

Chapter 6

Water Quality Incidents

While Chapters 3 through 5 of this report describe the theoretical and technical background of the potential for hydraulic fracturing to affect underground sources of drinking water (USDWs), this chapter summarizes citizens' accounts of water quality and quantity incidents. These reports reflect the opinions of citizens living near coalbed methane operations who expressed concerns about contaminated drinking water wells and wells experiencing water quantity impacts such as reduced production. EPA has, through letters and telephone calls, contacted and been contacted by citizens who believed their water wells were affected by coalbed methane production in the San Juan, Black Warrior, Central Appalachian, and Powder River Basins. Stakeholders commenting on the study methodology (65 FR 45774 (USEPA, 2000)) asked that EPA consider personal experiences regarding coalbed methane impacts on drinking water wells in addition to data from formal studies.

As a result of the stakeholder comments, EPA published a *Federal Register* notice requesting information on water quality incidents believed to be associated with coalbed methane production (66 FR 39396 (USEPA, 2001)). In addition, the Agency **contacted notified** over 500 local and county agencies in areas of potential coalbed methane production alerting them to this *Federal Register* notice, but EPA received no information regarding citizen complaints from these officials. Therefore, EPA believes it knows the major geographic areas where citizens have reported problems that they attribute to coalbed methane development. These areas are concentrated in the most active basins: the San Juan, Black Warrior, Central Appalachian, and Powder River Basins. The Agency has included relevant information from the water quantity and quality incident reports that were received in response to the July 2001 *Federal Register* notice.

In part because of the inherent nature of citizen reports, most of the reported information could not be confirmed by reviewing publications and other data sources. Many of the reported incidents (such as impacts to water supply quantities or the effects of discharged ground water extracted during the coalbed methane production process) are beyond the scope of this Phase I of the study. This study is specifically focused on whether a threat to public health exists **as a result of USDW contamination** from hydraulic fracturing fluid injection into coalbed methane wells.

It is important to note that activities or conditions other than hydraulic fracturing fluid injection may account for the contamination of **drinking water** wells. These potential causes include surface discharge of fracturing and production fluids, poorly sealed or poorly installed production wells, and improperly abandoned production wells.

For Phase I of this study, EPA consulted with state agencies to determine if they had received reports of groundwater problems, to learn of any follow-up steps typically taken by the state, and to determine the states' overall findings regarding any impacts that hydraulic fracturing of coalbed methane wells may have had on groundwater.

This chapter summarizes correspondence EPA has had with individual citizens and states, organized by basin, as follows:

- San Juan Basin (Colorado and New Mexico).
- Powder River Basin (Wyoming and Montana).
- Black Warrior Basin (Alabama).
- Central Appalachian Basin (Virginia and West Virginia).

6.1 San Juan Basin (Colorado and New Mexico)

For over a decade, citizens in the San Juan Basin region have reported that coalbed methane development has resulted in increased concentrations of methane and hydrogen sulfide in their water wells. Other complaints about coalbed methane development include the loss of water, the appearance of anaerobic bacteria in water wells, and the transient appearance of particulates in well water. In conversations with EPA, most citizens and local government officials did not specify hydraulic fracturing as the cause of well water problems. Summaries of reported incidents and state follow-up are discussed in sections 6.1.1 and 6.1.2, respectively.

EPA reviewed the Bureau of Land Management's (BLM) study summarizing the history of methane seeps, citizen complaints, and follow-up investigations related to conventional gas and coalbed methane development in the San Juan Basin to determine if they contained information pertaining to coalbed methane hydraulic fracturing and its impact, if any, on the quality of water in drinking water aquifers in the basin. A summary of pertinent findings is provided in section 6.1.3.

6.1.1 Summary of Reported Incidents

- EPA spoke with a former county employee who, earlier in his career, had worked for Exxon performing hydraulic fracturing jobs (Holland, 1999). As a county employee, he took measurements for methane and hydrogen sulfide inside homes in response to citizen complaints. He indicated that there were no significant problems until the shallowest formation of coal (the Fruitland Formation) began being developed. He believes that the main route of contamination is from older, poorly cemented wells, and he estimated that hundreds of wells have been affected. He said the biggest problems associated with the apparent effects of coalbed methane development are the explosive levels of methane and the toxic levels of hydrogen sulfide in homes. In his opinion, this is due to the removal of water, rather than to hydraulic fracturing.
- The San Juan Citizens Alliance estimated that hundreds of water wells have been affected by coalbed methane production in the area of Durango, CO. These complaints include the following:
 - A lawyer representing several Durango citizens whose wells were contaminated, allegedly due to coalbed methane development, said there have always been methane seeps in the river, which have manifested as bubbling water (McCord, 1999). In the early 1980s, however, people began to see increased concentrations of natural gas in their water wells shortly after companies began producing methane from the Fruitland Formation.
 - One individual reported that two of his wells were degraded because of increased methane levels. According to this individual, his neighbor's pump house door was blown off, presumably as a result of explosive levels of methane. Amoco bought three ranches after county officials tested indoor air and found extremely high levels of methane. This individual also told EPA staff that an area of the Southern Ute tribal land has increased levels of hydrogen sulfide at the surface. He reported he had also heard of black water due to pulverized coal.
 - Another private well owner claimed that her neighbors' wells are contaminated by gas infiltration from dewatering. First methane contaminates the well, then hydrogen sulfide, then anaerobic bacteria. She claimed that data exists showing that methane concentrations in water have increased by 1,000 parts per million (ppm).

