U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY AND ENVIRONMENT
HEARING CHARTER

Fractured Science – Examining EPA's Approach to Ground Water Research: The Pavillion Analysis

Wednesday, February 1, 2012
10:00 a.m. to 12:00 p.m.
2318 Rayburn House Office Building

PURPOSE

On Wednesday, February 1, at 10:00 a.m. the Subcommittee on Energy and Environment of the House Committee on Science, Space, and Technology Committee will hold a hearing to review the EPA's approach to ground water research in Pavillion, Wyoming.

WITNESSES

- **Mr. Jim Martin**, Region 8 Administrator, Environmental Protection Agency
- **Mr. Tom Doll,** State Oil & Gas Supervisor, Wyoming Oil & Gas Conservation Commission
- **Ms. Kathleen Sgamma**, Vice President, Government & Public Affairs, Western Energy Alliance
- **Dr. Bernard Goldstein**, Professor and Dean Emeritus, Graduate School of Public Health, University of Pittsburgh

BACKGROUND

On December 8, 2011, the Environmental Protection Agency (EPA) released a draft report summarizing the Agency's findings of its groundwater investigation in Pavillion, Wyoming. EPA initiated this inquiry in September 2008 in response to complaints made by some private well-owners in the area regarding taste and odor problems in their well water. Utilizing its authority under the Comprehensive Environmental Response, Compensation, and Liability Act, commonly known as Superfund, the purpose of EPA's investigation was to determine "the presence, not extent, of groundwater contamination in the area".[1]

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[1] EPA Draft Research Report, *Investigation of Ground Water Contamination near Pavillion, Wyoming*, Office of Research and Development, December 2011. Available at http://www.epa.gov/region8/superfund/wy/pavillion/EPA_ReportOnPavillion_Dec-8-2011.pdf (p. xi).

Pavillion, Wyoming

The town of Pavillion is a small agricultural community established in the early 1900s in Fremont County, Wyoming (Figure 1). As of 2010, the town had a reported population of 231 residents. The town of Pavillion and the surrounding areas have a history of poor drinking water quality, which includes issues of objectionable taste and odor. In a report issued by the Wyoming Water Development Commission[2], it is noted that, for the period immediately following World War II, "most wells produced marginal quality water at best."[3] Additionally, the report characterizes the pursuit of a domestic well with quality water during this time period as "always an uncertain venture". The problem of variable water quality is due to the complexity of the geology of the Wind River Formation.

> *It was determined, through this and other studies, that the water quality of this aquifer varies widely over very short distances between wells. Likewise, water quality varies widely among wells that are of the same depth. In summary, there is no identifiable trend in groundwater quality that shows an area or a drilling depth that offers assurance of installing a well with good quality water.*[4]

To address this problem, the town installed a central water system in the 1940s, which tended to produce higher quality drinking water than the surrounding wells, a trend the Commission concludes is largely the same today.[5]

Pavillion has a history of oil and gas exploration and production dating back to the 1960s. The Pavillion natural gas field—one of several fields within the Wind River Basin—is the focus of the study, as the private drinking water wells of interest in the investigation overlie this formation. According to the EPA report, there are 169 vertical production wells in the Pavillion field.

Investigation

The stated objective of the investigation was to determine if there was a contamination of groundwater above the Pavillion gas field. The specific area of investigation as defined by the EPA study is "a sparsely populated rural area in west-central Wyoming directly east of the town of Pavillion."[6] According to the Wyoming Water Development Commission report, the areas north and east of the town historically have been characterized by uncertainty with regard to whether or not one might be able to produce good water quality from a domestic well.

