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EPA REPORT SUMMARIES ON OIL & GAS PRODUCTION HYDRAULIC "FRACING"

Main Category:	General Engineering
Sub Category:	Environmental
Course #:	ENV-100
Course Content:	8 pgs
PDH/CE Hours:	1

OFFICIAL COURSE/EXAM

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ENV-100 EXAM PREVIEW

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Exam Preview:

1. In December 2016, EPA released its final report on the relationship between hydraulic fracturing activities and drinking water resources. EPA found scientific evidence that hydraulic fracturing activities can impact drinking water resources under some circumstances.
   a. True
   b. False
2. The EPA report identifies certain conditions under which impacts from hydraulic fracturing activities can be more frequent or severe. Which of the following is not one of the conditions/activities cited?
   a. Spills during the handling of hydraulic fracturing fluids and chemicals or produced water that result in large volumes or high concentrations of chemicals reaching groundwater resources.
   b. Injection of hydraulic fracturing fluids directly into groundwater resources.
   c. Discharge of inadequately treated hydraulic fracturing wastewater to surface water.
   d. Disposal or storage of hydraulic fracturing wastewater in lined pits.
3. As part of the EPA's broader study of the potential impacts of hydraulic fracturing for oil and gas on drinking water resources, the EPA conducted retrospective case studies at ____ locations where hydraulic fracturing had already occurred, and where residents had reported concerns about impacts to drinking water resources.
   a. 2
   b. 4
   c. 5
   d. 10

4. One location where residents had concerns over impacts on drinking water was Wise County, TX. Residents specific complaints were about changes in water quality, namely turbidity and staining, from domestic wells.
   a. True
   b. False
5. For the Wise County, TX location in question, the EPA found that in 1 of the 3 study areas, 2 domestic wells were impacted. Based on the screening of potential sources of impacts, ____ associated with the specific geological formation were the only source that was consistent with the observed impacts to 2 of the study wells.
   a. Leachate
   b. Methane
   c. Chloride
   d. Brines
6. To help understand the role of well design & construction practices in preventing pathways for subsurface fluid movement, the EPA conducted a statistical survey of oil and gas production wells hydraulically fractured by 9 oil and gas service companies in the United States during 2009 and 2010. A statistically representative sample of ____ study wells was selected from a list of wells
   a. 95
   b. 323
   c. 1000
   d. 78
7. For the wells investigated, Hydraulic Fracturing took place in a variety of different rock types, including sandstone and shale. Drinking water resources (e.g., surface water bodies, public water supply intakes, ground water wells) were commonly found within ____ mile deep of study wellhead locations.
   a. 0.5
   b. 0.75
   c. 1
   d. 1.25
8. An estimated ____ % of the wells investigated had perforations used for hydraulic fracturing that are placed at depths shallower than operator-reported protected ground water resources which could create a pathway for fluids to flow from the inside of the well to a ground water resource, if a ground water resource is present at that depth.
   a. 0.3
   b. 0.4
   c. 4
   d. 5

9. The volumes and chemical compositions of hydraulic fracturing fluids and flowback fluids (i.e., fluids that return to the surface after hydraulic fracturing) managed on oil and gas production well pads have led to concerns about potential impacts from surface spills of these fluids to drinking water resources. The data sources used in this study contained over 46,000 total spill events.
    a. True
    b. False

10. The EPA report presents the results of a broad review of state and industry spill data identified 457 hydraulic fracturing-related spill events. The most common material spilled was flowback and produced water, and the most common cause of spills was ____.
    a. Casing failure
    b. Poor engineering well design
    c. Isolation valve failure
    d. Human error

