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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.

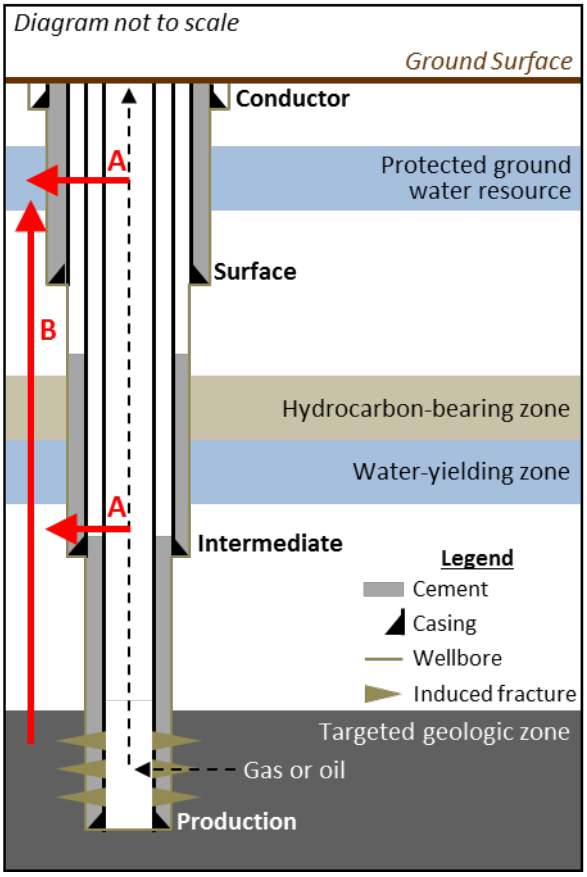

Figure 1. Potential well construction pathways for subsurface gas and fluid migration. Pathway A illustrates fluid movement from the inside of the well to the outside. Pathway B illustrates fluid movement along the wellbore.

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.

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