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- EPA Region 8 received letters from citizens concerned that coalbed methane development had contaminated their water with methane and hydrogen sulfide. The EPA employee receiving the complaints looked into the situation but thought it was not within EPA's jurisdiction because the contaminants occur naturally.
- During a visit to Durango, CO, EPA met with several citizens who claimed to have experienced problems with their water due to coalbed methane development. Most of the citizens experienced water loss, but two well owners from New Mexico claimed that the quality of their water was affected by hydraulic fracturing. According to their accounts, the water turned cloudy with grayish sediment a day or two after nearby fracturing events. Eventually, the well water returned to its normal appearance.

EPA also toured the area during that visit. EPA staff viewed areas where patches of grass and trees were turning brown and dying. In some places, large, old-growth trees located within the patch indicated that the area previously had prolonged normal soil conditions. Many citizens and some local officials believed that the areas suffered from increased methane and decreased air in the soil gas in the shallow root zone.

- A La Plata County official reported that citizens have called to complain that well water flow decreases when coalbed methane wells are hydraulically fractured (Keller, 1999). He reported that "a lot" of people are hauling water due to water loss. The county official said that, in two separate reports, well owners noticed problems with their well water approximately 2 weeks after nearby fracturing events. They reportedly believe hydraulic fracturing is responsible because the timing of the water loss coincides with the fracturing. Citizens know when gas producers fracture wells because they can see and hear the operation, which involves several trucks, tanks, manifolds, and mobile trailers. The county official noted that the formation being developed, the Fruitland Formation, is located approximately 2,400 feet below ground surface, and water wells are generally drilled from 100 feet to 200 feet below ground surface. He qualified his statements by indicating that wells do go dry for a variety of reasons.
- EPA contacted the Colorado Department of Health (CDH), which has primacy for the Safe Drinking Water Act. An official with whom EPA spoke said CDH believes that water removal associated with coalbed methane development has caused problems in private water wells (Bodnar, 1999).

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- EPA received one complaint from a citizen living in the Raton Basin in Trinidad, CO. She reported that water wells in her area have begun to decline in production and quality, often producing more and more gas. She believes the decline of water wells in her area is due to dewatering associated with coalbed methane production.

6.1.2 State Agency Follow-Up in the San Juan Basin

Colorado Oil and Gas Conservation

The Colorado Oil and Gas Conservation Commission (COGCC) is responsible for environmental issues related to oil and gas production in the state. The COGCC responds to every complaint called in to its office (Baldwin, 2000).

{Cadmus deleted the paragraph below based on Chi Ho's review. If 20,000 septic tanks can cause methane contamination problems, this would be a problem in other parts of the country. Leaving the COGCC's speculation in this report could subject EPA to ridicule.}

The COGCC staff believes the 20,000 unregulated septic tanks installed as a result of increased population and development may be the source of nutrients and coliform bacteria that can produce biogenic methane. (Biogenic methane is formed by bacterial decomposition of organic matter; coalbed methane was produced under high temperatures and is thermogenic methane). Based on observations during the drilling of monitoring wells in the San Juan Basin, very thin coal zones and carbonaceous shales in the Animas and Kirkland Formations overlay the Fruitland Formation. COGCC staff speculate that this organic material could be a source of nutrients consumed by bacteria that produce methane. Given the numerous possible sources of thermogenic methane (associated with coal zones) and biogenic methane (derived from bacterial action), the large increase in private residential wells tapping local aquifers results in more people coming into contact with both biogenic, and in some places, thermogenic methane.

The COGCC staff believes that increased methane concentrations in water wells and buildings in some areas are also partially due to old, improperly abandoned gas wells and older, deeper conventional gas wells in which the Fruitland Formation was not completely isolated. The state bases its opinions on monitoring and studies conducted in the San Juan Basin in response to complaints (see section 6.1.3). According to COGCC officials, the state's mitigation program focused on sealing old, improperly abandoned gas wells and appears to have reduced methane concentrations in approximately 27 percent of the water wells sampled. They believe that methane concentrations will decrease over time in other water wells where the source of the methane was gas wells.