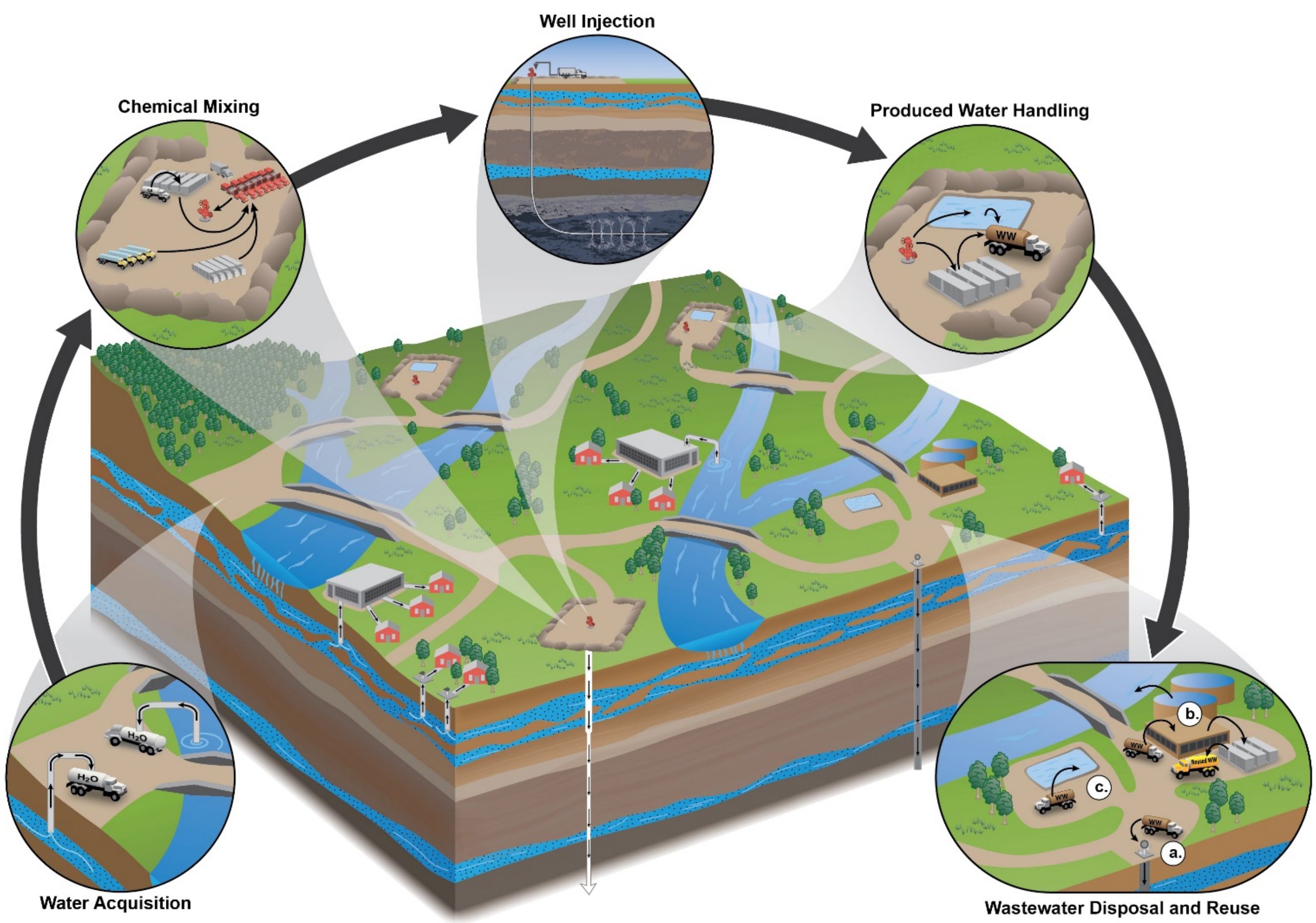
EPA "SCIENCE IN ACTION" REPORT SUMMARIES ON STUDIES RELATED TO OIL/GAS PRODUCTION HYDRAULIC "FRACING"

PART I

Hydraulic Fracturing for Oil and Gas:
Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States

In December 2016, EPA released its final report on the relationship between hydraulic fracturing activities and drinking water resources. It is the culmination of a multi-year study requested by Congress after the public began to raise concerns about potential impacts of hydraulic fracturing at nearby oil and gas production wells on their drinking water. The report provides states and others the scientific foundation to better protect drinking water resources in areas where hydraulic fracturing is occurring or being considered.

