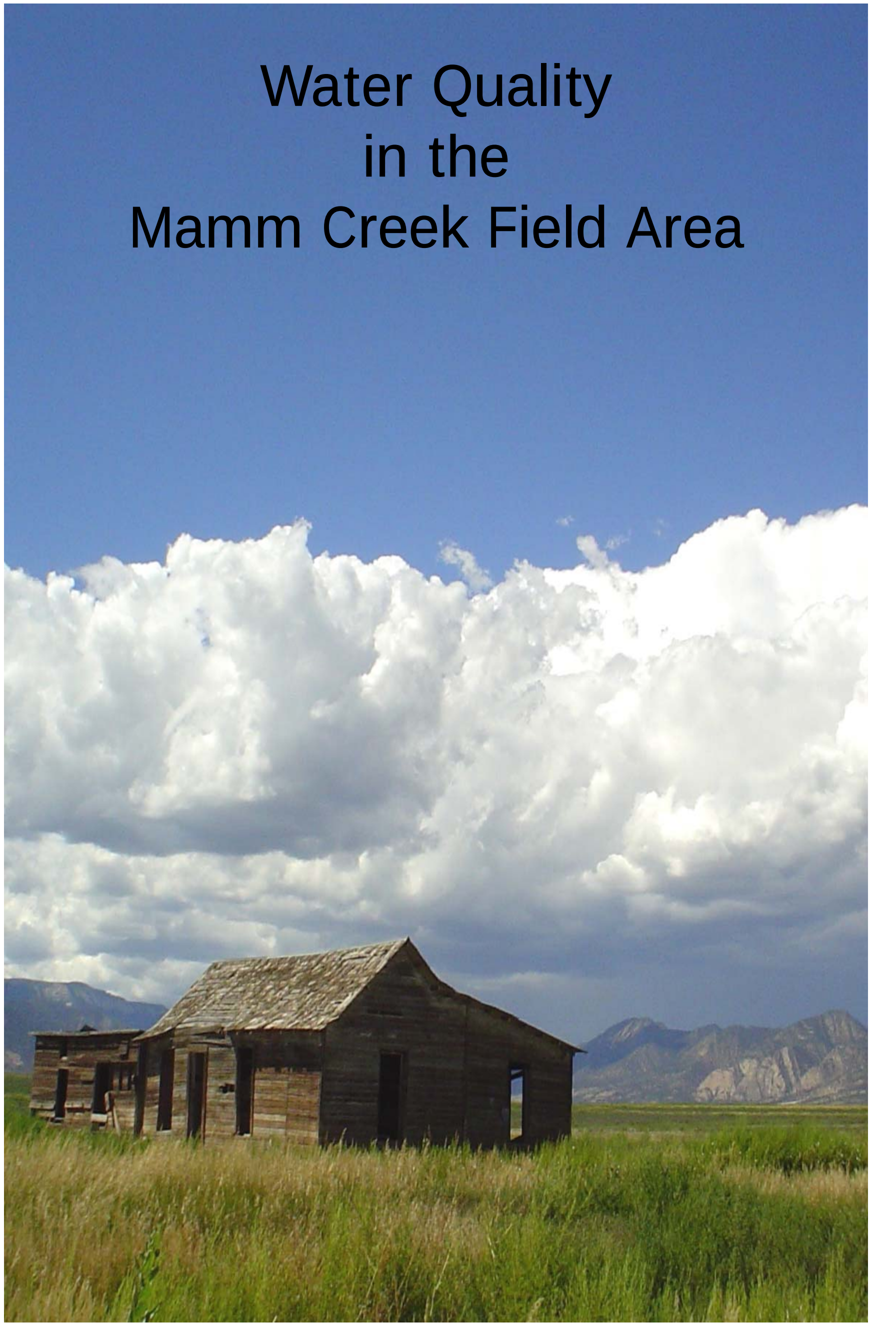
Appendix E

Well Owner Water Quality Information Pamphlet – Water Quality in the Mamm Creek Field Area


Water Quality in the Mamm Creek Field Area
Garfield County, Colorado


Water Quality
in the
Mamm Creek Field Area

Introduction

Private water supply wells are not subject to the rigorous sampling requirements of municipal water supply wells. Nonetheless, it is important to know the quality of the water in private wells that are being used for drinking and household purposes or for livestock watering.

Frequently private water supply wells are never sampled after the initial construction or they are only sampled to estimate the hardness of the water.