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There are other areas of the San Juan Basin where the methane in water wells is produced by methanogenic bacteria in the aquifer. Methane concentrations in water wells in these areas probably will not decrease.

Officials cite studies that use stable carbon and hydrogen isotopes of methane and gas composition to differentiate between thermogenic methane from the Fruitland, Mesaverde, and Dakota Formations, and biogenic methane that is produced in shallower formations by naturally occurring methanogenic bacteria. By 1998, approximately two-thirds of the water wells for which gas isotopic analyses had been performed appeared to contain biogenic gas, while one-third appeared to contain thermogenic gas.

The state also noted that, in the interior basin, 1,100 feet of shale separates the Fruitland Formation and the shallow formations in which private wells are completed.

New Mexico Oil Conservation Division

EPA spoke with a District Geologist employed by the New Mexico Oil Conservation Division (NMOCD). He said that several years ago the office received many complaints that methane had contaminated water wells (Chavez, 2001). The state held water fairs at which anyone could have his water tested. In addition, the state initiated a program for cemented wells (some active, some abandoned) that prohibited open holes 100 feet above the casing string. The District Geologist indicated that the program seemed to solve the problem and that NMOCD has not received many subsequent complaints.

6.1.3 Major Studies That Have Been Conducted in the San Juan Basin

As noted previously, EPA reviewed a BLM study on the San Juan Basin to determine if it contained information pertaining to coalbed methane hydraulic fracturing and its impact, if any, on the quality of water in drinking water aquifers in the basin. EPA's review of this report focused on the two mechanisms that could potentially threaten USDWs:

1) direct injection of hydraulic fracturing fluids into a USDW or injection of fracturing fluids into a coal seam already in hydraulic communication with a USDW (e.g., through a natural fracture system), and 2) movement of hydraulic fracturing fluids through hydraulic fractures into a USDW. The reports did not specifically address hydraulic fracturing, and only very little information indirectly addresses the question specific to this study: *Does hydraulic fracturing of coalbed methane wells threaten USDWs?*

The studies provided information on evidence that a hydraulic connection exists between coal beds in the Fruitland Formation and overlying shallow aquifers and on possible conduits that may be the basis of the hydraulic connection. For example, the presence in a shallow aquifer of methane documented to be from the underlying Fruitland Formation

is indirect evidence of a hydraulic connection, through some type of conduit, between the Fruitland Formation and shallower formations. This information may be relevant to the issue of underground movement of hydraulic fracturing fluids injected into target coalbeds such as those in the Fruitland Formation.

Evidence that a hydraulic connection exists between coal beds and the shallow aquifer

The U.S. Department of the Interior's BLM (1999) provides a history of gas seeps and methane contamination of drinking water wells in the San Juan Basin. The gas seeps and methane contamination of water wells appear to indicate that there may be a conduit through which fluid may flow from coal beds in the formation targeted for hydraulic fracturing to the shallower USDWs and the drinking water wells that tap them. This section will review the evidence that indicates the existence of a hydraulic connection between the deep coal beds and shallow USDWs.

Even prior to oil and gas drilling operations, shallow water wells in the San Juan Basin produced methane gas. Some wells in the Cedar Hill, NM, area of the basin were reported to have a strong sulfur odor. Some shallow water wells around the basin rim penetrated the Fruitland and Menefee coal beds and produced methane (BLM, 1999). Thus, coalbed methane was the source of at least some of the observed methane contamination. Water from the Fruitland coal bed discharges in the western part of the basin and migrates upward across the Kirtland shale into the Animas and San Juan Rivers (Stone et al., 1983). In areas such as La Plata County, CO, along the northern and western rims of the basin, the methane presumably moves through natural fractures.

In the interior of the basin, gas seeps were observed in pastures in the Animas River Valley south of Durango near Bondad, CO, and Cedar Hill, NM, in the early to mid-1980s. Bubbles were also observed in the Animas River and in the tap water of rural properties in these areas. Methane was also responsible for explosions in several pump houses. A landowner in New Mexico reported that gas was bubbling out of his alfalfa field and in the Animas River in 1985. Gas seeps were likely the cause of patches of dead grass growing in soils overlying the Mesaverde sandstone (BLM, 1999). Thus, conduits between methane-containing units and the surface were present both at the rim and in the interior of the basin.

After coalbed methane production began in the basin in the late 1980s, a local citizens' group voiced concerns that natural gas contamination of drinking water wells had increased in La Plata County. One study reported that 34 percent of the 205 domestic water wells tested in the county showed measurable concentrations of methane (BLM,

1999). This appears to indicate that there is a conduit for fluid to flow to the shallower USDW and its drinking water wells.