What's in the Report?
The report is organized around activities in the hydraulic fracturing water cycle and their potential to impact drinking water resources. The stages include: (1) acquiring water to be used for hydraulic fracturing (Water Acquisition), (2) mixing the water with chemical additives to prepare hydraulic fracturing fluids (Chemical Mixing), (3) injecting the hydraulic fracturing fluids into the production well to create fractures in the targeted production zone (Well Injection), (4) collecting the wastewater that returns through the well after injection (Produced Water Handling), and (5) managing the wastewater via disposal or reuse methods (Wastewater Disposal and Reuse).



To do this, EPA conducted independent research, engaged stakeholders through technical workshops and roundtables, and reviewed approximately 1,200 cited sources of data and information. A draft of the report underwent a rigorous and independent peer review by EPA's Science Advisory Board.

Major Findings

Data gaps and uncertainties limited EPA's ability to fully assess the potential impacts on drinking water resources both locally and nationally. Generally, comprehensive information on the location of activities in the hydraulic fracturing water cycle is lacking, either because it is not collected, not publicly available, or prohibitively difficult to aggregate. In places where we know activities in the hydraulic fracturing water cycle have occurred or are occurring, data were scarce that could be used to characterize the presence, migration, or transformation of hydraulic fracturing-related chemicals in the environment before, during, and after hydraulic fracturing.

EPA found scientific evidence that hydraulic fracturing activities can impact drinking water resources under some circumstances. The report identifies certain conditions under which impacts from hydraulic fracturing activities can be more frequent or severe:

- Water withdrawals for hydraulic fracturing in times or areas of low water availability, particularly in areas with limited or declining groundwater resources;
- Spills during the handling of hydraulic fracturing fluids and chemicals or produced water that result in large volumes or high concentrations of chemicals reaching groundwater resources;
- Injection of hydraulic fracturing fluids into wells with inadequate mechanical integrity, allowing gases or liquids to move to groundwater resources;
- Injection of hydraulic fracturing fluids directly into groundwater resources;
- Discharge of inadequately treated hydraulic fracturing wastewater to surface water; and
- Disposal or storage of hydraulic fracturing wastewater in unlined pits, resulting in contamination of groundwater resources.

It was not possible to calculate or estimate the national frequency of impacts on drinking water resources from activities in the hydraulic fracturing water cycle or fully characterize the severity of impacts. Our inability to quantitatively determine a national impact frequency, or to characterize the severity of impacts, however, did not prevent us from qualitatively describing factors that affect the frequency or severity of impacts at the local level.

Who Can Use the Report?

EPA's report advances the scientific understanding of hydraulic fracturing's impact on drinking water resources, and can inform decisions by federal, state, tribal, and local officials; industry; and communities to protect drinking water resources now and in the future. As science evolves, the understanding of the impacts of hydraulic fracturing on drinking water resources will continue to improve.

Where to Get the Report?

