l
Boron	0.0227	mg/l	NS	0.75	mg/l
Cadmium	ND	mg/l	0.005	0.01	mg/l
Calcium	60	mg/l	NS	NS	
Chromium	ND	mg/l	0.1	0.1	mg/l
Cobalt	ND	mg/l	NS	0.05	mg/l
Copper	ND	mg/l	1	0.2	mg/l
Iron	ND	mg/l	0.3	5	mg/l
Lead	ND	mg/l	0.05	0.1	mg/l
Lithium	0.0141	mg/l	NS	NS	
Magnesium	5.57	mg/l	NS	NS	
Manganese	ND	mg/l	0.05	0.2	mg/l
Molybdenum	ND	mg/l	0.035	NS	mg/l
Nickel	ND	mg/l	0.1	0.2	mg/l
Potassium	1.43	mg/l	NS	NS	
Selenium	ND	mg/l	0.05	0.02	mg/l
Silver	ND	mg/l	0.05	NS	mg/l
Sodium	97.1	mg/l	NS	NS	
Strontium	1.23	mg/l	NS	NS	
Thallium	ND	mg/l	0.002	NS	mg/l
Uranium	0.00114	mg/l	0.03	NS	mg/l
Zinc	ND	mg/l	5	2	mg/l
Chloride	52.3	mg/l	250	NS	mg/l
Nitrite	ND	mg/l	1.0	10	mg/l
Nitrate	3.62	mg/l	10.0	100	mg/l
Total Nitrite/Nitrate	3.62	mg/l	10.0	100	mg/l
Fluoride	2	mg/l	4.0	NS	mg/l
Total Dissolved Solids	496	mg/l	400	*1500	mg/l
pH	7.45	No units	6.5 - 8.5	6.5 - 8.5	No units
Sulfate	39.2	mg/l	250	NS	mg/l
Bromide	ND	mg/l	NS	NS	
Total Alkalinity	292	mg/l	NS	NS	
Bicarbonate	292	mg/l	NS	NS	
Carbonate	ND	mg/l	NS	NS	
Conductivity	716	umhos/cm	NS	NS	
methane	3.1	mg/l	NS	NS	

Notes

CDPHE	Colorado Department of Public Health and the Environment.
Domestic	Water Quality Control Commission 5 CCR 1002-41, Regulation No. 41 - The Basic Standards For Groundwater.
Agriculture	* Standards for agriculture complied from CDPHE and other sources.
mg/l	milligrams per liter (ppm or parts per million).
µmhos/cm	micromhos per centimeter
NA	Not analyzed.
ND	Not detected.
NS	No Standard.
****	Health Advisory.
	Human health standard.
	Secondary standard.

TABLE 2
Comparison of Results
Complaint 200213187
Stonewall Fire Protection District
Wet Canyon Station

Parameter	Sample Date 22-Jun-09 Result	Sample Date 11-Aug-09 Result	Unit	CDPHE Standards Domestic	Agriculture	Units
Chloride	52.3	56.6	mg/l	250	NS	mg/l
Nitrite	ND	ND	mg/l	1.0	10	mg/l
Nitrate	3.62	5.09	mg/l	10.0	100	mg/l
Total Nitrite/Nitrate	3.62	5.09	mg/l	10.0	100	mg/l
Fluoride	2	1.6	mg/l	4.0	NS	mg/l
Sulfate	39.2	41.5	mg/l	250	NS	mg/l
Total Alkalinity	292	300	mg/l	NS	NS	
Bicarbonate	292		mg/l	NS	NS	
Carbonate	ND		mg/l	NS	NS	
methane	3.1	3.9	mg/l	NS	NS	
				Groundwater Standard	**Drinking Water MCL**	
bromodichlormethane	3.1	1.7	µg/l	0.56	80	µg/l
bromoform	19.5	6.6	µg/l	4	80	µg/l
bromomethane	0.42	ND(<4)	µg/l	NS	NS	
chloroform	1.7	1.4	µg/l	3.5	80	µg/l
dibromochlormethane	7.9	2.9	µg/l	14	80	µg/l

Notes

CDPHE	Colorado Department of Public Health and the Environment.
Domestic	Water Quality Control Commission 5 CCR 1002-41, Regulation No. 41 - The Basic Standards For Groundwater.
Agriculture	* Standards for agriculture complied from CDPHE and other sources.
mg/l	milligrams per liter (ppm or parts per million).
µg/l	micrograms per liter (ppb or parts per billion)
µmhos/cm	micromhos per centimeter
NA	Not analyzed.
ND	Not detected.
NS	No Standard.
******	Health Advisory.
	Human health standard.
	Secondary standard.

Isotopic Composition of Methane from SFPD Wet Canyon Water Well