Shortly after the start of coalbed methane production in the basin, 11 coalbed methane wells were drilled within 2 miles of the Pine River Ranches Subdivision at the rim of the San Juan Basin. Nine to 35 feet of alluvium separate the surface from the Fruitland Formation coals in this area. A number of problems were reported following the onset of coalbed methane production. A man who complained that his well was contaminated with methane saw streams of gas bubbles in the nearby Los Pinos River. His report of methane contamination was confirmed by the San Juan Regional Authority (SJRA), which investigated reported contamination of this well and of nearby wells. The other wells were also contaminated with methane. Two of the 4 residences near the 11 coalbed methane wells contained explosive levels of methane in crawl spaces (BLM, 1999). The methane sampled in the shallow wells and the bubbling river and the high concentrations of methane detected in residences suggest that coalbed methane was following some conduit from the Fruitland Formation to the surface or to shallow USDWs.

Evidence that methane in shallow drinking water wells originates in the Fruitland Formation (location of the coal beds targeted by hydraulic fracturing)

Several lines of evidence show that methane detected in alluvial wells is not a result of sewage-derived methane contamination (BLM, 1999). Rather, the methane in the domestic wells studied originates either in conventional gas reservoirs such as the Dakota sandstone and the Lewis Shale or in the coals of the Fruitland Formation.

The composition of the gas in samples from shallow, private drinking water wells was analyzed to confirm the well owners' observations. The data obtained showed that the methane in approximately half of the samples appeared to have originated in the Fruitland Formation coal beds and not from other possible sources such as septic tanks (BLM, 1999).

Similar sampling and analyses conducted in an additional study cited by BLM (1999) concluded that gas in a domestic well in alluvium overlying the Fruitland Formation had the same gas composition and carbon-13 isotope ratio as gas from a nearby gas well also in the Fruitland Formation. This study found that C13 isotopic signatures of individual near-surface gas samples correlated with production gas from discrete formations beneath the study area (BLM, 1999). In addition, an area resident's well contained 680 ppm total dissolved solid (TDS), primarily sodium bicarbonate. Fruitland-produced water has the same composition, although other domestic wells in the area do not. (TDS values tend to be in the 100 to 200 ppm in these other domestic wells.) Both the gas and the water analyses indicate that the shallow aquifer in the area (from which the

methane-contaminated domestic wells draw drinking water) is in hydraulic communication with the deeper Fruitland Formation coal beds.

Possible conduits for fluid movement from the coal beds to the aquifer

Several studies have assessed possible natural or manmade conduits to account for the confirmed occurrence of methane in wells tapping the shallow aquifer that overlies the deeper coal beds in the Fruitland Formation. Possible pathways enabling methane to move from a deep source to a shallow aquifer include natural fractures, hydraulically-induced fractures, disposed of produced water from coalbed methane wells, and poorly constructed, sealed, or cemented conventional gas wells, coalbed methane wells, shallow drinking water wells, and cathodic protection wells installed to protect oil and gas pipelines from corrosion (BLM, 1999).

The history of documented gas seeps and methane occurrence in water wells indicates that natural fractures probably serve as conduits in parts of the basin where coal formations are near or at the surface and in the interior of the basin, where the coal formations are deeper. These conduits may enable hydraulic fracturing fluids to travel from targeted coal beds to shallow aquifers, however there is no unequivocal evidence that this fluid movement is occurring.

A study comparing soil-gas-methane concentrations adjacent to 352 gas-well casings and 192 groundwater wells found that the gas-well annuli (i.e., the spaces between the steel well casings and the walls of the drilled bore holes) were frequently the reason methane moved from the coal beds to the near-surface environment (BLM, 1999). Thus, gas-well annuli are clearly one type of conduit for movement of methane from deeper sources up to overlying shallow aquifers.

The possibility of leaking gas wells acting as conduits through which methane flows from the Fruitland Formation to shallow aquifers was investigated by a joint Colorado Gas and Oil Conservation Commission/BLM study (BLM 1999). One hundred twenty water wells were tested for methane before and after nearby gas wells were “remediated” (better sealed). The study concluded that the relationship between gas well remediation and lower methane concentrations in drinking water was “complex” and may have been affected by the lingering presence of methane in drinking water after gas well remediation. More than half the water wells showed no significant change in methane occurrence, a quarter showed lower methane levels, and one-tenth showed increased methane.

In summary, there appears to be evidence that methane seeps and methane in shallow geologic strata and water wells may occur because the methane moves through a variety

of conduits. These conduits include natural fractures; poorly constructed, sealed, or cemented manmade wells used for various purposes; and possibly, hydraulically induced fractures (although no reports provide direct information regarding hydraulic fracturing). Methane, fracturing fluid, and water with a naturally high TDS content could possibly move through any of these conduits. In some cases, improperly sealed gas wells have been remediated, resulting in decreased concentrations of methane in drinking water wells. There is no unequivocal evidence that natural and hydraulic fractures are transporting fracturing fluids to shallow formations because none of the studies discussed in this section addressed the effects of hydraulically induced fracturing or involved sampling for fracturing fluid constituents. (Chi Ho felt this statement was not supported.)