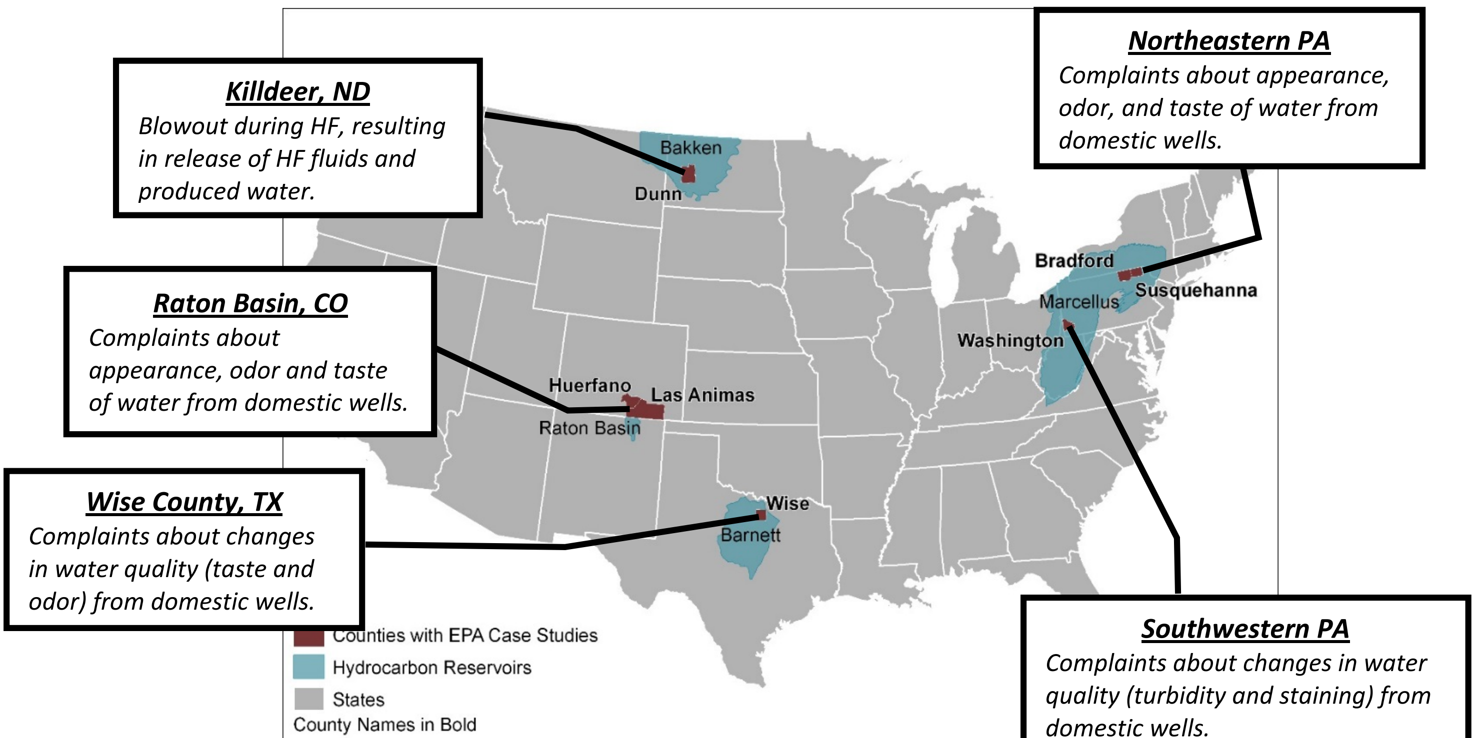
The report is being distributed as three files: (1) A stand-alone executive summary; (2) the main text including the executive summary, all chapters, and supporting citations; and, (3) a separate volume with supporting appendices. All may be downloaded from the website: www.epa.gov/hfstudy. The web site includes additional information about EPA's study and the assessment report, as well as a link to frequently asked questions about the assessment.

PART II

EPA's Hydraulic Fracturing Study: Retrospective Case Studies

Introduction: As part of the EPA's broader study of the potential impacts of hydraulic fracturing for oil and gas on drinking water resources, the EPA conducted retrospective case studies at five locations where hydraulic fracturing had already occurred, and where residents had reported concerns about impacts to drinking water resources. Through these case studies, the EPA sought to identify whether an impact had occurred, and if so, to better understand the potential causes of those impacts.

The case studies provide valuable insights into vulnerabilities and potential pathways for impacts to drinking water from hydraulic fracturing activities, such as; surface activities (including impoundment, well pads, and associated spills), and well construction and integrity. The case studies highlight the value of site-specific background data, including the chemicals used on site, and local geological information. States worked cooperatively with the EPA on these case studies, and have independently taken follow-up steps to protect water resources at all the case study locations.