Natural gas exploration and production in the Mamm Creek Field area in eastern Garfield County has motivated water sampling efforts by the Colorado Oil & Gas Conservation Commission (COGCC), Garfield County, and the oil and gas operators active in the area. This pamphlet has been prepared to assist well owners in understanding the sample results from Garfield County's sampling efforts in summer 2007 as well as from other sampling conducted in the area.

* * *

There are hundreds of different compounds (also called parameters, constituents or analytes) that can be tested for in water. Typically during water sampling events, specified objectives motivate sampling of a limited list of compounds. Testing of all compounds is impractical, very expensive, and unnecessary.

This pamphlet discusses compounds analyzed in sampling conducted in the Mamm Creek Field area, and contains explanations of:

- General (or standard) water quality compounds;
- Drinking water compounds that are regulated due to health-related concerns;
- Drinking water compounds that are regulated for aesthetic reasons such as taste or odor; and
- Methane and other compounds that may be naturally occurring or related to natural gas production activities.

The discussion and accompanying tables provided below emphasize the most common compounds present in groundwater as well as selected compounds that may be of concern in Garfield County.

The discussion below frequently refers to water quality characteristics that may be mitigated by a water treatment system. As such a short section is provided at the end of this pamphlet that discusses some of the basic considerations for water treatment for household water supply systems.

Water Treatment Options

Water from many of the private wells in Garfield County would benefit from treatment prior to household use to improve taste, odor, hardness, and other aesthetic qualities of the water and/or to reduce exposure to contaminants with health-based risks. Determining the appropriate treatment system for a well can be difficult and well owners should evaluate their options carefully.

There are written guidelines that can be obtained from local health departments and various government agencies, describing various water treatment options . Additionally, water treatment assistance can be found by contacting vendors of treatment equipment directly; although the well owner should be cautious in dealing with vendors of specific technologies unless they are familiar with the vendor's services and credentials. If possible, for any other than relatively simple analytical tests, a qualified, independent third-party should conduct the sampling and a certified analytical laboratory should perform the sample analysis.

Several sources for obtaining information on private wells and water treatment are provided below.

"Water Treatment Decision Guide." Available from the Garfield County Public Health Service (In Rifle: 195 W. 14th St., 970-625-5200; in Glenwood Springs: 2014 Blake Ave., 970-945-6614).

Water Treatment and Decision Guide in **"How Well Do You Know Your Water Well?"** (Plateau Environmental Services and CDS Environmental Services, June 2001)
http://co.laplata.co.us/water_well_web/Water%20Well%20Brochure.pdf

Sections 6 and 7 in "Water on Tap – What You Need to Know" (EPA, October 2003, EPA 816-K-03-007)
http://www.epa.gov/safewater/wot/pdfs/book_waterontap_full.pdf)

"Drinking Water from Household Wells" (Colorado Department of Public Health and Environment, October 2002)
http://www.cdphe.state.co.us/wq/drinkingwater/pdf/ColoradoHouseholdWellWater.pdf

Water Quality Sampling and Treatment in **"A Guide for the Private Well Owner"** (Santa Clara Valley Water District, May 2001)
http://www.valleywater.org/media/pdf/Guide%20for%20Well%20Owners.pdf

"A Guide To Home Water Treatment" (Michigan State University Cooperative Extension Service, January 1990, Bulletin WQ21)
http://web1.msue.msu.edu/msue/iac/disasterresp/HomeImprovement/WQ21.pdf

"Water Filters and Purification" (Michigan State University Cooperative Extension Service, July 28, 1998)
http://www.gem.msu.edu/gw/wtr_trt.html)

Wellcare® Hotline operated by the Water Systems Council, a national organization focused on household well and small private water supply systems. Call 888-395-1033
http://www.wellcarehotline.org or *http://www.watersystemscouncil.org*

Additional Compounds

The compounds listed above constitute only a partial list of the most common ones analyzed in private well sampling. Others, such as organic compounds that are present in cleaning solvents, fertilizers, pesticides, or in gasoline, diesel fuel, heating oil and other petroleum products, are not included because they are generally only targeted in directed industrial or agricultural contamination investigation programs or if a well owner has buried petroleum storage tanks near a well.