6.2 Powder River Basin (Wyoming and Montana)

EPA spoke with several individuals familiar with coalbed methane activity in the Powder River Basin area who believe coalbed methane production is causing water quantity issues. These individuals have reported that dewatering during coalbed methane production resulted in loss of water from wells and in flooding problems on the surface. Many of the drinking water wells in the Powder River Basin are screened and completed in the same formation being dewatered for methane production. EPA followed up and, according to a consulting hydrogeologist, as much as 1 million gallons of water are pumped from each coalbed methane production well during its lifetime. Consequently, the aquifer has dropped 200 feet in some areas (Merchat, 1999). EPA has also learned that, as of 1999, oil and gas companies have drilled 2,000 wells in the Powder River Basin, and they reportedly plan to drill 15,000 in total (Merchat, 1999). However, EPA also has information that deeper aquifers are available, and the oil and gas companies have drilled new water wells in those aquifers for private individuals.

Reports of incidents in the Powder River Basin are summarized here. However, hydraulic fracturing is performed infrequently in the Powder River Basin, and no one living in that area has reported problems relating to the process. Moreover, many of the complaints relate to water quantity issues, which are beyond the scope of this study.

6.2.1 Summary of Reported Incident

- EPA contacted the state and local offices of the Wyoming Health Department and the Water Quality Division of the Wyoming Department of Environmental Quality to determine if these departments had received complaints of water quality degradation due to coalbed methane production. Local authorities reported one complaint of black sediments in drinking water, but most concerns centered around water loss and flooding caused by large

quantities of water discharged at the surface (Heath, 1999). There has been discussion among stakeholders regarding the handling of large volumes of water brought to the surface during coalbed methane production. Some individuals remain concerned about the consequences of dewatering aquifers, which include loss of the resource, effects on soil chemistry, flooding, and the potential for coalbed fires and subsidence.

- EPA spoke with a consultant for the Powder River Basin Resource Council (PRBRC), a citizen's group formed around environmental issues associated with coalbed methane production (Merchat, 1999). He stated that the biggest concern among people in the area is loss of water. However, some have had problems with increased methane content in their water. He said people reported methane in the water results in frothing and bubbles. The water is generally used for agricultural purposes and for drinking water. He said that each methane well produces millions of gallons of water in its lifetime. The discharge of water has created new ponds and swamps that are not naturally occurring in that region. The secondary effects from pumping water are subsidence and clinker beds (burning coal). When underground coal catches fire from lightning, it burns until it reaches groundwater. However, if there is no groundwater, the fire will continue to burn. The cost of manually extinguishing those fires is enormous. Furthermore, the burning of the coal can leave behind benzo(a)pyrene and other polycyclic aromatic hydrocarbons that are toxic and/or carcinogenic and could affect drinking water.

EPA Region 8 is participating in a study that addresses the environmental effects of all aspects of coalbed methane development and not just hydraulic fracturing.

6.3 Black Warrior Basin (Alabama)

The *LEAF (Legal Environmental Assistance Foundation) v. EPA* case arose from an alleged water quality degradation related to activities in Alabama. As discussed in Chapter 1, the Eleventh Circuit's 1997 decision in *LEAF v. EPA* held that, because hydraulic fracturing of coal beds to produce methane is a form of underground injection, Alabama's EPA-approved underground injection control (UIC) program must effectively regulate this practice 118F.3d 1467 (11th Cir., 1997). In response to an Eleventh Circuit Court of Appeals decision (*LEAF v. EPA*, 118F.3d 1467 (11th Cir., 1997)), Alabama recently supplemented its rules governing the fracturing of wells to include additional requirements that govern the protection of USDWs during the hydraulic fracturing of coalbed methane. Summaries of reported incidents are presented in section 6.3.1 below.

6.3.1 Summary of Reported Incidents

- In the drinking water well case that precipitated *LEAF v. EPA*, an individual complained that drinking water from his well contained a milky white substance and had strong odors shortly after a fracturing event. He also reported that 6 months after the fracturing event his water had increasingly bad odors and occasionally contained black coal fines. The EPA Administrative Record regarding the Alabama Class II UIC Program contains other similar descriptions of well water problems.
- Another Alabama citizen reported to EPA problems with her drinking water well that began in 1989. In her letter, the citizen reported that her property was located near a coalbed methane gas well and that there was coal mining in the area. She wrote that she believes hydraulic fracturing of the coalbed methane well adversely affected her drinking water well, and coal resource exploitation in the area caused various, significant environmental damage. The individual believed that the hydraulic fracturing contributed to well contamination because, shortly after a fracturing event, her kitchen water contained globs of black, jelly-like grease and smelled of petroleum. She said her drinking water turned brown and contained slimy, floating particles. She reported that her neighbors also said their water smelled like petroleum.