Study Limitations: Retrospective case studies are often constrained by a lack of baseline data (e.g., site-specific water quality data) which limited the EPA's ability to link drinking water resource impacts to definitive causes or sources. Despite the difficulties in determining the specific sources of potential impacts, scientists were still able to use the data collected to shed light on potential vulnerabilities to drinking water resources.

Key Findings: The key findings of each retrospective case study relied on the best available science and incorporated historical water quality datasets, publicly available information for drilling and hydraulic fracturing operations within each study area, environmental site assessments, and the results of data collected during the case study sampling events. A summary of the key findings is below:

Location	Key Findings
Killdeer, ND	The drinking water wells sampled did not show the presence of chemicals or brine associated with the blowout. However two monitoring wells screened in the Killdeer aquifer showed the presence of brine and tert-butyl alcohol (TBA). Based on the data analysis performed, the only potential source consistent with the TBA and brine at the two monitoring wells was the blowout during hydraulic fracturing that occurred in Killdeer, ND.
Northeastern PA	Background data showed that methane is naturally occurring in the study area; however, using multiple lines of evidence EPA concluded that up to nine of the 36 drinking water wells are impacted by stray gas (methane and ethane) associated with nearby hydraulic fracturing activities.
Southwestern PA	Increased levels of chloride in ground water at locations near an impoundment site which contained hydraulic fracturing wastewaters and drilling waste. The chloride contamination likely originates from the impoundment site based on multiple lines of evidence. Background data showed that methane is naturally occurring in this area and was detected in 24% of the samples collected from domestic wells. The isotopic signature of the methane present in domestic wells was not similar to that of gas produced from the shale being hydraulically fractured.
Wise County, TX	In one of the three study areas, two domestic wells were impacted. Based on the screening of potential sources of impacts, brines associated with the specific geological formation were the only source that was consistent with the observed impacts to two of the study wells. Screening also identified a third well located at an industrial facility that was potentially impacted by brines and/or landfill leachate.
Raton Basin, Co	Background data indicates that dissolved methane is naturally present through-out the Raton Basin and EPA detected it in all samples collected from the domestic wells. In one of the sampling areas (Little Creek Field; Huerfano County), gas migration had occurred but cannot be definitively linked to hydraulic fracturing. Tertiary Butyl-Alcohol (TBA) was also detected in samples from domestic, monitoring, and production well; however, we were not able to confirm the specific source(s) of the TBA.

For detailed information on the individual case studies, visit http://www2.epa.gov/hfstudy/case-studies-epas-hydraulic-fracturing-study.

Approach and Sampling Activities: To help determine if an impact occurred, researchers conducted literature reviews and analyzed historical background geology and hydrology data for each site. From summer 2011 to spring 2013, the EPA collected water samples from domestic wells, monitoring wells, municipal wells, water supply wells, production wells and surface water sources during multiple sampling trips at the five case study locations. EPA scientists analyzed the water samples for a broad range of water quality parameters and chemicals. The water quality results were used to evaluate potential impacts to drinking water resources, and if possible, identify potential sources of the identified impacts. Quality assured data from the retrospective case studies have been made publicly available in a usable format on the study's website along with the peer reviewed case study reports.

Case Study Selection: The EPA invited stakeholders from across the country to participate in the identification of locations for potential case studies through informational public meetings and the submission of electronic or written comments. Over 40 locations were nominated for inclusion in the study. Locations were then prioritized and chosen based on a rigorous set of criteria, including proximity of population and drinking water supplies, reported evidence of impaired water quality, health and environmental concerns, and knowledge gaps that could be filled by a case study at each potential location. Sites were prioritized based on geographic and geologic diversity, population at risk, geologic and hydrologic features, characteristics of water resources, and land use.