Although EPA has no jurisdiction to regulate the water quality of privately-owned wells, the Agency initiated an investigation under its authority over Superfund due to citizen complaints

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[2] *Pavillion Area Water Supply Level 1 Study, for the Wyoming Water Development Commission*, October 2011.
[3] ibid. p I-1
[4] ibid. p. I-3
[5] ibid.
[6] EPA Draft Research Report, p. 1

regarding the taste and odor of their water. This collaborative effort between EPA Region 8 and the Office of Research and Development (ORD) included sampling of private residential wells, stock wells used for agriculture, municipal wells, a local creek, produced water, soil, and existing shallow monitoring wells already installed. The deepest stock water well is approximately 800 ft below the surface; however, a majority of the residential wells used for drinking water are drilled to 500 ft or shallower.[7]

In addition, there are 3 shallow pits within the investigation area. These pits are considered legacy sites due to their development and use well before State regulations governing the disposal of wastewater from natural gas and oil production were updated. Although these pits are no longer in use and are undergoing voluntary remediation, they are considered a potential pathway for shallow water contamination as they are part of the same groundwater formation used by most domestic wells. Consistent with this, EPA's report notes that Agency sampling of the shallow monitoring wells near the pits detected high concentrations of "benzene, xylenes, gasoline range organics, diesel range organics, and total purgeable hydrocarbons."[8] EPA is a member of a stakeholder group working to determine the distance and depth of the shallow groundwater and the contamination caused by these pits.

Based on its preliminary assessment of the study area, EPA decided that the detection of methane and other organic chemicals in domestic wells from its two sampling events in March 2009 and January 2010 warranted drilling two additional monitoring wells in June of 2010. EPA drilled these monitoring wells to a depth of 785 ft and 980 ft below the surface.[9] (For perspective, the majority of drinking water wells in the area are at a depth of 500 feet or less, and the shallowest natural gas well developed using hydraulic fracturing is 1220 feet.) EPA sampled the monitoring wells in September 2010 and April 2011.

Draft Report

The report, entitled "*Draft Research Report: Investigation of Ground Water Contamination near Pavillion, Wyoming*", was released on December 8, 2011 and published in the Federal Register on December 14, 2011. Notice was given for a 45 day public comment period, until January 27, 2012. EPA subsequently extended this comment period until March 12, 2012.

The draft report postulates numerous "lines of reasoning" associated with various chemical compounds detected through the course of the study, and presents as its key conclusion "that ground water in the aquifer contains compounds likely associated with gas production practices, including hydraulic fracturing".[10] Additional detail regarding EPA methods and findings is summarized in the report's extended abstract (Appendix I), as well as in a recent

[7] Taucher and Bartos, et al. *Available Groundwater Determination, Technical Memorandum.* WWDC Wing/Bighorn River Basin Plan Update – Groundwater Study. Prepared for the Wyoming Water Development Commission 2010-2011. Chapter 8. Accessed at http://waterplan.state.wy.us/plan/bighorn/2010/finalrept/gw_toc.html

[8] EPA Draft Report. p. 33.

[9] Figure 2 shows a bar graph representing the depths of different types of wells in the investigation area. Note the pink line between the two monitoring wells indicating there had been a gas release during the drilling of a drinking water well deeper than the permit allowed, suggesting another potential pathway for contamination of the groundwater.

[10] EPA 2011 News Releases, *EPA Releases Draft Findings of Pavillion, Wyoming Ground Water Investigation for Public Comment and Independent Scientific Review*, 12/08/2011.

Congressional Research Service report.[11] Additional background regarding hydraulic fracturing and the EPA's broader comprehensive study of the relationship between hydraulic fracturing and drinking water can be found in the charter of the Committee's May 2011 hearing on "Review of Hydraulic Fracturing Technology and Practices".[12]

In light of immediate and ongoing criticism of the scientific methods used in the study, concerns have been raised with regard to sampling size and integrity, quality assurance and quality control, the construction and drilling of monitoring wells, and the Agency's refusal to publicly release all its data, leaving many unanswered questions.