For the sampling conducted by Garfield County in 2007, there are two other types of compounds that were analyzed in certain wells:

- Inorganic compounds that may be present in trace amounts in groundwater, but that can sometimes be used to help determine possible sources of the water. These compounds include boron (B), strontium (Sr), and bromide (Br). None of the compounds are present at high concentrations and none of them cause health or taste or odor effects in the water.
- Dissolved gases present in groundwater. In samples analyzed for isotopes of specific elements (i.e., carbon and hydrogen in methane andr other natural gas hydrocarbon molecules), the concentrations of several other dissolved gases commonly found in water are also measured. These other gases are argon (Ar), helium (He), nitrogen (N_2), oxygen (O_2), carbon monoxide (CO), and carbon dioxide (CO_2). These gases do not constitute a health hazard at their concentrations in groundwater and normally do not impart any taste or coloration to the water, although they can bubble out of the water after it comes out of a tap if they are present at high enough concentrations.

Water Sample Results Interpretation

Concentration limits are established for many compounds in groundwater. These limits are established based on known human health effects or an aesthetic or cosmetic considerations such as taste, odor, staining, etc.

All of the compounds sampled by Garfield County in 2007 are listed in the discussion and tables. There are also compounds that were not sampled in every well; the information provided for these compounds may be of interest even though they were not considered necessary for analysis in all wells.

The water sample results data sheets provided for the sampling conducted by Garfield County contain results only for the well. They do not contain the quality assurance/quality control (QA/QC) results from additional analyses that the laboratory performs to ensure that the results for the sample are accurate enough to meet laboratory certification standards. If the QA/QC results are of interest, a well owner should contact the entity who conducted the sampling or the laboratory project manager to obtain them.

General Water Quality Compounds and Water Hardness

All natural water contains several compounds in addition to the H_2O part of the water. Table 1 includes the compounds that are the most common in groundwater, and two other indicators of the general quality of the water (total dissolved solids and pH). Most of these compounds are dissolved into the water as it travels through the subsurface prior to being pumped from a well.

The general (or standard) water quality compounds include those parameters that are primarily responsible for giving water its characteristic taste or feel. Most do not present health threats at the concentrations found in drinking water.

Table 1: General Water Quality Parameters

Compound	Acceptable Concentration Range	Characteristics
Calcium (Ca)	---	A common element in many types of rocks. Contributes to hardness of water.
Sodium (Na)	---	A common element in many types of rocks. Also a major component of ocean water.
Magnesium (Mg)	---	A common element in many types of rocks; usually present in lower concentrations than either calcium or sodium. Contributes to hardness of water.
Potassium (K)	---	A common element in many types of rocks; usually present in lower concentrations than either calcium or sodium.
Chloride (Cl)	Less than 250 mg/L[1, 2]	A common element; usually associated with dissolution of evaporites such as halite (salt). Also occurs due to mixing with either modern or ancient ocean waters underground. Gives water its salty taste.
Sulfate (SO_4)	Less than 250 mg/L[2]	May occur due to dissolution of minerals containing sulfur (such as gypsum) or from decay of organic material. Imparts a bitter taste to water.
Alkalinity Bicarbonate (HCO_3) Carbonate (CO_3)	---	A measure of the ability of water to neutralize acids. The principal sources of alkalinity are the carbon dioxide (CO_2) species, bicarbonate and carbonate, which occur naturally in groundwater.
Nitrate/Nitrite (NO_3/NO_2)	Less than 10 mg/L[3]	May occur naturally in low concentrations, but more often a by-product of fertilizers or human or animal wastes leaching into groundwater (from septic tanks, sewer infiltration, etc). Concentrations above 10 mg/L can be dangerous to infants.
Total Dissolved Solids (TDS)	Less than 500 mg/L[2]	Dissolved mineral residue left after evaporating all the water from a sample (or calculated from the concentrations of the compounds listed above). High concentrations of TDS can increase hardness, affect taste of water, and cause staining or scaling on fixtures.
pH	6.5 to 8.5 pH units	Measure of the amount of acid or alkali (base) present in water. Measured on a scale of 0 to 14 based on the concentration of hydrogen ions (H^+) present. As pH decreases below 7, the water becomes more acidic; as pH increases above 7, the water becomes more alkaline.

--- No limit established

1 mg/L = milligrams/Liter. 1 mg/L is equivalent to 1 part per million (ppm).