PART III

Review of Well Operator Files for Hydraulically Fractured Oil and Gas Production Wells: Well Design and Construction

Background: Most production well locations have ground water and/or oil and gas in the pore spaces of rock formations in the subsurface of the earth. Some ground water resources may be considered for protection as drinking water resources, depending on ground water quality and local regulatory requirements.

Hydraulically fractured oil and gas production wells are designed, constructed and completed to access and extract hydrocarbons from targeted geologic formations. Well components, such as casing (i.e., pipe) and cement used to construct production wells, can block pathways for unintended subsurface gas and liquid movement to ground water resources (Figure 1).

To help understand the role of well design and construction practices in preventing pathways for subsurface fluid movement, the EPA conducted a statistical survey of oil and gas production wells hydraulically fractured by nine oil and gas service companies in the United States during 2009 and 2010.

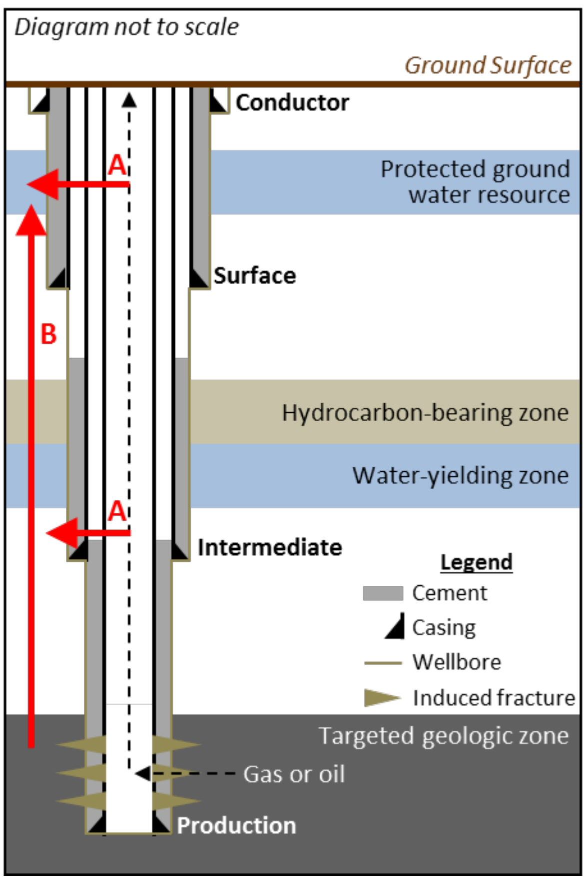


Figure 1. Potential well construction pathways for subsurface gas and fluid migration. Pathway A illustrates fluid movement from the inside of the well to the outside. Pathway B illustrates fluid movement along the wellbore.

A statistically representative sample of 323 study wells was selected from a list of wells corresponding to onshore oil and gas production wells that were reported by the nine service companies. EPA collected and summarized drilling, construction, completion, and operation information from the selected wells from nine well operators. Results of the survey are presented as rounded point estimates of the frequency of occurrence of hydraulically fractured production well design or construction characteristics with 95 percent confidence intervals. The results are statistically representative of an estimated 23,200 (95 percent confidence interval: 21,400-25,000) onshore oil and gas production wells hydraulically fractured in 2009 and 2010 by nine service companies. Confidence intervals reflect observed variability in well design and construction characteristics. The estimate provided is the center of the confidence interval and represents the best estimate of the true number of wells in a category given this sample of hydraulically fractured oil and gas production wells.

Results: Hydraulic fracturing for oil and gas production occurred in both new and old wells at depths that ranged from less than 1,000 to more than 10,000 feet deep. Hydraulic fracturing took place in a variety of different rock types, including sandstone and shale. Drinking water resources (e.g., surface water bodies, public water supply intakes, ground water wells) were commonly found within half a mile of study wellhead locations. Ninety-three (95 percent confidence interval: 78-99) percent of wells passed through protected ground water resources 2,000 feet deep or less.