Issues for Consideration

Data Availability/Transparency

Prior to release of the report, EPA met with representatives of the State of Wyoming and Encana Oil and Gas to discuss its findings. At that time, many items of concern were raised, most of which were outlined in four pages of questions presented at a November 22, 2011 meeting of the Pavillion Technical Working Group, a group consisting of state regulators, industry experts and EPA personnel.[13]

- In a letter dated December 20, 2011[14], Governor Matt Mead wrote to Administrator Lisa Jackson requesting EPA release all the data and records it collected as part of its investigation and to conduct additional testing and analysis.
- On December 21, 2011[15], Encana Oil & Gas (which purchased the Pavillion natural gas field in 2004 and operates production wells located in the study area) sent a similar letter to Jim Martin, EPA Region 8 Administrator, requesting information including records related to analytical methods used to conduct sample testing, methods and materials used in drilling the EPA deep wells, and the raw data results of water samples analyzed by EPA labs and contractor labs.
- Encana Oil & Gas sent a second letter[16] on January 6, 2012 to Assistant Administrator Paul Anastas, reiterating its request for information.
- Governor Mead sent a second letter[17] to Administrator Jackson on January 16, 2012 stating he had not received a response on his request for additional information, more testing, and an extension of the comment period.

On January 19, Administrator Lisa Jackson responded[18] to Governor Mead assuring the Pavillion study was undertaken using the highest level of scientific integrity. Despite this

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[11] The EPA Draft Report of Groundwater Contamination Near Pavillion, Wyoming: Main Findings and Stakeholder Responses

[12] http://science.house.gov/hearing/full-committee-hearing-hydraulic-fracturing-technology-0

[13] Fugleberg, Jeremy. "Wyoming Officials: No EPA Answer to Our Pavillion Data Questions." Casper Star Tribune [Casper, Wyoming]. 9 December 2011. Online.

[14] Mead, Matt. Letter to EPA Administrator Lisa Jackson. 20 December 2011.

[15] Schopp, John. Letter to EPA Region 8 Administrator James B. Martin. 21 December 2011.

[16] Schopp, John. Letter to Assistant Administrator Paul Anastas. 6 January 2012.

[17] Mead, Matt. Letter to EPA Administrator Lisa Jackson. 16 January 2012.

[18] Jackson, Lisa P. Letter to Wyoming Governor Matt Mead. 19 January 2012.

assertion, EPA has not yet released key information requested by the State and Encana, raising questions as to why such information is being withheld.

Monitoring Wells and Sampling Plan

EPA has a number of guidelines[19] outlining planning requirements for developing a monitoring and sampling plan for Superfund investigation and sites. These guidelines provide steps EPA should take to ensure a scientifically robust study plan. The information available on EPA's website[20] dedicated to this study indicates that guidelines related to developing monitoring and sampling plans were not followed. Additionally, a number of Federal and State agencies have been involved in testing and analyzing groundwater quality and availability in the Wind River Formation dating back to the 1950s. In 2005, the United States Geological Survey (USGS) issued a report that specifically lays out a sampling plan for groundwater quality in the Wind River Indian Reservation, Wyoming.[21] EPA has stated that it did not consult with USGS during the development and execution of this study. Stakeholders have pressed EPA for an explanation regarding the factors that led to selection and location of sampled wells for the initial phases of the study, noting that EPA did not fully eliminate the legacy pits as a source of contamination, and ignored the potential for septic tanks in the area to be a potential pathway of contamination. Concerns have also been raised that the number of sampling events (EPA conducted two sample events on the deep monitoring wells) is insufficient to make statistical inferences and conclusions.

Questions have been raised about EPA's choice for the location of the deep monitoring wells. The utility of installing monitoring wells at a Superfund site is to determine the background water quality and how the area under investigation may have changed it. Typically, this results in a monitoring well upgradient of the suspected contamination, and several wells downgradient of the suspected contamination. The Draft report does not explain why the monitoring wells were drilled where they were. Additionally, the report does not identify which well is intended to be the background quality monitor, nor does it identify in which direction the groundwater flows.

Despite repeated requests from stakeholders, EPA continues to withhold detailed records regarding the drilling, installation and monitoring of the two wells. These wells were drilled and installed without the State of Wyoming's knowledge or assistance. Without these records, it is difficult to eliminate the possibility that EPA's actions in drilling and installing the monitoring wells may have contributed to the contamination detected in the samples.