She included, as an attachment, a letter from the Alabama Oil and Gas Board (OGB) approving the use of proppants tagged with radioactive material. Their approval was based on the hydrogeology and the absence of water wells in the immediate area, the depths of the coal intervals to be fractured, well construction, and adherence to a program designed to monitor and contain radioactive material at the surface. Also attached was a letter from EPA Region 4 describing analytical results for samples the Agency collected from her drinking water well on June 26, 1990. The results indicated no purgeable and extractable organic compounds were detected. In addition, the letter said that a water/oil inter-phase detector was used to determine if petroleum products were floating in the well, and none was detected.

- An Alabama homeowner complained to the Natural Resources Defense Council that recovered hydraulic fracturing fluid from a nearby coalbed methane well installation was allowed to drain from the coalbed methane well site to a location near her home. She claimed that this fluid was initially obtained from an abandoned strip-mining quarry that had been used as a landfill for municipal and industrial waste. As this fluid drained from the fracturing site, the homeowner asserted, it killed all animal and plant life in its

path. She further stated that shortly after this fracturing event and the associated runoff, her 110-foot deep drinking water well became contaminated with brown, slimy, petroleum-smelling fluid similar to the discharged fracturing fluid from the coalbed methane well site.

- In response to EPA's July 2001 call for information on water quality incidents (found in Water Docket W-01-09), an individual reported that her drinking water well had become filled with methane gas, causing it to hiss (66 FR 39396 (USEPA, 2001)); the tap water became cloudy, oily, and had a strong, unpleasant odor. In addition, the tap water left behind an oily film and contained fine particles. The drinking water well owner had her well tested by a private consultant, who confirmed the presence of methane.

The Alabama OGB tested this drinking water well, but only looked for naturally occurring contaminants. EPA also sampled and tested this drinking water well, but not until 6 months after the event. No mention is made of the analytical results obtained from the drinking water well by these agencies.

6.3.2 State Agency Follow-Up (Alabama Oil and Gas Board)

LEAF v. EPA originated in Alabama. The water well that was reportedly contaminated as a result of hydraulic fracturing operations was sampled independently by the Alabama OGB, the Alabama Department of Environmental Management (ADEM), and EPA Region 4. Water analyses performed by these agencies indicated that the water well had not been contaminated as a result of the fracturing operation. The Alabama OGB reported to EPA that it investigates every complaint it receives, and it does not believe that hydraulic fracturing has affected water wells. Investigations include research into historical water quality data, some of which often pre-dates coalbed methane activity. Such historical information is important because the coal-bearing Pottsville Formation often contains high concentrations of iron, and groundwater from this formation can be found to contain iron bacteria, which can sometimes result in water having an unpleasant taste or odor or a white or red-brown, stringy, gelatinous material (Valkenburg and others, 1975, as cited by the Alabama OGB, 2002). In addition, water whose quality has been good for quite some time can suddenly begin to leave iron stains. Water well yield can also decline due to the presence of iron bacteria in high concentrations.

According to the Alabama OGB, one factor considered in each investigation is whether historical data are available on water quality in a particular area, including data that pre-date coalbed methane activity. Published reports and open-file data show that the quality of water in the coal-bearing Pottsville Formation can vary from good to very poor. Data collected from the 1950s through 1970s in localities throughout a large area

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where the Pottsville Formation has served as a source of water contain reports of water having “bad taste,” “bad odors,” “oily films or sheens,” and waters causing “red stains” and “black stains” (Geological Survey of Alabama, 1930s to Present; Johnston, 1933, as cited by the Alabama OGB, 2002).

The Alabama OGB reported to EPA that it has investigated several complaints of methane gas in water wells. In each instance, the OGB determined that the water well problem was unrelated to coalbed methane extraction operations, which often were not occurring in the areas of reported water problems. Moreover, in some areas methane gas was reported in water wells many years before the advent of underground mining and the commercial development of this resource (Geological Survey of Alabama, 1930s to Present, as cited by the Alabama OGB, 2002). The problem of methane gas in water wells has generally occurred where water wells, usually less than 200 feet deep, penetrated gas-bearing coal strata, particularly following low rainfall years that caused a lowering of water tables. In these areas, there commonly had been a recent increase in the drilling of water wells and an acceleration in the rates of water withdrawal from the aquifer. When sufficient amounts of water are removed from these water wells, methane can begin to desorb from the coal seams and be produced.