2 See section on ***Drinking Water Quality Standards Contaminants*** for additional information.

3 See section on ***Drinking Water Health Standards Contaminants*** for additional information.

Table 5: Dissolved Methane Concentrations in Water Wells

Methane Concentration	Effects/Actions
Less than 1 mg/L	No effects. Resample well on a periodic basis if in an area of active oil and gas development or production.
1 – 2 mg/L	No effects. Resample well on a periodic basis.
2 -7 mg/L	Unlikely to be effects, although concentrations in air in closed environments (e.g., cisterns or holding tanks) can build up if concentrations in water stay at the upper end of this range. Resample well on a periodic basis. If not already done, have an isotope sample collected to evaluate the source of the gas.
7 – 13 mg/L	Ventilate closed environments or confined spaces (including basement areas where water is used) to prevent gas buildup to explosive levels. Resample well on a periodic basis. If not already done, have an isotope sample collected to evaluate the source of the gas. Consider implementing a gas mitigation plan to prevent future gas buildup.
Greater than 13 mg/L	Ventilate closed environments or confined spaces (including basement areas where water is used) to prevent gas buildup to explosive levels. **Implement a gas mitigation plan to prevent future gas buildup.** If not already done, have an isotope sample collected to evaluate the source of the gas. Resample well on a periodic basis.

Methane in Groundwater

Methane is a colorless, odorless and tasteless gas which can usually be divided into two classes based on its source:

- Biogenic methane is produced by biological decay of organic materials. Methane in groundwater that is formed from this process is often relatively young and forms in vegetation-rich swampy areas or where shallowly buried deposits of organic matter occur within sedimentary deposits. Often sources of biogenic methane in water wells are close to the wells where biogenic methane production occurs.
- Thermogenic methane is produced by very high temperatures acting for long periods of time on organic materials such as organic-rich shale or coal beds. These processes are responsible for the generation of the gas that is produced from conventional natural gas wells and coalbed methane wells. This gas may be several million years old and usually forms thousands of feet below the ground surface.

The specific source of methane found in groundwater can often be determined by a specialized laboratory analysis of the gas using a technique called stable isotope analysis, whereby concentrations of very slightly heavier atoms of carbon and hydrogen in the methane are measured.

Methane has no known direct health effect; however, it becomes a problem in water wells when it is allowed to build up in confined spaces. High concentrations of methane can displace oxygen, or in the presence of a spark, can explode. Table 5 provides a guideline for dealing with methane in water wells. If methane has been detected in a well, periodic resampling should be conducted because methane concentrations in groundwater can fluctuate over time.

Hardness in water is a measure of the multivalent cations calcium and magnesium and possibly other dissolved compounds such as bicarbonates or sulfates. The higher the concentrations, the harder the water. Hard water causes white, scaly deposits on plumbing fixtures and cooking appliances, and it decreases cleaning action of soaps and detergents.

The degree of hardness in water may be expressed in either milligrams per liter (mg/L) or grains per gallon (gpg). Table 2 provides a comparative scale of hardness measurements. Water that is characterized as hard or very hard is considered to be a good candidate for softening using a household treatment unit. For more information on treatment options and measuring the level of hard water, refer to the back page of this pamphlet.

Table 2: Water Hardness Classifications

Milligrams per Liter (mg/L)	Grains per Gallon (gpg)	Relative Hardness
Below 60	Below 3.5	Soft
60 to 120	3.5 to 7.0	Moderately Hard
120 to 180	7.0 to 10.5	Hard
180 and above	10.5 and above	Very Hard

Drinking Water Health Standards Contaminants

Federal and State governments regulate a large number of compounds in water on the basis of their potential to cause adverse health effects. Public drinking water supplies are regulated under the Safe Drinking Water Act (SDWA); however, the SDWA does not regulate private wells or water supply systems serving fewer than 25 individuals.

Most of the regulated compounds (or contaminants) are introduced to groundwater from industrial, commercial, agricultural, or other activities. Some of the compounds however, occur naturally and are widespread enough that they warrant sampling in private wells. Several of these compounds have been sampled in the Mamm Creek area; those compounds, their regulatory concentration limits and their health effects are listed in Table 3.

(No organic compounds associated with manufacturing processes, such as cleaning solvents, or with petroleum products such as gasoline or diesel are included. Methane, the most likely organic chemical compound to occur in the area is discussed below.)