Quality Assurance/Quality Control

One of the basic ways to test for quality and accuracy of samples taken in the field is the testing of blank samples. These samples are typically distilled water and included among the

[19] EPA Guidance for Monitoring at Hazardous Waste Site: Framework for Monitoring Plan Development and Implementation OSWER Directive No. 9355.4-28; EPA Guidance on Choosing a Sampling Design for Environmental Data Collection for Use in Developing a Quality Assurance Project Plan EPA QA/G-5S; EPA Guidance on Data Quality Indicators EPA QA/G-5i

[20] http://www.epa.gov/region8/superfund/wy/pavillion/

[21] USGS 2005. "Monitoring-Well Network and Sampling Design for Groundwater Quality, Wind River Indian Reservation, Wyoming." Scientific Investigations Report 2005-5027.

vials of real samples collected in the field for labs to test. Detecting chemical compounds in a blank sample is not unusual, but it does point to a greater potential for cross-contamination of samples at the lab or in the field when the samples are actually bottled. The samples EPA tested were analyzed for contaminants in parts per billion. The level of sensitivity of the equipment needed to accurately detect these low concentrations means an even greater attention to detail is required. It could be as simple as a lab technician not changing their gloves when analyzing successive samples that leads to contamination. A significant number of EPA's blanks were contaminated with the very same compounds it found in the samples from the monitoring wells (albeit at significantly lower concentrations). This raises a number of questions regarding the quality control of the sampling methods used.

Figure 1. Location of physiographic features in and near the Wind River Indian Reservation.[22]