Alabama’s regulations have been approved by EPA for incorporation into Alabama’s Class II UIC Program. Operators must provide written certification to the Board that the proposed fracturing operation will not occur in a USDW or that the fracturing fluids do not exceed the maximum contaminant levels (MCLs) in 40 CFR § 141 Subparts B and G. Fracturing is prohibited from ground surface to 299 feet below ground surface (bgs). For all fracture jobs performed between 300 feet and 749 feet bgs, the company must perform a reconnaissance of fresh-water supply wells within 1/4 mile of the well to be fractured, submit a fracturing program to the OGB, and perform a cement bond log analysis. For fracturing events performed between 750 feet and 1,000 feet bgs, only a cement bond log is required. For fracturing events performed below 1,000 feet bgs, operators must submit to the OGB the depth to be fractured, well construction information, cementing specifications, and logs identifying overlying, impervious strata.

In Alabama, Rule 400-3-8-.03 says that coal beds shall not be hydraulically fractured until written approval of the Oil and Gas Supervisor has been obtained. The Supervisor must be notified when an approved fracturing operation is to occur so that an agent of the Board may be present. In order to receive approval, operators must submit details of the proposed fracturing operation. The Board’s staff evaluates each proposal for compliance to ensure USDW protection. Basic information that must be submitted with an operator’s proposal to hydraulically fracture a well includes details on the depths of coal beds to be fractured; construction of the well, including casing and cementing specifications; a geophysical log showing the type and thickness of impervious strata overlying the

uppermost coal bed to be fractured; and, if the operation is to be performed in a USDW-bearing interval, a statement certifying that fracturing fluids will not exceed the MCLs of federally mandated primary drinking water regulations (40 CFR § 141 Subparts B and G). In addition to the basic information, a fracturing program, a water well inventory within a ¼-mile radius, and a cement bond log must be provided with fracturing proposals in the depth interval 300 to 749 feet. Since water supply wells are generally shallower than coal beds, Alabama's Rule 400-3-8-.03 was designed to increasingly strengthen the requirements for USDW protection with decreasing depths of proposed fracturing operations. Furthermore, the fracturing of coal beds shallower than 300 feet is prohibited.

6.4 Central Appalachian Basin (Virginia and West Virginia)

EPA became aware of several complaints relating to the effects of coalbed methane production on sources of drinking water in the southwestern portion of Virginia through correspondence initiated by citizens. Information about water quality incidents was gathered through meetings and telephone conversations with members of the Virginia Division of Oil and Gas within the Department of Mines, Minerals and Energy (VDMME); local health officials; and representatives of a county citizen's group. In total, VDMME provided EPA with over 70 "Complaint Detail Reports" (registered between 1990 and 2001) that related to drinking water source impacts by coalbed methane development.

Although the majority of the incidents outlined in the complaints pertain to water-loss issues, approximately one-quarter relate to water quality. Virginians living near coalbed methane production areas reported private well and spring water contamination evidenced by oily films, soaps, iron oxide precipitates, black sediments, methane gas, and bad odor and taste. Reports of water loss in the well ranged from noticeably reduced supply rates to total loss of water from domestic drinking water wells. Summaries of reported incidents and state follow-up are discussed in sections 6.4.1 and 6.4.2, respectively.

6.4.1 Summary of Virginia Incidents

- The state received complaints of soap bubbles flowing from residential household fixtures. VDMME attributes soap coming out of water faucets to the drilling process associated with both conventional wells and coalbed methane wells. Soaps are used to extract drilling cuttings from the borehole because the foam expands, rises, and, as it rises, carries the cuttings to the surface (Wilson, 2001). These soaps may migrate from the borehole into the

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drinking water zone that supplies private wells during drilling of the shallow portion of the hole and before the required groundwater casing is cemented in place. In the few occurrences of soap contamination, water was provided until the soap was completely purged from the contributing area surrounding their water well.

- In early August 2001, EPA met with approximately 15 to 20 residents of Buchanan and Dickenson Counties in Virginia. Coalbed methane production activity is steadily increasing in the area surrounding Buchanan County since the coal reserves in this area have proven to be extremely profitable sources for coalbed methane in recent years (Wilson, 2001). The subjects of the citizen complaints were very similar to those logged in the VDMME complaint reports. Residents described the presence of black sediments, iron precipitates, soaps, diesel fuel smells, and increased methane gas in drinking water from their wells. One resident brought a water sample collected from her drinking water well. The water was translucent with a dark gray color and with dark black suspended sediment. Several other citizens reported drinking water supplies diminishing or drying up entirely. One resident of Buchanan County said that he had an ample water supply from his drinking well for over 54 years, until shortly after coalbed methane wells were installed on his property. He reported that within 60 days of the coalbed methane well installations, his 276-foot deep drinking water supply well, which used to produce over 20 gallons per minute of potable flow, dried up. The resident mentioned that over 380 homes in the region do not have potable water as a result of coalbed methane mining activities.