Two potential pathways for underground gas and liquid movement were examined—from the inside of the well to the outside (Pathway A in Figure 1) and along the outside of the well (Pathway B). The following key findings contribute to an understanding of the role of well design and construction practices with respect to these pathways:

Hydraulically fractured oil and gas production wells generally had multiple casing (i.e., pipe) and cement barriers that can block potential pathways for underground fluid movement. The most common number of barriers between the inside of the well and the outside was either two (i.e., one cemented casing) or three (i.e., one cemented casing and one uncemented casing). More than half of the wells represented in this study had two or more barriers to subsurface fluid movement along the outside of a well. In most wells, casing installed through protected ground water resources was cemented. Protected groundwater resources noted in this report were reported as "protected" by the well operators.

While multiple barriers were often present in hydraulically fractured oil and gas production wells, some exceptions that create pathways for subsurface fluid movement were identified. Uncemented intervals have been shown to be pathways for fluid movement along Pathway B in Figure 1. An estimated 66 (95 percent confidence interval: 44-83) percent of wells had one or more uncemented intervals, and 3 (95 percent confidence interval: 0.5-13) percent of wells had uncemented intervals within operator-reported protected ground water resources. Perforations used for hydraulic fracturing that are placed at depths shallower than operator-reported protected ground water resources create a pathway for fluids to flow from the inside of the well to a ground water resource, if a ground water resource is present at that depth (Pathway A). An estimated 0.4 (95 percent confidence interval: 0.1-3) percent of wells had perforations that were placed shallower than the bottom of the operator-reported protected ground water resource. Based on this analysis, hydraulic fracturing has occurred within rock formations that contain both protected ground water and oil and/gas. However, the overall frequency of this practice appears to be low.

Estimates of the frequency of occurrence of well design and construction characteristics are presented at the national scale. Estimates may be different for different regions of the country, because of differences in local geologic characteristics, state regulations and company preferences. It is also possible that the estimates presented in this report may not apply to wells constructed and hydraulically fractured after 2010, if well design and construction practices have changed (e.g., a greater proportion of horizontal well completions). Additionally, the results presented in this report are generated from data provided by oil and gas well operators. The EPA did not attempt to independently and systematically verify data supplied by operators. Consequently, the study results, which include comparisons of operator-reported protected ground water resources to well construction characteristics, are of the same quality as the supplied data.

Overview of the EPA's *Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources*

The EPA released a draft assessment of the potential impacts of oil and gas hydraulic fracturing activities on the quality and quantity of drinking water resources in the United States. The draft assessment is based upon extensive review of literature, results from EPA research projects, and technical input from state; industry; non-governmental organizations; the public; and other stakeholders. As part of this effort, the EPA characterized oil and gas production wells hydraulically fractured by nine oil and gas service companies in the United States during 2009 and 2010.

PART IV

Review of State and Industry Spill Data:
Characterization of Hydraulic Fracturing-Related Spills

Background

Advances in hydraulic fracturing and horizontal drilling technologies have led to increased oil and gas exploration and production activity in different regions across the United States. Hydraulic fracturing is a stimulation technique used to produce economically viable quantities of oil, natural gas, and natural gas liquids from underground rock formations. The volumes and chemical compositions of hydraulic fracturing fluids and flowback fluids (i.e., fluids that return to the surface after hydraulic fracturing) managed on oil and gas production well pads have led to concerns about potential impacts from surface spills of these fluids to drinking water resources. To better understand what is known about spills associated with hydraulic fracturing, the EPA has analyzed spill data from states and industry (service companies, oil and gas well operator) sources. For the purposes of the study, hydraulic fracturing-related spills were defined as those occurring on or near the well pad before or during the mixing and injection of hydraulic fracturing fluids or during the post-injection recovery of fluids.