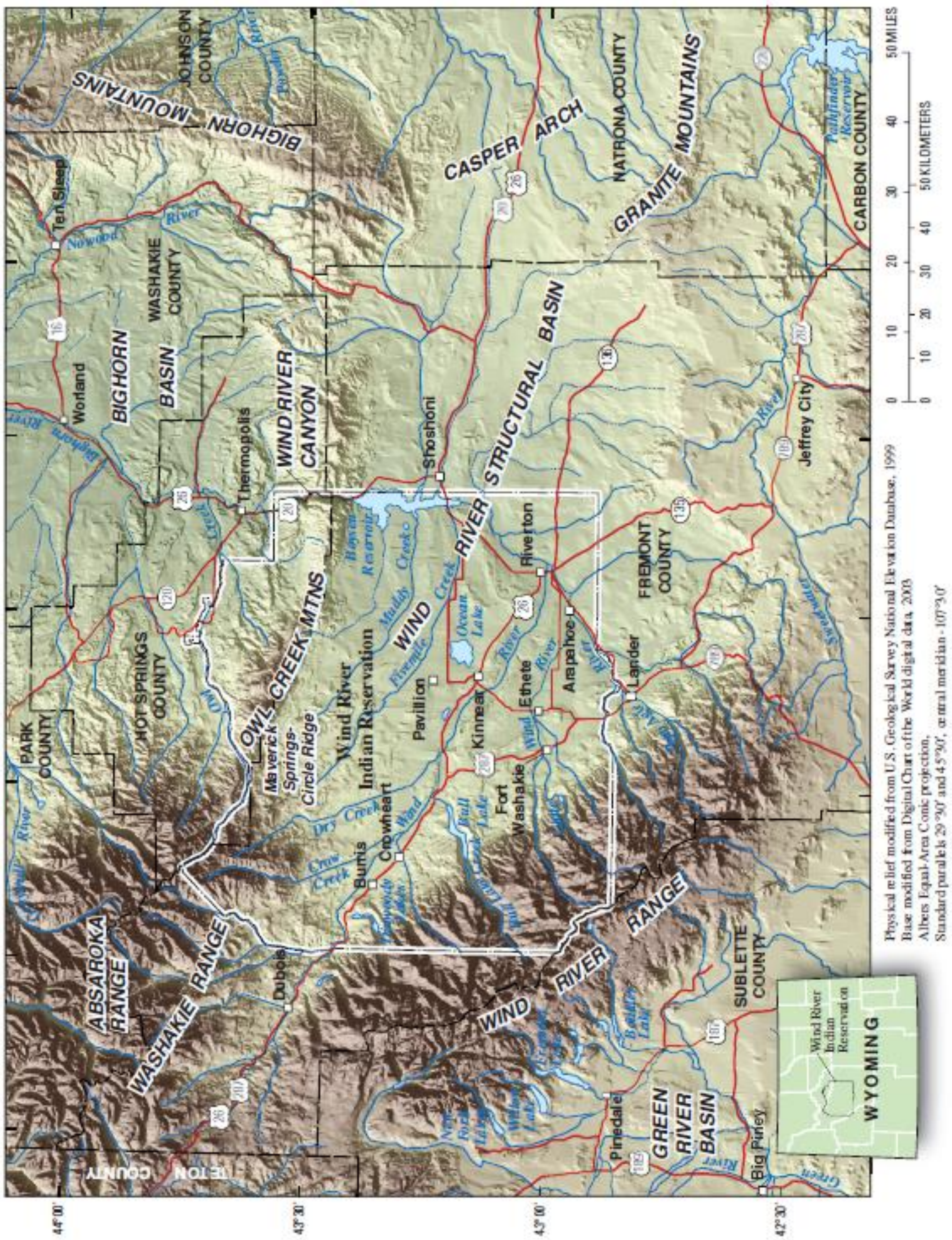

Figure 1. Location of physiographic features in and near the Wind River Indian Reservation, Wyoming.

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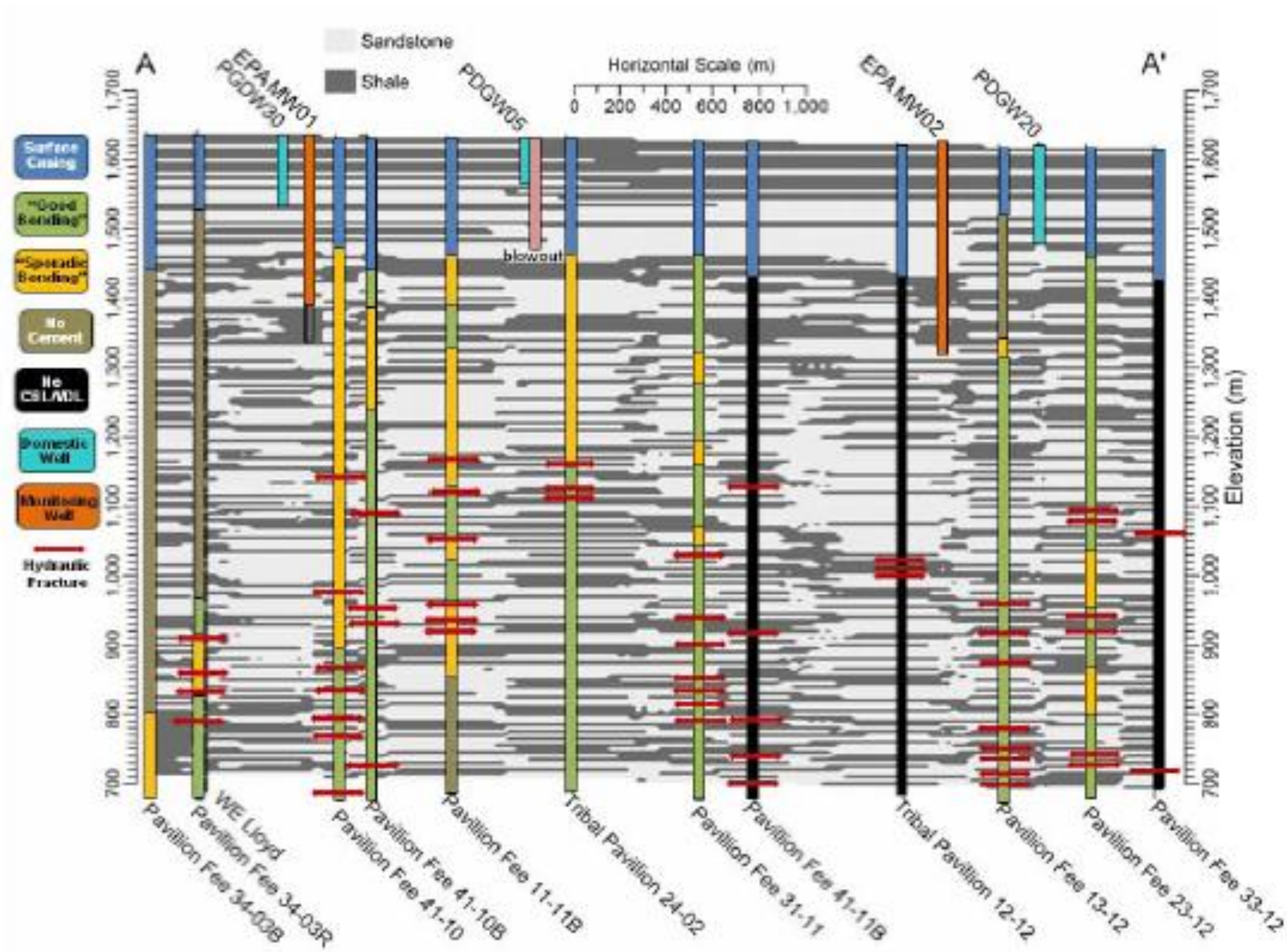
[22] United States Geological Survey. "Monitoring-Well Network and Sampling Design for Ground-Water Quality, Wind River Indian Reservation, Wyoming". Scientific Investigations Report 2005-5027. 2005