Table 3: Common Domestic Water Human Health Standards Contaminants and Their Effects

Contaminant	Human Health Standard[1]	Sources / Potential Health Effects
Fecal Coliform Bacteria[2]	Absent	Human sewage and animal wastes leaking into groundwater wells and water supply lines. Severe flu-like symptoms such as nausea, vomiting, fever, and diarrhea. Infants, elderly, and the sick are especially susceptible.
Fluoride (F)	4.0 mg/L	Naturally leached from bedrock. Low levels of fluoride can help prevent dental cavities. At high levels, fluorides can result in tooth and bone damage.
Selenium (Se)	0.05 mg/L	Naturally leached from soil and bedrock. Long-term exposure at levels above health standards can result in hair and fingernail loss; damage to kidney and liver tissue and to the nervous and circulatory systems. Can cause similar symptoms in animals.
Lead (Pb)	0.05 mg/L	Typically leached into water from plumbing system components such as brass faucets, lead caulking, lead pipes and soldered joints. Causes nervous disorders and mental impairment especially in fetuses, infants, and young children. Can also cause damage to kidneys, blood disorders, and brain damage.
Arsenic (As)	0.01 mg/L	Naturally leached from bedrock; also contained in certain pesticides. Dangerous to humans and animals alike. May cause skin damage, circulatory system problems and an increased risk of cancer.
Nitrates (NO_3) and Nitrites (NO_2)[3]	10 mg/L NO_3-N, 1 mg/L nitrite-N, or 10 mg/L NO_3+ NO_2-N, depending on analysis performed.	Forms when nitrogen from fertilizers, animal wastes, septic systems, municipal sewage sludge, or decaying plants combines with oxygenated water. In infants less than 6 months of age, can cause *blue baby syndrome* an acute illness requiring immediate medical care. Low health threat to children and adults, although for pregnant women it may reduce the amount of oxygen available to the growing fetus.

[1] From Colorado Basic Standards for Ground Water (5 CCR 1002-41).

[2] ***Coliform bacteria*** are the most common contaminant found in private water systems. There are many strains of coliform bacteria, most of which do not cause illness. However, ***E. coli*** is a strain which can cause illness. Because coliform bacteria can easily be introduced into private water supply systems, private wells should be tested once each year, at a minimum, by a lab that will test for *E. coli* if coliform bacteria are detected.

[3] Every private water well should be tested for ***nitrate*** at least once, and more often if the well is located near any nitrate-forming source.

Drinking Water Quality Standards Contaminants

Drinking water quality standards compounds (or contaminants) are compounds considered to have no adverse health effects at normal concentrations, but that can result in poor taste or appearance or that can make water unsuitable for many household purposes at elevated concentrations. Table 4 lists several common water quality standards compounds with their acceptable concentration limits and their characteristics in groundwater.

Table 4: Common Domestic Drinking Water Quality Standards Contaminants and Their Effects

Compound	Acceptable Concentration Limit[1]	Characteristics / Effects
Chloride (Cl)	250 mg/L	Occurs naturally; can also occur due to infiltration of water contaminated by road salt. Salty or brackish taste; corrosive; blackens and pits stainless steel.
Copper (Cu)	1.0 mg/L	Can occur naturally in low concentrations or due to industrial activities; most commonly corroded off of copper plumbing fixtures by low pH water. Blue-green stains on plumbing fixtures; bitter, metallic taste.
Iron (Fe)	0.3 mg/L	Several sources, commonly natural; also from industrial sources, landfill leachates, acid mine drainage, and corrosion of metal water supply system components. Metallic taste; discoloration of water; reddish brown stains on fixtures.
Manganese (Mn)	0.05 mg/L	Occurs naturally, often with iron; can also be contaminant from industrial sources and from acid mine drainage. Causes black specks on fixtures; bitter taste.
Sulfate (SO_4)	250 mg/L	Occurs naturally. Bitter, medicinal taste; corrosive.
Zinc (Zn)	5 mg/L	Occurs naturally, but also can leach off of certain water system components. Imparts a metallic taste to water.
Total Dissolved Solids (TDS)	Less than 500 mg/L	General indicator of water quality. High concentrations can increase hardness, affect taste of water, and staining or scaling on fixtures.
Iron and Sulfur Bacteria[2]	---	Grows as orange- to brown-colored slime in water and on plumbing fixtures. Can impart sulfurous (rotten egg odor) to water.

[1] From Colorado Basic Standards for Ground Water (5 CCR 1002-41)

[2] Enhanced by conditions in water supply system that foster bacterial growth. Can often be dealt with by disinfecting the well and water supply system.