Water is an integral part of hydraulic fracturing (HF). According to the U.S. Environmental Protection Agency (EPA), there are five steps in the HF water cycle: acquisition, mixing, injection, flowback and production, and treatment and disposal. This Short Subject discusses the role of water in HF: where it comes from, how it is used, the composition of HF fluids, and what happens to the fluids after the fracture event. In this Short Subject, an HF event is defined as "a precise stimulation activity, limited to the fluid action in initiating and extending cracks in the rock."  

**Sources and Use of Water in HF**

In HF, water serves as a carrier for the mixture of fluids that are injected at high pressure to fracture the rock or shale formation and cause the release of oil and gas. Sources of water used for HF vary depending upon the type of HF event, the geographic site and geologic situation of the operation, and available water resources. Besides identifying and mapping the locations of nearby surface and near-surface waters, operators may also use computer models for each proposed HF event to determine the estimated quantity and quality of fluids required.

While the exact amount of water required for a particular type of HF event is difficult to estimate precisely in advance, interim regulations by the California Department of Conservation, Division of Oil, Gas, and Geothermal Resources (DOGGR) requires that notification of HF events include the estimated amount of water needed. Operators must also submit a plan for water management and groundwater monitoring. Notification of nearby property owners and tenants is also required. Additional, post-event notification will make it possible to document the amount of water actually used over time.

To meet the estimated water need for an HF event, operators may acquire water by purchase from available sources or obtain it from company-owned wells. For example, in a notice submitted to DOGGR dated 12/24/13, operator Occidental of Elk Hills, Inc. planned to acquire fresh water from West Kern Water District, an entity that obtains its water from groundwater sources as well as the State Water Project. In another notice submitted to DOGGR dated 12/21/13, Aera Energy, LLC planned to draw water from its own wells and from the Belridge Water Storage District, a local district which receives water from the California Aqueduct.

The estimated amount of water used per event varies in accordance with the type of HF-event. Two recent notices submitted to DOGGR estimated 180 barrels (7,560 gallons), and 4,800 barrels (201,600 gallons), respectively. This range of water use may or may not be typical for HF in California; post-event notifications submitted to DOGGR will allow for better data on water sources and uses. For comparative purposes, Table 1 offers average volumes of water for shale well fracturing events (not including volumes used for drilling) in key U.S. oil and gas producing formations.

<table>
<thead>
<tr>
<th>Gallons Used</th>
<th>Geologic Formation</th>
<th>State(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 million</td>
<td>Niobrara Shale</td>
<td>Colorado, Wyoming</td>
</tr>
<tr>
<td>4.6 million</td>
<td>Barnett Shale</td>
<td>Texas</td>
</tr>
<tr>
<td>5 million</td>
<td>Eagle Ford Shale</td>
<td>Texas</td>
</tr>
<tr>
<td>5 million</td>
<td>Haynesville Shale</td>
<td>Texas, Louisiana</td>
</tr>
<tr>
<td>5.6 million</td>
<td>Marcellus Shale</td>
<td>Pennsylvania, New York</td>
</tr>
</tbody>
</table>

**Table 1: Average Volumes of Water per HF Event in Key U.S. Oil and Gas Producing Formations**

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High-pressure injection of HF fluids results in an initial return flow of fluids ("flowback water"). The amount and rate of flow of this returning water slows over time. The permeability of the formation impacts how much water returns to the surface, and how much HF fluid remains below the surface.²

**Composition of HF Fluids**

Industry service companies offer many different fluid products for use in HF events. The basic components of a fluid mixture for use in a "slick water frac" include water, proppant, friction reducer, disinfectant, surfactants, gelation chemicals, scale inhibitors, hydrochloric acid, and corrosion inhibitors.² Each product is designed for a treatment that is geared to a specific application and location.

Because there are different kinds of HF events, the amount of water in a fluid product varies. Two recent notices submitted to DOGGR estimated 44 percent water in one fluid mixture, and 99 percent water in another fluid mixture, respectively.³ Consider that fluid for a slick water frac may contain a greater percentage of water than that needed for a "gel"- or "foam"-type HF event. For each HF event, the operator provides the water to be mixed with the set of HF event-specific additives that a company specializing in producing mixtures provides. The fluid used in an HF event is not mixed in advance; rather, it is mixed at the moment the fluid is being pumped into the well.²

The most frequent chemical components found in HF fluid products (used by operators across the United States that are subject to federal regulation under the Safe Drinking Water Act or the Clean Water Act) are: Methanol, Ethylene Glycol, Naphthalene, Xylene, Hydrochloric Acid, Toluene, Ethylbenzene, Diethanolamine, and Formaldehyde. In addition to Methanol and Ethylene Glycol, five other chemicals are commonly found in the majority of HF fluids produced by service companies for use in HF events: Isopropanol, Crystalline Silica, 2-Butoxyethanol, Hydrotreated Light Petroleum Distillates, and Sodium Hydroxide.¹

**Disposal of Water Used in HF**

Water is also a major byproduct of the oil and gas development process. When oil and gas are released as part of the drilling of the well, or at the initiation of a hydraulic fracturing event, large amounts of water previously stored in the shale may rise to the surface. This water ("produced water") may be composed of oil, gas, HF fluids, and water that may have been residing in the rock or shale. Little public data exists about the extent to which chemicals from HF fluid products may be present in detectable quantities in source waters used for public drinking water supplies. Permanent regulations which will become effective January 1, 2015 suggest that more data will become available over time.

According to EPA, the most common practice used by U.S. operators after the HF event is to separate the produced water from the oil and gas, pump it into trucks, treat it to EPA standards at a company-owned treatment plant, and then inject it back into the ground into designated wells.¹ Depending upon the geographic location, compliance with California Public Resources Code Sections 3315-3347 may require re-injection to reduce potential subsidence. Given the additional costs associated with treatment, an operator may also store produced water underground for possible use in a future HF event.¹

Although the amount of produced water reported by the oil and gas industry in California has increased over time,⁴ it is unclear how much of this produced water is associated with HF. As more data becomes available on HF in California, it will be possible to better understand how much water is used in this precise stimulation activity.

**Endnotes**