Figure 2. Cross-section of well depths near site. Orange lines are EPA monitoring wells drilled. Light blue lines are drinking water wells. Red lines indicate hydraulic fracture in production wells.[23]



[23] EPA Draft Report. p. 31.

Appendix I. Extended Abstract from Draft Research Report: Investigation of Ground Water Contamination near Pavillion, Wyoming.

In response to complaints by domestic well owners regarding objectionable taste and odor problems in well water, the U.S. Environmental Protection Agency initiated a ground water investigation near the town of Pavillion, Wyoming under authority of the Comprehensive Environmental Response, Compensation, and Liability Act. The Wind River Formation is the principal source of domestic, municipal, and stock (ranch, agricultural) water in the area of Pavillion and meets the Agency's definition of an Underground Source of Drinking Water. Domestic wells in the area of investigation overlie the Pavillion gas field which consists of 169 production wells which extract gas from the lower Wind River Formation and underlying Fort Union Formation. Hydraulic fracturing in gas production wells occurred as shallow as 372 meters below ground surface with associated surface casing as shallow as 110 meters below ground surface. Domestic and stock wells in the area are screened as deep as 244 meters below ground surface. With the exception of two production wells, surface casing of gas production wells do not extend below the maximum depth of domestic wells in the area of investigation. At least 33 surface pits previously used for the storage/disposal of drilling wastes and produced and flowback waters are present in the area. The objective of the Agency's investigation was to determine the presence, not extent, of ground water contamination in the formation and if possible to differentiate shallow source terms (pits, septic systems, agricultural and domestic practices) from deeper source terms (gas production wells).