Data on spills that occurred between January 2006 and April 2012 were obtained from nine states with online spill databases or other data sources, nine hydraulic fracturing service companies, and nine oil and gas production well operators. The data sources used in this study contained over 36,000 spill events. Spill records from an estimated 12,000 spill events (33 percent of the total number of spills reviewed) contained insufficient information to determine whether the event was related to hydraulic fracturing. Of the spill events with sufficient information, the EPA identified an estimated 24,000 spill events (66 percent) as not related to hydraulic fracturing and 457 spill events (approximately 1 percent) as related to hydraulic fracturing. The 457 hydraulic fracturing-related spill events occurred in 11 different states over six years (January 2006 and April 2012).

For these 457 hydraulic fracturing-related spill events, the most commonly reported information obtained from state and industry data sources was the type of material spilled (reported in 97 percent of the hydraulic fracturing-related spill events), followed by the volume spilled and then the source and cause of the spill. In approximately 90 percent of the hydraulic fracturing-related spill events, information was available on whether or not the spill reached at least one environmental receptor (surface water, ground water, and/or soil). This study did not determine if or how spilled fluids may have affected surface or ground water quality, nor did it evaluate spill reporting requirements.

Results

This report presents the results of a broad review of state and industry spill data that identified 457 hydraulic fracturing-related spill events. Data from these spills were used to characterize volumes and materials spilled, spill sources and causes, and environmental receptors. There were several key findings that contribute to an understanding of the characteristics of hydraulic fracturing-related spill events that may reach surface or ground water resources. The hydraulic fracturing-related spills were characterized by numerous low volume events (up to 1,000 gallons) and relatively few high volume events (greater than 20,000 gallons). The most common material spilled was flowback and produced water, and the most common cause of spills was human error. There were 300 spill events (66 percent of the 457 spill events identified in this study) in which spilled fluids reached at least one environmental receptor.

Twenty-four of these events reached multiple environmental receptors. Spilled fluids were reported to have reached surface water in 32 hydraulic fracturing-related spill events (7 percent); the median volume per spill for these events was 3,500 gallons, and volumes per spill ranged from 90 gallons (5th percentile) to 45,000 gallons (95th percentile). There was one spill event in which spilled fluids were reported to have reached ground water (0.2 percent). Spilled fluids were reported as not reaching surface or ground water in 186 spill events (41 percent). While the data sources indicated that some spills reached ground or surface water resources, the EPA did not determine if or how spilled fluids may have affected surface or ground water quality. However, available information indicates that responses to hydraulic fracturing-related spills generally include both immediate actions to stop the spill and/or contain spilled fluids and longer term actions to remediate the affected area. These results, as well as other information on the spill characteristics and containment and response activities, provide important insights into the nature of hydraulic fracturing-related spills in several key states with hydraulic fracturing.

The spills characterized in this study were likely a subset of the total number of hydraulic fracturing-related spills that occurred in the United States between January 2006 and April 2012. Although spill data were obtained from nine states that are among the top oil and gas producing states in the country, similar data from other oil and gas producing states were not included. The state data sources used in this study may not have included all spills related to hydraulic fracturing because some spills may not have met the spill reporting requirements that were in place at the time of the spill. Additionally, some reported spills may not have been identified as related to hydraulic fracturing due to insufficient information in the data sources. The quantitative characterization of hydraulic fracturing-related spills presented in this report (e.g., the percentages in the paragraph above) may have been different if more hydraulic fracturing-related spills could have been identified from the data sources used in this study.

Overview of the EPA's *Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources*

The EPA released a draft assessment of the potential impacts of oil and gas hydraulic fracturing activities on the quality and quantity of drinking water resources in the United States. The draft assessment is based upon extensive review of literature, results from EPA research projects, and technical input from state; industry; non-governmental organizations; the public; and other stakeholders. As part of this effort, the EPA characterized hydraulic fracturing-related spills with respect to volumes and materials spilled, spill sources and causes, and environmental receptors.

For more information, please visit: www.epa.gov/hfstudy
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