Most of the residents said that their complaints to the state usually resulted in investigations without resolution. Some residents mentioned that the gas companies were providing them with potable water to compensate for the contamination or loss of their drinking water wells. However, the residents said that this was not adequate compensation for the impacts to, or loss of, their private drinking water supplies.

- EPA was able to record numerous complaints through telephone conversations and e-mails with Virginia residents, who reported that they believed their drinking water wells had been affected by coalbed methane industry activities. All the logged complaints were from Buchanan and Dickenson Counties. Complaints include water loss, soapy water, diesel odors, iron and sulfur in wells, rashes from showering, gassy taste, and murky water. One report discusses a miner who was burned by a fluid, possibly hydrochloric acid used in hydraulic fracturing, that infiltrated a mineshaft.

Another report describes the contamination of a stream and the resulting fish kills caused by the runoff from drilling fluids. One complainant explained that several thousand wells had “gone dry, overnight.” According to the individuals EPA spoke with, compensation to homeowners for these impacts is in the form of money, newly drilled wells to replace dry or contaminated wells or temporary provision of potable water, which is supplied “until things clear out.”

6.4.2 State Agency Follow-Up (VDMME)

VDMME, Division of Gas and Oil (DGO), is responsible for responding to environmental issues associated with oil and gas development; it investigates every water problem reported. Responses may include an interview with the citizen reporting the problem, a site visit, water well testing, or a review of the physical aspects of the water well and surrounding activities. According to Robert Wilson of VDMME, his agency tests for contaminants that may be introduced by drilling such as chlorides, oil and grease, and volatile organics. The results of those analyses are compared to baseline values. VDMME witnesses surface casing and plugging jobs as part of its oversight duties. VDMME reviews information from drilling and completion reports to assist with investigations into complaints.

Based on investigations of the more than 70 complaints received, VDMME believes that coalbed methane production has not affected private drinking water wells. VDMME recognizes soap migrating into drinking water wells, but considers this only a transient problem. While a number of complaints report a noticeable reduction in or a total loss of drinking water supply, in almost all cases, the state investigator determined that the water loss was not likely to be caused by local hydraulic fracturing events or coalbed methane production activity because:

- The distance from the private well to the nearest coalbed methane well is too far (1,500 feet or more) to have any impact.
- There is no hydrologic connection between the water contribution zones of the private and coalbed methane wells; therefore, it is physically impossible for coalbed methane wells to affect private drinking water wells.
- The well was constructed according to VDMME regulatory guidelines; therefore, a sufficient buffer exists between the private well and the coalbed methane well.

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- The existing supply was reduced because of recent drought conditions in the region.
- The complainant experienced mechanical difficulty with his or her pumping system, which led to a reduction in pumped water; however, the supply was not affected.

According to VDMME, these citizen complaints refer to incidents that can occur during the drilling of any type of well, not just coalbed methane. The few incidents of this kind were equally divided between conventional wells and coalbed wells (VDMME, 2002).

Chi Ho's Comment: We do not have information on how deep are the coal beds involved in the Virginia incidents. In contrast, the information is provided for the section above on the San Juan Basin. The evidence presented by the citizens is in line with the impact of hydraulic fracturing fluids on USDWs. Should EPA take VDMME's words as facts? Should independent investigation, say by EPA Region 3, be introduced? If we are saying that hydraulic connectivity can be postulated in San Juan Basin, how can we say nothing about these Virginia incidents. On the whole, there is imbalance between the sections between the San Juan and Central Appalachian Basins.

6.5 Summary

In this chapter, EPA has presented information (in addition to technical, conceptual, or theoretical information presented previously) on personal experiences with regard to coalbed methane activities and their potential (or perceived potential) to impact drinking water wells. These personal accounts regarding potential incidences in four producing coal basins across the United States do not present scientific findings. However, the body of reported problems considered collectively suggest that water quality (and quantity) problems might be associated with some of the production activities common to coalbed methane extraction. These activities include surface discharge of fracturing and production fluids, aquifer/formation dewatering, water withdrawal from production wells, methane migration through conduits created by drilling and fracturing practices, or any combination of these. Other potential sources of drinking water problems include various aspects of resource development, naturally occurring conditions, population growth and historical practices.

In several of the coalbed methane investigation areas, local agencies concluded that hydraulic fracturing could not affect drinking water wells. Either horizontal distances between the coalbed methane production wells and the drinking water wells were too great, or the production wells and drinking water wells were drilled to and are active within subsurface horizons separated by significant vertical distances.