The Agency conducted four sampling events (Phase I - IV) beginning in March 2009 and ending in April, 2011. Ground water samples were collected from domestic wells and two municipal wells in the town of Pavillion in Phase I. Detection of methane and dissolved hydrocarbons in several domestic wells prompted collection of a second round of samples in January, 2010 (Phase II). During this phase, EPA collected additional ground water samples from domestic and stock wells and ground water samples from 3 shallow monitoring wells and soil samples near the perimeter of three known pit locations. Detection of elevated levels of methane and diesel range organics (DRO) in deep' domestic wells prompted the Agency to install 2 deep monitoring wells screened at 233 - 239 meters (MW01) and 293 - 299 meters (MW02) below ground surface, respectively, in June 2010 to better evaluate to deeper sources of contamination. The expense of drilling deep wells while utilizing blowout prevention was the primary limiting factor in the number of monitoring wells installed. In September 2010 (Phase III), EPA collected gas samples from well casing from MW01 and MW02. In October 2010, EPA collected ground water samples from MW01 and MW02 in addition to a number of domestic wells. In April 2011 (Phase IV), EPA resampled the 2 deep monitoring wells to compare previous findings and to expand the analyte list to include glycols, alcohols, and low molecular weight acids.

Detection of high concentrations of benzene, xylenes, gasoline range organics, diesel range organics, and total purgeable hydrocarbons in ground water samples from shallow monitoring wells near pits indicates that pits are a source of shallow ground water contamination in the area of investigation. When considered separately, pits represent potential source terms for localized ground water plumes of unknown extent. When considered as whole they represent potential broader contamination of shallow ground water. A number of stock and domestic wells in the area of investigation are fairly shallow (e.g., < 30 meters below ground surface) representing potential receptor pathways.

Determination of the sources of inorganic and organic geochemical anomalies in deeper ground water was considerably more complex than determination of sources in shallow media necessitating the use of multiple lines of reasoning approach common to complex scientific investigations. pH values in MW01 and MW01 are highly alkaline (11.2-12.0) with up to 94% of the total alkalinity contributed by hydroxide suggesting addition of a strong base as the causative factor. Reaction path modeling indicates that sodium-sulfate composition of ground water typical of deeper portions of the Wind River Formation provides little resistance to elevation of pH with small addition of potassium hydroxide. Potassium hydroxide was used in a crosslinker and in a solvent at this site.

The inorganic geochemistry of ground water from the deep monitoring wells is distinctive from that in the domestic wells and expected composition in the Wind River formation. Potassium concentration in MW02 (43.6 milligrams per liter) and MW01 (54.9 milligrams per liter) is between 14.5 and 18.3 times values in domestic wells and expected values in the formation. Chloride concentration in monitoring well MW02 (466 milligrams per liter) is 18 times the mean chloride concentration (25.6 milligrams per liter) observed in ground water from domestic wells and expected in the formation. Chloride enrichment in this well is significant because regional anion trends show decreasing chloride concentration with depth. In addition, the monitoring wells show low calcium, sodium, and sulfate concentrations compared to the general trend observed in domestic well waters. The formulation of fracture fluid provided for carbon dioxide foam hydraulic fracturing jobs typically consisted of 6% potassium chloride. Potassium metaborate was used in crosslinkers. Potassium hydroxide was used in a crosslinker and in a solvent. Ammonium chloride was used in crosslinker.

A number of synthetic organic compounds were detected in MW01 and MW02. Isopropanol was detected in MW01 and MW02 at 212 and 581 micrograms per liter, respectively. Diethylene glycol was detected in MW01and MW02 at 226 and 1570 micrograms per liter, respectively. Triethylene glycol was detected in MW01 and MW02 at 46 and 310 micrograms per liter, respectively. Another synthetic compound, tert-butyl alcohol, was detected in MW02 at a concentration of 4470 micrograms per liter. Isopropanol was used in a biocide, in a surfactant, in breakers, and in foaming agents. Diethylene glycol was used in a foaming agent and in a solvent. Triethylene glycol was used in a solvent. Tert-butyl alcohol is a known breakdown product of methyl tert-butyl ether (a fuel additive) and tert-butyl hydro peroxide (a gel breaker used in hydraulic fracturing). Material Safety Data Sheets do riot indicate that fuel or tert-butyl hydroperoxide were used in the Pavillion gas field. However, Material Safety Data Sheets do not contain proprietary information and the chemical ingredients of many additives.

The source of tert-butyl alcohol remains unresolved. However, tert-butyl alcohol is not expected to occur naturally in ground water.

Benzene, toluene, ethylbenzene, and xylenes (BT~X) were detected in MW02 at concentrations of 246, 617, 67, and 750 micrograms per liter, respectively. Trimethylbenzenes were detected in MW02 at 105 micrograms per liter. Gasoline range organics were detected in MW01 and MW02 at 592 and 3710 micrograms per liter. Diesel range organics were detected in MW01 and MW02 at 924 and 4050 micrograms per liter, respectively. Aromatic solvent (typically BTEX mixture) was used in a breaker. Diesel oil (mixture of saturated and aromatic hydrocarbons including naphthalenes and alkylbenzenes) was used in a guar polymer slurry/liquid gel concentrate and in a solvent. Petroleum raffinates (mixture of paraffinic, cycloparaffinic, olefinic, and aromatic hydrocarbons) were used in a breaker. Heavy aromatic petroleum naphtha (mixture of paraffinic, cycloparaffinic and aromatic hydrocarbons) was used in surfactants and in a solvent. Toluene and xylene were used in flow enhancers and a breaker.

Detections of organic chemicals were more numerous and exhibited higher concentrations in the deeper of the two monitoring wells. Natural breakdown products of organic contaminants like BTEX and glycols include acetate and benzoic acid. These breakdown products are more enriched in the shallower of the two monitoring wells, suggesting upward/lateral migration with natural degradation and accumulation of daughter products. Hydraulic gradients are currently undefined in the area of investigation. However, there are flowing conditions in a number of deep stock wells suggesting that upward gradients exist in the area of investigation.

Alternative explanations were carefully considered to explain individual sets of data. However, when considered together with other lines of evidence, the data indicates likely impact to ground water that can be explained by hydraulic fracturing. A review of well completion reports and cement bond/variable density logs in the area around MW01 and MW02 indicates instances of sporadic bonding outside production casing directly above intervals of hydraulic fracturing. Also, there is little lateral and vertical continuity of hydraulically fractured tight sandstones and no lithologic barrier (laterally continuous shale units) to stop upward vertical migration of aqueous constituents of hydraulic fracturing in the event of excursion from fractures. In the event of excursion from sandstone units, vertical migration of fluids could also occur via nearby well bores. For instance, at one production well, the cement bond/variable density log indicates no cement until 671 m below ground surface. Hydraulic fracturing occurred above this depth at nearby production wells.

A similar lines of reasoning approach was utilized to evaluate the presence of gas in monitoring and domestic wells. A comparison of gas composition and stable carbon isotope values indicate that gas in production and monitoring wells is of similar thermogenic origin and has undergone little or no degradation. A similar evaluation in domestic wells suggests the presence of gas of thermogenic origin undergoing biodegradation. This observation is consistent with a pattern of dispersion and degradation with upward migration observed for organic compounds.

Elevated levels of dissolved methane in domestic wells generally increase in those wells in proximity to gas production wells. Near surface concentrations of methane appear highest in the area encompassing MW01. Ground water is saturated with methane at MW01 which is screened at a depth (239 meters below ground surface) typical of deeper domestic wells in the area. A blowout occurred during drilling of a domestic well at a depth of only 159 meters below ground surface close to MW01. A mud-gas log conducted in 1980 (prior to intensive gas production well installation) located only 300 m from the location of the blowout does not indicate a gas show (distinctive peaks on a gas chromatograph) within 300 meters of the surface. Again, with the exception of two production wells, surface casing of gas production wells do not extend below the maximum depth of domestic wells in the area of investigation. A number of production wells in the vicinity of MW01 have sporadic bonding or no cement over large vertical instances. Again, alternate explanations of data have been considered. Although some natural migration of gas would be expected above a gas field such as Pavillion, data suggest that enhanced migration of gas has occurred within ground water at depths used for domestic water supply and to domestic wells. Further investigation would be needed to determine the extent of gas migration
and the fate and transport processes influencing migration to domestic wells.